Chapter 3

THERMAL CONTROLLER, Mk. 1

(*Completely revised*)

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LEADING PARTICULARS

Thermal controller, Mk. 1	**Ref. No. 5CZ/6639**
Maker's part number	*NC* 0075215/800*H*
Overall dimensions	
Height	2·65 *in.*
Width	5·1 *in.*
Depth	3·8 *in.*
Input voltages	115*V*, 400*c/s a.c.* ±10 *per cent and* 28*V d.c.*
Power consumption	...2*V.A.* (*unheated*)
	2*V.A.* (*heated*)
Ambient temperature range	—55°C *to* +55°C

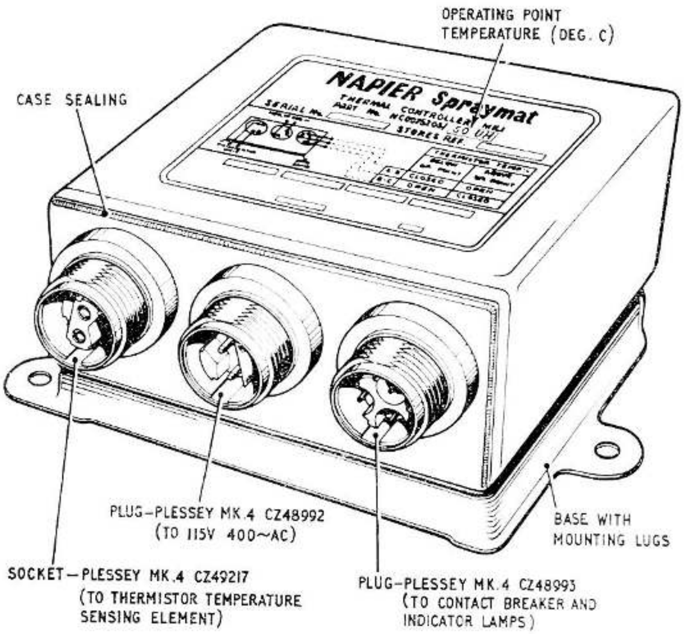

Fig. 1. Thermal controller, Mk. 1

Introduction

1. The thermal controller, Mk. 1, is designed to automatically control the temperature of Spraymat heaters used on aircraft flying surfaces to prevent ice formation.

DESCRIPTION

2. The thermal controller Mk. 1 consists of a bridge circuit amplifier with a self contained relay, and is used in conjunction with a thermistor sensing element. The controller is set to operate when the temperature of the thermistor, (which has a negative temperature coefficient) causes its resistance to fall to a pre-determined value. This temperature is known as the " operating point ", and is set during manufacture.

3. Below the operating point, the relay within the controller is de-energised and the relay contacts are set to energise a contactor which connects a supply to the heater system. At and above the operating point, the output from the amplifier energises the relay and causes the contacts to change over. The heating system is thus disconnected from the supply, and from the new position of the relay a warning lamp may be illuminated.

4. A block schematic diagram is shown in fig. 2. The thermistor temperature sensing element forms one arm of a Wheatstone bridge network, the output of which is fed into an a.c. transistor amplifier and phase discriminator, and finally into a dual transistor output stage. The output voltage of this stage operates the relay.

5. All components are contained in a hermetically sealed case which is mounted on an attachment bracket which has three lugs, drilled to take 2 BA screws. The case is evacuated of air and then filled with dry nitrogen at sea level temperature and pressure.

6. Within the sealed case the components of the transistor amplifier and phase discriminator are " potted " in Silastomer silicone rubber which is contained in an aluminium block mounted on the base plate. The transistors are mounted separately in the block. Connection to the controller is by three Plessey Mk. 4 connectors mounted on one end of the case.

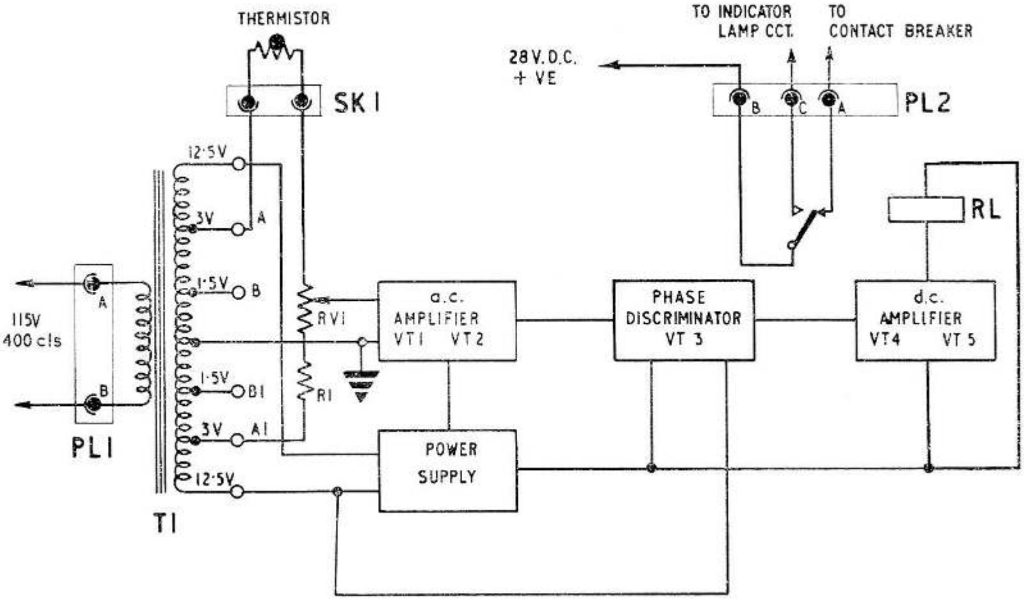

Fig. 2. Block schematic diagram

Circuit

7. With reference to fig. 3, the thermal controller is operated by a temperature sensing element (a thermistor THR with a nominal resistance of 5000 ohms at 20 degrees C). The resistance of the sensing element decreases with increase in temperature and, on reaching a pre-determined value, causes the bridge circuit to pass through balance thus providing a voltage which, when amplified, will operate the relay RL.

8. To accomplish this, a 400c/s a.c. bridge network is used, composed of windings of a centre tapped transformer T1 for two of the arms, and the potentiometer windings RV1, which are shared between the third and fourth arms in which are resistor R1 and the thermistor THR respectively. Thus, any change in the thermistor resistance will affect the bridge balance.

9. The transformer T1 steps down the 115V supply voltage to 12·5V, and tappings are provided from the secondary windings to give 1·5V and 3V. When the operating point is set between 50–100 degrees C, the thermistor, potentiometer and resistance R1 are connected to the 1·5V tapping. For operating points below 50 degrees C, connection is made to the 3V winding.

10. The potentiometer RV1 has sufficient range to counteract any inequality in the transformer windings, and it is by adjustment of this potentiometer that the final setting of the operating point for a specific temperature is obtained. The power dissipation of the thermistor is limited to about 4mW since the heating effect of this power will not produce an appreciable error in the operating point.

11. The output from the unbalanced bridge is fed from the slider of potentiometer RV1 to the base of the first stage transistor VT1 of the amplifier, via a non-polarised tantalum capacitor C1. It should be noted that signals from the unbalanced bridge network may be 180 degrees out of phase depending upon the direction of the out of balance current. In this circuit, only the signals above the operating point will pass through the phase discriminator and ultimately cause the operation of the relay.

12. The required power gain necessitates a two-stage amplifier consisting of transistors VT1 and VT2. Phase changes of inconstant value which take place due to changes in transistor temperature and which would allow signals to pass during the "off" condition, are controlled by the phase discriminator by applying a pulse signal to

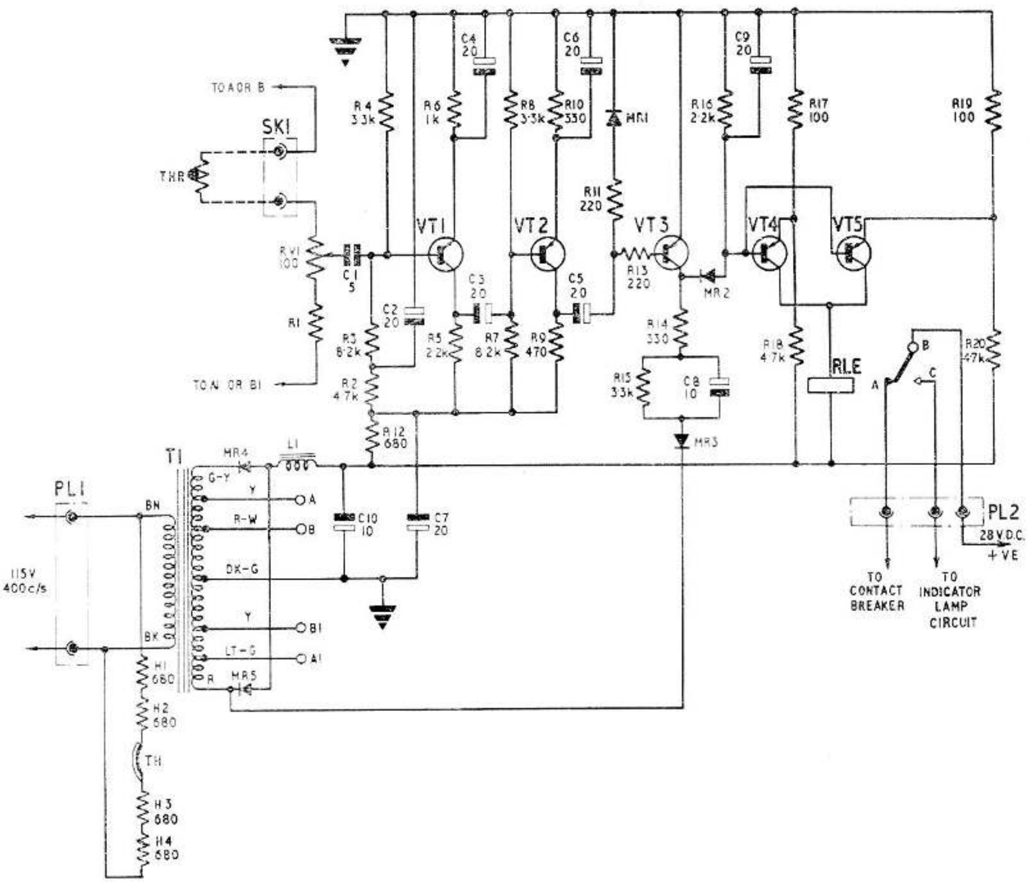

Fig. 3. Circuit diagram

the collector of transistor VT3 for a time shorter than one half cycle. This arrangement, although not allowing maximum power transfer, ensures that no power is passed during the " off " condition.

13. The delay is effected by introduction of an RC combination of R14, R15, and C8 in series with a half wave rectifying diode MR3 so that the unsmoothed d.c. bias is applied to the collector of transistor VT3. Diode MR2 is connected between transistor VT3 and smoothing capacitor C9 to prevent C9 from discharging through the transistor during the interval of time between collector supply pulses.

14. The output from the phase discriminator is then fed into a d.c. amplifier consisting of two matched transistors in parallel, VT4 and VT5, the output of which is employed to energise the relay. The relay completes a circuit to the energising coil of a contactor, or when energised, de-energises the contactor and illuminates a warning lamp.

15. The controller signal circuits, incorporating transistors VT1, VT2, VT4 and VT5 are energised by a d.c. supply of 10 to 25mA at 10V, the higher current being taken when the relay is operated. This current is obtained from the 115V, 400c/s a.c. supply which is used to energise the thermistor bridge circuit and phase discriminator. Full wave rectification is obtained by means of the germanium junction type diodes MR4 and MR5. Smoothing is provided by inductor L1 and capacitor C10.

16. To ensure satisfactory circuit operation and to give protection against derangement at low temperatures, four series connected heaters H1, H2, H3 and H4, each of 680 ohm resistance, are mounted in the amplifier component block and are connected across the 115V a.c. supply via a bi-metal thermostat, TH, which closes at —10°C.

OPERATION

17. The thermistor temperature sensing element is normally installed in such a position that any change of temperature in the system being monitored will be detected with the minimum delay.

18. A thermistor has a negative temperature coefficient of resistance, i.e. the resistance decreases with increase in temperature. The a.c. bridge circuit (of which the thermistor forms one arm) is in balance only at the operating point of the thermal controller.

19. Below the operating point, the signals from the unbalanced bridge circuit arrive at the phase discriminator, after amplification, out of phase with the energising voltage of the transistor and are therefore rejected.

20. At temperatures above the operating point, the signals arriving at the phase discriminator are in phase with the energising voltage and pass through the phase discriminator to the d.c. amplifier and hence operate the relay.

SERVICING

21. The thermal controller, Mk. 1 is nitrogen filled and sealed at manufacture, hence little servicing is possible. Examination for cleanliness and apparent damage should be carried out at stated intervals. Defective thermal controllers should be returned to stores.

Testing

22. The thermal controllers, Mk. 1, may be tested in accordance with the Standard Serviceability Test, Appendix A to this chapter.

Appendix A

STANDARD SERVICEABILITY TEST FOR THERMAL CONTROLLER, Mk. 1

Introduction

1. The following tests may be applied to ascertain the serviceability of the thermal controller, Mk. 1, or prior to its installation in an aircraft.

TEST EQUIPMENT

2. The following test equipment or suitable equivalents will be required:—

(1) Resistance, Decade, 0–1000 ohm Ref. No. 5G/3217

(2) Lamps warning, Type B Ref. No. 5CX/1553

(3) Lamps filament, 28V, 2·8W Ref. No. 5L/9951286

(4) 28V d.c. supply

(5) 115V, 400c/s Variable a.c. supply.

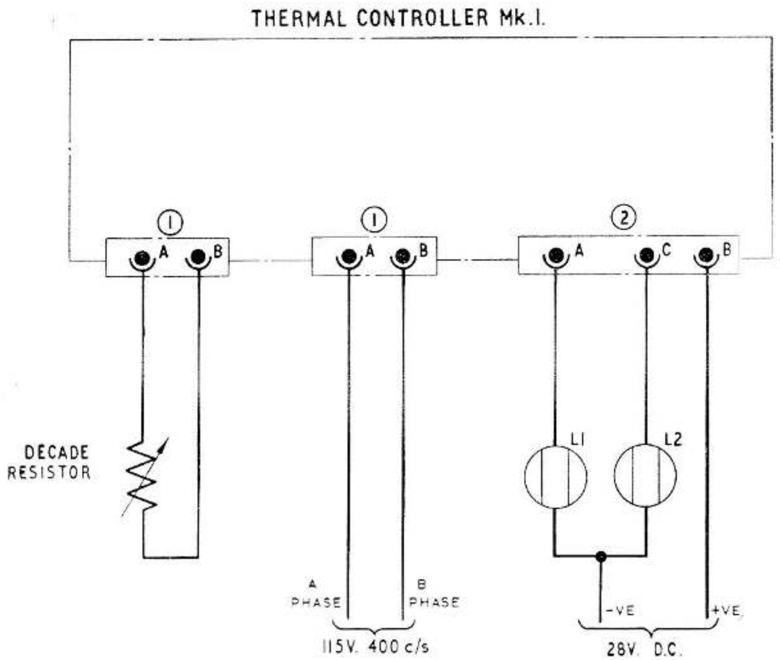

Fig. 1. Test Circuit

TEST PROCEDURE

Functional test

3. (1) Connect the controller to the test circuit as shown in fig. 1.

(2) Adjust the a.c. voltage to 115 volts.

(3) Set the decade resistance to 800 ohms.

(4) Switch on the 28V d.c. supply and ensure that lamp L1 is illuminated.

(5) Decrease the decade resistance until lamp L1 is extinguished, and lamp L2 is illuminated. Note the resistance value which should be between 689 and 727 ohms.

(6) Increase the decade resistance until L2 is extinguished and L1 illuminated. The resistance value should be between 689 and 727 ohms.

(7) Set the a.c. voltage to 104V and repeat sub-para. (5) and (6). The operating point should not vary by more than 10 ohms.

(8) Set the a.c. voltage to 126V and repeat sub-para. (5) and (6). The operating point should not vary by more than 10 ohms.

Insulation resistance test

4. (1) Using a 500V insulation resistance tester, test between the case and pins A and B of plug 1. The reading obtained should be not less than 5 megohms.

(2) Using a 250V insulation resistance tester, test between the case and Pins A, B and C of plug 2. The reading obtained should be not less than 5 megohms.

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