Westinghouse Electric Corporation
Relay and Telecommunications Division
Coral Springs, FL 33065

October, 1988
New Information
Mailed to: E, D, C/41-400B

In FT-31 Flexitest Case①

Type KRD-4 and KRD-5 Directional Overcurrent Ground Relays

KRD-4 Relay

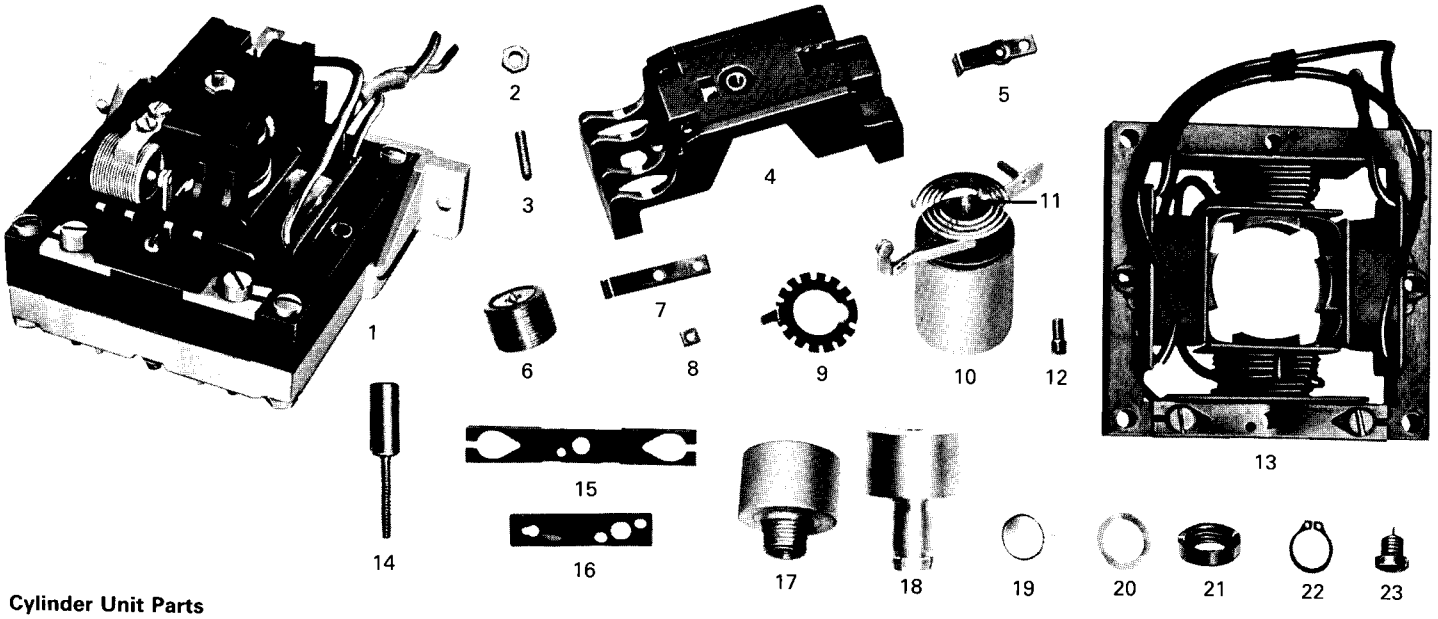
Complete Relay Style Number	Frequency (Hz)	Rating (Amp)	Indicator Rating (Amp)	Style Number of Part	
				Cylinder Unit⑩	Cylinder Unit⑪
293B307A09	60	.5-2	1.0	**290B750G28**	**290B750G29**
293B307A10	60	1-4	1.0	**290B750G28**	**290B750G29**
293B307A11	60	2-8	1.0	**290B750G28**	**290B750G29**
293B307A12	60	.5-2	0.2-2.0	**290B750G28**	**290B750G29**
293B307A13	60	1-4	0.2-2.0	**290B750G28**	**290B750G29**
293B307A14	60	2-8	0.2-2.0	**290B750G28**	**290B750G29**
293B307A15	60	10-40	0.2-2.0	**290B750G28**	**290B750G31**
293B307A16	60	4-16	0.2-2.0	**290B750G28**	**290B750G31**
293B307A25	50	1-4	0.2-2.0	**290B750G28**	**290B750G29**
293B307A26	50	2-8	1.0	**290B750G28**	**290B750G29**
293B307A27	50	.5-2	0.2-2.0	**290B750G28**	**290B750G29**
293B307A28	50	.5-2	1.0	**290B750G28**	**290B750G29**
293B307A29	50	1-4	1.0	**290B750G28**	**290B750G29**
293B307A30	50	4-16	0.2-2.0	**290B750G28**	**290B750G29**

KRD-5 Relay

Complete Relay Style Number	Frequency (Hz)	Rating (Amp)	Indicator Rating (Amp)	Style Number of Part	
				Cylinder Unit⑩	Cylinder Unit⑪
606B718A09	60	.5-1	None	**290B750G32**	**290B750G33**
606B718A21	60	.5-1	None	**290B750G32**	**290B750G33**

① For Flexitest case parts refer to RPD 41-076A1.
⑪ This is the Overcurrent (Upper) Cylinder Unit.
⑩ This is the Directional (Lower) Cylinder Unit.

Ordering Information
- Give style number and name of part.
- Give the complete nameplate reading.
- State method of shipment desired.
- Send all orders or correspondence to nearest sales office of the company.



Cylinder Unit Parts

Ref. No.	Description of Part	Style Number
1	Cylinder Unit Complete	**See Table Ⓔ**
2	Nut for Upper Bearing Screw	**203 056**
3	Upper Bearing Screw	**3499A37G11***
4	Bridge, Insert and Pin	**183A660G01④**
4	Bridge, Insert and Pin	**60A1533G03⑤**
4	Bridge, Insert and Pin	**184A285G02⑥**
5	Pressure Spring to Lock Stationary Contact	**1730 953⑦**
6	Stationary Contact Assembly (L.H.)	**See Table***
6	Stationary Contact Assembly (R.H.)	**See Table***
7	Clamp for Spring Adjuster	**1730 954**
8	Nut for Spring Adjuster Clamp Screw	**1008 149**
9	Spring Adjuster	**1730 950**
10	Moving Element with Contact and Torque Spring (Less Adjuster)	**See TableⒹ***
11	Upper Bearing	**289B392G01**
12	Lower Bearing	**289B393G02**
13	Electromagnet	**See Table***
14	Plug Screw	**1730 095③⑤**
15	Upper Plug Clip	**1730 939⑤**
16	Lower Plug Clip	**1730 096③⑤**
17	Core	**629A652H01④**
18	Core (Long)	**292B405H01⑧**
19	Spacer	**186A069H09⑧**
20	Core Washer	**837 754⑧**
21	Core Nut	**1730 945④**
22	Core Retainer Clip	**31D5056H03⑧**
23	Lower Bearing Screw	**3499A37G10***

NOTE: Parts indented are included in the part under which they are indented.

Cylinder UnitⒺ

Complete Unit Style Number	Style Number of Part			
	Electromagnet	Moving Element	Stationary Contact (L.H.)	Stationary Contact (R.H.)
290B750G28	**289B172G19**	**60A1555G09**	**183A765G01**	....
290B750G29	**290B483G22**	**60A1555G10**	**183A765G01**	**183A765G01**
290B750G31	**290B483G23**	**60A1555G11**	**183A765G01**	**183A765G04**
290B750G32	**290B483G20**	**60A1555G15**	....	**183A765G02**
290B750G33	**290B483G22**	**60A1555G10**	....	**183A765G04**

③ Two (2) Used.
④ Used in cylinder unit style 290B750G28 only.
⑤ Used in cylinder unit style 290B750G29, G31 and G33.
⑥ Used in cylinder unit style 290B750G32 only.
⑦ One (1) used in all cylinder units, except styles 290B750G29 and G31 which use two (2).
⑧ Used in all cylinder units, except style 290B750G28.
Ⓓ This assembly is factory adjusted, do not tamper with cemented sealed screw and nut on contact support arm.
Ⓔ The style numbers of the cylinder unit, reactor, transformer and autotransformer are stamped on their frames.
* Recommended for stock.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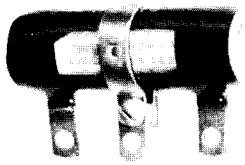
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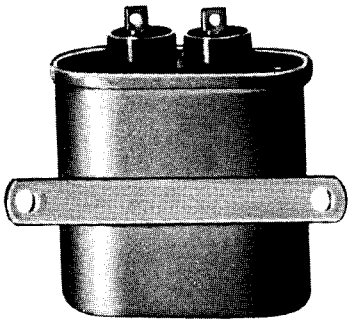
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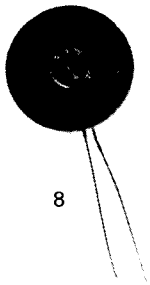
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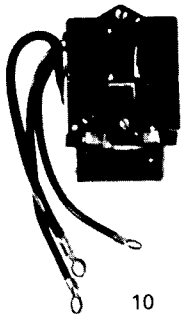
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Common Parts

Ref. No.	Description of Part	Style Number
1Δ	Tapped Transformer Assembly	**See Table Ⓔ***
2	Tap Screw	**1545 282③**
3	Resistor 56 Ohm, 3.5 Inch, Fixed	**1164 657Ⓐ***
3	Resistor 280 Ohm, 3.5 Inch, Adjustable	**1730 745Ⓐ***
4Δ	Transformer Assembly	**293B290G01ⒶⒺ***
5Δ	Reactor Assembly	**289B189G08Ⓔ⑨***
5Δ	Reactor Assembly	**289B189G09Ⓔ⑨***
5Δ	Reactor Assembly	**644B273G01Ⓔ⑩***
5Δ	Reactor Assembly	**644B273G02Ⓔ⑩***
6	Capacitor .38 MFD	**14C9400H19⑪***
6	Capacitor 1.0 MFD	**1877 966⑫***
6	Capacitor 3.0 MFD	**18C6551H03③⑨***
6	Capacitor 4.0 MFD	**1723 407③⑩***
7Δ	Auto-Transformer Assembly	**407C654G04ⒶⒺ***
8	Varistor	**183A122H02⑫***
9Δ	Current Shunt	**629A396G01⑪***
10	ICS Unit, .2-2.0 Amp, Double Trip, Blank (R.H.)	**3491A37G18②***
10	ICS Unit, 1.0 Amp, Double Trip, Blank (R.H.)	**3491A37G24②***
11	Stationary Contact for ICS Unit	**1732 868Ⓐ③***
12Δ	Stationary Contact for ICS Unit	**183A860G02Ⓐ***

Tapped Transformer Assembly

Range (Amp)	Style Number
.5-2	**408C461G06**
1-4	**408C461G07**
2-8	**408C461G08**
4-16	**408C461G10**
10-40	**408C461G09**
....	**408C461G11Ⓑ⑪**

NOTE: Parts indented are included in the part under which they are indented.
② For ICS unit parts refer to RPD 41-852A1.
③ Two (2) used.
⑨ Used in 60Hz KRD-4 and KRD-5 relays only.
⑩ Used in 50Hz KRD-4 relays only
⑪ Used in KRD-5 relays only.
⑫ Used in KRD-4 relays only.
Ⓐ Used in all KRD-4 and KRD-5 relays.
Ⓑ This transformer does not have a tap block.
Ⓔ The style numbers of the cylinder unit, reactor, transformer and autotransformer are stamped on their frames.
Δ Not illustrated.
* Recommended for stock.

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INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

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.

APPLICATION

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

They are also used, without modifications to provide directional ground fault protection in the KD-4 carrier relaying scheme. Operation of the relays in connection with the carrier scheme is fully described in I.L. 41-911.

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 Fig. 1 to 3.

A. DIRECTIONAL UNIT (D)

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

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

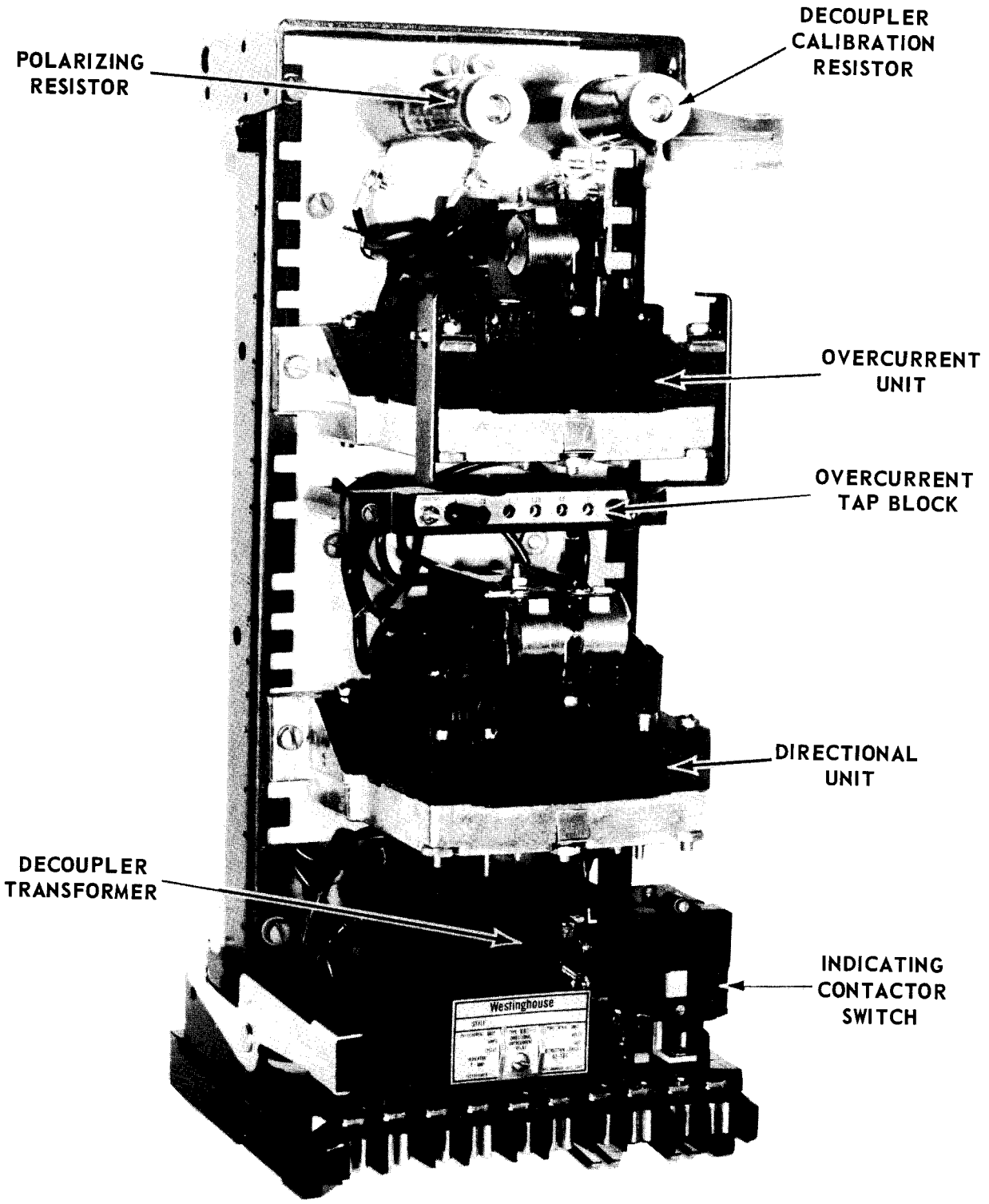

Fig. 1. Type KRD-4 Relay (Front View).

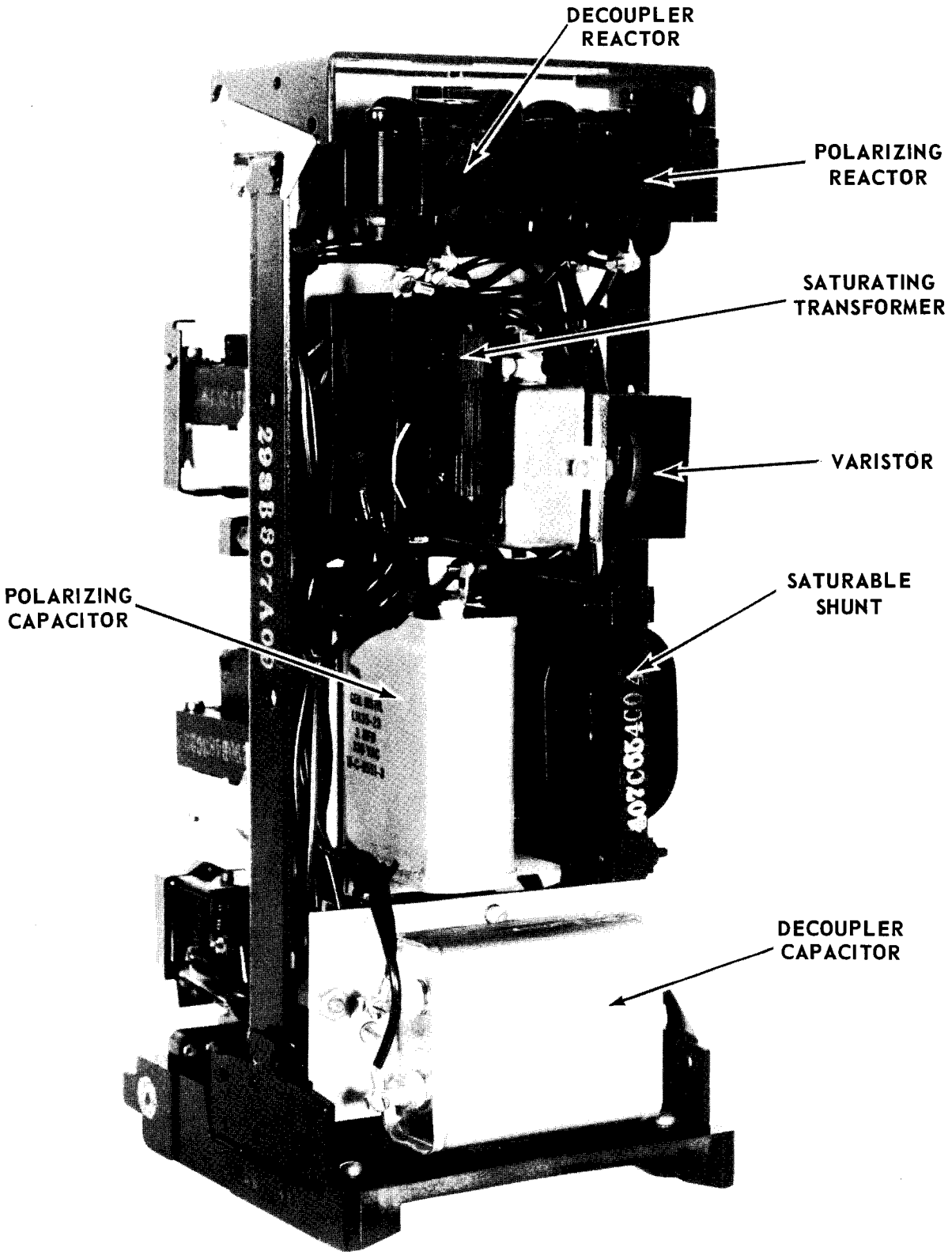

Fig. 2. Type KRD-4 Relay (Rear View).

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.

B. 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.

C. INDICATING CONTACTOR SWITCH (ICS)

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

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.

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 65 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.

TIME CURVES

The time curves for the KRD-4 relay are shown in Fig. 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 voltage polarized.

Fig. 6 shows the instantaneous overcurrent unit closing time.

The voltage polarized curve (curve A 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.

(Example One) definition of symbols are shown on Fig. 5.

let: I_{pol} = 1.5 amp.

I_{op} = 3 amp

tap value (T) = 0.5 amp.

$\emptyset = 0°$

for a current polarized relay:

$$MMP = \frac{I_{op} I_{pol} \cos \emptyset}{0.25}$$

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

Entering the curves in Fig. 5 at multiples of product pickup of 18 the directional unit opening time is 4 ms, and the closing time for this unit is 33 ms.

For the overcurrent unit:

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

$$= \frac{3}{0.5} = 6$$

Entering the curve in Fig. 6 at multiples of pickup equal to 6 the closing time for the overcurrent is 14 ms. However, the total operating time for the overcurrent unit is 14 plus 4 ms, which is the opening time of back contacts of the directional unit, or 18 ms total operating time for the overcurrent unit. The total operating time for the directional unit is 33 ms; and since this is the longest time, 33 ms is the total operating time of the relay.

(Example Two)

let: I_{pol} = 15 amp

I_{op} = 25 amp

T (tap) = 1 amp.

$\emptyset = 0$

$$MMP = \frac{I_{op} I_{pol} \cos \emptyset}{0.25}$$

$$MMP = 1500$$

referring to Fig. 5 the directional unit closing time is 8 ms, and the opening time of its back contacts is 3 ms. The total operating time for the directional unit is 8 ms.

For the overcurrent unit:

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

$$= 25$$

referring to Fig. 6 the overcurrent unit contact closing time is 10 ms. Therefore, the total operating time for this unit is 10 + 3 ms or 13 ms. In this case the total operating time of the relay is 13 ms.

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 a pickup of approximately 1 ampere. Its d-c resistance is 0.1 ohms.

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 I

DIRECTIONAL UNIT SENSITIVITY

Polarizing Quantity	Values for Min. Pickup		Phase Angle Relationship
	Volts	Amperes	
VOLTAGE	1	0.6	I lagging V by 65°
	1	1.4	I In Phase with V
CURRENT		0.5	In-phase

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

TABLE II

DIRECTIONAL UNIT CALIBRATION

Relay Rating	Current Amperes	Both Plugs In Condition	Adjustment
All Ranges	80	Spurious torque in contact closing direction (left front view)	Right (front view Plug Screwed out until spurious torque is reversed.
All Ranges	80	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 directions. Then the plug is screwed in until spurious torque is reversed.

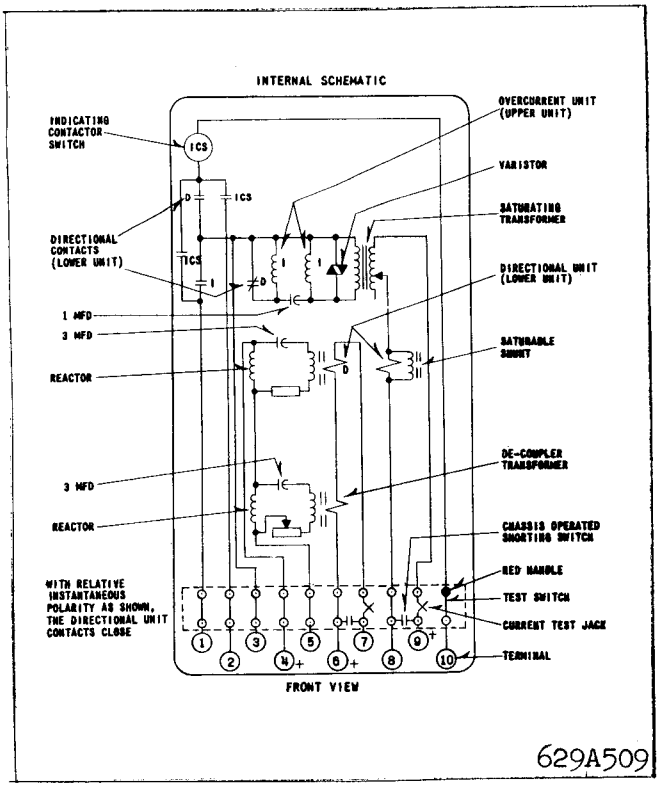

Fig. 3. Internal Schematic of the Type KRD-4 Relay in the Type FT31 Case.

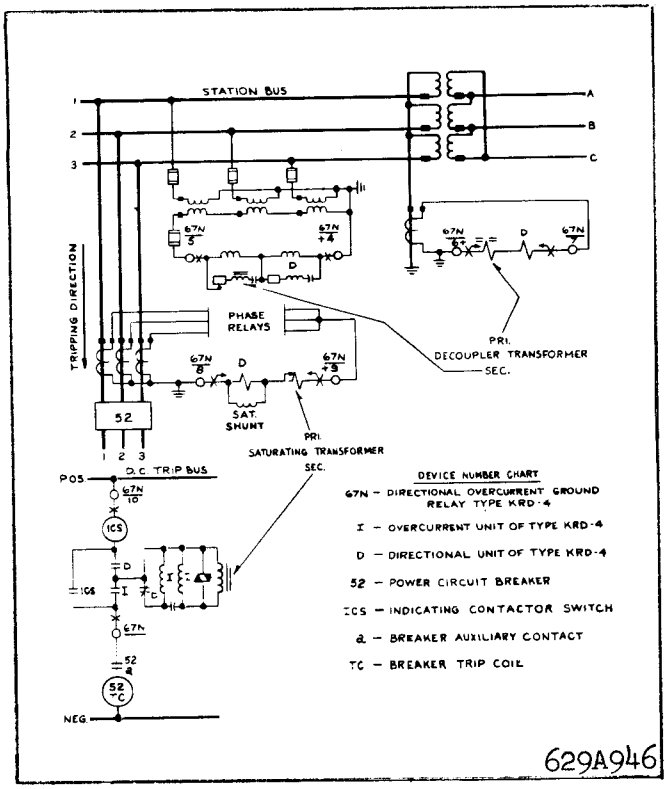

Fig. 4. External Schematic for the Type KRD-4 Relay.

SETTINGS

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 pick-up 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 unit 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: 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 the 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 CYCLES

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 △	POWER FACTOR ANGLE Ø
Current	230†† amperes	1.20	3° Lag
Voltage	208††† volts *	21.0	28° Lead

Ø Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.

△ 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.

Directional Unit (D)

No setting is required.

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 holes on 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 I.L. 41-076.

ADJUSTMENTS AND MAINTENANCE

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

Acceptance Check

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

Overcurrent Unit (I)

1. Contact Gap - The gap between the stationary and moving contacts with the relay in the de-energized position should be approximately .020."
2. Minimum Trip Current - The normally-closed contact of the directional unit should be blocked open when checking the pick-up of the overcurrent unit.

   The pick-up 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.

Directional Unit (D)

1. Contact Gap - The gap between the stationary contact and moving contact with the relay in the de-energized 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 - Three 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.

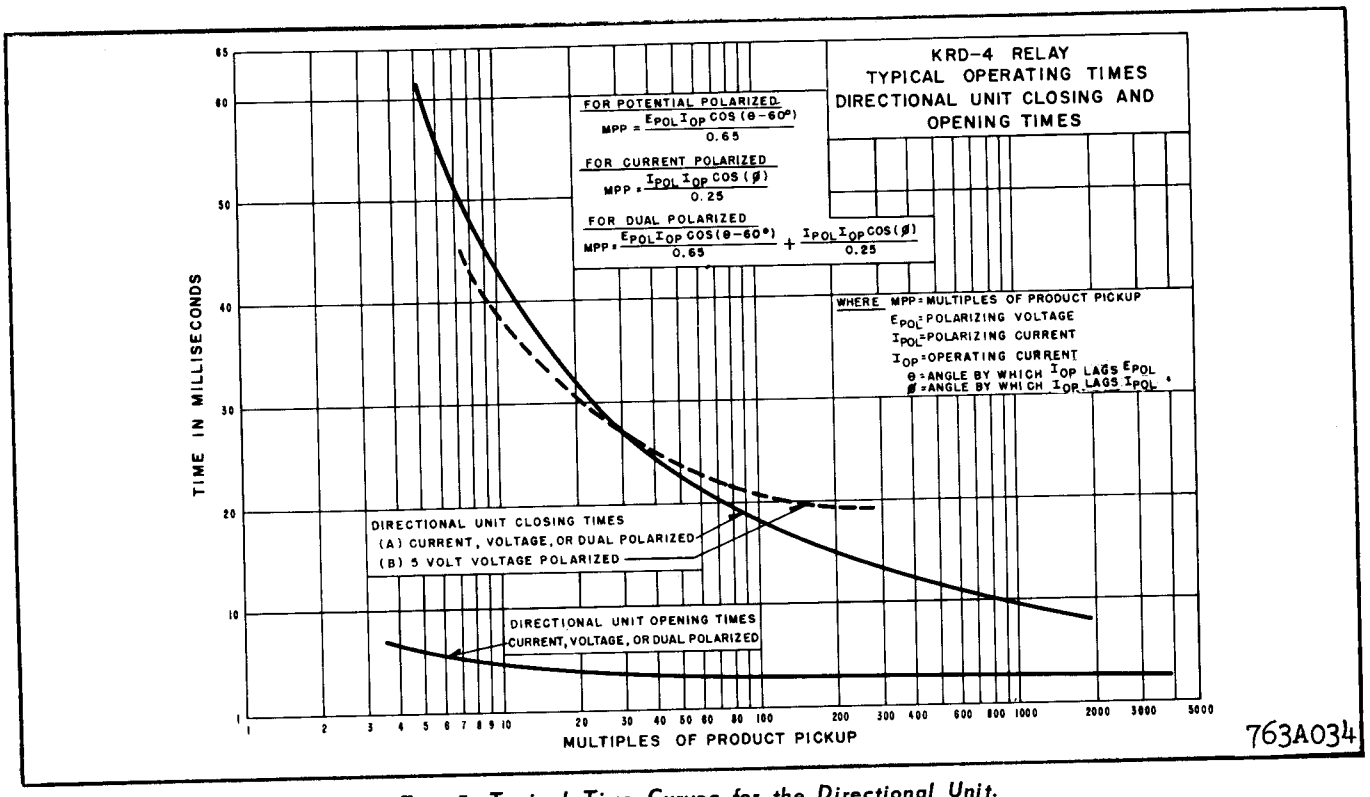

Fig. 5. Typical Time Curves for the Directional Unit.

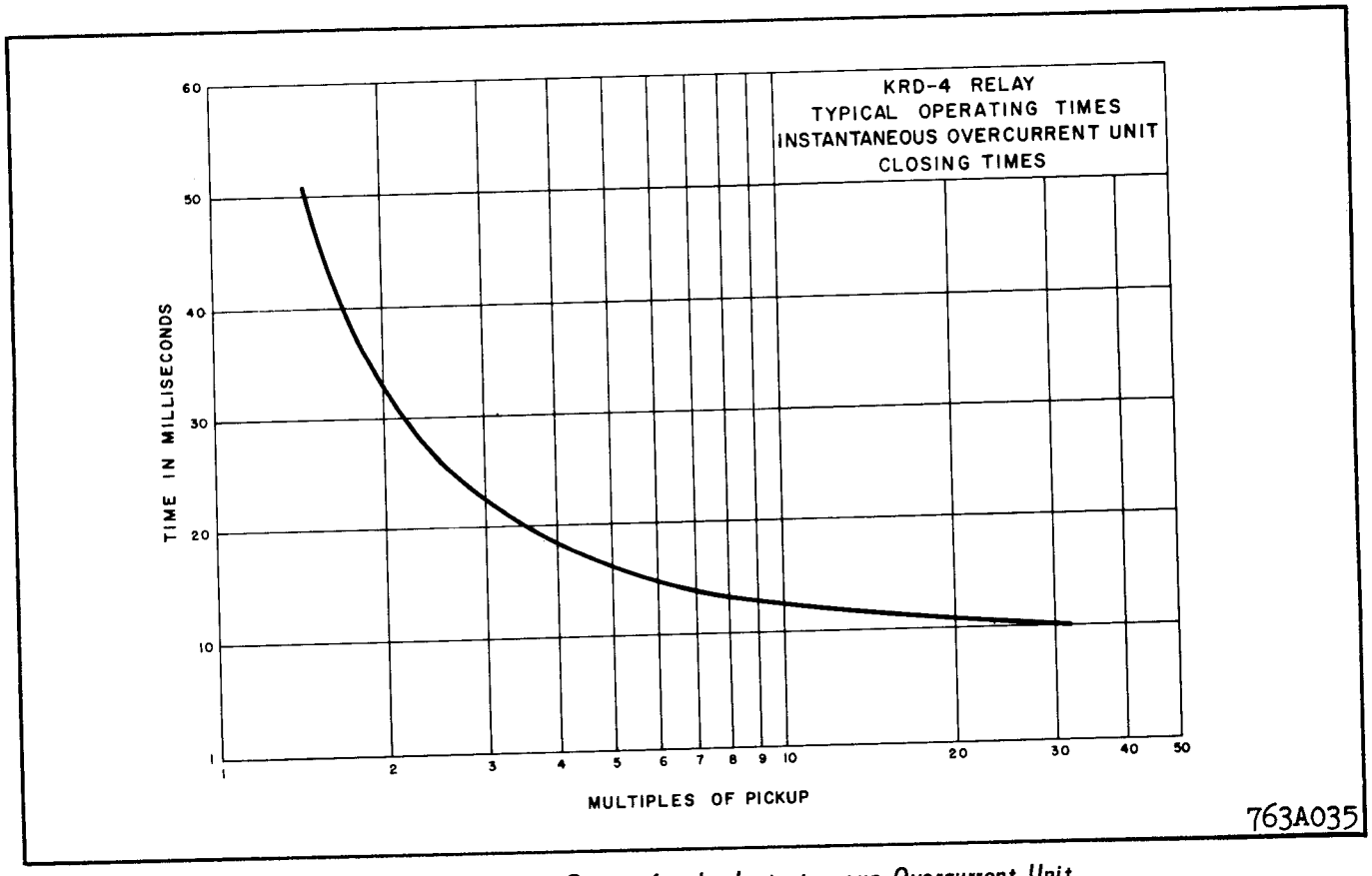

Fig. 6. Typical Time Curves for the Instantaneous Overcurrent Unit.

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 be between 1 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 adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

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.

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'').

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 pick up of the overcurrent unit with the tap screw in any other tap should be within ±5% of tap value.

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 in 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.

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 left 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 terterminals 8 and 9 with all other terminals open circuited. Adjust core such that the contacts remain open. The core can be adjusted by the 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 all other terminals open circuited. Plug adjustment is then made per Table II 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.

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 pick up and the target drops between 1 and 1.2 amperes 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 the complete nameplate data.

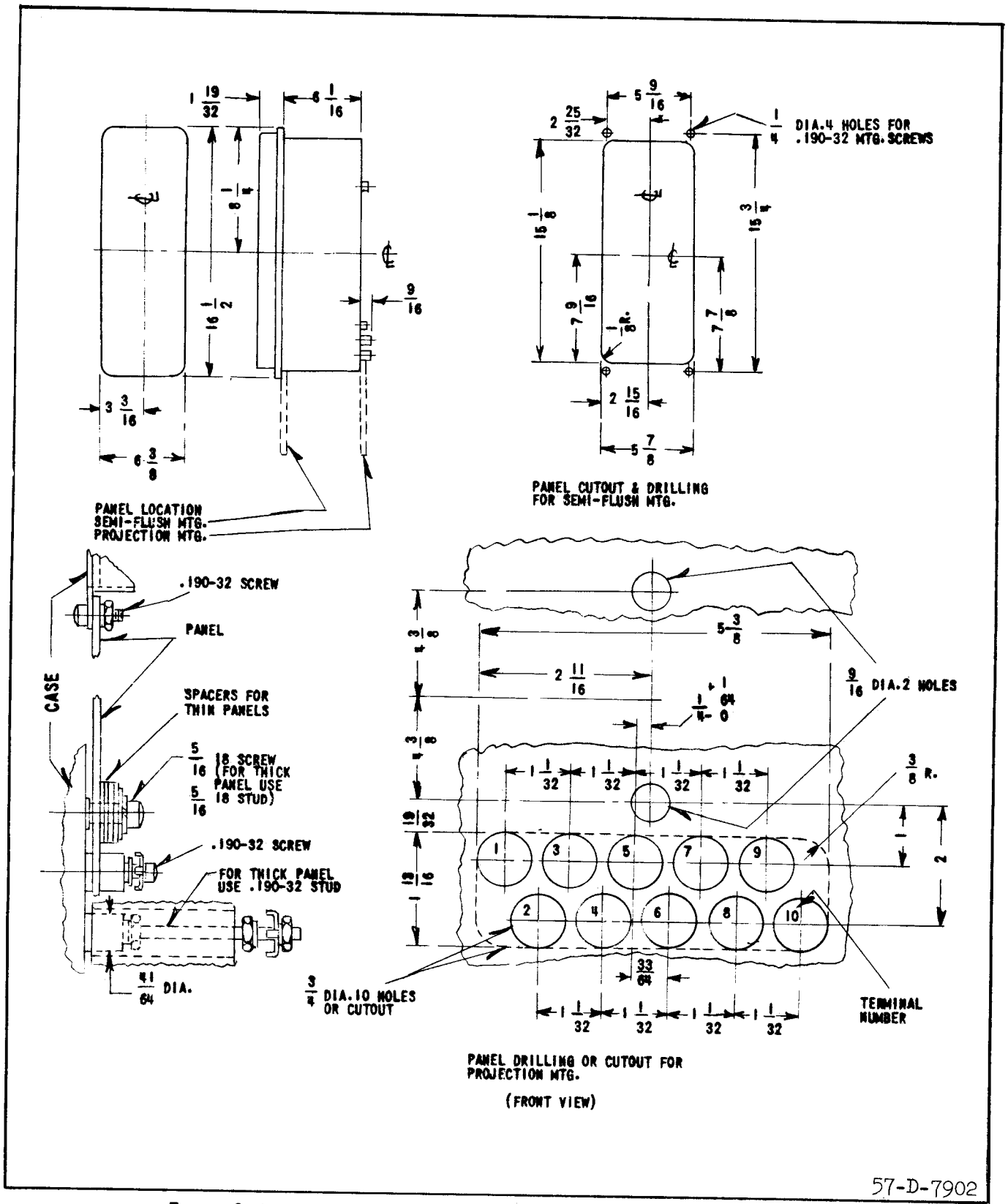

Fig. 7. Outline and Drilling Plan for the Type KRD-4 Relay in the FT31 Case.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

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.

APPLICATION

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

They are also used, without modifications to provide directional ground fault protection in the KD-4 carrier relaying scheme. Operation of the relays in connection with the carrier scheme is fully described in I.L. 41-911.

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 Fig. 1 to 3.

A. DIRECTIONAL UNIT (D)

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

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

SUPERSEDES I.L. 41-137.3A
*Denotes change from superseded issue.

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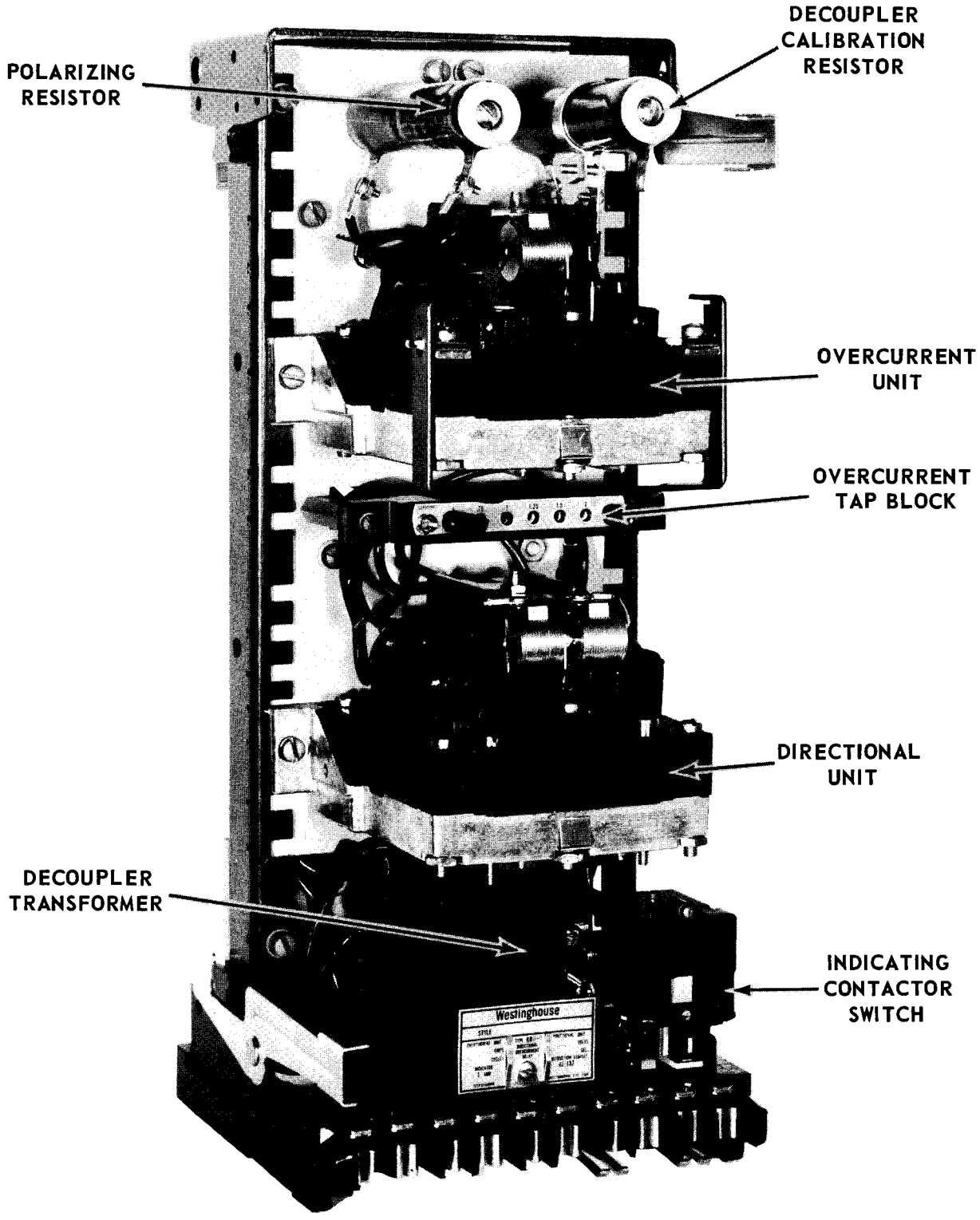


Fig. 1. Type KRD-4 Relay (Front View).

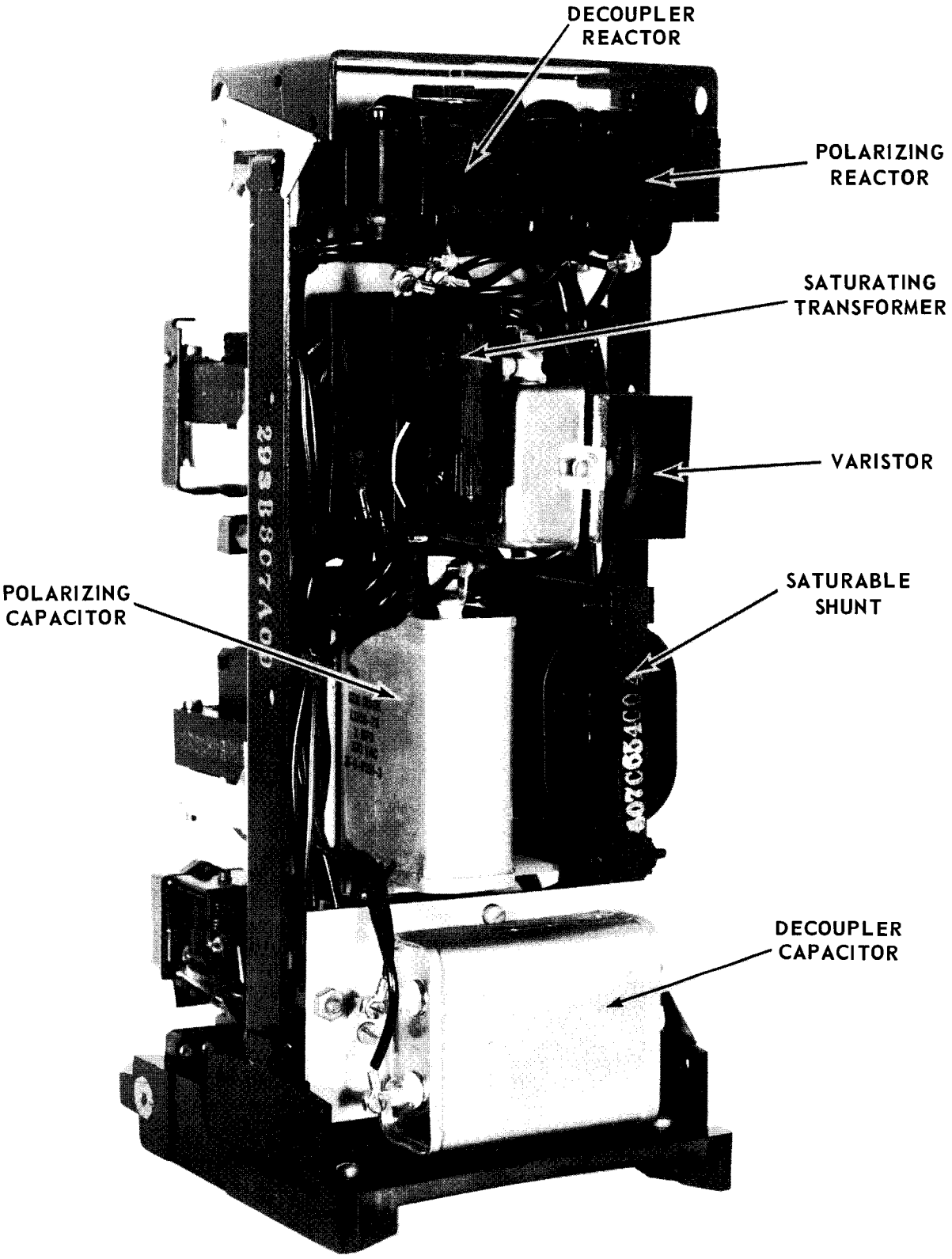


Fig. 2. Type KRD-4 Relay (Rear View).

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.

B. 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.

C. INDICATING CONTACTOR SWITCH (ICS)

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

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.

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 65 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.

TIME CURVES

The time curves for the KRD-4 relay are shown in Fig. 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 voltage 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.

(Example One) definition of symbols are shown on Fig. 5.

let: I_{pol} = 1.5 amp.
I_{op} = 3 amp
tap value (T) = 0.5 amp.
$\emptyset = 0°$

for a current polarized relay:

$$* \text{ MPP} = \frac{I_{op} I_{pol} \cos \emptyset}{0.25}$$

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

Entering the curves in Fig. 5 at multiples of product pickup of 18 the directional unit opening time is 4 ms, and the closing time for this unit is 33 ms.

For the overcurrent unit:

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

$$= \frac{3}{0.5} = 6$$

Entering the curve in Fig. 6 at multiples of pickup equal to 6 the closing time for the overcurrent is 14 ms. However, the total operating time for the overcurrent unit is 14 plus 4 ms, which is the opening time of back contacts of the directional unit, or 18 ms total operating time for the overcurrent unit. The total operating time for the directional unit is 33 ms; and since this is the longest time, 33 ms is the total operating time of the relay.

(Example Two)

let: I_{pol} = 15 amp
I_{op} = 25 amp
T (tap) = 1 amp.
$\emptyset = 0$

$$* \text{ MPP} = \frac{I_{op} I_{pol} \cos \emptyset}{0.25}$$

$$* \text{ MPP} = 1500$$

referring to Fig. 5 the directional unit closing time is 8 ms, and the opening time of its back contacts is 3 ms. The total operating time for the directional unit is 8 ms.

For the overcurrent unit:

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

$$= 25$$

referring to Fig. 6 the overcurrent unit contact closing time is 10 ms. Therefore, the total operating time for this unit is 10 + 3 ms or 13 ms. In this case the total operating time of the relay is 13 ms.

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 a pickup of approximately 1 ampere. Its d-c resistance is 0.1 ohms.

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 I

DIRECTIONAL UNIT SENSITIVITY

Polarizing Quantity	Values for Min. Pickup		Phase Angle Relationship
	Volts	Amperes	
VOLTAGE	1	0.6	I lagging V by 65°
	1	1.4	I In Phase with V
CURRENT		0.5	In-phase

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

TABLE II

DIRECTIONAL UNIT CALIBRATION

Relay Rating	Current Amperes	Both Plugs In Condition	Adjustment
All Ranges	80	Spurious torque in contact closing direction (left front view)	Right (front view Plug Screwed out until spurious torque is reversed.
All Ranges	80	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 directions. Then the plug is screwed in until spurious torque is reversed.

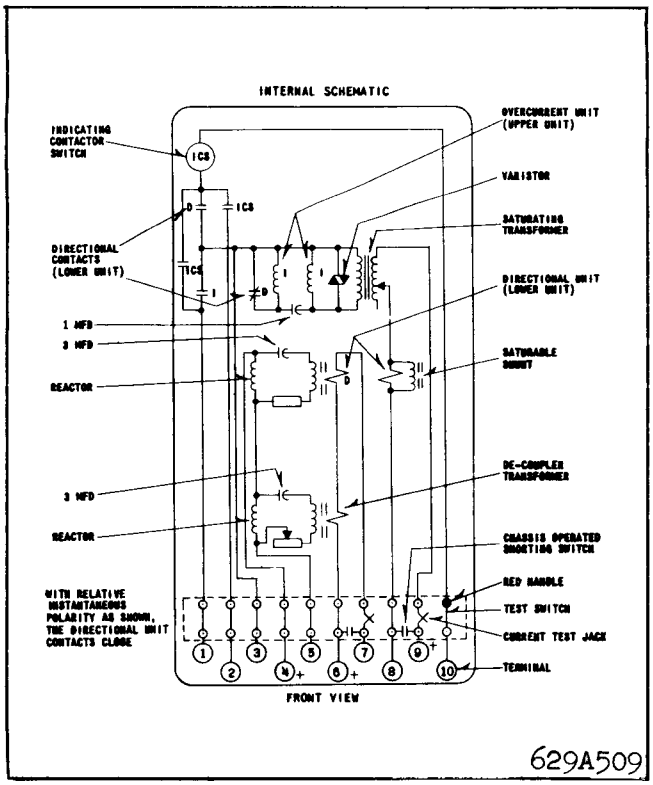


Fig. 3. Internal Schematic of the Type KRD-4 Relay in the Type FT31 Case.

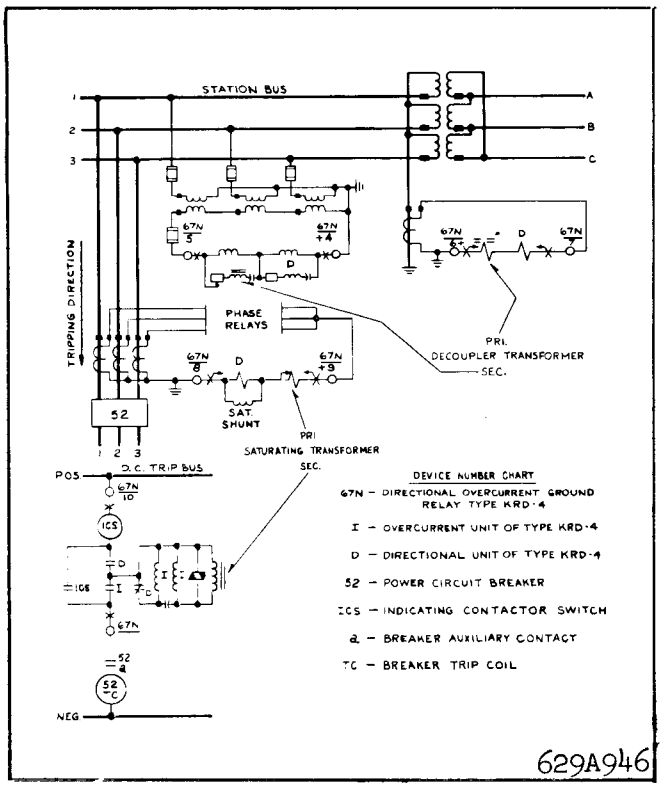


Fig. 4. External Schematic for the Type KRD-4 Relay.

SETTINGS

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 pick-up 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 unit 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: 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 the 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 CYCLES

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△	POWER FACTOR ANGLE Ø
Current	230†† amperes	1.20	3° Lag
Voltage	208††† volts	21.0	28° Lead

Ø Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.

△ 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.

Directional Unit (D)

No setting is required.

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 holes on 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 I.L. 41-076.

ADJUSTMENTS AND MAINTENANCE

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

Acceptance Check

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

Overcurrent Unit (I)

1. Contact Gap - The gap between the stationary and moving contacts with the relay in the de-energized position should be approximately .020."
2. Minimum Trip Current - The normally-closed contact of the directional unit should be blocked open when checking the pick-up of the overcurrent unit.

   The pick-up 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.

Directional Unit (D)

1. Contact Gap - The gap between the stationary contact and moving contact with the relay in the de-energized 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 - Three 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.

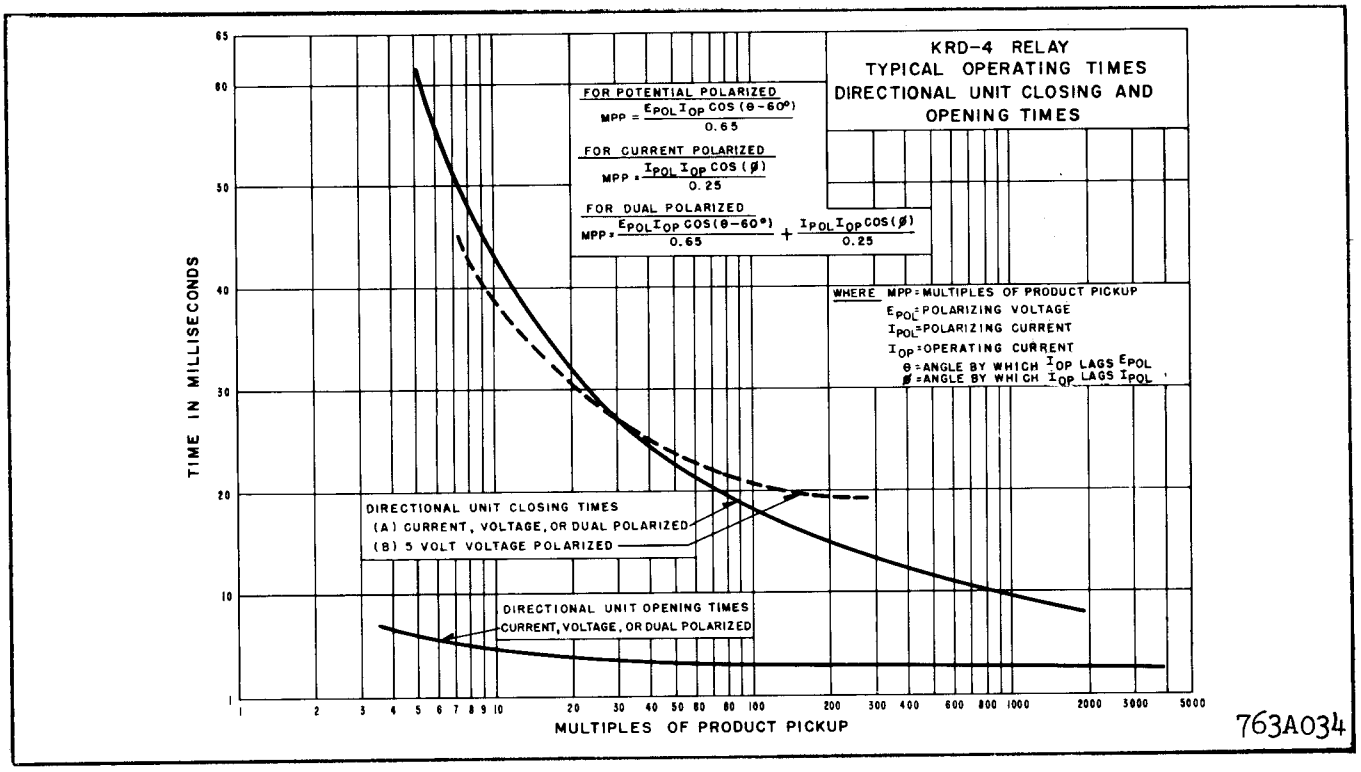


Fig. 5. Typical Time Curves for the Directional Unit.

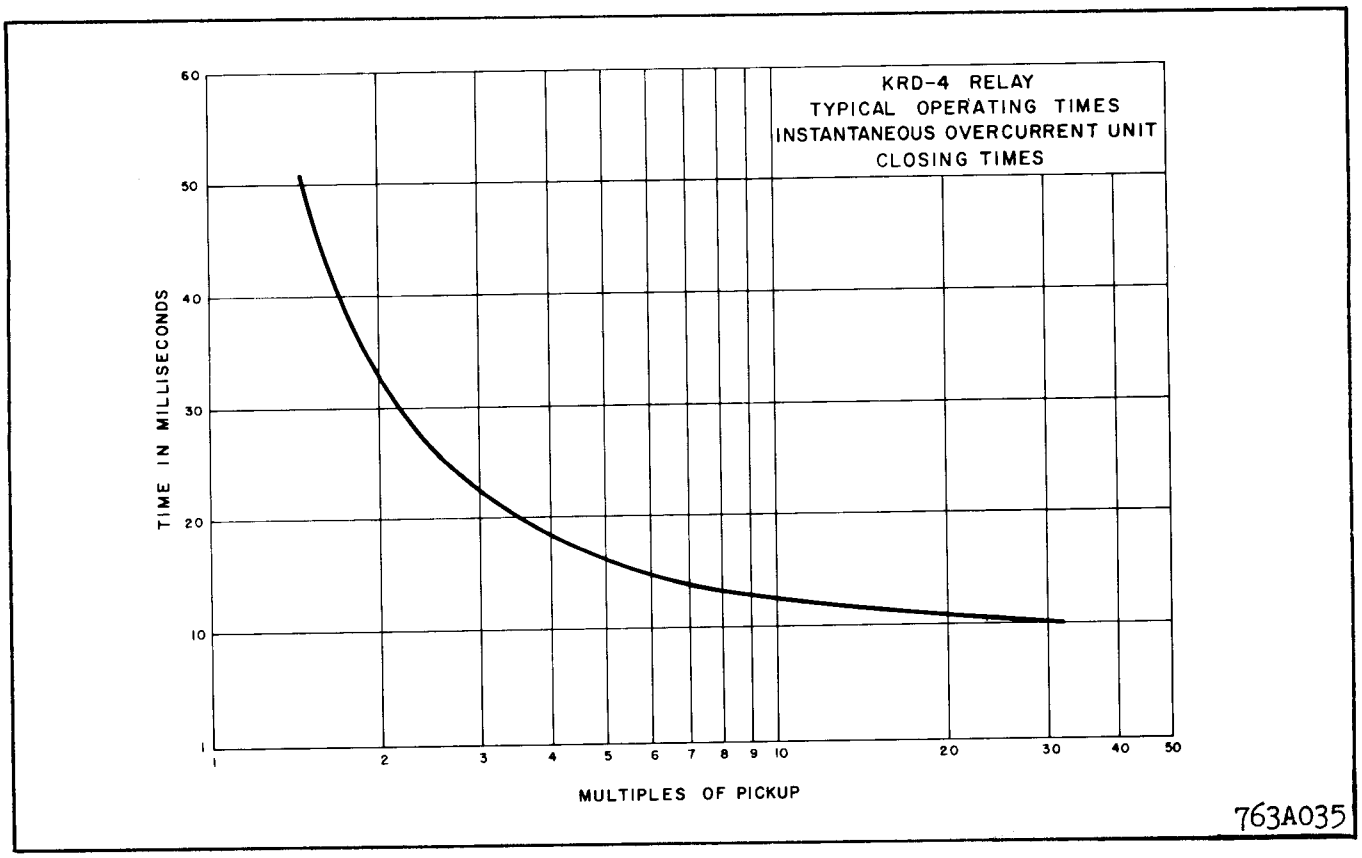


Fig. 6. Typical Time Curves for the Instantaneous Overcurrent Unit.

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 be between 1 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 adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

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.

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'').

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 pick up of the overcurrent unit with the tap screw in any other tap should be within ±5% of tap value.

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 in 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.

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 left 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 terterminals 8 and 9 with all other terminals open circuited. Adjust core such that the contacts remain open. The core can be adjusted by the 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 all other terminals open circuited. Plug adjustment is then made per Table II 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.

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 pick up and the target drops between 1 and 1.2 amperes 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 the complete nameplate data.

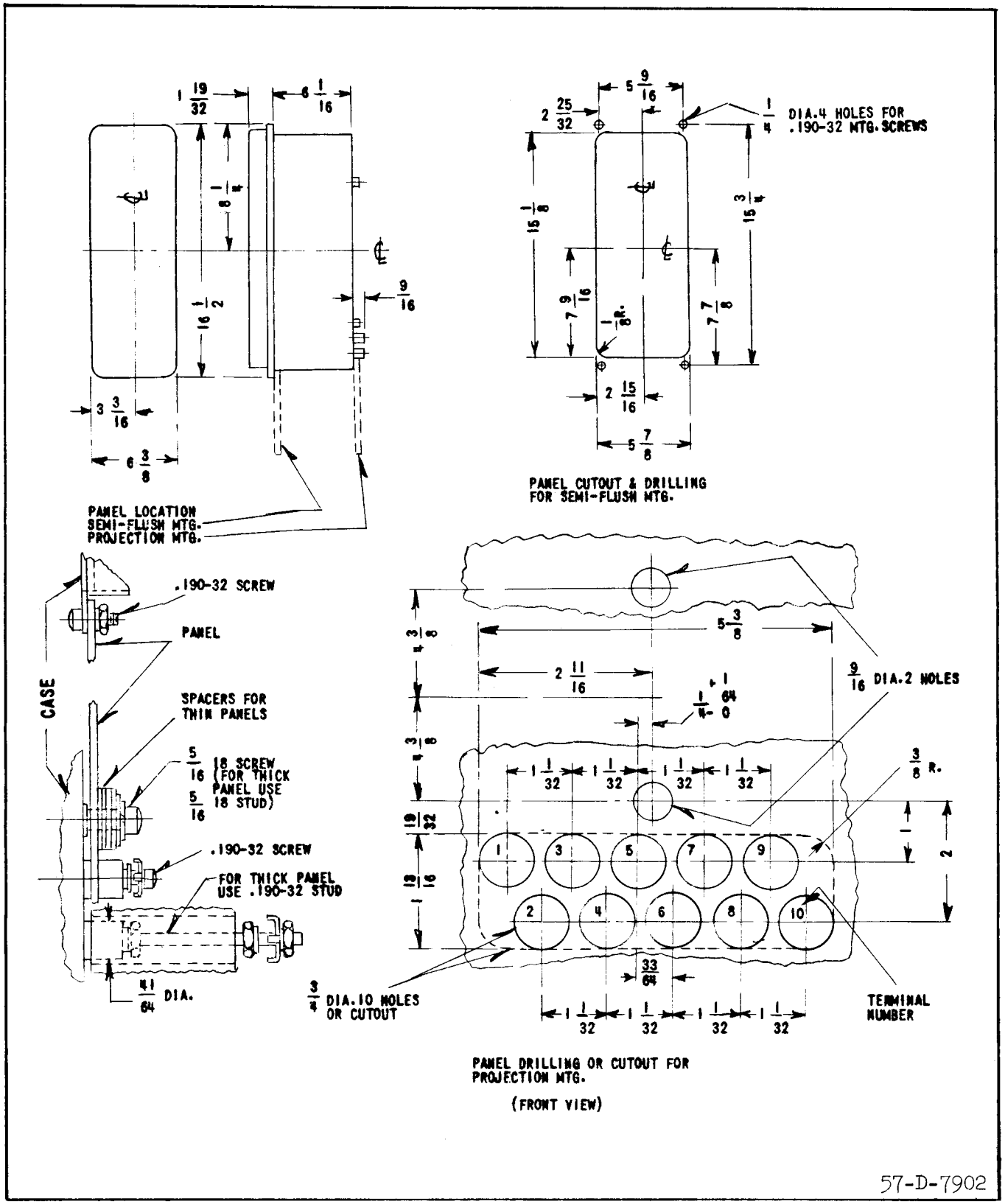


Fig. 7. Outline and Drilling Plan for the Type KRD-4 Relay in the FT31 Case.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

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.

APPLICATION

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

They are also used, without modifications to provide directional ground fault protection in the KD-4 carrier relaying scheme. Operation of the relays in connection with the carrier scheme is fully described in I.L. 41-911.

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 Fig. 1 to 3.

A. DIRECTIONAL UNIT (D)

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

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

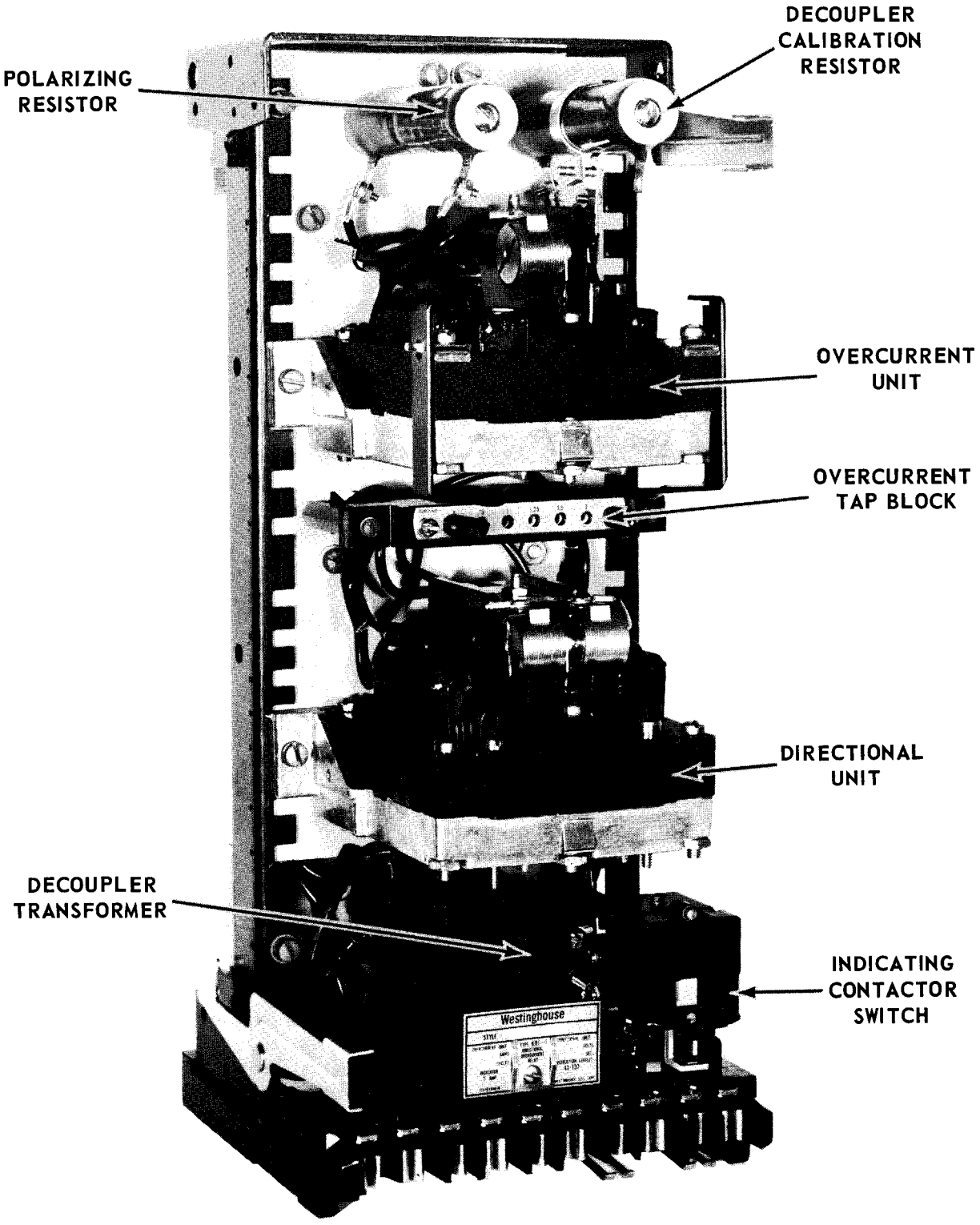


Fig. 1. Type KRD-4 Relay (Front View).

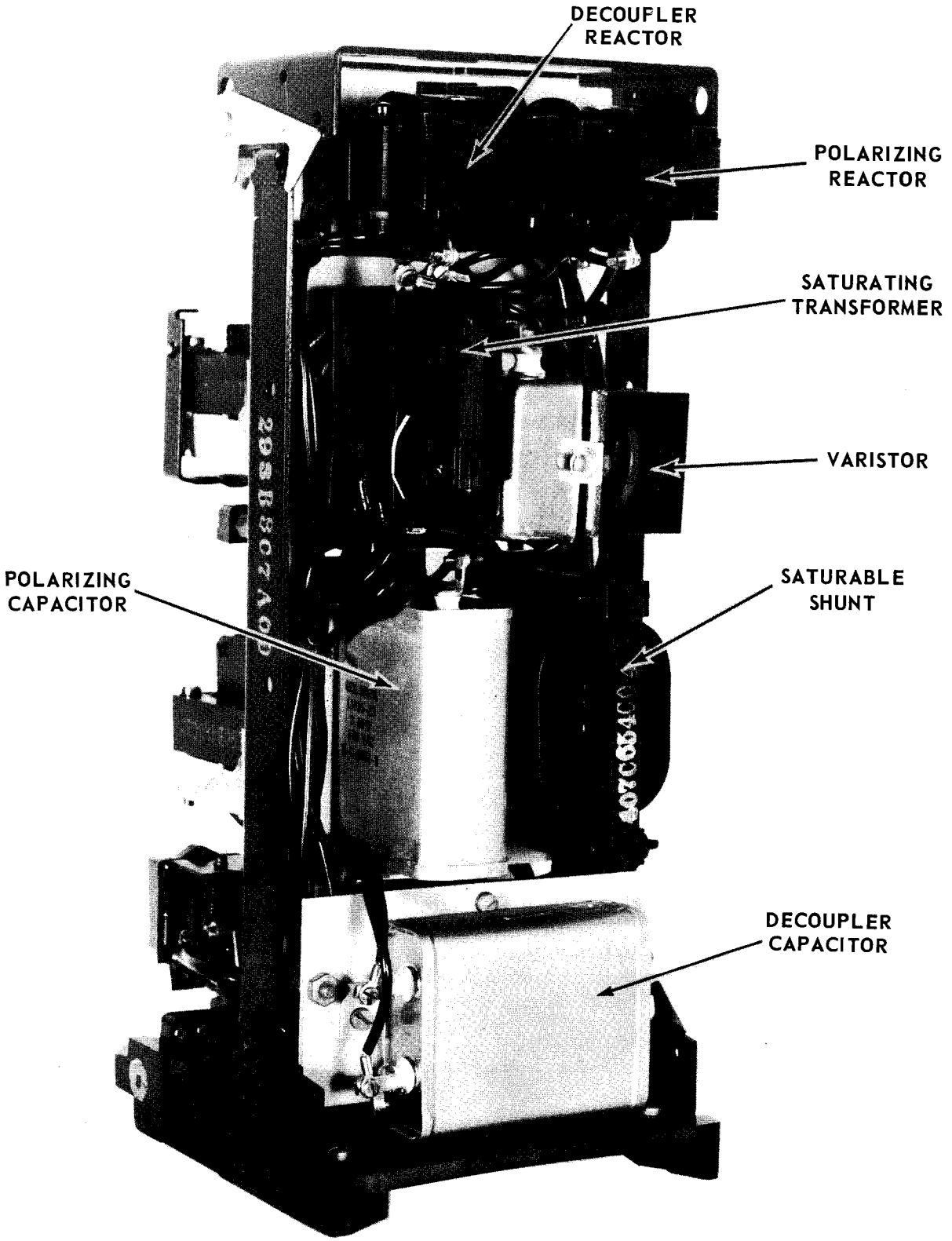


Fig. 2. Type KRD-4 Relay (Rear View).

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.

B. 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.

C. INDICATING CONTACTOR SWITCH (ICS)

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

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.

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 65 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.

TIME CURVES

The time curves for the KRD-4 relay are shown in Fig. 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 voltage 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.

(Example One) definition of symbols are shown on Fig. 5.

let: I_{pol} = 1.5 amp.

I_{op} = 3 amp

tap value (T) = 0.5 amp.

$\emptyset = 0°$

for a current polarized relay:

$$* \quad MPP = \frac{I_{op} I_{pol} \cos \emptyset}{0.25}$$

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

Entering the curves in Fig. 5 at multiples of product pickup of 18 the directional unit opening time is 4 ms, and the closing time for this unit is 33 ms.

For the overcurrent unit:

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

$$= \frac{3}{0.5} = 6$$

Entering the curve in Fig. 6 at multiples of pickup equal to 6 the closing time for the overcurrent is 14 ms. However, the total operating time for the overcurrent unit is 14 plus 4 ms, which is the opening time of back contacts of the directional unit, or 18 ms total operating time for the overcurrent unit. The total operating time for the directional unit is 33 ms; and since this is the longest time, 33 ms is the total operating time of the relay.

(Example Two)

let: I_{pol} = 15 amp

I_{op} = 25 amp

T (tap) = 1 amp.

$\emptyset = 0$

$$MPP = \frac{I_{op} I_{pol} \cos \emptyset}{0.25}$$

$$MPP = 1500$$

referring to Fig. 5 the directional unit closing time is 8 ms, and the opening time of its back contacts is 3 ms. The total operating time for the directional unit is 8 ms.

For the overcurrent unit:

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

$$= 25$$

referring to Fig. 6 the overcurrent unit contact closing time is 10 ms. Therefore, the total operating time for this unit is 10 + 3 ms or 13 ms. In this case the total operating time of the relay is 13 ms.

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 a pickup of approximately 1 ampere. Its d-c resistance is 0.1 ohms.

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 I

DIRECTIONAL UNIT SENSITIVITY

Polarizing Quantity	Values for Min. Pickup		Phase Angle Relationship
	Volts	Amperes	
VOLTAGE	1	0.6	I lagging V by 65°
	1	1.4	I In Phase with V
CURRENT		0.5	In-phase

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

TABLE II

DIRECTIONAL UNIT CALIBRATION

Relay Rating	Current Amperes	Both Plugs In Condition	Adjustment
All Ranges	80	Spurious torque in contact closing direction (left front view)	Right (front view Plug Screwed out until spurious torque is reversed.
All Ranges	80	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 directions. Then the plug is screwed in until spurious torque is reversed.

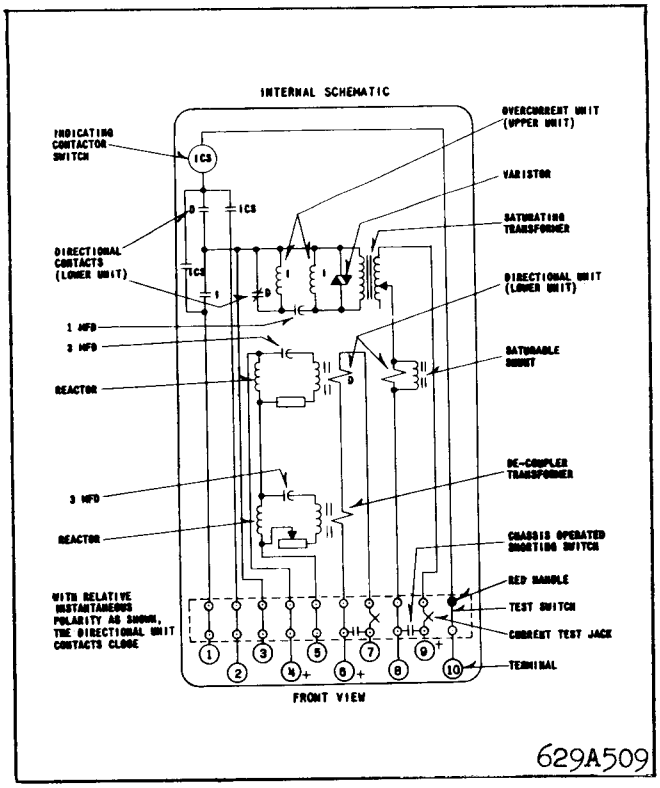


Fig. 3. Internal Schematic of the Type KRD-4 Relay in the Type FT31 Case.

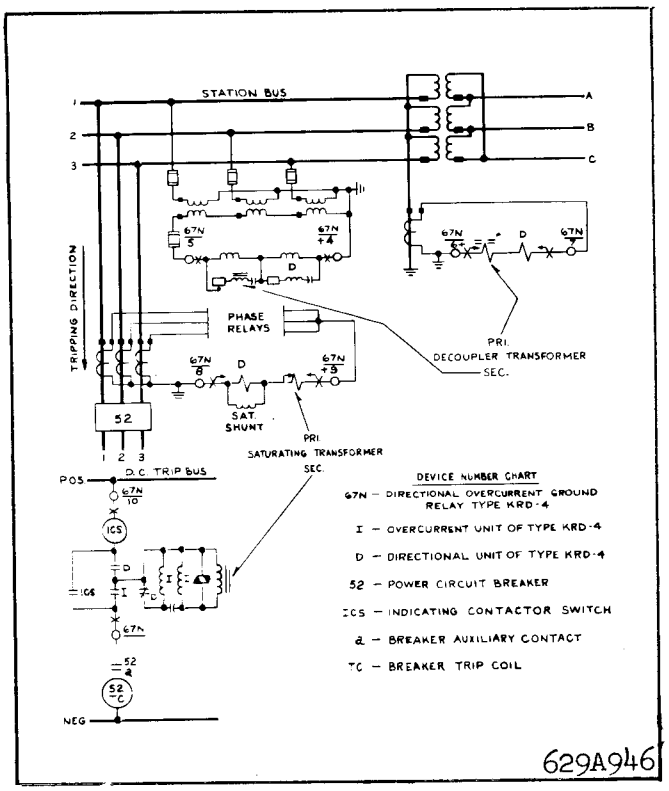


Fig. 4. External Schematic for the Type KRD-4 Relay.

SETTINGS

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 pick-up 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 unit 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: 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 the 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 CYCLES

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△	POWER FACTOR ANGLE Ø
Current	230†† amperes	1.20	3° Lag
Voltage	208††† volts	21.0	28° Lead

Ø Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.

△ 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.

Directional Unit (D)

No setting is required.

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 holes on 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 I.L. 41-076.

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 th[illegible]e covered under "SETTINGS," should be required.

Acceptance Check

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

Overcurrent Unit (I)

1. Contact Gap - The gap between the stationary and moving contacts with the relay in the de-energized position should be approximately .020."
2. Minimum Trip Current - The normally-closed contact of the directional unit should be blocked open when checking the pick-up of the overcurrent unit.

   The pick-up 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.

Directional Unit (D)

1. Contact Gap - The gap between the stationary contact and moving contact with the relay in the de-energized 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 - Three 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.

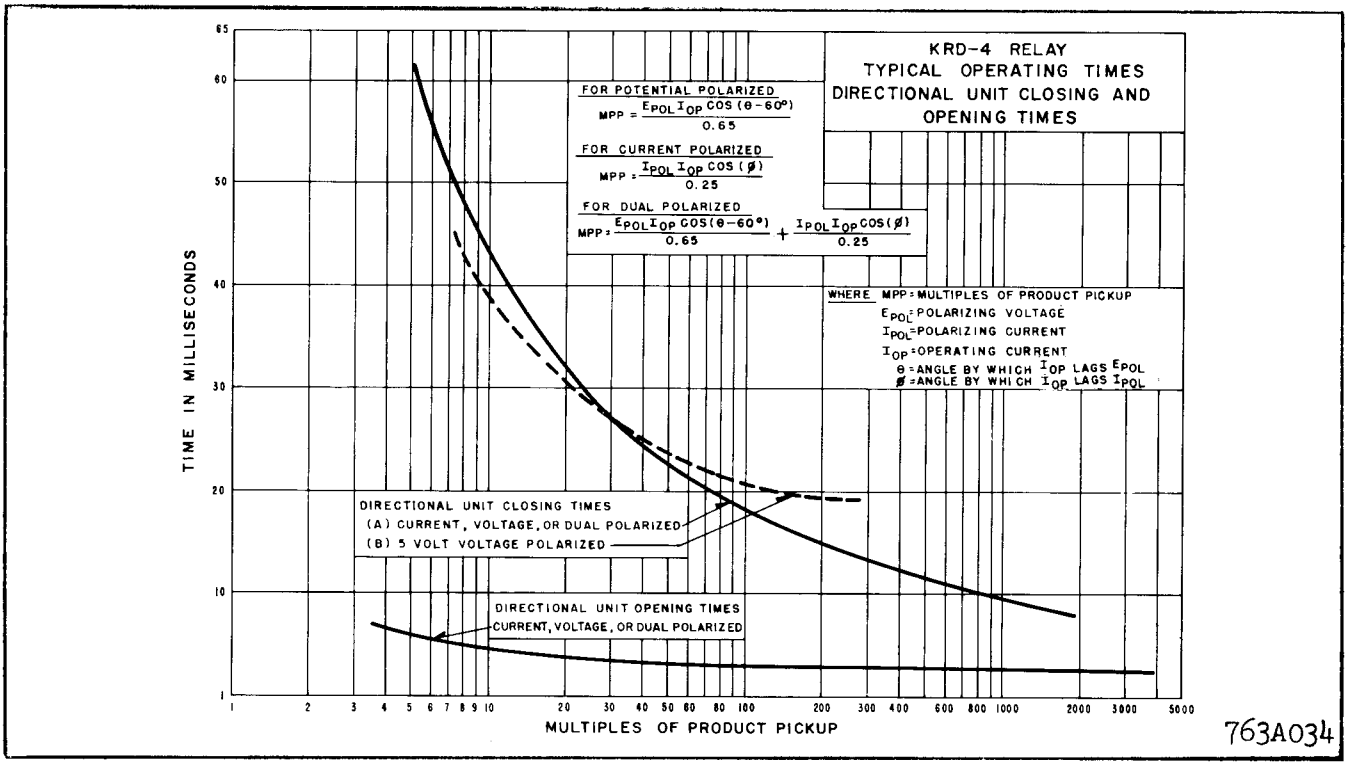


Fig. 5. Typical Time Curves for the Directional Unit.

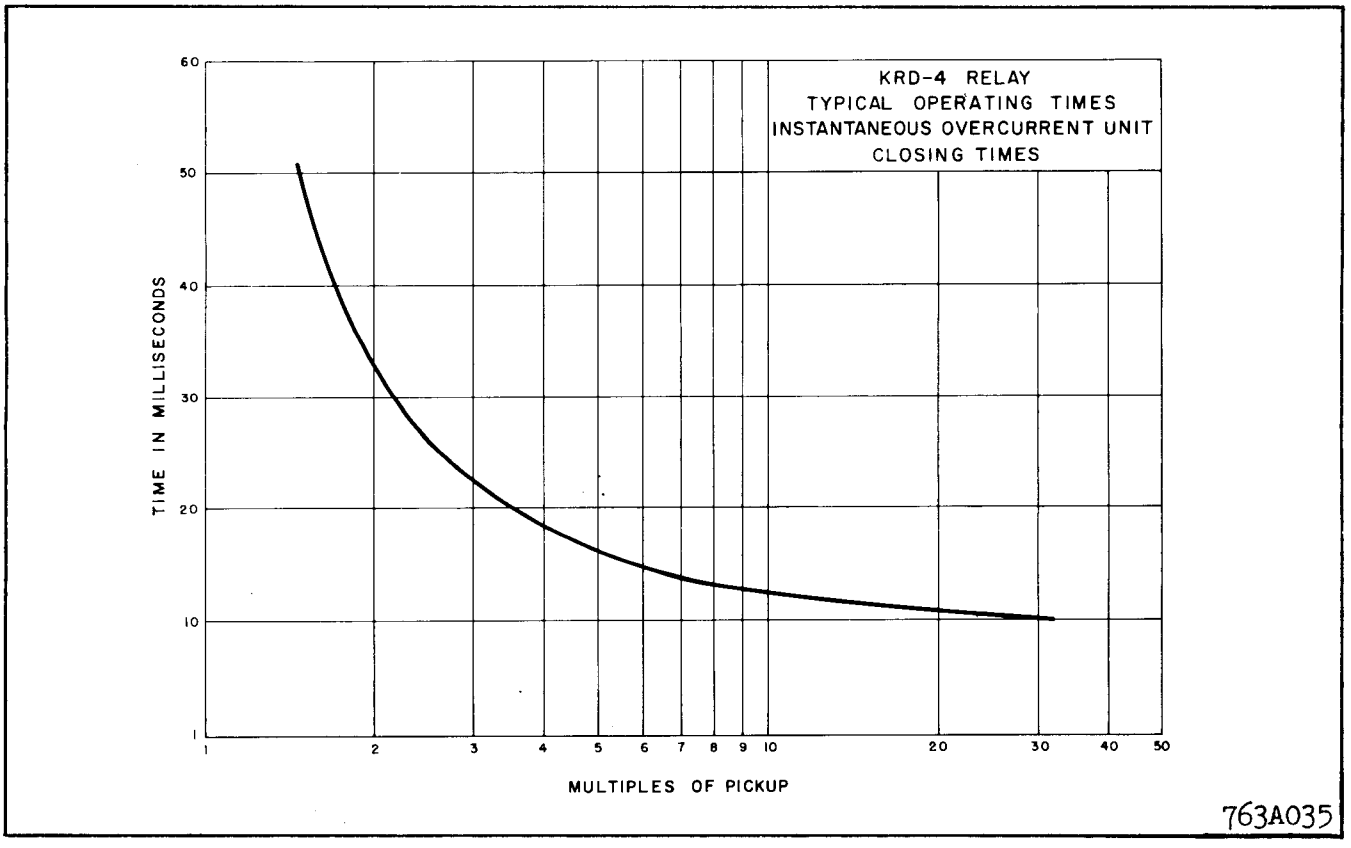


Fig. 6. Typical Time Curves for the Instantaneous Overcurrent Unit.

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 be between 1 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 adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

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.

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").

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 pick up of the overcurrent unit with the tap screw in any other tap should be within ±5% of tap value.

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 in 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.

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 terterminals 8 and 9 with all other terminals open circuited. Adjust core such that the contacts remain open. The core can be adjusted by the 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 all other terminals open circuited. Plug adjustment is then made per Table II 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.

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 pick up and the target drops between 1 and 1.2 amperes 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 the complete nameplate data.

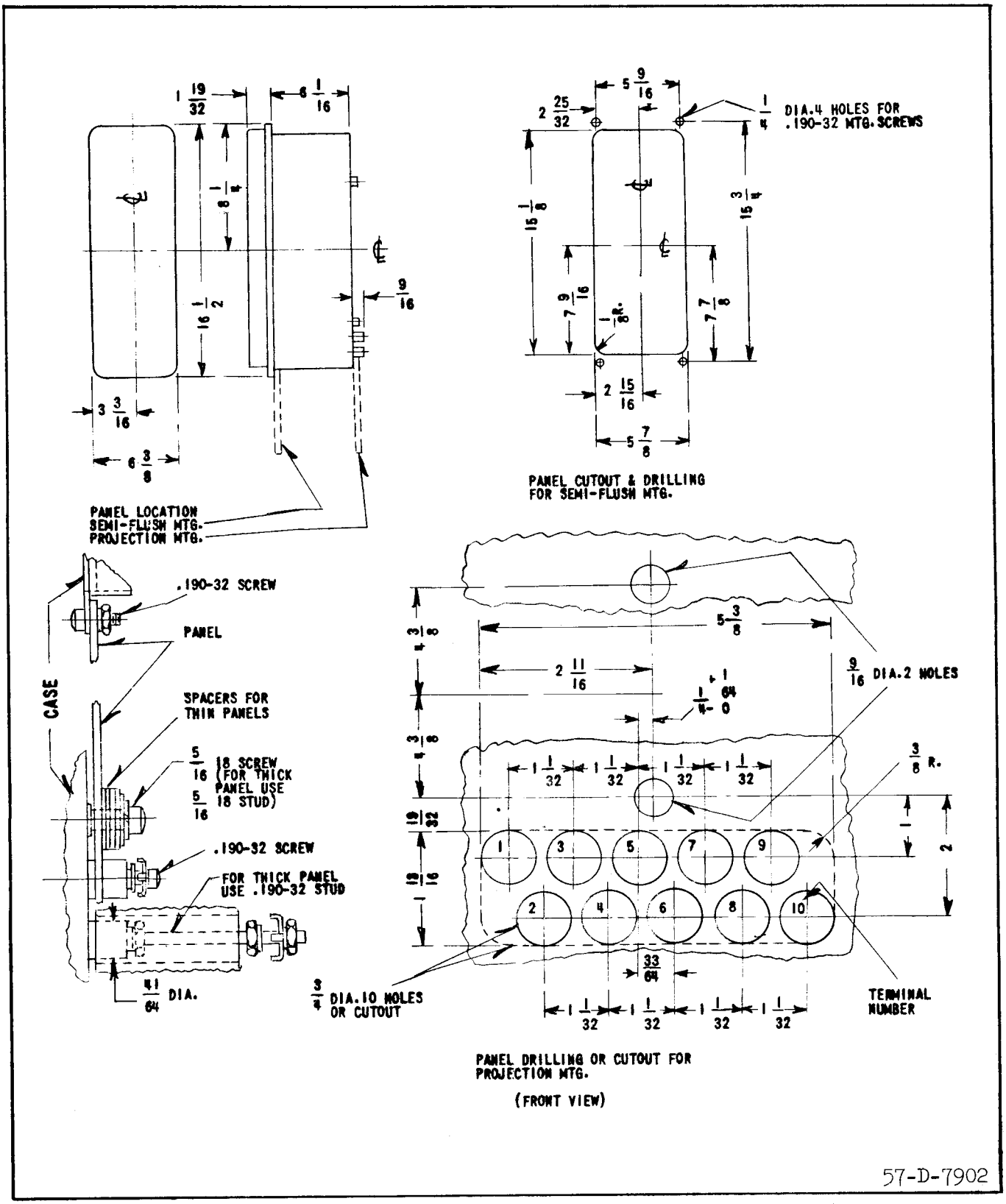


Fig. 7. Outline and Drilling Plan for the Type KRD-4 Relay in the FT31 Case.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

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.

APPLICATION

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

They are also used, without modifications to provide directional ground fault protection in the KD-4 carrier relaying scheme. Operation of the relays in connection with the carrier scheme is fully described in I.L. 41-911.

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 Fig. 1 to 3.

A. DIRECTIONAL UNIT (D)

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

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

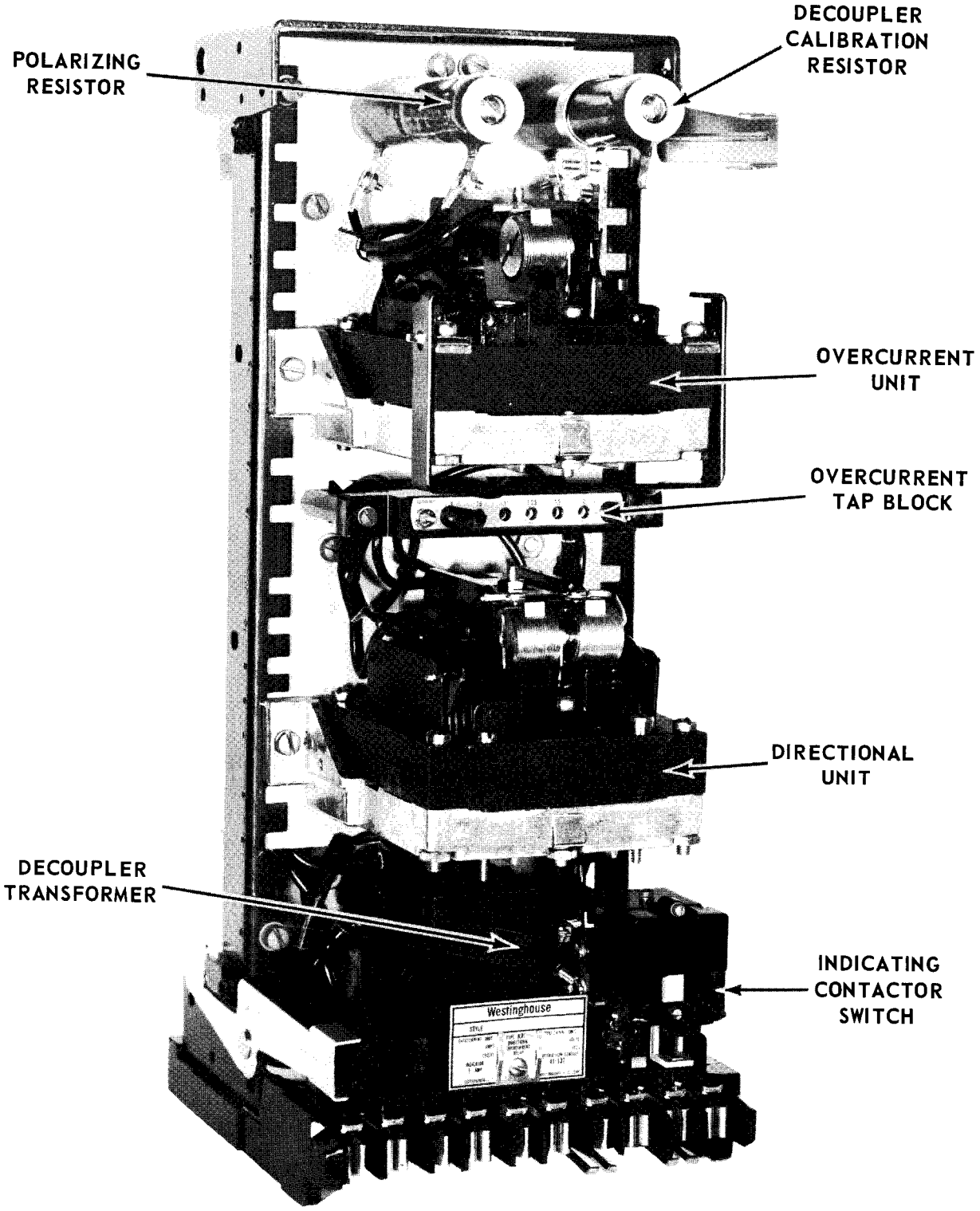


Fig. 1. Type KRD-4 Relay (Front View).

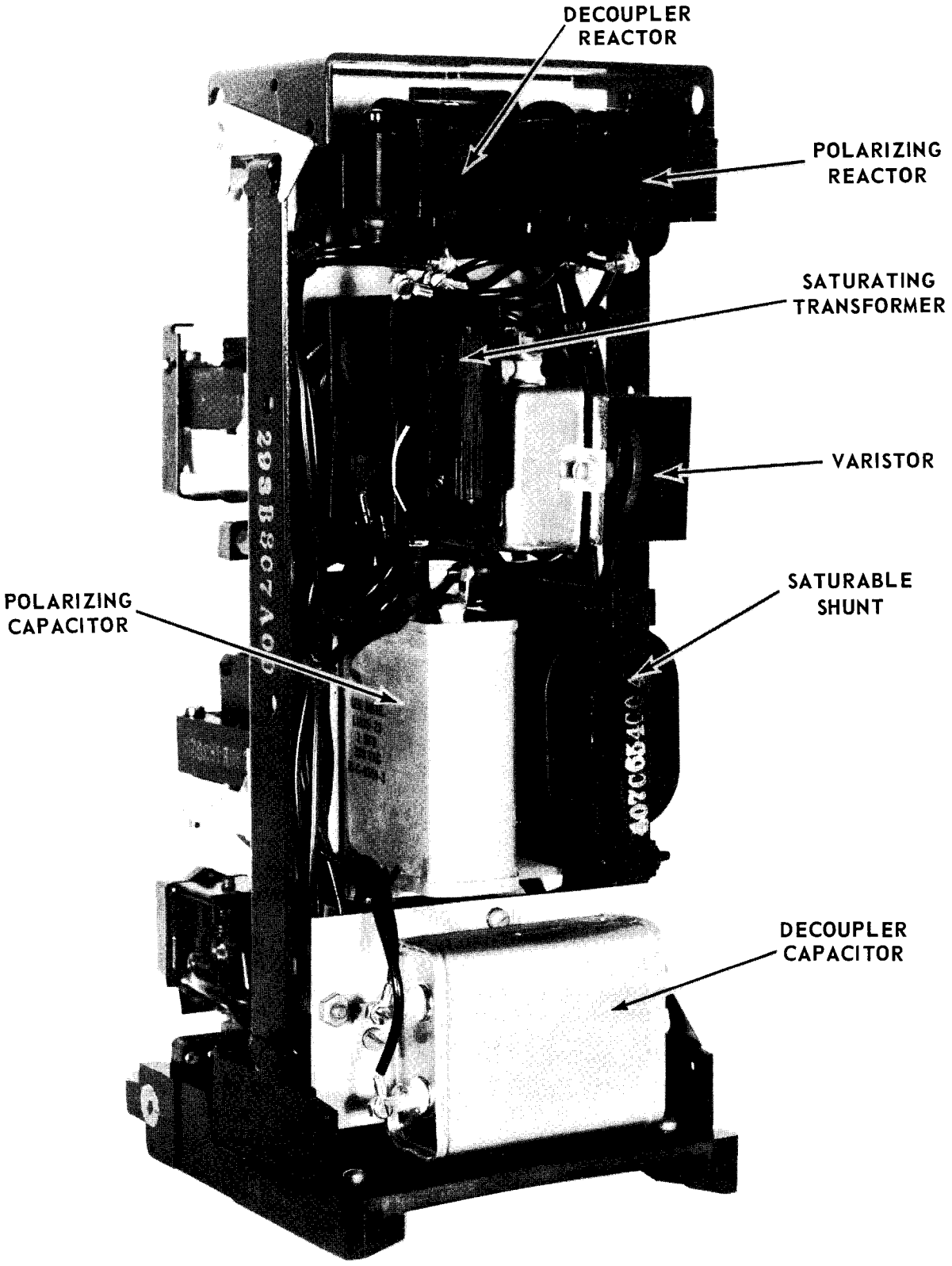


Fig. 2. Type KRD-4 Relay (Rear View).

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.

B. 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.

C. INDICATING CONTACTOR SWITCH (ICS)

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

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.

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 65 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.

TIME CURVES

The time curves for the KRD-4 relay are shown in Fig. 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 voltage 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.

(Example One) definition of symbols are shown on Fig. 5.

let: I_{pol} = 1.5 amp.
I_{op} = 3 amp
tap value (T) = 0.5 amp.
$\emptyset = 0°$

for a current polarized relay:

$$* \quad MPP = \frac{I_{op} I_{pol} \cos \emptyset}{0.25}$$

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

Entering the curves in Fig. 5 at multiples of product pickup of 18 the directional unit opening time is 4 ms, and the closing time for this unit is 33 ms.

For the overcurrent unit:

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

$$= \frac{3}{0.5} = 6$$

Entering the curve in Fig. 6 at multiples of pickup equal to 6 the closing time for the overcurrent is 14 ms. However, the total operating time for the overcurrent unit is 14 plus 4 ms, which is the opening time of back contacts of the directional unit, or 18 ms total operating time for the overcurrent unit. The total operating time for the directional unit is 33 ms; and since this is the longest time, 33 ms is the total operating time of the relay.

(Example Two)

let: I_{pol} = 15 amp
I_{op} = 25 amp
T (tap) = 1 amp.
$\emptyset = 0$

$$MPP = \frac{I_{op} I_{pol} \cos \emptyset}{0.25}$$

$$MPP = 1500$$

referring to Fig. 5 the directional unit closing time is 8 ms, and the opening time of its back contacts is 3 ms. The total operating time for the directional unit is 8 ms.

For the overcurrent unit:

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

$$= 25$$

referring to Fig. 6 the overcurrent unit contact closing time is 10 ms. Therefore, the total operating time for this unit is 10 + 3 ms or 13 ms. In this case the total operating time of the relay is 13 ms.

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 a pickup of approximately 1 ampere. Its d-c resistance is 0.1 ohms.

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 I

DIRECTIONAL UNIT SENSITIVITY

Polarizing Quantity	Values for Min. Pickup		Phase Angle Relationship
	Volts	Amperes	
VOLTAGE	1	0.7	I lagging V by 65°
	1	1.5	I In Phase with V
CURRENT		0.5	In-phase

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

TABLE II

DIRECTIONAL UNIT CALIBRATION

Relay Rating	Current Amperes	Both Plugs In Condition	Adjustment
All Ranges	80	Spurious torque in contact closing direction (left front view)	Right (front view Plug Screwed out until spurious torque is reversed.
All Ranges	80	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 directions. Then the plug is screwed in until spurious torque is reversed.

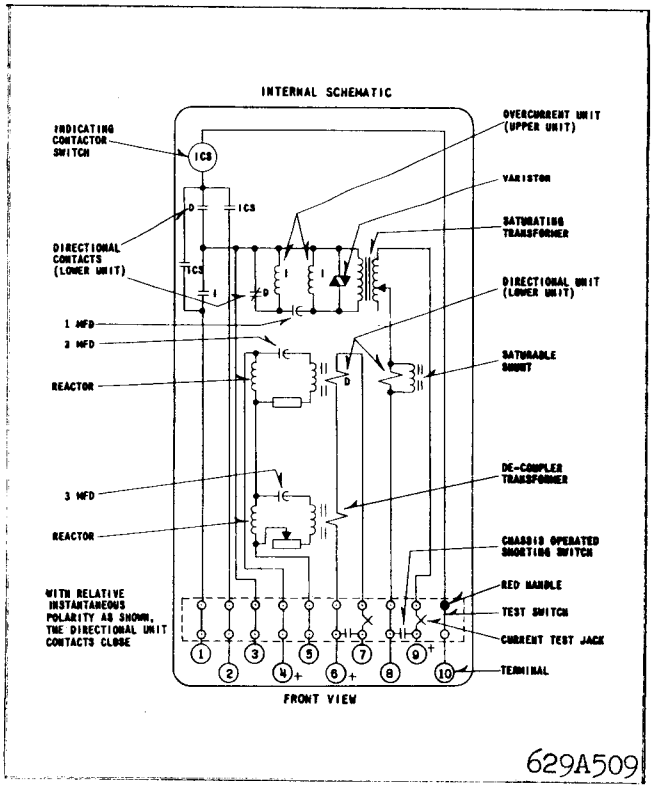


Fig. 3. Internal Schematic of the Type KRD-4 Relay in the Type FT31 Case.

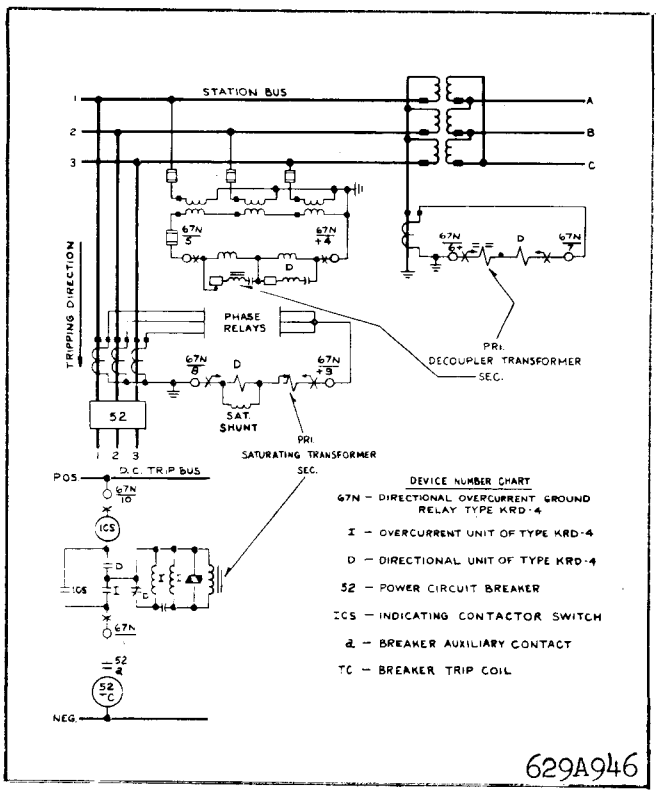


Fig. 4. External Schematic for the Type KRD-4 Relay.

SETTINGS

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 pick-up 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 unit 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: 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 the 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 CYCLES

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.

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 be between 1 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 adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

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.

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").

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 pick up of the overcurrent unit with the tap screw in any other tap should be within ±5% of tap value.

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 in 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 terterminals 8 and 9 with all other terminals open circuited. Adjust core such that the contacts remain open. The core can be adjusted by the 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 all other terminals open circuited. Plug adjustment is then made per Table II 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.

Indicating Contact Switch (ICS)

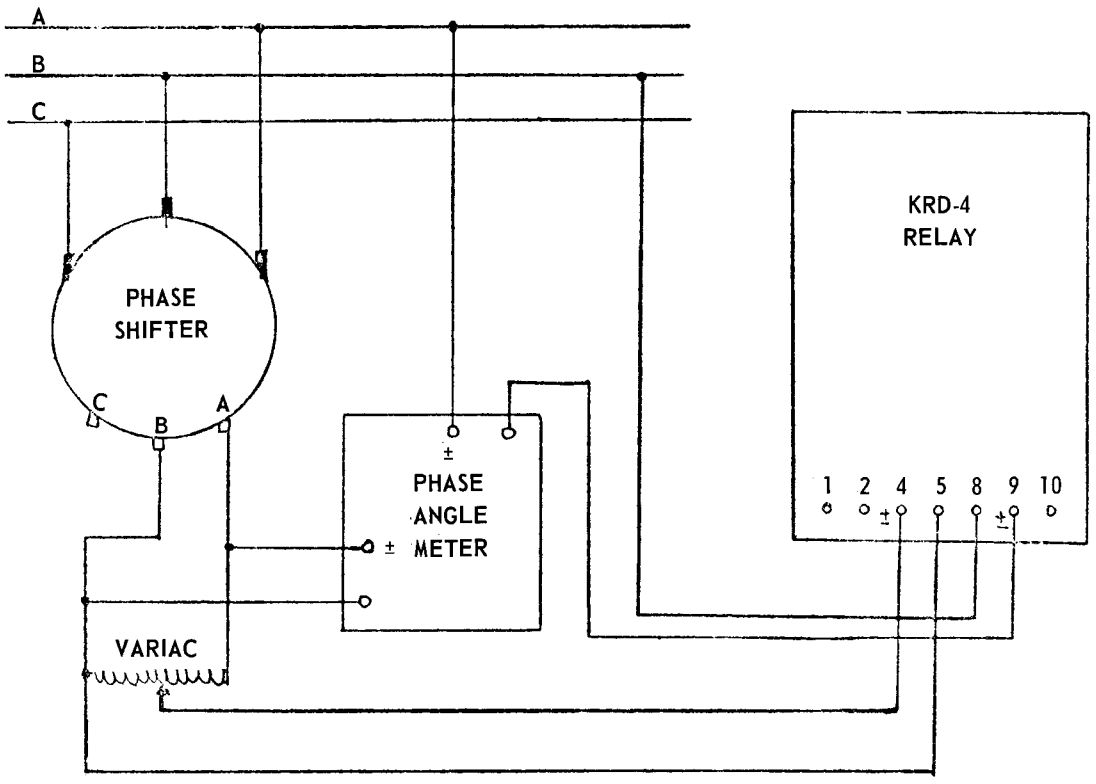
Adjust the contact gap for approximately 5/64" (-1/64", +0).

Close the main relay contacts and check to see that the relays pick up and the target drops between 1 and 1.2 amperes 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 the complete nameplate data.

KRD-4 RELAY
TEST CIRCUIT



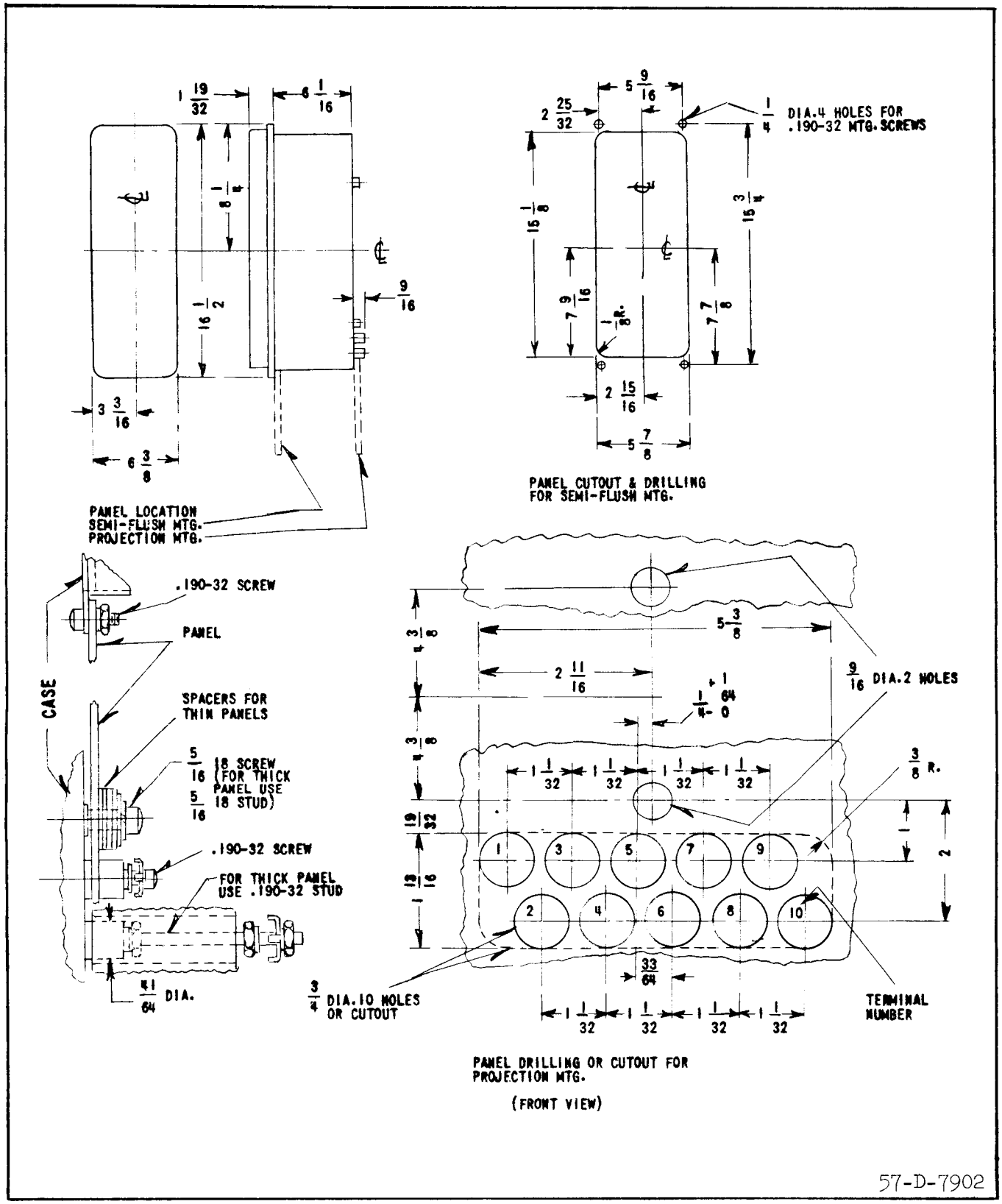


Fig. 7. Outline and Drilling Plan for the Type KRD-4 Relay in the FT31 Case.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

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.

APPLICATION

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

They are also used, without modifications to provide directional ground fault protection in the KD-4 carrier relaying scheme. Operation of the relays in connection with the carrier scheme is fully described in I.L. 41-911.

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 Fig. 1 to 3.

A. DIRECTIONAL UNIT (D)

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

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

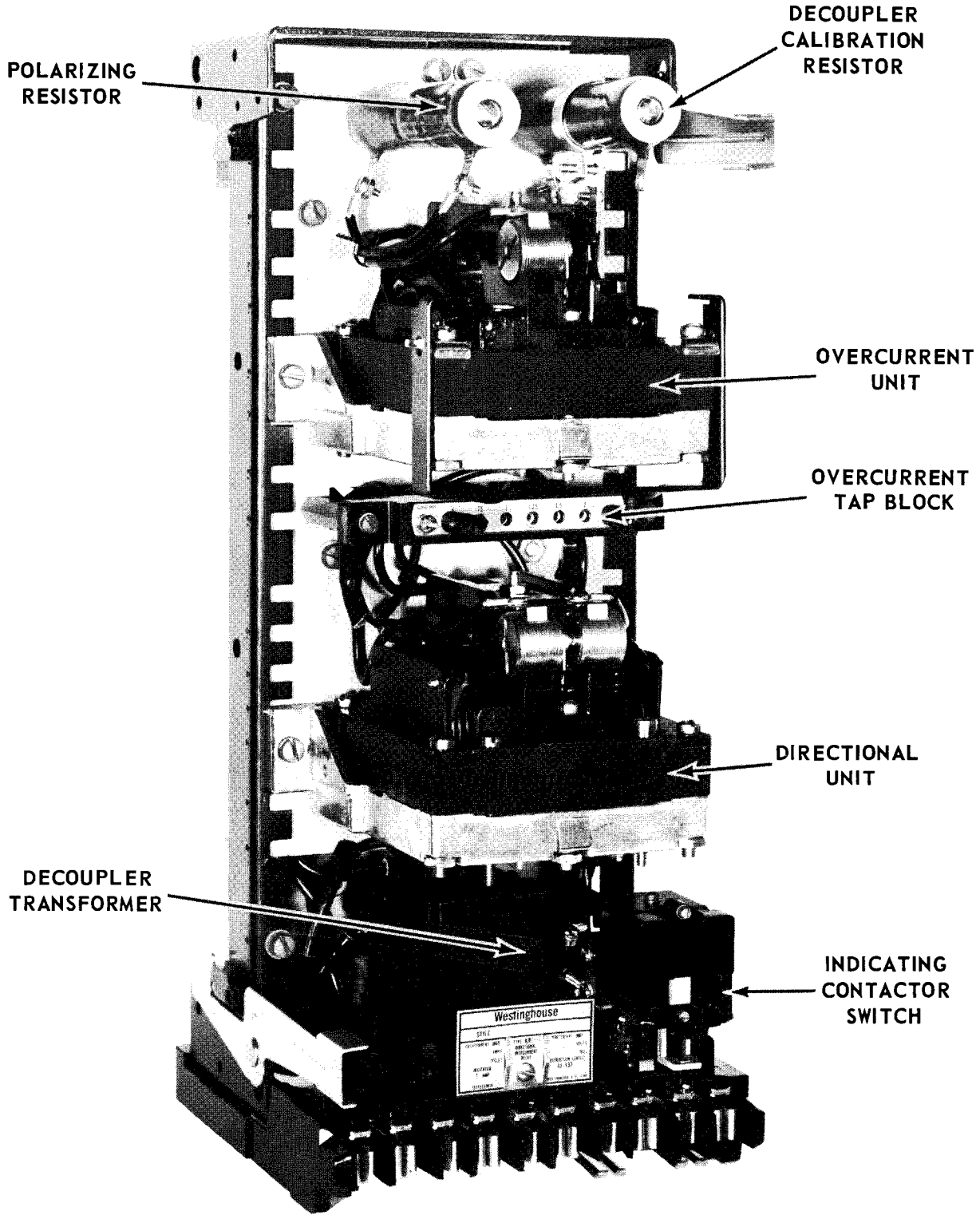


Fig. 1. Type KRD-4 Relay (Front View).

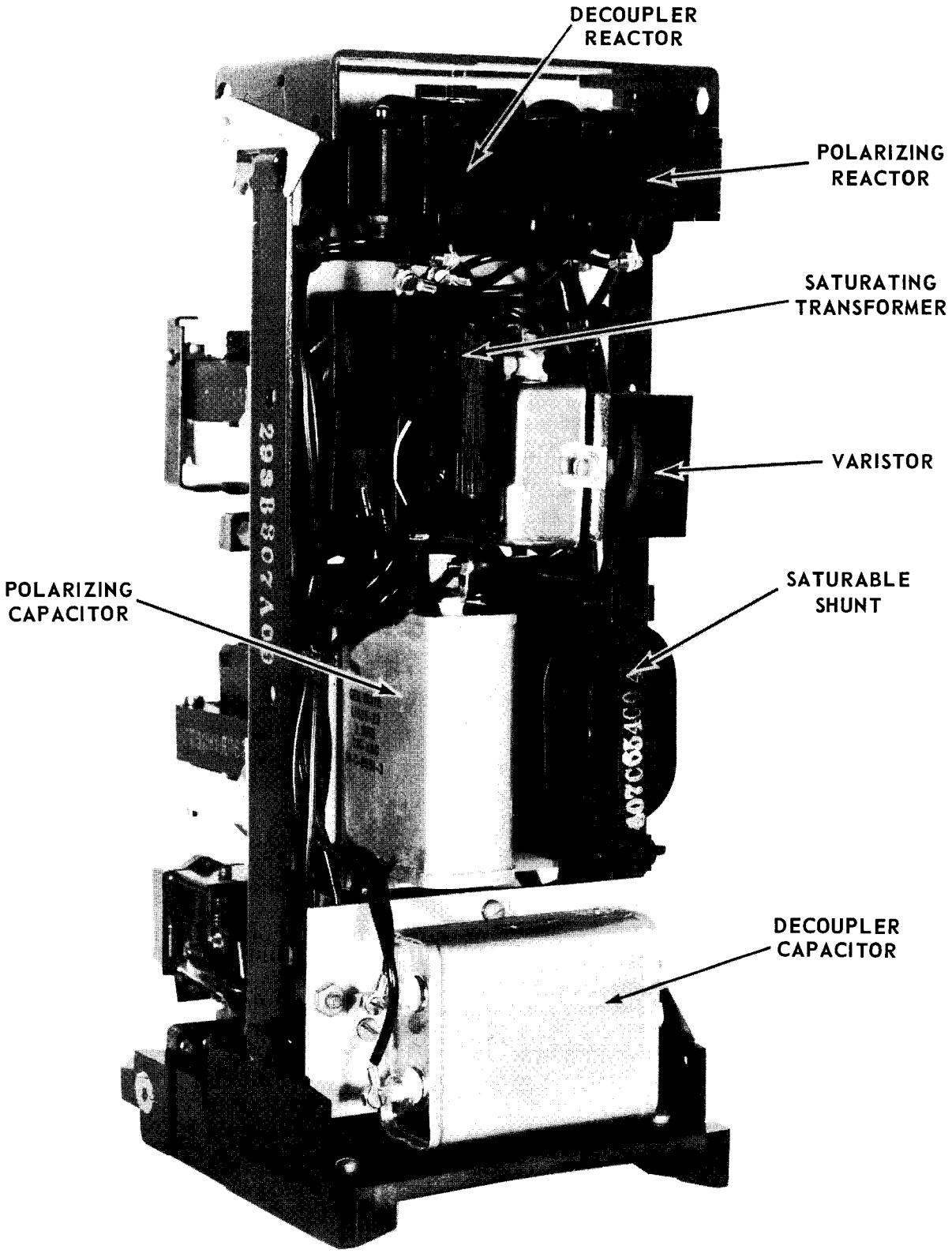


Fig. 2. Type KRD-4 Relay (Rear View).

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.

B. 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.

C. INDICATING CONTACTOR SWITCH (ICS)

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

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.

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 65 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.

TIME CURVES

The time curves for the KRD-4 relay are shown in Fig. 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 voltage 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.

(Example One) definition of symbols are shown on Fig. 5.

let: I_{pol} = 1.5 amp.

I_{op} = 3 amp

tap value (T) = 0.5 amp.

$\emptyset = 0°$

for a current polarized relay:

$$* \quad MPP = \frac{I_{op} I_{pol} \cos \emptyset}{0.25}$$

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

Entering the curves in Fig. 5 at multiples of product pickup of 18 the directional unit opening time is 4 ms, and the closing time for this unit is 33 ms.

For the overcurrent unit:

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

$$= \frac{3}{0.5} = 6$$

Entering the curve in Fig. 6 at multiples of pickup equal to 6 the closing time for the overcurrent is 14 ms. However, the total operating time for the overcurrent unit is 14 plus 4 ms, which is the opening time of back contacts of the directional unit, or 18 ms total operating time for the overcurrent unit. The total operating time for the directional unit is 33 ms; and since this is the longest time, 33 ms is the total operating time of the relay.

(Example Two)

let: I_{pol} = 15 amp

I_{op} = 25 amp

T (tap) = 1 amp.

$\emptyset = 0$

$$MPP = \frac{I_{op} I_{pol} \cos \emptyset}{0.25}$$

$$MPP = 1500$$

referring to Fig. 5 the directional unit closing time is 8 ms, and the opening time of its back contacts is 3 ms. The total operating time for the directional unit is 8 ms.

For the overcurrent unit:

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

$$= 25$$

referring to Fig. 6 the overcurrent unit contact closing time is 10 ms. Therefore, the total operating time for this unit is 10 + 3 ms or 13 ms. In this case the total operating time of the relay is 13 ms.

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 a pickup of approximately 1 ampere. Its d-c resistance is 0.1 ohms.

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 I

DIRECTIONAL UNIT SENSITIVITY

Polarizing Quantity	Values for Min. Pickup		Phase Angle Relationship
	Volts	Amperes	
VOLTAGE	1	0.7	I lagging V by 65°
	1	1.5	I In Phase with V
CURRENT		0.5	In-phase

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

TABLE II

DIRECTIONAL UNIT CALIBRATION

Relay Rating	Current Amperes	Both Plugs In Condition	Adjustment
All Ranges	80	Spurious torque in contact closing direction (left front view)	Right (front view Plug Screwed out until spurious torque is reversed.
All Ranges	80	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 directions. Then the plug is screwed in until spurious torque is reversed.

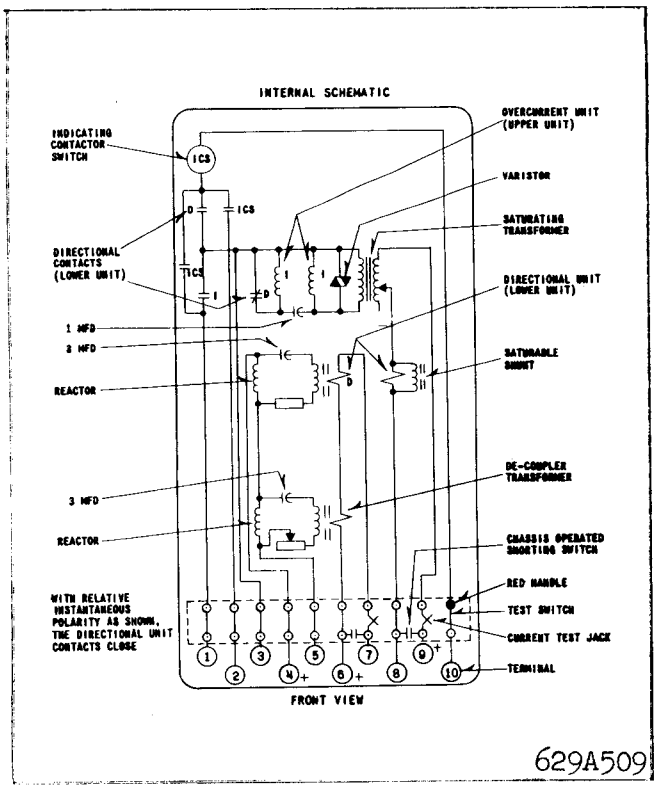


Fig. 3. Internal Schematic of the Type KRD-4 Relay in the Type FT31 Case.

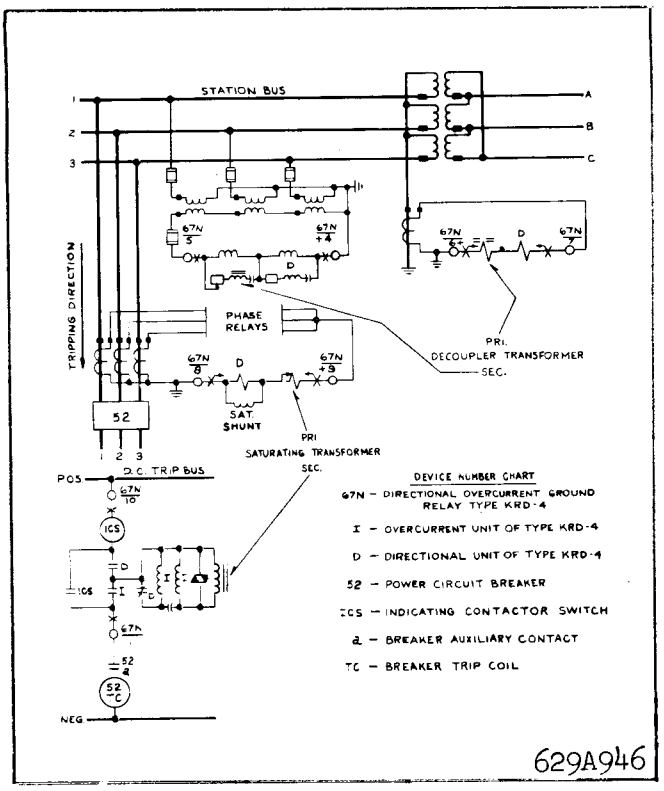


Fig. 4. External Schematic for the Type KRD-4 Relay.

SETTINGS

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 pick-up 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 unit 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: 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 the 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 CYCLES

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.

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 be between 1 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 adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

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.

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").

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 pick up of the overcurrent unit with the tap screw in any other tap should be within ±5% of tap value.

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 in 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 terterminals 8 and 9 with all other terminals open circuited. Adjust core such that the contacts remain open. The core can be adjusted by the 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 all other terminals open circuited. Plug adjustment is then made per Table II 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.

Indicating Contact Switch (ICS)

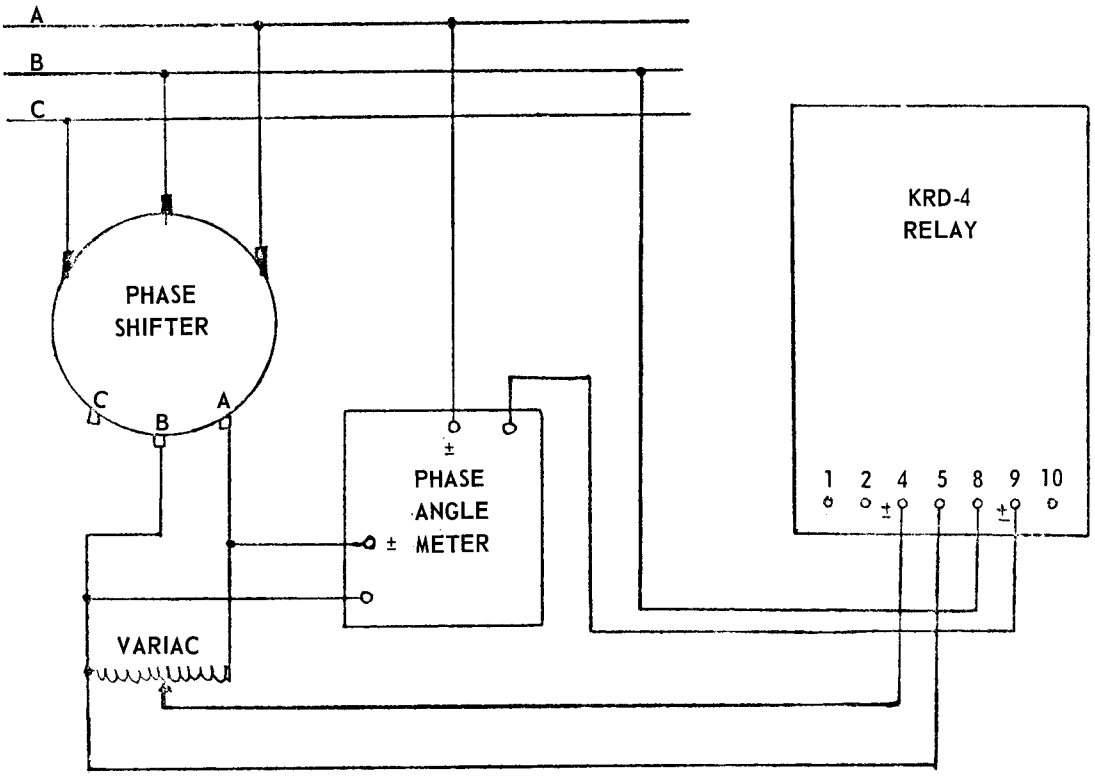
Adjust the contact gap for approximately 5/64'' (-1/64'', +0).

Close the main relay contacts and check to see that the relays pick up and the target drops between 1 and 1.2 amperes 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 the complete nameplate data.

KRD-4 RELAY
TEST CIRCUIT



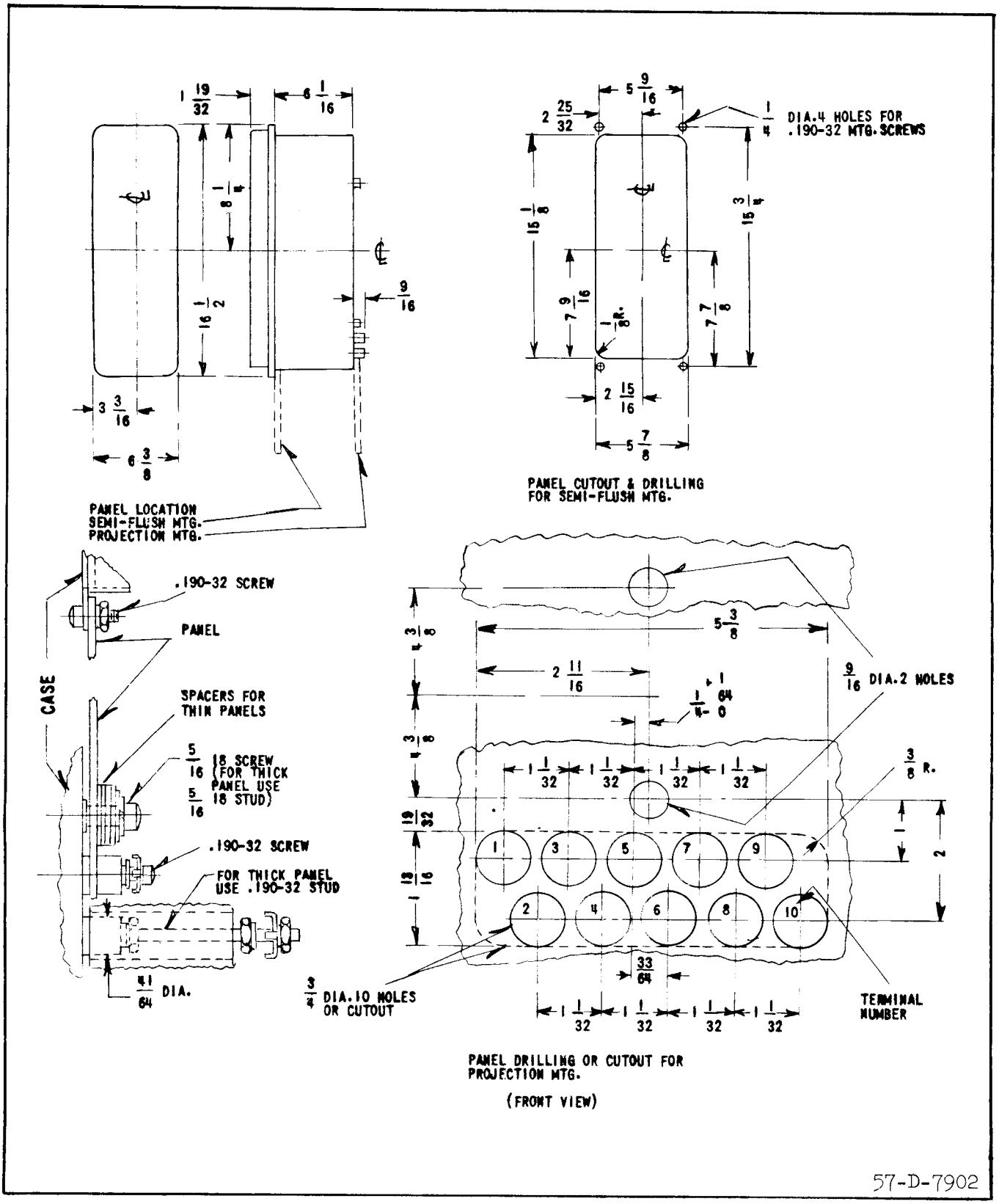


Fig. 7. Outline and Drilling Plan for the Type KRD-4 Relay in the FT31 Case.

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INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

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.

APPLICATION

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

They are also used, without modifications to provide directional ground fault protection in the KD-4 carrier relaying scheme. Operation of the relays in connection with the carrier scheme is fully described in I.L. 41-911.

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 Fig. 1 to 3.

A. DIRECTIONAL UNIT (D)

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

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

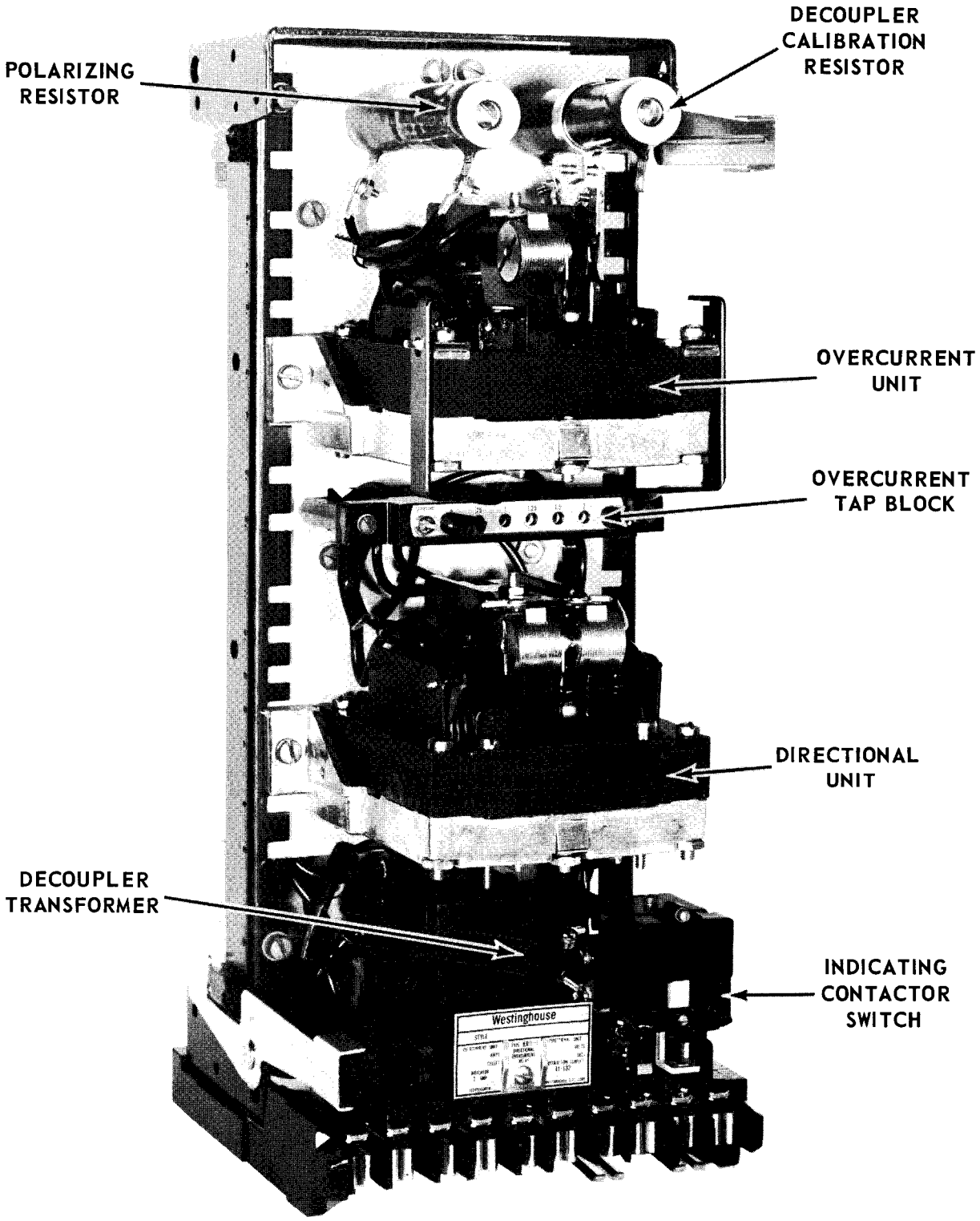


Fig. 1. Type KRD-4 Relay (Front View).

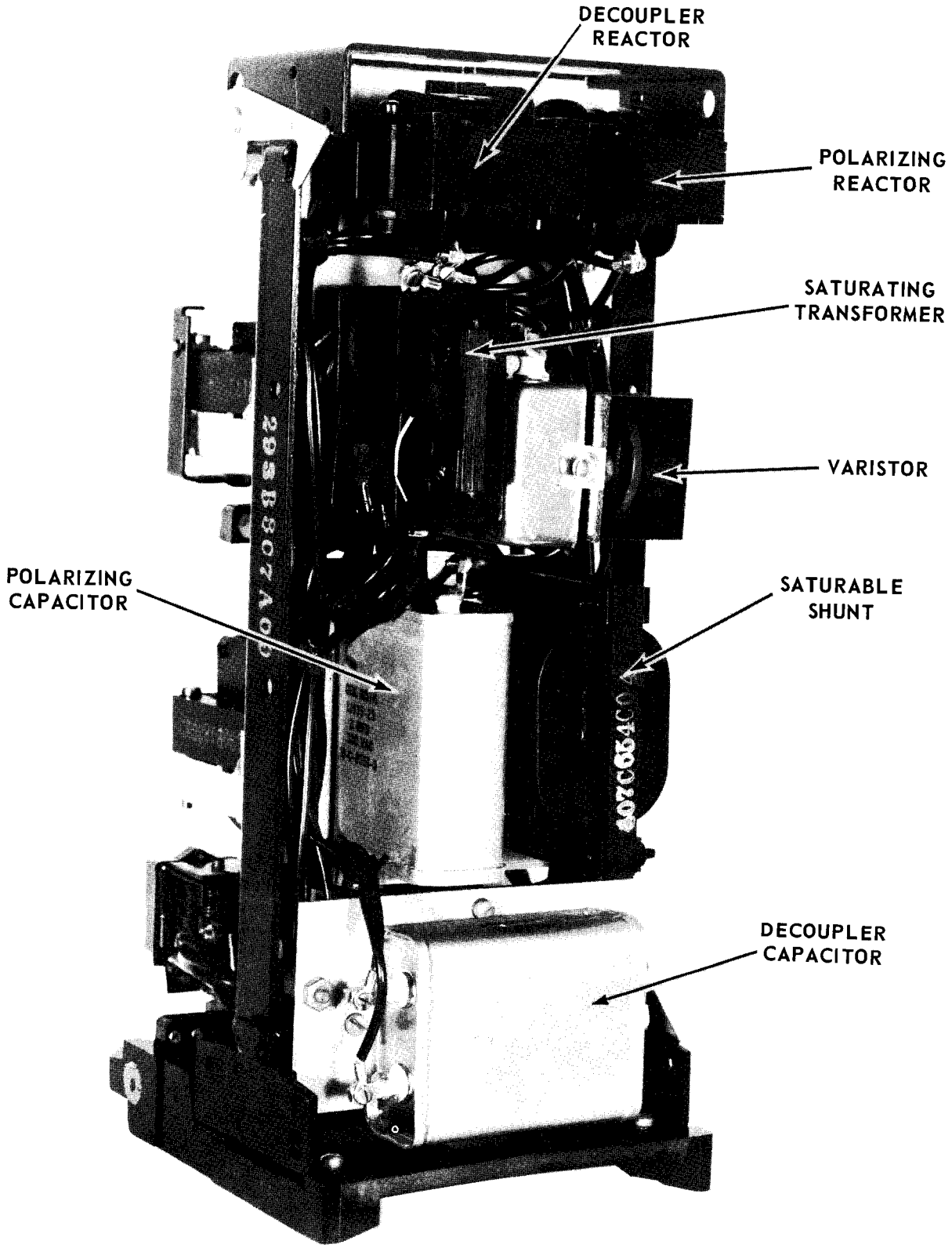


Fig. 2. Type KRD-4 Relay (Rear View).

* TABLE I

DIRECTIONAL UNIT SENSITIVITY

Polarizing Quantity	Values for Min. Pickup		Phase Angle Relationship
	Volts	Amperes	
VOLTAGE	1	0.7 ★	I lagging V by 65°
	1	1.5 ★	I In Phase with V
CURRENT		0.5 ★	In-phase

★ or less

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

TABLE II

DIRECTIONAL UNIT CALIBRATION

Relay Rating	Current Amperes	Both Plugs In Condition	Adjustment
All Ranges	80	Spurious torque in contact closing direction (left front view)	Right (front view Plug Screwed out until spurious torque is reversed.
All Ranges	80	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 directions. Then the plug is screwed in until spurious torque is reversed.

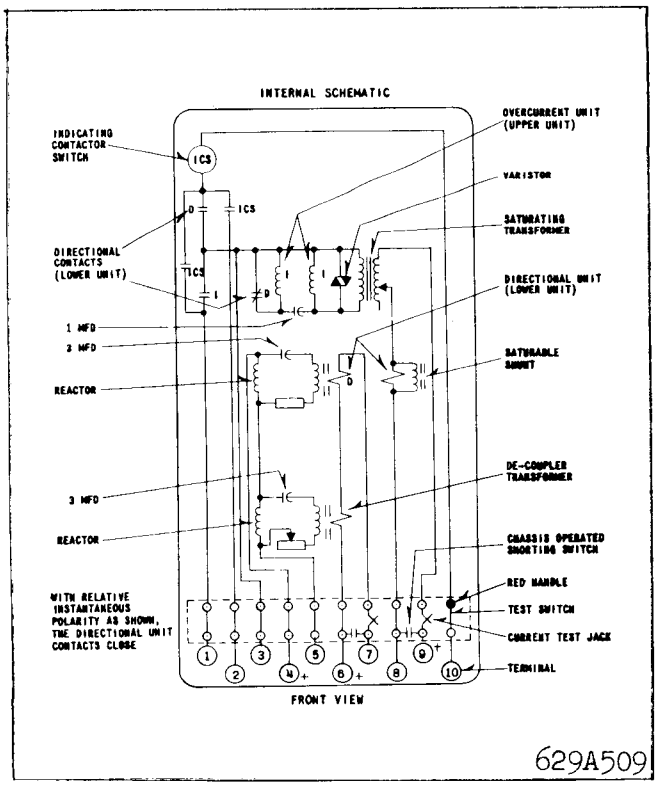


Fig. 3. Internal Schematic of the Type KRD-4 Relay in the Type FT31 Case.

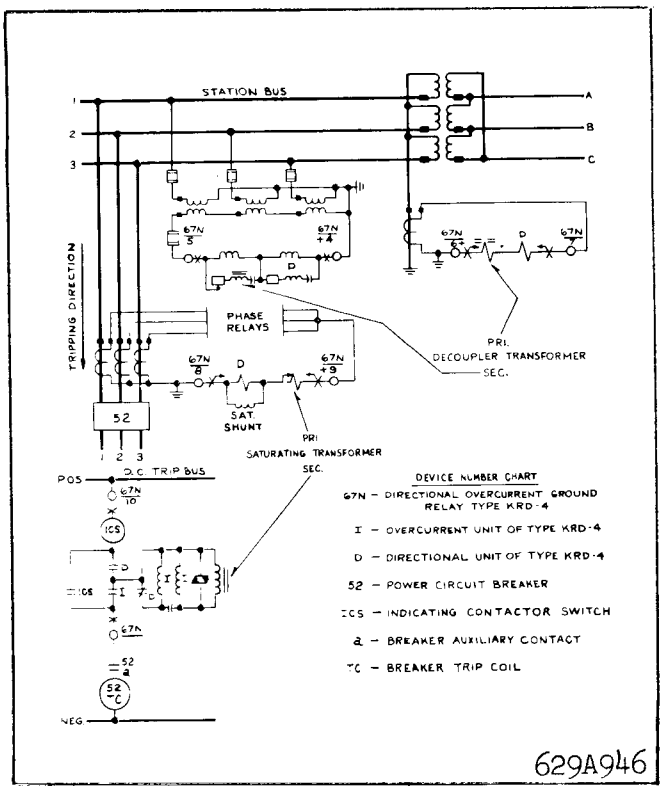


Fig. 4. External Schematic for the Type KRD-4 Relay.

SETTINGS

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 pick-up 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 unit 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: 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 the 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 CYCLES

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 △	POWER FACTOR ANGLE Ø
Current	230†† amperes	1.20	3° Lag
Voltage	208††† volts	21.0	28° Lead

Ø Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.

△ 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.

Directional Unit (D)

No setting is required.

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 holes on 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 I.L. 41-076.

ADJUSTMENTS AND MAINTENANCE

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

Acceptance Check

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

Overcurrent Unit (I)

1. Contact Gap - The gap between the stationary and moving contacts with the relay in the de-energized position should be approximately .020."
2. Minimum Trip Current - The normally-closed contact of the directional unit should be blocked open when checking the pick-up of the overcurrent unit.

   The pick-up 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.

Directional Unit (D)

1. Contact Gap - The gap between the stationary contact and moving contact with the relay in the de-energized 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.

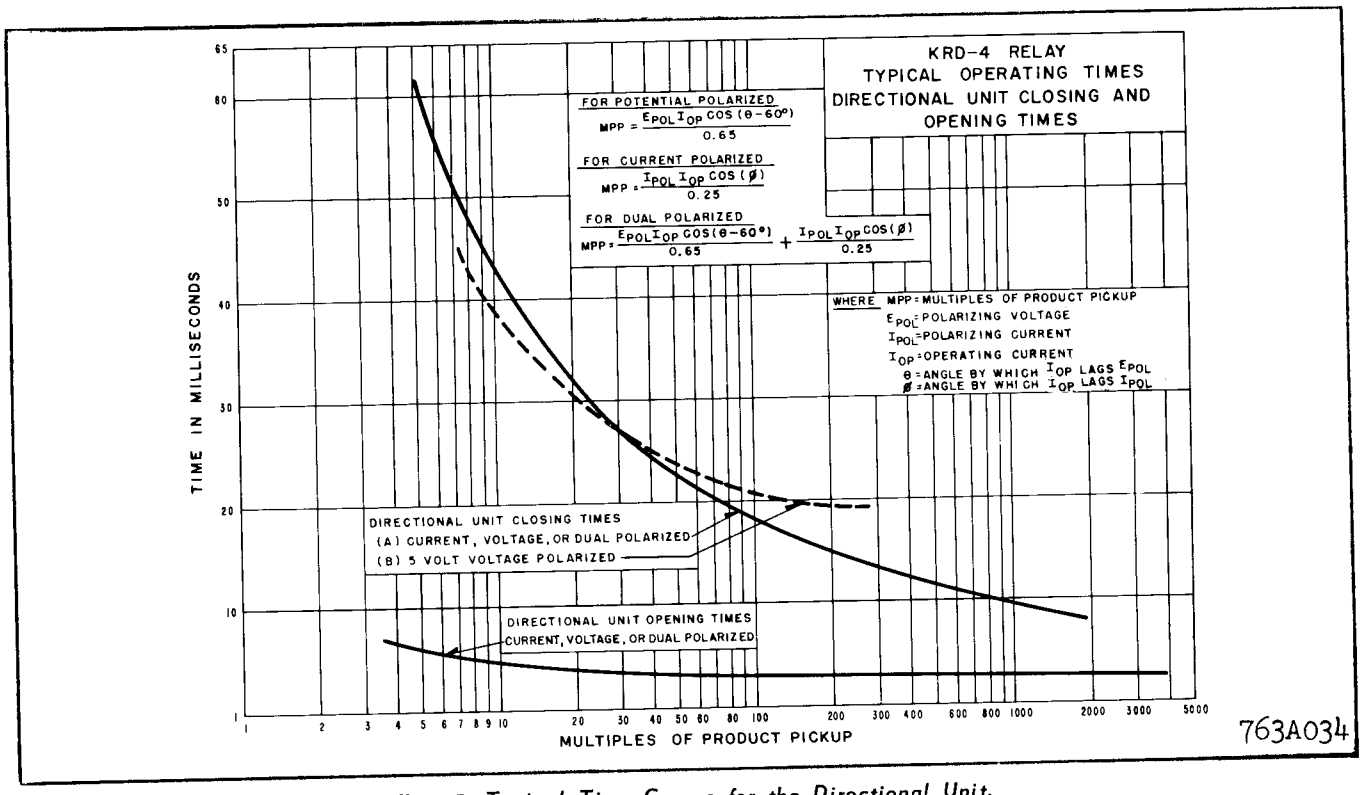


Fig. 5. Typical Time Curves for the Directional Unit.

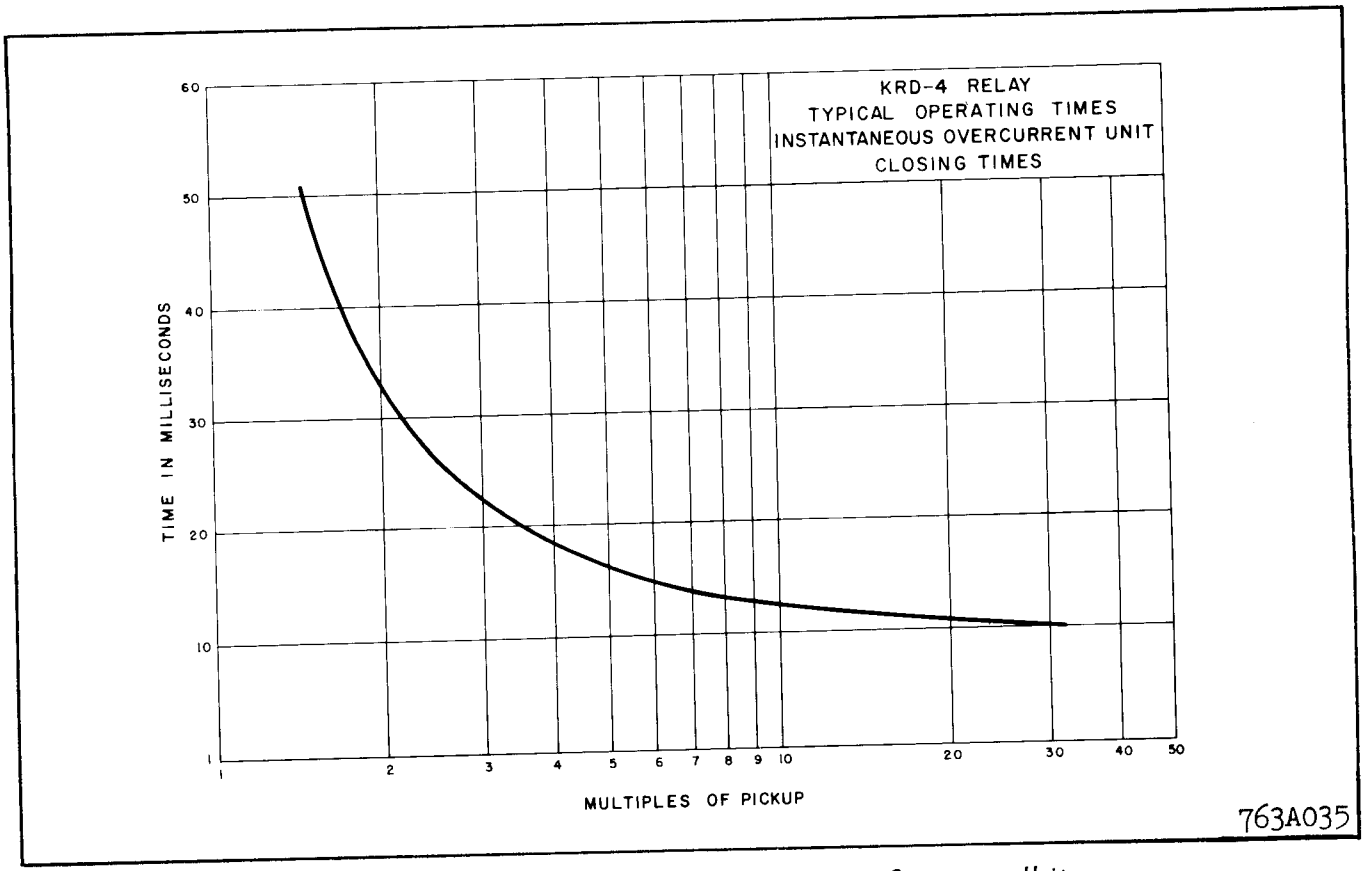


Fig. 6. Typical Time Curves for the Instantaneous Overcurrent Unit.

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 be between 1 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 adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

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.

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").

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 pick up of the overcurrent unit with the tap screw in any other tap should be within ±5% of tap value.

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 in 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 terterminals 8 and 9 with all other terminals open circuited. Adjust core such that the contacts remain open. The core can be adjusted by the 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 all other terminals open circuited. Plug adjustment is then made per Table II 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.

Indicating Contact Switch (ICS)

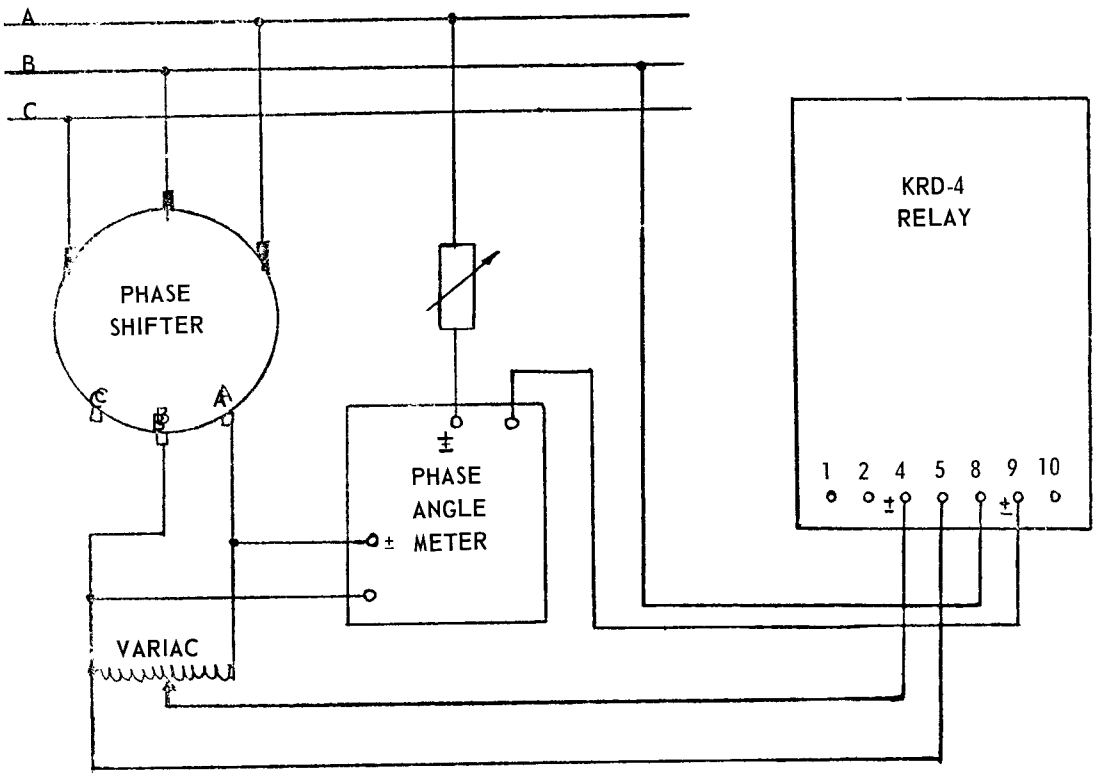
Adjust the contact gap for approximately 5/64'' (-1/64'', +0).

Close the main relay contacts and check to see that the relays pick up and the target drops between 1 and 1.2 amperes 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 the complete nameplate data.

KRD-4 RELAY
TEST CIRCUIT



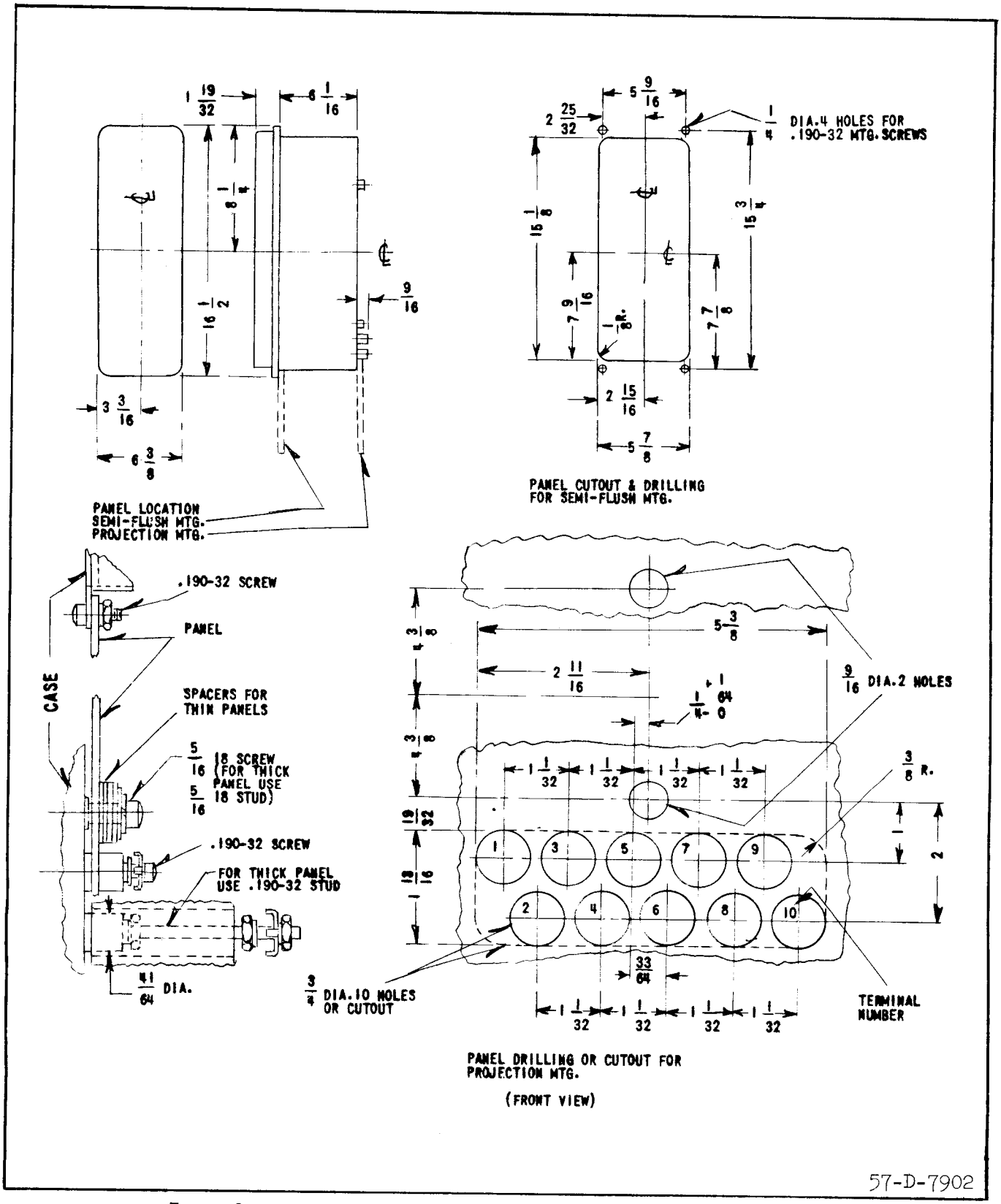


Fig. 7. Outline and Drilling Plan for the Type KRD-4 Relay in the FT31 Case.

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INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

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.

APPLICATION

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

They are also used, without modifications to provide directional ground fault protection in the KD-4 carrier relaying scheme. Operation of the relays in connection with the carrier scheme is fully described in I.L. 41-911.

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 Fig. 1 to 3.

A. DIRECTIONAL UNIT (D)

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

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

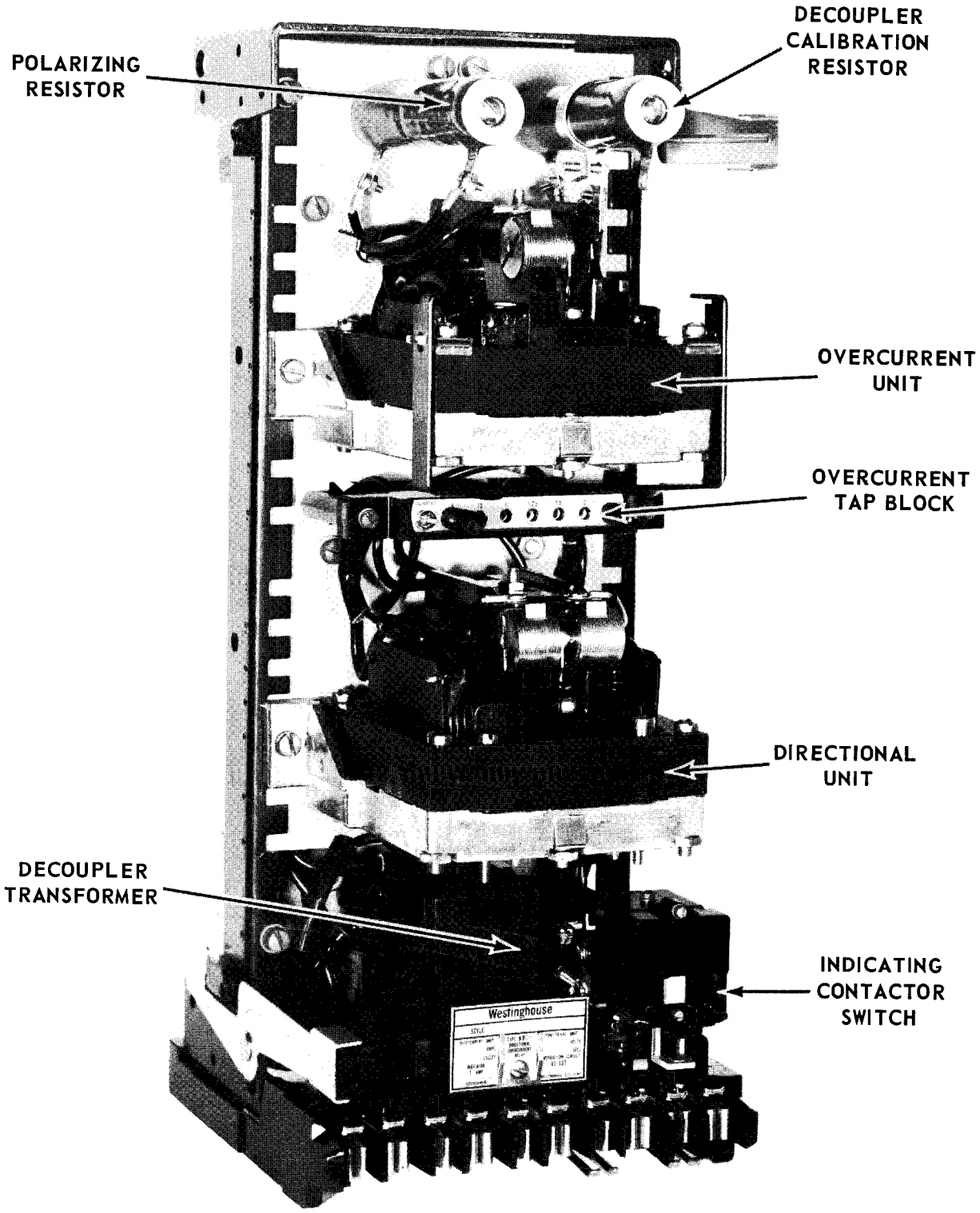


Fig. 1. Type KRD-4 Relay (Front View).

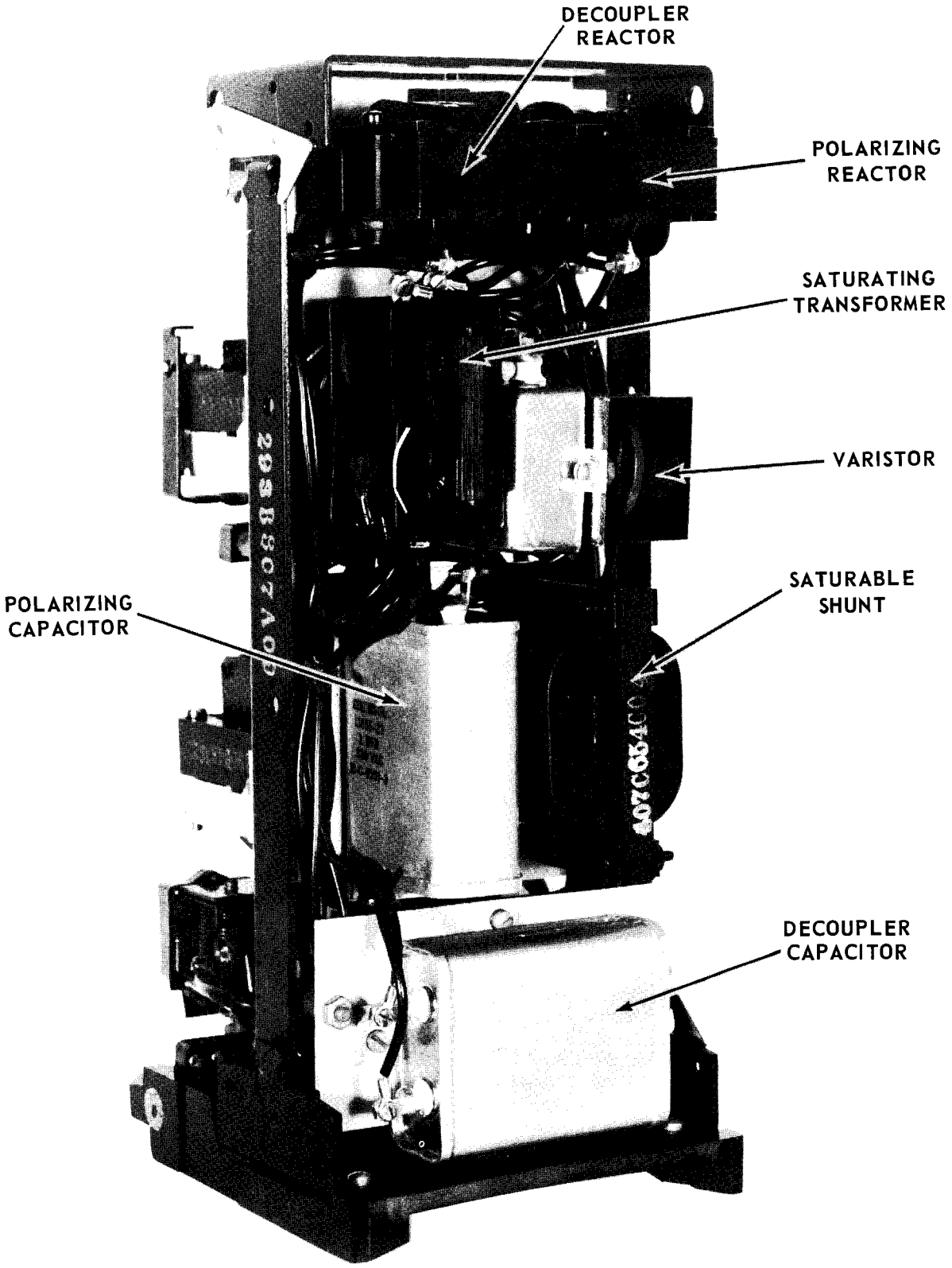


Fig. 2. Type KRD-4 Relay (Rear View).

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.

B. 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.

C. INDICATING CONTACTOR SWITCH (ICS)

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

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.

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 65 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.

TIME CURVES

The time curves for the KRD-4 relay are shown in Fig. 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 voltage 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.

(Example One) definition of symbols are shown on Fig. 5.

let: I_{pol} = 1.5 amp.
I_{op} = 3 amp
tap value (T) = 0.5 amp.
$\phi = 0°$

for a current polarized relay:

$$MPP = \frac{I_{op} I_{pol} \cos \phi}{0.25}$$

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

Entering the curves in Fig. 5 at multiples of product pickup of 18 the directional unit opening time is 4 ms, and the closing time for this unit is 33 ms.

For the overcurrent unit:

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

$$= \frac{3}{0.5} = 6$$

Entering the curve in Fig. 6 at multiples of pickup equal to 6 the closing time for the overcurrent is 14 ms. However, the total operating time for the overcurrent unit is 14 plus 4 ms, which is the opening time of back contacts of the directional unit, or 18 ms total operating time for the overcurrent unit. The total operating time for the directional unit is 33 ms; and since this is the longest time, 33 ms is the total operating time of the relay.

(Example Two)

let: I_{pol} = 15 amp
I_{op} = 25 amp
T (tap) = 1 amp.
$\phi = 0$

$$MPP = \frac{I_{op} I_{pol} \cos \phi}{0.25}$$

$$MPP = 1500$$

referring to Fig. 5 the directional unit closing time is 8 ms, and the opening time of its back contacts is 3 ms. The total operating time for the directional unit is 8 ms.

For the overcurrent unit:

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

$$= 25$$

referring to Fig. 6 the overcurrent unit contact closing time is 10 ms. Therefore, the total operating time for this unit is 10 + 3 ms or 13 ms. In this case the total operating time of the relay is 13 ms.

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 a pickup of approximately 1 ampere. Its d-c resistance is 0.1 ohms.

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 I

DIRECTIONAL UNIT SENSITIVITY

Polarizing Quantity	Values for Min. Pickup		Phase Angle Relationship
	Volts	Amperes	
VOLTAGE	1	0.7 ★	I lagging V by 65°
	1	1.5 ★	I In Phase with V
CURRENT		0.5 ★	In-phase

★ or less

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

TABLE II

DIRECTIONAL UNIT CALIBRATION

Relay Rating	Current Amperes	Both Plugs In Condition	Adjustment
All Ranges	80	Spurious torque in contact closing direction (left front view)	Right (front view Plug Screwed out until spurious torque is reversed.
All Ranges	80	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 directions. Then the plug is screwed in until spurious torque is reversed.

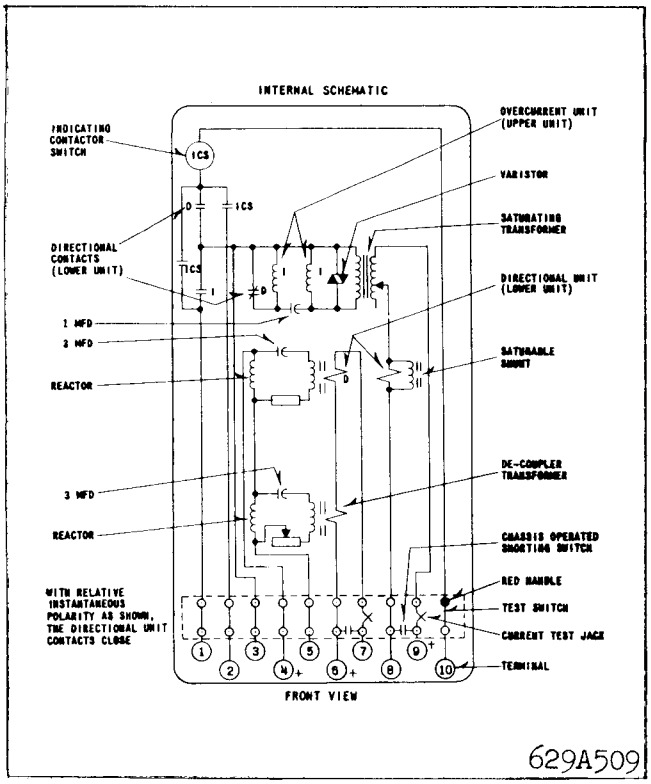


Fig. 3. Internal Schematic of the Type KRD-4 Relay in the Type FT31 Case.

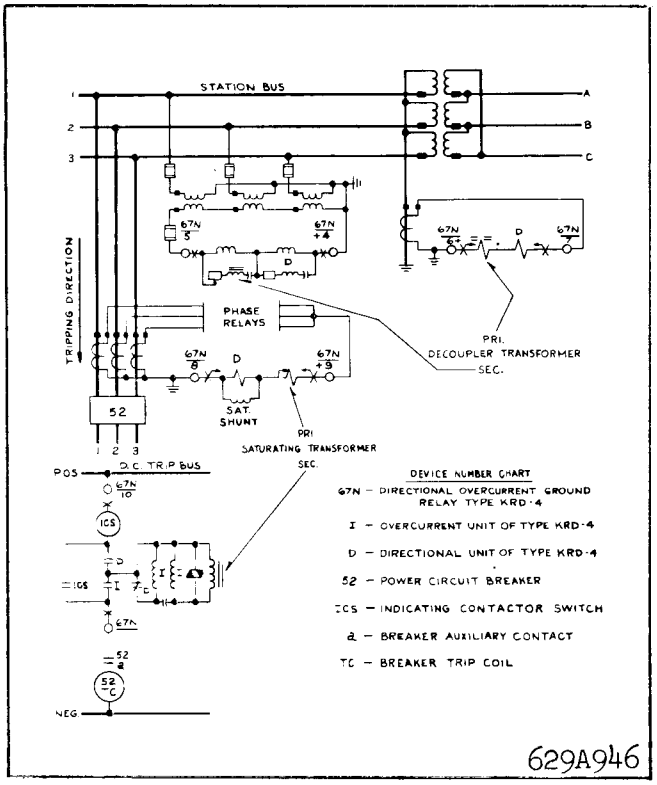


Fig. 4. External Schematic for the Type KRD-4 Relay.

SETTINGS

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 pick-up 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 unit 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: 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 the 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 CYCLES

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△	POWER FACTOR ANGLE Ø
Current	230†† amperes	1.20	3° Lag
Voltage	208††† volts	21.0	28° Lead

Ø Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.

△ 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.

Directional Unit (D)

No setting is required.

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 holes on 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 I.L. 41-076.

ADJUSTMENTS AND MAINTENANCE

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

Acceptance Check

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

Overcurrent Unit (I)

1. Contact Gap - The gap between the stationary and moving contacts with the relay in the de-energized position should be approximately .020."
2. Minimum Trip Current - The normally-closed contact of the directional unit should be blocked open when checking the pick-up of the overcurrent unit.

   The pick-up 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.

Directional Unit (D)

1. Contact Gap - The gap between the stationary contact and moving contact with the relay in the de-energized 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.

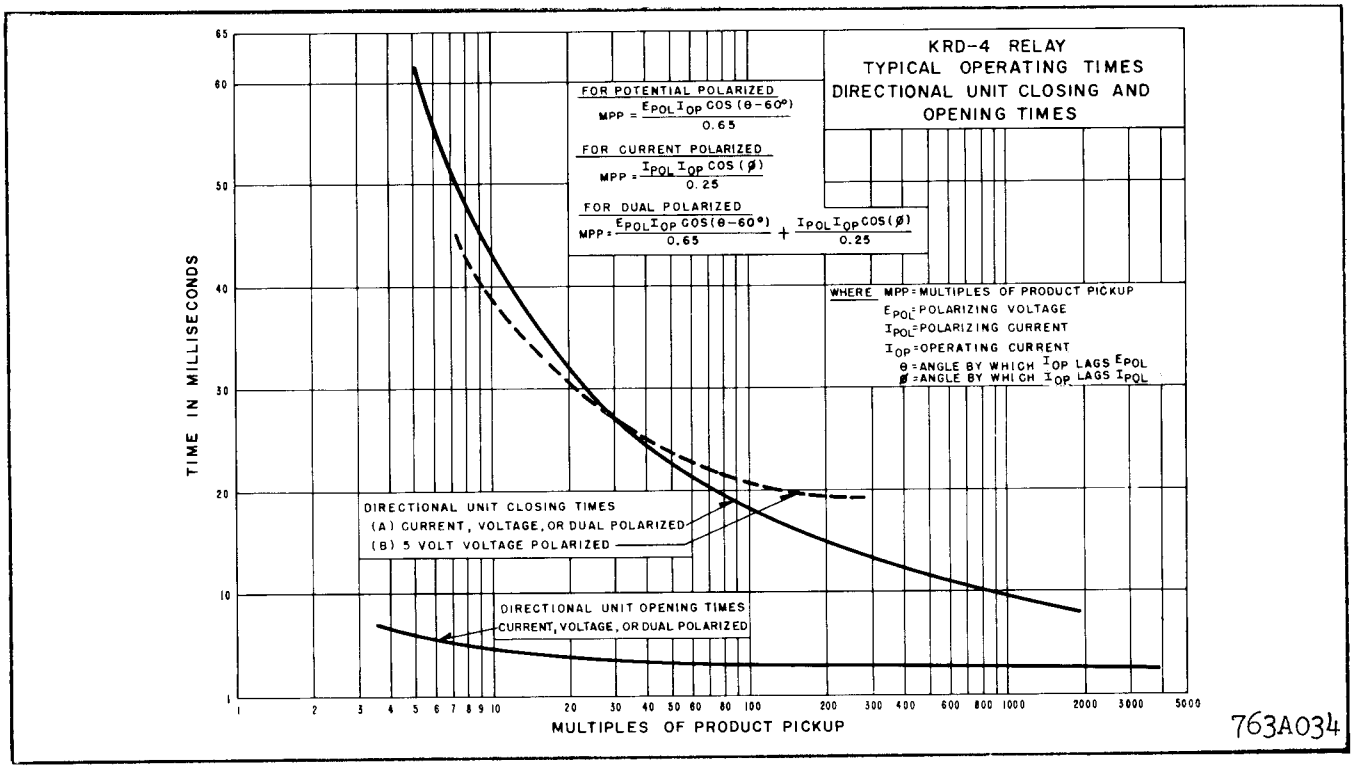


Fig. 5. Typical Time Curves for the Directional Unit.

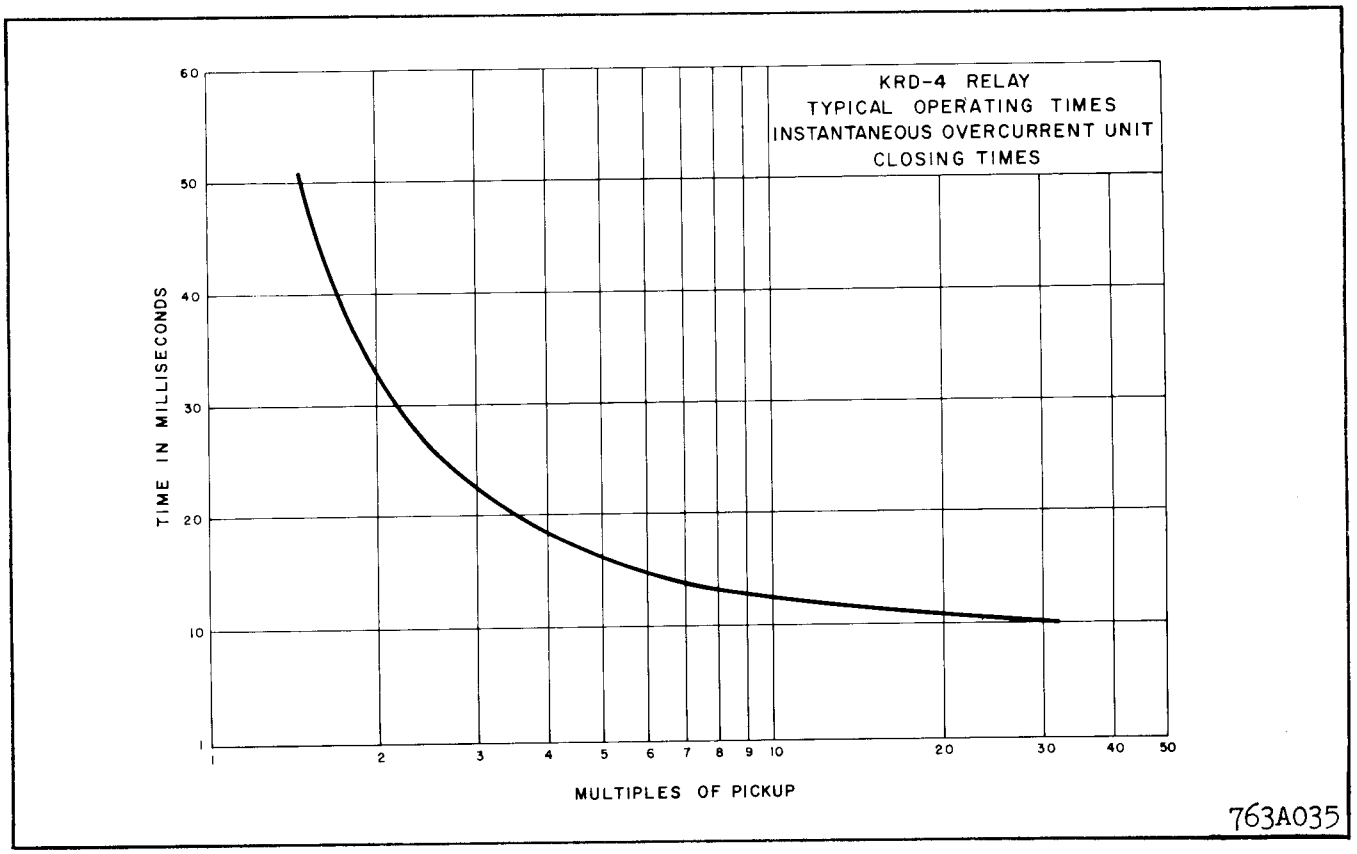


Fig. 6. Typical Time Curves for the Instantaneous Overcurrent Unit.

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 be between 1 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 adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

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.

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").

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 pick up of the overcurrent unit with the tap screw in any other tap should be within ±5% of tap value.

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 in 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 terterminals 8 and 9 with all other terminals open circuited. Adjust core such that the contacts remain open. The core can be adjusted by the 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 all other terminals open circuited. Plug adjustment is then made per Table II 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.

Indicating Contact Switch (ICS)

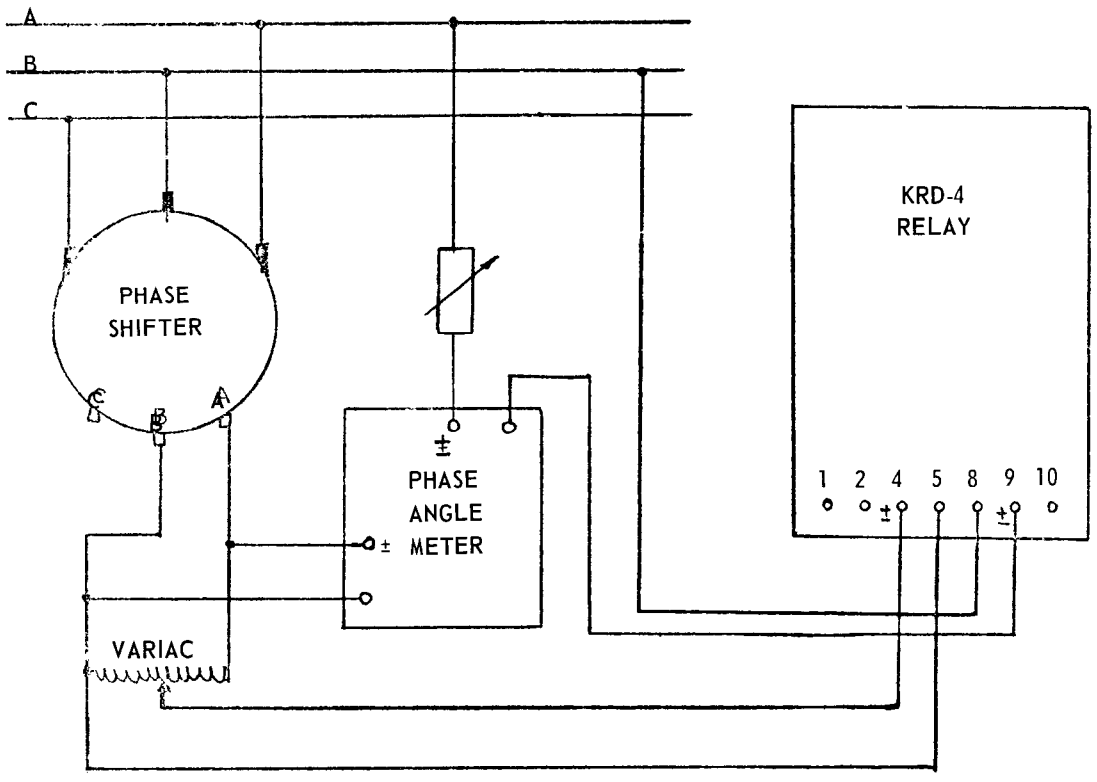
Adjust the contact gap for approximately 5/64'' (-1/64'', +0).

Close the main relay contacts and check to see that the relays pick up and the target drops between 1 and 1.2 amperes 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 the complete nameplate data.

KRD-4 RELAY
TEST CIRCUIT



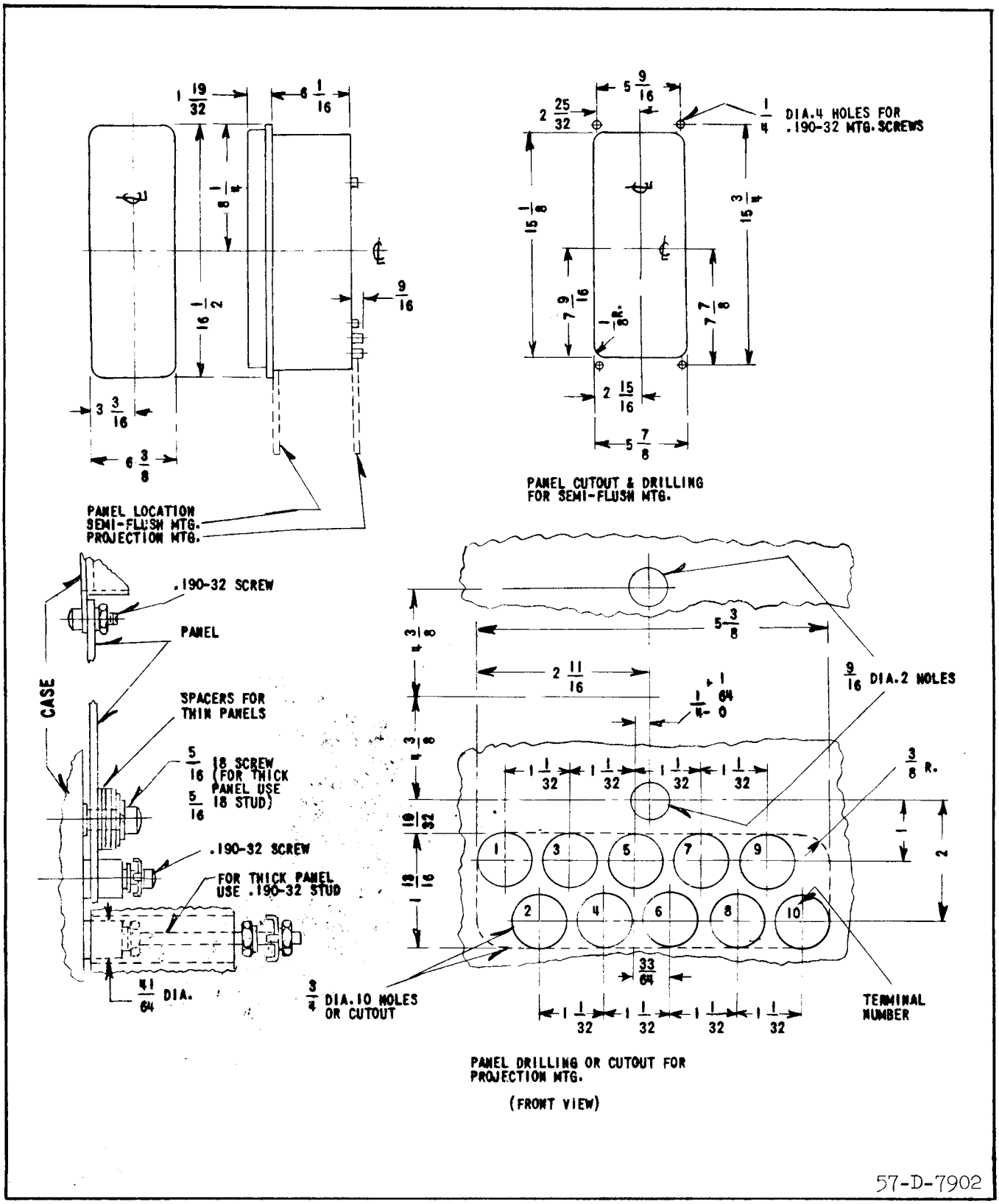


Fig. 7. Outline and Drilling Plan for the Type KRD-4 Relay in the FT31 Case.

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INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

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.

APPLICATION

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

They are also used, without modifications to provide directional ground fault protection in the KD-4 carrier relaying scheme. Operation of the relays in connection with the carrier scheme is fully described * in I.L. 40-208.

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 Fig. 1 to 3.

A. DIRECTIONAL UNIT (D)

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

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

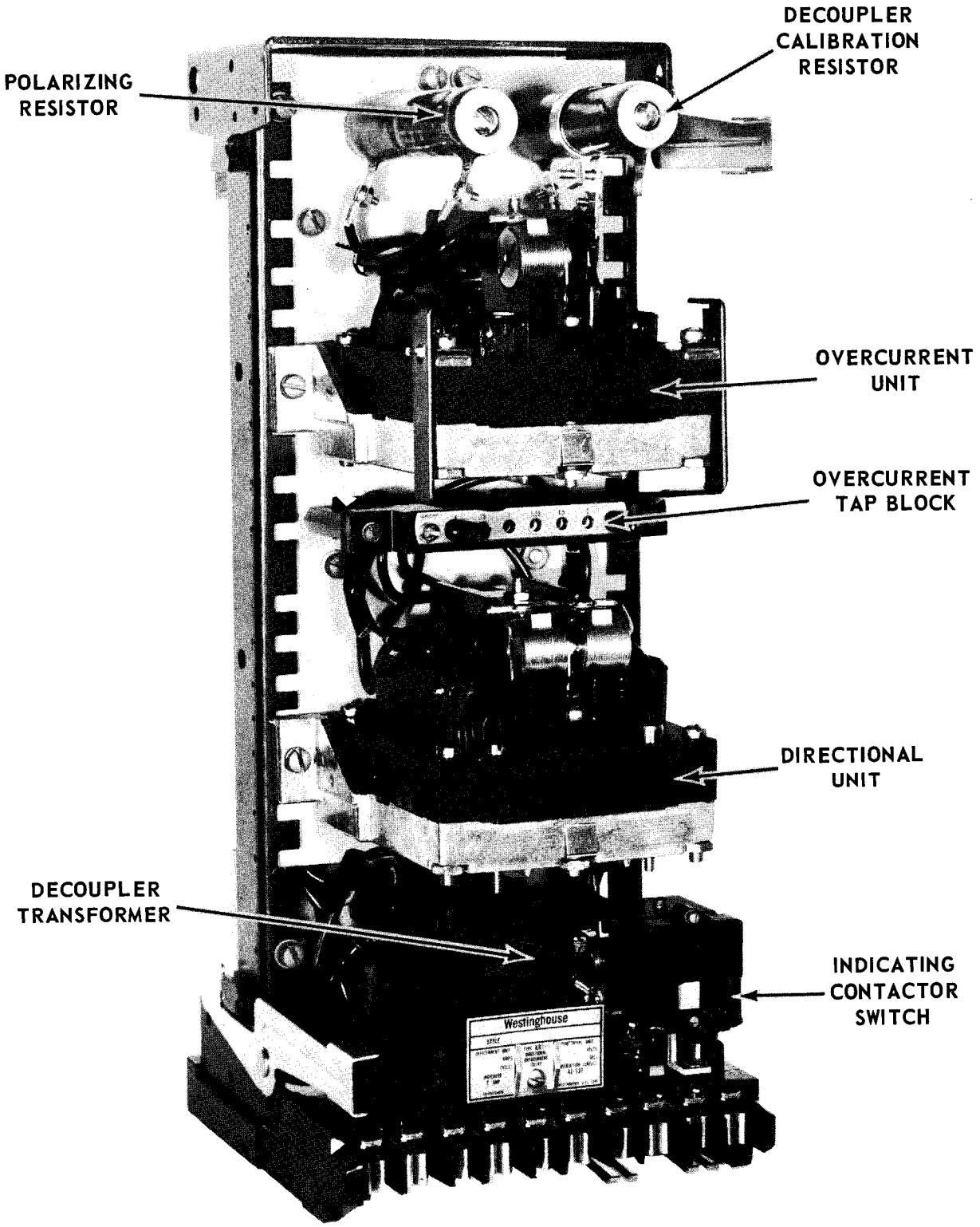


Fig. 1. Type KRD-4 Relay (Front View).

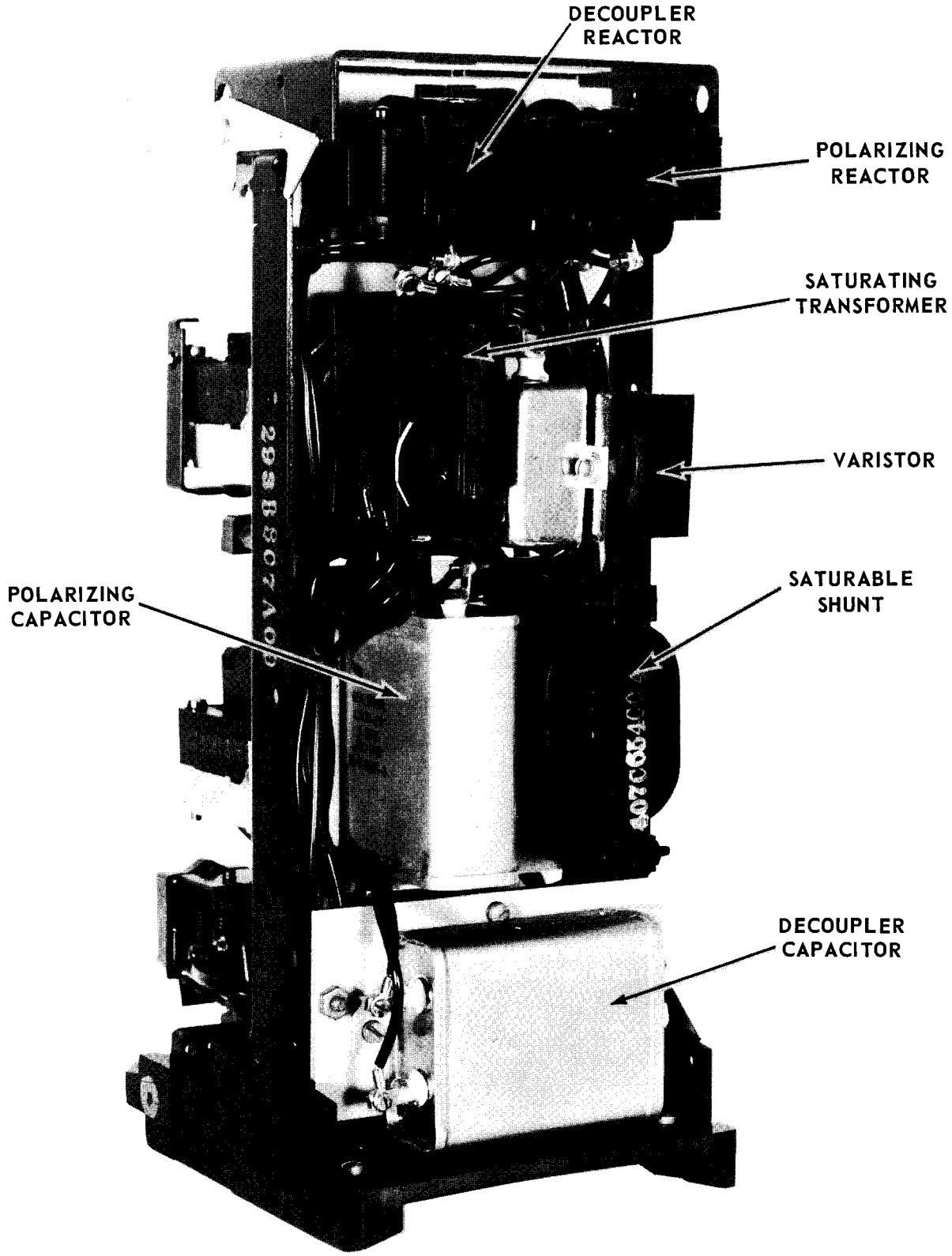


Fig. 2. Type KRD-4 Relay (Rear View).

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.

B. 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.

C. INDICATING CONTACTOR SWITCH (ICS)

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

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.

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 65 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.

TIME CURVES

The time curves for the KRD-4 relay are shown in Fig. 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 voltage 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.

(Example One) definition of symbols are shown on Fig. 5.

let: I_{pol} = 1.5 amp.
I_{op} = 3 amp
tap value (T) = 0.5 amp.
$\phi = 0°$

for a current polarized relay:

$$MPP = \frac{I_{op}I_{pol}\cos\phi}{0.25}$$

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

Entering the curves in Fig. 5 at multiples of product pickup of 18 the directional unit opening time is 4 ms, and the closing time for this unit is 33 ms.

For the overcurrent unit:

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

$$= \frac{3}{0.5} = 6$$

Entering the curve in Fig. 6 at multiples of pickup equal to 6 the closing time for the overcurrent is 14 ms. However, the total operating time for the overcurrent unit is 14 plus 4 ms, which is the opening time of back contacts of the directional unit, or 18 ms total operating time for the overcurrent unit. The total operating time for the directional unit is 33 ms; and since this is the longest time, 33 ms is the total operating time of the relay.

(Example Two)

let: I_{pol} = 15 amp
I_{op} = 25 amp
T (tap) = 1 amp.
$\phi = 0$

$$MPP = \frac{I_{op}I_{pol}\cos\phi}{0.25}$$

$$MPP = 1500$$

referring to Fig. 5 the directional unit closing time is 8 ms, and the opening time of its back contacts is 3 ms. The total operating time for the directional unit is 8 ms.

For the overcurrent unit:

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

$$= 25$$

referring to Fig. 6 the overcurrent unit contact closing time is 10 ms. Therefore, the total operating time for this unit is 10 + 3 ms or 13 ms. In this case the total operating time of the relay is 13 ms.

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 a pickup of approximately 1 ampere. Its d-c resistance is 0.1 ohms.

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 I

DIRECTIONAL UNIT SENSITIVITY

Polarizing Quantity	Values for Min. Pickup		Phase Angle Relationship
	Volts	Amperes	
VOLTAGE	1	0.7 ★	I lagging V by 60°
	1	1.5 ★	I In Phase with V
CURRENT		0.5 ★	In-phase

★ or less

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

TABLE II

DIRECTIONAL UNIT CALIBRATION ①

Relay Rating	Current Amperes	Both Plugs In Condition	Adjustment
All Ranges	80	Spurious torque in contact closing direction (left front view)	Right (front view Plug Screwed out until spurious torque is reversed.
All Ranges	80	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 directions. Then the plug is screwed in until spurious torque is reversed.

① Short Terminals 4 & 5.

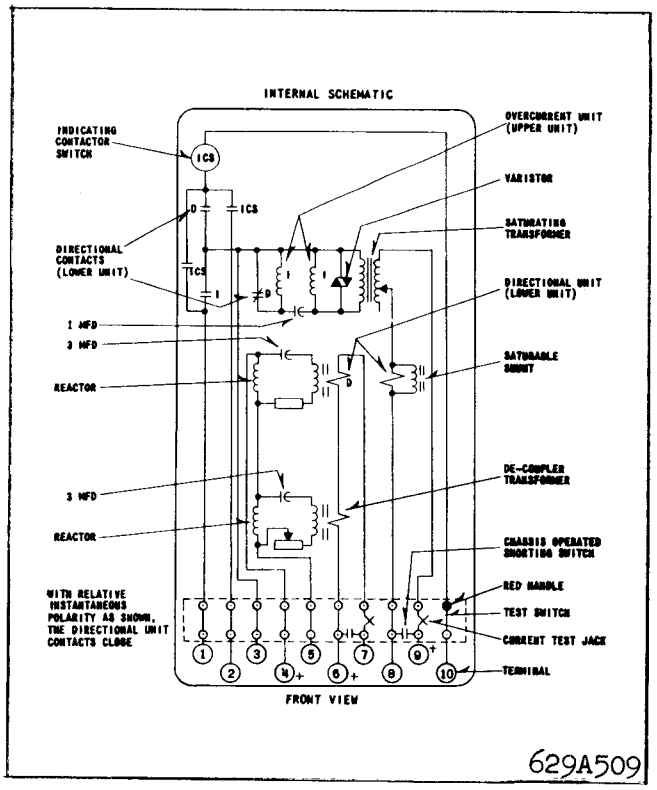
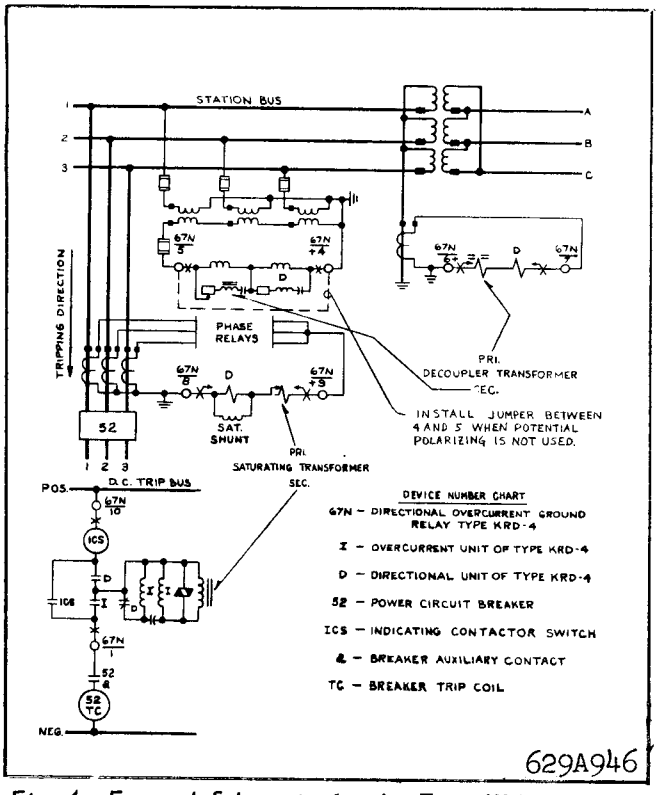


Fig. 3. Internal Schematic of the Type KRD-4 Relay in the Type FT31 Case.



** Fig. 4. External Schematic for the Type KRD-4 Relay.*

SETTINGS

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 pick-up 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 unit 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: 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 the 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 CYCLES

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 △	POWER FACTOR ANGLE Ø
Current	230†† amperes	1.20	3° Lag
Voltage	208††† volts	21.0	28° Lead

Ø Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.

△ 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.

Directional Unit (D)

No setting is required.

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 holes on 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 I.L. 41-076.

ADJUSTMENTS AND MAINTENANCE

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

Acceptance Check

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

Overcurrent Unit (I)

1. Contact Gap - The gap between the stationary and moving contacts with the relay in the de-energized position should be approximately .020."
2. Minimum Trip Current - The normally-closed contact of the directional unit should be blocked open when checking the pick-up of the overcurrent unit.

   The pick-up 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.

Directional Unit (D)

1. Contact Gap - The gap between the stationary contact and moving contact with the relay in the de-energized 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.

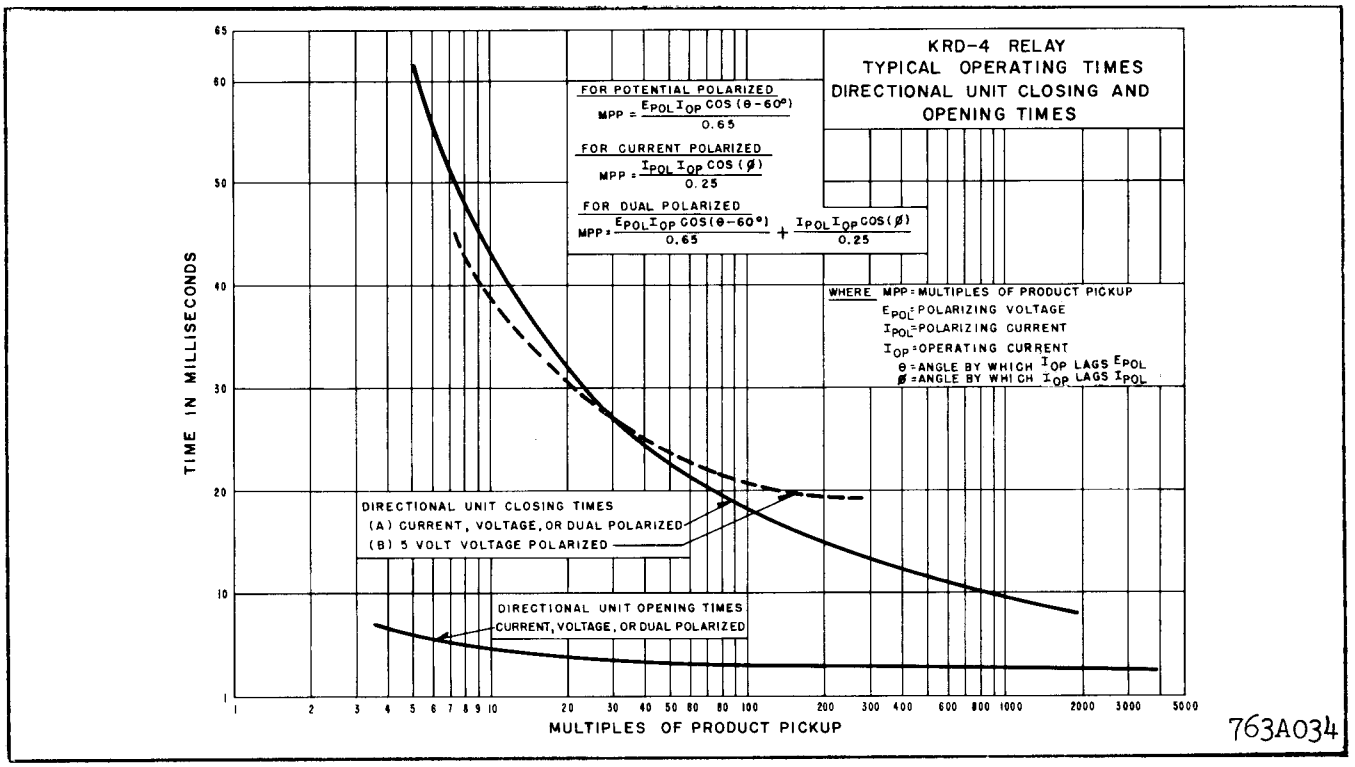


Fig. 5. Typical Time Curves for the Directional Unit.

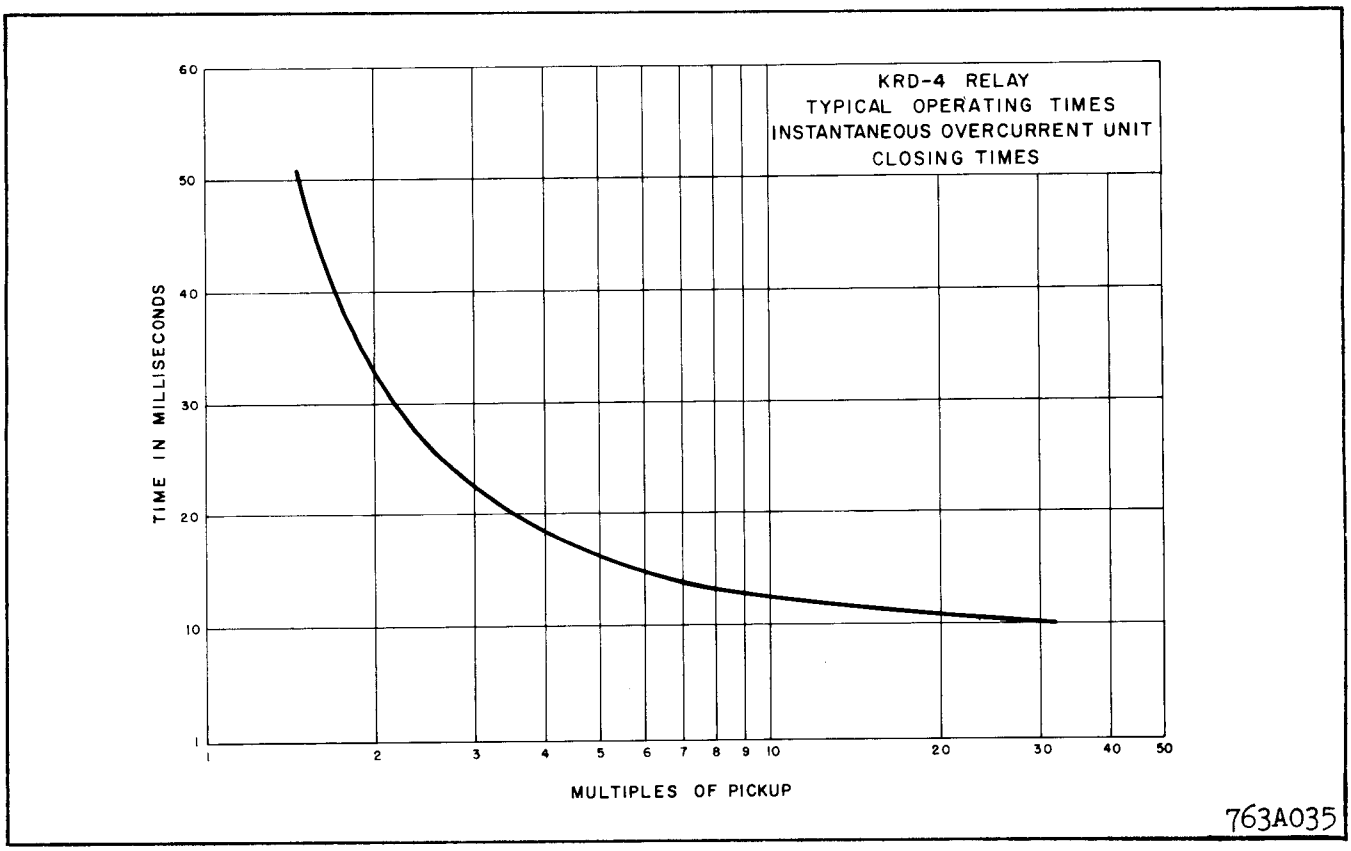


Fig. 6. Typical Time Curves for the Instantaneous Overcurrent Unit.

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 be between 1 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 adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

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.

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").

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 pick up of the overcurrent unit with the tap screw in any other tap should be within ±5% of tap value.

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 in 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 terterminals 8 and 9 with all other terminals open circuited. Adjust core such that the contacts remain open. The core can be adjusted by the 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 all other terminals open circuited. Plug adjustment is then made per Table II 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.

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 pick up and the target drops between 1 and 1.2 amperes 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 the complete nameplate data.

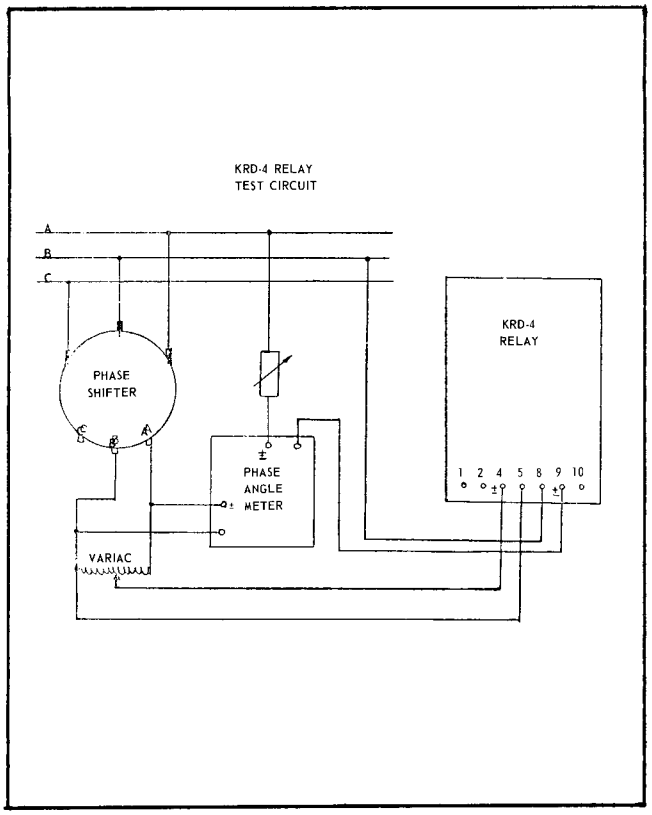


Fig. 7. KRD-4 Relay Test Circuit

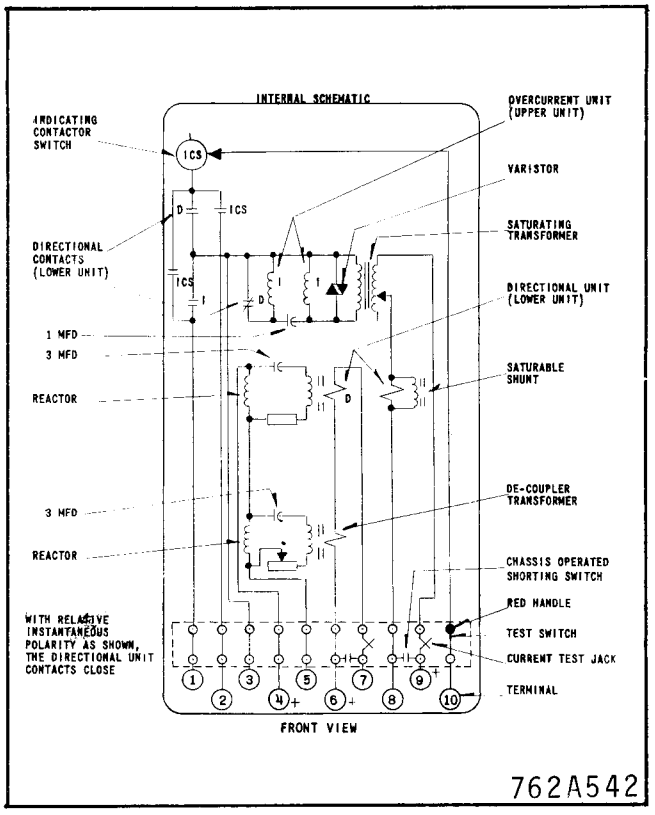


Fig. 8.

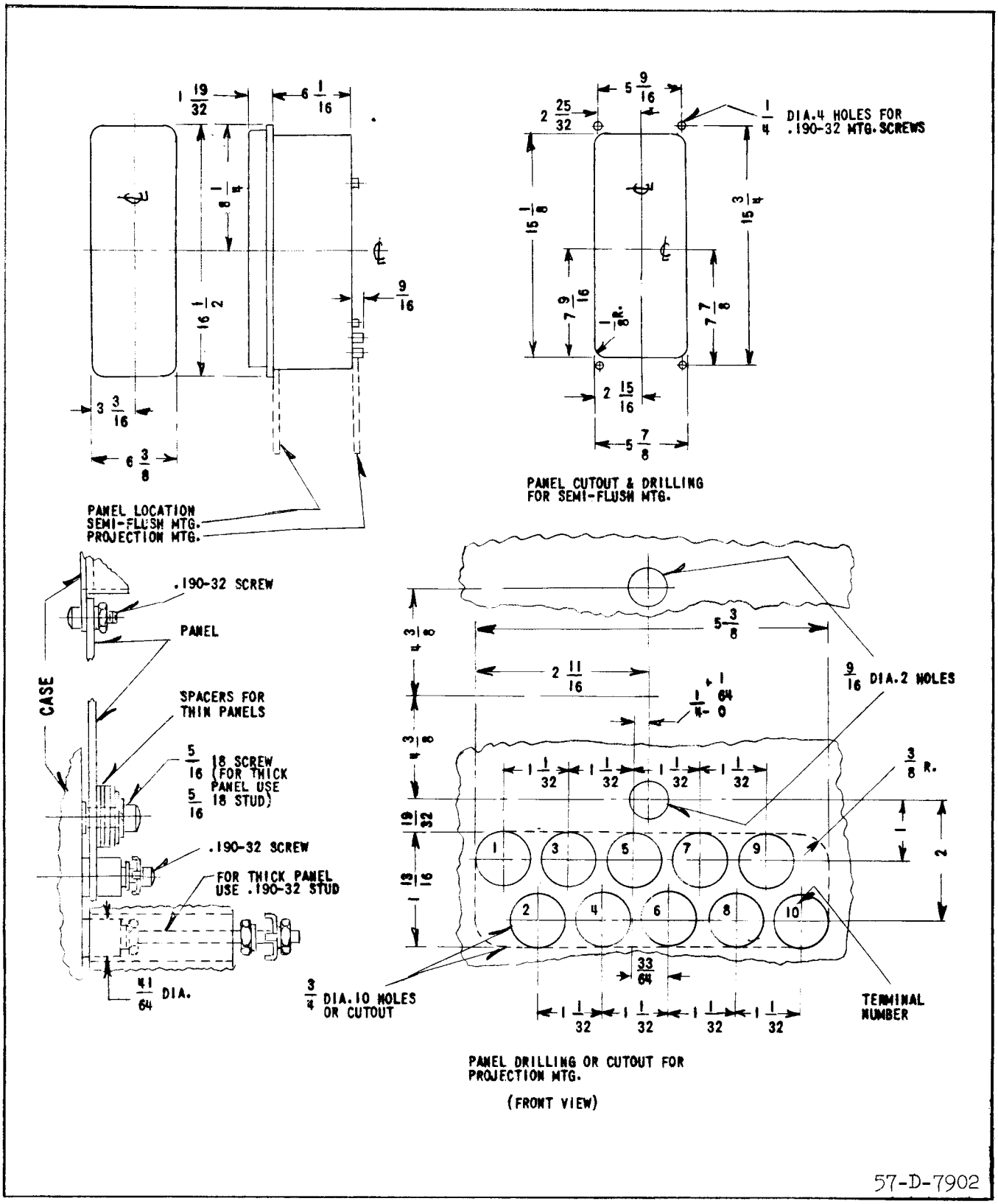


Fig. 9. Outline and Drilling Plan for the Type KRD-4 Relay in the FT31 Case.

WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**
Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

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.

APPLICATION

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

They are also used, without modifications to provide directional ground fault protection in the KD-4 carrier relaying scheme. Operation of the relays in connection with the carrier scheme is fully described * in I.L. 40-208.

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 Fig. 1 to 3.

A. DIRECTIONAL UNIT (D)

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

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

SUPERSEDES I.L. 41-137.3E - Dated June 1972
*Denotes change from superseded issue.

EFFECTIVE FEBRUARY 1975

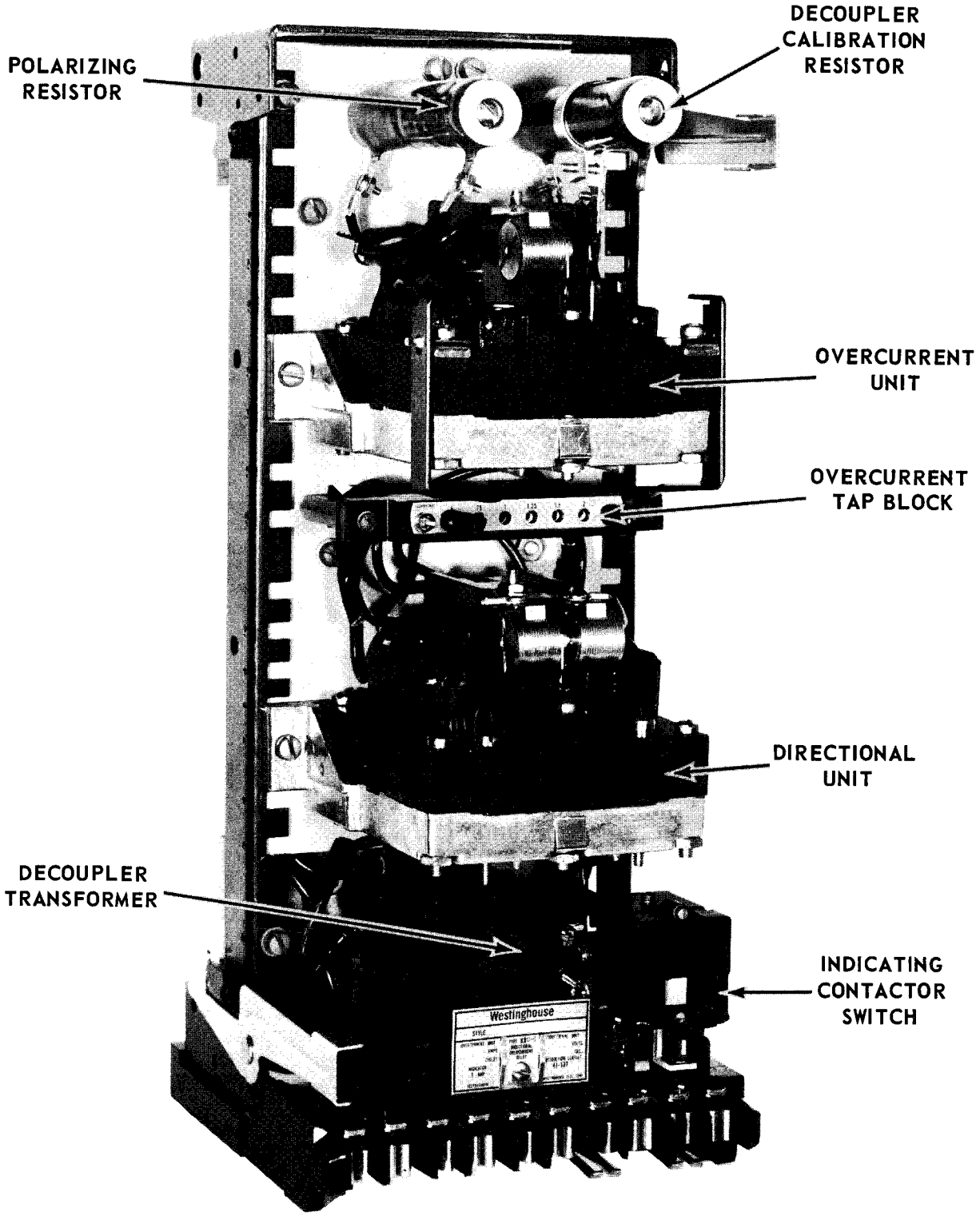


Fig. 1. Type KRD-4 Relay (Front View).

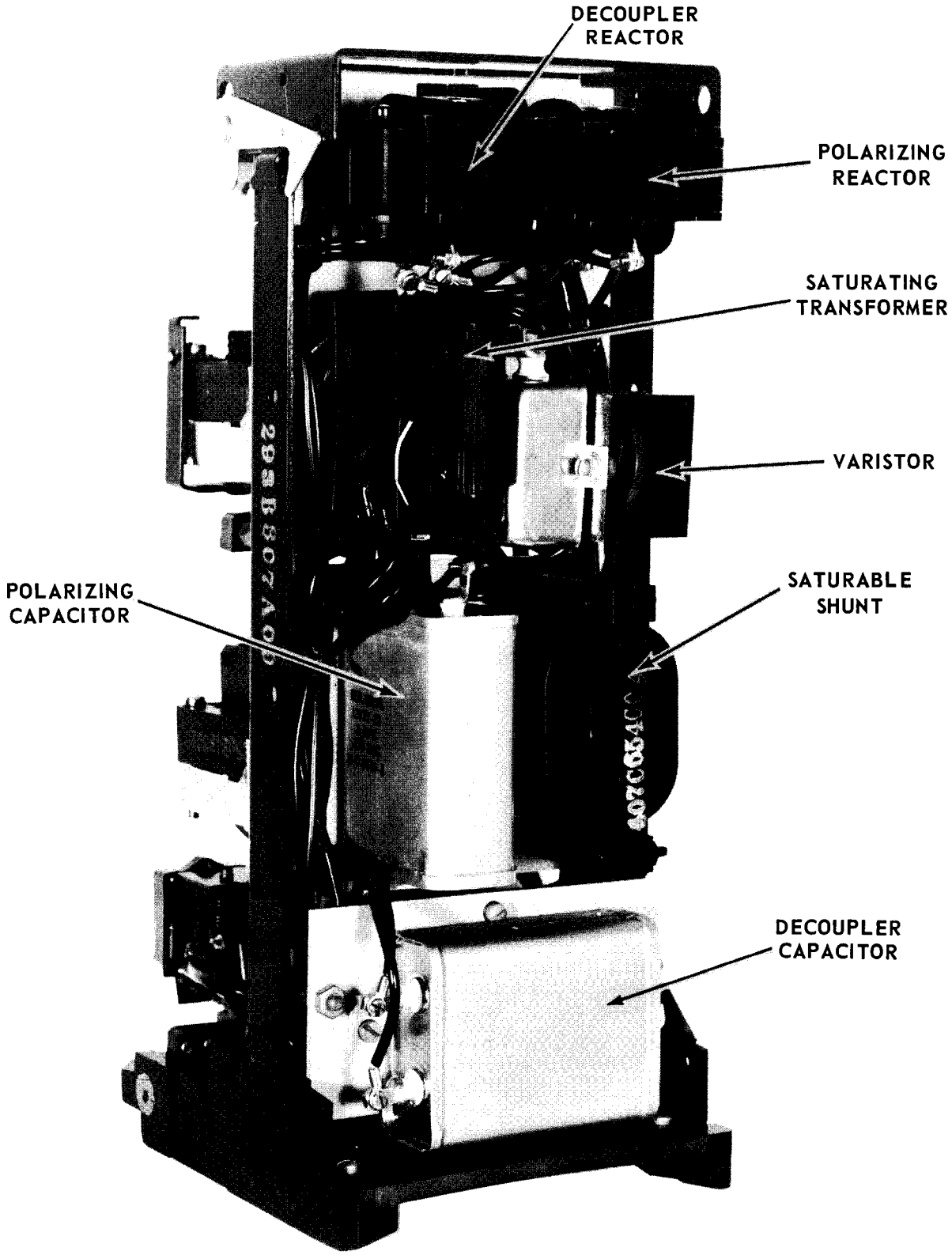


Fig. 2. Type KRD-4 Relay (Rear View).

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.

B. 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.

C. INDICATING CONTACTOR SWITCH (ICS)

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

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.

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 65 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.

TIME CURVES

The time curves for the KRD-4 relay are shown in Fig. 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 voltage 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.

(Example One) definition of symbols are shown on Fig. 5.

let: I_{pol} = 1.5 amp.
I_{op} = 3 amp
tap value (T) = 0.5 amp.
$\phi = 0°$

for a current polarized relay:

$$MPP = \frac{I_{op}I_{pol} \cos \phi}{0.25}$$

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

Entering the curves in Fig. 5 at multiples of product pickup of 18 the directional unit opening time is 4 ms, and the closing time for this unit is 33 ms.

For the overcurrent unit:

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

$$= \frac{3}{0.5} = 6$$

Entering the curve in Fig. 6 at multiples of pickup equal to 6 the closing time for the overcurrent is 14 ms. However, the total operating time for the overcurrent unit is 14 plus 4 ms, which is the opening time of back contacts of the directional unit, or 18 ms total operating time for the overcurrent unit. The total operating time for the directional unit is 33 ms; and since this is the longest time, 33 ms is the total operating time of the relay.

(Example Two)

let: I_{pol} = 15 amp
I_{op} = 25 amp
T (tap) = 1 amp.
$\phi = 0$

$$MPP = \frac{I_{op}I_{pol} \cos \phi}{0.25}$$

$$MPP = 1500$$

referring to Fig. 5 the directional unit closing time is 8 ms, and the opening time of its back contacts is 3 ms. The total operating time for the directional unit is 8 ms.

For the overcurrent unit:

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

$$= 25$$

referring to Fig. 6 the overcurrent unit contact closing time is 10 ms. Therefore, the total operating time for this unit is 10 + 3 ms or 13 ms. In this case the total operating time of the relay is 13 ms.

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 a pickup of approximately 1 ampere. Its d-c resistance is 0.1 ohms.

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 I

DIRECTIONAL UNIT SENSITIVITY

Polarizing Quantity	Values for Min. Pickup		Phase Angle Relationship
	Volts	Amperes	
VOLTAGE	1	0.7 ★	I lagging V by 60°
	1	1.5 ★	I In Phase with V
CURRENT		0.5 ★	In-phase

★ or less

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

TABLE II

DIRECTIONAL UNIT CALIBRATION ①

Relay Rating	Current Amperes	Both Plugs In Condition	Adjustment
All Ranges	80	Spurious torque in contact closing direction (left front view)	Right (front view Plug Screwed out until spurious torque is reversed.
All Ranges	80	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 directions. Then the plug is screwed in until spurious torque is reversed.

① Short Terminals 4 & 5.

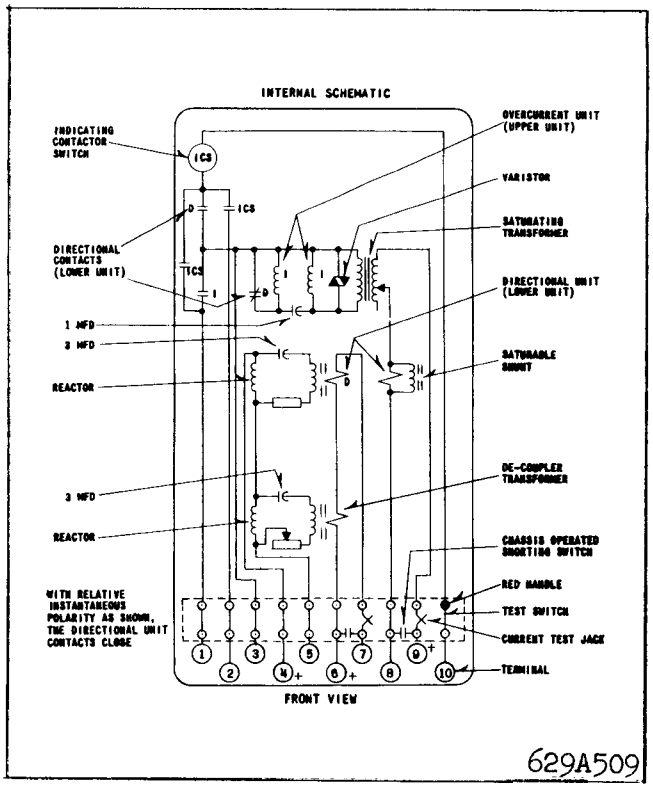
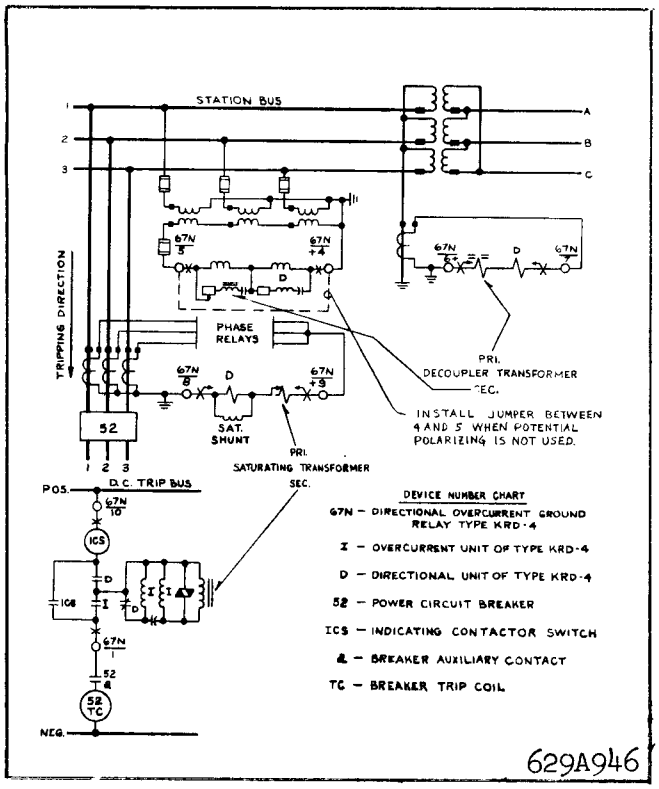


Fig. 3. Internal Schematic of the Type KRD-4 Relay in the Type FT31 Case.



★ *Fig. 4. External Schematic for the Type KRD-4 Relay.*

SETTINGS

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 pick-up 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 unit 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: 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 the 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 CYCLES

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△	POWER FACTOR ANGLE Ø
Current	230†† amperes	1.20	3° Lag
Voltage	208††† volts	21.0	28° Lead

Ø Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.

△ 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.

Directional Unit (D)

No setting is required.

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 holes on 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 I.L. 41-076.

ADJUSTMENTS AND MAINTENANCE

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

Acceptance Check

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

Overcurrent Unit (I)

1. Contact Gap - The gap between the stationary and moving contacts with the relay in the de-energized position should be approximately .020."
2. Minimum Trip Current - The normally-closed contact of the directional unit should be blocked open when checking the pick-up of the overcurrent unit.

   The pick-up 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.

Directional Unit (D)

1. Contact Gap - The gap between the stationary contact and moving contact with the relay in the de-energized 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.

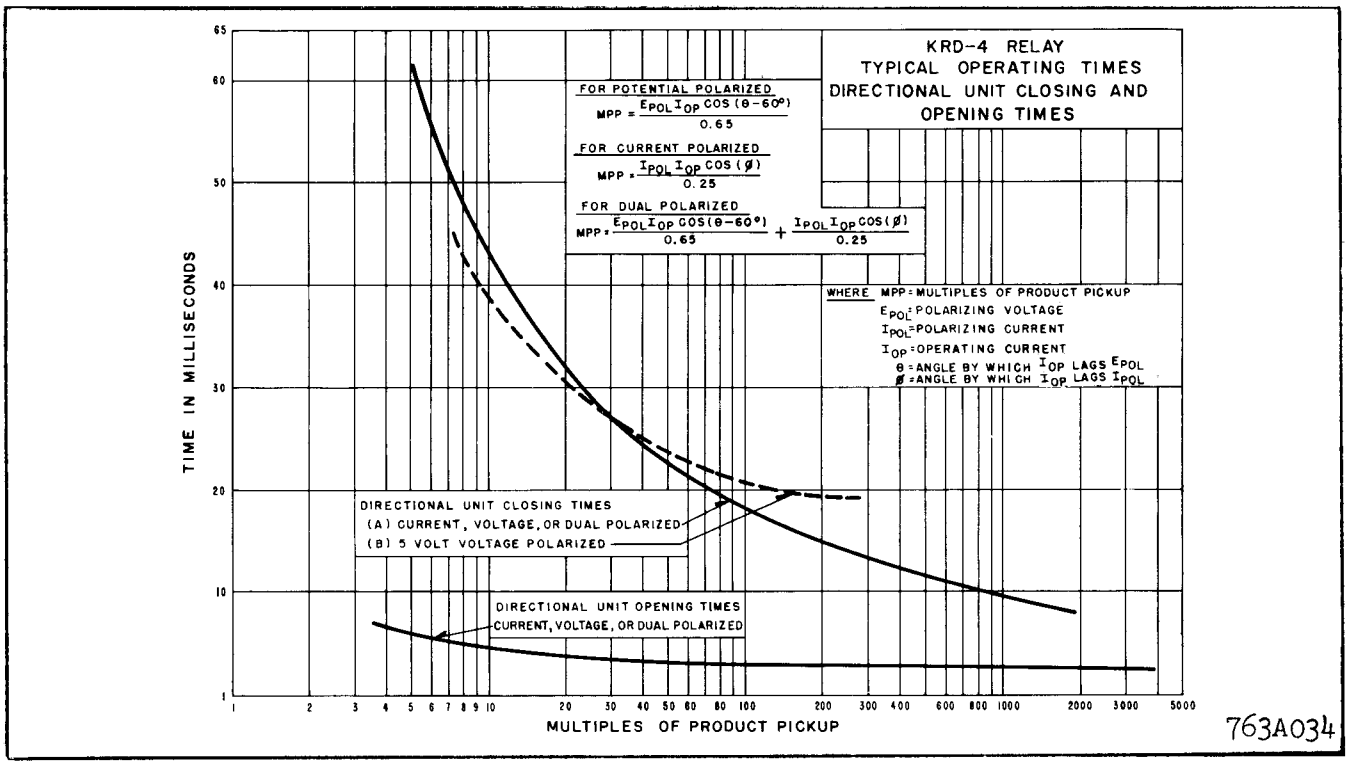


Fig. 5. Typical Time Curves for the Directional Unit.

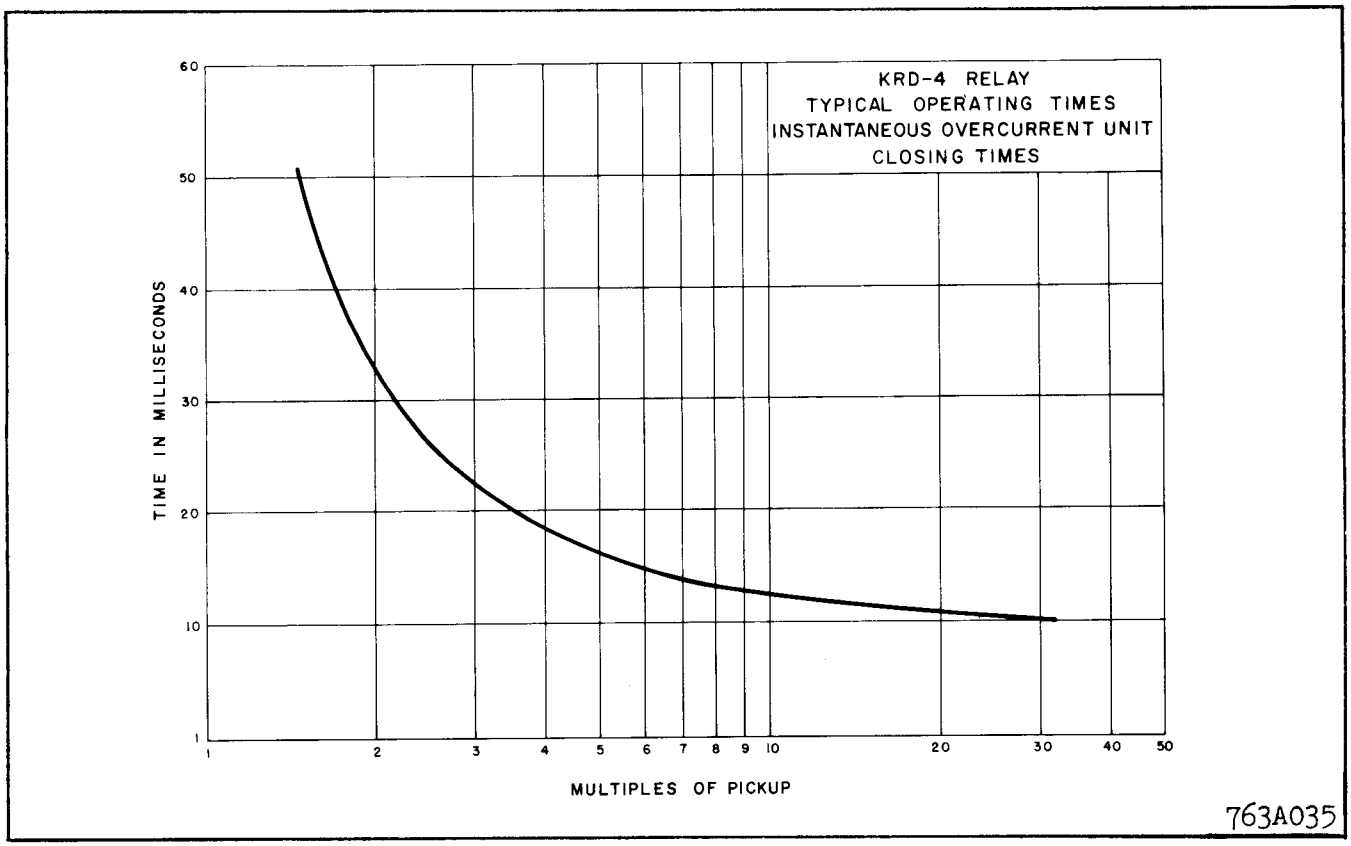


Fig. 6. Typical Time Curves for the Instantaneous Overcurrent Unit.

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 be between 1 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 adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

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.

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").

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 pick up of the overcurrent unit with the tap screw in any other tap should be within ±5% of tap value.

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 in 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 terterminals 8 and 9 with all other terminals open circuited. Adjust core such that the contacts remain open. The core can be adjusted by the 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 all other terminals open circuited. Plug adjustment is then made per Table II 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.

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 pick up and the target drops between 1 and 1.2 amperes 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 the complete nameplate data.

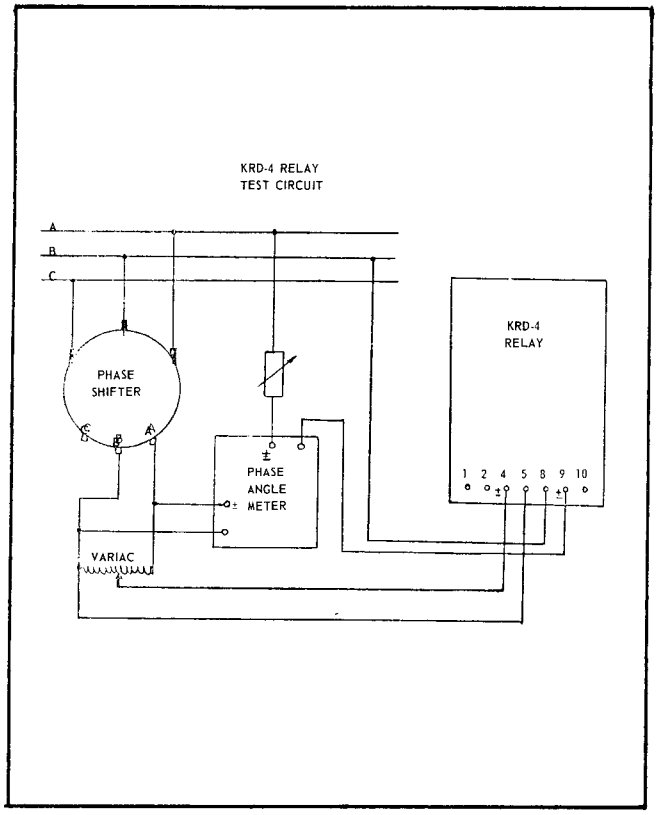


Fig. 7. KRD-4 Relay Test Circuit

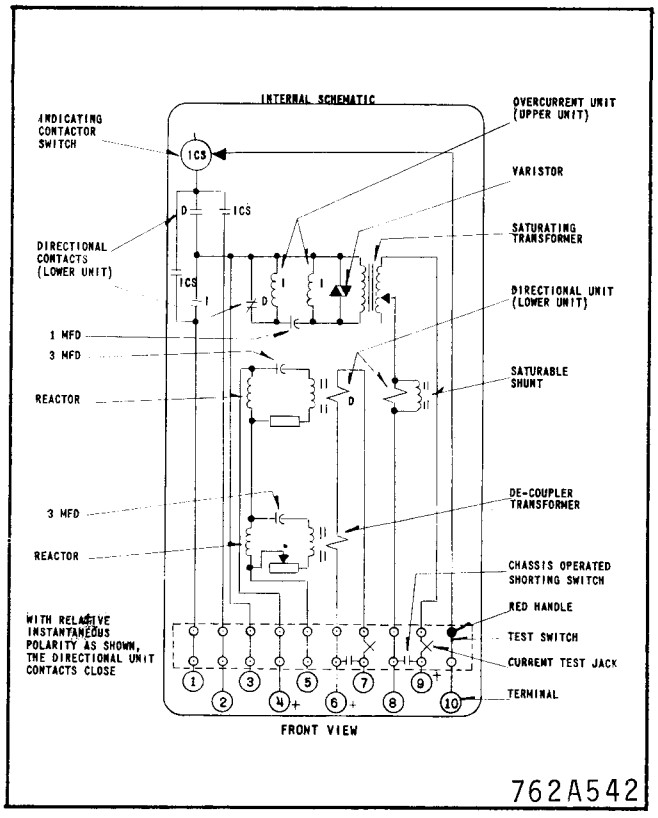


Fig. 8.

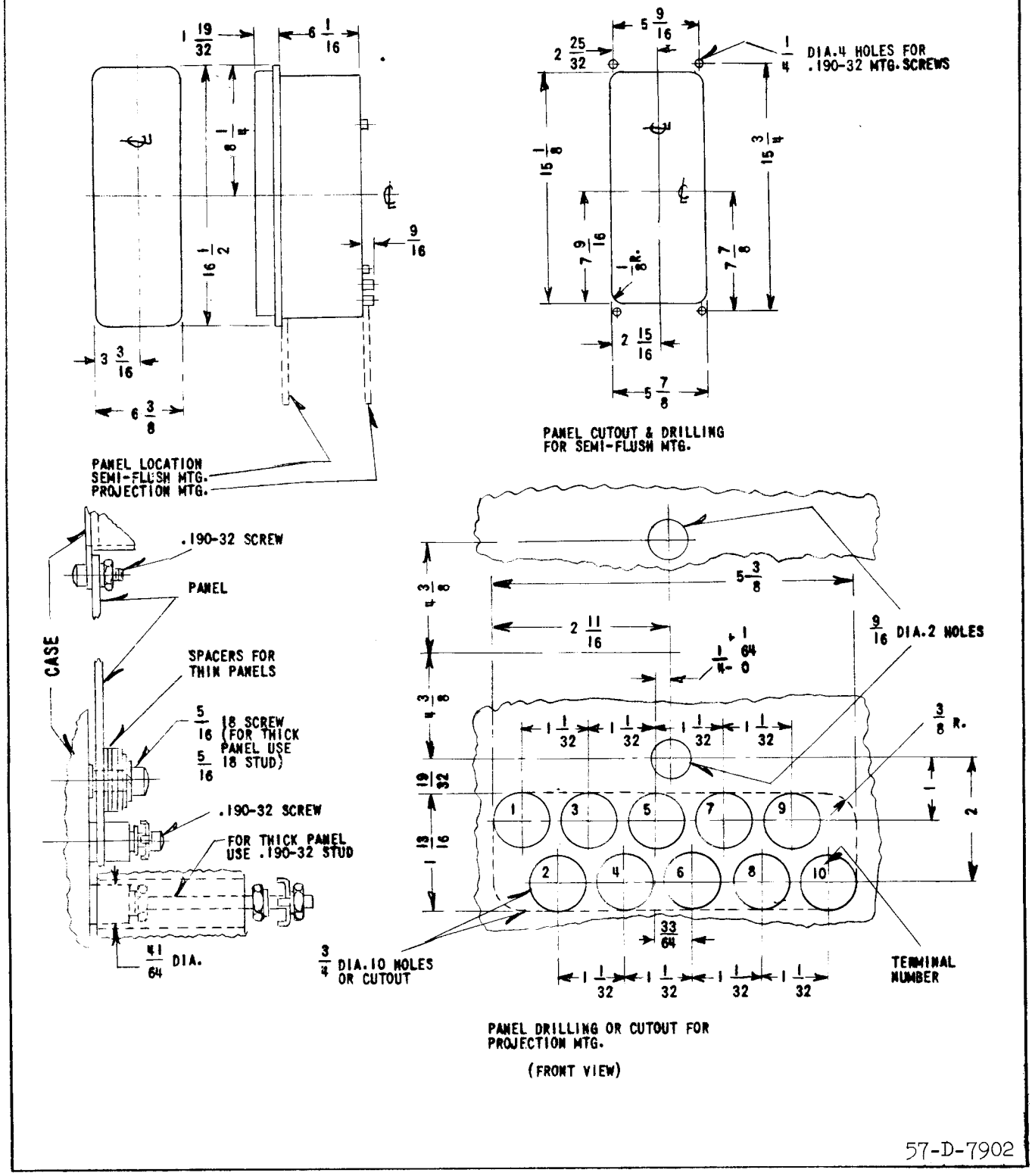


Fig. 9. Outline and Drilling Plan for the Type KRD-4 Relay in the FT31 Case.