Part I—Description and Management of Systems

Chapter 11—Pressurisation and Heating Systems

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Cabin Air System

1 Cabin air, general

(*a*) The cabin is pressurised and air-conditioned with air from the engine compressors, the flow of air passing through automatic flow control valves to the air-conditioning unit and thence to the cabin. Provision is made for conditioning the cabin air both on the ground and in unpressurised flight.

(*b*) Cabin pressure is maintained by two pressure controllers. Pressurisation can be at two alternative levels, either cruise conditions or combat conditions. Provision is made for emergency de-pressurisation. An automatic flood-flow system is provided.

(*c*) The main controls for cabin heating and pressurisation are grouped together on a panel on the starboard console. A cabin altimeter (B/6) is provided on the engine instruments panel.

2 Cabin air conditioning unit

(*a*) The air conditioning unit is in the nosewheel bay. It consists of an air-to-air cooler, a temperature control valve, a cooling brake-turbine unit and a water separator.

(*b*) The cooler is supplied with cold air from a ram air intake on the port side of the aircraft, between the cabin and the engine air intake. The cold air passes round the cooler and is exhausted through a rearward-facing duct below the unit.

(*c*) The brake turbine unit consists of an inward flow turbine coupled to a centrifugal braking compressor. The turbine receives air via the temperature control valve and passes it to a water separator and thence to the cabin. The compressor receives air through a filter from the nosewheel bay and passes it through the exhaust duct.

(*d*) The temperature control valve is electrically-operated, either automatically, or manually. When maximum heat is selected, the engine air passes direct from the flow valves, through the temperature control valve, to the cabin ; the cooler and the turbine are by-passed. At medium temperature settings, the engine air passes through the cooler and the temperature valve to the cabin. For lower air temperatures, the air passes first through the cooler, then through the control valve to the turbine and then to the cabin.

(*e*) An underheat sensing element, set for 2°C, opens a by-pass valve when the air from the turbine falls below this value, thus allowing warm air to mix with the cold air before it reaches the water separator.

(*f*) An overheat switch, set for 175°C, operates to move the control valve towards the cool position, when the output temperature rises to this figure.

3 Cabin pressurisation

(*a*) Cabin pressure is maintained by two pressure controllers, one motorised and the other unmotorised ; the latter acts as a stand-by for the former. Each controller discharges excessive cabin air to a combined valve unit on the forward face of the front pressure bulkhead. Each controller is fitted with a wire-locked pressure adjusting knob and a ground test lever. The latter must always be fully down for flight.

(*b*) Two alternative pressure settings can be obtained. For the cruise condition, pressure is maintained at 8,000 feet until the maximum differential pressure of 9 PSI is reached. For the combat condition, pressure is maintained at 25,000 feet so that a differential pressure of 3·5 PSI is reached at 50,000 feet. Change from cruise to combat condition is achieved at the rate of 12 PSI per minute and from combat to cruise at 1 PSI per minute.

(*c*) *Safety devices*

If a serious loss in cabin pressure occurs, a warning horn sounds and red warning lights come on at each rear crew member's station. The horn can be isolated by operating a switch on the equipment crate structure inboard of the pressure controllers. An inwards relief valve, set to $\frac{1}{2}$ PSI, on the front pressure bulkhead, compensates for any negative differential pressure. Excess cabin pressure is prevented by an outwards relief valve, set to $9\frac{3}{4}$ PSI, also on the front bulkhead.

(*d*) *Flood flow* (inoperative)

(i) Flood flow operates automatically if the cabin pressure falls to 29,000 feet, to provide some measure of pressurisation in an emergency. A relay opens the flood flow valve and, at the same time, moves the temperature control valve to the mid position. The system can be reset if the emergency has ceased to exist. The flood flow can be controlled by closing one or more engine air switches ; this results in a reduction of temperature.

(ii) Should the cabin be intentionally depressurised by any of the controls provided (see para. 5(*g*) below) and cabin pressure is

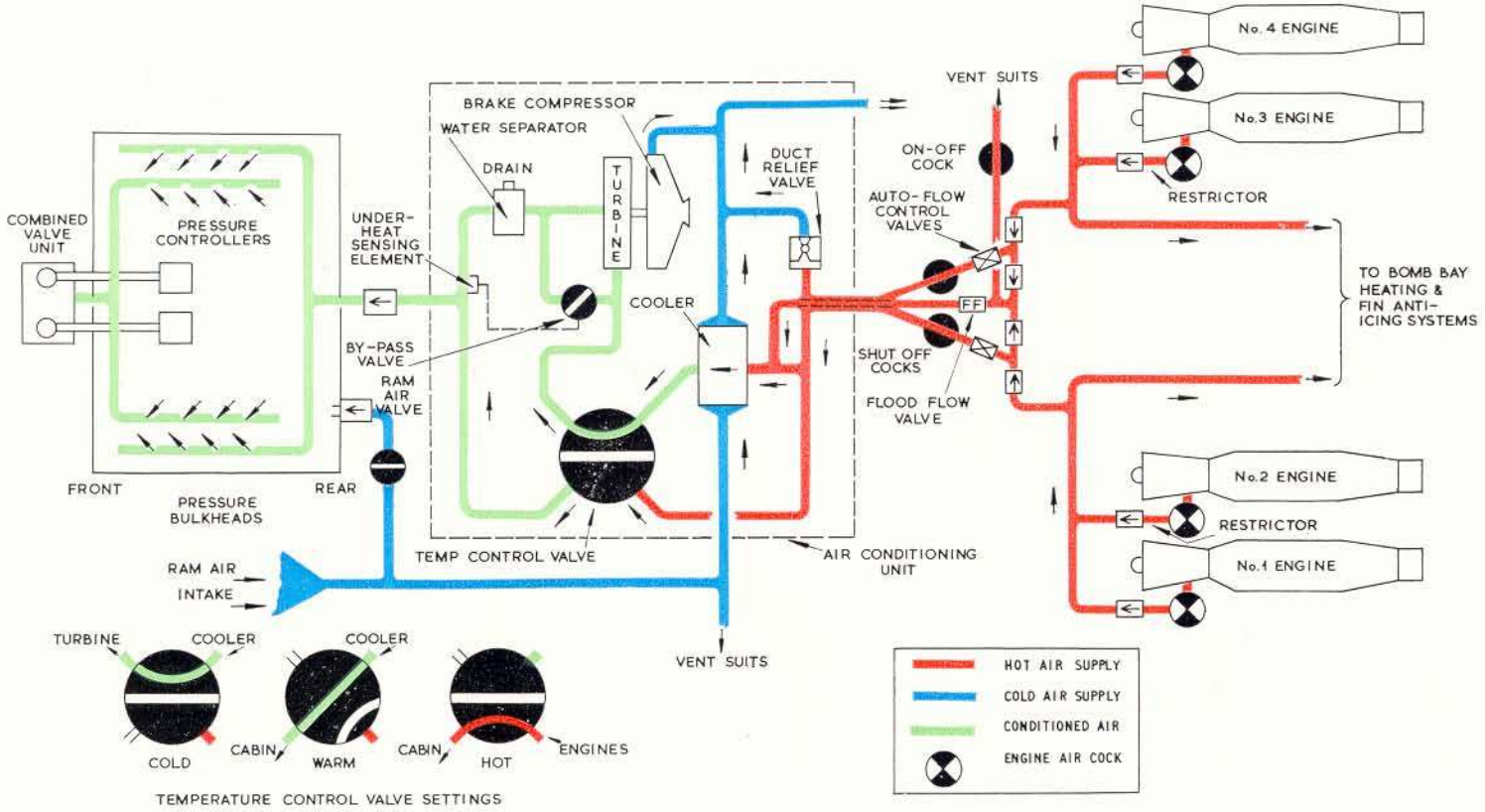

Fig. 1 Cabin Pressurising and Air-Conditioning

selected on again, the flood flow will start up immediately, if the cabin altitude is above 29,000 feet.

(*e*) *Decompression*

Decompression valves, which can be operated electrically by either pilot, or manually by the rear crew, allow decompression of the cabin in an emergency. The air will pass directly into the combined valve unit through a lightly loaded flap-spring. It may take up to 30 seconds for the pressure to fall sufficiently to allow door opening. The ENGINE AIR switches should be SHUT when depressurising the cabin in emergency.

4 Cabin ventilation

(*a*) During unpressurised flight, the cabin may be ventilated by opening the ram air valve on the port side of the cabin. This allows ram air, from the same source as the air cooler supplies, to enter the cabin. The ram air valve must be closed before pressurisation can take place.

(*b*) The cabin and bomb bay may be ventilated on the ground with air supplies from a ground air-conditioning unit. A ground conditioning connection is provided on the starboard side of the aircraft.

5 Cabin air conditioning, controls and indicators

(*a*) *General*

The main cabin conditioning controls and indicators are grouped on a panel on the starboard console.

(*b*) *Engine air switches*

The four ENGINE AIR, OPEN—SHUT switches (E/8), on the outboard side of the panel, control the supply of engine air to the flow control valves. These switches also control the supply of engine air to the anti-icing systems and bomb bay heating. To eliminate fatigue factors in the air ducting lines, the air pressure supply from each inboard engine is reduced to 100 PSI by means of a restrictor plate. The supply from the outboard engine is, however, unrestricted, and for this reason the outboard engine air switches must not be selected OPEN below 10,000 feet above 80% RPM. When cruising below 10,000 feet, all the engine air switches may be selected OPEN but the outboard engine air switches must be selected SHUT before exceeding 80% RPM. Because of the reduced operating pressure above this height the outboard engine air switches may be selected OPEN without causing excess pressure in the air ducting lines. The switches must not be set OPEN when the cabin air switches are SHUT. (See (*c*) below.

(*c*) *Cabin air switches*

The two CABIN AIR OPEN—SHUT switches (E/10), beside the engine air switches, open the shut-off valves allowing the engine air to pass to the air-conditioning unit. One switch controls the port supply and the other the starboard. The switches must not be set to SHUT whilst the ENGINE AIR switches are OPEN.

(*d*) *Flow control*

(i) The mass flow control system consists of automatic flow controllers, which combine shut-off valves, in the triangular ducting assembly (see Fig. 1) at the rear of the nosewheel bay.

(ii) Each flow controller automatically maintains the mass flow to the air-conditioning unit within the required limits. The electrically-operated shut-off valves are normally opened or closed by selection of the CABIN AIR switches.

(iii) Non-return valves in the supply ducting isolate the port and starboard air supplies to the conditioning unit from each other, to prevent complete loss of air if one side of the system is damaged, but permit either side to feed air to the flood flow control valve and to the air-ventilated suit system.

(*e*) *Cabin temperature controls*

(i) Cabin temperature can be controlled automatically or manually. Selection of auto or manual control is made by a four-position CABIN TEMP CONTROL switch (E/37) ; when the

switch is moved in the outboard direction, to AUTO, the temperature is automatically controlled according to the setting of the AUTO TEMP SELECTOR rotary control (E/39), which is infinitely variable. If manual control is desired, the switch is moved inboard and either forward or aft to the MANUAL, COLD or HOT positions until the desired temperature is obtained. The switch is spring-loaded from both these positions to the central (neutral) position. Above the temperature selector is a desynn-type indicator (E/40), showing the position of the temperature control valve.

(ii) *Cold-air unit overspeed*

Any tendency to overspeed will cause a pressure ratio switch to close the port cabin air valve to stop the over-speeding. While the switch is in operation, a magnetic indicator (E/36) on the panel, marked COLD-AIR UNIT OVERSPEED WARNING, will show white.

(*f*) *Cabin ventilation controls*

Ram air valve

The ram air valve is controlled by a 3-position guarded SHUT—OPEN switch (E/11), spring-loaded to the central (neutral) position. A desynn-type indicator (E/9), beside the switch, shows the position of the valve.

(*g*) *Cabin pressure controls*

(i) Cabin pressure is controlled by the 3-position CABIN PRESSURE, COMBAT—CRUISE—NO PRESSURE (gated) switch (E/41). Para. 3(*b*) gives the pressure settings for the COMBAT and CRUISE selections. With the switch at NO PRESSURE, pressurisation does not take place or, if the cabin is already pressurised, moving the switch to NO PRESSURE decompresses the cabin.

(ii) Cabin decompression can also be achieved by operation of either the ABANDON AIRCRAFT switch (C/26) or the EMERGENCY DECOMPRESSION switch (C/27) on the port console or by manual operation of the lever above the crew station. It can also be achieved, on the ground, by a switch in the nosewheel bay. Post-Mod. 2045, the abandon aircraft and emergency decompression switches are single toggle types which must be pulled up before selection.

(iii) The flood flow may be reset by operation of the FLOOD FLOW RETURN TO NORMAL FLOW. RESET switch (E/12).

Operation of Cabin Air System

6 Operation of the pressurisation system

(*a*) Before starting the engines, set the pressurising and air-conditioning controls as follows:

EMERGENCY DECOMPRESS switch	NORMAL (forward)
ABANDON AIRCRAFT switch	NORMAL (forward)
CANOPY UNLOCKED indicator	Black
CREW DECOMPRESS lever	OFF
CABIN AIR switches	SHUT
CABIN PRESSURE SELECTOR	Set to CRUISE
ENGINE AIR switches	All four SHUT
AUTO TEMP SELECTOR	NORMAL temperature
CABIN TEMP CONTROL switch	Neutral (central position)
TEMP CONTROL VALVE	As required
COLD AIR UNIT OVERSPEED WARNING	Black
RAM AIR switch	Operate ram air valve and leave as required. (In hot weather the ram air valve may have to be put in the open position while taxying)

(*b*) After starting engines, both cabin air switches should be set OPEN and may be left open for the sortie. Cabin pressurisation and conditioning may be controlled by selective use of the engine air switches and the cabin temperature controls. The following selections of the engine air switches are recommended for safe and efficient operation of the system:

(i) After starting the engines and while taxying, all SHUT.

(ii) After take-off and during climb to 10,000 feet, No. 2 only OPEN.

(iii) At 10,000 feet Nos. 2 and 4 OPEN.

(iv) On reaching cruising height (above 40,000 feet), all OPEN.

(v) During descent, shut Nos. 1 and 3 at 40,000 feet and No. 4 at 10,000 feet (No. 2 OPEN).

(vi) Before landing the pressure selector should be set to NO PRESS and all engine air switches shut. The ram air valve may be set as required.

(*c*) During prolonged flight, below 10,000 feet, all four engine air switches may be selected OPEN but Nos. 1 and 4 must be SHUT before exceeding 80% RPM.

(*d*) Air conditioning is marginal when the OAT is near +29°C. Before descent, when prolonged flight at low levels is intended, the cabin should be refrigerated using the cold air unit. All engine air switches and both cabin air switches should be selected OPEN at low level.

(*e*) *Use of manual control*

If the automatic cabin temperature control fails, manual control of the cabin temperature may be exercised by moving the CABIN TEMP CONTROL switch from the AUTO position into either of the COLD or HOT positions as required. The switch is spring-loaded and should be inched towards either of these positions until the cabin air valve has moved towards HOT or COLD as shown on the indicator; the TEMP SELECTOR AUTO rheostat is inoperative when manual control is used.

7 Cold air unit overspeed

If the COLD AIR UNIT OVERSPEED WARNING magnetic indicator momentarily changes to white, a pressure ratio switch automatically operates to prevent the cold air unit overspeeding and the magnetic indicator should revert to black. If the magnetic indicator continues to blink to white, however, the No. 3 & 4 ENGINE AIR switches must be set SHUT until overspeeding stops and the indicator shows steady black.

8 Loss of cabin pressure

If there is a serious leak in cabin pressure, or if, during the climb, the aircraft rate of climb exceeds the rate of pressurisation, the warning horn will sound and, if the cabin altitude rises to 29,000 feet, the flood flow will operate automatically. If pressure is regained, the flood flow RESET switch should be operated.

9 Emergency decompression

In an emergency the cabin pressure can be released by one of the following means :

(*a*) Setting the EMERGENCY DECOMPRESS switch to its rear position. (1st Pilot)

(*b*) Setting the ABANDON AIRCRAFT switch to its rear position. (1st Pilot)

(*c*) Selecting NO PRESSURE on the pressure selector switch. (co-pilot)

(*d*) Operation of the CABIN PRESSURE RELEASE handle in the roof of the crew's compartment.

(*e*) A double-pole switch in the nosewheel bay—for external use.

If the cabin is subsequently re-pressurised, it must be remembered that the flood flow will operate if the cabin altitude is above 29,000 feet.

NOTE 1: In order to increase the rate of depressurisation, the engine air switches should be SHUT at the same time as decompression action is taken.

NOTE 2: When re-pressurising the cabin, COMBAT should be selected initially.

Air-ventilated Suits System

10 Air-ventilated suits system, general

(*a*) The air-ventilated suits are supplied from an air-conditioning unit, similar to that used for cabin conditioning. A tapping of engine air is taken from the flood flow line of the cabin system and cold air is taken from the cabin system ram air intake.

(*b*) The main components in the air-conditioning unit are an air-to-air cooler, a turbine and fan, a water extractor, a heat-exchanger and a filter.

(*c*) From the filter, the conditioned air passes, via a non-return valve, into a manifold in the cabin and thence to the individual suits.

(*d*) A ground-conditioning connection is provided, so that an external supply may be plugged into the suits.

11 Suit air-conditioning unit

(*a*) The suit air-conditioning unit is in the nosewheel bay, just aft of the cabin conditioning unit. Engine air from the flood flow supply line passes, via an electrically-operated on-off cock, to the air-to-air cooler and thence to the turbine and the water extractor. A branch line passes through a temperature control valve to the heat exchanger.

(*b*) A tapping from the air from the cooler passes, via a flow augmenter, to the forward side of the water extractor, in order to provide additional pressure at altitude. This air mixes with the air from the turbine and passes through the filter to the manifold in the cabin.

12 Suit components and controls in cabin

(*a*) The temperature of the air in the manifold is controlled by a sensing unit operating the temperature control valve which controls the flow of heating air to the heat exchanger. Overheat conditions are controlled by an overheat switch operating the cock controlling the supply of hot air to the conditioning unit. Pressure in the manifold is regulated by the pressure controller in conjunction with the relief valve.

(*b*) From the manifold, individual lines pass to each suit connection. An electric heater is incorporated in each line, controls being provided at each crew station. From the electric heaters, the air passes to manual control valves, which regulate the flow of air to the suits.

(*c*) *Controls*

(i) The main on-off cock in the hot air supply is controlled by an OPEN-CLOSE switch (E/22) at the rear of the starboard console.

(ii) Temperature and flow controls are provided for each individual suit, as follows :—

1st and co-pilots	Temperature control on starboard side of each seat, flow control on port side.
Nav./radar (prone station)	On the port side, on pilots' floor supports.
Rear crew members	Temperature control on port side of each seat, flow control on starboard side.

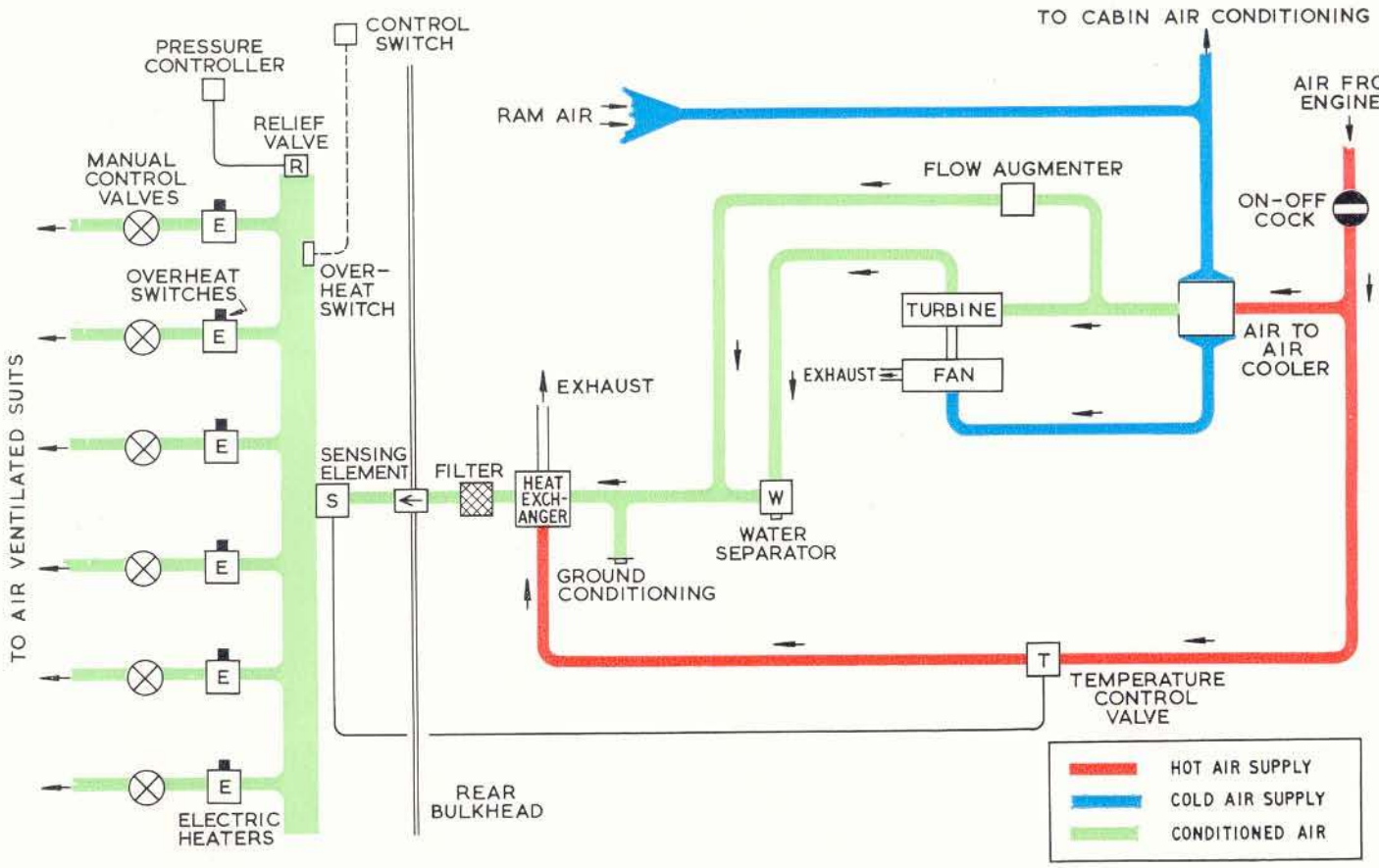

Fig. 2 Air Ventilated Suits System

(iii) The system can be operated when the cabin is unpressurised and when taxying. When the engines are not running the suits may be ventilated from a ground supply through a connection on the underside of the port wing centre section.

(iv) Overheat protection is provided.

Bomb-Bay Heating

13 Bomb-bay heating system

(a) General

The bomb bay is heated with engine air from the cabin air supplies, a branch pipe leading from each of the port and starboard supply lines. This supply is also fed to the fin anti-icing system.

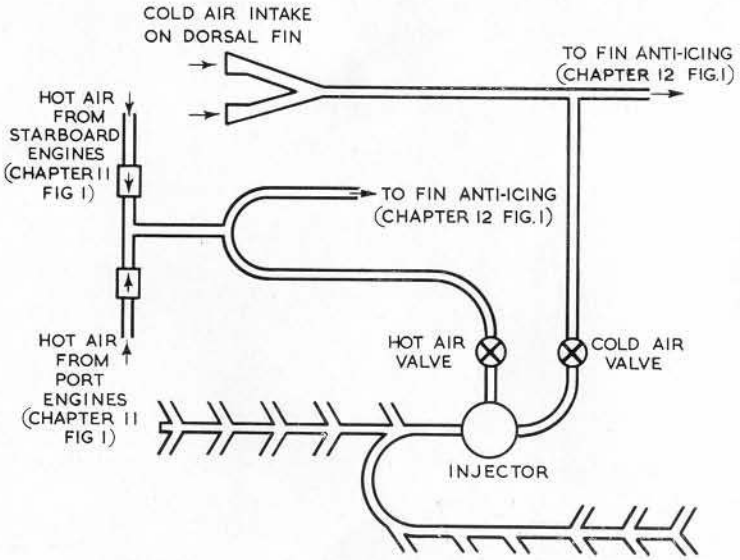

Fig. 3 Bomb-bay Heating

(b) Air supplies

Cold air is provided by twin dorsal intakes, which also supply the fin anti-icing. The hot and cold air supplies are fed to a mixing unit and then to two ducts in the bomb-bay. Branches from the ducts distribute the warm air throughout the bomb-bay. An outlet louvre in the port bomb door exhausts the air to atmosphere.

(c) Bomb door sealing

(i) To assist in preventing heat losses from the bomb-bay, non-inflatable seals are fitted to the doors at all hinges and joints, with the exception of the forward and aft ends of the bay where inflatable seals are fitted.

(ii) The inflatable seals are supplied with air from the hydraulic reservoir air supply line from the port and starboard engines. The air supply is arranged so that when the " bomb doors closed " micro-switch at the forward end of the doors, on the port side is " made ", solenoid-operated valves permit air to inflate the seals. When the bomb doors are opened the current to the solenoid-operated valves is cut off and, as a result, the air pressure is exhausted to atmosphere through these valves.

(d) Method of control

The system can be controlled automatically or manually. Under automatic control, the temperature of the bomb-bay can be selected to between 0 and 25°C, with a tolerance of ±5°C, depending on the store carried ; the temperature of the heating air is between 95° and 105°C. An overheat switch in the ducting shuts off the hot air supply if the temperature of the heating air rises above 130°C.

14 Bomb-bay heating controls and operation

(a) The controls for bomb-bay heating are at the nav/radar's station and consists of an AUTO-OFF-MANUAL double-pole switch, a temperature selector (for use with AUTO), a MANUAL HEAT CONTROL, INC-OFF-DEC switch, spring-loaded to the OFF position, and a temperature gauge.

(*b*) To operate the bomb-bay heating, the engine air switches on the cabin conditioning panel must be OPEN and the double-pole switch selected to AUTO or MANUAL as required. Manual control should be used below 10,000 feet. When in manual, a careful watch should be kept on the temperature gauge to avoid overheating, and the temperature should be controlled within the range −5°C to +30°C, or within the requirements of any store carried.

Windscreen Thermal Demisting

15 Windscreen demisting supplies

(*a*) *Thermal system*

(i) To demist the inside of the windscreen, hot air is supplied from a spray pipe on each side of the centre panel. Heated cabin air is supplied to a blower motor, below the pilot's floor on the starboard side. From the blower motor, the air passes to a 1 kW heater unit and thence to the windscreens.

(ii) An overheat switch in the system cuts off electrical supplies if the temperature of the air in the ducting rises above 80°C and switches supplies on again when the temperature falls to 60°C.

(iii) The blower motor is operated by a 115-volt AC supply from the No. 1 inverter, and the heater unit supplied by the 112-volt section.

(*b*) *Silica gel system*

The three centre panels of the windscreen are of the sandwich type, and to prevent internal misting the air space between the outer and inner windows are each connected to a separate silica gel contained in the cabin, on the port side forward of the instrument panels.

16 Windscreen demisting controls and operation

(*a*) Windscreen demisting is controlled by the W/SCREEN DEMIST ON-OFF switch (E/16) on the starboard console. When switched ON, current is supplied to the heater and the blower motor.

(*b*) The system should be tested before flight, after starting the engines, by switching on and physically checking the airflow from the ducts.