Addendum to
Instruction Leaflet

41-137.3H

Effective: November 1990
This Addendum Supersedes all Previous Addenda

Type KRD-4 Directional Overcurrent Ground Relay

A - Add New Information ❖ C - Change Existing Information ❖ D - Delete Information

D **Page 7**

SETTINGS:

Delete the fourth paragraph beginning "CAUTION"

Delete the fifth paragraph beginning "In order to avoid opening . . . .".

A **Page 7**

SETTINGS:

Add the following

CAUTION

Since the tap block screw carries operating current, be sure that the screws are turned tight. In order to avoid opening current transformer circuits when changing taps under load, the relay must be first removed from the case. Chassis operating shorting switches on the case will short the secondary of the current transformer. The taps should then be changed with the relay outside of the case and then reinserted into the case.

All possible contingencies which may arise during installation, operation or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If further information is desired by purchaser regarding this particular installation, operation or maintenance of this equipment, the local ABB Inc. representative should be contacted.

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ABB

Instruction Leaflet

41-137.3H

Effective: June 1985
Supersedes I.L. 41-137.3G, Dated February 1981

(|) Denotes Change Since Previous Issue

Type KRD-4 Directional Overcurrent Ground Relay

CAUTION

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

1.0 APPLICATION

The KRD-4 relay is a high speed directional ground overcurrent relay which is used for the protection of transmission lines. These relays are dual polarized relays which can be polarized from a zero sequence voltage source, from a local ground current source, or from both simultaneously.

They are also used, without modifications to provide directional ground fault protection in the KD-10 carrier relaying scheme. Operation of the relays in connection with the carrier scheme is fully described in I.L. 40-208.

2.0 CONSTRUCTION

The type KRD-4 directional overcurrent ground relay consists of a dual polarized directional unit, an instantaneous overcurrent unit, and an indicating contactor switch. The principal parts of the relay and their location are shown in Figs. 1 to 3.

2.1 DIRECTIONAL UNIT (D)

The directional unit of the KRD-4 consists of an induction cylinder unit, phase shifting network. and a. decoupling network.

1. Induction Cylinder Unit

The cylinder unit is a product type in which torque is produced by the phase relationship of an operating flux and a polarizing flux on an aluminum cylinder supporting a moving contact arm. A contact opening torque or a contact closing torque is produced depending upon the phase relationship between the two fluxes.

The Cylinder unit consists of three basic assemblies: an electromagnet assembly, a moving element assembly, and a stationary closing assembly.

The electromagnet assembly consists of an electromagnet, an adjustable magnetic core, two magnetic adjusting plugs, lower bearing pin, and a die-carted aluminum frame. The moving element assembly consists of a spiral spring, contact carrying member, and an aluminum cylinder which is assembled to a molded hub which holds the shaft. The shaft has removable top and bottom jewel bearings. The stationary contact assembly consists of a molded bridge, upper bearing pin, stationary contact housing and spring adjuster is located *on* the underside of the bridge and is held in place by a spring type clamp. It is attached to the *moving* contact arm by a spiral spring.

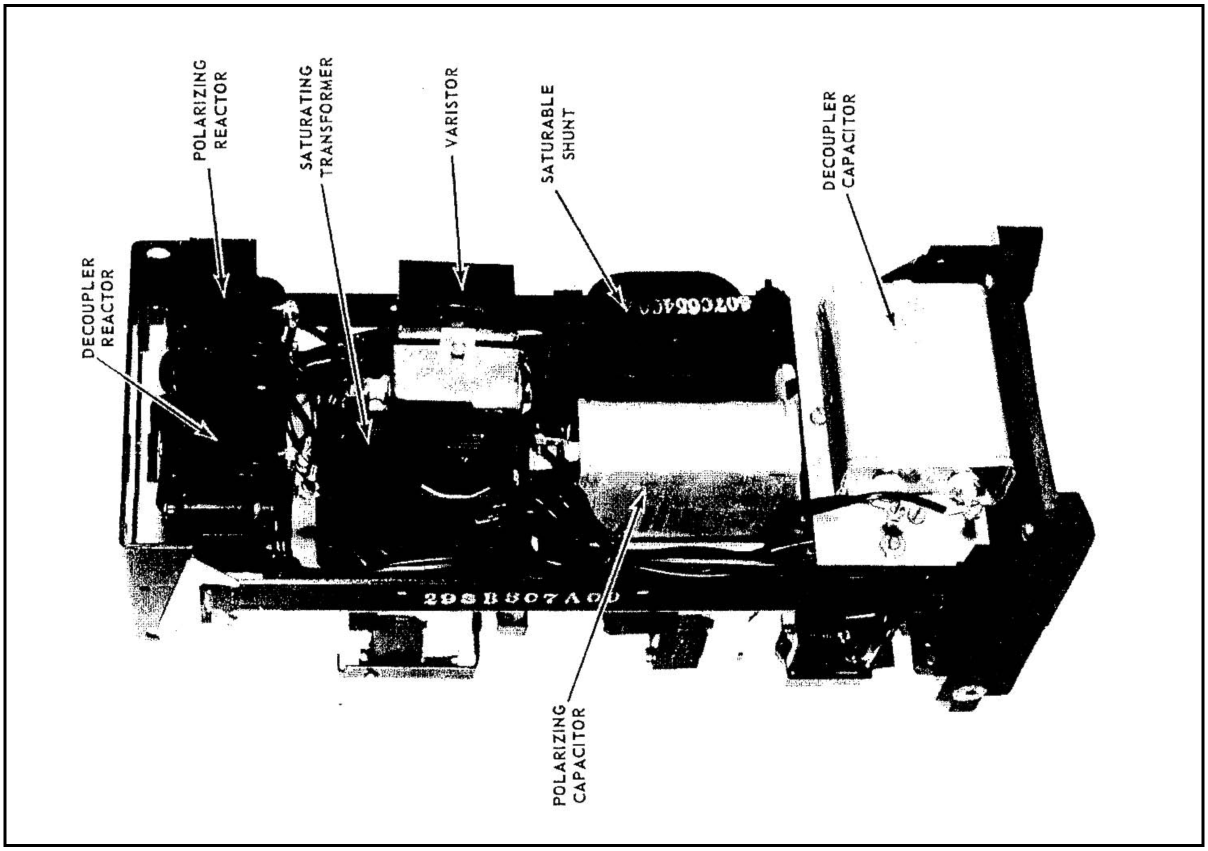

Figure 2 Type KRD-4 Relay (Rear View)

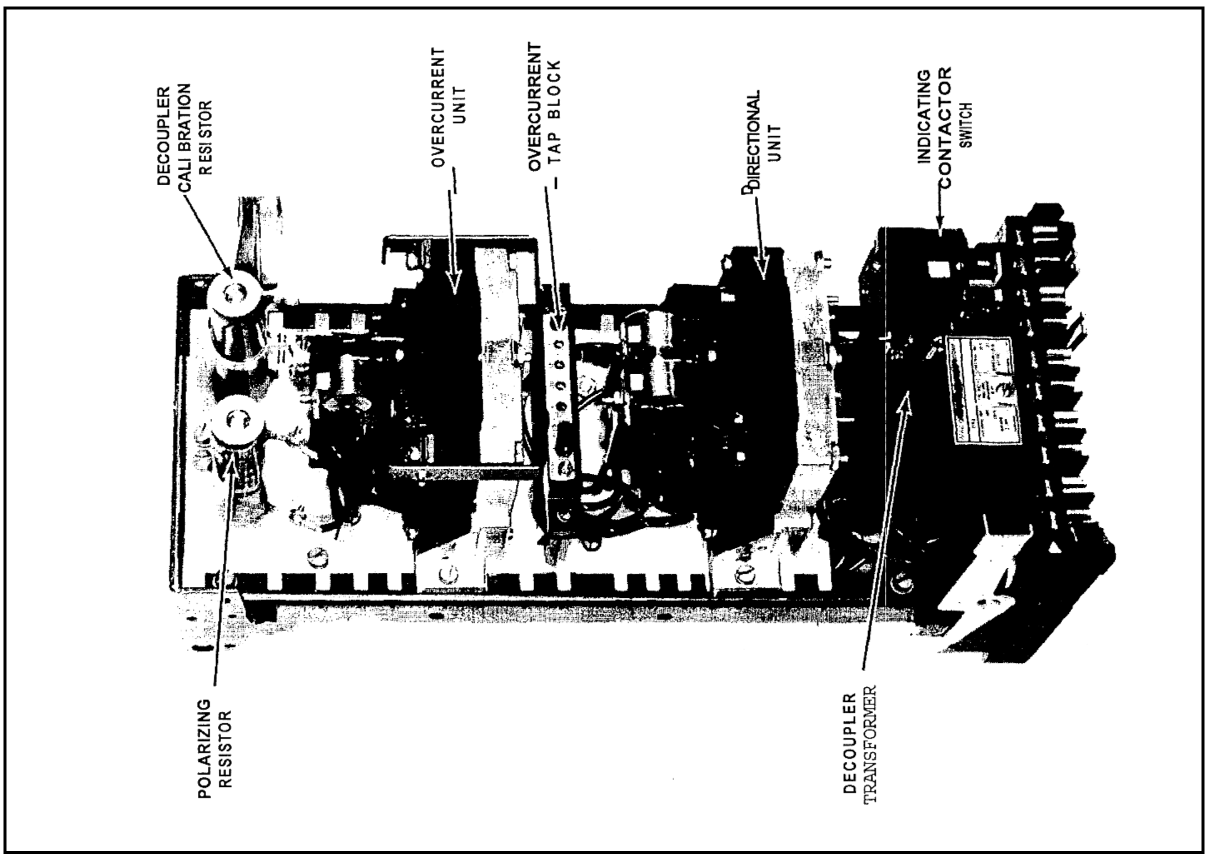

Figure 1: Type KRD-4 Relay

The electromagnet has four poles, two operating poles and two polarizing poles. Each pair of poles are diametrically opposite each other and are excited by series connected coils. (Two sets of series connected coils are used to excite the polarizing poles, one set for current polarizing and the other set for voltage polarizing). The electromagnet is permanently mounted to the frame in such a manner that an air gap exists between ' the pole faces of the electromagnet and the magnetic core. The aluminum cylinder of the moving element assembly rotates in this air gap on the upper and lower pin bearing.

With the contacts closed, the electrical connection is made through the stationary contact housing clamp, then the moving contact, through the spiral spring out to the spring adjusted clamp.

2. Phase Shifting Network

The phase shifting network consists of a resistor, capacitor and reactor in the polarizing circuit of the directional unit, and a saturable shunt in the operating circuit.

3. De-Coupling Network

The de-coupling network consists of an air gap transformer, capacitor, reactor, and resistor. Electrically this network is equivalent to the polarizing circuit of the induction cylinder unit and is utilized to minimize the coupling between the current and potential polarized sources.

2.2 INSTANTANEOUS OVERCURRENT UNIT (I)

The instantaneous overcurrent unit consists of an induction cylinder unit, capacitor, varistor, and a transformer. The components are connected such that a contact closing torque is produced when the current exceeds a specified value.

1. Cylinder Unit

The cylinder unit is similar in construction to the cylinder unit of the directional unit except that: all coils are similar. The phase relationship of the two air gap fluxes necessary for the development of torque is achieved by means of a capacitor connected in series with one pair of pole windings.

2. Transformer

The transformer is a saturating type consisting of' a tapped primary winding and a secondary winding. A varistor is connected across the secondary winding to reduce the voltage peaks applied to the cylinder unit and phase shifting capacitor.

2.3 INDICATING CONTACTOR SWITCH (ICS)

The indicating contactor switch is a small do operated clapper type device. A magnetic armature to which leafspring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contacts, completing the trip circuit. Also during this operation two fingers on the armature deflect a spring located on the front of the switch, which allows the operation indicator target to drop. The target is reset from 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.

3.0 OPERATION

The type KRD-4 relay is connected to the protected transmission line as shown in Fig. 4. In such a connection, the relay operates to disconnect the line for ground faults of a definite magnitude that are flowing in a specified direction.

The directional unit of the relay compares the phase angle between the fault current and the polarizing quantities of the system and either produces a contact closing torque for faults in the trip direction or produces a contact opening torque for faults in the non-trip direction. Relay operation occurs when both the directional unit and the instantaneous overcurrent unit close their contacts. Hence, the fault current must be greater than the tap setting of the overcurrent unit.

For faults in the non-trip direction, a contact opening torque is produced by the directional unit such that the normally closed contact of this unit shorts out a pair of windings on the overcurrent unit. This prevents the overcurrent unit from developing torque to close its contacts. For faults in the trip direction, the directional unit will pickup and remove this short circuit, allowing the overcurrent contact to commence closing almost simultaneously with the directional contact for high speed operation.

4.0 CHARACTERISTICS

The relays are available in the following current ranges:

Range	Taps					
0.5-2 Amps.	0.5	0.75	1.0	1.25	1.5	2
1-4	1.0	1.5	2.0	2.5	3.0	4.0
4-16	4.0	6.0	8.0	9.0	12	16
10-40	10	15	20	25	30	40

The tap value is the minimum current required to just close the overcurrent relay contacts. For pickup settings in between taps refer to the section under SETTINGS.

The KRD-4 relay is designed for dual polarizing and can be polarized from a potential source, a local ground source or from both simultaneously. When the relay is potential polarized. the maximum torque of the relay occurs when the operating current lags the polarizing voltage by approximately 60 degrees. When the relay is current polarized, the maximum torque of the relay occurs when the operating current is in phase with the polarizing current.

4.1 TIME CURVES

The time curves for the KRD-4 relay are shown in Figs. 5 and 6. Fig. 5 includes three curves which are:

1. Directional Unit opening times for current, voltage, or dual polarized.

2. Directional unit closing times for current, voltage or dual polarized.

3. Directional unit closing time for 5 volts volt age polarized.

Fig. 6 shows the instantaneous overcurrent unit closing time.

The voltage polarized curve (curve B in Fig. 5) begins to deviate from curve A at about 10 volts polarization.

Both the directional unit and the overcurrent unit must operate before the trip circuit can be completed. Hence, the unit which takes the longer time to operate determines when the breaker will be tripped. The overcurrent unit contacts cannot operate until the back contacts of the directional unit open; therefore, the total time for the overcurrent unit to operate is its closing time given in Fig. 6 plus the directional unit's opening time given in Fig. 5. The total closing time for the directional unit is given in Fig. 5. The two examples below will serve to illustrate the use of the curves.

Examples: Definition of symbols are shown on Fig. 5.

let: E_{pol} = 20 volts

I_{pol} = 4.0 amp.

l_{op} = 10.0 amp.

tap value (T) = 0.5 amp.

Ø = 0°, θ = 60°

(1) for a current polarized relay:

$$MPP = \frac{I_{pol} I_{pol} \cos\theta}{0.25}$$

$$MPP = \frac{(3)(1.5)}{0.25} = 18$$

$$MPP = \frac{(10)(4)\cos 0°}{0.25} = 160$$

Entering the curves in Fig. 5 at multiples of product pickup of 160, the directional unit opening time is 3 ms, and the closing time for this unit 16 ms.

For the overcurrent unit:

multiples of pickup = $\frac{I_{op}}{T}$

$$= \frac{10}{0.5} = 20$$

Entering the curve in Fig. 6 at multiples of pickup equal to 20, the closing time for the overcurrent is I I ms. However, the total operating time for the overcurrent unit is 11 plus 3 ms, which is the opening time of back contacts of the directional unit, or 14 ms total operating time for the overcurrent unit. The total operating time for the directional unit is 16 ms; and since this is the longest time, 16 ms is the total operating time of the relay when current polarized only.

(2) for a potential polarized relay:

$$MMP = \frac{I_{op}E_{pol}\cos(\theta - 60°)}{0.65}$$

$$MPP = \frac{(20)(4)\cos(60° - 60°)}{0.65}$$

$$MPP = 123$$

Referring to Fig. 5 the directional unit closing time is 17 ms, and the opening time of its back contacts is 4 ms. The total operating time for the directional unit is 8 ms.

For the overcurrent unit:

$$\text{multiples of pickup} = \frac{I_{op}}{T}$$

$$= \frac{10}{0.5} = 20$$

Referring to Fig. 6 the overcurrent unit contact closing time is 11 ms. Therefore, the total operating time for this unit is 11 + 4 ms or 15 ms. In this case the total operating time of the relay is 17 ms when potential polarized only.

(3) for a dual polarized relay:

MPP = (current polarized MPP + potential polarized MPP)

= 160 + 123 = 283

Entering the curves in Fig. 5 at multiples of product pickup of 283, the directional unit opening time is 3 ms and the closing time for this unit is 13 ms.

For the overcurrent unit:

$$\text{multiples of pickup} = \frac{I_{op}}{T} = \frac{10}{0.5} = 20$$

Entering the curve in Fig. 6 at MPP = 20. the closing time for the overcurrent unit is 11. ms. However, the total operating time for this unit is 11 + 3 or 14 ms. Since this is the longest time, 14 ms is the total operating time of the relay when it is dual polarized.

4.2 TRIP CIRCUIT

The main contacts will safely close 30 amperes at 250 volts do 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 a pickup of approximately 1 ampere. Its do resistance is 0.1 ohms.

Table 1:
DIRECTIONAL UNIT SENSITIVITY

Polarizing Quantity	Ampere Range	Value of Min. Pickup		Phase Angle Relationship
		Volts	Amperes	
Voltage		1 1	0.65* 1.5*	I lagging V by 60° I in phase with V
Current	0.5-2 1-4 4.16 10-40		0.5* 0.7*	I0 in phase with IP Io in phase with Ip

* or less

The energization quantities are input quantities at the relay terminals. Maximum torque angle.

4.3 CYLINDER UNIT CONTACTS

The moving contact assembly has been factory adjusted for low contact bounce performance and should not be changed.

The set screw in each stationary contact has been shop adjusted for optimum follow and this adjustment should not be disturbed.

Table 2: DIRECTIONAL UNIT CALIBRATION ① ②

RELAY RATING	CURRENT AMPERES	BOTH PLUGS IN CONDITION	ADJUSTMENT
ALL RANGES	40	Spurious torque in contact closing direction (left front vies)	Right (front view) Plug Screwed out until spurious torque is reversed
ALL RANGES	40	Spurious torque in contact opening direction (Right front view) (Contact remain Open)	Left (front view) Plug screwed out until spurious torque is in contact closing direction. Then the plug is screwed in until spurious torque is reversed.

① Short Terminals 4 and 5.

② Overcurrent unit must be set at highest tap position during this test

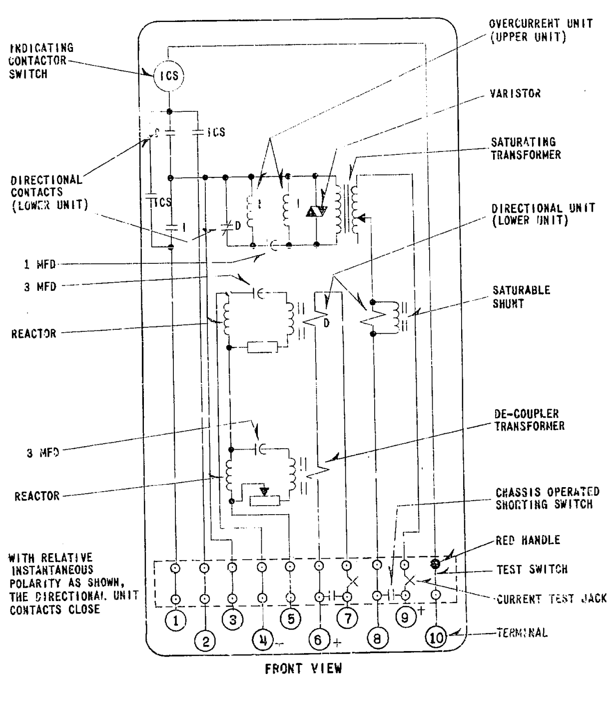

Figure 3: Internal Schematic of the Type KRD-4 Relay in the Type FT-31 Case

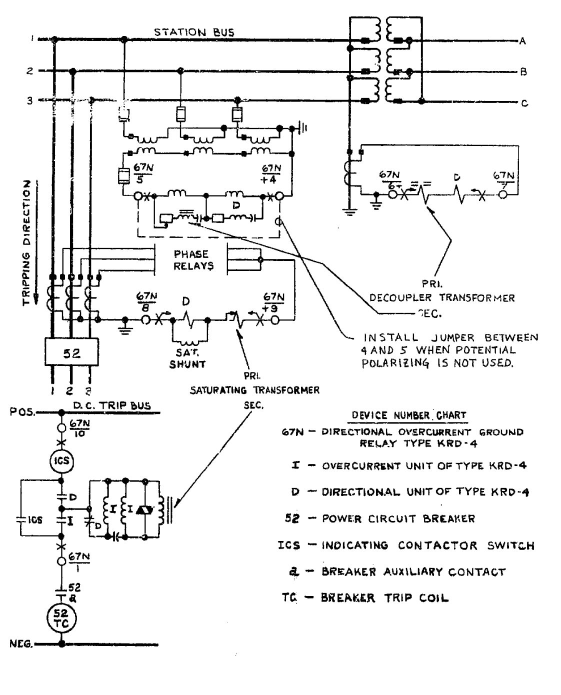

Figure 4: External Schematic for the Type KRD-4 Relay

5.0 SETTINGS

5.1 OVERCURRENT UNIT (I)

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

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

For carrier relaying the carrier trip overcurrent trait located in the type KRD-4 relay should be set higher than the carrier start overcurrent unit located in the type KA-4 relay at the opposite end of the line.

CAUTION

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

In order to avoid opening the current transformer circuits when changing taps under load, connect a spare tap screw in the desired tap position before removing the other tap screw from the original tap position.

ENERGY REQUIREMENTS

BURDEN DATA OF OPERATING CURRENT CIRCUIT - 60 HERTZ

Ampere Range	Tap	VA at Tap Value	P.F. Angle Ø	VA at 5 Amps	P.F. Angle Ø
.5-2	.5	.23	54°	47	52°
	.75	.52	54°	36	52.5°
	1.0	.94	54°	31	53°
	1.25	1.56	54°	28	53.5°
	1.5	2.17	54°	26.5	54°
	2.0	3.88	54°	24	55°
1-4	1.0	1.3	52°	31.5	51°
	1.5	2.85	52°	27.3	51.5°
	2.0	5.2	52°	25.0	52°
	2.5	7.75	52°	24.2	52.5°
	3.0	11.4	52°	23.8	53°
	4.0	10.6	52°	23.3	53.5°
4-16	4	5.6	43°	610†	53°
	6	10.8	46°	570†	54°
	8	17.6	47°	560†	54°
	9	22.5	48°	550†	55°
	12	39.5	50°	550†	56°
	16	69	52°	550†	56°
10-40	10	28	49°	545†	50°
	15	61	51°	540†	51°
	20	108	53°	535†	52°
	25	169	54°	530†	53°
	30	252	56°	525†	53°
	40	432	57°	525†	53°

† VA at 50 Amperes.

DIRECTIONAL UNIT POLARIZING CIRCUIT BURDEN

Circuit	Rating	Volt Amperes Δ	Power Factor Angel Ø
Current Voltage	230 †† Amperes 208††† volts	1.20 21.0	3° Lag 28° Lead

Ø Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.
Δ Burden of voltage polarized unit taken at 120 volts. Burden of current polarized units taken at 5 amperes.
†† One second rating
††† 30 second rating. The 10 second rating is 345 volts. The continuous rating is 120 volts.

5.2 DIRECTIONAL UNIT (D)

No setting is required.

6.0 INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration and heat. Mount the relay vertically by means of the two mounting studs for projection mounting or by means of the four mounting hales an the flange for the semi-flush mounting. Either of the studs 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 terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the studs and then turning the proper nut with a wrench.

For detailed information, refer to LL. 41-076.

7.0 ADJUSTMENTS AND MAINTENANCE

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

7.1 ACCEPTANCE CHECK

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

7.2 OVERCURRENT UNIT (I)

1. Contact Gap

The gap between the stationary and moving contacts with the relay in the deenergized position should be approximately .020”

2. Minimum Trip Current

The normally-closed contact of the directional unit: should be blocked open when checking the pickup of the overcurrent unit.

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

7.3 DIRECTIONAL UNIT (D)

1. Contact Gap

The gap between the stationary contact and moving contact with the relay in the deenergized position should be approximately .020".

2. Sensitivity

The respective directional units should trip with value of energization and phase angle relationships as indicated in Table 1.

3. Spurious Torque Adjustments

There should be no spurious closing torques when the operating circuits are energized per Table 2.

4. Coupling

Apply 20 amperes to terminals 6 and 7. Measure voltage across terminals 4 and 5. Should be less than 20 volts.

7.4 INDICATING CONTACTOR SWITCH (ICS)

Close the main relay contacts and pass sufficient do current through the trip circuit to close the contacts of the ICS. This value of current should be between I and 1.2 amperes. The indicator target. should drop freely.

The contact gap should be approximately 5/64” between the bridging moving contact and the adjust-

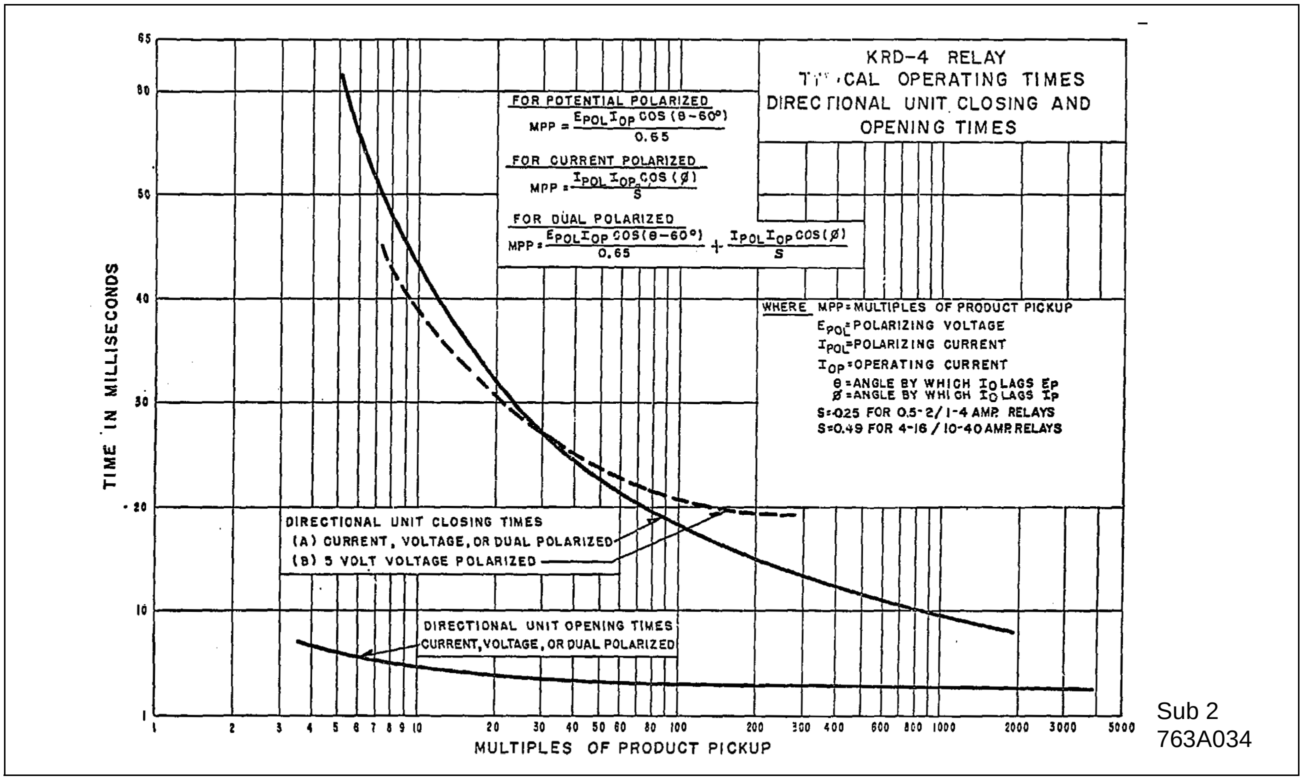

Figure 5: Typical Time Curves for the Directional Unit

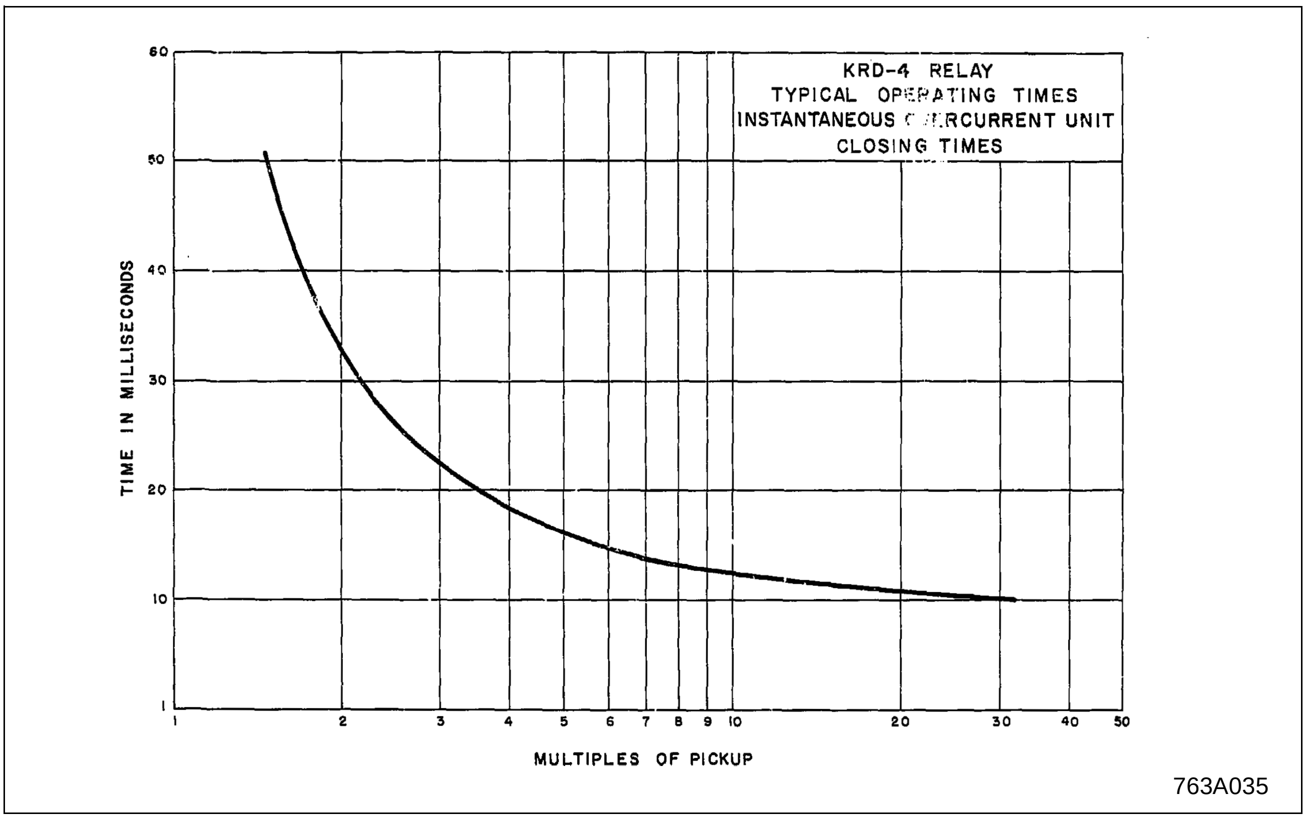

Figure 6: Typical Time Curves for the Instantaneous Overcurrent Unit

able stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

8.0 ROUTINE MAINTENANCE

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

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

8.1 CALIBRATION

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

8.2 OVERCURRENT UNIT (I)

1. **The upper pin bearing** should be screwed down until there is approximately .025 clearance between it and the top of shaft bearing. The upper pin bearing should then be securely locked in position with the lock nut. The lower bearing position is fixed and cannot be adjusted.

2. **The contact gap adjustment** for the overcurrent unit is made with the moving contact in the reset position, e.g., against the right side of the bridge. Advance the stationary contact until the contacts just close. Then back off the stationary contact 2/3 of one turn for a gap of approximately .020". The clamp holding the stationary contact housing need not be loosened for the adjustment since the clamp utilizes a spring type action in holding the stationary contact in position.

3. **The sensitivity adjustment** is made by varying the tension of the spiral spring attached to the moving element assembly. The spring is adjusted by placing a screwdriver or similar tool into one of the notches located on the periphery of the spring adjuster and rotating it. The spring adjuster is located on the underside of the bridge and is held in place by a spring type clamp that does not have to be loosened prior to making the necessary adjustments.

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

8.3 DIRECTIONAL UNIT (D)

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

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

Now move the left-hand stationary contact until it just touches the moving contact. Then back off the stationary contact 2/3 of one turn for a contact gap of approximately .020". The clamp holding the stationary contact housing need not be loosened for the adjustment since the clamp utilizes a spring-type action in holding the stationary contact in position.

3. **Sensitivity.** Insert tap screw of overcurrent unit in highest tap. The sensitivity adjustment is made by varying the tension of the spiral spring attached to the moving element assembly. The spring is adjusted by placing a screwdriver or similar tool into one of the notches located on the periphery of the spring adjuster and rotating it. The spring adjuster is located on the underside of the bridge and is held in place by a spring type clamp that does not have to be loosened prior to making the necessary adjustments.

The spring is to be adjusted such that the contacts will close with .5 amperes flowing into terminal 6 and out terminal 8 with terminals 7 and 9 jumped together. (use 0.7 Amps for 4-16 and 10-40 Amps.)

4. **De-Coupling Adjustment.** Connect high resistance, low reading voltmeter across terminals 4 and 5. Pass 80 amperes into terminals 6 and 7 and adjust top right hand resistor (front view) until a minimum voltage is obtained. Use care not to overheat: relay during test.

5. **Core Adjustment.** Apply 10 amperes to terminals 8 and 9 with voltage terminals short circuited. Adjust core such that the contacts remain open. The core can be adjusted by use of a screwdriver in the slots in the bottom of the cylinder unit.

6. **Plug Adjustment.** Apply current to terminals 8 and 9 with voltage terminals short circuited. Plug adjustment is then made per Table 2 such that the spurious torques are reversed. The plugs are held in position by upper and lower plug clips. These clips need not be disturbed in any manner when making the necessary adjustment.

8.4 INDICATING CONTACT SWITCH (ICS)

Adjust the contact gap for approximately 5/64" (-1 /64", +0).

Close the main relay contacts and check to see that the relays pickup and the target drops between 1 and 1.2 amperes dc.

9.0 RENEWAL PARTS

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

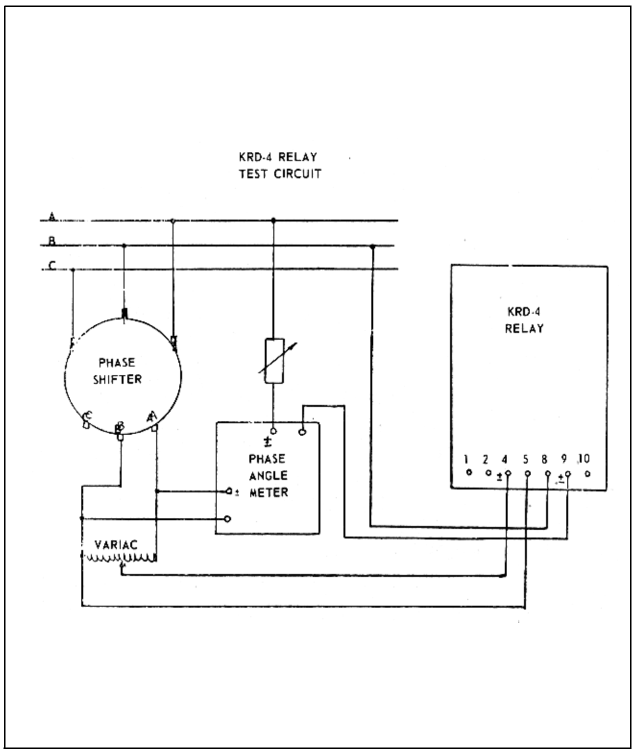

Figure 7: KRD-4 Relay Test

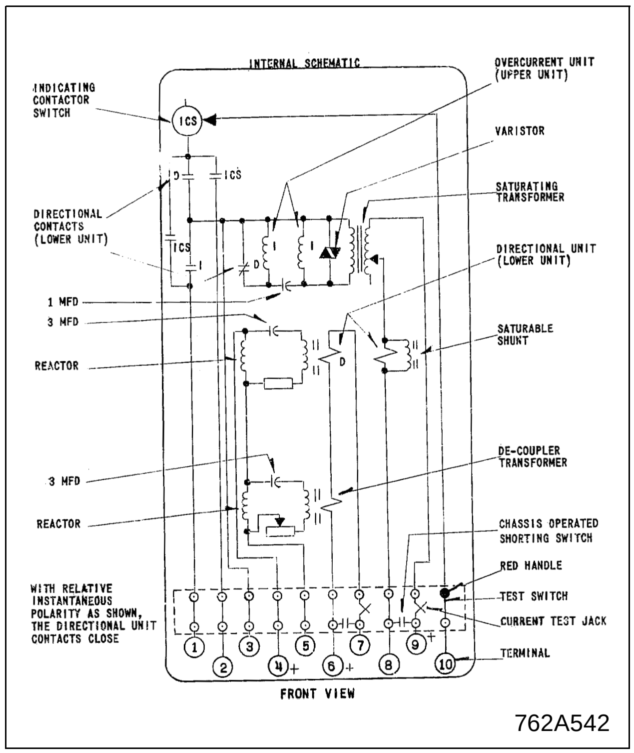

Figure 8:

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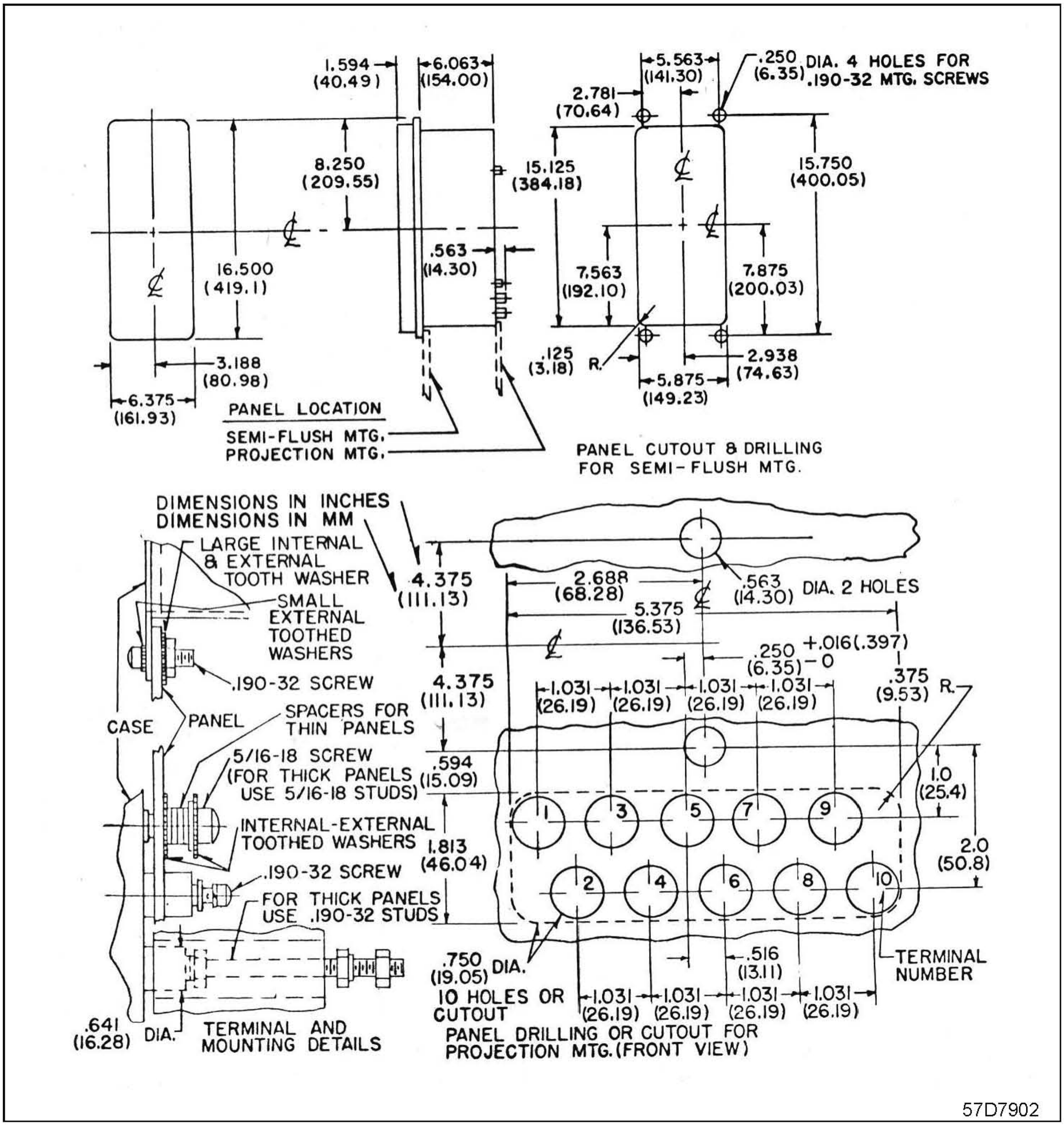

Figure 9: Outline and Drilling Plan for the Type KRD-4 Relay in the FT-31 Case

IL 41-137.3 - Revision H

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