INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE CRS DIRECTIONAL OVERCURRENT NEGATIVE SEQUENCE RELAY FOR GROUND PROTECTION

CAUTION Before putting the relay into service, remove blocking from all the moving parts. Inspect the relay and operate all elements by hand to be sure no damage has occurred during shipment.

APPLICATION

The type CRS relay is a directional overcurrent ground relay in which the directional unit operates on negative sequence current and voltage, and the overcurrent unit operates on residual or ground current. The negative sequence current and voltage is obtained by means of a negative sequence filter connected between the relay and the current and potential transformers.

The relay and filter are intended for use at locations where the present equipment or system conditions do not permit the use of the conventional types of directional ground relays operating entirely on residual current and voltage.

At an ungrounded substation on grounded systems where only two potential transformers are available, or where the potential transformers are on the low-tension delta side of a power transformer bank, the type CRS relay is applicable for ground protection.

In all applications of the type CRS relay, the magnitude of negative sequence current and voltage during ground faults should be carefully determined by calculation or test before installing the relay. The type CRS directional unit will operate on a minimum of 0.20 volt and 1.4 amperes negative sequence quantities applied to the filter terminals at the relay maximum torque angle.

One style of the type CRS relay has the addition of a negative sequence fault detector to protect transmission lines that are subject to high induced currents during ground faults on neighboring parallel lines. Standard transpositions practically eliminate the possibility of induced negative sequence quantities in the parallel lines so that the negative sequence fault detector will only operate during a fault on the protected line.

CONSTRUCTION AND OPERATION

The type CRS relay consists of an induction disc type overcurrent unit operating on residual current, and an induction-disc type directional unit, operating on the negative sequence quantities supplied by the negative sequence filter.

Directional Unit

The induction disc of the directional unit is a thin, 4" diameter, copper disc mounted on a vertical shaft. This shaft is fastened to the element frame on the lower end thru a steel ball bearing riding between the concave sapphire jewel surfaces, and on the upper end by a pin inserted in the shaft.

The moving contact assembly consists of a rigid counter-weighted arm to which is fastened a leaf spring. A silver contact is fastened to the free end of this leaf spring. When the moving contact strikes the stationary contact, the spring deflects to provide the required contact follow. The arm is fastened to an insulated section of the disc shaft, and to one end of a spiral spring. The other end of the spring is fastened to a circular disc which in turn is fastened by a tight press fit to the element frame. The spring tension is adjustable by inserting a screw driver in the slotted segments of the circular spring disc and rotating it in the desired direction. The electrical connection is made to the spring frame as the moving contact is electrically as well as mechanically connected to the spiral spring.

The moving disc is rotated by an electromagnet in the rear and damped by a permanent magnet in the front. Its rotation of only a few degrees is limited in the opening direction by a projecting stop on the disc which strikes the element frame, and in the closing direction by the rigid moving arm striking the stationary contact arm. The upper two poles of the electromagnet are energized by negative sequence current, and the lower pole by negative sequence voltage. The fluxes produced by these two electrical quantities cause rotation of the disc in a di-

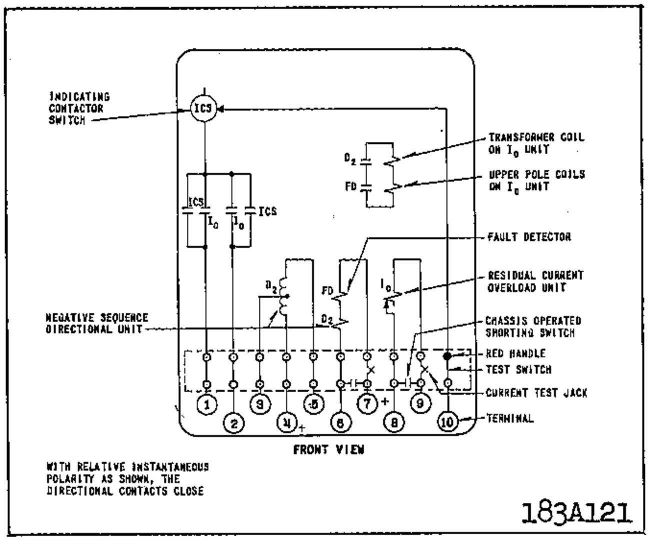

Fig. 1. Internal Schematic of Double Trip Type CRS Relay in the Type FT31 Case. Fault Detector omitted and leads shorted when not required. For the Single Trip Relay the Circuits Associated with Terminal 2 are omitted.

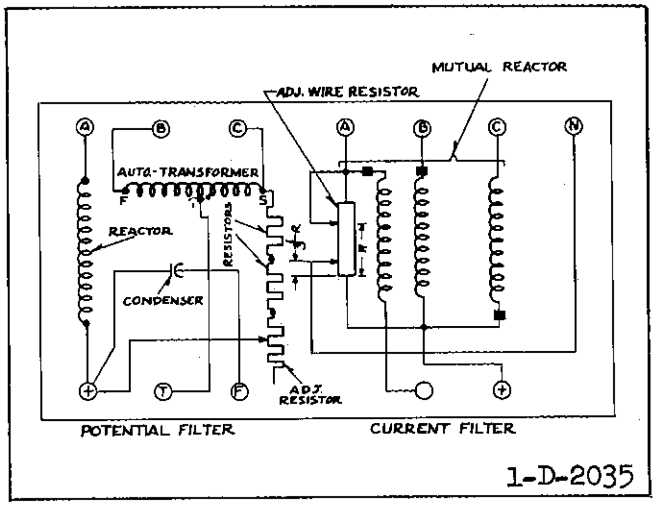

Fig. 2. Internal Wiring Diagram of the Negative Sequence Filter.

rection depending on the phase angle between the current and voltage. As fault power reverses, the current in the relay reverses, while the voltage remains fixed, thus directional indication is obtained.

Overcurrent Unit

The overcurrent unit is similar in construction to the directional unit except for the contact assembly and for the quantities used to rotate the disc. A silver contact fastened to the end of a rigid arm forms the moving contact on the overcurrent unit. This arm and a spiral spring assembly similar to that used on the directional unit are mounted on a short separate shaft which is geared to the main induction disc shaft. The electrical connection to the moving contact is made thru the spiral spring. The stationary contact assembly consists of a silver contact fastened on the free end of the leaf spring. This spring is fastened to a Micarta block and mounted on the element frame. A small set screw permits the adjustment of the contact follow. When double trip is used another leaf spring is mounted on the Micarta block, and a double contact is mounted on the rigid moving arm. Then the stationary contact set screws permit adjustment so that both circuits will be made simultaneously.

The tapped lower pole current coil of the overcurrent electromagnet is energized by residual current. Torque in the relay is obtained by energizing the upper pole circuit with a voltage induced across a few secondary turns on the lower pole. The contacts of the directional unit are connected in this circuit so that the overcurrent unit cannot operate until the directional unit is closed. This is known as directional control.

Fault Detector

The fault detector unit is a small solenoid switch whose coil is in series with the directional unit and is energized by negative sequence current from the filter. The plunger has a circular conducting disc mounted on its lower end, and as the plunger travels upward, the disc bridges three silver stationary contacts. The contacts are in series with the directional unit contacts and close the directional control circuit to the overcurrent unit as described above under the directional unit. The position of the Micarta disc at the bottom of the unit indicates the negative sequence ampere input to the filter required to pick up the unit.

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

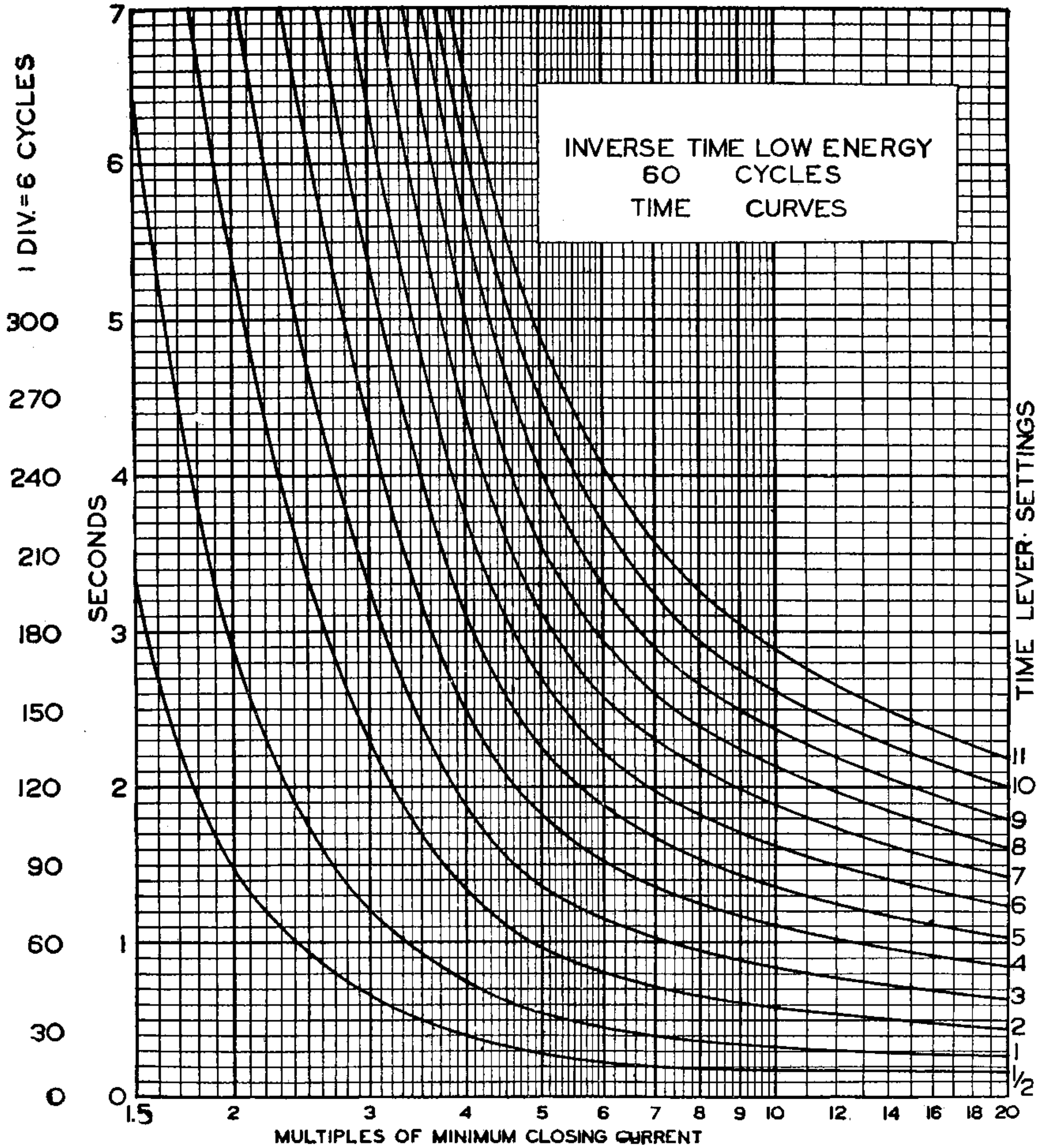

Fig. 3. Typical Time-Ampere Curves for the Overcurrent Unit.

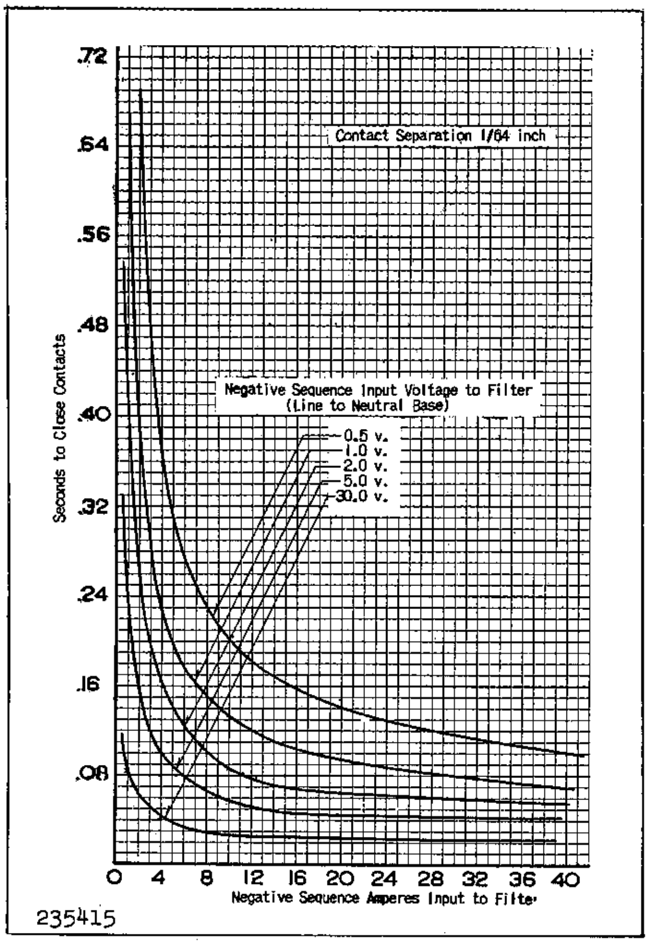

Fig. 4. Typical Time-Ampere Curves for the Negative Sequence Directional Unit and Filter.

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.

Negative Sequence Filter

The current and voltage filters consist of reactors, resistors, and condensers connected together as shown in Fig. 2, and mounted in an external box, Fig. 12.

CHARACTERISTICS AND SETTINGS

The minimum pick-up value of the relay overcurrent unit is given by the tap values which are 0.5, 0.6, 0.8, 1.0, 1.5, 2.0 and 2.5 amperes. The time curve of Fig. 3 shows the operating time of the relay in seconds for any value of fault current expressed as a percentage of the minimum pick-up current or tap value used. This minimum pick-up value may be adjusted so that relay trips exactly on its tap value, or on a value in between by means of the spring adjuster described above. If the spring adjuster is used to secure tripping values materially different from the tap values, the time curve of Fig. 3 will be somewhat changed.

Since the relay is directionally controlled the overcurrent unit cannot operate until the directional unit has operated. Fig. 4 shows the time curve of the directional unit and filter. The curves of Fig. 4 do not include the directional unit operating time and consequently the operating time of the relay will be the sum of the times shown on the two curves. The directional unit operating time may be neglected except for low values of negative sequence current and voltage.

When changing taps, the extra tap screw should be inserted in the desired tap before removing the undesired tap screw. This is important to prevent opening the current transformers which are directly connected to the tap plates.

The time lever setting is adjustable by moving contact stop guide around the semi-circular index until the correct lever setting is obtained. The guide should then be tightly clamped in place by means of the screw at the pivot. The relay is calibrated on the #10 lever setting.

The scale markings on the fault detector are 1.5, 3, and 6 amperes negative sequence input to the current filter.

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.

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

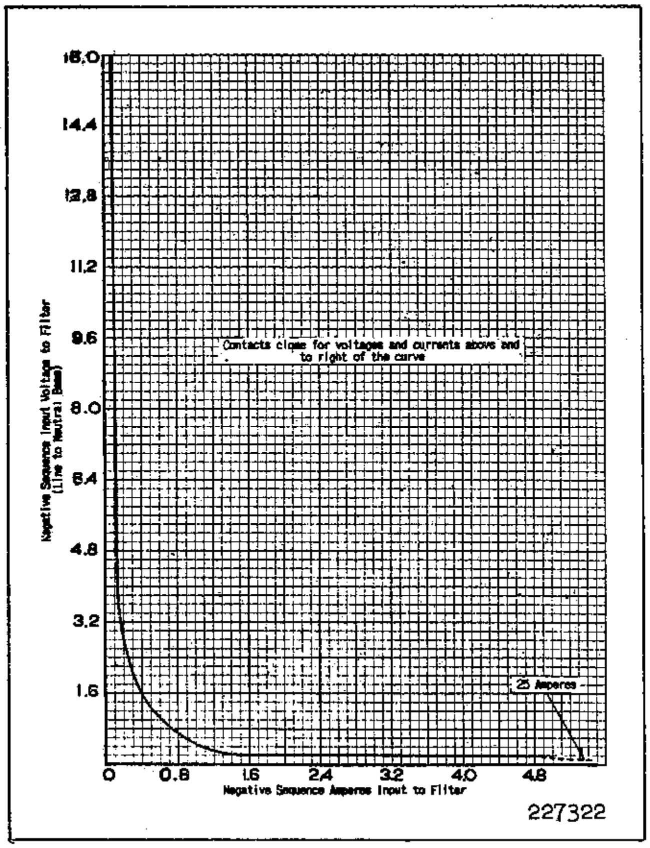

Fig. 5. Typical Sensitivity Curves for the Negative Sequence Directional Unit and Filter.

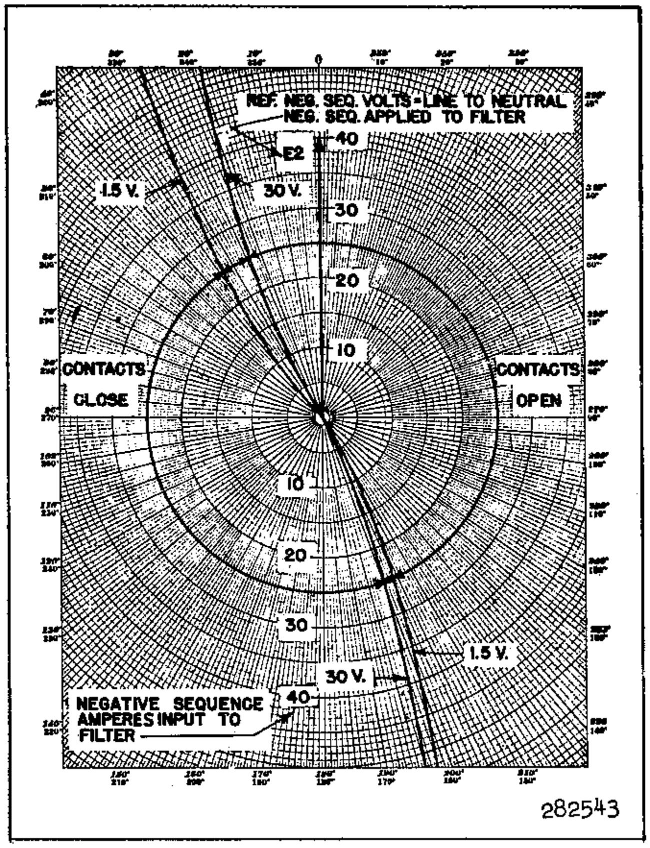

Fig. 6. Typical Phase Angle Curve for the Negative Sequence Directional Unit and Filter.

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.

The negative sequence filter should be as near the relay terminals as possible. To obtain maximum sensitivity, the leads connecting the relay and filter current coils should not have a resistance greater than 0.01 ohm (5 feet of #12 switchboard wire).

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 contact 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.

Overcurrent Unit

Adjust the back stop on the time lever so the

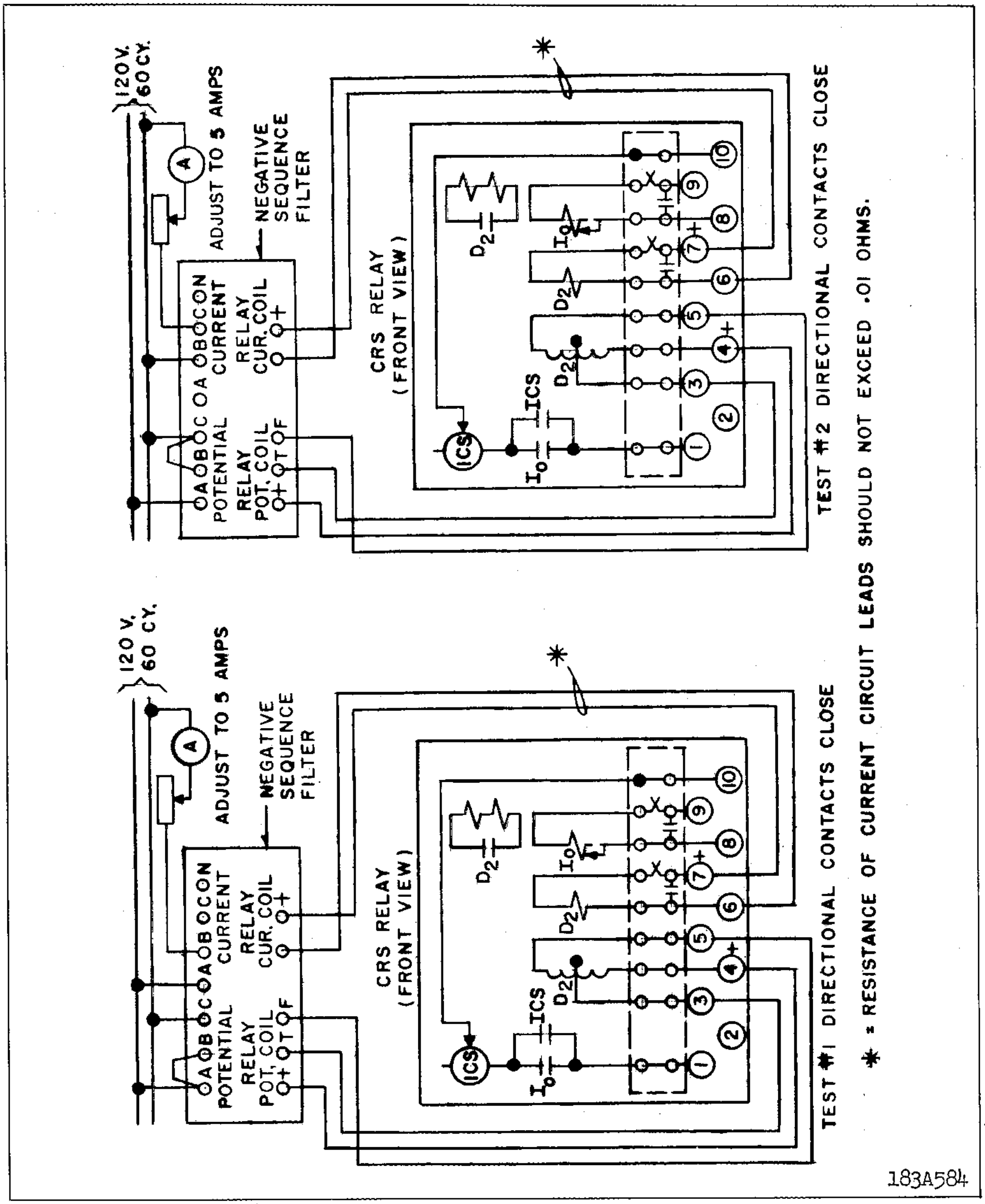

Fig. 7. Single Phase Polarity Test Diagram for Negative Sequence Directional Unit and Filter.

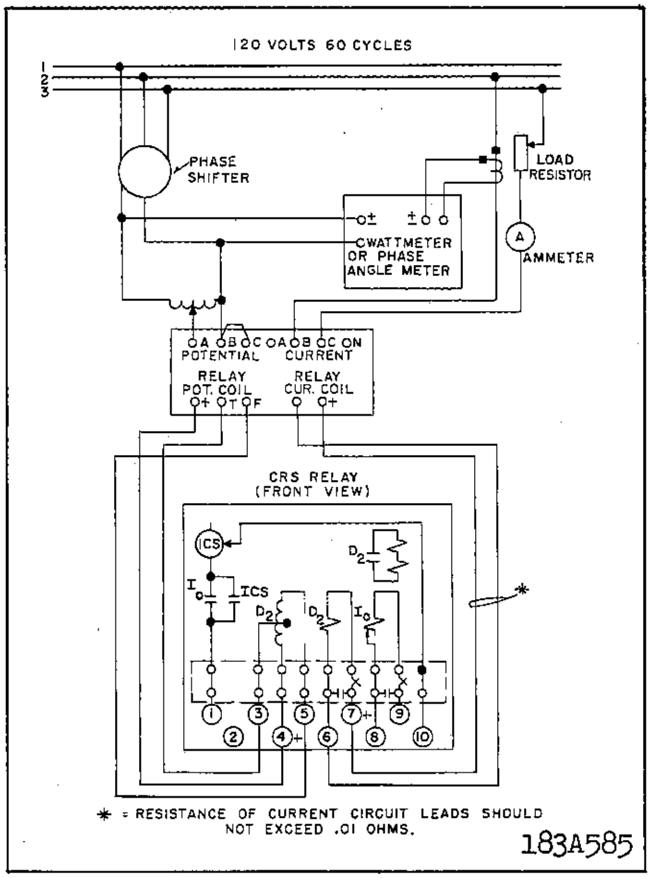

Fig. 8. Phase Angle and Minimum Pick-Up Test Diagram for Negative Sequence Directional Unit and Filter.

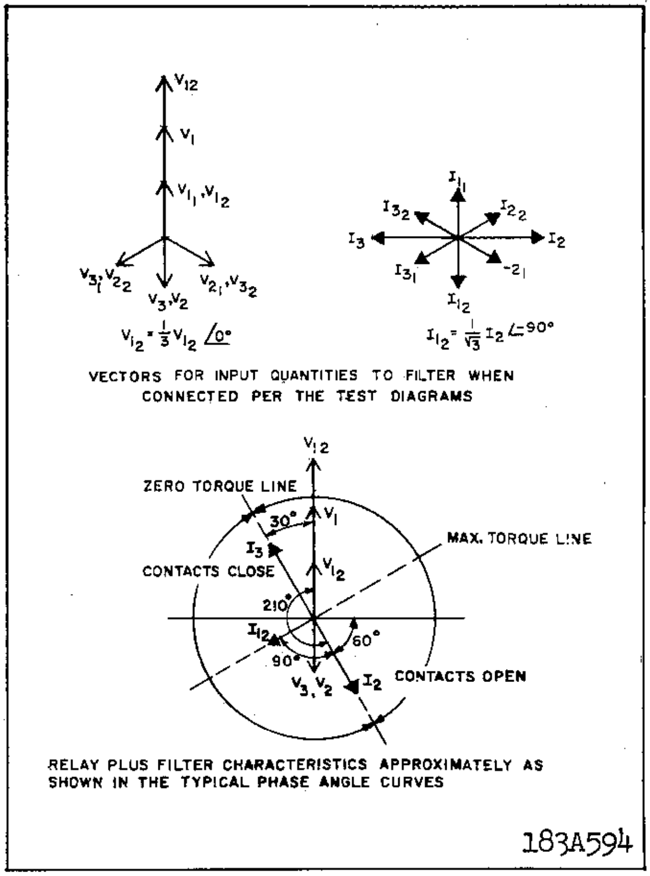

Fig. 9. Vectors for the Maximum Contact Closing Torque Conditions When Relay Is Connected Per Test Diagram Fig. 8.

moving contact just touches the stationary contact when the time lever is in the zero position. The small adjustment screw on the stationary contact should not be screwed in far enough to limit the follow of the stationary contact. For double trip relays adjust the screws so that both circuits make at the same instant.

Adjust the tension of the spiral spring so the contacts will close on Tap Value current as shown by the position of the screw in the tap block. Shift the position of the damping magnets to give the time characteristic of the relay shown on the calibration curve. Since directional control is used, the overcurrent unit cannot operate until the directional unit contacts have closed, hence the directional unit contacts have closed, hence the directional unit contacts should be blocked closed for this adjustment. For relays with a fault detector, the fault detector contacts should be closed or shorted for the above adjustments.

Directional Unit

Adjust the top bearing screw so that very little play (.001 to .003 inch) can be detected by pressing up and down on the disc. This adjustment can be made best by carefully screwing down the top bearing screws until the disc fails to turn freely and then backing up a fraction of a turn. Great care must be taken in making this adjustment to prevent damaging the bearings. Make sure the lock nut on the top bearing screw is tight.

Adjust the spring adjuster so that neither the moving contact touches the stationary contact or the disc stop touches the movement frame and pass 20 amperes thru the current element with the potential circuit connected to the proper out-put terminals of the negative sequence filter but with the potential input terminals short circuited. Adjust the two current torque adjusters so there is no creep in the disc, and tighten the set screws. These screws are on either side of the electromagnet just below the disc and

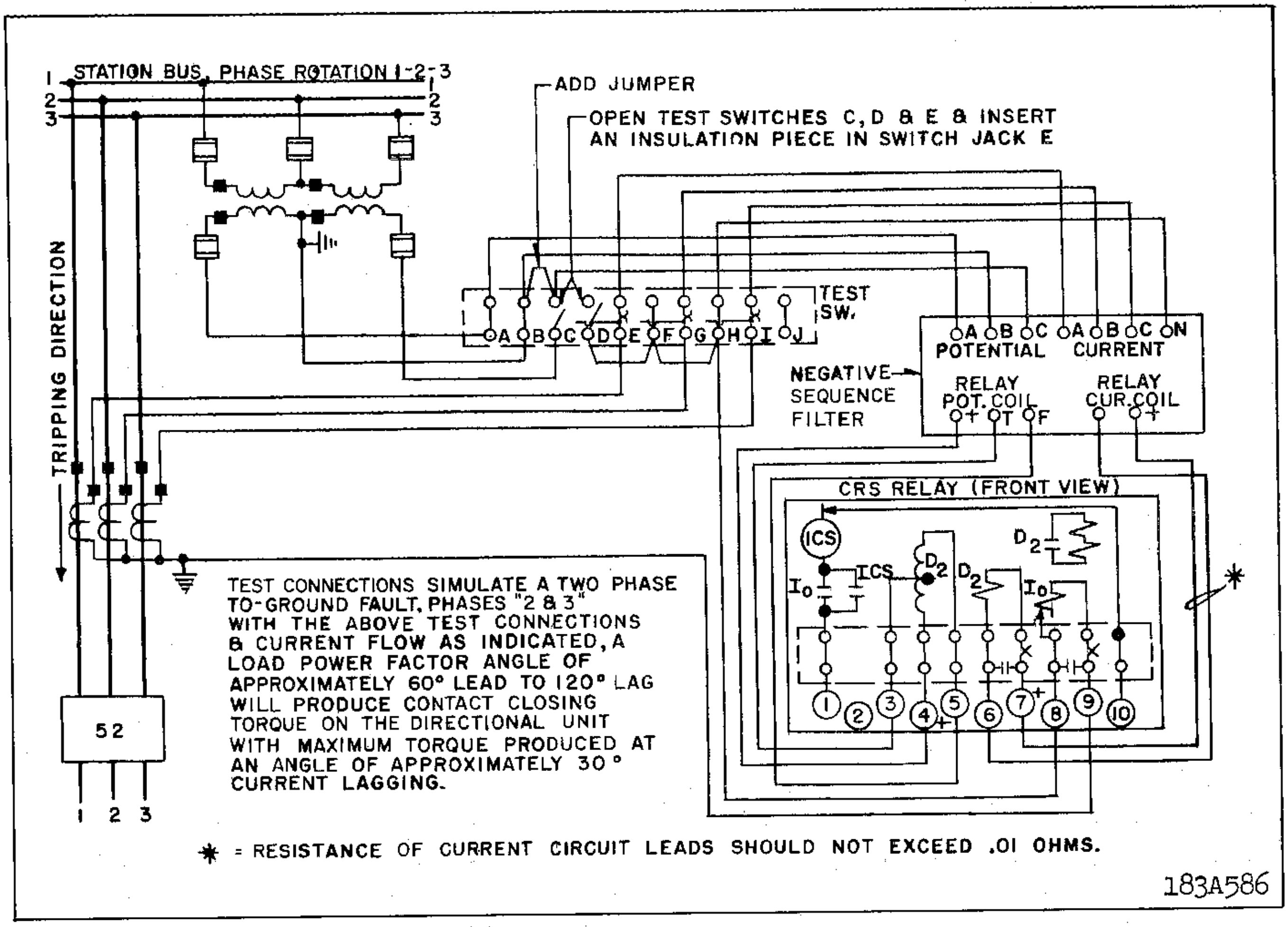

Fig. 10. Test Diagram for Checking Polarity After Installation.

can be reached by a long screw-driver inserted from the front of the relay between the permanent magnet. For this test the current torque adjusters should initially each be turned away from the shaft as far as possible. Then, if the disc creeps, the torque adjuster on the side towards which the disc creeps should be turned inward until the disc ceases to creep. It is important that the disc be level for this test.

The start and finish terminal on the potential coil can be easily identified since the resistance between T and F is about 8 times that between S and T.

Connect the directional unit and filter as shown in Fig. 8 with 115 volts a-c applied to terminals A and B. This should give a filter output voltage of about 45 volts, from + to T. With the spring still adjusted as above there should be zero contact closing torque and possibly a small amount of contact opening torque.

De-energize the relay and wind up the spring approximately 1/20 of a turn. Adjust the contact for 1/64" separation by screwing up the stationary contact screw and locking it in place. The contact follow is permanently fixed on the moving contact.

Negative Sequence Filter

The filters are adjusted for balance in the factory and no further adjustments or maintenances should be required. The normal voltage and current output of the filters on positive sequence is zero. This serves as a convenient check on the balance of the filters. If any two input leads to the potential filter should be interchanged, a high voltage occurs across the output terminals of the filter when the directional unit of the relay is properly connected to it. This voltage may be 300 volts between terminal F and the other output terminals. Similarly, if any two of

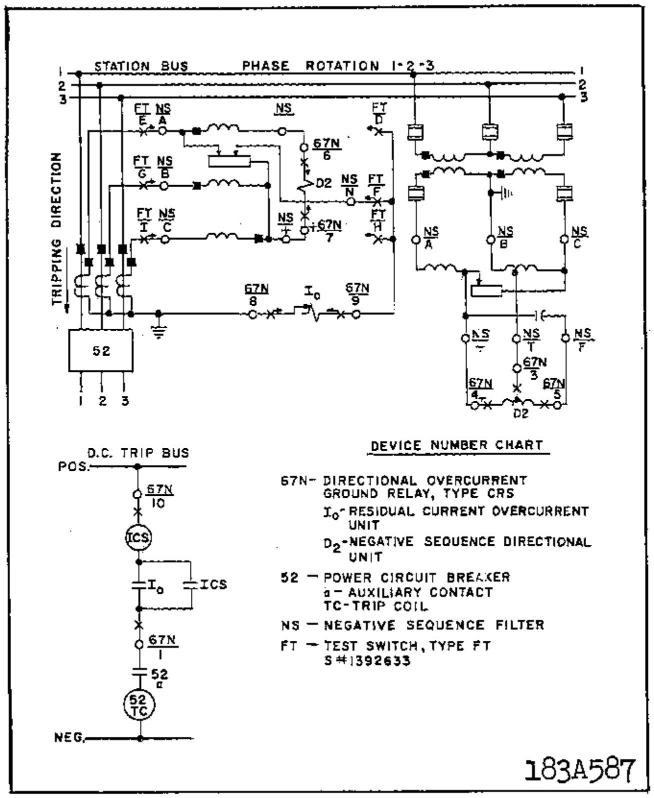

Fig. 11. External Schematic of the Type CRS Relay in the Type FT31 Case.

the phase leads to the input terminals of the current filter are interchanged, an output current will be obtained.

Fault Detector

The pick-up of the fault detector switch is changed by raising or lowering the plunger. This is done by means of the Micarta disc. This disc should be raised or lowered to the proper position by loosening the lock nut which locks the Micarta disc and rotating the Micarta disc. When the disc is at the 1.5 scale mark, the single phase current thru terminals B and C of the current filter should be 2.6 amperes ±5%.

The drop-out value is varied by raising or lowering the core screw at the top of the switch and after the final adjustment is made, the core screw should be securely locked in place with the lock nut. With the pick-up adjusted to the value above, the contacts should drop out at 1.9 amperes single phase current between terminals B and C of the current filter or 1.1 amperes negative sequence input to the filter. These values are to be measured with gradually changing current. Check the pick-up and drop-out values for the silver disc and core rotated to various positions with respect to the rest of the unit. Test for sticking after 30 amperes single phase is applied to the current filter.

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.

Overall Test

Fig. 7 shows the connections for checking the polarity of the negative sequence directional unit.

If it is desired to test the relay for the phase angle of maximum torque, test connections as shown in Fig. 8 should be used. For this test both unbalanced voltages and currents are applied to the filter, simulating a line-to-line fault on phase 23. Thus, both positive sequence and negative sequence voltage and current are simultaneously applied to the filter.

In the test diagram, connections are such that when I_2 leads V_{12} by approximately 120° or 300° the relay directional element has zerotorque, or when I_2 leads V_{12} by 210° the relay directional unit has maximum closing torque. The maximum closing torque condition corresponds to a phase 2 to phase 3 fault in which phase 2 current lags the voltage producing it by 60°.

The phase angle meter reading for instruments that indicate current leading voltage will indicate an angle 90° greater than the angle I_{a2} lead V_{a2}. Therefore, phase angle meter reading minus 90° equals phase angle that the negative sequence current leads the negative sequence voltage to neutral applied to the filter.

The above statements may be verified by inspection of Fig. 9.

RENEWAL PARTS

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

ENERGY REQUIREMENTS

(All burdens at 60 Cycles)

The burden of the overcurrent unit on the various taps is as follows.

Tap	Continuous Rating-Amps.	One Second Rating-Amps.	Volt-Amps. at Tap Current	Volt-Amps. at 5 Amps.	Power Factor Angle
.5	2	70	2	200	66° Lag
.6	2	70	2	140	66° Lag
.8	2	70	2	78	66° Lag
1.0	3	70	2	50	66° Lag
1.5	3	70	2	22	66° Lag
2.0	4	70	2	12.5	66° Lag
2.5	5	70	2	8	66° Lag

The burden of the standard energy current filter with positive sequence currents applied (no output current to the directional unit) is as follows:

Phase	Continuous Rating-Amps.	One Second Rating-Amps.	Watts at 5 Amps.	Volt-Amps. at 5 Amps.	Power Factor Angle
1	5	100	1.34	1.34	0°
2	5	100	0	1.20	90° Lag
3	5	100	1.70	2.83	55° Lag

The burden of the high energy current filter with positive sequence currents applied (no output current to the directional unit or fault detector) is as follows:

1	5	100	5.3	5.3	0°
2	5	100	0.0	.98	90° Lag
3	5	100	4.0	7.25	56° Lag

The burden of the potential filter with positive sequence voltage applied (no output voltage to the directional unit) is as follows:

Pot. Transf. Across Phase	Continuous Rating Volts	Watts	Volt-Amps.	Power Factor Angle

Burden values on three star connected potential transformers. Values at the star voltage of 66.4 volts (115 volts delta).

1	115	0	26.8	90° Lag
2	115	0.2	0.3	48° Lag
3	115	23.2	27.0	30° Lag

Burden values on two open-delta potential transformers. Values at 115 volts.

12	115	−23.2	46.5	120° Lag
23	115	46.6	46.6	0° Lag
23	115	0.11	0.52	78° Lag
31	115	23.2	46.5	60° Lag
31	115	23.2	46.6	60° Lag
12	115	0.50	0.52	18° Lag

Burden values on three delta connected potential transformers. Values at 115 volts.

31	115	15.4	31.0	60° Lag
12	115	−7.8	15.6	120° Lag
23	115	0	15.6	90° Lag

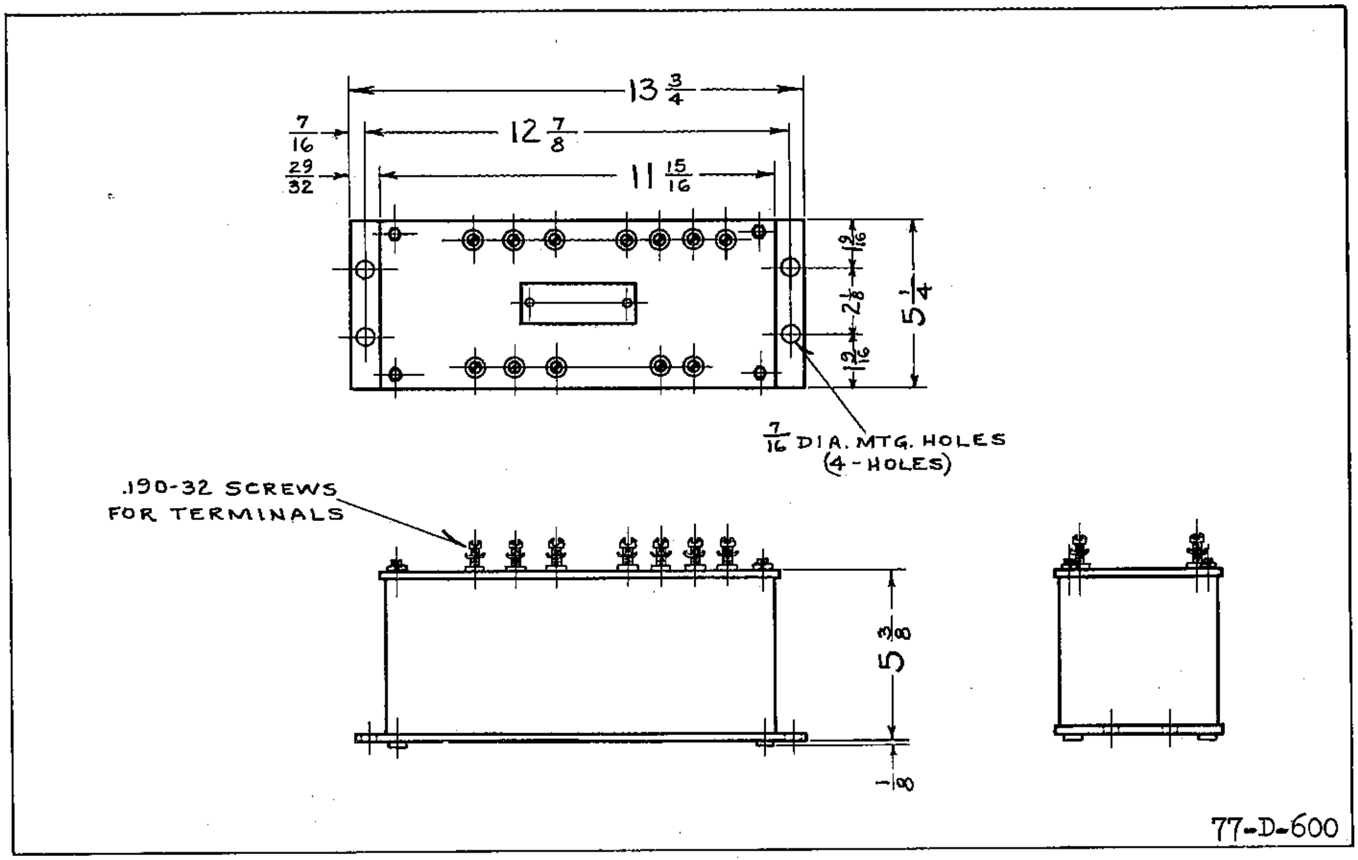

Fig. 12. Outline and Drilling Plan of the Negative Sequence Filter.

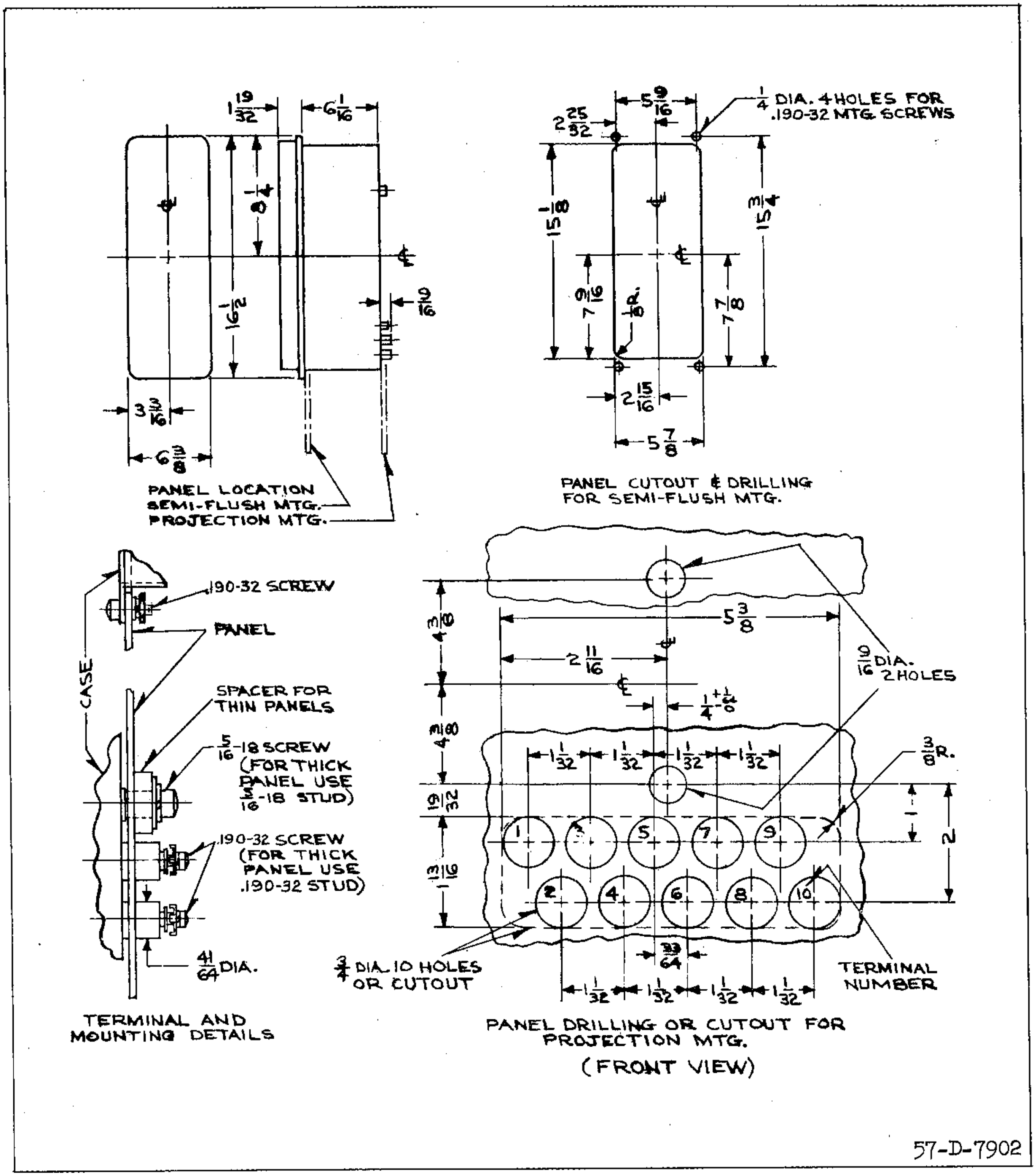

Fig. 13. Outline and Drilling Plan for the Type CRS Relay in the Type FT31 Case.