INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

PR RECLOSER

CONSTRUCTION AND OPERATION

The type PR Recloser static control consists of (1) three current to voltage transformers, (2) a phase minimum pickup printed circuit board, (3) a phase time curve printed circuit board, (4) a d-c amplifier printed circuit board, (5) a reclose timer printed circuit board, (6) a reset timer printed circuit board, and (7) an integrator. All timing functions are accomplished through the use of semiconductor components. All components are identified on the internal schematic in Figure 8.

Phase Minimum Pickup Board:

The secondary voltages from the three-phase transformers are applied to three full-wave bridges. The output of the bridges are connected in parallel to form a maximum voltage network. Hence, the voltage applied to the phase timer is proportional to the phase with the largest magnitude of fault current. The filtered d-c activates the minimum trip circuit and the phase time curve circuits simultaneously.

Phase Time Curve Board:

The phase time curve board consists of two time delay and three instantaneous biased-diode curve shaping and timing circuits which at a predetermined level apply a signal to the input of the d-c amplifier.

D-C Amplifier:

The amplifier receives low-level signals from the phase time curve board and amplifies them to a value that is of sufficient magnitude to operate the trip circuit of the control.

Trip Circuit:

The trip circuit consists of a thyristor which has an anode, cathode, and a gate. The anode of the SCR is connected to the positive side of the recloser's battery. The cathode of the SCR is connected to the negative side of the battery through the trip coil and a normally closed contact of the recloser. The gate of the SCR is connected to the output of the d-c amplifier. With no gate current flowing, the thyristor acts as an open circuit to the recloser's trip coil. When gate current is applied to the SCR, the SCR turns on and connects the recloser trip coil across the battery opening the recloser and the trip circuit.

Reset Timer:

The reset timer is controlled by the integrator and the auxiliary switches on the recloser. The front panel settings allow a choice of 4 different times for the resetting interval. The time delay circuit is of the quick reset type enabling the reset times to always be consistent with times indicated on the front panel. Fault current supervision is provided by the Phase Minimum Pickup circuitry to hold the reset timer inoperative as long as a fault is present on the protected line.

Reclose Timer:

The reclose timer utilizes a type SG auxiliary relay for energizing the closing motor of the recloser. The front panel setting allows a choice of 5 different times for each interval of reclosing. The time delay circuit is of the quick reset ytpe which allows a specific timing circuit to be used for all reclosing intervals.

Cold Load Pickup:

Shorting PR terminal 5 to ground with the cold load pickup switch will raise the fault current needed to trip open the recloser by a factor of 2 to 3, i.e. if the phase minimum trip settings are in the 3-ampere taps, it would take approximately 6 to 9 amperes to trip open the recloser.

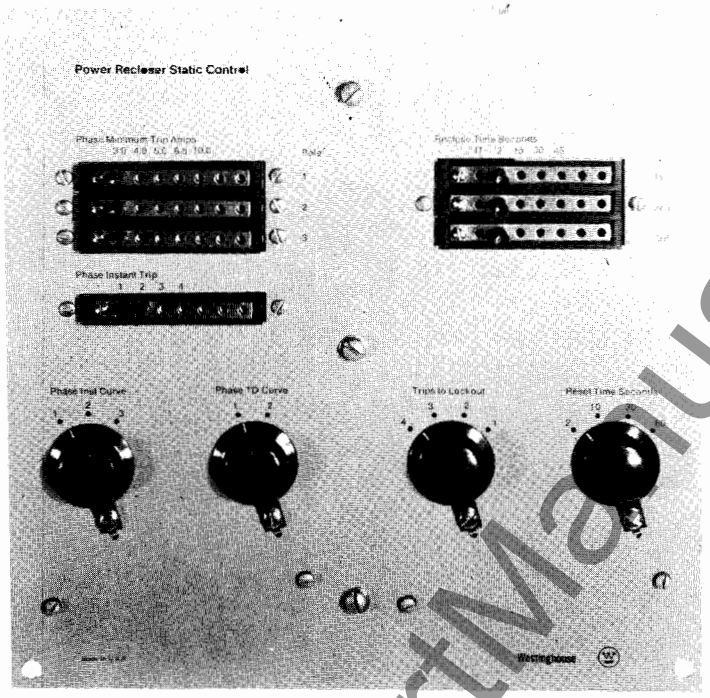

Fig. 1. Type PR Recloser Static Control (Front View)

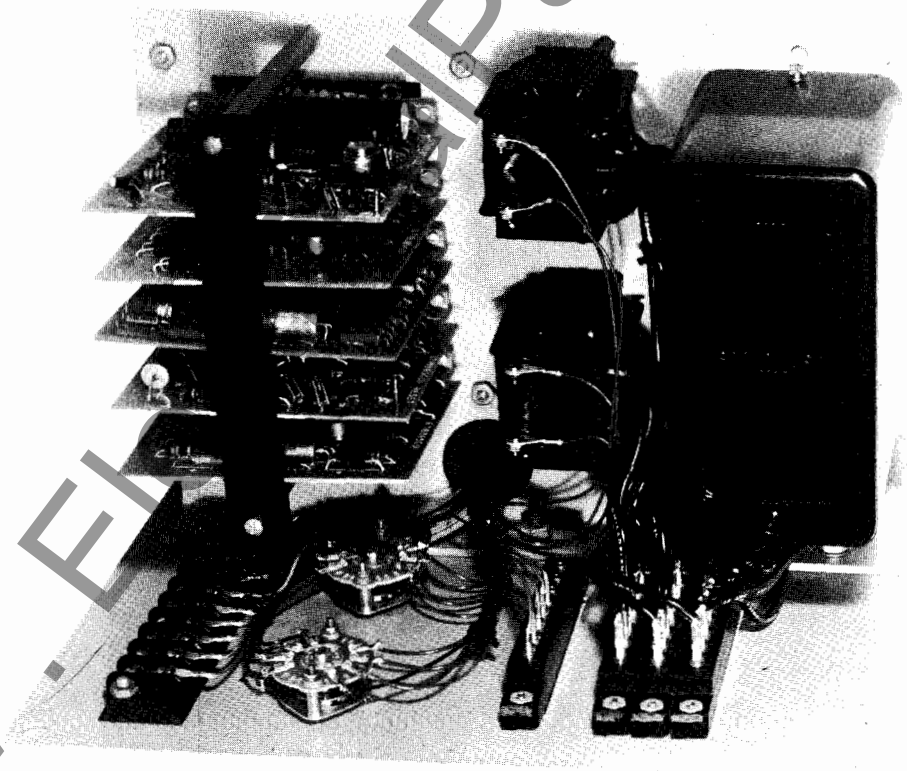

Fig. 2. Type PR Recloser Static Control (Rear View)

THEORY OF OPERATION

Operation of the control will be described with reference to schematic drawing 5105D66. We will assume that the control is set for two instantaneous and two time-delayed operations, and that a permanent phase fault occurs on the line being protected. Multi-ratio bushing current transformers feed the alternating current signal to the primary of phase transformers T1, T2 and T3. The secondary voltages from these transformers are fed to three full-wave bridges. The output of the bridges are connected in parallel to from a maximum voltage network. Hence, the voltage applied to filter capacitor C18 is proportional to the pole of the recloser with the largest magnitude of fault current.

The filtered d-c is now applied to the minimum trip circuit. When the breakdown voltage of zener diode Z6 is exceeded (measured at pin 9 Phase MPU Board 671B389) current flows into the gate of thyristor SCR-4. This turns SCR-4 on dropping the voltage on its anode to a low value. This deprives transistor Q15 of its base drive, and it no longer conducts, removing the short circuit from the time curve capacitors. Transistors Q8 and Q9 (and thereby Q11 are also deprived of their base drives and they cease to conduct. This removes the short circuit from the instantaneous and time-delayed inputs to the amplifier.

The filtered d-c from capacitor C18 is applied from PR terminal 11 through level 6 of the integrator to the phase instantaneous trip tap block. Because of an instantaneous setting on the "PHASE INSTANTANEOUS" tap block, the filtered d-c is sent to the "PHASE INSTANTANEOUS CURVE" selector switch and, depending upon the setting, is applied to one of the biased-diode instantaneous timing circuits. From here a signal is applied through the "PHASE INSTANTANEOUS CURVE" switch to the instantaneous input of the amplifier (terminal 7 of Amplifier Board 671B387). Here, after charging up capacitor C13, the d-c signal is amplified through transistors Q12, Q13 and Q14 to fire unijunction transistor U1 into the primary of pulse transformer TR-1. The secondary of TR-1 applies a trip signal to the gate of SCR-3, turning it on to connect the recloser battery across the trip coil, opening the recloser contacts and removing the fault input to the phase circuitry.

A 52a contact in series with terminal 19 opens, and this stops SCR-3 from conducting as there is no longer a complete path for current flow. With no input to the phase transformers, the voltage applied to zener diode Z6 falls to zero. SCR-4 no longer has any current flow into its gate and becuase of the design of the circuitry associated with SCR-4, it cuts off. The anode voltage on SCR-4 rises to a magnitude sufficiently high enough to breakdown Z7 and allow current to flow into the bases of transistors Q15, Q8 and Q9 (and thereby Q11). These transistors start to conduct and all timing capacitors are quickly discharged. When the trip coil was placed across the reclose battery tripping the recloser, battery voltage was applied, by a closing 52b contact, to the integrator coil through terminal 20, the normally closed integrator contacts (SS2), and level 2 of the integrator. As the armature of the integrator picks up, the normally closed contacts (SS2) of the integrator open, stopping current flow.

The integrator armature compressed a spring when the coil was energized. When the SS contacts open and the coil is de-energized, the spring moves the take-off arm to step 1.

The reclose timer is now energized through the take-off arm of level 4, step 1, and interval one of the RECLOSE TIMER tap blocks. With all inputs removed from the base of transistor Q5, the resistor-capacitor timing circuit commences to charge to a voltage that will be sufficient to allow current to flow into the base of transistor Q6 through zener diode Z2. This signal is amplified by transistor Q6 and applied to the gate of SCR-2, turning SCR-2 on and placing the Motor Close Relay (MCR) across the battery through the 52b contact (terminal 20). The MCR contacts energize the closing motor, and the motor closes the main contacts of the recloser and prepares the spring for another tripping operation. When terminal 20 loses its positive voltage, due to the opening of the 52b, SCR-2 cuts off and the MCR relay drops out.

The low potential of the anode of SCR-2 when it fired also took the base drive away from transistor Q4, allowing transistor Q5 to turn on and discharge the time delay capacitors C8, C9 and C10 in the reclosing interval.

The reset timer was kept inoperative by terminal 20 being highly positive and supplying base drive for transistor Q2 to keep the reset time delay capacitors short-circuited. With the recloser closed and base drive removed from transistor Q2, the time de-

lay capacitors will attempt to charge up through the RESET TIME selector switch to turn on SCR-1 and reset the integrator to its home position (step 10). The fault sensing circuitry will hold the reset timer inoperative by shorting the timing capacitors through resistor R49 and the "on" transistor Q10 to ground.

When the MCR relay had picked up, the MCR contact in series with level 7 of the integrator and the coil of the integrator closed to place the battery across the integrator coil. This causes the armature to pickup compressing the spring on the integrator. When the MCR contacts opened, the integrator coil was de-energized and the spring moved the take-off arm to step 2.

Since the control was set for two instantaneous faults, another instantaneous fault takes place in a similar manner to that which was described for the previous operation. The integrator is advanced to step 3 through the 52b contact to terminal 20 and level 2 of the integrator.

The reclose timer resistor-capacitor time delay circuit is now energized through level 4, step 3, and the setting on the reclose timer interval 2 and will operate in accordance with that setting. After the predetermined time delay SCR-2 will turn on and the MCR relay will be energized. The MCR contacts will energize the closing motor, closing the recloser contacts, which removes battery positive from terminal 20. This allows SCR-2 to cutoff and the MCR Relay to dropout. During the time that the reclose timer was operating, the reset timer was held inoperative by the positive voltage on terminal 20. This voltage supplies base drive for transistor Q2 making Q2 conduct, short circuiting the capacitors in the reset-timer time delay circuitry.

When the MCR relay had picked up, the MCR contact in series with level 7 and the coil of the integrator closed to move the integrator on to step 4 in a manner previously described.

With the reclosure of the recloser, the base drive is removed from transistor Q2 and the reset timer attempts to time out and reset the integrator to the home position (step 10). The phase transformers again sense the fault, and the minimum trip circuitry reacts in the same way as previously described to hold the reset timing capacitors inoperative, and to allow a third operation. Since the control was not set for a third instantaneous operation, the biased-diode time delay curve shaping circuitry is activated and, at a predetermined level, applies a signal to the d-c amplifier through diode D10. In the same manner as previously mentioned, SCR-3 fires to put the battery across the trip coil, opening the recloser contacts and removes the fault input to the phase circuitry. Again, the integrator advances another step, to step 5, and the reclose timer circuitry is energized through level 4 of the integrator and the setting on the reclose timer tap block interval 3. After the predetermined time delay, SCR-2 turns on picking up the MCR relay. The MCR contacts energize the closing motor (which closes the recloser main contacts and prepares it for another opening operation), and through level 7 moves the stepping switch to step 6. The potential of terminal 20 drops to zero turning off SCR-2 and de-energizes the MCR relay. This, in turn, in the same manner as before, shorts out the reclose timing capacitors and allows the reset timing circuitry to attempt to time out and reset the integrator to the home position (step 10).

The fault reappears to keep the reset timing circuitry inoperative and the recloser goes through another time-delayed operation as no instantaneous operation was preset on the phase instantaneous tap block. The trip coil is again placed across the battery by SCR-3 firing, and, once again, the integrator is advanced another step, to step 7. The internal wiring of the integrator (level 3) moves the integrator to step 8. Levels 2, 3, 5, 6 and 7 have no functional connections on step 8 as this is the "lockout" step. The reclose timer is kept inoperative by the positive signal that is present at the base of transistor Q5. This signal keeps transistor Q5 conducting and prevents any build-up of voltage on the reclose timer-time delay capacitors.

The reset timer is kept inoperative by the short-circuiting of the time delay capacitors due to the base drive applied to transistor Q2 by the positive voltage on terminal 20. The control will remain in this condition until the recloser is manually or electrically closed.

If the control is closed with the close switch to feed a positive signal to the gate of SCR-2 through terminal 26, capacitor C11 and zener diode Z14, SCR-2 turns on instantaneously. The MCR relay is energized, and its contacts energize the closing motor. This closes the recloser main contacts and prepares the main spring for another opening operation. The reset timer attempts to time out and reset the integrator to its home position (step 10). Since

the fault still exists, the fault voltage activates the minimum trip circuitry. With the integrator on step 8, there can only be a time delayed operation because of the absence of any connections on the stepping switch. The control will perform in accordance with the previous description for time-delayed operation. As SCR-3 is turned on by the output of the amplifier, tripping the control, positive voltage is again present on terminal 20. However, since there is no connection made on level 2, step 8 of the integrator, the integrator remains at step 8 or "Lockout". If for some reason, the "close" switch was held in the close position, capacitor C11 would pass the pulse as the switch is first made and whould then charge and remain charged to the positive voltage on terminal 26. Then, when the control opened again, the reclose timer would not reclose until capacitor C11 was given a chance to discharge. Capacitor C11 can only discharge when the "close" switch is returned to its "NORM" position. Thus, the control exhibits an antipump feature on reclosing.

Since the control is at step 8 after the last operation, the control will remain at "Lockout" until it is manually or electrically closed. If we now assume that the fault has been cleared and the recloser is closed in, utilizing the "CLOSE" switch, SCR-2 will turn on and the MCR relay will be energized, Thereby energizing the closing motor. This closes the recloser main contacts and prepares the main spring for an opening operation. The potential of terminal 20 drops to zero, allowing SCR-2 to turn off, and the MCR relay to dropout. Transistor Q2 loses its base drive, turning off to allow the reset time delay capacitors (C1, C2 and C3) to charge up to a voltage of sufficient magnitude to allow Z1 to conduct current into the base of transistor Q3. Transistor Q3 amplified the signal which is applied to the gate of SCR-1. SCR-1 turns on placing the integrator coil across the battery through the integrator contacts (SS-1) and the homing contact (HC). As the armature pulls in, the integrator contacts open allowing the integrator to move to step 9. Since the reset timer capacitors remain charged, SCR-1 remains fired and the integrator advances to step 10, or the integrator's home position. All circuits are de-energized except for step 10, level 3, which feeds a positive voltage to the base circuitry of transistor Q2 in the reset timer. This positive voltage makes transistor Q2 conduct, discharging the reset timer time-delay capacitors, and keeps these capacitors discharged when the integrator is at its home position (step 10).

The homing contact (HC), a cam-operated switch, is open at step 10 and keeps the integrator coil from being energized when at the integrator's home position. The control is now reset and ready to go through a full sequence in line with the settings made at the beginning of this description.

CHARACTERISTICS

The control is available with the following secondary ampere ranges:

Phase Range	Taps
3.0 to 10.0	3.0, 4.0, 5.0, 8.5, 10.0

The time versus current characteristics are shown in curves 538139 and 538140. These characteristics give the control operating time for the Time Delay and instantaneous settings when the indicated multiples of tap value current are applied to the control. Two different time-current characteristics are available for phase protection along with three different instantaneous curves. When reclosing after lockout, the control will always be set up for a time-delayed operation until the integrator resets to its home position, where the effective settings then apply.

Tripping Sequences:

The tripping sequences can be all instantaneous, all time delayed, or any combination of instantaneous and time delayed as desired.

Reset Time:

The reset timer can be set for 2, 10, 30 and 60 seconds resetting time.

Reclose Time:

The reclose timer can be set for 2, 15, 30 or 45-seconds reclosing time for each reclosing interval. Instantaneous reclosure can be set on intervals 1 and 2; interval 3 will automatically provide a 2-second reclosure if the timer is set for an instantaneous reclosure.

Operations to Lockout:

The control can be set to lockout the recloser after 1, 2, 3 or 4 operations.

INTEGRATOR LEVEL AND STEP FUNCTIONS

Integrator	Step 10 Home Position	Step 1	Step 2	Step 3	Step 4
Level 1 Not used					
Level 2	Pulses Integrator to step 1 when 52b contact in series with Term. 20 Closes	Pulses Integrator to Step 2 if One Shot to Lockout Switch is Closed	Pulses Integrator to Step 3 when 52b contact in series with Term. 20 Closes	Pulses Integrator to Step 4 if One Shot to Lockout Switch is closed	Pulses Integrator to Step 5 when 52b contact in series with Term. 20 Closes
Level 3 and Trips to Lockout Selector Switch Setting	Supplies Base Drive for Q2 to Keep Reset Timer inoperative	Pulses Integrator to Step 2 when set for One Trip to Lockout	No Connection	Pulses Integrator to Step 4 when set for 1 or 2 trips to Lockout	No Connection
Level 4 and Reclose Time Tap Block Setting	No Connection	Energizes Re-close Timer Delay Circuit Through Inter-	No Connection	Energizes Re-Timer Time De-Delay Circuit Through Inter-	No Connection
Level 5 and Ground Inst. Tap Block Setting #	Determines Ground Inst. Operations	No Connection	Same as Step 10	No Connection	Same as Step 10
Level 6 and Phase Inst. Tap Block Setting	Determines Inst. Operations	No Connection	Same as Step 10	No Connection	Same as Step 10
Level 7	No Connection	Pulses Integrator to Next Step Up-on Closure of MCR Contacts	Same as Step 1	Same as Step 1	Same as Step 1

— When Used.

INTEGRATOR LEVEL AND STEP FUNCTIONS

Integrator	Step 5	Step 6	Step 7	Lockout Pos. Step 8	Step 9
Level 1 Not Used					
Level 2	Pulses Integrator to Step 6 if One Shot to Lockout Switch is Closed	Pulses Integrator to Step 7 when 52b contact in series with Term. 20 Closes	No Connection	No Connection	No Connection
Level 3 and Trips to Lockout Selector Switch Setting	Pulses Integrator to Step 6 when set for 1, 2, or 3 Trips to Lockout	No Connection	Pulses Integrator to Step 8	Supplies Voltage for Lockout Indicator at Terminal 8	No Connection
Level 4 and Reclose Timer Tap Block Setting	No Connection	Energize Reclose Timer Time Delay Circuit Through Interval 3	No Connection	Short Circuits Reclose Timer Time Delay Capacitors	No Connections
Level 5 and Ground Inst. Tap Block Setting #	No Connection	Same as Step 10	No Connection	No Connection	No Connection
Level6 Phase Inst. Tap Block Setting	No Connection	Same as Step 10	No Connection	No Connection	No Connection
Level 7	Same as Step 1	Same as Step 1	Same as Step 1	No Connection	No Connection

— When Used.

ENERGY REQUIREMENTS

VOLT AMPERES #*

Ph. Ckt. Tap	At Tap Value Current	At 3X Tap Value Current	At 10X Tap Value Current	At 20X Tap Value Current	Continuous Rating (Amperes)	One Sec. Rating # (Amperes)
3.0	.78	7.11	72.9	216	16	460

\# – Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

*# – Voltages taken with Rectox type voltmeter (5000 ohms/volt).

Light Circuit – 240 Volts a-c Battery Charging Circuit 240 Volts a-c Battery – 24 Volts d-c

Front Panel Settings

1. Phase Minimum Trip:

   The connector screw on the tap plate of the phase timer makes connection to various turns on the primary coil of the current-to-voltage transformer. By placing this screw in the various tap plate holes, the control will respond to multiples of tap value currents in accordance with the typical time curves. Since the tap block connector 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 (located in the phase instantaneous tap block) in the desired tap position before removing the other tap screw from its original position.

2. Phase Instantaneous:

   Place tap screws in the desired taps for obtaining instantaneous operation. The numbers above the taps indicates which of the sequence of trips that would be instantaneous. For instantaneous operations on the first two trips, tap screws should be placed in the taps numbered 1 and 2. Time delayed trips will occur on all positions that do not have a tap screw.

3. Reclosing Timer (Intervals):

   Tap screws may be placed in different numbered taps for all three intervals or in the same number for all intervals (except for all instantaneous settings – the third reclosure is automatically 2 sec). A tap screw must be in each interval, otherwise the recloser will not close on that interval. When operating on less than 4 operations to lockout, the reclosing intervals will be dropped starting with the third interval first, i.e. for 3 operations to lockout, the control will reclose in accordance with the tap screws in intervals one and two, and then the control will proceed to lockout.

4. Reset Timer

   Place selector switch in proper position to obtain the desired reset time.

5. Trips to Lockout:

   Place switch in desired position for obtaining 1 to 4 operations to lockout. The numbers on the panel indicate the number of operations that will occur before lockout is reached.

6. Phase Time Delay Curve

   Place switch in proper position to obtain desired time current characteristics for time-delayed operations.

7. Phase Instantaneous Curve:

   Place switch in proper position to obtain desired time-current characteristics for instantaneous operations.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this control have been made at the factory. Upon receipt of the control, no customer adjustments other than those covered under "Settings" should be required.

Acceptance Check

The following check is recommended to insure that the control is in proper working order:

1. Check front panel settings, they should be as follows:
   a. Minimum trip current pole 1, pole 2 and pole 3 in the 3.0 amp tap.
   b. Phase Time Delay Curve Selector to position 1.
   c. Phase Instantaneous Selector Tap Screws in positions 1 and 2.
   d. Operation to Lockout Switch in Position 4.
   e. Reset Timer Switch in 2-second position.
   f. Reclosing Timer Intervals, all tap screws in the 2-second position.
   g. One shot to Lockout and Ground Trip By-pass switches in the ON position (when supplied).
   h. Connect control to recloser as per external schematic drawing Figure 9.
   i. Cold Load Pickup Switch in the NORM position (when supplied).
   j. Trip and Close Switch in the NORM position.

CAUTION: No tests should be made until both a-c and d-c connections have been made to control.

1. Trip Switch:

   Trip control utilizing the TRIP switch. Control should lockout and the green indicating light should remain lit.

2. Close Switch:

   Close the control utilizing the CLOSE switch. The control should close the recloser instantaneously and the red light should light. After approximately 2 seconds, the integrator should step to its home position.

3. One Shot to Lockout Switch:

   Energize terminals 28 and 29 with 2 times tap value current. The control should trip open the recloser and the integrator should advance to lockout. Move the ONE SHOT TO LOCKOUT switch to NORM. De-energize circuit. Close the control utilizing the CLOSE switch. Wait for integrator to reset before continuing.

4. Phase Minimum Trip Current

   Place VTVM across test point 3(Amplifier Board) and battery negative. Energize terminals 28 and 29 with approximately tap value current, raise current until a slowly increasing voltage can be seen on the voltmeter. Check value of current, this value should be equal to tap value setting on the pole 3-phase minimum-trip tap block plus or Minus 5%. Repeat the preceding procedure energizing terminals 30 and 31, and terminals 32 and 33. This will check all three poles for the correct minimum trip setting.

5. Operation to Lockout - Phase Instantaneous:

   Observe if the control locks the recloser open in the correct number of operations, and note if the correct number of fast and time-delayed operation occur in line with the settings that were made, when terminals 28 and 29 are energized with 2 times tap value current.

6. Phase Timer - Time Curve Calibration:

   Repeat step 5 using different values of fault current, and check the times required for tripping the recloser open. These times should equal the times shown under typical time curves 538139 and 538140 plus or minus 10%

7. Reset Timer:

   With control at lockout position, close the recloser utilizing the CLOSE switch, and simultaneously start a timer, time the interval that elapses before the integrator resets. This time should equal the front panel RESET TIMER setting plus or minus 10%.

8. Reclose Timer:

   Connect a VTVM to terminal 20 and battery negative (Positive lead to terminal 20). Energize terminals 28 and 29 with 2 times tap value current. When recloser opens, terminal 20 will become 24 volts positive with respect to terminal 27. Start timer when terminal 20 becomes positive, and the interval until the voltage falls to 0. This time should equal the first interval of the RECLOSER TIMER SETTINGS on the front panel plus or minus 10%. Repeat timing procedure to check the second and their reclosing intervals. For instantaneous reclosing, an electronic timer would have to be utilized.

PR RECLOSER

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE STYLE NUMBER
CAPACITORS		
C1	150 MFD, 6 V, 5%	187A508H20
C2	150 MFD, 6 V, 5%	187A508H20
C3	Determined in Test	
C4	.25 MFD, 200 V, 20%	187A624H02
C5	.25 MFD, 200 V, 20%	187A624H02
C6	10 MFD, 150 V	27D5476H09
C7	.05 MFD, 200 V, 25%	187A624H08
C8	150 MFD, 6 V, 5%	184A661H08
C9	Determined in Test	184A661H06
C10	100 MFD, 6 V, 5%	184A661H06
C11	6.8 MFD, 35 V, 20%	184A661H10
C12	33 MFD, 20 V, 20%	184A661H11
C13	.22 MFD, 60 V, 5%	187A508H22
C14	1.5 MFD, 20 V, 5%	184A661H22
C15	.5 MFD, 200 V, 20%	187A624H03
C16	2 MFD, 200 V, 20%	187A624H05
C17	47 MFD, 35 V, 20%	184A661H03
C18	1 MFD, 330 V, 10%	1876999
C25	2.2 MFD, 125 V, 10%	197A508H19
C26	.1 MFD, 50 V	184A663H04
C27	2.2 MFD, 35 V	837A241H16
C28	47 MFD, 50 V, 5%	862A177H06
C29	4.7 MFD, 35 V, 5%	862A530H02
C30	150 MFD, 30 V, 5%	862A177H05
C32	6.8 MFD, 35 V, 5%	184A661H21
TRANSISTORS		
Q1 to Q13	2N3417	848A851H02
Q14	2N4249	849A441H03
Q15	2N3417	848A851H02
Q17, Q18	2N3417	848A851H02
U1	2N2647 Unijunction	629A435H01
SILICON CONTROLLED RECTIFIERS		
SCR-1		184A640H14
SCR-2		184A640H14
SCR-3		184A614H04
SCR-4		184A640H14

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE STYLE NUMBER
ZENER DIODES		
Z1, Z2	1N748A	186A797H13
Z3	HW18B	849A515H01
Z4	1N706	837A693H07
Z5	HW22B	185A212H16
Z6, Z7	1N748A	186A797H13
Z8	1N706	837A693H07
Z9	1N957B	186A797H06
Z10	1N706	837A693H07
Z13	HW33B	849A515H02
Z14	1N957B	186A797H06
Z15	1N960B	186A797H10
Z16 to Z18	1N748A	186A797H13
DIODES		
D1	1N4816	188A342H10
D2	T1-55	183A790H09
D3, D4	1N4816	188A342H10
D5	1N4822	188A342H11
D7	1N4822	188A342H11
D8 to D14	1N4816	188A342H10
D15 to D26	1N5053	188A342H12
D27	T1-55	188A342H10
D28 to D41	T1-55	183A790H09
D42	1N4816	188A342H10
THERMISTORS		
TH1	3D402	185A211H03
TH2	1D051	185A211H05
TH3	1D203	185A211H02
MISCELLANEOUS		
TR-1	Pulse Transformer—H62	629A453H01
MCR	SG Relay	290B138H16
SS	Stepping Switch	899C409G01
T1	Phase Transformer	408C374G11
T2	Phase Transformer	408C374G13
T3	Phase Transformer	408C374G12

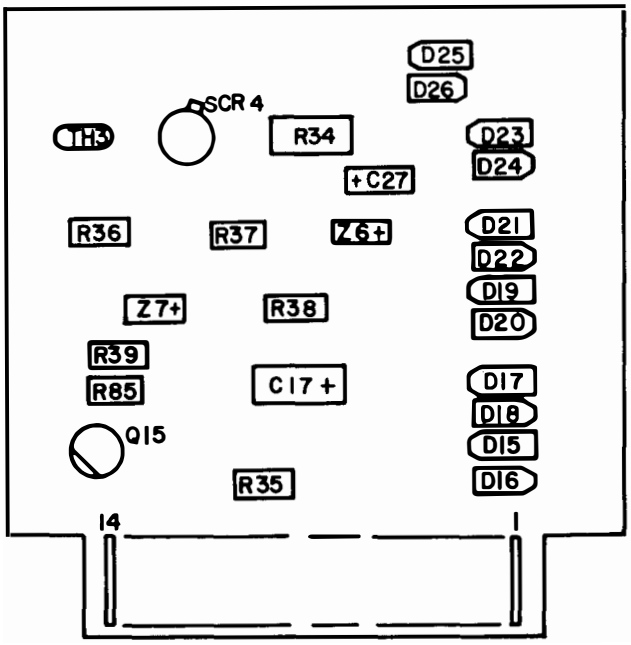

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Fig. 3. Phase Minimum Trip Board Component Location

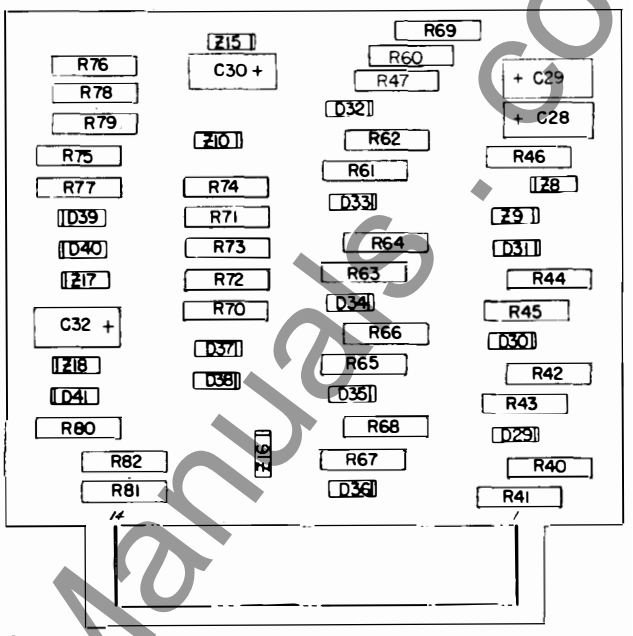

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Fig. 4. Phase Time Curve Board Component Location

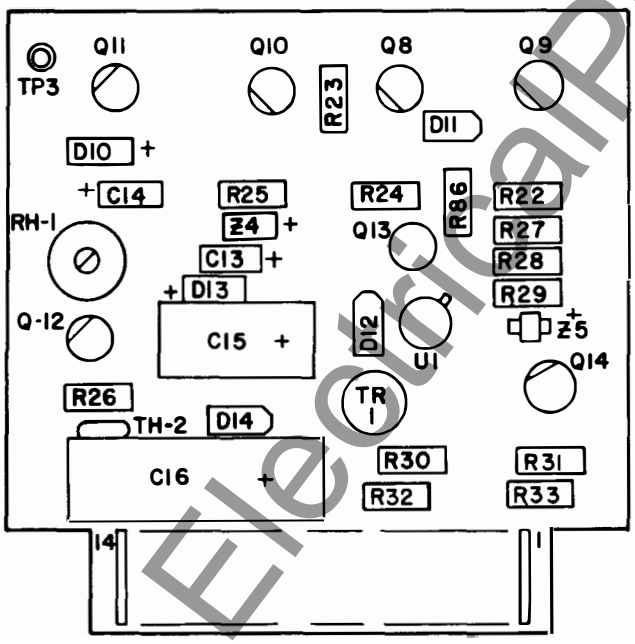

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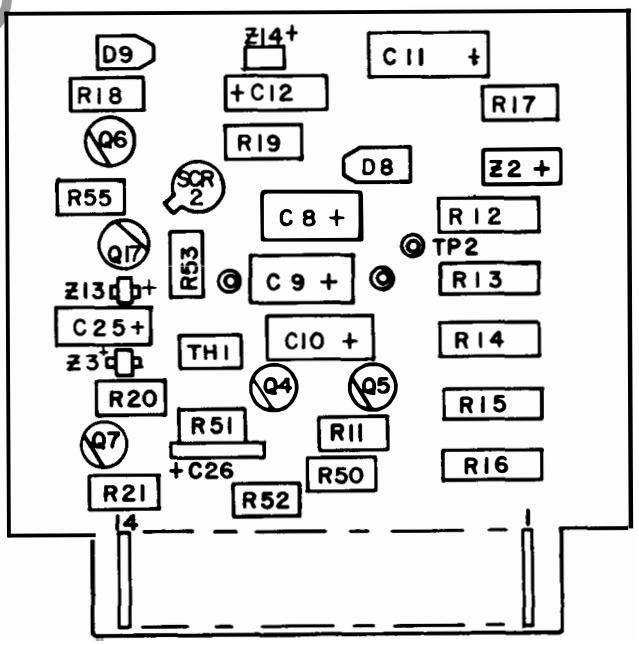
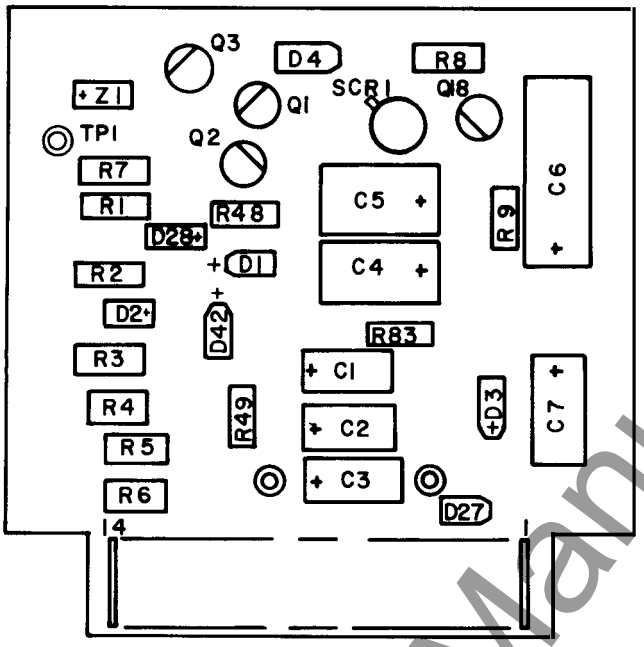
Fig. 5. Amplifier Board Component Location



877A044

Fig. 6. Reclose Board Component Location



877A041

Fig. 7. Reset Board Component Location

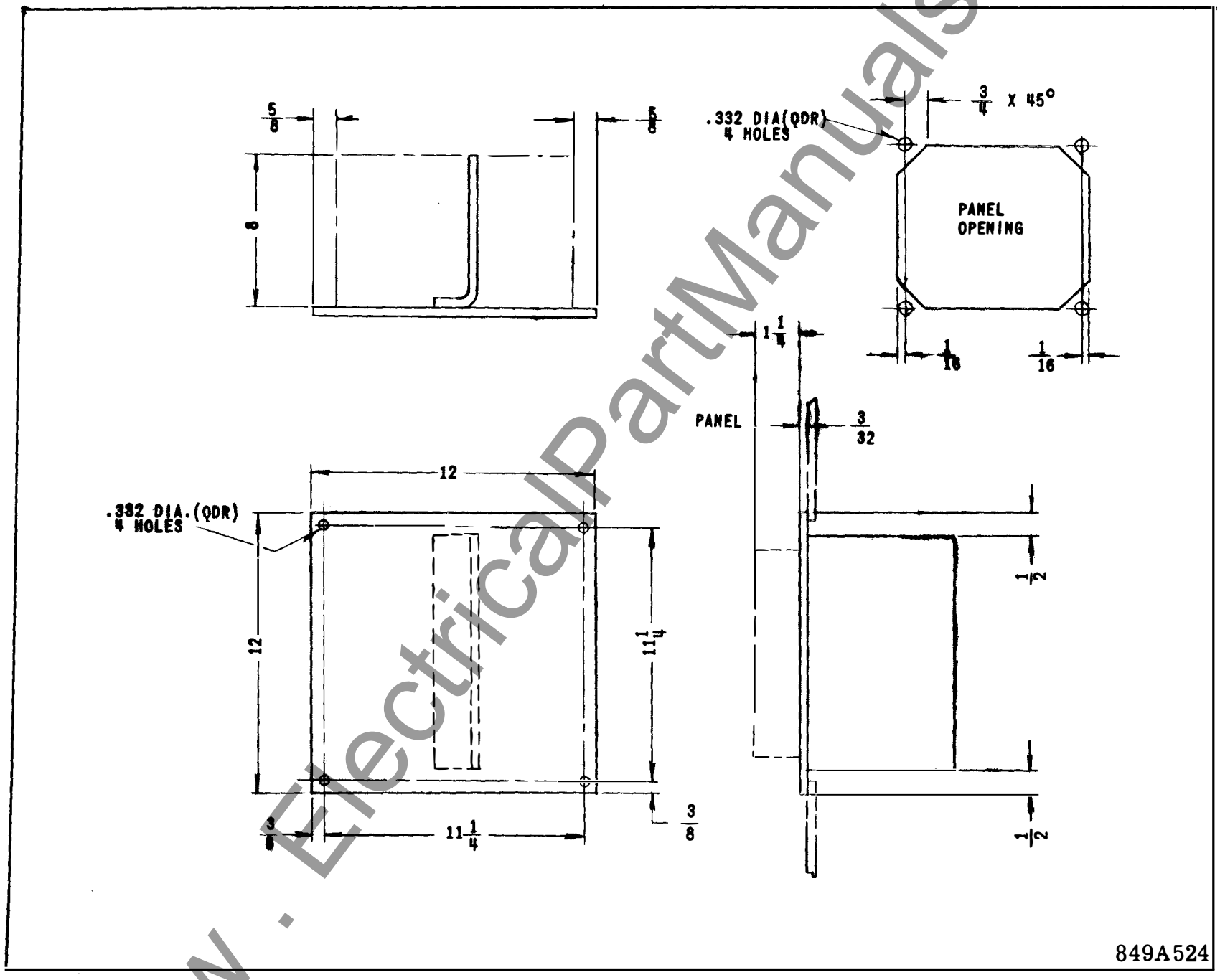


Fig. 9. Outline and Drilling

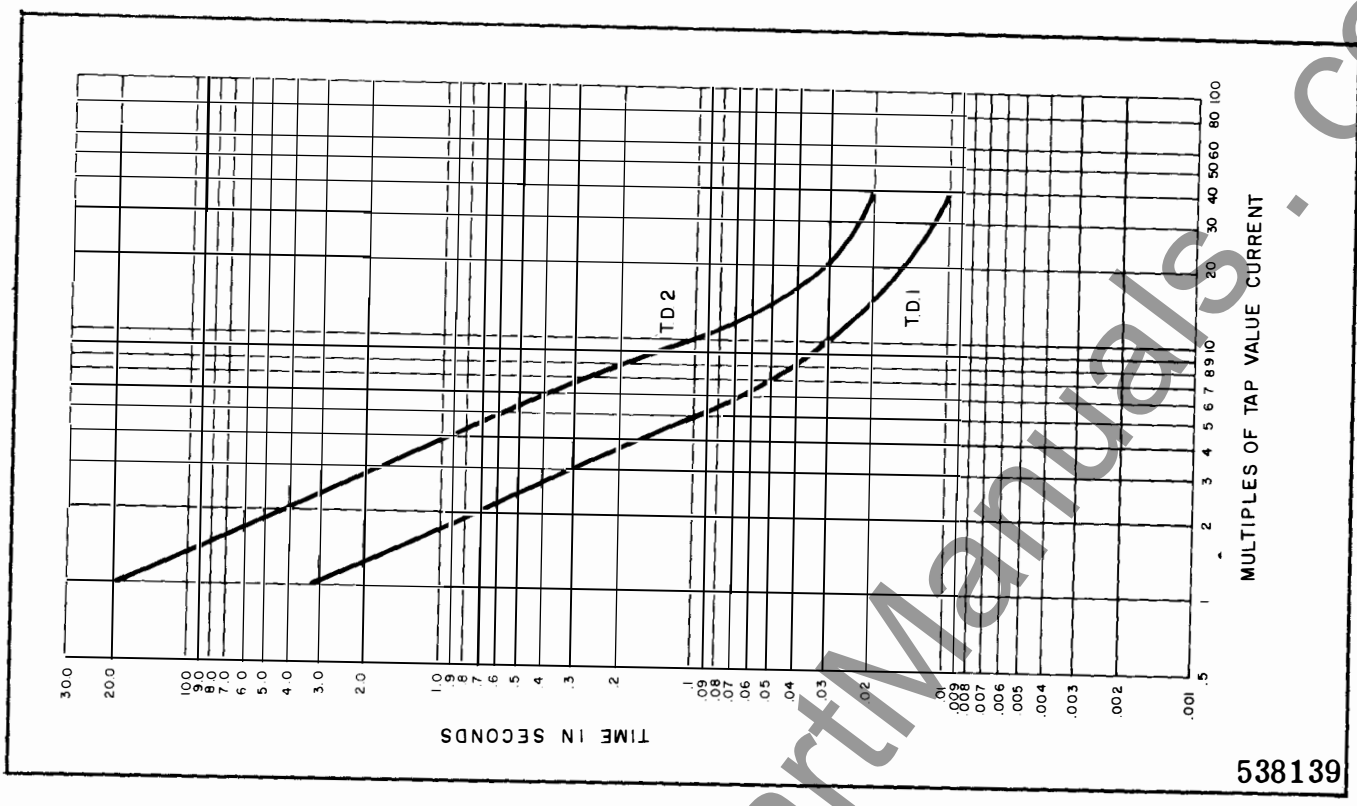


Fig. 10. Typical Time Curves, Type PR Time Delay

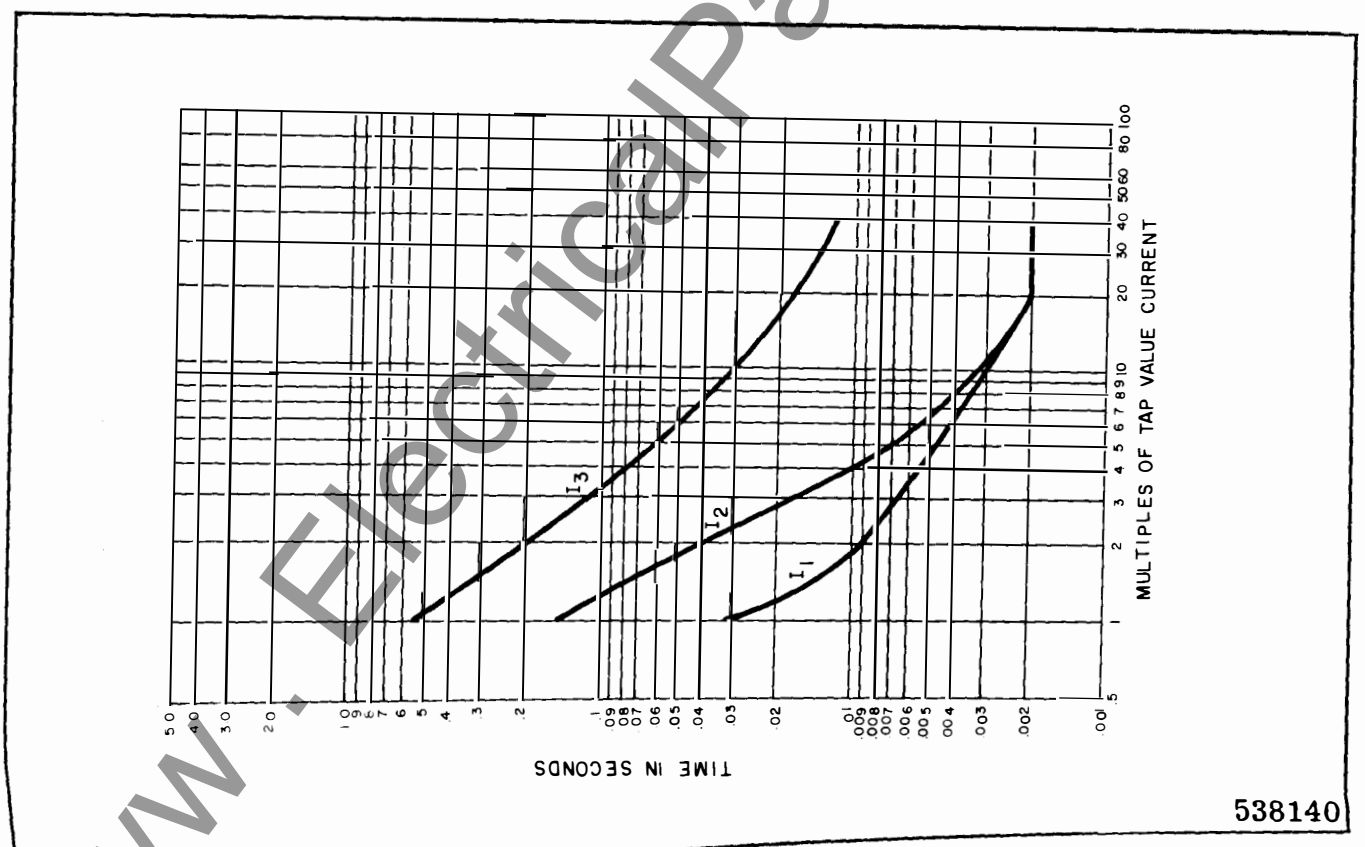


Fig. 11. Typical Time Curves, Type PR Instantaneous