INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE PM LINE OF RELAYS FOR PILOT-WIRE MONITORING AND TRANSFERRED TRIPPING

CAUTION Before putting protective relays into service, remove all blocking which may have been inserted for the purpose of securing 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.

APPLICATION

Type PM Monitoring Relays provide continuous monitoring of a pilot-wire circuit to detect open circuits, short circuits, grounds, and wire reversal. In addition, transferred tripping can be effected where the PM-3, PM-13, PMG-13 or PM-23 relays are used. Table I illustrates the functions available with each relay.

Each circuit requires the following:

At one end to introduce monitoring current

One of the following:

For a-c Supply	For d-c Supply
PMA	PMD
PMA-1	PMD-1
PM-13 or PMG-13 (a.c.)	PM-13 or PMG-13 (d.c.)

At the other end to receive monitoring current (two-terminal line)

One PM-23 or PM-2 or PM-4

At the other ends to receive monitoring current (three-terminal line)

Two PM-23 or two PM-4 or two PM-2 or any combination of two of these relays.

CONSTRUCTION

PM relays consist of the following:

PMA

1—Polar Alarm Unit (1)
1—Polar Ground Unit (5)
1—Tapped Transformer
1—Full-Wave Rectifier
3—4 mfd. Capacitors
1—Set of Voltage Dividing Resistors

PMA-1

1—Polar Alarm Unit
1—Tapped Transformer
1—Full-Wave Rectifier
1—4 mfd. Capacitor
1—Set of Voltage Dividing Resistors

PMD

1—Polar Alarm Unit (1)
1—Polar Ground Unit (5)
2—4 mfd. Capacitors
1—Set of Potential Divider Resistors

PMD-1

1—Polar Alarm Unit
1—Set of Potential Divider Resistors

PMG-13

1—Polar Alarm Unit (1)
1—Polar Ground Unit (5)
1—Polar Trip Unit (3)
1—Indicating Contactor Switch
1—Set of Potential Divider Resistors
1—Tapped Transformer (A.C. Relay only)
1—Full-WaveRectifier (A.C. Relay only)
1—Blocking Rectifier
2—Remote Trip Resistors
3—4 mfd. Capacitors (A-C Relay)
2—4 mfd. Capacitors (D-C Relay)

PM-13

1—Polar Alarm Unit (1)
1—Polar Trip Unit (3)
1—Indicating Contactor Switch
1—Set of Potential Divider Resistors
1—Tapped Transformer (A.C. Relay only)
1—Full-Wave Rectifier (A.C. Relay only)
1—Blocking Rectifier
2—Remote Trip Resistors
1—4 mfd. Capacitor

PM-23

1—Polar Alarm Unit (2)
1—Polar Trip Unit (3)
1—Indicating Contactor Switch (ICS)
1—Milliammeter, 5.0 ma.
1—Set of Adjustable and Fixed Resistors
2—Blocking Rectifiers

PM-2

1—Polar Alarm Unit (2)
1—Milliammeter, 5.0 ma.
1—Set of Adjustable Resistors
1—Blocking Rectifier

*Supersedes IL 41-973.4 Complete Revision

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PM-3

1–Polar Trip Unit (3)
1–Resistor
1–Blocking Rectifier
1–Indicating Contactor Switch (ICS)

PM-4

1–Blocking Rectifier
1–Set of Adjustable & Fixed Resistors

PM-5

1–Polar Ground Unit (5)
2–4 mfd. Capacitors
1–Fixed Resistor

TABLE I

FUNCTION	PMA & PMD	PMA-1 & PMD-1	PM-13	PMG-13	PM-23	PM-2	PM-3	PM-4	PM-5
Monitoring Current Source	X	X	X	X					
Receives Monitoring Current					X	X		X	
Trouble Alarm	X	X	X	X	X	X			X
Transmits Trip Signal	X with external resistors	X with external resistors	X	X					
Receives Trip Signal			X	X	X		X		
Sensitive Ground Detection	X			X					X
Measures Monitoring Current					X	X			

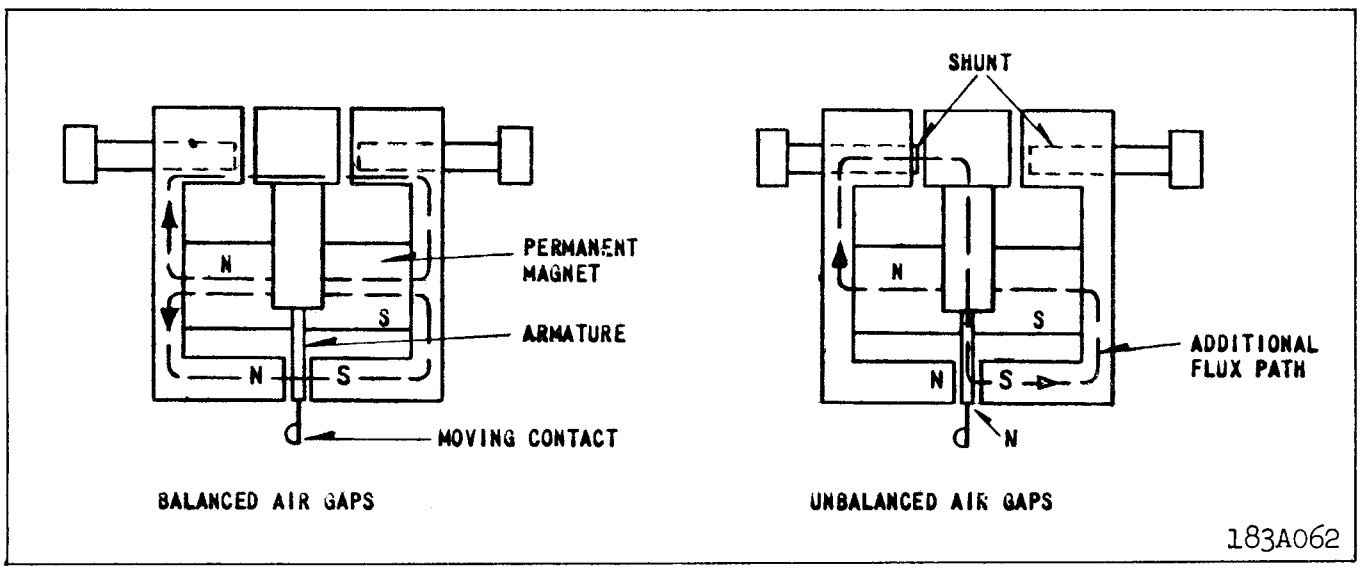


Fig. 1. Polar Unit Permanent Magnet Flux Paths.

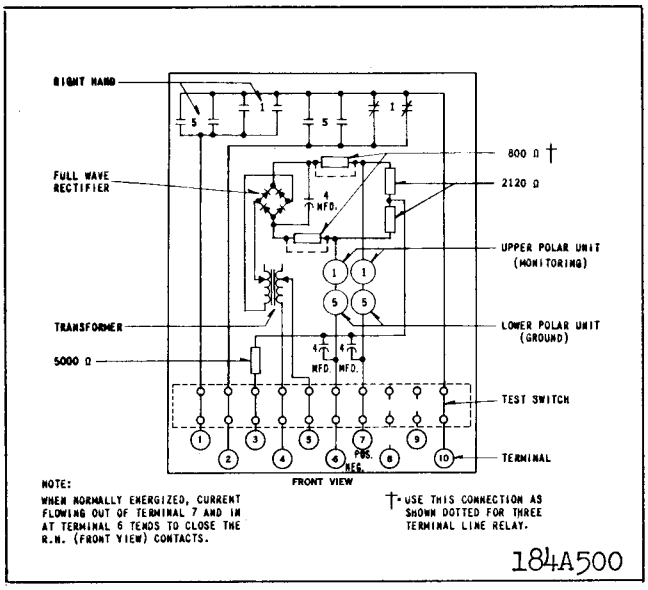


Fig. 2. Internal Schematic of the Type PMA Relay in the FT31 Case – 120 Volt, 60 cycle supply – For Two and Three Terminal Lines.

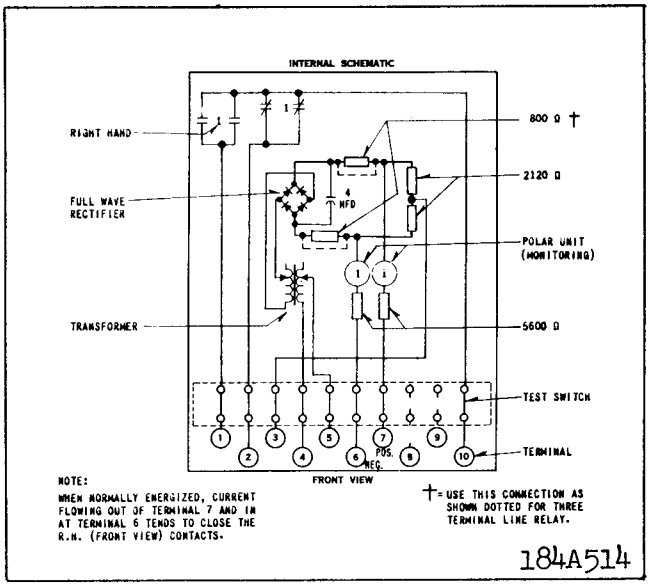


Fig. 3. Internal Schematic of the Type PMA-1 Relay in the FT21 Case – 120 Volt, 60 cycle supply – For Two and Three Terminal Lines.

Polar Unit

The polar unit consists of a rectangular shaped magnetic frame, an 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 winding or 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.

Indicating Contactor Switch

The d-c 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 cover.

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

OPERATION

Pilot Wire Monitoring

Monitoring current is introduced into the pilot wire as shown in the external schematics, figures 19 to 25, by the monitoring current source. External schematics showing other combinations are available on request. A nominal 20 volts is impressed across the 10 mfd. capacitor at the left-hand line terminal in Figures 19 to 25. This voltage produces a current circulating through one winding of the HCB insulating transformer, one pilot wire, the PM-23, PM-2, or PM-4, and back through the other pilot wire and the other winding of HCB insulating transformer.

Adjustment of the resistors of the PM-23, PM-2 or PM-4 relay at the other end of the pilot wire provides a normal one-milliampere d-c circulating current. In the case of three-terminal lines, the monitoring source relay output current is 2 ma. in order to provide each receiving end relay with 1 ma. The alarm unit of the monitoring current source relay is adjusted to float between the high and low current contacts with normal monitoring current. The PM-23, receiving-end alarm relay, is adjusted to float between the low-current alarm contact and a contact stop with 1 ma. flowing.

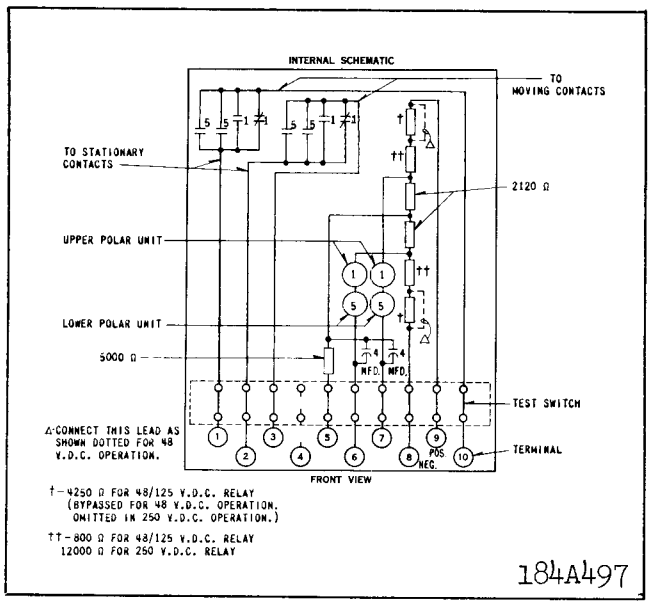


Fig. 4. Internal Schematic of the Type PMD Relay in the FT21 Case – DC Supply – For Two Terminal Lines.

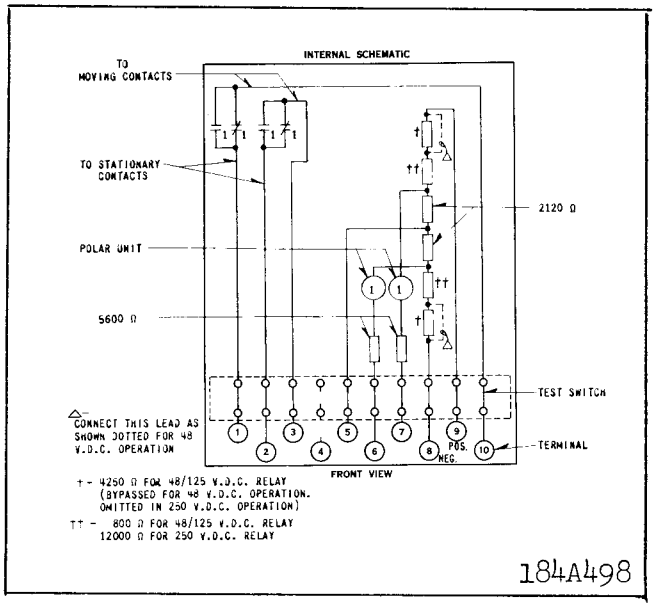


Fig. 5. Internal Schematic of the Type PMD-1 Relay in the FT11 Case – DC Supply – For Two Terminal Lines.

Short Circuits

A complete or partial short circuit on the pilot wires increases the current in the current-source relay, causing the high-current alarm contacts to close. The resulting current decrease in the PM-23 relay closes the alarm contact. Short circuits of 5000 ohms or less will be detected.

Open Circuits

Current decreases to zero in all relays. Low-current alarm contact of the current source relay closes. Alarm contact of PM-23 relay closes.

Reversed Wires

On applications using the PM-23 relay, current increases in the sending end relay to close the high-current alarm contacts. Current drops to zero in the PM-23 relay monitoring coil to close the low-current alarm contacts.

The current decreases in both sending and receiving end relays when the PM-2, or PM-4 relays are used. Low current alarm contacts close.

The voltage-divider circuit of the PMA, PMD, and PMG-13 source relays has its midpoint grounded through a current-limiting resistor. Thus, a pilot-wire ground will cause an increase in current in one coil circuit, and a decrease in the other one. This unbalance in the current flowing through the two windings (5) of the ground alarm relay unit will cause it to close one of its contacts (depending on which pilot wire is grounded) to give an alarm. Grounds of 10,000 ohms or less will be detected.

For adding the sensitive ground detection where PMA-1, PMD-1, or PM-13 relays have been installed, the PM-5 relay can be added to the circuitry, as shown in figure 24. This relay also has a 10,000-ohm ground sensitivity.

Transferred Tripping

Breakers located at the PMG-13 or PM-13 and PM-3 or PM-23 stations can be tripped by the application of a d-c voltage to the pilot wires at remote locations, as shown in figures 19 to 25. Transferred tripping can be effected from any location by applying 48 volts d-c (through dropping resistors when required) to the pilot wire with polarity opposite to that of the monitoring voltage. When tripping the PM-23, the current is increased above 2.0 ma, in reverse direction, to close the trip contact. When tripping the PMG-13 or PM-13, the reversed d.c. voltage operates the trip unit (3).

See Tables II and III for tripping resistor values. Nominal tripping current is 5 ma. at all rated voltages.

Polar Unit

Polar unit flux paths are shown in figure 1. With balanced air gaps, permanent magnet flux flows in

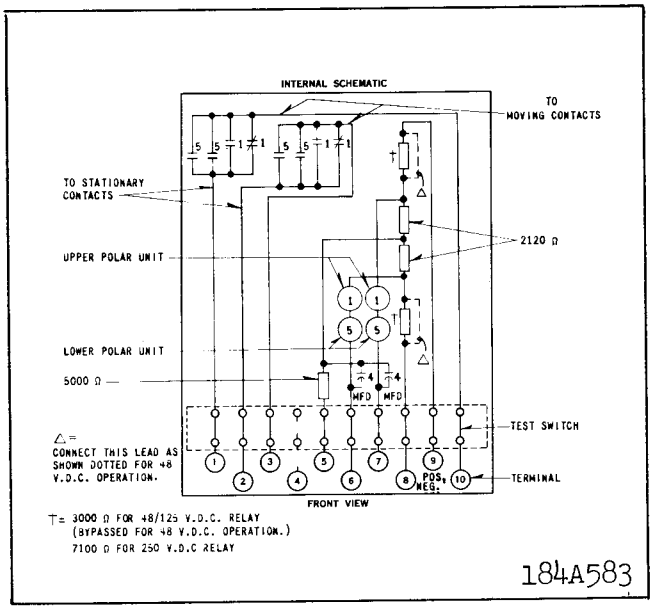


Fig. 6. Internal Schematic of the Type PMD Relay in the FT21 Case – DC Supply – For Three Terminal Lines.

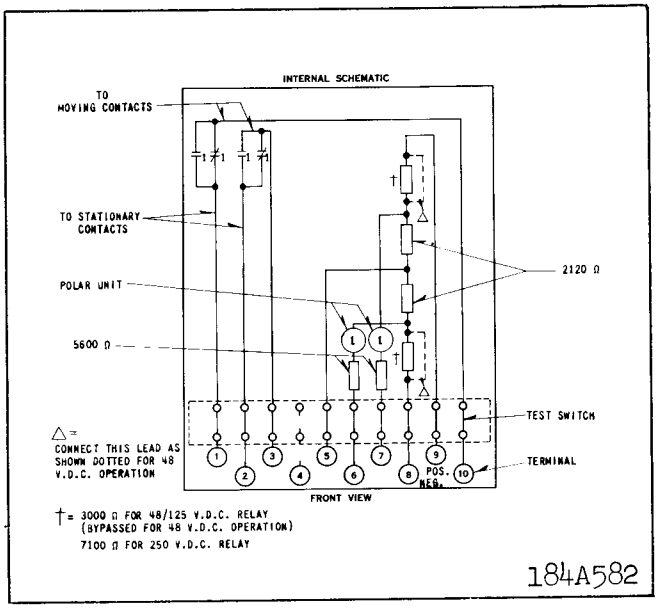


Fig. 7. Internal Schematic of the Type PMD-1 Relay in the FT11 Case – DC Supply – For Three Terminal Lines.

two paths, one through the front, and one through the rear gaps. This flux produces north and south poles, as shown. By turning the left shunt in, some of the flux is forced through the armature, making it a north pole. Thus, reducing the left hand rear gap will produce a force tending to pull the armature to the right. Similarly, reducing the right hand gap will make the armature a south pole and produce a force tending to pull the armature to the left.

The alarm unit contacts of the sending and receiving end relays are biased to move to the left when the relay is deenergized. The PMG-13 or PM-13 and PM-23 trip unit contact is biased to move to the left when the relay is deenergized. The PM-5 is adjusted so that the moving contact floats when the relay is deenergized.

CHARACTERISTICS

Nominal Calibration Values

Nominal current values to close contacts are listed in Tables IV and V.

Voltage Ratings

Supply voltage ratings of the monitoring source relays to obtain continuous monitoring current are as follows:

DC – 48, 125, and 250 volts
AC – 120 volts, 60 cycles (Primary taps 100, 110, 120 & 130)

Voltage impressed on the pilot wire is a nominal 20 volts for monitoring, and 48 volts for tripping.

Supply voltage ratings to obtain remote tripping are: 48, 125, and 250 volts d-c.

Coil Resistance

Relay	DC Resistance
PMA, PMA-1, PMD, PMD-1	
PM-13, & PMG-13	
Alarm Coils (each winding)	1050-1250 Ω
PM-2, PM-23 (alarm coil)	2200-2600 Ω
PMG-13, PM-13, PM-23, & PM-3	
Trip Coil	1800-2200 Ω
PMA, PMD & PMG-13	
Ground Unit Coil (each winding)	5200-5800

PM-4 and PM-23 Resistance

Nominal PM-4 and PM-23 total resistance when adjusted for service is 20,000 ohms less pilot wire loop resistance at 1 ma.

PMA, PMA-1 and AC PMG-13, PM-13 Burden

0.5 VA at tap voltage – 2-terminal line relay
1.0 VA at tap voltage – 3-terminal line relay

Rectifiers

Approximate forward resistance - 560 ohms at 1 ma
300 ohms at 2 ma

Rating

Continuous forward current - amperes — 1

Continuous back voltage - rms volts — 200

Remote Tripping

Remote trip resistors are listed in Table II and III for 48, 125, and 250 volts d-c.

The relays have sufficient thermal capacity to withstand 20 MA d-c continuously when remote tripping. Nominal trip currents in the tripping relays are 5.0 MA d-c with 48, 125, and 250 volts d-c supply and a 2000-ohm pilot wire.

TABLE II

PMA, PMA-1, PMD, AND PMD-1 APPLICATIONS

EXTERNAL RESISTORS FOR D.C. REMOTE TRIPPING
(2 REQUIRED PER STATION)

# LINE TERMINALS	D.C. VOLTAGE	STATION A PMA or PMA-1	STATION A PMD or PMD-1	STATION B PM-2 & PM-3 or PM-23 or PM-4	STATION C PM-2 & PM-3 or PM-23 or PM-4	TO OPERATE
2	48	200	200	—	—	PM-23 or PM-3
	125	3550	3550	—	—	,,
	250	9300	9300	—	—	,,
3	48	200	200	—	—	,,
	125	2000	2000	—	—	,,
	250	5600	5600	—	—	,,

TABLE IIIA

PMG-13 AND PM-13 (D.C. SUPPLY) APPLICATIONS

RESISTORS FOR D.C. REMOTE TRIPPING
(2 REQUIRED PER STATION)

# LINE TERMINALS	D.C. VOLTAGE	STATION A PMG-13 or PM-13	STATION B PM-2 & PM-3 or PM-23 or PM-4	STATION C PM-2 & PM-3 or PM-23 or PM-4	TO OPERATE
2	48	200 †	200	—	PMG-13 or PM-13 and PM-23 or PM-3
	125	2120 †	2120	—	,,
	250	5600 †	5600	—	,,
3	48	200 †	200	200	,,
	125	1500 †	1500	1500	,,
	250	4000 †	4000	4000	,,

† Mounted in Relay

TABLE IIIB

PMG-13 AND PM-13 (A.C. SUPPLY) APPLICATIONS
(2 REQUIRED PER STATION)

RESISTORS FOR D.C. REMOTE TRIPPING

# LINE TERMINALS	D.C. VOLTAGE	STATION A PMG-13 or PM-13	STATION B PM-2 & PM-3 or PM-23 or PM-4	STATION C PM-2 & PM-3 or PM-23 or PM-4	TO OPERATE
2	48	200 †	200	–	PMG-13 or PM-13 and PM-23 or PM-3
	125	2120 †	2120	–	”
	250	5600 †	5600	–	”
3	48	200 †	200	200	”
	125	1500 †	1500	1500	”
	250	4000 †	4000	4000	”

† Mounted in Relay

TABLE IV

NOMINAL CALIBRATION VALUES – TWO TERMINAL LINES

RELAY	LOW CURRENT ALARM [1]	HIGH CURRENT ALARM [2]	TRIP
PMA or PMA-1	0.7 ma	1.3 ma	–
PMD or PMD-1	0.7	1.3	–
PM-5 †	–	±0.3	–
PMG-13 or PM-13	0.7 ††	1.3 ††	14 V.
PM-23 or PM-2 & PM-3 †	0.7	–	14 V.

† Same relay as for three-terminal lines
†† These are pilot-wire current values

1—Left-hand contacts, front view.
2—Right-hand contacts, front view.

TABLE V

NOMINAL CALIBRATION VALUES – THREE TERMINAL LINES

RELAY	LOW CURRENT ALARM	HIGH CURRENT ALARM	TRIP
PMA or PMA-1	1.7 ma	2.3 ma	–
PMD or PMD-1	1.7	2.3	–
PM-5 †	–	±0.3	–
PMG-13 or PM-13	1.7 ††	2.3 ††	14 V.
PM-23 or PM-2 & PM-3 †	0.7	–	14 V.

† Same relay as for two-terminal lines
†† These are pilot-wire current values

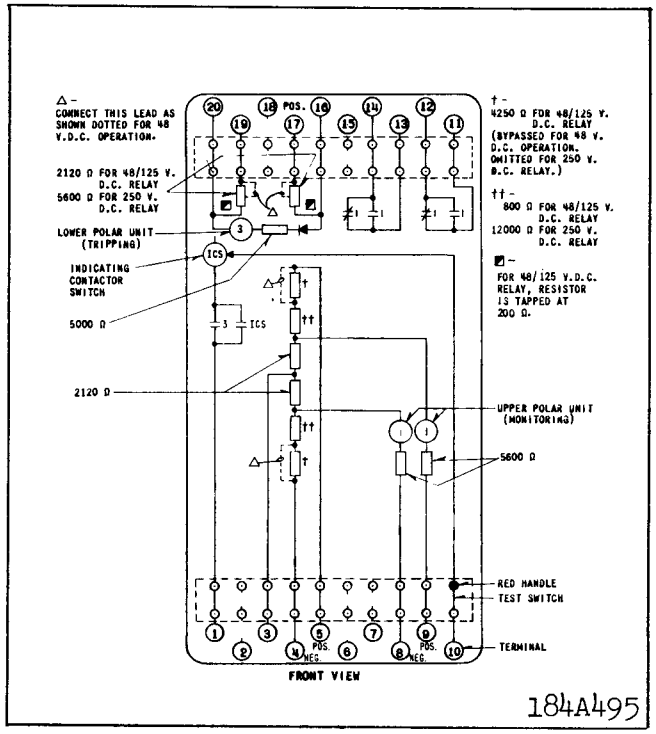


Fig. 8. Internal Schematic of the Type PM-13 Relay in the FT32 Case – DC Supply – For Two Terminal Lines.

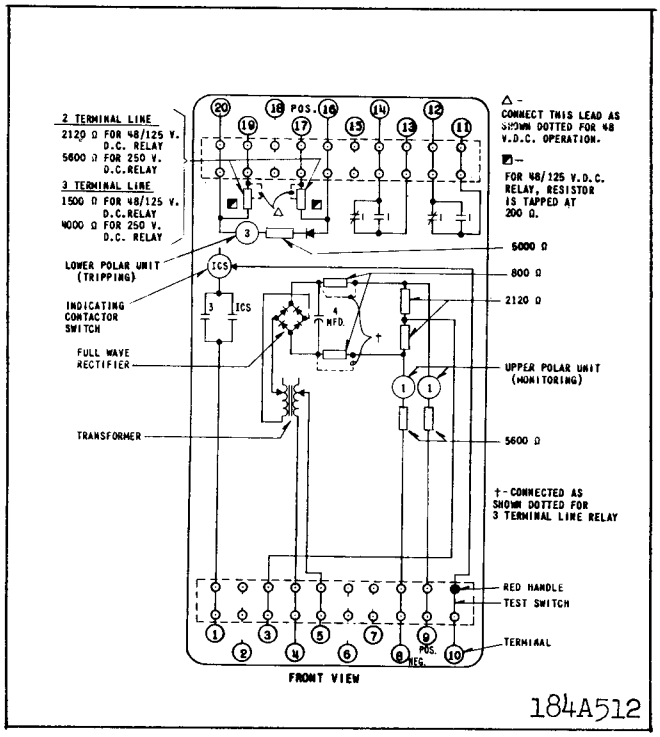


Fig. 9. Internal Schematic of the Type PM-13 Relay in the FT32 Case – 120 Volt, 60 cycle supply – For Two and Three Terminal Lines.

Trip Circuit

The main contacts will safely close 30 amperes at 250 volts d-c and the seal-in contacts of the indicating contactor switch 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 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.

Trip Circuit Constant

Indicating Contactor Switch (ICS)

0.2 ampere tap 6.5 ohms d-c resistance
2.0 ampere tap 0.15 ohms d-c resistance

SETTING THE RELAY

Operating units of all relays are adjusted in the factory to the values listed in Tables IV and V to a tolerance of ±5%. No settings are required on these units.

For all 48/125-volt d.c. relays, connect jumpers across resistors as shown on the internal schematics.

PM-4, PM-2, and PM-23 Relays

Adjust the resistors in the PM-4, PM-2, or PM-23 relay or relays to a value of 1 MA d-c with the monitoring circuits connected for service. Use the milliammeter in the PM-23 for this purpose or use a portable milliammeter with a resistance of less than 200 ohms. Where it is not practical on three-terminal lines to adjust both receiving relays simultaneously, set one receiving relay for 18,000 ohms total resistance (including relay coil and resistors) by measurement prior to final adjustment of the other receiving relay. This procedure will minimize the change in monitoring current in the first relay to be adjusted when making the final adjustment of the second relay.

PMA, PMA-1, PMG-13 and PM-13 Relays

Select the transformer tap nearest to expected normal a-c supply voltage. The full wave rectifier is connected to a secondary transformer tap. Where desired, the output voltage can be raised about 5% by reconnecting across the full secondary winding.

Indicating Contactor Switch

No setting is required on the ICS unit except the

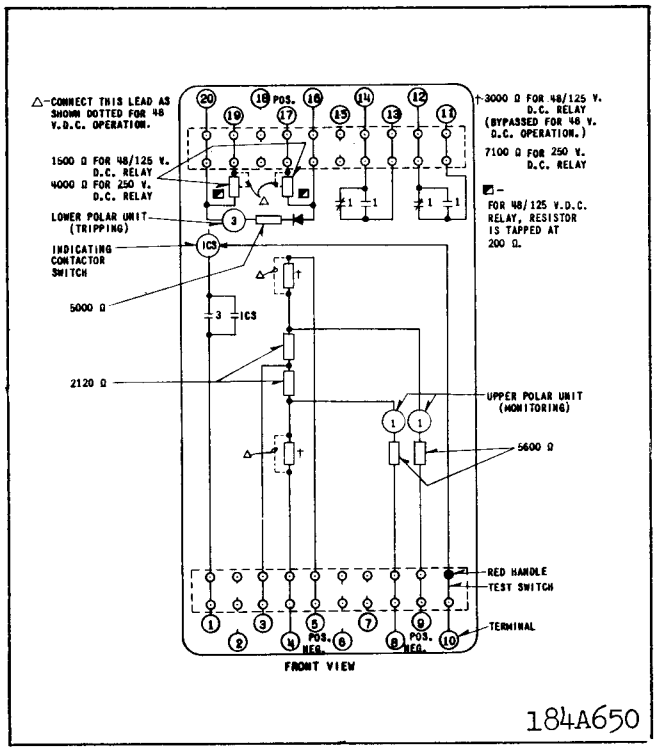


Fig. 10. Internal Schematic of the Type PM-13 Relay in the FT32 Case – DC Supply – For Three Terminal Lines.

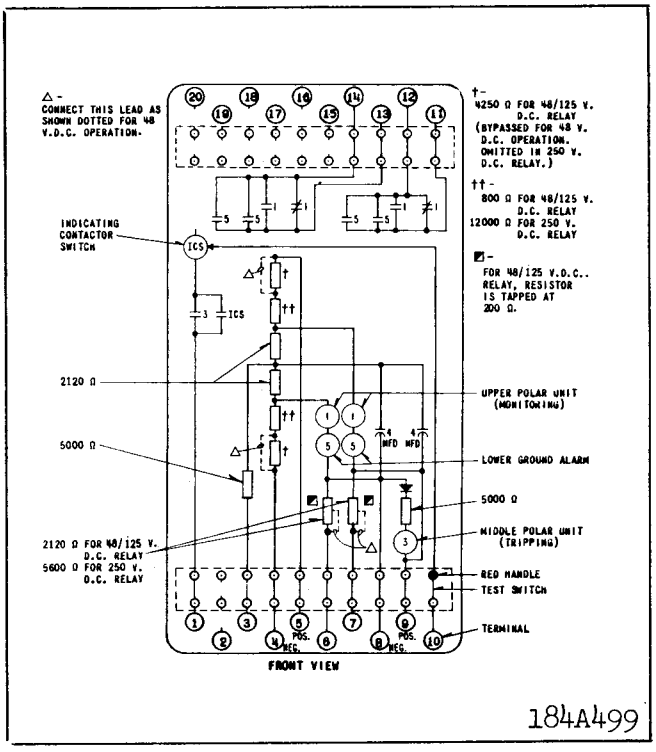


Fig. 11. Internal Schematic of the Type PMG-13 Relay in the FT32 Case – DC Supply – For Two Terminal Lines.

selection of the 0.2 or 2.0 ampere tap setting. This selection is made by connecting the lead located in front of the tap block to the desired setting by means of the connecting screw. When the relay energizes a type WL relay switch, or equivalent, use the 0.2 ampere tap.

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 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 I.L. 41-076.

Where the potential to ground impressed on the relays can exceed 700 volts, a drainage reactor in conjunction with a KX-642 tube, or the reactor in conjunction with 700 volt carbon-block arresters, is recommended. For details, see Protection of Pilot-Wire Circuits, AIEE Committee Report, paper 58-1190, AIEE Transactions, 1959, Volume 78, Part III B pp. 205-212. Also, see AIEE Special Publication S-117, Applications and Protection of Pilot-Wire Circuits for Protective Relaying, July 1960.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory and should not be disturbed after receipt by the customer. If the adjustments have been changed, the relay taken apart for repairs, or if it is desired to check the adjustments at regular maintenance periods, the instructions in the succeeding sections should be followed.

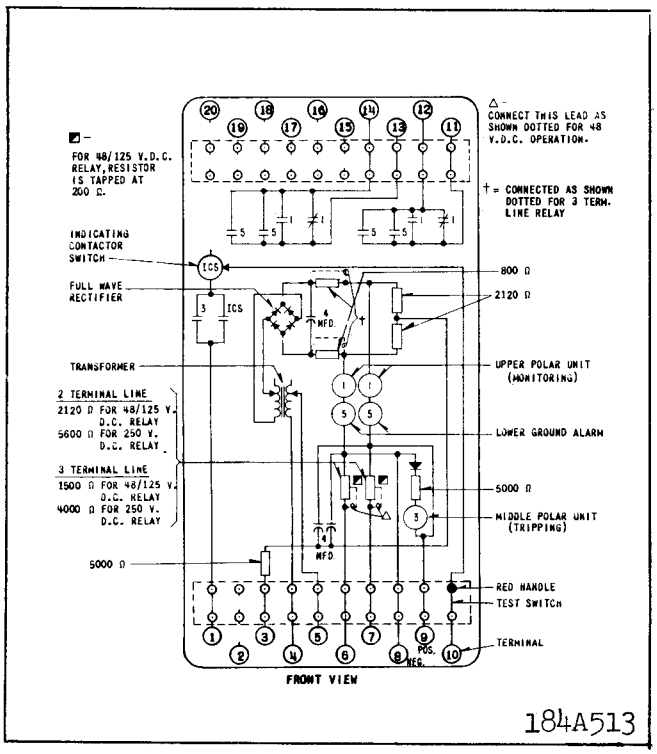


Fig. 12. Internal Schematic of the Type PMG-13 Relay in the FT32 Case – 120 Volt, 60 cycle supply – For Two or Three Terminal Lines.

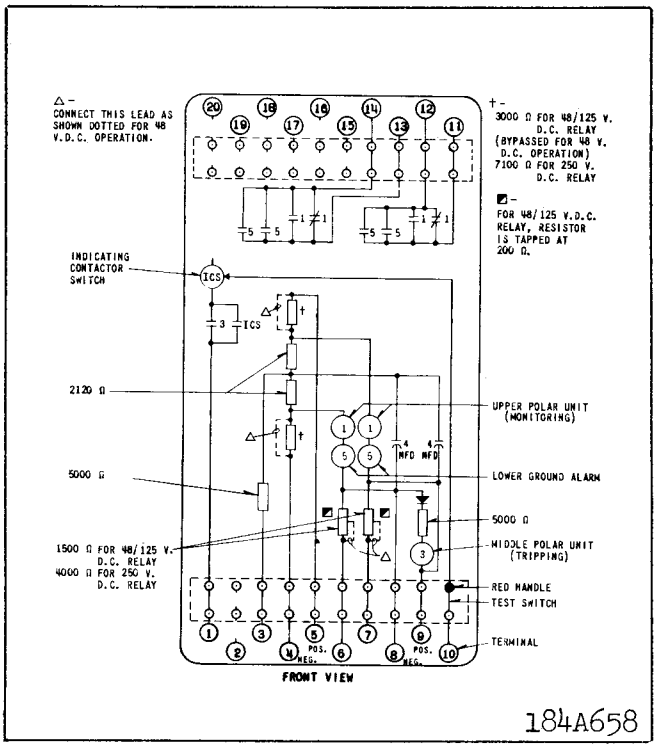


Fig. 13. Internal Schematic of the Type PMG-13 Relay in the FT32 Case – DC Supply – For Three Terminal Lines.

Acceptance Tests

The following tests are recommended when the relay is received from the factory. If the relay does not perform as specified below, the relay either is not properly calibrated or it contains a defect.

PMA and PMA-1 Relays

Alarm Unit (1)

Set the primary tap on 120 volts. Connect a variable resistor of approximately 20,000 ohms in series with a low-range d-c milliammeter across terminals 6 and 7 with the instrument positive connected to terminal 7. Apply 120 volts at rated frequency to terminals 4 and 5. Adjust the 20,000-ohm resistor to obtain a current of one ma. d.c. For a three-terminal line relay, use a 10,000-ohm resistor and set the current to 2 ma. d.c. At this value, the moving contact of the alarm or monitoring relay unit (1) should float between the two sets of stationary contacts. In the PMA relay, the ground alarm unit (5) contact should also float. (This contact will also float when the relay is de-energized.) Increase and decrease the one or two-milliampere monitoring current to check the calibration values listed in Tables IV and V.

Ground Unit (5)

Reconnect the 20,000-ohm resistor. For the PMA relay only, short terminals 7 and 3. The contact of the ground alarm unit (5) should close to the right when the relay is energized. Remove the short, and connect it between terminals 6 and 3. The ground alarm unit (5) should close to the left. The action of the monitoring unit (1) contact is of no significance in this simulated pilot-wire ground test. To check the pickup current of the ground detector, first remove the 20,000-ohm resistor from terminals 6 and 7. Connect a 0-1 d.c. milliammeter in series with a variable resistor of about 50,000 ohms between terminals 3 and 6. The ground unit should close its left-hand contact at approximately 0.3 ma. d.c. With the milliammeter and resistor connected between terminals 3 and 7, the right-hand contact should close at 0.3 ma. d.c.

PMD and PMD-1 Relays

Alarm and Ground Units

Connect an adjustable 20,000-ohm resistor (or 10,000-ohms for a 3-terminal relay) in series with a d-c milliammeter across terminals 6 and 7 with the

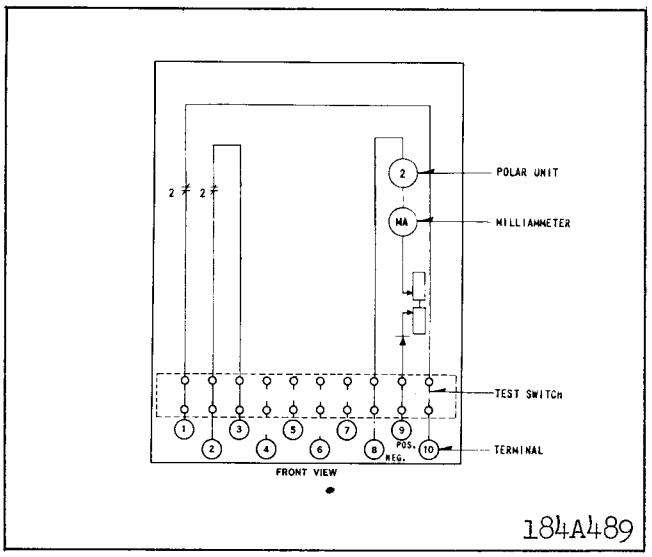


Fig. 14. Internal Schematic of the Type PM-2 Relay in the FT21 Case.

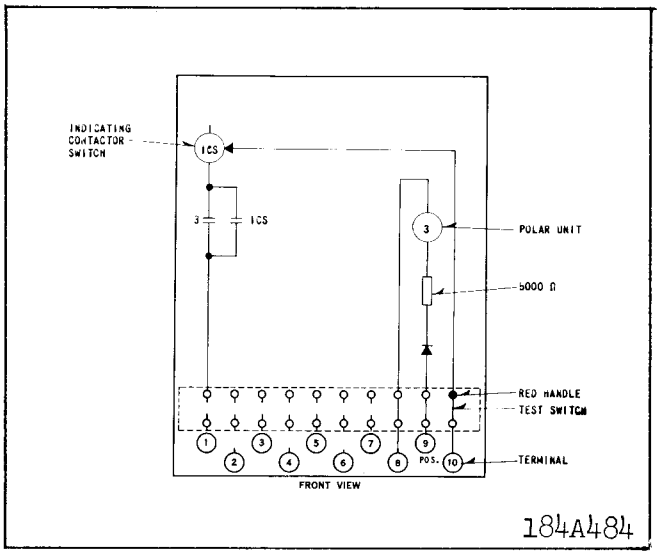


Fig. 15. Internal Schematic of the Type PM-3 Relay in the FT11 Case.

instrument positive connected to terminal 7. Apply rated d-c voltage to terminals 8 and 9 with positive on terminal 9. Now check the PMD and PMD-1 relays, following the procedure given in the previous section for the PMA and PMA-1 relays, respectively. Note, however, that terminal 5 of the PMD relay corresponds to terminal 3 of the PMA relay.

PM-2, PM-3, and PM-23 Relays

Alarm Unit (2)

Apply a variable d-c voltage of approximately 20 volts to relay terminals 8 and 9 (terminal 9 positive) of the PM-2 or PM-23 relay. Adjust the voltage to obtain a reading of one ma. on the relay milliammeter. The monitoring polar unit (2) contacts should float. Reduce the current gradually. The monitoring alarm contacts should close at 0.7 ma. d.c. The tripping unit (3) of the PM-23 relay should not move during this test.

Tripping Unit (3)

To check the PM-3 relay or the tripping unit of the PM-23 relay, apply the variable d-c voltage in series with an external milliammeter to relay terminals 8 and 9 with terminal 8 positive for the PM-23 relay, or terminal 9 positive for the PM-3 relay.

The tripping relay unit (3) should pick up with positive action at 14 volts d.c. and should drop out at approximately 10 volts. The alarm unit of the PM-23 relay will not operate during this test.

Indicating Contactor Switch (ICS) – PM-3 and PM-23 relays. Close the contact of the tripping unit (3), and pass sufficient direct current through the trip circuit (terminals 1 and 10) to close the contacts of the ICS unit. This value of current should not be greater than the particular ICS tap setting being used (0.2 or 2.0). The indicator target should drop freely.

PM-4 Relay

This device is simply a set of resistors and a diode to connect into the pilot-wire circuit to provide a path for the monitoring current. The resistors can be checked with an ohmmeter, and the diode can be checked either with an ohmmeter, or as explained in the section entitled "Rectifier Check" under "Routine Maintenance". If an ohmmeter is used, the difference in forward and reverse resistance readings obtained will be dependent on the current flowing through the diode.

PM-5 Relay

Apply 5 volts d.c. in series with a 0-1 d.c. milliammeter and a 20,000-ohm variable resistor to terminals 6 and 7 with positive on terminal 6. The left-hand contact should close at approximately 0.3 ma. Now apply the same circuit to terminals 8 and 9 with positive on terminal 9. The right-hand contact should close at approximately 0.3 ma.

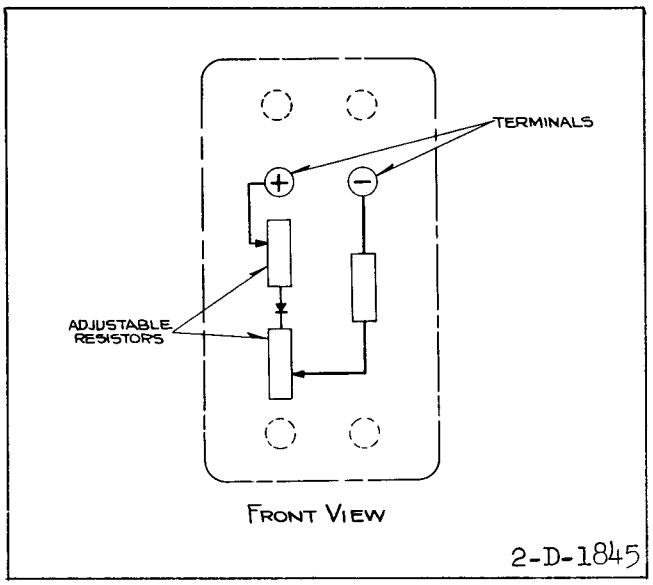


Fig. 16. Internal Schematic of the Type PM-4 Auxiliary Unit in the Small Molded Case.

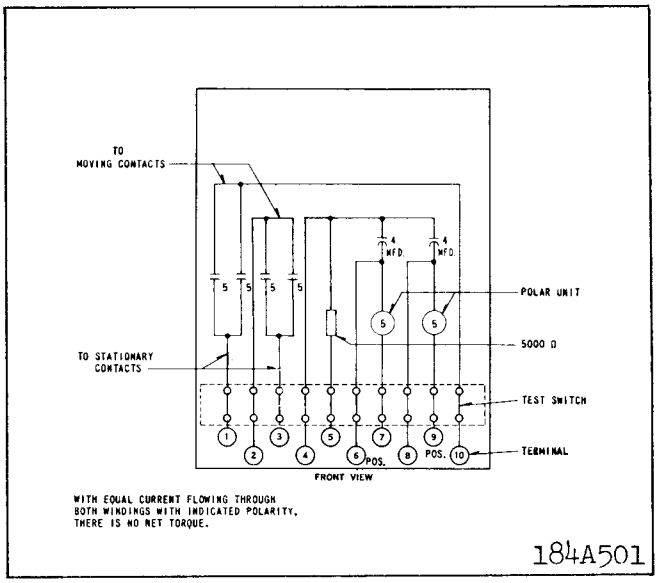


Fig. 17. Internal Schematic of the Type PM-5 Ground Detector Relay in the FT11 Case.

PM 13 Relays — A.C. and D.C.

Alarm Unit (1)

Connect a variable 20,000-ohm resistor (10,000 ohms for a 3-terminal-line relay) in series with a d-c milliammeter across terminals 8 and 9 with the instrument positive on terminal 9. For the a-c relay, set the primary tap on 120 volts. Now apply the rated supply voltage to terminals 4 and 5. This will be 48, 125, or 250 volts d.c., or 120 volts a.c. as indicated on the relay nameplate. Adjust the variable resistor to obtain a current of one ma. for a 2-terminal line relay, or 2 ma. for a 3-terminal relay. At this value, the moving contacts of the alarm or monitoring (1) relay unit (the upper polar unit) should float between the two sets of stationary contacts. Increase and decrease the one or 2-ma. monitoring current to check the calibration values listed in Tables IV and V.

Tripping Unit (3)

To check the operation of the tripping unit 3 (the lower polar unit), apply a d.c. potential across terminals 16 (positive) and 20 (negative). The tripping polar unit should pick up at 14 volts, and should drop out at approximately 10 volts. The resistance of the series dropping resistors for transferred tripping (listed in Tables III A and III B) can be checked with an ohmmeter. The circuit location of these resistors can readily be seen from the external schematic, Figure 25.

Indicating Contactor Switch (ICS)

Close the contact of the tripping unit (3), and pass sufficient direct current through the trip circuit (terminals 1 and 10) to close the contacts of the ICS. This value of current should not be greater than the particular ICS tap setting being used (0.2 or 2.0). The indicator target should drop freely.

PMG-13 Relays — A.C. and D.C.

Alarm and Tripping Units

Follow the procedure given in the previous section for the a-c. and d-c. PM-13 relays.

Ground Unit (5)

Connect the 20,000-ohm (or 10,000-ohm) resistor and milliammeter across terminals 8 and 9. With rated voltage applied and one ma. (or 2 ma.) flowing, successively short circuit terminals 3 and 8, then 3 and 9. The ground alarm unit 5 (lower polar unit) should move first to the left, then to the right. To check the pickup current of the ground detector, first remove the 20,000-ohm resistor from terminals 8 and 9. Connect a 0-1 d.c. milliammeter in series with a variable

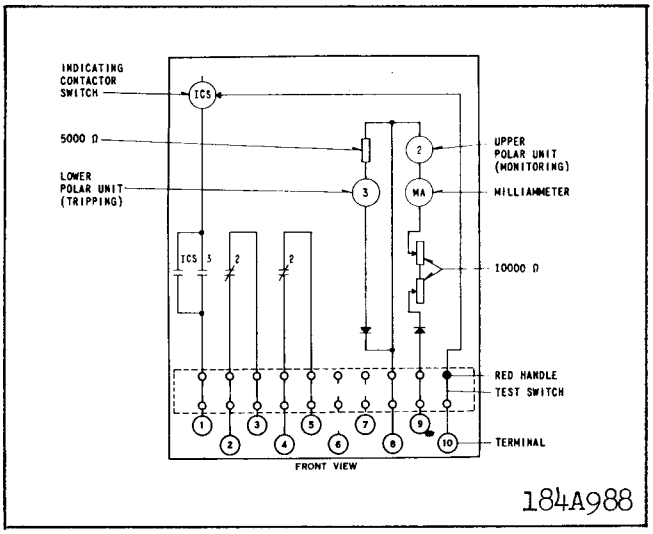


Fig. 18. Internal Schematic of the Type PM-23 Relay in the FT21 Case.

resistor of about 50,000 ohms between terminals 3 and 8. The left-hand contact should close at approximately 0.3 ma. d.c. With the milliammeter and resistor connected between terminals 3 and 9, the right-hand contact should close at 0.3 ma. d.c. The external schematic diagrams for these relays are shown in Figure 21 and 23.

Indicating Contactor Switch (ICS)

Follow the procedure given for this device in the previous section on the a-c and d-c PM-13 relays.

Routine Maintenance

CAUTION – Do not make any performance check, calibration tests, or adjustments while the PM relays are energized or connected to the pilot wires, to prevent the possibility of inadvertantly causing a breaker operation. The PM relays may be removed from service for testing, without jeopardizing HCB relay protection, providing that the connections between the 10-mfd capacitor and the HCB insulating transformer are not disturbed.

Contacts

All contacts should be periodically cleaned. A contact burnisher S#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.

Operational Check

In addition to cleaning contacts, it is recommended that an operational check be performed periodically by opening and short-circuiting the pilot wires, as well as grounding them at the relay terminals. Note: These pilot-wire faults should not be applied directly to the pilot wires when the HCB relays are in service. It is also recommended that the trip circuits of the PM relays be opened (where tripping is used), to prevent the possibility of inadevertently tripping the associated circuit breaker during testing. If the relays do not perform as expected, and diode failure is suspected, the diode tests described in the following section may be performed.

Rectifier (Diode) Check

If there is suspicion of a rectifier (diode) failure, apply 30 volts d.c. reverse voltage (positive on arrowhead) through a 300-ohm resistance to the diode. Measure the voltage across the diode. If this voltage is not essentially 30 volts, the diode is short-circuited. Now apply 30 volts d.c. in the forward direction through the 300-ohm resistor, and measure the voltage across the resistor. If the voltage is not essentially 30 volts, the diode may have a high forward resistance. If the voltage is zero, the diode is open-circuited.

Calibration

If the relay has been dismantled or the calibration has been disturbed, use the following procedure for calibration.

With the permanent magnet removed, see that the moving armature floats in the central area of the air-gap between the poles of the polar unit frame. If necessary, loosen the core screw in the center rear of the unit and shift the core and contact assembly until the armature floats. (This can best be done with the polar unit removed from the relay.) Then retighten the core screw and replace the permanent magnet with the dimple (north pole) on the magnet to the left when viewed from the front.

Polar Units-General

The following mechanical adjustments are given as a guide, and some deviation from them may be necessary to obtain proper electrical calibration.

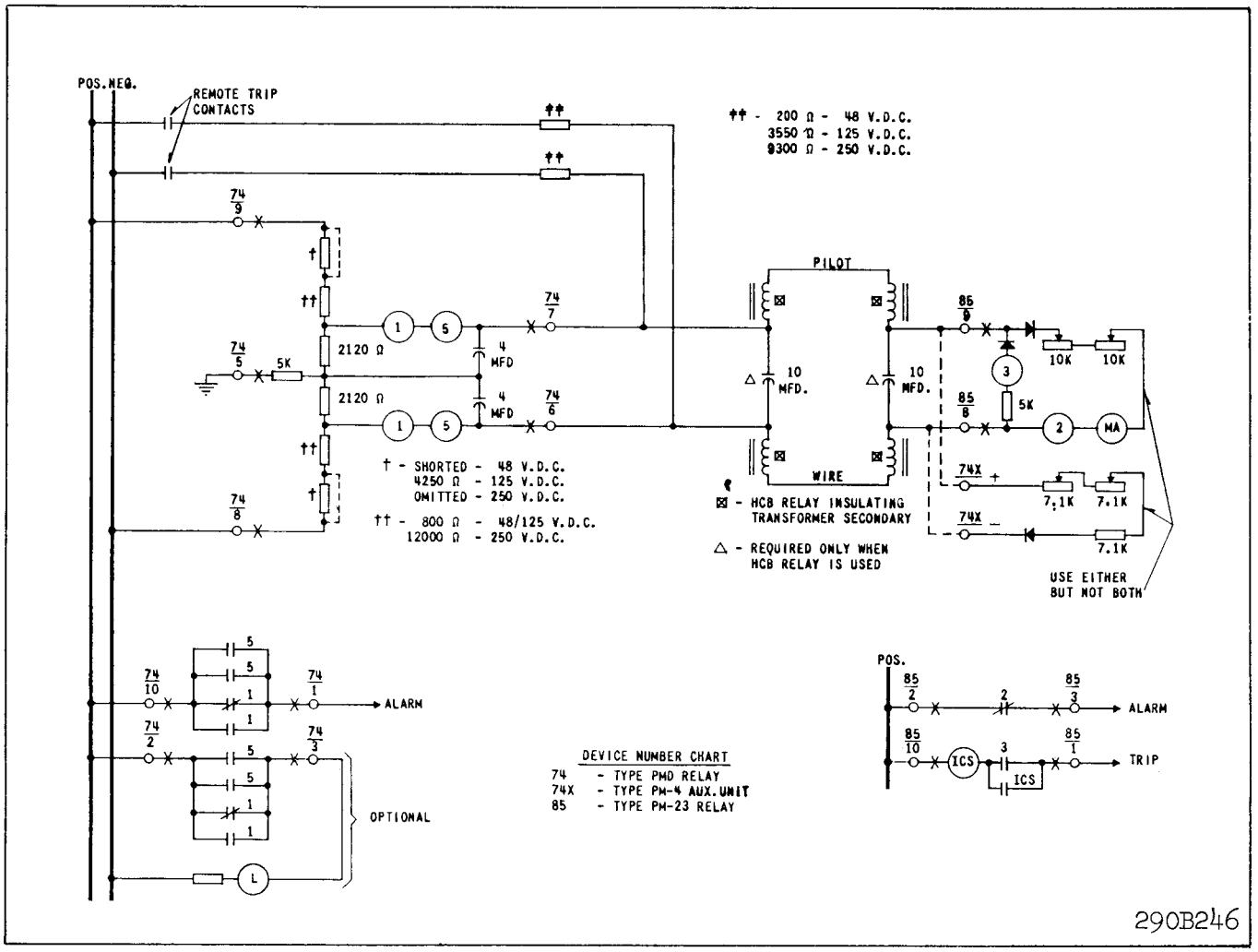


Fig. 19. External Schematic of the Type PMD Relay with Type PM-23 or PM-4 Relay – Two Terminal Lines.

Magnetic Shunt Adjustment

The sensitivity of the polar unit is adjusted by means of two magnetic, screw-type shunts at the rear of the unit, as shown in Fig. 1. These shunt screws are held in proper adjustment by a flat strip spring across the back of the polar unit frame, so no locking screws are required. Looking at the relay, front view, turning out the right-hand shunt to open the right-hand air gap decreases the amount of current required to close the right-hand contact. Conversely, drawing out the left-hand shunt increases the amount of current required to close the right-hand contact, or decreases the amount of current required to close the left-hand current (with the proper direction of current flow). Also, if a relay trips to the right at the proper current, the dropout current can be raised by turning in the right-hand shunt. The two shunt-screw adjustments are not independent, however, and a certain amount of trimming adjustment of both shunt screws is generally necessary to obtain the desired pickup and dropout calibration.

In general, the farther out the two shunt screws are turned, the greater the toggle action will be, and as a result, the lower the dropout current. For the tripping units (3) of the PM-3, PM-13, and PM-23 relays, toggle action is desirable, with a dropout current around 75 percent of the pickup current. For the monitoring alarm relay units, toggle action is not desired. Instead, the armature is adjusted to float between the pole faces at a given current (1 or 2 ma.), and to move gradually toward the high or low-current alarm as the coil current is increased or decreased. Similarly, the floating adjustment of the armature of

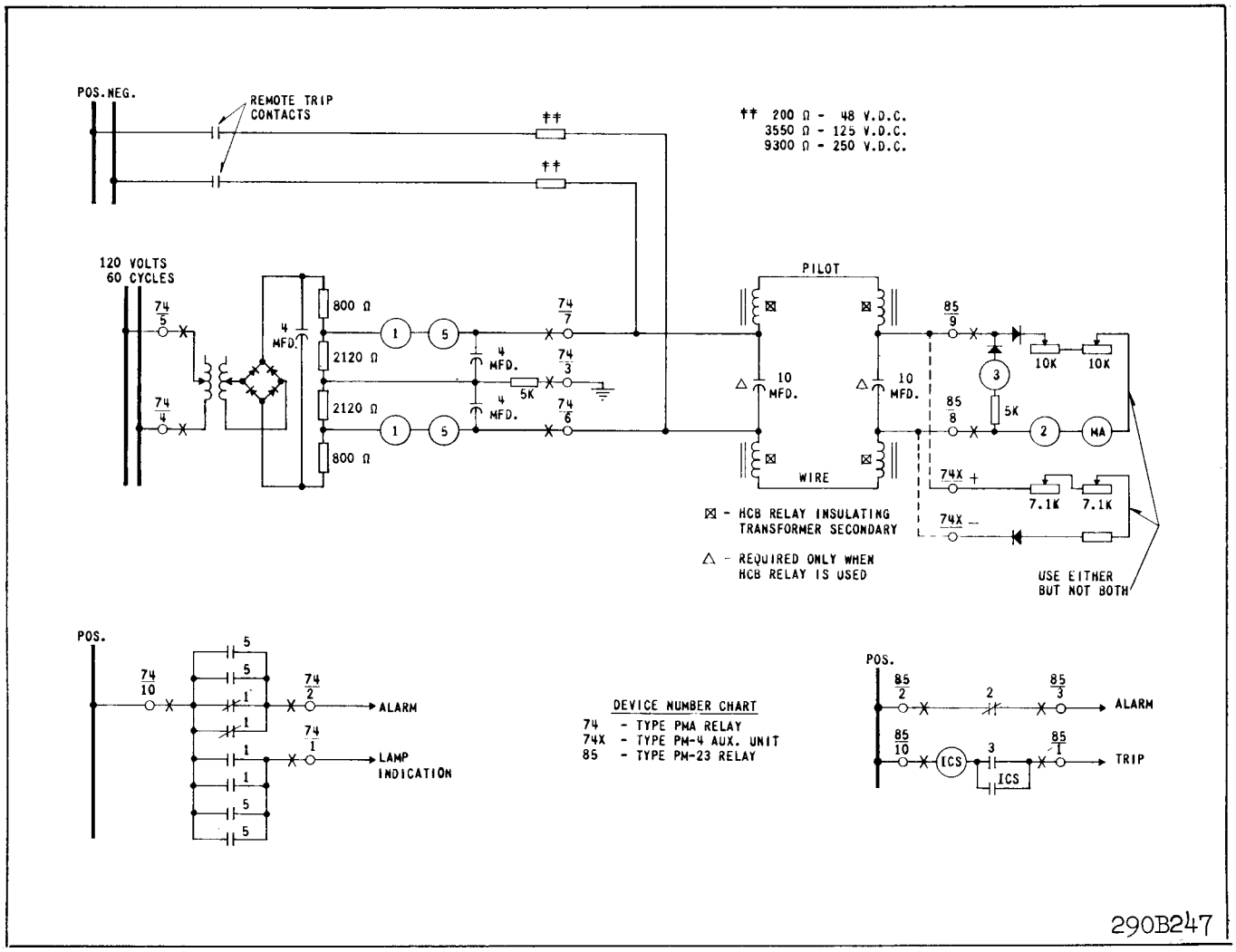


Fig. 20. External Schematic of the Type PMA Relay with Type PM-23 or PM-4 Relay – Two Terminal Lines.

the ground alarm unit (5) requires that both shunt screws be turned in relatively far. Then the armature will move gradually to the left or right as the current through the two #5 coils is unbalanced.

The electrical calibration of the polar unit is also affected by the contact adjustment as this changes the position of the polar unit armature. Do not change the contact adjustment without rechecking the electrical calibration.

Contact Adjustment – All Relays

For all monitoring alarm units, designated (1) or (2), turn in all the stationary contact and contact stop screws until they just touch the moving contact. Advance the screws to hold the armature in the central portion of the magnetic air gap between the two pole faces. (The stationary contact screws have a round silver contact face; the stop screws do not have this silver facing.) Now back off all the contact and contact stop screws one full turn. This will give a total contact travel of 0.050 inch. When the relay is properly calibrated, some touch-up adjustment may be necessary so that double contacts will both close at the same current value. The contact gap between the floating moving contact and the right-hand or left-hand stationary contacts or contact stops will be approximately 0.025 inch when the relay is in operation.

For the tripping (3) units of the PM-3, PM-13, PMG-13, and PM-23 relays, adjust the contacts as

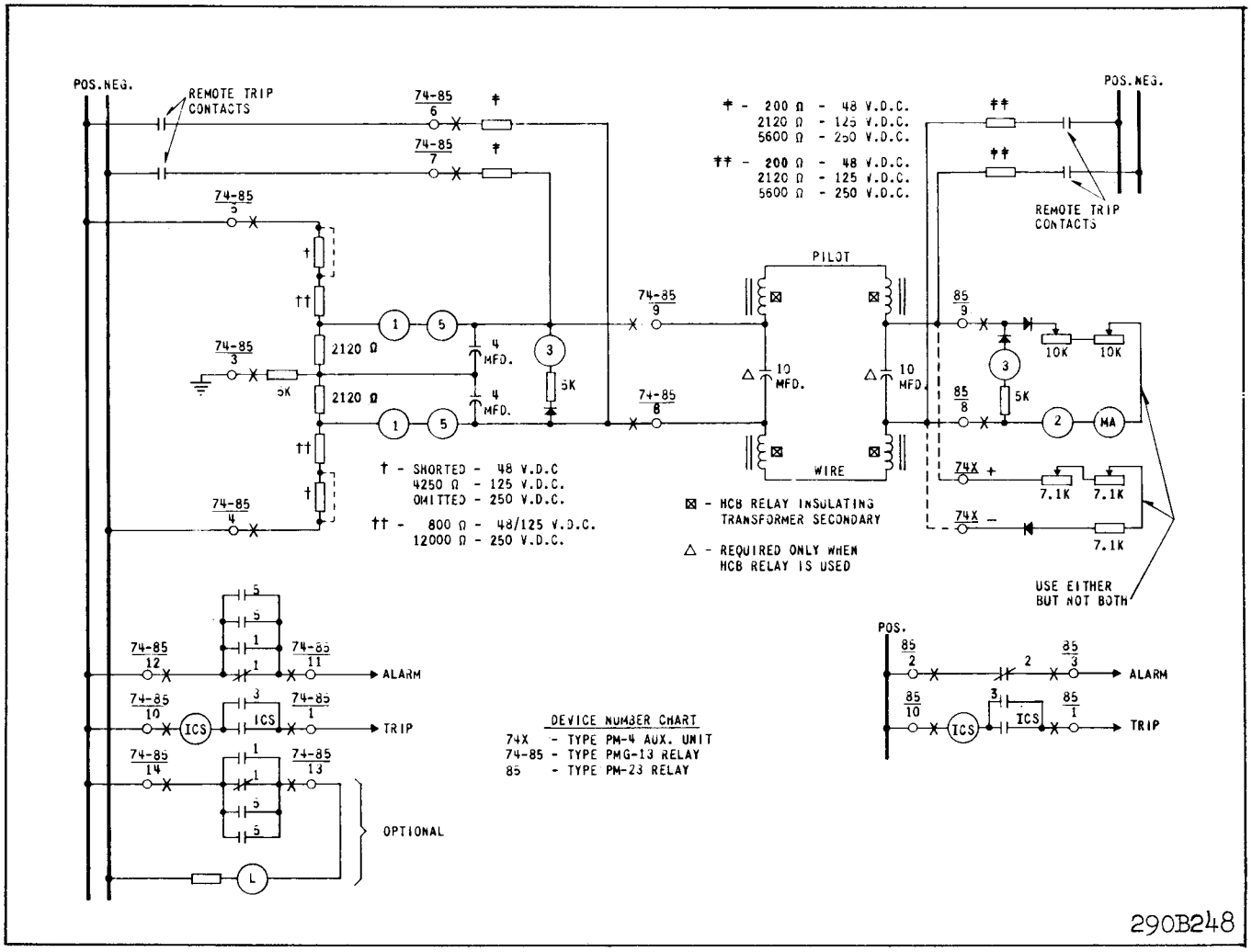


Fig. 21 External Schematic of the DC Type PMG-13 Relay with Type PM-23 or PM-4 Relay – Two Terminal Lines.

described in the previous paragraph, except back off the contact and stop screws one-half turn each to give a total moving contact travel of approximately 0.025 inch. In operation of the tripping unit, the moving contact will normally rest against the contact stop screw, and will pick up only for a transferred-tripping operation.

For the pilot-wire ground alarm unit (5) of the PMA, PMD, PM5, and PMG-13 relays, follow the same general procedure except back off both stationary contact screws two turns each. This will give a contact gap of 0.050 on each side of the moving contact when it is its normal central position.

Electrical Calibration – All Relays

In the following sections, the calibration instructions are given for the polar unit which performs a certain function, such as alarm (1) or (2), ground (5), or trip (3), rather than giving calibration instructions for each complete relay. In this way, considerable duplication of instructions has been eliminated.

The following chart indicates the units present in each relay.

Function and Unit	PMA PMD	PMA-1 PMD-1	PM2	PM3	PM4	PM5	PM13	PMG13	PM23
Alarm for p.w. open, short, or reversal (1) (2)	(1)	(1)	(2)				(1)	(1)	(2)
Transfer-Trip Unit (3)				(3)			(3)	(3)	(3)
Alarm for p.w. ground (5)	(5)					(5)		(5)	
D.C. Path for Monitoring Current					√				

Alarm Unit (1)

Connect the relay as described under Acceptance Tests for the particular relay involved. Screw the two magnetic shunts all the way in, then back them out five turns each. With the relay energized at rated voltage, set the monitoring current at 1.3 or 2.3 ma. d.c. for 2 or 3-terminal relay respectively, by adjusting the external resistor. If the relay does not close its right-hand contact, turn in the left shunt screw until the right-hand contact just closes. If the right-hand contact is closed at 1.3 ma., turn in the right shunt until a point is reached when the right-hand contact is just closed at 1.3 ma.

Now drop the current to 0.7 ma. and adjust the opposite shunt until the left-hand contact just closes at 0.7 ma. d.c. At 1.0 ma. d.c., the moving contact should float half way between the two sets of stationary contacts with a 0.025-inch gap on each side. Recheck the high and low current calibration several times, touching up the shunt adjustments as required to obtain the desired calibration.

Polarization Check

For all the source relays, which are listed below, make the following additional calibration check:

PMA
PMA-1
PMD
PMD-1
PM-13 (a.c. and d.c.)
PMG-13 (a.c. and d.c.)

After calibration as described in the previous sections, connect a 20,000 ohm resistor (or 10,000 ohms for 3-terminal applications) across the output terminals, and energize the relay at its rated supply voltage. With these connections, approximately one (or two) milliamperes d.c. will flow through the monitor relay coils and external resistor, thus representing normal operating conditions.

Now momentarily (one second or so) apply 48 volts d.c. directly to the pilot-wire terminals of the relay, as indicated in the following table.

Relay	Terminals for Momentary Application of 48 V. d.c.	
	POS.	NEG.
PMA, PMA-1 } PMD, PMD-1 }	6	7
PM-13 (a.c. or d.c.) } PM-13 (a.c. or d.c.) }	9	8

After momentary application of the transfer-trip voltage as just explained, recheck the calibration of the monitoring alarm unit (1). If it has changed, make necessary trimming adjustments of the shunt screws until there is no change in calibrating of the alarm unit (1) after the transfer-trip voltage has been applied. The purpose of this test is to compensate for the small residual magnetism in the relay unit. The ground alarm unit (5) will not be affected by this test as the ampere-turns of the two windings cancel each other.

Alarm Unit (2)

For the alarm unit of the PM-2 or PM-23 relays, adjust the shunts so that the relay moving contact

floats at one ma. d.c., and closes the left-hand contact at 0.7 ma. d.c. The moving contact should float midway between the contact and contact stop at 1.0 ma. d.c. There is no high-current calibration for this relay unit.

Now apply 48 volts d.c. momentarily (one second or so) across the alarm unit coil-circuit terminals in a direction to operate the alarm relay. Then recheck the alarm unit calibration. If there is any change, touch up the shunt adjustments until there is no change in calibration after 48 v. d.c. has been applied.

Tripping Unit (3)

To calibrate the tripping unit of the PM-3, PM-13, PMG-13, or PM-23 relays apply a d.c. voltage as explained below, to the following relay terminals:

Relays	D.C. Voltage	
	Pos.	Neg.
PM-3	9	8
PM-13 (a.c. or d.c.)	16	20
PMG-13 (a.c. or d.c.)	8	9
PM-23	8	9

Momentarily (one second or so) apply 48 volts d.c. to the terminals shown in the chart. Then starting with both shunts all the way in, turn out the right-hand shunt screw until the relay closes its right-hand trip contact at 14 volts d.c. (This will give approximately 2 ma. through the relay coil.) Now draw out the left-hand shunt until the relay resets with toggle action (not gradually) at not less than 10 volts d.c. When the calibration is approximately correct, again apply 48 volts d.c. to the indicated terminals, then recheck the pickup and dropout voltage, making any necessary trimming adjustments of the shunts. When the relay is properly adjusted, the application of 48 volts d.c. will not change the pickup or dropout voltage points. The relay should trip and reset with toggle action in this application. This will require both shunt screws to be withdrawn farther than for floating action.

Ground Alarm Unit (5)

For the PM-5 relay, turn both shunt screws all the way in, then back them out five turns each. Pass a current of 0.3 ma. d.c. in terminal 6 and out terminal 7. Following the same general procedure as described previously in the section entitled "Alarm Unit (1)," adjust the shunt screws so that the left-hand contact closes at 0.3 ma. Now pass 0.3 ma. d.c. in terminal 9 and out terminal 8, and adjust for closing of the right-hand contact at 0.3 ma. Recheck both pickup points several times, and make trimming adjustments of both shunts as required to obtain contact closing at 0.3 ma. d.c. in each direction.

For the ground unit (5) of the PMA, PMD, and PMG-13 relays, connect a variable resistance of about 50,000 ohms in series with a 0-1 d.c. milliammeter between the terminals indicated in the following table:

Ground Alarm (5) Calibration		
	Relay Terminals	
Relay	L.H. Contact Check	R.H. Contact Check
PMA	3 + and 6	3 and 7 +
PMD	5 + and 6	5 and 7 +
PMG-13	3 + and 8	3 and 9 +

+ Milliammeter positive to this terminal

Turn the shunts all the way in, then back them out five turns each. With the relay connected as shown in the left-hand column of the table, apply rated voltage to the relay and adjust the 50,000-ohm resistor for 0.3 ma. d.c. Now following the procedure in the previous paragraph for the PM-5 relay, adjust the shunts until the left-hand contact closes at 0.3 ma. d.c. Change the connections as indicated in the right-hand column, and adjust the opposite shunt until the right-hand contact closes. Recheck back and forth several times and make necessary trimming adjustments to obtain pickup at 0.3 ma. in each direction. The armature will move gradually as the current is changed for this relay unit.

ICS Unit

Close the main relay tripping contact circuit with a jumper connected directly across the contact terminals of the polar unit. Pass sufficient direct current through the relay trip circuit to close the contacts of the ICS unit. This value of current should not be greater than the ICS tap setting being used (0.2 or 2.0). The indicator target should drop freely. The contact gap should be approximately 0.047 inch between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

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.

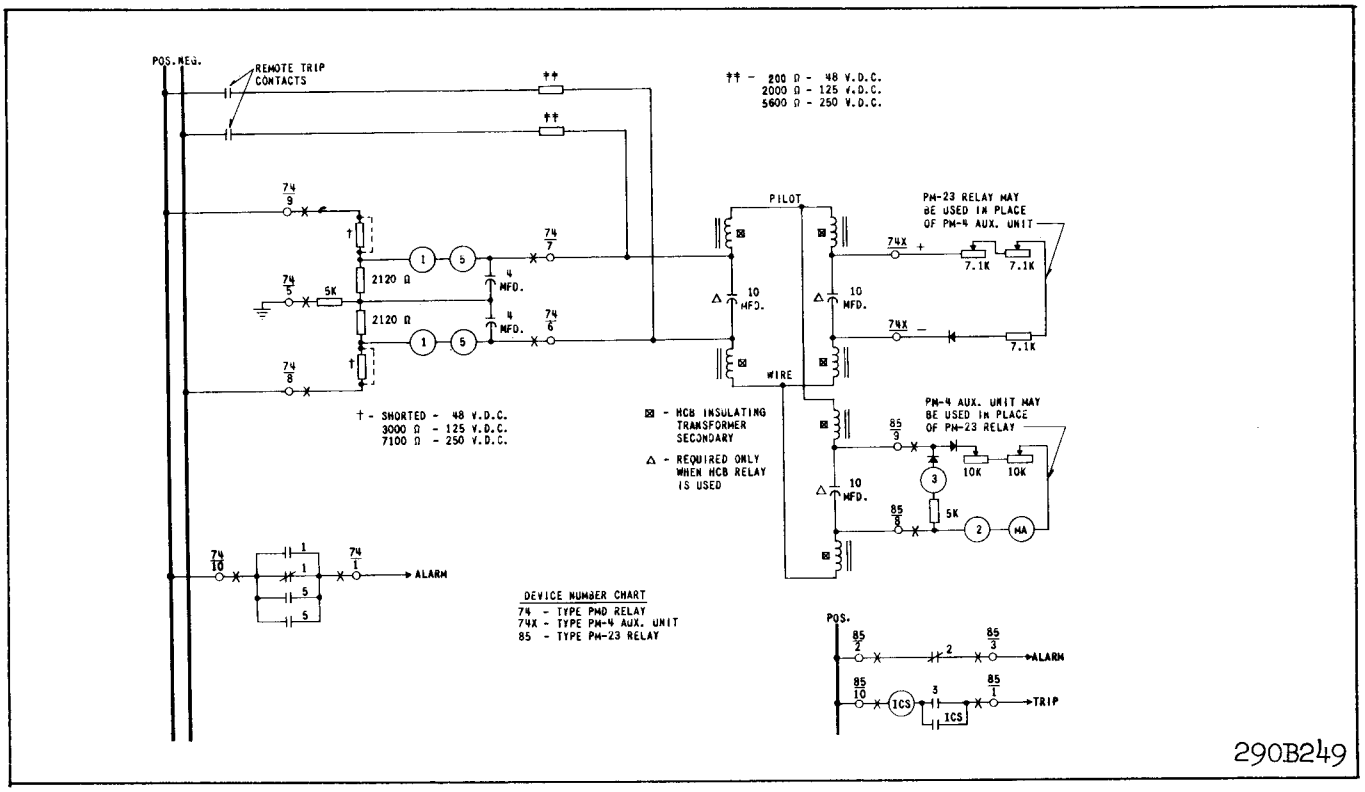


Fig. 22. External Schematic of the Type PMD Relay with Type PM-23 and PM-4 Relays – Three Terminal Lines.

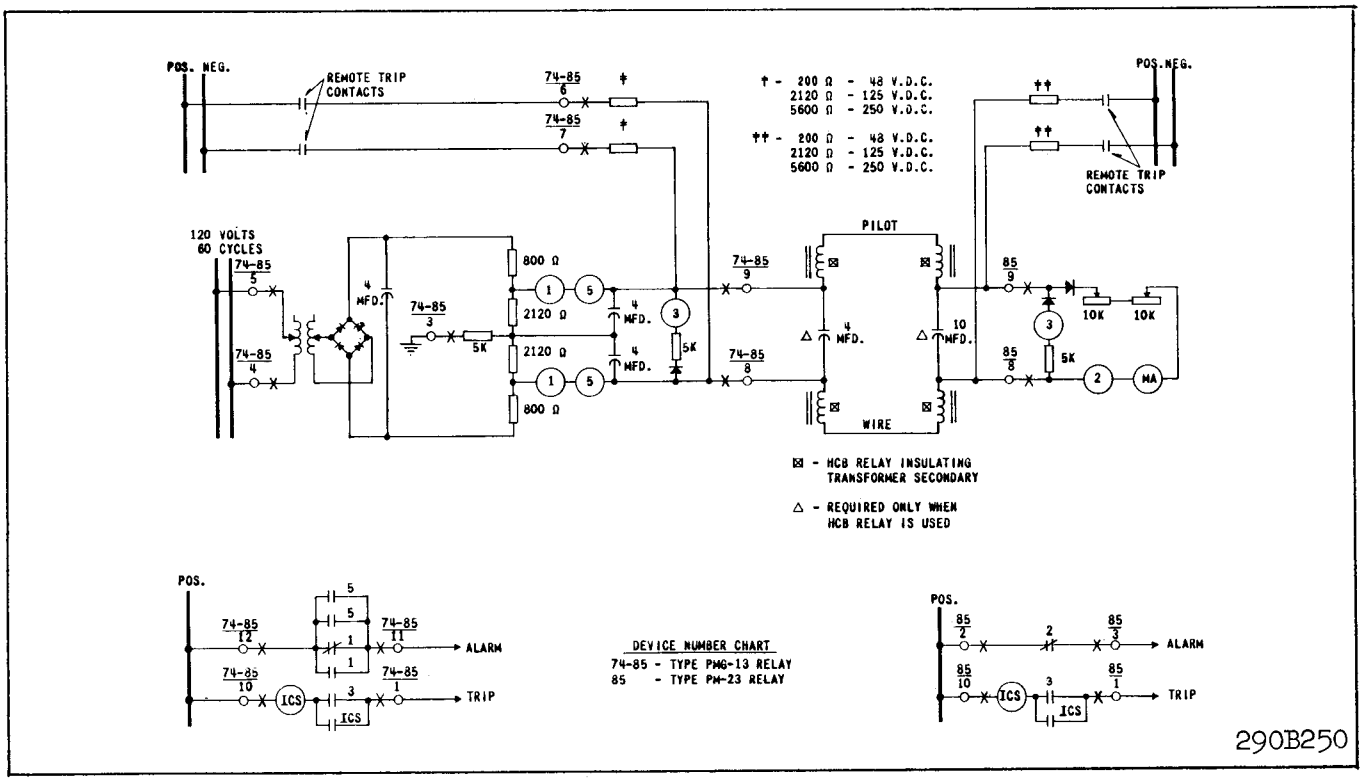


Fig. 23. External Schematic of the AC Type PMG-13 with Type PM-23 Relay – Two Terminal Lines.

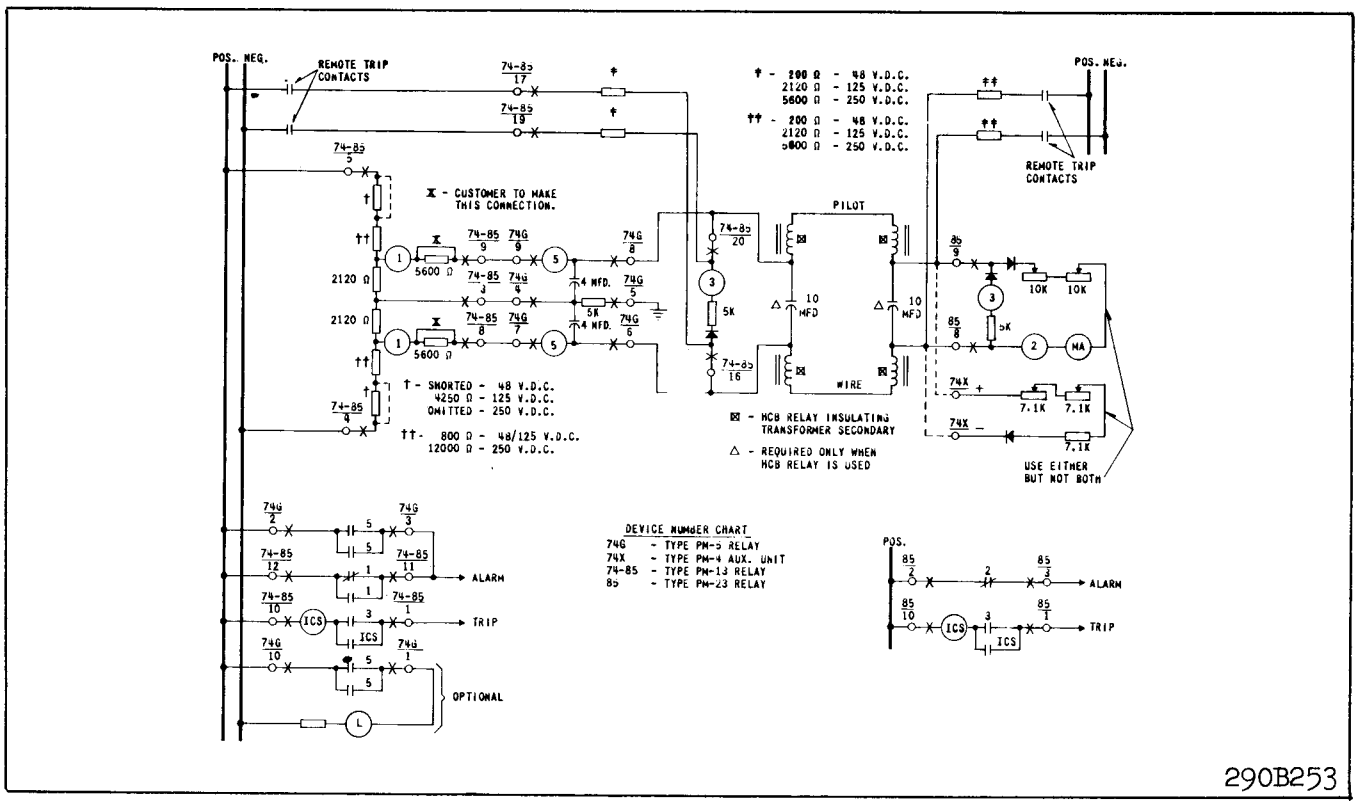


Fig. 24. External Schematic of the DC Type PM-13 and PM-5 Relay with Type PM-23 or PM-4 Relay – Two Terminal Lines.

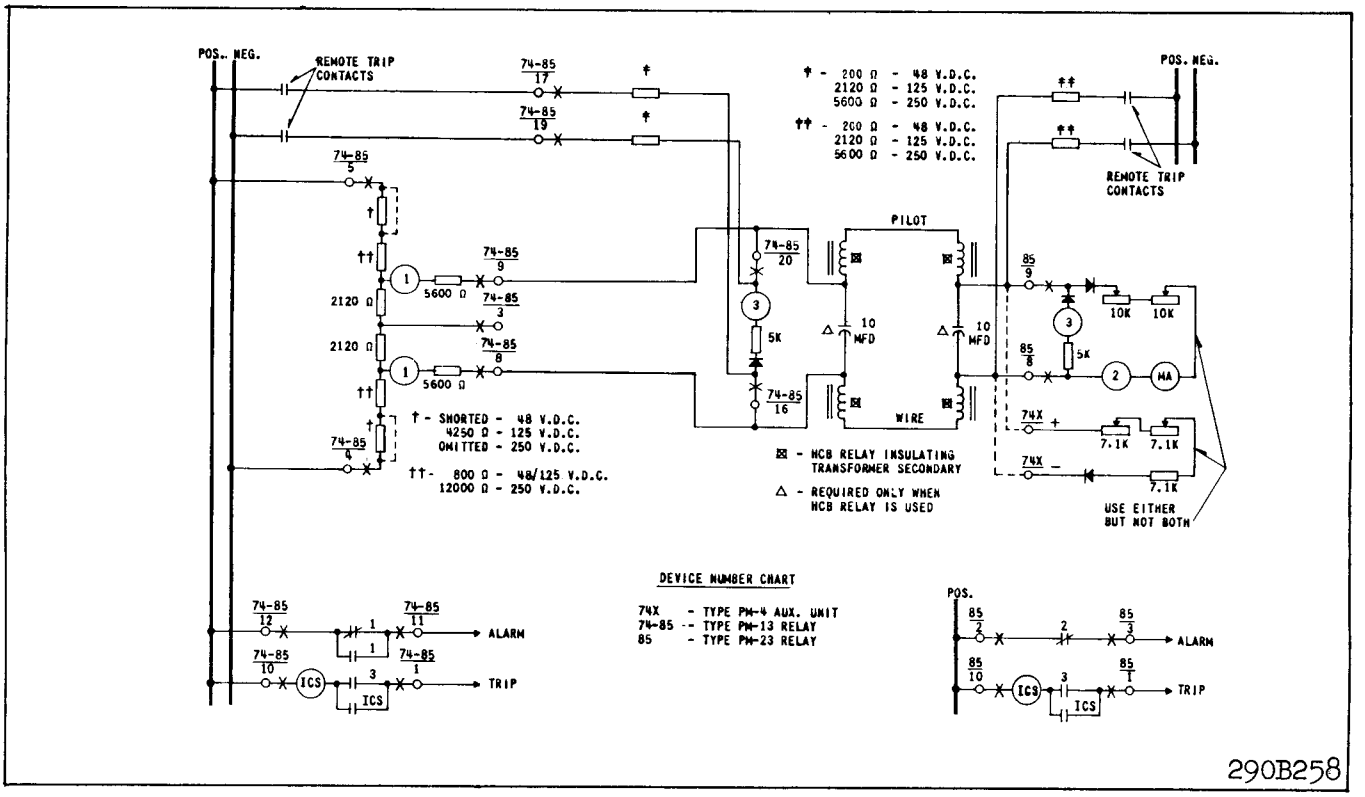


Fig. 25. External Schematic of the DC Type PM-13 Relay with Type PM-23 or PM-4 Relay – Two Terminal Lines.

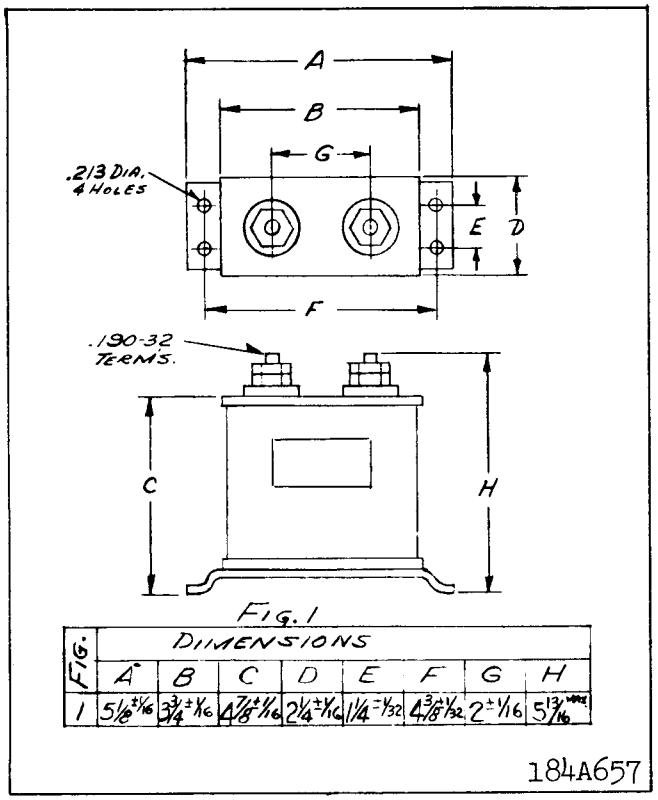


FIG. 1

FIG.	DIMENSIONS							
	A	B	C	D	E	F	G	H
1	5 1/16 ±1/16	3 3/4 ±1/16	4 7/8 ±1/16	2 1/4 ±1/16	1 1/4 ±1/32	4 3/8 ±1/32	2 ±1/16	5 13/16 ±1/32

Fig. 26. Outline & Drilling Plan for 10 mfd. Capacitor For Reference only.

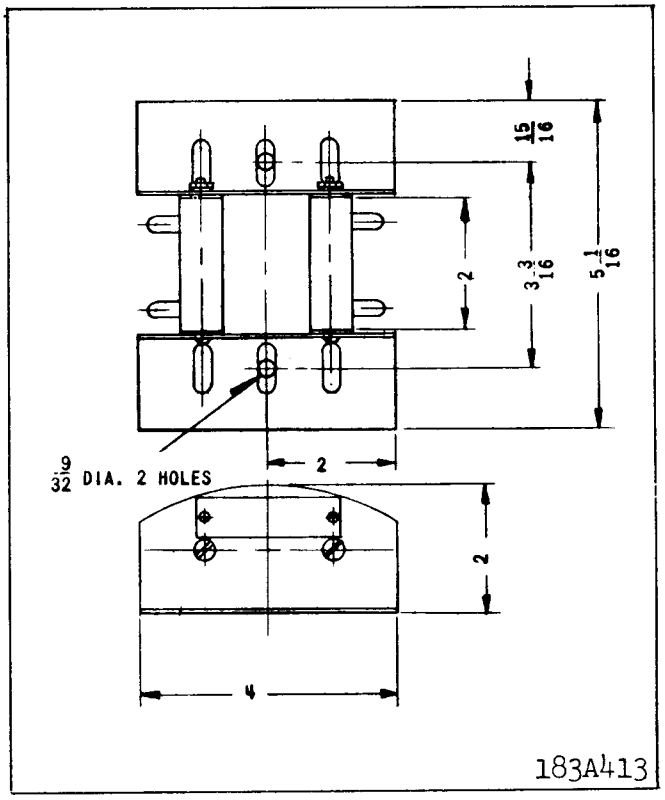


Fig. 27. Outline & Drilling Plan for External Remote Trip Resistor Assembly.

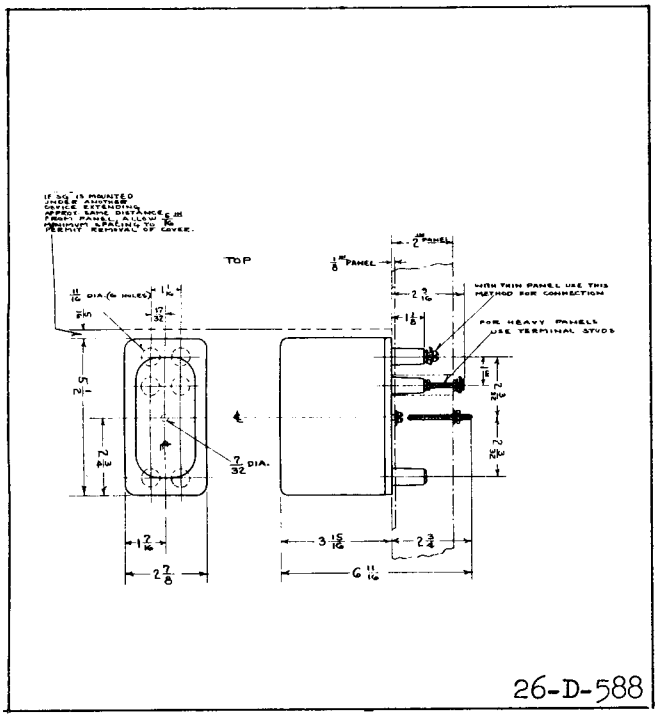


Fig. 28. Outline & Drilling Plan For the Type PM-4 Auxiliary Unit in the Projection Molded Case.

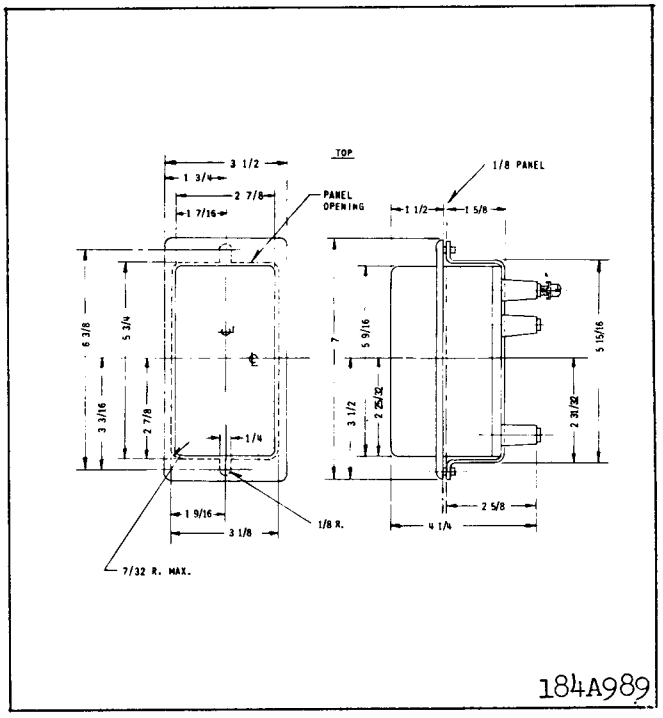


Fig. 29. Outline & Drilling Plan for the Type PM-4 Auxiliary Unit in the Semi-Flush Molded Case.

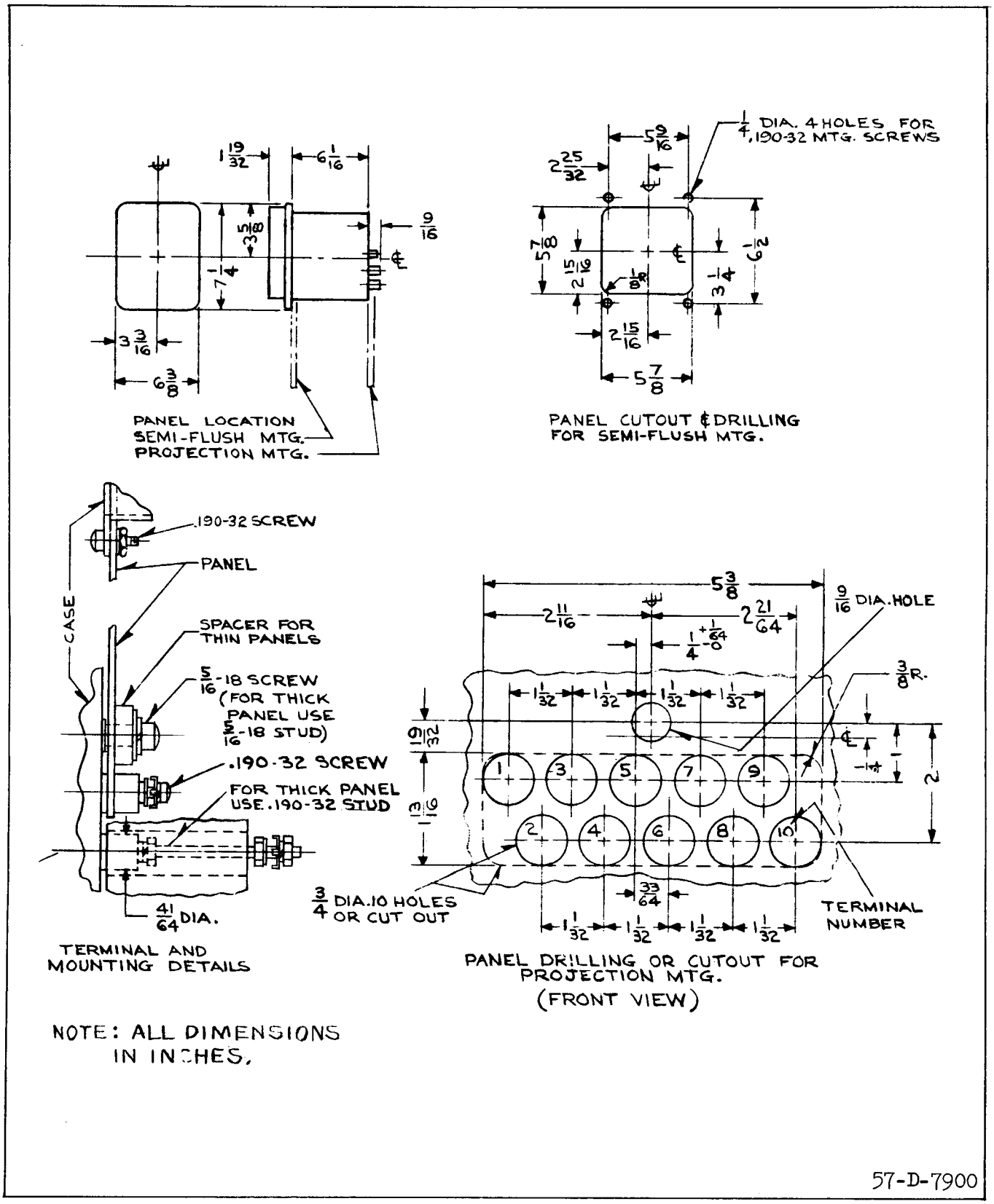


Fig. 30. Outline & Drilling Plan for the Type PM-3, PM-5 and PMD-1 Relays in the Type FT11 Case.

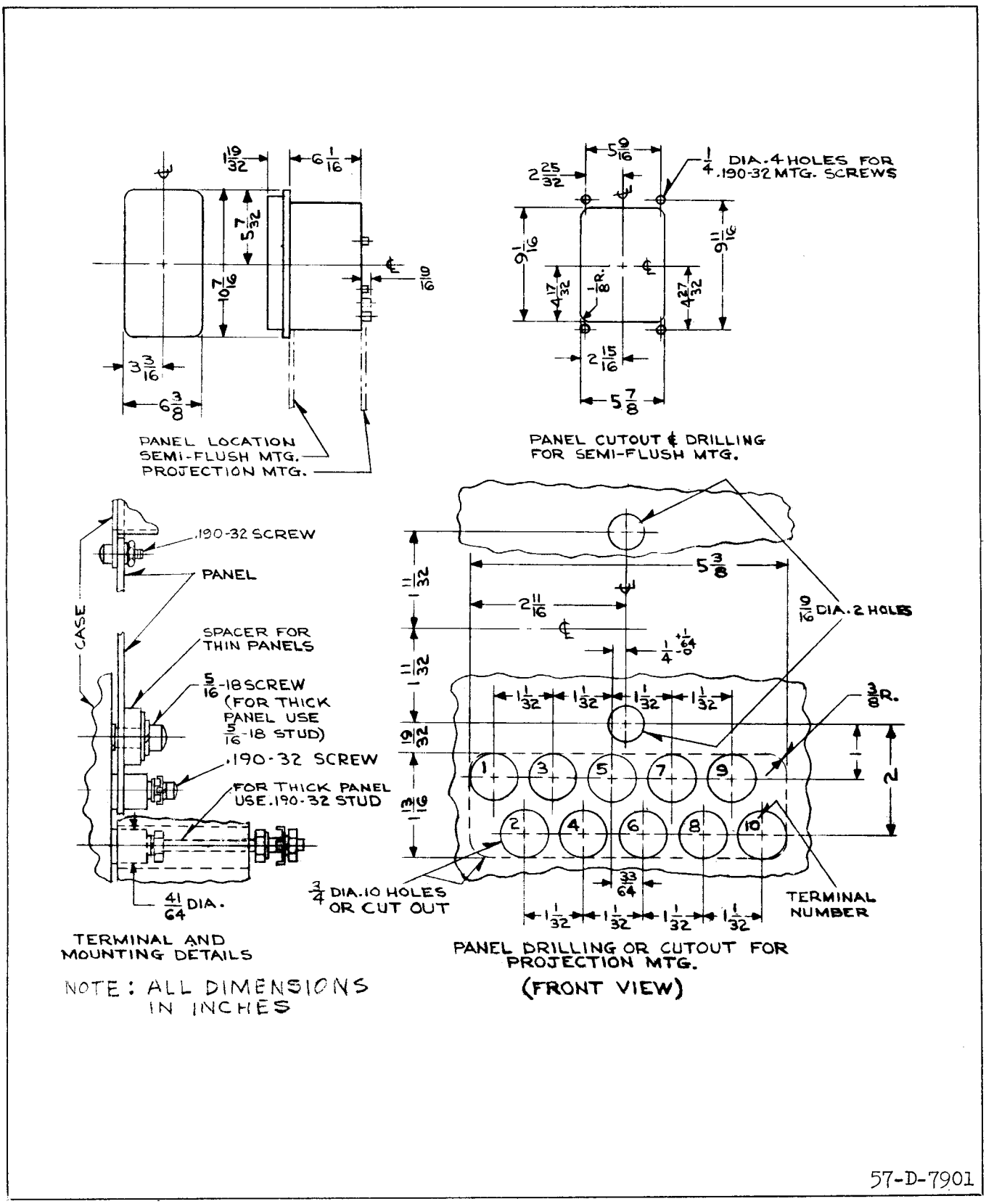


Fig. 31. Outline & Drilling Plan for the Type PM-2, PM-23, PMA-1 and PMD Relays in the Type FT21 Case.

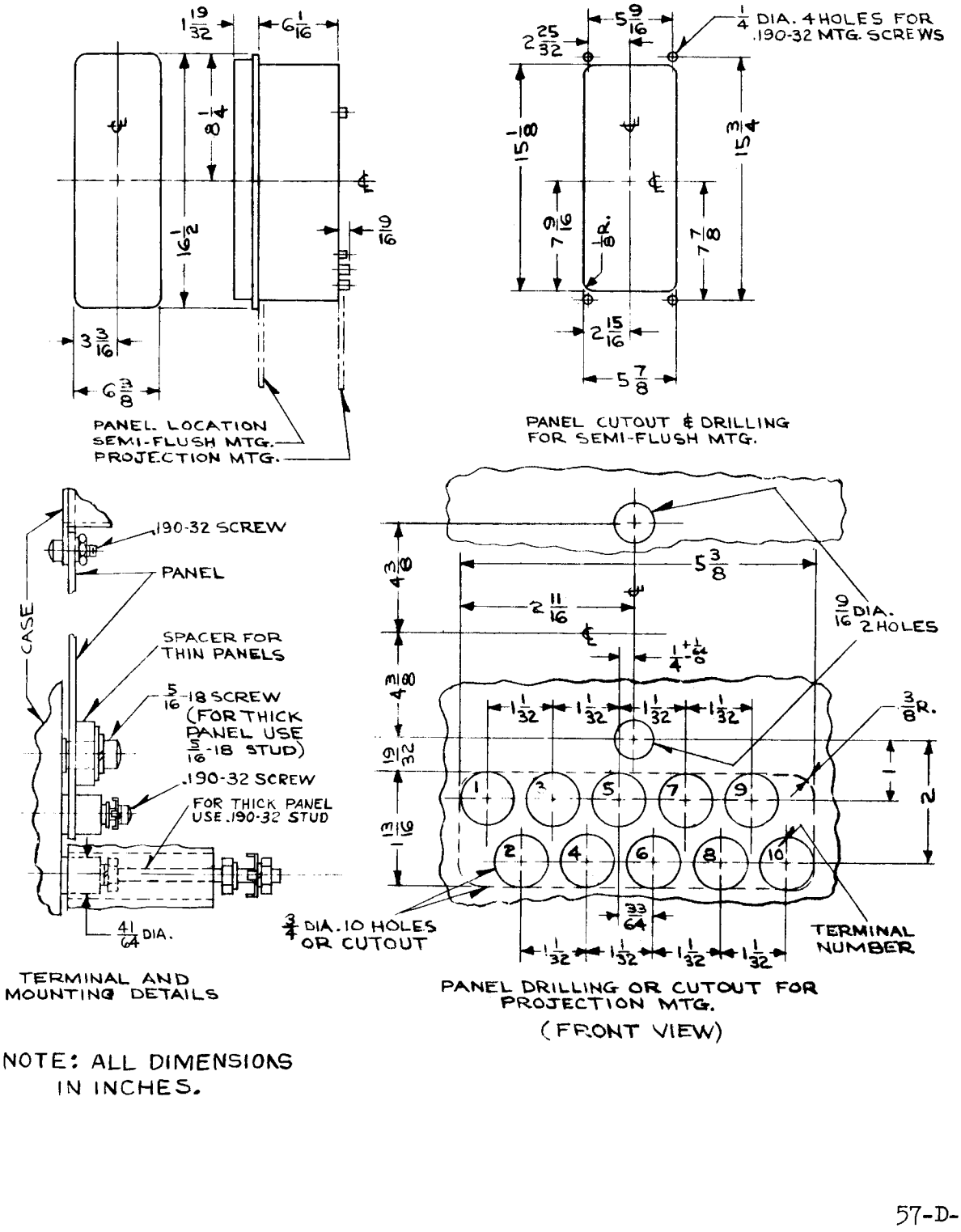


Fig. 32. Outline & Drilling Plan for the Type PMA Relay in the Type FT31 Case.

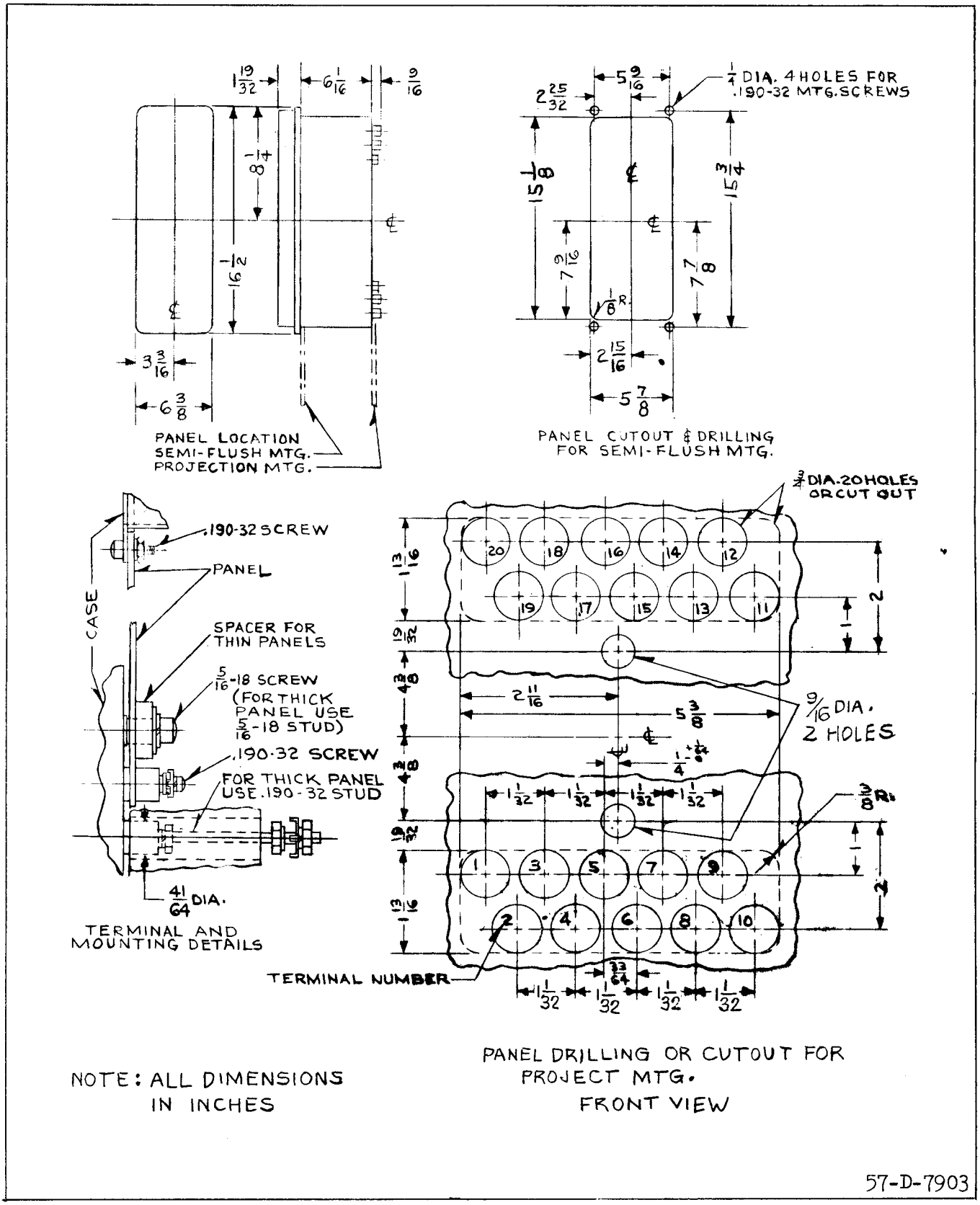
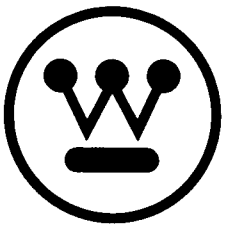


Fig. 33. Outline & Drilling Plan for the Type PM-13 and PMG-13 Relays in the Type FT32 Case.



WESTINGHOUSE ELECTRIC CORPORATION
RELAY DEPARTMENT **NEWARK, N. J.**
Printed in U. S. A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPES PMA, PMA-1, PMD, PMD-1, PM-4, PM-5, PM-13, PMG-13, PM-2, PM-3, AND PM-23 PILOT WIRE MONITORING RELAYS

CAUTION Before putting protective relays into service, remove all blocking which may have been inserted for the purpose of securing 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.

APPLICATION

Type PM Monitoring Relays provide continuous supervision of a pilot wire circuit to detect open circuits, short circuits, grounds, and wire reversal. In addition, remote tripping can be effected where the PM-13, PMG-13 or PM-23 relays are used. Table I illustrates the functions available with each relay.

Each circuit requires the following:

At one end to introduce monitoring current

One of the following:

PMA PMD-1
PMA-1 PM-13
PMD PMG-13

At other end to receive monitoring current (two terminal line)

One PM-23 or PM-2 or PM-4

At the other ends to receive monitoring current (three terminal line)

Two PM-23 or two PM-4 or two PM-2 or
One PM-23 & one PM-2 or one PM-23 & one PM-4 or
One PM-2 & one PM-4

CONSTRUCTION

PM relays consist of the following:

PMA
- 1—Polar Alarm Unit (1)
- 1—Polar Ground Unit (5)
- 1—Tapped Transformer
- 1—Full Wave Rectifier
- 3—4 mfd. Capacitors
- 1—Set of Potential Divider Resistors

PMA-1
- 1—Polar Alarm Unit
- 1—Tapped Transformer
- 1—Full Wave Rectifier
- 1—4 mfd. Capacitor
- 1—Set of Potential Divider Resistors

PMD
- 1—Polar Alarm Unit (1)
- 1—Polar Ground Unit (5)
- 2—4 mfd. Capacitors
- 1—Set of Potential Divider Resistors

PMD-1
- 1—Polar Alarm Unit
- 1—Set of Potential Divider Resistors

PMG-13
- 1—Polar Alarm Unit (1)
- 1—Polar Ground Unit (5)
- 1—Polar Trip Unit (3)
- 1—Indicating Contactor Switch
- 1—Set of Potential Divider Resistors
- 1—Tapped Transformer (A.C. Relay only)
- 1—Full Wave Rectifer (A.C. Relay only)
- 1—Blocking Rectifier
- 2—Remote Trip Resistors (125 & 250 volts d-c trip voltage only)
- 3—4 mfd. Capacitors

PM-13
- 1—Polar Alarm Unit (1)
- 1—Polar Trip Unit (3)
- 1—Indicating Contactor Switch
- 1—Set of Potential Divider Resistors
- 1—Tapped Transformer (A.C. Relay only)
- 1—Full Wave Rectifier (A.C. Relay only)
- 1—Blocking Rectifier
- 2—Remote Trip Resistors (125 & 250 volts d-c trip voltage only)
- 1—4 mfd. Capacitor

PM-23
- 1—Polar Alarm Unit (2)
- 1—Polar Trip Unit (3)
- 1—Indicating Contactor Switch (ICS)
- 1—Milliammeter, 5.0 ma.
- 1—Set of Adjustable & Fixed Resistors
- 2—Blocking Rectifiers

PM-2
- 1—Polar Alarm Unit (2)
- 1—Milliammeter, 5.0 ma.
- 1—Set of Adjustable Resistors
- 1—Blocking Rectifier

PM-3
- 1—Polar Trip Unit (3)

PM-4
- 1—Blocking Rectifier

1 – Resistor
1 – Blocking Rectifier
1 – Indicating Contactor Switch (ICS)

1 – Set of Adjustable & Fixed Resistors

PM-5

1 – Polar Ground Unit (5)
2 – 4 mfd. Capacitors
1 – Fixed Resistor

TABLE I

FUNCTION	PMA & PMD	PMA-1 & PMD-1	PM-13	PMG-13	PM-23	PM-2	PM-3	PM-4	PM-5
Monitoring Current Source	X	X	X	X					
Receives Monitoring Current					X	X		X	
Trouble Alarm	X	X	X	X	X	X			X
Transmits Trip Signal	X	X	X	X					
Receives Trip Signal			X	X	X		X		
Sensitive Ground Detection	X			X					X
Measures Monitoring Current					X	X			

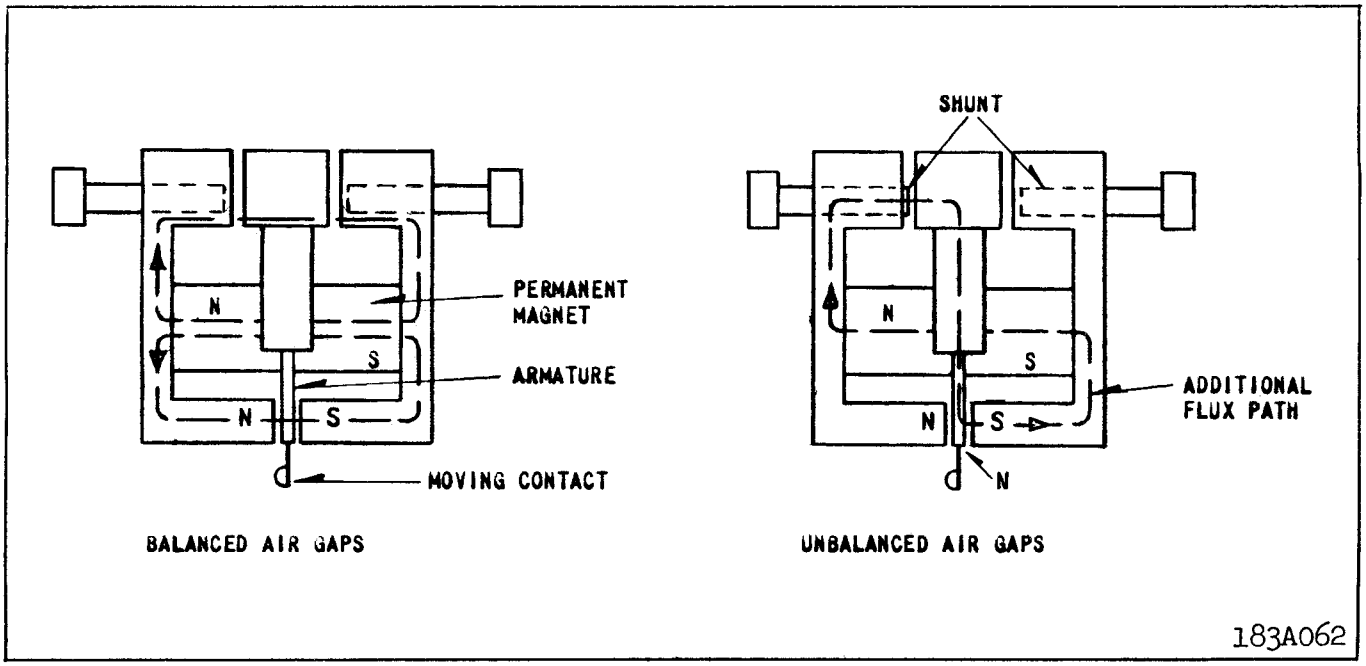


Fig. 1. Polar Unit Permanent Magnet Flux Paths.

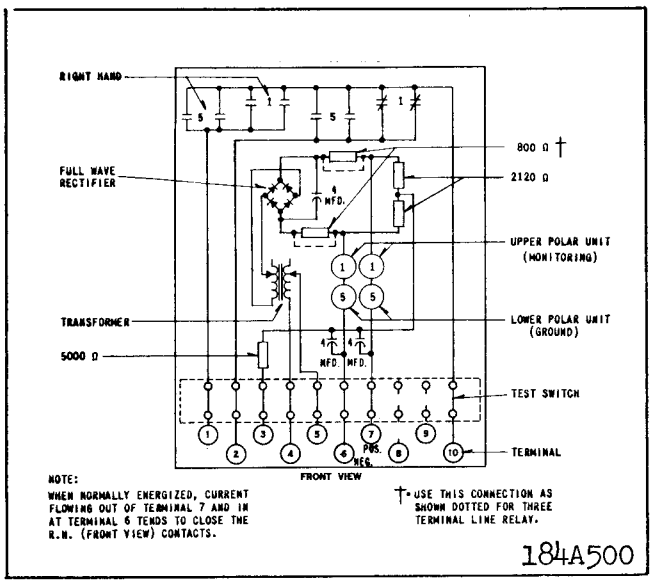


Fig. 2. Internal Schematic of the Type PMA Relay in the FT31 Case – 120 Volt, 60 cycle supply – For Two and Three Terminal Lines.

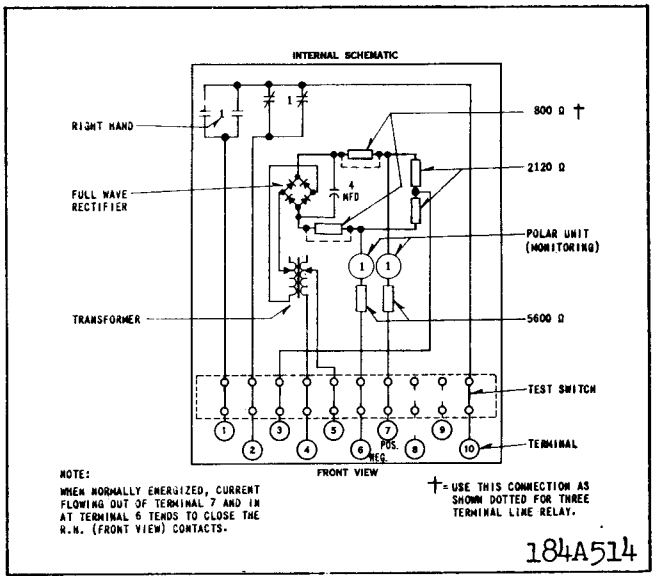


Fig. 3. Internal Schematic of the Type PMA-1 Relay in the FT21 Case – 120 Volt, 60 cycle supply – For Two and Three Terminal Lines.

Polar Unit

The polar unit consists of a rectangular shaped magnetic frame, an 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 winding or 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.

Indicating Contactor Switch

The d-c 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 cover.

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

OPERATION

Pilot Wire Monitoring

Monitoring current in introduced into the pilot wire as shown in the external schematics, figures 19 to 25, by the monitoring current source. External schematics showing other combinations are available on request. A nominal 20 volts is impressed across the 10 mfd. capacitors. This voltage produces a current circulating through one winding of the HCB insulating transformer, one pilot wire, the PM-23, PM-2, or PM-4, and back through the other pilot wire.

Adjustment of the resistors of the PM-23, PM-2 or PM-4 relay at the other end of the pilot wire provides a normal one milliampere d-c circulating current. In the case of three terminal lines, the monitoring source relay output current is 2 ma. in order to provide each receiving end relay with 1 ma. The alarm unit of the monitoring current source relay is adjusted to float between the high and low current contacts with normal monitoring current. The PM-23, receiving end relay, is adjusted to float between the low current contact and stop with 1 ma. flowing.

Short Circuits

Current increases in the current source relay to close the high current alarm contact, current decreases in the PM-23 relay to close the alarm contact. Short circuits of 5000 ohms or less will be detected.

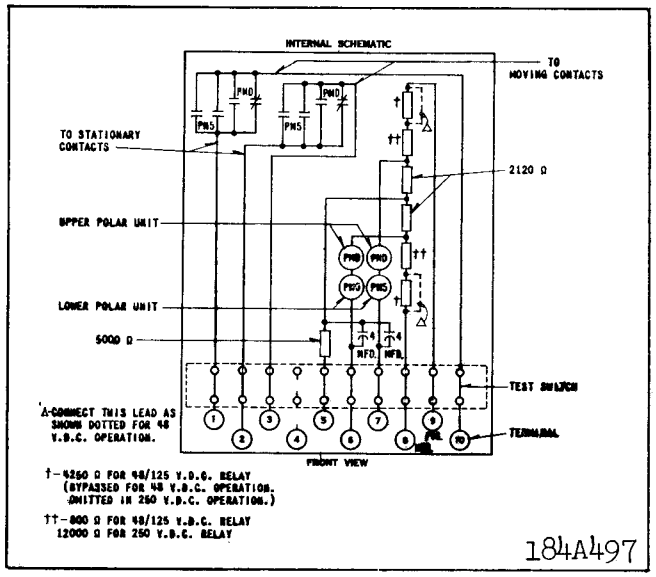


Fig. 4. Internal Schematic of the Type PMD Relay in the FT21 Case – DC Supply – For Two Terminal Lines.

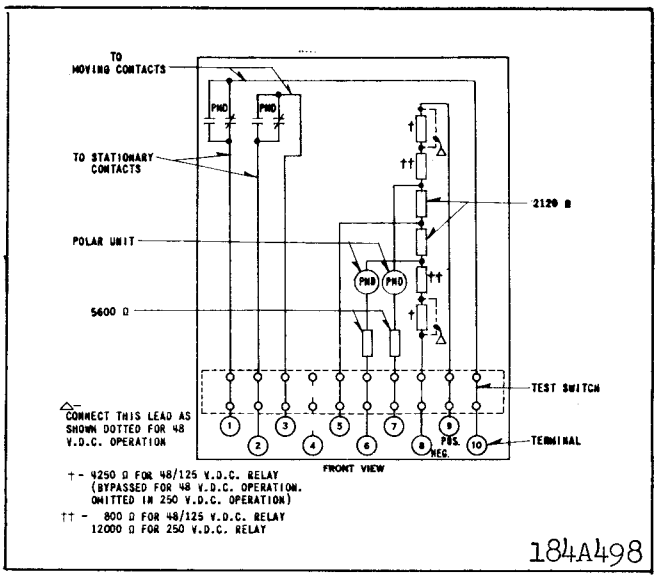


Fig. 5. Internal Schematic of the Type PMD-1 Relay in the FT11 Case – DC Supply – For Two Terminal Lines.

Open Circuits

Current decreases to zero in all relays. Low current alarm contact of the current source relay closes. Alarm contact of PM-23 relay closes.

Reversed Wires

On applications using the PM-23 relay current increases in the sending end relay to close the high current alarm contacts. Current decreases in the PM-23 relay to close the low current alarm contacts.

The current decreases in both sending and receiving end relays when the PM-2, or PM-4 relays are used. Low current alarm contacts close.

Grounds

The sending end relays (PMA, PMD, or PMG-13) are mid-point grounded, so that a pilot wire ground will cause an increase in current in one of the two alarm unit coils of the PMA, PMD, or PMG-13, closing the high current alarm contact. Grounds of 10,000 ohms or less will be detected. The high internal resistance of the PMD and d-c PMG-13 relays will prevent a pilot wire ground from affecting the station battery ground lamps. An accidental ground on the battery circuits will affect the sensitivity of the relays in detecting pilot wire grounds.

For sensitive ground detection a PM-5 relay can be inserted in the PMA-1, PMD-1 or PM-13 relays. This relay will detect grounds of 10,000 ohms or less. Because of its sensitivity, it may be desirable that the PM-5 contact be connected to an indicating lamp rather than to an alarm.

Remote Tripping

Breakers located at the PMG-13 or PM-13 and PM-23 stations can be tripped by the application of a d-c voltage to the pilot wires at remote locations, as shown in figures 19 to 25. Remote tripping can be effected from any location by applying 48 volts d-c or more to the pilot wire. When tripping the PM-23, the current is increased above 2.0 ma, in the reverse direction, to close the trip contact. When tripping the PMG-13 or PM-13, current above 2 ma is circulated to operate the trip unit (3).

See Tables II and III for tripping resistor values. Nominal trip current is 5 ma at all voltages rated.

Polar Unit

Polar unit flux paths are shown in figure 1. With balanced air gaps, permanent magnet flux flows in two paths, one through the front, and one through the rear gaps. This flux produces north and south poles, as shown. By turning the left shunt in, some of the flux is forced through the armature, making it a north pole. Thus, reducing the left hand rear gap will produce a force tending to pull the armature to the right. Similarly, reducing the right hand gap will make the armature a south pole and produce a force tending to pull the armature to the left.

The alarm unit contacts of the sending and receiving end relays are biased to move to the left

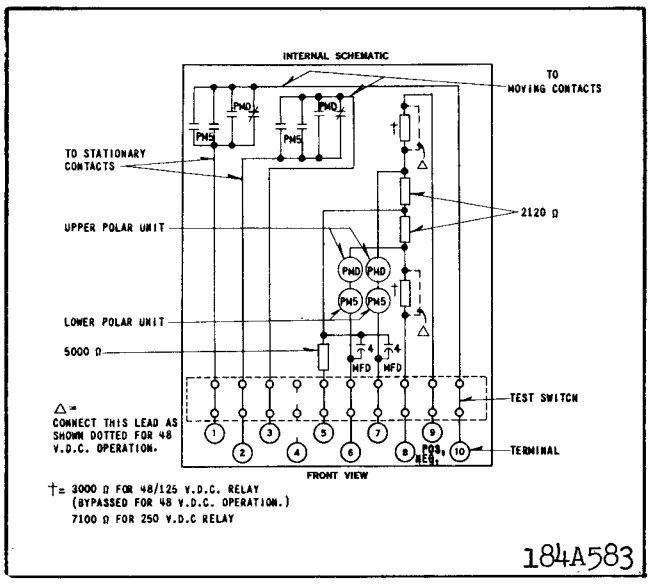


Fig. 6. Internal Schematic of the Type PMD Relay in the FT21 Case – DC Supply – For Three Terminal Lines.

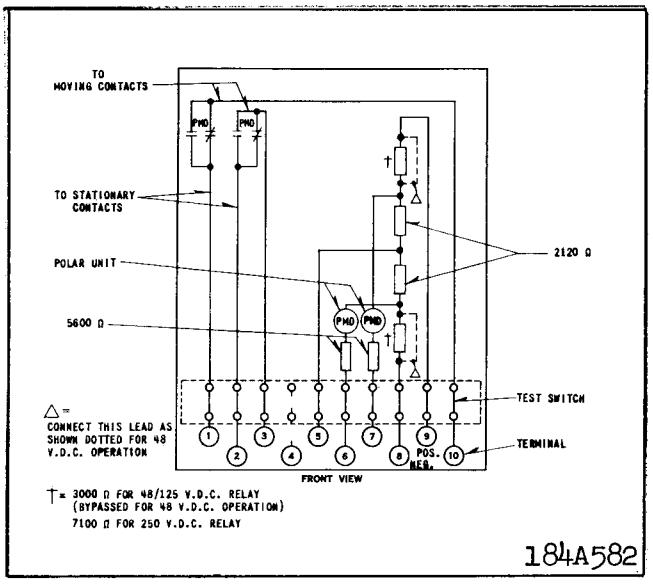


Fig. 7. Internal Schematic of the Type PMD-1 Relay in the FT11 Case – DC Supply – For Three Terminal Lines.

when the relay is deenergized. The PMG-13 or PM-13 and PM-23 trip unit contact is biased to move to the right when the relay is deenergized. The PM-5 is adjusted so that the moving contact floats when the relay is deenergized.

CHARACTERISTICS

Nominal Calibration Values

Nominal current values to close contacts are listed in Tables IV and V.

Voltage Ratings

Supply voltage ratings of the monitoring source relays to obtain continuous monitoring current are as follows:

DC – 48, 125, and 250 volts

AC – 120 volts, 60 cycles (Primary taps 100, 110, 120 & 130)

Voltage impressed on the pilot wire is a nominal 20 volts for monitoring.

Supply voltage ratings to obtain remote tripping are: 48, 125 and 250 volts d-c.

Coil Resistance

Relay	DC Resistance
PMA, PMA-1, PMD, PMD-1	
PM-13, & PMG-13	
Alarm Coils (2)	1050-1250 Ω
PM-23, PM-2	2200-2600 Ω
PMG-13, PM-13, PM-23, & PM-3	
Trip Coil	790-970 Ω
PMA, PMD & PMG-13	
Ground Unit Coil (2)	5500-5700 Ω

PM-4 and PM-23 Resistance

Nominal PM-4 and PM-23 total resistance when adjusted for service is 20,000 ohms less pilot wire loop resistance at 1 ma.

PMA, PMA-1 and AC PMG-13, PM-13 Burden

0.5 VA at tap voltage	–	2 terminal line relay
1.0 VA at tap voltage	–	3 terminal line relay

Rectifiers

Approximate forward resistance - 560 ohms at 1 ma
300 ohms at 2 ma

Rating	
Continuous forward current - amperes	1
Continuous back voltage - rms volts	200

Remote Tripping

Remote trip resistors are listed in Table II and III for 48, 125 and 250 volts d-c.

TABLE II

PMA, PMA-1, PMD, AND PMD-1 APPLICATIONS

EXTERNAL RESISTORS FOR D.C. REMOTE TRIPPING
(2 REQUIRED PER STATION)

# LINE TERMINALS	D.C. VOLTAGE	STATION A PMA or PMA-1	STATION A PMD or PMD-1	STATION B PM-2 & PM-3 or PM-23 or PM-4	STATION C PM-2 & PM-3 or PM-23 or PM-4	TO OPERATE
2	48	0	0	—	—	PM-23 or PM-3
	125	3550	3550	—	—	"
	250	9300	9300	—	—	"
3	48	0	0	—	—	"
	125	2000	2000	—	—	"
	250	5000	5600	—	—	"

TABLE IIIA

PMG-13 AND PM-13 (D.C. SUPPLY) APPLICATIONS

RESISTORS FOR D.C. REMOTE TRIPPING
(2 REQUIRED PER STATION)

# LINE TERMINALS	D.C. VOLTAGE	STATION A PMG-13 or PM-13	STATION B PM-2 & PM-3 or PM-23 or PM-4	STATION C PM-2 & PM-3 or PM-23 or PM-4	TO OPERATE
2	48	0 †	0	—	PMG-13 or PM-13 and PM-23 or PM-3
	125	2120 †	2120	—	"
	250	5600 †	5600	—	"
3	48	0 †	0	0	"
	125	1500 †	1500	1500	"
	250	4000 †	4000	4000	"

TABLE IIIB

PMG-13 AND PM-13 (A.C. SUPPLY) APPLICATIONS
(2 REQUIRED PER STATION)

RESISTORS FOR D.C. REMOTE TRIPPING

# LINE TERMINALS	D.C. VOLTAGE	STATION A PMG-13 or PM-13	STATION B PM-2 & PM-3 or PM-23 or PM-4	STATION C PM-2 & PM-3 or PM-23 or PM-4	TO OPERATE
2	48	0 †	0	—	PMG-13 or PM-13 and PM-23 or PM-3
	125	2120 †	2120	—	"
	250	5600 †	5600	—	"
3	48	0 †	0	0	"
	125	1500 †	1500	1500	"
	250	4000 †	4000	4000	"

† Mounted in Relay

TABLE IV

NOMINAL CALIBRATION VALUES – TWO TERMINAL LINES

RELAY	LOW CURRENT ALARM	HIGH CURRENT ALARM	TRIP
PMA or PMA-1	0.7 ma	1.3 ma	—
PMD or PMD-1	0.7	1.3	—
PM-5†	—	±0.3	—
PMG-13 or PM-13	0.7††	1.3††	2.0 ma
PM-23 or PM-2 & PM-3†	0.7	—	2.0

† Same relay as for three terminal lines
†† These are pilot wire current values

TABLE V

NOMINAL CALIBRATION VALUES – THREE TERMINAL LINES

RELAY	LOW CURRENT ALARM	HIGH CURRENT ALARM	TRIP
PMA or PMA-1	1.7 ma	2.3 ma	—
PMD or PMD-1	1.7	2.3	—
PM-5†	—	±0.3	—
PMG-13 or PM-13	1.7††	2.3††	2.0 ma
PM-23 or PM-2 & PM-3	0.7	—	2.0

† Same relay as for two terminal lines
†† These are pilot wire current values

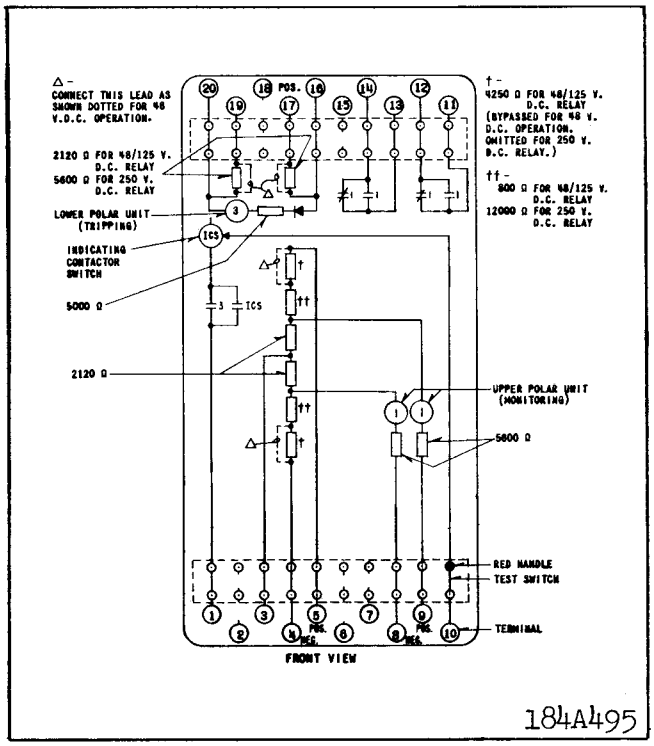


Fig. 8. Internal Schematic of the Type PM-13 Relay in the FT32 Case – DC Supply – For Two Terminal Lines.

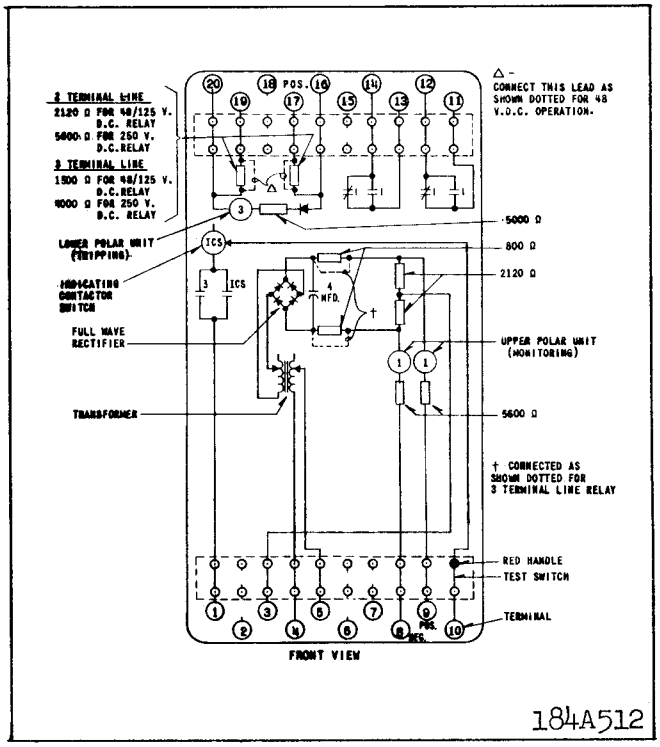


Fig. 9. Internal Schematic of the Type PM-13 Relay in the FT32 Case – 120 Volt, 60 cycle supply – For Two and Three Terminal Lines.

The relays have sufficient thermal capacity to withstand 20 MA d-c continuously when remote tripping. Nominal trip currents in the tripping relays are 5.0 MA d-c with 48, 125, and 250 volts d-c.

Trip Circuit

The main contacts will safely close 30 amperes at 250 volts d-c and the seal-in contacts of the indicating contactor switch 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 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.

Trip Circuit Constant

Indicating Contactor Switch (ICS)

0.2 ampere tap 6.5 ohms d-c resistance
2.0 ampere tap 0.15 ohms d-c resistance

SETTING THE RELAY

Operating units of all relays are adjusted in the factory to the values listed in Tables IV and V to a tolerance of ±5%. No settings are required on these units.

PM-4, PM-2, and PM-23 Relays

Adjust the resistors in the PM-4, PM-2, or PM-23 relay or relays to a value of 1 MA d-c with the supervision circuits connected for service. Use the milliammeter in the PM-23 for this purpose or use a portable milliammeter with a resistance of less than 200 ohms. Where it is not practical on three terminal lines to adjust both receiving relays simultaneously, set one receiving relay for 18,000 ohms total resistance by measurement prior to final adjustment of the other receiving relay. This procedure will minimize the change in monitoring current in the first relay to be adjusted when making the final adjustment of the second relay.

PMA, PMA-1, PMG-13 and PM-13 Relays

Select the transformer tap nearest to expected normal a-c supply voltage. The full wave rectifier is connected to a secondary transformer tap. Where desired, the output voltage can be raised about 5% by reconnecting across the full secondary winding.

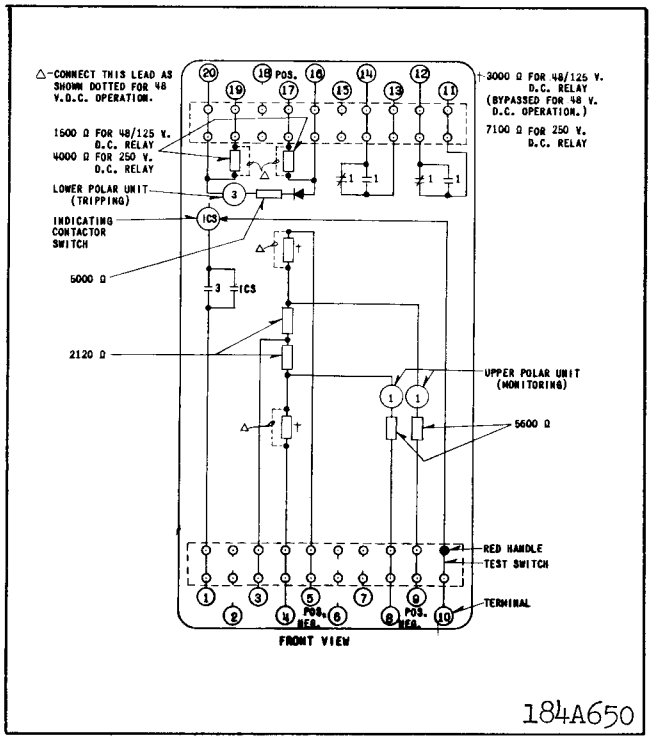


Fig. 10. Internal Schematic of the Type PM-13 Relay in the FT32 Case – DC Supply – For Three Terminal Lines.

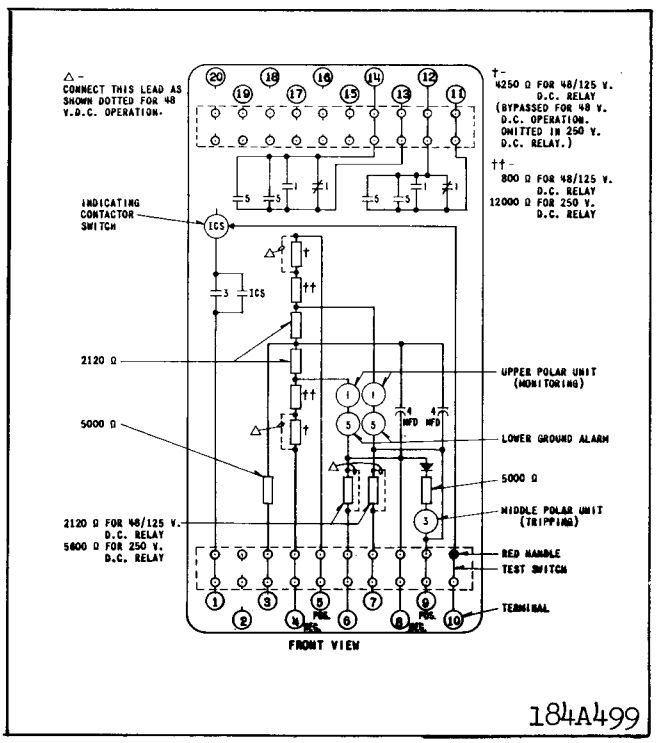


Fig. 11. Internal Schematic of the Type PMG-13 Relay in the FT32 Case – DC Supply – For Two Terminal Lines.

Indicating Contactor Switch

No setting is required on the ICS unit except the selection of the 0.2 or 2.0 ampere tap setting. This selection is made by connecting the lead located in front of the tap block to the desired setting by means of the connecting screw. When the relay energizes a type WL relay switch, or equivalent, use the 0.2 ampere tap.

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 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 I.L. 41-076.

If the potential to ground impressed on the relays will exceed 200 volts, protection is recommended. If the potential will not exceed 500 volts, connect a 5 mfd capacitor to ground on each side of the 10 mfd capacitor (or to the each pilot wire if HCB relays are not connected) at the monitoring source station. If the potential to ground can exceed 500 volts, gap or neutralizing reactor protection is recommended.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory and should not be disturbed after receipt by the customer. If the adjustments have been changed, the relay taken apart for repairs, or if it is desired to check the adjustments at regular maintenance periods, the instructions below should be followed.

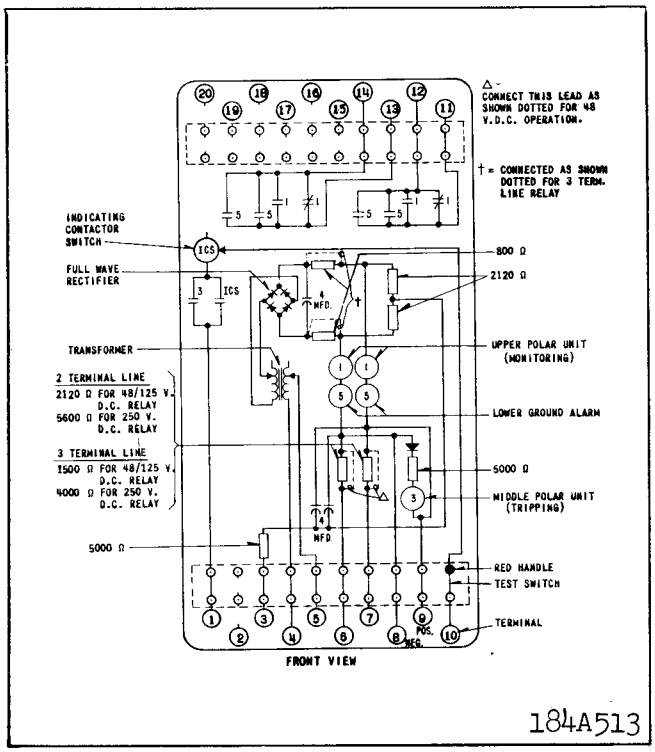


Fig. 12. Internal Schematic of the Type PMG-13 Relay in the FT32 Case – 120 Volt, 60 cycle supply – For Two or Three Terminal Lines.

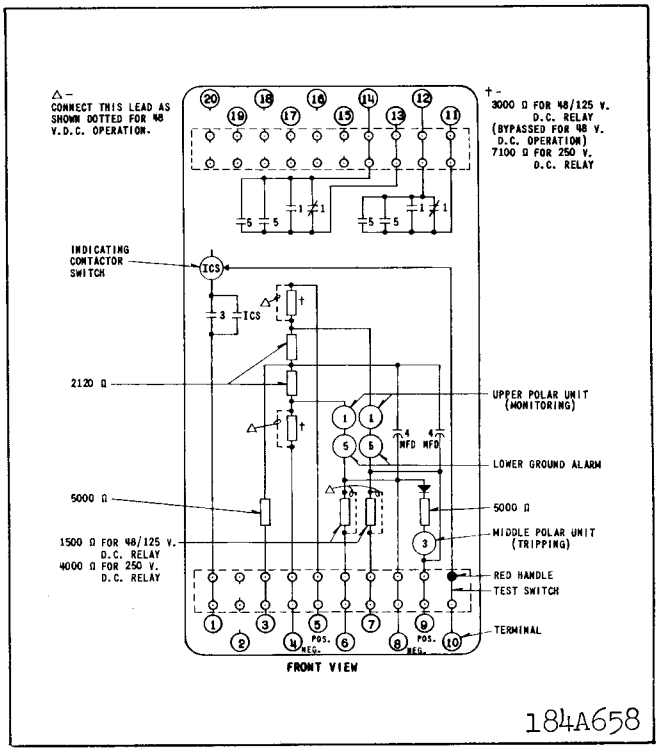


Fig. 13. Internal Schematic of the Type PMG-13 Relay in the FT32 Case – DC Supply – For Three Terminal Lines.

Contacts

All contacts should be cleaned periodically. A contact burnisher S#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.

Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient d-c 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.

Rectifier Check

If there is suspicion of a rectifier failure, apply 30 volts d-c back voltage (positive on arrowhead), through a 300-ohm resistance. Measure the voltage across the rectifier. If this voltage is not essentially 30 volts, the rectifier is shorted. Now apply 30 volts d-c in the forward direction through a 300-ohm resistor and measure the voltage across the resistor. If this voltage is not essentially 30 volts, the rectifier is open. Also see "Acceptance Tests", below, for tests when the rectifiers are connected in the relay.

Acceptance Tests

The following tests are recommended when the relay is received from the factory. If the relay does not perform as specified below, the relay either is not properly calibrated or it contains a defect.

PMA and PMA-1 Relays

Connect per figure 20, except load terminals 6 and 7 with 20,000 ohms resistance for two terminal line relays and 10,000 ohms for three terminal line relay. Set in 100 volt tap and apply 100 volts, 60 cycles to terminals 4 and 5. The contact should float. Then successively short-circuit and open-circuit terminals 6 and 7. The right contact should close with a short circuit. The left hand contact should close with an open circuit. Now successively short circuit terminals 6 and 3, 7 and 3. In both cases the right-hand contact should close. The ground unit of the PMA should operate first to the right and then to the left.

PMD and PMD-1 Relays

Connect per figure 19 except load terminals 6 and 7 with 20,000 ohms resistance for two terminal line

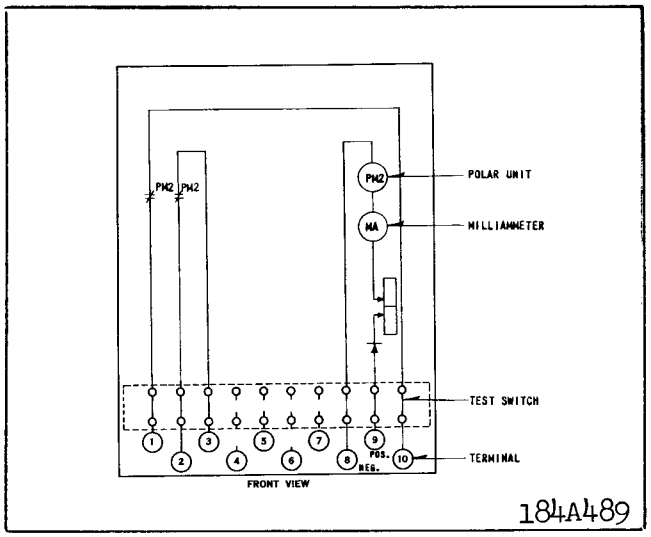


Fig. 14. Internal Schematic of the Type PM-2 Relay in the FT21 Case.

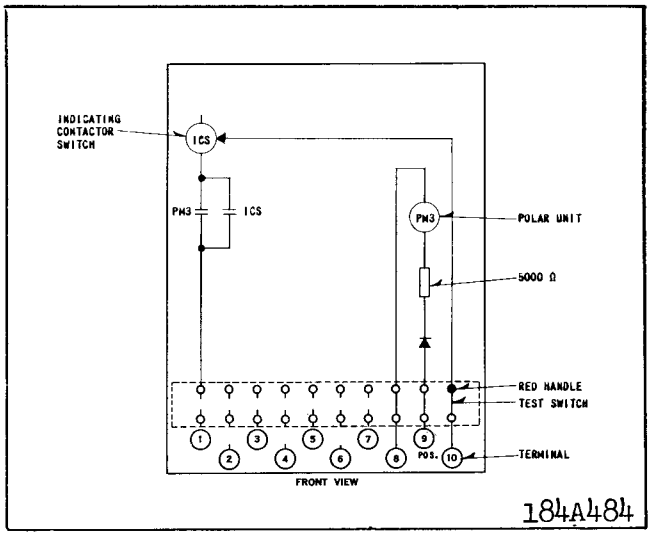


Fig. 15. Internal Schematic of the Type PM-3 Relay in the FT11 Case.

relays and 10,000 ohms, for three terminal line relays. Apply rated d-c voltage to terminals 8 and 9. The contact should float. Then successively short circuit and open circuit terminals 6 and 7. The right-hand contact should close with a short circuit. The left-hand contact should close with an open circuit. Now successively short circuit terminals 7 and 5, 6 and 5. In both cases the right-hand contact should close. The ground unit (5) of the PMD should operate first to the right and then to the left.

PM-4 Auxiliary Unit

Measure forward resistance with an ohmmeter. Resistance should be about 7,000 to 23,000 ohms, depending on resistor settings. Apply 30 volts d-c back voltage (positive on "minus" terminal). The voltage across the resistors should be substantially zero.

PM-5

Apply 5 volts d-c to terminals 8 and 9. Apply 5 volts d-c to terminals 6 and 7. Both right and left hand contacts should close.

PMG-13 and PM-13 (DC)

Connect per figures 21 or 25, except load terminals 8 and 9 with 20,000 ohms resistance for 2 terminal line relays and 10,000 ohms for three terminal line relays. Apply rated d-c voltage to terminals 4 and 5. The upper polar unit (1) contact should float. Then successively short circuit and open circuit terminals 8 and 9. The right-hand contact of the upper polar unit (1) should close with a short circuit. The left-hand contact should close with an open circuit. Now successively short circuit terminals 9 and 3, 8 and 3. In both cases the right-hand contact should close. During all of these operations the middle polar unit (3) should not operate. The ground unit (5) of the PMG-13 should operate first to the right and then to the left.

Apply 48 volts d-c to terminals 8 and 9 in reverse polarity (terminal 8 positive). The middle polar unit (3) should close. Note that in the PM-13 external terminal 16 is connected to 8, and 20 to 9.

PMG-13 and PM-13 (AC)

Load terminals 8 and 9 with 20,000 ohms for two terminal line relays and 10,000 ohms for 3 terminal line relays. Apply 100 volts, 60 cycles across terminals 4 and 5, with transformer tap at 100 volts. The upper polar unit (1) contact should float. Then successively short circuit and open circuit terminals 8 and 9. The right-hand contact of the upper polar unit should close with a short circuit; left-hand contact should close with an open circuit. Now successively short circuit terminals 9 and 3, 8 and 3. In both cases the right-hand contact should close. During all of these operations the middle polar unit (3) should not operate. The ground unit (5) of the PMG-13 should operate first to the right and then to the left.

Apply 48 volts d-c to terminals 8 and 9 in reverse polarity (terminal 8 positive). The middle polar unit (3) should close. Note that in the PM-13 external terminal 16 is connected to 8, and 20 to 9.

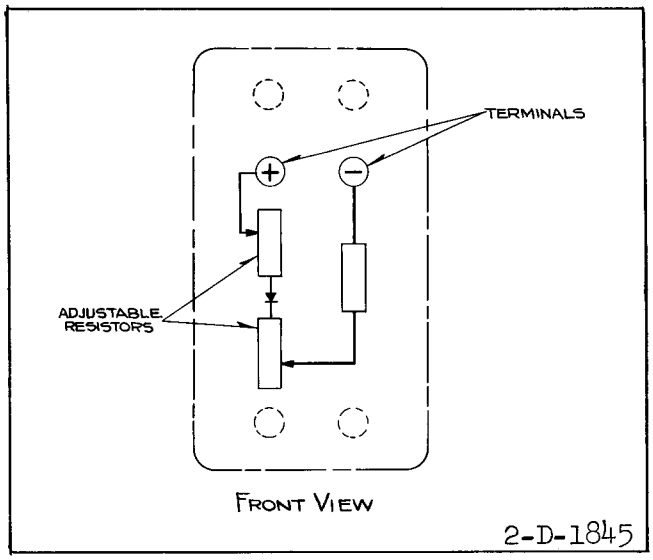


Fig. 16. Internal Schematic of the Type PM-4 Auxiliary Unit in the Small Molded Case.

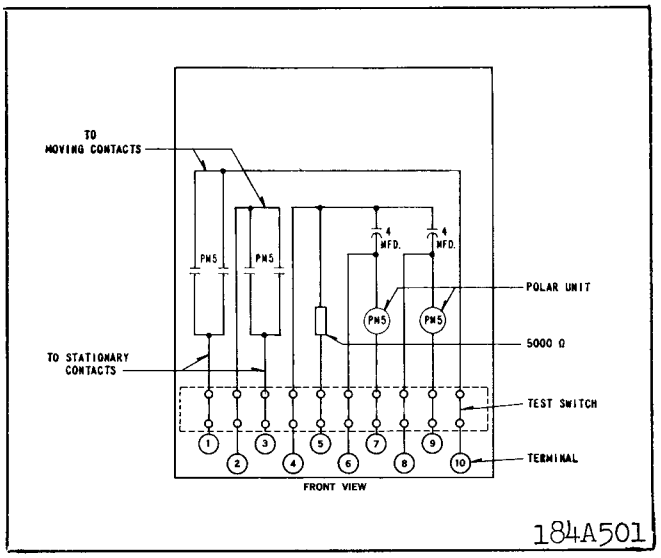


Fig. 17. Internal Schematic of the Type PM-5 Ground Detector Relay in the FT11 Case.

PM-2, PM-3, and PM-23

Apply 18 volts d-c to terminals 8 and 9 of the PM-2 or PM-23 Relay (terminal 9 positive). The monitoring polar unit (2) contacts should float, and the milliammeter should read 1 ma.

Apply 48 volts d-c to terminals 8 and 9 of the PM-3 or PM-23 Relay (terminal 8 positive). The tripping polar unit (3) should operate to the right. The monitoring polar unit (2) of the PM-23 Relay should not operate during this check.

Calibration Check

CAUTION While the PM relays are connected to the pilot wire it should be assumed that they are energized. Adjustments should be made with the pilot wire disconnected.

The PM relays may be removed from service for testing, without jeopardizing HCB relay protection, provided that the connections between the 10 mfd capacitor and HCB insulating transformer are not disturbed. However, it is recommended that the HCB relay trip circuits be opened prior to the circulation of remote trip current, even though the HCB relays should not operate on nominal remote trip currents.

Currents for contact closing are shown in Tables IV and V. The following procedure can be used to check these values.

PMA, PMA-1, PMD, and PMD-1 Relays

Open switches 6 and 7 and connect a load and milliammeter across switch jaws 6 and 7. (The load should be adjustable between 16,000 and 28,000 ohms for two terminal lines and between 8,000 and (12,000 ohms for three terminal lines.) With contact initially floating, check current values to close contacts.

PM-5 Relays

Open switches 8 and 9. Apply approximately 5 volts dc across switch jaws 8 and 9. Check pick up current with relay initially floating.

PMG-13 and PM-13 Relays

Open switches 8, 9 and 10 and connect a load and milliammeter across switch jaws 8 and 9. (The load should be adjustable between 16,000 and 28,000 ohms for two terminal lines and between 8,000 and 12,000 ohms for three terminal lines). With upper polar unit (1) contact initially floating check current values to close contacts.

Then apply approximately 48 volts d-c across switch jaws 8 and 9, with positive on a check pickup of middle polar unit (3) contact with contact initially reset, in the PMG-13 Relay. Use terminals 16 and 20 in the PM-13 Relay, with positive on 16.

PM-2 Relay

Open switches 8, 9 and 10 and apply approximately 18 volts d-c across switch jaws 8 and 9, with positive on 9. Check pickup with contact initially reset or floating.

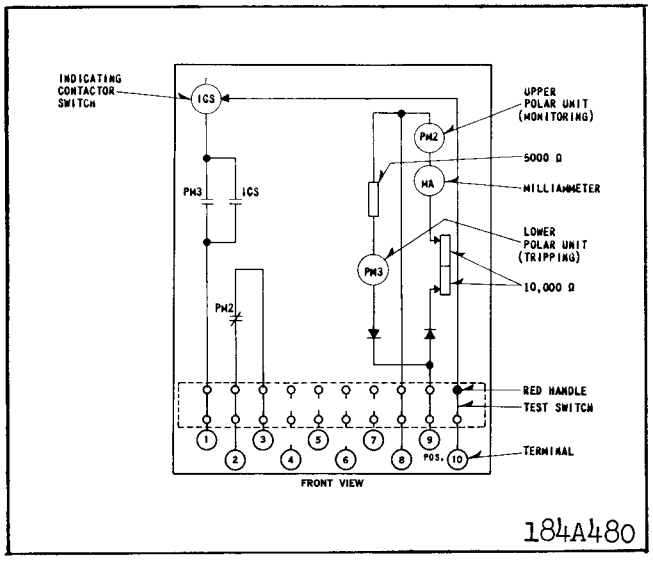


Fig. 18. Internal Schematic of the Type PM-23 Relay in the FT21 Case.

PM-3 Relay

Open switches 8, 9 and 10 and apply approximately 48 volts d-c across switch jaws 8 and 9, with positive on 8. Check pickup with contact initially reset.

PM-23 Relay

Open switches 8, 9, and 10 and apply 18 volts d-c across switch jaws 8 and 9 (terminal 9 positive). Check pickup of monitoring polar unit (2) with contact initially reset or floating.

Then apply approximately 48 volts d-c across switch jaws 8 and 9, with positive on 8. Check pickup of tripping polar unit (3) contact with contact initially reset.

Routine Maintenance

CAUTION While the PM relays are connected to the pilot wire, it should be assumed that they are energized. Adjustments should be made with the pilot wire disconnected.

In addition to cleaning contacts it is recommended that a functional check be performed by open and short circuiting, and grounding the monitoring circuits at the pilot wire terminals. These pilot wire faults should not be applied directly to the pilot wire when the HCB relays are in service. If the HCB relays are not in service, simulate a remote trip operation with switch 10 of the PM-23, PMG-13 and PM-13 relays open by closing the remote trip contacts. If the HCB relays are in service, open switches 8, 9, and 10 of the PMG-13, and PM-23 relays or 16, 20, and 10 of the PM-13 relay, and apply about 48 volts d-c to switch jaws 8 and 9 or 16 and 20 (PM-13), with positive on jaw 8 or 16. The tripping contact of these relays should close.

If the relays do not perform as expected and rectifier failure is suspected, the rectifier tests described under "Acceptance Tests" may be performed.

Calibration

If the relay has been dismantled or the calibration has been disturbed, use the following procedure for calibration.

With the permanent magnet removed see that the moving armature floats between the poles or lightly touches the left-hand pole piece. If necessary, loosen the core screw in the center rear of the unit and shift the core and contact assembly until the armature floats. Then retighten the core screw. Continue as follows:

PMA, PMA-1, PMD and PMD-1 Relays

For the monitoring polar units, adjust the stationary contacts so that they just make when the armature touches the pole faces. Then turn each contact screw four turns to obtain approximately 5/32" between the stationary contacts. Reassemble the permanent magnet with the north pole to the right (front view). Turn both shunts all the way in. With 1.3 or 2.3 ma flowing in 1 ma or 2 ma rating relays, respectively, draw out the right hand shunt until the right hand contacts close. Then, with 0.7 or 1.7 ma flowing in 1 ma or 2 ma rating relays, respectively, draw out left-hand shunt until left-hand contacts close. Recheck and readjust right-hand contact pickup. Then recheck and readjust left-hand contact pickup. Continue as required.

For the ground units of the PMA and PMD relays, adjust the stationary contacts so that they just make with the moving contact when the armature is floating midway between the pole pieces. Then turn the contact screws two full turns in the opening direction to obtain approximately 0.050" contact opening. Reassemble permanent magnet with the north pole to the right. Turn both shunts all the way in. Energize with 0.3 ma, positive on terminal 9. Draw out the right-hand shunt until the right-hand contact closes. Energize with 0.3 ma, positive on terminal 8. Draw out left hand shunt until left hand contact closes. Recheck and readjust right-hand contact pickup. Then

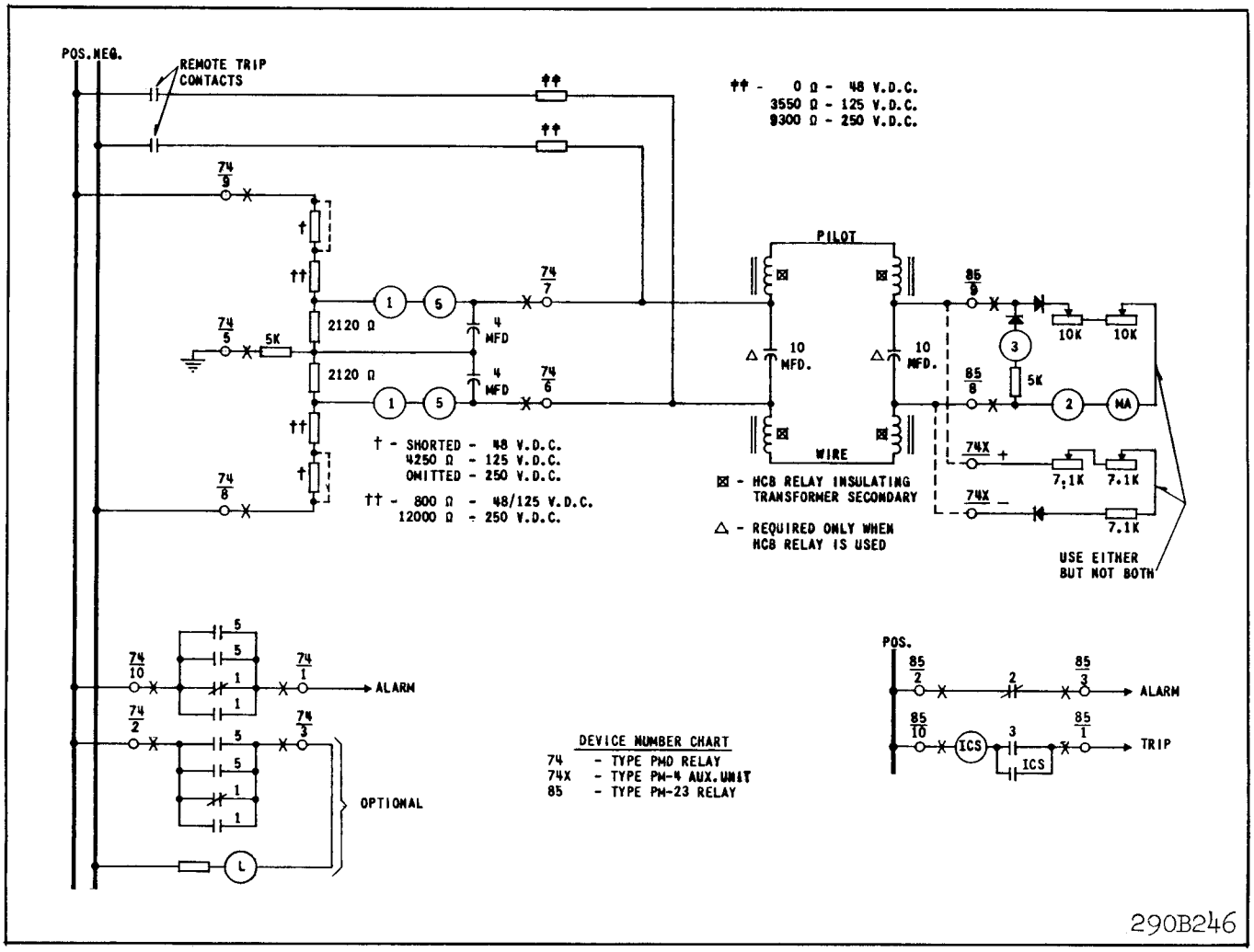


Fig. 19. External Schematic of the Type PMD Relay with Type PM-23 or PM-4 Relay – Two Terminal Lines.

recheck and readjust left hand contact pickup. Continue as required.

PM-5 Relays

Adjust the stationary contacts so that they just make with the moving contact when the armature is floating midway between the pole pieces. Then turn the contact screws two full turns in the opening direction to obtain approximately 0.050" contact opening. Reassemble permanent magnet with the north pole to the right. Turn both shunts all the way in. Energize with 0.3 ma, positive on terminal 8. Draw out the right-hand shunt until the right-hand contact closes. Energize with 0.3 ma, positive on terminal 6. Draw out left hand shunt until left hand contact closes. Recheck and readjust right-hand contact pickup. Then recheck and readjust left hand contact pickup. Continue as required.

PMG-13 and PM-13 Relays

Adjust the stationary contacts so that they just make when the armature touches the pole faces. Then turn each contact screw four turns to obtain approximately 5/32" between stationary contacts. Reassemble the permanent magnet with the north pole on the left. Turn both shunts all the way in. Continue as follows.

For the monitoring and tripping polar units, draw out the right-hand shunt until the right-hand contact closes at 1.3 or 2.3 ma, for the 1 ma and 2 ma relay ratings, respectively. Then draw out the left hand shunt until the left-hand contacts close at 0.7 or 1.7 ma, for the 1 and 2 ma relay ratings respectively. Recheck and readjust right hand contact pickup. Then recheck and readjust left hand contact pickup. Continue as required.

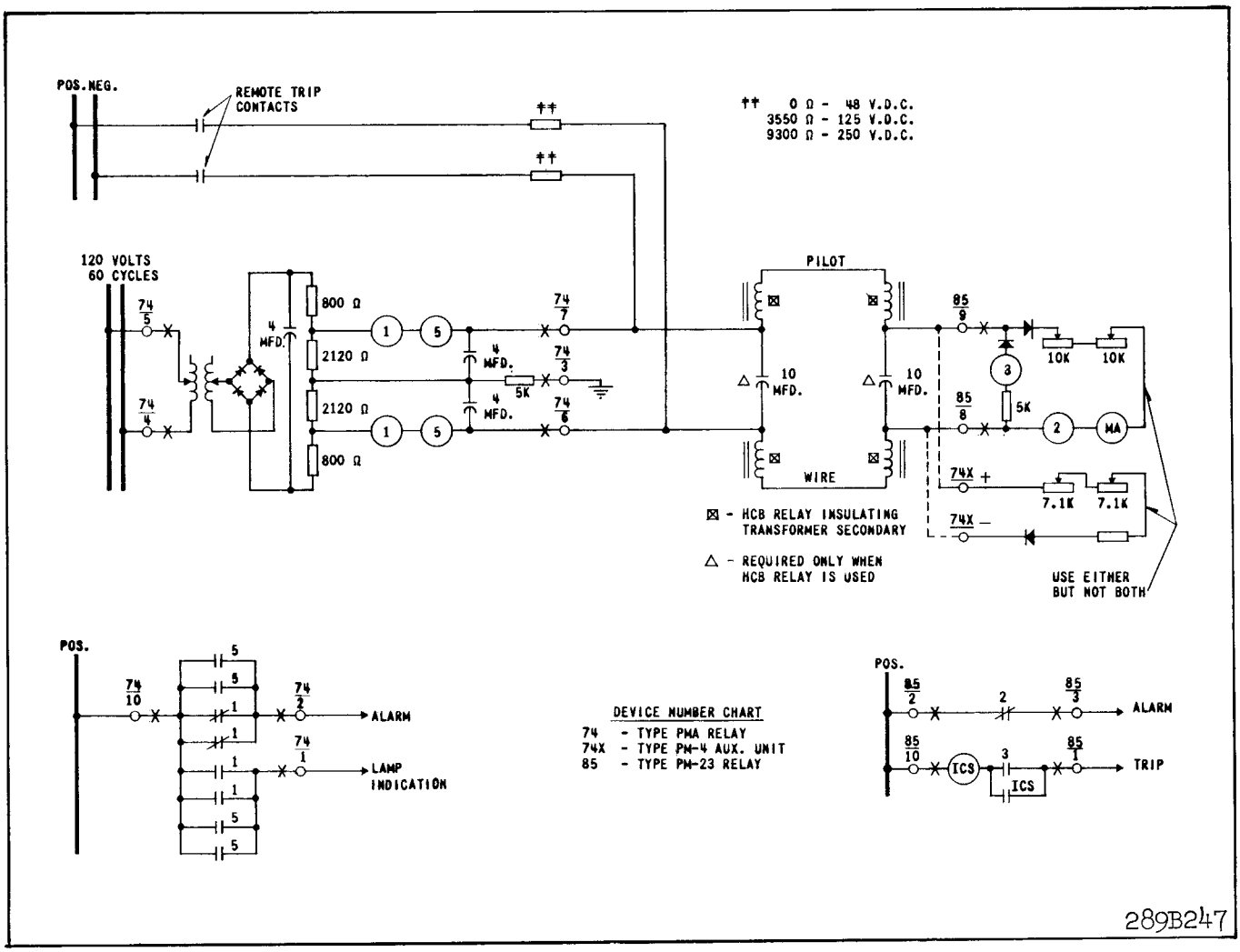


Fig. 20. External Schematic of the Type PMA Relay with Type PM-23 or PM-4 Relay – Two Terminal Lines.

For the ground unit (5) of the PMG-13 Relay, adjust the stationary contacts so that they just make with the moving contact when the armature is floating midway between the pole pieces. Then turn the contact screws two full turns in the opening direction to obtain approximately 0.050" contact opening. Reassemble permanent magnet with the north pole to the right. Turn both shunts all the way in. Energize with 0.3 ma, positive on terminal 9. Draw out the right-hand shunt until the right-hand contact closes. Energize with 0.3 ma, positive on terminal 8. Draw out left hand shunt until left hand contact closes. Recheck and readjust right-hand contact pickup. Then recheck and readjust left hand contact pickup. Continue as required.

PM-2 Relay

Adjust the moving armature so that it floats between the stops with the magnet removed. Adjust the stationary contacts so that they just make when the armature touches the pole faces. Then turn each contact screw four turns to obtain approximately 5/32" gap between stationary contacts. Reassemble the permanent magnet with the north pole on the left. Turn both shunts in all the way and then draw both out about seven turns. Adjust the shunts until the left-hand contacts close at 0.6 ma d-c, and the contacts float in the center at 1.0 ma d-c.

PM-3 Relay

Adjust the moving armature so that it floats between the stops with the magnet removed. Adjust the stationary contacts so that they just make when the armature touches the pole faces. Then turn each contact screw four turns to obtain approximately 5/32" gap between stationary contacts. Reassemble the

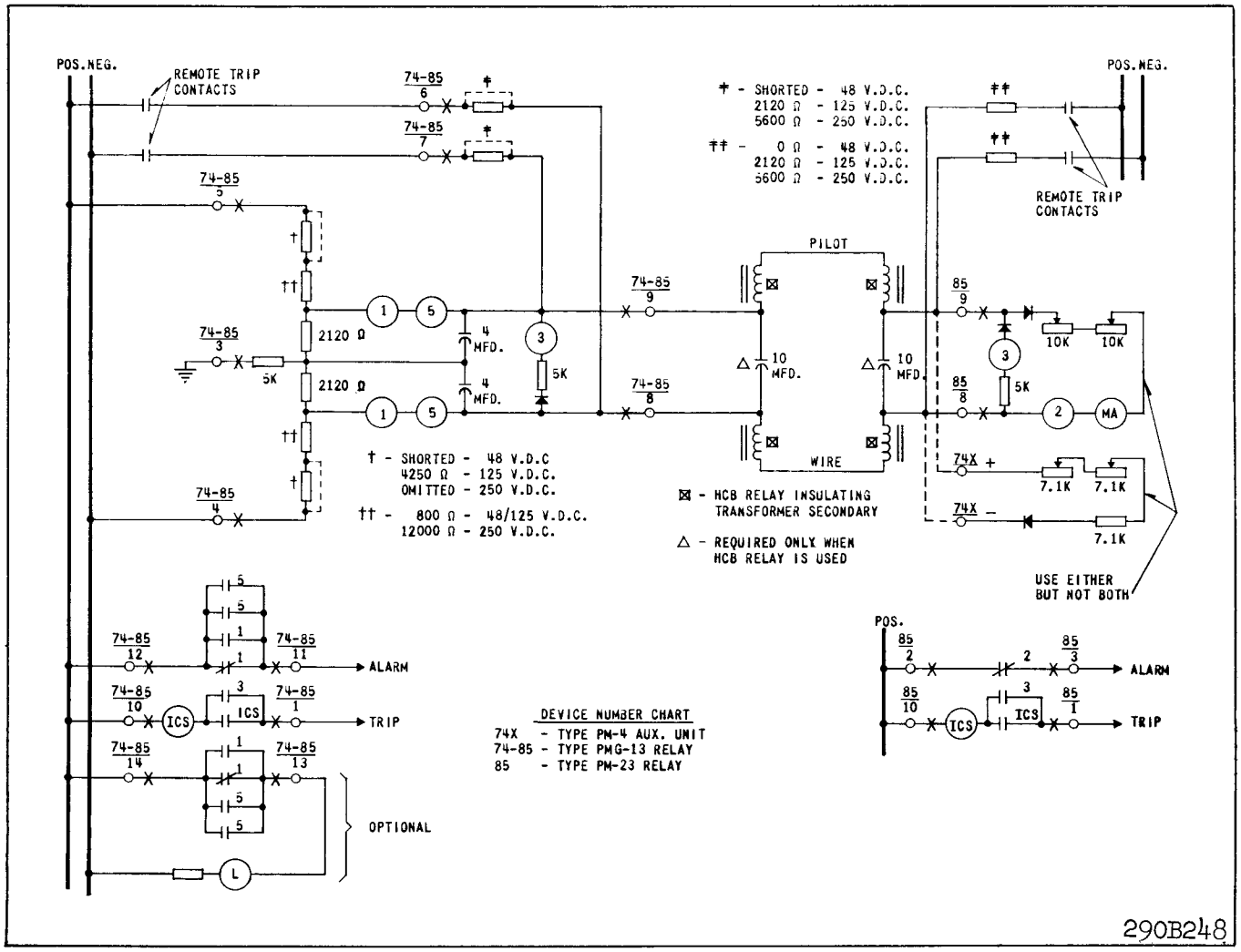


Fig. 21. External Schematic of the DC Type PMG-13 Relay with Type PM-23 or PM-4 Relay — Two Terminal Lines.

permanent magnet with the north pole on the left. Turn both shunts in all the way and then draw both out about seven turns. Adjust the shunts until the right-hand contacts close at 2.0 ma d-c, and the left hand contacts reset at 1.5 ma d-c.

PM-23 Relay

Adjust the moving armature in both polar units so that it floats between the stops with the magnet removed. Adjust the stationary contacts so that they just make when the armature touches the pole faces. Then turn each contact screw four turns to obtain approximately 5/32" gap between stationary contacts. Reassemble the permanent magnet with the north pole on the left. Turn both shunts in all the way and then draw both out about seven turns. Adjust the shunts until the left-hand contacts close at 0.6 ma d-c, and the contacts float in the center at 1.0 ma d-c for the upper polar unit. Adjust the shunts in the lower polar unit until the right-hand contacts close at 2.0 ma d-c, and the left hand contacts reset at 1.5 ma d-c.

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 complete nameplate data.

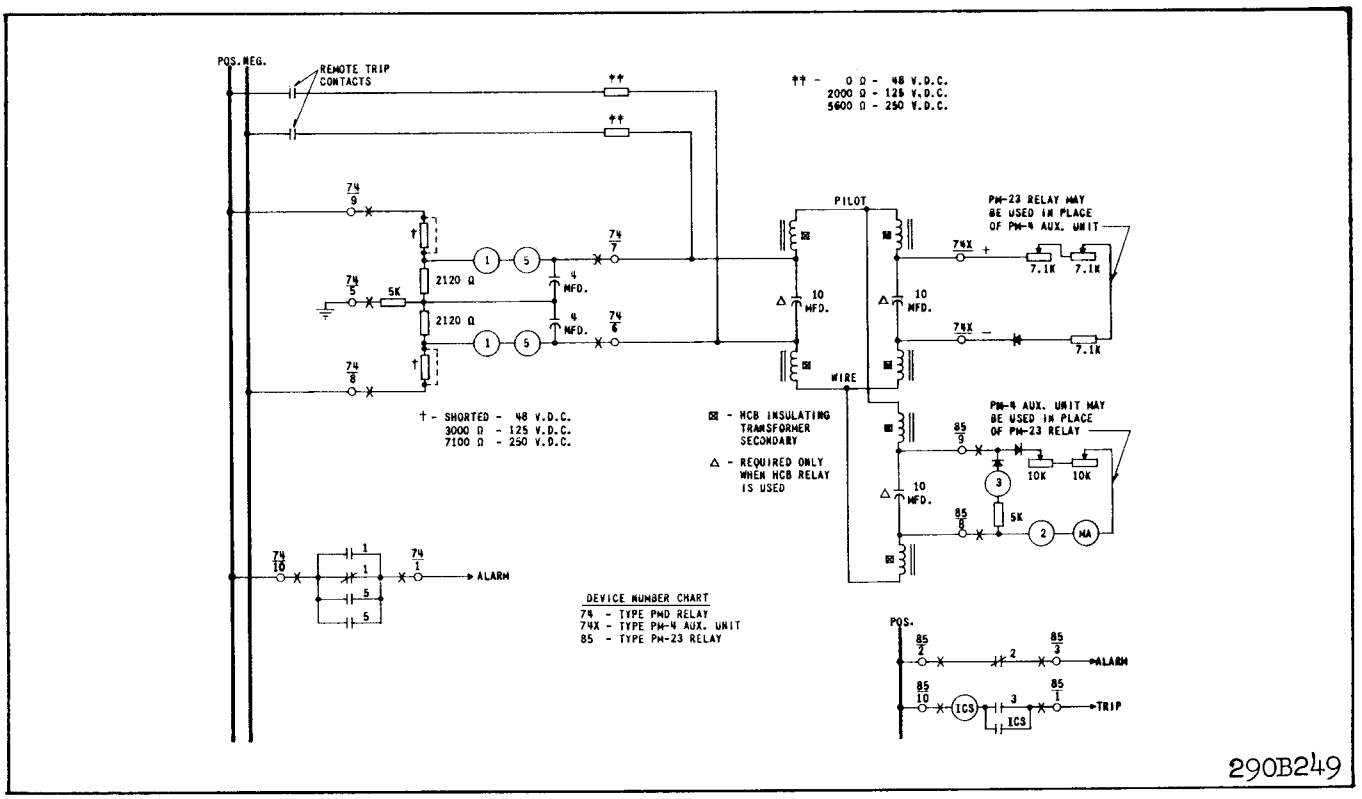


Fig. 22. External Schematic of the Type PMD Relay with Type PM-23 and PM-4 Relays – Three Terminal Lines.

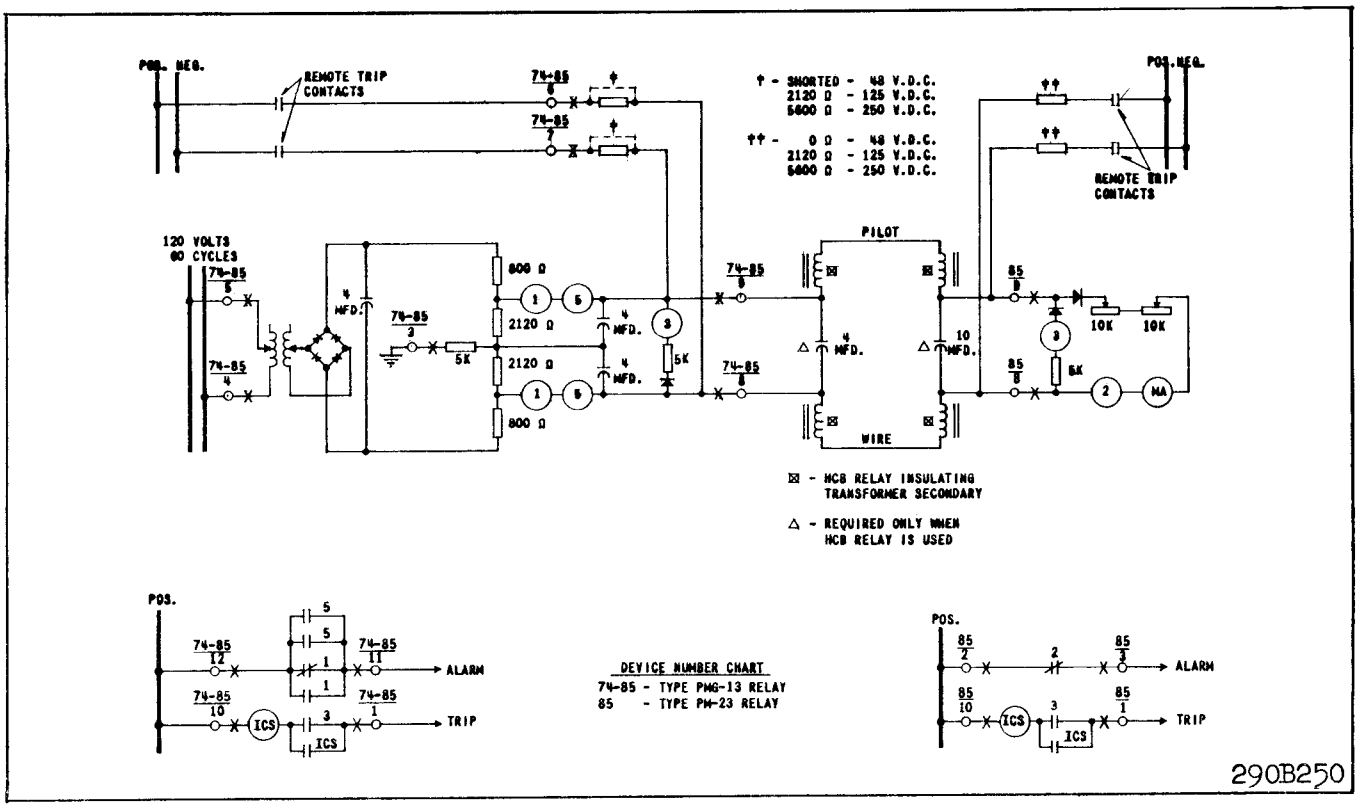


Fig. 23. External Schematic of the AC Type PMG-13 with Type PM-23 Relay – Two Terminal Lines.

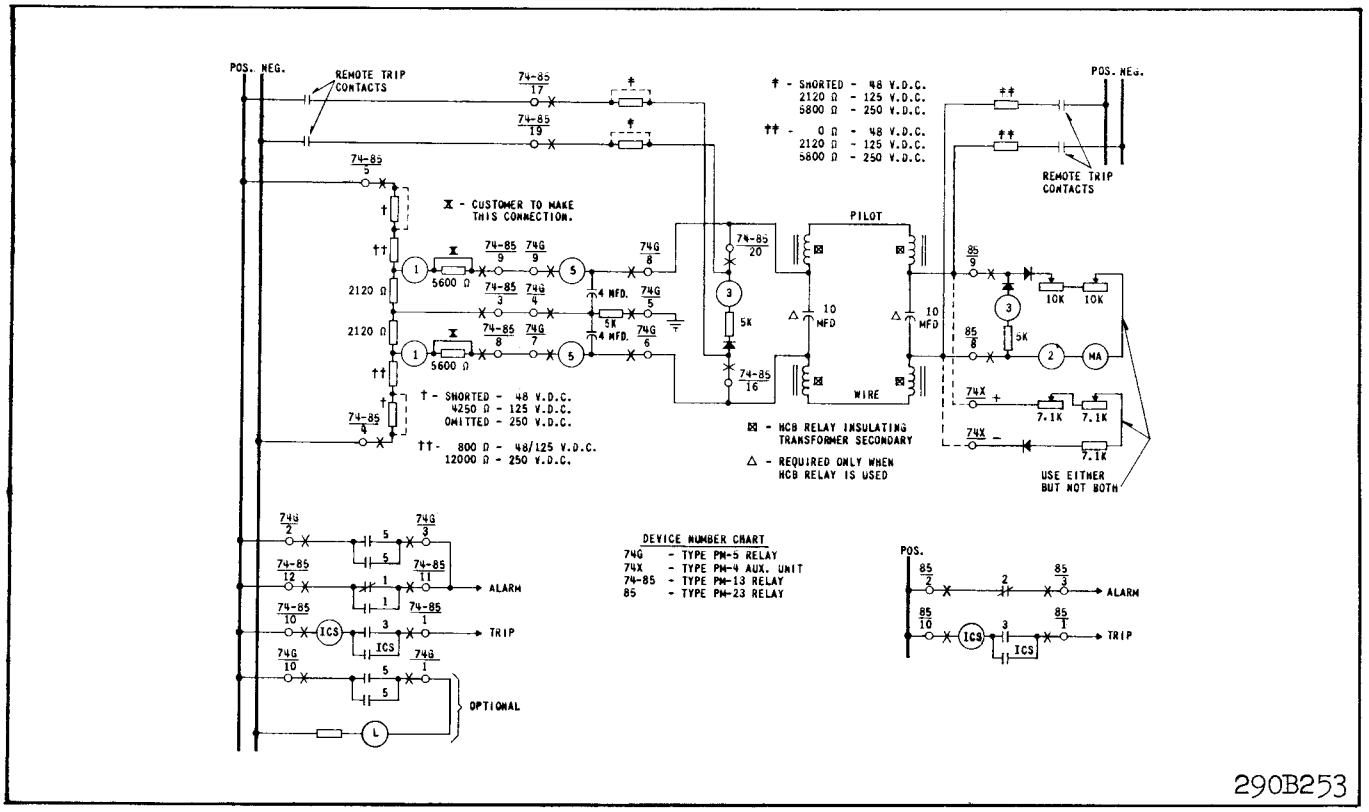


Fig. 24. External Schematic of the DC Type PM-13 and PM-5 Relay with Type PM-23 or PM-4 Relay – Two Terminal Lines.

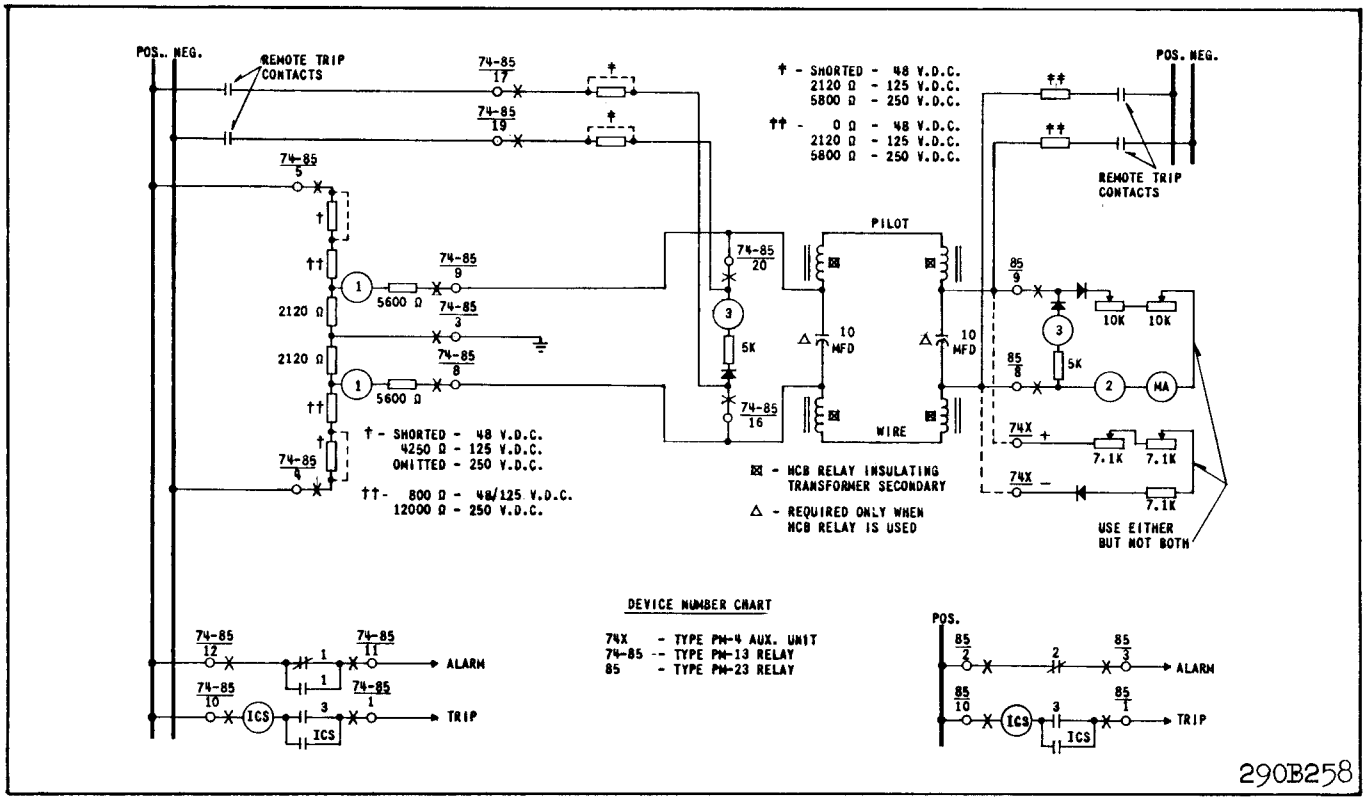


Fig. 25. External Schematic of the DC Type PM-13 Relay with Type PM-23 or PM-4 Relay – Two Terminal Lines.

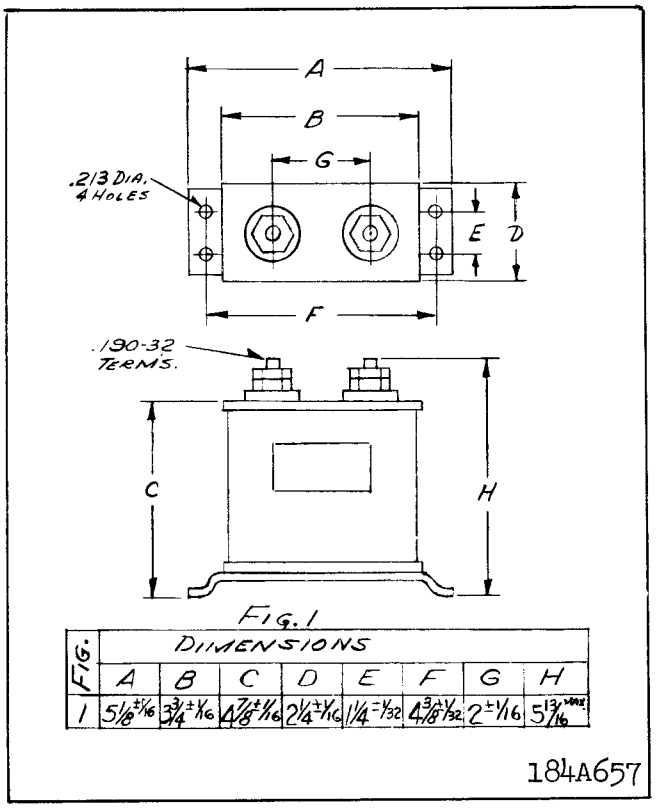


FIG. 1

FIG.	DIMENSIONS							
	A	B	C	D	E	F	G	H
1	5 1/8 ±1/16	3 3/4 ±1/16	4 7/8 ±1/16	2 1/4 ±1/16	1 1/4 -1/32	4 3/8 +1/32	2 ±1/16	5 13/16 MAX.

Fig. 26. Outline & Drilling Plan for 10 mfd. Capacitor For Reference only.

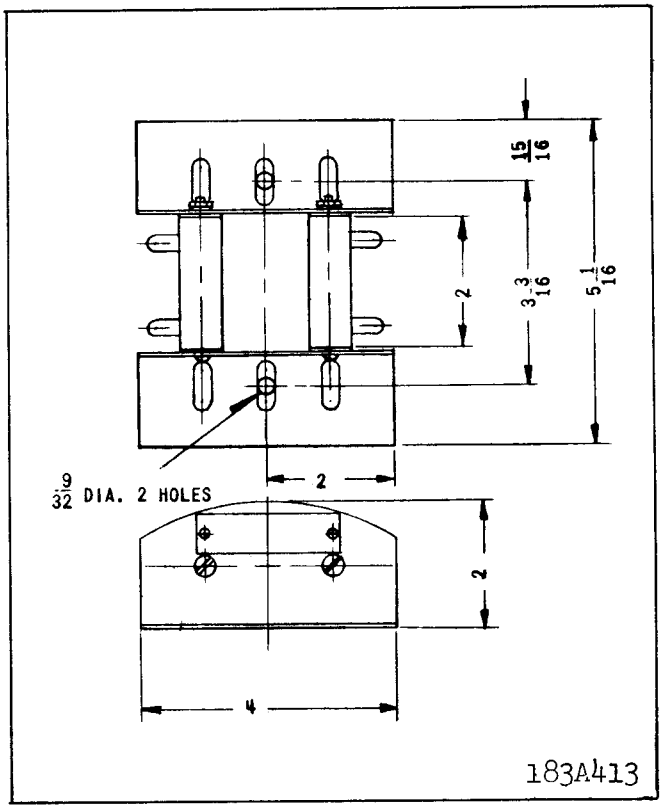


Fig. 27. Outline & Drilling Plan for External Remote Trip Resistor Assembly.

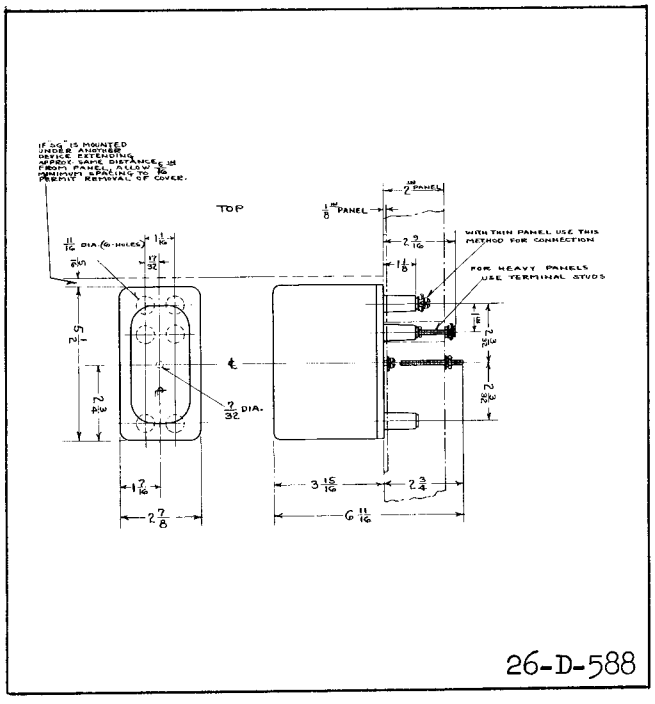


Fig. 28. Outline & Drilling Plan For the Type PM-4 Auxiliary Unit in the Projection Molded Case.

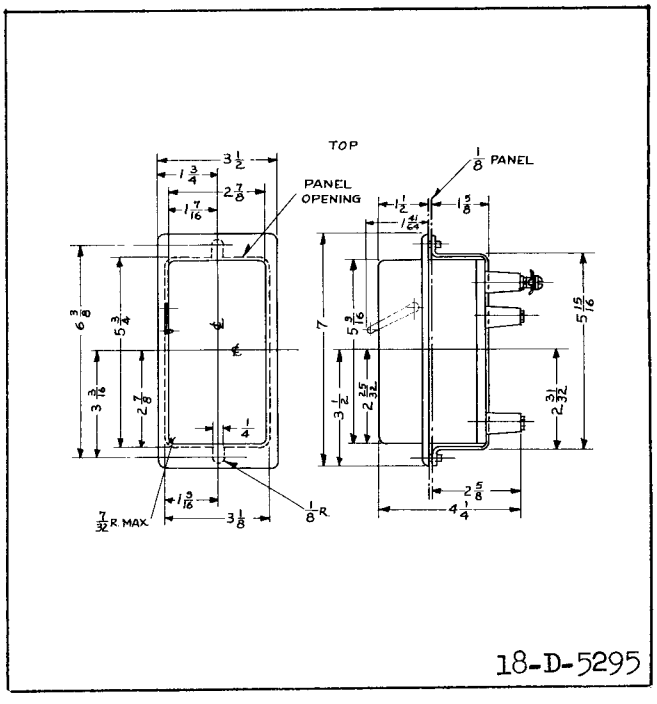


Fig. 29. Outline & Drilling Plan for the Type PM-4 Auxiliary Unit in the Semi-Flush Molded Case.

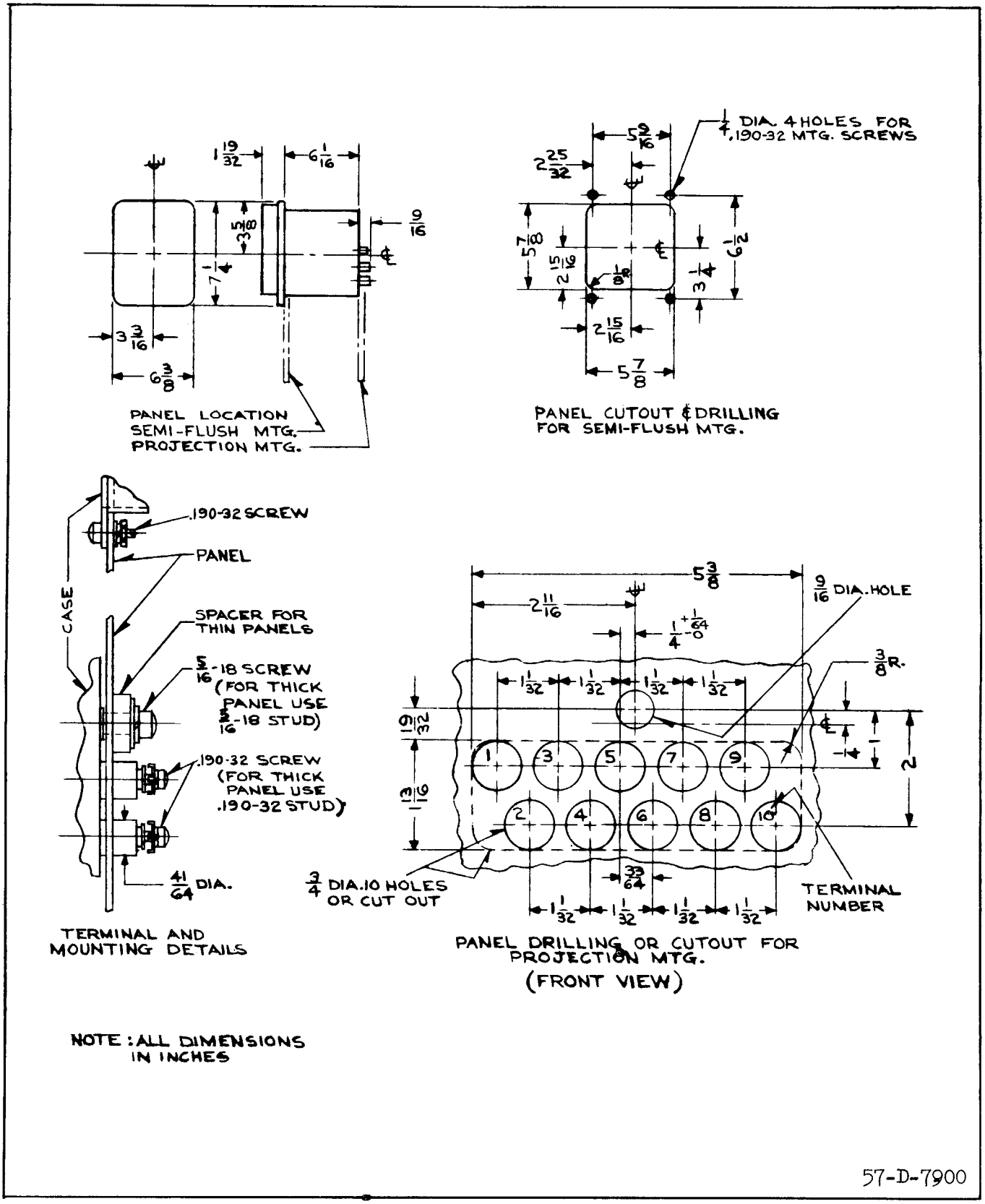


Fig. 30. Outline & Drilling Plan for the Type PM-3, PM-5 and PMD-1 Relays in the Type FT11 Case.

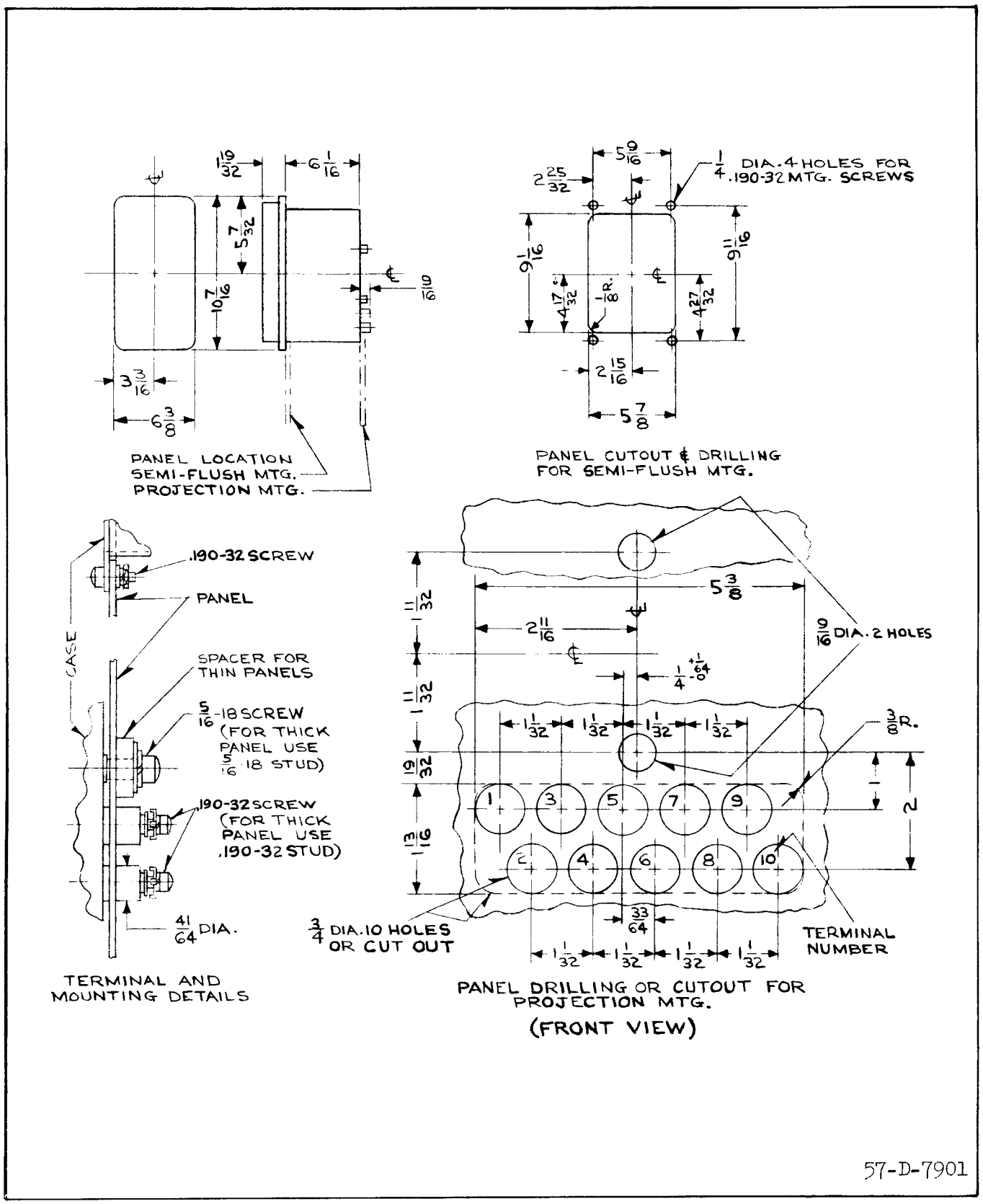


Fig. 31. Outline & Drilling Plan for the Type PM-2, PM-23, PMA-1 and PMD Relays in the Type FT21 Case.

WESTINGHOUSE ELECTRIC CORPORATION

RELAY DEPARTMENT **NEWARK, N. J.**

Printed in U. S. A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE PM LINE OF RELAYS FOR PILOT-WIRE MONITORING AND TRANSFERRED TRIPPING

CAUTION Before putting protective relays into service, remove all blocking which may have been inserted for the purpose of securing 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.

APPLICATION

Type PM Monitoring Relays provide continuous monitoring of a pilot-wire circuit to detect open circuits, short circuits, grounds, and wire reversal. In addition, transferred tripping can be effected where the PM-3, PM-13, PMG-13 or PM-23 relays are used. Table I illustrates the functions available with each * relay. A 10-mfd. capacitor is supplied with each PM relay. This capacitor provides an a-c path between the two halves of the insulating transformer secondary windings as shown in Figs. 19 through 25.

Each circuit requires the following:

At one end to introduce monitoring current

One of the following:

For a-c Supply	For d-c Supply
PMA	PMD
PMA-1	PMD-1
PM-13 or PMG-13 (a.c.)	PM-13 or PMG-13 (d.c.)

At the other end to receive monitoring current (two-terminal line)

One PM-23 or PM-2 or PM-4

At the other ends to receive monitoring current (three-terminal line)

Two PM-23 or two PM-4 or two PM-2 or any combination of two of these relays.

CONSTRUCTION

PM relays consist of the following:

PMA

1—Polar Alarm Unit (1)
1—Polar Ground Unit (5)
1—Tapped Transformer
1—Full-Wave Rectifier
3—4 mfd. Capacitors
1—Set of Voltage Dividing Resistors

PMA-1

1—Polar Alarm Unit
1—Tapped Transformer
1—Full-Wave Rectifier
1—4 mfd. Capacitor
1—Set of Voltage Dividing Resistors

PMD

1—Polar Alarm Unit (1)
1—Polar Ground Unit (5)
2—4 mfd. Capacitors
1—Set of Potential Divider Resistors

PMD-1

1—Polar Alarm Unit
1—Set of Potential Divider Resistors

PMG-13

1—Polar Alarm Unit (1)
1—Polar Ground Unit (5)
1—Polar Trip Unit (3)
1—Indicating Contactor Switch
1—Set of Potential Divider Resistors
1—Tapped Transformer (A.C. Relay only)
1—Full-Wave Rectifier (A.C. Relay only)
1—Blocking Rectifier
2—Remote Trip Resistors
3—4 mfd. Capacitors (A-C Relay)
2—4 mfd. Capacitors (D-C Relay)

PM-13

1—Polar Alarm Unit (1)
1—Polar Trip Unit (3)
1—Indicating Contactor Switch
1—Set of Potential Divider Resistors
1—Tapped Transformer (A.C. Relay only)
1—Full-Wave Rectifier (A.C. Relay only)
1—Blocking Rectifier
2—Remote Trip Resistors
1—4 mfd. Capacitor

PM-23

1—Polar Alarm Unit (2)
1—Polar Trip Unit (3)
1—Indicating Contactor Switch (ICS)
1—Milliammeter, 5.0 ma.
1—Set of Adjustable and Fixed Resistors
2—Blocking Rectifiers

PM-2

1—Polar Alarm Unit (2)
1—Milliammeter, 5.0 ma.
1—Set of Adjustable Resistors
1—Blocking Rectifier

*Supersedes I.L. 41-973.4A
*Denotes changes from superseded issue.

EFFECTIVE OCTOBER 1961

PM-3

1—Polar Trip Unit (3)
1—Resistor
1—Blocking Rectifier
1—Indicating Contactor Switch (ICS)

PM-4

1—Blocking Rectifier
1—Set of Adjustable & Fixed Resistors

PM-5

1—Polar Ground Unit (5)
2—4 mfd. Capacitors
1—Fixed Resistor

TABLE I

FUNCTION	PMA & PMD	PMA-1 & PMD-1	PM-13	PMG-13	PM-23	PM-2	PM-3	PM-4	PM-5
Monitoring Current Source	X	X	X	X					
Receives Monitoring Current					X	X		X	
Trouble Alarm	X	X	X	X	X	X			X
Transmits Trip Signal	X with external resistors	X with external resistors	X	X					
Receives Trip Signal			X	X	X		X		
Sensitive Ground Detection	X			X					X
Measures Monitoring Current					X	X			

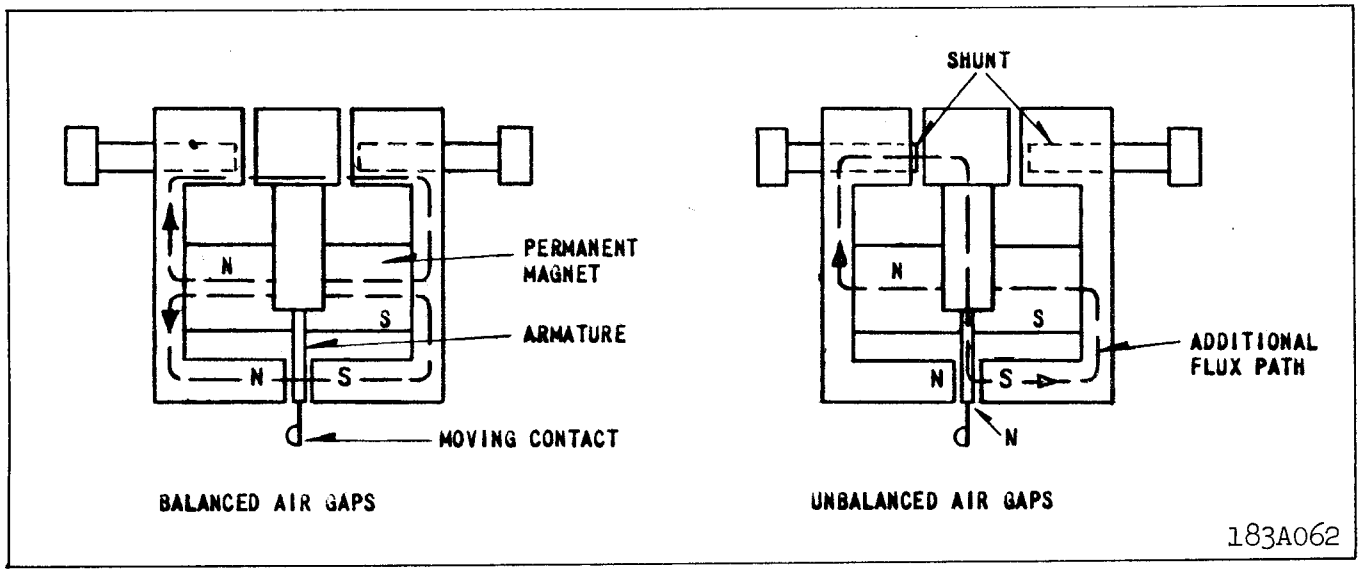


Fig. 1. Polar Unit Permanent Magnet Flux Paths.

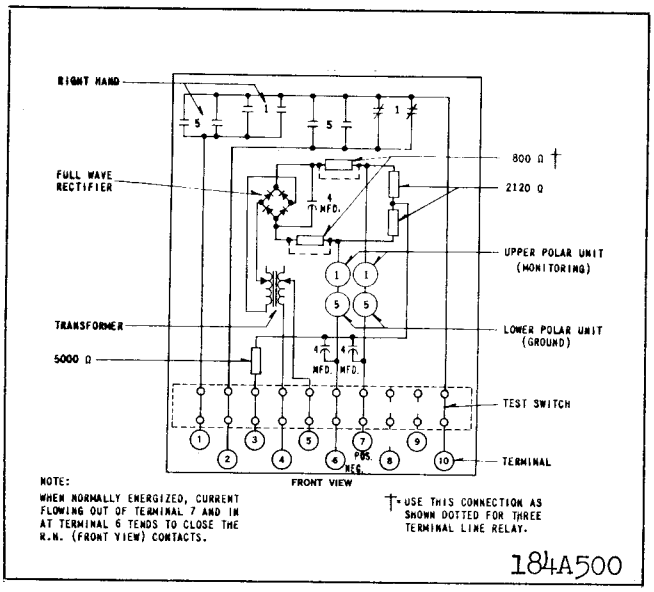


Fig. 2. Internal Schematic of the Type PMA Relay in the FT31 Case – 120 Volt, 60 cycle supply – For Two and Three Terminal Lines.

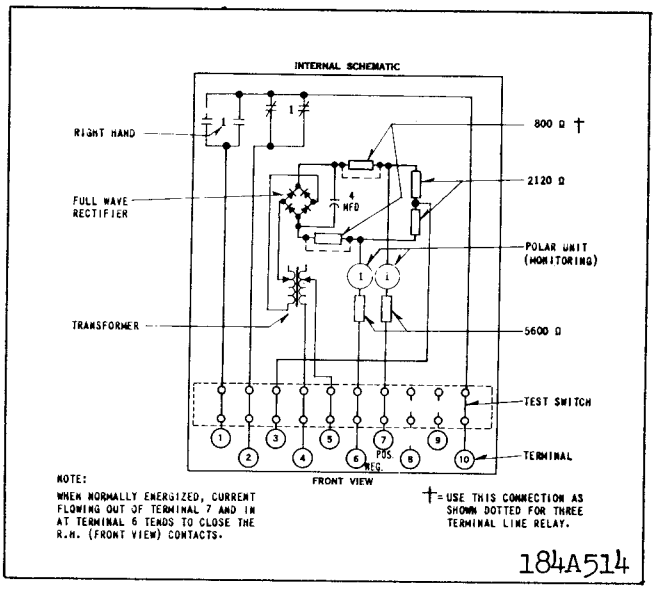


Fig. 3. Internal Schematic of the Type PMA-1 Relay in the FT21 Case – 120 Volt, 60 cycle supply – For Two and Three Terminal Lines.

Polar Unit

The polar unit consists of a rectangular shaped magnetic frame, an 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 winding or 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.

Indicating Contactor Switch

The d-c 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 cover.

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

OPERATION

Pilot Wire Monitoring

Monitoring current is introduced into the pilot wire as shown in the external schematics, figures 19 to 25, by the monitoring current source. External schematics showing other combinations are available on request. A nominal 20 volts is impressed across the 10 mfd. capacitor at the left-hand line terminal in Figures 19 to 25. This voltage produces a current circulating through one winding of the HCB insulating transformer, one pilot wire, the PM-23, PM-2, or PM-4, and back through the other pilot wire and the other winding of HCB insulating transformer.

Adjustment of the resistors of the PM-23, PM-2 or PM-4 relay at the other end of the pilot wire provides a normal one-milliampere d-c circulating current. In the case of three-terminal lines, the monitoring source relay output current is 2 ma. in order to provide each receiving end relay with 1 ma. The alarm unit of the monitoring current source relay is adjusted to float between the high and low current contacts with normal monitoring current. The PM-23, receiving-end alarm relay, is adjusted to float between the low-current alarm contact and a contact stop with 1 ma. flowing.

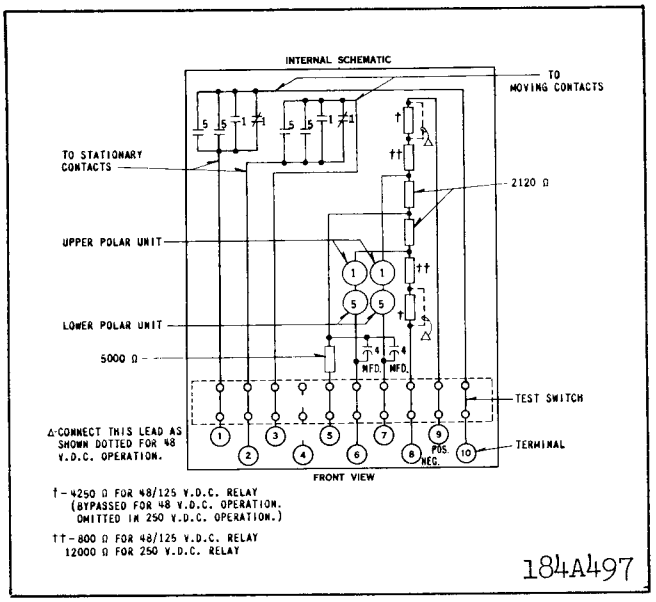


Fig. 4. Internal Schematic of the Type PMD Relay in the FT21 Case – DC Supply – For Two Terminal Lines.

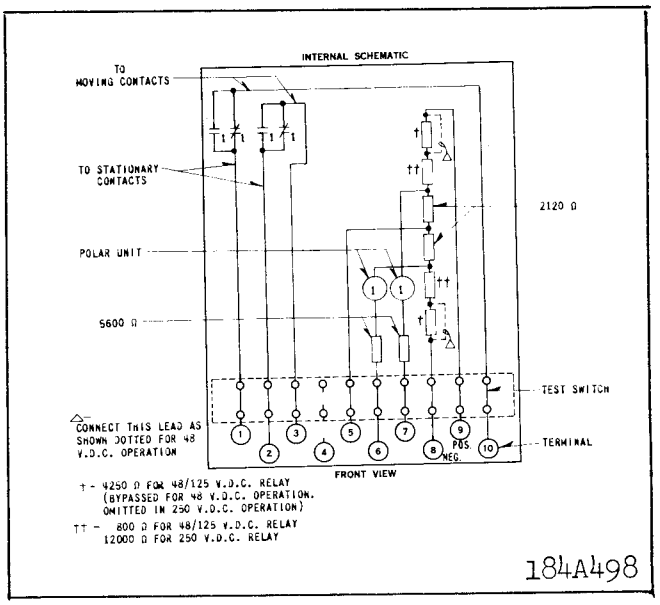


Fig. 5. Internal Schematic of the Type PMD-1 Relay in the FT11 Case – DC Supply – For Two Terminal Lines.

Short Circuits

A complete or partial short circuit on the pilot wires increases the current in the current-source relay, causing the high-current alarm contacts to close. The resulting current decrease in the PM-23 relay closes the alarm contact. Short circuits of 5000 ohms or less will be detected.

Open Circuits

Current decreases to zero in all relays. Low-current alarm contact of the current source relay closes. Alarm contact of PM-23 relay closes.

Reversed Wires

On applications using the PM-23 relay, current increases in the sending end relay to close the high-current alarm contacts. Current drops to zero in the PM-23 relay monitoring coil to close the low-current alarm contacts.

The current decreases in both sending and receiving end relays when the PM-2, or PM-4 relays are used. Low current alarm contacts close.

The voltage-divider circuit of the PMA, PMD, and PMG-13 source relays has its midpoint grounded through a current-limiting resistor. Thus, a pilot-wire ground will cause an increase in current in one coil circuit, and a decrease in the other one. This unbalance in the current flowing through the two windings (5) of the ground alarm relay unit will cause it to close one of its contacts (depending on which pilot wire is grounded) to give an alarm. Grounds of 10,000 ohms or less will be detected.

For adding the sensitive ground detection where PMA-1, PMD-1, or PM-13 relays have been installed, the PM-5 relay can be added to the circuitry, as shown in figure 24. This relay also has a 10,000-ohm ground sensitivity.

Transferred Tripping

Breakers located at the PMG-13 or PM-13 and PM-3 or PM-23 stations can be tripped by the application of a d-c voltage to the pilot wires at remote locations, as shown in figures 19 to 25. Transferred tripping can be effected from any location by applying 48 volts d-c (through dropping resistors when required) to the pilot wire with polarity opposite to that of the monitoring voltage. When tripping the PM-23, the current is increased above 2.0 ma, in reverse direction, to close the trip contact. When tripping the PMG-13 or PM-13, the reversed d.c. voltage operates the trip unit (3).

See Tables II and III for tripping resistor values. Nominal tripping current is 5 ma. at all rated voltages.

Polar Unit

Polar unit flux paths are shown in figure 1. With balanced air gaps, permanent magnet flux flows in

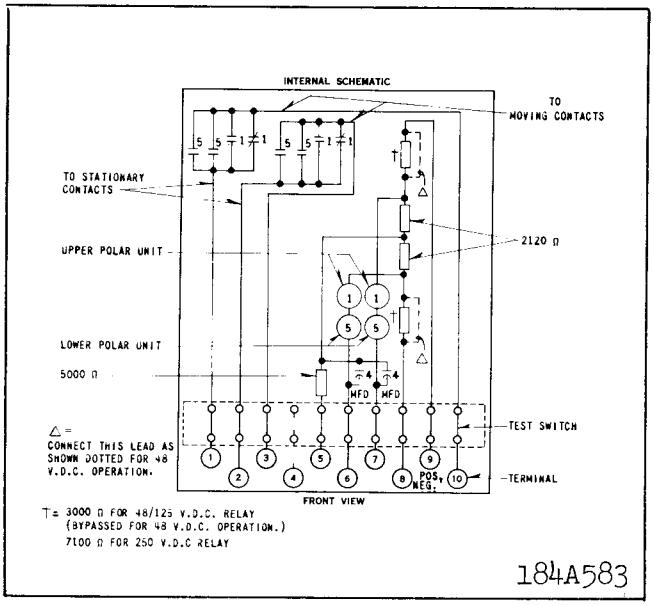


Fig. 6. Internal Schematic of the Type PMD Relay in the FT21 Case – DC Supply – For Three Terminal Lines.

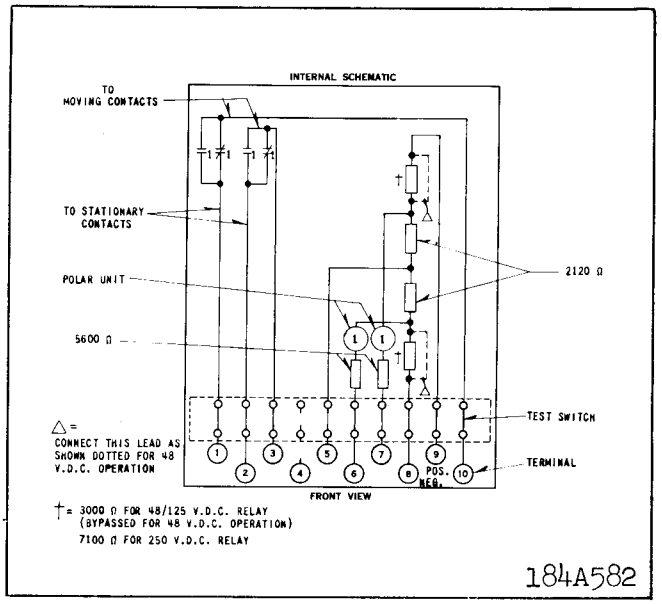


Fig. 7. Internal Schematic of the Type PMD-1 Relay in the FT11 Case – DC Supply – For Three Terminal Lines.

two paths, one through the front, and one through the rear gaps. This flux produces north and south poles, as shown. By turning the left shunt in, some of the flux is forced through the armature, making it a north pole. Thus, reducing the left hand rear gap will produce a force tending to pull the armature to the right. Similarly, reducing the right hand gap will make the armature a south pole and produce a force tending to pull the armature to the left.

The alarm unit contacts of the sending and receiving end relays are biased to move to the left when the relay is deenergized. The PMG-13 or PM-13 and PM-23 trip unit contact is biased to move to the left when the relay is deenergized. The PM-5 is adjusted so that the moving contact floats when the relay is deenergized.

CHARACTERISTICS

Nominal Calibration Values

Nominal current values to close contacts are listed in Tables IV and V.

Voltage Ratings

Supply voltage ratings of the monitoring source relays to obtain continuous monitoring current are as follows:

DC – 48, 125, and 250 volts

AC – 120 volts, 60 cycles (Primary taps 100, 110, 120 & 130)

Voltage impressed on the pilot wire is a nominal 20 volts for monitoring, and 48 volts for tripping.

Supply voltage ratings to obtain remote tripping are: 48, 125, and 250 volts d-c.

Coil Resistance

Relay	DC Resistance
PMA, PMA-1, PMD, PMD-1 PM-13, & PMG-13	
Alarm Coils (each winding)	1050-1250 Ω
PM-2, PM-23 (alarm coil)	2200-2600 Ω
PMG-13, PM-13, PM-23, & PM-3	
Trip Coil	1800-2200 Ω
PMA, PMD & PMG-13	
Ground Unit Coil (each winding)	5200-5800

PM-4 and PM-23 Resistance

Nominal PM-4 and PM-23 total resistance when adjusted for service is 20,000 ohms less pilot wire loop resistance at 1 ma.

PMA, PMA-1 and AC PMG-13, PM-13 Burden

0.5 VA at tap voltage	–	2-terminal line relay
1.0 VA at tap voltage	–	3-terminal line relay

Rectifiers

Approximate forward resistance - 560 ohms at 1 ma
300 ohms at 2 ma

Rating

Continuous forward current - amperes — 1

Continuous back voltage - rms volts — 200

Remote Tripping

Remote trip resistors are listed in Table II and III for 48, 125, and 250 volts d-c.

The relays have sufficient thermal capacity to withstand 20 MA d-c continuously when remote tripping. Nominal trip currents in the tripping relays are 5.0 MA d-c with 48, 125, and 250 volts d-c supply and a 2000-ohm pilot wire.

TABLE II

PMA, PMA-1, PMD, AND PMD-1 APPLICATIONS

EXTERNAL RESISTORS FOR D.C. REMOTE TRIPPING
(2 REQUIRED PER STATION)

# LINE TERMINALS	D.C. VOLTAGE	STATION A PMA or PMA-1	STATION A PMD or PMD-1	STATION B PM-2 & PM-3 or PM-23 or PM-4	STATION C PM-2 & PM-3 or PM-23 or PM-4	TO OPERATE
2	48	200	200	—	—	PM-23 or PM-3
	125	3550	3550	—	—	,,
	250	9300	9300	—	—	,,
3	48	200	200	—	—	,,
	125	2000	2000	—	—	,,
	250	5600	5600	—	—	,,

TABLE IIIA

PMG-13 AND PM-13 (D.C. SUPPLY) APPLICATIONS

RESISTORS FOR D.C. REMOTE TRIPPING
(2 REQUIRED PER STATION)

# LINE TERMINALS	D.C. VOLTAGE	STATION A PMG-13 or PM-13	STATION B PM-2 & PM-3 or PM-23 or PM-4	STATION C PM-2 & PM-3 or PM-23 or PM-4	TO OPERATE
2	48	200 †	200	—	PMG-13 or PM-13 and PM-23 or PM-3
	125	2120 †	2120	—	,,
	250	5600 †	5600	—	,,
3	48	200 †	200	200	,,
	125	1500 †	1500	1500	,,
	250	4000 †	4000	4000	,,

† Mounted in Relay

TABLE IIIB

PMG-13 AND PM-13 (A.C. SUPPLY) APPLICATIONS (2 REQUIRED PER STATION)

RESISTORS FOR D.C. REMOTE TRIPPING

# LINE TERMINALS	D.C. VOLTAGE	STATION A PMG-13 or PM-13	STATION B PM-2 & PM-3 or PM-23 or PM-4	STATION C PM-2 & PM-3 or PM-23 or PM-4	TO OPERATE
2	48	200 †	200	—	PMG-13 or PM-13 and PM-23 or PM-3
	125	2120 †	2120	—	"
	250	5600 †	5600	—	"
3	48	200 †	200	200	"
	125	1500 †	1500	1500	"
	250	4000 †	4000	4000	"

† Mounted in Relay

TABLE IV

NOMINAL CALIBRATION VALUES – TWO TERMINAL LINES

RELAY	LOW CURRENT ALARM [1]	HIGH CURRENT ALARM [2]	TRIP
PMA or PMA-1	0.7 ma	1.3 ma	—
PMD or PMD-1	0.7	1.3	—
PM-5 †	—	±0.3	—
PMG-13 or PM-13	0.7 ††	1.3 ††	14 V.
PM-23 or PM-2 & PM-3 †	0.7	—	14 V.

† Same relay as for three-terminal lines
†† These are pilot-wire current values

1—Left-hand contacts, front view.
2—Right-hand contacts, front view.

TABLE V

NOMINAL CALIBRATION VALUES – THREE TERMINAL LINES

RELAY	LOW CURRENT ALARM	HIGH CURRENT ALARM	TRIP
PMA or PMA-1	1.7 ma	2.3 ma	—
PMD or PMD-1	1.7	2.3	—
PM-5 †	—	±0.3	—
PMG-13 or PM-13	1.7 ††	2.3 ††	14 V.
PM-23 or PM-2 & PM-3 †	0.7	—	14 V.

† Same relay as for two-terminal lines
†† These are pilot-wire current values

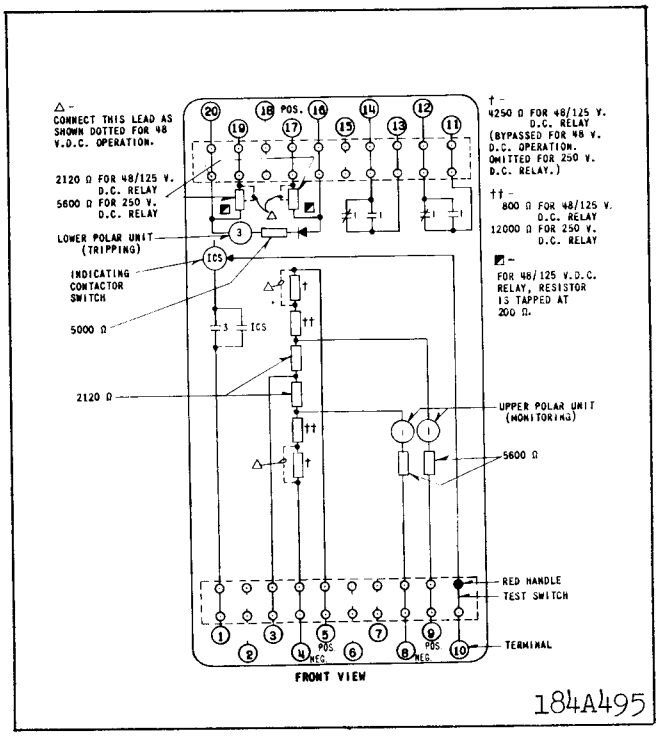


Fig. 8. Internal Schematic of the Type PM-13 Relay in the FT32 Case – DC Supply – For Two Terminal Lines.

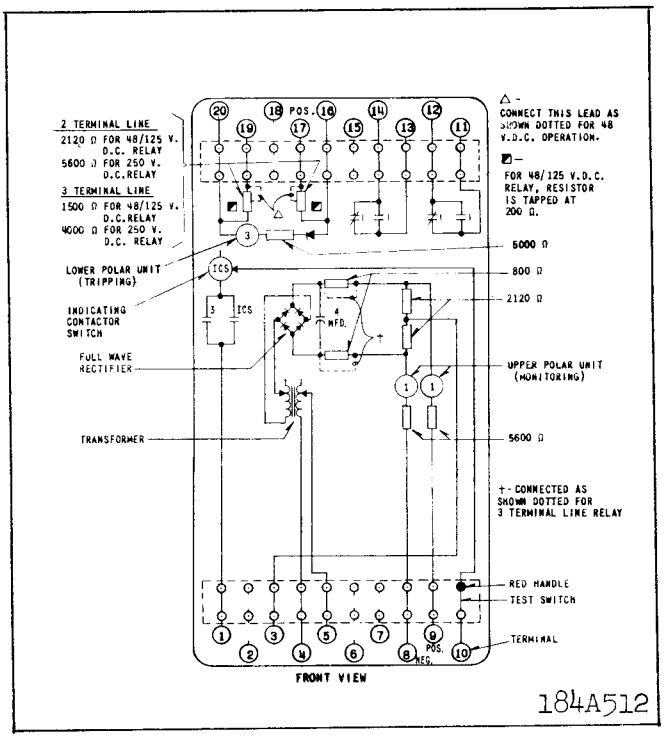


Fig. 9. Internal Schematic of the Type PM-13 Relay in the FT32 Case – 120 Volt, 60 cycle supply – For Two and Three Terminal Lines.

Trip Circuit

The main contacts will safely close 30 amperes at 250 volts d-c and the seal-in contacts of the indicating contactor switch 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 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.

Trip Circuit Constant

Indicating Contactor Switch (ICS)

0.2 ampere tap 6.5 ohms d-c resistance
2.0 ampere tap 0.15 ohms d-c resistance

SETTING THE RELAY

Operating units of all relays are adjusted in the factory to the values listed in Tables IV and V to a tolerance of ±5%. No settings are required on these units.

For all 48/125-volt d.c. relays, connect jumpers across resistors as shown on the internal schematics.

PM-4, PM-2, and PM-23 Relays

Adjust the resistors in the PM-4, PM-2, or PM-23 relay or relays to a value of 1 MA d-c with the monitoring circuits connected for service. Use the milliammeter in the PM-23 for this purpose or use a portable milliammeter with a resistance of less than 200 ohms. Where it is not practical on three-terminal lines to adjust both receiving relays simultaneously, set one receiving relay for 18,000 ohms total resistance (including relay coil and resistors) by measurement prior to final adjustment of the other receiving relay. This procedure will minimize the change in monitoring current in the first relay to be adjusted when making the final adjustment of the second relay.

PMA, PMA-1, PMG-13 and PM-13 Relays

Select the transformer tap nearest to expected normal a-c supply voltage. The full wave rectifier is connected to a secondary transformer tap. Where desired, the output voltage can be raised about 5% by reconnecting across the full secondary winding.

Indicating Contactor Switch

No setting is required on the ICS unit except the

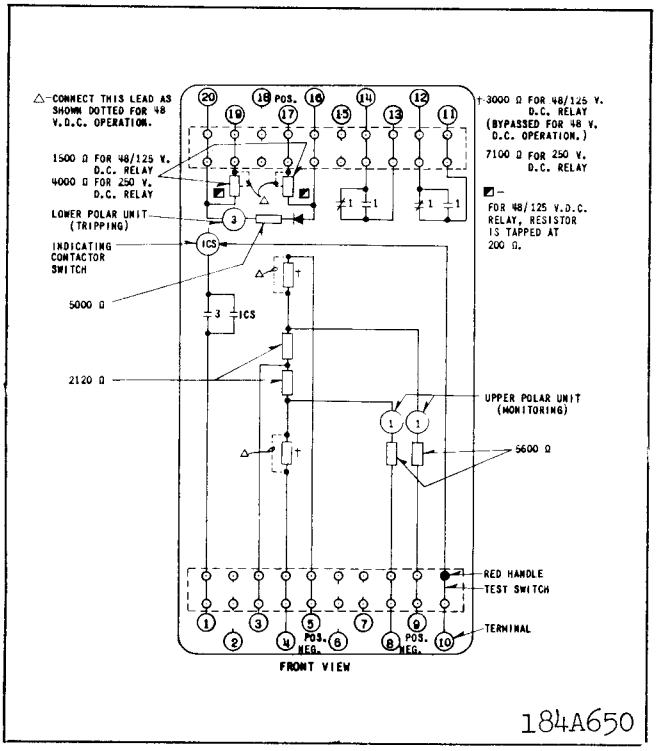


Fig. 10. Internal Schematic of the Type PM-13 Relay in the FT32 Case – DC Supply – For Three Terminal Lines.

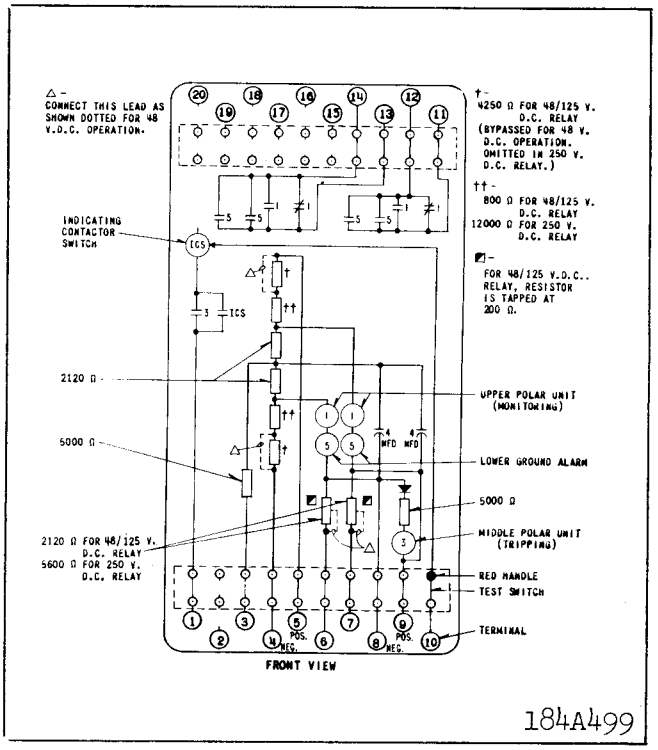


Fig. 11. Internal Schematic of the Type PMG-13 Relay in the FT32 Case – DC Supply – For Two Terminal Lines.

selection of the 0.2 or 2.0 ampere tap setting. This selection is made by connecting the lead located in front of the tap block to the desired setting by means of the connecting screw. When the relay energizes a type WL relay switch, or equivalent, use the 0.2 ampere tap.

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 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 I.L. 41-076.

Where the potential to ground impressed on the relays can exceed 700 volts, a drainage reactor in conjunction with a KX-642 tube, or the reactor in conjunction with 700 volt carbon-block arresters, is recommended. For details, see Protection of Pilot-Wire Circuits, AIEE Committee Report, paper 58-1190, AIEE Transactions, 1959, Volume 78, Part III B pp. 205-212. Also, see AIEE Special Publication S-117, Applications and Protection of Pilot-Wire Circuits for Protective Relaying, July 1960.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory and should not be disturbed after receipt by the customer. If the adjustments have been changed, the relay taken apart for repairs, or if it is desired to check the adjustments at regular maintenance periods, the instructions in the succeeding sections should be followed.

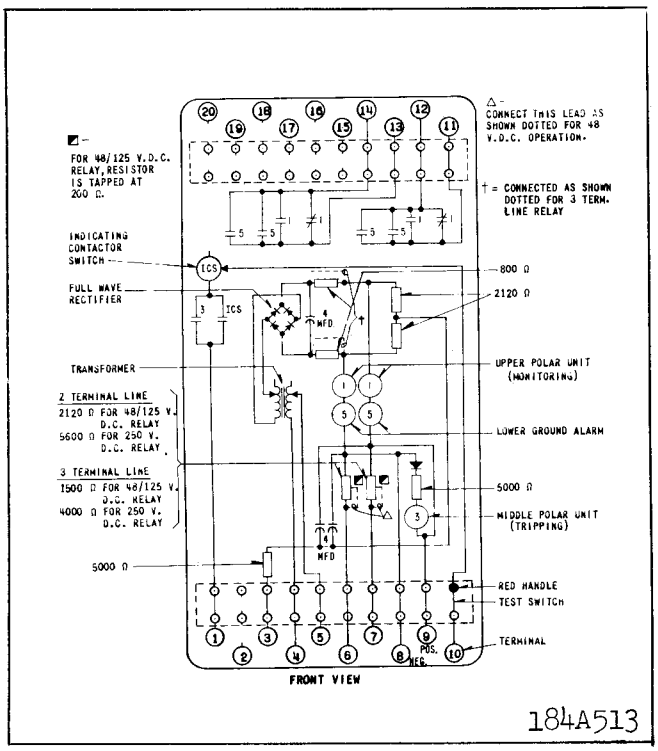


Fig. 12. Internal Schematic of the Type PMG-13 Relay in the FT32 Case – 120 Volt, 60 cycle supply – For Two or Three Terminal Lines.

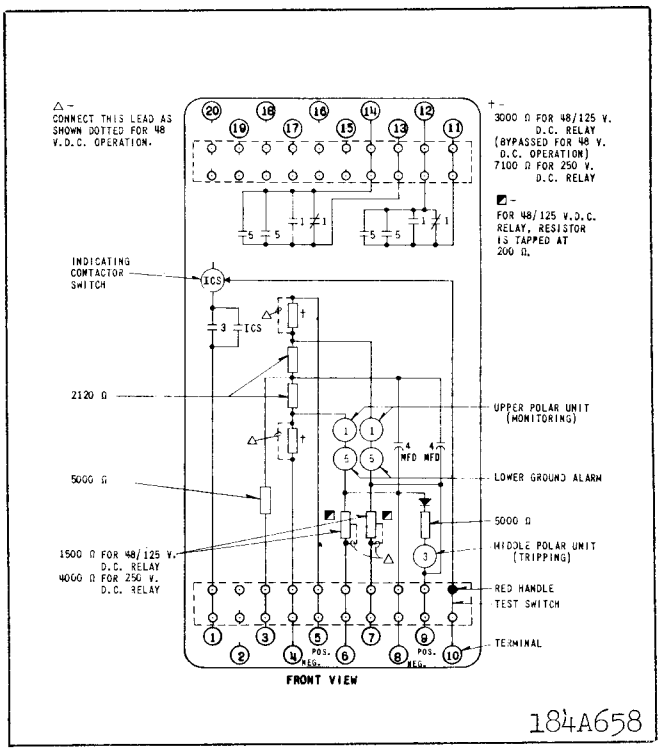


Fig. 13. Internal Schematic of the Type PMG-13 Relay in the FT32 Case – DC Supply – For Three Terminal Lines.

Acceptance Tests

The following tests are recommended when the relay is received from the factory. If the relay does not perform as specified below, the relay either is not properly calibrated or it contains a defect.

PMA and PMA-1 Relays

Alarm Unit (1)

Set the primary tap on 120 volts. Connect a variable resistor of approximately 20,000 ohms in series with a low-range d-c milliammeter across terminals 6 and 7 with the instrument positive connected to terminal 7. Apply 120 volts at rated frequency to terminals 4 and 5. Adjust the 20,000-ohm resistor to obtain a current of one ma. d.c. For a three-terminal line relay, use a 10,000-ohm resistor and set the current to 2 ma. d.c. At this value, the moving contact of the alarm or monitoring relay unit (1) should float between the two sets of stationary contacts. In the PMA relay, the ground alarm unit (5) contact should also float. (This contact will also float when the relay is de-energized.) Increase and decrease the one or two-milliampere monitoring current to check the calibration values listed in Tables IV and V.

Ground Unit (5)

Reconnect the 20,000-ohm resistor. For the PMA relay only, short terminals 7 and 3. The contact of the ground alarm unit (5) should close to the right when the relay is energized. Remove the short, and connect it between terminals 6 and 3. The ground alarm unit (5) should close to the left. The action of the monitoring unit (1) contact is of no significance in this simulated pilot-wire ground test. To check the pickup current of the ground detector, first remove the 20,000-ohm resistor from terminals 6 and 7. Connect a 0-1 d.c. milliammeter in series with a variable resistor of about 50,000 ohms between terminals 3 and 6. The ground unit should close its left-hand contact at approximately 0.3 ma. d.c. With the milliammeter and resistor connected between terminals 3 and 7, the right-hand contact should close at 0.3 ma. d.c.

PMD and PMD-1 Relays

Alarm and Ground Units

Connect an adjustable 20,000-ohm resistor (or 10,000-ohms for a 3-terminal relay) in series with a d-c milliammeter across terminals 6 and 7 with the

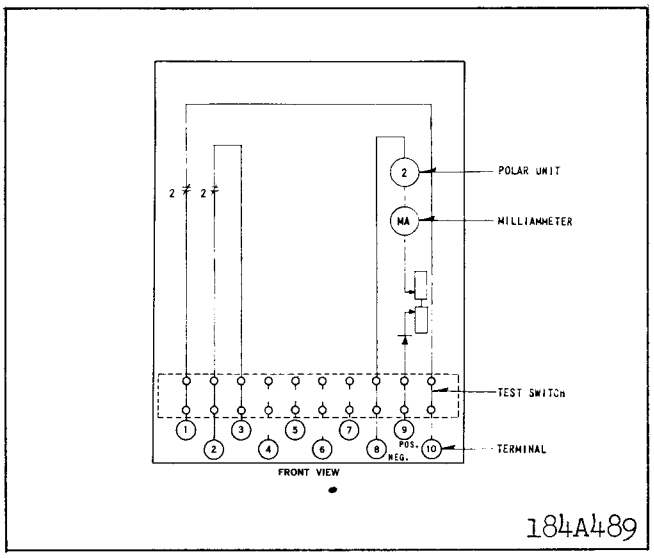


Fig. 14. Internal Schematic of the Type PM-2 Relay in the FT21 Case.

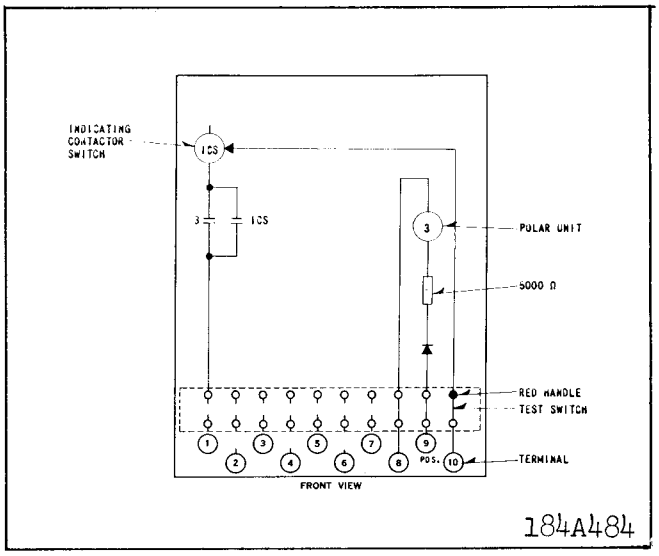


Fig. 15. Internal Schematic of the Type PM-3 Relay in the FT11 Case.

instrument positive connected to terminal 7. Apply rated d-c voltage to terminals 8 and 9 with positive on terminal 9. Now check the PMD and PMD-1 relays, following the procedure given in the previous section for the PMA and PMA-1 relays, respectively. Note, however, that terminal 5 of the PMD relay corresponds to terminal 3 of the PMA relay.

PM-2, PM-3, and PM-23 Relays

Alarm Unit (2)

Apply a variable d-c voltage of approximately 20 volts to relay terminals 8 and 9 (terminal 9 positive) of the PM-2 or PM-23 relay. Adjust the voltage to obtain a reading of one ma. on the relay milliammeter. The monitoring polar unit (2) contacts should float. Reduce the current gradually. The monitoring alarm contacts should close at 0.7 ma. d.c. The tripping unit (3) of the PM-23 relay should not move during this test.

Tripping Unit (3)

To check the PM-3 relay or the tripping unit of the PM-23 relay, apply the variable d-c voltage in series with an external milliammeter to relay terminals 8 and 9 with terminal 8 positive for the PM-23 relay, or terminal 9 positive for the PM-3 relay.

The tripping relay unit (3) should pick up with positive action at 14 volts d.c. and should drop out at approximately 10 volts. The alarm unit of the PM-23 relay will not operate during this test.

Indicating Contactor Switch (ICS) — PM-3 and PM-23 relays. Close the contact of the tripping unit (3), and pass sufficient direct current through the trip circuit (terminals 1 and 10) to close the contacts of the ICS unit. This value of current should not be greater than the particular ICS tap setting being used (0.2 or 2.0). The indicator target should drop freely.

PM-4 Relay

This device is simply a set of resistors and a diode to connect into the pilot-wire circuit to provide a path for the monitoring current. The resistors can be checked with an ohmmeter, and the diode can be checked either with an ohmmeter, or as explained in the section entitled "Rectifier Check" under "Routine Maintenance". If an ohmmeter is used, the difference in forward and reverse resistance readings obtained will be dependent on the current flowing through the diode.

PM-5 Relay

Apply 5 volts d.c. in series with a 0-1 d.c. milliammeter and a 20,000-ohm variable resistor to terminals 6 and 7 with positive on terminal 6. The left-hand contact should close at approximately 0.3 ma. Now apply the same circuit to terminals 8 and 9 with positive on terminal 9. The right-hand contact should close at approximately 0.3 ma.

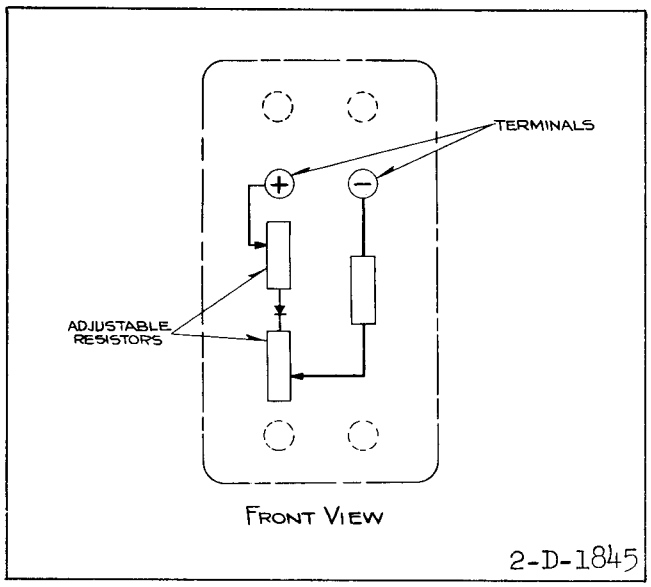


Fig. 16. Internal Schematic of the Type PM-4 Auxiliary Unit in the Small Molded Case.

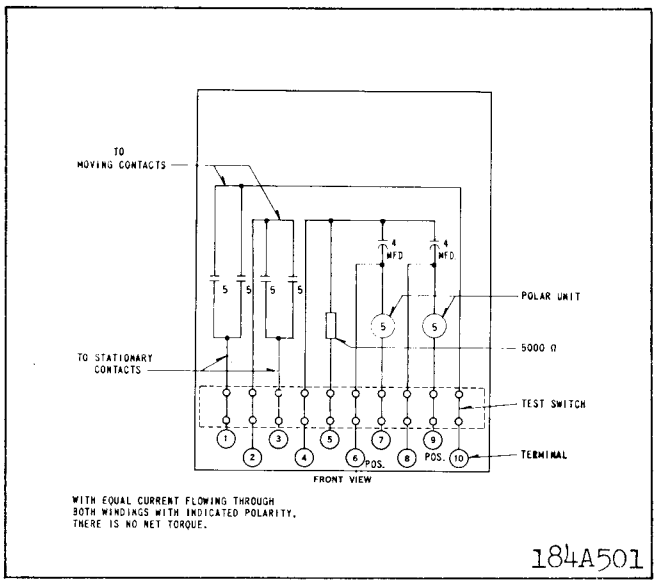


Fig. 17. Internal Schematic of the Type PM-5 Ground Detector Relay in the FT11 Case.

PM 13 Relays – A.C. and D.C.

Alarm Unit (1)

Connect a variable 20,000-ohm resistor (10,000 ohms for a 3-terminal-line relay) in series with a d-c milliammeter across terminals 8 and 9 with the instrument positive on terminal 9. For the a-c relay, set the primary tap on 120 volts. Now apply the rated supply voltage to terminals 4 and 5. This will be 48, 125, or 250 volts d.c., or 120 volts a.c. as indicated on the relay nameplate. Adjust the variable resistor to obtain a current of one ma. for a 2-terminal line relay, or 2 ma. for a 3-terminal relay. At this value, the moving contacts of the alarm or monitoring (1) relay unit (the upper polar unit) should float between the two sets of stationary contacts. Increase and decrease the one or 2-ma. monitoring current to check the calibration values listed in Tables IV and V.

Tripping Unit (3)

To check the operation of the tripping unit 3 (the lower polar unit), apply a d.c. potential across terminals 16 (positive) and 20 (negative). The tripping polar unit should pick up at 14 volts, and should drop out at approximately 10 volts. The resistance of the series dropping resistors for transferred tripping (listed in Tables III A and III B) can be checked with an ohmmeter. The circuit location of these resistors can readily be seen from the external schematic, Figure 25.

Indicating Contactor Switch (ICS)

Close the contact of the tripping unit (3), and pass sufficient direct current through the trip circuit (terminals 1 and 10) to close the contacts of the ICS. This value of current should not be greater than the particular ICS tap setting being used (0.2 or 2.0). The indicator target should drop freely.

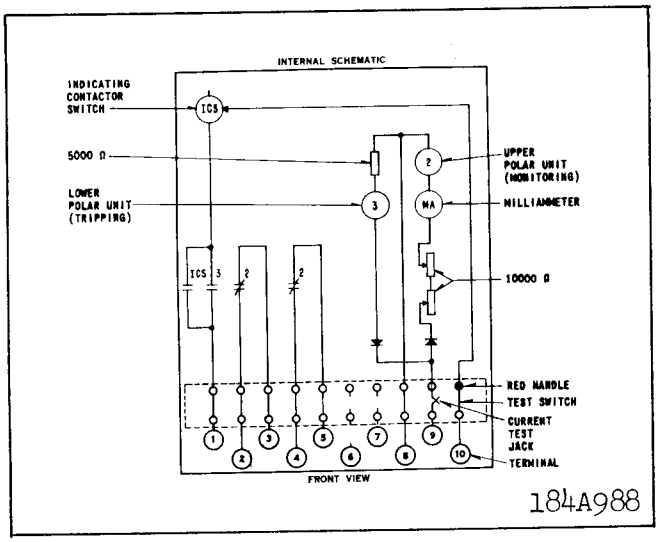
PMG-13 Relays – A.C. and D.C.

Alarm and Tripping Units

Follow the procedure given in the previous section for the a-c. and d-c. PM-13 relays.

Ground Unit (5)

Connect the 20,000-ohm (or 10,000-ohm) resistor and milliammeter across terminals 8 and 9. With rated voltage applied and one ma. (or 2 ma.) flowing, successively short circuit terminals 3 and 8, then 3 and 9. The ground alarm unit 5 (lower polar unit) should move first to the left, then to the right. To check the pickup current of the ground detector, first remove the 20,000-ohm resistor from terminals 8 and 9. Connect a 0-1 d.c. milliammeter in series with a variable



* *Fig. 18. Internal Schematic of the Type PM-23 Relay in the FT21 Case.*

resistor of about 50,000 ohms between terminals 3 and 8. The left-hand contact should close at approximately 0.3 ma. d.c. With the milliammeter and resistor connected between terminals 3 and 9, the right-hand contact should close at 0.3 ma. d.c. The external schematic diagrams for these relays are shown in Figure 21 and 23.

Indicating Contactor Switch (ICS)

Follow the procedure given for this device in the previous section on the a-c and d-c PM-13 relays.

Routine Maintenance

CAUTION — Do not make any performance check, calibration tests, or adjustments while the PM relays are energized or connected to the pilot wires, to prevent the possibility of inadvertantly causing a breaker operation. The PM relays may be removed from service for testing, without jeopardizing HCB relay protection, providing that the connections between the 10-mfd capacitor and the HCB insulating transformer are not disturbed.

Contacts

All contacts should be periodically cleaned. A contact burnisher S#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.

Operational Check

In addition to cleaning contacts, it is recommended that an operational check be performed periodically by opening and short-circuiting the pilot wires, as well as grounding them at the relay terminals. Note: These pilot-wire faults should not be applied directly to the pilot wires when the HCB relays are in service. It is also recommended that the trip circuits of the PM relays be opened (where tripping is used), to prevent the possibility of inadevertently tripping the associated circuit breaker during testing. If the relays do not perform as expected, and diode failure is suspected, the diode tests described in the following section may be performed.

Rectifier (Diode) Check

If there is suspicion of a rectifier (diode) failure, apply 30 volts d.c. reverse voltage (positive on arrowhead) through a 300-ohm resistance to the diode. Measure the voltage across the diode. If this voltage is not essentially 30 volts, the diode is short-circuited. Now apply 30 volts d.c. in the forward direction through the 300-ohm resistor, and measure the voltage across the resistor. If the voltage is not essentially 30 volts, the diode may have a high forward resistance. If the voltage is zero, the diode is open-circuited.

Calibration

If the relay has been dismantled or the calibration has been disturbed, use the following procedure for calibration.

With the permanent magnet removed, see that the moving armature floats in the central area of the air-gap between the poles of the polar unit frame. If necessary, loosen the core screw in the center rear of the unit and shift the core and contact assembly until the armature floats. (This can best be done with the polar unit removed from the relay.) Then retighten the core screw and replace the permanent magnet with the dimple (north pole) on the magnet to the left when viewed from the front.

Polar Units-General

The following mechanical adjustments are given as a guide, and some deviation from them may be necessary to obtain proper electrical calibration.

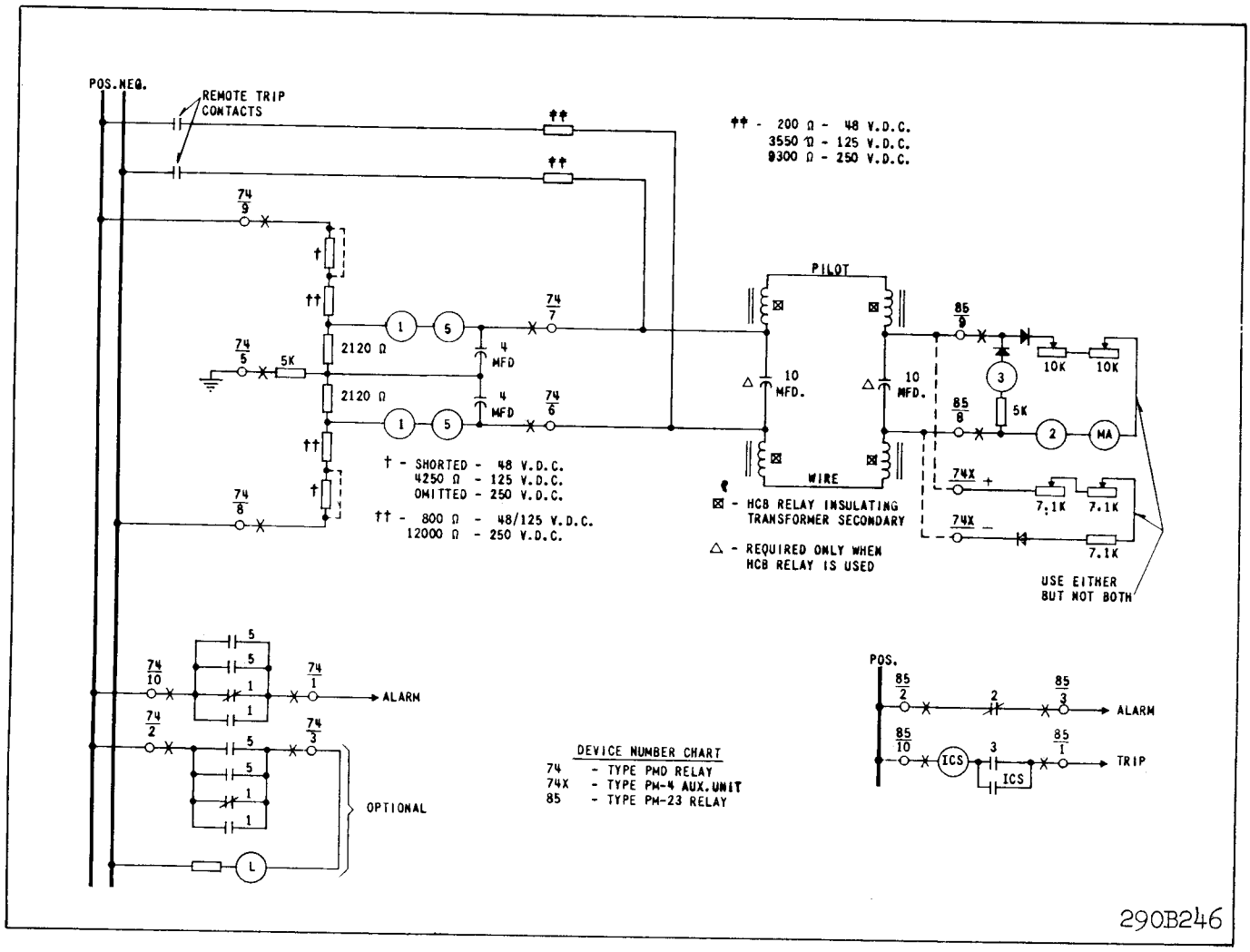
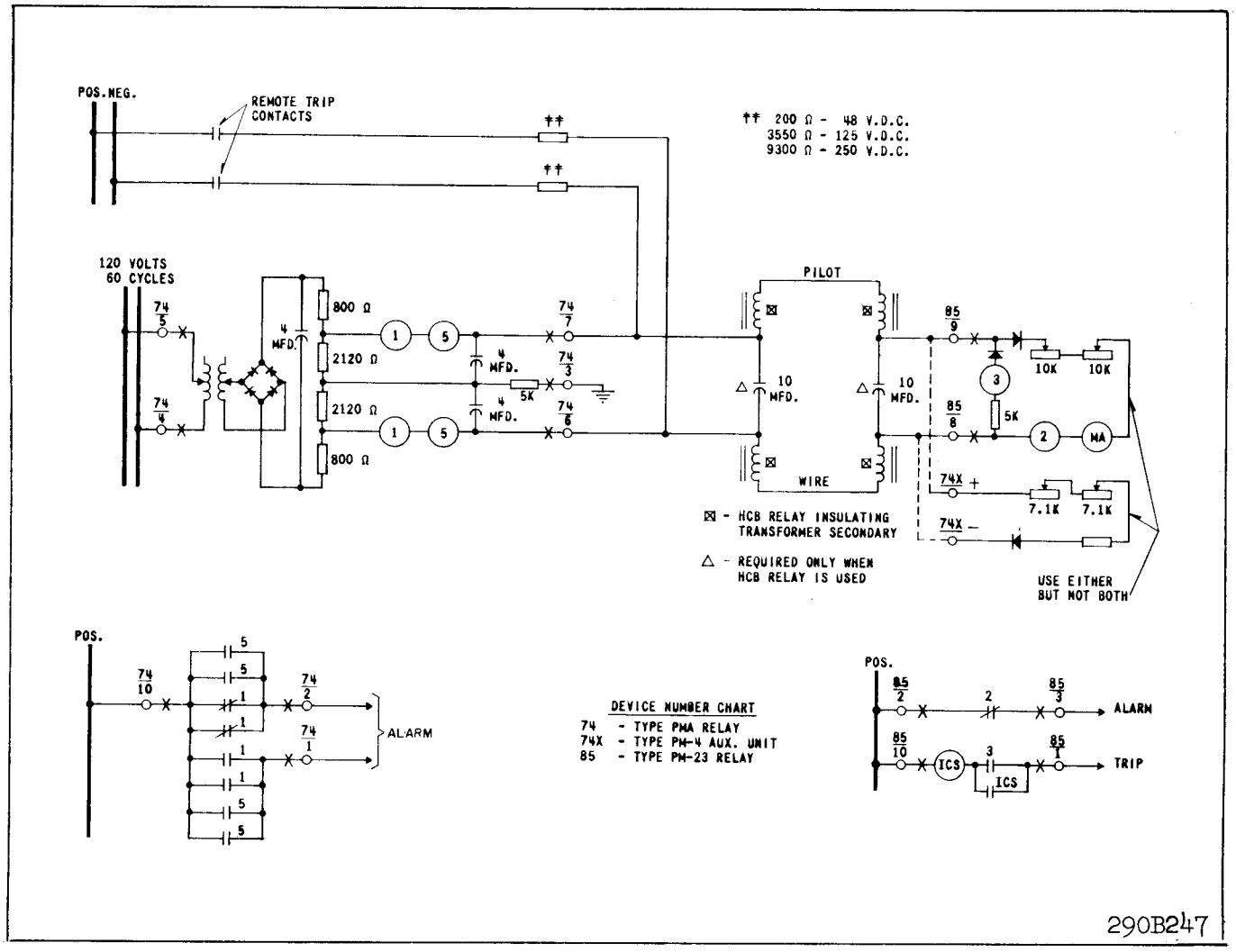


Fig. 19. External Schematic of the Type PMD Relay with Type PM-23 or PM-4 Relay – Two Terminal Lines.

Magnetic Shunt Adjustment

The sensitivity of the polar unit is adjusted by means of two magnetic, screw-type shunts at the rear of the unit, as shown in Fig. 1. These shunt screws are held in proper adjustment by a flat strip spring across the back of the polar unit frame, so no locking screws are required. Looking at the relay, front view, turning out the right-hand shunt to open the right-hand air gap decreases the amount of current required to close the right-hand contact. Conversely, drawing out the left-hand shunt increases the amount of current required to close the right-hand contact, or decreases the amount of current required to close the left-hand contact (with the proper direction of current flow). Also, if a relay trips to the right at the proper current, the dropout current can be raised by turning in the right-hand shunt. The two shunt-screw adjustments are not independent, however, and a certain amount of trimming adjustment of both shunt screws is generally necessary to obtain the desired pickup and dropout calibration.

In general, the farther out the two shunt screws are turned, the greater the toggle action will be, and as a result, the lower the dropout current. For the tripping units (3) of the PM-3, PM-13, and PM-23 relays, toggle action is desirable, with a dropout current around 75 percent of the pickup current. For the monitoring alarm relay units, toggle action is not desired. Instead, the armature is adjusted to float between the pole faces at a given current (1 or 2 ma.), and to move gradually toward the high or low-current alarm as the coil current is increased or decreased. Similarly, the floating adjustment of the armature of



* *Fig. 20. External Schematic of the Type PMA Relay with Type PM-23 or PM-4 Relay – Two Terminal Lines.*

the ground alarm unit (5) requires that both shunt screws be turned in relatively far. Then the armature will move gradually to the left or right as the current through the two #5 coils is unbalanced.

The electrical calibration of the polar unit is also affected by the contact adjustment as this changes the position of the polar unit armature. Do not change the contact adjustment without rechecking the electrical calibration.

Contact Adjustment – All Relays

For all monitoring alarm units, designated (1) or (2), turn in all the stationary contact and contact stop screws until they just touch the moving contact. Advance the screws to hold the armature in the central portion of the magnetic air gap between the two pole faces. (The stationary contact screws have a round silver contact face; the stop screws do not have this silver facing.) Now back off all the contact and contact stop screws one full turn. This will give a total contact travel of 0.050 inch. When the relay is properly calibrated, some touch-up adjustment may be necessary so that double contacts will both close at the same current value. The contact gap between the floating moving contact and the right-hand or left-hand stationary contacts or contact stops will be approximately 0.025 inch when the relay is in operation.

For the tripping (3) units of the PM-3, PM-13, PMG-13, and PM-23 relays, adjust the contacts as

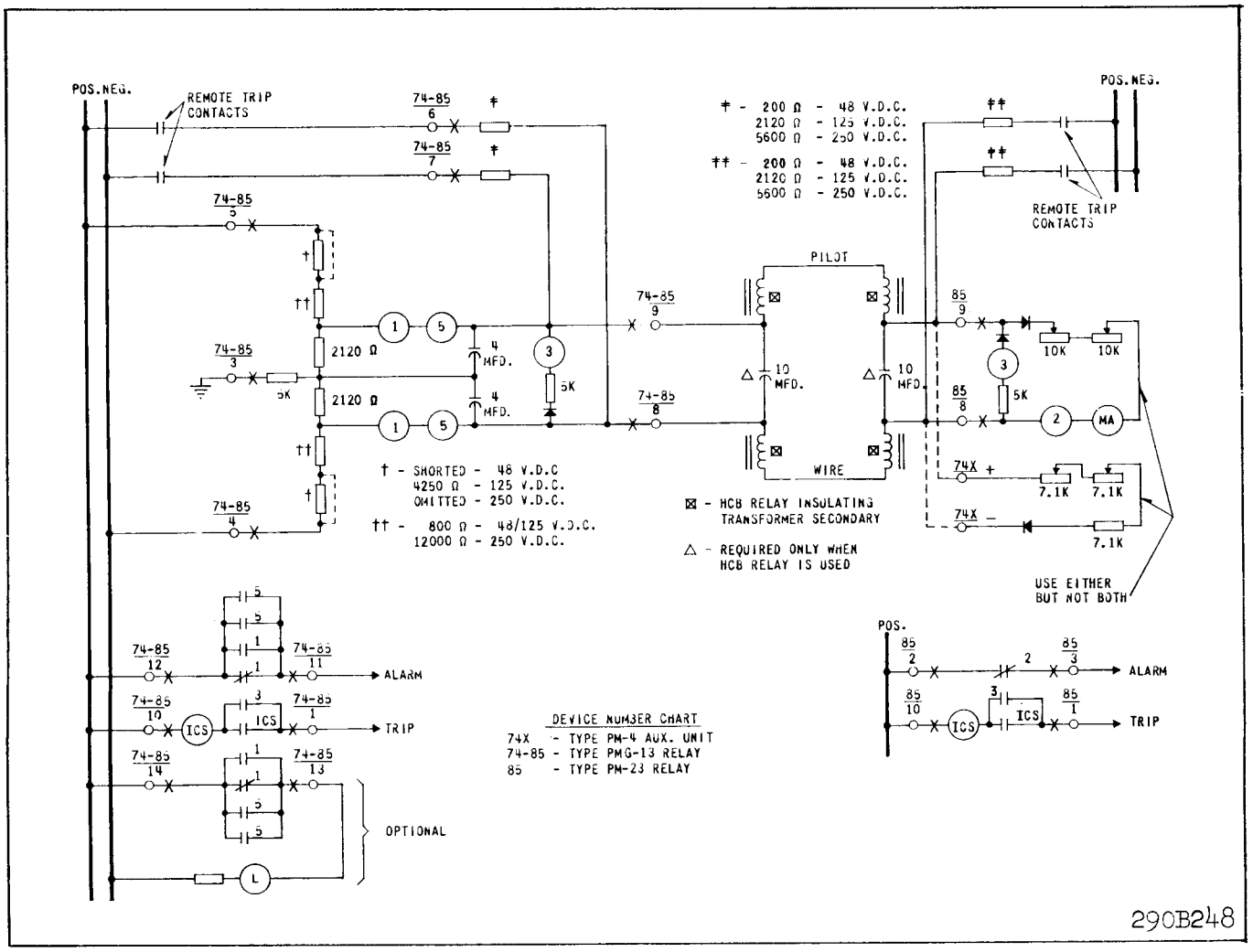


Fig. 21 External Schematic of the DC Type PMG-13 Relay with Type PM-23 or PM-4 Relay – Two Terminal Lines.

described in the previous paragraph, except back off the contact and stop screws one-half turn each to give a total moving contact travel of approximately 0.025 inch. In operation of the tripping unit, the moving contact will normally rest against the contact stop screw, and will pick up only for a transferred-tripping operation.

For the pilot-wire ground alarm unit (5) of the PMA, PMD, PM5, and PMG-13 relays, follow the same general procedure except back off both stationary contact screws two turns each. This will give a contact gap of 0.050 on each side of the moving contact when it is its normal central position.

Electrical Calibration – All Relays

In the following sections, the calibration instructions are given for the polar unit which performs a certain function, such as alarm (1) or (2), ground (5), or trip (3), rather than giving calibration instructions for each complete relay. In this way, considerable duplication of instructions has been eliminated.

The following chart indicates the units present in each relay.

Function and Unit	PMA PMD	PMA-1 PMD-1	PM2	PM3	PM4	PM5	PM13	PMG13	PM23
Alarm for p.w. open, short, or reversal (1) (2)	(1)	(1)	(2)				(1)	(1)	(2)
Transfer-Trip Unit (3)				(3)			(3)	(3)	(3)
Alarm for p.w. ground (5)	(5)					(5)		(5)	
D.C. Path for Monitoring Current					√				

Alarm Unit (1)

Connect the relay as described under Acceptance Tests for the particular relay involved. Screw the two magnetic shunts all the way in, then back them out five turns each. With the relay energized at rated voltage, set the monitoring current at 1.3 or 2.3 ma. d.c. for 2 or 3-terminal relay respectively, by adjusting the external resistor. If the relay does not close its right-hand contact, turn in the left shunt screw until the right-hand contact just closes. If the right-hand contact is closed at 1.3 ma., turn in the right shunt until a point is reached when the right-hand contact is just closed at 1.3 ma.

Now drop the current to 0.7 ma. and adjust the opposite shunt until the left-hand contact just closes at 0.7 ma. d.c. At 1.0 ma. d.c., the moving contact should float half way between the two sets of stationary contacts with a 0.025-inch gap on each side. Recheck the high and low current calibration several times, touching up the shunt adjustments as required to obtain the desired calibration.

Polarization Check

For all the source relays, which are listed below, make the following additional calibration check:

PMA	PM-13 (a.c. and d.c.)
PMA-1	PMG-13 (a.c. and d.c.)
PMD	
PMD-1	

After calibration as described in the previous sections, connect a 20,000 ohm resistor (or 10,000 ohms for 3-terminal applications) across the output terminals, and energize the relay at its rated supply voltage. With these connections, approximately one (or two) milliamperes d.c. will flow through the monitor relay coils and external resistor, thus representing normal operating conditions.

Now momentarily (one second or so) apply 48 volts d.c. directly to the pilot-wire terminals of the relay, as indicated in the following table.

Relay	Terminals for Momentary Application of 48 V. d.c.	
	POS.	NEG.
PMA, PMA-1 PMD, PMD-1	6	7
PM-13 (a.c. or d.c.) PM-13 (a.c. or d.c.)	9	8

After momentary application of the transfer-trip voltage as just explained, recheck the calibration of the monitoring alarm unit (1). If it has changed, make necessary trimming adjustments of the shunt screws until there is no change in calibrating of the alarm unit (1) after the transfer-trip voltage has been applied. The purpose of this test is to compensate for the small residual magnetism in the relay unit. The ground alarm unit (5) will not be affected by this test as the ampere-turns of the two windings cancel each other.

Alarm Unit (2)

For the alarm unit of the PM-2 or PM-23 relays, adjust the shunts so that the relay moving contact

floats at one ma. d.c., and closes the left-hand contact at 0.7 ma. d.c. The moving contact should float midway between the contact and contact stop at 1.0 ma. d.c. There is no high-current calibration for this relay unit.

Now apply 48 volts d.c. momentarily (one second or so) across the alarm unit coil-circuit terminals in a direction to operate the alarm relay. Then recheck the alarm unit calibration. If there is any change, touch up the shunt adjustments until there is no change in calibration after 48 v. d.c. has been applied.

Tripping Unit (3)

To calibrate the tripping unit of the PM-3, PM-13, PMG-13, or PM-23 relays apply a d.c. voltage as explained below, to the following relay terminals:

Relays	D.C. Voltage Pos.	Neg.
PM-3	9	8
PM-13 (a.c. or d.c.)	16	20
PMG-13 (a.c. or d.c.)	8	9
PM-23	8	9

Momentarily (one second or so) apply 48 volts d.c. to the terminals shown in the chart. Then starting with both shunts all the way in, turn out the right-hand shunt screw until the relay closes its right-hand trip contact at 14 volts d.c. (This will give approximately 2 ma. through the relay coil.) Now draw out the left-hand shunt until the relay resets with toggle action (not gradually) at not less than 10 volts d.c. When the calibration is approximately correct, again apply 48 volts d.c. to the indicated terminals, then recheck the pickup and dropout voltage, making any necessary trimming adjustments of the shunts. When the relay is properly adjusted, the application of 48 volts d.c. will not change the pickup or dropout voltage points. The relay should trip and reset with toggle action in this application. This will require both shunt screws to be withdrawn farther than for floating action.

Ground Alarm Unit (5)

For the PM-5 relay, turn both shunt screws all the way in, then back them out five turns each. Pass a current of 0.3 ma. d.c. in terminal 6 and out terminal 7. Following the same general procedure as described previously in the section entitled "Alarm Unit (1)," adjust the shunt screws so that the left-hand contact closes at 0.3 ma. Now pass 0.3 ma. d.c. in terminal 9 and out terminal 8, and adjust for closing of the right-hand contact at 0.3 ma. Recheck both pickup points several times, and make trimming adjustments of both shunts as required to obtain contact closing at 0.3 ma. d.c. in each direction.

For the ground unit (5) of the PMA, PMD, and PMG-13 relays, connect a variable resistance of about 50,000 ohms in series with a 0-1 d.c. milliammeter between the terminals indicated in the following table:

Ground Alarm (5) Calibration		
	Relay Terminals	
Relay	L.H. Contact Check	R.H. Contact Check
PMA	3 +and 6	3 and 7 +
PMD	5 +and 6	5 and 7 +
PMG-13	3 +and 8	3 and 9 +

+ Milliammeter positive to this terminal

Turn the shunts all the way in, then back them out five turns each. With the relay connected as shown in the left-hand column of the table, apply rated voltage to the relay and adjust the 50,000-ohm resistor for 0.3 ma. d.c. Now following the procedure in the previous paragraph for the PM-5 relay, adjust the shunts until the left-hand contact closes at 0.3 ma. d.c. Change the connections as indicated in the right-hand column, and adjust the opposite shunt until the right-hand contact closes. Recheck back and forth several times and make necessary trimming adjustments to obtain pickup at 0.3 ma. in each direction. The armature will move gradually as the current is changed for this relay unit.

ICS Unit

Close the main relay tripping contact circuit with a jumper connected directly across the contact terminals of the polar unit. Pass sufficient direct current through the relay trip circuit to close the contacts of the ICS unit. This value of current should not be greater than the ICS tap setting being used (0.2 or 2.0). The indicator target should drop freely. The contact gap should be approximately 0.047 inch between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

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.

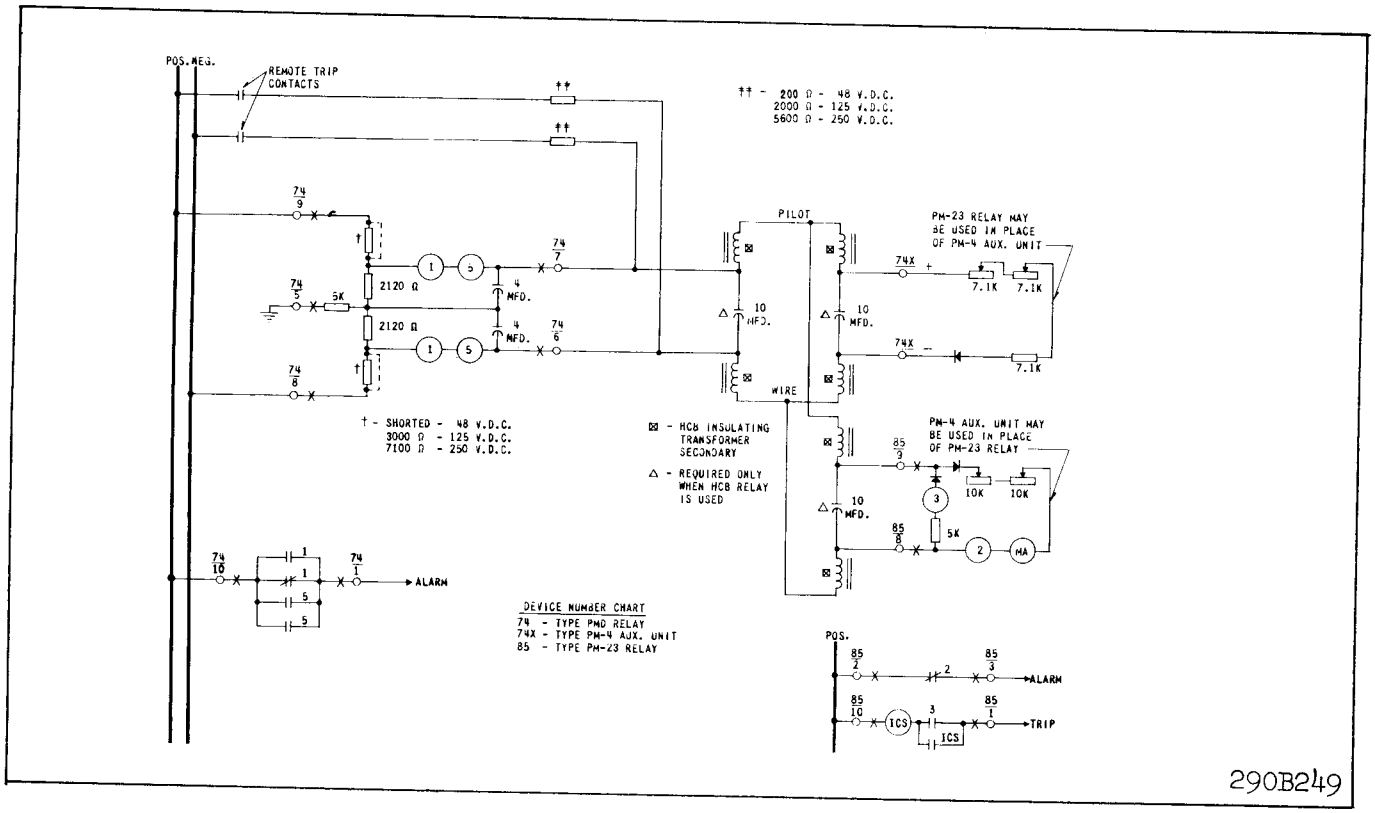


Fig. 22. External Schematic of the Type PMD Relay with Type PM-23 and PM-4 Relays – Three Terminal Lines.

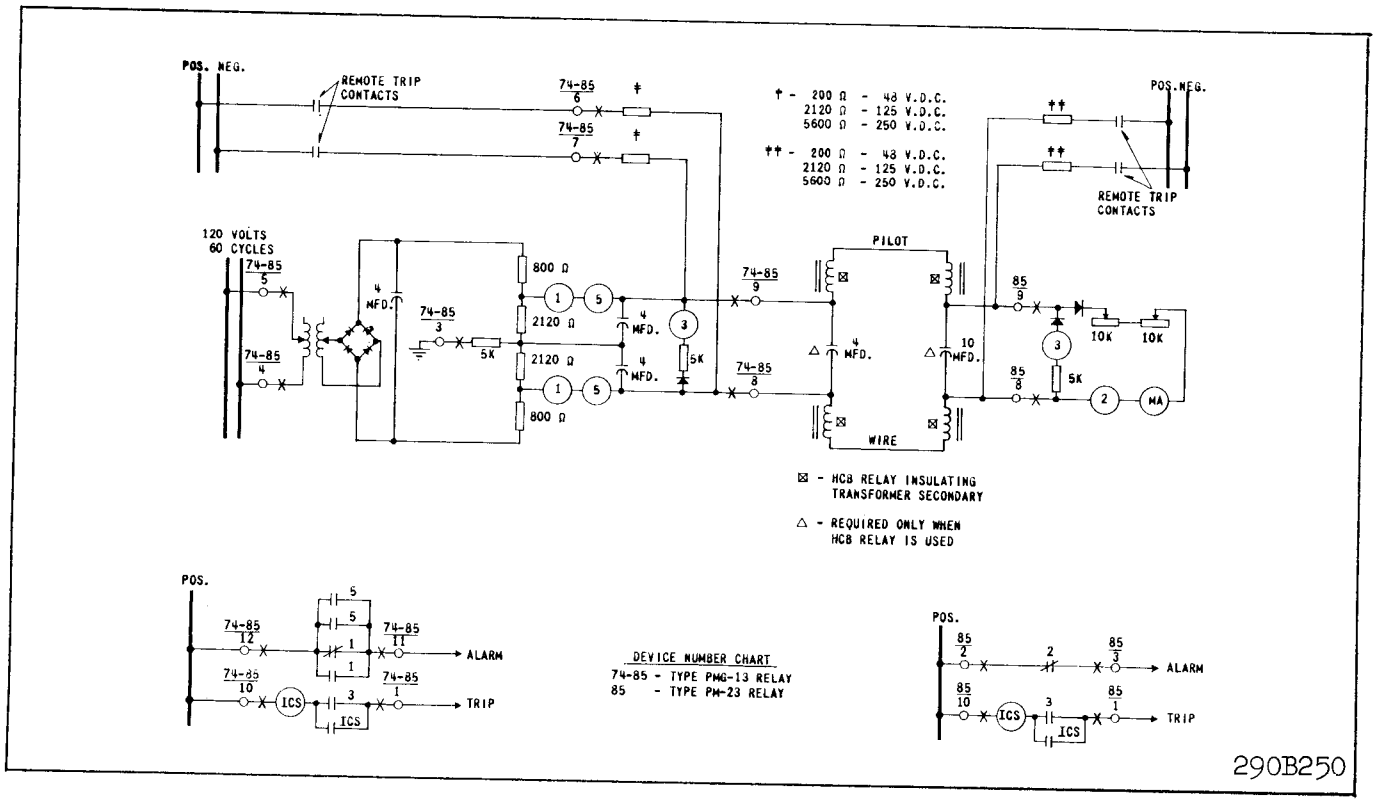


Fig. 23. External Schematic of the AC Type PMG-13 with Type PM-23 Relay – Two Terminal Lines.

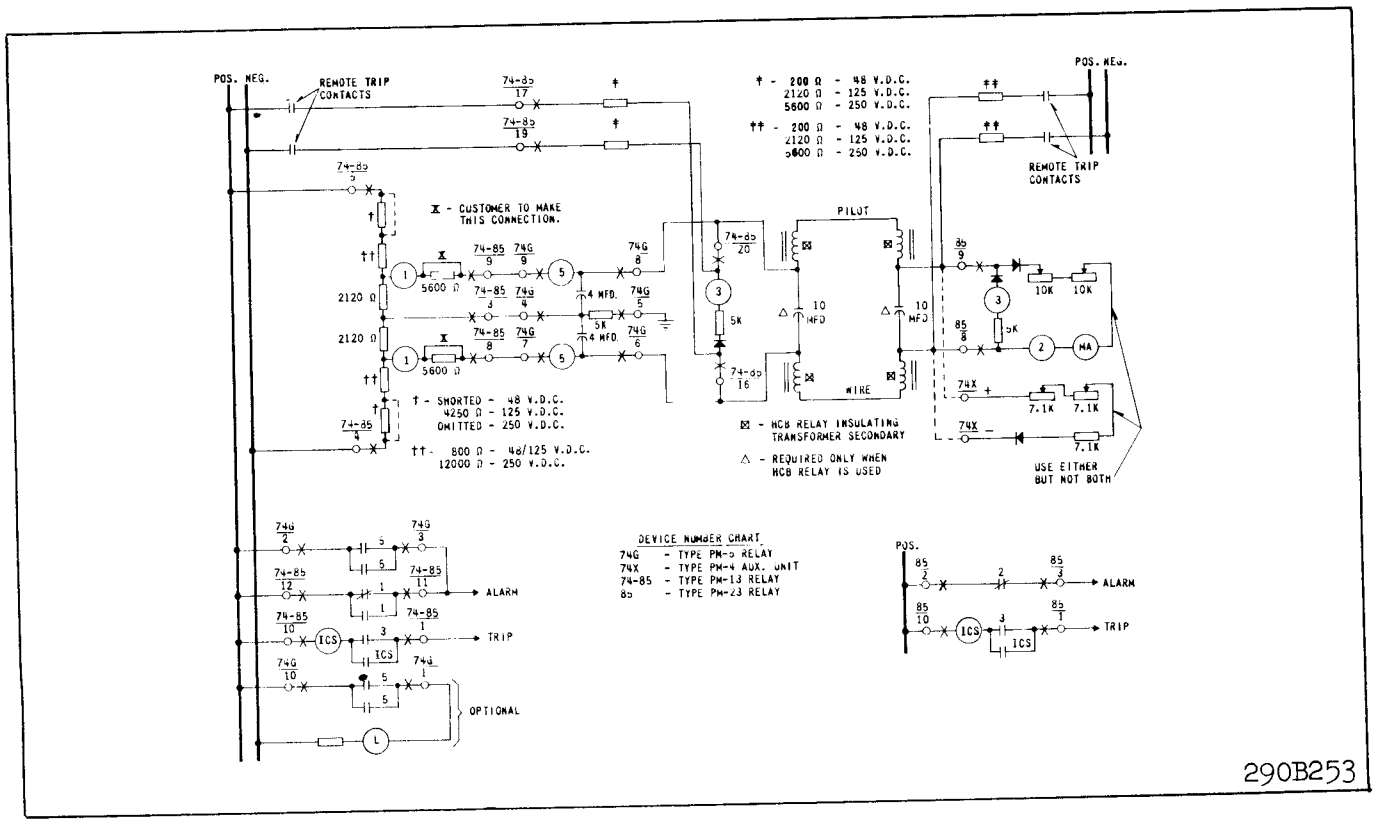


Fig. 24. External Schematic of the DC Type PM-13 and PM-5 Relay with Type PM-23 or PM-4 Relay – Two Terminal Lines.

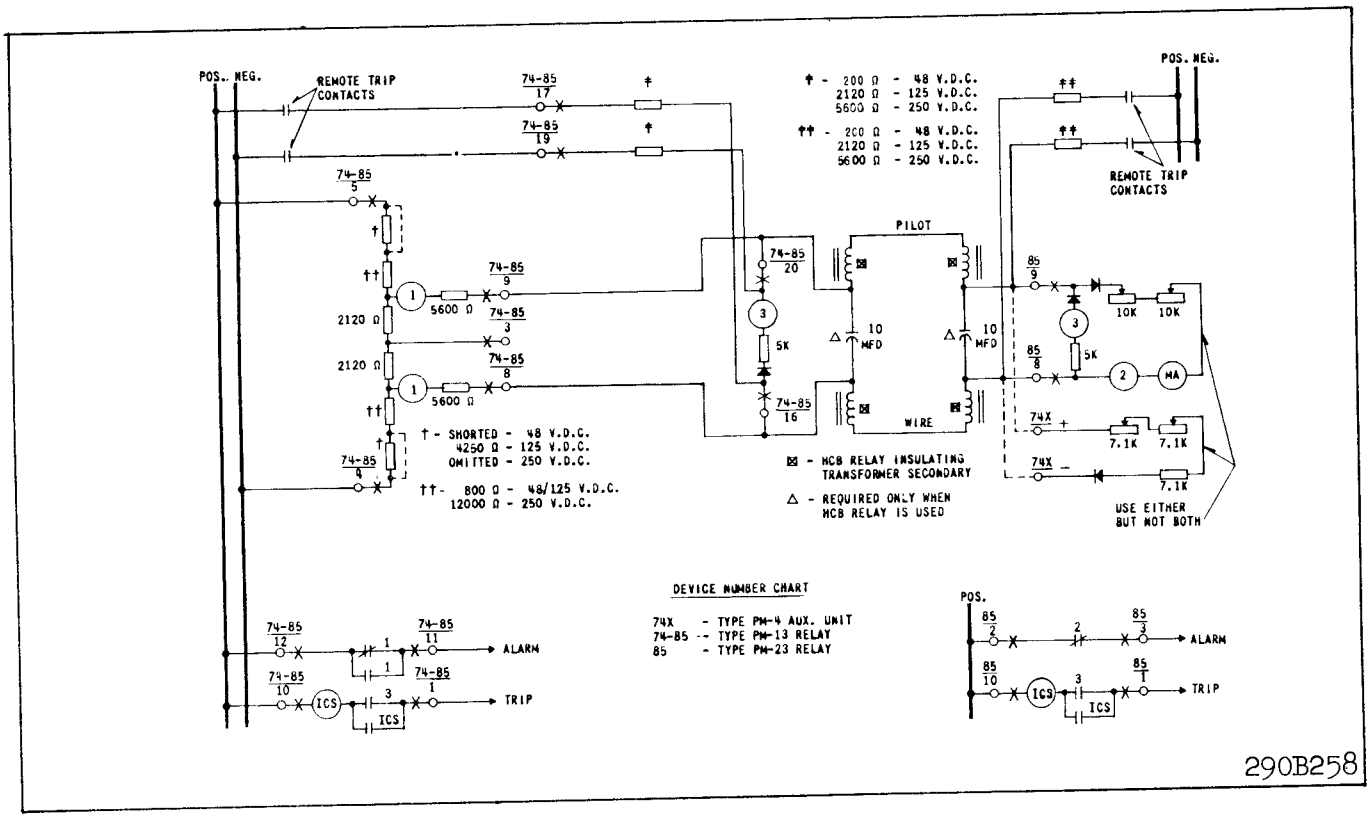


Fig. 25. External Schematic of the DC Type PM-13 Relay with Type PM-23 or PM-4 Relay – Two Terminal Lines.

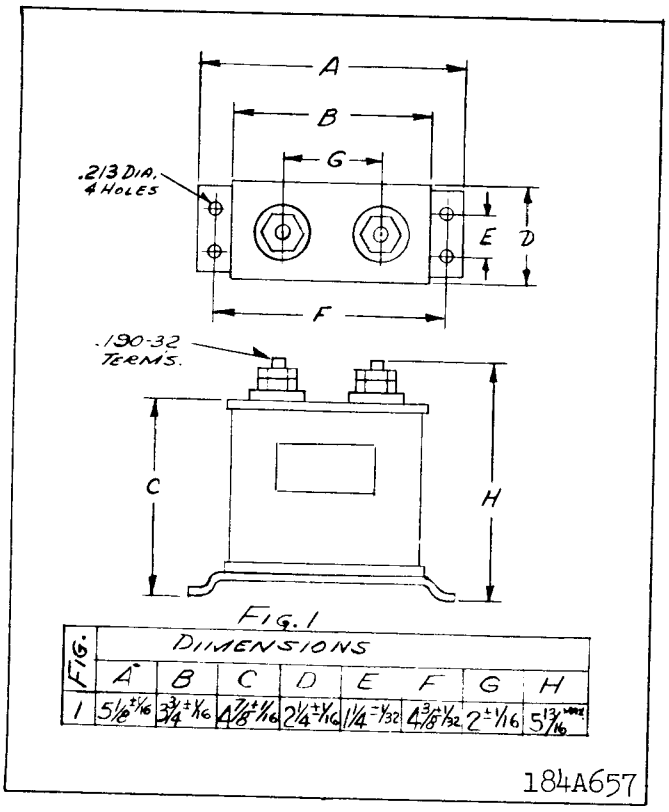


FIG. 1

FIG.	DIMENSIONS							
	A	B	C	D	E	F	G	H
1	5 1/8 ±1/16	3 3/4 ±1/16	4 7/8 ±1/16	2 1/4 ±1/16	1 1/4 -1/32	4 3/8 ±1/32	2 ±1/16	5 13/16 MAX.

Fig. 26. Outline & Drilling Plan for 10 mfd. Capacitor For Reference only.

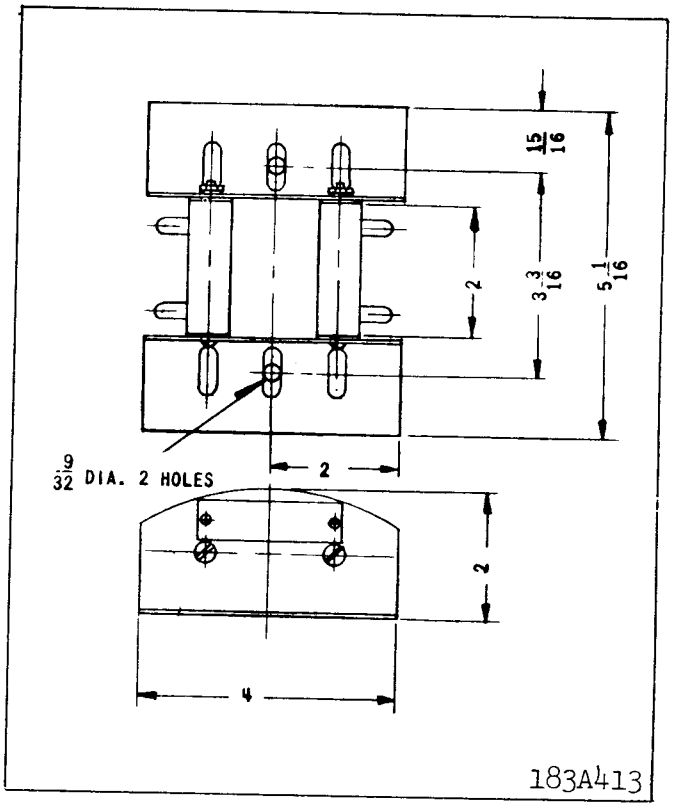


Fig. 27. Outline & Drilling Plan for External Remote Trip Resistor Assembly.

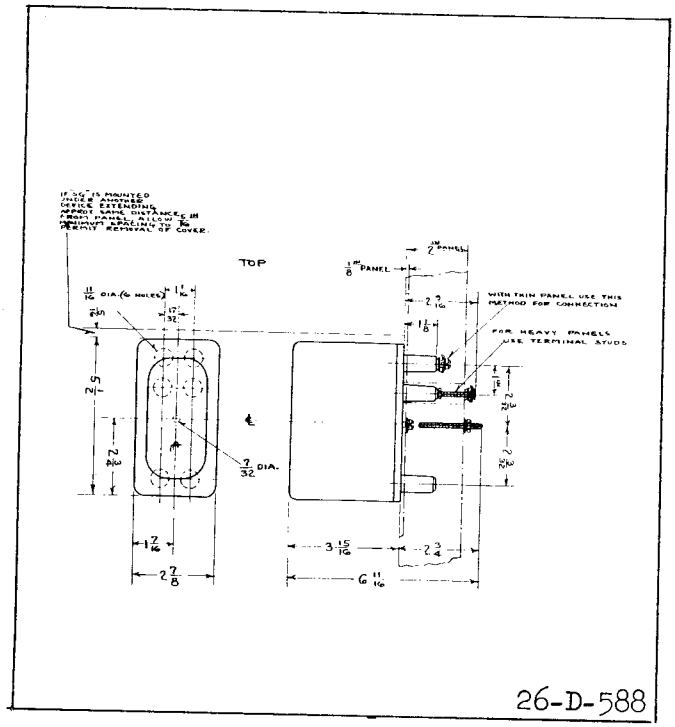


Fig. 28. Outline & Drilling Plan For the Type PM-4 Auxiliary Unit in the Projection Molded Case.

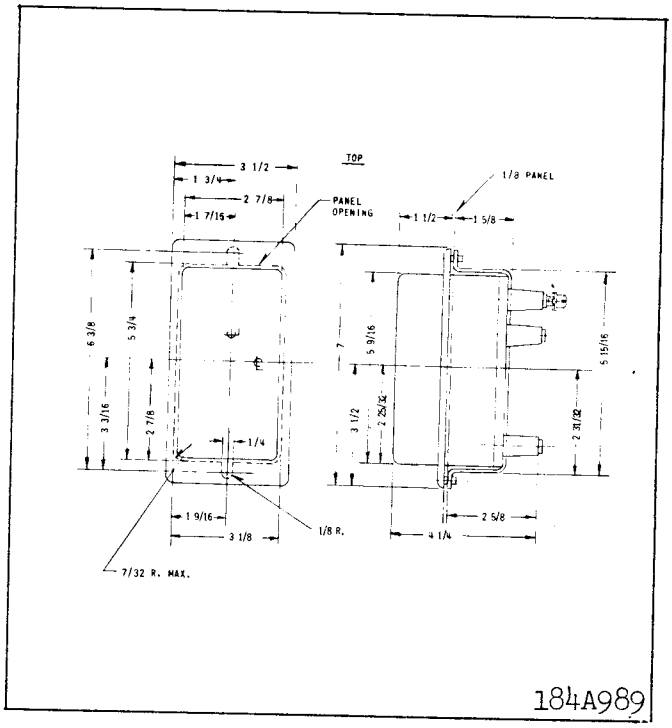


Fig. 29. Outline & Drilling Plan for the Type PM-4 Auxiliary Unit in the Semi-Flush Molded Case.

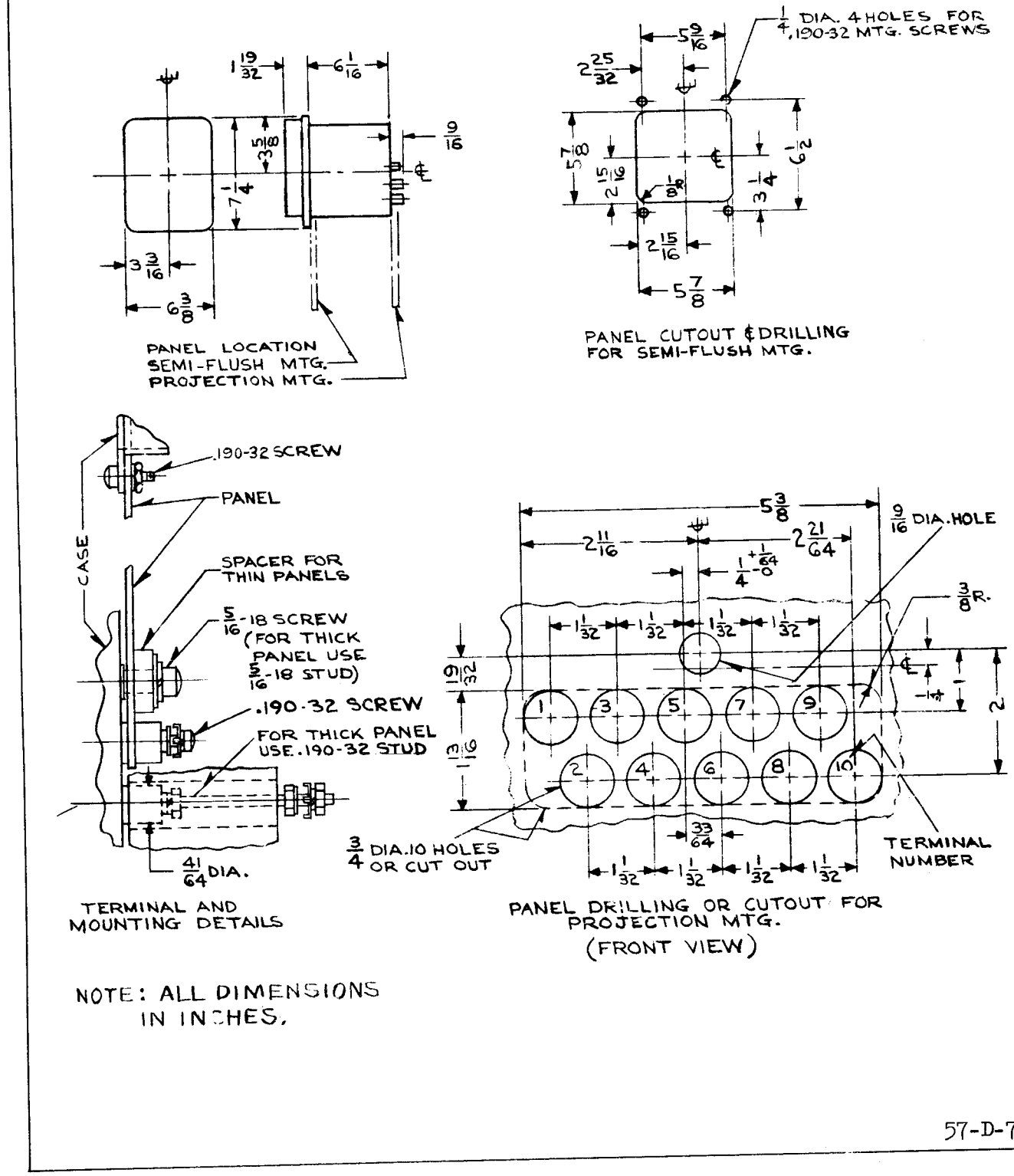


Fig. 30. Outline & Drilling Plan for the Type PM-3, PM-5 and PMD-1 Relays in the Type FT11 Case.

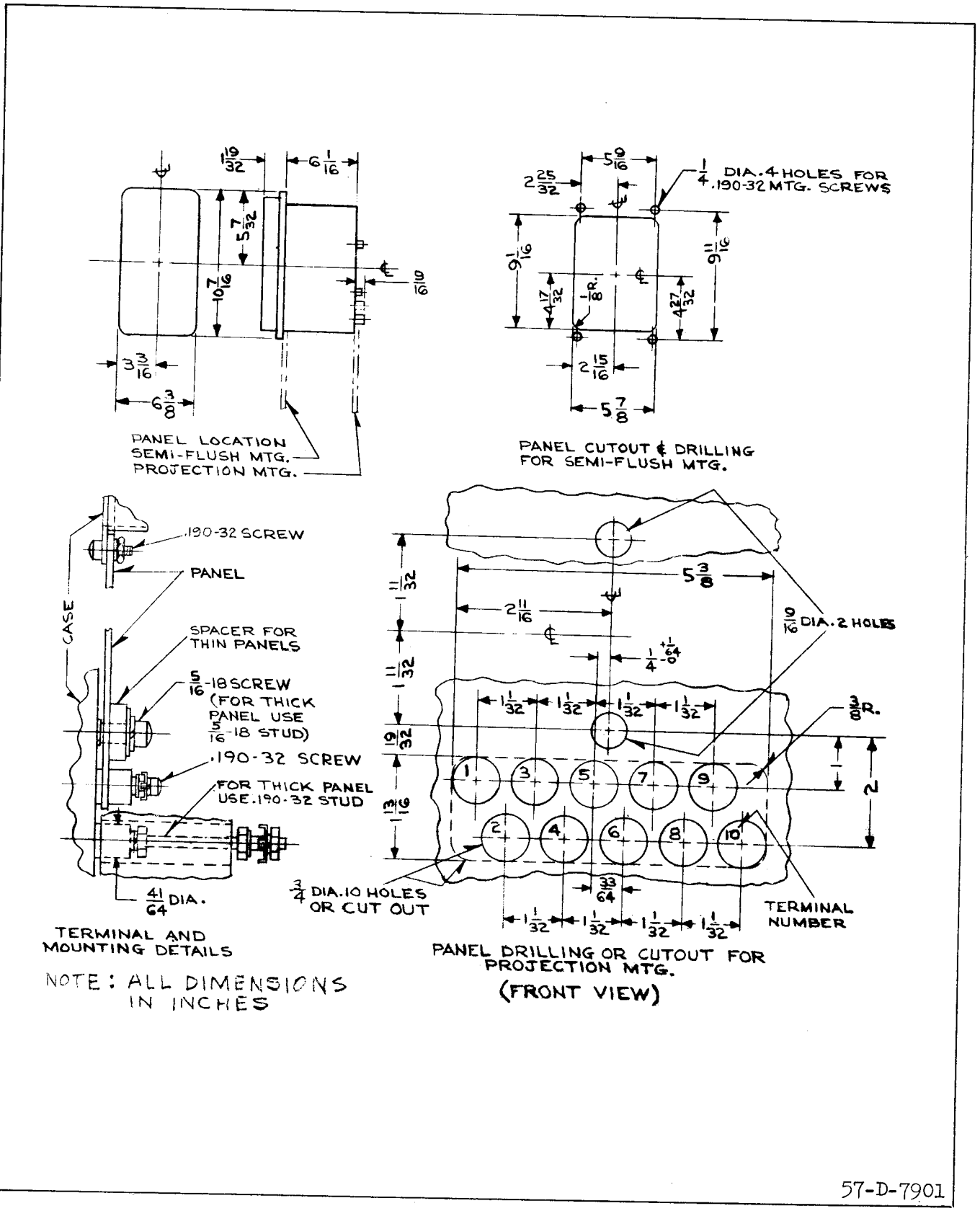


Fig. 31. Outline & Drilling Plan for the Type PM-2, PM-23, PMA-1 and PMD Relays in the Type FT21 Case.

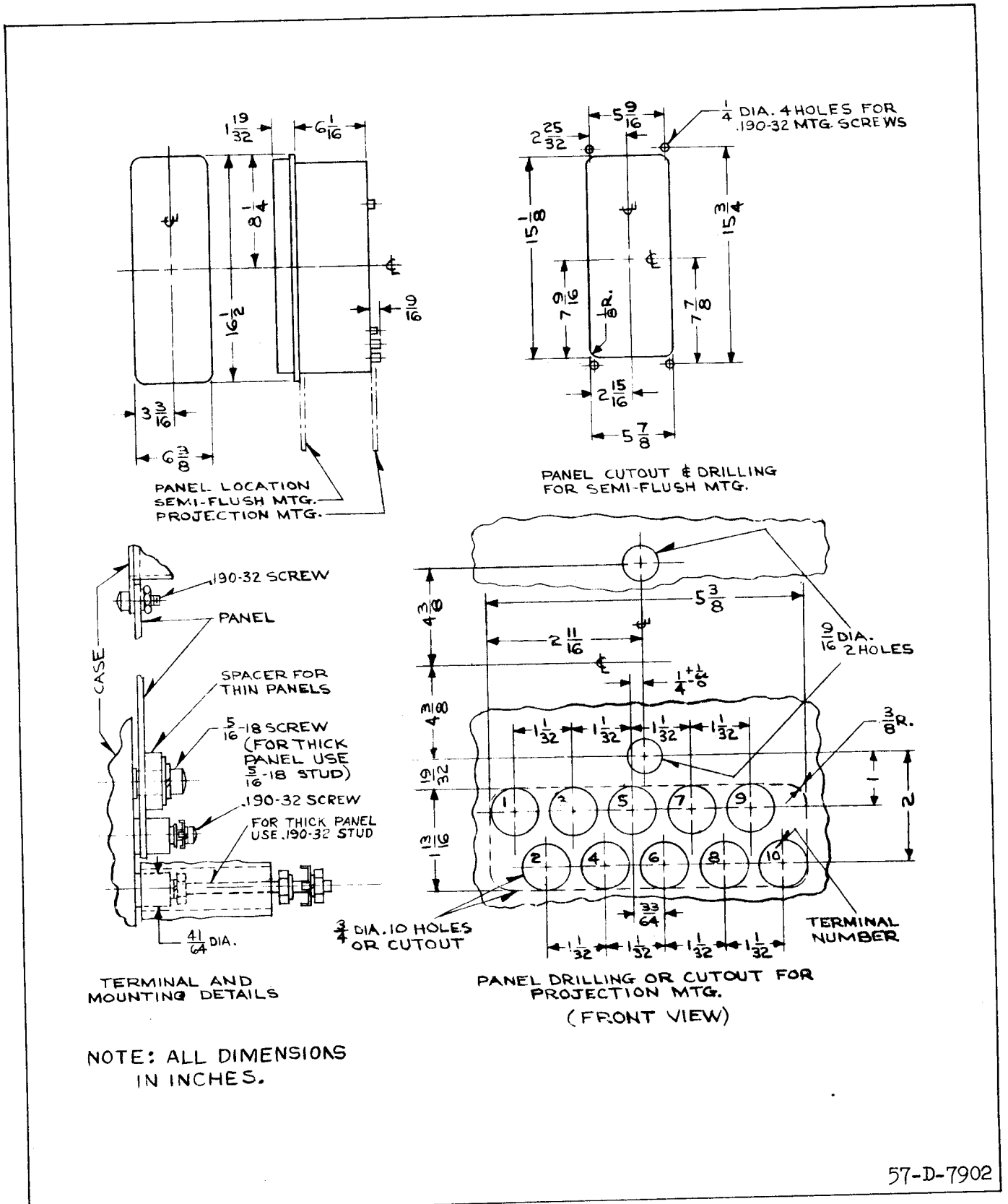


Fig. 32. Outline & Drilling Plan for the Type PMA Relay in the Type FT31 Case.

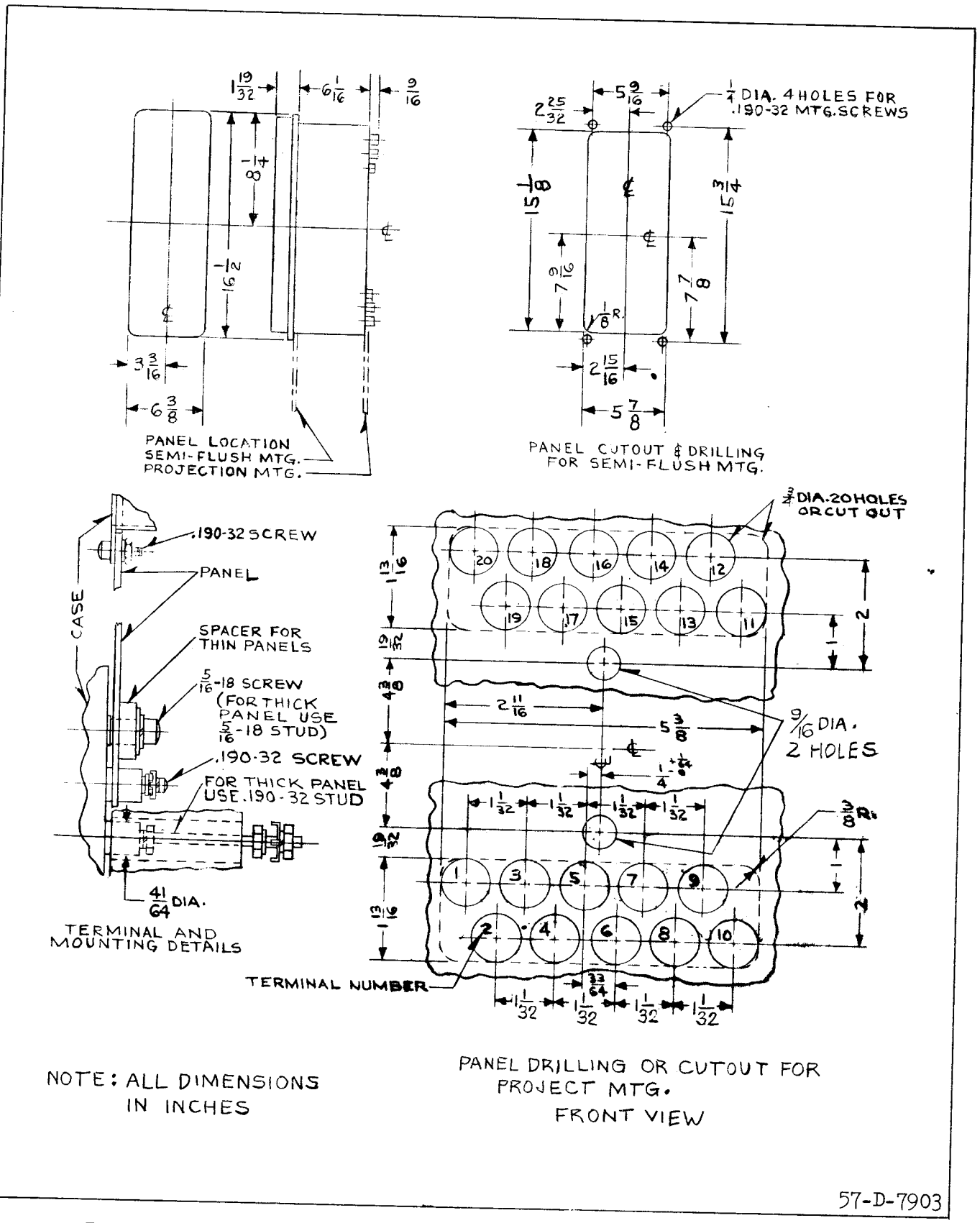
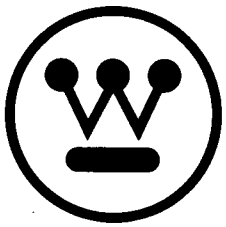


Fig. 33. Outline & Drilling Plan for the Type PM-13 and PMG-13 Relays in the Type FT32 Case.



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