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Types CR, CRC, CRP and CRD Directional Overcurrent Relays

CONTENTS

This instruction leaflet applies to the following types of relays:

- Type CR Voltage Polarized Phase Relay
- Type CRC Current Polarized Ground Relay
- Type CRP Voltage Polarized Ground Relay
- Type CRD Dual Polarized Ground Relay

! CAUTION

Before putting relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

1.0 APPLICATION

These time delayed directional overcurrent relays are used to detect phase or ground faults in a particular direction on a power system and to initiate isolation of these faults. Each is torque-controlled by a built-in high speed directional unit.

The CR is a phase relay with a directional unit polarized by phase to phase voltage while the CRC, CRP and CRD are ground relays. The CRC directional unit is zero-sequence-current polarized, the CRP is zero-sequence-voltage polarized and the CRD contains two directional units, one zero-sequence-current polarized and another zero-sequence-voltage polarized.

The choice of the CRC or CRP is dependent on the reliability of the zero-sequence polarizing current or voltage for all ground faults with all power system variations. Where neither alone is generally reliable for all ground faults, but one or the other is always present for ground faults, the dual polarized CRD is used.

2.0 CONSTRUCTION AND OPERATION

The various types of relays as outlined in the contents consists of a directional unit or units, an overcurrent unit, an indicating contactor switch unit, and an indicating instantaneous trip unit when required. The type CRP and type CRD relays also utilize an internal phase shifting mechanism. The principal component parts of the relay and their location are shown in Figures 1 and 2, page 9; Figures 3 and 4, page 10.

2.1 Overcurrent Unit (CO)

The overcurrent unit operates on the induction principle. A main tapped coil located on the center leg of an "E" type laminated structure 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 causes a contact closing torque.

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 this instructions. If further informaitonis desired by purchaser regarding this particular installation, operation or maintenance of this equipment, the local ABB Power T&D Company Inc. representative should be contacted.

2.2 Indicating Contactor Switch Unit (ICS)

The indicating contactor switch is a small dc operated 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.

2.3 Indicating Instantaneous Trip Unit (IIT)

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

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

2.4 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 mounted on the frame, with respect to the upper 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 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 stops for the moving element contact arm are an integral part of the bridge.

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 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.

The contacts of the directional unit are connected in series with the shading coil of the overcurrent unit. This arrangement prevents the relay from operating for faults in the non-tripping direction.

3.0 CHARACTERISTICS

The time characteristics of the directional overcurrent relays are designated by specific numbers as indicated in Table 1, page 3 (e.g. CR-8).

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 Figures 17 to 23 (starting on page 23). 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.

3.1 Trip Circuit

The main contacts will safely close 30 amperes at 250 volts dc 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 dc, 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.

3.2 Trip Circuit Constants

Indicating Contactor Switch
0.2 amp tap . . . . 6.5 ohms dc resistance
2.0 amp tap . . . . 0.15 ohms dc resistance

3.3 Type CR Relay

This voltage polarized type relay is intended for phase fault protection and the directional unit has its maximum torque when the current leads the voltage by approximately 30°. The directional unit minimum pickup is 1 volt and 4 amperes at its maximum torque angle for the 4 and 12 ampere range relays and 1 volt and 2 amperes for the 2 to 6 ampere and 0.5 to 2.5 ampere range relays.

The directional unit should be connected using the current in one phase wire and the potential across the other two phase wires. This connection is commonly referred to as the 90° connection. When utilizing the 90° connection the maximum torque of the relay occurs when the fault current lags its 100% P.F. position by approximately 60°. (See Figure 13, page 21.)

3.4 Type CRC Relay

The current polarized type relay is intended for ground fault protection and operates on residual current. (See Figure 15, page 22.) The type CRC relay has its maximum torque when the operating current leads the polarizing current by approximately 40°. The directional unit minimum pickup is 0.5 ampere in each winding in phase for the 0.5 to 2.5 ampere and the 2 to 6 ampere range relays.

3.5 Type CRP Relay

The voltage polarized relay is intended for ground fault protection and has its maximum torque when the current lags the voltage by approximately 60°. The shifting of the maximum torque angle has been accomplished by the use of an internally mounted phase shifter as illustrated in Figure 7 (page 17).

The type CRP relay operates on residual voltage and residual current. (See Figure 14, page 21).

The directional unit minimum pickup is 1 volt and 2 amperes at its maximum torque angle for the 0.5 to 2.5 ampere and the 2 to 6 ampere range relays.

3.6 Type CRD Relay

The dual polarized type relay is intended for ground fault protection. The relay can be polarized from a potential source, from a local ground source, or from both simultaneously.

The type CRD relay utilizes the directional unit of the CRC relay in conjunction with the directional unit and phase shifting mechanism of the type CRP relay. The directional contacts are connected in parallel to torque-control a common overcurrent unit. See Figure 8 (page 17).

The current-polarized directional unit of the type CRD relay operates on residual currents while the potential polarized directional unit of the type CRD relay operates on residual voltage and residual current. See Figure 16 (page 22).

For the 0.5 to 2.5 ampere and the 2 to 6 ampere range relays, the minimum pickup of the current polarized unit is 0.5 ampere in each winding in-phase and the minimum pickup for the voltage polarized unit is 1 volt and 2 amperes with the current lagging voltage by 60°.

4.0 SETTINGS

4.1 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 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 affected.

The connector screw on the terminal plate above the time dial makes connection 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 screws carry operating current, be sure that the screws are turned tight.

In order to avoid opening current transformer circuits when changing taps under load, start with RED handles FIRST and open all switchblades. Chassis operating shorting switches on the case will short the secondary of the current transformer. Taps may then be changed with the relay either inside or outside the case. Then reclose all switchblades making sure the RED handles are closed LAST.

4.2 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 contacts 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.

4.3 Indicating Contactor Switch (ICS)

The only setting required on the ICS unit is the selection of the 0.2 or 2.0 ampere tap setting. This selection is made by connecting the lead located in front of the tap block to the desired setting by means of the connecting screw.

4.4 Indicating Instantaneous Trip (IIT)

The core screw must be adjusted to the value of pickup desired.

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

4.5 Directional Unit (D)

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.

The external ac connections of the directional overcurrent relays are shown in Figures 13 to 16 (starting on page 21).

6.0 ADJUSTMENTS

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" (page 4), should be required.

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 #3. With this arrangement the overcurrent units can be tested separately.

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

6.1 Acceptance Check

6.1.1 Overcurrent Unit (CO)

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

6.1.2 Contact

a) By turning the time dial, move the moving contacts until they deflect the stationary contact to a position where the stationary contact is resting against its backstop. The index mark located on the movement frame should coincide with the "0" mark on the time dial. For double trip relays, the follow on the stationary contacts should be approximately 1/64".

b) For relays identified with a "T", located at lower left of stationary contact block, the index mark on the movement frame will coincide with the "0" 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 "0" mark by approximately .020". The placement of the various time dial positions in line with the index mark will give operating times shown on the respective time-current curves. For double trip relays, the follow on the stationary contacts should be approximately 1/32".

6.1.3 Minimum Trip Current

Set the time dial to position 6. Alternately apply tap value current plus 3% and tap value current minus 3%. The moving contact should leave the backstop at tap value current plus 3% and should return to the backstop at tap value current minus 3%.

6.1.4 Time Curve

Table 2 (page 11) shows the time curve calibration points for the various types of relays. With the time dial set to the indicated position, apply the currents specified by Table 2 (e.g. for the CR-8, 2 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 percent.

For type CR-11 relay only, the 1.30 times tap value operating time from the number 6 time dial position is 54.9 ±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 characteristics (Figure 23, page 29). A 1% variation in the 1.30 times tap value current (including measuring instrument deviation) will change the nominal operating time by approximately 4%.

6.2 Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient dc 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 follow should be approximately 1/64” to 3/64”. The bridging moving contacts should touch both stationary contacts simultaneously.

6.3 Indicating Instantaneous Trip Unit (IIT)

The core screw must be adjusted to the value of pickup current desired.

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

6.4 Directional Unit (D)

6.4.1 Contact Gap

The gap between the stationary contact and moving contact with the relay in a de-energized position should be approximately .020".

6.4.2 Sensitivity

The respective directional units should trip with value of energization and phase angle relationships as indicated in Table 3 (page 11).

6.4.3 Spurious Torque Adjustments

There should be no spurious closing torques when the operating circuits are energized, per Table 4 (page 12), with the polarizing circuits short-circuited for the voltage polarized units and open-circuited for the current polarized units.

7.0 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 rating CO-5 and CO-6 induction unit use the alternative test circuit in Figure 24 (page 30) 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 10L50 or better).

All contacts should be periodically cleaned. A contact burnisher, Style number 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.

8.0 CALIBRATION

Use the following procedure for calibrating the relay if the relay has been taken apart for repairs or adjustments have been disturbed. This procedure should not be used unless it is apparent that the relay is not in proper working order. (See “ACCEPTANCE CHECK”, page 5).

8.1 Overcurrent Unit (CO)

8.1.1 Contact

a) By turning the time dial, move the moving contacts until they deflect the stationary contact to a position where the stationary contact is resting against its backstop. The index mark located on the movement frame should coincide with the “0” mark on the time dial. For double trip relays, the follow on the stationary contacts should be approximately 1/64”.

b) For relays identified with a “T”, located at lower left of stationary contact block, the index mark on the movement frame will coincide with the “0” 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 “0” 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”.

8.2 Minimum Trip Current

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

With the time dial set on “0”, 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 plus 1.0% and will return to the backstop at tap value current minus 1.0%.

8.3 Time Curve Calibration

Install the permanent magnet. Apply the indicated current (per Table 2, page 11) for the permanent magnet adjustment (e.g. CR-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 CR-11 relay only, the 1.30 times tap value operating time from the number 6 time dial position is 54.9 ±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 (Figure 23, page 29). 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 pickup 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 of the electromagnet plug adjustment (e.g. CR-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.

8.4 Indicating Contactor Switch Unit (ICS)

Close the main relay contacts and pass sufficient dc 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.

8.5 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 normal 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” wipe. The bridging moving contact should touch both stationary contacts simultaneously.

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

8.6 Directional Unit (D)

a. 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.

b. 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 factory 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 disturbed.

c. 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 as indicated by a neon lamp in the contact circuit when energized with the required current and voltage as shown in Table 3 on page 11. This table indicates that the spring can be adjusted when the phase angle relationship between the operating circuit and the polarizing circuit is at the maximum torque angle or when the circuit relationship has the operating and polarizing circuits in phase. It is recommended that a single phase (in-phase relationship) setup be used as a matter of ease and convenience.

4. 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) Voltage circuit terminals on the voltage polarized relays (CR, CRP and CRD voltage polarized unit) are short-circuited.

   b) The polarizing circuit of the current polarized relays (CRC and CRD current polarized unit) are open-circuited.

Upon completion of either “a” or “b” apply currents from 5 to 40 amps or 5 to 80 amps.

Note: High current to be applied only momentarily.

Plug adjustment is then made per Table 4 (see page 12) such that the 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.

9.0 RENEWAL PARTS

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

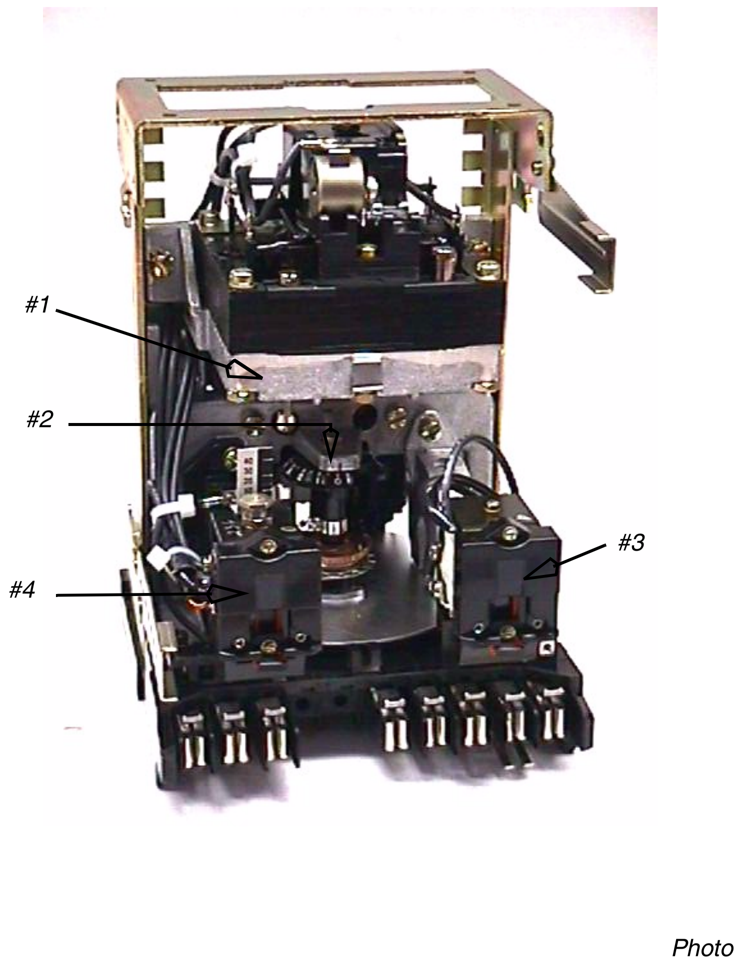

Figure 1: *Type CR Relay Without Case*

#1 – Directional Unit (D)
#2 – Overcurrent Unit (CO)
#3 – Indicating Contactor Switch (ICS)
#4– Indicating Instantaneous Trip Unit IIIT)

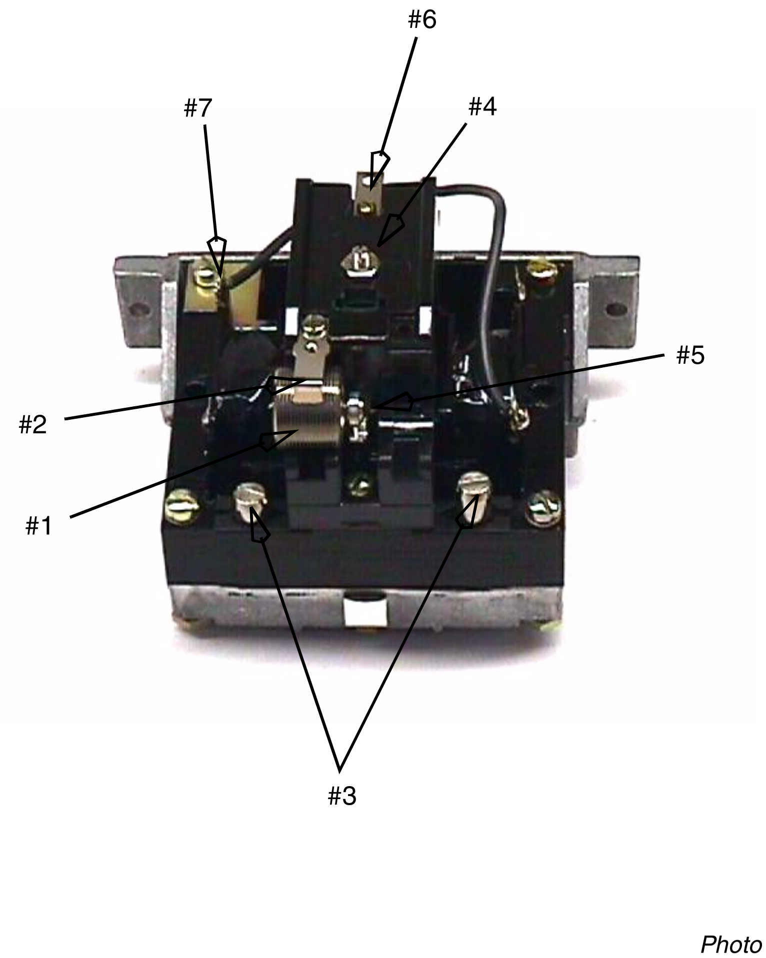

Figure 2: *Directional Unit*

#1 – Stationary Contact
#2 – Stationary Contact Pressure Spring
#3 – Magnetic Adjusting Plugs
#4 – Upper Bearing Screw
#5 – Moving Element Assembly
#6 – Spring Adjuster Clamp
#7 – Current Bias Vane

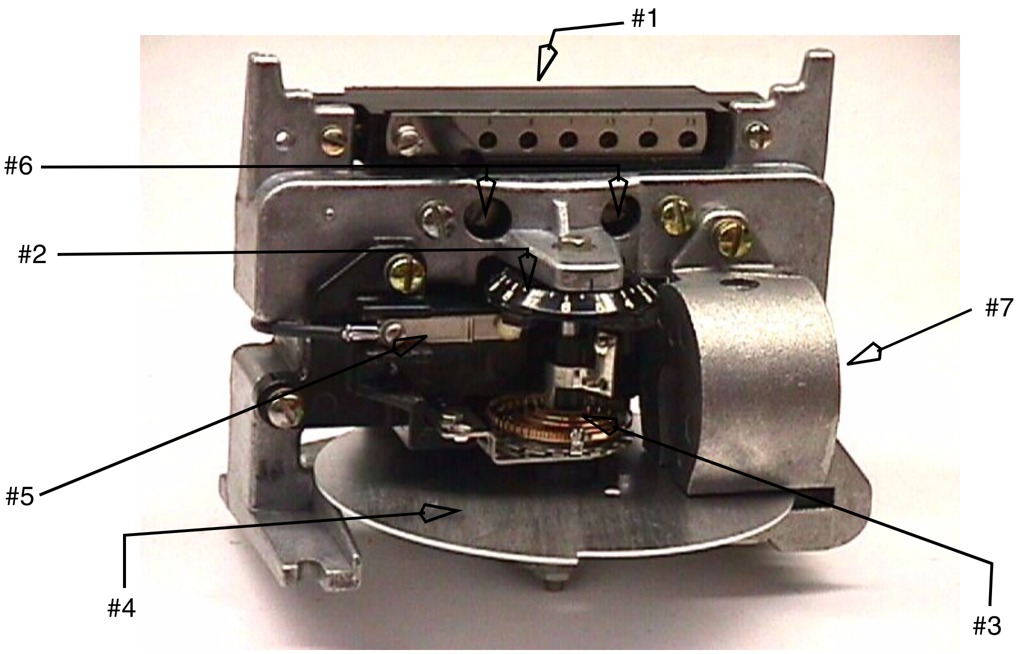

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Figure 3: *Time Overcurrent Unit (Front View)*

1-Tap Block · *2-Time Dial* · *3-Control Spring Assembly*
4-Disc · *5-Stationary Contact Assembly* · *6-Magnetic Plugs*
7-Permanent Magnet.

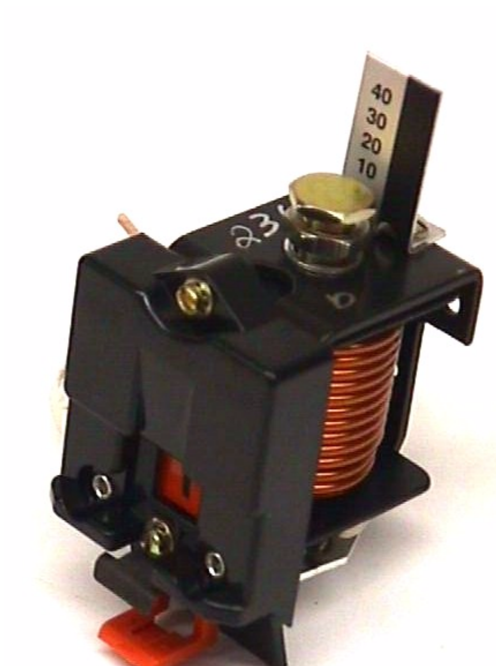

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Figure 4: *Indicating Instantaneous Trip Unit (IIT)*

TABLE 2: TIME CURVE CALIBRATION DATA - 50 AND 60 HERTZ FOR OVERCURRENT UNIT

		PERMANENT MAGNET ADJUSTMENT		ELECTROMAGNET PLUG ADJUSTMENT	
RELAY TYPE	TIME DIAL POSITION	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME (SECONDS)	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME (SECONDS)
2	6	3	0.57	20	0.22
5	6	2	37.80	10	14.30
6	6	2	2.46	20	1.19
7	6	2	4.27	20	1.11
8	6	2	13.35	20	1.11
9	6	2	8.87	20	0.65
11	6	2	11.27	20	0.24*

* *For 50 Herz CO-11, the "20 times multiple" Time Limits are 0.24 sec. +20% -5%.*

TABLE 3: DIRECTIONAL UNIT SENSITIVITY

RELAY TYPE	SETTING RANGE OF TIME - OVERCURRENT UNIT	Values for Min. Pick-Up*		
		Volts†	Amperes	Phase Angle Relationship
CR	0.5 - 2.5 2 - 6	1	2.0	I Leading V by 30°‡
		1	2.3	I in-phase with V
	4 - 12	1	4.0	I Leading V by 30°‡
		1	4.6	I in-phase with V
CRP	0.5 - 2.5 2 - 6	1	2.0	I lagging V by 60°‡
		1	4.0	I in-phase with V
	4 - 12	1	4.0	I Leading V by 60°‡
		1	4.6	I in-phase with V
CRC	0.5-2.5 2-6		0.5	I in-phase
CRD (Voltage Unit)	05-2.5 2-6	1	2.0	I Lagging V by 60°‡
			4.0	I in-phase with V
	4-12	1	4.0	I Lagging V by 60°‡
			8.0	I in-phase with V
CRD (Current Unit)	0.5-2.5 2-6		0.5	in-phase

* *The energization quantities are input quantities at the relay terminals.*

† *For relays rated 240 volts, apply 2 volts.*

‡ *Maximum torque angle.*

TABLE 4: DIRECTIONAL UNIT CALIBRATION

SETTING RANGE OF TIME–OVERCURRENT UNIT	CURRENT AMPERES	CONDITION FOR BOTH PLUGS "IN"	ADJUSTMENT
0.5 - 2.5 Amps 2 - 6 Amps	5 to 40	Spurious Torque in contact closing direction (left front view)	Right (front-view) plug screwed out until spurious torque is reversed.
4 - 12 Amps	5 to 80		
0.5 - 2.5 Amps 2 - 6 Amps	5 to 40	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.
4 - 12 Amps	5 to 80		

DIRECTIONAL UNIT POLARIZING CIRCUIT BURDEN

Relay Type	**Rating**	**Volt Amperes***	**Power Factor Angle†**
CR	132‡ Volts	11.5	58° Lag
CRC	230** Amperes	1.45	8° Lag
CRP	208†† Volts	11.2	28° Lead
CRD Current Unit	230 ** Amperes	1.45	8° Lag
CRD Voltage Unit	208†† Volts	11.2	28° Lead

* *Voltages taken with high impedance type voltmeter - Burden of Voltage polarized units taken at 120 volts - Burden of current polarized units taken at 5 amperes.*

† *Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.*

‡ *Continuous rating.*

** *One second rating.*

†† *30 second rating.*

DIRECTIONAL UNIT OPERATING CIRCUIT BURDEN

Relay Type	Range (Amperes)	Continuous Rating (Amperes)	One Second Rating* (Amperes)	Power Factor Angle†	VOLT AMPERES ‡ At Minimum Tap Value Current	3 Times Minimum Tap Value Current	At 10 Times Minimum Tap Value Current	At 20 Times Minimum Tap Value Current
CR	2-6	10	230	34.5	0.44	4.08	48.0	182.0
	4-12	12	280	25.0	0.53	5.0	59.2	236.0
CRC	0.5-2.5	-	230	44.0	0.033	0.30	3.3	14.2
	2-6	-	230	42.5	0.58	5.28	58.0	240.0
CRP	0.5-2.5	10	230	34.5	0.03	0.23	2.8	11.5
	2-6	10	230	34.5	0.44	4.08	48.0	182.0
CRD	0.5-2.5	10	230	45.0	0.07	0.59	6.6	26.0
	2-6	10	230	45.0	1.04	9.9	106.0	420.0

* *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.*

† *Degrees current lags voltage at tap value current.*

‡ *Voltages taken with high impedance type voltmeter.*

ENERGY REQUIREMENTS

OVERCURRENT UNITS = CR-2, CRC-2, CRP-2 CRD-2

AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE†	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	.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
0.5/2.5	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
	2.5	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
2/6	3.5	4.8	110	47	5.53	44.0	329	1120
	4.0	5.2	110	45	5.72	46.0	360	1216
	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
4/12	7.0	9.6	230	46	5.53	45.8	364	1260
	8.0	10.4	230	43	5.86	49.9	400	1408
	10.0	11.2	230	37	6.60	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.*

† *Degrees current lags voltage at tap value current.*

‡ *Voltages taken with high impedance type voltmeter.*

ENERGY REQUIREMENTS

OVERCURRENT UNITS = CR-5, CRC-5, CRP-5, CRD-5, CR-6, CRC-6, CRP-6, CRD-6

AMPERE RANGE	TAP	CONTINUOUS RATING AMPERES	ONE SECOND RATING * AMPERES	POWER FACTOR ANGLE †	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	2.7	88	69	3.92	20.6	103	270
	0.6	3.1	88	68	3.96	20.7	106	288
	0.8	3.7	88	67	3.96	21	114	325
	1.0	4.1	88	66	4.07	21.4	122	360
	1.5	5.7	88	62	4.19	23.2	147	462
	2.0	6.8	88	60	4.30	24.9	168	548
	2.5	7.7	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

OVERCURRENT UNITS = CR-7, CRC-7, CRP-7, CRD-7

AMPERE RANGE	TAP	CONTINUOUS RATING AMPERES	ONE SECOND RATING* AMPERES	POWER FACTOR ANGLE†	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	2.7	88	68	3.88	20.7	103	278
	0.6	3.1	88	67	3.93	20.9	107	288
	0.8	3.7	88	66	3.93	21.1	114	320
	1.0	4.1	88	64	4.00	21.6	122	356
	1.5	5.7	88	61	4.08	22.9	148	459
	2.0	6.8	88	58	4.24	24.8	174	552
	2.5	7.7	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.*

† *Degrees current lags voltage at tap value current.*

‡ *Voltages taken with high impedance type voltmeter.*

ENERGY REQUIREMENTS

OVERCURRENT UNITS = CR-8, CRC-8, CRP-8, CRD-8 and CR-9, CRC-9 CRP-9 CRD-9

AMPERE RANGE	TAP	CONTINUOUS RATING AMPERES	ONE SECOND RATING* AMPERES	POWER FACTOR ANGLE†	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	2.7	88	72	2.38	21	132	350
	0.6	3.1	88	71	2.38	21	134	365
	0.8	3.7	88	69	2.40	21.1	142	400
	1.0	4.1	88	67	2.42	21.2	150	440
	1.5	5.7	88	62	2.51	22	170	530
	2.0	6.8	88	57	2.65	23.5	200	675
	2.5	7.7	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

OVERCURRENT UNITS = CR-11, CRC-11, CRP-11 CRD-11

AMPERE RANGE	TAP	CONTINUOUS RATING AMPERES	ONE SECOND RATING* AMPERES	POWER FACTOR ANGLE†	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	1.89	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	3.0	7.0	230	32	0.73	6.30	74.0	264
	2.5	7.8	230	30	0.78	7.00	78.5	285
	2.0	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.*

† *Degrees current lags voltage at tap value current.*

‡ *Voltages taken with high impedance type voltmeter.*

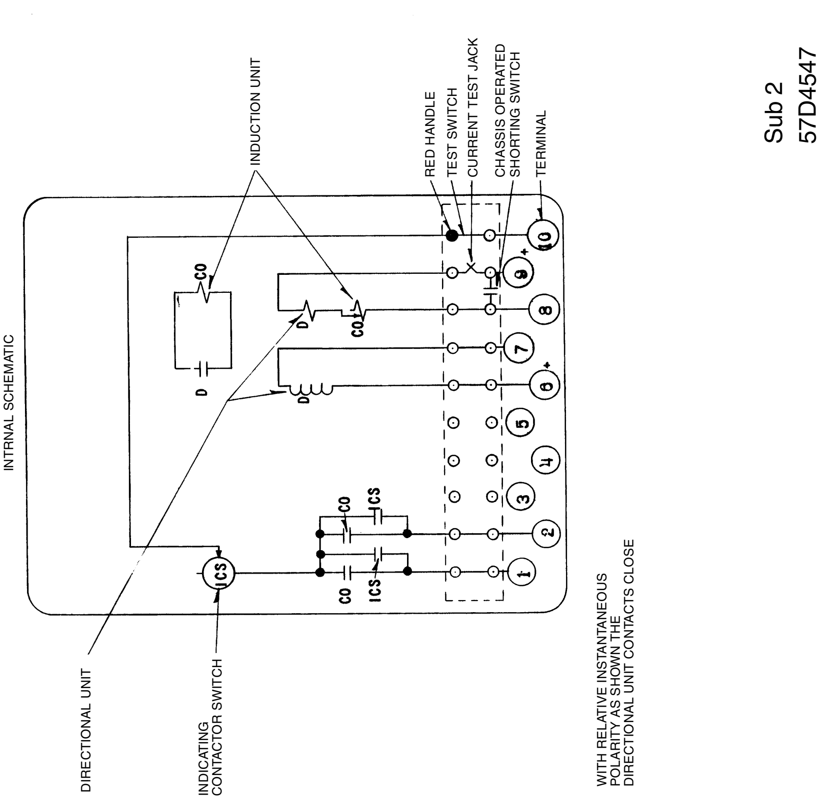


Figure 5: *Internal Schematic of double-trip, directional overcurrent relay type CR in type FT-21 Case. For the single-trip relay the circuits associated with terminal 2 are omitted, 57D4549*

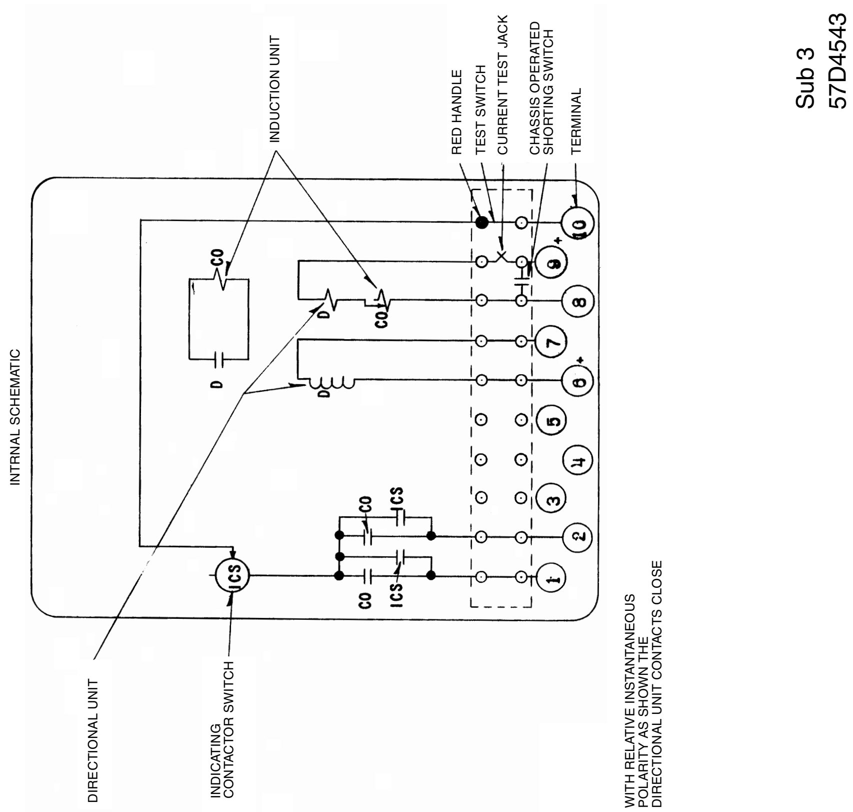


Figure 6: *Internal Schematic of double-trip, directional overcurrent relay type CRC in type FT-21 Case. For the single -rip relay the circuits associated with terminal 2 are omitted, 57D4539*

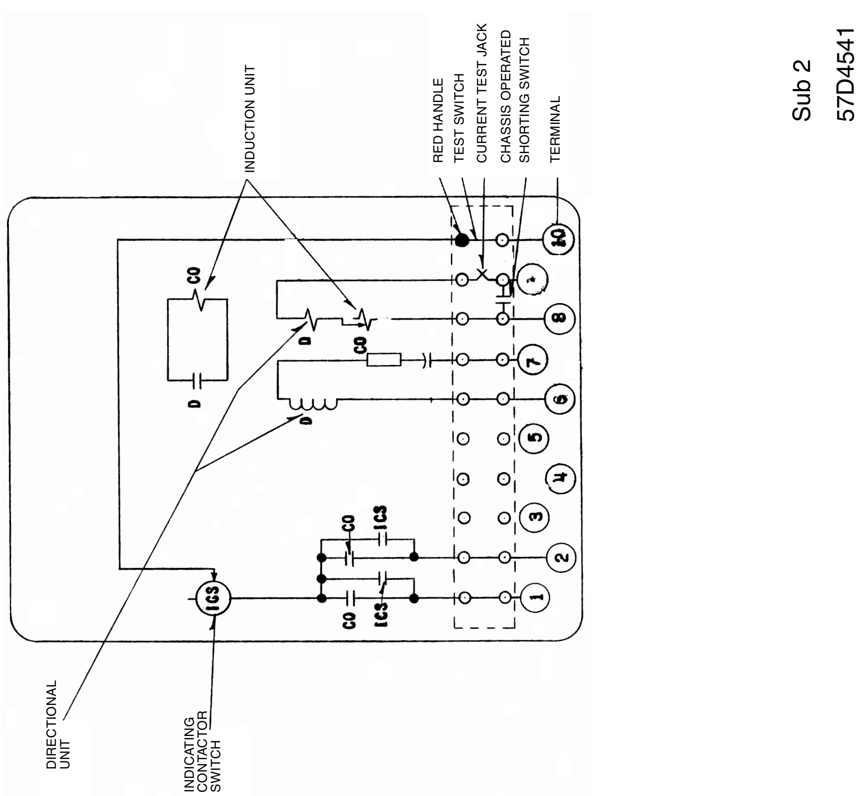


Figure 7: Internal Schematic of double-trip, directional overcurrent relay type CRP in type FT-21 Case. For the single-trip relay the circuits associated with terminal 2 are omitted, 57D4545

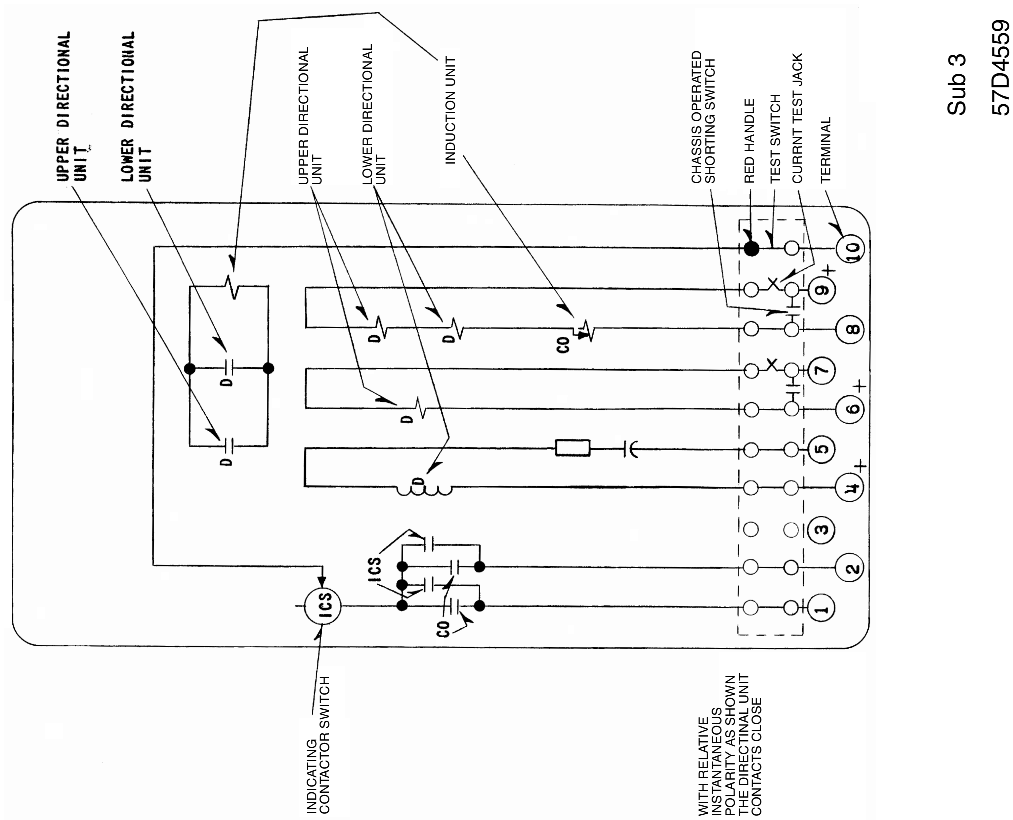


Figure 8: Internal Schematic of double-trip, directional overcurrent relay type CRD in type FT-21 Case. For the single-trip relay the circuits associated with terminal 2 are omitted, 57D4561

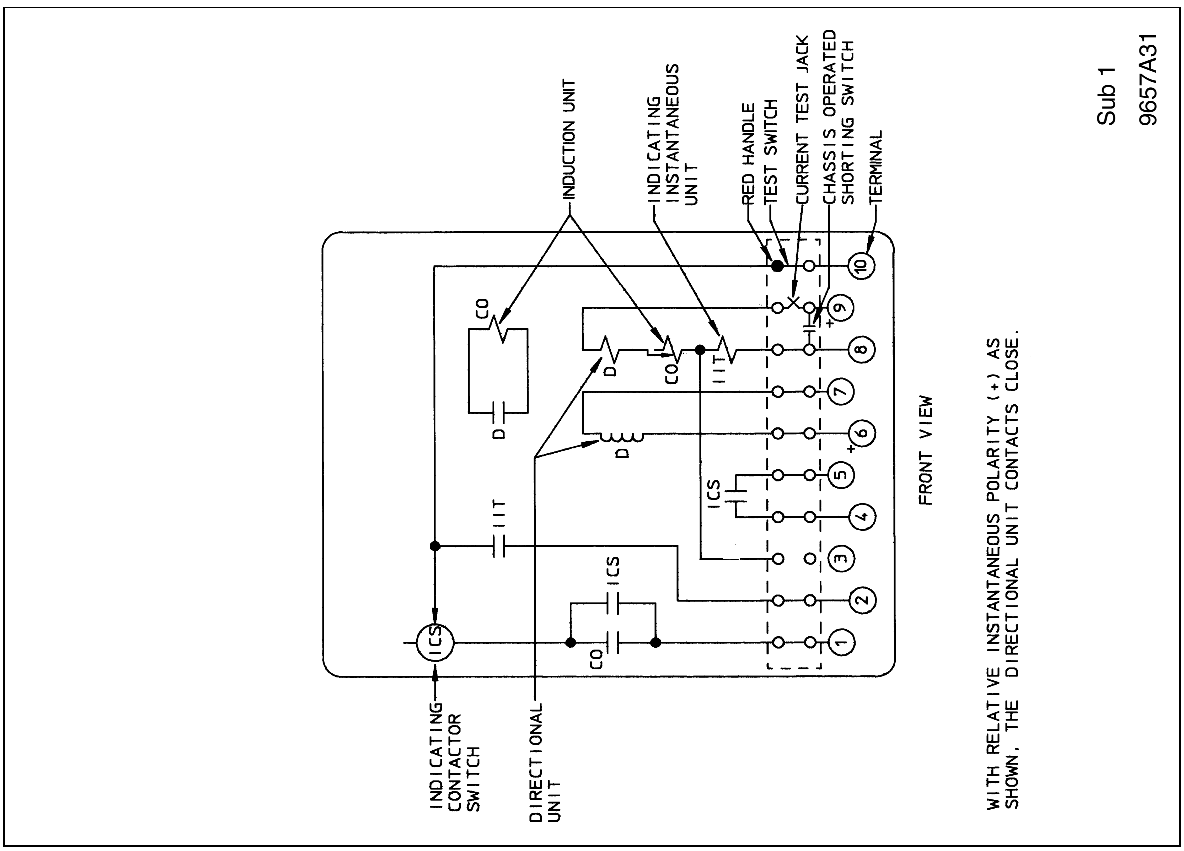


Figure 9A: *Internal schematic of single-trip, directional control relay type CR with indicating instantaneous trip unit, and ICS unit having two independent contacts, in type FT-21 case*

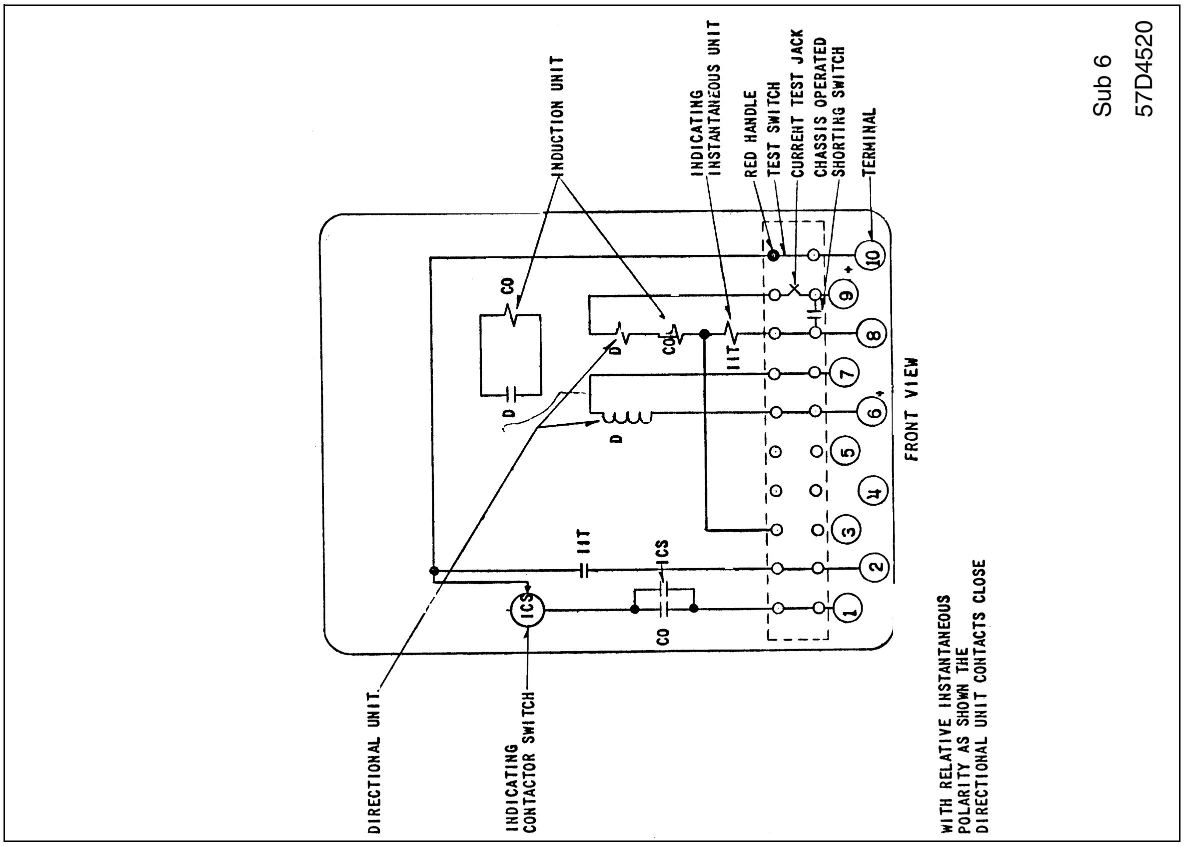


Figure 9B: *Internal schematic of single-trip directional control relay type CR with indicating instantaneous trip unit, in Type FT-21 case*

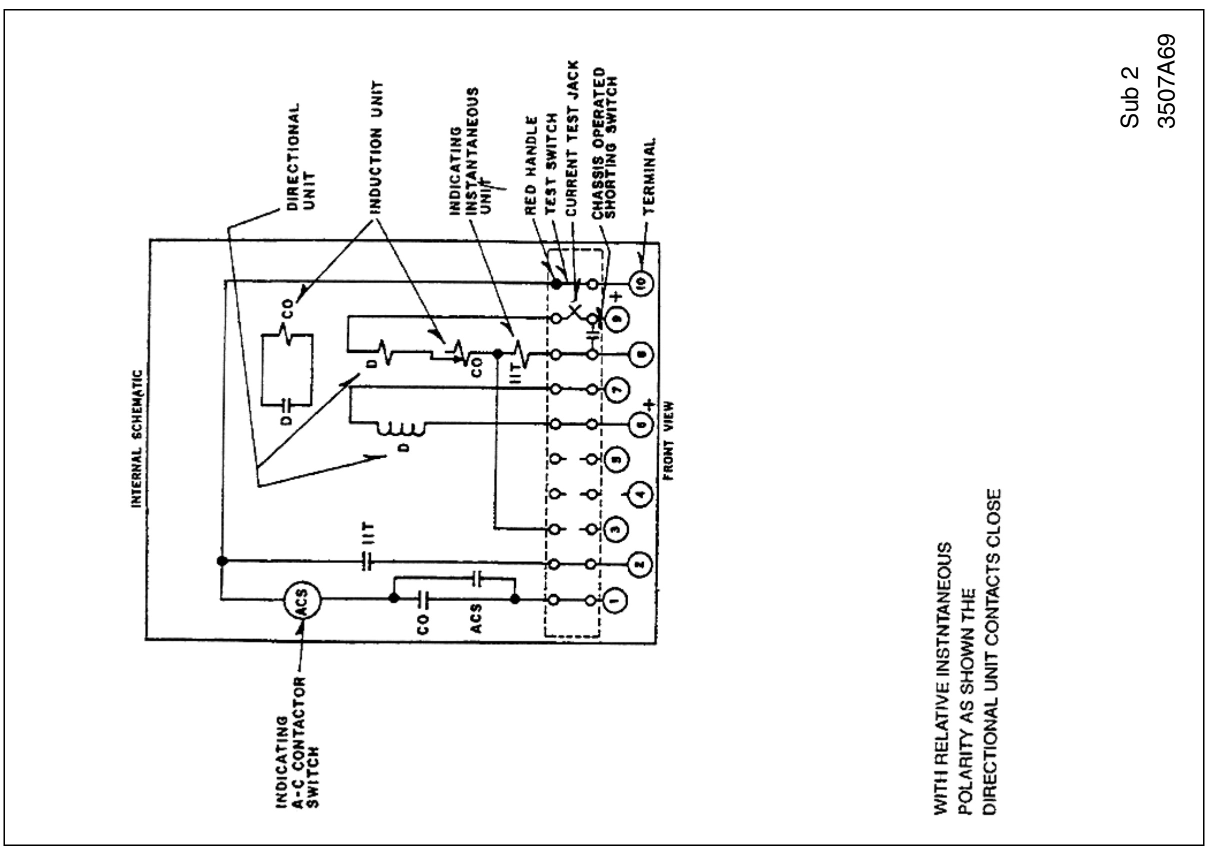


Figure 10A: Internal schematic of single-trip directional control relay type CR with indicating instantaneous trip unit and ac shunt trip, in type FT-21 case

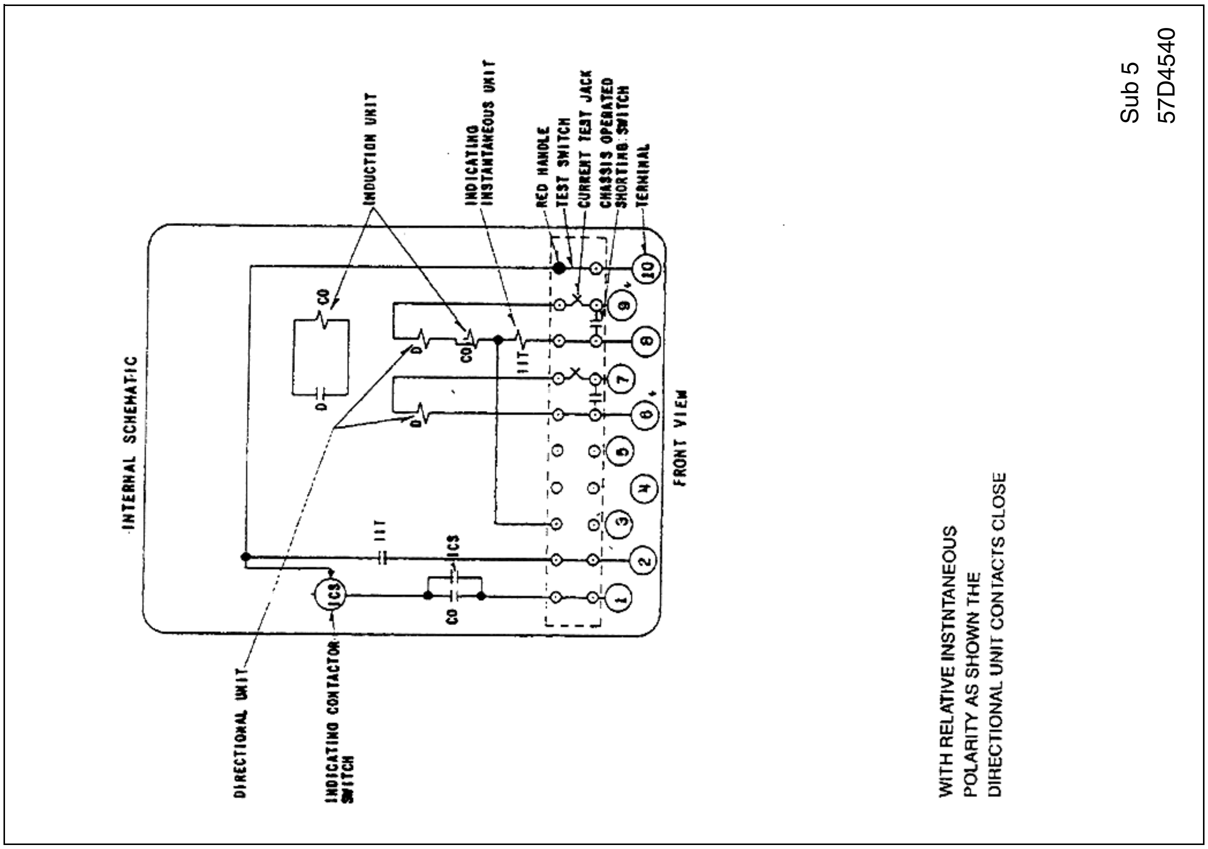


Figure 10B: Internal Schematic of single-trip directional control relay type CRC with Indicating Instantaneous Trip Unit, in type FT21 case

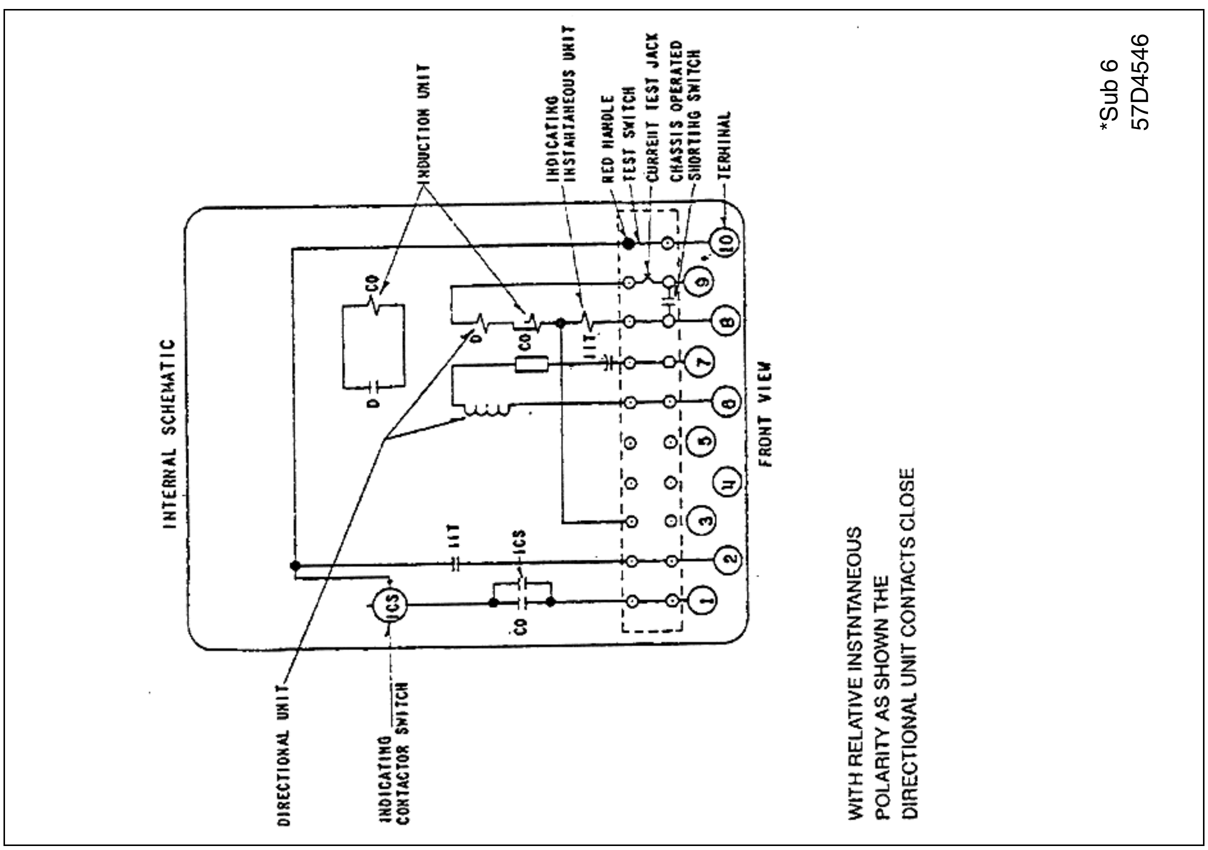


Figure 11: *Internal schematic of single-trip directional control relay type CRP with indicating instantaneous trip unit, in type FT-21 case*

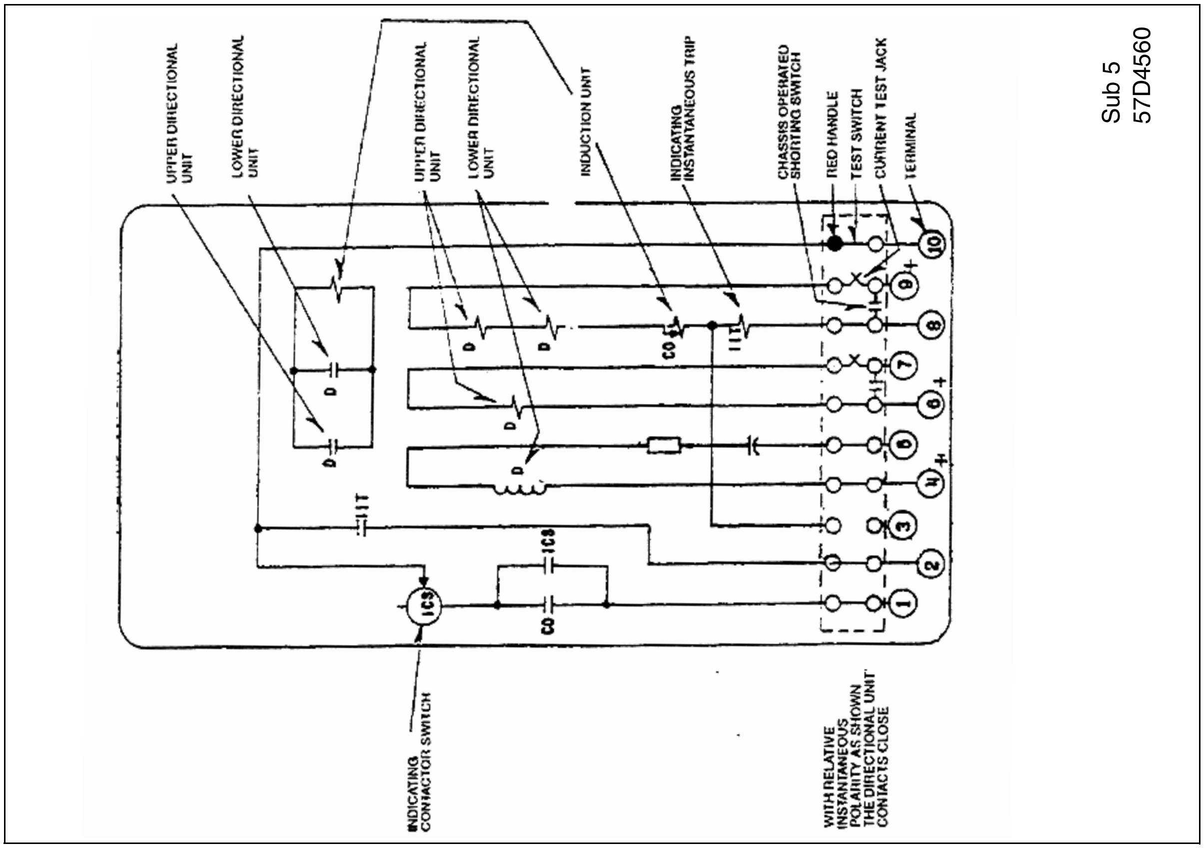


Figure 12: *Internal schematic of single-trip directional control relay type CRD with indicating instantaneous trip unit, in type FT-31 case*

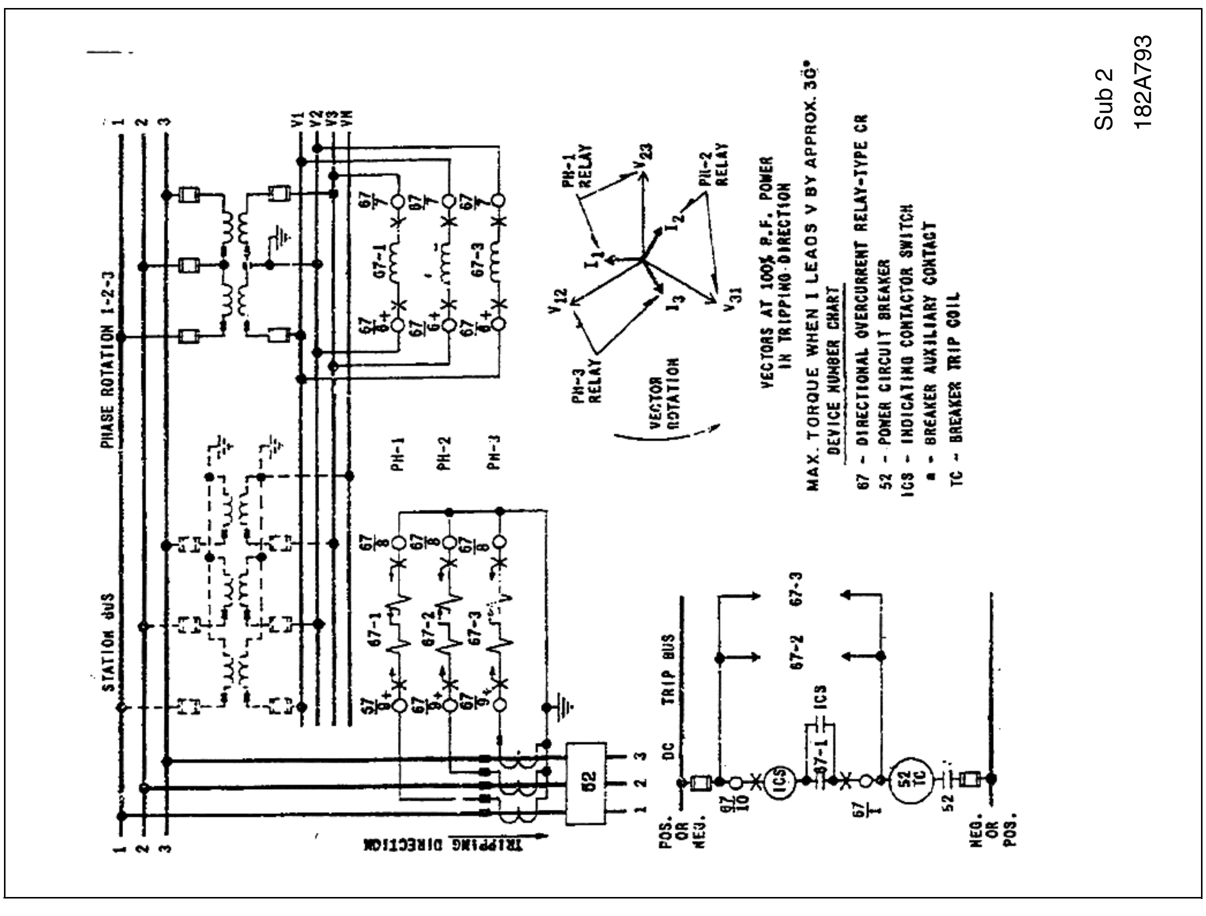


Figure 13: *External schematic of the type CR relay for phase fault protection*

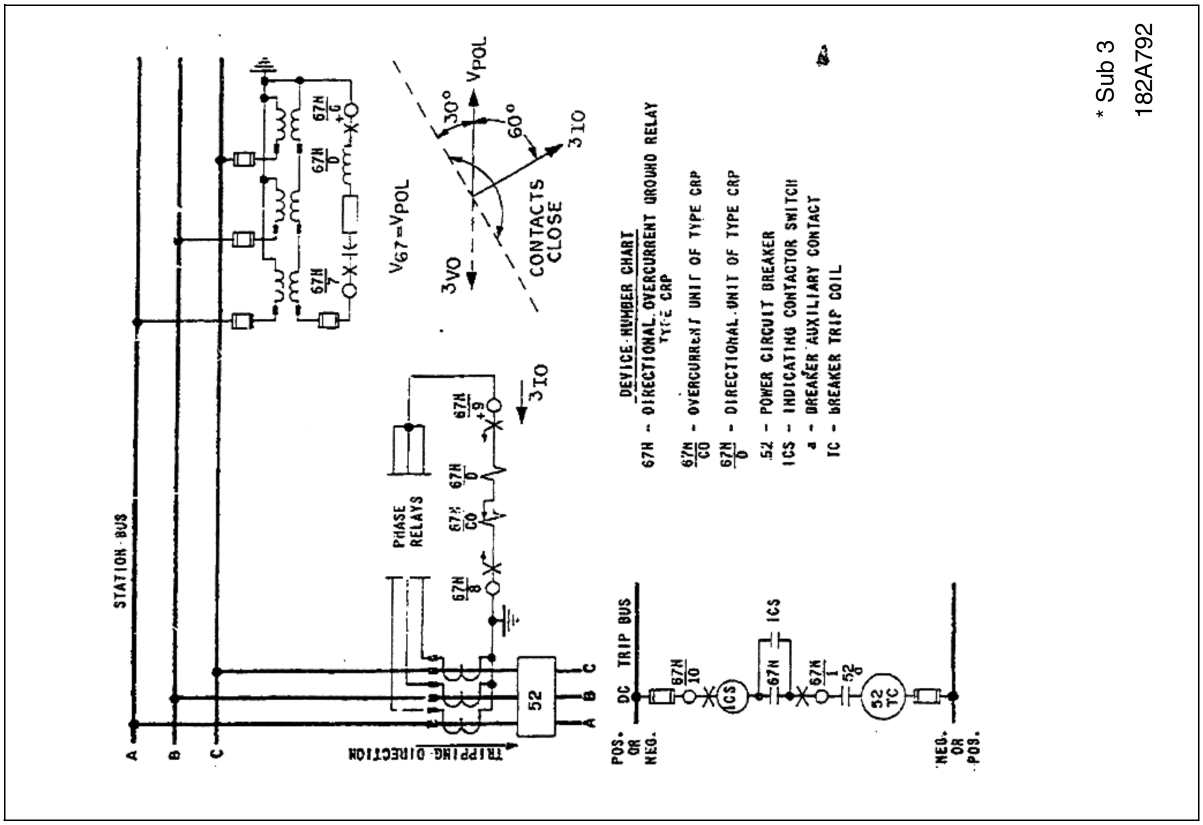


Figure 14: *External schematic of the type CRP relay for ground fault protection*

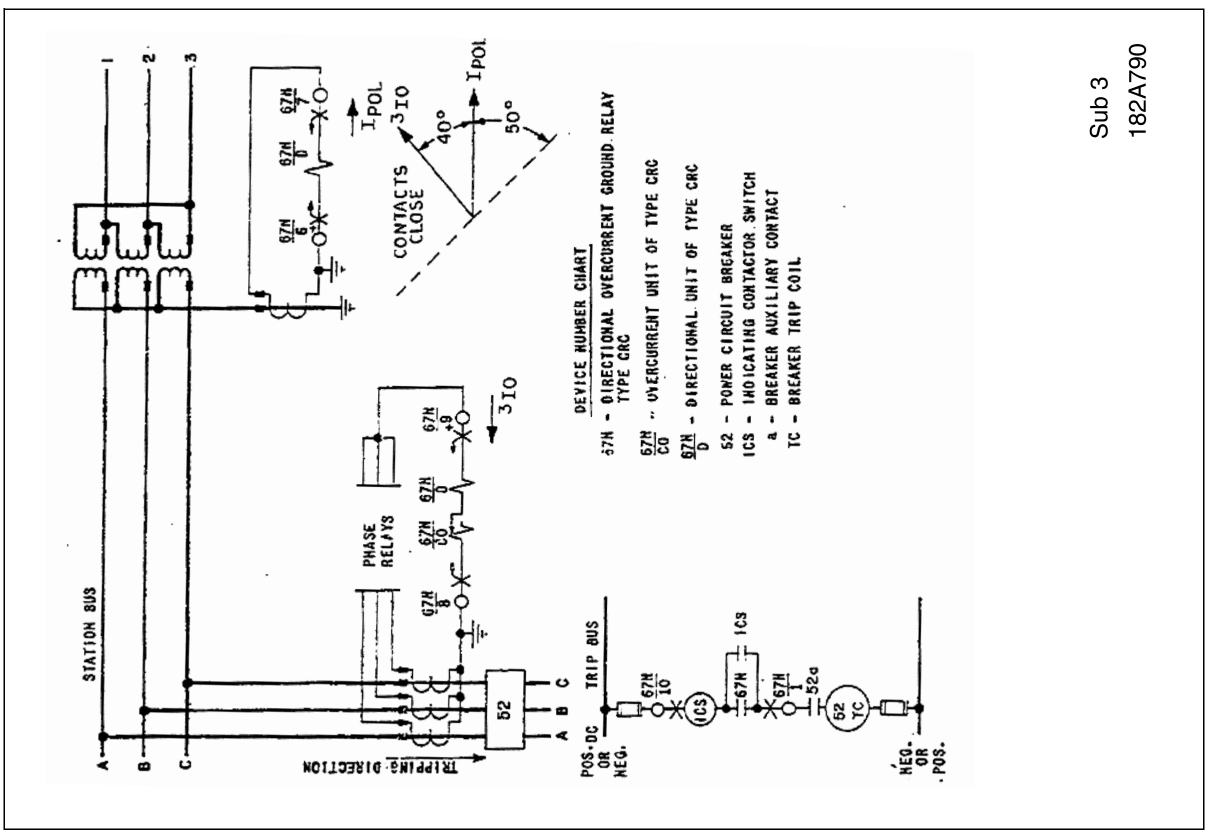


Figure 15: External schematic of the type CRC relay for ground fault protection

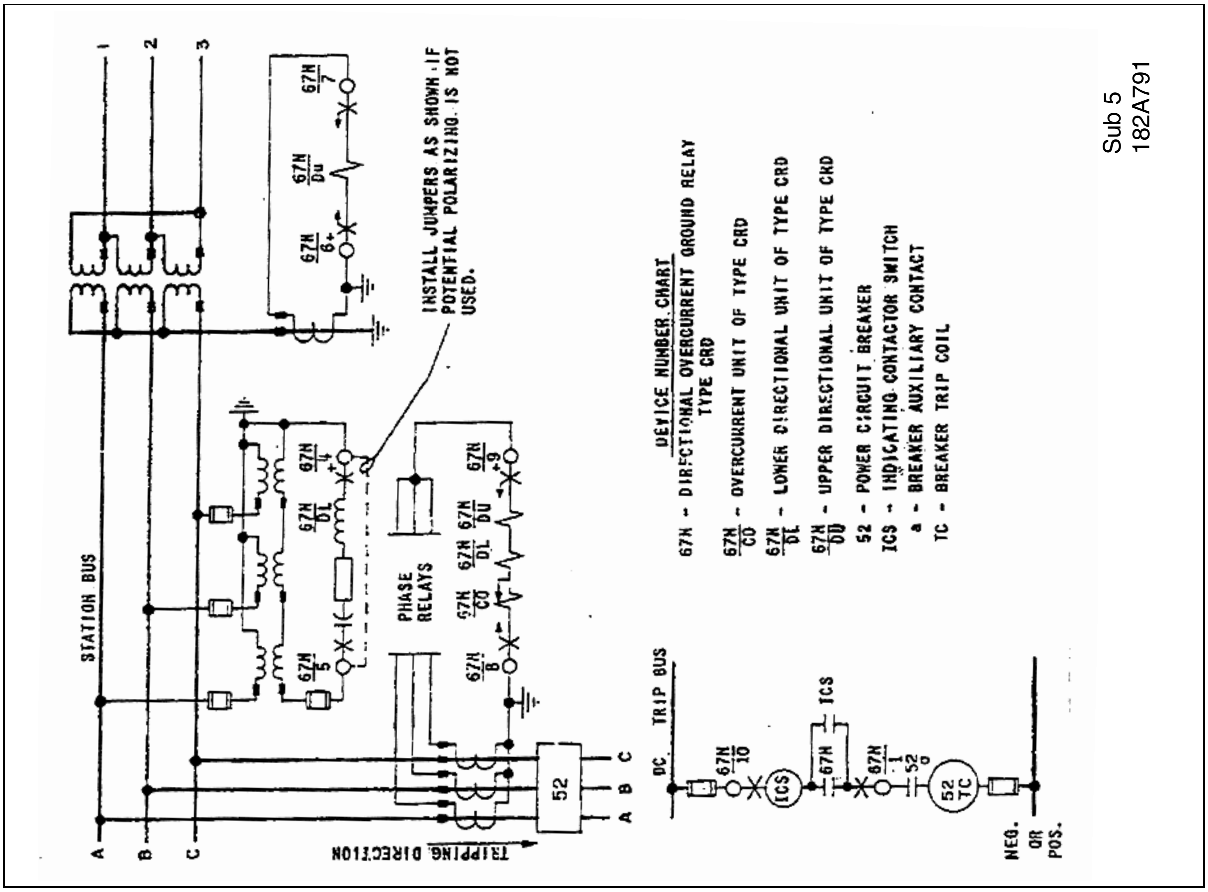
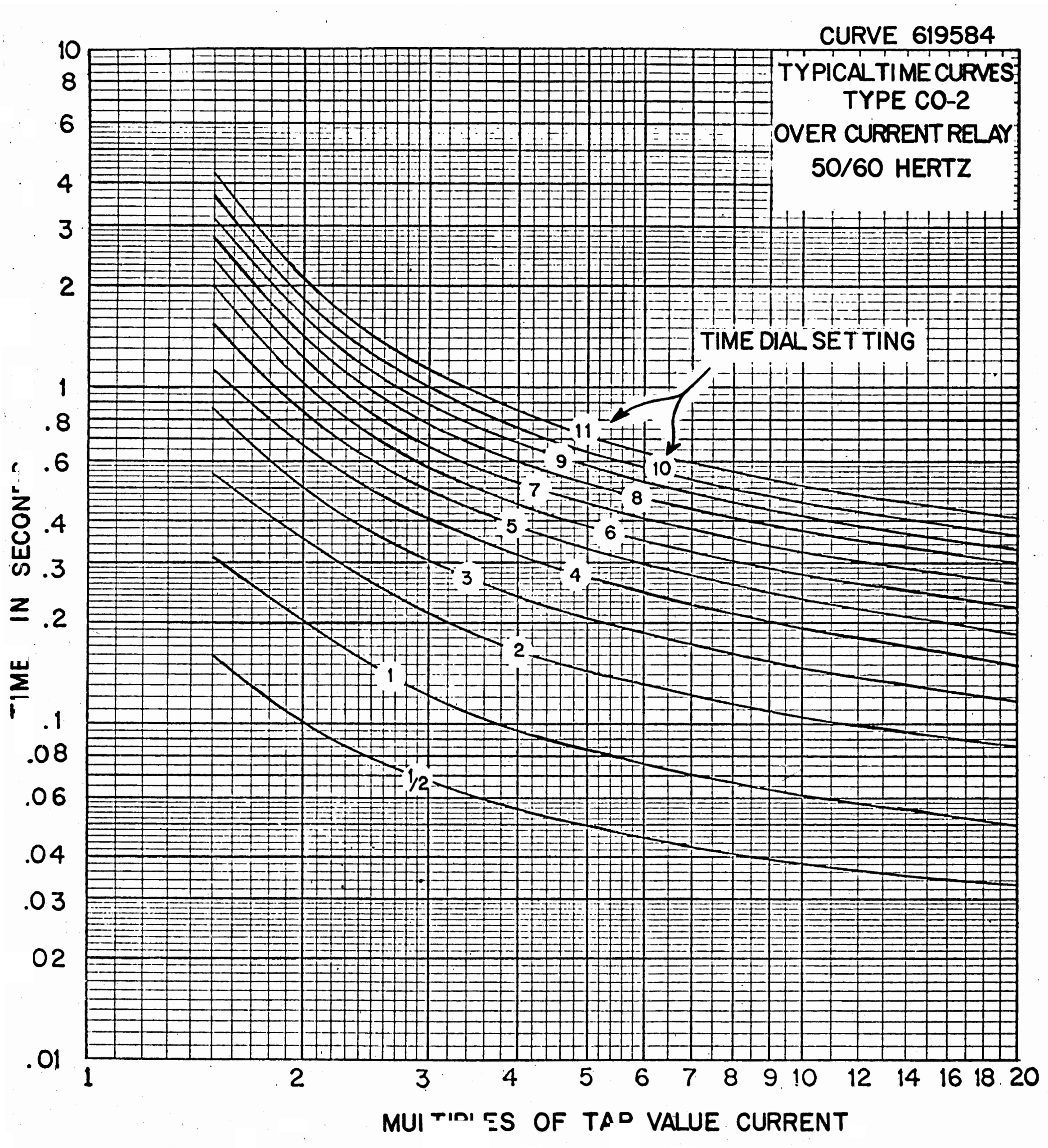
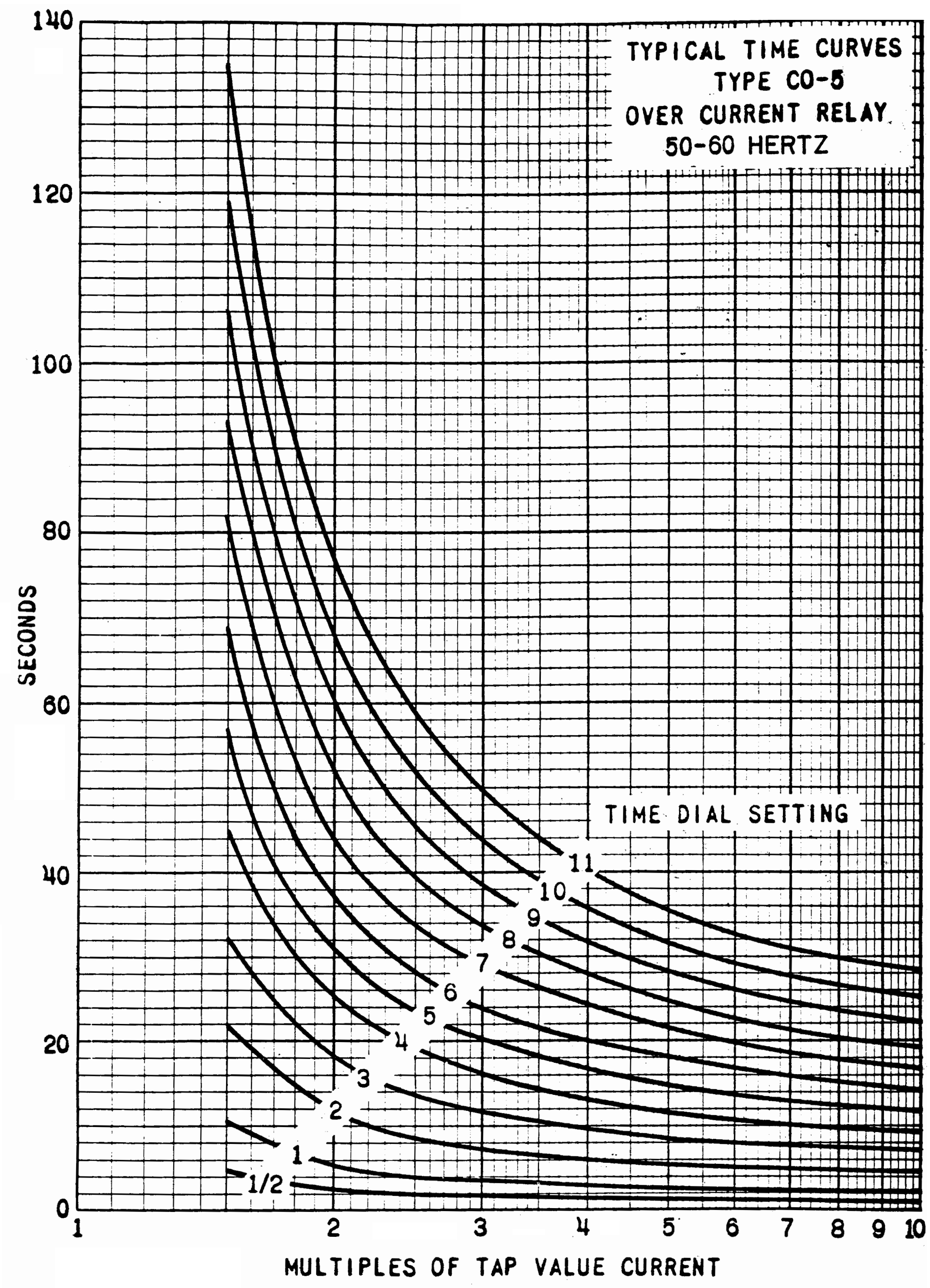


Figure 16: External schematic of the type CRD relay for ground fault protection



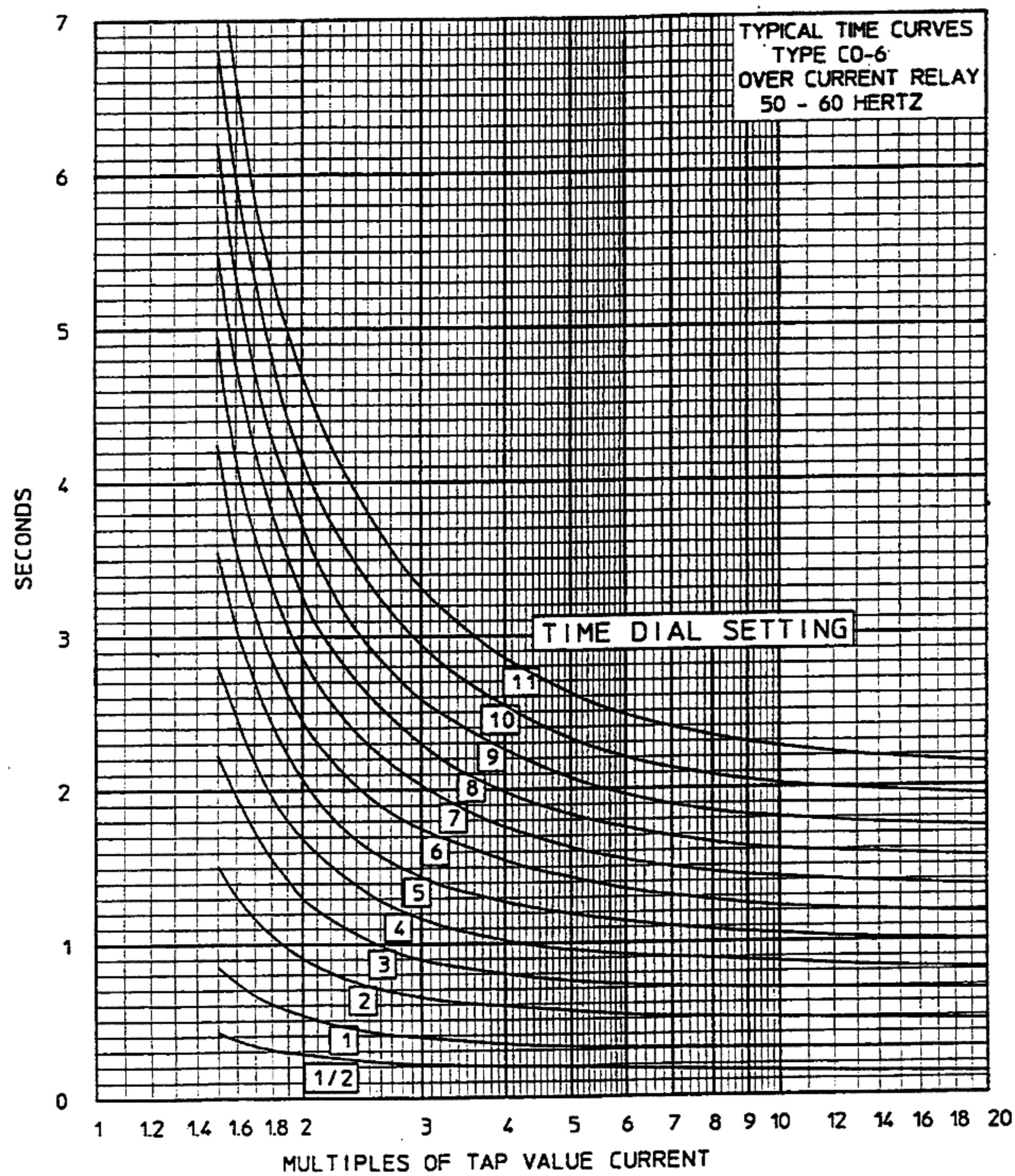
Sub 1
Curve 619584

Figure 17: *Typical time curves for relays with CO-2 units*



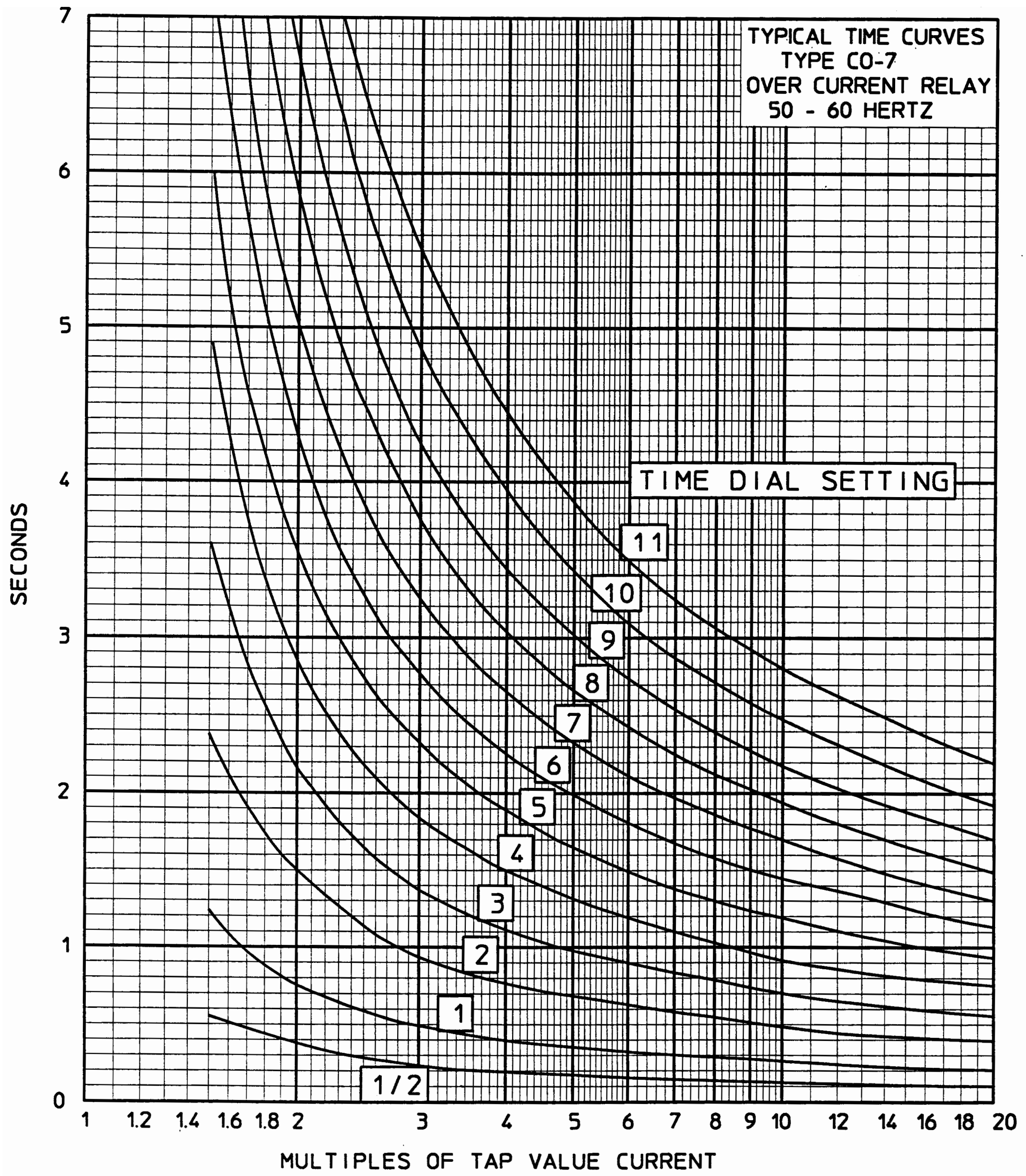
Sub 2
Curve 418245

Figure 18: *Typical time curves for relays with CO-5 units*



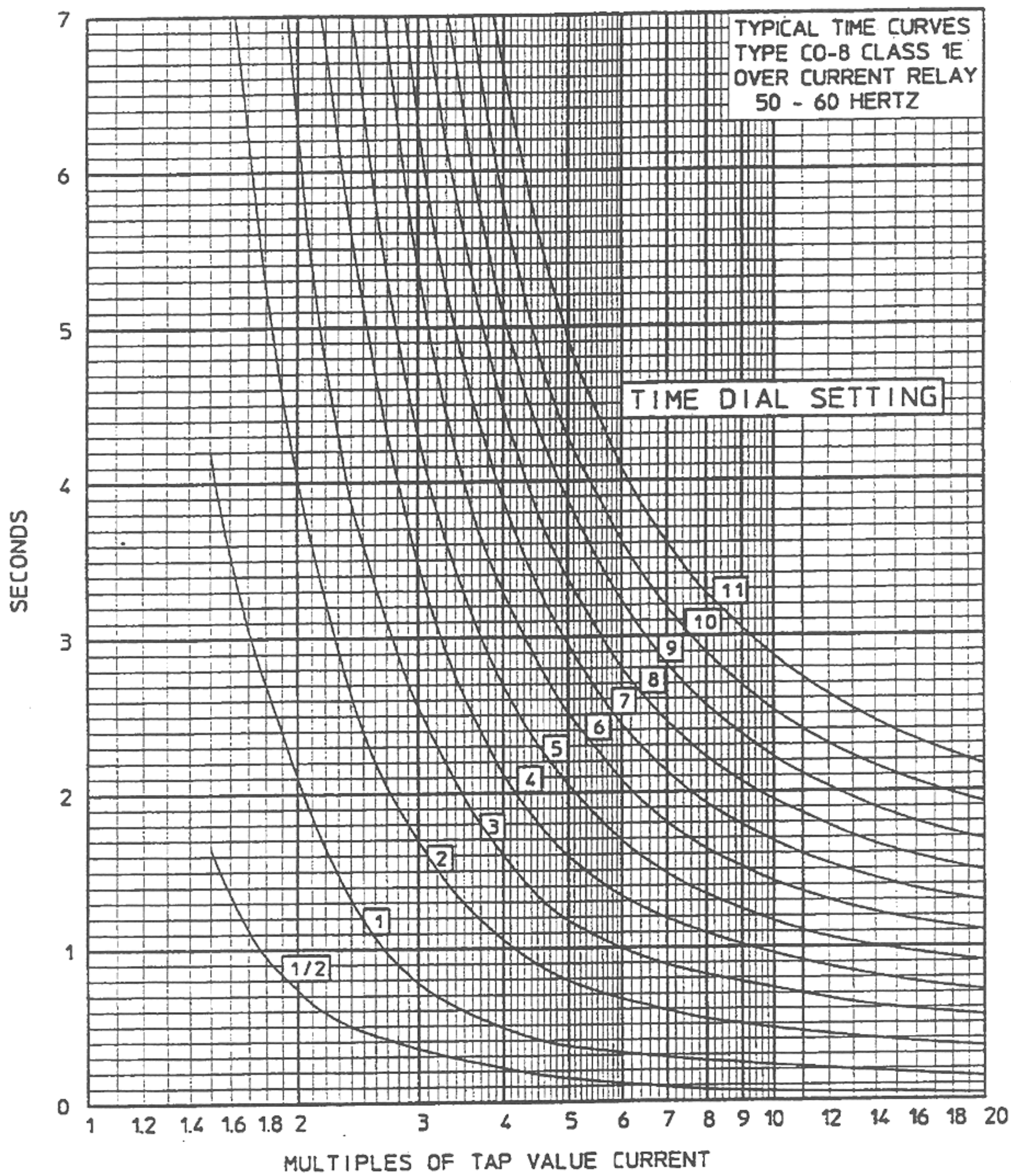
Sub 3
Curve 418246

Figure 19: *Typical time curves for relays with CO-6 units*



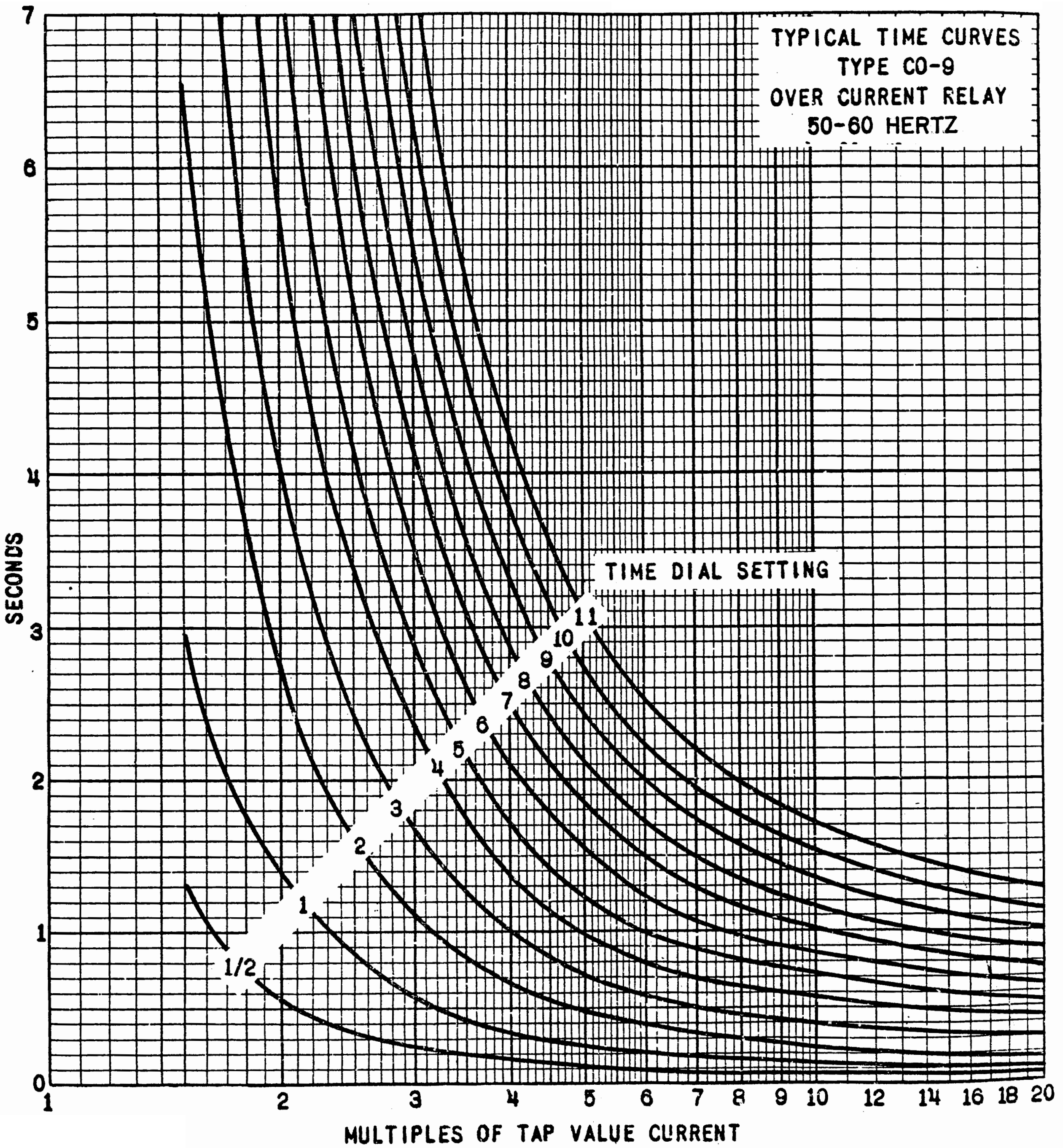
Sub 3
Curve 418247

Figure 20: *Typical time curves for relays with CO-7 units*



Sub 3
Curve 418248

Figure 21: *Typical time curves for relays with CO-8 units*



Sub 2
Curve 418249

Figure 22: *Typical time curves for relays with CO-9 units*

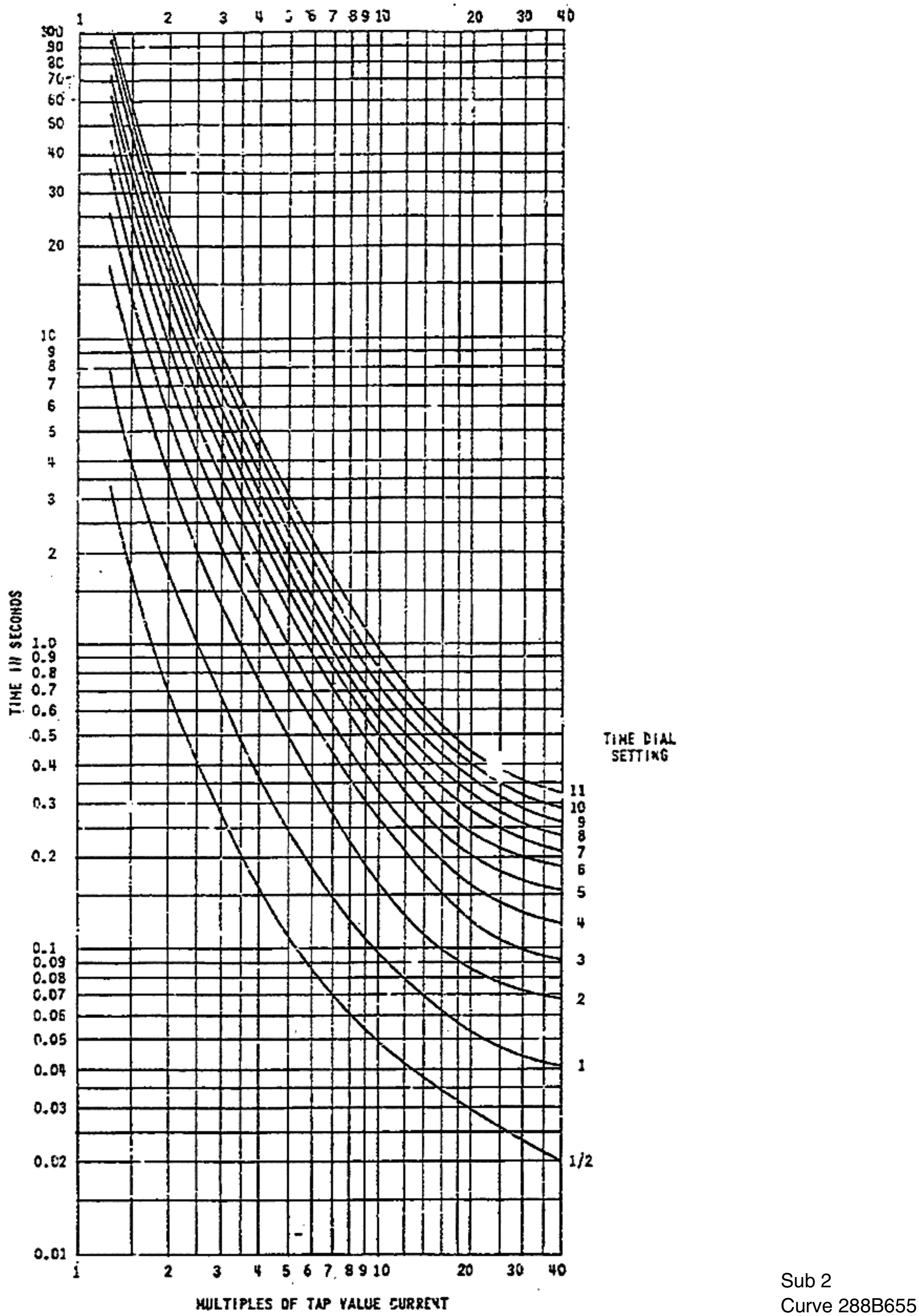


Figure 23: *Typical time curves for relays with CO-11 units*

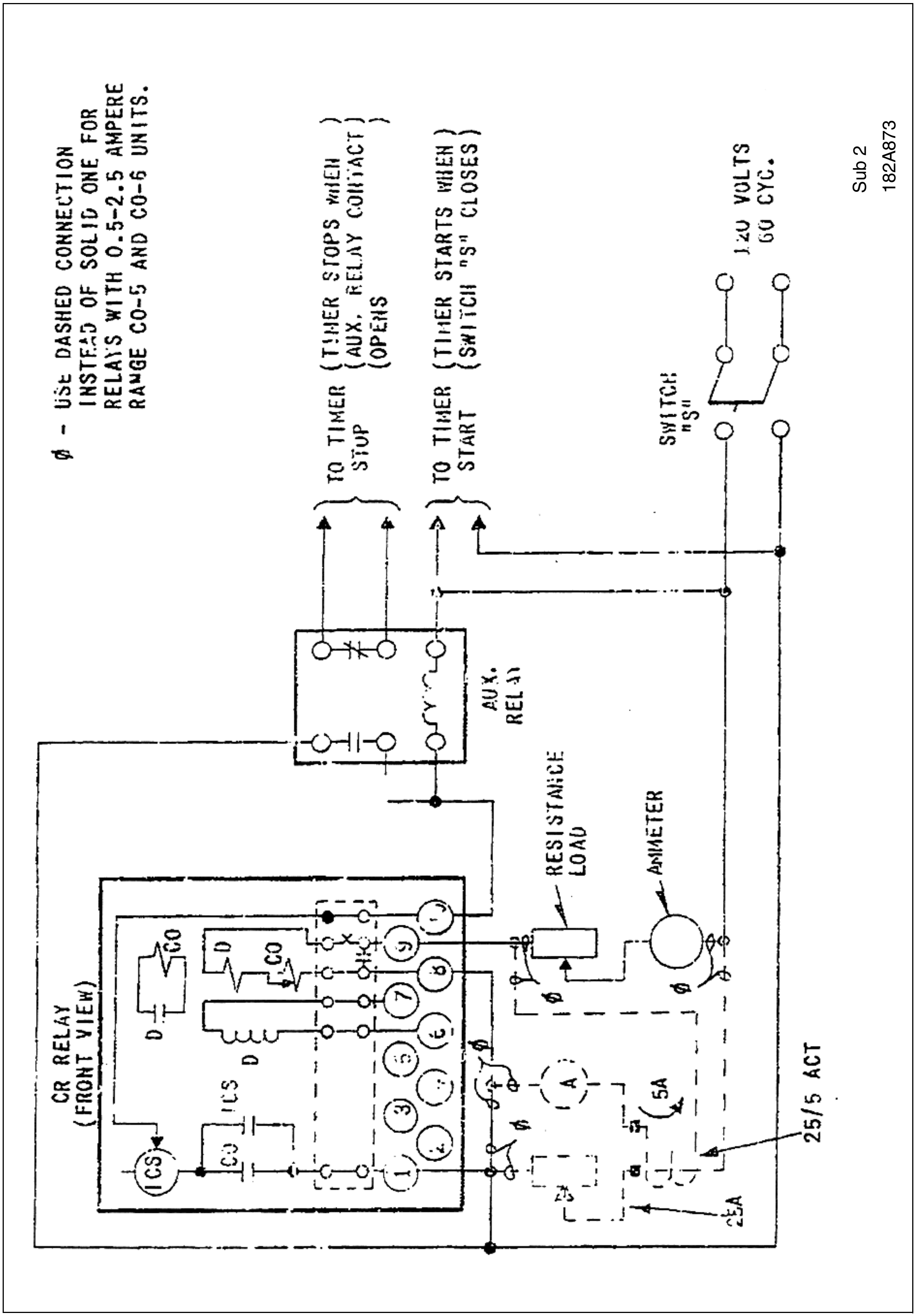
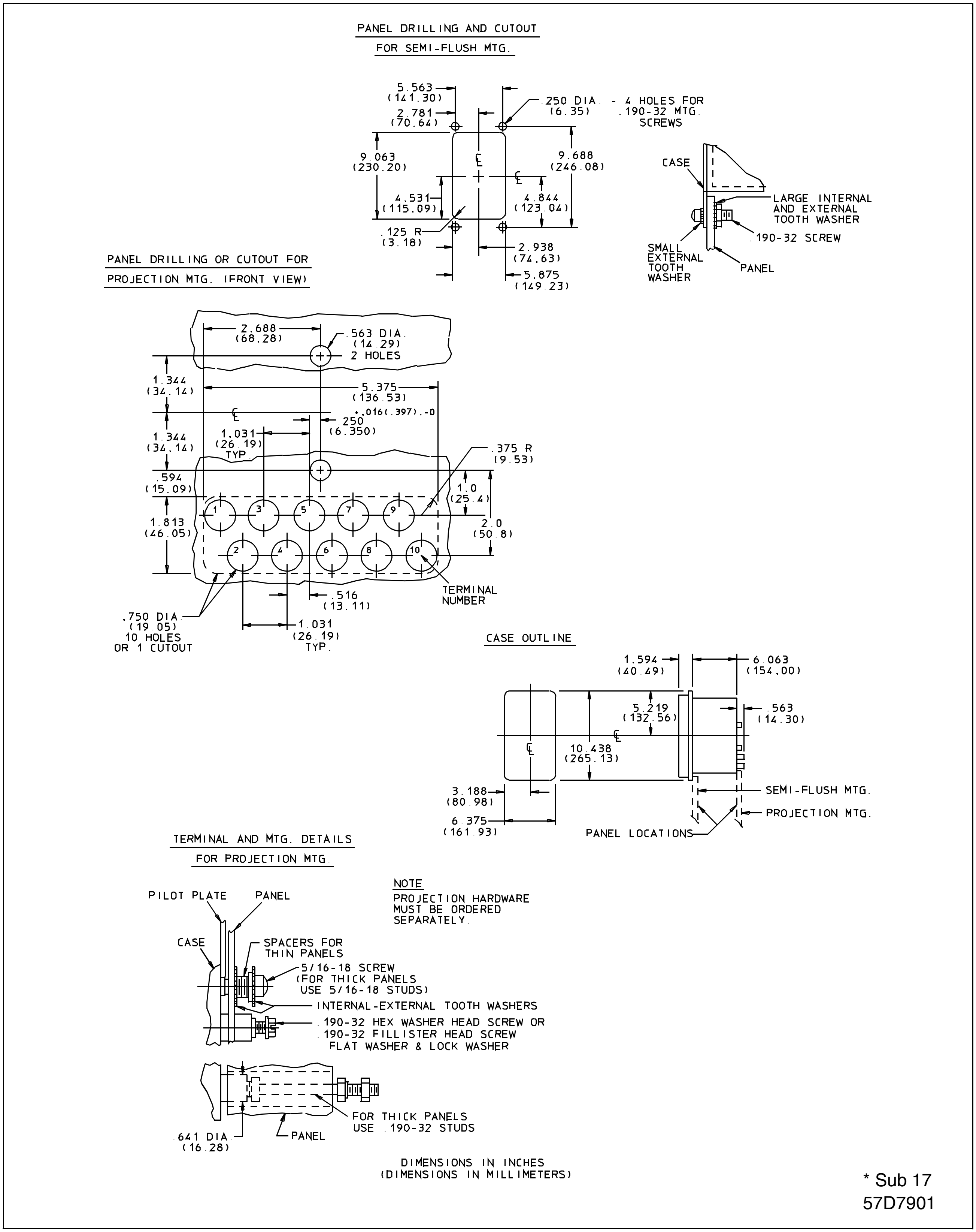
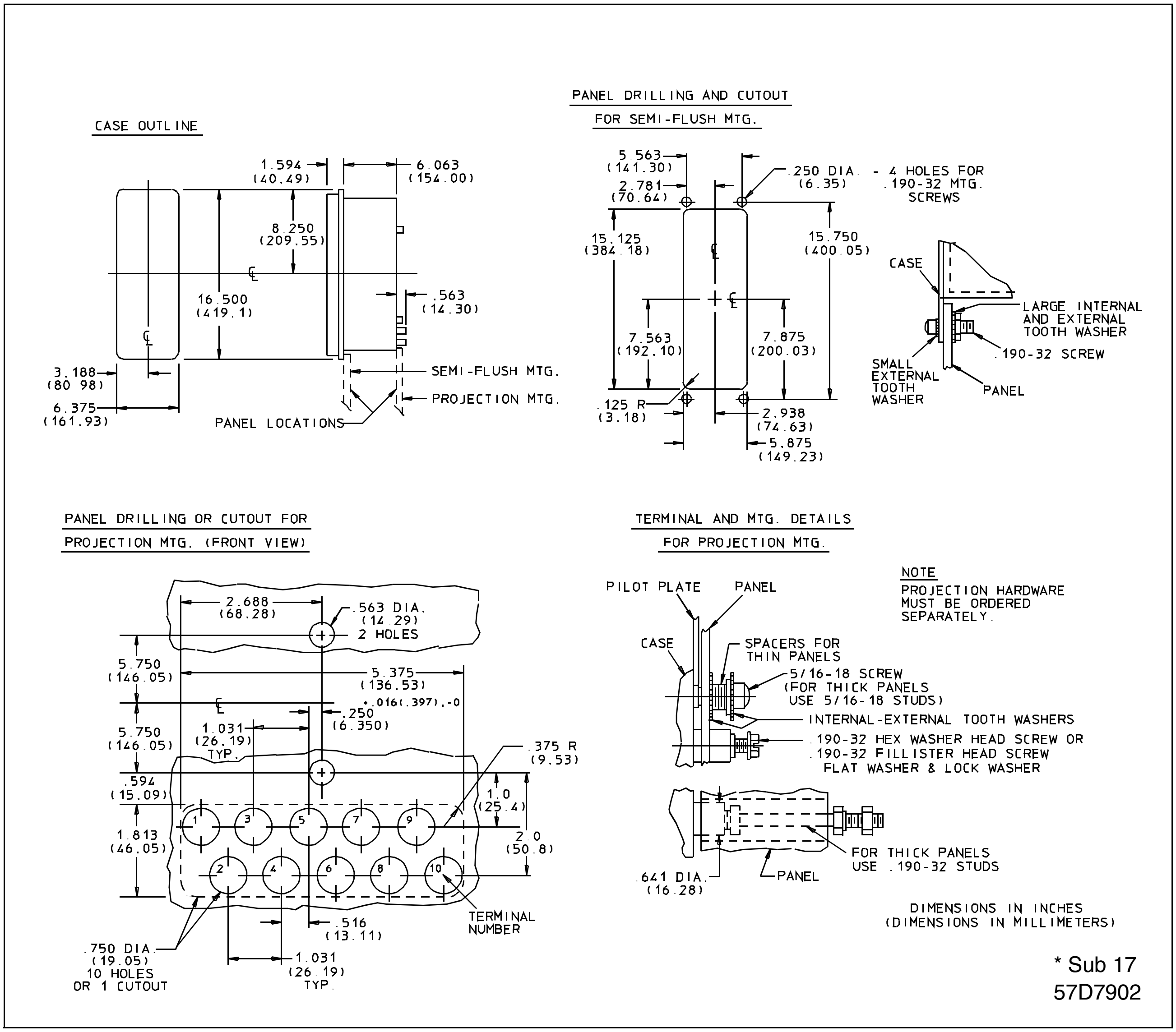


Figure 24: *Diagram of test connections of the overcurrent units*



* *Denotes Change Since Previous Issue*

Figure 25: *Outline and drilling plan for the type CR, CRC and CRP relays in the type FT-21 case*



* *Denotes Change Since Previous Issue*

Figure 26: *Outline and drilling plan for the type CRD relay in the type FT-21 case*

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