INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE SRGU DUAL POLARIZED GROUND DIRECTIONAL RELAY

APPLICATION

The SRGU is a high speed dual-polarized directional overcurrent ground relay. It may be used as a current or potential polarized relay. It is suitable for overreaching pilot systems where the pilot auxiliary provides a coordinating delay of at least 15 ms during a sudden reversal in the direction of fault-power flow due to a sequentially cleared external fault. This SRGU design is not suitable for underreaching applications, pilot or non-pilot, since the overcurrent unit is not designed for minimum transient overreach and the directional-unit reset during a reversal is as much as 12 ms.

CONSTRUCTION AND OPERATION

As shown in Fig. 1, 2, & 3 the relay contains a power supply, a directional unit and overcurrent unit in a 19 inch rack unit.

Directional Unit

The directional unit consist of air gap current transformers, T_2 and T_3, a voltage transformer T_1, a phase shifting network, and two printed circuit boards (dual directional and directional amplifier).

Transformer T_1 and T_2 are used in the current polarizing circuit and in the operating circuit. The operating current transformer has two separate secondary windings.

The phase shifting network consist of a capacitor (C6), resistor (R1) and a reactor (L1) in voltage polarizing circuit and a reactor (L2) in current polarizing circuit. Fig. 3 shows the connections of the transformers and the phase shifting network to the ring modulator.

The directional circuit board consist of two sets of ring modulators, an amplifier, a timer, a filter and an output transistor.

The ring modulator consists of four diodes. The anode of each diode is connected to the cathode of the following diode to produce a maximum output voltage of 1.4 volts or two diodes forward voltage drop.

Amplifier: The amplifier consist of the two NPN transistors 1Q1, and 1Q3. The second stage of the amplifier is an emitter follower which provides an output to the next stage.

The turn on timer consists of a potentiometer 1R14, a resistor 1R12, a unijunction transistor 2Q1, a capacitor 1C3, and normally conducting transistor 1Q4 for a rapid discharge of the capacitor.

The filter consists of a diode 2D1, a capacitor 2C1 and the resistor 2R3. There are two outputs one of which is the directional unit output. The other controls the overcurrent unit. The directional outputs of a NPN 2Q2 and PNP 2Q3 with a diode 2D2 and zener diode 2Z1 for the protection of output unit from the surge. The control output unit consist of two NPN transistors 2Q4 and 2Q5 in which 2Q5 is normally conducting.

Instantaneous Overcurrent Unit

The overcurrent unit consists of an input transformer T4, a setting circuit, a phase splitter circuit, a sensing circuit, a voltage regulator circuit, a feedback circuit and a transistor output.

1. Input Transformer - A two winding type with a non-tapped primary winding and a tapped secondary winding, the secondary is connected to the setting circuit and from the fixed tap to the phase splitter circuit.

2. Setting Circuit - The setting circuit is connected across the secondary winding of the input transformer and consists of two branches, a resistor and a rheostat, connected in parallel with a resistor and zener diode. This circuit loads the transformer and produces a secondary voltage proportional to the input current. The rheostat has a locking feature to minimize the accidental change of current setting.

positive with respect to negative then transistor 1Q1 turns on. If the two input currents are of opposite polarity or if either input is zero the voltage 1TP-1 will be negative or zero with respect to negative and 1Q1 will be off and 1Q4 will be on, to short circuit capacitor 1Q3. The same thing applys to the ring modulator consisting of diodes 5 to 8.

Assume 1TP1 goes positive to turn on 1Q3. Then capacitor 1C3 charges, and if the voltage across the the capacitor reaches the "firing voltage" of the unijunction transistor, the unijunction fires. The current pulse resulting from the unijunction will be transfered to the capacitor 2C1 and hence turns on 2Q2 and 2Q3 and the output voltage appears at varicon terminal 6. Also it turns 2Q5 off to develop the overcurrent unit output.

1R14 is adjusted so that the time required for 1C3 to reach the voltage level of the unijunction is 4.1 m.s. If one or both input quantities goes to zero, and causes transistor 1Q4 turns on, 1C3 is rapidly discharged and the output goes to zero.

Two sets of Ring Modulators are used, one for voltage polarizing and the other for current polarizing. The output of the Ring Modular from the current polarizing circuit is fed back to 1Q3 and if either 1Q1 or 1Q2 or both turn on, 1Q4 will be turned off and the capacitor 1C3 starts to charge up.

The output circuit consists of two transistors, 2Q3 and 2Q5, in which 2Q5 is normally conducting and supervises the overcurrent unit. The normally conducting transistor, of the directional unit, is connected to the input of the first transistor 3Q1 in overcurrent unit, so that short circuits any voltage resulting from the overcurrent unit. If the direction of current is in the trip direction, the directional unit will pick up and the output transistor will act as an open circuit, and allows the overcurrent unit to operate.

The second output of the directional unit consist of two transistors. These two transistors are normally off when the trip signal comes from the unijunction transistor, turns the NPN transistor 2Q2 on, and then allows the PNP transistor 2Q3 to saturate, and hence a twenty volt output will appear across resistor 2R7.

Overcurrent Unit Operation

The overcurrent unit is also a static device and produces a dc voltage output when the input current exceeds the set value.

The components of the overcurrent unit are connected as shown in Fig. 3 with no input to the relay, transistors 3Q1 and 3Q2 are in the nonconducting condition and no output is obtained from the relay. Zener diode 3Z1 of the sensing circuit establishes the reference voltage from the base of 3Q1 to negative and allows a base current to flow in 3Q1 through 3R5 to negative.

When ac current is applied to the primary of the transformer T4, a voltage is produced on the secondary side that is proportional to the amount of resistance in the rheostat 3S1. This single phase voltage is applied to the phase splitter circuit where a three phase voltage is produced, rectified, and applied to resistor 3R5 of the sensing circuit. If the voltage from the rectifier is greater than the reference voltage across the sensing circuit, 3Q1 turns on to allow 3Q2 to turn on which produce a 20 volts dc output.

When 3Q2 turns on, positive feedback voltage is applied to the base of 3Q1. By varying the magnitude of this voltage, the dropout of the relay can be regulated from approximately 98% to 0% of the pick up.

When large current are applied to the primary of the input transformer, the zener clipper on the secondary prevents the current from becoming excessive.

Relay Operation (Directional and Overcurrent)

The type SRGU relay is connected to the protected transmission line as shown in Fig. 4. The relay operates for ground fault currents of a definite magnitude that are flowing in a specified direction with respect to the reference voltage or current.

The directional unit circuitry of the relay compares the phase angle between the fault current and the polarizing quantities of the system and produces either an output voltage for a fault in the trip direction or no output for a fault in the non-trip direction. Relay operation occurs when both the directional unit and the instantaneous overcurrent unit produce a 20 dc voltage output. Hence, the fault current must be greater than the setting of the overcurrent unit.

For a fault in non-trip direction, the transistor 2Q5 of the directional unit short circuits the base to emitter junction of transistor 3Q1 of overcurrent

unit, and does not permit the transistor 3Q1 to turn on. For fault current in the trip direction, the directional unit operates and removes this short circuit, allowing the overcurrent unit to produce an output simultaneously with the directional unit output.

CHARACTERISTICS

Directional Unit

1. As a voltage polarized directional unit, "maximum sensitivity" occurs with current lagging voltage by 60° + 6°.

   As a current polarized directional unit, "maximum sensitivity" occurs with operating and polarizing currents in phase ± 6°.

Overcurrent Unit

2. The SRGU relays are available in the following current ranges:

RANGE	SCALE MARKING				
.5-2 AMPS.	.5	.75	1.0	1.5	2.0
1-4 AMPS.	1.0	1.5	2.0	3.0	4.0
2-8 AMPS.	2	3	4	6	8

   The setting is the minimum current required to obtain a 20 volts dc output. For pick up settings between calibrated markings refer to the section under "Setting". The SRGU relay is designed for dual polarizing and can be polarized from a zero sequence potential source, a zero sequence current source or from both simultaneously.

Time Curves:

The time curves for SRGU relay are shown in Fig. 5, 6, and 7. Figure 5 includes directional unit operating time for current, voltage or dual polarized.

Fig. 6 is overcurrent unit operating time, and Fig. 7 is overcurrent unit reset time.

Operating Time:

The tuned circuits in the directional unit impart a slight inverse time characteristic at low energy levels and cause a longer operating time at the minimum pick up.

Reset Time:

The tuned circuits in the directional unit also delays the reset time, and the amount of delay depends on the initial energization (the max. reset time is 30 ms).

Current Reversal Reset Time:

When a fault current reversal occurs, the relay is reversed and the directional unit resets in 12 ms or less.

Both the directional unit and overcurrent unit must operate before a trip output can be obtained. Hence, the unit which takes the longer time to operate determines when an output will occur. The overcurrent unit cannot operate until the short circuit in its input circuit is removed by the operation of the directional unit. Once the directional unit operates, the overcurrent unit will operate instantaneously.

If the operating and polarizing quantities are more than the minimum required the directional unit operates, but because of the setting, the overcurrent unit may not operate and therefore the overall output will be zero.

If under these conditions, a current reversal happens, the directional unit resets a maximum of 12 ms to short circuit the overcurrent unit, but the overcurrent unit may operate in less than 12 ms, and hence an illegitimate 20 volts output will appear across the varicon terminals 5 and 3.

Reset Time:

Although the reset (de-energization) of the directional unit is longer than overcurrent unit. The relay reset time is completely independent of directional unit reset time, and it only depends on overcurrent unit reset time. Therefore, the curve shown for overcurrent unit reset time is the same for the relay reset time.

Setting (Overcurrent Unit)

The operating level of the relay is selected by adjusting the rheostat 3S1 in the front of the panel. Settings in between the scale marking can be made by applying the desired current and adjusting the rheostat until an output is obtained.

Directional Unit

No setting is required.

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 adjustments, other than those covered under "Settings" should be required.

Acceptance Check

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

Overcurrent Unit

A. Minimum trip current

1. Apply the rated dc to terminals 3 and 4 (4 is positive) and make sure 20 ± 2 volts exist at the "printed circuit board" terminal 1 and 14 (14 is positive). For checking the pick up remove the directional amplifier board, and then by the circulating the specified current through "Terminal Block" terminals 1 and 2 the dc voltmeter in the output should read approximately 20 volts, when the current is within 3% of the setting.

2. Dropout;

   After checking pick up, the dropout should be checked to be approximately 97% of the pick up with the ac current gradually reduced.

Directional Unit

Refer to Fig. 8 with the directional amplifier back in place. Apply 100 volts, 60 Hz to terminals 7 and 8. The output voltage measured from jack terminal 2JR to negative should be zero.

Remove 60 Hz voltage input from terminals 7 and 8 and circulate 10 amperes 60 Hz through "Terminal Block" terminals 1 and 2. The output voltage measured from 2JR to 2JB should be zero.

Apply 100 volts 60 Hz to terminal 7 and 8 circulate 18 amperes through "Terminal Block" terminals 1 and 2 with polarities as shown on the external schematic.

Adjust the phase angle between voltage and current until voltage output of 20 volts ± 10% from jack terminals 2JB and 2JR is obtained. At this point the angle between voltage and current should be 330° ± 3° voltage leading current. Adjust the phase shifter until the 20 volts output drops to zero. This angle should be 150 ± 3 degrees.

Circulate 5 amperes into "Terminal Block" terminal 4 and out 3 into terminal 1 and out 2, (in phase). The voltage output should be obtained.

Apply 10 amperes into 4 out 3, into 1 out 2. Apply 100 volts to terminals 7 and 8, (current lags voltage by 60°). Voltage output should be obtained. Reverse terminal connections 7 and 8, the output should read zero. Take out terminal 7 and 8, the relay should operate.

Repair Calibration

If the relay does not meet the acceptance tests or has been dismantled for repairs, use the following procedure to put in proper working order.

Avoid stressing component leads. If a test probe must be connected to a component lead, connect it so as to avoid stress on the leads of delicate components. Use the test points provided wherever possible rather than connecting a test probe directly to the component board.

Use the following procedure for calibrating the SRGU Relay if the relay adjustments have been disturbed. This procedure should not be used until it is apparent that the relay is not in proper working order.

A. Directional Unit (Polarity Check)

1. Connect as per Fig. 8.
2. Replace the dual directional circuit board with a card extender style 849A534G01 and disconnect, not remove, all other boards.

   Apply rated dc voltage across "Varicon" terminal 3 and 4, with terminal 4 positive. Measure the voltage across the printed circuit board terminal 1 and 14 with positive on terminal 14. The voltage should be 20 ± 2 volts.

3. Connect the dual directional board and all the other boards back to the relay.
4. Circulate 10 amperes through "Terminal Block" terminals 1 and 2.
5. Apply 100 volts to Varicon terminal 7 and 8, (7 is polarity) and circulate 10 amperes through "Terminal Block" terminals 1 and 2, (1 is polarity). Set the phase shifter to 60° (current lags voltage). The relay should operate.

6. Circulate 5 amperes into "Terminal Block" 4 out of 3, into 1 and out 2. Disconnect the voltage from terminals 7 and 8. The relay should operate.

7. If the relay operated in 5, but not in 6, the connections to "Terminal Block" terminals 3 and 4 are wrong and should be reversed.

8. If relay operated in 6 but not in 5, the connections to 7 and 8 are reversed and should be changed.

9. If the relay did not operate in 5 or 6, the connections to "Terminal Block" terminals 1 and 2 are wrong and should be changed.

Phase Angle Adjustment: Fig. 8.

10. Turn the phase shifter in either direction until the dc voltage output between terminal 2JB and 2JR in the front panel just drops to zero, and read the phase shifter angle. (angle between I and V).

11. Continue the turning in the same direction until the dc voltmeter across jack terminal 2JB and 2JR just reads 20 ± 2 volts, and read the angle on the phase shifter.

12. Adjust the potentiometer 1R14 in front panel until the difference between the above angles becomes 180 ± 2 degrees.

Zero Sensitivity Check:

13. Apply 120 volts and 10 amperes as indicated above.

14. Check that the zero sensitivity angle occurs within 4 degrees at 150° and 330° of the phase shifter.

Minimum Pick Up Check: Fig. 8.

15. Apply 1 volt between terminals 7 and 8 (7 is polarity) and circulate 0.4 amperes through "Terminal Block" terminals 1 and 2 (1 is polarity). The relay should pick up at maximum sensitivity (current lags 60°).

16. Disconnect the voltage terminal (7 and 8) and circulate 0.5 amperes through "Terminal Block" terminals 1 and 2 and through 4 and 3. The relay should operate at 20 volts dc which is obtained between "Jack Terminal" 2JR and 2JB. Also check a 20 volts dc output between "printed circuit board" terminals 6 and 1 (6 is positive).

B. Overcurrent Unit Adjustment

Phase Splitter Adjustment

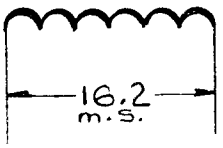
1. Disconnect the directional amplifier circuit board from the relay.

2. Extend module with board extender, and adjust knob on rheostat 3S1 (front of module) such that white pointer is equidistance from each side of locking tab when S1 is fully rotated.

3. Turn rheostat 3S1 all the way towards lowest dial current marking.

4. Circulate minimum current marked on the dial through terminals 1 and 2.

5. Connect scope across 3TP-2 and printed circuit terminal #1 (ground). Adjust potentiometer 3R13 (middle-top of board) to obtain following waveform:



Dial Calibration

1. Apply rated dc voltage to relay.

2. Connect high resistance dc voltmeter to test points on front of module. (Red J = Pos. Black J = Neg.).

3. Apply desired 3S1 current to "Terminal Block" 1 and 2.

4. Turn 3S1 rheostat until the relay operates as indicated by a sudden reading of approximately 20 volts dc on meter.

Dropout Adjustment (3R12)

1. Set Rheostat 3S1 on minimum dial current value, apply rated dc voltage, and connect the dc voltmeter across "Jack Terminal J_R and J_B" of overcurrent unit.

2. Apply minimum setting current to proper relay terminals. Overcurrent unit should operate at a current level within 2% of the marked value on the dial.

3. Reduce ac current to 97% of pick up current for minimum setting.

4. Rotate potentiometer 3R12, until the relay resets as indicated by voltmeter dropping from 20 to zero volts.

5. Verify pick up and dropout by raising and lowering ac current. The overcurrent unit should pick up within 2% of marked value and dropout at 97% of pick up current.

Trouble Shooting Procedure

Use the following procedure to locate the source of trouble if the relay is not operating correctly.

1. The first step is inspecting all wires and connections of the transformers, and also paying particular attention to printed circuit board terminal.

2. Check phase shifting component on their connection and values as listed on the internal schematic of the relays.

3. Check the circuit board at different test point as listed below by an oscilloscope to see if the waveforms of Fig. 10 are obtained for a given test condition.

Test Condition:

Set the relay for voltage polarizing, apply 100 volt to the voltage terminal and 10 amperes to the operating current transformer (terminal block 1 and 2) with the proper polarity. Set the phase shifter on "0", check the test point number 1 by an oscilloscope and compare them with the given waveforms.

If the ring modulator output is obtained but there is no final output, the trouble would be on the circuit board.

If the final output is obtained, and the period of the waveforms are not the same as shown for this particular angle relation between current and voltage, the phase shifting network of the relay has to be checked.

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.

BURDEN DATA

DIRECTIONAL UNIT VOLTAGE CIRCUIT

$I_O = 0$ or $I_O = S14$

VOLTAGE	VA	WATT	VAR
100	9.20	8.9	2.3
75	5.10	4.92	1.27
50	2.24	2.16	0.62
25	.56	.54	.015
10	.08	.078	.022
5	.015	.0144	.0041
1	.006	.0058	.0016

DIRECTIONAL UNIT, CURRENT CIRCUIT

OPERATING CURRENT	VA	WATT	VI
1	.043	.041	.0125
5	1.05	1.0	.031
10	4.2	4.0	1.23
20	18.0	17.2	5.25
30	39	37	12.7
40	64	61.	20.8
50	120	115	35

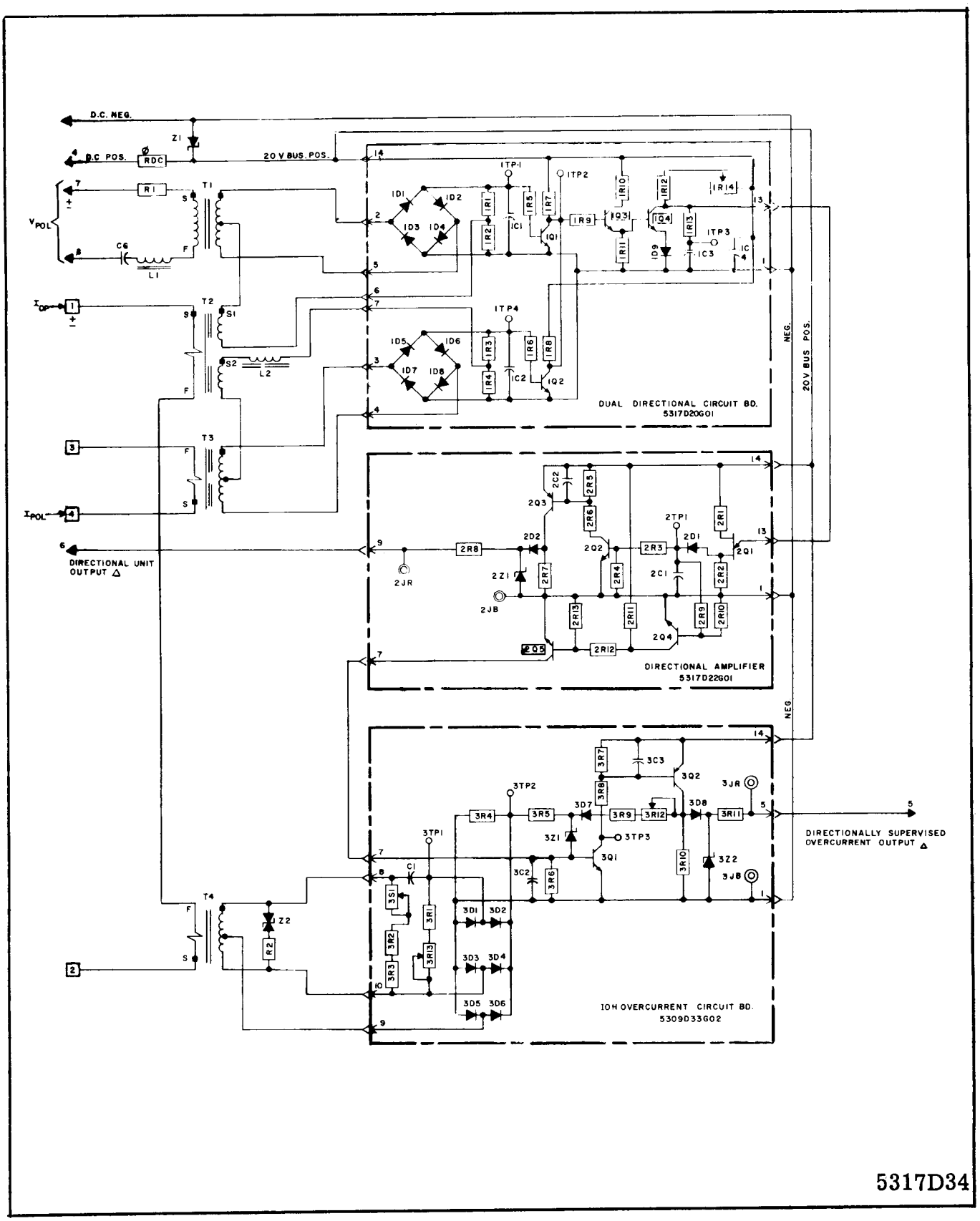


Fig. 3. Internal Schematic

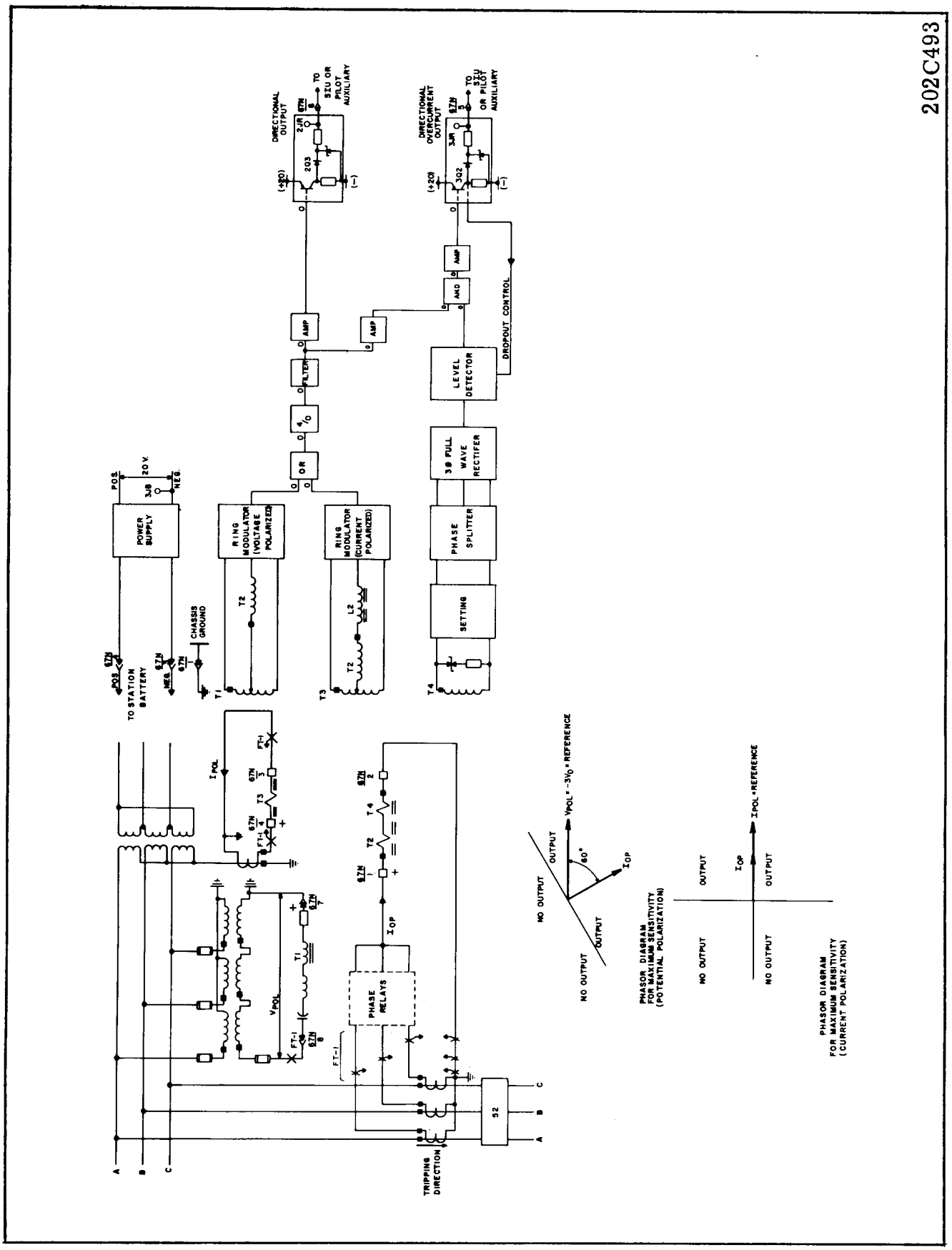


Fig. 4. External Schematic

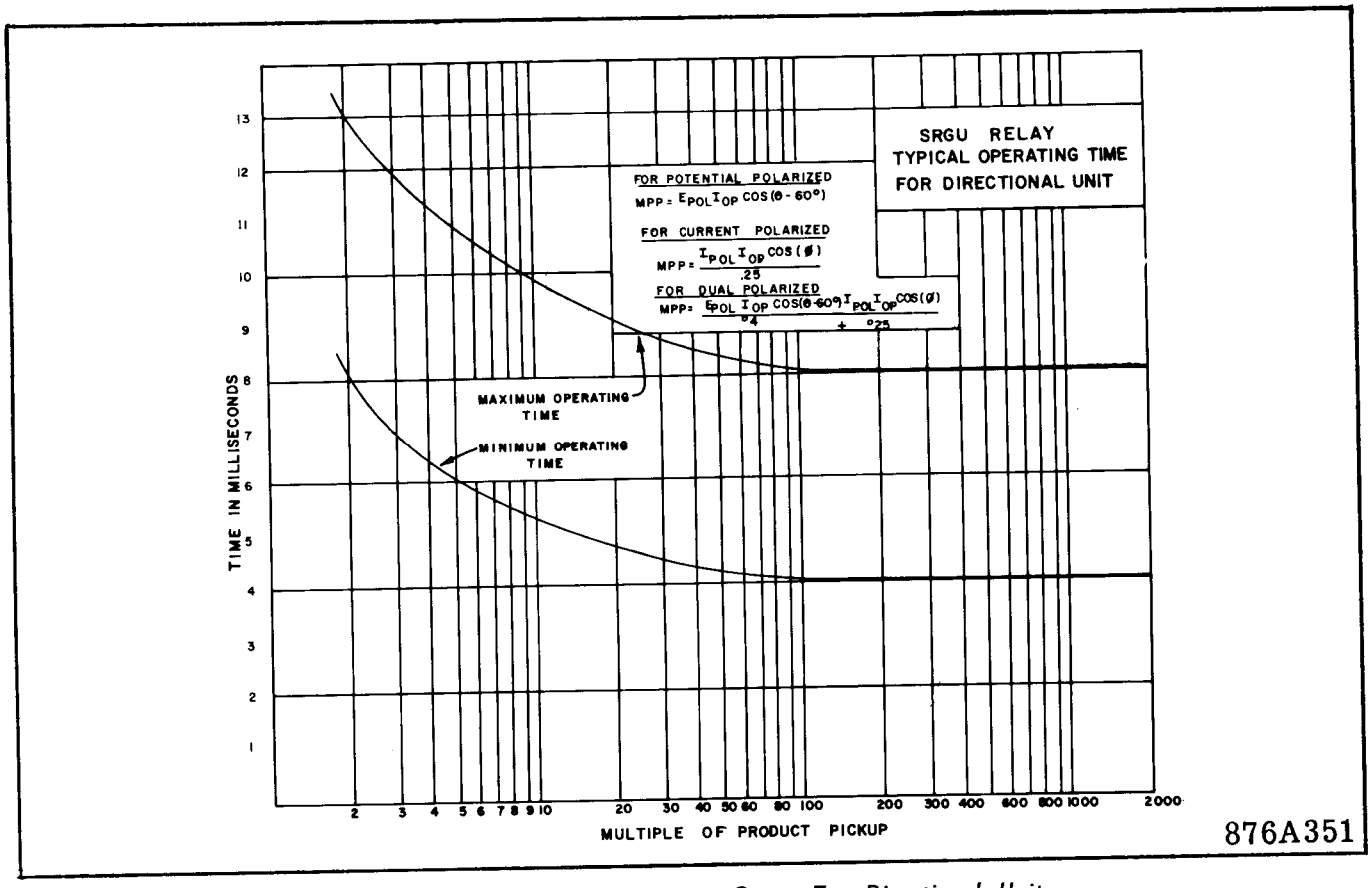


Fig. 5. Operating Timing Curve For Directional Unit.

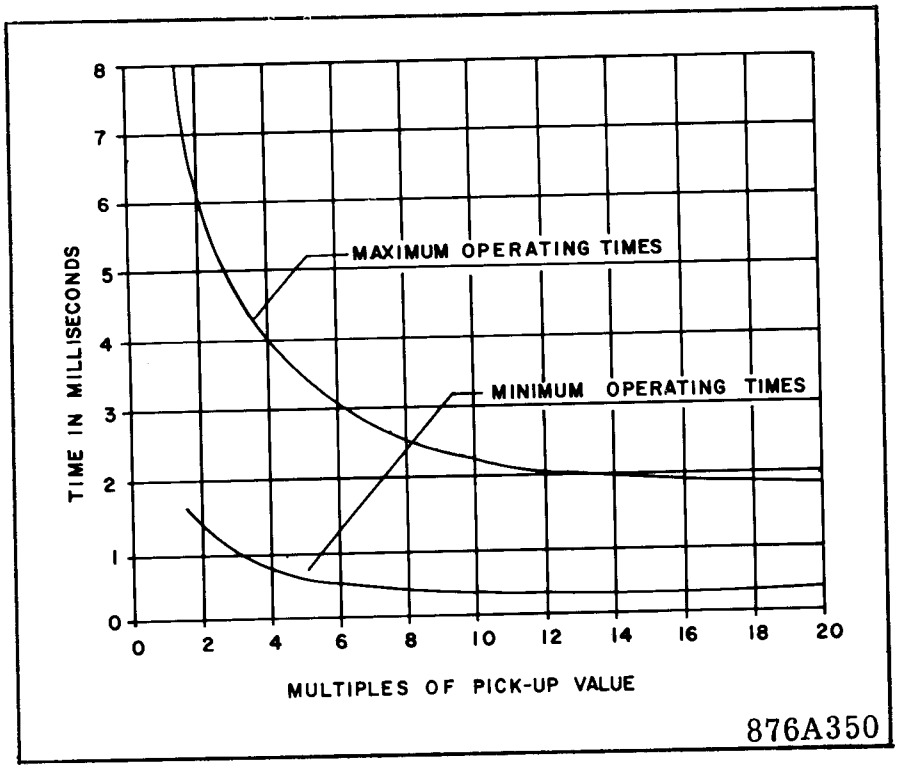


Fig. 6. Operating Timing Curve For Overcurrent Unit.

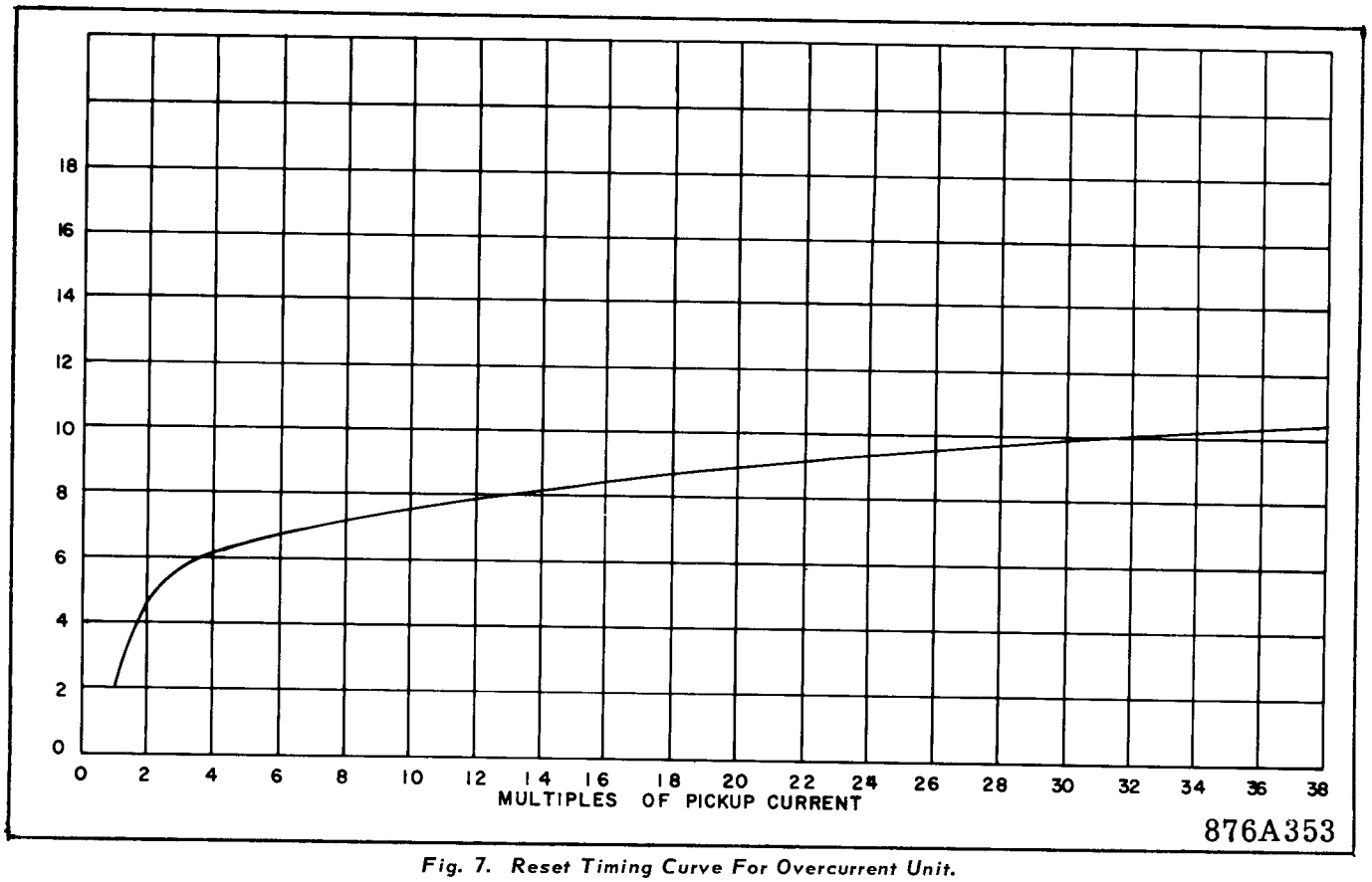


Fig. 7. Reset Timing Curve For Overcurrent Unit.

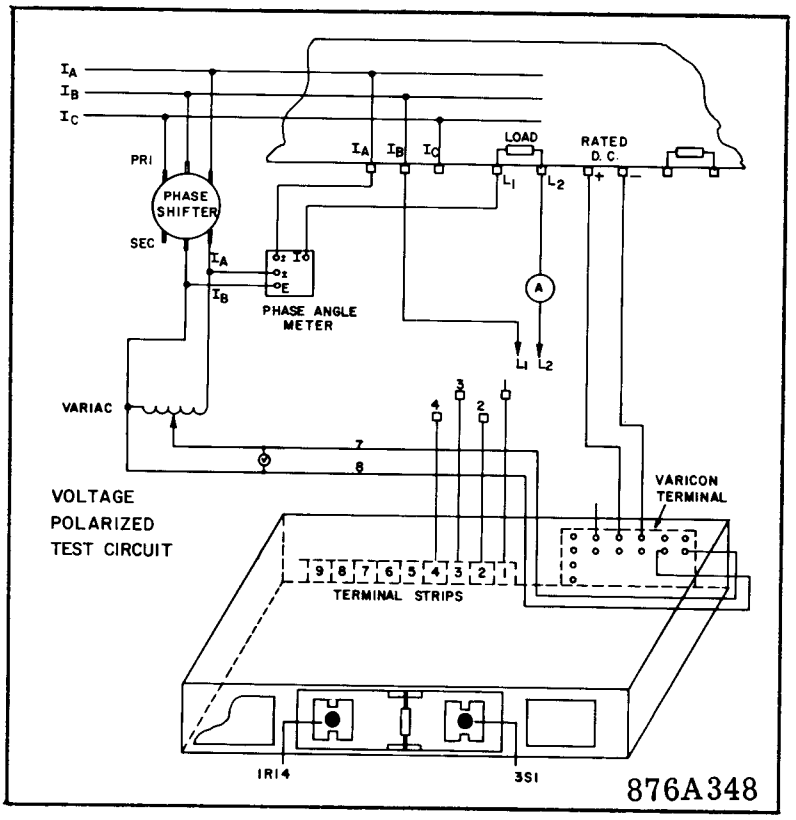


Fig. 8. Testing Circuit

5317D20
5317D22-5309D33

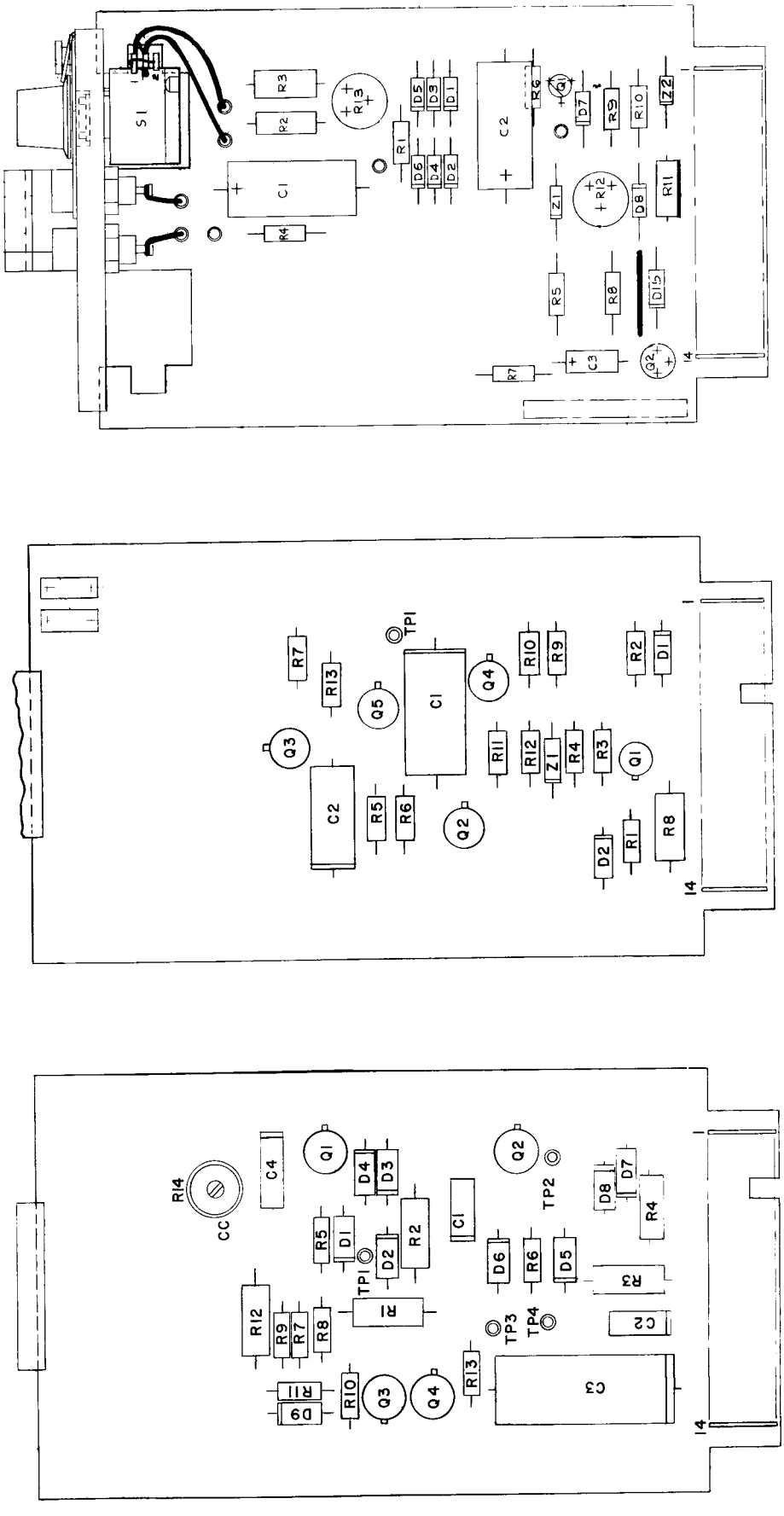


Fig. 9. Printed Circuit Board

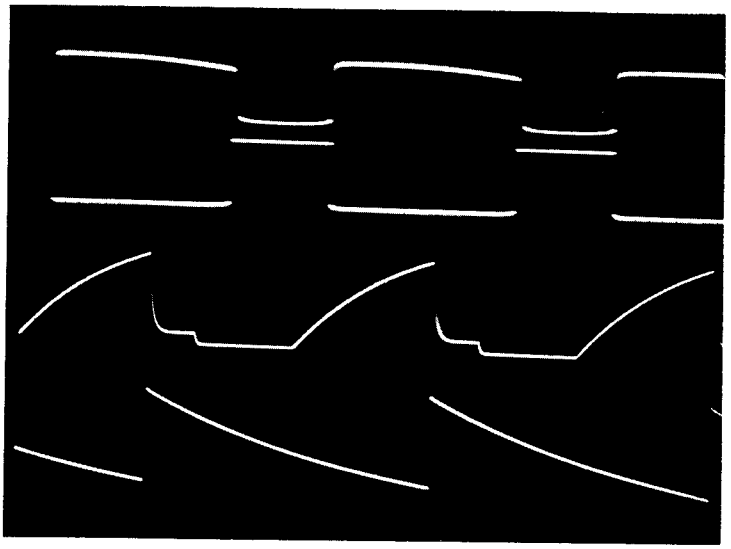
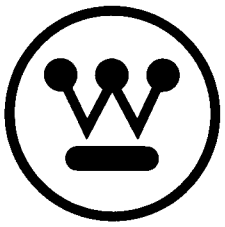


Fig. 10. Waveforms
Sweep – 2 ms/cm.

Voltage #1	*Ring Modulator Output*	*2 volt/cm.*
#2	*Transistor Output*	*10 volt/cm.*
#3	*C1 Output*	*10 volt/cm.*
#4	*Filter Output*	*2 volt/cm.*



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