INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE HRZ DIRECTIONAL IMPEDANCE OVERCURRENT RELAY

CAUTION

Before putting protective 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 setting and electrical connections.

APPLICATION

This relay is used for line protection, particularly in sub-transmission networks, where directional instantaneous-distance relay protection is desired over 80-90% of the protected line and directional time-overcurrent protection is required for the remainder of the line section.

CONSTRUCTION AND OPERATION

The Type HRZ Relay contains an instantaneous impedance unit (HZ), an overcurrent unit (CO), a directional unit (D), an auxiliary contactor switch and indicating contactor switches (ICS). When required, an instantaneous trip (IT) can also be supplied. *

Instantaneous Impedance Unit (HZ)

This unit is similar to the first impedance unit of the Type HZ Relay. It consists of a balanced beam pivoted at the center (Figure 3) and pulled downward by current coil force on the forward end to close the relay contacts. This pull is opposed by two voltage coils acting on the rear end of the beam. The fluxes set up by these two potential coils are shifted out of phase with respect to each other so that the balance between current and voltage fluxes can be held within desirable limits for all phase angles.

A tap screw on the front of the unit permits changing the number of turns on the current coil, and a core screw on the bottom of the unit changes an air gap in the magnetic path. These two adjustments make is possible to set the impedance unit so that it will operate instantaneously, for all faults occurring within 80 to 90% of the protected line section. For a fault at the balance point of the unit (determined by setting) the pull of the voltage coil, which measures the IZ drop from the fault to the relay, will just equal the pull of the current coil, which receives the fault current, I. If the fault occurs inside the balance point, the IZ voltage pull will be less than the I current pull and the beam will tip closing its contacts. Conversely, if the fault occurs outside the relay balance point, the IZ voltage pull will be greater than the I current pull and the beam will not tip.

A rectangular silver contact is flexibly fastened on the forward end of the beam. As the beam tips, the contact bridges two silver stationary hemispherical contacts mounted on the free end of a short leaf spring. A small set screw determines the position of the leaf spring and provides means for adjusting the contact gap and follow.

Overcurrent Unit (CO)

The relay is supplied with CO-6 (definite minimum), CO-7 (moderately inverse), CO-8 (inverse) or CO-9 (very inverse) time-overcurrent characteristics. The electromagnets have a main tapped coil located on the center leg of an "E" type magnetic laminated structure. The flux produced by the main coil crosses the air gap and the magnetic keeper and returns through the outer legs. A shading coil causes the flux through the one leg to lag the main pole flux. The out-of-phase fluxes thus produced in the air gap cause a contact closing torque.

Directional Unit (D)

A small voltage transformer causes a large current to flow in a single-turn movable aluminum secondary, which current is substantially in phase with the voltage. The current coils are mounted on a magnetic frame and the current and voltage elements are assembled at a right angle to each other with the one-turn voltage loop in the air gaps of the current coil flux path. The interaction of the current and voltage fluxes produces torque and rotates the loop

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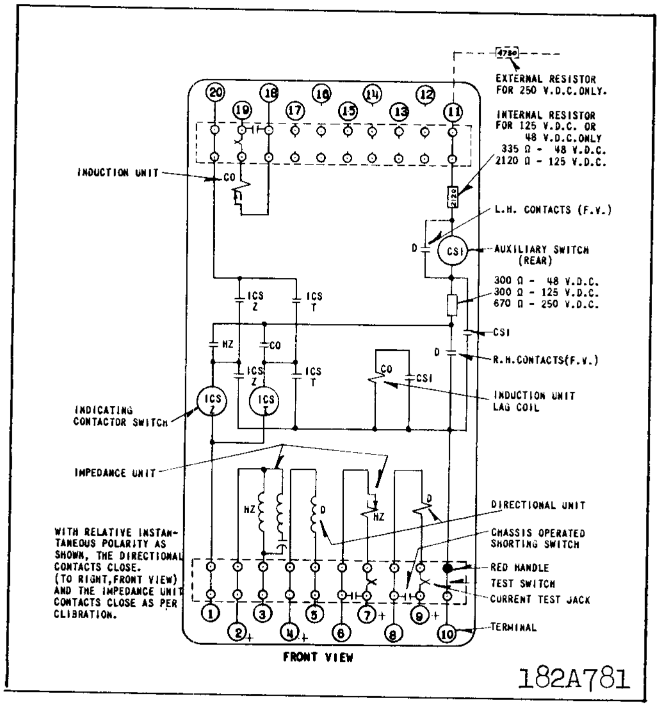
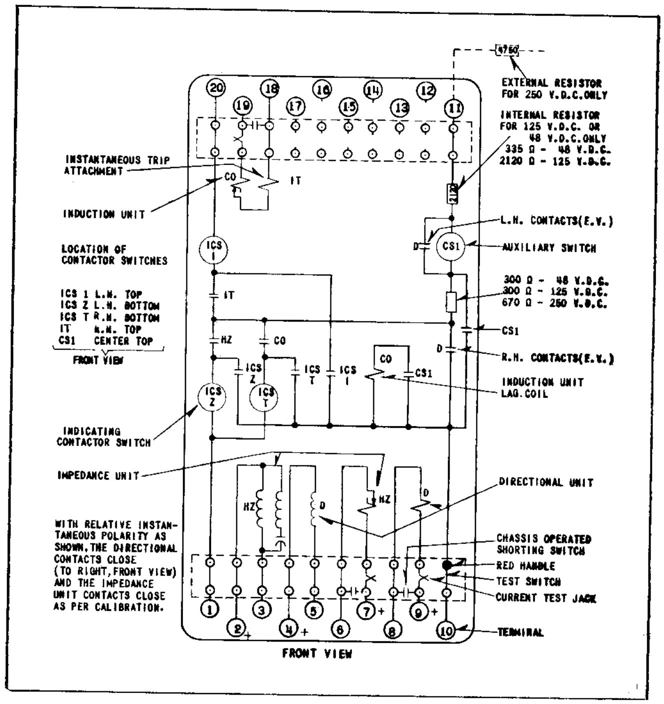
*Denotes change from superseded issue.



* *Fig. 1. Internal Schematic of the Type HRZ Relay in the FT32 Case.*



* *Fig. 2. Internal Schematic of the Type HRZ Relay with Indicating Instantaneous Trip Unit in the Type FT32 Case.*

in one of two directions, depending on the direction of power flow.

* When the directional unit is energized on voltage alone, there may be a small torque which may hold contacts either open or closed. This torque is small and shows up only at high voltages with the entire absence of current. At voltages high enough to make this torque discernible, it will be found that only a fraction of an ampere in the current coils will produce wattmeter torque to insure positive action. This is mentioned because the slight torque shown on voltage alone has no significance to actual service and has no practical effect on the directional element operation.

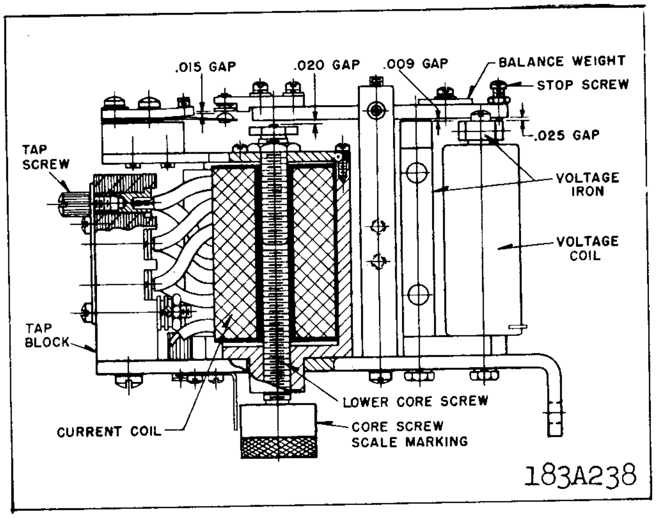
A ceramic arm extends from the moving loop and supports a rectangular silver contact which bridges two stationary contacts located on either side of the loop. The stationary contacts are silver hemispheres mounted on the lower end of vertically hanging spring leaves. The contact separation is adjustable by a small screw near the upper end of the right stationary contact supporting arm. One of these supporting arms hangs parallel to each of the four stationary contacts. The set screw on the lower end of this arm provides the contact follow adjustment. The additional screws on the movement frame beneath the current coil iron limit the movement of the one-turn loop.

Auxiliary Contactor Switch (CS1)

This unit is a small solenoid-type switch. A small cylindrical plunger with a silver disc supported on its lower end rides up and down on a vertical guide rod in the center of the solenoid coil. The guide rod is fastened to the stationary core which in turn screws into the element frame. When the coil is energized, the silver disc moves upward bridging three cone shaped stationary contacts. The operation of this D-C auxiliary switch is controlled by the directional unit which in turn directionally controls the CO overcurrent unit. When fault current flows in the tripping direction, the auxiliary contactor switch operates to short circuit the lag coil of the CO unit. If the direction of the fault current reverses, a contact on the directional unit short circuits the auxiliary contactor switch coil, causing it to drop out. When CS1 drops out, the directional control circuit of the CO unit is opened.

Indicating Contactor Switch (ICS)

The d-c indicating contactor switch is a small clapper type device. A magnetic armature, to which



* *Fig. 3. Sectional View of the Impedance Unit (HZ)*

leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contacts, completing the trip circuit. Also, during this operation two fingers on the armature deflect a spring located on the front of the switch, which allows the operation indicator target to drop. The target is reset from the outside of the case by a push rod located at the bottom of the cover.

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

* **Instantaneous Trip (IT) (When Used)**

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

A core screw accessible from the top of the switch provides the adjustable pick-up range. The minimum and maximum pick-up points are indicated on the scale, which is located to the rear of the core screw.

CHARACTERISTICS

Burden and thermal ratings are listed under "Energy Requirements".

Impedance Unit (HZ)

This unit has the following markings:

0.2 – 2.0 ohms range

Tap = 2, 3, 4, 6, 9, 13
Core Screw = .8, .9, 1.0, 1.1, 1.2, 1.4, 1.6

0.6 – 6.0 ohm range

Tap = 6.2, 9.4, 13.5, 20.8, 29.8, 45
Core Screw = .8, .9, 1.0, 1.1, 1.2, 1.3, 1.4

Figures 4 to 7 show additional characteristics.

Balance Point Voltage

For accurate impedance measurement the relay voltage should be at least 5 volts for a fault at the balance point.

Overcurrent Unit (CO)

The overcurrent unit taps are:

2 – 6 Amp. Range

2	2.5	3	3.5	4	5	6

4 – 12 Amp. Range

4	5	6	7	8	10	12

The tap value is the minimum current required to just close the contacts. The moving contacts will leave the time dial stop, regardless of the time dial setting, and move to touch the stationary contacts at tap value current.

The time-current characteristics are shown in Figs. 8 to 11. 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.

Directional Unit (D)

Maximum torque occurs when the relay voltage and current are in phase. Sensitivity at the maximum torque angle is 10 amperes and 2 volts or 2 amperes and 10 volts.

Trip Circuit

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

* The indicating contactor switch has a pick-up of approximately 1 ampere. Its d-c resistance is 0.1 ohms.

ENERGY REQUIREMENTS

CO-6 DEFINITE MINIMUM TIME RELAY

AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE ϕ	VOLT AMPERES** AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
	(0.5	2	56	69	3.92	20.6	103	270
	(0.6	2.2	56	68	3.96	20.7	106	288
	(0.8	2.5	56	67	3.96	21	114	325
0.5/2.5	(1.0	2.8	56	66	4.07	21.4	122	360
	(1.5	3.4	56	62	4.19	23.2	147	462
	(2.0	4.0	56	60	4.30	24.9	168	548
	(2.5	4.4	56	58	4.37	26.2	180	630
	(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

CO-7 MODERATELY INVERSE TIME RELAY

AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE ϕ	VOLT AMPERES** AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
	(0.5	2	56	68	3.88	20.7	103	278
	(0.6	2.2	56	67	3.93	20.9	107	288
	(0.8	2.5	56	66	3.93	21.1	114	320
0.5/2.5	(1.0	2.8	56	64	4.00	21.6	122	356
	(1.5	3.4	56	61	4.08	22.9	148	459
	(2.0	4.0	56	58	4.24	24.8	174	552
	(2.5	4.4	56	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

CO-8 INVERSE TIME AND CO-9 VERY INVERSE TIME OVERCURRENT UNITS

AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE ɸ	VOLT AMPERES** AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
	(0.5	2	56	72	2.38	21	132	350
	(0.6	2.2	56	71	2.38	21	134	365
	(0.8	2.5	56	69	2.40	21.1	142	400
0.5/2.5	(1.0	2.8	56	67	2.42	21.2	150	440
	(1.5	3.4	56	62	2.51	22	170	530
	(2.0	4.0	56	57	2.65	23.5	200	675
	(2.5	4.4	56	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.[illegible]6	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.*

ɸ *Degrees current lags voltage at tap value current.*

** *Voltages taken with Rectox type voltmeter.*

DIRECTIONAL UNIT SERIES COIL

Rating	V.A. at 5 Amperes	Power Factor	One Second Rating (Amperes)
5	3.5	45^{o} lag	140

DIRECTIONAL UNIT POTENTIAL POLARIZING COIL, ALONE

Rating	V.A. at 120 Volts	Power Factor
120 V	10	28^{o} lag

IMPEDANCE UNIT CURRENT COILS

Tap	V.A. at 5 Amperes	Power Factor
45	2.0	30^{o} lag
13.5	0.55	30^{o} lag

IMPEDANCE UNIT POTENTIAL COILS

V.A. at 120 Volts	Power Factor
2	20^{o} lag

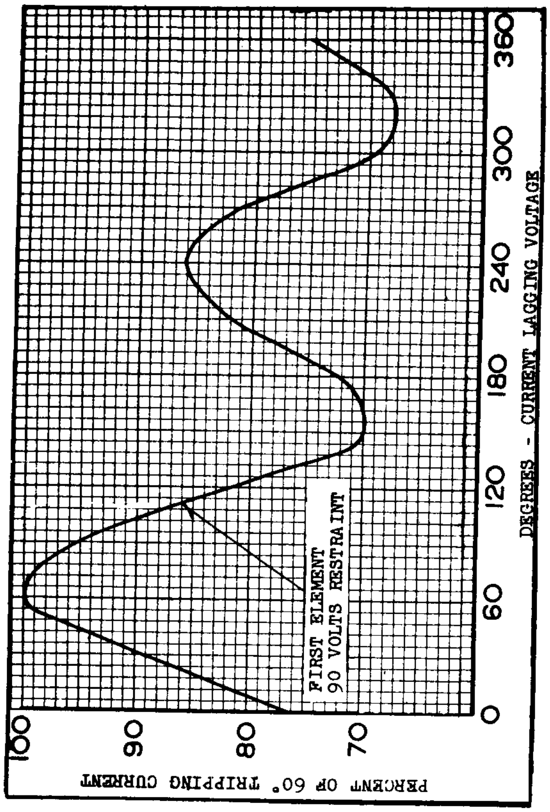


Fig. 5. Typical Phase Angle Curve of the Impedance Unit (HZ)

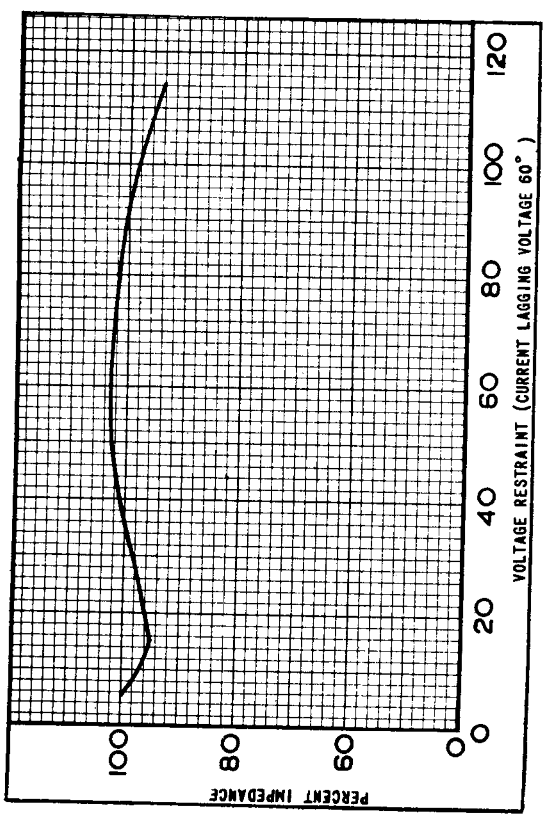


Fig. 4. Typical Impedance Curve of the Impedance Unit. (HZ)

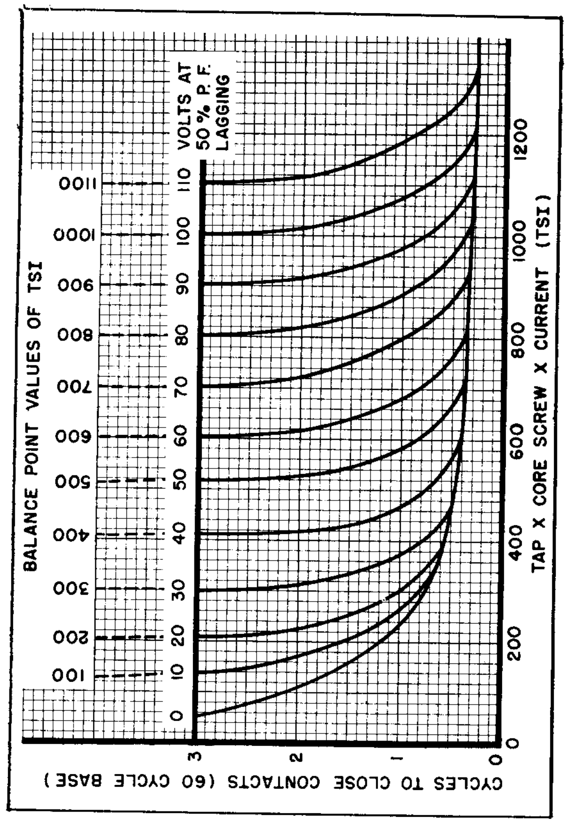


Fig. 7. Typical Time Curves of the Impedance Unit (HZ)

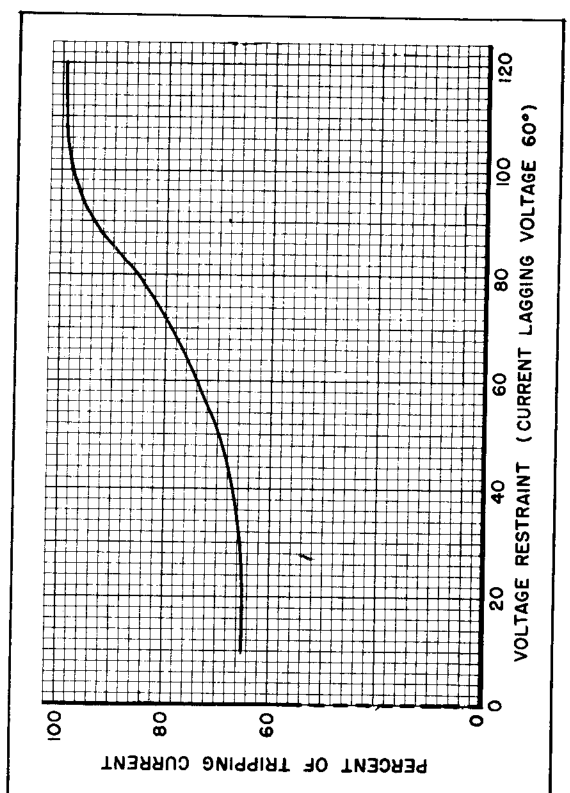


Fig. 6. Typical Reset Curve of the Impedance Unit (HZ)

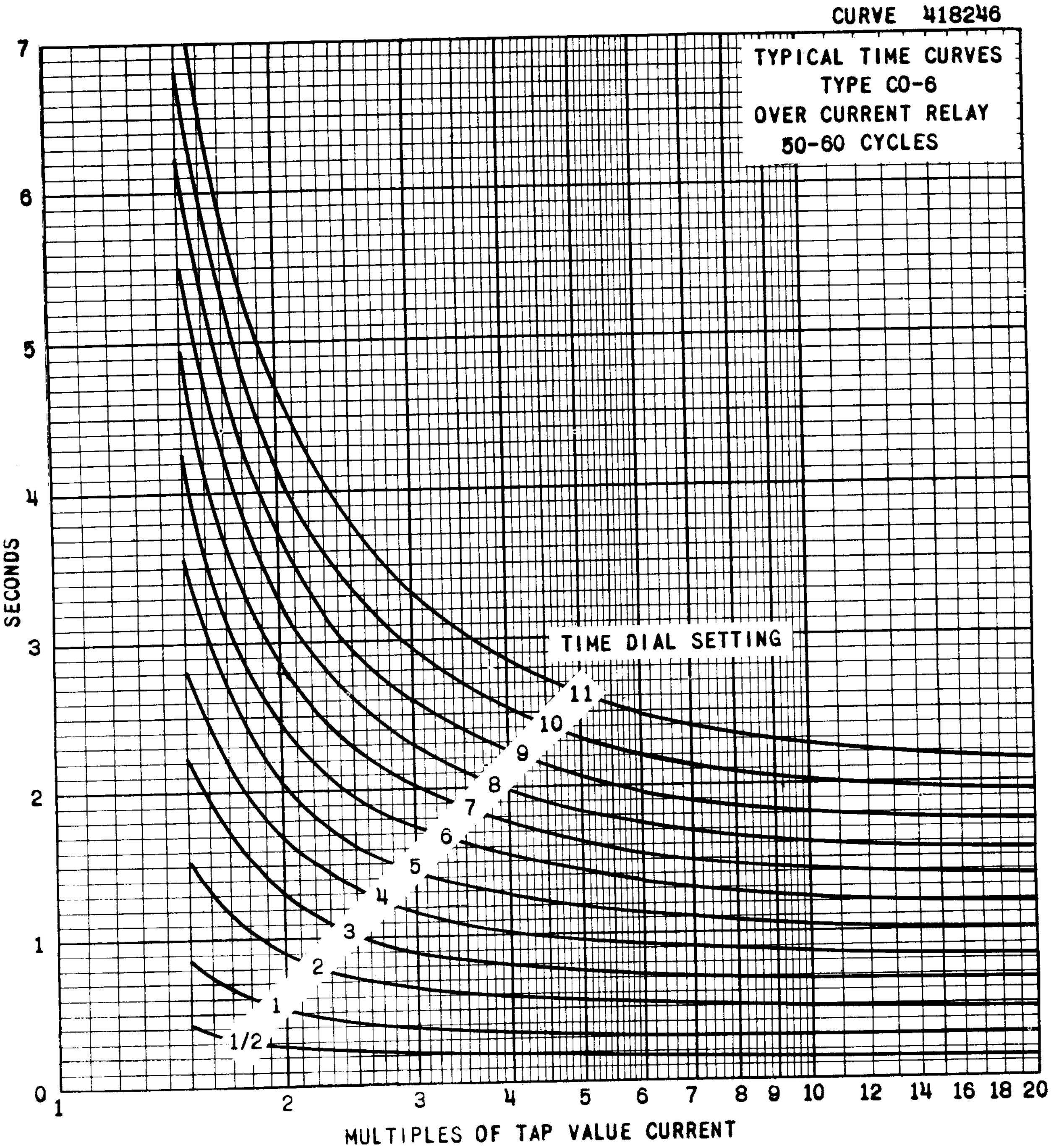


Fig. 8. Typical Time Curves of the Definite Minimum Time Overcurrent Unit (CO-6)

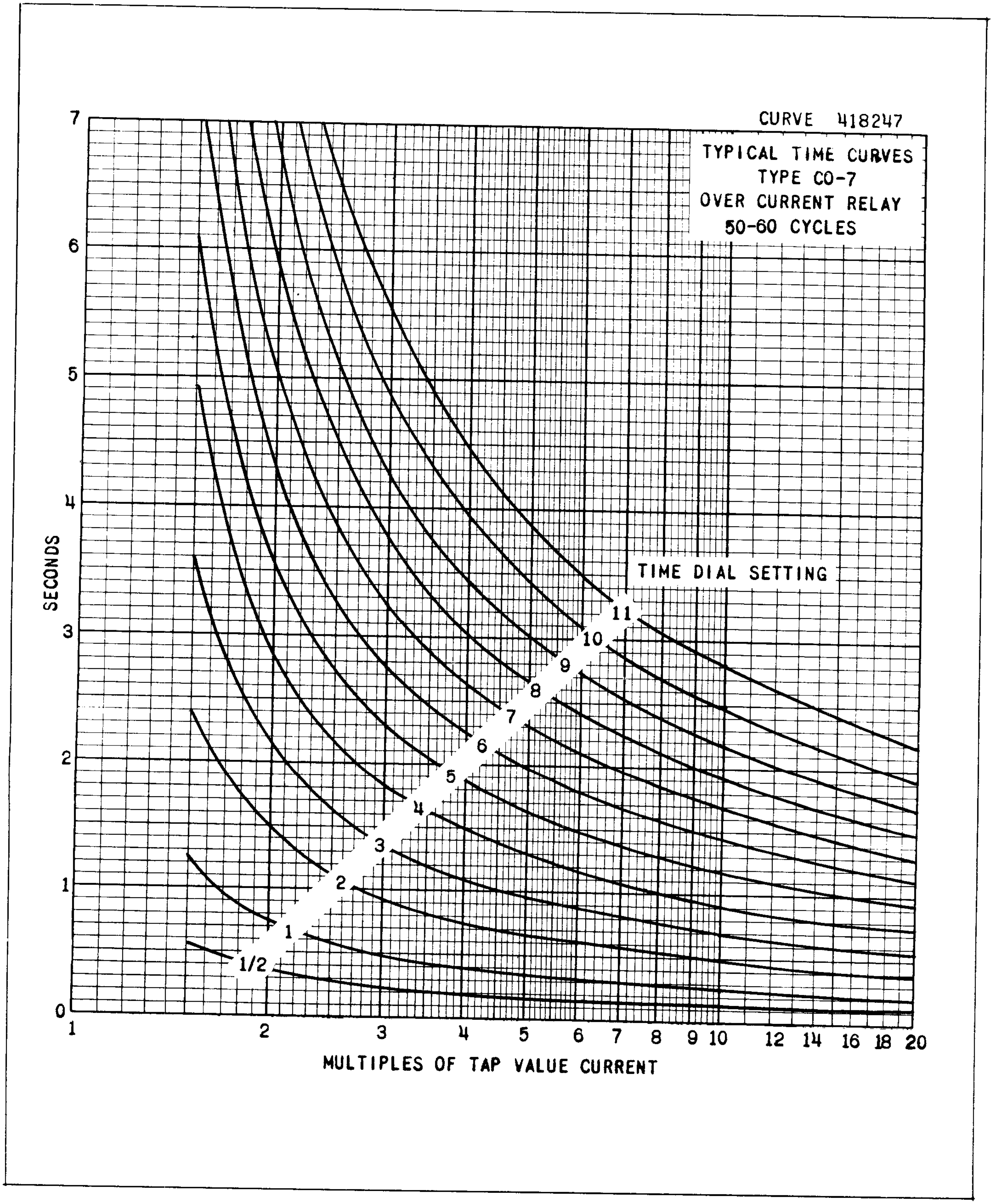


Fig. 9. Typical Time Curves of the Moderately Inverse Time Overcurrent Unit (CO-7)

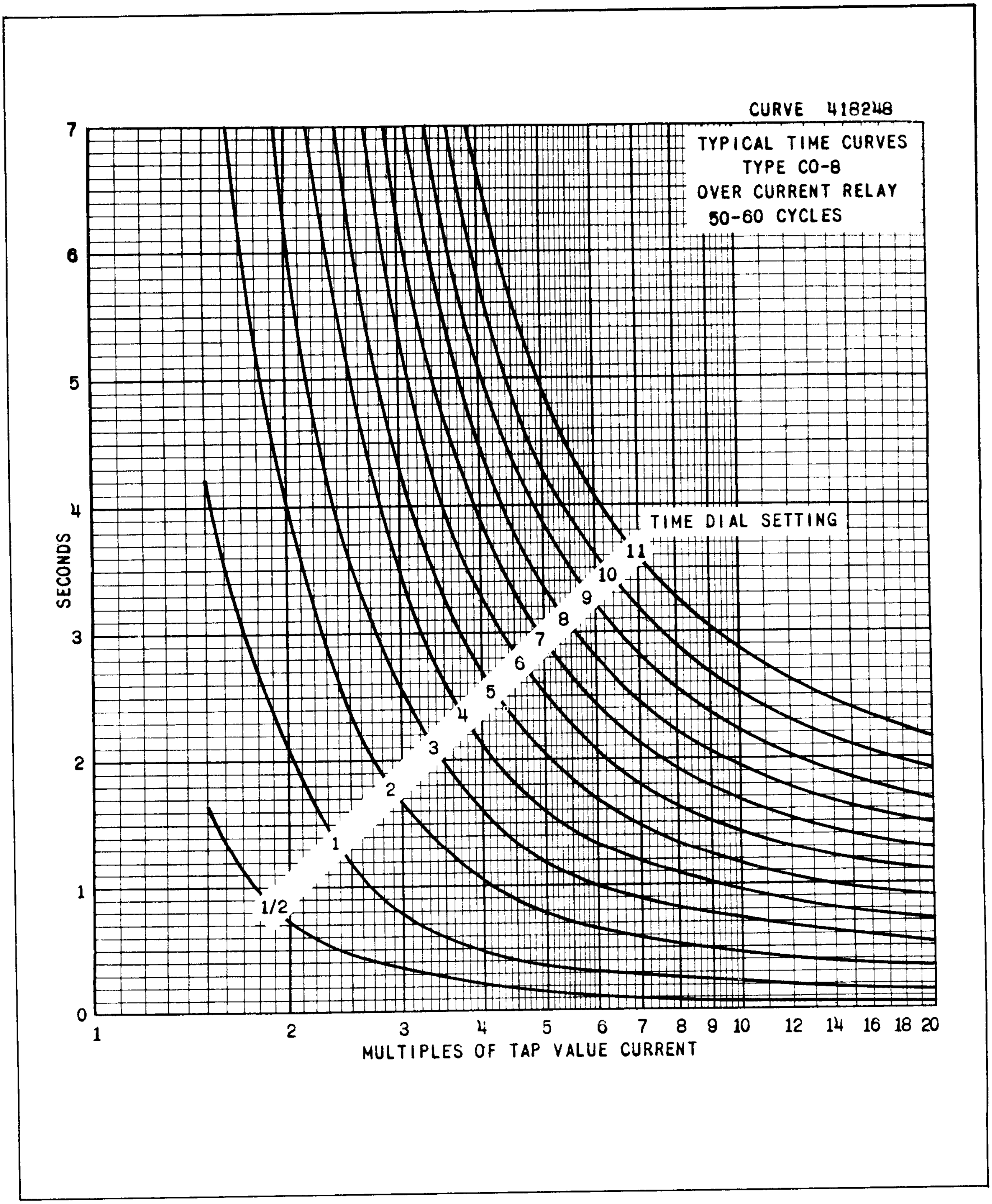


Fig. 10. Typical Time Curves of the Inverse Overcurrent Unit (CO-8)

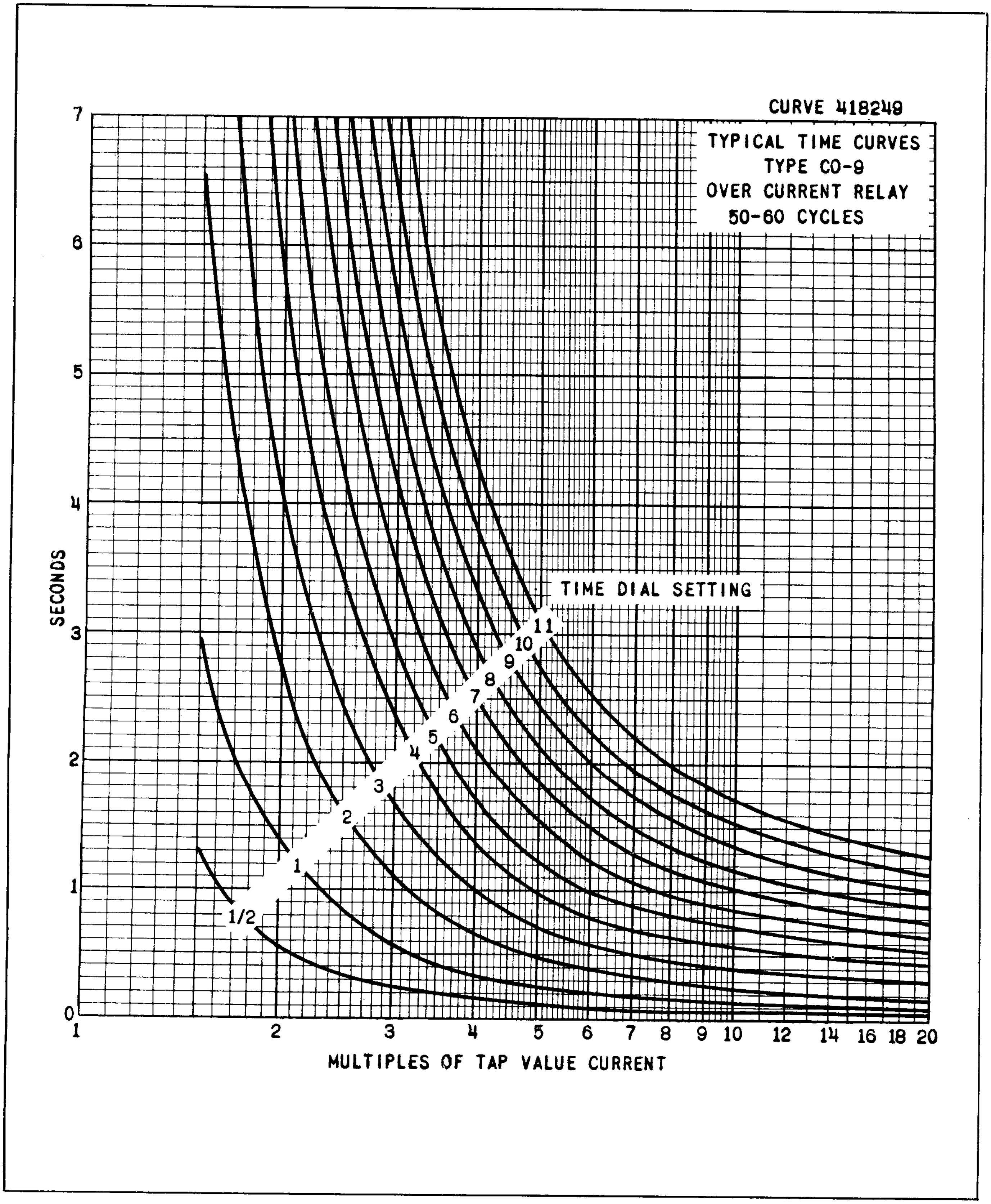


Fig. 11. Typical Time Curves of the Very Inverse Overcurrent Unit (CO-9

SETTING CALCULATIONS

Impedance Unit (HZ)

The following nomenclature is used:

Z = desired line-to-neutral ohmic reach referred to protected line voltage

R_c = main current transformer ratio (e.g. 400/5 or 80)

R_v = potential transformer ratio

T = relay current tap

S = relay core screw marking

This unit is set to give instantaneous protection over approximately 90% of the protected line section. Since the impedance of the voltage coil is the same at all times, the balance point of the unit is adjusted by changing the pull on the current coil. This is done by taps (T) on the current coil winding and by the core screw (S) which varies the magnetic air gap for the current flux.

The most satisfactory method of arriving at the tap settings is by the use of the following equation:

$$TS = \frac{10\ Z\ R_c}{R_v} \qquad (1)$$

Select tap, T, so that, when divided into the desired TS product, the required core screw setting is within the available range. Since the core screw is continuously adjustable, it may be set in between the markings.

* Equation (1) applies if the protected line section impedance angle is 60°. At other line angles the settings can be corrected by using Fig. 5. For example, if the line angle is 45°, the unit will operate at 96% of the 60° tripping current. Therefore, reduce the TS product by 4% (100% – 96%).

The formula settings are sufficiently accurate for most installations. When it is desired to set the balance point more accuratley the tap and scale values may be checked by applying to the relay the voltage, current and phase angle values, which will be impressed on it for a fault at the desired balance point. A slight change in the scale value from that calculated may be required so that the relay will just trip for the simulated fault at the balance point.

Setting Example

Assume:

Impedance of protected line at rated voltage = 6 ohms

Current transformer ratio = R_c = 200/5 = 40

Potential transformer ratio = R_v = 120,000/120 = 1000

Impedance range = 0.2-2.0 ohms

Desired reach = 90% of protected line

From equation (1):

$$TS = \frac{10 \times 0.90 \times 6 \times 40}{1000} = 2.16$$

Set in 2 tap, then:

$$S = \frac{TS}{T} = \frac{2.16}{2} = 1.08$$

Overcurrent Unit (CO)

The 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, 2 time dial position or 4 tap, 0.6 seconds at 6 times tap value current).

Determine the desired tap. (A pickup setting of approximately twice full load is recommended.) Determine the desired time of operation at the current magnitude representing the most critical in the coordination with adjacent relays. A minimum coordinating time interval of 0.3 seconds plus adjacent circuit breaker time is recommended between the relay being set and the relays with which coordination is to be effected. For example, if the adjacent relays operate in 20 cycles for the critical fault condition and the adjacent breakers operate in 5 cycles, then, at the critical current magnitude, set time of operation at 20 + 5 + 0.3 x 60 = 43 cycles.

Enter the time current curves (Figs. 8 to 11) by determining the set point current in terms of multiples of tap value current and by using the desired time of operation at this current. Then, estimate the time dial position.

Instantaneous Trip (IT)

The pick-up current is continously adjusted by means of the core screw. The scale plate indicates only the minimum and maximum screw positions, so that this unit must be set by application of pick-up current.

SETTING THE RELAY

The following settings must be performed:

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

Impedance Unit (HZ)

Set the current tap and adjust the core screw.

The numbers on the core screw appear in ascending order as the core screw is screwed into the core. In some cases, a question of doubt may arise as to whether the scale setting is correct, or is out by one full turn of the core screw. In such a case, the point may be verified by turning the core screw all the way in. Then back out the core screw until the highest scale marking and then continuing to back it off until the desired value appears exactly under the end of the pointer. Sufficiently accurate setting can be made by interpolating between the marked points when necessary. Sufficiently accurate settings can be made by interpolating between the marked points. Where it is desired to set the balance point more accurately the tap and scale values may be checked by applying to the relay the voltage, current and phase angle values which will be impressed on it for a fault at the desired balance point.

Directional Unit (D)

There are no settings to be made on the directional unit.

Overcurrent Unit (CO)

Set the required tap and time dial position. The time may be set by inspection or by applying current and adjusting the dial for the desired time of operation.

Indicating Conductor Switch (ICS)

No setting is required on the ICS unit.

Instantaneous Trip (IT)

Since the minimum and maximum markings on the scale only indicate the working range of the core screw, the core screw must be adjusted to the value of pick-up current desired.

The nameplate data will furnish the actual current range that may be obtained from the IT unit.

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 four mounting holes on the flange for semi-flush mounting or by means of the rear mounting stud or studs for projection mounting. Either a mounting stud or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the 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 stud and then turning the proper nut with a wrench.

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

The resistance of the auxiliary tripping relay coil circuit (if used) should be less than 35 ohms for 125 volt d-c HRZ relays and less than 70 ohms for 250 volt d-c HRZ relays. If the coil resistance exceeds these values, a loading resistor should be connected in parallel with the coil.

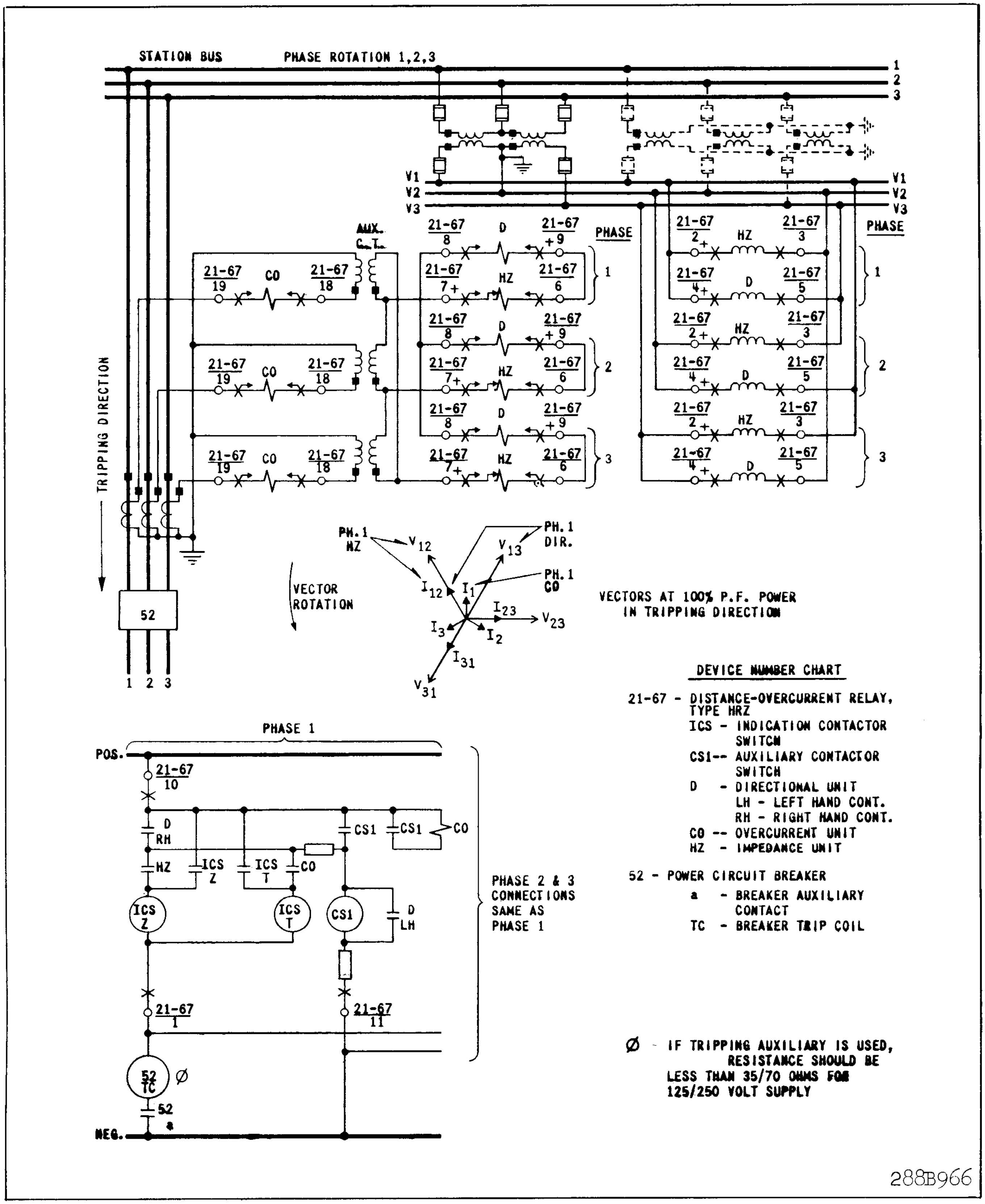
ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory. Upon receipt of the relay no adjustments are required except those described under "Setting the Relay".

Caution

The relay voltage should be of good wave form. The combination of a phase shifter and autotransformer may give an output voltage of poor wave form if the magnetizing current of the autotransformer is high in proportion to the impedance of the phase shifter used. In case of doubt, check the output voltage wave form with an oscilloscope.

Phantom loads should not be used in testing induction-type relays because of the resulting dis-



* *Fig. 12. External Schematic of the HRZ Relay for Line Protection.*

torted current wave form which produces an error in timing.

Acceptance Check

The following checks are recommended to insure that the relay is in proper working order:

Impedance Unit

0.2-2.0 ohm range

Connect per Fig. 13. Set in 13 tap and 1.6 core screw. Energize with 35 volts and minimum tripping current at 60°, current lagging voltage. Operation should occur at approximately 16.8 amperes. Then, set core screw at 0.8 and repeat test. Operation should occur at approximately 33.7 amperes.

0.6-6.0 ohm range

Connect per Fig. 13. Set in 20.8 tap and 1.4 core screw. Energize with 35 volts and minimum tripping current at 60°, current lagging voltage. Operation should occur at approximately 12 amperes. Then, set core screw at 0.8 and repeat test. Operation should occur at approximately 21.1 amperes.

Directional Unit

Apply 2 amperes and 10 volts, in phase, with the connections of Fig. 13 and see that the right-hand contact closes positively. Reverse the current direction and see that the left-hand contact closes positively.

Check the coordination of the directional unit and impedance unit, as described below, with connections per Fig. 13. Set the impedance unit on the maximum tap and scale setting. Apply 115 volts a-c to the impedance and directional unit potential coils and pass 5 amperes at unity power factor through the current circuit. Check the trip circuit to see that it is not completed when the voltage on the impedance and directional units is suddenly applied or interrupted. Do not interrupt the current circuit. Make several such tests. The trip circuit should be connected with the loading resistor for this test. This coordination test has been described for the most severe conditions. Consequently, an occasional failure to coordinate may be tolerated, since, in service, the directional units will be resetting under the positive action of reverse power flow rather than under the influence of gravity alone, as described in this test. If proper coordination is not obtained, reduce the follow on the directional or impedance unit contacts.

Overcurrent Unit (CO)

By turning the time dial, move the moving contacts until they deflect the stationary contact to a position where the stationary contact is just resting against its backstop. The index mark located on the movement frame should coincide with the "O" mark on the time dial.

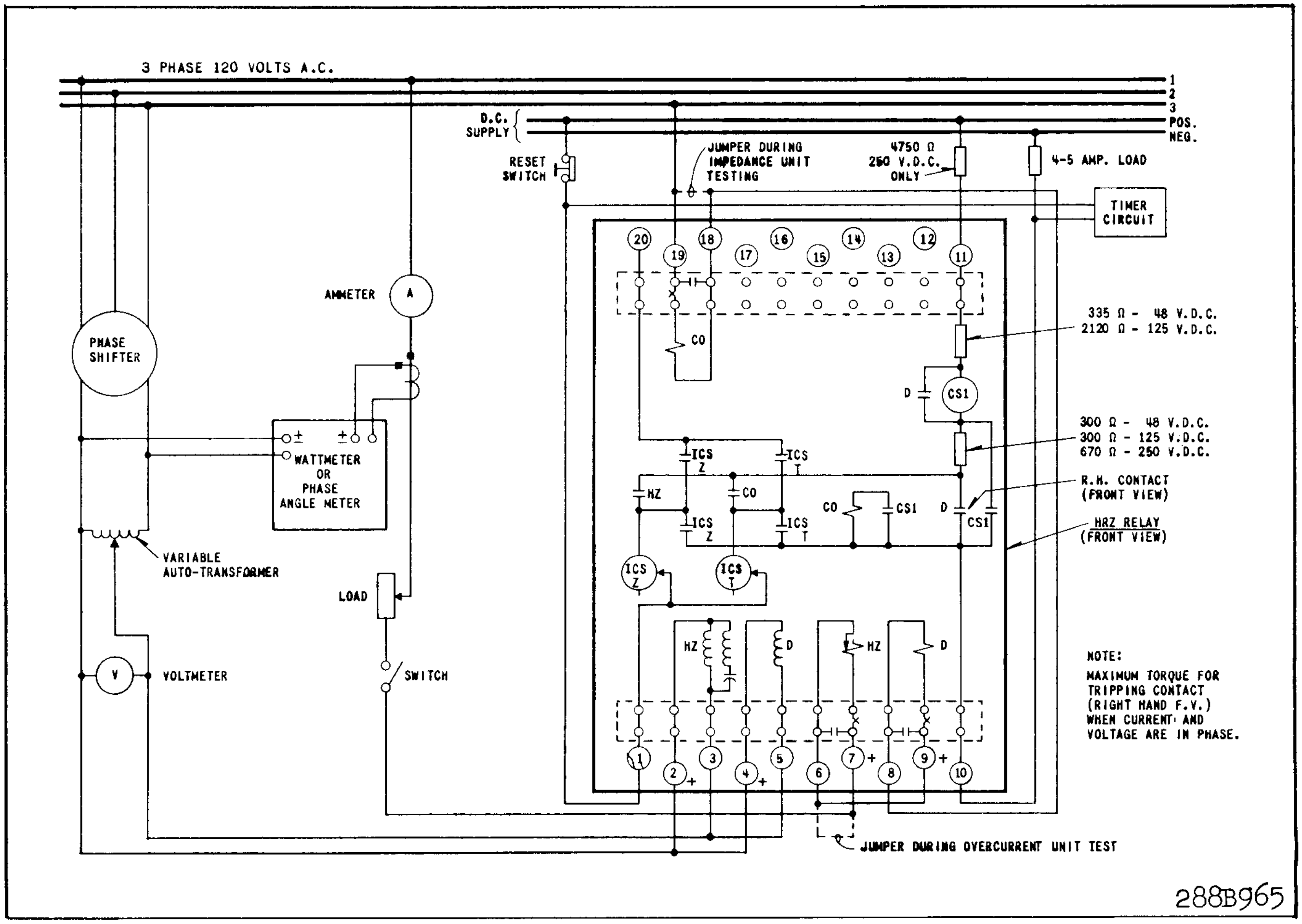
Set the time dial to position 6. Alternately apply tap value current plus 3% and tap value current minus 3%. The moving contact should leave the backstop at tap value current plus 3% and should return to the backstop at tap value current minus 3%.

Table I 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 I. (e.g. for the CO-8, 2 and 20 times tap value current) and measure the operating time of the relay. The operating times should equal those of Table I plus or minus 5 percent.

TABLE I

TIME CURVE CALIBRATION DATA – 60 CYCLES

	PERMANENT MAGNET ADJUSTMENT			ELECTROMAGNET PLUGS	
RELAY TYPE	TIME DIAL POSITION	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS
CO–6	6	2	2.46	20	1.19
CO–7	6	2	4.27	20	1.11
CO–8	6	2	13.35	20	1.11
CO–9	6	2	8.87	20	0.65



*✱ **Fig. 13. Diagram of Test Connections for the Type HRZ Relay in the Type FT32 Case.***

✱ Instantaneous Trip Unit (IT)

The core screw, which is adjustable from the top of the trip unit determines the pick-up value. The trip unit has a nominal radio of adjustment of 1 to 4 and an accuracy within the limits of 10%.

Apply sufficient current to operate the IT.

Directional Control Circuit

With the relay connected per Fig. 13, apply 110% of rated d-c voltage and see that the CS1 unit operates. Then apply 70% of rated d-c voltage, close the left-hand directional contact, and see that CS1 resets. Now suddenly apply 50 volts, 10 amperes, in phase, to the directional unit, with rated d-c voltage on CS1 circuit, and see that the CS1 contacts close positively.

Routine Maintenance

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.

Connect the relay per Fig. 13 and apply current and voltage of the approximate magnitude and phase angle, which are encountered by the impedance unit during faults. Observe the relay for proper functioning. Check the timing of the (X) unit at one or two currents, which are critical for the specific application. ✱ Check the pickup point of the instantaneous trip, when used.

Calibration

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

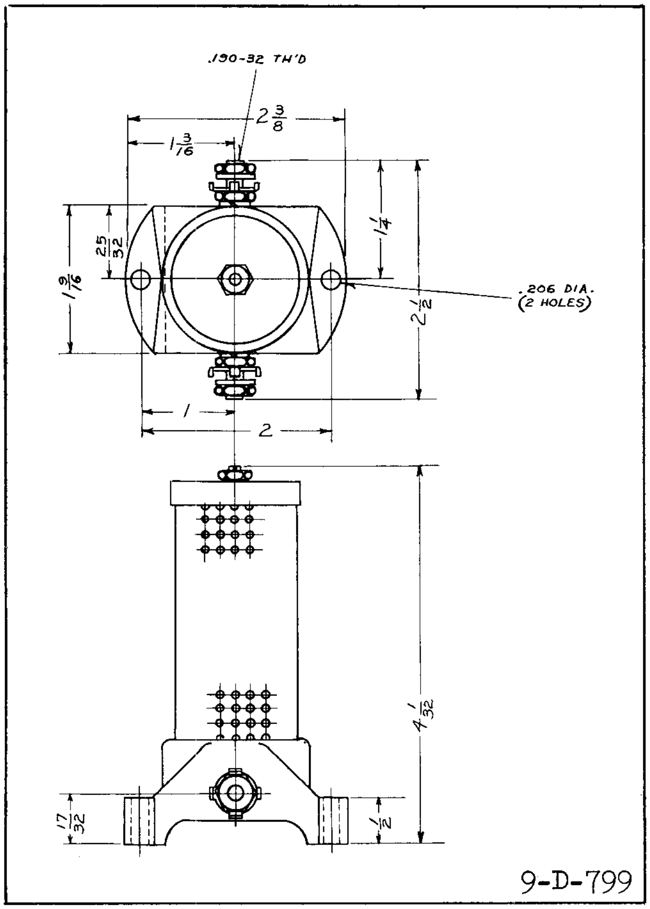


Fig. 14. Outline and Drilling Plan for the External Resistor Used with 250 Volt Trip Circuits.

Impedance Unit

Refer to Fig. 3. For the 60-cycle relays adjust the stop screw on the rear of the beam to give a clearance of .025 inch between the rear of the beam and the voltage iron circuit. This may be checked with a feeler gauge. With the beam in the reset position, i.e., back against the stop, adjust the gap between the adjustable iron and the beam to .009 inch. Care should be taken in this adjustment to keep the gap the same on both sides. Also, with the beam in the same position, adjust the gap between the front end of the beam and the stop in the upper core screw to .020 inch.

The beam should be balanced as follows. Connect the relay as shown in the test diagram, Fig. 13. With any tap and scale setting, check the impedance measured by the relay with 35 volts potential restraint. Then apply 5 volts restraint and adjust the balance weight on the beam until the beam just trips
* with 1/7 of the current required to trip with 35 volts restraint. Make certain that the stop on the voltage side is absolutely clean, otherwise the impedance at which the beam trips may be affected, particularly at the low voltages. The stop can be easily cleaned by drawing a piece of clean white paper between the beam and the stop while the beam is firmly pressed down.

The stationary contacts should be adjusted to give .015 inch clearance between them and the silver bridge on the beam when the beam is in the reset position. The bridge should be made to touch both contacts simultaneously, and deflect the contact springs at least .010 inch before the beam strikes the bronze stop on the core screw.

It is difficult to accurately adjust the contacts by eye. A good method consists of first adjusting one of the contacts to the correct gap and then applying just sufficient current to trip the beam against a restraint of about 5 volts. While the beam is in this position, that is, lighting pressing on the one contact, the other contact should be slowly adjusted upward by means of the set screw until it just touches the silver bridge without lifting it off the other contact. The trip circuit should be energized so that the lighting of a lamp or the tripping of an auxiliary relay will show when both contacts are made.

A further caution in regard to the contact adjustment is that too much follow or deflection of the stationary contacts will slightly delay the resetting of the impedance unit and thus the directional unit contacts may get closed before the impedance contacts are open and result in unnecessary tripping.

Directional Unit

With the loop in the vertical position adjust the front and back stationary contacts for .020 inch separation from the vertical moving contact. Adjust the contact back stop screws to just touch the stationary contacts, then back off 1/4 of a turn to give correct contact follow. Adjust the two stop screws which limit the movement of the loop (these screws are located to the rear of the current coil) so that the loop strikes the stops at the same instant the stationary contacts strike their back stop.

Too much follow on the directional unit contacts should be avoided in order to allow the directional unit to reset fast enough by gravity to properly coordinate with the high speed impedance unit.

Energize the loop with normal potential long enough to bring it up to temperature (about 10 or 15 minutes) and adjust the bearing screws so there is about .010 inch end play. See that the loop does not bind or strike against the iron or coil when pressed against either end jewel.

Overcurrent Unit (CO)

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.

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%.

For time calibration install the damping magnet and use the following procedure:

Apply twice tap value current with the time dial at 6, and measure the operating time. Adjust the permanent magnet keeper until the operating time corresponds to the value of Table I.

Apply 20 times tap value current and measure the operating time. Adjust the proper electromagnet plug until the operating- time corresponds to the value in Table I. (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.

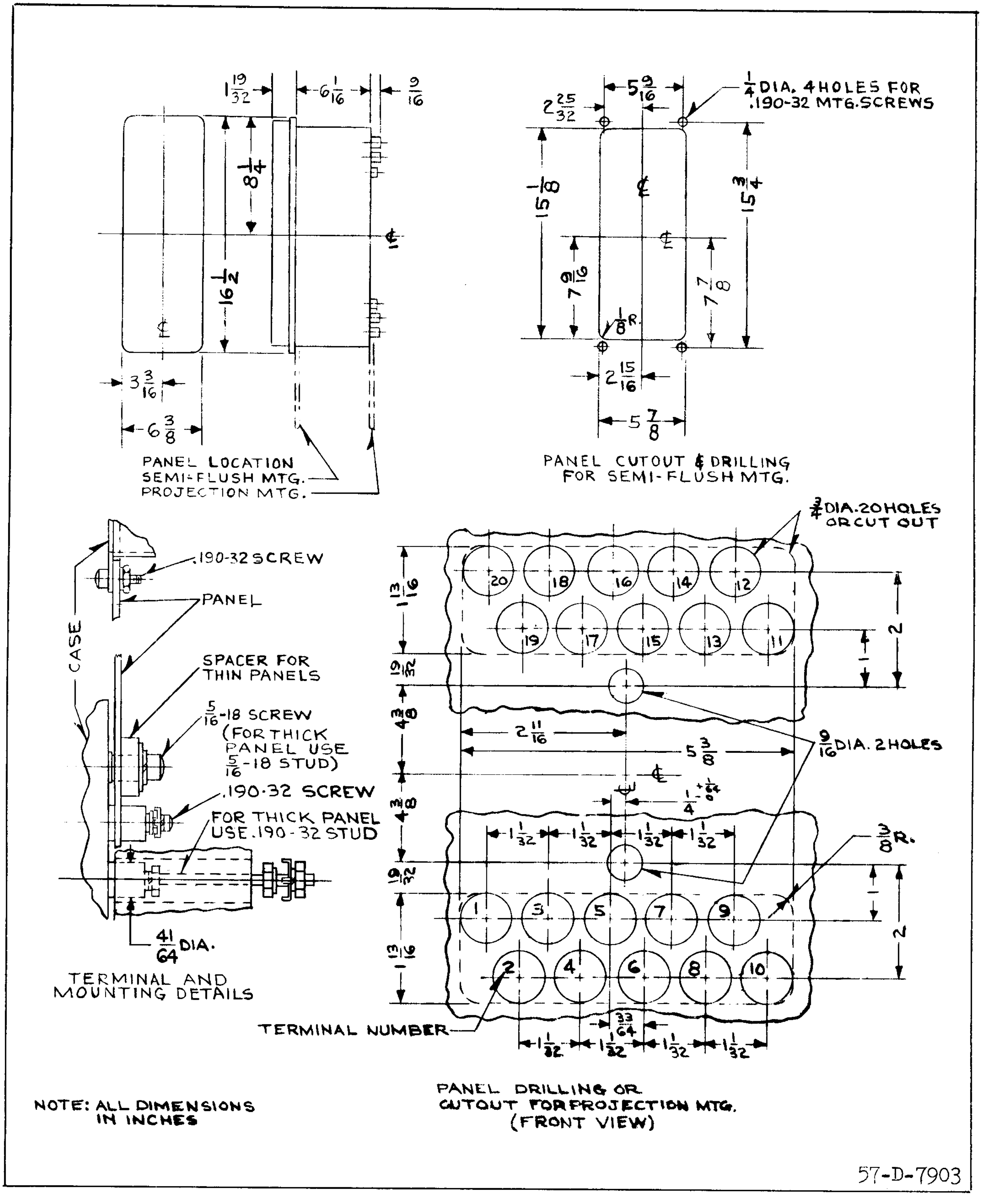
Recheck the permanent magnet adjustment. If the operating time for this calibration point has changed, readjust the permanent magnet and then recheck the electromagnet plug adjustment.

CS1 Unit

Turn the relay upside down. Screw up the core screw until the contact ring starts rotating. Now back off the core until the contact ring stops rotating. Back off the core screw one more turn and lock in place. Adjust the two nuts at the bottom of the switch so that there is 3/64 inch clearance between the moving contact ring and the stationary contacts in the open position. The guide rod may be used as a scale as it has 52 threads per inch, therefore, 2-1/2 turns of the nuts will equal approximately 3/64 inch.

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. 15. Outline and Drilling Plan for the Type HRZ Relay in the Type FT32 Case.*

WESTINGHOUSE ELECTRIC CORPORATION
RELAY DEPARTMENT
NEWARK, N. J.
Printed in U. S. A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE HRZ DIRECTIONAL IMPEDANCE OVERCURRENT RELAY

CAUTION

Before putting protective 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 setting and electrical connections.

APPLICATION

This relay is used for line protection, particularly in sub-transmission networks, where directional instantaneous-distance relay protection is desired over 80-90% of the protected line and directional time-overcurrent protection is required for the remainder of the line section.

CONSTRUCTION AND OPERATION

The Type HRZ Relay contains an instantaneous impedance unit (HZ), an overcurrent unit (CO), a directional unit (D), an auxiliary contactor switch and indicating contactor switches (ICS). When required, an indicating instantaneous trip (IIT) can also be supplied.

Instantaneous Impedance Unit (HZ)

This unit is similar to the first impedance unit of the Type HZ Relay. It consists of a balanced beam pivoted at the center (Figure 3) and pulled downward by current coil force on the forward end to close the relay contacts. This pull is opposed by two voltage coils acting on the rear end of the beam. The fluxes set up by these two potential coils are shifted out of phase with respect to each other so that the balance between current and voltage fluxes can be held within desirable limits for all phase angles.

A tap screw on the front of the unit permits changing the number of turns on the current coil, and a core screw on the bottom of the unit changes an air gap in the magnetic path. These two adjustments make is possible to set the impedance unit so that it will operate instantaneously, for all faults occurring within 80 to 90% of the protected line section. For a fault at the balance point of the unit (determined by setting) the pull of the voltage coil, which measures the IZ drop from the fault to the relay, will just equal the pull of the current coil, which receives the fault current, I. If the fault occurs inside the balance point, the IZ voltage pull will be less than the I current pull and the beam will tip closing its contacts. Conversely, if the fault occurs outside the relay balance point, the IZ voltage pull will be greater than the I current pull and the beam will not tip.

A rectangular silver contact is flexibly fastened on the forward end of the beam. As the beam tips, the contact bridges two silver stationary hemispherical contacts mounted on the free end of a short leaf spring. A small set screw determines the position of the leaf spring and provides means for adjusting the contact gap and follow.

Overcurrent Unit (CO)

The relay is supplied with CO-6 (definite minimum), CO-7 (moderately inverse), CO-8 (inverse) or CO-9 (very inverse) time-overcurrent characteristics. The electromagnets have a main tapped coil located on the center leg of an "E" type magnetic laminated structure. The flux produced by the main coil crosses the air gap and the magnetic keeper and returns through the outer legs. A shading coil causes the flux through the one leg to lag the main pole flux. The out-of-phase fluxes thus produced in the air gap cause a contact closing torque.

Directional Unit (D)

A small voltage transformer causes a large current to flow in a single-turn movable aluminum secondary, which current is substantially in phase with the voltage. The current coils are mounted on a magnetic frame and the current and voltage elements are assembled at a right angle to each other with the one-turn voltage loop in the air gaps of the current coil flux path. The interaction of the current and voltage fluxes produces torque and rotates the loop

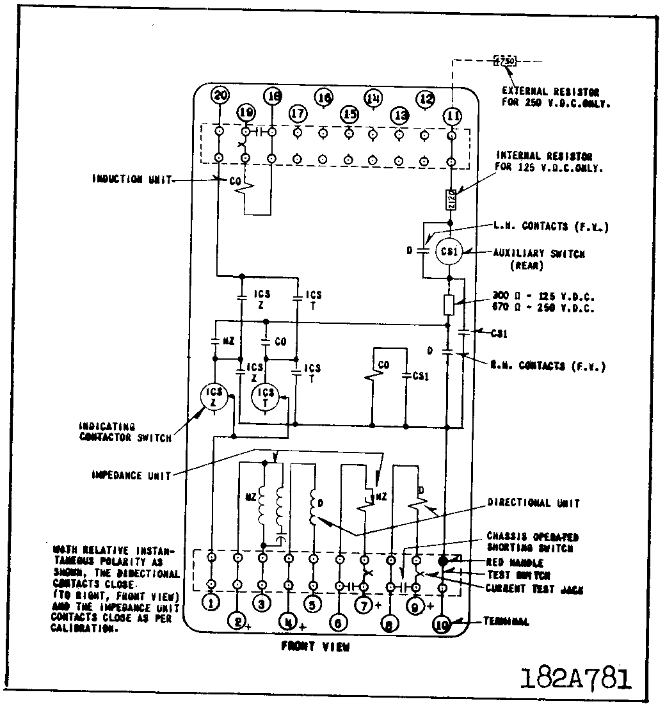


Fig. 1. Internal Schematic of the Type HRZ Relay in the FT32 Case.

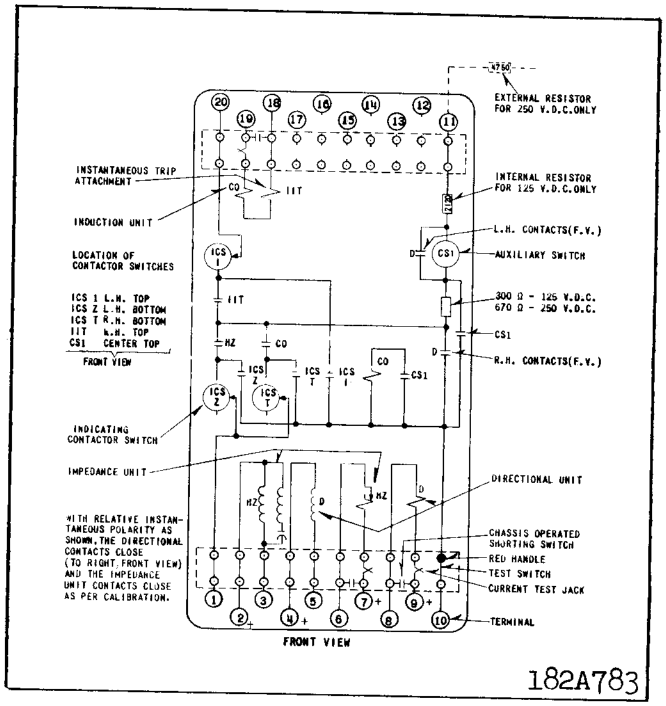


Fig. 2. Internal Schematic of the Type HRZ Relay with Indicating Instantaneous Trip Unit in the Type FT32 Case.

in one of two directions, depending on the direction of power flow.

An Isolantite arm extends from the moving loop and supports a rectangular silver contact which bridges two stationary contacts located on either side of the loop. The stationary contacts are silver hemispheres mounted on the lower end of vertically hanging spring leaves. The contact separation is adjustable by a small screw near the upper end of the rigid stationary contact supporting arm. One of these supporting arms hangs parallel to each of the four stationary contacts. The set screw on the lower end of this arm provides the contact follow adjustment. Two additional screws on the movement frame beneath the current coil iron limit the movement of the one-turn loop.

Auxiliary Contactor Switch (CS1)

This unit is a small solenoid-type switch. A small cylindrical plunger with a silver disc supported on its lower end rides up and down on a vertical guide rod in the center of the solenoid coil. The guide rod is fastened to the stationary core which in turn screws into the element frame. When the coil is energized, the silver disc moves upward bridging three cone shaped stationary contacts. The operation of this D-C auxiliary switch is controlled by the directional unit which in turn directionally controls the CO overcurrent unit. When fault current flows in the tripping direction, the auxiliary contactor switch operates to short circuit the lag coil of the CO unit. If the direction of the fault current reverses, a contact on the directional unit short circuits the auxiliary contactor switch coil, causing it to drop out. When CS1 drops out, the directional control circuit of the CO unit is opened.

Indicating Contactor Switch (ICS)

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 target is reset from the outside of the case by a push rod located at the bottom of the cover.

The front spring, in addition to holding the target, provides restraint for the armature and, thus, controls

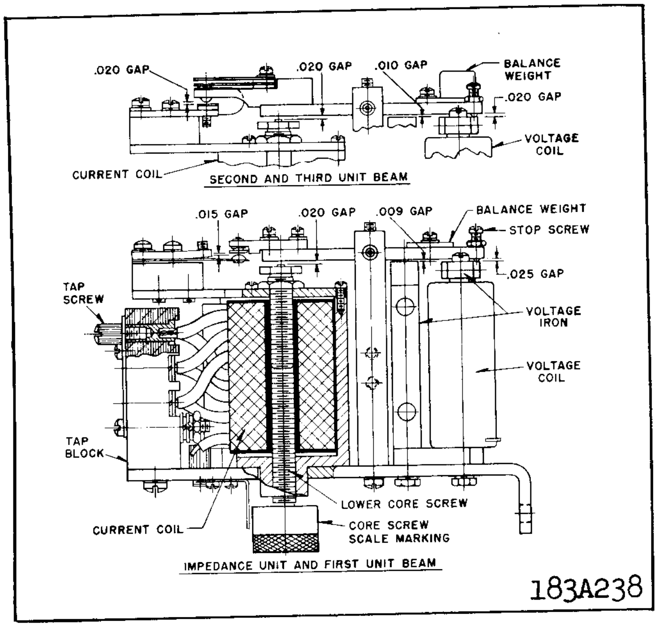


Fig. 3. Sectional View of the Impedance Unit (HZ)

the pickup value of the switch.

Indicating Instantaneous Trip (IIT) (When Used)

The instantaneous trip unit is a small a-c operated clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contacts completing the trip circuit. Also, during the operation two fingers on the armature deflect a spring located on the front of the switch which allows the target to drop. The target is reset from the outside of the case by a push rod located at the bottom of the cover.

A core screw accessible from the top of the switch provides the adjustable pickup range. The minimum and maximum pickup points are indicated on the scale, which is located to the rear of the core screw.

CHARACTERISTICS

Burden and thermal ratings are listed under "Energy Requirements".

Impedance Unit (HZ)

This unit has the following markings:

0.2 – 2.0 ohms range

Tap = 2, 3, 4, 6, 9, 13
Core Screw = .8, .9, 1.0, 1.1, 1.2, 1.4, 1.6

0.6 – 6.0 ohm range

Tap = 6.2, 9.4, 13.5, 20.8, 29.8, 45
Core Screw = .8, .9, 1.0, 1.1, 1.2, 1.3, 1.4

Figures 4 to 7 show additional characteristics.

Balance Point Voltage

For accurate impedance measurement the relay voltage should be at least 5 volts for a fault at the balance point.

Overcurrent Unit (CO)

The overcurrent unit taps are:

2 – 6 Amp. Range

2	2.5	3	3.5	4	5	6

4 – 12 Amp. Range

4	5	6	7	8	10	12

The tap value is the minimum current required to just close the contacts. The moving contacts will leave the time dial stop, regardless of the time dial setting, and move to touch the stationary contacts at tap value current.

The time-current characteristics are shown in Figs. 8 to 11. 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.

Directional Unit (D)

Maximum torque occurs when the relay voltage and current are in phase. Sensitivity at the maximum torque angle is 10 amperes and 2 volts or 2 amperes and 10 volts.

Trip Circuit

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

The indicating instantaneous trip contacts will safely close 30 amperes at 250 volts d-c, and will carry this current long enough to trip a 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.

ENERGY REQUIREMENTS

CO-6 DEFINITE MINIMUM TIME RELAY

AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE ϕ	VOLT AMPERES** AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
	(0.5	2	56	69	3.92	20.6	103	270
	(0.6	2.2	56	68	3.96	20.7	106	288
	(0.8	2.5	56	67	3.96	21	114	325
0.5/2.5	(1.0	2.8	56	66	4.07	21.4	122	360
	(1.5	3.4	56	62	4.19	23.2	147	462
	(2.0	4.0	56	60	4.30	24.9	168	548
	(2.5	4.4	56	58	4.37	26.2	180	630
	(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

CO-7 MODERATELY INVERSE TIME RELAY

AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE ϕ	VOLT AMPERES** AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
	(0.5	2	56	68	3.88	20.7	103	278
	(0.6	2.2	56	67	3.93	20.9	107	288
	(0.8	2.5	56	66	3.93	21.1	114	320
0.5/2.5	(1.0	2.8	56	64	4.00	21.6	122	356
	(1.5	3.4	56	61	4.08	22.9	148	459
	(2.0	4.0	56	58	4.24	24.8	174	552
	(2.5	4.4	56	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

CO-8 INVERSE TIME AND CO-9 VERY INVERSE TIME OVERCURRENT UNITS

AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE ⊄	VOLT AMPERES** AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
	(0.5	2	56	72	2.38	21	132	350
	(0.6	2.2	56	71	2.38	21	134	365
	(0.8	2.5	56	69	2.40	21.1	142	400
0.5/2.5	(1.0	2.8	56	67	2.42	21.2	150	440
	(1.5	3.4	56	62	2.51	22	170	530
	(2.0	4.0	56	57	2.65	23.5	200	675
	(2.5	4.4	56	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

* *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.*

DIRECTIONAL UNIT SERIES COIL

Rating	V.A. at 5 Amperes	Power Factor	One Second Rating (Amperes)
5	3.5	45^{0} lag	140

DIRECTIONAL UNIT POTENTIAL POLARIZING COIL, ALONE

Rating	V.A. at 120 Volts	Power Factor
120 V	10	28^{0} lag

IMPEDANCE UNIT CURRENT COILS

Tap	V.A. at 5 Amperes	Power Factor
45	2.0	30^{0} lag
13.5	0.55	30^{0} lag

IMPEDANCE UNIT POTENTIAL COILS

V.A. at 120 Volts	Power Factor
2	20^{0} lag

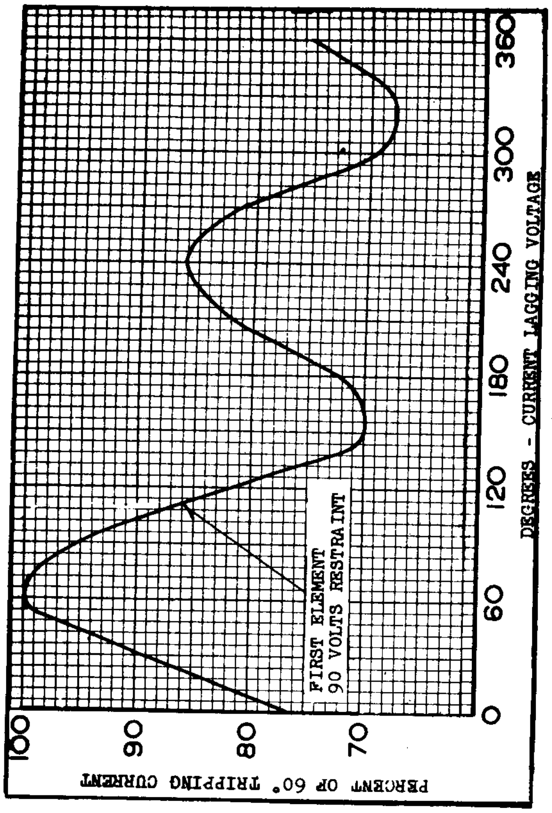


Fig. 5. Typical Phase Angle Curve of the Impedance Unit (HZ)

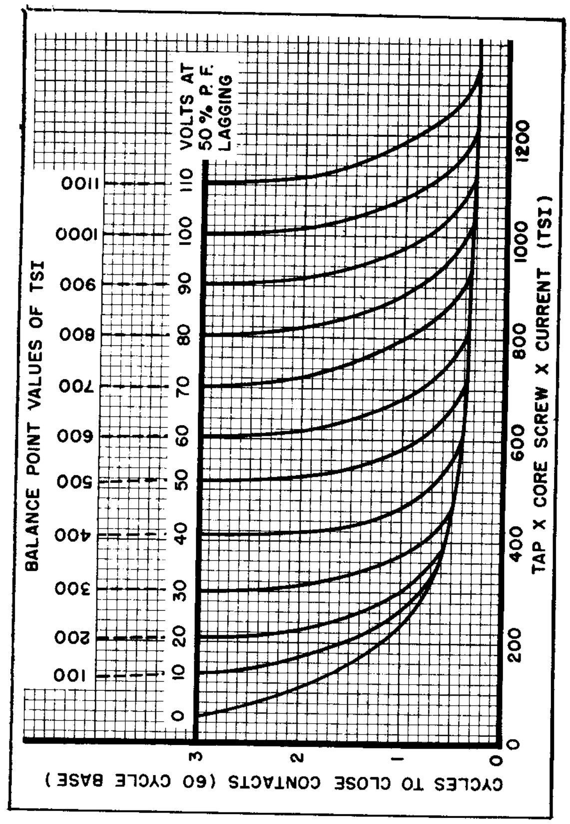


Fig. 7. Typical Time Curves of the Impedance Unit (HZ)

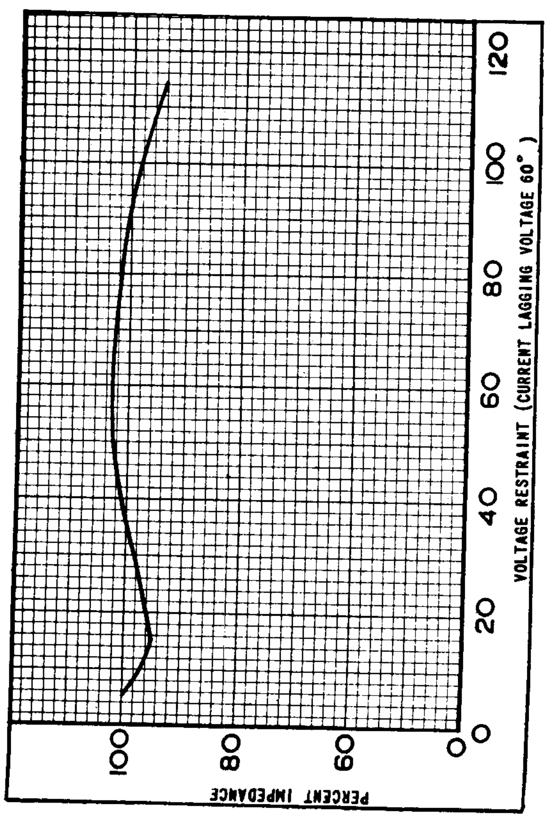


Fig. 4. Typical Impedance Curve of the Impedance Unit. (HZ)

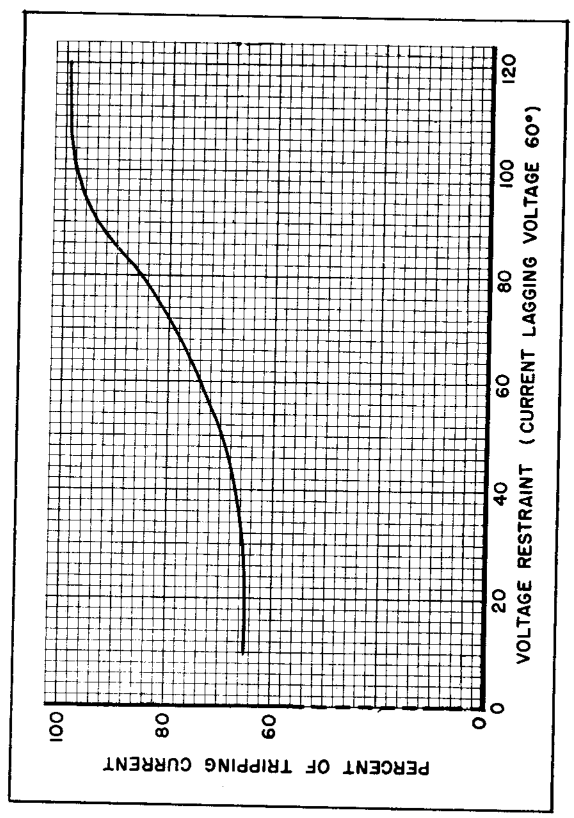


Fig. 6. Typical Reset Curve of the Impedance Unit (HZ)

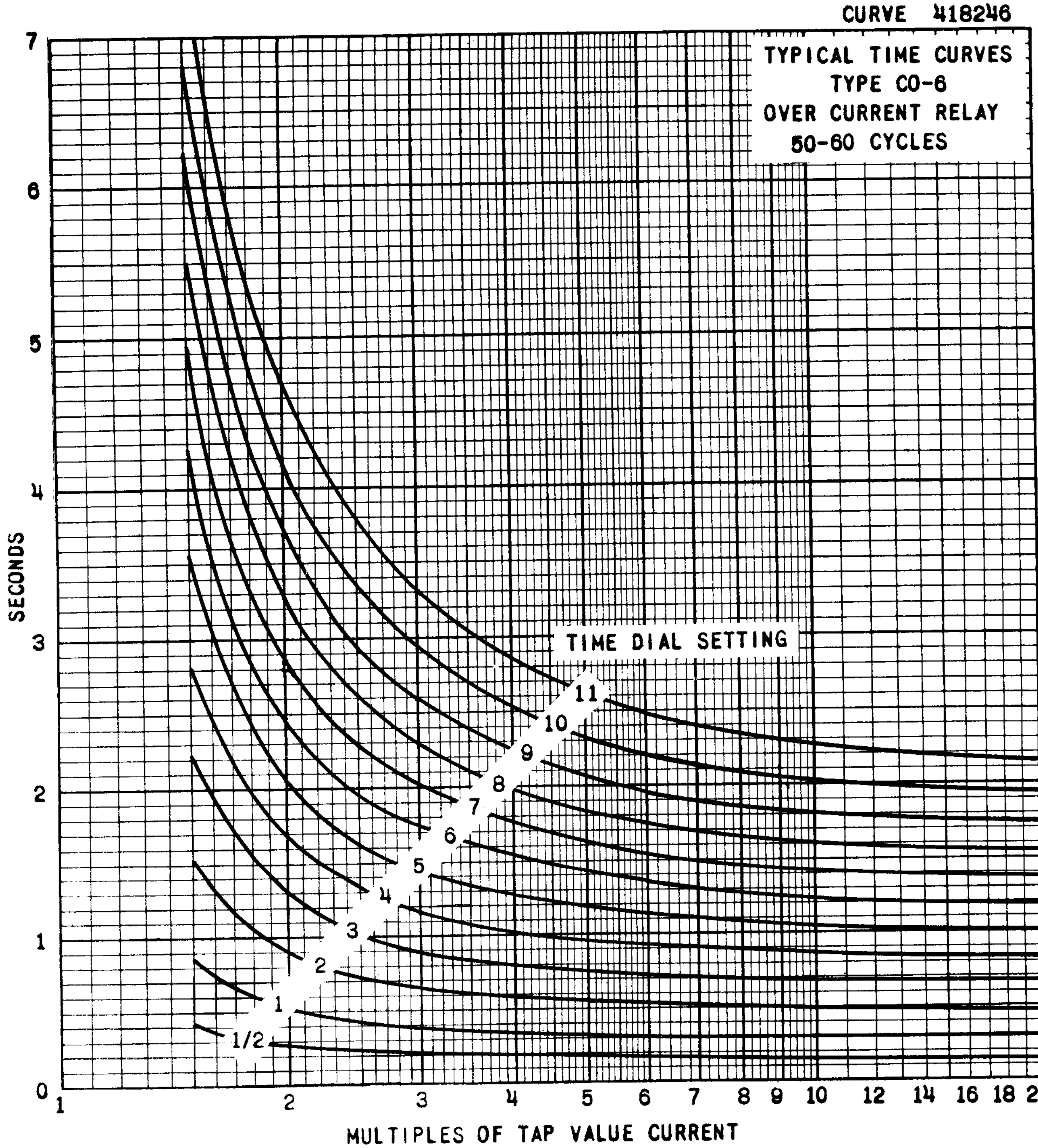


Fig. 8. Typical Time Curves of the Definite Minimum Time Overcurrent Unit (CO-6)

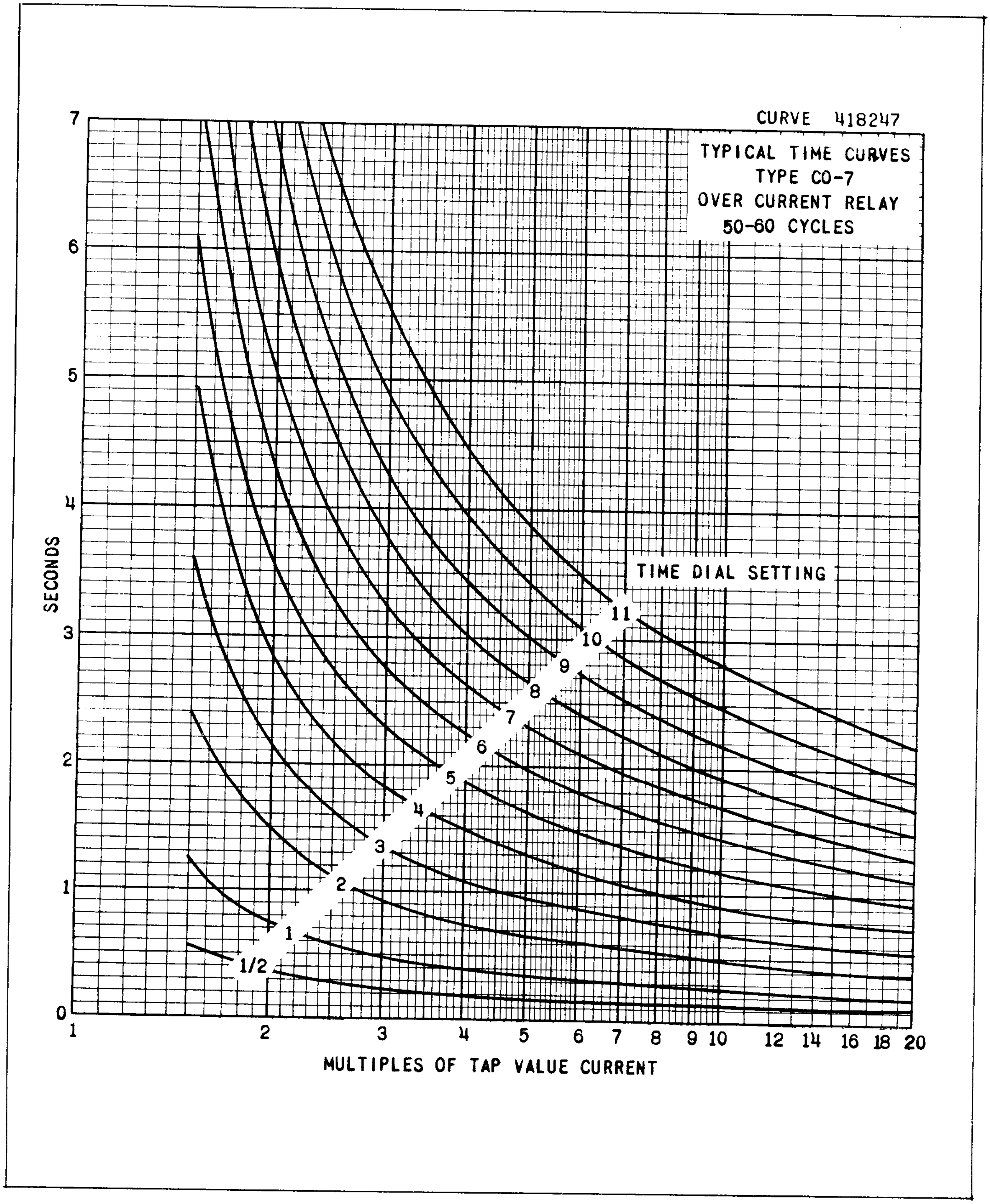


Fig. 9. Typical Time Curves of the Moderately Inverse Time Overcurrent Unit (CO-7)

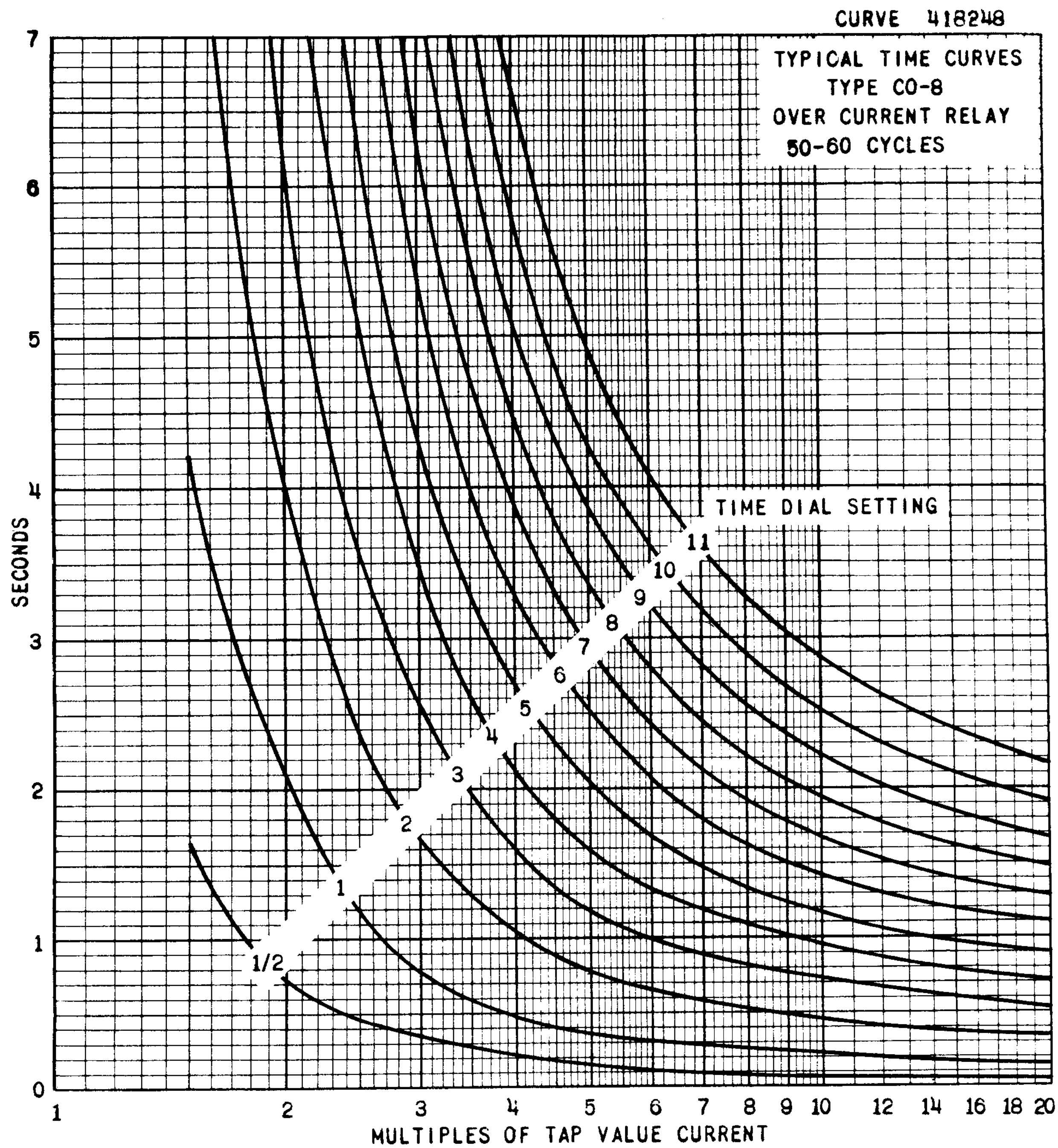


Fig. 10. Typical Time Curves of the Inverse Overcurrent Unit (CO-8)

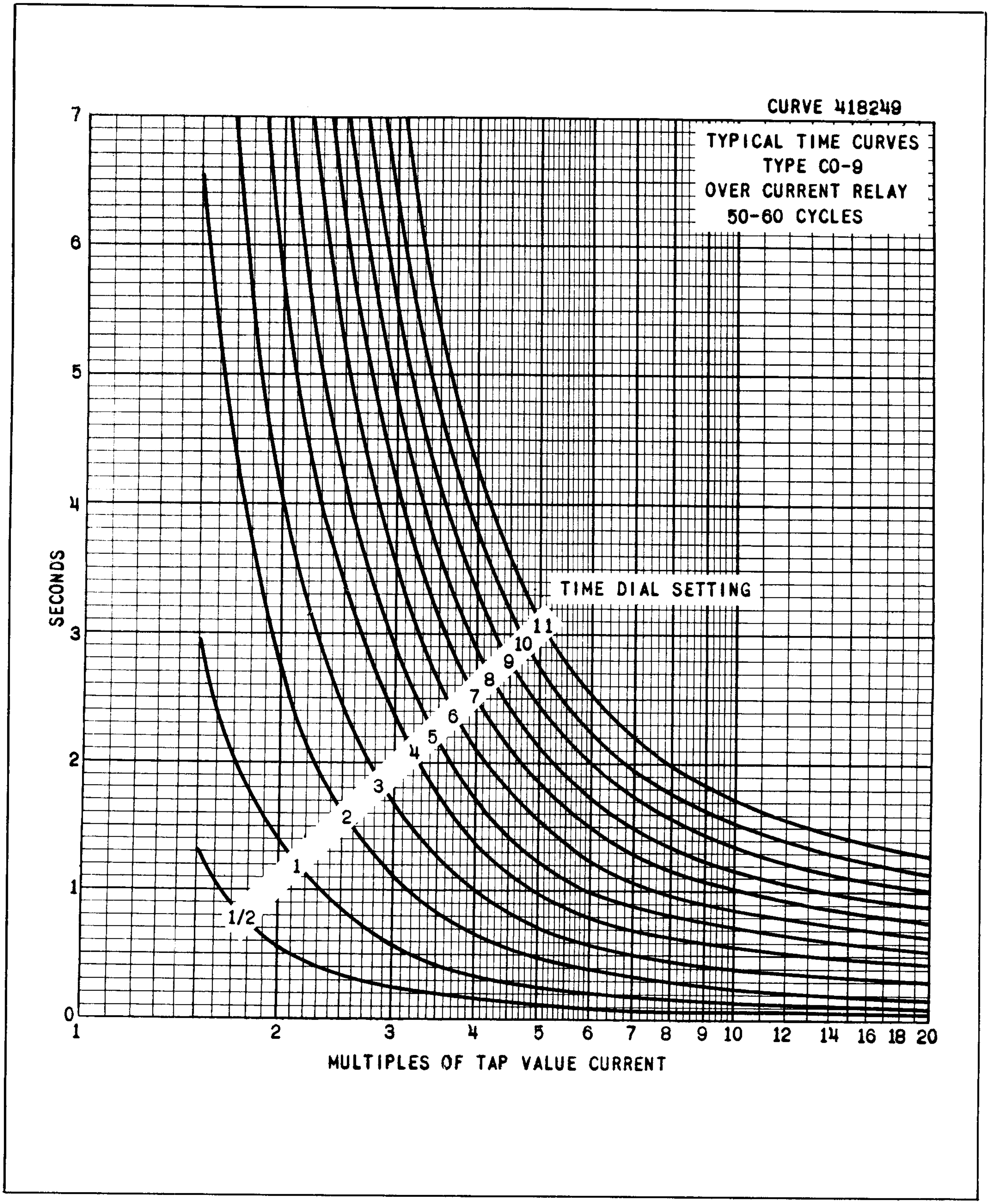


Fig. 11. Typical Time Curves of the Very Inverse Overcurrent Unit (CO-9

Trip Circuit Constant

Indicating Contactor Switch (ICS)

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

SETTING CALCULATIONS

Impedance Unit (HZ)

The following nomenclature is used:

Z = desired line-to-neutral ohmic reach referred to protected line voltage

R_c = main current transformer ratio (e.g. 400/5 or 80)

R_v = potential transformer ratio

T = relay current tap

S = relay core screw marking

This unit is set to give instantaneous protection over approximately 90% of the protected line section. Since the impedance of the voltage coil is the same at all times, the balance point of the unit is adjusted by changing the pull on the current coil. This is done by taps (T) on the current coil winding and by the core screw (S) which varies the magnetic air gap for the current flux.

The most satisfactory method of arriving at the tap settings is by the use of the following equation:

$$TS = \frac{10 \, Z \, R_c}{R_v} \qquad (1)$$

Select tap, T, so that, when divided into the desired TS product, the required core screw setting is within the available range. Since the core screw is continuously adjustable, it may be set in between the markings.

Equation (1) applies if the protected line section impedance angle is 60°. At other line angles the settings can be corrected by using Fig. 5. For example, if the line angle is 45°, the unit will operate at 96% of the 60° tripping current. Therefore, reduce the TS product by the reciprocal of 96% or 4.3%.

The formula settings are sufficiently accurate for most installations. Where it is desired to set the balance point more accurately the tap and scale values may be checked by applying to the relay the relay the voltage, current and phase angle values, which will be impressed on it for a fault at the desired balance point. A slight change in the scale value from that calculated may be required so that the relay will just trip for the simulated fault at the balance point.

Setting Example

Assume:

Impedance of protected line at rated voltage = 6 ohms

Current transformer ratio = R_c = 200/5 = 40

Potential transformer ratio = R_v = 120,000/120 = 1000

Impedance range = 0.2-2.0 ohms

Desired reach = 90% of protected line

From equation (1):

$$TS = \frac{10 \times 0.90 \times 6 \times 40}{1000} = 2.16$$

Set in 2 tap, then:

$$S = \frac{TS}{T} = \frac{2.16}{2} = 1.08$$

Overcurrent Unit (CO)

The 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, 2 time dial position or 4 tap, 0.6 seconds at 6 times tap value current).

Determine the desired tap. (A pickup setting of approximately twice full load is recommended.) Determine the desired time of operation at the current magnitude representing the most critical in the coordination with adjacent relays. A minimum coordinating time interval of 0.3 seconds plus adjacent circuit breaker time is recommended between the relay being set and the relays with which coordination is to be effected. For example, if the adjacent relays operate in 20 cycles for the critical fault condition and the adjacent breakers operate in 5 cycles, then, at the critical current magnitude, set time of operation at 20 + 5 + 0.3 x 60 = 43 cycles.

Enter the time current curves (Figs. 8 to 11) by determining the set point current in terms of multiples of tap value current and by using the desired time of operation at this current. Then, estimate the time dial position.

Indicating Contactor Switch Unit (ICS)

Select the desired tap – 0.2 or 2.0. When the relay energizes a WL relay switch, or equivalent, use the 0.2 ampere tap.

Indicating Instantaneous Trip (IIT)

The pickup current is continuously adjusted by means of the core screw. The scale plate indicates only the minimum and maximum screw positions, so that this unit must be set by application of pickup current.

SETTING THE RELAY

The following settings must be performed:

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

Impedance Unit (HZ)

Set the current tap and adjust the core screw.

The numbers on the core screw appear in ascending order as the core screw is screwed into the core. In some cases, a question of doubt may arise as to whether the scale setting is correct, or is out by one full turn of the core screw. In such a case, the point may be verified by turning the core screw all the way in. Then back out the core screw until the highest scale marking and then continuing to back it off until the desired value appears exactly under the end of the pointer. Sufficiently accurate setting can be made by interpolating between the marked points when necessary. Sufficiently accurate settings can be made by interpolating between the marked points. Where it is desired to set the balance point more accurately the tap and scale values may be checked by applying to the relay the voltage, current and phase angle values which will be impressed on it for a fault at the desired balance point.

Directional Unit (D)

There are no settings to be made on the directional unit.

Overcurrent Unit (CO)

Set the required tap and time dial position. The time may be set by inspection or by applying current and adjusting the dial for the desired time of operation.

Indicating Contactor Switch (ICS)

No setting is required on the ICS unit 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. When the relay energizes a type WL relay switch, or equivalent, use the 0.2 ampere tap.

Indicating Instantaneous Trip (IIT)

Since the minimum and maximum markings on the scale only indicate the working range of the core screw, the core screw must be adjusted to the value of pickup current desired.

The nameplate data will furnish the actual current range that may be obtained from the IIT unit.

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 four mounting holes on the flange for semi-flush mounting or by means of the rear mounting stud or studs for projection mounting. Either a mounting stud or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the 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 stud and then turning the proper nut with a wrench.

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

The resistance of the auxiliary tripping relay coil circuit (if used) should be less than 35 ohms for 125 volt d-c HRZ relays and less than 70 ohms for 250 volt d-c HRZ relays. If the coil resistance exceeds these values, a loading resistor should be connected in parallel with the coil.

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 adjustments are required except those described under "Setting the Relay".

Caution

The relay voltage should be of good wave form. The combination of a phase shifter and autotransformer may give an output voltage of poor wave form if the magnetizing current of the autotransformer is high in proportion to the impedance of the phase

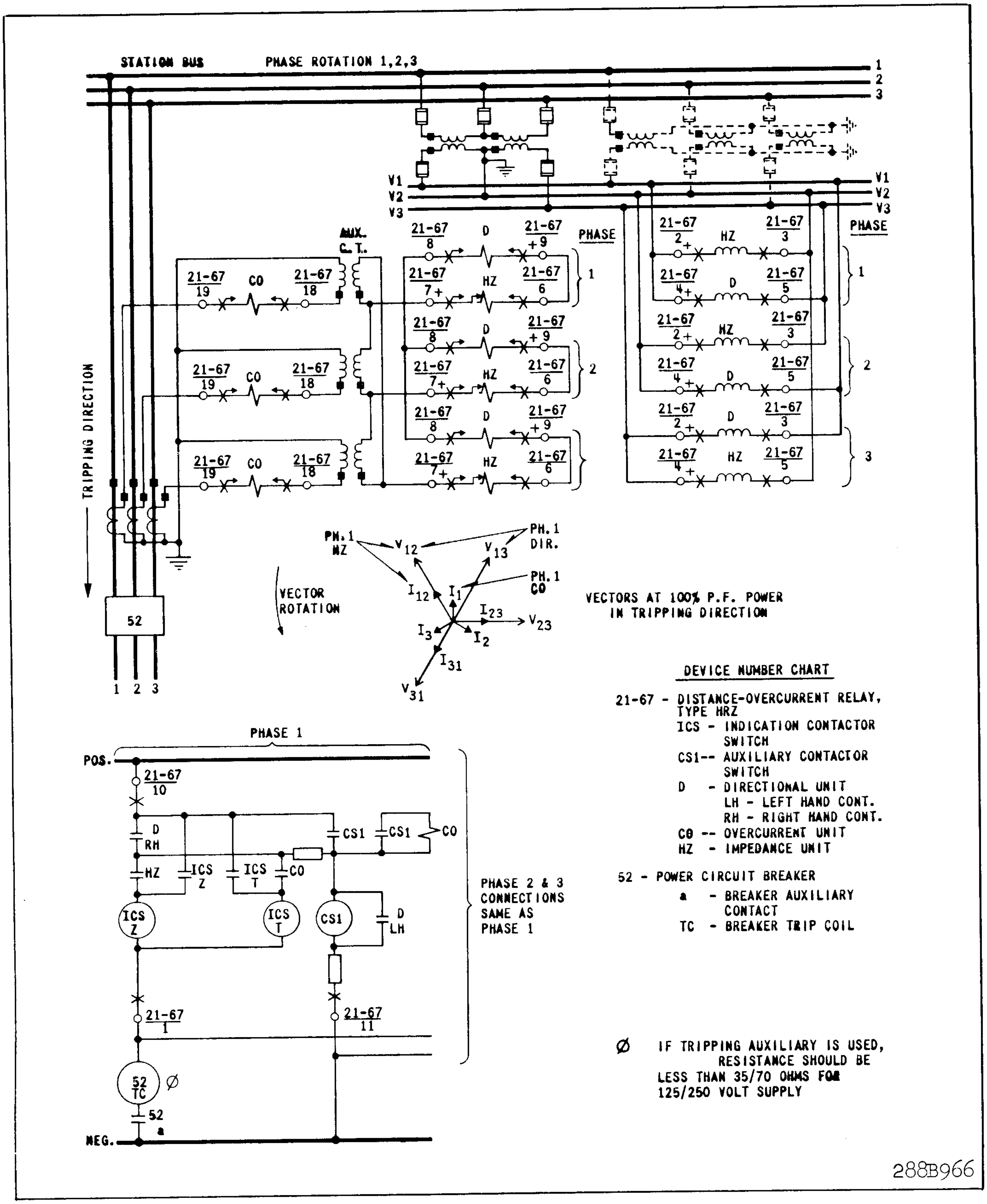


Fig. 12. External Schematic of the HRZ Relay for Line Protection.

shifter used. In case of doubt, check the output voltage wave form with an oscilloscope.

Phantom loads should not be used in testing induction-type relays because of the resulting distorted current wave form which produces an error in timing.

Acceptance Check

The following checks are recommended to insure that the relay is in proper working order:

Impedance Unit

0.2-2.0 ohm range

Connect per Fig. 13. Set in 13 tap and 1.6 core screw. Energize with 35 volts and minimum tripping current at 60°, current lagging voltage. Operation should occur at approximately 16.8 amperes. Then, set core screw at 0.8 and repeat test. Operation should occur at approximately 33.7 amperes.

0.6-6.0 ohm range

Connect per Fig. 13. Set in 20.8 tap and 1.4 core screw. Energize with 35 volts and minimum tripping current at 60°, current lagging voltage. Operation should occur at approximately 12 amperes. Then, set core screw at 0.8 and repeat test. Operation should occur at approximately 21.1 amperes.

Directional Unit

Apply 2 amperes and 10 volts, in phase, with the connections of Fig. 13 and see that the right-hand contact closes positively. Reverse the current direction and see that the left-hand contact closes positively.

Check the coordination of the directional unit and impedance unit, as described below, with connections per Fig. 13. Set the impedance unit on the maximum tap and scale setting. Apply 115 volts a-c to the impedance and directional unit potential coils and pass 5 amperes at unity power factor through the current circuit. Check the trip circuit to see that it is not completed when the voltage on the impedance and directional units is suddenly applied or interrupted. Do not interrupt the current circuit. Make several such tests. The trip circuit should be connected with the loading resistor for this test. This coordination test has been described for the most severe conditions. Consequently, an occasional failure to coordinate may be tolerated, since, in service, the directional units will be resetting under the positive action of reverse power flow rather than under the influence of gravity alone, as described in this test. If proper coordination is not obtained, reduce the follow on the directional or impedance unit contacts.

Overcurrent Unit (CO)

By turning the time dial, move the moving contacts until they deflect the stationary contact to a position where the stationary contact is just resting against its backstop. The index mark located on the movement frame should coincide with the "O" mark on the time dial.

Set the time dial to position 6. 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%.

Table I 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 I. (e.g. for the CO-8, 2 and 20 times tap value current) and measure the operating time of the relay. The operating times should equal those of Table I plus or minus 5 percent.

TABLE I

TIME CURVE CALIBRATION DATA – 60 CYCLES

	PERMANENT MAGNET ADJUSTMENT			ELECTROMAGNET PLUGS	
RELAY TYPE	TIME DIAL POSITION	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS	CURRENT (MULTIPLES OF TAP VALUE)	OPERATING TIME SECONDS
CO–6	6	2	2.46	20	1.19
CO–7	6	2	4.27	20	1.11
CO–8	6	2	13.35	20	1.11
CO–9	6	2	8.87	20	0.65

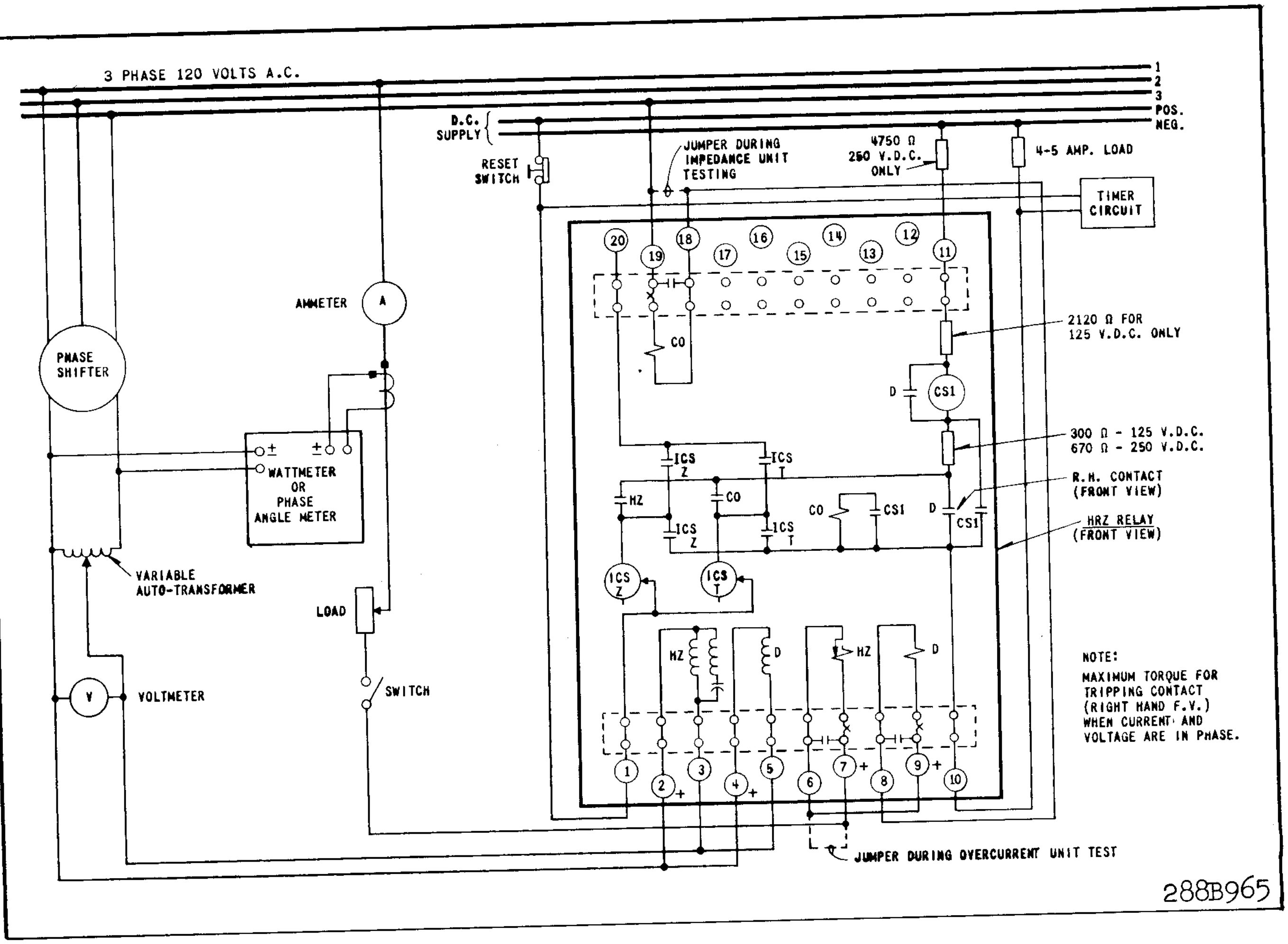


Fig. 13. Diagram of Test Connections for the Type HRZ Relay in the Type FT32 Case.

Indicating Instantaneous Trip Unit (IIT)

The core screw, which is adjustable from the top of the trip unit determines the pickup value. The trip unit has a nominal ratio of adjustment of 1 to 4 and an accuracy within the limits of 10%.

Apply sufficient current to operate the IIT. The target should drop freely.

Directional Control Circuit

With the relay connected per Fig. 13, apply 110% of rated d-c voltage and see that the CS1 unit operates. Then apply 70% of rated d-c voltage, close the left-hand directional contact, and see that CS1 resets. Now suddenly apply 50 volts, 10 amperes, in phase, to the directional unit, with rated d-c voltage on CS1 circuit, and see that the CS1 contacts close positively.

Routine Maintenance

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.

Connect the relay per Fig. 13 and apply current and voltage of the approximate magnitude and phase angle, which are encountered by the impedance unit during faults. Observe the relay for proper functioning. Check the timing of the CO unit at one or two currents, which are critical for the specific application. Check the pickup point of the indicating instantaneous trip, when used.

Calibration

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

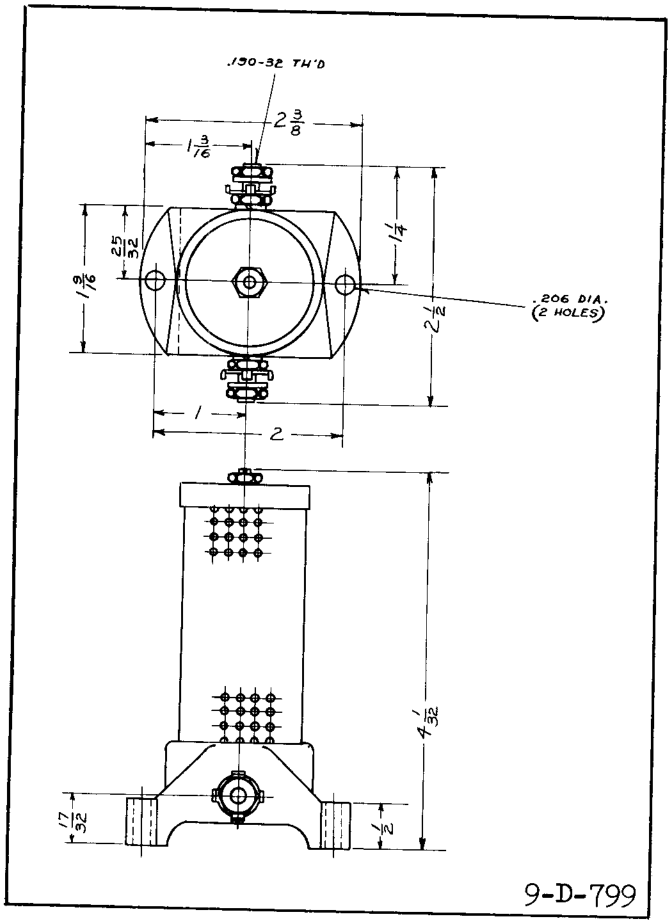


Fig. 14. Outline and Drilling Plan for the External Resistor Used with 250 Volt Trip Circuits.

Impedance Unit

Refer to Fig. 3. For the 60-cycle relays adjust the stop screw on the rear of the beam to give a clearance of .025 inch between the rear of the beam and the voltage iron circuit. This may be checked with a feeler gauge. With the beam in the reset position, i.e., back against the stop, adjust the gap between the adjustable iron and the beam to .009 inch. Care should be taken in this adjustment to keep the gap the same on both sides. Also, with the beam in the same position, adjust the gap between the front end of the beam and the stop in the upper core screw to .020 inch.

The beam should be balanced as follows. Connect the relay as shown in the test diagram, Fig. 13. With any tap and scale setting, check the impedance measured by the relay with 35 volts potential restraint. Then apply 5 volts restraint and adjust the balance weight on the beam until the beam just trips with 1/17 of the current required to trip with 35 volts restraint. Make certain that the stop on the voltage side is absolutely clean, otherwise the impedance at which the beam trips may be affected, particularly at the low voltages. The stop can be easily cleaned by drawing a piece of clean white paper between the beam and the stop while the beam is firmly pressed down.

The stationary contacts should be adjusted to give .015 inch clearance between them and the silver bridge on the beam when the beam is in the reset position. The bridge should be made to touch both contacts simultaneously, and deflect the contact springs at least .010 inch before the beam strikes the bronze stop on the core screw.

It is difficult to accurately adjust the contacts by eye. A good method consists of first adjusting one of the contacts to the correct gap and then applying just sufficient current to trip the beam against a restraint of about 5 volts. While the beam is in this position, that is, lighting pressing on the one contact, the other contact should be slowly adjusted upward by means of the set screw until it just touches the silver bridge without lifting it off the other contact. The trip circuit should be energized so that the lighting of a lamp or the tripping of an auxiliary relay will show when both contacts are made.

A further caution in regard to the contact adjustment is that too much follow or deflection of the stationary contacts will slightly delay the resetting of the impedance unit and thus the directional unit contacts may get closed before the impedance contacts are open and result in unnecessary tripping.

Directional Unit

With the loop in the vertical position adjust the front and back stationary contacts for .020 inch separation from the vertical moving contact. Adjust the contact back stop screws to just touch the stationary contacts, then back off 1/4 of a turn to give correct contact follow. Adjust the two stop screws which limit the movement of the loop (these screws are located to the rear of the current coil) so that the loop strikes the stops at the same instant the stationary contacts strike their back stop.

Too much follow on the directional unit contacts should be avoided in order to allow the directional unit to reset fast enough by gravity to properly coordinate with the high speed impedance unit.

Energize the loop with normal potential long enough to bring it up to temperature (about 10 or 15 minutes) and adjust the bearing screws so there is about .010 inch end play. See that the loop does not bind or strike against the iron or coil when pressed against either end jewel.

Overcurrent Unit (CO)

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.

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%.

For time calibration install the damping magnet and use the following procedure:

Apply twice tap value current with the time dial at 6, and measure the operating time. Adjust the permanent magnet keeper until the operating time corresponds to the value of Table I.

Apply 20 times tap value current and measure the operating time. Adjust the proper electromagnet plug until the operating-time corresponds to the value in Table I. (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.

CS1 Unit

Turn the relay upside down. Screw up the core screw until the contact ring starts rotating. Now back off the core until the contact ring stops rotating. Back off the core screw one more turn and lock in place. Adjust the two nuts at the bottom of the switch so that there is 3/64 inch clearance between the moving contact ring and the stationary contacts in the open position. The guide rod may be used as a scale as it has 52 threads per inch, therefore, 2-1/2 turns of the nuts will equal approximately 3/64 inch.

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.

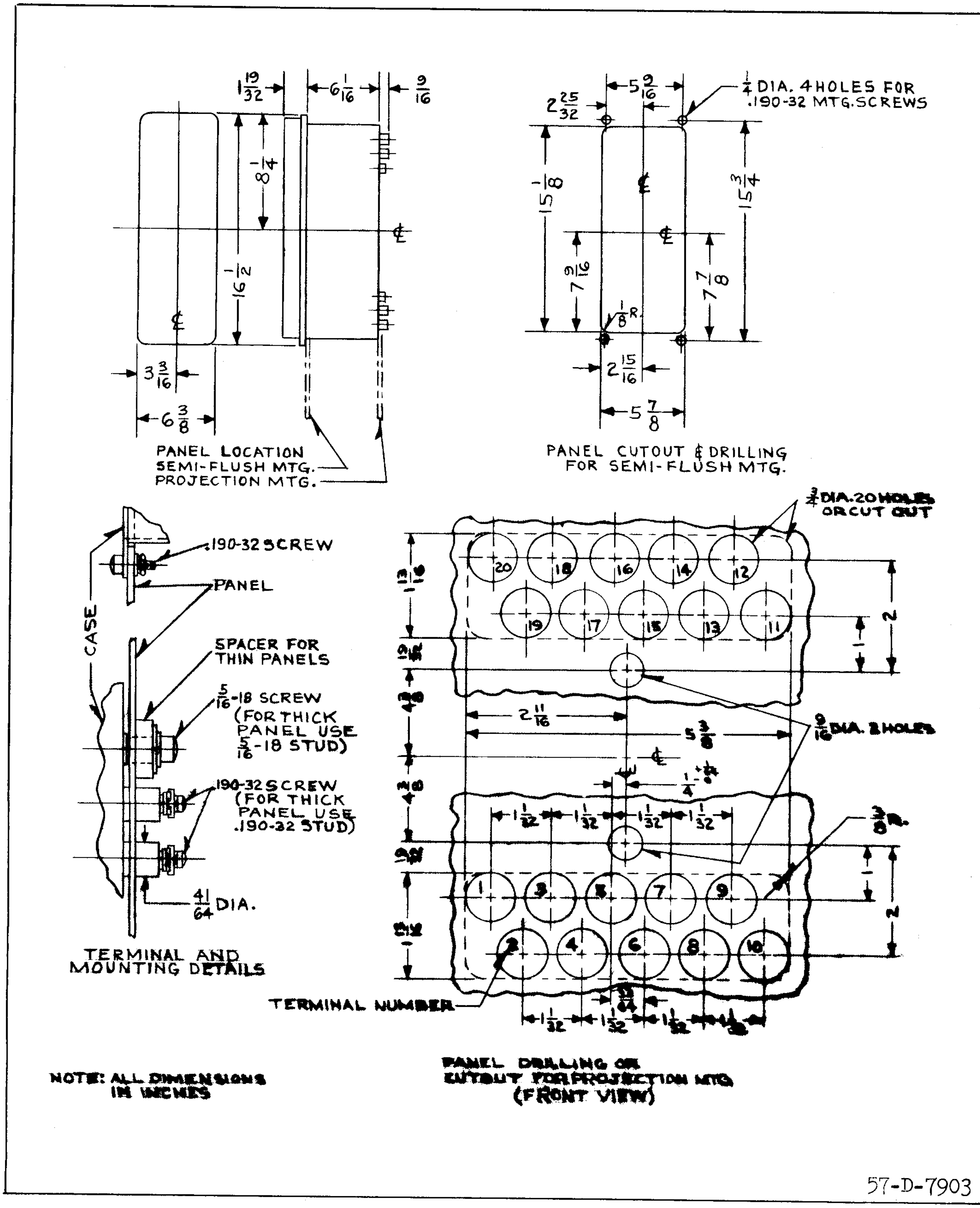


Fig. 15. Outline and Drilling Plan for the Type HRZ Relay in the Type FT32 Case.

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