Chapter 1

FIRETEC THERMO-ELECTRIC FIRE DETECTION SYSTEM

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Introduction

1. The Firetec, thermo-electric, fire detection system is designed to give warning of an abnormal rate of temperature rise that would occur in fire danger conditions, and to indicate in multi-zone systems the location of the temperature rise.

2. The system consists of a control unit which is connected to one or more chains of thermocouple detectors fitted in the fire danger zones on the aircraft, and warning lamps which indicate the location of the fire. In the event of a fire a voltage, developed by the detectors, is applied to the control unit which operates and gives the warning. An audible warning device is sometimes fitted. If, after a fire warning, temperatures return to normal, the system automatically re-sets itself ready to give another warning when necessary.

DESCRIPTION AND OPERATION

Detector head

3. A detector consists of two thermocouples working in opposition, so that, with normal slow temperature variations their voltages cancel each other and little output is applied to the control unit. With a rapid rise of temperature, however, as in fire danger conditions, the outer (exposed) thermocouple responds to the rise in temperature before the inner (shrouded) one, and the difference voltage developed is sufficient to cause the control unit to give the warning.

4. As the temperature difference between the inner and outer thermocouples decreases, the difference in their voltages will decrease until the resultant e.m.f. is insufficient to maintain the warning signal. The decrease in the temperature difference of the exposed and

shrouded thermocouples may be due to either:—

(1) The fire, or overheat condition, reaching a stable temperature, or the rate of increase in the temperature being small, such that the inner thermocouple attains a temperature approaching that of the outer thermocouple.

(2) Successful extinguishing action on the fire allows the thermocouple detector to cool, so that the outer thermocouple falls to a temperature approaching the inner thermocouple.

5. The Firetec system utilises very small voltages to initiate a warning and the resistance of the detector chain will affect the correct operation of the unit. Ideally the system is designed to give warning most rapidly when the resistance of the complete detector chain is 2 ohms. Assuming an outbreak of fire the temperature will very rapidly rise giving a large increase in the e.m.f. developed across the detectors. If the resistance of the detector chain is relatively high the voltage drop in the circuit will cause insufficient voltage at the control unit which will then fail to initiate a fire warning even though the e.m.f. developed may exceed the 7·5mV necessary. Consequently a more rapid rise or higher temperature may be necessary to give a warning signal so that the time taken between the outbreak and warning may be large or in the extreme case of a badly maintained chain no warning may be received. It is therefore essential that the detectors in the chain circuit be correctly serviced as given in A.P.4343E, Vol. 1, Book 3, Sect. 14 and that the chain resistance be maintained at the figure quoted in the relevant Aircraft Handbook. ▶

6. The wiring of the control unit and detectors is such that any earth fault will not cause a false warning to be given but, if an earth fault is present, then when the test button is pressed no warning will be obtained, thereby indicating the presence of a fault. Detailed information on the detector heads is contained in A.P.4343E, Vol. 1, Book 3, Sect. 14.

Control unit

7. The chassis of the control unit is mounted on four anti-vibration pads which are fixed into a tray assembly, the front of which forms the front panel of the control unit. A test push switch, a multi-pin plug and◀ , in multi-zone units, ▶a fuse box are mounted on the front panel. Two radio type mountings which support the unit are secured to the bottom of the panel. The tray assembly is located in guide rails inside a steel case and two mounting spigots are fitted at the rear of the case.

8. The control unit contains a warning operation circuit for each chain of detectors being used. When only one chain of detectors is being used, the control unit consists of only one warning circuit, but when two or four chains are in use the control unit has two and four warning circuits respectively. The circuits are basically similar, and this general description and fig. 1 deal with a unit for use with only one chain of detectors. Additional information on specific types of control unit will be found in the relevant chapters in A.P.4343E, Vol. 1, Book 3, Sect. 14. The operating voltages◀ and detector chain resistances ▶ quoted in the following paragraphs may differ in certain aircraft installations and the relevant Aircraft Handbook should be referred to before testing at these figures.

9. The control unit contains a sensitive moving coil relay (M1) which is operated when 7·5mV is developed by the thermocouples of a chain of detectors. This voltage is obtained when the combined temperature of the exposed thermocouples exceeds that of the shrouded thermocouples by 185 deg. C. The relay (M1) operates a miniature sealed master relay (L5), which completes the warning circuit and operates the warning device. This master relay is initially energized through the contacts of the moving coil relay but, when operated, remains energized by its own hold contacts. These hold contacts short-circuit the contacts of the moving coil relay and relieve the latter of the electrical load which was originally passing through it.

10. When the thermocouple output has dropped to a safe level a release relay (L4) becomes energized through the back contacts of the moving coil relay M1 and short circuits the master relay, to cancel the warning.

11.◀ Two single-coil Post Office relays, Type 600 (Post Mod. E/281, Type 2400) form a pulse circuit which regularly interrupts the supply to the moving coil relay by the continual cycling of the change-over (Z) contacts on L1 relay. This pulsing circuit lessens the chance of a false fire warning being given in the event of excessive acceleration conditions, which may cause the contacts of the millivolt

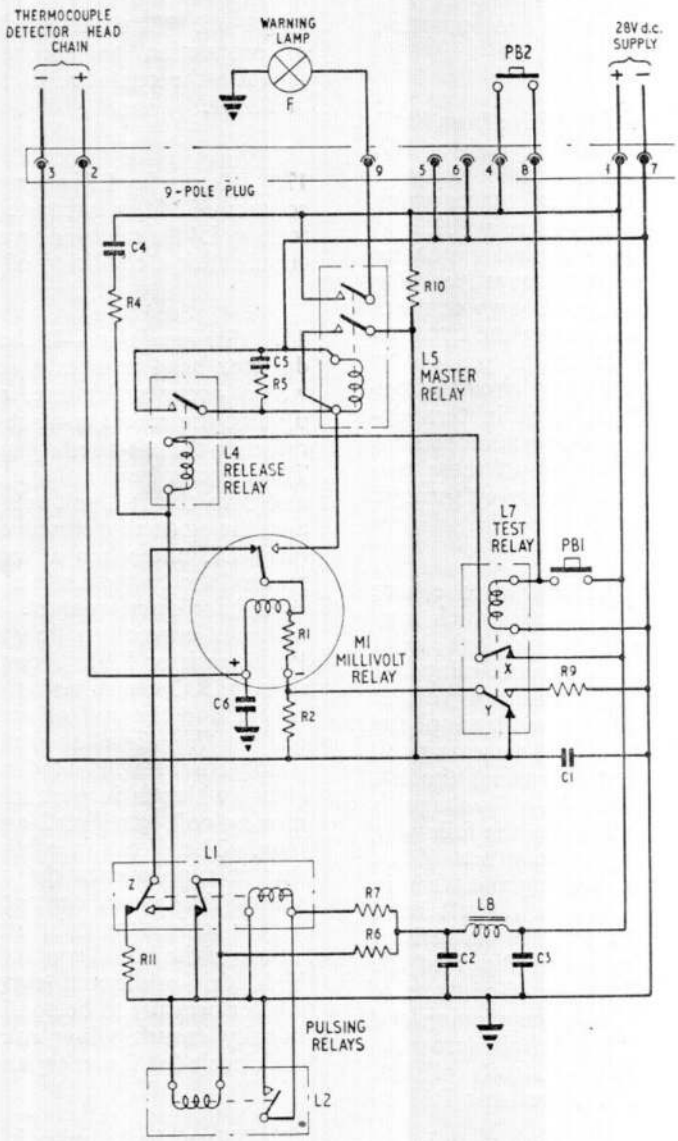


Fig. 1. Circuit diagram of single zone control unit.

relay to make contact momentarily, by providing a knock-off voltage to the millivolt relay. This also reduces the possibility of arcing at the contacts of the millivolt relay. The pulsing of the two Post Office relays also provides mechanical vibration through the chassis of the unit to overcome any lag in the operation of the millivolt relay and allows accurate setting of the operating voltage. ▶

Circuit

12. The circuit shown in fig. 1 is for the single zone control unit (Type TP4501 or TP5901) but the principle of operation is identical to that of the twin and four zone units. ◀ The principal difference in the actual circuitry of the twin and four zone units is the incorporation of 2·5 amp fuses in the warning circuits and pulse circuits. ▶

13. *Normal conditions.*—Under normal conditions the pulsing circuit and the knock off circuit are functioning. The pulse circuit is formed by resistors R6, R7, choke L8 and condensers C2 and C3, and has a consumption of 85mA.

14. The pulsing circuit is positive from Pin 1 of the 9 pole plug, choke L8, resistor R7, coil of relay L1 to negative at Pin 7. Relay L1 is energized, thus opening its contacts which are short circuiting the coil of relay L2, and allowing L2 relay to be energized via choke L8 and resistor R6 to chassis negative. The operation of relay L2 closes its own contacts which short circuit L1, causing the latter to be de-energized, and its break contacts to close. These replace the short circuit across the coil of relay L2, which is in turn de-energized, and the cycle of operation restarts to create a continual pulsing of these two relays, so that vibration is conveyed through the chassis to M1.

15. The "knock-off" circuit is to ensure that any film of foreign matter which may exist between the centre and left hand contacts of M1 does not prevent relay M1 operating when the detector head voltage reaches 7·5mV. This is achieved by applying voltage across the millivolt relay moving coil when its centre contact is against the left hand contact. This knock-off voltage is derived from the 28V supply in the following manner. The changeover contacts Z on relay L1 are continually pulsing and when in the de-energized position the M1 left hand contact is connected to negative via resistor R11. Current will flow from Pin 1 of the 9 pole plug, resistor R10, the Y contacts of relay L7, resistor R1 (with the moving coil of M1 and the detector head chain across it), the centre and left hand contacts of M1, contact Z of relay L1 and resistor R11 to negative.

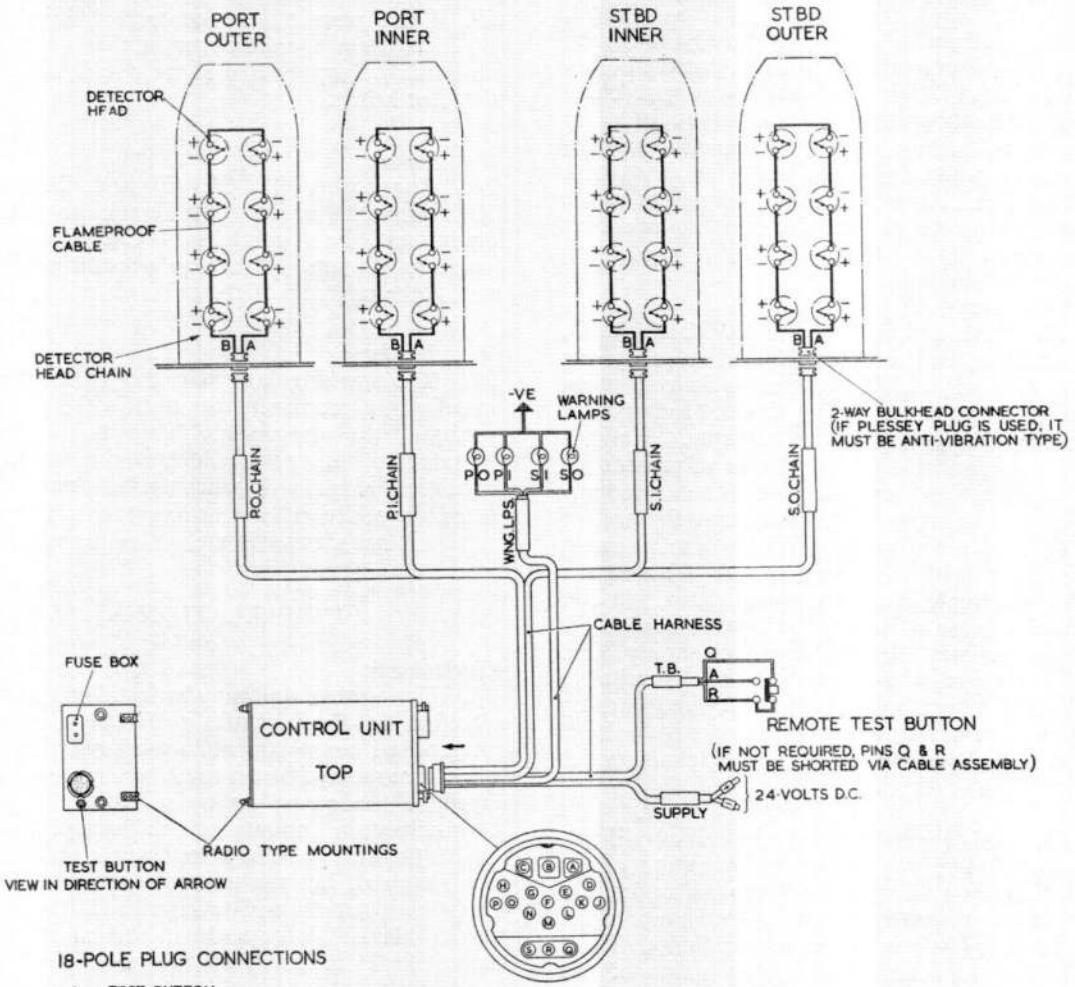
16. The effect of this knock-off voltage is to cause current to flow through the moving coil of M1 in such a direction that it rotates clock-wise and moves the centre contact away from the left hand contact. Directly this happens the circuit for the knock off voltage is interrupted and, if the detector chain voltage is not near the 7·5mV level, the centre contact returns to the left-hand contact under the action of the biasing spring of the moving coil. The centre contact of M1 is therefore continually oscillating at the same frequency as the pulsing relay. Circuit values are such that when no stickiness exists between the contacts a current flow of 1mA through R11 is sufficient to produce knock-off. This current flow will increase, in proportion to the work required to separate the contacts, to a maximum value of 50mA.

17. When relay L1 is energized the left-hand contact of M1 is connected, via contacts Z, to relay L4 for release or reset of the detection circuit after a condition of fire.

18. *Fire condition.*—If the voltage from the detector head reaches a level of 7·5mV, as would occur under fire, or abnormal conditions, the centre contact of M1 would not return to the left-hand contact after knock-off. The detector head voltage is fed from Pins 2 and 3 to the millivolt relay, via resistor R1 and the normally closed contacts Y of test relay L7, and when a voltage of 7·5mV is reached the centre contact of M1 touches the right hand fixed contact. This immediately causes a current to flow from positive via Pin 1, resistor R10, Y contacts of relay L7, resistor R1, centre and right hand contacts of M1 and the coil of relay L5 to negative on Pin 7. Simultaneously, a part of the supply current will be fed to the detector head chain, which is in parallel with R1 and the moving coil, via Pins 2 and 3 of the 9 pole plug. The direction of this current is such that it supplements the chain current and causes the centre contact of M1 to press harder against the right hand contact. Thus, although the initial contact resistance may be high, this additional current causes much greater pressure to be applied to the contacts, thereby ensuring low contact resistance in the circuit for the energizing of relay L5.

19. When the L5 relay is energized it feeds, via one pair of its contacts, the 24V positive supply through Pin 9 to light a remote warning lamp F, and also closes its other pair of contacts to complete a hold-on circuit, short circuiting the M1 contacts. By this means the electrical load imposed by the coil of L5 is removed from the centre and right hand contacts of M1 and the moving coil is controlled only by the detector chain voltage. The circuit to keep relay L5 energized is, positive via Pin 1, resistor R10, hold contacts of relay L5, relay coil L5 to negative at Pin 7.

20. *Re-set.*—The L5 relay will remain operated until the fire conditions in the fire zone disappear, when the detector chain output voltage will fall to a level of 5mV or less, and the moving coil of M1, and therefore the centre contact, will rotate anti-clockwise under the influence of its biasing spring until the centre contact touches the left hand contact of M1. Immediately contact is made the following circuit is completed—positive from Pin 1, X contacts of relay L7, coil of relay L4, Z contacts of relay L1, left hand and centre contacts of M1, resistor R1, Y contacts of relay L7, hold contacts of



18-POLE PLUG CONNECTIONS

A	TEST BUTTON
B	-VE SUPPLY
C	PORT OUTER LAMP
D	PORT INNER LAMP
E	-VE SCREEN
F	STBD INNER LAMP
G	PORT OUTER CHAIN + VE
H	PORT OUTER CHAIN - VE
J	PORT INNER CHAIN + VE
K	PORT INNER CHAIN - VE
L	STBD INNER CHAIN + VE
M	STBD INNER CHAIN - VE
N	STBD OUTER CHAIN + VE
O	STBD OUTER CHAIN - VE
P	STBD OUTER LAMP
Q	TEST BUTTON
R	TEST BUTTON
S	+VE SUPPLY

Fig. 2. Typical installation of a four zone system.

relay L5, and coil of relay L5 to negative at Pin 7. The voltage drop across R1, which has the detector head chain and the moving coil of M1 across it, will cause current to flow through the chain and moving coil. The direction of this current is such that it opposes, and overcomes, the voltage from the detector heads, and the centre contact is thus pressed hard against the left hand contact.

21. Release relay L4 is thereby energized and its contacts close to short out the coil of relay L5. Relay L5 is thus de-energized, and its contacts open, breaking the supply to the remote warning lamp and also its own hold circuit contacts which, being in series with the circuit for both L4 and L5 relays, cause the complete electrical circuit to re-set to normal.

Test circuit

22. Push switch PB1 (and PB2 if fitted), relay L7, and resistors R2 and R9, form the test circuit which operates as follows when the test push switch is pressed. Relay L7 is energized, operating its contents. Resistor R9 is connected to the R1 side of resistor R2 and the short circuit across R2 is removed, causing current to flow through the coil of M1, from the positive supply line, through resistor R10, dividing through R2 and the series circuit of detector head chain, M1 coil and resistor R1 which are in parallel with R2 and resistor R9 to negative supply line. This current through M1 coil results in normal operation of the L5 relay and warning lamp, as would occur with excessive voltage output from the detector head chain under conditions of fire.

23. This current through the coil of millivolt relay M1 results in normal operation of the L5 relay and warning lamp as under fire conditions, providing that the resistance of the detector chain is within certain limits. These limits are determined by the value of the resistors R2 and R9 which are connected in parallel with the chain when the test push is operated. In later versions of the relay box the resistance values are chosen such that the maximum chain resistance for the test circuit to function correctly is 13 ohms. Obviously this value is not necessarily the value at which the chain should be maintained and it is therefore possible to successfully test the system with a chain resistance in excess of that laid down in the Aircraft Handbook and periodic servicing as laid down must also be made.

24. Cancelling or re-set of the circuit occurs when the test push switch is released, since then the L4 re-set relay is connected to the positive supply via the break contacts on test relay L7. This test circuit operation will indicate faults on components within the control unit as well as open circuits and positive and negative supply line short circuits to the detector head chain.

25. False warning or incorrect indication by the system cannot occur in the event of an earth or supply line short circuit to the detector heads.

Suppression

26. Condensers C1, C2, C3 and C6 and R.F. choke L8 prevent interference to radio equipment, and condensers C4, C5 and resistors R4 and R5 are to prevent arcing across the contacts of the millivolt relay M1.

Warning lamps

27. The warning lamps in the system are usually in a prominent position in the pilots position, the appropriate lamp being illuminated to indicate in which engine the fire condition exists. A warning bell may be fitted in addition to warning lamps if the latter are not situated in a prominent position.

INSTALLATION

Control unit

28. The control unit may be installed in any position in the aircraft, preferably in the pressurised compartment in the fuselage. It should be secured by the radio type mountings fixed to the cover, or by suitable clamps. Anti-vibration mountings are incorporated inside the unit and therefore no external ones are required, but the unit must be installed with the instruction plate inscribed MOUNT THIS SIDE UP uppermost and must not be within 21 inches of the compass.

29. Wiring to the control unit and up to the fireproof bulkhead may be any approved type cable capable of carrying a 2A load. It is essential where long runs are required to the bulkhead, that the complete detector head chain circuit resistance, when checked at the cable socket pins, does not exceed the value specified in the appropriate aircraft publication; a typical value being 2 ohms. Screened cables are not required as the control unit is internally suppressed for radio interference.

Detector heads

30. The detector heads should be mounted in such a position as to ensure that their exposed thermocouple junctions will receive the maximum rate of rise of temperature possible when a fire condition occurs. The positioning and number used in each fire zone are dependent upon the particular engine installation but this number should not exceed that which will cause the chain to give an output in excess of the re-setting figures of 5mV under any condition of normal rates of rise of ambient temperature. Where through-bulkhead type of mounting is required stand-off pillars should be used to ensure that the air flow compensation slots are not covered or shrouded. Further instructions covering the installation of the detector heads are contained in A.P.4343E, Vol. 1, Book 3, Sect. 14.

Installation tests

31. *Prior to engine installation.*—The following checks should be made prior to installing an engine. The Test Set, Fire Detector (*Ref. No.* 5G/3294), a description of which is contained in A.P.4343S, Vol. 1, Book 3, Sect. 17, Chap. 3, should be used for operation 3.

(1) Check the loop continuity of the detector head chain.

(2) Test the insulation of the detector head chain to earth with a 500V resistance tester. This insulation reading should not be less than 100000 ohms.

(3) Check the polarity of each detector head, and the wiring of the complete chain, by connecting the Test Set, Fire Detector across the ends of the chain and by applying the heat probe of the test set to the exposed thermocouple junction in each head. If one or more of the heads is incorrectly wired the millivolt meter will indicate negative, or anti-clockwise deflection, upon the application of heat to the heads.

32. *After engine installation.*—Before connecting the terminating socket of the control unit cable to the bulkhead plug on the detector head chain, perform the checks specified in para. 31 (1) and (2). Press the test button on the control unit to ensure that the warning lamp does not light, then proceed as follows:—

(1) Connect the control unit cable to the bulkhead plug of the detector head chain. Press the test button and check that the warning lamp lights, and is extinguished when the button is released.

(2) Disconnect the control unit cable at the control unit and check the resistance of the complete loop of the detector head chain and cable at the socket pins. This resistance should not exceed the value specified in the appropriate aircraft publication.

(3) Connect the test set across the detector chain pins at the control unit socket and, as in para. 31 (3), apply heat to each detector head exposed junction in turn to check for incorrect wiring.

(4) Inspect the detector heads visually to ensure that they have not been damaged during installation and that the ventilating slots are unobstructed.

SERVICING

General

33. The installation should be periodically checked for cleanliness and security of connections, and cleanliness or signs of damage of the detector heads. The loop resistance of each of the detector head chains should be checked at the bulkhead, the maximum resistance is specified in the appropriate aircraft publication. A 500V insulation resistance tester should be used to periodically test the insulation of each detector head chain to earth with the control unit disconnected. The minimum reading should be 10000 ohms.

34. The test push switch should be pressed to ensure that the warning lamp lights and is extinguished when the switch is released. Incorrect operation of the warning lamp may indicate one of several faults, the diagnosis of which is contained in the following paragraphs.

Warning lamp does not light

35. If the warning lamp fails to operate, perform the following checks:—

(1) Check the fuses on the front of the control unit and the aircraft main fuse panel. Renew any faulty fuses.

(2) Check by listening for the regular ticking of the pulse relays that the unit is receiving a 20–30V d.c. supply. Check polarity of the supply by the use of a voltmeter. If on early control units, (Part No. TP4501, 4502 and 4504) the

pulsing relays are not heard to operate they should be cleaned in accordance with the instructions contained in para. 39. In control units Part No. TP5901, 5902 and 5904, the new type of relay does not require these cleaning operations, neither should they be carried out.

(3) Examine the warning lamp and its wiring for continuity.

(4) Disconnect the cable between the control unit and the detector head chain at a convenient bulkhead and short circuit the chain pins and operate the test push switch. If the warning lamp does not operate check the continuity of the detector head chain leads back to the control unit and also the continuity of the external test push button (PB2) if fitted. If the continuity of both these items is correct the fault lies within the control unit.

(5) If the warning lamp lights at operation (4), the detector head chain is faulty. Check the loop resistance of the chain at the socket on the bulkhead, and the insulation resistance between the chain and the airframe. If the loop resistance exceeds the specified maximum value for the installation, short circuit the detector head chain step by step until the loose connection or broken wire is located. If the insulation resistance is below the maximum value, 10000 ohms, check for any signs of corrosion, or damaged detector heads.

(6) Repair or reconnect any defective wiring, and renew any damp cables or damaged detector heads which were located in operation (6). Check the polarity of the detector heads, as given in para. 31 (3) if the wiring of the chain has been disturbed, and reconnect the control unit to the detector head chain and test the installation.

Warning lamp lights but is not extinguished

36. A condition may exist whereby the warning lamp lights when the test button is pressed, but is not extinguished when the button is released. The following procedure should be adopted in this instance:—

(1) If a remote test button is used check that its contacts operate correctly, i.e. that its make contacts do not remain shorted, and that its break contacts do actually re-make, when the button is released. This involves checking the leads to and from the control unit and the test button.

(2) If the test button is functioning correctly, or a remote test button is not used, disconnect the control unit and check the detector head chain for a low resistance to the aircraft supply positive. Should this resistance be above 1000 ohms then the fault is in the control unit.

Warning lamp unsteady

37. If the warning lamp flickers on and off when the test button is pressed check the external wiring and plug connection outside the control unit for short circuits or breaks. The remote test switch and its associated wiring should also be carefully examined.

Calibration

38. If it is desired to check the control unit for serviceability and input calibration, use the test set to simulate a condition of fire. The warning lamp should light when a voltage of 7·5mV is registered on the test set and be extinguished when the voltage drops to 5·0mV. The tolerance on these voltages is $\pm$0·5mV.

Cleaning the pulse relay contacts (*Pre. Mod. E*/281)

39. Failure of the pulse relays L1 and L2 in the control unit (and L3 on the four zone control unit) is often caused by an accumulation of dirt on the contacts. This foreign matter may be retained on the contacts by a film of the silicone grease which is used to lubricate the blade operating pip on the armature and the fault can usually be cleared by cleaning the contacts and removing the grease from the blade operating pip, as follows:—

(1) Wet a piece of clean fluffless cloth with lead free petrol or trichlorethylene and, using a thin bladed screwdriver or similar tool, thoroughly clean the contacts, contact blades and operating pip with the cloth. Extreme care must be taken to prevent distortion of the blades due to excessive pressure with the cleaning tool. Do not attempt to insert the tool between the contacts—use a strip of the cloth and pull it gently to and fro. When cleaning " make " contacts apply light pressure to the top blade to obtain sufficient friction on the cloth.

(2) Wash the blades with the grease solvent (petrol or trichlorethylene) and dry them with clean fluffless cloth.

(3) Examine the blades under a magnifying glass to ensure that all traces of grease and dirt have been removed from the contacts and the blades. Any traces of grease remaining on the operating pip may be allowed to remain there providing that the amount present is kept to a minimum.

(4) Paint both sides of the contact blades for half their length at the contact end with a small brush charged with a solution of 1 per cent ceto-steryl alchohol in methyl-alchohol (*Ref. No.* 33C/1558) ensuring that the contacts are kept free from the solution. The object of the operation is to prevent the grease on the blade operating pip from creeping along the blade on to the contacts.

(5) Allow about 10 minutes drying time for the solution and apply silicone grease (*Ref. No.* 34B/NIV) between the armature insulators and contact operating pins and between the latter and the contact blade insulators. The surplus grease should be wiped off so that only a film remains. The grease is obtainable from Midland Silicones Ltd. quoting silicone grease X.G.250.

Printed for H.M. Stationery Office by L.P.S. Liverpool.
(81838) Wt. 24858-208. 3,000/6/63. G.375/1.