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( | ) Denotes Change Since Previous Issue

# Type CRQ Directional Negative Sequence Relay for Ground Protection



**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 setting and electrical connections.**

## 1.0 APPLICATION

The type CRQ relay is a directional overcurrent ground relay in which the directional unit operates on negative sequence current and voltage, and the over-current unit operates on residual or ground current. The negative sequence current and voltage are obtained by means of self-contained negative sequence filters connected between the directional unit and the current and potential transformers.

The relay is 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 delta side of a wye-delta or delta-wye power transformer bank, the type CRQ relay is applicable for ground protection.

## 2.0 CONSTRUCTION AND OPERATION

The type CRQ relay consists of a directional cylinder

unit (D) operating on negative sequence quantities, negative-sequence current and voltage filters, a time overcurrent induction disc unit (CO) operating on residual current, and an indicating contactor switch (ICS). The CRQ is available with an indicating instantaneous trip unit (IIT), and/or fault detector (FD) when required which operates on residual current.

### Directional Unit (D)

The directional unit is a product induction cylinder type unit operating on the interaction between the polarizing circuit flux and the operating circuit flux.

Mechanically, the directional unit is composed of four basic components; A die-cast aluminum frame, an electromagnet, a moving element assembly, and a molded bridge.

The frame serves as the mounting structure for the magnetic core. The magnetic core which houses the lower pin bearing is secured to the frame by a locking nut. The bearing can be replaced, if necessary, without having to remove the magnetic core from the frame.

The electromagnet has two series-connected polarizing coils mounted diametrically opposite one another; two series-connected operating coils mounted diametrically opposite one another; two magnetic adjusting plugs; upper and lower adjusting plug clips, and two locating pins. The locating pins are used to accurately position the lower pin bearing, which is threaded into the bridge. The electromagnet is secured to the frame by four mounting screws.

The moving element assembly consists of a spiral spring, contact carrying member, and an aluminum cylinder assembled to a molded hub which holds the

***All possible contingencies which may arise during installation, operation or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If further information is desired by purchaser regarding this particular installation, operation or maintenance of this equipment, the local ABB Inc. representative should be contacted.***

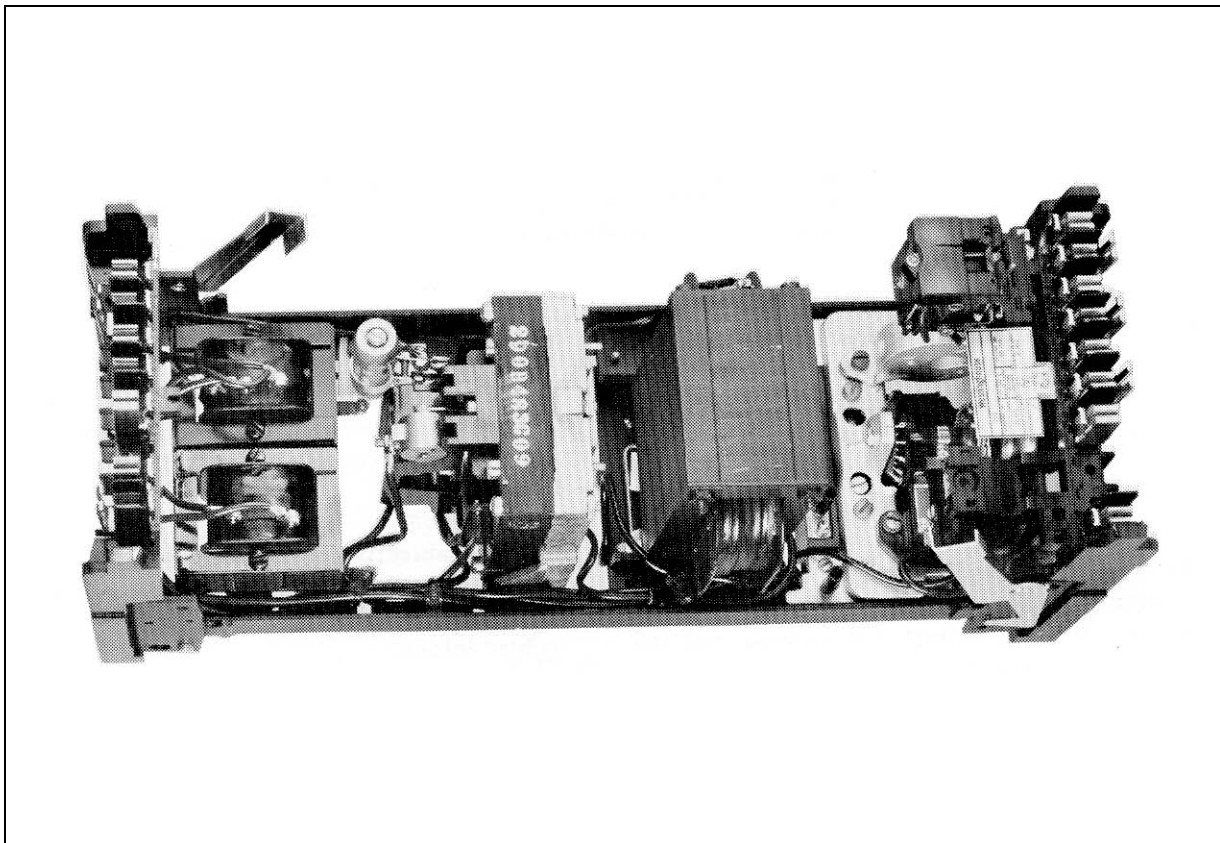


Figure 2: Type CRQ Relay without case (front view).

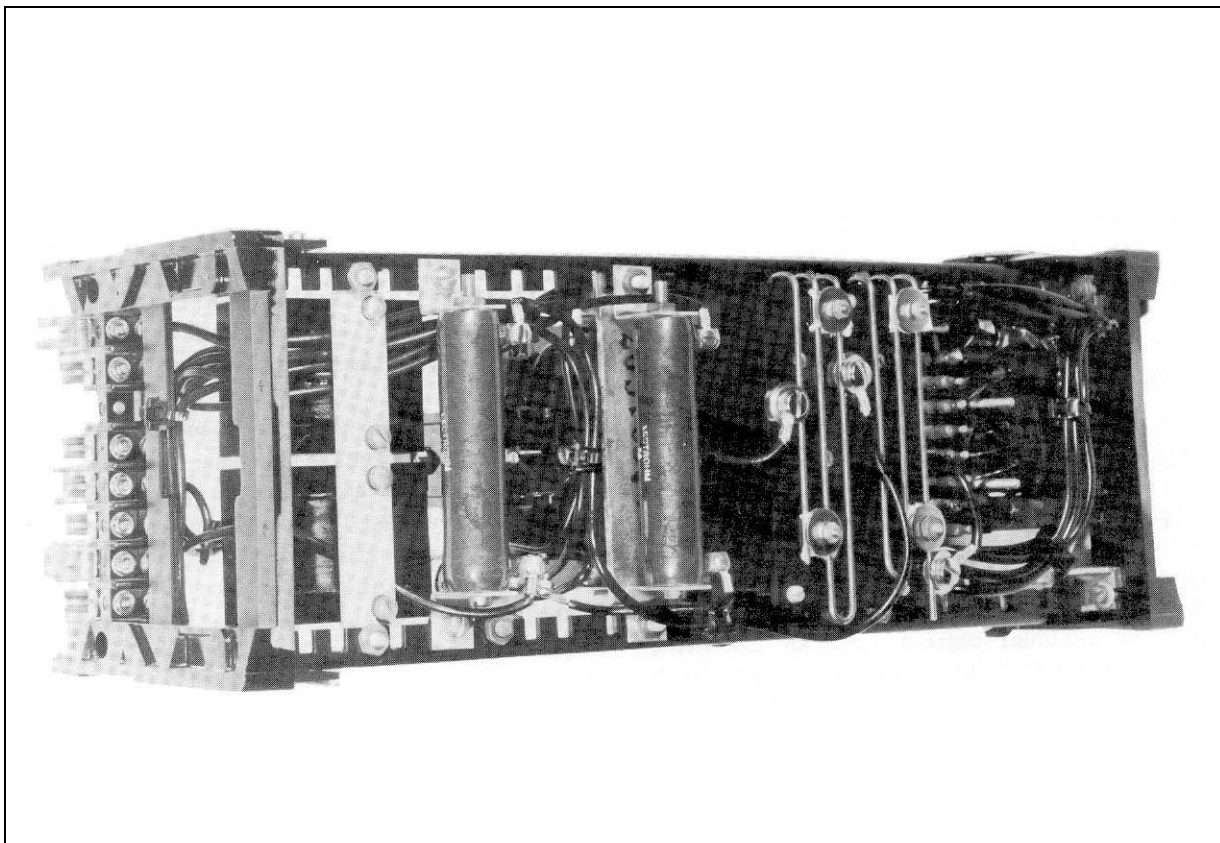


Figure 1: Type CRQ Relay without case (rear view).

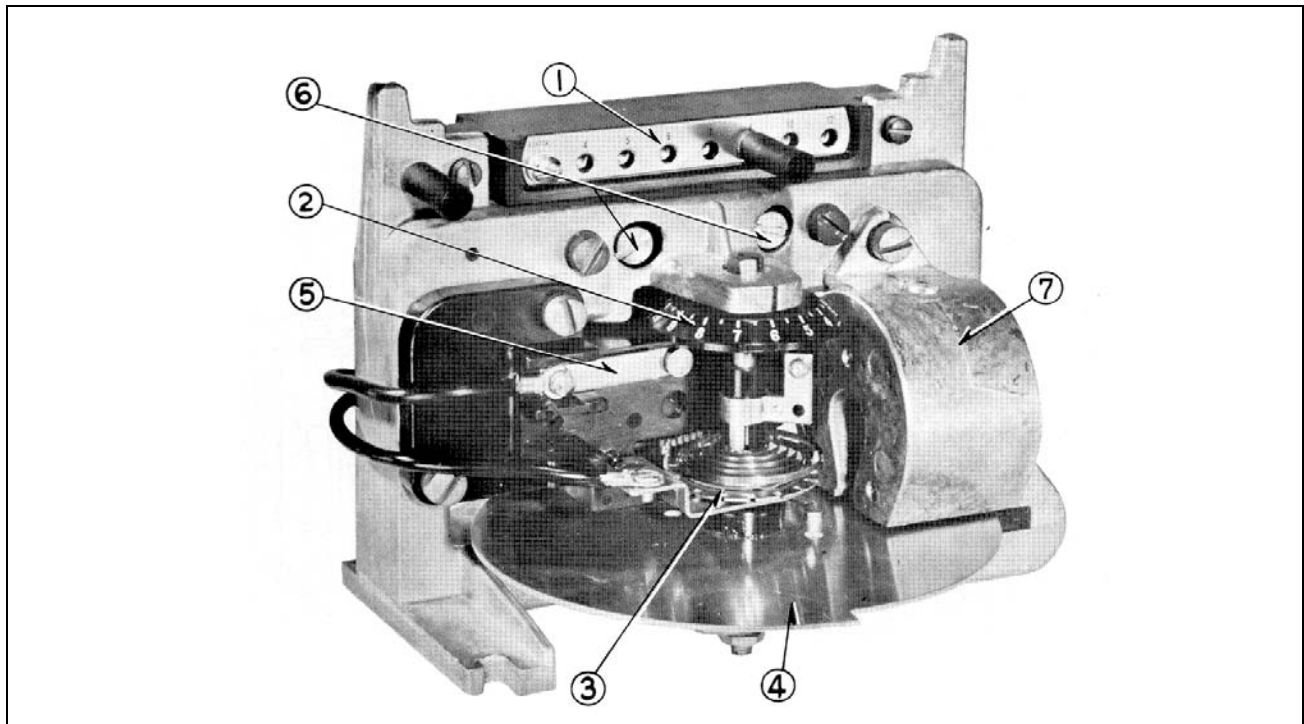


Figure 3: Time Overcurrent Unit (front view) 1 - Tap Block 2 - Time Dial 3 - Control Spring Assembly 4 - Disc. 5 - Stationary Contact Assembly 6 - Magnetic Plugs 7 - Permanent Magnet.

shaft. The shaft has removable top and bottom jewel bearings. The shaft rides between the bottom pin bearing and the upper pin bearing with the cylinder rotating in an air gap formed by the electromagnet and the magnetic core.

The bridge is secured to the electromagnet and frame by two mounting screws. In addition to holding the upper pin bearing, the bridge is used for mounting the adjustable stationary contact housing. The stationary contact housing is held in position by a spring type clamp. The spring adjuster is located on the underside of the bridge and is attached to the moving contact arm by a spiral spring. The spring adjuster is also held in place by a spring type clamp.

With the contacts closed, the electrical connection is made through the stationary contact housing clamp, to the moving contact, through the spiral spring out to the spring adjuster clamp.

### **Negative Sequence Filter**

The current and voltage filters consist of reactors and resistors connected together as shown in the internal schematics (Figs. 4, 5, 6.)

### **Time-Overcurrent Unit (CO)**

The electromagnets for the types CRQ-5, CRQ-6, CRQ-7, CRQ-8 and CRQ-9 relays have a main tapped coil located on the center leg of an "E" type laminated structure that produces a flux which divides and returns through the outer legs. A shading coil causes the flux through the left leg to lag the main pole flux. The out-of-phase fluxes thus produced in the air gap cause a contact closing torque.

The electromagnets for the types CRQ-2 and CRQ-11 relays have a main coil consisting of a tapped primary winding and a secondary winding. Two identical coils on the outer legs of the lamination structure are connected to the main coil secondary in a manner so that the combination of all the fluxes produced by the electromagnet result in out-of-phase fluxes in the air gap. The out-of-phase air gap fluxes produced cause a contact closing torque.

### **Indicating Contactor Switch Unit (ICS)**

The dc 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.

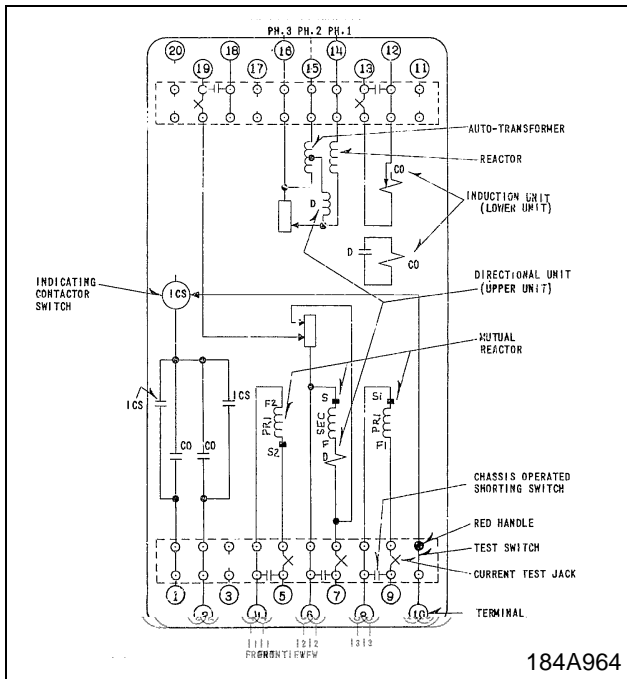


Figure 4: Internal Schematic of CRQ Double Trip Relay. For Single Trip Omit Circuits Associated with Terminal 2.

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

**Fault Detector (FD)**

The fault detector is a small solenoid type element. A cylindrical plunger rides up and down on a vertical guide rod in the center of the solenoid coil. The guide rod is fastened to the stationary core, which in turn screws into the unit frame. A silver disc is fastened to the moving plunger through a helical spring. When the coil is energized, the plunger moves upward carrying the silver disc which bridges three conical-shaped stationary contacts. In this position, the helical spring is compressed and the plunger is free to move while the contact remains stationary. Thus, ac vibrations of the plunger are prevented from causing contact bouncing. A Micarta disc is fastened to the bottom of the guide rod by two small nuts. Its position determines the pick-up current of the element.

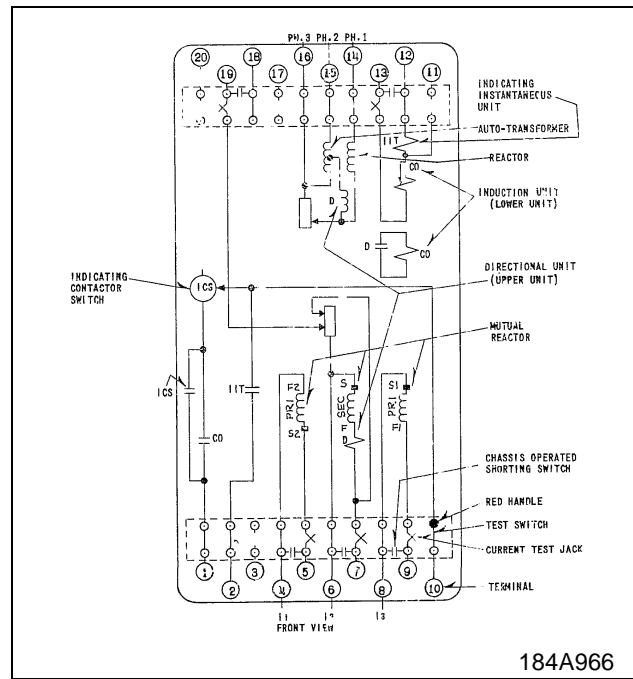


Figure 5: Internal Schematic of CRQ Relay, with IIT.

The fault detector coil is in series with the directional element and is energized by negative sequence current from the f filter.

The contacts are in series with the directional element contacts and close the directional control circuit to the overcurrent element.

**Indicating Instantaneous Trip Unit (IIT)**

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

A core screw accessible from the top of the switch provides the adjustable pickup range

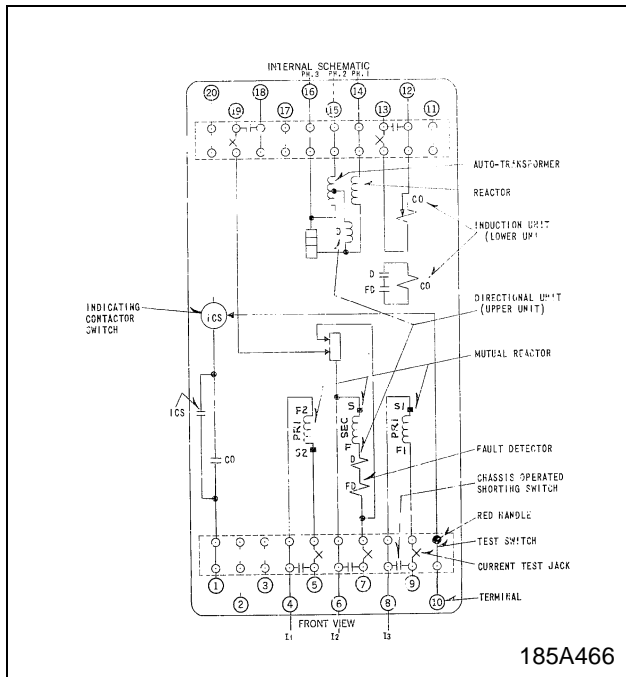


Figure 6: Internal Schematic of CRQ Relay, with Fault Detector.

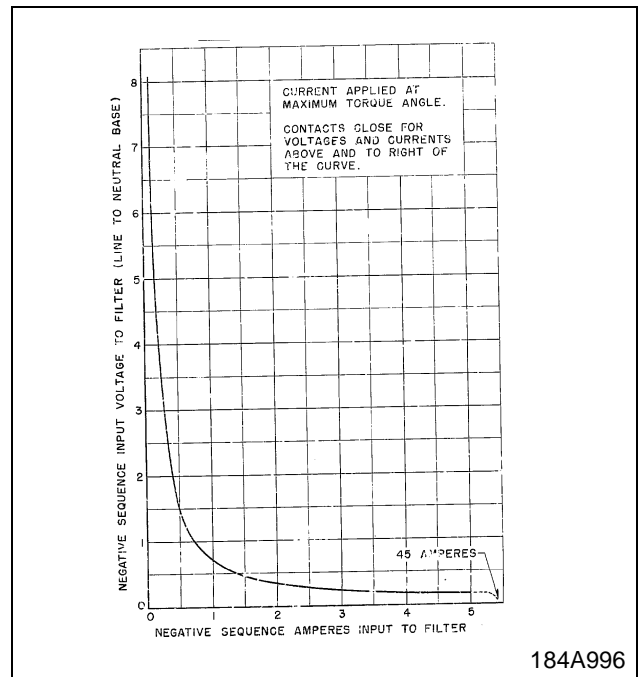


Figure 7: Sensitivity Curve of the Directional Unit (D).

### 3.0 CHARACTERISTICS

The time characteristics of the time over-current relays are designated by specific numbers as indicated in Table 1.

Table 1

**Time**

Characteristics	Designation
Short Time	2
Long Time	5
Definite Time	6
Moderately Inverse Time	7
Inverse Time	8
Very Inverse Time	9
Extremely Inverse Time	11

The relays are generally available in the following overcurrent unit current ranges:

Range	Taps							
0.5 – 2.5	0.5	0.6	0.8	1.0	1.5	2.0	2.5	
2 – 6	2	2.5	3	3.5	4	5	6	
4 – 12	4	5	6	7	8	10	12	

These relays may have either single or double circuit closing contacts for tripping either one or two circuit breakers.

The time vs. current characteristics are shown in Figs. 15 to 21. These characteristics give the contact closing time for the various time dial settings when the indicated multiples of tap value current are applied to the relay.

#### Indicating Instantaneous Trip Unit (IIT)

The relay is also available with an IIT unit having the following current ranges;

#### Range

- .5-2 amps
- 1-4
- 2-8
- 4-16
- 10-40
- 20-80
- 40-160

The operating time of the IIT unit is approximately one cycle at 3 times pickup setting.

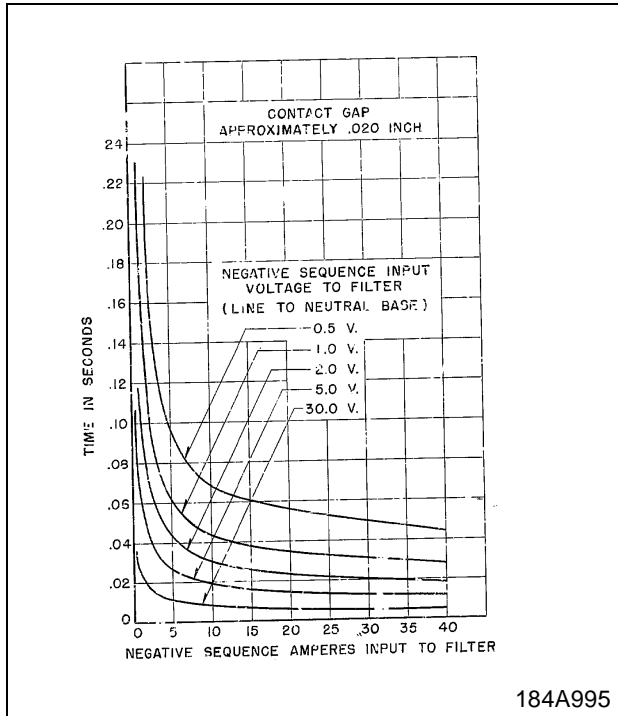


Figure 6: Time curves of the Directional Unit (D).

The core screw which is adjustable from the top of the trip unit determines the pickup value. The trip unit has a nominal ratio of adjustment of 1 to 4 and an accuracy within the limits of 10%.

#### Directional Unit (D)

The directional unit minimum pick-up is approximately 0.76 voltamperes (e.g. 0.19 volt and 4 amperes) in terms of negative sequence quantities applied at the relay terminals at the maximum torque angle of approximately  $98^\circ$  (current leading voltage.)

A typical sensitivity curve for the negative sequence directional unit is shown in Fig. 7.

The time vs. current characteristics for the directional unit is shown in Fig. 8.

#### 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 instantaneous trip contacts will safely close 30 amperes at 250 volts d-c, and will carry this current long enough to trip a breaker.

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

#### Trip Circuit Constants

Indicating Contactor Switch –

0.2 amp tap 6.5 ohms d-c resistance

2.0 amp tap 0.15 ohms d-c resistance

#### Cylinder Unit Contacts

The moving contact assembly has been factory adjusted for low contact bounce performance and should not be changed.

The set screw in each stationary contact has been adjusted for optimum follow and this adjustment should not be disturbed.

#### Fault Detector (FD)

A fault detector when supplied has a pick up range of 1.5 to 6.0 amperes with scale markings at 1.5, 3 and 6 amperes (negative sequence current input to the relay terminals).

The operating time is approximately one cycle at three times pickup setting.

## 4.0 SETTINGS

#### Directional Unit (D)

No setting required.

#### Overcurrent Unit (CO)

The overcurrent unit settings can be defined either by tap settings and time dial position or by tap setting and a specific time of operation at some current multiple of the tap setting (e.g. 4 tap setting, 2 time dial position or 4 tap setting, 0.6 seconds at 6 times tap value current).

To provide selective circuit breaker operation, a minimum coordinating time of 0.3 seconds plus breaker time is recommended between the relay being set and the relays with which coordination is to be effected.

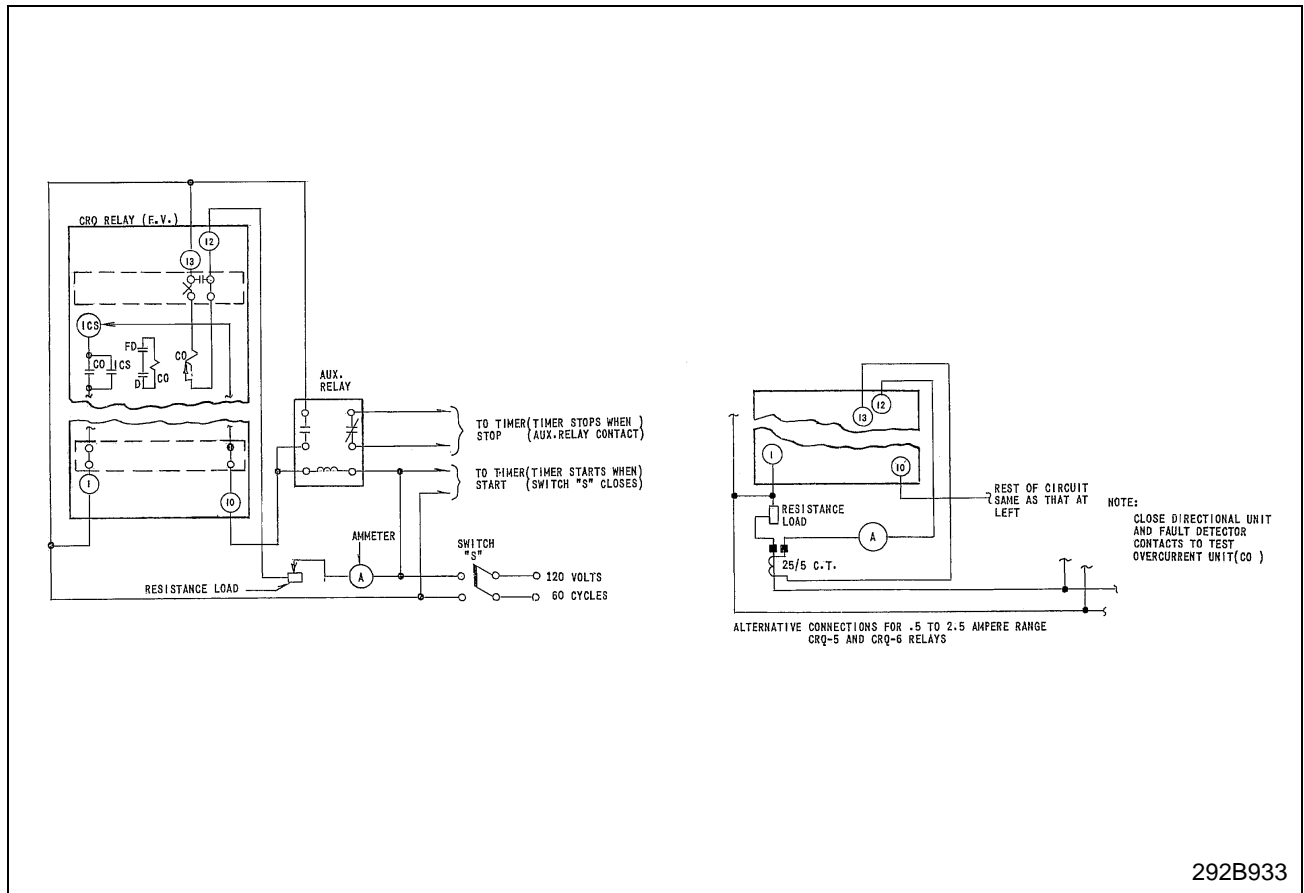


Figure 9: Diagram of Test Connections for the Circuit Closing Time Overcurrent Unit of the CRQ.

The connector screw on the terminal plate above the time dial makes connections to various turns on the operating coil. By placing the screw in the various terminal plate holes, the relay will respond to multiples of tap value currents in accordance with the various typical time-current curves.

**Caution**

Since the tap block connector screw carries operating current, be sure that the screw is turned tight. In order to avoid opening the current transformer circuits when changing taps under load, connect the spare tap screw in the desired tap position before removing the other tap screw from the original tap position.

**Instantaneous Reclosing**

The factory adjustment of the CO unit contacts provides a contact follow. Where circuit breaker reclosing will be initiated immediately after a trip by the CO contact, the time of the opening of the con-

tacts should be a minimum. This condition is obtained by loosening the stationary contact mounting screw, removing the contact plate and then replacing the plate with the bent end resting against the contact spring.

For double trip relays, the upper stationary contact is adjusted such that the contact spring rests solidly against the back stop. The lower stationary contact is then adjusted such that both stationary contacts make contact simultaneously with their respective moving contact.

**Fault Detector (FD)**

The pickup 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 locknut which locks the micarta disc and rotating the micarta disc. The disc should be lined up by eye with the desired marking on the scale plate.

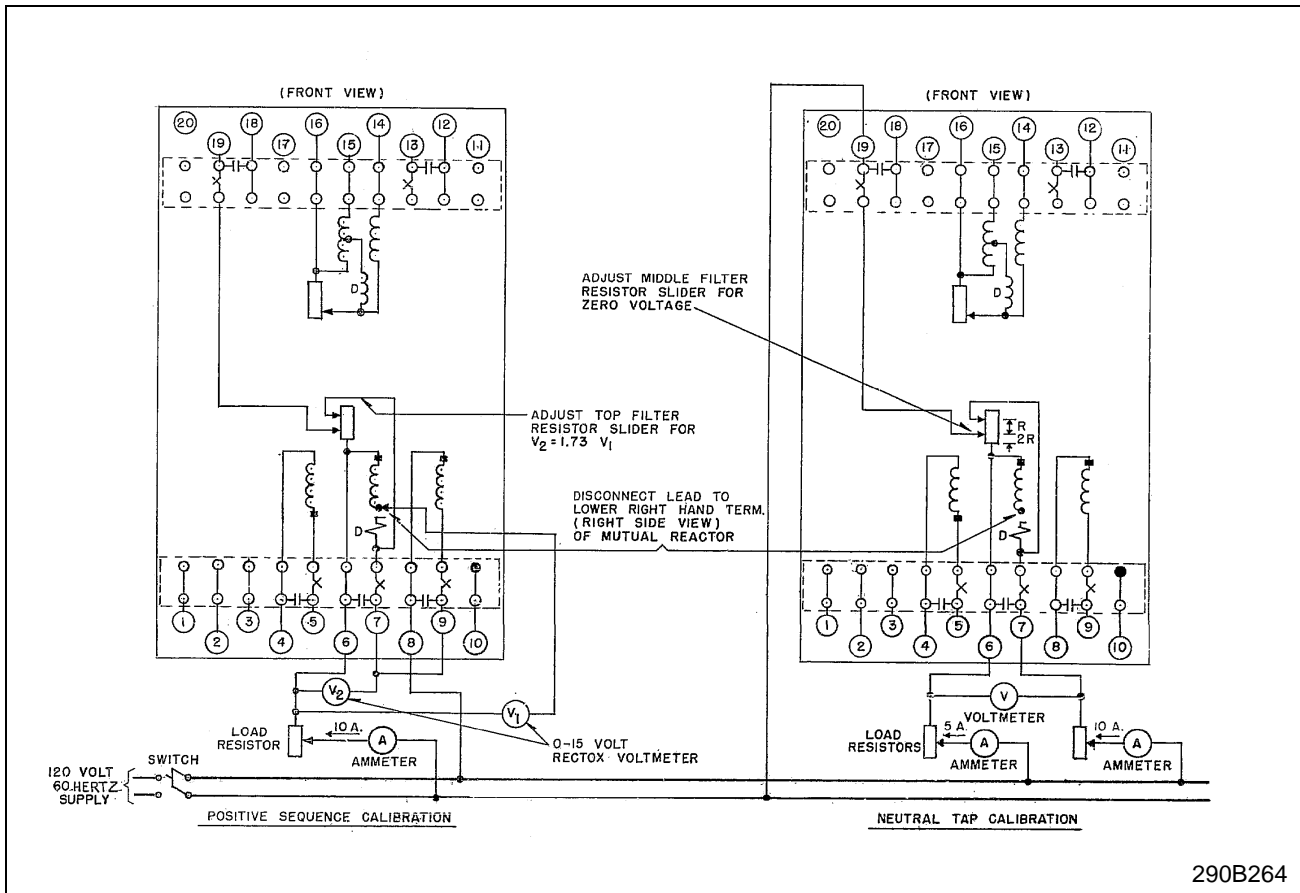


Figure 10: Test Diagram for Calibration of Negative Sequence Current Filter in CRQ Relay.

### **Indicating Contactor Switch (ICS)**

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

### **Indicating Instantaneous Trip (IIT)**

The core screw must be adjusted to the value of pick-up desired.

### **Negative Sequence Filter**

No setting is required.

## **5.0 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 two mounting studs

for the type FT projection case or by means of the four mounting holes on the flange for the semi-flush type FT case. Either of the studs or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel panel mounting or to 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 studs and then turning the proper nut with a wrench.

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

## **6.0 ADJUSTMENTS AND MAINTENANCE**

The proper adjustments to insure correct operation of this relay have been made at the factory. Upon receipt of the relay, no customer adjustments, other than those covered under "SETTINGS", should be required.



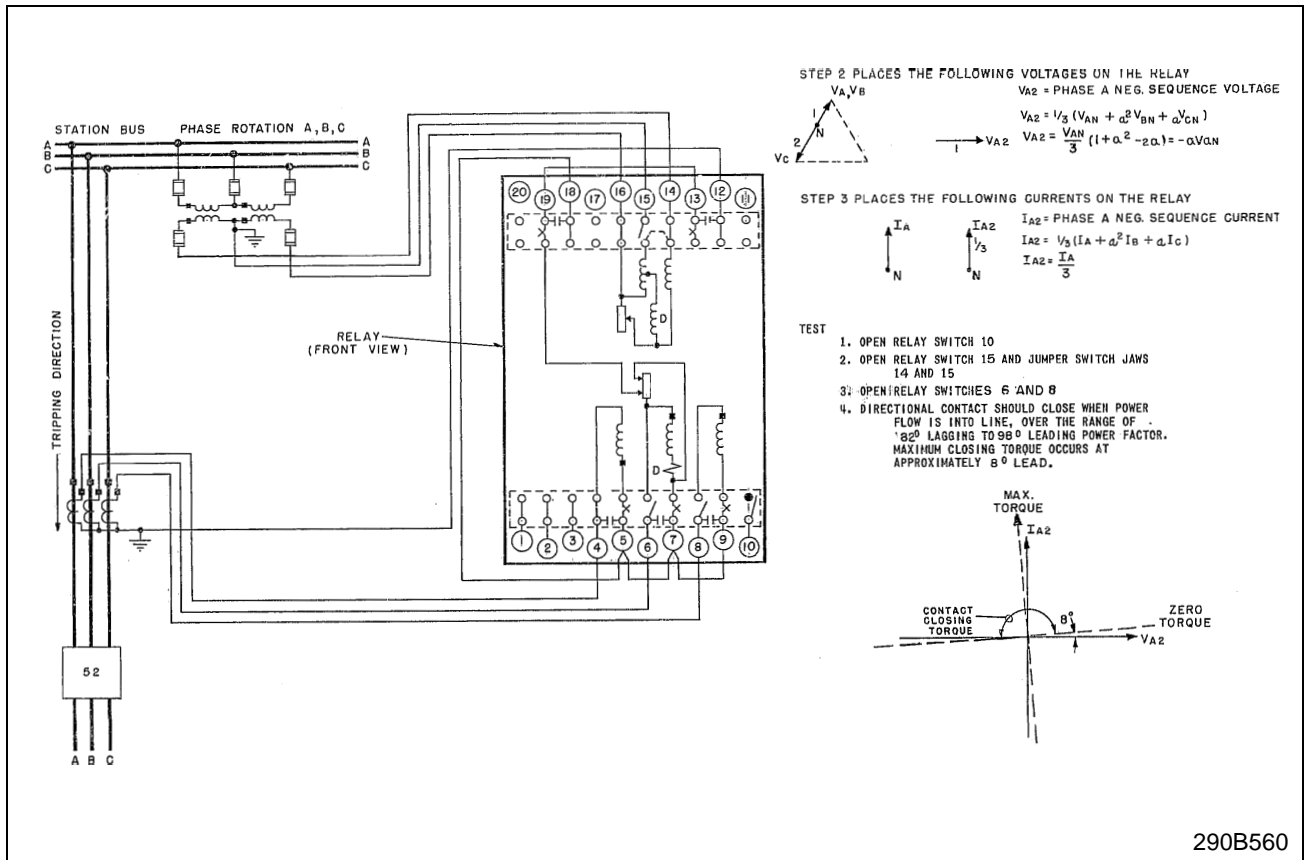


Figure 11: In service test procedure for verifying proper external connections where ct neutral is formed within the relay.

For relays which include an indicating instantaneous trip unit (IIT), the junction of the induction and indicating instantaneous trip coils is brought out to switch jaw # 11. With this arrangement the overcurrent units can be tested separately.

**Acceptance Check**

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

**Negative Sequence Filter**

The filters are adjusted for balance in the factory and no further adjustments or maintenances should be required. The nominal voltage and current output of the filters on positive sequence is approximately 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. Similarly, if any two of the phase leads to the input terminals of the current filter are inter changed, an output current will be obtained.

**Directional Unit (D)**

1. Contact Gap - The gap between the stationary contact and moving contact with the relay in the de-energized position should be approximately .020".
2. Sensitivity - Refer to the test diagram in fig. 13. Apply a single-phase voltage  $V_{12}$  equal to 0.57 volts (corresponds to a negative-sequence input voltage of .19 volts) and a single-phase current equal to 6.93 amperes as shown (corresponds to a negative sequence input current of 4 amperes). With a phase angle meter connected as shown, rotate the phase shifter until the current leads the voltage by  $188^\circ$ . This corresponds to the negative sequence component of current leading the negative sequence component of voltage by  $98^\circ$ . The directional unit contact should pick up within  $\pm 10\%$  of the above input voltage to the relay.
3. Spurious Torque - With the relay connected in the test diagram as above, remove the input voltage and connect terminals 14, 15, and 16 together.

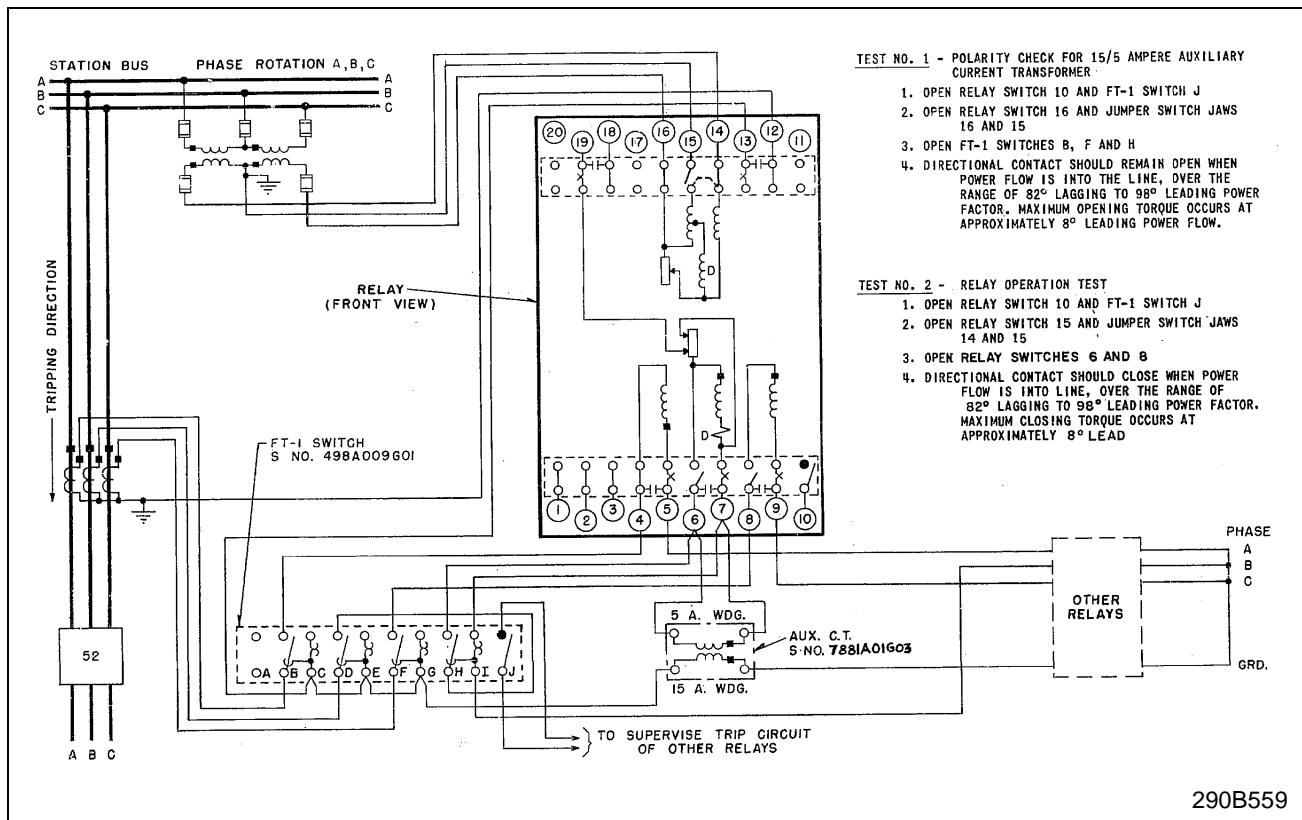


Figure 12: In service test procedure for verifying proper external connections where ct neutral is formed externally.

Remove the phase-angle meter. With 80 amperes single-phase current applied, there should be no spurious closing torque.

### Time Overcurrent Unit (CO)

The directional unit contacts must be in the closed position when checking the operation of the overcurrent unit.

1. Contact – The index mark on the movement frame will coincide with the “O” mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the “O” mark by approximately .020". The placement of the various time dial positions 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 – Set the time dial to position 6 using the lowest tap setting, alternately

apply tap value current plus 3% and tap value current minus 3%. The moving contact should leave the back-stop at tap value current plus 3% and should return to the backstop at tap value current minus 3%.

3. Time Curve - Table 2 shows the time curve calibration points for the various types of relays. With the time dial set to the indicated position and the relay set on the lowest tap setting, apply the currents specified by Table 2, (e.g. for the CRQ 2, 3 and 20 times tap value current) and measure the operating time of the relay. The operating times should equal those of Table 2 plus or minus 5%.

For type CRQ-11 relay only, the 1.30 times tap value operating time from the number 6 time dial position is  $54.9 \pm 5\%$  seconds. It is important that the 1.30 times tap value current be maintained accurately. The maintaining of this current accurately is necessary because of the steepness of the slope of the time-current characteristic (Fig. 21). A 1% variation in the 1.30 times tap value current (including measuring instrument deviation) will change the nominal operating time by approximately 4%.

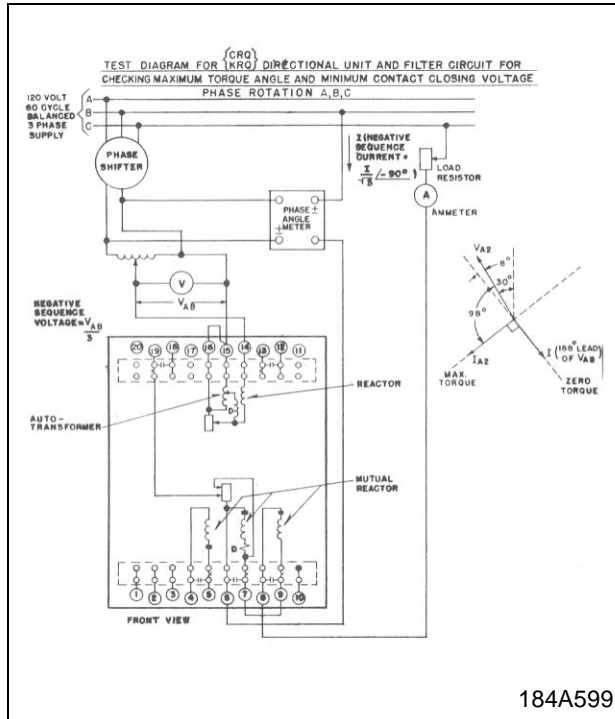


Figure 13: Test diagram for checking max. torque angle and minimum voltage for contact closure of direct units.

**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.

**Fault Detector (FD)** Either apply three phase negative sequence current equal to the scale setting or apply single phase current equal to N/~3 times the scale setting. These currents are applied to the relay terminals as shown in Fig. 13. The contacts should pick-up within 10% of these currents.

**Indicating Instantaneous Trip Unit (IIT)**- The core screw which is adjustable from the top of the trip unit determines the pickup value. The trip unit has a nominal ratio of adjustment of 1 to 4 and an accuracy within the limits of 10%.

The making of the contacts and target indication should occur at approximately the same instant. Position the stationary contact for a minimum of 1/32" wiper. The bridging moving contact should touch both stationary contacts simultaneously.

Apply sufficient current to operate the IIT. The operation indicator target should drop freely.

**Routine Maintenance**

All relays should be inspected and checked periodically to assure proper operation. Generally a visual inspection should call attention to any noticeable changes. A minimum suggested check on the relay system is to close the contacts manually to assure that the breaker trips and the target drops. Then release the contacts and observe that the reset is smooth and positive.

If an additional time check is desired, pass secondary current through the relay and check the time of operation. It is preferable to make this at several times pickup current at an expected operating point for the particular application. For the .5 to 2.5 ampere CRQ-5 and CRQ-6 induction unit use the alternative test circuit in Fig. 9 as these relays are affected by a distorted wave form. With this connection the 25/5 ampere current transformers should be worked well below the knee of the saturation (i.e. use 1OL50 or better).

All contacts should be periodically cleaned. A contact burnisher #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.

**7.0 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")

**Negative Sequence Voltage Filter**

- A. Apply 120 volts balanced 3 phase voltage 60 hertz to terminals 14, 15, and 16 of the relay, making sure that phase 1, 2 and 3 of the applied voltage is connected to terminals 14, 15 and 16 respectively.

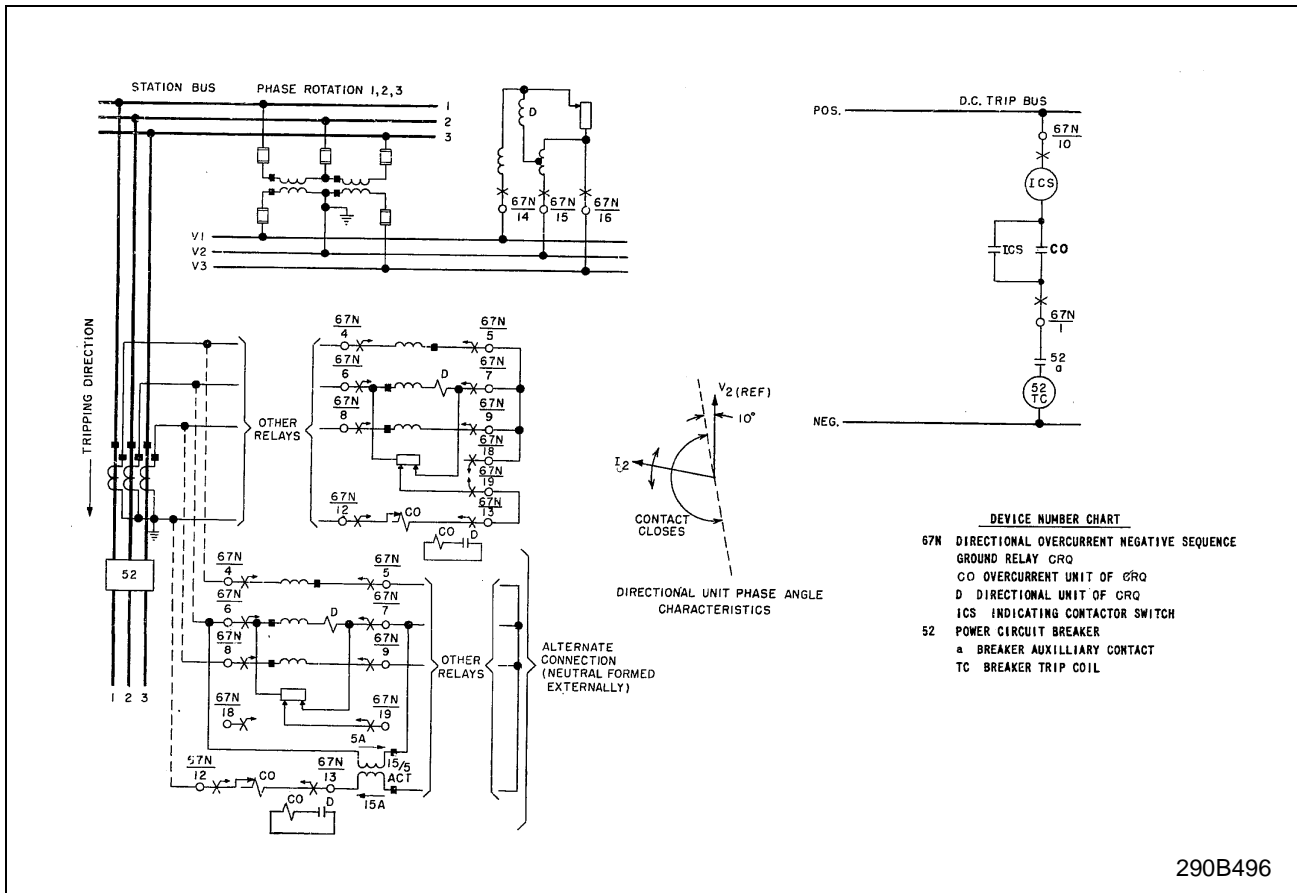


Figure 14: External schematic of CRQ Relay.

B. Using a calibrated high resistance rectox voltmeter, measure the voltage between the tap on the autotransformer (middle terminal, lower right hand reactor, front view) and the tap on the adjustable 2" resistor. If the voltage is high (40 to 50 volts) the filter is probably improperly connected. If properly connected, the voltage will be low. Using a low range (approximately 5 volts) move the adjustable tap until the voltage reads a minimum. This value should be less than 1.5 volts.

**Negative Sequence Current Filter**

Refer to fig. 10 for positive sequence calibration.

A. Connect relay terminals 7 and 9 together. Remove lead to lower right hand terminal of mutual reactor (right side view) to disconnect the directional unit.

B. Pass 10 amperes in terminal 6 and out terminal 8.

C. With a 0-15 volts, rectox type voltmeter, mea-

sure and record voltage between terminals 6 and the lower right hand terminal of mutual reactor. This voltage should be between 1.85 and 1.95 volts.

D. Now measure the voltage from terminal 6 to terminal 7. Adjust the top filter resistor tap until this voltage is 1.73 times the reading of part C.

Refer to fig. 10 for neutral tap calibration.

E. Using the test connections as shown and a low range voltmeter connected between terminal 6 and 7, adjust the middle filter resistor tap connection until the measured voltage is zero. Reconnect lead to mutual reactor at end of this test.

**A. Directional Unit (D)**

1. The upper pin bearing should be screwed down until there is approximately .025" clearance between it and the top of shaft bearing. The upper pin bearing should then be securely locked in position with the lock nut. The lower bearing position is fixed and cannot be adjusted.

2. The contact gap adjustment for the directional unit is made as follows:

With the moving contact in the normally-opened position, i.e. against the right stop on bridge, screw in the stationary contact until both contacts just close as indicated by a neon lamp in the contact circuit. Then, screw the stationary contact away from the moving contact 3/4 of a turn. The clamp holding the stationary contact housing need not be loosened for the adjustment since the clamp utilizes a spring-type action in holding the stationary contact in position.

The set screw in the stationary contacts has been shop adjusted for optimum follow and this adjustment should not be disturbed.

The moving contact assembly has been factory adjusted for low contact bounce performance and should not be changed.

3. The sensitivity adjustment is made by varying the tension of the spiral spring attached to the moving element assembly. The spring is adjusted by placing a screwdriver or similar tool into one of the notches located on the periphery of the spring adjuster and rotating it. The spring adjuster is located on the underside of the bridge and is held in place by a spring type clamp that does not have to be loosened prior to making the necessary adjustments.

The spring is to be adjusted such that the contacts will close when the relay is energized with 0.57 volts and 6.93 amps at 188 ° (current leading voltage 1 considering the relay connected to the test circuit in Fig. 13).

The magnetic plugs are used to reverse any unwanted spurious torques that may be present when the relay is energized on current alone.

The reversing of the spurious torques is accomplished by using the adjusting plugs in the following manner:

a) Connect the relay voltage circuit terminals (phase 1, 2 and 3) together.

b) Apply 80 amperes single-phase current

(momentarily) in phase 2 terminal and out phase 3 terminal.

Plug adjustment is then made per Table 3 such that

any contact closing spurious torques are reversed. The plugs are held in position by upper and lower plug clips. These clips need not be disturbed in any manner when making the necessary adjustment.

The magnetic plug adjustment may be utilized to positively close the contacts on current alone. This may be desired on some installations in order to insure that the relay will always trip the breaker on zero potential.

### CO Unit

1. Contact - The index mark on the movement frame will coincide with the "O" mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "O" mark by approximately .020°. The placement of the various time dial positions 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 spring tension in setting the minimum trip current value of the relay is most conveniently made with the damping magnet removed.

With the time dial set on "O", wind up the spiral spring by means of the spring adjuster until approximately 6-3/4 convolutions show.

Set the relay on the minimum tap setting, the time dial to position 6,

Adjust the control spring tension so that the moving contact will leave the backstop at tap value current +1.0% and will return to the backstop at tap value current -1.0%.

3. Time Curve Calibration - Install the permanent magnet.

Apply the indicated current per Table 2 for permanent magnet adjustment (e.g. CRQ-8, 2 times tap value) and measure the operating time. Adjust the permanent magnet keeper until the operating time corresponds to the value of Table 2.

For type CRQ-11 relay only, the 1.30 times tap value operating time from the number 6 time dial position is

54.9 25% seconds. It is important that the 1.30 times tap value current be maintained accurately. The maintaining of this current accurately is necessary because of the steepness of the slope of the time-current characteristic (Figure 21). A 1% variation in the 1.30 times tap value current (including measuring instrument deviation) will change the nominal operating time by approximately 4%. If the operating time at 1.3 times tap value is not within these limits, a minor adjustment of the control spring will give the correct operating time without any undue effect on the minimum pick-up of the relay. This check is to be made after the 2 times tap value adjustment has been completed.

Apply the indicated current per Table 2 for the electromagnet plug adjustment (e.g. CRQ-8, 20 times tap value) and measure the operating time. Adjust the proper plug until the operating time corresponds to the value in Table 2. (Withdrawing the left hand plug, front view, increases the operating time and withdrawing the right hand plug, front view, decreases the time.) In adjusting the plugs, one plug should be screwed in completely and the other plug run in or out until the proper operating time has been obtained.

Recheck the permanent magnet adjustment. If the operating time for this calibration point has changed, readjust the permanent magnet and then recheck the electromagnet plug adjustment.

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 indica-

tor target should drop freely.

#### **Indicating Instantaneous Trip Unit (IIT)**

The core screw must be adjusted to the value of pick-up current desired.

The nameplate data will furnish the actual current range that may be obtained from the IIT unit.

#### **Fault Detector (FD)**

Inspect the assembly to see that the micarta disc on top of the silver disc does not interfere with any one of the three stationary contacts when the plunger is up. See that the guide rod is not bent out of line and that the convolutions of the spiral spring are uniformly spaced.

Apply single phase current as shown in fig. 13. Set the micarta disc at some particular current setting on the scale plate. The contact should close within 10% of this value. The core screw at the top of the switch will affect the pickup (as well as dropout). If this is moved then the unit should be checked for erratic action at 30 amps A.C.

## **8.0 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.

TABLE 2

## ★ TIME CURVE CALIBRATION DATA - 60 HERTZ

RELAY TYPE	PERMANENT MAGNET ADJUSTMENT			ELECTROMAGNET PLUGS	
	TIME DIAL POSITION	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS
CRQ-2	6	3	.057	20	0.22
CRQ-5	6	2	37.80	10	14.30
CRQ-6	6	2	2.46	20	1.19
CRQ-7	6	2	4.27	20	1.11
CRQ-8	6	2	13.35	20	1.11
CRQ-9	6	2	8.87	20	0.65
CRQ-11	6	2	11.27	20	0.24

TABLE 3

## DIRECTIONAL UNIT CALIBRATION

RELAY RATING	CURRENT AMPERES	BOTH PLUGS IN CONDITION	ADJUSTMENT
All Ranges	80	Spurious Torque in Contact Closing Direction (Left Front View)	Right (Front-View) Plug Screwed Out Until Spurious Torque is Reversed.
All Ranges	80	Spurious Torque in Contact Opening Direction (Right Front View) (Contacts remain open)	Left (Front View) Plug Screwed Out Until Spurious Torque is in Contact Closing Direction. Then The plug is screwed in Until Spurious Torque is Reversed.

ENERGY REQUIREMENTS

INDICATING INSTANTANEOUS TRIP UNIT

AMPERE RANGE	VA AT MIN. PICK-UP	VA AT MAX. PICK-UP	ONE SECOND RATING
0.5-2	4.5	32.0	18.0
1-4	4.5	32.0	35.0
2-8	4.5	32.0	70.0
4-16	4.5	32.0	140.0

TYPE CRQ-2 TIME OVERCURRENT UNIT

AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE $\phi$	VOLT AMPERES**			
					AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
0.5/2.5	0.5	0.91	28	58	4.8	39.6	256	790
	0.6	0.96	28	57	4.9	39.8	270	851
	0.8	1.18	28	53	5.0	42.7	308	1024
	1.0	1.37	28	50	5.3	45.4	348	1220
	1.5	1.95	28	40	6.2	54.4	435	1740
	2.0	2.24	28	36	7.2	65.4	580	2280
2/6	2.5	2.50	28	29	7.9	73.6	700	2850
	2.0	3.1	110	59	5.04	38.7	262	800
	2.5	4.0	110	55	5.13	39.8	280	920
	3.0	4.4	110	51	5.37	42.8	312	1008
	3.5	4.8	110	47	5.53	42.8	329	1120
	4.0	5.2	110	45	5.72	46.0	360	1216
4/12	5.0	5.6	110	41	5.90	50.3	420	1500
	6.0	6.0	110	37	6.54	54.9	474	1800
	4.0	7.3	230	65	4.92	39.1	268	848
	5.0	8.0	230	50	5.20	42.0	305	1020
	6.0	8.8	230	47	5.34	44.1	330	1128
	7.0	9.6	230	46	5.53	45.8	364	1260
4/12	8.0	10.4	230	43	5.86	49.9	400	1408
	10.0	11.2	230	37	6.6	55.5	470	1720
	12.0	12.0	230	34	7.00	62.3	528	2064

\* Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

$\phi$  Degrees current lags voltage at tap value current.

\*\* Voltages taken with Rectox type voltmeter.



**ENERGY REQUIREMENTS****CRQ-5, CRQ-6 TIME OVERCURRENT UNITS**

AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE $\phi$	VOLT AMPERES**			
					AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
0.5/2.5	(0.5)	2	88	69	3.92	20.6	103	270
	(0.6)	2.2	88	68	3.96	20.7	106	288
	(0.8)	2.5	88	67	3.96	21	114	325
	(1.0)	2.8	88	66	4.07	21.4	122	360
	(1.5)	3.4	88	62	4.19	23.2	147	462
	(2.0)	4.0	88	60	4.30	24.9	168	548
	(2.5)	4.4	88	58	4.37	26.2	180	630
2/6	(2)	8	230	67	3.88	21	110	308
	(2.5)	8.8	230	66	3.90	21.6	118	342
	(3)	9.7	230	64	3.93	22.1	126	381
	(3.5)	10.4	230	63	4.09	23.1	136	417
	(4)	11.2	230	62	4.12	23.5	144	448
	(5)	12.5	230	59	4.20	24.8	162	540
	(6)	13.7	230	57	4.38	26.5	183	624
4/12	(4)	16	460	65	4.00	22.4	126	376
	(5)	18.8	460	63	4.15	23.7	143	450
	(6)	19.3	460	61	4.32	25.3	162	531
	(7)	20.8	460	59	4.35	26.4	183	611
	(8)	22.5	460	56	4.40	27.8	204	699
	(10)	25	460	53	4.60	30.1	247	880
	(12)	28	460	47	4.92	35.6	288	1056

**CRQ-7 TIME OVERCURRENT UNITS**

AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE $\phi$	VOLT AMPERES**			
					AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
0.5/2.5	(0.5)	2	88	68	3.88	20.7	103	278
	(0.6)	2.2	88	67	3.93	20.9	107	288
	(0.8)	2.5	88	66	3.93	21.1	114	320
	(1.0)	2.8	88	64	4.00	21.6	122	356
	(1.5)	3.4	88	61	4.08	22.9	148	459
	(2.0)	4.0	88	58	4.24	24.8	174	552
	(2.5)	4.4	88	56	4.38	25.9	185	640
2/6	(2)	8	230	66	4.06	21.3	111	306
	(2.5)	8.8	230	63	4.07	21.8	120	342
	(3)	9.7	230	63	4.14	22.5	129	366
	(3.5)	10.4	230	62	4.34	23.4	141	413
	(4)	11.2	230	61	4.34	23.8	149	448
	(5)	12.5	230	59	4.40	25.2	163	530
	(6)	13.7	230	58	4.62	27	183	624
4/12	(4)	16	460	64	4.24	22.8	129	392
	(5)	18.8	460	61	4.30	24.2	149	460
	(6)	19.3	460	60	4.62	25.9	168	540
	(7)	20.8	460	58	4.69	27.3	187	626
	(8)	22.5	460	55	4.80	29.8	211	688
	(10)	25	460	51	5.20	33	260	860
	(12)	28	460	46	5.40	37.5	308	1032

\* Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

$\phi$  Degrees current lags voltage at tap value current.

\*\* Voltages taken with Rectox type voltmeter.

**ENERGY REQUIREMENTS**

**CRQ-8, CRQ-9 TIME OVERCURRENT UNITS**

AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE $\phi$	VOLT AMPERES**			
					AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
0.5/2.5	(0.5)	2	88	72	2.38	21	132	350
	(0.6)	2.2	88	71	2.38	21	134	365
	(0.8)	2.5	88	69	2.40	21.1	142	400
	(1.0)	2.8	88	67	2.42	21.2	150	440
	(1.5)	3.4	88	62	2.51	22	170	530
	(2.0)	4.0	88	57	2.65	23.5	200	675
	(2.5)	4.4	88	53	2.74	24.8	228	800
2/6	(2)	8	230	70	2.38	21	136	360
	(2.5)	8.8	230	66	2.40	21.1	142	395
	(3)	9.7	230	64	2.42	21.5	149	430
	(3.5)	10.4	230	62	2.48	22	157	470
	(4)	11.2	230	60	2.53	22.7	164	500
	(5)	12.5	230	58	2.64	24	180	580
	(6)	13.7	230	56	2.75	25.2	198	660
4/12	(4)	16	460	68	2.38	21.3	146	420
	(5)	18.8	460	63	2.46	21.8	158	480
	(6)	19.3	460	60	2.54	22.6	172	550
	(7)	20.8	460	57	2.62	23.6	190	620
	(8)	22.5	460	54	2.73	24.8	207	700
	(10)	25	460	48	3.00	27.8	248	850
	(12)	28	460	45	3.46	31.4	292	1020

**CRQ- 11 TIME OVERCURRENT UNITS**

AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE $\phi$	VOLT AMPERES**			
					AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
0.5/2.5	0.5	1.7	56	36	0.72	6.54	71.8	250
	0.6	1.9	56	34	0.75	6.80	75.0	267
	0.8	2.2	56	30	0.81	7.46	84.0	298
	1.0	2.5	56	27	0.89	8.30	93.1	330
	1.5	3.0	56	22	1.13	10.04	115.5	411
	2.0	3.5	56	17	1.30	11.95	136.3	502
	2.5	3.8	56	16	1.48	13.95	160.0	610
2/6	2.0	7.0	230	32	0.73	6.30	74.0	264
	2.5	7.8	230	30	0.78	7.00	78.5	285
	3.0	8.3	230	27	0.83	7.74	84.0	309
	3.5	9.0	230	24	0.88	8.20	89.0	340
	4.0	10.0	230	23	0.96	9.12	102.0	372
	5.0	11.0	230	20	1.07	9.80	109.0	430
	6.0	12.0	230	20	1.23	11.34	129.0	504
4/12	4.0	14	460	29	0.79	7.08	78.4	296
	5.0	16	460	25	0.89	8.00	90.0	340
	6.0	17	460	22	1.02	9.18	101.4	378
	7.0	18	460	20	1.10	10.00	110.0	454
	8.0	20	460	18	1.23	11.1	124.8	480
	10.0	22	460	17	1.32	14.9	131.6	600
	12.0	26	460	16	1.8	16.3	180.0	720

\* Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

$\phi$  Degrees current lags voltage at tap value current.

\*\* Voltages taken with Rectox type voltmeter.

## ENERGY REQUIREMENTS

⊕ (All Burdens at 60 Hertz)

The current burden of the relay 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
2	10	150	5.5	5.5	0°
3	10	150	.35	1.28	74° Lag
1	10	150	5.4	7.5	44° Lag

The current burden of the relay with zero sequence currents applied is as follows:

Phase	Watts At 5 Amps.	Volt - Amps. At 5 Amps.	Power Factor Angle
1	4.66	5.5	32°
2	4.92	5.0	10°
3	3.30	3.7	27°

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

Pot. Transf. Across Phase	Volts	Watts	Volt-Amps.	Power Factor Angle
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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°
23	115	.10	.48	58° Lag
31	115	23.2	46.5	60° Lag
31	115	23.2	46.6	60° Lag
12	115	0.50	0.52	2° Lead

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	15.6	15.6	0°

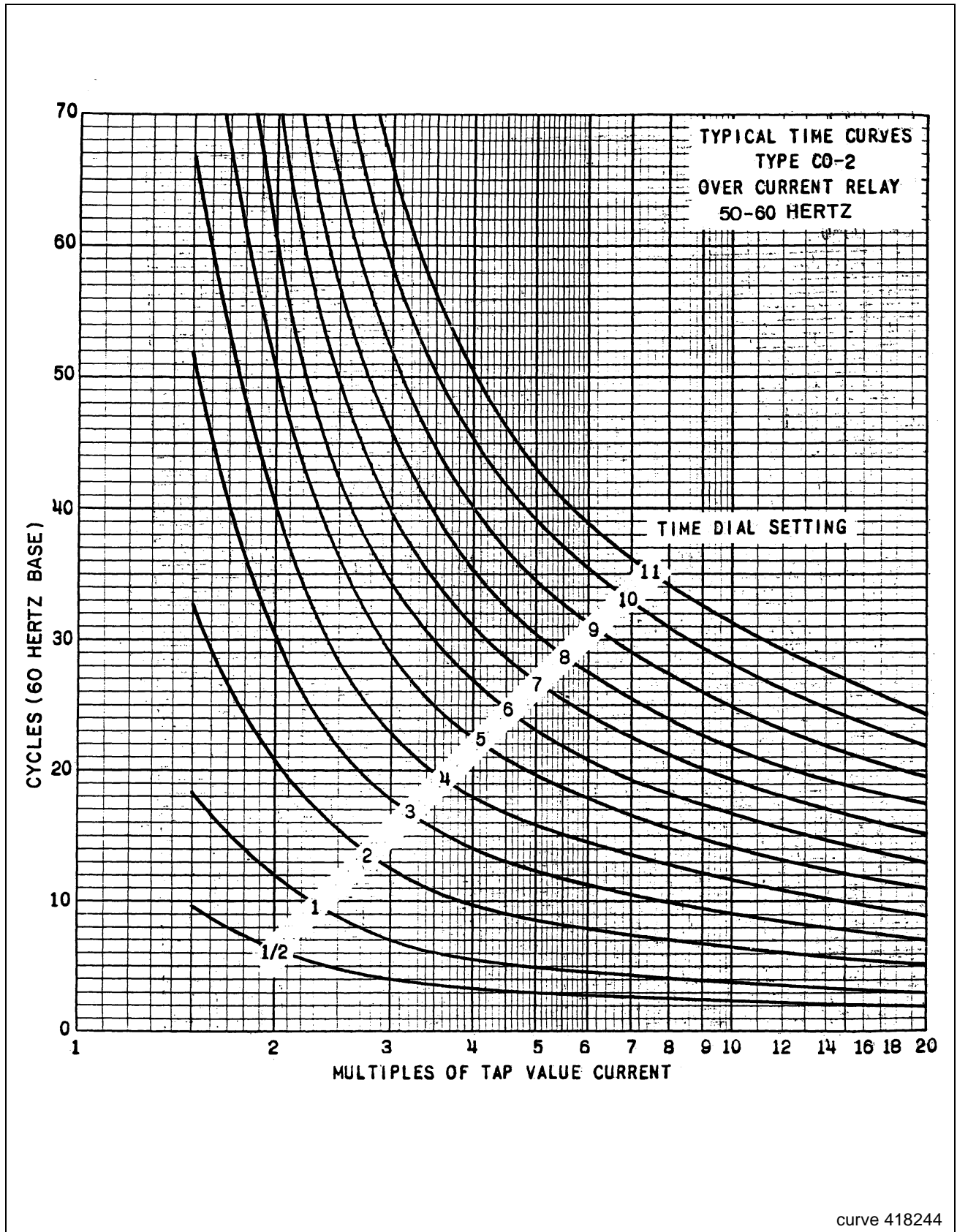


Figure 15: Typical time curve of the time-overcurrent unit of the short time (2) relay.

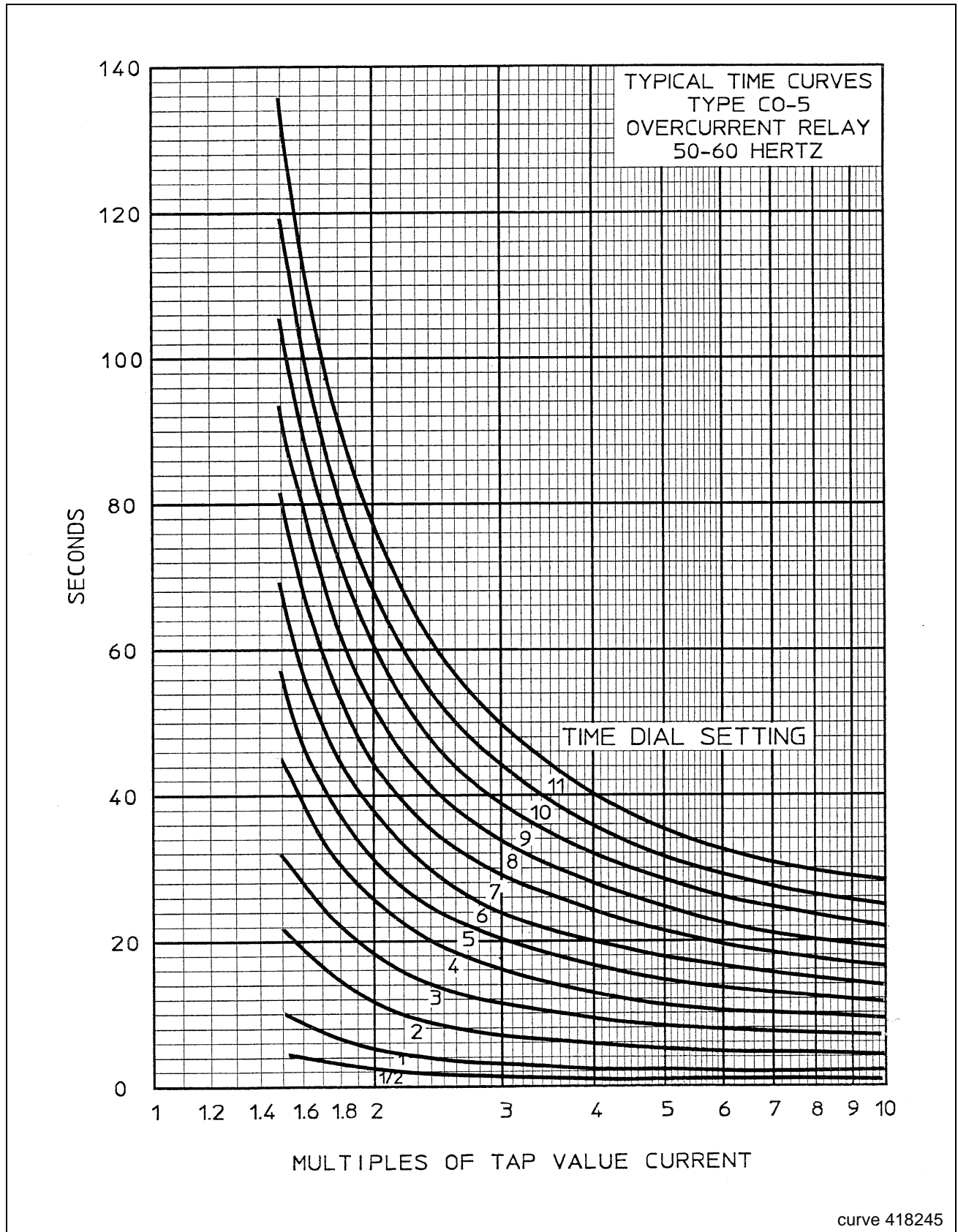


Figure 16: Typical time curve of the time-overcurrent unit of the long time (5) relay.

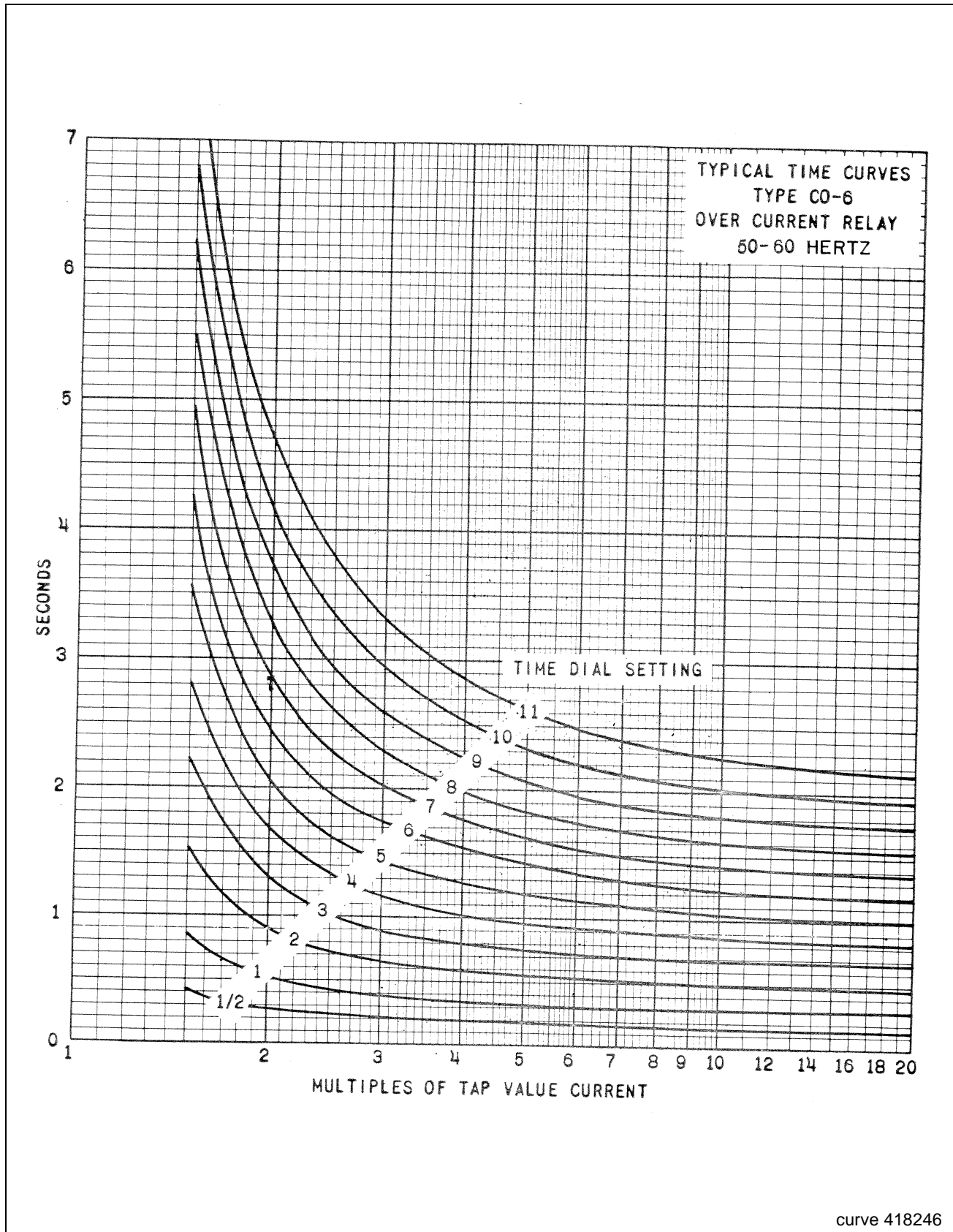


Figure 17: Typical time curve of the time-overcurrent unit of the definite time (6) relay.

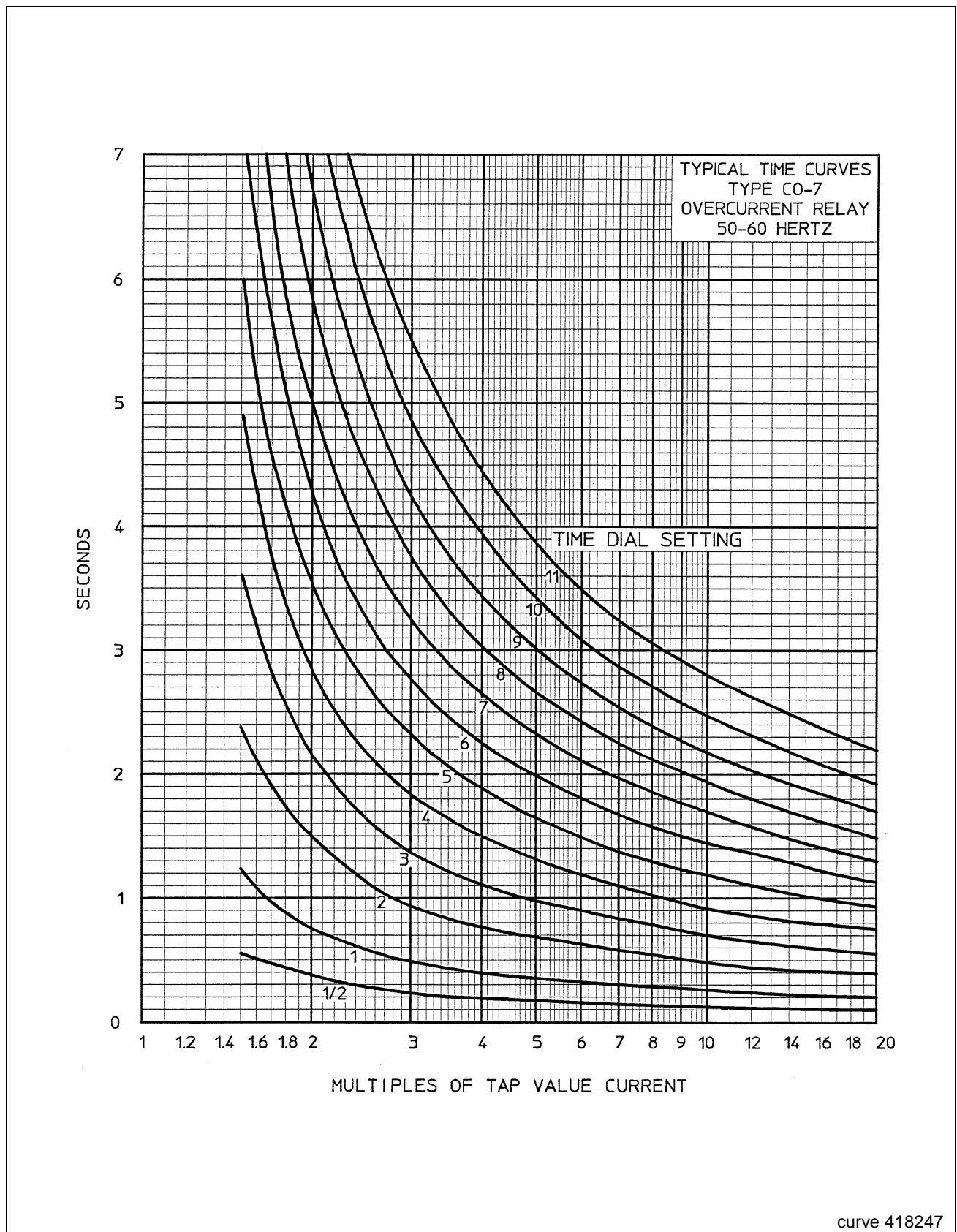
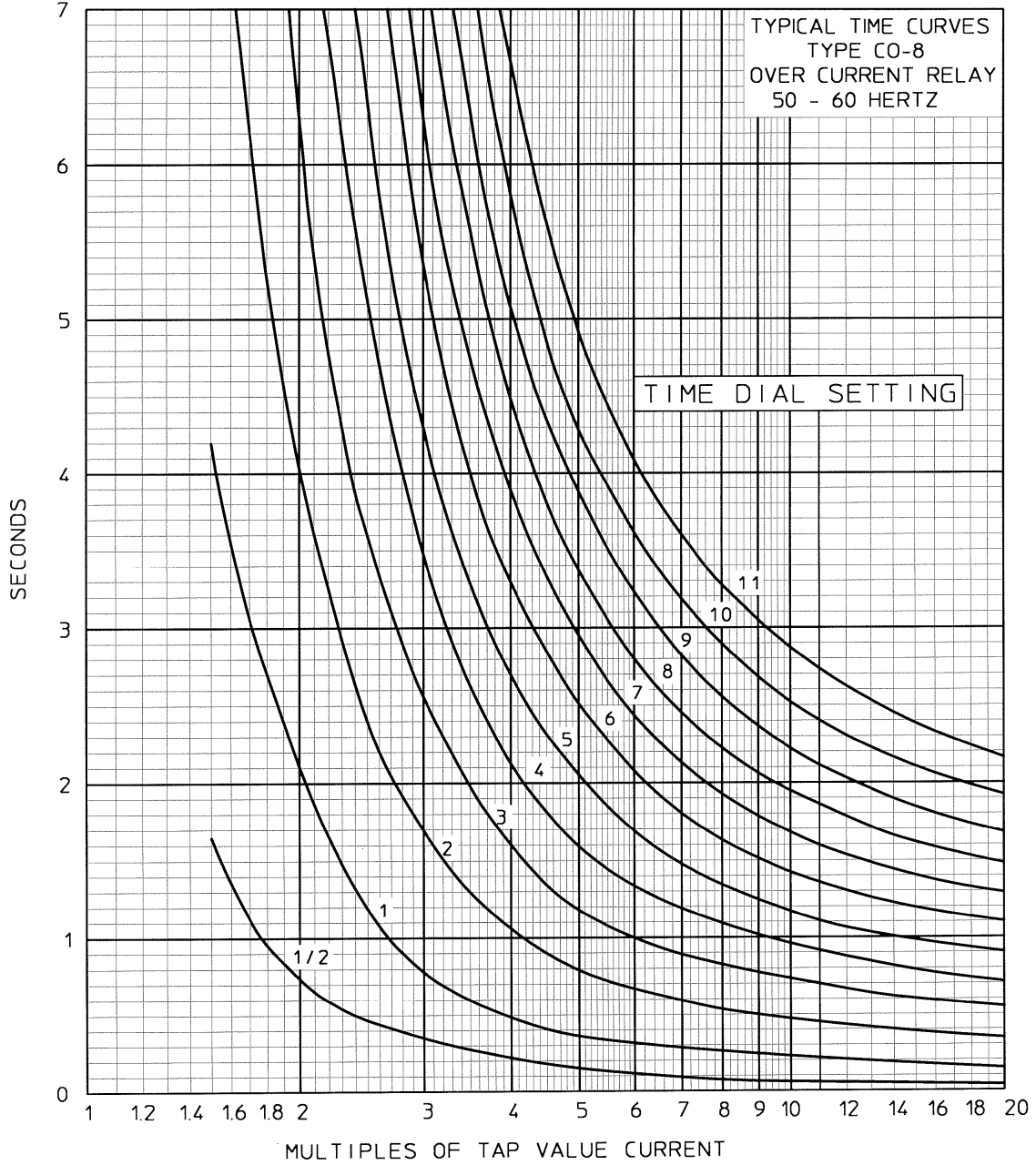


Figure 18 :Typical time curve of the time-overcurrent unit of the moderately inverse (7) relay.



curve 418248

Figure 19: Typical time curve of the time-overcurrent unit of the inverse (8) relay.



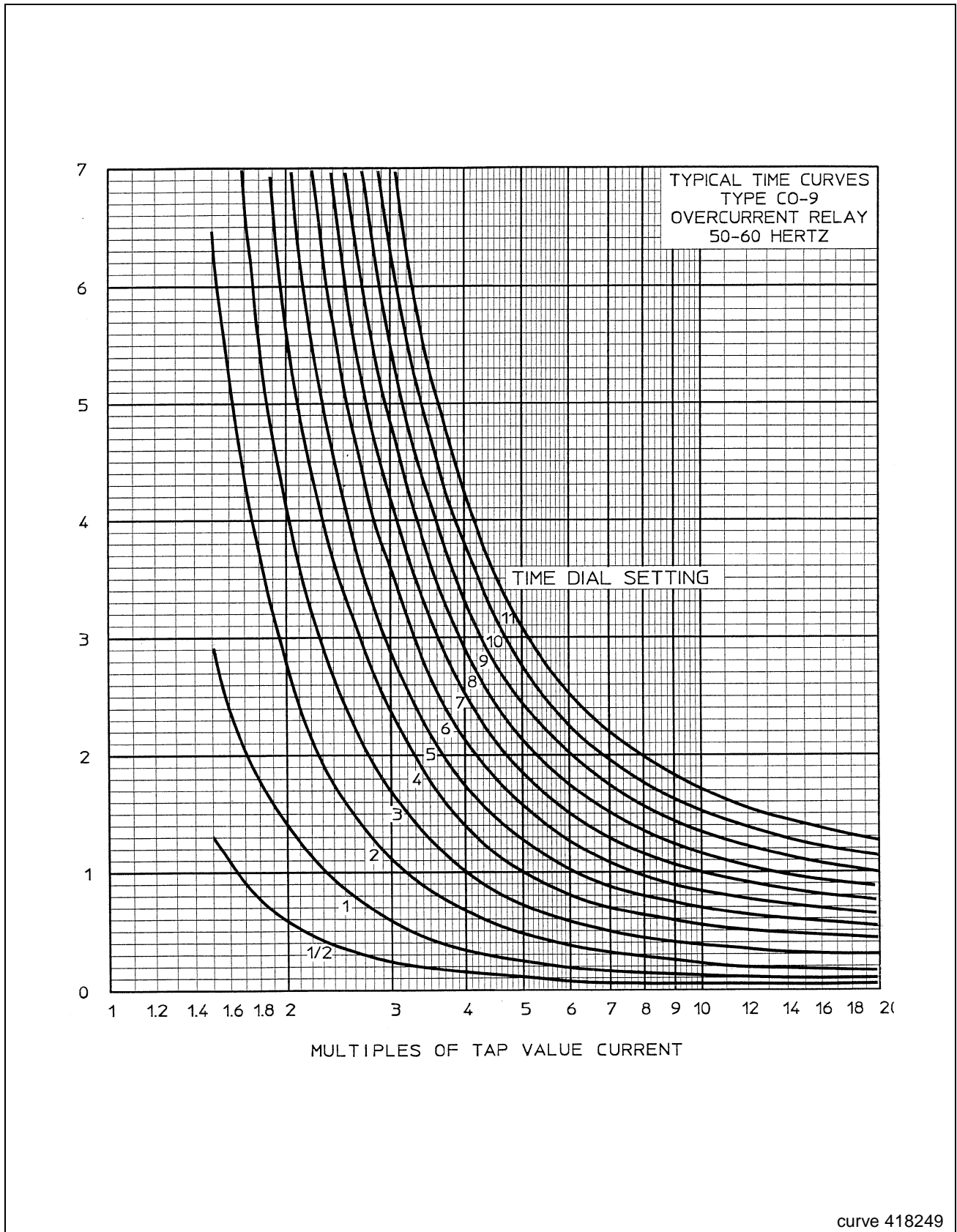
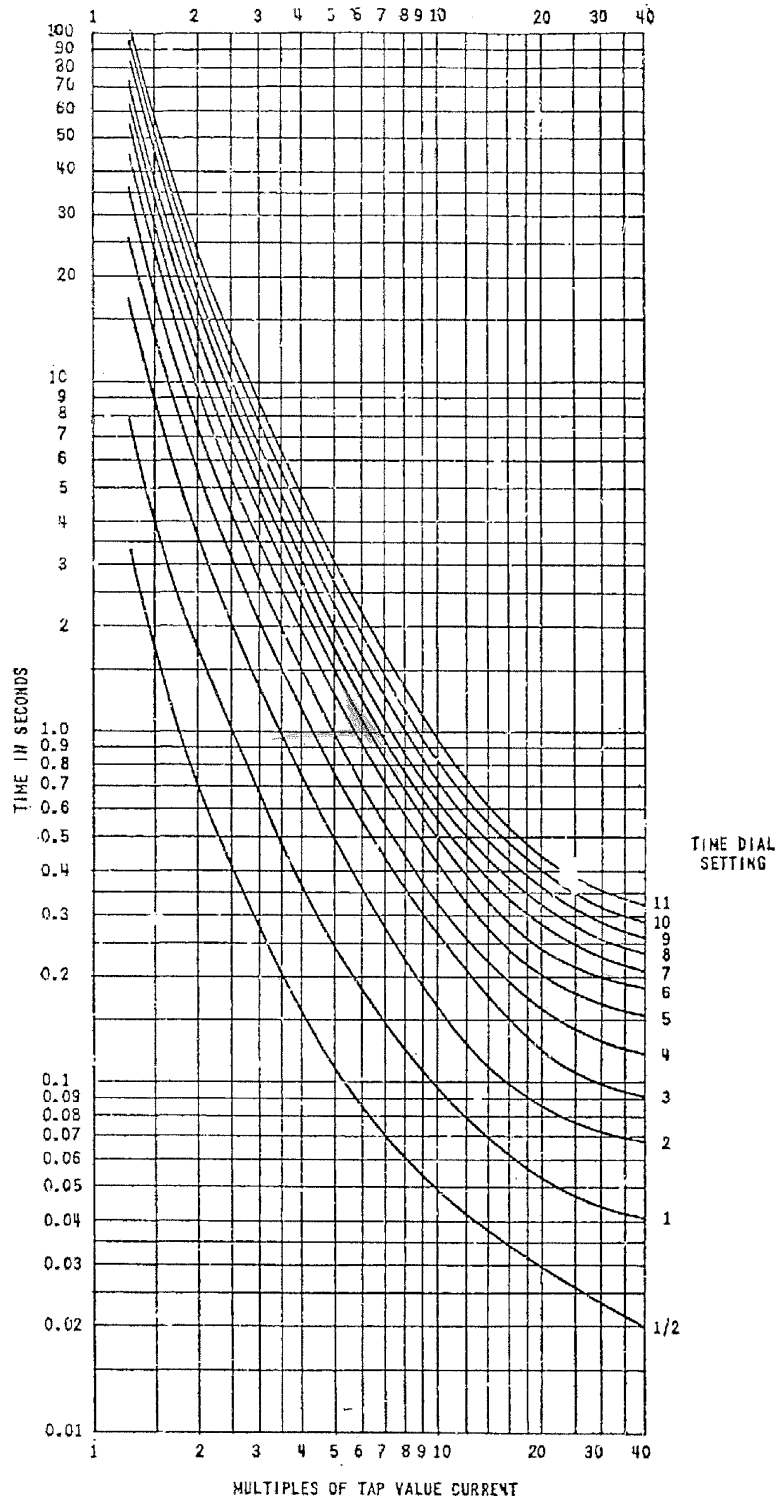


Figure 20: Typical time curve of the time-overcurrent unit of the very inverse (9) relay.



curve 288B655

Figure 21: Typical time curve of the time-overcurrent unit of the extremely inverse (11) relay.

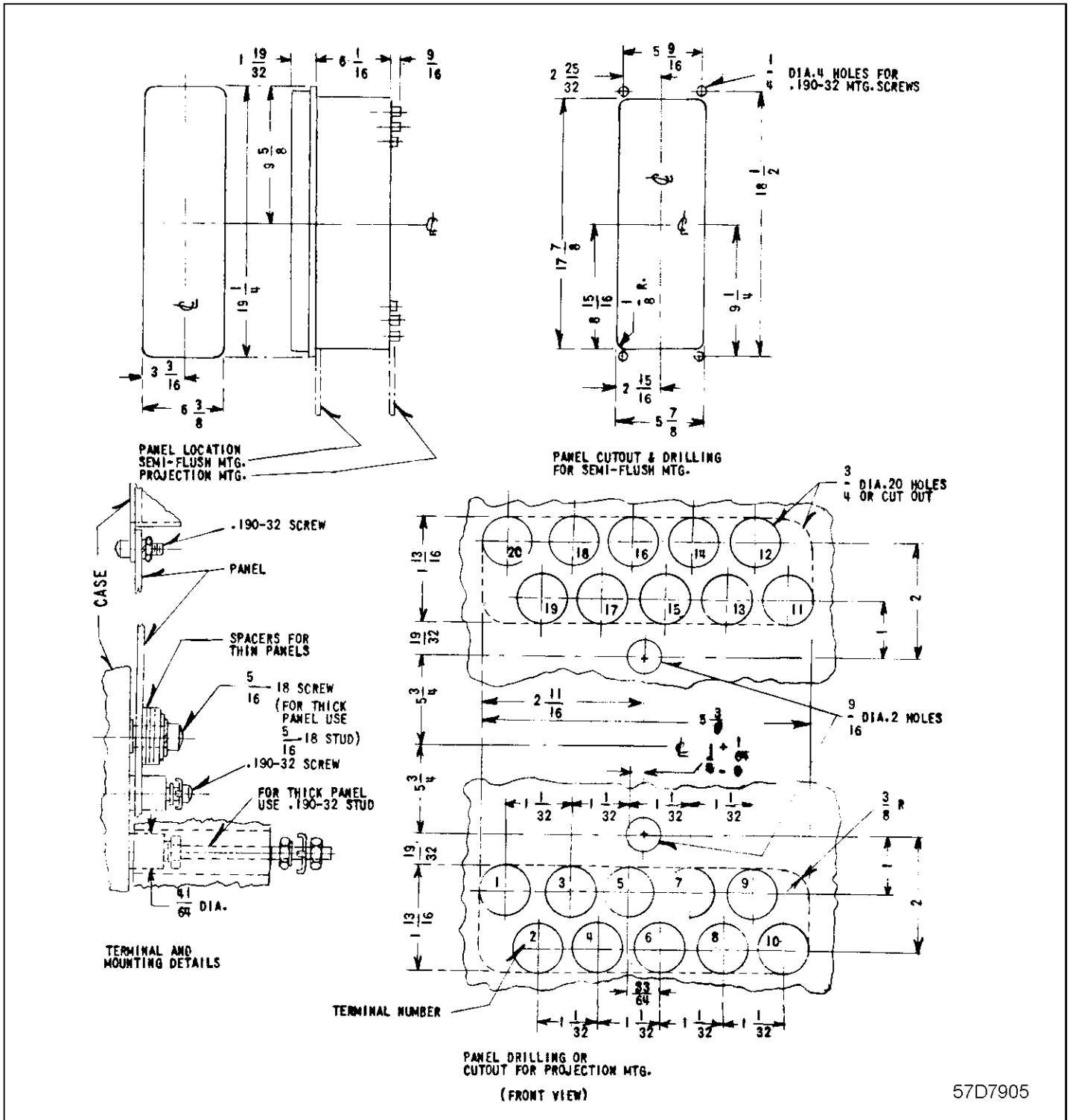


Figure 22: Outline and drilling plan for the type CRQ relay in the Type FT-42 case.

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