

SECTION 2 - WARNING SYSTEMS

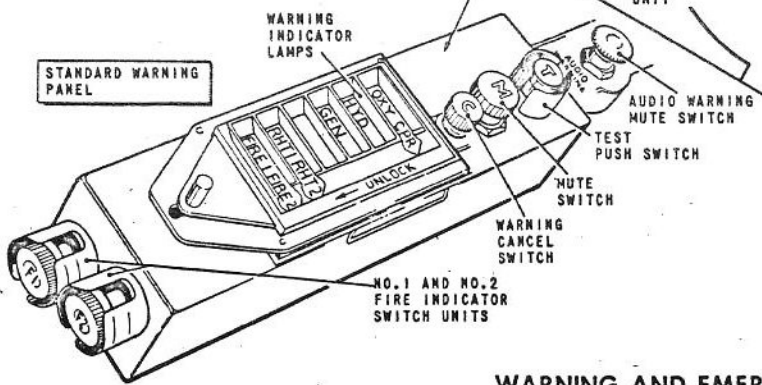
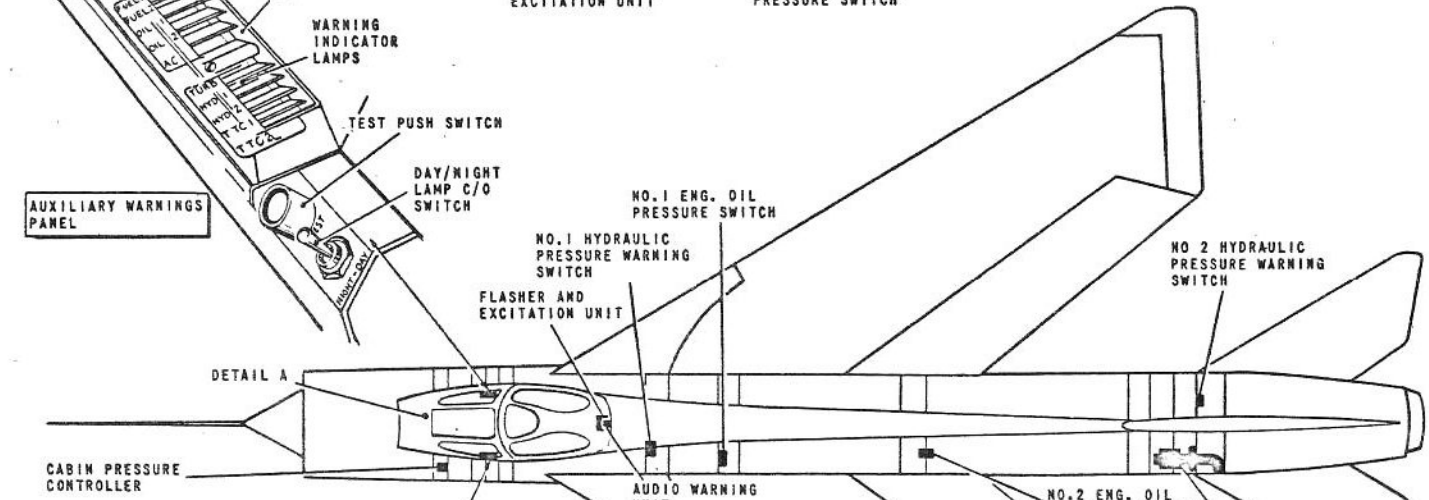
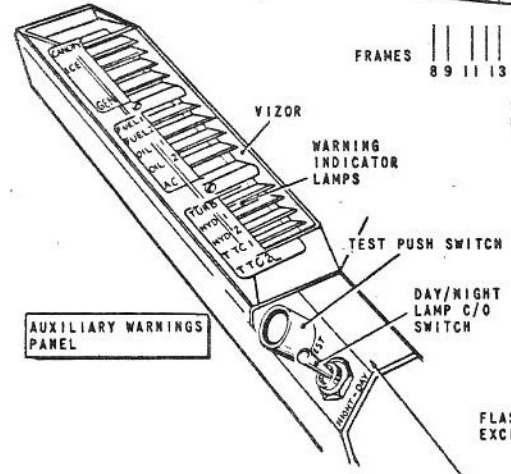
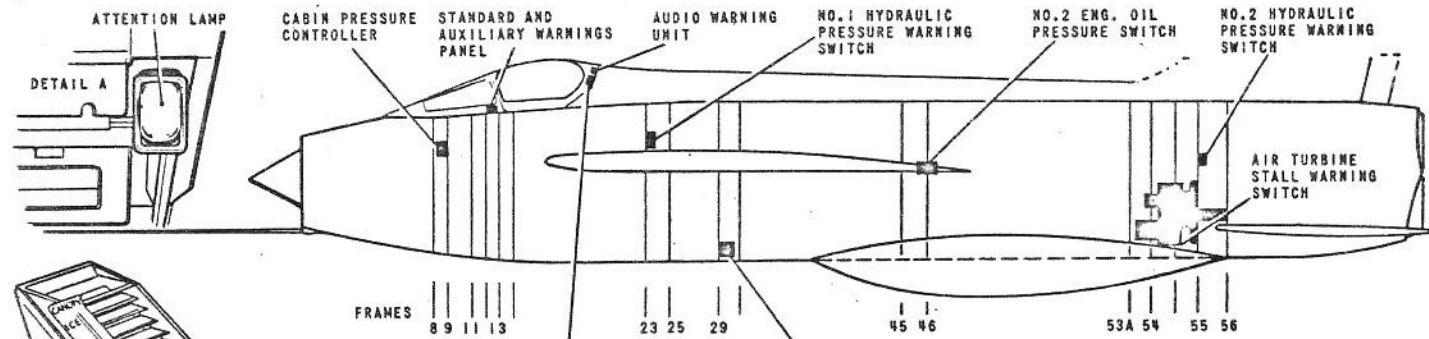
CHAPTER 1 — FIRE WARNING SYSTEM

CHAPTER 2 — STANDARD WARNING SYSTEM

CHAPTER 3 — AUXILIARY WARNING SYSTEM
(and Additional Warnings)

CHAPTER 1 - FIRE WARNING SYSTEM

- Para. 1-6 - Description.
- Para. 7-10 - Operation.
- Para. 11 - Component Location.



WARNING AND EMERGENCY SERVICES DETAILS

RESTRICTED

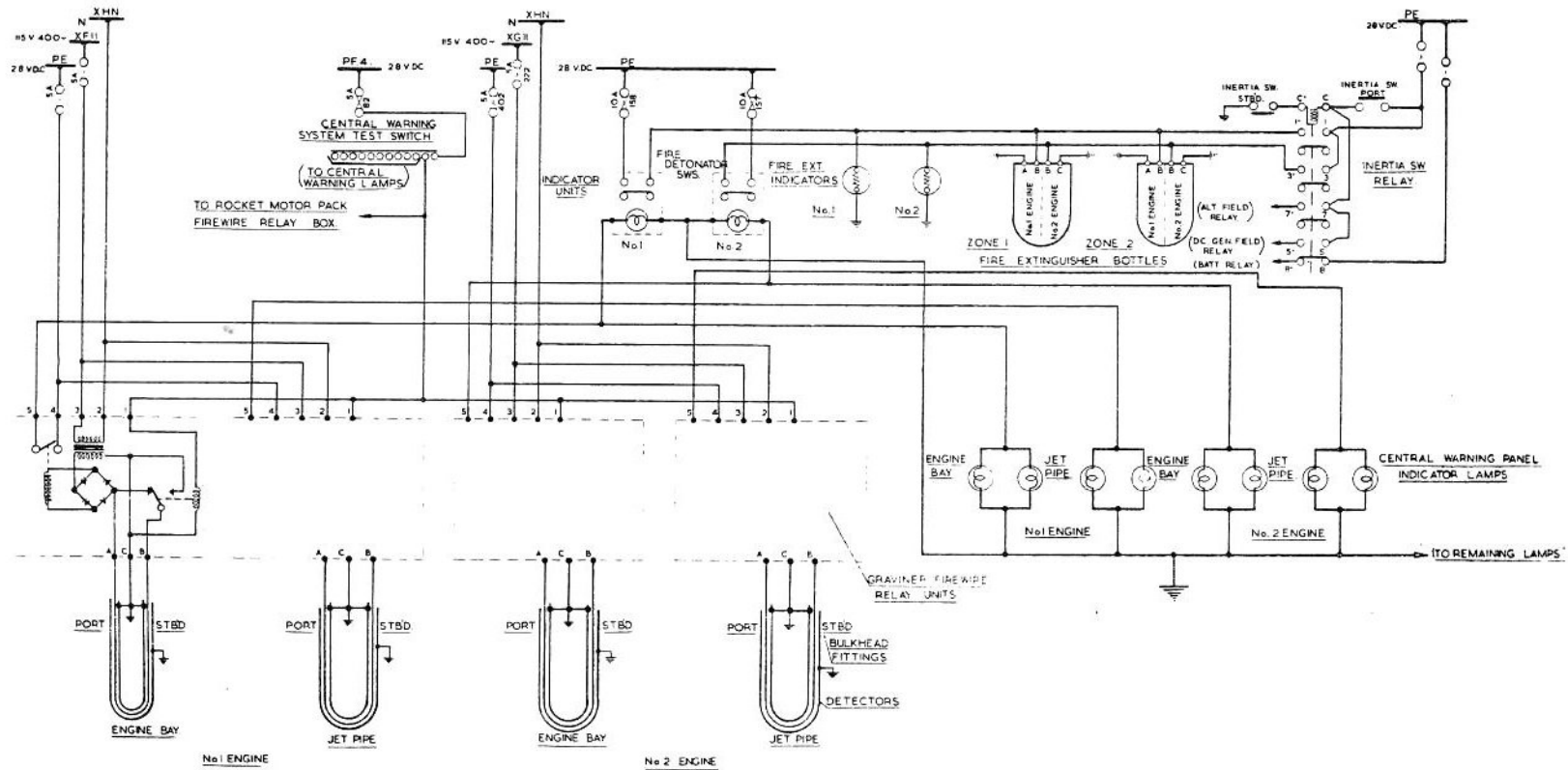
CHAPTER 1 - FIRE WARNING SYSTEM.

DESCRIPTION

1. The Graviner firewire detection system consists of flexible sensing elements, unit detectors, coupling units, bulkhead fittings and a control unit.
2. The system is designed to give maximum coverage, high speed fire and high temperature detection, and rapid cancellation of the warning when the fire or the overheat condition has been controlled.
3. The flexible sensing elements consists of stainless steel capillaries and are provided with integral means of inter-connection and a co-axial centre conductor.
4. The centre conductor is separated from the walls of the capillary by a filling material, the electrical resistance of which decreases with increase in temperature and conversely increases as the temperature decreases. Each end fitting contains a ceramic bush and co-axial centre pin assembly.
5. Fire detection equipment provides for the continuous monitoring of all three zones of both engines. Zones 1 and 2 only are protected by fire extinguishing apparatus. Two Inertia Switches discharge both bottles into No. 1. and No. 2. zones in the event of a crash landing.
6. Two sensing elements serve each engine, one in No. 1. and No. 2. zones and one in No. 3. zone. The elements are connected to 4 relay boxes which control the four indicators on the central warning system panel.

OPERATION.

7. With the outbreak of fire, the decreasing resistance in the element results in a flow of A.C. through the element to the bridge rectifier in the relay box.
8. The D.C. output from the rectifier closes a relay the contacts of which make the supply to the appropriate warning lamp.
9. The elements are connected in the form of a loop and fed at both ends. This ensures the system will remain operative in the event of a fractured element.
10. Each of the 4 relay boxes incorporates a relay a transformer (fed from 115 volt single phase supply) and a full wave bridge rectifier. Additional relays are controlled by the central warning system test switch and when energised they short across the ends of the firewire elements. The input circuit to the bridge rectifiers is thus completed and the warning light relays are energised. Illumination of the warning lamps proves the continuity of the firewire and operation of the relays.



FIREWIRE SYSTEM.

FIRE WARNING & EXTINGUISHERS SYSTEM.

AIRCRAFT SERVICE SCHOOL
"LIGHTNING" MK.3.
EL 2/1

<u>11.</u>	<u>COMPONENT</u>	<u>LOCATION</u>	<u>COMPONENT</u>	<u>LOCATION</u>
	4 Firewire Relay Boxes.	Main Equipment Bay	<u>No. 2 Engine.</u> Single Phase (XG) Supply Fuse 5 amp.	Fuse No. 371 A.C. Fuse & Relay Box Fwd. Spine.
	Fire Extinguisher Indicator Fuse.	Between Frs. 47-48 Port side. Access Panel 61P.	Fire Warning Lights Supply Circuit Fuse 5 amp.	Fuse No. 193 Emergency Services Fuse Box. Frs. 22 - 23 Port.
	Fire Extinguisher Indicator Fuse-Holder.	Between Frs. 47-48 Port side. Access Panel 61P.	Fire Extinguisher Supply Fuse 10 Amp.	Fuse No. 184. Emergency Services Fuse Box.
	Fire Extinguisher Bottle (12lb.) 2 off. Port & Stbd.	No. 3 Fire Zone Between Frs. 44-45 Port & Starboard.	<u>No. 1 Engine</u> Single Phase (XF) Supply Fuse 5 amp.	Fuse No. 387 A.C. Fuse and Relay Box Fwd. Spine.
	Inertia Switch 2 off. Port & Stbd.	Fwd. of No. 2. Engine between Frs. 42-43 Port & Stbd.	Fire Warning Lights Supply Circuit Fuse 5 amp.	Fuse No. 192 Emergency Services Fuse Box. Frs. 22-23 Port
	Crash Relay	D2 Relay Box between Frs. 52-53 Port side.	Fire Extinguisher Supply Fuse 10 Amp.	Fuse No. 185 Emergency Services Fuse Box.
	Sensing Elements 5' 0" 10' 0" 1' 6"	Fitted in Fire Zones.	<u>No. 1 and 2 Engines</u> Crash Fire Extinguisher Supply Fuse 20 Amp.	Fuse No. 198 Emergency Services Fuse Box.

CHAPTER 1 - FIRE WARNING APPENDIX 1

TRIPLE F.D. (FAULT FREE FIRE DETECTION) CONTROL UNIT

INTRODUCTION

1. The Triple F.D. Control Units are used in conjunction with the standard FIREWIRE detector. The type used in the Lightning Mk.III is the 162D (this is a potted assembly).

OPERATION

2. Basic detector circuit:- As shown in FIG, the circuit comprises a transformer with three windings. Windings 3 - 4 and 4 - 5 are wound so that at any instance the voltages at 3 and 5 are identical when referred to 4 (the centre tapping). Winding 5 - 6 is used to derive the power to switch relay R.L.A.

3. Firewire cold:- When the FIREWIRE is cold the impedance between sheath and centre conductors is high and it appears as an open circuit. There are therefore no circulating currents and there can be no potential across R₄. Hence the thyristor will not be triggered.

4. Firewire hot:-

(a) The Charging Period (the positive going half cycle). In this condition 3 and 5 are positive with respect to 4 and the diode MR.1 is free to conduct. The FIREWIRE, being hot, is able to accept energy and this is supplied from winding 3 - 4 via MR.1 and R₃ and from winding 4 - 5 via R₄ and L₁. The forward impedance MR.1 is low and the impedance of L₁ to A.C. is high, the majority of the charge is therefore derived from windings 3 - 4.

As this is the positive part of the cycle a small negative potential will appear across R₄ since the current flow is from 5 to 4 (i.e. anti-clockwise). This small voltage tends to prevent the thyristor from triggering under the

charge condition.

(b) The Discharge or Detecting Period (the negative going half cycle).

In this condition 3 and 5 are negative with respect to 4 and the FIREWIRE is free to discharge. It cannot discharge back to point 3 because of the blocking action of the diode MR.1, it therefore discharges through L₁ and R₄ and is assisted in this since point 5 is now negative. Since the charge on the FIREWIRE is unidirectional then conversely so is the discharge and the inductance L₁ will appear as a low impedance to the resultant D.C. current. The "read-out" voltage appearing across R₄ will therefore be due to the charge existing on the FIREWIRE. Since the ability of the FIREWIRE to store a charge is dependent upon temperature then the read-out voltage across R₄ is also dependent upon temperature.

6. When the FIREWIRE temperature reaches the warning point sufficient voltage will appear across R₄ to cause the thyristor to "trigger". When this happens the impedance of the thyristor drops to a very low value and sufficient current can flow from winding 5 - 6 through diode MR.2 to operate relay R.L.A. This causes the contactor R.L.A.2 to close and energise the warning circuit.

7. The second contacts R.L.A.1 short circuit R₃ and allow a larger charging voltage to become available. This has two functions.

(1) It locks the warning on.

(2) It provides the operate and reset values since now that a larger voltage is available the FIREWIRE will have to fall to a lower temperature before the system can reset.

8. It can be seen from the foregoing that if a short circuit appears on the element then there can be no charge and therefore no discharge. Hence it is not possible for the system to false warn under these conditions. The current in the circuit is governed by R3, R1, and L1, and these values are so chosen that the voltage required to trigger the thyristors are never reached under short circuit conditions.

9. Referring now to the complete control unit, it can be seen that a number of components have been added to the basic circuit. The function of these components are as follows.

TEST CIRCUIT

10. Test of the systems is carried out by interposing Capacitor C1, into circuit in series with the FIREWIRE centre conductor by means of the contacts R.L.B.1 on the test relay R.L.B. Capacitor C1 simulates the "apparent" capacitance of the FIREWIRE element when hot.

(a) If the centre conductor is open circuit then the capacitor C1 is not connected into circuit and the system will fail to test, i.e. will correctly show a fault condition.

(b) Since the element insulation resistance is interposed between the test capacitor C1 and earth, deterioration in the element resistance will tend to short out the capacitor C1 to earth and no read-out voltage will appear across R4. Hence the system will fail to test i.e. will correctly show a fault condition.

11. This type of test facility has the advantage that if the system deteriorates due to moisture contamination, the fault will be picked up and indicated before the system becomes inoperative. The figures for a typical system using various degrees of salt solution to contaminate the temperature sensitive material are as follows:-

12. A.C. Resistance	Effect on Test Facility	Flame Test (1/2" Torch)
7500	None	Warning
1500	Light Remains on After Test *	Warning
845	Light Remains on After Test *	Warning
630	Light Remains on After Test *	Warning
430	Light Remains on After Test *	Warning
290	Light Remains on After Test *	Warning
270	Fail to Test (No Response)	Warning
220	Fail to Test (No Response)	Warning
190	Fail to Test (No Response)	Fail to Warn

System reset by breaking and remaking to control unit before flame test commence.

13. It will be seen from the foregoing that evidence of the system being unserviceable will appear well before its fire detector ability is lost.

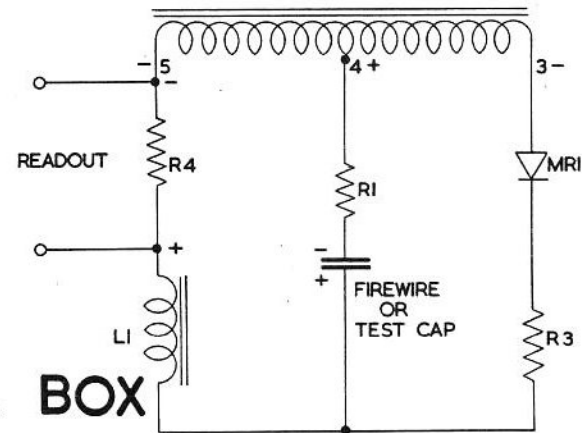
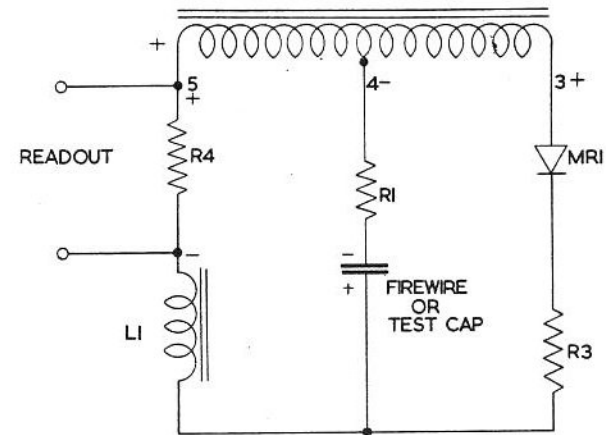
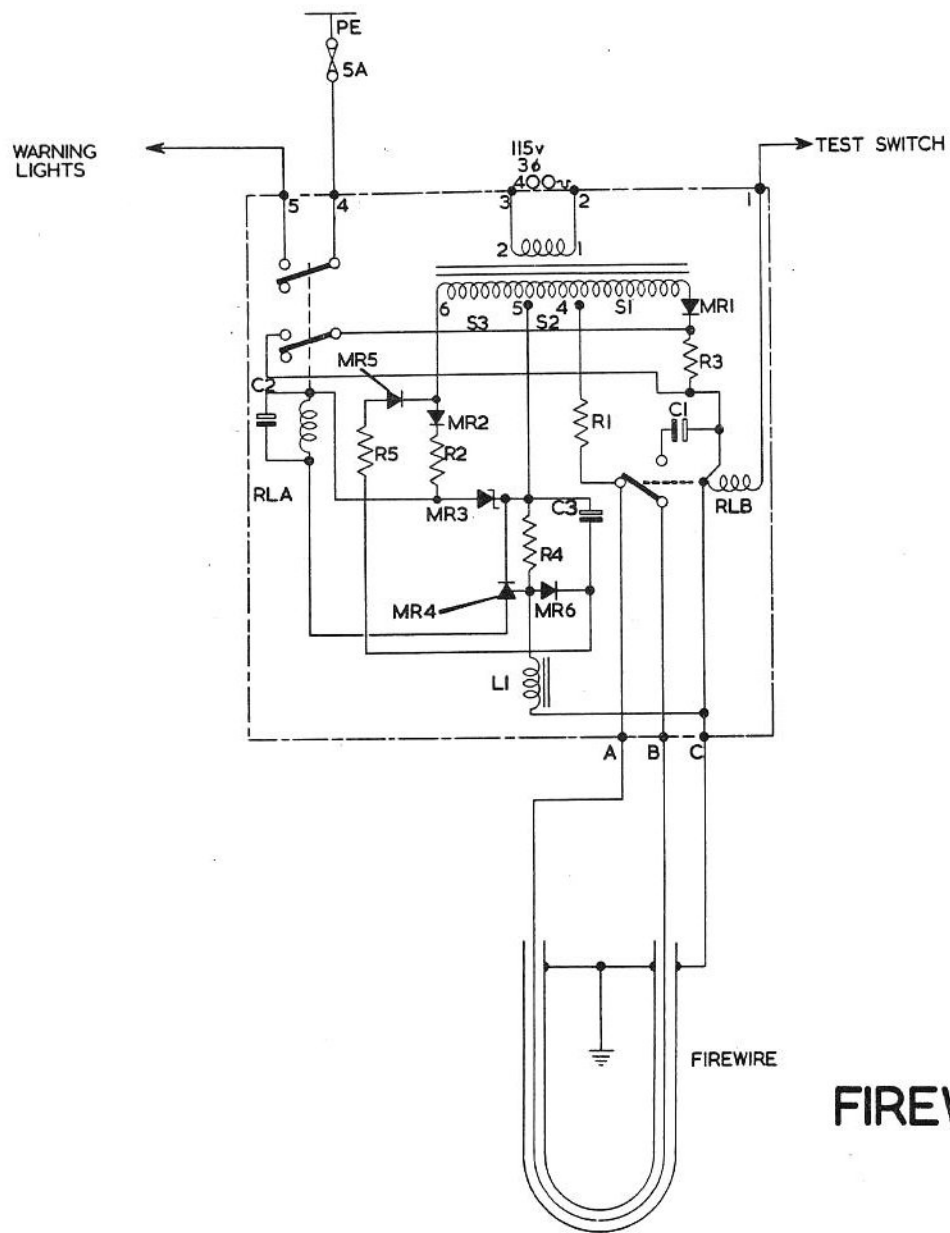
TRANSIENT AND PEAK VOLTAGE SUPPRESSION CIRCUIT

14. Diode MR.3 and R2 are incorporated to prevent transient or peak voltage on the supply line reaching the thyristor. C2 is incorporated to integrate the current pulse appearing across the relay coil terminations in order to maintain the relay in the energised condition during the half cycle when the thyristor is non-conducting.

THE BIAS CIRCUIT

15. This comprises Diode MR.5, Resistor R5, Diode MR.6 and capacitor C3. This circuit is included to stabilize the characteristics under voltage and control unit ambient temperature variations.

16. The negative bias is derived from windings 5 - 6, rectified by diode MR.5, limited and integrated by R5 and C3. Since capacitor C3 is of the polarised type diode MR.6 is interposed to prevent a positive potential appearing on C3.



FIREWIRE CONTROL BOX

CHAPTER 2 - STANDARD WARNING SYSTEM

- Para. 1 - General
- Para. 2-5 - Components
- Para. 6-7 - Operation
- Para. 8-10 - Test Switch.

GENERAL.

1. This system is designed to attract the immediate attention of the pilot to any failure of the critical services essential to the safety of the aircraft. These services are :-

- (a) Fire (Engine and Reheat)
- (b) D.C. Failure.
- (c) Controls Hydraulic Pressure Failure.
- (d) Cabin Pressure Failure.
- (e) Oxygen Pressure Failure.

Provision exists to incorporate additional warnings should they become necessary.

COMPONENTS.

2. The system incorporates a flasher and excitation unit, an indicator unit, an audio warning unit, and a RED attention light.

Flasher and Excitation Unit.

3. This unit houses two double coil, high speed relays, one coil being the operating and the other the holding coil with a capacitor and rectifier for each warning in series with the operating coil. Also housed is a flashing circuit consisting of four transistors, two of which are used in a multi-vibrator switching circuit and the remaining two as output transistors controlling the supply voltage to the attention light and cancel switch light.

The Indicator Unit.

4. The Indicator Unit groups together the various warning lights which are duplicated for each service in the event of filament failure. Fitted on the unit are the fire detonator push switches, a cancel switch for cutting out visual and audible ATTENTION warnings, a mute switch for use by ground staff to remove warnings which would be "ON" with both engines

stationary and the D.C. bus bars live, and a test switch for checking the system for correct operation.

Audio Warning Unit.

5. The audio warning unit incorporates a transistorised multi-vibrator circuit which, in the event of an emergency, feeds a sound resembling a fire bell into the pilots headphones.

OPERATION.

6. When an emergency occurs the appropriate lamps on the indicator unit illuminate. At the same time the surge current through the associated capacitor and rectifier in the excitation unit energises the operating coil of each high speed relay. On closing, these complete a "hold in" circuit through a pair of their own contacts and the normally closed contacts of the attention cancel switch to the "hold in" coil of each relay and through other contacts, feeds a positive from one relay to the audio warning unit and from the other relay to the flasher circuit which controls the action of the attention light.

7. The above indications will continue as long as the emergency exists but depressing the cancel switch will de-energise the high speed relays, thus cutting off the supply to the audio warning unit and the flasher unit. The audio warning will cease, the attention light and the cancel switch light will go out. The appropriate WARNING indication will remain until the emergency has been rectified.

TEST SWITCH.

8. A functional check of the system can be made by depressing the test switch. The following indications should appear simultaneously with depression of the test switch.

- (a) The Attention Light Flashes.
- (b) The Audio Warning is injected into the Pilots Headphones.

- (c) All the Warning Lights on the Indicator Unit are illuminated.
- (d) The Cancel Switch Light Flashes.
- (e) The Fire Extinguisher Switch Lights are illuminated.
- (f) The Mute Switch Light is illuminated.

9. When the test switch is released the following should occur :-

- (a) The Attention Light Continues to Flash.
- (b) The Audio Warning Continues to Operate.
- (c) All Warning Lights on the Indicator Unit are Extinguished.
- (d) The Cancel Switch Light continues to Flash.
- (e) The Fire Extinguisher Switch Lights are Extinguished.
- (f) The Mute Switch Light is Extinguished.

10. Depressing the cancel switch should cause the attention light and cancel switch light to be extinguished, and the audio warning to cease.

CHAPTER 3 - AUXILIARY WARNING SYSTEM
(and additional warnings)

- Para. 1 - General.
- Para. 2 - Indicator Panel.
- Para. 3 - Operation.
- Para. 4 - Engines Oil and Fuel Pressure Warnings.
- Para. 5 - Testing.

ADDITIONAL WARNINGS

- Para. 6 - Oxygen Flow.
- Para. 7 - Canopy Operation.
- Para. 8 - Canopy Unlock.

and additional warnings.

GENERAL

1. The warnings given on the AUXILIARY WARNING PANEL are of a less critical nature than those previously described in Chapter 2 and are mainly associated with engine services. The warnings given are as follows:-

- (a) Fuel Pressure - No.1 Engine.
- (b) Fuel Pressure - No.2 Engine.
- (c) Oil Pressure - No.1 Engine.
- (d) Oil Pressure - No.2 Engine.
- (e) Reheat Top Temperature Trip - No.1 Engine.
- (f) Reheat Top Temperature Trip - No.2 Engine.
- (g) Alternator Failure.
- (h) Air Turbine Stall Warning.
- (i) No.1 Power Controls Hydraulic Failure.
- (j) No.2 Power Controls Hydraulic Failure.
- (k) Main D.C. Generator Failure.
- (l) Ice Warning.
- (m) Canopy Unlock.

INDICATOR PANEL

2. The indicator panel, mounted on the starboard canopy sill, houses the warning lights, four for each warning, wired in paralleled pairs in case of filament failure, the appropriate pair of lamps being selected by means of the NIGHT/DAY switch on the unit. To counteract the possibility of the introduction of stray feeds due to the method of night/day switching, blocking rectifiers are wired in series with each pair of lamps. These rectifiers are also fitted in the panel.

OPERATION

3. All warning circuits are D.C. operated and all are similar in operation. When the appropriate warning switch or relay is made, a supply is fed via the rectifiers to the lamps and, as the earth circuit is completed via the NIGHT/DAY switch, the appropriate lamps are illuminated.

ENGINE OIL AND FUEL PRESSURE WARNINGS

4. In these circuits low voltage filaments are used.

The 100 Ohm resistors drop the voltage to the filaments via the pressure switches but in the test circuit 62 Ohm resistors are used as voltage droppers. The reason for this being that the 62 Ohm resistors provide the correct test voltage, but the 100 ohm resistors limit the current if one of the parallel filaments open circuit.

TESTING

5. The system can be checked by pressing the test switch located at the forward end of the panel. This checks the continuity of the lamp filaments and panel wiring. Whilst pressing the test switch, the NIGHT/DAY switch should be operated to test both pairs of lamp filaments.

ADDITIONAL WARNINGS.

OXYGEN FLOW

6. A diaphragm operated switch fitted in the oxygen regulator controls a magnetic indicator located on the port top panels. The action of the pilot's breathing alternately makes and breaks the diaphragm operated switch and the indicator fed by this switch is energised white or de-energised black to show respiratory pulses under normal demand conditions. Under pressure breathing conditions the indicator would remain permanently energised owing to the displacement of the diaphragm holding the switch made.

CANOPY OPERATION

7. A warning horn is installed in the cockpit to warn personnel whenever the power operated canopy is being opened or closed.

CANOPY UNLOCK

8. Two parallel connected micro-switches operated by the canopy locking mechanism feed a D.C. supply to two warning lamps fitted in the auxiliary warning panel. When the canopy is locked the micro switches open, breaking the supply to the warning lamps.

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