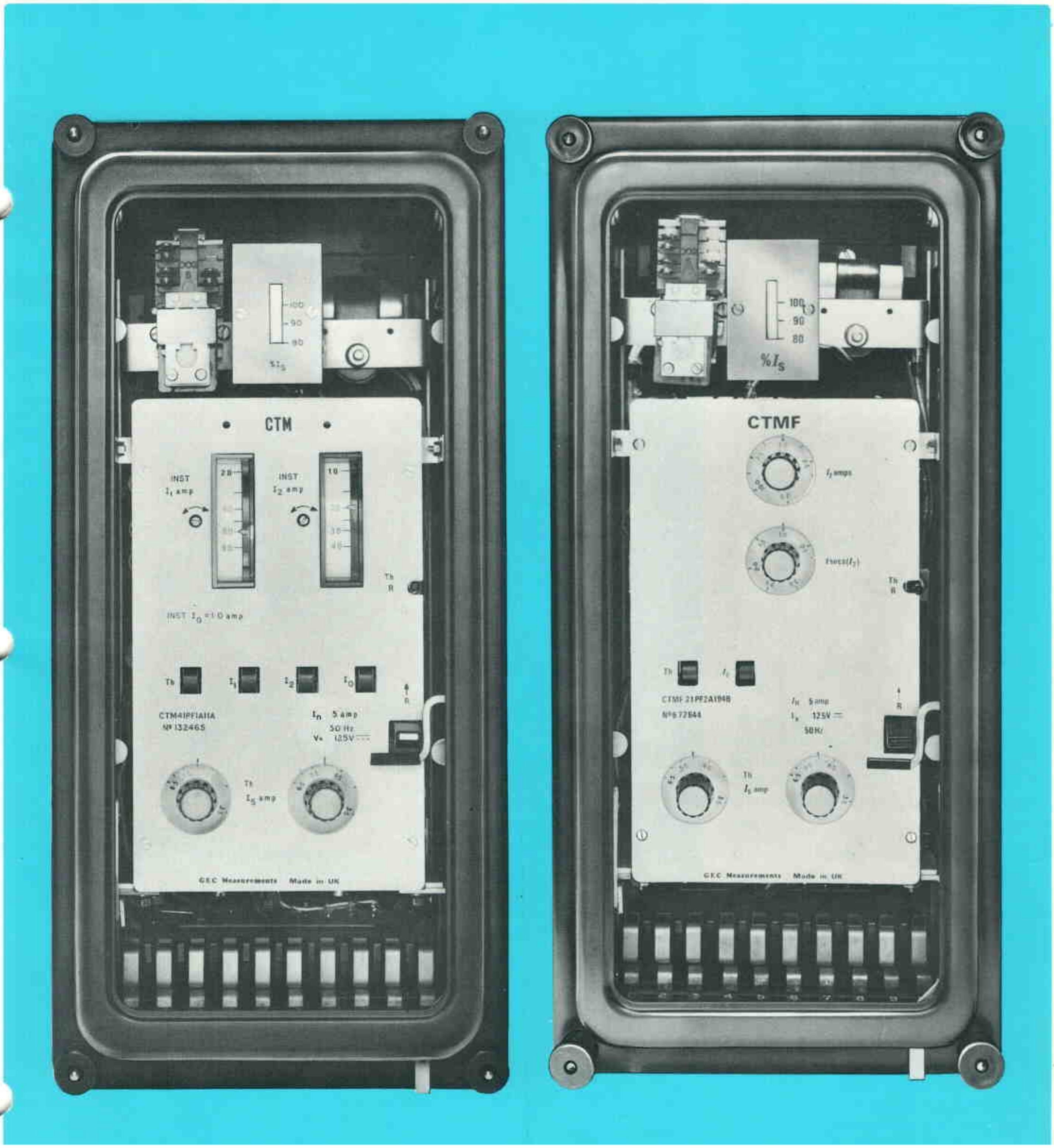
GEC Measurements

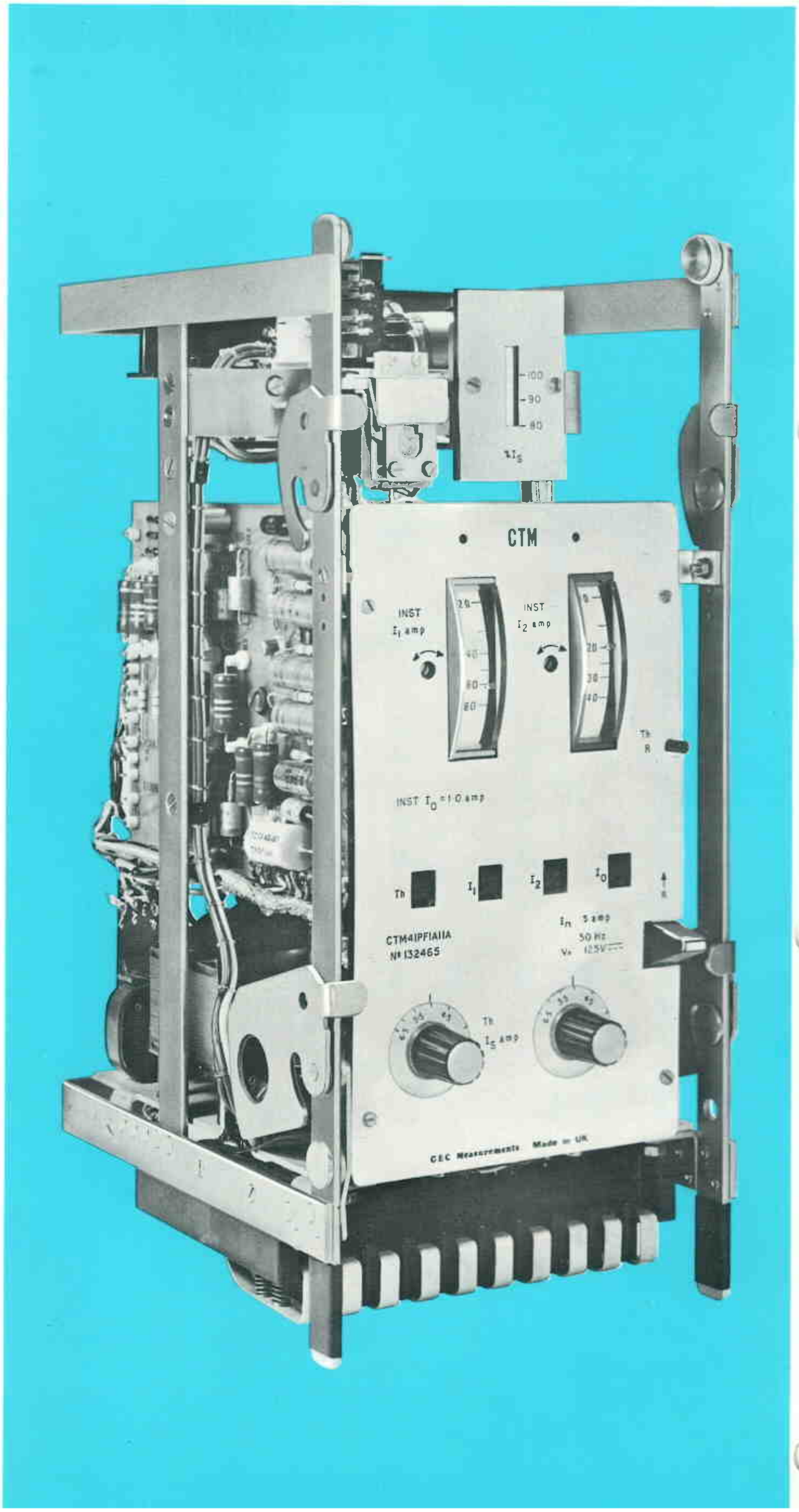
Types CTM & CTMF Motor Protection Relays



Types CTM & CTMF

FEATURES

* Current setting range continuously adjustable
* Greater choice of characteristic curves
* Improved unbalance protection
* Low burden—less than 1VA per phase
* Less than 2% thermal overshoot
* Improved accuracy
* Single phase stalling protection
* Optional running load indicators
* Thermal re-set facility (Th_R) to enable hot re-starting



APPLICATION CONSIDERATIONS		TYPICAL CORRELATION OF RELAY AND MOTOR TYPES					
Protection Provided	Motor Controlled by	Submersible Pump Motors	C.M.R. Motors	Standard Industrial Motors		Special Motors For High Inertia Drives	
i) Thermal (Th)	Circuit Breaker	CTM11	CTM12	CTM13	CTM14	CTM15	CTM16
i) Thermal (Th) ii) Instantaneous earth fault (I_0)	Circuit Breaker	CTM21	CTM22	CTM23	CTM24	CTM25	CTM26
i) Thermal (Th) ii) Time delayed, unbalance & single phasing (I_2)	Fused Contactor	CTMF21	CTMF22	CTMF23	CTMF24	CTMF25	CTMF26
i) Thermal (Th) ii) Instantaneous three phase overcurrent (I_1) iii) Instantaneous unbalance & single phasing (I_2)	Circuit Breaker	CTM31	CTM32	CTM33	CTM34	CTM35	CTM36
i) Thermal (Th) ii) Time delayed, unbalance & single phasing (I_2) iii) Time delayed earth fault (I_0)	Fused Contactor	CTMF31	CTMF32	CTMF33	CTMF34	CTMF35	CTMF36
i) Thermal (Th) ii) Instantaneous three phase overcurrent (I_1) iii) Instantaneous unbalance & single phasing (I_2) iv) Instantaneous earth fault (I_0)	Circuit Breaker	CTM41	CTM42	CTM43	CTM44	CTM45	CTM46
Relay Thermal Operation Characteristic: Curve Number	CTM & CTMF	1	2	3	4	5	6
Relay Thermal Operation Characteristic: Nominal Operation Time (s) at 5 x Setting Current ('Cold' curves)		4	8	16	32	64	128

APPLICATION

The protection usually provided for three phase motors, while generally effective against overloads and short circuit conditions, rarely takes into full account the harmful effects of unbalanced line currents. Even a modest unbalance can cause damage to a motor by overheating and in the extreme instance of a motor stalling due to loss of one phase, severe rotor damage can occur within the normal starting time.

The types CTM & CTMF relays measure the load current and the unbalance current independently, and provide accurate protection against thermal damage under all operating conditions. The thermal characteristic of the relay is designed to follow closely the thermal withstand characteristic of typical motors, this ensures that the relay isolates the motors only when the insulation life is threatened.

protection against motor circuit faults.

A range of type CTM and CTMF relays, manufactured to suit various applications of motors, controlled either by circuit-breakers or fuse contactors are shown in the table above.

One group in the series, designated CTMF, has been designed for motor control centre applications where fuse contactors are used. These relays include a time delayed single phasing element and an earth fault element which, in the event of the fault level being above the rupturing capacity of the contactor, allows the fuse to blow before the contactor operates.

To cater for a wide range of motor characteristics, a range of alternative operating characteristics is provided

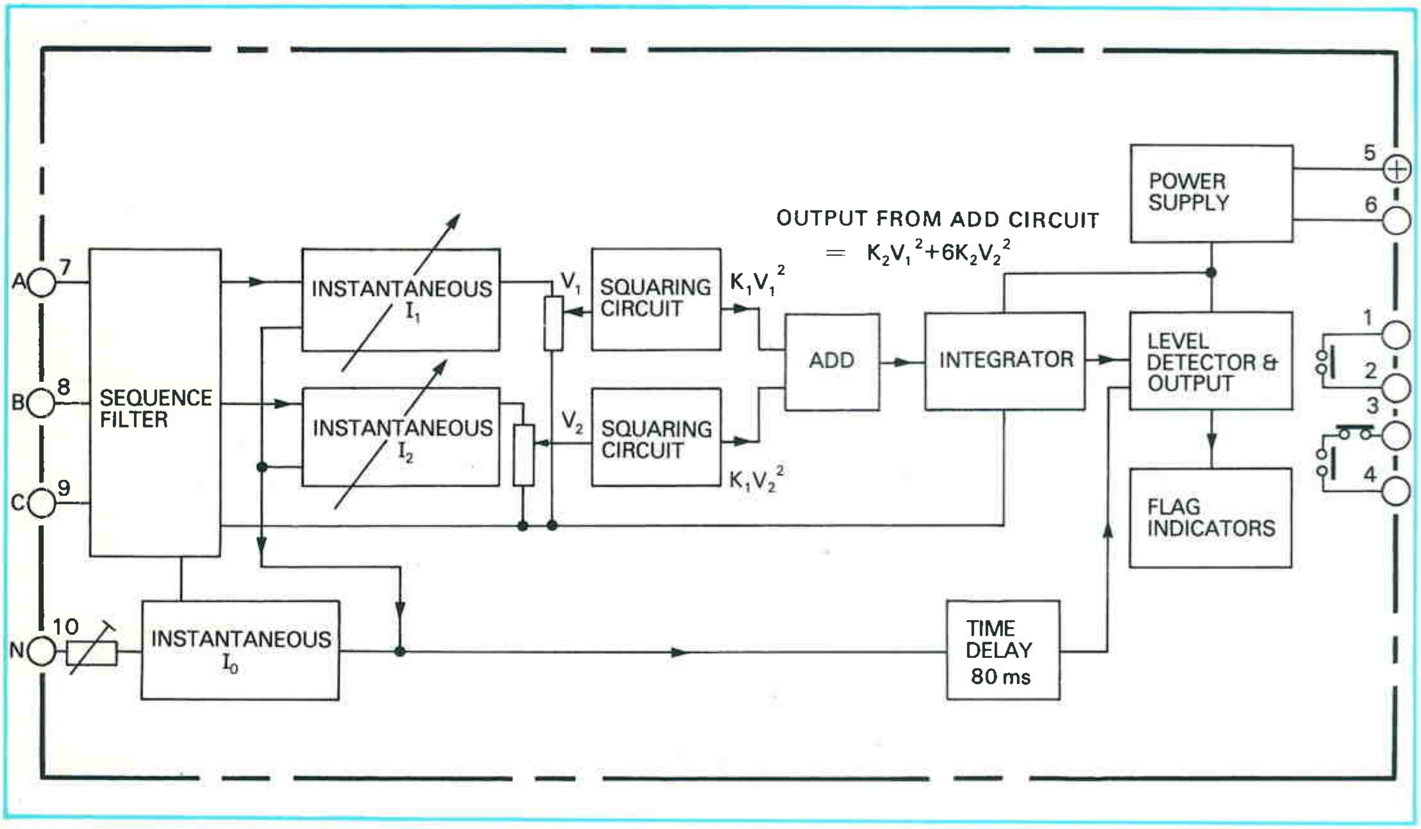
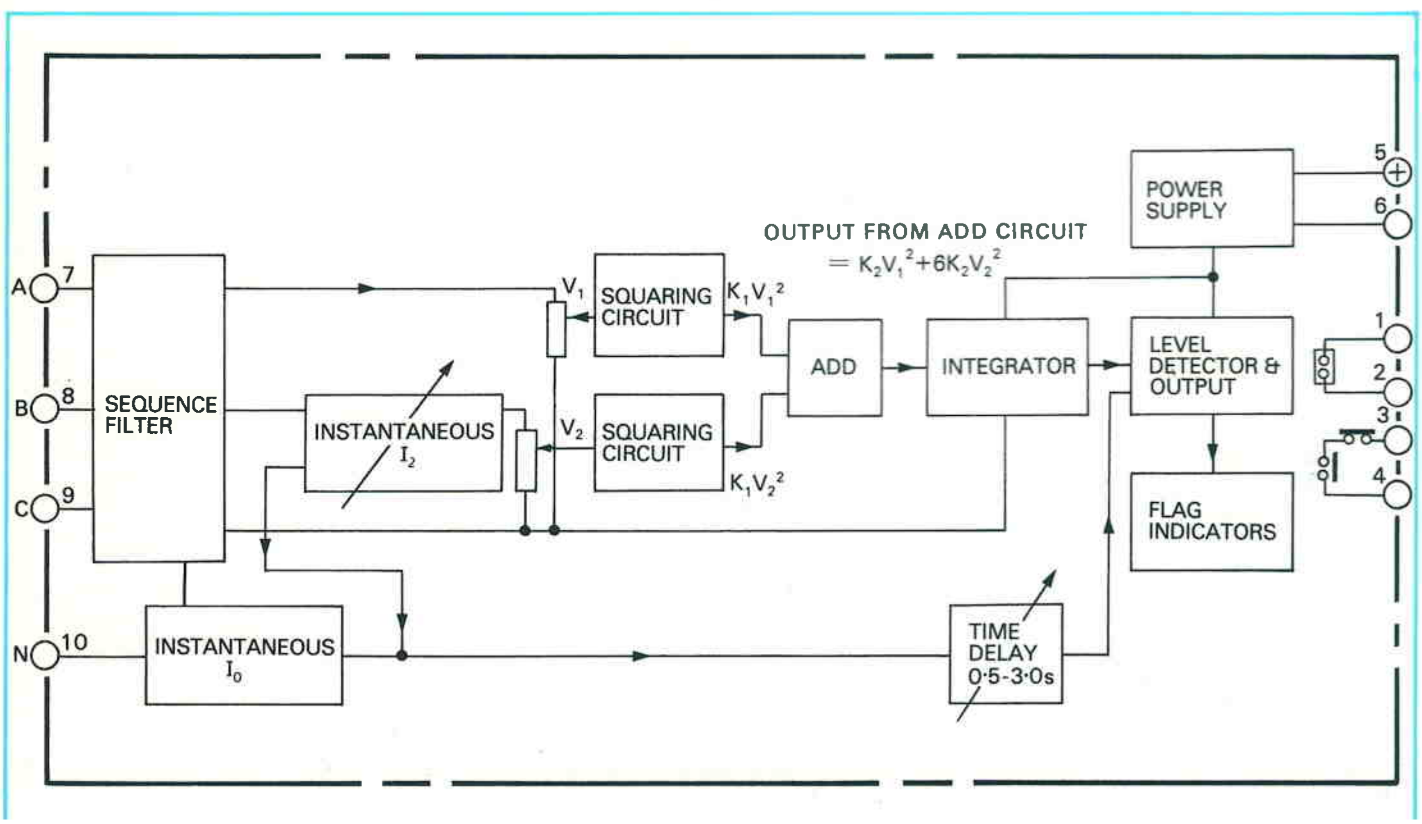


Figure 1 TYPICAL BLOCK SCHEMATIC DIAGRAM OF CTM RELAY
The input connections correspond to those shown in Figure 4



CIRCUIT DESCRIPTION

Figures 1 and 2 show block schematic diagrams of typical CTM and CTMF relays. In both cases, the inputs from the current transformers, which are connected in each phase of the motor supply, are fed to a sequence filter network which separates the positive and negative sequence components of the input current. These quantities are in turn fed to separate setting potentiometers via instantaneous operating elements, I_1 and I_2. The potentiometers provide two output voltages V_1 and V_2 which are proportional to the positive and negative phase sequence components then added to give an input voltage to the integrator, $K_2V_1^2 + 6K_2V_2^2$. A feedback circuit across the integrator causes the output voltage from the integrator circuit to rise exponentially from zero up to a voltage which is equivalent to 105% of the relay setting current and linearly above this setting.

The output voltage from the integrator is fed to a level detector which, when the set voltage is reached, energises an electromagnetic output unit. This operates two pairs of electrically separate contacts which are used to trip the circuit-breaker or fuse contactor controlling the supply to the motor.

Instantaneous elements—CTM relay (see Figure 1)

The three instantaneous elements are for overcurrent (I_1), single phasing and unbalance (I_2) and earth fault (I_0).

The I_1 and I_2 elements are connected in the appropriate outputs of the sequence filter and are continuously adjustable over their setting ranges. The I_0 element has a fixed setting and is included in the neutral connection of the C.T. secondary circuits together with a continuously adjustable stabilising resistor. This ensures stability when, under motor starting conditions, unequal saturation of the current transformers might otherwise cause operation of the relay.

The output of each element is fed into a common electromagnetic output unit via a nominal time delay of 80 milliseconds which prevents operation due to the initial starting transient.

Time delayed elements—CTMF relay (see Figure 2)

In this relay there are two such elements, single phasing and unbalance (I_2) and earth fault (I_0). Both are connected in a similar manner to the instantaneous elements of the CTM types. Their outputs are fed via an adjustable definite time delay element (0.5 to 3.0 seconds) to the electromagnetic output unit. This ensures that any high fault currents are cleared by the fuse and not the contactor. A positive sequence element (I_1) is not necessary in this application because of the protection provided by the fuses.

OPERATION

Balanced conditions

Under normal conditions the motor draws balanced load currents from the supply and the filter delivers only positive sequence voltage to the relay. If the motor current exceeds the relay setting, tripping will occur as shown in the thermal operation characteristics.

Unbalanced conditions

An unbalance in the supply voltage results in negative sequence currents flowing in the motor stator windings. The degree of unbalance will depend upon the level of the negative sequence component in the supply voltage and the negative sequence impedance of the machine. This latter value is much less than the positive sequence impedance and hence the ratio of negative/positive sequence current is much greater than the ratio of the negative/positive sequence voltage.

The negative sequence stator current will induce a corresponding negative sequence current in the rotor circuit, the effective frequency of which will be approximately twice normal frequency; thus for a 50 Hz supply the effective frequency will be 100 Hz.

The ratio of the rotor a.c. resistance at double the system frequency, to the d.c. resistance, which applies under normal running conditions, is in the range 3 to 6 for the majority of machines. Thus one unit of negative sequence current will have a greater heating effect than one unit of positive sequence current. This unequal heating effect should be taken into account in the design of a relay which protects against unbalanced conditions, so that the motor will not be tripped unnecessarily. The equivalent current for operation of this range of relays is in accordance with the following expression:

$$I_{eq} = \sqrt{I_1^2 + 6I_2^2}$$

where I_{eq} = Equivalent operating current

I_1 = Positive sequence component of the supply current

I_2 = Negative sequence component of the supply current

The I_2 multiplying factor of 6 has been carefully chosen to provide adequate protection to both the

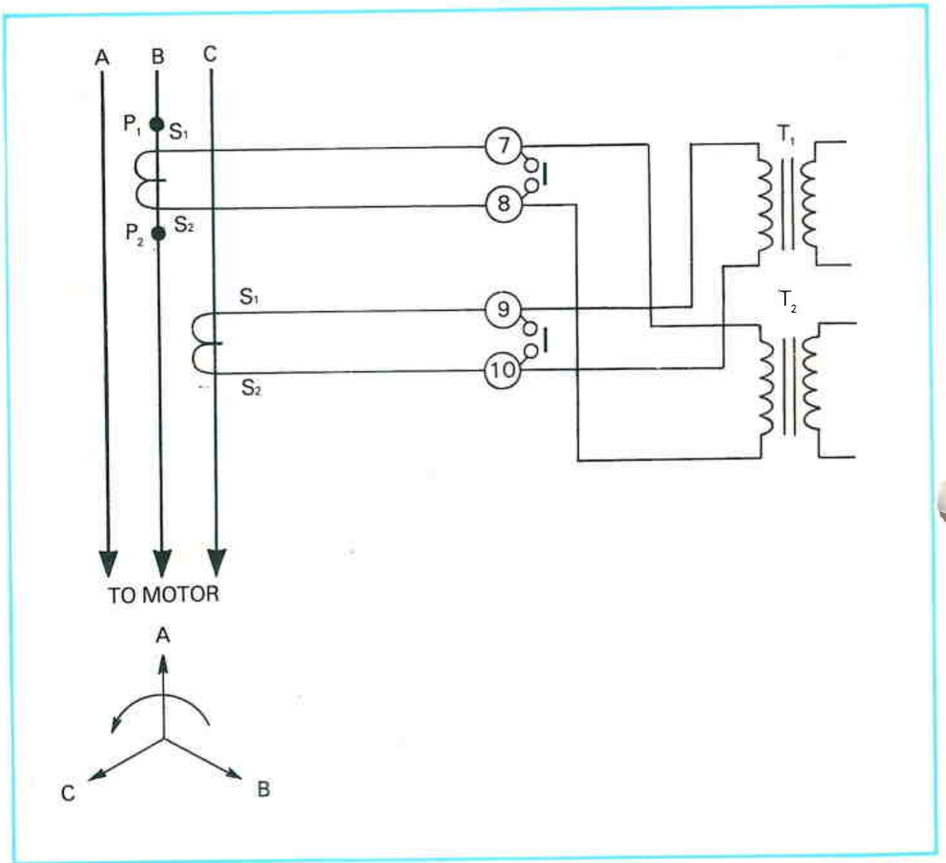


Figure 3 EXTERNAL CONNECTIONS CTM11 TO 16, CTM31 TO 36 AND CTMF21 TO 26

STALLING PROTECTION

Three phase stall

For normal machines started direct-on-line the starting current is virtually constant and equal to the locked rotor current throughout the starting period. One of the features of this relay is the very small thermal overshoot—less than 2%. This means that the relay operating time can be set very close to the motor starting time. Providing the allowable stall

be selected to prevent damage to the machine when stalled.

In the case of motors driving high inertia loads, the allowable stall time may be less than the starting time. In this event, protection against stalling can only be provided by means of a shaft speed monitoring relay in conjunction with a relay measuring motor current.

Single phase stall

The most likely cause of stalling in induction motors is the loss of one phase of the supply, due for example, to the blowing of a back-up fuse by the inrush current when the motor is first energised. In this situation, the motor would be connected to a single phase supply with the motor in a stationary condition. This could result in excessive damage to sections of the rotor winding unless the motor is disconnected quickly, although the stator current, under this condition is only 0.866 of the normal starting current. A relay measuring stator current to detect this condition would therefore have to have a time delay longer than the instantaneous element which is arranged to operate from the negative sequence component of the stator current. This will not operate under normal starting conditions and can therefore be arranged to trip the motor instantaneously in the event of a single phase stall condition. In the CTMF relay, this element is time delayed as described previously.

OPERATING CURRENT

Current settings are adjusted by two potentiometers on the relay front plate. The setting ranges enable the standard 1A and 5A relays to cover a wide range of motor ratings.

The thermal element begins to operate when the motor current rises to 1.05 times the relay current setting. This may be due to a load increase, or to a combination of normal load current and negative phase sequence current due to unbalanced supply voltages. If this increased current is due entirely to negative phase sequence current, the relay will begin to operate when the negative sequence current is 13.1% of the relay setting current.

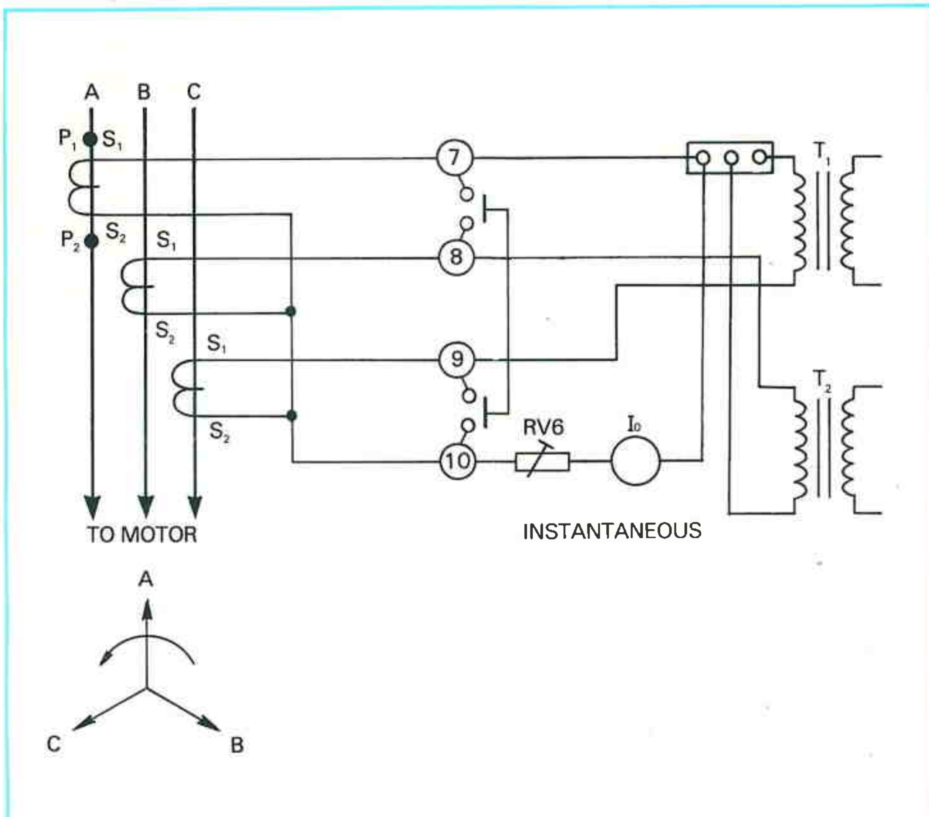
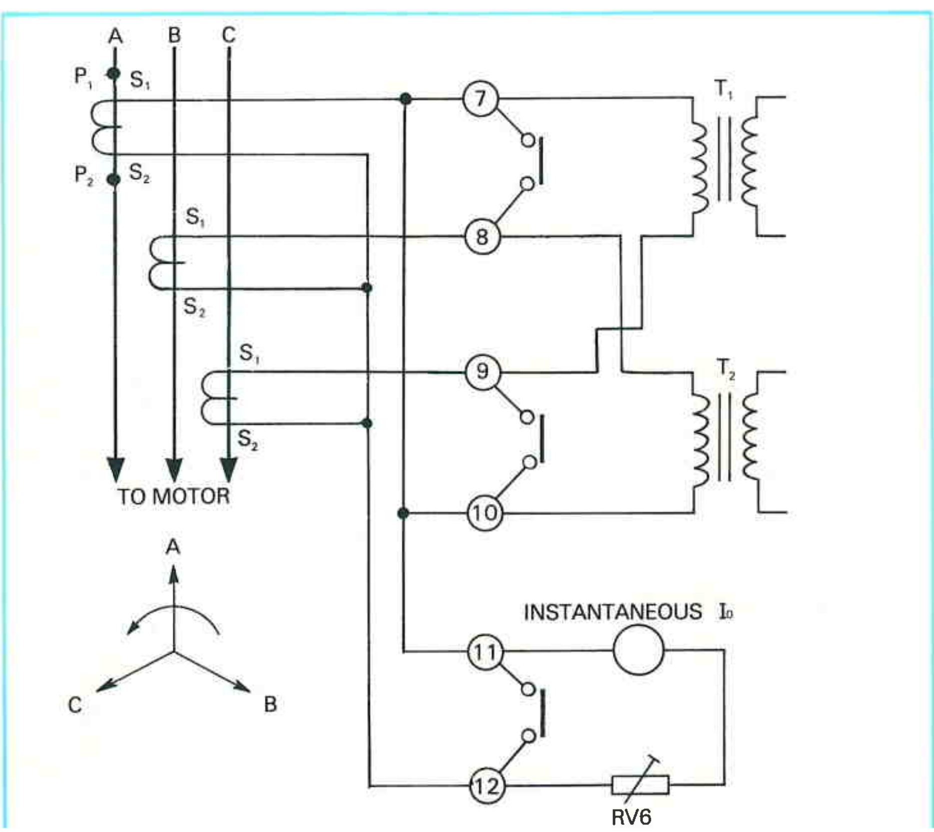


Figure 4 EXTERNAL CONNECTIONS CTM21 TO 26, CTM41 TO 46 AND CTMF31 TO 36 with internal star connection



TECHNICAL DATA

Current ratings (I_n)

Suitable for operation from C.T.'s with secondary current ratings of 1A or 5A.

Frequency rating

Separate designs are available for nominal frequencies of 50 Hz and 60 Hz.

Current settings

Settings are expressed as percentages of the relay rated current.

Thermal element (Th)
70%—130% continuously adjustable.
Instantaneous overcurrent element (I_1)

400%—1600% continuously adjustable.

Instantaneous unbalance element, CTM relay (I_2)
200%—800% continuously adjustable.

Delayed unbalance element, CTMF relay (I_2)
50%—250% continuously adjustable.

Instantaneous earth fault element (I_0)
20% fixed. Other fixed settings are available. This element incorporates an adjustable stabilising resistor.
0—27 ohms for 5A
0—240 ohms for 1A

Operating times

CTM
Instantaneous elements I_1, I_2 and I_0
All nominally less than 80 ms at 5 x respective setting current.
CTMF
Elements I_2 and I_0
Common time delay continuously variable from 0·5 secs. to 3·0 secs.

Disengaging and resetting times—thermal elements

Curve reference no.	Disengaging time (seconds)	Time to reset to the cold curve (minutes)
1	40	10
2	42	13
3	50	20
4	66	33
5	120	63
6	400	120

The times quoted above may vary slightly from relay to relay and should therefore be treated as a guide only. With all versions, it is possible to reset the thermal units instantaneously by means of a push button (Th_R). This feature is provided essentially to facilitate testing. The push button can only be operated when the relay cover is removed, this

Pick-up current

The thermal element begins to operate at 1.05 times the nominal setting current.

Accuracy

Current Settings:
Thermal element. Th.
± 3% of the nominal pick-up current.

Instantaneous elements I_1, I_2 and I_0 (CTM relays) ± 10% of nominal setting.

Time Settings:
Time delayed elements I_2 and I_0 (CTMF relays) ± 10% of nominal setting.

Operating Time:
Thermal element. Th.
± 10% of nominal operation time at 5 x the equivalent current setting for both hot and cold curves.

Frequency variation:

The thermal operating times vary less than 10% over the following frequency ranges:

Nominal Frequency 50 Hz:
47 Hz to 51 Hz.
Nominal Frequency 60 Hz:
57 Hz to 61 Hz.

Temperature limits

Ambient −5°C to +40°C. Variation of thermal element operating time is within ± 10%. The relay will operate satisfactorily over the ambient temperature range of −20°C to +50°C.

Thermal overshoot

The thermal overshoot for all relays is less than 2%.

Current transformer requirements

Relay and C.T. Sec'dary Rating (A)	Nominal Output (VA)	Accuracy Class	Accuracy Limit Current (x rated current)	Limiting Lead Resistance (ohms)
5	10	5P	10	0·31
1	7·5	5P	10	3·0

These requirements comply with BS3938—1973.
Class 5P corresponds to the maximum composite transformation errors of ± 1% at rated current (I_n) and ± 5% at the accuracy limit.
The accuracy limit is a value of current expressed as a multiple of rated current.

Note: The limiting resistance is given leads when the relay includes an earth fault element (I_o).

Auxiliary supplies

Separate designs are available for operation from any one of the following rated voltages. Relays suitable for other rated voltages are available upon request.

D.C.: 110V, 125V, 220V
operating range 80% to 115% of rated voltage.

A.C.: 110V, 240V
operating range 80% to 115% of rated voltage.

Note: Auxiliary supplies above 125V require an external resistor.

Contacts

Two pairs of electrically separate contacts are provided on the standard relay. These may be either hand reset or self reset.
All contacts of the electromechanical output element are rated to make and carry 7500 VA for 3 seconds with maxima of 30A or 660V a.c. or d.c.

Impulse withstand level

The relay will withstand impulses of 5 kV peak and 1/50 microsecond wave form applied both transversely and between relay terminals and earth, in accordance with BEAMA document No. 219 and IEC draft recommendation.

High frequency disturbance

The relay meets the draft IEC test recommendation for the High Frequency Disturbance test.
The relay accuracy is unaffected by repetitive 1 MHz bursts having an initial peak of 1.0 kV superimposed across input circuits, and 2.5 kV between independent circuits, and circuits to earth, with a decay time of 3 to 6 microseconds and with the relay energised.

Insulation

The relay will withstand:
2 kV, 50 Hz for 1 minute between all circuits and the case, and also between all separate circuits.
1 kV, 50 Hz for 1 minute between normally open contacts.

Operation indicators

A miniature rotary operation indicator is provided as standard for each of the four tripping elements.

(i) Thermal (Th)
(ii) Instantaneous (I_1)

Calibrated from 80% to 100% of the thermal element current setting, the load indicator can be provided to give continuous monitoring of the motor load condition.

Overload ratings

The relay will withstand:

(i) The relay setting current continuously.
(ii) 20 times the relay rated current for 9 seconds.
(iii) 100 times the relay rated current for 0·5 seconds.

Selection of optimum current setting

The calculation of the optimum setting for the thermal unit simply requires knowledge of:

Motor full load current (A) : I
C.T. ratio (A) : I_P/I_R
Required minimum operation (equivalent) current (% full load) : I_{eq}

The values usually recommended for I_{eq} are:

for CMR motors : 100% full load
for totally enclosed motors : 110% full load
for open type motors : 125% full load

Optimum current setting

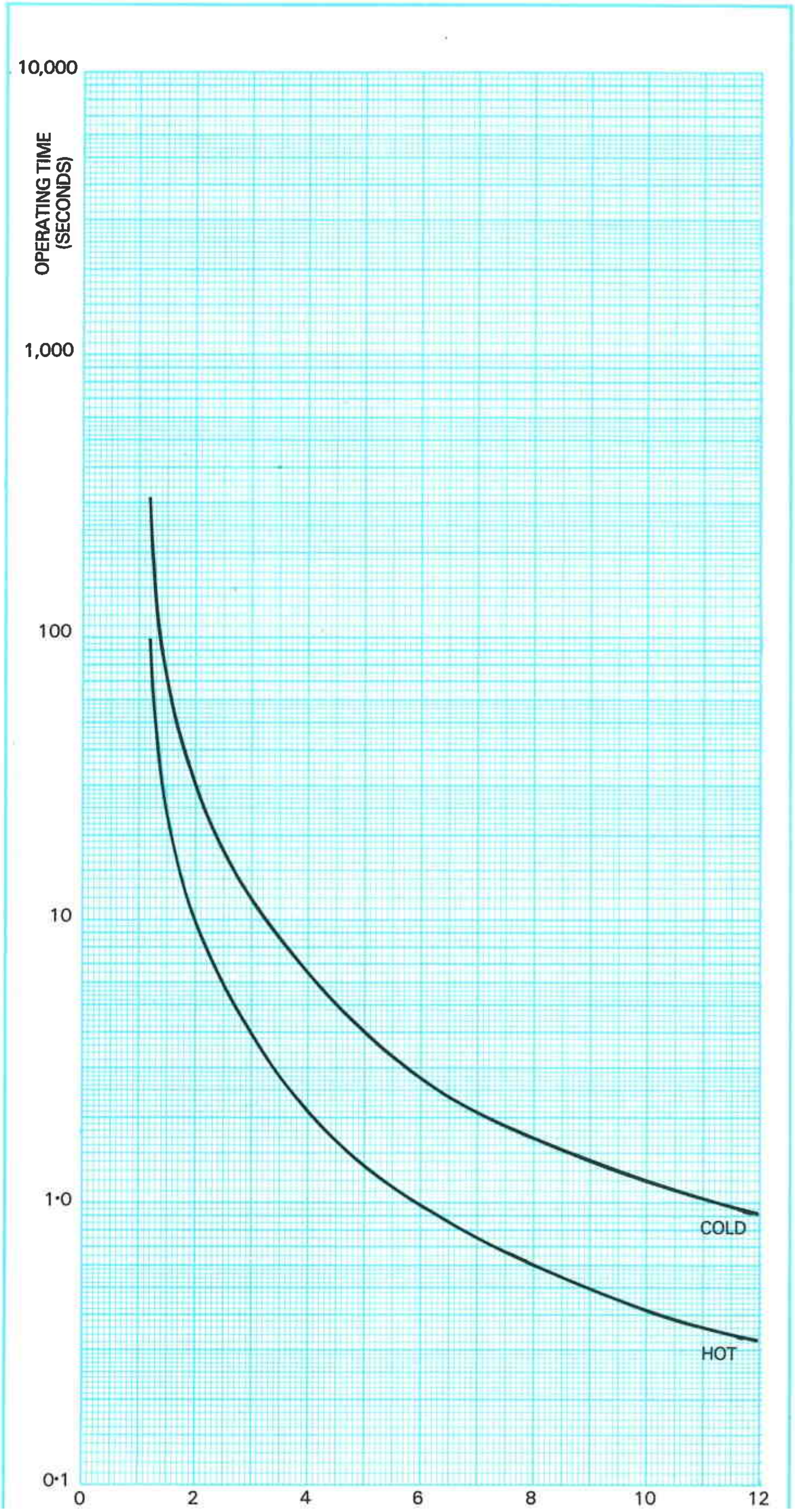
$$\text{Th } I_s \text{ (A)} = \frac{I_{eq} \times I \times I_R}{100 \times 1.05 \times I_P}$$

Burden

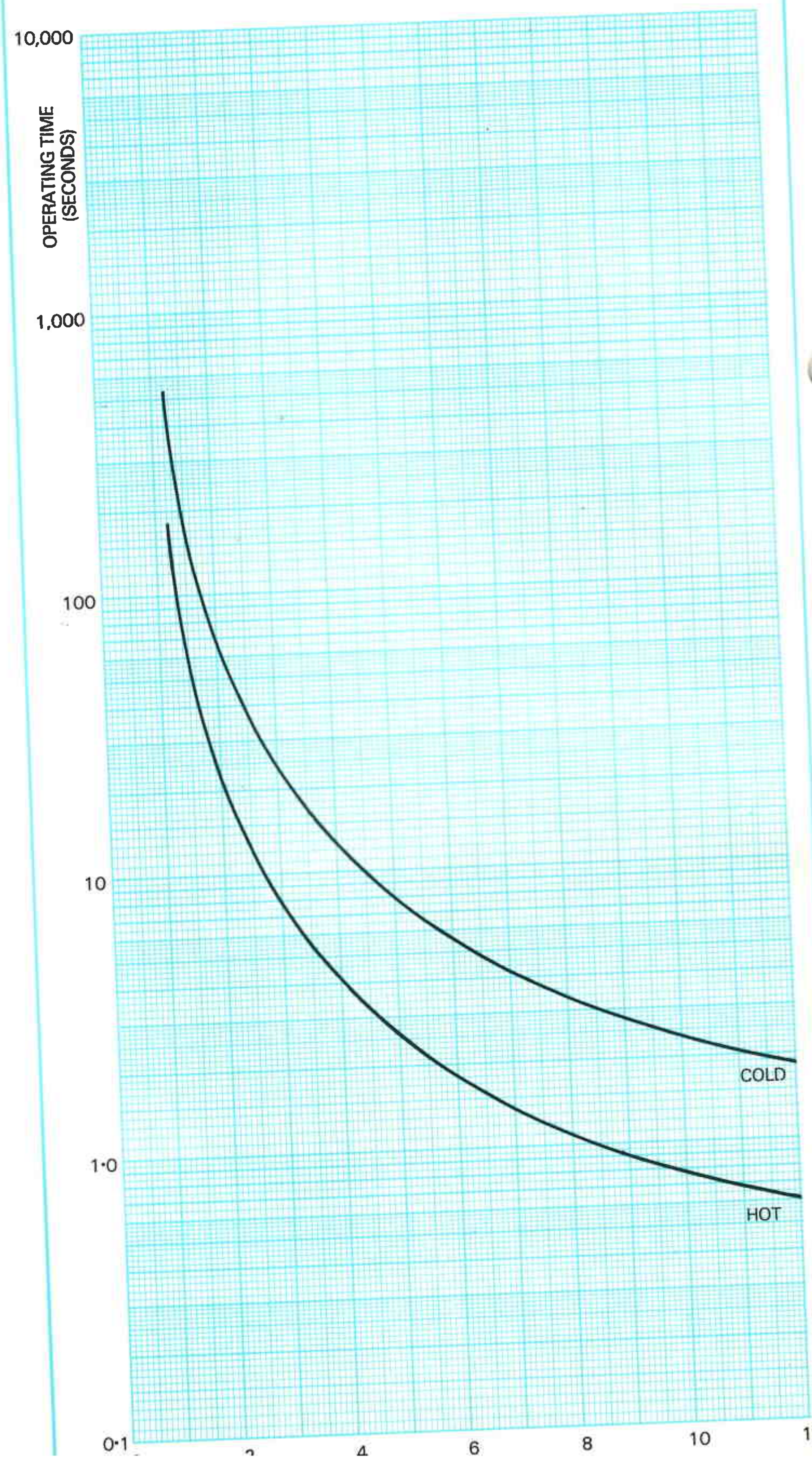
AC burden : less than 1 VA per phase at rated current

Auxiliary burden:
14W at nominal voltage.

THERMAL CHARACTERISTIC
REFERENCE 1



THERMAL CHARACTERISTIC
REFERENCE 2



THERMAL CHARACTERISTIC
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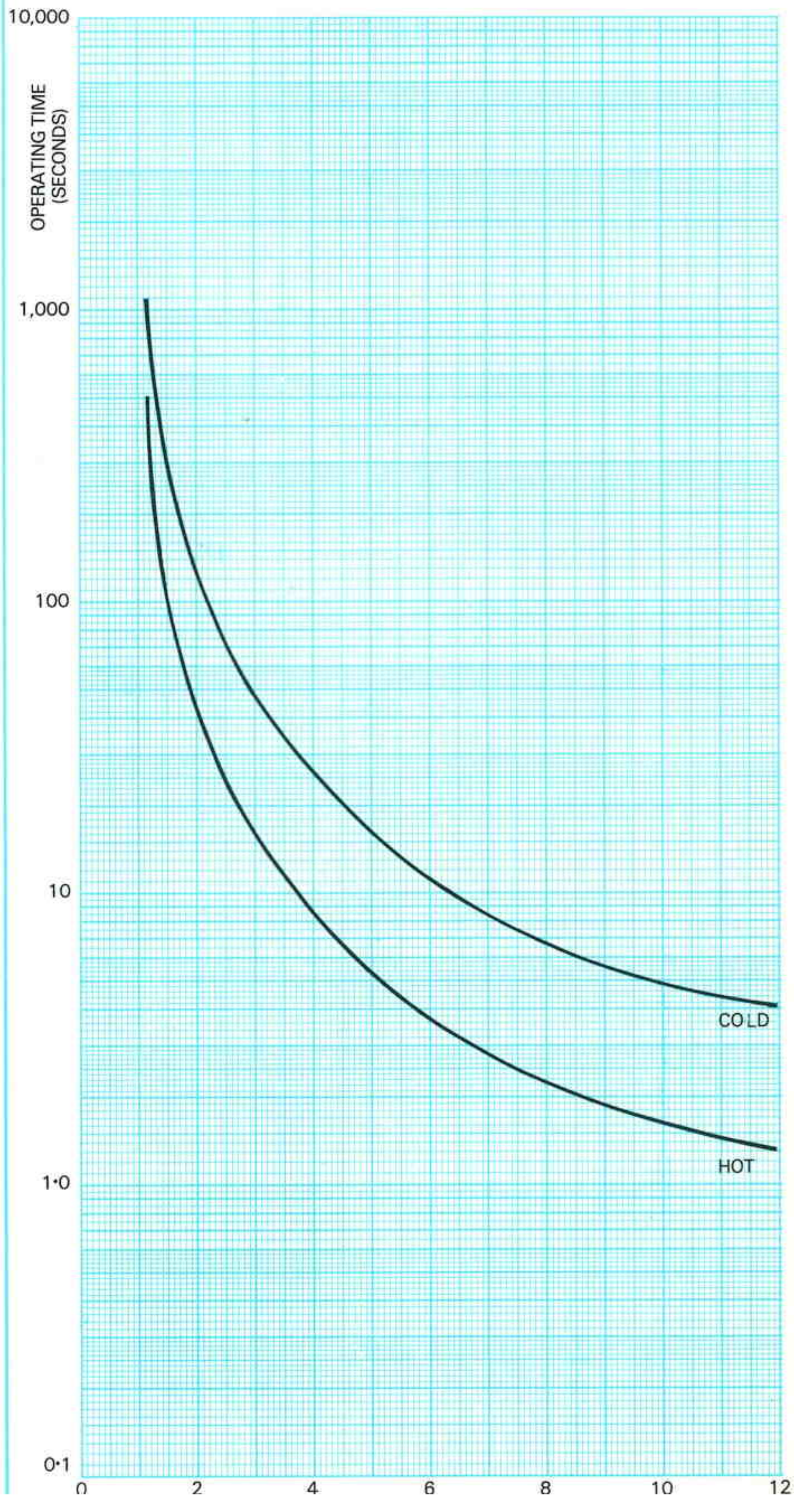
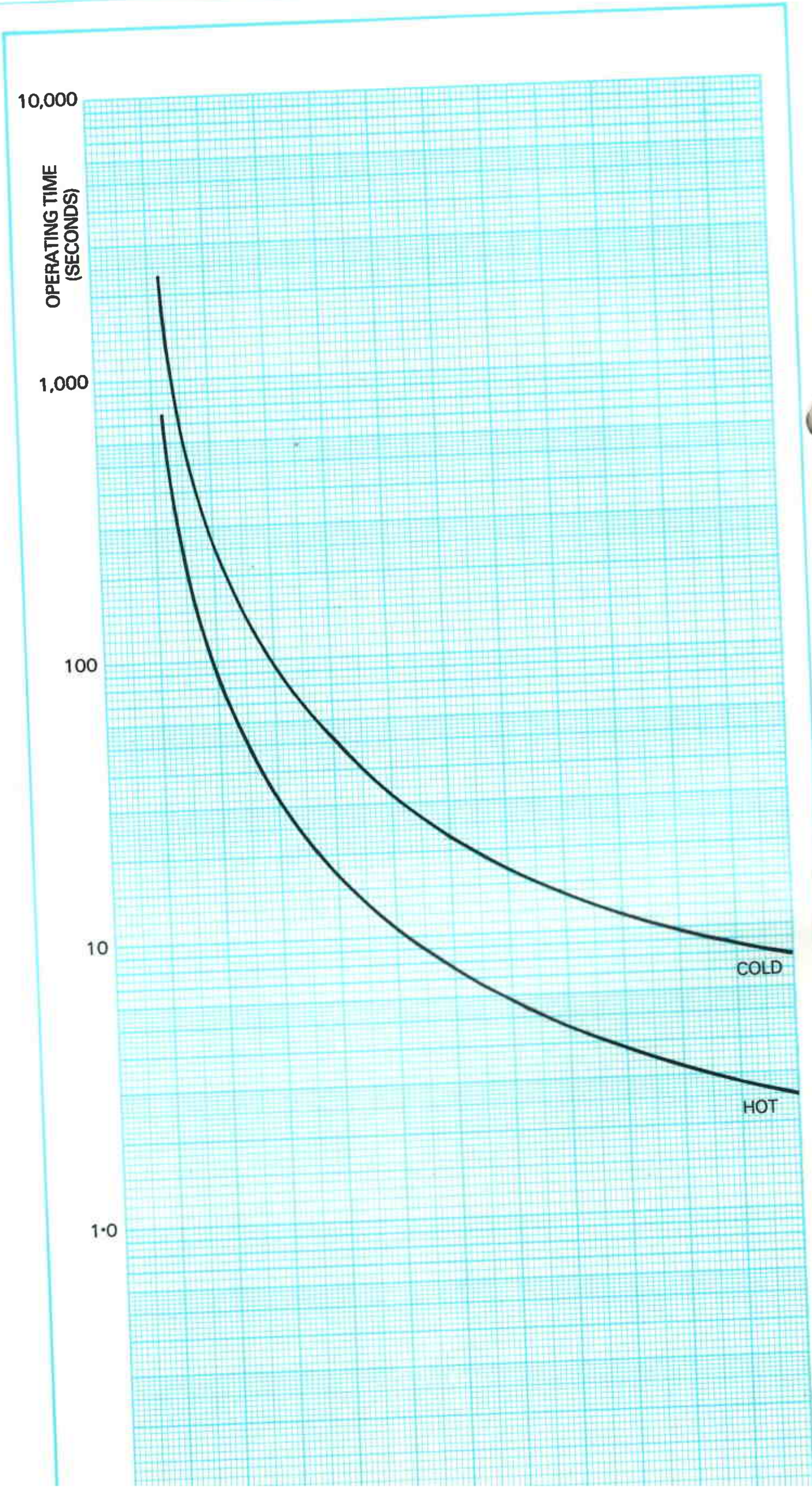


THERMAL CHARACTERISTIC
REFERENCE 4



THERMAL CHARACTERISTIC
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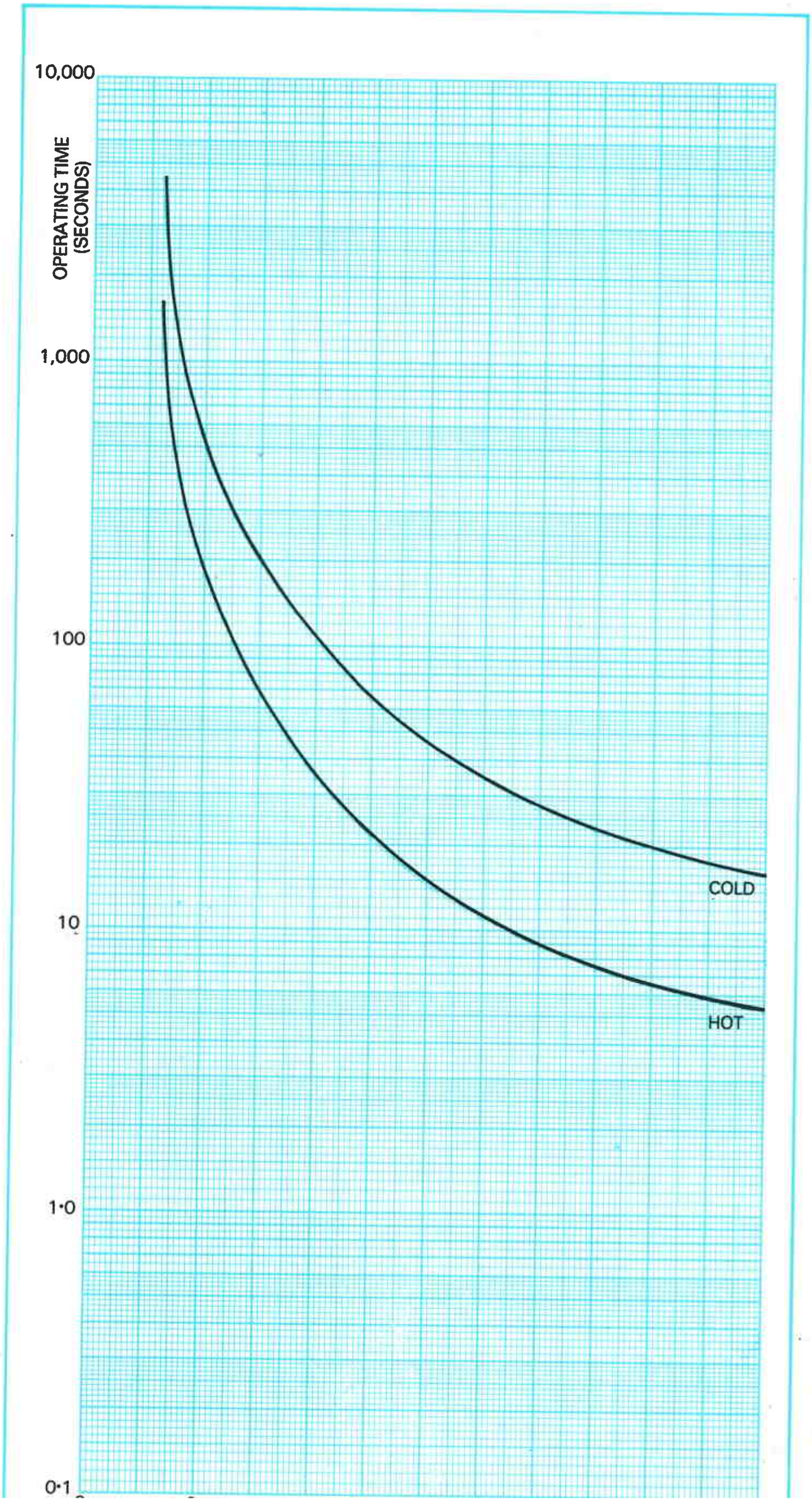

THERMAL CHARACTERISTIC
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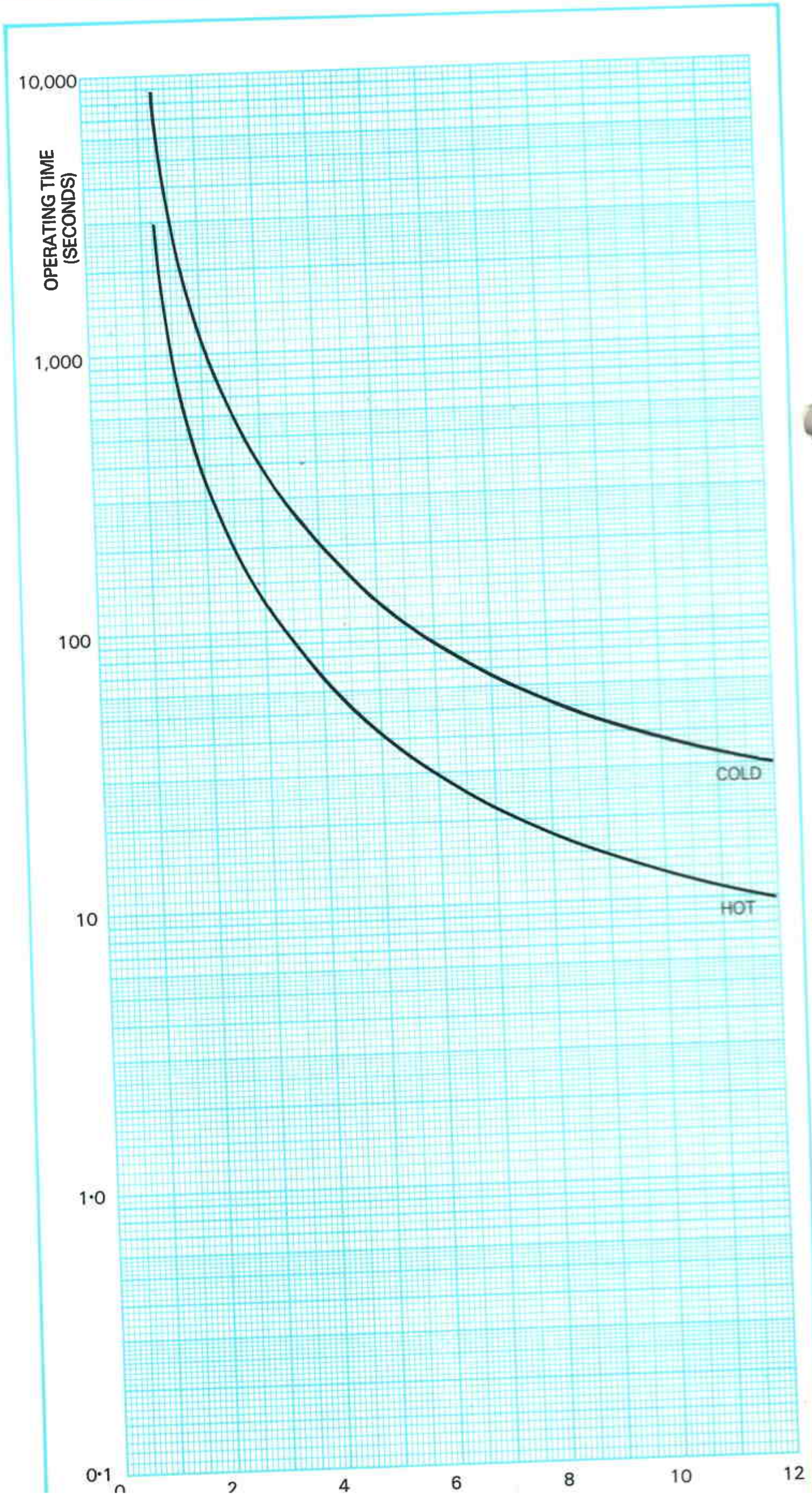

CASES

Relays in the CTM and CTMF series are accommodated in either a single ended size 1½D case or a double ended size 2D case, depending principally upon the C.T. connections required.

The size 1½D case is used for the basic arrangements, including those with an internal star connection, as shown in Figures 3 and 4. Alternatively, where special contact arrangements and/or an external star connection are required, as shown for example in Figure 5, the double ended size 2D case is used.

Cases of both sizes are available for flush or projection mounting, and finished phenolic black as standard.

Relays for use in exceptionally severe environments can be finished to BS2011 : 20/50/56 at extra cost. Standard relays are finished to BS2011 : 20/40/4 and are satisfactory for normal tropical use.

INFORMATION REQUIRED WITH ORDER

Relay type.
Relay current rating (1A or 5A).
Supply Frequency (50 Hz or 60 Hz).
Contact arrangement—hand or self reset, normally open or normally closed.
Auxiliary supply voltage rating and whether a.c. or d.c.
Case mounting (Flush or projection).
Load indicator—whether or not required.

Whether internal or external star connection is required. The alternative connections and relevant relay types are shown in Figures 3, 4 and 5.

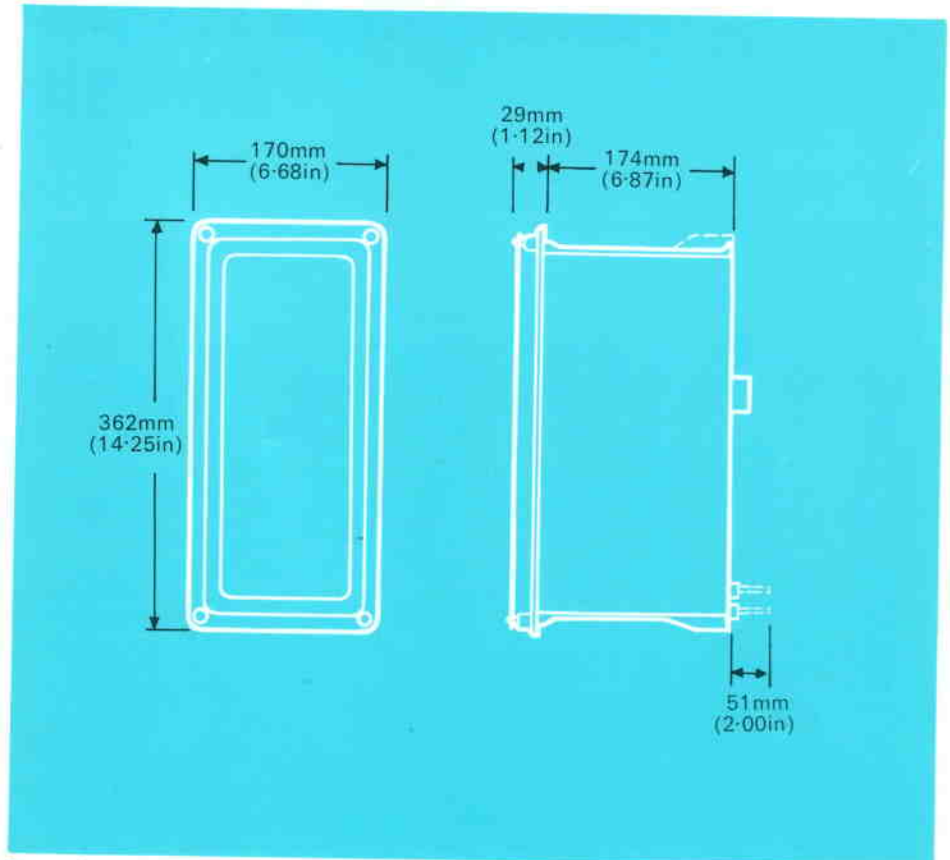

Figure 6 OUTLINE FOR SIZE 1½D CASE