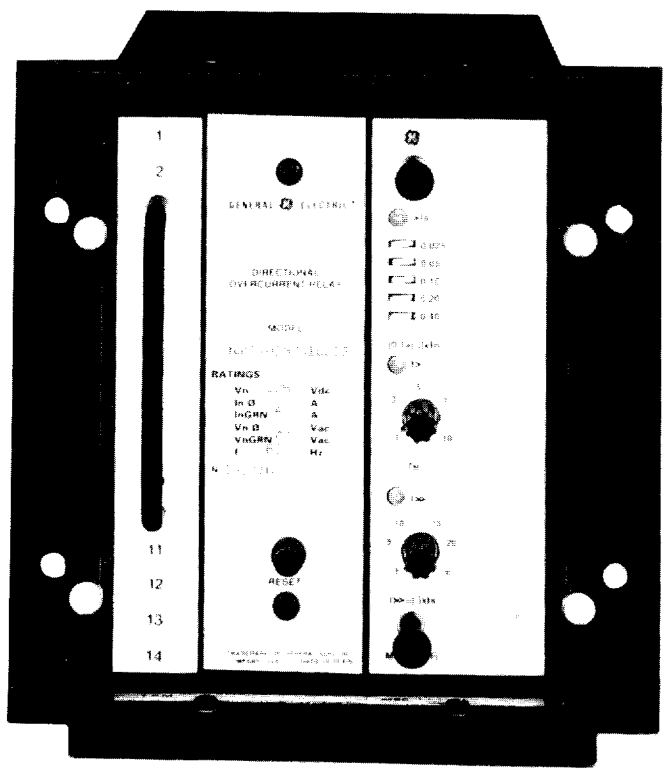
INSTRUCTIONS

GEK - 90566

MODULAR DIRECTIONAL OVERCURRENT RELAYS

TCC SERIES 1000S



GENERAL ELECTRIC

U. S. A.

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DESCRIPTION

The relays type TCC series 1000S are directional overcurrent relays for phase and/or ground fault protection with overcurrent INVERSE TIME or DEFINITE TIME measuring units and with or without INSTANTANEOUS units.

The TCC series 1000Srelays are available with the inverse BS142, inverse ANSI, very inverse or extremely inverse characteristic.

The units are solid state modular relays and fit in a 1/3 or 1 standard 19 inches rack, containing one or several functions forming in this case complete protection systems.

MODEL LIST

PROTECTION FUNCTIONS		BASIC MODELS	
PHASE	GROUND	INSTANTANEOUS UNIT WITHOUT	INSTANTANEOUS UNIT WITH
3	1	TCC1000A	TCC1000B
3	-	TCC4000A	TCC4000B
-	1	TCC5000A	TCC5000B
2	1	TCC6000A	TCC6000B

Table 1

Models TCC1000A are directional three-phase relays, with three independent inverse time overcurrent measuring unit for the phases and one additional unit for detection of ground faults. Models TCC1000B include moreover three independent instantaneous units.

Models TCC4000A are directional three-phase relays, with three independent inverse time overcurrent measuring units. Models TCC4000B include moreover three instantaneous units.

Models TCC5000A are directional ground relays, with one inverse time overcurrent measuring unit. Models TCC5000B include moreover one instantaneous unit.

Models TCC6000A are directional two-phase and ground relays with two independent inverse time overcurrent measuring units, two for the phases and one for the ground. Models TCC6000B include intantaneous units.

Models TCCx1xxx include moreover test block/s.

CURRENT RANGES

RATED CURRENT In (A)	RANGE OF INVERSE TIME CURRENT Is (A)	INSTANTANEOUS UNIT (TIMES Is)
1	0.1 —— 0.875	1 to 20
	0.3 —— 2.625	
5	0.5 —— 4.375	
	1.5 —— 13.125	

Table 2

The operating value of instantaneous units can be adjusted between 1 and 20 times the value selected for the inverse time unit.

In those models provided with instantaneous units, the operation of these units can be inhibited by placing the adjusting potentiometer in the position marked infinite .

The operation of either inverse time or instantaneous units can be inhibited by means of an external signal.

In some applications it is a common practice to block the instantaneous overcurrent units as soon as the reclosing relay associated with the protection begins to operate. This implies that the instantaneous overcurrent unit will trip the first time at once. If the fault still remains, the following times the breaker is closed, the tripping will be performed by the inverse time unit, thus allowing for fuse blowing for instance.

The standard models are provided with an output relay common for all measuring units, with three normally open tripping contacts.

Optionally, these relays can be supplied with signalling contacts provided by two or four auxiliar relays (functions 51, 51N, 50, 50N , depending on the model). In these cases, the number of available tripping contacts is two.

APPLICATION

These relays are mainly used for protection of distribution and transmission lines, when the coordination with overcurrent non-directional relays is impossible or is not particularly selective for a certain area of the system or as back-up protection in distance schemes.

Figure 5 shows the external connections for TCC relays. Under normal conditions, no current flows in either the operating or current polarizing circuit. On some applications, system conditions may at one time be such that potential polarization is desirable, and at other times be such that current polarization would be preferred. The type TCC relays, with its dual polarization feature, is well suited for such applications. The simultaneous use of both sets of polarizing circuits is advantageous on application where current and potential polarizing sources are available and when one source may be temporarily be lost.

Five basic time characteristics are available in type TCC relays.

The inverse time current characteristic is generally applied where short circuit current magnitude is dependent largely upon the system generating capacity at the time of the fault. See figure 1 and figure 2 for both BS142 and ANSI characteristic respectively.

The very inverse time current characteristic shown in figure 3 is generally applied where the magnitude of short circuit current flowing through any given relay is more dependent upon the relative location of the fault to the relay than on system generation setup at the time of the fault.

The extremely inverse time characteristic shown in figure 4 is preferred for applications where sufficient time delay must be provided to allow a re-energized circuit to pick up an accumulated cold load without unnecessary tripping on inrush currents. Distribution feeder circuits are a good example of such applications, and the extremely inverse characteristic is best suited to such applications because it more nearly approximates typical power fuse and fuse cutout characteristic.

The definite time characteristic means that tripping delay does not depend on the fault current. Delay between fault and tripping is adjustable in the 0.1 - 10 seconds range by means of the potentiometer 4 of figure 9.

The pick up of the TCC time unit should be chosen it will operate for all short circuits in the protected zone, and also provide back up protection for short circuits in the inmediately adjacent system element when possible. The time unit pick up should be set low enough to ensure that the minimum fault current is at least 1.5 times the pick up level.

The time delay adjustment of the time unit should be chosen to assure selectivity with the protection on the adjacent system elements. This adjustment should be made for the condition which yields maximum fault current at the relay location. The time delay is determined by the adjacent relay operating time for this condition, plus a coordinating time allowance which includes the adjacent circuit breaker maximum operating time and a safety factor to accommodate any uncertainties.

Since TCC relays have insignificant overtravel, the time margin between two adjacent sections recommended in practice is 0.2 seconds.

TCC relays also include instantaneous overcurrent units that can be applied in many instances to reduce the fault clearing time for high fault currents. These units are normally set to pick up only on internal faults in the protected zone. Significant transient overreach can be experienced under certain conditions, and this must the taken into account by selecting a pick up setting that is higher than that which would be dictated by the maximum steady state external fault current. The transient overreach characteristic for the instantaneous unit is shown in figure 7.

The operation of any instantaneous overcurrent unit can be inhibited by placing the adjusting potentiometer in the position marked infinite. This allows for a reduction of spares. Optionally, it can be delayed, if desired, between 0 and 1 second by means of an internal adjusting potentiometer.

TECHNICAL SPECIFICATIONS

1.- CURRENT CIRCUITS

Pickup current
Inverse time unit : 1.1 times the selected tap value.
Instantaneous unit : 1 time the selected tap value.

Reset
Current : ≥ 90 % of tap value.
Time : < 50 ms.

Operating time
Inverse time unit : Four types of curves (see figs. 1, 2, 3 and 4).
Instantaneous unit: Adjustable continuously between minimum and 1 second (see fig.6 for minimum operating time).
Definite time : Adjustable continuously between 0.1 and 10 s.

Overtravel
Inverse time unit : < 30 ms.
Instantaneous unit: < 10 ms.

Thermal capacity
Continuously : 2 In.
For 3 seconds: 50 In.
For 1 second : 100 In.

Burdens in current circuits

BURDENS IN CURRENT CIRCUITS

Range (A)	Frequency (Hz)	Minimum tap (A)	Burdens in ohms (Ω) for multiples of minimum operating current: At minimum pickup R	jX	Z	3 times Z	10 times Z	20 times Z
1.5 -13	50/60	1.5	0.02	0.008	0.021	0.02	0.02	0.02
0.5 - 4	50/60	0.5	0.02	0.01	0.022	0.02	0.02	0.02
0.3 - 2.6	50/60	0.3	0.07	0.08	0.107	0.09	0.09	0.08
0.1 - 0.8	50/60	0.1	0.07	0.12	0.14	0.109	0.09	0.96

Table 3

Polarizing circuit : 0.5 VA at In.

2.- VOLTAGE CIRCUITS

Thermal capacity : 3.6 Vn.
Burden : 0.05 VA.

3.- D.C. POWER SUPPLY

Rated voltage Vdc	Operating range Vdc
48	38 - 60
110	88 - 132
125	100 - 150
220	176 - 264
250	200 - 300

POWER SUPPLY CONSUMPTION

MODEL	CONSUMPTION (mA)		
	NORMAL	TRIPPED	TRIPPED WITH AUXILIARY SIGNALLING RELAYS
TCC1000A	300	345	365
TCC4000A	225	270	270/290
TCC5000A	75	120	120
TCC6000A	225	270	270/290
TCC1000B	300	345	385
TCC4000B	225	270	290/310
TCC5000B	75	120	140
TCC6000B	225	270	290/310

Table 4

4.- OUTPUT CONTACTS

Make and carry
3000 W , resistive, with a maximum of 30 A and 300 Vdc for 0.2 s.

Break
50 W , resistive, with a maximum of 2 A and 300 Vdc.

Make and carry continuously
5 A with a maximum of 300 Vdc.

5.- DIRECTIONAL UNIT

The characteristic line forms an angle of ± 90° with the maximum torque line, with accuracy of ± 5% .

Phase directional units

- Rated polarization voltage: 110 V 50 Hz, or 120 V 60 Hz.
- Continuous thermal capacity: 1.2 Vn.
- Characteristic angle: 45° leading (factory adjusted). As an option,the unit may be adjusted at the factory 30° leading.
- Directional stability: It does not operate for current in the opposite direction for up to 30 times the rated current, and with polarization voltages between 0 and 1.2 Vn.
- Directional sensitivity: Minimum operating current, 4% of In. Minimum operating voltage, 0.5 V.
- Operating time: Less than 25 ms. for current making an angle with the polarizing voltage equal to the characteristic angle, and rated values for polarizing voltage and operating current.

Ground directional units

- Rated polarization voltage: 63.5 V 50 Hz, or 69.3 V 60 Hz.
- Continuous thermal capacity: 3.6 Vn.
- Characteristic angle: 45° lagging (factory adjusted). As an option, the unit may be adjusted at the factory at 60° or 15° lagging.
- Directional stability: It does not operate for current in the opposite direction for up to 30 times the rated current, and with polarization voltages between 0 and 3 Vn and/or polarization currents between 0 and 30 times the rated current.
- Directional sensitivity: Minimum operating current, 4% of In. Minimum operating voltage, 0.5 V.
- Operating time: Less than 25 ms. for current making an angle with the polarizing voltage equal to the characteristic angle, and rated values for polarizing voltage and operating current.

6.- TEMPERATURES RANGES

Effective range: - 5°C to + 40°C.
Operating range: - 20°C to + 55°C.
Storage range: - 40°C to + 60°C.

7.- AMBIENT HUMIDITY

Up to 95% provided that no condensations occurs.

8.- INSULATION

Between any terminal and the chassis
2000 Vac for 1 minute at industrial frequency.

Between independent circuits
2000 Vac for 1 minute at industrial frequency.

Between terminals of each output circuit
1000 Vac for 1 minute at industrial frequency.

NOTE

Interference supression ground connection

The TCC relay contains high frequency interference protecction consisting of a series of capacitors connected between the different input terminals and terminal C7.

Terminal C7 of the relay should be connected to ground so these interference supression circuits can perfom their protective function . This connection should be as short as possible to assure maximun rotection . Braided # 12 AWG conductors (2.5 mm) are recomended .

The purpose of this connection is to prevent the high frequency disturbances from affecting the electronic circuits of sistem operation.With this terminal connected,the protecction capacitors are connected from the terminal to the case. Therefore one needs to take special care upon applying high voltage between these terminals and the case .

The suppression capacitors used in this relay are capable of withstanding voltages up to 3 kv. However , during high voltage tests , even higher overvoltages can be generated , and the capacitors should not be sujected to these types of test. Therefore , the ground conductor should be disconnected from terminal C7 during these tests.

9.- TYPE TESTS

Impulse test

Voltage wave having a 1.2 μs ± 30% rise time and a 50 μs ± 20% decay time constant.
Test per IEC standards 255-4.
Test voltage 5 kV peak.

High frequency disturbance test

Damped oscillatory wave with envelope decaying to 50% of its peak value after 3 to 6 cycles.
Frequency 1MHz ± 10% .
Repetition frequency 400 times per second.
Test per IEC standards 255-4.
Longitudinal mode voltage 2.5 kV.
Transverse mode voltage 1 kV.

OPERATING PRINCIPLES

1.- INPUT

Figure 8 shows the block diagram of a one phase board.

The current transformers of the protected circuit provide a secondary current which is applied to the input of the relay and then reduced by means of internal current transformers located in the magnetic module (they are not shown in figure 8).

The secondary circuits of the internal current transformers of the relay are connected to a full wave rectifier.

The output of the rectifier feeds a setting stage by means of a potentiometer. This setting determines the pickup current of the relay.

The voltage Vin generated in this potentiometer represents the input current of the relay.

2.- INVERSE TIME UNIT

The input signal Vin is controlled by the pickup current level detector unit, which determines the primary current level to the circuit breaker.

The function generator converts the Vin voltage (filtered) into another Vf voltage, suitable to provide the operating characteristic of the relay (BS142, inverse, very inverse or extremely inverse).

The linear ramp generator is a simple integrating circuit that integrates the Vf signal produced by the function generator. The time constants which provide the relay operating curves are obtained by means of the adjusting potentiometer. The operation of the linear ramp generator si controlled by the output of the pickup current level detector in such way that the output voltage of the rectifier is lower than the pickup level, no output ramp is generated, and the pickup current indicating led is off (see fig.9).

The ramp generator output is applied to a level detector which has an adjustable threshold to calibrate the operation time.

Once this threshold is reached, an output is generated. This output energizes the tripping relay and ligths up the time unit operation indicating led located on the front plate (see figure 9).

3.- INSTANTANEOUS UNIT

The instantaneous unit uses the same input signal as the inverse time unit. The operation of this circuit gets under way when the input signal, rectified and filtered , gets over the selected threshold operating value. The performance thus obtained has a low transient overreach characteristic with short operating time. Figure 6 shows the operating time for the instantaneous unit. The times indicated in this figure do not include the operating time of the output relay, 8 ms. aproximately.

Figure 8 shows the instantaneous unit block diagram. The voltage Vin is compared with a voltage reference Vri, which is adjustable between 1 and 20 times the operating level selected for the inverse time unit. When the input to the comparator (Vin) is higher than the reference Vri, an output is produced which applies to a delay circuit to make sure that the signal remains long enough to operate the output circuitry. After a time , adjustable between 0 and 1 second, a latched output to the instantaneous unit indicating led located on the front plate is produced (see figure 9). The operation of both, instantaneous unit and time unit, are controlled by the directional control signal to produce a selective directional characteristic.

4.- PHASE DIRECTIONAL UNIT

The phase directional unit block diagram is shown in figure 12. The unit measures the phase shift angle between the line current and the polarizing voltage (see figures 13 and 14). This is accomplished by lagging the line current IL a certain angle (characteristic angle) obtaining IL' (see figure 15), and now phase shift between IL' and Vp is measured. This is due to the imposibility of overtaking the voltage.

If this angle is lower than 90° the line current and the polarizing voltage will be located at the same side of the characteristic, and therefore the associated overcurrent relay will be located to trip. If the phase shift angle is greater than 90°, both vectors will be located at different sides of the characteristic, and the associated overcurrent relay will not be allowed to trip.

The phase shift measuring unit operation is shown in figure 15. The positive and negative half-cycles of the input transformers incoming signal are applied to squaring circuits, where they are transformed in square waves. The IL positive cycles are lagged a certain angle (X) by means of the timer T1/T1 thus obtaining IL'.

The signal Vpol and IL'are applied to the AND1 gate, and its output is a pulse train. The pulse width is the time that that both signals are coincident. The AND2 gate makes the same function as the AND1 gate but with the negative half-cycles of the IL' and Vp signals.

The outputs of AND1 and AND2 are applied to the OR1 gate, resulting a pulse train whose frequency is twice the frequency of each half-cycle. Finally the T/T' timer checks if the phase shift angle between IL' and Vp is higher or lower than 90° by measuring the pulses width at the OR1 output. If the pulse width is greater than 90° the train pulse will be transformed at the output of the T' timer in a continuous signal for the telephone relay.

5.- GROUND DIRECTIONAL UNIT

The ground directional unit block diagram is shown in figure 16.

Voltage polarization

The ground directional unit measures the phase shift between the Io current and the Vo polarizing voltage, in the same way as described above. The Vo voltage is lagged the characteristic angle X (see figure 16) obtaining V'o, and now the phase shift angle between Io and V'o is measured. If this angle is smaller than 90°, Io and V'o are in the same side of the characteristic, and therefore the associated overcurrent relay ground unit will be allowed to trip. If this angle is greater than 90°, V'o and Io will be located at different sides of the characteristic, and therefore tripping will not be allowed. The phase shift measuring circuit operation is shown in figure 19.

Current polarization

The current polarized ground directional unit measures the angle between the operating current (Io) and the polarizing current (Ip). Both can be in phase or phase-shifted 180°.

The phase-shift measuring circuit operation is similar to that described before. The positive and negative half-cycles of the signals coming from the input transformers are applied to squaring circuits. The AND1 and AND2 gates combine the Io and Ip signals, which results in a pulse train. The width of each pulse will be equal to the coincidence time of both signals. At the output of the OR1 gate a pulse train is obtained, whose frequency is double of the initial one. The T/T' timer measures the width of the output pulses of OR1 resulting a continuous signal to the telephone output relay, in case of Io and Ip being phase-coincident.

CONSTRUCTION

1.- CASE

TCC series 1000S relays case is manufactured with steel plate. The general outline is shown in figures 20 and 21.

The front cover is made up of plastic material and fits over the relay case making pressure over a rubber joint located around the enclosure, this produces a tight proof sealing avoiding the entrance of dust. The modules are vertically assembled. They are provided in the rear part with connectors that serve as mechanical support and as electric connection elements, holding the modules tightly in their right position. Each module is provided with plastic guides, one upwards, and another downwards, that provide a perfect alignment.

2.- ELECTRIC WIRING AND INTERNAL CONNECTIONS

The wiring of the external circuits is achieved by means of the three terminal blocks assembled on the rear side of the case (see figure 22). Each terminal block is provided with 7 terminals made up of a 4 mm. diameter screw threaded in a contact board.

Connections between printed circuit boards are made by means of " a + c " 32 pins connectors. Female connectors for printed circuits boards are assembled on rear plates located to approximately 4 cm. from the case rear plate. The socket for normal connections and test connections (optional) is assembled on the relay front.

All current inputs are connected on a terminal block, located on the rear side. This block has enough capacity to support the secondary currents of the current transformers. The internal input current carrying wires are of larger cross-section than the rest of the internal wiring. They have been designed to have as low a lenght as possible, to minimize the resistive load of the current transformers.

Connections are made with crimped terminals. The input current wires are grouped into braids, separated from the other groups, in order to minimize electromagnetic coupling, associated with input current, over the internal low level signal wires.

3.- IDENTIFICATION

The complete relay model is indicated in the nameplate of the input magnetic module.

In the up and down side of the case front there are two strips stuck on it with the identification of the position which each module must occupy into the case. The terminal blocks are identified by means of a letter located in the rear plate, just over the left border of each block looking at the relay from the backside (see figure 22).

There are three terminal blocks in each case and each one has its own code (from A to C) to avoid mistakes when making connection of the external wires.

In each terminal block, the external studs (1 to 7) are identified on the upper part by engraved numbers.

4.- EXTERNAL CONNECTIONS

Figures 5, 23, 24 and 25 show, respectively, external connections for TCC1100, TCC4100, TCC5100 and TCC6100 relays.

Figure 26 shows external connections for TCC5000 relays with 220 Vdc supply. See the detail of the external resistor box and its connection to the relay. That box is only needed for 220 Vdc supply relays.

5.- PRINTED CIRCUIT BOARDS

Each module consists of two printed circuit boards, the main phase or ground board and the directional control board (see figure 27), with a front plate mounted on it through two suports. Over this plate, there are two elements which fit into two nuts on the box and that serve the purpose of pulling it into it. The electrical connections are made through a male conector (a + c) which fits into a female connector located on the back plane. Each module has its corresponding module identification consisting of a three letter code followed by a three digit number, located in the down side of each front plate.

6.- LOCATION OF CONTROLS AND TARGETS

Figures 9 and 10 show, respectively, the front plate of a phase unit and a ground unit. Those figures include both, the inverse time and the instantaneous unit with all the controls and indicating signals.

MODEL TCC1000

Includes four units , with two printed circuits boards per unit , three for phases and one for ground.

1.- Led (light emitting diode) indicating the pickup current of the inverse time unit has been reached.

2.- Adjustment switches it select the current tap of inverse time unit.

3.- Led for indication of inverse time unit tripping.

4.- Potentiometer for selecting the operation curve of the inverse time unit. This potentiometer selects the tripping delay in DEFINITE TIME models.

5.- Led for indication of instantaneous unit tripping.

6.- Adjustment potentiometer to select the current tap of the the instantaneous unit.

Model TCC1000A

Includes four units (3 for phases and one for ground). Each unit includes only elements 1, 2, 3 and 4.

Model TCC1000B

Includes four units (3 for phases and one for ground). Each unit includes elements 1, 2, 3, 4, 5 and 6.

Model TCC4000A

Includes three units, one for each phase. Each unit includes only elements 1, 2, 3 and 4.

Model TCC4000B

Includes three units, one for each phase. Each unit includes elements 1, 2, 3, 4, 5 and 6.

Model TCC5000A

Includes one unit with elements 1, 2, 3 and 4.

Model TCC5000B

Includes one unit with elements 1, 2, 3, 4, 5 and 6.

Model TCC6000A

Includes three units (2 for phases and one for ground). Each unit includes only elements 1, 2, 3 and 4.

Model TCC6000B

Includes three units (2 for phases and one for ground). Each unit includes elements 1, 2, 3, 4, 5 and 6.

7.- INTERNAL CONTROLS AND TEST POINTS

The relays are calibrated at the factory, thus there is no need of any further calibration. However, if a recalibration were necessary, the identification of the internal adjustment controls is given bellow.

Figure 27 shows their location in the relay boards.

Mainboard

P2 : Time calibration of inverse time unit.
P3 : Pickup current calibration of inverse time unit.
P5 : Delay control of instantaneous unit operation (0 - 1 second).

Directional board

P2 : Trimmer to adjust the maximum torque angle.
P5 : Trimmer to adjust the characteristic spread.
P6 : Factory adjustment.

Models TCCxxxxB include the six adjustment trimmers.

Models TCCxxxxA do not include the mainboard P5 trimmer because they do not have instantaneous time tripping characteristic.

RECEIVING, HANDLING AND STORAGE

The relays are supplied to the customer in a special packing unit that properly protects it during transportation, provided it is done under normal conditions.

Inmediately after receiving the relay, the customer should check if there is any evidence of the relay having suffered damage during transportation, because of rough handling. Reasonable care should be exercised in unpacking the relay in order that none of the parts are injured or the adjustments disturbed.

If the relay is not going to be installed inmediately, it is convenient to store it in its original packing, in a place free from moisture, dust, heat and metalic chips.

It is important to check that the inscription on the nameplate matches the data or specifications handed over with the order.

If injury or damage resulting from rough handling is evident, file a damage claim at once with the transportation company and promptly notify the factory.

NOTE : THE OPERATION INDICATING TARGETS LOCATED IN THE FRONT PLATE RESET ELECTRICALLY BY PRESSING THE RESET PUSHBUTTON.

DO NOT MANIPULATE THE MOVING PARTS OF THE TARGETS SINCE THEY MAY BE DAMAGED.

ACCEPTANCE TESTS

It is recommended, once the relay is received, that a visual inspection and the tests given below be performed to make sure that the relay has not suffered any damage in transportation and the factory calibration has not been altered. If the checks or the test carried out show that a readjustment of the relay is necessary, see the section RELAY CALIBRATION.

These tests can be carried out as installation or acceptance tests, depending on the criteria of the user. Since most users have different procedures for installation and acceptance tests, this section explains all the tests that can be performed with these relays.

1.- VISUAL INSPECTION

Check that the model indicated in the front plate matches the data given in the order. Unpack the relay and check there are no broken parts and no signs that the relay has suffered any damage during transportation.

2.- ELECTRIC TESTS

2.1.- GENERAL CONSIDERATIONS ON THE POWER SUPPLY NETWORK

All devices operating with alternating current are affected by frequency. Since a non-sine wave is the result of a fundamental wave shape plus a series of harmonics of the fundamental wave, it is deduced that devices operating with alternating current (relays) are affected by the shape of the applied wave.

To properly test relays operating with alternating current, it is essential to use sine wave current and voltages. The purity of a sine wave, absence of harmonics, cannot be expressed in a specific form for a determined relay. However any relay which includes tuned circuits, R-L and R-C circuits or non linear elements such as the inverse time overcurrent relays, will be affected by non-sine wave shapes.

Likewise, relays having d.c. power supply must be tested with d.c. and not rectified a.c. supply, because if this power supply is not properly smooth, it is possible the relays do not operate properly due to voltage drops in the power source. Zener diodes, for example, may stop conducting because of power supply voltage drops.

As general rule, the d.c. power supply must not have a ripple higher than 5% .

These relays respond to the current shape in a way different from most a.c. ammeters. If the power supply network used for tests contains very high amplitude harmonics, the response of the ammeter and the relay will be different.

The relays have been calibrated at the factory using a 50 or 60 Hz network with a minimum content of harmonics. When tests are performed on the relay, a network must be used with a wave shape free from harmonics. The ammeters and timers used to perform pickup current and operation time tests with the relay must be calibrated and their accuracy must be better than that of the relay. The power supply used in the tests must remain stable, specially near the level of the pickup (starting) current as well as during the operation time according to the curve that is being tested. It is important to point out that the accuracy with which the test is performed depends on the nerwork and on the instruments used.

Functional tests performed with unsuitable power supply network and instruments are useful to check that the relay operates properly and therefore its operating characteristics are verified in an approximate manner. However, if the relay would be calibrated in these conditions, its operational characteristics would be outside the tolerance range values.

2.2.- INVERSE TIME UNIT

2.2.1.- Pickup current calibration check

Connect the relay as indicated in figure 30, without the phase shifter. Note that voltage is still needed for polarizing the relay. See figures 31 and 32 for models different to TCC5000.

To apply current to the relay use a 127 or 220 V - 50 Hz or 120 V - 60 Hz power source with a variable resistor in series.

Adjust the relay in the minimum tap. Place all the switches to the left (identified as 2 in figure 9) :

0.3 .... for relays of 1.5 - 13.125 A and 0.3-2.625 range
0.1 .... for relays of 0.5 - 4.375 A and 0.1-0.875 range

The instantaneous unit must be adjusted at infinite position by means of potentiometer 6 of figure 9.

RELAY RANGE (A)	APPLIED CURRENT (A)
1.5 - 13.125	1.567 - 1.732
0.5 - 4.375	0.522 - 0.577
0.3 - 2.625	0.313 - 0.346
0.1 - 0.875	0.104 - 0.115

Table 5

Apply current to the relay and check within the margins indicated in table 5, that the led identified with 1 in figure 9 lights up, that the contact of the output relay closes and that afterwards the led identified as 3 in figure 9 indicating the tripping of the inverse time unit lights up.

With the contacts of the output relay closed, reduce the applied current, verifying that with the current values indicated in table 6 the output relay resets and the led 1 of figure 9 turns off.

RELAY RANGE (A)	APPLIED CURRENT (A)
1.5 - 13.175	1.5
0.5 - 4.375	0.5
0.3 - 2.625	0.3
0.1 - 0.875	0.1

Table 6

2.2.2.- Operating time check

With the relay connected as indicated in the section 2.2.1, adjust it at curve number 5 by means of potentiometer indicated by 4 in figure 9 and adjust the inverse time unit at the minimum tap as indicated in 2.2.1.

Apply successively currents of 2, 5 and 10 times the minimum tap value checking that the operating time is within the margins indicated in tables 7, 8, 9 and 10.

For definite time units, check that with the relay connected in the same way (adjusted at curve number 5 with potentiometer 4 of figure 9), the operating time is 5 seconds.

Times minimum current	Applied current (A)				Operating time for curve 5 (s)
	Range				
	1.5-13	0.5-4	0.3-2.6	0.1-0.8	
2	3	1	0.6	0.2	4.60 - 5.40
5	7.5	2.5	1.5	0.5	2.00 - 2.25
10	15	5	3	1	1.40 - 1.60

Relays with BS142 INVERSE characteristics.
Table 7

Times minimum current	Applied current (A)				Operating time for curve 5 (s)
	Range				
	1.5-13	0.5-4	0.3-2.6	0.1-0.8	
2	3	1	0.6	0.2	2.80 - 3.30
5	7.5	2.5	1.5	0.5	1.40 - 1.60
10	15	5	3	1	1.05 - 1.20

Relays with ANSI INVERSE characteristics.
Table 8

Times minimum current	Applied current (A)				Operating time for curve 5 (s)
	Range				
	1.5-13	0.5-4.3	0.3-2.6	0.1-0.8	
2	3	1	0.6	0.2	4.10 - 4.80
5	7.5	2.5	1.5	0.5	1.10 - 1.30
10	15	5	3	1	0.75 - 0.85

Relays with VERY INVERSE characteristics.
Table 9

Times minimum current	Applied current (A)				Operating time for curve 5 (s)
	Range				
	1.5-13	0.5-4.3	0.3-2.6	0.1-0.8	
2	3	1	0.6	0.2	3.90 - 4.55
5	7.5	2.5	1.5	0.5	0.55 - 0.65
10	15	5	3	1	0.20 - 0.25

Relays with EXTREMELY INVERSE characteristics.
Table 10

Adjust the relay at the minimum tap and applying a current 5 times the minimum tap, indicated below, check that the operation time is within the margins indicated in table 11.

7.5 A for 1.5 A - 13.125 A range
2.5 A for 0.5 A - 4.375 A range
1.5 A for 0.3 A - 2.625 A range
0.5 A for 0.1 A - 0.875 A range

Curve	Time (s)				
	BS142 INV.	ANSI INV.	VERY INV.	EXTR. INV.	DEF. TIME
1	0.35 0.50	0.25 0.35	0.20 0.30	0.10 0.15	0.90 1.10
3	1.15 1.40	0.80 1.00	0.65 0.85	0.30 0.40	2.70 3.30
7	2.70 3.30	1.90 2.30	1.55 1.90	0.70 0.95	6.30 7.70
10	3.90 4.65	2.70 3.30	2.20 2.70	1.10 1.30	9.90 11.00

Table 11

2.3.- INSTANTANEOUS UNIT

2.3.1.- Pickup current check

Connect the relay as indicated in section 2.2.1.

To apply current to the relay use a power source of 127 or 220 V - 50 Hz, or 120 V - 60 Hz with a variable resistor in series.

Adjust the relay in the minimum tap. Place all the switches to the left (identified as 2 in figure 9) :

0.3 .... for relays of 1.5 - 13.125 A and 0.3-2.625 range
0.1 .... for relays of 0.5 - 4.375 A and 0.1-0.875 range

Adjust the instantaneous unit at 1 time the adjustment value of the inverse time unit by means of potentiometer 6 of fig.9.

Check that the operation of the instantaneous unit is within the margins indicated in table 12.

RELAY RANGE (A)	APPLIED CURRENT (A)
1.5 - 13.175	1.567 - 1.732
0.5 - 4.375	0.522 - 0.577
0.3 - 2.625	0.313 - 0.346
0.1 - 0.875	0.104 - 0.115

Table 12

NOTE : WHEN PERFORMING EACH TEST, THE CURRENT APPLIED TO THE RELAY MUST BE DISCONNECTED AFTER THE OPERATION OF THE RELAY, IN ORDER NOT TO EXCEED ITS THERMAL CAPACITY.

2.3.2.- Operating time check

With the relay connected as indicated in section 2.3.1, apply current to the relay according to table 13.

RELAY RANGE (A)	APPLIED CURRENT (A)
1.5 - 13.125	7.5
0.5 - 4.375	2.5
0.3 - 2.625	1.5
0.1 - 0.875	0.5

Table 13

Check that the operation time lies between 21 and 35 ms.

2.4.- Directional unit

2.4.1.- Current polarization check

Reverse connections as indicated in figure 29 and check that when applying current above tap setting neither inverse time unit nor instantaneous unit will operate.

2.4.2.- Voltage polarization check

Connect the relay as shown in figure 30. To apply current to the relay use a 63.5 V - 50 Hz source, or a 69.3 V - 60 Hz source with a variable resistor in series. Applied current and voltage shall be made phase coincident by means of the phase shifter.

Set the inverse time unit at minimum pickup tap. Apply current above tap setting and check that the unit will operate. Repeat this operation with instantaneous unit set at minimum tap.

By means of the phase shifter make the current leads the voltage and check that the relay will produce an output for values of phase angle meter reading as indicated below.

Figures 31 and 32 show, respectively, test connections with current and voltage polarization for TCC1000, TCC4000, TCC5000 and TCC6000 relays. See test diagrams in figures 28, 29 and 30.

Ground unit

Relays with maximum torque angle	Phase angle meter readings (± 5°)
15°	From 0° to 75° and from 255° to 360°
45°	From 0° to 45° and from 225° to 360°
60°	From 0° to 30° and from 210° to 360°

Phase unit

Relays with maximum torque angle	Phase angle meter readings (± 5°)
30°	From 0° to 120° and from 300° to 360°
45°	From 0° to 135° and from 315° to 360°

INSTALLATION

1.- INTRODUCTION

The place where the relay will be installed must be clean, dry, free of dust and vibrations and must also be well lit to ease the task of inspection and testing.

The relay must be mounted on a vertical surface. Figures 20 and 21 show the outline and drilling drawings.

External connections are shown in figures 5, 23, 24, 25 and 26. If the inspection or test performed show the need for a readjustment of the relay, see section RELAY CALIBRATION.

2.- GROUND CONNECTION FOR SURGE OVERVOLTAGE SUPPRESSION

Tap C7 of the relay must be connected to ground so that the surge suppression circuits provided within the relay operate properly.

This connection must be as short as possible to assure maximum protection level (preferably 25 cm or less).

3.- TAP ADJUSTMENT

3.1.- INVERSE TIME UNIT

3.1.1.- Adjustment of the pickup tap

It is performed on all models by means of the switches blocking identified as 2 in figure 12 , the following expression is shown:

$$Is = [\ 0.3 + (\ )\ ] * In$$

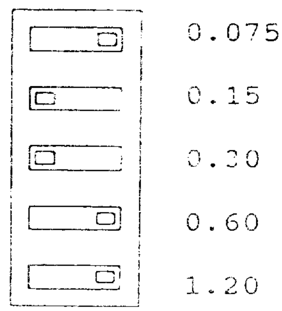
Where:

Is Pickup current in amperes.
( ) Value selected with the switches 2 .
In Rated current (5 A or 1A) of the unit being tested.

This value is also identified in the front plate as:

In%   Rated phase current.
INGR Rated ground current.

For example , let's imagine that the switches at the relays front (corresponnding to the pick-up current selection) for a fhase plate whose rated current is 5 A present the following configuration :



Is = [0.3 + ( )] * In
The formula that must be applied to obtain the pick-up current is :

Is = [0.3 + ( )] + In (given that is a high range plate)

In order to know the value to insert inside the brackets , the operation to carry out is the sum of the values indicated for the activated switches (ridht hand switch) , in this case :

( ) = 0.075 + 0.60 + 1.20 = 1.875

where

Is = [0.3 + 1.875] * 5 = 10.875 A

3.1.2.- Adjustment of the time dial

It is adjusted in all models by means of the potentiometer 4 of figure 9. By means of this element the relay operating curve is selected. Operating times depend upon the applied currents and are indicated in the curves of figures 1, 2, 3 and 4, bearing in mind that the applied current is indicated in multiples of the pickup tap, Is, selected in section 3.1.1.

3.2.- INSTANTANEOUS UNIT

In those models including the instantaneous unit, the adjustment is made by means of the potentiometer identified as 6 in figure 9. Under this element there is the expression:

$$I >> = (\ ) * Is$$

where :

I	is the instantaneous unit adjustment value
( )	is the value selected with the potentiometer 6 of figure 9, for example (15).
Is	is the pickup current in amperes selected in section 3.1.1.

Therefore, if potentiometer 6 has been adjusted with 15, it results:

$$15 * 4 = 60\ A$$
$$I >> 60\ A$$

4.- TESTS

Since most users have different procedures in the installation tests, the section ACCEPTANCE TEST includes all the necessary tests that can be performed as installation tests depending on the user criteria. Following tests are considered as minimum.

4.1.- Inverse unit tests

Adjust the relay in the desired pickup tap. Apply current to the relay and check that it operates between 1.05 and 1.15 times adjustment value.

The section ACCEPTANCE TEST includes a detailed explanation of the starting current tests for the inverse time unit.

Adjust the relay in the desired time curve. Check the operation time applying a current 5 times the value of the starting tap. Check once more the operating time applying currents of 2 and 10 times the starting tap value. The section ACCEPTANCE TESTS includes a detailed information about operation time for the inverse time unit.

4.2.- Instantaneous unit tests

Adjust the instantaneous unit of the relay in the desired value and refer to the section ACCEPTANCE TESTS for starting current and operation time checking tests.

4.3.- Directional unit tests

The section ACCEPTANCE TESTS include a detailed explanation of the tests (with both voltage and current polarization) for directional units.

All tests described in the section INSTALLATION must be performed in the moment in which the relay is mounted.

If for any reason, the tests specified on the section ACCEPTANCE TESTS would have not been performed in time, it is recommended they be carried out at the moment of installation.

RELAY CALIBRATION

If during tests it is found that the relay is out of tolerance (first of all make sure that the power source and the instuments used comply with the requierements specified in the section ACCEPTANCE TESTS) calibration can be made in the following way:

1.- Pickup calibration

Connect the relay as indicated in figure 28.

To apply current to the relay use a power source of 127/220 V - 50 Hz or 120 V - 60 Hz with a variable resistor in series.

Adjust the relay at the minimum tap :

0.3 ..... for relays of 1.5 - 13.125 A and 0.3 - 2.625 A range
0.1 ..... for relays of 0.5 - 4.375 A and 0.1 - 0.875 A range

The instantaneous unit will be adjusted at 1 time the value adjusted for the inverse time unit.

Apply gradually current to the relay from 0 to the value indicated in table 14. Check for 1 minute that this current is constant with a tolerance of ± 1 % .

RELAY RANGE (A)	APPLIED CURRENT (A)
1.5 - 13.175	1.65
0.5 - 4.375	0.55
0.3 - 2.625	0.33
0.1 - 0.875	0.11

Table 14

Then operate potentiometer P3 of figure 27 until just the leds identified by 1 and 5 in figure 9 are lit for the applied current, checking moreover the closing of the output contacts and that after some time the red led identified by 3 in figure 9 lights up.

2.- Calibration of operating time

With the relay connected as in the above section, apply a current 5 times the tap value as indicated in table 15.

RELAY RANGE (A)	APPLIED CURRENT (A)
1.5 - 13.175	7.5
0.5 - 4.375	2.5
0.3 - 2.625	1.5
0.1 - 0.875	0.5

Table 15

Select the curve number 5 with potentiometer 4 of fig.9.

Operate the main board potentiometer P2 of figure 27, until the operating time is that of the table 16.

BS142	ANSI INVERSE	VERY INVERSE	EXTREM.INVERSE
2.140	1.508	1.235	0.602

Table 16

For definite time relays the measured time might be 5 s.

Once this time has been adjusted, check the operating times for several pickup current taps and curves, such as indicated in tables 7, 8, 9 or 10.

3.- Calibration of instantaneous unit operation delay

With the relay connected as in the above section, apply a current 5 times the value adjusted for the inverse time unit.

The existing time delay circuit at the output of the instantaneous unit is adjustable between 0 and 1 second by means of the main board trimmer P5 of the figure 27.

4.- DIRECTIONALITY

Connect the relay as shown in figure 30.

To apply current to the relay use a 127/220 V - 50 Hz or 120 V - 60 Hz sourve with a variable resistor in series.

To polarize the relay, use a 63.5 V - 50 Hz or a 69.3 V - 60 Hz voltage by means of an autotransformer with a phase shifter in series.

By means of the phase shifter make the current leads the voltage and check that the relay will produce an output for values of phase-angle meter readings as indicated below:

Ground units

Relays with maximum torque angle	Phase angle meter readings (± 5°)
15°	From 0° to 75° and from 255° to 360°
45°	From 0° to 45° and from 225° to 360°
60°	From 0° to 30° and from 210° to 360°

Phase units

Relays with maximum torque angle	Phase angle meter readings (± 5°)
30°	From 0° to 120° and from 300° to 360°
45°	From 0° to 45° and from 225° to 360°

If the relay output is not produced for the phase angle meter readings shown in the above table, turn directional control board potentiometer P2 to adjust the angle of maximum torque and P5 (of the same board) to adjust the spread (see figure 27). The difference of phase between maximum and minimum points of operation must lie in the 179° - 181 ° range.

PERIODIC TESTS AND MAINTENANCE

In view of the fundamental role of the protection relays in the operation of any installation, it is recommended to follow a program of a periodical tests. Since the interval between periodical tests varies for different types of relays, types of installation, as well as with the experience of the user on periodical tests, it is recommended that the points described under paragraph INSTALLATION be checked at intervals of 1 to 2 years.

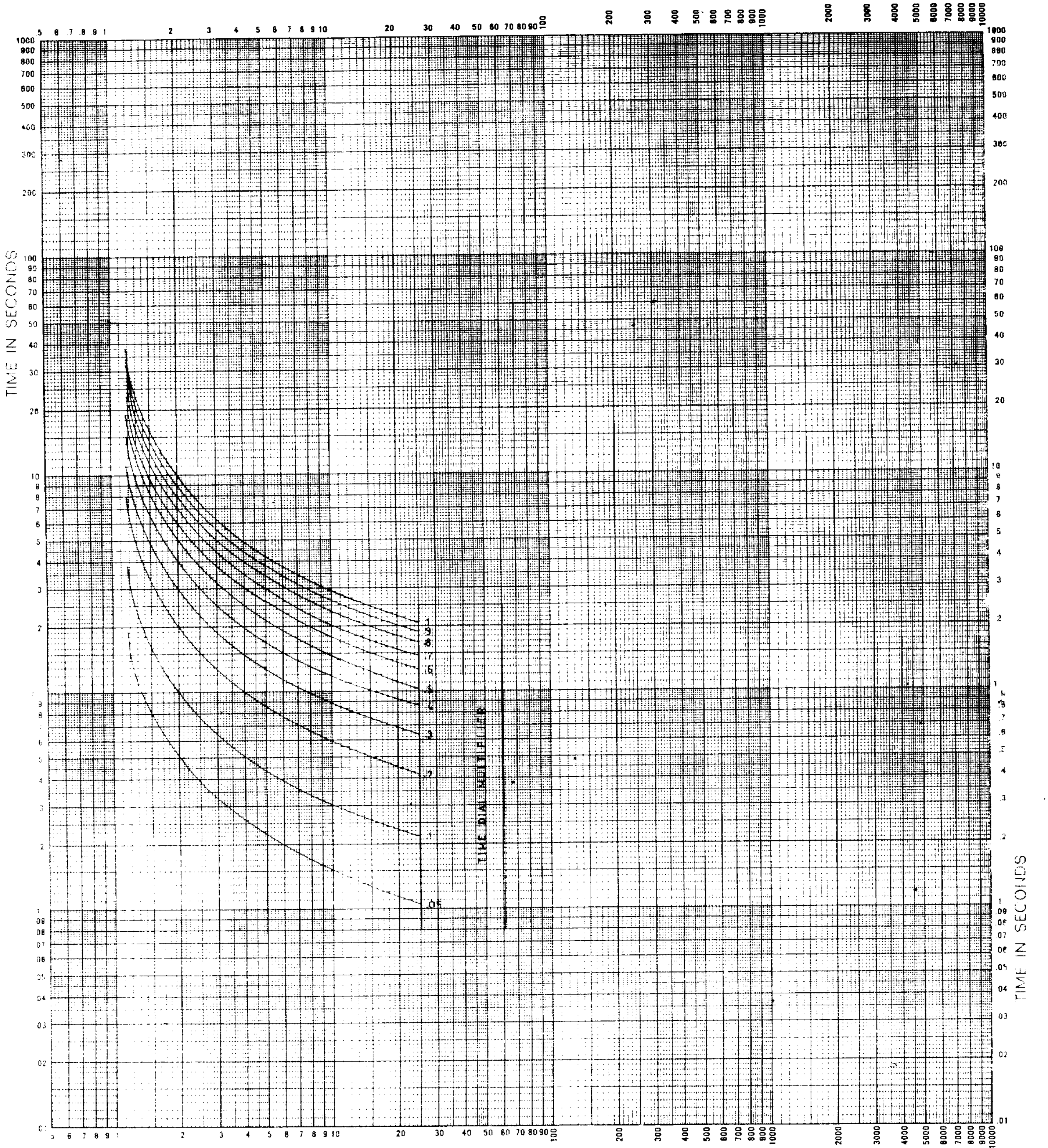


Fig. 1. Operating curves with BS142 INVERSE characteristic.

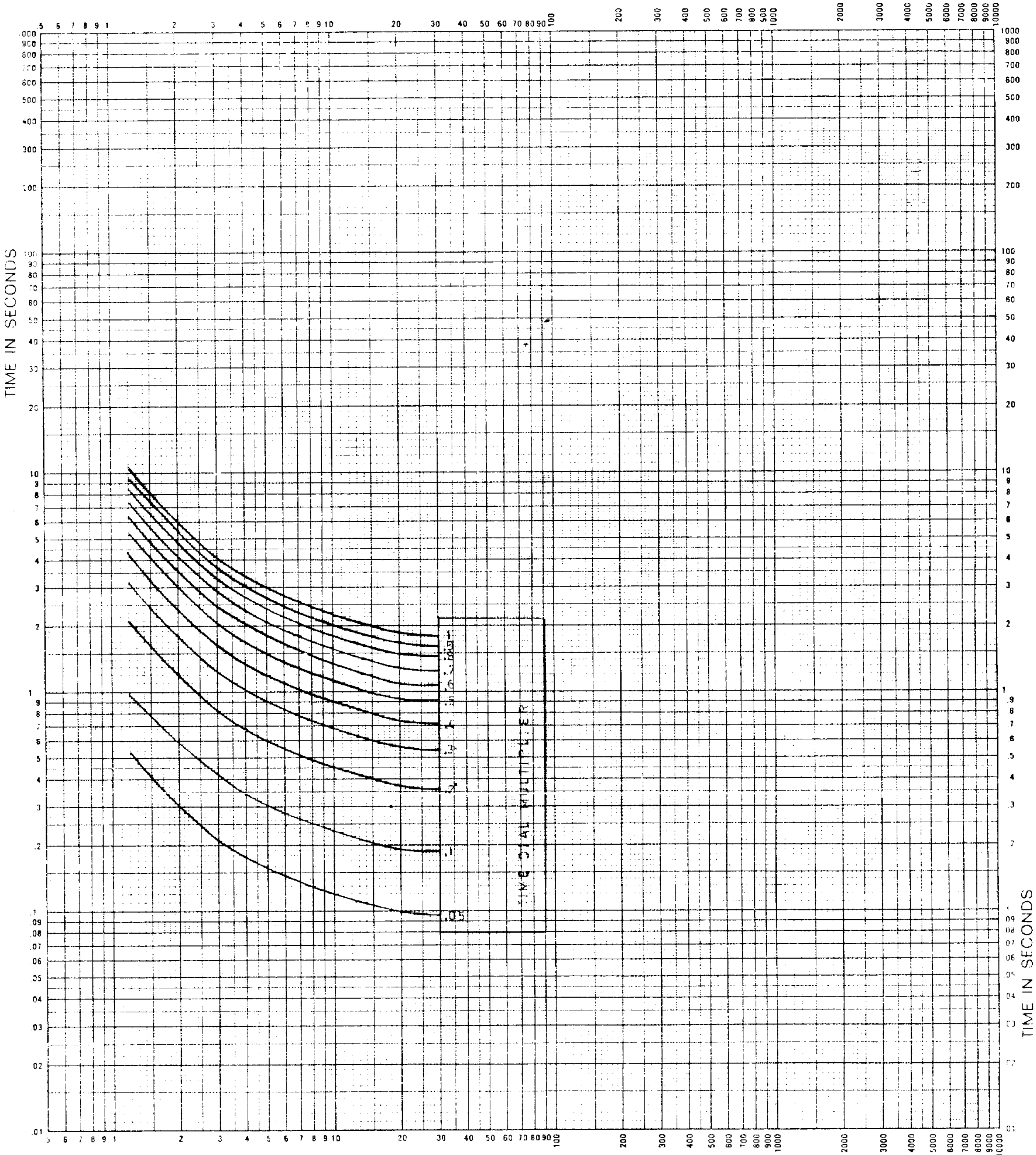


Fig. 2. Operating curves with ANSI INVERSE characteristic.

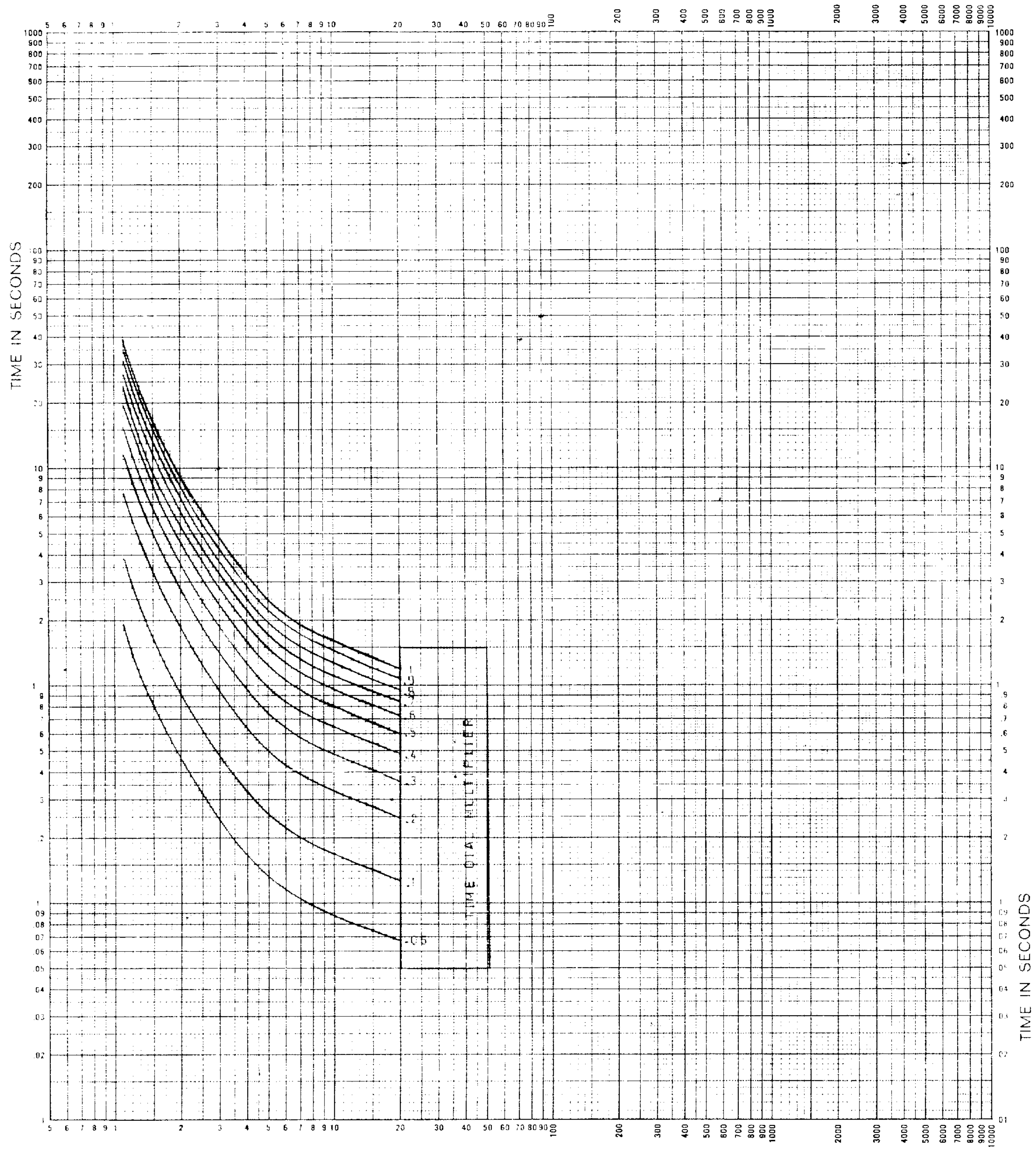


Fig. 3. Operating curves with VERY INVERSE characteristic.

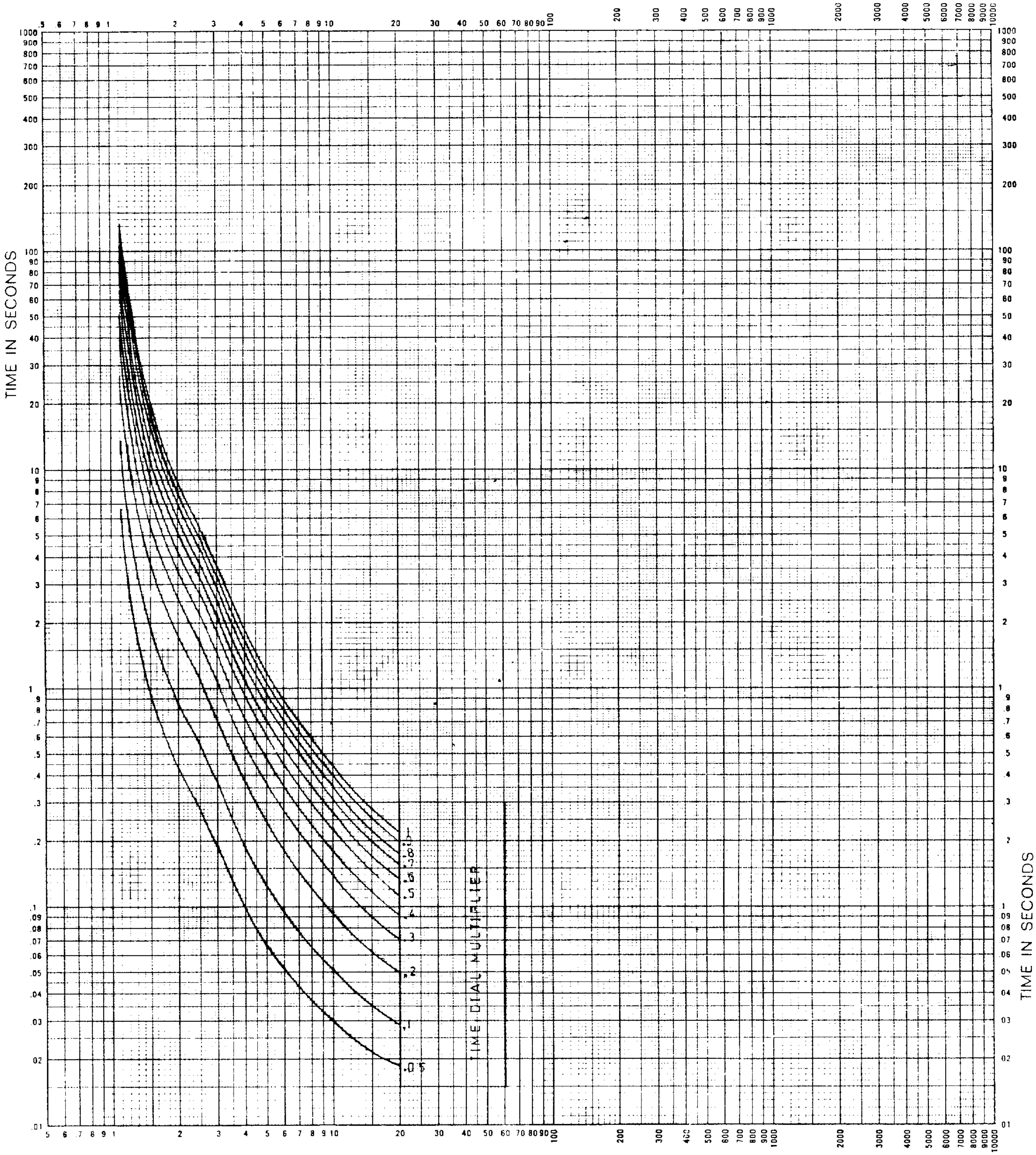


Fig. 4. Operating curves with EXTREMELY INVERSE characteristic.

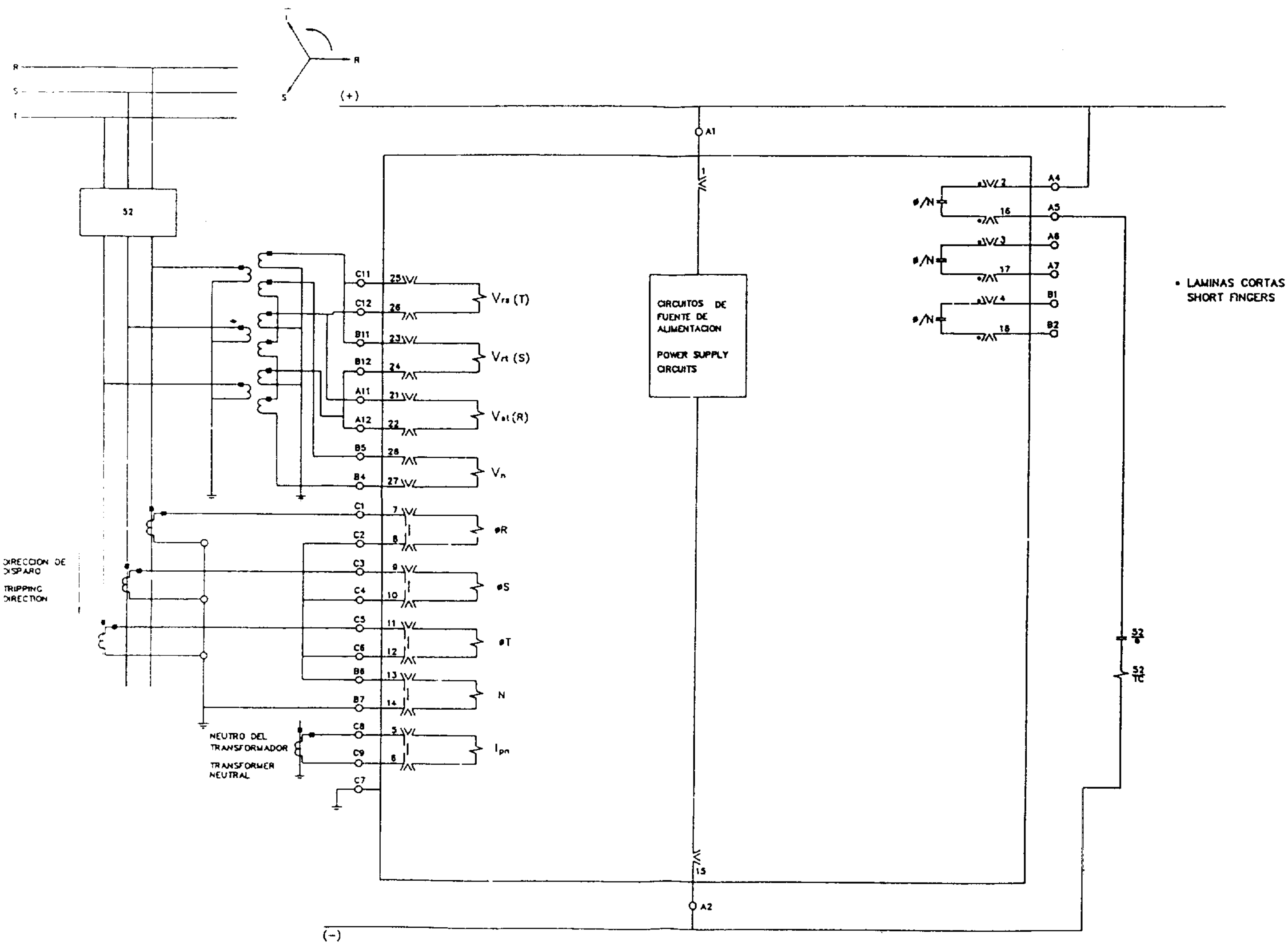


Fig. 5. External connections for three phase and ground directional relay TCC 1100.

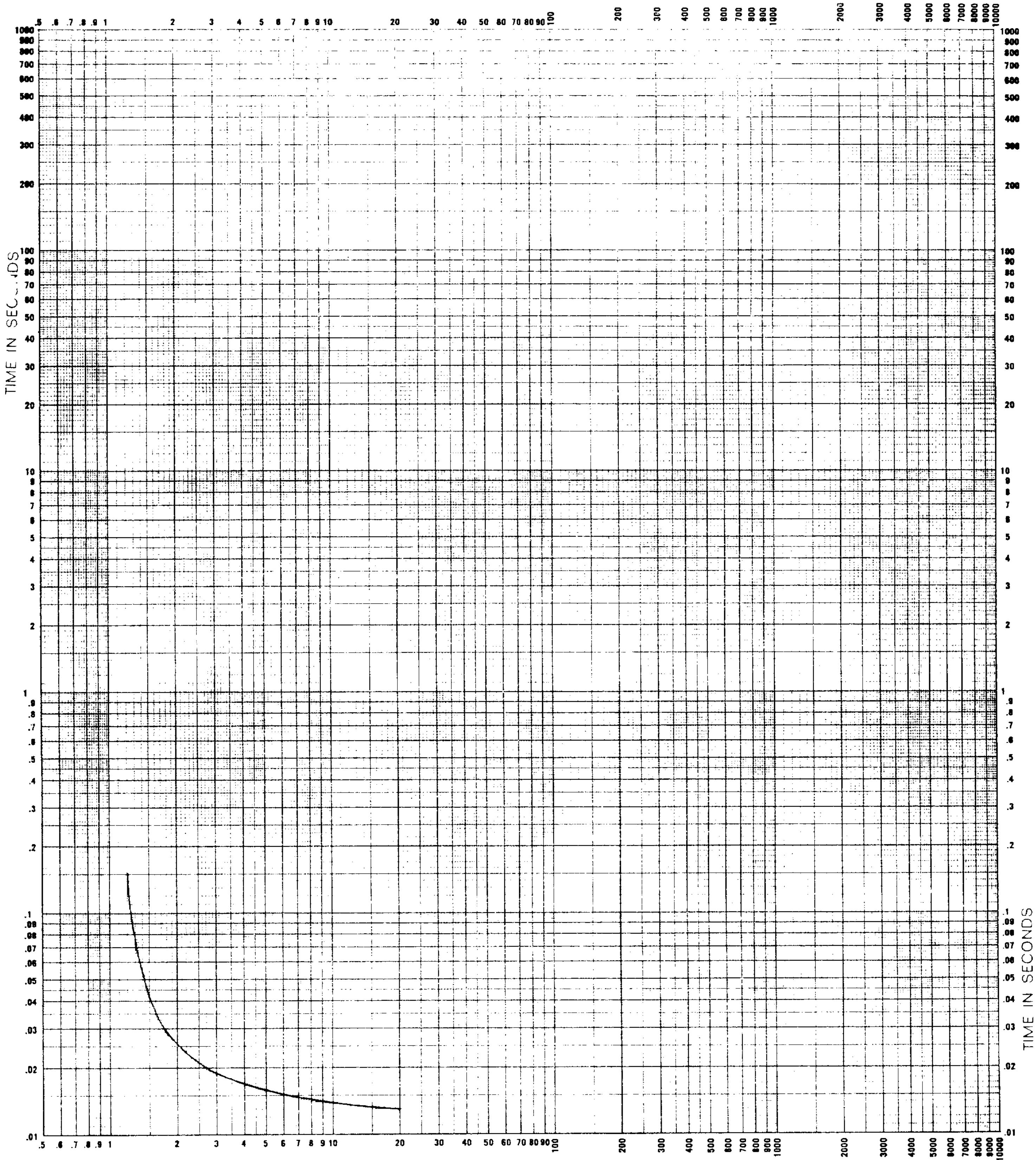


Fig. 6. Operating time of the instantaneous unit.

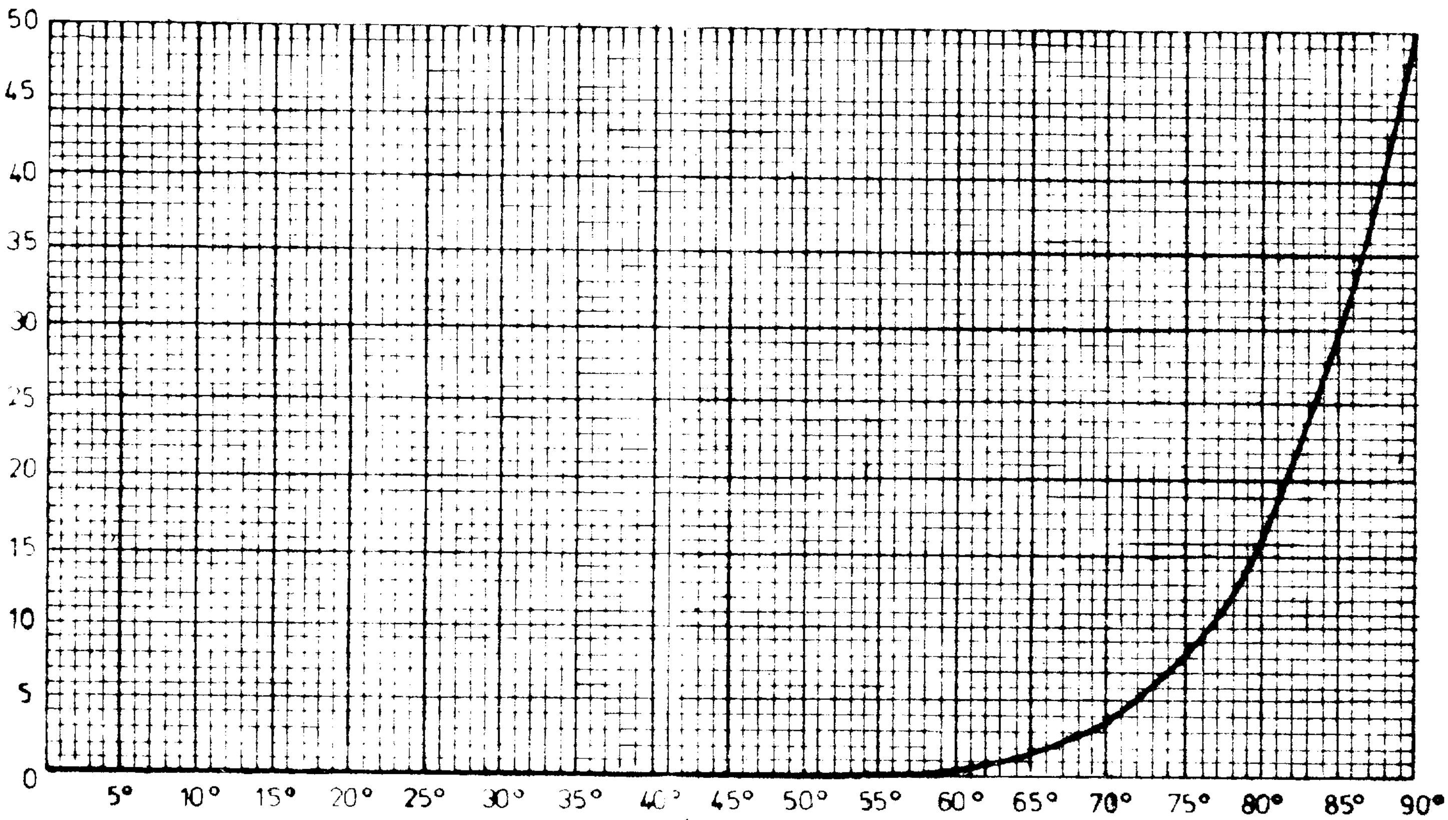


Fig. 7. Transient overreaching characteristic of the instantaneous unit.

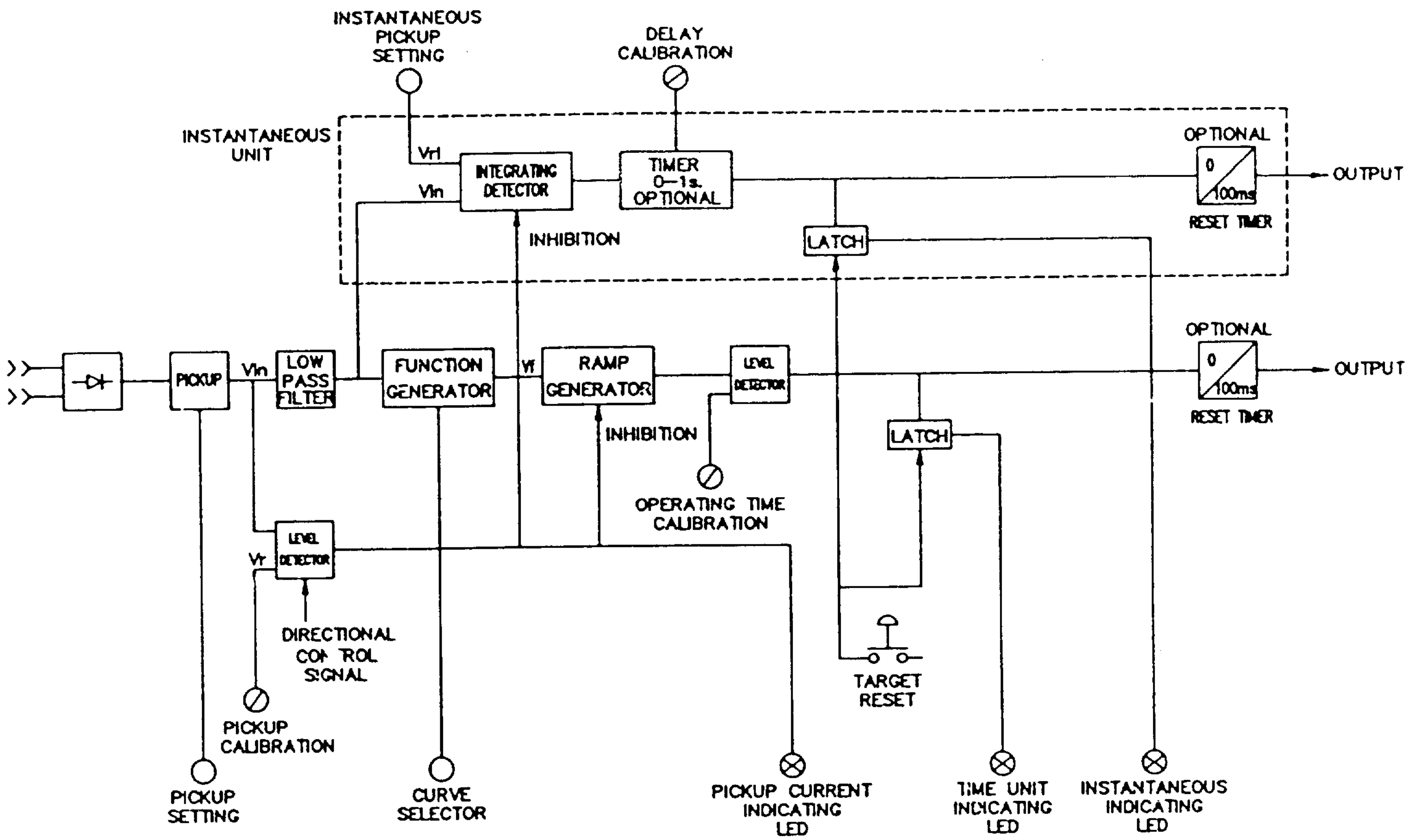


Fig. 8. Block diagram of a one phase board.

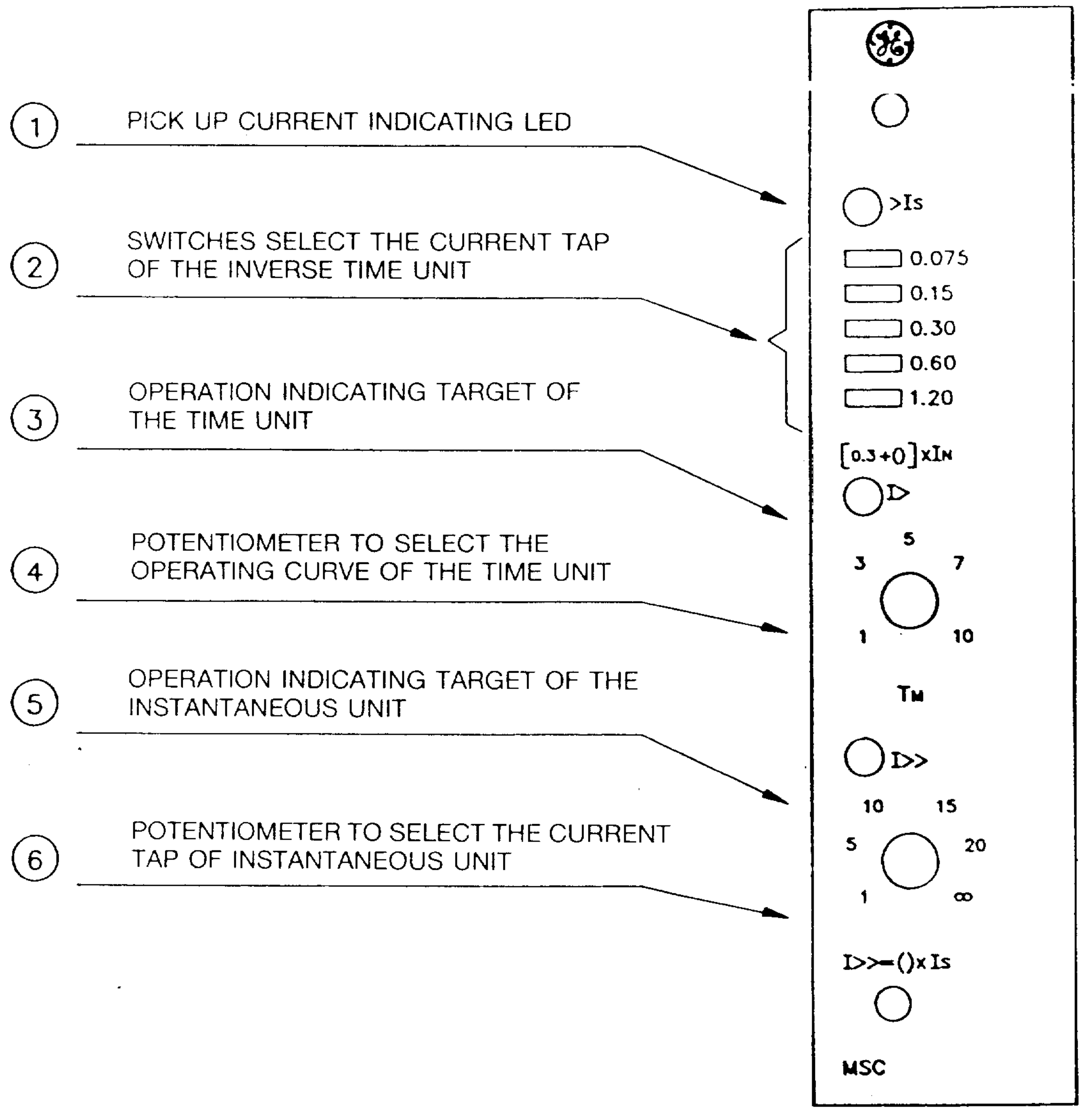


Fig. 9. Location of controls and targets in a phase unit.

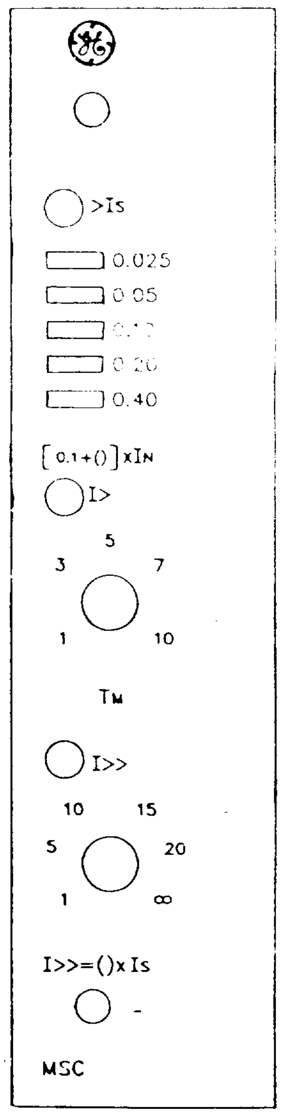


Fig. 10. Location of controls and targets in a ground unit.

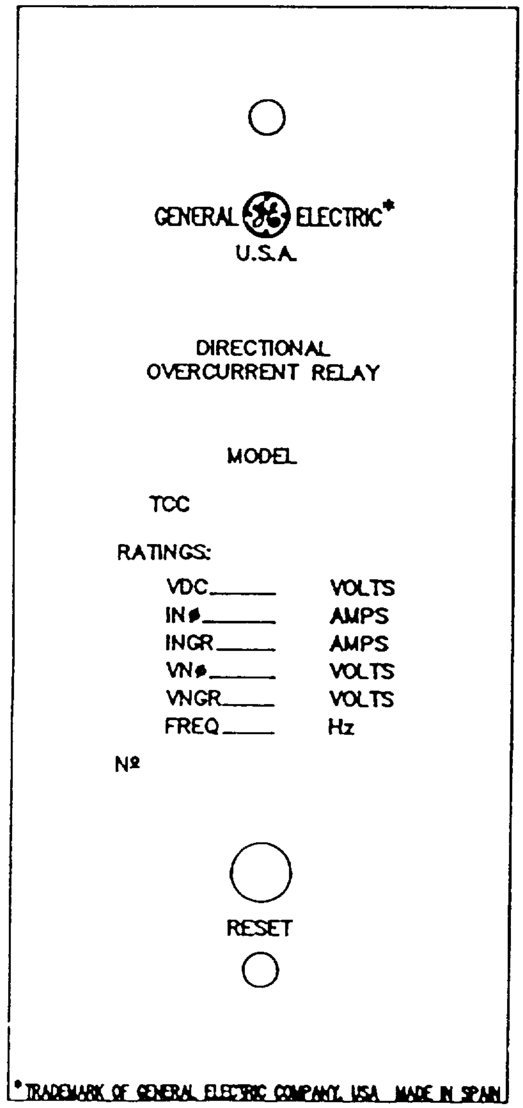


Fig. 11. Front plate of TCC 1000 relay.

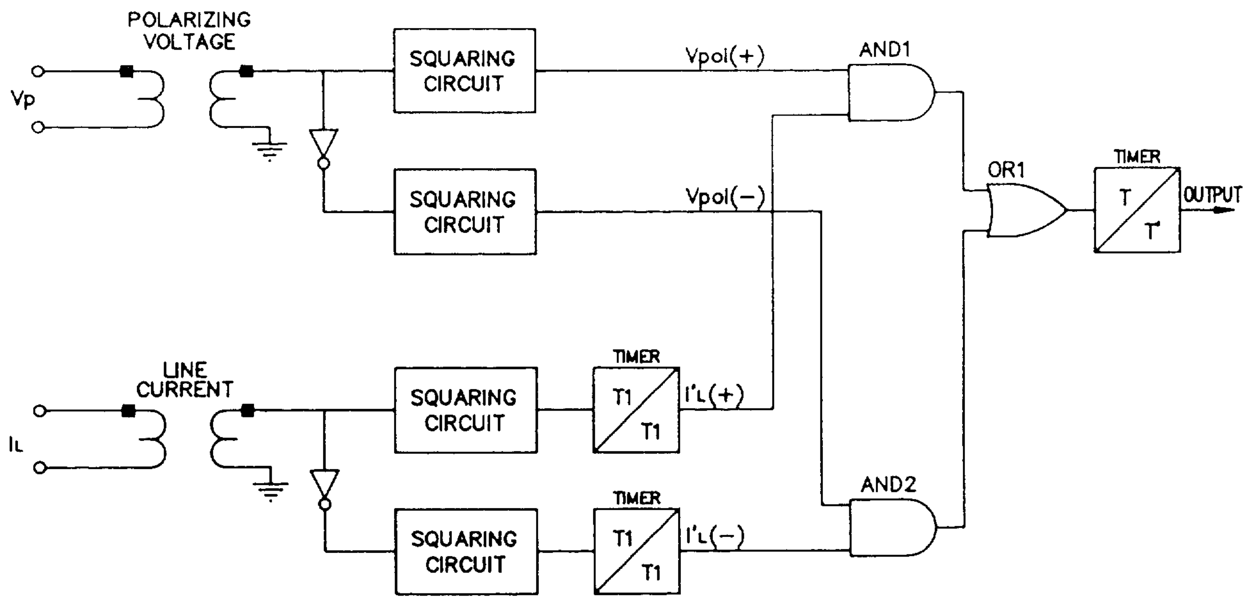


Fig. 12. Phase directional unit block diagram.

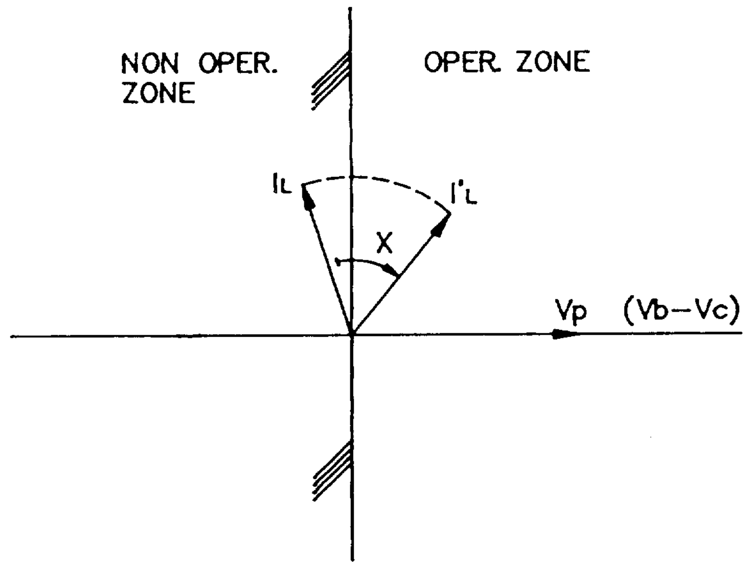


Fig. 13. Operating characteristic of a phase directional unit.

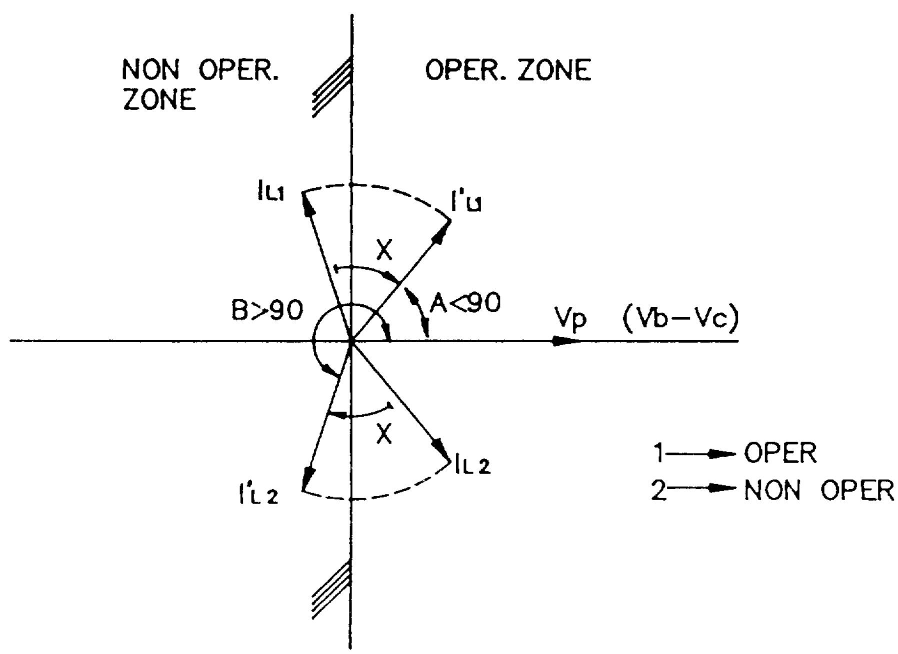


Fig. 14. Phase directional unit operating principles.

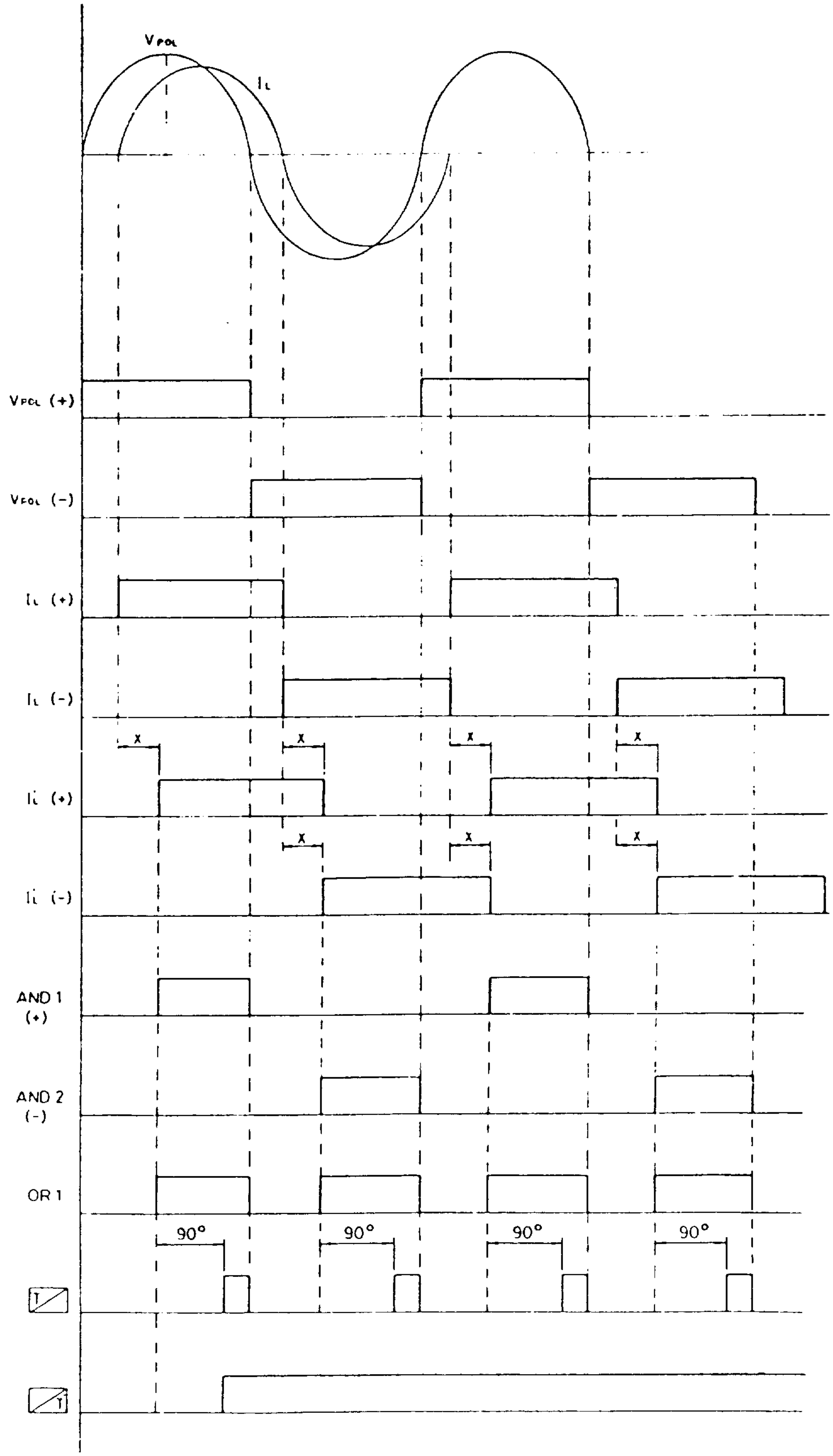


Fig. 15. Phase directional unit time diagram.

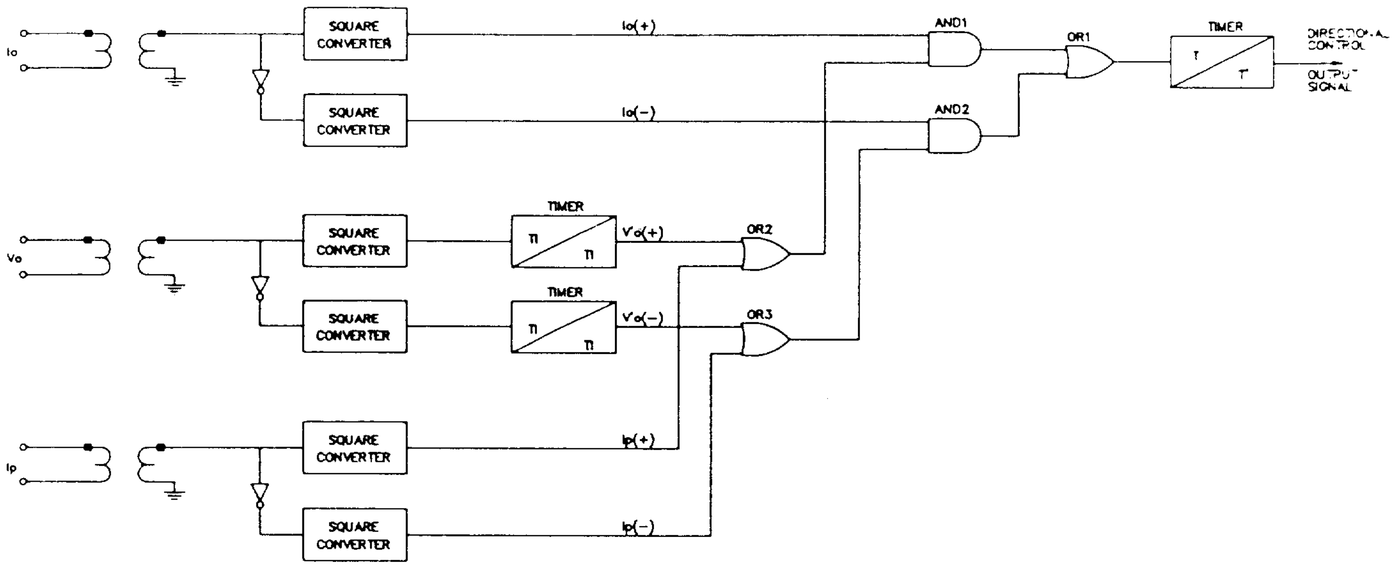


Fig. 16. Ground directional unit block diagram.

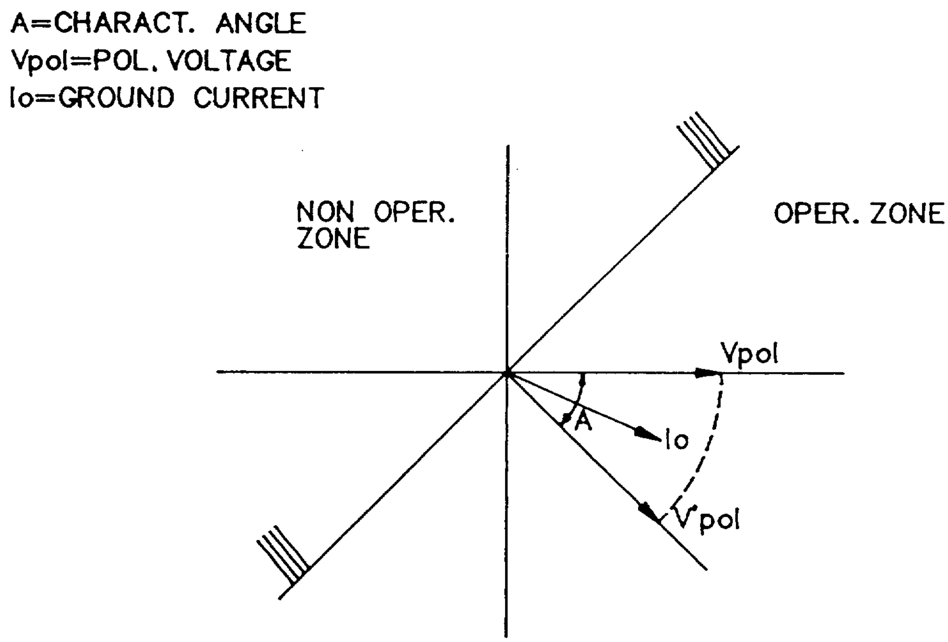


Fig. 17. Operating characteristic of a ground directional unit.

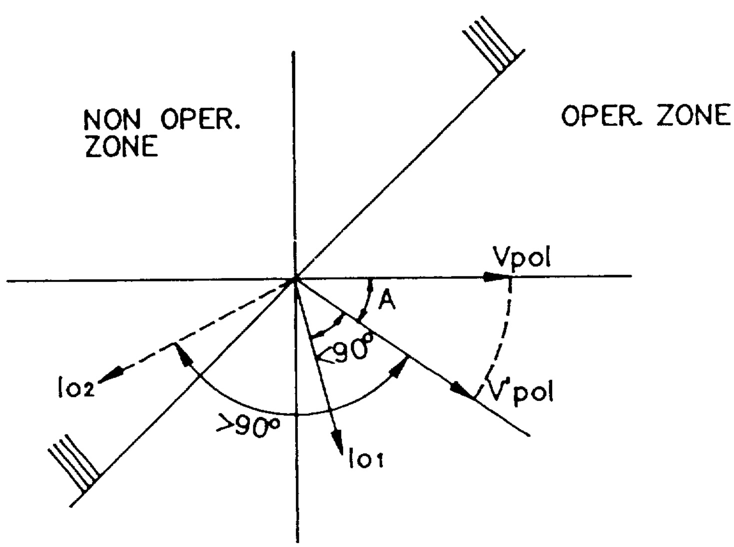


Fig. 18. Ground directional unit operating principles.

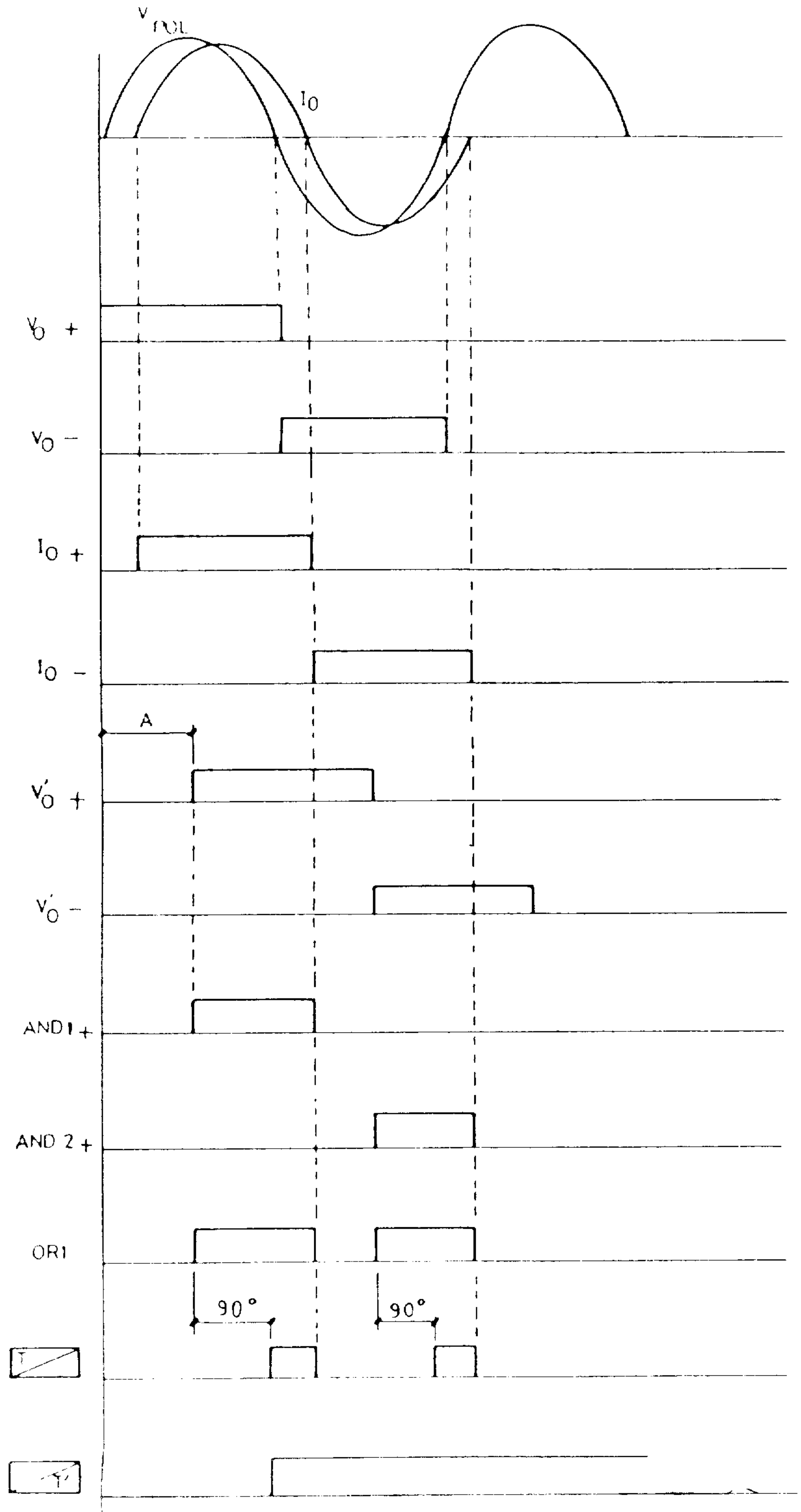


Fig. 19. Ground directional unit time diagram.

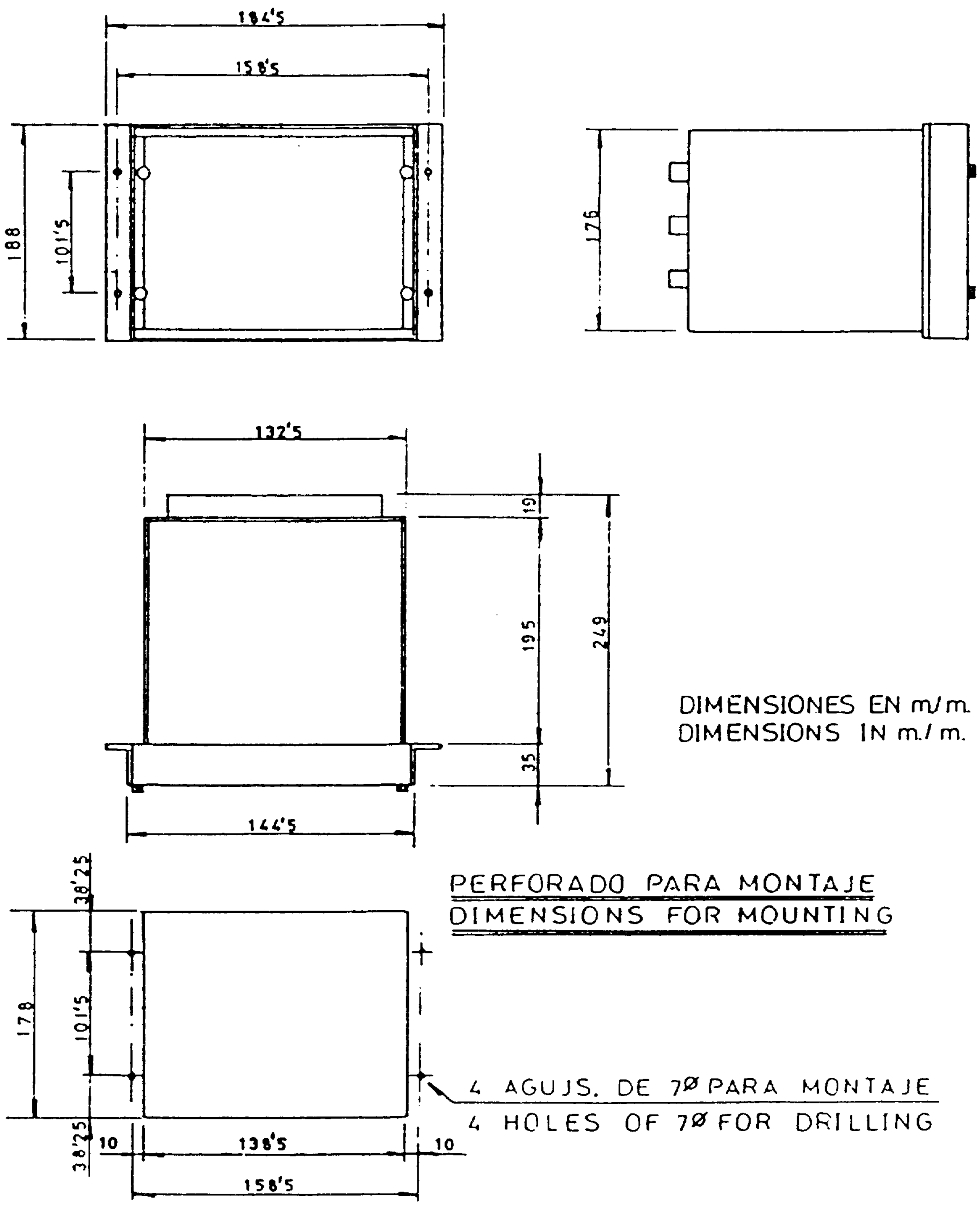


Fig. 20. Outline and panel drilling 1/3 rack case.

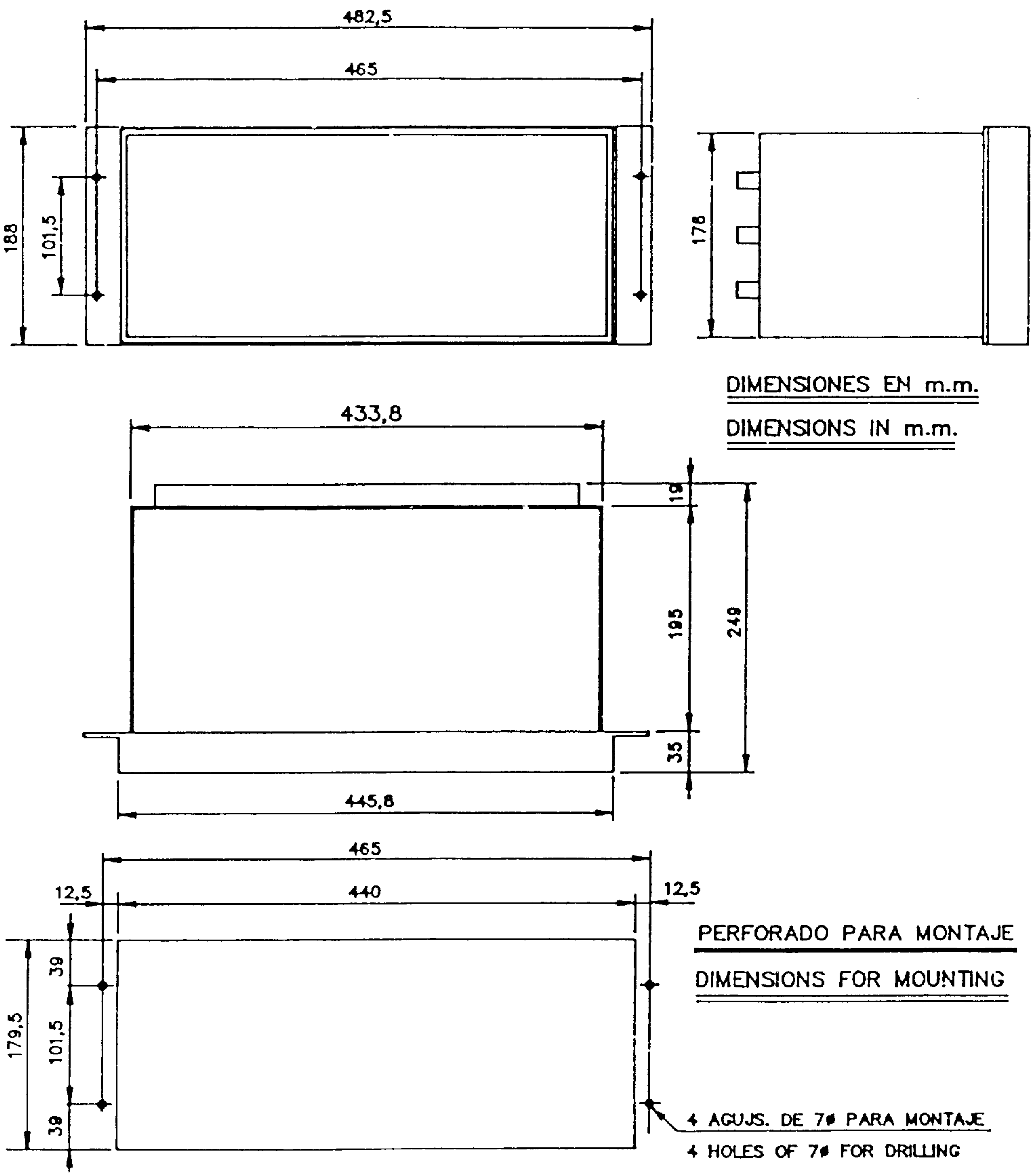


Fig. 21. Outline and panel drilling 1 rack case.

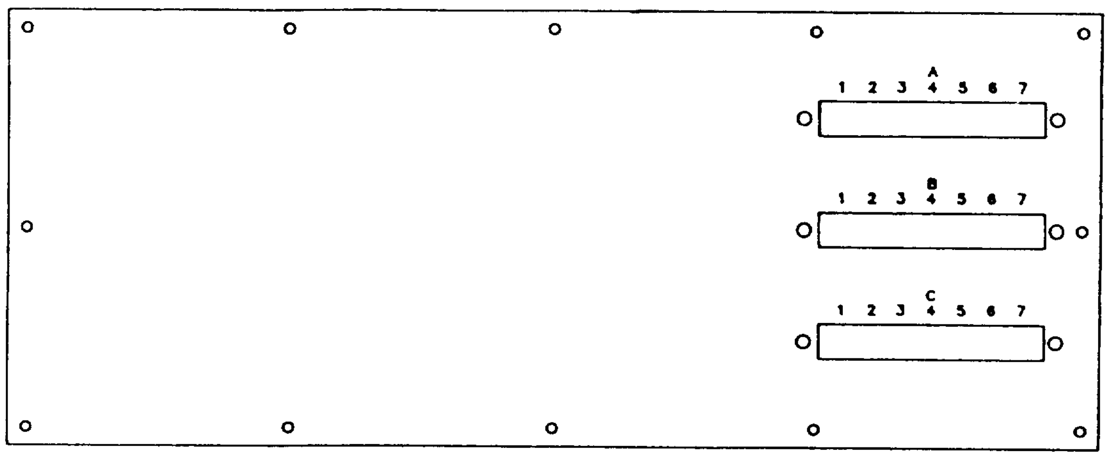


Fig. 22. Layout of terminal blocks on the rear side of the 19" rack case.

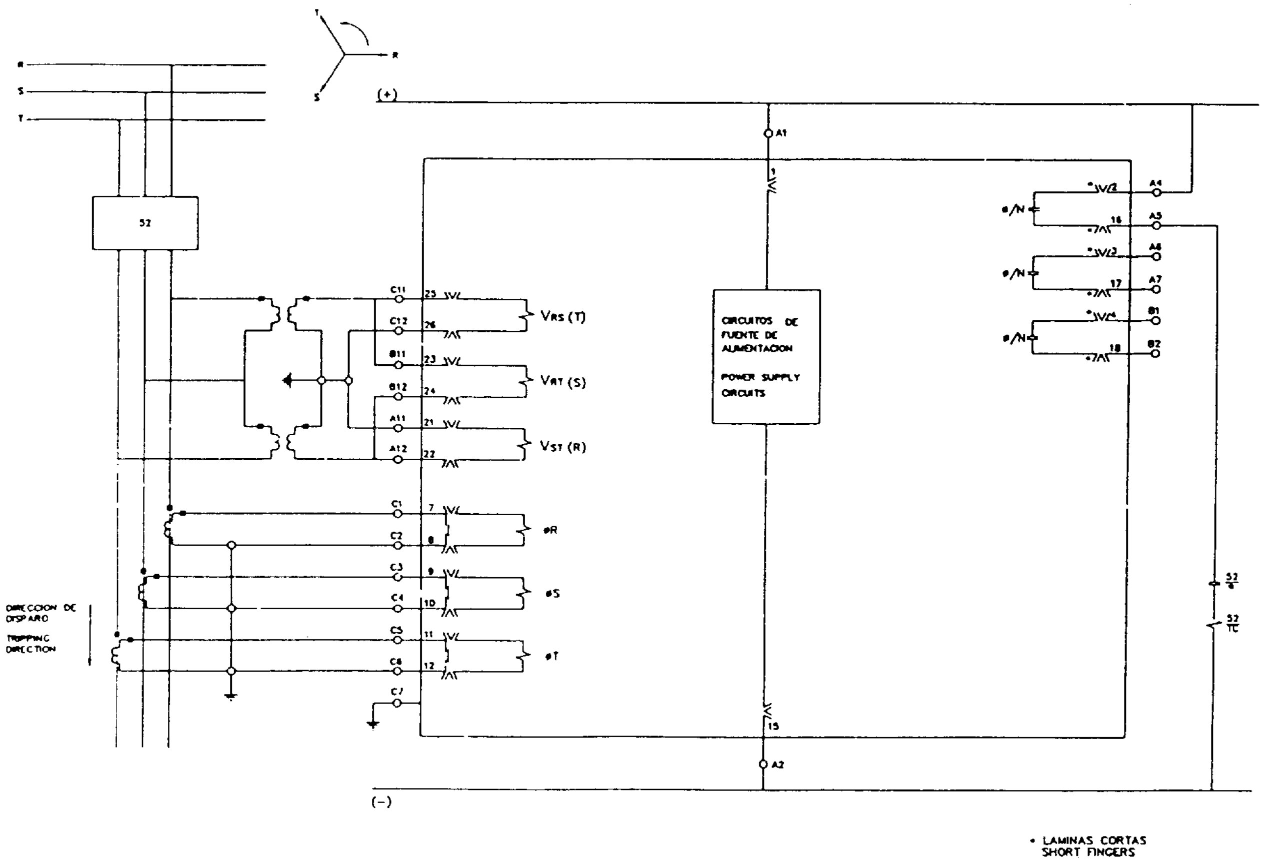


Fig. 23. External connections for directional relay TCC4100.

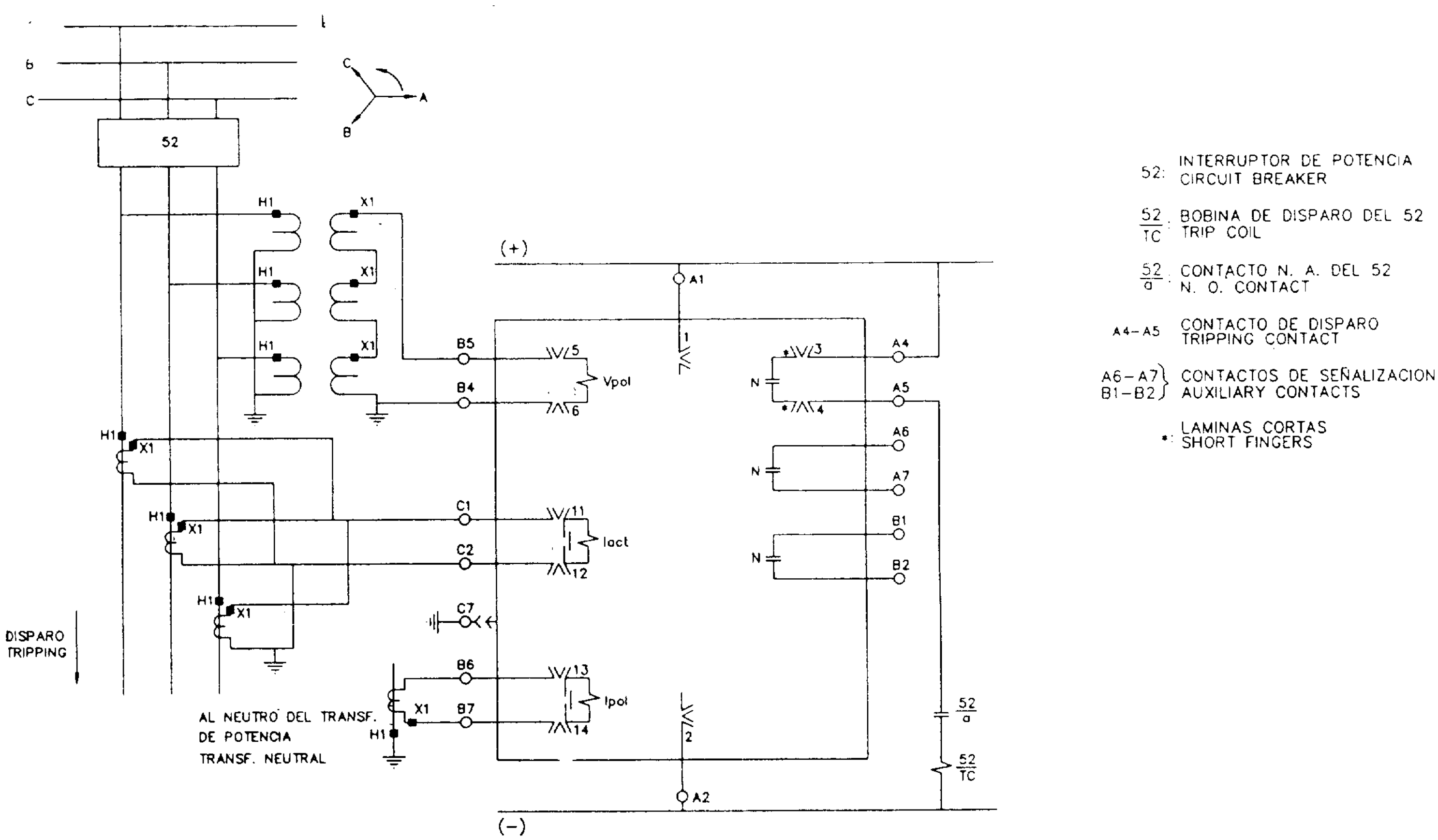


Fig. 24. External connections for directional relay TCC5100.

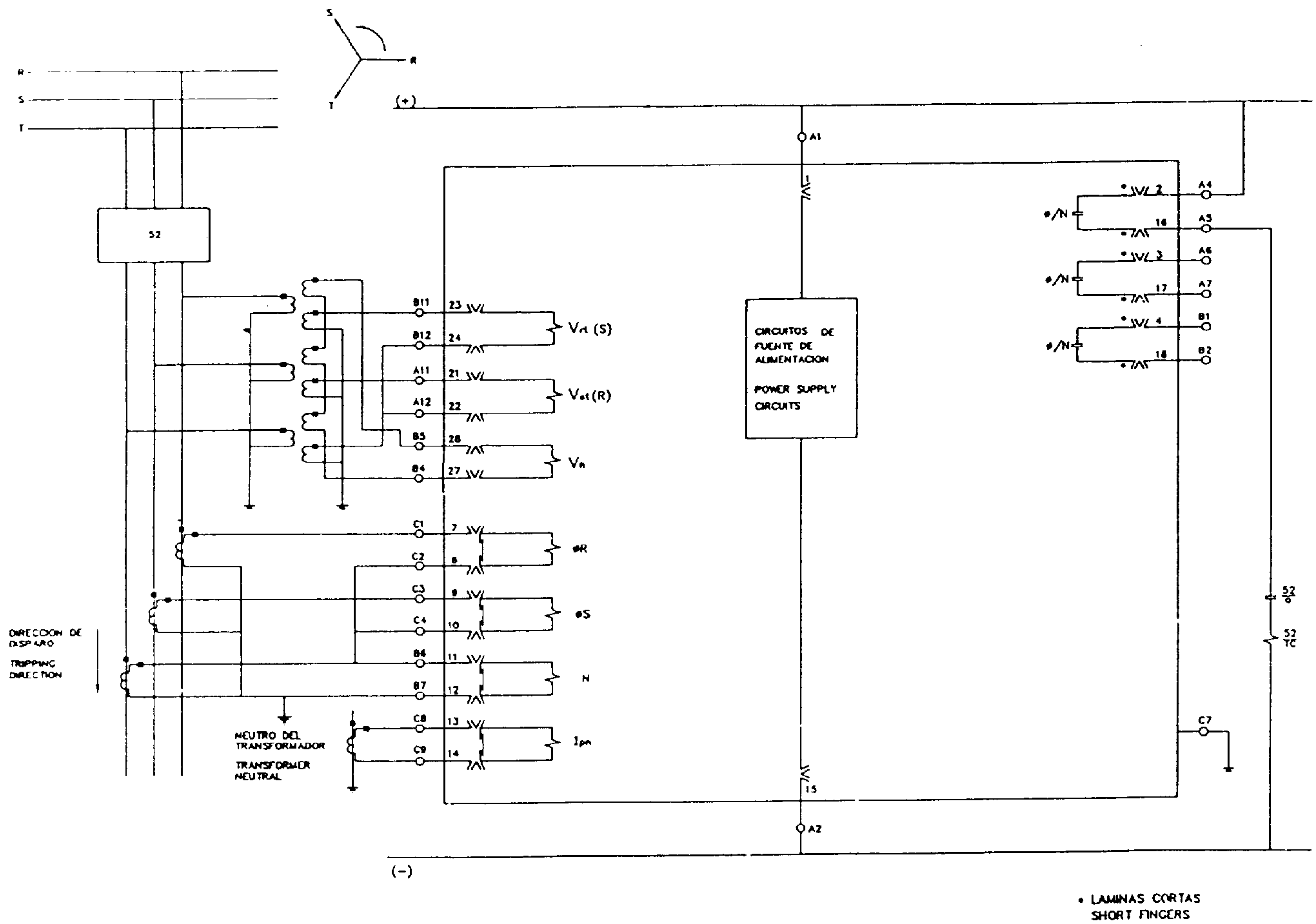


Fig. 25. External connections for directional relay TCC6100.

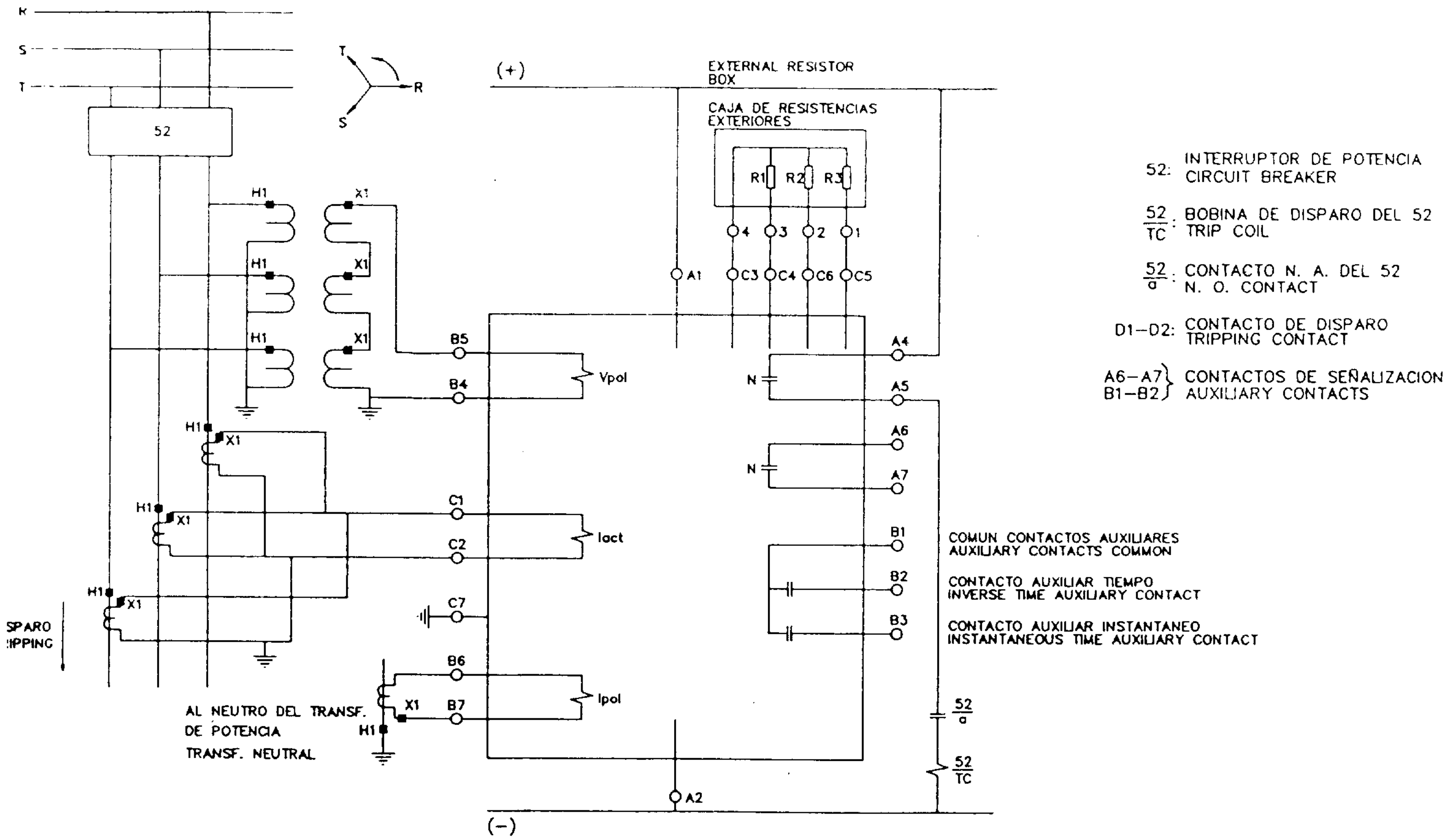


Fig. 26. External connections for TCC5000 with the resistor box for 220 Vdc supply.

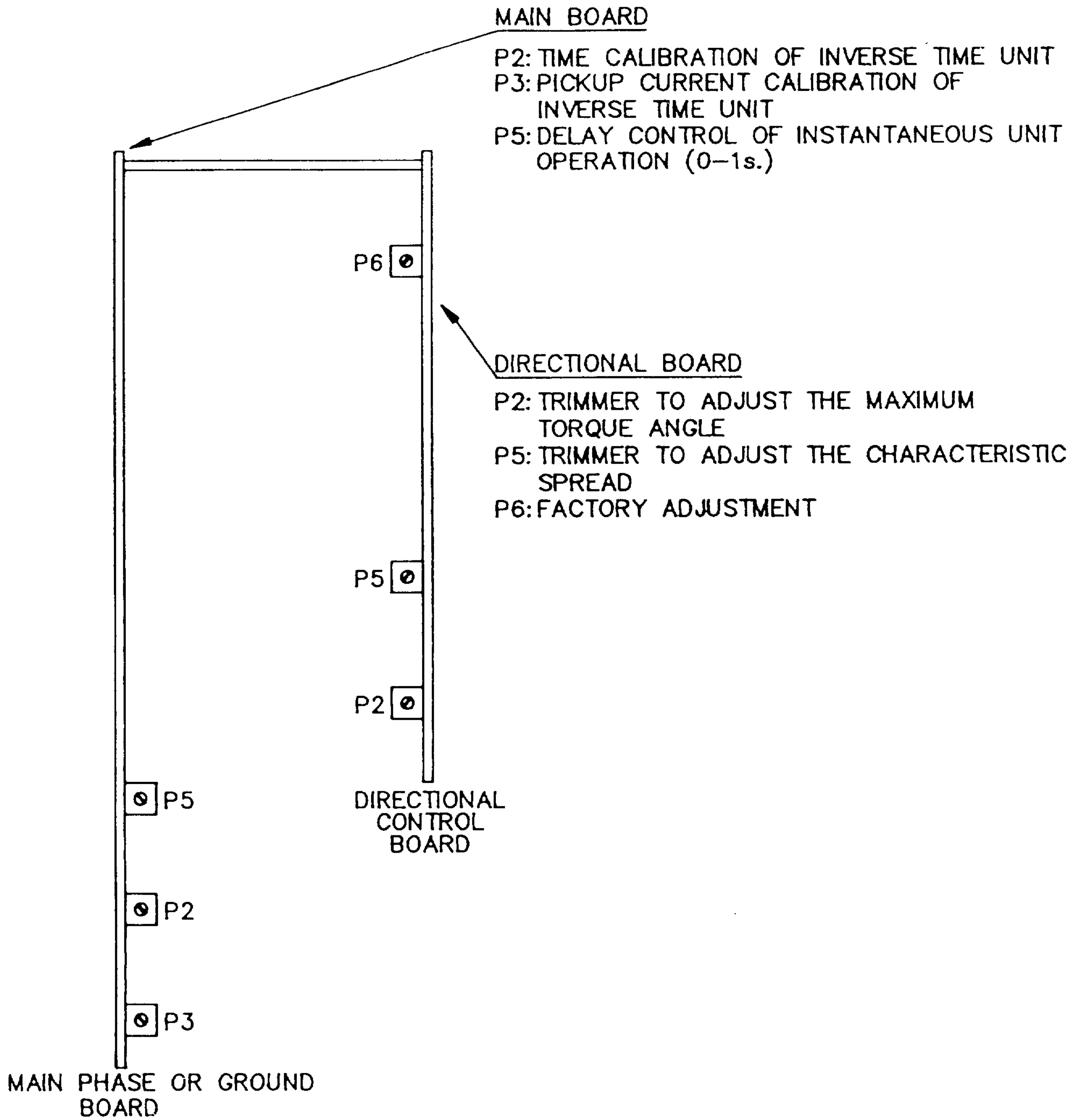


Fig. 27. Internal controls.

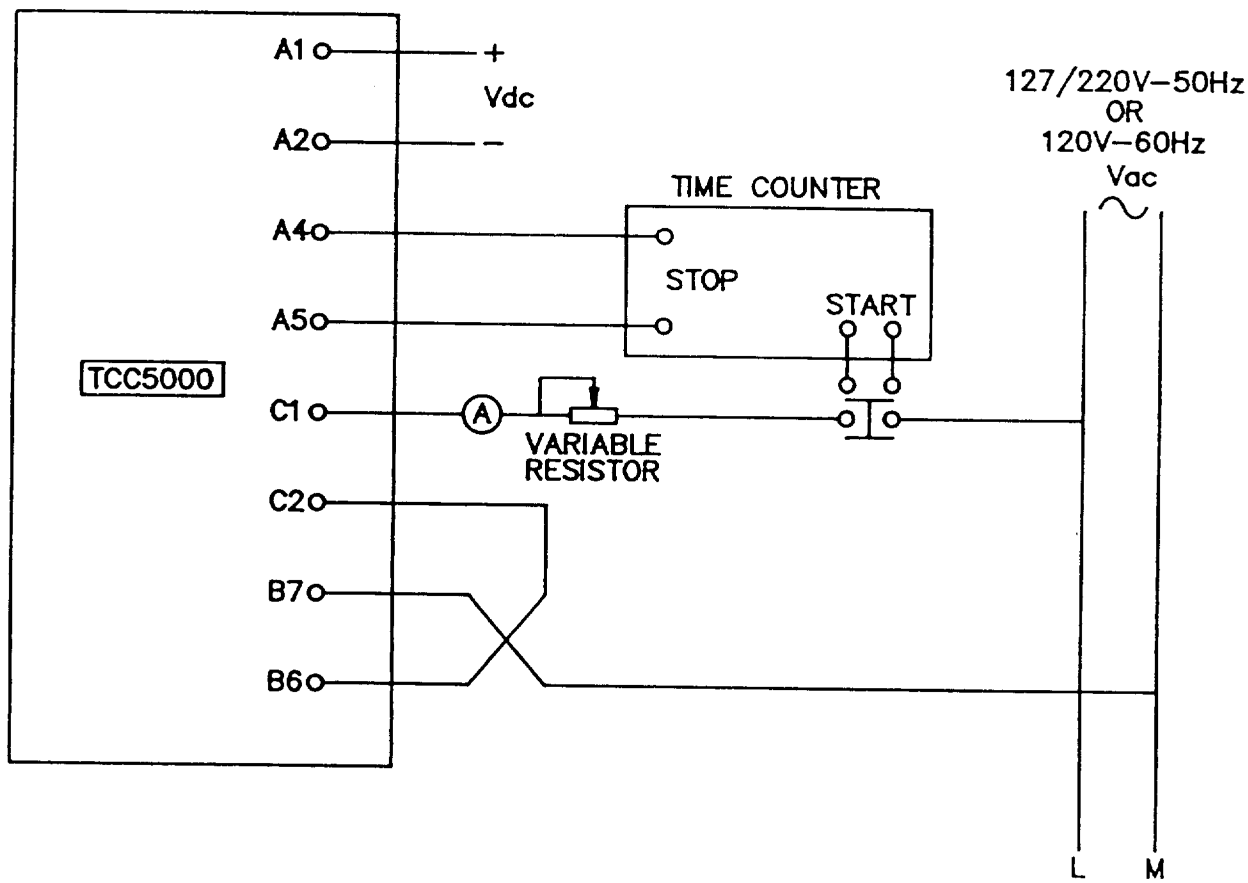


Fig. 28. Test connections with current polarization for tripping conditions for TCC5000.

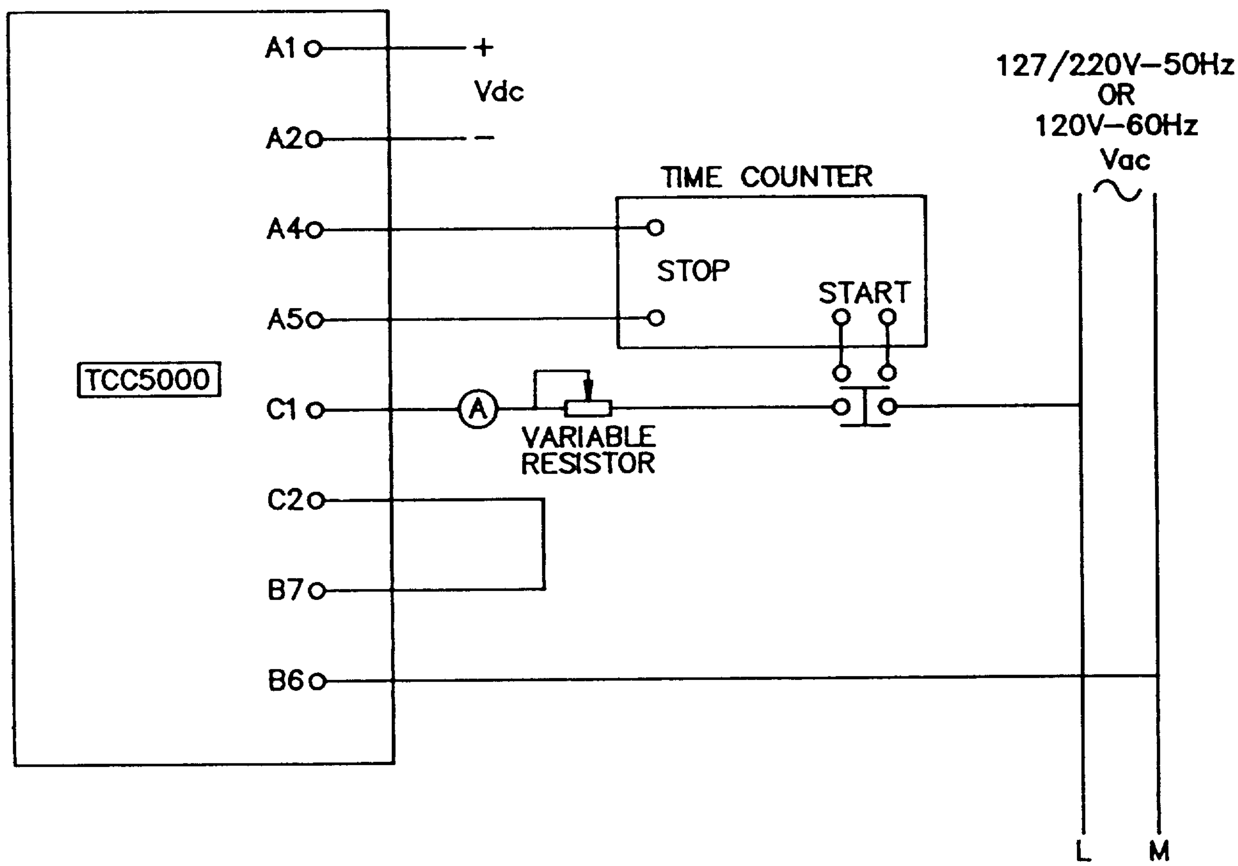
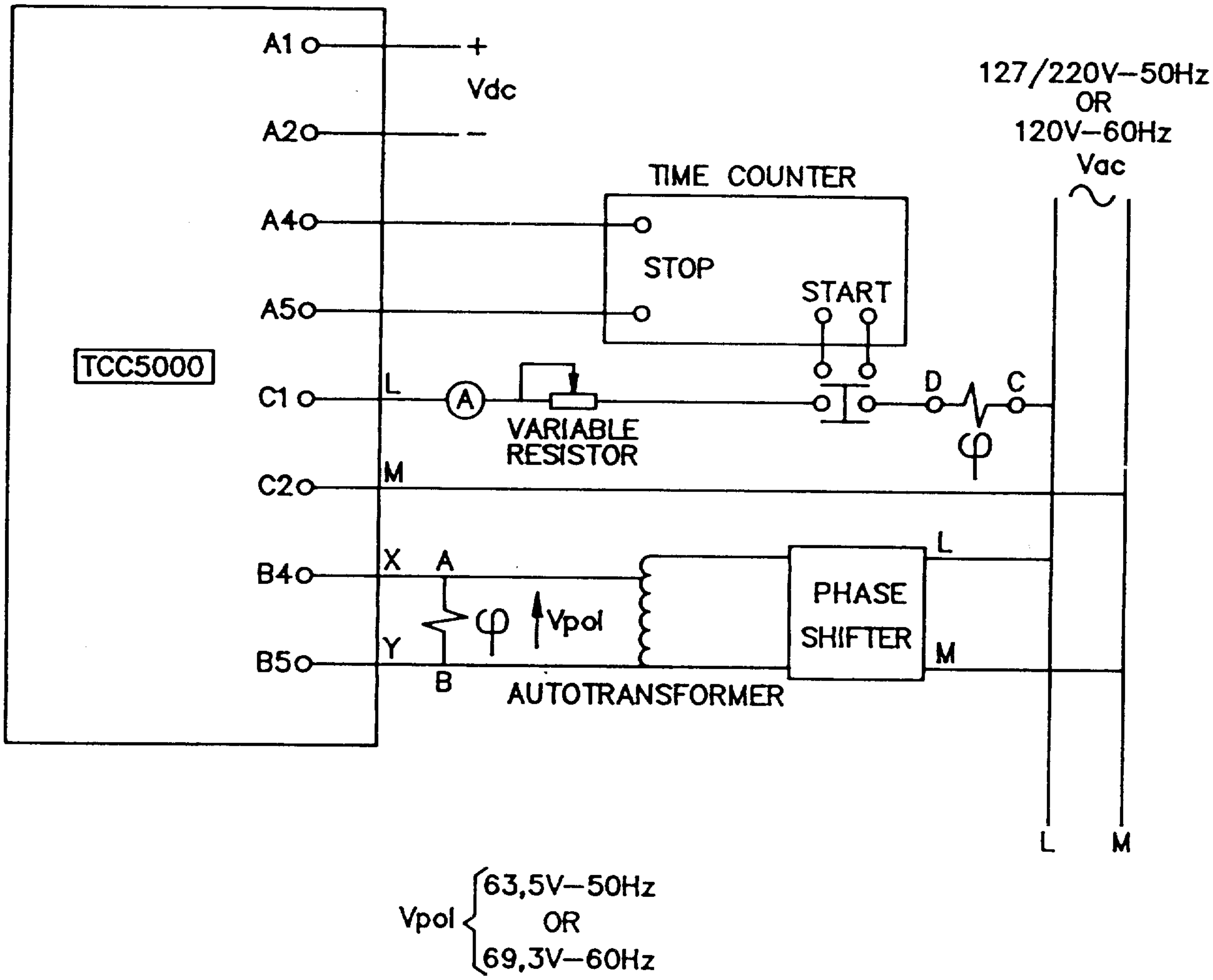


Fig. 29. Test connections with current polarization for non tripping conditions for TCC5000.



φ: PHASE ANGLE METER. PHASE ANGLE METER READS ANGLE BY WHICH I LEADS V.
A: POLARITY OF PHASE ANGLE METER VOLTAGE CIRCUIT
B: NON POLARITY OF PHASE ANGLE METER VOLTAGE CIRCUIT
C: POLARITY OF PHASE ANGLE METER CURRENT CIRCUIT
D: NON POLARITY OF PHASE ANGLE METER CURRENT CIRCUIT

Fig. 30. Test connections with voltage polarization for TCC5000.

TEST CONNECTION TABLE

FOR THE GROUND UNIT

CURRENT POLARIZATION

TYPE	PHASE UNDER TEST	CONNECT L TO	CONNECT M TO	CONNECT
TCC1000	GROUND	B6	C8	B7 TO C7
TCC5000	GROUND	C1	B6	C2 TO B7
TCC6000	GROUND	B6	C8	B7 TO C9

CONNECTIONS FOR TRIPPING

TYPE	PHASE UNDER TEST	CONNECT L TO	CONNECT M TO	CONNECT
TCC1000	GROUND	B6	C9	C8 TO B7
TCC5000	GROUND	C1	B7	C2 TO B6
TCC6000	GROUND	B6	C9	C8 TO B7

CONNECTIONS FOR NON TRIPPING

Fig. 31. Test connections with current polarization for ground units.

TEST CONNECTION TABLE

FOR PHASE UNITS

VOLTAGE POLARIZATION

TYPE	PHASE UNDER TEST	CONNECT X TO	CONNECT Y TO	CONNECT L TO	CONNECT M TO
TCC1000	R	C11	C12	C5	C6
	S	B12	B11	C3	C4
	T	A11	A12	C1	C2
	GROUND	B4	B5	B6	B7
TCC4000	R	C11	C12	C5	C6
	S	B12	B11	C3	C4
	T	A11	A12	C1	C2
TCC5000	GROUND	B4	B5	C1	C2
TCC6000	R	A11	A12	C1	C2
	S	B12	B11	C3	C4
	GROUND	B4	B5	B6	B7

Fig. 32. Test connections with voltage polarization.

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