INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE CA-4 PERCENTAGE DIFFERENTIAL RELAY

CAUTION Before putting protective 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-4 percentage differential relay is designed for the differential protection of three-winding transformers, and has three restraining coils - one for each winding of the transformer. It is a current-operated induction disc relay designed so that the operating coil current required to close the contacts varies in proportion to the current through the restraining windings. This feature prevents tripping on through faults, because of unbalanced current transformer characteristics or loading, and allows the relay to be set for sensitive protection. The relay has three percentage taps of 15, 25 and 40%. The choice of a particular tap is based on the performance of the main current transformers under heavy through faults and the severity of the magnetizing current inrush when the protected transformer is energized.

When this magnetizing inrush current is large enough in magnitude and long enough in duration to cause the Type CA-4 relay to trip when the transformer is energized, it is necessary to provide auxiliary time-delay features to restrain the action of the Type CA-4 until the magnetizing current has diminished below the pick-up value of the relay. The time-delay relay used for this purpose is the Type TSI Magnetizing Inrush Tripping Suppressor Relay described in I. L. 41-346.1.

External current balancing auto transformers are required where the main current transformers do not provide equal secondary currents with the correct phase relation for the Type CA-4 restraining windings. Figures 8 and 9 show the auxiliary auto-transformers and Type CA-4 relay external connections for typical installations.

The power transformer connections as shown in Figs. 8 and 9 have been made on the assumption that the delta winding is the low voltage side of the transformer, and in conformance with the ASA Standard that the voltages on the HV side lead the voltages on the LV side by 30°. In following the relay connections it will be simpler to illustrate the principles involved by using a two-winding transformer application. The method illustrated may then be applied to any transformer bank, whether in conformance with the standard or not. When applied to a three winding bank, each delta winding is checked separately against the star winding.

Fig. 6 shows a two winding transformer protected by three differential relays. In order to establish the proper connections to the relays, first assume a set of reference currents, A, B and C flowing into the wye side of the transformer. The currents flowing out of the delta side of the transformer will by A-C, B-A, and C-B, as shown in Fig. 6, by virtue of the way this particular bank is connected. On the delta side of the power transformer the current transformers will be connected in star. The connections to the relays must be such as to have the same currents entering and leaving the relay through the restraining windings, for the condition illustrated of primary current flowing through the bank. Considering the top relay, for example, it is seen that A-C current delivered to the right hand restraining coil from the a-phase current transformer on the delta side of the bank is passed right on through the other restraining coil of the relay to satisfy the requirements of the A- and C- phase current transformers on the wye side of the bank. This keeps the current out of the operating coil, which is proper for the through load condition illustrated by the primary current direction arrows. An improper connection in the diagram will show up in this analysis

SUPERSEDES I.L. 41-334.1
*Denotes change from superseded issue.

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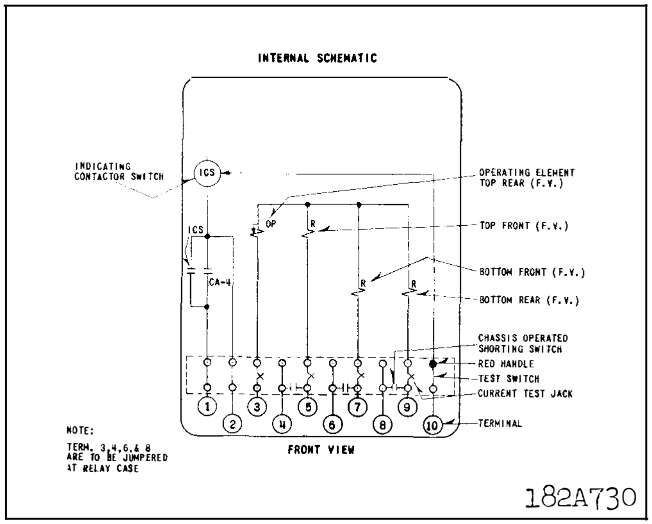

Fig. 1. Internal Schematic of the Type CA-4 Relay in the Type FT31 Case.

through involving the operating coil of one or more relays in the return circuit for the currents, or through not having the same current entering and leaving the restraining coils for the same relay.

Fig. 7 is similar to Fig. 6 except that the delta connected windings are the high voltage windings, necessitating a rearrangement of connections to satisfy the requirement that the high side voltages lead the low side voltages by 30°. This changes the currents to the relays to A-B, B-C, and C-A instead of the A-C, B-A, and C-B currents of Fig. 6.

CONSTRUCTION AND OPERATION

DIFFERENTIAL UNIT

The type CA-4 relay operates on the induction disc principle and consists of four electromagnets operating on two discs which are fastened to the same shaft. Three of the electromagnets are restraining elements and are connected to receive the secondary currents from the various current transformers. The fourth electromagnet element is connected to receive the differential or unbalance current. The operating winding is tapped so that the relay will just operate on 15, 25, or 40 percent unbalance. An extra connector block screw is provided so that taps on the relay can be changed without opening the current differential circuit.

The currents in the three restraining elements produce contact opening torque proportional to the currents in the various windings of the protected transformer. The current in the difference or operating element produces a contact closing torque proportional to the difference of the three restraining currents when these currents are flowing through the power transformer. The necessary quadrature flux to produce torque is supplied by the upper pole coil of the electromagnet. These coils are excited by transformer windings on the main poles of the vari-electromagnets.

Because of the restraint which exists in the relay during through faults when the current is heavy, the current transformer characteristics need not be accurately matched, since there is a restraining torque on the relay disc that permits a certain discrepancy of current transformer ratio characteristics without resulting in faulty tripping. This is illustrated in figure 2 which shows typical operating characteristics for a through fault. Figs. 3 and 4 show typical time current curves for the type CA-4 relay.

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 pickup value of the switch.

CHARACTERISTICS

The type CA-4 relay has three percentage taps, 15%, 25% and 40% on the operating coil. These values represent the percentage unbalance current required to operate the relay on a through to external fault as shown by Fig. 5.

Typical time curves are shown in Figs. 3 and 4.

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

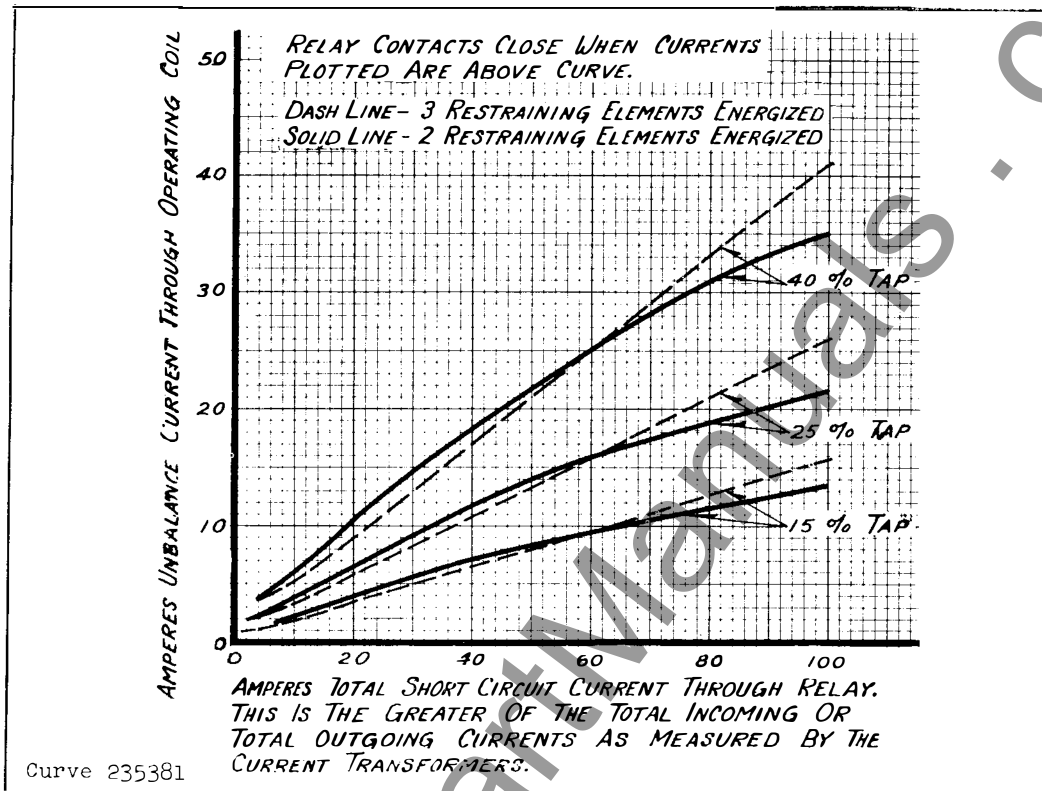

Fig. 2. Typical Operating Characteristic for an External Fault.

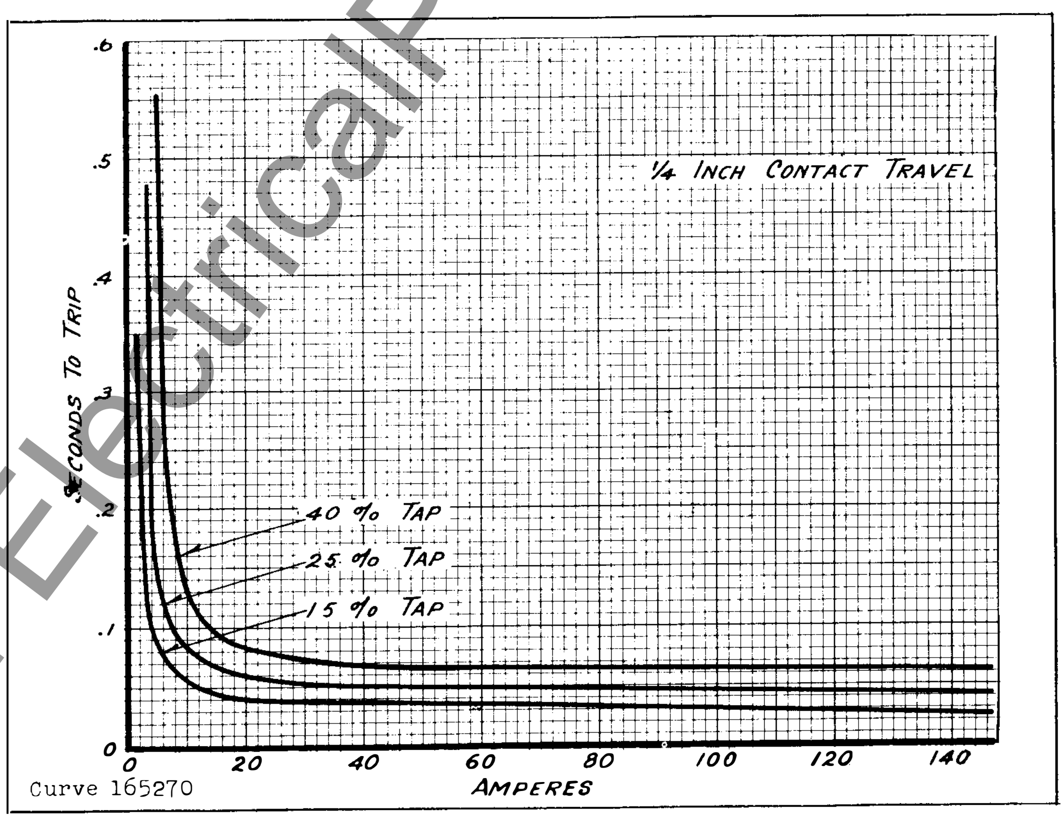

Fig. 3. Typical Time-Current Curves with Current in One Restraint Coil.

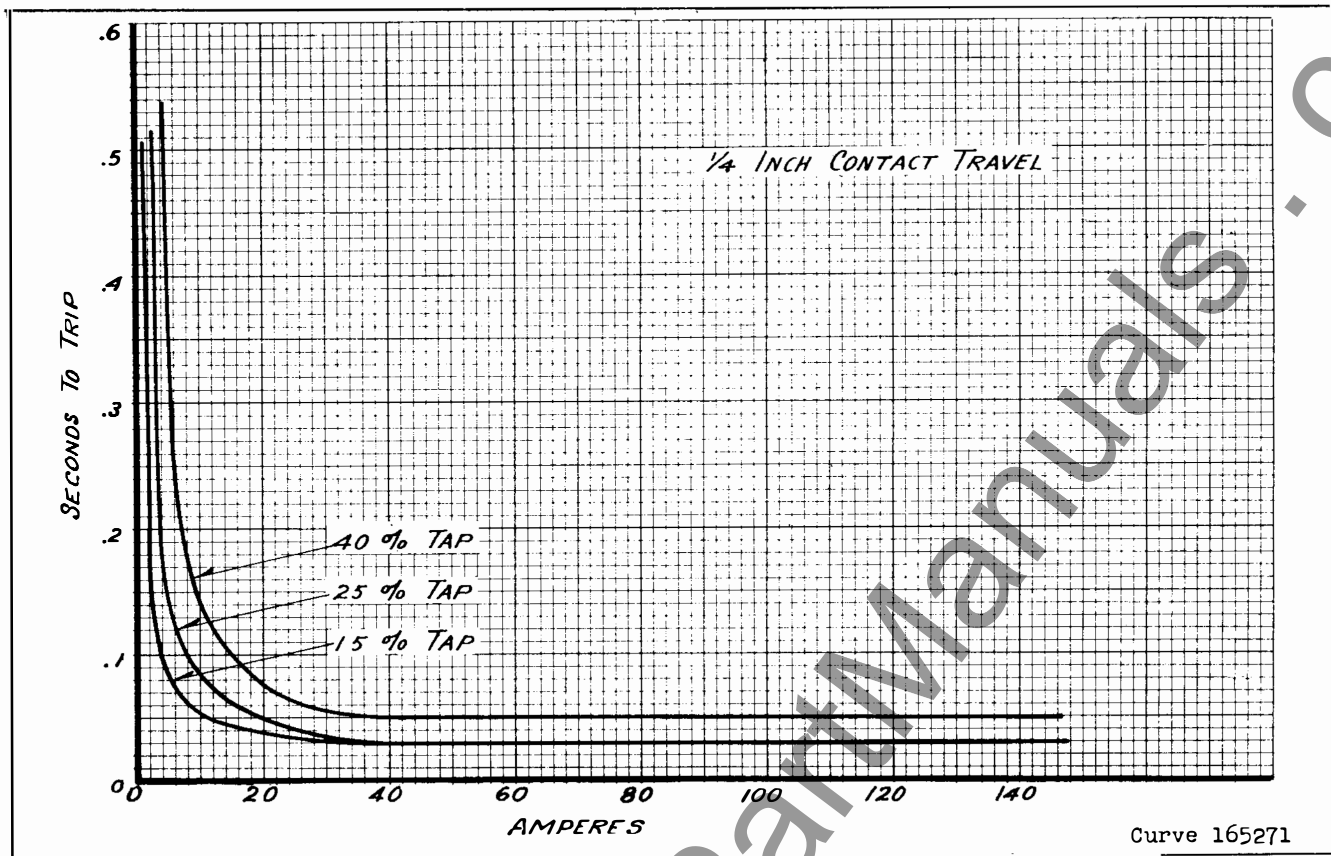

Fig. 4. Typical Time-Current Curves of the Type CA-4 Relay - One Third of Operating Coil Current in Each Restraint Coil.

long enough to trip a circuit breaker.

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 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

DIFFERENTIAL UNIT

Select the desired percent slope tap -- 15, 25 or 40. The 25% slope tap is recommended for transformers with no load taps. Where the transformers have tap changing under load mechanisms, the 40% tap is recommended.

INDICATING CONTACTOR SWITCH (ICS)

No setting is required on the ICS unit except the selection of the current tap – 0.2 or 2.0 amperes. 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. Where the CA-4 * relay energizes a 125 or 250 volt d-c Type WL relay switch, or its equivalent, the 0.2 ampere tap is recommended.

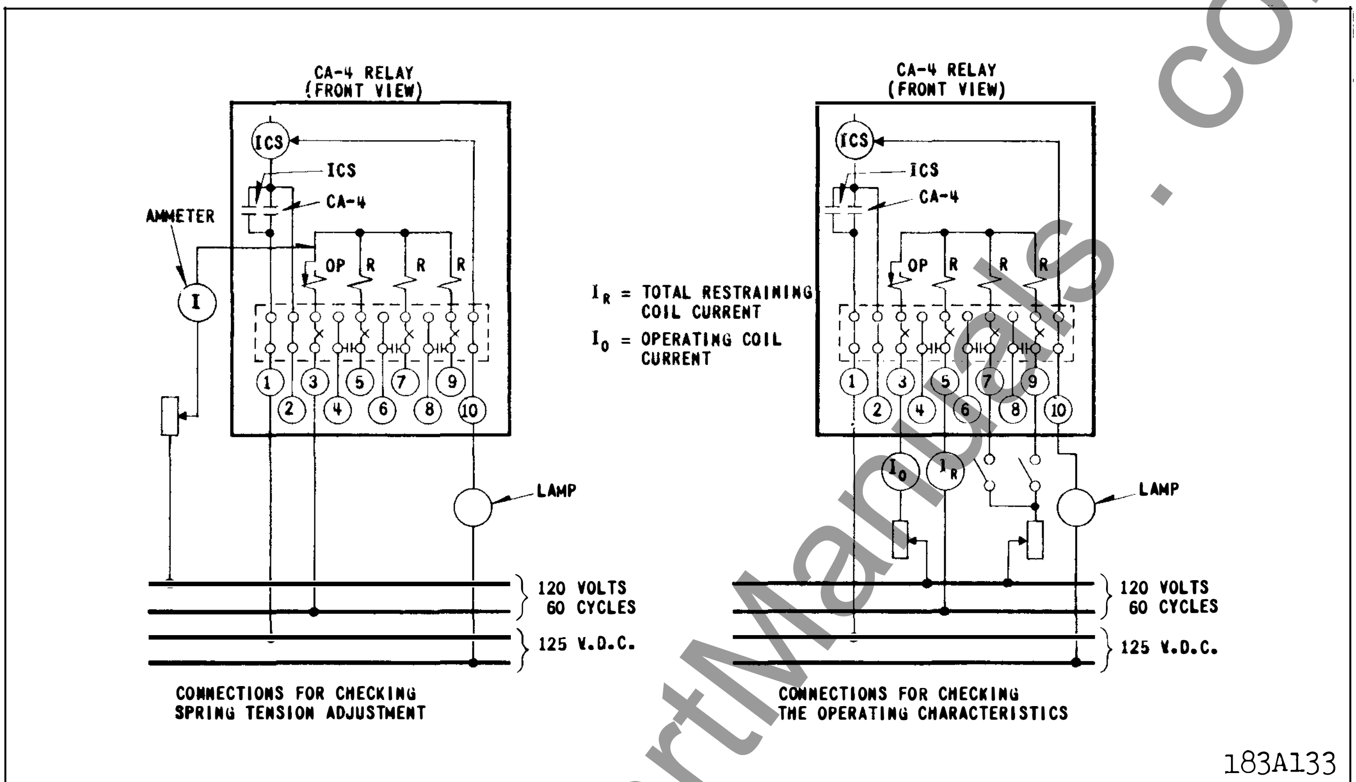

Fig. 5. Diagram of Test Connections.

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.

DIFFERENTIAL UNIT

The top bearing screw should have approximately .002" clearance between it and the shaft. Adjust the stationary contact so that 1/4 inch contact separation is obtained when the moving contact is held open against its stop.

The tension of the spiral spring should be adjusted so that the contacts just close between 3.9 to 4.1 amperes 60 cycles gradually increasing current thru the operating coil on the 40% tap. On the 25% tap these values are 2.1 to 2.6 amperes and on the 15% tap, 1.2 to 1.4 amperes. This current should be passed thru the operating coil only as shown in the left half of figure 5.

The relay operating characteristics of figure 2 may be checked by connecting the relay as shown in the right half of figure 5.

With 80 amperes through the operating coil and one of the restraining coils, the relay should close the contacts properly with little chattering. If it does not, look for incorrect location of the disc in the air gap.

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.

ENERGY REQUIREMENTS

The burden of the type CA-4 restraining windings with 5 amperes flowing is .75 volt-amperes per element. With 5 amperes flowing through the operating winding its burden is as follows:

15% Tap	24.0 volt amperes	58° Lag
25%	8.5 " "	53° "
40%	3.3 " "	45° "

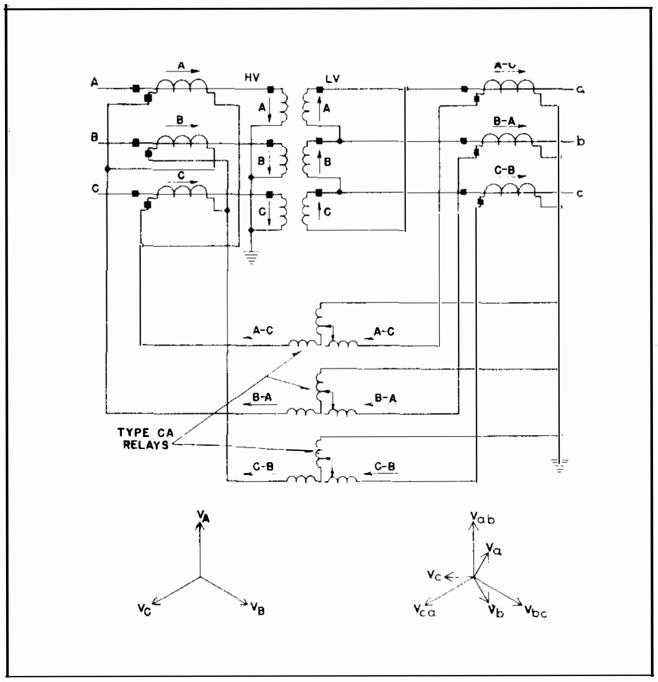

Fig. 6. Current and Voltage Relationships for Wye-Delta Transformer Differential Protection — Wye Voltages Lead Delta Voltages by 30°.

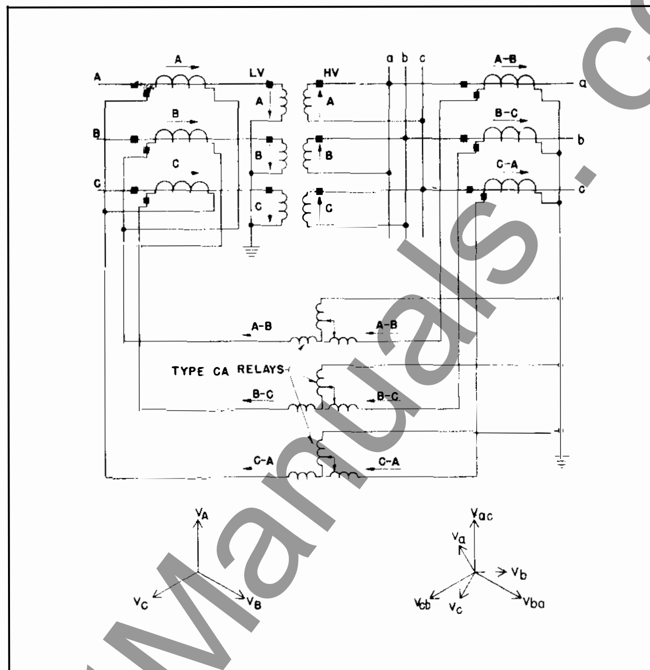

Fig. 7. Current and Voltage Relationships for Wye-Delta Transformer Differential Protection — Delta Voltages Lead Wye Voltages by 30°.

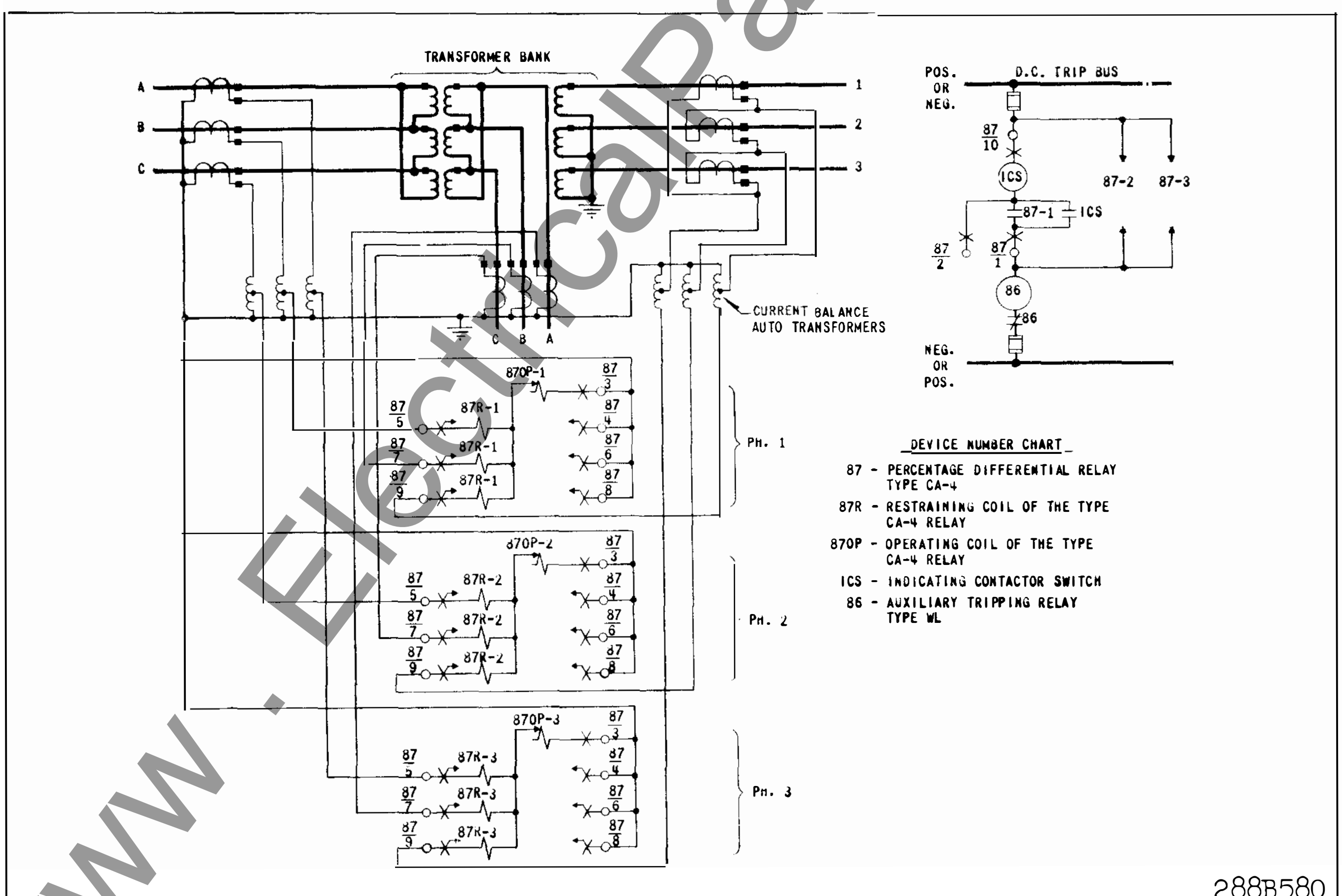

Fig. 8. External Schematic of the Type CA-4 Relay for Wye — Delta — Delta Transformer Protection.

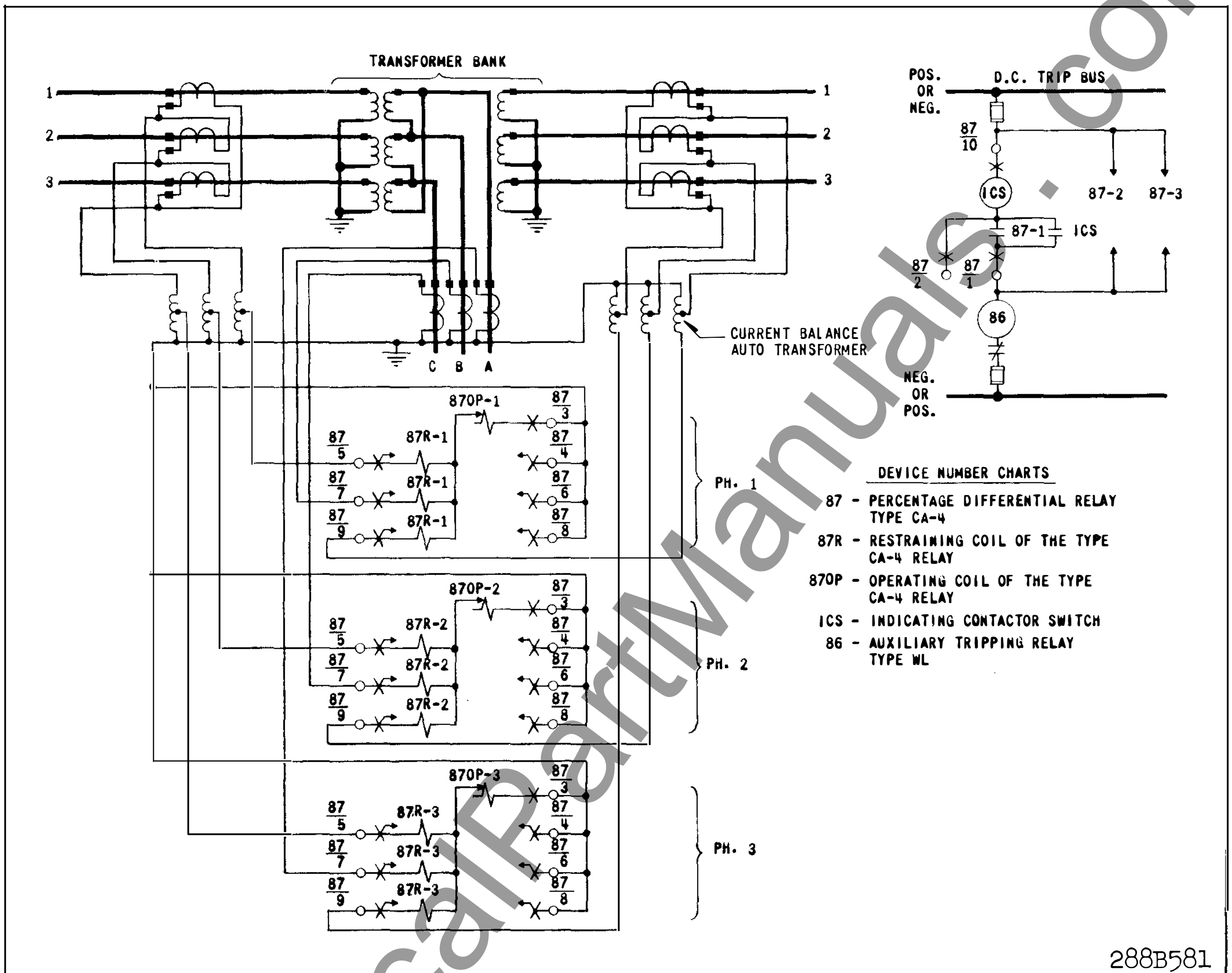

Fig. 9. External Schematic of the Type CA-4 Relay for Wye – Delta – Wye Transformer Protection.

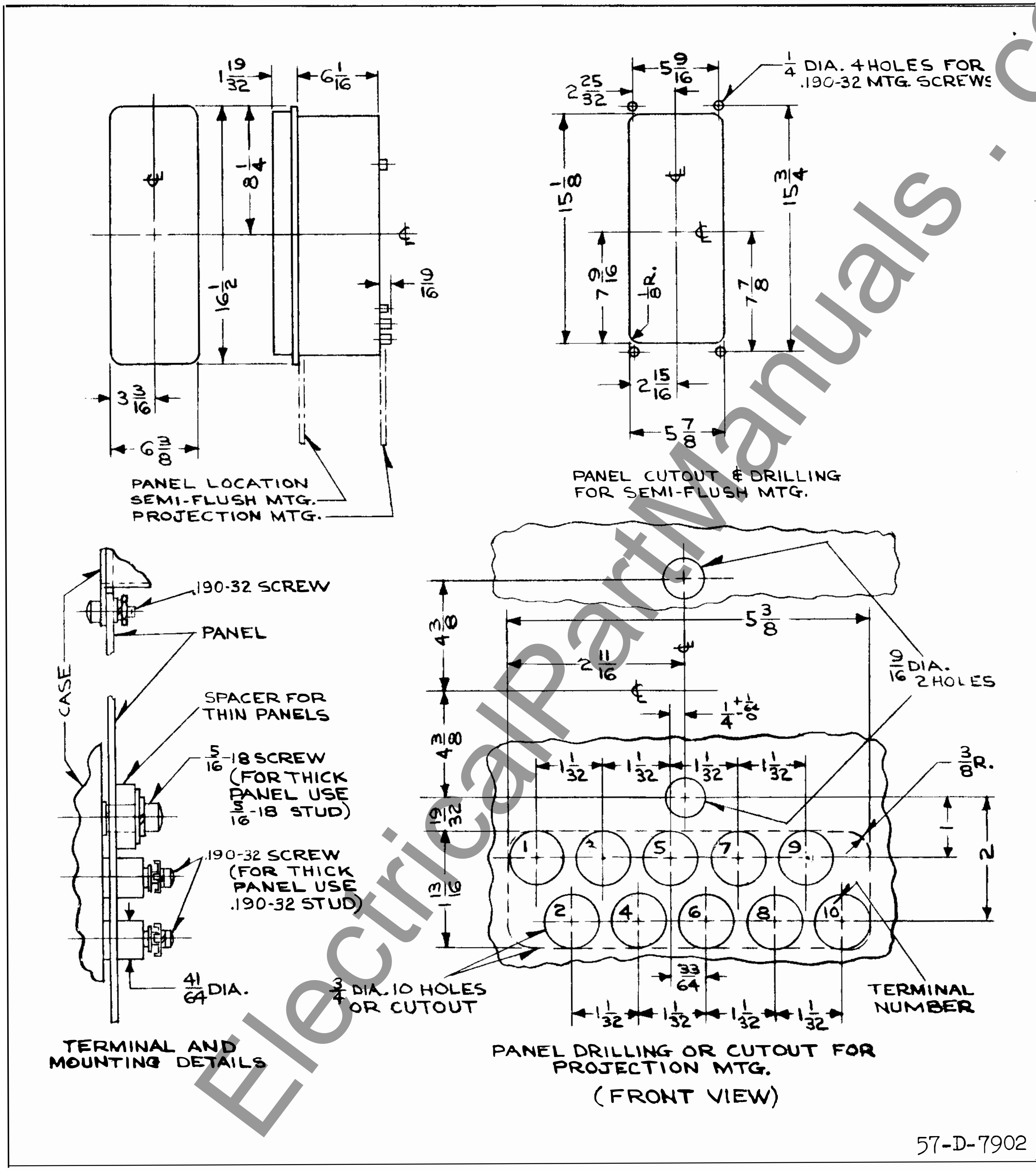

Fig. 10. Outline and Drilling Plan for the Type CA-4 Relay in the FT31 Case.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE CA-4 PERCENTAGE DIFFERENTIAL RELAY

CAUTION Before putting protective 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-4 percentage differential relay is designed for the differential protection of three-winding transformers, and has three restraining coils - one for each winding of the transformer. It is a current-operated induction disc relay designed so that the operating coil current required to close the contacts varies in proportion to the current through the restraining windings. This feature prevents tripping on through faults, because of unbalanced current transformer characteristics or loading, and allows the relay to be set for sensitive protection. The relay has three percentage taps of 15, 25 and 40%. The choice of a particular tap is based on the performance of the main current transformers under heavy through faults and the severity of the magnetizing current inrush when the protected transformer is energized.

When this magnetizing inrush current is large enough in magnitude and long enough in duration to cause the Type CA-4 relay to trip when the transformer is energized, it is necessary to provide auxiliary time-delay features to restrain the action of the Type CA-4 until the magnetizing current has diminished below the pick-up value of the relay. The time-delay relay used for this purpose is the Type TSI Magnetizing Inrush Tripping Suppressor Relay described in I. L. 41-346.1.

External current balancing auto transformers are required where the main current transformers do not provide equal secondary currents with the correct phase relation for the Type CA-4 restraining windings. Figures 8 and 9 show the auxiliary autotransformers and Type CA-4 relay external connections for typical installations.

The power transformer connections as shown in Figs. 8 and 9 have been made on the assumption that the delta winding is the low voltage side of the transformer, and in conformance with the ASA Standard that the voltages on the HV side lead the voltages on the LV side by 30°. In following the relay connections it will be simpler to illustrate the principles involved by using a two-winding transformer application. The method illustrated may then be applied to any transformer bank, whether in conformance with the standard or not. When applied to a three winding bank, each delta winding is checked separately against the star winding.

Fig. 6 shows a two winding transformer protected by three differential relays. In order to establish the proper connections to the relays, first assume a set of reference currents, A, B and C flowing into the wye side of the transformer. The currents flowing out of the delta side of the transformer will by A-C, B-A, and C-B, as shown in Fig. 6, by virtue of the way this particular bank is connected. On the delta side of the power transformer the current transformers will be connected in star. The connections to the relays must be such as to have the same currents entering and leaving the relay through the restraining windings, for the condition illustrated of primary current flowing through the bank. Considering the top relay, for example, it is seen that A-C current delivered to the right hand restraining coil from the a-phase current transformer on the delta side of the bank is passed right on through the other restraining coil of the relay to satisfy the requirements of the A- and C- phase current transformers on the wye side of the bank. This keeps the current out of the operating coil, which is proper for the through load condition illustrated by the primary current direction arrows. An improper connection in the diagram will show up in this analysis

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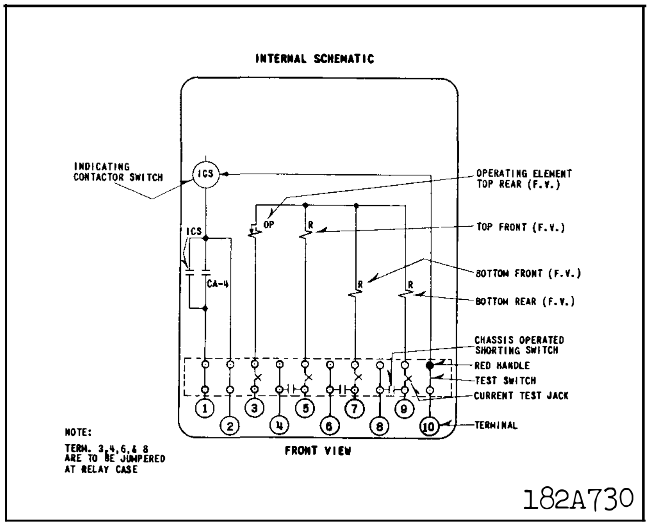

Fig. 1. Internal Schematic of the Type CA-4 Relay in the Type FT31 Case.

through involving the operating coil of one or more relays in the return circuit for the currents, or through not having the same current entering and leaving the restraining coils for the same relay.

Fig. 7 is similar to Fig. 6 except that the delta connected windings are the high voltage windings, necessitating a rearrangement of connections to satisfy the requirement that the high side voltages lead the low side voltages by 30°. This changes the currents to the relays to A-B, B-C, and C-A instead of the A-C, B-A, and C-B currents of Fig. 6.

CONSTRUCTION AND OPERATION

DIFFERENTIAL UNIT

The type CA-4 relay operates on the induction disc principle and consists of four electromagnets operating on two discs which are fastened to the same shaft. Three of the electromagnets are restraining elements and are connected to receive the secondary currents from the various current transformers. The fourth electromagnet element is connected to receive the differential or unbalance current. The operating winding is tapped so that the relay will just operate on 15, 25, or 40 percent unbalance. An extra connector block screw is provided so that taps on the relay can be changed without opening the current differential circuit.

The currents in the three restraining elements produce contact opening torque proportional to the currents in the various windings of the protected transformer. The current in the difference or operating element produces a contact closing torque proportional to the difference of the three restraining currents when these currents are flowing through the power transformer. The necessary quadrature flux to produce torque is supplied by the upper pole coil of the electromagnet. These coils are excited by transformer windings on the main poles of the vari-electromagnets.

Because of the restraint which exists in the relay during through faults when the current is heavy, the current transformer characteristics need not be accurately matched, since there is a restraining torque on the relay disc that permits a certain discrepancy of current transformer ratio characteristics without resulting in faulty tripping. This is illustrated in figure 2 which shows typical operating characteristics for a through fault. Figs. 3 and 4 show typical time current curves for the type CA-4 relay.

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 pickup value of the switch.

CHARACTERISTICS

The type CA-4 relay has three percentage taps, 15%, 25% and 40% on the operating coil. These values represent the percentage unbalance current required to operate the relay on a through to external fault as shown by Fig. 5.

Typical time curves are shown in Figs. 3 and 4.

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

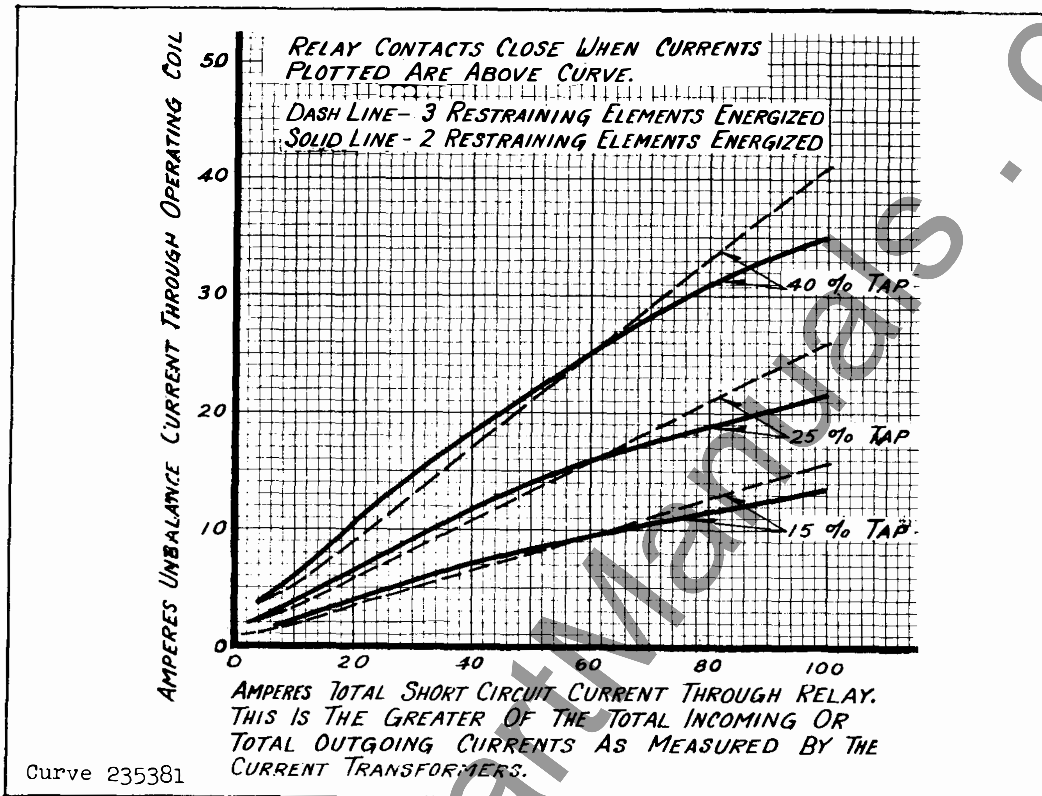

Fig. 2. Typical Operating Characteristic for an External Fault.

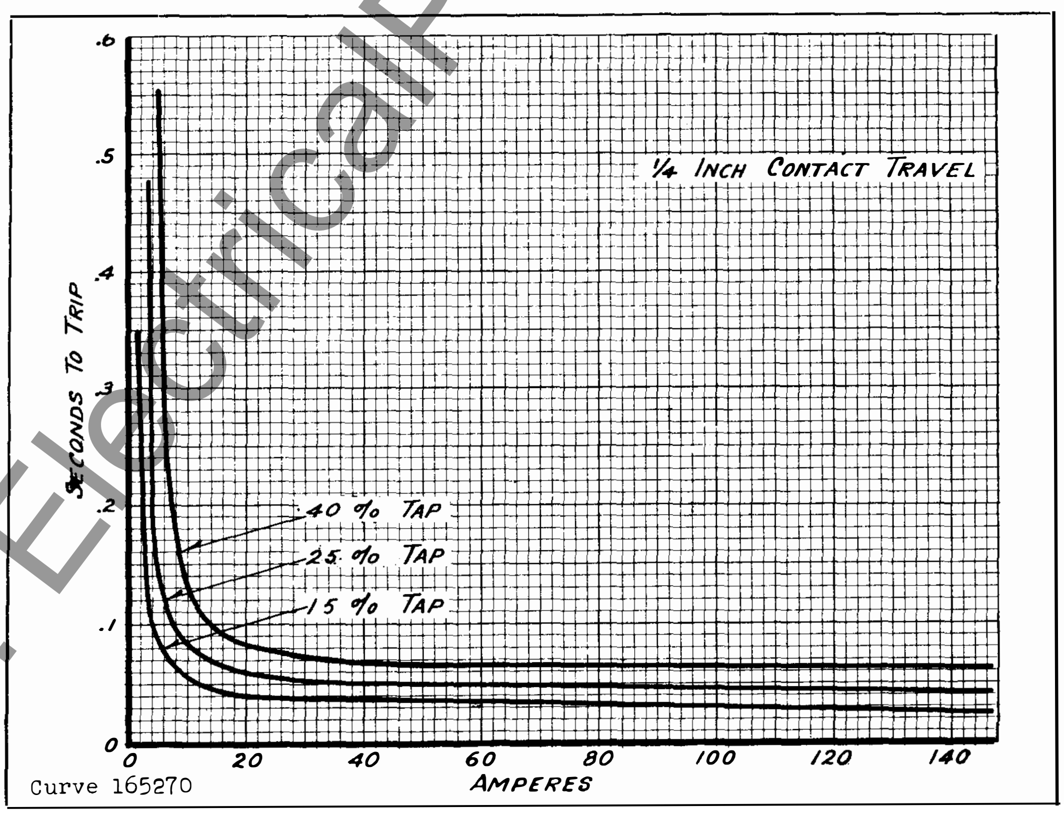

Fig. 3. Typical Time-Current Curves with Current in One Restraint Coil.

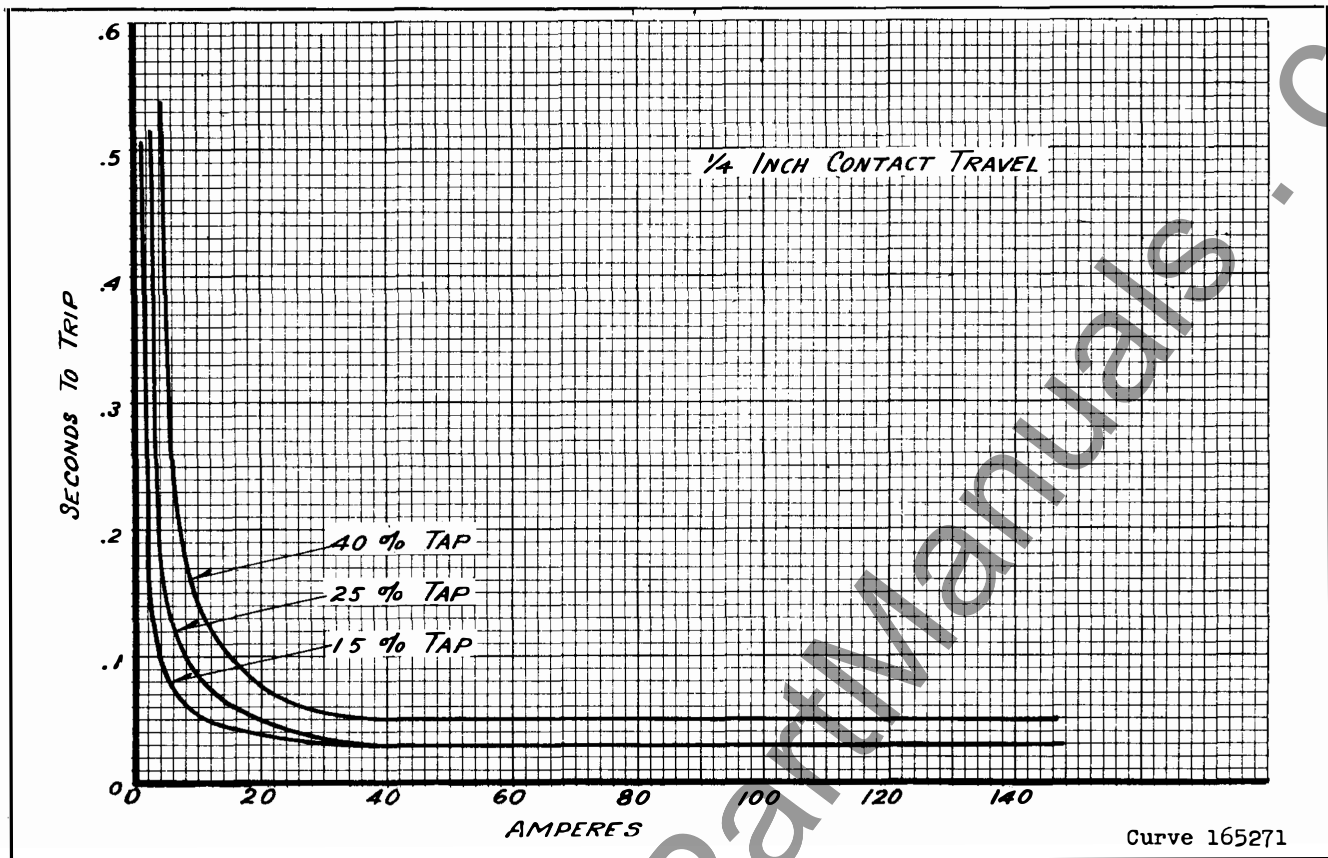

Fig. 4. Typical Time-Current Curves of the Type CA-4 Relay - One Third of Operating Coil Current in Each Restraint Coil.

long enough to trip a circuit breaker.

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 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

DIFFERENTIAL UNIT

Select the desired percent slope tap -- 15, 25 or 40. The 25% slope tap is recommended for transformers with no load taps. Where the transformers have tap changing under load mechanisms, the 40% tap is recommended.

INDICATING CONTACTOR SWITCH (ICS)

No setting is required on the ICS unit except the selection of the current tap – 0.2 or 2.0 amperes. 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. Where the CA-4 * relay energizes a 125 or 250 volt d-c Type WL relay switch, or its equivalent, the 0.2 ampere tap is recommended.

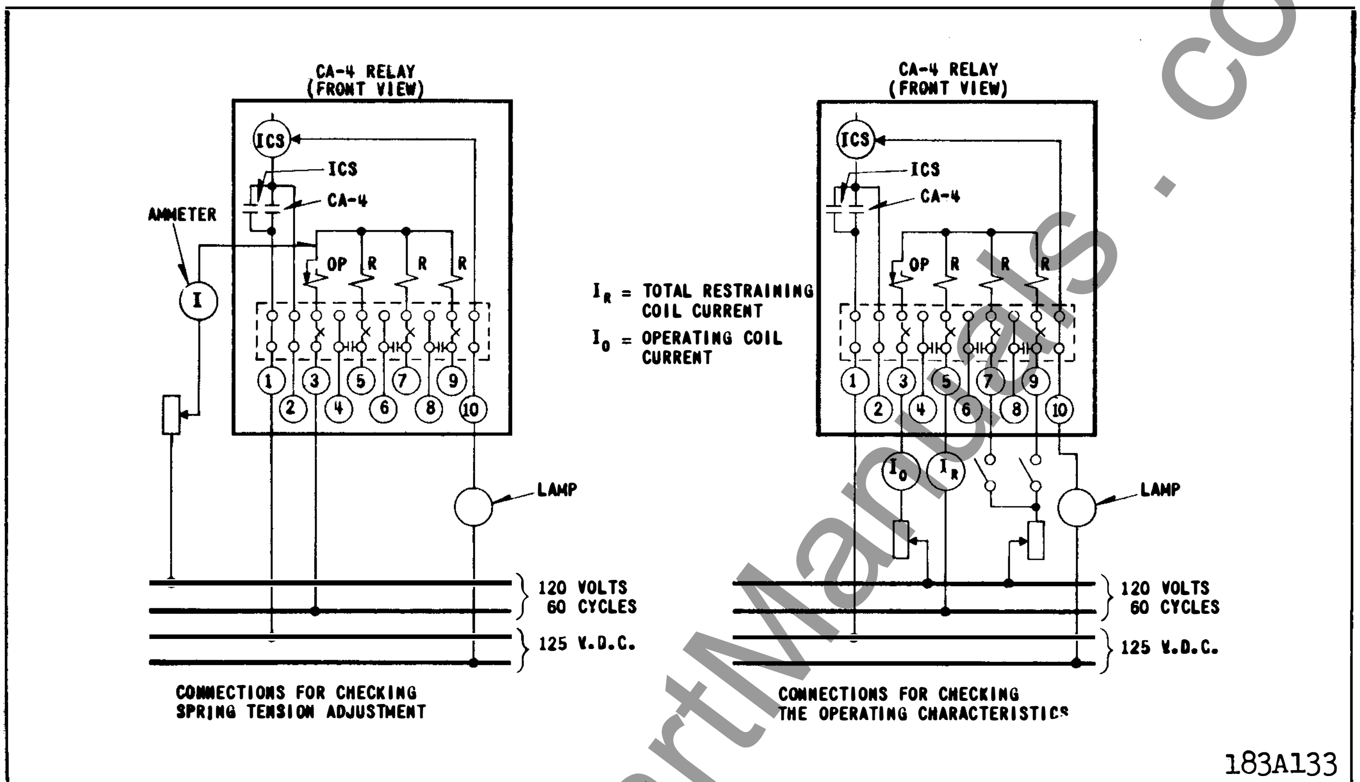

Fig. 5. Diagram of Test Connections.

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.

DIFFERENTIAL UNIT

The top bearing screw should have approximately .002" clearance between it and the shaft. Adjust the stationary contact so that 1/4 inch contact separation is obtained when the moving contact is held open against its stop.

The tension of the spiral spring should be adjusted so that the contacts just close between 3.9 to 4.1 amperes 60 cycles gradually increasing current thru the operating coil on the 40% tap. On the 25% tap these values are 2.1 to 2.6 amperes and on the 15% tap, 1.2 to 1.4 amperes. This current should be passed thru the operating coil only as shown in the left half of figure 5.

The relay operating characteristics of figure 2 may be checked by connecting the relay as shown in the right half of figure 5.

With 80 amperes through the operating coil and one of the restraining coils, the relay should close the contacts properly with little chattering. If it does not, look for incorrect location of the disc in the air gap.

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.

ENERGY REQUIREMENTS

The burden of the type CA-4 restraining windings with 5 amperes flowing is .75 volt-amperes per element. With 5 amperes flowing through the operating winding its burden is as follows:

15% Tap	24.0 volt amperes	58° Lag
25%	8.5 " "	53° "
40%	3.3 " "	45° "

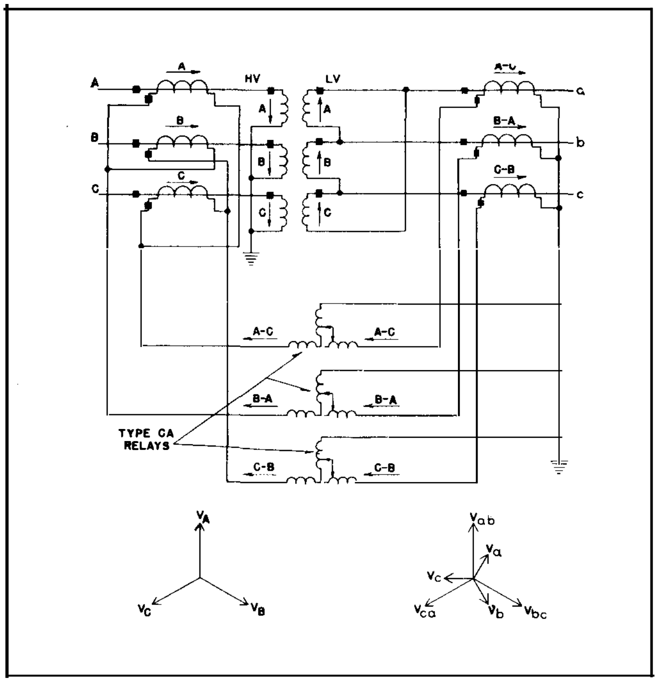

Fig. 6. Current and Voltage Relationships for Wye-Delta Transformer Differential Protection — Wye Voltages Lead Delta Voltages by 30°.

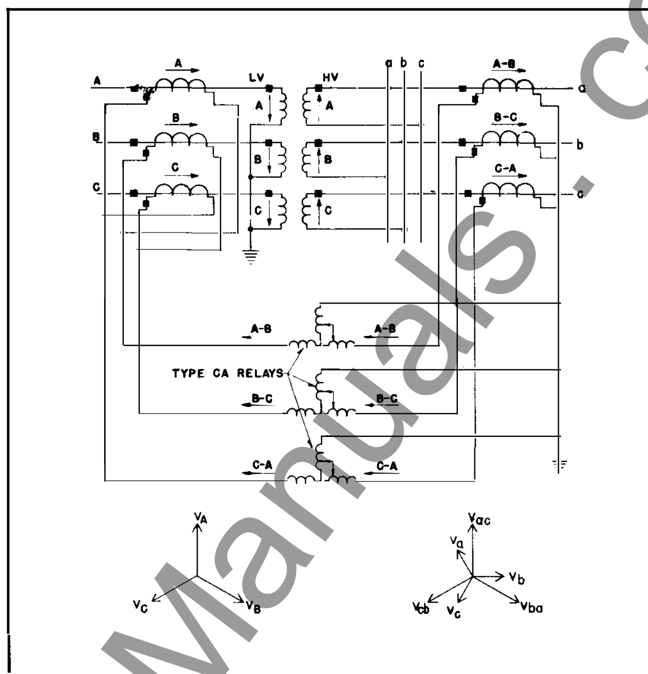

Fig. 7. Current and Voltage Relationships for Wye-Delta Transformer Differential Protection — Delta Voltages Lead Wye Voltages by 30°.

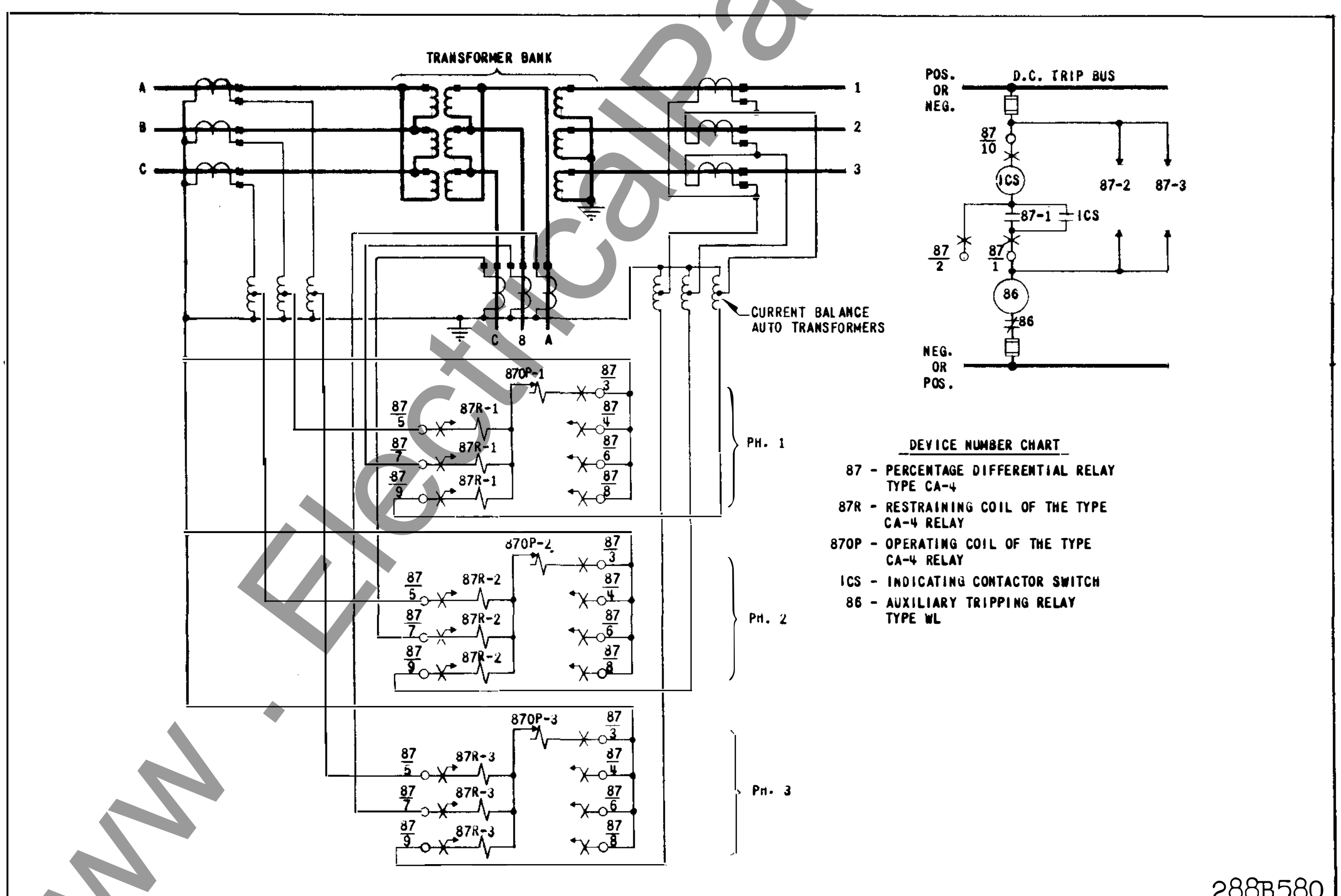

Fig. 8. External Schematic of the Type CA-4 Relay for Wye — Delta — Delta Transformer Protection.

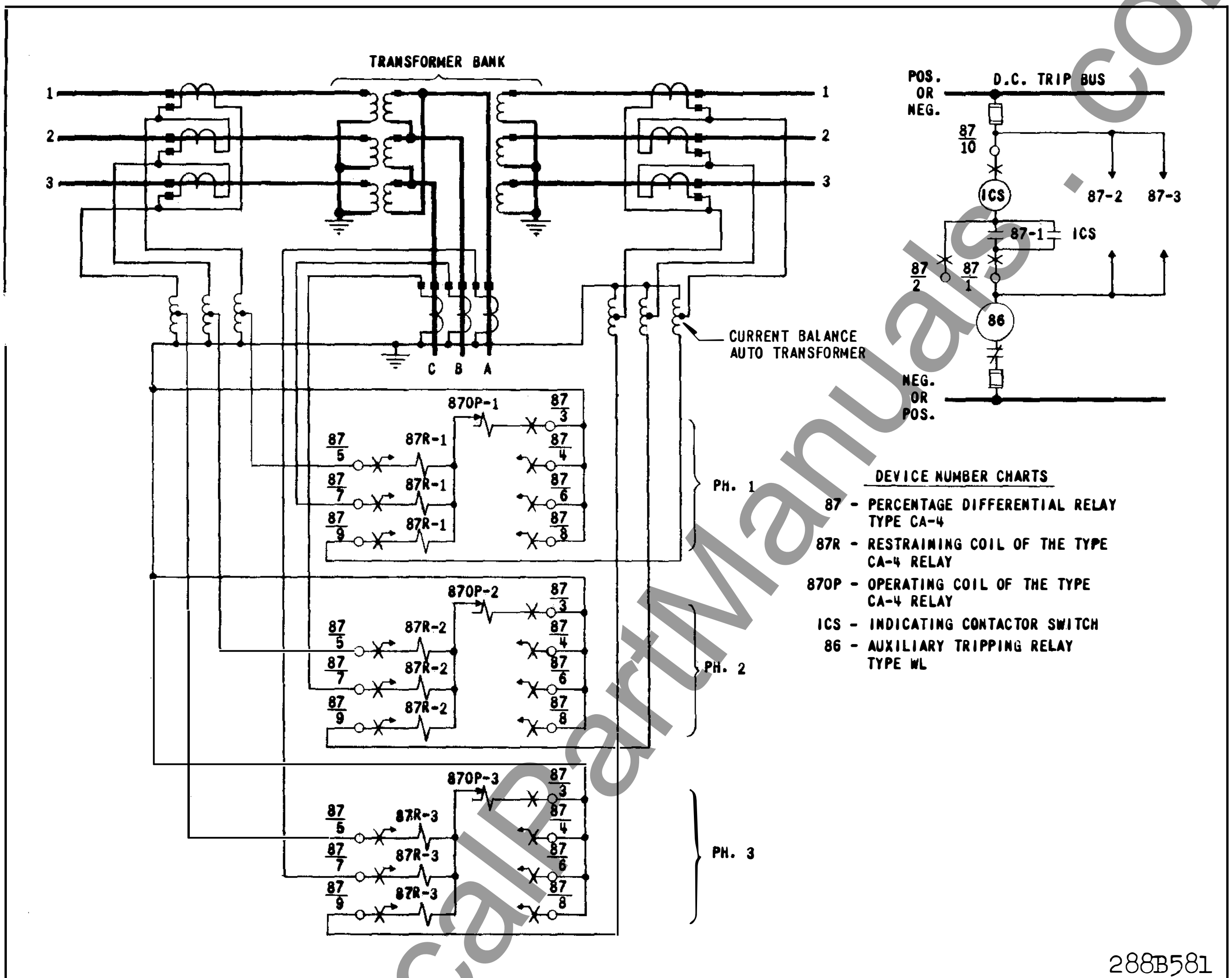

Fig. 9. External Schematic of the Type CA-4 Relay for Wye – Delta – Wye Transformer Protection.

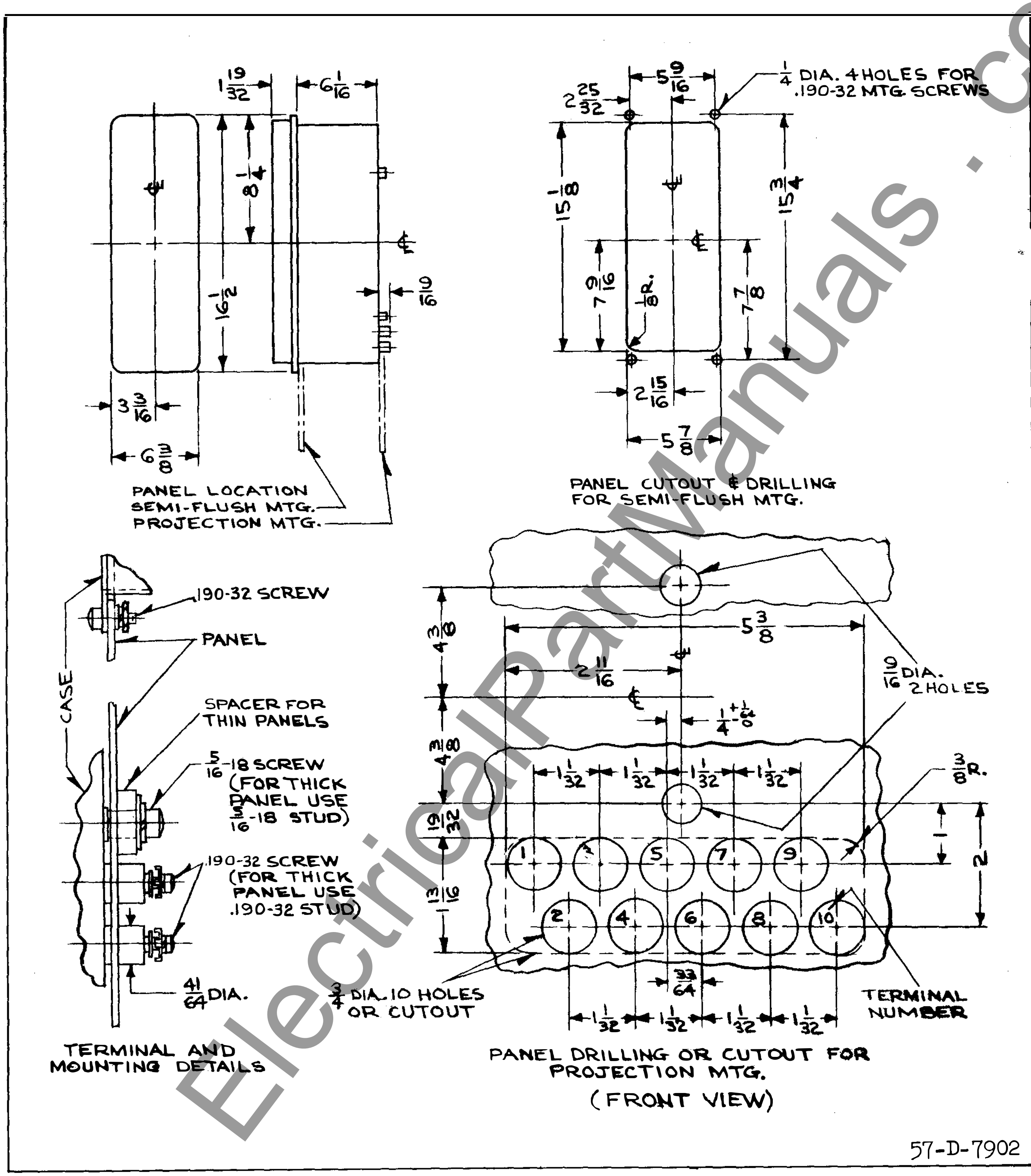

Fig. 10. Outline and Drilling Plan for the Type CA-4 Relay in the FT31 Case.