SECTION 13

ENGINE BLEED AIR SERVICES

1. Introduction (General)

Compressed air obtained from the engines is utilised for a variety of purposes throughout the aircraft. The air supply from the engines is taken out of the delivery casing, an area situated behind the last stage of the high pressure compressore spool. The following services are dependent on the air bleed.

a. Cabin pressurisation and temperature control.
b. Wing anti-icing.
c. Fin anti-icing and bomb bay heating.
d. Engine intake anti-icing.
e. Primary alternator cooling air inducers.
f. Internal engine starting (See Section 7).
g. Ventilated suits.

These services are described in the following paragraphs in the order previously given.

CABIN PRESSURISATION AND TEMPERATURE CONTROL

2. Introduction

The high operational ceiling of the aircraft makes crew cabin pressurisation a necessity. Pressurisation is achieved by bleeding air from the eingines at a temperature of approximately 300°C, and conditioning the air by reducing its temperature and controlling its humidity and then admitting it through suitable feed pipes to and around the cabin. The level of pressurisation required in the cabin is determined by the setting of pressure controllers and a discharge valve. The discharge valve is a mechanical device which "Leaks" air at a controlled rate from the pressure cabin. Provision is made for cabin ventilation during unpressurised flight by the use of ram air obtained from an intake near the port engine intake. The intake ducting has a shut off valve electrically actuated and is operated by a switch on 7P.

Two levels of cabin pressure are employed i.e CRUISE - cabin pressure equivalent to 8,000', and COMBAT - cabin pressure equivalent to 19,500'. These values are determined by two pressure controllers one of which is electrically controlled by a small electric motor which alters certain settings on a differential capsule.

The motor is controlled by a three position switch on 7P marked CRUISE - COMBAT - NO PRESSURE.

CABIN TEMPERATURE CONTROL

3. Engine Air Isolation Valves

Each engine is provided with an electrically controlled engine air isolation cock. The cocks are controlled by four switches on 7P, each switch being labelled OPEN - SHUT. The cocks admit or shut off the engine air supplies as required.

4. Auto Flow control valves (Mass Flow)

The ducted air supplies from the port and starboard engines are isolated from one an other by two pairs of non return valves. Between each pair of non return valves a branch pipe is connected and supplies air to the cabin air

/controlling

conditioning unit via two electrically actuated auto flow valves. Another name for these valves is CABIN AIR SUPPLY VALVES, and two switches on 7P control the opening and closing of the auto flow valves.

5. Air Conditioning Unit

The air conditioning unit controls the temperature of the air entering the cabin. The complete unit is removable from the aircraft. The major components are listed below:-

a. Heat exchanger
b. Brake turbine (Refrigerator)
c. Temperature control valve
d. Water seperator
e. Underheat sensing unit
f. Overheat switch
g. Pressure ratio switch
h. Duct relief valve
j. By pass valve

6. Temperature control valve

The temperature control valve is a four way electrically actuated air valve which is either automatically or manually controlled. Automatically the actuator operates in conjunction with temperature sensative elements in the cabin, a magnetic amplifier and a temperature selector on 7P marked HOT - COLD - AUTO.

7. Brake Turbine Unit

This unit may be described as a heat energy exchanger. Energy is expended by the turbine thus taking energy from the driving force (ie the air to be cooled) in the form of heat, thus cooling the air.

8. Underheat sensing unit and system

Since the brake turbine unit is extremely efficient then under certain operating conditions the outlet air from the turbine could fall below freezing point. To avoid this condition theby pass valve - controlled by temperature sensitive lements and an underheat switch unit - is operated to by pass hot air across the turbine should the outlet temperature fall to 2°C.

9. Overheat Switch

The overheat switch fitted in the air ducting downstream of the temperature control valve is set to close its contacts should the temperature of the air in the duct rise to 175°C. The contacts on closing complete a circuit to move the temperature conrol valve actuator towards the cool position. When the temperature returns to 165°C the overheat switch opens. The switch overrides any selection that may be made on the temperature control valve operating switch on 7P.

10. Pressure Ratio Switch

This switch is fitted to measure the pressure ratio across input and output of the brake turbine unit. Should this ratio exceed 4.34 to 1 the contacts of the pressure ratio switch - High ratio - close to operate the temperature control valve towards the HOT position. In so doing the amount of air passed to the turbine is reduced and the pressure ratio switch changes its contacts back to low ratio. During this action a magnetic indicator on 7P is energised white.

CABIN PRESSURISATION

11. Pressure controllers and discharge valve

Two pressure controllers are fitted, one of which is electrically controlled, the operation of the controllers nd discharge valve have been sufficiently

/described

described in paragraph 2. A lever on the motorised controller may be lifted to test the loss of pressure warning horn.

12. Decompression Valve

Two solenoid valves are employed for de-pressurising the cabin. Operation of the valves results in the discharge vlave outlet exhausting air from the cabin at the maximum rate. The solenoids may be energised in five different ways, ie:-

a. Selecting NO PRESSURE on the pressure selector switch on 7P
b. Selecting EMERGENCY DE-COMPRESSION at the switch on 6P
c. Selecting the ABANDON AIRCRAFT switch on 6P
d. A test switch in the nose wheel bay
e. A manually operated lever above the AEO's position operates the de-compression valves.

ANTI-ICING AND BOMB BAY HEATING

13. Anti-Icing Introduction

The termal anti-icing system provides a means of keeping the temperature of the leading edges of the wings and fin sufficiently high to prevent the formation of ice.

The required heat is provided by air bled from the main engine delivery casings, and after suitable mixing with cold air is distributed to the leading edges of the wings and fin. and around the engine intake leading edge and engine splitter walls. The various systems can be controlled automatically or manually by suitable selection. of switches fitted to 7P.

The aircraft installation is divided into three separate systems. One for the port wing and one for the starboard wing, the third being the fin system. Each system has its own injector barrel (mixing chamber). A short description of system components begins in the next paragraph.

14. Controls and Indicators

The controls and indicators are grouped together on a panel fitted to the aft end of 7P. They are as follows:-

a. An individual control switch for each system ie WING - FIN - WING and each switch is labelled AUTO - OFF - MANUAL.

b. Three manual heat control switches associated with the switches mentioned in the previous sub paragraph and labelled INC - OFF - DEC (Spring loaded to OFF position)

c. Three temperature indicators, one for each system record the temperature of the air at the outlets of individual injector barrels. The indicators read from 0 - 200°C.

d. Three setting potentiometers on the rear face of 2nd pilots floor for setting the operating temperatures of the systems. The potentiometers are only used during calibration checks.

15. Injector Barrel Equipment

Each system is equipped with an injector barrel which is essentially a mixing chamber for hot and cold air. Each barrel has a cold air valve actuator and a hot air valve actuator.

/16.

16. Step Inching Control Units

Each system is provided with one of these units. They control the "OPEN" & "CLOSE" fields of the individual barrel cold air valve actuators thus controlling the amount of cold air entering the barrel intake. In the case of the wing anti-ice system the barrel cold air actuator and the step inching unit form basically one assembly. The cold air actuator working the small air intake flap beneath the engine intakes. The step incher senses changes in barrel outlet temperature by means of a fluid filled capilliary tube fitted in the barrel outlet duct. A rise in barrel temperature causes the fluid to expand the expansion being felt via a flexible pipe by a capsule operated switch in the step incher. This will cause resultant cold air actuator movement to admit more cool air to the barrel by opening the intake flap further. A mechanical follow up connection between the actuator and the inching unit ensures small increments of actuator movement.

17. Magnetic Amplifiers (Hot Air Valve Controllers)

A magnetic Amplifier fitted close by to each system injector barrel caters for control of the barrel hot air valve actuator. (In this respect it works in conjunction with the system described in paragraph 19) The controllers are brought into action by placing the appropriate switch on 7P to "AUTO". Two temperature sensing elements on the wing and fin leading edge surfact (Identified as two small black rectangles) detect changes in leading edge skin temperatures. These elements cause changes inside the magnetic amplifier to cause 28 V DC to be applied from the magnetic amplifier to the HOT or COOL fields of the barrel hot air valve actuator as appropriate to the temperature changes on the skin sensing elements. A follow up resistor assembly on the hot air valve actuator is connected in the mag amp circuit to cancel further movement of the actuator when a new temperature setting has been achieved.

18. Overheat Switch (Flamestat)

Fitted in the outlet duct of each barrel is an overheat switch set to close their contacts at 165°C ± 5°C. These contacts when closed complete a circuit to energise a relay which closes the barrel hot air valve actuator.

19. Safety Micro Switches

The hot air actuator operating linkage is equipped with a micro switch. This micro switch is set to close its contacts when hot air valve actuator is fully closed completing a circuit to the cold air actuator "CLOSE" field.

20. "Sunvic" delay switches

The delay switches are fitted to each system to "hold off" the operation of the step inching units. After selecting AUTO a 10 second delay to the step inching units is allowed, to ensure that the de-icing ducting air is fully established.

21. Engine splitter wall Anti-icing system

The wing anti-icing systems also incorporate the necessary electrical circuits to enable hot air from the wing injector barrels to be circulated around the engine intake splitter walls. The air is exhausted via a small electrically actuated flap underneath the engine intakes. This actuator receives its supply from the wing anti-icing control relays.

ENGINE INTAKE ANTI-ICING

22. Engine de-icing actuator

Each engine is equipped with a small electrically operated gate valve

/located

located on the port side of the engine. The valve controls air from the delivery casing and distributes the air around the engine intake compressor webs. The actuators are brought into operation in conjunction with the wing anti-icing systems.

BOMB BAY HEATING

23. General Introduction

The bomb bay system is for all purposes identical to the wing and fin anti-icing control. The controls for the heating system are grouped together at the navigator/plotters position. The purpose of bomb bay heating is to maintain the temperature of the bay air to a few degrees above freezing point.

ALTERNATOR AIR INDUCERS

24. Introduction

The main alternators together with their associated SCDU's are cooled during flight by ram air obtained from NACA intakes beneath the engine intakes.

This cooling air flows over the alternators and is exhausted from rearward facing ducts on the engine access doors. During ground running and taxying however, the cooling air supply is poor. To augment this air, a tapping taken from the delivery casing is ducted to high velocity nozzles at the exhaust end of the cooling system thus inducing air to flow rapidly into the NACA intakes.

The air tappingsupply is controlled by a small electrically actuated valve fitted to the starboard side of the engine. These actuators are controlled by the undercarriage circuit (See Section 10)

OPEN - Undercarriage DOWN
CLOSED - Undercarriage UP

25. Ventilated Suit Heating (Introduction)

The suit ventilation system provides a flow of dry air which can be heated to individual crew member's requirements. Engine compressor air is passed through a separate air conditioning system. After conditioning the air flows to a multi-outlet manifold which distributes the air to the crew member's suits. A duct containing an electrical heater and a sensing element is fitted in the supply line to each suit.

Fitted adjacent to each crew members station is a transductor amplifier and the controls for regulating the flow of air and the heater. The current supply to each heater can be controlled either manually or automatically. A description of circuit compnents is given in the following paragraphs.

26. Air On-Off Cock Actuator

The supply of conditioned air to the distribution manifold is via an actuator operated ON-OFF cock controlled by a single pole master switch fitted to the starboard console (7P).

27. Overheat Switch

Fitted into the manifold is an overheat switch, the contacts of which close if the temperature of the air flowing in the duct exceeds 70°C. If the switch closes, the actuator will move the ON - OFF cock to the closed position.

The circuit is so arranged that when the overheat condition has ceased to exist, the ON-OFF cock will remain closed due to a holding circuit on R.136. The holding circuit can be broken by selecting the master switch to CLOSE and then back to OPEN.

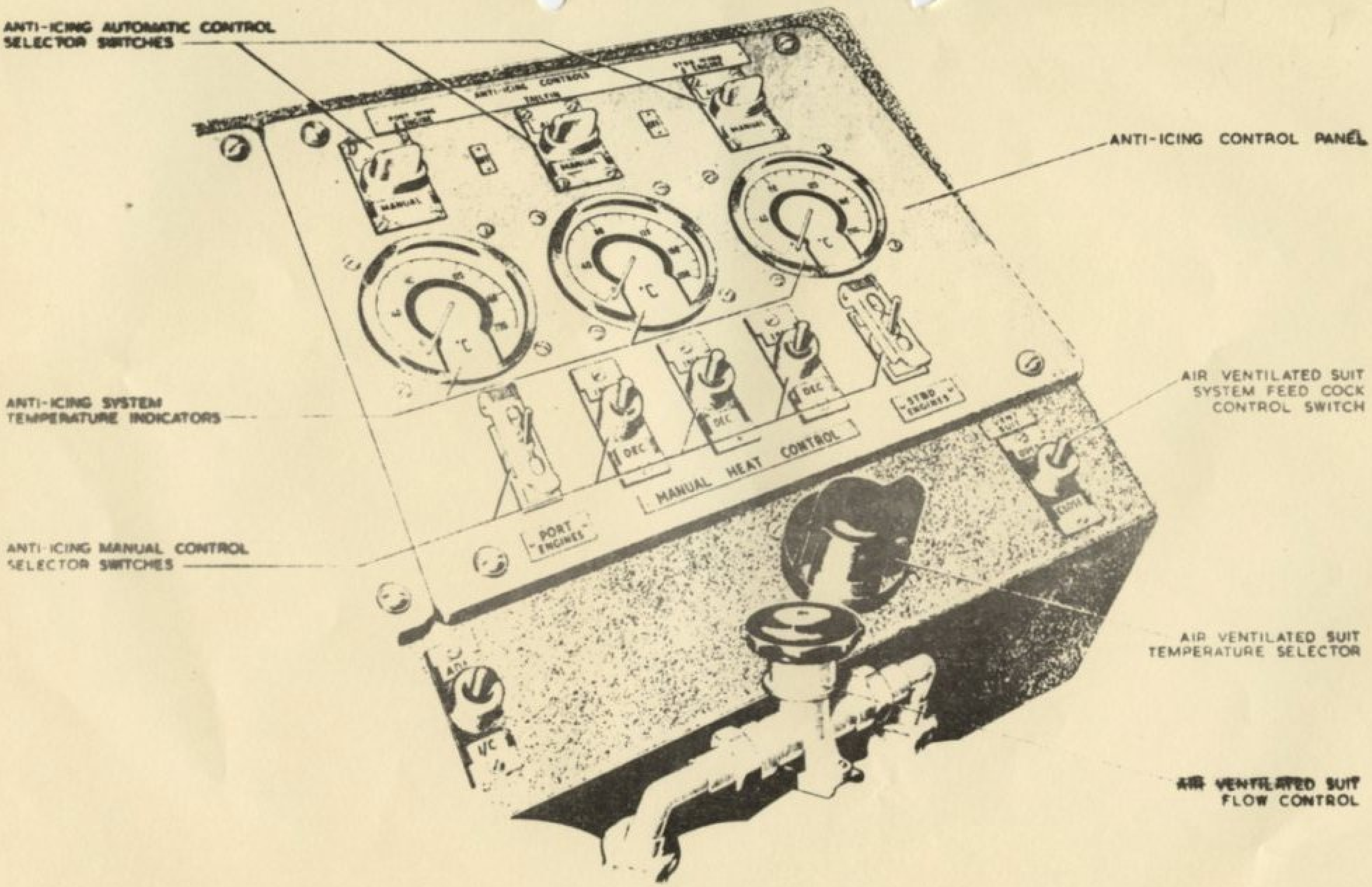


Fig. 1. De-icing system control panel

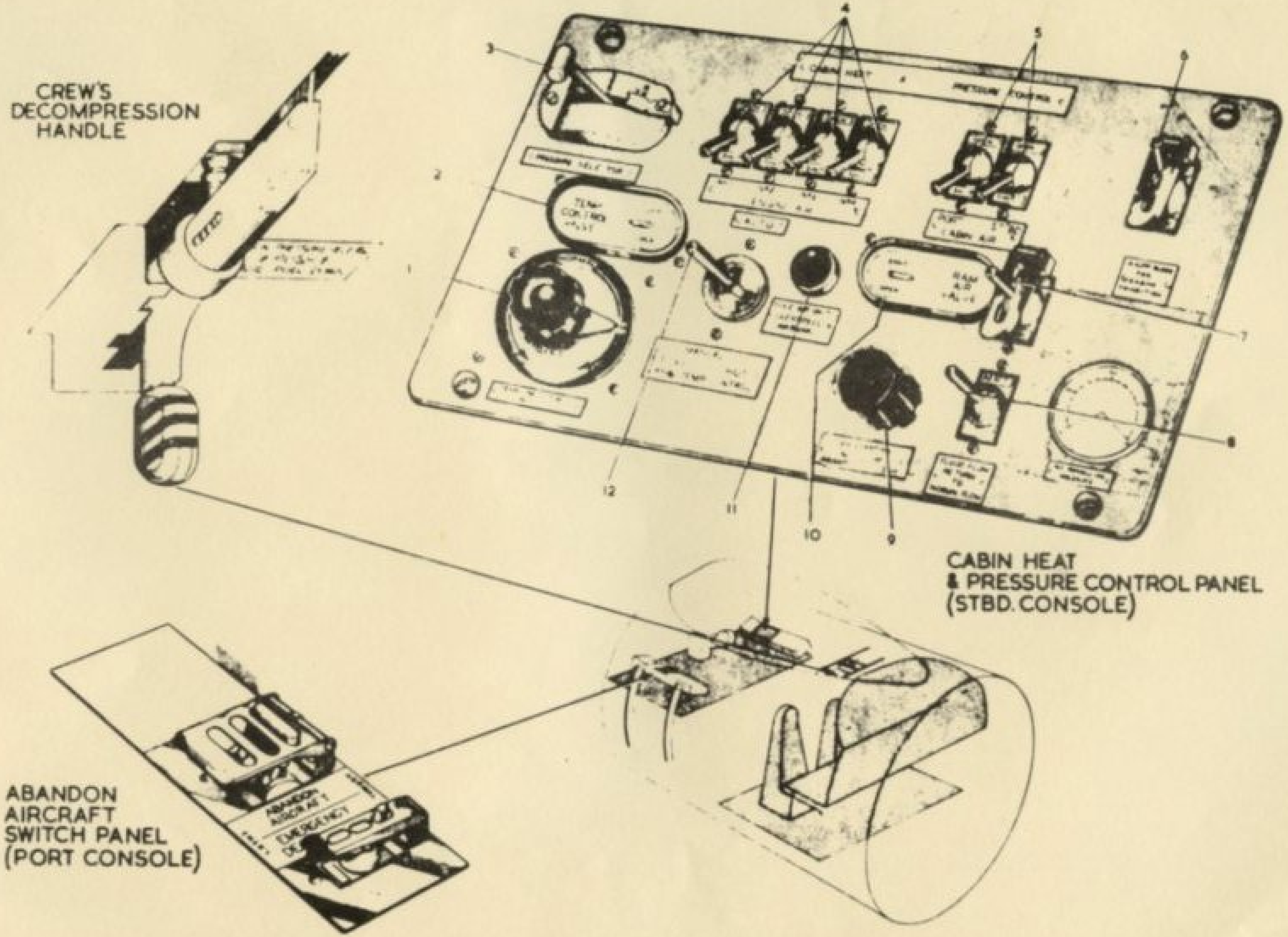
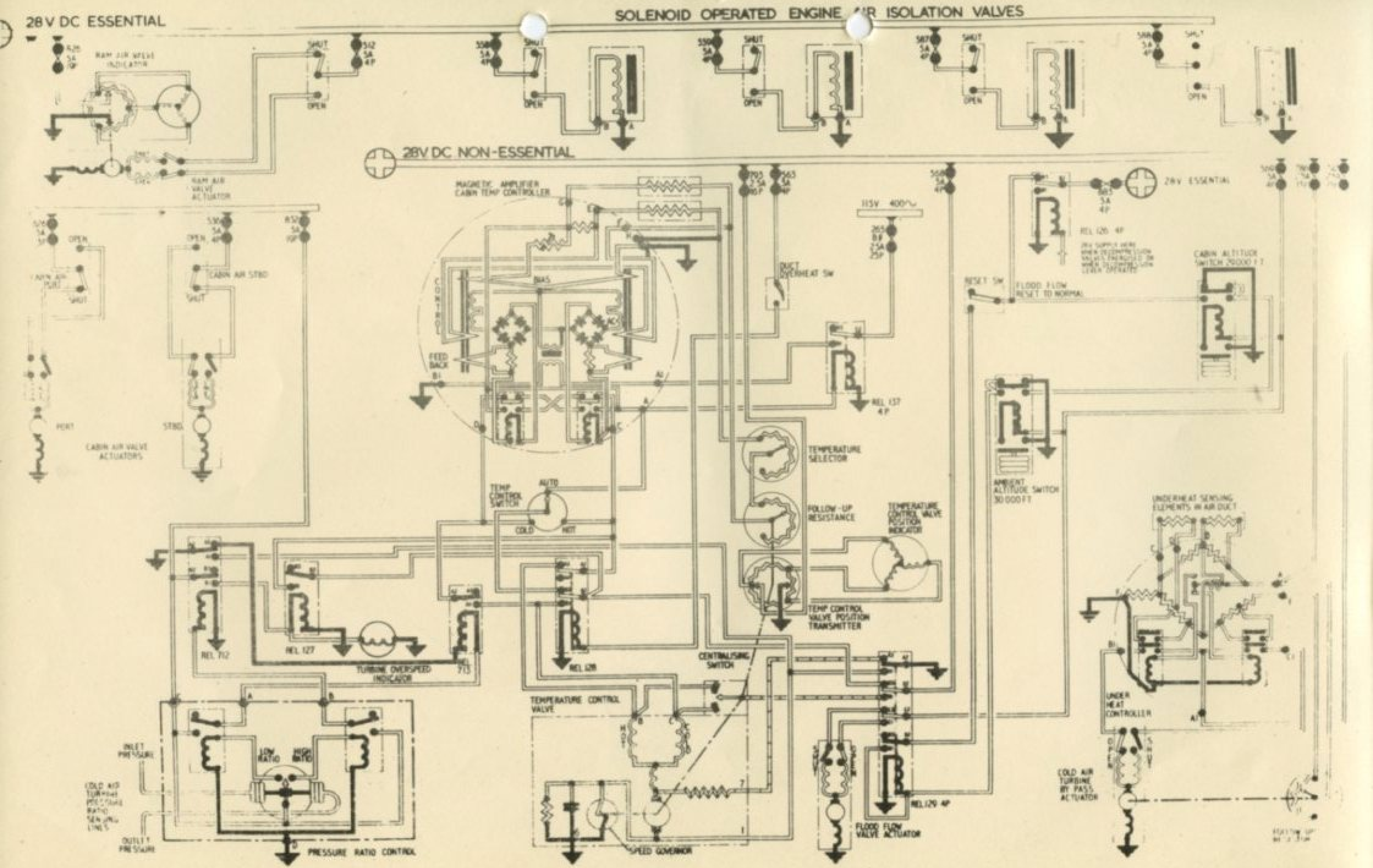
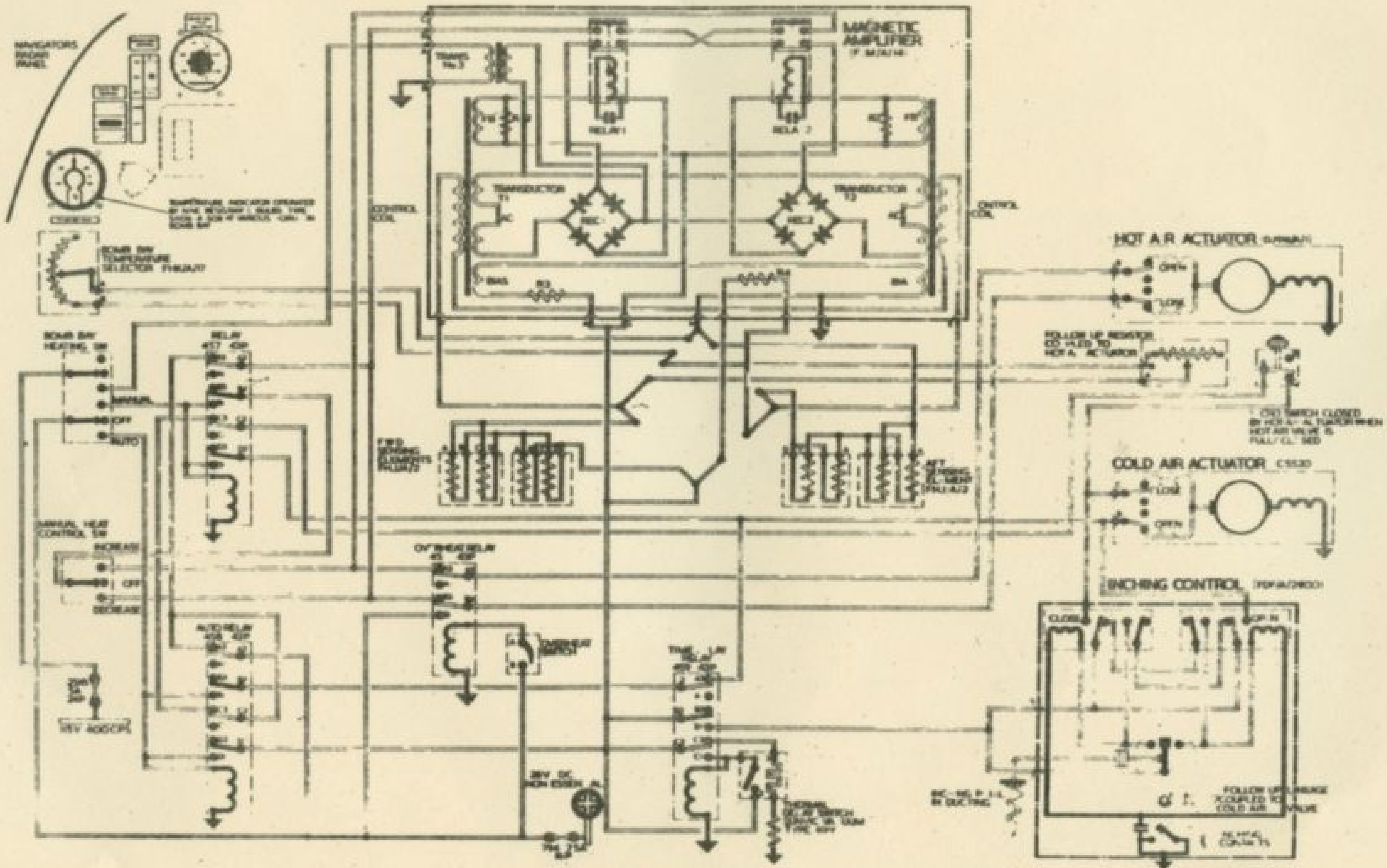


Fig. 1. Controls, air conditioning system.



SOLENOID OPERATED ENGINE AIR ISOLATION VALVES
28V DC ESSENTIAL
28V DC NON-ESSENTIAL
SHUT
OPEN
RAM AIR VALVE ACTUATOR
MAGNETIC AMPLIFIER CABIN TEMP CONTROLLER
CONTROL
BIAS
FEED BACK
115V 400~
DUCT OVERHEAT SW
28V ESSENTIAL
REL 126 4P
RESET SW
FLOOD FLOW RESET TO NORMAL
CABIN ALTITUDE SWITCH 29000 FT
REL 137 4P
AMBIENT ALTITUDE SWITCH 30000 FT
CABIN AIR STBD
PORT
STBD
CABIN AIR VALVE ACTUATORS
TEMPERATURE SELECTOR
FOLLOW-UP RESISTANCE
TEMPERATURE CONTROL VALVE POSITION INDICATOR
TEMP CONTROL VALVE POSITION TRANSMITTER
TEMP CONTROL SWITCH
AUTO
COLD
HOT
UNDERHEAT SENSING ELEMENTS IN AIR DUCT
REL 712
REL 127
TURBINE OVERSPEED INDICATOR
REL 713
REL 128
CENTRALISING SWITCH
UNDER HEAT CONTROLLER
TEMPERATURE CONTROL VALVE
INLET PRESSURE
LOW RATIO
HIGH RATIO
COLD AIR TURBINE PRESSURE RATIO SENSING LINES
OUTLET PRESSURE
PRESSURE RATIO CONTROL
SPEED GOVERNOR
FLOOD FLOW VALVE ACTUATOR
REL 129 4P
COLD AIR TURBINE BY PASS ACTUATOR



BOMB BAY HEATING

DIAGRAM No. 21 6

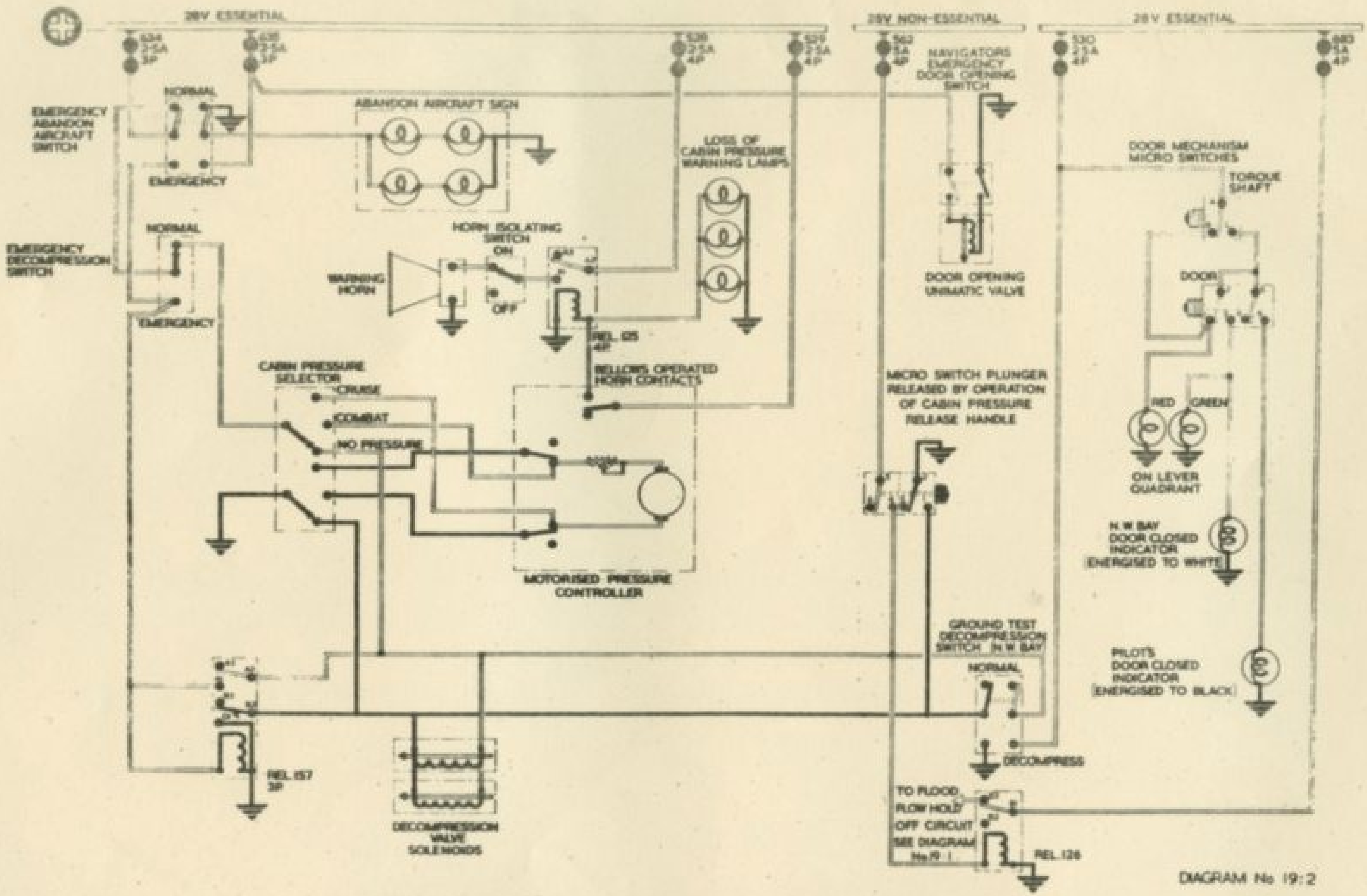
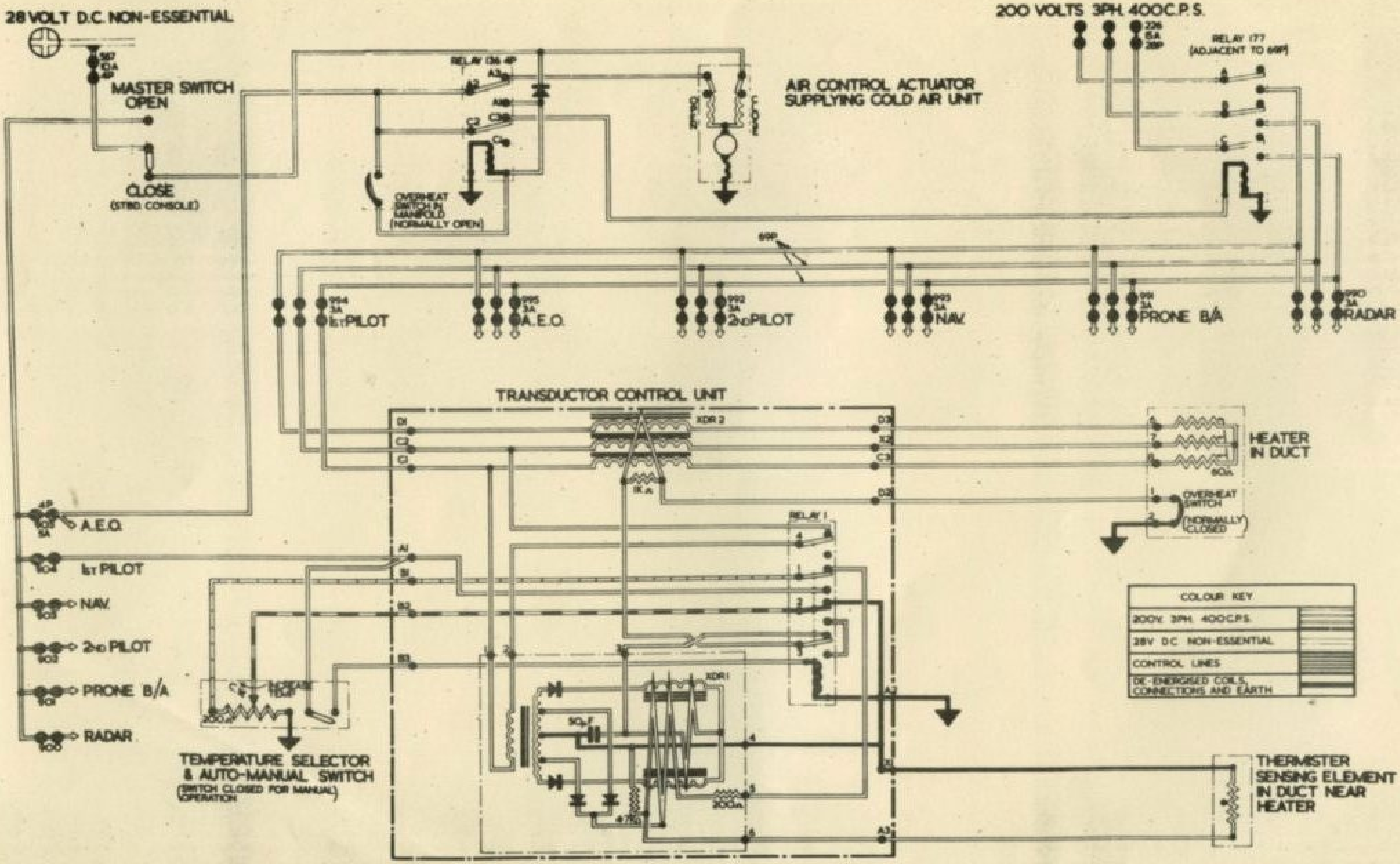


DIAGRAM No 19:2

PRESSURISATION, DECOMPRESSION & WARNING CIRCUIT


28 VOLT D.C. NON-ESSENTIAL
MASTER SWITCH
OPEN
CLOSE
(STBD. CONSOLE)
RELAY 136 4P
OVERHEAT SWITCH IN MANIFOLD (NORMALLY OPEN)
AIR CONTROL ACTUATOR SUPPLYING COLD AIR UNIT
200 VOLTS 3PH. 400C.P.S.
RELAY 177 (ADJACENT TO 69P)
69P
1ST PILOT
A.E.O.
2ND PILOT
NAV.
PRONE B/A
RADAR
TRANSDUCTOR CONTROL UNIT
XDR 2
XDR 1
RELAY 1
HEATER IN DUCT
OVERHEAT SWITCH (NORMALLY CLOSED)
A.E.O.
1ST PILOT
NAV.
2ND PILOT
PRONE B/A
RADAR
TEMPERATURE SELECTOR & AUTO-MANUAL SWITCH
(SWITCH CLOSED FOR MANUAL OPERATION)
THERMISTER SENSING ELEMENT IN DUCT NEAR HEATER
COLOUR KEY
200V. 3PH. 400C.P.S.
28V D.C. NON-ESSENTIAL
CONTROL LINES
DE-ENERGISED COILS, CONNECTIONS AND EARTH


TELEBRIEF
CONNECTIONS
E