Chapter 12

TRIPLE FIRE DETECTION A.C. CONTROL UNIT, GRAVINER, TYPE 164D(2)

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

LIST OF APPENDICES

LEADING PARTICULARS

A.C. Control unit, Graviner, Type 164D(2)	**Ref. No. 5CZ/7605**
Input voltage	115*V*, 400 *c/s*
Input current—	
Unit at standby	10*mA* (*max.*)
Unit operating warning system (*normal*)	20*mA* (*max.*)
Unit operating warning system (*maximum*)	60*mA* (*max.*)
Overall dimensions (*case and mounting*)—	
Length	6·25 *in.*
Width	3·33 *in.*
Height	2·55 *in.*
Weight	1·8 *lb.*
Ambient temperature range	—55°C to 120°C
Contact rating—	
Warning relay	3 *amp. at* 28*V D.C.*
Test relay	3 *amp. at* 28*V D.C.*

Introduction

1. The Graviner, Type 164D, A.C. control unit is used in conjunction with a single loop sensing element to give a warning when fire or overheat conditions exist in the monitored fire zone. The control unit may be mounted in any attitude and remote from the fire zone where the ambient temperature will not exceed 120°C. A general view of the unit is shown in Fig. 1.

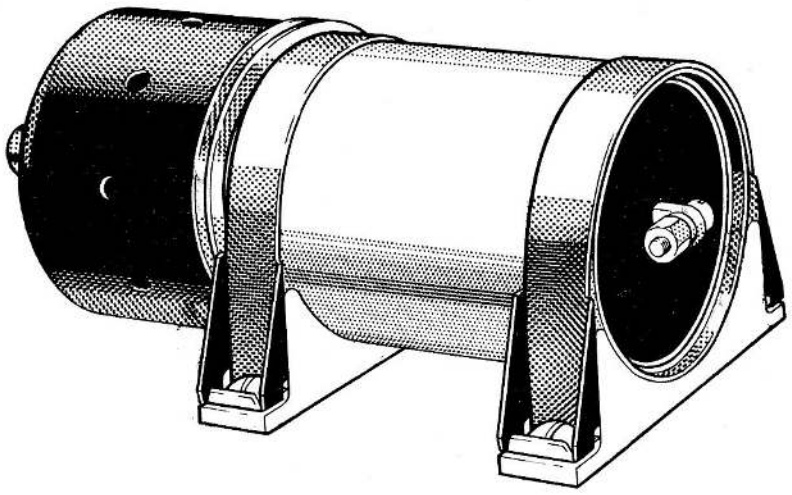

Fig. 1. General view of a.c. control unit, Graviner, Type 164D(2)

2. Electrical connections to the control unit are made via a 9 way terminal block fitted at one end of the unit. The terminals are protected by a removable rubber cap which has a centre aperture to receive cable and binding post.

3. Operation of the unit is achieved by utilising the a.c. impedance and capacitance of the sensing element. A false warning will not be given should a short circuit occur due to damage of the sensing element or a fault in the wiring between the sensing element and the control unit.

4. This chapter deals only with the Type 164D(2) control unit. Details of the sensing element and accessories are given in Chapter 2 of this section.

Note . . .

Mk. 1 sensing elements listed in Table 1 of Chapter 2 are NOT to be used with the Triple F.D. control units.

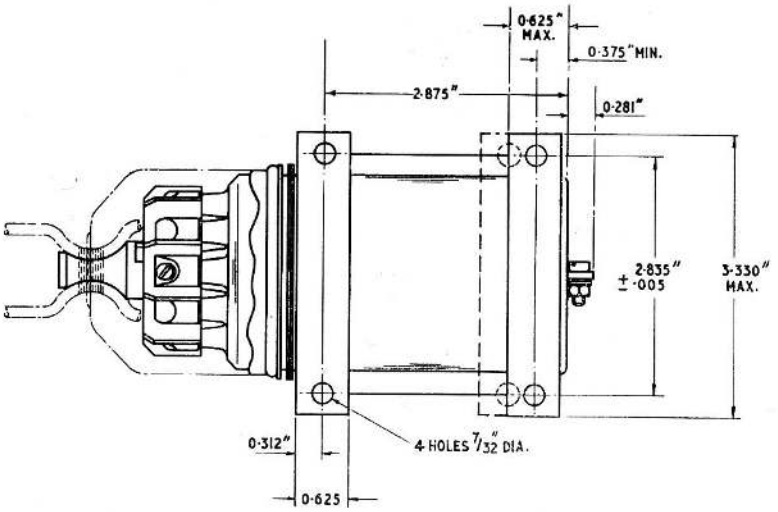

Fig. 2. View of terminal block and mounting arrangements

DESCRIPTION

General

5. The control unit consists of modules containing the circuit components, coated in 'Silastomer' and sealed within a stainless steel case. Mounting is by means of two saddles and straps which hold the unit securely when the four 2 B.A. or 10 U.N.F. fixing bolts are tightened.

Circuit

6. The a.c. control unit circuit shown in Fig. 3 can be split into three sections, each performing a separate function. These are the internal charging or sensing circuit, the read-out or signal circuit and the warning circuit. The supply for these three circuits is provided by the transformer T1.

7. The transformer secondary windings are wound such that if terminal 3 is positive with respect to terminal 4, then terminal 5 is positive to terminal 6 and terminal 5 is positive to terminal 4, i.e. winding S2 is counter-wound with respect to windings S1 and S3. The output voltage, of windings S1 and S2 is approximately 13V, and that of winding S3 is approximately 32V.

8. The charging circuit feeds a half wave rectified supply to the sensing element and comprises winding S1, diode MR1, resistor R3, the sensing element and resistor R1. The read-out or signal circuit comprises the following; winding S2, resistor R4, choke L1, the sensing element and resistor R1. The warning circuit comprises S3, diode MR2, resistor R2, relay RLA and capacitor C2, and the silicon controlled rectifier MR4. The bias on the SCR is maintained during the non-conducting half cycle by capacitor C3 and resistor R4. S3 winding charges capacitor C3 in series with R5 and MR5, MR6 acting as a blocker. The Zener diode MR3 controls the voltage across the SCR by-passing surges, R2 acting as a limiting resistor while the Zener diode is conducting.

9. A test circuit is incorporated in the unit to allow in situ testing of both the unit and the sensing element. This consists of a test relay RLB and a capacitor C1 which simulates the capacitive effect of the sensing element during testing.

OPERATION

10. The Triple F.D. Firewire system utilises the total impedance and the capacitive effect of the sensing element, whereas previous systems only utilised the value of resistance between inner and outer conductors of the sensing element. To facilitate the monitoring function of the read-out circuit the charging current flows for one half cycle only. During the alternate half cycle energy stored during the previous half cycle in the sensing element is discharged into the read-out circuit.

11. The supply to the sensing element produces a positive charge on the outer electrode and a negative charge on the centre electrode. The quantity of charge stored is regulated by the temperature of the sensing element. The operating characteristic of the element is such that an increase of temperature increases the quantity of charge stored and simultaneously decreases the resistance between centre and outer electrodes, within the warning band of temperature.

Standby condition

12. Standby conditions exist when the temperature of the fire zone is below that required for a warning signal and the impedance of the sensing element is high. This high impedance limits the charging current flowing through the sensing element for the positive half cycle to a negligible value, hence a negligible charge is accepted by the sensing element. Winding S2 is also connected across the sensing element, but the high impedance of the choke L1 to a.c. prevents it contributing to the effective charging current.

13. During the next half cycle, no current flows in the charging circuit because of the blocking action of the rectifier MR1, therefore any charge potential across the sensing element is now presented as a d.c. voltage in the read-out circuit in series with the negative half cycle output of S2 winding. Negligible current flows in the read-out circuit as the charge on the element is small and the impedance of the choke to the a.c. voltage from S2 winding is high. This sequence continues in the charging and the read-out circuit during standby condition.

14. The SCR (MR4) is biased off when the system is at standby, the bias potential on the

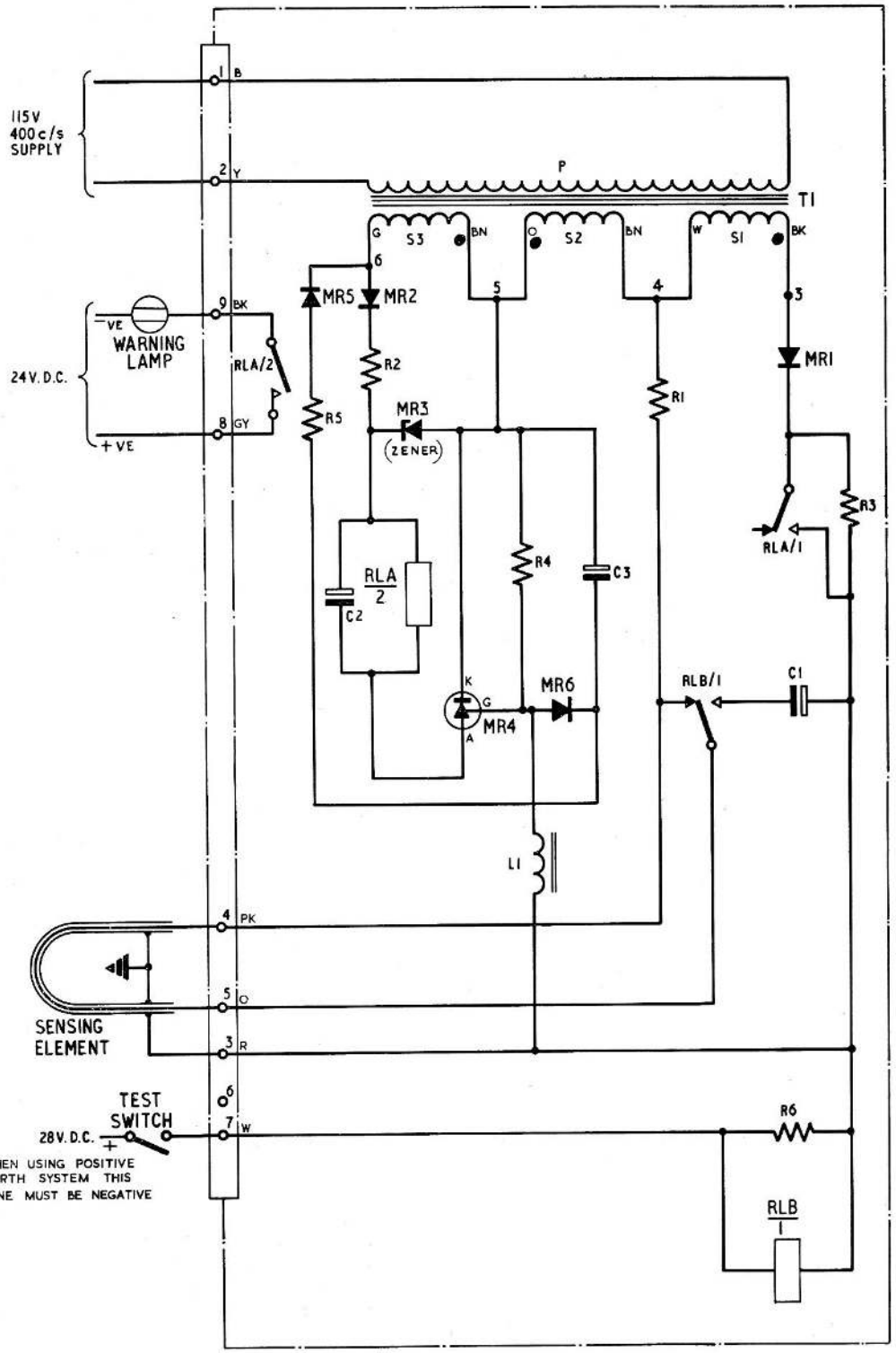

Fig. 3. Circuit diagram

Printed for H.M. Stationery Office by J. Looker Ltd., Poole
Wt. 51509 D/d 5426 1875 3/65 **375/3**

gate is dependant upon the potential drop across resistor R4. During the positive half cycle the bias is established by the output of S3 winding passing a current via R4, MR6, R5 and MR5, capacitor C3 is charged at the same time in series with R5 and MR5. During the negative half cycle no current flows in the bias circuit, but the bias potential on the SCR is maintained by capacitor C3 discharging through resistor R4. The SCR is held in the non-conducting state and the warning relay RLA remains de-energized.

Warning condition

15. When the temperature at any point in the monitored fire zone reaches a warning condition, the impedance of the sensing element is reduced and a greater quantity of charge is allowed to be stored. During the negative half cycle this charge on the sensing element discharges through resistor R4, in series with winding S2 (additive). The bias potential on the gate of the SCR is now at a sufficient level to allow the SCR to conduct. Current will now flow through MR2, R2, operating coil of relay RLA and at the same time charge capacitor C2, the SCR and so back to winding S3.

16. When the warning relay RLA is energized the contacts RLA-1 and RLA-2 close. RLA-1 contact will short out the resistor R3, thus increasing the charging current to the sensing element during the next positive half cycle. The resulting increase of charge on the sensing element further raising the potential on the gate of the SCR, supplementing the original warning signal. Contact RLA-2 completes the positive supply to the fire warning circuit giving a warning signal.

17. During the next positive half cycle the sensing element is re-charged to a further increased level, due to R3 being shorted. Relay RLA is held in the energized position by the discharge current of capacitor C2. This cycle is repeated for as long as the sensing element maintains the warning level signal to the gate of the SCR. Raising the potential of the gate at the SCR reverses the potential, which exists in the standby condition, of this point with respect to the positive plate of capacitor C3. The silicone diode MR6 is included in the circuit to protect capacitor C3 during the warning condition, the forward voltage drop across MR6 being greater than the voltage drop across R4, thus a reversal of potential across capacitor C3 is prevented.

18. When the temperature throughout the monitored fire zone has reduced to a safe level, the impedance of the sensing element will increase and the charge stored across it decrease. Hence the potential at the gate will be removed and the SCR will return to the non-conducting state. The value of the sensing element impedance to return the SCR to a non-conducting state will have to be of a higher order than the value at which the warning signal was initiated. This is due to resistor R3 being shorted out by contact RLA-1, thus lowering the total impedance of the sensing circuit.

19. Therefore to reduce the charge on the sensing element to the standby condition the impedance of the element must increase to a value which exceeds the initial warning impedance by the value of R3. The removal of the signal on the gate of the SCR causes it to stop conducting and hence relay RLA will be de-energized. The system is then restored to the standby state.

Test of system and a.c. control unit

20. In-situ testing of the Triple F.D. system is achieved by a test switch normally mounted on the aircraft warning panel. With the control unit supplies switched on, (115 volt 400 c/s and warning circuit 28 volts d.c.) and the sensing element connected, operation of the test switch completes the circuit to the operating coil of test relay RLB. If RLB does not energize this indicates a fault in the earth connection of the outer electrode of the sensing element, as the return path is via this connection. When RLB energizes and closes contact RLB-1, this connects capacitor C1 in series with the centre electrode of the sensing element.

21. A charge will now be built up across C1, the charging circuit being completed via contacts RLB-1 and the entire length of the centre electrode of the sensing element. The value of the capacitor C1 is such that, during a positive half cycle sufficient charge will be stored in C1 combined with the sensing element to raise the potential on the gate of the SCR when it discharges during the following negative half cycle. The SCR will then

conduct thus energizing relay RLA and a fire warning will be given as previously described in para. 15.

22. The warning will be given as long as the test switch is held closed. On releasing the test switch, relay RLB will be de-energized taking capacitor C1 out of the circuit. Insufficient charge will now be stored in the sensing element therefore the potential at the gate of the SCR will fall and the SCR will revert to the non-conducting state hence warning relay RLA will de-energise and the warning signals will cease.

23. There is in fact a time delay of 100 milliseconds between release of the test switch and cessation of the warning signal. This is due to the time constant of the control unit circuit. This time delay must be taken into consideration when testing units which are used in conjunction with an automatic fire extinquishing system, where the test switch renders the extinquishing circuit safe during test. Details of specific fire warning and extinquishing systems, together with test procedures, are written into the relevant Aircraft Handbooks to which reference should be made.

Fault indication

24. An advantage of the Triple F.D. system is that the built in test circuit can readily discriminate between serviceable and unserviceable detector systems and give fault indication. Correct interpretation of the indications given when the test switch is operated are necessary for fault diagnosis. Maximum benefit of the test facility may be obtained when optimum fault detecting conditions exists in the fire zone:—

(1) Prior to engine start.

(2) Prior to engine shut down, especially if the aircraft has flown.

Fault diagnosis

25. All faults indicated by use of the test switch do not necessarily render the system inoperative, but early detection and rectification will avoid subsequent failure in service. For example, if the warning lamp lights when the test switch is closed and remains lighted when the test switch is opened, the sensing element impedance will have fallen below the reset level, probably due to contamination of a sensing element interconnector. When this condition exists the system will continue to function as a fire and overheat detector, but it is necessary to interrupt the supply to the control unit momentarily to extinguish the warning lamp, further investigation will be necessary at the earliest opportunity. Combinations of test switch positions and indications with their possible causes are listed in Table 1.

TABLE 1

Fault location for in-situ servicing

Test switch closed	Test switch open	Remarks
		SERVICEABLE
Warning lamp glows	Warning lamp extinguished	(a) Continuity of sensing circuit (b) Insulation resistance acceptable (c) Control unit serviceable
		UNSERVICEABLE
Warning lamp does not glow		(a) Discontinuity of sensing circuit (b) Short or low insulation between sensing electrodes (c) Fault in control unit
		SERVICEABLE SEE PARA 25
Warning lamp glows	Warning lamp glows	Low impedance between sensing element electrodes

INSTALLATION

26. The control unit may be mounted in any attitude using the two clamp assemblies. The clamp at the terminal block end is to be positioned against the flange of the case, the other clamp to be positioned within the limits as illustrated in Fig. 2. The earth terminal, at remote end from the terminal block, must be bonded to the aircraft structure.

SERVICING

27. Servicing of the control unit is restricted to a visual examination to ensure it is mechanically sound and undamaged, no dismantling is permissible. The security of the connections, access to which is obtained by removal of the rubber end cap, should be checked. Servicing information on the sensing elements and accessories will be found in Chapter 2 of this section.

In-situ testing

28. Testing of the control unit when fitted to the aircraft is described in para. 20 and probable faults listed in Table 1.

29. Experience has shown that deterioration of the system can arise whilst the aircraft is stood at dispersal such that a warning is given when supplies are switched on. A warning given under these conditions indicates a fault due to the ingress of a salt water solution between the inner and outer electrodes of the sensing element. This type of warning will only arise under a combination of adverse weather conditions and a failure of the sensing element, permitting the ingress of the salt solution.

30. The solution acts as an electrolyte between the sensing element electrodes causing a primary cell affect. This e.m.f. is then added to that across the faulty detector, due to the normal charging during the positive half cycle, the total e.m.f. being of sufficient value to trigger off a warning signal. The warning can be cancelled by opening the supplies, after which the faulty sensing element or connector must be renewed.

31. When a fault indication is given by operation of the test switch the functioning of the control unit may be checked by the following procedure:—

(1) Disconnect the electrical connection from control unit (terminals 3, 4 and 5) to the sensing element.
(2) Connect a 470 ohm resistor across terminals 4 and 5 and connect terminal 3 to earth.
(3) Operate test switch and a warning signal should be given. If this test is satisfactory the sensing element should then be serviced using the information contained in Chapter 2 of this section.

Bench testing

32. The control box may be functionally tested using the procedure and test circuit contained in the Standard Serviceability Tests, in Appendix A to this chapter. Additionally the following tests may be made.

Input current tests

33. Connect circuit as shown in Fig. 4, the input current for various states of operation may be measured as follows:—

(1) Set the decade resistance box to 10K ohms, switches B and C to position 2, switch A to OFF. Switch ON the supplies and read the current indicated on the milliammeter, this should not exceed 10mA.
(2) Repeat (1) with switch B set to position 1.
(3) Reduce the value of decade resistance box until the warning lamp glows, the setting of the decade resistor at this point should be between 1,160 ohms and 900 ohms and the input current indicated on milliammeter must not exceed 20mA.
(4) Repeat (3) with switch B to position 2.
(5) Set switch C to position 1, set decade resistance box to ZERO ohms, the maximum input current reading on milliammeter should not exceed 60mA.
(6) Set switch B to position 1 and repeat (5) above.

False warning test

34. This test is to ensure that the unit will not give a false warning due to voltage surges. Test procedure is as follows:—

(1) Connect a 150 volt 400c/s a.c. supply, with a variable resistor shunted by a normally open push switch in series

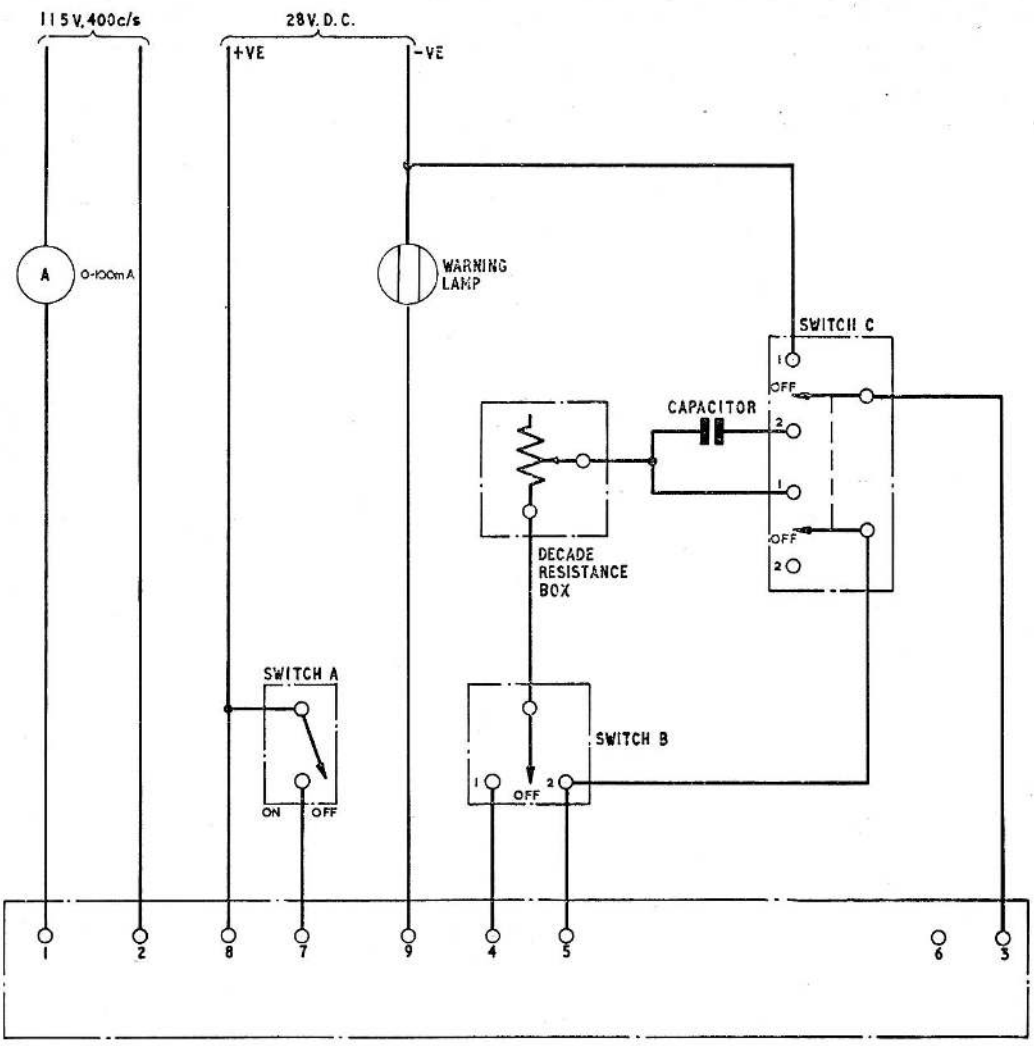

Fig. 4. Test circuit diagram

with one lead to terminals 1 and 2 of control unit. Value of variable resistor to be 0—5000 ohms with a current rating of 20mA.

(2) Connect a 28 volt d.c. supply, with a 28 volt test lamp in series with one lead, to terminals 8 and 9 of control unit.

(3) Connect a 600 ohm resistor between terminals 3 and 4 of control unit.

(4) Set the variable resistor to place maximum resistance in series with supply

(5) Switch on supplies and adjust the variable resistor to give 115 volts across terminals 1 and 2 of the control unit, and check that the warning lamp is extinguished.

(6) After a slight pause raise the supply voltage to the unit by momentarily operating the push switch and ensure that the warning lamp remains extinguished.

After this test the relay unit must be tested using the procedure given in the Standard Serviceability Test, Appendix A to this chapter.

35. Units which fail any of the above tests should be returned for repair in accordance with current authorised procedure.

Appendix A

STANDARD SERVICEABILITY TEST

for

CONTROL UNIT, GRAVINER, TYPE 164D(2)

Introduction

1. The following tests may be applied to a control unit prior to installation or whenever serviceability is suspect.

TEST EQUIPMENT

2. The following test equipment, or equivalents will be necessary to perform these tests:-

(1) A decade resistance box, 0—11,100 ohms Ref. No. 10S/16239.

(2) A Type B warning lamp, Ref. No. 5CX/1553 with a 24 volt, 3·5 watt lamp.

(3) A 1·0 ± 5%μF, 35 volt working capacitor.

(4) A 28 volt d.c. supply and a 115 volt 400c/s a.c. supply having a harmonic content no greater than 5% i.e. normal aircraft supply.

(5) A 500 volt insulation resistance tester, Type A, Ref. No. 5G/1621.

(6) A single pole ON-OFF switch Ref. No. 5CW/6430.

(7) A single pole change over switch with a centre off position Ref. No. 5CW/6431.

(8) A double pole change over switch, centre off position Ref. No. 5CW/6437.

TEST PROCEDURE

3. (1) Connect the control unit to a test circuit, as shown in Fig. 1 with the value of resistance set to 3000 ohms and switches set to off position.

(2) Set switch B to position 1 and switch C to position 2 ensuring the warning lamp does not burn.

(3) Steadily reduce the value of resistance until the warning lamp lights, the resistance value at this point should be between 1,160 ohms and 900 ohms.

(4) Increase value of resistance slowly until the warning lamp is extinguished, resistance value at this point should be between 1,600 ohms and 2,700 ohms.

(5) Set switch B to position 2 and repeat steps (3) and (4).

(6) Increase the decade resistance box to 3000 ohms.

(7) Set switch B to position 1 and switch C to position 1.

(8) Set decade resistance box to 470 ohm.

(9) Set switch A to ON and ensure that the warning lamp lights.

(10) Set switch A to OFF and ensure that the warning lamp is extinguished.

(11) Set all switches to OFF, remove supplies and disconnect control unit from test circuit.

Insulation resistance test

4. Measure the insulation resistance of the control unit using a 500 volt insulation resistance tester. The reading between terminals 2 and 4 and between all terminals and the steel case should not be less than 20 megohms.

5. Units which fail any of the above tests should be returned for repair in accordance with the current authorised procedure.

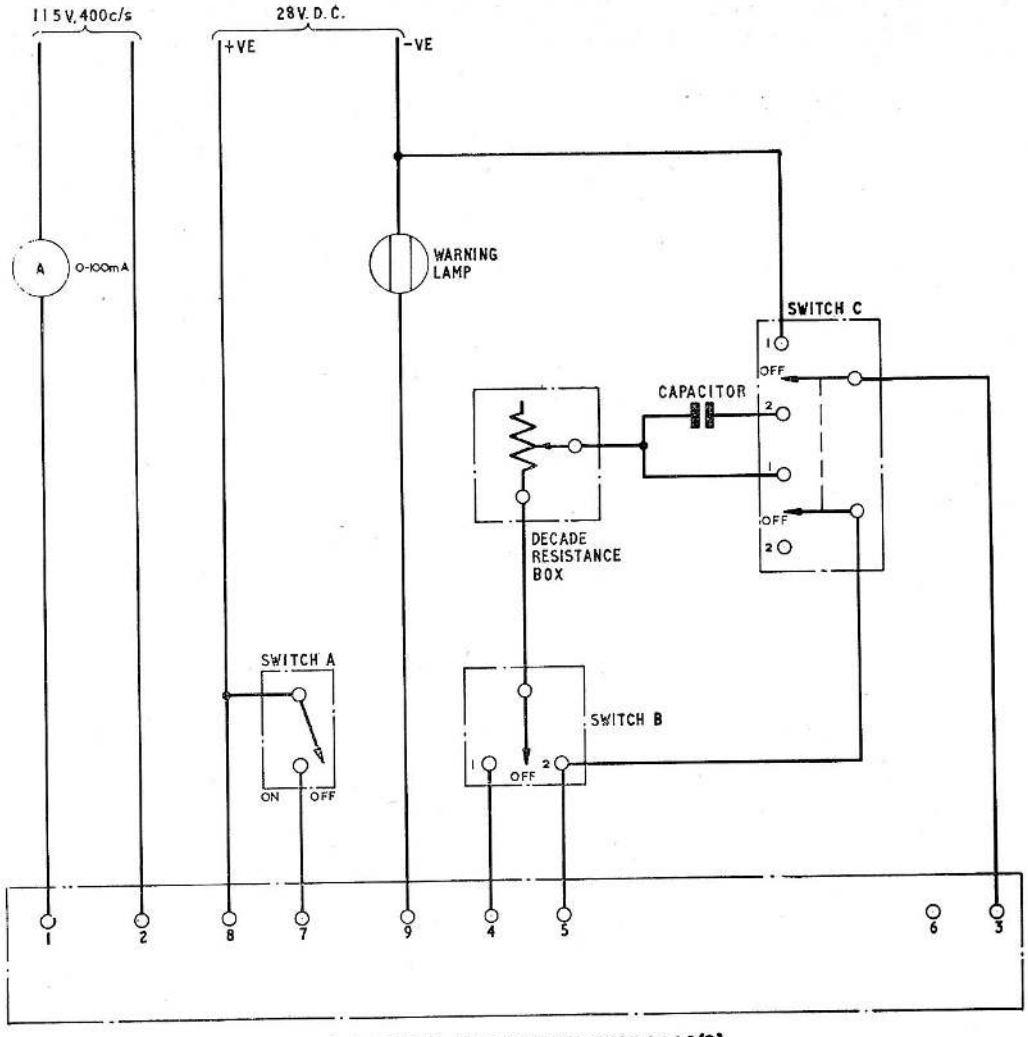

Fig. 1. A.C. control unit, Graviner, Type 164D(2)

Printed for H.M. Stationery Office by L.P.(McC) Ltd., Liverpool.
(82246) Wt. 36239—4229. 1875/11/64. Gp. 375 1