Effective: September 2000
Supersedes I.L. 41-133.3H, dated May 1997
(|) Denotes Changes since previous issue

Type IRV Directional Overcurrent Relay for Phase Protection

CAUTION

Before putting protective relays into service, remove all blocking 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.

This instruction leaflet applies to the following types of relays	
Type	**Time Delay Characteristics**
IRV - 2	Short Time
IRV - 5	Long Time
IRV - 6	Definite Time
IRV - 7	Moderately Inverse Time
IRV - 8	Inverse Time
IRV - 9	Very Inverse Time
IRV - 11	Extremely Inverse Time

1.0 APPLICATIONS

These relays are phase directional overcurrent relays which are used for the protection of transmission lines and feeder circuits. Both the time-overcurrent and instantaneous overcurrent units are directionally controlled.

2.0 CONSTRUCTION AND OPERATION

The IRV relay consists of : (See Figures 1 & 2, page 2)

1. a time-overcurrent unit (CO)
2. a directional unit (D)
3. an instantaneous overcurrent unit (I) with a staturating transformer (I-ST)
4. two indicating contactor switches (ICS-I and ICS-T)
5. an auxiliary unit (CS-1 or TR-1)

2.1 TIME-OVERCURRENT UNIT (CO)

The electromagnets for the types CO-5, CO-6, CO-7, CO-8 and CO-9 units have a main tapped coil located on the center lag 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 causes a contact closing torque.

The electromagnet for the type CO-2 and CO-11 units 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.

2.2 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.

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.

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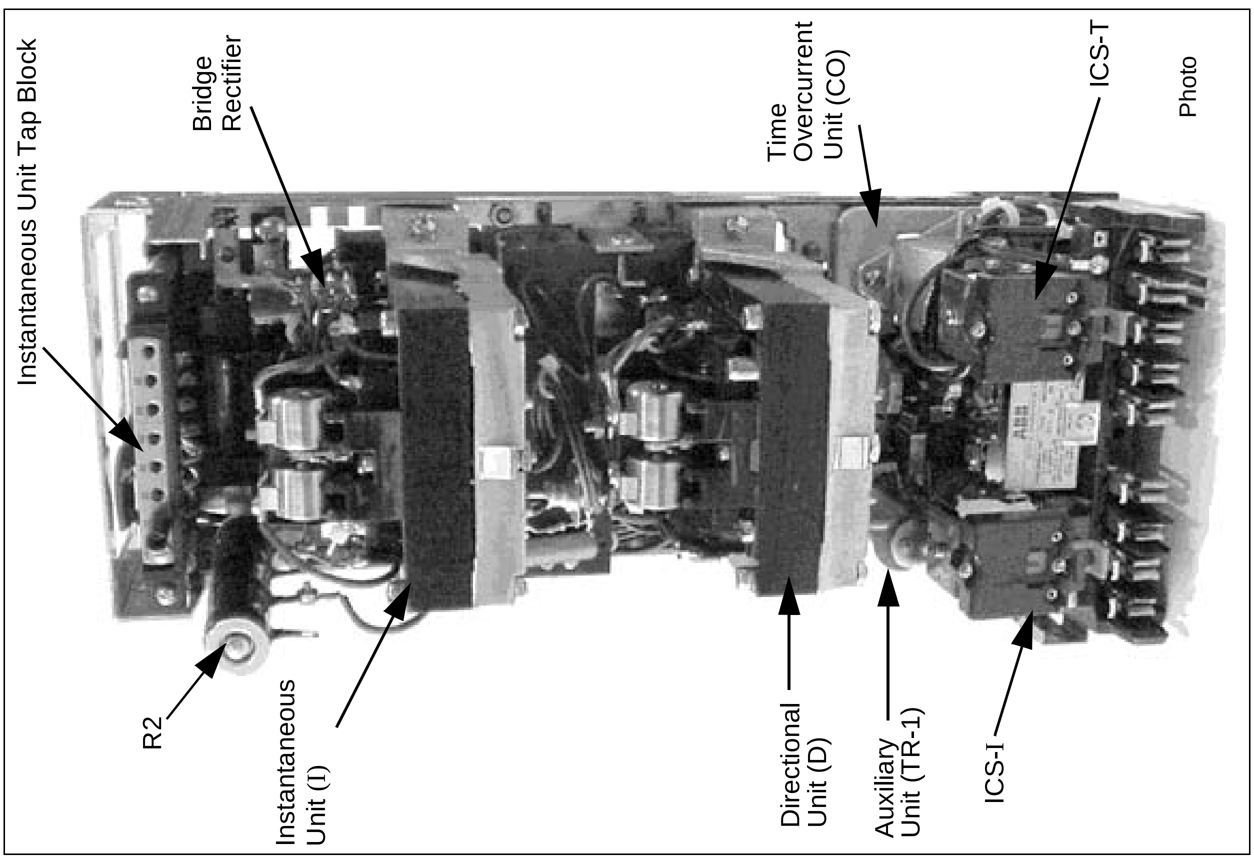


Figure 1. Type IRV Relay without case (Front View)

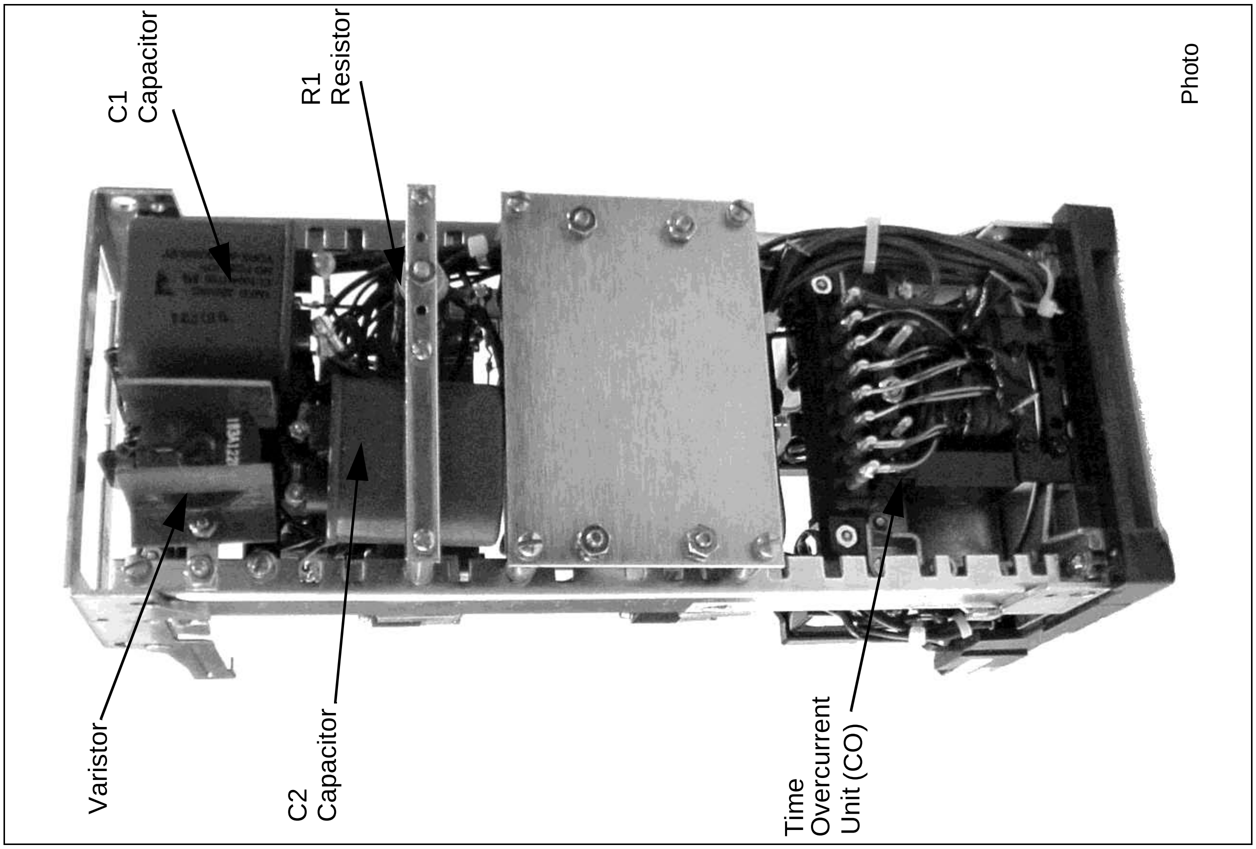


Figure 2. Type IRV Relay without Case (Rear View)

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 spring and snap ring. This is an adjustable core which has a .025 inch flat on one side and is held in its adjusted position by the clamping action of two compressed springs. 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 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.

2.3 INSTANTANEOUS OVERCURRENT UNIT (I) WITH SATURATING TRANSFORMER (I-ST)

The instantaneous overcurrent unit is similar in construction to the directional unit. The time phase relationship of the two air gap fluxes necessary for the development of torque is achieved by means of a capacitor connected in series with one pair of pole windings.

When the make contact of D closes, it permits the I-unit to operate. It connects capacitor C3 and one pair of I-unit coils across the output voltage of the saturating transformer I-ST. The full-wave bridge in this connection and the rectifier in series with the D contact serve to isolate the ac and dc circuits.

The transformer is of the saturating type for limiting the energy to the instantaneous overcurrent unit at higher values of fault current and to reduce ct burden. The primary winding is tapped and these taps are brought out to a tap block for ease in changing the pick-up of the instantaneous overcurrent unit. The use of a tapped transformer provides approximately the same energy level at a given multiple of pick-up current for any tap setting, resulting in one time curve throughout the range of the relay.

Across the secondary is connected a non-linear resistor known as a varistor. The effect of the varistor is to reduce the voltage peaks applied to the overcurrent unit and phase shifting capacitor.

2.4 INDICATING CONTACTOR SWITCH UNITS (ICS-I AND ICS-T)

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. 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 case.

The front spring, in addition to holding the target, provides restraint for the armature and thus controls the pick-up value of the switch. The ICS unit is commonly used to provide a seal-in around the main protective relay contacts relieving them of carrying heavy duty trip currents.

2.5 AUXILIARY UNIT (CS-1 OR TR-1)

Older relays manufactured prior to 1988 contained an auxiliary unit which was a plunger type device designated “CS-1”. The CS-1 unit is a solenoid type dc switch. A cylindrical plunger, with a silver disc mounted on its lower end moves in the core of the solenoid. As the plunger travels upward, the disc bridges the silver stationary contacts. A tapped resistor (R2) is used to enable the use of the auxiliary unit on a 48, 125 or 250 volt dc system (24 volt relays come with a fixed 100 ohm resistor for R2), (See Figure 14 page 26 for appropriate settings and resistance values of R2).

The CS-1 auxiliary unit has been replaced by a telephone type relay which is designated “TR-1”. Additional components, mounted on a small printed circuit board, have also been added as follows:

- A “free-wheeling” diode in parallel with the TR-1 coil.

- An (RC) arc suppressing circuit across the normally open “D” contact.

The resistance of the TR-1 coil is 2000 ohms. A tapped resistor (R2) is also used to enable the use of the auxiliary unit on a 48, 125 or 250 volt dc system (24 volt relays come with a fixed 500 ohm resistor for R2), (see Figure 14 page 26 for appropriate settings and resistance values of R2).

The auxiliary unit (TR-1) is a telephone type relay with two normally open contacts. The operation of the auxiliary unit (TR-1) is controlled by the directional unit (D) normally closed contact, which in turn directionally controls the time-overcurrent unit (CO) as shown in Figure 4, page 17. When sufficient power flows in the tripping direction to close the normally open D contact, the auxiliary unit operates and bridges the lag coil of the time-overcurrent unit (CO) permitting this unit to operate.

The other contact of the auxiliary unit seals in its coil through the break contact of the “I” unit, in order to relieve the make contact of the “D” unit from carrying the auxiliary unit coil current. The break contact of the “D” unit breaks this seal by short circuiting the auxiliary unit coil. The break contact of the “I” unit also breaks the seal of the auxiliary unit coil to prevent tripping on reverse faults where the directional unit has preclosed on load current.

3.0 CHARACTERISTICS

The time characteristics of the directional over-current relays are designated by specific numbers as indicated by relay type. (See chart on front cover)

The relays are available in the following current ranges:

Time Overcurrent Unit (CO)

Range (Amps)	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

The tap value is the minimum current required to just close the relay contacts.

The time vs. current characteristics for the time-overcurrent unit are shown in Figures 5 to 11 (page 18 to 24). 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.

Instantaneous Overcurrent Unit (I)

Range (Amps)	Taps					
0.5 - 2	0.5	0.75	1.0	1.25	1.5	2
1 - 4	1.0	1.5	2.0	2.5	3.0	4.0
2 - 8	2	3	4	5	6	8
4 - 16	4	6	8	9	12	16
10 - 40	10	15	20	24	30	40
20 - 80	20	30	40	48	60	80

The time vs. current characteristics for the instantaneous overcurrent unit is shown in Figure 12, page 25.

The time vs. current characteristics for the directional unit is shown in Figure 13, page 25.

3.1 TRIP CIRCUIT

The relay contacts will safely close 30 amps at 250 volts dc and the seal-in contacts of the indicating contactor switches will safely carry this current long enough to trip a circuit breaker.

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

3.2 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 shop adjusted for optimum follow and ***this adjustment should not be disturbed.***

3.3 TRIP CIRCUIT CONSTANTS

Indicating Contactor Switch Coil Taps	
0.2 amps tap 2.0 amps tap	6.5 ohms dc resistance 0.15 ohms dc resistance

3.4 AUXILIARY UNIT (CS-1 OR TR-1)

The auxiliary unit operating time is approximately 5 milliseconds.

CS-1	
48-250 volt dc relay	dc resistance – 1165 ohms
24 volt dc relay	dc resistance – 100 ohms
TR-1	
Coil resistance is 2000 ohms for all dc voltages.	

3.5 DIRECTIONAL UNIT

The IRV relay is intended for phase fault protection and the directional unit has its maximum torque when the current leads the voltage by 30° ±10°. The directional unit minimum pickup is 1.2 volts and 4 amps at its maximum torque angle for 4 - 12 amps range relays, and 1.2 volts and 2 amps or less for the 0.5 - 2.5 amps and the 2 -6 amps 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 60°, ±10°. See Figure 4 (page 17).

4.0 RELAY SETTINGS

CAUTION

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. Since the tap block screws carry operating current, be sure that the screws are turned tight. Then reclose all switchblades making sure the RED handles are closed LAST.

4.1 TIME OVERCURRENT UNIT (CO)

The time overcurrent unit settings can be defined either by tap setting 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 circuit breaker time is recommended between the relay being set and the relays with which coordination is to be effected.

The connector screws on the plate above the time dial makes connections to various turns on the operating coil. By placing this 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.

The factory adjustment of the CO unit contact 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.

4.2 DIRECTIONAL UNIT (D)

No setting is required.

4.3 INSTANTANEOUS OVERCURRENT UNIT (I) WITH SATURATING TRANSFORMER (I-ST)

CAUTION

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. Since the tap block screws carry operating current, be sure that the screws are turned tight. Then reclose all switchblades making sure the RED handles are closed LAST.

The only setting required is the pickup current setting which is made by means of the connector screw located on the tap plate. By placing the connector screw in the desired tap, the unit will just close its contacts at the tap value current.

4.4 INDICATING CONTACTOR SWITCH (ICS-I AND ICS-T)

The only setting required on the ICS units is the selection of the 0.2 or 2.0 amps 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.

4.5 AUXILIARY UNIT

The only setting required on the auxiliary unit is the 48, 125 or 250 voltage on the tapped resistor (R2). This connection can be made by referring to Figure 14, page 26.

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 projection mounting or by means of the four mounting holes on the flange for the semi-flush mounting. Either of the studs or the mounting screws may be used 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 detail information on the FT Case refer to Instruction Leaflet 41-076.

The external connection of the directional overcurrent relays is shown in Figure 4, page 17.

6.0 ACCEPTANCE TEST

NOTE:
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 "RELAY SETTINGS", should be made.

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

6.1 TIME OVERCURRENT UNIT (CO)

1. Contacts — 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.

2. Minimum Trip Current — Set the time dial to position 6 with the auxiliary unit (CS-1 or TR-1) contacts blocked closed (or short the CO lag coil with a jumper), 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%.

3. Time Curve — Table 1 (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 1 (e.g., for the IRV-2, 3 and 20 times tap value current) and measure the operating time of the relay. The operating times should equal those of Table 1 plus or minus 5%.

   For type IRV-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 11, page 24). 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 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 — The directional unit should trip with 1.2 volts and 4 amps at its maximum torque angle (current leading the voltage by 30°) for the 4 - 12 amps range relays and 1.2 volts and 2 amps for the 0.5 - 2.5 amps and the 2 - 6 amps range relays.

3. Spurious Torque Adjustments — There should be no spurious closing torques when the operating circuits are energized per Table 2 (page 11) with the polarizing circuit and CO coil short circuited.

6.3 INSTANTANEOUS OVERCURRENT UNIT (I) WITH SATURATING TRANSFORMER (I-ST)

1. Contact Gap — The gap between the stationary and moving contacts with the relay in the de-energized position should be approximately .020”.

2. Minimum Trip Current (Pickup) — The directional unit (D) contacts should be blocked closed when checking the pickup of the instantaneous overcurrent unit.

3. The pickup of the instantaneous overcurrent unit can be checked by inserting the tap screw into the desired tap hole and applying rated tap value current. The contact should close within ± 5% of tap value current.

6.4 INDICATING CONTACTOR SWITCHES (ICS-I AND ICS-T)

1. Close the contacts of the CO and the directional unit (D) and pass sufficient dc current through the trip circuit to close the contacts of (ICS-T). This value of current should not be greater than the particular (ICS-T) tap setting being used. The operation indicator target should drop freely, bringing the letter “T” into view.

2. Close the contacts of the instantaneous over-current unit (I) and the directional unit (D). Pass sufficient dc current through the trip circuit to close the contacts of (ICS-I). This value of current should not be greater than the particular (ICS-I) tap setting being used. The operation indicator target should drop freely, bringing the letter “I” into view.

6.5 AUXILIARY UNIT (CS-1, TR-1)

Verify the R2 resistor tap is set to the appropriate control voltage (See “RELAY SETTINGS”).

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 0.5 - 2.5 amps range CO-5 and CO-6 induction unit use the alternative test circuit in Figure 15 (page 27) as these relays are affected by a distorted wave form. With this connection the 25/5 amps 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 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 the 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 TEST”).

8.1 TIME OVERCURRENT UNIT (CO)

1. **Contacts** — 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.

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 “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.

   With the auxiliary unit (CS-1 or TR-1) contacts blocked closed, 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 1 for permanent magnet adjustment (e.g., IRV-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 1.

   For type IRV-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 11, page 24). 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 1 for the electromagnet plug adjustment (e.g., IRV-8, 20 times tap value) and measure the operating time. Adjust the proper plug until the operating time corresponds to the value in Table 1. ***(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.

8.2 DIRECTIONAL UNIT (D)

The directional unit is the lower cylinder unit.

1. The upper bearing screw should be screwed down until there is approximately .025" clearance between it and the top of the shaft bearing. The upper pin bearing should then be securely locked in position with the lock nut.

2. Contact gap adjustment for the directional unit is made with the moving contact in the reset position, i.e., against the right side of the bridge. Advance the right hand stationary contact until the contacts just close. Then advance the stationary contact an additional one-half turn.

   Now move in the left-hand stationary contact until it just touches the moving contact. Then back off the stationary contact 2/3 of one turn for a contact gap of .020". 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.

3. Insert tap screw of overcurrent unit in highest tap. 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 contact will close as indicated by a neon lamp in the contact circuit when energized with 1.2 volts and 4 amps (current leading 30°) for the 4 - 12 amps range relays and 1.2 volts and 2 amps for the 0.5 - 2.5 and 2 - 6 amps range relays. This can be done approximately using current in phase with voltage by increasing the pickup current to 4.6 and 2.3 amps respectively.

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

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

   Apply 120 Vac 60 Hz to terminals 6 and 7, relay contacts should stay open. If the contacts are closed rotate core by means of adjustor located on the bottom side of the cylinder unit until contacts stay open. The core assembly is held in position by the clamping action of two compressed springs. This allows its position to be changed by inserting a non-magnetic tool into the slot on the bottom side of the unit.

   Short circuit both the voltage terminals and CO coil. Apply current to the operating circuit terminals as per Table 2 (page 11).

   Plug adjustment is then made per Table 2 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 used 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.

† ***Plugs should be at "fully screwed in" position prior to adjustment of core.***

8.3 INSTANTANEOUS OVERCURRENT UNIT (I) WITH SATURATING TRANSFORMER (I-ST)

1. The upper pin bearing should be screwed down until there is approximately 0.025" 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 overcurrent unit is made with the moving contact in the reset position, i.e., against the right side of the bridge.

   Move in the left-hand stationary contact until it just touches the moving contact. Then back off the stationary contact 2/3 of one turn for a gap of approximately .020". 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.

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.

   Before applying current, block close the contacts of the D unit. Insert the tap screw in the minimum value tap setting and adjust the spring such that the contacts will close as indicated by a neon lamp in the contact circuit when energized with the required current. The pickup of the overcurrent unit with the tap screw in any other tap should be within ± 5% of tap value.

   If adjustment of pickup current between tap settings is desired, insert the tap screw in the next lowest tap setting and adjust the spring as described. It should be noted that this adjustment results in a slightly different time characteristic curve and burden.

8.4 INDICATING CONTACTOR SWITCHES (ICS-I AND ICS-T)

1. Adjust the contact gap for approximately 0.047". For proper contact adjustment, insert a .030" feeler gauge between the core pin and the armature. Hold the armature closed against the core pin and gauge. Adjust the stationary contacts such that they just make with the moving contact. Both stationary contacts should make at approximately the same time. The contact follow will be approximately 1/64 "to 3/64".

2. Close the contacts of the CO and the directional unit and pass sufficient dc current through the trip circuit to close the contacts of the (ICS-T). This value of current should not be greater than the particular (ICS-T) tap setting being used. The operation indicator target should drop freely, bringing the letter "T" into view.

3. Close contacts of instantaneous overcurrent unit (I) and directional unit (D). Pass sufficient dc current through the trip circuit to close contacts of the (ICS-I). This value of current should not be greater than the particular (ICS-I) tap setting being used. The operation indicator target should drop freely bringing the letter "I" into view.

8.5 AUXILIARY UNIT (CS-1 OR TR-1)

1. CS-1 **–** Adjust the stationary core of the CS-1 for a clearance between the stationary core and the moving core when the switch is picked up. This can be done by turning the relay upside-down. Then screw up the core screw until the moving core starts rotating. Now back off the core screw until the moving core stops rotating. This indicates the points when the play in the assembly is taken up, and where the moving core just separates from the stationary core screw. Back off the core screw approximately one turn and lock in place. This prevents the moving core from striking and sticking to the stationary core because of residual magnetism. Adjust the contact clearance for 3/64" by means of the two small nuts on either side of the Micarta disc.

2. TR-1 – No adjustments or calibrations are required for the auxiliary unit (TR-1).

3. Connect lead (A) to proper resistor terminal per Figure 14, page 26. Block directional unit (D) contacts closed and energize trip circuit with rated voltage. Contacts of auxiliary unit should make, this is indicated by a neon lamp in the contact circuit.

9.0 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 1:

TIME CURVE CALIBRATION DATA — 60 HERTZ

		PERMANENT MAGNET ADJUST.		ELECTROMAGNET PLUGS	
TIME-OVERCURRENT UNIT 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
11	6	1.3	54.9		

Table 2:

DIRECTIONAL UNIT CALIBRATION †

Relay Rating	Current	Adjust	Adjustment
0.5 to 2.5 amps and 2-6 amps	40 amps	Magnetic Plugs	If spurious torque is in the contact closing direction (left front view) screw out right magnetic plug until direction of spurious torque is reversed.
4-12	80 amps		If spurious torque is in the contact opening direction, screw out left plug until spurious torque is slight contact opening. Recheck at 40, 25 and 10 amps for the lower range units and 80, 50 and 20 amps for the 4-12 amps range relays.

† *Short circuit the voltage polarizing circuit at the relay terminals before making the above adjustments*

ENERGY REQUIREMENTS

Instantaneous Overcurrent Unit Operating Current Circuit — 60 Hertz

Ampere Range	Tap	Continuous Rating (amps)	One Second Rating (amps)†	VA at Tap Value††	Power Factor Angle‡	VA at 5 Amps.††	Power Factor Angle‡
.5 - 2	0.5	5	100	.37	39	24	46
	0.75	5	100	.38	36	13	37
	1.0	5	100	.39	35	8.5	34
	1.25	5	100	.41	34	6.0	32
	1.5	5	100	.43	32	4.6	31
	2.0	5	100	.45	30	2.9	28
1 - 4	1.0	8	140	.41	44	9.0	36
	1.5	8	140	.44	32	5.0	32
	2.0	8	140	.47	30	3.0	29
	2.5	8	140	.50	28	2.1	27
	3.0	8	140	.53	26	1.5	26
	4.0	8	140	.59	24	0.93	24
2 - 8	2.0	8	140	1.1	49	6.5	48
	3.0	8	140	1.2	43	3.3	42
	4.0	8	140	1.3	38	2.1	37
	5.0	8	140	1.4	35	1.4	35
	6.0	8	140	1.5	33	1.1	33
	8.0	8	140	1.8	29	0.7	29
4 - 16	4.0	10	200	1.5	51	2.4	51
	6.0	10	200	1.7	45	1.2	45
	8.0	10	200	1.8	40	0.7	40
	9.0	10	200	1.9	38	0.6	38
	12.0	10	200	2.2	34	.37	34
	16.0	10	200	2.5	30	.24	31
10 - 40	10.0	10	200	1.7	28	0.43	28
	15.0	10	200	2.4	21	0.27	21
	20.0	10	200	3.1	16	0.20	17
	24.0	10	200	3.6	15	0.15	15
	30.0	10	200	4.2	12	0.11	13
	40.0	10	200	4.9	11	0.08	12
20 - 80	20.0	10	200	6.6	31	0.04	31
	30.0	10	200	9.3	24	0.25	24
	40.0	10	200	12.0	20	0.18	20
	48.0	10	200	13.5	18	0.14	18
	60.0	10	200	15.9	16	0.10	16
	80.0	10	200	19.2	15	0.07	15

† *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 REQUIREMENTSs

Type IRV-2 Time Overcurrent Unit

Ampere Range	Tap	Continuous Rating (amps)	One Second Rating† (amps)	Power Factor Angle‡	Volt amps†† 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
	2.5	2.50	28	29	7.9	73.6	700	2850
2/6	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
	5.0	5.6	110	41	5.90	50.	420	1500
	6.0	6.0	110	37	6.54	54.9	474	1800
4/12	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	5.35	45.8	364	1260
	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

Type IRV-5 — IRV-6 Time Overcurrent Units

Ampere Range	Tap	Continuous Rating (amps)	One Second Rating† (amps)	Power Factor Angle‡	Volt amp†† 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	.5	2.7	88	69	3.92	20.6	103	270
	.6	3.1	88	68	3.96	20.7	106	288
	.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	3.87	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	4.08	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	4.27	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

† *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

Type IRV-7 Time Overcurrent Units

Ampere Range	Tap	Continuous Rating (amps)	One Second Rating† (amps)	Power Factor Angle‡	Volt amps†† 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	256
	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

IRV-8 — IRV-9 Time Overcurrent Units

Ampere Range	Tap	Continuous Rating (amps)	One Second Rating† (amps)	Power Factor Angle‡	Volt amps†† At Tap Value Current	At 3 Times Tap Value Current	At 10 Times Tap Value Current	At 20 Times Tap Value Current
.05/2.5	.5	2.7	88	72	2.38	21	132	350
	.6	3.1	88	71	2.38	21	134	365
	.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

† *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

Type IRV-11 Time Overcurrent Units

Ampere Range	Tap	Continuous Rating (amps)	One Second Rating† (amps)	Power Factor Angle‡	Volt amps†† 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	6.8	75.0	267
	0.8	2.2	56	30	0.81	7.46	84.0	298
	1.0	3.5	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	1.80	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.*

ENERGY REQUIREMENTS

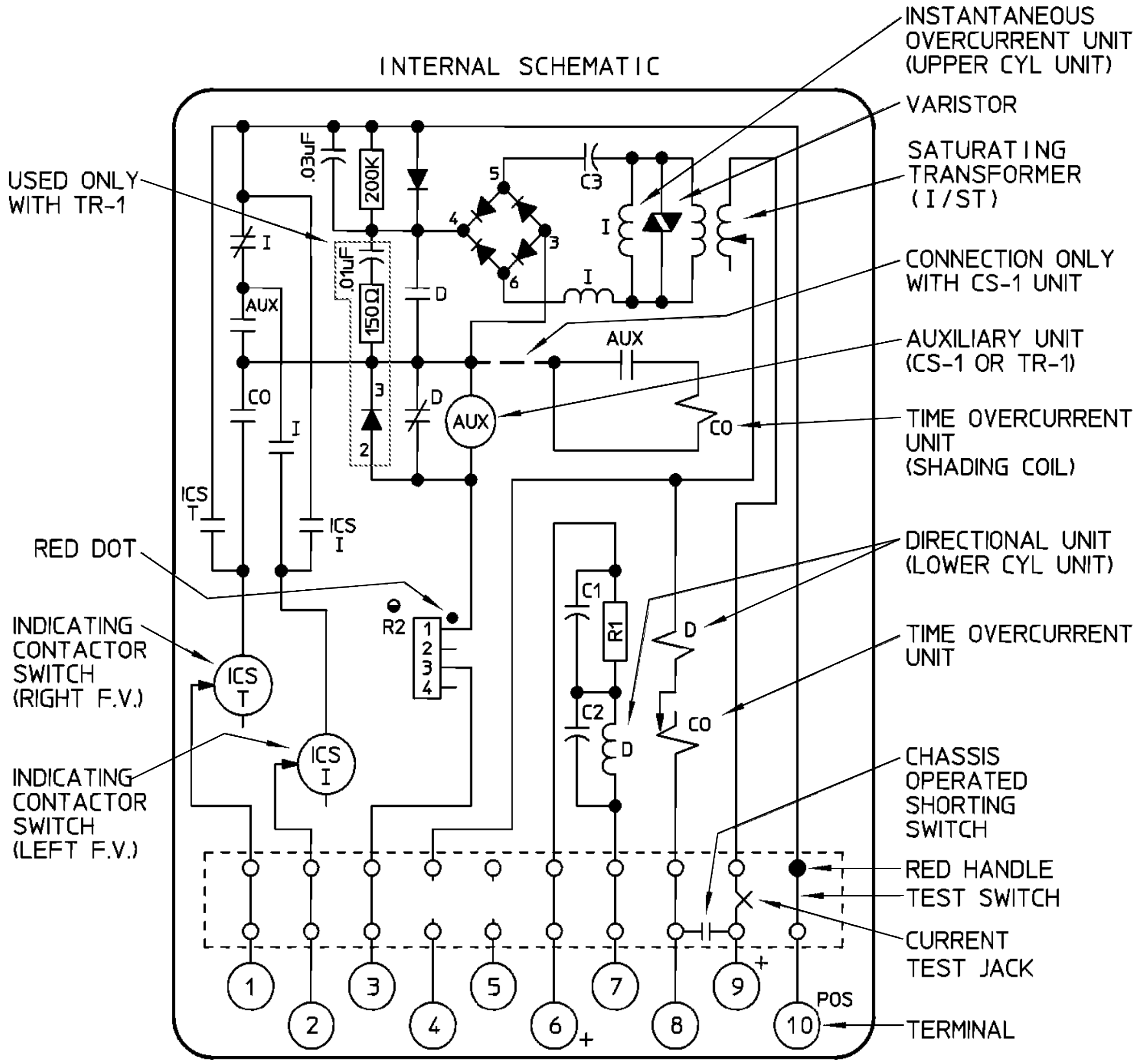
Directional Unit Operating Circuit Burden– 60 Hertz

Ampere Range	Continuous Rating (amps)	One Second Rating† (amps)	Power Factor Angle‡	Volt amps†† At Minimum Tap Value Current	At 3 Times Minimum Tap Value Current	At 10 Times Minimum Tap Value Current	At 20 Times Minimum Tap Value Current
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
4 - 12	12	280	28.5	0.48	4.62	53.6	216.0

† *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.*

DIRECTIONAL UNIT POLARIZING CIRCUIT BURDEN

The burden at 120V, 60 cycles, is 12.5 volt-amps at 15 degrees. (Current leading voltage).



FRONT VIEW

DC CONTROL CIRCUIT			
AUX UNIT	TRIP VOLT	⊖ - RESISTOR R2	
		LEAD POS	VALUE
CS-1	24 Δ	FIXED POS.	100 Ω
	48	2	300 Ω
	125	3	2700 Ω
	250	4	6500 Ω
TR-1	24 Δ	FIXED POS.	500 Ω
	48	2	2200 Ω
	125	3	9300 Ω
	250	4	20800 Ω

Δ = 24 VOLT RELAYS ARE SEPARATE STYLE NO's.

NOTE:

WITH RELATIVE INSTANTANEOUS POLARITY AS SHOWN, THE DIRECTIONAL CONTACTS CLOSE.

*Sub 11
185A421

Figure 3 .Internal Schematic of the Type IRV Relay in the Type FT-31 Case

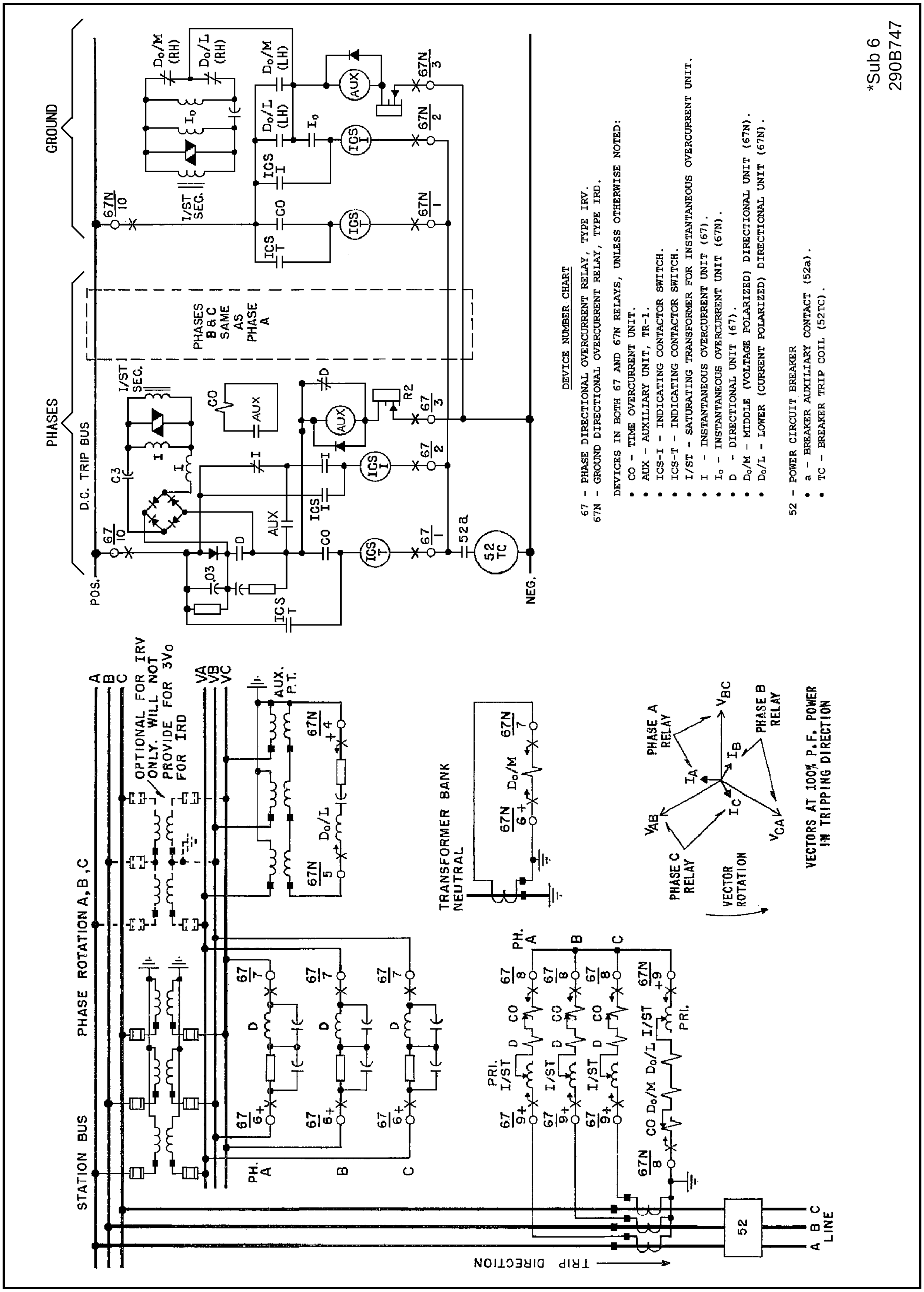


Figure 4. External Schematic of the IRV Relay for Phase Protection and the IRD Relay for Ground Protection

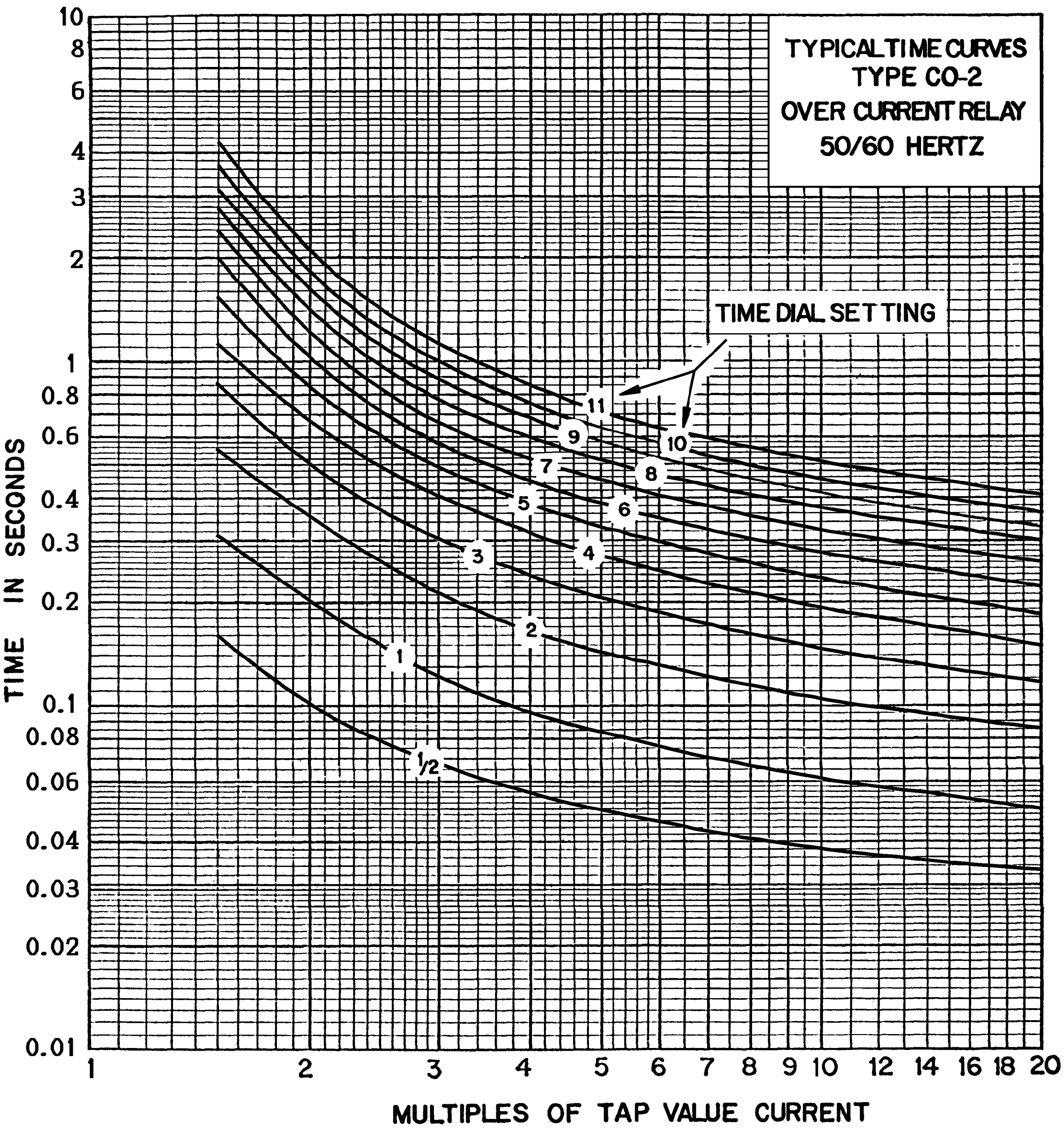
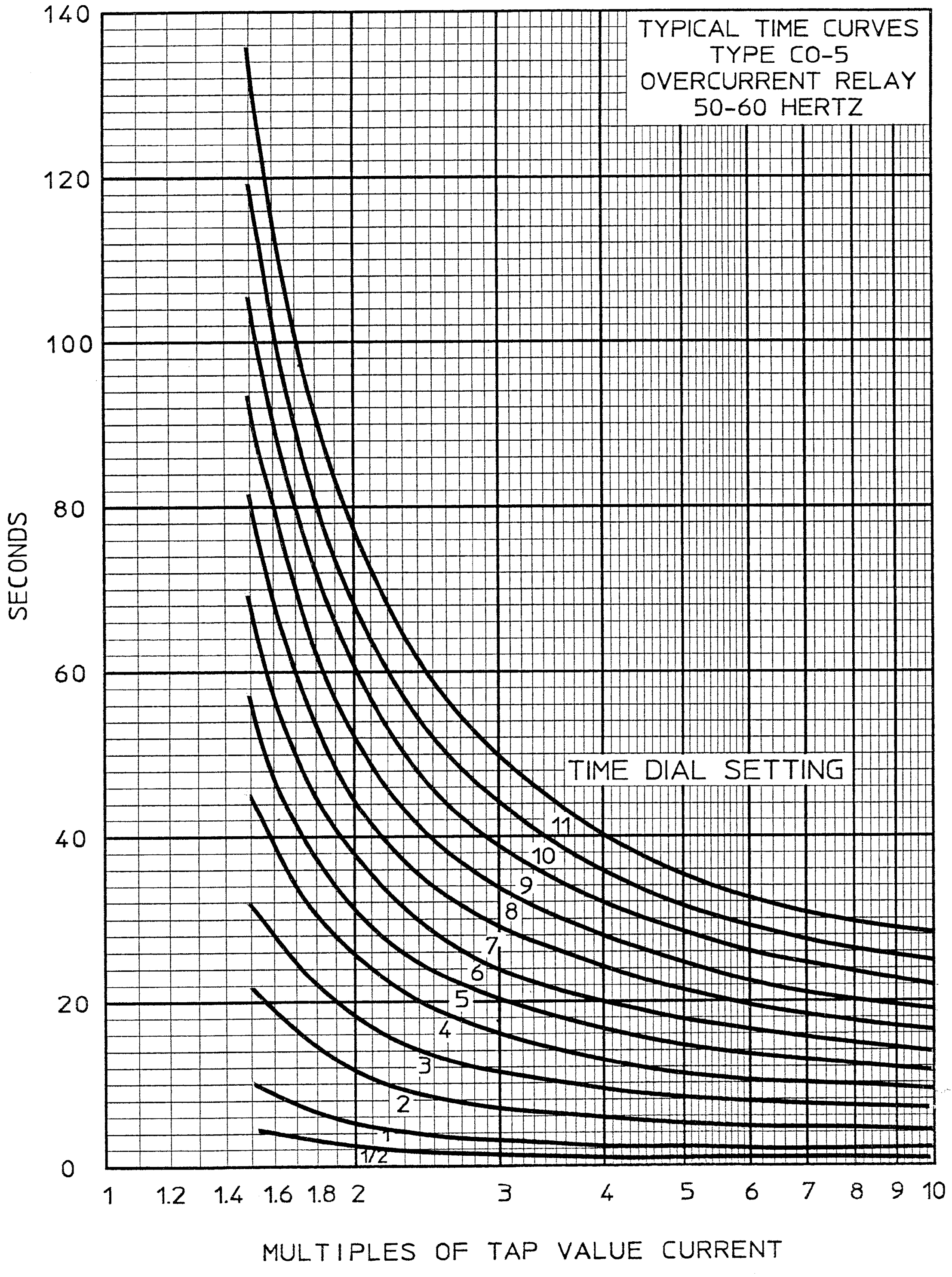


Figure 5 .Typical Time Curves of the Time-Overcurrent Unit Short Time (CO-2) Relays.



*Sub 3
418245

Figure 6. Typical time Curve of the Time-Overcurrent Unit Long Time (CO-5) Relays

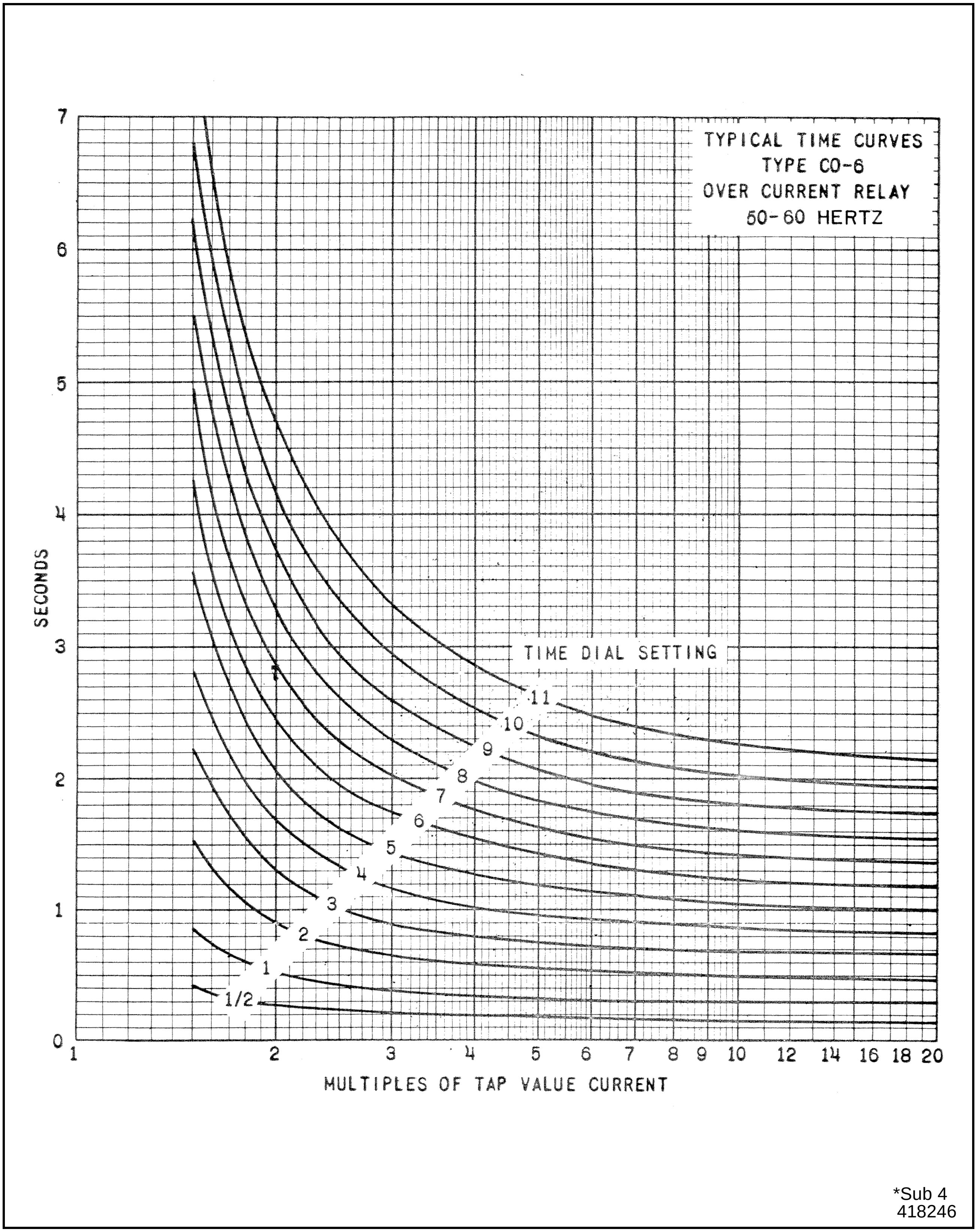


Figure 7. Typical Time Curve of the Time-Overcurrent Unit Definite Time (CO-6) Relays

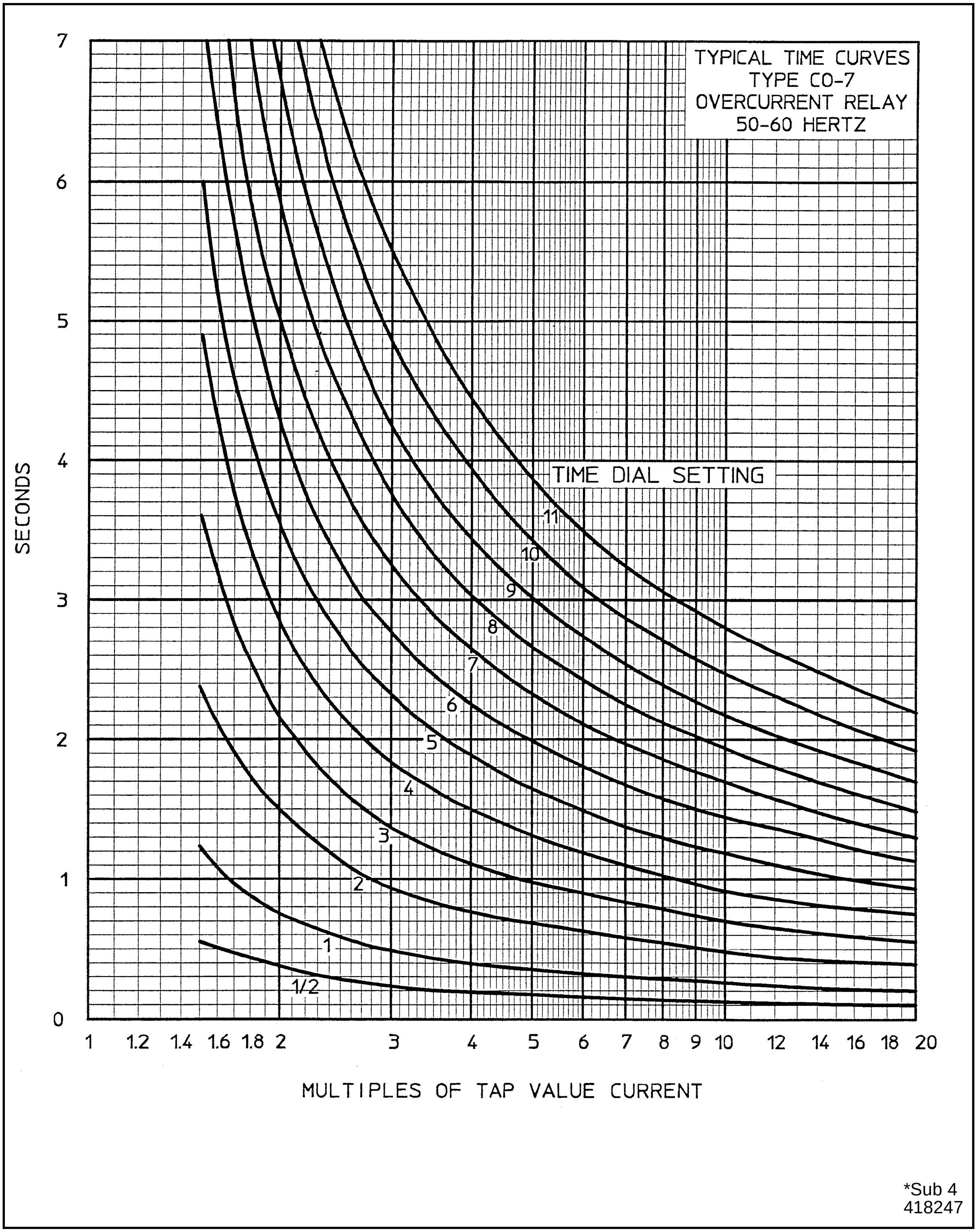


Figure 8 .Typical Time Curve of the Time-Overcurrent Unit Moderately Inverse (CO-7) Relays.

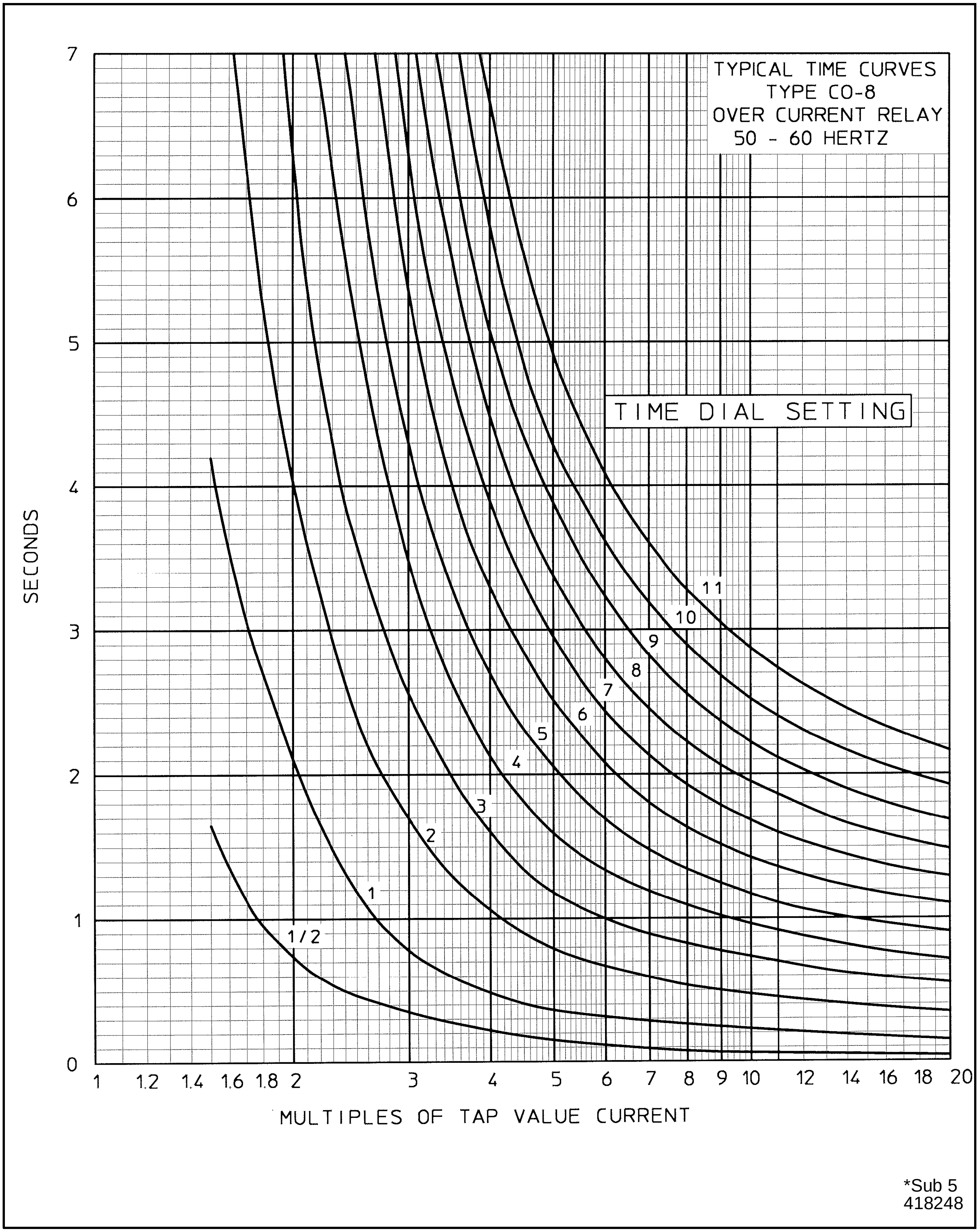


Figure 9. Typical Time curve of the Time-Overcurrent Unit Inverse (CO-8) Relays

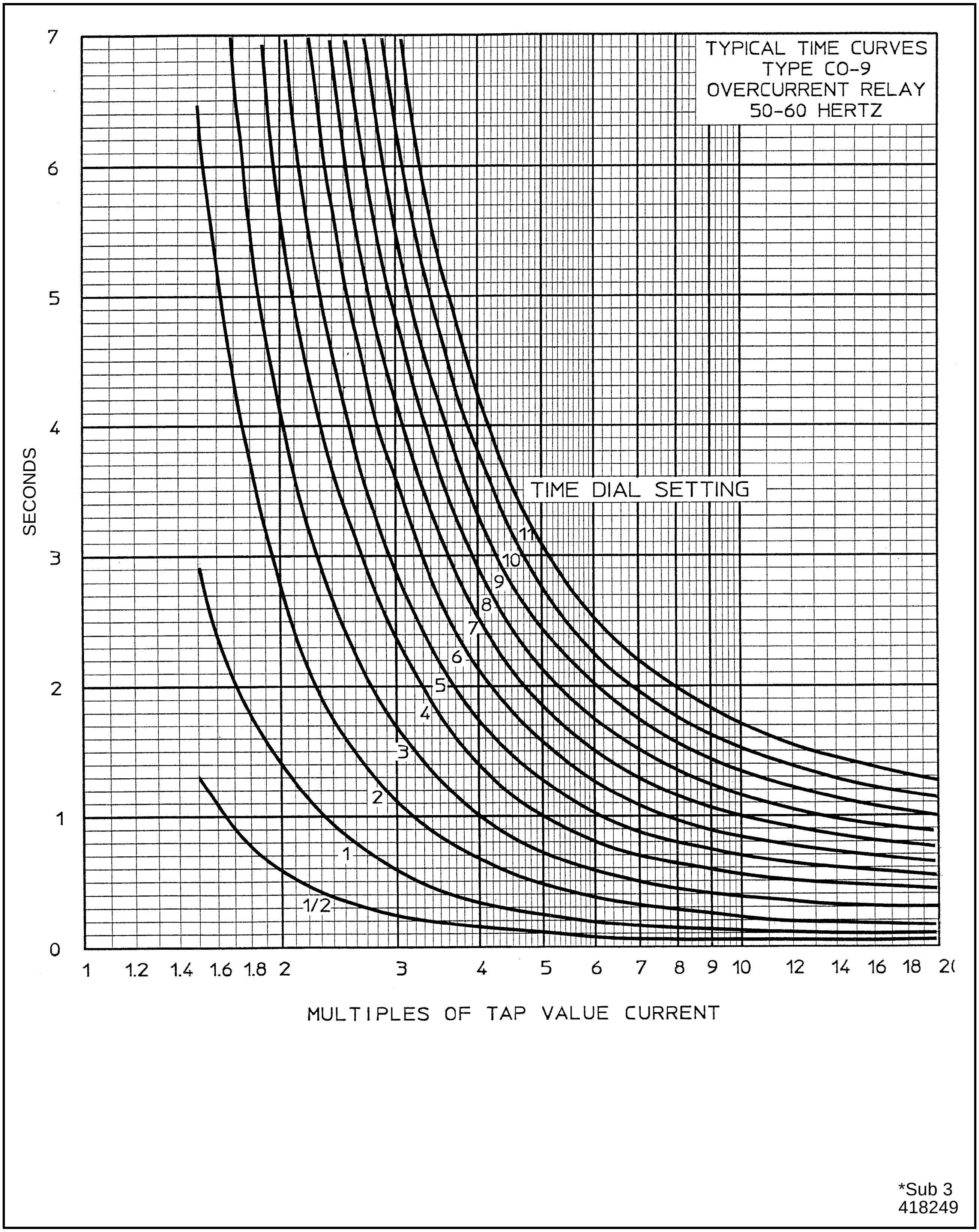
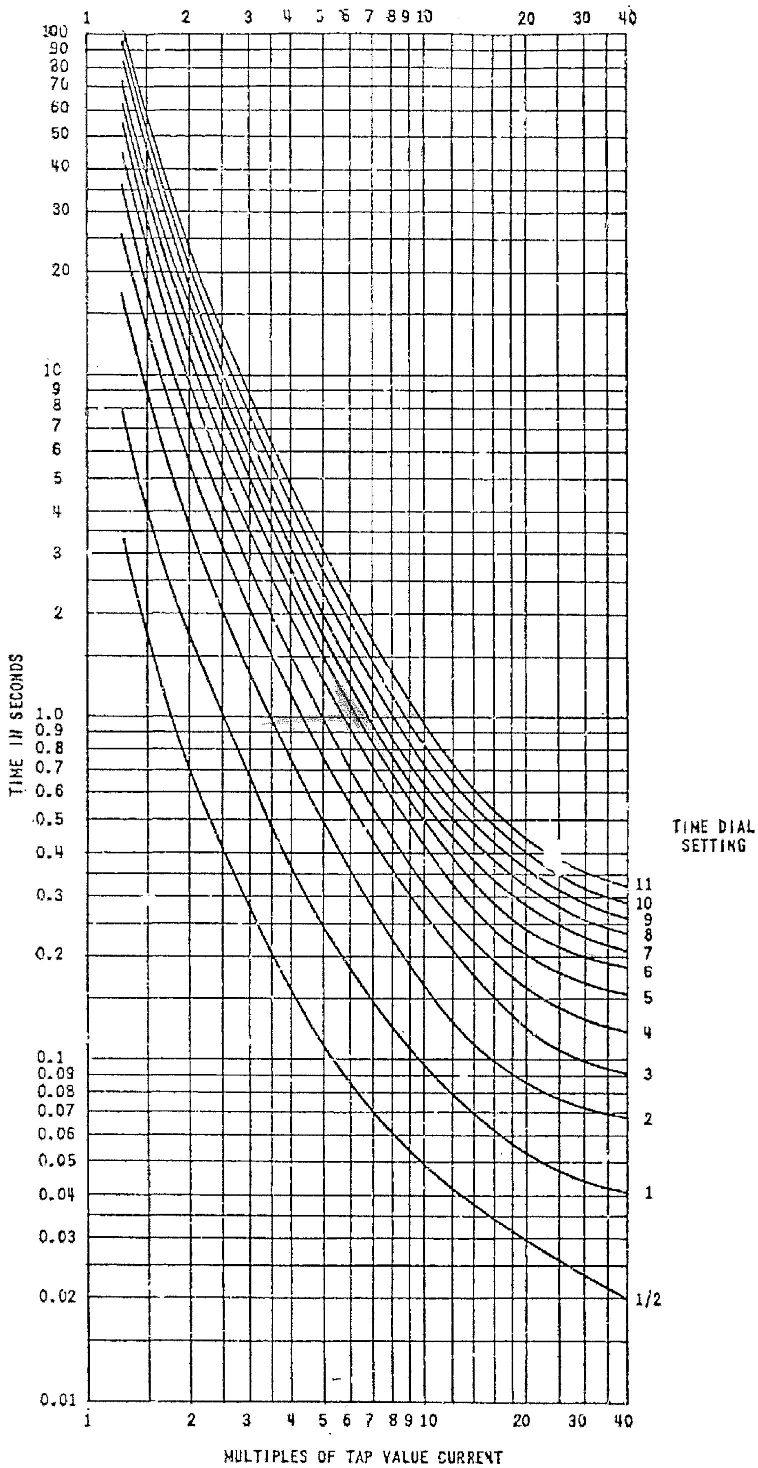


Figure 1 0 Typical Time Curve of the Time-Overcurrent Unit Very Inverse (CO-9) Relays



Sub 2
288B655

Figure 1 1 Typical Time Curve of the Time-Overcurrent Unit Extremely Inverse (CO-11) Relays

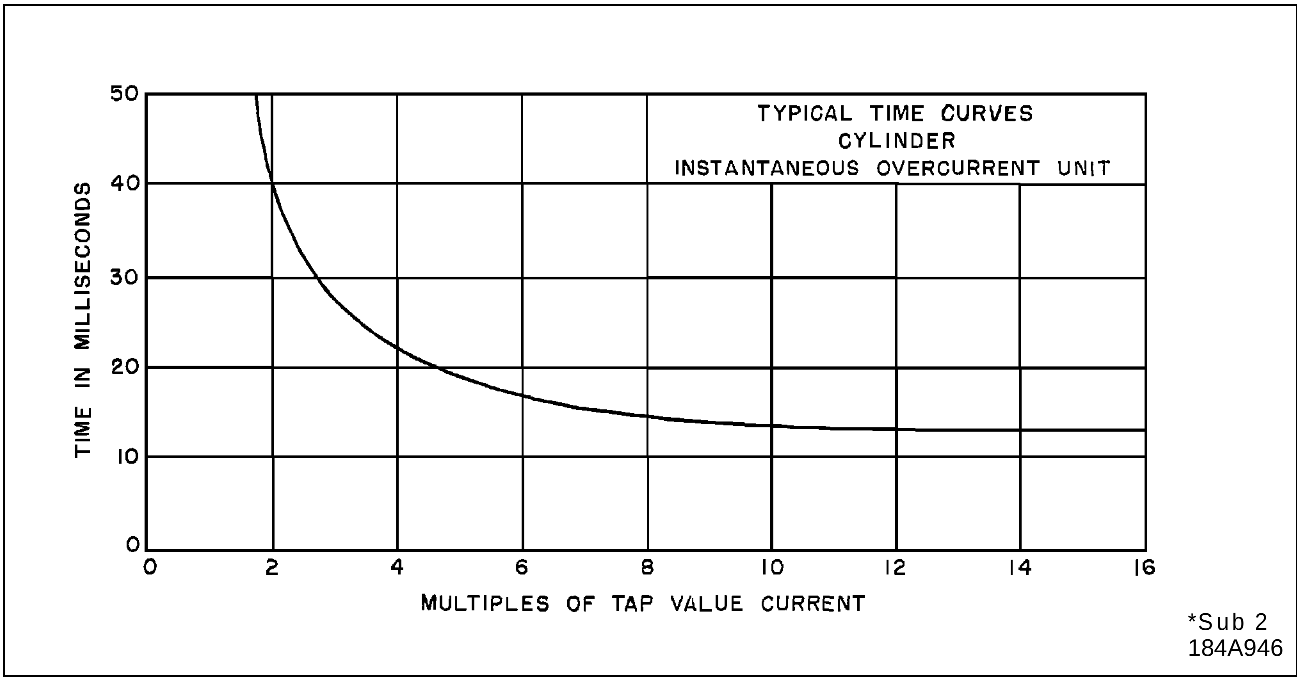


Figure 1 2 Typical Time Curve of the Instantaneous Overcurrent Unit.

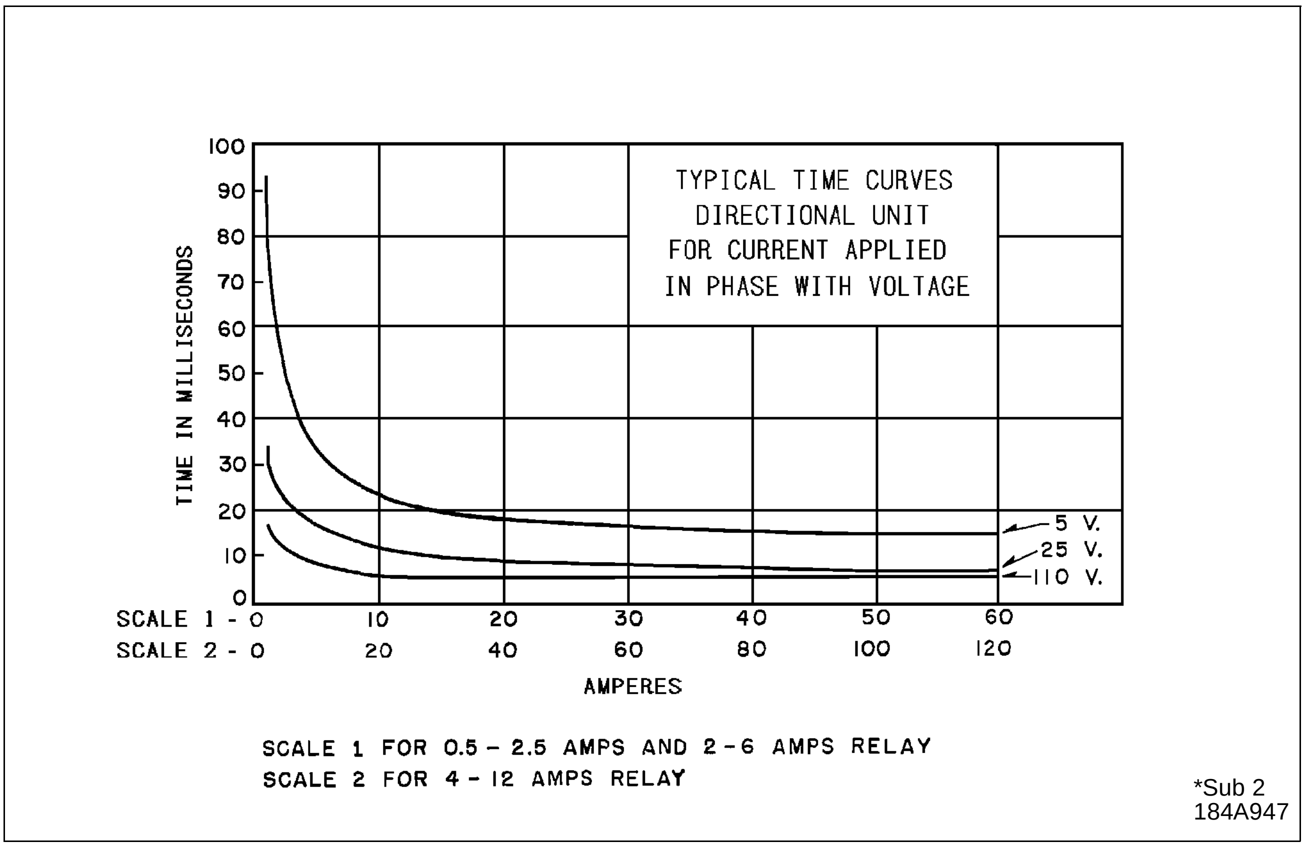
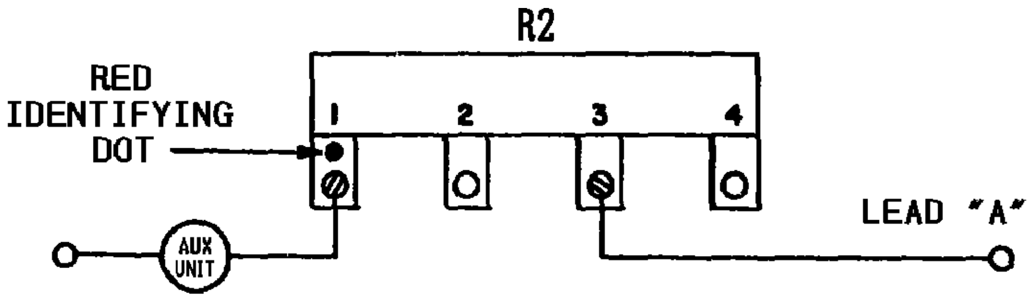


Figure 1 3 Typical Time Curve of the Directional Unit



DC CONTROL CIRCUIT			
AUX UNIT	TRIP VOLTAGE	RESISTOR "R2"	
		LEAD "A" POS.	VALUE
CS-1	**24** *	FIXED POS.	100
	48	**2**	**300**
	125	**3**	**2700**
	250	**4**	**6500**
TR-1	**24** *	FIXED POS.	500
	48	**2**	**2200**
	125	**3**	**9300**
	250	**4**	**20800**

* = 24 VOLT RELAYS ARE SEPARATE STYLE NUMBERS, WITH FIXED VALUE OF R2.

NOTE: 48/125/250 VOLT RELAYS ARE SHIPPED ON THE 125 VOLT TAP.

* Sub 1
9672A85

Figure 1 4 Selection of Proper Voltage Tap for auxiliary unit *(CS-1 or TR-1) Operation*

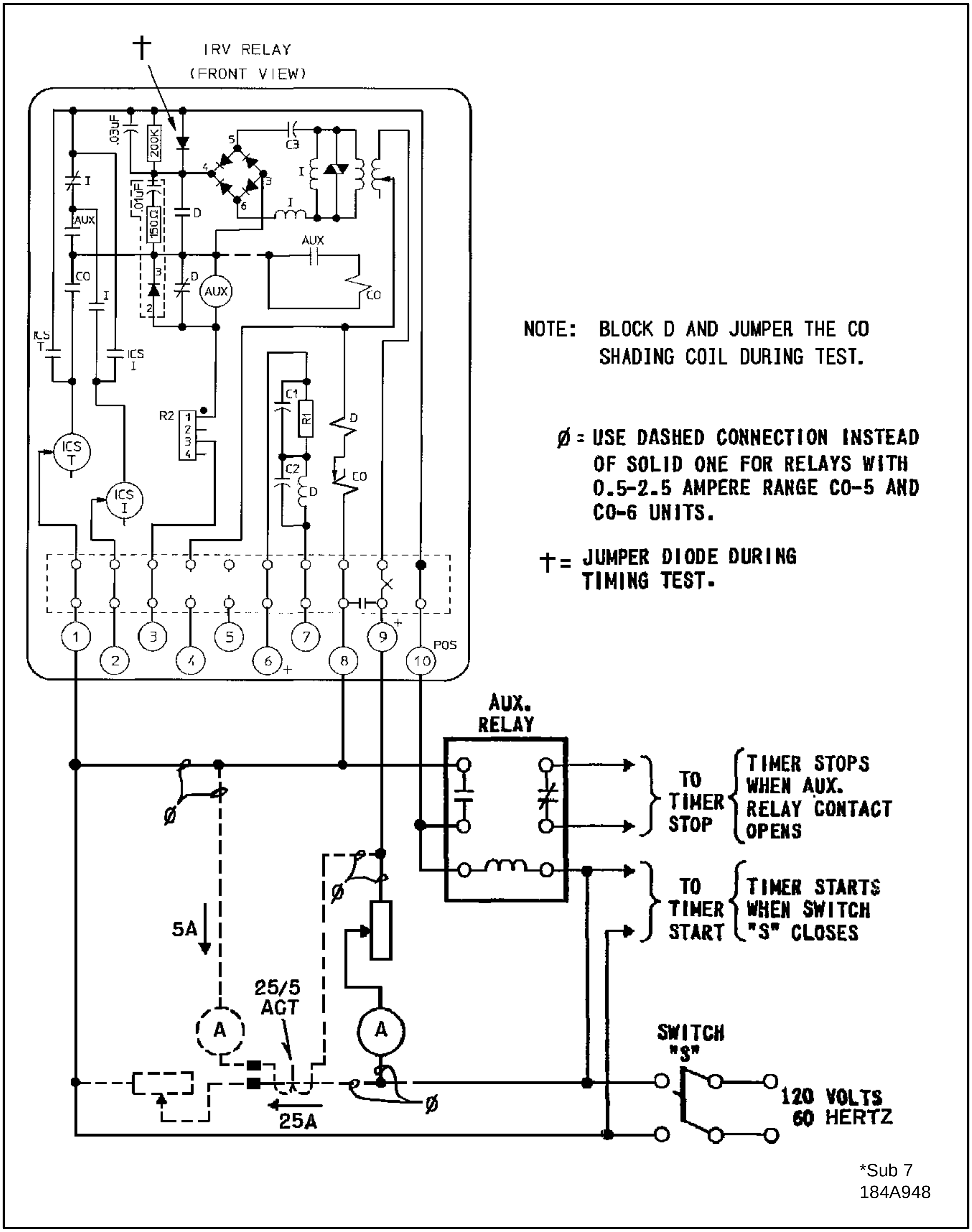


Figure 1 5 Diagram of Test Connections of the Time-overcurrent Unit

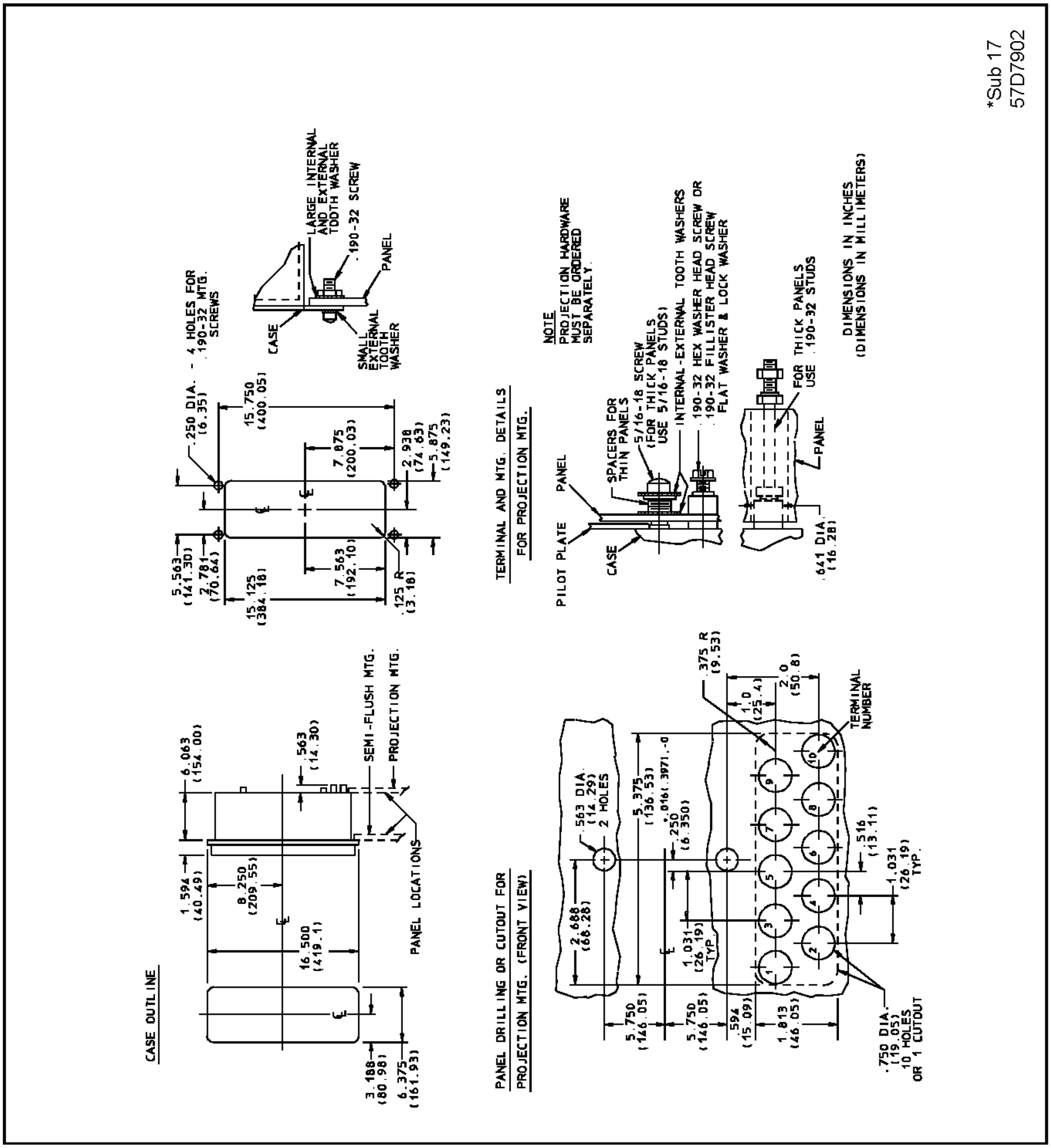


Figure 16. Outline and Drilling Plan for the Type IRV Relay in the Type FT31 Case

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