

Chapter 4

SPRAYMAT THERMAL CONTROLLERS, NAPIER, MK.4, 4A AND 4B.

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LEADING PARTICULARS

**Spraymat thermal controller, Napier, Mk.4 (Amplifier, Type FLM/A/907),
Ref. No. 5CZ/6145.**

Temperature range $80 \pm 1 \text{ deg. C}$

Dimensions:-

Length 3.45 in.

Diameter 3.49 in.

Weight 1 lb. 8 oz.

Voltages 28 V.d.c. and 115 V. 400 c/s

**Spraymat thermal controller, Napier, Mk.4A (Amplifier, Type FLM/A/910),
Ref. No. 5CZ/6547.**

Temperature range 20 to 80 deg.C

Dimensions:-

Length 3.45 in.

Diameter 3.49 in.

Weight 1 lb. 8 oz.

Voltages 28 V.d.c. and 115 V. 400 c/s

**Spraymat thermal controller, Napier, Mk.4B (Amplifier, Type FLM/A/917),
Ref. No. 5CZ/6952**

Temperature range 35 to 80 deg.C

Dimensions:-

Length 3.63 in.

Diameter 3.49 in.

Weight 1 lb. 8 oz.

Voltages 28 V.d.c. and 115 V. 400 c/s

Introduction

1. Spraymat thermal controllers are designed to prevent overheating of de-icing heater mats. They are used in conjunction with thermistor sensing elements, which are mounted adjacent to the heater mats, and relays in the heater mat power supply circuits.

2. An increase in temperature above a predetermined level is detected by the sensing element which transmits the signal back to the input circuit of the amplifier. The output circuit of the amplifier operates a relay which breaks the power supply to the appropriate heater mat.

3. A thermal controller consists basically of two amplifiers driven from two bridge networks, the external sensing elements forming part of the bridge circuits. In the output stage of each amplifier is a relay which, when energized, breaks the power supply to the heater mats.

DESCRIPTION

General

4. The unit is enclosed in a cylindrical light-alloy cover with circular end plates at the front and rear. The components are mounted on decks which are arranged in layers and secured to the forward end plate by studs and spacers. The decks are

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interconnected by a cable loom and the connections are brought out to two plugs mounted on the forward end plate.

5. The case is sealed by 'O' rings inserted between the end plates and the cover to withstand a pressure of 20 lb/in². The plug outlets are sealed by gaskets and special washers and the screw heads sealing washers.

6. A bracket for mounting the unit is riveted to the underside of the cover.

Spraymat thermal controller, Napier Mk.4.

7. The two amplifiers (fig.3) are identical in construction. Each is a three stage transistor amplifier with capacitive coupling between stages. Power supplies for the amplifiers are derived from a full wave rectifier comprising rectifiers D2 and D4, which supply the first two stages of both amplifiers and half wave rectifiers D1 and D4 which supply the output transistors.

8. The transistors and associated components for the first two stages of both amplifiers are mounted on two semi-circular printed circuit boards. The output transistors, relays, power supply transformer and the 500 ohm elements of the bridge networks, R1, R13, R24 and R25, are mounted on a circular deck which is located behind the front plate. A circular printed circuit board mounted in front of the rear cover carries the power supply rectifiers, D1 to D4, capacitors C2, C3, C9 and C10, thermistors R10 and R22, resistors R11, R12 and R23, and the 102.5 ohm bridge elements R2 and R14. The two semi-circular decks are mounted between the front and rear decks.

9. The transformer primary winding is supplied with 115 V.400 c.p.s. A 20 - 0 - 20 V. secondary winding supplies the full wave rectifiers D2 and D4 and the half

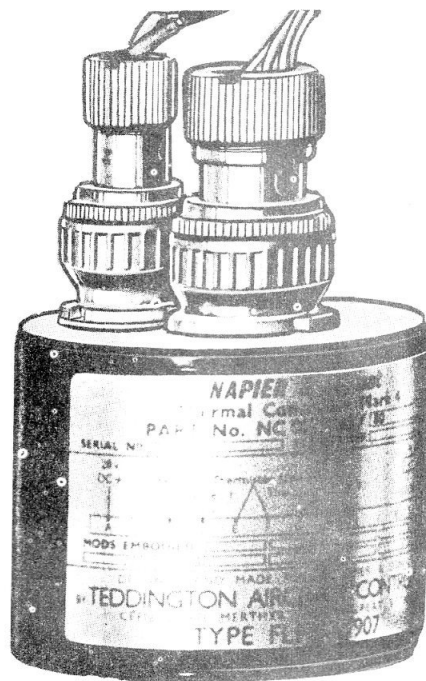


Fig. 1. Spraymat thermal controller, Napier, Mk.4

wave rectifiers D1 and D3. Two 2.5 V windings energize the bridge circuits. A fourth secondary winding is not used.

10. The relays are double pole change-over types and they are connected so that when energized they break the supply to the heater mats which they control. Both relays are shunted by 12 uF capacitors, C2 and C9.

11. Two thermistors, R10 and R22, are connected in the base circuits of the amplifier output stages. The purpose of these is to maintain stability of operation with variations in ambient temperature.

12. Electrical connections to the unit are made via a 2-pole and a 12-pole plug, Mk.4. The 115 V, 400 C/S supply is brought in via the 2-pole plug. The 28 V. d.c. supply is connected to pin A of the 12-

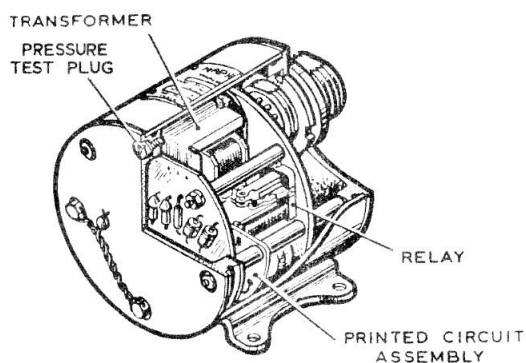


Fig.2. Sectional view of controller

pole plug and from there to the moving contacts of the relays. The connections from the normally closed contacts of relay RL1 are brought to pin C and those from the normally closed contacts of relay RL2 to pin D. The two external sensing elements are connected into the bridge networks via pins E and F and pins G and H respectively.

Spraymat thermal controller, Napier, Mk.4A 13. The variations between this unit and the Mk.4 are as follows:-

(1) Two extra resistors, R28 and R29, both of 397.5 ohms resistance are connected in series with the 102.5 ohm bridge elements R2 and R14. R28 and R29 are each shunted by a pair of relay contacts which are normally closed but open when the appropriate relay is energized. The effect of this arrangement is to increase the differential between 'making' and 'breaking' of the relays.

(2) The 12000 ohm resistors, R7 and R19, in the base circuits of the second amplifying stages are replaced by silicon junction diodes, D7 and D8.

Spraymat thermal controller, Napier, Mk.4B 14. The variations between this unit and the Mk.4 are as follows:-

(1) Two extra resistors, R28 and R29, both of 217 ohms resistance are connected in series with the 102.5 ohm bridge elements, R2 and R14. R28 and R29 are each shunted by a pair of relay contacts which are normally closed but open when the appropriate relay is

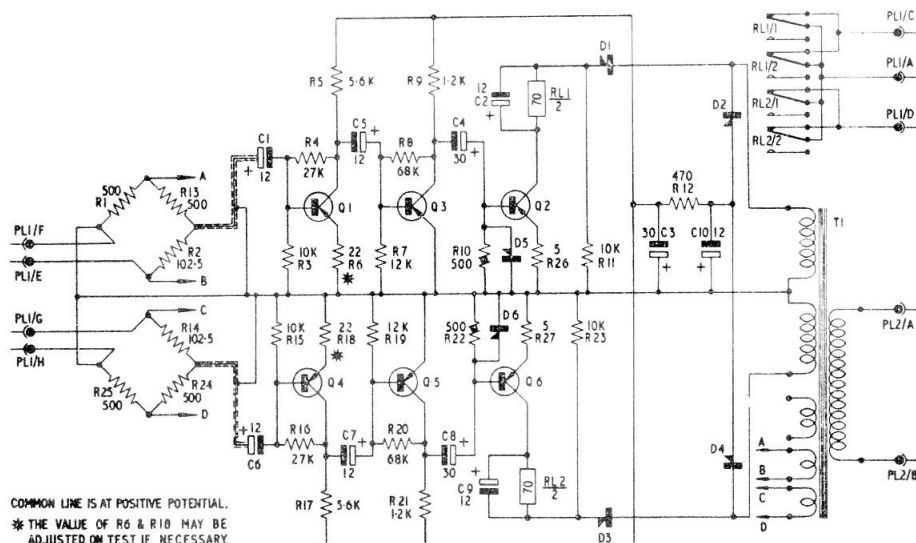


Fig.3. Circuit diagram, spraymat thermal controller, Napier, Mk.4

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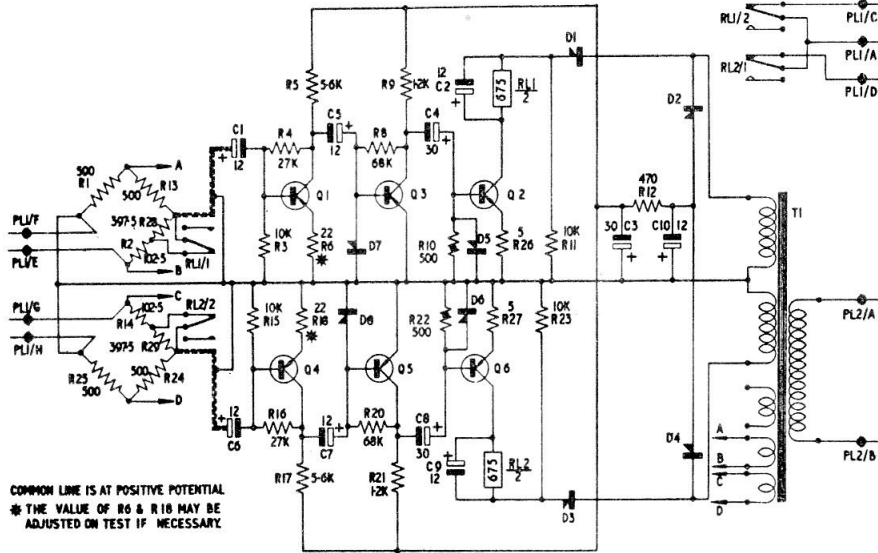


Fig. 4. Circuit diagram, spraymat thermal controller, Napier, Mk.4A

energized. The effect of this arrangement is to increase the differential between 'making' and 'breaking' of the relays.

(2) The 12000 ohm resistors, R7 and R19, in the base circuits of the second amplifying stages are replaced by silicon junction diodes, D6 and D7.

(3) The electrical connections are made via a 3-pole Cannon plug, MS 3102C - 10SL - 3P and a 7-pole Cannon plug, MS3102C - 16S - 1P. The 115 V. 400 c.p.s. supply is taken to pins A and B of the 3-pole plug. The 28 V. d.c. supply is taken to the relay moving contacts via pin A of the 7-pole plug, and the normally closed

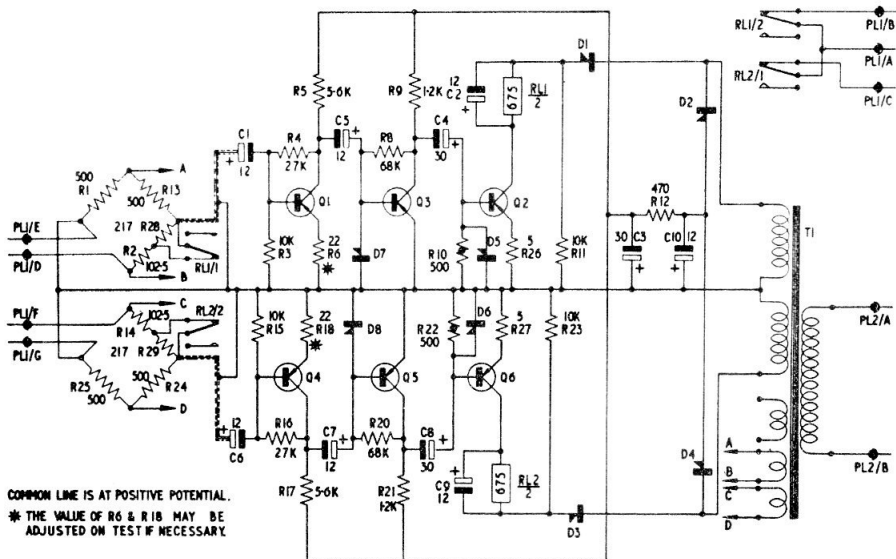


Fig.5. Circuit diagram, spraymat thermal controller, Napier, Mk.4B

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contacts on relays RL1 and RL2 are connected to pins B and C respectively. The two external sensing elements are connected into the two bridge networks via pins D and E and pins F and G respectively.

OPERATION

Spraymat thermal controller, Napier, Mk.4.

15. The two amplifiers are fed from common power supplies, but are separate in all other respects. Each amplifier performs the same function, enabling two heater mats to be controlled by one unit. In the following the operation of one amplifier only will be described.

Bridge network

16. The thermistor sensing element which is external to the controller has a resistance of 500 ohms at 20 deg. C and 102.5 ohms at 80 deg. C. At 80 deg. C the bridge circuit is balanced and no signal is developed across it. A variation in temperature from 80 deg. C causes the resistance of the sensing element to change and unbalance the bridge circuit, causing a signal to be applied to the amplifier. A signal resulting from a decrease in the temperature of the sensing element will be opposite in phase to one resulting from an increase in temperature.

Amplifier

17. Any signal which is developed across the bridge circuit is amplified by the first and second stages of the amplifier and applied to the base of the output transistor. The output transistor is supplied from a half wave rectifier and therefore conducts only for a half of each cycle of the supply voltage, i.e. when the collector is negative with respect to the emitter, so any signal which appears at its base during the non conducting half cycle will not be amplified.

18. The bridge circuit is connected so that an unbalance signal resulting from a rise in the temperature of the sensing element

is in phase with the supply to the output transistor so this signal will cause an increase in the collector current of the transistor sufficient to energize the relay. Operation of the relay opens the contacts which are in series with the 28 V. d.c. supply to the heater mats, cutting off the supply to the mats.

19. The 12 μ F (C2) capacitor connected across the relay coil stores sufficient energy to keep the relay energized during the half cycle when the transistor is not conducting.

20. An unbalance signal resulting from a decrease in the temperature of the sensing element will be amplified only by the first two stages of the amplifier, and will not affect the output stage, so will not cause the relay to energize. By this arrangement the temperature of the heater mats is kept at 80 ± 1 deg. C.

Spraymat thermal controller, Napier, Mk.4A

21. The bridge is balanced when the temperature of the sensing element is 80 deg. C. An increase in temperature results in a signal of the correct phase to operate the relay and break the supply to the heater mats. Operation of the relay also opens the contacts across the 397.5 resistor (R28) in the bridge circuit, placing this resistor in series with the 102.5 ohm element (R2) of the bridge. This increases the resistance of that limb of the bridge to 500 ohms, putting the bridge more out of balance. It will be necessary for the resistance of the sensing element to increase up to 500 ohms before the bridge is balanced again. It does not reach this value until its temperature has decreased to 20 deg. C. When it reaches this temperature the bridge balances again and the relay de-energizes, re-making the circuit to the heater mats and once again closing the contacts across the 397.5 ohm resistor (R28). The heater mats now remain switched on until the temperature once again reaches 80 deg. C. when the cycle of operations starts again. By this arrange-

ment a differential of 60 deg. C. between "breaking" and "making" of the heater mat circuit is achieved.

Spraymat thermal controller, Napier, Mk.4B

22. The operation of this unit is identical with that of the Mk.4A, except that the relays operate when the temperature of the sensing elements rises above 80 deg. C. and de-energize when the temperature falls to 35 deg. C. This gives a differential of 45 deg. C. between 'breaking' and 'making' of the heater mat circuits.

INSTALLATION

23. Before installing a thermal controller refer to the appropriate aircraft air publication.

SERVICING

Inspection

24. Examine the unit for external damage, corrosion and security of fastenings, check locking and security of screws on the rear end plate.

TESTING

25. If the serviceability of a thermal controller is in doubt, apply the tests described below.

26. All tests should be carried out at normal room temperature (approximately 20 deg.C).

TEST EQUIPMENT

27. The following test equipment is required:-

- (1) 500V insulation resistance tester, Ref. No. 5G/203.
- (2) Bonding tester Ref. No. 5G/2126.

(3) Two standard variable resistance boxes, Ref. No. 5G/3217.

(4) Two lamps 28 V, 2.8 W.

(5) Plugs and sockets as shown in test wiring diagrams.

(6) A 28 V. d.c. supply.

(7) A 110 to 120 V 400 C/S supply.

(8) Suitable adapter to connect air line to pressure test point.

(9) Pressurizing pump, Ref. No. 5G/5435.

TESTS

Leakage test

28. Remove the pressure test plug and discard the sealing washer. Fit a suitable adapter to the pressure test hole (adapter should be threaded 4 BA). Connect the pressurizing pump to the adapter and pressurize to 20 lb/in². Check the unit for leaks by immersing it in a vessel of industrial methylated spirits for one minute. Remove the unit from the spirits before releasing the pressure. Replace the test plug using a new sealing washer.

Note . . .

The air used for pressurizing must be clean and dry.

Functional tests

Spraymat thermal controller, Napier, Mk.4.

29. (1) Connect the unit as shown in fig.6. Switch on the 400 C/S, a.c. supply, set the input voltage at 115V and allow time for the unit to stabilize. Switch on the 28 V.d.c. supply.

(2) Adjust variable resistance R1 until lamp L1 illuminates and adjust

variable resistance R2 until lamp L2 illuminates.

(3) Decrease variable resistance R1 until lamp L1 extinguishes and note the resistance value. Increase variable resistance R1 until lamp L1 illuminates and note the resistance value. The difference between the two resistance values must be less than 2 ohms and the value at which lamp L1 extinguishes must be between 99 and 103 ohms.

(4) Decrease variable resistance R2 until lamp L2 extinguishes and note the resistance value. Increase variable resistance R2 until lamp L2 illuminates and note the resistance value. The difference between the two resistance values must be less than 2 ohms and the value at which lamp L2 extinguishes must be between 99 and 103 ohms.

(5) Repeat the above tests with supply voltages of 110V, 380 C/S and 120 V, 420 C/S.

Spraymat thermal controller, Napier, Mk.4A.

30. (1) Connect the unit as shown in fig. 6. Switch on the 115V supply and allow time for the unit to stabilize. Switch on the 28 V.d.c. supply.

(2) Adjust variable resistance R1 until lamp L1 illuminates and adjust variable resistance R2 until lamp L2 illuminates.

(3) Decrease variable resistance R1 until lamp L1 extinguishes and note the resistance value. The resistance must be between 99 and 103 ohms.

(4) Increase variable resistance R1 until lamp L1 illuminates and note the resistance value. The resistance must be between 490 and 510 ohms.

(5) Decrease variable resistance R2 until lamp L2 extinguishes and note the resistance value. The resistance must be between 99 and 103 ohms.

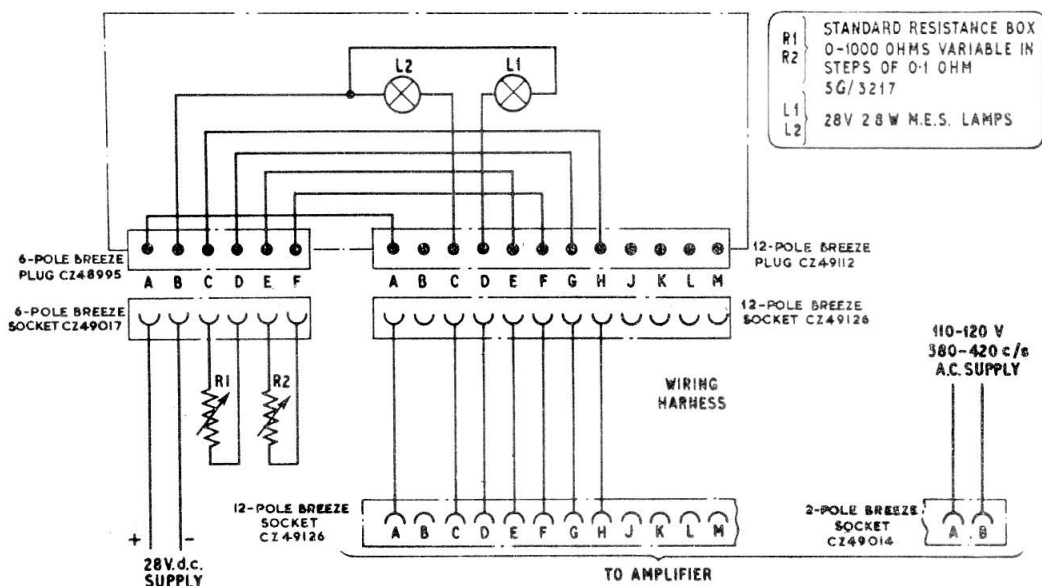


Fig.6. Test wiring diagram, spraymat thermal controllers, Napier, Mk.4 and 4A

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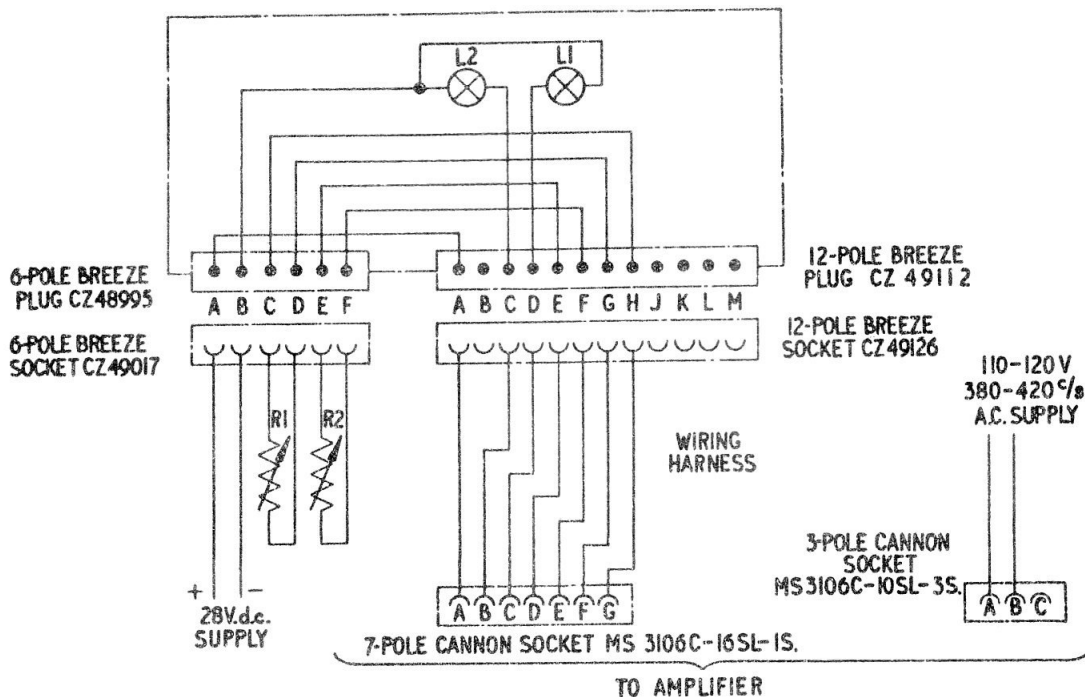


Fig.7. Test wiring diagram, spraymat thermal controller, Napier, Mk.4B

(6) Increase variable resistance R2 until lamp L2 illuminates and note the resistance value. The resistance must be between 490 and 510 ohms.

(7) Repeat the above tests with supplies of 110V, 380 C/S and 120V, 420 C/S.

Spraymat thermal controller, Napier, Mk.4B

31. (1) Connect the unit as shown in fig.7. Switch on the 115V supply and allow time for the unit to stabilize. Switch on the 28V d.c. supply.

(2) Adjust variable resistance R1 until lamp L1 illuminates and adjust variable resistance R2 until lamp L2 illuminates.

(3) Decrease variable resistance R1 until lamp L1 extinguishes and note

the resistance value. The resistance must be between 99 and 103 ohms.

(4) Increase variable resistance R1 until lamp L1 illuminates and note the resistance value. The resistance must be between 309 and 327 ohms.

(5) Decrease variable resistance R2 until lamp L2 extinguishes and note the resistance value. The resistance must be between 99 and 103 ohms.

(6) Increase variable resistance R2 until lamp L2 illuminates and note the resistance value. The resistance must be between 309 and 327 ohms.

(7) Repeat the above tests with supplies of 110V, 380 C/S and 120V, 420 C/S.

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Electrical tests

Insulation resistance

32. The resistance between all the pins of the electrical plugs and the cover of the unit must not be less than 30 meg-ohms at 500 V.d.c., the test voltage being applied for not less than 15 seconds.

Bonding test

33. The resistance between the bodies of the electrical plugs and the mounting bracket of the instrument must not exceed 0.025 ohms.

Location and rectification of faults

34. If a thermal controller fails to meet the requirements of the functional test, break the locking wire at the rear cover and remove the five nuts and sealing washers. Slide the main cover off the unit and carry out the appropriate checks

described below to determine the cause of failure. If these checks fail to locate the defect, change the semi-circular deck containing the first two amplification stages of the faulty channel. If the fault is still present change the rear deck and, if necessary, the front deck, the faulty deck can then be examined separately.

Note . . .

When soldering miniature components it is essential to ensure that heat from the iron does not reach the components. If the connecting wire is gripped with a pair of pliers between the iron and the component the pliers will make an efficient heat shunt and prevent the component overheating. When unsoldering components from printed circuit boards care must be taken to avoid raising the copper strip from the surface of the board.

SYMPTOM	CHECKS
Lamps L1 and L2 extinguished at all values of R1 and R2.	(1) Check the connection at pin A of the 12-pole or 7-pole plug. Check the wiring from this pin to the moving contacts of the relays.
Lamps L1 and L2 both illuminated at all values of R1 and R2.	(1) Check the connection between the centre tap of the main secondary winding of the transformer and the amplifier common positive line. (2) If satisfactory, check the voltages across each half of the centre-tapped secondary winding. The voltage across each half of the winding should be approximately 20V. Check voltages across the bridge energizing windings of the transformer. These windings should both give approximately 2.5 V. If the correct voltages are present the transformer and the a.c. input circuits are satisfactory. (3) If the preceding check is unsatisfactory check for 115 V across the transformer primary winding. If a voltage of

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SYMPTOM	CHECKS
One amplifier functions satisfactorily but the test lamp for the other remains illuminated at all values of its variable resistor.	115 V appears across the transformer primary winding then the transformer may be considered to be unserviceable. If there is no voltage across the transformer primary winding, check the connections from the transformer to the a.c. input plug. (4) If checks (1) and (2) are satisfactory, check for d.c. voltage across C3 and C10. There should be a minimum voltage of 15V. If no voltage is present across C3 or C10, check both capacitors for short circuit. If voltage is present across C10 but not across C3, check C3 for short circuit and R12 for open circuit. (5) If C3, C10 and R12 are satisfactory, disconnect in turn the leads supplying the semi-circular amplifier decks. If voltage appears across C3 with either deck disconnected, the deck is faulty. If there is still no voltage across C3 with both amplifier decks disconnected change D2 and D4. (1) Check the connections from the 7-pole or 12-pole plug to the appropriate bridge circuit. Check the bridge resistors for open or short circuit. If satisfactory, check for a 2.5V energizing voltage across the bridge. If no energizing voltage exists, check across the appropriate transformer winding. If no voltage exists across the winding, change the transformer. If satisfactory, check the connections from the bridge to the amplifier input circuit. Check capacitor C1 or C6 for open circuit. (2) If the bridge circuit is satisfactory, check for d.c. volts across the appropriate output stage i.e. across R11 or R23. This should be approximately 20 V. If no voltage exists, check the connection from D1 or D3 to the transformer. If the connection is satisfactory change the diodes.

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SYMPTOM	CHECKS
One amplifier functions satisfactorily but the test lamp for the other one remains extinguished at all values of its variable resistor.	(3) If the d.c. voltage is correct check the relay coil, RL1 or RL2 for open circuit. Check C2 or C9 for short circuit. Check connection between R26 or R27 and the common positive line. Check R26 or R27 for open circuit. (4) If the component and the connection checks in (3) are satisfactory, check the connection between C3 and the appropriate semi-circular deck. If this is satisfactory the fault is in the semi-circular deck.
Amplifier functions but is outside the specified limits.	(1) Check the connections from the 7-pole or 12-pole plug to the bridge network. Check the bridge components for open or short circuits. (2) Check the connections from the contacts of the appropriate relay to the 7-pole or 12-pole plug. (3) Check for a short circuit between the positive side of C2 or C9 and the common positive line. (4) If checks (1), (2) and (3) are satisfactory change the appropriate semi-circular deck. (1) Check all the bridge components for correct values. If the discrepancy is slight it may be corrected by replacing R6 or R18 with a resistor of a different value.

35. After rectifying the defects on a thermal controller, apply the functional test again, then slide the main cover over the unit so that it locates with the pin fitted at the periphery of the front plate.

Replace the five nuts and sealing washers. Apply the leakage test and functional test and if satisfactory lock the two nuts with drilled heads with locking wire and a lead seal.