Group 15

E.C.M. COOLING SYSTEM

(Completely revised)

LIST OF CONTENTS

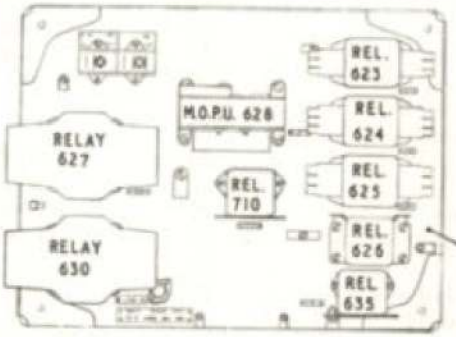
LIST OF TABLES

LIST OF ILLUSTRATIONS

GLYCOL PUMPS

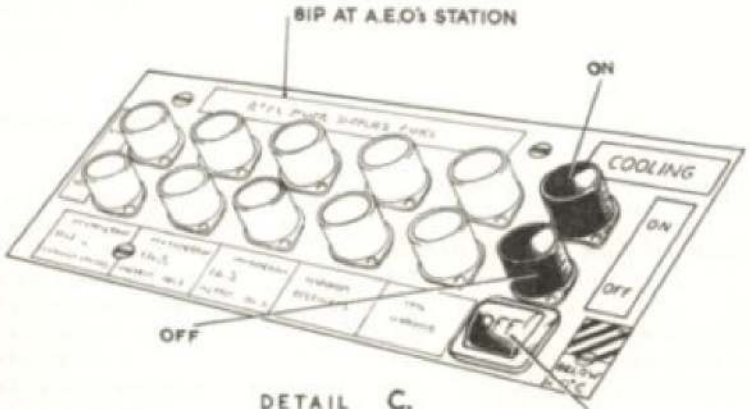
HIGH PRESSURE CUT-OUT SWITCH

DETAIL B.



RELAY PANEL 44P

DETAIL D



BIP AT A.E.O's STATION

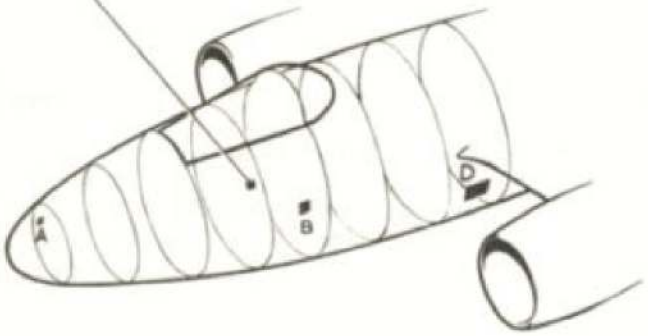
ON

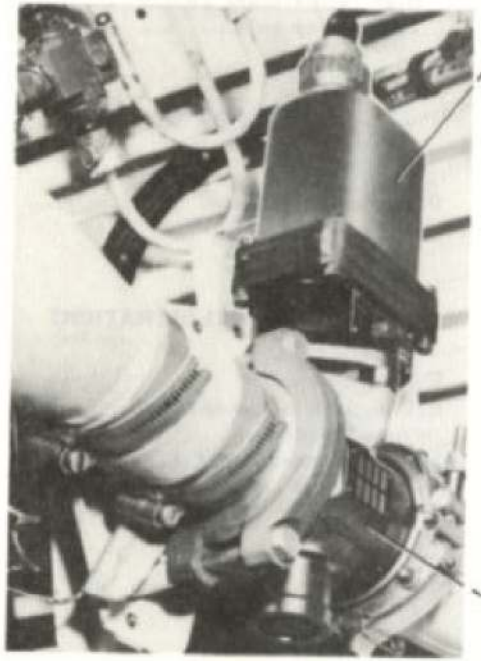
OFF

DETAIL C.

COOLING SYSTEM WARNING INDICATOR

FREON UNIT
SEE BOOK 1, SECTION 3, CHAPTER 16.





A.R.I. 5919 RAM AIR VALVE ACTUATOR

BUTTERFLY VALVE

DETAIL A.

Fig. 1 Location of cooling equipment
(◂ Mod 1616 ▸)

Introduction

1. This chapter contains descriptive and servicing information on the E.C.M. cooling system fitted to those aircraft which have been converted to Mk.1A by the embodiment of Mod.613. Control of the cooling air to the A.R.I.5919 scanner and information on Mod.1480 and Mod.1616 is also included.

2. The E.C.M. cooling system is designed to control the temperature at which the E.C.M. units function under all aircraft operating conditions. Fully descriptive notes on the mechanical aspects of the system, together with location illustrations, will be found in Book 1, Sect.3, Chap.16 of this publication.

3. Power supplies are dealt with in Group 14 and location illustrations, together with theoretical diagrams, are included in the text that follows. A table of distribution fuses and the necessary routing charts will be found at the end of this group.

DESCRIPTION AND OPERATION

General

4. Two push switches (located on panel 81P) one labelled OFF and the other labelled ON, control the power supplies to cooling system. The cooling system is in effect in two stages, one being the water/glycol mixture which is circulated around the E.C.M. units and the other stage, the vapour cycle cooling pack which regulates (not necessarily cools, Book 1, Sect.3, Chap.16) the temperature of the water/glycol mixture. In view of this, the description of the system will be split into parts.

Water/glycol system

Circulating pumps

5. Two electrically operated pumps, Type S.P.E.16291, are used to circulate the water/glycol mixture inside canisters surrounding the E.C.M. units. The pump circuits are so arranged that if one pump fails the remaining one will continue to circulate the water/glycol mixture, but at a reduced rate.

High pressure cutout switch

6. A high pressure cutout switch is fitted, in the water/glycol delivery line from the pumps, to prevent a high pressure overload on the pumps. This high pressure can occur when the water/glycol mixture is at a low temperature. When the delivery pressure reaches a predetermined value, the cutout switch breaks the electrical supply to the pumps. As the pressure drops, the cutout switch contacts will remake and the pumps will start up again; this cycle will be repeated until an input of heat reduces the viscosity of the water/glycol mixture.

Low temperature indication

7. The E.C.M. units should not be operated below a predetermined temperature. Warning of low temperature conditions is given by a 3-position magnetic indicator at the A.E.O's station. A thermostat is positioned in the water/glycol mixture outlet from the vapour cycle cooling pack. When the mixture temperature is normal a relay is energised via the closed contacts of the thermostat; this action causes the magnetic indicator to show ON. When the temperature of the mixture falls too low the thermostat contacts open and the relay is de-energised; this action causes the magnetic indicator to give a LOW indication. When the cooling system is shut off the magnetic indicator also shows OFF.

8. A further temperature indication is given by a temperature gauge (Ref.No. 6A/3682) mounted adjacent to the magnetic indicator. This gauge is operated by a temperature sensing bulb (Ref.No.6A/3684) inserted into the water/glycol mixture outlet from the vapour cycle cooling pack. Full details of these are given in A.P.1275, Vol.1, Sect.17.

Vapour cycle cooling system

Cooling pack

9. The vapour cycle cooling pack, Type VCP-1 Mk.1, controls the temperature of the water/glycol mixture circulating through the E.C.M. canisters. The pack is installed on the starboard side of the aft rear fuselage structure and its associated condenser is positioned inside a ram air intake on the starboard side of the rear fuselage. Incorporated in the cooling pack are the following electrical units:-

Compressor motor
High pressure switch
High temperature switch
Time delay unit

Compressor motor

10. The motor used to drive the compressor is controlled by the push switches on the A.E.O's panel. The 3-phase a.c. supply passes to the motor via a contactor and a motor overload protection unit in panel 44P. The combined compressor and motor unit fitted in the pack (post Mod. 1480) is a Type A.C.M.8/200, Mk.3.

High pressure switch

11. In the event of an increase in the

vapour pressure above the permitted figure, a spring-loaded plunger presses against a micro switch. This micro switch causes a high pressure switch to become energised, which in turn, de-energises the contactor and stops the compressor motor.

High temperature switch

12. If the temperature of the system becomes excessive, a high temperature switch, situated adjacent to the oil/vapour separator, opens and causes the compressor motor to stop in a manner similar to the high pressure switch. At the same time the 3-position magnetic indicator becomes de-energised and indicates OFF.

Time delay unit

13. A time delay unit ensures that, when the compressor motor is switched off, either from the push-switch control or on the operation of either the high pressure or temperature switches, a restart cannot be made until a period of one to two minutes has elapsed.

14. The time delay unit consists of three N.P.N. silicon transistors, three capacitors, ten resistors and a relay designated M. The relay M, when energised, will remain locked-in by its hold-in contacts for a period of time (one to two minutes) determined by the charging of two capacitors, C1, C2.

Ram air de-icing

15. The nose portion of the ram air intake, containing the vapour cycle condenser, embodies an electrical heater for de-icing control via the aircraft fin de-icing circuit. A de-icing test switch is provided for ground testing of the heater without the necessity of operating the fin de-icing circuit.

Panel 44P

16. Panel 44P (fig.1) contains the necessary relays and contactors used in the control circuits of the combined cooling system. Also fitted to the panel is a motor overload protection unit, Avro Part No. 62V/11313, introduced by Mod. 1616. This unit is manufactured in two parts, a sub-assembly and a plug-in unit, to cater for the characteristics of individual motors and different systems of motor control.

Motor overload protection unit

17. Two of the three a.c. lines to the motor pass through the primary windings of two current transformers. Voltages are developed in the circuit which are proportional to the currents passing through the a.c. lines being monitored. These voltages are applied to a fixed potentiometer. The circuit is so designed that a capacitor, connected with the potentiometer, is caused to charge at a voltage proportional to the higher of the two currents passing through the two a.c. supply lines. Furthermore the voltage at the capacitor will only exceed the breakdown voltage of an associated 4-layer diode when the motor current becomes dangerously high.

18. Overload protection is achieved when the 4-layer diode breaks down and discharges the capacitor into a resistance network and so triggers a silicon controlled rectifier. This S.C.R. energises a relay (710) which in turn de-energises the a.c. contactor (627) controlling the supply to the compressor motor.

19. The motor overload protection unit is designed so that there is a time lag of 2 to 3 seconds before the protective circuit comes into effect. This time lag is sufficient to prevent the operation of the unit during the starting of the compressor motor, when a heavy current is being used.

Tail warning cooling

20. The A.R.I. warning unit, fitted in the tail cone of the extended rear fuselage, is cooled by ram air admitted by an actuator-operated butterfly valve. The actuator is controlled by two temperature sensing switches (fig.2). When the temperature of the radar installation rises to above + 10 deg.C the high temperature sensing switch completes a circuit which results in the actuator opening the butterfly valve. When the temperature of the installation drops to - 20 deg.C the low temperature sensing switch completes a circuit which results in the actuator closing the butterfly valve.

Internal pressure

21. Within the radar head is an integral air circuit incorporating a safety valve, which is fitted to the casing of the radar unit. This valve is set to operate at a pre-determined pressure difference between the unit air and the external air. A lamp lights on the indicator unit at the A.E.O's station, when the radar head pressurisation is adequate. The installation is automatically switched off when the pressure falls too low.

CIRCUIT OPERATIONS

Water/glycol system

22. Referring to fig.2 it will be seen that when the ON push switch is pressed a 28-volt supply from fuse 1130 will energise relay 626 with the following circuit action:-

(1) Contacts 626/1 close to form a hold-in circuit for relay 626 via the OFF push switch contacts.

(2) Contacts 626/2 close to energise relay No.623 and relay 625, via the high pressure cutout switch.

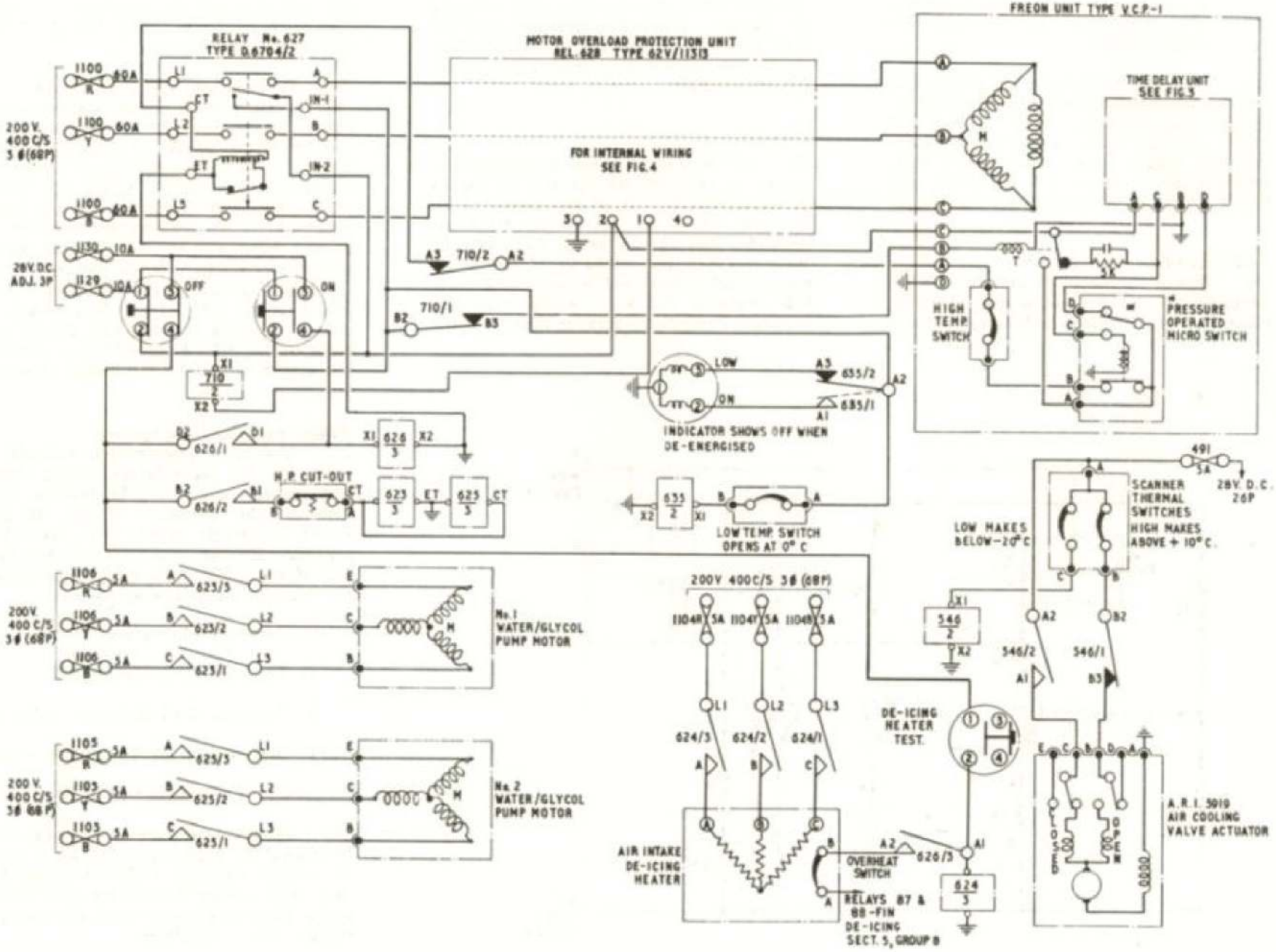


Fig.2. Cooling system controls
(◄ Mod. 1480 and 1616 ►)

(3) Contacts 626/3 close to prime the circuit for the ram air intake de-icing heaters.

23. With the energising of relays 623 and 625 the supply from fuses 1106 R.Y.B. passes via contacts 623/1, 623/2 and 623/3 to No.1 water/glycol pump motor and the supply from fuses 1105 R.Y.B. passes via contacts 625/1, 625/2 and 625/3 to No.2 water/glycol pump motor.

High pressure cutout switch

24. Should the delivery pressure of the water/glycol mixture pumps rise, the high pressure cutout switch will open and de-energise relays 623 and 625, thus stopping the pumps. When the pressure falls the high pressure cutout switch will remake; the relays become energised again to re-start the pumps.

Ram air de-icing

25. As long as relay 626 is energised a circuit is prepared for the ram air intake de-icing heaters. If, at any time, the fin de-icing switch is placed to AUTO or MANUAL (Group 8) relay 624 will be energised via the normally closed overheat switch (fitted inside the heater duct) and contacts 626/3. When relay 624 becomes energised contacts 624/1, 624/2 and 624/3 close to complete the supply circuit from fuses 1104 R.Y.B. to the heater elements.

26. If, or when, the temperature in the ram air intake rises above a predetermined value, the overheat switch contacts open and break the supply to the coil of relay 624. The de-energising of relay 624 opens contacts 624/1, 624/2 and 624/3, thus cutting off the supply to the heater elements. A test switch enables the heater elements to be checked during ground servicing. When the test switch is pressed a supply from fuse 1130 energises relay 624, thus by-passing the normal de-icing circuit, and closes contacts 624/1, 624/2 and 624/3 to complete the supply circuit for the heater elements.

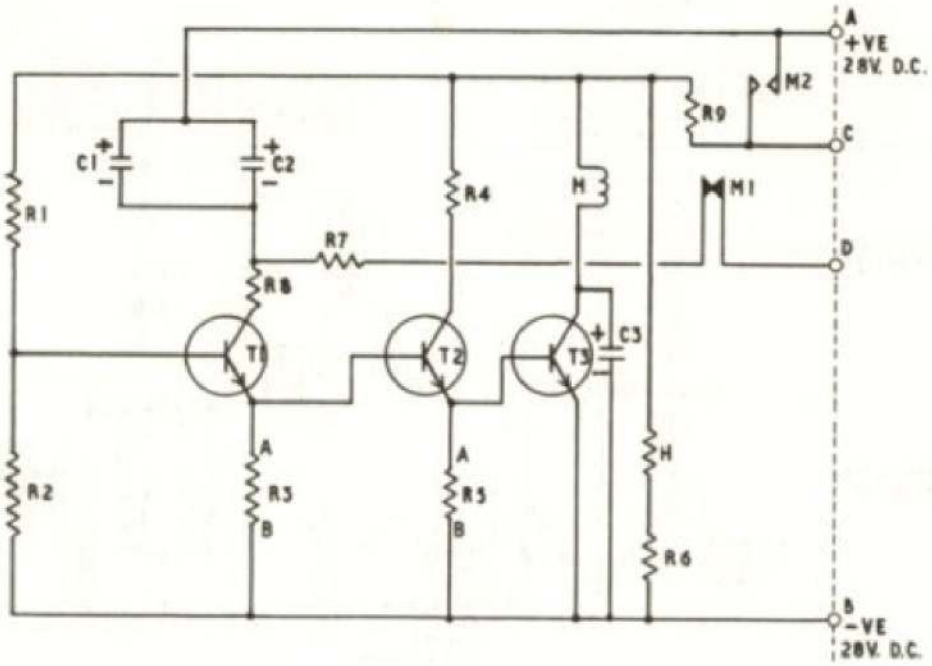


Fig.3 Time delay unit circuit

Vapour cycle cooling system

27. The same push switch controls are used for the water/glycol pump motors and for the vapour cycle cooling pack. Prior to the operation of the ON push switch a 28-volt supply from fuse 1129, passing through the closed terminals 1-2 of the OFF push switch, is already available at the following points:-

(1) Terminal X1 of relay 710

(2) Terminal 1N-2 of relay 627

(3) Terminal 2 of M.O.P.U. relay 628

(4) One contact of the trigger relay T

(5) Pin A of the time delay unit

28. When the ON push switch is pressed (it should be kept depressed for a period of about 5 seconds) a 28-volt supply from fuse 1129 passes through the push switch to the following points, with the resultant circuit action described.

(1) Via normally closed contacts 710/1 to energise the trigger

relay T. The supply positive already at the trigger relay contact (para.27 (4)) now passes through the high pressure switch contacts, through the high temperature switch and through normally closed contacts 710/2 to energise relay 627.

(2) Terminal A2 of relay 635. This results in the 3-position magnetic indicator giving one of two indications, LOW or ON. When the water/glycol mixture is below 0 deg.C the low temperature switch contacts open de-energising relay 635 and making contacts 635/2, with the result that the supply positive passes to terminal 3 of the indicator to cause the LOW indication. When, on the other hand, the water/glycol mixture temperature is above 0 deg.C the low temperature switch contacts are closed, relay 635 is energised and contacts 635/1 provide a path for the supply to terminal 2 of the magnetic indicator, with the result that the ON indication is shown.

(3) 1N-1 of relay 627. This has no circuit action until the relay is energised (para.29).

29. Referring to para.27 (1), the energising of relay 627 closes contacts L1-A, L2-B and L3-C to complete the circuit for the a.c. supplies from fuses 1100 R.Y.B. to the compressor motor, via M.O.P.U. relay 628. At the same time contacts 1N-1 and 1N-2 are closed, this action ensures that when the ON push switch is released both the relay 627 and the trigger relay remain energised by the supply from fuse 1129.

High pressure switch

30. If the pressure of vapour in the cooling pack exceeds the normal figure the micro switch, incorporated within the pressure switch, will be operated. The closed micro switch contacts energise the pressure switch and also connect the same supply from the trigger relay contact, to pin C at the time delay unit. When the pressure switch is energised, its contacts open to break the supply (coming via the trigger relay contact) to relay 627 and the magnetic indicator. The compressor motor stops and the magnetic indicator displays OFF.

High temperature switch

31. When the high temperature switch operates it breaks the line between the pressure switch relay contacts and the energising coil of relay 627. This de-energises relay 627 breaking the supply to the compressor motor and also de-energising the trigger relay by opening contacts 1N-1 and 1N-2.

Time delay unit

32. For the time delay unit to operate, in addition to the supply already at A (para.27 (5)) there must also be a supply at pin C of the delay unit. Any of the following conditions make this supply available.

(1) A build up of pressure operates the pressure microswitch which in addition to energising the pressure switch relay makes the same supply available at pin C of the unit (para.35).

(2) The operation of the OFF push switch breaks the supply from fuse 1129, via contacts 1N-1 and 1N-2 of relay 627 and normal closed contacts 710/1, to the trigger relay T. When the trigger relay T de-energises, the supply at the trigger relay contacts (previously supplying the energising coil of relay 627) is transferred to pin C of the time delay unit.

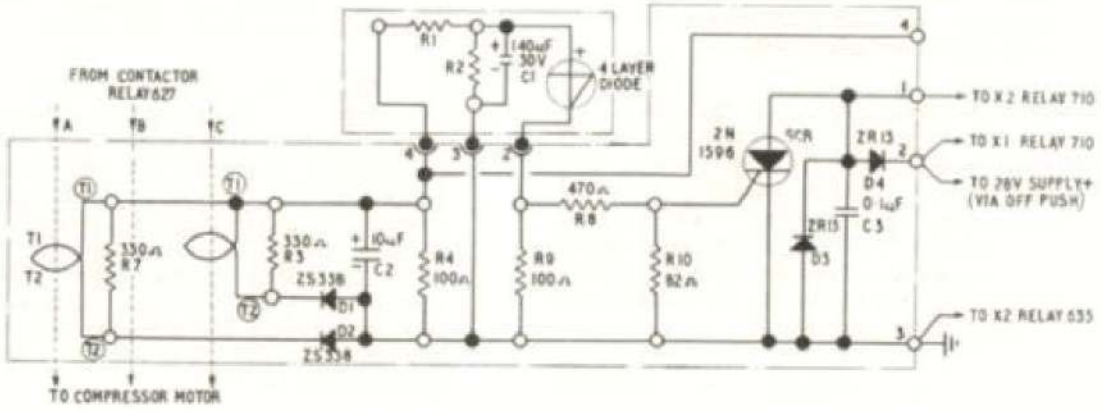


Fig.4 Motor overload protection unit circuit

(3) The operation of relay 710 (by the motor overload protection unit in the event of overload) opens contacts 710/1 and de-energises trigger relay T with the effect already detailed in (2).

(4) The operation of the high temperature switch de-energises relay 627 thus opening contacts 1N-1 and 1N-2 and de-energising the trigger relay T with the effect detailed in (2).

33. Let us now consider the circuit action, in the time delay unit, from the moment a supply is at pin C. Reference to fig.3 will show that the supply from pin C is fed through R9 and R1 to the base of transistor T1 which will start to conduct. The top of R3 (A) which is coupled to the base of T2 goes positive, bringing T2 out of the cut-off condition to high current flow. Its emitter, the top of R5 (A) and the base of T3 goes positive to switch T3 from cut-off to high current flow. Relay M in the collector of T3 will be energised and contacts M2 will close to connect pin C with the supply positive at pin A.

34. Referring back for a moment to fig.2, it will be seen that a supply from pin C of the time delay unit will energise the pressure switch relay and break the energising circuit for relay 627. This means that any attempt to start the compressor will be abortive until the time delay unit has completed its function.

35. Referring again to fig.3, with the normally closed contacts M1 now opened capacitors C1 and C2 will charge up through transistor T1. This will cause T1 collector, and therefore the top of R3 (A), to move towards negative potential thus reducing the current flow through T1. After a period of between one to two minutes, this point will have fallen sufficiently to return transistor T1 into the cut-off region. This in turn cuts off the current flow in transistors T2 and T3, thus de-energising relay M. Contacts M2 open and de-energise the pressure switch relay. The energising circuit for relay 627 is now primed again and the compressor motor may be restarted.

36. Although the triggering positive supply may still be on the pin C line, the time delay will not recommence because of the fully charged state of capacitors C1 and C2. When the compressor motor is restarted the capacitors will be discharged by virtue of the shorting circuit formed internally by R7 and contacts M1, externally by the pressure switch microswitch 'at rest' contacts and the now operated contacts of the trigger relay T, and then internally again via pin A to the capacitors.

Motor overload protection unit

37. For the purpose of the following description of the circuit action of the motor overload protection unit it is presumed that the compressor motor has been started satisfactorily.

38. Reference to fig.2 and fig.4 will show that two of the three a.c. supply lines, from relay 627 to the motor, each pass through a primary winding of one of two current transformers. The currents thus induced in the secondary windings of the transformers develop voltages, across R3 and R7 (fig.4), which are proportional to the primary currents.

39. These voltages are rectified, smoothed and applied to a fixed potentiometer formed by R1 and R2. The smoothing is sufficient to ensure that the voltage at the potentiometer will follow the higher of the two voltages induced at R3 and R7. This causes the capacitor C1 to charge at a voltage proportional to the higher of the two currents flowing in the a.c. lines being monitored.

40. The circuit is so arranged that the voltage at C1 will only exceed the breakdown voltage of the four layer diode when the motor current is becoming dangerously high. When the four layer diode breaks down C1 discharges through it into the resistance network R8, R9 and R10 and triggers the silicon controlled rectifier SCR.

41. The triggering of the SCR completes a path for the negative side of the energising coil of relay 710 to earth, this energises the relay and opens contacts 710/1 and 710/2. The hold-in circuit for trigger relay T is broken by contacts 710/1 and this causes the trigger relay contacts to open and break the hold-in supply for relay 627. A further break in the supply line for the coil of relay 627 is made by contacts 710/2. The de-energising of relay 627 isolates the supplies from the compressor motor which then stops.

42. When this happens no current will flow in the a.c. lines passing through the motor overload protection unit current transformers, capacitor C1 will cease to charge and the four layer diode will not conduct. The SCR will still conduct until an open circuit is created in the line to either the cathode or the anode. This is achieved by pressing the cooling control OFF push switch which breaks the supply positive to relay 710 and in doing so open circuits the SCR.

SERVICING

Precautions

43. Servicing personnel in particular are warned that a.c. and d.c. voltage in excess of 100-volt can be dangerous to the extent of causing personal injury fatal or otherwise. It is essential that

the utmost attention be given to servicing instructions where matters of safety are concerned and that maximum co-operation be maintained between trades mutually concerned in servicing operations.

Relays

44. At the times and periods laid down in the appropriate Servicing Schedule, all relays and contactors should be examined for pitting and burning of contacts, all the associated wiring should be examined for security, damage and corrosion.

Water/glycol pumps

45. The pumps should be examined for general security and damage. Check that associated wiring is secure and free from damage. Testing of the pumps and the high pressure cut-out switch is contained in Book 1, Sect.3, Chap.16 of this publication.

Time delay unit

46. Functioning of the time delay unit should be carried out in conjunction with the appropriate fitter trades, at the times laid down in the Servicing Schedule. It is suggested that if a unit is suspect the following checks can be made. A stop watch will be required for items (6) and (7).

(1) Connect ground power supply to the aircraft.

(2) Connect a ground cooling trolley Ref.No. 4F/2584 or 2396 to the condenser (see Book 1, Sect.3, Chap.16).

(3) Remove fuse 1130 in the fuse box adjacent to 3P. This will isolate the water/glycol pumps if not required.

(4) On panel 81P, select and press the ON cooling switch. Check that magnetic indicator displays ON.

(5) Allow a period of time for the Freon unit compressor motor to run up to speed.

(6) On panel 81P, select and press the OFF cooling switch and at the same time start the stop watch. Check that the magnetic indicator shows OFF.

(7) Again press the ON cooling switch keeping the switch operated until the magnetic indicator shows ON. At this indication stop the watch and check that the time interval is between one and two minutes.

A.R.I.5919 cooling actuator

47. The actuator attached to the ram air intake valve should be examined at the times and periods laid down in the appropriate Servicing Schedule. Check for security and signs of damage. Examine associated wiring for serviceability.

48. If it is desired to check that the actuator moves to the fully open or closed position, it will be necessary to remove the cable and socket assembly F.3393, connected to PLH on the thermostat assembly, fitted to the heat exchanger (part of the radar head).

49. With pin socket A and B on the detached socket shorted together, and a 28-volt, d.c. supply to fuse 491 on panel 26P, the actuator should run to the fully open position. Similarly with pin socket A and C shorted the actuator should run to the fully closed position. After testing re-fit cable and socket assembly to plug PLH. Further details will be found in A.P.2891J, Vol.1, Part 1, Sect.1, Chap.2.

REMOVAL AND INSTALLATION

General

50. Access to the equipment is straightforward and therefore removal instructions are not considered necessary. When it becomes necessary to remove any item of equipment for servicing or replacement, ensure that the supplies to the equipment concerned are switched off and all detached cables and connectors are suitably protected and stowed.

51. When removing any item of electrical equipment connected into the water/glycol or Freon vapour system, the co-operation of the fitter trades must be obtained in removing any pipes or pressure operated equipment (Book 1, Sect.3, Chap.16).

TABLE 1

Distribution fuses

No.	Rating	Type	Service
200-volt, 3-phase, 400 c/s			
Panel 68P (rear fuselage)			
1100 R.Y.B.	60	H	Vapour cycle cooling package
1104 R.Y.B.	5	EO	De-icing heater for air intake
1105 R.Y.B.	5	EO	No.2 water-glycol pump
1106 R.Y.B.	5	EO	No.1 water-glycol pump
28-volt d.c.			
Fusebox adjacent to 3P			
1129	10	S	Cooling system control
1130	2.5	S	Cooling pumps control
Panel 26P			
491	5	S	Air cooling control to A.R.I.5919 scanner

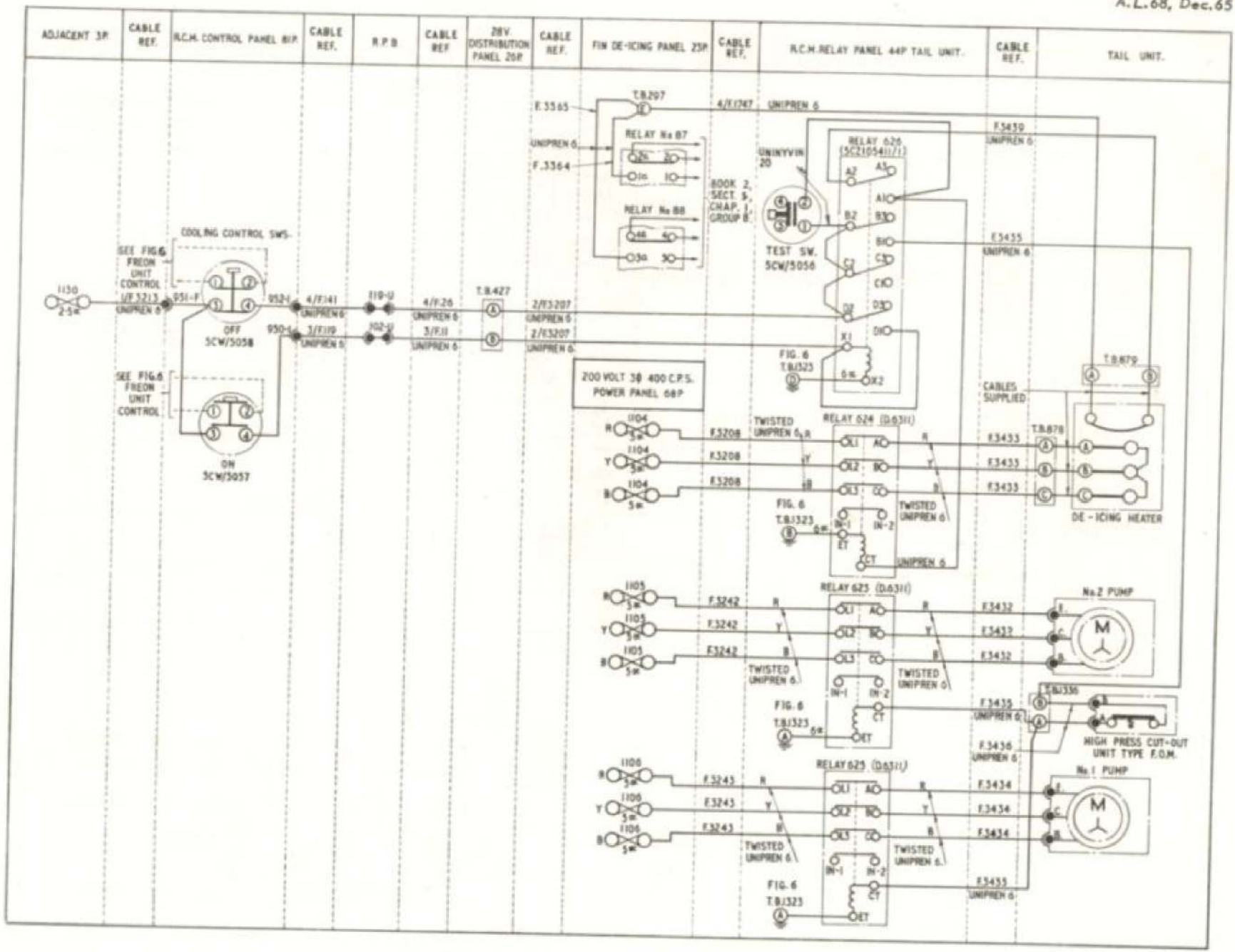


Fig.5 E.C.M. cooling pumps and intake de-icing

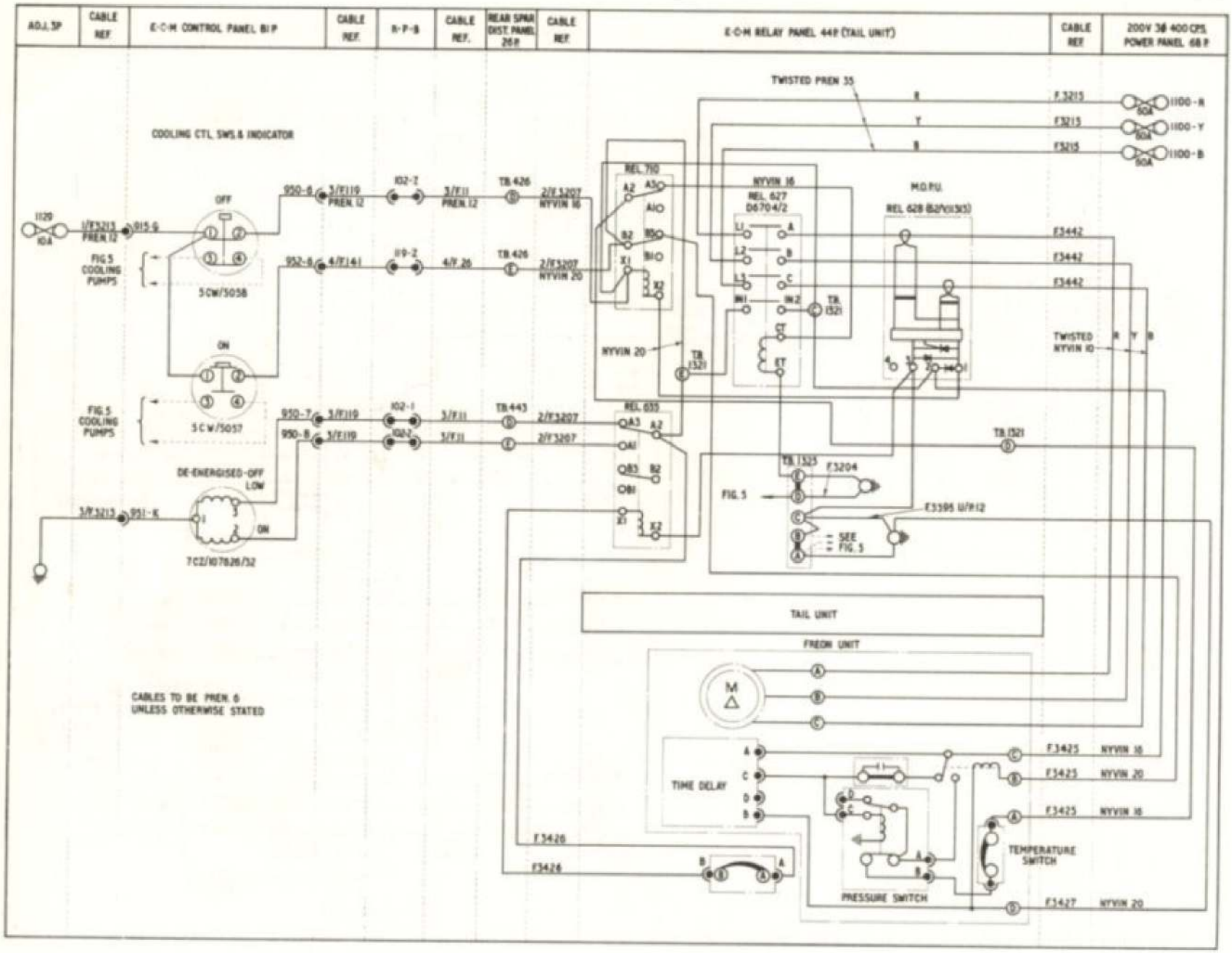


Fig. 6 Start and control of E.C.M. cooling unit

(◄ Mod. 1480 and 1616 ►)

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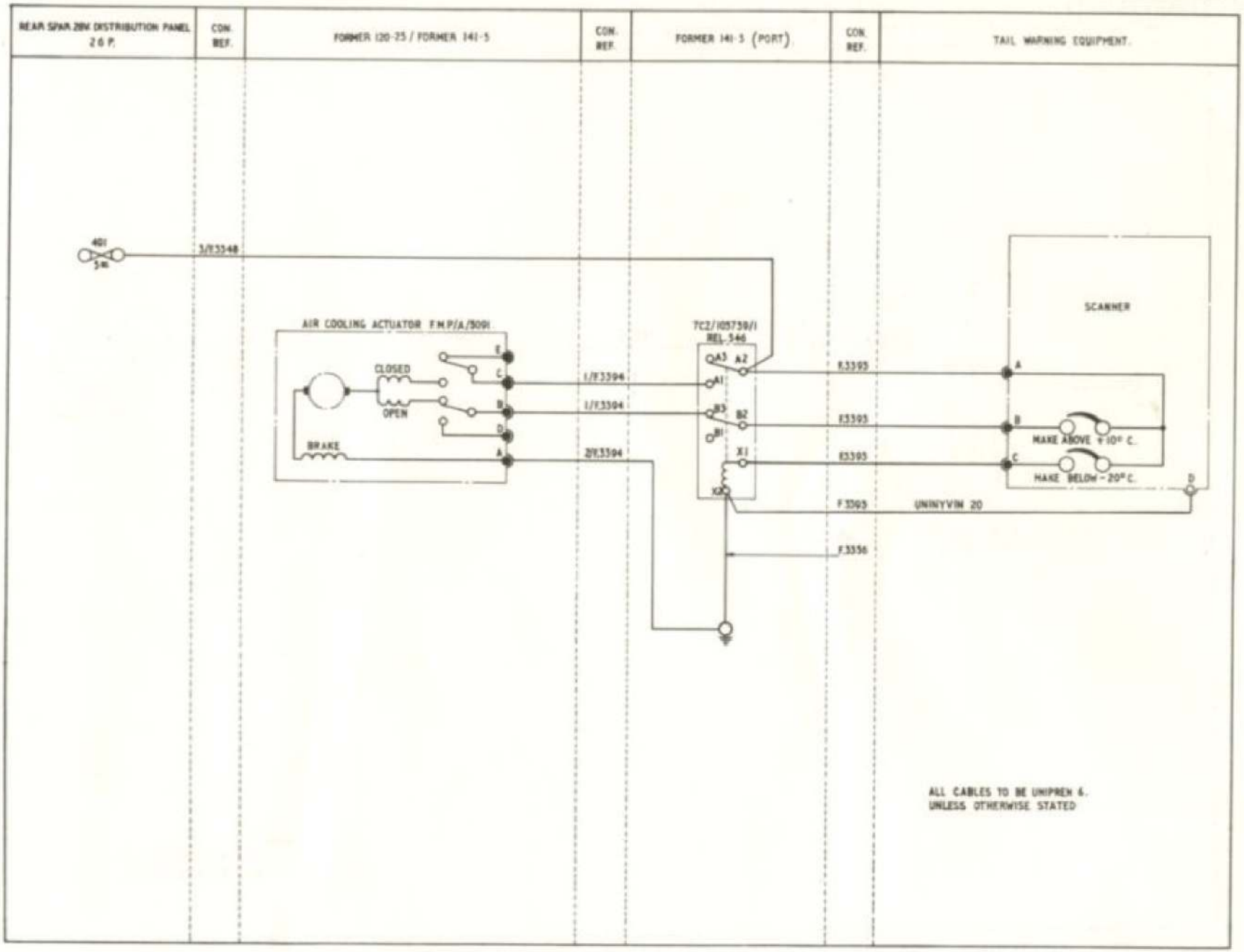

Fig. 7. Control of cooling air to A.R.I. 5919.

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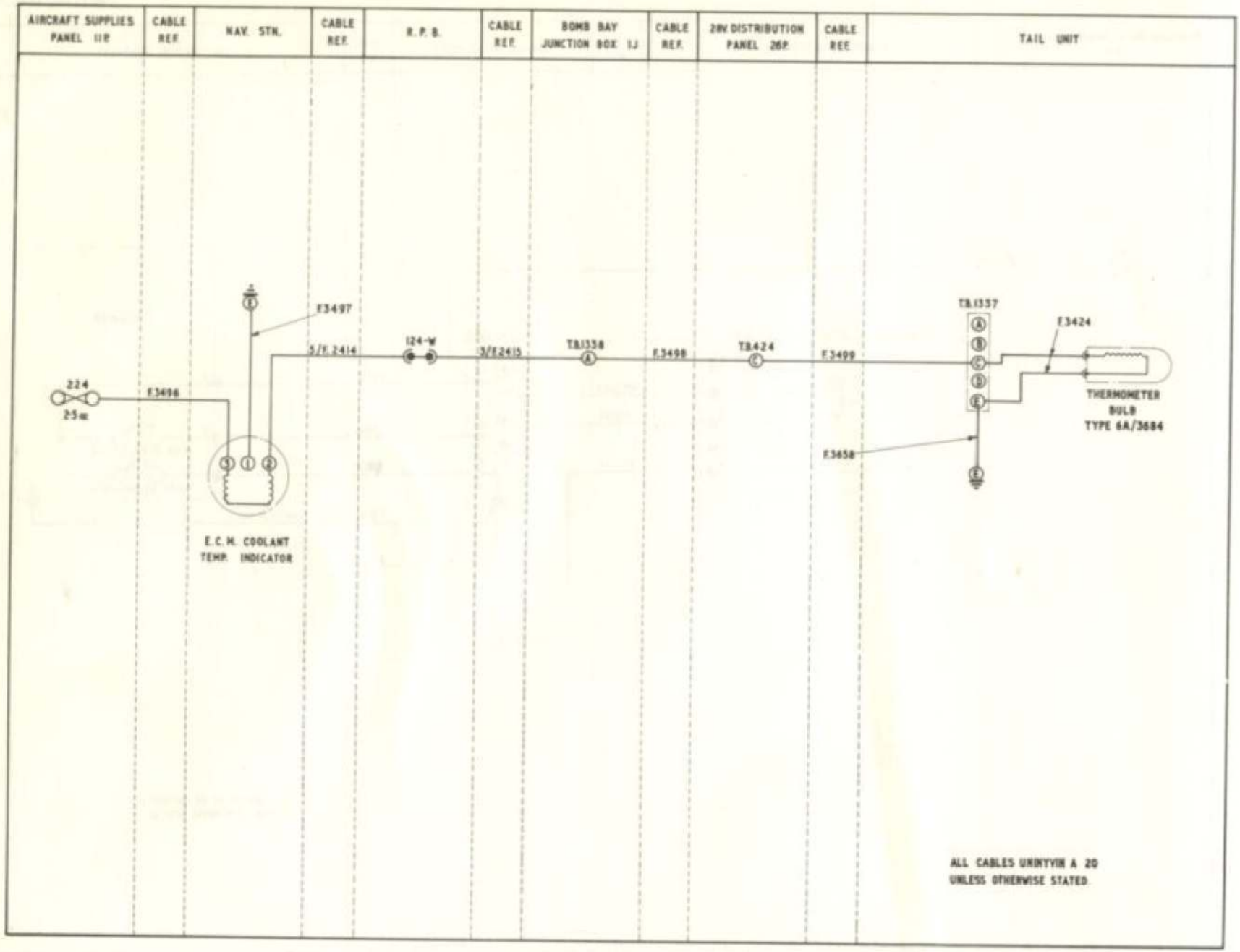

Fig. 8 Temperature indication – E.C.M. cooling system.