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

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

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 an operating coil 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.

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 this 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, or effectively equal if appropriate auto balance taps are used to compensate for 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 difference 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 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 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 incon-

Supersedes I.L. 41-332.2
*Denotes change from superseded issue

EFFECTIVE JANUARY 1966

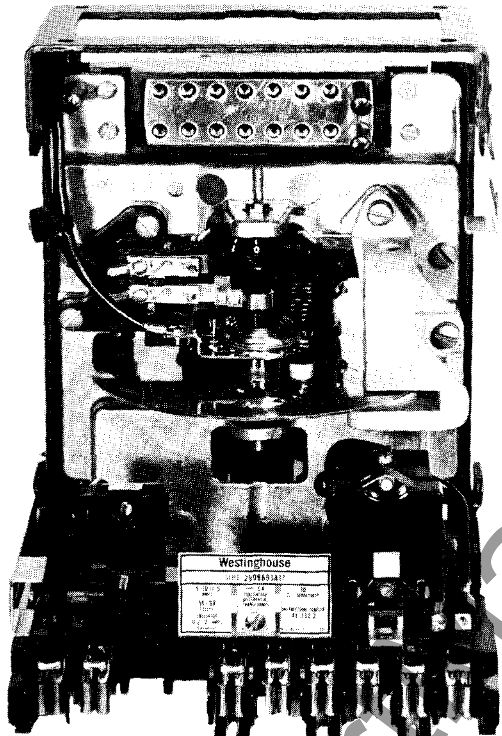


Fig. 1. Type CA Transformer Relay (Front View)

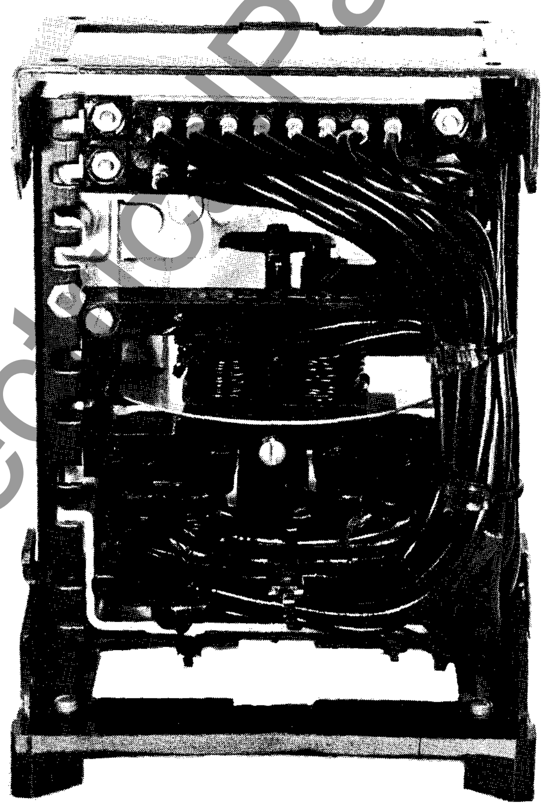


Fig. 2. 'Type CA Transformer Relay (Rear View)

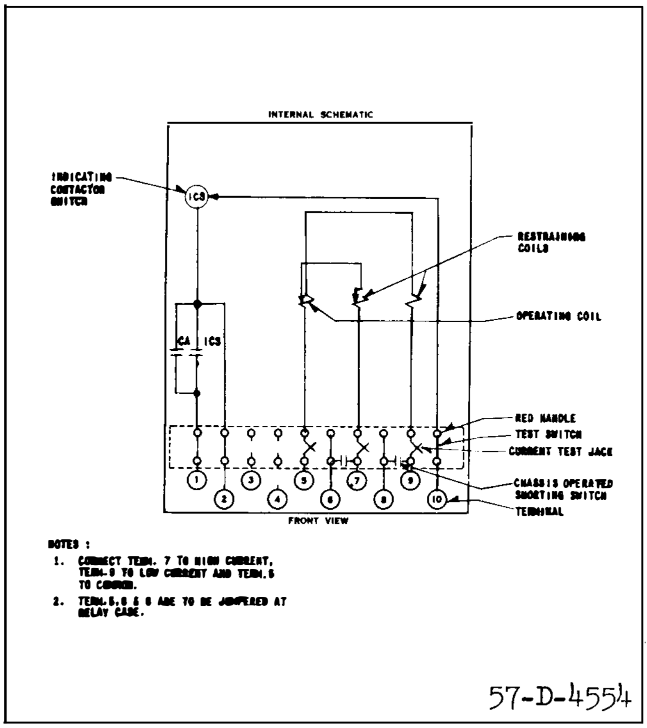


Fig. 3. Internal Schematic of the type CA Transformer Relay in the type FT21 Case.

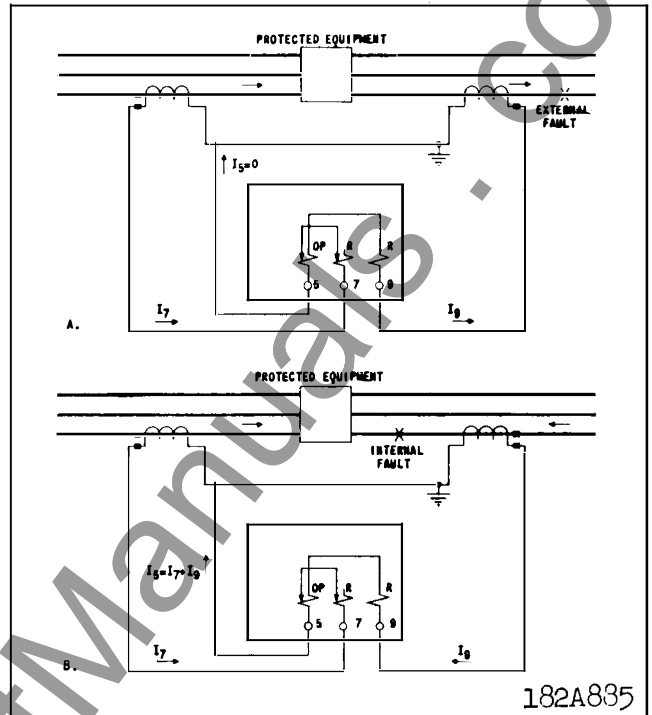


Fig. 4. Schematic diagrams of the percentage differential relays (A) shows the fault current distribution for an external fault; (B) the distribution for an internal fault.

sequential, and a large amount of contact closing torque is produced.

CHARACTERISTICS

The operating characteristics of the relay for normal through load current and through fault current are shown in Fig. 5 and 6. 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 Fig. 5 and 6, the two curves going with the 5-5 tap are tied together with a bracket to indicate that these two curves go together. Similarly, the two curves for the 5-10 tap are also tied together with a bracket. 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: $I_9 = \frac{7.517}{T}$ (1)

For the lower curve: $I_7 = .3TI_9$ (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_7 = 43.5, and I_9 = 30, read from the lower curve for the 5-5 tap, Fig. 4. Applying the formula, equation (2) the calculated value of I_7 is found to be 45 amperes, which is fairly close to the curve value, I_7 = 43.5.

The derivations of equations (1) and (2) are given in Fig. 7, which has been included to illustrate the meaning of these equations.

Typical time-of-operation curves are shown in Fig. 9.

Figure 8 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.

Trip Circuit

The main contacts will safely close 30 amperes

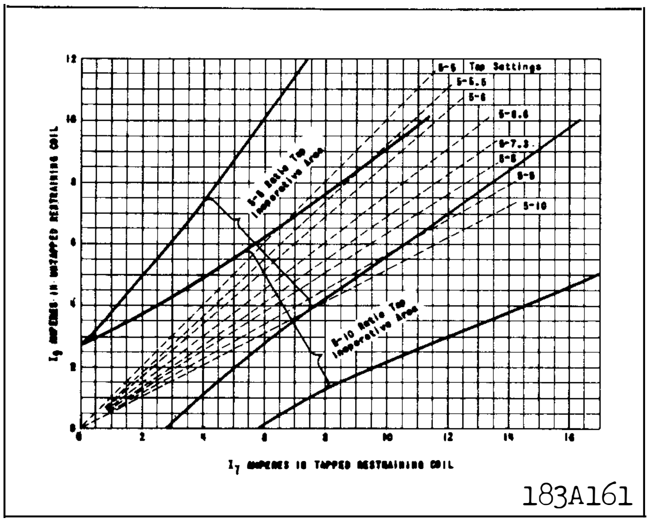


Fig. 5. Typical operating curves for low values of current.

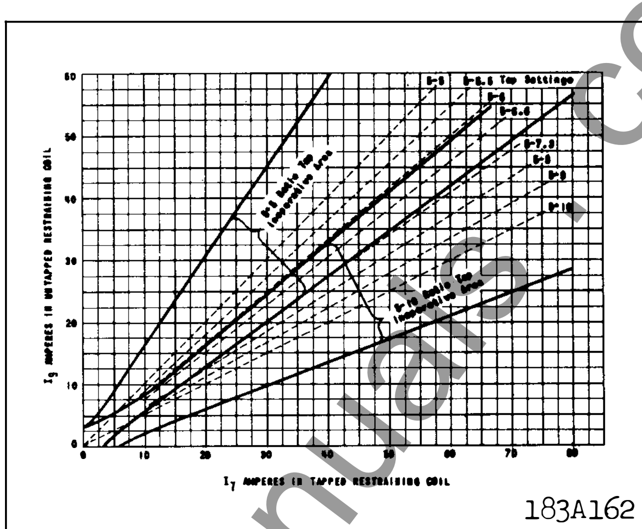


Fig. 6. Typical operating curves for high values of current.

at 250 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.

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 type CA relay are best given in curve formulas illustrated and given by the curves, Fig. 10, 11 and 12.

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 over-loading 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.

SETTINGS

Percentage Differential Unit

The transformer relay is detailed in Fig. 4. 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 4.67/7.8 is equal to 5/8.47. The nearest tap ratio on the relay is 5/8, and this pair of taps should be used.

The time dial should be set on the number 1 position.

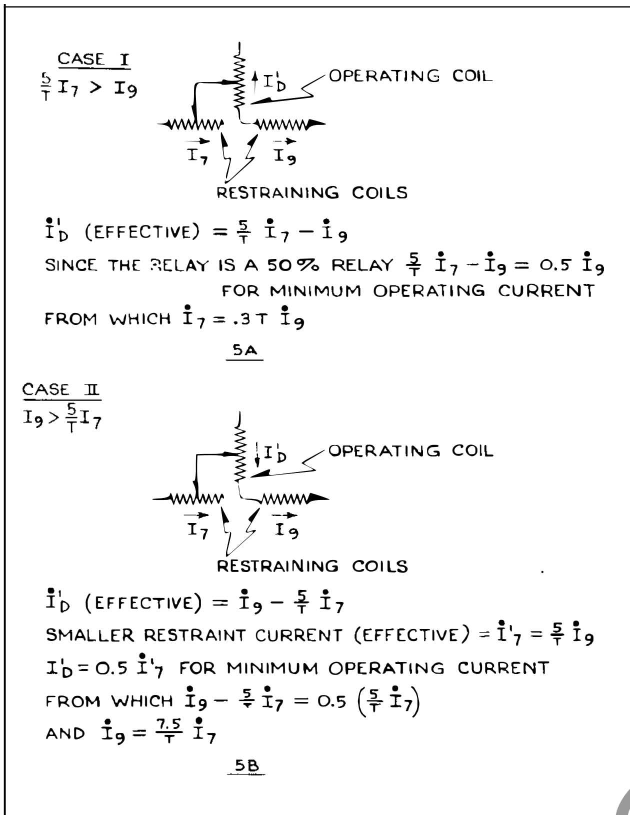


Fig. 7. Fundamental relationships in the Type CA Electromagnet.

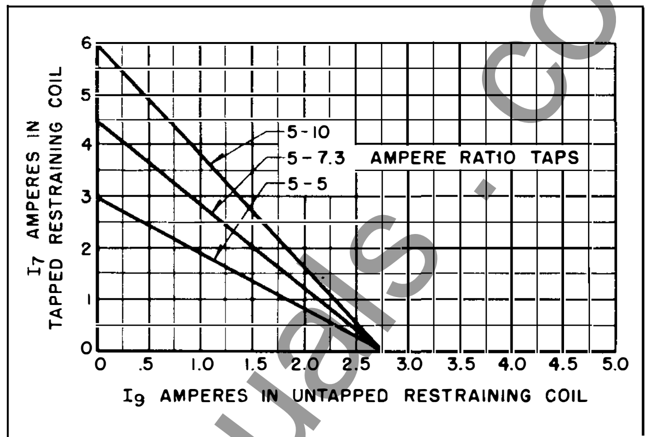


Fig. 8. Typical sensitivity characteristics of the Type CA Transformer Relay.

Indicating Contactor Switch (ICS)

No setting is required on the ICS unit except the selection of the 0.2 or 2.0 amp 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; for 48 volt d-c applications set relay in 2 ampere and use WL relay coil S#304C209G01 or equivalent.

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.

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 the relay set on the 5-5 tap, the contacts

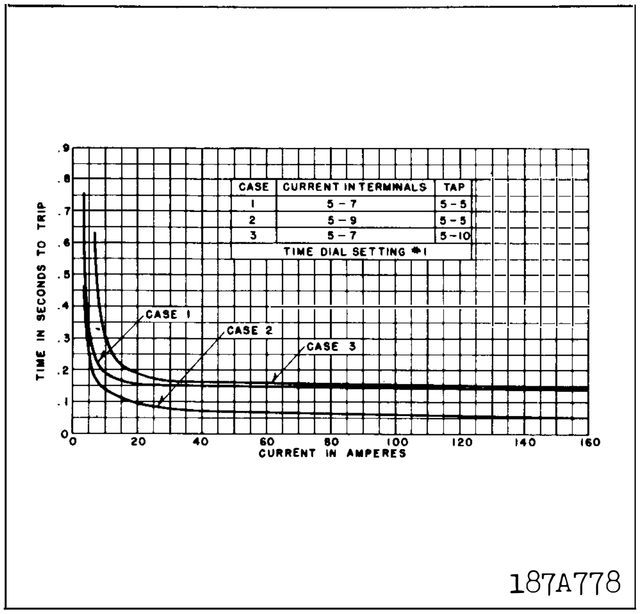


Fig. 9. Typical 60 cycle Time Curves for the Type CA Transformer Relay.

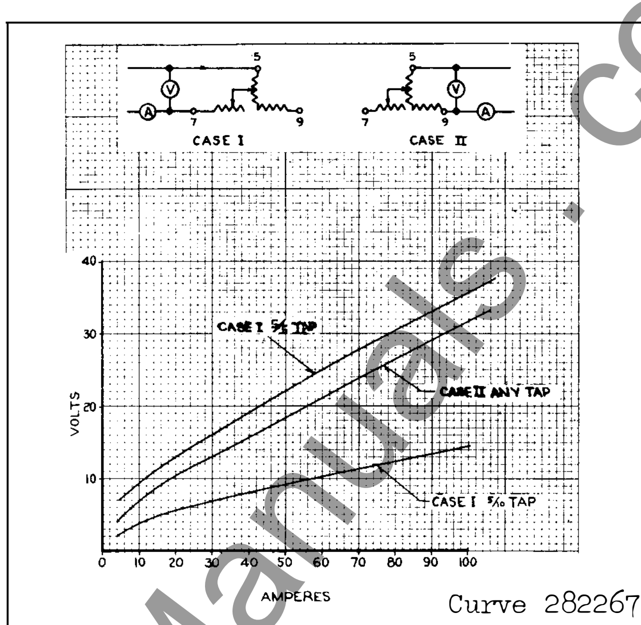


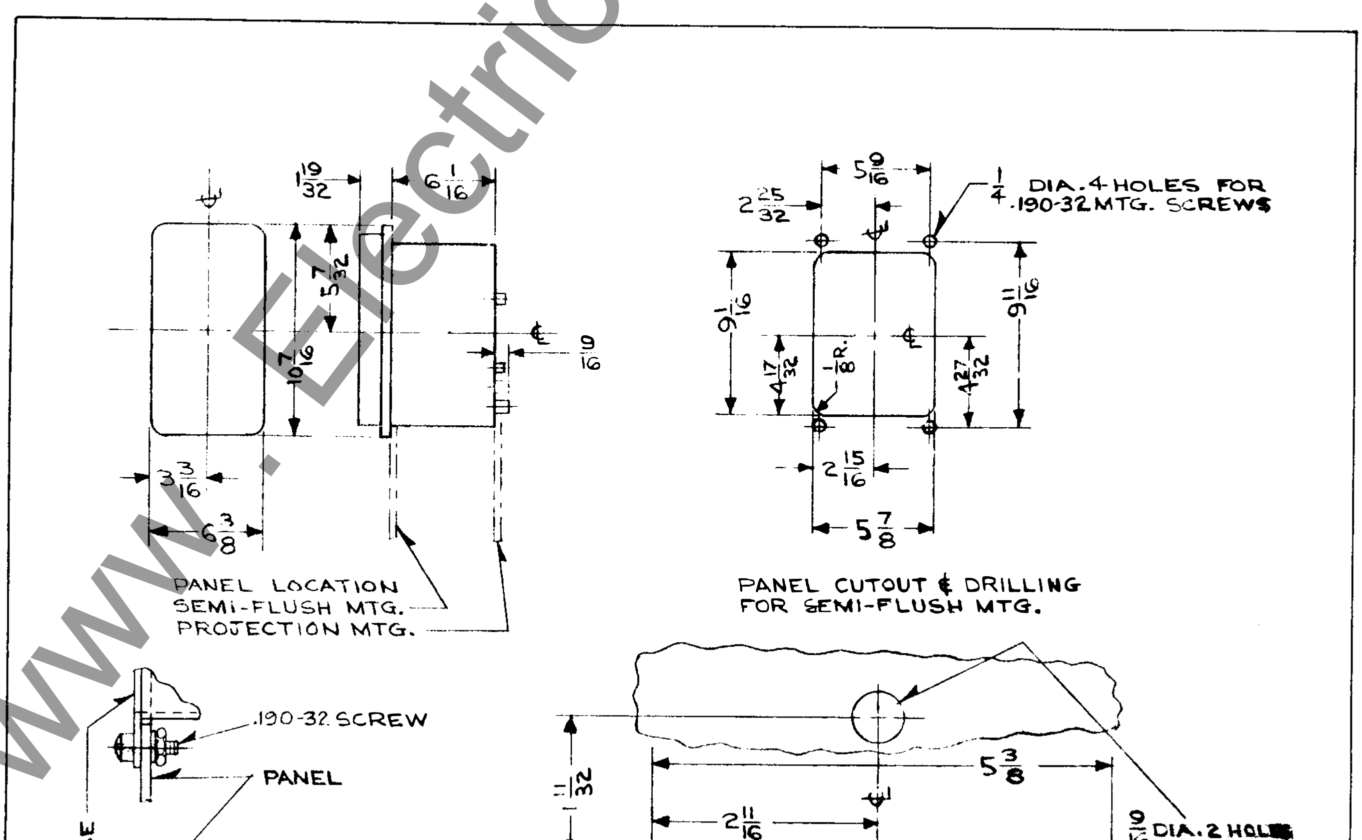
Fig. 10. Typical 60 cycle saturation curves for the Type CA Transformer Relay

should close within the following limits with current applied to the specified terminals:

terminal 9 and 5	2.7 to 2.8 amperes
terminal 7 and 5	2.9 to 3.2 amperes.

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.

TYPE CA TRANSFORMER RELAY



WESTINGHOUSE ELECTRIC CORPORATION

RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**

Printed in U.S.A.

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

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

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 an operating coil 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.

Indicating Contactor Switch Unit (ICS)

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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, or effectively equal if appropriate auto balance taps are used to compensate for 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 difference 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 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 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 incon-

SUPERSEDES I.L. 41-332.2A
*Denotes change from superseded issue.

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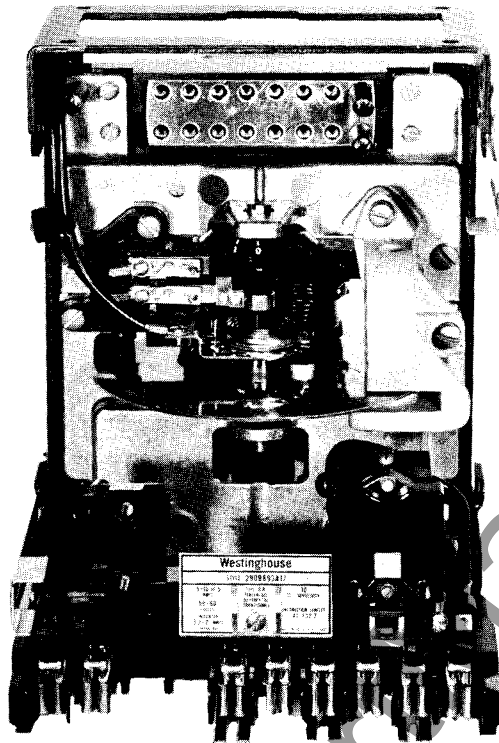

Fig. 1. Type CA Transformer Relay (Front View)

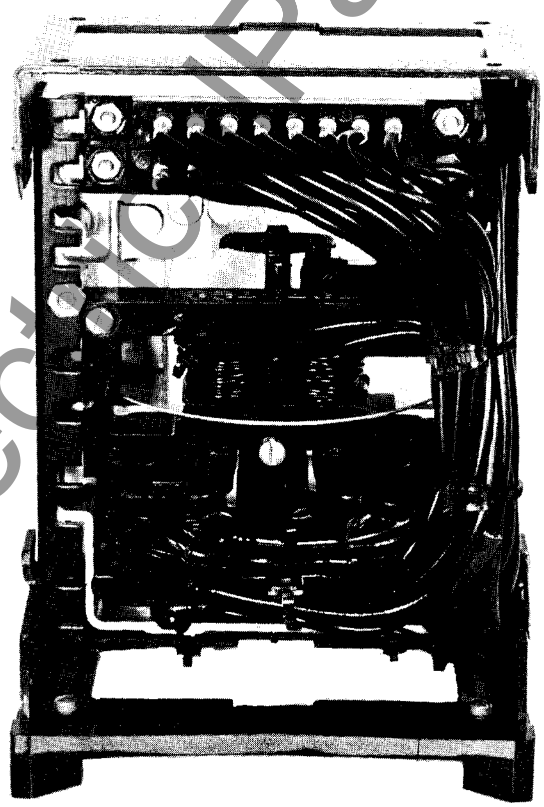

Fig. 2. Type CA Transformer Relay (Rear View)

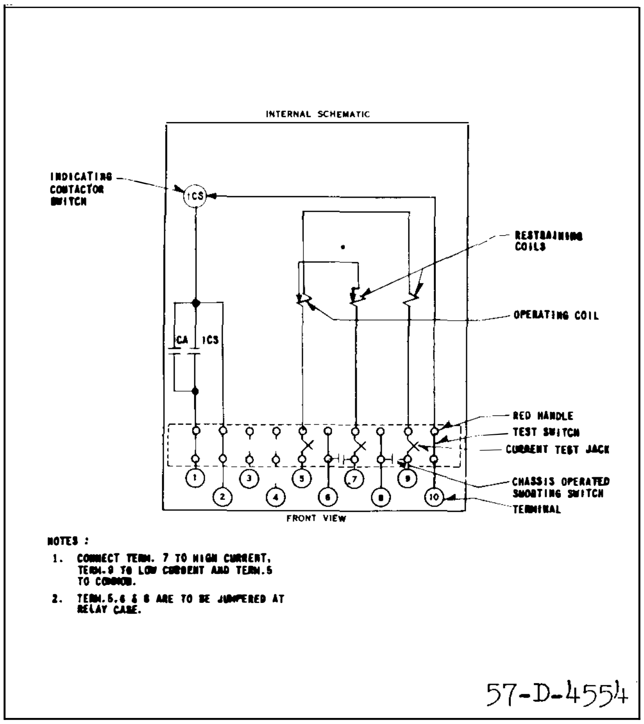

Fig. 3. Internal Schematic of the type CA Transformer Relay in the type FT21 Case.

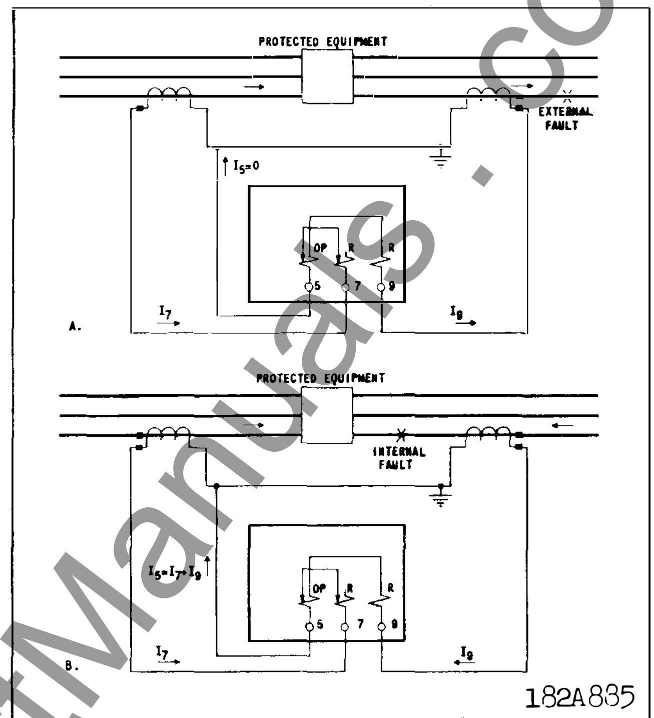

Fig. 4. Schematic diagrams of the percentage differential relays (A) shows the fault current distribution for an external fault; (B) the distribution for an internal fault.

sequential, and a large amount of contact closing torque is produced.

CHARACTERISTICS

The operating characteristics of the relay for normal through load current and through fault current are shown in Fig. 5 and 6. 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 Fig. 5 and 6, the two curves going with the 5-5 tap are tied together with a bracket to indicate that these two curves go together. Similarly, the two curves for the 5-10 tap are also tied together with a bracket. 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: $I_9 = \frac{7.5}{T} I_7$ (1)

* For the lower curve: $I_7 = .3T\ I_9$ (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.

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Typical time-of-operation curves are shown in Fig. 9.

Figure 8 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.

Trip Circuit

The main contacts will safely close 30 amperes

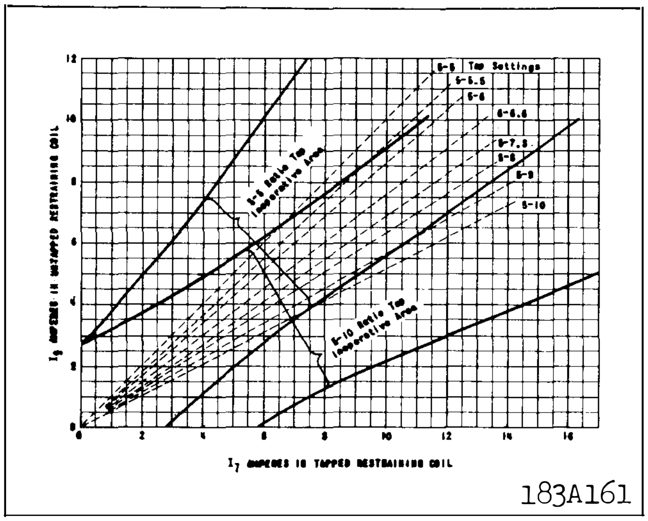

Fig. 5. Typical operating curves for low values of current.

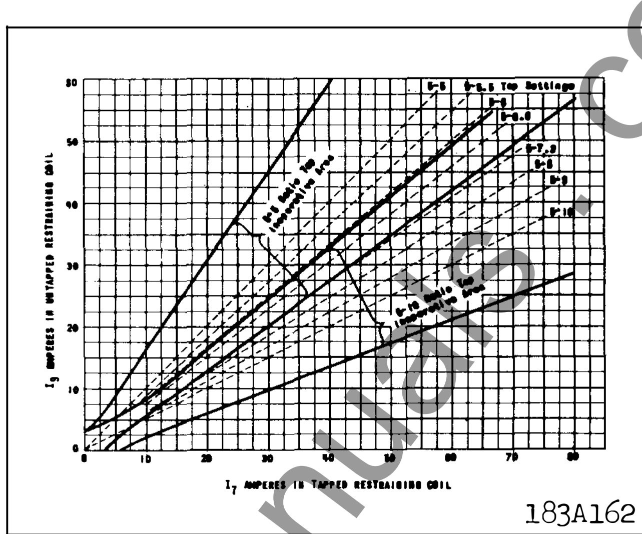

Fig. 6. Typical operating curves for high values of current.

at 250 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.

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 type CA relay are best given in curve formulas illustrated and given by the curves, Fig. 10, 11 and 12.

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 over-loading 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.

SETTINGS

Percentage Differential Unit

The transformer relay is detailed in Fig. 4. 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 4.67/7.8 is equal to 5/8.47. The nearest tap ratio on the relay is 5/8, and this pair of taps should be used.

The time dial should be set on the number 1 position.

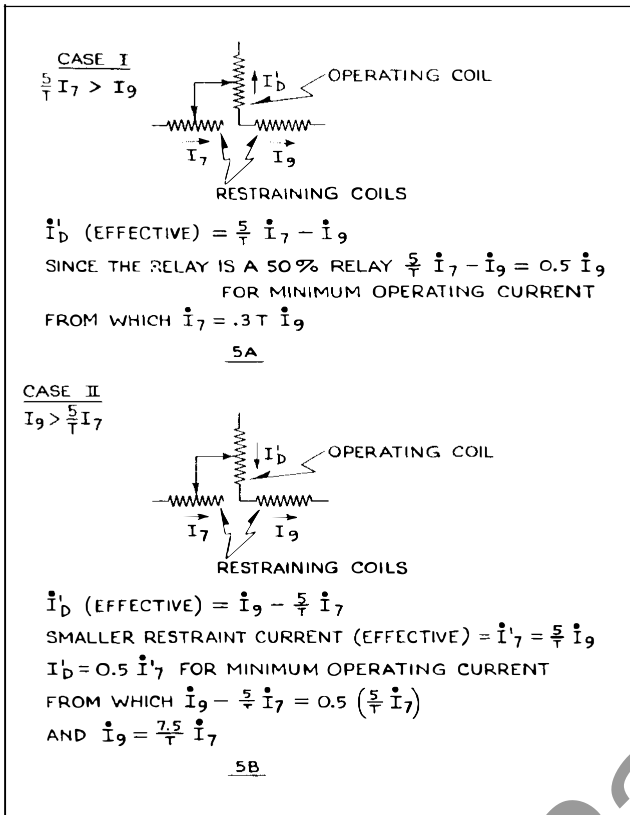

Fig. 7. Fundamental relationships in the Type CA Electromagnet.

Indicating Contactor Switch (ICS)

No setting is required on the ICS unit except the selection of the 0.2 or 2.0 amp 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; for 48 volt d-c applications set relay in 2 ampere and use WL relay coil S#304C209G01 or equivalent.

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

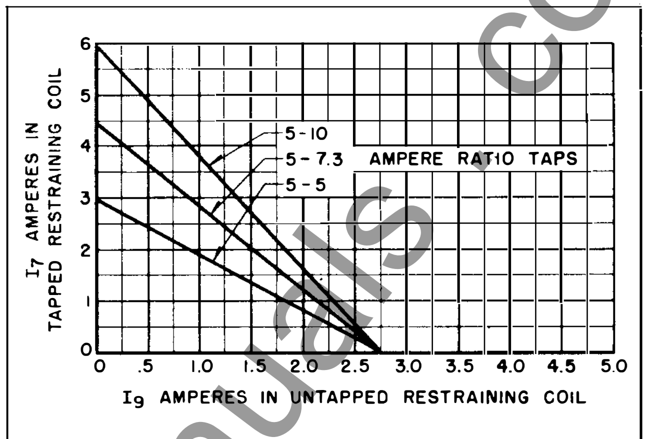

Fig. 8. Typical sensitivity characteristics of the Type CA Transformer Relay.

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

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 the relay set on the 5-5 tap, the contacts

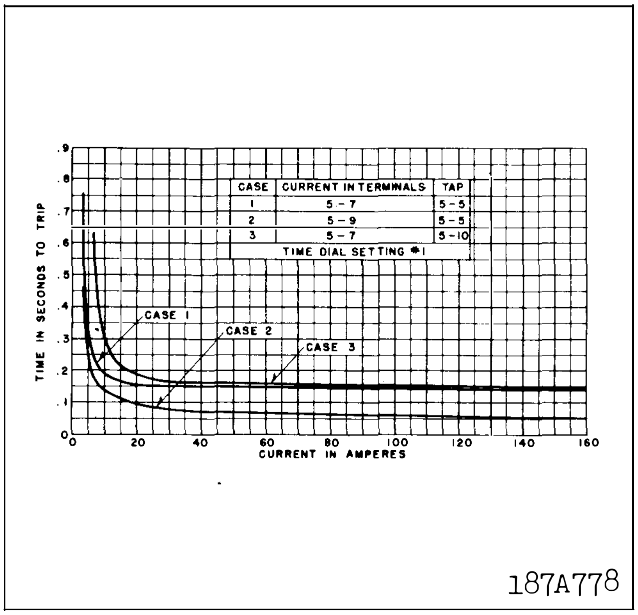

Fig. 9. Typical 60 cycle Time Curves for the Type CA Transformer Relay.

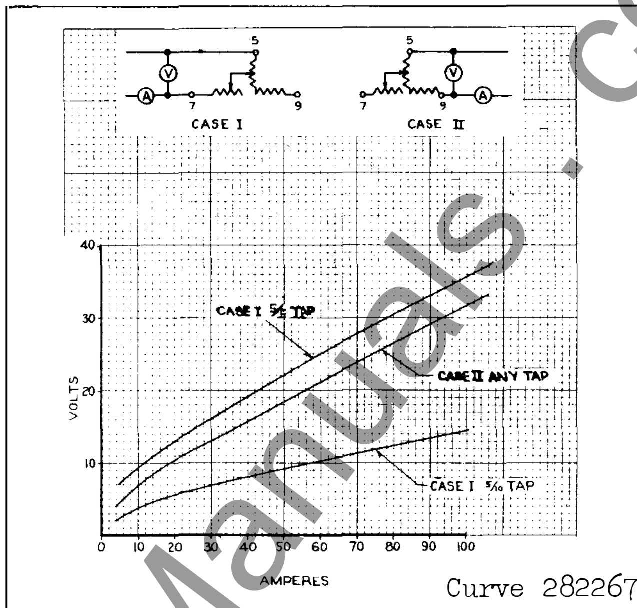

Fig. 10. Typical 60 cycle saturation curves for the Type CA Transformer Relay

should close within the following limits with current applied to the specified terminals:

terminal 9 and 5	2.7 to 2.8 amperes
terminal 7 and 5	2.9 to 3.2 amperes.

3. Differential Characteristics

Connect the relay per the test circuit of figure 13. (NORMAL CONNECTION). Set the relay on the 5-5 tap and apply 20 amperes to terminal 9. The relay should just operate when the current from terminal 7 is between the limits of 28.5 to 31.5 amperes.

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

Reverse the connection to terminal 7 and 9 and apply 20 amperes to terminal 7. The relay should just operate when the current from terminal 9 is between the limits of 29 to 33 amperes.

4. Time Curve

With the time dial on the number 1 position, apply 20 amperes to terminals 5 and 9. The relay should operate between .080 and .10 seconds with a tap setting of 5-5.

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.

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 such time intervals as may be dictated by experience to be suitable to the particular application.

All contacts should be periodically cleaned. A contact burnisher Style #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").

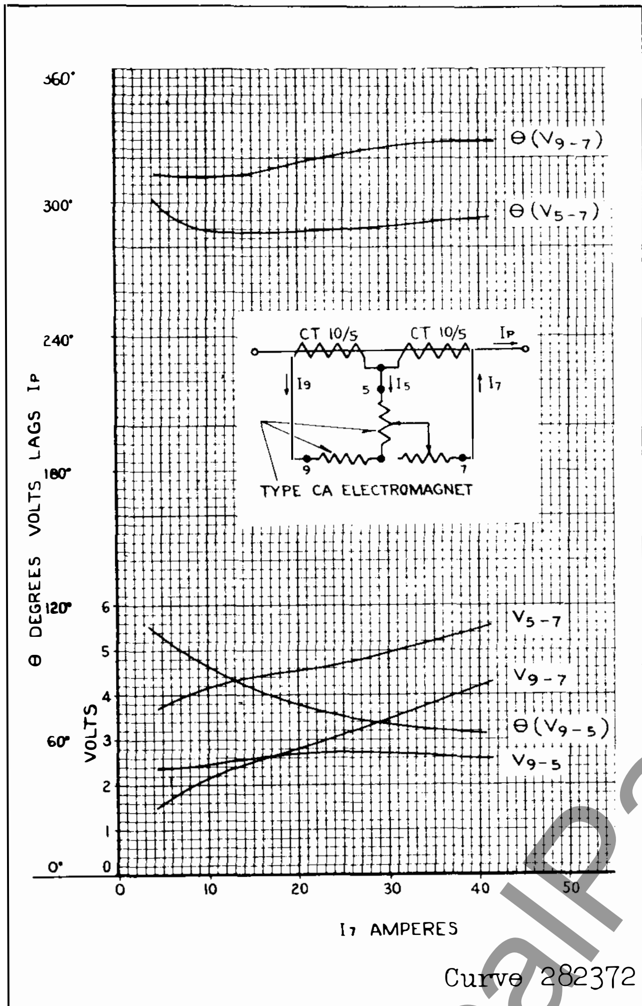

Fig. 11. Typical 60 cycle burden curves for the type CA Transformer Relay on the 5-5 tap ($I_5 = 0$)

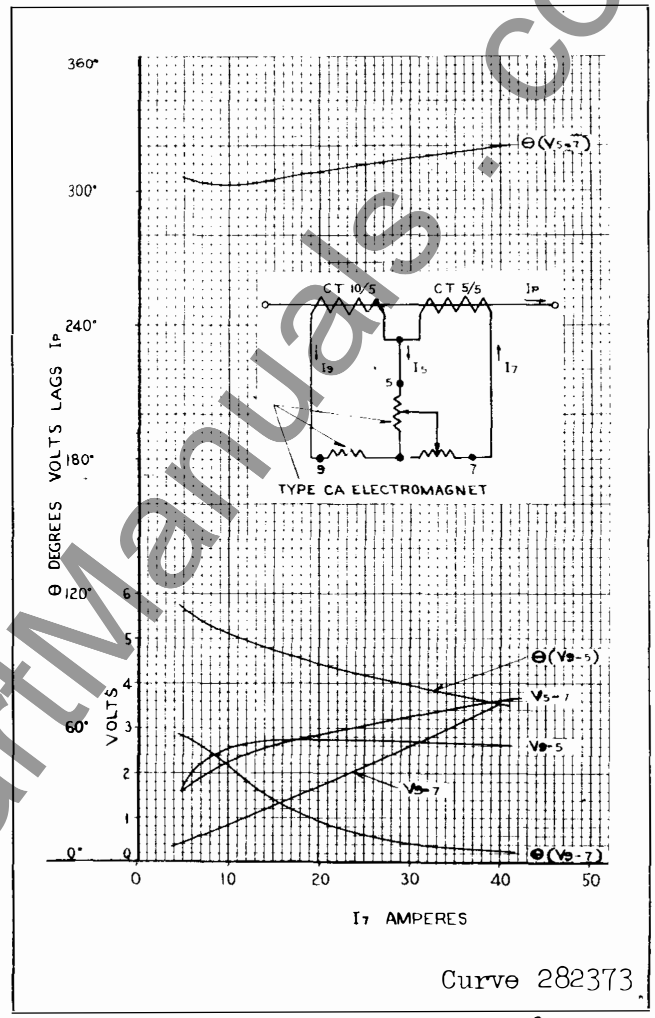

Fig. 12. Typical 60 cycle burden curves for the Type CA Transformer Relay on the 5-10 Tap ($I_5 = \frac{1}{2} I_7$)

1. Contact

The index mark on the movement frame will coincide with "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 curves. 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.

With a tap setting of 5-5, apply current to terminals 9 and 5 of the relay and adjust the control spring tension so that the moving contact just closes between limits of 2.7 to 2.8 amperes. Apply current to terminals 7 and 5 of the relay. The contacts should just close between the limits of 2.9 to 3.1 ampere.

3. Percentage Slope Characteristics

Points on the percentage slope curve can be checked by use of the test circuit of Fig. 13. 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.

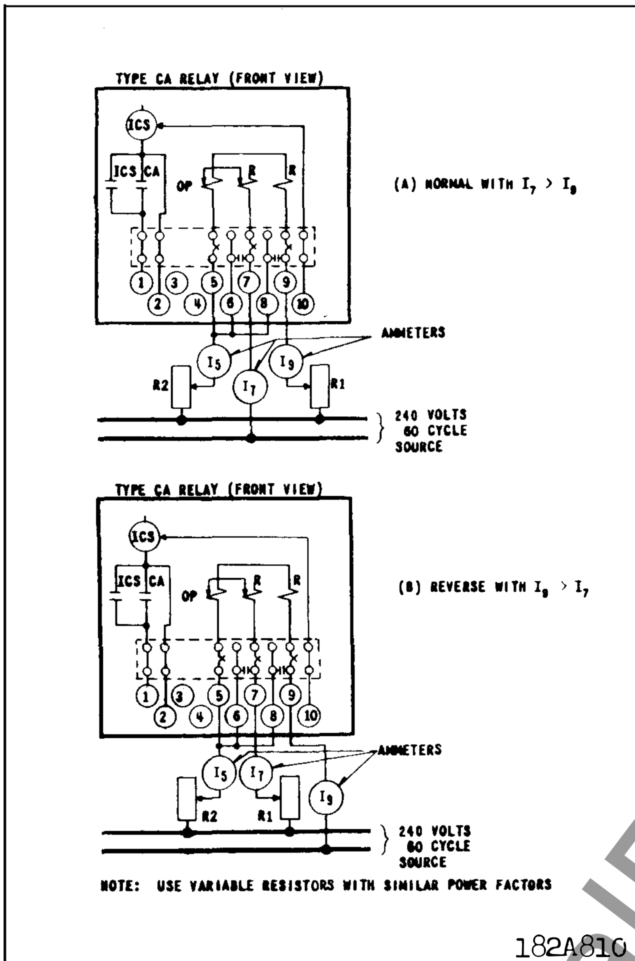

Fig. 13. Diagram of Test Connections for the Type CA Transformer Relay in the Type FT21 Case.

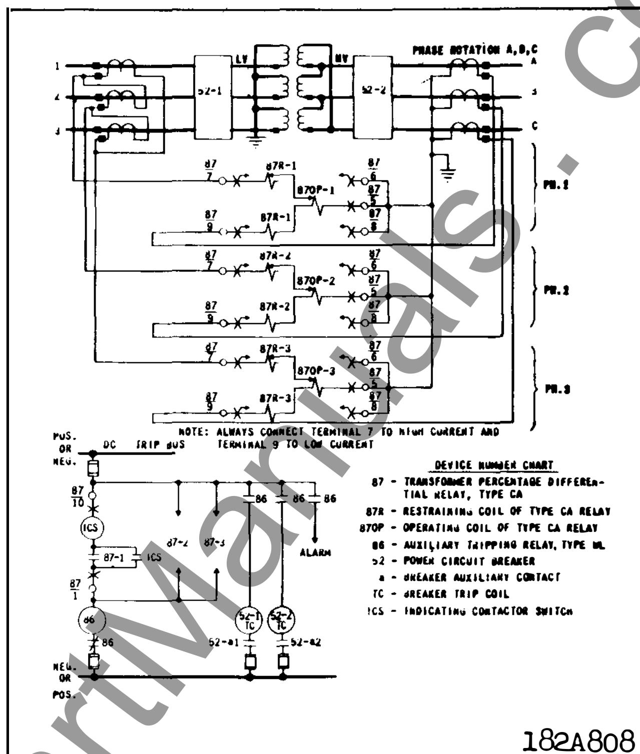

Fig. 14. External Schematic Diagram of the Type CA Transformer Relay in the Type FT21 Case for Protection of a Wye-Delta Transformer Bank

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 between the limit of .085 to .095 sec. with 20 amperes applied to terminals 5 and 9.

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.

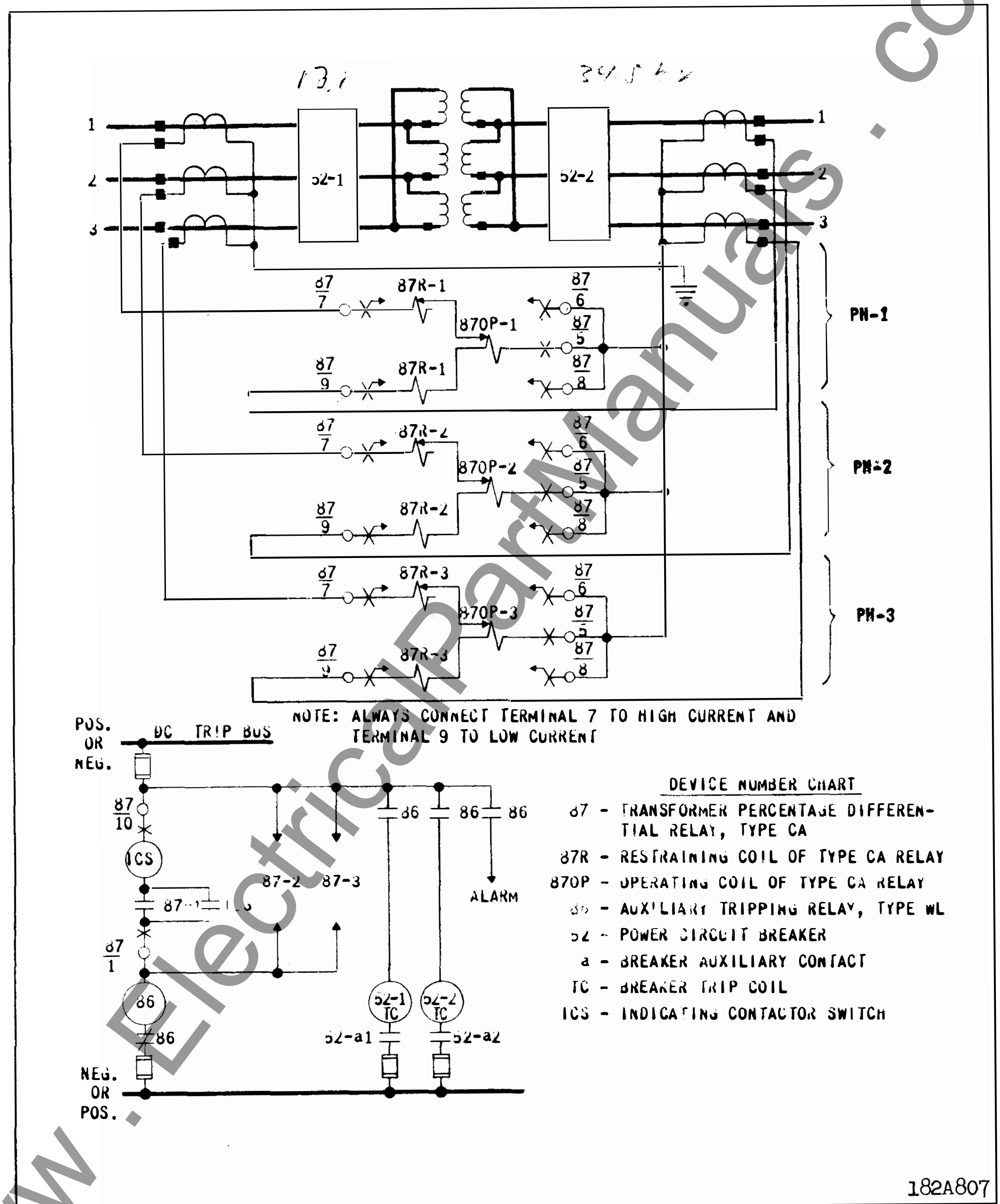

Fig. 15. External Schematic Diagram of the Type CA Transformer Relay in the Type FT21 Case for Protection of a Delta-Delta Transformer Bank

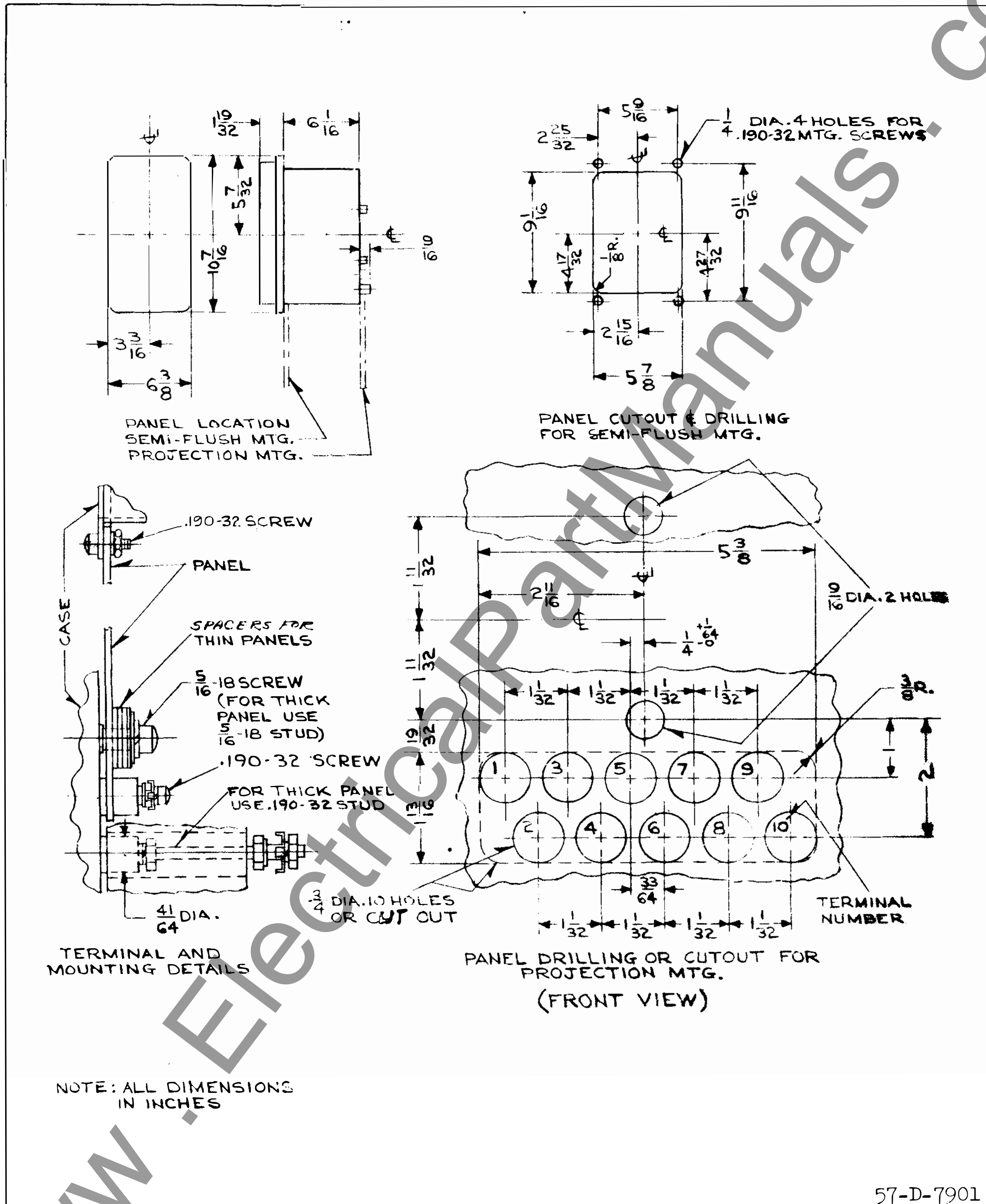

Fig. 16. Outline and Drilling Plan for the Type CA Transformer Relay in the Type FT21 Case.

WESTINGHOUSE ELECTRIC CORPORATION

RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**

Printed in U.S.A.

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 unit, and an indicating contactor switch unit. The construction and operation of these units are as follows:

PERCENTAGE DIFFERENTIAL UNIT

This unit has an electromagnet with several windings as shown in Fig. 2. 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.

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 difference 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. 3 and 4.

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. 6 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.

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 this 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

SUPERSEDES I.L. 41-332.1C
* Denotes change from superseded issue.

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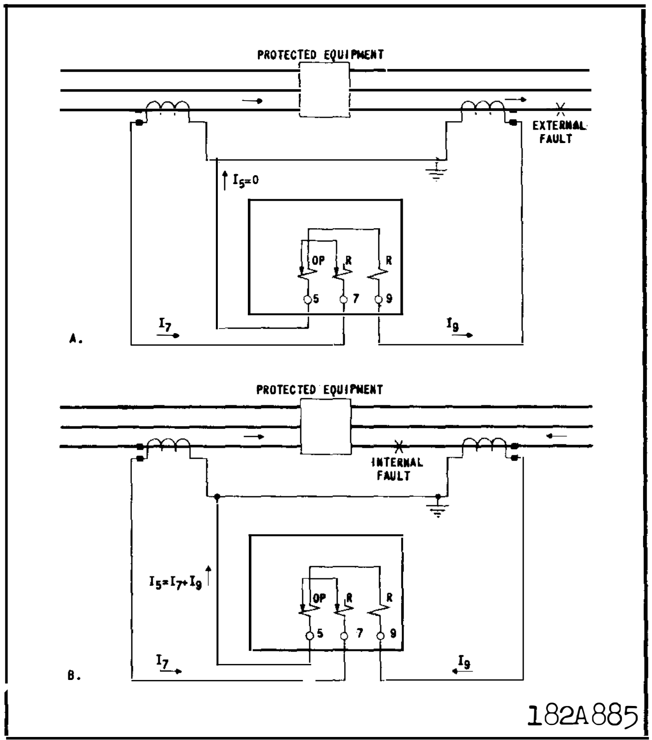

Fig. 1. Schematic Diagrams of the Percentage Differential Relay. (A) Shows the Fault Current Distribution for an External Fault; (B) The Distribution for an Internal Fault.

cover.

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

CHARACTERISTICS

The operating characteristics of the relay for normal through load current and through fault current are shown in Fig. 3 and 4. 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 Fig. 3 and 4, the two curves going with the 5-5 tap are tied together with a bracket to indicate that these two curves go together. Similarly, the two curves for the 5-10 tap are also tied together with a bracket. 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 ap-

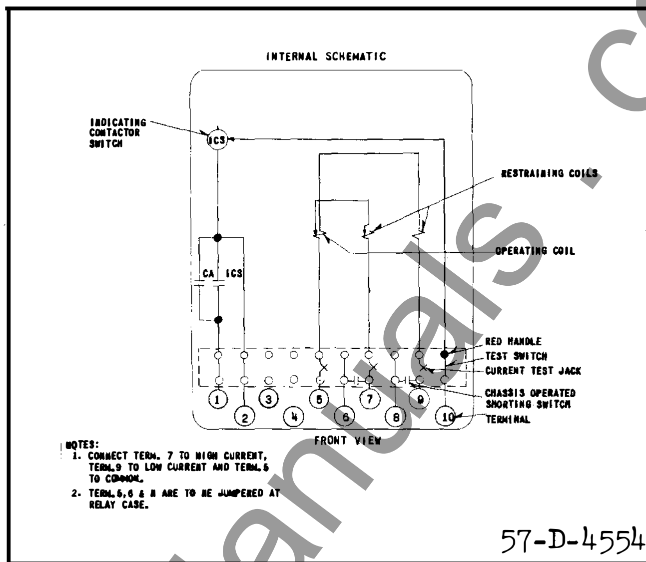

Fig. 2. Internal Schematic of the Type CA Transformer Relay in the Type FT21 Case.

proximately by means of the following formulas:

For the upper curve: $$I_9 = \frac{7.5I_7}{T} \qquad (1)$$

For the lower curve: $$I_7 = .3TI_9 \qquad (2)$$

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 $I_7 = 43.5$, and $I_9 = 30$, read from the lower curve for the 5-5 tap, Fig. 4. Applying the formula, equation (2), the calculated value of I_7 is found to be 45 amperes, which is fairly close to the curve value, $I_7 = 43.5$.

The derivations of equations (1) and (2) are given in Fig. 5, which has been included to illustrate the meaning of these equations.

Typical time-of-operation curves are shown in Fig. 7.

TRIP CIRCUIT

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

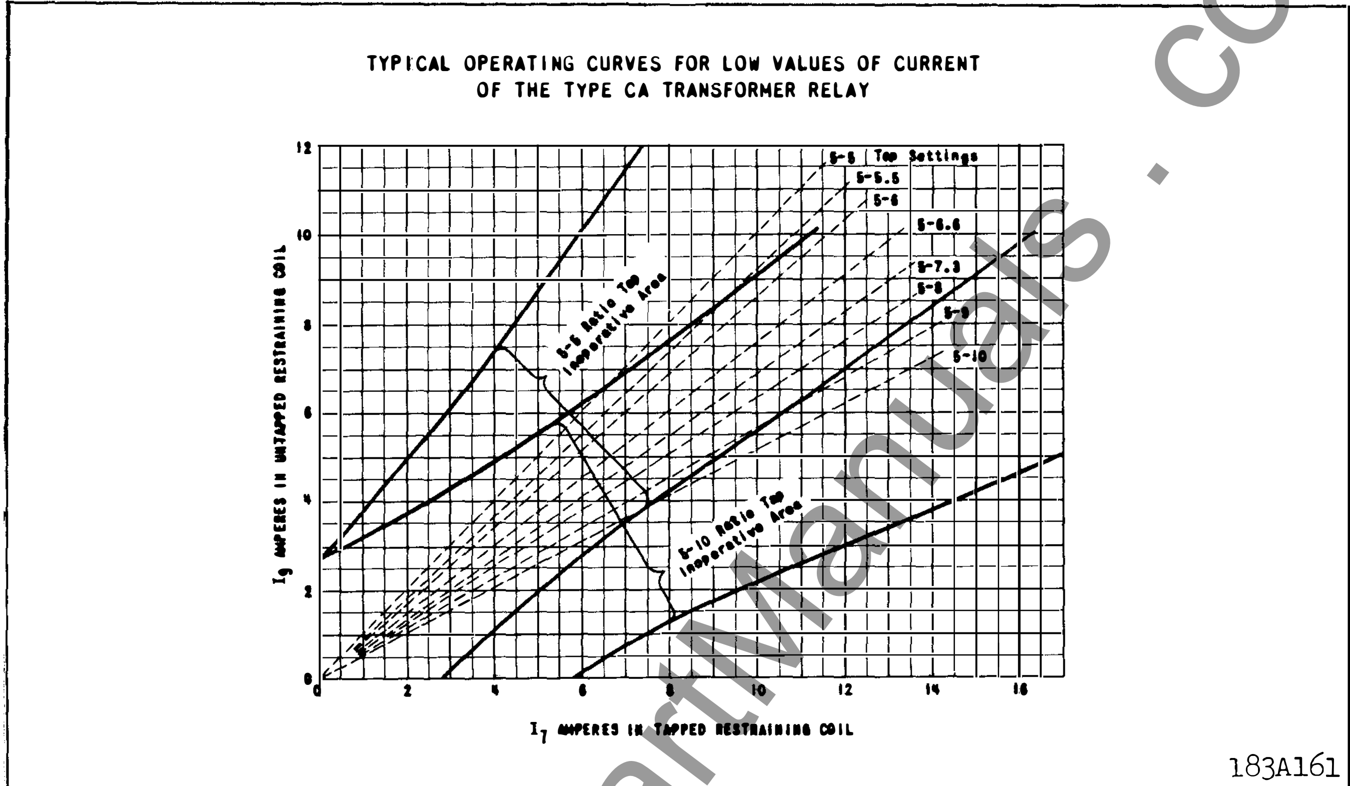

Fig. 3. Typical Operating Curves for Low Values of Current.

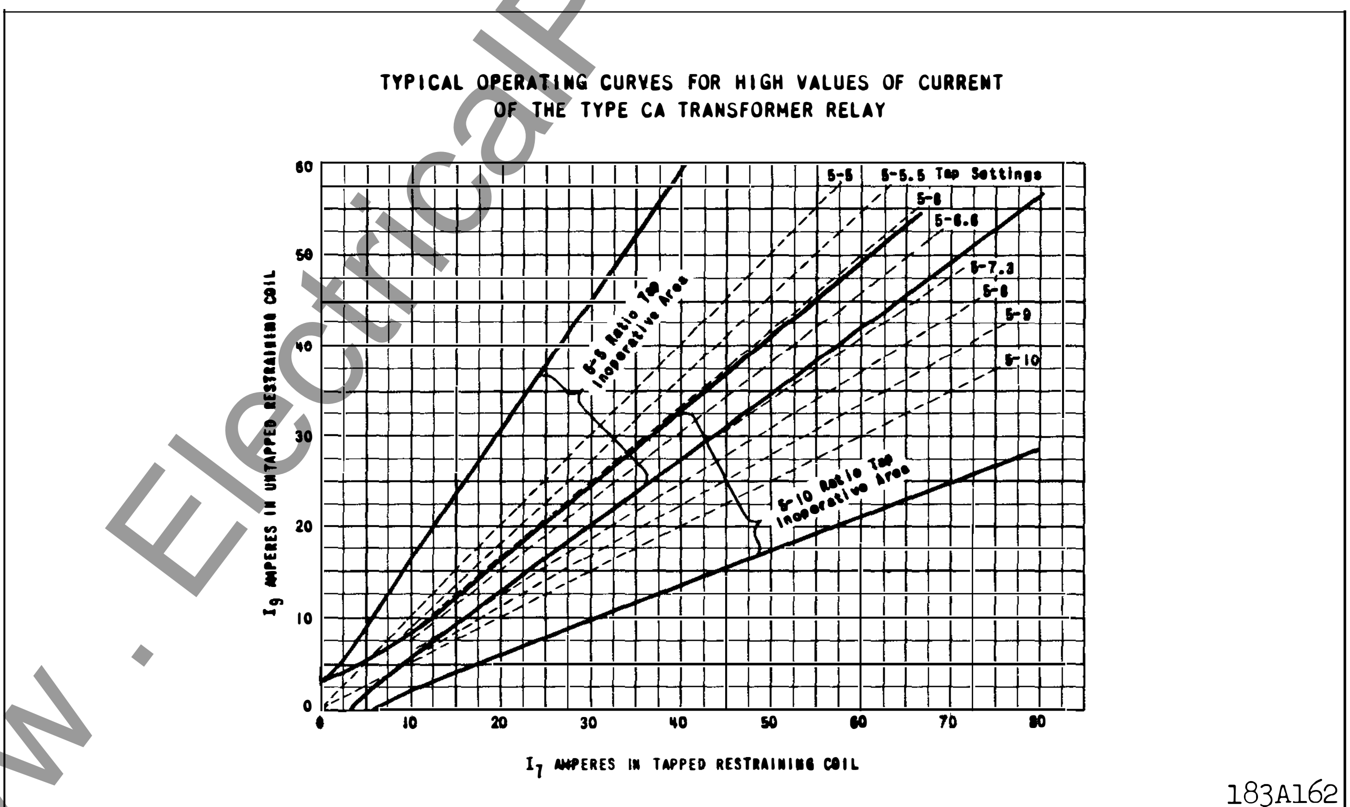

Fig. 4. Typical Operating Curves for High Values of Current.

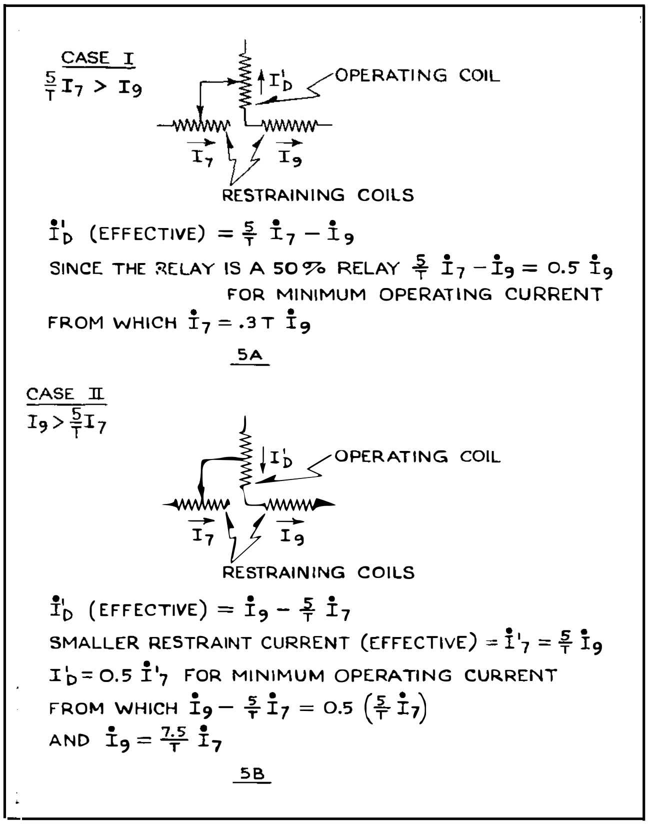

Fig. 5. Fundamental Relationships in the Type CA Electromagnet.

The indicating contactor switch has two taps that provide a pickup 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.

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

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

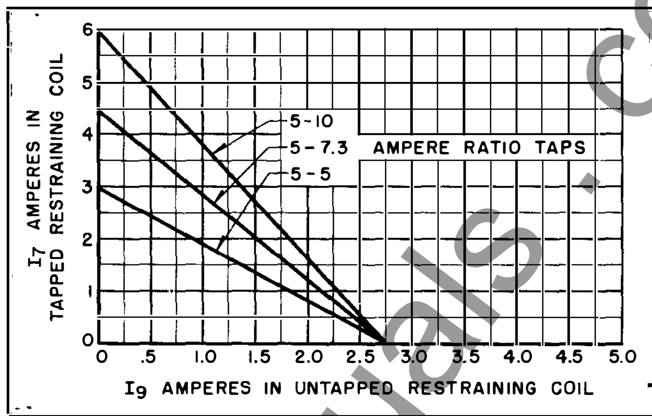

Fig. 6. Typical Sensitivity Characteristics of the Type CA Transformer Relay.

steel panel mounting or to the terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the stud and then turning the proper nut with a wrench.

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

SETTINGS

The transformer relay is detailed in Fig. 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

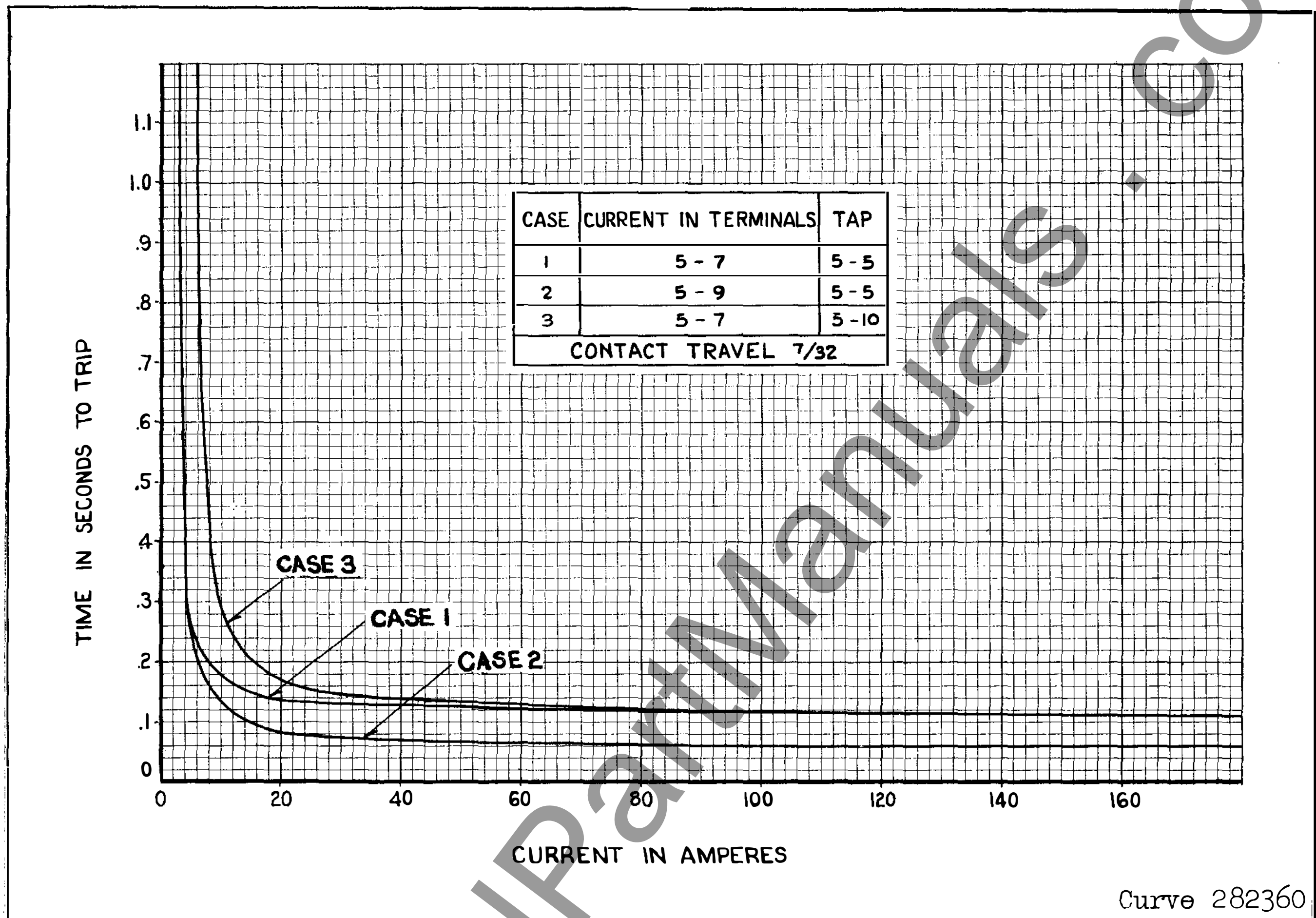

Fig. 7. Typical 60 cycle Time-of-Operation Curves for the Type CA Transformer Relay.

is 5/8, and this pair of taps should be used.

INDICATING CONTACTOR SWITCH (ICS)

No setting is required on the ICS unit except the selection of the 0.2 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.

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.

PERCENTAGE DIFFERENTIAL UNIT

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. 11 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. Similarily, 5 amperes flowing in one restraining coil and the operating coil should produce a positive contact closing torque.

Adjust the position of the contact stop, and the

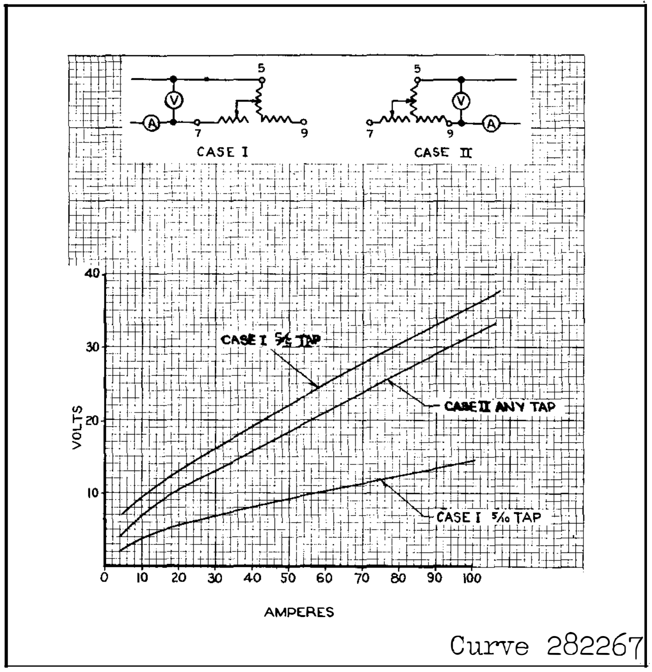

Fig. 8. Typical 60 cycle Saturation Curves for the Type CA Transformer Relay.

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. 11 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. 11 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. 4 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. 3 and 4.

<u>INDICATING CONTACTOR SWITCH (ICS)</u>

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.

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 customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

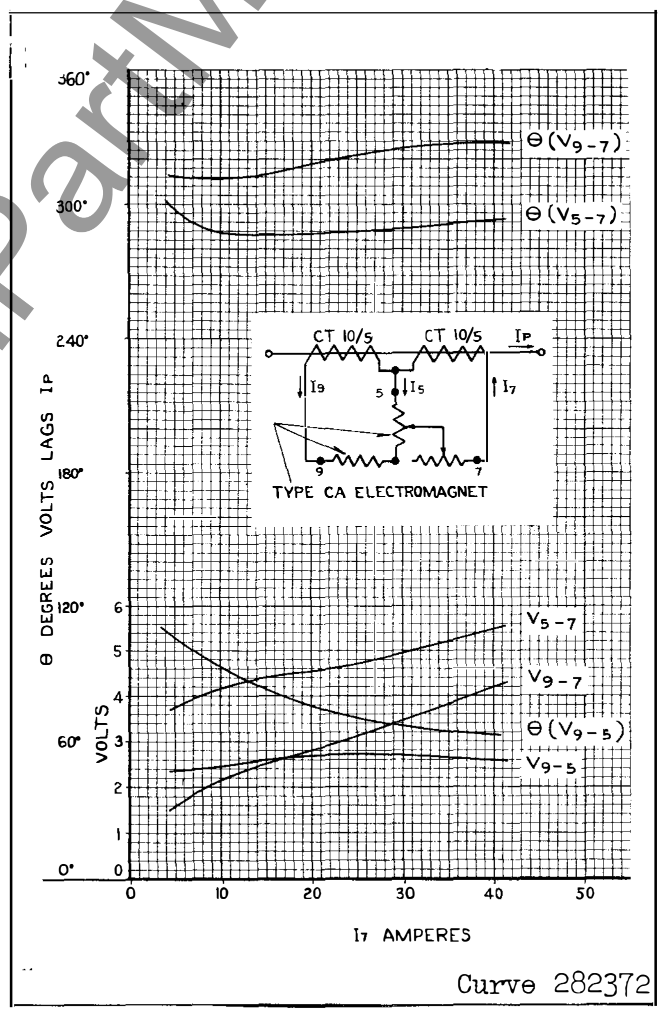

Fig. 9. Typical 60 cycle Burden Curves for the Type CA Transformer Relay on the 5-5 Tap ($I_5 = 0$).

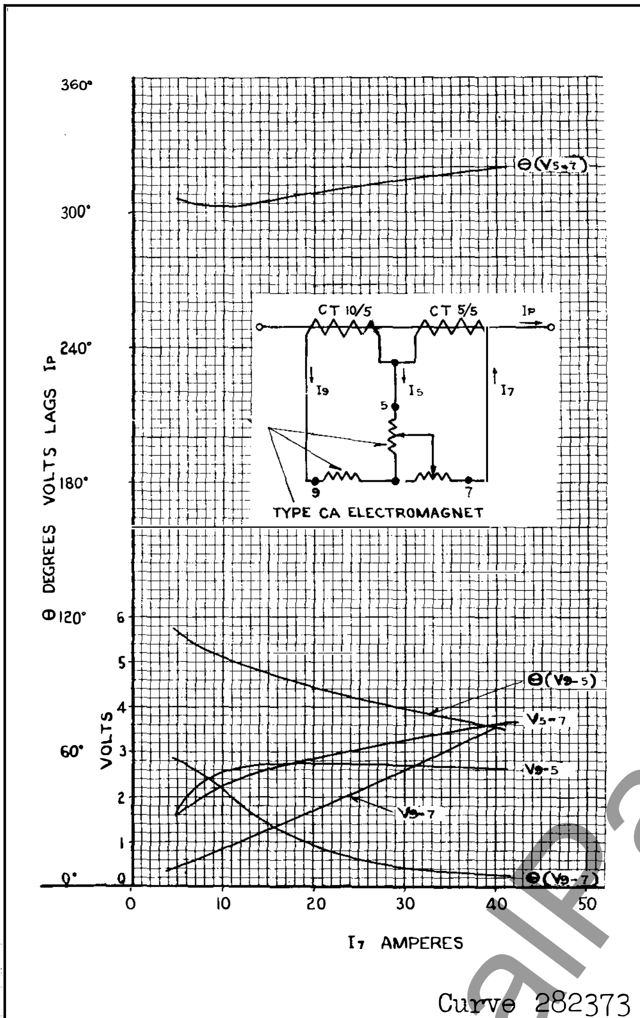

Fig. 10. Typical 60 cycle Burden Curves for the Type CA Transformer Relay on the 5-10 Tap ($I_5 = \frac{1}{2} I_7$). *

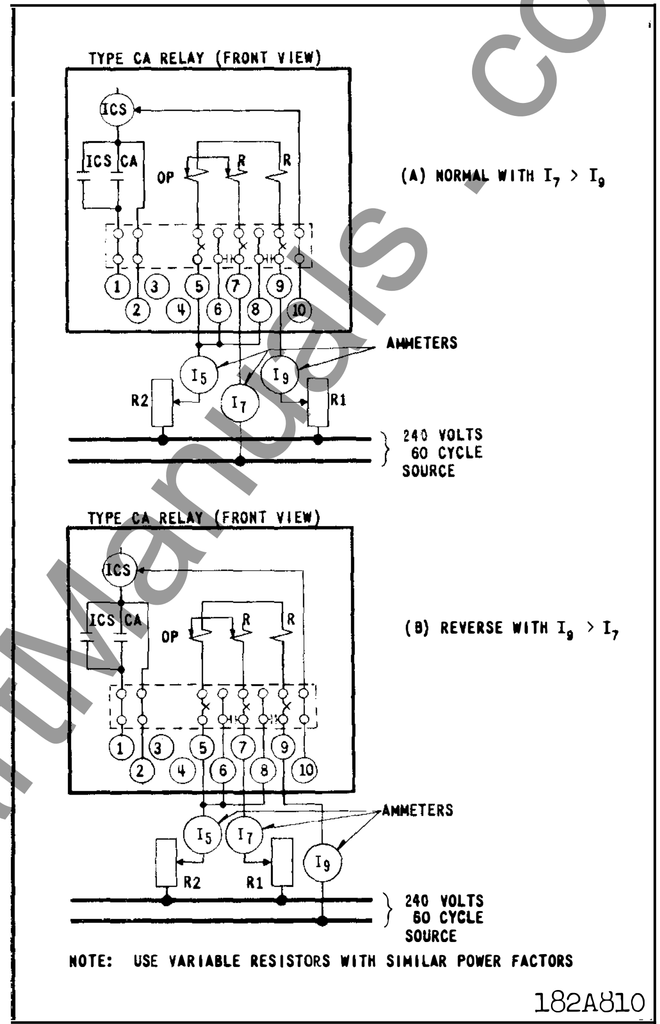

Fig. 11. Diagram of Test Connections for the Type CA Transformer Relay in the Type FT21 Case.

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. 8, 9, and 10.

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 over-loading 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.

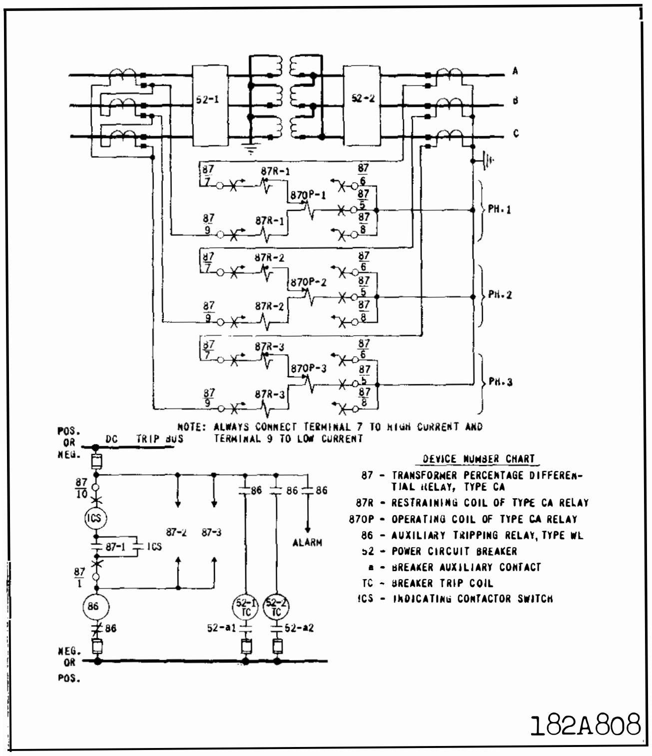

Fig. 12. External Schematic Diagram of the Type CA Transformer Relay in the Type FT21 Case for Protection of a Wye-Delta Transformer Bank.

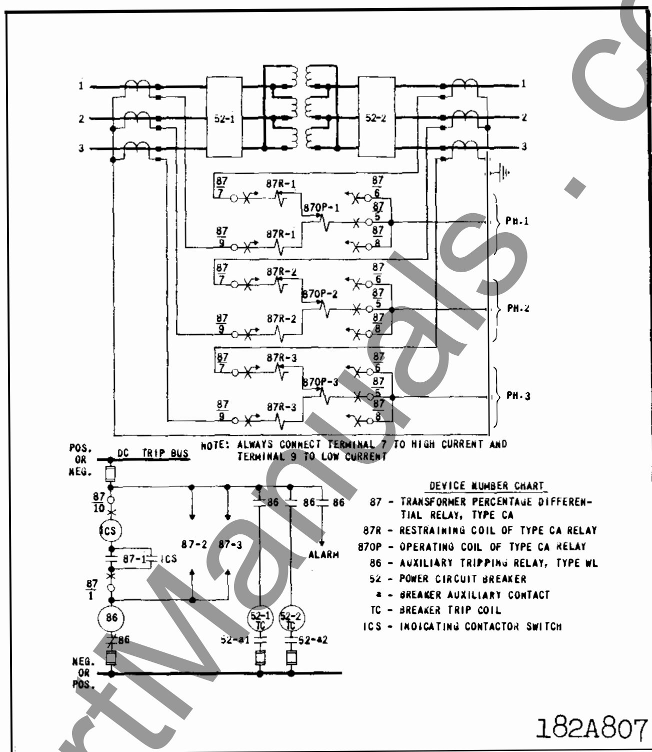

Fig. 13. External Schematic Diagram of the Type CA Transformer Relay in the Type FT21 Case for Protection of a Delta-Delta Transformer Bank.

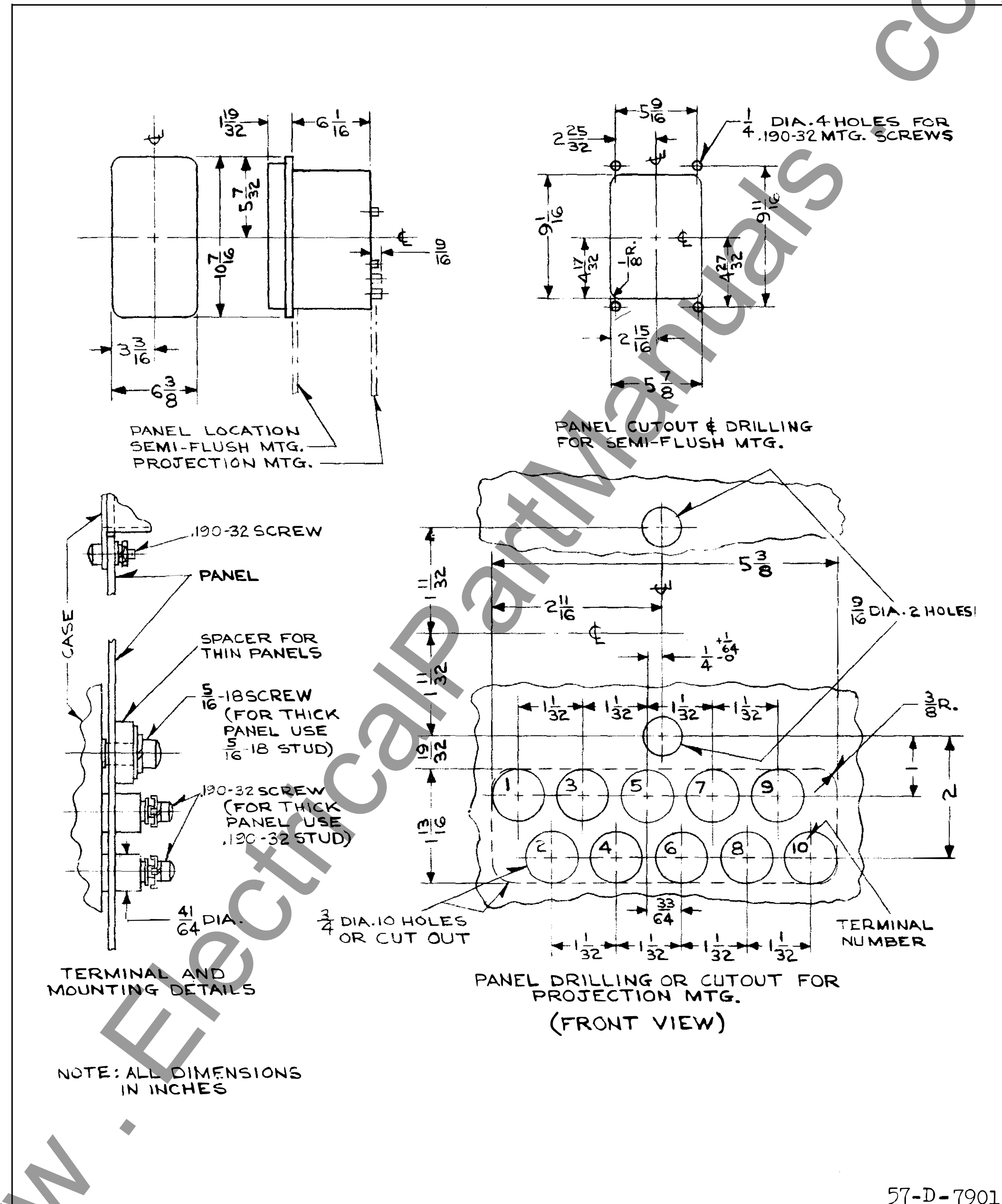

Fig. 14. Outline and Drilling Plan for the Type CA Transformer Relay in the Type FT21 Case.

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