

#### INSTALLATION . OPERATION . MAINTENANCE

## INSTRUCTIONS

# DIRECTIONAL OVERCURRENT GROUND RELAYS TYPES IRP, IRC AND IRD

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**

These relays are ground directional overcurrent relays which are used for the protection of transmission lines and feeder circuits. Both the time-overcurrent and instantaneous overcurrent units are directionally controlled.

The type IRP relay is potential polarized. The type IRC relay is current polarized. The type IRD relay is a dual polarized relay which can be polarized from a potential source, from a local ground source or from both simultaneously.

#### CONSTRUCTION AND OPERATION

The various types of relays consist of a directional unit or units (D), an auxiliary switch (CS-1), a time-overcurrent unit (CO), an instantaneous overcurrent unit (I), an instantaneous overcurrent unit transformer, and two indicating contactor switches (ICS/I) and (ICS/T). The principle component parts of the relays and their location are shown in Fig. 1 through 6.

#### Time-Overcurrent Unit (CO)

- \* The electromagnets for the types IR-5, IR-6, IR-7, IR-8 and IR-9 units have a main tapped coil located on the center leg of an "E" type laminated structure that produces a flux which divides and returns through the outer legs. A shading coil causes the flux through the left leg to lag the main pole flux. The out-of-phase fluxes thus produced in the air gap cause a contact closing torque.
- \* The electromagnet for the type IR-2 and IR-11 units has a main coil consisting of a tapped primary winding and a secondary winding. Two identical coils

on the outer legs of the lamination structure are connected to the main coil secondary in a manner so that the combination of all the fluxes produced by the electromagnet result in out-of-phase fluxes in the air gap. The out-of-phase air gap fluxes produced cause a contact closing torque.

#### Indicating Contactor Switch Units (ICS/I and ICS/T)

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

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

#### Directional Unit (1)

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 the magnetic core. The magnetic core which houses the lower pin bearing is secured to the 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

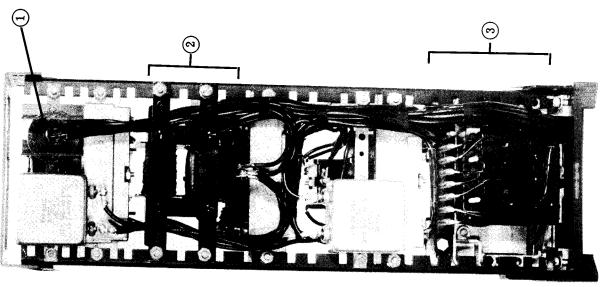


Fig. 2. Type IRD Relay Without Case (Rear View). 1- Varistor. 2- Saturating Transformer. 3- "E" Type Electromagnet.

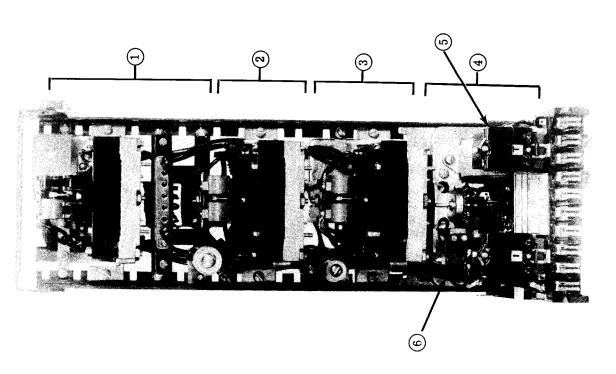


Fig. 1. Type IRD Relay Without Case (Front View). 1 — Instantaneous Over-current Unit and Saturating Transformer. 2 — Current Polarized Directional Unit. 3 — Voltage Polarized Directional Unit. 4 — Time Overcurrent Unit. 5 — Indicating Contactor Switch. 6 — Auxiliary Switch.

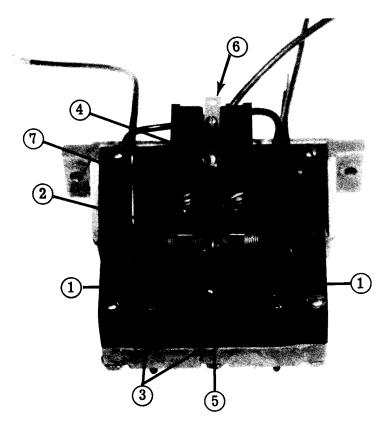


Fig. 3. Directional Unit. 1 - Stationary Contacts. 2 - Stationary Contact Pressure Spring. 3 - Magnetic Adjusting Plugs. 4 - Upper Bearing Screw. 5 - Moving Contact. 6 - Spring Adjuster Clamp. 7 - Current Bias Vane.

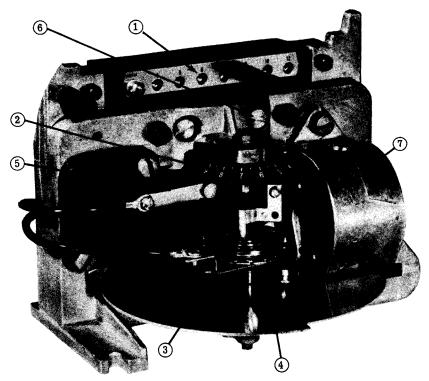


Fig. 4. Time Overcurrent Unit. 1—Tap Block. 2—Time Dial. 3—Control Spring Assembly. 4— Disc. 5—Stationary Contact Assembly. 6—Magnetic Plugs. 7—Permanent Magnet.

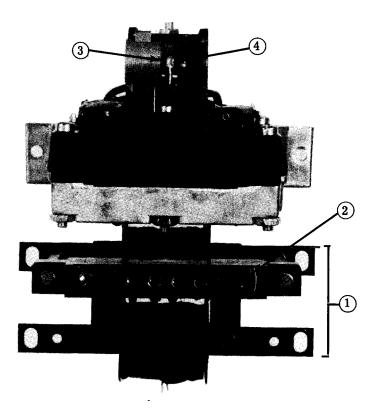


Fig. 5. Instantaneous Overcurrent Unit. 1 - Saturating Transformer. 2 - Tap Block. 3 - Stationary Contact. 4 - Moving Contact.

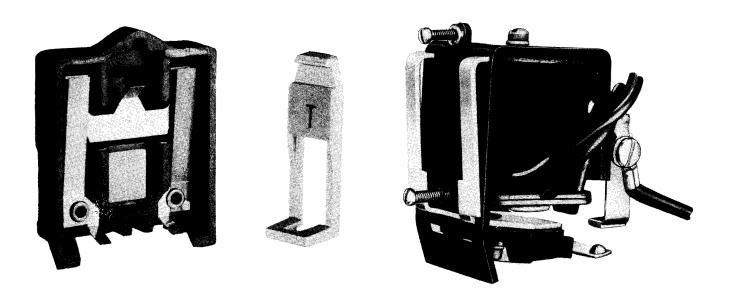


Fig. 6. Indicating Contactor Switch (ICS).

accurately position the lower pin bearing, which is mounted on the frame, with respect to the upper 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 rotating in an 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.

#### Auxiliary Switch (CS-1)

The auxiliary switch is a small solenoid type d.c. switch. A cylindrical plunger, with a silver disc mounted on its lower end, moves in the core of the solenoid. As the plunger travels upward, the disc bridges the silver stationary contacts. A tapped resistor is used to enable one to use the contactor switch on a 24, 48, 125 or 250 volt d.c. system connected per Fig. 21. The operation of the CS-1 switch is controlled by the directional unit (D) which in turn directionally controls the time-overcurrent unit (CO). When sufficient power flows in the tripping direction, the CS-1 switch operates and bridges the lag coil of the time-overcurrent unit (CO) permitting this unit to operate.

#### Instantaneous Overcurrent Unit (1)

The instantaneous 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 instantaneous overcurrent unit as shown in the internal schematics. This arrangement short-circuits the operating current around the pole windings; pre-

venting the instantaneous overcurrent unit from developing torque. If the directional unit should pick up for a fault, this short-circuit is removed, allowing the instantaneous overcurrent contact to commence closing almost simultaneously with the directional contact for high speed operation.

#### Instantaneous Overcurrent Unit Transformer

This transformer is of the saturating type for limiting the energy to the instantaneous overcurrent unit at higher values of fault current and to reduce C.T. burden. The primary winding is tapped and these taps are brought out to a tap block for ease in changing the pick-up of the instantaneous 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.

#### **CHARACTERISTICS**

The relays are available in the following current ranges:

#### Instantaneous Overcurrent Unit (I)

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	<b>4</b> 0			

#### Time Overcurrent Unit

Range				7	<u> Taps</u>		
.5-2.5 2-6 4-12	0.5 2 4	0.6 2.5 5	0.8 3 6	1.0 3.5	1.5 4 8	2.0 5 10	2.5 6 12

The tap value is the minimum current required to just close the relay contacts.

The time vs. current characteristics for the timeovercurrent unit are shown in Figs. 10 to 15. These characteristics give the contact closing time for the various time dial settings when the indicated multiples of tap value current are applied to the relay.

#### Trip Circuit

The relay contacts will safely close 30 amperes

at 250 volts d c and the seal-in contacts of the indicating contactor switches will safely carry this current long enough to trip a circuit breaker.

The indicating contactor switch has two taps that provide a pickup setting of 0.2 or 2 amperes. To change taps requires connecting the lead located in front of the tap block to the desired setting by means of a screw connection.

#### 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.

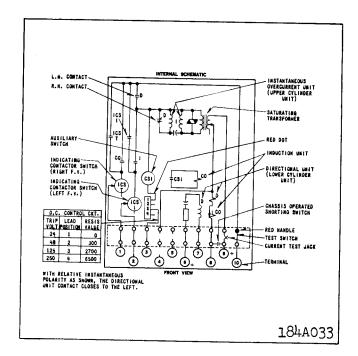


Fig. 7. Internal Schematic of the Type IRP Relay in the Type FT31 Case.

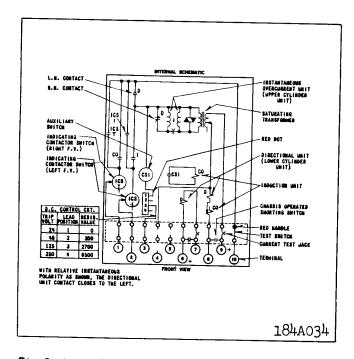


Fig. 8. Internal Schematic of the Type IRC Relay in the Type FT31 Case.

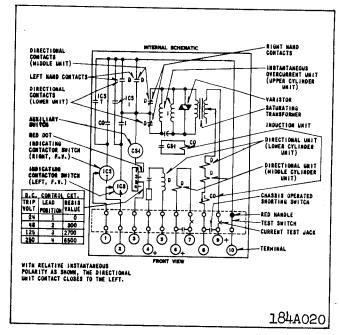


Fig. 9. Internal Schematic of the Type IRD Relay in the Type FT41 Case.

ENERGY REQUIREMENTS

INSTANTANEOUS OVERCURRENT UNIT OPERATING CURRENT CIRCUIT - 60 CYCLES

MPERE RANGE	TAP	VA AT TAP VALUE	P.F. ANGLE	VA*AT 5 AMPS.	P.F. ANGLE
WII LICE ICINE		07	39	24	46
	.5	.37	36	13	37
l	.75	.38		8.5	34
	1	.39	35	6.0	32
.5-2	1.25	.41	34	4.6	31
	1.5	.43	32	2.9	28
	2	.45	30	2.3	
	1	.41	36	9.0	36
	t	.44	32	5.0	32
	1.5	.47	30	3.0	29
1-4	2	.50	28	2.1	27
1 1	2.5	.53	26	1.5	26
	3	.59	24	0.93	24
	4	.39			
	2	1.1	49	6.5	48
	3	1.2	43	3.3	42
	4	1.3	38	2.1	37
2-8	5	1.4	35	1.4	35
	6	1.5	33	1.1	33
	8	1.8	29	0.7	29
	+	<del>                                     </del>	-1	2.4	51
	4	1.5	51	1.2	45
	6	1.7	45	0.7	40
4-16	8	1.8	40	0.6	38
	9	1.9	38	l l	34
	12	2.2	34	0.37	31
	16	2.5	30	0.24	21
	10	1.7	28	0.43	28
	<b>I</b>	2.4	21	0.27	21
	15	3.1	16	0.20	17
10-40	20	3.6	15	0.15	15
10 40	24	1	12	0.11	13
	30	4.2	11	0.08	12
	40	4.9			

RANGE	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING * (AMPERES)
5.0	5	100
.5-2	8	140
1-4	8	140
2-8	10	200
4-16		200
10-40	10	

<sup>\*</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

φ Degrees current lags voltage.

<sup>\*\*</sup> Voltages taken with Rectox type voltmeter.

#### ENERGY REQUIREMENTS - 60 CYCLES

#### DIRECTIONAL UNIT OPERATING CIRCUIT BURDEN

**VOLT AMPERES\*\*** 

Relay Type	Range Amps	Continuous Rating (Amperes)	One Second Rating* (Amperes)	Power Factor Angle $\phi$	At Minimum Tap Value Current	At 3 Times Minimum Tap Value Current	At 10 Times Minimum Tap Value Current	At 20 Times Minimum Tap Value Current		
	0.5-2.5	•	230	44.0	0.033	0.30	3.3	14.2		
IRC	2-6	-	230	42.5	0.58	5.28	58.0	240.0		
	4-12	12	280	-	0.64	6.12	70.0	272.0		
	0.5-2.5	10	230	34.5	0.03	0.23	2.8	11.5		
IRP	2-6	10	230	34.5	0.44	4.08	48.0	182.0		
	4-12	12	280	-	0.48	4.62	53.6	216.0		
	0.5-2.5	10	230	45.0	0.07	0.59	6.6	26.0		
IRD	2-6	10	230	45.0	1.04	9.9	106.0	420.0		
	4-12	12	280	-	1.16	10.8	121.2	472.0		

 $<sup>\</sup>phi$  Degrees current lags voltage at tap value current.

#### ENERGY REQUIREMENTS - 60 CYCLES DIRECTIONAL UNIT POLARIZING CIRCUIT BURDEN

RELAY TYPE	RATING	VOLT AMPERES △	POWER FACTOR ANGLE
IRC	230* Amperes	1.45	8º Lag
IRP	208** Volts	11.2	28 <sup>0</sup> Lead
IRD Current Unit	230* Amperes	1.45	8° Lag
IRD Voltage Unit	208** Volts	11.2	28° Lead

 $<sup>\</sup>phi$  Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units..

<sup>\*</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

<sup>\*\*</sup> Voltages taken with Rectox type voltmeter.

 $<sup>\</sup>Delta$  Burden of voltage polarized units taken at 120 volts. Burden of current polarized units taken at 5 amperes.

<sup>\*</sup> One second rating.

<sup>\*\* 30</sup> second rating. The 10 second rating is 345 volts. The continuous rating is 120 volts.

#### **ENERGY REQUIREMENTS**

#### TYPE IRD-2, IRC-2, IRP-2 TIME OVERCURRENT UNITS

				VOLT AMPERES**					
AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE $\phi$	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT	
0.5/2.5	0.5 0.6 0.8 1.0 1.5 2.0 2.5	0.91 0.96 1.18 1.37 1.95 2.24 2.50	28 28 28 28 28 28 28	58 57 53 50 40 36 29	4.8 4.9 5.0 5.3 6.2 7.2 7.9	39.6 39.8 42.7 45.4 54.4 65.4 73.6	256 270 308 348 435 580 700	790 851 1024 1220 1740 2280 2850	
2/6	2.0 2.5 3.0 3.5 4.0 5.0 6.0	3.1 4.0 4.4 4.8 5.2 5.6 6.0	110 110 110 110 110 110 110	59 55 51 47 45 41	5.04 5.13 5.37 5.53 5.72 5.90 6.54	38.7 39.8 42.8 42.8 46.0 50.3 54.9	262 280 312 329 360 420 474	800 920 1008 1120 1216 1500 1800	
4/12	4.0 5.0 6.0 7.0 8.0 10.0 12.0	7.3 8.0 8.8 9.6 10.4 11.2	230 230 230 230 230 230 230	65 50 47 46 43 37 34	4.92 5.20 5.34 * 5.53 5.86 6.6 7.00	39.1 42.0 44.1 45.8 49.9 55.5 62.3	268 305 330 364 400 470 528	848 1020 1128 1260 1408 1720 2064	

<sup>\*</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

 $<sup>\</sup>phi$  Degrees current lags voltage at tap value current.

<sup>\*\*</sup> Voltages taken with Rectox type voltmeter.

#### **ENERGY REQUIREMENTS**

IRD-5, IRC-5, IRP-5, TIME OVERCURRENT UNITS

						VOLT A	AMPERES**	
AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE $\phi$	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
0.5/2.5	(0.5 (0.6 (0.8 (1.0 (1.5 (2.0 (2.5	2 2.2 2.5 2.8 3.4 4.0 4.4	88 88 88 88 88	69 68 67 66 62 60 58	3.92 3.96 3.96 4.07 4.19 4.30	20.6 20.7 21 21.4 23.2 24.9 26.2	103 106 114 122 147 168 180	270 288 325 360 462 548 630
2/6	(2 (2.5 (3 (3.5 (4 (5 (6	8 8.8 9.7 10.4 11.2 12.5 13.7	230 230 230 230 230 230 230 230	67 66 64 63 62 59	3.88 * 3.90 3.93 4.09 * 4.12 4.20 4.38	21 21.6 22.1 23.1 23.5 24.8 26.5	110 118 126 136 144 162 183	308 342 381 417 448 540 624
4/12	(4 (5 (6 (7 (8 (10 (12	16 18.8 19.3 20.8 22.5 25	460 460 460 460 460 460	65 63 61 59 56 53 47	4.00 4.15 4.32 * 4.35 4.40 4.60 4.92	22.4 23.7 25.3 26.4 27.8 30.1 35.6	126 143 162 183 204 247	376 450 531 611 699 880 1056

#### IRD-7, IRC-7, IRP-7 TIME OVERCURRENT UNITS

						VOLT	AMPERES**	
AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE $\phi$	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
0.5/2.5	(0.5 (0.6 (0.8 (1.0 (1.5 (2.0 (2.5	2 2.2 2.5 2.8 3.4 4.0 4.4	88 88 88 88 88	68 67 66 64 61 58	3.88 3.93 3.93 4.00 4.08 4.24 4.38	20.7 20.9 21.1 21.6 22.9 24.8 25.9	103 107 114 122 148 174	278 288 320 356 459 552 640
2/6	(2 (2.5 (3 (3.5 (4 (5 (6	8 8.8 9.7 10.4 11.2 12.5 13.7	230 230 230 230 230 230 230	66 63 63 62 61 59	4.06 4.07 4.14 4.34 4.34 4.40 4.62	21.3 21.8 22.5 23.4 23.8 25.2	111 120 129 141 149 163 183	306 342 366 413 448 530 624
4/12	(4 (5 (6 (7 (8 (10 (12	16 18.8 19.3 20.8 22.5 25	460 460 460 460 460 460	64 61 60 58 55 51	4.24 4.30 4.62 4.69 4.80 5.20 5.40	22.8 24.2 25.9 27.3 29.8 33 37.5	129 149 168 187 211 260 308	392 460 540 626 688 860

<sup>\*</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

φ Degrees current lags voltage at tap value current.

<sup>\*\*</sup> Voltages taken with Rectox type voltmeter.

#### **ENERGY REQUIREMENTS**

IRD-8, IRC-8, IRP-8, TIME OVERCURRENT UNITS IRD-9, IRC-9, IRP-9,

				-				
			ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE $\phi$		VOLT A	MPERES**	
AMPERE RANGE	TAP	RATING			AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
	(0,5	2	88	72	2.38	21	132	350
	(0.6	2.2	88	71	2.38	21	134	365
	(0.8	2.5	88	69	2,40	21.1	142	400
0.5/2.5	(1.0	2.8	88	67	2.42	21.2	150	440
0.5/2.5	(1.5	3.4	88	62	2.51	22	170	530
	(2.0	4.0	88	57	2.65	23.5	200	675
	(2.5	4.4	88	53	2.74	24.8	228	800
	(2	8	230	70	2.38	21	136	360
	(2.5	8.8	230	66	2.40	21.1	142	395
	(3	9.7	230	64	2.42	21.5	149	430
2/6	(3.5	10.4	230	62	2.48	22	157	470
2/0	(4	11.2	230	60	2.53	22.7	164	500
	(5	12.5	230	58	2.64	24	180	580
	(6	13.7	230	56	2.75	25.2	198	660
	(4	16	460	68	2.38	21.3	146	420
	(5	18.8	460	63	2.46	21.8	158	480
	(6	19.3	460	60	2.54	22.6	172	550
4/12	(7	20.8	460	57	2.62	23.6	190	620
7/12	(8	22.5	460	54	2.73	24.8	207	700
	(10	25	460	48	3.00	27.8	248	850
	(12	28	460	45	3.46	31.4	292	1020

#### IRD-11, IRC-11, IRP-11 OVERCURRENT UNITS

			RATING* FA			VOLT A	AMPERES**	
AMPERE RANGE TAP	TAP	CONTINUOUS RATING (AMPERES)		POWER FACTOR ANGLE $\phi$	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
		1.7	56	36	0.72	6.54	71.8	250
	0.5	1.9	56	34	0.75	6.80	75.0	267
	0.6	2.2	56	30	0.81	7.46	84.0	298
	0.8	* 2.5	56	27	0.89	8.30	93.1	330
0.5/2.5	1.0	3.0	56	22	1.13	10.04	115.5	411
	1.5	3.0	56	17	1.30	11.95	136.3	502
	2.0 2.5	3.8	56	16	1.48	13.95	160.0	610
		7.0	230	32	0.73	6.30	74.0	264
	2.0	7.8	230	30	0.78	7.00	78.5	285
	2.5 3.0	8.3	230	27	0.83	7.74	84.0	309
0.40	3.5	9.0	230	24	0.88	8.20	89.0	340
2/6	4.0	10.0	230	23	0.96	9.12	102.0	372
	5.0	11.0	230	20	1.07	9.80	109.0	430
	6.0	12.0	230	20	1.23	11.34	129.0	504
			460	29	0.79	7.08	78.4	296
	4.0	14	460	25	0.89	8.00	90.0	340
	5.0	16	460	22	1.02	9.18	101.4	378
	6.0	17	460	20	1,10	10.00	110.0	454
4/12	7.0	18	460	18	1.23	11.1	124.8	480
	8.0	20	460	17	1.32	14.9	131.6	600
	10.0 12.0	22 26	460	16	1.8	16.3	180.0	720

<sup>\*</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

 $<sup>\</sup>phi$  Degrees current lags voltage at tap value current.

<sup>\*\*</sup> Voltages taken with Rectox type voltmeter.

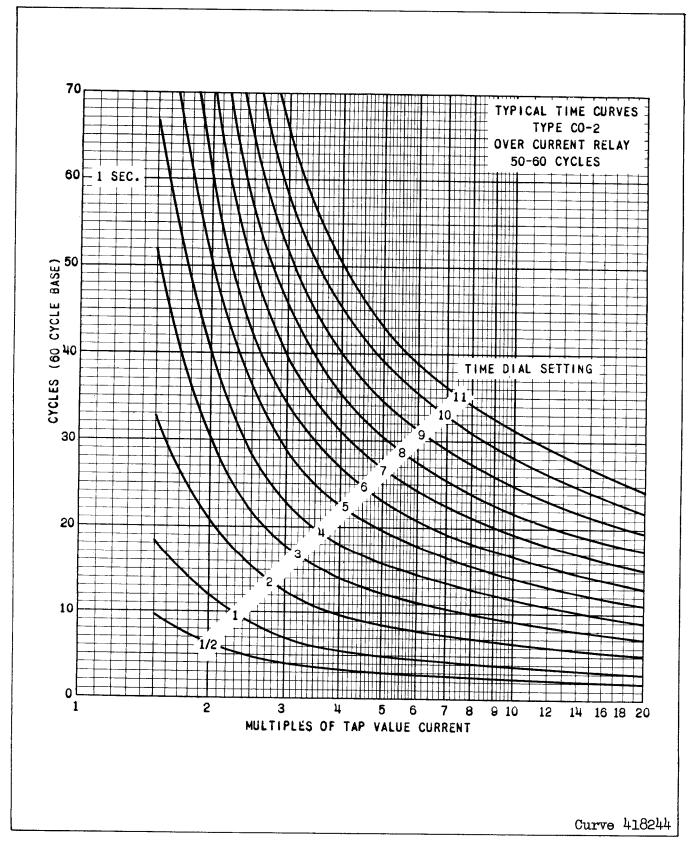


Fig. 10. Typical Time Curves of the Time-Overcurrent Unit of the Short Time (2) Relays.

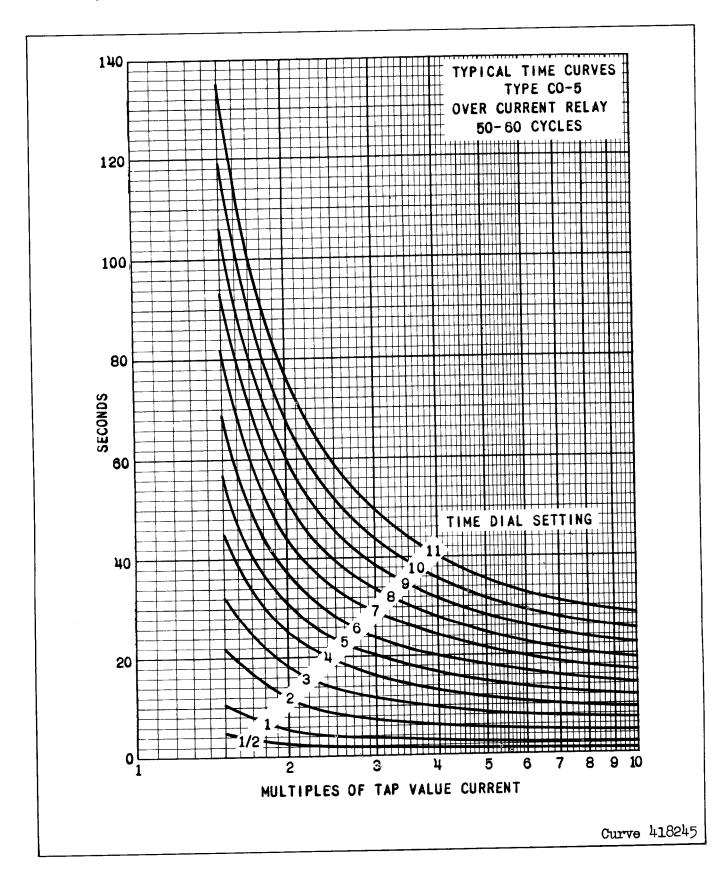


Fig. 11. Typical Time Curve of the Time-Overcurrent Unit of the Long Time (5) Relays.

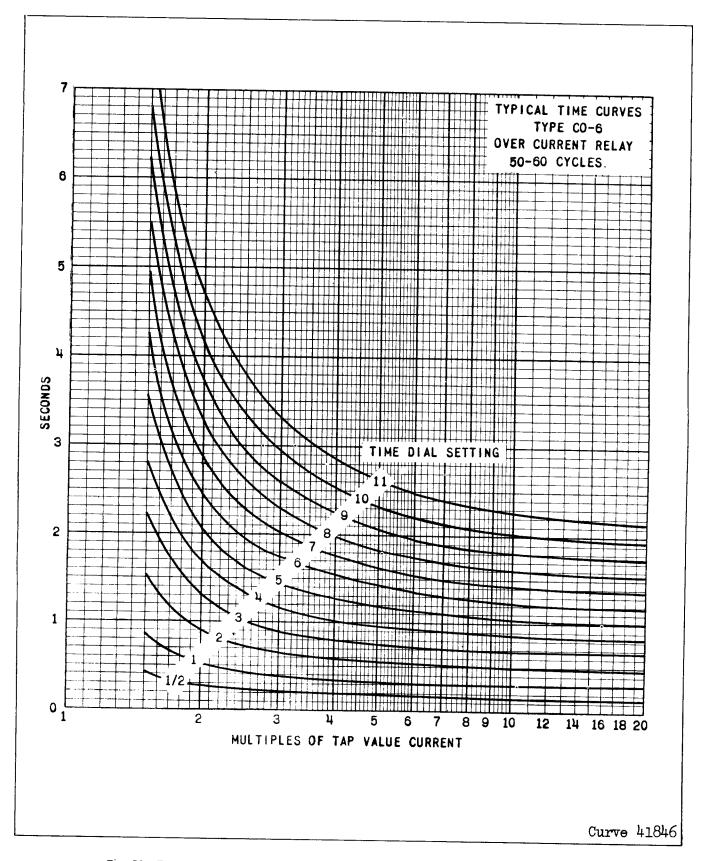


Fig. 12. Typical Time Curve of the Time-Overcurrent Unit of the Definite Time (6) Relays.

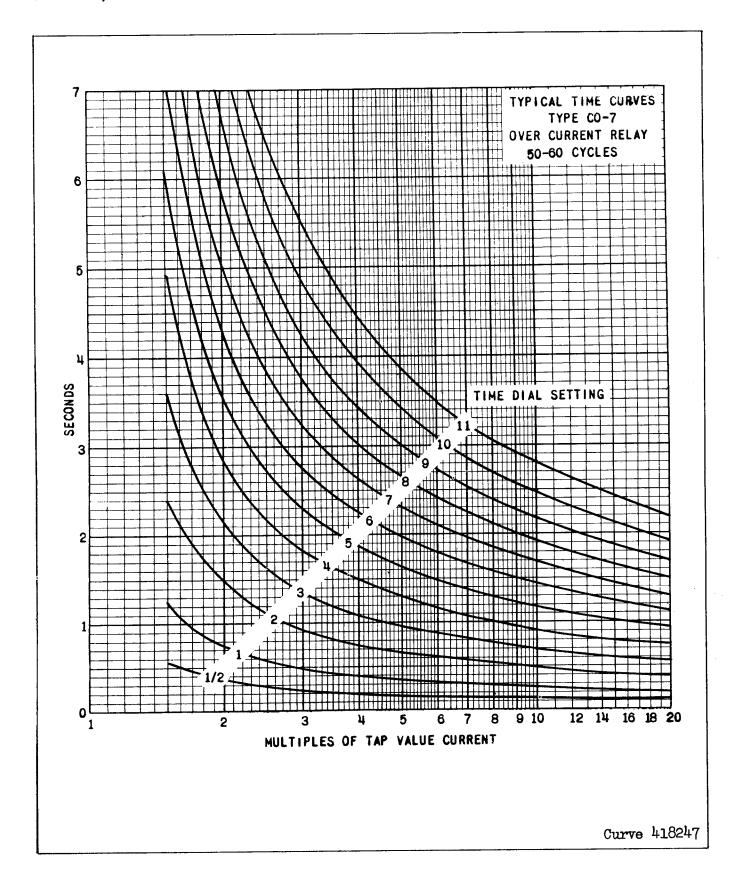


Fig. 13. Typical Time Curve of the Time-Overcurrent Unit of the Moderately Inverse (7) Relays.

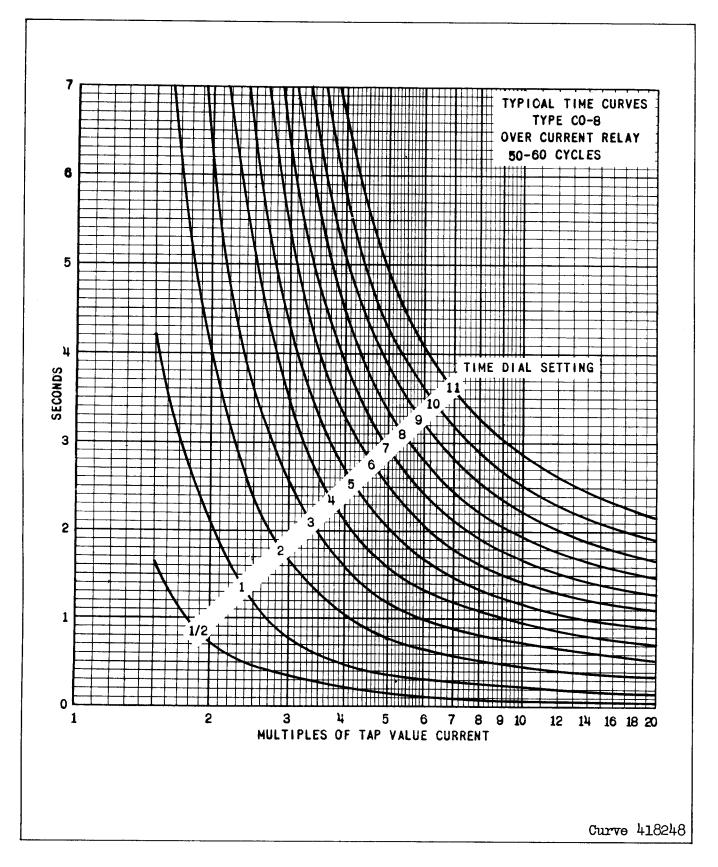


Fig. 14. Typical Time Curve of the Time-Overcurrent Unit of the Inverse (8) Relays.

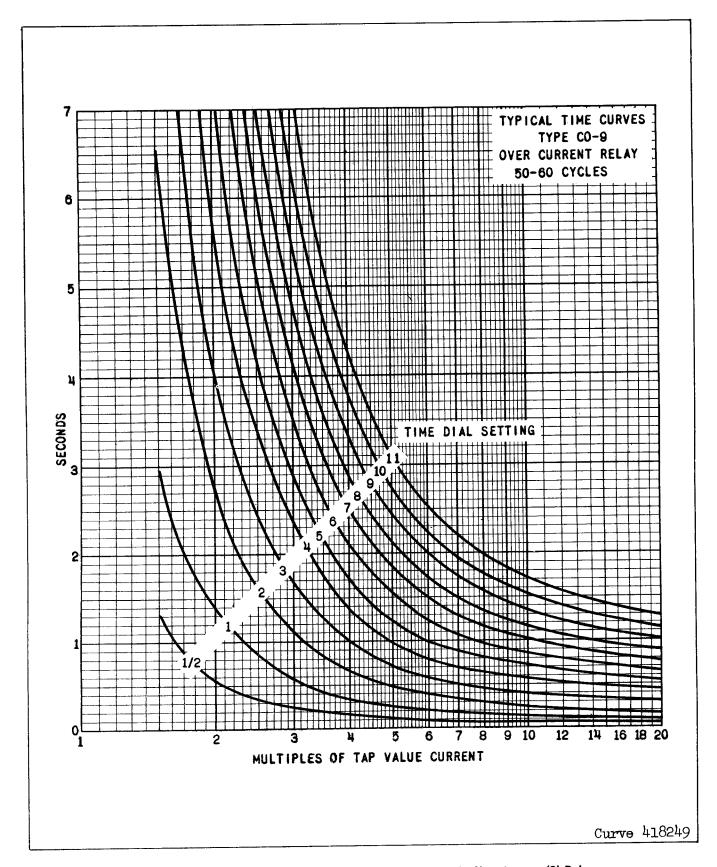


Fig. 15. Typical Time Curve of the Time-Overcurrent Unit of the Very Inverse (9) Relays.

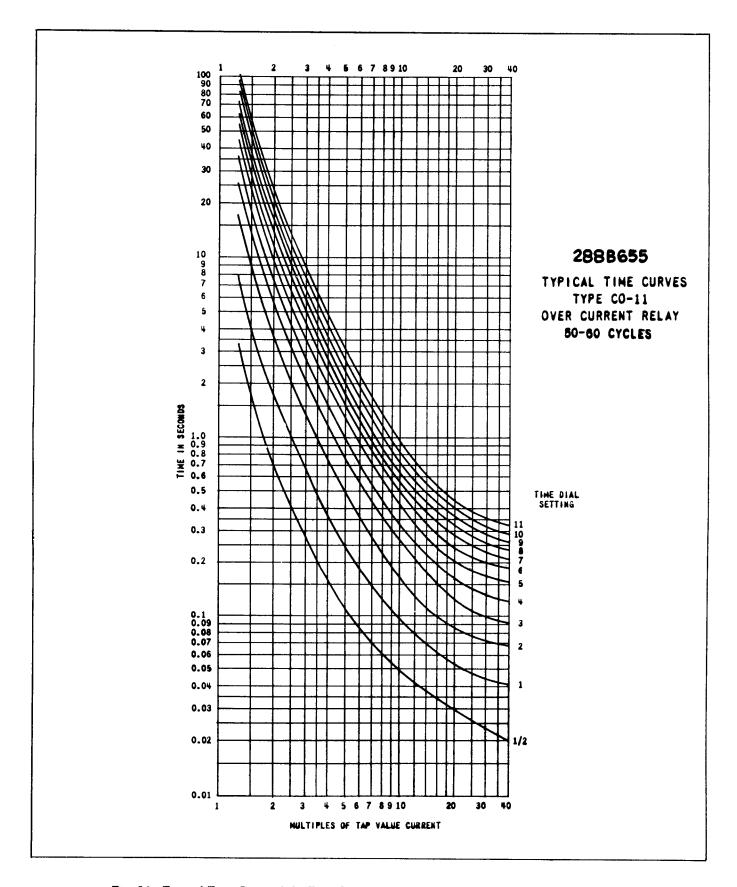


Fig. 16. Typical Time Curve of the Time-Overcurrent Unit of the Extremely Inverse (11) Relays.

#### Trip Circuit Constants

Indicating Contactor Switch —

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

#### Auxiliary Switch (CS-1)

The auxiliary switch has a d-c resistance of 1165 ohms.

#### Type IRP Relay

The IRP 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 pick-up is approximately 1 volt and 2 amperes at its maximum torque angle for the directional units used with the 0.5 to 2.5 and 2 to 6 ampere range time over-current units. For the directional units used with the 4-12 ampere range time overcurrent units the minimum pick-up is 1 volt and 4 amperes.

#### Type IRC Relay

The IRC relay is designed for current polarization and has its maximum torque when the operating current leads the polarizing current by approximately  $40^{\circ}$ .

The directional unit minimum pick-up is 0.5 ampere in each winding at the maximum torque angle for the directional units used with the 0.5 to 2.5 and 2 to 6 ampere range time overcurrent units. For the directional units used with the 4-12 ampere range time overcurrent units the minimum pickup is 1 ampere.

#### Type IRD Relay

The type IRD relay utilizes a directional unit similar to the IRC relay in conjunction with the directional unit and phase-shifting circuit of the IRP relay.

The current-polarized directional unit of the IRD relay operates on residual currents while the potential-polarized directional unit of the IRD relay operates on residual voltage and residual current.

For the directional units used with the 0.5 to 2 and 2 to 6 ampere time overcurrent units, the minimum pick-up of the current polarized unit is 0.5 ampere in each winding at the maximum torque angle. The minimum pick-up for the voltage polarized unit is

1 volt and 2 amperes with the current lagging voltage by  $60^{\circ}$ .

For the directional units used with the 4 to 12 ampere range time overcurrent units, the minimum pick-up is 1 ampere for the current-polarized directional unit.

#### **SETTINGS**

#### Time Overcurrent Unit (CO)

The time overcurrent unit settings can be defined either by tap setting and time dial position or by tap setting and a specific time of operation at some current multiple of the tap setting (e.g. 4 tap setting, 2 time dial position or 4 tap setting, 0.6 seconds at 6 times tap value current).

To provide selective circuit breaker operation, a minimum coordinating time of 0.3 seconds plus circuit breaker time is recommended between the relay being set and the relays with which coordination is to be effected.

The connector screws on the tap plate above the time dial makes connections to various turns on the operating coil. By placing this screw in the various tap plate holes, the relay will just close its contacts at the corresponding current 4-5-6-7-8-10-12 amperes, or as marked on the tap plate.

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, connext the spare connector screw in the desired position before removing the other tap screw from the original tap position.

#### Instantaneous Reclosing

The factory adjustment of the CO unit contacts provides a contact follow. Where circuit breaker reclosing will be initiated immediately after a trip by the CO contact, the time of the opening of the contacts should be a minimum. This condition is obtained by loosening the stationary contact mounting screw, removing the contact plate and then replacing the plate with the bent end resting against the contact spring.

#### Instantaneous Overcurrent Unit (1)

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 con-

nector screw in the desired tap, the relay will just close its contacts at the tap value current.

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.

#### Directional Units (D)

No setting is required.

#### Indicating Contactor Switch (ICS/I and ICS/T)

No setting is required on the ICS units except the selection of the 0.2 or 2.0 ampere tap setting. This selection is made by connecting the lead located in front of the tap block to the desired setting by means of the connecting screw.

#### Auxiliary Switch (CS-1)

No setting required on the CS-1 unit except for the selection of the required 24, 48, 125 or 250 voltage on the tapped resistor. This connection can be made by referring to Fig. 21.

#### 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 be means of the two mounting studs for the type FT projection case or by means of the four mounting holes on the flange for the semi-flush type FT case. 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 detail information on the FT Case refer to I.L. 41-076.

The external a-c connections of the directional overcurrent relays are shown in Figs. 18, 19 and 20. If no voltage polarizing source is to be connected to the IRD relay, short-circuit the voltage polarizing circuit at the terminals of the relay.

#### 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:

#### Instantaneous 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.

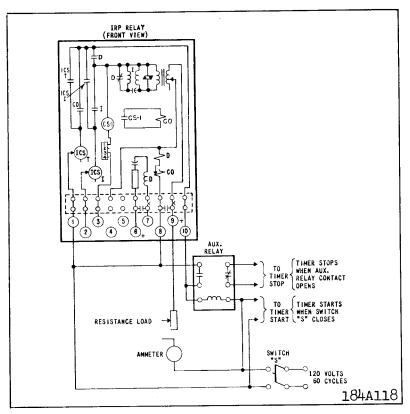
The pick-up of the overcurrent unit can be checked by inserting the tap screw in the desired tap hole and applying rated tap value current. The contact should close within  $\pm 5\%$  of tap value current.

#### Directional Unit (D)

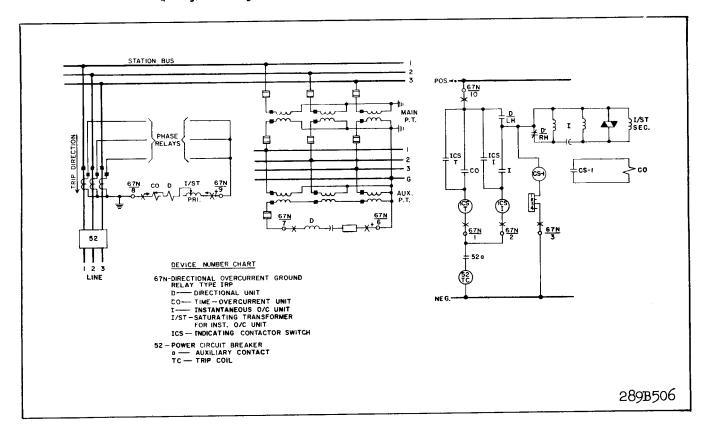
- 1. Contact Gap The gap between the stationary contact and moving contact with the relay in the deenergized position should be approximately .020".
- 2. <u>Sensitivity</u> The respective directional units should trip with value of energization and phase angle relationship as indicated in Table 1.
- 3. Spurious Torque Adjustments There should be no spurious closing torques when the operating circuits are energized per Table 2 with the polarizing circuits short circuited for the voltage polarized units and open-circuited for the current polarized units.

#### Time Overcurrent Unit (CO)

- 1. Contacts The index mark on the movement frame will coincide with the "O" mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "O" mark by approximately .020". The placement of the various time dial positions in line with the index mark will give operating times as shown on the respective time-current curves.
- 2. Minimum Trip Current Set the time dial to position 6 with the auxiliary switch (CS-1) contacts



\* Fig. 17. Diagram of test connections of the time-overcurrent unit.



\* Fig. 18. External Schematic of the IRP Relay for Ground Fault Protection.

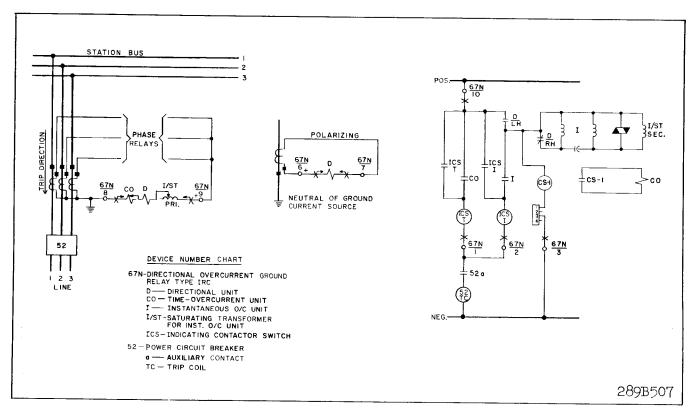


Fig. 19. External Schematic of the IRC Relay for Ground Fault Protection.

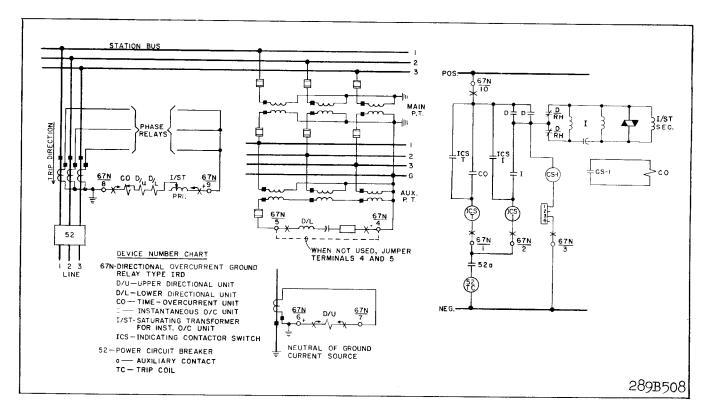


Fig. 20. External Schematic of the IRD Relay for Ground Fault Protection.

blocked closed, alternately apply tap value current plus 3% and tap value current minus 3%. The moving contact should leave the backstop at tap value current plus 3% and should return to the backstop at tap value current minus 3%.

3. <u>Time Curve</u> — Table 3 shows the time curve calibration points for the various types of relays. With the time dial set to the indicated position, apply the currents specified by Table 3 (e.g. for the CO-2, 3 and 20 times tap value current) and measure the operating time of the relay. The operating times should equal those of Table 3 plus or minus 5 percent.

#### Indicating Contactor Switches (ICS/I) and (ICS/T)

- A) Close the contacts of the CO and pass sufficient d.c. current through the trip circuit to close the contacts of (ICS/T). This value of current should not be greater than the particular (ICS/T) tap setting being used. The operation indicator target should drop freely, bringing the letter "T" into view.
- B) Close the contacts of the instantaneous overcurrent unit (I) and the directional unit (D). Pass sufficient d.c. current through the trip circuit to close the contacts of (ICS/I). This value of current should not be greater than the particular (ICS/I) tap setting being used. The operation indicator target should drop freely, bringing the letter "I" into view.
- C) The contact gap should be approximately .047" 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 time of 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. The use of phantom loads, in testing induction-type relays, should be avoided, since the resulting distorted current wave form will produce an error in timing.

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

#### Calibration

Use the following procedure for calibrating the

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

#### Instantaneous Overcurrent Unit (1)

- 1. The upper pin bearing should be screwed down with 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, i.e., against the right side of the bridge. Move 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 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  $\pm 5\%$  of tap value.

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.

#### Directional Unit (D)

In the type IRP and IRC relays the directional unit is the lower cylinder unit. In the type IRD the directional units are the lower and middle cylinder 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 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 as indicated by a neon lamp in the contact circuit when energized with the required current and voltage as shown in Table 1. 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 (IRP and IRD voltage polarized unit) are short-circuited.
- b) The polarizing circuits of the current polarized relays (IRC and IRD 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 some installations in order to insure that the relay will always trip the breaker on zero potential.

#### Time Overcurrent Unit (CO)

- 1. Contacts The index mark on the movement frame will coincide with the "O" mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "O" mark by approximately .020". The placement of the various time dial positions in line with the index mark will give operating times as shown on the respective time-current curves.
- 2) Minimum Trip Current The adjustment of the spring tension in setting the minimum trip current value of the relay is most conveniently made with the damping magnet removed.

With the time dial set on "O", wind up the spiral spring by means of the spring adjuster until approximately 6-3/4 convolutions show.

Set the relay on the minimum tap setting, the time dial to position 6.

With the auxiliary switch (CS-1) contacts blocked closed, adjust the control spring tension so that the moving contact will leave the backstop at tap value current +1.0% and will return to the backstop at tap value current -1.0%.

3) <u>Time Curve Calibration</u> — Install the permanent magnet.

Apply the indicated current per Table 3 for permanent magnet adjustment (e.g. IRP-8, 2 times tap value) and measure the operating time. Adjust the permanent magnet keeper until the operating time corresponds to the value of Table 3.

Apply the indicated current per Table 3 for the electromagnet plug adjustment (e.g. IRP-8, 20 times tap value) and measure the operating time. Adjust the proper plug until the operating time corresponds to the value in Table 3. (Withdrawing the left hand plug, front view increases the operating time and withdrawing the right hand plug, front view, decreases the time.) In adjusting the plugs, one plug should be

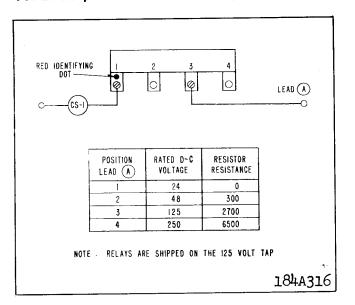


Fig. 21. Selection of Proper Voltage Tap for Auxiliary Switch (CS-1) Operation.

screwed in completely and the other plug run in or out until the proper operating time has been obtained.

Recheck the permanent magnet adjustment. If the operating time for this calibration point has changed, readjust the permanent magnet and then recheck the electromagnet plug adjustment.

#### Indicating Contactor Switches (ICS/I) and (ICS/T)

Adjust the contact gap for approximately .047".

A) Close the contacts of the CO and pass sufficient d.c. current through the trip circuit to close the contacts of the (ICS/T). This value of current should not be greater than the particular (ICS/T) tap setting being used. The operation indicator target should drop freely bringing the letter "T" into view.

B) Close contacts of instantaneous overcurrent unit (I) and directional unit (D). Pass sufficient d.c. current through the trip circuit to close contacts of the (ICS/I). This value of current should not be greater than the particular (ICS/I) tap setting being used. The operation indicator target should drop freely bringing the letter "I" into view.

#### Auxiliary Switch (CS-1)

Adjust the stationary core of the switch for a clearance between the stationary core and the moving core when the switch is picked up. This can be done by turning the relay upside-down. Then screw up the core screw until the moving core starts rotating. Now back off the core screw until the moving core stops rotating. This indicates the points where the play in the assembly is taken up, and where the moving core just separates from the stationary core screw. Back off the core screw approximately one turn and lock in place. This prevents the moving core from striking and sticking to the stationary core because of residual magnetism. Adjust the contact clearance for 3/64" by means of the two small nuts on either side of the Micarta disc.

Connect lead (A) to proper terminal per Fig. 21. Block directional unit (D) contacts close and energize trip circuit with rated voltage. Contacts of auxiliary switch (CS-1) should make as indicated by a neon lamp in the contact circuit.

#### 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.

TABLE I

RELAY TYPE	AMPERE RATING	VALUES FOI	R MIN. PICKUP*	PHASE ANGLE RELATIONSHIP
	TIME-OVERCURRENT UNIT	VOLTS	AMPERES	
	.5-2.5	1	2.0	I lagging V by 60°**
IRP	2-6	1	4.0	I in-phasse with V
IRD (Voltage Unit)		1	4.0	I lagging V by $60^{O}**$
O III O	4-12	1	8.0	I in-phase with V
	_		0.5	Ioleading Ip by 400**
IRC	.5-2.5 2-6		0.65	In-phase
IRD (Current Unit)	4-12		1.0	Io leading Ip by 400**
,	4-12		1.3	In-phase

<sup>\*</sup>The energization quantities are input quantities at the relay terminals.

<sup>\*\*</sup> 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) (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.

<sup>†</sup> Short circuit the voltage polarizing circuit at the relay terminals before making the above adjustment.

TABLE III

TIME CURVE CALIBRATION DATA - 60 CYCLES

	PERMANENT	ELECTROMAGN	ET PLUGS		
TIME- OVERCURRENT UNIT TYPE	TIME I DIAL POSITION	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS
2	6	3	0.57	20	0.22
5	6	2	37.80	10	14.30
6	6	2	2.46	20	1.19
7	6	2	4.27	20	1.11
8	6	2	13.35	20	1.11
9	6	2	8.87	20	0.65

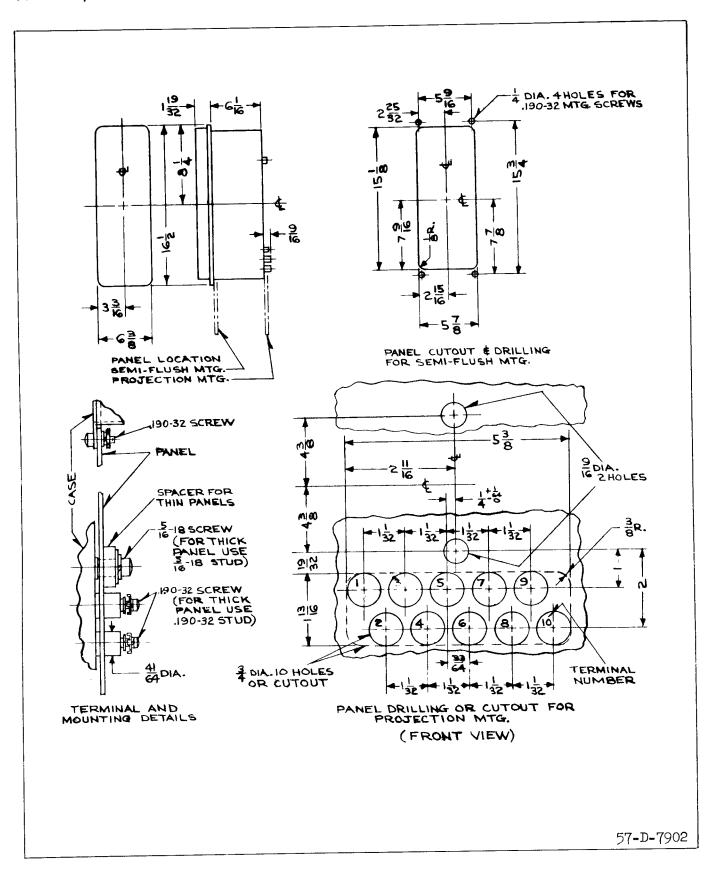


Fig. 22. Outline and Drilling Plan for the IRP and IRC Relays in the Type FT31 Case.

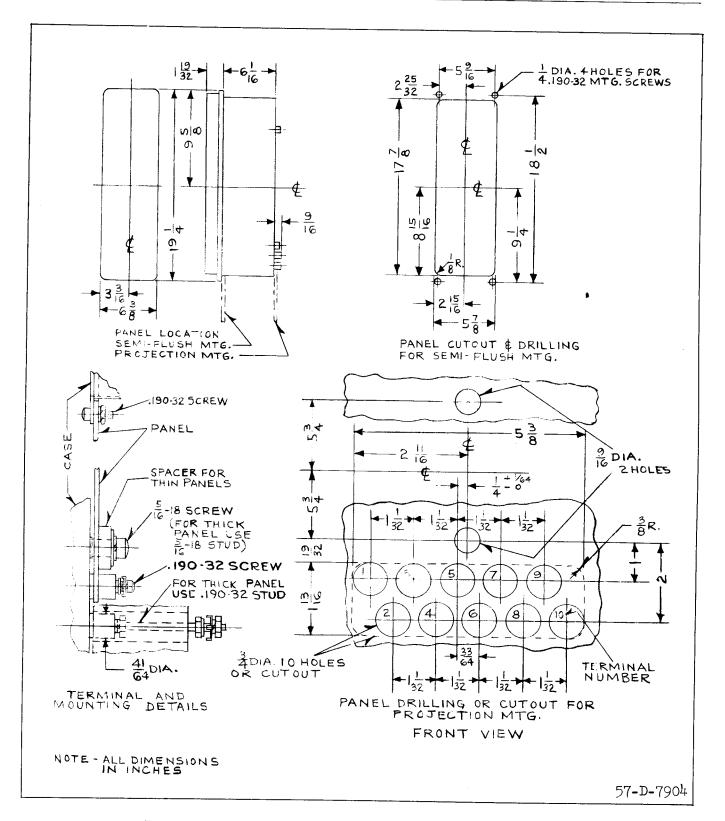


Fig. 23. — Outline and Drilling Plan for the IRD Relay in the Type FT41 Case.

## WESTINGHOUȘE ELECTRIC CORPORATION RELAY DEPARTMENT



#### INSTALLATION . OPERATION . MAINTENANCE

### INSTRUCTIONS

# DIRECTIONAL OVERCURRENT GROUND RELAYS TYPES IRP, IRC AND IRD

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

These relays are ground directional overcurrent relays which are used for the protection of transmission lines and feeder circuits. Both the time-overcurrent and instantaneous overcurrent units are directionally controlled.

The type IRP relay is potential polarized. The type IRC relay is current polarized. The type IRD relay is a dual polarized relay which can be polarized from a potential source, from a local ground source or from both simultaneously.

#### CONSTRUCTION AND OPERATION

The various types of relays consist of a directional unit or units (D), an auxiliary switch (CS-1), a time-overcurrent unit (CO), an instantaneous overcurrent unit (I), an instantaneous overcurrent unit transformer, and two indicating contactor switches (ICS/I) and (ICS/T). The principle component parts of the relays and their location are shown in Fig. 1 through 6.

#### Time-Overcurrent Unit (CO)

The electromagnets for the types IR-5, IR-6, IR-7, IR-8 and IR-9 relays have a main tapped coil located on the center leg of an "E" type laminated structure that produces a flux which divides and returns through the outer legs. A shading coil causes the flux through the left leg to lag the main pole flux. The out-of-phase fluxes thus produced in the air gap cause a contact closing torque.

The electromagnet for the type IR-2 and IR-11 \* relays has a main coil consisting of a tapped primary winding a secondary winding. Two identical coils

on the outer legs of the lamination structure are connected to the main coil secondary in a manner so that the combination of all the fluxes produced by the electromagnet result in out-of-phase fluxes in the air gap. The out-of-phase air gap fluxes produced cause a contact closing torque.

#### Indicating Contactor Switch Units (ICS/I and ICS/T)

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

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

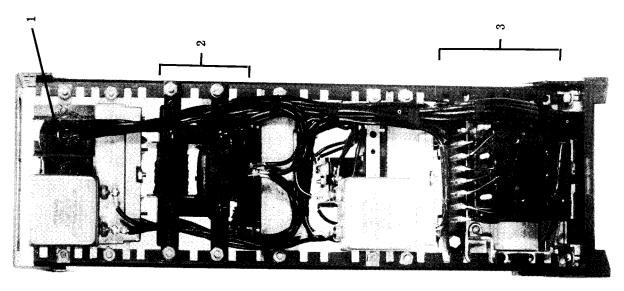
#### Directional Unit (D)

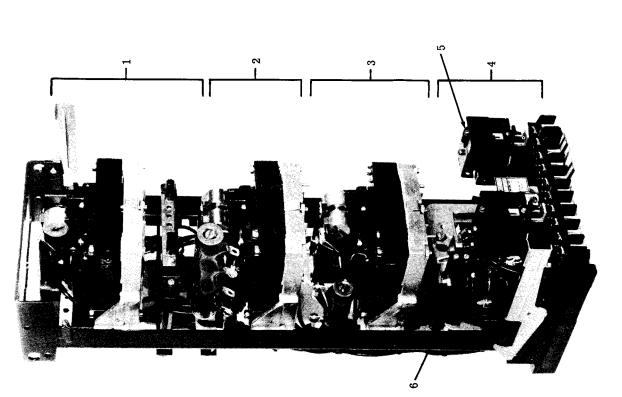
The directional unit is a product induction cylinder type unit operating on the interaction between the polarizing circuit flux and the operating circuit flux.

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 the magnetic core. The magnetic core which houses the lower pin bearing is secured to the 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





\* Fig. 1. Type IRD Relay Without Case (Front View). 1 - Instantaneous Overcurrent Unit and Saturating Transformer, 2 - Current Polarized Directional Unit. 3 — Voltage Polarized Directional Unit. 4 — Time Overcurrent Unit. 5 - Indicating Contactor Switch. 6 - Auxiliary Switch.

Fig. 2. Type IRD Relay Without Case (Rear View). 1 — Varistor, 2 — Saturating Transformer, 3 — "E" Type Electromagnet.

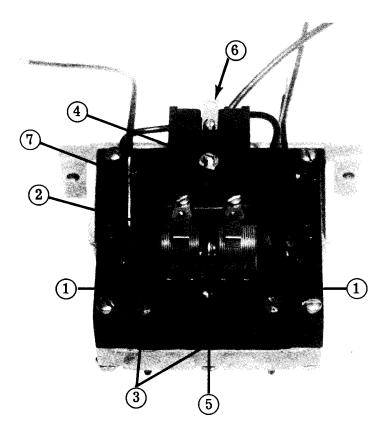
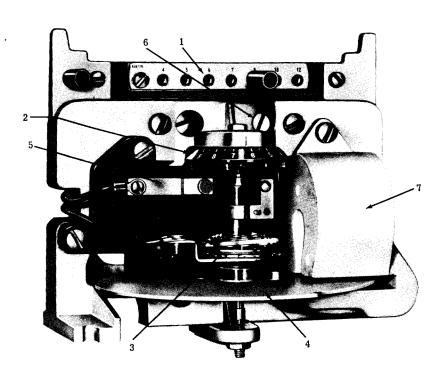


Fig. 3. Directional Unit. 1 – Stationary Contacts. 2 – Stationary Contact Pressure Spring. 3 – Magnetic Adjusting Plugs. 4 – Upper Bearing Screw. 5 – Moving Contact. 6 – Spring Adjuster Clamp. 7 – Current Bias Vane.



\* Fig. 4. Time Overcurrent Unit. 1 - Tap Block. 2 - Time Dial. 3 - Control Spring Assembly. 4 - Disc. 5 - Stationary Contact Assembly. 6 - Magnetic Plugs. 7 - Permanent Magnet.

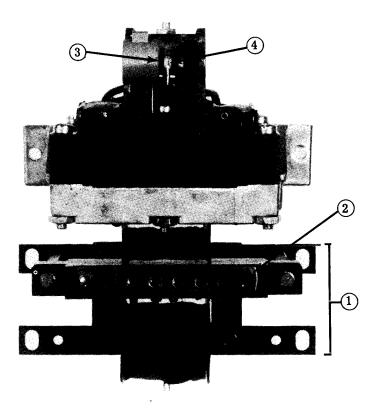


Fig. 5. Instantaneous Overcurrent Unit. 1 - Saturating Transformer. 2 - Tap Block. 3 - Stationary Contact. 4 - Moving Contact.

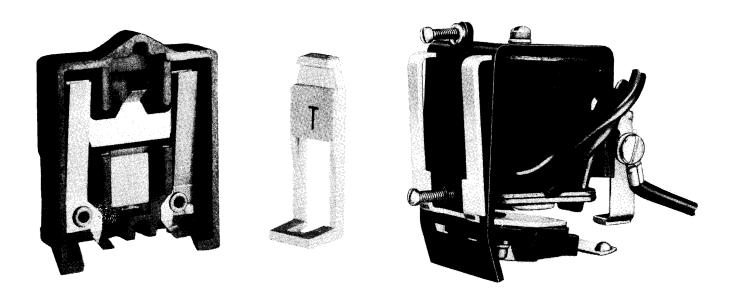


Fig. 6. Indicating Contactor Switch (ICS).

accurately position the lower pin bearing, which is mounted on the frame, with respect to the upper 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 rotating in an 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.

#### Auxiliary Switch (CS-1)

The auxiliary switch is a small solenoid type d.c. switch. A cylindrical plunger, with a silver disc mounted on its lower end, moves in the core of the solenoid. As the plunger travels upward, the disc bridges the silver stationary contacts. A tapped resistor is used to enable one to use the contactor switch on a 24, 48, 125 or 250 volt d.c. system connected per Fig. 21. The operation of the CS-1 switch is controlled by the directional unit (D) which in turn directionally controls the time-overcurrent unit (CO). When sufficient power flows in the tripping direction, the CS-1 switch operates and bridges the lag coil of the time-overcurrent unit (CO) permitting this unit to operate.

#### Instantaneous Overcurrent Unit (1)

The instantaneous 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 instantaneous overcurrent unit as shown in the internal schematics. This arrangement short-circuits the operating current around the pole windings; pre-

venting the instantaneous overcurrent unit from developing torque. If the directional unit should pick up for a fault, this short-circuit is removed, allowing the instantaneous overcurrent contact to commence closing almost simultaneously with the directional contact for high speed operation.

#### Instantaneous Overcurrent Unit Transformer

This transformer is of the saturating type for limiting the energy to the instantaneous overcurrent unit at higher values of fault current and to reduce C.T. burden. The primary winding is tapped and these taps are brought out to a tap block for ease in changing the pick-up of the instantaneous 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.

#### CHARACTERISTICS

The time characteristics of the directional overcurrent relays are designated by specific numbers as indicated below (e.g., IR - 8).

Time	
Characteristics	Designation
Short Time	2
Long Time	5
Definite Time	6
Moderately Inverse Time	7
Inverse Time	8
Very Inverse Time	9
Extremely Inverse Time	11

The relays are available in the following current ranges:

#### Instantaneous Overcurrent Unit (I)

Range	nge <u>Taps</u>					
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
20-80	20	30	40	48	60	80

#### Time Overcurrent Unit

Range				Tap	s		
.5-2.5	0.5	0.6	0.8	1.0	1.5	2.0	2.5
2-6	2	2.5	3	3.5	4	5	6
4-12	4	5	6	7	8	10	12

The tap value is the minimum current required to just close the relay contacts.

The time vs. current characteristics for the timeovercurrent unit are shown in Figs. 10 to 16. These characteristics give the contact closing time for the various time dial settings when the indicated multiples of tap value current are applied to the relay.

#### Trip Circuit

The relay contacts will safely close 30 amperes at 250 volts d.c. and the seal-in contacts of the indicating contactor switches will safely carry this current long enough to trip a circuit breaker.

The indicating contactor switch has two taps that provide a pickup setting of 0.2 or 2 amperes. To change taps requires connecting the lead located in front of the tap block to the desired setting by means of a screw connection.

# AUXILLIARY SMITCH AUXILLIARY SMITCH INDICATING CONTACTOR SMITCH INDICAT

Fig. 8. Internal Schematic of the Type IRC Relay in the Type FT31 Case.

#### 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.

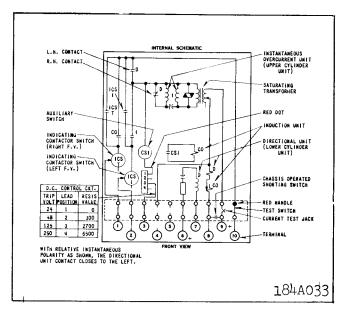


Fig. 7. Internal Schematic of the Type IRP Relay in the Type FT31 Case.

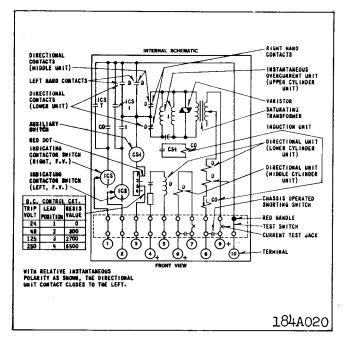


Fig. 9. Internal Schematic of the Type IRD Relay in the Type FT41 Case.

ENERGY REQUIREMENTS

INSTANTANEOUS OVERCURRENT UNIT OPERATING CURRENT CIRCUIT - 60 CYCLES

AMPERE RANGE	TAP	†† VA AT TAP VALUE	P.F. ANGLE	VA AT 5 AMPS.	P.F. ANGLE	
	.5	.37	39	24	46	
	.75	.38	36	13	37	
	1	.39	35	8.5	34	
.5-2	1.25	.41	34	6.0	32	
	1.5	.43	32	4.6	31	
	2	.45	30	2.9	28	
	1	.41	36	9.0	36	
	1.5	.44	32	5.0	32	
	2	.47	30	3.0	29	
1-4	2.5	.50	28	2.1	27	
	3	.53	26	1.5	26	
	4	.59	24	0.93	24	
	2	1.1	49	6.5	48	
	3	1.2	43	3.3	42	
0_0	4	1.3	38	2.1	37	
2-8	5	1.4	35	1.4	35	
	6	1.5	33	1.1	33	
	8	1.8	29	0.7	29	
	4	1.5	51	2.4	51	
	6	1.7	45	1.2	45	
4-16	8	1.8	40	0.7	40	
	9	1.9	38	0.6	38	
	12	2.2	34	0.37	34	
	16	2.5	30	0.24	31	
	10	1.7	28	0.43	28	
	15	2.4	21	0.27	21	
	20	3.1	16	0.20	17	
10-40	24	3.6	15	0.15	15	
	30	4.2	12	0.11	13	
	40	4.9	11	0.08	12	
	20	6.6	31	0.40	31	
	30	9.3	24	0.25	24	
20.00	40	12	20	0.18	20	
20-80	48	13.5	18	0.14	18	
	60	15.9	16	0.10	16	
	80	19.2	15	0.07	15	
RANGE		CONTINUOUS RATI	NG	ONE SECOND R	ATING	
KANGE		(AMPERES)		† (AMPERE	S)	
. 5-2		5		100		
1-4	8			140		
2-8		8		140		
4-16		10		200		
10-40		10		200		
20-80		10		200		
20-00		10				

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

φ Degrees current lags voltage.

<sup>† †</sup> Voltages taken with Rectox type voltmeter.

 $<sup>\</sup>phi$  Degrees current lags voltage.

<sup>\*\*</sup> Voltages taken with Rectox type voltmeter.

#### ENERGY REQUIREMENTS - 60 CYCLES

#### DIRECTIONAL UNIT OPERATING CIRCUIT BURDEN

#### **VOLT AMPERES\*\***

Relay Type	Range Amps	Continuous Rating (Amperes)	One Second Rating* (Amperes)	Power Factor Angle $\phi$	At Minimum Tap Value Current	At 3 Times Minimum Tap Value Current	At 10 Times Minimum Tap Value Current	At 20 Times Minimum Tap Value Current	
	0.5-2.5	-	230	44.0	0.033	0.30	3.3	14.2	
IRC	2-6	-	230	42.5	0.58	5.28	58.0	240.0	
	4-12	12	280	31.8	0.64	6.12	70.0	272.0	
	0.5-2.5	10	230	34.5	0.03	0.23	2.8	11.5	
IRP	2-6	10	230	34.5	0.44	4.08	48.0	182.0	
	4-12	12	280	25.0	0.48	4.62	53.6	216.0	
	0.5-2.5	10	230	45.0	0.07	0.59	6.6	26.0	
IRD	2-6	10	230	45.0	1.04	9.9	106.0	420.0	
	4-12	12	280	32.4	1.16	10.8	121.2	472.0	
	2-6 4-12 0.5-2.5 2-6	10 12 10 10	230 280 230 230	34.5 25.0 45.0 45.0	0.44 0.48 0.07 1.04	4.08 4.62 0.59 9.9		48.0 53.6 6.6 106.0	

 $<sup>\</sup>phi$  Degrees current lags voltage at tap value current.

## ENERGY REQUIREMENTS - 60 CYCLES DIRECTIONAL UNIT POLARIZING CIRCUIT BURDEN

RELAY TYPE	RATING	VOLT AMPERES △	POWER FACTOR ANGLE $\phi$
IRC	230* Amperes	1.45	8 <sup>O</sup> Lag
IRP	208** Volts	11.2	28 <sup>0</sup> Lead
IRD Current Unit	230* Amperes	1.45	8 <sup>0</sup> Lag
IRD Voltage Unit	208** Volts	11.2	28 <sup>0</sup> Lead

 $<sup>\</sup>phi$  Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.

<sup>\*</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

<sup>\*\*</sup> Voltages taken with Rectox type voltmeter.

 $<sup>\</sup>Delta$  Burden of voltage polarized units taken at 120 volts. Burden of current polarized units taken at 5 amperes.

<sup>\*</sup> One second rating.

<sup>\*\* 30</sup> second rating. The 10 second rating is 345 volts. The continuous rating is 120 volts.

#### TYPE IRD-2, IRC-2, IRP-2 TIME OVERCURRENT UNITS

VOLT AMPERES\*\* POWER AT AT 3 TIMES AT 10 TIMES AT 20 TIMES CONTINUOUS ONE SECOND TAP VALUE FACTOR TAP VALUE TAP VALUE TAP VALUE RATING\* RATING AMPERE CURRENT CURRENT CURRENT CURRENT (AMPERES)  $ANGLE \phi$ (AMPERES) RANGE TAP 790 39.6 256 58 4.8 0.5 0.9128 39.8 270 851 57 4.9 28 0.6 0.96 5.0 42.7 308 1024 28 53 0.8 1.18 50 5.3 45.4 348 1220 28 0.5/2.51.0 1.37 54.4 435 1740 28 40 6.2 1.5 1.95 580 2280 36 7.2 65.4 2.0 2.24 28 700 2850 7.9 73.6 28 29 2.5 2.50 800 59 5.04 38.7 262 2.0 3.1 110 39.8 280 920 5,13 55 2.5 4.0 110 312 1008 5.37 42.8 51 3.0 4.4 110 329 1120 42.8 5.53 2/6 3.5 4.8 110 47 360 1216 46.0 5.72 45 4.0 5,2 110 50.3 420 1500 5.90 5.6 110 41 5.0 1800 54.9 474 37 6.546.0 110 6.0 4.92 39.1 268 848 230 65 4.0 7.3 1020 5.2042.0 305 5.0 8.0 230 50 44.1 330 1128 5.34 230 47 6.0 8.8 1260 5.53 45.8 364 230 46 4/12 7.0 9.6 49.9 400 1408 230 43 5.86 8.0 10.4 1720 470 230 37 6.6 55.5 10.0 11.2 2064 7.00 528 62.3 12.0 12.0 230 34

<sup>\*</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

 $<sup>\</sup>phi$  Degrees current lags voltage at tap value current.

<sup>\*\*</sup> Voltages taken with Rectox type voltmeter.

IRD-5, IRC-5, IRP-5, IRD-6, IRC-6, IRP-6,

VOI	T' AM1	PERES*	*

AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE $\phi$	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
	(0.5	2	88	69	3.92	20.6	103	270
	(0.6	2.2	88	68	3.96	20.7	106	288
	(0.8	2.5	88	67	3.96	21	114	325
0.5/2.5	(1.0	2.8	88	66	4.07	21.4	122	360
	(1.5	3.4	88	62	4.19	23.2	147	462
	(2.0	4.0	88	60	4.30	24.9	168	548
	(2.5	4.4	88	58	4.37	26.2	180	630
	(2	8	230	67	3.88	21	110	308
	(2.5	8.8	230	66	3.90	21.6	118	342
	(3	9.7	230	64	3.93	22.1	126	381
2/6	(3.5	10.4	230	63	4.09	23.1	136	417
	(4	11.2	230	62	4.12	23.5	144	448
	(5	12.5	230	59	4.20	24.8	162	540
	(6	13.7	230	57	4.38	26,5	183	624
	(4	16	460	65	4.00	22.4	126	376
	(5	18.8	460	63	4.15	23.7	143	450
	(6	19.3	460	61	4.32	25.3	162	531
4/12	(7	20.8	460	59	4.35	26.4	183	611
	(8	22.5	460	56	4.40	27.8	204	699
	(10	25	460	53	4.60	30.1	247	880
	(12	28	460	47	4.92	35.6	288	1056

#### IRD-7, IRC-7, IRP-7 TIME OVERCURRENT UNITS

**VOLT AMPERES\*\*** CONTINUOUS ONE SECOND POWER  $\mathbf{AT}$ AT 3 TIMES AT 10 TIMES AT 20 TIMES AMPERE FACTOR RATING RATING\* TAP VALUE TAP VALUE TAP VALUE TAP VALUE (AMPERES) RANGE TAP (AMPERES) ANGLE  $\phi$ CURRENT CURRENT CURRENT CURRENT (0.5)2 68 88 3.88 20.7 103 278 (0.6)2.2 67 3.93 20.9 107 88 288 (0.8 2.5 66 3.93 21.1 88 114 320 0.5/2.5(1.0 2.8 88 64 4.00 21.6 122 356 (1.5)3.4 88 61 4.08 22.9 148 459 (2.0)4.0 88 58 4.24 24.8 174 552 (2.5)4.4 88 56 4.38 25.9 185 640 (2 8 230 66 4.06 21.3 111 306 (2.5 8.8 230 63 4.07 21.8 120 342 (3 9.7 230 63 4.14 22.5 129 366 2/6 (3.5)10.4 230 62 4.34 23.4 141 413 (4 11.2 230 61 4.34 23.8 149 448 (5 12.5 230 59 4.40 25.2 163 530 (6 13.7 230 58 4.62 27 183 624 (4 16 460 64 4.24 22.8 129 392 (5 18.8 460 61 4.30 24.2 149 460 4/12 (6 19.3 460 60 4.62 25.9 168 540 (7 20.8 460 58 4.69 27.3 187 626 (8 22.5 460 55 4.80 29.8 211 688 (10 25 460 51 5.20 33 260 860 (12 28 460 46 5.40 37.5 308 1032

<sup>\*</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

φ Degrees current lags voltage at tap value current.

<sup>\*\*</sup> Voltages taken with Rectox type voltmeter.

IRD-8, IRC-8, IRP-8, TIME OVERCURRENT UNITS IRD-9, IRC-9, IRP-9,

						VOLT A	MPERES**	
AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE $\phi$	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
0.5/2.5	(0.5) (0.6) (0.8) (1.0) (1.5) (2.0) (2.5)	2 2.2 2.5 2.8 3.4 4.0 4.4	88 88 88 88 88 88	72 71 69 67 62 57 53	2.38 2.38 2.40 2.42 2.51 2.65 2.74	21 21 21.1 21.2 22 23.5 24.8	132 134 142 150 170 200 228	350 365 400 440 530 675 800
2/6	(2 (2.5 (3 (3.5 (4 (5 (6	8 8.8 9.7 10.4 11.2 12.5 13.7	230 230 230 230 230 230 230 230	70 66 64 62 60 58 56	2.38 2.40 2.42 2.48 2.53 2.64 2.75	21 21.1 21.5 22 22.7 24 25.2	136 142 149 157 164 180 198	360 395 430 470 500 580 660
4/12	(4 (5 (6 (7 (8 (10 (12	16 18.8 19.3 20.8 22.5 25	460 460 460 460 460 460	68 63 60 57 54 48 45	2.38 2.46 2.54 2.62 2.73 3.00 3.46	21.3 21.8 22.6 23.6 24.8 27.8 31.4	146 158 172 190 207 248 292	420 480 550 620 700 850 1020

#### IRD-11, IRC-11, IRP-11 OVERCURRENT UNITS

						VOLT A	AMPERES**	
AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE $\phi$	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
0.5/2.5	0.5 0.6 0.8 1.0 1.5 2.0 2.5	1.7 1.9 2.2 2.5 3.0 3.5 3.8	56 56 56 56 56 56	36 34 30 27 22 17 16	0.72 0.75 0.81 0.89 1.13 1.30	6.54 6.80 7.46 8.30 10.04 11.95 13.95	71.8 75.0 84.0 93.1 115.5 136.3 160.0	250 267 298 330 411 502 610
2/6	2.0 2.5 3.0 3.5 4.0 5.0 6.0	7.0 7.8 8.3 9.0 10.0 11.0	230 230 230 230 230 230 230	32 30 27 24 23 20 20	0.73 0.78 0.83 0.88 0.96 1.07	6.30 7.00 7.74 8.20 9.12 9.80 11.34	74.0 78.5 84.0 89.0 102.0 109.0 129.0	264 285 309 340 372 430 504
4/12	4.0 5.0 6.0 7.0 8.0 10.0 12.0	14 16 17 18 20 22 26	460 460 460 460 460 460	29 25 22 20 18 17	0.79 0.89 1.02 1.10 1.23 1.32	7.08 8.00 9.18 10.00 11.1 14.9 16.3	78.4 90.0 101.4 110.0 124.8 131.6 180.0	296 340 378 454 480 600 720

<sup>\*</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

 $<sup>\</sup>phi$  Degrees current lags voltage at tap value current.

<sup>\*\*</sup> Voltages taken with Rectox type voltmeter.

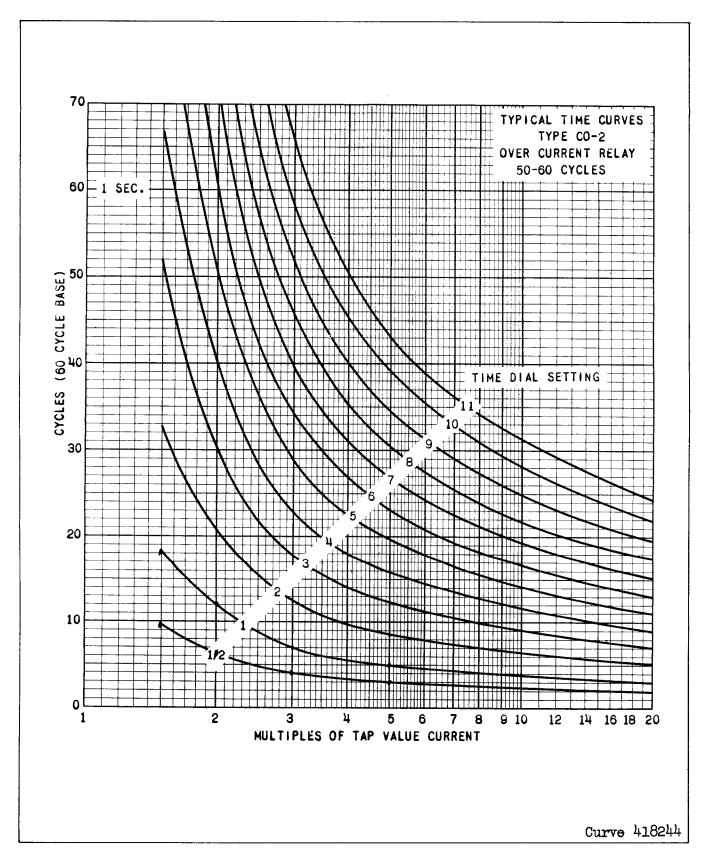


Fig. 10. Typical Time Curves of the Time-Overcurrent Unit of the Short Time (2) Relays.

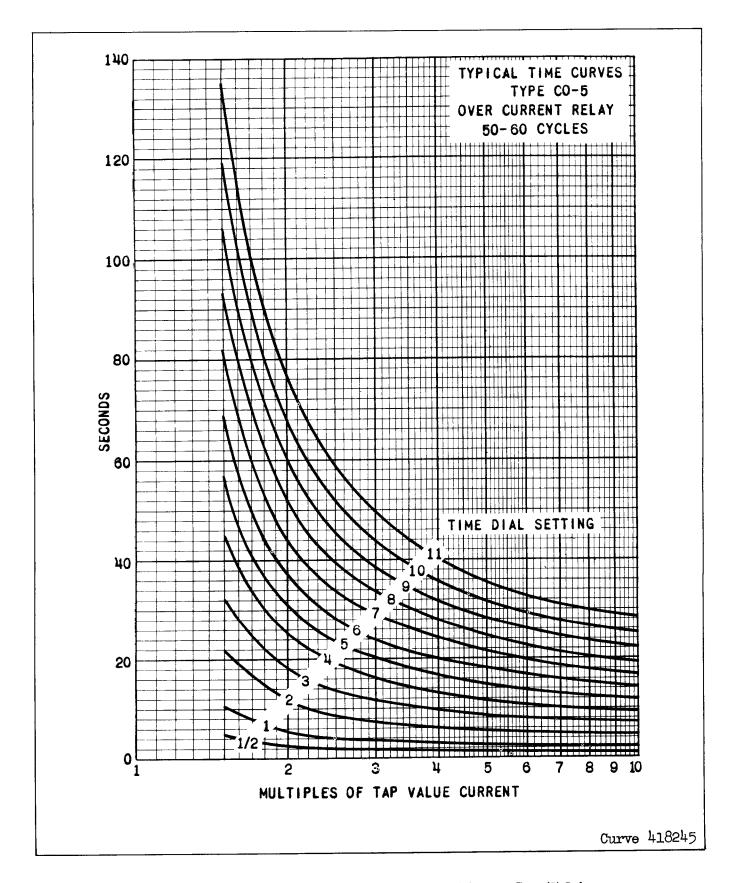


Fig. 11. Typical Time Curve of the Time-Overcurrent Unit of the Long Time (5) Relays.

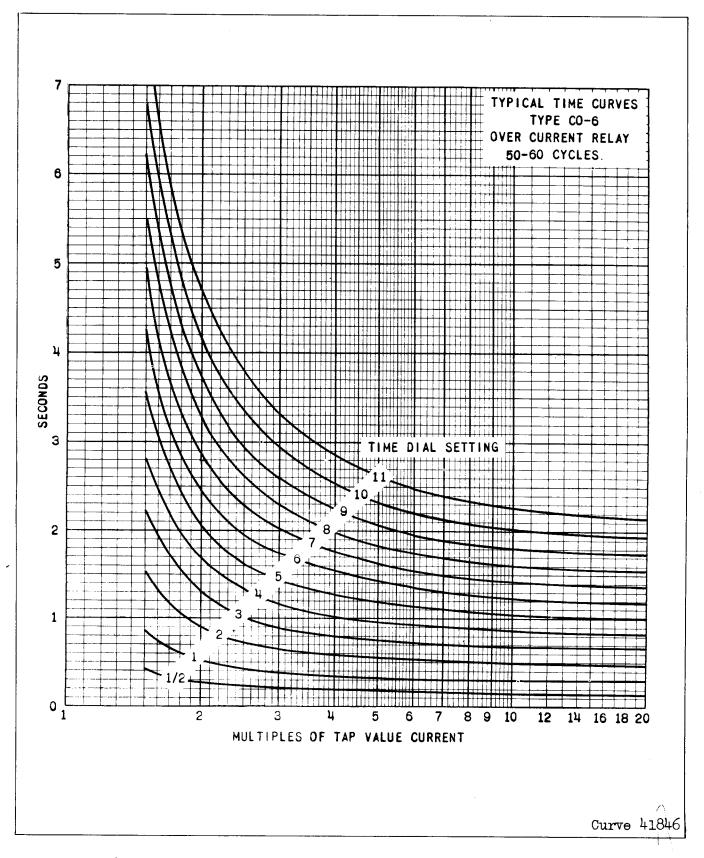


Fig. 12. Typical Time Curve of the Time-Overcurrent Unit of the Definite Time (6) Relays.

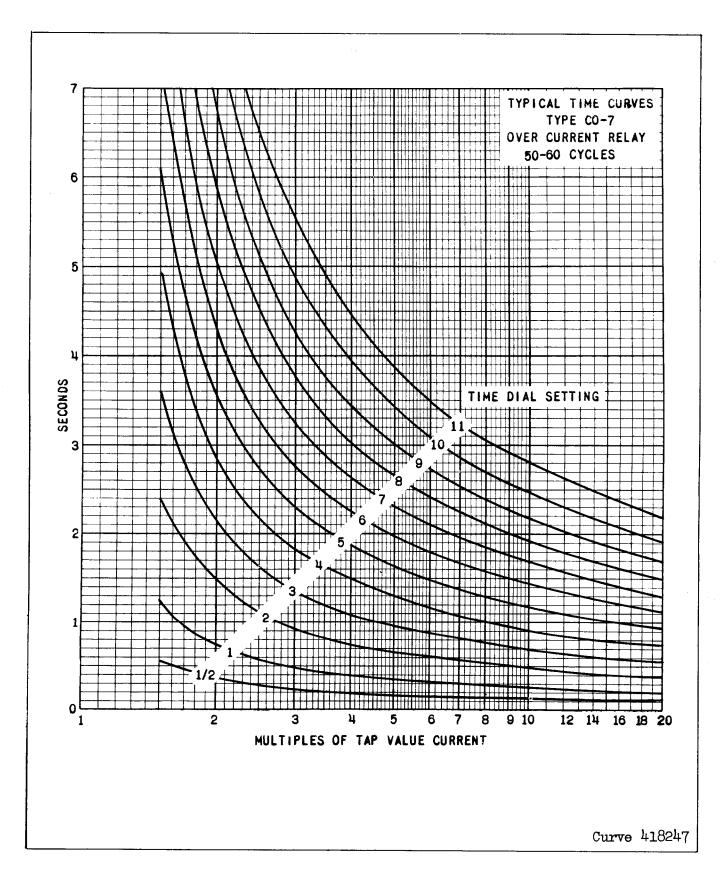


Fig. 13. Typical Time Curve of the Time-Overcurrent Unit of the Moderately Inverse (7) Relays.

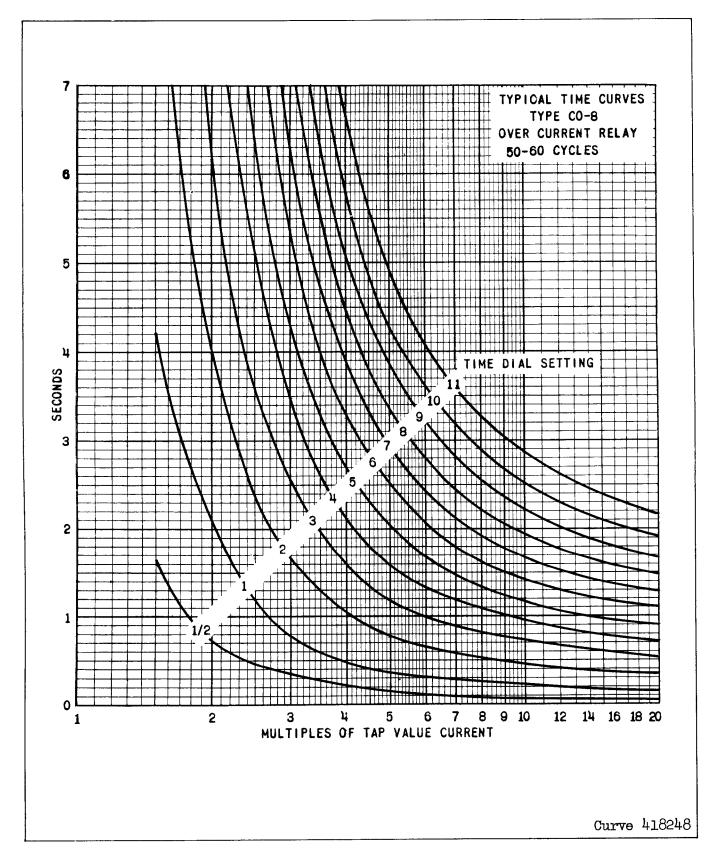


Fig. 14. Typical Time Curve of the Time-Overcurrent Unit of the Inverse (8) Relays.

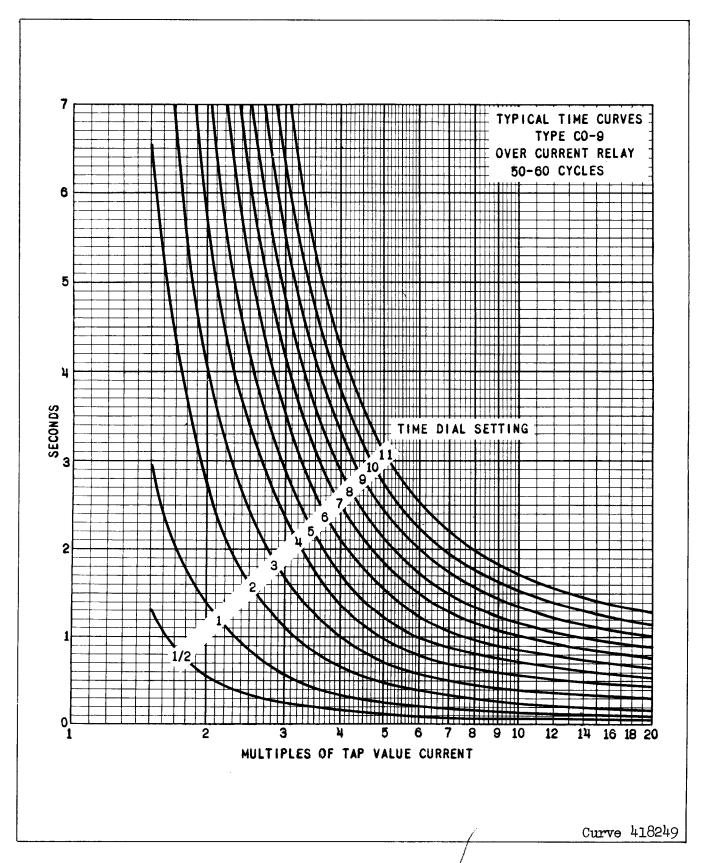


Fig. 15. Typical Time Curve of the Time-Overcurrent Unit of the Very Inverse (9) Relays.

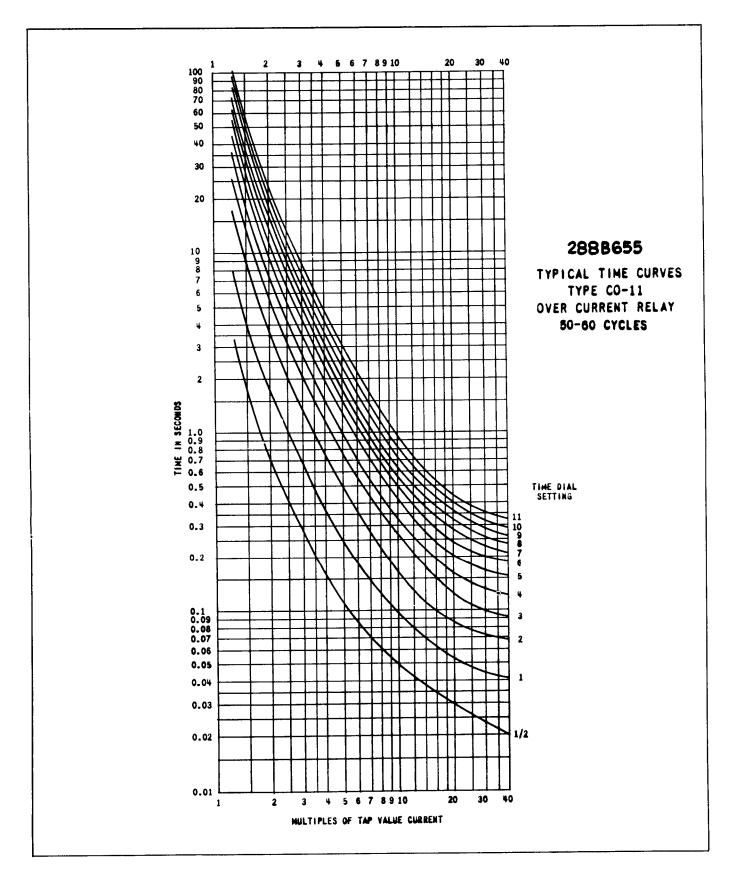


Fig. 16. Typical Time Curve of the Time-Overcurrent Unit of the Extremely Inverse (11) Relays.

#### **Trip Circuit Constants**

Indicating Contactor Switch -

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

#### Auxiliary Switch (CS-1)

The auxiliary switch has a d-c resistance of 1165 ohms.

#### Type IRP Relay

The IRP 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 pick-up is approximately 1 volt and 2 amperes at its maximum torque angle for the directional units used with the 0.5 to 2.5 and 2 to 6 ampere range time over-current units. For the directional units used with the 4-12 ampere range time overcurrent units the minimum pick-up is 1 volt and 4 amperes.

#### Type IRC Relay

The IRC relay is designed for <u>current</u> polarization and has its maximum torque when the operating current leads the polarizing current by approximately  $40^{\circ}$ .

The directional unit minimum pick-up is 0.5 ampere in each winding at the maximum torque angle for the directional units used with the 0.5 to 2.5 and 2 to 6 ampere range time overcurrent units. For the directional units used with the 4-12 ampere range time overcurrent units the minimum pickup is 1 ampere.

#### Type IRD Relay

The type IRD relay utilizes a directional unit similar to the IRC relay in conjunction with the directional unit and phase-shifting circuit of the IRP relay.

The current-polarized directional unit of the IRD relay operates on residual currents while the potential-polarized directional unit of the IRD relay operates on residual voltage and residual current.

For the directional units used with the 0.5 to 2 and 2 to 6 ampere time overcurrent units, the minimum pick-up of the current polarized unit is 0.5 ampere in each winding at the maximum torque angle. The minimum pick-up for the voltage polarized unit is

1 volt and 2 amperes with the current lagging voltage by  $60^{\circ}$ .

For the directional units used with the 4 to 12 ampere range time overcurrent units, the minimum pick-up is 1 ampere for the current-polarized directional unit and 1 volt and 4 amperes for the voltage-polarized directional unit.

#### SETTINGS

#### Time Overcurrent Unit (CO)

The time overcurrent unit settings can be defined either by tap setting and time dial position or by tap setting and a specific time of operation at some current multiple of the tap setting (e.g. 4 tap setting, 2 time dial position or 4 tap setting, 0.6 seconds at 6 times tap value current).

To provide selective circuit breaker operation, a minimum coordinating time of 0.3 seconds plus circuit breaker time is recommended between the relay being set and the relays with which coordination is to be effected.

The connector screws on the tap plate above the time dial makes connections to various turns on the operating coil. By placing this screw in the various tap plate holes, the relay will just close its contacts at the corresponding current 4-5-6-7-8-10-12 amperes, or as marked on the tap plate.

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, connext the spare connector screw in the desired position before removing the other tap screw from the original tap position.

#### Instantaneous Reclosing

The factory adjustment of the CO unit contacts provides a contact follow. Where circuit breaker reclosing will be intiated immediately after a trip by the CO contact, the time of the opening of the contacts should be a minimum. This condition is obtained by loosening the stationary contact mounting screw, removing the contact plate and then replacing the plate with the bent end resting against the contact \*spring. With this change and the contact mounting screw tightened, the stationary contact will rest solidly against its backstop.

#### Instantaneous Overcurrent Unit (1)

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.

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.

#### Directional Units (D)

No setting is required.

#### Indicating Contactor Switch (ICS/I and ICS/T)

No setting is required on the ICS units except the selection of the 0.2 or 2.0 ampere tap setting. This selection is made by connecting the lead located in front of the tap block to the desired setting by means of the connecting screw.

#### Auxiliary Switch (CS-1)

No setting required on the CS-1 unit except for the selection of the required 24, 48, 125 or 250 voltage on the tapped resistor. This connection can be made by referring to Fig. 21.

#### 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 be means of the two mounting studs for the type FT projection case or by means of the four mounting holes on the flange for the semi-flush type FT case. 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 detail information on the FT Case refer to I.L. 41-076.

The external a-c connections of the directional overcurrent relays are shown in Figs. 18, 19 and 20. If no voltage polarizing source is to be connected to the IRD relay, short-circuit the voltage polarizing circuit at the terminals of the relay.

#### 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;

#### Instantaneous 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. <u>Minimum Trip Current</u> 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 within  $\pm 5\%$  of tap value current.

#### Directional Unit (D)

- 1. Contact Gap The gap between the stationary contact and moving contact with the relay in the deenergized position should be approximately .020".
- 2. <u>Sensitivity</u> The respective directional units should trip with value of energization and phase angle relationship 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 with the polarizing circuits short circuited for the voltage polarized units and open-circuited for the current polarized units.

#### Time Overcurrent Unit (CO)

- 1. Contacts The index mark on the movement frame will coincide with the "O" mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "O" mark by approximately .020". The placement of the various time dial positions in line with the index mark will give operating times as shown on the respective time-current curves.
- 2. Minimum Trip Current Set the time dial to position 6 with the auxiliary switch (CS-1) contacts

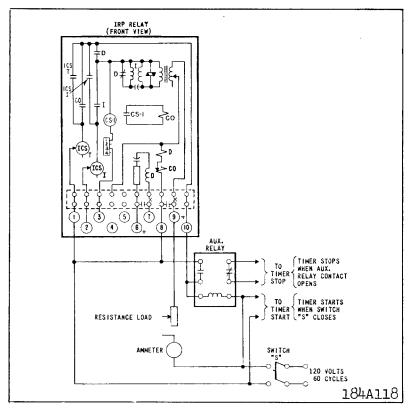


Fig. 17. Diagram of test connections of the time-overcurrent unit.

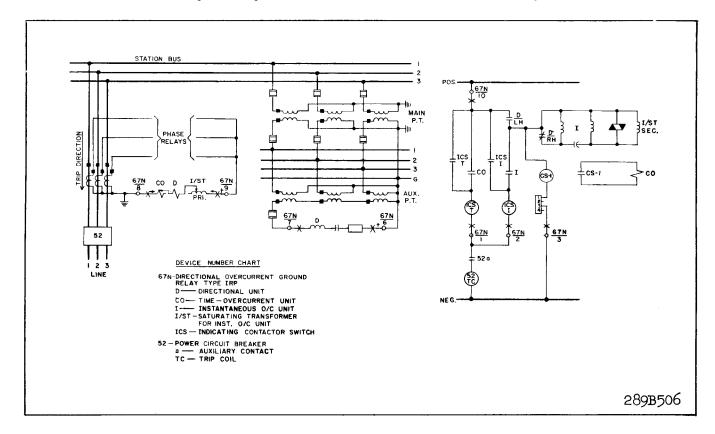


Fig. 18. External Schematic of the IRP Relay for Ground Fault Protection.

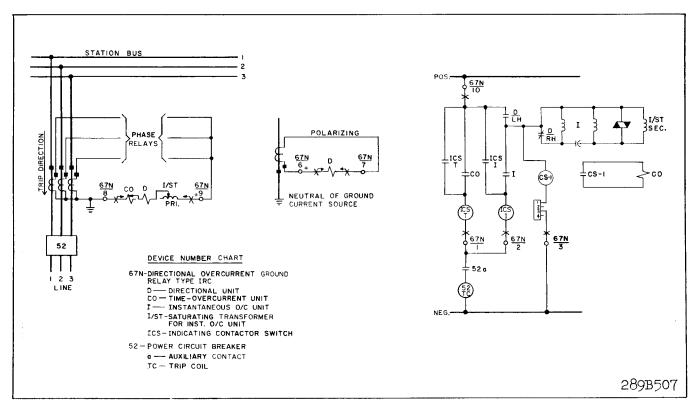


Fig. 19. External Schematic of the IRC Relay for Ground Fault Protection.

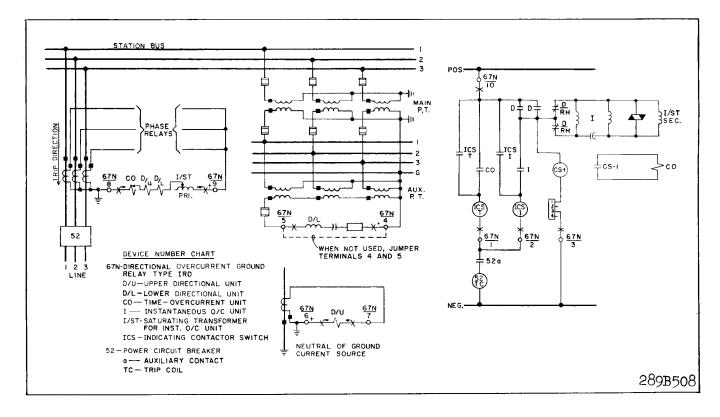


Fig. 20. External Schematic of the IRD Relay for Ground Fault Protection.

blocked closed, alternately apply tap value current plus 3% and tap value current minus 3%. The moving contact should leave the backstop at tap value current plus 3% and should return to the backstop at tap value current minus 3%.

3. <u>Time Curve</u> — Table 3 shows the time curve calibration points for the various types of relays. With the time dial set to the indicated position, apply the currents specified by Table 3 (e.g. for the CO-2, 3 and 20 times tap value current) and measure the operating time of the relay. The operating times should equal those of Table 3 plus or minus 5 percent.

#### Indicating Contactor Switches (ICS/I) and (ICS/T)

- A) Close the contacts of the CO and pass sufficient d.c. current through the trip circuit to close the contacts of (ICS/T). This value of current should not be greater than the particular (ICS/T) tap setting being used. The operation indicator target should drop freely, bringing the letter "T" into view.
- B) Close the contacts of the instantaneous overcurrent unit (I) and the directional unit (D). Pass sufficient d.c. current through the trip circuit to close the contacts of (ICS/I). This value of current should not be greater than the particular (ICS/I) tap setting being used. The operation indicator target should drop freely, bringing the letter "I" into view.
- C) The contact gap should be approximately .047" 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 time of 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. The use of phantom loads, in testing induction-type relays, should be avoided, since the resulting distorted current wave form will produce an error in timing.

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

#### Calibration

Use the following procedure for calibrating the

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

#### Instantaneous Overcurrent Unit (1)

- 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, i.e., against the right side of the bridge. Move 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 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  $\pm 5\%$  of tap value.

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.

#### Directional Unit (D)

In the type IRP and IRC relays the directional unit is the lower cylinder unit. In the type IRD the directional units are the lower and middle cylinder 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 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 as indicated by a neon lamp in the contact circuit when energized with the required current and voltage as shown in Table 1. 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 (IRP and IRD voltage polarized unit) are short-circuited.
- b) The polarizing circuits of the current polarized relays (IRC and IRD 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 some installations in order to insure that the relay will always trip the breaker on zero potential.

#### Time Overcurrent Unit (CO)

- 1. Contacts The index mark on the movement frame will coincide with the "O" mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "O" mark by approximately .020". The placement of the various time dial positions in line with the index mark will give operating times as shown on the respective time-current curves.
- 2) <u>Minimum Trip Current</u> The adjustment of the spring tension in setting the minimum trip current value of the relay is most conveniently made with the damping magnet removed.

With the time dial set on "O", wind up the spiral spring by means of the spring adjuster until approximately 6-3/4 convolutions show.

Set the relay on the minimum tap setting, the time dial to position 6.

With the auxiliary switch (CS-1) contacts blocked closed, adjust the control spring tension so that the moving contact will leave the backstop at tap value current +1.0% and will return to the backstop at tap value current -1.0%.

3) <u>Time Curve Calibration</u> — Install the permanent magnet.

Apply the indicated current per Table 3 for permanent magnet adjustment (e.g. IRP-8, 2 times tap value) and measure the operating time. Adjust the permanent magnet keeper until the operating time corresponds to the value of Table 3.

Apply the indicated current per Table 3 for the electromagnet plug adjustment (e.g. IRP-8, 20 times tap value) and measure the operating time. Adjust the proper plug until the operating time corresponds to the value in Table 3. (Withdrawing the left hand plug, front view increases the operating time and withdrawing the right hand plug, front view, decreases the time.) In adjusting the plugs, one plug should be

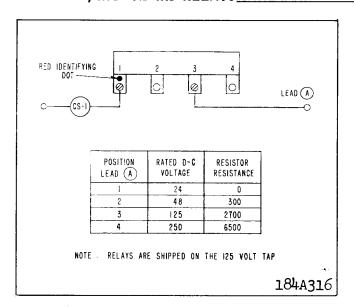


Fig. 21. Selection of Proper Voltage Tap for Auxiliary Switch (CS-1) Operation.

screwed in completely and the other plug run in or out until the proper operating time has been obtained.

Recheck the permanent magnet adjustment. If the operating time for this calibration point has changed, readjust the permanent magnet and then recheck the electromagnet plug adjustment.

#### Indicating Contactor Switches (ICS/I) and (ICS/T)

Adjust the contact gap for approximately .047".

A) Close the contacts of the CO and pass sufficient d.c. current through the trip circuit to close the contacts of the (ICS/T). This value of current should not be greater than the particular (ICS/T) tap setting being used. The operation indicator target should drop freely bringing the letter "T" into view.

B) Close contacts of instantaneous overcurrent unit (I) and directional unit (D). Pass sufficient d.c. current through the trip circuit to close contacts of the (ICS/I). This value of current should not be greater than the particular (ICS/I) tap setting being used. The operation indicator target should drop freely bringing the letter "I" into view.

#### Auxiliary Switch (CS-1)

Adjust the stationary core of the switch for a clearance between the stationary core and the moving core when the switch is picked up. This can be done by turning the relay upside-down. Then screw up the core screw until the moving core starts rotating. Now back off the core screw until the moving core stops rotating. This indicates the points where the play in the assembly is taken up, and where the moving core just separates from the stationary core screw. Back off the core screw approximately one turn and lock in place. This prevents the moving core from striking and sticking to the stationary core because of residual magnetism. Adjust the contact clearance for 3/64" by means of the two small nuts on either side of the Micarta disc.

Connect lead (A) to proper terminal per Fig. 21. Block directional unit (D) contacts close and energize trip circuit with rated voltage. Contacts of auxiliary switch (CS-1) should make as indicated by a neon lamp in the contact circuit.

#### 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.

TABLE | DIRECTIONAL UNIT SENSITIVITY

RELAY TYPE	AMPERE RATING OF	VALUES FO	R MIN. PICKUP*	PHASE ANGLE RELATIONSHIP
	TIME-O VERCURRENT UNIT	VOLTS	AMPERES	
	.5-2.5	1	2.0	I lagging V by $60^{\circ}**$
IRP IRD (Voltage	2-6	1	4.0	I in-phasse with V
Unit)	4-12	1	4.0	I lagging V by $60^{O}**$
•	4-12	1	8.0	I in-phase with V
	.5-2.5		0.5	Ioleading Ip by 40°**
IRC IRD (Current	2-6		0.65	In-phase
Unit)	4-12		1.0	Io leading Ip by 400**
			1.3	In-phase

<sup>\*</sup>The energization quantities are input quantities at the relay terminals.

<sup>\*\*</sup> 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) (Contacts remain open)	Left (Front View) Plug Screwed Out Until Spurious Torque is in Contact Closing Direction. Then the plug is screwed in Until Spuri ous Torque is Reversed.

<sup>†</sup> Short circuit the voltage polarizing circuit at the relay terminals before making the above adjustment.

TABLE III

TIME CURVE CALIBRATION DATA - 60 CYCLES

	PERMANENT	MAGNET ADJUSTM	<u>IENT</u>	ELECTROMAGN	IET PLUGS
TIME- OVERCURRENT UNIT TYPE	TIME T DIAL POSITION	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS
2	6	3	0.57	20	0.22
5	6	2	37.80	10	14.30
6	6	2	2.46	20	1.19
7	6	2	4.27	20	1.11
-8	6	2	13.35	20	1.11
.9	6	2	8.87	20	0.65
* 11	6	2	11.27	20	0.24

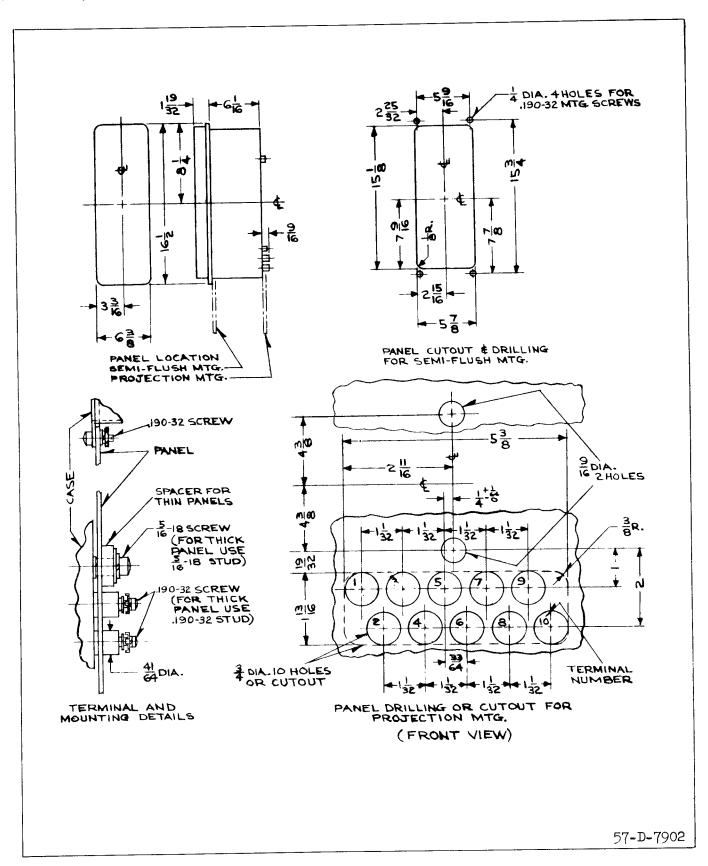


Fig. 22. Outline and Drilling Plan for the IRP and IRC Relays in the Type FT31 Case.

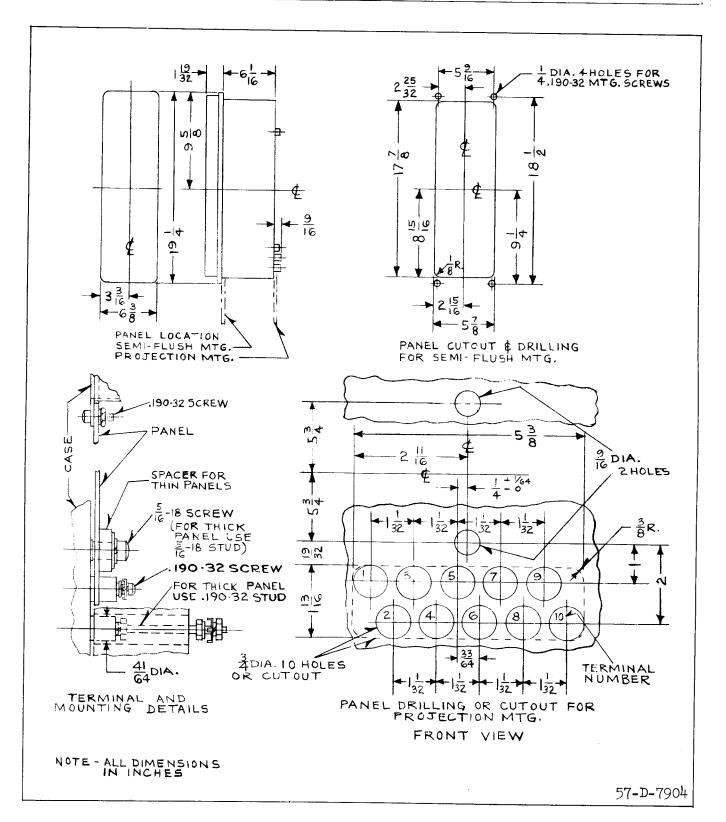


Fig. 23. - Outline and Drilling Plan for the IRD Relay in the Type FT41 Case.

# WESTINGHOUSE ELECTRIC CORPORATION RELAY DEPARTMENT NEWARK, N. J.



### INSTALLATION . OPERATION . MAINTENANCE

## INSTRUCTIONS

# DIRECTIONAL OVERCURRENT GROUND RELAYS TYPES IRP, IRC AND IRD

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**

These relays are ground directional overcurrent relays which are used for the protection of transmission lines and feeder circuits. Both the time-overcurrent and instantaneous overcurrent units are directionally controlled.

The type IRP relay is potential polarized. The type IRC relay is current polarized. The type IRD relay is a dual polarized relay which can be polarized from a potential source, from a local ground source or from both simultaneously.

#### CONSTRUCTION AND OPERATION

The various types of relays consist of a directional unit or units (D), an auxiliary switch (CS-1), a time-overcurrent unit (CO), an instantaneous overcurrent unit (I), an instantaneous overcurrent unit transformer, and two indicating contactor switches (ICS/I) and (ICS/T). The principle component parts of the relays and their location are shown in Fig. 1 through 6.

#### Time-Overcurrent Unit (CO)

The electromagnets for the types IR-5, IR-6, IR-7, IR-8 and IR-9 relays have a main tapped coil located on the center leg of an "E" type laminated structure that produces a flux which divides and returns through the outer legs. A shading coil causes the flux through the left leg to lag the main pole flux. The out-of-phase fluxes thus produced in the air gap cause a contact closing torque.

The electromagnet for the type IR-2 and IR-11 relays has a main coil consisting of a tapped primary winding a secondary winding. Two identical coils

on the outer legs of the lamination structure are connected to the main coil secondary in a manner so that the combination of all the fluxes produced by the electromagnet result in out-of-phase fluxes in the air gap. The out-of-phase air gap fluxes produced cause a contact closing torque.

#### Indicating Contactor Switch Units (ICS/I and ICS/T)

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

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

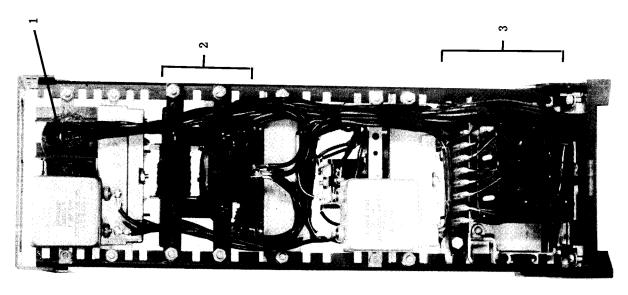
#### Directional Unit (D)

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 the magnetic core. The magnetic core which houses the lower pin bearing is secured to the 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



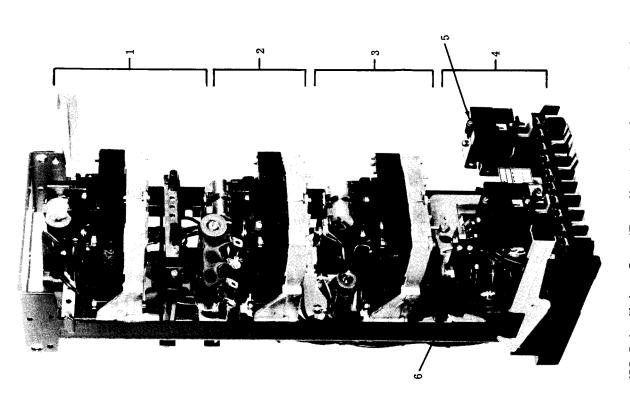


Fig. 1. Type IRD Relay Without Case (Front View). 1 - Instantaneous Overcurrent Unit and Saturating Transformer. 2 - Current Polarized Directional Unit. 3 - Voltage Polarized Directional Unit. 4 - Time Overcurrent Unit. 5 - Indicating Contactor Switch. 6 - Auxiliary Switch.

Fig. 2. Type IRD Relay Without Case (Rear View). 1 — Varistor. 2 — Saturating Transformer. 3 — "E" Type Electromagnet.

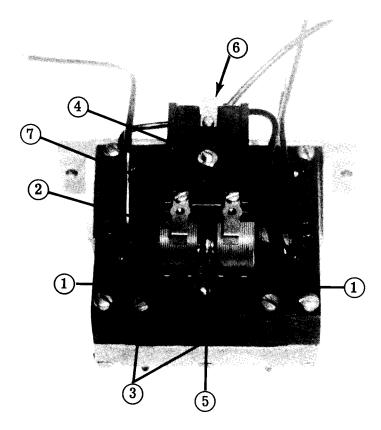


Fig. 3. Directional Unit. 1 - Stationary Contacts. 2 - Stationary Contact Pressure Spring. 3 - Magnetic Adjusting Plugs. 4 - Upper Bearing Screw. 5 - Moving Contact. 6 - Spring Adjuster Clamp. 7 - Current Bias Vane.

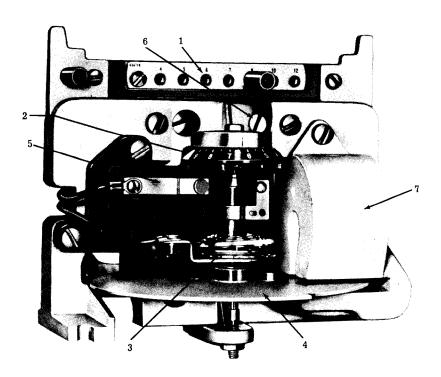


Fig. 4. Time Overcurrent Unit. 1—Tap Block. 2—Time Dial. 3—Control Spring Assembly. 4—Disc. 5—Stationary Contact Assembly. 6—Magnetic Plugs. 7—Permanent Magnet.

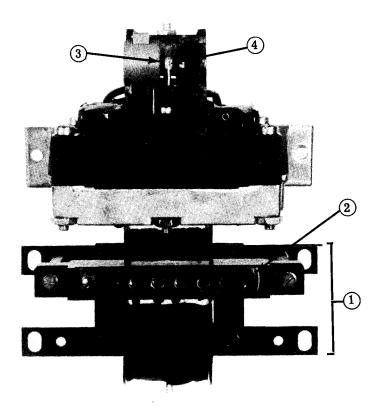


Fig. 5. Instantaneous Overcurrent Unit. 1 — Saturating Transformer. 2 — Tap Block. 3 — Stationary Contact. 4 — Moving Contact.

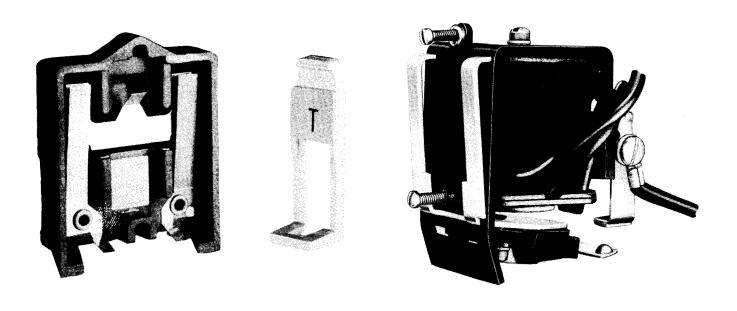


Fig. 6. Indicating Contactor Switch (ICS).

accurately position the lower pin bearing, which is mounted on the frame, with respect to the upper pin bearing, which is threaded into the bridge. The elec tromagnet 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 rotating in an 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.

#### Auxiliary Switch (CS-1)

The auxiliary switch is a small solenoid type d.c. switch. A cylindrical plunger, with a silver disc mounted on its lower end, moves in the core of the solenoid. As the plunger travels upward, the disc bridges the silver stationary contacts. A tapped resistor is used to enable one to use the contactor switch on a 24, 48, 125 or 250 volt d.c. system connected per Fig. 23. The operation of the CS-1 switch is controlled by the directional unit (D) which in turn directionally controls the time-overcurrent unit (CO). When sufficient power flows in the tripping direction, the CS-1 switch operates and bridges the lag coil of the time-overcurrent unit (CO) permitting this unit to operate.

#### Instantaneous Overcurrent Unit (1)

The instantaneous 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 instantaneous overcurrent unit as shown in the internal schematics. This arrangement short-circuits the operating current around the pole windings; pre-

venting the instantaneous overcurrent unit from developing torque. If the directional unit should pick up for a fault, this short-circuit is removed, allowing the instantaneous overcurrent contact to commence closing almost simultaneously with the directional contact for high speed operation. Total operating times are shown in Figs. 17 and 18.

#### Instantaneous Overcurrent Unit Transformer

This transformer is of the saturating type for limiting the energy to the instantaneous overcurrent unit at higher values of fault current and to reduce C.T. burden. The primary winding is tapped and these taps are brought out to a tap block for ease in changing the pick-up of the instantaneous 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.

#### CHARACTERISTICS

The time characteristics of the directional overcurrent relays are designated by specific numbers as indicated below (e.g., IRV-8).

Time	
Characteristics	Designation
Short Time	2
Long Time	5
Definite Time	6
Moderately Inverse Time	7
Inverse Time	8
Very Inverse Time	9
Extremely Inverse Time	11

The relays are available in the following current ranges:

#### Instantaneous Overcurrent Unit (I)

Range			T	aps		
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
20-80	20	30	40	48	60	80

#### Time Overcurrent Unit

Range	Tap	s					
.5-2.5	0.5	0.6	0.8	1.0	1.5	2.0	2.5
2-6	2	2.5	3	3.5	4	5	6
4-12	4	5	6	7	8	10	12

The tap value is the minimum current required to just close the relay contacts.

The time vs. current characteristics for the timeovercurrent unit are shown in Figs. 10 to 16. These characteristics give the contact closing time for the various time dial settings when the indicated multiples of tap value current are applied to the relay.

#### Trip Circuit

The relay contacts will safely close 30 amperes at 250 volts d-c and the seal-in contacts of the indicating contactor switches will safely carry this current long enough to trip a circuit breaker.

The indicating contactor switch has two taps that provide a pickup setting of 0.2 or 2 amperes. To change taps requires connecting the lead located in front of the tap block to the desired setting by means of a screw connection.

#### 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.

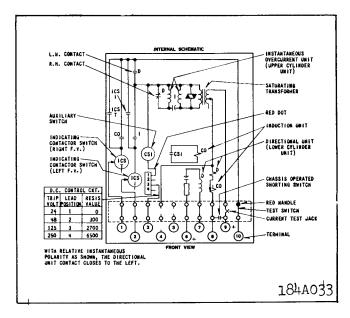


Fig. 7. Internal Schematic of the Type IRP Relay in the Type FT31 Case.

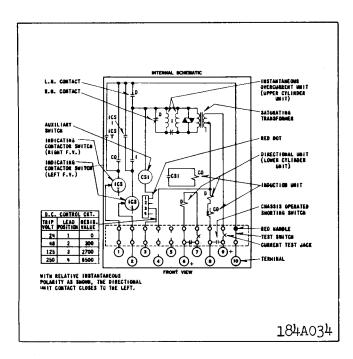


Fig. 8. Internal Schematic of the Type IRC Relay in the Type FT31 Case.

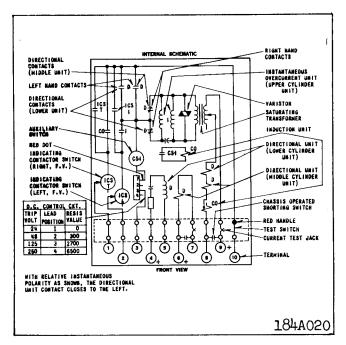


Fig. 9. Internal Schematic of the Type IRD Relay in the Type FT41 Case.

ENERGY REQUIREMENTS

INSTANTANEOUS OVERCURRENT UNIT OPERATING CURRENT CIRCUIT - 60 CYCLES

AMPERE RANGE	TAP	VA AT TAP VALUE	P.F. ANGLE	VA AT 5 AMPS.	P.F. ANGLE
	.5	.37	39	24	46
	.75	.38	36	13	37
r 0	1	.39	35	8.5	34
.5-2	1.25	.41	34	6.0	32
	1.5	.43	32	4.6	31
	2	.45	30	2.9	28
	1	.41	36	9.0	36
	1.5	.44	32	5.0	32
1-4	2	.47	30	3.0	29
	2.5	.50	28	2.1	27
	3	.53	26	1.5	26
	4	.59	24	0.93	24
	2	1.1	49	6.5	48
	3	1.2	43	3.3	42
2-8	4	1.3	38	2.1	37
20	5	1.4	35	1.4	35
	6	1.5	33	1.1	33
	8	1.8	29	0.7	29
4-16	4	1.5	51	2.4	51
	6	1.7	45	1.2	45
	8	1.8	40	0.7	40
	9	1.9	38	0.6	38
	12	2.2	34	0.37	34
	16	2.5	30	0.24	31
	10	1.7	28	0.43	28
	15	2.4	21	0.27	21
10-40	20	3.1	16	0.20	17
10-40	24	3.6	15	0.15	15
	30	4.2	12	0.11	13
	40	4.9	11	0.08	12
	20	6.6	31	0.40	31
	30	9.3	24	0.25	24
20-80	40	12	20	0.18	20
20 00	48	13.5	18	0.14	18
	60	15.9	16	0.10	16
	80	19.2	15	0.07	15
RANGE		CONTINUOUS RATIN	1G	ONE SECOND R	ATING
		(AMPERES)		† (AMPERES	
. 5-2		5		100	
1-4		8		140	
2-8		8		140	
4-16		10		200	
10-40		10		200	
20-80		10		200	

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

 $<sup>\</sup>phi$  Degrees current lags voltage.

<sup>† †</sup> Voltages taken with Rectox type voltmeter.

#### ENERGY REQUIREMENTS - 60 CYCLES

#### DIRECTIONAL UNIT OPERATING CIRCUIT BURDEN

#### **VOLT AMPERES\*\***

Relay Type	Range Amps	Continuous Rating (Amperes)	One Second Rating* (Amperes)	Power Factor Angle $\phi$	At Minimum Tap Value Current	At 3 Times Minimum Tap Value Current	At 10 Times Minimum Tap Value Current	At 20 Times Minimum Tap Value Current
	0.5-2.5	-	230	44.0	0.033	0.30	3.3	14.2
IRC	2-6	-	230	42.5	0.58	5.28	58.0	240.0
	4-12	12	280	31.8	0.64	6.12	70.0	272.0
	0.5-2.5	10	230	34.5	0.03	0.23	2.8	11.5
IRP	2-6	10	230	34.5	0.44	4.08	48.0	182.0
	4-12	12	280	25.0	0.48	4.62	53.6	216.0
	0.5-2.5	10	230	45.0	0.07	0.59	6.6	26.0
IRD	2-6	10	230	45.0	1.04	9.9	106.0	420.0
	4-12	12	280	32.4	1.16	10.8	121.2	472.0

 $<sup>\</sup>phi$  Degrees current lags voltage at tap value current.

### ENERGY REQUIREMENTS - 60 CYCLES

#### DIRECTIONAL UNIT POLARIZING CIRCUIT BURDEN

RELAY TYPE	RATING	VOLT AMPERES △	POWER FACTOR ANGLE $\phi$
IRC	230* Amperes	1.45	8 <sup>0</sup> Lag
IRP	208** Volts	11.2	28 <sup>0</sup> Lead
IRD Current Unit	230* Amperes	1.45	8 <sup>0</sup> Lag
IRD Voltage Unit	208** Volts	11.2	28 <sup>0</sup> Lead

 $<sup>\</sup>phi$  Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.

<sup>\*</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

<sup>\*\*</sup> Voltages taken with Rectox type voltmeter.

 $<sup>\</sup>Delta$  Burden of voltage polarized units taken at 120 volts. Burden of current polarized units taken at 5 amperes.

<sup>\*</sup> One second rating.

<sup>\*\* 30</sup> second rating. The 10 second rating is 345 volts. The continuous rating is 120 volts.

**ENERGY REQUIREMENTS** 

#### TYPE IRD-2, IRC-2, IRP-2 TIME OVERCURRENT UNITS

				POWER FACTOR ANGLE $\phi$	VOLT AMPERES**				
AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)		AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT	
	0.5	0.91	28	58	4.8	39.6	256	790	
	0.6	0.96	28	57	4.9	39.8	270	851	
	8.0	1.18	28	53	5.0	42.7	308	1024	
0.5/2.5	1.0	1.37	28	50	5.3	45.4	348	1220	
	1.5	1.95	28	40	6.2	54.4	435	1740	
	2.0	2.24	28	36	7.2	65.4	580	2280	
	2.5	2.50	28	29	7.9	73.6	700	2850	
	2.0	3.1	110	59	5.04	38.7	262	800	
	2.5	4.0	110	55	5.13	39.8	280	920	
	3.0	4.4	110	51	5.37	42.8	312	1008	
2/6	3.5	4.8	110	47	5.53	42.8	329	1120	
	4.0	5.2	110	45	5.72	46.0	360	1216	
	5.0	5.6	110	41	5.90	50.3	420	1500	
	6.0	6.0	110	37	6.54	54.9	474	1800	
	4.0	7.3	230	65	4.92	39,1	268	848	
	5.0	8.0	230	50	5.20	42.0	305	1020	
	6.0	8.8	230	47	5.34	44.1	330	1128	
4/12	7.0	9.6	230	46	5.53	45.8	364	1260	
	8.0	10.4	230	43	5.86	49.9	400	1408	
	10.0	11.2	230	37	6.6	55.5	470	1720	
	12.0	12.0	230	34	7.00	62.3	528	2064	

<sup>\*</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

 $<sup>\</sup>phi$  Degrees current lags voltage at tap value current.

<sup>\*\*</sup> Voltages taken with Rectox type voltmeter.

IRD-5, IRC-5, IRP-5, IRD-6. IRC-6, IRP-6,

	1KD-0, 1KC-0, 1KF-0,					VOLT AMPERES**				
AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE $\phi$	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT		
0.5/2.5	(0.5) (0.6) (0.8) (1.0) (1.5) (2.0) (2.5)	2 2.2 2.5 2.8 3.4 4.0 4.4	88 88 88 88 88 88	69 68 67 66 62 60 58	3.92 3.96 3.96 4.07 4.19 4.30 4.37	20.6 20.7 21 21.4 23.2 24.9 26.2	103 106 114 122 147 168 180	270 288 325 360 462 548 630		
2/6	(2 (2.5 (3 (3.5 (4 (5 (6	8 8.8 9.7 10.4 11.2 12.5 13.7	230 230 230 230 230 230 230 230	67 66 64 63 62 59	3.88 3.90 3.93 4.09 4.12 4.20 4.38	21 21.6 22.1 23.1 23.5 24.8 26.5	110 118 126 136 144 162 183	308 342 381 417 448 540 624		
4/12	(4 (5 (6 (7 (8 (10 (12	16 18.8 19.3 20.8 22.5 25	460 460 460 460 460 460	65 63 61 59 56 53 47	4.00 4.15 4.32 4.35 4.40 4.60 4.92	22.4 23.7 25.3 26.4 27.8 30.1 35.6	126 143 162 183 204 247 288	376 450 531 611 699 880 1056		

#### IRD-7, IRC-7, IRP-7 TIME OVERCURRENT UNITS

					VOLT AMPERES**			
		CONTINUOUS	ONE SECOND	POWER	AT	AT 3 TIMES	AT 10 TIMES	AT 20 TIMES
AMPERE		RATING	RATING*	FACTOR	TAP VALUE	TAP VALUE	TAP VALUE	TAP VALUE
RANGE	TAP	(AMPERES)	(AMPERES)	ANGLE $\phi$	CURRENT	CURRENT	CURRENT	CURRENT
	(0.5	2	88	68	3.88	20.7	103	278
	(0.6)	2.2	88	67	3.93	20.9	107	288
	(0.8	2.5	88	66	3.93	21.1	114	320
0.5/2.5	(1.0	2.8	88	64	4.00	21.6	122	35 <del>6</del>
	(1.5	3.4	88	61	4.08	22.9	148	459
	(2.0	4.0	88	58	4.24	24.8	174	552
	(2.5	4.4	88	56	4.38	25.9	185	640
	(2	8	230	66	4.06	21.3	111	306
	(2.5	8.8	230	63	4.07	21.8	120	342
	(3	9.7	230	63	4.14	22.5	129	366
2/6	(3.5	10.4	230	62	4.34	23.4	141	413
	(4	11.2	230	61	4.34	23.8	149	448
	(5	12.5	230	59	4.40	25.2	163	530
	(6	13.7	230	58	4.62	27	183	624
	(4	16	460	64	4.24	22.8	129	392
	(5	18.8	460	61	4.30	24.2	149	460
4/10					4.62	25.9	168	540
4/12	(6	19.3	460	60				
	(7	20.8	460	58	4.69	27.3	187	626
	(8	22.5	460	55	4.80	29.8	211	688
	(10	25	460	51	5.20	33	260	860
	(12	28	460	46	5.40	37.5	308	1032

<sup>\*</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

 $<sup>\</sup>phi$  Degrees current lags voltage at tap value current.

<sup>\*\*</sup> Voltages taken with Rectox type voltmeter.

IRD-8, IRC-8, IRP-8, IRD-9, IRC-9, IRP-9,

					VOLT AMPERES**			
AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE $\phi$	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
0.5/2.5	(0.5) (0.6) (0.8) (1.0) (1.5) (2.0) (2.5)	2 2.2 2.5 2.8 3.4 4.0 4.4	88 88 88 88 88 88	72 71 69 67 62 57 53	2.38 2.38 2.40 2.42 2.51 2.65 2.74	21 21 21.1 21.2 22 23.5 24.8	132 134 142 150 170 200 228	350 365 400 440 530 675 800
2/6	(2 (2.5 (3 (3.5 (4 (5 (6	8 8.8 9.7 10.4 11.2 12.5 13.7	230 230 230 230 230 230 230	70 66 64 62 60 58 56	2.38 2.40 2.42 2.48 2.53 2.64 2.75	21 21.1 21.5 22 22.7 24 25.2	136 142 149 157 164 180	360 395 430 470 500 580 660
4/12	(4 (5 (6 (7 (8 (10 (12	16 18.8 19.3 20.8 22.5 25 28	460 460 460 460 460 460	68 63 60 57 54 48 45	2.38 2.46 2.54 2.62 2.73 3.00 3.46	21.3 21.8 22.6 23.6 24.8 27.8 31.4	146 158 172 190 207 248 292	420 480 550 620 700 850 1020

#### IRD-11, IRC-11, IRP-11 OVERCURRENT UNITS

					VOLT AMPERES**			
		CONTINUOUS	ONE SECOND	POWER	AT	AT 3 TIMES	AT 10 TIMES	AT 20 TIMES
AMPERE		RATING	RATING*	FACTOR	TAP VALUE	TAP VALUE	TAP VALUE	TAP VALUE
RANGE	TAP	(AMPERES)	(AMPERES)	$\underline{\text{ANGLE }\phi}$	CURRENT	CURRENT	CURRENT	CURRENT
	0.5	1.7	56	36	0.72	6.54	71.8	250
	0.6	1.9	56	34	0.75	6.80	75.0	267
	0.8	2.2	56	30	0.81	7.46	84.0	298
0.5/2.5	1.0	2.5	56	27	0.89	8.30	93.1	330
	1.5	3.0	56	22	1.13	10.04	115.5	411
	2.0	3.5	56	17	1.30	11.95	136.3	502
	2.5	3.8	56	16	1.48	13.95	160.0	610
	2.0	7.0	230	32	0.73	6.30	74.0	264
	2.5	7.8	230	30	0.78	7.00	78.5	285
	3.0	8.3	230	27	0.83	7.74	84.0	309
2/6	3.5	9.0	230	24	0.88	8.20	89.0	340
	4.0	10.0	230	23	0.96	9.12	102.0	372
	5.0	11.0	230	20	1.07	9.80	109.0	430
	6.0	12.0	230	20	1.23	11.34	129.0	504
	4.0	14	460	29	0.79	7,08	78.4	296
	5.0	16	460	25	0.89	8.00	90.0	340
	6.0	17	460	22	1.02	9.18	101.4	378
4/12	7.0	18	460	20	1.10	10.00	110.0	454
	8.0	20	460	18	1.23	11.1	124.8	480
	10.0	22	460	17	1.32	14.9	131.6	600
	12.0	26	460	16	1.8	16.3	180.0	720

<sup>\*</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

 $<sup>\</sup>phi$  Degrees current lags voltage at tap value current.

<sup>\*\*</sup> Voltages taken with Rectox type voltmeter.

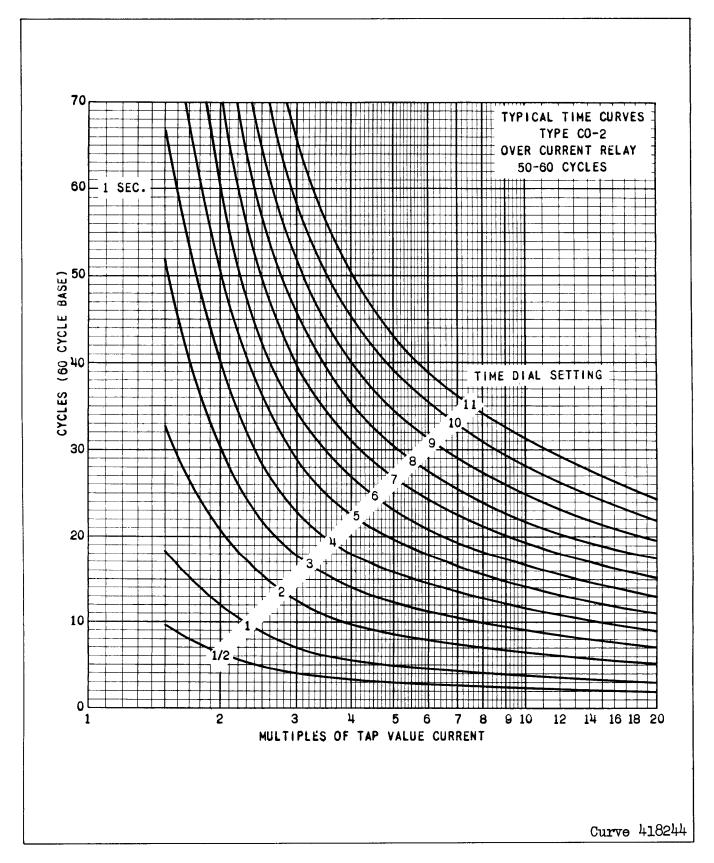


Fig. 10. Typical Time Curves of the Time-Overcurrent Unit of the Short Time (2) Relays.

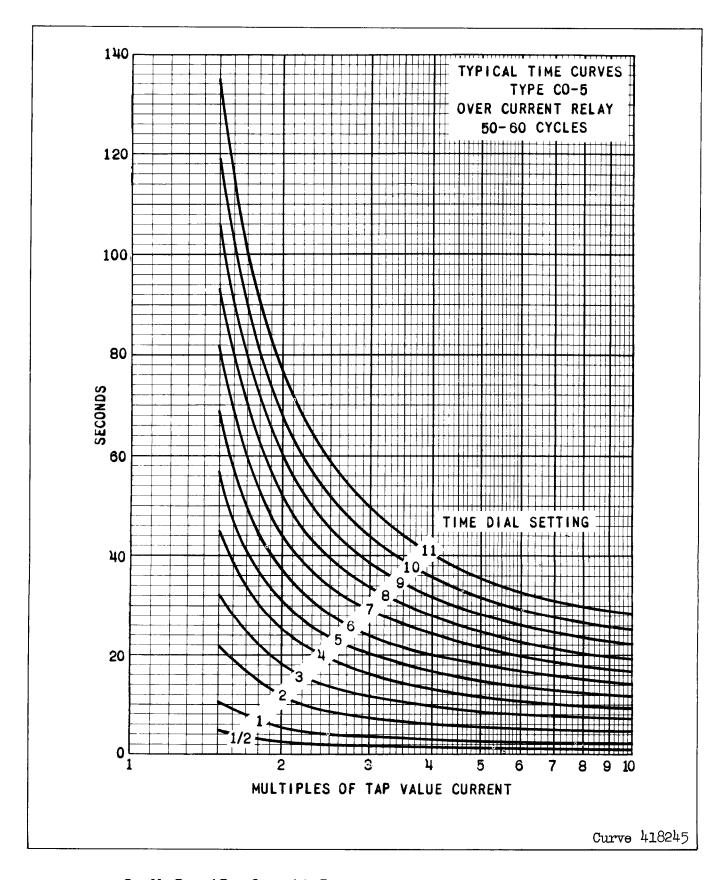


Fig. 11. Typical Time Curve of the Time-Overcurrent Unit of the Long Time (5) Relays.

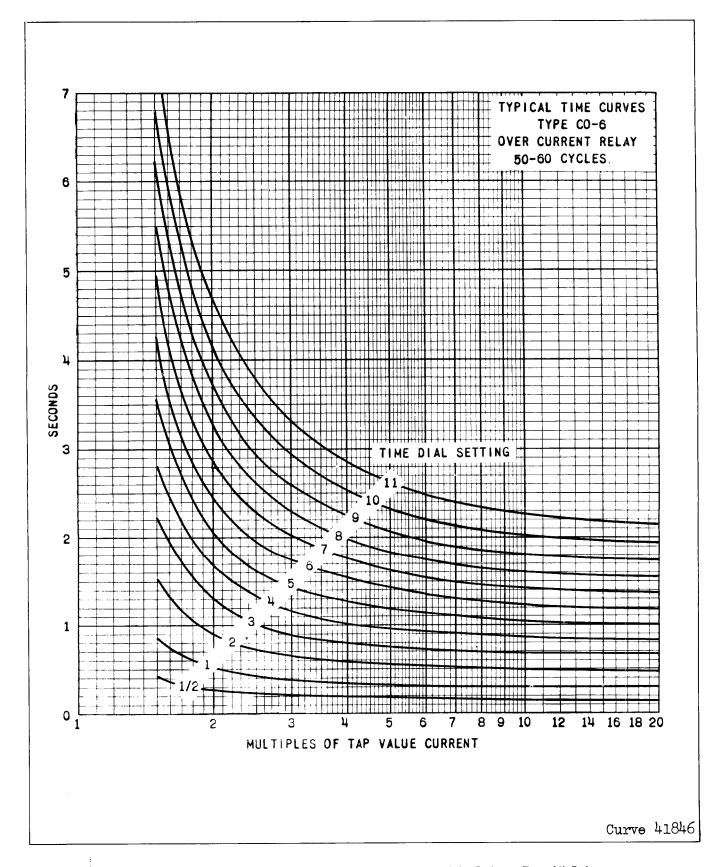


Fig. 12. Typical Time Curve of the Time-Overcurrent Unit of the Definite Time (6) Relays.

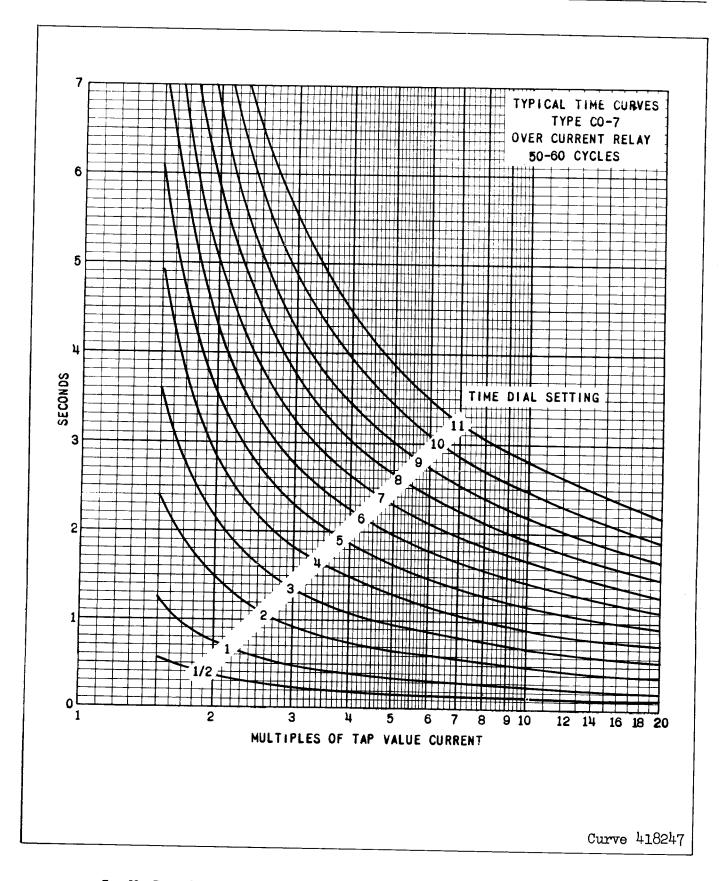


Fig. 13. Typical Time Curve of the Time-Overcurrent Unit of the Moderately Inverse (7) Relays.

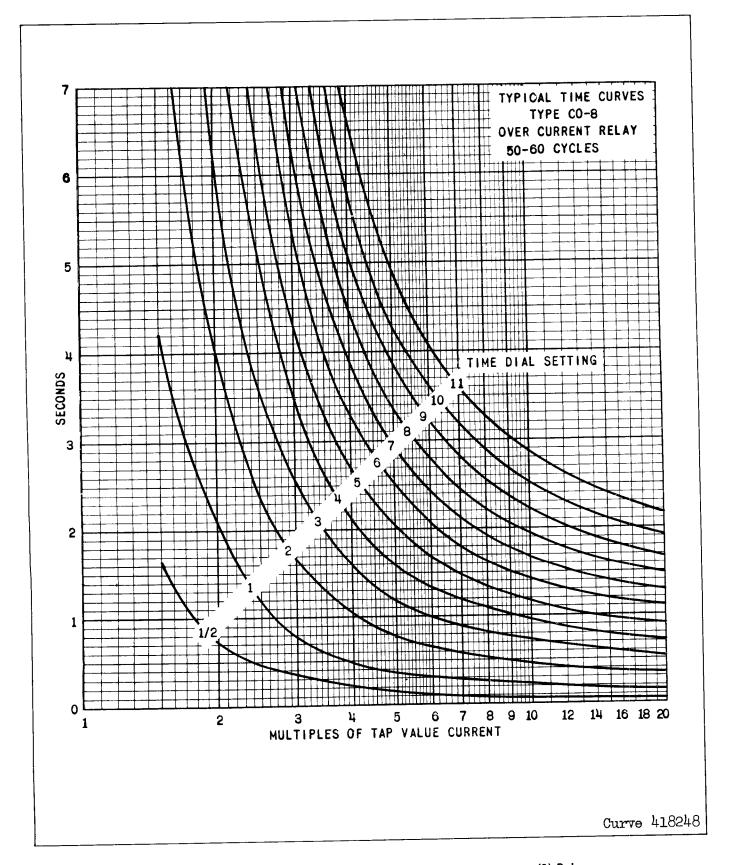


Fig. 14. Typical Time Curve of the Time-Overcurrent Unit of the Inverse (8) Relays.

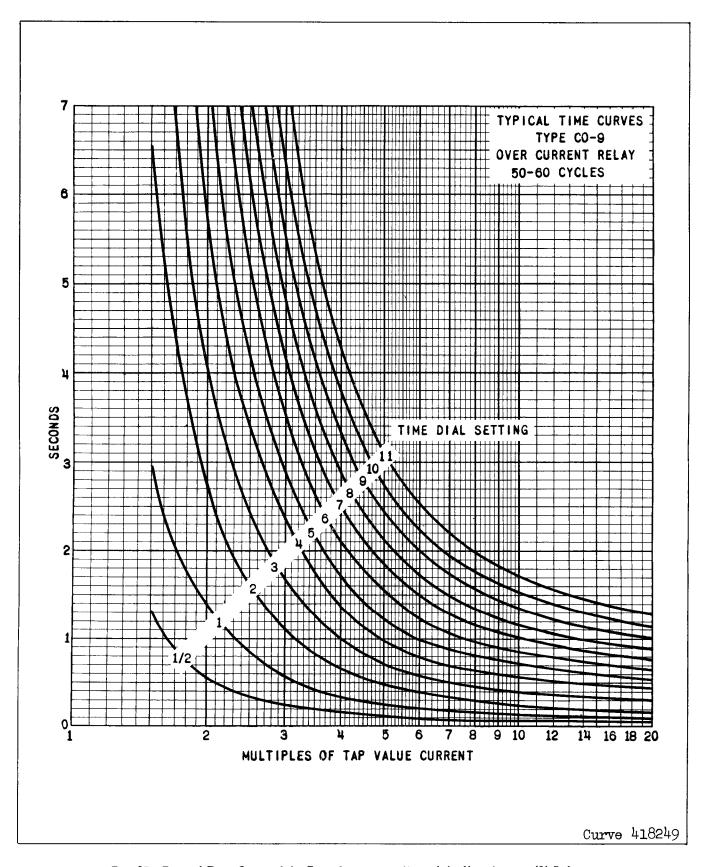


Fig. 15. Typical Time Curve of the Time-Overcurrent Unit of the Very Inverse (9) Relays.

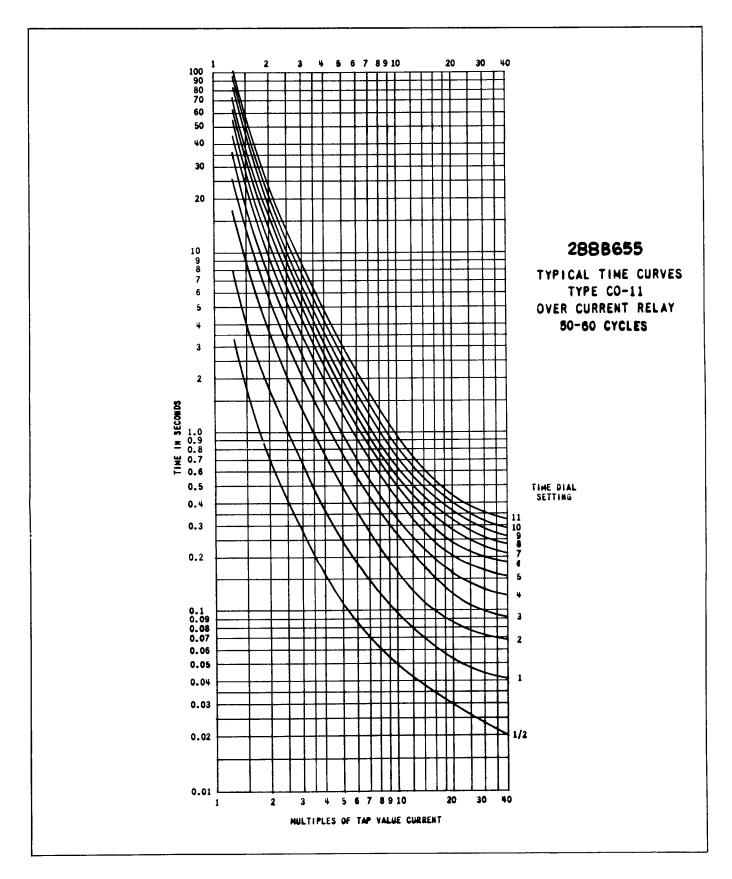
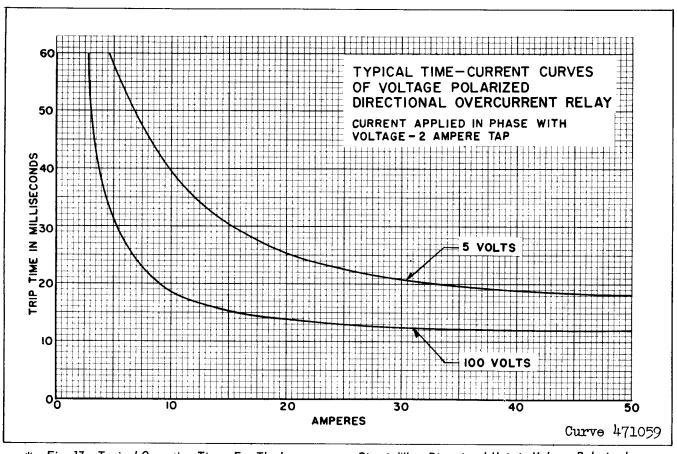


Fig. 16. Typical Time Curve of the Time-Overcurrent Unit of the Extremely Inverse (11) Relays.



\* Fig. 17. Typical Operating Times For The Instantaneous Circuit When Directional Unit is Voltage Polarized.

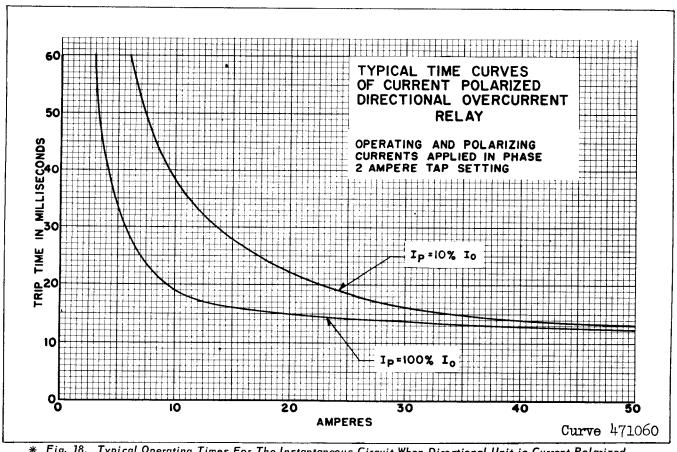


Fig. 18. Typical Operating Times For The Instantaneous Circuit When Directional Unit is Current Polarized.

#### Trip Circuit Constants

Indicating Contactor Switch -

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

#### Auxiliary Switch (CS-1)

The auxiliary switch has a d-c resistance of 1165 ohms.

#### Type IRP Relay

The IRP 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 pick-up is approximately 1 volt and 2 amperes at its maximum torque angle for the directional units used with the 0.5 to 2.5 and 2 to 6 ampere range time over-current units. For the directional units used with the 4-12 ampere range time overcurrent units the minimum pick-up is 1 volt and 4 amperes.

#### Type IRC Relay

The IRC relay is designed for current polarization and has its maximum torque when the operating current leads the polarizing current by approximately  $40^{\circ}$ .

The directional unit minimum pick-up is 0.5 ampere in each winding at the maximum torque angle for the directional units used with the 0.5 to 2.5 and 2 to 6 ampere range time overcurrent units. For the directional units used with the 4-12 ampere range time overcurrent units the minimum pickup is 1 ampere.

#### Type IRD Relay

The type IRD relay utilizes a directional unit similar to the IRC relay in conjunction with the directional unit and phase-shifting circuit of the IRP relay.

The current-polarized directional unit of the IRD relay operates on residual currents while the potential-polarized directional unit of the IRD relay operates on residual voltage and residual current.

For the directional units used with the 0.5 to 2 and 2 to 6 ampere time overcurrent units, the minimum pick-up of the current polarized unit is 0.5 ampere in each winding at the maximum torque angle. The minimum pick-up for the voltage polarized unit is

1 volt and 2 amperes with the current lagging voltage by  $60^{\circ}$ .

For the directional units used with the 4 to 12 ampere range time overcurrent units, the minimum pick-up is 1 ampere for the current-polarized directional unit and 1 volt and 4 amperes for the voltage-polarized directional unit.

#### **SETTINGS**

#### Time Overcurrent Unit (CO)

The time overcurrent unit settings can be defined either by tap setting and time dial position or by tap setting and a specific time of operation at some current multiple of the tap setting (e.g. 4 tap setting, 2 time dial position or 4 tap setting, 0.6 seconds at 6 times tap value current).

To provide selective circuit breaker operation, a minimum coordinating time of 0.3 seconds plus circuit breaker time is recommended between the relay being set and the relays with which coordination is to be effected.

The connector screws on the tap plate above the time dial makes connections to various turns on the operating coil. By placing this screw in the various tap plate holes, the relay will just close its contacts at the corresponding current 4-5-6-7-8-10-12 amperes, or as marked on the tap plate.

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, connext the spare connector screw in the desired position before removing the other tap screw from the original tap position.

#### Instantaneous Reclosing

The factory adjustment of the CO unit contacts provides a contact follow. Where circuit breaker reclosing will be intiated immediately after a trip by the CO contact, the time of the opening of the contacts should be a minimum. This condition is obtained by loosening the stationary contact mounting screw, removing the contact plate and then replacing the plate with the bent end resting against the contact spring. With this change and the contact mounting screw tightened, the stationary contact will rest solidly against its backstop.

#### Instantaneous Overcurrent Unit (1)

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.

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.

#### Directional Units (D)

No setting is required.

#### Indicating Contactor Switch (ICS/I and ICS/T)

No setting is required on the ICS units except the selection of the 0.2 or 2.0 ampere tap setting. This selection is made by connecting the lead located in front of the tap block to the desired setting by means of the connecting screw.

#### Auxiliary Switch (CS-1)

No setting required on the CS-1 unit except for the selection of the required 24, 48, 125 or 250 voltage on the tapped rexistor. This connection can be made by referring to Fig. 23.

#### 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 be means of the two mounting studs for the type FT projection case or by means of the four mounting holes on the flange for the semi-flush type FT case. 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 detail information on the FT Case refer to I.L. 41-076.

The external a-c connections of the directional overcurrent relays are shown in Figs. 20, 21 and 22. If no voltage polarizing source is to be connected to the IRD relay, short-circuit the voltage polarizing circuit at the terminals of the relay.

#### 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;

#### Instantaneous 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. <u>Minimum Trip Current</u> 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 within  $\pm 5\%$  of tap value current.

#### Directional Unit (D)

- 1. Contact Gap The gap between the stationary contact and moving contact with the relay in the deenergized position should be approximately .020".
- 2. <u>Sensitivity</u> The respective directional units should trip with value of energization and phase angle relationship 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 with the polarizing circuits short circuited for the voltage polarized units and open-circuited for the current polarized units.

#### Time Overcurrent Unit (CO)

- 1. Contacts The index mark on the movement frame will coincide with the "O" mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "O" mark by approximately .020". The placement of the various time dial positions in line with the index mark will give operating times as shown on the respective time-current curves.
- 2. Minimum Trip Current Set the time dial to position 6 with the auxiliary switch (CS-1) contacts

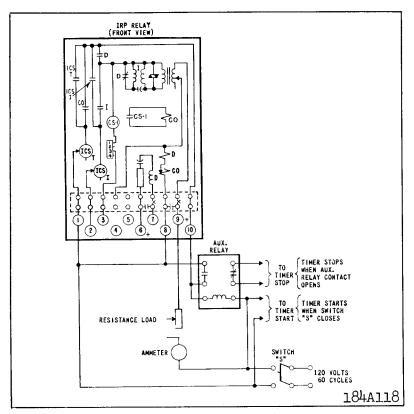


Fig. 19. Diagram of test connections of the time-overcurrent unit.

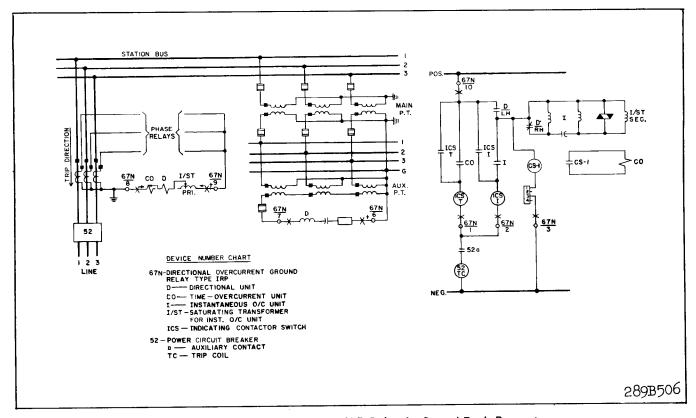


Fig. 20. External Schematic of the IRP Relay for Ground Fault Protection.

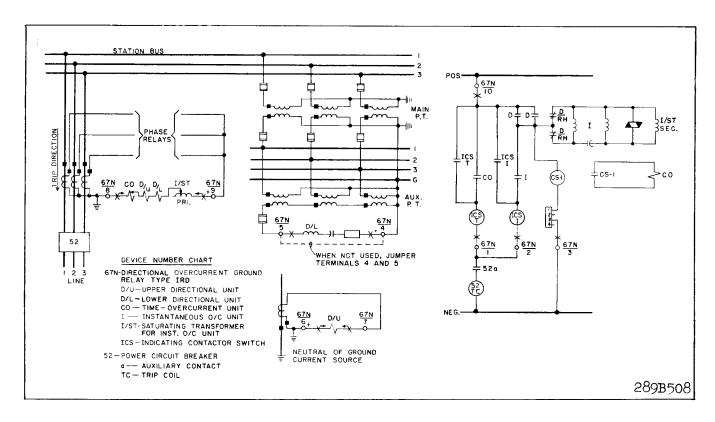


Fig. 21. External Schematic of the IRC Relay for Ground Fault Protection.

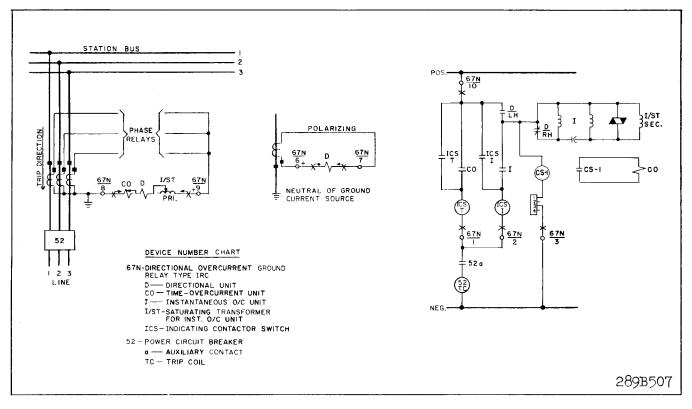


Fig. 22. External Schematic of the IRD Relay for Ground Fault Protection.

blocked closed, alternately apply tap value current plus 3% and tap value current minus 3%. The moving contact should leave the backstop at tap value current plus 3% and should return to the backstop at tap value current minus 3%.

3. <u>Time Curve</u> — Table 3 shows the time curve calibration points for the various types of relays. With the time dial set to the indicated position, apply the currents specified by Table 3 (e.g. for the CO-2, 3 and 20 times tap value current) and measure the operating time of the relay. The operating times should equal those of Table 3 plus or minus 5 percent.

#### Indicating Contactor Switches (ICS/I) and (ICS/T)

- A) Close the contacts of the CO and pass sufficient d.c. current through the trip circuit to close the contacts of (ICS/T). This value of current should not be greater than the particular (ICS/T) tap setting being used. The operation indicator target should drop freely, bringing the letter "T" into view.
- B) Close the contacts of the instantaneous overcurrent unit (I) and the directional unit (D). Pass sufficient d.c. current through the trip circuit to close the contacts of (ICS/I). This value of current should not be greater than the particular (ICS/I) tap setting being used. The operation indicator target should drop freely, bringing the letter "I" into view.
- C) The contact gap should be approximately .047" 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 time of 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. The use of phantom loads, in testing induction-type relays, should be avoided, since the resulting distorted current wave form will produce an error in timing.

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

#### Calibration

Use the following procedure for calibrating the

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

#### Instantaneous Overcurrent Unit (1)

- 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, i.e., against the right side of the bridge. Move 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 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  $\pm 5\%$  of tap value.

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.

#### Directional Unit (D)

In the type IRP and IRC relays the directional unit is the lower cylinder unit. In the type IRD the directional units are the lower and middle cylinder 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 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 as indicated by a neon lamp in the contact circuit when energized with the required current and voltage as shown in Table 1. 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 (IRP and IRD voltage polarized unit) are short-circuited.
- b) The polarizing circuits of the current polarized relays (IRC and IRD 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 some installations in order to insure that the relay will always trip the breaker on zero potential.

#### Time Overcurrent Unit (CO)

- 1. Contacts The index mark on the movement frame will coincide with the "O" mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "O" mark by approximately .020". The placement of the various time dial positions in line with the index mark will give operating times as shown on the respective time-current curves.
- 2) <u>Minimum Trip Current</u> The adjustment of the spring tension in setting the minimum trip current value of the relay is most conveniently made with the damping magnet removed.

With the time dial set on "O", wind up the spiral spring by means of the spring adjuster until approximately 6-3/4 convolutions show.

Set the relay on the minimum tap setting, the time dial to position 6.

With the auxiliary switch (CS-1) contacts blocked closed, adjust the control spring tension so that the moving contact will leave the backstop at tap value current +1.0% and will return to the backstop at tap value current -1.0%.

3) <u>Time Curve Calibration</u> — Install the permanent magnet.

Apply the indicated current per Table 3 for permanent magnet adjustment (e.g. IRP-8, 2 times tap value) and measure the operating time. Adjust the permanent magnet keeper until the operating time corresponds to the value of Table 3.

Apply the indicated current per Table 3 for the electromagnet plug adjustment (e.g. IRP-8, 20 times tap value) and measure the operating time. Adjust the proper plug until the operating time corresponds to the value in Table 3. (Withdrawing the left hand plug, front view increases the operating time and withdrawing the right hand plug, front view, decreases the time.) In adjusting the plugs, one plug should be

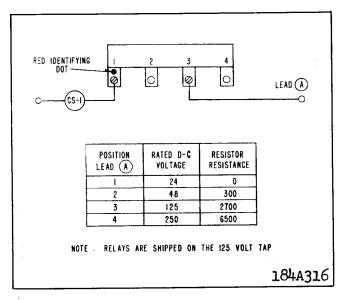


Fig. 23. Selection of Proper Voltage Tap for Auxiliary Switch (CS-1) Operation.

screwed in completely and the other plug run in or out until the proper operating time has been obtained.

Recheck the permanent magnet adjustment. If the operating time for this calibration point has changed, readjust the permanent magnet and then recheck the electromagnet plug adjustment.

#### Indicating Contactor Switches (ICS/I) and (ICS/T)

Adjust the contact gap for approximately .047".

A) Close the contacts of the CO and pass sufficient d.c. current through the trip circuit to close the contacts of the (ICS/T). This value of current should not be greater than the particular (ICS/T) tap setting being used. The operation indicator target should drop freely bringing the letter "T" into view.

B) Close contacts of instantaneous overcurrent unit (I) and directional unit (D). Pass sufficient d.c. current through the trip circuit to close contacts of the (ICS/I). This value of current should not be greater than the particular (ICS/I) tap setting being used. The operation indicator target should drop freely bringing the letter "I" into view.

#### Auxiliary Switch (CS-1)

Adjust the stationary core of the switch for a clearance between the stationary core and the moving core when the switch is picked up. This can be done by turning the relay upside-down. Then screw up the core screw until the moving core starts rotating. Now back off the core screw until the moving core stops rotating. This indicates the points where the play in the assembly is taken up, and where the moving core just separates from the stationary core screw. Back off the core screw approximately one turn and lock in place. This prevents the moving core from striking and sticking to the stationary core because of residual magnetism. Adjust the contact clearance for 3/64" by means of the two small nuts on either side of the Micarta disc.

Connect lead (A) to proper terminal per Fig. 23. Block directional unit (D) contacts close and energize trip circuit with rated voltage. Contacts of auxiliary switch (CS-1) should make as indicated by a neon lamp in the contact circuit.

#### 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.

TABLE I
DIRECTIONAL UNIT SENSITIVITY

DIKE	CHUNAL UNIT	2EM2[[]AIII		
AMPERE RATING	VALUES FOR	R MIN. PICKUP*	PHASE ANGLE RELATIONSHIP	
TIME-OVERCURRENT UNIT	VOLTS	AMPERES		
.5-2.5	1	2.0	I lagging V by $60^{\circ}**$	
2-6	1	4.0	I in-phase with V	
	1	4.0	I lagging V by $60^{\circ}**$	
4-12	1	8.0	I in-phase with V	
5.05		0.5	I <sub>0</sub> leading I <sub>p</sub> by 40°**	
2-6		0.65	In-phase	
4-19		1.0	Io leading Ip by 400**	
4-12		1.3	In-phase	
	AMPERE RATING OF TIME-OVERCURRENT UNIT .5-2.5 2-6 4-12	AMPERE RATING OF TIME-OVERCURRENT UNIT  .5-2.5 2-6  4-12  1 .5-2.5 2-6	OF TIME-OVERCURRENT UNIT  .5-2.5 2-6  1 2.0 1 4.0  4-12  1 4.0 1 8.0 0.5 .5-2.5 2-6 0.65 4-12	

<sup>\*</sup>The energization quantities are input quantities at the relay terminals.

<sup>\*\*</sup> 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) (Contacts remain open)	Left (Front View) Plug Screwed Out Until Spurious Torque is in Contact Closing Direction. Then the plug is screwed in Until Spuri ous Torque is Reversed.

<sup>†</sup> Short circuit the voltage polarizing circuit at the relay terminals before making the above adjustment.

TABLE III

TIME CURVE CALIBRATION DATA - 60 CYCLES

-	PERMANENT	ELECTROMAGNET PLUGS			
TIME- OVERCURRENT UNIT TYPE	TIME DIAL POSITION	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS
2	6	3	0.57	20	0.22
5	6	2	37.80	10	14.30
6	6	2	2.46	20	1.19
7	6	2	4.27	20	1.11
8	6	2	13.35	20	1.11
9	6	2	8.87	20	0.65
11	6	2	11.27	20	0.24

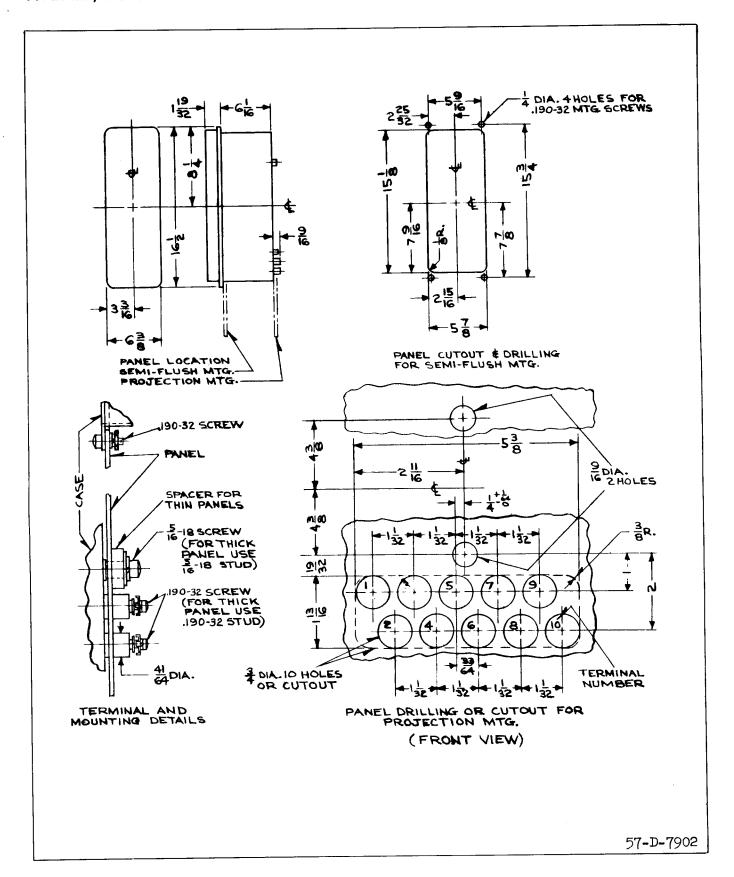


Fig. 24. Outline and Drilling Plan for the IRP and IRC Relays in the Type FT31 Case.

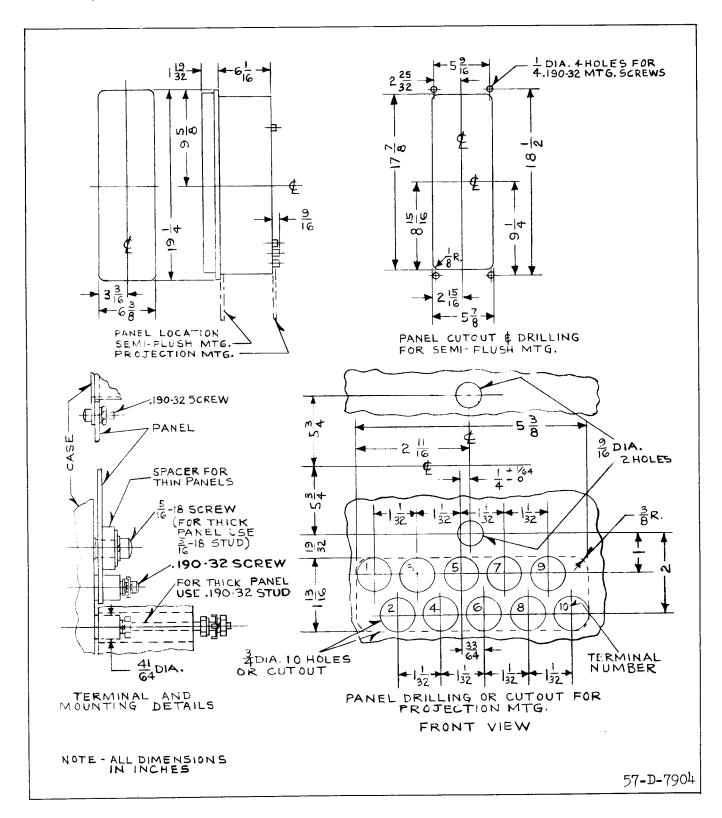


Fig. 25. Outline and Drilling Plan for the IRD Relay in the Type FT41 Case.

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WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION
NEWARK, N. J.



## INSTALLATION . OPERATION . MAINTENANCE

# INSTRUCTIONS

# DIRECTIONAL OVERCURRENT GROUND RELAYS TYPES IRP, IRC AND IRD

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

These relays are ground directional overcurrent relays which are used for the protection of transmission lines and feeder circuits. Both the time-overcurrent and instantaneous overcurrent units are directionally controlled.

The type IRP relay is potential polarized. The type IRC relay is current polarized. The type IRD relay is a dual polarized relay which can be polarized from a potential source, from a local ground source or from both simultaneously.

## CONSTRUCTION AND OPERATION

The various types of relays consist of a directional unit or units (D), an auxiliary switch (CS-1), a time-overcurrent unit (CO), an instantaneous overcurrent unit (I), an instantaneous overcurrent unit transformer, and two indicating contactor switches (ICS/I) and (ICS/T). The principle component parts of the relays and their location are shown in Fig. 1 through 6.

#### Time-Overcurrent Unit (CO)

The electromagnets for the types IR-5, IR-6, IR-7. IR-8 and IR-9 relays have a main tapped coil located on the center leg of an "E" type laminated structure that produces a flux which divides and returns through the outer legs. A shading coil causes the flux through the left leg to lag the main pole flux. The out-of-phase fluxes thus produced in the air gap cause a contact closing torque.

The electromagnet for the type IR-2 and IR-11 relays has a main coil consisting of a tapped primary winding a secondary winding. Two identical coils

on the outer legs of the lamination structure are connected to the main coil secondary in a manner so that the combination of all the fluxes produced by the electromagnet result in out-of-phase fluxes in the air gap. The out-of-phase air gap fluxes produced cause a contact closing torque.

#### Indicating Contactor Switch Units (ICS/I and ICS/T)

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

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

#### 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 the magnetic core. The magnetic core which houses the lower pin bearing is secured to the 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

#### Time Overcurrent Unit

Range				Taps			
.5-2.5	0.5	0.6	0.8	1.0	1.5	2.0	2.5
2-6	2	2.5	3	3.5	4	5	6
4-12	4	5	6	7	8	10	12

The tap value is the minimum current required to just close the relay contacts.

The time vs. current characteristics for the timeovercurrent unit are shown in Figs. 10 to 16. These characteristics give the contact closing time for the various time dial settings when the indicated multiples of tap value current are applied to the relay.

#### TIME CURVES

The time curves for the IRD relay are shown in Fig. 17 and 18. Fig. 17 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.

Fig. 18 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 Fig. 18 plus the directional unit opening time given in Fig. 17. The total closing time for the directional unit is given in Fig. 17. The two examples below will serve to illustrate the use of the curves.

Example 1: Using the formulas and definition of symbols on Fig. 17, we have—

Let: Ipol = 2 amps.  
Iop = 2.31  
Tap Value (T) = 0.5 amp.  

$$\phi$$
 = 0 °

For current polarized relay:

MPP = 
$$\frac{\text{Iop Ipol Cos } \phi}{0.42}$$
  
MPP =  $\frac{(2.31)(2)}{0.42}$  = 11

Referring to Fig. 17 at multiples of product pickup of 11, the directional unit opening time is about 10 ms, and the closing time for this unit is 51 ms.

For overcurrent unit:  
Multiples of pickup = 
$$\frac{10p}{T} = \frac{2.31}{0.5} = 4.6$$

Entering the curve in Fig. 18 at multiples of pickup equal to 4.6, the closing time for the overcurrent is 16 ms. However, the total operating time for the overcurrent unit is 16 plus 10, which is the opening time of back contacts of the directional unit, or 26 ms total operating time for overcurrent unit. The total time for directional unit is 51 ms; and, since this is the longest time, 51 ms is the total operating time of the relay.

Example 2:

Let: Ipol = 20 amps.  
Iop = 23.1 amps.  
T (tap) = 1 amp.  

$$\phi = 0$$
  
MPP = Iop Ipol Cos  $\phi$   
0.42  
MPP = (20) (23.1) = 1100

Entering Fig. 17, the directional unit closing time is 8.5 ms, and the opening time of its back contacts is 1 ms. The total operating time for the directional unit is 8.5 ms.

For overcurrent unit:  
Multiples of pickup = 
$$\frac{\text{Iop}}{\text{T}} = \frac{23.1}{1} = 23.1$$

Referring to Fig. 18, the overcurrent unit contact closing time is about 10 ms. Therefore, the total operating time for this unit is 10 plus 1 or 11 ms. In this case the total operating time of relay is 11 ms.

#### Trip Circuit

The relay contacts will safely close 30 amperes at 250 volts d c and the seal-in contacts of the indicating contactor switches will safely carry this current long enough to trip a circuit breaker.

The indicating contactor switch has two taps that provide a pickup setting of 0.2 or 2 amperes. To change taps requires connecting the lead located in front of the tap block to the desired setting by means of a screw connection.

#### 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.

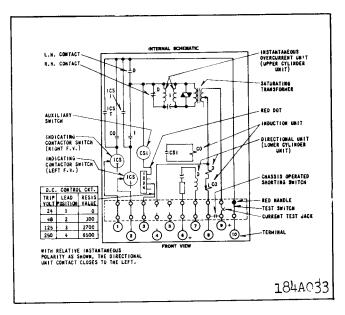


Fig. 7. Internal Schematic of the Type IRP Relay in the Type FT31 Case.

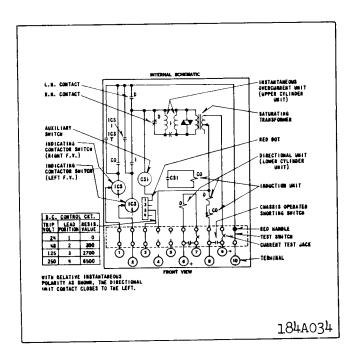


Fig. 8. Internal Schematic of the Type IRC Relay in the Type FT31 Case.

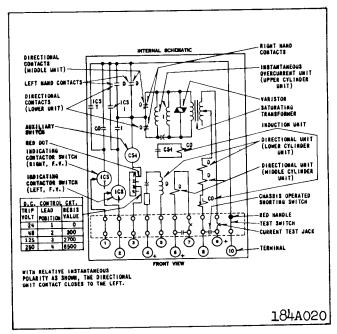


Fig. 9. Internal Schematic of the Type IRD Relay in the Type FT41 Case.

ENERGY REQUIREMENTS

INSTANTANEOUS OVERCURRENT UNIT OPERATING CURRENT CIRCUIT - 60 CYCLES

AMPERE RANGE	TAP	VA AT TAP VALUE	P.F. ANGLE	VA AT 5 AMPS.	P.F. ANGLE
	.5	.37	39	24	46
	.75	.38	36	13	37
	1	.39	35	8.5	34
.5-2	1.25	.41	34	6.0	32
	1.5	.43	32	4.6	31
	2	.45	30	2.9	28
	1	.41	36	9.0	36
	1.5	.44	32	5.0	32
1-4	2	.47	30	3.0	29
	2.5	.50	28	2.1	27
	3	.53	26	1.5	26
	4	.59	24	0.93	24
	2	1.1	49	6.5	48
	3	1.2	43	3.3	42
2-8	4	1.3	38	2.1	37
2 0	5	1.4	35	1.4	35
	6	1.5	33	1.1	33
	8	1.8	29	0.7	29
	4	1.5	51	2.4	51
	6	1.7	45	1.2	45
4-16	8	1.8	40	0.7	40
	9	1.9	38	0.6	38
	12	2.2	34	0.37	34
	16	2.5	30	0.24	31
	10	1.7	28	0.43	28
	15	2.4	21	0.27	21
10-40	20	3.1	16	0.20	17
10-40	24	3.6	15	0.15	15
	30	4.2	12	0.11	13
	40	4.9	11	0.08	12
	20	6.6	31	0.40	31
	30	9.3	24	0.25	24
20-80	40	12	20	0.18	20
	48	13.5	18	0.14	18
	60	15.9	16	0.10	16
	80	19.2	15	0.07	15
RANGE		CONTINUOUS RATII	NG	ONE SECOND R	
		(AMPERES)		† (AMPERES	<i>,</i>
. 5-2		5		100	
1-4		8		140	
2-8		8		140	
4-16		10		200	
10-40		10		200	
20-80		10		200	
20-00		10		200	

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

φ Degrees current lags voltage.

 $<sup>\</sup>dagger \dagger$  Voltages taken with Rectox type voltmeter.

### \* IRD INSTANTANEOUS OVERCURRENT UNIT BURDEN DATA AT HIGH CURRENTS

Ampere Range	10-40											
Tap Value Current	10			20			40					
Multiples of Tap Value Current	22	4	6	8	1	2	3	4	.5	1	1.5	2.0
VA $\pi$	9	36.8	84	156	5	26	57	104	4.8	19.2	44.4	78.8
P.F. Angle $\phi$	18.7°	18.3 °	17.5°	15.7°	9.3°	8.5°	8.8°	9.0°	$4.5^\circ$	4.5 °	4.5 °	4.8°

# ENERGY REQUIREMENTS - 60 CYCLES DIRECTIONAL UNIT OPERATING CIRCUIT BURDEN

		-				VO	LT AMPERES	††
Relay Type	Range Amps	Continuous Rating (Amperes)	One Second Rating † (Amperes)	Power Factor Angle $\phi$	At Minimum Tap Value Current	At 3 Times Minimum Tap Value Current	At 10 Times Minimum Tap Value Current	At 20 Times Minimum Tap Value Current
IRC	0.5-2.5	-	230	44.0	0.033	0.30	3.3	14.2
	2-6	-	230	42.5	0.58	5.28	58.0	240.0
	4-12	12	280	31.8	0.64	6.12	70.0	272.0
IRP	0.5-2.5	10	230	34.5	0.03	0.23	2.8	11.5
	2-6	10	230	34.5	0.44	4.08	48.0	182.0
	4-12	12	280	25.0	0.48	4.62	53.6	216.0
IRD	0.5-2.5	10	230	45.0	0.07	0.59	6.6	26.0
	2-6	10	230	45.0	1.04	9.9	106.0	420.0
	4-12	12	280	32.4	1.16	10.8	121.2	472.0

<sup>\$\</sup>phi\$ Degrees current lags voltage at tap value current.

## ENERGY REQUIREMENTS - 60 CYCLES DIRECTIONAL UNIT POLARIZING CIRCUIT BURDEN

RELAY TYPE	RATING	VOLT AMPERES $\triangle$	POWER FACTOR ANGLE $\phi$
IRC	230 Amperes †	1.45	8° Lag
IRP	208 Volts ††	11.2	28° Lead
KRD Current Unit	230 Amperes ††	1.45	8° Lag
IRD Voltage Unit	208 Volts ††	11.2	28° Lead

 $<sup>\</sup>phi$  Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

<sup>††</sup> Voltages taken with Rectox type voltmeter.

 $<sup>\</sup>triangle$  Burden of voltage polarized units taken at 120 volts. Burden of current polarized units taken at 5 amperes.

<sup>†</sup> One second rating.

<sup>†† 30</sup> second rating. The 10 second rating is 345 volts. The continuous rating is 120 volts.

#### **ENERGY REQUIREMENTS**

#### TYPE IRD-2, IRC-2, IRP-2 TIME OVERCURRENT UNITS

					VOLT AMPERES††			
AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING† (AMPERES)	POWER FACTOR ANGLE $\phi$	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
0.5/2.5	0.5 0.6 0.8 1.0 1.5 2.0 2.5	0.91 0.96 1.18 1.37 1.95 2.24 2.50	28 28 28 28 28 28 28	58 57 53 50 40 36 29	4.8 4.9 5.0 5.3 6.2 7.2 7.9	39.6 39.8 42.7 45.4 54.4 65.4 73.6	256 270 308 348 435 580 700	790 851 1024 1220 1740 2280 2850
2/6	2.0 2.5 3.0 3.5 4.0 5.0 6.0	3.1 4.0 4.4 4.8 5.2 5.6 6.0	110 110 110 110 110 110 110	59 55 51 47 45 41	5.04 5.13 5.37 5.53 5.72 5.90 6.54	38.7 39.8 42.8 42.8 46.0 50.3 54.9	262 280 312 329 360 420 474	800 920 1008 1120 1216 1500
4/12	4.0 5.0 6.0 7.0 8.0 10.0 12.0	7.3 8.0 8.8 9.6 10.4 11.2	230 230 230 230 230 230 230	65 50 47 46 43 37	4.92 5.20 5.34 5.53 5.86 6.6 7.00	39.1 42.0 44.1 45.8 49.9 55.5 62.3	268 305 330 364 400 470 528	848 1020 1128 1260 1408 1720 2064

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

 $<sup>\</sup>phi$  Degrees current lags voltage at tap value current.

 $<sup>\</sup>dagger\dagger$  Voltages taken with Rectox type voltmeter.

#### **ENERGY REQUIREMENTS**

IRD-5, IRC-5, IRP-5, TIME OVERCURRENT UNITS

VOLT AMPERES † †

							THE LEVEL OF T	
		CONTINUOUS	ONE SECOND	POWER	AT	AT 3 TIMES	AT 10 TIMES	AT 20 TIMES
AMPERE		RATING	RATING <sup>†</sup>	FACTOR	TAP VALUE	TAP VALUE	TAP VALUE	TAP VALUE
RANGE	TAP	(AMPERES)	(AMPERES)	ANGLE $\phi$	CURRENT	CURRENT	CURRENT	CURRENT
	(0.5	2	88	69	3.92	20.6	103	270
	(0.6	2.2	88	68	3.96	20.7	106	288
	(0.8	2.5	88	67	3.96	21	114	325
0.5/2.5	(1.0	2.8	88	66	4.07	21.4	122	360
	(1.5	3.4	88	62	4.19	23.2	147	462
	(2.0	4.0	88	60	4.30	24.9	168	548
	(2.5	4.4	88	58	4.37	26.2	180	630
	(2	8	230	67	3.88	21	110	308
	(2.5	8.8	230	66	3.90	21.6	118	342
	(3	9.7	230	64	3.93	22.1	126	381
2/6	(3.5	10.4	230	63	4.09	23.1	136	417
	(4	11.2	230	62	4.12	23.5	144	448
	(5	12.5	230	59	4.20	24.8	162	540
	(6	13.7	230	57	4.38	26.5	183	624
		10	400	05	4.00	22.4	100	272
	(4	16	460	65	4.00	22.4	126	376
	(5	18.8	460	63	4.15	23.7	143	450
	(6	19.3	460	61	4.32	25.3	162	531
4/12	(7	20.8	460	59	4.35	26.4	183	611
	(8	22.5	460	56	4.40	27.8	204	699
	(10	25	460	53	4.60	30.1	247	880
	(12	28	460	47	4.92	35.6	288	1056

#### IRD-7, IRC-7, IRP-7 TIME OVERCURRENT UNITS

VOLT AMPERES † †

					VOLITAMI BICES ( )					
		CONTINUOUS	ONE SECOND	POWER	AT	AT 3 TIMES	AT 10 TIMES	AT 20 TIMES		
AMPERE		RATING	RATING <sup>†</sup>	FACTOR	TAP VALUE	TAP VALUE	TAP VALUE	TAP VALUE		
RANGE	TAP	(AMPERES)	(AMPERES)	ANGLE $\phi$	CURRENT	CURRENT	CURRENT	CURRENT		
	(0.5	2	88	68	3.88	20.7	103	278		
	(0.6	2.2	88	67	3.93	20.9	107	288		
	(0.8	2.5	88	66	3.93	21.1	114	320		
0.5/2.5	(1.0	2.8	88	64	4.00	21.6	122	356		
	(1.5	3.4	88	61	4.08	22.9	148	459		
	(2.0	4.0	88	58	4.24	24.8	174	552		
	(2.5	4.4	88	56	4.38	25.9	185	640		
	(2	8	230	66	4.06	21.3	111	306		
	(2.5	8.8	230	63	4.07	21.8	120	342		
	(3	9.7	230	63	4.14	22.5	129	366		
2/6	(3.5	10.4	230	62	4.34	23.4	141	413		
	(4	11.2	230	61	4.34	23.8	149	448		
	(5	12.5	230	59	4.40	25.2	163	530		
	(6	13.7	230	58	4.62	27	183	624		
	(4	16	460	64	4.24	22.8	129	392		
	(5	18.8	460	61	4.30	24.2	149	460		
4/12	(6	19.3	460	60	4.62	25.9	168	540		
	(7	20.8	460	58	4.69	27.3	187	626		
	(8	22.5	460	55	4.80	29.8	211	688		
	(10	25	460	51	5.20	33	260	860		
	(12	28	460	46	5.40	37.5	308	1032		

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

φ Degrees current lags voltage at tap value current.

<sup>††</sup> Voltages taken with Rectox type voltmeter.

#### **ENERGY REQUIREMENTS**

IRD-8, IRC-8, IRP-8, TIME OVERCURRENT UNITS IRD-9, IRC-9, IRP-9,

				***	VOLT AMPERES ††			
		Continuous	One Second	Power	At	At 3 Times	At 10 Times	At 20 Times
Ampere		Rating	Rating †	Factor	Tap Value	Tap Value	Tap Value	Tap Value
Range	Tap	(Amperes)	(Amperes)	Angle $\phi$	Current	Current	Current	Current
	(0.5	2	88	72	2.38	21	132	350
Ì	(0.6	2.2	88	71	2.38	21	134	365
	(0.8	2.5	88	69	2.40	21.1	142	400
0.5/2.5	(1.0	2.8	88	67	2.42	21.2	150	440
	(1.5	3.4	88	62	2.51	22	170	530
	(2.0	4.0	88	57	2.65	23.5	200	675
	(2.5	4.4	88	53	2.74	24.8	228	800
	(2	8	230	70	2.38	21	136	360
	(2.5	8.8	230	66	2.40	21.1	142	395
	(3	9.7	230	64	2.42	21.5	149	430
2/6	(3.5	10.4	230	62	2.48	22	157	470
	(4	11.2	230	60	2.53	22.7	164	500
	(5	12.5	230	58	2.64	24	180	580
	(6	13.7	230	56	2.75	25.2	198	660
	(4	16	460	68	2.38	21.3	146	420
	(5	18.8	460	63	2.46	21.8	158	480
	(6	19.3	460	60	2.54	22.6	172	550
4/12	(7	20.8	460	57	2.62	23.6	190	620
	(8	22.5	460	54	2.73	24.8	207	700
	(10	25	460	48	3.00	27.8	248	850
	(12	28	460	45	3.46	31.4	292	1020

IRD-11, IRC-11, IRP-11 OVERCURRENT UNITS

			117 117	11, 1101 11	OYENCURKEN	11 011110			
					VOLT AMPERES ††				
Ampere Range	Тар	Continuous Rating (Amperes)	One Second Rating † (Amperes)	Power Factor Angle $\phi$	At Tap Value Current	At 3 Times Tap Value Current	At 10 Times Tap Value Current	At 20 Times Tap Value Current	
0.5/2.5	0.5 0.6 0.8 1.0 1.5 2.0 2.5	1.7 1.9 2.2 2.5 3.0 3.5 3.8	56 56 56 56 56 56	36 34 30 27 22 17 16	0.72 0.75 0.81 0.89 1.13 1.30 1.48	6.54 6.80 7.46 8.30 10.04 11.95 13.95	71.8 75.0 84.0 93.1 115.5 136.3 160.0	250 267 298 330 411 502 610	
2/6	2.0 2.5 3.0 3.5 4.0 5.0 6.0	7.0 7.8 8.3 9.0 10.0 11.0 12.0	230 230 230 230 230 230 230 230	32 30 27 24 23 20 20	0.73 0.78 0.83 0.88 0.96 1.07 1.23	6.30 7.00 7.74 8.20 9.12 9.80 11.34	74.0 78.5 84.0 89.0 102.0 109.0 129.0	264 285 309 340 372 430 504	
4/12	4.0 5.0 6.0 7.0 8.0 10.0 12.0	14 16 17 18 20 22 26	460 460 460 460 460 460 460	29 25 22 20 18 17 16	0.79 0.89 1.02 1.10 1.23 1.32 1.8	7.08 8.00 9.18 10.00 11.1 14.9 16.3	78.4 90.0 101.4 110.0 124.8 131.6 180.0	296 340 378 454 480 600 720	

#### IRD TIME OVERCURRENT UNIT BURDEN DATA AT HIGH CURRENTS

Ampere Range	.5-2.5							
Tap Value Current	.5		1.0		2.5			
Multiples of Tap Value Current	40	80	20	40	8	16		
VA ††	790	2600	380	1280	60	280		
P.F. Angle $\phi$	46.7°	42 °	37 °	26.5 °	4.8 °	4.3°		

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

<sup>\$\</sup>phi Degrees current lags voltage at tap value current.

<sup>††</sup>Voltages taken with Rectox type voltmeter.

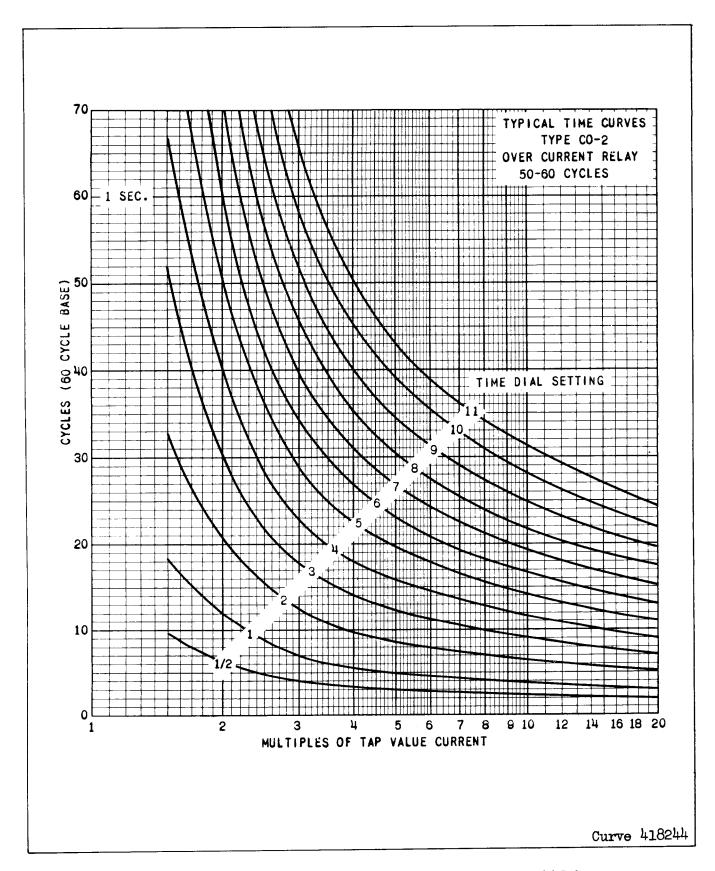


Fig. 10. Typical Time Curves of the Time-Overcurrent Unit of the Short Time (2) Relays.

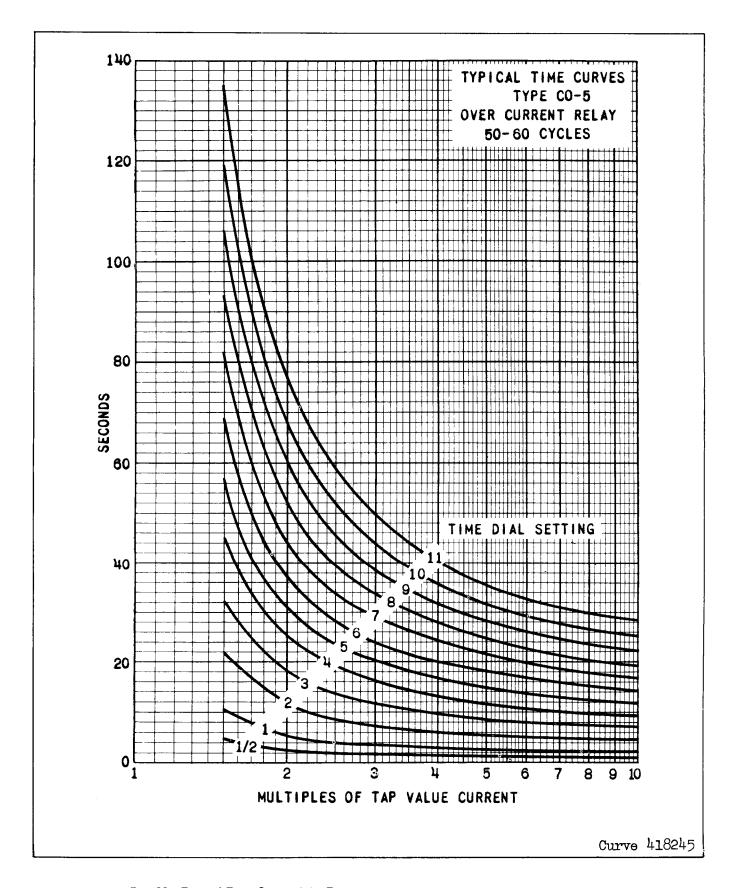


Fig. 11. Typical Time Curve of the Time-Overcurrent Unit of the Long Time (5) Relays.

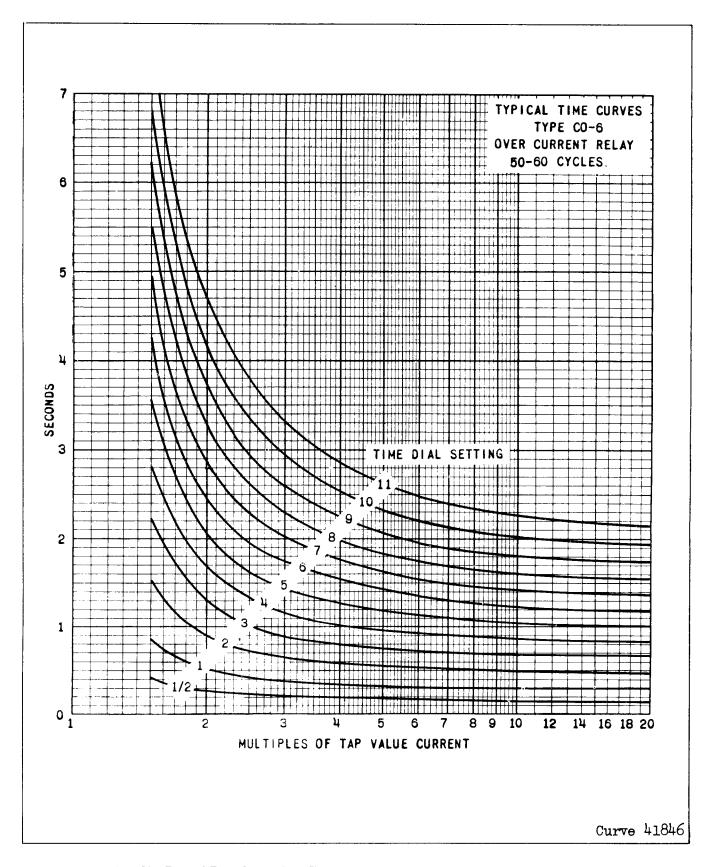


Fig. 12. Typical Time Curve of the Time-Overcurrent Unit of the Definite Time (6) Relays.

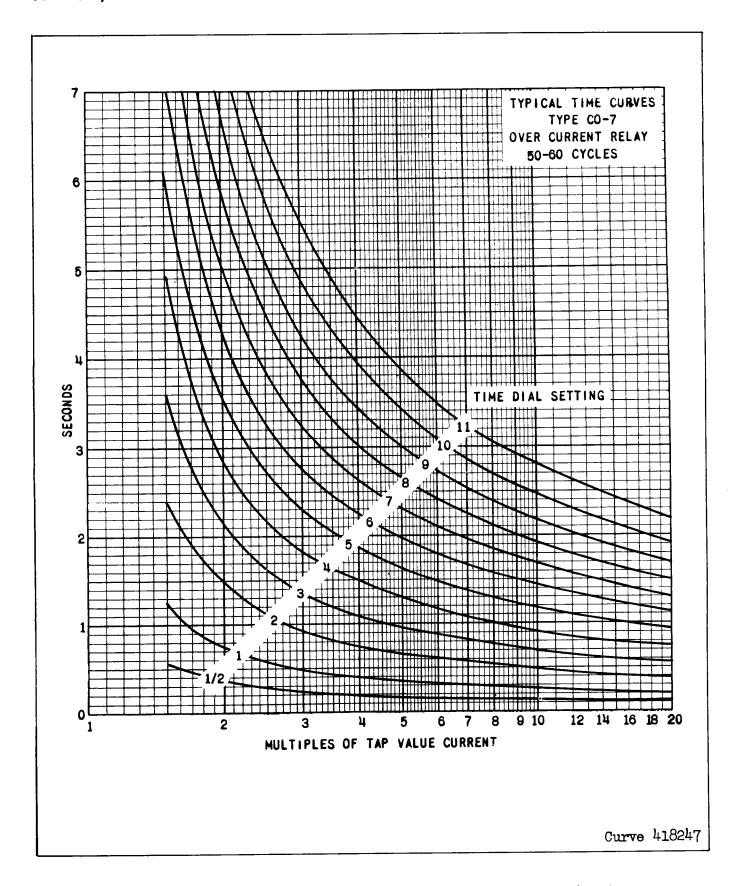


Fig. 13. Typical Time Curve of the Time-Overcurrent Unit of the Moderately Inverse (7) Relays.

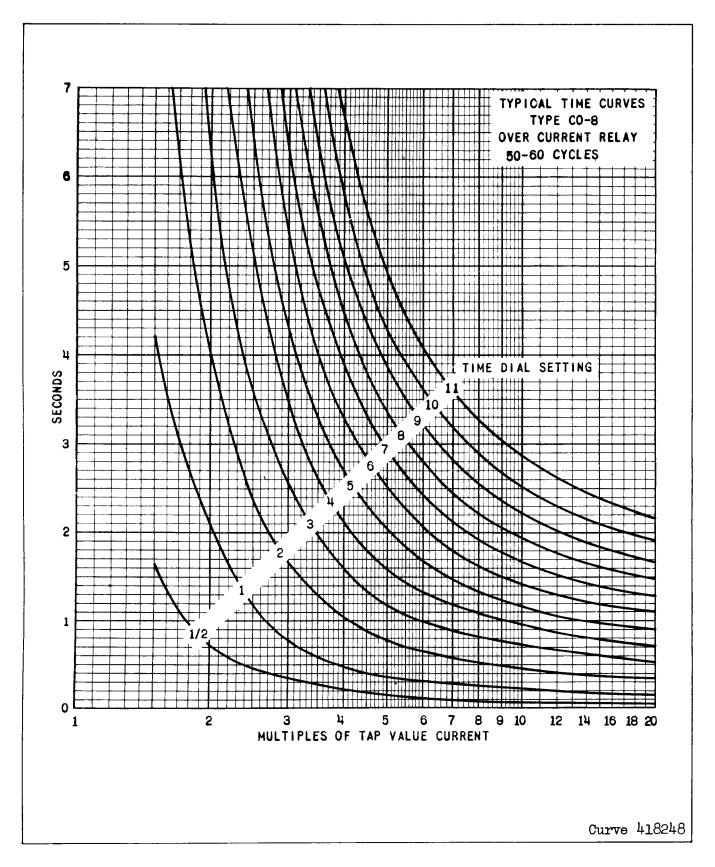


Fig. 14. Typical Time Curve of the Time-Overcurrent Unit of the Inverse (8) Relays.

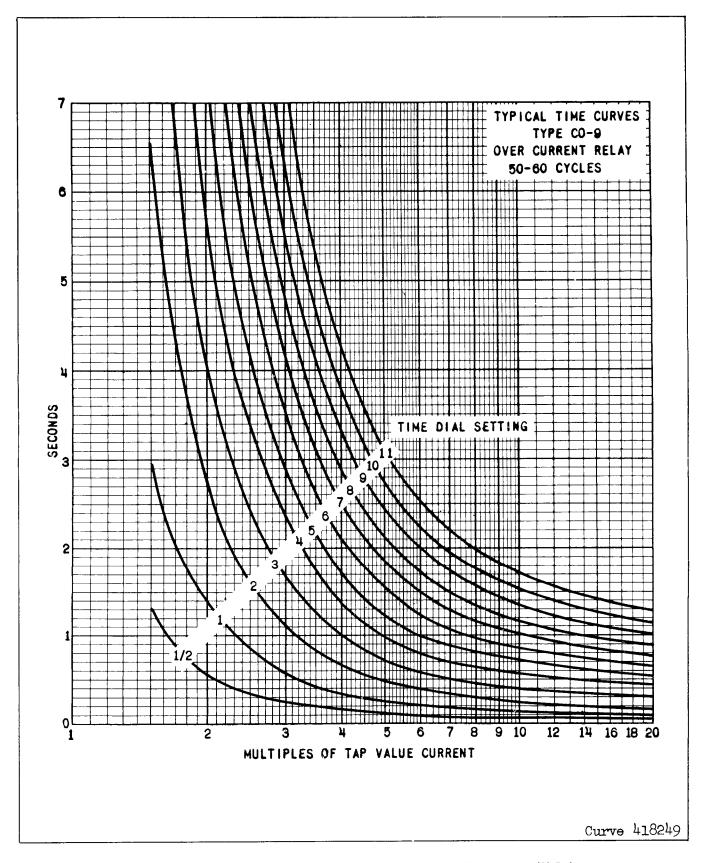


Fig. 15. Typical Time Curve of the Time-Overcurrent Unit of the Very Inverse (9) Relays.

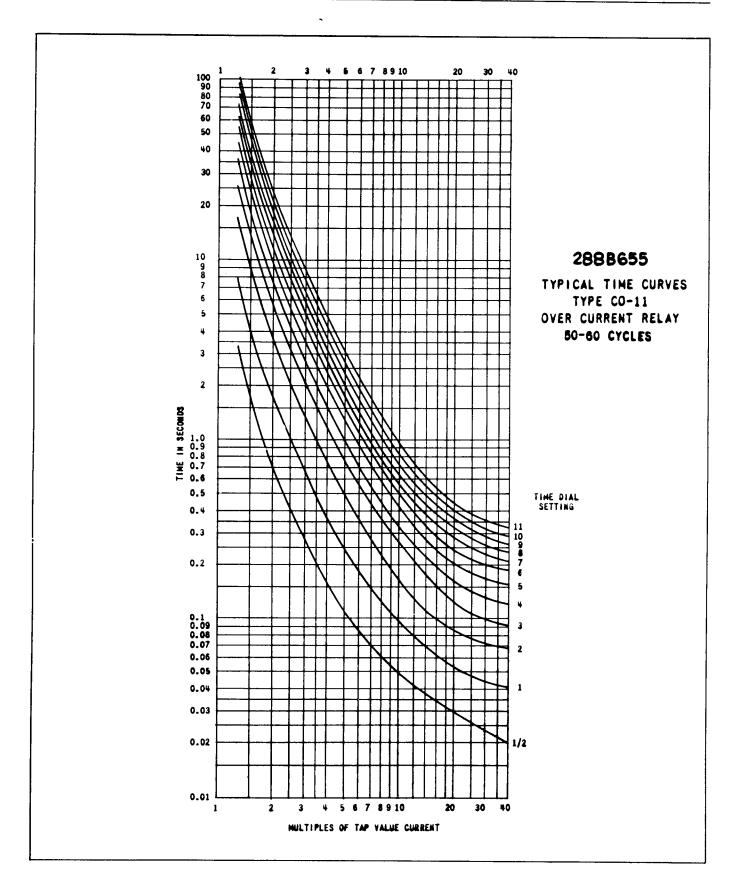
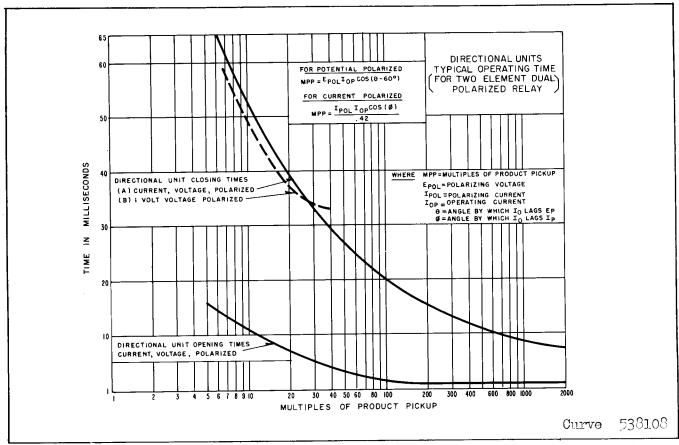
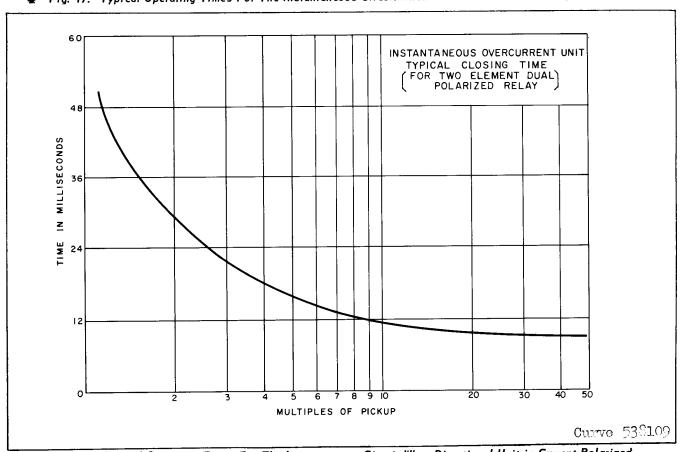


Fig. 16. Typical Time Curve of the Time-Overcurrent Unit of the Extremely Inverse (11) Relays.



\* Fig. 17. Typical Operating Times For The Instantaneous Circuit When Directional Unit is Voltage Polarized.



\* Fig. 18. Typical Operating Times For The Instantaneous Circuit When Directional Unit is Current Polarized.

#### Trip Circuit Constants

Indicating Contactor Switch —
0.2 ampere tap — 6.5 ohms d-c resistance

2.0 ampere tap - 0.15 ohms d-c resistance

#### Auxiliary Switch (CS-1)

The auxiliary switch has a d-c resistance of 1165 ohms.

#### Type IRP Relay

The IRP 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 pick-up is approximately 1 volt and 2 amperes at its maximum torque angle for the directional units used with the 0.5 to 2.5 and 2 to 6 ampere range time over-current units. For the directional units used with the 4-12 ampere range time overcurrent units the minimum pick-up is 1 volt and 4 amperes.

#### Type IRC Relay

The IRC relay is designed for current polarization and has its maximum torque when the operating current leads the polarizing current by approximately  $40^{\circ}$ .

The directional unit minimum pick-up is 0.5 ampere in each winding at the maximum torque angle for the directional units used with the 0.5 to 2.5 and 2 to 6 ampere range time overcurrent units. For the directional units used with the 4-12 ampere range time overcurrent units the minimum pickup is 1 ampere.

#### Type IRD Relay

The type IRD relay utilizes a directional unit similar to the IRC relay in conjunction with the directional unit and phase-shifting circuit of the IRP relay.

The current-polarized directional unit of the IRD relay operates on residual currents while the potential-polarized directional unit of the IRD relay operates on residual voltage and residual current.

For the directional units used with the 0.5 to 2 and 2 to 6 ampere time overcurrent units, the minimum pick-up of the current polarized unit is 0.5 ampere in each winding at the maximum torque angle. The minimum pick-up for the voltage polarized unit is

1 volt and 2 amperes with the current lagging voltage by  $60^{\circ}$ .

For the directional units used with the 4 to 12 ampere range time overcurrent units, the minimum pick-up is 1 ampere for the current-polarized directional unit and 1 volt and 4 amperes for the voltage-polarized directional unit.

#### SETTINGS

#### Time Overcurrent Unit (CO)

The time overcurrent unit settings can be defined either by tap setting and time dial position or by tap setting and a specific time of operation at some current multiple of the tap setting (e.g. 4 tap setting, 2 time dial position or 4 tap setting, 0.6 seconds at 6 times tap value current).

To provide selective circuit breaker operation, a minimum coordinating time of 0.3 seconds plus circuit breaker time is recommended between the relay being set and the relays with which coordination is to be effected.

The connector screws on the tap plate above the time dial makes connections to various turns on the operating coil. By placing this screw in the various tap plate holes, the relay will just close its contacts at the corresponding current 4-5-6-7-8-10-12 amperes, or as marked on the tap plate.

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, connext the spare connector screw in the desired position before removing the other tap screw from the original tap position.

#### Instantaneous Reclosing

The factory adjustment of the CO unit contacts provides a contact follow. Where circuit breaker reclosing will be intiated immediately after a trip by the CO contact, the time of the opening of the contacts should be a minimum. This condition is obtained by loosening the stationary contact mounting screw, removing the contact plate and then replacing the plate with the bent end resting against the contact spring. With this change and the contact mounting screw tightened, the stationary contact will rest solidly against its backstop.

#### Instantaneous Overcurrent Unit (1)

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.

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.

#### Directional Units (D)

No setting is required.

#### Indicating Contactor Switch (ICS/I and ICS/T)

The setting required on the ICS units is the selection of the 0.2 or 2.0 ampere tap setting. This selection is made by connecting the lead located in front of the tap block to the desired setting by means of the connecting screw.

#### Auxiliary Switch (CS-1)

No setting required on the CS-1 unit except for the selection of the required 24, 48, 125 or 250 voltage on the tapped rexistor. This connection can be made by referring to Fig. 23.

#### 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 be means of the two mounting studs for the type FT projection case or by means of the four mounting holes on the flange for the semi-flush type FT case. 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 detail information on the FT Case refer to I.L. 41-076.

The external a-c connections of the directional overcurrent relays are shown in Figs. 20, 21 and 22. If no voltage polarizing source is to be connected to the IRD relay, short-circuit the voltage polarizing circuit at the terminals of the relay.

#### 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;

#### Instantaneous 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. <u>Minimum Trip Current</u> 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 within  $\pm 5\%$  of tap value current.

#### Directional Unit (D)

- 1. Contact Gap The gap between the stationary contact and moving contact with the relay in the deenergized position should be approximately .020".
- 2. <u>Sensitivity</u> The respective directional units should trip with value of energization and phase angle relationship as indicated in Table 1.
- 3. <u>Spurious Torque Adjustments</u> There should be no spurious closing torques when the operating circuits are energized per Table 2 with the polarizing circuits short circuited for the voltage polarized units and open-circuited for the current polarized units.

#### Time Overcurrent Unit (CO)

- 1. Contacts The index mark on the movement frame will coincide with the "O" mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "O" mark by approximately .020". The placement of the various time dial positions in line with the index mark will give operating times as shown on the respective time-current curves.
- 2. Minimum Trip Current Set the time dial to position 6 with the auxiliary switch (CS-1) contacts

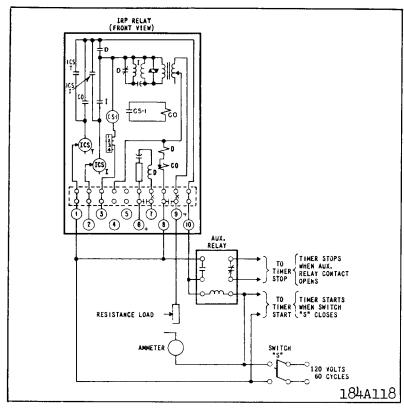


Fig. 19. Diagram of test connections of the time-overcurrent unit.

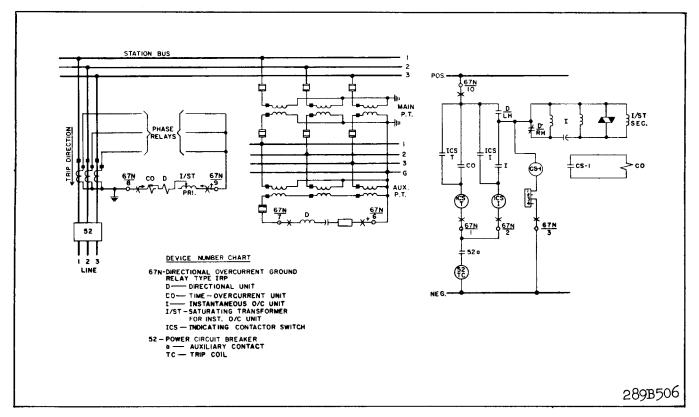


Fig. 20. External Schematic of the IRP Relay for Ground Fault Protection.

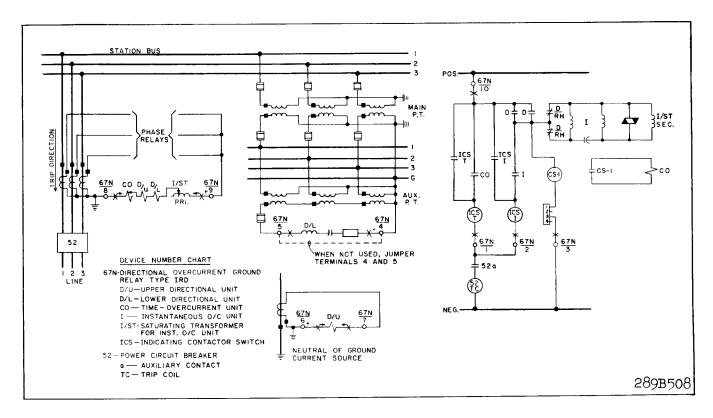


Fig. 21. External Schematic of the IRD Relay for Ground Fault Protection.

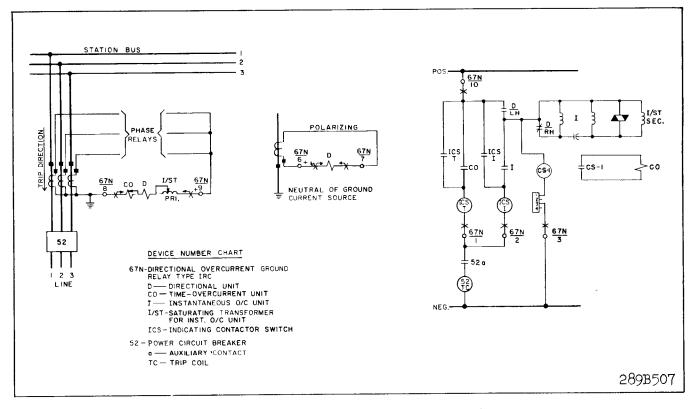


Fig. 22. External Schematic of the IRC Relay for Ground Fault Protection.

blocked closed, alternately apply tap value current plus 3% and tap value current minus 3%. The moving contact should leave the backstop at tap value current plus 3% and should return to the backstop at tap value current minus 3%.

3. <u>Time Curve</u> — Table 3 shows the time curve calibration points for the various types of relays. With the time dial set to the indicated position, apply the currents specified by Table 3 (e.g. for the CO-2, 3 and 20 times tap value current) and measure the operating time of the relay. The operating times should equal those of Table 3 plus or minus 5 percent.

## Indicating Contactor Switches (ICS/I) and (ICS/T)

- A) Close the contacts of the CO and pass sufficient d.c. current through the trip circuit to close the contacts of (ICS/T). This value of current should not be greater than the particular (ICS/T) tap setting being used. The operation indicator target should drop freely, bringing the letter "T" into view.
- B) Close the contacts of the instantaneous overcurrent unit (I) and the directional unit (D). Pass sufficient d.c. current through the trip circuit to close the contacts of (ICS/I). This value of current should not be greater than the particular (ICS/I) tap setting being used. The operation indicator target should drop freely, bringing the letter "I" into view.
- C) The contact gap should be approximately .047" 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 time of 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. The use of phantom loads, in testing induction-type relays, should be avoided, since the resulting distorted current wave form will produce an error in timing.

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

### Calibration

Use the following procedure for calibrating the

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

## Instantaneous Overcurrent Unit (1)

- 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, i.e., against the right side of the bridge. Move 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 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  $\pm 5\%$  of tap value.

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.

## Directional Unit (D)

In the type IRP and IRC relays the directional unit is the lower cylinder unit. In the type IRD the directional units are the lower and middle cylinder 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 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 as indicated by a neon lamp in the contact circuit when energized with the required current and voltage as shown in Table 1. 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 (IRP and IRD voltage polarized unit) are short-circuited.
- b) The polarizing circuits of the current polarized relays (IRC and IRD 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 some installations in order to insure that the relay will always trip the breaker on zero potential.

## Time Overcurrent Unit (CO)

- 1. Contacts The index mark on the movement frame will coincide with the "O" mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "O" mark by approximately .020". The placement of the various time dial positions in line with the index mark will give operating times as shown on the respective time-current curves.
- 2) <u>Minimum Trip Current</u> The adjustment of the spring tension in setting the minimum trip current value of the relay is most conveniently made with the damping magnet removed.

With the time dial set on "O", wind up the spiral spring by means of the spring adjuster until approximately 6-3/4 convolutions show.

Set the relay on the minimum tap setting, the time dial to position 6.

With the auxiliary switch (CS-1) contacts blocked closed, adjust the control spring tension so that the moving contact will leave the backstop at tap value current +1.0% and will return to the backstop at tap value current -1.0%.

3) <u>Time Curve Calibration</u> - Install the permanent magnet.

Apply the indicated current per Table 3 for permanent magnet adjustment (e.g. IRP-8, 2 times tap value) and measure the operating time. Adjust the permanent magnet keeper until the operating time corresponds to the value of Table 3.

Apply the indicated current per Table 3 for the electromagnet plug adjustment (e.g. IRP-8, 20 times tap value) and measure the operating time. Adjust the proper plug until the operating time corresponds to the value in Table 3. (Withdrawing the left hand plug, front view increases the operating time and withdrawing the right hand plug, front view, decreases the time.) In adjusting the plugs, one plug should be

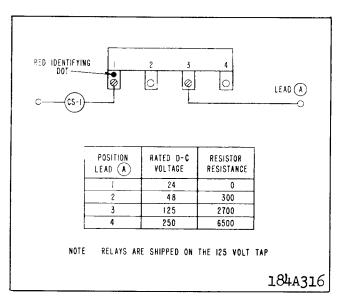


Fig. 23. Selection of Proper Voltage Tap for Auxiliary Switch (CS-1) Operation.

screwed in completely and the other plug run in or out until the proper operating time has been obtained.

Recheck the permanent magnet adjustment. If the operating time for this calibration point has changed, readjust the permanent magnet and then recheck the electromagnet plug adjustment.

## Indicating Contactor Switches (ICS/I) and (ICS/T)

Adjust the contact gap for approximately .047".

A) Close the contacts of the CO and pass sufficient d.c. current through the trip circuit to close the contacts of the (ICS/T). This value of current should not be greater than the particular (ICS/T) tap setting being used. The operation indicator target should drop freely bringing the letter "T" into view.

B) Close contacts of instantaneous overcurrent unit (I) and directional unit (D). Pass sufficient d.c. current through the trip circuit to close contacts of the (ICS/I). This value of current should not be greater than the particular (ICS/I) tap setting being used. The operation indicator target should drop freely bringing the letter "I" into view.

#### Auxiliary Switch (CS-1)

Adjust the stationary core of the switch for a clearance between the stationary core and the moving core when the switch is picked up. This can be done by turning the relay upside-down. Then screw up the core screw until the moving core starts rotating. Now back off the core screw until the moving core stops rotating. This indicates the points where the play in the assembly is taken up, and where the moving core just separates from the stationary core screw. Back off the core screw approximately one turn and lock in place. This prevents the moving core from striking and sticking to the stationary core because of residual magnetism. Adjust the contact clearance for 3/64" by means of the two small nuts on either side of the Micarta disc.

Connect lead (A) to proper terminal per Fig. 23. Block directional unit (D) contacts close and energize trip circuit with rated voltage. Contacts of auxiliary switch (CS-1) should make as indicated by a neon lamp in the contact circuit.

## 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.

TABLE I DIRECTIONAL UNIT SENSITIVITY

RELAY TYPE	AMPERE RATING OF	VALUES FO	R MIN. PICKUP †	PHASE ANGLE RELATIONSHIP	
	TIME-OVERCURRENT UNIT	VOLTS AMPERES			
	.5-2.5	1	2.0	I lagging V by 60°††	
IRP IRD (Voltage	2-6	1	4.0	I in-phasæ with V	
Unit)	4-12	1	4.0	I lagging V by 60° ††	
		1	8.0	I in-phase with V	
	.5-2.5		0.5	Ioleading Ip by 40°††	
IRC IRD (Current	2-6		0.65	In-phase	
Unit)	4-12		1.0	${ m I_O}$ leading ${ m I_D}$ by $40^{\circ}$ ††	
			1.3	In-phase	

<sup>†</sup> The energization quantities are input quantities at the relay terminals.

<sup>††</sup> 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) (Contacts remain open)	Left (Front View) Plug Screwed Out Until Spurious Torque is in Contact Closing Direction. Then the plug is screwed in Until Spuri ous Torque is Reversed.

<sup>†</sup> Short circuit the voltage polarizing circuit at the relay terminals before making the above adjustment.

TABLE III

TIME CURVE CALIBRATION DATA - 60 CYCLES

_	PERMANENT	ELECTROMAGN	IET PLUGS		
TIME- OVERCURRENT UNIT TYPE	TIME DIAL POSITION	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS
2	6	3	0.57	20	0.22
5	6	2	37.80	10	14.30
6	6	2	2.46	20	1.19
7	6	2	4.27	20	1.11
8	6	2	13.35	20	1.11
9	6	2	8.87	20	0.65
11	6	2	11.27	20	0.24

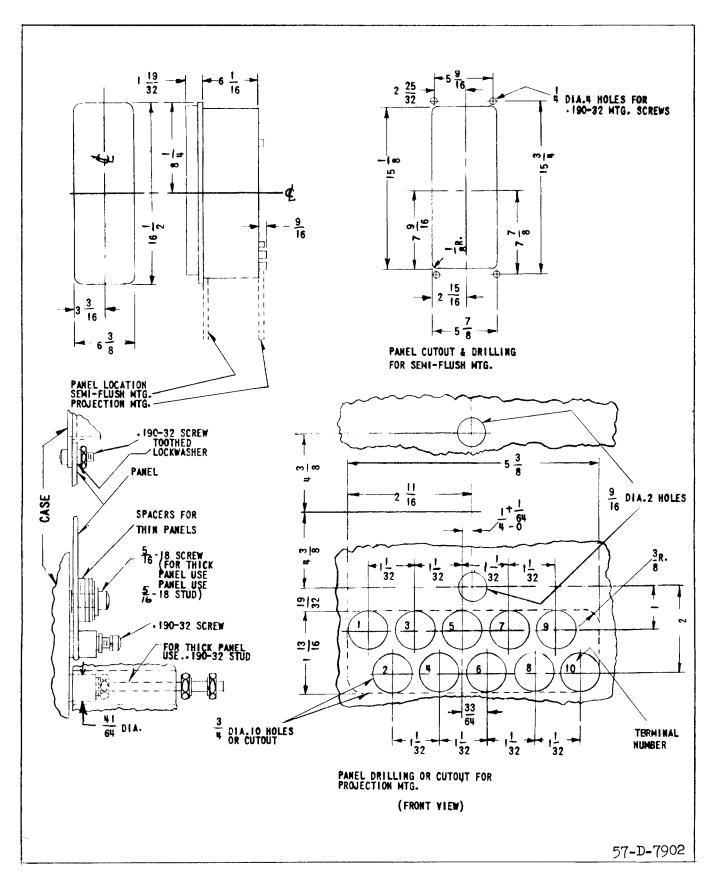


Fig. 24. Outline and Drilling Plan for the IRP and IRC Relays in the Type FT31 Case.

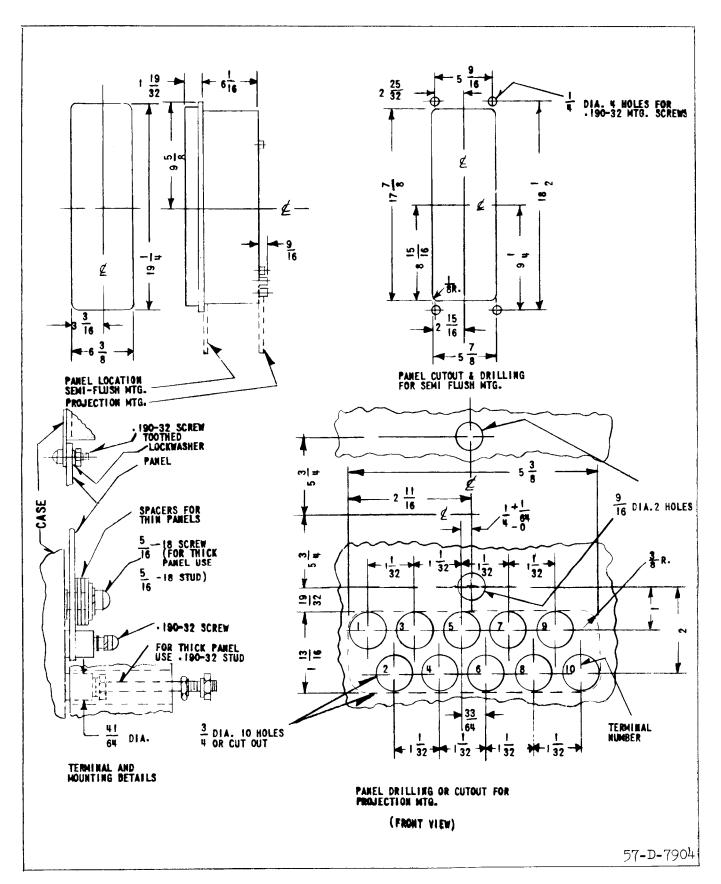


Fig. 25. Outline and Drilling Plan for the IRD Relay in the Type FT41 Case.

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## INSTALLATION . OPERATION . MAINTENANCE

## INSTRUCTIONS

# DIRECTIONAL OVERCURRENT GROUND RELAYS TYPES IRP. IRC AND IRD

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**

These relays are ground directional overcurrent relays which are used for the protection of transmission lines and feeder circuits. Both the time-overcurrent and instantaneous overcurrent units are directionally controlled.

The type IRP relay is potential polarized. The type IRC relay is current polarized. The type IRD relay is a dual polarized relay which can be polarized from a potential source, from a local ground source or from both simultaneously.

## CONSTRUCTION AND OPERATION

The various types of relays consist of a directional unit or units (D), an auxiliary switch (CS-1), a time-overcurrent unit (CO), an instantaneous overcurrent unit (I), an instantaneous overcurrent unit transformer, and two indicating contactor switches (ICS/I) and (ICS/T). The principle component parts of the relays and their location are shown in Fig. 1 through 6.

## Time-Overcurrent Unit (CO)

The electromagnets for the types IR-5, IR-6, IR-7, IR-8 and IR-9 relays have a main tapped coil located on the center leg of an "E" type laminated structure that produces a flux which divides and returns through the outer legs. A shading coil causes the flux through the left leg to lag the main pole flux. The out-of-phase fluxes thus produced in the air gap cause a contact closing torque.

The electromagnet for the type IR-2 and IR-11 relays has a main coil consisting of a tapped primary winding a secondary winding. Two identical coils

on the outer legs of the lamination structure are connected to the main coil secondary in a manner so that the combination of all the fluxes produced by the electromagnet result in out-of-phase fluxes in the air gap. The out-of-phase air gap fluxes produced cause a contact closing torque.

## Indicating Contactor Switch Units (ICS/I and ICS/T)

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

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

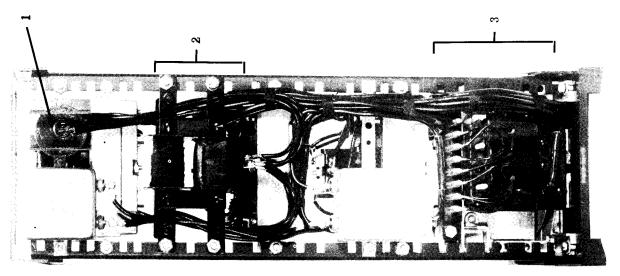
## Directional Unit (D)

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 the magnetic core. The magnetic core which houses the lower pin bearing is secured to the 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



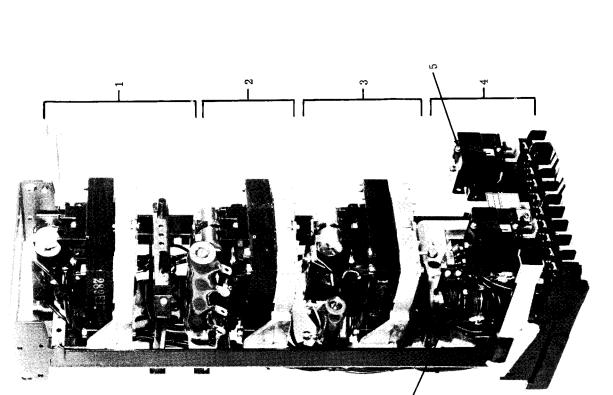


Fig. 1. Type IRD Relay Without Case (Front View). 1 — Instantaneous Over-Fig.: current Unit and Saturating Transformer. 2 — Current Polarized Directional Unit. 3 — Voltage Polarized Directional Unit. 4 — Time Over-current Unit. 5 — Indicating Contactor Switch. 6 — Auxiliary Switch.

Fig. 2. Type IRD Relay Without Case (Rear View). 1- Varistor. 2- Saturating Transformer. 3- "E" Type Electromagnet.

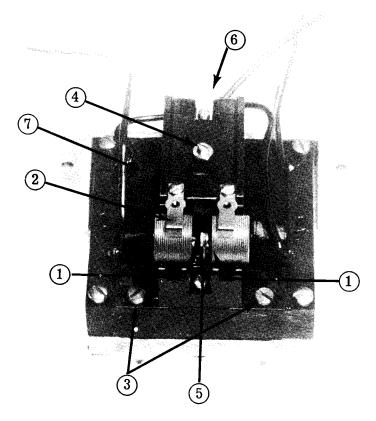


Fig. 3. Directional Unit. 1 - Stationary Contacts. 2 - Stationary Contact Pressure Spring. 3 - Magnetic Adjusting Plugs. 4 - Upper Bearing Screw. 5 - Moving Contact. 6 - Spring Adjuster Clamp. 7 - Current Bias Vane.

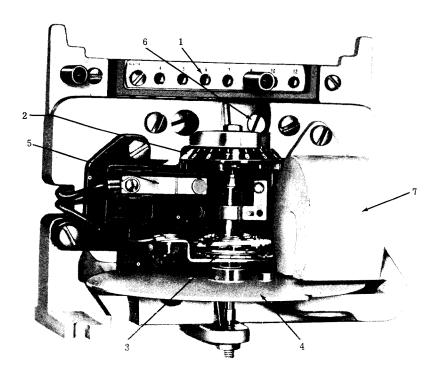


Fig. 4. Time Overcurrent Unit. 1-Top Block. 2-Time Dial. 3-Control Spring Assembly. 4-Disc. 1-Stationary Contact Assembly. 6-Magnetic Plags. 7-Formanent Magnets.

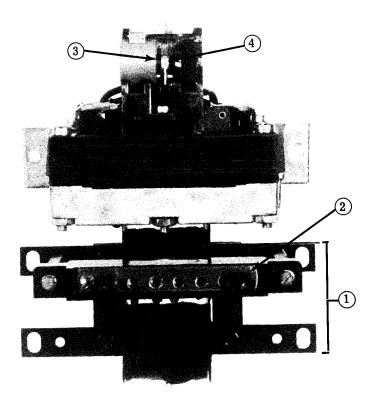


Fig. 5. Instantaneous Overcurrent Unit. 1 — Saturating Transformer. 2 — Tap Block. 3 — Stationary Contact. 4 — Moving Contact.

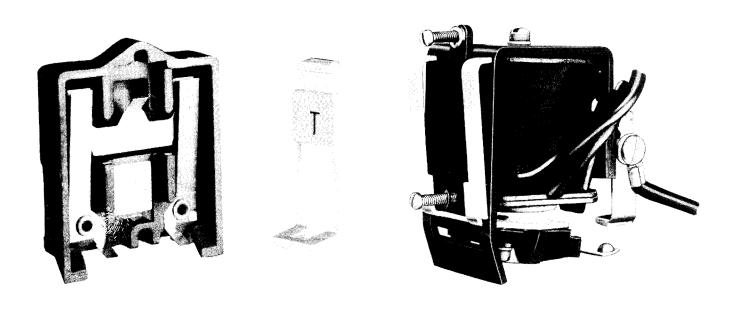


Fig. 6. Indicating Contactor Switch (ICS).

accurately position the lower pin bearing, which is mounted on the frame, with respect to the upper 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 rotating in an 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.

## Auxiliary Switch (CS-1)

The auxiliary switch is a small solenoid type d.c. switch. A cylindrical plunger, with a silver disc mounted on its lower end, moves in the core of the solenoid. As the plunger travels upward, the disc bridges the silver stationary contacts. A tapped resistor is used to enable one to use the contactor switch on a 24, 48, 125 or 250 volt d.c. system connected per Fig. 23. The operation of the CS-1 switch is controlled by the directional unit (D) which in turn directionally controls the time-overcurrent unit (CO). When sufficient power flows in the tripping direction, the CS-1 switch operates and bridges the lag coil of the time-overcurrent unit (CO) permitting this unit to operate.

#### Instantaneous Overcurrent Unit (1)

The instantaneous 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 instantaneous overcurrent unit as shown in the internal schematics. This arrangement short-circuits the operating current around the pole windings; pre-

venting the instantaneous overcurrent unit from developing torque. If the directional unit should pick up for a fault, this short-circuit is removed, allowing the instantaneous overcurrent contact to commence closing almost simultaneously with the directional contact for high speed operation. Total operating times are shown in Figs. 17 and 18.

## Instantaneous Overcurrent Unit Transformer

This transformer is of the saturating type for limiting the energy to the instantaneous overcurrent unit at higher values of fault current and to reduce C.T. burden. The primary winding is tapped and these taps are brought out to a tap block for ease in changing the pick-up of the instantaneous 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.

#### CHARACTERISTICS

The time characteristics of the directional overcurrent relays are designated by specific numbers as indicated below (e.g., IRV-8).

Time	
Characteristics	Designation
Short Time	2
Long Time	5
Definite Time	6
Moderately Inverse Time	7
Inverse Time	8
Very Inverse Time	9
Extremely Inverse Time	11

The relays are available in the following current ranges:

## Instantaneous Overcurrent Unit (I)

	$\underline{\mathtt{Taps}}$				
0.5	0.75	1.0	1.25	1.5	2
1.0	1.5	2.0	2.5	3.0	4.0
2	3	4	5	6	8
4	6	8	9	12	16
10	15	20	24	30	40
20	30	40	48	60	80
	1.0 2 4 10	1.0 1.5 2 3 4 6 10 15	0.5 0.75 1.0 1.0 1.5 2.0 2 3 4 4 6 8 10 15 20	0.5 0.75 1.0 1.25 1.0 1.5 2.0 2.5 2 3 4 5 4 6 8 9 10 15 20 24	0.5 0.75 1.0 1.25 1.5 1.0 1.5 2.0 2.5 3.0 2 3 4 5 6 4 6 8 9 12 10 15 20 24 30

## Time Overcurrent Unit

Range				Tap	s		
.5-2.5	0.5	0.6	0.8	1.0	1.5	2.0	2.5
2-6	2	2.5	3	3.5	4	5	6
4-12	4	5	6	7	8	10	12

The tap value is the minimum current required to just close the relay contacts.

The time vs. current characteristics for the timeovercurrent unit are shown in Figs. 10 to 16. These characteristics give the contact closing time for the various time dial settings when the indicated multiples of tap value current are applied to the relay.

## TIME CURVES

The time curves for the IRD relay are shown in Fig. 17 and 18. Fig. 17 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.

Fig. 18 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 Fig. 18 plus the directional unit opening time given in Fig. 17. The total closing time for the directional unit is given in Fig. 17. The two examples below will serve to illustrate the use of the curves.

Example 1: Using the formulas and definition of symbols on Fig. 17, we have—

Let: Ipol = 2 amps.  
Iop = 2.31  
Tap Value (T) = 0.5 amp.  

$$\phi$$
 = 0  $^{\circ}$ 

\* (For timing unit, assume CP-9 with ½ time dial setting) For current polarized relay:  $MPP = \underbrace{\text{Iop Ipol Cos } \phi}_{0.42}$   $MPP = \underbrace{(2.31)(2)}_{=11}$ 

Referring to Fig. 17 at multiples of product pickup of 11, the directional unit opening time is about 10 ms, and the closing time for this unit is 51 ms.

> For overcurrent unit: Multiples of pickup =  $\frac{\text{Iop}}{\overline{T}} = \frac{2.31}{0.5} = 4.6$

Entering the curve in Fig. 18 at multiples of pickup equal to 4.6, the closing time for instantaneous
overcurrent is 16 ms. However, the total operating time
for the overcurrent unit is 16 plus 10, which is the
opening time of back contacts of the directional unit,
or 26 ms total operating time for overcurrent unit. The
total time for directional unit is 51 ms; and, since
\* this is the longest time, 51 ms is the total operating
time of the instantaneous overcurrent circuit.

Entering the curve in Fig. 15 at 4.6, the  $\frac{1}{2}$  time dial setting gives 140 ms. The total time for the time-overcurrent circuit is 51 ms directional unit time plus 16 ms CS-1 time plus 140 ms = 207 ms.

Example 2:

Let: Ipol = 20 amps.  
Iop = 23.1 amps.  
T (tap) = 1 amp.  

$$\phi = 0$$
  
MPP = Iop Ipol Cos  $\phi$   
0.42  
MPP = (20) (23.1) = 1100

Entering Fig. 17, the directional unit closing time is 8.5 ms, and the opening time of its back contacts is 1 ms. The total operating time for the directional unit is 8.5 ms.

For overcurrent unit: Multiples of pickup =  $\frac{\text{Iop}}{T} = \frac{23.1}{1} = 23.1$ 

Referring to Fig. 18, the overcurrent unit contact closing time is about 10 ms. Therefore, the total operating time for this unit is 10 plus 1 or 11 ms. In this case the total operating time of relay is 11 ms.

\* Fig. 15 gives an operate time of about 50 ms. The time-overcurrent circuit is 8.5 plus 50 = 50.5 ms.

## Trip Circuit

The relay contacts will safely close 30 amperes at 250 volts d c and the seal-in contacts of the indicating contactor switches will safely carry this current long enough to trip a circuit breaker.

The indicating contactor switch has two taps that provide a pickup setting of 0.2 or 2 amperes. To change taps requires connecting the lead located in front of the tap block to the desired setting by means of a screw connection.

#### 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.

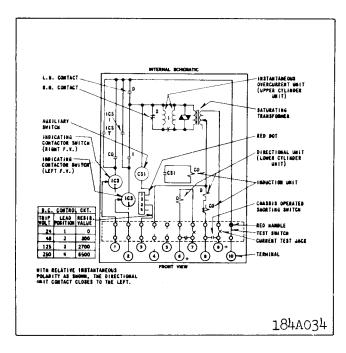


Fig. 8. Internal Schematic of the Type IRC Relay in the Type FT31 Case.

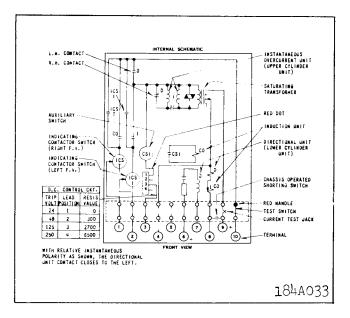


Fig. 7. Internal Schematic of the Type IRP Relay in the Type FT31 Case.

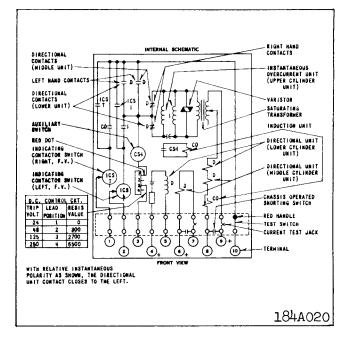


Fig. 9. Internal Schematic of the Type IRD Relay in the Type FT41 Case.

ENERGY REQUIREMENTS

INSTANTANEOUS OVERCURRENT UNIT OPERATING CURRENT CIRCUIT - 60 CYCLES

MPERE RANGE	TAP	VA AT TAP VALUE	P.F. ANGLE	VA AT 5 AMPS.	P.F. ANGLE
	.5	.37	39	24	46
	.75	.38	36	13	37
	1	.39	35	8.5	34
.5-2	1.25	.41	34	6.0	32
	1.5	.43	32	4.6	31
	2	.45	30	2.9	28
	1	.41	36	9.0	36
	1.5	.44	32	5.0	32
	2	.47	30	3.0	29
1-4	2.5	.50	28	2.1	27
	3	.53	26	1.5	26
	4	.59	24	0.93	24
	2	1.1	49	6.5	48
	3	1.2	43	3.3	42
	4	1.3	38	2.1	37
2-8	5	1.4	35	1.4	35
	6	1.5	33	1.1	33
	8	1.8	29	0.7	29
	4	1.5	51	2.4	51
	6	1.7	45	1.2	45
4-16	8	1.8	40	0.7	40
4-10	9	1.9	38	0.6	38
	12	2.2	34	0.37	34
	16	2.5	30	0.24	31
	10	1.7	28	0.43	28
	15	2.4	21	0.27	21
	20	3.1	16	0.20	17
10-40	24	3.6	15	0.15	15
	30	4.2	12	0.11	13
	40	4.9	11	0.08	12
	20	6.6	31	0.40	31
	30	9.3	24	0.25	24
	40	12	20	0.18	20
20-80	48	13.5	18	0.14	18
	60	15.9	16	0.10	16
	80	19.2	15	0.07	15
RANGE		CONTINUOUS RAT	ring	ONE SECOND	l l
	1	(AMPERES)		† (AMPER	المع
. 5-2		5		100	
1-4		8		140	
2-8		8		140	
4-16		10		200	
10-40		10		200	
20-80		10		200	
20-00	1	10			

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

φ Degrees current lags voltage.

<sup>† †</sup> Voltages taken with Rectox type voltmeter.

IDD INCTANTANEOUS	OVERCHIRDENT HAIT BUD	DEN DATA AT HIGH CURRENTS
IKU INSTANTANEUUS	UVEKCUKKENI UNII BUKI	DEN DATA AT HIGH CURRENTS

Ampere Range	10-40											
Tap Value Current	10			20			40					
Multiples of Tap Value Current	22	4	6	8	1	2	3	4	.5	1	1.5	2.0
VA π	9	36.8	84	156	5	26	57	104	4.8	19.2	44.4	78.8
P.F. Angle $\phi$	18.7 °	18.3 °	17.5 °	15.7°	9.3°	8.5 °	8.8 °	9.0°	4.5 °	4.5 °	4.5 °	4.8 °

## ENERGY REQUIREMENTS - 60 CYCLES DIRECTIONAL UNIT OPERATING CIRCUIT BURDEN

						VO	LT AMPERES	††
Relay Type	Range Amps	Continuous Rating (Amperes)	One Second Rating † (Amperes)	Power Factor Angle $\phi$	At Minimum Tap Value Current	At 3 Times Minimum Tap Value Current	At 10 Times Minimum Tap Value Current	At 20 Times Minimum Tap Value Current
IRC	0.5-2.5	-	230	44.0	0.033	0.30	3.3	14.2
	2-6	-	230	42.5	0.58	5.28	58.0	240.0
	4-12	12	280	31.8	0.64	6.12	70.0	272.0
IRP	0.5-2.5	10	230	34.5	0.03	0.23	2.8	11.5
	2-6	10	230	34.5	0.44	4.08	48.0	182.0
	4-12	12	280	25.0	0.48	4.62	53.6	216.0
IRD	0.5-2.5	10	230	45.0	0.07	0.59	6.6	26.0
	2-6	10	230	45.0	1.04	9.9	106.0	420.0
	4-12	12	280	32.4	1.16	10.8	121.2	472.0

<sup>\$\</sup>phi\$ Degrees current lags voltage at tap value current.

## ENERGY REQUIREMENTS - 60 CYCLES DIRECTIONAL UNIT POLARIZING CIRCUIT BURDEN

RELAY TYPE	RATING	VOLT AMPERES △	POWER FACTOR ANGLE $\phi$
IRC	230 Amperes †	1.45	8° Lag
IRP	208 Volts ††	11.2	28° Lead
KRD Current Unit	230 Amperes ††	1.45	8° Lag
IRD Voltage Unit	208 Volts ††	11.2	28 ° Lead

<sup>\$\</sup>phi\$ Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.

 $\Delta$  Burden of voltage polarized units taken at 120 volts. Burden of current polarized units taken at 5 amperes.

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

<sup>††</sup> Voltages taken with Rectox type voltmeter.

<sup>†</sup> One second rating.

<sup>†† 30</sup> second rating. The 10 second rating is 345 volts. The continuous rating is 120 volts.

## **ENERGY REQUIREMENTS**

## TYPE IRD-2, IRC-2, IRP-2 TIME OVERCURRENT UNITS

					VOLT AMPERES††				
AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING† (AMPERES)	POWER FACTOR ANGLE $\phi$	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT	
0.5/2.5	0.5 0.6 0.8 1.0 1.5 2.0	0.91 0.96 1.18 1.37 1.95 2.24	28 28 28 28 28 28 28	58 57 53 50 40 36	4.8 4.9 5.0 5.3 6.2 7.2	39.6 39.8 42.7 45.4 54.4 65.4	256 270 308 348 435 580	790 851 1024 1220 1740 2280	
	2.5 2.0 2.5 3.0	2.50 3.1 4.0 4.4	28 110 110 110	29 59 55 51	7.9 5.04 5.13 5.37	73.6 38.7 39.8 42.8	700 262 280 312	2850 800 920 1008	
2/6	3.5 4.0 5.0 6.0	4.8 5.2 5.6 6.0	110 110 110 110	47 45 41 37	5.53 5.72 5.90 6.54	42.8 46.0 50.3 54.9	329 360 420 474	1120 1216 1500 1800	
4/12	4.0 5.0 6.0 7.0 8.0 10.0 12.0	7.3 8.0 8.8 9.6 10.4 11.2 12.0	230 230 230 230 230 230 230	65 50 47 46 43 37	4.92 5.20 5.34 5.53 5.86 6.6 7.00	39.1 42.0 44.1 45.8 49.9 55.5 62.3	268 305 330 364 400 470 528	848 1020 1128 1260 1408 1720 2064	

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

 $<sup>\</sup>phi$  Degrees current lags voltage at tap value current.

<sup>††</sup> Voltages taken with Rectox type voltmeter.

## **ENERGY REQUIREMENTS**

IRD-5, IRC-5, IRP-5, IRD-6, IRC-6, IRP-6, TIME OVERCURRENT UNITS

				POWER FACTOR ANGLE $\phi$	VOLT AMPERES † †				
AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	RATING RATING†		AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT	
0.5/2.5	(0.5 (0.6 (0.8 (1.0 (1.5 (2.0 (2.5	2 2.2 2.5 2.8 3.4 4.0 4.4	88 88 88 88 88 88	69 68 67 66 62 60 58	3.92 3.96 3.96 4.07 4.19 4.30	20.6 20.7 21 21.4 23.2 24.9 26.2	103 106 114 122 147 168 180	270 288 325 360 462 548 630	
2/6	(2 (2.5 (3 (3.5 (4 (5 (6	8 8.8 9.7 10.4 11.2 12.5 13.7	230 230 230 230 230 230 230	67 66 64 63 62 59	3.88 3.90 3.93 4.09 4.12 4.20	21 21.6 22.1 23.1 23.5 24.8 26.5	110 118 126 136 144 162 183	308 342 381 417 448 540 624	
4/12	(4 (5 (6 (7 (8 (10 (12	16 18.8 19.3 20.8 22.5 25	460 460 460 460 460 460	65 63 61 59 56 53	4.00 4.15 4.32 4.35 4.40 4.60 4.92	22.4 23.7 25.3 26.4 27.8 30.1 35.6	126 143 162 183 204 247 288	376 450 531 611 699 880 1056	

## IRD-7, IRC-7, IRP-7 TIME OVERCURRENT UNITS

					VOLT AMPERES † †			
AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING <sup>†</sup> (AMPERES)	POWER FACTOR ANGLE $\phi$	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
0.5/2.5	(0.5 (0.6 (0.8 (1.0 (1.5 (2.0 (2.5	2 2.2 2.5 2.8 3.4 4.0 4.4	88 88 88 88 88 88	68 67 66 64 61 58	3.88 3.93 3.93 4.00 4.08 4.24 4.38	20.7 20.9 21.1 21.6 22.9 24.8 25.9	103 107 114 122 148 174	278 288 320 356 459 552 640
2/6	(2 (2.5 (3 (3.5 (4 (5 (6	8 8.8 9.7 10.4 11.2 12.5 13.7	230 230 230 230 230 230 230	66 63 63 62 61 59	4.06 4.07 4.14 4.34 4.34 4.40	21.3 21.8 22.5 23.4 23.8 25.2 27	111 120 129 141 149 163 183	306 342 366 413 448 530 624
4/12	(4 (5 (6 (7 (8 (10 (12	16 18.8 19.3 20.8 22.5 25	460 460 460 460 460 460	64 61 60 58 55 51	4.24 4.30 4.62 4.69 4.80 5.20 5.40	22.8 24.2 25.9 27.3 29.8 33	129 149 168 187 211 260 308	392 460 540 626 688 860 1032

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

φ Degrees current lags voltage at tap value current.

 $<sup>\</sup>dagger\dagger$  Voltages taken with Rectox type voltmeter.

## **ENERGY REQUIREMENTS**

IRD-8, IRC-8, IRP-8, TIME OVERCURRENT UNITS IRD-9, IRC-9, IRP-9,

	•				VOLT AMPERES ††			
Ampere Range	Тар	Continuous Rating (Amperes)	One Second Rating † (Amperes)	Power Factor Angle $\phi$	At Tap Value Current	At 3 Times Tap Value Current	At 10 Times Tap Value Current	At 20 Times Tap Value Current
0.5/2.5	(0.5 (0.6 (0.8 (1.0 (1.5 (2.0 (2.5	2 2.2 2.5 2.8 3.4 4.0 4.4	88 88 88 88 88 88	72 71 69 67 62 57 53	2.38 2.38 2.40 2.42 2.51 2.65 2.74	21 21.1 21.2 22.2 23.5 24.8	132 134 142 150 170 200 228	350 365 400 440 530 675 800
2/6	(2.5 (2.5 (3.5 (4 (5)	8 8.8 9.7 10.4 11.2 12.5 13.7	230 230 230 230 230 230 230 230	70 66 64 62 60 58 56	2.38 2.40 2.42 2.48 2.53 2.64 2.75	21 21.1 21.5 22 22.7 24 25.2	136 142 149 157 164 180	360 395 430 470 500 580 660
4/12	(4 (5 (6 (7 (8 (10 (12	16 18.8 19.3 20.8 22.5 25 28	460 460 460 460 460 460 460	68 63 60 57 54 48 45	2.38 2.46 2.54 2.62 2.73 3.00 3.46	21.3 21.8 22.6 23.6 24.8 27.8 31.4	146 158 172 190 207 248 292	420 480 550 620 700 850 1020

IRD-11, IRC-11, IRP-11 OVERCURRENT UNITS

IRD-11, IRC-11, IRF-11 OVERCORRENT ONTS								
						VOLT AM	PERES ††	
Ampere Range	Тар	Continuous Rating (Amperes)	One Second Rating † (Amperes)	Power Factor Angle $\phi$	At Tap Value Current	At 3 Times Tap Value Current	At 10 Times Tap Value Current	At 20 Times Tap Value Current
0.5/2.5	0.5 0.6 0.8 1.0 1.5 2.0 2.5	1.7 1.9 2.2 2.5 3.0 3.5	56 56 56 56 56 56	36 34 30 27 22 17 16	0.72 0.75 0.81 0.89 1.13 1.30 1.48	6.54 6.80 7.46 8.30 10.04 11.95 13.95	71.8 75.0 84.0 93.1 115.5 136.3 160.0	250 267 298 330 411 502 610
2/6	2.0 2.5 3.0 3.5 4.0 5.0 6.0	7.0 7.8 8.3 9.0 10.0 11.0 12.0	230 230 230 230 230 230 230 230	32 30 27 24 23 20 20	0.73 0.78 0.83 0.88 0.96 1.07 1.23	6.30 7.00 7.74 8.20 9.12 9.80 11.34	74.0 78.5 84.0 89.0 102.0 109.0 129.0	264 285 309 340 372 430 504
4/12	4.0 5.0 6.0 7.0 8.0 10.0 12.0	14 16 17 18 20 22 26	460 460 460 460 460 460 460	29 25 22 20 18 17 16	0.79 0.89 1.02 1.10 1.23 1.32	7.08 8.00 9.18 10.00 11.1 14.9 16.3	78.4 90.0 101.4 110.0 124.8 131.6 180.0	296 340 378 454 480 600 720

## IRD TIME OVERCURRENT UNIT BURDEN DATA AT HIGH CURRENTS

Ampere Range	.5-2.5							
Tap Value Current	.5		1.0		2.5			
Multiples of Tap Value Current	40	80	20	40	8	16		
VA ††	790	2600	380	1280	60	280		
P.F. Angle $\phi$	46.7°	42 °	37°	26.5 °	4.8 °	4.3 °		

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

<sup>\$\</sup>phi Degrees current lags voltage at tap value current.

<sup>††</sup>Voltages taken with Rectox type voltmeter.

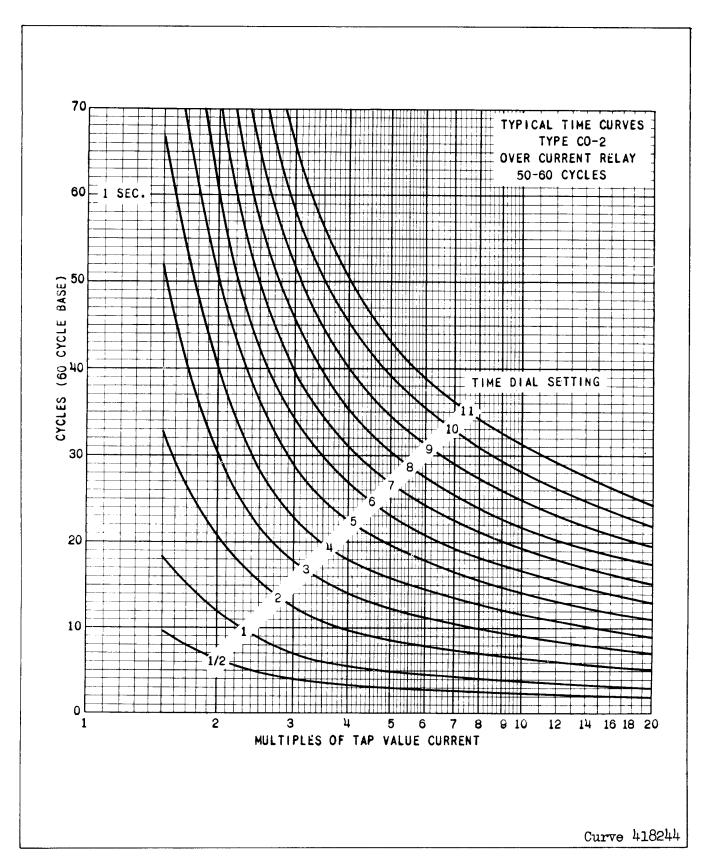


Fig. 10. Typical Time Curves of the Time-Overcurrent Unit of the Short Time (2) Relays.

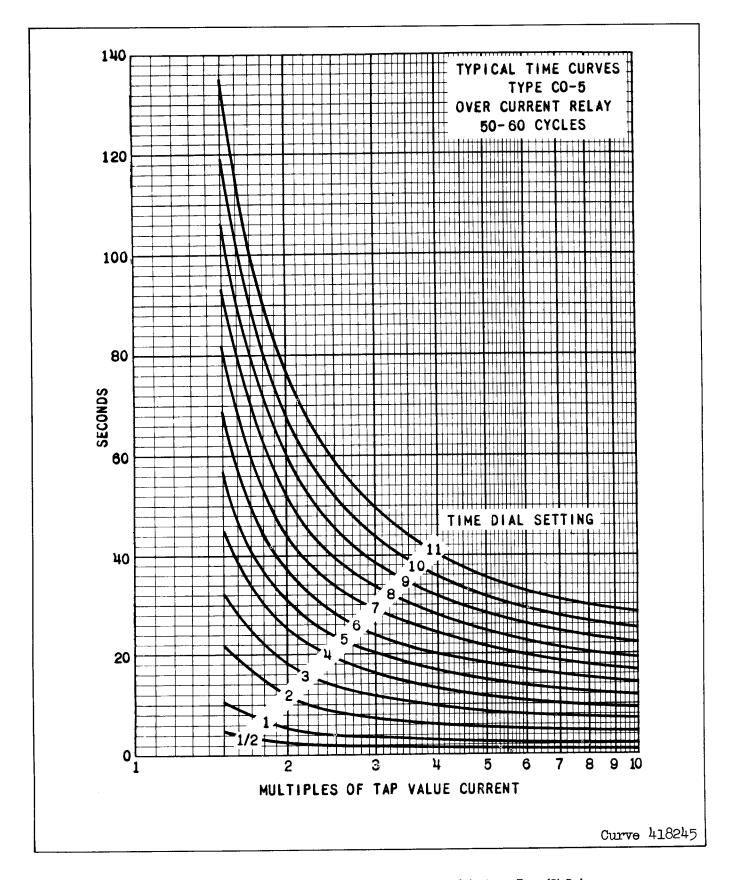


Fig. 11. Typical Time Curve of the Time-Overcurrent Unit of the Long Time (5) Relays.

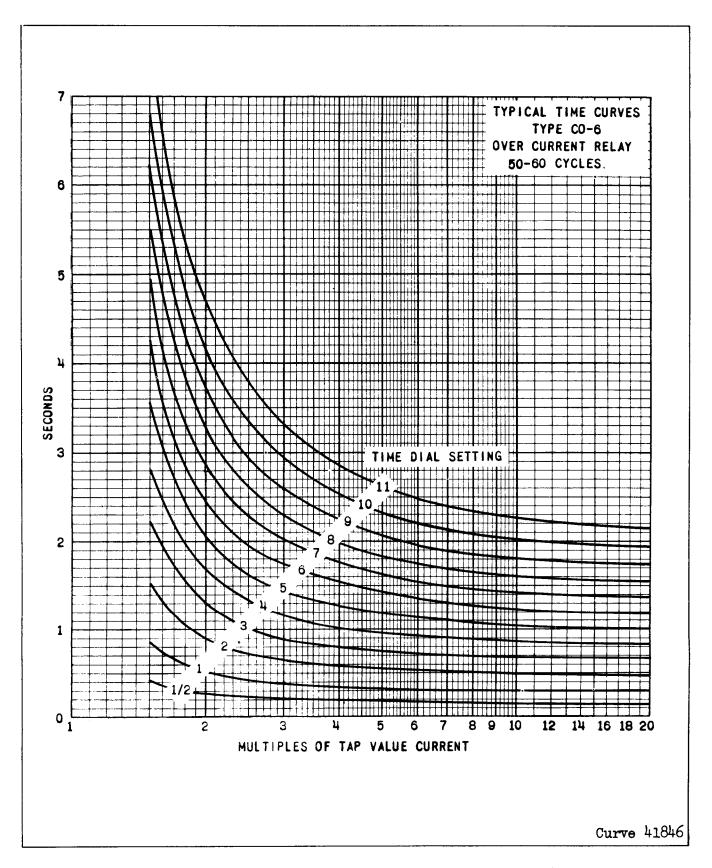


Fig. 12. Typical Time Curve of the Time-Overcurrent Unit of the Definite Time (6) Relays.

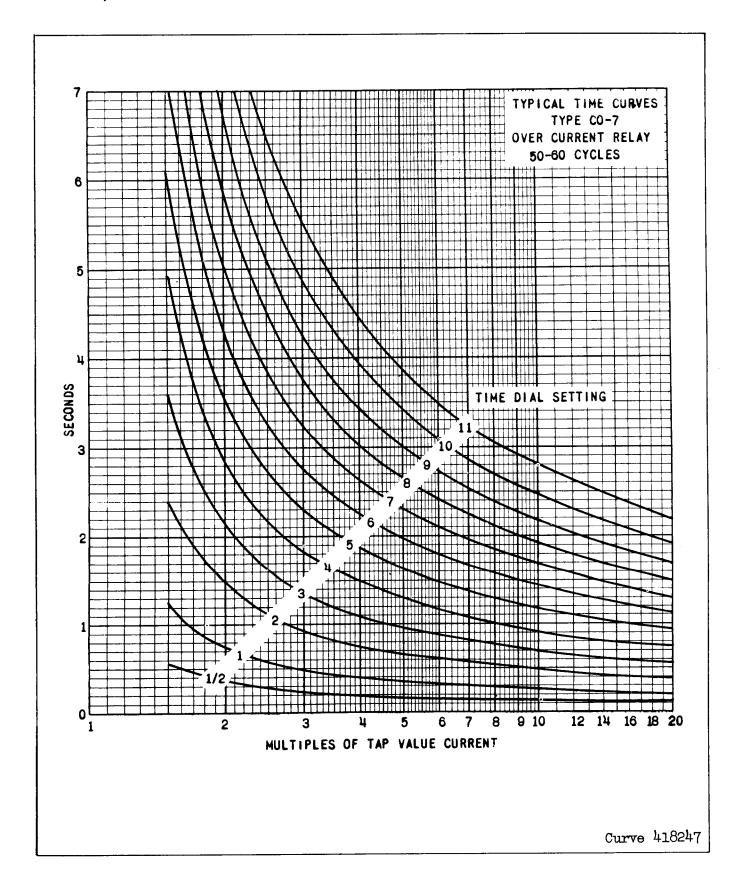


Fig. 13. Typical Time Curve of the Time-Overcurrent Unit of the Moderately Inverse (7) Relays.

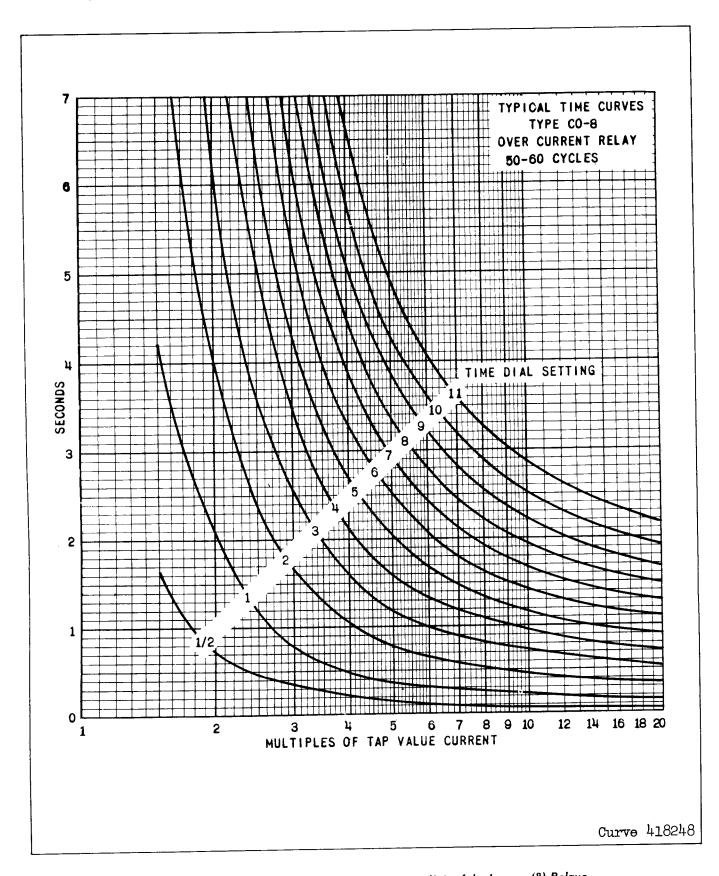


Fig. 14. Typical Time Curve of the Time-Overcurrent Unit of the Inverse (8) Relays.

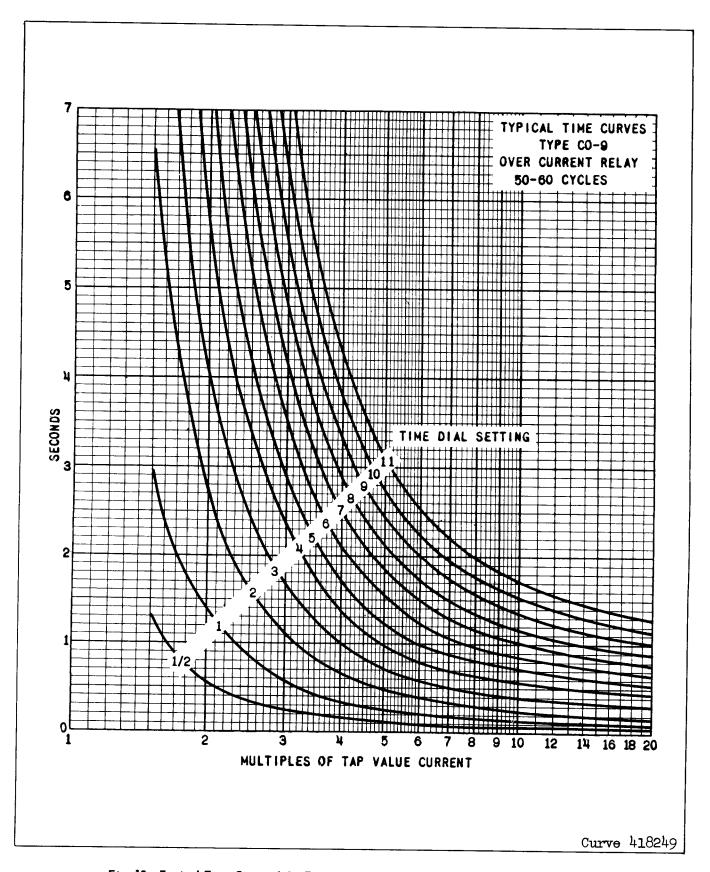


Fig. 15. Typical Time Curve of the Time-Overcurrent Unit of the Very Inverse (9) Relays.

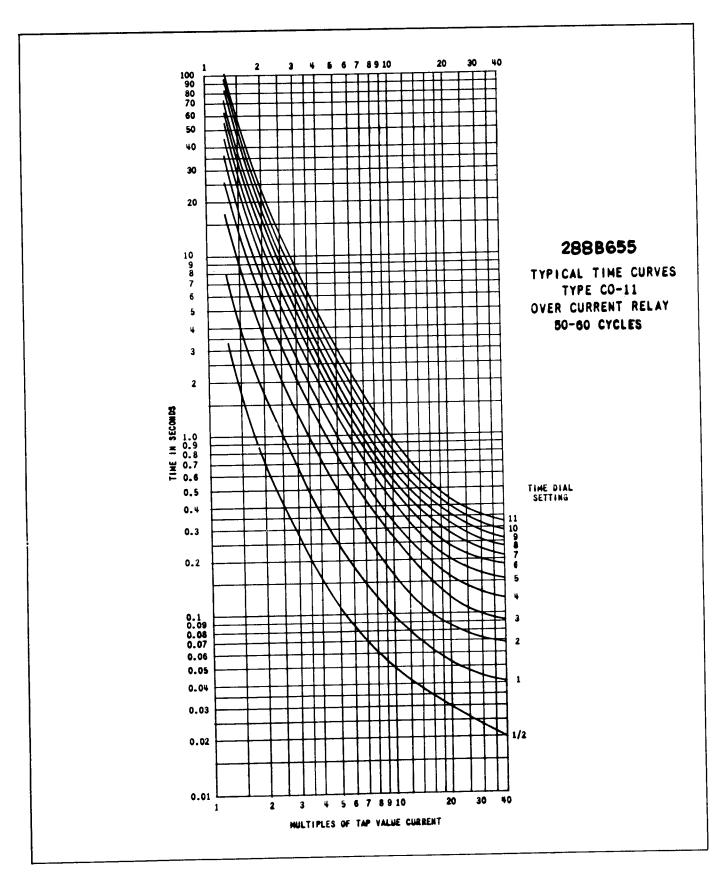


Fig. 16. Typical Time Curve of the Time-Overcurrent Unit of the Extremely Inverse (11) Relays.

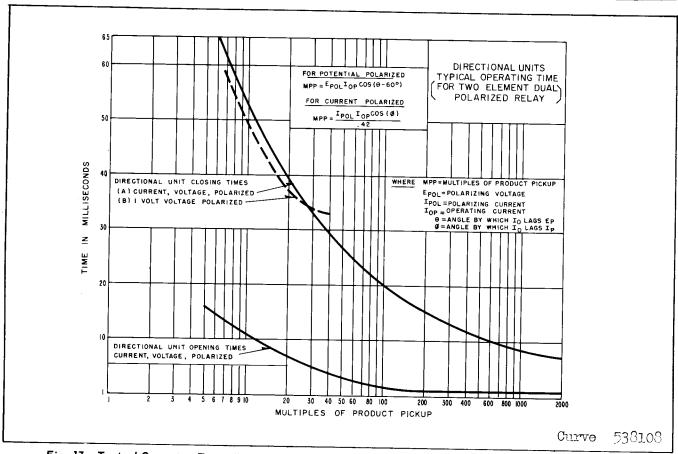
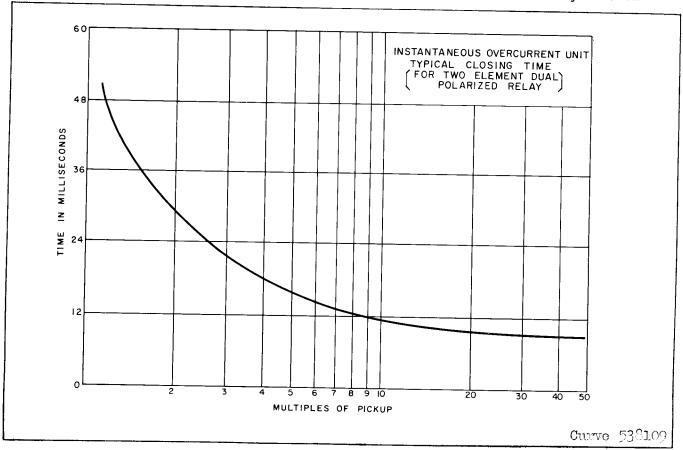


Fig. 17. Typical Operating Times For The Instantaneous Circuit When Directional Unit is Voltage Polarized.



## **Trip Circuit Constants**

Indicating Contactor Switch -

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

#### Auxiliary Switch (CS-1)

The auxiliary switch has a d-c resistance of 1165 ohms.

## Type IRP Relay

The IRP 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 pick-up is approximately 1 volt and 2 amperes at its maximum torque angle for the directional units used with the 0.5 to 2.5 and 2 to 6 ampere range time over-current units. For the directional units used with the 4-12 ampere range time overcurrent units the minimum pick-up is 1 volt and 4 amperes.

#### Type IRC Relay

The IRC relay is designed for current polarization and has its maximum torque when the operating current leads the polarizing current by approximately  $40^{\circ}$ .

The directional unit minimum pick-up is 0.5 ampere in each winding at the maximum torque angle for the directional units used with the 0.5 to 2.5 and 2 to 6 ampere range time overcurrent units. For the directional units used with the 4-12 ampere range time overcurrent units the minimum pickup is 1 ampere.

## Type IRD Relay

The type IRD relay utilizes a directional unit similar to the IRC relay in conjunction with the directional unit and phase-shifting circuit of the IRP relay.

The current-polarized directional unit of the IRD relay operates on residual currents while the potential-polarized directional unit of the IRD relay operates on residual voltage and residual current.

For the directional units used with the 0.5 to 2 and 2 to 6 ampere time overcurrent units, the minimum pick-up of the current polarized unit is 0.5 ampere in each winding at the maximum torque angle. The minimum pick-up for the voltage polarized unit is

1 volt and 2 amperes with the current lagging voltage by  $60^{\circ}$ .

For the directional units used with the 4 to 12 ampere range time overcurrent units, the minimum pick-up is 1 ampere for the current-polarized directional unit and 1 volt and 4 amperes for the voltage-polarized directional unit.

## SETTINGS

### Time Overcurrent Unit (CO)

The time overcurrent unit settings can be defined either by tap setting and time dial position or by tap setting and a specific time of operation at some current multiple of the tap setting (e.g. 4 tap setting, 2 time dial position or 4 tap setting, 0.6 seconds at 6 times tap value current).

To provide selective circuit breaker operation, a minimum coordinating time of 0.3 seconds plus circuit breaker time is recommended between the relay being set and the relays with which coordination is to be effected.

The connector screws on the tap plate above the time dial makes connections to various turns on the operating coil. By placing this screw in the various tap plate holes, the relay will just close its contacts at the corresponding current 4-5-6-7-8-10-12 amperes, or as marked on the tap plate.

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, connext the spare connector screw in the desired position before removing the other tap screw from the original tap position.

## Instantaneous Reclosing

The factory adjustment of the CO unit contacts provides a contact follow. Where circuit breaker reclosing will be intiated immediately after a trip by the CO contact, the time of the opening of the contacts should be a minimum. This condition is obtained by loosening the stationary contact mounting screw, removing the contact plate and then replacing the plate with the bent end resting against the contact spring. With this change and the contact mounting screw tightened, the stationary contact will rest solidly against its backstop.

## Instantaneous Overcurrent Unit (1)

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.

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.

## Directional Units (D)

No setting is required.

#### Indicating Contactor Switch (ICS/I and ICS/T)

The setting required on the ICS units is the selection of the 0.2 or 2.0 ampere tap setting. This selection is made by connecting the lead located in front of the tap block to the desired setting by means of the connecting screw.

## Auxiliary Switch (CS-1)

No setting required on the CS-1 unit except for the selection of the required 24, 48, 125 or 250 voltage on the tapped rexistor. This connection can be made by referring to Fig. 23.

## 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 be means of the two mounting studs for the type FT projection case or by means of the four mounting holes on the flange for the semi-flush type FT case. 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 detail information on the FT Case refer to I.L. 41-076.

The external a-c connections of the directional overcurrent relays are shown in Figs. 20, 21 and 22. If no voltage polarizing source is to be connected to the IRD relay, short-circuit the voltage polarizing circuit at the terminals of the relay.

## 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;

## Instantaneous 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. <u>Minimum Trip Current</u> 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 within  $\pm 5\%$  of tap value current.

## Directional Unit (D)

- 1. Contact Gap The gap between the stationary contact and moving contact with the relay in the deenergized position should be approximately .020".
- 2. <u>Sensitivity</u> The respective directional units should trip with value of energization and phase angle relationship 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 with the polarizing circuits short circuited for the voltage polarized units and open-circuited for the current polarized units.

## Time Overcurrent Unit (CO)

- 1. Contacts The index mark on the movement frame will coincide with the "O" mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "O" mark by approximately .020". The placement of the various time dial positions in line with the index mark will give operating times as shown on the respective time-current curves.
- 2. <u>Minimum Trip Current</u> Set the time dial to position 6 with the auxiliary switch (CS-1) contacts

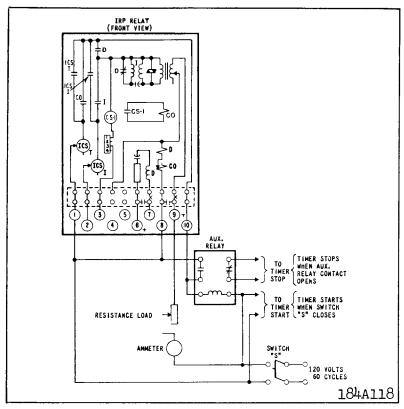


Fig. 19. Diagram of test connections of the time-overcurrent unit.

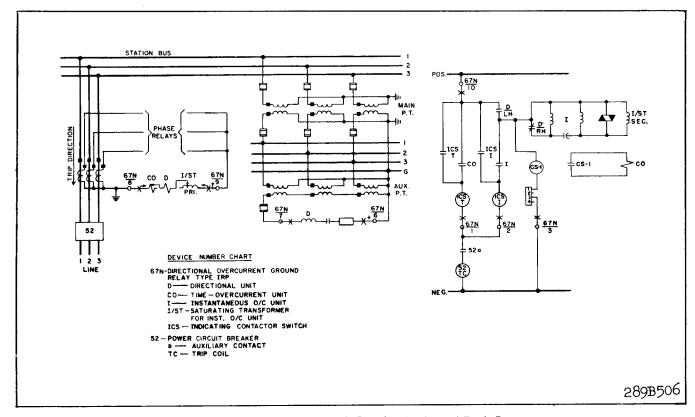


Fig. 20. External Schematic of the IRP Relay for Ground Fault Protection.

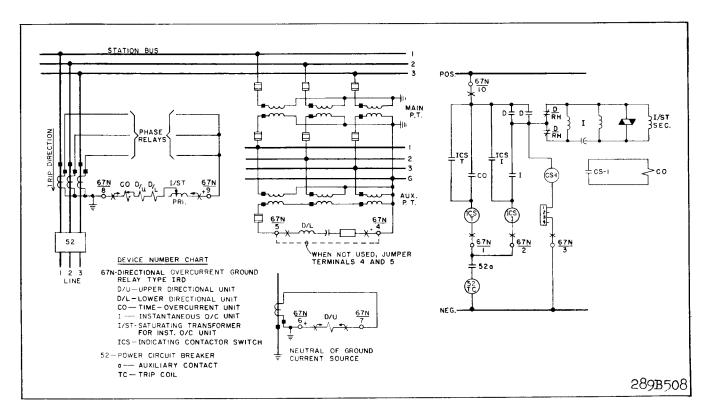


Fig. 21. External Schematic of the IRD Relay for Ground Fault Protection.

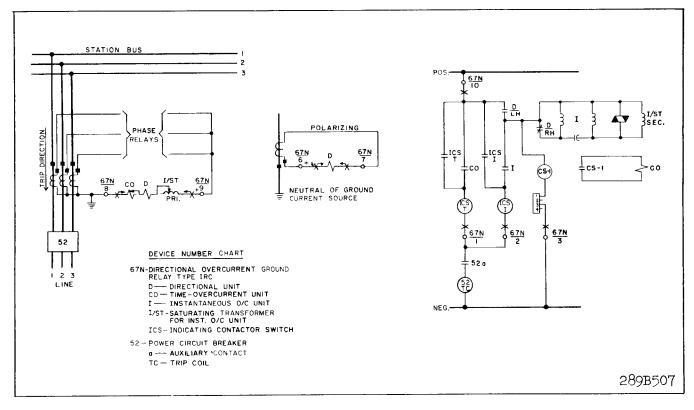


Fig. 22. External Schematic of the IRC Relay for Ground Fault Protection.

blocked closed, alternately apply tap value current plus 3% and tap value current minus 3%. The moving contact should leave the backstop at tap value current plus 3% and should return to the backstop at tap value current minus 3%.

3. <u>Time Curve</u> — Table 3 shows the time curve calibration points for the various types of relays. With the time dial set to the indicated position, apply the currents specified by Table 3 (e.g. for the CO-2, 3 and 20 times tap value current) and measure the operating time of the relay. The operating times should equal those of Table 3 plus or minus 5 percent.

### Indicating Contactor Switches (ICS/I) and (ICS/T)

- A) Close the contacts of the CO and pass sufficient d.c. current through the trip circuit to close the contacts of (ICS/T). This value of current should not be greater than the particular (ICS/T) tap setting being used. The operation indicator target should drop freely, bringing the letter "T" into view.
- B) Close the contacts of the instantaneous overcurrent unit (I) and the directional unit (D). Pass sufficient d.c. current through the trip circuit to close the contacts of (ICS/I). This value of current should not be greater than the particular (ICS/I) tap setting being used. The operation indicator target should drop freely, bringing the letter "I" into view.
- C) The contact gap should be approximately .047" 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 time of 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. The use of phantom loads, in testing induction-type relays, should be avoided, since the resulting distorted current wave form will produce an error in timing.

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

### Calibration

Use the following procedure for calibrating the

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

#### Instantaneous Overcurrent Unit (1)

- 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, i.e., against the right side of the bridge. Move 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 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  $\pm 5\%$  of tap value.

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.

## Directional Unit (D)

In the type IRP and IRC relays the directional unit is the lower cylinder unit. In the type IRD the directional units are the lower and middle cylinder 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 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 as indicated by a neon lamp in the contact circuit when energized with the required current and voltage as shown in Table 1. 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 (IRP and IRD voltage polarized unit) are short-circuited,
- b) The polarizing circuits of the current polarized relays (IRC and IRD 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 some installations in order to insure that the relay will always trip the breaker on zero potential.

#### Time Overcurrent Unit (CO)

- 1. Contacts The index mark on the movement frame will coincide with the "O" mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "O" mark by approximately .020". The placement of the various time dial positions in line with the index mark will give operating times as shown on the respective time-current curves.
- 2) <u>Minimum Trip Current</u> The adjustment of the spring tension in setting the minimum trip current value of the relay is most conveniently made with the damping magnet removed.

With the time dial set on "O", wind up the spiral spring by means of the spring adjuster until approximately 6-3/4 convolutions show.

Set the relay on the minimum tap setting, the time dial to position 6.

With the auxiliary switch (CS-1) contacts blocked closed, adjust the control spring tension so that the moving contact will leave the backstop at tap value current +1.0% and will return to the backstop at tap value current -1.0%.

3) <u>Time Curve Calibration</u> — Install the permanent magnet.

Apply the indicated current per Table 3 for permanent magnet adjustment (e.g. IRP-8, 2 times tap value) and measure the operating time. Adjust the permanent magnet keeper until the operating time corresponds to the value of Table 3.

Apply the indicated current per Table 3 for the electromagnet plug adjustment (e.g. IRP-8, 20 times tap value) and measure the operating time. Adjust the proper plug until the operating time corresponds to the value in Table 3. (Withdrawing the left hand plug, front view increases the operating time and withdrawing the right hand plug, front view, decreases the time.) In adjusting the plugs, one plug should be

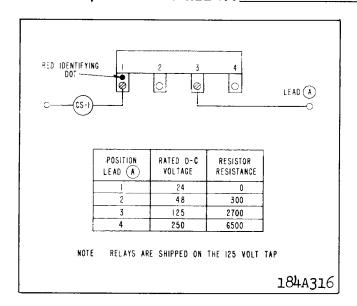


Fig. 23. Selection of Proper Voltage Tap for Auxiliary Switch (CS-1) Operation.

screwed in completely and the other plug run in or out until the proper operating time has been obtained.

Recheck the permanent magnet adjustment. If the operating time for this calibration point has changed, readjust the permanent magnet and then recheck the electromagnet plug adjustment.

## Indicating Contactor Switches (ICS/I) and (ICS/T)

Adjust the contact gap for approximately .047".

A) Close the contacts of the CO and pass sufficient d.c. current through the trip circuit to close the contacts of the (ICS/T). This value of current should not be greater than the particular (ICS/T) tap setting being used. The operation indicator target should drop freely bringing the letter "T" into view.

B) Close contacts of instantaneous overcurrent unit (I) and directional unit (D). Pass sufficient d.c. current through the trip circuit to close contacts of the (ICS/I). This value of current should not be greater than the particular (ICS/I) tap setting being used. The operation indicator target should drop freely bringing the letter "I" into view.

#### Auxiliary Switch (CS-1)

Adjust the stationary core of the switch for a clearance between the stationary core and the moving core when the switch is picked up. This can be done by turning the relay upside-down. Then screw up the core screw until the moving core starts rotating. Now back off the core screw until the moving core stops rotating. This indicates the points where the play in the assembly is taken up, and where the moving core just separates from the stationary core screw. Back off the core screw approximately one turn and lock in place. This prevents the moving core from striking and sticking to the stationary core because of residual magnetism. Adjust the contact clearance for 3/64" by means of the two small nuts on either side of the Micarta disc.

Connect lead (A) to proper terminal per Fig. 23. Block directional unit (D) contacts close and energize trip circuit with rated voltage. Contacts of auxiliary switch (CS-1) should make as indicated by a neon lamp in the contact circuit.

#### 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.

TABLE | DIRECTIONAL UNIT SENSITIVITY

	DIKE	CITONAL UNIT	SENSITIVITI		
RELAY TYPE	AMPERE RATING OF	VALUES FOR	R MIN. PICKUP †	PHASE ANGLE RELATIONSHIP	
	TIME-OVERCURRENT UNIT	VOLTS AMPERES			
	.5-2.5	1	2.0	I lagging V by 60°††	
IRP IRD (Voltage	2-6	1	4.0	I in-phas⇔ with V	
Unit)	4.40	1	4.0	I lagging V by 60° ††	
	4-12	1	8.0	I in-phase with V	
	E 9 E		0.5	Ioleading Ip by 40°††	
IRC IRD (Current $\triangle$	.5-2.5 2-6		* .57	In-phase	
Unit)	4-12		1.0	${ m I_O}$ leading ${ m I_D}$ by $40^\circ$ ††	
			1.3	In-phase	

<sup>†</sup> The energization quantities are input quantities at the relay terminals.

<sup>††</sup> Maximum torque angle.

<sup>\*</sup> A When normal system conditions limit the current to less than twice pickup, performance may be improved by sellecting a higher current C.T. tap to energize the polarizing circuit.

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) (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.

<sup>†</sup> Short circuit the voltage polarizing circuit at the relay terminals before making the above adjustment.

TABLE III

TIME CURVE CALIBRATION DATA - 60 CYCLES

	PERMANENT	ELECTROMAGNET PLUGS			
TIME- OVERCURRENT UNIT TYPE	TIME DIAL POSITION	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS
2	6	3	0.57	20	0.22
5	6	2	37.80	10	14.30
6	6	2	2.46	20	1.19
7	6	2	4.27	20	1.11
8	6	2	13.35	20	1.11
9	6	2	8.87	20	0.65
11	6	2	11.27	20	0.24

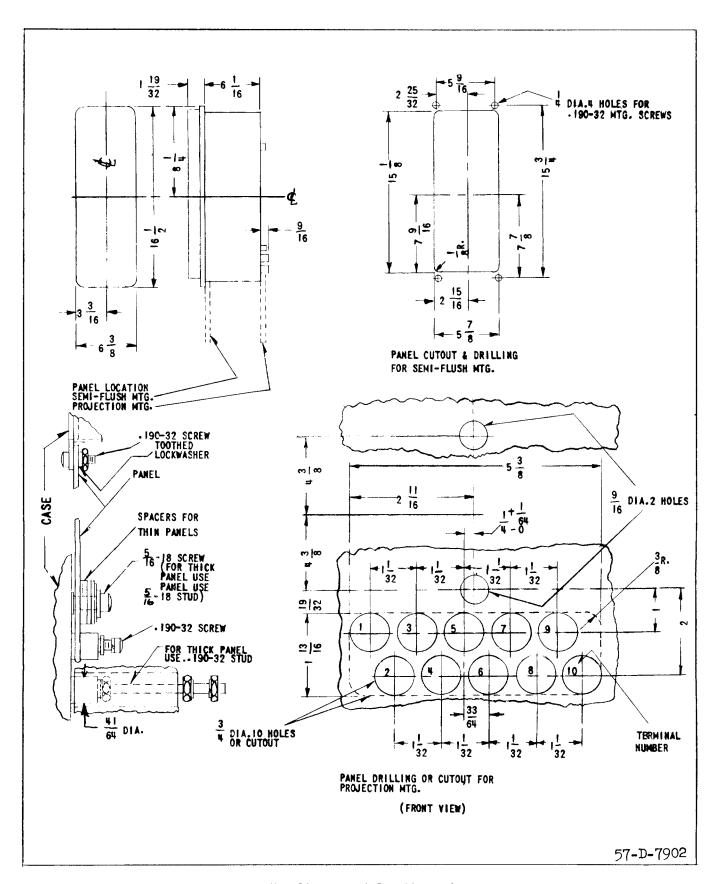


Fig. 24. Outline and Drilling Plan for the IRP and IRC Relays in the Type FT31 Case.

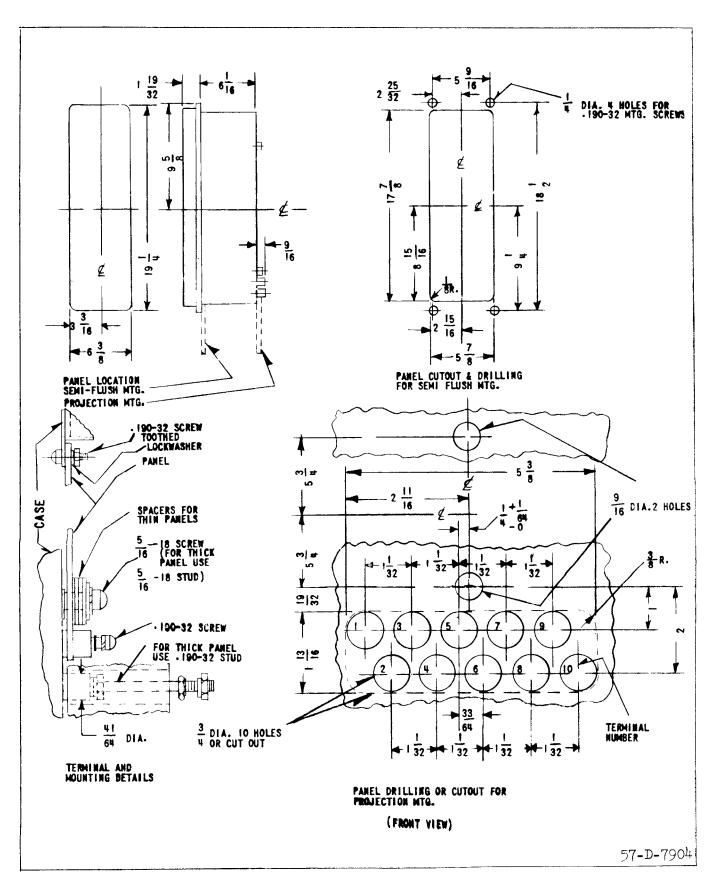


Fig. 25. Outline and Drilling Plan for the IRD Relay in the Type FT41 Case.





# INSTALLATION . OPERATION . MAINTENANCE

# INSTRUCTIONS

# DIRECTIONAL OVERCURRENT GROUND RELAYS TYPES IRP, IRC AND IRD

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

These relays are ground directional overcurrent relays which are used for the protection of transmission lines and feeder circuits. Both the time-overcurrent and instantaneous overcurrent units are directionally controlled.

The type IRP relay is potential polarized. The type IRC relay is current polarized. The type IRD relay is a dual polarized relay which can be polarized from a potential source, from a local ground source or from both simultaneously.

### CONSTRUCTION AND OPERATION

The various types of relays consist of a directional unit or units (D), an auxiliary switch (CS-1), a time-overcurrent unit (CO), an instantaneous overcurrent unit (I), an instantaneous overcurrent unit transformer, and two indicating contactor switches (ICS/I) and (ICS/T). The principle component parts of the relays and their location are shown in Fig. 1 through 6.

#### Time-Overcurrent Unit (CO)

The electromagnets for the types IR-5, IR-6, IR-7, IR-8 and IR-9 relays have a main tapped coil located on the center leg of an "E" type laminated structure that produces a flux which divides and returns through the outer legs. A shading coil causes the flux through the left leg to lag the main pole flux. The out-of-phase fluxes thus produced in the air gap cause a contact closing torque.

The electromagnet for the type IR-2 and IR-11 relays has a main coil consisting of a tapped primary winding a secondary winding. Two identical coils

on the outer legs of the lamination structure are connected to the main coil secondary in a manner so that the combination of all the fluxes produced by the electromagnet result in out-of-phase fluxes in the air gap. The out-of-phase air gap fluxes produced cause a contact closing torque.

### Indicating Contactor Switch Units (ICS/I and ICS/T)

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

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

#### 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 the magnetic core. The magnetic core which houses the lower pin bearing is secured to the 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

ENERGY REQUIREMENTS

INSTANTANEOUS OVERCURRENT UNIT OPERATING CURRENT CIRCUIT - 60 CYCLES

AMPERE RANGE	TAP	VA AT TAP VALUE	P.F. ANGLE	VA AT 5 AMPS.	P.F. ANGLE	
	.5	.37	39	24	46	
	.75	.38	36	13	37	
5.0	1	.39	35	8.5	34	
.5-2	1.25	.41	34	6.0	32	
	1.5	.43	32	4.6	31	
	2	.45	30	2.9	28	
	1	.41	36	9.0	36	
	1.5	.44	32	5.0	32	
1-4	2	.47	30	3.0	29	
	2.5	.50	28	2.1	27	
	3	.53	26	1.5	26	
	4	.59	24	0.93	24	
	2	1.1	49	6.5	48	
	3	1.2	43	3.3	42	
2-8	4	1.3	38	2.1	37	
20	5	1.4	35	1.4	35	
	6	1.5	33	1.1	33	
	8	1.8	29	0.7	29	
	4	1.5	51	2.4	51	
	6	1.7	45	1.2	45	
4-16	8	1.8	40	0.7	40	
	9	1.9	38	0.6	38	
	12	2.2	34	0.37	34	
	16	2.5	30	0.24	31	
	10	1.7	28	0.43	28	
	15	2.4	21	0.27	21	
10-40	20	3.1	16	0.20	17	
10 10	24	3.6	15	0.15	15	
	30	4.2	12	0.11	13	
	40	4.9	11	0.08	12	
	20	6.6	31	0.40	31	
	30	9.3	24	0.25	24	
20-80	40	12	20	0.18	20	
	48	13.5	18	0.14	18	
	60 80	15.9 19.2	16 15	0.10 0.07	16 15	
RANGE		CONTINUOUS RATIN	1G	ONE SECOND RA		
		(AMPERES)		† (AMPERES		
. 5-2		5		100		
1-4		8		140		
2-8		8		140		
4-16		10		200		
10-40	10			200		
20-80		10		200		

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

φ Degrees current lags voltage.

<sup>† †</sup> Voltages taken with Rectox type voltmeter.

## IRD INSTANTANEOUS OVERCURRENT UNIT BURDEN DATA AT HIGH CURRENTS

Ampere Range						10	-40					
Tap Value Current	10			20			40					
Multiples of Tap Value Current	22	4	6	8	1	2	3	4	.5	1	1.5	2.0
VA 77	9	36.8	84	156	5	26	57	104	4.8	19.2	44.4	78.8
P.F. Angle $\phi$	18.7°	18.3 °	17.5°	15.7°	9.3°	8.5°	8.8°	9.0°	$4.5^{\circ}$	4.5 °	4.5 °	4.8 °

# ENERGY REQUIREMENTS - 60 CYCLES DIRECTIONAL UNIT OPERATING CIRCUIT BURDEN

						VO	LT AMPERES	††
Relay Type	Range Amps	Continuous Rating (Amperes)	One Second Rating † (Amperes)	Power Factor Angle $\phi$	At Minimum Tap Value Current	At 3 Times Minimum Tap Value Current	At 10 Times Minimum Tap Value Current	At 20 Times Minimum Tap Value Current
IRC	0.5-2.5	-	230	44.0	0.033	0.30	3.3	14.2
	2-6	-	230	42.5	0.58	5.28	58.0	240.0
	4-12	12	280	31.8	0.64	6.12	70.0	272.0
IRP	0.5-2.5	10	230	34.5	0.03	0.23	2.8	11.5
	2-6	10	230	34.5	0.44	4.08	48.0	182.0
	4-12	12	280	25.0	0.48	4.62	53.6	216.0
IRD	0.5-2.5	10	230	45.0	0.07	0.59	6.6	26.0
	2-6	10	230	45.0	1.04	9.9	106.0	420.0
	4-12	12	280	32.4	1.16	10.8	121.2	472.0

<sup>\$\</sup>phi\$ Degrees current lags voltage at tap value current.

# ENERGY REQUIREMENTS - 60 CYCLES DIRECTIONAL UNIT POLARIZING CIRCUIT BURDEN

RELAY TYPE	RATING	VOLT AMPERES △	POWER FACTOR ANGLE $\phi$
IRC	230 Amperes †	1.45	8° Lag
IRP	208 Volts ††	11.2	28° Lead
KRD Current Unit	230 Amperes ††	1.45	8° Lag
IRD Voltage Unit	208 Volts ††	11.2	28 ° Lead

 $<sup>\</sup>phi$  Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

<sup>††</sup> Voltages taken with Rectox type voltmeter.

 $<sup>\</sup>triangle \ Burden \ of \ voltage \ polarized \ units \ taken \ at \ 120 \ volts. Burden \ of \ current \ polarized \ units \ taken \ at \ 5 \ amperes.$ 

<sup>†</sup> One second rating.

<sup>†† 30</sup> second rating. The 10 second rating is 345 volts. The continuous rating is 120 volts.

#### **ENERGY REQUIREMENTS**

#### TYPE IRD-2, IRC-2, IRP-2 TIME OVERCURRENT UNITS

						VOLT A	AMPERES † †	
		CONTINUOUS	ONE SECOND	POWER	ΑT	AT 3 TIMES	AT 10 TIMES	AT 20 TIMES
AMPERE		RATING	RATING †	FACTOR	TAP VALUE	TAP VALUE	TAP VALUE	TAP VALUE
RANGE	TAP	(AMPERES)	(AMPERES)	$\underline{\text{ANGLE }\phi}$	CURRENT	CURRENT	CURRENT	CURRENT
	0.5	0.91	28	58	4.8	39.6	256	790
	0.6	0.96	28	57	4.9	39.8	270	851
	0.8	1.18	28	53	5.0	42.7	308	1024
0.5/2.5	1.0	1.37	28	50	5.3	45.4	348	1220
	1.5	1.95	28	40	6.2	54.4	435	1740
	2.0	2.24	28	36	7.2	65.4	580	2280
	2.5	2.50	28	29	7.9	73.6	700	2850
	2.0	3.1	110	59	5.04	38.7	262	800
	2.5	4.0	110	55	5.13	39.8	280	920
	3.0	4.4	110	51	5.37	42.8	312	1008
2/6	3.5	4.8	110	47	5.53	42.8	329	1120
	4.0	5.2	110	45	5.72	46.0	360	1216
	5.0	5.6	110	41	5.90	50.3	420	1500
	6.0	6.0	110	37	6.54	54.9	474	1800
	4.0	7.3	230	65	4.92	39.1	268	848
	5.0	8.0	230	50	5.20	42.0	305	1020
	6.0	8.8	230	47	5.34	44.1	330	1128
4/12	7.0	9.6	230	46	5.53	45.8	364	1260
	8.0	10.4	230	43	5.86	49.9	400	1408
	10.0	11.2	230	37	6.6	55.5	470	1720
	12.0	12.0	230	34	7.00	62.3	528	2064

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

φ Degrees current lags voltage at tap value current.

<sup>††</sup> Voltages taken with Rectox type voltmeter.

#### **ENERGY REQUIREMENTS**

IRD-5, IRC-5, IRP-5, TIME OVERCURRENT UNITS

						VOLT A	MPERES   1	
AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING† (AMPERES)	POWER FACTOR ANGLE $\phi$	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
0.5/2.5	(0.5 (0.6 (0.8 (1.0 (1.5 (2.0 (2.5	2 2.2 2.5 2.8 3.4 4.0	88 88 88 88 88 88	69 68 67 66 62 60 58	3.92 3.96 3.96 4.07 4.19 4.30 4.37	20.6 20.7 21 21.4 23.2 24.9 26.2	103 106 114 122 147 168 180	270 288 325 360 462 548 630
2/6	(2 (2.5 (3 (3.5 (4 (5 (6	8 8.8 9.7 10.4 11.2 12.5 13.7	230 230 230 230 230 230 230 230	67 66 64 63 62 59 57	3.88 3.90 3.93 4.09 4.12 4.20 4.38	21 21.6 22.1 23.1 23.5 24.8 26.5	110 118 126 136 144 162 183	308 342 381 417 448 540 624
4/12	(4 (5 (6 (7 (8 (10 (12	16 18.8 19.3 20.8 22.5 25	460 460 460 460 460 460	65 63 61 59 56 53 47	4.00 4.15 4.32 4.35 4.40 4.60 4.92	22.4 23.7 25.3 26.4 27.8 30.1 35.6	126 143 162 183 204 247 288	376 450 531 611 699 880 1056

### IRD-7, IRC-7, IRP-7 TIME OVERCURRENT UNITS

					VOLT AMPERES††				
AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING <sup>†</sup> (AMPERES)	POWER FACTOR ANGLE $\phi$	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT	
	(0.5	2	88	68	3.88	20.7	103	278	
	(0.6	2.2	88	67	3.93	20.9	107	288	
	(0.8	2.5	88	66	3.93	21.1	114	320	
0.5/2.5	(1.0	2.8	88	64	4.00	21.6	122	35 <b>6</b>	
0.0, 2.0	(1.5	3.4	88	61	4.08	22.9	148	459	
	(2.0	4.0	88	58	4.24	24.8	174	552	
	(2.5	4.4	88	56	4.38	25.9	185	640	
	(2	8	230	66	4.06	21.3	111	306	
	(2.5	8.8	230	63	4.07	21.8	120	342	
	(3	9.7	230	63	4.14	22.5	129	366	
2/6	(3.5	10.4	230	62	4.34	23.4	141	413	
_, -	(4	11.2	230	61	4.34	23.8	149	448	
	(5	12.5	230	59	4.40	25.2	163	530	
	(6	13.7	230	58	4.62	27	183	624	
	(4	16	460	64	4.24	22.8	129	392	
	(5	18.8	460	61	4.30	24.2	149	460	
4/12	(6	19.3	460	60	4.62	25.9	168	540	
7/12	(7	20.8	460	58	4.69	27.3	187	626	
	(8	22.5	460	55	4.80	29.8	211	688	
	(10	25	460	51	5.20	33	260	860	
	(12	28	460	46	5.40	37.5	308	1032	

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

φ Degrees current lags voltage at tap value current.

<sup>††</sup> Voltages taken with Rectox type voltmeter.

#### **ENERGY REQUIREMENTS**

IRD-8, IRC-8, IRP-8, TIME OVERCURRENT UNITS IRD-9, IRC-9, IRP-9,

				-	VOLT AMPERES ††						
Ampere Range	Тар	Continuous Rating (Amperes)	One Second Rating † (Amperes)	Power Factor Angle $\phi$	At Tap Value Current	At 3 Times Tap Value Current	At 10 Times Tap Value Current	At 20 Times Tap Value Current			
0.5/2.5	(0.5 (0.6 (0.8 (1.0 (1.5 (2.0	2 2.2 2.5 2.8 3.4 4.0	88 88 88 88 88	72 71 69 67 62 57	2.38 2.38 2.40 2.42 2.51 2.65	21 21 21.1 21.2 22 23.5	132 134 142 150 170 200	350 365 400 440 530 675			
2/6	(2.5 (2 (2.5 (3 (3.5 (4 (5 (6	4.4 8 8.8 9.7 10.4 11.2 12.5 13.7	88 230 230 230 230 230 230 230 230	53 70 66 64 62 60 58 56	2.74 2.38 2.40 2.42 2.48 2.53 2.64 2.75	24.8 21 21.1 21.5 22 22.7 24 25.2	228 136 142 149 157 164 180 198	800 360 395 430 470 500 580 660			
4/12	(4 (5 (6 (7 (8 (10 (12	16 18.8 19.3 20.8 22.5 25 28	460 460 460 460 460 460 460	68 63 60 57 54 48 45	2.38 2.46 2.54 2.62 2.73 3.00 3.46	21.3 21.8 22.6 23.6 24.8 27.8 31.4	146 158 172 190 207 248 292	420 480 550 620 700 850 1020			

IRD-11, IRC-11, IRP-11 OVERCURRENT UNITS

				11,110	VOLT AMPERES ††					
Ampere Range	Тар	Continuous Rating (Amperes)	One Second Rating † (Amperes)	Power Factor Angle $\phi$	At Tap Value Current	At 3 Times Tap Value Current	At 10 Times Tap Value Current	At 20 Times Tap Value Current		
0.5/2.5	0.5 0.6 0.8 1.0 1.5 2.0 2.5	1.7 1.9 2.2 2.5 3.0 3.5 3.8	56 56 56 56 56 56	36 34 30 27 22 17 16	0.72 0.75 0.81 0.89 1.13 1.30 1.48	6.54 6.80 7.46 8.30 10.04 11.95 13.95	71.8 75.0 84.0 93.1 115.5 136.3 160.0	250 267 298 330 411 502 610		
2/6	2.0 2.5 3.0 3.5 4.0 5.0 6.0	7.0 7.8 8.3 9.0 10.0 11.0 12.0	230 230 230 230 230 230 230 230	32 30 27 24 23 20 20	0.73 0.78 0.83 0.88 0.96 1.07 1.23	$\begin{array}{c} 6.30 \\ 7.00 \\ 7.74 \\ 8.20 \\ 9.12 \\ 9.80 \\ 11.34 \end{array}$	74.0 78.5 84.0 89.0 102.0 109.0 129.0	264 285 309 340 372 430 504		
4/12	4.0 5.0 6.0 7.0 8.0 10.0 12.0	14 16 17 18 20 22 26	460 460 460 460 460 460 460	29 25 22 20 18 17 16	0.79 0.89 1.02 1.10 1.23 1.32 1.8	7.08 8.00 9.18 10.00 11.1 14.9 16.3	78.4 90.0 101.4 110.0 124.8 131.6 180.0	296 340 378 454 480 600 720		

### IRD TIME OVERCURRENT UNIT BURDEN DATA AT HIGH CURRENTS

Ampere Range	.5-2.5								
Tap Value Current	.5	5	1.0		2.5				
Multiples of Tap Value Current	40	80	20	40	8	16			
VA ††	790	2600	380	1280	60	280			
P.F. Angle $\phi$	46.7°	42 °	37 °	26.5 °	4.8 °	4.3 °			

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

<sup>\$\</sup>phi Degrees current lags voltage at tap value current.

<sup>††</sup>Voltages taken with Rectox type voltmeter.

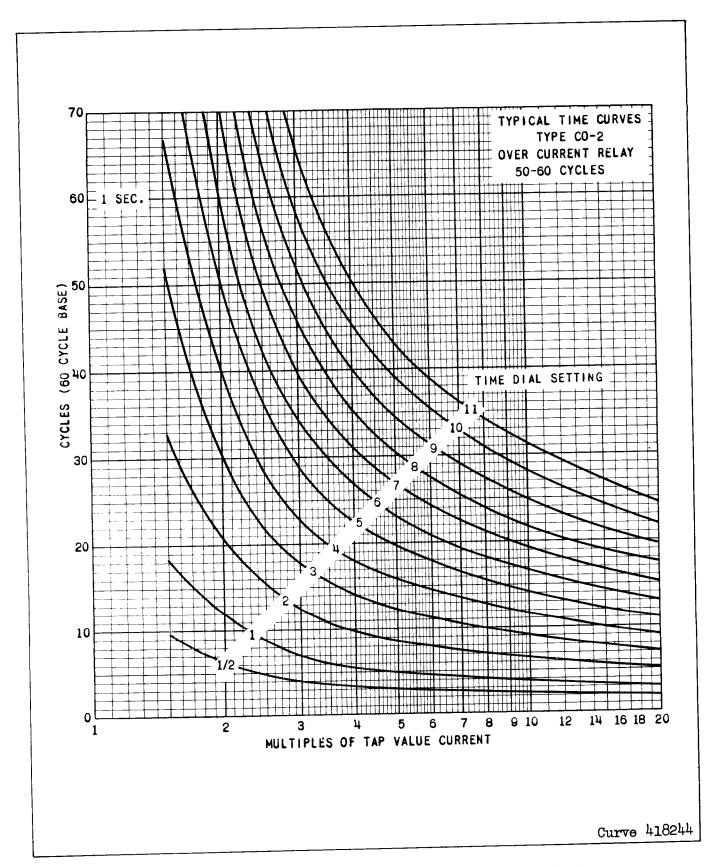


Fig. 10. Typical Time Curves of the Time-Overcurrent Unit of the Short Time (2) Relays.

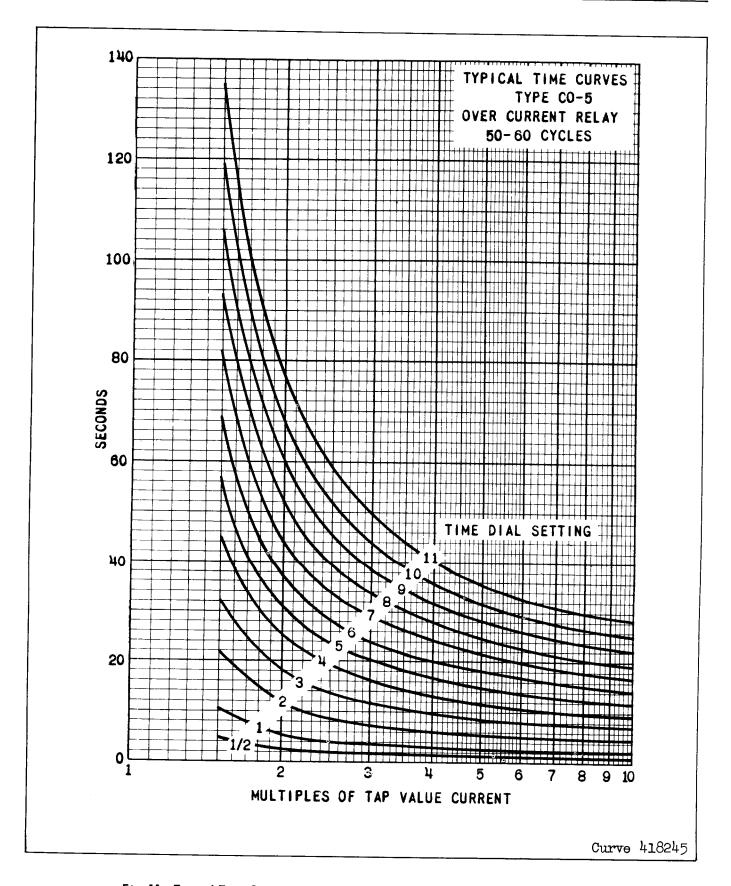


Fig. 11. Typical Time Curve of the Time-Overcurrent Unit of the Long Time (5) Relays.

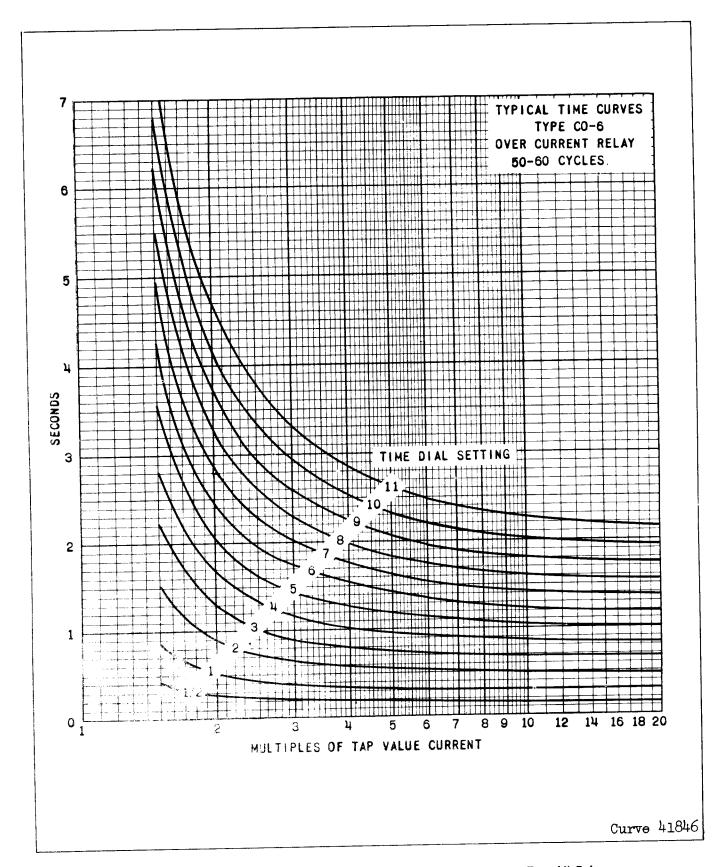


Fig. 12. Typical Time Curve of the Time-Overcurrent Unit of the Definite Time (6) Relays.

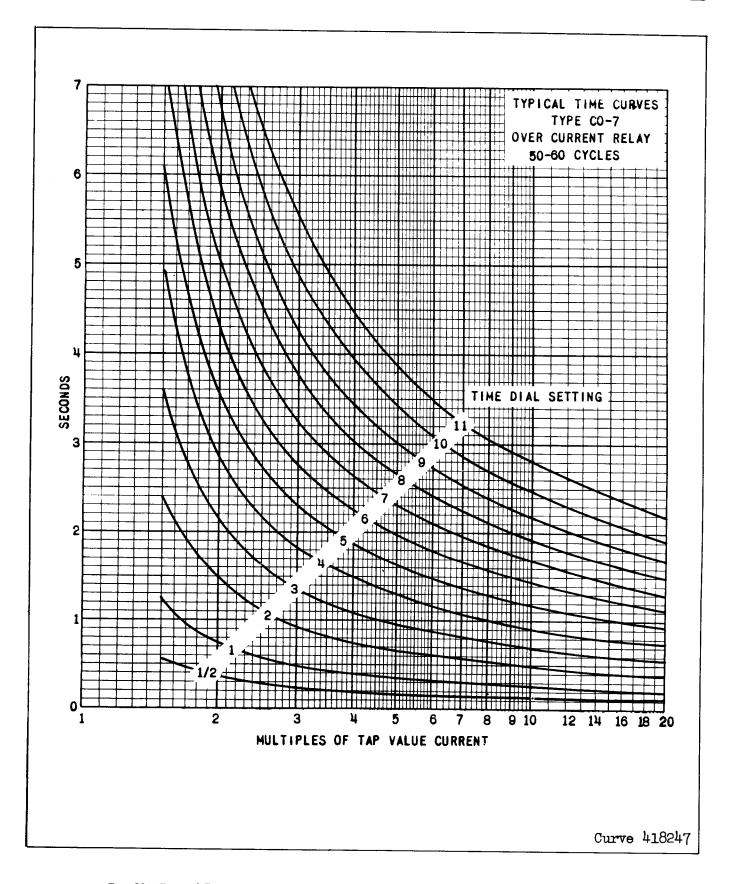


Fig. 13. Typical Time Curve of the Time-Overcurrent Unit of the Moderately Inverse (7) Relays.

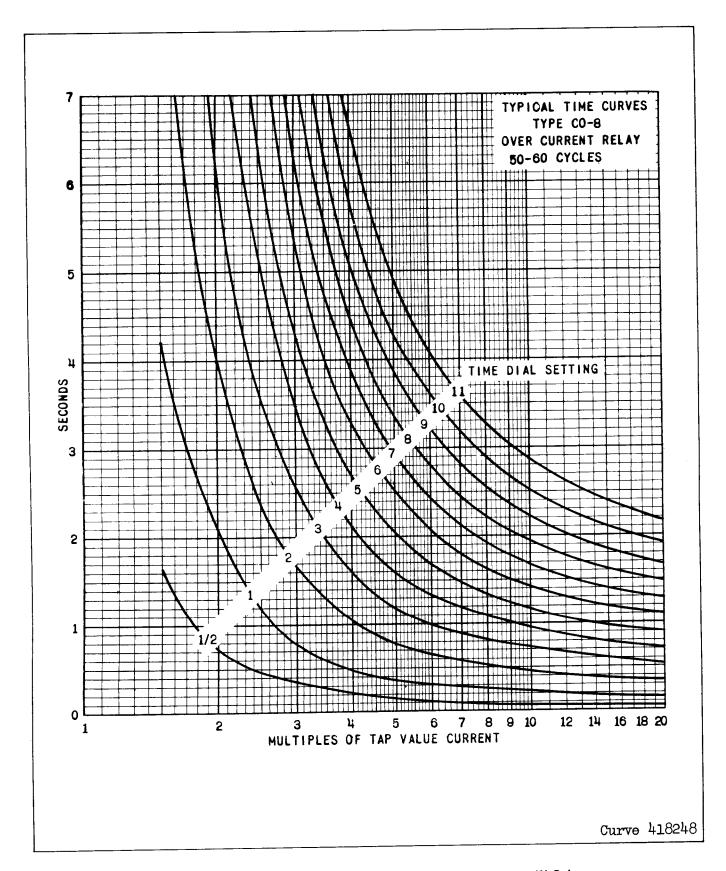


Fig. 14. Typical Time Curve of the Time-Overcurrent Unit of the Inverse (8) Relays.

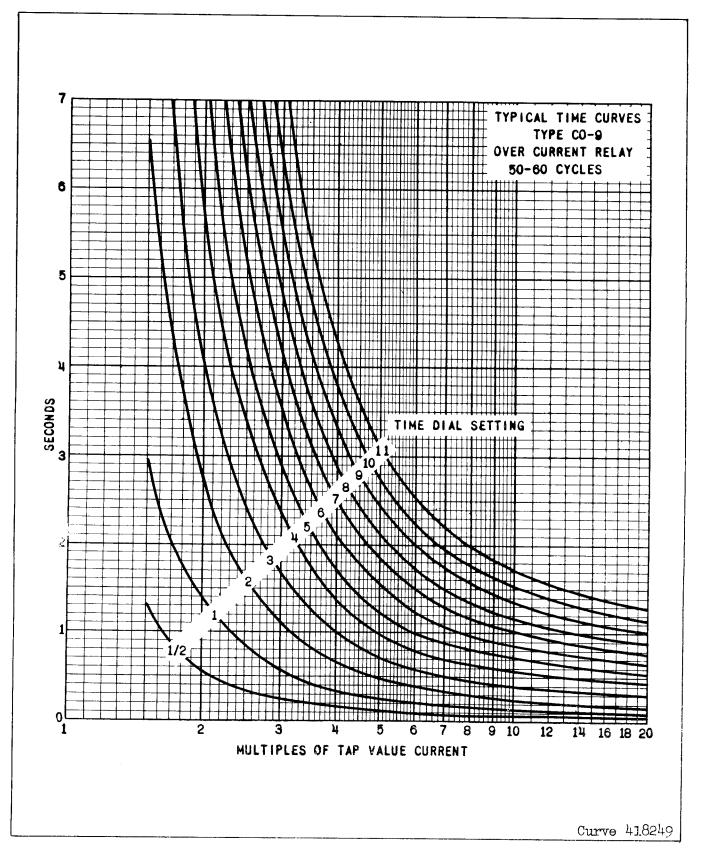


Fig. 15. Typical Time Curve of the Time-Overcurrent Unit of the Very Inverse (9) Relays.

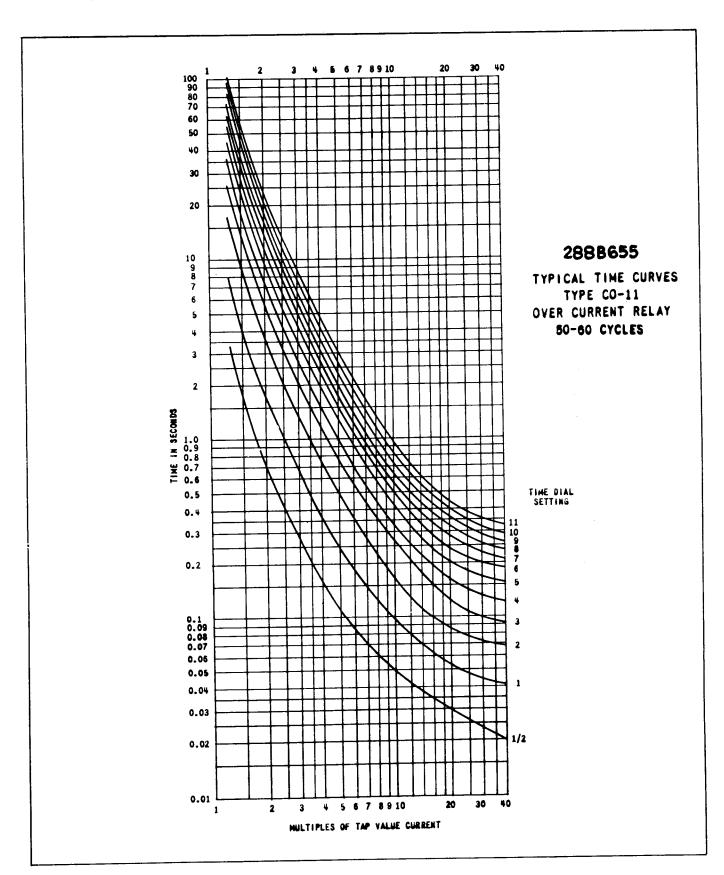
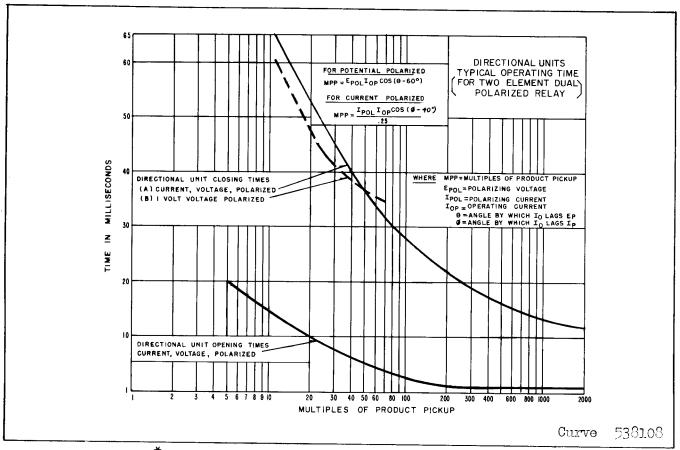
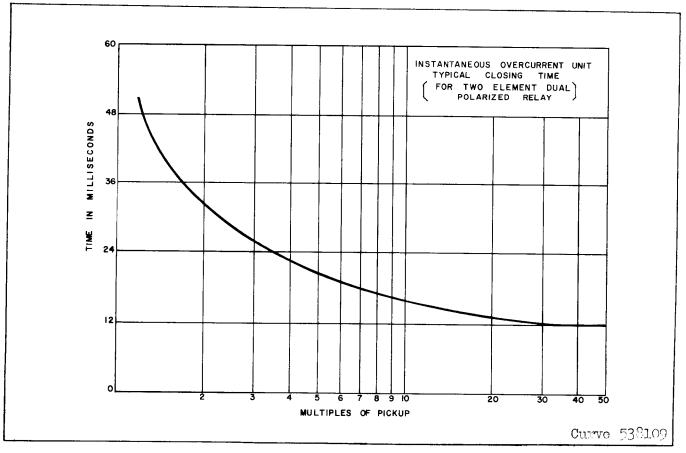


Fig. 16. Typical Time Curve of the Time-Overcurrent Unit of the Extremely Inverse (11) Relays.



\* Fig. 17. Typical Operating Times For The Directional Unit.



\* Fig. 18. Typical Operating Times For The Instantaneous Overcurrent Unit.

#### Trip Circuit Constants

Indicating Contactor Switch -

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

#### Auxiliary Switch (CS-1)

The auxiliary switch has a d-c resistance of 1165 ohms.

#### Type IRP Relay

The IRP 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 pick-up is approximately 1 volt and 2 amperes at its maximum torque angle for the directional units used with the 0.5 to 2.5 and 2 to 6 ampere range time over-current units. For the directional units used with the 4-12 ampere range time overcurrent units the minimum pick-up is 1 volt and 4 amperes.

#### Type IRC Relay

The IRC relay is designed for current polarization and has its maximum torque when the operating current leads the polarizing current by approximately  $40^{\circ}$ .

The directional unit minimum pick-up is 0.5 ampere in each winding at the maximum torque angle for the directional units used with the 0.5 to 2.5 and 2 to 6 ampere range time overcurrent units. For the directional units used with the 4-12 ampere range time overcurrent units the minimum pickup is 1 ampere.

#### Type IRD Relay

The type IRD relay utilizes a directional unit similar to the IRC relay in conjunction with the directional unit and phase-shifting circuit of the IRP relay.

The current-polarized directional unit of the IRD relay operates on residual currents while the potential-polarized directional unit of the IRD relay operates on residual voltage and residual current.

For the directional units used with the 0.5 to 2 and 2 to 6 ampere time overcurrent units, the minimum pick-up of the current polarized unit is 0.5 ampere in each winding at the maximum torque angle. The minimum pick-up for the voltage polarized unit is

1 volt and 2 amperes with the current lagging voltage by  $60^{\circ}$ .

For the directional units used with the 4 to 12 ampere range time overcurrent units, the minimum pick-up is 1 ampere for the current-polarized directional unit and 1 volt and 4 amperes for the voltage-polarized directional unit.

#### SETTINGS

#### Time Overcurrent Unit (CO)

The time overcurrent unit settings can be defined either by tap setting and time dial position or by tap setting and a specific time of operation at some current multiple of the tap setting (e.g. 4 tap setting, 2 time dial position or 4 tap setting, 0.6 seconds at 6 times tap value current).

To provide selective circuit breaker operation, a minimum coordinating time of 0.3 seconds plus circuit breaker time is recommended between the relay being set and the relays with which coordination is to be effected.

The connector screws on the tap plate above the time dial makes connections to various turns on the operating coil. By placing this screw in the various tap plate holes, the relay will just close its contacts at the corresponding current 4-5-6-7-8-10-12 amperes, or as marked on the tap plate.

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, connext the spare connector screw in the desired position before removing the other tap screw from the original tap position.

#### Instantaneous Reclosing

The factory adjustment of the CO unit contacts provides a contact follow. Where circuit breaker reclosing will be intiated immediately after a trip by the CO contact, the time of the opening of the contacts should be a minimum. This condition is obtained by loosening the stationary contact mounting screw, removing the contact plate and then replacing the plate with the bent end resting against the contact spring. With this change and the contact mounting screw tightened, the stationary contact will rest solidly against its backstop.

#### Instantaneous Overcurrent Unit (1)

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.

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.

#### Directional Units (D)

No setting is required.

#### Indicating Contactor Switch (ICS/I and ICS/T)

The setting required on the ICS units is the selection of the 0.2 or 2.0 ampere tap setting. This selection is made by connecting the lead located in front of the tap block to the desired setting by means of the connecting screw.

#### Auxiliary Switch (CS-1)

No setting required on the CS-1 unit except for the selection of the required 24, 48, 125 or 250 voltage on the tapped rexistor. This connection can be made by referring to Fig. 23.

#### INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, motoure, excessive vibration and heat. Mount the relay vertically be means of the two mounting studs for the type FT projection case or by means of the four mounting holes on the flange for the semi-flush type FT case. 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 detail information on the FT Case refer to I.L. 41-076.

The external a-c connections of the directional overcurrent relays are shown in Figs. 20, 21 and 22. If no voltage polarizing source is to be connected to the IRD relay, short-circuit the voltage polarizing circuit at the terminals of the relay.

#### 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;

#### Instantaneous Overcurrent Unit (1)

- 1. Contact Gap The gap between the stationary and moving contacts with the relay in the de-energized position should be approximately .020".
- 2. <u>Minimum Trip Current</u> 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 within  $\pm 5\%$  of tap value current.

#### Directional Unit (D)

- 1. Contact Gap The gap between the stationary contact and moving contact with the relay in the deenergized position should be approximately .020".
- 2. <u>Sensitivity</u> The respective directional units should trip with value of energization and phase angle relationship 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 with the polarizing circuits short circuited for the voltage polarized units and open-circuited for the current polarized units.

#### Time Overcurrent Unit (CO)

- 1. Contacts The index mark on the movement frame will coincide with the "O" mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "O" mark by approximately .020". The placement of the various time dial positions in line with the index mark will give operating times as shown on the respective time-current curves.
- 2. <u>Minimum Trip Current</u> Set the time dial to position 6 with the auxiliary switch (CS-1) contacts

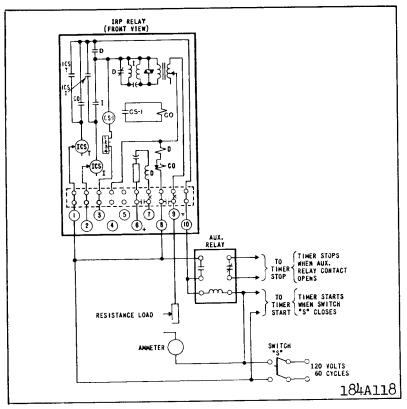


Fig. 19. Diagram of test connections of the time-overcurrent unit.

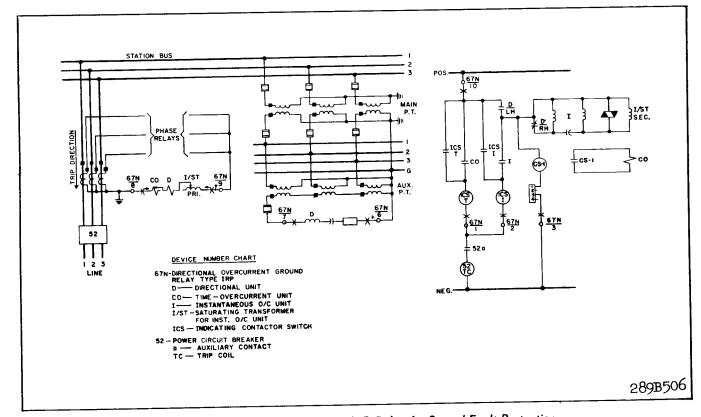


Fig. 20. External Schematic of the IRP Relay for Ground Fault Protection.

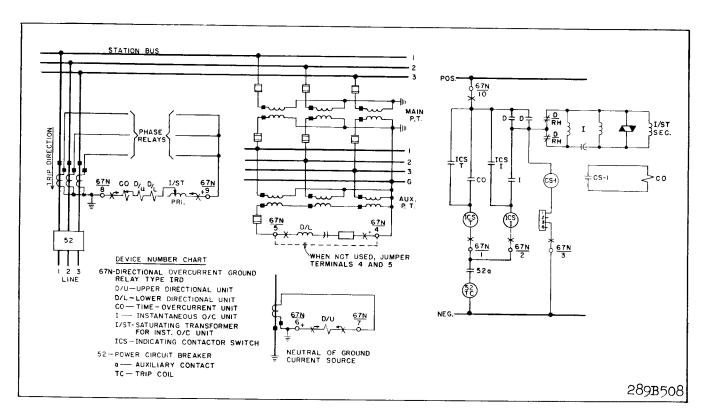


Fig. 21. External Schematic of the IRD Relay for Ground Fault Protection.

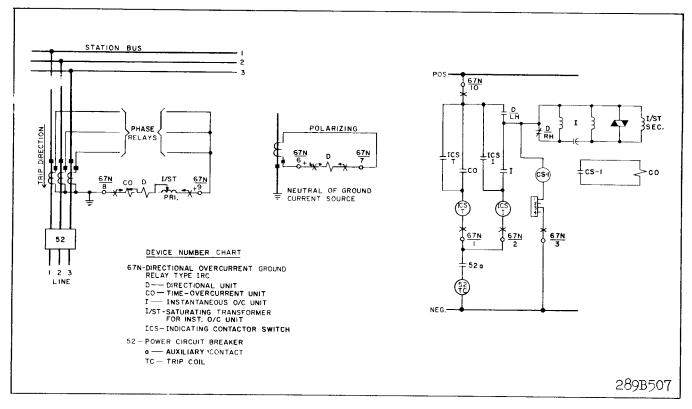


Fig. 22. External Schematic of the IRC Relay for Ground Fault Protection.

blocked closed, alternately apply tap value current plus 3% and tap value current minus 3%. The moving contact should leave the backstop at tap value current plus 3% and should return to the backstop at tap value current minus 3%.

3. <u>Time Curve</u> — Table 3 shows the time curve calibration points for the various types of relays. With the time dial set to the indicated position, apply the currents specified by Table 3 (e.g. for the CO-2, 3 and 20 times tap value current) and measure the operating time of the relay. The operating times should equal those of Table 3 plus or minus 5 percent.

#### Indicating Contactor Switches (ICS/I) and (ICS/T)

- A) Close the contacts of the CO and pass sufficient d.c. current through the trip circuit to close the contacts of (ICS/T). This value of current should not be greater than the particular (ICS/T) tap setting being used. The operation indicator target should drop freely, bringing the letter "T" into view.
- B) Close the contacts of the instantaneous overcurrent unit (I) and the directional unit (D). Pass sufficient d.c. current through the trip circuit to close the contacts of (ICS/I). This value of current should not be greater than the particular (ICS/I) tap setting being used. The operation indicator target should drop freely, bringing the letter "I" into view.
- C) The contact gap should be approximately .047" 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 time of 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. The use of phantom loads, in testing induction-type relays, should be avoided, since the resulting distorted current wave form will produce an error in timing.

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

#### Calibration

Use the following procedure for calibrating the

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

#### Instantaneous Overcurrent Unit (1)

- 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, i.e., against the right side of the bridge. Move 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 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  $\pm 5\%$  of tap value.

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.

#### Directional Unit (D)

In the type IRP and IRC relays the directional unit is the lower cylinder unit. In the type IRD the directional units are the lower and middle cylinder 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 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 as indicated by a neon lamp in the contact circuit when energized with the required current and voltage as shown in Table 1. 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 (IRP and IRD voltage polarized unit) are short-circuited.
- b) The polarizing circuits of the current polarized relays (IRC and IRD 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 some installations in order to insure that the relay will always trip the breaker on zero potential.

#### Time Overcurrent Unit (CO)

- 1. Contacts The index mark on the movement frame will coincide with the "O" mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "O" mark by approximately .020". The placement of the various time dial positions in line with the index mark will give operating times as shown on the respective time-current curves.
- 2) <u>Minimum Trip Current</u> The adjustment of the spring tension in setting the minimum trip current value of the relay is most conveniently made with the damping magnet removed.

With the time dial set on "O", wind up the spiral spring by means of the spring adjuster until approximately 6-3/4 convolutions show.

Set the relay on the minimum tap setting, the time dial to position 6.

With the auxiliary switch (CS-1) contacts blocked closed, adjust the control spring tension so that the moving contact will leave the backstop at tap value current +1.0% and will return to the backstop at tap value current -1.0%.

3) <u>Time Curve Calibration</u> — Install the permanent magnet.

Apply the indicated current per Table 3 for permanent magnet adjustment (e.g. IRP-8, 2 times tap value) and measure the operating time. Adjust the permanent magnet keeper until the operating time corresponds to the value of Table 3.

Apply the indicated current per Table 3 for the electromagnet plug adjustment (e.g. IRP-8, 20 times tap value) and measure the operating time. Adjust the proper plug until the operating time corresponds to the value in Table 3. (Withdrawing the left hand plug, front view increases the operating time and withdrawing the right hand plug, front view, decreases the time.) In adjusting the plugs, one plug should be

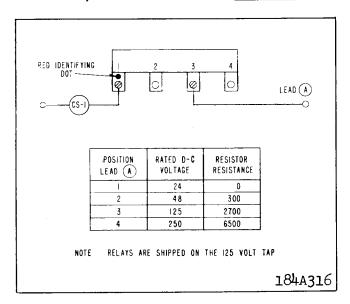


Fig. 23. Selection of Proper Voltage Tap for Auxiliary Switch (CS-1) Operation.

screwed in completely and the other plug run in or out until the proper operating time has been obtained.

Recheck the permanent magnet adjustment. If the operating time for this calibration point has changed, readjust the permanent magnet and then recheck the electromagnet plug adjustment.

#### Indicating Contactor Switches (ICS/I) and (ICS/T)

Adjust the contact gap for approximately .047".

A) Close the contacts of the CO and pass sufficient d.c. current through the trip circuit to close the contacts of the (ICS/T). This value of current should not be greater than the particular (ICS/T) tap setting being used. The operation indicator target should drop freely bringing the letter "T" into view.

B) Close contacts of instantaneous overcurrent unit (I) and directional unit (D). Pass sufficient d.c. current through the trip circuit to close contacts of the (ICS/I). This value of current should not be greater than the particular (ICS/I) tap setting being used. The operation indicator target should drop freely bringing the letter "I" into view.

#### Auxiliary Switch (CS-1)

Adjust the stationary core of the switch for a clearance between the stationary core and the moving core when the switch is picked up. This can be done by turning the relay upside-down. Then screw up the core screw until the moving core starts rotating. Now back off the core screw until the moving core stops rotating. This indicates the points where the play in the assembly is taken up, and where the moving core just separates from the stationary core screw. Back off the core screw approximately one turn and lock in place. This prevents the moving core from striking and sticking to the stationary core because of residual magnetism. Adjust the contact clearance for 3/64" by means of the two small nuts on either side of the Micarta disc.

Connect lead (A) to proper terminal per Fig. 23. Block directional unit (D) contacts close and energize trip circuit with rated voltage. Contacts of auxiliary switch (CS-1) should make as indicated by a neon lamp in the contact circuit.

#### 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.

TABLE I
DIRECTIONAL UNIT SENSITIVITY

	DIKE	CHUNAL UNIT	351131114111	
RELAY TYPE	AMPERE RATING OF	VALUES FOR	R MIN. PICKUP †	PHASE ANGLE RELATIONSHIP
	TIME-OVERCURRENT UNIT	VOLTS	AMPERES	
	.5-2.5	1	2.0	I lagging V by 60° † †
IRP	2-6	1	4.0	I in-phase with V
IRD (Voltage Unit)		1	4.0	I lagging V by 60° ††
Office	4-12	1	8.0	I in-phase with V
			0.5	$I_{O}$ leading $I_{D}$ by $40^{\circ}$ ††
$\begin{array}{c} \textbf{IRC} \\ \textbf{IRD} \; (\textbf{Current} \; \triangle \\ \textbf{Unit}) \end{array}$	.5-2.5 2-6		* .57	In-phase
	4.10		1.0	I <sub>O</sub> leading I <sub>p</sub> by 40°††
	4-12		1.3	In-phase
		L		<u> </u>

<sup>†</sup> The energization quantities are input quantities at the relay terminals.

<sup>††</sup> Maximum torque angle.

Δ When normal system conditions limit the current to less than twice pickup, performance may be improved by sellecting a higher current C.T. tap to energize the polarizing circuit.

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) (Contacts remain open)	Left (Front View) Plug Screwed Out Until Spurious Torque is in Contact Closing Direction. Then the plug is screwed in Until Spuri ous Torque is Reversed.

<sup>†</sup> Short circuit the voltage polarizing circuit at the relay terminals before making the above adjustment.

TABLE III

TIME CURVE CALIBRATION DATA - 60 CYCLES

-	PERMANENT	MAGNET ADJUSTM	MENT	ELECTROMAGN	ET PLUGS
TIME- OVERCURRENT UNIT TYPE	TIME DIAL POSITION	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS
2	6	3	0.57	20	0.22
5	6	2	37.80	10	14.30
6	6	2	2.46	20	1.19
7	6	2	4.27	20	1.11
8	6	2	13.35	20	1.11
9	6	2	8.87	20	0.65
11	6	2	11.27	20	0.24

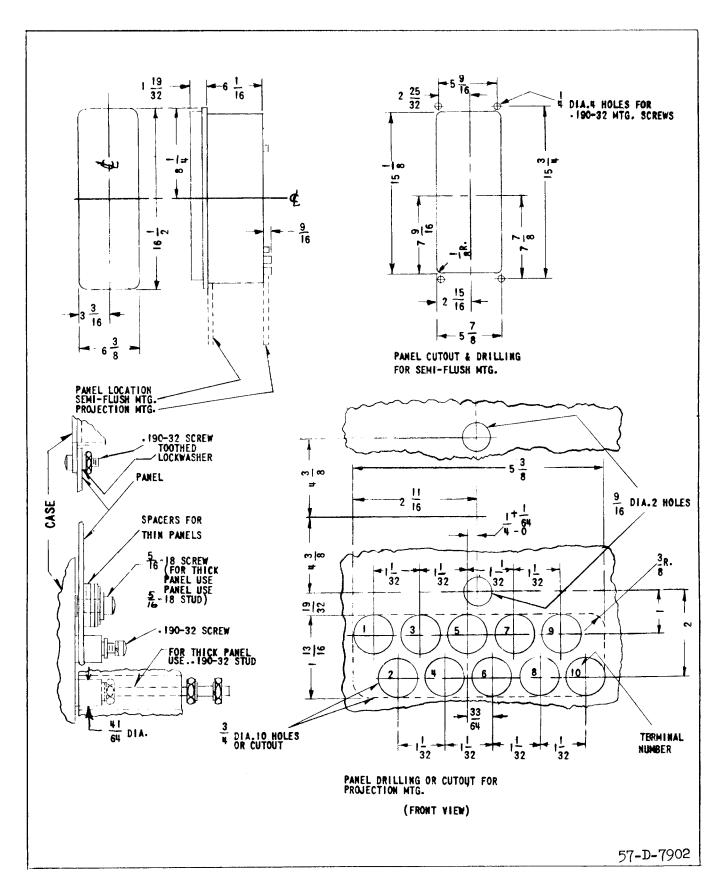


Fig. 24. Outline and Drilling Plan for the IRP and IRC Relays in the Type FT31 Case.

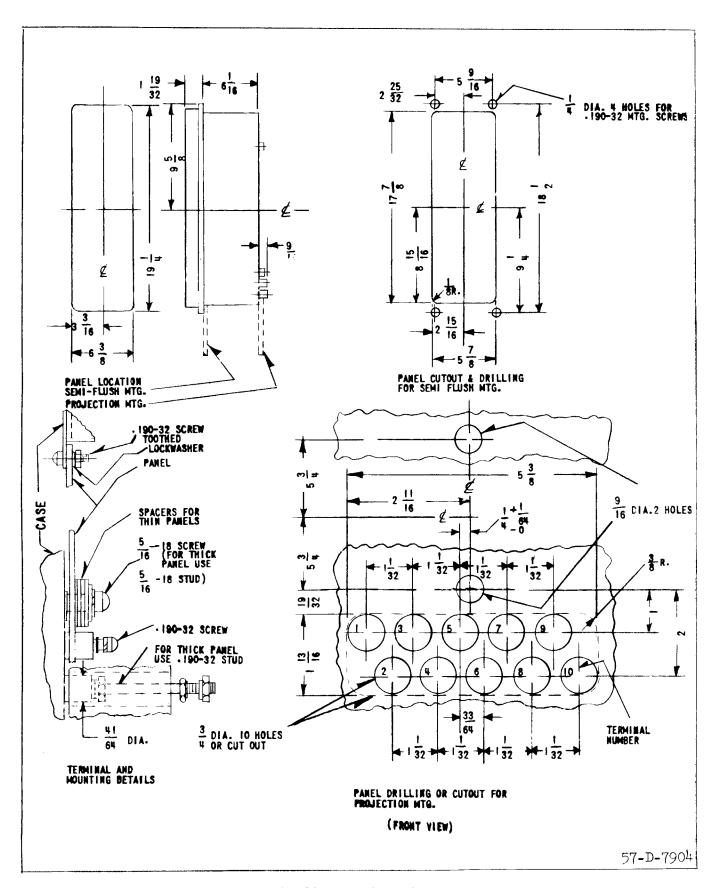


Fig. 25. Outline and Drilling Plan for the IRD Relay in the Type FT41 Case.

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 $\mathbf{x}_{i}(\mathbf{x}_{i}) = \mathbf{r}_{i}^{(i)}$ 

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WESTINGHOUSE ELECTRIC CORPORATION RELAY-INSTRUMENT DIVISION NEWARK, N. J.



# INSTALLATION . OPERATION . MAINTENANCE

# INSTRUCTIONS

# DIRECTIONAL OVERCURRENT GROUND RELAYS TYPES IRP, IRC AND IRD

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

These relays are ground directional overcurrent relays which are used for the protection of transmission lines and feeder circuits. Both the time-overcurrent and instantaneous overcurrent units are directionally controlled.

The type IRP relay is potential polarized. The type IRC relay is current polarized. The type IRD relay is a dual polarized relay which can be polarized from a potential source, from a local ground source or from both simultaneously.

# CONSTRUCTION AND OPERATION

The various types of relays consist of a directional unit or units (D), an auxiliary switch (CS-1), a time-overcurrent unit (CO), an instantaneous overcurrent unit (I), an instantaneous overcurrent unit transformer, and two indicating contactor switches (ICS/I) and (ICS/T). The principle component parts of the relays and their location are shown in Fig. 1 through 6.

### Time-Overcurrent Unit (CO)

The electromagnets for the types IR-5, IR-6, IR-7, IR-8 and IR-9 relays have a main tapped coil located on the center leg of an "E" type laminated structure that produces a flux which divides and returns through the outer legs. A shading coil causes the flux through the left leg to lag the main pole flux. The out-of-phase fluxes thus produced in the air gap cause a contact closing torque.

The electromagnet for the type IR-2 and IR-11 relays has a main coil consisting of a tapped primary winding a secondary winding. Two identical coils

on the outer legs of the lamination structure are connected to the main coil secondary in a manner so that the combination of all the fluxes produced by the electromagnet result in out-of-phase fluxes in the air gap. The out-of-phase air gap fluxes produced cause a contact closing torque.

## Indicating Contactor Switch Units (ICS/I and ICS/T)

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

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

#### 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 the magnetic core. The magnetic core which houses the lower pin bearing is secured to the 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

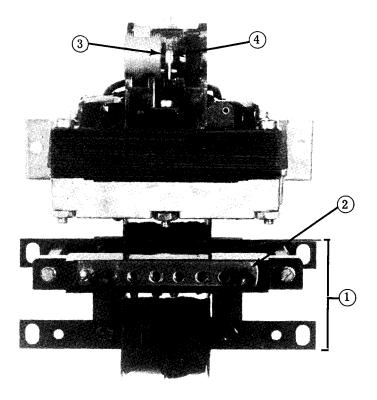


Fig. 5. Instantaneous Overcurrent Unit. 1 — Saturating Transformer. 2 — Tap Block. 3 — Stationary Contact. 4 — Moving Contact.

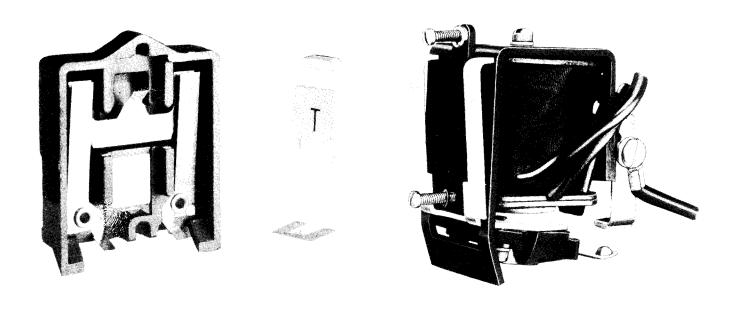


Fig. 6. Indicating Contactor Switch (ICS).

accurately position the lower pin bearing, which is mounted on the frame, with respect to the upper 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 rotating in an 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.

#### Auxiliary Switch (CS-1)

The auxiliary switch is a small solenoid type d.c. switch. A cylindrical plunger, with a silver disc mounted on its lower end, moves in the core of the solenoid. As the plunger travels upward, the disc bridges the silver stationary contacts. A tapped resistor is used to enable one to use the contactor switch on a 24, 48, 125 or 250 volt d.c. system connected per Fig. 23. The operation of the CS-1 switch is controlled by the directional unit (D) which in turn directionally controls the time-overcurrent unit (CO). When sufficient power flows in the tripping direction, the CS-1 switch operates and bridges the lag coil of the time-overcurrent unit (CO) permitting this unit to operate.

#### Instantaneous Overcurrent Unit (I)

The instantaneous 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 instantaneous overcurrent unit as shown in the internal schematics. This arrangement short-circuits the operating current around the pole windings; pre-

venting the instantaneous overcurrent unit from developing torque. If the directional unit should pick up for a fault, this short-circuit is removed, allowing the instantaneous overcurrent contact to commence closing almost simultaneously with the directional contact for high speed operation. Total operating time is shown in Figs. 17 and 18.

#### Instantaneous Overcurrent Unit Transformer

This transformer is of the saturating type for limiting the energy to the instantaneous overcurrent unit at higher values of fault current and to reduce C.T. burden. The primary winding is tapped and these taps are brought out to a tap block for ease in changing the pick-up of the instantaneous 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.

#### CHARACTERISTICS

The time characteristics of the directional overcurrent relays are designated by specific numbers as indicated below (e.g., IRV-8).

Time			
Characteristics	Designation		
Short Time	2		
Long Time	5		
Definite Time	6		
Moderately Inverse Time	7		
Inverse Time	8		
Very Inverse Time	9		
Extremely Inverse Time	11		

The relays are available in the following current ranges:

#### Instantaneous Overcurrent Unit (I)

Range			T	aps		
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
20-80	20	30	40	48	60	80

Time Overcurrent Unit

Range			Taps				
.5-2.5	0.5	0.6	0.8	1.0	1.5	2.0	2.5
2-6	2	2.5	3	3.5	4	5	6
4-12	4	5	6	7	8	10	12

The tap value is the minimum current required to just close the relay contacts.

The time vs. current characteristics for the timeovercurrent unit are shown in Figs. 10 to 16. These characteristics give the contact closing time for the various time dial settings when the indicated multiples of tap value current are applied to the relay.

#### TIME CURVES

The time curves for the IRD relay are shown in Fig. 17 and 18. Fig. 17 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.

Fig. 18 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 Fig. 18 plus the directional unit opening time given in Fig. 17. The total closing time for the directional unit is given in Fig. 17. The two examples below will serve to illustrate the use of the curves.

\* Example 1: Using the formulas and definition of symbols on Fig. 17, we have—

Let: Ipol = 2 amps.  
Iop = 2.31  
Tap Value (T) = 0.5 amp.  

$$\phi = 0^{\circ}$$
  
(For timing unit, assume  
CO-9 with ½ time dial setting)

For current polarized relay:

$$MPP = \frac{Iop Ipol Cos \phi}{0.25}$$

$$MPP = \frac{(2.31)(2) = 18.5}{0.25}$$

Referring to Fig. 17 at multiples of produce pickup of 18.5,the directional unit operating time is about 11 ms, and the closing time for this unit is 56 ms.

For overcurrent unit:

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

Entering the curve in Fig. 18 at multiples of pickup equal to 4.6, the closing time for instantaneous overcurrent is 16 ms. However, the total operating time for the overcurrent unit is 16 plus 11, which is the opening time of back contacts of the directional unit, or 27 ms total operating time for overcurrent unit. The total time for directional unit is 56 ms; and, since this is the longest time, 56 ms is the total operating time of the instantaneous overcurrent circuit.

Entering the curve in Fig. 15 at 4.6, the  $\frac{1}{2}$  time dial setting gives 140 ms. The total time for the time-overcurrent circuit is 56 ms directional unit time plus 16 ms CS-1 time plus 140 ms = 212 ms.

#### \* Example 2:

Let: Ipol = 20 amps.  
Iop = 23.1 amps  

$$T(tap) = 1$$
 amp.  
 $\phi = 0$   
MPP = Iop Ipol Cos  $\phi$   
0.25  
MPP = (20) (23.1) = 1850

Entering Fig. 17, the directional unit closing time is 12 ms, and the opening time of its back contacts is 1 ms. The total operating time for the directional unit is 13 ms.

For overcurrent unit:

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

Referring to Fig. 18, the overcurrent unit contact closing time is about 14 ms. Therefore, the total operating time for this unit is 14 plus 1 or 15 ms. In this case the total operating time of relay is 15 ms.

Fig. 15 gives an operating time of about 50 ms. The time-overcurrent circuit is 12 plus 16 ms CS-1 time plus 50 = 78 ms.

#### Trip Circuit

The relay contacts will safely close 30 amperes at 250 volts d.c and the seal-in contacts of the indicating contactor switches will safely carry this current long enough to trip a circuit breaker.

The indicating contactor switch has two taps that provide a pickup setting of 0.2 or 2 amperes. To change taps requires connecting the lead located in front of the tap block to the desired setting by means of a screw connection.

#### 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.

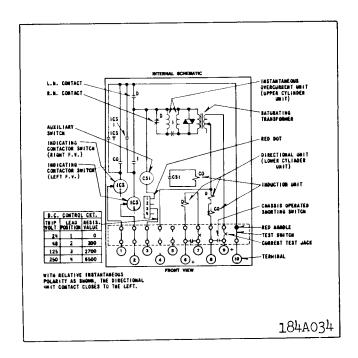


Fig. 8. Internal Schematic of the Type IRC Relay in the Type FT31 Case.

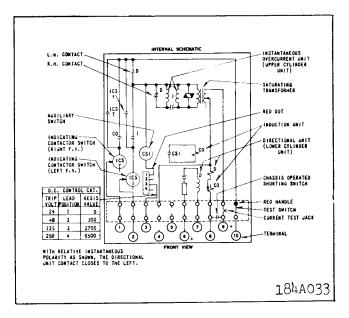


Fig. 7. Internal Schematic of the Type IRP Relay in the Type FT31 Case.

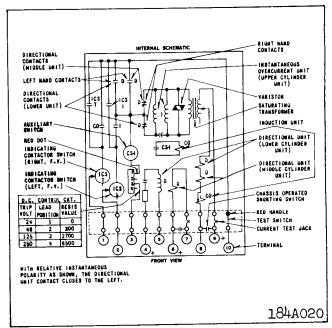


Fig. 9. Internal Schematic of the Type IRD Relay in the Type FT41 Case.

ENERGY REQUIREMENTS

INSTANTANEOUS OVERCURRENT UNIT OPERATING CURRENT CIRCUIT - 60 CYCLES

MPERE RANGE	TAP	VA AT TAP VALUE	P.F. ANGLE	VA AT 5 AMPS.	P.F. ANGLE	
	.5	.37	39	24	46	
	.75	.38	36	13	37	
	1	.39	35	8.5	34	
.5-2	1.25	.41	34	6.0	32	
	1.5	.43	32	4.6	31	
	2	.45	30	2.9	28	
	1	.41	36	9.0	36	
	1.5	.44	32	5.0	32	
1-4	2	.47	30	3.0	29	
1-4	2.5	.50	28	2.1	27	
	3	.53	26	1.5	26	
	4	.59	24	0.93	24	
	2	1.1	49	6.5	48	
	3	1.2	43	3.3	42	
2-8	4	1.3	38	2.1	37	
2-0	5	1.4	35	1.4	35	
	6	1.5	33	1.1	33	
<del></del>	8	1.8	29	0.7	29	
	4	1.5	51	2.4	51	
	6	1.7	45	1.2	45	
4-16	8	1.8	40	0.7	40	
	9	1.9	38	0.6	38	
	12	2.2	34	0.37	34	
	16	2.5	30	0.24	31	
	10	1.7	28	0.43	28	
	15	2.4	21	0.27	21	
10-40	20	3.1	16	0.20	17	
10-40	24	3.6	15	0.15	15	
	30	4.2	12	0.11	13	
	40	4.9	11	0.08	12	
	20	6.6	31	0.40	31	
	30	9.3	24	0.25	24	
20-80	40	12	20	0.18	20	
	48	13.5	18	0.14	18	
	60 80	15.9 19.2	16 15	0.10 0.07	16 15	
RANGE		CONTINUOUS RATI (AMPERES)	NG	ONE SECOND R		
					·	
. 5-2	5			100		
1-4	8			140		
2-8	8			140		
4-16		10		200		
10-40		10		200		
20-80		10		200		

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

 $<sup>\</sup>phi$  Degrees current lags voltage,

<sup>† †</sup> Voltages taken with Rectox type voltmeter.

# IRD INSTANTANEOUS OVERCURRENT UNIT BURDEN DATA AT HIGH CURRENTS

Ampere Range						10	-40					
Tap Value Current	10			20			40					
Multiples of Tap Value Current	22	4	6	8	1	2	3	4	.5	1	1.5	2.0
VA TI	9	36.8	84	156	5	26	57	104	4.8			78.8
P.F. Angle $\phi$	18.7°	18.3 °	17.5 °	15.7°	9.3°	8.5°	8.8°	9.0°	4.5 °	4.5 °	4.5 °	4.8 °

# ENERGY REQUIREMENTS - 60 CYCLES DIRECTIONAL UNIT OPERATING CIRCUIT BURDEN

						VO	LT AMPERES	††
Relay Type	Range Amps	Continuous Rating (Amperes)	One Second Rating † (Amperes)	Power Factor Angle $\phi$	At Minimum Tap Value Current	At 3 Times Minimum Tap Value Current	At 10 Times Minimum Tap Value Current	At 20 Times Minimum Tap Value Current
IRC	0.5-2.5	-	230	44.0	0.033	0.30	3.3	14.2
	2-6	-	230	42.5	0.58	5.28	58.0	240.0
	4-12	12	280	31.8	0.64	6.12	70.0	272.0
IRP	0.5-2.5	10	230	34.5	0.03	0.23	2.8	11.5
	2-6	10	230	34.5	0.44	4.08	48.0	182.0
	4-12	12	280	25.0	0.48	4.62	53.6	216.0
IRD	0.5-2.5	10	230	45.0	0.07	0.59	6.6	26.0
	2-6	10	230	45.0	1.04	9.9	106.0	420.0
	4-12	12	280	32.4	1.16	10.8	121.2	472.0

<sup>\$\</sup>phi\$ Degrees current lags voltage at tap value current.

# ENERGY REQUIREMENTS - 60 CYCLES DIRECTIONAL UNIT POLARIZING CIRCUIT BURDEN

RELAY TYPE	RATING	VOLT AMPERES △	POWER FACTOR ANGLE $\phi$
IRC	230 Amperes †	1.45	8° Lag
IRP	208 Volts ††	11.2	28 ° Lead
KRD Current Unit	230 Amperes ††	1.45	8° Lag
IRD Voltage Unit	208 Volts ††	11.2	28 ° Lead

 $<sup>\</sup>phi$  Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.

 $\triangle$  Burden of voltage polarized units taken at 120 volts. Burden of current polarized units taken at 5 amperes.

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

<sup>††</sup> Voltages taken with Rectox type voltmeter.

<sup>†</sup> One second rating.

<sup>†† 30</sup> second rating. The 10 second rating is 345 volts. The continuous rating is 120 volts.

## TYPE IRD-2, IRC-2, IRP-2 TIME OVERCURRENT UNITS

						VOLT A	AMPERES † †	
AMPERE RANGE I	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING † (AMPERES)	POWER FACTOR ANGLE $\phi$	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
0.5/2.5	0.5 0.6 0.8 1.0 1.5 2.0 2.5	0.91 0.96 1.18 1.37 1.95 2.24 2.50	28 28 28 28 28 28 28	58 57 53 50 40 36 29	4.8 4.9 5.0 5.3 6.2 7.2 7.9	39.6 39.8 42.7 45.4 54.4 65.4 73.6	256 270 308 348 435 580 700	790 851 1024 1220 1740 2280 2850
2/6	2.0 2.5 3.0 3.5 4.0 5.0 6.0	3.1 4.0 4.4 4.8 5.2 5.6 6.0	110 110 110 110 110 110 110	59 55 51 47 45 41	5.04 5.13 5.37 5.53 5.72 5.90 6.54	38.7 39.8 42.8 42.8 46.0 50.3 54.9	262 280 312 329 360 420 474	800 920 1008 1120 1216 1500 1800
4/12	4.0 5.0 6.0 7.0 8.0 10.0 12.0	7.3 8.0 8.8 9.6 10.4 11.2	230 230 230 230 230 230 230	65 50 47 46 43 37	4.92 5.20 5.34 5.53 5.86 6.6 7.00	39.1 42.0 44.1 45.8 49.9 55.5 62.3	268 305 330 364 400 470 528	848 1020 1128 1260 1408 1720 2064

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

 $<sup>\</sup>phi$  Degrees current lags voltage at tap value current.

<sup>††</sup> Voltages taken with Rectox type voltmeter.

# IRD-5, IRC-5, IRP-5, TIME OVERCURRENT UNITS

VOLT AMPERES † †

					VOLI AMPERES II					
AMPERE RANGE	CONTINUOUS ONE SECOND POWER RATING RATING† FACTOR TAP (AMPERES) (AMPERES) ANGLE $\phi$	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT					
	(0.5	2	88	69	3.92	20.6	103	270		
	(0.5	2.2	88	68	3.96	20.7	106	288		
	-	2.5	88	67	3.96	21	114	3 2 5		
0.5/0.5	(0.8	2.8	88	66	4.07	21.4	122	360		
0.5/2.5	(1.0	3.4	88	62	4.19	23.2	147	462		
	(1.5 (2.0	4.0	88	60	4.30	24.9	168	548		
	(2.5	4.4	88	58	4.37	26.2	180	630		
	(2	8	230	67	3.88	21	110	308		
	(2.5	8.8	230	66	3.90	21.6	118	342		
	(3	9.7	230	64	3.93	22.1	126	381		
2/6	(3.5	10.4	230	63	4.09	23.1	136	417		
2, 0	(4	11.2	230	62	4.12	23.5	144	448		
	(5	12.5	230	59	4.20	24.8	162	540		
	(6	13.7	230	57	4.38	26.5	183	624		
	(4	16	460	65	4.00	22.4	126	376		
	(5	18.8	460	63	4.15	23.7	143	450		
	(6	19.3	460	61	4.32	25.3	162	531		
4/12	(7	20.8	460	59	4.35	26.4	183	611		
1/ 12	(8	22.5	460	56	4.40	27.8	204	699		
	(10	25	460	53	4.60	30.1	247	880		
	(12	28	460	47	4.92	35.6	288	1056		

## IRD-7, IRC-7, IRP-7 TIME OVERCURRENT UNITS

VOLT AMPERES † †

					VOLI AMPERES				
AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING <sup>†</sup> (AMPERES)	POWER FACTOR ANGLE $\phi$	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT	
0.5/2.5	(0.5 (0.6 (0.8 (1.0 (1.5 (2.0	2 2.2 2.5 2.8 3.4 4.0	88 88 88 88 88	68 67 66 64 61 58	3.88 3.93 3.93 4.00 4.08 4.24	20.7 20.9 21.1 21.6 22.9 24.8	103 107 114 122 148 174	278 288 320 356 459 552	
	(2.5	4.4	88	56	4.38	25.9	185	640	
2/6	(2 (2.5 (3 (3.5 (4 (5 (6	8 8.8 9.7 10.4 11.2 12.5	230 230 230 230 230 230 230	66 63 63 62 61 59	4.06 4.07 4.14 4.34 4.34 4.40 4.62	21.3 21.8 22.5 23.4 23.8 25.2	111 120 129 141 149 163 183	306 342 366 413 448 530 624	
4/12	(4 (5 (6 (7 (8 (10 (12	16 18.8 19.3 20.8 22.5 25	460 460 460 460 460 460	64 61 60 58 55 51 46	4.24 4.30 4.62 4.69 4.80 5.20 5.40	22.8 24.2 25.9 27.3 29.8 33 37.5	129 149 168 187 211 260 308	392 460 540 626 688 860 1032	

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

φ Degrees current lags voltage at tap value current.

<sup>††</sup> Voltages taken with Rectox type voltmeter.

IRD-8, IRC-8, IRP-8, TIME OVERCURRENT UNITS

						VOLT AME	PERES ††	
Ampere Range	Тар	Continuous Rating (Amperes)	One Second Rating † (Amperes)	Power Factor Angle $\phi$	At Tap Value Current	At 3 Times Tap Value Current	At 10 Times Tap Value Current	At 20 Times Tap Value Current
0.5/2.5	(0.5 (0.6 (0.8 (1.0 (1.5 (2.0 (2.5	2 2.2 2.5 2.8 3.4 4.0 4.4	88 88 88 88 88 88	72 71 69 67 62 57 53	2.38 2.38 2.40 2.42 2.51 2.65 2.74	21 21 21.1 21.2 22 23.5 24.8	132 134 142 150 170 200 228	350 365 400 440 530 675
2/6	(2 (2.5 (3 (3.5 (4 (5 (6	8 8.8 9.7 10.4 11.2 12.5 13.7	230 230 230 230 230 230 230 230	70 66 64 62 60 58 56	2.38 2.40 2.42 2.48 2.53 2.64 2.75	21.1 21.1 21.5 22 22.7 24 25.2	136 142 149 157 164 180	800 360 395 430 470 500 580 660
4/12	(4 (5 (6 (7 (8 (10 (12	16 18.8 19.3 20.8 22.5 25 28	460 460 460 460 460 460 460	68 63 60 57 54 48 45	2.38 2.46 2.54 2.62 2.73 3.00 3.46	21.3 21.8 22.6 23.6 24.8 27.8 31.4	146 158 172 190 207 248 292	420 480 550 620 700 850 1020

IRD-11, IRC-11, IRP-11 OVERCURRENT UNITS

	TRO-11, TRE-11 OVERCURRENT UNITS								
	1					VOLT AM	PERES ††		
Ampere Range	Тар	Continuous Rating (Amperes)	One Second Rating † (Amperes)	Power Factor Angle $\phi$	At Tap Value Current	At 3 Times Tap Value Current	At 10 Times Tap Value Current	At 20 Times Tap Value Current	
0.5/2.5	0.5 0.6 0.8 1.0 1.5 2.0 2.5	1.7 1.9 2.2 2.5 3.0 3.5 3.8	56 56 56 56 56 56	36 34 30 27 22 17 16	0.72 0.75 0.81 0.89 1.13 1.30	6.54 6.80 7.46 8.30 10.04 11.95 13.95	71.8 75.0 84.0 93.1 115.5 136.3 160.0	250 267 298 330 411 502 610	
2/6	2.0 2.5 3.0 3.5 4.0 <b>5.</b> 0 6.0	7.0 7.8 8.3 9.0 10.0 11.0 12.0	230 230 230 230 230 230 230 230	32 30 27 24 23 20 20	0.73 0.78 0.83 0.88 0.96 1.07	6.30 7.00 7.74 8.20 9.12 9.80 11.34	74.0 78.5 84.0 89.0 102.0 109.0 129.0	264 285 309 340 372 430 504	
4/12	4.0 5.0 6.0 7.0 8.0 10.0 12.0	14 16 17 18 20 22 26	460 460 460 460 460 460 460	29 25 22 20 18 17 16	0.79 0.89 1.02 1.10 1.23 1.32 1.8	7.08 8.00 9.18 10.00 11.1 14.9 16.3	78.4 90.0 101.4 110.0 124.8 131.6 180.0	296 340 378 454 480 600 720	

# IRD TIME OVERCURRENT UNIT BURDEN DATA AT HIGH CURRENTS

A						
Ampere Range			.5-	2.5		
Tap Value Current	.5		1.0		2.5	
Multiples of Tap Value Current	40	80	20	40	8	16
VA ††	790	2600	380	1280	60	280
P.F. Angle $\phi$	46.7°	42 °	37 °	26.5 °	4.8 °	4.3°

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

<sup>\$\</sup>phi Degrees current lags voltage at tap value current.

 $<sup>\</sup>dagger\dagger Voltages\ taken\ with\ Rectox\ type\ voltmeter.$ 

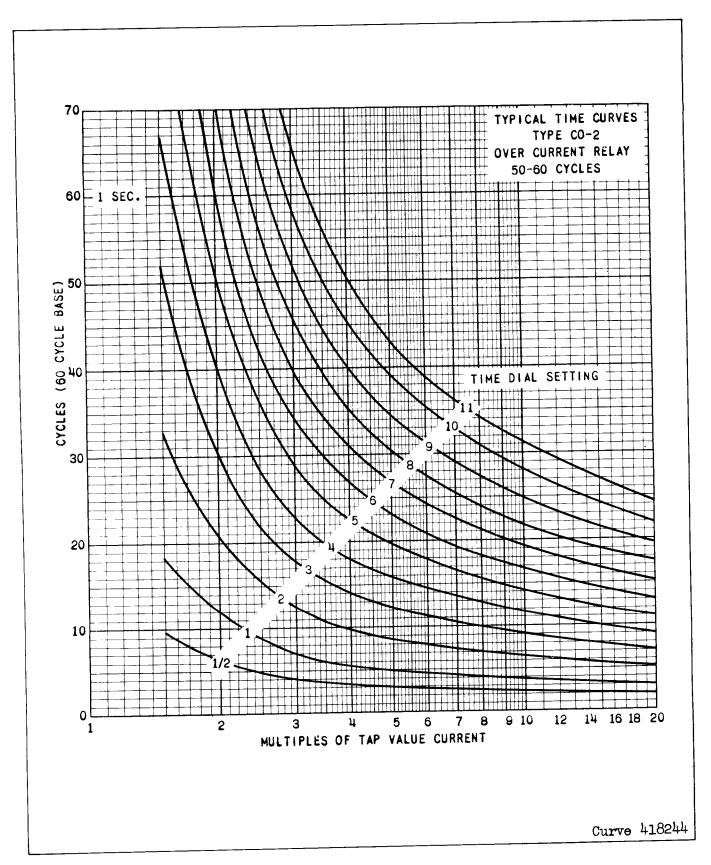


Fig. 10. Typical Time Curves of the Time-Overcurrent Unit of the Short Time (2) Relays.

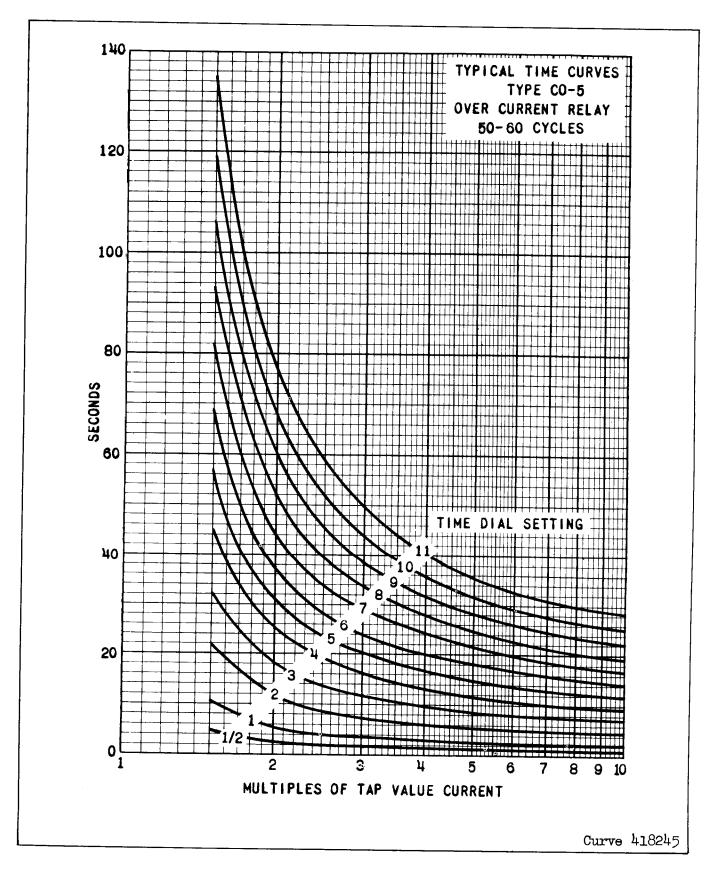


Fig. 11. Typical Time Curve of the Time-Overcurrent Unit of the Long Time (5) Relays.

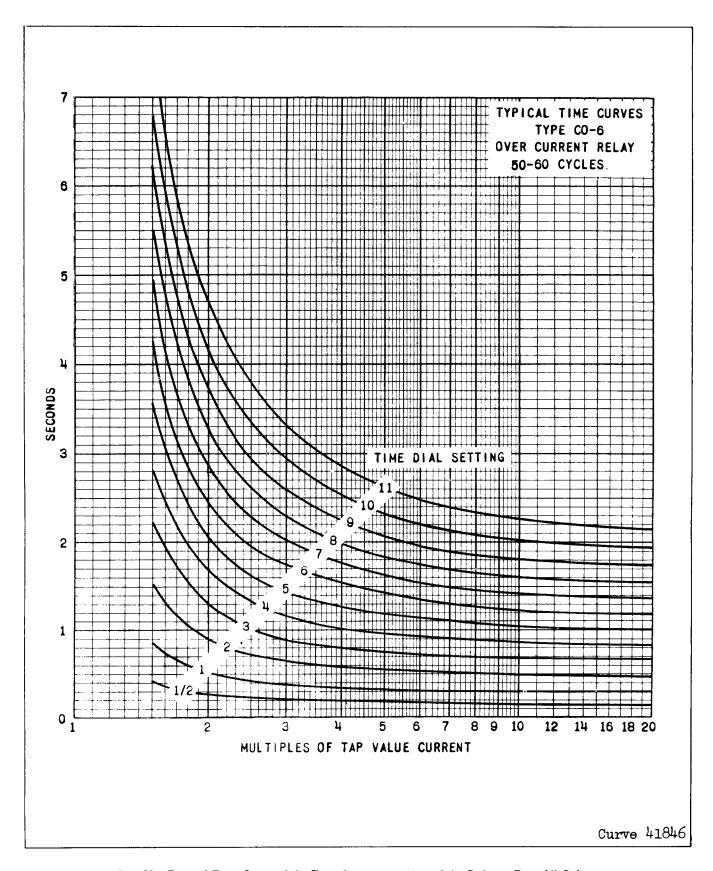


Fig. 12. Typical Time Curve of the Time-Overcurrent Unit of the Definite Time (6) Relays.

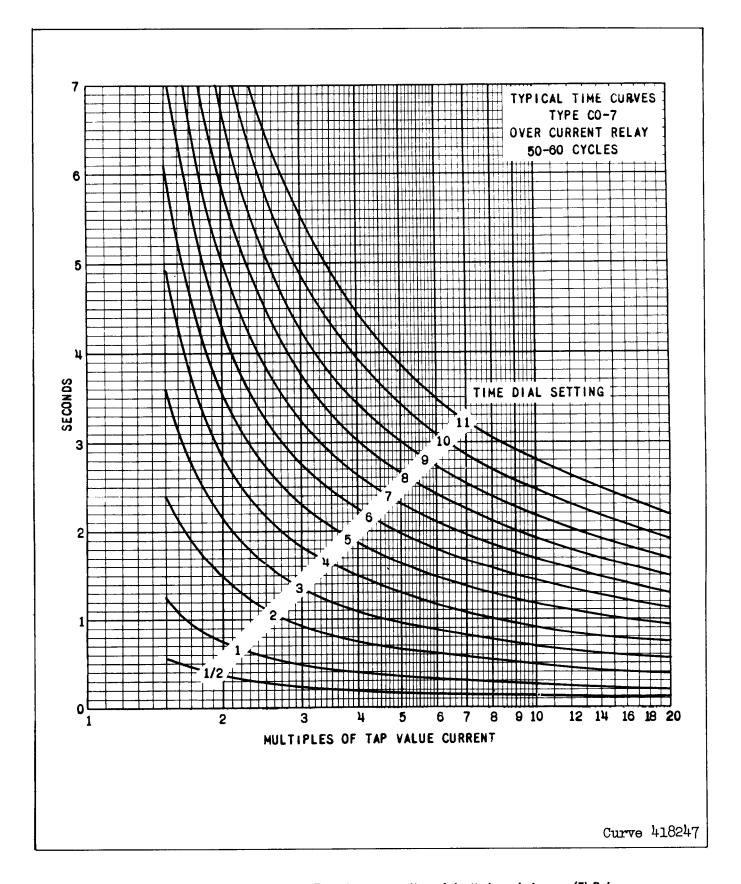


Fig. 13. Typical Time Curve of the Time-Overcurrent Unit of the Moderately Inverse (7) Relays.

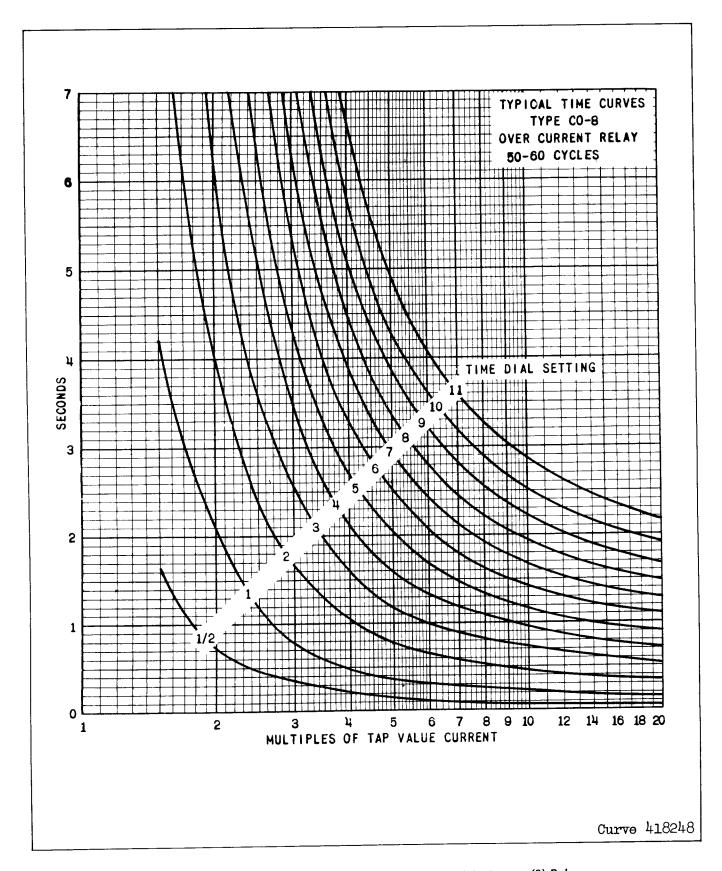


Fig. 14. Typical Time Curve of the Time-Overcurrent Unit of the Inverse (8) Relays.

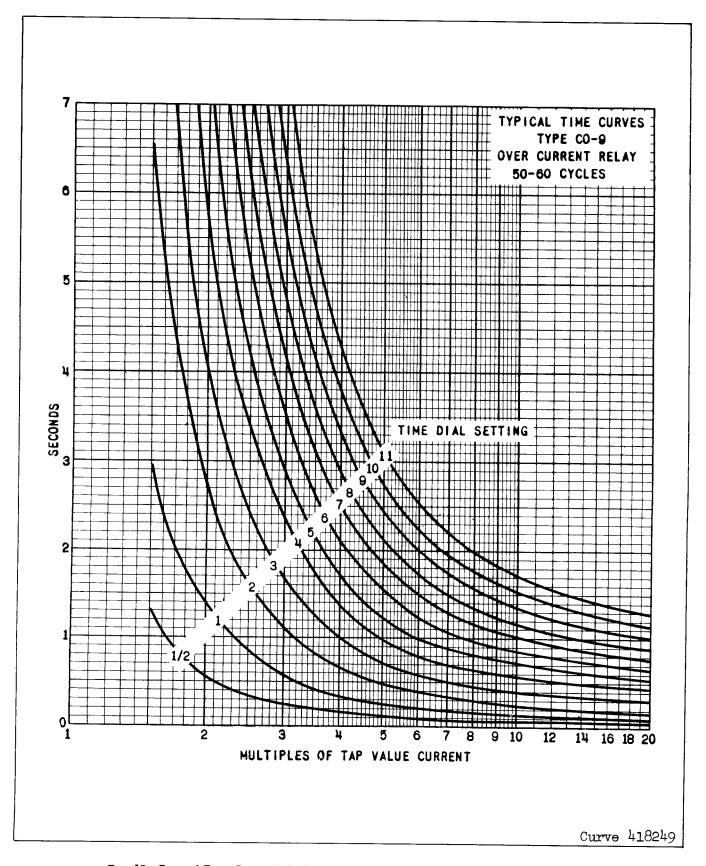


Fig. 15. Typical Time Curve of the Time-Overcurrent Unit of the Very Inverse (9) Relays.

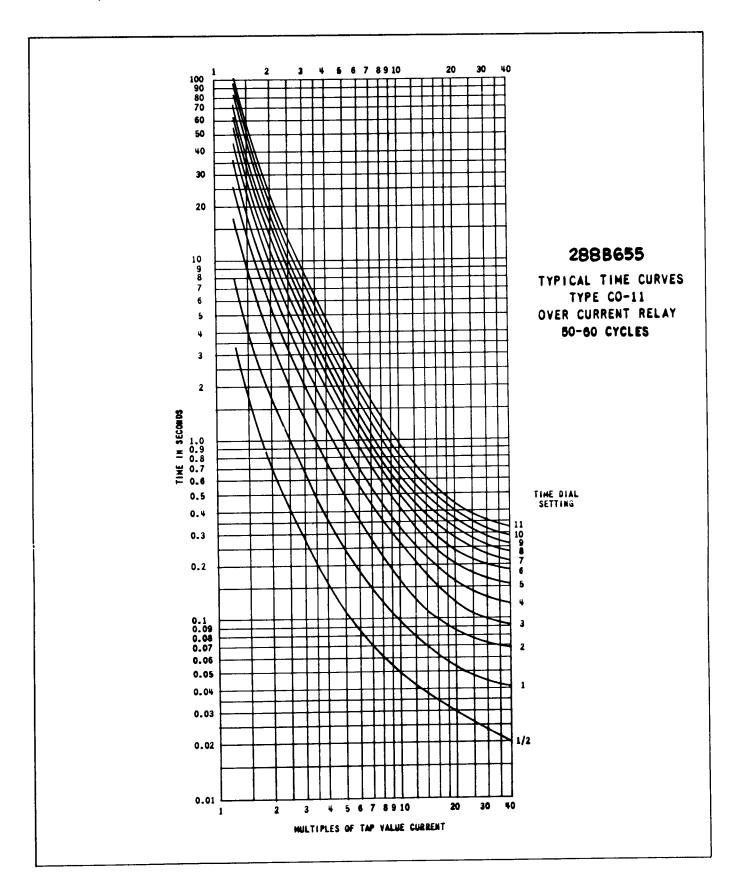


Fig. 16. Typical Time Curve of the Time-Overcurrent Unit of the Extremely Inverse (11) Relays.

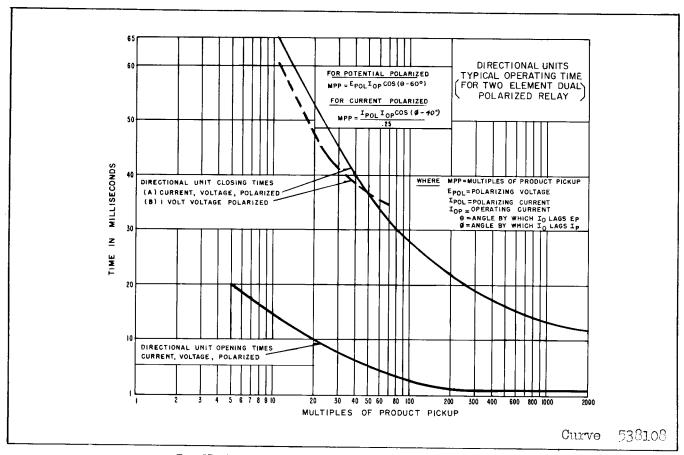


Fig. 17. Typical Operating Times For The Directional Unit.

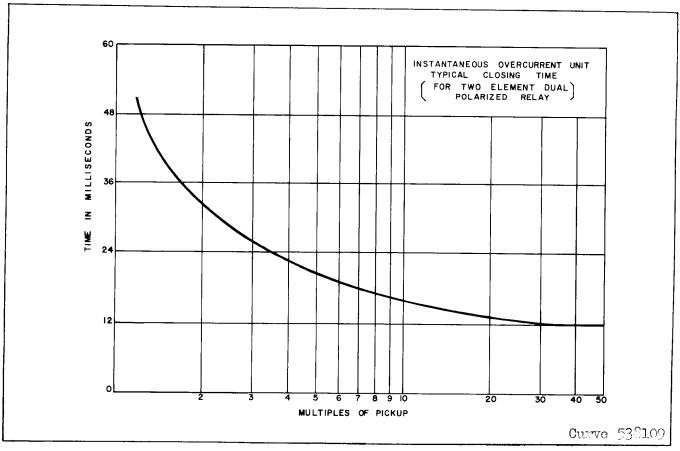


Fig. 18. Typical Operating Times For The Instantaneous Overcurrent Unit.

#### Trip Circuit Constants

Indicating Contactor Switch -

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

#### Auxiliary Switch (CS-1)

The auxiliary switch has a d-c resistance of 1165 ohms.

#### Type IRP Relay

The IRP 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 pick-up is approximately 1 volt and 2 amperes at its maximum torque angle for the directional units used with the 0.5 to 2.5 and 2 to 6 ampere range time over-current units. For the directional units used with the 4-12 ampere range time overcurrent units the minimum pick-up is 1 volt and 4 amperes.

#### Type IRC Relay

The IRC relay is designed for current polarization and has its maximum torque when the operating current leads the polarizing current by approximately  $40^{\circ}$ .

The directional unit minimum pick-up is 0.5 ampere in each winding at the maximum torque angle for the directional units used with the 0.5 to 2.5 and 2 to 6 ampere range time overcurrent units. For the directional units used with the 4-12 ampere range time overcurrent units the minimum pickup is 1 ampere.

#### Type IRD Relay

The type IRD relay utilizes a directional unit similar to the IRC relay in conjunction with the directional unit and phase-shifting circuit of the IRP relay.

The current-polarized directional unit of the IRD relay operates on residual currents while the potential-polarized directional unit of the IRD relay operates on residual voltage and residual current.

For the directional units used with the 0.5 to 2 and 2 to 6 ampere time overcurrent units, the minimum pick-up of the current polarized unit is 0.5 ampere in each winding at the maximum torque angle. The minimum pick-up for the voltage polarized unit is

1 volt and 2 amperes with the current lagging voltage by  $60^{\circ}$ .

For the directional units used with the 4 to 12 ampere range time overcurrent units, the minimum pick-up is 1 ampere for the current-polarized directional unit and 1 volt and 4 amperes for the voltage-polarized directional unit.

#### SETTINGS

#### Time Overcurrent Unit (CO)

The time overcurrent unit settings can be defined either by tap setting and time dial position or by tap setting and a specific time of operation at some current multiple of the tap setting (e.g. 4 tap setting, 2 time dial position or 4 tap setting, 0.6 seconds at 6 times tap value current).

To provide selective circuit breaker operation, a minimum coordinating time of 0.3 seconds plus circuit breaker time is recommended between the relay being set and the relays with which coordination is to be effected.

The connector screws on the tap plate above the time dial makes connections to various turns on the operating coil. By placing this screw in the various tap plate holes, the relay will just close its contacts at the corresponding current 4-5-6-7-8-10-12 amperes, or as marked on the tap plate.

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 space connector screw in the desired position before removing the other tap screw from the original tap position.

#### Instantaneous Reclosing

The factory adjustment of the CO unit contacts provides a contact follow. Where circuit breaker reclosing will be intiated immediately after a trip by the CO contact, the time of the opening of the contacts should be a minimum. This condition is obtained by loosening the stationary contact mounting screw, removing the contact plate and then replacing the plate with the bent end resting against the contact spring. With this change and the contact mounting screw tightened, the stationary contact will rest solidly against its backstop.

#### Instantaneous Overcurrent Unit (1)

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 con-

nector screw in the desired tap, the relay will just close its contacts at the tap value current.

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.

#### Directional Units (D)

No setting is required.

#### Indicating Contactor Switch (ICS/I and ICS/T)

The setting required on the ICS units is the selection of the 0.2 or 2.0 ampere tap setting. This selection is made by connecting the lead located in front of the tap block to the desired setting by means of the connecting screw.

#### Auxiliary Switch (CS-1)

No setting required on the CS-1 unit except for the selection of the required 24, 48, 125 or 250 voltage on the tapped rexistor. This connection can be made by referring to Fig. 23.

#### 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 be means of the two mounting studs for the type FT projection case or by means of the four mounting holes on the flange for the semi-flush type FT case. 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 detail information on the FT Case refer to I.L. 41-076.

The external a-c connections of the directional overcurrent relays are shown in Figs. 20, 21 and 22. If no voltage polarizing source is to be connected to the IRD relay, short-circuit the voltage polarizing circuit at the terminals of the relay.

#### 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;

#### Instantaneous 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. <u>Minimum Trip Current</u> 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 within  $\pm\,5\%$  of tap value current.

#### Directional Unit (D)

- 1. Contact Gap The gap between the stationary contact and moving contact with the relay in the deenergized position should be approximately .020".
- 2. <u>Sensitivity</u> The respective directional units should trip with value of energization and phase angle relationship 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 with the polarizing circuits short circuited for the voltage polarized units and open-circuited for the current polarized units.

#### Time Overcurrent Unit (CO)

- 1. Contacts The index mark on the movement frame will coincide with the "O" mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "O" mark by approximately .020". The placement of the various time dial positions in line with the index mark will give operating times as shown on the respective time-current curves.
- 2. Minimum Trip Current Set the time dial to position 6 with the auxiliary switch (CS-1) contacts

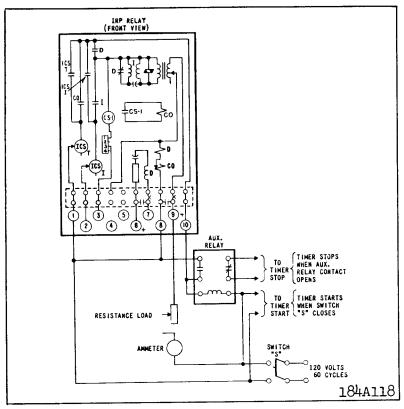


Fig. 19. Diagram of test connections of the time-overcurrent unit.

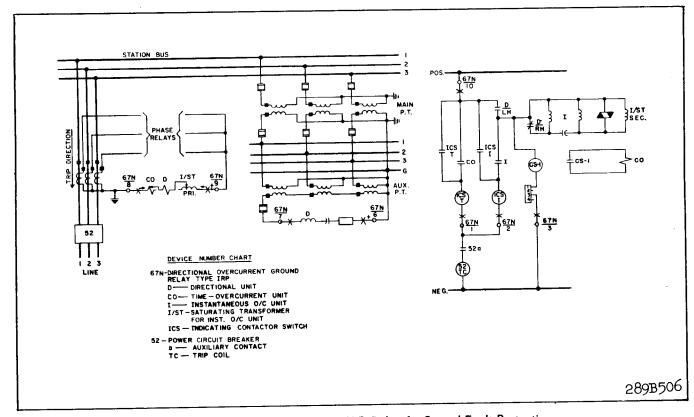


Fig. 20. External Schematic of the IRP Relay for Ground Fault Protection.

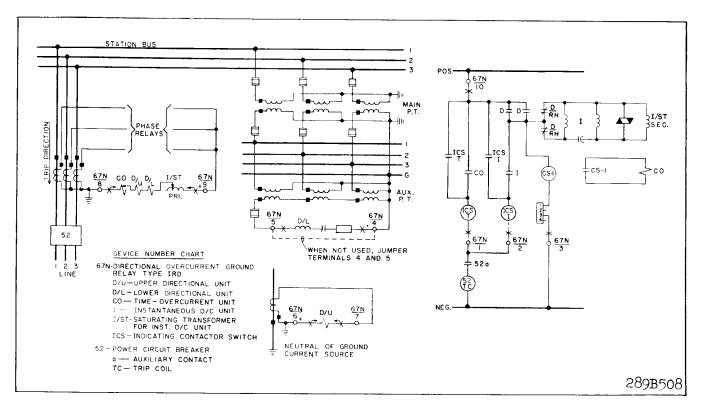


Fig. 21. External Schematic of the IRD Relay for Ground Fault Protection.

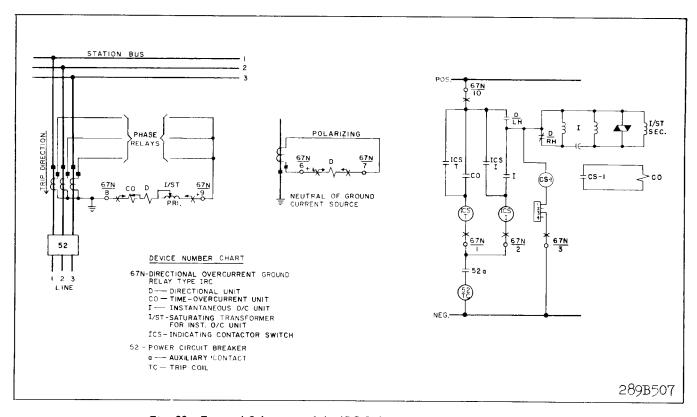


Fig. 22. External Schematic of the IRC Relay for Ground Fault Protection.

blocked closed, alternately apply tap value current plus 3% and tap value current minus 3%. The moving contact should leave the backstop at tap value current plus 3% and should return to the backstop at tap value current minus 3%.

3. <u>Time Curve</u> — Table 3 shows the time curve calibration points for the various types of relays. With the time dial set to the indicated position, apply the currents specified by Table 3 (e.g. for the CO-2, 3 and 20 times tap value current) and measure the operating time of the relay. The operating times should equal those of Table 3 plus or minus 5 percent.

#### Indicating Contactor Switches (ICS/I) and (ICS/T)

- A) Close the contacts of the CO and pass sufficient d.c. current through the trip circuit to close the contacts of (ICS/T). This value of current should not be greater than the particular (ICS/T) tap setting being used. The operation indicator target should drop freely, bringing the letter "T" into view.
- B) Close the contacts of the instantaneous overcurrent unit (I) and the directional unit (D). Pass sufficient d.c. current through the trip circuit to close the contacts of (ICS/I). This value of current should not be greater than the particular (ICS/I) tap setting being used. The operation indicator target should drop freely, bringing the letter "I" into view.
- C) The contact gap should be approximately .047" 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 time of 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. The use of phantom loads, in testing induction-type relays, should be avoided, since the resulting distorted current wave form will produce an error in timing.

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

#### Calibration

Use the following procedure for calibrating the

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

#### Instantaneous Overcurrent Unit (1)

- 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, i.e., against the right side of the bridge. Move 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 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  $\pm 5\%$  of tap value.

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.

#### Directional Unit (D)

In the type IRP and IRC relays the directional unit is the lower cylinder unit. In the type IRD the directional units are the lower and middle cylinder 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 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 as indicated by a neon lamp in the contact circuit when energized with the required current and voltage as shown in Table 1. 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 or voltage 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 (IRP and IRD voltage polarized unit) are short-circuited.
- b) The polarizing circuits of the current polarized relays (IRC and IRD 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 some installations in order to insure that the relay will always trip the breaker on zero potential.

#### Time Overcurrent Unit (CO)

- 1. Contacts The index mark on the movement frame will coincide with the "O" mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "O" mark by approximately .020". The placement of the various time dial positions in line with the index mark will give operating times as shown on the respective time-current curves.
- 2) <u>Minimum Trip Current</u> The adjustment of the spring tension in setting the minimum trip current value of the relay is most conveniently made with the damping magnet removed.

With the time dial set on "O", wind up the spiral spring by means of the spring adjuster until approximately 6-3/4 convolutions show.

Set the relay on the minimum tap setting, the time dial to position 6.

With the auxiliary switch (CS-1) contacts blocked closed, adjust the control spring tension so that the moving contact will leave the backstop at tap value current +1.0% and will return to the backstop at tap value current -1.0%.

3) <u>Time Curve Calibration</u> — Install the permanent magnet.

Apply the indicated current per Table 3 for permanent magnet adjustment (e.g. IRP-8, 2 times tap value) and measure the operating time. Adjust the permanent magnet keeper until the operating time corresponds to the value of Table 3.

Apply the indicated current per Table 3 for the electromagnet plug adjustment (e.g. IRP-8, 20 times tap value) and measure the operating time. Adjust the proper plug until the operating time corresponds to the value in Table 3. (Withdrawing the left hand plug, front view increases the operating time and withdrawing the right hand plug, front view, decreases the time.) In adjusting the plugs, one plug should be

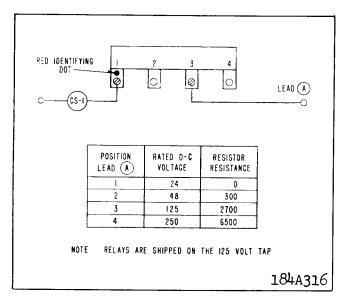


Fig. 23. Selection of Proper Voltage Tap for Auxiliary Switch (CS-1) Operation.

screwed in completely and the other plug run in or out until the proper operating time has been obtained.

Recheck the permanent magnet adjustment. If the operating time for this calibration point has changed, readjust the permanent magnet and then recheck the electromagnet plug adjustment.

#### Indicating Contactor Switches (ICS/I) and (ICS/T)

Adjust the contact gap for approximately .047".

A) Close the contacts of the CO and pass sufficient d.c. current through the trip circuit to close the contacts of the (ICS/T). This value of current should not be greater than the particular (ICS/T) tap setting being used. The operation indicator target should drop freely bringing the letter "T" into view.

B) Close contacts of instantaneous overcurrent unit (I) and directional unit (D). Pass sufficient d.c. current through the trip circuit to close contacts of the (ICS/I). This value of current should not be greater than the particular (ICS/I) tap setting being used. The operation indicator target should drop freely bringing the letter "I" into view.

#### Auxiliary Switch (CS-1)

Adjust the stationary core of the switch for a clearance between the stationary core and the moving core when the switch is picked up. This can be done by turning the relay upside-down. Then screw up the core screw until the moving core starts rotating. Now back off the core screw until the moving core stops rotating. This indicates the points where the play in the assembly is taken up, and where the moving core just separates from the stationary core screw. Back off the core screw approximately one turn and lock in place. This prevents the moving core from striking and sticking to the stationary core because of residual magnetism. Adjust the contact clearance for 3/64" by means of the two small nuts on either side of the Micarta disc.

Connect lead (A) to proper terminal per Fig. 23. Block directional unit (D) contacts close and energize trip circuit with rated voltage. Contacts of auxiliary switch (CS-1) should make as indicated by a neon lamp in the contact circuit.

#### 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.

TABLE I
DIRECTIONAL UNIT SENSITIVITY

		CITOTIAL OTT	·	
RELAY TYPE	AMPERE RATING OF	VALUES FOR	R MIN. PICKUP †	PHASE ANGLE RELATIONSHIP
	TIME-OVERCURRENT UNIT	VOLTS AMPERES		
	.5-2.5	1	2.0	I lagging V by 60°††
IRP IRD (Voltage Unit)	2-6	1	4.0	I in-phas≥ with V
	4.10	1	4.0	I lagging V by 60° ††
	4-12	1	8.0	I in-phase with V
	.5-2.5		0.5	I <sub>O</sub> leading I <sub>p</sub> by 40°††
IRC IRD (Current $\triangle$ Unit)	2-6		. 57	In-phase
	4-12		1.0	${ m I_O}$ leading ${ m I_p}$ by $40^{\circ}$ ††
			1.3	In-phase

<sup>†</sup> The energization quantities are input quantities at the relay terminals.

<sup>††</sup> Maximum torque angle.

<sup>△</sup> When normal system conditions limit the current to less than twice pickup, performance may be improved by selecting a higher current C.T. tap to energize the polarizing circuit.

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) (Contacts remain open)	Left (Front View) Plug Screwed Out Until Spurious Torque is in Contact Closing Direction. Then the plug is screwed in Until Spuri ous Torque is Reversed.

<sup>†</sup> Short circuit the voltage polarizing circuit at the relay terminals before making the above adjustment.

TABLE III

TIME CURVE CALIBRATION DATA - 60 CYCLES

-	PERMANENT	MAGNET ADJUSTM	MENT	ELECTROMAGNET PLUGS		
TIME- OVERCURRENT UNIT TYPE	TIME DIAL POSITION	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS	
2	6	3	0.57	20	0.22	
5	6	2	37.80	10	14.30	
6	6	2	2.46	20	1.19	
7	6	2	4.27	20	1.11	
8	6	2	13.35	20	1,11	
9	6	2	8.87	20	0.65	
11	6	2	11.27	20	0.24	

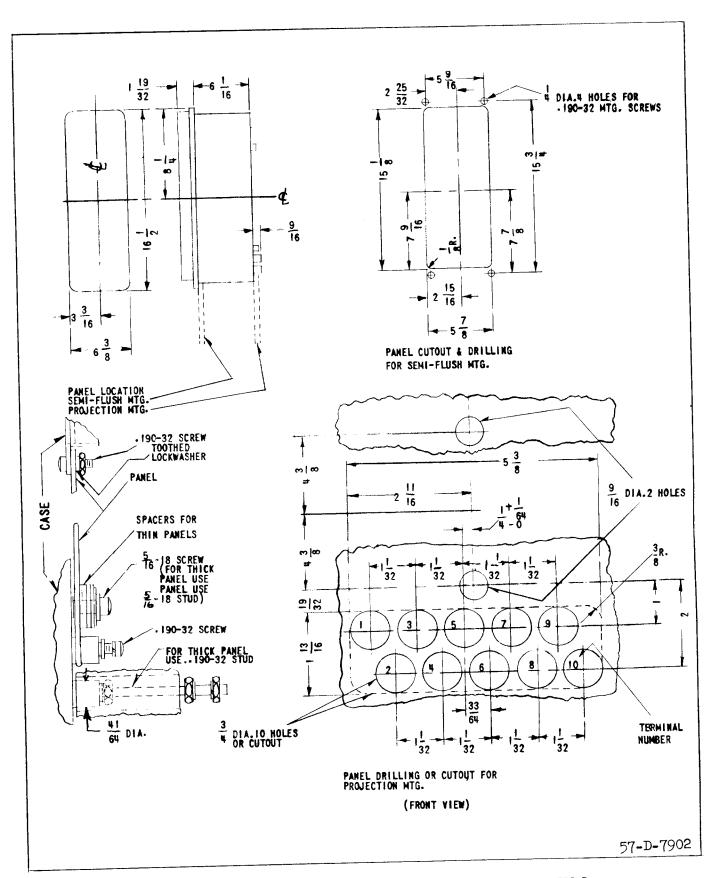


Fig. 24. Outline and Drilling Plan for the IRP and IRC Relays in the Type FT31 Case.

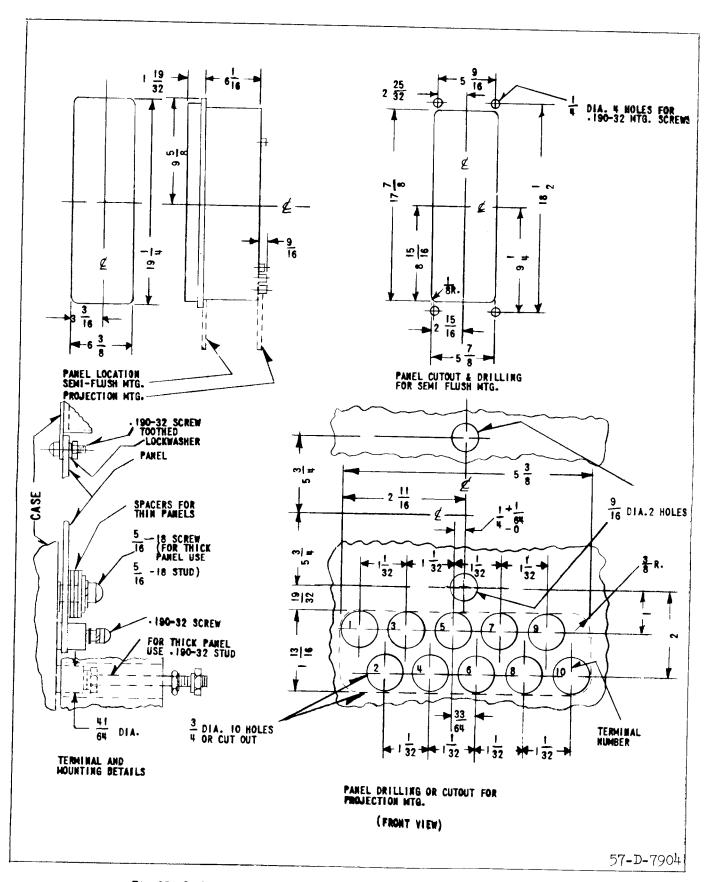


Fig. 25. Outline and Drilling Plan for the IRD Relay in the Type FT41 Case.



WESTINGHOUSE ELECTRIC CORPORATION RELAY-INSTRUMENT DIVISION NEWARK, N. J.



# INSTALLATION • OPERATION • MAINTENANCE

# INSTRUCTIONS

# DIRECTIONAL OVERCURRENT GROUND RELAYS TYPES IRP, IRC AND IRD

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

These relays are ground directional overcurrent relays which are used for the protection of transmission lines and feeder circuits. Both the time-overcurrent and instantaneous overcurrent units are directionally controlled.

The type IRP relay is potential polarized. The type IRC relay is current polarized. The type IRD relay is a dual polarized relay which can be polarized from a potential source, from a local ground source or from both simultaneously.

## CONSTRUCTION AND OPERATION

The various types of relays consist of a directional unit or units (D), an auxiliary switch (CS-1), a time-overcurrent unit (CO), an instantaneous overcurrent unit (I), an instantaneous overcurrent unit transformer, and two indicating contactor switches (ICS/I) and (ICS/T). The principle component parts of the relays and their location are shown in Fig. 1 through 6.

## Time-Overcurrent Unit (CO)

The electromagnets for the types IR-5, IR-6, IR-7, IR-8 and IR-9 relays have a main tapped coil located on the center leg of an "E" type laminated structure that produces a flux which divides and returns through the outer legs. A shading coil causes the flux through the left leg to lag the main pole flux. The out-of-phase fluxes thus produced in the air gap cause a contact closing torque.

The electromagnet for the type IR-2 and IR-11 relays has a main coil consisting of a tapped primary winding a secondary winding. Two identical coils

on the outer legs of the lamination structure are connected to the main coil secondary in a manner so that the combination of all the fluxes produced by the electromagnet result in out-of-phase fluxes in the air gap. The out-of-phase air gap fluxes produced cause a contact closing torque.

## Indicating Contactor Switch Units (ICS/E and ICS/T)

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

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

#### 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 the magnetic core. The magnetic core which houses the lower pin bearing is secured to the 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

Time Overcurrent Unit

Range			Taps					
.5-2.5	0.5	0.6	0.8	1.0	1.5	2.0	2.5	
2-6	2	2.5	3	3.5	4	5	6	
4-12	4	5	6	7	8	10	12	

The tap value is the minimum current required to just close the relay contacts.

The time vs. current characteristics for the timeovercurrent unit are shown in Figs. 10 to 16. These characteristics give the contact closing time for the various time dial settings when the indicated multiples of tap value current are applied to the relay.

#### TIME CURVES

The time curves for the IRD relay are shown in Fig. 17 and 18. Fig. 17 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.
- Directional Unit closing time for 1 volt, voltage polarized.

Fig. 18 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 Fig. 18 plus the directional unit opening time given in Fig. 17. The total closing time for the directional unit is given in Fig. 17. The two examples below will serve to illustrate the use of the curves.

\* Example 1: Using the formulas and definition of symbols on Fig. 17, we have—

Let: Ipol = 2 amps.   
Iop = 2.31   
Tap Value (T) = 0.5 amp.   

$$\phi$$
 = 0 °   
(For timing unit, assume   
CO-9 with ½ time dial setting)

For current polarized relay:

$$MPP = \frac{\text{Iop Ipol Cos } \phi}{0.25}$$

$$MPP = \frac{(2.31)(2) = 18.5}{0.25}$$

Referring to Fig. 17 at multiples of produce pickup of 18.5,the directional unit operating time is about 11 ms, and the closing time for this unit is 56 ms.

For overcurrent unit:

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

Entering the curve in Fig. 18 at multiples of pickup equal to 4.6, the closing time for instantaneous overcurrent is 16 ms. However, the total operating time for the overcurrent unit is 16 plus 11, which is the opening time of back contacts of the directional unit, or 27 ms total operating time for overcurrent unit. The total time for directional unit is 56 ms; and, since this is the longest time,56 ms is the total operating time of the instantaneous overcurrent circuit.

Entering the curve in Fig. 15 at 4.6, the  $\frac{1}{2}$  time dial setting gives 140 ms. The total time for the time-overcurrent circuit is 56 ms directional unit time plus 16 ms CS-1 time plus 140 ms = 212 ms.

\* Example 2:

Let: Ipol = 20 amps.
Iop = 23.1 amps
$$T(tap) = 1 amp.$$
 $\phi = 0$ 

MPP = Iop Ipol Cos  $\phi$ 
0.25

MPP = (20) (23.1) = 1850

Entering Fig. 17, the directional unit closing time is 12 ms, and the opening time of its back contacts is 1 ms. The total operating time for the directional unit is 13 ms.

For overcurrent unit:

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

Referring to Fig. 18, the overcurrent unit contact closing time is about 14 ms. Therefore, the total operating time for this unit is 14 plus 1 or 15 ms. In this case the total operating time of relay is 15 ms.

Fig. 15 gives an operating time of about 50 ms. The time-overcurrent circuit is 12 plus 16 ms CS-1 time plus 50 = 78 ms.

#### Trip Circuit

The relay contacts will safely close 30 amperes at 250 volts d c and the seal-in contacts of the indicating contactor switches will safely carry this current long enough to trip a circuit breaker.

The indicating contactor switch has two taps that provide a pickup setting of 0.2 or 2 amperes. To change taps requires connecting the lead located in front of the tap block to the desired setting by means of a screw connection.

#### 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.

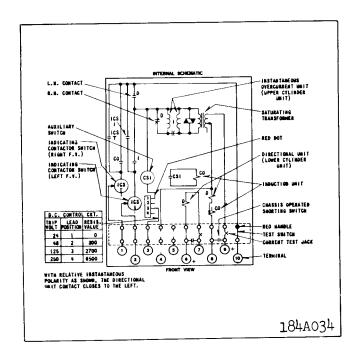


Fig. 8. Internal Schematic of the Type IRC Relay in the Type FT31 Case.

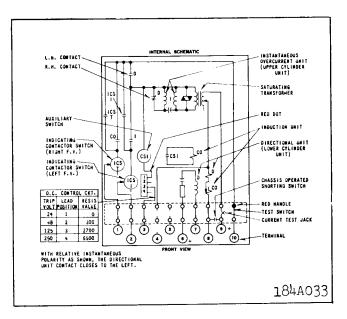


Fig. 7. Internal Schematic of the Type IRP Relay in the Type FT31 Case.

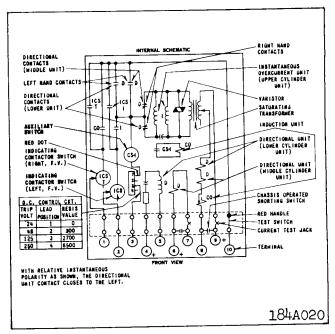


Fig. 9. Internal Schematic of the Type IRD Relay in the Type FT41 Case.

ENERGY REQUIREMENTS

INSTANTANEOUS OVERCURRENT UNIT OPERATING CURRENT CIRCUIT - 60 CYCLES

MPERE RANGE	TAP	VA AT TAP VALUE	P.F. ANGLE	VA AT 5 AMPS.	P.F. ANGLE
	.5	.37	39	24	46
	.75	.38	36	13	37
ļ	1	.39	35	8.5	34
.5-2	1.25	.41	34	6.0	32
	1.5	.43	32	4.6	31
	2	.45	30	2.9	28
	1	.41	36	9.0	36
	1.5	.44	32	5.0	32
1-4	2	.47	30	3.0	29
1-4	2.5	.50	28	2.1	27
	3	.53	26	1.5	26
	4	.59	24	0.93	24
	2	1.1	49	6.5	48
	3	1.2	43	3.3	42
2-8	4	1.3	38	2.1	37
2-8	5	1.4	35	1.4	35
	6	1.5	33	1.1	33
<u> </u>	8	1.8	29	0.7	29
	4	1.5	51	2.4	51
i	6	1.7	45	1.2	45
4-16	8	1.8	40	0.7	40
	9	1.9	38	0.6	38
	12	2.2	34	0.37	34
	16	2.5	30	0.24	31
	10	1.7	28	0.43	28
	15	2.4	21	0.27	21
10-40	20	3.1	16	0.20	17
10-40	24	3.6	15	0.15	15
	30	4.2	12	0.11	13
	40	4.9	11	0.08	12
	20	6.6	31	0.40	31
	30	9.3	24	0.25	24
20-80	40	12	20	0.18	20
	48	13.5	18	0.14	18
	60	15.9	16	0.10	16
	80	19.2	15	0.07	15
RANGE		CONTINUOUS RATII (AMPERES)	٧G	ONE SECOND R	
. 5-2	*	5		100	
1-4		8		140	
2-8		8		140	ĺ
4-16		10		200	
10-40		10		200	
20-80		10		200	

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

φ Degrees current lags voltage.

<sup>† †</sup> Voltages taken with Rectox type voltmeter.

## IRD INSTANTANEOUS OVERCURRENT UNIT BURDEN DATA AT HIGH CURRENTS

Ampere Range						10	-40					
Tap Value Current		1	.0		20 40			10				
Multiples of Tap Value Current	22	4	6	8	1	2	3	4	.5	1	1.5	2.0
VA TI	9	36.8	84	156	5	26	57	104	4.8	19.2	44.4	78.8
P.F. Angle $\phi$	18.7 °	18.3 °	17.5 °	15.7°	9.3°	8.5 °	8.8 °	9.0°	4.5 °	4.5 °	4.5 °	4.8 °

# ENERGY REQUIREMENTS - 60 CYCLES DIRECTIONAL UNIT OPERATING CIRCUIT BURDEN

						VO	LT AMPERES	††
Relay Type	Range Amps	Continuous Rating (Amperes)	One Second Rating † (Amperes)	Power Factor Angle $\phi$	At Minimum Tap Value Current	At 3 Times Minimum Tap Value Current	At 10 Times Minimum Tap Value Current	At 20 Times Minimum Tap Value Current
IRC	0.5-2.5	-	230	44.0	0.033	0.30	3.3	14.2
	2-6	-	230	42.5	0.58	5.28	58.0	240.0
	4-12	12	280	31.8	0.64	6.12	70.0	272.0
IRP	0.5-2.5	10	230	34.5	0.03	0.23	2.8	11.5
	2-6	10	230	34.5	0.44	4.08	48.0	182.0
	4-12	12	280	25.0	0.48	4.62	53.6	216.0
IRD	0.5-2.5	10	230	45.0	0.07	0.59	6.6	26.0
	2-6	10	230	45.0	1.04	9.9	106.0	420.0
	4-12	12	280	32.4	1.16	10.8	121.2	472.0

<sup>\$\</sup>phi\$ Degrees current lags voltage at tap value current.

# ENERGY REQUIREMENTS - 60 CYCLES DIRECTIONAL UNIT POLARIZING CIRCUIT BURDEN

RELAY TYPE	RATING	VOLT AMPERES △	POWER FACTOR ANGLE $\phi$
IRC	230 Amperes †	1.45	8° Lag
IRP	208 Volts ††	11.2	28° Lead
KRD Current Unit	230 Amperes ††	1.45	8° Lag
IRD Voltage Unit	208 Volts ††	11.2	28 ° Lead

 $<sup>\</sup>phi$  Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

<sup>††</sup> Voltages taken with Rectox type voltmeter.

 $<sup>\</sup>triangle \ \textit{Burden of voltage polarized units taken at 120 volts.} \textit{Burden of current polarized units taken at 5 amperes.}$ 

<sup>†</sup> One second rating.

 $<sup>\</sup>dagger\dagger$  30 second rating. The 10 second rating is 345 volts. The continuous rating is 120 volts.

#### TYPE IRD-2, IRC-2, IRP-2 TIME OVERCURRENT UNITS

					VOLT AMPERES††					
		CONTINUOUS	ONE SECOND	POWER	ΑT	AT 3 TIMES	AT 10 TIMES	AT 20 TIMES		
AMPERE		RATING	RATING†	FACTOR	TAP VALUE	TAP VALUE	TAP VALUE	TAP VALUE		
RANGE	TAP	(AMPERES)	(AMPERES)	$\underline{ANGLE\phi}$	CURRENT	CURRENT	CURRENT	CURRENT		
	0.5	0.91	28	58	4.8	39.6	256	790		
	0.6	0.96	28	57	4.9	39.8	270	851		
	0.8	1.18	28	53	5.0	42.7	308	1024		
0.5/2.5	1.0	1.37	28	50	5.3	45.4	348	1220		
	1.5	1.95	28	40	6.2	54.4	435	1740		
	2.0	2.24	28	36	7.2	65.4	580	2280		
	2.5	2.50	28	29	7.9	73.6	700	2850		
	2.0	3.1	110	59	5.04	38.7	262	800		
	2.5	4.0	110	55	5.13	39.8	280	920		
	3.0	4.4	110	51	5.37	42.8	312	1008		
2/6	3.5	4.8	110	47	5.53	42.8	329	1120		
	4.0	5.2	110	45	5.72	46.0	360	1216		
	5.0	5.6	110	41	5.90	50.3	420	1500		
	6.0	6.0	110	37	6.54	54.9	474	1800		
	4.0	7.3	230	65	4.92	39.1	268	848		
	5.0	8.0	230	50	5.20	42.0	305	1020		
	6.0	8.8	230	47	5.34	44.1	330	1128		
4/12	7.0	9.6	230	46	5.53	45.8	364	1260		
	8.0	10.4	230	43	5.86	49.9	400	1408		
	10.0	11.2	230	37	6.6	55.5	470	1720		
	12.0	12.0	230	34	7.00	62.3	528	2064		

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

φ Degrees current lags voltage at tap value current.

 $<sup>\</sup>dagger\dagger$  Voltages taken with Rectox type voltmeter.

# IRD-5, IRC-5, IRP-5, TIME OVERCURRENT UNITS

VOLT AMPERES † † AT 3 TIMES AT 10 TIMES AT 20 TIMES POWER ΑT CONTINUOUS ONE SECOND TAP VALUE TAP VALUE TAP VALUE TAP VALUE AMPERE RATING RATING† FACTOR CURRENT (AMPERES) CURRENT CURRENT CURRENT ANGLE  $\phi$ RANGE TAP (AMPERES) 270 88 69 3.92 20.6 103 2 (0.5)106 288 3.96 20.7 68 (0.6)2.2 88 114 325 21 (0.8)2.5 88 67 3.96 66 4.07 21.4 122 360 88 0.5/2.52.8 (1.0 147 462 23.2 (1.5 3.4 88 62 4.19 88 60 4.30 24.9 168 548 4.0 (2.0 180 630 88 26.2 4.37 58 (2.5 4.4 21 110 308 67 3.88 230 (2 8 342 21.6 118 (2.5 8.8 230 66 3.90 230 64 3.93 22.1 126 381 9.7 (3 136 417 23.1 2/6 10.4 230 63 4.09 (3.5)230 62 4.12 23.5 144 448 (4 11.2 162 540 24.8 4.20 (5 12.5 230 59 (6 13.7 230 57 4.38 26.5 183 624 376 126 460 65 4.00 22.4 (4 16 63 4.15 23.7 143 450 18.8 460 (5 531 162 (6 460 61 4.32 25.3 19.3 4.35 26.4 183 611 4/12 460 59 (7 20.8 204 699 (8 22.5 460 56 4,40 27.8 880 460 53 4.60 30.1 247 (10 25 47 4.92 35.6 288 1056 460 (12 28

#### IRD-7, IRC-7, IRP-7 TIME OVERCURRENT UNITS

VOLT AMPERES † † AT 10 TIMES AT 20 TIMES AT 3 TIMES POWER CONTINUOUS ONE SECOND AT TAP VALUE TAP VALUE TAP VALUE TAP VALUE AMPERE RATING T FACTOR RATING ANGLE  $\phi$ CURRENT CURRENT CURRENT CURRENT (AMPERES) (AMPERES) RANGE TAP 278 3.88 20.7 103 2 68 (0.5)88 288 107 67 3.93 20.9 2.2 (0.6)88 21.1 114 320 66 3.93 2.5 88 (0.8)122 356 21.6 64 4.00 0.5/2.52.8 88 (1.0 61 4.08 22.9 148 459 88 (1.5)3.4 174 552 24.8 4.24 4.0 88 58 (2.0 640 56 4.38 25.9 185 88 (2.5)4.4 306 66 4.06 21.3 111 230 (2 8 342 230 63 4.07 21.8 120 8.8 (2.5 22.5 129 366 63 4.14 (3 9.7 230 141 413 23.4 230 62 4.34 2/6 (3.5 10.4 61 4.34 23.8 149 448 230 (4 11.2 530 25.2 163 4.40 (5 12.5 230 59 624 4.62 27 183 230 58 (6 13.7 22.8 129 392 64 4.24 16 460 (4 24.2 149 460 61 4.30 460 (5 18.8 168 540 25.9 (6 19.3 460 60 4.62 4/12 27.3 187 626 58 4.69 460 (7 20.8 29.8 211 688 460 55 4.80 22.5 (8 860 5.20 33 260 51 (10 25 460 308 1032 5.40 37.5 460 46 28 (12

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

φ Degrees current lags voltage at tap value current.

<sup>††</sup> Voltages taken with Rectox type voltmeter.

IRD-8, IRC-8, IRP-8, TIME OVERCURRENT UNITS

					VOLT AMPERES ††				
		Continuous	One Second	Power	At	At 3 Times	At 10 Times	At 20 Times	
Ampere		Rating	Rating †	Factor	Tap Value	Tap Value	Tap Value	Tap Value	
Range	Tap	(Amperes)	(Amperes)	Angle $\phi$	Current	Current	Current	Ĉurrent	
	(0.5	2	88	72	2.38	21	132	350	
	(0.6	2.2	88	71	2.38	21	134	365	
0 = /0 =	(0.8	2.5	88	69	2.40	21.1	142	400	
0.5/2.5	(1.0	2.8	88	67	2.42	21.2	150	440	
	(1.5	3.4	88	62	2.51	22	170	530	
	(2.0	4.0	88	57	2.65	23.5	200	675	
	(2.5	4.4	88	53	2.74	24.8	228	800	
	(2	8	230	70	2.38	21	136	360	
	(2.5	8.8	230	66	2.40	21.1	142	395	
	(3	9.7	230	64	2.42	21.5	149	430	
2/6	(3.5	10.4	230	62	2.48	22	157	470	
	(4	11.2	230	60	2.53	22.7	164	500	
	(5	12.5	230	58	2.64	24	180	580	
	(6	13.7	230	56	2.75	25.2	198	660	
	(4	16	460	68	2.38	21.3	146	420	
	(5	18.8	460	63	2.46	21.8	158	480	
	(6	19.3	460	60	2.54	22.6	172	550	
4/12	(7	20.8	460	57	2.62	23.6	190	62 <b>0</b>	
	(8	22.5	460	54	2.73	24.8	207	700	
	(10	25	460	48	3.00	27.8	248	850	
	(12	28	460	45	3.46	31.4	292	1020	

IRD-11, IRC-11, IRP-11 OVERCURRENT UNITS

	IND-11, INC-11, INF-11 OVERCORRENT UNITS										
						VOLT AM	PERES ††				
Ampere Range	Тар	Continuous Rating (Amperes)	One Second Rating † (Amperes)	Power Factor Angle $\phi$	At Tap Value Current	At 3 Times Tap Value Current	At 10 Times Tap Value Current	At 20 Times Tap Value Current			
0.5/2.5	0.5 0.6 0.8 1.0 1.5 2.0 2.5	1.7 1.9 2.2 2.5 3.0 3.5 3.8	56 56 56 56 56 56	36 34 30 27 22 17 16	0.72 0.75 0.81 0.89 1.13 1.30	6.54 6.80 7.46 8.30 10.04 11.95 13.95	71.8 75.0 84.0 93.1 115.5 136.3 160.0	250 267 298 330 411 502 610			
2/6	2.0 2.5 3.0 3.5 4.0 5.0 6.0	7.0 7.8 8.3 9.0 10.0 11.0 12.0	230 230 230 230 230 230 230 230	32 30 27 24 23 20 20	0.73 0.78 0.83 0.88 0.96 1.07 1.23	6.30 7.00 7.74 8.20 9.12 9.80 11.34	74.0 78.5 84.0 89.0 102.0 109.0 129.0	264 285 309 340 372 430 504			
4/12	4.0 5.0 6.0 7.0 8.0 10.0 12.0	14 16 17 18 20 22 26	460 460 460 460 460 460 460	29 25 22 20 18 17 16	0.79 0.89 1.02 1.10 1.23 1.32 1.8	7.08 8.00 9.18 10.00 11.1 14.9 16.3	78.4 90.0 101.4 110.0 124.8 131.6 180.0	296 340 378 454 480 600 720			

## IRD TIME OVERCURRENT UNIT BURDEN DATA AT HIGH CURRENTS

Ampere Range	.5-2.5								
Tap Value Current	.5	5	1	.0	2	.5			
Multiples of Tap Value Current	40	80	20	40	8	16			
VA ††	790	2600	380	1280	60	280			
P.F. Angle $\phi$	46.7°	42 °	37 °	26.5 °	4.8 °	4.3 °			

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

<sup>\$\</sup>phi Degrees current lags voltage at tap value current.

<sup>††</sup>Voltages taken with Rectox type voltmeter.

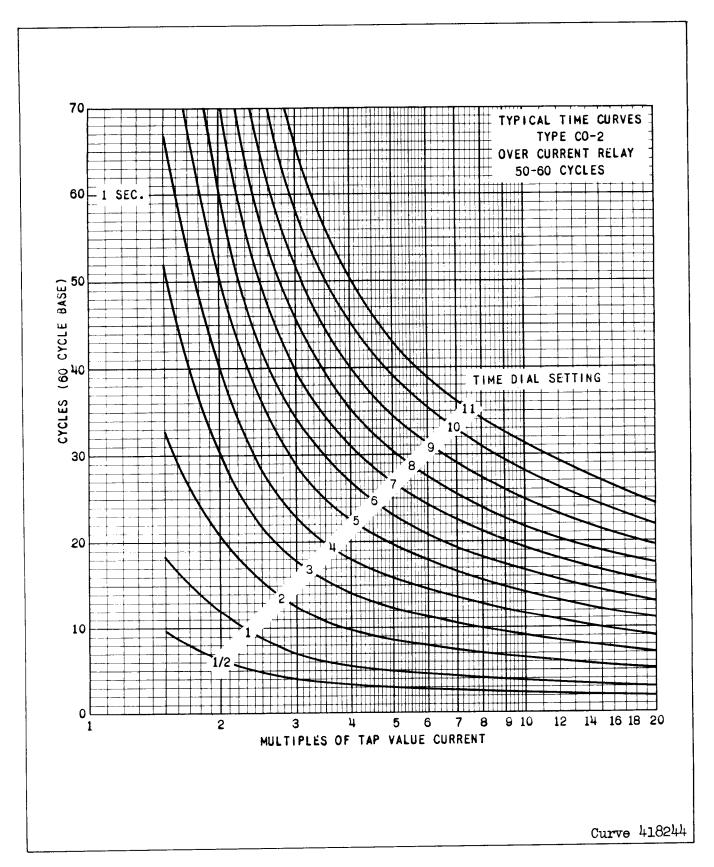


Fig. 10. Typical Time Curves of the Time-Overcurrent Unit of the Short Time (2) Relays.

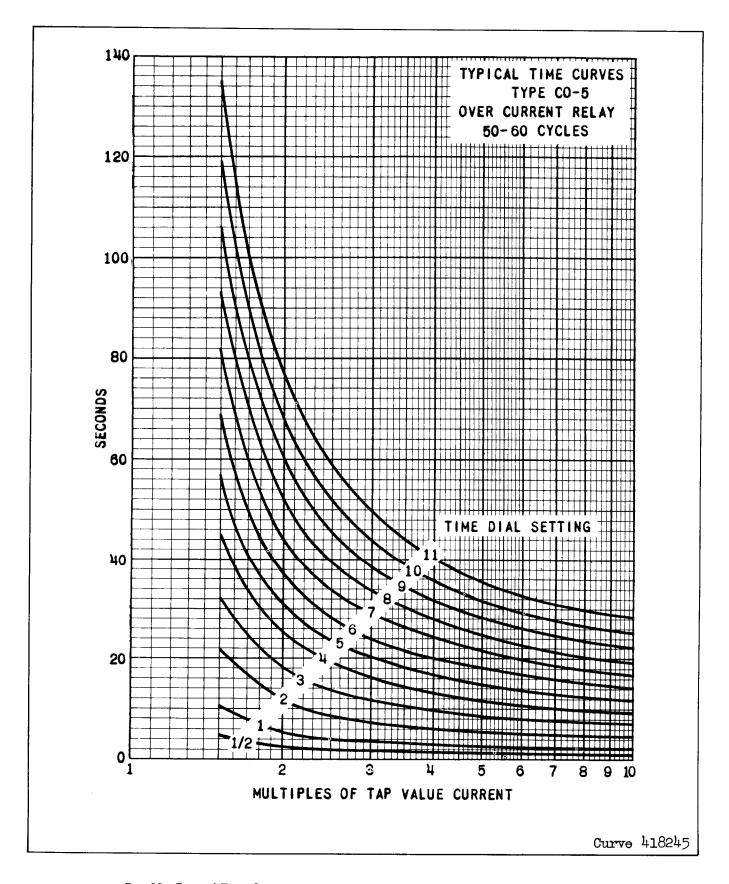


Fig. 11. Typical Time Curve of the Time-Overcurrent Unit of the Long Time (5) Relays.

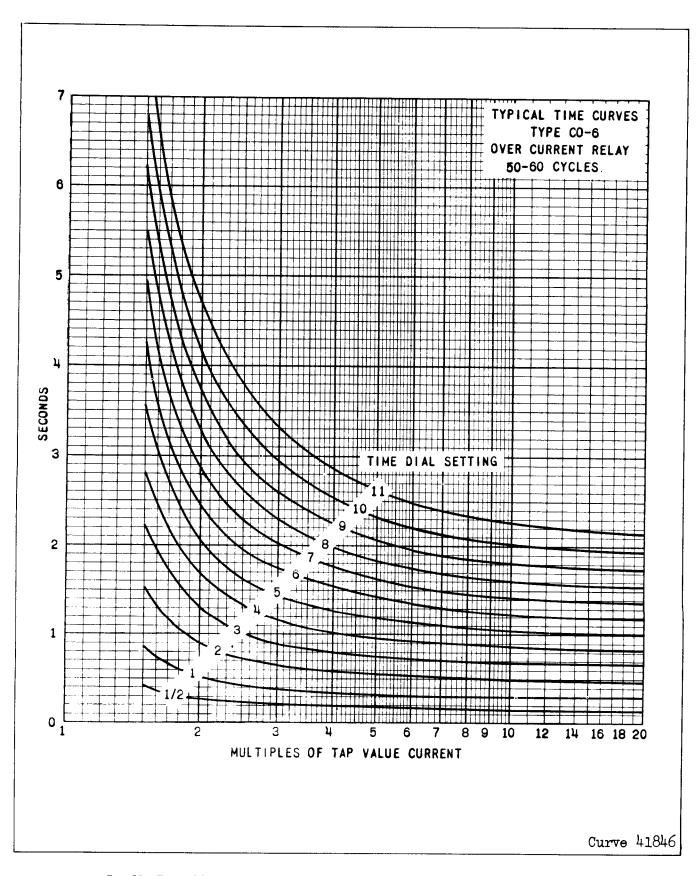


Fig. 12. Typical Time Curve of the Time-Overcurrent Unit of the Definite Time (6) Relays.

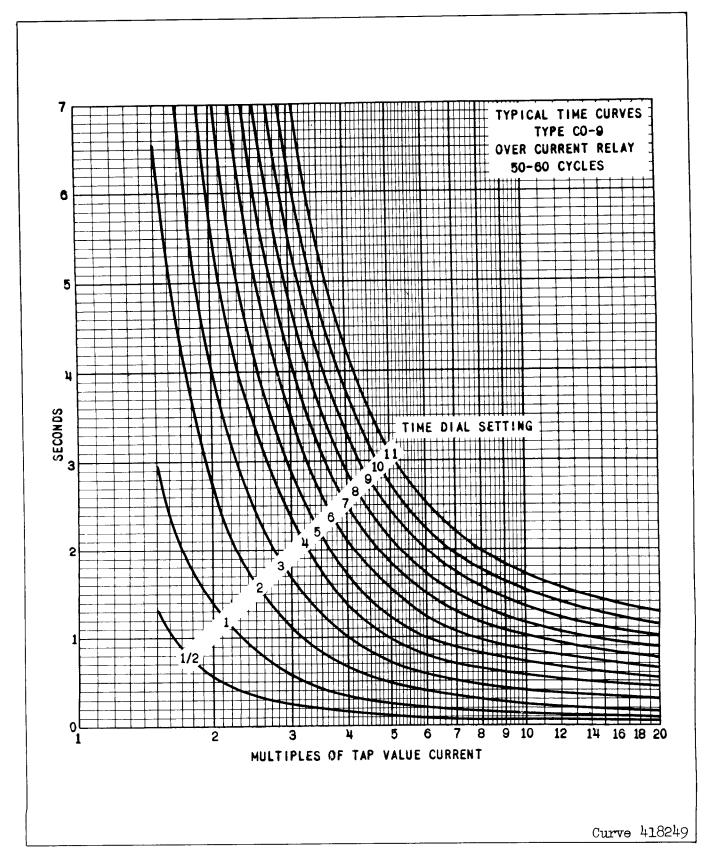


Fig. 15. Typical Time Curve of the Time-Overcurrent Unit of the Very Inverse (9) Relays.

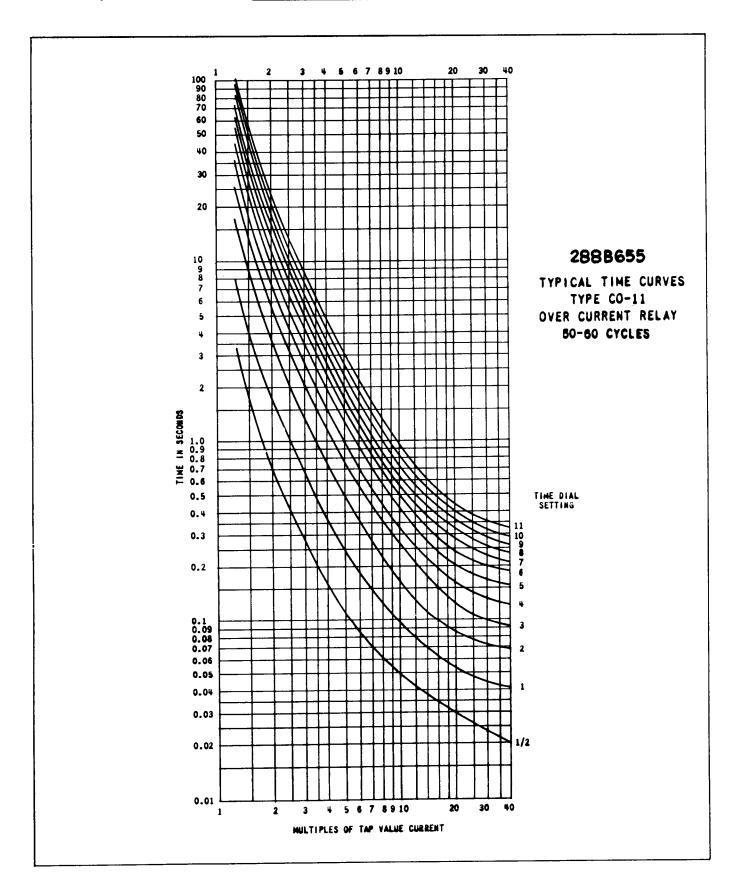


Fig. 16. Typical Time Curve of the Time-Overcurrent Unit of the Extremely Inverse (11) Relays.

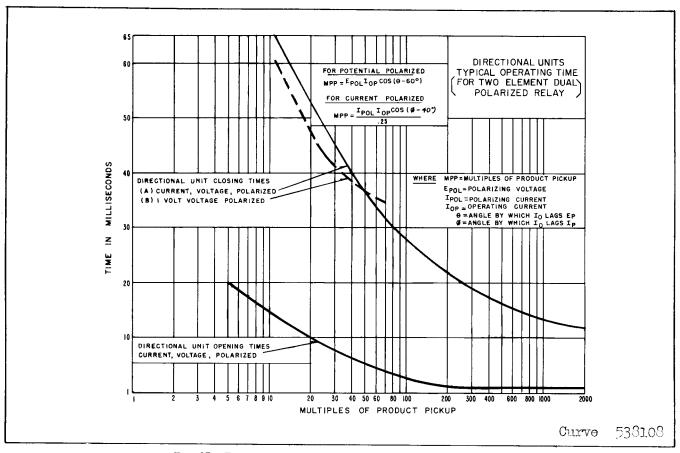


Fig. 17. Typical Operating Times For The Directional Unit.

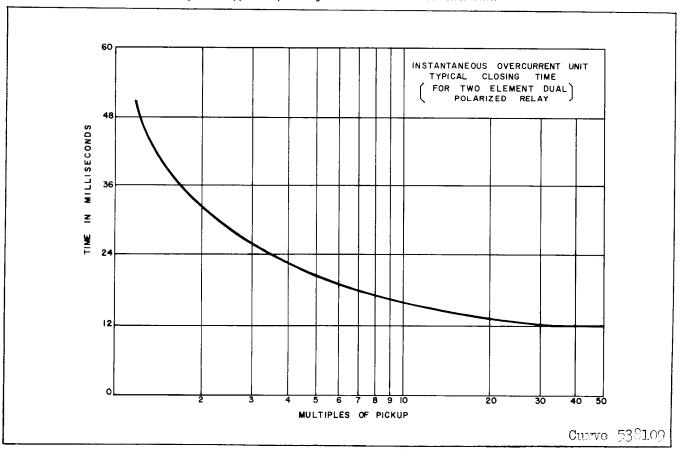


Fig. 18. Typical Operating Times For The Instantaneous Overcurrent Unit.

### Trip Circuit Constants

Indicating Contactor Switch -

0.2 ampere tap - 6.5 ohms d-c resistance

2.0 ampere tap -0.15 ohms d-c resistance

### Auxiliary Switch (CS-1)

The auxiliary switch has a d-c resistance of 1165 ohms.

### Type IRP Relay

The IRP 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 pick-up is approximately 1 volt and 2 amperes at its maximum torque angle for the directional units used with the 0.5 to 2.5 and 2 to 6 ampere range time over-current units. For the directional units used with the 4-12 ampere range time overcurrent units the minimum pick-up is 1 volt and 4 amperes.

### Type IRC Relay

The IRC relay is designed for current polarization and has its maximum torque when the operating current leads the polarizing current by approximately  $40^{\circ}$ .

The directional unit minimum pick-up is 0.5 ampere in each winding at the maximum torque angle for the directional units used with the 0.5 to 2.5 and 2 to 6 ampere range time overcurrent units. For the directional units used with the 4-12 ampere range time overcurrent units the minimum pickup is 1 ampere.

### Type IRD Relay

The type IRD relay utilizes a directional unit similar to the IRC relay in conjunction with the directional unit and phase-shifting circuit of the IRP relay.

The current-polarized directional unit of the IRD relay operates on residual currents while the potential-polarized directional unit of the IRD relay operates on residual voltage and residual current.

For the directional units used with the 0.5 to 2 and 2 to 6 ampere time overcurrent units, the minimum pick-up of the current polarized unit is 0.5 ampere in each winding at the maximum torque angle. The minimum pick-up for the voltage polarized unit is

1 volt and 2 amperes with the current lagging voltage by  $60^{\circ}$ .

For the directional units used with the 4 to 12 ampere range time overcurrent units, the minimum pick-up is 1 ampere for the current-polarized directional unit and 1 volt and 4 amperes for the voltage-polarized directional unit.

### **SETTINGS**

### Time Overcurrent Unit (CO)

The time overcurrent unit settings can be defined either by tap setting and time dial position or by tap setting and a specific time of operation at some current multiple of the tap setting (e.g. 4 tap setting, 2 time dial position or 4 tap setting, 0.6 seconds at 6 times tap value current).

To provide selective circuit breaker operation, a minimum coordinating time of 0.3 seconds plus circuit breaker time is recommended between the relay being set and the relays with which coordination is to be effected.

The connector screws on the tap plate above the time dial makes connections to various turns on the operating coil. By placing this screw in the various tap plate holes, the relay will just close its contacts at the corresponding current 4-5-6-7-8-19-12 amperes, or as marked on the tap plate.

**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 space connector screw in the desired position before removing the other tap screw from the original tap position.

### Instantaneous Reclosing

The factory adjustment of the CO unit contacts provides a contact follow. Where circuit breaker reclosing will be intiated immediately after a trip by the CO contact, the time of the opening of the contacts should be a minimum. This condition is obtained by loosening the stationary contact mounting screw, removing the contact plate and then replacing the plate with the bent end resting against the contact spring. With this change and the contact mounting screw tightened, the stationary contact will rest solidly against its backstop.

### Instantaneous Overcurrent Unit (1)

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.

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.

### Directional Units (D)

No setting is required.

### Indicating Contactor Switch (ICS/I and ICS/T)

The setting required on the ICS units is the selection of the 0.2 or 2.0 ampere tap setting. This selection is made by connecting the lead located in front of the tap block to the desired setting by means of the connecting screw.

#### Auxiliary Switch (CS-1)

No setting required on the CS-1 unit except for the selection of the required 24, 48, 125 or 250 voltage on the tapped rexistor. This connection can be made by referring to Fig. 23.

### 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 be means of the two mounting studs for the type FT projection case or by means of the four mounting holes on the flange for the semi-flush type FT case. 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 detail information on the FT Case refer to I.L. 41-076.

The external a-c connections of the directional overcurrent relays are shown in Figs. 20, 21 and 22. If no voltage polarizing source is to be connected to the IRD relay, short-circuit the voltage polarizing circuit at the terminals of the relay.

### 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;

### Instantaneous 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. <u>Minimum Trip Current</u> 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 within  $\pm 5\%$  of tap value current.

### Directional Unit (D)

- 1. Contact Gap The gap between the stationary contact and moving contact with the relay in the deenergized position should be approximately .020".
- 2. <u>Sensitivity</u> The respective directional units should trip with value of energization and phase angle relationship 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 with the polarizing circuits short circuited for the voltage polarized units and open-circuited for the current polarized units.

### Time Overcurrent Unit (CO)

- 1. Contacts The index mark on the movement frame will coincide with the "O" mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "O" mark by approximately .020". The placement of the various time dial positions in line with the index mark will give operating times as shown on the respective time-current curves.
- 2. <u>Minimum Trip Current</u> Set the time dial to position 6 with the auxiliary switch (CS-1) contacts

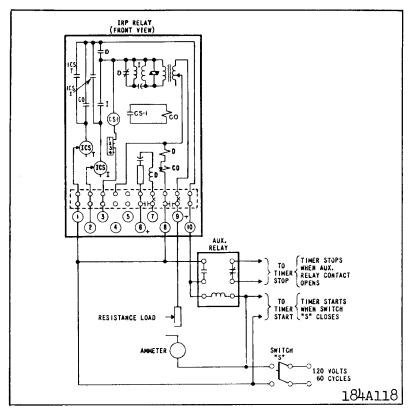


Fig. 19. Diagram of test connections of the time-overcurrent unit.

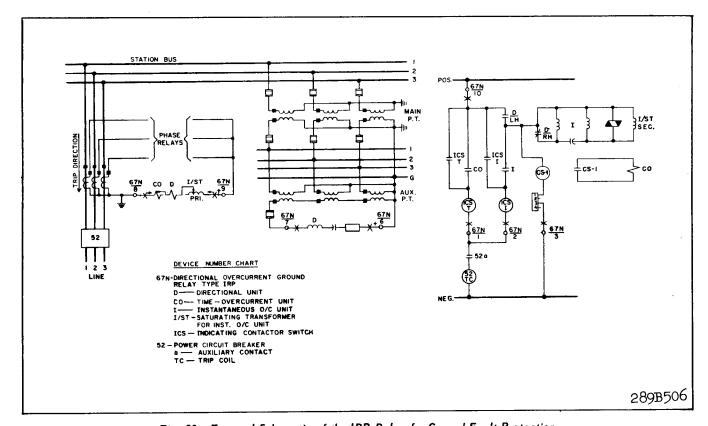


Fig. 20. External Schematic of the IRP Relay for Ground Fault Protection.

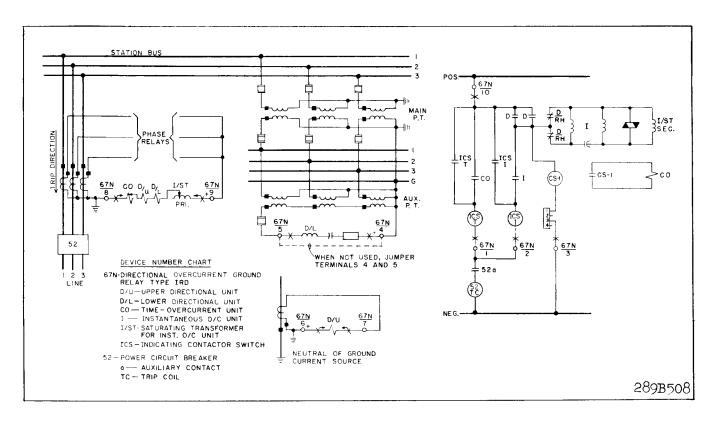


Fig. 21. External Schematic of the IRD Relay for Ground Fault Protection.

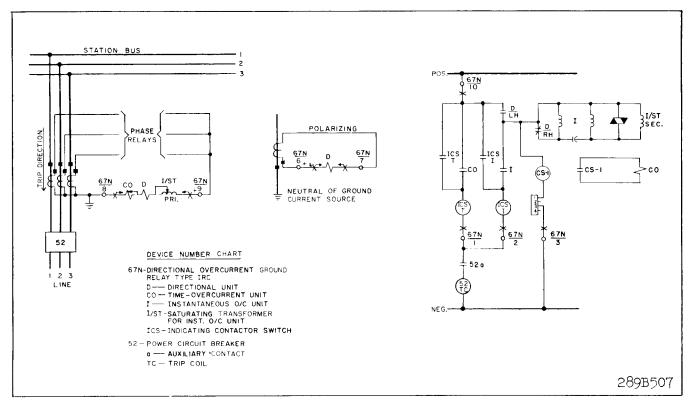


Fig. 22. External Schematic of the IRC Relay for Ground Fault Protection.

blocked closed, alternately apply tap value current plus 3% and tap value current minus 3%. The moving contact should leave the backstop at tap value current plus 3% and should return to the backstop at tap value current minus 3%.

3. <u>Time Curve</u> — Table 3 shows the time curve calibration points for the various types of relays. With the time dial set to the indicated position, apply the currents specified by Table 3 (e.g. for the CO-2, 3 and 20 times tap value current) and measure the operating time of the relay. The operating times should equal those of Table 3 plus or minus 5 percent.

### Indicating Contactor Switches (ICS/I) and (ICS/T)

- A) Close the contacts of the CO and pass sufficient d.c. current through the trip circuit to close the contacts of (ICS/T). This value of current should not be greater than the particular (ICS/T) tap setting being used. The operation indicator target should drop freely, bringing the letter "T" into view.
- B) Close the contacts of the instantaneous overcurrent unit (I) and the directional unit (D). Pass sufficient d.c. current through the trip circuit to close the contacts of (ICS/I). This value of current should not be greater than the particular (ICS/I) tap setting being used. The operation indicator target should drop freely, bringing the letter "I" into view.
- C) The contact gap should be approximately .047" 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 time of 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. The use of phantom loads, in testing induction-type relays, should be avoided, since the resulting distorted current wave form will produce an error in timing.

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

### Calibration

Use the following procedure for calibrating the

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

### Instantaneous Overcurrent Unit (1)

- 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, i.e., against the right side of the bridge. Move 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 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  $\pm 5\%$  of tap value.

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.

### Directional Unit (D)

In the type IRP and IRC relays the directional unit is the lower cylinder unit. In the type IRD the directional units are the lower and middle cylinder 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 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 as indicated by a neon lamp in the contact circuit when energized with the required current and voltage as shown in Table 1. 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 or voltage 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 (IRP and IRD voltage polarized unit) are short-circuited.
- b) The polarizing circuits of the current polarized relays (IRC and IRD 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 some installations in order to insure that the relay will always trip the breaker on zero potential.

### Time Overcurrent Unit (CO)

- 1. Contacts The index mark on the movement frame will coincide with the "O" mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "O" mark by approximately .020". The placement of the various time dial positions in line with the index mark will give operating times as shown on the respective time-current curves.
- 2) <u>Minimum Trip Current</u> The adjustment of the spring tension in setting the minimum trip current value of the relay is most conveniently made with the damping magnet removed.

With the time dial set on "O", wind up the spiral spring by means of the spring adjuster until approximately 6-3/4 convolutions show.

Set the relay on the minimum tap setting, the time dial to position 6.

With the auxiliary switch (CS-1) contacts blocked closed, adjust the control spring tension so that the moving contact will leave the backstop at tap value current +1.0% and will return to the backstop at tap value current -1.0%.

3) <u>Time Curve Calibration</u> — Install the permanent magnet.

Apply the indicated current per Table 3 for permanent magnet adjustment (e.g. IRP-8, 2 times tap value) and measure the operating time. Adjust the permanent magnet keeper until the operating time corresponds to the value of Table 3.

Apply the indicated current per Table 3 for the electromagnet plug adjustment (e.g. IRP-8, 20 times tap value) and measure the operating time. Adjust the proper plug until the operating time corresponds to the value in Table 3. (Withdrawing the left hand plug, front view increases the operating time and withdrawing the right hand plug, front view, decreases the time.) In adjusting the plugs, one plug should be

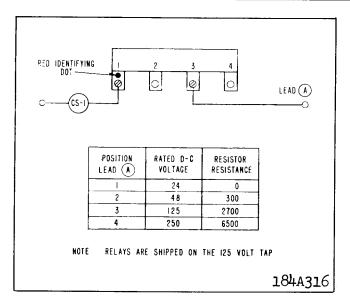


Fig. 23. Selection of Proper Voltage Tap for Auxiliary Switch (CS-1) Operation.

screwed in completely and the other plug run in or out until the proper operating time has been obtained.

Recheck the permanent magnet adjustment. If the operating time for this calibration point has changed, readjust the permanent magnet and then recheck the electromagnet plug adjustment.

### Indicating Contactor Switches (ICS/I) and (ICS/T)

Adjust the contact gap for approximately .047".

A) Close the contacts of the CO and pass sufficient d.c. current through the trip circuit to close the contacts of the (ICS/T). This value of current should not be greater than the particular (ICS/T) tap setting being used. The operation indicator target should drop freely bringing the letter "T" into view.

B) Close contacts of instantaneous overcurrent unit (I) and directional unit (D). Pass sufficient d.c. current through the trip circuit to close contacts of the (ICS/I). This value of current should not be greater than the particular (ICS/I) tap setting being used. The operation indicator target should drop freely bringing the letter "I" into view.

### Auxiliary Switch (CS-1)

Adjust the stationary core of the switch for a clearance between the stationary core and the moving core when the switch is picked up. This can be done by turning the relay upside-down. Then screw up the core screw until the moving core starts rotating. Now back off the core screw until the moving core stops rotating. This indicates the points where the play in the assembly is taken up, and where the moving core just separates from the stationary core screw. Back off the core screw approximately one turn and lock in place. This prevents the moving core from striking and sticking to the stationary core because of residual magnetism. Adjust the contact clearance for 3/64" by means of the two small nuts on either side of the Micarta disc.

Connect lead (A) to proper terminal per Fig. 23. Block directional unit (D) contacts close and energize trip circuit with rated voltage. Contacts of auxiliary switch (CS-1) should make as indicated by a neon lamp in the contact circuit.

### 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.

TABLE I DIRECTIONAL UNIT SENSITIVITY

	DIKE	CITONAL UNIT	3E1/3[1] 4 [ ] 1	
RELAY TYPE	AMPERE RATING OF	VALUES FOI	R MIN. PICKUP †	PHASE ANGLE RELATIONSHIP
	TIME-OVERCURRENT UNIT	VOLTS AMPERES		
	.5-2.5	1	2.0	I lagging V by 60°††
IRP IRD (Voltage	2-6	1	4.0	I in-phase with V
Unit)	4.10	1	4.0	I lagging V by 60° ††
	4-12	1	8.0	I in-phase with V
ID C	.5-2.5		0.5	I <sub>O</sub> leading I <sub>D</sub> by 40°††
IRC IRD (Current $\triangle$ Unit)	2-6		. 57	In-phase
	4-12		1.0	$I_0$ leading $I_p$ by $40^{\circ}$ ††
			1.3	In-phase

<sup>†</sup> The energization quantities are input quantities at the relay terminals.

<sup>††</sup> Maximum torque angle.

<sup>△</sup> When normal system conditions limit the current to less than twice pickup, performance may be improved by sellecting a higher current C.T. tap to energize the polarizing circuit.

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) (Contacts remain open)	Left (Front View) Plug Screwed Out Until Spurious Torque is in Contact Closing Direction. Then the plug is screwed in Until Spuri ous Torque is Reversed.	

<sup>†</sup> Short circuit the voltage polarizing circuit at the relay terminals before making the above adjustment.

TABLE III

TIME CURVE CALIBRATION DATA - 60 CYCLES

-	PERMANENT	MAGNET ADJUSTM	MENT	ELECTROMAGN	ET PLUGS
TIME- OVERCURRENT UNIT TYPE	TIME DIAL POSITION	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS
2	6	3	0.57	20	0.22
5	6	2	37.80	10	14.30
6	6	2	2.46	20	1.19
7	6	2	4.27	20	1.11
8	6	2	13.35	20	1.11
9	6	2	8.87	20	0.65
11	6	2	11.27	20	0.24

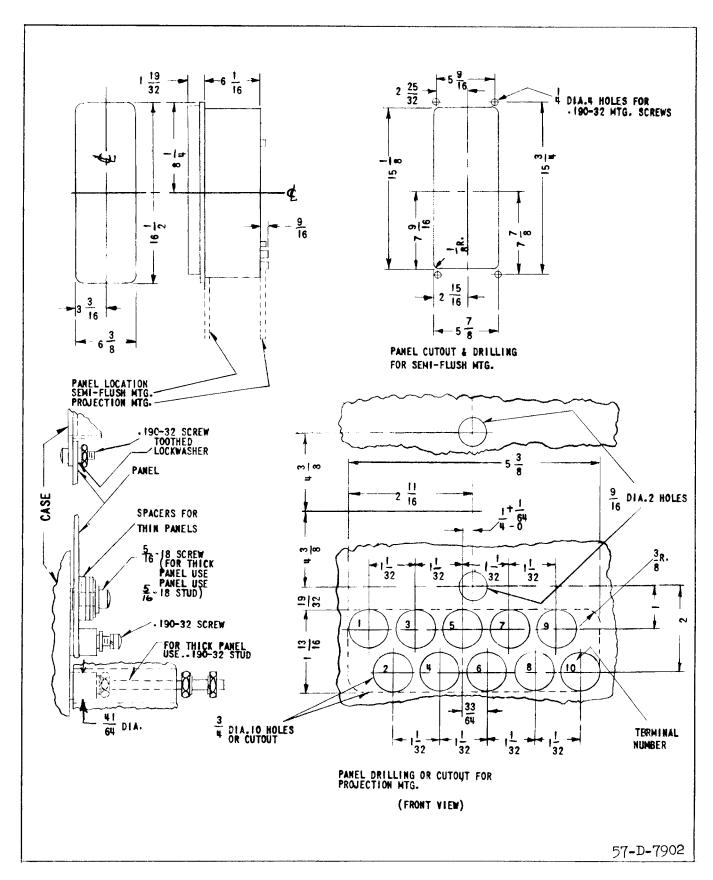


Fig. 24. Outline and Drilling Plan for the IRP and IRC Relays in the Type FT31 Case.

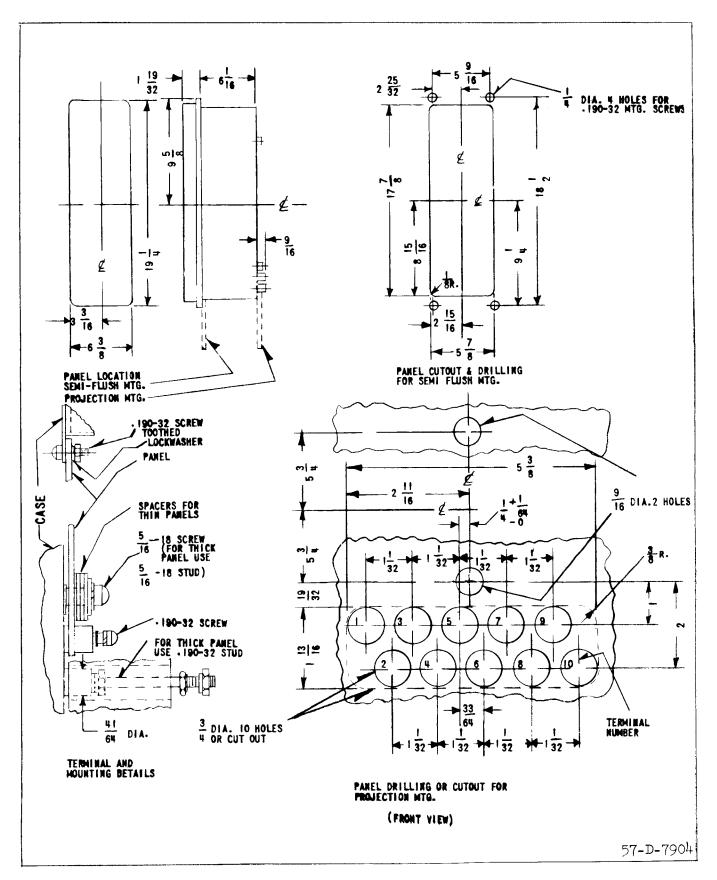


Fig. 25. Outline and Drilling Plan for the IRD Relay in the Type FT41 Case.

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### INSTALLATION . OPERATION . MAINTENANCE

# INSTRUCTIONS

# DIRECTIONAL OVERCURRENT GROUND RELAYS TYPES IRP, IRC AND IRD

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**

These relays are ground directional overcurrent relays which are used for the protection of transmission lines and feeder circuits. Both the time-overcurrent and instantaneous overcurrent units are directionally controlled.

The type IRP relay is potential polarized. The type IRC relay is current polarized. The type IRD relay is a dual polarized relay which can be polarized from a potential source, from a local ground source or from both simultaneously.

### CONSTRUCTION AND OPERATION

The various types of relays consist of a directional unit or units (D), an auxiliary switch (CS-1), a time-overcurrent unit (CO), an instantaneous overcurrent unit (I), an instantaneous overcurrent unit transformer, and two indicating contactor switches (ICS/I) and (ICS/T). The principle component parts of the relays and their location are shown in Fig. 1 through 6.

### Time-Overcurrent Unit (CO)

The electromagnets for the types IR-5, IR-6, IR-7, IR-8 and IR-9 relays have a main tapped coil located on the center leg of an "E" type laminated structure that produces a flux which divides and returns through the outer legs. A shading coil causes the flux through the left leg to lag the main pole flux. The out-of-phase fluxes thus produced in the air gap cause a contact closing torque.

The electromagnet for the type IR-2 and IR-11 relays has a main coil consisting of a tapped primary winding a secondary winding. Two identical coils

on the outer legs of the lamination structure are connected to the main coil secondary in a manner so that the combination of all the fluxes produced by the electromagnet result in out-of-phase fluxes in the air gap. The out-of-phase air gap fluxes produced cause a contact closing torque.

### Indicating Contactor Switch Units (ICS/I and ICS/T)

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

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

### 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 the magnetic core. The magnetic core which houses the lower pin bearing is secured to the 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

ENERGY REQUIREMENTS

INSTANTANEOUS OVERCURRENT UNIT OPERATING CURRENT CIRCUIT - 60 CYCLES

AMPERE RANGE	TAP	VA AT TAP VALUE	P.F. ANGLE	VA AT 5 AMPS.	P.F. ANGLE	
	.5	.37	39	24	46	
	.75	.38	36	13	37	
	1	.39	35	8.5	34	
.5-2	1.25	.41	34	6.0	32	
	1.5	.43	32	4.6	31	
	2	.45	30	2.9	28	
	1	.41	36	9.0	36	
	1.5	.44	32	5.0	32	
	2	.47	30	3.0	29	
1-4	2.5	.50	28	2.1	27	
	3	.53	26	1.5	26	
	4	.59	24	0.93	24	
	2	1.1	49	6.5	48	
	3	1.2	43	3.3	42	
0.0	4	1.3	38	2.1	37	
2-8	5	1.4	35	1.4	35	
	6	1.5	33	1.1	33	
	8	1.8	29	0.7	29	
	4	1.5	51	2.4	51	
	6	1.7	45	1.2	45	
4-16	8	1.8	40	0.7	40	
	9	1.9	38	0.6	38	
	12	2.2	34	0.37	34	
	16	2.5	30	0.24	31	
	10	1.7	28	0.43	28	
	15	2.4	21	0.27	21	
10-40	20	3.1	16	0.20	17	
10-40	24	3.6	15	0.15	15	
	30	4.2	12	0.11	13	
	40	4.9	11	0.08	12	
	20	6.6	31	0.40	31	
	30	9.3	24	0.25	24	
20-80	40	12	20	0.18	20	
	48	13.5	18	0.14	18	
	60	15.9	16	0.10	16	
	80	19.2	15	0.07	15	
RANGE		CONTINUOUS RATI	NG	ONE SECOND R	ATING	
		(AMPERES)		† (AMPERES		
. 5-2		5	-	100		
1-4		8		140		
2-8		8		140		
4-16		10		200		
10-40		10		200		
20-80		40				
20-00		10		200		

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

 $<sup>\</sup>phi$  Degrees current lags voltage,

 $<sup>\</sup>dagger$  † Voltages taken with Rectox type voltmeter.

### IRD INSTANTANEOUS OVERCURRENT UNIT BURDEN DATA AT HIGH CURRENTS

Ampere Range 10-40												
Tap Value Current	10			20				40				
Multiples of Tap Value Current	22	4	6	8	1	2	3	4	.5	1	1.5	2.0
VA π	9	36.8	84	156	5	26	57	104	4.8	19.2	44.4	78.8
P.F. Angle $\phi$	18.7°	18.3 °	17.5 °	15.7°	9.3°	8.5 °	8.8 °	9.0°	$4.5^\circ$	4.5 °	4.5 °	4.8 °

# ENERGY REQUIREMENTS - 60 CYCLES DIRECTIONAL UNIT OPERATING CIRCUIT BURDEN

						VO	LT AMPERES	††
Relay Range Type Amps	Range Amps	Continuous Rating (Amperes)	One Second Rating † (Amperes)	Power Factor Angle $\phi$	At Minimum Tap Value Current	At 3 Times Minimum Tap Value Current	At 10 Times Minimum Tap Value Current	At 20 Times Minimum Tap Value Current
IRC	0.5-2.5	-	230	44.0	0.033	0.30	3.3	14.2
	2-6	-	230	42.5	0.58	5.28	58.0	240.0
	4-12	12	280	31.8	0.64	6.12	70.0	272.0
IRP	0.5-2.5	10	230	34.5	0.03	0.23	2.8	11.5
	2-6	10	230	34.5	0.44	4.08	48.0	182.0
	4-12	12	280	25.0	0.48	4.62	53.6	216.0
IRD	0.5-2.5	10	230	45.0	0.07	0.59	6.6	26.0
	2-6	10	230	45.0	1.04	9.9	106.0	420.0
	4-12	12	280	32.4	1.16	10.8	121.2	472.0

<sup>\$\</sup>phi\$ Degrees current lags voltage at tap value current.

## ENERGY REQUIREMENTS - 60 CYCLES DIRECTIONAL UNIT POLARIZING CIRCUIT BURDEN

RELAY TYPE	RATING	VOLT AMPERES △	POWER FACTOR ANGLE $\phi$
IRC	230 Amperes †	1.45	8° Lag
IRP	208 Volts ††	11.2	28 ° Lead
KRD Current Unit	230 Amperes ††	1.45	8° Lag
IRD Voltage Unit	208 Volts ††	11.2	28 ° Lead

<sup>\$\</sup>phi\$ Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.

 $\Delta$  Burden of voltage polarized units taken at 120 volts. Burden of current polarized units taken at 5 amperes.

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

<sup>††</sup> Voltages taken with Rectox type voltmeter.

<sup>†</sup> One second rating.

<sup>††30</sup> second rating. The 10 second rating is 345 volts. The continuous rating is 120 volts.

### **ENERGY REQUIREMENTS**

IRD-8, IRC-8, IRP-8, TIME OVERCURRENT UNITS IRD-9, IRC-9, IRP-9,

	_					VOLT AMP	ERES ††	
		Continuous	One Second	Power	At	At 3 Times	At 10 Times	At 20 Times
Ampere		Rating	Rating †	Factor	Tap Value	Tap Value	Tap Value	Tap Value
Range	Тар	(Amperes)	(Amperes)	Angle $\phi$	Current	Current	Current	Current
	(0.5	2	88	72	2.38	21	132	350
	(0.6	2.2	88	71	2.38	21	134	365
_	(0.8	2.5	88	69	2.40	21.1	142	400
0.5/2.5	(1.0	2.8	88	67	2.42	21.2	150	440
	(1.5	3.4	88	62	2.51	22	170	530
	(2.0	4.0	88	57	2.65	23.5	200	675
	(2.5	4.4	88	53	2.74	24.8	228	800
	(2	8	230	70	2.38	21	136	360
	(2.5	8.8	230	66	2.40	21.1	142	395
	(3	9.7	230	64	2.42	21.5	149	430
2/6	(3.5	10.4	230	62	2.48	22	157	470
·	(4	11.2	230	60	2.53	22.7	164	500
	(5	12.5	230	58	2.64	24	180	580
	(6	13.7	230	56	2.75	25.2	198	660
	(4	16	460	68	2.38	21.3	146	420
	(5	18.8	460	63	2.46	21.8	158	480
	(6	19.3	460	60	2.54	22.6	172	550
4/12	(7	20.8	460	57	2.62	23.6	190	620
_,	(8	22.5	460	54	2.73	24.8	207	700
	(10	25	460	48	3.00	27.8	248	850
	(12	28	460	45	3.46	31.4	292	1020

IRD-11, IRC-11, IRP-11 OVERCURRENT UNITS

			110 11, 110	11, 1101 11	STERCORREN			
						VOLT AM	PERES ††	
Ampere Range	Тар	Continuous Rating (Amperes)	One Second Rating † (Amperes)	Power Factor Angle $\phi$	At Tap Value Current	At 3 Times Tap Value Current	At 10 Times Tap Value Current	At 20 Times Tap Value Current
0.5/2.5	0.5 0.6 0.8 1.0 1.5 2.0 2.5	1.7 1.9 2.2 2.5 3.0 3.5 3.8	56 56 56 56 56 56	36 34 30 27 22 17 16	0.72 0.75 0.81 0.89 1.13 1.30 1.48	6.54 6.80 7.46 8.30 10.04 11.95 13.95	71.8 75.0 84.0 93.1 115.5 136.3 160.0	250 267 298 330 411 502 610
2/6	2.0 2.5 3.0 3.5 4.0 5.0 6.0	7.0 7.8 8.3 9.0 10.0 11.0	230 230 230 230 230 230 230 230 230	32 30 27 24 23 20 20	0.73 0.78 0.83 0.88 0.96 1.07 1.23	6.30 7.00 7.74 8.20 9.12 9.80 11.34	74.0 78.5 84.0 89.0 102.0 109.0 129.0	264 285 309 340 372 430 504
4/12	4.0 5.0 6.0 7.0 8.0 10.0 12.0	14 16 17 18 20 22 26	460 460 460 460 460 460 460	29 25 22 20 18 17 16	0.79 0.89 1.02 1.10 1.23 1.32 1.8	7.08 8.00 9.18 10.00 11.1 14.9 16.3	78.4 90.0 101.4 110.0 124.8 131.6 180.0	296 340 378 454 480 600 720

### IRD TIME OVERCURRENT UNIT BURDEN DATA AT HIGH CURRENTS

Ampere Range	.5-2.5								
Tap Value Current	.5	5	1.	.0	2.5				
Multiples of Tap Value Current	40	80	20	40	8	16			
VA ††	790	2600	380	1280	60	280			
P.F. Angle $\phi$	46.7°	42 °	37 °	26.5 °	4.8	4.3 °			

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

Degrees current lags voltage at tap value current.

TtVoltages taken with Rectox type voltmeter.

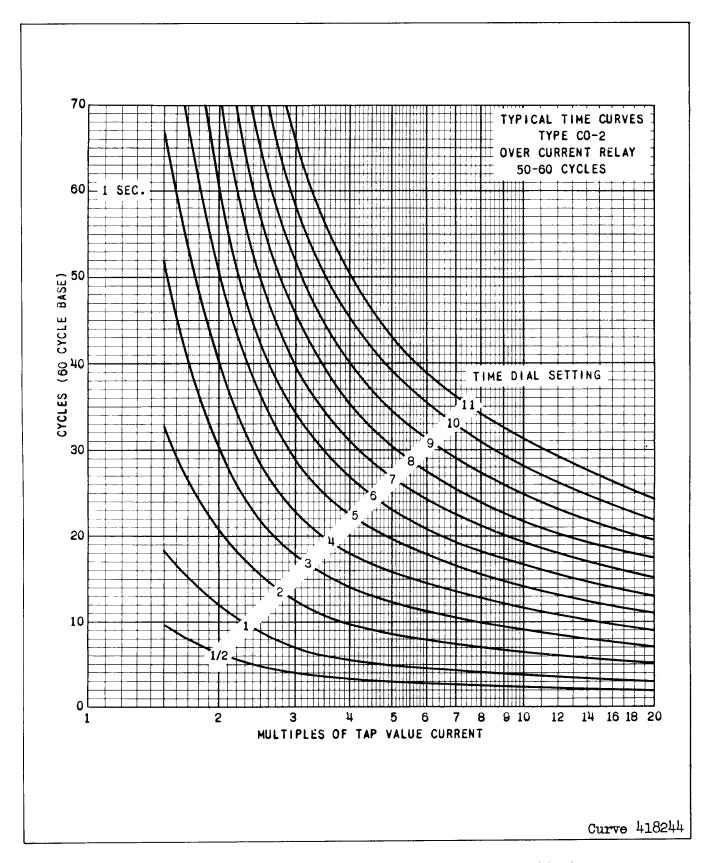


Fig. 10. Typical Time Curves of the Time-Overcurrent Unit of the Short Time (2) Relays.

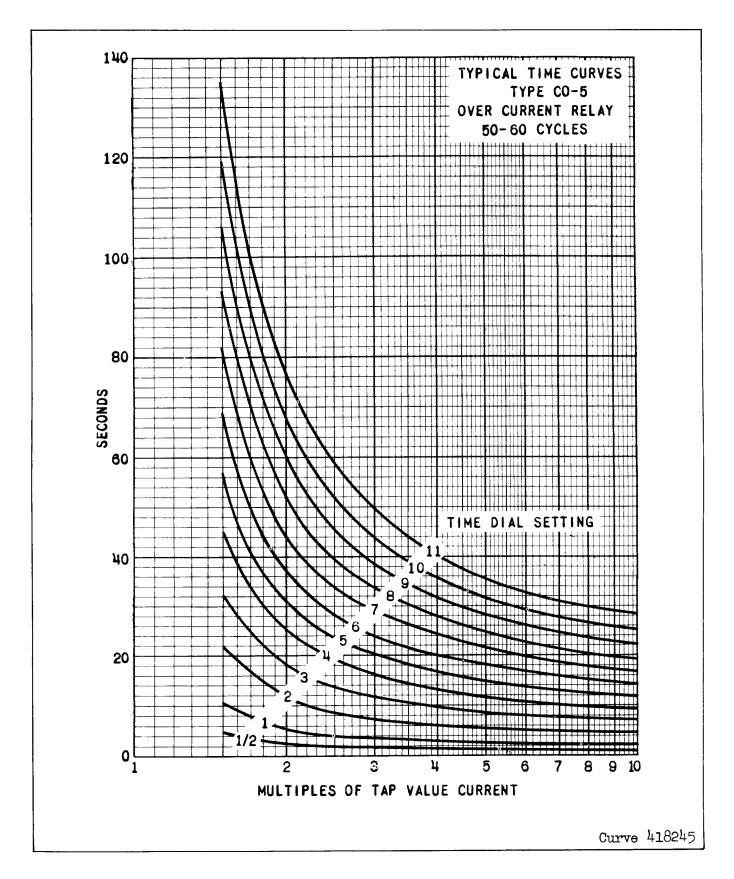


Fig. 11. Typical Time Curve of the Time-Overcurrent Unit of the Long Time (5) Relays.

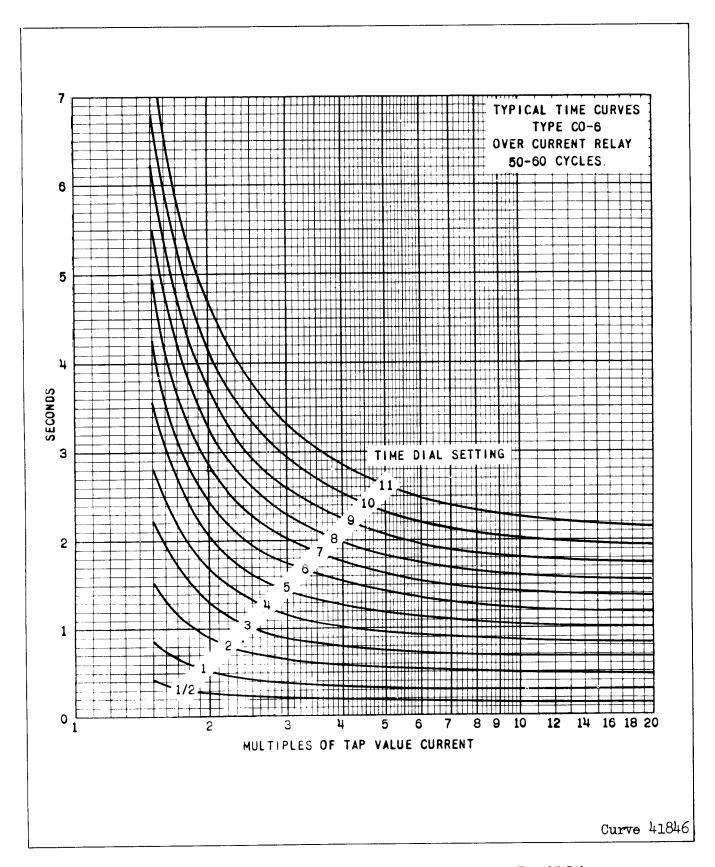


Fig. 12. Typical Time Curve of the Time-Overcurrent Unit of the Definite Time (6) Relays.

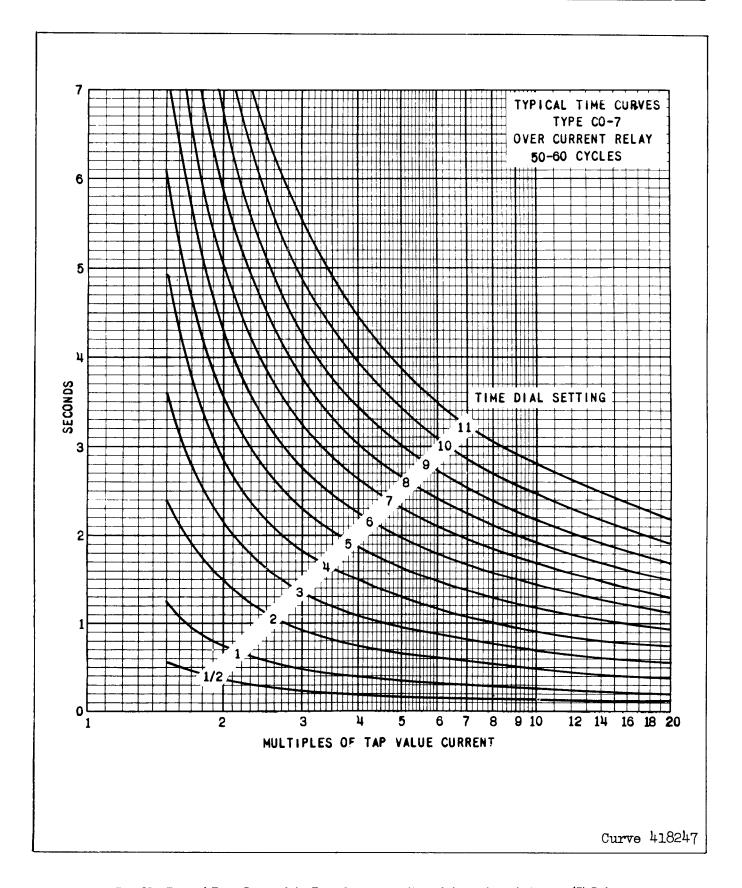


Fig. 13. Typical Time Curve of the Time-Overcurrent Unit of the Moderately Inverse (7) Relays.

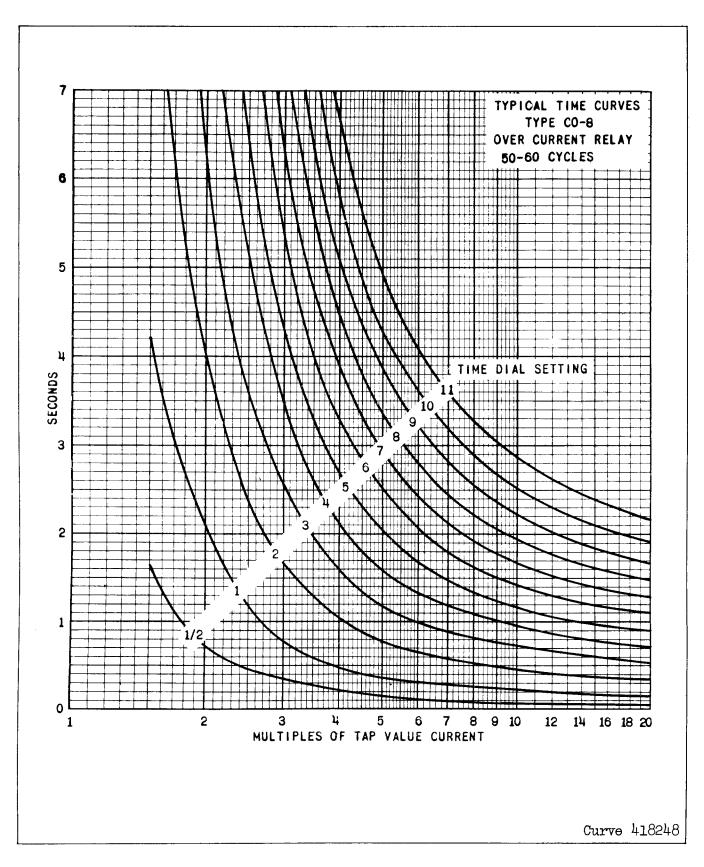


Fig. 14. Typical Time Curve of the Time-Overcurrent Unit of the Inverse (8) Relays.

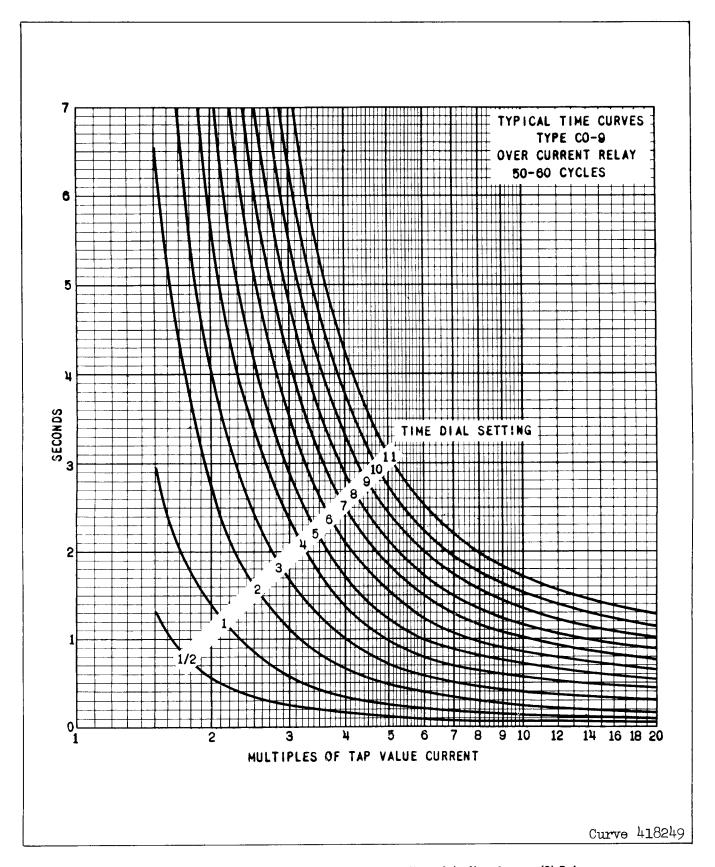


Fig. 15. Typical Time Curve of the Time-Overcurrent Unit of the Very Inverse (9) Relays.

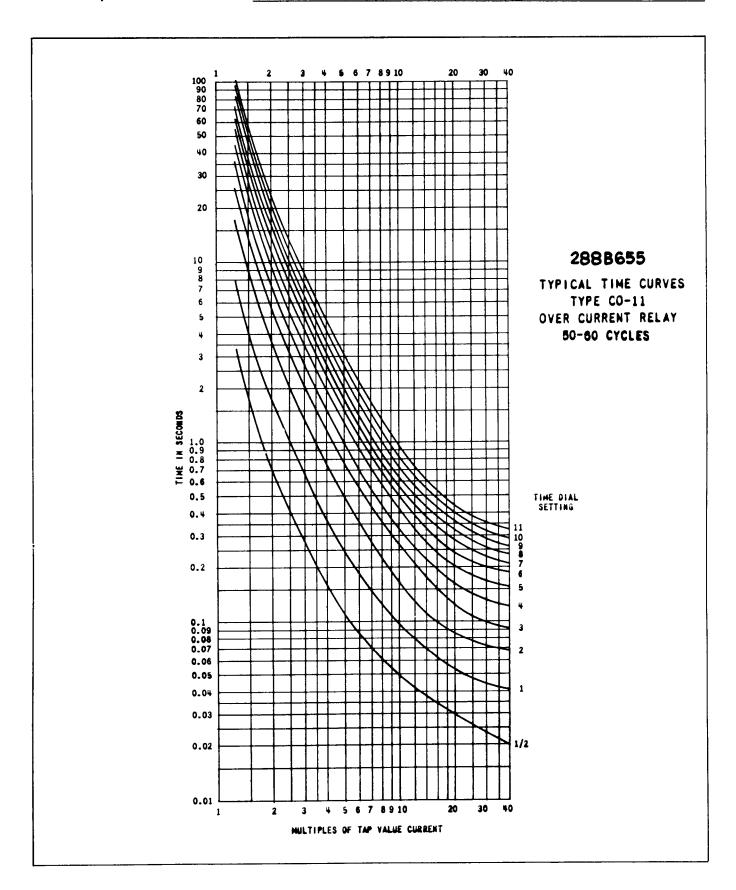
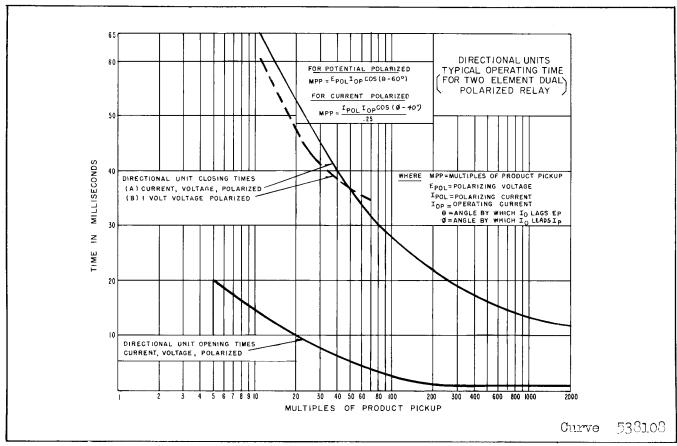


Fig. 16. Typical Time Curve of the Time-Overcurrent Unit of the Extremely Inverse (11) Relays.



\* Fig. 17. Typical Operating Times For The Directional Unit.

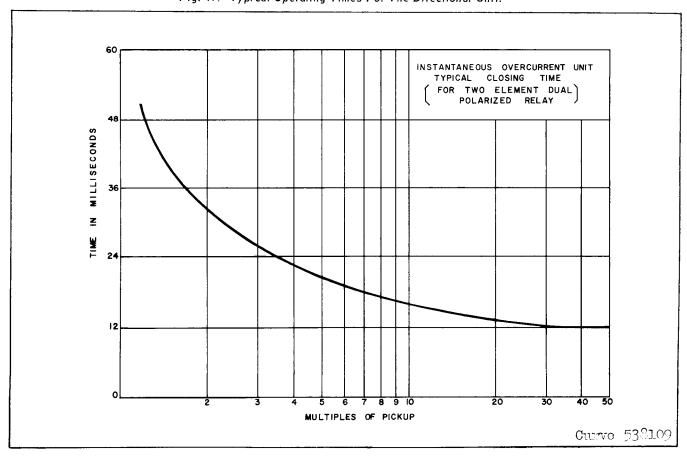


Fig. 18. Typical Operating Times For The Instantaneous Overcurrent Unit.

### Trip Circuit Constants

Indicating Contactor Switch -

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

### Auxiliary Switch (CS-1)

The auxiliary switch has a d-c resistance of 1165 ohms.

### Type IRP Relay

The IRP 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 pick-up is approximately 1 volt and 2 amperes at its maximum torque angle for the directional units used with the 0.5 to 2.5 and 2 to 6 ampere range time over-current units. For the directional units used with the 4-12 ampere range time overcurrent units the minimum pick-up is 1 volt and 4 amperes.

### Type IRC Relay

The IRC relay is designed for current polarization and has its maximum torque when the operating current leads the polarizing current by approximately  $40^{\circ}$ .

The directional unit minimum pick-up is 0.5 ampere in each winding at the maximum torque angle for the directional units used with the 0.5 to 2.5 and 2 to 6 ampere range time overcurrent units. For the directional units used with the 4-12 ampere range time overcurrent units the minimum pickup is 1 ampere.

### Type IRD Relay

The type IRD relay utilizes a directional unit similar to the IRC relay in conjunction with the directional unit and phase-shifting circuit of the IRP relay.

The current-polarized directional unit of the IRD relay operates on residual currents while the potential-polarized directional unit of the IRD relay operates on residual voltage and residual current.

For the directional units used with the 0.5 to 2 and 2 to 6 ampere time overcurrent units, the minimum pick-up of the current polarized unit is 0.5 ampere in each winding at the maximum torque angle. The minimum pick-up for the voltage polarized unit is

1 volt and 2 amperes with the current lagging voltage by  $60^{\circ}$ .

For the directional units used with the 4 to 12 ampere range time overcurrent units, the minimum pick-up is 1 ampere for the current-polarized directional unit and 1 volt and 4 amperes for the voltage-polarized directional unit.

### SETTINGS

### Time Overcurrent Unit (CO)

The time overcurrent unit settings can be defined either by tap setting and time dial position or by tap setting and a specific time of operation at some current multiple of the tap setting (e.g. 4 tap setting, 2 time dial position or 4 tap setting, 0.6 seconds at 6 times tap value current).

To provide selective circuit breaker operation, a minimum coordinating time of 0.3 seconds plus circuit breaker time is recommended between the relay being set and the relays with which coordination is to be effected.

The connector screws on the tap plate above the time dial makes connections to various turns on the operating coil. By placing this screw in the various tap plate holes, the relay will just close its contacts at the corresponding current 4-5-6-7-8-10-12 amperes, or as marked on the tap plate.

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 space connector screw in the desired position before removing the other tap screw from the original tap position.

### Instantaneous Reclosing

The factory adjustment of the CO unit contacts provides a contact follow. Where circuit breaker reclosing will be intiated immediately after a trip by the CO contact, the time of the opening of the contacts should be a minimum. This condition is obtained by loosening the stationary contact mounting screw, removing the contact plate and then replacing the plate with the bent end resting against the contact spring. With this change and the contact mounting screw tightened, the stationary contact will rest solidly against its backstop.

### Instantaneous Overcurrent Unit (1)

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.

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.

### Directional Units (D)

No setting is required.

### Indicating Contactor Switch (ICS/I and ICS/T)

The setting required on the ICS units is the selection of the 0.2 or 2.0 ampere tap setting. This selection is made by connecting the lead located in front of the tap block to the desired setting by means of the connecting screw.

#### Auxiliary Switch (CS-1)

No setting required on the CS-1 unit except for the selection of the required 24, 48, 125 or 250 voltage on the tapped rexistor. This connection can be made by referring to Fig. 23.

### 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 be means of the two mounting studs for the type FT projection case or by means of the four mounting holes on the flange for the semi-flush type FT case. 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 detail information on the FT Case refer to I.L. 41-076.

The external a-c connections of the directional overcurrent relays are shown in Figs. 20, 21 and 22. If no voltage polarizing source is to be connected to the IRD relay, short-circuit the voltage polarizing circuit at the terminals of the relay.

### 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;

### Instantaneous 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. <u>Minimum Trip Current</u> 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 within  $\pm\,5\%$  of tap value current.

### Directional Unit (D)

- 1. Contact Gap The gap between the stationary contact and moving contact with the relay in the deenergized position should be approximately .020".
- 2. <u>Sensitivity</u> The respective directional units should trip with value of energization and phase angle relationship as indicated in Table 1.
- 3. <u>Spurious Torque Adjustments</u> There should be no spurious closing torques when the operating circuits are energized per Table 2 with the polarizing circuits short circuited for the voltage polarized units and open-circuited for the current polarized units.

### Time Overcurrent Unit (CO)

- 1. Contacts The index mark on the movement frame will coincide with the "O" mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "O" mark by approximately .020". The placement of the various time dial positions in line with the index mark will give operating times as shown on the respective time-current curves.
- 2. <u>Minimum Trip Current</u> Set the time dial to position 6 with the auxiliary switch (CS-1) contacts

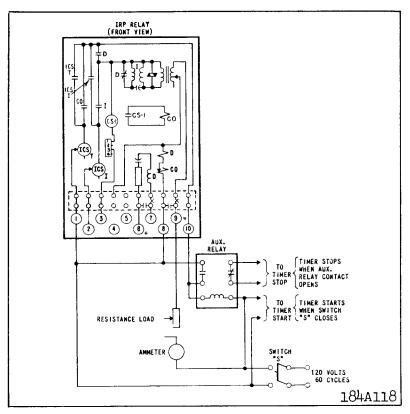


Fig. 19. Diagram of test connections of the time-overcurrent unit.

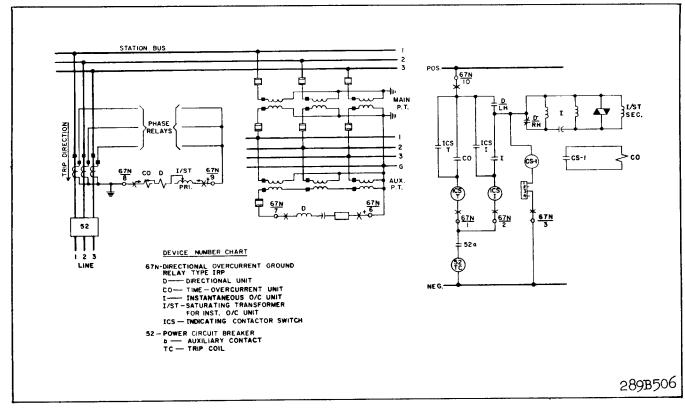


Fig. 20. External Schematic of the IRP Relay for Ground Fault Protection.

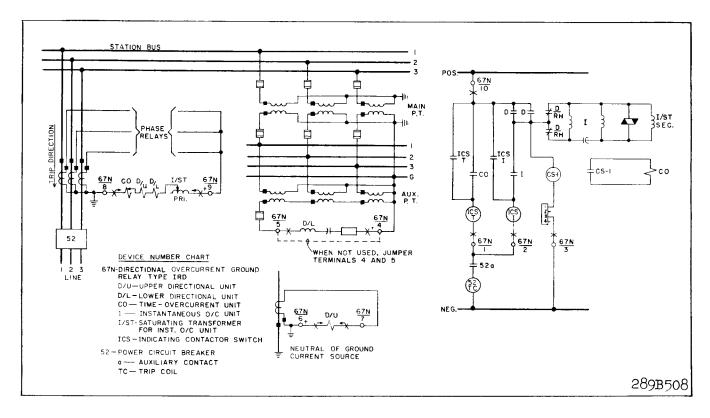


Fig. 21. External Schematic of the IRD Relay for Ground Fault Protection.

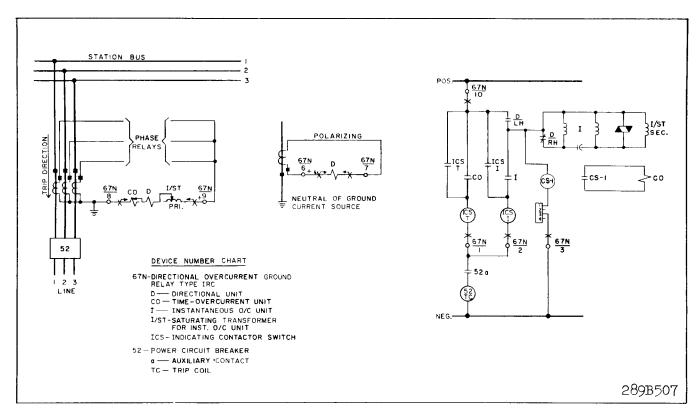


Fig. 22. External Schematic of the IRC Relay for Ground Fault Protection.

blocked closed, alternately apply tap value current plus 3% and tap value current minus 3%. The moving contact should leave the backstop at tap value current plus 3% and should return to the backstop at tap value current minus 3%.

3. <u>Time Curve</u> — Table 3 shows the time curve calibration points for the various types of relays. With the time dial set to the indicated position, apply the currents specified by Table 3 (e.g. for the CO-2, 3 and 20 times tap value current) and measure the operating time of the relay. The operating times should equal those of Table 3 plus or minus 5 percent.

### Indicating Contactor Switches (ICS/I) and (ICS/T)

- A) Close the contacts of the CO and pass sufficient d.c. current through the trip circuit to close the contacts of (ICS/T). This value of current should not be greater than the particular (ICS/T) tap setting being used. The operation indicator target should drop freely, bringing the letter "T" into view.
- B) Close the contacts of the instantaneous overcurrent unit (I) and the directional unit (D). Pass sufficient d.c. current through the trip circuit to close the contacts of (ICS/I). This value of current should not be greater than the particular (ICS/I) tap setting being used. The operation indicator target should drop freely, bringing the letter "I" into view.
- C) The contact gap should be approximately .047" 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 time of 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. The use of phantom loads, in testing induction-type relays, should be avoided, since the resulting distorted current wave form will produce an error in timing.

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

### Calibration

Use the following procedure for calibrating the

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

#### Instantaneous Overcurrent Unit (1)

- 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, i.e., against the right side of the bridge. Move 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 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  $\pm 5\%$  of tap value.

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.

### Directional Unit (D)

In the type IRP and IRC relays the directional unit is the lower cylinder unit. In the type IRD the directional units are the lower and middle cylinder 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 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 as indicated by a neon lamp in the contact circuit when energized with the required current and voltage as shown in Table 1. 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 or voltage 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 (IRP and IRD voltage polarized unit) are short-circuited.
- b) The polarizing circuits of the current polarized relays (IRC and IRD 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 some installations in order to insure that the relay will always trip the breaker on zero potential.

### Time Overcurrent Unit (CO)

- 1. Contacts The index mark on the movement frame will coincide with the "O" mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "O" mark by approximately .020". The placement of the various time dial positions in line with the index mark will give operating times as shown on the respective time-current curves.
- 2) <u>Minimum Trip Current</u> The adjustment of the spring tension in setting the minimum trip current value of the relay is most conveniently made with the damping magnet removed.

With the time dial set on "O", wind up the spiral spring by means of the spring adjuster until approximately 6-3/4 convolutions show.

Set the relay on the minimum tap setting, the time dial to position 6.

With the auxiliary switch (CS-1) contacts blocked closed, adjust the control spring tension so that the moving contact will leave the backstop at tap value current +1.0% and will return to the backstop at tap value current -1.0%.

3) <u>Time Curve Calibration</u> — Install the permanent magnet.

Apply the indicated current per Table 3 for permanent magnet adjustment (e.g. IRP-8, 2 times tap value) and measure the operating time. Adjust the permanent magnet keeper until the operating time corresponds to the value of Table 3.

Apply the indicated current per Table 3 for the electromagnet plug adjustment (e.g. IRP-8, 20 times tap value) and measure the operating time. Adjust the proper plug until the operating time corresponds to the value in Table 3. (Withdrawing the left hand plug, front view increases the operating time and withdrawing the right hand plug, front view, decreases the time.) In adjusting the plugs, one plug should be

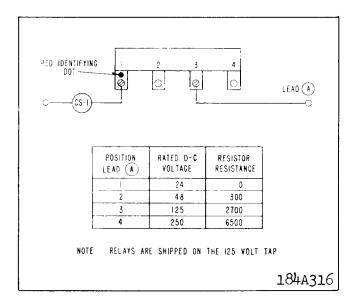


Fig. 23. Selection of Proper Voltage Tap for Auxiliary Switch (CS-1) Operation.

screwed in completely and the other plug run in or out until the proper operating time has been obtained.

Recheck the permanent magnet adjustment. If the operating time for this calibration point has changed, readjust the permanent magnet and then recheck the electromagnet plug adjustment.

### Indicating Contactor Switches (ICS/I) and (ICS/T)

Adjust the contact gap for approximately .047".

A) Close the contacts of the CO and pass sufficient d.c. current through the trip circuit to close the contacts of the (ICS/T). This value of current should not be greater than the particular (ICS/T) tap setting being used. The operation indicator target should drop freely bringing the letter "T" into view.

B) Close contacts of instantaneous overcurrent unit (I) and directional unit (D). Pass sufficient d.c. current through the trip circuit to close contacts of the (ICS/I). This value of current should not be greater than the particular (ICS/I) tap setting being used. The operation indicator target should drop freely bringing the letter "I" into view.

### Auxiliary Switch (CS-1)

Adjust the stationary core of the switch for a clearance between the stationary core and the moving core when the switch is picked up. This can be done by turning the relay upside-down. Then screw up the core screw until the moving core starts rotating. Now back off the core screw until the moving core stops rotating. This indicates the points where the play in the assembly is taken up, and where the moving core just separates from the stationary core screw. Back off the core screw approximately one turn and lock in place. This prevents the moving core from striking and sticking to the stationary core because of residual magnetism. Adjust the contact clearance for 3/64" by means of the two small nuts on either side of the Micarta disc.

Connect lead (A) to proper terminal per Fig. 23. Block directional unit (D) contacts close and energize trip circuit with rated voltage. Contacts of auxiliary switch (CS-1) should make as indicated by a neon lamp in the contact circuit.

### 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.

TABLE I DIRECTIONAL UNIT SENSITIVITY

	UIKE	CITONAL UNIT	3EH3[[]4[]	
RELAY TYPE	AMPERE RATING OF	VALUES FO	R MIN. PICKUP †	PHASE ANGLE RELATIONSHIP
	TIME-OVERCURRENT UNIT	VOLTS	AMPERES .	
	.5-2.5	1	2.0	I lagging V by 60°††
IRP IRD (Voltage Unit)	2-6	1	4.0	I in-phasæ with V
	4-12	1	4.0	I lagging V by 60° ††
·		1	8.0	I in-phase with V
	5-2.5		0.5	I <sub>O</sub> leading I <sub>p</sub> by 40°††
IRC IRD (Current $\triangle$ Unit)	.5-2.5 2-6		. 57	In-phase
	4-12		1.0	${ m I_O}$ leading ${ m I_p}$ by $40^{\circ}$ ††
	1-12		1.3	In-phase

<sup>†</sup> The energization quantities are input quantities at the relay terminals.

<sup>††</sup> Maximum torque angle.

<sup>△</sup> When normal system conditions limit the current to less than twice pickup, performance may be improved by sellecting a higher current C.T. tap to energize the polarizing circuit.

TABLE II

DIRECTIONAL UNIT CALIBRATION †

RELAY RATING   CURRENT AMPERE		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.  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.	
All Ranges	80	Spurious Torque In Contact Opening Direction (Right Front View) (Contacts remain open)		

<sup>†</sup> Short circuit the voltage polarizing circuit at the relay terminals before making the above adjustment.

TABLE III

TIME CURVE CALIBRATION DATA - 60 CYCLES

PERMANENT MAGNET ADJUSTMENT				ELECTROMAGNET PLUGS	
TIME- OVERCURRENT UNIT TYPE	TIME T DIAL POSITION	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS
2	6	3	0.57	20	0.22
5	6	2	37.80	10	14.30
6	6	2	2.46	20	1.19
7	6	2	4.27	20	1.11
8	6	2	13.35	20	1.11
9	6	2	8.87	20	0.65
11	6	2	11.27	20	0.24

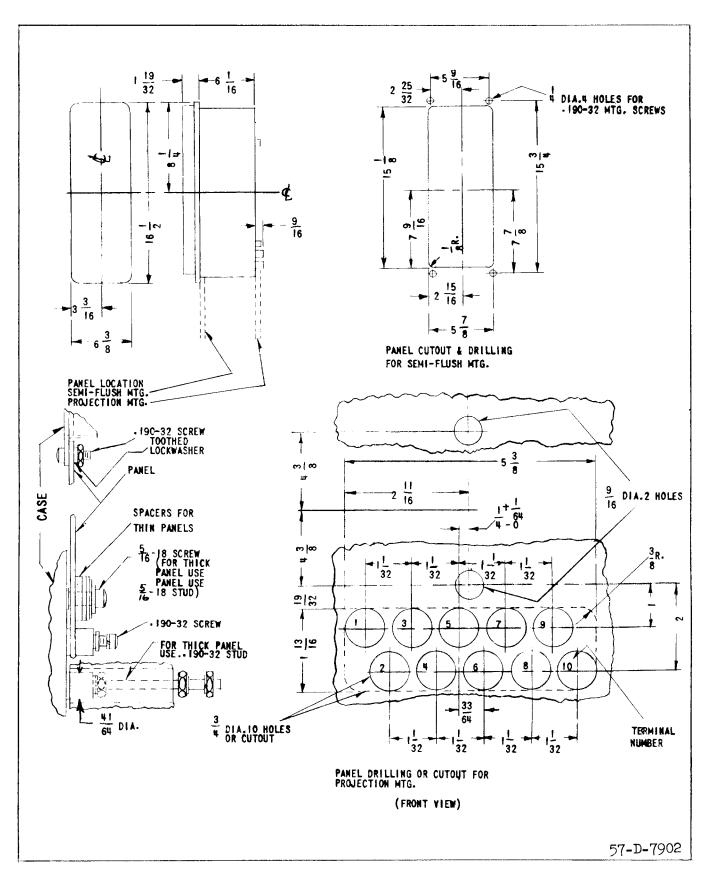


Fig. 24. Outline and Drilling Plan for the IRP and IRC Relays in the Type FT31 Case.

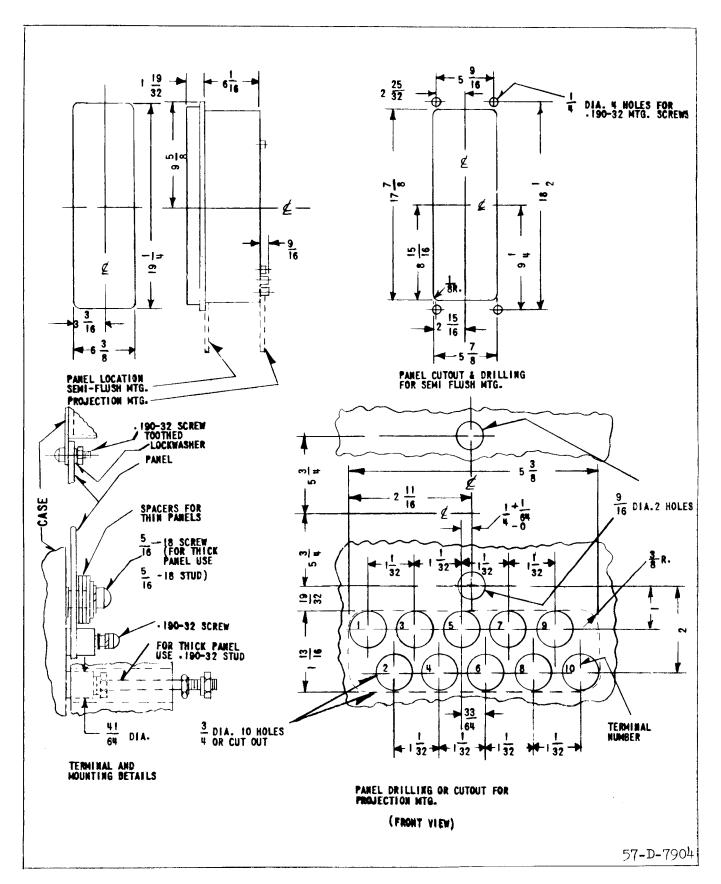


Fig. 25. Outline and Drilling Plan for the IRD Relay in the Type FT41 Case.

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WESTINGHOUSE ELECTRIC CORPORATION RELAY-INSTRUMENT DIVISION NEWARK, N. J.



## INSTALLATION . OPERATION . MAINTENANCE

## INSTRUCTIONS

# DIRECTIONAL OVERCURRENT GROUND RELAYS TYPES IRP, IRC AND IRD

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

These relays are ground directional overcurrent relays which are used for the protection of transmission lines and feeder circuits. Both the time-overcurrent and instantaneous overcurrent units are directionally controlled.

The type IRP relay is potential polarized. The type IRC relay is current polarized. The type IRD relay is a dual polarized relay which can be polarized from a potential source, from a local ground source or from both simultaneously.

### CONSTRUCTION AND OPERATION

The various types of relays consist of a directional unit or units (D), an auxiliary switch (CS-1), a time-overcurrent unit (CO), an instantaneous overcurrent unit (I), an instantaneous overcurrent unit transformer, and two indicating contactor switches (ICS/I) and (ICS/T). The principle component parts of the relays and their location are shown in Fig. 1 through 6.

#### Time-Overcurrent Unit (CO)

The electromagnets for the types IR-5, IR-6, IR-7, IR-8 and IR-9 relays have a main tapped coil located on the center leg of an "E" type laminated structure that produces a flux which divides and returns through the outer legs. A shading coil causes the flux through the left leg to lag the main pole flux. The out-of-phase fluxes thus produced in the air gap cause a contact closing torque.

The electromagnet for the type IR-2 and IR-11 relays has a main coil consisting of a tapped primary winding a secondary winding. Two identical coils

on the outer legs of the lamination structure are connected to the main coil secondary in a manner so that the combination of all the fluxes produced by the electromagnet result in out-of-phase fluxes in the air gap. The out-of-phase air gap fluxes produced cause a contact closing torque.

### Indicating Contactor Switch Units (ICS/I and ICS/T)

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

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

#### 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 the magnetic core. The magnetic core which houses the lower pin bearing is secured to the 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

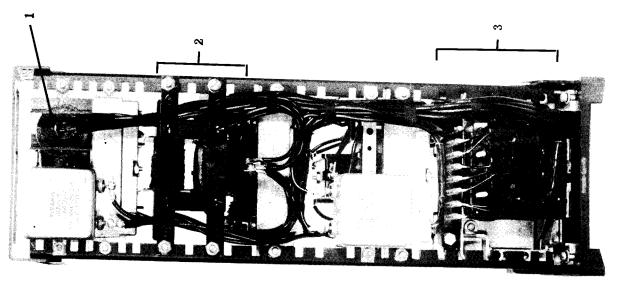


Fig. 2. Type IRD Relay Without Case (Rear View). 1 — Varistor. 2 — Saturating Transformer. 3 — "E" Type Electromagnet.

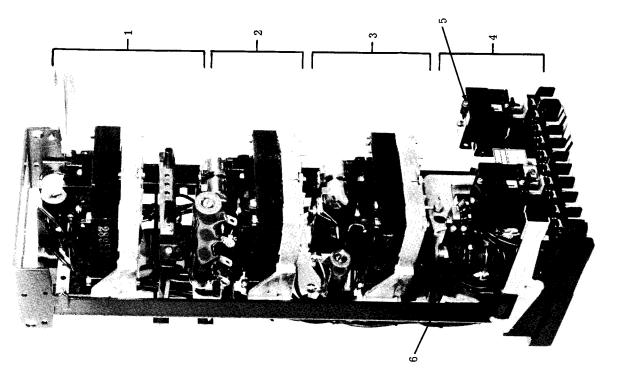


Fig. 1. Type IRD Relay Without Case (Front View). 1 — Instantaneous Over-current Unit and Saturating Transformer. 2 — Current Polarized Directional Unit. 3 — Voltage Polarized Directional Unit. 4 — Time Overcurrent Unit. 5 — Indicating Contactor Switch. 6 — Auxiliary Switch.

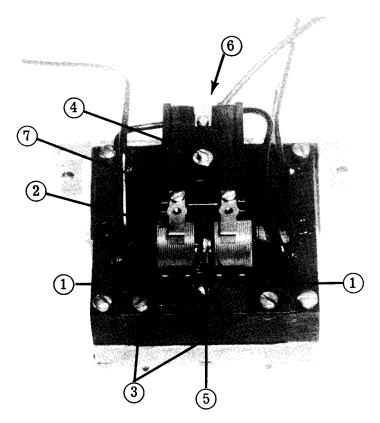


Fig. 3. Directional Unit. 1 — Stationary Contacts. 2 — Stationary Contact Pressure Spring. 3 — Magnetic Adjusting Plugs. 4 — Upper Bearing Screw. 5 — Moving Contact. 6 — Spring Adjuster Clamp. 7 — Current Bias Vane.

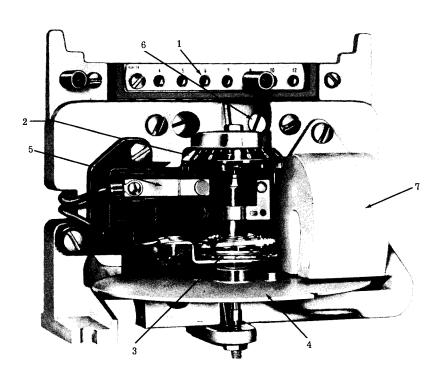


Fig. 4. Time Overcurrent Unit. 1—Tap Block. 2—Time Dial. 3—Control Spring Assembly. 4— Disc. 5—Stationary Contact Assembly. 6—Magnetic Plugs. 7—Permanent Magnet.

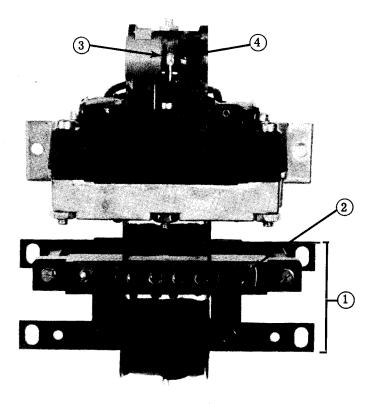


Fig. 5. Instantaneous Overcurrent Unit. 1 — Saturating Transformer. 2 — Tap Block. 3 — Stationary Contact. 4 — Moving Contact.

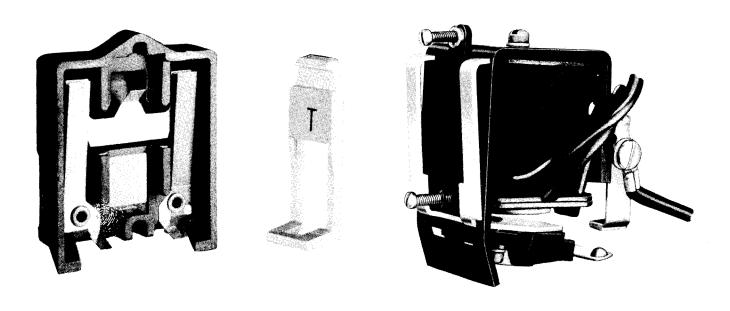


Fig. 6. Indicating Contactor Switch (ICS).

accurately position the lower pin bearing, which is mounted on the frame, with respect to the upper 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 rotating in an 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.

#### Auxiliary Switch (CS-1)

The auxiliary switch is a small solenoid type d.c. switch. A cylindrical plunger, with a silver disc mounted on its lower end, moves in the core of the solenoid. As the plunger travels upward, the disc bridges the silver stationary contacts. A tapped resistor is used to enable one to use the contactor switch on a 24, 48, 125 or 250 volt d.c. system connected per Fig. 23. The operation of the CS-1 switch is controlled by the directional unit (D) which in turn directionally controls the time-overcurrent unit (CO). When sufficient power flows in the tripping direction, the CS-1 switch operates and bridges the lag coil of the time-overcurrent unit (CO) permitting this unit to operate.

#### Instantaneous Overcurrent Unit (I)

The instantaneous 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 instantaneous overcurrent unit as shown in the internal schematics. This arrangement short-circuits the operating current around the pole windings; pre-

venting the instantaneous overcurrent unit from developing torque. If the directional unit should pick up for a fault, this short-circuit is removed, allowing the instantaneous overcurrent contact to commence closing almost simultaneously with the directional contact for high speed operation. Total operating time is shown in Figs. 17 and 18.

#### Instantaneous Overcurrent Unit Transformer

This transformer is of the saturating type for limiting the energy to the instantaneous overcurrent unit at higher values of fault current and to reduce C.T. burden. The primary winding is tapped and these taps are brought out to a tap block for ease in changing the pick-up of the instantaneous 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.

#### CHARACTERISTICS

The time characteristics of the directional overcurrent relays are designated by specific numbers as indicated below (e.g., IRV-8).

Time	
Characteristics	Designation
Short Time	2
Long Time	5
Definite Time	6
Moderately Inverse Time	7
Inverse Time	8
Very Inverse Time	9
Extremely Inverse Time	11

The relays are available in the following current ranges:

#### Instantaneous Overcurrent Unit (I)

	Taps					
0.5	0.75	1.0	1.25	1.5	2	
1.0	1.5	2.0	2.5	3.0	4.0	
2	3	4	5	6	8	
4	6	8	9	12	16	
10	15	20	24	30	40	
20	30	40	48	60	80	
	1.0 2 4 10	1.0 1.5 2 3 4 6 10 15	0.5 0.75 1.0 1.0 1.5 2.0 2 3 4 4 6 8 10 15 20	0.5 0.75 1.0 1.25 1.0 1.5 2.0 2.5 2 3 4 5 4 6 8 9 10 15 20 24	0.5 0.75 1.0 1.25 1.5 1.0 1.5 2.0 2.5 3.0 2 3 4 5 6 4 6 8 9 12 10 15 20 24 30	

#### Time Overcurrent Unit

Range			Taps					
.5-2.5	0.5	0.6	0.8	1.0	1.5	2.0	2.5	
2-6	2	2.5	3	3.5	4	5	6	
4-12	4	5	6	7	8	10	12	

The tap value is the minimum current required to just close the relay contacts.

The time vs. current characteristics for the timeovercurrent unit are shown in Figs. 10 to 16. These characteristics give the contact closing time for the various time dial settings when the indicated multiples of tap value current are applied to the relay.

#### TIME CURVES

The time curves for the IRD relay are shown in Fig. 17 and 18. Fig. 17 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.

Fig. 18 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 Fig. 18 plus the directional unit opening time given in Fig. 17. The total closing time for the directional unit is given in Fig. 17. The two examples below will serve to illustrate the use of the curves.

Example 1: Using the formulas and definition of symbols on Fig. 17, we have—

Let: Ipol = 2 amps.  
Iop = 2.31  
Tap Value (T) = 0.5 amp.  

$$\phi - 40^{\circ} = 0^{\circ}$$
  
(For timing unit, assume  
CO-9 with ½ time dial setting)

For current polarized relay:

$$MPP = \frac{Iop Ipol Cos (\phi - 40^{\circ})}{0.25}$$

MPP = 
$$\frac{(2.31)(2)}{0.25}$$
 = 18.5

Referring to Fig. 17 at multiples of produce pickup of 18.5,the directional unit operating time is about 11 ms, and the closing time for this unit is 56 ms.

For overcurrent unit:

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

Entering the curve in Fig. 18 at multiples of pickup equal to 4.6, the closing time for instantaneous overcurrent is 16 ms. However, the total operating time for the overcurrent unit is 16 plus 11, which is the opening time of back contacts of the directional unit, or 27 ms total operating time for overcurrent unit. The total time for directional unit is 56 ms; and, since this is the longest time,56 ms is the total operating time of the instantaneous overcurrent circuit.

Entering the curve in Fig. 15 at 4.6, the  $\frac{1}{2}$  time dial setting gives 140 ms. The total time for the time-overcurrent circuit is 56 ms directional unit time plus 16 ms CS-1 time plus 140 ms = 212 ms.

Example 2:

Let: Ipol = 20 amps.  
Iop = 23.1 amps  

$$T(tap) = 1$$
 amp.  
 $\phi - 40^{\circ} = 0$   
MPP = 
$$\frac{\text{Iop Ipol Cos } (\phi - 40^{\circ})}{0.25}$$
MPP = 
$$\frac{(20)(23.1)}{0.25} = 1850$$

Entering Fig. 17, the directional unit closing time is 12 ms, and the opening time of its back contacts is 1 ms. The total operating time for the directional unit is 13 ms.

For overcurrent unit:

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

Referring to Fig. 18, the overcurrent unit contact closing time is about 14 ms. Therefore, the total operating time for this unit is 14 plus 1 or 15 ms. In this case the total operating time of relay is 15 ms.

Fig. 15 gives an operating time of about 50 ms. The time-overcurrent circuit is 12 plus 16 ms CS-1 time plus 50=78 ms.

#### Trip Circuit

The relay contacts will safely close 30 amperes at 250 volts d.c and the seal-in contacts of the indicating contactor switches will safely carry this current long enough to trip a circuit breaker.

The indicating contactor switch has two taps that provide a pickup setting of 0.2 or 2 amperes. To change taps requires connecting the lead located in front of the tap block to the desired setting by means of a screw connection.

#### 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.

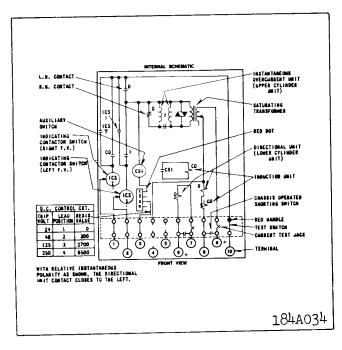


Fig. 8. Internal Schematic of the Type IRC Relay in the Type FT31 Case.

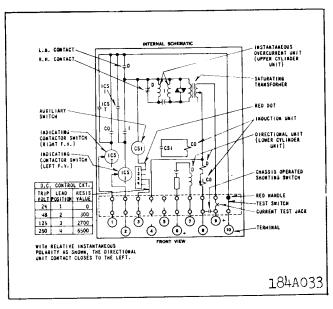


Fig. 7. Internal Schematic of the Type IRP Relay in the Type FT31 Case.

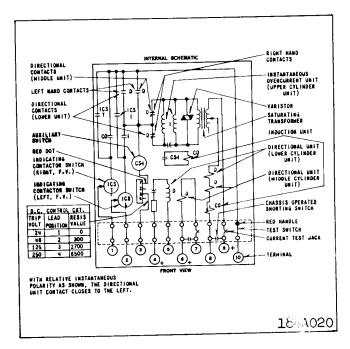


Fig. 9. Internal Schematic of the Type IRD Relay in the Type FT41 Case.

ENERGY REQUIREMENTS

INSTANTANEOUS OVERCURRENT UNIT OPERATING CURRENT CIRCUIT - 60 CYCLES

AMPERE RANGE	TAP	VA AT TAP VALUE	P.F. ANGLE	VA AT 5 AMPS.	P.F. ANGLE
	.5	.37	39	24	46
	.75	.38	36	13	37
5.0	1	.39	35	8.5	34
.5-2	1.25	.41	34	6.0	32
	1.5	.43	32	4.6	31
	2	.45	30	2.9	28
	1	.41	36	9.0	36
	1.5	.44	32	5.0	32
1-4	2	.47	30	3.0	29
	2.5	.50	28	2.1	27
	3	.53	26	1.5	26
	4	.59	24	0.93	24
	2	1.1	49	6.5	48
	3	1.2	43	3.3	42
2-8	4	1.3	38	2.1	37
20	5	1.4	35	1.4	35
	6	1.5	33	1.1	33
	8	1.8	29	0.7	29
	4	1.5	51	2.4	51
4-16	6	1.7	45	1.2	45
	8	1.8	40	0.7	40
	9	1.9	38	0.6	38
	12	2.2	34	0.37	34
	16	2.5	30	0.24	31
	10	1.7	28	0.43	28
	15	2.4	21	0.27	21
10-40	20	3.1	16	0.20	17
10 40	24	3.6	15	0.15	15
	30	4.2	12	0.11	13
	40	4.9	11	0.08	12
	20	6.6	31	0.40	31
	30	9.3	24	0.25	24
20-80	40	12	20	0.18	20
	48	13.5	18	0.14	18
	60 80	15.9 19.2	16 15	0.10	16
	00	15.2	15	0.07	15
RANGE		CONTINUOUS RATIN	IG	ONE SECOND RA	ATING
		(AMPERES)		† (AMPERES	)
. 5-2		5		100	
1-4		8		140	
2-8		8		140	Ì
4-16		10		200	
10-40		10		200	
20-80					
∠u-6U		10		200	

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

φ Degrees current lags voltage.

<sup>† †</sup> Voltages taken with Rectox type voltmeter.

## ENERGY REQUIREMENTS - 60 CYCLES DIRECTIONAL UNIT OPERATING CIRCUIT BURDEN

<del>-</del> 1	1					VOI	T AMPERES	††
Relay Type	Range Amps	Continuous Rating (Amperes)	One Second Rating † (Amperes)	Power Factor Angle $\phi$	At Minimum Tap Value Current	At 3 Times Minimum Tap Value Current	At 10 Times Minimum Tap Value Current	At 20 Times Minimum Tap Value Current
IRC	0.5-2.5	-	230	44.0	0.033	0.30	3.3	14.2
	2-6	-	230	42.5	0.58	5.28	58.0	240.0
	4-12	12	280	31.8	0.64	6.12	70.0	272.0
IRP	0.5-2.5	10	230	34.5	0.03	0.23	2.8	11.5
	2-6	10	230	34.5	0.44	4.08	48.0	182.0
	4-12	12	280	25.0	0.48	4.62	53.6	216.0
IRD	0.5-2.5	10	230	45.0	0.07	0.59	6.6	26.0
	2-6	10	230	45.0	1.04	9.9	106.0	420.0
	4-12	12	280	32.4	1.16	10.8	121.2	472.0

 $<sup>\</sup>phi$  Degrees current lags voltage at tap value current.

## ENERGY REQUIREMENTS - 60 CYCLES DIRECTIONAL UNIT POLARIZING CIRCUIT BURDEN

RELAY TYPE	RATING	VOLT AMPERES △	POWER FACTOR ANGLE $\phi$
IRC	230 Amperes †	1.45	8° Lag
IRP	208 Volts ††	11.2	28° Lead
KRD Current Unit	230 Amperes ††	1.45	8° Lag
IRD Voltage Unit	208 Volts ††	11.2	28 ° Lead

 $<sup>\</sup>phi$  Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.

 $\triangle$  Burden of voltage polarized units taken at 120 volts. Burden of current polarized units taken at 5 amperes.

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

<sup>††</sup> Voltages taken with Rectox type voltmeter.

 $<sup>\</sup>dagger$  One second rating.

<sup>†† 30</sup> second rating. The 10 second rating is 345 volts. The continuous rating is 120 volts.

#### **ENERGY REQUIREMENTS**

#### TYPE IRD-2, IRC-2, IRP-2 TIME OVERCURRENT UNITS

**VOLT AMPERES††** CONTINUOUS ONE SECOND POWER ATAT 3 TIMES AT 10 TIMES AT 20 TIMES AMPERE RATING RATING † FACTOR TAP VALUE TAP VALUE TAP VALUE TAP VALUE RANGE TAP (AMPERES) (AMPERES)  $ANGLE\phi$ CURRENT CURRENT CURRENT CURRENT 0.5 0.91 28 58 4.8 39.6 256 790 0.6 0.96 28 57 4.9 39.8 270 851 0.8 1.18 28 53 5.0 42.7 308 1024 0.5/2.51.0 1.37 28 50 5.3 45.4 348 1220 1.5 1.95 28 40 6.2 54.4 435 1740 2.0 2.24 28 36 7.2 65.4 580 2280 2.5 2.50 28 29 7.9 73.6 700 2850 2.0 3.1 110 59 5.04 38.7 262 800 2.5 4.0 110 55 5.13 39.8 280 920 3.0 4.4 110 51 5.37 42.8 312 1008 2/6 3.5 4.8 110 47 5.53 42.8 329 1120 4.0 5.2 110 45 5.72 46.0 360 1216 5.0 5.6 110 41 5.90 50.3 420 1500 6.0 6.0 110 37 6.54 54.9 474 1800 4.0 7.3 230 65 4.92 39.1 268 848 5.0 8.0 230 50 5.20 42.0 305 1020 6.0 8.8 230 47 5.34 44.1 330 1128 4/12 7.0 9.6 230 46 5.53 45.8 364 1260 8.0 10.4 230 43 5.86 49.9 400 1408 10.0 11.2 230 37 6.6 55.5 470 1720 12.0 12.0 230 34 7.00 62.3 528 2064

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

 $<sup>\</sup>phi$  Degrees current lags voltage at tap value current.

<sup>††</sup> Voltages taken with Rectox type voltmeter.

#### **ENERGY REQUIREMENTS**

## IRD-5, IRC-5, IRP-5, TIME OVERCURRENT UNITS

VOLT AMPERES † †

						VOLIT	WIT EATERS 1 1	
AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING† (AMPERES)	POWER FACTOR ANGLE $\phi$	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
0.5/2.5	(0.5 (0.6 (0.8 (1.0 (1.5 (2.0 (2.5	2 2.2 2.5 2.8 3.4 4.0	88 88 88 88 88 88	69 68 67 66 62 60 58	3.92 3.96 3.96 4.07 4.19 4.30 4.37	20.6 20.7 21 21.4 23.2 24.9 26.2	103 106 114 122 147 168 180	270 288 325 360 462 548 630
2/6	(2 (2.5 (3 (3.5 (4 (5 (6	8 8.8 9.7 10.4 11.2 12.5 13.7	230 230 230 230 230 230 230	67 66 64 63 62 59	3.88 3.90 3.93 4.09 4.12 4.20 4.38	21 21.6 22.1 23.1 23.5 24.8 26.5	110 118 126 136 144 162	308 342 381 417 448 540 624
4/12	(4 (5 (6 (7 (8 (10 (12	16 18.8 19.3 20.8 22.5 25	460 460 460 460 460 460	65 63 61 59 56 53 47	4.00 4.15 4.32 4.35 4.40 4.60 4.92	22.4 23.7 25.3 26.4 27.8 30.1 35.6	126 143 162 183 204 247 288	376 450 531 611 699 880 1056

#### IRD-7, IRC-7, IRP-7 TIME OVERCURRENT UNITS

VOLT AMPERES † † AT 20 TIMES AT 10 TIMES AT 3 TIMES CONTINUOUS ONE SECOND POWER AT TAP VALUE TAP VALUE TAP VALUE TAP VALUE RATING† FACTOR AMPERE RATING CURRENT CURRENT CURRENT CURRENT (AMPERES) (AMPERES) ANGLE  $\phi$ TAP RANGE 278 20.7 103 3.88 68 (0.5 88 107 288 67 3.93 20.9 2.2 (0.6)88 320 21.1 114 3.93 (0.8 2.5 88 66 122 356 21.6 64 4.00 88 2.8 0.5/2.5(1.0 459 148 4.08 22.9 61 (1.5 3.4 88 552 24.8 174 4.24 4.0 88 58 (2.0 640 185 56 4.38 25.9 88 (2.5)4.4 306 4.06 21.3 111 230 66 8 (2 342 120 230 63 4.07 21.8 8.8 (2.5)366 22.5 129 4.14 63 (3 9.7 230 141 413 23.4 230 62 4.34 10.4 (3.5 2/6 448 149 61 4.34 23.8 230 (4 11.2 530 25.2 163 4.40 230 59 12.5 (5 624 183 58 4.62 27 230 (6 13.7 129 392 22.8 64 4.24 460 16 (4 460 24.2 149 61 4.30 (5 18.8 460 168 540 25.9 460 60 4.62 19.3 4/12 (6 626 4.69 27.3 187 58 460 (7 20.8 211 688 29.8 460 55 4.80 22.5 (8 860 5.20 33 260 51 460 (10 25 5.40 308 1032 37.5 28 460 46 (12

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

φ Degrees current lags voltage at tap value current.

<sup>††</sup> Voltages taken with Rectox type voltmeter.

#### **ENERGY REQUIREMENTS**

IRD-8, IRC-8, IRP-8, TIME OVERCURRENT UNITS

					VOLT AMPERES ††				
Ampere Range	Тар	Continuous Rating (Amperes)	One Second Rating † (Amperes)	Power Factor Angle $\phi$	At Tap Value	At 3 Times Tap Value	At 10 Times Tap Value	At 20 Times Tap Value	
Trumbe		<del></del>			Current	Current	Current	Current	
	(0.5	$\begin{vmatrix} 2 \\ 2 \end{vmatrix}$	88	72	2.38	21	132	350	
		2.2	88	71	2.38	21	134	365	
0.5/2.5	(0.8)	2.5 2.8	88	69	2.40	21.1	142	400	
0.0/ 2.0	(1.5		88	67	2.42	21.2	150	440	
	(2.0)	3.4	88	62	2.51	22	170	530	
	(2.5)	4.0	88	57	2.65	23.5	200	675	
	<u> </u>	4.4	88	53	2.74	24.8	228	800	
	(2	8	230	70	2.38	21	136	360	
	(2.5	8.8	230	66	2.40	21.1	142	395	
a ( a	(3	9.7	230	64	2.42	21.5	149	430	
2/6	(3.5	10.4	230	62	2.48	22	157	470	
	(4	11.2	230	60	2.53	22.7	164	500	
	(5	12.5	230	58	2.64	24	180	580	
	(6	13.7	230	56	2.75	25.2	198	660	
	(4	16	460	68	2.38	21.3	146	420	
	(5	18.8	460	63	2.46	21.8	158	480	
	(6	19.3	460	60	2.54	22.6	172	550	
4/12	(7	20.8	460	57	2.62	23.6	190	620	
1	(8	22.5	460	54	2.73	24.8	207	700	
İ	(10	25	460	48	3.00	27.8	248	850	
	(12	28	460	45	3.46	31.4	$\overline{292}$	1020	

IRD-11, IRC-11, IRP-11 OVERCURRENT UNITS

TRE-11, TRE-11 OVERCURRENT UNITS									
	ĺ					VOLT AMPERES ††			
Ampere Range	Тар	Continuous Rating (Amperes)	One Second Rating † (Amperes)	Power Factor Angle $\phi$	At Tap Value Current	At 3 Times Tap Value Current	At 10 Times Tap Value Current	At 20 Times Tap Value Current	
0.5/2.5	0.5 0.6 0.8 1.0 1.5 2.0 2.5	1.7 1.9 2.2 2.5 3.0 3.5 3.8	56 56 56 56 56 56	36 34 30 27 22 17	0.72 0.75 0.81 0.89 1.13 1.30	6.54 6.80 7.46 8.30 10.04 11.95 13.95	71.8 75.0 84.0 93.1 115.5 136.3 160.0	250 267 298 330 411 502 610	
2/6	2.0 2.5 3.0 3.5 4.0 5.0 6.0	7.0 7.8 8.3 9.0 10.0 11.0 12.0	230 230 230 230 230 230 230 230	32 30 27 24 23 20 20	0.73 0.78 0.83 0.88 0.96 1.07	6.30 7.00 7.74 8.20 9.12 9.80 11.34	74.0 78.5 84.0 89.0 102.0 109.0 129.0	264 285 309 340 372 430 504	
4/12	4.0 5.0 6.0 7.0 8.0 10.0 12.0	14 16 17 18 20 22 26	460 460 460 460 460 460 460	29 25 22 20 18 17 16	0.79 0.89 1.02 1.10 1.23 1.32 1.8	7.08 8.00 9.18 10.00 11.1 14.9 16.3	78.4 90.0 101.4 110.0 124.8 131.6 180.0	296 340 378 454 480 600 720	

#### IRD TIME OVERCURRENT UNIT BURDEN DATA AT HIGH CURRENTS

		· · · · ·		COKKE	1115	
Ampere Range			.5-	2.5		
Tap Value Current	.5	5	1	.0	2	.5
Multiples of Tap Value Current	40	80	20	40	8	16
VA ††	790	2600	380	1280	60	280
P.F. Angle $\phi$	46.7°	42 °	37 °	26.5°	4.8°	4.3°

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

<sup>\$\</sup>phi Degrees current lags voltage at tap value current.

 $<sup>\</sup>dagger\dagger Voltages\ taken\ with\ Rectox\ type\ voltmeter.$ 

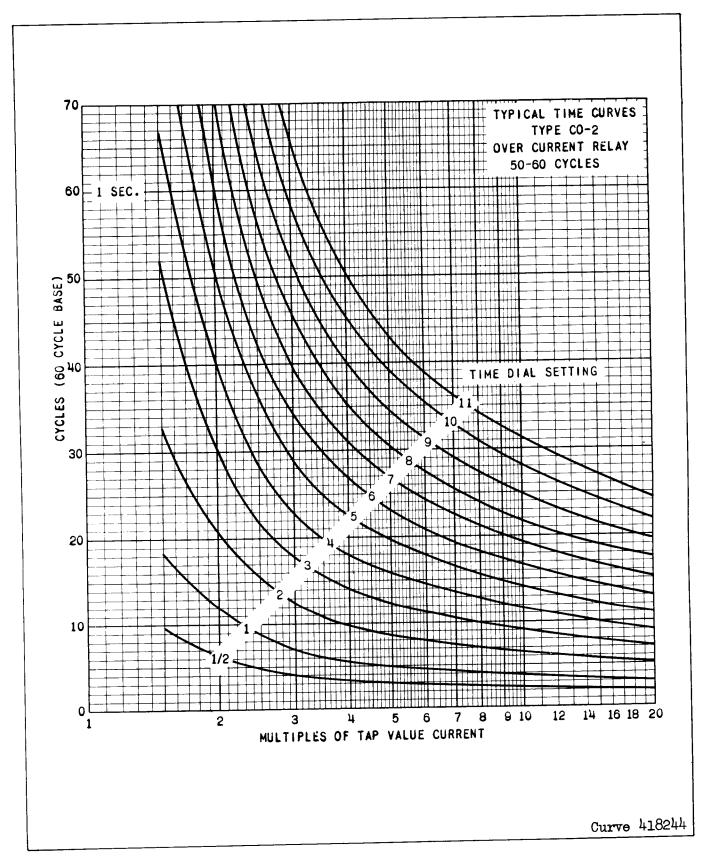


Fig. 10. Typical Time Curves of the Time-Overcurrent Unit of the Short Time (2) Relays.

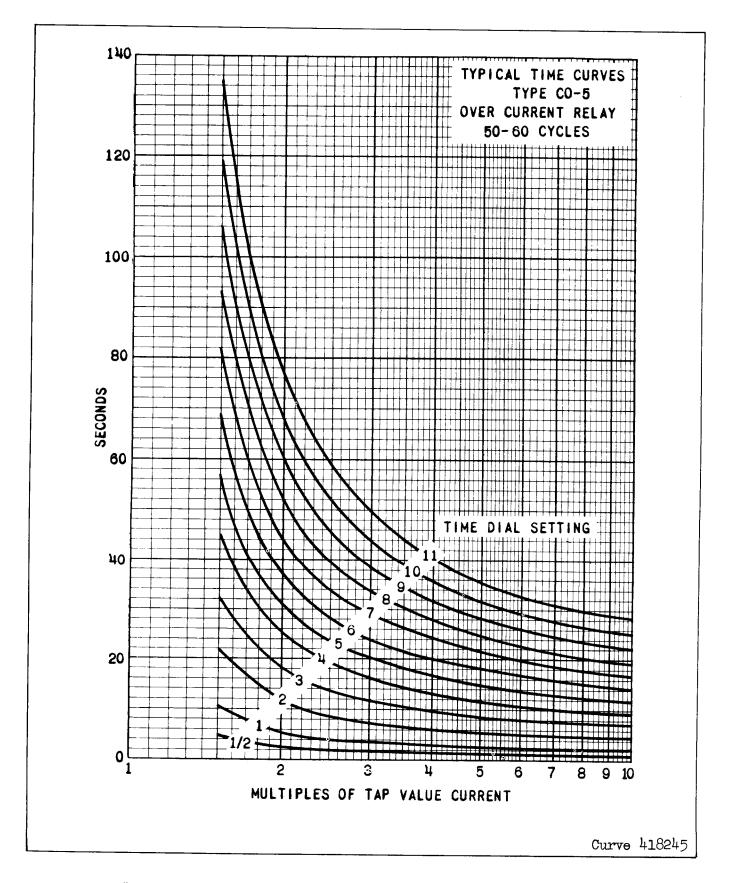


Fig. 11. Typical Time Curve of the Time-Overcurrent Unit of the Long Time (5) Relays.

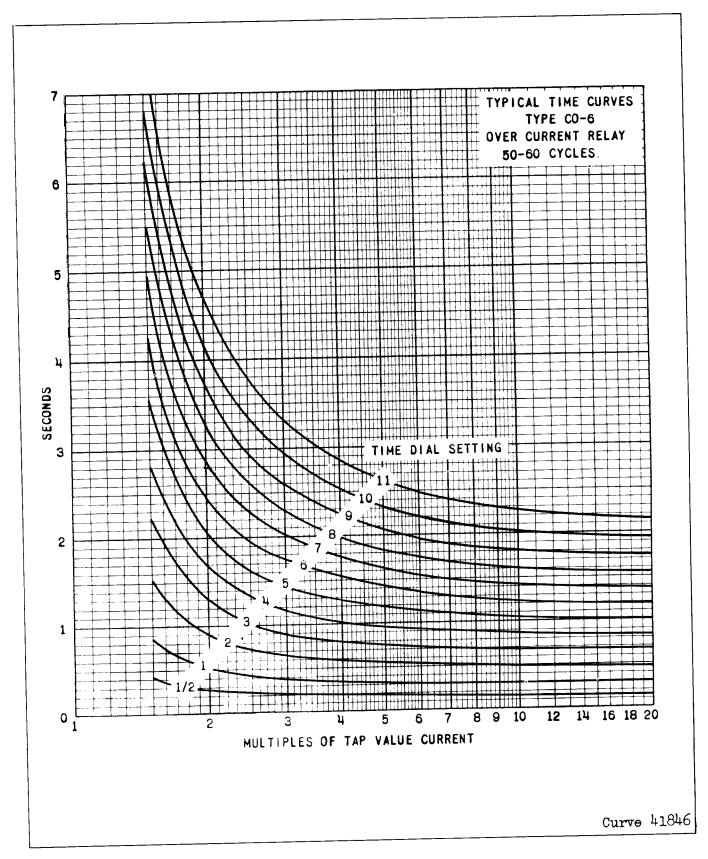


Fig. 12. Typical Time Curve of the Time-Overcurrent Unit of the Definite Time (6) Relays.

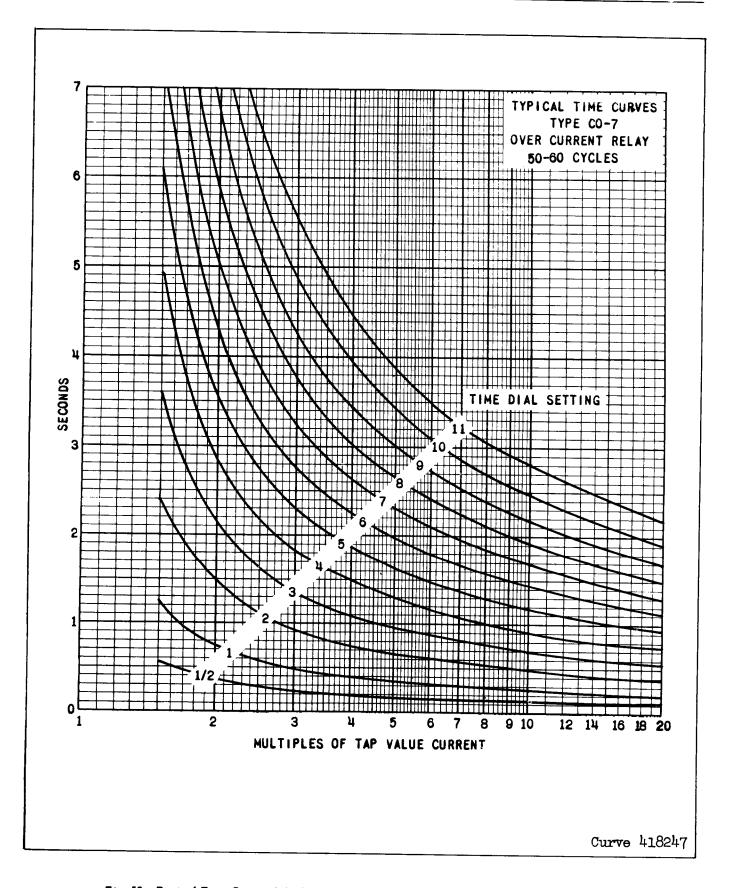


Fig. 13. Typical Time Curve of the Time-Overcurrent Unit of the Moderately Inverse (7) Relays.

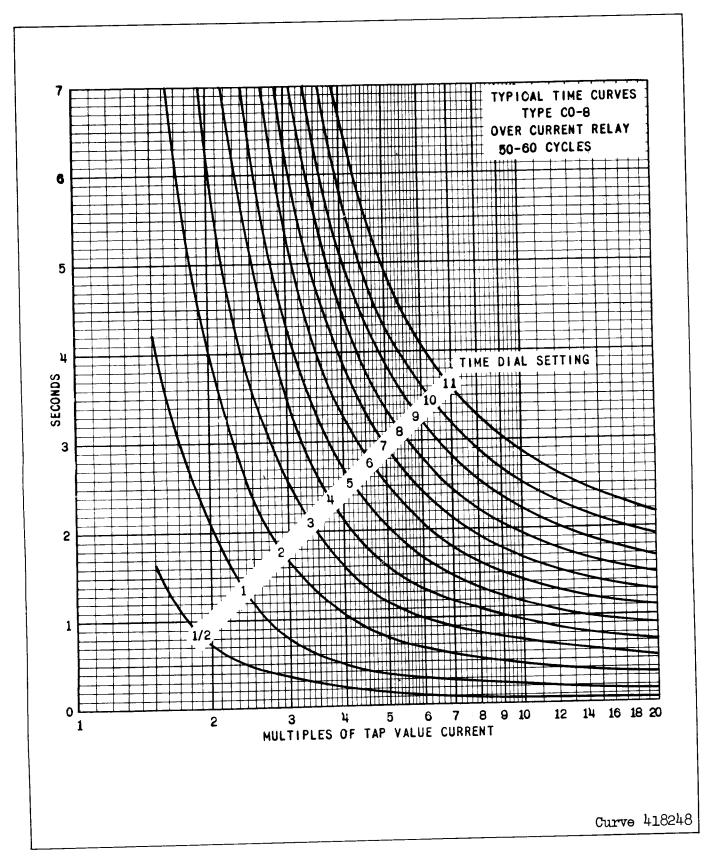


Fig. 14. Typical Time Curve of the Time-Overcurrent Unit of the Inverse (8) Relays.

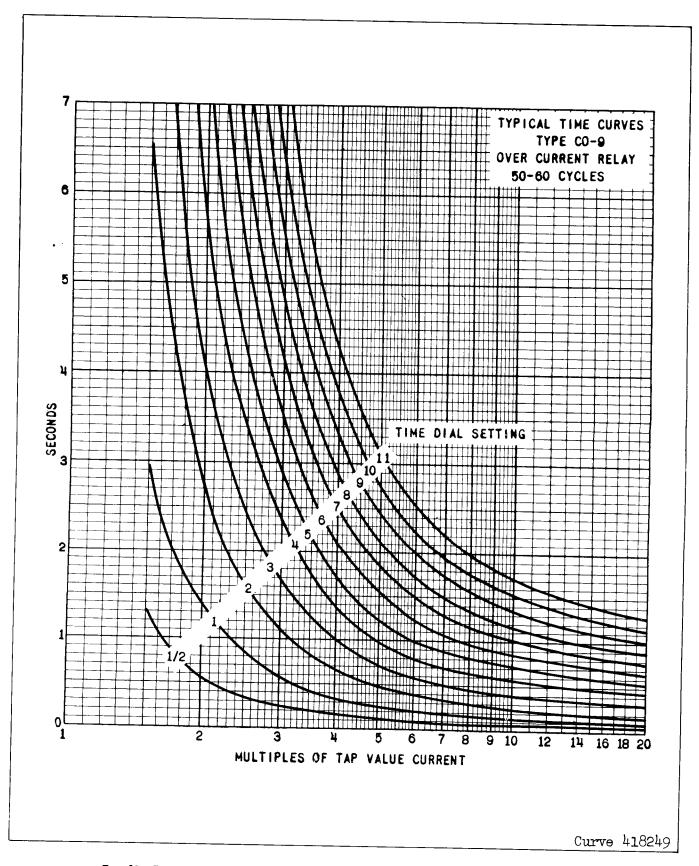


Fig. 15. Typical Time Curve of the Time-Overcurrent Unit of the Very Inverse (9) Relays.

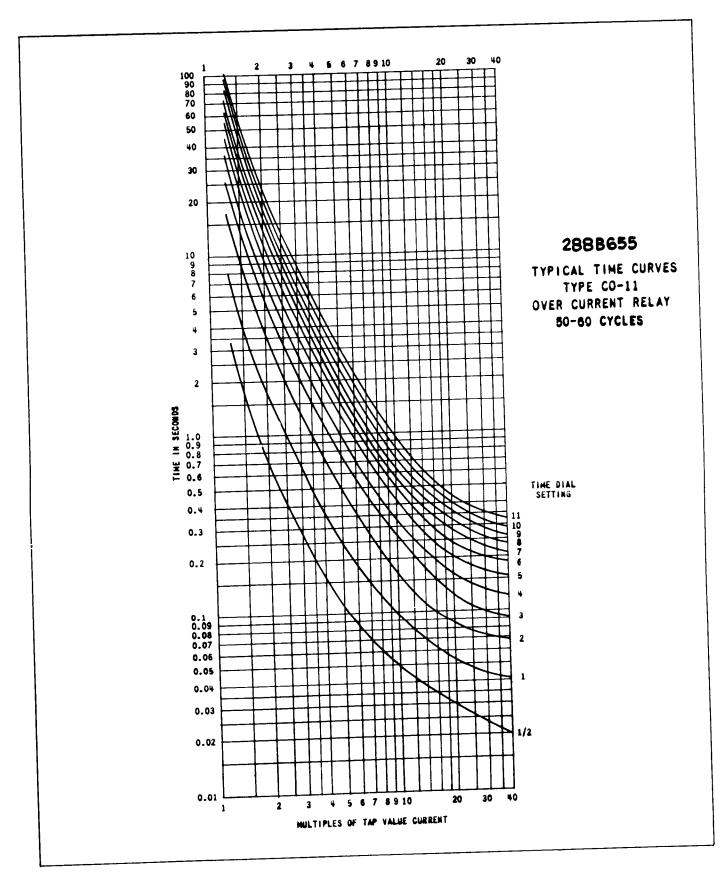
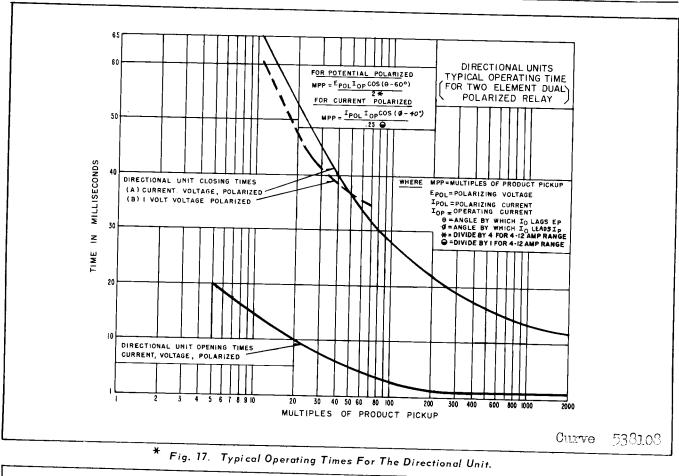


Fig. 16. Typical Time Curve of the Time-Overcurrent Unit of the Extremely Inverse (11) Relays.



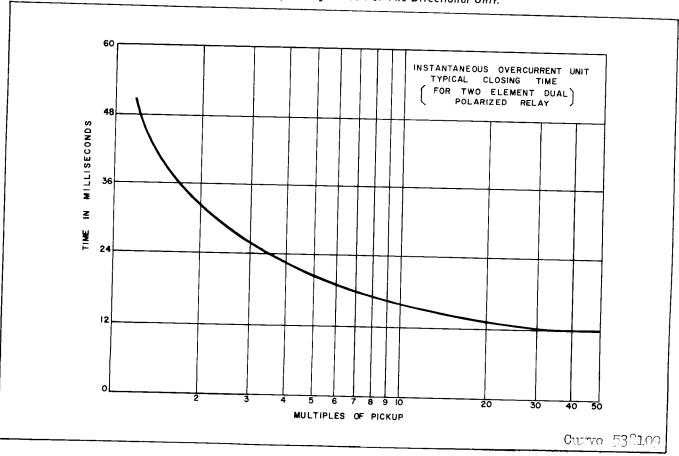


Fig. 18. Typical Operating Times For The Instantaneous Overcurrent Unit.

#### Trip Circuit Constants

Indicating Contactor Switch -

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

#### Auxiliary Switch (CS-1)

The auxiliary switch has a d-c resistance of 1165 ohms.

#### Type IRP Relay

The IRP 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 pick-up is approximately 1 volt and 2 amperes at its maximum torque angle for the directional units used with the 0.5 to 2.5 and 2 to 6 ampere range time over-current units. For the directional units used with the 4-12 ampere range time overcurrent units the minimum pick-up is 1 volt and 4 amperes.

#### Type IRC Relay

The IRC relay is designed for current polarization and has its maximum torque when the operating current leads the polarizing current by approximately  $40^{\circ}$ .

The directional unit minimum pick-up is 0.5 ampere in each winding at the maximum torque angle for the directional units used with the 0.5 to 2.5 and 2 to 6 ampere range time overcurrent units. For the directional units used with the 4-12 ampere range time overcurrent units the minimum pickup is 1 ampere.

#### Type IRD Relay

The type IRD relay utilizes a directional unit similar to the IRC relay in conjunction with the directional unit and phase-shifting circuit of the IRP relay.

The current-polarized directional unit of the IRD relay operates on residual currents while the potential-polarized directional unit of the IRD relay operates on residual voltage and residual current.

For the directional units used with the 0.5 to 2 and 2 to 6 ampere time overcurrent units, the minimum pick-up of the current polarized unit is 0.5 ampere in each winding at the maximum torque angle. The minimum pick-up for the voltage polarized unit is

1 volt and 2 amperes with the current lagging voltage by  $60^{\circ}$ .

For the directional units used with the 4 to 12 ampere range time overcurrent units, the minimum pick-up is 1 ampere for the current-polarized directional unit and 1 volt and 4 amperes for the voltage-polarized directional unit.

#### **SETTINGS**

#### Time Overcurrent Unit (CO)

The time overcurrent unit settings can be defined either by tap setting and time dial position or by tap setting and a specific time of operation at some current multiple of the tap setting (e.g. 4 tap setting, 2 time dial position or 4 tap setting, 0.6 seconds at 6 times tap value current).

To provide selective circuit breaker operation, a minimum coordinating time of 0.3 seconds plus circuit breaker time is recommended between the relay being set and the relays with which coordination is to be effected.

The connector screws on the tap plate above the time dial makes connections to various turns on the operating coil. By placing this screw in the various tap plate holes, the relay will just close its contacts at the corresponding current 4-5-6-7-8-10-12 amperes, or as marked on the tap plate.

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 space connector screw in the desired position before removing the other tap screw from the original tap position.

#### Instantaneous Reclosing

The factory adjustment of the CO unit contacts provides a contact follow. Where circuit breaker reclosing will be intiated immediately after a trip by the CO contact, the time of the opening of the contacts should be a minimum. This condition is obtained by loosening the stationary contact mounting screw, removing the contact plate and then replacing the plate with the bent end resting against the contact spring. With this change and the contact mounting screw tightened, the stationary contact will rest solidly against its backstop.

#### Instantaneous Overcurrent Unit (1)

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 con-

nector screw in the desired tap, the relay will just close its contacts at the tap value current.

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.

#### Directional Units (D)

No setting is required.

#### Indicating Contactor Switch (ICS/I and ICS/T)

The setting required on the ICS units is the selection of the 0.2 or 2.0 ampere tap setting. This selection is made by connecting the lead located in front of the tap block to the desired setting by means of the connecting screw.

#### Auxiliary Switch (CS-1)

No setting required on the CS-1 unit except for the selection of the required 24, 48, 125 or 250 voltage on the tapped rexistor. This connection can be made by referring to Fig. 23.

#### 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 be means of the two mounting studs for the type FT projection case or by means of the four mounting holes on the flange for the semi-flush type FT case. 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 detail information on the FT Case refer to I.L. 41-076.

The external a-c connections of the directional overcurrent relays are shown in Figs. 20, 21 and 22. If no voltage polarizing source is to be connected to the IRD relay, short-circuit the voltage polarizing circuit at the terminals of the relay.

#### 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:

#### Instantaneous 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 within  $\pm\,5\%$  of tap value current.

#### Directional Unit (D)

- 1. Contact Gap The gap between the stationary contact and moving contact with the relay in the deenergized position should be approximately .020".
- 2. <u>Sensitivity</u> The respective directional units should trip with value of energization and phase angle relationship 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 with the polarizing circuits short circuited for the voltage polarized units and open-circuited for the current polarized units.

#### Time Overcurrent Unit (CO)

- 1. Contacts The index mark on the movement frame will coincide with the "O" mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "O" mark by approximately .020". The placement of the various time dial positions in line with the index mark will give operating times as shown on the respective time-current curves.
- 2. Minimum Trip Current Set the time dial to position 6 with the auxiliary switch (CS-1) contacts

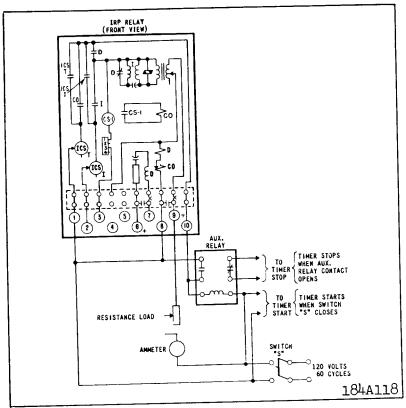


Fig. 19. Diagram of test connections of the time-overcurrent unit.

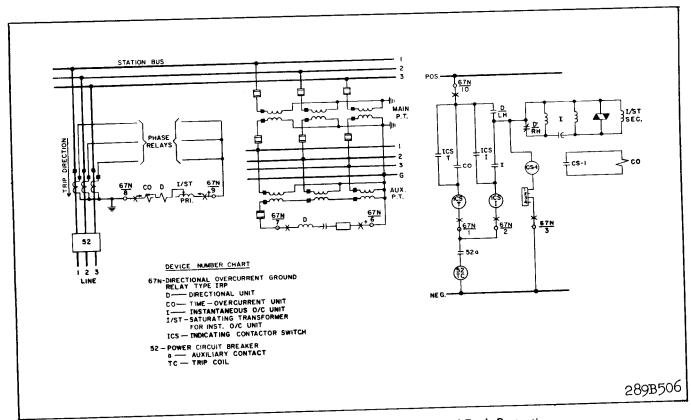


Fig. 20. External Schematic of the IRP Relay for Ground Fault Protection.

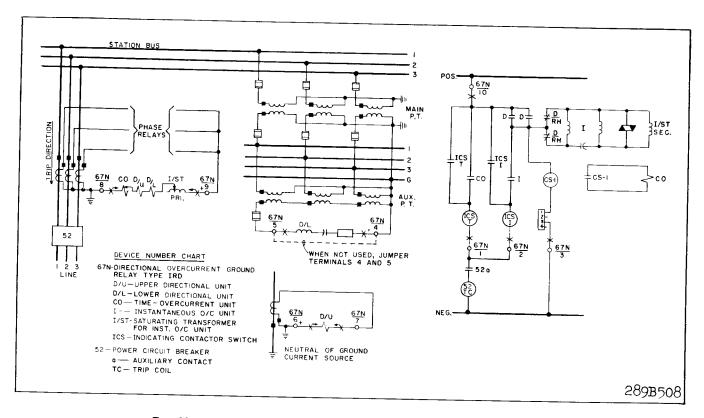


Fig. 21. External Schematic of the IRD Relay for Ground Fault Protection.

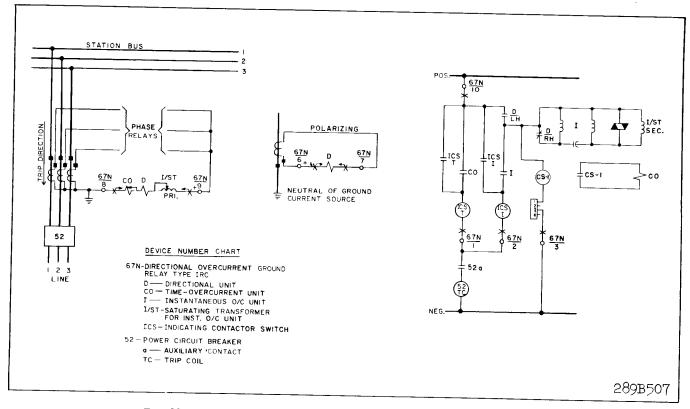


Fig. 22. External Schematic of the IRC Relay for Ground Fault Protection.

blocked closed, alternately apply tap value current plus 3% and tap value current minus 3%. The moving contact should leave the backstop at tap value current plus 3% and should return to the backstop at tap value current minus 3%.

3. <u>Time Curve</u> — Table 3 shows the time curve calibration points for the various types of relays. With the time dial set to the indicated position, apply the currents specified by Table 3 (e.g. for the CO-2, 3 and 20 times tap value current) and measure the operating time of the relay. The operating times should equal those of Table 3 plus or minus 5 percent.

### Indicating Contactor Switches (ICS/I) and (ICS/T)

- A) Close the contacts of the CO and pass sufficient d.c. current through the trip circuit to close the contacts of (ICS/T). This value of current should not be greater than the particular (ICS/T) tap setting being used. The operation indicator target should drop freely, bringing the letter "T" into view.
- B) Close the contacts of the instantaneous overcurrent unit (I) and the directional unit (D). Pass sufficient d.c. current through the trip circuit to close the contacts of (ICS/I). This value of current should not be greater than the particular (ICS/I) tap setting being used. The operation indicator target should drop freely, bringing the letter "I" into view.
- C) The contact gap should be approximately .047" 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 time of 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. The use of phantom loads, in testing induction-type relays, should be avoided, since the resulting distorted current wave form will produce an error in timing.

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

#### Calibration

Use the following procedure for calibrating the

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

#### Instantaneous Overcurrent Unit (1)

- 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, i.e., against the right side of the bridge. Move 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 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  $\pm 5\%$  of tap value.

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.

#### Directional Unit (D)

In the type IRP and IRC relays the directional unit is the lower cylinder unit. In the type IRD the directional units are the lower and middle cylinder 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 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 as indicated by a neon lamp in the contact circuit when energized with the required current and voltage as shown in Table 1. 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 or voltage 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 (IRP and IRD voltage polarized unit) are short-circuited.
- b) The polarizing circuits of the current polarized relays (IRC and IRD 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 some installations in order to insure that the relay will always trip the breaker on zero potential.

#### Time Overcurrent Unit (CO)

- 1. Contacts The index mark on the movement frame will coincide with the "O" mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "O" mark by approximately .020". The placement of the various time dial positions in line with the index mark will give operating times as shown on the respective time-current curves.
- 2) Minimum Trip Current The adjustment of the spring tension in setting the minimum trip current value of the relay is most conveniently made with the damping magnet removed.

With the time dial set on "O", wind up the spiral spring by means of the spring adjuster until approximately 6-3/4 convolutions show.

Set the relay on the minimum tap setting, the time dial to position 6.

With the auxiliary switch (CS-1) contacts blocked closed, adjust the control spring tension so that the moving contact will leave the backstop at tap value current +1.0% and will return to the backstop at tap value current -1.0%.

3)  $\underline{\text{Time Curve Calibration}}$  - Install the permanent magnet.

Apply the indicated current per Table 3 for permanent magnet adjustment (e.g. IRP-8, 2 times tap value) and measure the operating time. Adjust the permanent magnet keeper until the operating time corresponds to the value of Table 3.

Apply the indicated current per Table 3 for the electromagnet plug adjustment (e.g. IRP-8, 20 times tap value) and measure the operating time. Adjust the proper plug until the operating time corresponds to the value in Table 3. (Withdrawing the left hand plug, front view increases the operating time and withdrawing the right hand plug, front view, decreases the time.) In adjusting the plugs, one plug should be

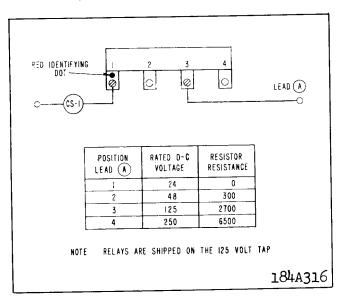


Fig. 23. Selection of Proper Voltage Tap for Auxiliary Switch (CS-1) Operation.

screwed in completely and the other plug run in or out until the proper operating time has been obtained.

Recheck the permanent magnet adjustment. If the operating time for this calibration point has changed, readjust the permanent magnet and then recheck the electromagnet plug adjustment.

#### Indicating Contactor Switches (ICS/I) and (ICS/T)

Adjust the contact gap for approximately .047".

A) Close the contacts of the CO and pass sufficient d.c. current through the trip circuit to close the contacts of the (ICS/T). This value of current should not be greater than the particular (ICS/T) tap setting being used. The operation indicator target should drop freely bringing the letter "T" into view.

B) Close contacts of instantaneous overcurrent unit (I) and directional unit (D). Pass sufficient d.c. current through the trip circuit to close contacts of the (ICS/I). This value of current should not be greater than the particular (ICS/I) tap setting being used. The operation indicator target should drop freely bringing the letter "I" into view.

#### Auxiliary Switch (CS-1)

Adjust the stationary core of the switch for a clearance between the stationary core and the moving core when the switch is picked up. This can be done by turning the relay upside-down. Then screw up the core screw until the moving core starts rotating. Now back off the core screw until the moving core stops rotating. This indicates the points where the play in the assembly is taken up, and where the moving core just separates from the stationary core screw. Back off the core screw approximately one turn and lock in place. This prevents the moving core from striking and sticking to the stationary core because of residual magnetism. Adjust the contact clearance for 3/64" by means of the two small nuts on either side of the Micarta disc.

Connect lead (A) to proper terminal per Fig. 28 Block directional unit (D) contacts close and ener gize trip circuit with rated voltage. Consider to auxiliary switch (CS-1) should make as indicated by a neon lamp in the contact circuit.

#### 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.

TABLE I DIRECTIONAL UNIT SENSITIVITY

	DIRE	CTIONAL UNIT	SENSITIVITY		
RELAY TYPE	AMPERE RATING	VALUES FOR	R MIN. PICKUP †	PHASE ANGLE RELATIONSHIP	
RLLAT THE	TIME-OVERCURRENT UNIT	VOLTS	AMPERES		
	.5-2.5	1	2.0	I lagging V by 60°††	
IRP	2-6	1	4.0	I in-phas∍ with V	
IRD (Voltage	4-12	1	4.0	I lagging V by 60° ††	
Unit)		1	8.0	I in-phase with V	
			0.5	$I_{O}$ leading $I_{D}$ by $40^{\circ}$ ††	
IRC IRD (Current $\triangle$ Unit)	.5-2.5 2-6		. 57	In-phase	
			1.0	${ m I_O}$ leading ${ m I_p}$ by $40^{\circ}\dagger^{\dagger}$	
	4-12		1.3	In-phase	

<sup>†</sup> The energization quantities are input quantities at the relay terminals.

<sup>††</sup> Maximum torque angle.

 $<sup>\</sup>Delta$  When normal system conditions limit the current to less than twice pickup, performance may be improved by sellecting a higher current C.T. tap to energize the polarizing circuit. 27

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) (Contacts remain open)	Left (Front View) Plug Screwed Out Until Spurious Torque is in Contact Closing Direction. Then the plug is screwed in Until Spuri ous Torque is Reversed.

<sup>†</sup> Short circuit the voltage polarizing circuit at the relay terminals before making the above adjustment.

TABLE III

TIME CURVE CALIBRATION DATA - 60 CYCLES

PERMANENT MAGNET ADJUSTMENT				ELECTROMAGNET PLUGS		
TIME- OVERCURRENT UNIT TYPE	TIME DIAL POSITION	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS	
2	6	3	0.57	20	0.22	
5	6	2	37.80	10	14.30	
6	6	2	2.46	20	1.19	
7	6	2	4.27	20	1.11	
8	6	2	13.35	20	1.11	
9	6	2	8.87	20	0.65	
11	6	2	11, 27	20	0.24	

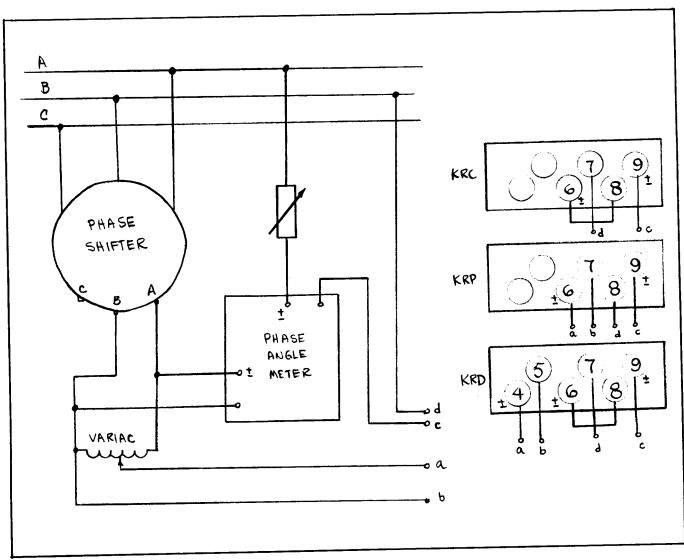


Fig. 24. Test Connections

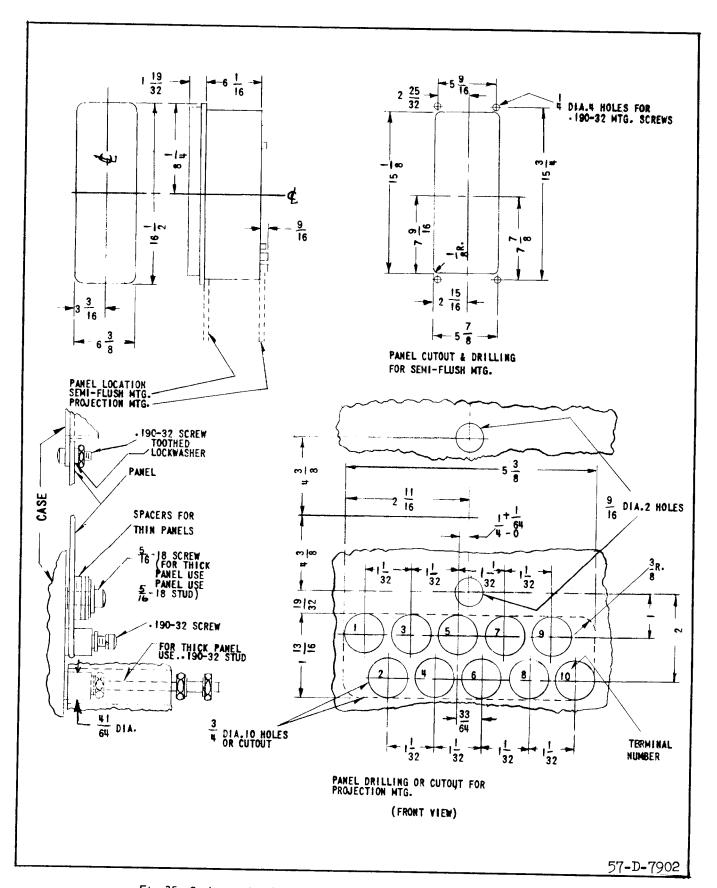


Fig. 25. Outline and Drilling Plan for the IRP and IRC Relays in the Type FT31 Case.

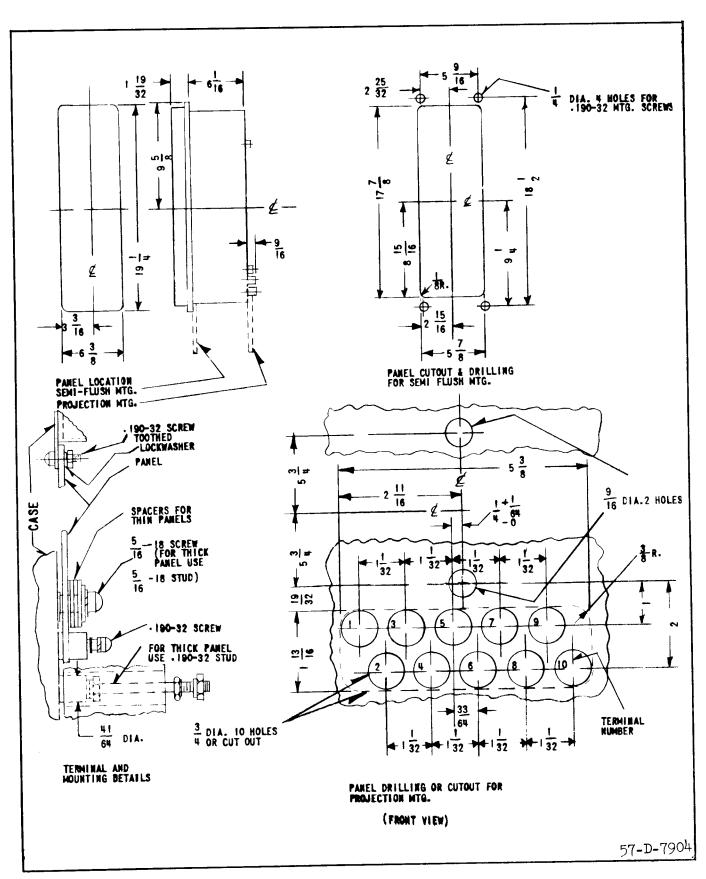


Fig. 26. Outline and Drilling Plan for the IRD Relay in the Type FT41 Case.



WESTINGHOUSE ELECTRIC CORPORATION RELAY-INSTRUMENT DIVISION NEWARK, N. J.



#### INSTALLATION . OPERATION . MAINT

## INSTRUCTIONS

# DIRECTIONAL OVERCURRENT GROUND RELAYS TYPES IRP, IRC AND IRD

minte

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**

These relays are ground directional overcurrent relays which are used for the protection of transmission lines and feeder circuits. Both the time-overcurrent and instantaneous overcurrent units are directionally controlled.

The type IRP relay is potential polarized. The type IRC relay is current polarized. The type IRD relay is a dual polarized relay which can be polarized from a potential source, from a local ground source or from both simultaneously.

### CONSTRUCTION AND OPERATION

The various types of relays consist of a directional unit or units (D), an auxiliary switch (CS-1), a time-overcurrent unit (CO), an instantaneous overcurrent unit (I), an instantaneous overcurrent unit transformer, and two indicating contactor switches (ICS/I) and (ICS/T). The principle component parts of the relays and their location are shown in Fig. 1 through 6.

#### Time-Overcurrent Unit (CO)

The electromagnets for the types IR-5, IR-6, IR-7, IR-8 and IR-9 relays have a main tapped coil located on the center leg of an "E" type laminated structure that produces a flux which divides and returns through the outer legs. A shading coil causes the flux through the left leg to lag the main pole flux. The out-of-phase fluxes thus produced in the air gap cause a contact closing torque.

The electromagnet for the type IR-2 and IR-11 relays has a main coil consisting of a tapped primary winding and a secondary winding. Two identical coils

on the outer legs of the lamination structure are connected to the main coil secondary in a manner so that the combination of all the fluxes produced by the electromagnet result in out-of-phase fluxes in the air gap. The out-of-phase air gap fluxes produced cause a contact closing torque.

#### Indicating Contactor Switch Units (ICS/I and ICS/T)

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

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

#### 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 the magnetic core. The magnetic core which houses the lower pin bearing is secured to the 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

Time Overcurrent Unit

Range			$\overline{\mathtt{Taps}}$				
.5-2.5	0.5	0.6	0.8	1.0	1.5	2.0	2.5
2-6	2	2.5	3	3.5	4	5	6
4-12	4	5	6	7	8	10	12

The tap value is the minimum current required to just close the relay contacts.

The time vs. current characteristics for the timeovercurrent unit are shown in Figs. 10 to 16. These characteristics give the contact closing time for the various time dial settings when the indicated multiples of tap value current are applied to the relay.

#### TIME CURVES

The time curves for the IRD relay are shown in Fig. 17 and 18. Fig. 17 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.

Fig. 18 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 Fig. 18 plus the directional unit opening time given in Fig. 17. The total closing time for the directional unit is given in Fig. 17. The two examples below will serve to illustrate the use of the curves.

Example 1: Using the formulas and definition of symbols on Fig. 17, we have—

Let: Ipol = 2 amps.  
Iop = 2.31  
Tap Value (T) = 0.5 amp.  

$$\phi - 40^{\circ} = 0^{\circ}$$
  
(For timing unit, assume  
CO-9 with ½ time dial setting)

For current polarized relay:

$$MPP = \frac{\text{Iop Ipol Cos}(\phi - 40^{\circ})}{0.25}$$

MPP = 
$$\frac{(2.31)(2)}{0.25}$$
 = 18.5

Referring to Fig. 17 at multiples of produce pickup of 18.5,the directional unit operating time is about 11 ms, and the closing time for this unit is 56 ms.

For overcurrent unit:

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

Entering the curve in Fig. 18 at multiples of pickup equal to 4.6, the closing time for instantaneous overcurrent is 16 ms. However, the total operating time for the overcurrent unit is 16 plus 11, which is the opening time of back contacts of the directional unit, or 27 ms total operating time for overcurrent unit. The total time for directional unit is 56 ms; and, since this is the longest time,56 ms is the total operating time of the instantaneous overcurrent circuit.

Entering the curve in Fig. 15 at 4.6, the  $\frac{1}{2}$  time dial setting gives 140 ms. The total time for the time-overcurrent circuit is 56 ms directional unit time plus 16 ms CS-1 time plus 140 ms = 212 ms.

Example 2:

Let: Ipol = 20 amps.  
Iop = 23.1 amps  

$$T(tap) = 1$$
 amp.  
 $\phi - 40^{\circ} = 0$   
MPP = 
$$\frac{\text{Iop Ipol Cos} (\phi - 40^{\circ})}{0.25}$$
MPP = 
$$\frac{(20)(23.1)}{0.25} = 1850$$

Entering Fig. 17, the directional unit closing time is 12 ms, and the opening time of its back contacts is 1 ms. The total operating time for the directional unit is 13 ms.

For overcurrent unit:

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

Referring to Fig. 18, the overcurrent unit contact closing time is about 14 ms. Therefore, the total operating time for this unit is 14 plus 1 or 15 ms. In this case the total operating time of relay is 15 ms.

Fig. 15 gives an operating time of about 50 ms. The time-overcurrent circuit is 12 plus 16 ms CS-1 time plus 50 = 78 ms.

#### Trip Circuit

The relay contacts will safely close 30 amperes at 250 volts d c and the seal-in contacts of the indicating contactor switches will safely carry this current long enough to trip a circuit breaker.

The indicating contactor switch has two taps that provide a pickup setting of 0.2 or 2 amperes. To change taps requires connecting the lead located in front of the tap block to the desired setting by means of a screw connection.

#### 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.

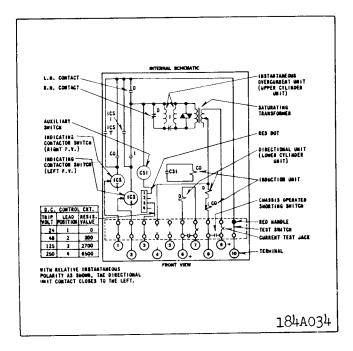


Fig. 8. Internal Schematic of the Type IRC Relay in the Type FT31 Case.

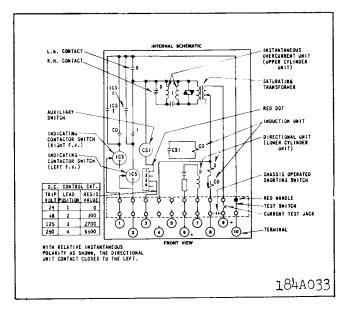


Fig. 7. Internal Schematic of the Type IRP Relay in the Type FT31 Case.

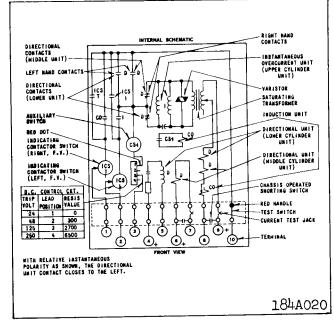


Fig. 9. Internal Schematic of the Type IRD Relay in the Type FT41 Case.

ENERGY REQUIREMENTS

INSTANTANEOUS OVERCURRENT UNIT OPERATING CURRENT CIRCUIT - 60 HERTZ

	1	††	φ	1 1 1	φ
AMPERE RANGE	TAP	VA AT TAP VALUE	P.F. ANGLE	VA AT 5 AMPS.	P.F. ANGLE
	.5	.37	39	24	46
	.75	.38	36	13	37
F 0	1	.39	35	8.5	34
.5-2	1.25	.41	34	6.0	32
	1.5	.43	32	4.6	31
	2	.45	30	2.9	28
	1	.41	36	9.0	36
	1.5	.44	32	5.0	32
1-4	2	.47	30	3.0	29
• •	2.5	.50	28	2.1	27
	3	.53	26	1.5	26
	4	.59	24	0.93	24
	2	1.1	49	6.5	48
	3	1.2	43	3.3	42
2-8	4	1.3	38	2.1	37
4.0	5	1.4	35	1.4	35
	6	1.5	33	1.1	33
	8	1.8	29	0.7	29
	4	1.5	51	2.4	51
	6	1.7	45	1.2	45
4-16	8	1.8	40	0.7	40
	9	1.9	38	0.6	38
	12	2.2	34	0.37	34
	16	2.5	30	0.24	31
	10	1.7	28	0.43	28
	15	2.4	21	0.27	21
10-40	20	3.1	16	0.20	17
10 10	24	3.6	15	0.15	15
	30	4.2	12	0.11	13
	40	4.9	11	0.08	12
	20	6.6	31	0.40	31
	30	9.3	24	0.25	24
20-80	40	12	20	0.18	20
	48	13.5	18	0.14	18
	60	15.9	16	0.10	16
	80	<b>1</b> 9.2	15	0.07	15
RANGE		CONTINUOUS RATIN	1G	ONE SECOND R	ATING
		(AMPERES)		† (AMPERES	
. 5-2		5		100	
1-4	8			140	
2-8		8		140	
					ļ 
4-16		10		200	
10-40		10		200	
20-80		10		200	

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

φ Degrees current lags voltage.

<sup>† †</sup> Voltages taken with Rectox type voltmeter.

# ENERGY REQUIREMENTS - 60 HERTZ DIRECTIONAL UNIT OPERATING CIRCUIT BURDEN

						VOI	T AMPERES	††
Relay Type	Range Amps	Continuous Rating (Amperes)	One Second Rating † (Amperes)	Power Factor Angle $\phi$	At Minimum Tap Value Current	At 3 Times Minimum Tap Value Current	At 10 Times Minimum Tap Value Current	At 20 Times Minimum Tap Value Current
IRC	0.5-2.5	-	230	44.0	0.033	0.30	3.3	14.2
	2-6	-	230	42.5	0.58	5.28	58.0	240.0
	4-12	12	280	31.8	0.64	6.12	70.0	272.0
IRP	0.5-2.5	10	230	34.5	0.03	0.23	2.8	11.5
	2-6	10	230	34.5	0.44	4.08	48.0	182.0
	4-12	12	280	25.0	0.48	4.62	53.6	216.0
IRD	0.5-2.5	10	230	45.0	0.07	0.59	6.6	26.0
	2-6	10	230	45.0	1.04	9.9	106.0	420.0
	4-12	12	280	32.4	1.16	10.8	121.2	472.0

<sup>\$\</sup>psi\$ Degrees current lags voltage at tap value current.

# ENERGY REQUIREMENTS - 60 HERTZ DIRECTIONAL UNIT POLARIZING CIRCUIT BURDEN

RELAY TYPE	RATING	VOLT AMPERES △	POWER FACTOR ANGLE $\phi$
IRC	230 Amperes †	1.45	8° Lag
IRP	208 Volts ††	11.2	28 ° Lead
KRD Current Unit	230 Amperes ††	1.45	8° Lag
IRD Voltage Unit	208 Volts ††	11.2	28 ° Lead

 $<sup>\</sup>not$  Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

<sup>††</sup> Voltages taken with Rectox type voltmeter.

 $<sup>\</sup>triangle \ Burden \ of \ voltage \ polarized \ units \ taken \ at \ 120 \ volts. Burden \ of \ current \ polarized \ units \ taken \ at \ 5 \ amperes.$ 

<sup>†</sup> One second rating.

<sup>††30</sup> second rating. The 10 second rating is 345 volts. The continuous rating is 120 volts.

# **ENERGY REQUIREMENTS**

# TYPE IRD-2, IRC-2, IRP-2 TIME OVERCURRENT UNITS

					VOLT AMPERES††			
AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING† (AMPERES)	POWER FACTOR ANGLE $\phi$	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
0.5/2.5	0.5 0.6 0.8 1.0 1.5 2.0 2.5	0.91 0.96 1.18 1.37 1.95 2.24 2.50	28 28 28 28 28 28 28	58 57 53 50 40 36 29	4.8 4.9 5.0 5.3 6.2 7.2 7.9	39.6 39.8 42.7 45.4 54.4 65.4 73.6	256 270 308 348 435 580 700	790 851 1024 1220 1740 2280 2850
2/6	2.0 2.5 3.0 3.5 4.0 5.0 6.0	3.1 4.0 4.4 4.8 5.2 5.6 6.0	110 110 110 110 110 110 110	59 55 51 47 45 41	5.04 5.13 5.37 5.53 5.72 5.90 6.54	38.7 39.8 42.8 42.8 46.0 50.3 54.9	262 280 312 329 360 420 474	800 920 1008 1120 1216 1500
4/12	4.0 5.0 6.0 7.0 8.0 10.0 12.0	7.3 8.0 8.8 9.6 10.4 11.2 12.0	230 230 230 230 230 230 230	65 50 47 46 43 37	4.92 5.20 5.34 5.53 5.86 6.6 7.00	39.1 42.0 44.1 45.8 49.9 55.5 62.3	268 305 330 364 400 470 528	848 1020 1128 1260 1408 1720 2064

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

 $<sup>\</sup>phi$  Degrees current lags voltage at tap value current.

<sup>††</sup> Voltages taken with Rectox type voltmeter.

# **ENERGY REQUIREMENTS**

IRD-5, IRC-5, IRP-5, TIME OVERCURRENT UNITS

VOLT AMPERES † †

					VOLI AMPERESTI				
AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	RATING† FACTOR T	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT		
	(O E	* 2.7	88	69	3.92	20.6	103	270	
	(0.5 (0.6	* 3.1	88	68	3.96	20.7	106	288	
	•	* 3.7	88	67	3.96	21	114	3 2 5	
0.5/0.5	(0.8	* 4.1	88	66	4.07	21.4	122	360	
0.5/2.5	(1.0	* 5.7	88	62	4.19	23.2	147	462	
	(1.5	* 6.8	88	60	4.30	24.9	168	548	
	(2.0)	* 0.8 * 7.7	88	58	4.37	26.2	180	630	
	(2	8	230	67	3.88	21	110	308	
	(2.5	8.8	230	66	3.90	21.6	118	342	
	(3	9.7	230	64	3.93	22.1	126	381	
2/6	(3.5	10.4	230	63	4.09	23.1	136	417	
2/6		11.2	230	62	4.12	23.5	144	448	
	(4 (5	12.5	230	59	4.20	24.8	162	540	
	(6	13.7	230	57	4.38	26.5	183	624	
	(4	16	460	65	4.00	22.4	126	376	
	(5	18.8	460	63	4.15	23.7	143	450	
	(6	19.3	460	61	4.32	25.3	162	531	
4/12	(7	20.8	460	59	4.35	26.4	183	611	
7/ 14	(8	22.5	460	56	4.40	27.8	204	699	
	(10	25	460	53	4.60	30.1	247	880	
	(12	28	460	47	4.92	35.6	288	1056	

# IRD-7, IRC-7, IRP-7 TIME OVERCURRENT UNITS

VOLT AMPERES † †

			ING RATING FACTOR	VOLT AMPERES!				
AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)			AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
				68	3.88	20.7	103	278
	(0.5	* 2.7	88	67	3.93	20.9	107	288
	(0.6	* 3.1	88		3.93	21.1	114	320
	8.0)	* 3.7	88	66	4.00	21.6	122	35 <b>6</b>
0.5/2.5	(1.0	* 4.1	88	64	4.08	22.9	148	459
	(1.5)	* 5.7	88	61	4.08	24.8	174	552
	(2.0	* 6.8	88	58		25.9	185	640
	(2.5	<b>*</b> 7.7	88	56	4.38	25.9	100	0.10
	(2	8	230	66	4.06	21.3	111	306
	(2.5	8.8	230	63	4.07	21.8	120	342
	(3	9.7	230	63	4.14	22.5	129	366
0.40		10.4	230	62	4.34	23.4	141	413
2/6	(3.5	11.2	230	61	4.34	23.8	149	448
	(4	12.5	230	59	4.40	25.2	163	530
	(5 (6	13.7	230	58	4.62	27	183	624
	(0	20						
	(4	16	460	64	4.24	22.8	129	392
	(5	18.8	460	61	4.30	24.2	149	460
4/12	(6	19.3	460	60	4.62	25.9	168	540
4/12	(7	20.8	460	58	4.69	27.3	187	626
	(8	22.5	460	55	4.80	29.8	211	688
	(10	25	460	51	5.20	33	260	860
	(10	28	460	46	5.40	37.5	308	1032
	(12	20	100					

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

 $<sup>\</sup>phi$  Degrees current lags voltage at tap value current.

<sup>††</sup> Voltages taken with Rectox type voltmeter.

# **ENERGY REQUIREMENTS**

IRD-8, IRC-8, IRP-8, TIME OVERCURRENT UNITS IRD-9, IRC-9, IRP-9,

					VOLT AMPERES ††			
Ampere Range	Тар	Continuous Rating (Amperes)	One Second Rating † (Amperes)	Power Factor Angle $\phi$	At Tap Value Current	At 3 Times Tap Value Current	At 10 Times Tap Value Current	At 20 Times Tap Value Current
0.5/2.5	(0.5 (0.6 (0.8 (1.0 (1.5 (2.0 (2.5	* 2.7 * 3.1 * 3.7 * 4.1 * 5.7 * 6.8 * 7.7	88 88 88 88 88	72 71 69 67 62 57 53	2.38 2.38 2.40 2.42 2.51 2.65 2.74	21 21 21.1 21.2 22 23.5 24.8	132 134 142 150 170 200 228	350 365 400 440 530 675 800
2/6	(2 (2.5 (3 (3.5 (4 (5 (6	8 8.8 9.7 10.4 11.2 12.5 13.7	230 230 230 230 230 230 230 230	70 66 64 62 60 58 56	2.38 2.40 2.42 2.48 2.53 2.64 2.75	21.1 21.1 21.5 22 22.7 24 25.2	136 142 149 157 164 180	360 395 430 470 500 580 660
4/12	(4 (5 (6 (7 (8 (10 (12	16 18.8 19.3 20.8 22.5 25	460 460 460 460 460 460 460	68 63 60 57 54 48 45	2.38 2.46 2.54 2.62 2.73 3.00 3.46	21.3 21.8 22.6 23.6 24.8 27.8 31.4	146 158 172 190 207 248 292	420 480 550 620 700 850 1020

IRD-11, IRC-11, IRP-11 OVERCURRENT UNITS

IND-11, INC-11, INF-11 OVERCURRENT UNITS									
					VOLT AMPERES ††				
Ampere Range	Тар	Continuous Rating (Amperes)	One Second Rating † (Amperes)	Power Factor Angle $\phi$	At Tap Value Current	At 3 Times Tap Value Current	At 10 Times Tap Value Current	At 20 Times Tap Value Current	
0.5/2.5	0.5 0.6 0.8 1.0 1.5 2.0 2.5	1.7 1.9 2.2 2.5 3.0 3.5 3.8	56 56 56 56 56 56	36 34 30 27 22 17	0.72 0.75 0.81 0.89 1.13 1.30	$\begin{array}{c} 6.54 \\ 6.80 \\ 7.46 \\ 8.30 \\ 10.04 \\ 11.95 \\ 13.95 \end{array}$	71.8 75.0 84.0 93.1 115.5 136.3 160.0	250 267 298 330 411 502 610	
2/6	2.0 2.5 3.0 3.5 4.0 5.0 6.0	7.0 7.8 8.3 9.0 10.0 11.0 12.0	230 230 230 230 230 230 230 230	32 30 27 24 23 20 20	0.73 0.78 0.83 0.88 0.96 1.07	6.30 7.00 7.74 8.20 9.12 9.80 11.34	74.0 78.5 84.0 89.0 102.0 109.0 129.0	264 285 309 340 372 430 504	
4/12	4.0 5.0 6.0 7.0 8.0 10.0 12.0	14 16 17 18 20 22 26	460 460 460 460 460 460 460	29 25 22 20 18 17 16	0.79 0.89 1.02 1.10 1.23 1.32 1.8	7.08 8.00 9.18 10.00 11.1 14.9 16.3	78.4 90.0 101.4 110.0 124.8 131.6 180.0	296 340 378 454 480 600 720	

# IRD TIME OVERCURRENT UNIT BURDEN DATA AT HIGH CURRENTS

				HON CONKE	1113	
Ampere Range			.5-	2.5		
Tap Value Current	.5		1.0		2.5	
Multiples of Tap Value Current	40	80	20	40	8	16
VA ††	790	2600	380	1280	60	280
P.F. Angle $\phi$	46.7 °	42 °	37°	26.5 °	4.8 °	4,3 °

<sup>†</sup> Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

<sup>\$\</sup>psi Degrees current lags voltage at tap value current.

 $<sup>\</sup>dagger\dagger Voltages\ taken\ with\ Rectox\ type\ voltmeter.$ 

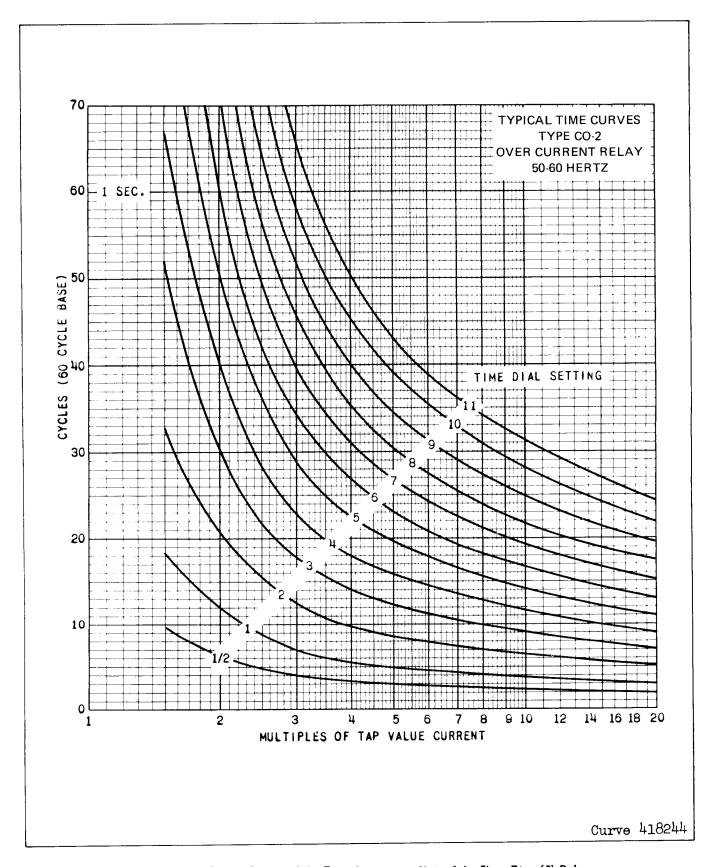


Fig. 10. Typical Time Curves of the Time-Overcurrent Unit of the Short Time (2) Relays.

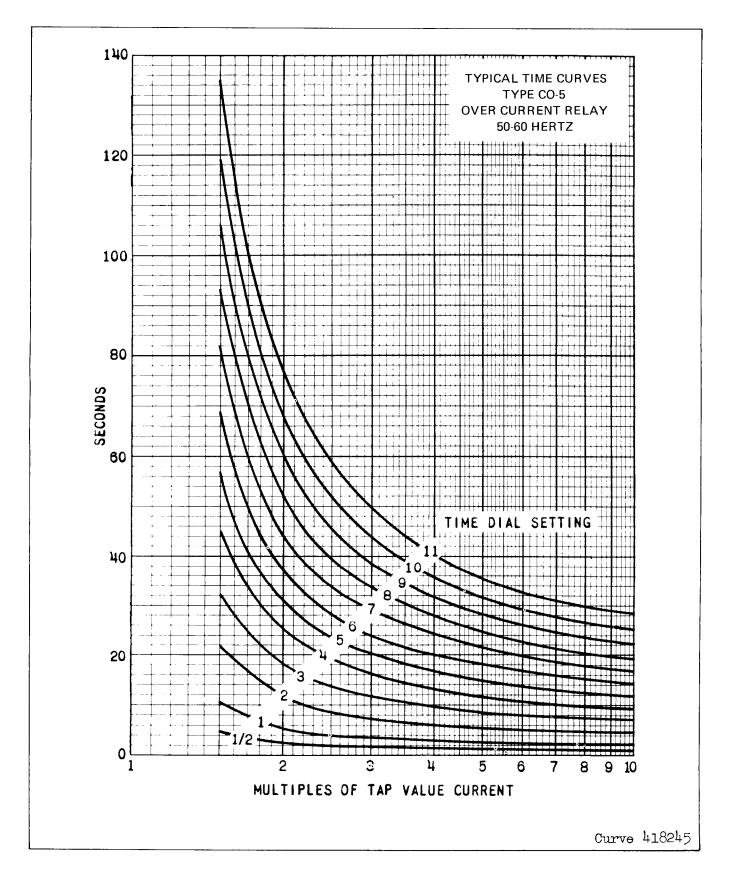


Fig. 11. Typical Time Curve of the Time-Overcurrent Unit of the Long Time (5) Relays.

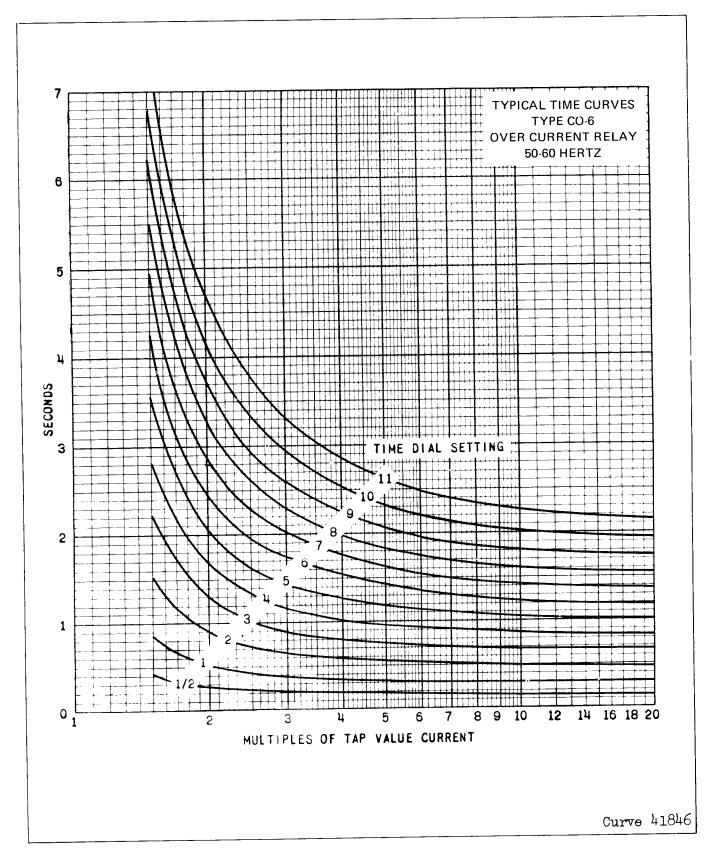


Fig. 12. Typical Time Curve of the Time-Overcurrent Unit of the Definite Time (6) Relays.

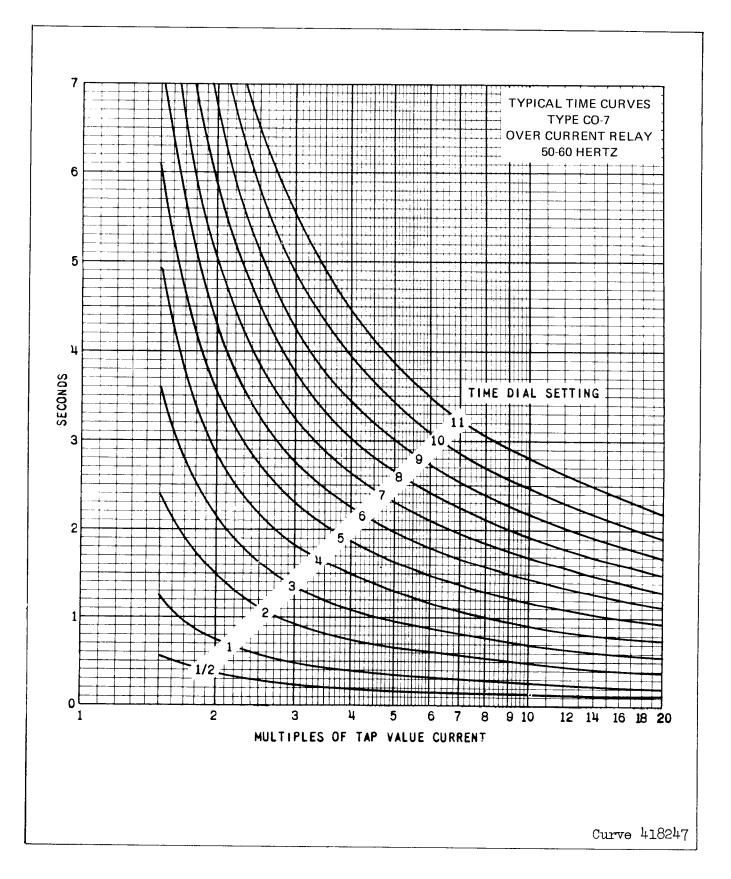


Fig. 13. Typical Time Curve of the Time-Overcurrent Unit of the Moderately Inverse (7) Relays.

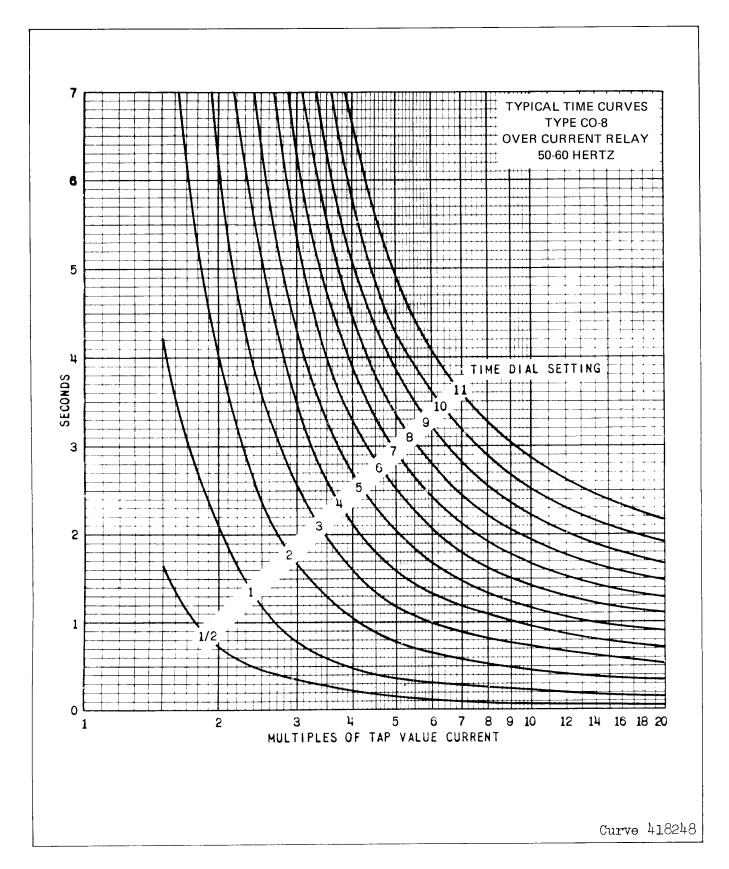


Fig. 14. Typical Time Curve of the Time-Overcurrent Unit of the Inverse (8) Relays.

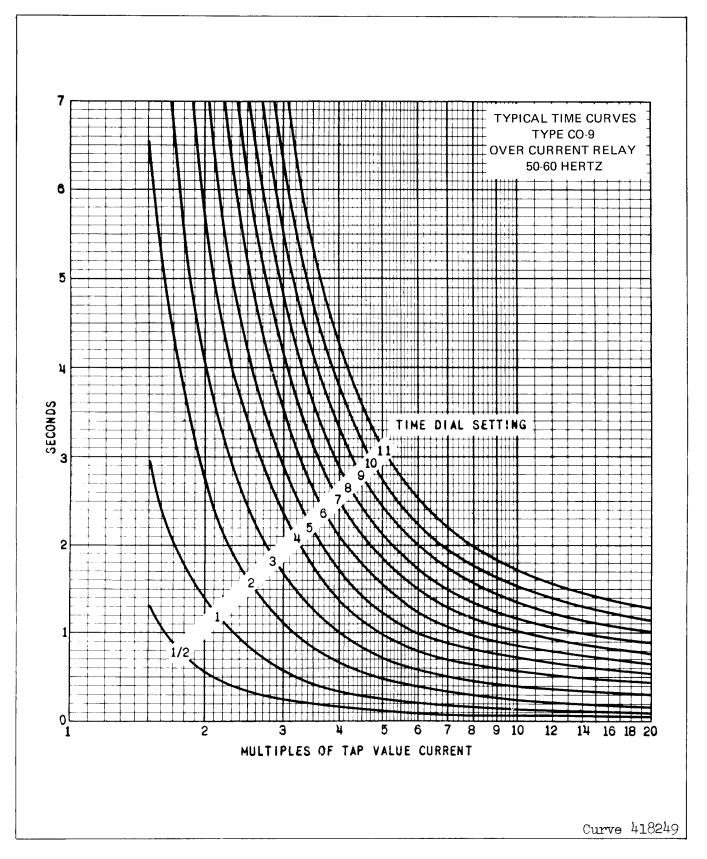


Fig. 15. Typical Time Curve of the Time-Overcurrent Unit of the Very Inverse (9) Relays.

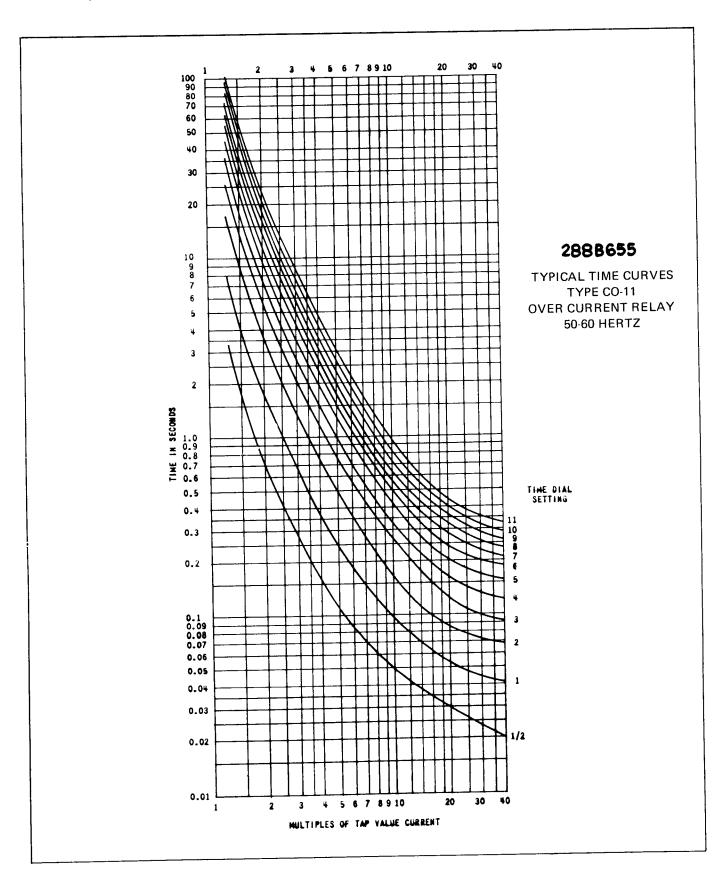


Fig. 16. Typical Time Curve of the Time-Overcurrent Unit of the Extremely Inverse (11) Relays.

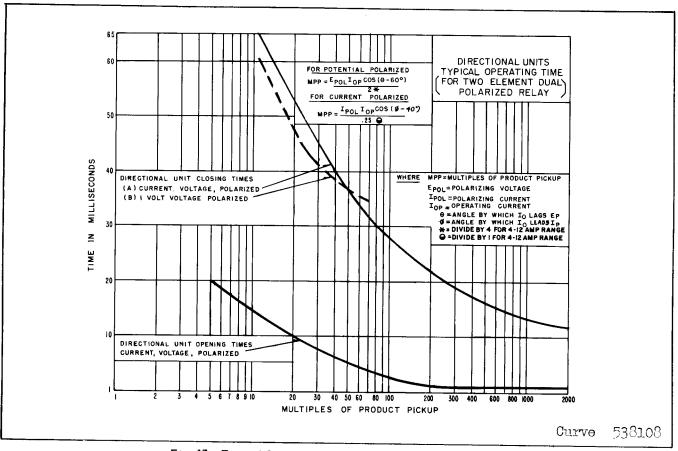


Fig. 17. Typical Operating Times For The Directional Unit.

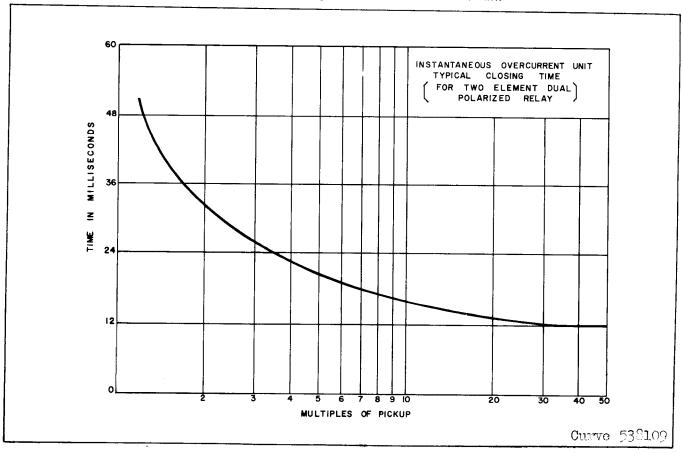


Fig. 18. Typical Operating Times For The Instantaneous Overcurrent Unit.

#### Trip Circuit Constants

Indicating Contactor Switch -

0.2 ampere tap - 6.5 ohms d-c resistance

2.0 ampere tap - 0.15 ohms d-c resistance

#### Auxiliary Switch (CS-1)

The auxiliary switch has a d-c resistance of 1165 ohms.

#### Type IRP Relay

The IRP 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 pick-up is approximately 1 volt and 2 amperes at its maximum torque angle for the directional units used with the 0.5 to 2.5 and 2 to 6 ampere range time over-current units. For the directional units used with the 4-12 ampere range time overcurrent units the minimum pick-up is 1 volt and 4 amperes.

#### Type IRC Relay

The IRC relay is designed for current polarization and has its maximum torque when the operating current leads the polarizing current by approximately  $40^{\circ}$ .

The directional unit minimum pick-up is 0.5 ampere in each winding at the maximum torque angle for the directional units used with the 0.5 to 2.5 and 2 to 6 ampere range time overcurrent units. For the directional units used with the 4-12 ampere range time overcurrent units the minimum pickup is 1 ampere.

#### Type IRD Relay

The type IRD relay utilizes a directional unit similar to the IRC relay in conjunction with the directional unit and phase-shifting circuit of the IRP relay.

The current-polarized directional unit of the IRD relay operates on residual currents while the potential-polarized directional unit of the IRD relay operates on residual voltage and residual current.

For the directional units used with the 0.5 to 2 and 2 to 6 ampere time overcurrent units, the minimum pick-up of the current polarized unit is 0.5 ampere in each winding at the maximum torque angle. The minimum pick-up for the voltage polarized unit is

1 volt and 2 amperes with the current lagging voltage by  $60^{\circ}$ .

For the directional units used with the 4 to 12 ampere range time overcurrent units, the minimum pick-up is 1 ampere for the current-polarized directional unit and 1 volt and 4 amperes for the voltage-polarized directional unit.

## SETTINGS

# Time Overcurrent Unit (CO)

The time overcurrent unit settings can be defined either by tap setting and time dial position or by tap setting and a specific time of operation at some current multiple of the tap setting (e.g. 4 tap setting, 2 time dial position or 4 tap setting, 0.6 seconds at 6 times tap value current).

To provide selective circuit breaker operation, a minimum coordinating time of 0.3 seconds plus circuit breaker time is recommended between the relay being set and the relays with which coordination is to be effected.

The connector screws on the tap plate above the time dial makes connections to various turns on the operating coil. By placing this screw in the various tap plate holes, the relay will just close its contacts at the corresponding current 4-5-6-7-8-10-12 amperes, or as marked on the tap plate.

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 space connector screw in the desired position before removing the other tap screw from the original tap position.

#### Instantaneous Reclosing

The factory adjustment of the CO unit contacts provides a contact follow. Where circuit breaker reclosing will be intiated immediately after a trip by the CO contact, the time of the opening of the contacts should be a minimum. This condition is obtained by loosening the stationary contact mounting screw, removing the contact plate and then replacing the plate with the bent end resting against the contact spring. With this change and the contact mounting screw tightened, the stationary contact will rest solidly against its backstop.

# Instantaneous Overcurrent Unit (1)

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 con-

nector screw in the desired tap, the relay will just close its contacts at the tap value current.

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.

#### Directional Units (D)

No setting is required.
Indicating Contactor Switch (ICS/I and ICS/T)

The setting required on the ICS units is the selection of the 0.2 or 2.0 ampere tap setting. This selection is made by connecting the lead located in front of the tap block to the desired setting by means of the connecting screw.

#### Auxiliary Switch (CS-1)

No setting required on the CS-1 unit except for the selection of the required 24, 48, 125 or 250 voltage on the tapped rexistor. This connection can be made by referring to Fig. 23.

## 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 rear mounting stud or studs for the type FT projection case or by means of the four mounting holes on the flange for the semiflush type FT case. Either the stud or the mounting screws may be utilized for grounding the relay. External toothed washers are provided for use in the locations shown on the outline and drilling plan to facilitate making a good electrical connection between the relay case, its mounting screws or studs, and the relay panel. Ground Wires are affixed to the mounting screws or studs as required for poorly grounded or insulating panels. Other electrical connections may be made directly to the terminals by means of screws for steel panel mounting or to the terminal stud furnished with the relay for thick panel mounting. The terminal stud may be easily removed or inserted by locking two nuts on the stud and then turning the proper nut with a wrench.

For detail information on the FT case refer to I.L. 41-076.

The external a-c connections of the directional overcurrent relays are shown in Figs. 20, 21 and 22. If no voltage polarizing source is to be connected to the IRD relay, short-circuit the voltage polarizing circuit at the terminals of the relay.

## 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;

# Instantaneous 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. <u>Minimum Trip Current</u> The normally-closed contact of the directional unit should be blocked open when checking the pick-up of the overcurrent unit.

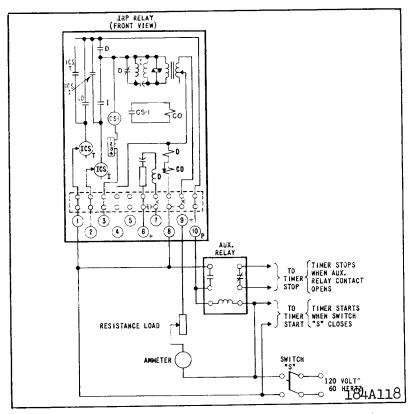
The pick-up of the overcurrent unit can be checked by inserting the tap screw in the desired tap hole and applying rated tap value current. The contact should close within  $\pm\,5\%$  of tap value current.

## Directional Unit (D)

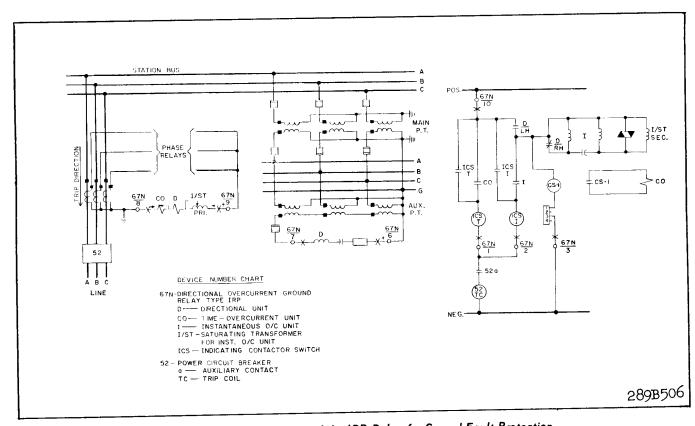
- 1. Contact Gap The gap between the stationary contact and moving contact with the relay in the deenergized position should be approximately .020".
- 2. <u>Sensitivity</u> The respective directional units should trip with value of energization and phase angle relationship as indicated in Table 1.
- 3. Spurious Torque Adjustments There should be no spurious closing torques when the operating circuits are energized per Table 2 with the polarizing circuits short circuited for the voltage polarized units and open-circuited for the current polarized units.

## Time Overcurrent Unit (CO)

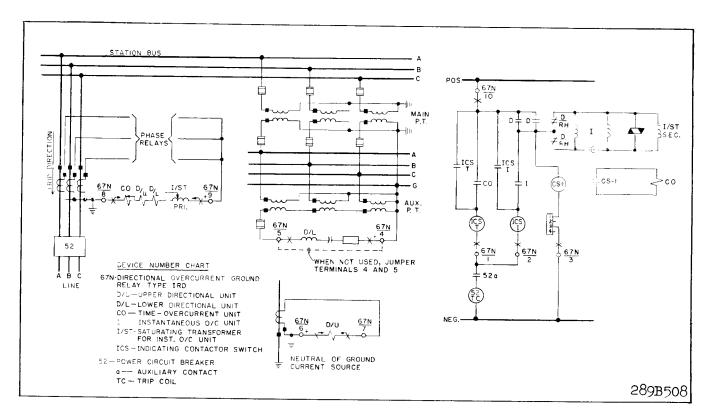
- 1. Contacts The index mark on the movement frame will coincide with the "O" mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "O" mark by approximately .020". The placement of the various time dial positions in line with the index mark will give operating times as shown on the respective time-current curves.
- 2. Minimum Trip Current Set the time dial to position 6 with the auxiliary switch (CS-1) contacts



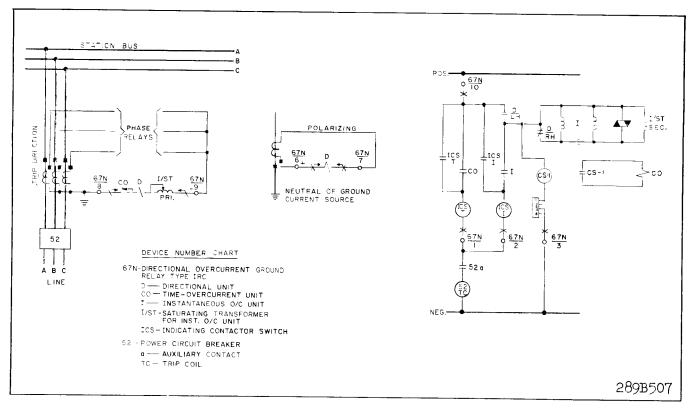
 $\star$  Fig. 19. Diagram of test connections of the time-overcurrent unit.



\* Fig. 20. External Schematic of the IRP Relay for Ground Fault Protection.



\* Fig. 21. External Schematic of the IRD Relay for Ground Fault Protection.



\* Fig. 22. External Schematic of the IRC Relay for Ground Fault Protection.

blocked closed, alternately apply tap value current plus 3% and tap value current minus 3%. The moving contact should leave the backstop at tap value current plus 3% and should return to the backstop at tap value current minus 3%.

3. <u>Time Curve</u> — Table 3 shows the time curve calibration points for the various types of relays. With the time dial set to the indicated position, apply the currents specified by Table 3 (e.g. for the CO-2, 3 and 20 times tap value current) and measure the operating time of the relay. The operating times should equal those of Table 3 plus or minus 5 percent.

# Indicating Contactor Switches (ICS/I) and (ICS/T)

- A) Close the contacts of the CO and pass sufficient d.c. current through the trip circuit to close the contacts of (ICS/T). This value of current should not be greater than the particular (ICS/T) tap setting being used. The operation indicator target should drop freely, bringing the letter "T" into view.
- B) Close the contacts of the instantaneous overcurrent unit (I) and the directional unit (D). Pass sufficient d.c. current through the trip circuit to close the contacts of (ICS/I). This value of current should not be greater than the particular (ICS/I) tap setting being used. The operation indicator target should drop freely, bringing the letter "I" into view.
- C) The contact gap should be approximately .047" 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 time of 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. The use of phantom loads, in testing induction-type relays, should be avoided, since the resulting distorted current wave form will produce an error in timing.

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

#### Calibration

Use the following procedure for calibrating the

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

# Instantaneous Overcurrent Unit (1)

- 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, i.e., against the right side of the bridge. Move 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 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  $\pm 5\%$  of tap value.

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.

#### Directional Unit (D)

In the type IRP and IRC relays the directional unit is the lower cylinder unit. In the type IRD the directional units are the lower and middle cylinder 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 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 as indicated by a neon lamp in the contact circuit when energized with the required current and voltage as shown in Table 1. 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 or voltage 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 (IRP and IRD voltage polarized unit) are short-circuited.
- b) The polarizing circuits of the current polarized relays (IRC and IRD 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 some installations in order to insure that the relay will always trip the breaker on zero potential.

### Time Overcurrent Unit (CO)

- 1. Contacts The index mark on the movement frame will coincide with the "O" mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "O" mark by approximately .020". The placement of the various time dial positions in line with the index mark will give operating times as shown on the respective time-current curves.
- 2) Minimum Trip Current The adjustment of the spring tension in setting the minimum trip current value of the relay is most conveniently made with the damping magnet removed.

With the time dial set on "O", wind up the spiral spring by means of the spring adjuster until approximately 6-3/4 convolutions show.

Set the relay on the minimum tap setting, the time dial to position 6.

With the auxiliary switch (CS-1) contacts blocked closed, adjust the control spring tension so that the moving contact will leave the backstop at tap value current +1.0% and will return to the backstop at tap value current -1.0%.

3) <u>Time Curve Calibration</u> — Install the permanent magnet.

Apply the indicated current per Table 3 for permanent magnet adjustment (e.g. IRP-8, 2 times tap value) and measure the operating time. Adjust the permanent magnet keeper until the operating time corresponds to the value of Table 3.

Apply the indicated current per Table 3 for the electromagnet plug adjustment (e.g. IRP-8, 20 times tap value) and measure the operating time. Adjust the proper plug until the operating time corresponds to the value in Table 3. (Withdrawing the left hand plug, front view increases the operating time and withdrawing the right hand plug, front view, decreases the time.) In adjusting the plugs, one plug should be

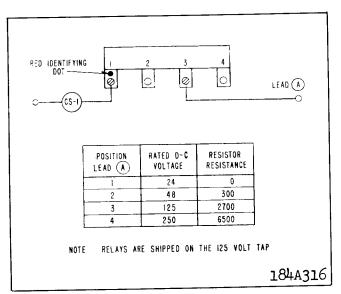


Fig. 23. Selection of Proper Voltage Tap for Auxiliary Switch (CS-1) Operation.

screwed in completely and the other plug run in or out until the proper operating time has been obtained.

Recheck the permanent magnet adjustment. If the operating time for this calibration point has changed, readjust the permanent magnet and then recheck the electromagnet plug adjustment.

# Indicating Contactor Switches (ICS/I) and (ICS/T)

Adjust the contact gap for approximately .047".

A) Close the contacts of the CO and pass sufficient d.c. current through the trip circuit to close the contacts of the (ICS/T). This value of current should not be greater than the particular (ICS/T) tap setting being used. The operation indicator target should drop freely bringing the letter "T" into view.

B) Close contacts of instantaneous overcurrent unit (I) and directional unit (D). Pass sufficient d.c. current through the trip circuit to close contacts of the (ICS/I). This value of current should not be greater than the particular (ICS/I) tap setting being used. The operation indicator target should drop freely bringing the letter "I" into view.

#### Auxiliary Switch (CS-1)

Adjust the stationary core of the switch for a clearance between the stationary core and the moving core when the switch is picked up. This can be done by turning the relay upside-down. Then screw up the core screw until the moving core starts rotating. Now back off the core screw until the moving core stops rotating. This indicates the points where the play in the assembly is taken up, and where the moving core just separates from the stationary core screw. Back off the core screw approximately one turn and lock in place. This prevents the moving core from striking and sticking to the stationary core because of residual magnetism. Adjust the contact clearance for 3/64" by means of the two small nuts on either side of the Micarta disc.

Connect lead (A) to proper terminal per Fig. 23. Block directional unit (D) contacts close and energize trip circuit with rated voltage. Contacts of auxiliary switch (CS-1) should make as indicated by a neon lamp in the contact circuit.

# 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.

TABLE I DIRECTIONAL UNIT SENSITIVITY

	DIRE	CTIONAL UNIT	SENSITIVITY		
RELAY TYPE	AMPERE RATING	VALUES FOR	R MIN. PICKUP †	PHASE ANGLE RELATIONSHIF	
KLLAT TITE	TIME-OVERCURRENT UNIT	VOLTS	AMPERES		
	.5-2.5	1	2.0	I lagging V by 60°††	
IRP	2-6	1	4.0	I in-phasæ with V	
IRD (Voltage		1	4.0	I lagging V by 60° ††	
Unit)	4-12	1	8.0	I in-phase with V	
			0.5	I <sub>O</sub> leading I <sub>p</sub> by 40°††	
IRC	.5-2.5 2-6		. 57	In-phase	
IRD (Current $\triangle$ Unit)			1.0	${ m I_O}$ leading ${ m I_p}$ by $40^\circ$ ††	
	4-12		1.3	In-phase	
		1	1	1	

<sup>†</sup> The energization quantities are input quantities at the relay terminals.

<sup>††</sup> Maximum torque angle.

 $<sup>\</sup>triangle$  When normal system conditions limit the current to less than twice pickup, performance may be improved by sellecting a higher current C.T. tap to energize the polarizing circuit.

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) (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.

 $<sup>\</sup>dagger$  Short circuit the voltage polarizing circuit at the relay terminals before making the above adjustment.

TABLE III

TIME CURVE CALIBRATION DATA — 60 HERTZ

_	PERMANEN'	IENT	ELECTROMAGNET PLUGS		
TIME- OVERCURRENT UNIT TYPE	TIME DIAL POSITION	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS
2	6	3	0.57	20	0.22
5	6	2	37.80	10	14.30
6	6	2	2.46	20	1.19
7	6	2	4.27	20	1.11
8	6	2	13.35	20	1.11
9	6	2	8.87	20	0.65
11	6	2	11.27	20	0.24

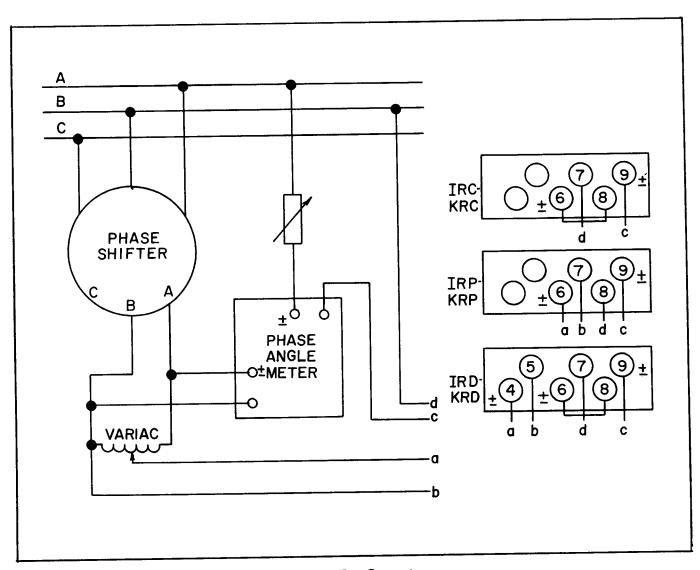


Fig. 24. Test Connections

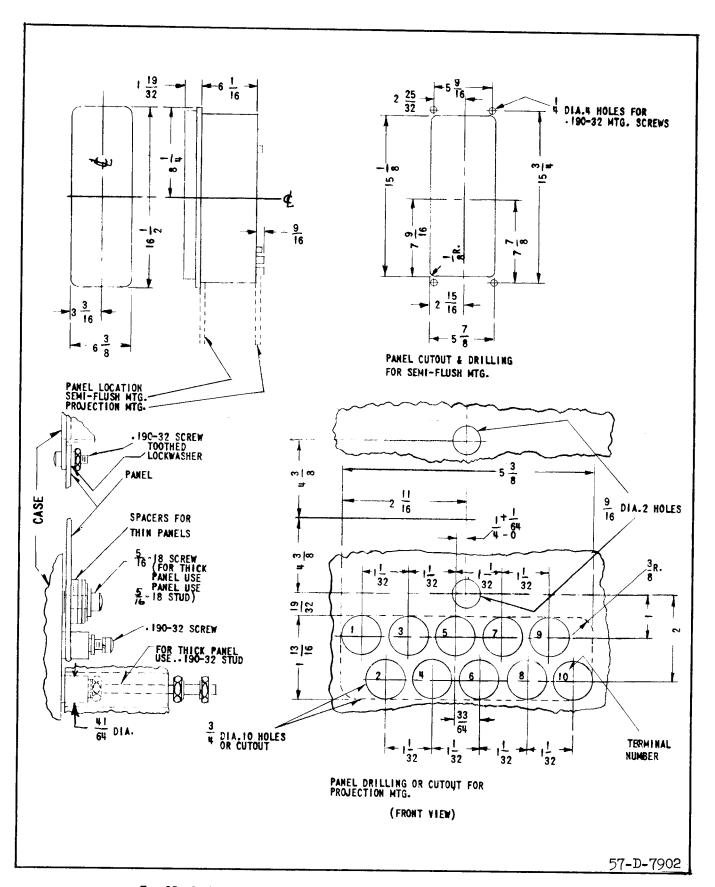


Fig. 25. Outline and Drilling Plan for the IRP and IRC Relays in the Type FT31 Case.

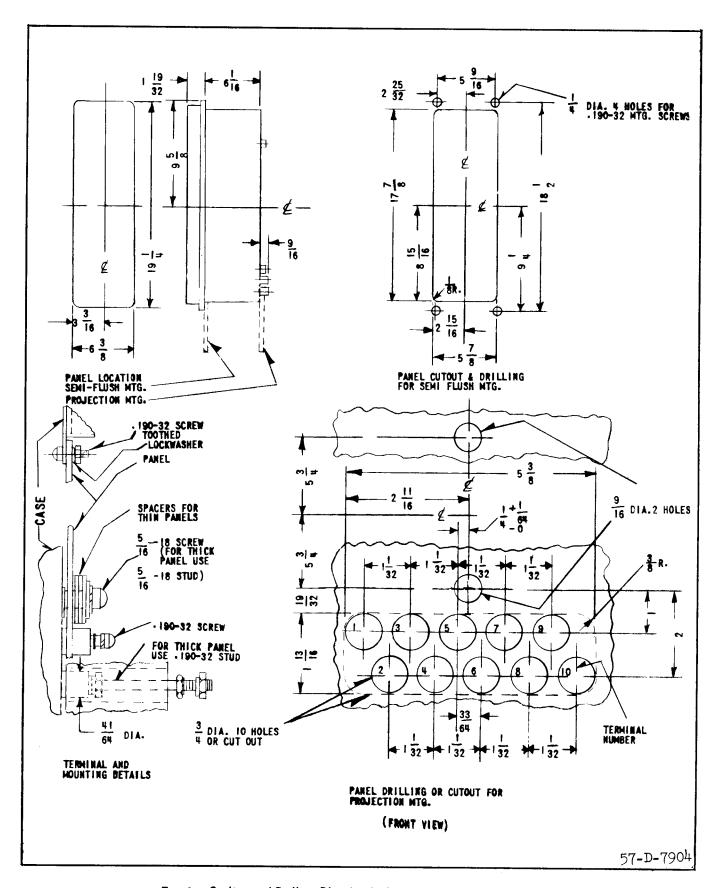


Fig. 26. Outline and Drilling Plan for the IRD Relay in the Type FT41 Case.



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