PART 2

CHAPTER 1 — AIR CONDITIONING SYSTEM

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PART 2

CHAPTER 1 — AIR CONDITIONING SYSTEM

General Description

1. The pressurisation and air conditioning system consists of two separately controlled systems, one on the left side and one on the right side of the aircraft, each system being supplied with air from two engine-driven compressors on the associated side. An integral flow control slide valve on each compressor in conjunction with the flow control system ensures that the power required to drive the compressor is kept to a minimum. The output of each pair of compressors is governed by a mass-flow control system.

2. Under automatic control, the fuselage can be pressurised up to a normal maximum differential pressure of approximately 9 PSI, so that with the aircraft at an altitude of 40,000 ft. the cabin can be maintained at a pressure equivalent to 6,000 ft.

3. The pressure control equipment is electro-pneumatically controlled and is automatic in operation, with provision for selection of cabin altitude and rate of cabin-altitude change. Over-pressurisation is prevented by two cabin safety valves, which, together with the discharge valves, also provide inward relief.

4. Failure of the normal pressure control mechanism, resulting in loss of cabin pressure, is guarded against by emergency pressure controllers, on each of the two discharge and safety valves, which are set to 9,000 ft.

5. A warning horn on panel A sounds intermittently when cabin altitude exceeds 10,000 ft.

6. A mechanically-operated dump valve enables the cabin pressure to be manually controlled or relieved. The thrust augmenters can also be used as an adjunct to this control.

7. The air supply from the pair of compressors on each side passes through its own separate air conditioning system, the system on the left supplying the passenger cabin and the system on the right the flight deck. Air surplus to flight deck requirements is diverted to the cabin. Automatic temperature control is fitted to both systems and provision is made for manual control.

8. Conditioned air is fed from the passenger cabin distribution ducting into wall bay ducts around the windows and from them into the cabin just below the hat rack. Individual louvres are provided; they are supplied with conditioned air, or recirculated air, depending upon temperature control selection via a louvre fan installed inboard of the right side evaporator.

9. A manually-switched humidifier is fitted down-stream of the evaporator in each system, utilising water from the domestic water supply tanks.

9A. A ducting at the forward end of the cabin right distribution duct supplies warm air to the superheating coils of the passenger oxygen system. Supply of warm air to the coils is automatic under certain operating conditions, but manual control is also provided (see Chapter 16, para. 9 of this Part). When under manual or automatic control, micro-switches isolate the protection switches in the mass flow sensing units. This ensures power is available to the auto-mass flow control to maintain airflow over the heater coil.

10. When ground equipment is to be used for air conditioning before flight, it may be connected to a ground connection on a panel in the fuselage forward of the right wing root.

11. A recirculation system, which is automatically introduced under certain temperature control selections or by manual selection, is tapped into the air supply ducting up-stream of each system's evaporator. The fan in the RH recirculation system can be used in unpressurised flight, or on the ground, to draw ambient air into the aircraft for ventilation purposes.

12. Two thrust augmenters are in the fuselage. When selected, most of the exhaust airflow from the cabin is diverted from the discharge valves through the augmenters, providing additional thrust to the aircraft.

13. With the exception of the mechanically-operated dump valve, all controls and indicators for both systems are located on the air conditioning or pressurisation panels at the engineer's station.

Distribution Ducts

14. The right and left distribution ducts down-stream of the evaporators are connected by a plenum duct in the evaporator bay. The right system plenum duct inlet arm embodies a branch to the flight deck distribution system.

15. Down-stream of the plenum duct, an outlet duct divides and runs outboard left and right, each branch forming a multi-branched cabin distribution duct. Two further ducts extend aft through the centre section and along the aft freight hold.

16. Flexible auxiliary ducts, taken from the main distribution ducts on each side, connect to the wall cavities from whence air is distributed through grilles at the top of the cavities, immediately below the lighting coves.

17. *Location of Controls and Indicators—Pressurisation System.* (See Table 1)

18. *Location of Controls and Indicators—Radio Rack Cooling.* (See Table 2)

Table 1. Location of Controls and Indicators — Pressurisation System

Item	*Location*	*Marking/Indication*
Cabin selector	Pressurisation panel	CABIN SELECTOR
Cabin altimeter	Pressurisation panel	CABIN HEIGHT
Cabin altimeter	Co-pilot's inner sill panel	CABIN HEIGHT
Cabin rate of climb indicator (VSI)	Pressurisation panel	CABIN RATE OF CLIMB
Cabin differential pressure gauge	Pressurisation panel	DIFF. PRESS. PSI.
Discharge valve switches (2)	Air conditioning panel	DISCHARGE VALVES FWD—NORM/SHUT AFT—NORM/SHUT
Discharge valve indicators (2)	Air conditioning panel	DISCHARGE VALVES FWD/AFT
Dump valve hand wheel	Engineer's station	DUMP CONTROL VALVE
Dump valve indicator	Engineer's table top	DUMP VALVE — OPEN/SHUT
Amplifier pack	Radio bay	Ground test switch on pack
Thrust augmenter switches (2)	Air conditioning panel	THRUST AUGMENTERS FWD — OPEN/RESET/SHUT AFT — OPEN/RESET/SHUT
Thrust augmenter indicators (2)		In-line; Cross-line
Unpressurised vent valve switch		UPVV-SHUT/OPEN
Unpressurised vent valve indicator		In-line; Cross-line
Humidifier control switch		HUMDFRS — LH ON/OFF/RH ON
Left compressor slide indicators (2)		LEFT COMPRESSOR SLIDES 1, 2
Right compressor slide indicators (2)		RIGHT COMPRESSOR SLIDES 3, 4
Left compressor 4 in. non-return valve warning lights (2)		NRV (Amber)
Right compressor 4 in. non-return valve warning lights (2)		NRV (Amber)
Left spill valve switch and indicator		NORM/OFF/SHUT/SPILL
Right spill valve switch and indicator		NORM/OFF/SHUT/SPILL
Left cabin supply 6 in. non-return valve warning light		NRV (Amber)
Right cabin supply 6 in. non-return valve warning light		NRV (Amber)
Mass-flow control warning lights (4)		AUTO OFF (Amber)
Mass-flow control switches (4)		AUTO/OFF/DEC/HOLD/INC
Compressor oil LP warning lights (4) (inoperative)	Flight controls panel at engineer's station	COMPRESSOR OIL LP — 1, 2, 3, 4
Cabin altitude warning horn	Panel A	—
Flight deck flow balance switch	Air conditioning panel	FLOW — INC/DEC
Flight deck flow balance indicator	Air conditioning panel	Indicates valve position

Table 2 — Location of Controls and Indicators — Radio Rack Cooling

Item	*Location*	*Marking/Indication*
Changeover switch for radio rack cooling fan	Air conditioning panel	RADIO FANS No 1, No 2
Warning light for radio cooling fans	Air conditioning panel	RADIO FANS (amber)
Radio cooling valve position indicator	Air conditioning panel	RADIO COOL VALVE In-line; cross-line

PRESSURISATION SYSTEM

Compressors

19. Air for both pressurisation and air conditioning systems is supplied by four engine-driven compressors, one on each engine; any pair of compressors can maintain normal cabin pressure but with air conditioning at a reduced standard should an engine or compressor fail. Each compressor is designed to deliver a nominal 43·75 lb per minute up to 40,000 feet.

20. The mass flow from each compressor can be varied by changing the position of the flow control slide valve on the compressor, by manual selection or automatically via the flow control system. A COMPRESSOR SLIDES quadrant-type indicator is provided for each compressor. Under automatic control, the output from each pair of compressors is controlled to a nominal 87·5 lb per minute.

21. Each compressor has a self-contained lubrication system. Oil is contained in a 4·42 litres (7·8 pints) capacity sump, which has a sight-level glass, on the side of the gearbox. A quick-release coupling is provided for refilling.

Compressor Four-Inch Non-Returu Valves

22. A four-inch non-return valve is provided in each compressor delivery duct (two on each side) to prevent a feedback into a failed compressor. A valve, which is held open by airflow, shuts when flow ceases. When the valve is closed, an NRV warning light on the engineer's panel comes on, indicating no flow from the associated compressor.

Metering Ducts

23. A venturi metering duct is fitted downstream of the junction of the delivery ducts from the pair of compressors in each system. Inlet and throat pressures are fed to an adjacent pneumatic pressure sensing unit.

Pneumatic Pressure Sensing Units

24. A pneumatic pressure sensing unit in each system forms the sensing and signalling element for the electro-pneumatic flow control circuit for its associated system. Each sensing unit comprises a sealed case, housing a diaphragm and capsule assembly. The venturi metering duct inlet and throat pressures in each system are fed to opposite sides of the associated diaphragm. Failure of a diaphragm or capsule results in isolation of the automatic flow control system and the illumination of the AUTO OFF warning lights on that system.

Dual Amplifiers

25. A dual amplifier is mounted next to each sensing unit in the rear fuselage. When a MASS FLOW CONTROL switch is set to AUTO, the output signal from the associated sensing unit is fed to its dual amplifier, whose signal in turn is fed to a torque motor which moves a spool valve to admit high pressure oil to one side of the slide valve piston. Also fed through the amplifiers are the compressor slide valve synchronising circuits and AUTO OFF warning light circuits.

Spill Valves

26. An electrically-operated spill valve is fitted in each supply duct from the fin, down-stream of the heat exchanger. The outlet from the spill valves terminate at outlet grilles in each side of the fin. On each side, the spill valve operates in conjunction with the stop valve (para 27), the spill valve and stop valve being electrically-sequenced by microswitches in both assemblies. Both valves on the one side are under the control of the associated spill valve switch. Each spill valve is controlled by a four-position, centre OFF/NORM/SHUT/SPILL switch. A quadrant-type valve position indicator, marked SPILL, is adjacent to each switch.

Stop Valves

27. An electrically-operated stop valve is fitted, in each side main supply ducting, down-stream of the spill valve. Each stop valve operates in sequence with its associated spill valve (para 26) and, when shut, prevents air from the compressors on that side from being delivered into the system.

Cabin Supply Six-Inch Non-Return Valves

28. A six-inch non-return valve is provided immediately down-stream of each stop valve on each side. A valve, which is held open by airflow, closes when flow ceases. When a valve is closed, an NRV warning light on the engineer's panel comes on, indicating no flow from the associated system.

Duct Pressure Relief Valves

29. A duct pressure relief valve is fitted in each system, to relieve excess pressure. The valves are mounted on the outlet duct assemblies at the rear of the heat exchanger in the dorsal fin.

Ground Conditioning Connection

30. A ground conditioning connection, fitted with a rubber flap-type non-return valve, is on a panel inside a door in the right side of the fuselage forward of the wing root. From the connection a pipe is led to the centre of the plenum duct which connects the right and left-hand systems within the vapour cycle bay.

Ground Pressure Test Point

31. A ground pressure test point is on the aft bulkhead, on the left main undercarriage bay.

Flow Balance Valve

32. An electrically-operated butterfly-type valve in the right side system, controlled by the FLOW — INC/DEC three-position switch, governs the air flow to the flight deck. The valve cannot be fully closed, a minimum of 30% of full flow being allowed to pass at full DEC selection. Air in excess of requirements mixes in the plenum duct with that of the left side system. A FLOW quadrant-type valve position indicator is provided adjacent to the switch.

Discharge Valves

33. Two identical discharge valves are fitted, one at the forward end and one at the aft end of the aircraft. The forward valve is on the rear arm of a Y-shaped air outlet on the left side of the nose of the aircraft. The aft valve is fitted to the left arm of a similar Y mounting in the centre of the rear pressure bulkhead.

34. The discharge valves are manually controlled by two DISCHARGE VALVES—FORWARD-AFT NORM/SHUT switches. Quadrant-type indicators, adjacent, indicate valve settings.

35. Each discharge valve is a small compact unit which regulates the discharge of fuselage air under the controlling action of an electro-pneumatic relay, which is energised from an amplifier pack (para 62). When there is no output from the amplifier the discharge valves are closed.

36. An emergency pressure controller, designed to regulate and maintain a cabin altitude of a nominal 9000 feet, is fitted on each discharge valve.

37. A solenoid valve is mounted on the top of the discharge valve casing and the static bleed line from the emergency controller is piped through it. The solenoid is energised when the associated DISCHARGE VALVES switch is set to SHUT. With the solenoid valve energised, the static bleed is closed and the discharge valve closes.

38. Automatic inward relief action is provided by the discharge valves which operate at a negative cabin/ambient pressure of 0·5 PSI.

39. A ditching cock on top of each discharge valve is not used on this aircraft and is wire-locked closed.

Safety Valves

40. Two identical safety valves, which operate in a similar manner to the discharge valves, but are pneumatically sensed and controlled are fitted, one at the forward end and one at the aft end of the aircraft on the Y-shaped air outlet fittings on which the discharge valves are located. A valve opens to bleed excess pressure via the associated emergency pressure controller should the cabin/ambient differential pressure exceed approximately $9{\cdot}5 \pm 0{\cdot}1$ PSI. The safety valves also provide automatic inward relief should a negative cabin/ambient pressure in excess of 0·5 PSI be exceeded. In addition, the safety valves are fitted with emergency pressure controllers to limit cabin altitude to 9000 feet in the event of failure towards the open setting.

Air Driers

41. A condenser-type air drier is fitted adjacent to each discharge/safety valve mounting.

Filter Units

42. A filter unit is fitted in the pipeline between each discharge/safety valve and air drier.

Table 3 — Location of Controls — Recirculation and Louvre Supplies

Item	*Location*	*Marking*
Louvre fan switch	Air conditioning panel	LOUVRE FAN—ON/OFF
Recirculation fan switches—left and right (two)		RECIRC—NORM/OFF/ON

Dump Valve

43. A mechanically-operated butterfly-type dump valve, located to the rear of the forward discharge valve, is provided for use in emergency. The valve is operated by a handwheel at the engineer's station. Normally the dump valve is closed and locked by a removable pin. A DUMP VALVE—SHUT/OPEN position indicator is above the handwheel on the engineer's table.

Thrust Augmenters

44. Two thrust augmenters are fitted, one on the lower right-hand side in the electrical bay, and one forward of the rear pressure bulkhead on the upper right-hand side. Each augmenter is separately controlled by an OPEN/RESET/SHUT switch. A magnetic indicator for each augmenter is adjacent to its associated switch.

45. When a thrust augmenter is in use, ie OPEN, the exhaust airflow from the cabin passes to atmosphere via a nozzle, providing thrust to the aircraft.

46. When either overheat protection circuit operates, the augmenters, if in use, automatically close, and remain closed until the overheat circuit is reset and the thrust augmenter switches set to RESET and OPEN.

47. Manual switching of the thrust augmenter switches can be used as a useful adjunct to the dump valve. Also, in the case of a discharge valve failing closed, the appropriate thrust augmenter can be used in cruise to maintain good cabin temperature distribution.

47A. *Location of Controls—Recirculation System and Louvre Supplies.* (See **Table 3**).

Recirculation System

48. The recirculation system (which is interconnected with the louvre supply when out of the frig range) and the unpressurised ventilation system is tapped into the system on each side just upstream of the evaporator.

49. Air for recirculation is drawn from the forward and centre portions of the cabin by an electrically-operated fan in each system, and is fed, via non-return valves, back into the left and right side air conditioning systems upstream of the evaporators. The mixed product is conditioned and passed into the associated distribution system.

49A. An electrically-operated anti-stall valve is fitted in a branch of the outlet ducting from each recirculation fan. The valves operate to bleed off air into the vapour cycle bay to prevent the fans from stalling when starting. In flight, the anti-stall valves open if the refrigerator is switched to NORM with the associated fan switch at NORM or whenever the fan switch is ON. On the ground, the anti-stall valves open when the recirculation fans are switched ON, but close if the temperature control is in the refrigeration range with the recirculation fan switches at NORM.

50. The recirculation system normally operates within the refrigeration range, by means of the two fans which are controlled by two RECIRC-NORM/OFF/ON switches. Setting a switch to NORM allows the associated fan to be switched on automatically when the associated refrigerator switch is set to NORM. An altitude switch on panel PA in the electrics bay, operative only during a NORM selection, cuts out the fans at heights above 30,000 feet. Setting a switch ON causes the associated fan to operate in spite of other prevailing conditions in the control circuit. Setting a switch OFF isolates the fan.

51. When the right-hand side refrigeration system is not in use, the louvre stop valve is automatically closed and the louvre fan (para 54) draws air from the recirculation ducting to supply the individual louvres.

52. During unpressurised conditions, an unpressurised ventilation valve can be opened. Air is then drawn from atmosphere to the right-side (flight deck) recirculation fan and fed into the distribution system. The radio rack cooling is electrically connected with the unpressurised vent valve.

Louvre Supply

53. Individually controlled cool air louvres are located throughout the passenger cabin, at each crew station on the flight deck, and in the galleys and toilets. The air supply is ducted to the louvres from one or two sources in the vapour cycle bay, dependent on temperature control selection. The louvre boost fan is electrically-operated, and controlled by a LOUVRE FAN — ON/OFF switch.

54. When the right side refrigeration system is started, the louvre stop valve automatically opens to permit conditioned air to be fed from the right side evaporator through the louvre boost fan into the louvre distribution system. In this condition, the recirculation fan is running and the louvre non-return valve is held closed by air pressure. When the right-hand refrigeration system is not operating, the louvre stop valve is closed and the louvre fan draws air from the recirculation air ducting to supply the individual louvres.

Unpressurised Ventilation

55. This system provides a means of ventilating the aircraft whilst it is on the ground or during unpressurised flight conditions. The unpressurised ventilation valve is mounted over an inlet grille in the evaporator bay pressure skin and connected by a duct to the RH recirculation air inlet duct between a non-return valve and the RH recirculation fan. A differential pressure switch in the electrical circuit prevents opening of the unpressurised ventilation valve when the fuselage is pressurised above 0·25 PSI pressure differential.

56. The valve, which is electrically-controlled by the UPVV-SHUT/OPEN switch, is wired in sequence with the radio rack cooling valve. On the ground, with the switch set to OPEN, the radio rack cooling valve is open. In flight, with the switch set to OPEN, the radio rack cooling valve is automatically closed by the operation of an undercarriage switch, to ensure that the ducts downstream of the radio cooling fans are not subjected to negative differential pressure.

57. Magnetic indicators are provided on the air conditioning panel to indicate the unpressurised ventilation valve and radio cooling valve settings.

Radio Rack Cooling

58. The air heated by the radio equipment is ducted and exhausted to atmosphere when the aircraft is on the ground, and into the vicinity of the forward discharge and safety valve during flight. The exhaust path is controlled by the radio rack cooling valve which is electrically sequenced with, and controlled by, operation of the unpressurised ventilation valve on the ground. The circuit to the radio rack cooling valve is through an undercarriage switch so that the valve automatically closes when the weight comes off the undercarriage — if the UPVV is selected OPEN.

59. Air is drawn through the ducting by either one of two electrically operated fans. Each fan has a performance in excess of normal radio rack cooling needs and the excess flow is utilised to exhaust the forward toilets and miscellaneous stowage unit/galley via a ducting.

60. Either fan is selected by a No 1/No 2 RADIO FANS changeover switch. An adjacent FAIL warning light comes on if a fan fails; this results in the other fan automatically starting up. Setting the changeover switch to the serviceable fan cancels the warning light and isolates the faulty fan.

61. A RADIO COOL VALVE magnetic indicator is provided adjacent to the FAIL warning light to indicate the setting of the valve.

Cabin Pressurisation Control

62. The cabin altitude selector controls the selected cabin altitude and has provision for regulating the rate of altitude change. It operates both discharge valves, to obtain a balanced flow of air from the cabin, by means of a pair of amplifiers housed in a pack located on shelf 16, on the right radio rack.

63. There are three control knobs on the face of the instrument:

a. The knob in the centre, which allows a pointer to be set to the prevailing barometric pressure against scales calibrated in millibars and inches of mercury. It should be used first when setting up the cabin altitude.

b. The knob A, which permits pre-selection of the desired cabin altitude within the range minus 2000 to plus 8000 feet, the cabin differential pressure being indicated on the DIFF PRESS gauge on the PRESSURISATION panel.

c. The knob R, which selects the rate of altitude change between 200 to 800 feet per minute, the change being indicated on the CABIN RATE OF CLIMB indicator.

64. a. A ground test switch and sockets on the amplifier pack are provided for ground testing purposes. For flight the switch should be set to FLT. The switch is covered by a flap which cannot be closed, owing to a nuisance bar, unless the switch is set to FLT.

b. The pack consists of two sensing elements and

amplifiers; one sensing element is for the rate of cabin altitude change and the other for the maximum differential pressure. The amplifiers control and synchronise the discharge valves to ensure proper pressure control and correct distribution of air in the cabin. The amplifier also ensures that malfunction of one discharge valve does not affect the other valve by more than a pre-determined amount.

MASS FLOW CONTROL

Mass-Flow Control

65. Two separate mass-flow control systems are provided. One system controls the output of the pair of compressors on the left side and the other system the output from the right side. A sensing unit, dual amplifier and metering duct in each system form the mass-flow control circuit for that side.

66. Each compressor is controlled from a five-position AUTO/DEC/INC/HOLD switch which is spring-loaded to CENTRE OFF from the INC setting. In the AUTO setting the compressor is controlled by the flow control system; the other settings permit manual control. Normally the switches of a pair of compressors on one side are set to AUTO. If one switch is at AUTO and the other in another setting, the flow control system positions the slide valve of the compressor in AUTO to meet the mass-flow requirements of the pair as far as possible. When AUTO is not selected an AUTO OFF warning light above the switch comes on. After start-up, when AUTO is selected the lights for each pair of compressors remain on until there is a 0·5 PSI differential across the venturi and the differential pressure switch operates. Both AUTO OFF lights also come on if the sensing unit diaphragm or capsule fails. A slide valve position indicator gives a linear indication of individual slide valve position. The slide valve position transmitter (Linvar) is also used to synchronise the position of each pair of slide valves.

67. Under mass-flow sensing unit control, the output of each pair of compressors is controlled to a nominal 87·5 lb/min up to 40,000 feet.

Normal Use of Flow Control

68. Normally the two systems are regulated by the automatic flow control system, all four controlling switches being set to AUTO. Failure of electrical power causes the compressor slide valves to move to the minimum flow setting.

69. Changes in the flow from the controlled datum, due to changes in altitude or engine RPM, are sensed by the flow control system. The output signal from the flow control system is used to position the compressor slide valves to meet the flow control demand.

70. Manual control of the system is effected by use of the five-position MASS - FLOW CONTROL switches to control the slide valves. After a DEC or INC selection has been made, a switch should be set to HOLD; this positively locks the slide valve in the selected setting. Under manual control the associated AUTO OFF warning light is on.

71. If the cabin altitude rises to 10,000 feet, the cabin altitude switch in the oxygen system isolates the pressure switch and vacuum switch in the mass-flow sensing unit, but maintains electrical supply to the amplifier to keep the mass-flow at 87·5 lb/min. During this operation the AUTO light remains out.

AIR CONDITIONING AND HUMIDIFICATION SYSTEMS

Temperature Control and Humidification

72. Two automatic temperature control systems are used, one controlling the left-hand set of equipment for the passenger cabin and the other, the right-hand set for the flight deck. If the automatic system fails, either system can be manually-operated to control delivery air temperature. Controls and indicators for both temperature control systems are on the air conditioning panel at the engineer's station.

73. Each conditioning system is automatically protected against excessive pressures and temperatures. Pressure is limited by a differential pressure switch, which is only effective when in the choke range and operates by sensing duct/ambient air differential pressure. A duct pressure relief valve, set to relieve at a slightly higher figure than the differential pressure switch, is provided, and operates if the differential pressure switch malfunctions or if the high pressure is not due to choke valve operation. The maximum temperature of a system is limited by two thermostats; the operation of a thermostat automatically shuts off the air supply on that side.

74. A manually-controlled humidification system is fitted to each air conditioning system. Only one humidifier can be used at a time.

75. *Location of Controls and Indicators — Temperature System.* (See **Table 4**).

Table 4 — Location of Controls and Indicators — Temperature System

The following temperature controls and indicators are on the air conditioning panel.

Item	*Marking/Indication*
Left cooling modulation isolate/choke override switch	MOD ISOL/NORM/CHOKE OVERRIDE
Left cooling modulation valve indicator	Indicates setting of valve
Right cooling modulation isolate/choke override switch	MOD ISOL/NORM/CHOKE OVERRIDE
Right cooling modulation valve indicator ...	Indicates setting of valve
Left overheat reset switch	NORM/O/HT RESET
Left overheat warning light	O/HT (red, press-to-test)
Right overheat reset switch	NORM/O/HT RESET
Right overheat warning light	O/HT (red, press-to-test)
Left choke valve indicator	Indicates valve setting
Right choke valve indicator	Indicates valve setting
Left refrigeration master switch	FRIG MASTER — NORM/RESET/ISOL
Left refrigeration fail light	FAIL (amber, press-to-test)
Left refrigeration setting indicator	FRIG HEAD
Right refrigeration master switch	FRIG MASTER — NORM/RESET/ISOL
Right refrigeration fail light	FAIL (amber, press-to-test)
Right refrigeration setting indicator	FRIG HEAD
Left overheat warning light	O/HT (red, press-to-test)
Right overheat warning light	O/HT (red, press-to-test)
Passenger cabin duct temperature gauge	PASSENGER CABIN °C/°F
Flight deck duct temperature gauge	FLIGHT DECK °C/°F
Flight deck/passenger cabin changeover switch ...	NORM/DUCT
Left temperature selector	COOL/NORMAL/WARM
Left temperature control switch	AUTO/INC/DEC/OFF (spring-loaded to OFF from INC and DEC)
Right temperature selector	COOL/NORMAL/WARM
Right temperature control switch	AUTO/INC/DEC/OFF (spring-loaded to OFF from INC and DEC)

Heat Exchangers and Cooling Modulation Valves

76. Two functionally separate heat exchangers, one for each system, form a dual unit and are fitted in the dorsal fin. The supply of air from each pair of compressors is ducted across the matrix of its heat exchanger. The heat exchangers are served by dual air intakes, each of which supplies cooling ram air to its associated heat exchanger under the control of an electrically-operated modulation valve. The ram air exhausts overboard through outlets in the fin, left and right.

77. Each cooling modulation valve (which is operated by signals from the associated temperature control system), by controlling the ram air cross-flow, regulates the heat extraction of its associated heat exchanger. Each has a quadrant-type indicator, on the air conditioning panel, to indicate the setting of the cooling modulation valve.

78. A duct pressure-relief valve in the charge air outlet duct from each heat exchanger relieves pressure to ram air exhaust if the associated duct pressure exceeds about 13 PSI.

79. When a cooling modulation valve switch, marked MOD ISOL/NORM/CHOKE OVERRIDE (one for each system) is set to ISOL, a relay is energised to allow the temperature control signal to bypass the valve, without affecting the use of sequencing of the other components of temperature control.

Choke Valves

80. Downstream of the stop valve and six inch NRV in each duct is an electronically-operated choke valve. Each has a quadrant-type indicator below the six inch NRV no-flow warning light on the air conditioning panel.

81. When moved to the closed setting, the valve increases the back-pressure in the ducting, the pressure ratio and hence the temperature rise across the paired compressors. Choke valve movement is limited, the valve never closing completely.

82. An emergency DC actuator is fitted in addition to the normal AC actuator. This actuator is operated by setting the associated cooling modulator valve switch to CHOKE OVERRIDE: the choke valve then positively opens. Returning the switch to NORM reverts control of the valve to the normal AC actuator.

Refrigeration

83. Two refrigeration packs are fitted in the wing-root leading edges and are each connected to an evaporator in the vapour cycle bay, one for each system, right and left.

84. Each pack, which has a turbine-driven compressor, condenser, condenser fan and associated controls, is powered and controlled pneumatically. Pneumatic power obtained from the wing anti-icing system is used to drive the turbine compressor and, for operation on the ground, the condenser fan draws cooling air through the condenser. Servo pressure for the controls is tapped from downstream of the engine HP stop valve and passed through a high pressure and low pressure reducing valve.

85. Refrigeration is controlled by controlling the RPM of the turbine compressor. A turbine control valve in the pneumatic power line regulates the driving air flow and its setting is controlled through a low pressure pneumatic servo by an electrically-operated compressor speed modulating sensor. The condenser fan control valve is opened by a solenoid valve wired in series with undercarriage safety switches when the aircraft is on the ground, and is closed in flight.

86. If RPM exceed 57,000, the turbine control valve is closed by an overspeed trip solenoid valve, and therefore the air supply to the turbine compressor is shut off. When the RPM falls to below 12,500, causing the refrigerator fail light to come on, the overspeed trip is automatically reset and the control valve opens to allow the speed to build up.

87. The refrigerator FAIL warning light comes on when RPM is below 12,500 and FRIG is selected. It is on for about two seconds during start-up.

88. An overheat temperature switch on the unit is fitted to lock out the pack if the compressor delivery temperature is excessive. The FAIL light then comes on and remains on.

89. A bursting disc on the liquid receiver, which discharges overboard, is provided to safeguard against excessive refrigerant pressure.

90. A thermostatic expansion valve in the refrigerant line upstream of each evaporator meters the flow of liquid refrigerant to the evaporator, to control the super heat of the refrigerant vapour at the evaporator outlet.

91. a. The refrigerators may be operated on the ground by use of the FRIG MASTER—NORM/RESET/ISOL switches. When NORM is selected the recirculation fans operate with the refrigerators. However, if the cabin air compressors are supplying the normal controlled airflow at the same time, the combined airflow through the evaporators could exceed the capacity of the refrigerators, since there is no cooling airflow through the heat exchangers. Therefore, to reduce the refrigerator loads during ground operation, the spill valves are fully opened and the stop valves partly-opened by the operation of FRIG HEAD microswitches and undercarriage switches, *provided that the spill valve switches are at NORM*. If refrigeration is not required, but merely ventilation on the ground, the right-hand recirculation fan should be set ON and the unpressurised ventilation valve switch set to UPVV-OPEN.

b. One refrigerator is adequate for normal flight conditions, except for low altitude flight in high temperatures.

92. a. Each refrigerator is controlled by a FRIG MASTER-NORM/RESET/ISOL switch. A FAIL warning light, and a FRIG HEAD quadrant-type indicator, showing setting of the compressor speed modulating sensor actuator, are adjacent.

b. When a FRIG MASTER switch is set to NORM the refrigerator operates automatically under the control of the cabin or flight deck temperature control circuit, as the case may be.

c. The RESET setting is used on the ground to restore normal operation following rectification or replacement after an overheat trip shutdown. *The switch should not be set to RESET in flight more than once* or damage may result.

d. The ISOL setting is used, in case of malfunction, to shut down the refrigerator and electrically bypass the FRIG HEAD in the automatic temperature control circuit, enabling this system to continue to operate on the remaining components. The switches should be set to ISOL for engine starting.

e. With the respective recirculation fan switch at NORMAL, the fan automatically starts up when the refrigerator comes into operation.

Duct Overheat Thermostats

93. Overheat protection is provided by two thermostats, in the ducting of each system, which sense excessive temperatures. One thermostat (120°C) is upstream of the choke valve and the other (75°C) is downstream of the humidifier.

94. Operation of either thermostat will, for the associated side:

Cause the corresponding O/HT warning light to come on.

*Open the associated spill valve.

*Close the stop valve.

Close the two thrust augmenter valves, if open.

95. Should a thermostat bulb break, a power failure relay becomes de-energised and both O/HT lights on that side come on. Similarly if the electrical power to the failure relay fails, both lights come on. These are the only two failures that cause both O/HT lights to come on.

*The valves and lights are locked in this condition until the NORM/O/HT RESET switch is operated.

Duct Differential Pressure Switches

96. Since the choke valve in each system can cause a back-pressure to be exerted on the associated compressors, a differential pressure switch upstream of the choke prevents further closing of the choke valve at 11·75 PSI and causes the choke to open if pressure rises to 12 PSI. If the differential pressure switch fails to limit duct pressure, the duct pressure relief valve on the respective heat exchanger opens at about 13 PSI.

Humidification

97. Two small spray-type humidifiers are fitted, one immediately downstream of each evaporator; they permit the moisture content of the conditioned air to be increased, when desirable. Water is taken from the domestic water tanks to a humidifier water control valve and thence via a solenoid, under air pressure, to the left or right humidifiers, according to selection. An altitude switch prevents operation below 30,000 feet. Consumption is approximately 2·9 gallons per hour per humidifier.

98. A HUMIDIFIERS-LEFT ON/OFF/RIGHT ON switch permits selection of either right or left humidifier. When set to LEFT ON, at heights above 30,000 feet, the air and water solenoid for the left humidifier is opened and a fine spray of water is injected into the ducting. When RIGHT ON is selected, the right-hand humidifier operates and since surplus air in the right-hand system is diverted to the cabin, serves both flight deck and cabin. When LEFT ON, is selected, only the cabin system is humidified.

TEMPERATURE CONTROL

Temperature Control

99. A PASSENGER CABIN and a FLIGHT DECK temperature gauge with a NORMAL/DUCT switch between them is provided. During normal operation, the switch should be set to DUCT and the appropriate gauges monitored to ensure that a maximum temperature of 75°C is not exceeded.

100. Below the temperature gauges are the passenger cabin and flight deck temperature selector switches and temperature control switches. The temperature selector switches are marked COOL/NORMAL/WARM. The OFF/AUTO/INC/DEC temperature control switches control the components of the associated temperature control system. These are:

The choke valve
The cooling modulation valve
The refrigeration head

and in conjunction with the latter:

The recirculation fan — below 30,000 feet
The louvre stop valve (right side only)
The refrigeration condenser fan (on the ground only)
The spill valve (on the ground only)
The stop valve (on the ground only)

101. If a temperature control is at the maximum heat end of its range and the temperature control switch is set and held at DEC, the sequence of events is as follows:

a. The choke valve moves from maximum closed to fully open. Under operating conditions, this reduces the pressure and temperature rise across the compressors, decreasing the temperature of the conditioned air flow.

b. When the choke valve is fully open, the cooling modulation valve begins to open, increasing the ram air flow through the heat exchanger and further cooling the conditioned air flow.

c. When the cooling modulation valve is fully open, the refrigeration pack compressor speed

modulation sensor begins to close. The recirculation fan starts up, if selected to NORMAL below 30,000 feet, the refrigerator circulates refrigerant through the evaporator and the temperature of the air passing through the evaporator is further reduced until the maximum available cooling is achieved. This is the full cold end of the range of the temperature control system.

d. The time taken to operate from one end of the range to the other is 3·5 to 4 minutes.

e. If the temperature control is then held at INC, the sequence of events is repeated in reverse order.

f. Since each of the three main valves has a quadrant-type indicator on the panel, the sequence of events can be observed by the engineer.

g. If the choke valve actuator fails, setting the MOD ISOL-NORM/CHOKE OVERRIDE switch to CHOKE OVERRIDE brings into operation the DC-operated actuator to open the choke valve fully. The temperature control switch then operates the cooling modulator valve and the refrigeration head valve only, in auto or manual.

h. Similarly in case of failure of the cooling modulation valve, by setting the switch to MOD ISOL, this valve is isolated and electrically bypassed. The temperature control switch then operates the choke valve and the refrigerator.

i. In case of failure of the refrigeration head actuator, the FRIG MASTER switch for the affected system should be set to ISOL. This isolates and electrically bypasses the refrigeration head, and the temperature control switch then operates only the choke valve and cooling modulation valve.

ELECTRICAL SUPPLIES

Electrical Supplies

102. Power supplies for the pressurisation and air conditioning system are:

a. 28-*Volt DC*

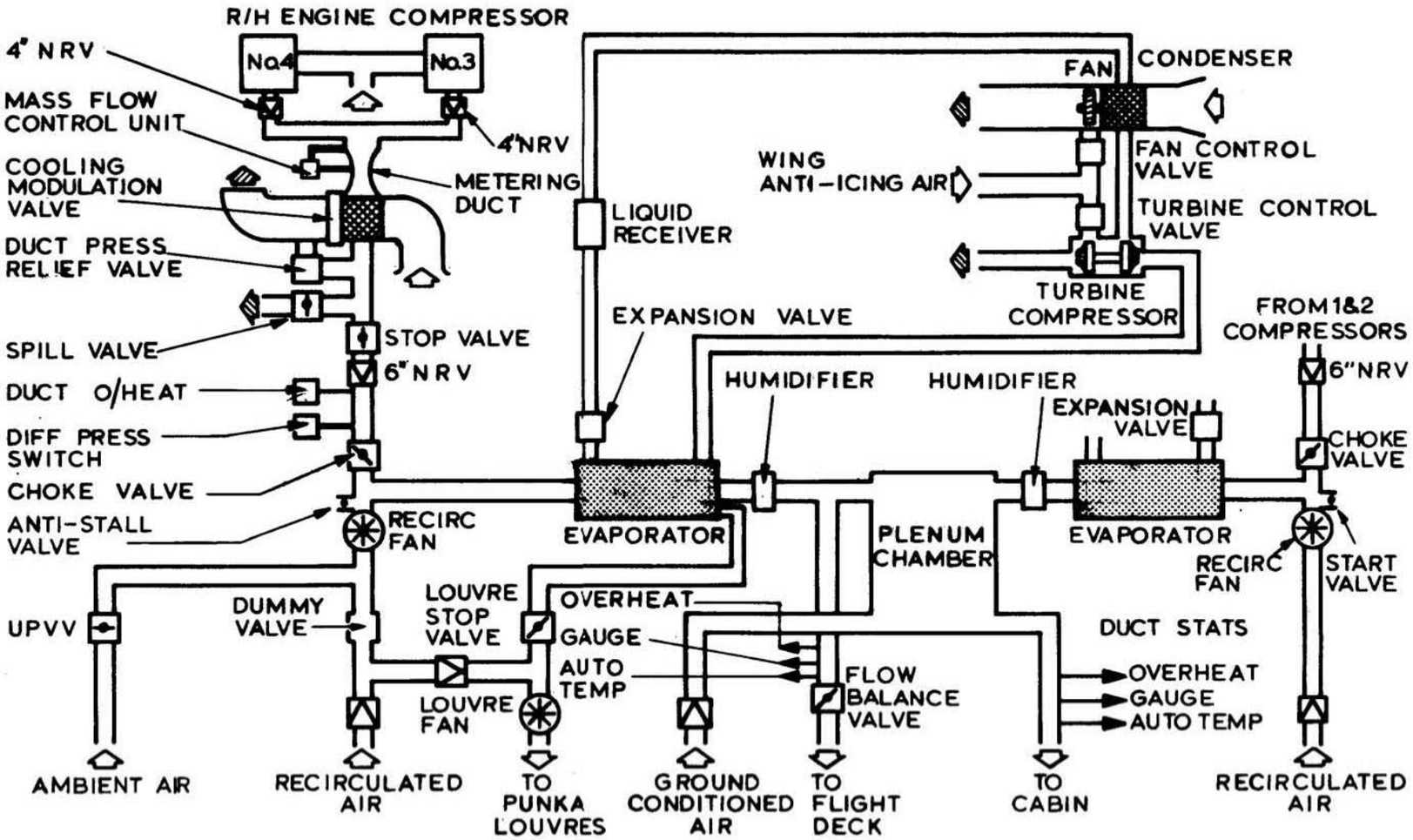
Compressor slides manual control
All quadrant indicators (except compressor slides)
All warning lights
All control circuits (except louvre fan)
Overheat circuit
Auto temperature control
Spill valves
Stop valves
UPVV
RRCV
Thrust augmenters
Anti-stall valves

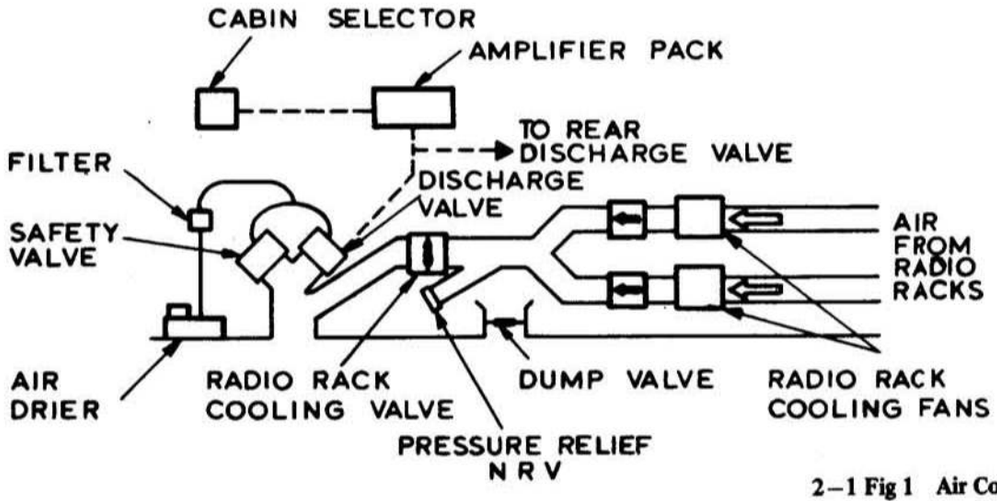
b. 115-*Volt AC-Single-Phase*

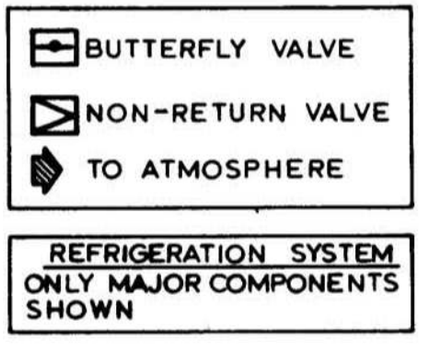
Compressor slides auto control (also requires DC)
Compressor slides quadrant indicators
Cooling modulation valves
Choke valves
Refrigerators (also requires DC)
Pressurisation amplifier
Flow balance valve
Louvre fan control circuit
Galley and toilet fans

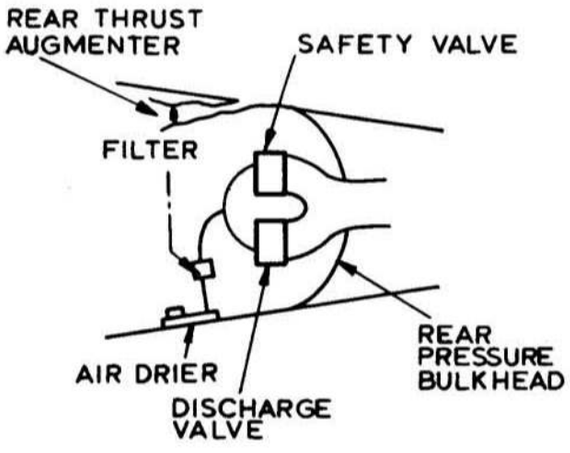
c. 200-*Volt AC-Three-Phase*

Radio rack cooling fans
Louvre fan
Recirculation fans





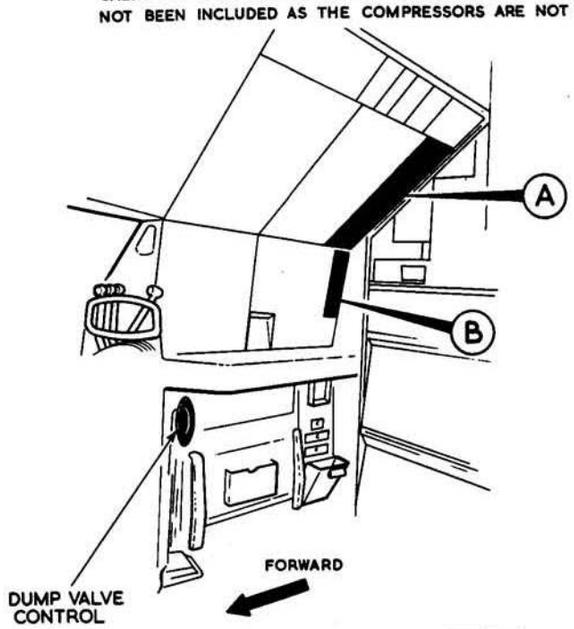


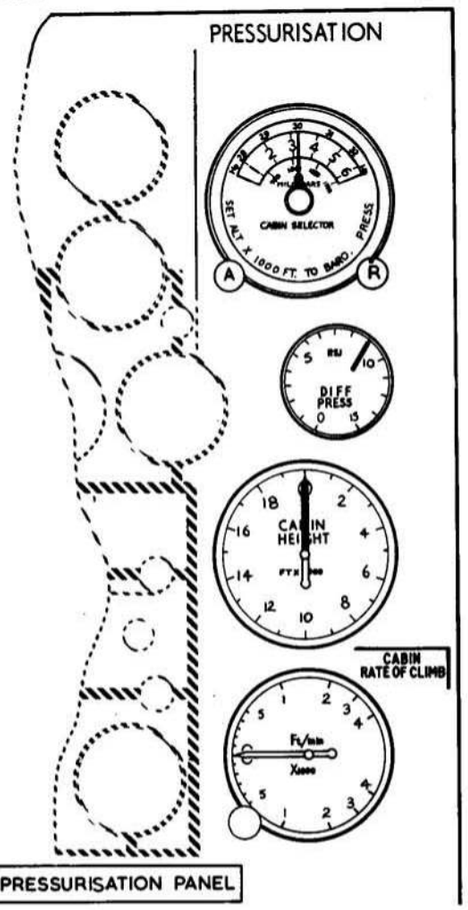


2–1 Fig 1 Air Conditioning and Pressurisation System
Diagram Updated

VC10/8C

CABIN COMPRESSOR LOW OIL PRESSURE WARNING LIGHTS HAVE NOT BEEN INCLUDED AS THE COMPRESSORS ARE NOT MODIFIED





VC10/9A

COOLING MODULATION VALVE ISOLATION SWITCHES (2)
WHEN SET TO ISOL CAUSES THE TEMP. CONTROL SIGNAL TO BY-PASS THE MODULATION VALVE. WHEN SET TO CHOKE OVERRIDE THE CHOKE VALVE IS OPENED BY MEANS OF AN EMERGENCY DC ACTUATOR. RETURNING THE SWITCH TO NORM REVERTS CONTROL OF THE VALVE TO THE NORMAL AC ACTUATOR. SELECTION OF OVERRIDE ALLOWS NORMAL OPERATION OF COOLING MOD. VALVE AND FRIG. COMPRESSOR SPEED MOD. SENSOR.

SPILL VALVE SWITCHES (2) & INDICATORS (2)
WHEN SET TO NORM. THE STOP VALVE OPENS FULLY AND THEN THE SPILL VALVE CLOSES FULLY ON THE GROUND, WHEN FRIG IS INTRODUCED, THE STOP VALVE OPENS HALFWAY AND THE SPILL VALVE OPENS FULLY WHEN SET TO SHUT, THE STOP VALVE OPENS FULLY AND THEN THE SPILL VALVE CLOSES FULLY.

CHOKE VALVE INDICATOR
FULL WHITE SEGMENT INDICATES VALVE FULLY OPEN GIVING LESS HEAT.

UNPRESSURISED VENT VALVE SWITCH & INDICATOR
WHEN ON THE GROUND, IN AN UNPRESSURISED STATE, THIS SWITCH CONTROLS THE OPENING AND CLOSING OF THE RADIO RACK COOLING VALVE. IF AIRCRAFT IS PRESSURISED A PSI A PRESSURE SWITCH PREVENTS OPENING SEQUENCE. ON TAKE-OFF WITH UPVV OPEN, THE RADIO RACK COOLING VALVE CLOSES WHEN THE WEIGHT COMES OFF THE UNDERCARRIAGE.

LOUVRE FAN CONTROL SWITCH

FRIG. FAIL LIGHTS (2)
LIGHT ON FOR PERIOD WHEN RUNNING UP TO SPEED ON ALSO WHEN OVERHEAT CIRCUIT OPERATES, IF FRIG. RPM FALL BELOW 12,500 RPM, OR IF FRIG. RPM RISES ABOVE 57,000 RPM.

REFRIGERATION DEMAND INDICATORS (2)

FRIG. MASTER SWITCH
SET TO NORM FOR NORMAL USE. RESET SETTING USED TO RELEASE AN OVERHEAT LOCK OUT. SET TO ISOL TO ISOLATE FRIG. AND ALLOW NORMAL OPERATION OF COOLING MOD. AND CHOKE VALVES.

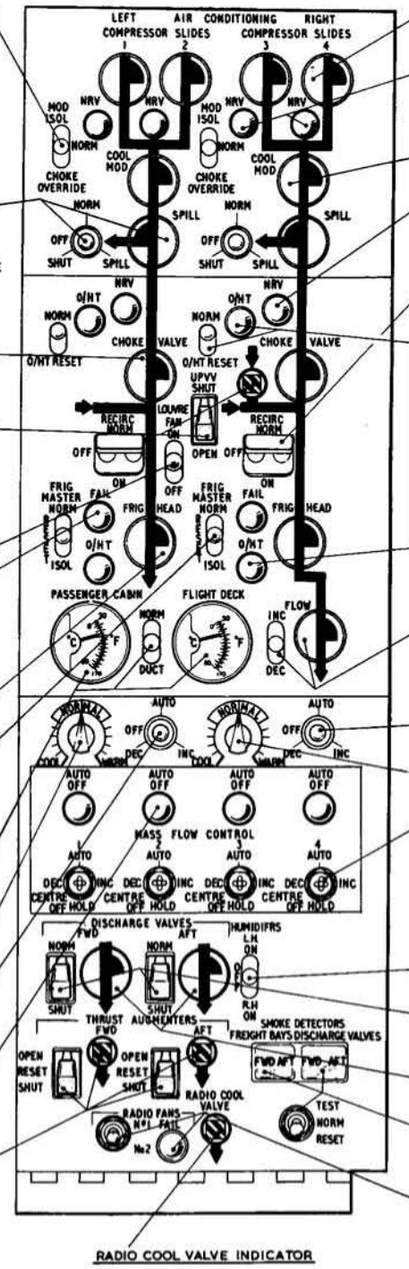
PASSENGER CABIN & FLIGHT DECK DUCT & ACTUAL TEMP. GAUGES & SELECTOR SWITCH
SWITCH NORMALLY SET TO DUCT WHEN OPERATING UNDER MANUAL CONTROL.

LEFT TEMPERATURE SELECTOR SWITCH

LEFT TEMPERATURE CONTROL SWITCH.

AUTO OFF LIGHTS (4)
LIGHTS ON WHEN ASSOCIATED MASS FLOW SWITCHES ARE NOT SET TO AUTO, ALSO IF THE SENSING UNIT DIAPHRAGM OR CAPSULE FAILS OR IF FLOW IS BELOW MINIMUM SENSING SETTING.

THRUST AUGMENTER SWITCHES & INDICATORS (2)
CONTROL SETTING OF THRUST AUGMENTERS. THRUST AUGMENTERS CLOSE AUTOMATICALLY UNDER OVERHEAT CONDITIONS. RESET MUST BE SELECTED TO RESET THE ELECTRICAL CIRCUIT. INDICATORS SHOW POSITION.



RADIO COOL VALVE INDICATOR

COMPRESSOR SLIDE VALVE INDICATORS (4)

4" NON-RETURN-VALVE LIGHTS (4)
LIGHT ON INDICATES 4" NRV CLOSED; i.e, NO FLOW FROM ASSOCIATED COMPRESSOR

COOLING MODULATION VALVE INDICATORS (2)

CABIN SUPPLY 6" NON-RETURN-VALVE LIGHTS (2)
LIGHT ON INDICATES 6" NRV CLOSED; i.e. NO FLOW FROM THE COMPRESSORS ON THE ASSOCIATED SIDE

RECIRCULATION FAN SWITCHES (2)
CONTROL RECIRCULATION FANS BY SELECTION. WHEN SET TO NORMAL, A FAN IS SWITCHED ON AUTOMATICALLY WHEN THE TEMP. CONTROL SYSTEM IN FRIG. RANGE UP TO 30,000 FT. WHEN AN ALTITUDE SWITCH DE-ENERGISES THE FAN.

DUCT OVERHEAT LIGHTS (TWO IN EACH SYSTEM)
IF EITHER O/HT LIGHT COMES ON, THE SPILL SELECTOR VALVE SWITCH IS ISOLATED, THE SPILL VALVE OPENED AND THE STOP VALVE CLOSED. THRUST AUGMENTERS, IF OPEN, ARE CLOSED. RE-SET MUST BE SELECTED TO RE-INSTATE THE SYSTEM. IF BOTH LIGHTS IN A SYSTEM COME ON, A FAULT IN THE SYSTEM CIRCUIT IS INDICATED.

FLIGHT DECK FLOW BALANCE SWITCH & INDICATOR
SWITCH CAN BE INCHED TO VARY FLOW TO FLIGHT DECK FROM 6LB/MIN. TO 30 LB/MIN. INDICATOR SHOWS POSITION OF BALANCE VALVE.

RIGHT TEMPERATURE CONTROL SWITCH

RIGHT TEMPERATURE SELECTOR SWITCH

MASS FLOW CONTROL SWITCHES (4)
WHEN SET TO AUTO, COMPRESSOR UNDER AUTO-CONTROL FOR MASS FLOW. WHEN SET TO HOLD, SLIDE VALVE LOCKED IN LAST POSITION. WHEN SET TO INC. OR DEC. SLIDE VALVE MOVES AS SELECTED TO VARY FLOW. WHEN SET TO OFF, THE SLIDE VALVE DRIFTS TO MINIMUM SETTING.

HUMIDIFIER SELECTOR SWITCH
AN ALTITUDE SWITCH PREVENTS HUMIDIFIERS OPERATING BELOW 30,000 FEET

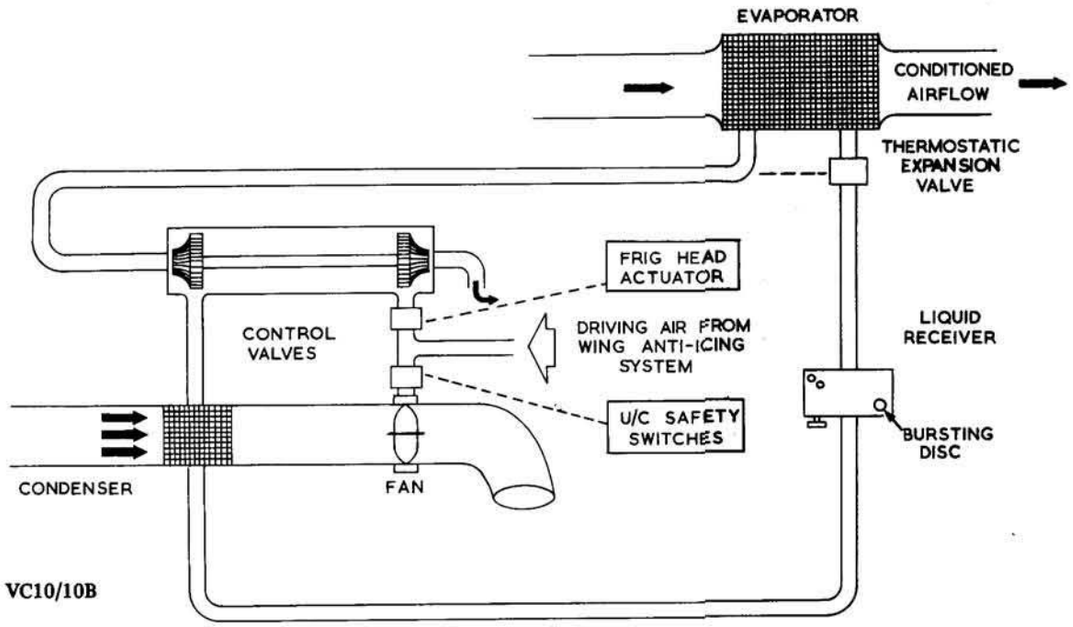
FORWARD & AFT DISCHARGE VALVE SWITCHES & INDICATORS (2) WHEN SET TO NORM. VALVES ARE UNDER AUTO-CONTROL AS SELECTED. WHEN SET TO SHUT, VALVES ARE SHUT. INDICATORS SHOW VALVE POSITIONS

SMOKE DETECTOR WARN. LIGHTS (4) & TEST/RESET SWITCH. LIGHTS ON IF SMOKE ENERGISES CIRCUIT OR TEST SWITCH USED.

RADIO RACK COOLING FAN SWITCH & WARN LIGHT.
NORMALLY SET TO No. 1; FAILURE INDICATED BY WARN. LIGHT COMING ON; No. 2 FAN STARTS AUTOMATICALLY; SETTING SWITCH TO No. 2. CAUSES WARN. LIGHT TO GO OUT

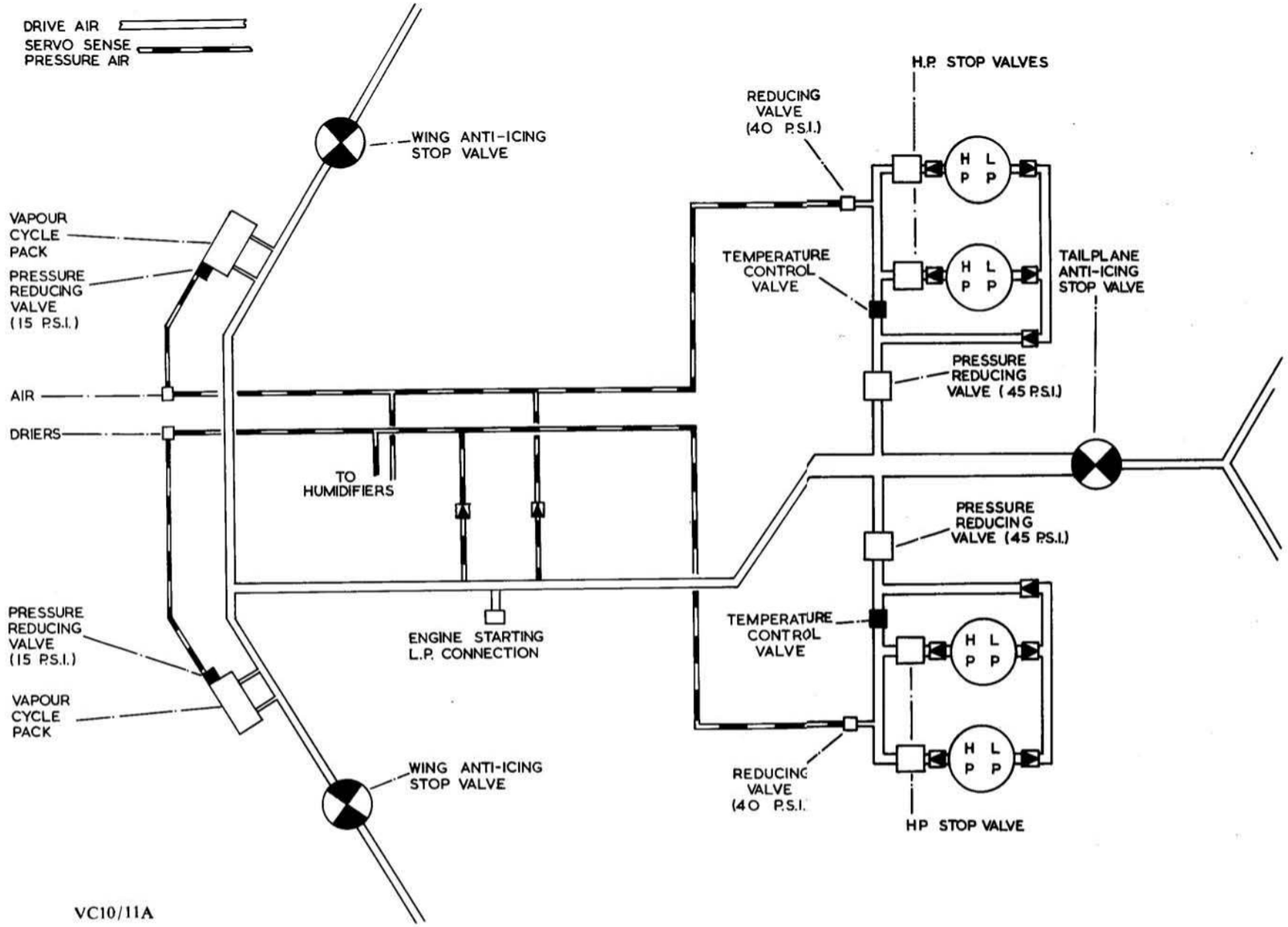
VC10/9B

2–1 Fig 2 Air Conditioning Controls



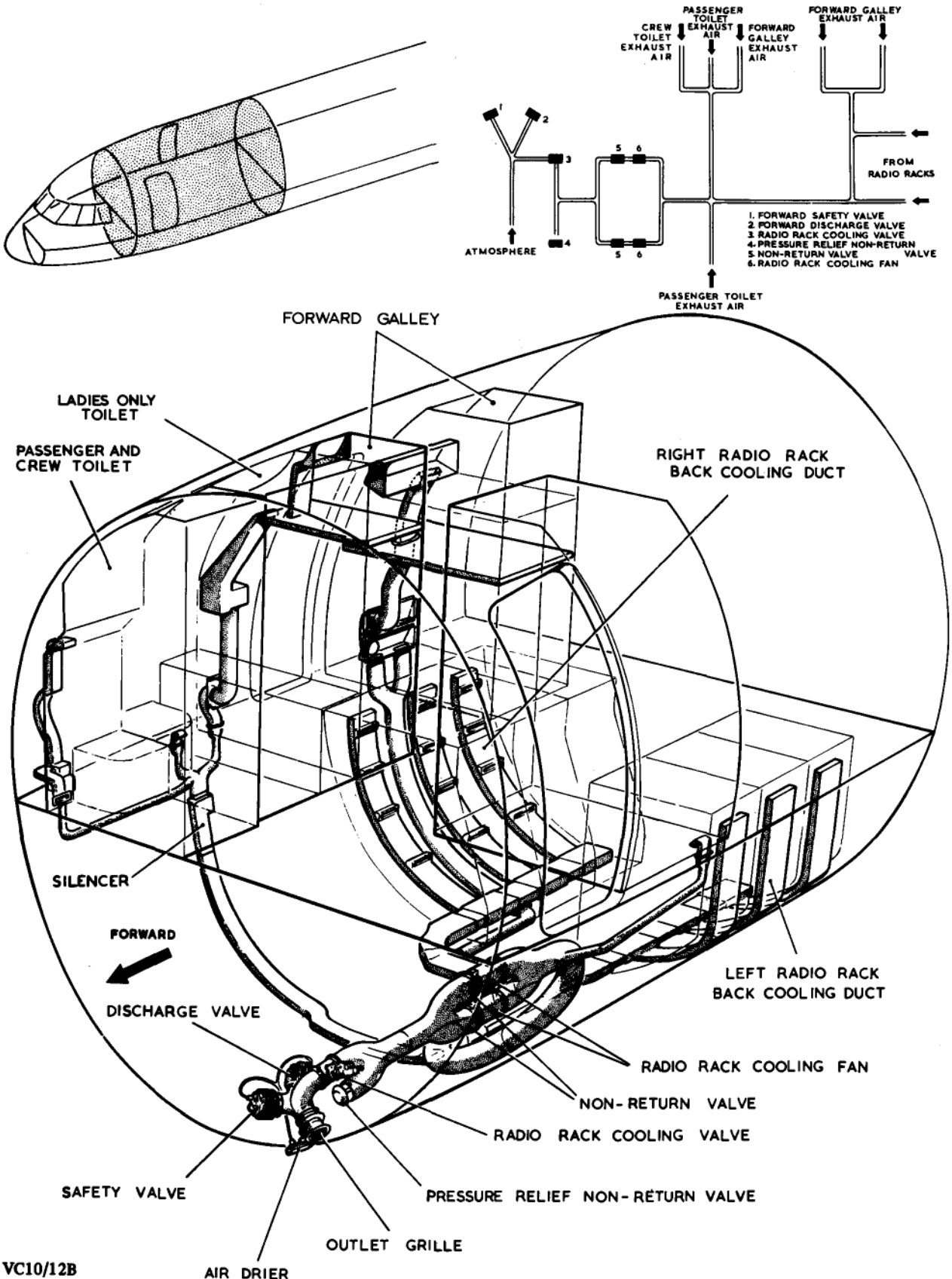
VC10/10B

2–1 Fig 3 **Refrigeration System (left side) – Simplified**



VC10/11A

2–1 Fig 4 **Air Supplies to Refrigeration System**



VC10/12B

2–1 Fig 5 Radio Rack Cooling

Minor Amendment