ABB Automation Inc.
Substation Automation and Protection Division
Coral Springs, FL 33065

Instruction Leaflet

41-137L

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(❙) Denotes Change Since Previous Issue

Types KRD, KRP and KRC Directional Overcurrent Ground Relay

CAUTION

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

1.0 APPLICATION

These relays are high speed ground directional overcurrent relays which are used for the protection of transmission lines and feeder circuits.

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

The type KRD relay is a dual polarized relay which can be polarized from a potential source, from a local ground source or from both simultaneously. The type KRP relay is used where residual voltage is available for polarizing the directional unit. The type KRC is used where this residual voltage is not available and residual current must be used.

2.0 CONSTRUCTION AND OPERATION

2.1 DIRECTIONAL UNIT (D)

The directional unit is a product induction cylinder type unit operating on the interaction between the polarizing circuit flux and the operating circuit flux.

Mechanically, the directional unit is composed of four basic components; A die-cast aluminum frame, an electromagnet, a moving element assembly, and a molded bridge.

The frame serves as the mounting structure for t he magnetic core. The magnetic core which houses the lower pin bearing is secured to t he frame by a locking nut. The bearing can be replaced, if necessary, without having to remove the magnetic core from the frame.

The electromagnet has two series-connected polarizing coils mounted diametrically opposite one another; two series-connected operating coils mounted diametrically opposite one another; two magnetic adjusting plugs; upper and lower adjusting plug clips, and two locating pins. The locating pins are used to accurately position the lower pin bearing, which is threaded into the bridge. The electromagnet is secured to the frame by four mounting screws.

The moving element assembly consists of a spiral spring, contact carrying member, and an aluminum cylinder assembled to a molded hub which holds the shaft. The shaft has removable top and bottom jewel bearings. The shaft rides between the bottom pin bearing and the upper pin bearing with the cylinder

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

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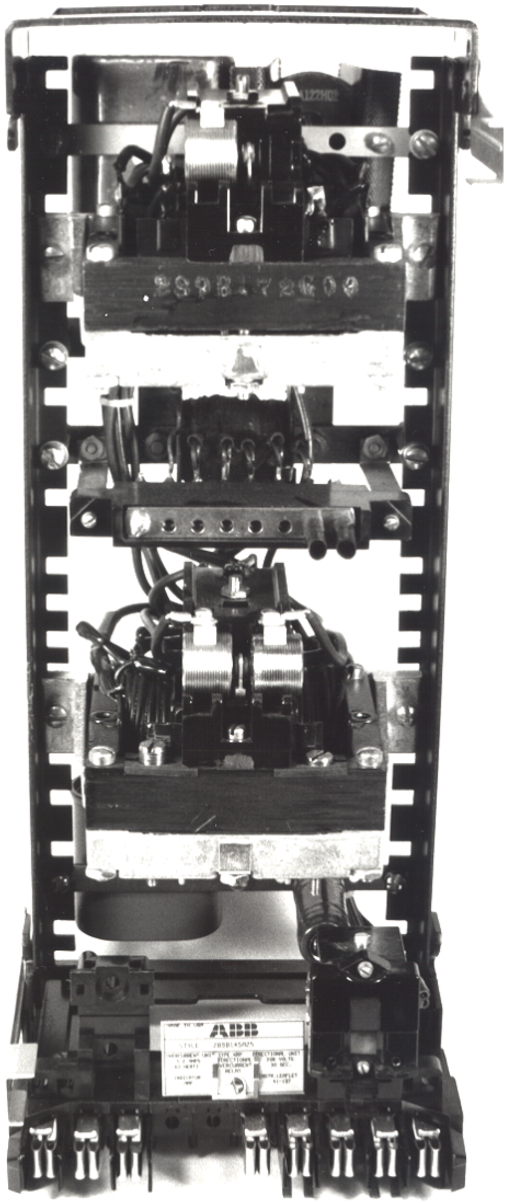
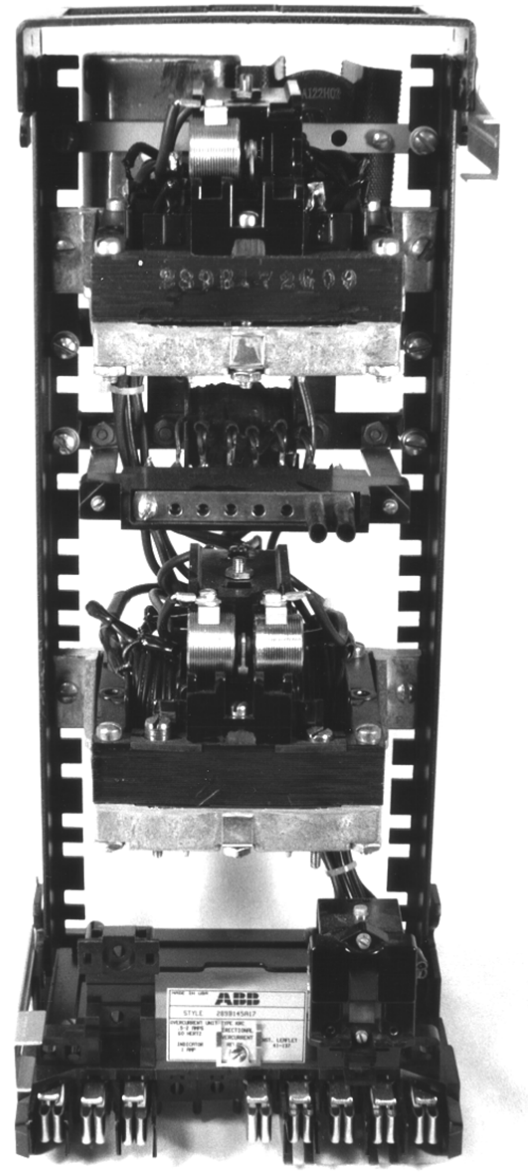


KRP Photo 9664A72



KRC Photo 9664A71

Figure 1: Type KRP and KRC Relay (without case)

rotating in a air gap formed by the electromagnet and the magnetic core.

The bridge is secured to the electromagnet and frame by two mounting screws. In addition to holding the upper pin bearing, the bridge is used for mounting the adjustable stationary contact housing. The stationary contact housing is held in position by a spring type clamp. The spring adjuster is located on the underside of the bridge and is attached to the moving contact arm by a spiral spring. The spring adjuster is also held in place by a spring type clamp.

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

2.2 OVERCURRENT UNIT (I)

The overcurrent unit is similar in construction to the directional unit. The time 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.

The normally-closed contact of the directional unit is connected across one pair of pole windings of the overcurrent unit as shown in the internal schematics (figures 2, 3 and 4). This arrangement short-circuits the operating current around the pole windings, preventing the overcurrent unit from developing torque. If the directional unit should pickup for a fault, this short-circuit is removed, allowing the overcurrent contact to commence closing almost simultaneously with the directional contact for high speed operation.

2.3 OVERCURRENT UNIT TRANSFORMER

This transformer is of the saturating type for limiting the energy to the overcurrent unit at higher values of fault current and to reduce ct burden. The primary winding is tapped and these taps are brought out to a tap block for ease in changing the pickup of the overcurrent unit. The use of a tapped transformer provides approximately the same energy level at a given multiple of pickup current for any tap setting, resulting in one time curve throughout the range of the relay.

Across the secondary is connected a non-linear resistor known as a varistor. The effect of the varistor is to reduce the voltage peaks applied to the overcurrent unit and phase shifting capacitor.

2.4 INDICATING CONTACTOR SWITCH UNIT (ICS)

The indicating contactor switch is a small dc 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 t he switch closes, the moving contacts bridge two stationary contacts, completing the trip circuit. Also during this operation two fingers on the armature deflect a spring located on the front of the switch, which allows the operation indicator target to drop. The target is reset from the outside of the case by a push-rod located at the bottom of the cover.

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

3.0 CHARACTERISTICS

The relays are available in the following current ranges:

Range	Taps					
0.5-2 amps	0.5	0.75	1.0	1.25	1.5	2
1-4	1.0	1.5	2.0	2.5	3.0	4.0
2-8	2	3	4	5	6	8
4-16	4	6	8	9	12	16
10-40	10	15	20	24	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 Section 7.0 “ADJUSTMENTS AND MAINTENANCE.”

3.1 TYPE KRD RELAY

The type KRD relay utilizes a directional unit similar to the KRC relay in conjunction with the directional unit and phase-shifting circuit of the KRP relay.

The current-polarized directional unit of the KRD relay operates on residual voltage and residual current.

3.2 TYPE KRP RELAY (PHOTO ON PAGE 2)

The KRP relay is designed for potential polarization and has its maximum torque when the current lags the voltage by approximately 60 degrees. The shifting of the maximum torque angle is accomplished by the use of an internally mounted phase shifter as shown in the internal schematic.

The directional unit minimum pickup is approximately 1 volt and 2 amperes at its maximum torque angle for the 0.5 to 2, 1 to 4 and 2 to 8 ampere range relays. For t he 4 to 16 and 10 to 40 ampere range, the minimum pickup is 1 volt and 4 amperes.

3.3 TYPE KRC RELAY (PHOTO ON PAGE 2)

The KRC relay is designed for current polarization and has its maximum torque when the operating current leads the polarizing current by approximately 40°.

The directional unit minimum pickup is 0.5 ampere in each winding at the maximum torque angle for the 0.5 to 2, 1 to 4 and 2 to 8 ampere range relays. For the 4 to 16 and 10 to 40 ampere range, the minimum pickup is 1 ampere.

For the 0.5 to 2, 1 to 4 and 2 to 8 ampere range relays, the minimum pickup of the current polarized unit is 0.5 ampere in each winding at the maximum torque angle. The minimum pickup for the voltage polarized unit is 1 volt and 2 amperes with the current lagging voltage by 60°.

For the 4 to 16 and the 10 to 40 ampere range relays, the minimum pickup is 1 ampere for the current-polarized directional unit, and 1 volt and 4 amperes for the voltage-polarized directional unit.

4.0 TIME CURVES

The time curves for the KRD relay are shown in figures 5 and 6. Figure 5 consists of three curves which are:

1. Directional Unit opening times for current and voltage polarized.
2. Directional Unit closing time for current and voltage polarized.
3. Directional Unit closing time for 1 volt, voltage polarized.

Figure 6 shows the instantaneous overcurrent unit closing time.

The voltage polarized curve B begins to deviate from curve A for less than 5 volts.

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 directional unit open; therefore, the total time for overcurrent unit to operate is its closing time given in figure 6 plus the directional unit opening time given in figure 5. The total closing time for the directional unit is given in figure 5. The two examples below will serve to illustrate the use of the curves.

EXAMPLE

1. Using the formulas and definition of symbols on figure 5, we have –

   Let: Ipol = 2 amps
   Iop = 2.31 amps
   Tap Value (T) = 0.5 amp
   Ø = 0°

   For current polarized relay:

$$MPP = \frac{Iop\ Ipol\ \cos(\phi - 40)}{.25}$$

$$MPP = \frac{2.31 \times 2 \times 0.766}{.25} = 14.2$$

   Referring to figure 5 at multiples of product pickup of 14.2, the directional unit opening time is about 12.2 ms, and the closing time for this unit is 58 ms.

   For overcurrent unit:

$$\text{Multiples of pickup} = \frac{Iop}{T} = \frac{2.31}{0.5} = 4.6$$

   Entering the curve in figure 6 at multiples of pickup equal to 4.6, the closing time for the overcurrent is 21.5 ms. However, the total operating time for the overcurrent unit is 21.5 plus 12.2, which is the opening time of back contacts of the directional unit, or 33.7 ms total operating time for overcurrent unit. The total time for directional unit is 58 ms; and, since this is the longest time, 58 ms is the total operating time of the relay.

Let: Ipol = 20 amps
Iop = 23.1 amps
Tap Value (T) = 1 amp
Ø = 0°

$$MPP = \frac{Iop\ Ipol\cos(\phi - 40)}{.25}$$

$$MPP = \frac{23.1 \times 20 \times 0.766}{.25} = 1415.6$$

Entering figure 5, the directional unit closing time is 12 ms and the opening time of its back contacts is 1 ms.

For overcurrent unit:

$$\text{Multiples of pickup} = \frac{Iop}{T} = \frac{23.1}{1} = 23.1$$

Referring to figure 6, the overcurrent unit contact closing time is about 12.8 ms. Therefore, the total operating time for this unit is 13 plus 1 or 14 ms. In this case the total operating time of relay is 14 ms.

4.1 TRIP CIRCUIT

The main contacts will safely close 30 amperes at 250 volts dc 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 dc resistance is 0.1 ohm.

4.2 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***.

5.0 SETTINGS

5.1 OVERCURRENT UNIT (I)

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

For blocking carrier relaying the carrier trip overcurrent unit located in the type KRP, KRC or KRD relay should be set on a higher tap 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, the relay must be first removed from the case. Chassis operating shorting switches on the case will short the secondary of the current transformer. Taps may then be changed with the relay either inside or outside the case. Then reclose all switch blades making sure the RED handles are closed LAST.

NOTE: When the voltage polarized unit of the KRD is not used, terminals 4 and 5 must be <u>shorted</u>. When the current polarized unit is not used terminals 7 and 8 are left <u>open</u>.

5.2 DIRECTIONAL UNIT (D)

No setting is required.

6.0 INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration and heat. Mount the relay vertically by means of the two mounting studs for projection mounting or by means of the four mounting holes on the flange for the semi-flush mounting.

Either of t he 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 Instruction Leaflet 41-076.

The external ac connections of the directional overcurrent relays are shown in figures 7, 8 and 9. If no voltage polarizing source is to be connected to the KRD relay, short-circuit the voltage polarizing circuit at the terminals of the relay.

7.0 ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory. Upon receipt of the relay, no customer adjustments, other than those covered under section 5.0, “SETTINGS”, should be required.

7.1 ACCEPTANCE CHECK

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

7.1.1 Overcurrent Unit (I)

Contact Gap – The gap between the stationary and moving contacts with the relay in the de-energized position should be approximately .020”.

Minimum Trip Current – The normally-closed contact of the directional unit should be blocked open when checking the pickup of the overcurrent unit.

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

7.1.2 Directional Unit (D)

Contact Gap – The gap between the stationary contact and moving contact with the relay in the de-energized position should be approximately .020”.

Sensitivity – The respective directional units should trip with value of energization and phase angle relationships as indicated in Table 1 (Directional Unit Sensitivity).

Spurious Torque Adjustments – There should be no spurious closing torques when the operating circuits are energized per Table 2 (Directional Unit Calibration) with the polarizing circuits short-circuited for the voltage polarized units and open-circuited for the current polarized units.

7.1.3 Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient dc current through the trip circuit to close the contacts of the ICS. This value of current should be 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.

8.0 ROUTINE MAINTENANCE

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

All contacts should be periodically cleaned. A contact burnisher style number 182A836H01 is recommended for this purpose.

CAUTION

The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

8.1 CALIBRATION

Use the following procedure for calibrating the relay if the relay has been taken apart for repairs or the adjustments have been disturbed. This procedure should not be used unless it is apparent that the relay is not in proper working order. (See section 7.1 “Acceptance Check”).

8.2 OVERCURRENT UNIT (I)

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

2. The contact gap adjustment for the overcurrent unit is made with the moving contact in the reset position, i.e., against the right side of the bridge. Advance t he 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 t he notches located on the periphery of the spring adjuster and rotating it. The spring adjuster is located on the underside of the bridge and is held in place by a spring-type clamp that does not have to be loosened prior to making the necessary adjustments.

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

   If adjustment of pickup current 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.

8.3 DIRECTIONAL UNIT (D)

In the type KRP and KRC relays the directional unit is the lower unit. In the type KRD the directional units are the lower and middle units.

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 the 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 in the left-hand stationary contact until it just touches the moving contact. Then back off the stationary contact 3/4 of one turn for a contact gap of .020” to .024”. 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. 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 i 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 as indicated by a neon lamp in the contact circuit when energized with the required current and voltage as shown in Table 1, (Directional Unit Sensitivity). This table indicates that the spring can be adjusted when the phase angle relationship between the operating circuit and the polarizing circuit is at the maximum torque angle or when the circuit relationship has the operating and polarizing circuits in phase.

4. The magnetic plugs are used to reverse any unwanted spurious torques that may be present when the relay is energized on current alone.

   The reversing of the spurious torques is accomplished by using the adjusting plugs in the following manner:

a) Voltage circuit terminals on the voltage polarized relays (KRP and KRD voltage polarized unit) are open-circuited.

b) The polarizing circuit of the current polarized relays (KRC and KRD current polarized unit) are open-circuited.

Upon completion of either “a” or “b”, current is applied to the operating circuit terminals as per Table 2.

Plug adjustment is then made per Table 2 such that the spurious torques are reversed. The plugs are held in position by upper and lower plug clips. These clips need not be disturbed in any manner when making the necessary adjustment.

The magnetic plug adjustment may be utilized to positively close the contacts on current alone. This may be desired on the same installations in order to insure that the relay will always trip the breaker on zero potential.

8.4 INDICATING CONTACTOR SWITCH (ICS)

Adjust the contact gap for approximately 5/64”
(-1/54”, +0).

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

To increase the pickup current remove the molded cover and bend the springs out or away from the cover. To decrease the pickup current bend the springs in toward the cover.

9.0 RENEWAL PARTS

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

OVERCURRENT UNIT BURDEN DATA AT HIGH CURRENTS

AMPERE RANGE	1 - 4											
Tap Value Current	1				2				4			
Multiples of Tap Value Current	20	40	60	80	10	20	30	40	5	10	15	20
VA†	56	176	330	560	27	76.8	156	236	12.4	40	85.2	136
P.F. Angle‡	41°	35°	27.2°	23.°6	35.6°	28.8°	23.8°	21.5°	24.3°	22.7°	19.9°	16.1°

† *Voltages taken with Rectox type voltmeter*
‡ *Degrees current lags voltage*

ENERGY REQUIREMENTS – 60 HERTZ
DIRECTIONAL UNIT POLARIZING CIRCUIT BURDEN

RELAY TYPE	RATING	VOLT AMPERES†	POWER FACTOR ANGLE‡
KRC	230†† amperes	1.45	8° Lag
KRP	208‡‡ volts	11.2	28° Lead
KRD Current Unit	230†† amperes	1.45	8° Lag
KRD Voltage Unit	208‡‡ volts	11.2	28° Lead

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

ENERGY REQUIREMENTS – 60 HERTZ
TYPE KRD RELAY

AMPERE RANGE	TAP	VA at Tap Value†	P.F. Angle‡	VA at 5 Amps†	P.F. Angle‡
.5-2	.5	0.42	39.5	28.30	47.0
	.75	0.51	39.5	19.80	43.0
	1.0	0.63	39.5	14.50	41.0
	1.25	0.78	40.0	12.10	40.0
	1.5	0.97	40.0	10.60	40.0
	2.0	1.44	40.0	8.80	40.0
1-4	1.0	0.65	39.0	15.20	40.0
	1.5	1.01	39.5	11.00	40.0
	2.0	1.48	40.0	9.10	40.0
	2.5	2.10	40.5	8.25	40.5
	3.0	3.85	41.0	7.75	41.0
	4.0	4.56	41.5	7.25	41.5
2-8	2	2.01	46.0	12.75	45.5
	3	3.44	44.0	9.50	43.5
	4	5.36	42.5	8.40	42.5
	5	7.75	42.0	7.75	42.0
	6	10.71	42.0	7.45	42.0
	8	18.40	42.0	7.15	41.5
4-16	4	2.86	40.0	4.45	40.0
	6	4.83	34.0	3.34	34.0
	8	7.58	32.0	2.90	31.0
	9	9.09	31.0	2.78	31.0
	12	14.70	30.0	2.58	30.0
	16	25.00	30.0	2.40	30.0
10-40	10	10.5	30.0	2.60	30.0
	15	22.0	29.5	2.40	29.5
	20	37.8	29.0	2.35	29.5
	24	55.2	29.0	2.30	29.5
	30	84.0	28.5	2.25	29.5
	40	149.0	28.0	2.24	29.5

† *Voltages taken with Rectox type voltmeter*
‡ *Degrees current lags voltage*

ENERGY REQUIREMENTS
BURDEN DATA OF OPERATING CURRENT CIRCUIT – 60 HERTZ
TYPE KRP RELAY

AMPERE RANGE	TAP	VA at Tap Value†	P.F. Angle‡	VA at 5 Amps†	P.F. Angle‡
.5-2	.5	0.40	36.8	26.10	42.3
	.75	0.45	35.3	16.70	36.9
	1.0	0.53	34.1	12.10	33.9
	1.25	0.62	33.1	9.43	33.1
	1.5	0.73	32.3	7.94	31.6
	2.0	0.96	32.1	6.06	31.1
1-4	1.0	0.53	31.1	12.50	31.2
	1.5	0.72	29.1	7.99	28.2
	2.0	0.96	28.7	6.09	27.8
	2.5	1.25	28.7	5.04	28.1
	3.0	1.63	29.6	4.57	28.9
	4.0	2.55	30.1	3.99	30.0
2-8	2	1.55	38.3	9.54	37.6
	3	2.26	35.5	6.25	34.8
	4	3.20	33.2	4.98	33.1
	5	4.39	32.8	4.40	32.7
	6	5.78	32.4	4.05	32.1
	8	9.31	31.8	3.62	32.4
4-16	4	2.05	42.8	3.24	42.0
	6	2.94	38.5	2.03	38.0
	8	4.09	35.7	1.59	35.7
	9	4.77	34.8	1.46	35.5
	12	7.30	33.3	1.24	34.3
	16	11.5	32.0	1.11	34.2
10-40	10	5.23	30.9	1.33	30.8
	15	10.5	30.3	1.15	31.3
	20	17.6	30.3	1.07	30.8
	24	24.1	29.4	1.05	29.9
	30	36.8	30.1	0.99	31.6
	40	64.9	28.9	0.97	31.9

† *Voltages taken with Rectox type voltmeter*
‡ *Degrees current lags voltage*

ENERGY REQUIREMENTS – 60 HERTZ
KRC RELAY

AMPERE RANGE	TAP	VA at Tap Value†	P.F. Angle‡	VA at 5 Amps†	P.F. Angle‡
.5-2	.5	0.42	36.5	27.50	43.6
	.75	0.49	37.9	17.60	39.5
	1.0	0.57	36.9	13.00	37.8
	1.25	0.68	36.0	10.50	35.9
	1.5	0.81	36.0	8.98	35.6
	2.0	1.10	36.4	6.94	35.4
1-4	1.0	0.57	37.1	13.30	38.1
	1.5	0.79	36.7	8.79	36.8
	2.0	1.10	37.1	6.84	36.8
	2.5	1.46	37.9	5.90	37.4
	3.0	1.92	38.4	5.34	38.1
	4.0	3.06	39.6	4.77	39.1
2-8	2	1.68	39.8	10.50	38.8
	3	2.58	37.3	7.03	36.5
	4	3.75	36.1	5.87	35.8
	5	5.19	35.8	5.17	35.7
	6	7.07	35.8	4.88	36.1
	8	11.30	35.7	4.51	36.8
4-16	4	2.17	42.2	3.37	42.0
	6	3.20	38.0	2.22	37.8
	8	4.64	35.5	1.80	36.0
	9	5.37	35.8	1.67	35.7
	12	8.52	34.8	1.46	35.0
	16	13.80	33.7	1.33	35.0
10-40	10	6.08	34.0	1.52	33.9
	15	12.2	32.6	1.34	34.1
	20	20.5	31.8	1.27	34.5
	24	28.7	31.3	1.24	34.5
	30	43.4	30.4	1.19	35.4
	40	78.3	28.5	1.16	35.6

† *Voltages taken with Rectox type voltmeter*
‡ *Degrees current lags voltage*

RATING OF OVERCURRENT UNIT

RANGE	CONTINUOUS RATING AMPERES	ONE SECOND RATING AMPERES
.5-2	5	100
1-4	8	140
2-8	8	140
4-16	10	200
10-40	10	200

Table 1: DIRECTIONAL UNIT SENSITIVITY

RELAY TYPE	AMPERE RATING	VALUES FOR MIN. PICKUP†		PHASE ANGLE RELATIONSHIP
		VOLTS	AMPERES	
KRP KRD (Voltage Unit)	.5-2 1-4 2-8	1	2.0	I Lagging V by 60°‡
		1	4.0	I In-phase with V
	4-16 10-40	1	4.0	I Lagging V by 60°‡
		1	8.0	I In-phase with V
KRC KRD (Current Unit)	.5-2 1-4 2-8		0.5	I_0 Leading I_P by 40°‡
			0.57	In-phase
	4-16 10-40		1.0	I_0 Leading I_P by 40°‡
			1.4	In-phase

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

Table 2: 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). Contacts remain open.	Left (front-view) plug screwed out until spurious torque is in contact closing direction. Then the plug is screwed in until spurious torque is reversed.

NOTE: Short circuit the voltage polarizing circuit and open circuit the current polarizing circuit at the relay terminals before making the above adjustments.

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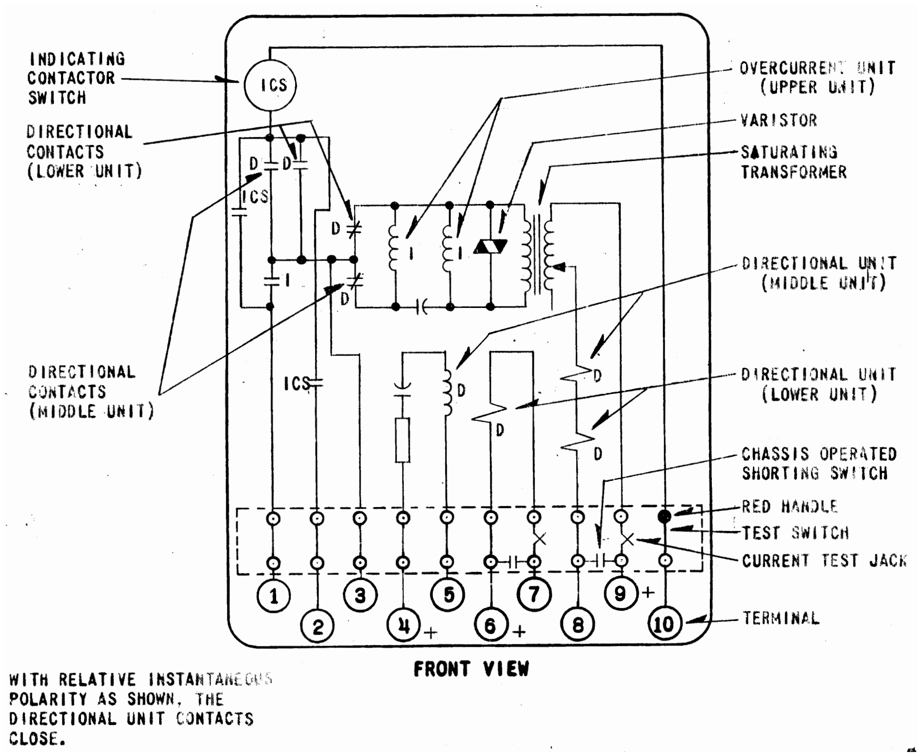
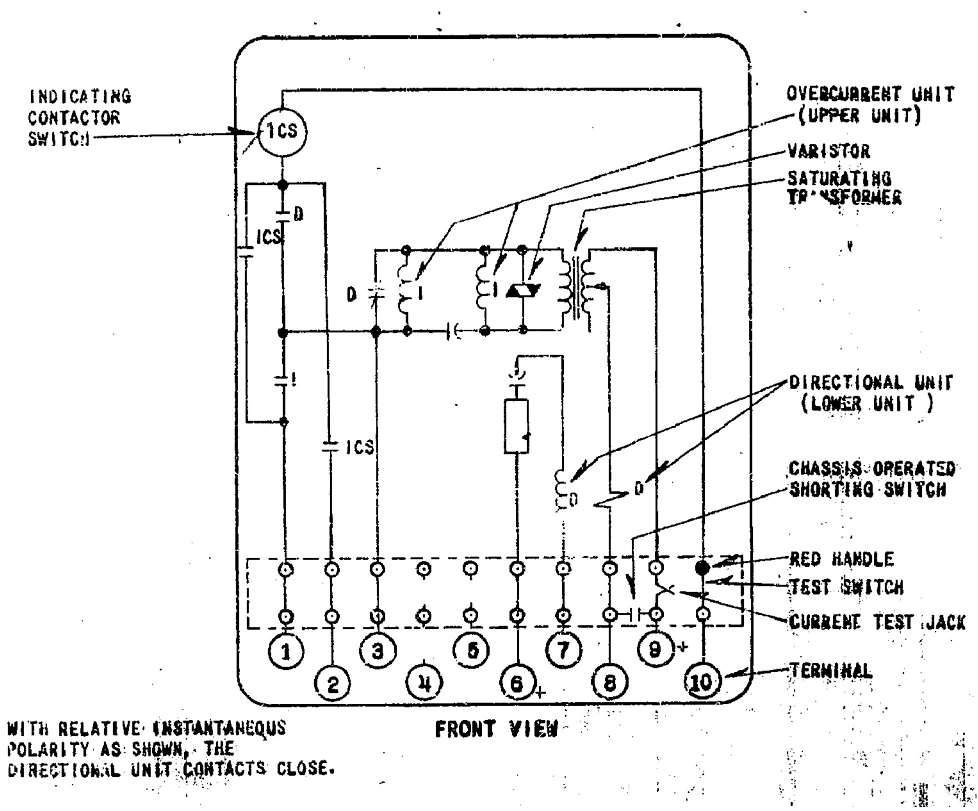


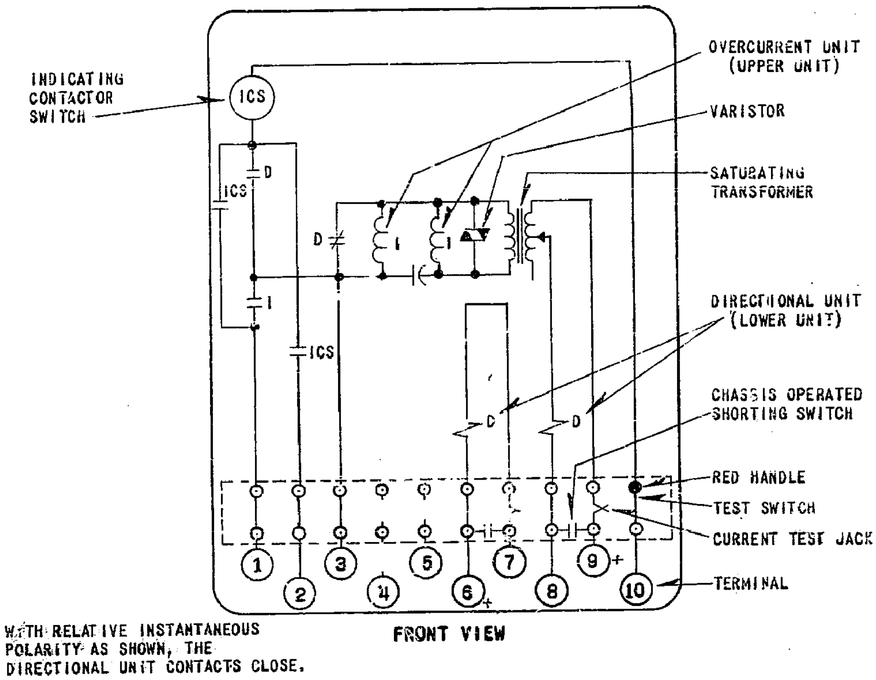
Sub 2
183A412

Figure 2: Internal Schematic of the Type KRD Relay in the FT-31 Case



*Sub 6
183A025

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



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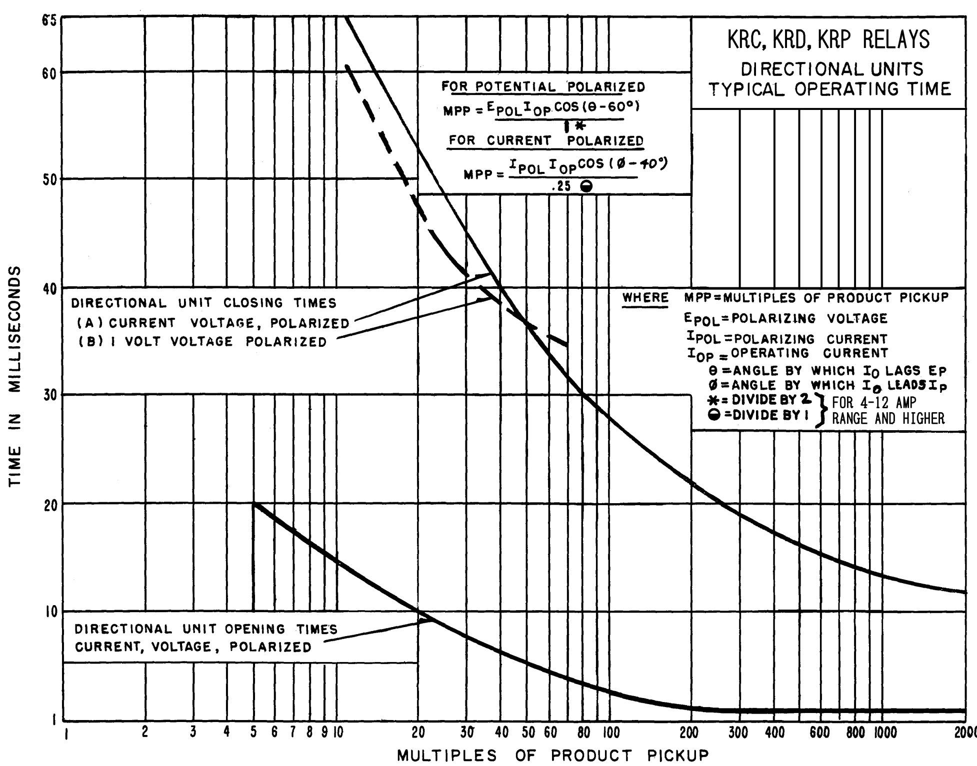
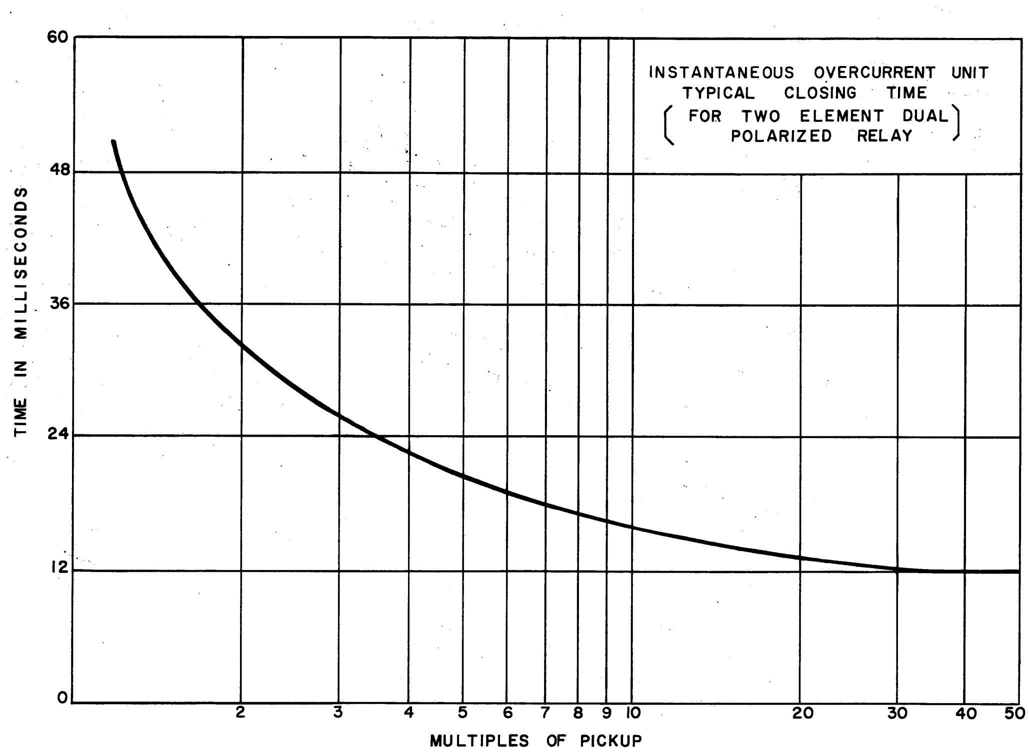
183A022

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



*Sub 1
619617

Figure 5: Typical Operating Times for the D-Unit of the Type KRD, KRP, and KRC Relays



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538109

Figure 6: Typical Operating Times for the D-Unit of the Type KRD, KRP and KRC Relays

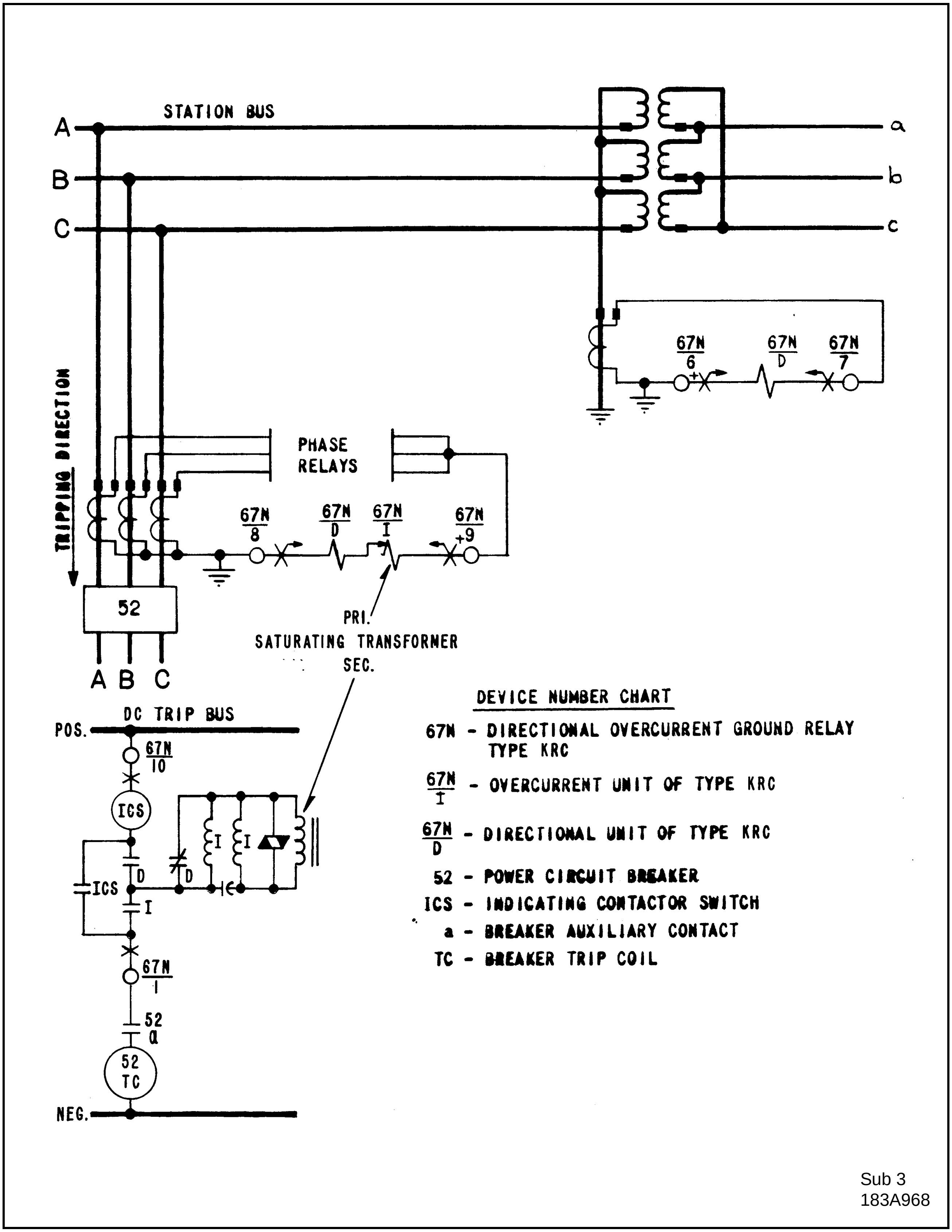


Figure 7: External Schematic of the Type KRC Relay

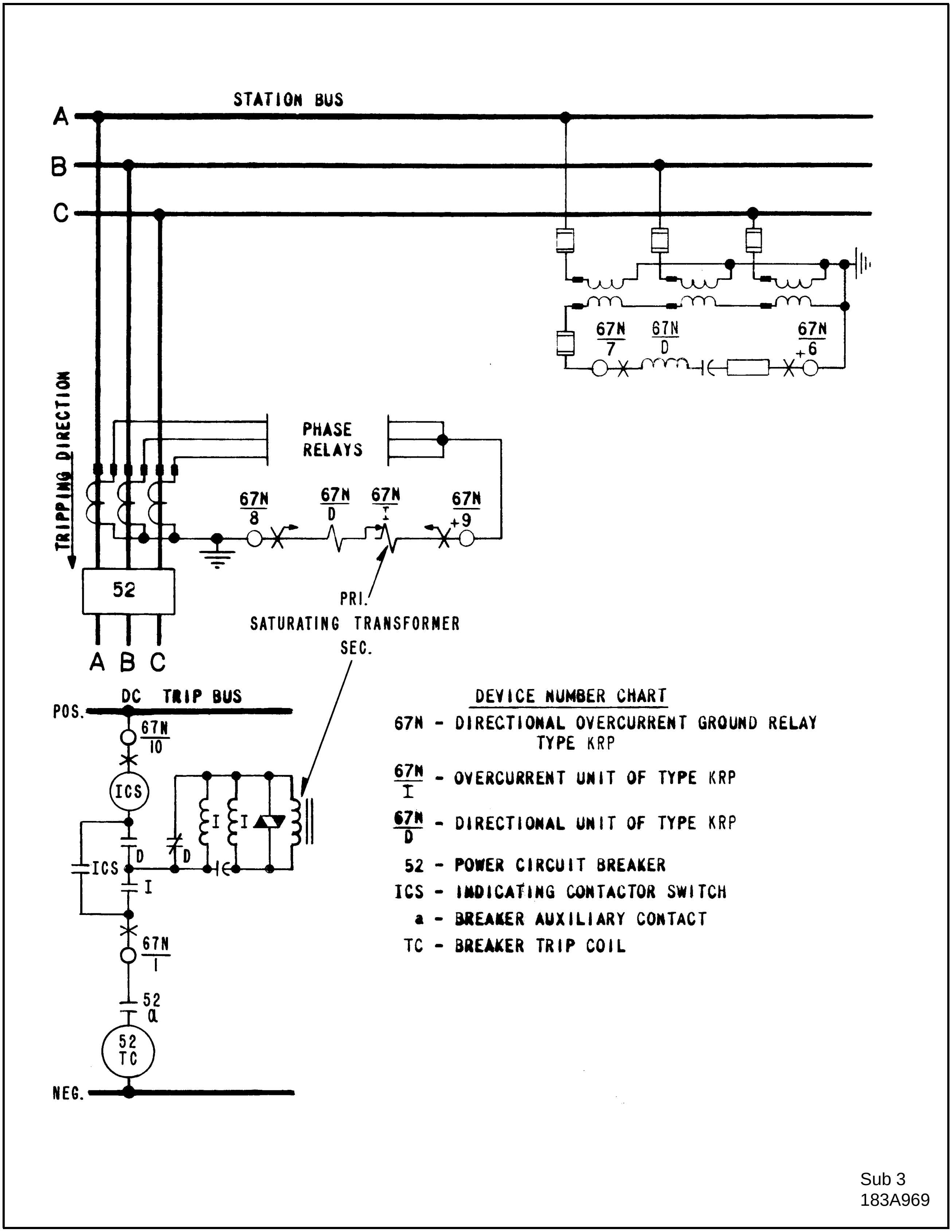


Figure 8: External Schematic of the Type KRP Relay

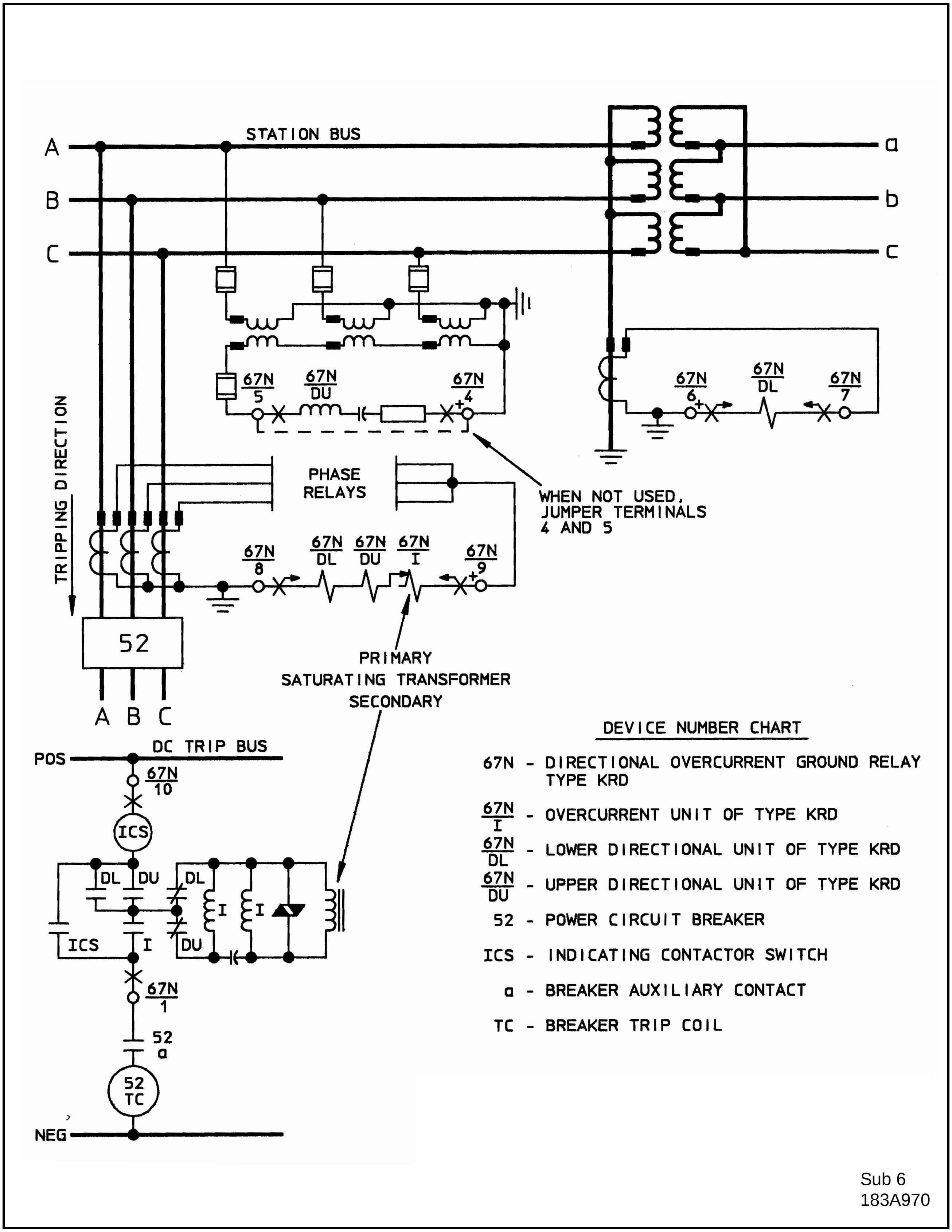
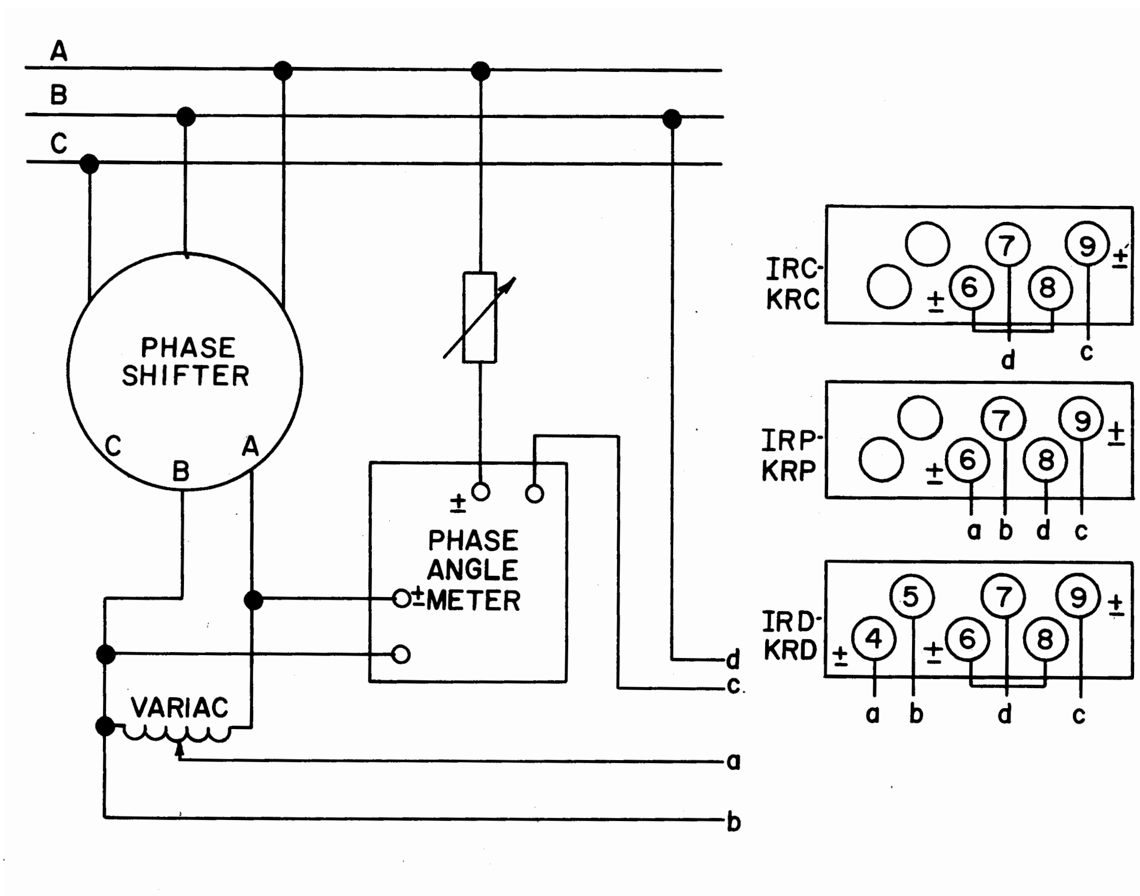


Figure 9: External Schematic of the Type KRD Relay



Sub 3
3512A85

Figure 10: Test Connections

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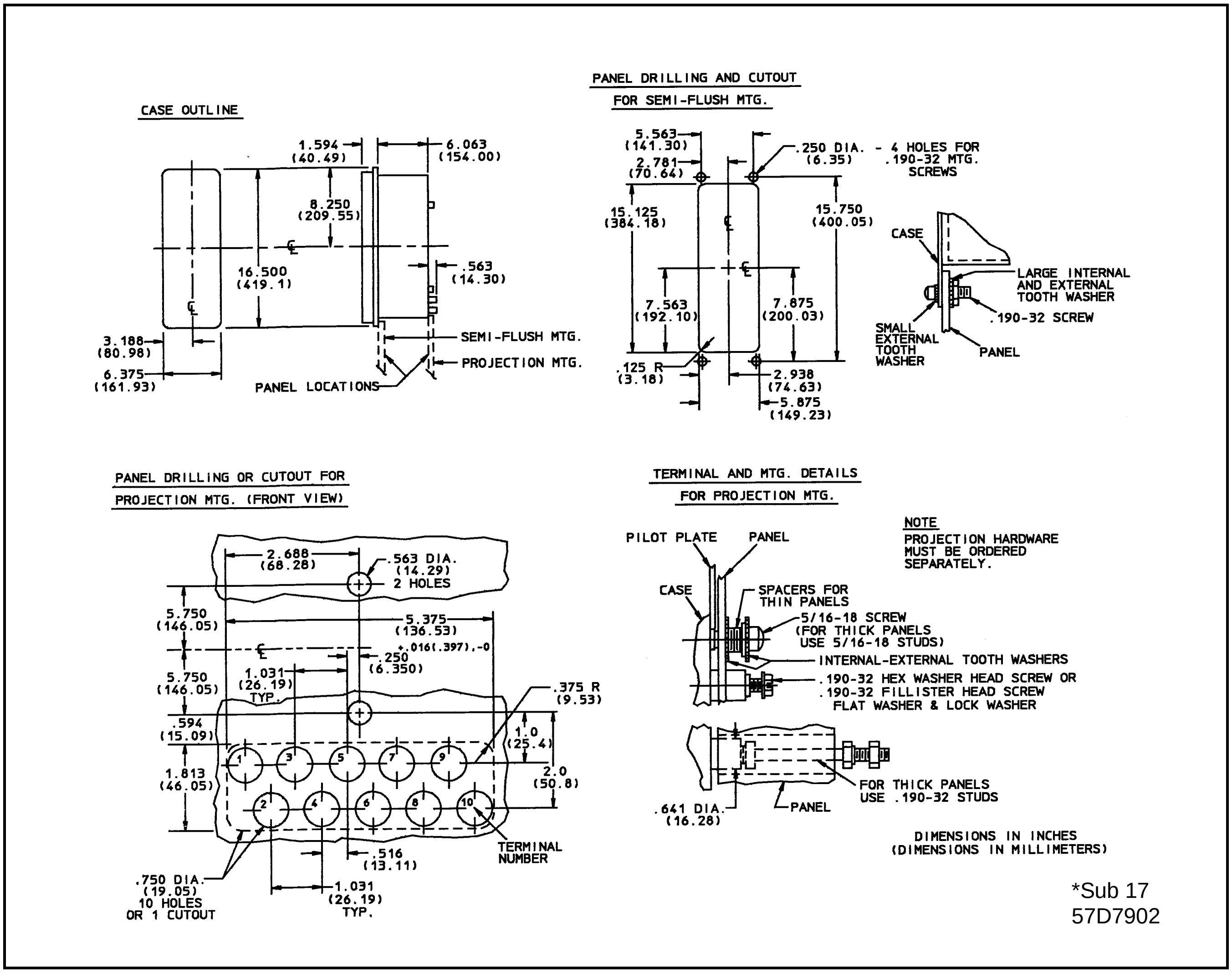

Figure 11: Outline and Drilling Plan for the KRD, KRP, and KRC Relays in the FT-31 Case

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