ABB Power T&D Company Inc.
Relay Divisions
Coral Springs, FL 33065

Instruction Leaflet
41-106.1B

Type CO-4 Step-Time Overcurrent Relay For Class IE Applications

Effective: July 1983
Supersedes I.L. 41-106.1A, Dated September 1979

✪ Denotes Change Since Previous Issue

CAUTION

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

APPLICATION

These relays have been specially designed and tested to establish their suitability for Class IE applications. Materials have been selected and tested to insure that the relays will perform their intended function for their design life when operated in a normal environment as defined by ANSI standard C37.90-1978, when exposed to radiation levels up to 10^4 rads, and when subjected to seismic events producing a Shock Response Spectrum within the limits of the relay rating.

With the synchronous timer (T) set for not less than 70 cycles, the type CO-4 relay has a seismic Zero Period Acceleration (ZPA) rating greater than 5.7 g as defined in IEEE standard C37.98 for broad-band multifrequency fragility testing.

"Class IE" is the safety classification of the electric equipment and systems in nuclear power generating stations that are essential to emergency shutdown of the reactor, containment isolation, cooling of the reactor, and heat removal from the containment and reactor, or otherwise are essential in preventing significant release of radioactive material to the environment.

The type CO-4 relay is used in applications that require a step-type current vs time characteristics. A typical application is as an overcurrent relay that is to coordinate with Westinghouse type DS circuit breaker or circuit breaker with similar tripping characteristics.

CONSTRUCTION AND OPERATION

The type CO-4 relay consists of an overcurrent unit (CO-5), an indicating contactor switch (ICS), an indicating instantaneous trip (IIT) mounted on the left hand pedestal, and a timer (T) which is activated by a current operated instantaneous trip (IT). See Figs. 1 and 2. Internal schematic, Fig. 3, shows the relationships of these units.

Electromagnet

The electromagnet of the overcurrent unit has a main tapped coil located on the center leg of an "E" type laminated structure that produces a flux which divides and returns through the outer legs. A shading coil causes the flux through the left leg to lag the main pole flux. The out-of-phase fluxes thus produced in the air gap cause a contact closing torque.

Indicating Contactor Switch Unit (ICS)

The dc indicating contactor switch is a small clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attached to the magnetic core upon energizing 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

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located on the front of the switch, which allows the operation indicator target to drop.

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

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.

A core screw accessible from the top of the switch and taps on the coil provides the adjustable pickup range.

Timer (T)

The timer may be either an electromechanical or a solid-state type. The electromechanical timer is a small synchronous motor which operates from the current circuit through a saturating transformer, and drives a moving contact arm through a gear train. The contact on the moving arm is a cylindrical silver sleeve, loosely fitted on the moving arm. In making contact, this sleeve strikes two vertically projecting stationary butt contacts to bridge the gap between them. The loose fit of the sleeve permits a positive alignment in bridging these contacts, and, therefore, correct contact action is not greatly dependent on their adjustment. The stationary contacts are mounted on a molded insulating block which is adjustable around a semicircular calibrated guide. The maximum time setting of the timer is three seconds.

The synchronous motor has a floating rotor which is in mesh with the gear train only when energized. The rotor falls out instantly when the motor is de-energized, allowing a spring to reset the moving arm.

The solid-state timer consists of a printed circuit board with an output telephone relay, a rectifier, two operational amplifiers and several associated components.

Instantaneous Trip Unit (IT)

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 timer circuit.

A core screw accessible from the top of the switch and taps on the coil provides the adjustable pickup range.

The IT contacts are connected in series with the timer to allow an adjustable time delay after the IT picks up.

CHARACTERISTICS

The typical current ranges of the unit of the type CO-4 relay are as follows:

CO-5 type long time overcurrent unit 4 to 12 amperes with taps at 4-5-6-7-8-10 and 12 amperes. The tap value is the minimum current required to just close the relay contacts.

IIT instantaneous unit has an adjustable range of 6 to 144 Amperes.

The IT instantaneous unit has an adjustable range of 6 to 144 amperes. However, the useable range of the device is 10 to 100 amperes. This range restriction is due to the timer (T) which is activated by the IT device. The range of the timer is 10 to 100 amperes and 0.5 to 3 seconds for the electromechanical unit or 0.25 to 3 seconds for the solid-state unit.

The typical operating curves of the CO-5 unit are shown by Fig. 4. The time dial indicates starting position of the moving contact over a 270^{o} range. Indexes from 1 (minimum time) to 11 (maximum time).

The typical band curves of the overall operating characteristic of the type CO-4 relay are shown by Fig. 5.

Trip Circuit

All tripping contacts are connected in parallel which allows tripping by the CO-5 long time unit,

IT plus time delay or IIT instantaneously, depending on the relative unit settings and current magnitude.

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

The indicating instantaneous trip contacts will close 30 amperes at 250 volts dc, and will carry this current long enough to trip a breaker.

Trip Circuit Constants

Indicating Contactor Switch Coil

Ampere Pickup	Ohms dc Resistance
0.2	8.5
1.0	0.37
2.0	0.10

SETTINGS

The settings are made to obtain an operating characteristic similar to that indicated by the example curve of Fig. 5.

CO Unit

The 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, 6.0 seconds at 4 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 screw on the terminal 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.

CAUTION

Since the tap block connector screw carries operating current, be sure that the screw is turned tight.

In order to avoid opening current transformer circuits when changing taps under load, the relay must be first removed from the case. Chassis operating shorting switches on the case will short the secondary of the current transformer. The taps should then be changed with the relay outside of the case and then re-inserted into the case.

Instantaneous Reclosing

The factory adjustment of the CO unit contact provides a contact follow. When instantaneous circuit breaker reclosing will be initiated upon the closure of the CO contact, this contact follow must be eliminated 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. With this change and the contact mounting screw tightened, the stationary contact will rest solidly against its backstop.

Indicating Contactor Switch (ICS)

There are no settings to make on the indicating contactor switch (ICS).

INDICATING INSTANTANEOUS TRIP (IIT)

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

The nameplate data will furnish the actual current range that may be obtained from the IIT unit. It is recommended that the IIT be set on the higher tap where there is a choice of tap settings. For example, for a 20 ampere setting use the 20 to 50 tap rather than the 6 to 20 tap.

INSTANTANEOUS TRIP UNIT (IT)

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

The nameplate data will furnish the actual current range that may be obtained from the IT

unit. It is recommended where there is a choice of tap settings that the IT unit be set on the higher tap setting. For example, for a 20 ampere setting use the 20 to 50 tap rather than the 6 to 20 tap.

Timer (T)

The operating time of the electromechanical timer is controlled by a molded insulating block, on which the stationary contacts are mounted. These are adjustable around a semi-circular calibrated guide. The maximum time setting of the timer is three seconds (180 cycles) and the minimum time setting of the timer is 0.5 seconds (30) cycles. Its setting should be 70 cycles or more to achieve a seismic fragility greater than 5.7 g ZPA.

The solid-state timer uses a trimpot P1 which controls the time delay from 0.25 to 3.0 seconds. This range is marked on the P.C. board. (See Fig. 6) The time delay is proportional to the time constant produced by P1, R7, C2 and C3 as shown in Fig. 7. The first op-amp is used as a voltage follower and the second one is used as a voltage level detector. As the voltage across the capacitor C2 exceeds the voltage level at pin 6 of IC2, the output telephone relay picks up to close the T contacts.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration and heat. Mount the relay vertically by means of the four mounting holes on the flange for the semi-flush type FT case. The mounting screws may be utilized for grounding the relay. External toothed washers are provided for use in the locations shown on the outline and drilling plan to facilitate making a good electrical connection between the relay case, its mounting screws and the relay panel. Ground wires should be affixed to the mounting screws as required for poorly grounded or insulating panels. Other electrical connections may be made directly to the terminals by means of screws for steel panel mounting.

For detail information on the FT case refer to I.L. 41-076 for semi-flush mounting.

ADJUSTMENTS AND MAINTENANCE

Proper adjustments have been made at the factory. Upon receipt of the relay no customer adjustments, other than those covered under "SETTINGS" should be required.

Performance Check

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

CO UNIT

1. Contact

The index mark on the movement frame will coincide with the "O" mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "O" mark by approximately .020". The placement of the various time dial positions in line with the index mark will give operating times as shown on the respective time-current curves.

2. 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%.

3. Time Curve

Table I shows the time curve calibration points. With the time dial set to the indicated position, apply the currents specified by Table I and measure the operating time of the relay. The operating times should equal those of Table I plus or minus 5 percent.

Indicating Instantaneous Trip (IIT)

The core screw which is adjustable from the top of the trip unit and the tap located on the top of the IIT determines the pickup value. The trip unit has a nominal ratio of adjustment of 1 to 24.

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

Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient dc current through the trip current to close the contacts of the ICS. This value of current should not be greater than the particular ICS nameplate rating. The indicator target should drop freely.

Repeat above except pass 85% of ICS nameplate rating current. Contacts should not pickup and target should not drop.

Instantaneous Trip Unit (IT)

The core screw which is adjustable from the top of the trip unit and the tap located on the side of the IT determines the pickup value. The unit has a nominal ratio of adjustment of 1 to 24 but its range is limited from 10 amperes to 100 amperes.

Apply sufficient current to operate the IT.

Timer (T)

When checking the electromechanical synchronous timer, complete the transformer circuit by a jumper around the contacts of the IT unit. Test the motor at 10 amperes (or the current indicated by the minimum possible setting of the IT unit) through the current circuit which includes the auxiliary transformer primary. This is the minimum current at which the timer will run in synchronism.

With the solid-state timer, it is not necessary to jumper around the IT contacts. Energize the IT circuit at 150% of the IT setting to check the timer setting. The time delay of the solid-state timer is adjusted by a trimpot P1. A small arrow on the trimpot indicates the setting position which is marked on the P.C. board. The timer is factory calibrated and set for a time delay of 2.5 seconds.

ROUTINE MAINTENANCE

All relays should be inspected periodically. They should receive a "Performance Check" at least once every year or at such other time intervals as may be dictated by experience to be suitable to the particular application. A minimum suggested check on the relay system is to close the contacts manually so 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 test current through the relay check the time of operation. It is preferable to make this at several times pick-up current at an expected operating point for the particular application.

All contacts should be checked and cleaned if necessary. A contact burnisher #182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

CALIBRATION

Use the following procedure for calibrating the relay if the relay has been taken apart for repairs or the adjustments disturbed. This procedure should not be used until it is apparent that the relay is not in proper working order. (See "Performance Check").

NOTE

A spring shield covers the reset spring on the CO unit. To remove the spring shield, requires that the damping magnet be removed first. The screw connection holding the lead to the moving contact should be removed next. The second screw holding the moving contact assembly should then be loosened not removed. (CAUTION: This screw terminates into a nut held captive beneath the molded block. If the screw is removed, difficulty will be experienced in the re-assembly of the moving contact assembly.) Slide the spring shield outward and remove from relay. Tighten the screw holding the moving contact assembly to the molded block.

CO UNIT

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.

The spiral can be adjusted with the spring shield in place as follows. One slot of the spring adjuster will be available for a screwdriver in one window of the front barrier of the spring shield. By adjusting this slot until a barrier of the spring shield prevents further adjustment, a second slot of the spring adjuster will appear in the window on the other side of the spring shield barrier. Adjusting the second slot in a similar manner will reveal a third slot in the opposite window of the spring shield.

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

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

3. Time Curve Calibration

Install the permanent magnet.

Apply the indicated current per Table I for permanent magnet adjustment and measure the operating time. Adjust the permanent magnet keeper until the operating time corresponds to the value of Table I.

Apply the indicated current per Table I for the electromagnet plug adjustment and measure the operating time. Adjust the proper plug until the operating time corresponds to the value in Table I. (Withdrawing the left-hand plug, front view, increases the operating time and withdrawing the right-hand plug, front view, decreases the operating 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 plug adjustment.

Indicating Contactor Switch (ICS)

Initially adjust unit on the pedestal so that armature fingers do not touch the yoke in the reset position. (Viewed from top of switch between cover and frame.) This can be done by loosening the mounting screw in the molded pedestal and moving the ICS in the downward position.

a. Contact Wipe – Adjust the stationary contact so that both stationary contacts make with the moving contacts simultaneously and wipe 1/64" to 3/64" when the armature is against the core.

b. Target – Manually raise the moving contacts and check to see that the target drops at the same time as the contacts make or 1/16" ahead. The cover may be removed and the tab holding the target reformed slightly if necessary. However, care should be exercised so that the target will not drop with a slight jar.

If the pickup is low, the front cover must be removed and the leaf spring bent outward equally.

Indicating Instantaneous Trip (IIT)

Initially adjust unit on the pedestal so that armature fingers do not touch the yoke in the reset position. (Viewed from top of switch between cover and frame.) This can be done by loosening the mounting screw in the molded pedestal and moving the IIT in the downward position.

a. Contact wipe – Adjust the stationary contacts so that both stationary contacts make with the moving contacts simultaneously and wipe

1/64" to 3/64" when the armature is against the core. This can be accomplished by inserting a .0125 thickness gauge between the armature and core and adjusting the stationary contacts until they just touch the moving contacts.

b. Target – Manually raise the moving contacts and check to see that the target drops at the same time as the contacts make. The cover may be removed and the tab holding the target reformed slightly if necessary. However, care should be exercised so that the target will not drop with a slight jar.

c. Pickup – Place tap screw in the 6 to 20 tap and turn the core screw all the way in. Contacts should pickup at less than 6.0 amps, but not lower than 5.1 amperes. If pickup is above this range it may be reduced by using a tweezer or similar tool and squeezing each leaf spring approximately equally by applying the tweezer between the leaf spring and the front surface of the cover at the bottom of the lower window. If the pickup is below this range is may be increased by removing the front cover and bending the leaf springs outward equally. An approximate adjustment would be where the end of the leaf spring is in line with the edge of the molded cover.

   The desired pickup is obtained by setting the tap screw in the proper range and adjusting the core screw.

Instantaneous Trip (IT)

Initially adjust unit on the pedestal so that armature fingers do not touch the yoke in the reset position. (Viewed from top of switch between cover and frame). This can be done by loosening the mounting screw in the molded pedestal and moving the IT in the downward position.

a. Contact Wipe - Adjust the stationary contacts so that both stationary contacts make with the moving contacts simultaneously and wipe 1/64" when the armature is against the core.

   This can be accomplished by inserting a .0125 thickness gauge between the armature and core and adjusting the stationary contacts until they just touch the moving contacts.

b. Pickup – Place tap screw in the 6 to 20 tap and turn the core screw all the way in. Contacts should pickup at less than 6.0 amp. but not lower than 5.1 amperes. If pickup is above this range it may be reduced by using a tweezer or similar tool and squeezing each leaf spring approximately equal by applying the tweezer between the leaf spring and the front surface of the cover at the bottom of the lower window. If the pickup is below this range it may be increased by removing the front cover and bending the leaf springs outward equally. An approximate adjustment would be where the end of the leaf spring is in line with the edge of the molded cover.

   The desired pickup is obtained by setting the tap screw in the proper range and adjusting the core screw.

Timer (T)

Complete the transformer circuit by a jumper around the contacts of the IT unit. Energize the timer transformer primary with 10 amperes and note the time of operation of the timer with a setting of 150 cycles. The operating time should be within ±5% of indicated value for the electro-mechanical timer.

For the solid-state timer, do not jumper around the IT contacts. Apply 150% of the minimum pickup current for the IT and note the time of operation of the timer with a setting of 2.5 seconds. The operating time should be within ±5% of indicated value. If time is not within limits, the time for a given P1 setting can be increased by adjusting multi-turn pot P2 in the clockwise direction. Conversely, the time can be decreased by counterclockwise rotation of P2.

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.

TABLE I

TIME CURVE CALABRATION
DATA – 60 HERTZ

PERMANENT MAGNET ADJUSTMENT

Time Dial Position	Current (Multiples of Tap Value)	Operating Time Seconds
6	2	37.8

ELECTROMAGNET PLUGS

Current (Multiples of Tap Value)	Operating Time Seconds
10	14.3

ENERGY REQUIREMENTS

Timer

The burden of the timer and auxiliary transformer at 5 amperes 60 Hertz is as follows:

IT contact open	0.7 VA at 80^{o} lag. (Both EM and SS)
IT contact close	0.6 VA at 65^{o} lag. (Electromechanical)
IT contact close	1.7 VA at 50^{o} lag. (Solid-state)

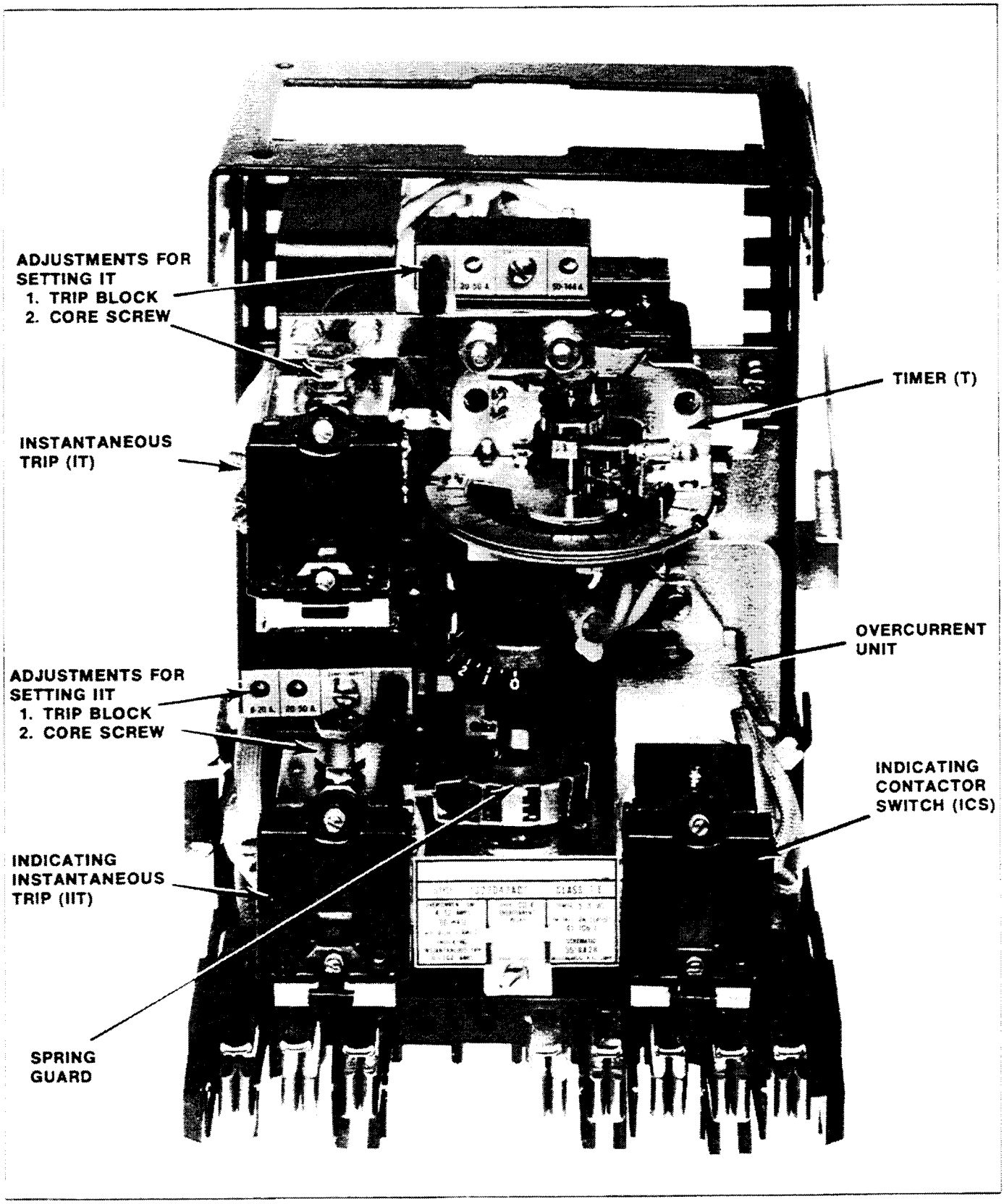

Fig. 1. Type CO-4 Relay With Electromechanical Timer, Without Case.

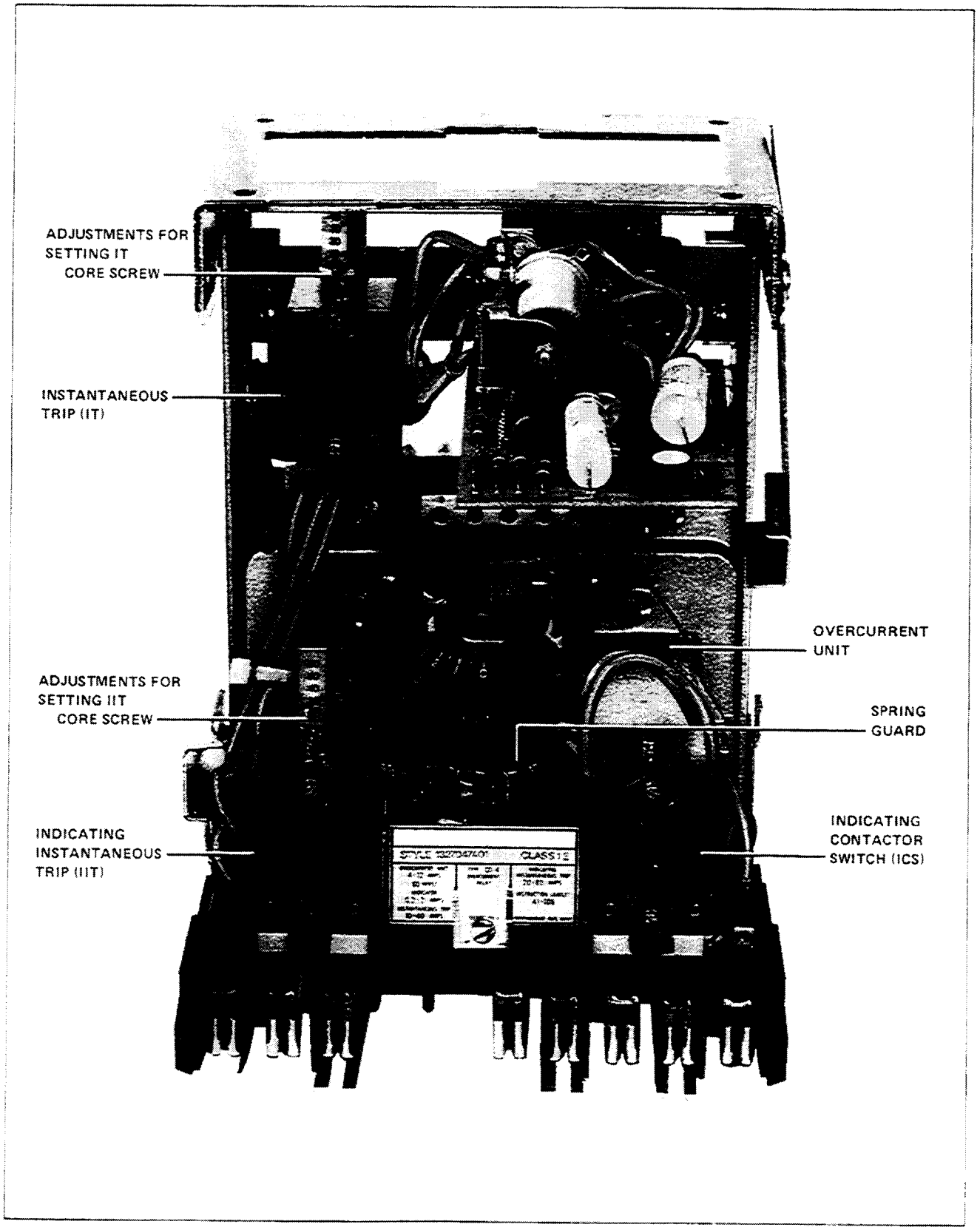

Fig. 2. Type CO-4 Relay With Solid-State Timer, Without Case.

INSTANTANEOUS TRIP UNIT (IIT) AND INSTANTANEOUS TRIP (IT) MEASURED SEPARATELY.

TYPE OF UNIT	RANGES AVAILABLE WITH CORE ADJUSTMENT	TAP SETTING	MINIMUM PICKUP	BURDEN						CONT. RATING AMPS	1 SECOND RATING AMPS
				AT PICKUP			3 TIMES PICKUP	OHMS 10 TIMES PICKUP	20 TIMES PICKUP		
				R	XL	Z					
6-144	6-20 20-50 50-144	6-20 20-50 50-144	6 20 50	.144 .023 .009	.108 .012 .002	.180 .026 .009	.180 .026 .009	.180 .026 .009	.180 .026 .009	6 13 20	100 230 370

CO-5 LONG TIME UNIT

AMPERE RANGE	TAP	CONTINUOUS ONE SECOND RATING (AMPERES)	CONTINUOUS ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE ϕ	AT TAP VALUE CURRENT	VOLT AMPERES** AT 3 TIMES TAP VALUE CURRENT	VOLT AMPERES** AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
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

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

ϕDegrees current lags voltage at tap value current.

***Voltages taken with high resistance voltmeter, not less than 2000 ohms per volt.*

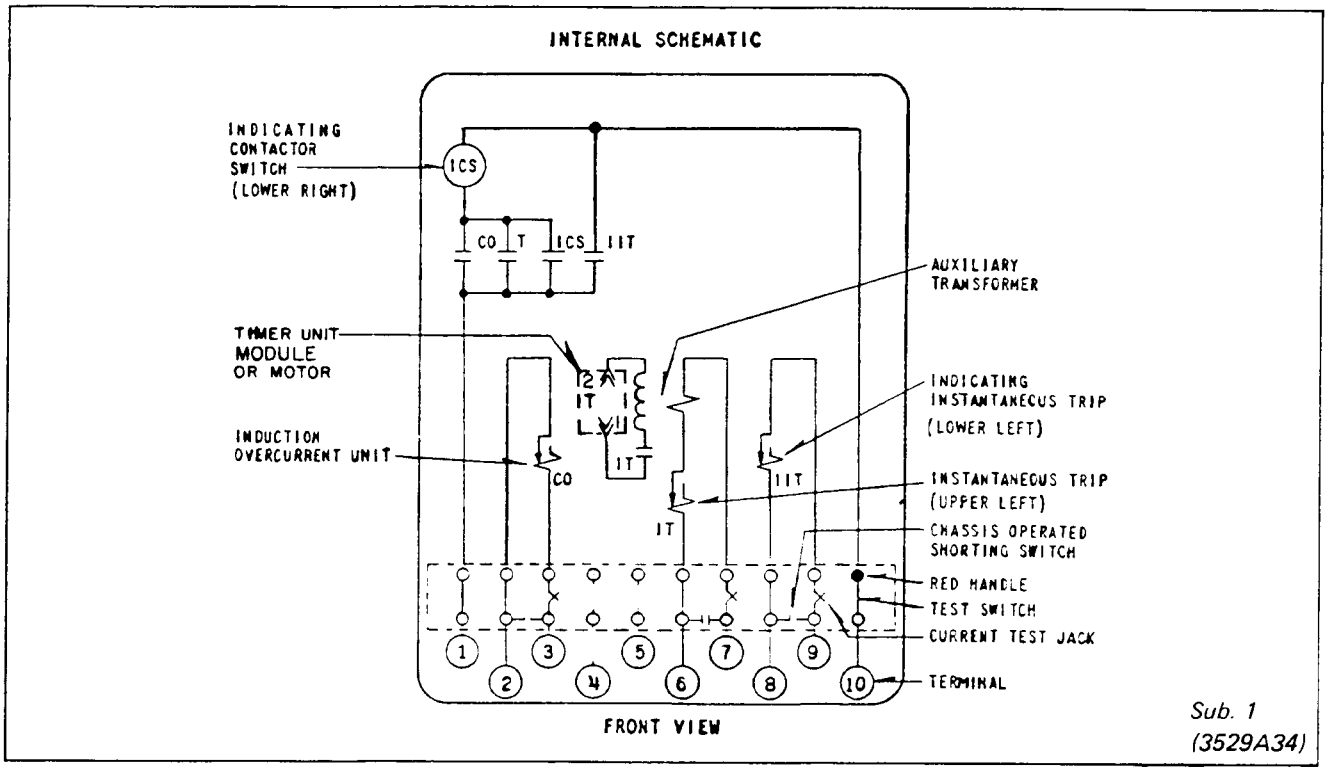

Fig. 3. Internal Schematic of the Type CO-4 Relay in Type FT-21 Case.

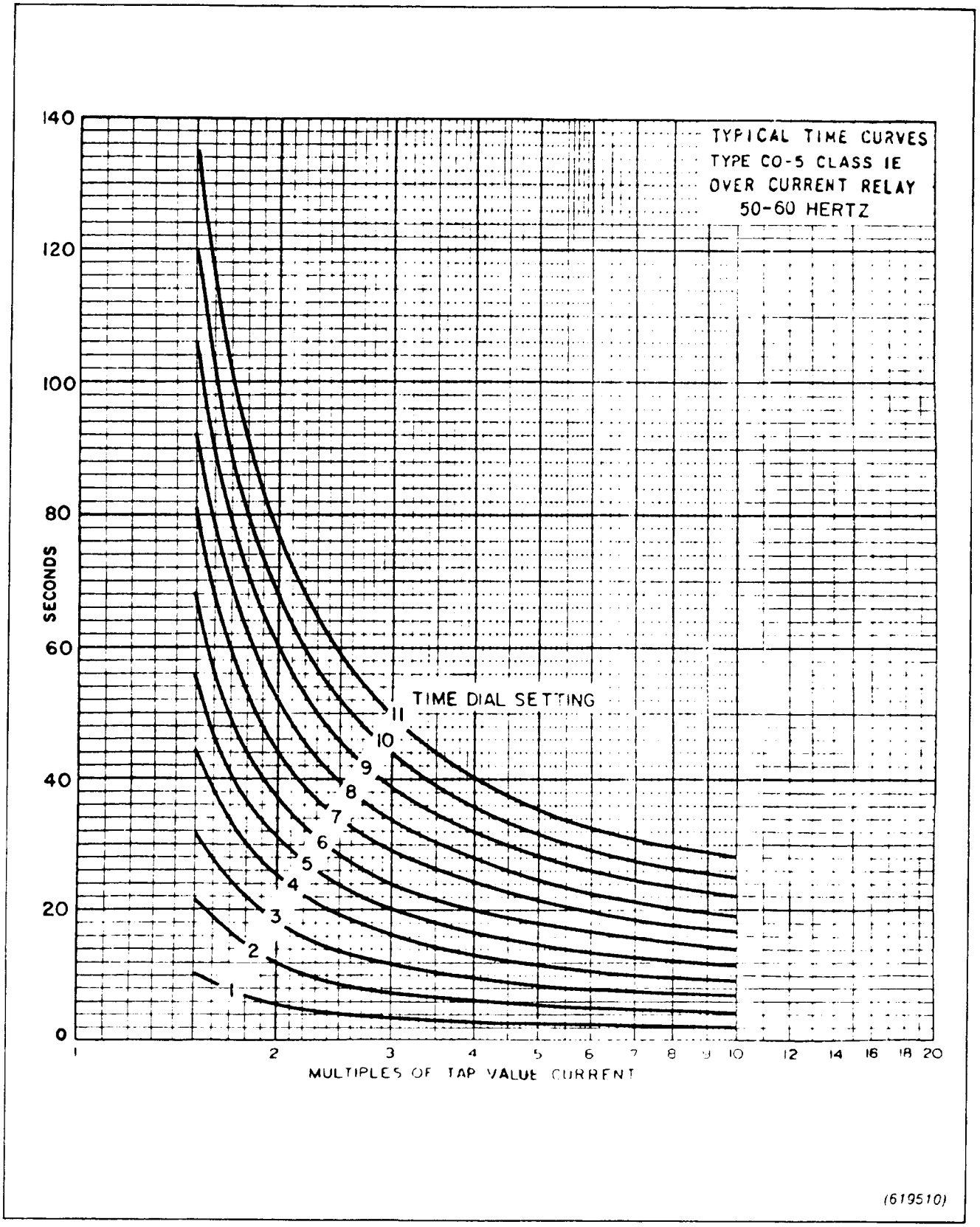

Fig. 4. Typical Time Curves for the Overcurrent Unit.

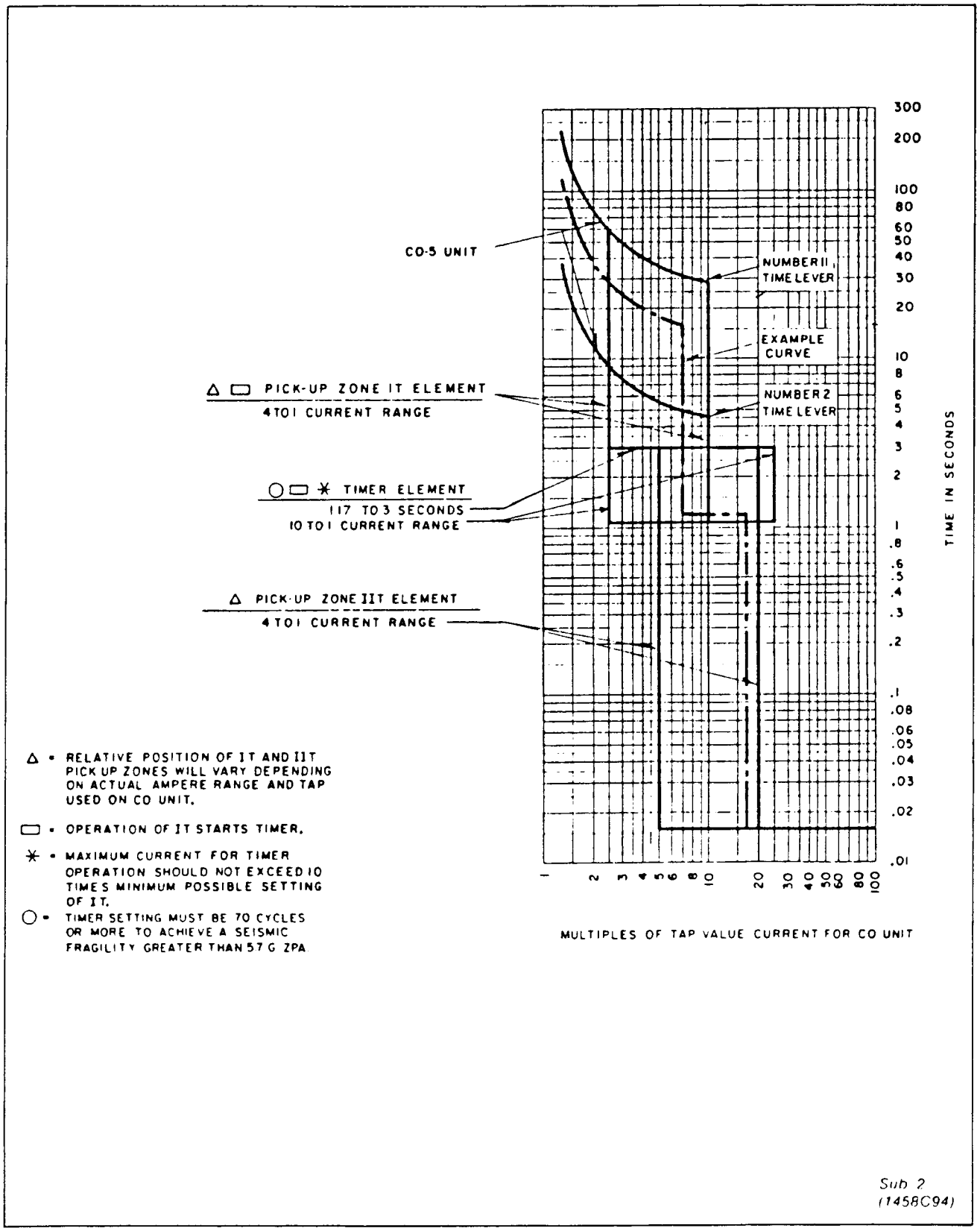

Fig. 5. Typical Current Time Curve Bands for Type CO-4 Relay.

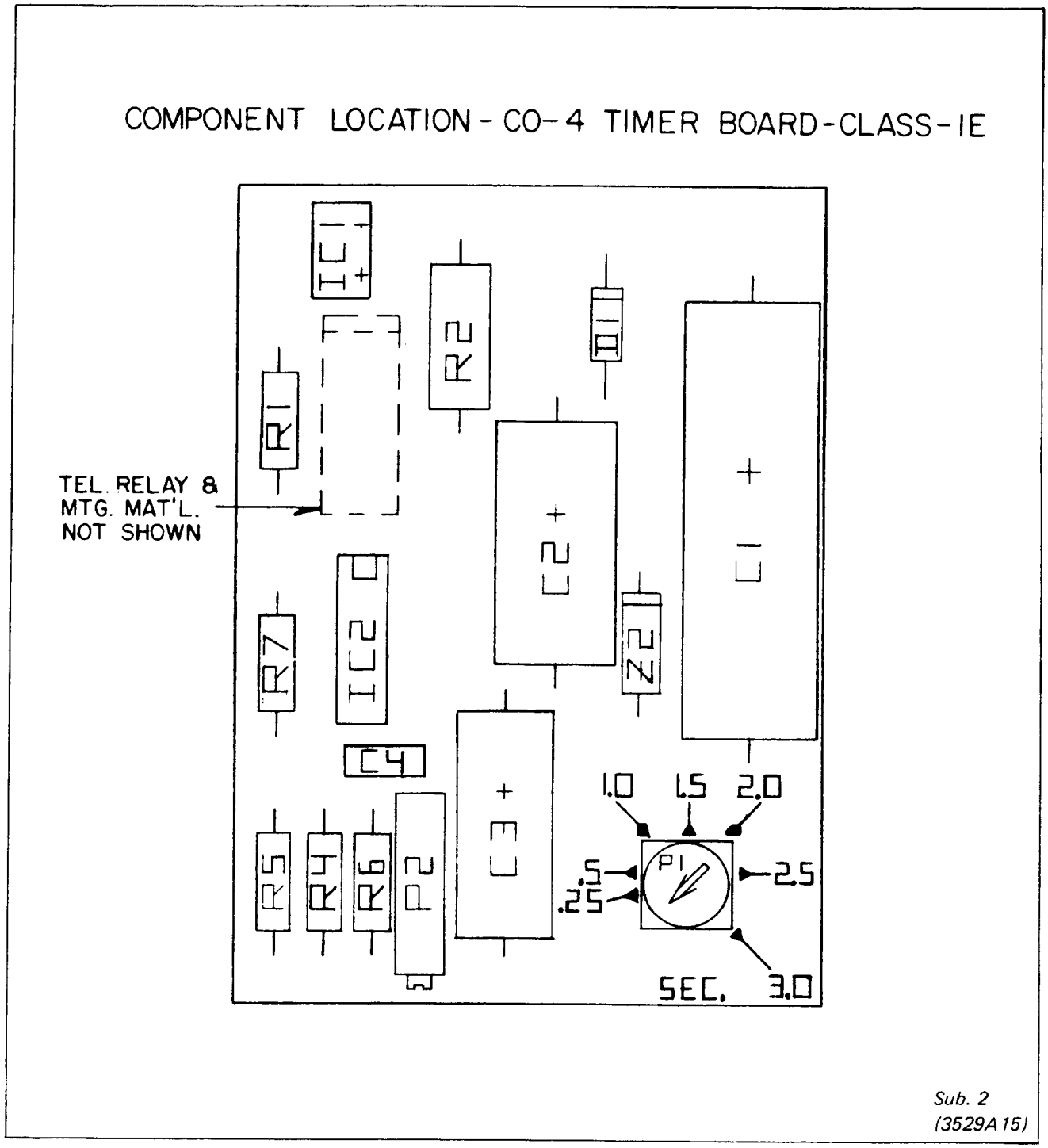

Fig. 6. Component Location - Timer Module.

158IC21G01

COMPONENT	DESCRIPTION	STYLE NO.	REQ.
CAPACITOR			
C1	8UF 200V ±20%	837A192H14	1
C2	2UF 100V ±10%	863A518H04	1
C3	1UF 200V ±20%	876A409H10	1
C4	.01UF 50V +80% -20	184A663H01	1
DIODE			
D1	IN645A	837A692H03	1
ZENER			
Z2	SZ15	849A487H02	1
INT.CKT.			
IC1	VM48	351IA90H01	1
IC2	747DM	1443C52H01	1
POT			
P1	760-30-1M	3512A37H02	1
P2	10K .75W 10%	880A826H05	1
RES.			
R1	100K .5W 2%	629A531H80	1
R2	2K 3W 5%	763A127H03	1
R4,R7	10K .5W 2%	629A531H56	3
R5	10K .5W 2%	629A531H56	
R6	470K .5W 2%	629A531H95	1
TEL.RELAY			
T		541D514H24	1

COMPONENT LOCATION 3529A15

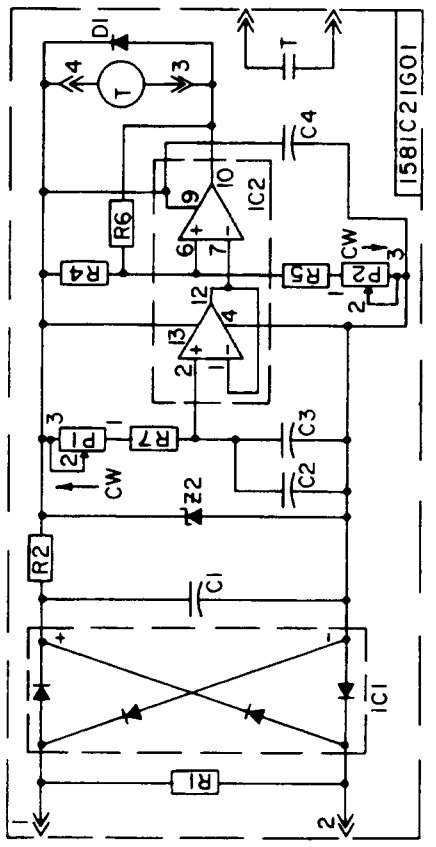

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Fig. 7. Internal Schematic - Timer Module.

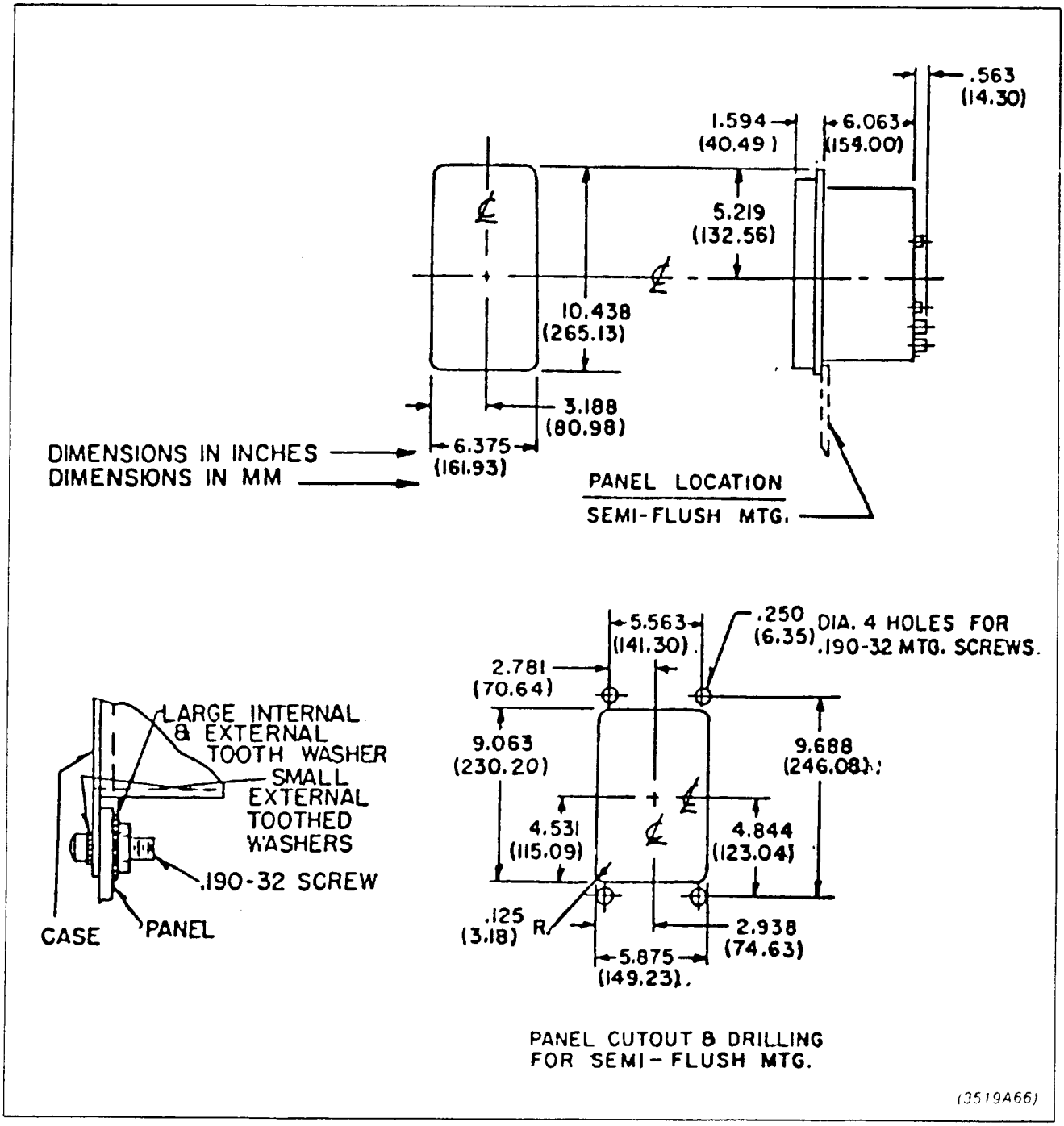

Fig. 8. Outline and Drilling for the Type CO-4 Relay in Type FT-21 Case.

ABB Network Partner

ABB Power T&D Company Inc.
4300 Coral Ridge Drive
Coral Springs Florida 33065
(954) 752-6700
FAX: (954) 345-5329

Printed in U.S.A.