Chapter 21

# TEMPERATURE CONTROL AMPLIFIERS, TYPE FLM/A SERIES

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### Introduction

**1.** Temperature control amplifiers are used in aircraft hot air systems to maintain temperatures within specified limits. They are used in conjunction with temperature sensing elements, hot air valves and follow up resistors.

**2.** Amplifiers of different Ref. No. may differ in construction and circuit components. A typical amplifier is described in this chapter. For details of a particular amplifier refer to the relevant Appendix.

## DESCRIPTION

### General

**3.** Sectioned views of the amplifier unit

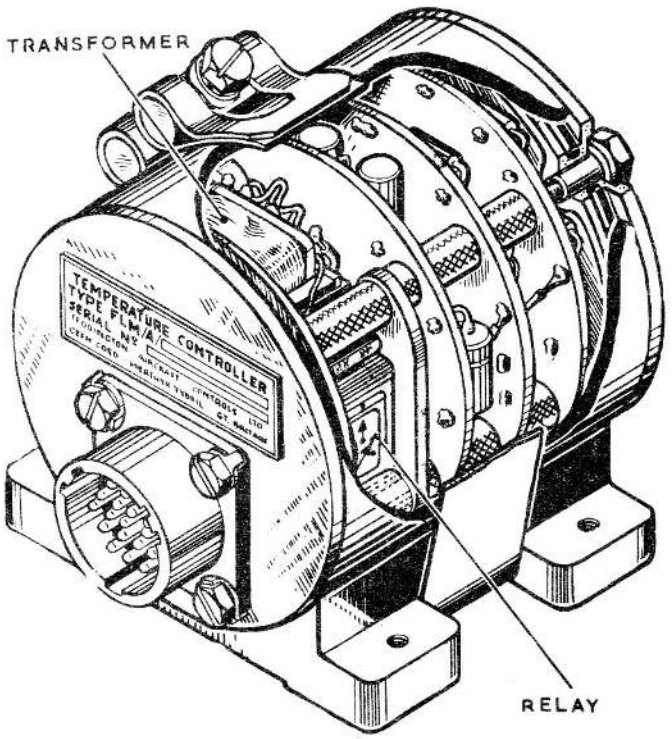


**Fig. 1. Amplifier unit, sectioned front view**

are given in fig. 1 and 2. The unit is contained within a cylindrical case, comprising two case end plates and a cylindrical cover. A strap secures the nut to a flanged mounting plate. The circuit components are arranged in layers and secured by four studs to the forward end plate. The connections are brought out on a 19-pole plug located on the front of the unit.

**4.** The unit is sealed to withstand 20 lb/in$^2$ pressure by means of 'O' rings inserted between the end plates and cylindrical cover and between the 19-pole plug and its mounting. On the rear end plate special washers are used to seal the screws securing the plate to the studs.

**Components**

**5.** The main components, consisting of two relays, a transformer and a potted bridge assembly are mounted adjacent to the forward end plate. The amplifier circuit components comprising, transistors, semi conductor diodes, resistors and capacitors are mounted on three printed circuit assemblies. The four layers of components are connected together by plug and socket type connectors and secured mechanically by studs and spacers.

**6.** The components are as follows:-

(1) The transformer, whose primary winding is supplied from 115V a.c. 400 c/s, has two secondary windings; a 20–0–20V. centre tapped winding supplies the amplifier and a 15V. winding supplies the bridge network.

(2) The output switching relays RL1/2 and RL2/2 are type F sealed relays, with 2 pairs of contacts and a 675 ohm coil. The relay coils form the

load in the output stage of the amplifier and capacitors C7 and C14 smooth out the half wave output.

(3) The potted bridge assembly mounted adjacent to the relays, contains resistors R1 to R6, the internal elements of the double-bridge network.

(4) The first printed circuit assembly, adjacent to the main components, carries the components of the output stage of both channels and the supply rectifying diodes.

(5) The second and third printed circuit assemblies each carry the components for the first three stages of the amplifier, one assembly for each channel.

## OPERATION

### General

**7.** A double bridge network is used to detect changes in the resistance of the sensing elements, which result from changes in temperature. The bridge network can distinguish between an increase and decrease in temperature and feeds a signal into the appropriate channel of the amplifier. The signal is amplified in three stages and fed into the output stage. The output stage is phase discriminating, and, if the phase of the signal is correct, will conduct to energise the relay. The d.c. supply is thereby switched to the actuator to increase or decrease the hot air supply.

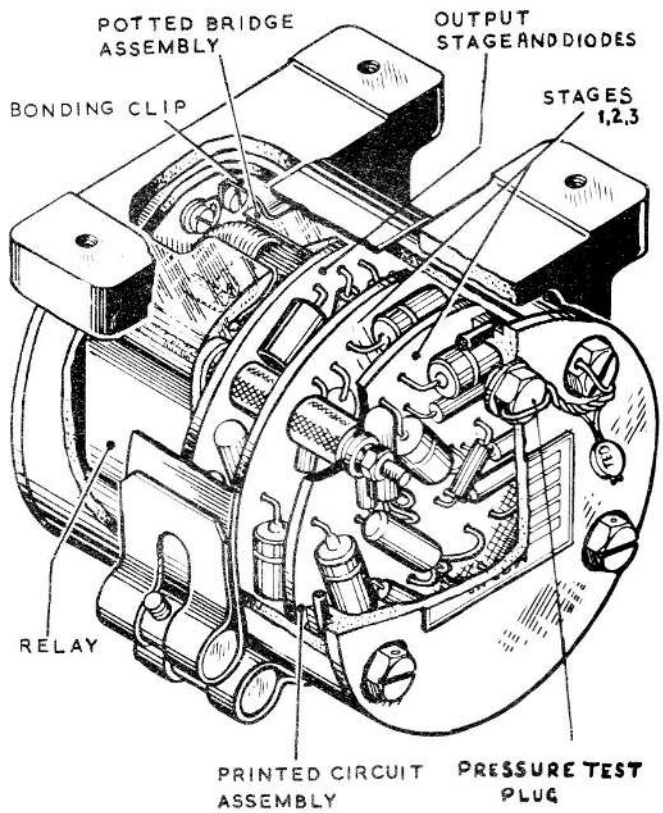


**Fig. 2. Amplifier unit, sectioned rear view**

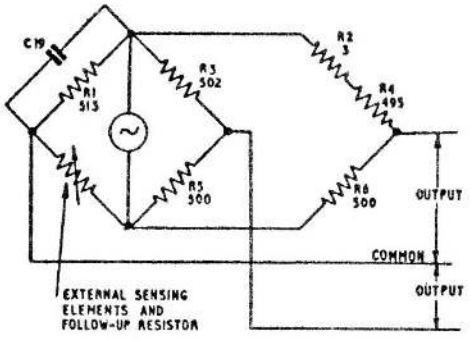


**Fig. 3. Schematic diagram of bridge circuit**

**Bridge network**

**8.** The external elements of the double bridge network, comprising the sensing elements and follow-up resistor, are connected in series between pole E and F of the 19-pole plug. The schematic arrangement of the double bridge is shown in fig.3, where it can be seen that the six resistance arms are arranged to form two bridges; R1 and the external elements being common to both bridges. The resistances of the two upper arms, containing R3 and R2 + R4, are 2 ohms either side of the lower arms R5 and R6, so that when the resistance of the external elements is equal to R1 (temperature at datum), both bridges are slightly out of balance. An out-of-balance signal is developed across each input to the amplifying channels; the two signals being displaced 180° with respect to the common connection. The phase of each signal with respect to the emitter and collector bias of the output transistor, however, is such that the transistor will not conduct and the relays will remain unergised.

**9.** Now assume an increase in temperature. The resistance of the sensing elements will increase, and the bridge containing R2 + R4 and R6 will approach balance, whereas the bridge containing R3 and R5 will move further away from balance condition. As the temperature increases further the bridge supplying the upper channel will pass through balance and become unbalanced in the opposite sense; the amount of unbalance being dependent on the temperature rise. The phase of the signal input to the upper channel is now reversed and the relay in the output stage of the amplifier will be energised, and the supply to the actuator switched on. The cycle of operation is stopped when the follow-up resistor, which is mechanically coupled to the actuator, compensates for the change in resistance of the sensing element and re-balances the bridge.

**10.** Since the balance condition of the two bridges are about 4 ohms apart, the system has a temperature differential. This allows for a small change in temperature during which, no compensating action by the amplifier will take place. In this way the stability of the system is increased and hunting prevented. With the circuit as shown in fig. 5 the differential is about 3°C. The differential can be increased to about 5°C. by shorting poles K and L of the 19-pole plug, hence shorting out R2. Capacitor V18 is included to compensate for capacitance in transformer T1.

**Amplifier channels**

**11.** The level of the signal output from the bridges is raised by three stages of amplification. The stages are RC coupled and the output fed on to the base of the output transistors. The output stages are fed via half wave rectifiers D3 and D4, so that the transistors are biased every half cycle; the upper channel on one half cycle and the lower channel on the other half cycle (fig. 5). The transistors will conduct, therefore, only when the base swings negative in phase with the collector and emitter being appropriately biased. This occurs only when the output signal from one of the bridges reverses in phase following a temperature change as described in para. 10.

**Relays**

**12.** During normal operation one relay only will close, depending on which channel is operating. The relay contacts

are electrically interlocked, and in the event of both relays becoming energised the supply to the actuator is cut off.

## SERVICING

### Removal of mounting plate and cover

**13.** (1) Slacken the screw securing the strap and remove the amplifier from the mounting plate.

(2) Break the locking wire and slacken the four nuts until the heads are clear of the rear plate. Place the amplifier on a bench with the front plate upward. Grip the cover and press downward to release the cover from the front plate. Remove the four nuts, slide the cover from the amplifier and remove the rear plate from the cover.

### Inspection

**14.** (1) Examine the case, the mounting plate, the strap, the end plates and the studs for distortion, corrosion, deterioration of protective treatment and condition of threads. Replace any faulty items.

(2) Examine the sealing rings on the end plates for deterioration. Replace if necessary.

(3) Examine electrical wiring for deterioration of insulation. Examine electrical components for evidence of overheating and soldered joints for security. Examine the electrolytic capacitors for leakage of electrolyte and examine nearby components for damage caused by leaking electrolyte.

### Functional test

**15.** Apply the functional test (App. A, para. 4).

### Repair

**16.** Repair is generally restricted to the renewal of major components and printed circuit boards. Should it be necessary to replace any of the printed circuit boards proceed as follows:-

(1) Remove the nuts, spring washers and plain washers which secure the rear printed circuit board to the studs. Slide the printed circuit boards off the studs and collect the spacers which separate the boards.

### Assembly

**17.** (1) Assemble the spacers and printed circuit boards over the studs and secure them with plain washers, spring washers and nuts.

(2) Slide the cover over the amplifier so that it fits over the sealing ring on the front plate. Fit the rear plate over the studs and fit a bonded seal over each stud. Secure the rear plate with four nuts.

(3) Fit the amplifier to the mounting plate and tighten the screw in the strap.

(4) Apply the bonding test (para. 18), the leakage test (para. 19) and the functional test (App. A, para. 4).

(5) Lock together the two lower nuts securing the end plate, using 24 S.W.G. stainless steel wire (Ref. No. 30A/3361) and a lead seal (Ref. No. 29H/2115).

### Bonding test

**18.** Measure the resistance between the body of the electrical plug and pins A, C, G, J, P, S, U and V of the plug, using a Bonding tester, Type B (Ref. No. 5G/2126). The resistance must not exceed 0·025 ohm.

**Leakage test**

**19.** Remove pressure test plug and discard sealing washer. Fit suitable (4.B.A.) adaptor to pressure test hole. Connect a pressurising pump (4G/5435) to the adaptor, and pressurise to 20 p.s.i. gauge. Check for leaks by immersing in industrial methylated spirit for one minute. Remove amplifier unit from spirit before releasing pressure. Replace pressure test plug using new washer.

**Note. . .**

*The air used for pressurising the amplifier unit must be clean and dry.*

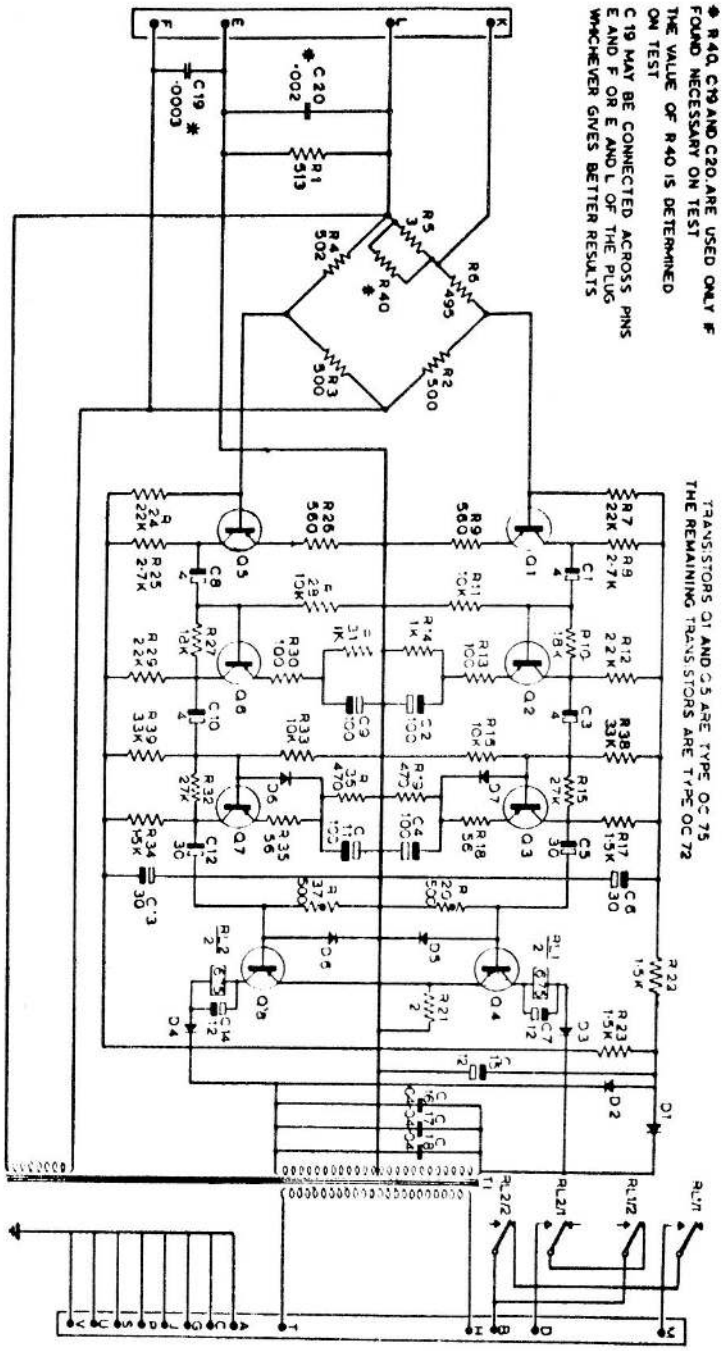


Fig. 4. Circuit diagram

# Appendix A

## STANDARD SERVICEABILITY TESTS

for

## TEMPERATURE CONTROL AMPLIFIERS, TYPE FLM/A SERIES

**Introduction**

1. The tests detailed in this Appendix are to be applied to a temperature control amplifier before its installation in aircraft, at any time when the serviceability of the amplifier is in doubt and at the appropriate re-examination periods at Equipment Depots.

**Test equipment**

2. The following test equipment is required:-

(1) Bridge-megger tester, Type B (Ref. No. 5G/1708), or suitable equivalent.

(2) Electrical components for the test circuits (fig. 1 and 2).

(3) Multimeter, Type 12889 (Ref. No. 5QP/17447).

**Test conditions**

3. All tests are to be applied at normal room temperature.

**Functional tests**

4. (1) Connect the amplifier to the appropriate test circuit and switch on the power supplies. Should the amplifier on test be Type FLM/A/905 or 915 set switch S1 to position 1.

(2) Adjust VR1 until both lamps are extinguished.

(3) Increase VR1 until lamp L2 illuminates then decrease VR1 until lamp L2 extinguishes. The difference between the two values of VR1 must be within the limits detailed under "Hold on" in Table 1.

(4) Decrease VR1 until lamp L1 illuminates then increase VR1 until lamp L1 extinguishes. The difference between the two values of VR1 must be within the limits detailed under "Hold on" in Table 1.

(5) The difference between the value of VR1 at which one lamp extinguishes and the value at which the other illuminates must be within the limits detailed under "Differential, narrow band" in Table 1.

(6) The mean of the values of VR1 at which lamps L1 and L2 extinguish must be within the limits detailed under "Centre of range" in Table 1.

(7) Should the amplifier on test be Type FLM/A/905 or 915 set switch S1 to position 2 and repeat the operations detailed in sub para. (2) to (4). The "hold-on" and "centre of range" values must be within the limits detailed in Table 1. The "differential" must be within the limits detailed under "Differential, wide band" in Table 1.

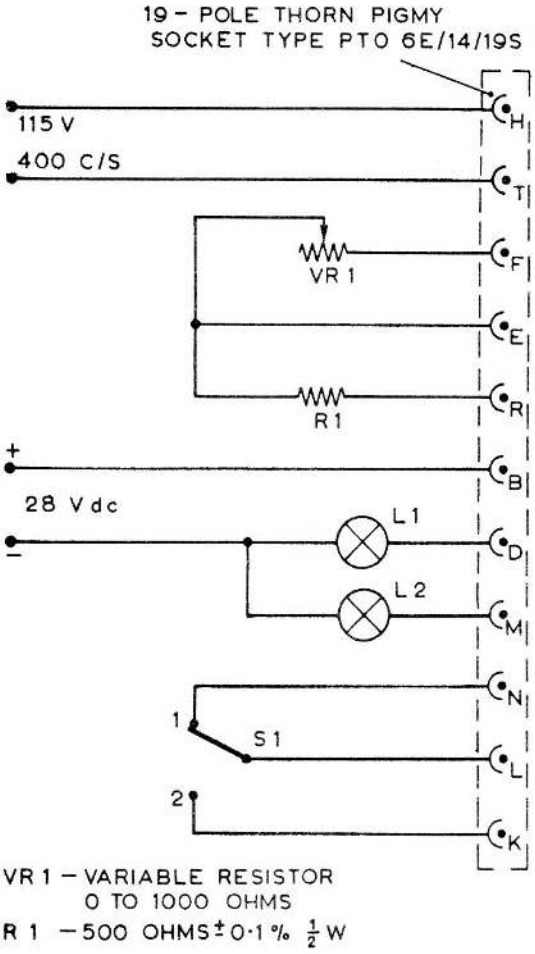


**Fig. 1.**
**Test circuit for FLM/A/905 and 915**

**Leakage current test**

**5.** Measure the leakage current as specified in sub. para. (1) and (2) by applying the following test. Connect a 0-50mA industrial grade ammeter (Multimeter Type 12889, Ref. No. 5QP/17447) in series with a 0·5 megohm, ¼ watt resistor. Connect the meter and resistor in series with a d.c. supply variable between 0 and 28V. Connect the test circuit as specified with the test voltage at **zero** potential. Now gradually increase the testing potential to 28V. The leakage current should not exceed 1·4 mA. The testing voltage must be increased and decreased gradually between 0 and 28V.

(1) Between pins B,D,E,F,H,K,L, M,N,R, and T of the 19-pole plug and the cover on amplifiers, Type FLM/A/905 and 915.

(2) Between pins B.D.E.F.H.M and T of the 19-pole plug and the cover on amplifier, Type FLM/A/909.

The test voltage must be applied for at least 15 seconds in each case.

**Note. . .**

*Insulation resistance tests should not be applied to any equipment which incorporates transistors or other semi-conductors. The voltage applied to such equipment must not exceed the voltage for which the sub-assembly items, e.g. capacitors, transistors, etc., are designed. Servicing information concerning semiconductors is contained in A.P.4343, Vol.1, Sect.1, Chap.4. Precautions referred to in this Chapter should be observed during all testing and servicing.*

**Continuity test**

**6.** The resistance between the following points must be zero:-

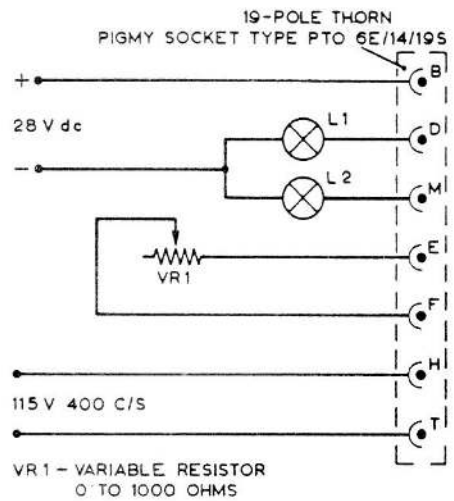


**Fig. 2. Test circuit for FLM/A/909**

(1) Between pins L and R of the 19-pole plug on amplifiers, Type FLM/A/905 and 915.

(2) Between the cover and pins A,C, G, J, P, S, U and V of the 19-pole plug on all types.

**Table 1**

**Test requirements**

| Amplifier Type FLM/A | Hold-on ohms | Differential ohms | | Centre of range ohms |
|---|---|---|---|---|
| | | Narrow band | Wide band | |
| 905 | 0·25 to 1·5 | 2·5 to 5 | 9 to 11 | 496 to 504 |
| 909 | 0·25 to 1·5 | 5 to 7 | Not applicable | 509 to 517 |
| 915 | 0·1 to 0·5 | 2 to 4 | 8 to 10 | 496 to 504 |

Appendix 1

# TEMPERATURE CONTROL AMPLIFIER, TYPE FLM/A/905

## LEADING PARTICULARS

| | |
|---|---|
| *Temperature control amplifier, FLM/A/905* | *Ref. No. 5CZ/7568* |
| *Power supplies* | *115V 400 c/s* |
| | *28V d.c.* |
| *Dimensions* | *3·2 in. x 2·7 in. x 2·8 in.* |
| *Weight* | *15 oz.* |

## DESCRIPTION

1. The amplifier, Type FLM/A/905 differs in the following respects from that described in the chapter:-

(1) No bonding clip is secured to the inside of the front plate. A bonding clip which is riveted to the inside of the cover adjacent to the rear printed circuit assembly is bent at right angles to fit over one of the mounting studs.

(2) Two flexible bonding strips are fitted to the amplifier. One is secured by a screw to the front plate and the other is riveted to the rear plate. The free ends of the strips are secured by screws to the mounting plate.

## OPERATION

2. The operation of the amplifier is similar to that given for the amplifier described in Chap.21.

## SERVICING

3. Servicing instructions for this amplifier are as described in the chapter except for the differences given in para. 4 and 5.

**Removal of cover**

4. (1) Remove the screws which secure the flexible bonding strips to the mounting plate. Collect the associated spring and plain washers.

(2) Slacken the screw securing the strap and remove the amplifier from the mounting plate.

(3) Break the locking wire and remove the four nuts which secure the rear plate to the studs. Collect the four bonded seals.

(4) Remove the sealing screw from the pressure test position and collect the bonded seal. Thread a 4 B.A. screw of suitable length into the hole. Grip the screw and pull the rear plate from the cover.

(5) Remove the nut which secures the bonding clip. Collect the spring washer, plain washer and skid washer.

(6) Fit the four special screws to the studs and place the amplifier on the bench with the front plate upward. Grip the cover and press downward to release the cover from the front plate. Remove the four special screws and slide the cover from the amplifier.

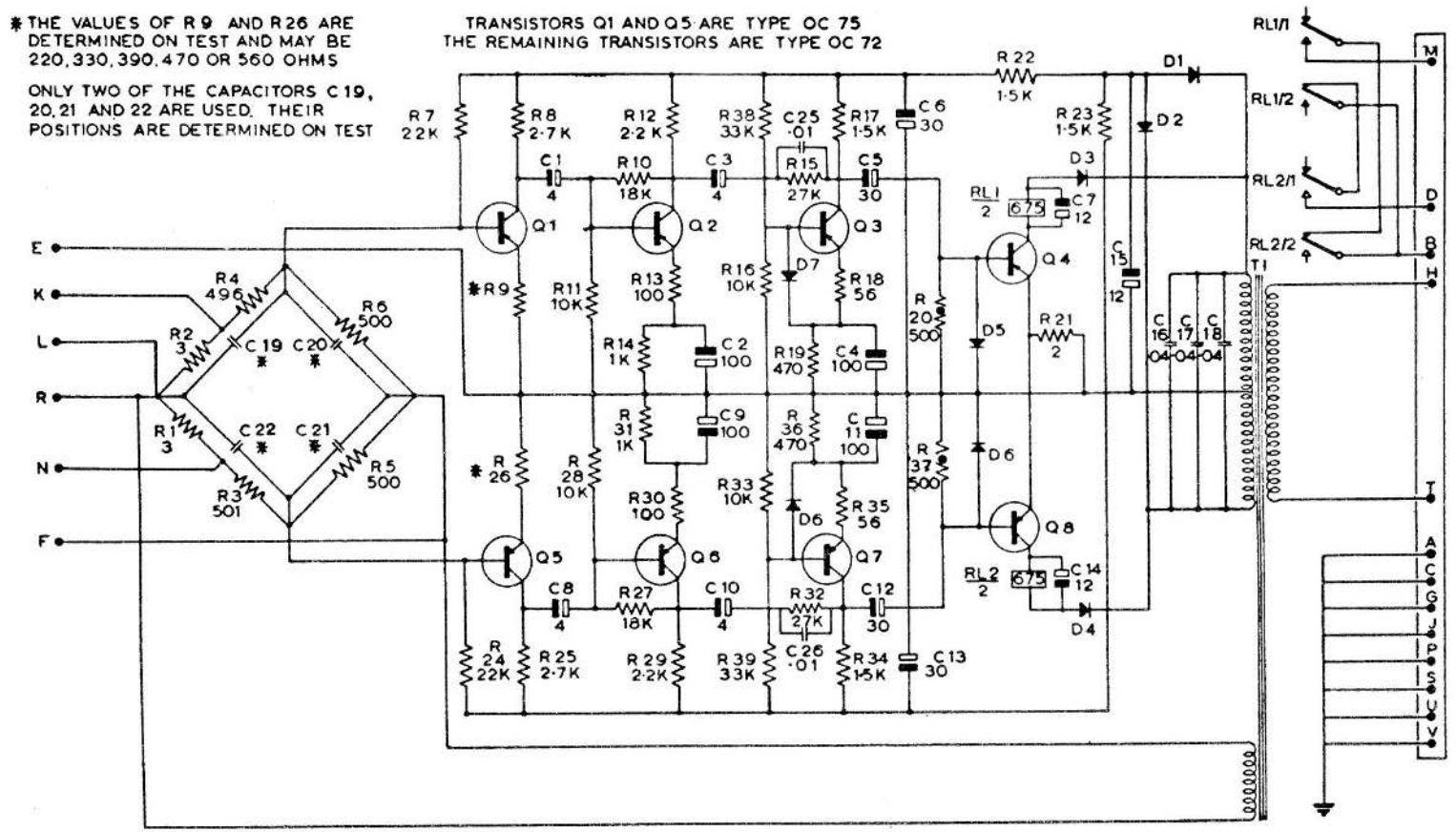


**Fig. 1. Circuit diagram**

RESTRICTED

**Assembly**

**5.** (1) Position the amplifier with the front plate away from the operator and the 19-pole plug lowermost.

(2) Fit the spacers and printed circuit boards over the studs and secure them with nuts fitted over plain and spring washers at each stud except the lower left hand one.

(3) Slide the cover over the amplifier so that the internal bonding clip fits over the lower left hand stud. Fit a skid washer, a plain washer and a spring washer over the bonding clip and secure them with a nut.

(4) Fit the rear plate over the studs and fit a bonded seal over each stud. Secure the rear plate with four special nuts.

(5) Fit the amplifier to the mounting plate and tighten the screw in the strap.

(6) Secure the flexible bonding strips to the mounting plate with screws fitted over spring and plain washers.

(7) Apply the bonding test (para. 18 of the chapter,) the leakage test (para. 19, of the chapter) and the functional test (App. A, para. 4).

(8) Lock together the two lower nuts securing the end plate, using a 24 S.W.G. stainless steel wire (Ref. No. 30A/3361) and a lead seal (Ref. No. 29H/2115).

# Appendix 2

## TEMPERATURE CONTROL AMPLIFIER, TYPE FLM/A/909

### LEADING PARTICULARS

| | |
|---|---|
| *Temperature control amplifier, FLM/A/909* | *Ref. No. 5CZ/6348* |
| *Power supplies* | *115 V 400 c/s* |
| | *28V d.c.* |
| *Dimensions* | *3·2 in. x 2·7 in. x 2·8 in.* |
| *Weight* | *15 oz.* |

1. This amplifier is identical with that described in the chapter.

Appendix 3

# TEMPERATURE CONTROL AMPLIFIER, TYPE FLM/A/915

## LEADING PARTICULARS

| | |
|---|---|
| *Temperature control amplifier, FLM/A/915* | *Ref. No. 5CZ/7790* |
| *Power supplies* | *115V 400 c/s* |
| | *28V d.c.* |
| *Dimensions* | *3·7 in. x 2·7 in. x 2·8 in.* |
| *Weight* | *1 lb: 2 oz.* |

## DESCRIPTION

1. The amplifier, Type FLM/A/915 differs in the following respects from that described in the chapter:-

(1) The transformer which is mounted to the front plate has only one secondary winding and supplies the rectifiers which feed the amplifying and output circuits. A second transformer which supplies the bridge is mounted on the first printed circuit board.

(2) The first printed circuit board carries, in addition to the bridge transformer, two relays, the supply rectifiers and the smoothing resistors and capacitors.

(3) The second printed circuit board carries the two output transistors and the components associated with their input circuits.

(4) The third printed circuit board carries eight transistors and associated resistors and capacitors to provide four stages of amplification for each channel.

(5) The electrolytic capacitors in this amplifier are solid tantalum types.

## OPERATION

2. The operation of this amplifier is similar to that given for the amplifier described in Chap.21.

## SERVICING

3. This amplifier should be serviced as detailed in para. 13 to 18 of the chapter except for the following:-

(1) It is not necessary to examine electrolytic capacitors for leakage.

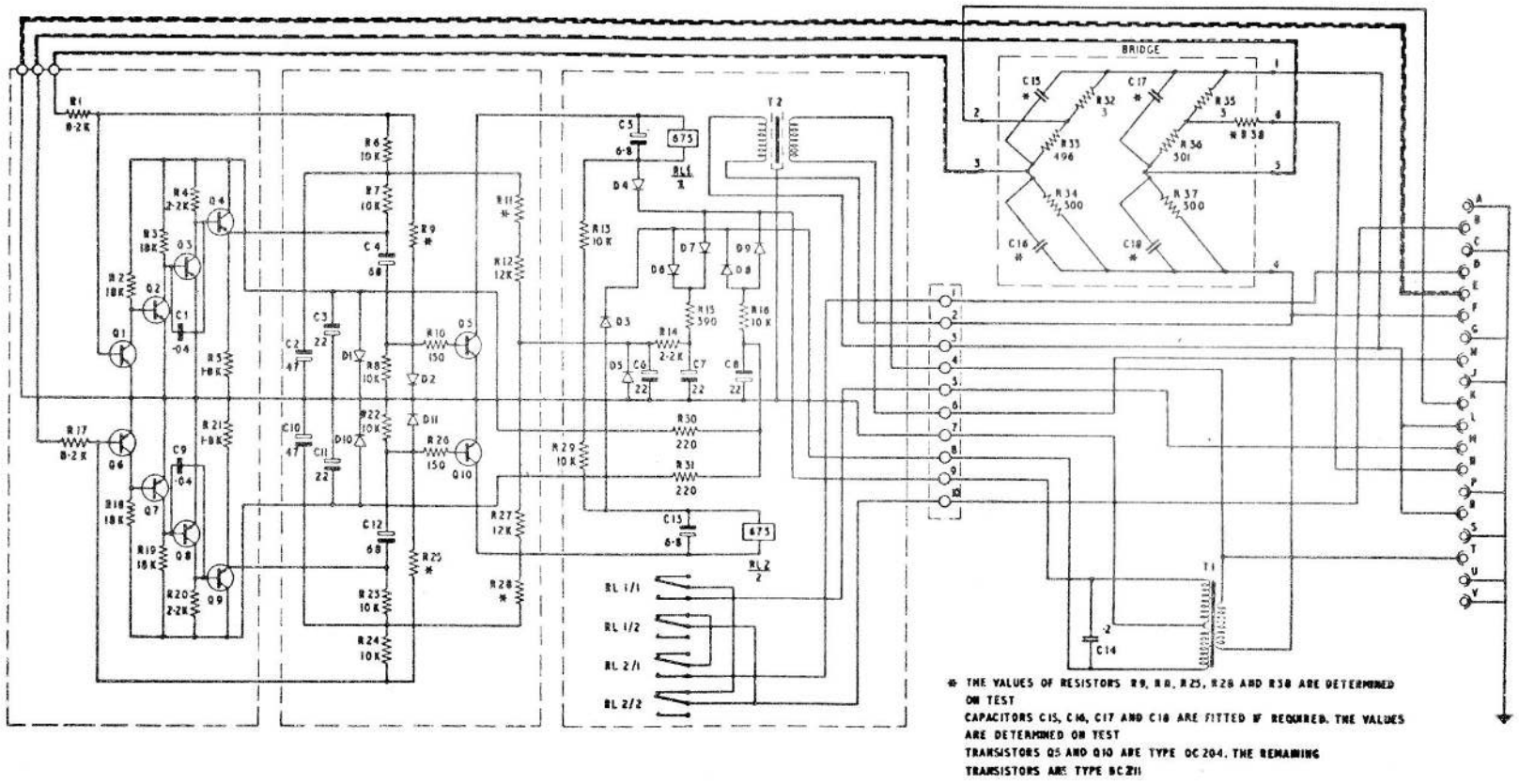


**Fig. 1. Circuit diagram**



7 15/32 8241 7623 1875 1/65 TAC 1480