

INSTALLATION . OPERATION . MAINTENANCE

INSTRUCTIONS

TYPE IRV DIRECTIONAL OVERCURRENT RELAY

FOR PHASE PROTECTION

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 phase 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.

CONSTRUCTION AND OPERATION

The Type IRV relay consists of a directional unit (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 and 2.

Time-Overcurrent Unit (CO)

The electromagnets for the types CO-5, CO-6, CO-7, CO-8 and CO-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 causes a contact closing torque.

The electromagnet for the type CO-2 and CO-11 units have 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 pick-up 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 spring and snap ring. This is an adjustable core which has a .025 inch flat on one side and is held in its adjusted position by the clamping action of two compressed springs. The bearing can be replaced, if necessary, without having to remove the magnetic core from the frame.

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

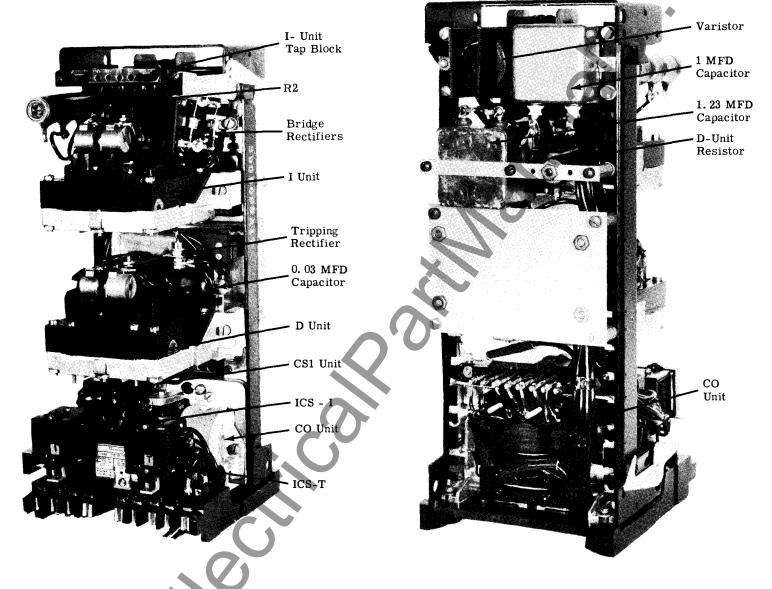


Fig. 1. Type IRV Relay Without Case (Front View).

Fig. 2. Type IRV Relay Without Case (Rear View).

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

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.

Instantaneous Overcurrent Unit Transformer (I/ST)

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 pick-up 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.

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 48, 125 or 250 volt d.c. system connected per Fig. 13. The operation of the CS-1 switch is controlled by the directional unit (D) which in turn directionally controls the time-overcurrent unit (CO) as shown in Fig. 15. 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.

Another contact of CS-1 seals in its coil through the break contact of the I unit, in order to relieve the make contact of D from carrying the CS-1 coil current. The break contact of D breaks this seal by short circuiting the CS-1 coil. The break contact of the I unit also breaks the seal of the CS-1 coil to prevent tripping on reversed faults where the directional unit was preclosed on load current.

Instantaneous-Unit Torque Control

When the make contact of D closes, it permits the I unit to operate. It connects capacitor C3 and one pair of I-unit coils across the output voltage of the saturating transformer I/ST. The full-wave bridge in this connection and the rectifier in series with the D contact serve to isolate the a-c and d-c circuits.

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:

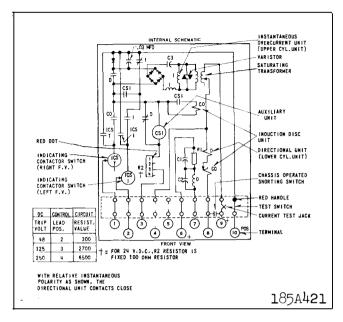


Fig. 3. Internal Schematic of the Type IRV Relay in the Type FT31 Case.

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				<u>Taps</u>	
.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. 4 to 10. 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.

The time vs. current characteristics for the instantaneous overcurrent unit is shown in Fig. 11.

The time vs. current characteristics for the directional unit is shown in Fig. 12.

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.

Cylinder Unit Contacts

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

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

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 operating time is approximately 5 milliseconds.

d-c resistance — 1165 ohms 24 volt d-c relay

d-c resistance -110 ohms (note that series resistor is a fixed 100 ohm resistor).

Directional Unit

The IRV relay is intended for phase fault protection and the directional unit has its maximum torque when the current leads the voltage by approximately 30°. The directional unit minimum pickup is 1.2 volts and 4 amperes at its maximum torque angle for the 4 to 12 ampere range relays and 1.2 volts and 2 amperes for the 0.5 to 2.5 ampere and the 2 to 6 ampere range relays.

The directional unit should be connected using the current in one-phase wire and the potential across the other two phase wires. This connection is commonly referred to as the 90 °connection. When utilizing the 90 °connection the maximum torque of the relay occurs when the fault current lags its 100% P.F. position by approximately 60 °. See Fig. 15.

ENERGY REQUIREMENTS

INSTANTANEOUS OVERCURRENT UNIT OPERATING CURRENT CIRCUIT - 60 CYCLES

	-		φ	4.4	д.
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
1 1	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
	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	7	CONTINUOUS RATIN	IG	ONE SECOND R.	ATING
		(AMPERES)		† (AMPERES	5)
. 5-2		5		100	
1-4		8		140	
2-8		8		140	
4-16		10		200	
10-40		10		200	
20-80		10		200	

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.

^{† †} Voltages taken with Rectox type voltmeter

ENERGY REQUIREMENTS

TYPE IRV-2 TIME OVERCURRENT UNITS

VOLT AMPERES † † CONTINUOUS ONE SECOND POWER AΤ AT 3 TIMES AT 10 TIMES AT 20 TIMES AMPERE RATING FACTOR TAP VALUE RATING† TAP VALUE TAP VALUE TAP VALUE TAP (AMPERES) (AMPERES) $ANGLE \phi$ CURRENT CURRENT RANGE CURRENT CURRENT 0.5 28 0.91 58 4.8 39.6 256 790 0.6 0.96 28 57 4.9 39.8 270 851 28 42.7 308 0.8 1.18 53 5.0 1024 0.5/2.51.37 28 50 5.3 1.0 45.4 348 1220 1.95 28 40 6.2 54.4 435 1740 1.5 2.0 2.24 28 36 7.2 65.4 580 2280 2.5 2.50 28 29 7.9 73.6 700 2850 59 2.0 3.1 110 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 6.54 474 1800 54.9 4.0 7.3 230 65 4.92 39.1 268 848 50 5.20 5.0 8.0 230 42.0 305 1020 6.0 8.8 230 47 5.34 44.1 330 1128 4/12 7.0 9.6 230 46 5.35 45.8 364 1260

IRV-5, TIME OVERCURRENT UNITS

5.86

7.00

6.6

49.9

55.5

62.3

400

470

528

1408

1720

2064

الثاهير

43

37

34

VOLT AMPERES † † ONE SECOND AT 20 TIMES CONTINUOUS POWER ΑТ AT 3 TIMES AT 10 TIMES FACTOR TAP VALUE TAP VALUE TAP VALUE AMPERE RATING RATING TAP VALUE (AMPERES) ANGLE ϕ CURRENT CURRENT CURRENT CURRENT RANGE TAP (AMPERES) 20.6 103 270 (0.5)2.7 88 69 3.92 (0.6 3.1 88 68 3.96 20,7 106 288 (0.8 88 67 3.96 21 114 325 3.7 0.5/2.5(1.0 4.1 88 66 4.07 21.4 122 360 88 (1.5 5.7 62 4.19 23.2 147 462 (2.0 88 60 4.30 168 548 24.9 6.8 88 (2.5 58 4.37 26.2 180 630 7.7 67 3.88 21 110 (2 8 230 308 (2.5 8.8 230 66 3.87 21.6 118 342 9.7 10.4 230 64 (3 3.93 22.1 126 381 2/6 (3.5 230 63 4.09 23.1 136 417 11.2 (4 230 62 4.08 23.5 144 448 (5 12.5 230 59 4.20 24.8 162 540 (6 13.7 57 230 4.38 26.5 183 624 (4 16 460 65 4.00 22.4 126 376 18.8 (5 460 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 4.27 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 (12 460 47 4.92 35.6 288 1056

10.4

11.2

12.0

8.0

10.0

12.0

230

230

230

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.

 $[\]phi$ Degrees current lags voltage at tap value current.

^{† †} Voltages taken with Rectox type voltmeter.

ENERGY REQUIREMENTS

IRV-7 TIME OVERCURRENT UNITS

						VOLT A	AMPERES† †	U
		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 ϕ	CURRENT	CURRENT	CURRENT	CURRENT
	(0.5	2.7	88	68	3.88	20.7	103	278
	(0.6	3.1	88	67	3.93	20.9	107	288
	(0.8	3.7	88	66	3.9 3	21.1	114	320
0.5/2.5	(1.0	4.1	88	64	4.00	21.6	122	35 6
	(1.5	5.7	88	61	4.08	22.9	148	459
	(2.0	6.8	88	58	4.24	24.8	174	552
	(2.5	7.7	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	4 60	60	4.62	25.9	168	540
	(7	20.8	4 60	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

IRV-8, TIME OVERCURRENT UNITS

					VOLT AMPERES † †			
AMPERE	man.	CONTINUOUS	ONE SECOND RATING*	POWER FACTOR	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE	AT 10 TIMES TAP VALUE	AT 20 TIMES TAP VALUE CURRENT
RANGE	TAP	(AMPERES)	(AMPERES)	ANGLE ϕ	CURRENT	CURRENT	CURRENT	CURRENT
	(0.5	2.7	88	72	2.38	21	132	350
	(0.6	3.1	88	71	2.38	21	134	365
	(0.8	3.7	88	69	2.40	21.1	142	400
0.5/2.5	(1.0	4.1	88	67	2.42	21.2	150	440
	(1.5	5.7	88	62	2.51	22	170	530
	(2.0	6.8	88	57	2.65	23.5	200	675
	(2.5	7.7	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
4/12	(8	22.5	460	54	2.73	24.8	207	700
	(10	25	460	48	3.00	27.8	248	850
	-			45	3.46		292	1020
	(12	28	460	40	3.40	31.4	292	1020

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.

[†] Voltages taken with Rectox type voltmeter.

ENERGY REQUIREMENTS

IRV-11 OVERCURRENT UNITS

						volt	AMPERES † †	
AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING† (AMPERES)	POWER FACTOR ANGLE ϕ	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE 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	3.5	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

[†] 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.

ENERGY REQUIREMENTS - 60 CYCLES DIRECTIONAL UNIT OPERATING CIRCUIT BURDEN

VOLT AMPERES † †

Range Amps	Continuous Rating (Amperes)	One Second Rating † (Amperes)	Power Factor Angle φ	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	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		0.48	4.62	53.6	216.0

^{\$\}phi\$ Degrees current lags voltage at tap value current.

DIRECTIONAL UNIT POLARIZING CIRCUIT BURDEN

The burden at 120V, 60 cycles, is 12.5 volt-amperes at 15 degrees. (current leading voltage).

φ Degrees current lags voltage at tap value current.

[†] Voltages taken with Rectox type voltmeter.

[†] 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.

^{††} Voltages taken with Rectox type voltmeter.

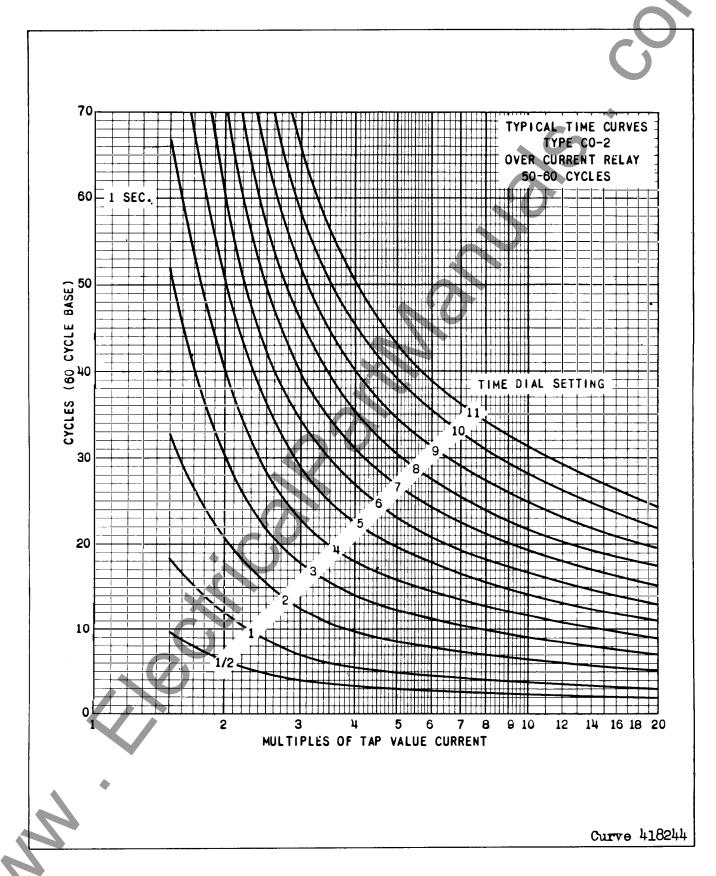


Fig. 4. Typical Time Curves of the Time-Overcurrent Unit of the Short Time (2) Relays.

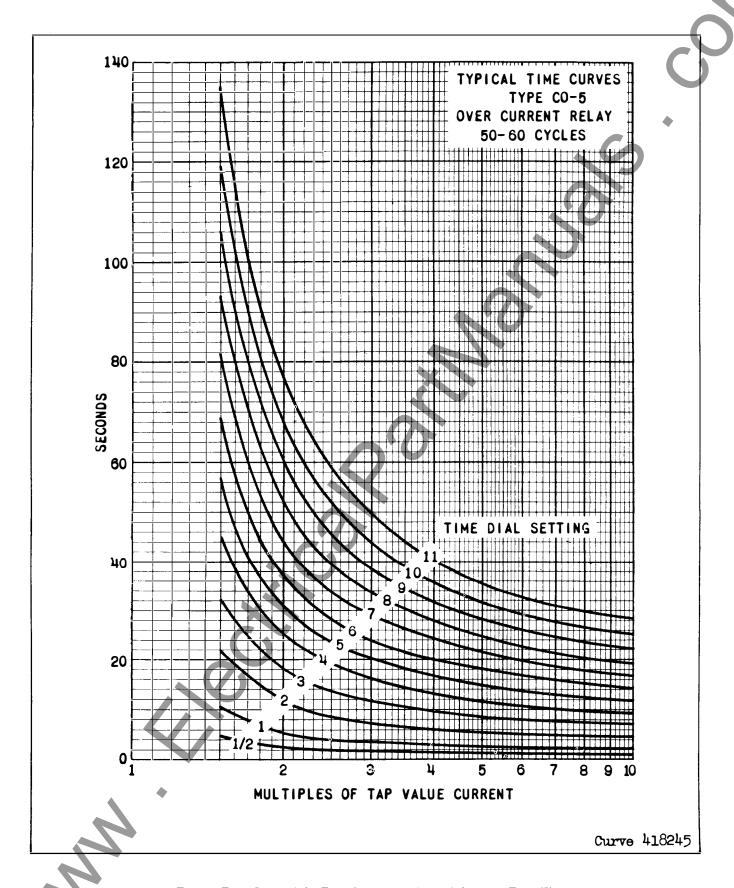


Fig. 5. Typical Time Curve of the Time-Overcurrent Unit of the Long Time (5) Relays.

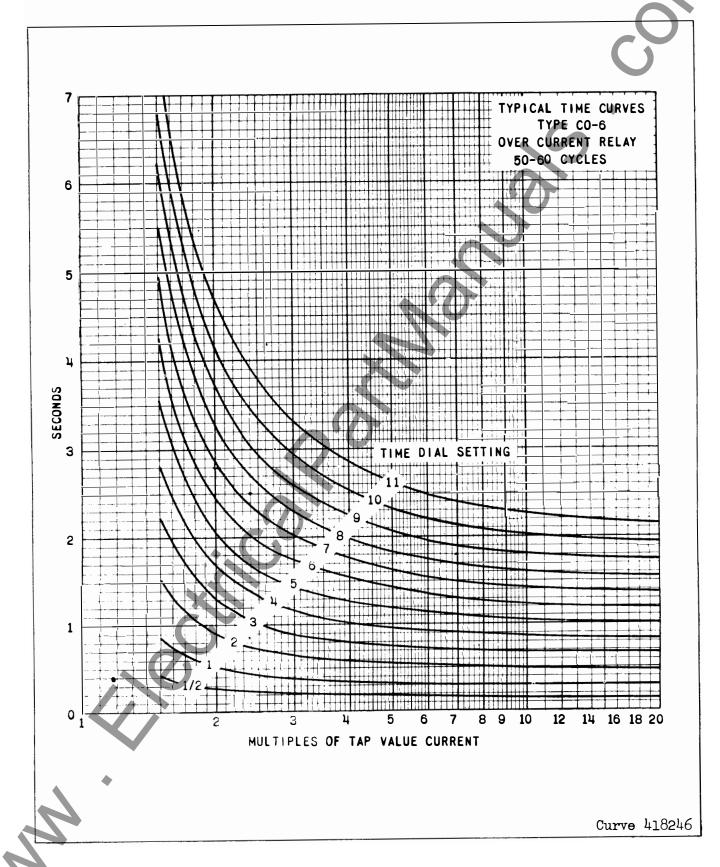


Fig. 6. Typical Time Curve of the Time-Overcurrent Unit of the Definite Time (6) Relays.

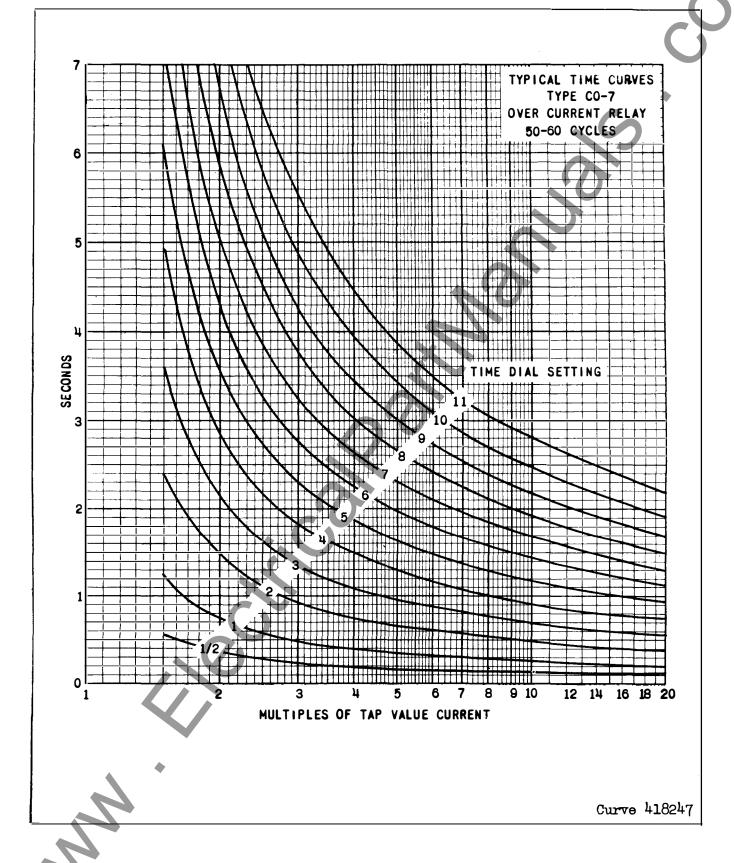


Fig. 7. Typical Time Curve of the Time-Overcurrent Unit of the Moderately Inverse (7) Relays.

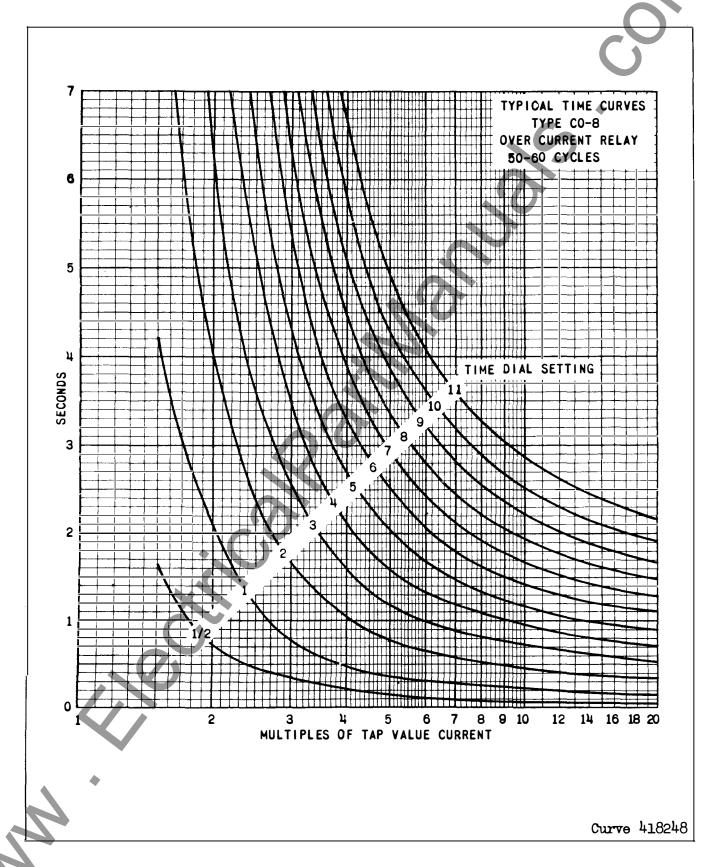


Fig. 8. Typical Time Curve of the Time-Overcurrent Unit of the Inverse (8) Relays.

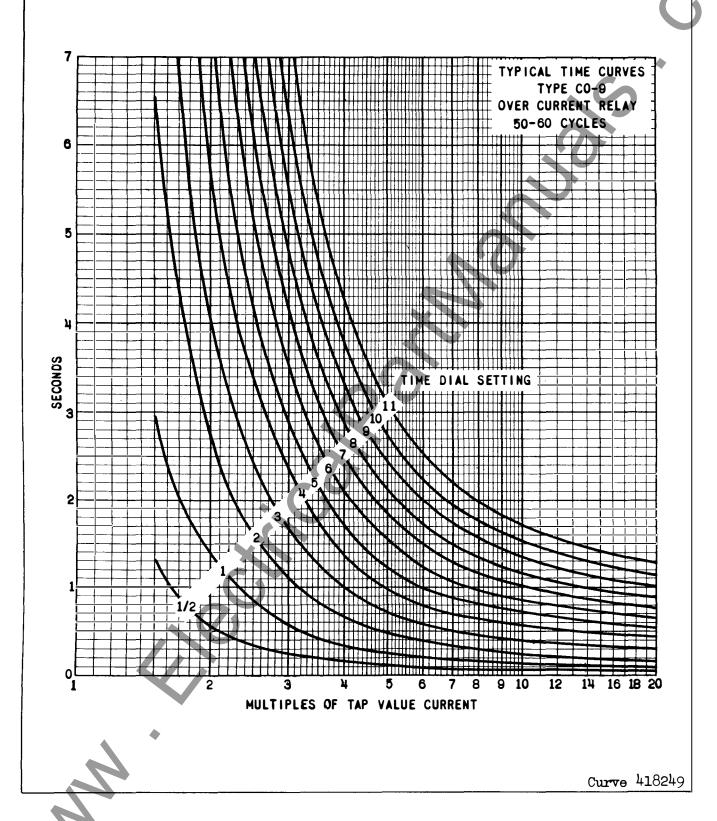


Fig. 9. Typical Time Curve of the Time-Overcurrent Unit of the Very Inverse (9) Relays.

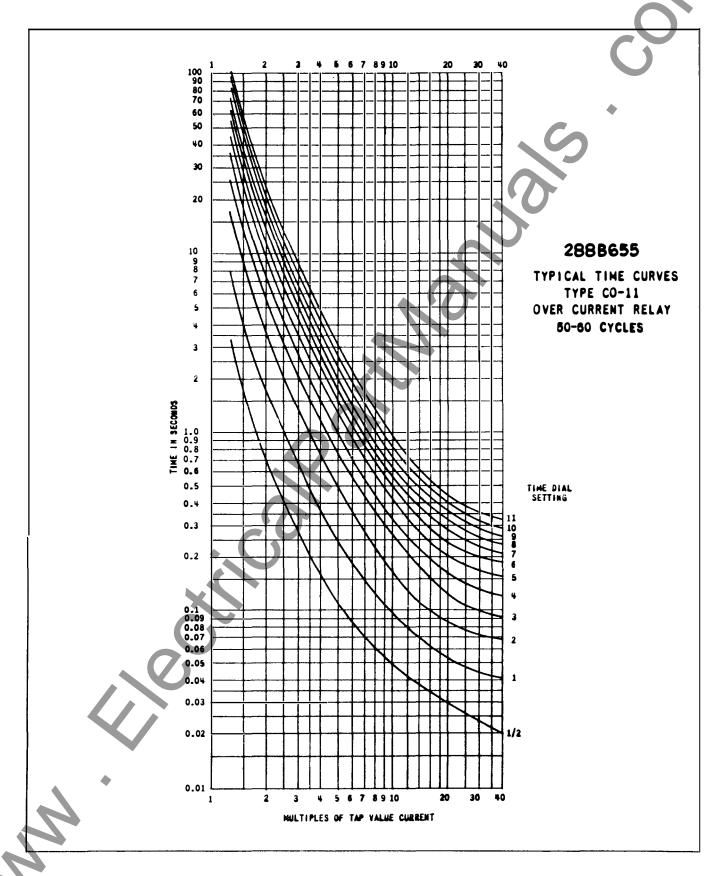


Fig. 10. Typical Time Curve of the Time-Overcurrent Unit of the Extremely Inverse (11) Relays.

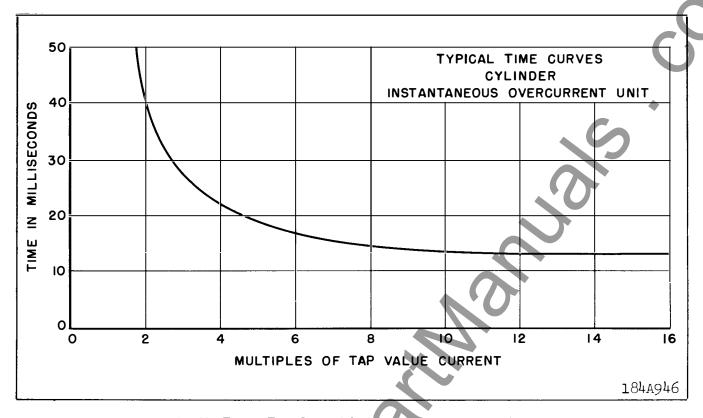


Fig. 11. Typical Time Curve of the Instantaneous Overcurrent Unit.

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 terminal plate holes, the relay will respond to multiples of tap value currents in accordance with the various typical time-current curves.

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 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 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 re-

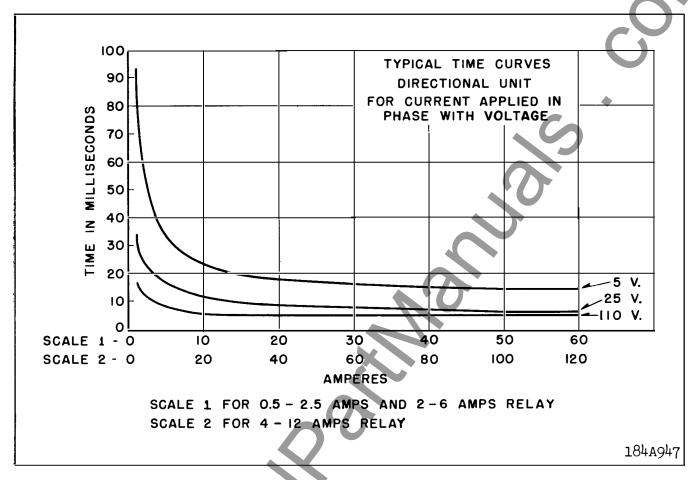


Fig. 12. Typical Time Curves of the Directional Unit.

moving the other tap screw from the original tap position.

Directional Units (D)

No setting is required.

Indicating Contactor Switch (ICS/1 and ICS/T)

The only 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 48, 125 or 250 voltage on the tapped resistor. This connection can be made by referring to Fig. 13.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt,

moisture, excessive vibration and heat Mount the relay vertically by means of the two mounting studs for projection mounting or by means of the four mounting holes on the flange for the semi-flush mounting. Either of the studs or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel panel mounting or to terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the studs and then turning the proper nut with a wrench.

For detail information on the FT Case refer to I.L. 41-076.

The external connection of the directional overcurrent relays is shown in Fig. 15.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory. Upon

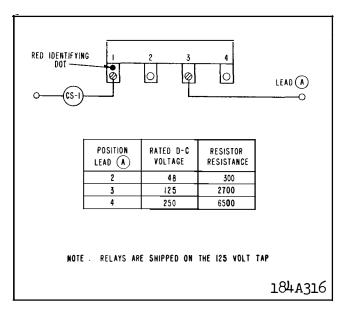


Fig. 13. Selection of Proper Voltage Tap for Auxiliary Switch (CS-1) Operation.

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 deenergized position should be approximately .020".
- 2. Minimum Trip Current The D contacts should be blocked closed 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 ± 5% of tap value current.

Directional Unit (D)

- 1. Contact Gap The gap between the stationary contact and moving contact with the relay in the de-energized position should be approximately .020".
- 2. Sensitivity The directional unit should trip with 1.2 volts and 4 amperes at its maximum torque angle (current leading the voltage by 30°) for the 4 to 12 ampere range relays and 1.2 volts and 2 amperes for the 0.5 to 2.5 ampere and the 2 to 6 ampere range relays.

3. Spurious Torque Adjustments — There should be no spurious closing torques when the operating circuits are energized per Table 2 with the polarizing circuit short circuited.

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 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 1 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 1 (e.g. for the IRV-2 3 and 20 times tap value current) And measure the operating time of the relay. The operating times should equal those of Table 1 plus or minus 5 percent,

For type IRV-11 relay only, the 1.30 times tap value operating time from the number 6 time dial position is $54.9\pm5\%$ seconds. It is important that the 1.30 times tap value current be maintained accurately. The maintaining of this current accurately is necessary because of the steepness of the slope of the time-current characteristic (Fig. 19). A 1% variation in the 1.30 times tap value current (including measuring instrument deviation) will change the nominal operating time by approximately 4%.

Indicating Contactor Switches (ICS/1) and (ICS/T)

- A) Close the contacts of the CO and the directional unit(D) 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 suf-

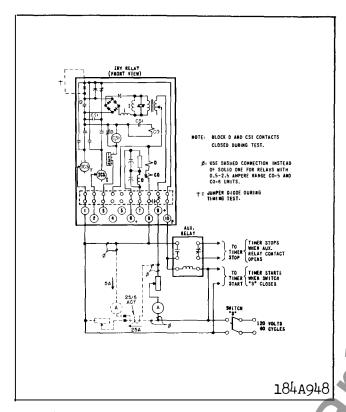


Fig. 14. Diagram of test connections of the time-overcurrent unit.

ficient 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) tan 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 and checked periodically to assure proper operation. Generally a visual inspection should call attention to any noticeable changes. A minimum suggested check on the relay system is to close the contacts manually to assure that the breaker trips and the target drops. Then release the contacts and observe that the reset is smooth and positive.

If an additional time check is desired, pass secondary current through the relay and check the time of operation. It is preferable to make this at several

times pick-up current at an expected operating point for the particular application. For the .5 to 2.5 ampere range CO-5 and CO-6 induction unit use the alternative test circuit in Fig. 16 as these relays are affected by a distorted wave form. With this connection the 25/5 ampere current transformers should be worked well below the knee of the saturation (i.e. use 10L50 or better).

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 postion 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 close the con-

tacts of the D unit. Insert the tap screw in the minimum value tap setting and adjust the spring such that the contacts will close as indicated by a neon lamp in the contact circuit when energized with the required current. The pickup of the overcurrent unit with the tap screw is 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)

The directional unit is the lower cylinder unit.

- 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 2/3 of one turn for a contact gap of .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. 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 contact will close as indicated by a neon lamp in the contact circuit when energized with 1.2 volts and 4 amps (current leading 30°) for the 4 to 12 ampere range relays and 1.2 volts and 2 amps for the 0.5 to 2.5 and 2 to 6 ampere range relays. This can be done approximately using current in phase with voltage by increasing the pickup current to 4.6 and 2.3 amperes

respectively.

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

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

Apply 120 VAC 60 Hz to terminals 6 and 7. Relay contacts should stay open. If the contacts are closed rotate core by means of adjustor located on the bottom side of the cylinder unit until contacts stay open. The core assembly is held in position by the clamping action of two compressed springs. This allows its position to be changed by inserting a nonmagnetic tool into the slot on the bottom side of the unit.

Short circuit the voltage terminals and apply current 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.

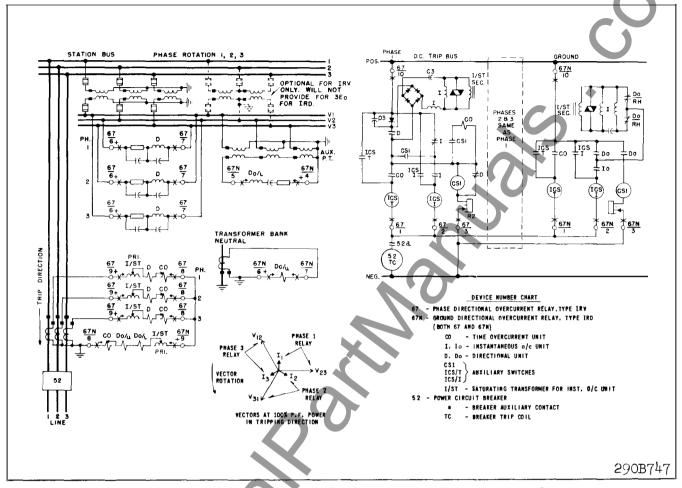


Fig. 15. External Schematic of the IRV Relay for Phase Protection and the IRD Relay for Ground Protection.

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%.

- †† Plugs should be at "fully screwed in" position prior to adjustment of core.
- 3) <u>Time Curve Calibration</u> Install the permanent magnet.

Apply the indicated current per Table 1 for permanent magnet adjustment (e.g. IRV-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 1.

For type IRV-11 relay only, the 1.30 times tap value operating time from the number 6 time dial position is $54.9 \pm 5\%$ seconds. It is important that the

1.30 times tap value current be maintained accurately. The maintaining of this current accurately is necessary because of the steepness of the slope of the time-current characteristic (Fig. 19). A 1% variation in the 1.30 times tap value current (including measuring instrument deviation) will change the nominal operating time by approximately 4%. If the operating time at 1.3 times tap value is not within these limits, a minor adjustment of the control spring will give the correct operating time without any undue effect on the on the minimum pick-up of the relay. This check is to be made after the 2 times tap value adjustment has been completed.

Apply the indicated current per Table 1 for the electromagnet plug adjustment (e.g. IRV-8, 20 times tap value) and measure the operating time. Adjust the proper plug until the operating time corresponds to the value in Table 1. (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 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 the directional unit 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 when 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. 13. 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

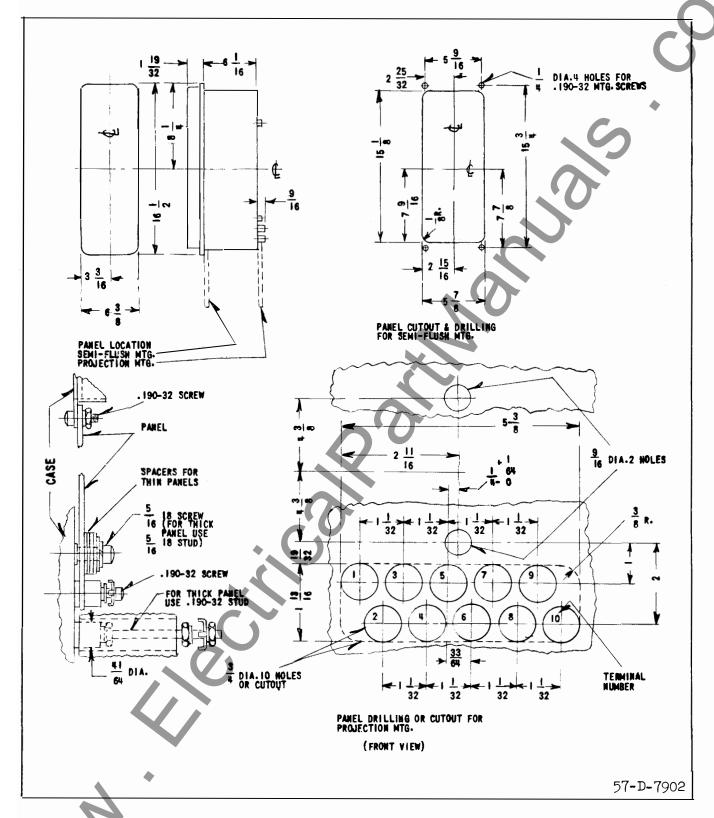
Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

TABLE I
TIME CURVE CALIBRATION DATA - 60 CYCLES

PERMANENT MAGNET ADJUSTMENT ELECTROMAGNET									
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				
	* TABLE 2								
	DIRECTIONAL UNIT CALIBRATION +								

	DIRECTIONAL	NIT CALIBRATION	!
Relay Rating	Current	Adjust	Adjustment
.5 to 2.5 amps and 2-6 amps	50 amps		If spurious torque is in the contact closing direction (left front view) screw out right magnetic plug until direction of spurious torque
		Magnetic	is reversed.
4-12	100 amps	Plugs	If spurious torque is in the contact opening direction, screw out left plug until spurious torque is slight contact opening
, (0			Recheck at 40, 25 and 10 amps for the lower range units and 80, 50 and 20 amps for the 4-12 amp range relays.

[†] Short circuit the voltage polarizing circuit at the relay terminals before making the above adjustments.



 $Fig. \ 16. \ \ Outline \ and \ Drilling \ Plan \ for \ the \ Type \ IRV \ Relay \ in \ the \ Type \ FT31 \ Case.$

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



INSTALLATION . OPERATION . MAINTENANCE

INSTRUCTIONS

TYPE IRQ DIRECTIONAL OVERCURRENT NEGATIVE SEQUENCE RELAY FOR GROUND PROTECTION

CAUTION Before putting the relay into service, remove blocking from all the moving parts. Inspect the relay and operate all elements by hand to be sure no damage has occured during shipment.

APPLICATION

The type IRQ is a directional overcurrent ground relay in which the directional unit operates on negative sequence current and voltage, and the overcurrent units operates on residual or ground current. The negative sequence current and voltage are obtained by means of self-contained negative sequence filters connected between the directional unit and the current and potential transformers.

The relay is intended for use at locations where the present equipment or system conditions do not permit the use of the conventional types of directional ground relays operating entirely on residual current and voltage.

At an ungrounded substation on grounded systems where only two potential transformers are available, or where the potential transformers are on the low-tension side of a wye-delta or delta-wye power transformer bank, the type IRQ relay is applicable for ground protection.

CONSTRUCTION AND OPERATION

The type IRQ relay consists of a directional cylinder unit (D) operating on negative sequence quantities, negative-sequence current and voltage filters an auxiliary switch (CS-1), a time-overcurrent unit (CO), an instantaneous overcurrent unit (I), and two indicating contactor switches (ICS/I) and (ICS/T). The principle component parts of the relays and their location are shown in Figs. 1 and 2.

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 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.

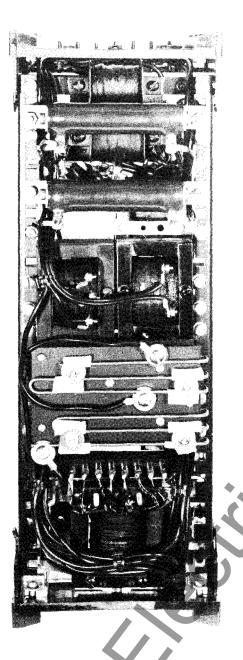


Fig. 1. Type IRQ Relay without Case (Rear View)

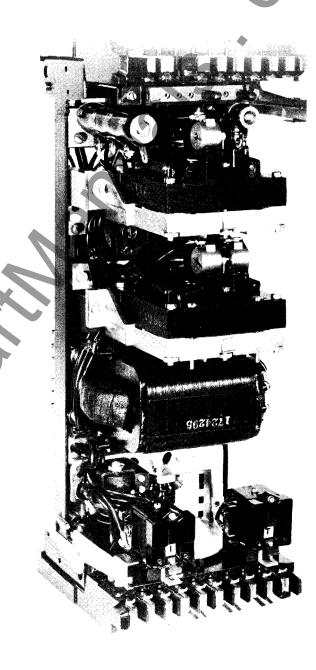


Fig. 2. Type IRQ Relay without Case (Front View)

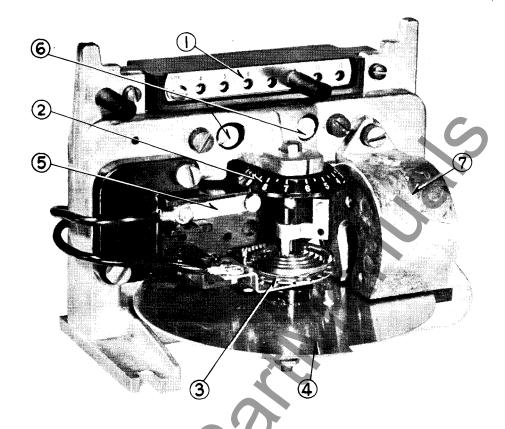


Fig. 3. Time Overcurrent Unit (Front View). 1-Tap Block, 2-Time Dial, 3-Control Spring Assembly, 4-Disc, 5-Stationary Contacts Assembly, 6-Magnetic Plugs, 7-Permanent Magnet

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.

Negative Sequence Filter

The current and voltage filters consist of reactors and resistors connected together as shown in the internal schematic (Fig. 4).

Time-Overcurrent Unit (CO)

The electromagnets for the types IRQ-5, IRQ-6, IRQ-7, IRQ-8 and IRQ-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 IRQ-2 and IRQ-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.

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. 14. 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.

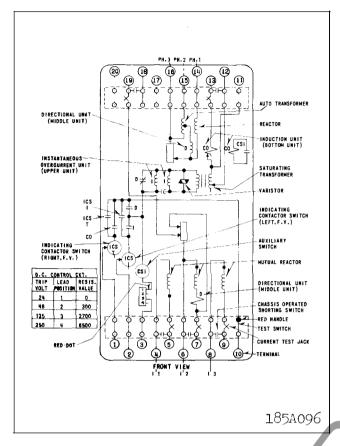


Fig. 4. Internal Schematic of the IRQ Relay.

Instantaneous Overcurrent Unit (I)

The instantaneous overcurrent unit consists of a induction cylinder type unit and a transformer. The induction cylinder 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; preventing 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.

The transformer is of the saturating type for limiting the energy to the instantaneous overcurrent unit at higher values of fault current and to reduce

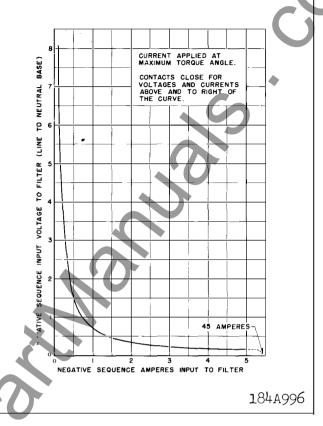


Fig. 5. Sensitivity Curve of the Directional Unit (D).

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 over-current 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.

Indicating Contactor Switch Unit (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.

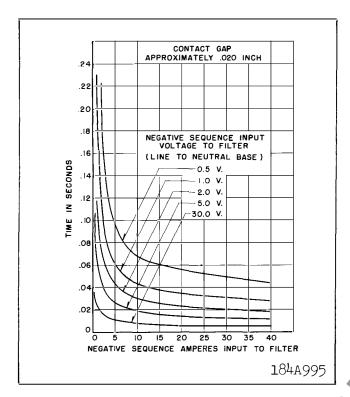


Fig. 6. Time Curve of the Directional Unit (D)

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

CHARACTERISTICS

The time characteristics of the time overcurrent relays are designated by specific numbers as indicated below (eg. IRQ-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:

Time Overcurrent Unit

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

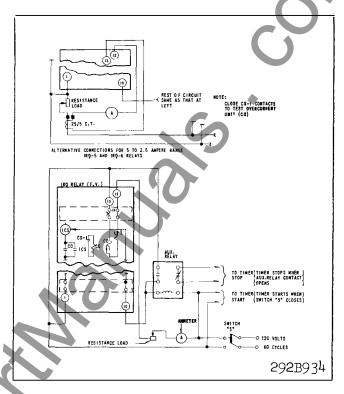


Fig. 7. Diagram of Test Connections for the Circuit Closing
Time Overcurrent Unit of the IRQ Relay.

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	40
20-80	20	30	40	48	60	80

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. 15 to 21. 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.

The time vs. current characteristics for the instantaneous overcurrent unit is shown in Fig. 13.

The time vs. current characteristics for the directional unit is shown in Fig. 6.

Directional Unit (D)

The directional unit minimum pick-up is approximately 0.76 volt-ampers (e.g. 0.19 volt and 4 am-

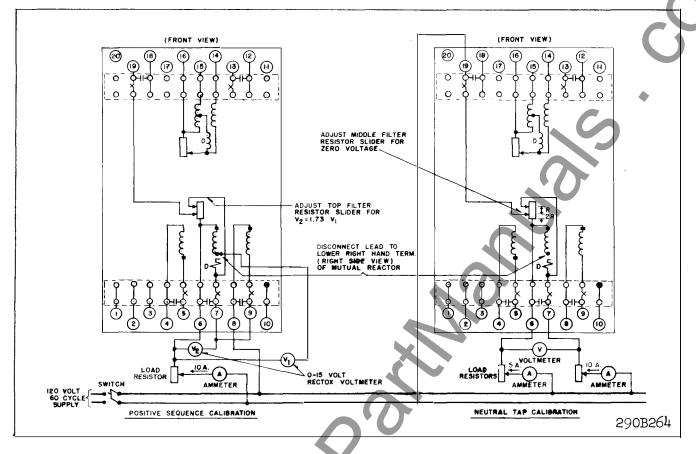


Fig. 8. Test Diagram for Calibration of the Negative Sequence Current Filter in the IRQ Relay.

peres) in terms of negative sequence quantities applied at the relay terminals at the maximum torque angle of approximately 98° (current leading voltage).

A typical sensitivity curve for the negative sequence directional unit is shown in Fig. 5.

The time vs current characteristic for the directional unit is shown in Fig. 6.

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.

Cylinder Unit Contacts

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

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

Trip Circuit Constants

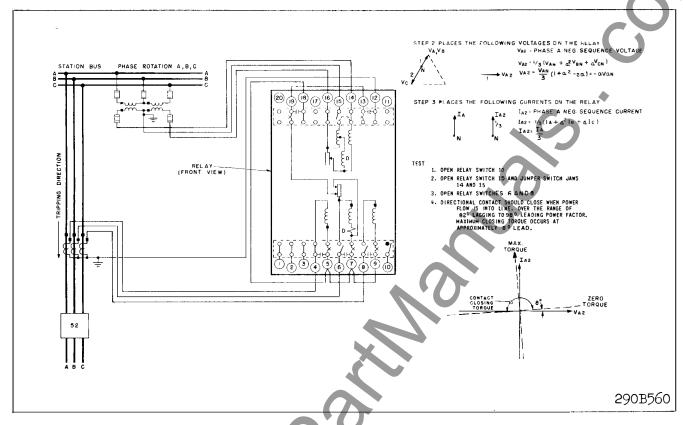
Inidcating Contactor Switch -

0.2 ampere taps -6.5 ohms d-c resistance

2.0 ampere taps - 0.15 ohms d.c resistance

The auxiliary switch operating time is approximately 5 milliseconds.

d.c resistance - 1165 ohms



* Fig. 9. In Service Test Procedure for Verifying Proper External Connections Where CT Neutral is Formed Within the Relay.

SETTINGS

Directional Unit (D)

No setting is required.

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 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 in amperes, or as marked on the tap plate.

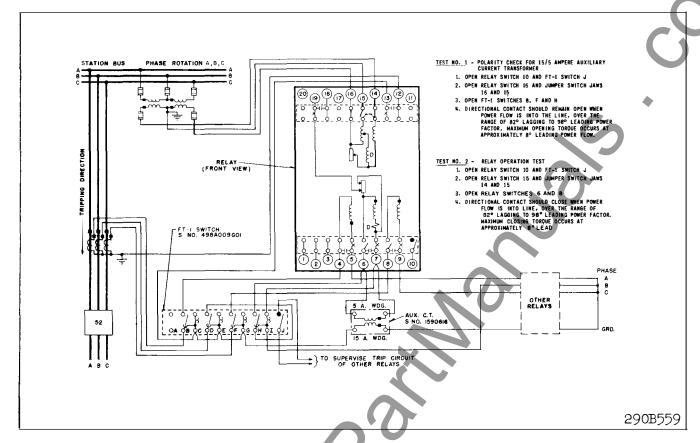
CAUTION: Since the tap block connector screw carries operating current, be sure that the screw is turned tight. In order to avoid opening the current transformer circuits when changing taps under load, connect the spare connector screw in the desired position before removing the other tap screw from 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 (I)

The only setting required is the pickup current setting which is made by means of the connector screw located on the tap plate. By placing the con-



★ Fig. 10. In Service Test Procedure for Verifying Proper External Connections Where CT Neutral is Formed Externally.

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 position before removing the other tap screw from the original tap position.

Negative Sequence Filter

No setting is required.

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

The only 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)

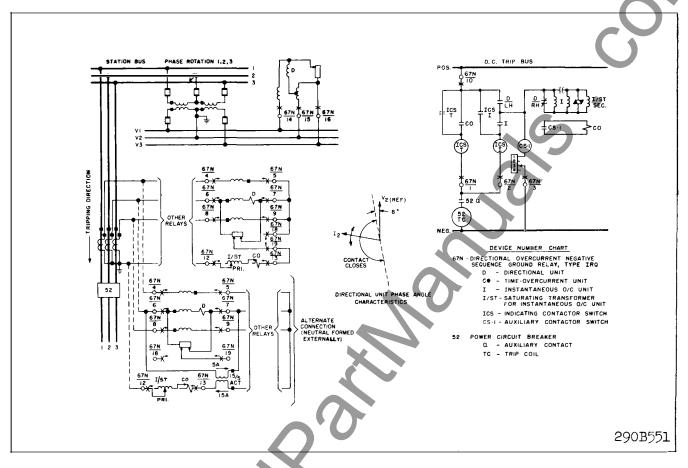
The only setting required on the CS-1 unit is

the selection of the required 24, 48, 125 or 250 voltage on the tapped resistor. This connection can be made by referring to Fig. 14.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration and heat. Mount the relay vertically by means of the two mounting studs for the FT projection case or by means of the four mounting holes in the flange of the semiflush type FT case. Either of the studs or the mounting screws may be utilized for grounding the relay. The electrical connection may be made directly to the terminals by means of screws for steel panel mounting or to terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the studs and then turning the proper nut with a wrench.

For detailed FT case information, refer to I.L. 41-076.



* Fig. 11. External Schematic of IRQ Relay.

The external connections of the directional overcurrent relay are shown in Fig. 12.

ADJUSTMENT 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;

Negative Sequence Filter

The filters are adjusted for balance in the factory and no further adjustments or maintenances should be required. The nominal voltage and current output of the filters on positive sequence is approximately zero. This serves as a convenient check on the balance of the filters. If any two input leads to the potential

filter should be interchanged, a high voltage occurs across the output terminals of the filter. Similarly, if any two of the phase leads to the input terminals of the current filter are interchanged, an output current will be obtained.

Directional Unit (D)

- 1. Contact Gap The gap between the stationary contact and moving contact with the relay in the de-energized position should be approximately .020"
- 2. Sensitivity Refer to the test diagram in fig. 12. Apply a single-phase voltage V $_{12}$ equal to 0.57 volts (corresponds to a negative-sequence input voltage of .19 volts) and a single-phase current equal to 6.93 amperes as shown (corresponds to a negative sequence input current of 4 amperes). With a phase angle meter connected as shown, rotate the phase shifter until the current leads the voltage by 188° . This corresponds to the negative sequence component of current leading the negative sequence component of voltage by 98° . The directional unit contact

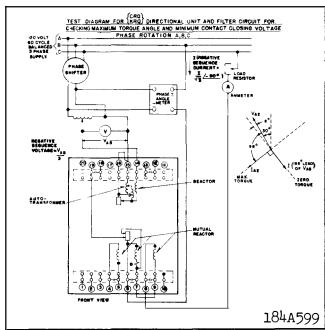


Fig. 12. Test Diagram for Checking Maximum Torque Angle and Minimum Voltage for Contact Closure of the Directional Unit.

The above quantities are determined as follows: $V_{A2} = Neg.$ Sequence Voltage

$$\begin{split} &V_{A2} = \frac{1}{3} \left(V_{AN} + a^2 \ V_{BN} + a \ V_{CN} \right) \\ &V_{A2} = \frac{1}{3} \left(\frac{2}{3} \ V_{AB} - \frac{1}{3} \ a^2 \ V_{AB} - \frac{1}{3} \ a \ V_{AB} \right) \\ &V_{A2} = \frac{V_{AB}}{3} \left(\frac{2}{3} - \frac{1}{3} \ a^2 - \frac{1}{3} \ a \right) \\ &V_{A2} = \frac{V_{AB}}{3} \\ & \text{for } V_{AB} = 0.57 \text{ volts} \\ &V_{A2} = 0.10 \text{ volts} \\ &I_{A2} = \frac{1}{3} \left(I_A + a^2 \ I_B + a I_C \right) \\ &I_{A2} = \frac{1}{3} \left(O + a^2 \ I - a I \right) \\ &I_{A2} = \frac{1}{\sqrt{3}} \frac{/-90^{\circ}}{\sqrt{90^{\circ}}} \\ & \text{for } I = 6.93 \text{ amps.} \\ &I_{A2} = 4 \ /-90^{\circ} \text{ amps.} \end{split}$$

should pick up within $\pm 10\%$ of the above input voltage to the relay.

3. Spurious Torque - With the relay connected in the test diagram as above, remove the input voltage and connect terminais 14, 15, and 16 together. Remove the phase-angle meter. With 80 amperes single-phase current applied, there should be no spurious closing torque.

Time Overcurrent Unit (CO)

1. <u>Contacts</u> - 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 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 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 1 shows the time curve calibration points for the various types of relays. With the time dial set to the indicated position, apply the current specified by Table 1 (e.g. for the IRQ-2, 3 and 20 times tap value current). And measure the operating time of the relay. The operating times should equal those of Table 1 plus or minus 5 percent.

For type IRQ-11 relay only, the 1.30 times tap value operating time from the number 6 time dial position in 54.9 ±5% seconds. It is important that the 1.30 times tap value current be maintained accurately. The maintaining of this current accurately is necessary because of the steepness of the slope of the time-current characteristic (Fig. 21). A 1% variation in the 1.30 times tap value current (including measuring instrument deviation) will change the nominal operating time by approximately 4%.

Instantaneous Overcurrent Unit (I)

- 1. <u>Contact Gap</u> 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 the tap value current.

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 (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

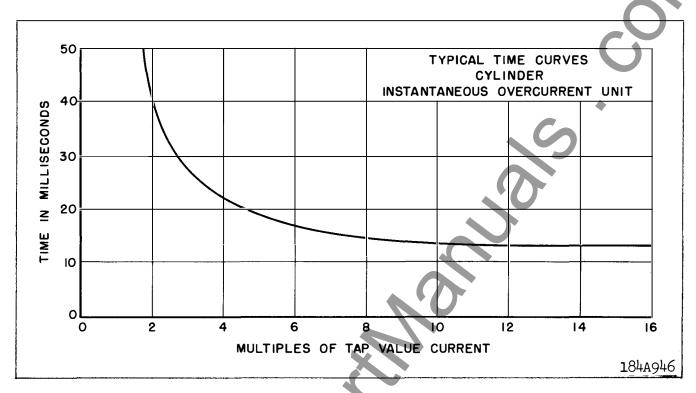


Fig. 13. Typical Time Curve of the Instantaneous Overcurrent Unit.

.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.

If an additional time check is desired, pass secondary current through the relay and check the time of operation. It is preferable to make this at several times pick-up current at an expected operating point for the particular application. For the .5 to 2.5 ampere range IRQ-5 and IRQ 6 induction unit use the alternative test circuit in Fig. 7 as these relays are affected by a distorted wave form. With this connection the 25/5 ampere current transformers should be worked well below the knee of the saturation (i.e., use 10L50 or better).

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").

Negative Sequence Voltage Filter

A. Apply 120 volts balanced 3 phase voltage 60 cycles to terminals 14, 15, and 16 of the relay, making sure that phase 1, 2, and 3 of the applied voltage is connected to terminals 14, 15, and 16 repectively.

B. Using a calibrated high resistance rectox voltmeter, measure the voltage between the tap on the auto-transformer (middle terminal, lower-right hand reactor, rear view of Fig. 1 and the tap on the adjustable 2' resistor on the upper right hand corner of Fig. 2. If the voltage is high (40 to 50 volts) the the filter is probably improperly connected. If properly connected, the voltage will be low. Using a low range (approximately 5 volts) move the adjustable tap until the voltage reads a minimum. This value should be less than 1.5 volts.

Negative Sequence Current Filter

Refer to fig. 8 for positive sequence calibration.

- A. Connect relay terminals 7 and 9 together. Remove lead to lower right hand terminal of mutual reactor (right side view) to disconnect the directional unit.
- B. Pass 10 amperes in terminal 6 and out terminal 8.
- C. With a 0-15 volts, rectox type voltmeter, measure and record voltage between terminals 6 and the lower right hand terminal of mutual reactor. This voltage should be between 1.85 and 1.95 volts.
- D. Now measure the voltage from terminal 6 to terminal 7. Adjust the top filter resistor tap until this voltage is 1.73 times the reading of part C.

Refer to fig. 8 for neutral tap calibration.

A. Using the test connections as shown and a low range voltmeter connected between terminal 6 and 7, adjust the middle filter resistor tap connection until the measured voltage is zero. Reconnect lead to mutual reactor at end of this test.

Directional Unit (D)

- 1. The upper bearing screw should be screwed down until there is approximately .025" clearance between it and the top of the shaft bearing. The upper pin bearing should then be securely locked in position with the lock nut.
- 2. Contact gap adjustment for the directional unit is made with 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 and 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 % 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. 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 when the relay is energized with 0.57 volts and 6.93 amps at 1880 (current leading voltage), considering the relay connected to the test circuit in Fig. 12.

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) Connect the relay voltage circuit terminals (phase 1, 2 and 3) together.
- b) Apply 80 amperes single-phase current (momentarily) in phase 2 terminal and out phase 3 terminal.

Plug adjustment is then made per Table II such that any contact closing 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.

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.

Time Overcurrent Unit (CO)

- 1) <u>Contacts</u> 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 adjusted 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 1 for permanent magnet adjustment (e.g. IRQ-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 1.

For type IRQ-11 relay only, the 1.30 times tap value operating time from the number 6 time dial position is $54.9 \pm 5\%$ seconds. It is important that the 1.30 times tap value current be maintained accurately. The maintaining of this current accurately is necessary because of the steepness of the slope of the time-current characteristic (Fig. 21). A 1% variation in the 1.30 times tap value current (including measuring instrument deviation) will change the nominal operating time by approximately 4% if the operating time at 1.3 times tap value is not within these limits, a minor adjustment of the control spring will give the correct operating time without any undue effect on the minimum pick-up of the relay. This check is to be made after the 2 times tap value adjustment has been completed.

Apply the indicated current per Table 1 for the electromagnet plug adjustment (e.g. IRQ-8, 20 times tap value) and measure the operating time. Adjust the proper plug until the operating time corresponds to the value in Table 1 (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 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 the directional unit 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 the core screw up until the moving core starts rotating. Now back off the core screw until the moving core stops rotating. This indicates the points when 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. 14. 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.

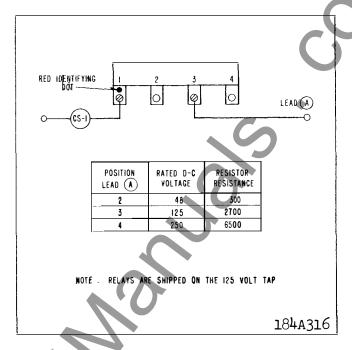


Fig. 14. Selection of Proper Voltage Tap for Auxiliary Switch (CS-1) Operation.

TABLE I
TIME CURVE CALIBRATION DATA - 60 CYCLES

<u>.</u>	PERMANENT	ELECTROMAGN	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
IRQ- 2	6	3	0.57	20	0.22
IRQ- 5	6	2	37.80	10	14.30
IRQ- 6	6	2	2.46	20	1.19
IRQ- 7	6	2	4.27	20	1.11
IRQ-8	6	2	13.35	20	1.11
IRQ- 9	6	2	8.87	20	0.65
IRQ-11	6	2	11,27	20	0.24

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.

[†] Short circuit the voltage polarizing circuit at the relay terminals before making the above adjustment.

IRQ-2 TIME OVERCURRENT UNITS

						VOLT A	MPERES**	
AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE ϕ	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
TANGE		(IIMI ERES)	(MMI ERCEO)	IMSELĢ	COMENT	COMMENT	COMMENT	COMMENT
	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 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
A	12.0	12.0	230	34	7.00	62.3	528	2064

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.

^{**} Voltages taken with Rectox type voltmeter.

IRQ-5, IRQ-6 TIME OVERCURRENT UNITS

VOI	т.	AMP	FR.	ES'	•

AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE ϕ	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
KANGE	IAF	(AMPERES)	(AMFERES)	ANGLE ϕ	CORRENT	CURRENT	CORRENT	CORRENT
	(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	53 1
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
						_ ·		

IRQ-7 TIME OVERCURRENT UNITS

VOLT AMPERES**

				_ ^				
		CONTINUOUS	ONE SECOND	POWER	АТ	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 ϕ	CURRENT	CURRENT	CURRENT	CURRENT
				TIT				
	(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
	, _ _	- 3						

^{*} 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.

 $[\]phi$ Degrees current lags voltage at tap value current.

^{**} Voltages taken with Rectox type voltmeter.

IRQ-8, IRQ-9 TIME OVERCURRENT UNITS

						VOLT	AMPERES**	•
AMPERE RANGE	TAP	CONFINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE ϕ	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
0.0, 2.0	(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
	•					1	220	000
	(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
	•						100	000
	(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

IRQ-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)	$ANGLE \phi$	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	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

^{*} 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.

 $[\]phi$ Degrees current lags voltage at tap value current.

^{**} Voltages taken with Rectox type voltmeter.

ENERGY REQUIREMENTS FOR THE SEQUENCE FILTER AND THE DIRECTIONAL UNIT (All Burdens at 60 Cycles)

The current burden of the relay with positive sequence currents applied (no output current to the directional unit) is as follows:

Phase	Continuous Rating-Amps.	One Second Rating-Amps.	Watts at 5 Amps.	Volt-Amps. at 5 Amps.	Power Factor Angle
2	10	150	5.5	5.5	00
3	10	150	.35	1.28	74 ⁰ Lag
1	10	150	5.4	7.5	44 ⁰ Lag

The current burden of the relay with zero sequence currents applied is as follows:

	Watts	Volt - Amps.	
Phase	At 5 Amps.	At 5 Amps.	Power Factor Angle
1	4.66	5.5	32 ⁰
2	4.92	5.0	10 ⁰
3	3.30	3.7	270

The voltage burden of the relay with positive sequence voltage applied (no output voltage to the directional unit) is as follows:

Pot. Transf. Across Phase Volts Watts Volt-Amps. Power Factor Angle

Burden values on three star connected potential transformers. Values at the star voltage of 66.4 volts (115 volts delta).

1	115	0	26.8	90 ⁰ Lag
2	115	0.2	0.3	48 ⁰ Lag
3	115	23.2	27.0	$30^{ m O}~{ m Lag}$

Burden values on two open-delta potential transformers. Values at 115 volts.

12	115	-23.2	46.5	120 ⁰ Lag
23	115	46.6	46.6	$0_{\rm O}$
23	115	.10	.48	58 ⁰ Lag
31	115	23.2	46.5	$60^{ m O}$ Lag
31	115	23.2	46.6	$60^{ m O}$ Lag
12	115	0.50	0.52	2 ⁰ Lead

Burden values on three delta connected potential transformers. Values at 115 volts.

31		1 15	15.4	31.0	60 ⁰ Lag
12		115	-7.8	15.6	120 ⁰ Lag
23	•	115	15.6	15.6	$\mathbf{o_o}$

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	.41	36	5.0	36
	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
	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		21	0.43	
		2.4			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
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 RATI	NG	ONE SECOND R	
		(AMPER F S)		† (AMPERE	S)
5-2		5		100	
1-4		8		140	
2-8		8		140	
4-16		10		200	
10-40					
10-40		10		200	
20-80		10		200	

[†] 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.

^{† †} Voltages taken with Rectox type voltmeter.

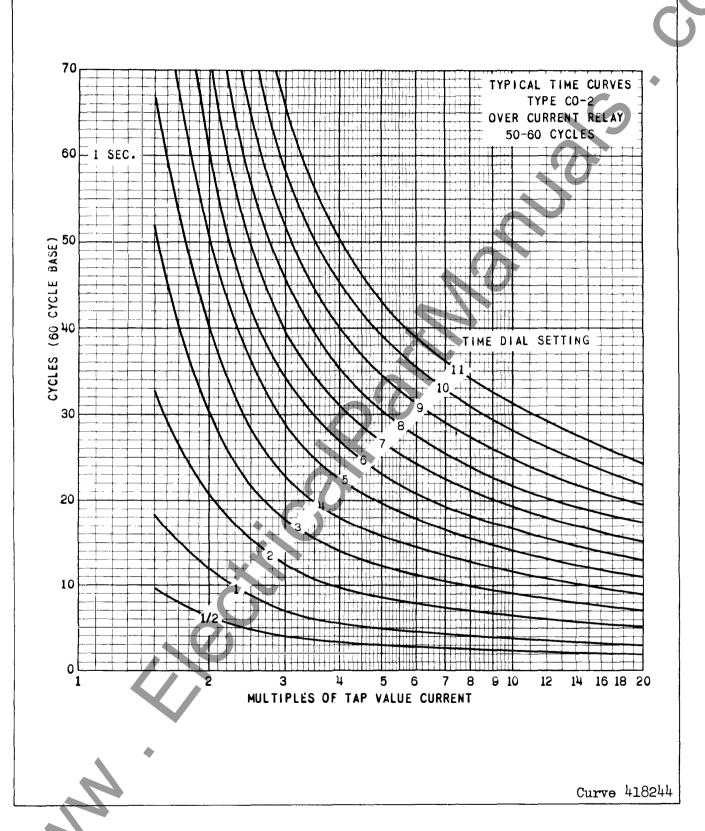


Fig. 15. Typical Time Curve of the Time-Overcurrent Unit of the Short Time (2) Relay.

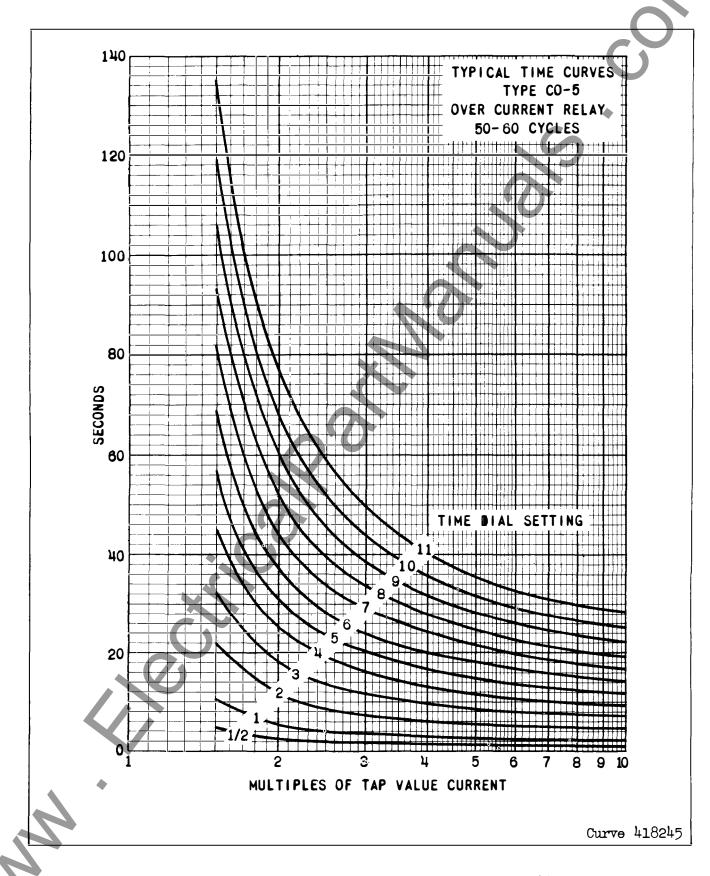


Fig. 16. Typical Time Curve of the Time-Overcurrent Unit of the Long Time (5) Relay.

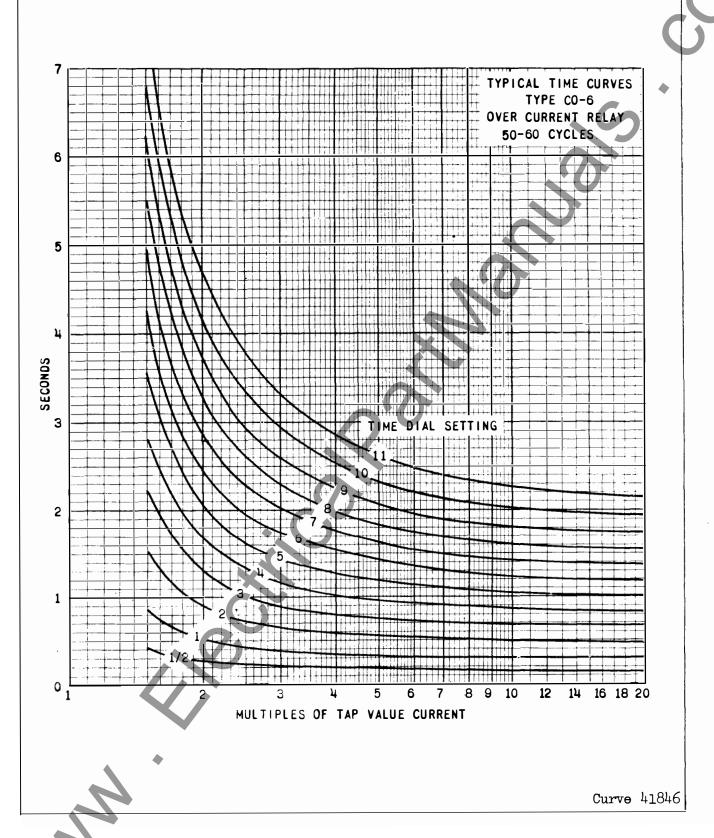


Fig. 17. Typical Time Curve of the Time-Overcurrent Unit of the Definite Time (6) Relay.

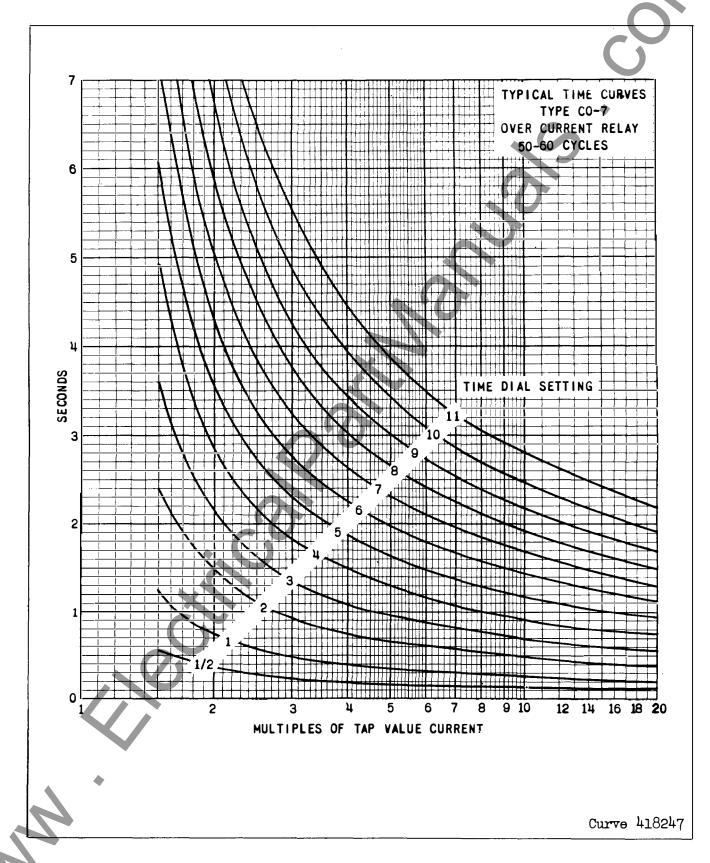


Fig. 18. Typical Time Curve of the Time-Overcurrent Unit of the Moderately Inverse (7) Relay.

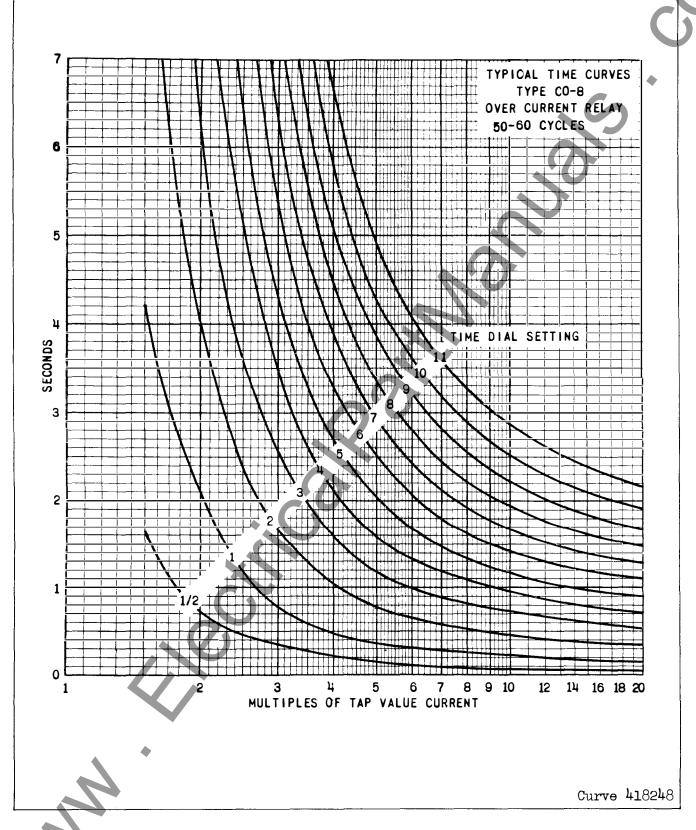


Fig. 19. Typical Time Curve of the Time-Overcurrent Unit of the Inverse (8) Relay.

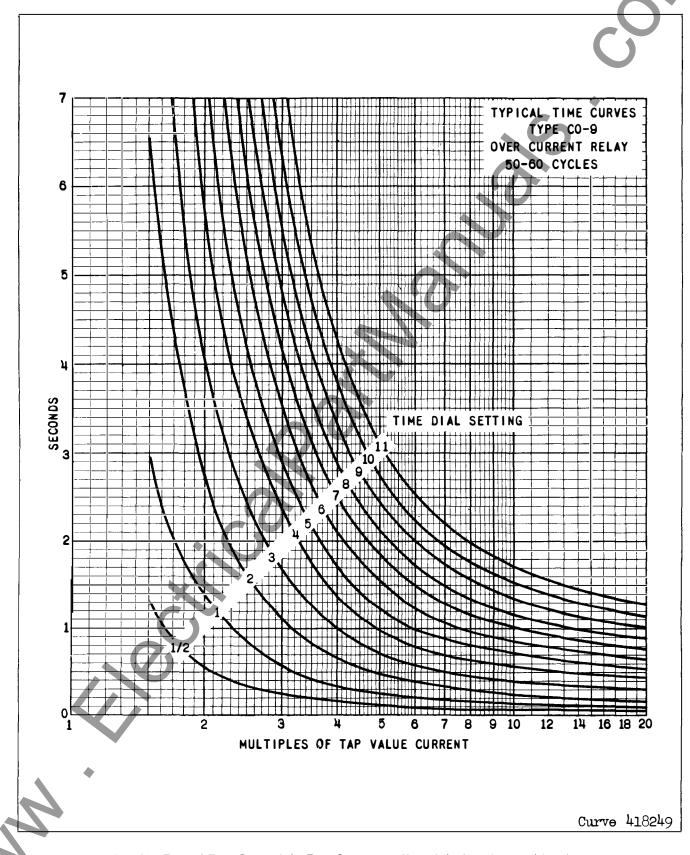


Fig. 20. Typical Time Curve of the Time-Overcurrent Unit of the Very Inverse (9) Relay.

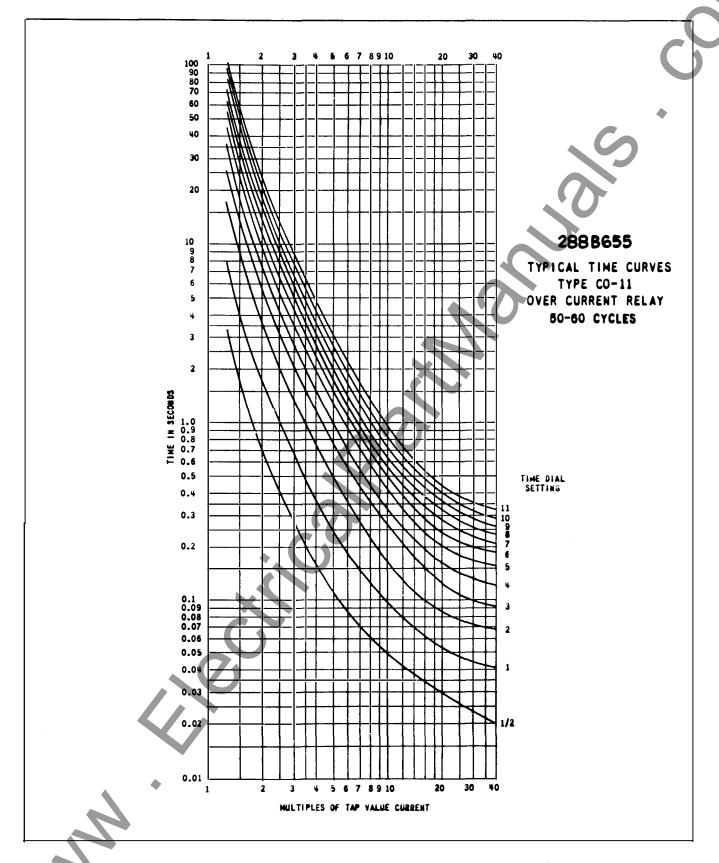


Fig. 21. Typical Time Curve of the Time-Overcurrent Unit of the Extremely Inverse (11) Relay.

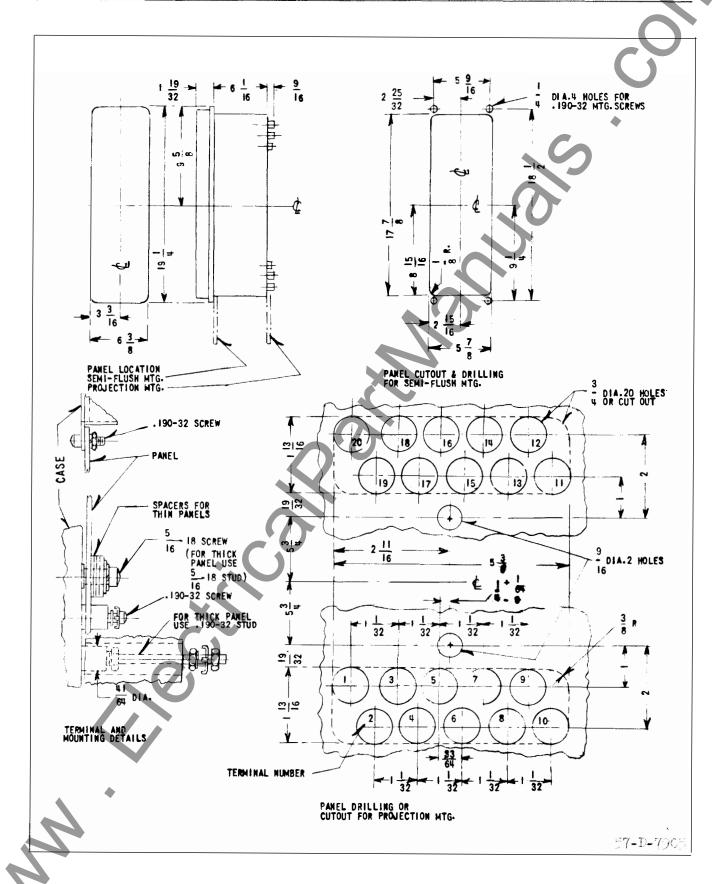


Fig. 22. Outline and Drilling Plan for the Type IRQ Relay in the FT42 Case.



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

Printed in U.S.A.



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

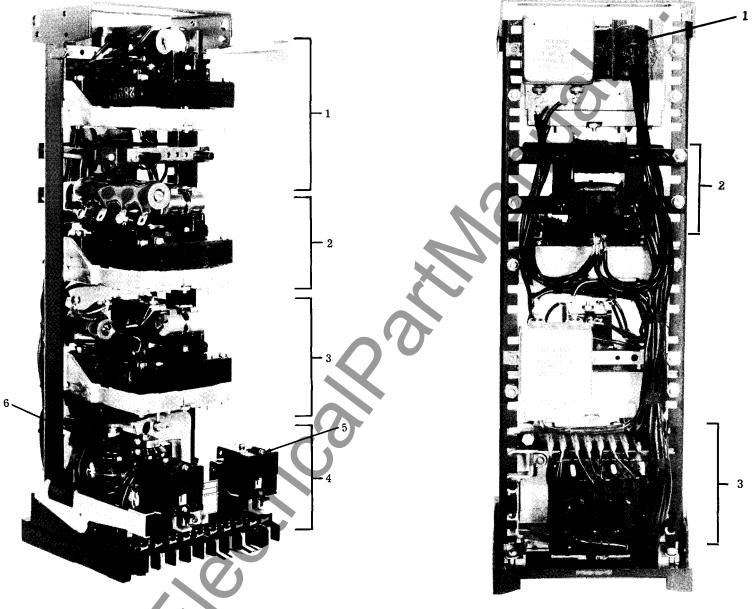


Fig. 1. Type IRD Relay Without Case (Front View). 1 — Instantaneous Overcurrent Unit and Saturating Transformer. 2 — Current Polarized Directional Unit. 3 — Voltage Polarized Directional Unit. 4 — Time Overcurrent Unit. 5 — Indicating Contactor Switch. 6 — Auxiliary Switch.

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

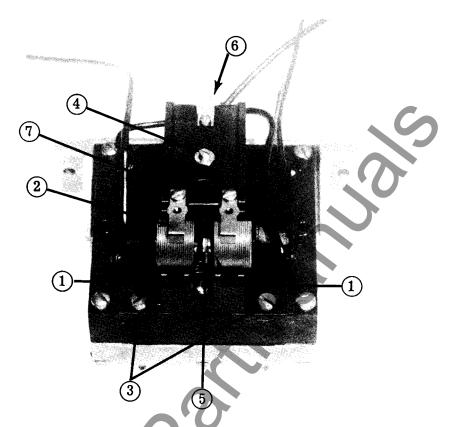


Fig. 3. Directional Unit. 1 — Stationary Contacts. 2 — Stationary Contact Pressure Spring. 3 — Magnetic Adjusting Plugs. 4 — Upper Bearing Screw. 5 — Moving Contact. 6 — Spring Adjuster Clamp. 7 — Current Bias Vane.

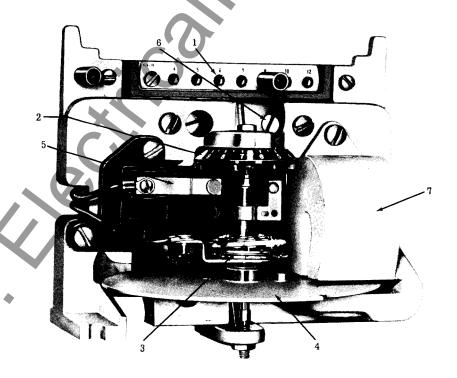


Fig. 4. Time Overcurrent Unit. 1—Tap Block. 2—Time Dial. 3—Control Spring Assembly. 4— Disc. 5—Stationary Contact Assembly. 6—Magnetic Plugs. 7—Permanent Magnet.

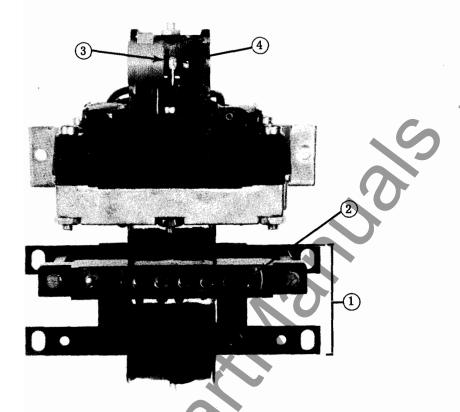


Fig. 5. Instantaneous Overcurrent Unit. 1 — Saturating Transformer. 2 — Tap Block. 3 — Stationary Contact. 4 — Moving Contact.

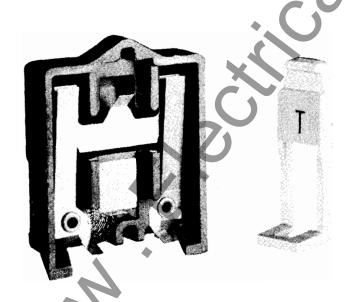




Fig. 6. Indicating Contactor Switch (ICS).

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 (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		Taps					
0.5-2 Amps	0.5	0.75	1.0	1.25	1.5	2	
1-4	1.0	1.5	2.0	2.5	3.0	4.0	
2-8	2	3	4	5	6	8	
4-16	4	6	8	9	12	16	
10-40	10	15	20	24	30	40	
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.
- 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.

$$\phi - 40^{\circ} = 0^{\circ}$$

(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 =
$$\frac{\text{Iop}}{T}$$
 = $\frac{2.31}{0.5}$ = 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.

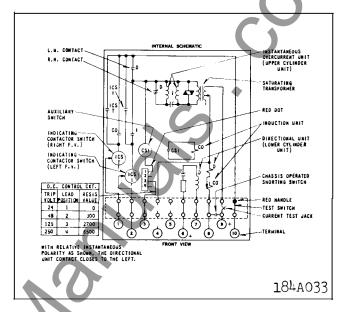


Fig. 7. Internal Schematic of the Type IRP Relay in the Type FT31 Case.

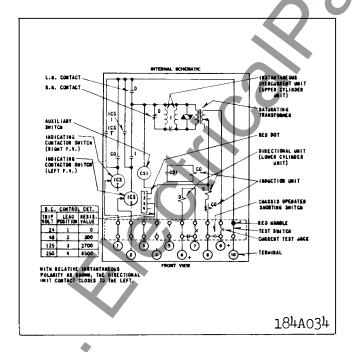


Fig. 8. Internal Schematic of the Type IRC Relay in the Type FT31 Case.

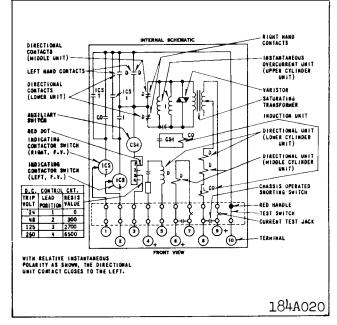


Fig. 9. Internal Schematic of the Type IRD Relay in the Type FT41 Case.

ENERGY REQUIREMENTS

INSTANTANEOUS OVERCURRENT UNIT OPERATING CURRENT CIRCUIT - 60 CYCLES

AMPERE RANGE	TAP	VA AT TAP VALUE	φ 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
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
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
10-40	40	4.9	11	0.08	12
	20	6.6	31	0.40	31
	30	9.3	24	0. 25	24
00.00	40	12	20	0.18	20
20-8 0	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
RANGE		(AMPERES)	NG	† (AMPERE	
5-2		5		100	
				140	
1-4 2-8		8		140	
		8		200	
4-16		10		200	
10-40		10			
20-80		10		200	

[†] 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.

[†] Voltages taken with Rectox type voltmeter.

ENERGY REQUIREMENTS - 60 CYCLES DIRECTIONAL UNIT OPERATING CIRCUIT BURDEN

						VOI	VOLT AMPERES ††		
					At	At 3 Times	At 10 Times	At 20 Times	
		Continuous	One Second	Power	Minimum	Minimum	Minimum	Minimum	
Relay	Range	Rating	Rating †	Factor	Tap Value	Tap Value	Tap Value	Tap Value	
Type	Amps	(Amperes)	(Amperes)	Angle ϕ	Current	Current	Current	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	
			l						

- \$\phi\$ Degrees current lags voltage at tap value current.
- † 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.
- †† Voltages taken with Rectox type voltmeter.

ENERGY REQUIREMENTS - 60 CYCLES DIRECTIONAL UNIT POLARIZING CIRCUIT BURDEN

RELAY TYPE	RATING	VOLT AMPERES △	POWER FACTOR ANGLE ϕ
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

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

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

						VOLT A	MPERES††	•
AMPERE		CONTINUOUS RATING	ONE SECOND RATING†	POWER FACTOR	AT TAP VALUE	AT 3 TIMES TAP VALUE	AT 10 TIMES TAP VALUE	AT 20 TIMES TAP VALUE
RANGE	TAP	(AMPERES)	(AMPERES)	$ANGLE \phi$	CURRENT	CURRENT	CURRENT	CURRENT
		(111112 21122)						
	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

[†] 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.

 $[\]dagger\dagger$ Voltages taken with Rectox type voltmeter.

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

			•	•	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	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	AТ	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 ϕ	CURRENT	CURRENT	CURRENT	CURRENT	
			7()						
	(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	

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.

^{††} Voltages taken with Rectox type voltmeter.

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

h		1						
						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	Tap	(Amperes)	(Amperes)	Angle ϕ	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	8.8 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	$\frac{22.6}{23.6}$	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

			IND-II, INC-	11, 1101 -11	OVERCORREN	1 011113					
						VOLT AM	PERES ††				
Amnoro		Continuous Rating	One Second Rating †	Power Factor	At Tap Value	At 3 Times Tap Value	At 10 Times Tap Value	At 20 Times Tap Value			
Ampere Range	Tap	(Amperes)	(Amperes)	Angle ϕ	Current	Current	Current	Current			
Tunge	_	` - /	•								
j	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			
i	2.5	7.8	230	30	0.78	7.00	78.5	285			
J	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			
1 1	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			
1	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			
1 1	8.0	20	460	18	1.23	11.1	124.8	480			
1	10.0	22	460	17	1.32	14.9	131.6	600			
	12.0	26	460	16	1.8	16.3	180.0	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 ϕ	46.7°	42 °	37°	26.5°	4.8 °	4.3 °		

[†] 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.

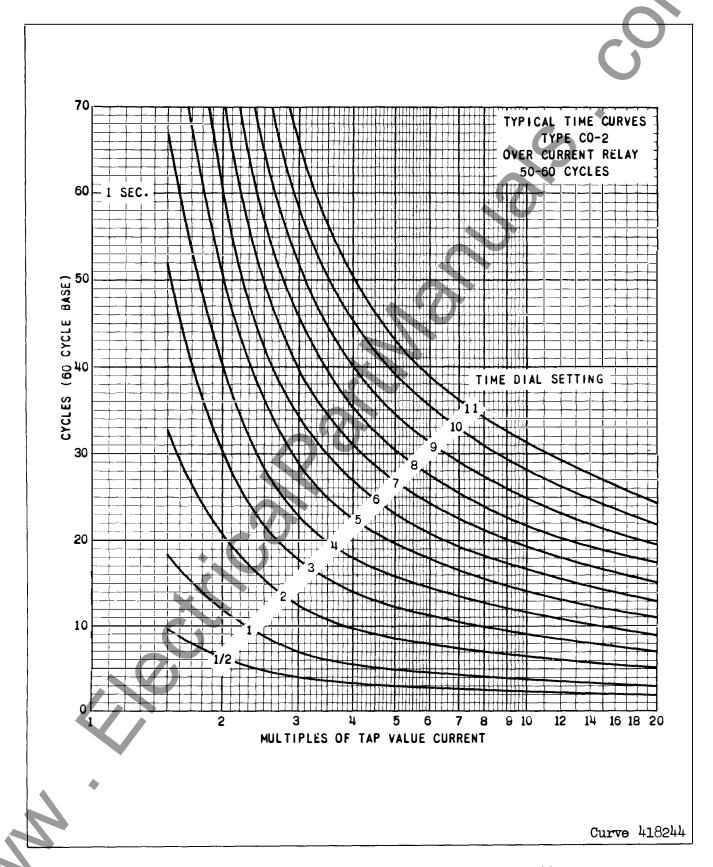


Fig. 10. Typical Time Curves of the Time-Overcurrent Unit of the Short Time (2) Relays.

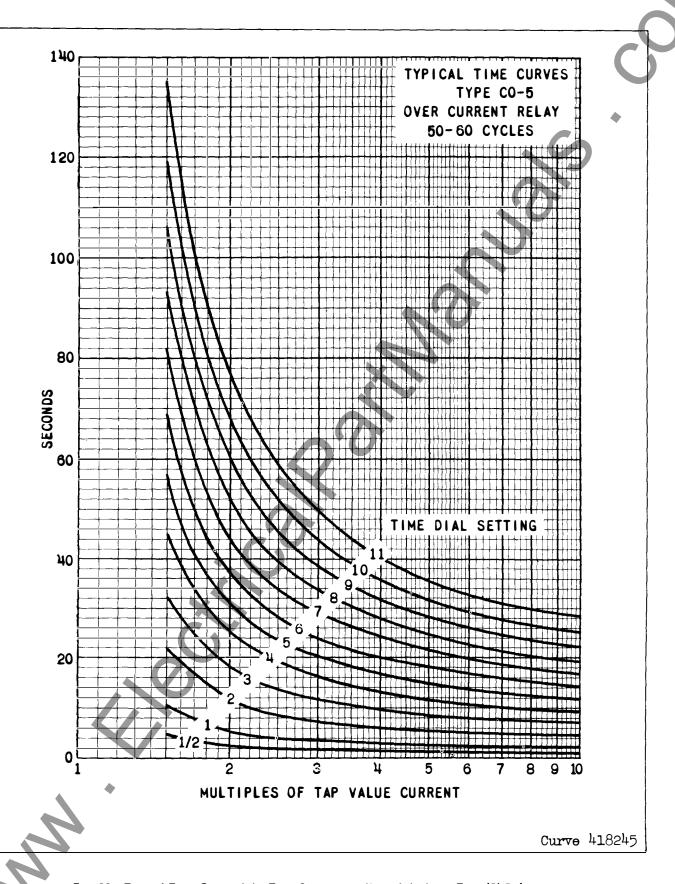


Fig. 11. Typical Time Curve of the Time-Overcurrent Unit of the Long Time (5) Relays.

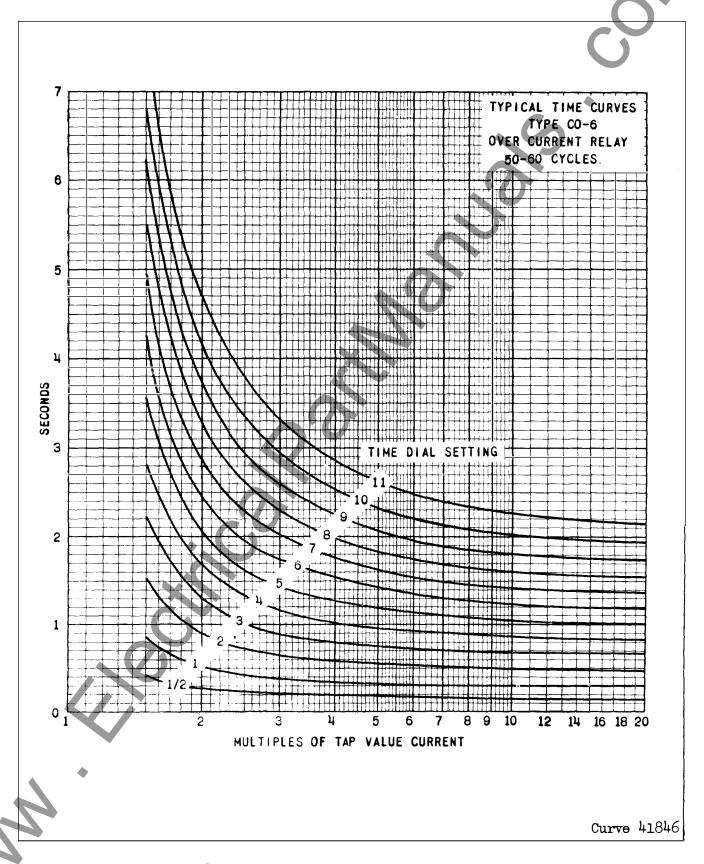


Fig. 12. Typical Time Curve of the Time-Overcurrent Unit of the Definite Time (6) Relays.

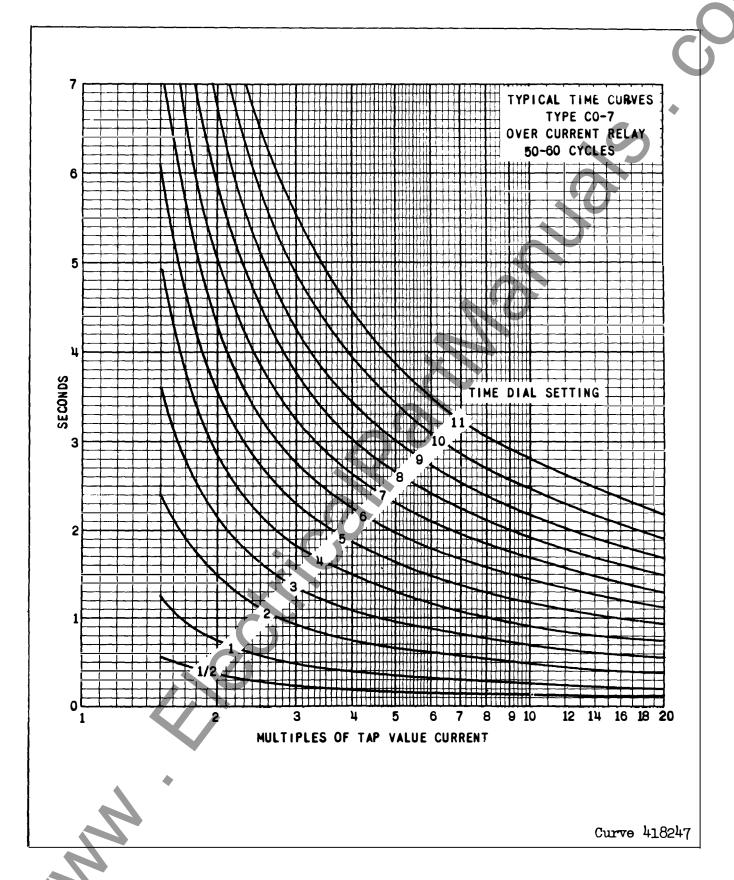


Fig. 13. Typical Time Curve of the Time-Overcurrent Unit of the Moderately Inverse (7) Relays.

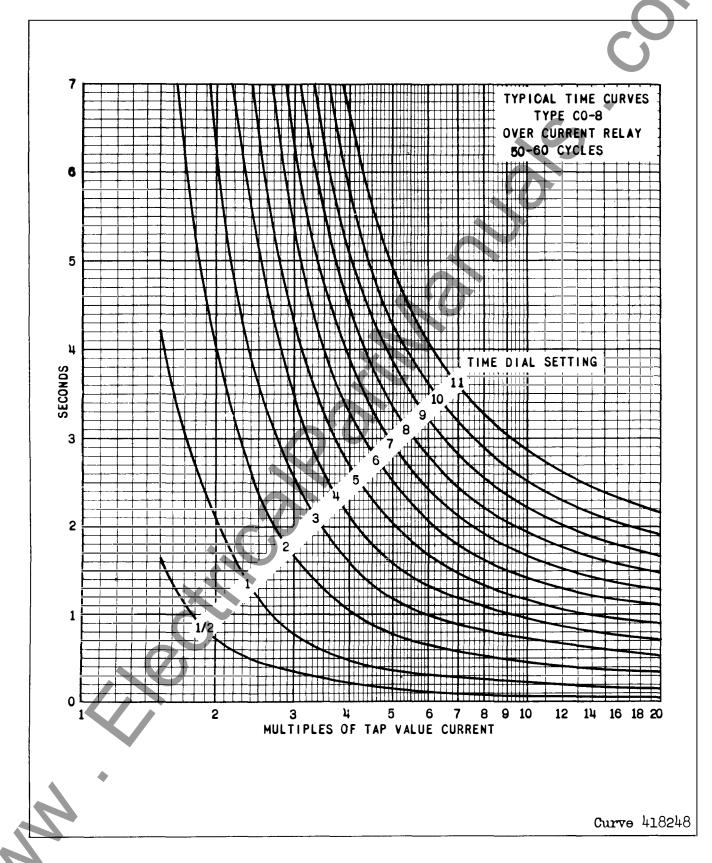


Fig. 14. Typical Time Curve of the Time-Overcurrent Unit of the Inverse (8) Relays.

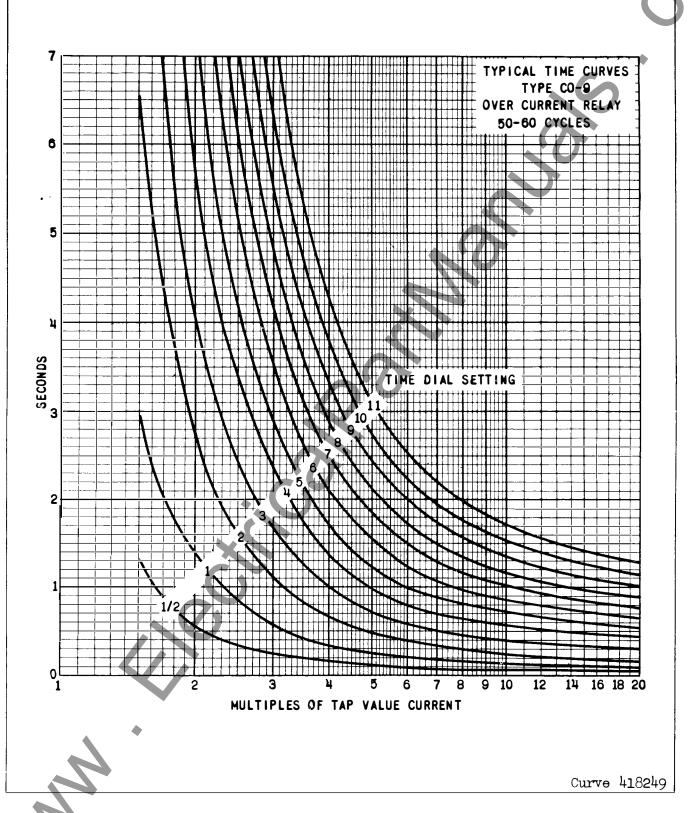


Fig. 15. Typical Time Curve of the Time-Overcurrent Unit of the Very Inverse (9) Relays.

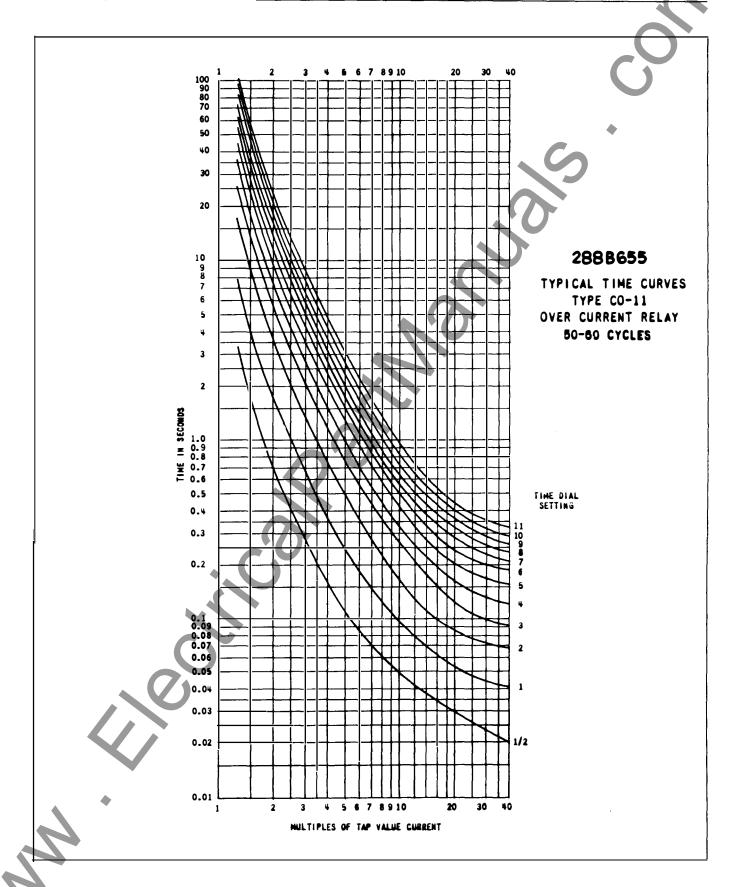
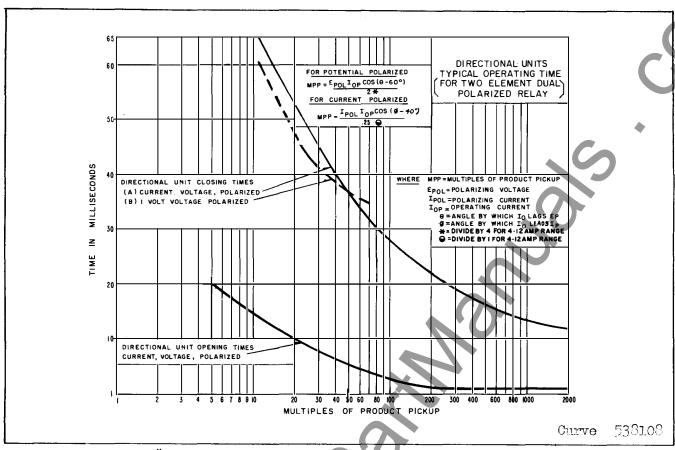


Fig. 16. Typical Time Curve of the Time-Overcurrent Unit of the Extremely Inverse (11) Relays.



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

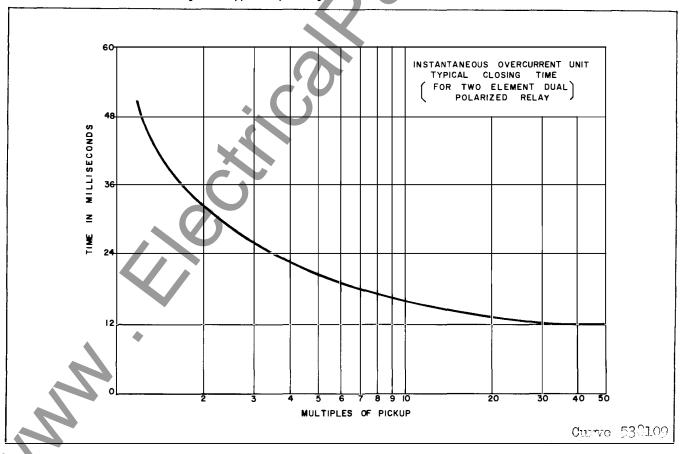


Fig. 18. Typical Operating Times For The Instantaneous Overcurrent Unit.

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° .

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° .

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

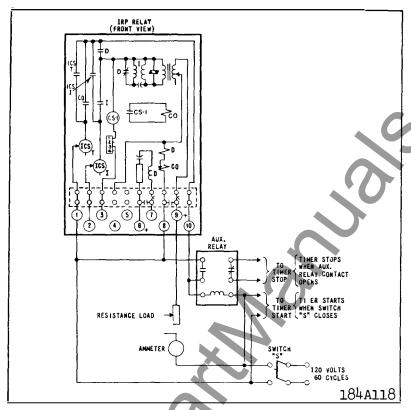


Fig. 19. Diagram of test connections of the time-overcurrent unit.

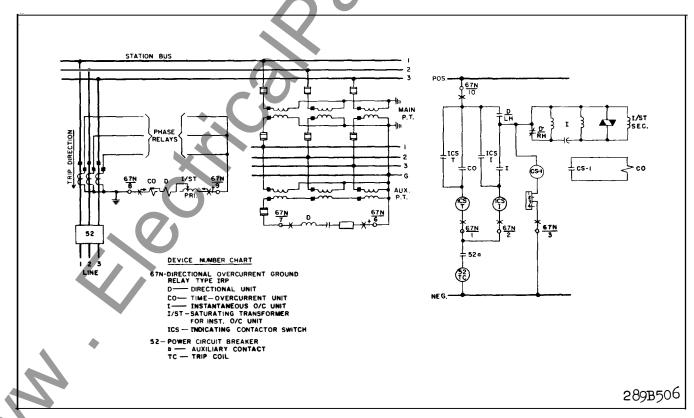


Fig. 20. External Schematic of the IRP Relay for Ground Fault Protection.

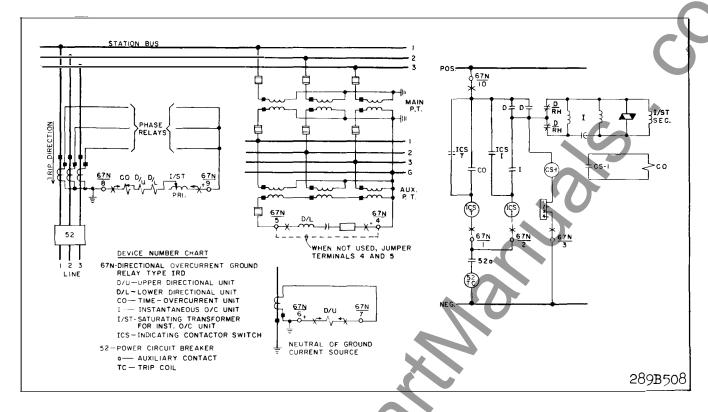


Fig. 21. External Schematic of the IRD Relay for Ground Fault Protection.

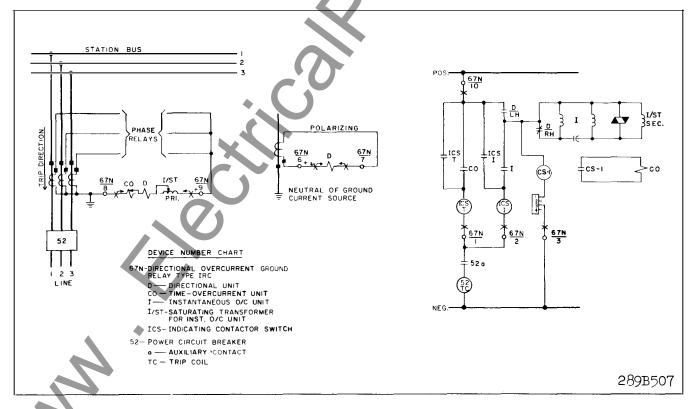


Fig. 22. External Schematic of the IRC Relay for Ground Fault Protection.

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) 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

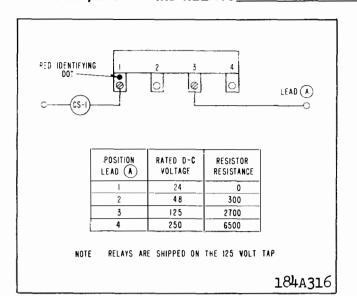


Fig. 23. Selection of Proper Voltage Tap for Auxiliary Switch (CS-1) Operation.

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 This indicates the points where the play rotating. 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	CITOTAL DIVI	OL: (OIII VIII		
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 (Voltage	2- 6	1	4.0	I in-phas with V	
IRD (Voltage Unit)	4.10	1	4.0	I lagging V by 60° ††	
	4-12	1	8.0	I in-phase with V	
_	E 0 E		0.5	I_O leading I_p by 40° ††	
IRC IRD (Current \triangle	.5-2.5 2-6		. 57	In-phase	
Unit)	4-12		1.0	I_{O} leading I_{p} by 40° ††	
			1.3	In-phase	

The energization quantities are input quantities at the relay terminals.

^{††} Maximum torque angle.

[△] 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.

[†] 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 ADJUST	MENT	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

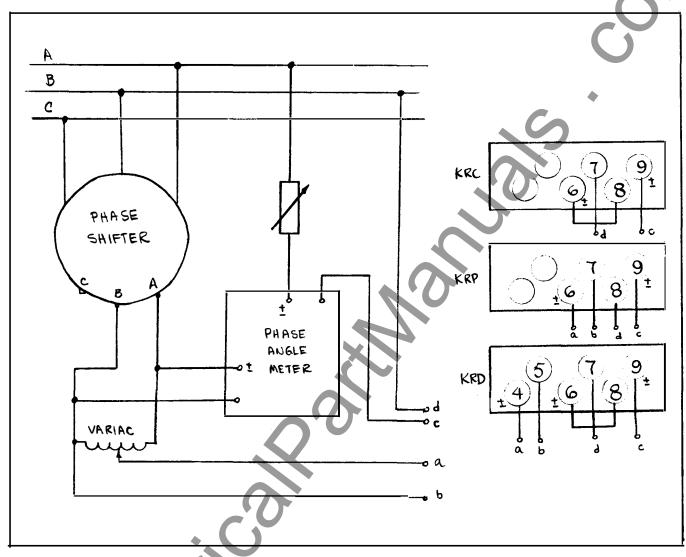


Fig. 24. Test Connections

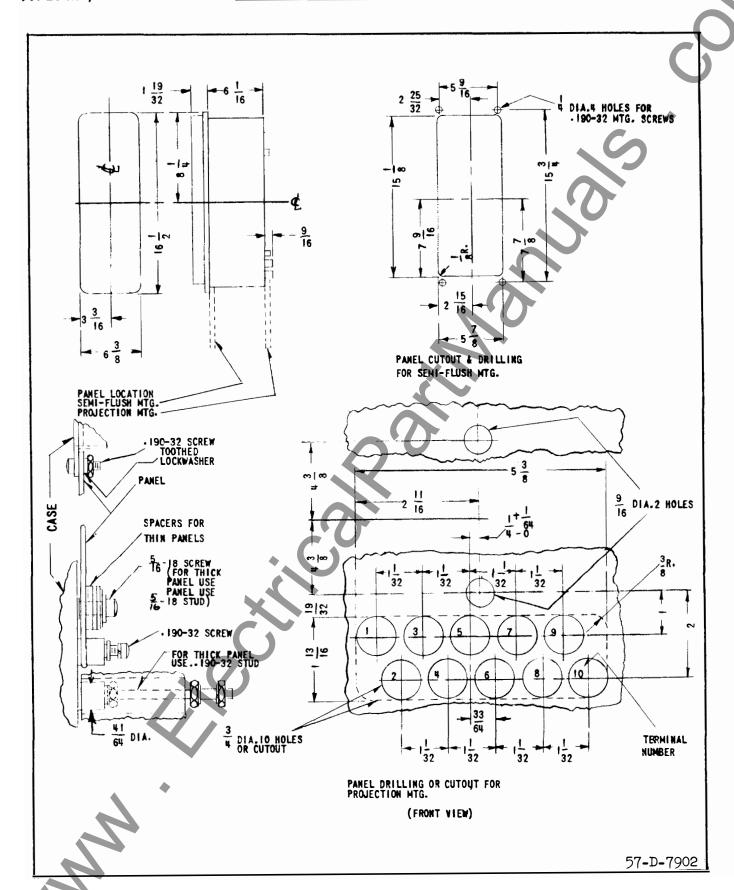


Fig. 25. Outline and Drilling Plan for the IRP and IRC Relays in the Type FT31 Case.

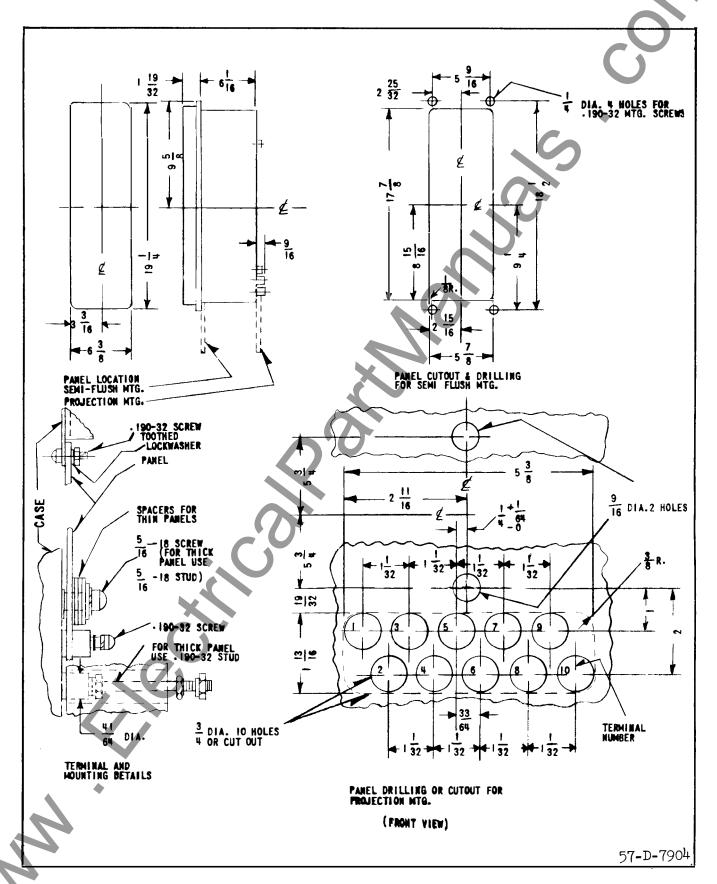


Fig. 26. Outline and Drilling Plan for the IRD Relay in the Type FT41 Case.

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



INSTALLATION . OPERATION . 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 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

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

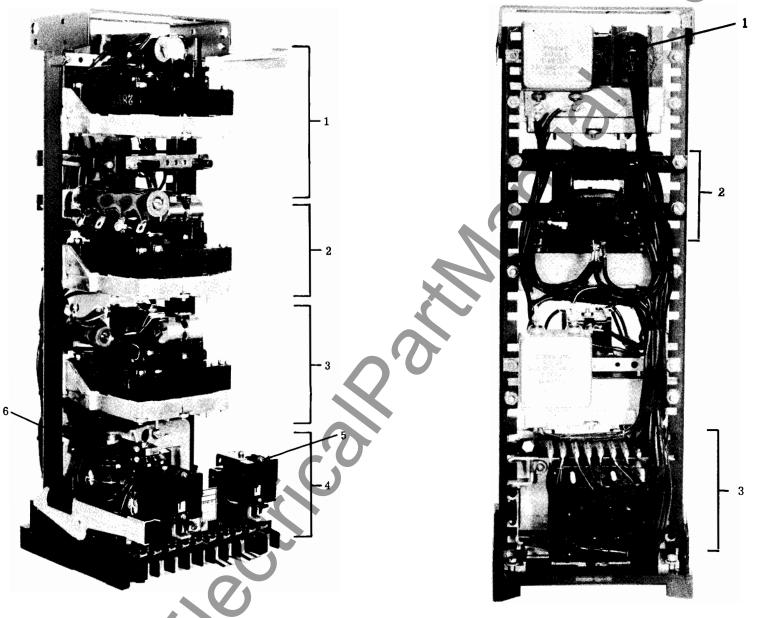


Fig. 1. Type IRD Relay Without Case (Front View). 1 — Instantaneous Overcurrent Unit and Saturating Transformer. 2 — Current Polarized Directional Unit. 3 — Voltage Polarized Directional Unit. 4 — Time Overcurrent Unit. 5 — Indicating Contactor Switch. 6 — Auxiliary Switch.

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

A

N,

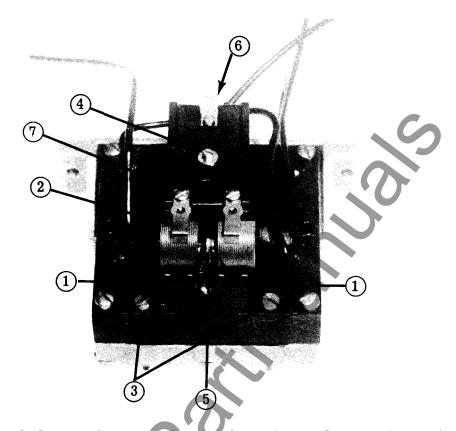


Fig. 3. Directional Unit. 1 — Stationary Contacts. 2 — Stationary Contact Pressure Spring. 3 — Magnetic Adjusting Plugs. 4 — Upper Bearing Screw. 5 — Moving Contact. 6 — Spring Adjuster Claimp. 7 — Current Bias Vane.

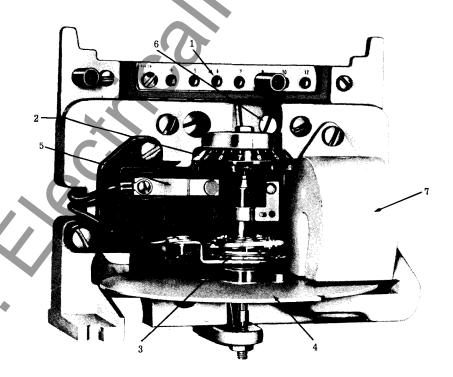


Fig. 4. Time Overcurrent Unit. 1—Tap Block. 2—Time Dial. 3—Control Spring Assembly. 4—Disc. 5—Stationary Contact Assembly. 6—Magnetic Plugs. 7—Permanent Magnet.

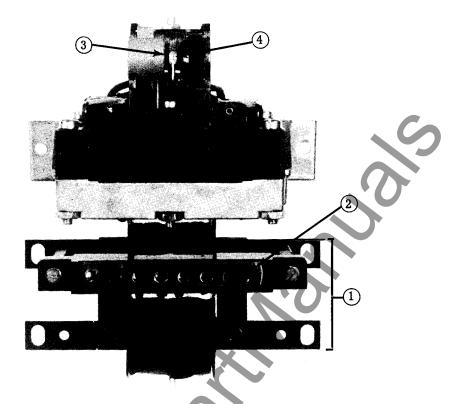


Fig. 5. Instantaneous Overcurrent Unit. 1 — Saturating Transformer. 2 — Tap Block. 3 — Stationary Contact. 4 — Moving Contact.

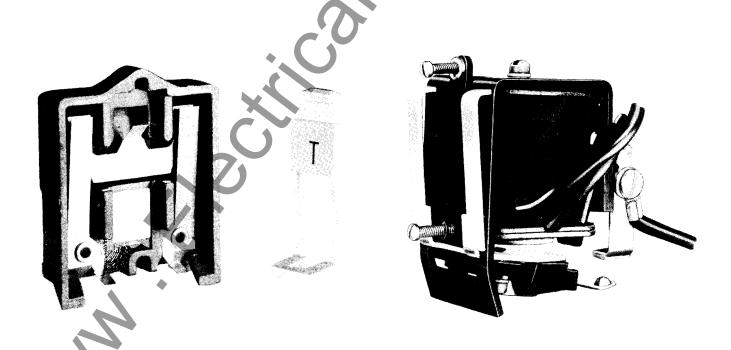


Fig. 6. Indicating Contactor Switch (ICS).

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 (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				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.
- 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 =
$$\frac{\text{Iop}}{T}$$
 = $\frac{2.31}{0.5}$ = 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
$$T (tap) = 1 amp.$$

$$\phi - 40^{\circ} = 0$$

$$MPP = \frac{Iop Ipol Cos (\phi - 40^{\circ})}{0.25}$$

$$MPP = \frac{(20)(23.1)}{0.25} = 1850$$

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 =
$$\frac{\text{Iop}}{T} = \frac{23.1}{1} = 23.1$$

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.

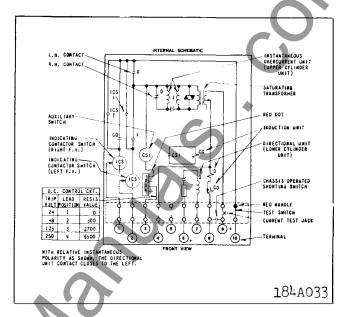


Fig. 7. Internal Schematic of the Type IRP Relay in the Type FT31 Case.

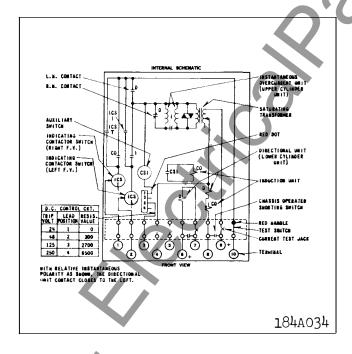


Fig. 8. Internal Schematic of the Type IRC Relay in the Type FT31 Case.

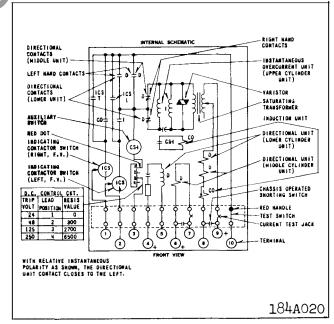


Fig. 9. Internal Schematic of the Type IRD Relay in the Type FT41 Case.

ENERGY REQUIREMENTS INSTANTANEOUS OVERCURRENT UNIT OPERATING CURRENT CIRCUIT - 60 HERTZ

MPERE RANGE	TAP	VA AT TAP VALUE	φ 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 1	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 RATIN	IG	ONE SECOND R	ATING
		(AMPERES)		† (AMPERES	I
. 5-2		5		100	
1-4	V	8		140	
2-8		8		140	
4-16		10		200	
10-40		10		200	
	V				
20-80		10		200	-

[†] 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,
†† Voltages taken with Rectox type voltmeter.

ENERGY REQUIREMENTS - 60 HERTZ DIRECTIONAL UNIT OPERATING CIRCUIT BURDEN

					.,	VOI	LT AMPERES	tt
Relay Type	Range Amps	Continuous Rating (Amperes)	One Second Rating † (Amperes)	Power Factor Angle ϕ	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	9.59	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

- \$\phi\$ Degrees current lags voltage at tap value current.
- † 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.
- tt Voltages taken with Rectox type voltmeter.

ENERGY REQUIREMENTS - 60 HERTZ DIRECTIONAL UNIT POLARIZING CIRCUIT BURDEN

RELAY TYPE	RATING	VOLT AMPERES △	POWER FACTOR ANGLE ϕ
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

 $[\]phi$ Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.

△ Burden of voltage polarized units taken at 120 volts. Burden of current polarized units taken at 5 amperes.

††30 second rating. The 10 second rating is 345 volts. The continuous rating is 120 volts.

[†] One second rating.

ENERGY REQUIREMENTS

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

						VOLT A	MPERES††	•
		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	0.91	28	58	4.8	39.6	256	7 90
	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
					7			

[†] 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.

^{††} Voltages taken with Rectox type voltmeter.

(5

(6

(7

(8

(10

(12

4/12

18.8

19.3

20.8

22.5

25

28

460

460

460

460

460

460

ENERGY REQUIREMENTS

VOLT AMPERES ††

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

AT 20 TIMES TAP VALUE AT 3 TIMES AT 10 TIMES CONTINUOUS ONE SECOND POWER ATAMPERE RATING RATING[†] FACTOR TAP VALUE TAP VALUE TAP VALUE CURRENT RANGE TAP (AMPERES) (AMPERES) ANGLE ϕ CURRENT CURRENT CURRENT 103 270 (0.5 ***** 2.7 69 20.6 88 3.92 (0.6 ***** 3.1 88 68 3.96 20.7 106 288 ***** 3.7 3.96 21 114 325 (0.8 88 67 0.5/2.5 (1.0 ***** 4.1 88 66 4.07 21.4 122 360 ***** 5.7 88 62 4.19 23.2 147 462 (1.5 88 60 24.9 168 548 (2.0 ***** 6.8 4.30 88 (2.5 ***** 7.7 58 4.37 26.2 180 630 21 (2 8 230 67 3.88 110 308 (2.5 8.8 230 66 3.90 21.6 118 342 22.1 (3 9.7 230 64 3.93 126 381 2/6 (3.5 10.4 230 63 4.09 136 417 23.1 (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 16 (4 460 65 4.00 22.4 126 376

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

4.15

4.32

4.40

4.60

4.92

4.35

23.7

25.3

26.4

27.8

30.1

35.6

143

162

183

204

247

288

450

531

611

699

880

1056

63

61

59

56

53

						VOLT A	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 ϕ	CURRENT	CURRENT	CURRENT	CURRENT
			_'()					
	(0.5	* 2.7	88	68	3.88	20.7	103	278
	(0.6)	* 3.1	88	67	3.93	20.9	107	288
	(0.8	* 3.7	88	66	3.93	21.1	114	320
0.5/2.5	(1.0	* 4.1	88	64	4.00	21.6	122	35 6
	(1.5	* 5.7	88	61	4.08	22.9	148	459
	(2.0	* 6.8	88	58	4.24	24.8	174	552
	(2.5	* 7.7	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

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.

Voltages taken with Rectox type voltmeter.

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	Tap	(Amperes)	(Amperes)	Angle ϕ	Current	Current	Current	Current
	(0.5	* 2.7	88	72	2.38	21	132	350
	(0.6	* 3.1	88	71	2.38	21	134	365
	(0.8	* 3.7	88	69	2.40	21.1	142	400
0.5/2.5	(1.0	* 4.1	88	67	2.42	21.2	150	440
	(1.5	* 5.7	88	62	2.51	22	170	530
	(2.0	* 6.8	88	57	2.65	23.5	200	675
	(2.5	* 7.7	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

TRO-11, TRC-11, TRF-11 OVERCORNENT UNITS												
					VOLT AMPERES ††							
Ampere Range	Tap	Continuous Rating (Amperes)	One Second Rating † (Amperes)	Power Factor Angle ϕ	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	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 ϕ	46.7°	42 °	37 °	26.5 °	4.8 °	4.3 °			

[†] 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.

Woltages taken with Rectox type voltmeter.

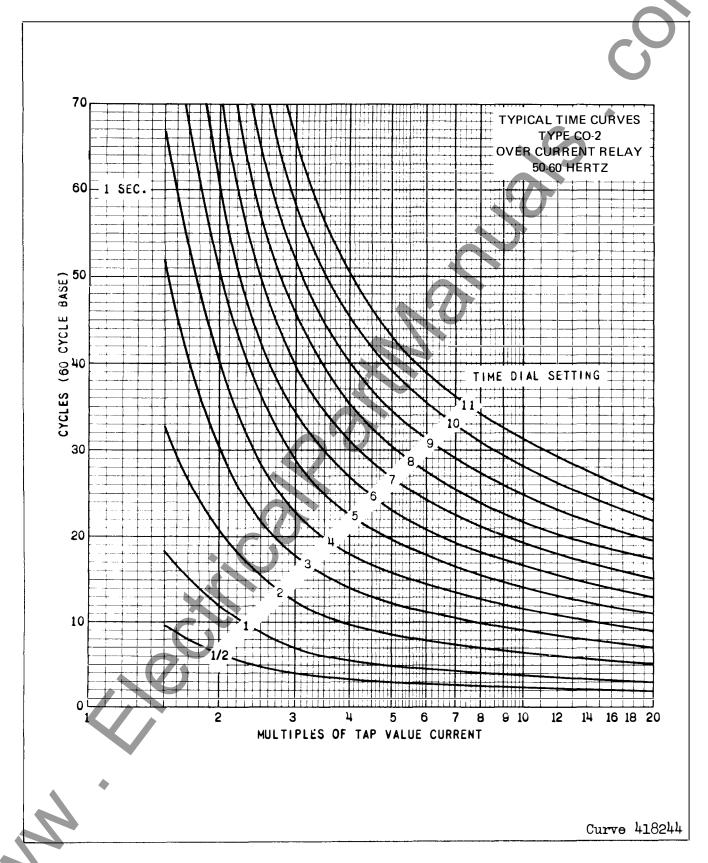


Fig. 10. Typical Time Curves of the Time-Overcurrent Unit of the Short Time (2) Relays.

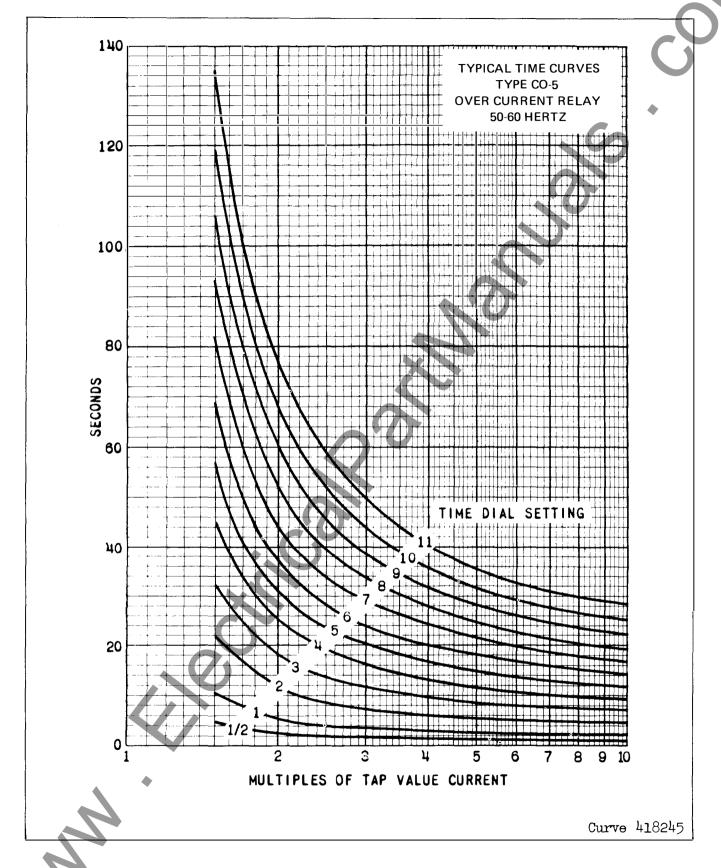


Fig. 11. Typical Time Curve of the Time-Overcurrent Unit of the Long Time (5) Relays.

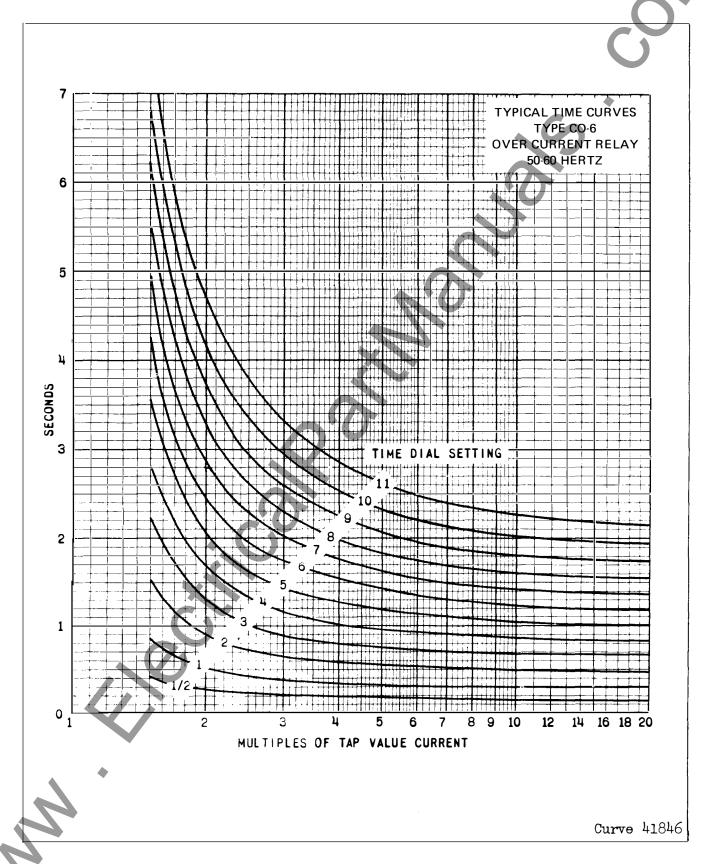


Fig. 12. Jypical Time Curve of the Time-Overcurrent Unit of the Definite Time (6) Relays.

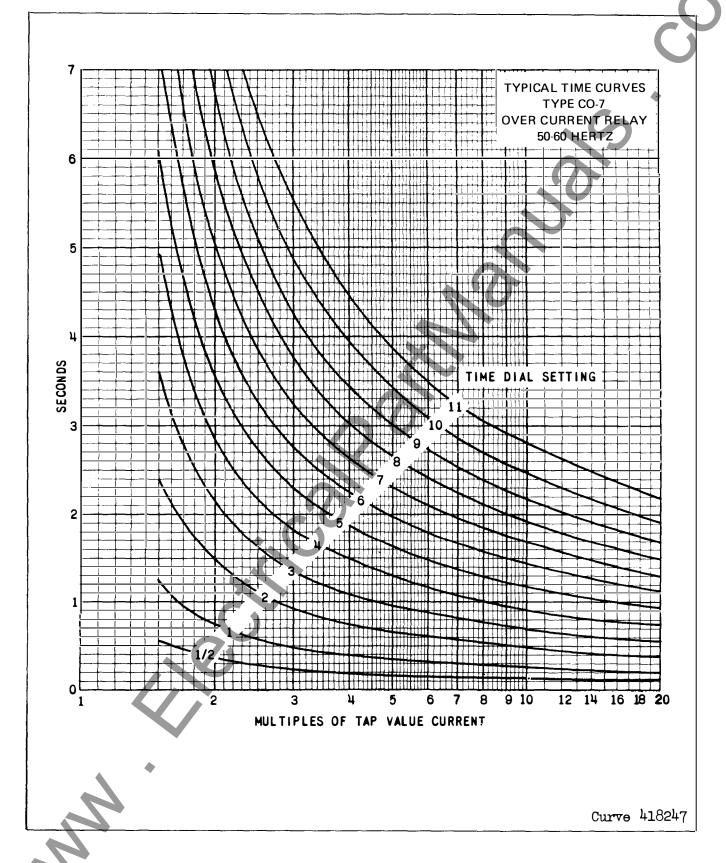


Fig. 13. Typical Time Curve of the Time-Overcurrent Unit of the Moderately Inverse (7) Relays.

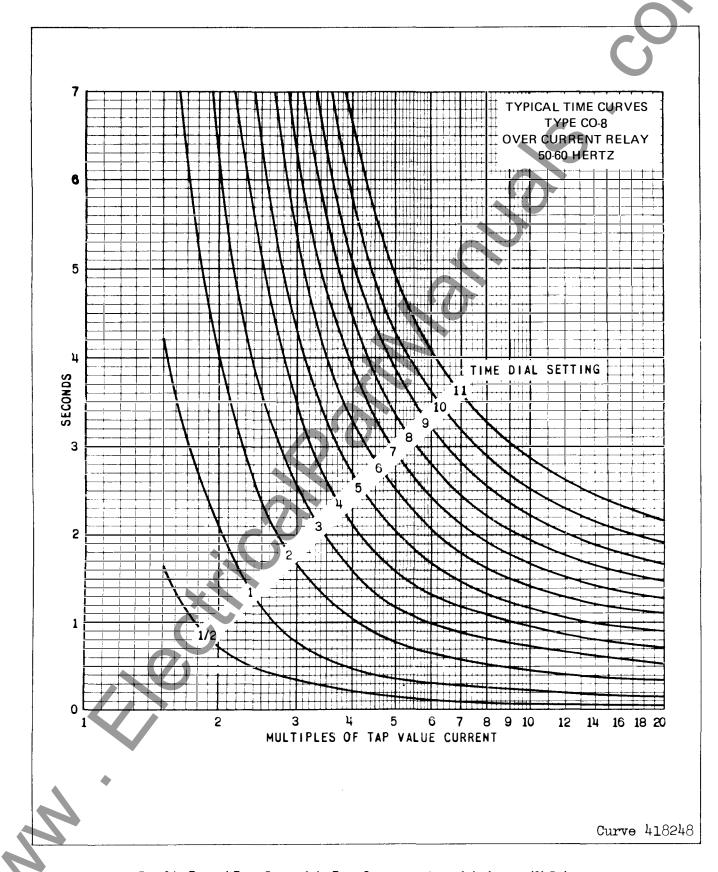


Fig. 14. Typical Time Curve of the Time-Overcurrent Unit of the Inverse (8) Relays.

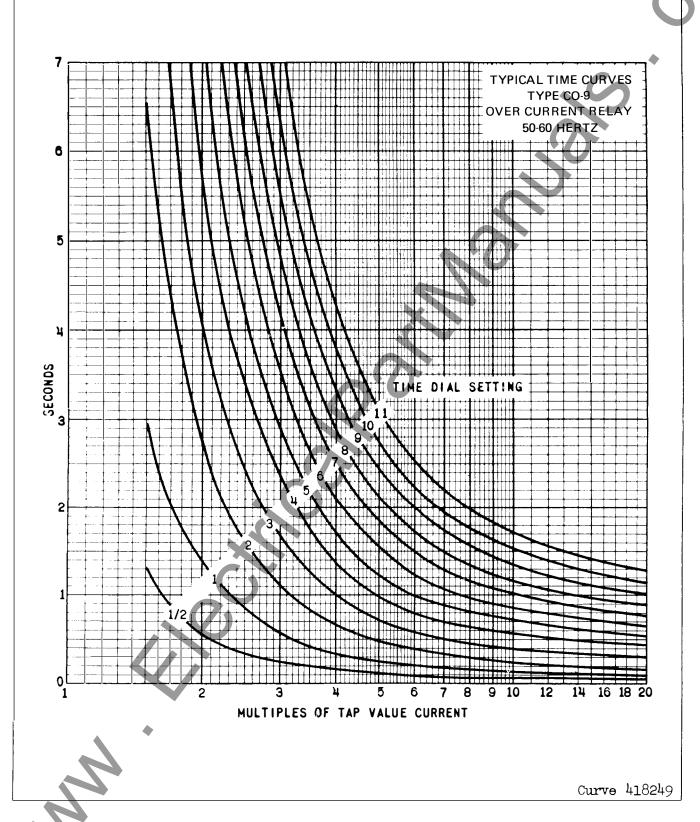


Fig. 15. Typical Time Curve of the Time-Overcurrent Unit of the Very Inverse (9) Relays.

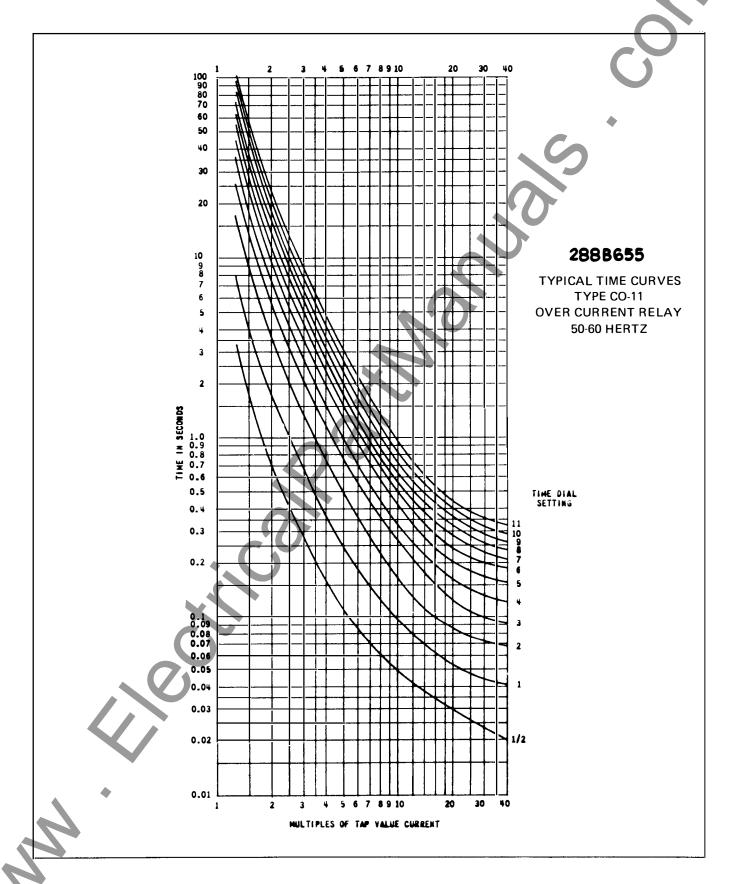


Fig. 16. Typical Time Curve of the Time-Overcurrent Unit of the Extremely Inverse (11) Relays.

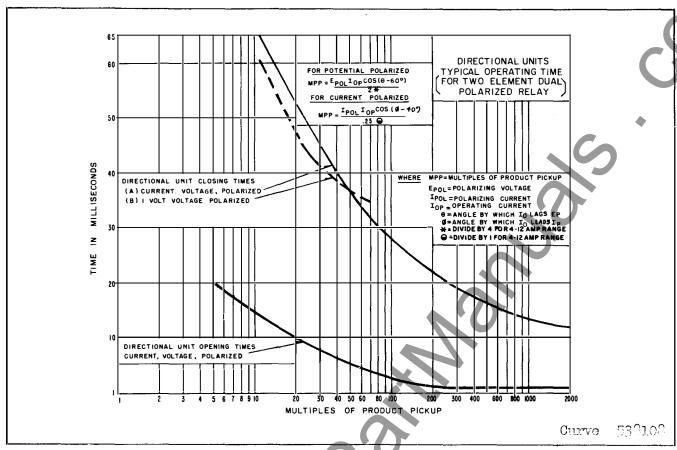


Fig. 17. Typical Operating Times For The Directional Unit.

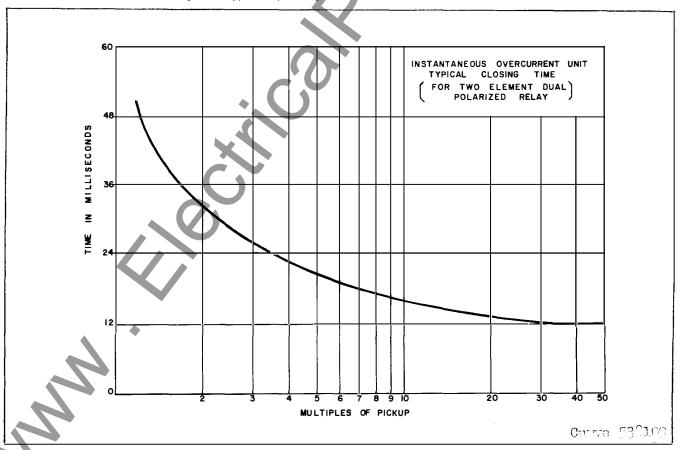


Fig. 18. Typical Operating Times For The Instantaneous Overcurrent Unit.

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° .

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° .

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 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.

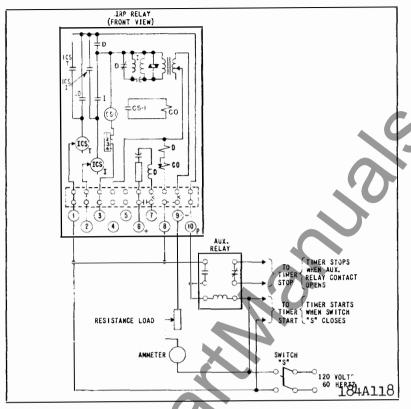
The pick-up of the overcurrent unit can be checked by inserting the tap screw in the desired tap hole and applying rated tap value current. The contact should close within $\pm\,5\%$ of tap value current.

Directional Unit (D)

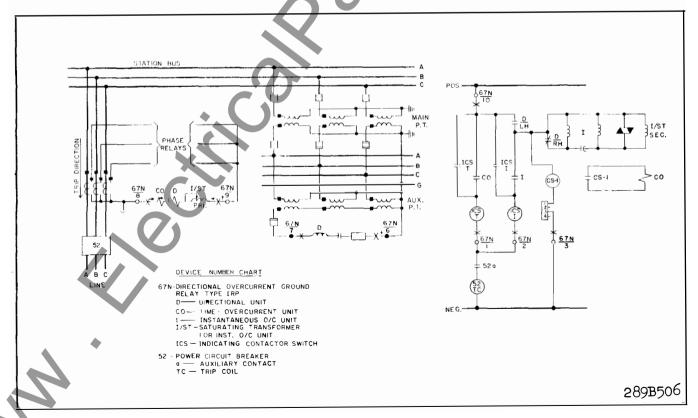
- 1. Contact Gap The gap between the stationary contact and moving contact with the relay in the deenergized position should be approximately .020".
- 2. <u>Sensitivity</u> The respective directional units should trip with value of energization and phase angle relationship as indicated in Table 1.
- 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)

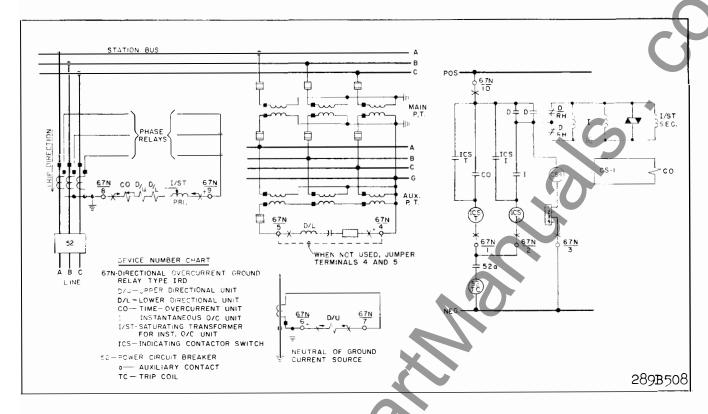
- 1. Contacts The index mark on the movement frame will coincide with the "O" mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right 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. <u>Minimum Trip Current</u> Set the time dial to position 6 with the auxiliary switch (CS-1) contacts



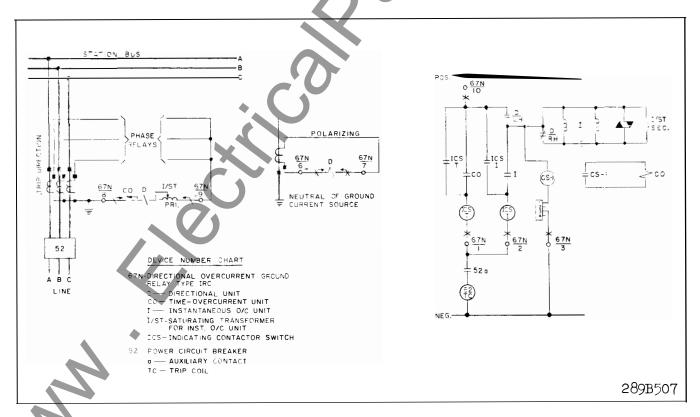
* Fig. 19. Diagram of test connections of the time-overcurrent unit.



* 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

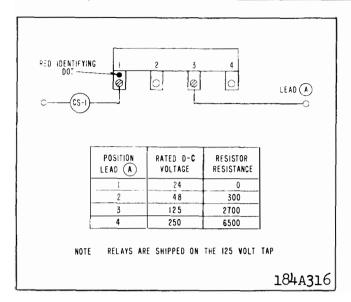


Fig. 23. Selection of Proper Voltage Tap for Auxiliary Switch (CS-1) Operation.

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	CHONAL UNIT	3LINSI II VIII I	
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-phasæ with V
Unit)	4.10	1	4.0	llagging V by 60° ††
	4-12	1	8.0	I in-phase with V
*	.5-2.5		0.5	I_{O} leading I_{p} by 40° ††
IRC IRD (Current \triangle	2-6		. 57	In-phase
Unit)	4-12		1.0	I_0 leading I_p by 40° ††
			1.3	In-phase

[†] The energization quantities are input quantities at the relay terminals.

t Maximum torque angle.

[△] 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.

[†] Short circuit the voltage polarizing circuit at the relay terminals before making the above adjustment.

TABLE III

TIME CURVE CALIBRATION DATA - 60 HERTZ

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				

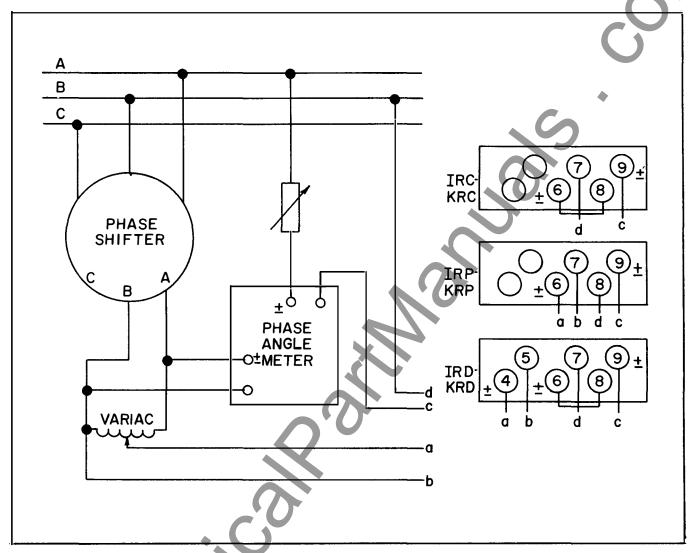


Fig. 24. Test Connections

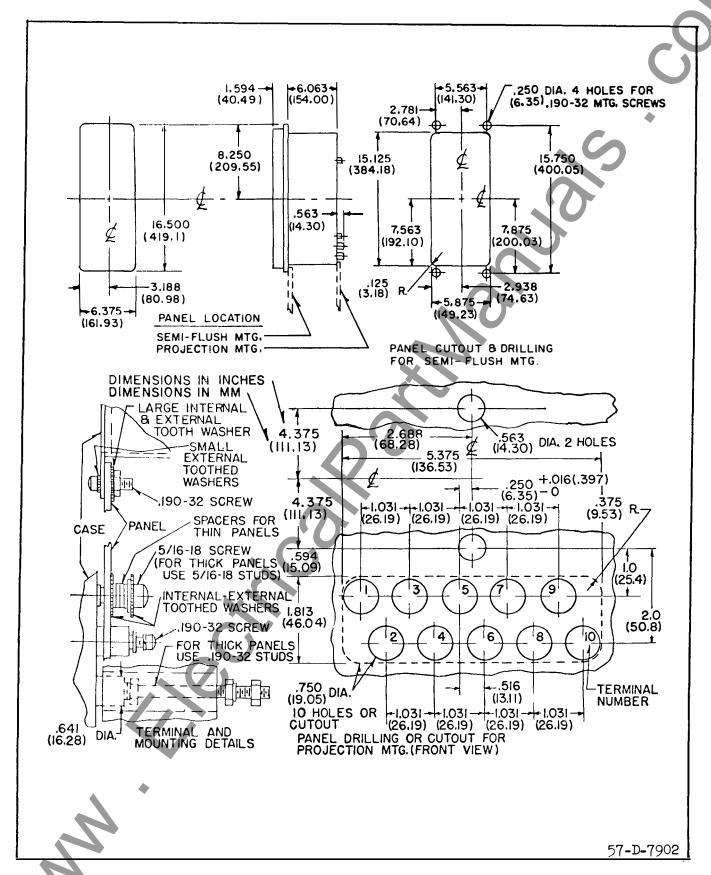


Fig. 25. Outline and Drilling Plan for the IRP and IRC Relays in the Type FT31 Case.

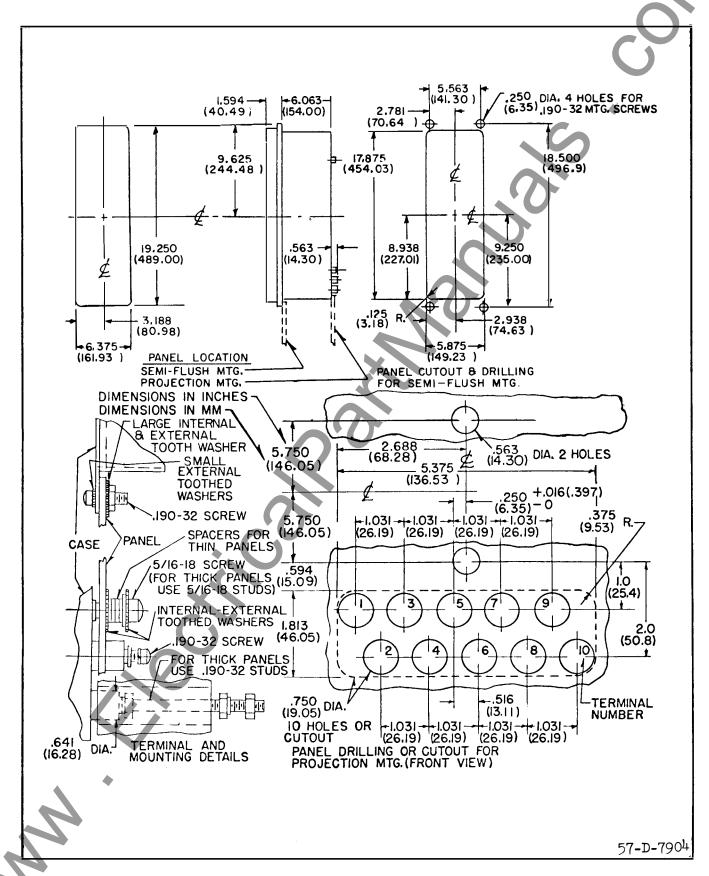


Fig. 26. Outline and Drilling Plan for the IRD Relay in the Type FT41 Case.



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

Printed in U.S.A.

WASIEK CUPY

RETURN TO FILE





914500

TYPE IRD RELAYS WITH 1 AMP ICS UNIT

This information is supplementary to Instruction Leaflet 41-133 and applies to the IRD line of relays with a 1 amp. dc ICS unit. Instruction Leaflet 41-133 will apply with the following exceptions:

The 0.2/2 amp. ICS of InstructionLeaflet 41-133 is omitted and a 1 amp. ICS unit is used in its place. This unit is similar in construction to the 0.2/2.0 ampere ICS except that the main coil is not tapped.

TRIP CIRCUIT CONSTANTS

1 amp. ICS

0.1 Ohms dc resistance

THERMAL CAPACITY

Ampere 1 second 140 Rating (Coil) continuous 5.0

The contact gap of the 1.0 amp. ICS should be 5/64 inch. Pick-up current of the device should not be less than 1.0 amp. dc nor greater than 1.2 amp. dc

These instructions apply to the following schematic: 185A358.

Attachments:

Instruction Leaflet Schematic Diagram

41-133 185A358

Westinghouse Electric Corporation
Relay-instrument Division
Newerk, N. J.

914500 12/76 MAN CORE



INSTALLATION . OPERATION . MAINTENANCE

INSTRUCTIONS

TYPE IRV DIRECTIONAL OVERCURRENT RELAY

FOR PHASE PROTECTION

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 phase 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.

CONSTRUCTION AND OPERATION

The Type IRV relay consists of a directional unit (D), an auxiliary switch (CS-1), a time-overcurrent unit (CO), 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 and 2.

Time-Overcurrent Unit (CO)

The electromagnets for the types CO-5, CO-6, CO-7, CO-8 and CO-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 causes a contact closing torque.

The electromagnet for the type CO-2 and CO-11 units have 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 pick-up 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 spring and snap ring. This is an adjustable core which has a .025 inch flat on one side and is held in its adjusted position by the clamping action of two compressed springs. The bearing can be replaced, if necessary, without having to remove the magnetic core from the frame.

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

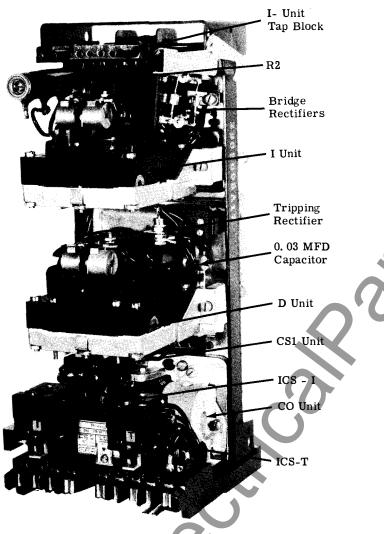


Fig. 1. Type IRV Relay Without Case (Front View).

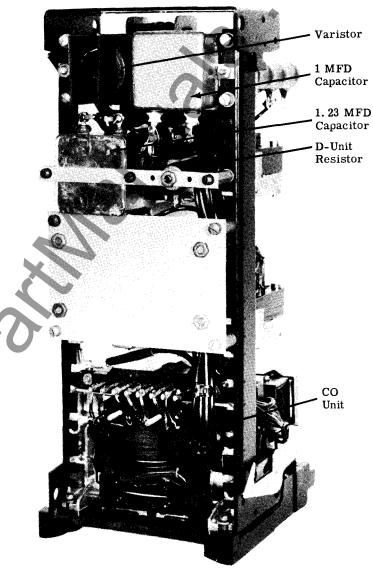


Fig. 2. Type IRV Relay Without Case (Rear View).

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

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.

Instantaneous Overcurrent Unit Transformer (I/ST)

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 pick-up 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.

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 48, 125 or 250 volt d.c. system connected per Fig. 13. The operation of the CS-1 switch is controlled by the directional unit (D) which in turn directionally controls the time-overcurrent unit (CO) as shown in Fig. 15. 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.

Another contact of CS-1 seals in its coil through the break contact of the I unit, in order to relieve the make contact of D from carrying the CS-1 coil current. The break contact of D breaks this seal by short circuiting the CS-1 coil. The break contact of the I unit also breaks the seal of the CS-1 coil to prevent tripping on reversed faults where the directional unit was preclosed on load current.

Instantaneous-Unit Torque Control

When the make contact of D closes, it permits the I unit to operate. It connects capacitor C3 and one pair of I-unit coils across the output voltage of the saturating transformer I/ST. The full-wave bridge in this connection and the rectifier in series with the D contact serve to isolate the a-c and d-c circuits.

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:

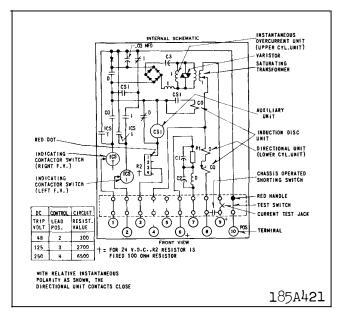


Fig. 3. Internal Schematic of the Type IRV Relay in the Type FT31 Case.

Instantaneous Overcurrent Unit (I)

Range			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

			Taps	
0.5	0.6	8.0	1.0 1.5 2.0	2.5
2	2.5	3	3.5 4 5	6
4	5	6	7 8 10	12
	0.5 2 4	2 2.5	2 2.5 3	0.5 0.6 0.8 1.0 1.5 2.0 2 2.5 3 3.5 4 5

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. 4 to 10. 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.

The time vs. current characteristics for the instantaneous overcurrent unit is shown in Fig. 11.

The time vs. current characteristics for the directional unit is shown in Fig. 12.

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.

Cylinder Unit Contacts

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

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

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 operating time is approximately 5 milliseconds.

48-250 volt d-c relay d-c resistance - 1165 ohms

24 volt d-c relay

d-c resistance — $110 \ \text{ohms}$ (note that series resistor is a fixed $100 \ \text{ohm}$ resistor).

Directional Unit

The IRV relay is intended for phase fault protection and the directional unit has its maximum torque when the current leads the voltage by approximately 30°. The directional unit minimum pickup is 1.2 volts and 4 amperes at its maximum torque angle for the 4 to 12 ampere range relays and 1.2 volts and 2 amperes for the 0.5 to 2.5 ampere and the 2 to 6 ampere range relays.

The directional unit should be connected using the current in one-phase wire and the potential across the other two phase wires. This connection is commonly referred to as the 90 °connection. When utilizing the 90 ° connection the maximum torque of the relay occurs when the fault current lags its 100% P.F. position by approximately 60°. See Fig. 15.

ENERGY REQUIREMENTS

INSTANTANEOUS OVERCURRENT UNIT OPERATING CURRENT CIRCUIT ~ 60 CYCLES

AMPERE RANGE TAP VAAT TAP VALUE P.F. ANGLE VAAT 5 AMPS. P.F. ANGLE 1.5						
.5-2	AMPERE RANGE	TAP	VA AT TAP VALUE	φ P.F. ANGLE	VA AT 5 AMPS.	P.F. ANGLE
1.5-2		.5	.37	39	24	46
1.5		.75	.38	36	13	37
1.5		1	.39	35	8.5	34
1	.5-2	1.25	.41			
1		1.5	.43	32	4.6	31
1.5			.45	30	2.9	28
1.5		1	41	26	9.0	26
1-4						
1-4 2.5 5.50 28 2.1 27 27 24 2.5 26 1.5 26 24 2.5 24 2.5 24 2.5 24 2.5 24 2.5 24 2.5 24 2.5		1				
3 3 5.53 26 1.5 26 24 0.93 24	1-4					
4 .59 24 0.93 24		1	1			
2-8 3		1	1			
2-8 3		i .	1,,	40		40
2-8						
2-8		1				
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 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 40 4.9 11 0.08 12 20 6.6 31 0.40 31 20 6.6 31 0.40 31 20 4.8 13.5 18 0.14 18 60 15.9 16 0.10 16 80 19.2 15 0.07 15 RANGE CONTINUOUS RATING (AMPERES) .5-2 5 100 1-4 8 140 2-8 8 8 140 4-16 10 200 10-40 10 200	2-8	1	ł			
8			1			
4		l .	l			
4-16		8	1.8	29	0.7	29
4-16		4	1.5	51	2.4	51
9		6	1.7	45	1.2	45
12	4-16	8	1.8	40	0.7	40
16		9	1.9		0.6	38
10		12	2.2		0.37	34
10-40 15 20 3.1 16 0.20 17 17 24 3.6 15 30 4.2 12 0.11 13 40 4.9 11 0.08 12 20-80 6.6 31 0.40 31 30 9.3 24 0.25 24 48 13.5 18 0.14 18 60 15.9 16 0.10 16 80 19.2 15 00E SECOND RATING (AMPERES) 100 1-4 8 140 1-4 8 140 1-4 8 140 1-4 16 10 200 10-40 10 200		16	2.5	30	0.24	31
10-40 15 20 3.1 16 0.20 17 17 24 3.6 15 30 4.2 12 0.11 13 40 4.9 11 0.08 12 20-80 6.6 31 0.40 31 30 9.3 24 0.25 24 48 13.5 18 0.14 18 60 15.9 16 0.10 16 80 19.2 15 00E SECOND RATING (AMPERES) 100 1-4 8 140 1-4 8 140 1-4 8 140 1-4 16 10 200 10-40 10 200		10	1.7	28	0.43	28
10-40		i .				
10-40 24 3.6 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 48 13.5 18 0.14 18 60 15.9 16 0.10 16 80 19.2 15 CONTINUOUS RATING (AMPERES) 100 1-4 8 8 140 2-8 8 140 4-16 10 200 10-40 10 200		l l				
30	10-40					
20 6.6 31 0.40 31 30 9.3 24 0.25 24 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 RATING (AMPERES)						
20-80 30		1				
20-80 30		00		21	0.40	21
20-80		1				
20-80 48 13.5 18 0.14 18 60 15.9 16 0.07 15 RANGE CONTINUOUS RATING (AMPERES) .5-2 5 100 1-4 8 140 2-8 8 140 4-16 10 200 10-40 10 200		1				
RANGE CONTINUOUS RATING (AMPERES)	20-80	T				
RANGE CONTINUOUS RATING (AMPERES) -5-2 -5 -100 -1-4 -8 -8 -8 -8 -140 -4-16 -10 -10-40 -10 -200 -10-40 -15 -15 -15 -15 -15 -100 -140 -15 -15 -100 -100 -100 -100 -100 -100						
RANGE CONTINUOUS RATING (AMPERES) .5-2						
(AMPERES) † (AMPERES) .5-2 5 100 1-4 8 140 2-8 8 140 4-16 10 200 10-40 10 200		30		10	0.01	10
(AMPERES) † (AMPERES) .5-2 5 100 1-4 8 140 2-8 8 140 4-16 10 200 10-40 10 200	RANGE		CONTINUOUS RATIN	1G	ONE SECOND RA	ATING
.5-2 5 100 .1-4 8 140 2-8 8 140 4-16 10 200 10-40 10 200	Tunide			••		
1-4 8 140 2-8 8 140 4-16 10 200 10-40 10 200						
2-8 8 140 4-16 10 200 10-40 10 200	. 5-2		5		100	
4-16 10 200 10-40 10 200	1-4		8		140	
10-40 10 200	2-8		8		140	
10-40 10 200	4-16		10		200	
			10		200	
10 200	20-80		10		200	
	20 00		10			

[†] 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.

^{† †} Voltages taken with Rectox type voltmeter.

ENERGY REQUIREMENTS

TYPE IRV-2 TIME OVERCURRENT UNITS

VOLT AMPERES † †

AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING† (AMPERES)	POWER FACTOR ANGLE ϕ	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
	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	5.35	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

IRV-5, TIME OVERCURRENT UNITS

VOLT AMPERES † †

						VOLT A	AMPERESTT	
AMPERE		CONTINUOUS RATING	ONE SECOND	POWER FACTOR	AT TAP VALUE	AT 3 TIMES TAP VALUE	AT 10 TIMES TAP VALUE	AT 20 TIMES TAP VALUE
RANGE	TAP	(AMPERES)	(AMPERES)	ANGLE ϕ	CURRENT	CURRENT	CURRENT	CURRENT
	(0.5	2.7	88	69	3.92 3.96	20.6	103 106	270 288
	(0.8	3.7	88	67	3.96	21	114	325
0.5/2.5	(1.0	4.1	88	66	4.07	21.4	122	360
0.0, 2.0	(1.5	5.7	88	62	4.19	23.2	147	462
	(2.0	6.8	88	60	4.30	24.9	168	548
	(2.5	7.7	88	58	4.37	26.2	180	630
	(2.0	1.1		00		20.2	100	000
	(2	8	230	67	3.88	21	110	308
	(2.5	8.8	230	66	3.87	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	4.08	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	4.27	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

[†] 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.

^{† †} Voltages taken with Rectox type voltmeter.

ENERGY REQUIREMENTS

IRV-7 TIME OVERCURRENT UNITS

						VOLT (AMPERES† †	
AMPERE		CONTINUOUS	ONE SECOND	POWER	AT	AT 3 TIMES	AT 10 TIMES	AT 20 TIMES
		RATING	RATING †	FACTOR	TAP VALUE	TAP VALUE	TAP VALUE	TAP VALUE
RANGE	TAP	(AMPERES)	(AMPERES)	ANGLE ϕ	CURRENT	CURRENT	CURRENT	CURRENT
	(0.5	2.7	88	68	3.88	20.7	103	278
	(0.6	3.1	88	67	3.93	20.9	107	288
	(0.8	3.7	88	66	3.93	21.1	114	320
0.5/2.5	(1.0	4.1	88	64	4.00	21.6	122	356
	(1.5	5.7	88	61	4.08	22.9	148	459
	(2. 0	6.8	88	58	4.24	24.8	174	552
	(2.5	7.7	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
	(12	20	400	70	5.10	31.3	308	1032

IRV-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 ϕ	CURRENT	CURRENT	CURRENT	CURRENT
			- 7//					
	(0.5	2.7	88	72	2.38	21	132	350
	(0.6	3.1	88 88	71	2.38	21	134	365
	(0.8	3.7	88	69	2.40	21.1	142	400
0.5/2.5	(1.0	4.1	88	67	2.42	21.2	150	440
	(1.5	5.7	88	62	2.51	22	170	530
	(2.0	6.8	88	57	2.65	23.5	200	675
	(2.5	7.7	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
	7	*						
	(4	16	460	68	2.38	21.3	146	420
	(5	18.8	460	63	2.46	21.8	158	480
Ì	(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

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.

[†] Voltages taken with Rectox type voltmeter.

ENERGY REQUIREMENTS

IRV-11 OVERCURRENT UNITS

						volt amperes† †				
AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING † (AMPERES)	POWER FACTOR ANGLE ϕ	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE 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	3.5	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		

[†] 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.

ENERGY REQUIREMENTS - 60 CYCLES

DIRECTIONAL UNIT OPERATING CIRCUIT BURDEN

VOLT AMPERES † †

Range Amps	Continuous Rating (Amperes)	One Second Rating † (Amperes)	Power Factor Angle ϕ	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	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		0.48	4.62	53.6	216.0

^{\$\}phi\$ Degrees current lags voltage at tap value current.

DIRECTIONAL UNIT POLARIZING CIRCUIT BURDEN

The burden at 120V, 60 cycles, is 12.5 volt-amperes at 15 degrees. (current leading voltage).

φ Degrees current lags voltage at tap value current.

^{† †} Voltages taken with Rectox type voltmeter.

[†] 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.

^{††} Voltages taken with Rectox type voltmeter.

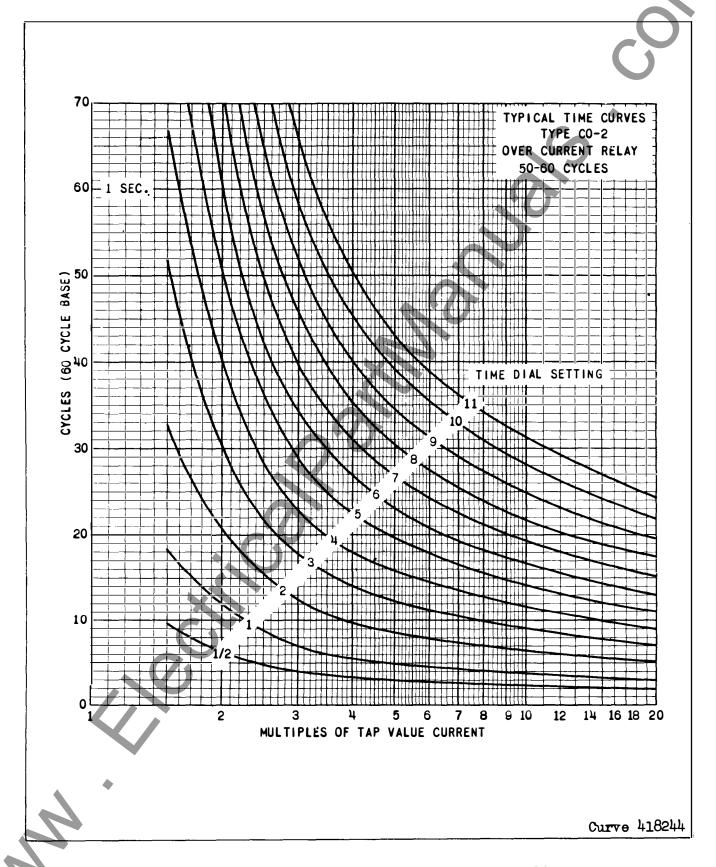


Fig. 4. Typical Time Curves of the Time-Overcurrent Unit of the Short Time (2) Relays.

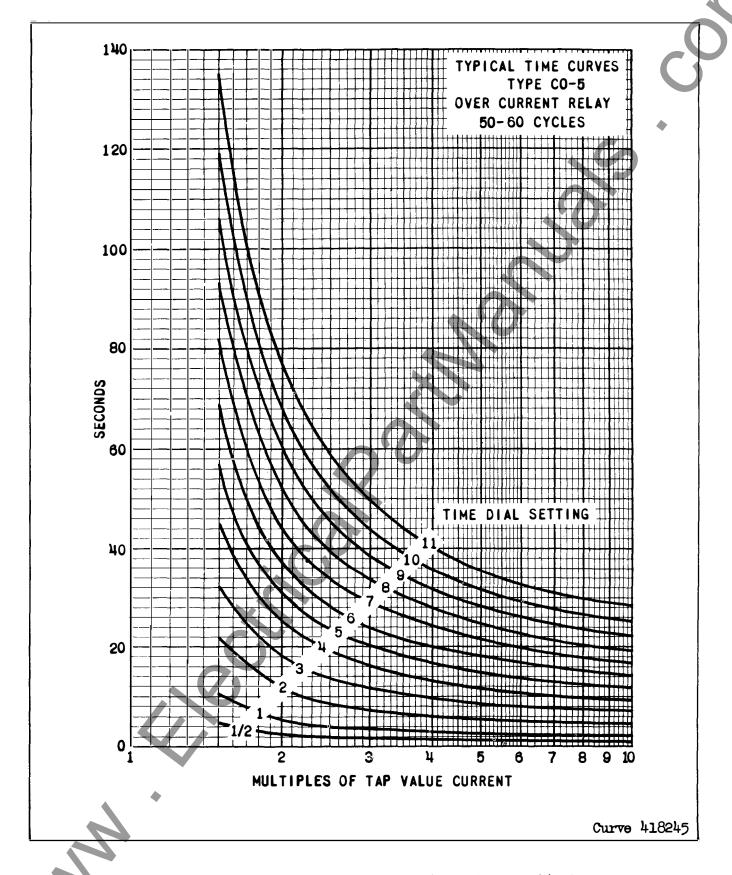


Fig. 5. Typical Time Curve of the Time-Overcurrent Unit of the Long Time (5) Relays.

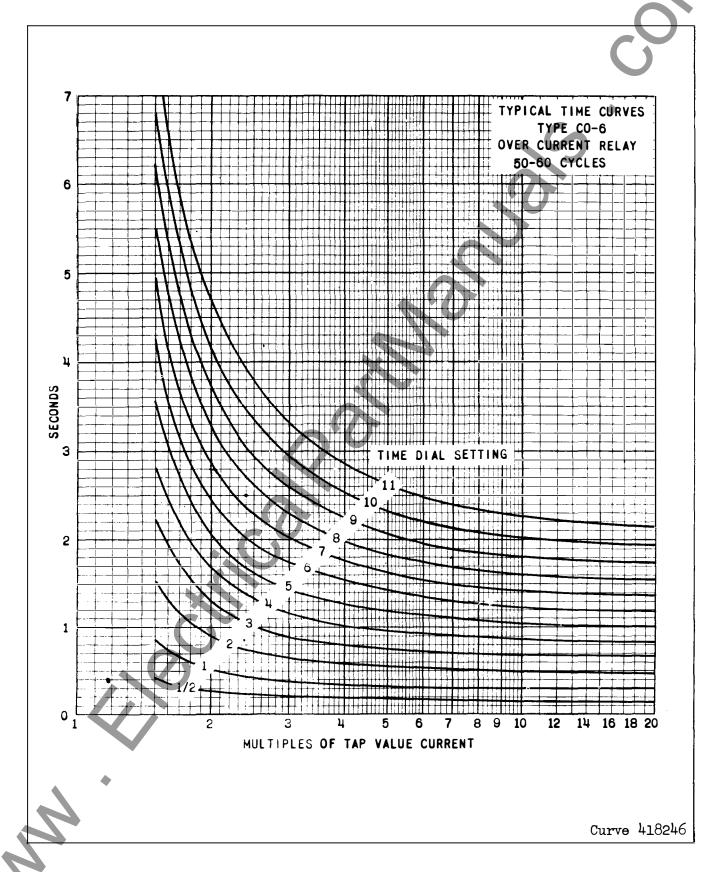


Fig. 6. Typical Time Curve of the Time-Overcurrent Unit of the Definite Time (6) Relays.

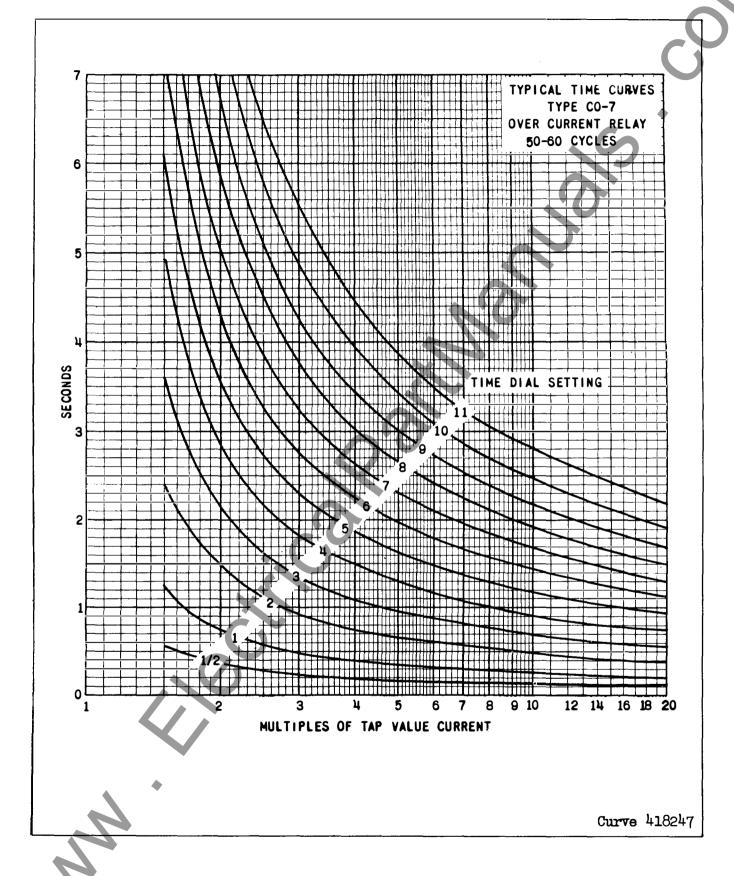


Fig. 7. Typical Time Curve of the Time-Overcurrent Unit of the Moderately Inverse (7) Relays.

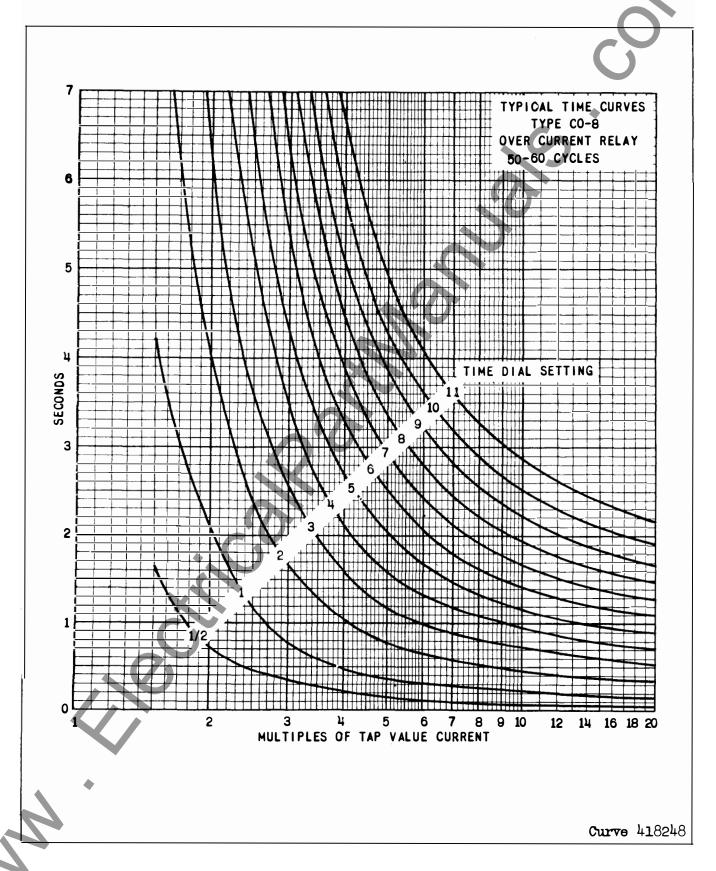


Fig. 8. Typical Time Curve of the Time-Overcurrent Unit of the Inverse (8) Relays.

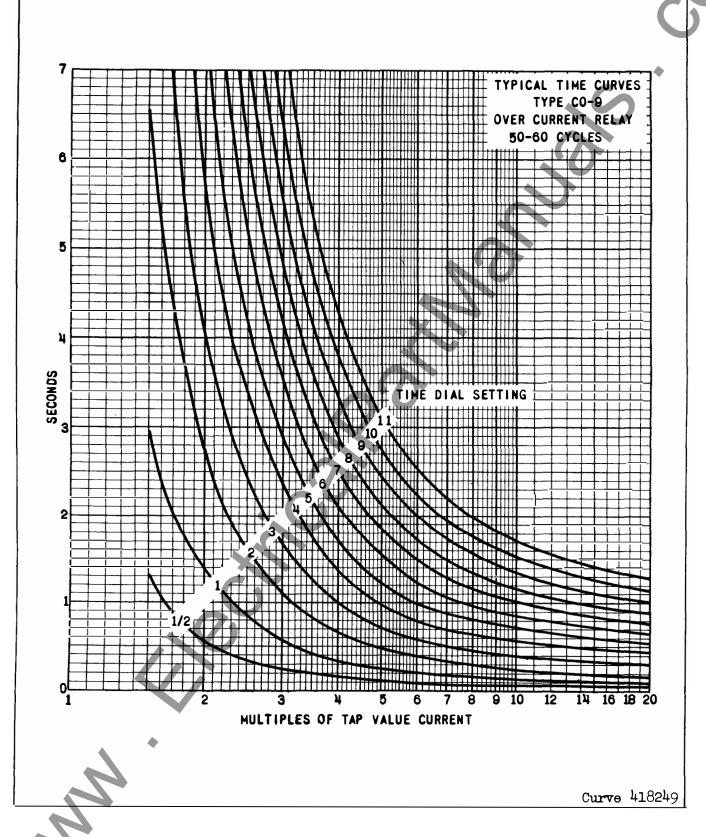


Fig. 9. Typical Time Curve of the Time-Overcurrent Unit of the Very Inverse (9) Relays.

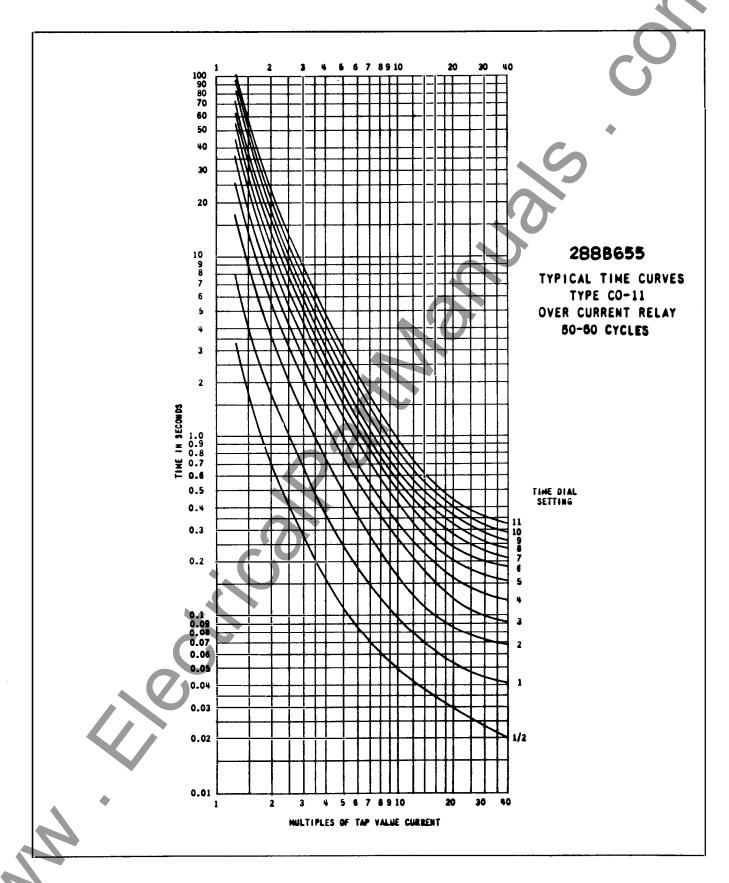


Fig. 10. Typical Time Curve of the Time-Overcurrent Unit of the Extremely Inverse (11) Relays.

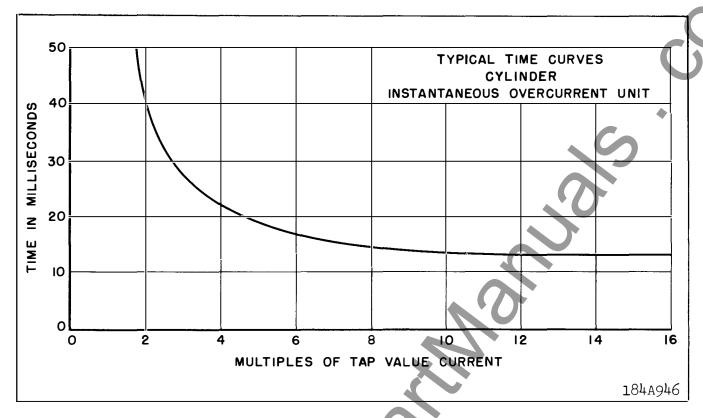


Fig. 11. Typical Time Curve of the Instantaneous Overcurrent Unit.

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 terminal plate holes, the relay will respond to multiples of tap value currents in accordance with the various typical time-current curves.

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 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 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 re-

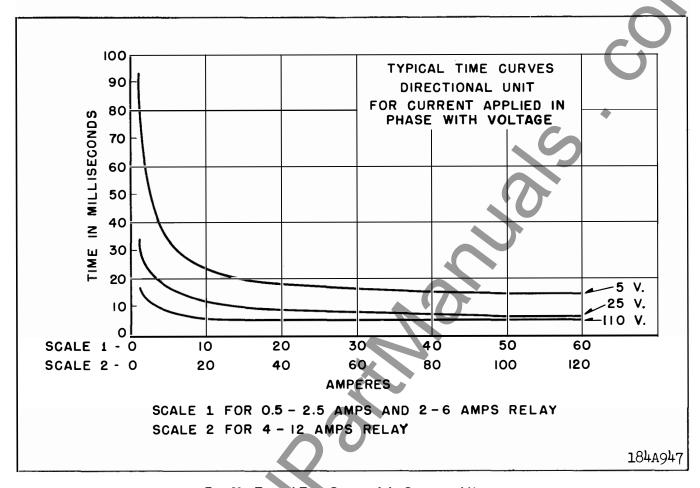


Fig. 12. Typical Time Curves of the Directional Unit.

moving 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 only 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 48, 125 or 250 voltage on the tapped resistor. This connection can be made by referring to Fig. 13.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt,

moisture, excessive vibration and heat Mount the relay vertically by means of the two mounting studs for projection mounting or by means of the four mounting holes on the flange for the semi-flush mounting. Either of the studs or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel panel mounting or to terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the studs and then turning the proper nut with a wrench.

For detail information on the FT Case refer to I.L. 41-076.

The external connection of the directional overcurrent relays is shown in Fig. 15.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory. Upon

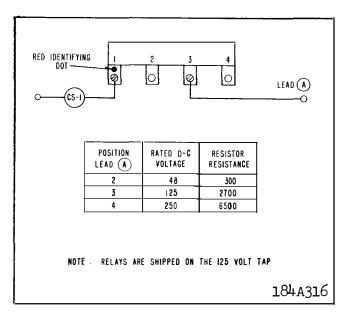


Fig. 13. Selection of Proper Voltage Tap for Auxiliary Switch (CS-1) Operation.

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 deenergized position should be approximately .020".
- 2. Minimum Trip Current The D contacts should be blocked closed 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 ± 5% of tap value current.

Directional Unit (D)

- 1. Contact Gap The gap between the stationary contact and moving contact with the relay in the de-energized position should be approximately .020".
- 2. Sensitivity The directional unit should trip with 1.2 volts and 4 amperes at its maximum torque angle (current leading the voltage by 30°) for the 4 to 12 ampere range relays and 1.2 volts and 2 amperes for the 0.5 to 2.5 ampere and the 2 to 6 ampere range relays.

3. Spurious Torque Adjustments — There should be no spurious closing torques when the operating circuits are energized per Table 2 with the polarizing circuit short circuited.

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 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 1 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 1 (e.g. for the IRV-2 3 and 20 times tap value current) And measure the operating time of the relay. The operating times should equal those of Table 1 plus or minus 5 percent,

For type IRV-11 relay only, the 1.30 times tap value operating time from the number 6 time dial position is 54.9±5% seconds. It is important that the 1.30 times tap value current be maintained accurately. The maintaining of this current accurately is necessary because of the steepness of the slope of the time-current characteristic (Fig. 19). A 1% variation in the 1.30 times tap value current (including measuring instrument deviation) will change the nominal operating time by approximately 4%.

Indicating Contactor Switches (ICS/1) and (ICS/T)

- A) Close the contacts of the CO and the directional unit (D) 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 suf-

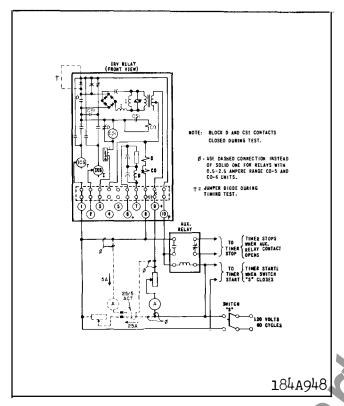


Fig. 14. Diagram of test connections of the time-overcurrent unit.

ficient 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 yiew.

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 and checked periodically to assure proper operation. Generally a visual inspection should call attention to any noticeable changes. A minimum suggested check on the relay system is to close the contacts manually to assure that the breaker trips and the target drops. Then release the contacts and observe that the reset is smooth and positive.

If an additional time check is desired, pass secondary current through the relay and check the time of operation. It is preferable to make this at several

times pick-up current at an expected operating point for the particular application. For the .5 to 2.5 ampere range CO-5 and CO-6 induction unit use the alternative test circuit in Fig. 16 as these relays are affected by a distorted wave form. With this connection the 25/5 ampere current transformers should be worked well below the knee of the saturation (i.e. use 10L50 or better).

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 postion 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 close the con-

tacts of the D unit. Insert the tap screw in the minimum value tap setting and adjust the spring such that the contacts will close as indicated by a neon lamp in the contact circuit when energized with the required current. The pickup of the overcurrent unit with the tap screw is 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)

The directional unit is the lower cylinder unit.

- 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 2/3 of one turn for a contact gap of .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. 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 contact will close as indicated by a neon lamp in the contact circuit when energized with 1.2 volts and 4 amps (current leading 30°) for the 4 to 12 ampere range relays and 1.2 volts and 2 amps for the 0.5 to 2.5 and 2 to 6 ampere range relays. This can be done approximately using current in phase with voltage by increasing the pickup current to 4.6 and 2.3 amperes

respectively.

4. The magnetic plugs and core 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 and core in the following manner:

Short circuit the voltage terminals and apply current to the operating circuit terminals as per Table 2.

Plug and core 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 core assembly is held in position by the clamping action of two compressed springs. This allows its position to be changed by inserting a non-magnetic tool into the slot on the bottom side of the unit.

The magnetic plug and core 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

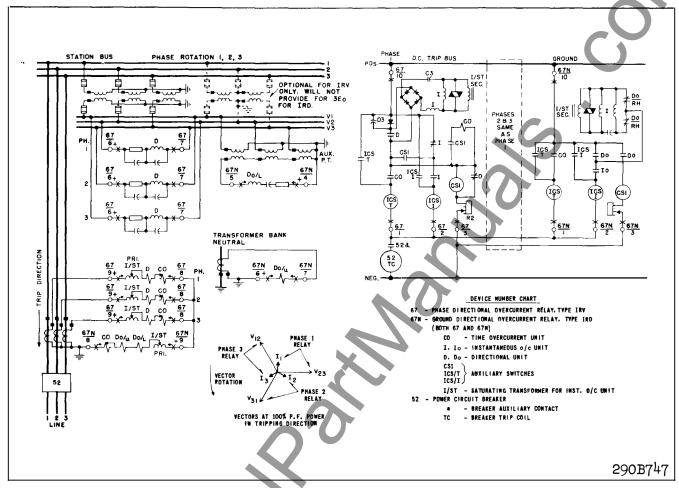


Fig. 15. External Schematic of the IRV Relay for Phase Protection and the IRD Relay for Ground Protection.

value current -1.0%.

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

Apply the indicated current per Table 1 for permanent magnet adjustment (e.g. IRV-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 1.

For type IRV-11 relay only, the 1.30 times tap value operating time from the number 6 time dial position is $54.9\pm5\%$ seconds. It is important that the 1.30 times tap value current be maintained accurately. The maintaining of this current accurately is necessary because of the steepness of the slope of the time-current characteristic (Fig. 19). A 1% variation in the 1.30 times tap value current (including measuring instrument deviation) will change the nominal operating time by approximately 4% if the operating

time at 1.3 times tap value is not within these limits, a minor adjustment of the control spring will give the correct operating time without any undue effect on the on the minimum pick-up of the relay. This check is to be made after the 2 times tap value adjustment has been completed.

Apply the indicated current per Table 1 for the electromagnet plug adjustment (e.g. IRV-8, 20 times tap value) and measure the operating time. Adjust the proper plug until the operating time corresponds to the value in Table 1. (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 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 the directional unit 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 when 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. 13. 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
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

TABLE 2
DIRECTIONAL UNIT CALIBRATION +

Relay Rating	Current	Adjust	Adjustment
.5 to 2.5 Amp and 2-6 amps.	25 Amp	Core ††	Rotate core by means of adjuster located on bottom side of cylinder unit. Adjust core so that a slight contact opening torque is made. Recheck at
4-12 amps	50 amps		15 and 5 amps. to see there is no closing torque for the lower range units and 30 amps and 10 amps for the 4-12 amp range relays.
.5 to 2.5 amps and 2-6 amps	50 amps	Magnetic Plugs	If spurious torque is in the contact closing direction (left front view) screw out right magnetic plug until direction of spurious torque is reversed. If spurious torque is in the contact opening direction, screw out left plug until spurious
4-12	100 amps		out left plug until spurious torque is slight contact opening. Recheck at 40, 25 and 10 amps for the lower range units and 80, 50 and 20 amps for the 4-12 amp range relays.

[†] Short circuit the voltage polarizing circuit at the relay terminals before making the above adjustments. †† Plugs should be at fully in position prior to adjustment of core.

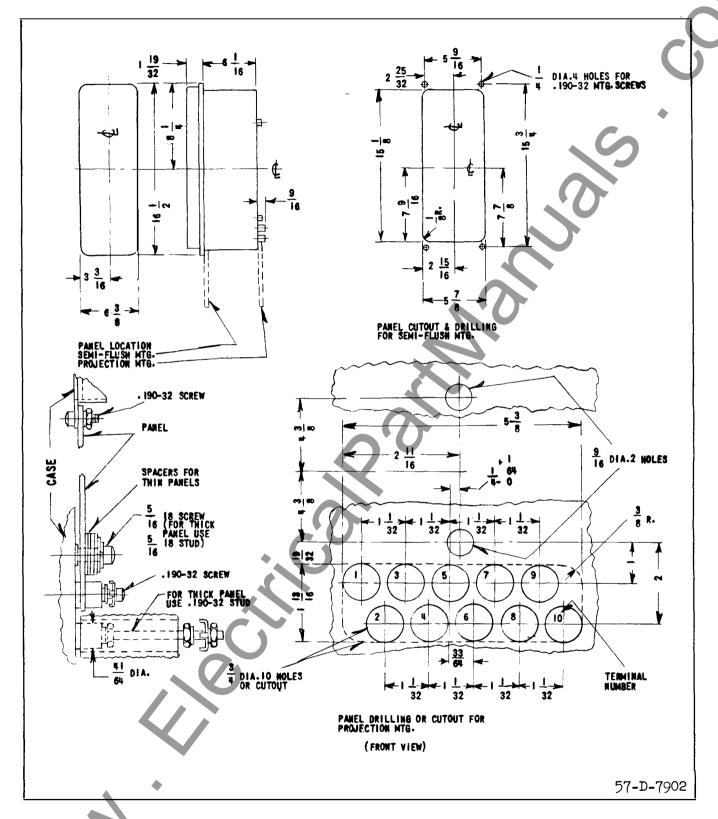


Fig. 16. Outline and Drilling Plan for the Type IRV Relay in the Type FT31 Case.

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



INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE IRQ DIRECTIONAL OVERCURRENT NEGATIVE SEQUENCE RELAY FOR GROUND PROTECTION

CAUTION Before putting the relay into service, remove blocking from all the moving parts. Inspect the relay and operate all elements by hand to be sure no damage has occured during shipment.

APPLICATION

The type IRQ is a directional overcurrent ground relay in which the directional unit operates on negative sequence current and voltage, and the overcurrent units operates on residual or ground current. The negative sequence current and voltage are obtained by means of self-contained negative sequence filters connected between the directional unit and the current and potential transformers.

The relay is intended for use at locations where the present equipment or system conditions do not permit the use of the conventional types of directional ground relays operating entirely on residual current and voltage.

At an ungrounded substation on grounded systems where only two potential transformers are available, or where the potential transformers are on the low-tension side of a wye-delta or delta-wye power transformer bank, the type IRQ relay is applicable for ground protection.

CONSTRUCTION AND OPERATION

The type IRQ relay consists of a directional cylinder unit (D) operating on negative sequence quantities, negative sequence current and voltage filters an auxiliary switch (CS-1), a time-overcurrent unit (CO), an instantaneous overcurrent unit (I), and two indicating contactor switches (ICS/I) and (ICS/T). The principle component parts of the relays and their location are shown in Figs. 1 and 2.

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 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.

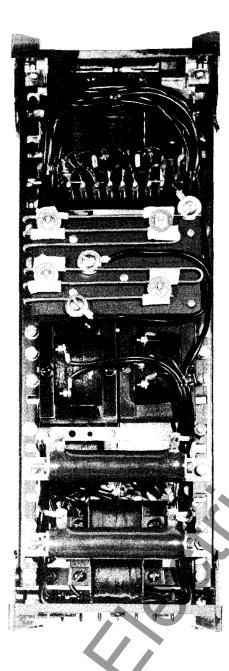


Fig. 1. Type IRQ Relay without Case (Rear View)

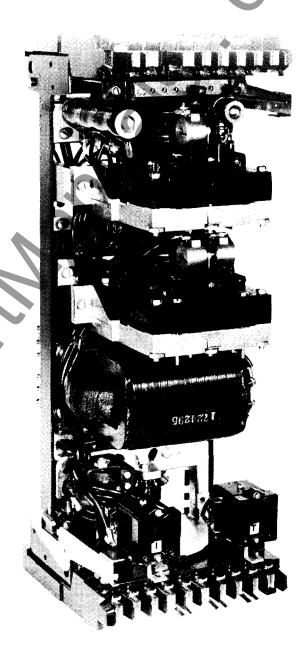


Fig. 2. Type IRQ Relay without Case (Front View)

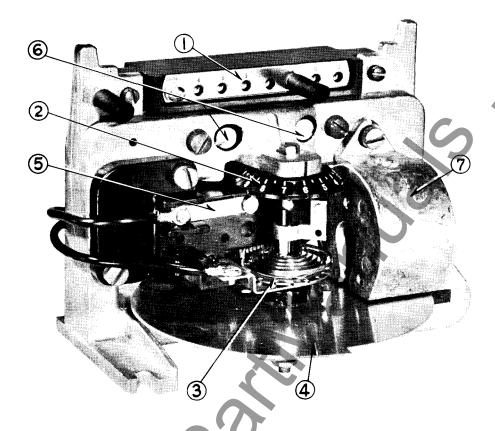


Fig. 3. Time Overcurrent Unit (Front View). 1-Tap Block, 2-Time Dial, 3-Control Spring Assembly, 4-Disc, 5-Stationary Contacts Assembly, 6-Magnetic Plugs, 7-Permanent Magnet

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.

Negative Sequence Filter

The current and voltage filters consist of reactors and resistors connected together as shown in the internal schematic (Fig. 4).

Time-Overcurrent Unit (CO)

The electromagnets for the types IRQ-5, IRQ-6, IRQ-7, IRQ-8 and IRQ-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 IRQ-2 and IRQ-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.

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. 14. 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.

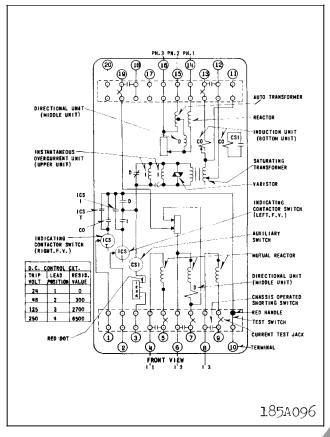


Fig. 4. Internal Schematic of the IRQ Relay.

Instantaneous Overcurrent Unit (I)

The instantaneous overcurrent unit consists of a induction cylinder type unit and a transformer. The induction cylinder 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; preventing 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.

The transformer is of the saturating type for limiting the energy to the instantaneous overcurrent unit at higher values of fault current and to reduce

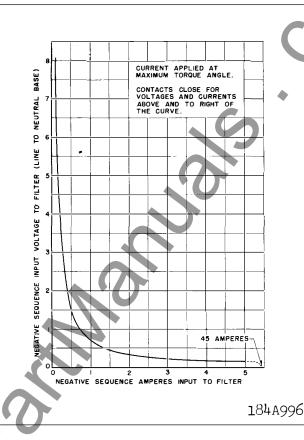


Fig. 5. Sensitivity Curve of the Directional Unit (D).

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 over-current 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.

Indicating Contactor Switch Unit (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.

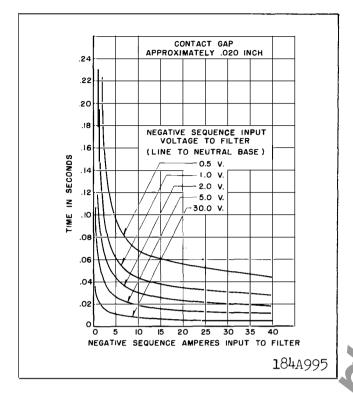


Fig. 6. Time Curve of the Directional Unit (D)

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

CHARACTERISTICS

The time characteristics of the time overcurrent relays are designated by specific numbers as indicated below (eg. IRQ-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:

Time Overcurrent Unit

Range	Taps						
.5-2.5 2-6 4-12	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

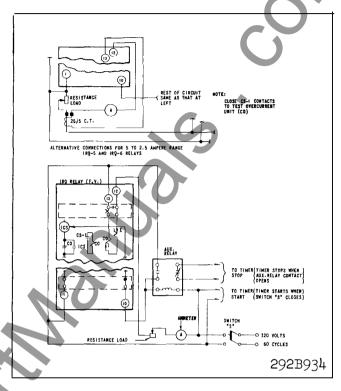


Fig. 7. Diagram of Test Connections for the Circuit Closing Time Overcurrent Unit of the IRQ Relay.

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	40	
20-80	20	30	40	48	60	80	

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. 15 to 21. 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.

The time vs. current characteristics for the instantaneous overcurrent unit is shown in Fig. 13.

The time vs. current characteristics for the directional unit is shown in Fig. 6.

Directional Unit (D)

The directional unit minimum pick-up is approximately 0.76 volt-ampers (e.g. 0.19 volt and 4 am-

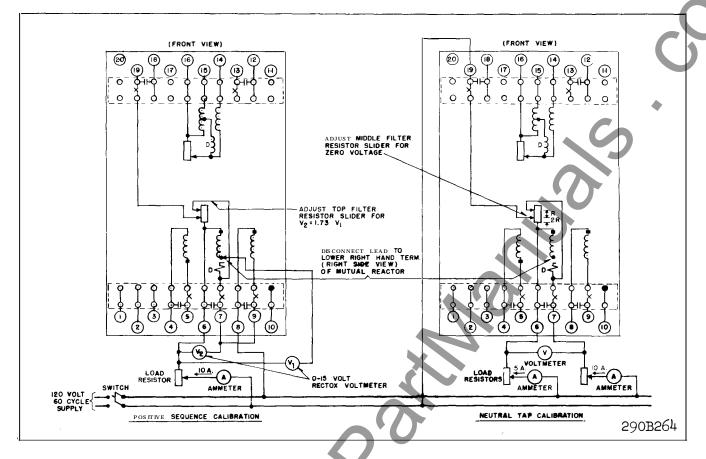


Fig. 8. Test Diagram for Calibration of the Negative Sequence Current Filter in the IRQ Relay.

peres) in terms of negative sequence quantities applied at the relay terminals at the maximum torque angle of approximately 980 (current leading voltage).

A typical sensitivity curve for the negative sequence directional unit is shown in Fig. 5.

The time vs current characteristic for the directional unit is shown in Fig. 6.

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.

Cylinder Unit Contacts

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

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

Trip Circuit Constants

Inidcating Contactor Switch -

0.2 ampere taps - 6.5 ohms d-c resistance

2.0 ampere taps - 0.15 ohms d.c resistance

The auxiliary switch operating time is approximately 5 milliseconds.

d.c resistance - 1165 ohms

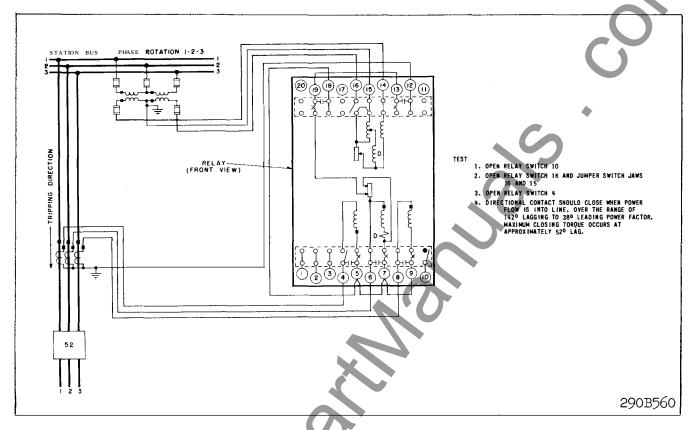


Fig. 9. In Service Test Procedure for Verifying Proper External Connections Where CT Neutral is Formed Within the Relay.

SETTINGS

Directional Unit (D)

No setting is required.

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 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 in 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 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.

$\underline{\textbf{Instantaneous Overcurrent Unit }(I)}$

The only setting required is the pickup current setting which is made by means of the connector screw located on the tap plate. By placing the con-

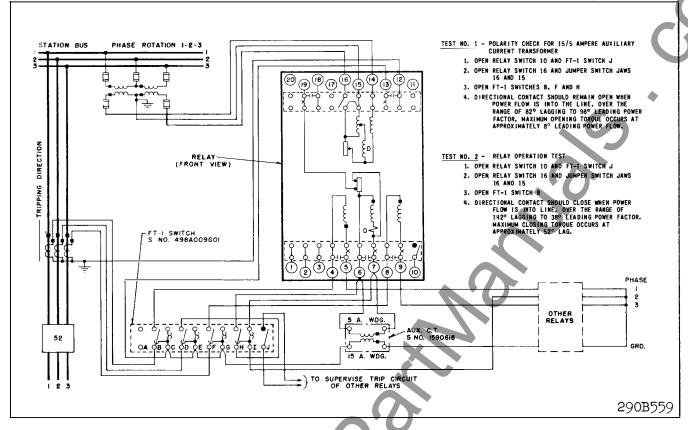


Fig. 10. In Service Test Procedure for Verifying Proper External Connections Where CT Neutral is Formed Externally.

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 position before removing the other tap screw from the original tap position.

Negative Sequence Filter

No setting is required.

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

The only 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)

The only setting required on the CS-1 unit is

the selection of the required 24, 48, 125 or 250 voltage on the tapped resistor. This connection can be made by referring to Fig. 14.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration and heat. Mount the relay vertically by means of the two mounting studs for the FT projection case or by means of the four mounting holes in the flange of the semiflush type FT case. Either of the studs or the mounting screws may be utilized for grounding the relay. The electrical connection may be made directly to the terminals by means of screws for steel panel mounting or to terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the studs and then turning the proper nut with a wrench.

For detailed FT case information, refer to I.L. 41-076.

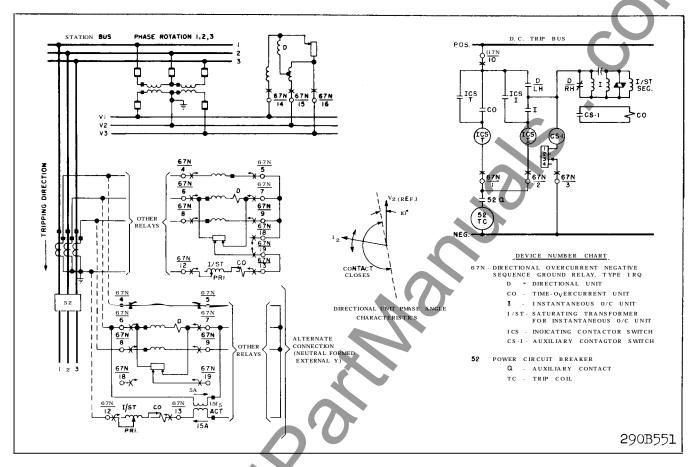


Fig. 11. External Schematic of IRQ Relay.

The external connections of the directional overcurrent relay are shown in Fig. 12.

ADJUSTMENT 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;

Negative Sequence Filter

The filters are adjusted for balance in the factory and no further adjustments or maintenances should be required. The nominal voltage and current output of the filters on positive sequence is approximately zero. This serves as a convenient check on the balance of the filters. If any two input leads to the potential

filter should be interchanged, a high voltage occurs across the output terminals of the filter. Similarly, if any two of the phase leads to the input terminals of the current filter are interchanged, an output current will be obtained.

Directional Unit (D)

- 1. Contact Gap The gap between the stationary contact and moving contact with the relay in the de-energized position should be approximately .020"
- 2. Sensitivity Refer to the test diagram in fig. 12. Apply a single-phase voltage V_{12} equal to 0.57 volts (corresponds to a negative-sequence input voltage of .19 volts) and a single-phase current equal to 6.93 amperes as shown (corresponds to a negative sequence input current of 4 amperes). With a phase angle meter connected as shown, rotate the phase shifter until the current leads the voltage by 188° . This corresponds to the negative sequence component of current leading the negative sequence component of voltage by 98° . The directional unit contact

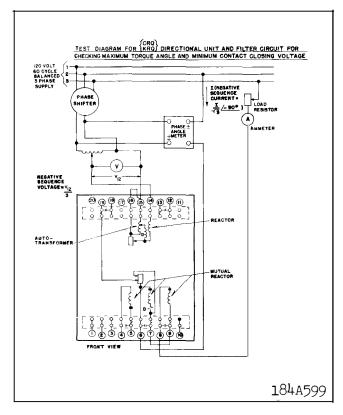


Fig. 12. Test Diagram for Checking Maximum Torque Angle and Minimum Voltage for Contact Closure of the Directional Unit.

should pick up within \pm 10% of the above input voltage to the relay.

3. Spurious Torque - With the relay connected in the test diagram as above, remove the input voltage and connect terminais 14, 15, and 16 together. Remove the phase-angle meter. With 80 amperes single-phase current applied, there should be no spurious closing torque.

Time Overcurrent Unit (CO)

- 1. <u>Contacts</u> 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 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 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 1 shows the time curve calibration points for the various types of relays. With the time dial set to the indicated position, apply the current specified by Table 1 (e.g. for the IRQ-2, 3 and 20 times tap value current). And measure the operating time of the relay. The operating times should equal those of Table 1 plus or minus 5 percent.

For type IRQ-11 relay only, the 1.30 times tap value operating time from the number 6 time dial position in 54.9±5% seconds. It is important that the 1.30 times tap value current be maintained accurately. The maintaining of this current accurately is necessary because of the steepness of the slope of the time-current characteristic (Fig. 21). A 1% variation in the 1.30 times tap value current (including measuring instrument deviation) will change the nominal operating time by approximately 4%.

Instantaneous Overcurrent Unit (I)

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 the tap value current.

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 (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

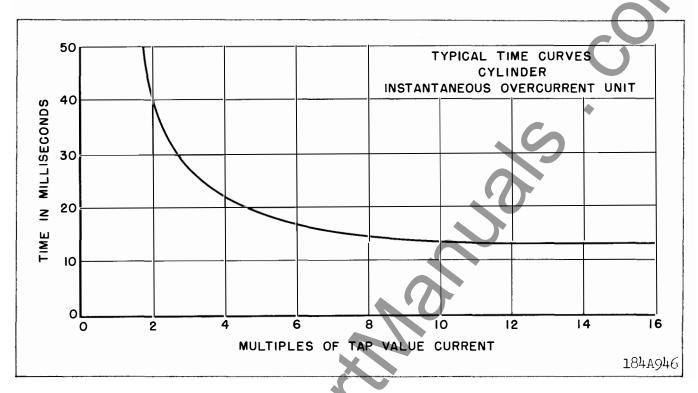


Fig. 13. Typical Time Curve of the Instantaneous Overcurrent Unit.

.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.

If an additional time check is desired, pass secondary current through the relay and check the time of operation. It is preferable to make this at several times pick-up current at an expected operating point for the particular application. For the .5 to 2.5 ampere range IRQ-5 and IRQ-6 induction unit use the alternative test circuit in Fig. 7 as these relays are affected by a distorted wave form. With this connection the 25/5 ampere current transformers should be worked well below the knee of the saturation (i.e., use 10L50 or better).

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").

Negative Sequence Voltage Filter

A. Apply 120 volts balanced 3 phase voltage 60 cycles to terminals 14, 15, and 16 of the relay, making sure that phase 1, 2, and 3 of the applied voltage is connected to terminals 14, 15, and 16 repectively.

B. Using a calibrated high resistance rectox voltmeter, measure the voltage between the tap on the auto-transformer (middle terminal, lower-right hand reactor, front view) and the tap on the adjustable 2" resistor. If the voltage is high (40 to 50 volts) the filter is probably improperly connected. If properly connected, the voltage will be low. Using a low range (approximately 5 volts) move the adjustable tap until the voltage reads a minimum. This value should be less than 1.5 volts.

Negative Sequence Current Filter

Refer to fig. 8 for positive sequence calibration.

- A. Connect relay terminals 7 and 9 together. Remove lead to lower right hand terminal of mutual reactor (right side view) to disconnect the directional unit.
- B. Pass 10 amperes in terminal 6 and out terminal 8.
- C. With a 0-15 volts, rectox type voltmeter, measure and record voltage between terminals 6 and the lower right hand terminal of mutual reactor. This voltage should be between 1.85 and 1.95 volts.
- D. Now measure the voltage from terminal 6 to terminal 7. Adjust the top filter resistor tap until this voltage is 1.73 times the reading of part C.

Refer to fig. 8 for neutral tap calibration.

A. Using the test connections as shown and a low range voltmeter connected between terminal 6 and 7, adjust the middle filter resistor tap connection until the measured voltage is zero. Reconnect lead to mutual reactor at end of this test.

Directional Unit (D)

- 1. The upper bearing screw should be screwed down until there is approximately .025" clearance between it and the top of the shaft bearing. The upper pin bearing should then be securely locked in position with the lock nut.
- 2. Contact gap adjustment for the directional unit is made with 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 and 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 ¾ 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. 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 when the relay is energized with 0.57 volts and 6.93 amps at 1880 (current leading voltage), considering the relay connected to the test circuit in Fig. 12.

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) Connect the relay voltage circuit terminals (phase 1, 2 and 3) together.
- b) Apply 80 amperes single-phase current (momentarily) in phase 2 terminal and out phase 3 terminal.

Plug adjustment is then made per Table II such that any contact closing 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.

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.

Time Overcurrent Unit (CO)

- 1) <u>Contacts</u> 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 adjusted 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 1 for permanent magnet adjustment (e.g. IRQ-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 1.

For type IRQ-11 relay only, the 1.30 times tap value operating time from the number 6 time dial position is 54.9 ±5% seconds. It is important that the 1.30 times tap value current be maintained accurately. The maintaining of this current accurately is necessary because of the steepness of the slope of the time-current characteristic (Fig. 21). A 1% variation in the 1.30 times tap value current (including measuring instrument deviation) will change the nominal operating time by approximately 4% if the operating time at 1.3 times tap value is not within these limits, a minor adjustment of the control spring will give the correct operating time without any undue effect on the minimum pick-up of the relay. This check is to be made after the 2 times tap value adjustment has been completed.

Apply the indicated current per Table 1 for the electromagnet plug adjustment (e.g. IRQ-8, 20 times tap value) and measure the operating time. Adjust the proper plug until the operating time corresponds to the value in Table 1 (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 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 the directional unit 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 the core screw up until the moving core starts rotating. Now back off the core screw until the moving core stops rotating. This indicates the points when 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. 14. 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.

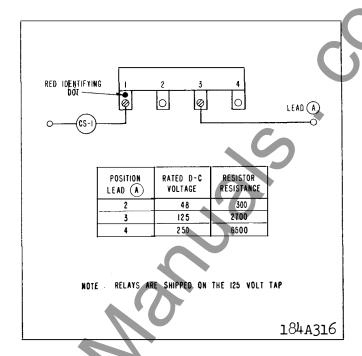


Fig. 14. Selection of Proper Voltage Tap for Auxiliary Switch (CS-1) Operation.

TABLE I

TIME CURVE CALIBRATION DATA - 60 CYCLES

_	PERMANENT	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
IRQ- 2	6	3	0.57	20	0.22
IRQ- 5	6	2	37.80	10	14.30
IRQ- 6	6	2	2.46	20	1.19
IRQ- 7	♦ 6	2	4.27	20	1.11
IRQ- 8	6	2	13.3 5	20	1.11
IRQ- 9	6	2	8.87	20	0.65
IRQ-11	6	2	11.27	20	0.24

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.

[†] Short circuit the voltage polarizing circuit at the relay terminals before making the above adjustment.

IRQ-2 TIME OVERCURRENT UNITS

				4		VOLT A	AMPERES**	
AMPERE	,	CONTINUOUS RATING	ONE SECOND RATING*	POWER FACTOR	AT TAP VALUE	AT 3 TIMES	AT 10 TIMES	AT 20 TIMES
RANGE		(AMPERES)	(AMPERES)	$ANGLE \phi$	CURRENT	CURRENT	CURRENT	CURRENT
TIMOE	- 111	(AMI EKEB)	(AMI EILES)	ANGEE	COMMENT	CORRENT	CORRENT	CURRENT
	0.5	0.91	28	58	4.8	39.6	256	7 90
	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	7 00	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	5.3 7	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. 7 2	46.0	360	1216
	5.0	5.6	110	41	5.90	50.3	420	1500
	6.0	6.0	110	3 7	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	3 7	6.6	55.5	470	1720
	12.0	12.0	230	34	7.00	62.3	528	2064

^{*} 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.

^{**} Voltages taken with Rectox type voltmeter.

IRQ-5, IRQ-6 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 ϕ	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
	(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
	•							

IRQ-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 ϕ	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 6
	(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

^{*} 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.

 $[\]phi$ Degrees current lags voltage at tap value current.

^{**} Voltages taken with Rectox type voltmeter.

IRQ-8, IRQ-9 TIME OVERCURRENT UNITS

						VOLT A	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 ϕ	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	4 60	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

IRQ-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)	$ANGLE \phi$	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
	X /	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	5 04
		4.0	14	460	29	0.79	7.08	78.4	296
7 .		5.0	16	460	25	0.89	8.00	90.0	340
		6.0	17	460	22	1.02	9.18	101.4	378
V	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

^{*} 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.

 $[\]phi$ Degrees current lags voltage at tap value current.

^{**} Voltages taken with Rectox type voltmeter.

ENERGY REQUIREMENTS FOR THE SEQUENCE FILTER AND THE DIRECTIONAL UNIT (All Burdens at 60 Cycles)

The current burden of the relay with positive sequence currents applied (no output current to the directional unit) is as follows:

Phase	Continuous Rating-Amps.	One Second Rating-Amps.	Watts at 5 Amps.	Volt-Amps. at 5 Amps.	Power Factor Angle
2	10	150	5.5	5.5	0 °
3	10	150	.35	1.28	74 ⁰ Lag
1	10	150	5.4	7.5	44 ⁰ Lag

The current burden of the relay with zero sequence currents applied is as follows:

	Watts	Volt - Amps.	
Phase	At 5 Amps.	At 5 Amps.	Power Factor Angle
1	4.66	5.5	32 ⁰
2	4.92	5.0	10 ⁰
3	3.30	3.7	27 ⁰

The voltage burden of the relay with positive sequence voltage applied (no output voltage to the directional unit) is as follows:

Pot. Transf. Across Phase Volts Watts Volt-Amps. Power Factor Angle

Burden values on three star connected potential transformers. Values at the star voltage of 66.4 volts (115 volts delta).

1	115	0	26.8	90° Lag
2	115	0.2	0.3	48 ⁰ Lag
3	115 🔈	23.2	27.0	30 ⁰ Lag

Burden values on two open-delta potential transformers. Values at 115 volts.

12	115	-23.2	46.5	120 ⁰ Lag
23	115	46.6	46.6	$0^{\rm o}$
23	115	.10	.48	58 ⁰ Lag
31	115	23.2	46.5	$60^{ m O}$ Lag
31	115	23.2	46.6	60 ⁰ Lag
12	115	0.50	0.52	2 ⁰ Lead

Burden values on three delta connected potential transformers. Values at 115 volts.

					•
31		1 15	15.4	31.0	60 ⁰ Lag
12		115	-7.8	15.6	120 ⁰ Lag
23	•	115	15.6	15.6	$\mathbf{0_{O}}$

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
	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
22.00	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	O NESECOND R	ATING
ITANGE	1	(AMPERES)		† (AMPERE	
.5-2		5		100	
1-4		8		140	
2-8		8		140	
4-16		10		200	
10-40		10		200	
				l	1

[†] 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.

^{† †} Voltages taken with Rectox type voltmeter.

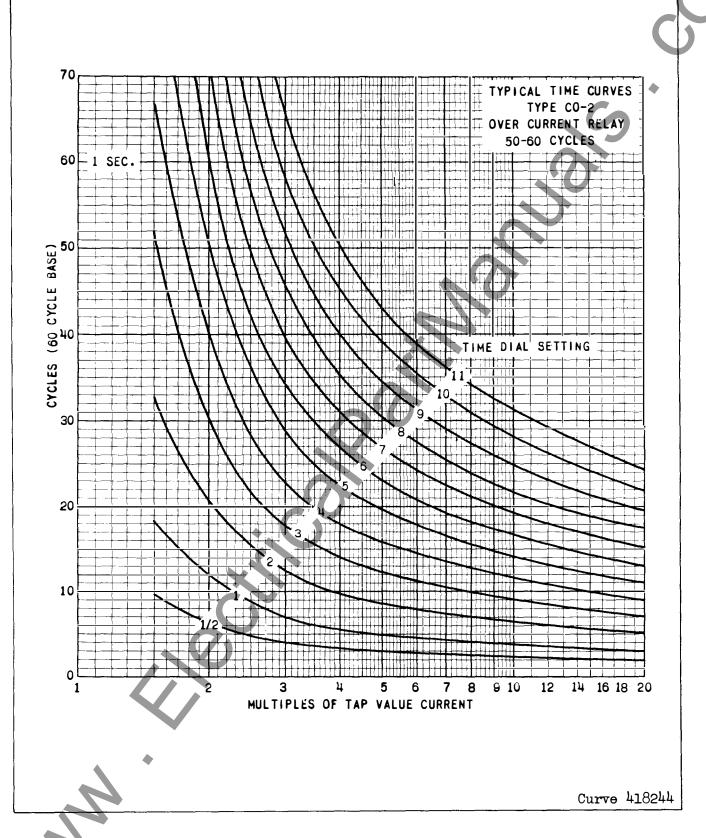


Fig. 15. Typical Time Curve of the Time-Overcurrent Unit of the Short Time (2) Relay.

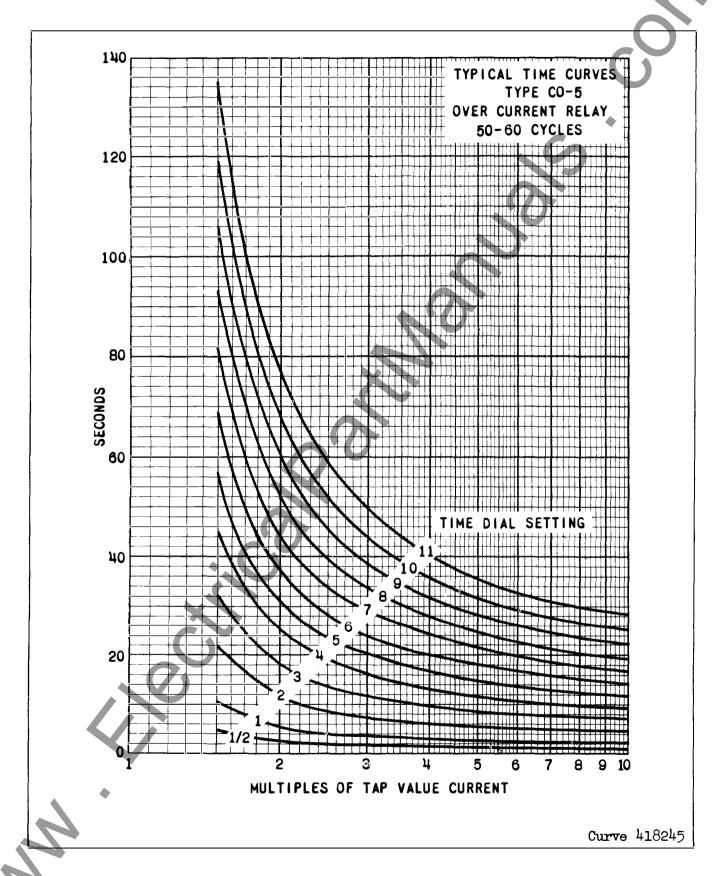
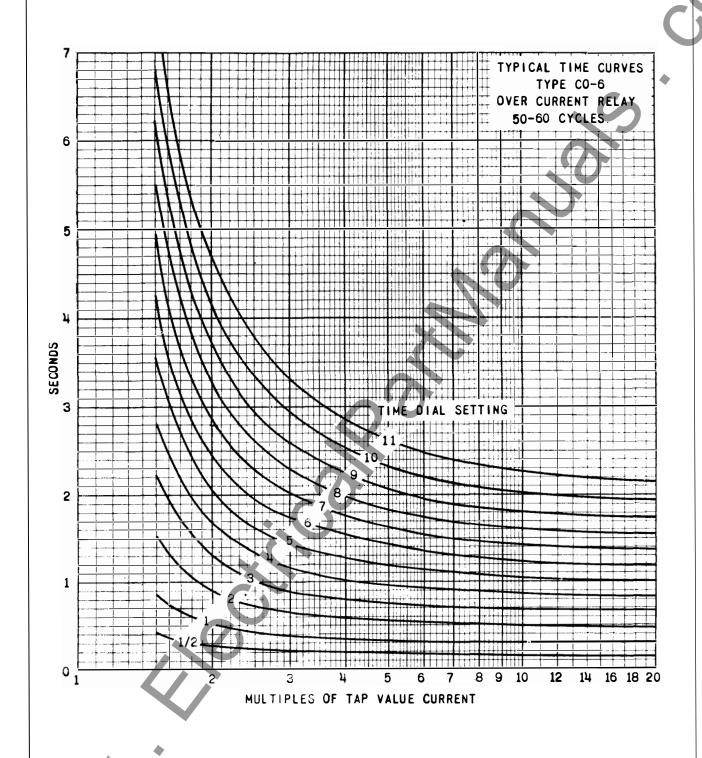


Fig. 16. Typical Time Curve of the Time-Overcurrent Unit of the Long Time (5) Relay.



Curve 41846

Fig. 17. Typical Time Curve of the Time-Overcurrent Unit of the Definite Time (6) Relay.

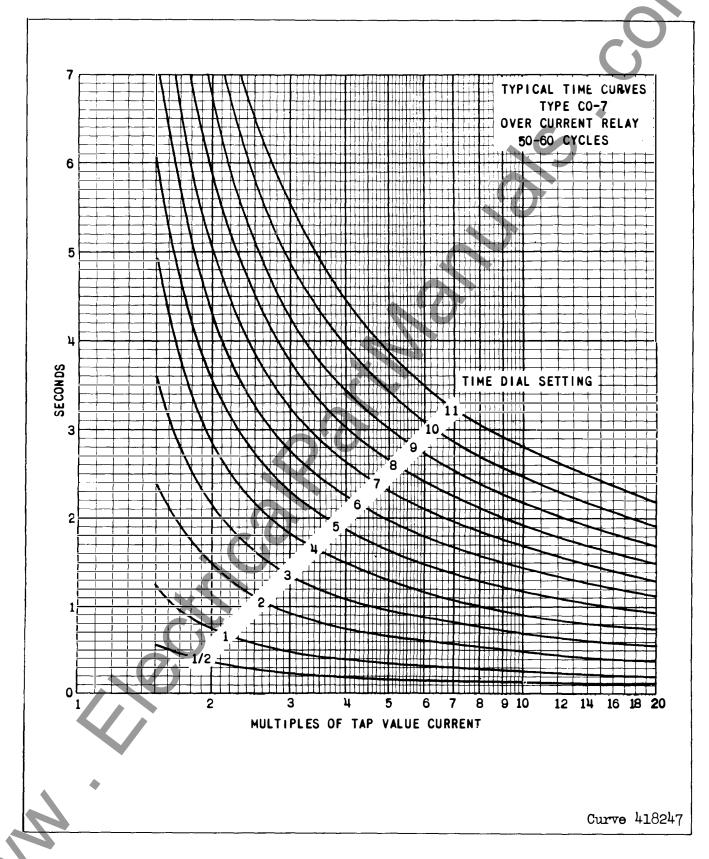


Fig. 18. Typical Time Curve of the Time-Overcurrent Unit of the Moderately Inverse (7) Relay.

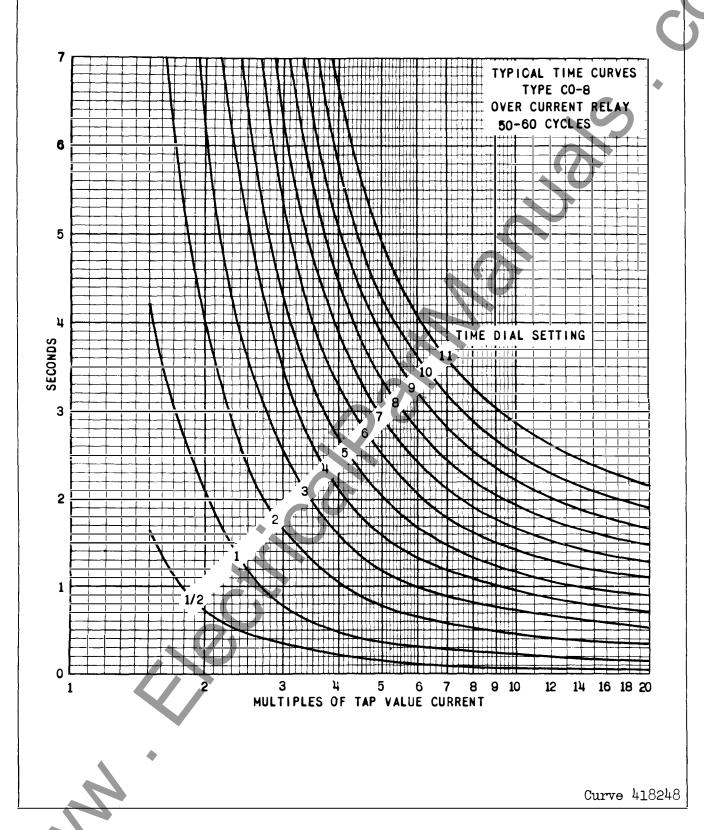


Fig. 19. Typical Time Curve of the Time-Overcurrent Unit of the Inverse (8) Relay.

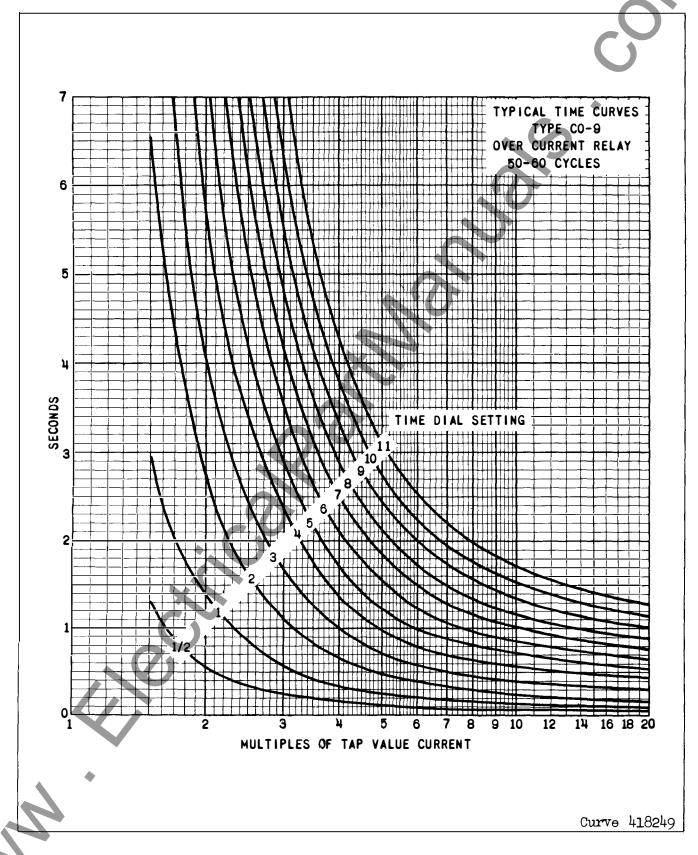


Fig. 20. Typical Time Curve of the Time-Overcurrent Unit of the Very Inverse (9) Relay.

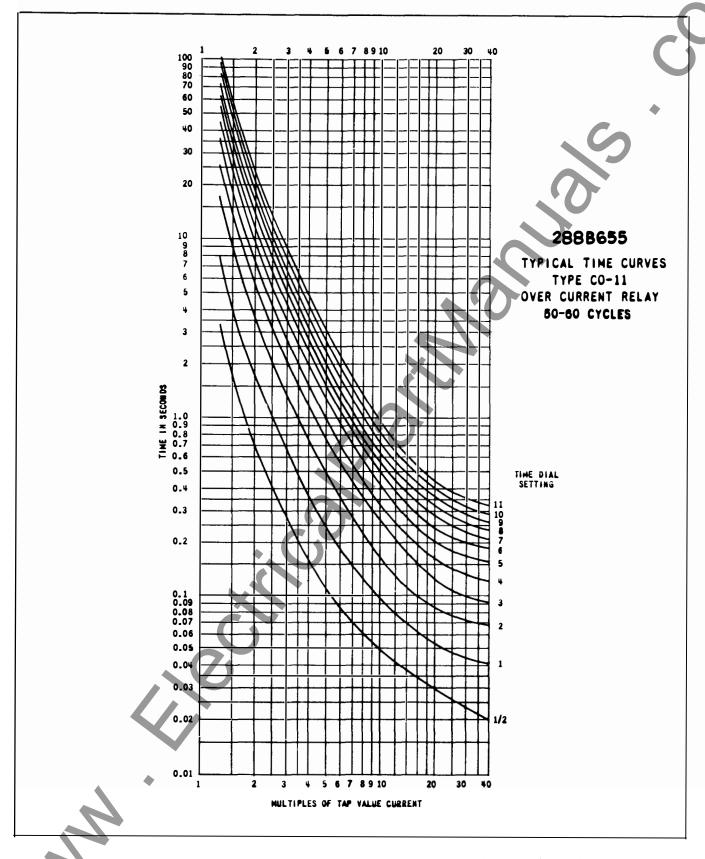


Fig. 21. Typical Time Curve of the Time-Overcurrent Unit of the Extremely Inverse (11) Relay.

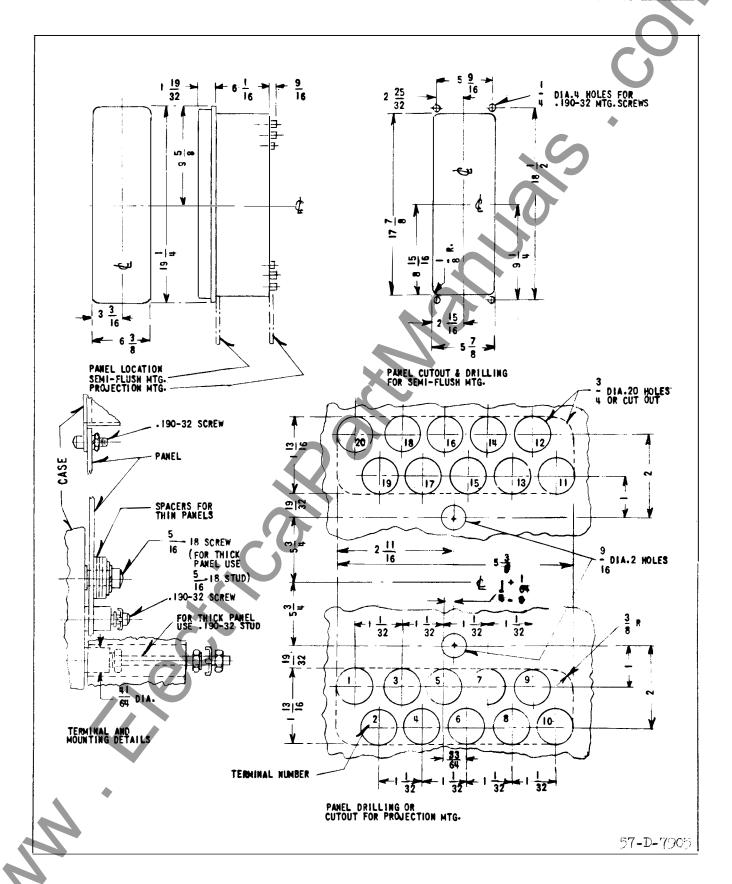


Fig. 22. Outline and Drilling Plan for the Type IRQ Relay in the FT42 Case.



WESTINGHOUSE ELECTRIC CORPORATION

NEWARK, N. J.

Printed in U.S.A.



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

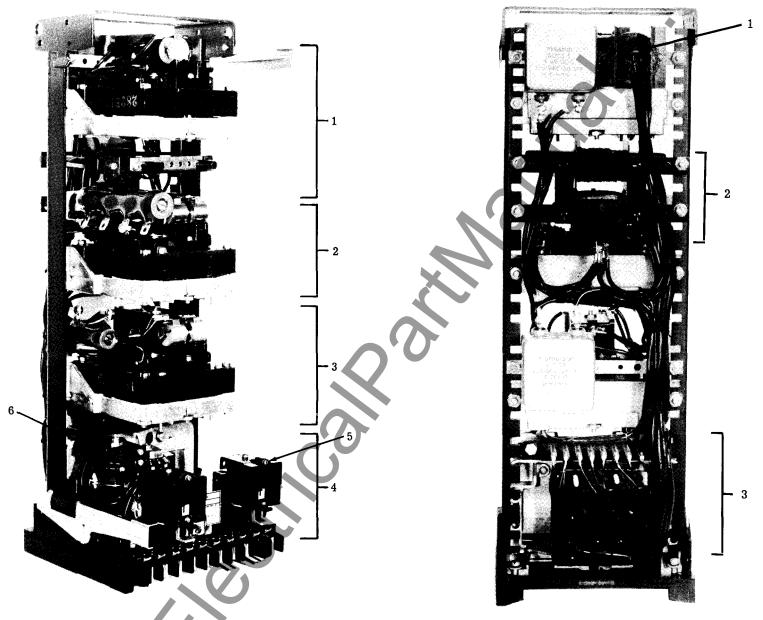


Fig. 1. Type IRD Relay Without Case (Front View). 1 — Instantaneous Overcurrent Unit and Saturating Transformer, 2 — Current Polarized Directional Unit, 3 — Voltage Polarized Directional Unit, 4 — Time Overcurrent Unit, 5 — Indicating Contactor Switch, 6 — Auxiliary Switch.

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

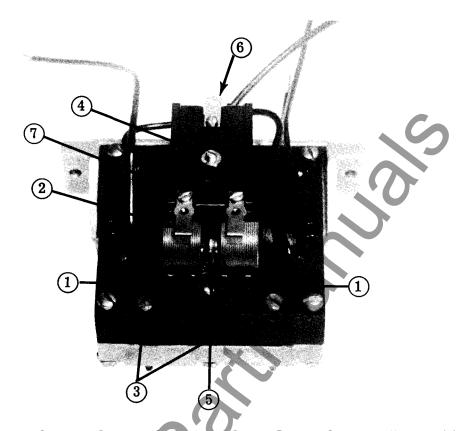


Fig. 3. Directional Unit. 1 — Stationary Contacts. 2 — Stationary Contact Pressure Spring. 3 — Magnetic Adjusting Plugs. 4 — Upper Bearing Screw. 5 — Moving Contact. 6 — Spring Adjuster Clamp. 7 — Current Bias Vane.

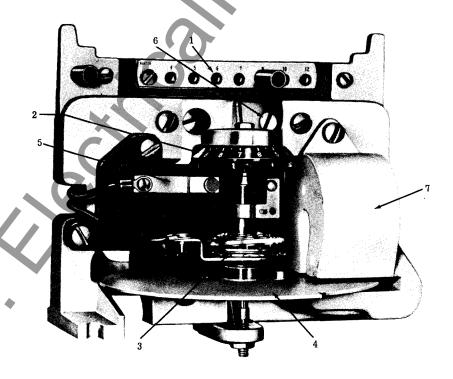


Fig. 4. Time Overcurrent Unit. 1—Tap Block. 2—Time Dial. 3—Control Spring Assembly. 4— Disc. 5—Stationary Contact Assembly. 6—Magnetic Plugs. 7—Permanent Magnet.

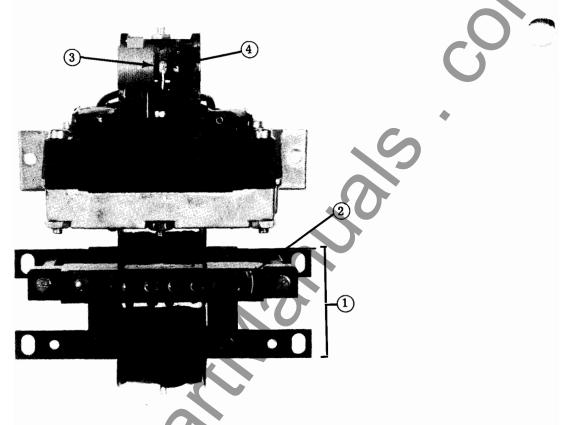


Fig. 5. Instantaneous Overcurrent Unit. 1 — Saturating Transformer. 2 — Tap Block. 3 — Stationary Contact. 4 — Moving Contact.

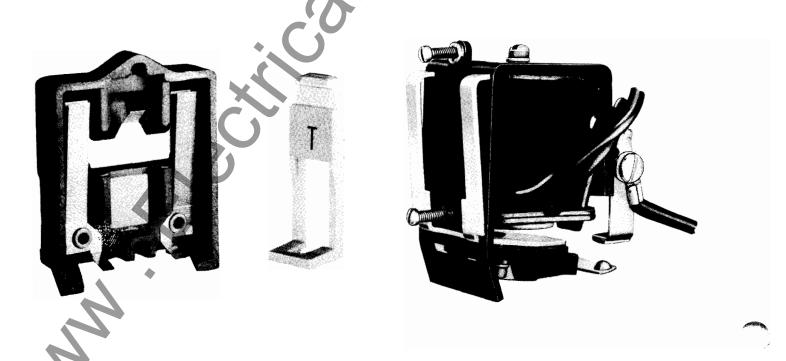


Fig. 6. Indicating Contactor Switch (ICS).

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; preventing 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 2 Short Time 5 Long Time Definite Time 6 7 Moderately Inverse Time Inverse Time 8 Very Inverse Time 9 Extremely Inverse Time

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	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.

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.

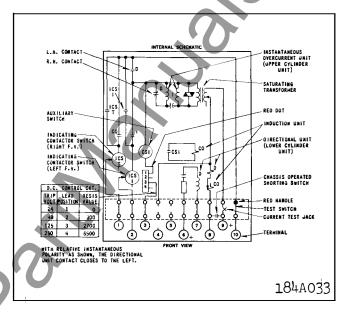


Fig. 7. Internal Schematic of the Type IRP Relay in the Type FT31 Case.

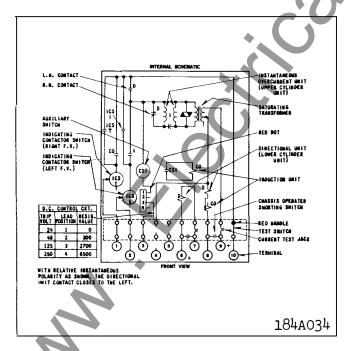


Fig. 8. Internal Schematic of the Type IRC Relay in the Type FT31 Case.

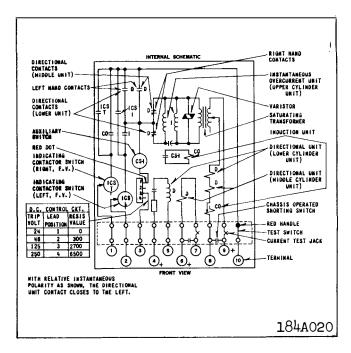


Fig. 9. Internal Schematic of the Type IRD Relay in the Type FT41 Case.

ENERGY REQUIREMENTS

INSTANTANEOUS OVERCURRENT UNIT OPERATING CURRENT CIRCUIT - 60 CYCLES

	1	++	φ	++	φ
AMPERE RANGE	TAP	VA AT TAP VALUE	P.F. ANGLE	tt 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
	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
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 RATING	 G	ONE SECOND R	ATING
		(AMPERES)		† (AMPERE	
. 5-2	74	5		100	
1-4		8		140	
2-8		8		140	
2-8 4-16				200	
		10			
10-40		10		200	
20-80		10		200	[

[†] 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.

Voltages taken with Rectox type voltmeter.

ENERGY REQUIREMENTS - 60 CYCLES

DIRECTIONAL UNIT OPERATING CIRCUIT BURDEN

					VOLT AMPERES † † *					
		Continuous	One Second	Power	At Minimum	At 3 Times Minimum	At 10 Times Minimum	At 20 Times Minimum		
Relay	Range	Rating	Rating † *	Factor	Tap Value	Tap Value	Tap Value	Tap Value		
Type	Amps	(Amperes)	(Amperes)	Angle ϕ	Current	Current	Current	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		

 $[\]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 ϕ
IRC	230† * Amperes	1.45	8 ⁰ Lag
IRP	208†† * Volts	11.2	28 ⁰ Lead
IRD Current Unit	230† * Amperes	1.45	8 ⁰ Lag
IRD Voltage Unit	208 † † * Volts	11.2	28 ⁰ Lead

 $[\]phi$ Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.

^{* †} 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.

^{* ††} Voltages taken with Rectox type voltmeter.

[△] Burden of voltage polarized units taken at 120 volts. Burden of current polarized units taken at 5 amperes.

[†] One second rating.

^{* †† 30} second rating. The 10 second rating is 345 volts. The continuous rating is 120 volts.

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

						VOLT A	MPERES††*	•
AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND, RATING † * (AMPERES)	POWER FACTOR ANGLE ϕ	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
		0.01	28	58	4.8	39.6	256	790
	0.5	0.91		5 7	4.9	39.8	270	851
	0.6	0.96	28	53	5.0	42.7	308	1024
	0.8	1.18	28		5.3	45.4	348	1220
0.5/2.5	1.0	1.37	28	50		54.4	435	1740
	1.5	1.95	28	40	6.2 7.2	65.4	580	2280
	2.0	2.24	28	36		73.6	700	2850
	2.5	2.50	28	29	7.9	13.0	100	2000
	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
0.70	3.5	4.8	110	47	5.53	42.8	329	1120
2/6			110	45	5.72	46.0	360	1216
	4.0	5.2		41	5.90	50.3	420	1500
	5.0	5.6	110	37	6.54	54.9	474	1800
	6.0	6.0	110	31	0.34	34.3	111	1000
	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
4/12	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
	12.0	12.0						

^{* †} 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.

^{* ††} Voltages taken with Rectox type voltmeter.

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

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 ϕ	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	3 25
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 † † *

AMPERE		CONTINUOUS RATING	ONE SECOND RATING† *	POWER FACTOR	AT TAP VALUE	AT 3 TIMES TAP VALUE	AT 10 TIMES TAP VALUE	AT 20 TIMES TAP VALUE
RANGE	TAP	(AMPERES)	(AMPERES)	ANGLE ϕ	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 6
	(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
	•							

^{* †} 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.

^{* ††} Voltages taken with Rectox type voltmeter.

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

						VOLT A	MPERES † *	•
AMPERE RANGE	TAP	CONFINUOUS RATING (AMPERES)	ONE SECOND RATING† * (AMPERES)	POWER FACTOR ANGLE ϕ	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
	40 5	0		T O	2.22	0.1	7100	050
	(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	5 00
	(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

					VOLT AMPERES††				
		CONTINUOUS	ONE SECOND	POWER	AT	AT 3 TIMES	AT 10 TIMES	AT 20 TIMES	
AMPERE		RATING	RATING *		TAP VALUE	TAP VALUE	TAP VALUE	TAP VALUE	
RANGE	TAP	(AMPERES)	(AMPERES)	ANGLE ϕ	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	11.0.0	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	

^{* †} 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.

 $[\]phi$ Degrees current lags voltage at tap value current.

^{*} \dagger^{\dagger} Voltages taken with Rectox type voltmeter.

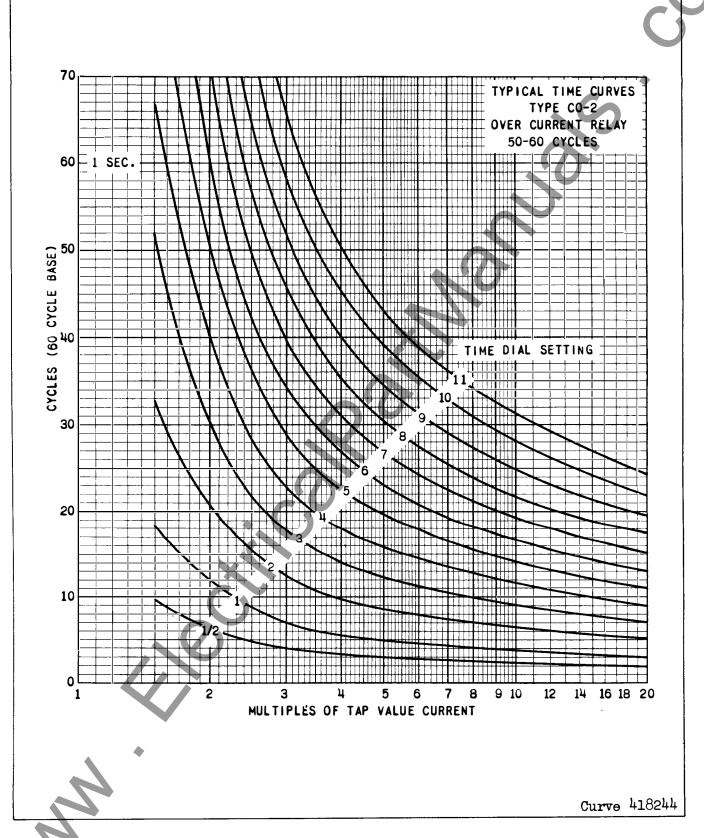


Fig. 10. Typical Time Curves of the Time-Overcurrent Unit of the Short Time (2) Relays.

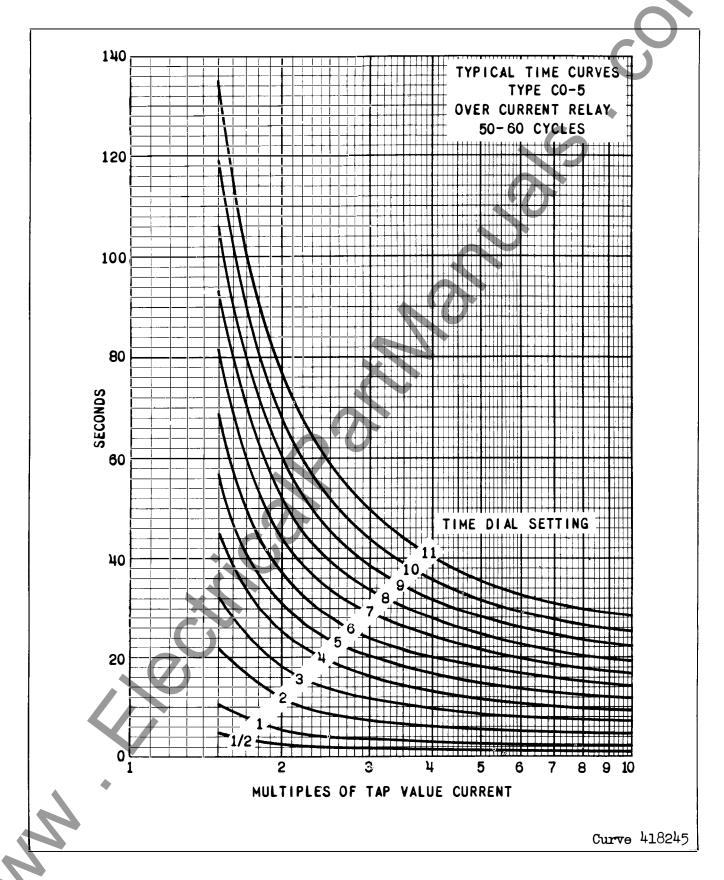


Fig. 11. Typical Time Curve of the Time-Overcurrent Unit of the Long Time (5) Relays.

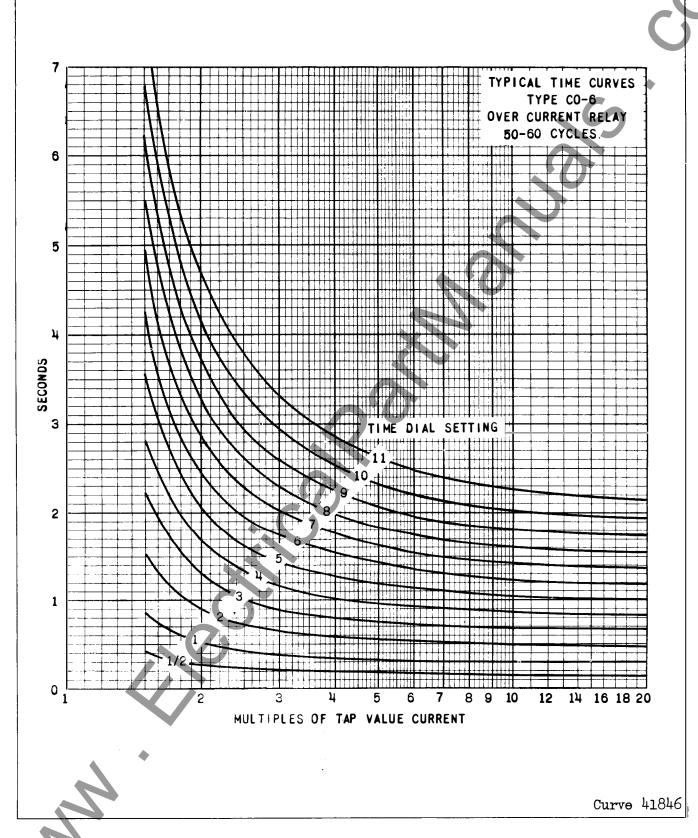


Fig. 12. Typical Time Curve of the Time-Overcurrent Unit of the Definite Time (6) Relays.

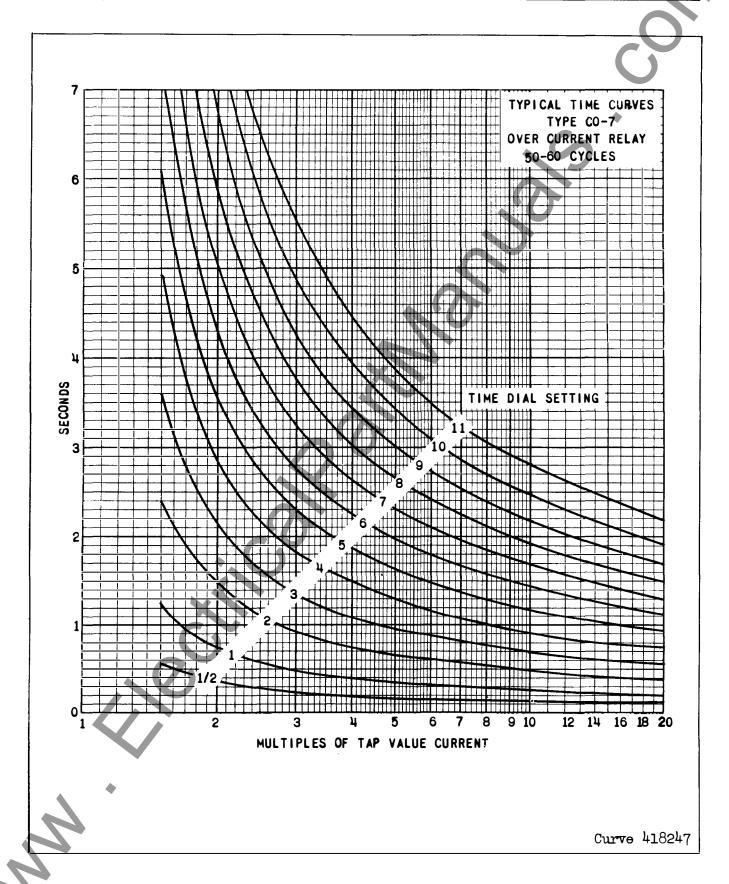


Fig. 13. Typical Time Curve of the Time-Overcurrent Unit of the Moderately Inverse (7) Relays.

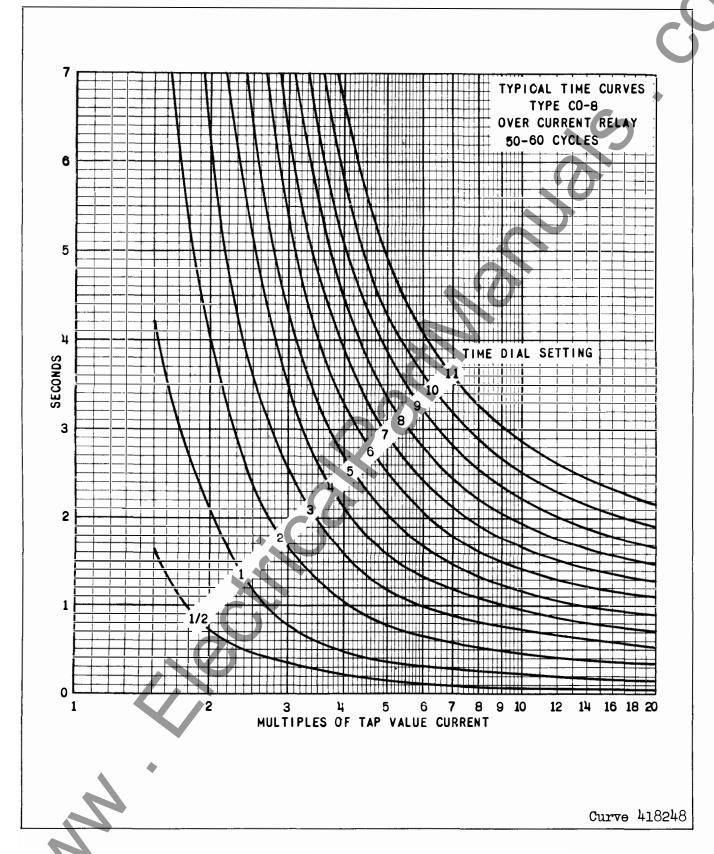


Fig. 14. Typical Time Curve of the Time-Overcurrent Unit of the Inverse (8) Relays.

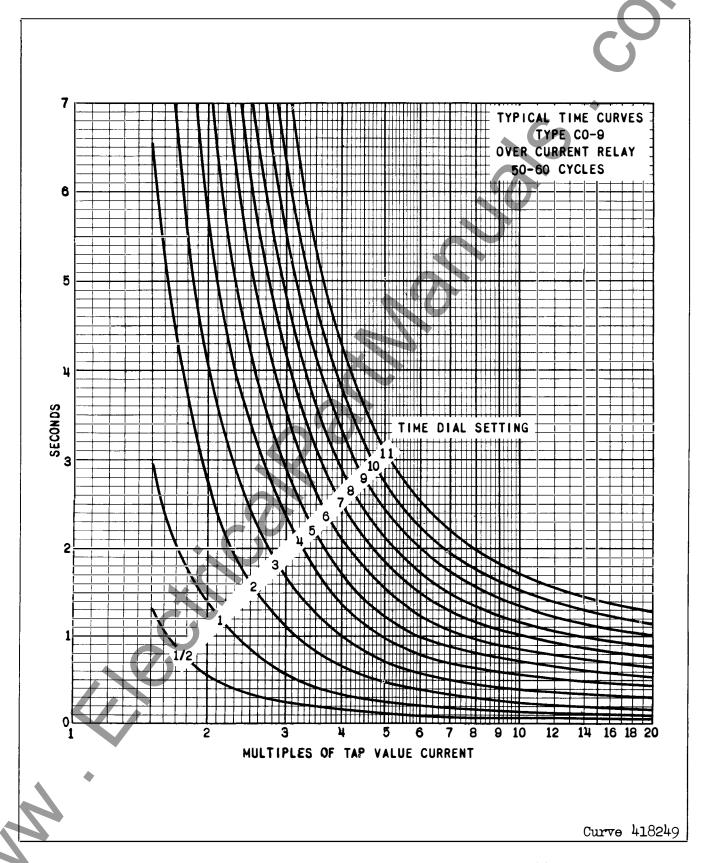


Fig. 15. Typical Time Curve of the Time-Overcurrent Unit of the Very Inverse (9) Relays.

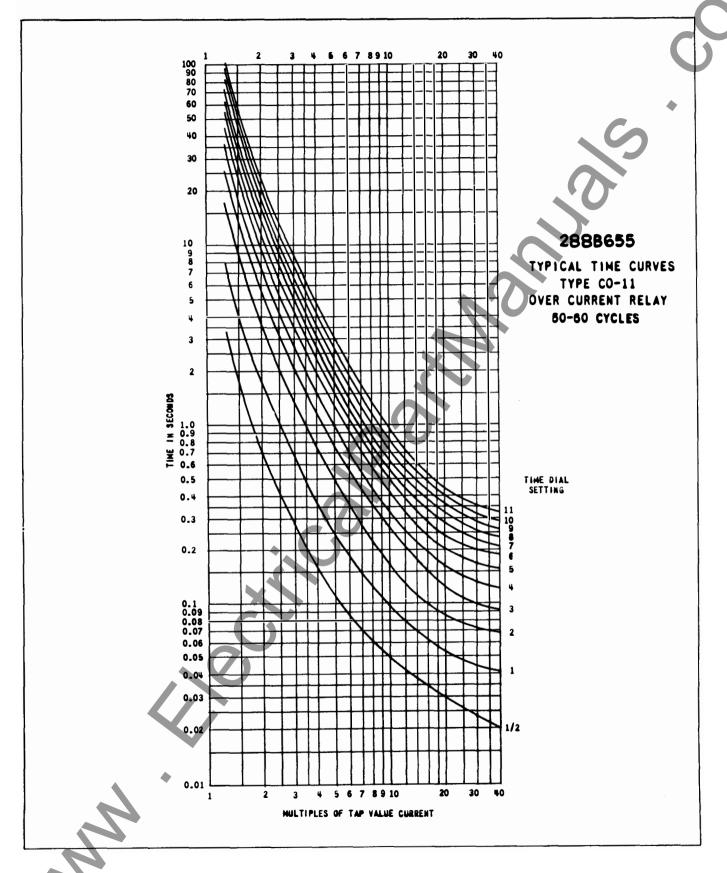
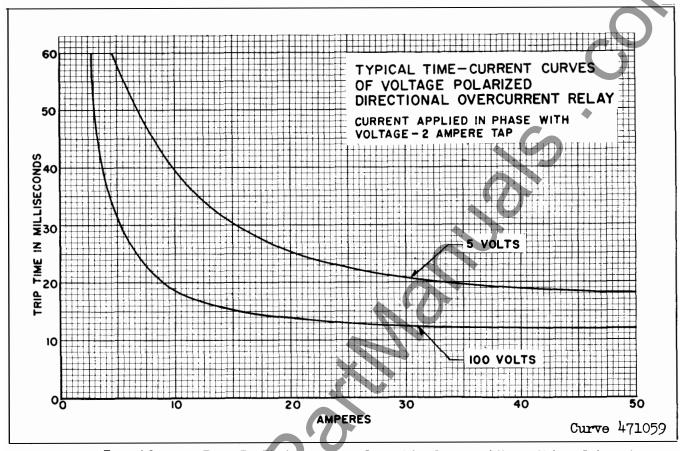
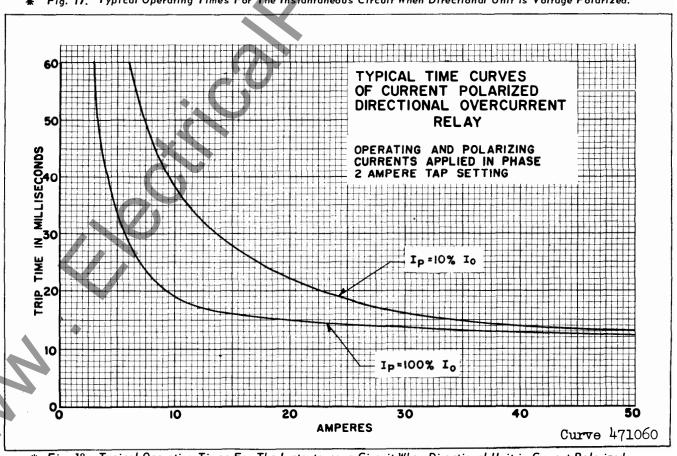


Fig. 16. Typical Time Curve of the Time-Overcurrent Unit of the Extremely Inverse (11) Relays.



* Fig. 17. Typical Operating Times For The 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° .

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° .

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 $\hfill \bigtriangleup$

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

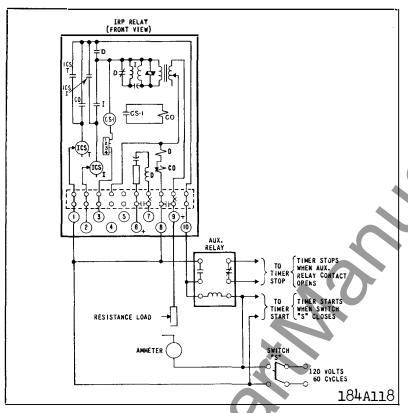


Fig. 19. Diagram of test connections of the time-overcurrent unit.

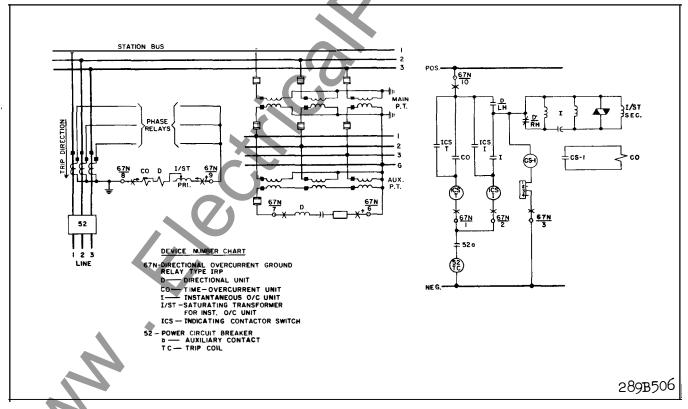
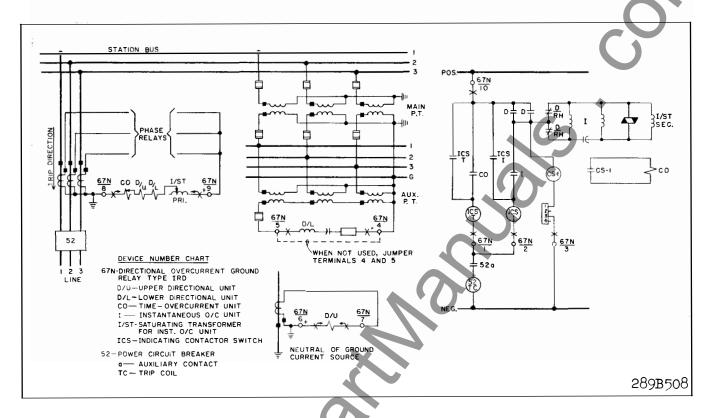
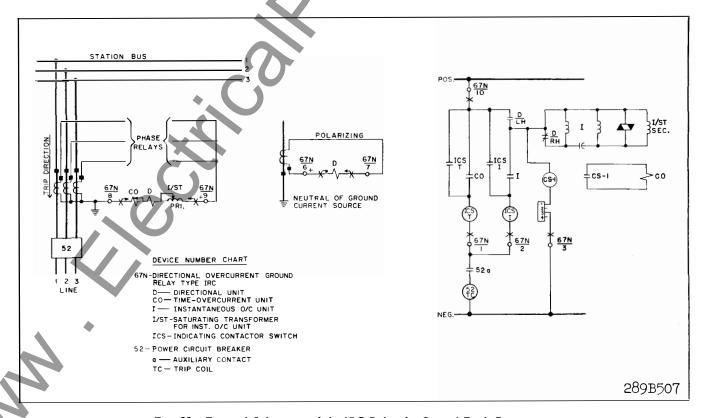


Fig. 20. External Schematic of the IRP Relay for Ground Fault Protection.



*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 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

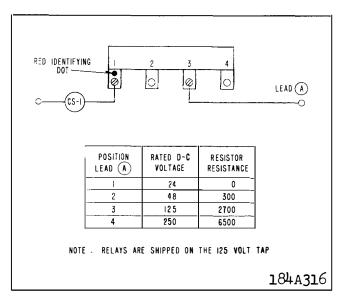


Fig. 23. Selection of Proper Voltage Tap for Auxiliary Switch (CS-1) Operation.

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 $3/64^n$ 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

		SIIONAL ONII	3E113111111		
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-phase with V	
	4.10	1	4.0	[lagging V by 60° †† *	
	4-12	1	8.0	I in-phase with V	
	.5-2.5		0.5	I ₀ leading I _p by 40°††	
IRC IRD (Current	2-6		0.57 -0.65	In-phase	
Unit)	4-12		1.0	I_0 leading I_p by 40° † *	
			1.3 1.14	In-phase	

^{* †} The energization quantities are input quantities at the relay terminals.

^{† ††} Maximum torque angle.

TABLE II

DIRECTIONAL UNIT CALIBRATION †

RELAY RATING	CURRENT AMPERES	BOTH PLUGS IN CONDITION	ADJUSTMENT
All Ranges	80	Spurious Torque In Contact Closing Direction (Left Front View)	Right (Front-View) Plug Screwed Out Until Spurious Torque is Reversed.
All Ranges	80	Spurious Torque In Contact Opening Direction (Right Front View) (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.

[†] 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	NET PLUGS		
TIME.	TIME	CHDDENT	ODED ATTING	CUDDENT	
TIME- OVERCURRENT	TIME	CURRENT	OPERATING	CURRENT	OPERATING
		(MULTIPLES OF	TIME	(MULTIPLES OF	TIME
UNIT TYPE	POSITION	TAP VALUE)	SECONDS	TAP VALUE)	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

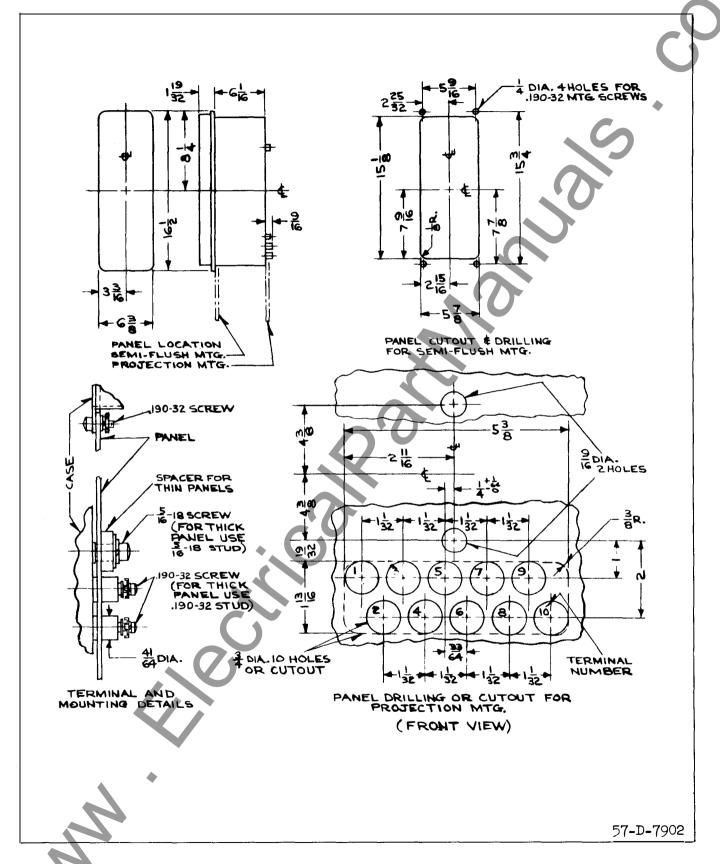


Fig. 24. Outline and Drilling Plan for the IRP and IRC Relays in the Type FT31 Case.

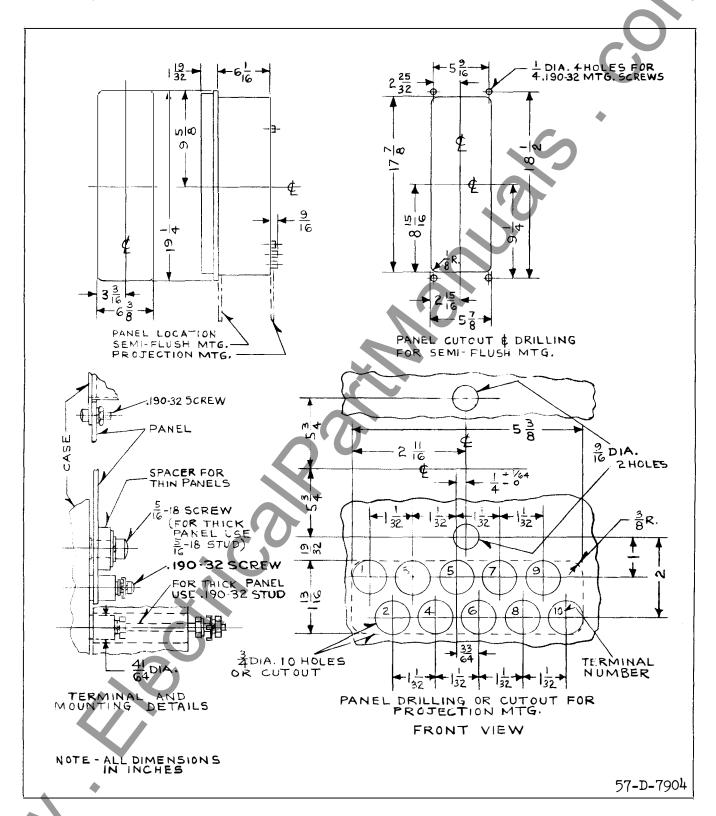


Fig. 25. Outline and Drilling Plan for the IRD Relay in the Type FT41 Case.

MAN CORE

MAN CORE CORE

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

Printed in U.S.A.



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.

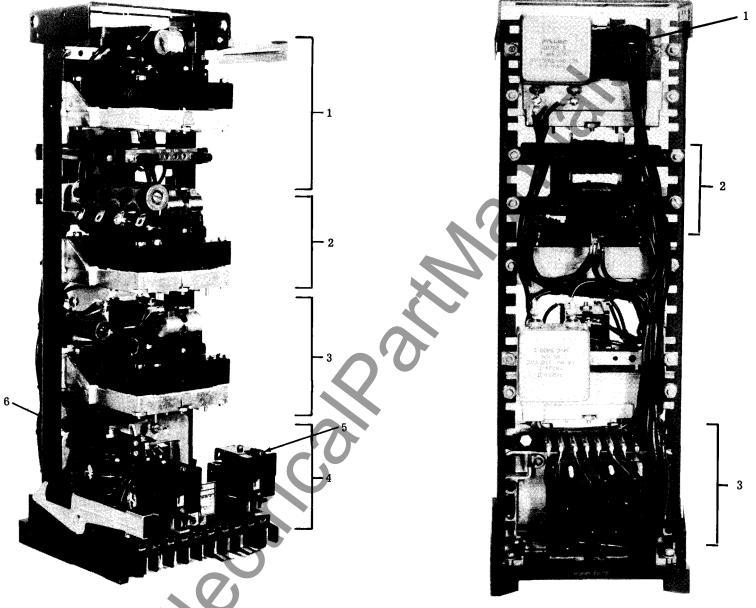
Directional Unit (D)

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.

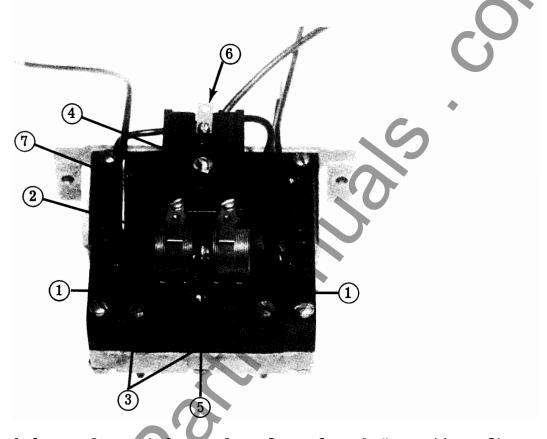


Fig. 3. Directional Unit. 1 — Stationary Contacts. 2 — Stationary Contact Pressure Spring. 3 — Magnetic Adjusting Plugs. 4 — Upper Bearing Screw. 5 — Moving Contact. 6 — Spring Adjuster Clamp. 7 — Current Bias Vane.

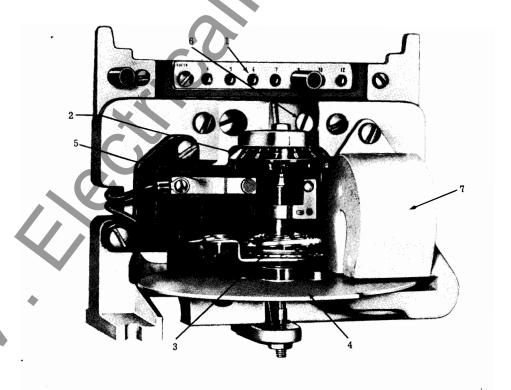


Fig. 4. Time Overcurrent Unit, 1—Tap Block, 2—Time Dial, 3—Control Spring Assembly, 4—Disc, 5—Stationary Contact Assembly, 6—Magnetic Plugs, 7—Permanent Magnet,

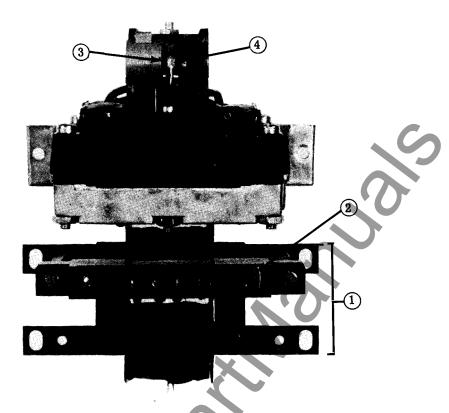


Fig. 5. Instantaneous Overcurrent Unit. 1 — Saturating Transformer. 2 — Tap Block. 3 — Stationary Contact. 4 — Moving Contact.

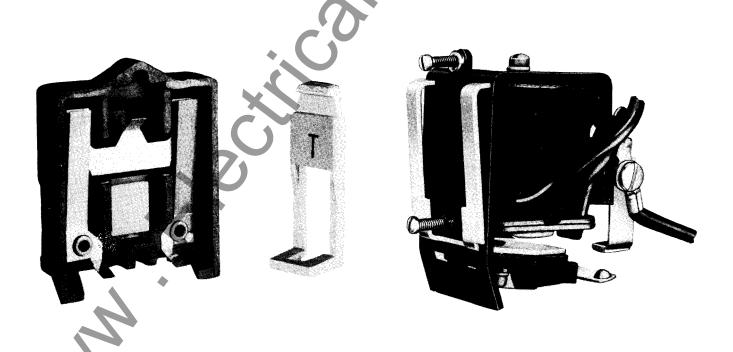


Fig. 6. Indicating Contactor Switch (ICS).

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; preventing 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		Taps					
0.5-2 Amps	0.5	0.75	1.0	1.25	1.5	2	
1-4	1.0	1.5	2.0	2.5	3.0	4.0	
2-8	2	3	4	5	6	8	
4-16	4	6	8	9	12	16	
10-40	10	15	20	24	30	40	
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.

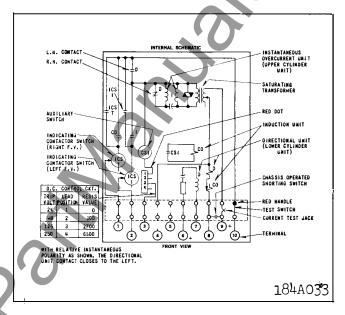


Fig. 7. Internal Schematic of the Type IRP Relay in the Type FT31 Case.

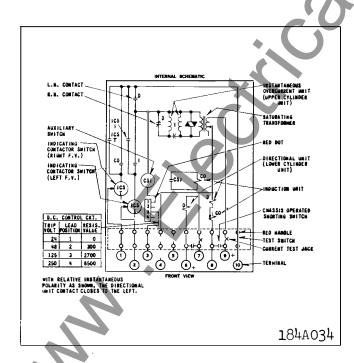


Fig. 8. Internal Schematic of the Type IRC Relay in the Type FT31 Case.

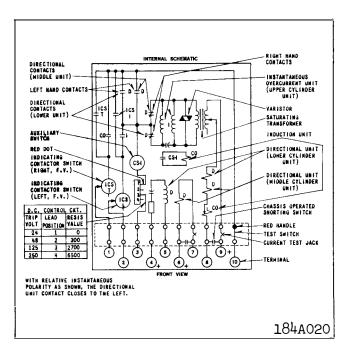


Fig. 9. Internal Schematic of the Type IRD Relay in the Type 7141 Case.

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
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
	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
10.10	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 -8 0	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	NG	ONE SECOND R.	ATING
		(AMPERES)		† (AMPERES	l l
. 5-2	74	5		100	
1-4		8		140	
2-8		8		140	
4-16		10		200	
				200	
10-40		10			
20-80		10		200	

[†] 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.

[†] 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 ϕ	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

 $[\]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 ϕ
IRC`	230* Amperes	1.45	8 ⁰ Lag
IRP	208** Volts	11.2	28 ⁰ Lead
IRD Current Unit	230* Amperes	1.45	8 ⁰ Lag
IRD Voltage Unit	208** Volts	11.2	28 ⁰ Lead

 $[\]phi$ Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.

^{*} 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.

^{**} Voltages taken with Rectox type voltmeter.

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

^{*} One second rating.

^{** 30} second rating. The 10 second rating is 345 volts. The continuous rating is 120 volts.

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

						VOLT A	MPERES**	\
AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE ϕ	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
					4.0	39.6	256	790
	0.5	0.91	28	58	4.8		270	851
	0.6	0.96	28	57	4.9	39.8		1024
	8.0	1.18	28	53	5.0	42.7	308	1220
0.5/2.5	1.0	1.37	28	50	5.3	45.4	348	1740
	1.5	1.95	28	40	6.2	54.4	435	
	2.0	2.24	28	36	7.2	65.4	580	2280
	2.5	2.50	28	29	7.9	73.6	700	2850
2/6	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	7.3 8.0 8.8 9.6 10.4	230 230 230 230 230 230	65 50 47 46 43 37	4.92 5.20 5.34 5.53 5.86 6.6	39.1 42.0 44.1 45.8 49.9 55.5	268 305 330 364 400 470	848 1020 1128 1260 1408 1720
	10.0 12.0	11.2 12.0	230	34	7.00	62.3	528	2064

^{*} 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.

^{**} Voltages taken with Rectox type voltmeter.

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

VOLT AMPERES**

AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE ϕ	AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE	
RANGE	1111	(AME ERES)	(AME ERES)	ANGLE	COMMENT	COULTENT	CONTENT	COMMENT	
	(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	
2/6	(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	
	(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	
4/12	(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	
	(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 AT AT 3 TIMES AT 10 TIMES AT 20 TIMES POWER AMPERE RATING RATING* FACTOR TAP VALUE TAP VALUE TAP VALUE TAP VALUE (AMPERES) ANGLE ϕ CURRENT CURRENT CURRENT CURRENT RANGE TAP (AMPERES) 3.88 20.7 278 (0.5 2 68 103 (0.6 2.2 67 3.93 20.9 107 288 88 (0.8 2.5 66 3.93 21.1 114 320 88 0.5/2.588 (1.0 2.8 64 4.00 21.6 122 356 (1.5 3.4 88 61 4.08 22.9 148 459 (2.0 4.0 4.24 174 552 88 24.8 58 (2.5 4.4 88 56 4.38 25.9 185 640 (2 4.06 8 230 66 306 21.3 111 (2.5 8.8 230 63 4.07 21.8 120 342 (3 230 63 4.14 22.5 129 366 2/6 (3.5)230 62 4.34 23.4 141 413 (4 230 61 4.34 23.8 149 448 230 59 4.40 25.2 163 530 230 58 4.62 27 183 624 16 460 22.8 129 392 64 4.24 (5 18.8 460 61 4.30 24.2 149 460 4/12 460 60 4.62 25.9 168 540 (6 19.3 (7 20.8 460 58 4.69 27.3 187 626 22.5 (8) 460 4.80 29.8 211 688 55 (10 25 460 51 5.20 33 260 860 (12 28 460 5.40 37.5 308 1032 46

^{*} 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.

^{**} Voltages taken with Rectox type voltmeter.

IRD-8, IRC-8, IRP-8, 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 ϕ	CURRENT	CURRENT	CURRENT	CURRENT
								0
	(0.5	2	88	72	2.38	21	132	350
	(0.6	2.2	88	71	2.38	21	134	365
	8.0)	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
					K			
	(4	16	460	68	2.38	21.3	146	420
4/12	(5	18.8	460	63	2.46	21.8	158	480
	(6	19.3	460	60	2.54	22.6	172	550
	(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
			100		0.10	01.1	202	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)	$ANGLE\phi$	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	
	12.0			-	· -	· -			

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.

 $[\]phi$ Degrees current lags voltage at tap value current.

^{**} Voltages taken with Rectox type voltmeter.

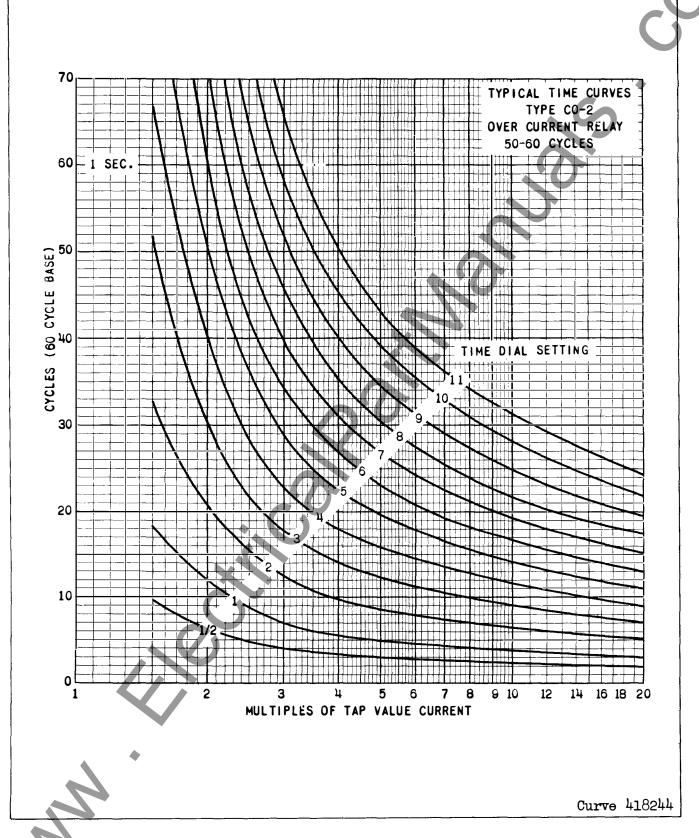


Fig. 10. Typical Time Curves of the Time-Overcurrent Unit of the Short Time (2) Relays.

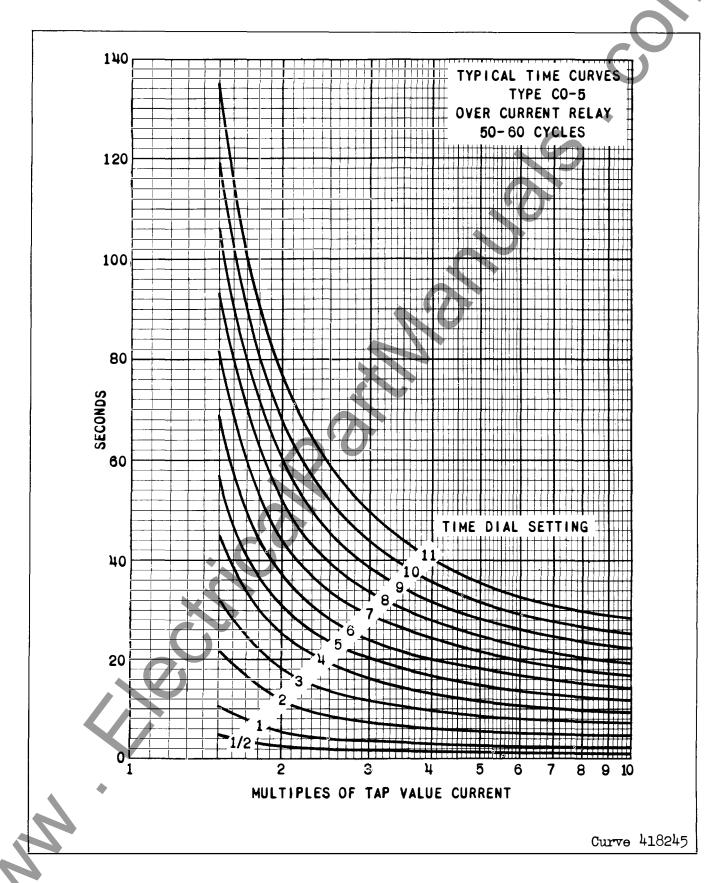


Fig. 11. Typical Time Curve of the Time-Overcurrent Unit of the Long Time (5) Relays.

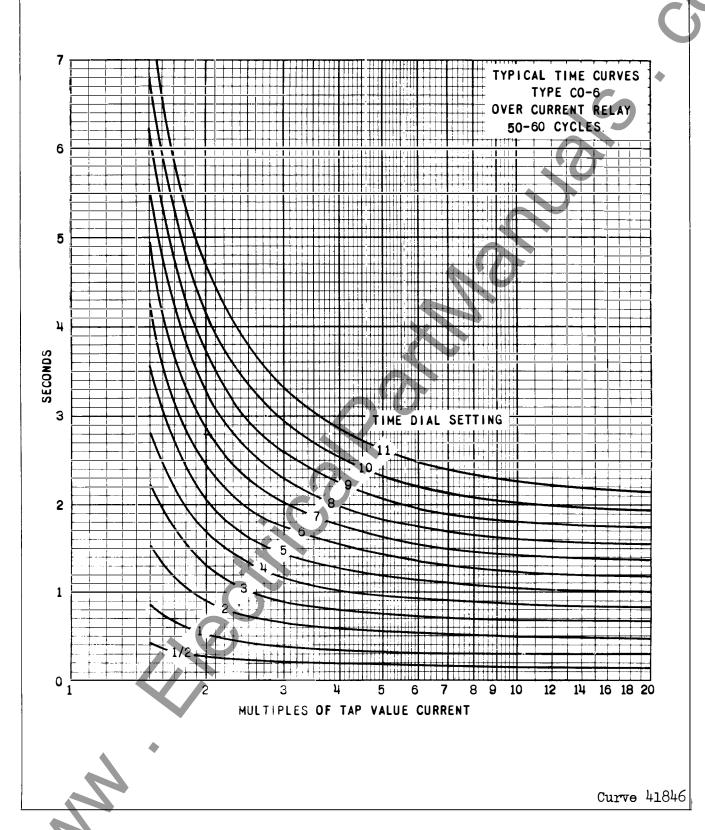


Fig. 12. Typical Time Curve of the Time-Overcurrent Unit of the Definite Time (6) Relays.

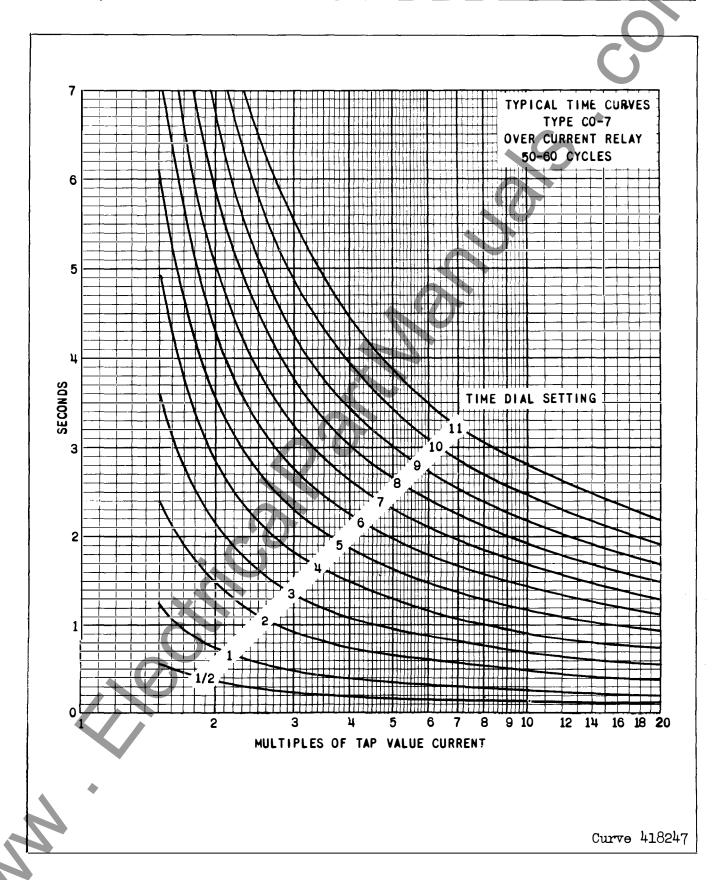


Fig. 13. Typical Time Curve of the Time-Overcurrent Unit of the Moderately Inverse (7) Relays.

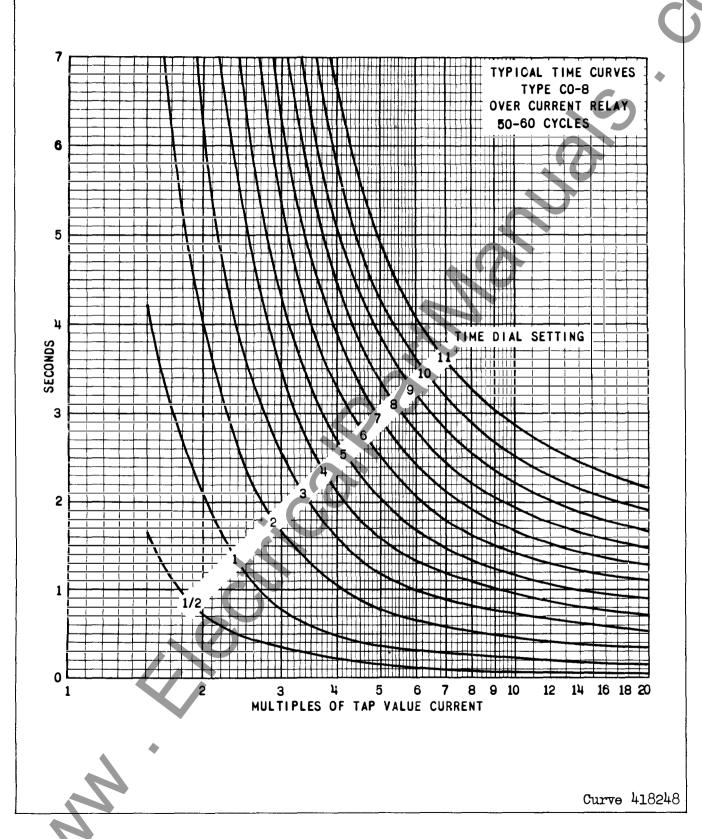


Fig. 14. Typical Time Curve of the Time-Overcurrent Unit of the Inverse (8) Relays.

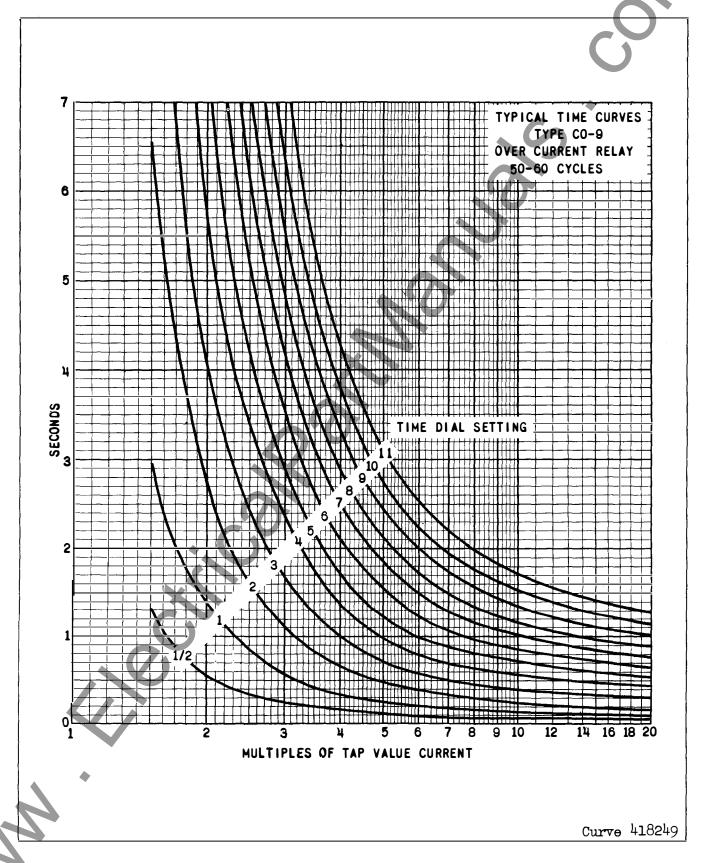


Fig. 15. Typical Time Curve of the Time-Overcurrent Unit of the Very Inverse (9) Relays.

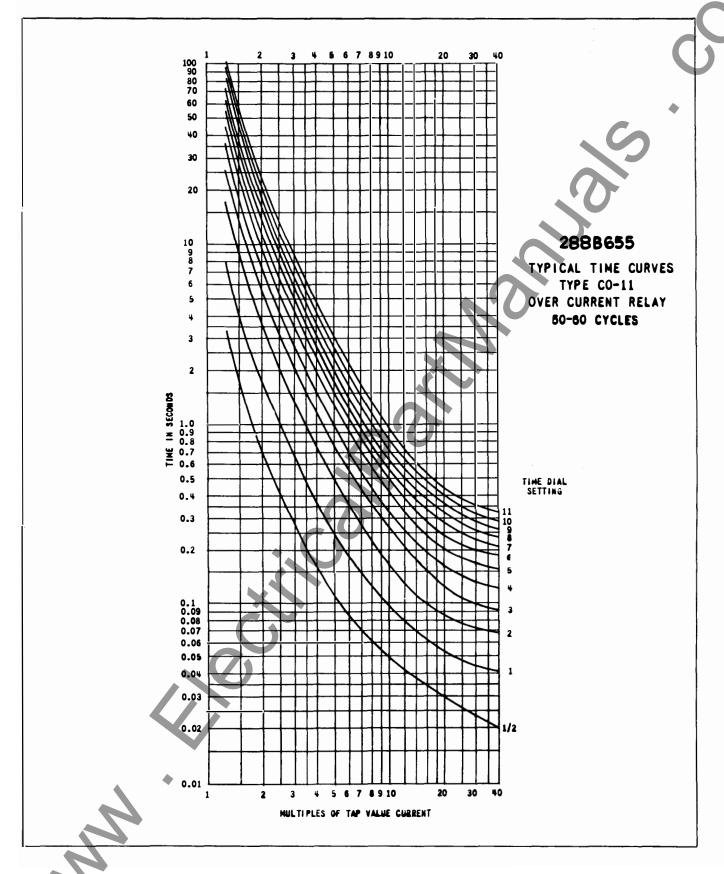


Fig. 16. Typical Time Curve of the Time-Overcurrent Unit of the Extremely Inverse (11) Relays.

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° .

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° .

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. <u>Minimum Trip Current</u> Set the time dial to position 6 with the auxiliary switch (CS-1) contacts

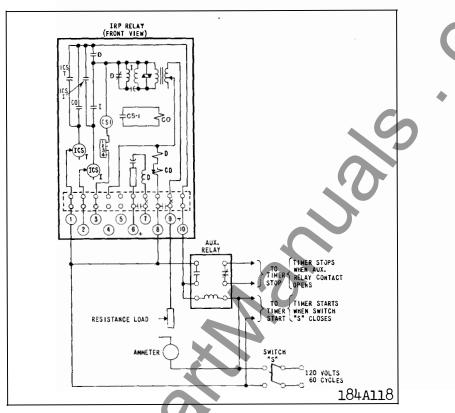


Fig. 17. Diagram of test connections of the time-overcurrent unit.

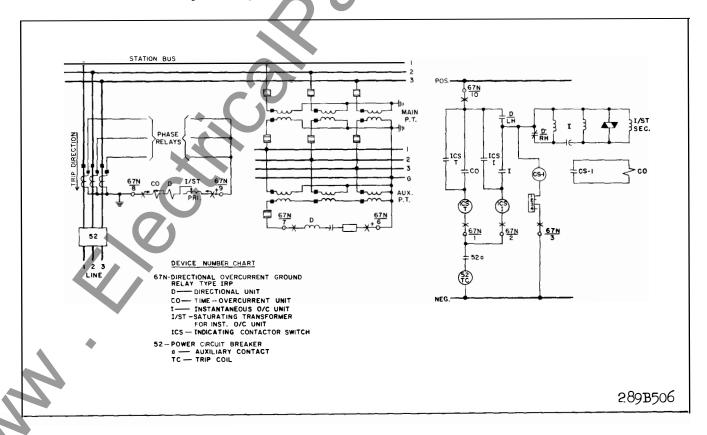


Fig. 18. External Schematic of the IRP Relay for Ground Fault Protection.

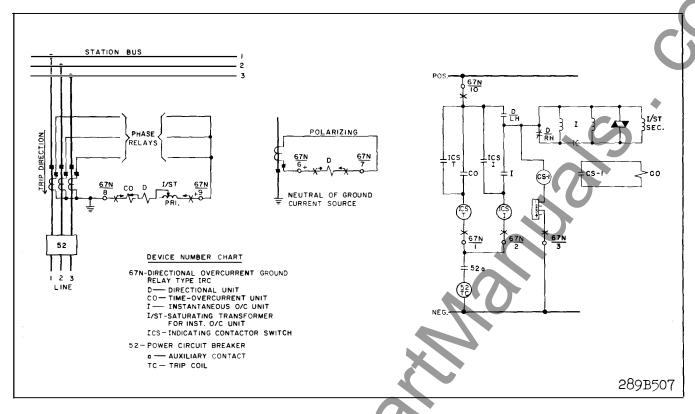


Fig. 19. External Schematic of the IRC Relay for Ground Fault Protection.

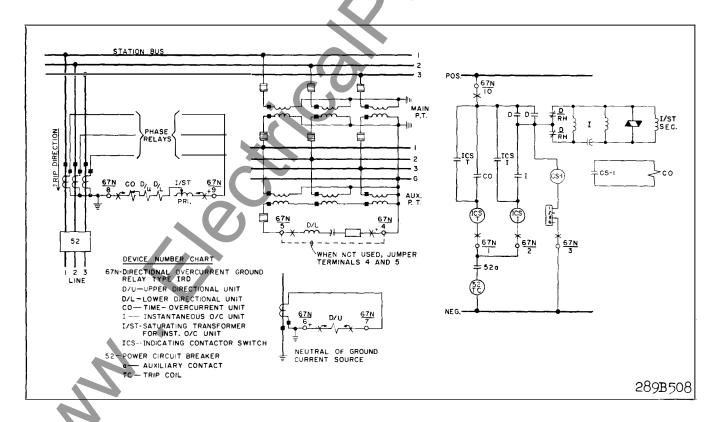


Fig. 20. External Schematic of the IRD Relay for Ground Fault Protection.

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) 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

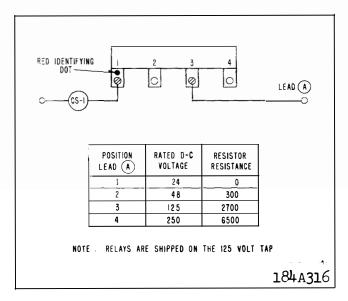


Fig. 21. Selection of Proper Voltage Tap for Auxiliary Switch (CS-1) Operation.

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 !
DIRECTIONAL UNIT SENSITIVITY

RELAY TYPE	AMPERE RATING OF	VALUES FOR MIN. PICKUP*		PHASE ANGLE RELATIONSHIP				
	TIME-OVERCURRENT UNIT	VOLTS	AMPERES					
IRP IRD (Voltage Unit)	.5-2.5	1	2.0	I lagging V by $60^{\circ}**$				
	2-6	1	4.0	I in-phasæ with V				
	4-12	1	4.0	I lagging V by $60^{\circ}**$				
		1	8.0	I in-phase with V				
_	5.0.5		0.5	Ioleading Ip by 400**				
IRC	.5-2.5							
IRD (Current Unit)	2-6		0.65	In-phase				
	4-12		1.0	Io leading Ip by 400**				
			1.3	In-phase				

^{*}The energization quantities are input quantities at the relay terminals.

^{**} Maximum torque angle.

TABLE II

DIRECTIONAL UNIT CALIBRATION †

RELAY RATING	CURRENT AMPERES	BOTH PLUGS IN CONDITION	ADJUSTMENT	
All Ranges	80	Spurious Torque In Contact Closing Direction (Left Front View)	Right (Front-View) Plug Screwed Out Until Spurious Torque is Reversed.	
All Ranges	80	Spurious Torque In Contact Opening Direction (Right Front View) (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.	

[†] 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

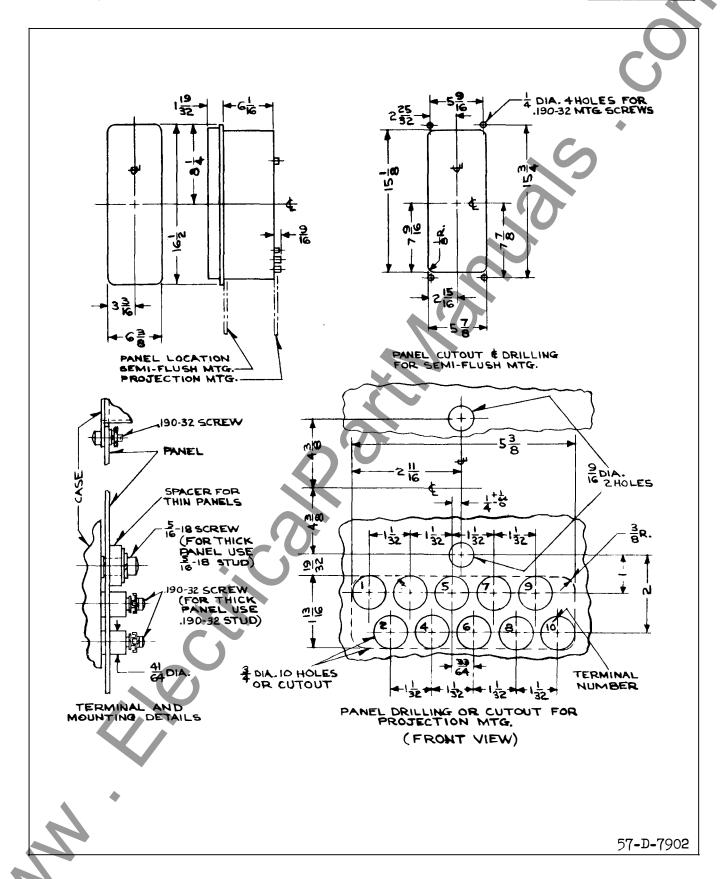


Fig. 22. Outline and Drilling Plan for the IRP and IRC Relays in the Type FT31 Case.

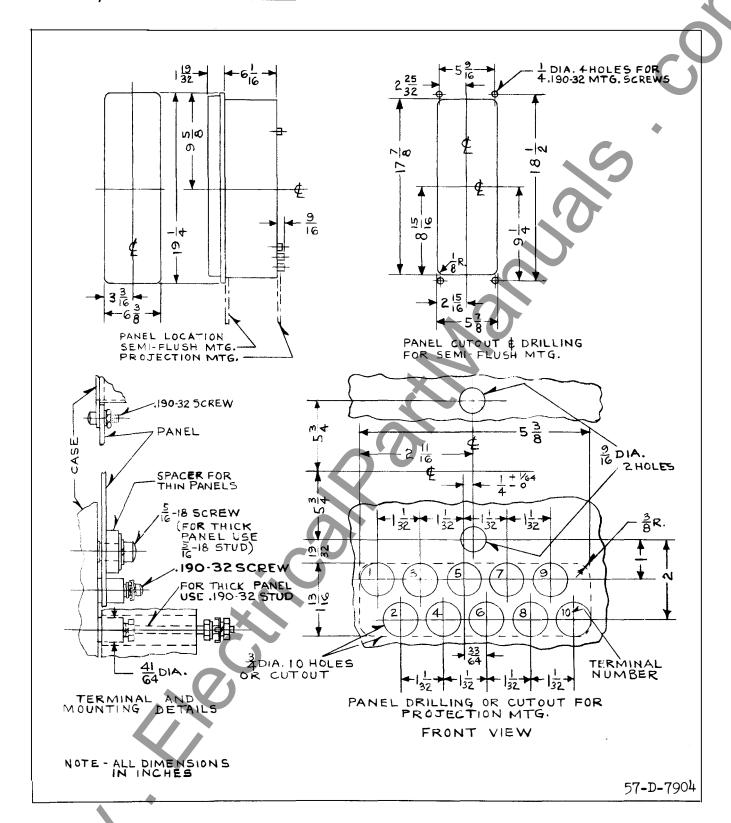


Fig. 23. - Outline and Drilling Plan for the IRD Relay in the Type FT41 Case.

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