Chapter 11

TRIPLE FIRE DETECTION RELAY UNIT, GRAVINER, TYPE 162D

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LEADING PARTICULARS

Relay unit, Graviner, Type 162D	*Ref. No.* 5CZ/7404
Input voltage	115*V*, 400*c/s*
Input current:	
Unit at standby	10*mA*
Unit operating warning system	20*mA*
Maximum, with sensing element short circuited	60*mA*
Overall dimensions	1·9 *in.* × 2·75 *in.* × 2·7 *in.*
Weight	1 *lb.*

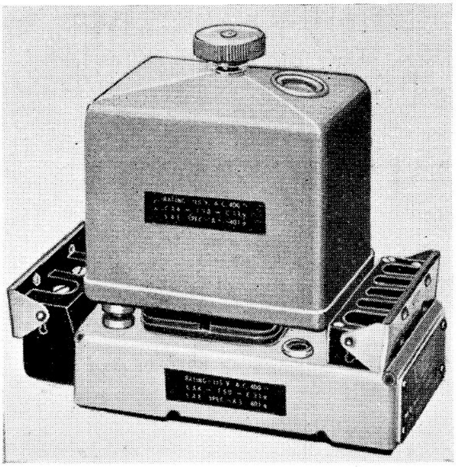


Fig. 1. Relay unit and Type D2240 mounting base

Introduction

1. The Graviner, Type 162D, relay unit is a single way unit used in conjunction with a single loop sensing element system to give warning if fire or overheat conditions arise in the monitored fire zone. The relay unit is fitted remote from the fire zone and is electrically connected to the sensing element which is a continuous type detector routed through the fire zone. Connection to the relay unit is made via a mounting base to which the relay unit is secured.

2. The operation of the unit employs an entirely new principle of Firewire operation utilizing the a.c. impedance of the sensing element and the ability of the element to accept and store an electrostatic charge under warning conditions. Systems using this principle of operation are designated Triple F.D. Firewire systems and offer advantages over the earlier conduction systems. The principal advantages are additional test facilities which can be used to detect faults in the sensing element system and elimination of false warning due to electrical short circuits.

3. This chapter deals only with the Type 162D relay unit which supersedes the Type D1740 relay unit with which it is interchangeable. Details of the sensing element and accessories and of the mounting base units are given in this Section, in Chapters 2 and 21 respectively.

DESCRIPTION

General

4. The relay unit consists of four modules containing the circuit components which are

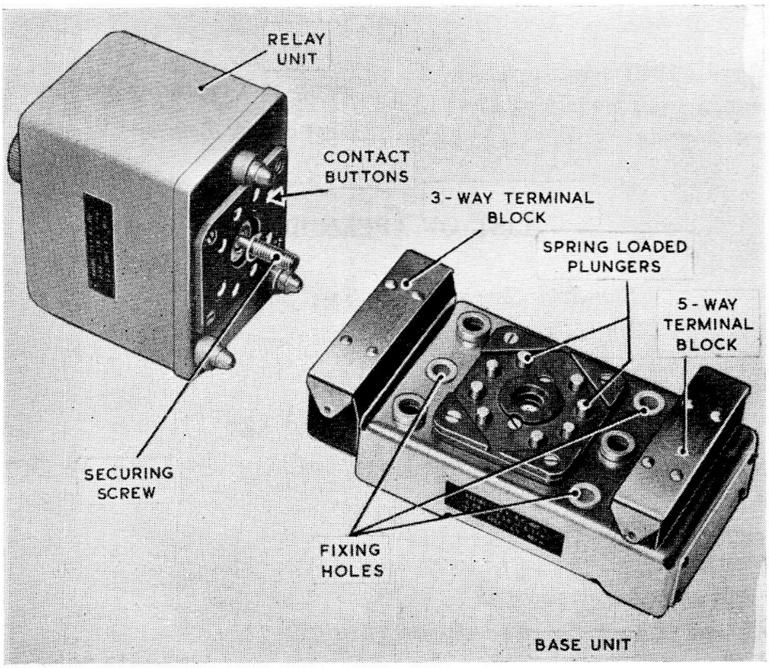


Fig. 2. Relay unit separated from mounting base

potted in a synthetic resin compound within the brass casing. It is mounted on a mounting base to which it is secured by a 2 B.A. knurled stud which passes through the centre of the unit to engage in an insert in the mounting base. There are two versions of the base unit, a rigid base secured direct to the airframe, shown in fig. 1 and 2, and an anti-vibration base unit which consists of the rigid unit carried on three anti-vibration mountings on a plate which is secured to the airframe.

5. Connection between the base unit and the relay unit is made by eight spring loaded contacts on the mounting base which mate with contact studs on the bottom of the relay unit. External connection to the mounting base is made via two terminal blocks one at each end of the base.

Circuit

6. The relay unit circuit, shown in Fig. 3, can be divided into three separate circuits each of which has an individual function. These are the charging or sensing circuit, the read-out or signal circuit and the warning circuit. Power for the three circuits is provided by a transformer, T1, which transforms the 115V, 400c/s a.c. supply to levels suitable for the three circuits.

7. The transformer secondary windings S1 and S3 are similarly wound, whilst winding S2 is counter-wound. Thus at any instance of time when transformer terminal 3 is positive with respect to terminal 4, terminal 5 is positive with respect to terminal 4 and also positive with respect to terminal 6 (as shown by the phasing dots on Fig. 3). The output level across windings S1 and S2 are similar, approximately 13V whilst the output across winding S3 is approximately 32V.

8. The charging circuit is connected across the Firewire sensing element and consists of winding S1, diode MR1 and resistors R3 and R1. The read-out or signal circuit is also connected across the sensing element and consists of winding S2, resistor R4, choke L1 and resistor R1. The warning circuit consists of winding S3, the silicone controlled rectifier (SCR) MR4, relay RLA, resistor R2 and diode MR2. A bias on the SCR is maintained by capacitor C3, resistors R4 and R5 and the diodes MR5 and MR6. The Zener diode, MR3, protects the SCR from transients in the transformer output, conducting at voltages which are approximately 15 per cent in excess of the normal level. For the transient condition resistor R2 serves as a limiting resistance as the resistance of the Zener approaches zero during conduction.

9. A test circuit is also incorporated in the unit to provide for in situ testing of the operation of the unit and of the serviceability of the sensing element system. The test circuit consists of relay RLB and capacitor C1 which is used to simulate the capacitive reactance of the sensing element during testing.

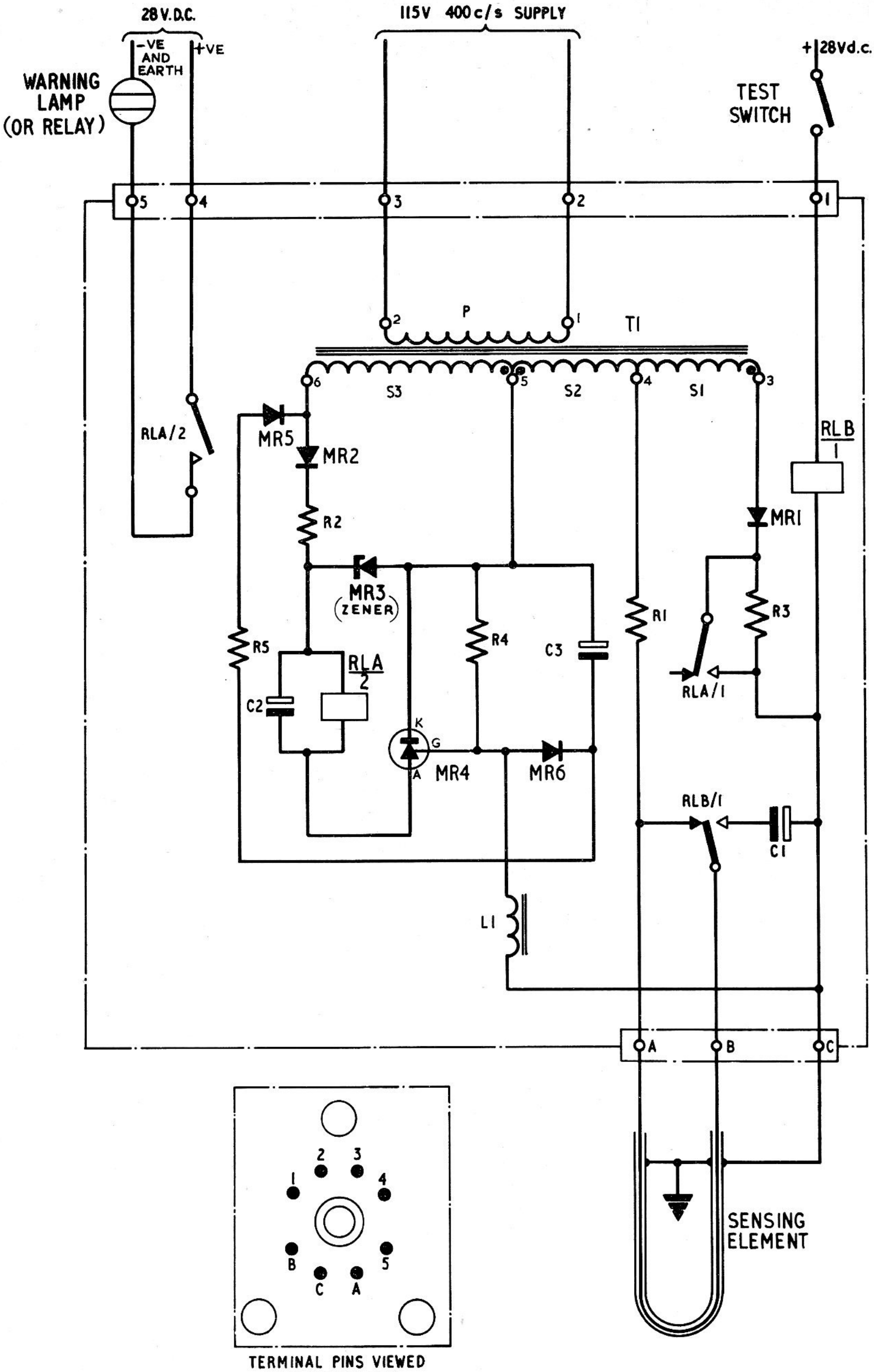
OPERATION

10. The operation of the Triple F.D. Firewire systems utilizes the total impedance of the sensing element, whereas the earlier conduction systems depended only on the change in resistance between the capillary and the centre electrode. The same sensing element is employed, which is energized at all times when the supplies are switched on as previously, but this system monitors the capacitive reactance in addition to the resistive component of the impedance. To facilitate the monitoring function of the read-out circuit the energizing current from the relay unit charging circuit flows for one half cycle only due to the effect of MR1.

11. The charge potential applied to the sensing element produces a positive charge on the capillary and a negative charge on the centre electrode, the quantity of electrostatic charge stored being regulated by the temperature of the sensing element. The operating characteristic of the element for this consideration being such that when heated an increase in the charge across the capillary and the centre electrode occurs, within the warning band of temperature, simultanesouly with a decrease in the resistance.

Standby conditions

12. Standby conditions exist when the temperature of the fire zone is below that required for a warning signal and the impedance value of the sensing element is consequently high. This high impedance limits the charging current flowing through the sensing element for the positive half cycle, in practice negligible current flows, there being a virtual open circuit existing and no charge is accepted by the testing element.



TERMINAL PINS VIEWED FROM MATING SIDE

Fig. 3. Relay unit circuit diagram

Although winding S2 of the read-out circuit is also connected across the sensing element the high inductance of the choke L1 to a.c. prevents it contributing to the effective charging current.

13. At the next half cycle, the negative half cycle, no current flows in the charging circuit because of the blocking action of the rectifier MR1, so 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 of the a.c. output of winding S2. Negligible current flows in the read-out circuit as the charge on the element is low and the reactance of the choke to the a.c. voltage due to winding S2 is high. This sequence continues in the charging and read-out circuits during standby conditions.

14. With the system at standby the SCR (MR4) is biased off, the bias potential at the gate being due to the potential drop across resistor R4. During the positive half cycle the bias is established by the output of winding S3 which passes a current through the bias circuit consisting of R4, and R5, MR5 and MR6, whilst charging capacitor C3 at the same time. At the negative half cycle no current can flow in the bias circuit but the bias potential is maintained by the discharge of capacitor C3 through resistor R4 resulting in a similar potential drop across the resistor. With the SCR maintained in the non-conductive state the warning relay RLA remains de-energized there being no current flowing in the warning circuit.

Warning conditions

15. When warning conditions exist the temperature of the sensing element is raised to a point such that the charge stored by the element in the positive half cycle reaches a pre-determined high level. At the next negative half cycle the d.c. potential due to the sensing element is sufficient to raise the potential of the gate so that the SCR conducts. Current then flows through relay RLA via rectifier MR2, resistor R2 and the SCR whilst capacitor C2 is charged.

16. At the next positive half cycle the charge potential in the sensing element is restored to the previous high level by the charging circuit whilst relay RLA is maintained energized by the discharge of capacitor C2. The cycle is then repeated for the time that the sensing element signal maintains the warning potential at the gate of the SCR. Raising the potential at the gate of the SCR reverses the potential normally existing at this point in respect to the positive plate of capacitor C3. The silicone junction diode MR6 is incorporated to protect this capacitor during the warning period, the forward voltage drop through it exceeding that across resistor R4, and thus preventing a reversal of potential across the capacitor.

17. When the warning relay RLA is energized both sets of contacts, RLA—1 and RLA—2 close. Contacts RLA—2 complete the positive supply to the fire warning circuit giving a warning signal. Contacts RLA—1 short out resistor R3 in the element charging circuit, thus increasing the charging current to the element at the next positive half cycle. The increase in the charge on the element further raises the potential on the gate of the SCR supplementing the original warning signal.

18. When the temperature in the fire zone falls the impedance of the sensing element will increase and the charge stored across it will decrease. In order to return the SCR to the non conducting state the potential at the gate must be removed. The value of element impedance necessary to remove the signal will be of a higher order than the impedance at which the signal was initiated. This is due to the shorting out of resistor R3 by the contacts RLA—1 which has lowered the total impedance of the element and charging circuit by the value of R3.

19. Consequently to reduce the charge on the element to the standby state the element impedance must increase to a value which is greater than the initial warning impedance by the value of resistor R3. This is shown diagrammatically by the R3 band on the resetting scale of the operating characteristic, fig. 4. With the removal of the signal from the gate of the SCR conduction ceases and relay RLA is de-energized. The fire warning is then cancelled and resistor R3 replaced in the charging circuit. The system is once more at standby.

Testing of a serviceable system and relay unit

20. In-situ testing of the Triple F.D. system is provided by a test switch, normally on the warning panel, and a test relay RLB in the

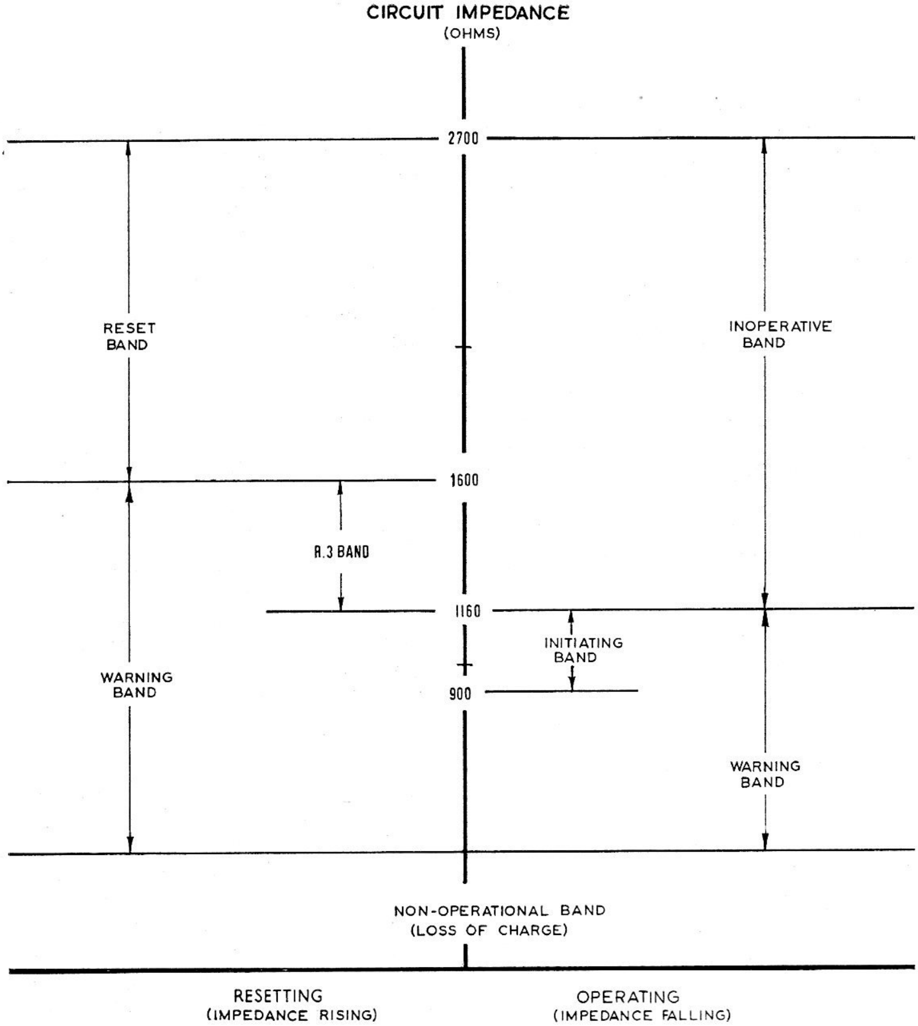


Fig. 4. Relay unit operating characteristic

relay unit. With the relay unit a.c. supply and the warning circuit d.c. supply switched on and the sensing element system connected, operation of the test switch completes the positive supply to the coil of the test relay RLB. The return circuit being connected to earth via the sensing element capillary. The test relay is then energized and contacts RLB—1 close, operation of the relay proving satisfactory connection between the control unit and the element capillary and between the element capillary and earth. Closing the contacts RLB—1 connects capacitor C1 of the relay unit in series with the central electrode of the sensing element.

21. As the relay unit is operative and monitoring the impedance of the sensing element system, the charging circuit will build up a charge across capacitor C1. The charging circuit being completed through the now closed contacts of relay RLB and the centre electrode of the sensing element. The value of the capacitor is chosen in manufacture so that with continuity through the centre electrode the charge stored during the positive half cycle will be sufficient to raise the potential at the gate of the SCR such that during the negative half cycle it will conduct. Relay RLA will then be energized and a fire warning given similarly to fire warning conditions.

22. The warning will remain on whilst the test switch is held closed. Releasing the switch will de-energize the test relay RLB, open the contacts in the circuit to capacitor C1 and hence remove the signal from the SCR. The SCR will then return to the non-conductive state and relay RLA will be de-energized and the warning signal cancelled.

23. In the design of the unit there is an inherent time delay in returning to the off condition of 100 milliseconds. This is due to the CR time constant of the various resistor-capacitor circuits and this time will elapse after releasing the test switch before the SCR returns to the non-conductive state. This time delay must be considered when testing units in installations with automatic fire extinguishing circuits in which the test switch is used to render the extinguishing circuits safe during test operation. Details of individual fire warning and extinguishing circuits, together with their test procedures, are given in the relevant Aircraft Handbook to which reference should be made.

Testing, fault indication

24. One of the advantages of the Triple F.D. fire detection system lies in the ability of the relay unit test circuit to discriminate between serviceable and unserviceable detector systems and give fault indication. Fault diagnosis is achieved by the correct interpretation of the indications given by the warning indicator when the test switch is operated and maximum advantage of the test facility may be made when optimum fault detecting conditions exist in the fire zone:—

(1) Prior to engine start.

(2) Before engine shut down, especially after the aircraft has flown.

25. The faults indicated by the use of the test switch may not immediately render the system inoperative as a fire and overheat detector, but by their early detection they may be removed and subsequent failure in service can be avoided. Indication of the faults is shown by the length of time the warning indicator operates on using the test switch (i.e., a warning signal may be received and remain on after release of the test switch). A list of the possible indications and of the probable causes is given in Table 1.

SERVICING

26. Servicing of the relay unit is restricted to an examination to ensure that it is mechanically sound and undamaged, as it is a potted unit no dismantling of the relay unit is permissible. The contact studs and the base of the relay unit should be examined for cleanliness, paying special attention to oil contamination in exposed installation locations. Servicing information for the sensing elements and accessories and for the mounting base may be found in Chapters 2 and 21 respectively.

In situ testing

27. Testing of the relay unit when fitted to the aircraft is effected by operation of the test switch. Closing the test switch checks the functioning of the relay unit and the serviceability of the sensing element system. Correct operation and a satisfactory sensing element system is indicated by normal indication of the fire warning indicator. Fault indication is also given by the warning indicator as shown in Table 1.

28. Experience gained during operational use has shown that a condition of system deterioration can arise whilst the aircraft is stood at dispersal such that a warning indication will be given when the fire warning supplies are switched on. A warning received in such conditions may therefore indicate a fault, the fault being due to deterioration of the sealing of the sensing element system allowing the ingress of a salt water solution. This type of false warning is given only under a combination of adverse climatic conditions and a failure of the sensing element seal whereby the solution is permitted to enter between the capillary and the centre electrode.

29. The solution then acts as an electrolyte between the two with a primary cell effect. The resulting e.m.f. being added to that arising across the faulty detector due to the normal charging cycle, the total being sufficient to initiate a warning signal. Though the flow of current may result in a decrease in the e.m.f. caused by the water ingress, due to drying out or to chemical change, the warning will be maintained, the low impedance of the sensing element failing to allow the relay unit to reset. The warning can be cancelled by breaking the supplies, after which the faulty sensing element must be renewed.

TABLE 1

Fault location for in-situ testing

Warning indicator (test switch made)	Warning indicator (test switch released)	Possible fault
Inoperative	—	Sensing element system, short circuit between centre electrode and capillary. Sensing element system, centre electrode open circuited. Failure of supplies, relay unit or warning indicator.
Operative	Operative	Low impedance in sensing element system between capillary and centre electrode (fails to allow unit to reset).

Note . . .

To cancel warning, the supplies to the relay box must be broken, verify fault by remaking supplies and retesting.

Operative	Inoperative	Fire warning system serviceable.

30. When a fault indication is given the functioning of the relay unit may be checked by the following procedure:—

(1) Disconnect the electrical connections between the sensing element and the control unit.

(2) Connect a 470 ohm resistor between terminals A and B and connect terminal C to earth.

(3) Operate the test switch, the relay unit should operate and a warning indication be given.

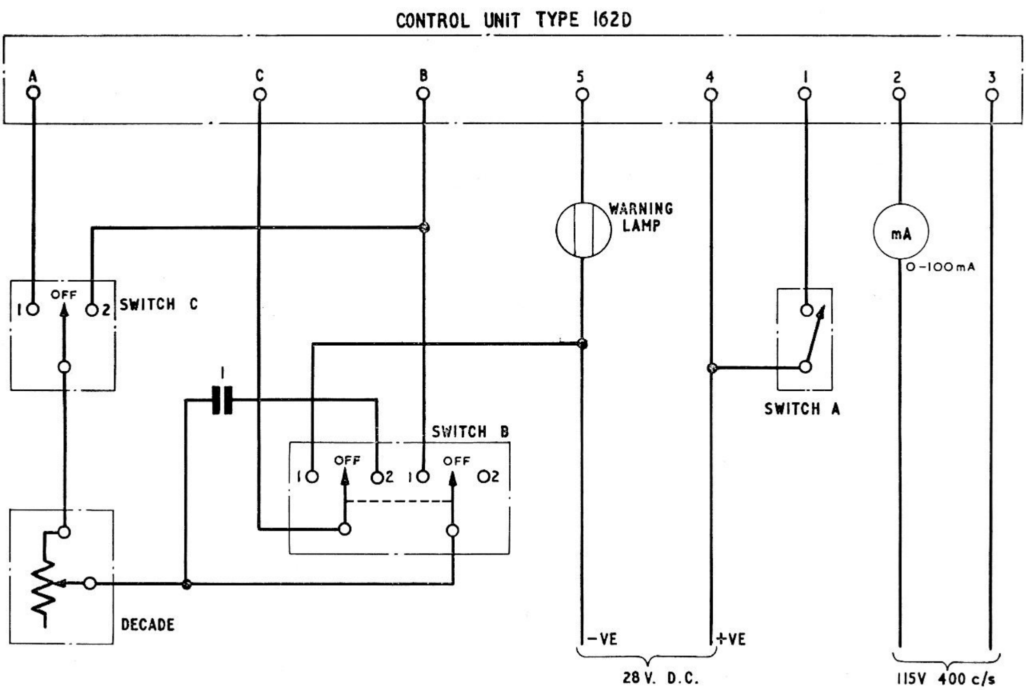


Fig. 5. Test circuit diagram

If the test is satisfactory the sensing element system should then be serviced as given in Chapter 2.

Bench testing

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

Input current tests

32. The input current to the relay unit for the various operating conditions may be measured by connecting the unit to a test circuit as shown in fig. 5. The following tests should then be made:—

(1) Set the decade resistance to 10000 ohm, switches B and C to position 2 and switch A to OFF. Switch on the supplies and ensure that the standby current indicated on the ammeter does not exceed 10 mA.

(2) Reduce the value of the decade resistance until the relay unit operates. The value of the resistance at this point should be between 900 and 1160 ohms and the operating current shown by the ammeter must not exceed 20 mA.

(3) Switch off the supplies and disconnect the capacitor and decade resistance box from terminals C, B and A and connect an ON/OFF switch across terminals C and A. Switch on the supplies and close the switch across terminals C and A. The short circuit current then shown on the ammeter must not exceed 60 mA.

False warning test

33. Connect a 150V 400c/s a.c. supply, in series with a ◀3·5Kohm▶ resistor, across terminals 2 and 3 of the relay unit and a test lamp and 28V d.c. supply across terminals 4 and 5 as previously in para. 32. Connect a normally open single-pole push switch across the ◀3·5Kohm▶ resistor and a 600 ohm resistor across terminals A and C of the relay unit. Switch on the supplies and check that the warning lamp is extinguished, after a short pause momentarily raise the a.c. voltage by operating the push switch to short out the ◀3·5Kohm▶ resistor 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.

34. 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

RELAY UNIT, GRAVINER, TYPE 162D

Introduction

1. The following tests may be applied to ascertain the serviceability of a relay unit or prior to its installation in an aircraft.

TEST EQUIPMENT

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

(1) A decade resistance box 0–11110 ohms, Ref. No. 10S/16239.

(2) Two changeover switches with centre-off position, one single-pole, Ref. No. 5CW/6431, one double-pole, Ref. No. 5CW/6437 and a single-pole ON/OFF switch Ref. No. 5CW/6430.

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

(4) A 1 mfd. 35V capacitor.

(5)◀A 28 volt d.c. supply and a 115 volt 400c/s a.c. supply having a harmonic content not greater than 5% i.e. normal aircraft supply.▶

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

TEST PROCEDURE

3. (1) Connect the relay to a test circuit, as shown in fig. 1, using a suitable mounting base (5CZ/5918).

(2) Set all switches to the OFF position and the decade resistance box to 3000 ohms.

(3) Make switches B and C to position 2 and ensure that the warning lamp remains extinguished.

(4) Reduce the resistance value of the decade resistance box until the warning lamp is illuminated. At this point the setting of the decade resistance box should be between 900 and 1160 ohms.

(5) Increase the value of the decade resistance box until the warning lamp is again extinguished. At this point the setting of the resistance box should be between 1600 and 2700 ohms.

(6) Further increase the decade resistance box to 3000 ohms and set switch C to position 1.

(7) Reduce the resistance of the decade resistance box until the warning lamp is illuminated. At this point the setting of the decade resistance box should be between 900 and 1160 ohms.

(8) Increase the value of the decade resistance box until the warning lamp is again extinguished. At this point the setting of the decade resistance should be between 1600 and 2700 ohms.

(9) Further increase the decade resistance to 3000 ohms and set switches C and B to position 1.

(10) With the decade resistance box now in circuit between terminals A and B of the relay unit set it to 470 ohms.

(11) Set switch A to ON and ensure that the warning lamp is illuminated.

(12) Set all switches to OFF, switch off the supplies and remove the relay unit from the mounting base.

Insulation resistance test

4. The insulation resistance of the relay unit may be measured using a 500 volt insulation resistance tester. The reading obtained when testing between terminals A and 3 and between all terminals and the 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.

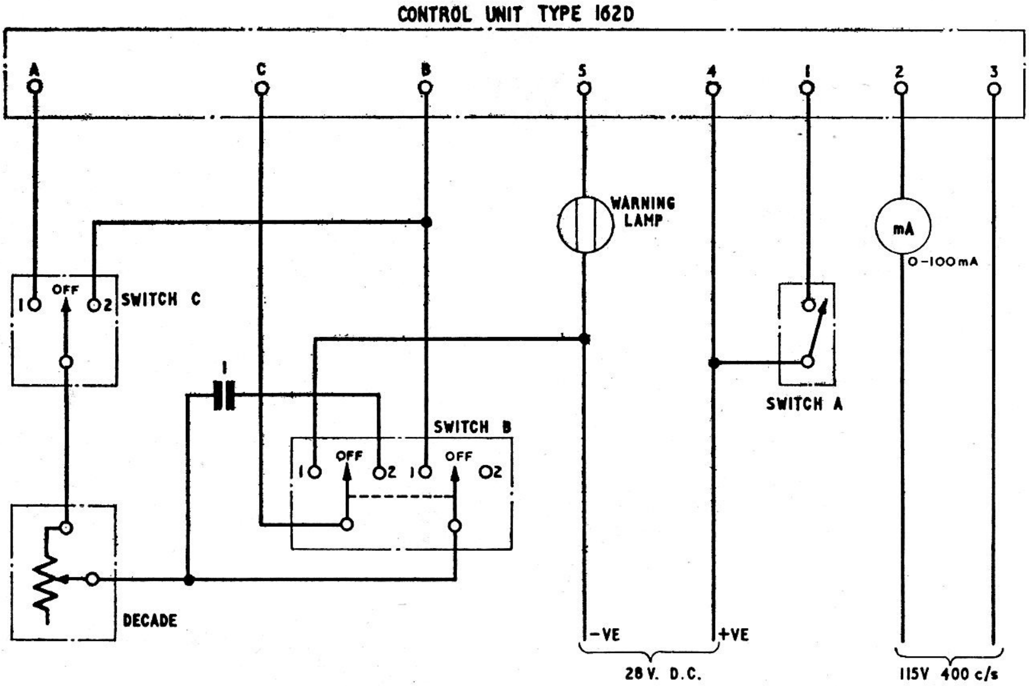


Fig. 1. Test circuit diagram