Instruction Leaflet
41-106E

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(▌) Denotes Change Since Previous Issue

Type CO-4 Step-Time Overcurrent Relay

⚠ 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.

1.0 APPLICATION

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.

2.0 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, an instantaneous trip (IT) and a timer (T). The timer may be either electromechanical with a synchronous motor or solid state with an RC timing circuit. (See figure 1.)

2.1 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.

2.2 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 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.

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.

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

The IIT contacts are connected in the trip circuit to trip instantaneously.

2.4 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 provides the adjustable pickup range.

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

2.5 TIMER (T)

The electromechanical timer is a small synchronous motor which operates from the current circuit through a saturating fransformer, 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.

3.0 CHARACTERISTICS

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

CO-5 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.

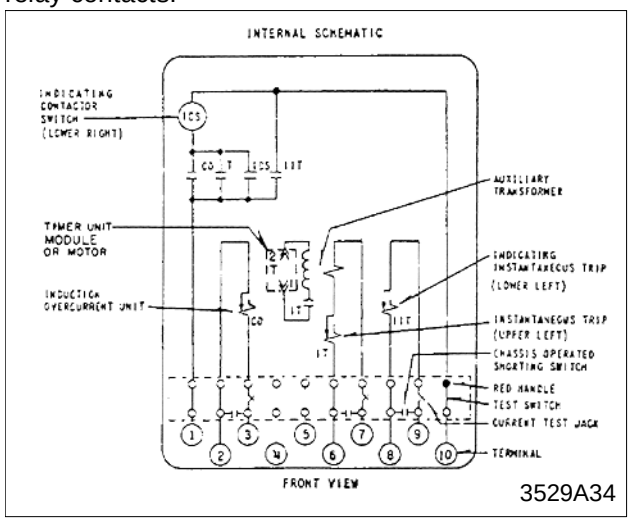

Figure 1: Internal Schematic of the Type CO-4 Relay in Type FT-21 Case.

IIT instantaneous unit has an adjustable range of 20 to 80 amperes.

IT instantaneous unit has an adjustable range of 10 to 40 amperes

Current range of timer 10 to 100 amperes.

The typical operating curves of the CO-5 unit are shown by figure 2.

The typical band curves of the overall operating characteristic of the type CO-4 relay are shown by figure 3.

3.1 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.

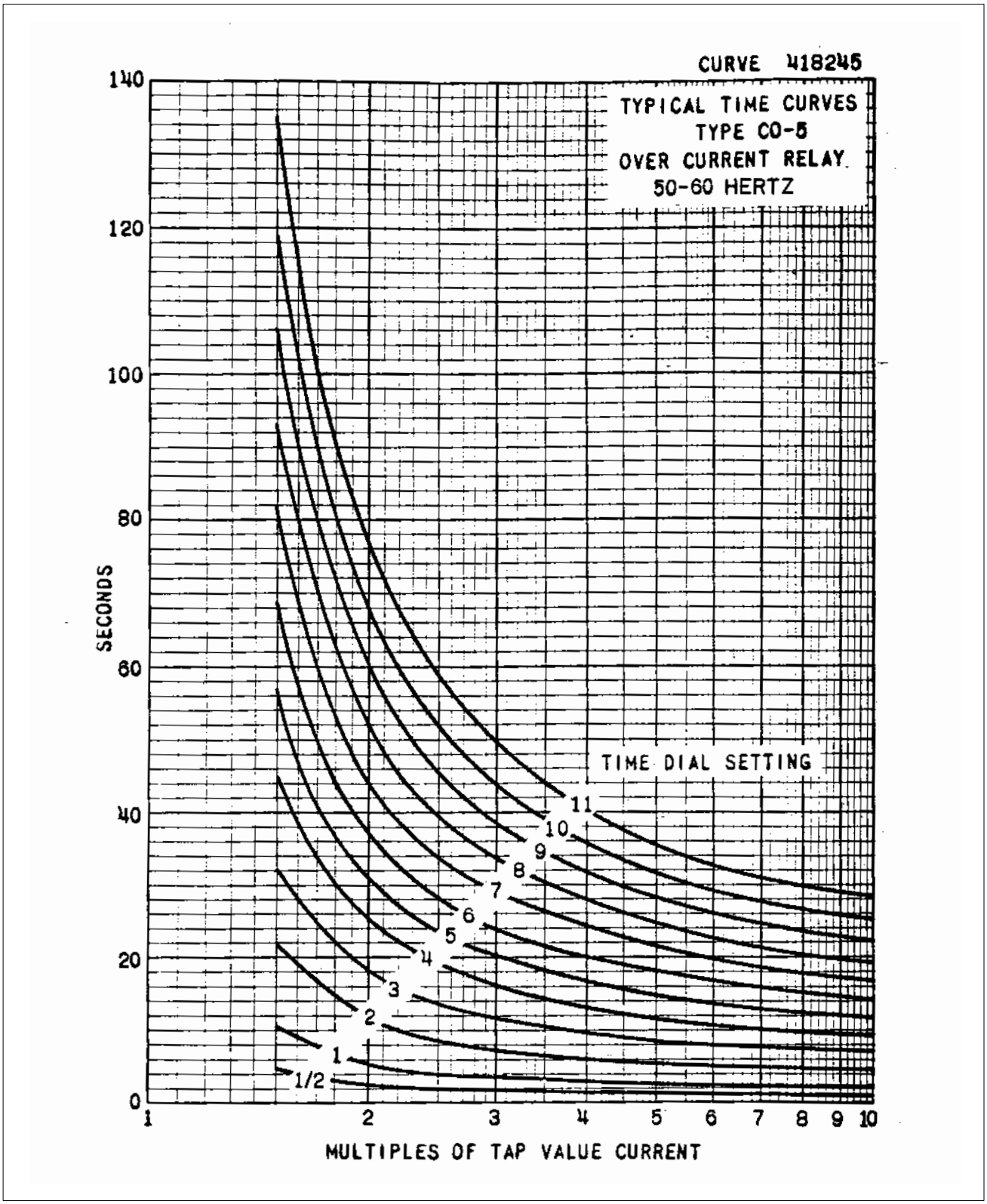

Figure 2: Typical Time Curves for the Overcurrent Unit.

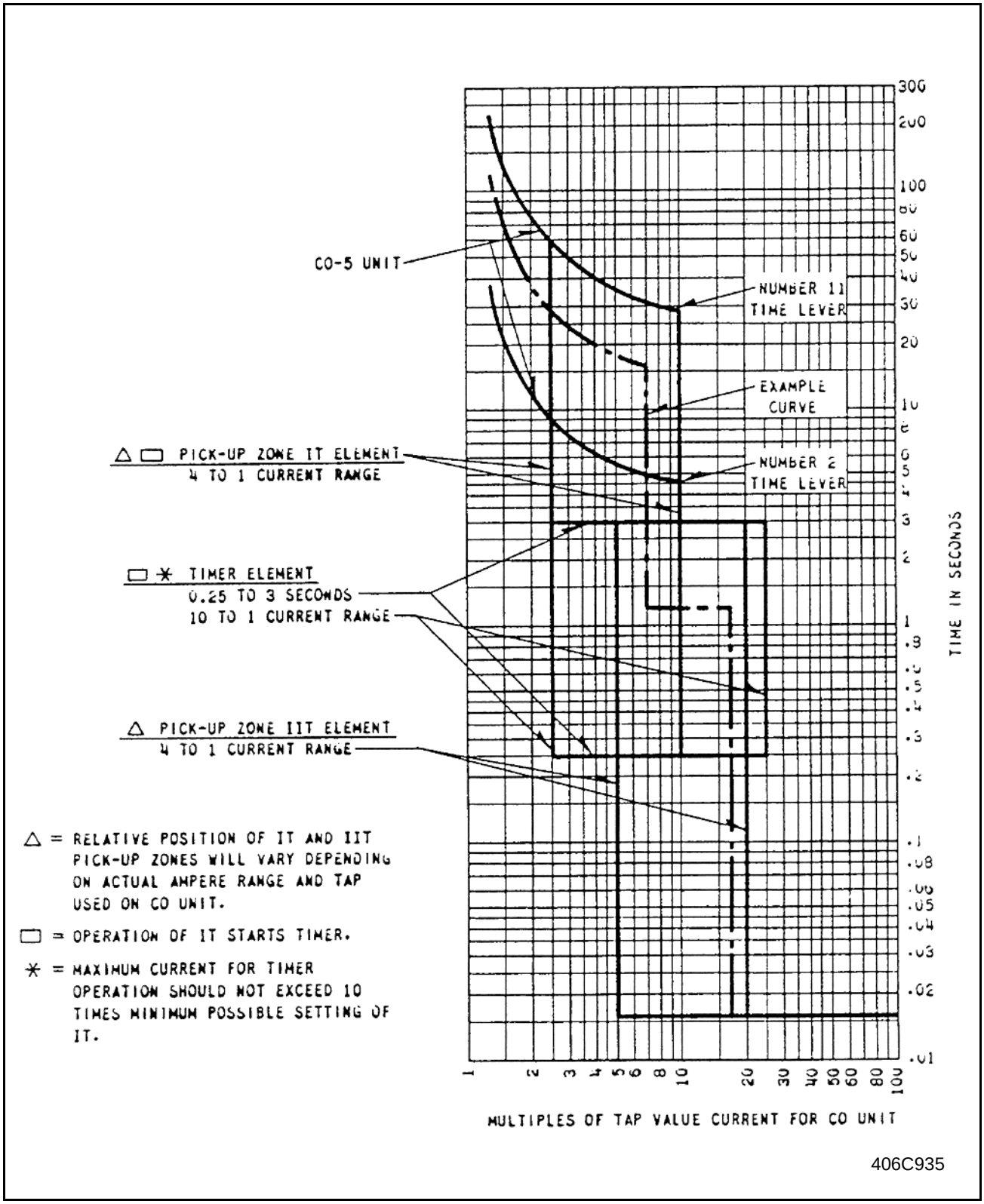

Figure 3: Typical Current Time Curve Bands for Type CO-4 Relay

ENERGY REQUIREMENTS
CO-5 LONG TIME UNIT

AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING * (AMPERES)	POWER FACTOR ANGLE Ø	VOLT AMPERES ** AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
	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
4/12	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.*

Ø Degrees current lags voltage at tap value current.

*** Voltages taken with Rectox type voltmeter.*

The indicating instantaneous trip contacts will 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 the lead located in front of the tap block to the desired setting by means of a screw connection.

3.2 TRIP CIRCUIT CONSTANTS

Contactor Switch –

0.2 ampere tap - 6.5 ohms dc resistance
2.0 ampere tap - 0.15 ohms dc resistance

3.3 INSTANTANEOUS UNITS

Unit	Ampere Range	Volt Amperes* Minimum Setting	P.F. Angle (lag)
IIT	20-80	0.4	40
IT	1-40	1.1	40

** At 5 amperes 60 Hertz*

The burden of the timer and auxiliary transformer at 5 amperes 60 Hertz is as follows for IT range of 10 to 40

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

4.0 SETTINGS

The settings are made to obtain an operating characteristic similar to that indicated by the example curve of figure 3.

4.1 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 on both the CO unit and IIT unit carries operating current, be sure that the screws are turned tight.

CAUTION

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.

4.2 INSTANTANEOUS RECLOSING

The factory adjustment of the CO unit contact provides a contact follow. Where 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.

4.3 INDICATING CONTACTOR SWITCH (ICS)

No setting is required on the ICS unit except the selection of the o.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 pick-up current desired.

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

4.5 INSTANTANEOUS TRIP UNIT (IT)

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.

4.6 TIMER (T)

The operating time of the electromechanical timer is controlled by a molded insulating block, on which the stationary contacts are mounted, which is adjustable around a semi-circular calibrated guide. The maximum time setting of the timer is three seconds.

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 PC board. (See figure 4.) The time delay is proportional to the time constant produced by P1, R7, C2 and C3 as shown in Figure 5. 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.

5.0 INSTALLATION

The relays should be mounted on switch board panels of their equivalent in a location free from dirt, moisture, excessive vibration and heat. Mount the relay vertically by means of the mounting stud 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 the stud or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel panel and mounting or to be terminal stud furnished with the relay for thick panel mounting. The terminal stud may be easily removed or inserted by locking two nuts on the stud and then turning the proper nut with a wrench.

For detail information on the FT case refer to Instruction Leaflet 41-076.

6.0 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.

6.1 PERFORMANCE CHECK

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

6.2 CO UNIT

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 "O" mark on the time dial.

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 "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 1 shows the time curve calibration points. With the time dial set to the indicated position, apply the currents specified by Table 1 and measure the operating time of the relay. The operating times should equal those of Table 1 plus or minus 5%.

6.3 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 be not greater than the particular ICS tap setting being used. The operation indicator target should drop freely.

Table 1:
TIME CURVE CALIBRATION
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

The contact gap should be approximately .047" between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

6.4 INDICATING INSTANTANEOUS TRIP UNIT (IIT)

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

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

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

6.5 INSTANTANEOUS TRIP UNIT (IT)

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

6.6 SYNCHRONOUS TIMER (T)

When checking the synchronous timer, complete the transformer circuit by a jumper around the contacts

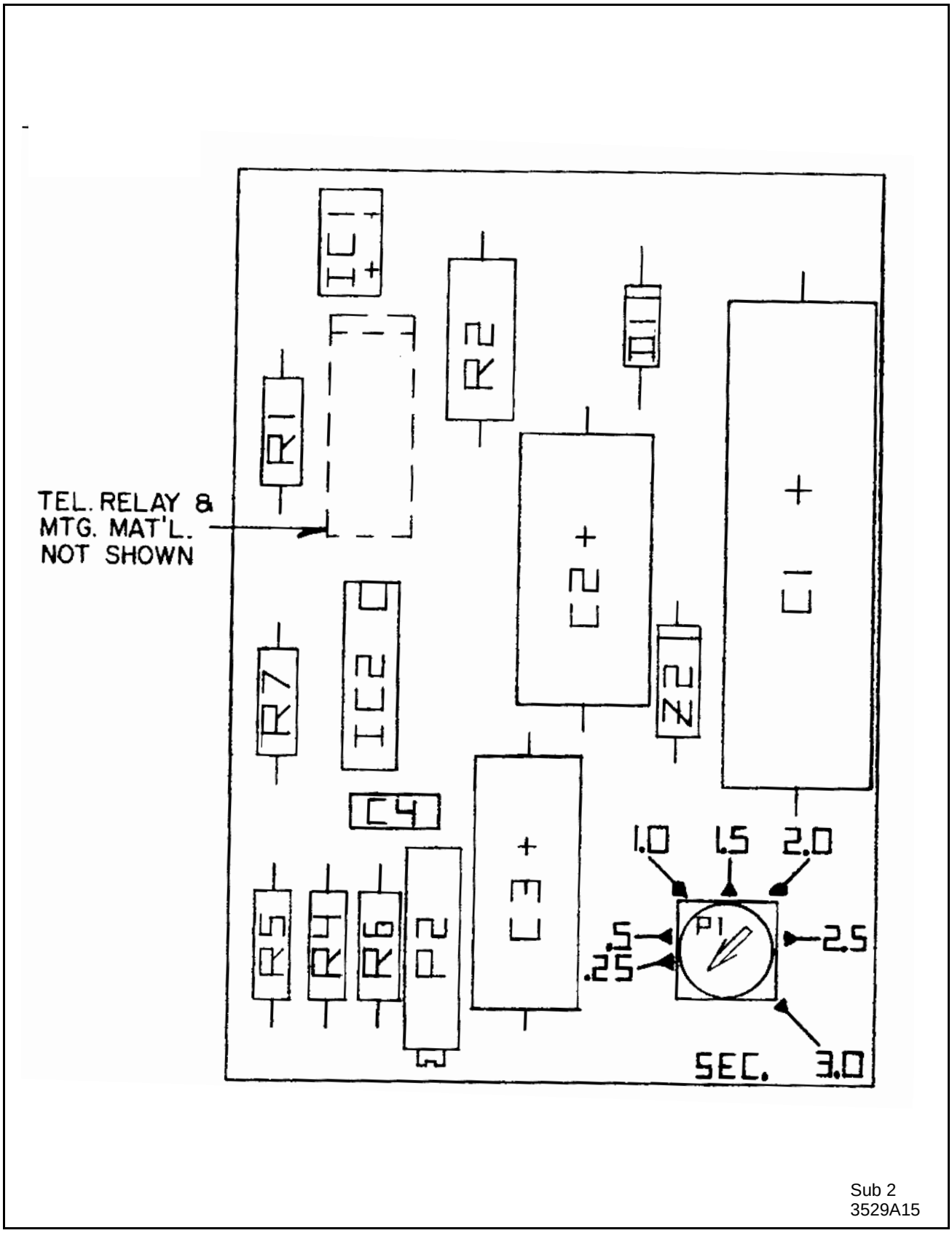

Figure 4: Component Location - Timer Module

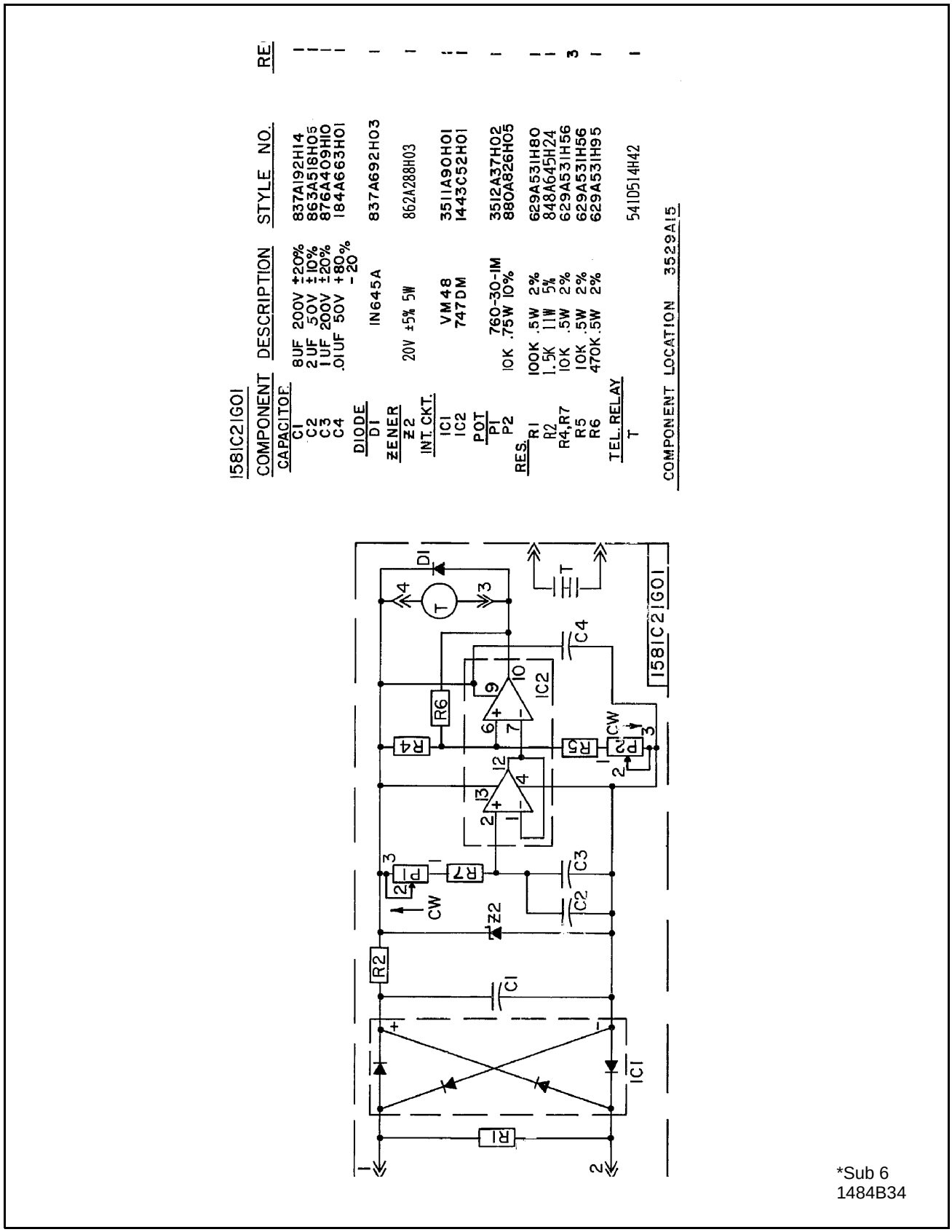

Figure 5: Internal Schematic - Timer Module

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 PC board. The timer is factory calibrated and set for a time delay of 2.5 seconds.

6.7 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.

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.

7.0 CALIBRATION

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

7.1 CO UNIT

1. Contacts

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 “O” mark on the time dial.

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 “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.

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 and measure the operating time. Adjust the permanent magnet keeper until the operating time corresponds to the value of Table 1.

Apply the indicated current per Table 1 for the electromagnet plug adjustment 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 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.

7.2 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 operation indicator target should drop freely.

7.3 INDICATING INSTANTANEOUS TRIP UNIT IIT

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

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

7.4 INSTANTANEOUS TRIP UNIT (IT)

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.

7.5 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 electromechanical 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.

NOTE

Relays having sub "A" following the style number on the nameplate contain a solid state timer without multi-turn pot P2. Relays with sub "B" following the style number DO have P2.

8.0 RENEWAL PARTS

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

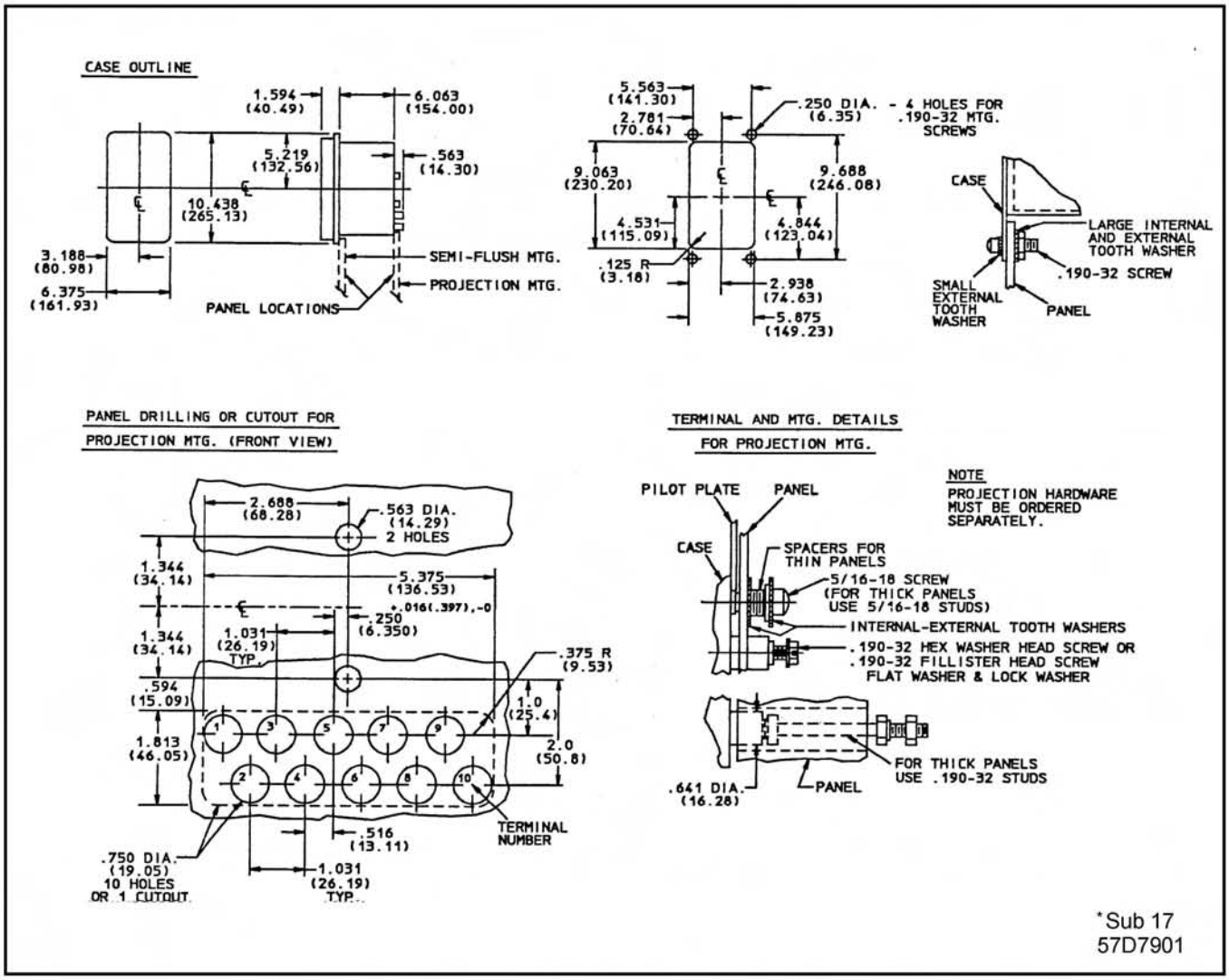

Figure 6 Outline and Drilling for the Type CO-4 Relay in Type FT-21 Case.

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