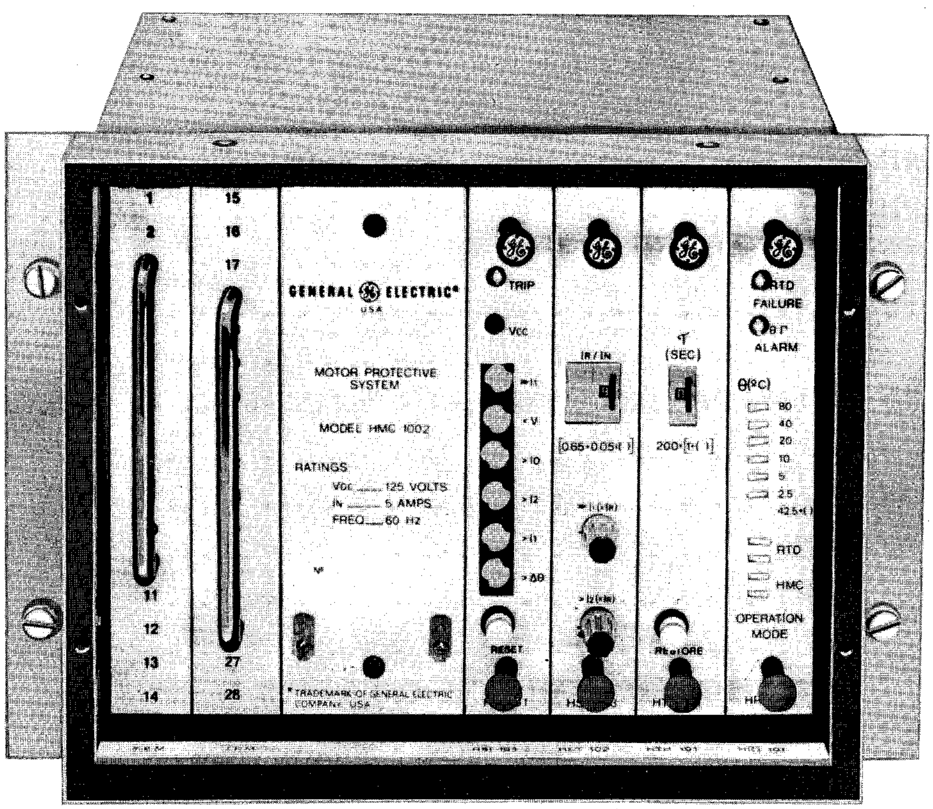
INSTRUCTIONS

GEK - 86096

HMC 1000

MODULAR RELAYING SYSTEM
FOR
MOTOR PROTECTION



GENERAL ELECTRIC

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DESCRIPTION

The HMC 1000 series is a relaying system that provides thermal protection for a.c. three phase motors by combining line current inputs with RTD inputs. In addition it also provides protection against interphase faults, ground faults, single-phase starting, prolonged starting, locked rotor conditions, unbalanced currents with options for phase reversal, undervoltage protection and test facility.

They are solid state modular relays and fit in 1/2 standard 19-inch four-unit rack.

Models are available with or without a test module and for application on motors controlled by circuit breaker or by contactor.

MODEL LIST

TYPE	TEST UNIT		MOTORS CONTROLLED BY	
	YES	NO	CIRCUIT BREAKER	CONTACTOR
HMC 1000-1099	X		X	
HMC 1100-1199	X			X
HMC 1200-1299		X	X	
HMC 1300-1399		X		X

The type HMC 1000 relays have 3 type "C" tripping contacts, 1 n.o. contact for overtemperature alarm and 1 n.o. contact for RTD failure. Optionally 1 type "C" contact for phase reversal, and up to 3 reed contacts to be used as auxiliary contacts of any of the protective functions can be provided.

The external connections for HMC 1000 relays are shown in figure 16.

OPERATING PRINCIPLES

THERMAL PROTECTION

As mentioned previously the HMC relaying system provides thermal protection for a.c. three-phase motors by combining line current inputs with RTD inputs. Thus the HMC 1000 has two different units that can be used either combined or separately (selection is made on the front plate) to provide thermal protection for a.c. three-phase motors. One of these units is the thermal image unit and the other is the RTD unit. See the block diagram shown in fig. 1.

Thermal image unit

The thermal image unit measures the motor phase currents. 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. Then by means of a sequence filter the positive and negative sequence components, I_1 and I_2, of the line currents are segregated. Using I_1 and I_2 the equivalent current is obtained from the formula:

$$Ieq = \sqrt{I_1^2 + K_1 I_2^2}$$

where K_1 is a negative sequence overvalue constant that can be selected from 1-3-4-6.

The negative sequence current is included in the above formula to protect the motor against the damaging effects of unbalanced currents that are caused by open-phase, phase unbalance or phase reversal conditions. If the line currents are not balanced it can be shown by using symmetrical components that a second flux wave is generated which rotates at synchronous speed but in the opposite direction. The effect of this flux wave on the rotor is to induce disproportionately large currents which can cause excessive heating. The thermal image unit protects the motor against overheating of either the stator or the rotor caused by balanced or unbalance overloads, and provides accurate protection against large overloads of short duration.

RTD unit

A low level reference d.c. current is applied to the RTD imbebed in the motor stator slots. This current in combination with the resistance of RTD will originate a voltage across the RTD that indicates the actual winding temperature. This voltage is applied to the relay inputs and is used to monitor the temperature of the motor stator.

The resistance variation of the RTD provides a reliable means of temperature winding monitoring as long as this temperature is constant or varies at low rates. If the conductor temperature varies rapidly the RTD will lag in time behind the conductor temperature. This lag in time is caused by the long thermal time constant of the insulation between the stator conductor and the RTD detector. The RTD unit provides accurate protection against small overloads of long duration.

OPERATION MODES

The HMC 1000 relay is designed so that the thermal protection of the motor may be accomplished by either the thermal image unit only (HMC MODE), the RTD unit (RTD MODE) only or by both (BOTH MODE) the thermal image unit and the RTD unit as described in the following paragraphs.

a) HMC MODE

In this mode of operation the thermal protection of the motor is provided by the thermal image unit only.

The equivalent current described previously is applied to an R-C circuit whose voltage shall be proportional to the motor temperature at all times, then through a level detector this is compared with a trip level θs which is adjustable between 42.5°C and 200°C.

Figure 2 shows the operating time versus the Ieq curve of the thermal image unit for a time constant τ= 200 sec. and motor starting in the cold state. Time constants from 200 to 3200 sec. in 200 sec. steps can be selected (on the front plate of the relay) by means of the thumbwheel type switch n°2 of fig. 4. Operating times for higher time constants than τ= 200 are multiples of those shown for τ= 200 (i.e. operating times for τ= 800 are 4 times those shown for τ= 200).

b) RTD MODE

A low level reference d.c. current of fixed value for each type of RTD sensor is applied to the RTD unit. Two amplifier stages convert the voltage across the RTD into a signal proportional to the temperature measured by the RTD (θRTD in the block diagram).

This temperature θRTD is applied to two level detectors: the trip level detector and the alarm level detector.

The trip level detector compares the θRTD temperature against the reference temperature θs. If θRTD is above θs a trip output is produced, the LED identified by 5 lights and the target identified by 13 indicates operation (see fig. 4).

The alarm trip detector compares the θRTD temperature against the reference temperature θs-Γ. This reference, θs-Γ is provided by a summation circuit to which two inputs are applied:

- Tripping temperature (θs)
- Alarm temperature decrement (Γ): it is an adjustable constant and it indicates the difference in °C between the tripping temperature and the temperature at which the temperature alarm is activated.

If θRTD is above the reference, θs-Γ, an output is provided. By means of an internal link this output can be used either for alarm indication or for tripping purposes. The latter case provides an independent additional tripping function for the HMC MODE and BOTH MODE settings.

c) BOTH MODE

As mentioned previously the RTD is an accurate detector of motor temperature on low-magnitude long-time overloads. However its long thermal time constant makes the RTD lag the actual motor winding temperature for high-magnitude short-time overloads by a large amount due to the motor characteristics.

Taking these considerations into account the HMC 1000 system has been designed in such a way that when set in the BOTH MODE the trip output is provided by the thermal unit, but for small overloads the RTD unit modifies the value of the winding temperature (θw) generated by the the thermal image unit.

The mechanism by which this modification is made is as follows: the thermal image generated winding temperature (θw) is applied to a heat transmission simulator where a simulated temperature θSIM is generated.

When this θSIM is generated two conditions are taken into account: a certain temperature drop between the motor winding and the RTD must exist and the RTD temperature must lag the actual motor winding temperature in time.

This simulated temperature is compared with the actual RTD temperature sensed by RTD at this instant and the difference, if any, is used to modify the generated winding temperature of the thermal image unit (a positive compensation signal is generated if the actual RTD temperature is higher than θSIM and a negative compensation signal is generated if the actual RTD temperature is lower than θSIM).

If the relay current tap setting is selected correctly and the relay is set for 125°C no difference will exist between the winding temperature detected by the thermal image unit and that detected by the RTD unit. For this condition correction from RTD unit will not take place and the tripping times, in case of overloads, will be those shown in figure 2.

If there is some mismatching between the setting of the relay and the actual temperature of the motor winding a correction from de RTD will take place. The operating times, in case of overloads, may differ from those shown in figure 2, but will be more close to the desired operating times for the actual conditions.

The three curves shown in figure 18 are for testing purposes only and are obtained with fixed values of external resistance (equivalent to fixed RTD temperatures) and do not correspond with normal winding temperature variation.

RTD FAILURE DETECTION

The RTD failure detector circuit provides an alarm signal by means of a n.o. contact, and visual indication by means of a red LED when the RTD resistance is lower than 88 ohm. or higher than 214 ohm. (equivalent to minus 30°C and plus 300°C respectively for the 100 ohm Pt models). Beside this, an inhibition circuit is also activated. This circuit operates in the following manner:

- Relay adjusted HMC MODE: it is not affected.
- Relay adjusted RTD MODE: the signal applied to the trip level detector circuit is interrupted and tripping is inhibited.
- Relay adjusted BOTH MODE: the compensation signal applied to the V-I converter is interrupted and the relay automatically changes to the HMC MODE.

ZERO SEQUENCE UNIT

The zero sequence current is applied to the relay either from a toroidal C.T. or from the residual circuit of three phase C.T.'s.

This current is rectified and then compared with the level detector. If the current is above the level detector the timer shared by the zero sequence current unit and the negative sequence current unit is initiated. When the timer times out a trip output is produced and visual indication by means of the red LED 5 and the target 10 of fig. 4 is provided.

NEGATIVE SEQUENCE UNIT

The negative sequence component of the line current obtained in the sequence filter is rectified and then applied to a level detector. When this current is above the level detector the timer described in the zero sequence unit is initiated. When the timer times out a trip output is produced and visual indication by means of the red LED 5 and the target 11 of fig. 4 is provided.

POSITIVE SEQUENCE UNIT

The positive sequence component of the line current obtained in the sequence filter is rectified and then applied to a level detector. When this current is above the level detector an instantaneous trip is produced and visual indication by means of the red LED 5 and target 8 of fig. 4 is also provided.

LOCKED ROTOR AND PROLONGED STARTING UNIT

When the positive sequence component of the line current is above twice the tap setting a timer is initiated. This timer should be adjusted slightly above the normal starting time of the motor.

Thus, when starting the motor, if the rotor is locked or load causes the starting time to be higher than normal, a current higher than rated current would be detected at the end of the starting time. This is an abnormal condition and a trip output will be provided. The red LED 5 and target 12 of fig. 4 will give visual indication that tripping has occurred for this condition.

PHASE SEQUENCE UNIT (OPTIONAL)

The application of the phase-sequence unit provides protection of motor for cooling equipment, pumps, compressors, etc., so that blocking of the closing circuit occurs if the rotation is reversed due to incorrect phase sequence.

The phase-sequence unit circuit is shown in figure 3. The voltage across points A and C is measured by means of the R-C network formed by R1,R2,R3 and C.

This voltage will be zero for correct phase-sequence conditions and approx. 70 V. for reverse phase conditions. The contacts of the voltage relay used to detect this condition are then used to block the closing circuit and starting is not permitted.

UNDERVOLTAGE UNIT (OPTIONAL)

This unit is adjustable over the range of 40% to 100% rated voltage. If the voltage decreases below the set value for longer than one second a trip output is provided.

POWER SUPPLY

The power supply provides the regulated voltage ± 14.2 Vdc. for internal circuitry. When the relay is correctly connected the green LED n°4 of fig. 4 is on.

APPLICATION

The damaging effect of overloads with the consequential reduction in the life of electric motors must be considered.

Two types of relays have been used to protect the motor against overloads: time overcurrent relays and bimetal relays. Time overcurrent relays do not provide adequate thermal protection since they do not measure the total heating effect and therefore cannot differentiate between the cold or the hot state of the motor which may be caused by conditions other than overcurrent.

Bimetal relays represent an improvement in this respect, however they do not accurately reproduce the heating level since the thermal effect produced by the negative sequence component of the current is not taken into account and because of the motor's thermal inertia they do not accurately track the temperature increase under transient and cyclic conditions of short time duration.

The HMC 1000 provides complete motor protection against:

- Overload/overtemperature by means of the thermal image unit and RTD unit.
- Interphase faults by means of the instantaneous positive sequence unit.
- Locked rotor and prolonged starting by means of the time adjustable positive sequence overcurrent unit.
- Single-phase starting by means of the instantaneous negative sequence unit.
- Ground faults by means of the zero sequence overcurrent unit.
- Phase reversal.

THERMAL PROTECTION

The HMC 1000 includes two different units to provide thermal protection, the thermal image unit and the RTD unit. The section OPERATING PRINCIPLES describes how these units can be used either combined or independently to provide thermal protection.

The following considerations should be taken into account at the time of selecting the operation mode.

The thermal image unit is internally calibrated so that when symmetrical three-phase current equal to the adjusted value (assumed to be equal to motor current) is applied, the thermal memory output, θw, will stabilize at a value corresponding to 125°C. Any load condition above pick-up will result in a thermal image trip with an operating time depending on the magnitude of the overload as indicated by the curves shown in fig. 2.

If the trip temperature is selected at a higher level (i.e. 200°C) a higher current than tap value will be required so that the thermal image unit is stabilized at this higher level. The opposite will happen for trip temperatures lower than 125°C.

Therefore the trip temperature setting, if other than 125°C, will modify the pick-up current of the thermal image unit. This must be taken into account when checking the operating curves of a relay with a trip temperature setting other than 125°C. Refer to section ACCEPTANCE TEST for this purpose.

If some other temperature trip setting is used a correction must be made in the current taps, to insure that when the desired operating current is applied the thermal unit stabilizes at the temperature selected for tripping.

The correction factor C, is calculated as follows:

$$C = \sqrt{\frac{105}{\theta s - 20}}$$

where θs is the selected trip temperature.

This correction factor C will be used to multiply the current tap setting calculated for relays adjusted at 125°C (refer to section CALCULATION OF SETTINGS).

The red LED n°5 of fig. 4 provides two types of indication. When it lights permanently it indicates that a trip output has been produced (target 10, 11, 12 or 13 should also indicate this trip output).

The other indication is for test puposes only and it is a blinking state. This indicates that an overload (current above tap setting) exists and the thermal image unit will provide a trip if this overload remains.

As explained previously the effect of setting the relay at trip temperature other than 125°C is to modify the pick-up current of the thermal image unit. Therefore the blinking indication of the red LED n°5 will only correctly indicate that the thermal image unit picks up when the relay is set in the HMC MODE, and for 125°C trip temperature.

For other trip temperatures the correction indicated in the table of Appendix I should be made.

If the HMC 1000 system is adjusted in the BOTH MODE there can be a correction from the RTD unit to the thermal image unit and the blinking indication of the red LED n°5 will not be valid as indication of the thermal image unit pick-up (only indicates that the applied current has reached the tap setting) eventhough the adjusted trip temperature is 125°C.

Protection against phase to phase faults

Interphase faults produce very fast local heating of the motor, as well as mechanical damage due to the electromagnetic forces produced.It would not be adequate to provide protection against these faults by means of the thermal unit, therefore an overcurrent unit is provided to operate on the positive sequence component of the motor current.

During normal operation at full load the slip is low and the current is the maximum rated current of the motor, but during the starting period the slip is high causing the starting current to be high. In most motors it will fluctuate around 6 In. Moreover during a very short period, approximately two cycles from the time of connection, the motor sees the subtransient value of current with peaks in the order of 20 or more times In. To avoid undesired tripping during the subtransient period the overcurrent unit used to detect interphase faults has a time delay of 35 milliseconds.

The pick-up setting of this unit must be greater than the starting current of the motor.

This unit is not included in relays used with motors controlled by contactors because the contactor does not have interrupting capacity to clear interphase faults. In these cases interphase faults are cleared by the power fuses.

Protection against locked rotor and prolonged starting time

Since the motors can only withstand the heating caused by the starting current for a very short period of time it is necessary to provide protection to limit the time that these high current flow in the motor windings. It should also be noted that the starting current will remain high until the motor is operating in the vicinity of full-speed. Once the motor reaches full-speed under normal conditions the current will decrease to rated valve.

The HMC 1000 includes an overcurrent detector with a fixed pick-up value equal to two times the current tap setting and adjustable operating time of 10-60 sec. The operating time must be adjusted slightly higher than the motor starting time.

Thus when starting the motor, if the motor is locked or loading causes the starting time to be longer than normal, a current greater than rated current would be detected at the end of the starting indicating abnormal condition and a trip output will be provided.

Protection against single-phasing and current unbalance

If during normal operating conditions an open-phase occurs then the positive and negative current components are equal in magnitude but 180° out of phase.

This would be detected by the thermal image unit and a trip output would be provided. The same will happen for unbalanced currents.

However if the open-phase condition occurs at starting the negative sequence current would be much higher and an excessive heating of the rotor would occur.

The HMC 1000 includes a negative sequence overcurrent detector that provides tripping for this condition, with 35 milliseconds time delay to prevent operation during the subtransient period.

Protection against ground faults

The HMC 1000 includes a zero sequence overcurrent detector with 35 msec. time delay operation to override C.T. saturation problems. This unit is connected to residual circuit of three phase C.T.'s. When the HMC is applied to motors operated by contactor the time delay for both the negative sequence current unit and the ground current unit is longer to allow the fuses to melt for fault currents exceeding the interrupting capacity of the contactor.

TECHNICAL SPECIFICATIONS

CURRENT CIRCUITS

Rated currents: 5A or 1A for phase and ground units. 20 mA for ground unit (special).

Thermal capacity:

Continuously	:	2 In
For 3 seconds	:	50 In
For 1 second	:	100 In

Burdens

Rated current	VA at rated current
20 mA	0.04
1 A	0.2
5 A	0.85

VOLTAGE CIRCUIT

Rated voltage : 120 V.a.c.

POWER SUPPLY

Rated Voltage Vdc	Operating Range Vdc	Consumption (mA) Rated	Tripped	Max Ripple
48	38-60	130	285	5%
110/125	88-137	130	285	5%

ADJUSTMENT RANGES (relays applied to motor controlled by circuit breaker)

THERMAL IMAGE UNIT

Current tap setting (Ir/In)

From 0.65 to 1.4 In in steps of 0.05 In.

Time constant (τ)

From 200 to 3200 sec in steps of 200 sec. The curve τ = 200 sec (cold start) is shown in fig. 2.

Tripping temperature (θs)

From 42.5 to 200°C in steps of 2.5°C.

Negative sequence overvalue constant (K1)

Among 1, 3, 4, 6.

Temperature alarm selector (θs-Γ)

Among 7.5-15 and 22.5°C below tripping temperature (θs).

ZERO SEQUENCE UNIT

Range

From 0.06 to 0.24 times rated current of zero sequence unit (Ion).

Rated current

1A or 5A. Optional: 20 mA.

Operating time

Fixed value: 35 msec.

Option: 80 msec.

NEGATIVE SEQUENCE UNIT

Range

From 2 to 8 times the current tap setting of the thermal image unit.

Operating time

Fixed value: 35 msec.

Option: 80 msec.

POSITIVE SEQUENCE UNIT

Range

From 4 to 16 times the current tap setting of the thermal image unit.

Operating time

Fixed value: 35 msec.

Option: 80 msec.

LOCKED ROTOR UNIT

Range

From 2 to 3 times the current tap setting of the thermal image unit.

Operating time

From 10 to 60 seconds or from 2 to 30 seconds depending on the model.

ADJUSTMENTS RANGES (Relays applied to motors controlled by contactors).

The adjustament ranges shown for relays applied to motors controlled by circuit breaker will apply except:

ZERO SEQUENCE UNIT

Operating time

Continuously adjustable between 0.5 and 10 seconds. This time adjustment is common for both the zero sequence unit and the negative sequence unit.

NEGATIVE SEQUENCE UNIT

Operating time

See the zero sequence unit operating time.

POSITIVE SEQUENCE UNIT

It is not included.

OUTPUT CONTACTS

Make and carry: 3000 W resistive for 0.2 seconds with a maximum of 30A.

Break: 50W resistive with a maximum of 1A y 300 Vdc.

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

ALARM CONTACTS

Make and carry: 2000 VA resistive with a maximum of 16 A and 250 Vac.
50W resistive with a maximum of 8A and 250 Vdc.

Make and carry continuously: 8A with a maximum of 250 Vdc.

ACCURACY

Operating current: ± 7.5%
Operating time : ± 7.5%

TEMPERATURE RANGES

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

AMBIENT HUMIDITY

Up to 95% provided that no condensation occurs.

INSULATION

Between any terminal and chassis

2000 V.a.c. for 1 minute at industrial frequency.

Between independent circuits

2000 V.a.c. for 1 minute at industrial frequency.

Between terminals of each output circuit

1000 V.a.c. for 1 minute at industrial frequency.

TYPE TESTS

Impulse test

Voltage wave having a 1.2 useconds ± 30% rise time and 50 useconds ± 20% decay time constant.

Test per IEC standard 255-4.
Test voltages 5 KV peak.

High frequency disturbance test

Damped ocillatory wave with envelope decaying to 50% of its peak value after 3 to 6 cycles.
Frequency 1M Hz ± 10%.
Repetition frequency 400 times per second.
Test per IEC standard 255-4.
Longitudinal mode voltage 2.5 KV.
Tranverse mode voltage 1KV.

CALCULATION OF SETTINGS

This section describes the method of calculating the settings of the HMC 1000 relay for each of the three operating modes.

1. BOTH MODE

Let's assume a motor with the following data:

- Rated output 800 HP.
- Rated voltage 6 KV.
- Efficiency 0.96
- Power factor 0.93
- Starting current 6 In.
- Starting time 25 sec.
- CT ratio 75/5.

a) The formula for the current setting in p.u. of relay rated current of the thermal image unit is:

$$\frac{Ir}{In} = \frac{Im}{Rt \times In}$$

where:

Ir: Current setting of the relay.

Rt: Current transformer ratio.

In: Relay rated current (5A or 1A).

Im: Motor rated full load current.

In this example:

$$Im = \frac{800 \times 0.746}{\sqrt{3} \times 6 \times 0.96 \times 0.93} = 64.3A$$

then:

$$\frac{Ir}{In} = \frac{64.3}{15 \times 5} = 0.85$$

To make this setting in the relay refer to fig. 4.

$$Ir/In = 0.65 + 0.05 \times (*)$$

$$0.85 = 0.65 + 0.05 \times 4$$

(*) Setting of switch 1.

Therefore the switch n°1 of fig. 4 must be adjusted in position 4.

In order to set the time constant the motor manufacturer should provide the time required by the motor to reach maximum temperature at a given current.

Then the formula $I^2t = K$ is applied. If in this example the motor takes 4 minutes at 150 A to reach the maximum temperature, then:

$$150 \times \frac{5}{75} = 10A \text{ is the secondary current}$$

$$10^2 \times (4x60) = 24000$$

Now in the basic curve (fig. 2) with $\tau = 200$ sec. we select a point that is 5 times the pick-up current (5 x Ir) with an operating time of 8.4 sec. (check this point in the curve).

$$5 \times Ir = 5 \times (0.85x5) = 21.25 \text{ A.}$$

$$I^2t = 21.25^2 \times 8.4 = 3793.125$$

Therefore the thermal constant of the motor is $\frac{24000}{3793.125} =$

6.32 times the thermal constant corresponding to the lowest curve ($\tau = 200$), thus by selecting a curve 6 times the minimum, the relay curve will still be below the maximum thermal capacity of the motor.

$$\tau \text{ SELECTED} = 200 \times 6 = 1200$$

to adjust this setting in the relay refer to fig. 4.

$$\tau = 200 \times [1 + (**)]$$

$$1200 = 200 \times [1 + (5)]$$

(**) Setting of switch 2.

therefore the switch n°2 of fig. 4 must be adjusted in position 5.

Above settings have been made assuming that maximum temperature of the motor is 125 C.

Let's assume now that the maximum temperature of the motor is 200°C, then a correction must be made in the current taps so that when the desired operating current (motor current) is applied, the thermal unit estabilishes at the temperature selected for trip (200°C).

The correction factor C (refer to section APPLICATION) is

$$C = \sqrt{\frac{105}{\theta s-20}} \quad \theta s\text{: selected trip temperature.}$$

$$C = \sqrt{\frac{105}{200-20}} = 0.76$$

thus the current tap should be adjusted to:

$$Ir = 0.85 \times 0.76 = 0.646$$

the nearest current tap is 0.65 (minimum tap) thus switch n°1 of fig.4 should be adjusted in position 0.

To adjust the relay at 200°C (see fig. 4 switches 17).

$\theta s = 42.5 + (\quad)$

$200 = 42.5 + (157.5)$

the following switches should be placed at the right = 80, 40, 20, 10, 5, 2.5 (80 + 40 + 20 + 10 + 5 + 2.5 = 157.5).

b) Protection against interphase faults ($\gg I_1$).

Since the starting current is 6 x In we must select $I \gg$ above this value to avoid undesired tripping during starting. In this case we would select 8 Ir. This is done by means of potentiometer 6 of fig. 4. Starting from left 8 Ir is the third dot engraved on the front plate. This unit is not included in those relays applied to motors controlled by contactors.

c) Protection against single-phase starting $I_2>$. This function is provided by the negative sequence current unit. The lowest setting should be selected in order to obtain maximum sensitivity. In this case 2 Ir. This is done by means of potentiometer 7 of fig. 4. 2 Ir correspond to the first dot starting from the left.

d) Zero sequence unit setting $I_0>$. The lowest setting should be selected to obtain maximum sensitivity. The adjustament is made by means of the potentiometer P8 on the HST 101 shown in fig. 6.

e) Locked rotor protection. The pick-up current has a range of 2 to 3 Ir and can be adjusted by means of the potentiometer P3 of fig. 6. The operating time should be adjusted slightly above the starting time of the motor (25 sec) approximately 28 or 29 sec. is recomended. Adjustment is made by potentiometer n°2 of fig. 6.

2. HMC ONLY

The setting procedure is the same as that described above. In this case the motor temperature is monitored only by the thermal image unit.

The relay temperature trip level can be set at 125°C and then the current tap setting must be adjusted without introducing any correction factor even though the maximum motor temperature is other tan 125°C.

3. RTD ONLY

Thermal protection is provided only by the RTD unit therefore the setting of current pick-up and time constant curve of the thermal image unit is not needed. Setting of the remaining protective functions is the same as that described for BOTH MODE.

CONSTRUCTION

CASE

The case is fabricated from anodized aluminum. A heavier gage aluminum is used on the side plates and side mounting brackets for added strength in these critical areas. Overall case dimensions are given in fig. 17.

The front cover is made of plastic material. Gasketing is inserted around the edges of the rear cover plate and around the cover contact surfaces of the front of the case in order to avoid dust infiltration.

These modules are mounted vertically. The sockets located inside the case (towards the rear) serve as mechanical supports as well as the means of electrical connection. They hold the modules firmly in position. Proper alignment is maintained by slotted plastic guides, one at the top and one at the bottom of each module.

ELECTRICAL CONNECTIONS AND INTERNAL WIRING

External connections are made to three terminal blocks mounted on the rear of the case. Each block contains 14 terminal points which consist of a # 6 screw threaded into a flat contact plate. Plastic covers are included over every terminal block. These covers reduce electrical shock hazard and protect against inadvertent short circuits between terminals. These covers are held on by plastic clips and are easily removed by hand (no tools necessary). There are slots in the covers above and below each terminal point to guide the incoming wire dress. In addition, there are small holes in the covers directly in front of each terminal point which allow probes to be inserted so that points may be tested without having to remove the protective cover.

Connection to the printed circuit board modules is made by means of 60-pin edge connectors.

The printed circuit board edge connectors are mounted on the backplane assembly approximately 4 centimeters from the back of the case. The receptacle for the connection plugs and test receptacle (optional) are mounted only 3 centimeters from the front of the cases.

All the current inputs are brought in on the same rear cover terminal block. This block is rated to handle the CT secondary currents. The internal current leads are made from substantially heavier gage wire than the remainder of the internal wiring. They are held to the shortest length practical to minimize the resistive burden on the CT's. Connection is made via crimped-on terminals. These leads are arranged in their own harnesses and are segregated from the other wiring. Again this is done to minimize the coupling of the fields associated with the current carrying conductors onto the low level signal conductors.

Identification

The HMC model number is indicated on the magnetic module nameplate.

Two marking strips which indicate the name and position of every module in the case are included on the lower and upper inside edges of the front of the case.

The terminal blocks are identified by one letter code which is given on the rear plate directly above the left-hand edge (rear view) of each block. There are three terminal blocks on each case, each of which have a unique code (A throgh C) in order to avoid confusion when making external connections.

On each terminal block, the screw terminals (1 through 14) are labelled top and bottom by stamped numbers. The numbers are visible even when the protective cover is in place.

PRINTED CIRCUIT BOARD MODULES

Each module consists of a printed circuit board and attached front panel mounted perpendicular to the board. Two knobs are provided on the front panel for removing and inserting the module. Electrical connection is made by contact pads at the back edge of the board.

In those cases where the circuit modules do not fill the available space, dummy modules are inserted. These consist simply of a blank board and a blank front panel.

Each module has its own model number consisting of a three letter code followed by a three digit number. These are shown at the bottom of each front panel.

HMC 1000 FRONT LAYOUT

The following adjustment and targets of the HMC 1000 are placed in the front plate of the printed circuit boards. See figure 4.

1. CURRENT TAP SETTING SELECTOR

   It selects the minimum operating current of the relay. The number displayed in the little window multiplied by 0.05 and added to 0.65, gives the relation between the current at which the relay is set (Ir) and the rated current (In).

   Current range:

   Ir from 0.65 to 1.40 times In

2. TIME CONSTANT SELECTOR

   It selects the time constant of the thermal image unit. The number displayed in the little window, added to 1 and multiplied by 200, gives de value in sec. of the time constant.

   Time constant range:

   From 200 to 3200 seconds.

3. THERMAL IMAGE RESTORE PUSH-BUTTON

   When the push-button is pressed, the thermal image returns to its cold state. It can't be pressed without removing the cover.

4. GREEN LED

It indicates that the auxiliary power voltage is connected.

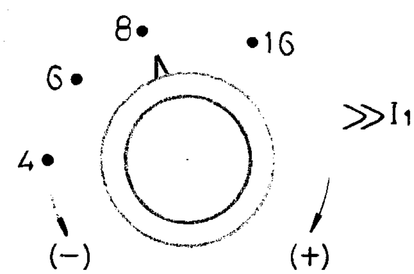
5. RED LED

When it is on permanently it indicates that a trip output has been provided. When it is blinking it indicates that the applied current is above the current tap setting of the thermal image unit.

6. POSITIVE SEQUENCE UNIT PICK-UP ADJUSTMENT

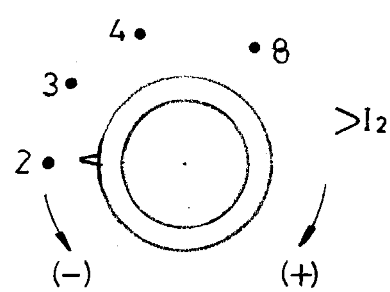
This potentiometer selects the pick-up of the positive sequence unit (short-circuit protection).

Four stamped dots represent the position of the potentiometer in which the pick-up level is adjusted at 4, 6, 8 and 16 times Ir.



7. NEGATIVE SEQUENCE UNIT PICK-UP ADJUSTMENT

This potentiometer selects the pick-up of the negative sequence unit (single phasing and current unbalance protection). Four stamped dots represent the position of the potentiometer in which the pick-up level is adjusted at 2, 3, 4, 8 times Ir.



8. LATCHING TARGET OF POSITIVE SEQUENCE UNIT

10. LATCHING TARGET OF ZERO SEQUENCE UNIT

11. LATCHING TARGET OF NEGATIVE SEQUENCE UNIT

12. LATCHING TARGET OF LOCKED ROTOR UNIT

13. LATCHING TARGET OF THERMAL UNIT/OVERTEMPERATURE UNIT

14. TARGET RESET PUSH-BUTTON

When this push-button is pressed, the activated flags change to its reset position. While the red led (number 5) remains lit, one should not attempt to reset the target.

The push-button can be pressed without removing the cover.

15. θ-Γ ALARM RED LED

It indicates that the thermal image/overtemperature is over the trip temperature minus a fixed quantity (Γ), which can be selected from 7.5, 15 and 22.5°C. It provides an indication that the thermal image/overtemperature is reaching the tripping temperature.

16. RTD FAILURE RED LED

It indicates that the RTD is not properly connected in the circuit because of:

- Short circuit.
- Broken wire.

17. TEMPERATURE SETTING SELECTION

It selects the tripping temperature of the thermal image/overtemperature unit.

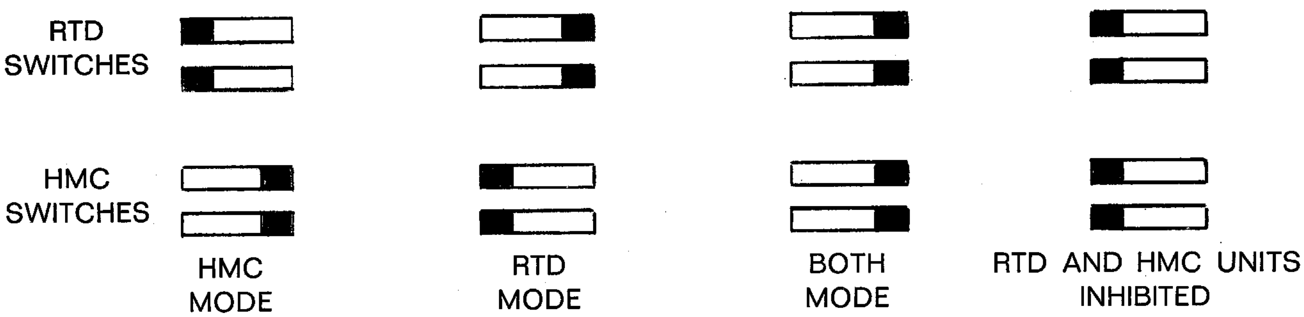
Each Grayhill-type switch has a particular weight, easy to read on the nameplate. When one of the switches is set to the right its own weight is added to the base value 42.5.

E.G.: Temperature = 127.5°C.

127.5 = 42.5 + 80 + 5

Therefore, the 1st and 5th switches must be turned right.

18. OPERATION MODE SELECTION.



As mentioned in the section OPERATING PRINCIPLES the RTD alarm can be used to perform two functions:

1. To provide an alarm function.

   Refer to fig. 8. The link must be positioned in CB15 and both switches 9-10 to the right. In this manner an RTD alarm with output contact is provided.

2. To provide an independent additional tripping function in addition to the operating modes shown above.

   Refer to fig. 8. The link must be positioned in CB14. It is also recommended that the other link be positioned in CB10 so that the RTD alarm provides a trip output at the same temperature as the adjusted trip level.

   The trip output can be produced via the common telephone output relay (both switches 9-10 positioned to the left) or independently (switches 9-10 positioned both to the right).

INTERNAL ADJUSTMENTS

HST - Input and instantaneous board (see fig. 6)

P8 ground fault unit Pick-up adjustment

P3 long starts and locked rotor unit pick-up adjustment

P2 long start and locked rotor unit time adjustment

P4 undervoltage unit operating time adjustment (optional)

CB7 undervoltage unit inhibition (optional)

HTH - Thermal image board (see fig. 7)

P4 negative sequence squarer circuit offset adjustment

P3 positive sequence squarer circuit offset adjustment

P6 negative sequence squarer circuit simmetry adjustment

P7 positive sequence squarer circuit simmetry adjustment

P2 memory unit D.C. undervoltage detector adjustment

P1 capacitor multiplier adjustment

P8 current to temperature scale gain adjustment

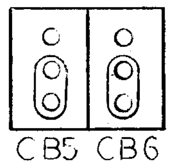
P9 current to temperature scale bias adjustment

NOTE: The potentiometers described above are adjusted at the factory and it is recommended not to change their setting.

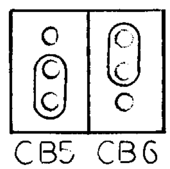
CB5, CB6 K1 selection plug of I_2 multiplication value

Set the plugs as shown for the different K1 values:

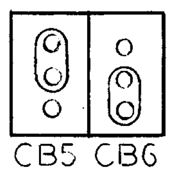
K1 = 1



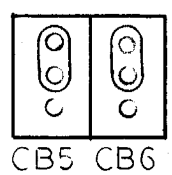
K1 = 3



K1 = 4



K1 = 6



HRT - RTD board (see fig. 8)

P2, P3 RTD amplifier adjustment

P4 Temperature (Winding-RTD) drop simulator adjustment

P1, P5 Trip reference generator adjustment

NOTE: It is recommended not to change the factory setting of potentiometers P1, P2, P3 and P5.

CB10, CB11, CB12, CB13 Temperature decrement (Γ) selection of the alarm.

CB14, CB15 Set to CB15 for normal operation and to CB14 to provide a trip output by RTD alarm function.

SW9-10 Output of the RTD alarm.

- Both switches positioned to the right. This position provides the alarm output contact or an independent trip output from the RTD alarm (see OPERATION MODE SELECTION).

- Both switches positioned to the left. This position provides the trip output from the RTD alarm via the telephone relay (see OPERATION MODE SELECTION).

HSI (see fig. 9)

P1: Blinking adjustment of LED n°5 of fig. 4.

NOTE:

Complete identification of the printed circuit boards (i.e. HRT 101, HST 101 depends on the relay model).

Adjustment controls indicated in this instruction book are the same for all relays regardless of the relay model.

RECEIVING, HANDLING AND STORAGE

These relays, when not included as a part of a control panel, will be shipped in cartons designed to protect them against damage. Immediately upon receipt of a relay, examine it for any damage sustained in transit. 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.

Reasonable care should be exercised in unpacking the relay in order that none of the parts are injured or the adjustments disturbed.

If the relays are not to be installed immediately, they should be stored in the original cartons in a place that is free from moisture, dust and metallic chips. Foreign matter collected on the outside of the case may find its way inside when the cover is removed and cause trouble in the operation of the relay.

NOTE: THE OPERATION INDICATING TARGETS LOCATED IN THE FRONT PLATE MUST BE RESET ELECTRICALLY BY PRESSING THE PUSH-BUTTON.

DO NOT MANIPULATE THE MOVING PART OF THE TARGETS SINCE THIS MAY CAUSE DAMAGE.

ACCEPTANCE TESTS

Immediately upon receipt of the relay an inspection and ACCEPTANCE TEST should be made to insure that no damage has been sustained in shipment and that the relay calibrations have not been disturbed. If the examination or test indicates that readjustments are necessary, refer to the section RELAY CALIBRATION.

These tests may be performed as part of the installation or acceptance test at the discretion of the user. Since most users use different procedures for acceptance and installation tests, the following section includes all applicable tests that may be performed on these relays.

VISUAL INSPECTION

Check the nameplate engraving to ensure that the model of the relay agrees with the order and also that every board is located in its housing.

Remove the relay from its case and check that there are no broken or cracked parts or other signs of physical damage.

POWER REQUIREMENTS GENERAL

All alternating current operated devices are affected by frequency. Since non-sinusoidal waveforms can be analyzed as a fundamental frequency, it follows that alternating current devices (relays) will be affected by the applied waveforms.

Therefore, in order to properly test alternating current relays, it is essential to use a sine wave of current and/or voltage. The purity of the sine wave (i.e. its freedom from harmonics) cannot be expressed as a finite number for any particular relay, however, any relay using tuned circuits, R-L or RC networks, or saturating electromagnets (such as time overcurrent relays) would be essentially affected by non-sinusoidal waveforms.

Similary, relays requiring dc control power should be tested using dc and not full wave rectified power. Unless the rectified supply is well filtered many relays will not operate properly due to the dips in the rectified power. Zener diodes, for example, can turn off during these dips. As a general rule, the dc source should not contain more than 5% ripple.

This relay respond to the input current waveform in a different manner than most a-c ammeters. Therefore, if the test source contains high amplitude harmonics, the ammeter and relay responses will be different. The relay has been calibrated using a conventional 50 or 60 Hz shop source of minimum harmonic content. It should be tested with a similar current source of sinusoidal waveform essentially free from harmonics.

The ammeter and timers used to establish pick-up and time delay characteristics must be calibrated and have accuracies which are considerably better than the accuracy of the relay. In addition, power sources must remain very stable for these tests especially during pick-up and timing tests near the pick-up level.

To minimize the effects of the non-linear impedances of the relay power supply, the current source should be an adjustable resistor (loadbox) in series with the power source.

It should be noted that the degree of test accuracy depends on the power source and instrumentation utilized. Functional tests performed with incorrect power supplies and instruments are useful to insure that the relay is functioning properly and its characteristics are approximately verified. However, recalibration of a relay under these conditions will not produce an accuracy that is any better than the tests system and would result in characteristics outside the tolerances as specified.

If examination or test indicates readjustment is necessary, refer to the section entitled RELAY CALIBRATION.

D.C. BURDEN TEST

1. Connect the relay as indicated in fig.15.
2. Adjust the relay using the minimum tap. See fig. 4 (which shows the front plate) and set the control as indicated below:

   Switch 17:all switches to the left.

   Switch 18:the upper switch to the right.
3. Gradually apply the auxiliary voltage Vdc. up to its rated value.
4. Check that the green LED identified as n°4,the LED n°5 and the RTD failure LED indentified as n°16 light. The D.C. burden is 135 mA approx.

THERMAL IMAGE/OVERTEMPERATURE UNIT

A. HMC MODE

This section contains the procedure to test the HMC 1000 systems with a three phase source. The testing procedure with a single-phase source is described in Appendix II.

1. Connect the relay as indicated in fig. 10.

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

2. Adjust the relay to the minimum tap and for 125°C.See fig. 4 which shows the front plate and set the controls as indicated below:

   Switch 1 in position 0

   Switch 2 in position 0

   Switch 17: switches 80 and 2.5 to the right

   Switch 18: the upper switches to the left and the lower switches to the right.

3. Succesively apply a current of 2,5 and 10 times the value of the minimum tap. Check that the operating time is within the margin indicated in table 1. Check that the output relay operates,the LED identified as n°5 lights and the target n°13 operates.

Rated current	Applied current	Times minimum pick-up	Operating time sec.
1	1.3 3.25 6.5	2 5 10	52.5 - 61.5 7.7 - 9.1 2.5 - 3
5	6.5 16.25 32.5	2 5 10	52.5 - 61.5 7.7 - 9.1 2.5 - 3

Table 1

4. Repeat the test indicated in point 3 but with the switch 2 in position 15. Check that the operating time is within the margins indicated in table 2.

THE THERMAL IMAGE RESTORE BUTTON MUST BE DEPRESSED AFTER EACH TEST SO THAT THE THERMAL IMAGE IS COMPLETELY RESET TO CORRESPOND TO THE MOTOR IN THE COLD STATE.

Rated current	Applied current	Times minimum pick-up	Operating time sec.
1	1.3 3.25 6.5	2 5 10	840 - 948 120 - 146 40 - 48
5	6.5 16.25 32.5	2 5 10	840 - 984 120 - 146 40 - 48

Table 2

NOTE

1. The Appendix I describes the procedure to test the thermal image unit for trip temperature other than 125°C with the relay set in the HMC MODE.

2. Due to the fact that the thermal image unit test is done by measuring the tripping time in which the relay operates when motor is started in the cold state, it is possible that the locked rotor unit may operate before the thermal image unit. Therefore it is recommended to set the locked rotor unit at maximum values of current and time in order to be able to check a wider range of the operating curves.

   Once this test has been completed the settings of the locked rotor unit must be readjusted.

B. RTD MODE

1. Connect the relay as indicated in fig. 11. The external resistor should be adjustable between 100 and 200 Ω.

2. Adjust the relay as follows:

   Switch 18: the upper switches to the right and the lower switches to the left.

3. Adjust each one of the switches identified by n°17 as indicated in table 4 where R means right and L means left. Check that an instantaneous trip is produced within the margins of resistance values indicated is this table, the red LED n°5 lights and the target n°13 operates. The alarm should be activated within the margins of resistance values indicated in the table, the red LED n°15 should light and the n.o. contact B11-B12 should close. The alarm function must be adjusted at 22.5°C below trip level.

Table 4

Trip Temperat. °C	Switches 80	40	20	10	5	2.5	Tripping Res. Value (Ω) Min.	Max.	Alarm Res. Value (Ω) Min.	Max.
42.5	L	L	L	L	L	L	116	118	107	109
45	L	L	L	L	L	R	116.5	118.5	107.5	109.5
47.5	L	L	L	L	R	L	117	119	108	110
52.5	L	L	L	R	L	L	120	122	111	113
62.5	L	L	R	L	L	L	124	126	115	117
82.5	L	R	L	L	L	L	132	134	123	125
122.5	R	L	L	L	L	L	147	149	138	140
200	R	R	R	R	R	R	176.5	178.5	167.5	169.5

Above table is for Pt 100 ohm RTD.

4. Disconnect the stud A12 in the relay case. Check that RTD failure alarm operates, the red LED n°16 lights and n.o. contact B13-B14 closes.

5. Make a jumper between studs A12 and A13 in the relay case. The relay must operate as indicated in point 4.

C. BOTH MODE

1. Connect the relay as indicated in fig. 12. The external resistor should be adjusted according to values shown in table 5.

2. Adjust the relay to the minimum tap and for 125°C. See fig. 4 (which shows the front plate) and set the control as indicated below:

   Switch 1 in position 0

   Switch 2 in position 0

   Switch 17: switches 80 and 2.5 to the right.

   Switch 18: both switches to the right.

3. Succesively apply currents of 2,5 and 10 times the value of the minimum tap. Check that the operating time is within the margins indicated in table 5 that the red LED n°5 lights and that the target n°13 operates.

Applied current In = 1A	In = 5A	Times minimum pick-up	Time in seconds 92 Ω (-20°C)	177 Ω (200°C)	Open
1.3	6.5	2	74 - 84	43 - 51	52-62
3.25	16.25	5	8.2 - 9.4	7.5 - 8.9	7.7-9.1
6.5	32.5	10	2.7 - 3.1	2.5 - 3.0	2.5-3.0

Table 5

NOTE: THE THERMAL IMAGE RESTORE BUTTON MUST BE DEPRESSED AFTER EACH TEST SO THAT THE THERMAL IMAGE IS COMPLETELY RESET TO CORRESPOND TO THE MOTOR IN THE COLD STATE.

LOCKED ROTOR UNIT

1. Connect the relay as indicated in fig. 10

2. Adjust the relay in the minimum tap as indicated below:

   Switch 1 in position 0

   Switch 2 in position 15

3. Apply currents as indicated in table 6 and check that the operating time is within the margins indicated in this table. Check that the output relay operates, taht the red LED n°5 lights and that the target 12 operates. (This unit set at factory for 20 sec.)

Applied current		Time (sec.)	
In = 1A	In = 5A	Min.	Max.
1.5	7.4	18.5	21.5
1.2	6.0		

Table 6

POSITIVE SEQUENCE UNIT

This test will only be performed for relays applied to motors protected by circuit breaker.

1. Connect the relay as indicated in fig. 10.

2. Adjust the relay to the minimum tap as indicated below:

   Switch 1 in position 0

   Switch 2 in position 15

3. The potentiometer identified by N°4 in fig. 4 has 4 reference points that correspond clockwise, to 4, 6, 8 and 16 times the adjusted pick-up current. Set the potentiometer in each one of these reference points and check that the currents for which an operating time of 35 msec. is produced, are within the margins indicated in table 7. Check that the red LED n°5 lights and the target n°8 operates.

Pick-up (Times Ir)	Operating current			
	In = 1A		In = 5A	
	Min.	Max.	Min.	Max.
4	2.4	2.8	12	14
6	3.6	4.2	18	21
8	4.8	5.6	24	28
16	9.6	11.2	48	56

Table 7

NEGATIVE SEQUENCE UNIT

a) This test will only be performed for relays applied to motors controlled by circuit breakers.

1. Connect the relay as indicated in fig. 13.

2. Adjust the relay to the minimum tap as indicated below:

   Switch 1 in position 0

   Switch 2 in position 15

3. The potentiometer identified by n°7 in fig. 4 has 4 reference points that correspond clockwise to 2, 3, 4 and 8 times the adjusted pick-up current. Set the potentiometer in each one of these reference points and check that the currents for which an operating time of 35 msec. is produced are within the margins indicated in table 8. Check that the LED n°5 lights and the target n°11 operates.

Pick-up (Times Ir)	Operating current			
	In = 1A		In = 5A	
	Min.	Max.	Min.	Max.
2	1.2	1.4	6	7
3	1.8	2.1	9	10.5
4	2.4	2.8	12	14
8	4.8	5.6	24	28

Table 8

b) This test will only performed for relays applied to motors controlled by contactors.

1. Connect the relay as indicated in fig. 13.

2. Adjust the relay to the minimum tap as indicated below:

   Switch 1 in position 0

   Switch 2 in position 15

3. Turn the potentiometer identified by n°6 in fig. 5 fully counter clockwise.

4. The potentiometer identified by n°7 in fig. 5 has 4 reference points that correspond clockwise to 0.5, 0.75, 1 and 2 times the adjusted pick-up current. Set the potentiometer in each one of these reference points and check that the currents for which an operating time of 35 msec. is produced, are within the margins indicated in table 9. Check that the LED n°5 lights and target n°11 operates.

Pick-up (Times Ir)	Operating current			
	In = 1A		In = 5A	
	Min.	Max.	Min.	Max.
0.5	0.30	0.35	1.50	1.75
0.75	0.45	0.53	2.25	2.62
1	0.60	0.70	3.00	3.50
2	1.20	1.40	6.00	7.00

Table 9

5. The potentiometer identified by n°6 in fig. 5 has 4 reference points that correspond clockwise to 0.5, 1, 2 and 10 sec.-the operating time of this unit. Turn the potentiometer 7 of fig. 5 fully counter clockwise and apply a current equal to 3A. Set the potentiometer 6 of fig. 5 in each one of the reference points and check that the operating times are within the margins indicated in table 10.

Time setting (sec.)	Time obtained	
	Min.	Max.
0.5	0.463	0.537
1	0.925	1.075
2	1.85	2.15
10	9.25	10.75

Table 10

ZERO SEQUENCE UNIT

a) This test will be performed only for relays applied to motors controlled by circuit breaker.

1. Connect the relay as indicated in fig. 14.

2. Apply current to the relay as indicated in table 11 and check that the relay will operate in 35 msec. for currents within the margins indicated in the table 11.

RATED ZERO SEQUENCE CURRENT (Ion)	APPLIED CURRENT	
	Min.	Max.
0.02	0.0037	0.0043
1	0.185	0.215
5	0.925	1.075

Table 11

b) This test will be performed only for relays applied to motors controlled by contactors.

1. Connect the relay as indicated in fig. 14.

2. Turn the potentiometer 6 of fig. 5 fully counter clockwise.

3. Check that in order to obtain a trip output a current as indicated in table 11 must be applied. The red LED n°5 of fig. 5 will light and the target n°10 will operate.

4. Apply current as indicated in table 12 and check when adjusting the potentiometer n°7 of fig. 5 that at every reference point the operating times obtained are within the margins indicated in table 10.

RATED ZERO SEQUENCE CURRENT (Ion)	APPLIED CURRENT
0.02	0.06
1	0.30
5	1.5

Table 12

PHASE SEQUENCE UNIT

1. Connect the relay as shown in figure 19. With these connections the phase-sequence unit will not operate (contact A3-A4 will remain open).

2. Reverse connections: C2 to S and C3 to R. The phase-sequence unit will operate (contact A3-A4 will close).

RELAY CALIBRATION

LOCKED ROTOR UNIT

If the operating time obtained during testing this unit is outside the tolerance it can be calibrated as follows:

1. Connect the relay as indicated in fig. 10.
2. Adjust the relay to the minimum current tap and maximum time constant curve as indicated below:

   Switch in position 0.

   Switch in position 15.
3. Apply current to the relay as indicated in table 13.

Rated current In (A)	Applied current (A)
1	2
5	10

Table 13

adjust to the desired operating time by means of the trimmer P2 of fig. 6.

ZERO SEQUENCE UNIT

1. Connect the relay as indicated in fig. 14.
2. Apply current to the relay as indicated in table 14.

Rated zero Sequence current Ion	Applied current (A)
0.02	0.004
1	0.2
5	1.0

Table 14

3. Turn P8 (see fig. 6) until a trip is produced.

4. In relays applied for motors controlled by contactor turn potentiometer 6 of fig. 5 fully counter clockwise.

5. Turn P8 (see fig. 6) until a trip is produced.

6. Check other operating times as indicated under section ACCEPTANCE TESTS.

THERMAL IMAGE/OVERTEMPERATURE UNIT

If it is found during installation or periodic tests that the thermal image unit is out of limits refer to a separate information entitled "HMC 1000 CALIBRATION PROCEDURE".

INSTALLATION

Relays should be installed in areas that are clean, dry, free of dust and vibrations and must be well lighted to simplify inspection and tests.

The relay should be mounted on a vertical surface. Figure 17 represents the outline and drilling diagramas. The internal and external connections diagrams are shown in figures 22 and 16. If the inspection or tests performed show the need for adjustment, see paragraph RELAY CALIBRATION.

GROUND CONNECTION FOR SURGE SUPPRESSION

TapC14 of the relay must be grounded so that the surge suppression circuits included with the relay operate correctly. This ground connection must be as short as possible to assure maximum protection (preferably 25 cm. or less).

RELAY SETTINGS

The relay is shipped with the following settings made in the factory (relay applied to motors controlled by circuit breaker).

- Current tap setting(n°1 of fig. 4): position 0.
- Thermal time constant (n°2 of fig. 4): position 7.
- Tripping temperature setting (n°17 of fig. 4): 125°C.
- Operation mode selector (n°18 of fig. 4): set for HMC MODE.
- Negative sequence current (n°7 of fig. 4): 2 Ir.
- Positive sequence current unit (n°6 of fig. 4): 8 Ir.
- Zero sequence current unit (P8 of fig. 6): 0.2 Ion.
- Operating time of the locked rotor unit (P2 of fig. 6): 20 sec.
- Alarm level: 15°C below trip level.
- Negative sequence overvalue constant (fig. 7): 3.

Relays applied to motors controlled by contactors are shipped with the same settings as above except:

- Positive sequence current unit: it does not exist.
- Negative sequence current unit: the pick-up (n°7 of fig. 5) set at 2 x Ir and the operating time (n°6 of fig. 5) set a 5 sec.
- Zero sequence current unit: the pick-up (P8 of fig. 6) set at 0.2 x Ion and the operating time (n°6 of fig. 5) set at 5 sec.

INSTALLATION TESTS

With the relay connected as shown in fig. 16 use the card extender so as to have access to the test points 8,38 and 44 of the thermal image board HTH.

Connect a voltmeter between 8 and 44 and another voltmeter between 38 and 44.

Connect the motor. A certain voltage must exist (1 V.a.c. approximately for motor running at full load)between points 8 and 44 and 0 V.a.c. approximately between points 38 and 44.

If voltage measured between points 8 and 44 is almost zero and there is some voltage between points 38 and 44 the phase sequence at relay inputs is not correct. Connections to studs C7 and C9 must be changed accordingly. Check the relay external connections.

If voltage between points 8 and 44 is approximately the same as voltage between points 38 and 44, one of the line current transformers is not connected to the relay inputs. Check the relay external connections. If one of the measured voltages is half the other, the polarity of one of the current transformers, either R or S, is reversed. Check the relay external connections.

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 periodical tests. Since the interval between periodical tests varies for different types of relays, types of installations, as well as 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.

APPENDIX I

As mentioned previously the thermal image circuit is internally calibrated so that when a symmetrical three-phase current equal to tap setting is applied the thermal memory output θw stabilizes at a value corresponding to 125°C.

This means that if a trip temperature of 125°C is selected and the relay is adjusted in the HMC MODE the thermal image unit will pick-up for a current equal to the current tap.

If a trip temperature other than 125°C is selected (relay adjusted in the HMC), the thermal image unit will pick-up at a value other than tap setting. Table I shows examples of pick-up current/tap setting for different trip temperatures:

$X = \frac{\text{Pick-up current}}{\text{Tap setting}}$	Selected trip Temperature (θs)
0	20
0.1	21.05
0.2	24.2
0.3	29.45
0.4	36.8
0.5	46.25
0.6	57.8
0.7	71.45
0.8	87.2
0.9	105.05
1.0	125
1.1	147.05
1.2	171.2
1.3	197.45
1.4	225.8

Table I

The formula that relates to above quantities is:

$$X = \sqrt{\frac{\theta s-20}{105}} \qquad (1)$$

This should be taken into account when checking the published operating curve of the relay with a trip temperature setting other than 125°C. In order to obtain the published times, the current applied should be corrected by the corresponding factor given by formula (1).

Examples:

a) Selected trip temperature 200°C.

Correction factor:
$$X = \sqrt{\frac{200-20}{105}} = 1.309$$

The operating time for a current equal to 5 times the tap setting and τ = 200 sec. will be:

(multiples of pick-up) $\frac{5}{1.309} = 3.819$

with 3.819 in fig. 2 we obtain: 14.5 sec.

b) Selected trip temperature 80°C.

Correction factor:
$$= \sqrt{\frac{80-20}{105}} = 0.75$$

This operating time for a current equal to 6 times the tap setting and τ = 200 will be:

(multiples of pick-up) $\frac{6}{0.75} = 8$

with 8 in fig. 2 we obtain: 3.45 sec.

NOTE

The blinking function of the red LED n°5 of fig. 4 is started when the current applied to the relay ($I_{eq} = \sqrt{I_1^2 + K_1 I_2^2}$) is above the current tap value. Therefore this blinking indication cannot be used directly for pick-up indication and will only coincide with the pick-up of the relay if the trip temperature is 125°C and the relay is set in the HMC MODE.

APPENDIX II

TEST OF THE HMC 1000 SYSTEM WITH A SINGLE PHASE SOURCE

Symmetrical components explain that a single phase current produces positive and negative sequence currents given by $I_1 = I_2 = I/\sqrt{3}$ where I_1 and I_2 are positive and negative sequence components of the applied current and I is the applied current.

Therefore when testing the HMC 1000 system with a single phase source the effect of the negative sequence current (it is zero in a balanced three-phase system) must be taken into account as follows:

Thermal image unit test

1. Connect the relay as indicated in fig. 20. To apply current to the relay use a 127 or 220V. 50 Hz. source or a 120V - 60 Hz. source with an adjustable resistor in series.

2. Adjust the relay to the minimum tap and for 125°C. See fig. 4 (which shows the front plate) and set the controls as indicated below:

   Switch 1 in position 0.

   Switch 2 in position 0.

   Switch 17: switches 80 and 2.5 to the right.

   Switch 18: the upper switches to the left and the lower switches to the right.

3. Obtain the equivalent current (defined under section OPERATING PRINCIPLES) with I_1 and I_2:

$$Ieq = \sqrt{I_1^2 + K_1 \, I_2^2}$$

$$I_1 = I_2 = \frac{I}{\sqrt{3}} \qquad K_1: \; 1 - 3 - 4 - 6$$

   if for instance the test is done for $K_1 = 4$ then

$$Ieq = \sqrt{\frac{I^2}{3} + 4\,\frac{I^2}{3}} = I\sqrt{\frac{5}{3}} = 1.29\ I$$

4. Apply succesively currents of 2,5 and 10 times the value of the minimum tap setting. Check that the operating times for $\tau = 200$ and $K_1 = 4$ are those indicated in table II.

Rated current (A)	Applied current (A)	Times minimum pick-up	Ieq. in times minimum pick-up for $K_1 = 4$	Operating time (SEC)
1	1	1.55	2	52.5 - 61.5
	2.52	3.87	5	7.5 - 9.1
	5.04	7.75	10	2.5 - 3
5	5.04	1.55	2	52.5 - 61.5
	12.6	3.87	5	7.5 - 9.1
	25.2	7.75	10	2.5 - 3

Table II

For other values of τ the obtained operating times will be a multiple of those shown above. For example, for $\tau = 1600$ the obtained operating times will be 8 times: 456,66.4 and 22 sec. respectively.

5. For other values of K_1 the test should be performed in the same manner taking into account the Ieq obtained for each case:

   For K_1 = 1 Ieq = 0,816 I

   For K_1 = 3 Ieq = 1,15 I

   For K_1 = 4 Ieq = 1,29 I

   For K_1 = 6 Ieq = 1,52 I

   It can be seen that for the same value of the applied current, I, a different value of Ieq is obtained for every K_1 setting, thus the operating times will vary accordingly.

6. Change C7 to C9 and C8 to C10. Repeat points 4 and 5 and check that the operating times are within the margins shown.

7. Connect the relay as indicated in figure 21. Repeat points 4 and 5 and check that the operating times are within the margins shown.

Test of the positive sequence unit, negative sequence unit and locked rotor unit

As mentioned previously the positive and negative sequence components produced by a single phase current are given by $I_1 = I_2 = I/\sqrt{3}$.

Therefore in order to get these units to operate the applied current must be 1.73 times that shown in tables 7, 8 and 6 respectively.

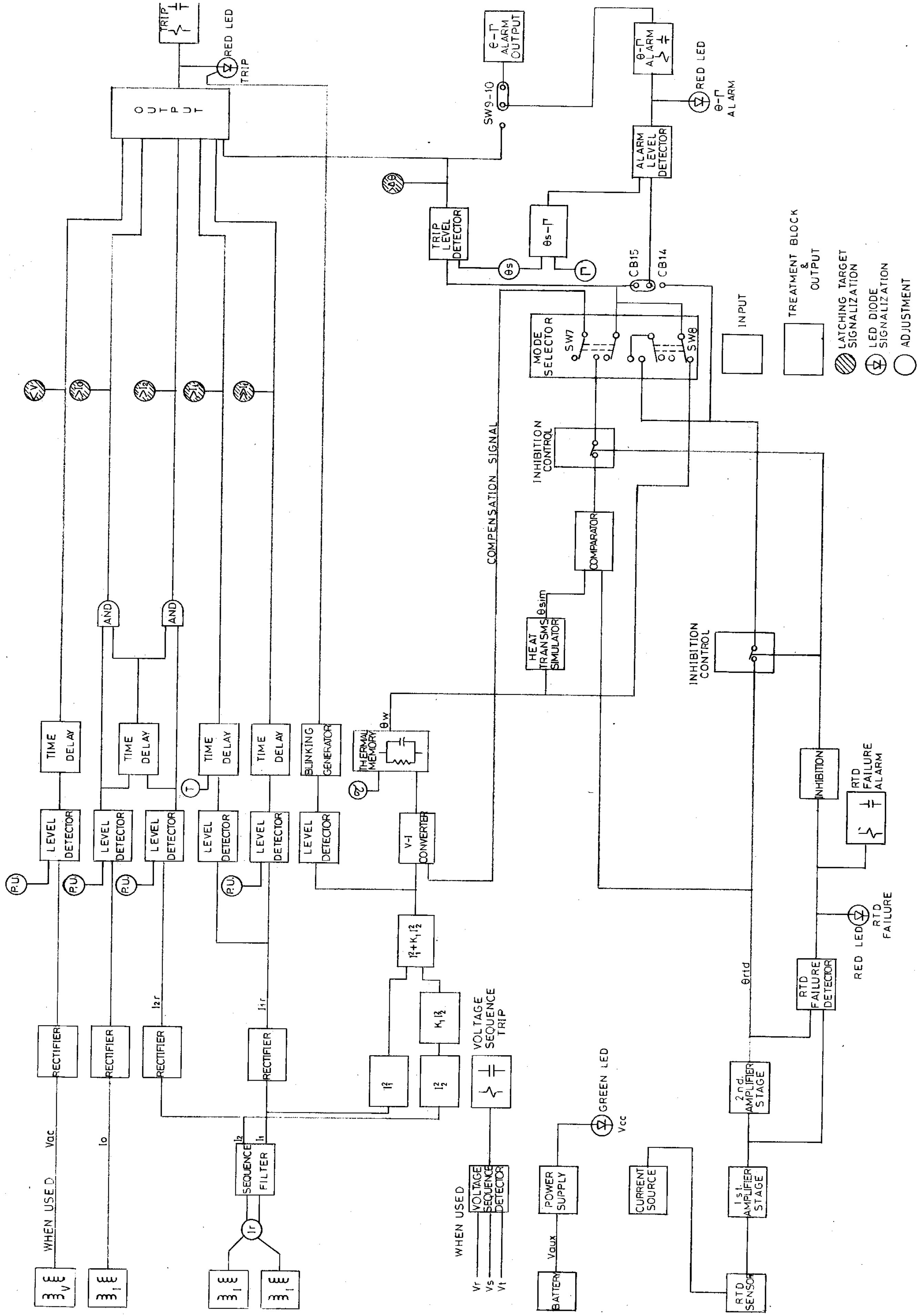


Fig. 1 Block diagram of HMC 1000

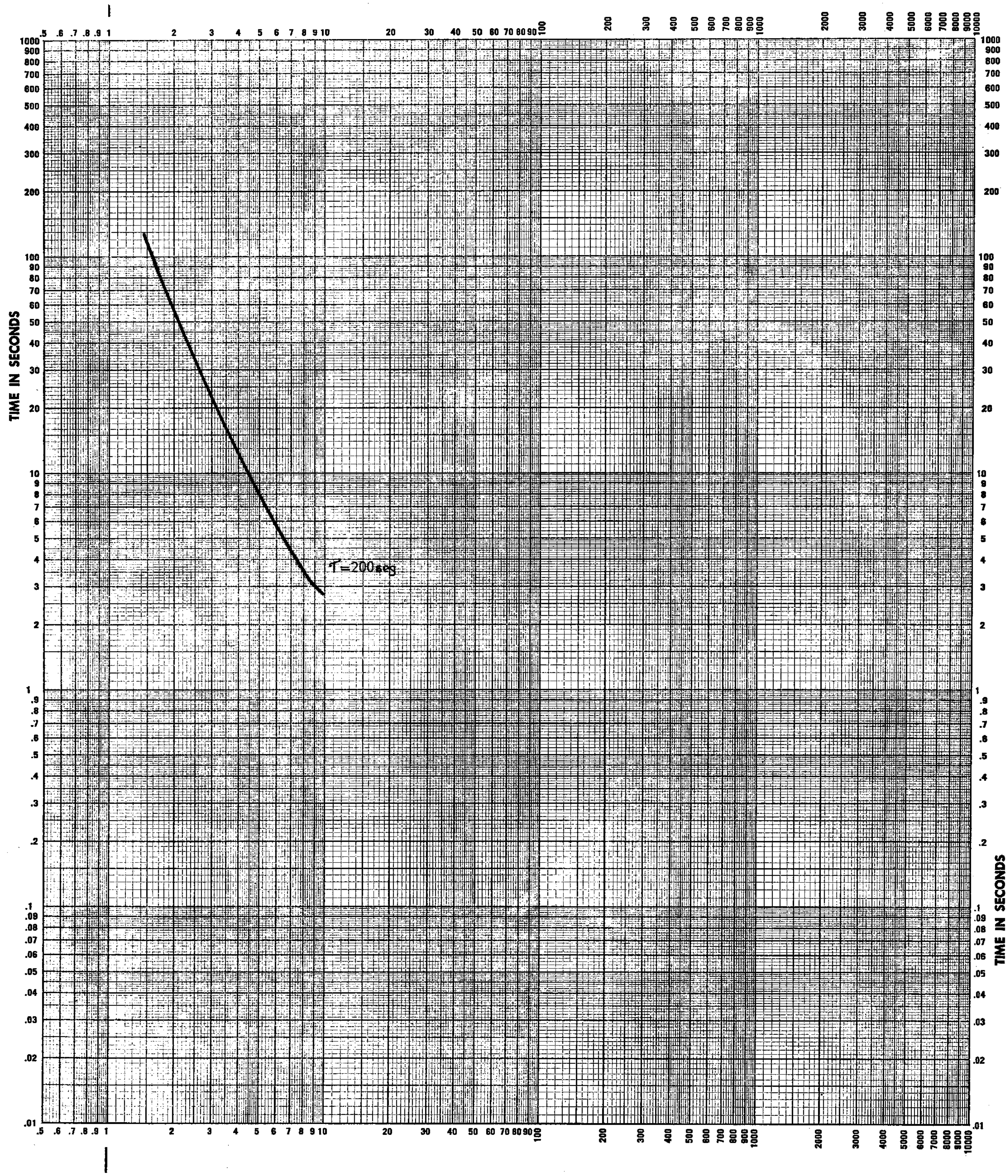


Fig. 2 Operating times of the thermal image unit

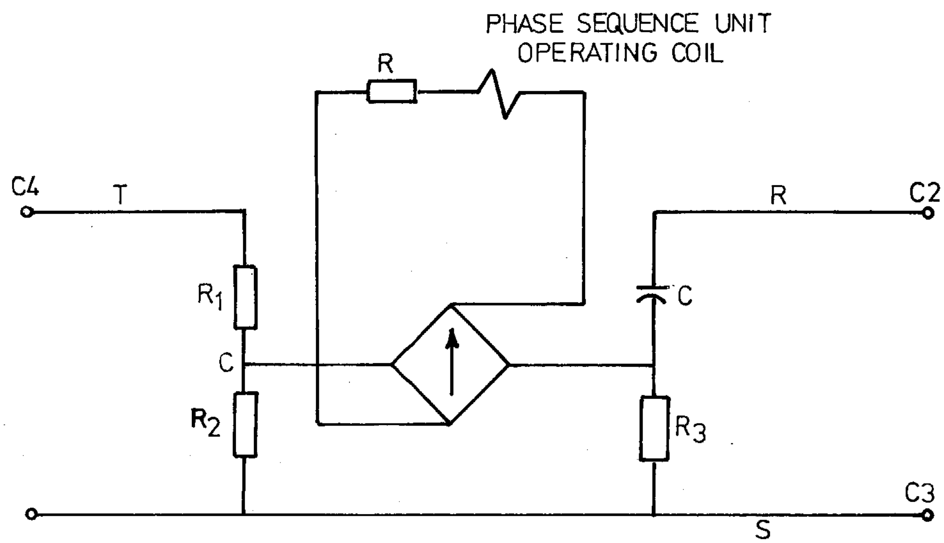


Fig. 3 Phase sequence unit circuit

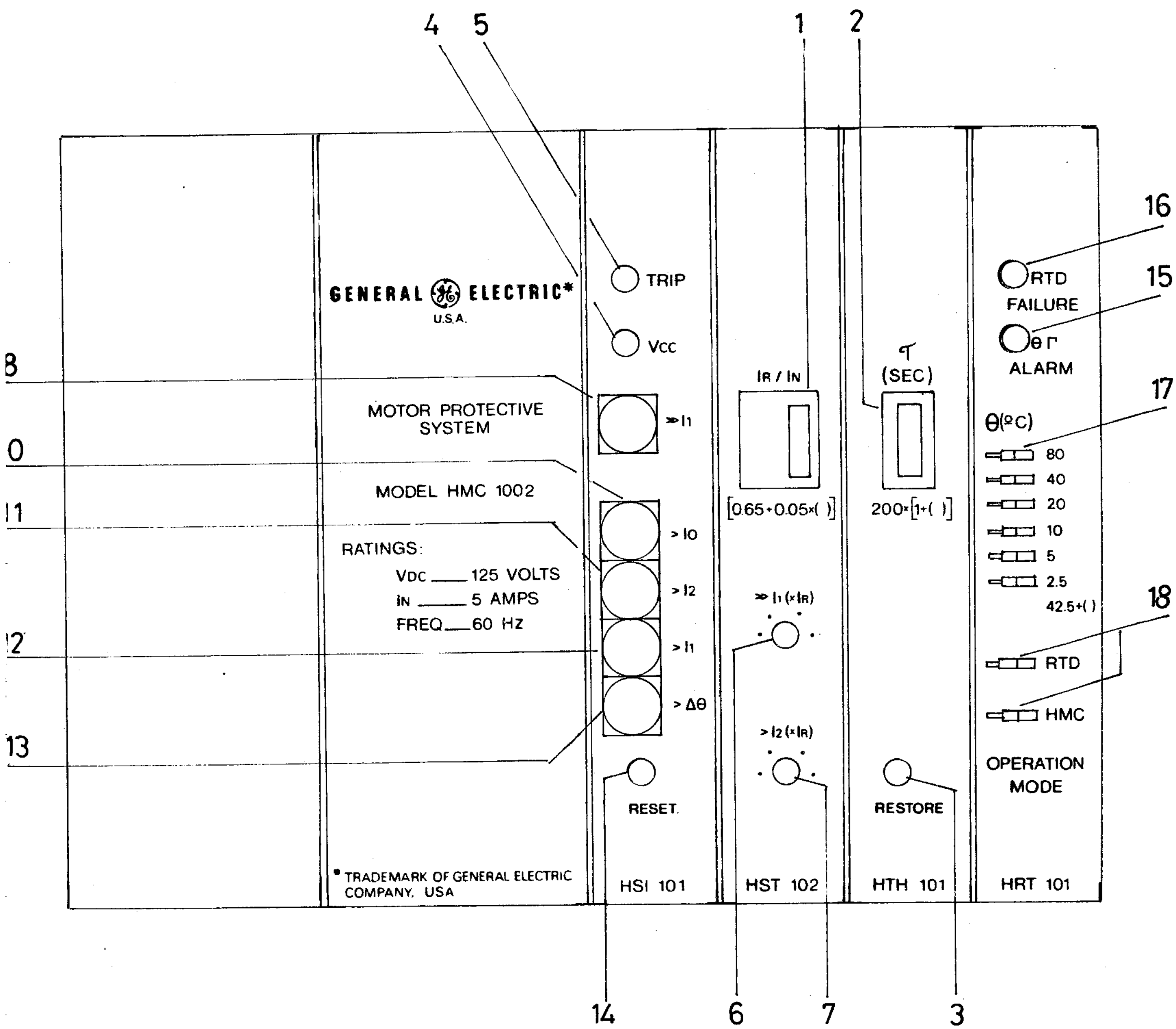


Fig. 4 HMC 1000 front layout. Relays applied to motors controlled by circuit breaker

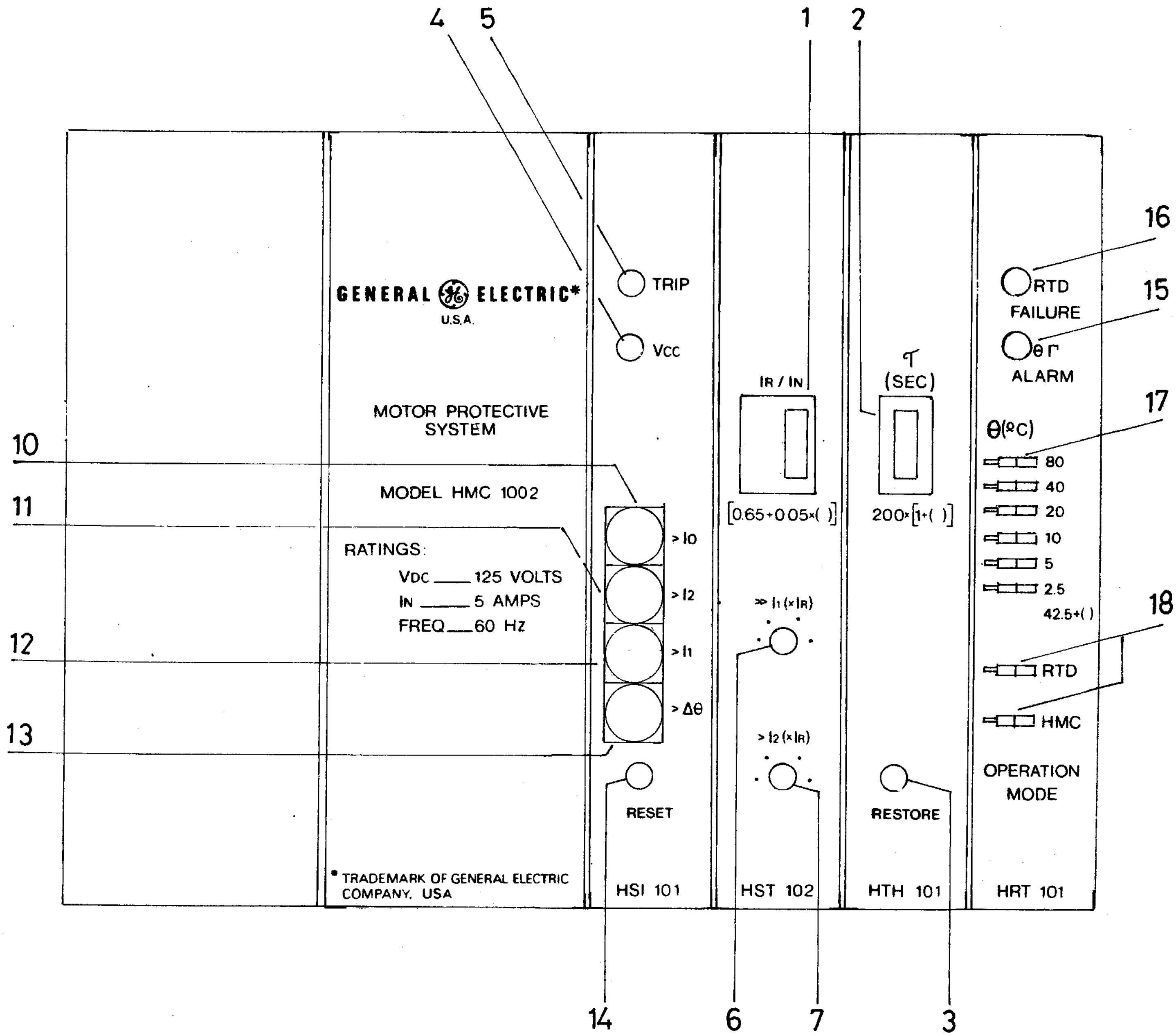


Fig. 5 HMC 1000 front layout. Relays applied to motors controlled by contactor

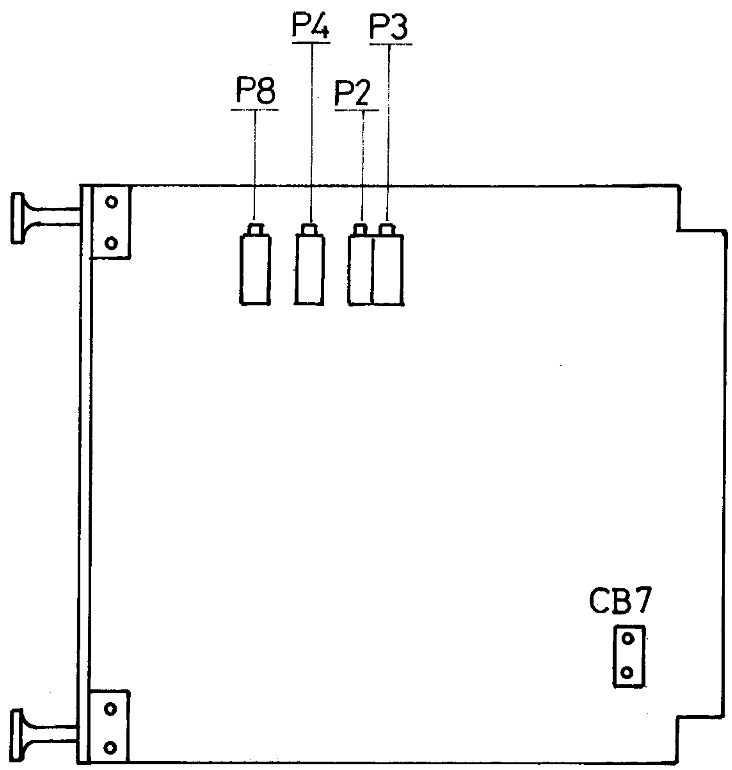


Fig. 6 HST board. Internal adjustments

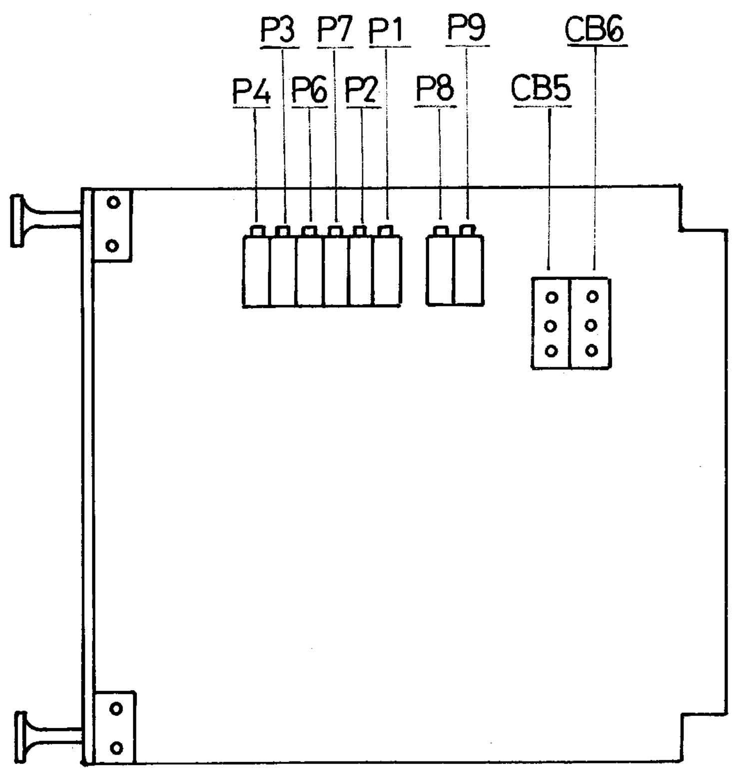


Fig. 7 HTH board. Internal adjustments

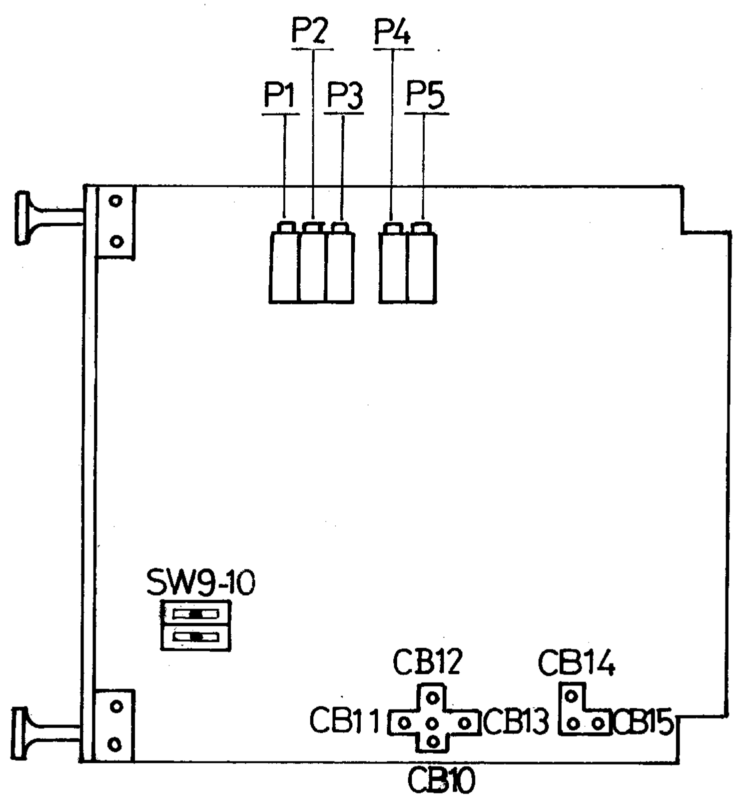


Fig. 8 HRT board. Internal adjustments

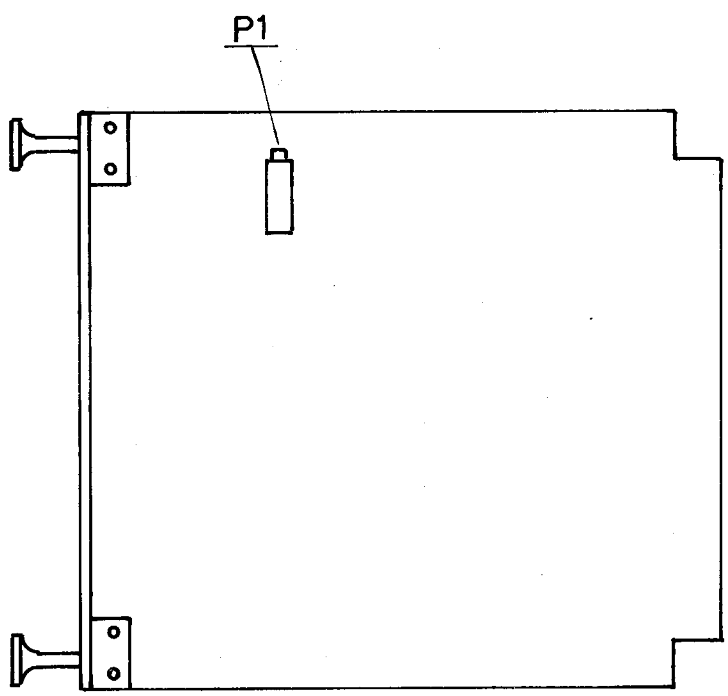


Fig. 9 HSI board. Internal adjustments

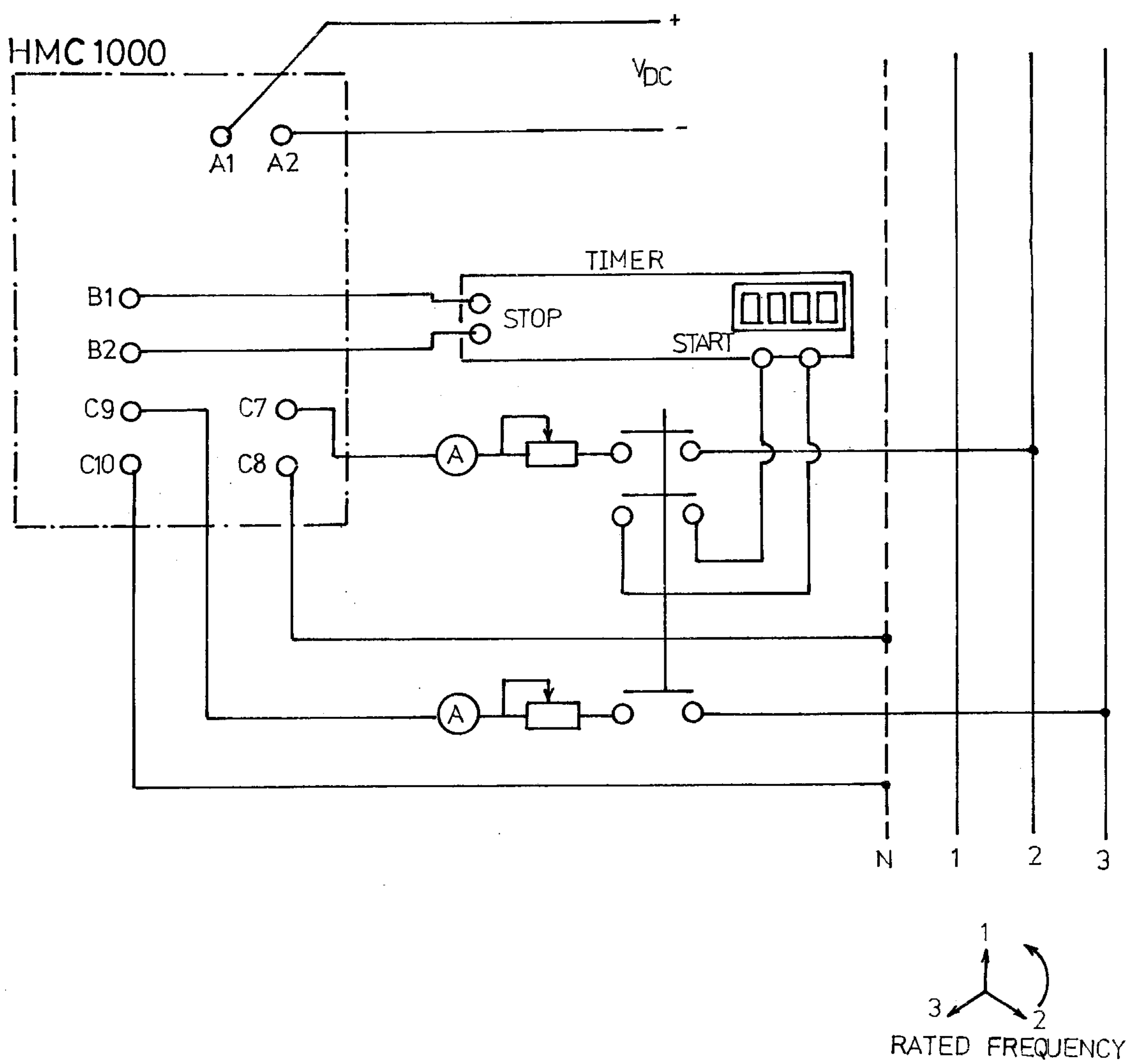


Fig. 10 Test connections for the thermal image unit (HMC MODE) positive sequence unit and locked rotor unit

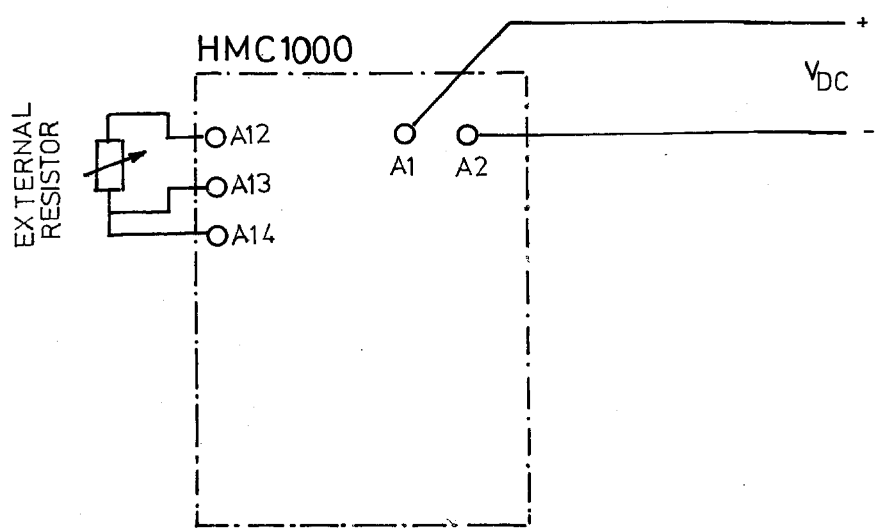


Fig. 11 Test connections for RTD MODE

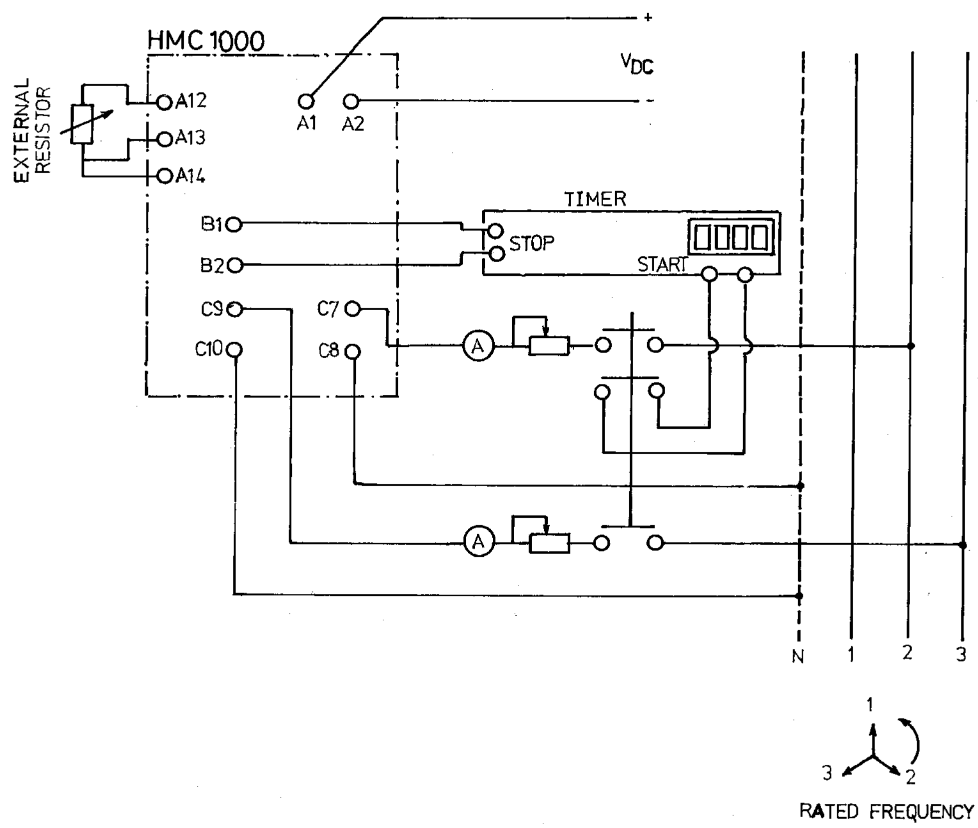


Fig. 12 Test connections for BOTH MODE

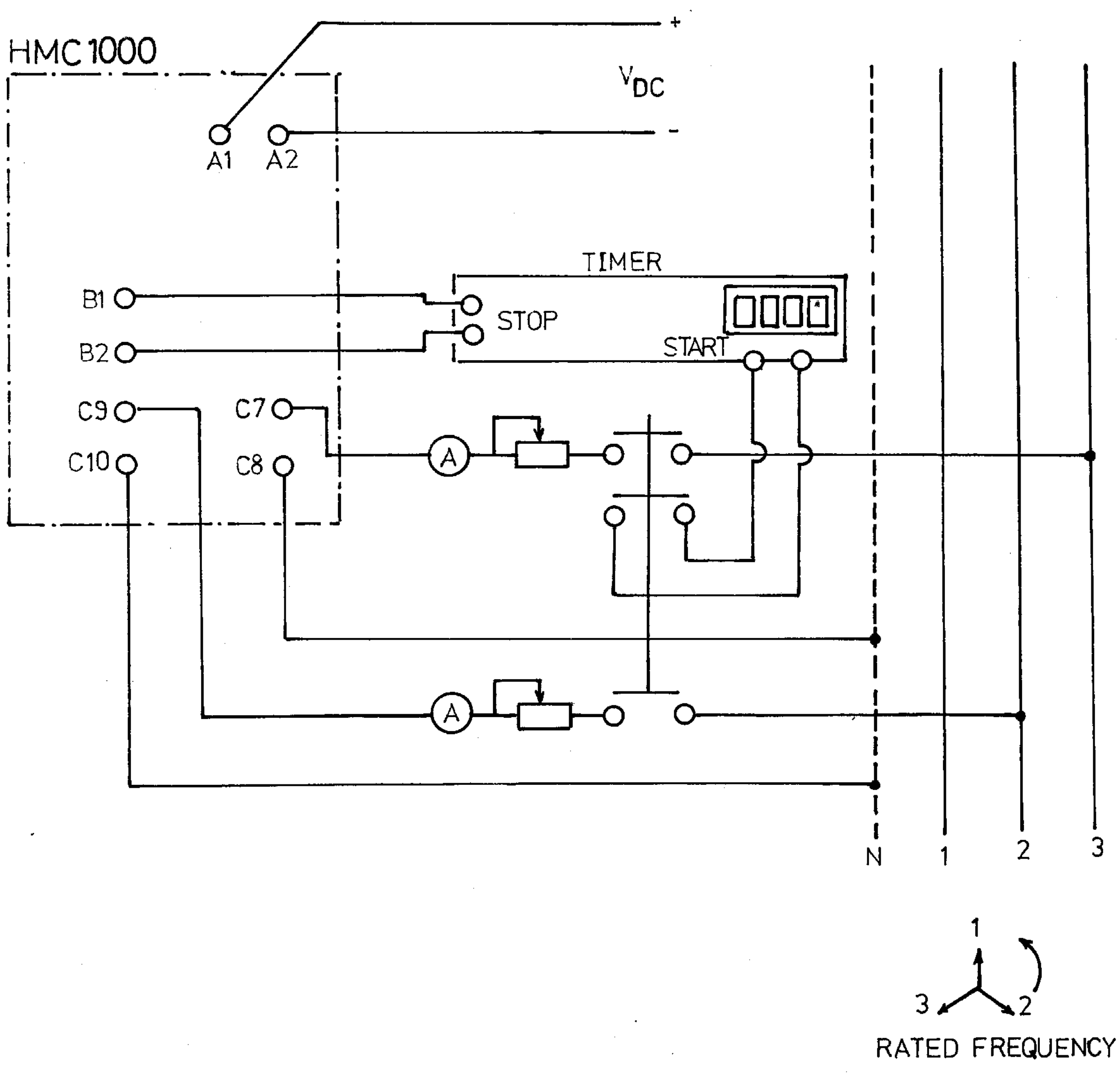


Fig. 13 Test connections for the negative sequence unit

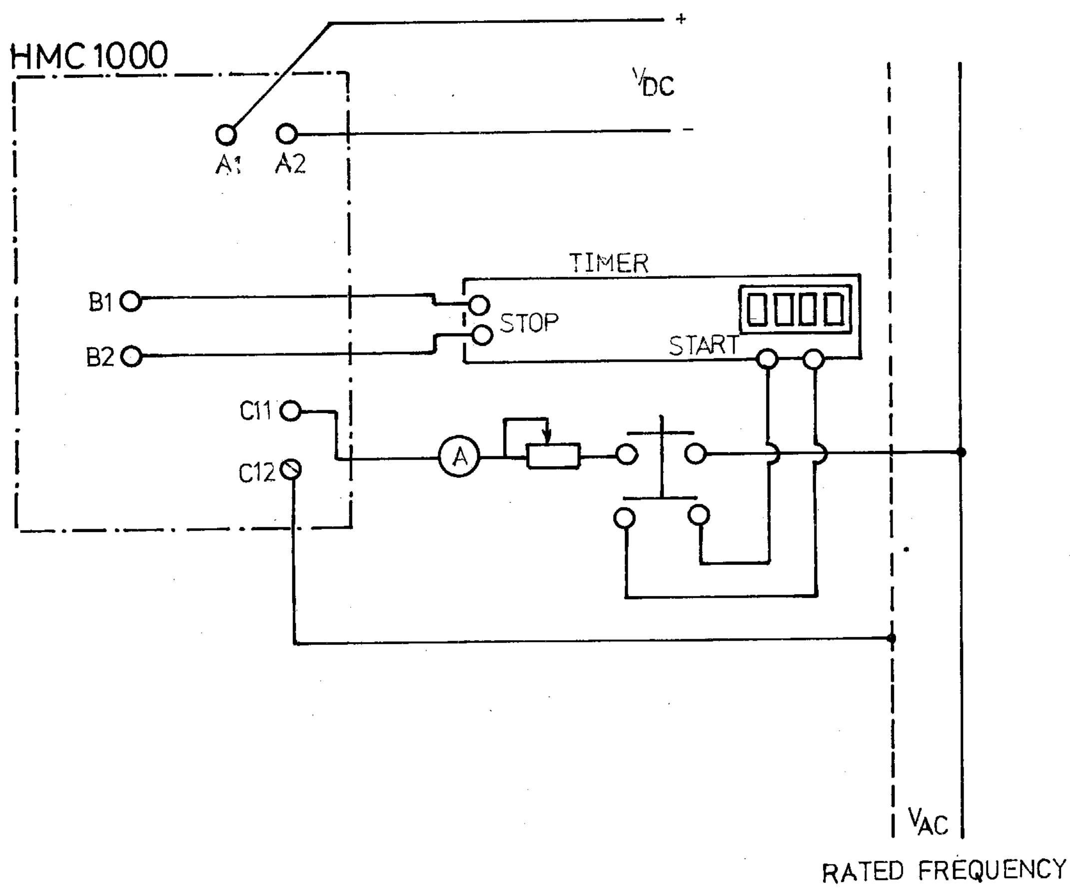


Fig. 14 Test connections for the zero sequence unit

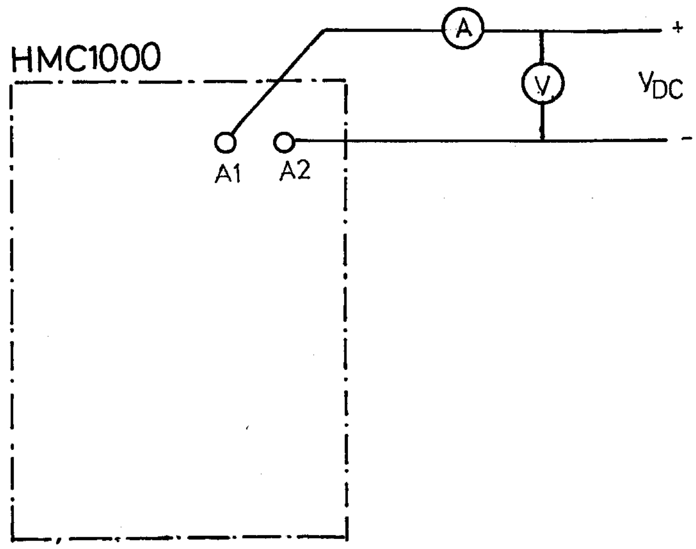


Fig. 15 D.C. burden test

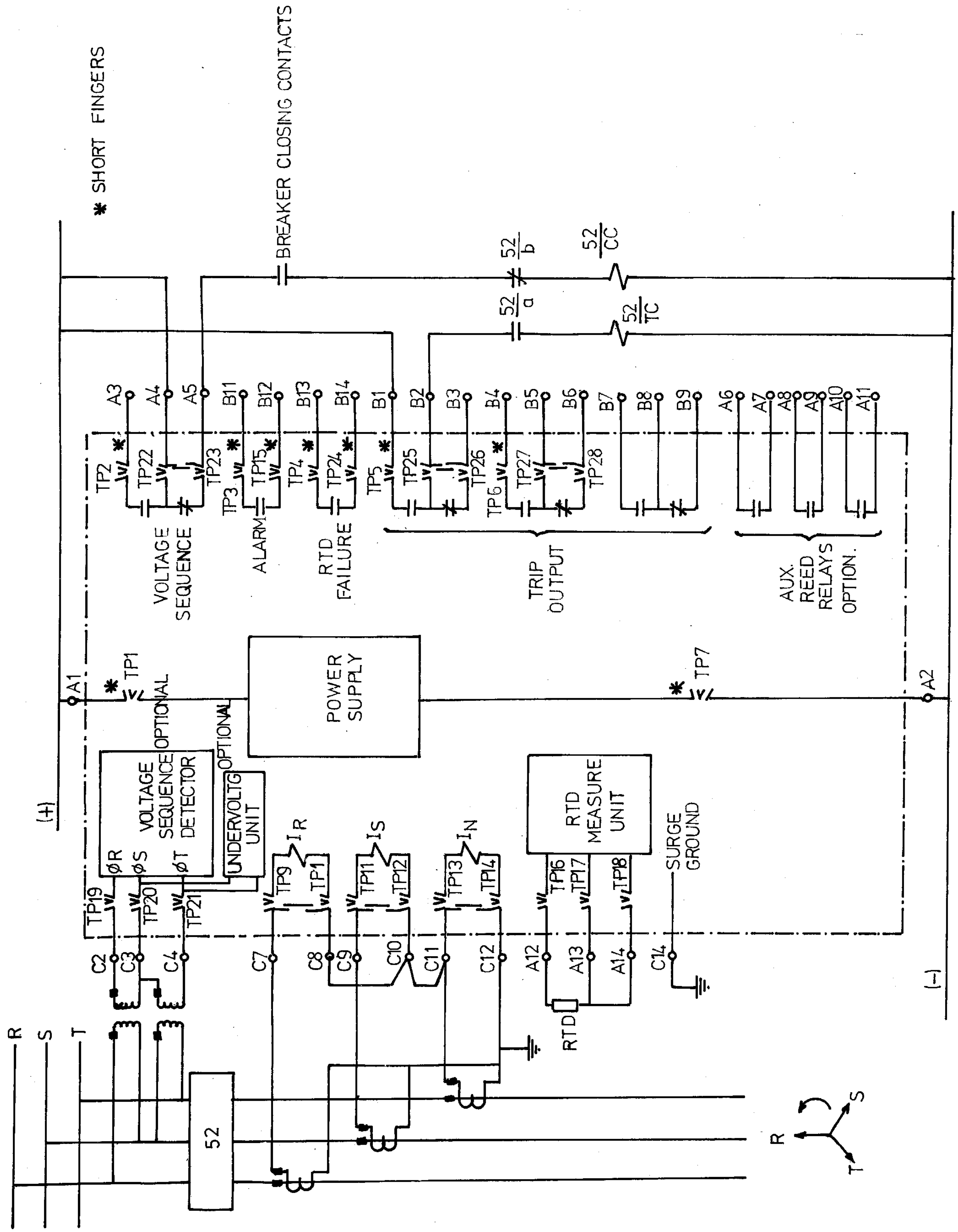


Fig. 16 External connections for the HMC 1000

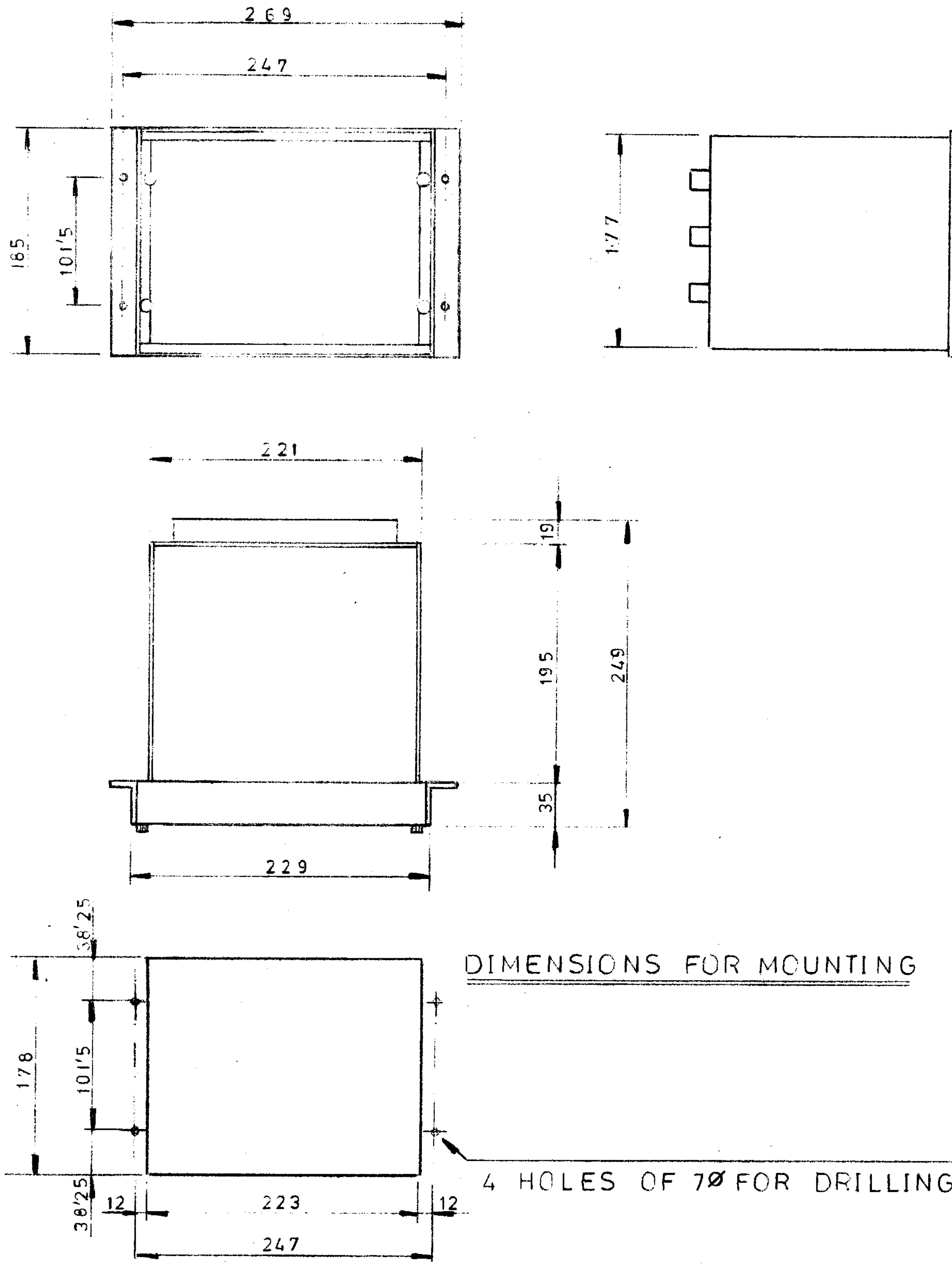


Fig. 17 Outline and panel drilling

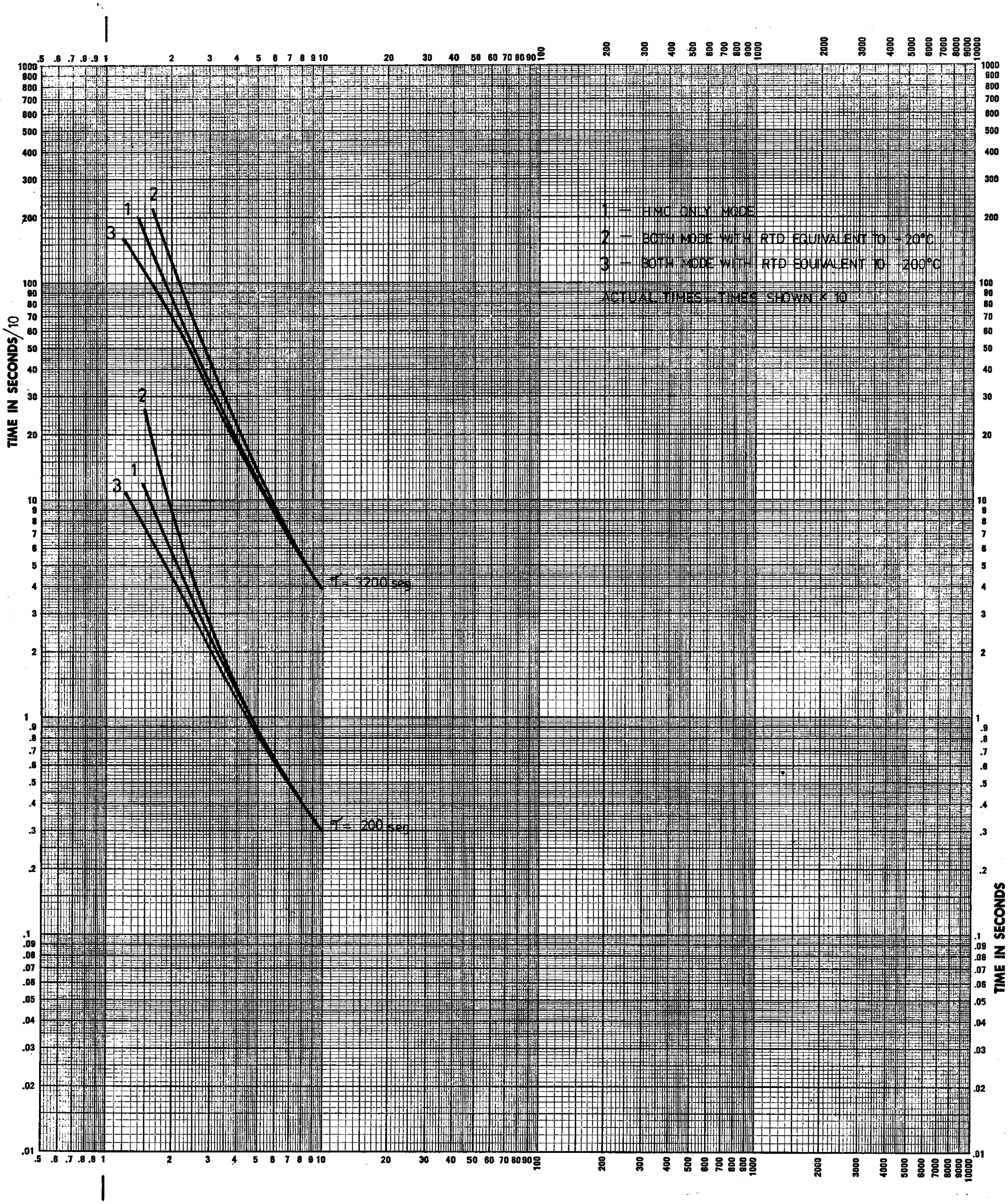


Fig. 18 Operating times for BOTH MODE

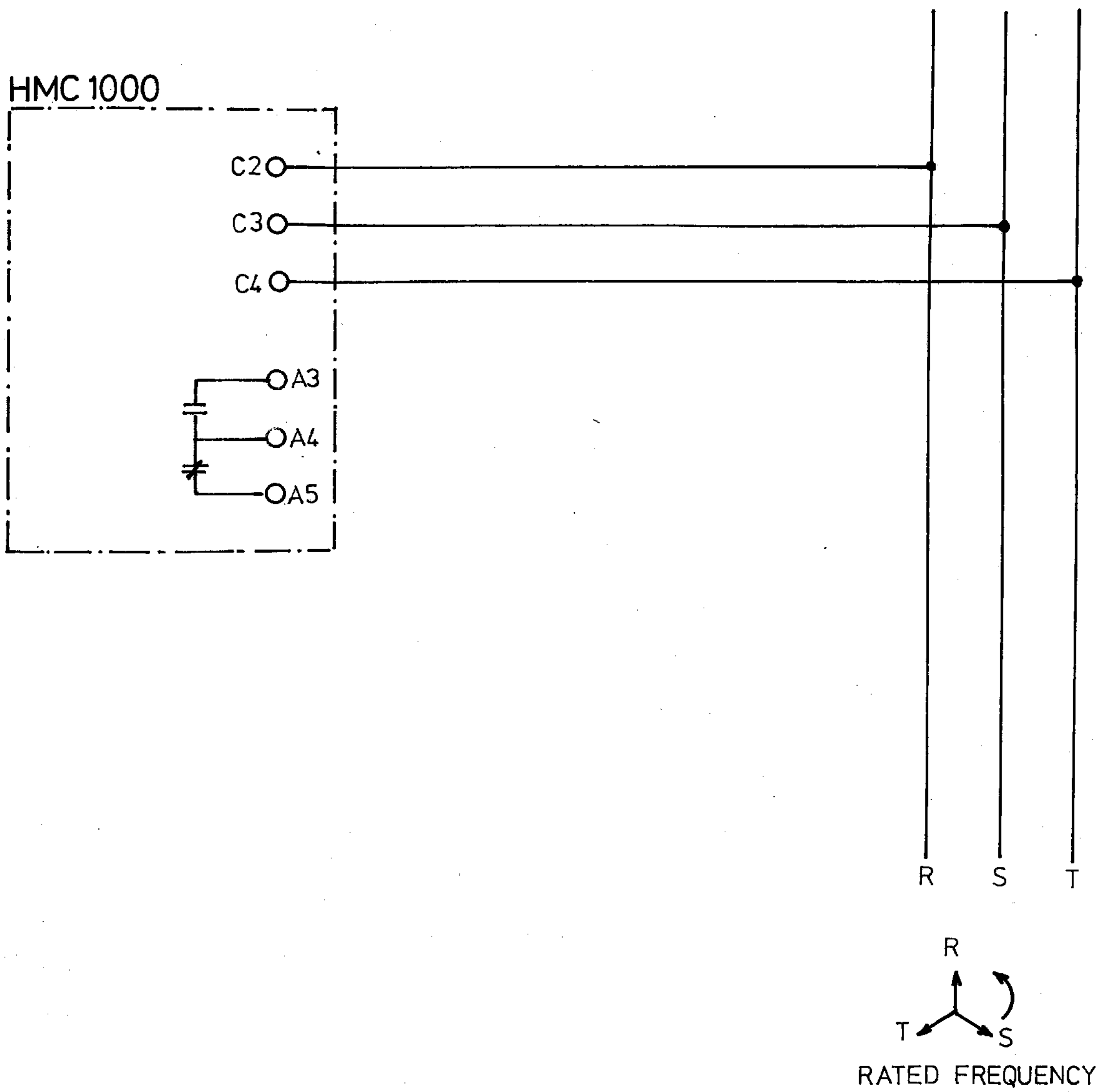


Fig. 19 Test connections for the phase sequence unit

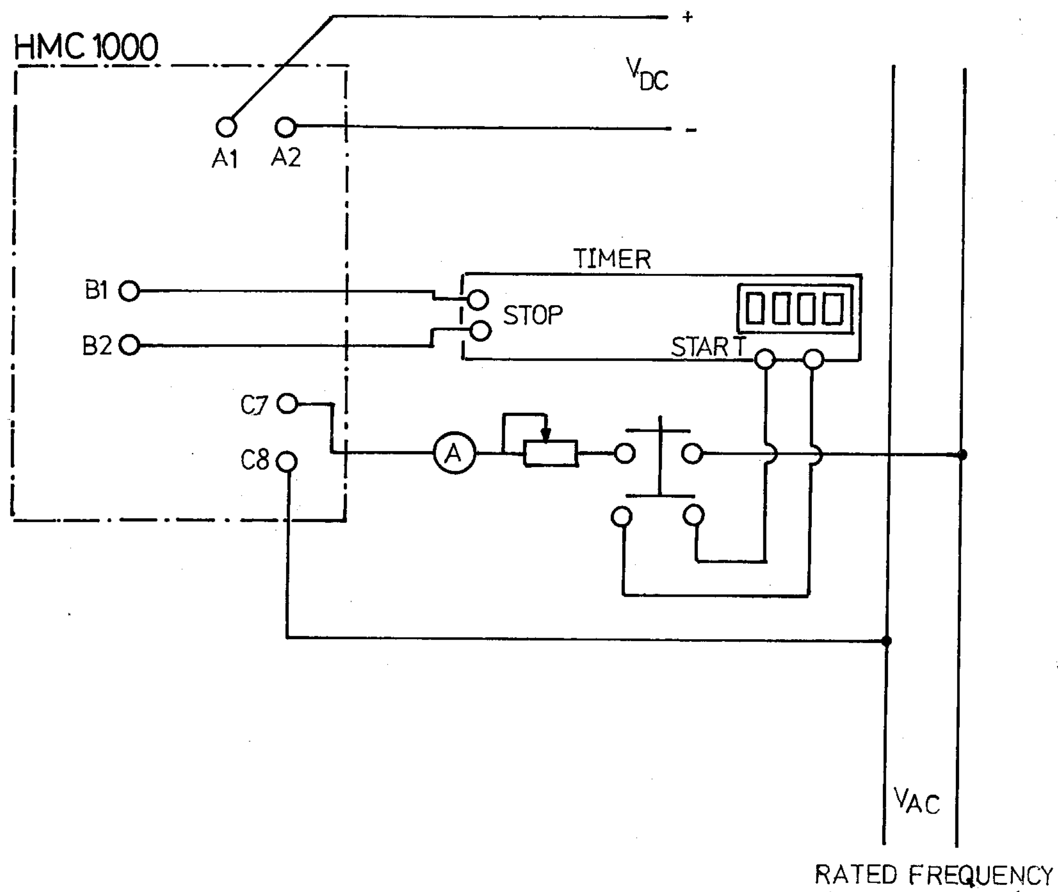


Fig. 20 Test connections for the thermal image unit with single phase source (one circuit)

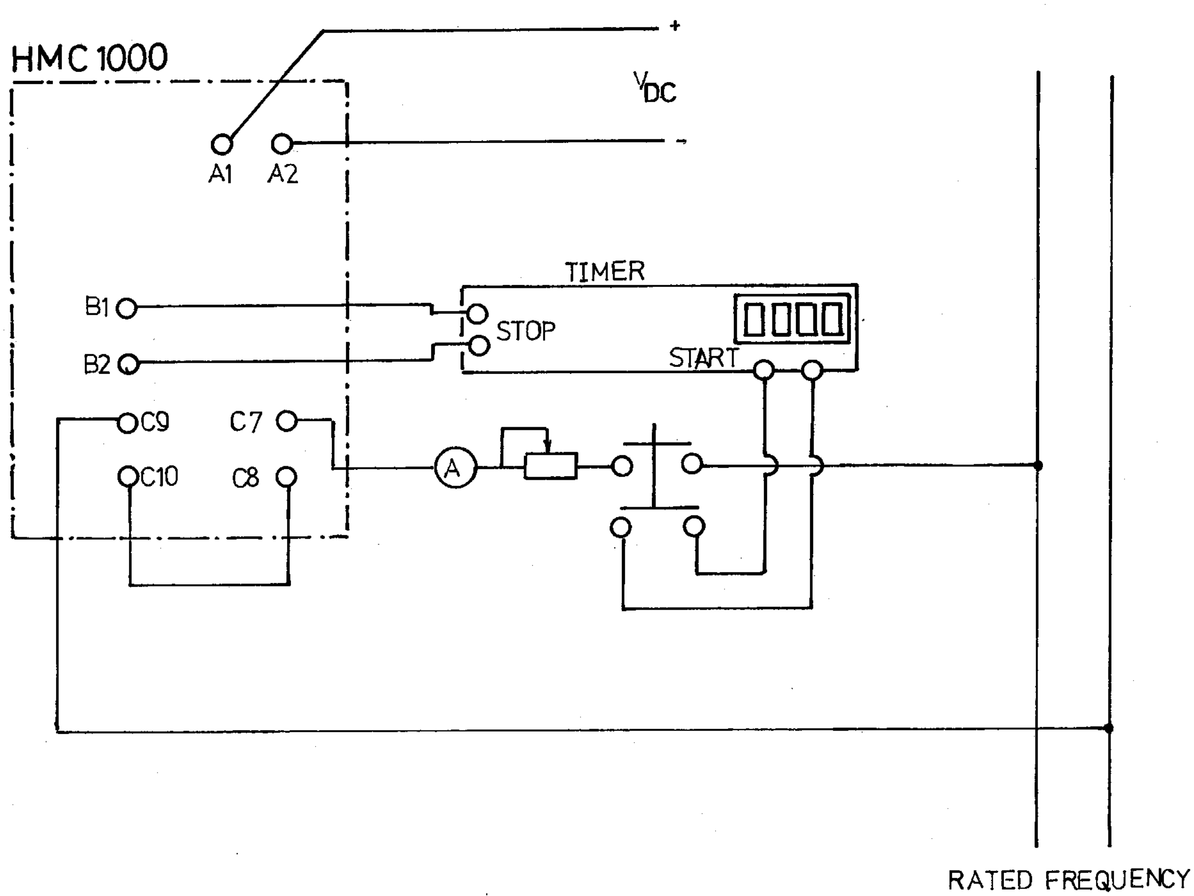


Fig. 21 Test connections for the thermal image unit with single phase source (two circuits)

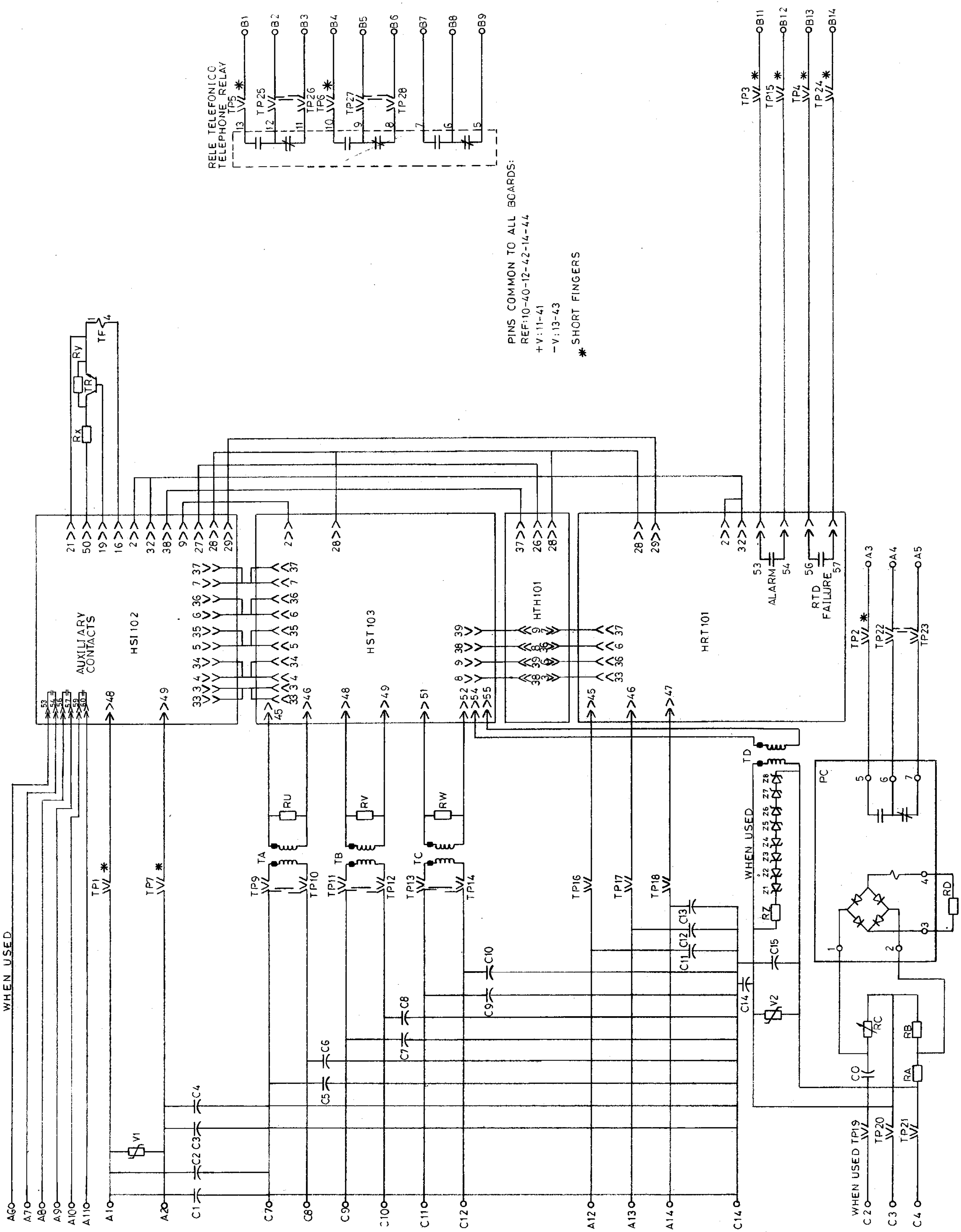


Fig. 22 Internal connection diagram of HMC 1000

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