Instruction Leaflet
41-347.3E

Type HRU Instantaneous Overcurrent Relay with Harmonic Restraint

Effective: September 1998
Supercedes: I.L. 41-347.3D, Dated November, 1996

(|) Denotes Change Since Previous Issue

⚠ CAUTION

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

1.0 APPLICATION

The type HRU harmonic restraint relay is a high speed relay used for supervising overcurrent, differential or pilot relays to avoid magnetizing inrush tripping. There are single phase and 3-phase units available as shown in figure 1 to figure 4.

The 3-phase HRU relay may be added to an existing induction-disc differential relay installation per figure 5 should inrush tripping become a problem.

Figure 6 shows the scheme using a 3-phase HRU relay to supervise the HCB or HCB-1 relay for preventing magnetizing inrush tripping.

Figure 7 shows the use of single phase HRU relays to provide sensitive instantaneous overcurrent protection for rectifier transformers, where there are no selectivity requirements with low-side protective devices. This scheme is not recommended where transformer loads are not supervised by individual local breakers, since this always involves load pickup with transformer energization.

2.0 CONSTRUCTION

The single phase HRU relays consist of an instantaneous trip unit, a harmonic restraint unit, and an indicating contactor switch. The principal component parts of the relay are shown in figure 1 and figure 2.

The 3-phase HRU relay consists of the same parts in the single phase HRU relays, except with a mixing transformer, as shown in figure 3 and 4.

HARMONIC RESTRAINT UNIT (HRU)

The harmonic restraint unit consists of an air-gap transformer, a second harmonic block filter, a fundamental block-second harmonic pass filter, two full-wave rectifiers, a varistor, and a dc polar unit.

POLAR UNIT

The polar unit consists of a rectangular shaped magnetic frame, and electromagnet, a permanent magnet, and an armature. The poles of the crescent shaped permanent magnet bridge the magnet frame. The magnetic frame consists of three pieces joined in the rear with two brass rods and silver solder. These non-magnetic joints represent air-gaps, which are bridged by two adjustable magnetic shunts. The windings are wound around a magnetic core. The armature is fastened to this core, and is free to move in the front air gap. The moving contact is connected to the free end of a leaf spring, which, in turn, is fastened to the armature.

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

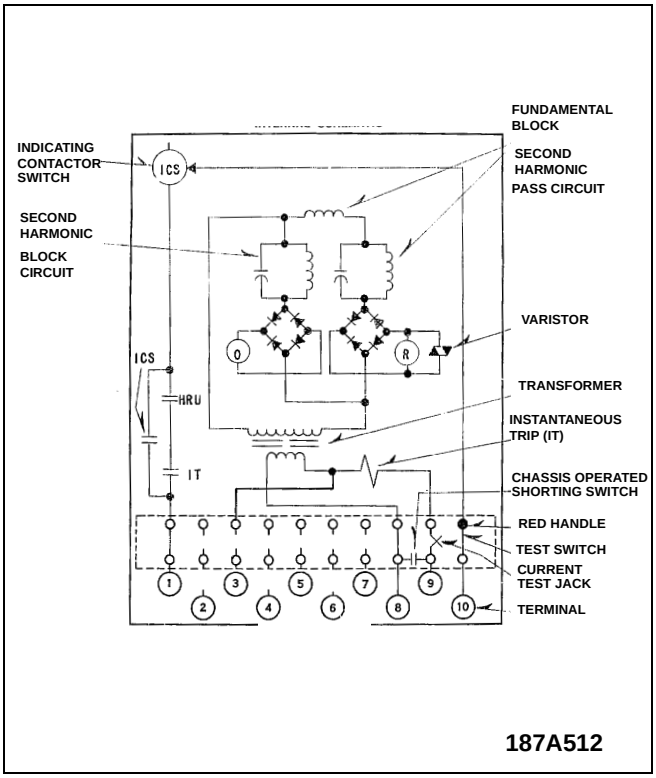

Figure 1. Internal Schematic of Single-Phase HRU Relay

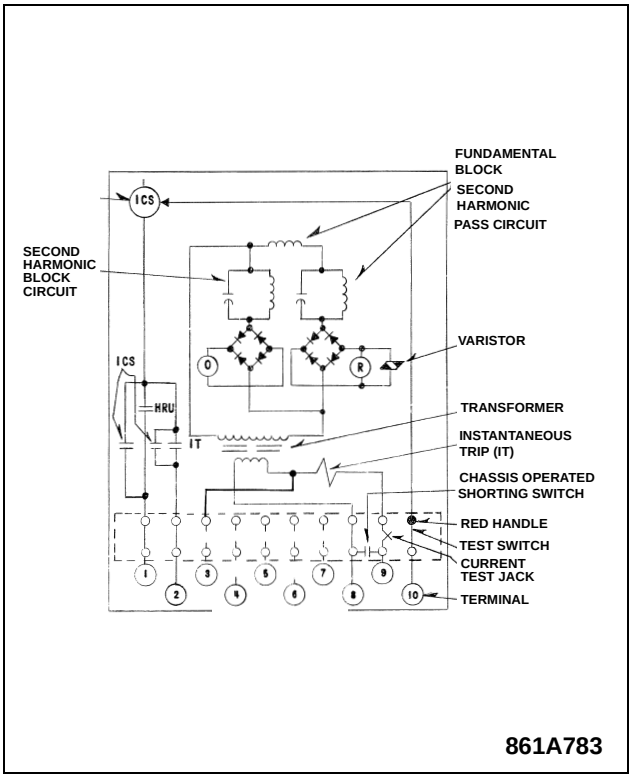

Figure 2. Internal Schematic of Single-Phase HRU Relay

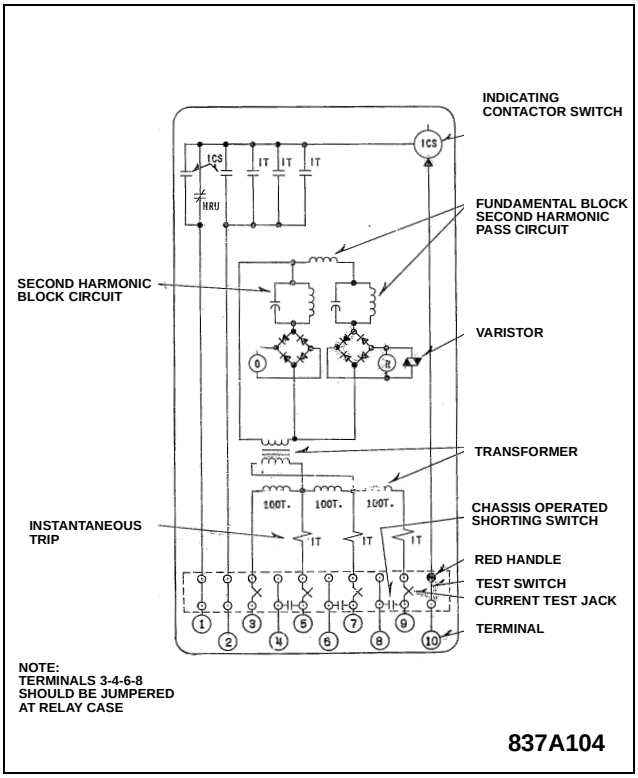

Figure 3. Internal Schematic of 3-Phase HRU Relay

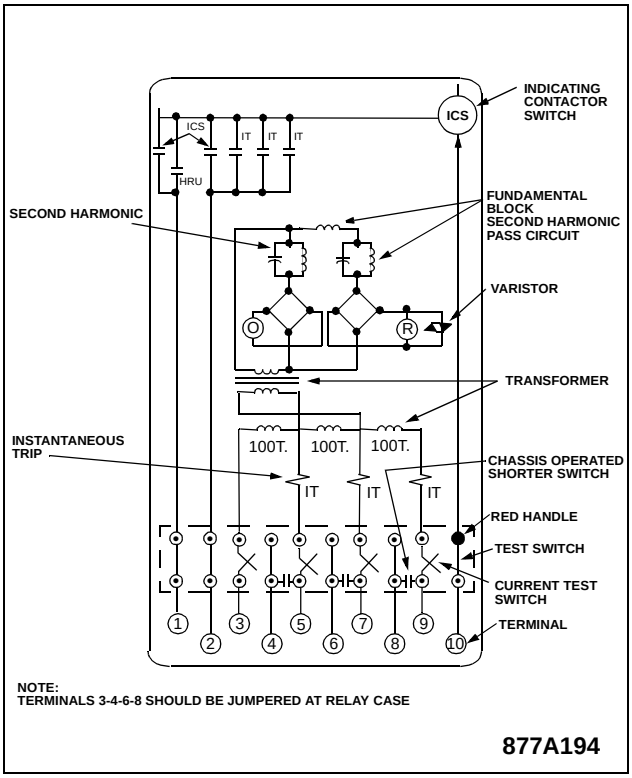

Figure 4. Internal Schematic of 3-Phase HRU Relay

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. A core screw accessible from the top of the switch provides the adjustable pickup range. The minimum and maximum pickup points are indicated on the scale, which is located to the rear of the core screw.

INDICATING CONTACTOR SWITCH UNIT (ICS)

The dc indicating contactor switch is a small clapper-type device. A magnetic armature to which leafspring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contacts, completing the trip circuit. Also, during 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.

3.0 OPERATION

The type HRU relay is connected to operate for faults internal to the differential zone of the transformer but not on magnetizing inrush currents associated with energization of the transformer.

MAGNETIZING INRUSH CURRENTS

Magnetizing inrush current waves have various wave shapes. A typical wave appears as a rectified half wave with decaying peaks. In any case, the various wave shapes are rich in harmonics with the second harmonic predominant. Since the second harmonic is always present in inrush waves and not in internal fault waves, this harmonic is used to restrain the harmonic-restraint unit during inrushes. The instantaneous trip unit may or may not close its contact, depending on the magnitude of the inrush.

When a magnetizing inrush wave is applied to the relay, the dc component of the wave is by-passed by the air-gap operating transformer. The other components are fed into the filter circuits. The impedance characteristics of these filters are such that the second harmonic component flows into the restraint coil of the polar unit, while the other harmonics flow into the operating coil. The polar unit will not close its contacts unless the second harmonic content is less than 15 percent of the fundamental component.

INTERNAL FAULTS

Faults normally appear as an offset sine wave with a decaying dc component, and contain very few harmonics. As a result, the harmonic-restraint unit and instantaneous trip will operate during internal faults to permit tripping of the relay.

The varistor connected across the dc side of the restraint rectifier of the harmonic restraint unit prevents excessive voltage peaks from appearing across the rectifiers. These peaks arise through transformer action of the harmonic-restraint polar-unit coils during heavy internal faults. The varistor has a large value of resistance for low voltages, while presenting a low value of resistance for high voltages. This characteristic effectively reduces the voltage spikes on heavy internal faults while not hampering performance during inrush, where the voltage is considerably lower.

4.0 SETTINGS

HARMONIC RESTRAINT UNIT (HRU)

No settings are required on the harmonic restraint unit. If desired, pickup may be varied by adjusting the right-hand shunt (front view).

INDICATING CONTACTOR SWITCH (ICS)

No setting required on the ICS unit except the selection of the 0.2 or 2.0 amperes tap setting. This selection is made by connecting the lead located in the front of the tap block to the desired setting by means of the connecting screw. When the relay energizes a 125 or 250 volt dc type WL relay switch or equivalent, use the 0.2 ampere tap; for 48 volt dc applications set relay in the 2.0 amp. tap and use WL relay coil S#304C209G01 or equivalent.

INSTANTANEOUS TRIP (IT)

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

The IT unit should be set above the maximum inrush expected, if its contact is in parallel with the normally open HRU contact.

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

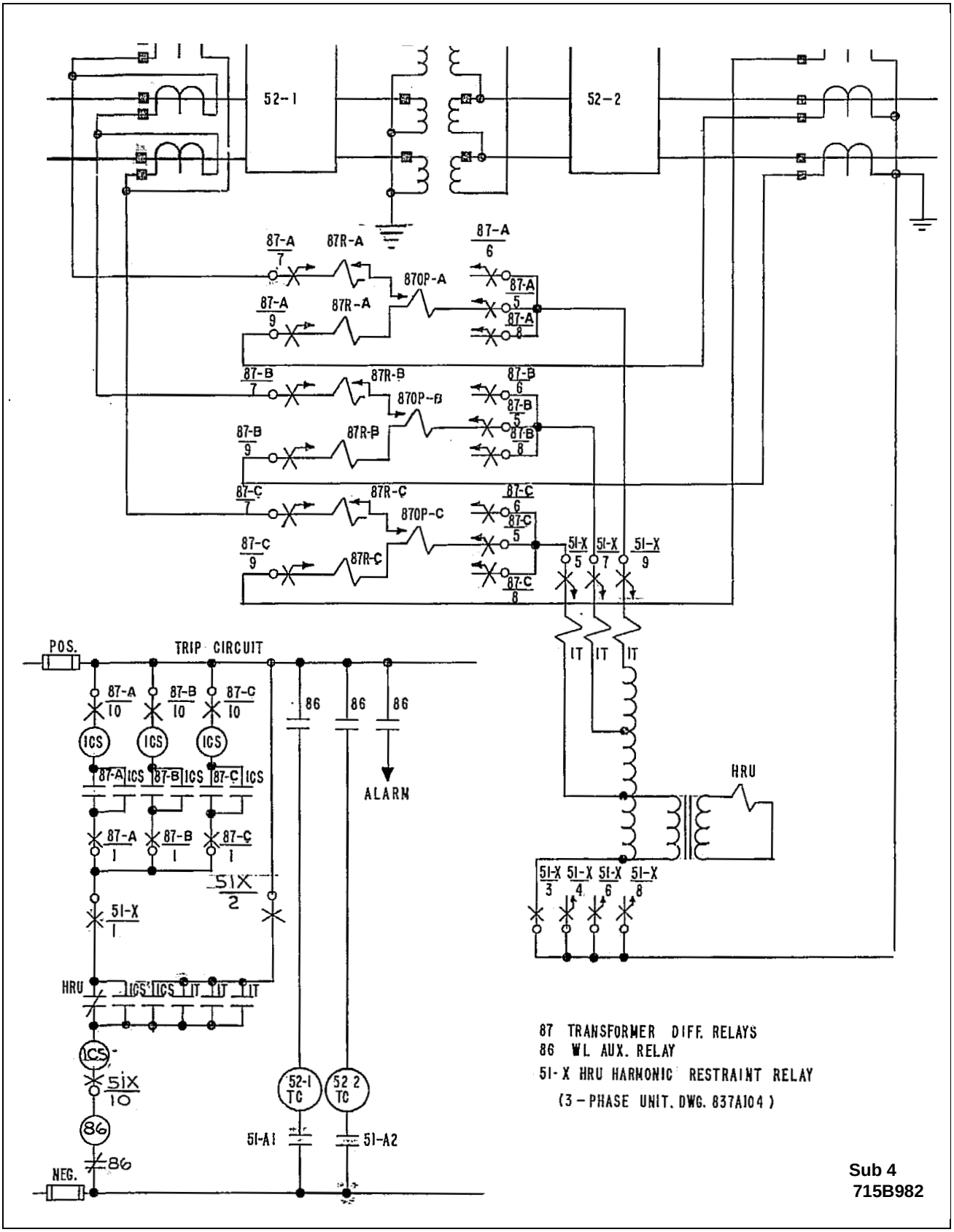
52-1
52-2
87-A
87R-A
87OP-A
87-B
87R-B
87OP-B
87-C
87R-C
87OP-C
51-X
IT
HRU
POS.
TRIP CIRCUIT
ICS
86
ALARM
NEG.
52-1 TC
52-2 TC
51-A1
51-A2
87 TRANSFORMER DIFF. RELAYS
86 WL AUX. RELAY
51-X HRU HARMONIC RESTRAINT RELAY
(3-PHASE UNIT. DWG. 837A104)
Sub 4
715B982

Figure 5.

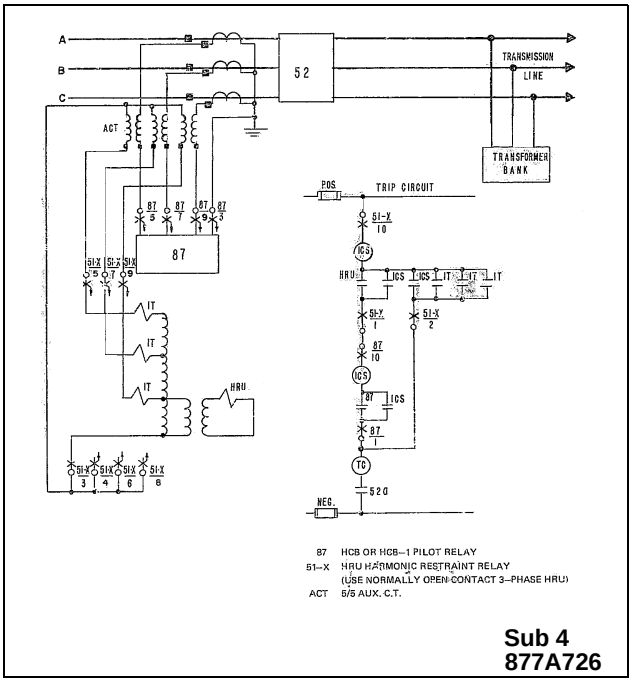

Figure 6.

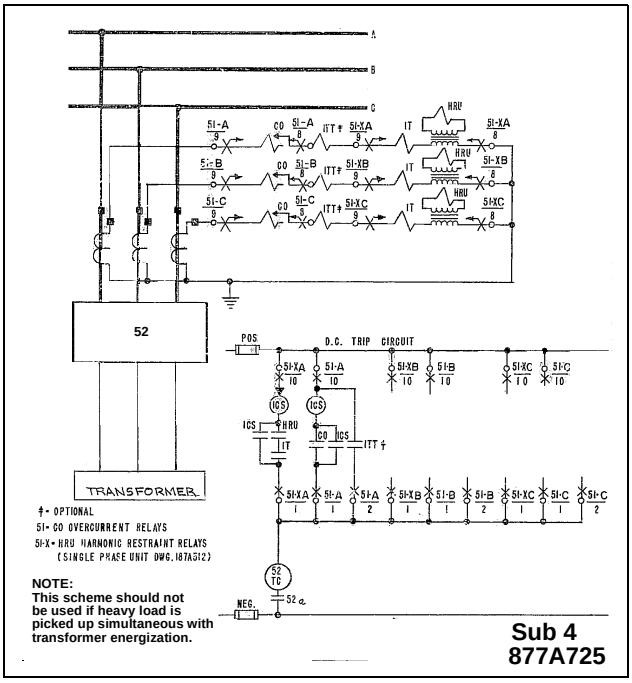

Figure 7.

5.0 INSTALLATION

The relays should be mounted on a switchboard panel or their equivalent in a location free from dirt, moisture, excessive vibration, and heat. Mount the relay vertically by means of four mounting holes on the flange for semi-flush mounting or by means of the rear mounting stud or studs for projection mounting. Either a mounting 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 mounting or to the 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 stud and then turning the proper nut with a wrench.

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

6.0 ADJUSTMENTS AND MAINTENANCE

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

ACCEPTANCE TESTS

The following check is recommended to insure that the relay is in proper working order. Use test circuit of figure 8 (single phase HRU) or figure 9 (3-phase HRU).

1. Minimum Trip Circuit

   A. Single Phase HRU Relays

      With the switch open, apply current to terminals 8 and 9 of the relay. The polar unit should operate at rated current. The polar unit may operate for lower currents, but not below value of table 1. This low pickup will not impair its operation on magnetizing inrush, and should not be disturbed if it is found to be less than rated current. However, if a higher pickup is desired, it is suggested that 100 amperes be momentarily applied to relay terminals 8 and 9. This will cause the polar unit to pickup at approximately rated current.

   B. 3-phase HRU Relays (Normally Open Contact)

      Use single-phase test for all 3 phases.

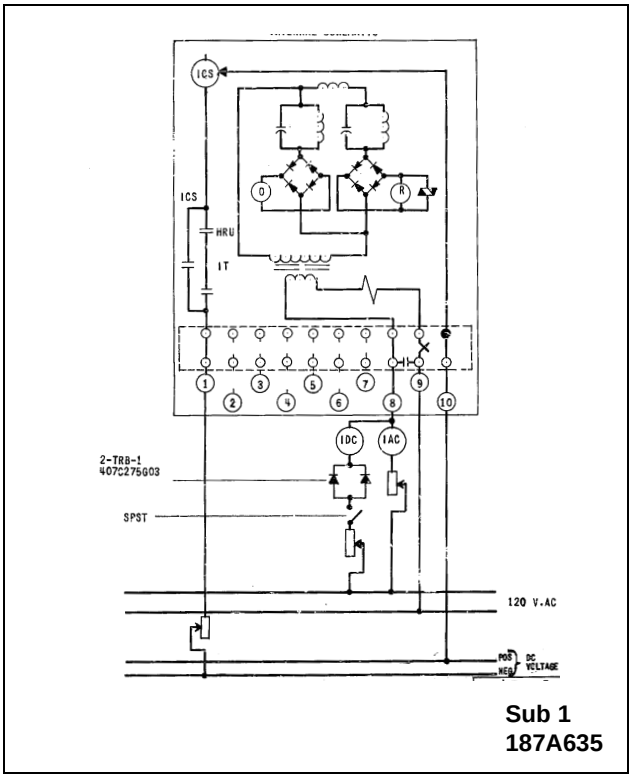

Figure 8. Test Circuit (Single Phase HRU Relay)

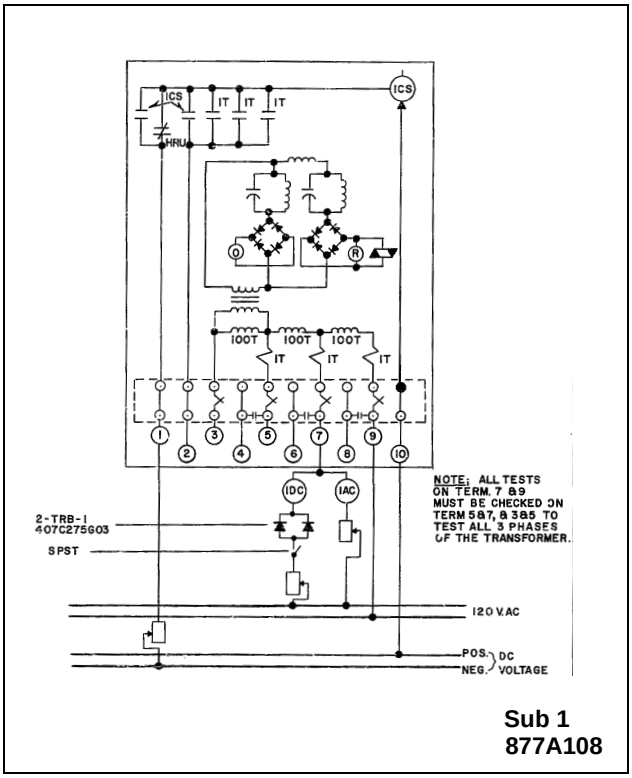

Figure 9. Test Circuit (3-Phase HRU Relay)

2. Harmonic Restraint Characteristic

   A. Single-phase HRU Relays or 3-Phase Relay (Normally Open Contact)

      Close switch of test circuit and set I_{dc} per table 2 and adjust I_{ac} until the polar unit operates. I_{ac} should be as indicated in table 2. These values of alternating current corresponds to 17 percent and 14 percent second harmonic. For 3-phase relay, check all three phases.

   B. 3-phase HRU Relays (Normally Closed Contact)

      In de-energized position, HRU contact should be closed to left.

      Energize relay with an I_{ac} of approximately 5 amps. Close switch of test circuit and set I_{dc} per table 2. Check to see that the polar unit contacts move to the right when I_{ac} is decreased to approximately 3.5 amps. Momentarily apply 100 amps I_{ac} to polarize unit, then set I_{dc} again per table 2. The polar unit contacts move to the left when I_{ac} is increased to approximately 3.8 amps. All three phases should be acceptance tested as per figure 9 and the above procedure.

3. Instantaneous Unit (IT)

   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%.

   Position the stationary contact for a minimum of 1/32 inch wipe. The bridging moving contact should touch both stationary contacts simultaneously. Apply sufficient current to operate the IT.

4. 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.

   The contact gap should be approximately .047 inches between the bridging moving contact and

that adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

ROUTINE MAINTENANCE

All relays should be checked at least once every year or at such other time intervals as may be dictated by experience to be suitable to the particular application.

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.

CALIBRATION

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

POLAR UNIT

1. Contacts: Place a .060 to .070 inch feeler gage between the right-hand pole face and the armature. This gap should be measured near the front of the right-hand pole face. Bring up the backstop screw until it just makes with the moving contact. Place gage between moving contact and stationary contact on the left-hand side of the polar unit. Bring up the stationary contact until it just makes with the gage and lock in place.

2. Minimum Trip Current - Harmonic Restraint Unit (HRU):

   Connect the relay to the test circuit of figure 8 or figure 9. Test all three phases on 3-phase units.

   With the switch open, pass I_{ac} = 100 amperes into the relay. This current should be applied for a very short period of time and it should be suddenly interrupted. Adjust the right-hand shunt on the polar unit until it trips with the I_{ac} = Rated Current. Lower I_{ac} gradually to 50% rated current, unit should reset, if not, adjust left-hand shunt until the unit resets.

   If additional adjustments are necessary, apply 100 amperes and adjust the right-hand shunt until the unit operates at rated current. Lower I_{ac} gradually to 50% rated current and adjust the left-hand shunt until the contacts reset. Repeat these steps until the unit will operate at rated current, lower immediately following the application of 100 amperes, and until the unit will drop out at 50% rated current or greater. After the dropout has been measured, the unit should pick up at .94 times rated current.

   On the application of the high current, the polar unit will be biased in the restraining direction and pickup will be rated current on the first application of pickup current. If the current is de-energized and pickup is measured again, the pickup current will be less than before. However, pickup will be stable after the second application of pickup current. If 100 amperes is applied again, the pickup immediately after applying this current will be rated current. However, measuring the pickup the second time will show that the pickup is again reduced. The variation between .94 and 1 times rated current.

   The filter circuits are charged by the application of this heavy current and upon the removal of the current, these circuits will discharge their energy. The element will be biased in the restraining direction because the restraint coil has approximately 7 times the number of turns as the operating coil. Upon the application of pickup current, the operating ampere turns will be greater than the restraint ampere turns and the bias will be removed.

   If a lower biasing current is used instead of 100 amperes, the pickup of the unit will be less than before for the application of pickup current. Pickup will be further reduced with the second application of pickup current, but the current will be stable after this energization. However, this value of pickup will be lower than the limit of .94 times rated current. This is in the direction of making the sensitivity of the polar unit lower than rated current but does not impair the performance of the unit on inrush current.

   If a pickup other than rated current is desired, the right-hand shunt can be screwed inward to give the desired pickup. This adjustment should be done after the application of 100 amperes.

3. Harmonic-Restraint Characteristics.

   A. Single-Phase and 3-phase HRU Relays (Normally open contact)

   Close switch of test circuit in figure 8 or 9. Adjust direct current I_{dc} per Table 2. Gradually increase alternating current until the polar unit operates with I_{ac} as indicated in Table 2. The percent second harmonic in the wave may be derived by the use of the formula.

$$\% \text{ second harmonic } = \frac{47\ I_{dc}}{I_{ac} + 1.11\ I_{dc}}$$

   Check all three phases for the 3-phase HRU.

   B. 3-Phase Relays (Normally closed HRU contact)

   De-energize relay and move the right-hand shunt (approximately 3 slots in) to make the contacts normally closed to the left. Re-energize the relay, close test switch and set I_{dc} per Table 2. Check that the polar unit contacts move to the right when I_{ac} is decreased to approximately 3.5 amps.

   Momentarily apply 100 amps I_{ac} to polarize unit, then set I_{dc} again per Table 2. The polar unit contacts should move to the left when I_{ac} is increased to approximately 3.8 amps.

   Check all 3 phases for pickup and dropout as per above test.

4.3.1. Indicating Contactor Switch (ICS)

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

4.3.2. Instantaneous Trip (IT)

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%.

Apply sufficient current to operate the IT.

ELECTRICAL CHECKPOINTS

Apply rated current to terminals 8 and 9. The following are the approximate voltages that should be obtained using a high-resistance ac voltmeter.

Output of operating transformer (Top Coil Terminals)	4.0 volts
4 mfd. capacitor	2.5 volts
0.45 mfd. capacitor	3.9 volts
Operating-rectifier bridge	2.5 volts
Restraint-rectifier bridge	0.6 volts
Series filter-reactor	0.2 volts

Table 1:
Polar Unit Min. Trip Values

Rated Current	Lower Current Limit
.87	.6
2.0	1.35
4.0	2.7

Table 2:
Harmonic Restraint Values

Rated Current	I_{dc}	I_{ac}
.87	2.3	3.8 - 5.3*
2.0	6.0	10.0 - 13.5
4.0	12.0	19.9 - 27.0

APPROXIMATE RESISTANCE VALUES OF COMPONENTS IN HRU RELAY

Unit	Circuit	Description
Harmonic Restraint	Operating	Transformer Secondary dc resistance 50 to 70 ohms Reactor dc resistance 8 to 10 ohms. 4 mfd. capacitor Rectifier 700 volts, 600 milliamperes silicon diodes. Polar unit coil dc resistance 80 to 100 ohms.

APPROXIMATE RESISTANCE VALUES OF COMPONENTS IN HRU RELAY

Unit	Circuit	Description
	Restraint	Series reactor dc resistance 100 to 130 ohms. Parallel reactor dc resistance 300 to 360 ohms. .45 mfd. capacitor Rectifier 700 volts, 600 milliamperes silicon diodes. Polar unit coil dc resistance 650 to 800 ohms. Varistor 100,000 ohms ±10% at 10 Vdc 4000 ohms ±25% at 30 Vdc.
Indicating Switch	Contactor Trip	0.2 amp. tap 6.5 ohms dc 2.0 amp. tap 0.15 ohms dc

ENERGY REQUIREMENTS†

Rated Current	Continuous Relay	1 sec.	Burden At	
			Top Value	8X
.87	10 amps	300 amps	2.26	76
2.0	18 amps	300 amps	2.50	92
4.0	22 amps	300 amps	3.18	132
			greater than	

†Continuous rating of 3 phase HRU-5.75 amps.

5.0 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.

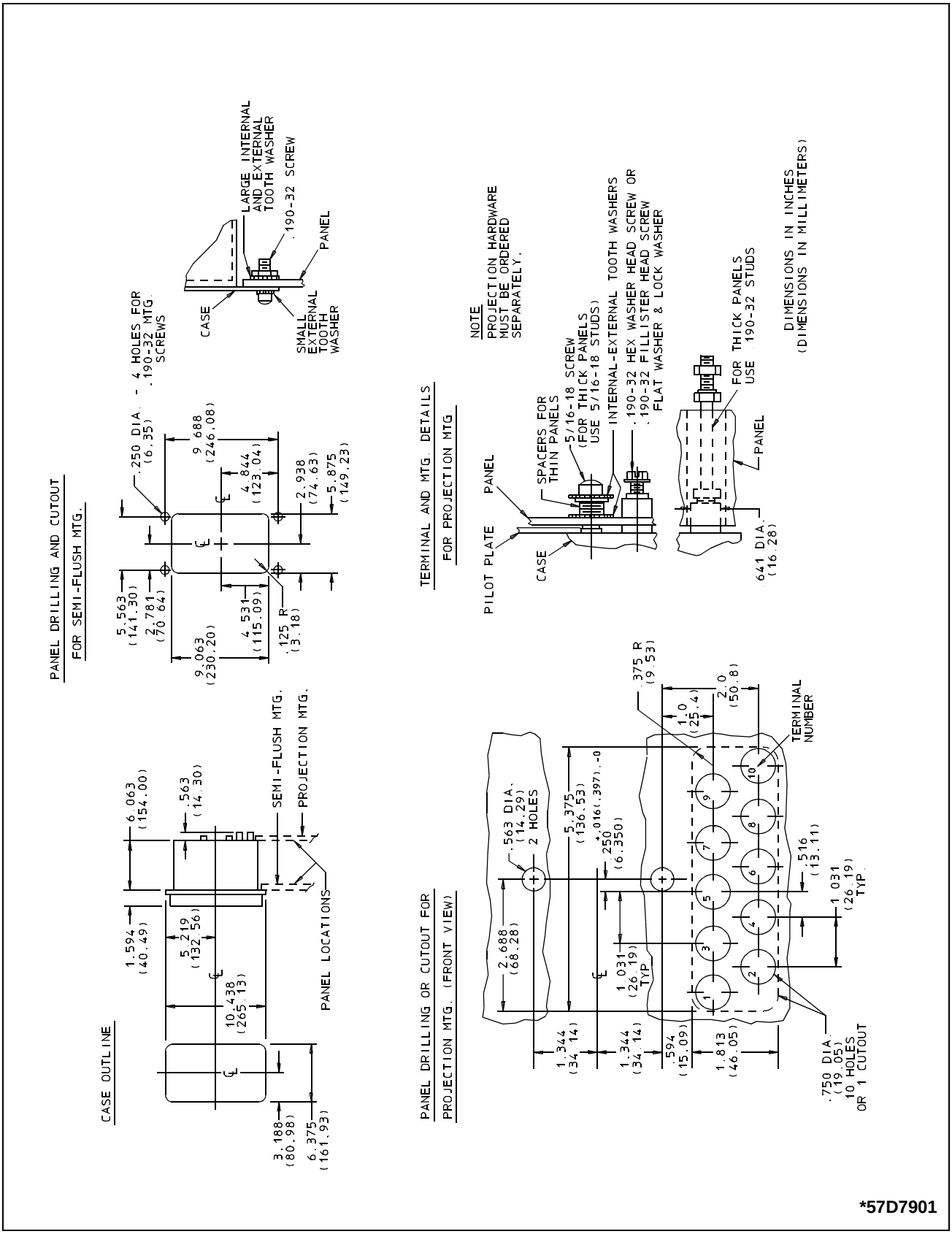

Figure 10. Outline & Drilling for FT-21

*** Changed since previous issue.**

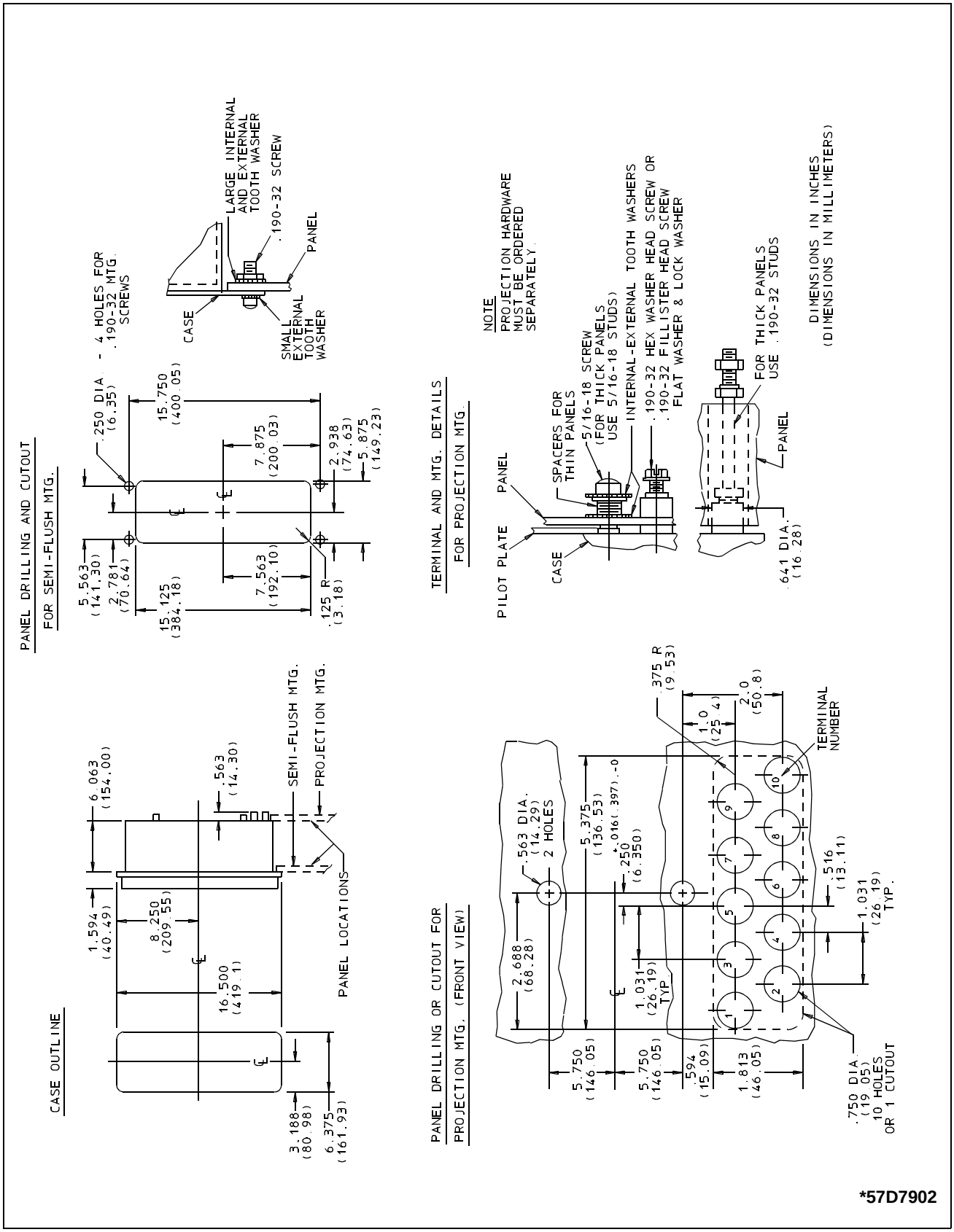

Figure 11. Outline & Drilling for FT-31

*** Changed since previous issue**

IL 41-347.3 - Revision E

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