

Reference: AP 4505B Vol 1
AP 4340 (A/C Pressurisation and Air Conditioning Equip)
AP 6022V (Cabin and A/C Pressurisation)

Introduction.

1. The air conditioning system in this a/c is installed for the purpose of cabin air conditioning and pressurisation, aircrew suit ventilation, windscreen de-misting by hot air and silica-gel crystals and bomb bay heating.
2. The air conditioning and pressurisation system enables operations to be carried out in the cabin, in comfort, at extreme altitudes and under varying conditions of flight, the air in the crews compartment being maintained at reasonable temperatures and pressures over the whole range of conditions likely to be encountered.
3. A similar conditioning plant, (of smaller dimensions) to that used for cabin air supply, is included in the ventilated suit system, and, maintains a flow of warm dry air through supply lines to individual suits at crew stations.

Air Supply.

4. Air for cabin pressurisation is tapped from each engine high pressure delivery casing from No.2 vane. After delivery from this casing the air passes through a non-return valve to a 3" dia. electrically operated carbon gate valve located on the engine intake casing at the top near centre. A common duct from each gate valve runs inboard under the engine bay roofs, to run and divide into two branches at the bomb bay rib, the hot air being ducted rearward, for bomb bay heating and fin thermal anti-icing, and forward for cabin conditioning and leading edge thermal anti-icing.
5. As the ducting on each side of the A/C approaches the front spar, it descends down the rear face of the front spar to pass through the spar into the lower air intake lip structure. Immediately afterwards the ducting divides into two branches, one going to the leading edge thermal anti-icing system, and the other to the cabin conditioning equipment, the ducting to the latter passing around the outside of No 2 tank bay and into the rear of the nosewheel bay and converging at a three duct assembly.
6. The two outer ducts, in each of which is fitted an auto-flow controller and shut off valve, are joined by a bridge piece to form a Y-shaped feed duct into the conditioning unit. Between the two outer ducts, and isolated from them by two non-return valves, is the flood flow duct which connects to the conditioning unit through the electrically actuated flood flow valve. Upstream of this valve is a branch duct for a supply of hot air to the ventilated suit system. A Y-shaped duct assembly connects the two air conditioning unit outlets to a non-return valve on the rear pressure bulkhead.

Automatic Flow Control System

7. The air supply from the engines, which varies according to engine speeds and changes of air density due to altitude changes, to the air conditioning unit is regulated by the auto-flow controller

Operation

8. The controller basically consists of a cylindrical body containing a spring loaded tapered cone and fixed orifice. The pressure of the air supply tends to force the tapered cone into the fixed orifice against the cone spring until a balance output of 55/60 lbs/min is achieved at ground levels, which falls off in a smooth characteristic to 13/15 lbs/min at 50,000 ft, thus maintaining the flow within the required limits for variations in engine and cabin conditions.
/Variations

Variations in pressure from the source of supply (engines) together with changes in density (altitude changes) vary the position of the cone in relation to the fixed orifice.

9. In certain conditions the air supply to the cabin may be in excess of requirements. The electrically operated shut-off valves directly downstream of the auto-flow controllers allow the air supply to the cabin, to be partially or totally cut off by operation of one or both of the ~~CABIN AIR~~ switches on the starboard console (PANEL 7P) pressurisation control panel.

Flood Flow Control System

10. A flood flow system is provided which will operate automatically should a serious cabin pressure loss occur, e.g. cabin puncture by enemy action. The flood flow valve is opened, allowing all the air supply from the engines to by-pass the autoflow controllers, and enable all the air supply to pass direct to the air conditioning unit and then to the cabin.

Operation

11. Flood flow is controlled by two altitude switches. One is sensitive to A/C altitude and operates at 32,000 ft. The other, in series with the first, is sensitive to cabin altitudes and operates at 29,000 ft. In the event of the cabin being holed and the cabin altitude rising to 29,000 ft, the cabin switch is operated, and, if the A/C is above 32,000 ft the flood flow valve is automatically opened. Also, the temperature-control valve in the air conditioning system is moved to the mid position, overriding any other previous selection prior to flood flow.

12. If the flood flow is beyond requirements it can be controlled by the engine carbon gate valve switches, and when the flood flow is no longer required it can be switched off by returning the flood flow valve to the closed condition. The switches for these operations are contained on the pressurisation control panel.

Air Supply Conditioning System

13. The air conditioning unit, controls the temperature of the air entering the cabin to maintain a reasonable cabin temperature through the widely varied conditions encountered in flight.

14. The unit, mounted in the roof of the nose wheel bay on the port side is easily removable for servicing and the principal components are as follows:-

- a. Air to Air Cooler.
- b. Temperature Control Valve.
- c. Cold Air Unit (comprising an air expanding turbine driving a brake in the form of a compressor.)
- d. Water Extractor.
- e. Underheat Bypass Valve.
- f. Pressure Relief Valve
- g. Pressure Ratio Switch.

Air To Air Cooler

15. The purpose of this item is to cool the hot air from the engines prior to its entry into the temperature control valve. The cooling air supply to the air to air cooler is from a small ram air intake on the port side of the centre section, between the fuselage wall and the engine intake boundary layer fence. After extracting heat from the engine air system, the air to air cooler exhaust duct terminates in a rearward facing slot, outboard of the port nosewheel undercarriage door.

16. Upstream of the air to air cooler the air supply ducting has a branch pipe which can allow all the engine air supply to go direct to the temperature control valve.

TEMPERATURE CONTROL VALVE

17. This item is an electrically actuated, four way carbon gate valve, and its purpose is to govern the path of air through the air conditioning unit. Operation may be automatic, in conjunction with temperature sensitive elements in the cabin and the TEMPERATURE SELECTOR on the starboard console or manually by the CABIN TEMPERATURE CONTROL on the same console.

OPERATION

18. Initially, if the temperature control valve is in the maximum heat position, all the air supply goes direct to this valve, by-passing the air to air cooler. From the temperature control valve, the hot air passes direct to the cabin by-passing the cold air unit.

19. When the temperature control valve is moved to the warm position, air direct from the engines and air via the air to air cooler enters the valve chamber. This cooler resultant air supply is passed direct to the cabin. When the temperature control valve is moved to the cool position, all the air from the engines passes through the air to air cooler to the temperature control valve. From this valve all this resultant cool air passes direct to the cabin. When the temperature control valve is moved to the cold condition, some of the cool air passes directly to the cabin, whilst the remainder passes through the cold air unit to mix with the cool air to the cabin and lower the resultant temperature. When further cooling for refrigerating conditions is required all the cooler air is passed to the cold air unit from the temperature control valve, to give maximum cold air in the cabin.

COLD AIR UNIT

20. This unit consists of a small centrifugal inward flow expansion turbine directly coupled to a small centrifugal outward flow compressor.

The expansion inlet is coupled to the temperature control valve and, the outlet discharges into a water extractor.

The compressor draws its air through a intake filter direct from the nose-wheel bay. The ejection of compressed air (which acts as a brake on the expansion turbine) from the compressor turbine outlet, is ducted to the outlet trunking of the ram air from the air to air cooler.

21. Under refrigeration conditions where all the air from the engines is passing through the air to air cooler and the temperature control valve to the cold air unit, the mass flow through the expansion turbine is high, and the cold air unit may overspeed.

The speed of the expansion turbine is related to the pressure drop between the inlet and outlet flow. This ratio is applied to a pressure ratio switch. Should the turbine speed, and therefore the pressure ratio, become too great the switch operates an electrical circuit to actuate the port autoflow controller shut-off valve to the closed position, and energise the COLD AIR UNIT OVERSPEED magnetic indicator on the pressurisation control panel, to show white.

WATER EXTRACTOR

22. When the A/C is operating in a warm humid atmosphere and the temperature control valve is in the cold air position, the air from the cold air unit will be cooler below the dew point, and the water vapour in the air will condense into droplets which, if permitted to enter the cabin would cause crew discomfort.

23. Basically the water extractor comprises a metal gauze coalescer, a tubular separator and a relieve valve. Air from the cold air unit passes through the coalescer gauzes and in doing so, loses its moisture content in the form of water droplets. These are deposited on the tubes of the separator, which is directly downstream of the coalescer. The water droplets run down the tubes to the base of the unit and are drained to atmosphere through the air to air cooler exhaust duct.

Should the coalescer become blocked, the relief valve will open to ensure

UNDERHEAT BY-PASS VALVE

24. Under refrigeration conditions, the temperature of the air afflux from the cold air unit could fall below freezing point. This would mean that the moisture in the air would be present in the form of frozen particles, which would be difficult to isolate and cause a blockage of the system.

25. A small electrically actuated carbon gate valve, controlled by a temperature sensitive element (set at 2°C), operates when the air leaving the water extractor is below this point. This allows a tapping of warm air to by-pass the expansion turbine of the cold air unit, to mix with the cold air before passing through the water extractor, to keep the air above freezing point.

PRESSURE RELIEF VALVE

26. This item is fitted in the ducting to the air to air cooler and is set to relieve at 55 p.s.i. The purpose of this valve is to control the maximum engine air flow pressure to prevent overspeed of the cold air unit under refrigeration conditions at ground level where the air density is high.

AIR CONDITIONING OVERHEAT SYSTEM

27. An overheat switch is coupled in the temperature control system between the temperature control valve and the direct ducting to the cabin, to prevent overheating during high mass conditions. Should the temperature in this ducting exceed 175°C, the switch operates automatically to move the temperature control valve to a cooler condition. When the temperature has fallen to 165°C the switch returns to normal.

28. The action of this switch over-rides any control action that may be taking place at the time.

RAM AIR VALVE

29. During local flying, where conditions are such that air conditioning is not required (non-pressurised flight) ventilation of the cabin can be carried out by opening the ram air valve to a desired selection, by the operation of the Ram Air Switch on the pressurisation control panel.

30. This actuator operated flap type valve is located at the forward end of the nose/wheel bay, port side. The ram air supply to it is taken from the same ram air intake to the air to air cooler. The air is then fed direct to the cabin, by passing the air conditioning system.

CABIN PRESSURIZATION SYSTEM

31. The pressurisation system controls the pressurisation of the conditioned air entering the cabin, by means of regulating the amount of air allowed to leave the cabin, to maintain a cabin pressure equivalent of 8000 ft altitude up to a maximum differential pressure of 9 p.s.i. but, may be set, when required, to maintain a cabin pressure equivalent of 19,500 ft altitude up to a maximum differential pressure of 4 p.s.i.

CABIN DUCTING

32. After entering the cabin through a manually operated non-return valve, the air supply ducting divides and runs forwards under the crew floor each side of the entrance door. Small stub pipes feed air into the wall ducts formed by the spaces between the trimming panels and the fibreglass sheet between adjacent formers, louvres at floor level allowing air into the cabin. The diameter of the duct is reduced, in stages, from the rear pressure bulkhead to its termination at the front pressure bulkhead position. Small branch pipes feed air on to the air bomber window to prevent misting.

33. Two extractor ducts run forward, adjacent to the feed ducts and short stub pipes, interposed between the wall feed pipes, connect them to the remaining wall ducts. Louvres at roof level in the extractor wall ducts allow air to enter the extractor pipes and lead to a common discharge point on the front pressure bulkhead. It is then passed through the bulkhead into a combined valve unit,

and then blown over the radar equipment for conditioning purposes.

Finally the air passes overboard through outlet grills on the rear undersurface of the radome.

COMBINED VALVE UNIT

34. A combined valve unit containing two bellows operated discharge valves, is mounted on the forward face of the front pressure bulkhead. Its function being to regulate the cabin pressure by offering a restriction to the discharge of the air leaving the cabin.

35. Each discharge valve is governed by a pressure controller, the controlling pressures supplied by the capsule chamber of the latter, regulate the pressure in the discharge valve bellows. The consequent restriction imposed by the valve bellows on the discharging air determines the cabin pressure. The combined valve unit is enclosed by a shroud, to which is attached a duct to lead discharge air to the radar equipment in the nose section. A decompression flap allows discharge air to pass directly to atmosphere during cabin decompression.

PRESSURE CONTROLLERS

36. Two Type F pressure controllers mounted under the second pilots floor, each control one discharge valve in the combined valve unit. One of the controllers includes a small rotary actuator which allows that particular controller to govern the maximum cabin pressure to either 9 p.s.i. differential (cruise conditions) or 4 p.s.i. differential (combat condition). The other unmotorised controller is also set to control at a maximum cabin pressure of 9 p.s.i. differential, so as to provide a system duplication in case of failure of the motorised controller.

37. Each controller consists basically of three pressure sensitive capsules, two of which are combined to form one unit, operating a needle control valve on a simple beam mechanism, the interior of the capsule chamber being open to cabin air through a small fixed orifice.

38. The double capsule unit, consists of an absolute capsule evacuated and sealed which is sensitive to absolute pressure, and a small differential capsule which is sensitive to ambient pressure.

The other capsule, with its interior connected to static ambient pressure responds to changes in differential pressure.

39. The pressure in the capsule chamber is regulated by the setting of the needle control valve, which is piped to atmosphere, in relation to the small fixed orifice. Since the capsule chamber is connected to the bellows of the combined valve unit, the pressure in the capsule chamber governs the position of the bellows and therefore the passage of air from the cabin.

OPERATION

40. At ground level the differential capsule is at its nominal length and the absolute capsule is compressed to a minimum, consequently the beam mechanism opens the needle valve to such an extent that pressure cannot build up in the bellows of the discharge valve and little resistance is offered to the flow of air from the cabin. The cabin pressure, therefore, is for all practical purposes, the same as atmospheric pressure.

41. As the aircraft climbs the absolute capsule expands causing the control needle valve to close progressively. At 300 ft the needle valve has begun to restrict the path of air from the capsule chamber to static, and enough pressure can now build up in the discharge valve, for the bellows to function and begin to restrict the flow of air from the cabin. This causes the differential pressure to increase.

42. As the aircraft climbs the cabin altitude is maintained at 8000 ft and the differential pressure increases progressively causing continued expansion of the absolute capsule, and contraction of the differential capsule, until at approximately 47,000 ft the differential pressure becomes 9 p.s.i.

43. At this altitude the absolute capsule becomes non-effective as that end of the beam lever comes against its stop. The differential capsule, the compressive movement of which has so far not effected the needle valve beam lever, has merely taken up the gap between its end fitting and the beam lever.

With a further increase in aircraft altitude, a further contraction of the differential capsule takes place causing the beam lever to be lifted allowing the needle valve to begin to open, so that any tendency for the 9 p.s.i. differential to increase is off-set by further contractions of the differential capsule. This action causes the discharge valve bellows to open progressively to begin to de-restrict the path of air from the cabin.

CABIN ALTITUDE SELECTION

44. In the motorised pressure controller the differential capsule can be reset by a rotary actuator controlled by the PRESSURE SELECTOR switch on the pressure-isation control panel.

If the switch is placed to the Combat position, the rotary mechanism is put in motion to raise the differential capsule so that its end fitting now contacts the beam lever, the movements of both capsule packs now affect the beam lever and in consequence not until approximately 19,500 ft does the needle control valve begin to restrict the passage of air from the capsule chamber and pressure can now build up in the discharge bellows to begin to restrict the flow of air from the cabin, until the differential pressure becomes 4 p.s.i.

In this condition the cabin pressure is governed by one discharge valve under the influence of the motorised controller, whilst the other discharge valve remains closed due to the attempt of its controller to increase the cabin pressure to the cruise setting.

45. If COMBAT is selected from the CRUISE position, the differential capsule is reset to give a rate of reduction of cabin pressure of 12 p.s.i./min. If CRUISE is selected from COMBAT the capsule is reset to give a rate of increase of cabin pressure of 1 p.s.i./min. These setting rates which are necessary for physiological reasons, are accomplished by the two speed gear box, which transfers the drive from the motor to the camshaft at different ratios according to the direction of rotation.

CABIN PRESSURE SAFETY VALVES

DECOMPRESSION

46. Air release valves, which can be operated electrically or manually, are connected in the pressure lines between the pressure controllers and their associated discharge valve bellows.

Operation of these release valves allows the pressure in the lines to be exhausted to atmosphere, thus effectively breaking the connection between the controllers and discharge valves. This causes the bellows of the discharge valve to collapse, allowing the maximum area for outlet flow of air from the cabin, therefore rapidly depressurising the cabin.

OPERATION

47. Electrical operation of the air release valve is obtained by moving the PRESSURE SELECTOR to the NO PRESSURE position, or by the EMERGENCY DECOMPRESS or ABANDON AIRCRAFT switches on the forward end of the PORT console and by the initial movement of item 48 below which operates a micro switch in the cabin roof.

48. The mechanical method of operating these valves is provided by a Teleflex linkage, attached to a lever in the cabin roof, above the rear crew members seat.

DUCT RELIEF FLAP

49. This lightly loaded spring flap is integral with the common discharge point on the front pressure bulkhead.

The airflow from the cabin during a decompression does not flow through the normal collection ducting, but passes directly into the combined valve unit via the duct relief flap. This ensures that the required rate of decompression is achieved, and at the same time avoids very large pressure drops in the ducting.

WARNING HORN

50. Should failure of air supply system or damage to the cabin structure cause loss of cabin pressure, the simultaneous expansion of the absolute and differential capsules in the motorised controller will cause contacts to close in the warning device circuit to sound a horn located adjacent to the pressure controllers, and to illuminate three loss of pressure warning lamps on the rear crew members instrument panel. The horn can be isolated for ground servicing purposes by a manually operated switch adjacent to the pressure controllers.

INWARDS RELIEF VALVE

51. The inwards relief valve mounted on the front pressure bulkhead, is to limit to a safe value any negative differential pressure which may arise. Normally the air supply to the cabin is sufficient to prevent any reversal of pressure, but in certain circumstances such as a very rapid descent following engine failure and subsequent cabin supply failure, the external pressure could exceed cabin pressure. In such a case the inwards relief valve will open to allow air to enter the cabin, and as soon as cabin and atmospheric pressures are approximately the same, the valve closes.

OUTWARDS RELIEF VALVE

52. The outwards relief valve fitted to the front pressure bulkhead, is to relieve excess pressures in the cabin in event of failure of the pressure controllers or associated equipment. As soon as the differential pressure reaches 9.75 p.s.i. the valve will relieve, and will maintain a cabin pressure differential of 10.25 p.s.i.

WINDSCREEN DEMISTING

THERMAL SYSTEM

53. For demisting the cabin side of the windscreen, an electrically operated system is provided, using heated cabin air directed onto the five windscreen panels as required. Control of the heating supply is by a two position switch located on the 1st pilots instrument panel. When the switch is moved to the ON position, current is supplied to drive the blower of a combined heater and blow unit mounted vertically adjacent to the front pressure bulkhead under the 2nd pilots floor. On MOD 908 A/C the switch is located on the inboard side of the 2nd pilots instrument panel.

DUCTING

54. From the heater, the flow of air is branched by a Y shaped duct to twin ducts which leads the flow to a feed duct situated beneath the centre windscreen. Three spray pipes then direct hot air to the centre windscreen. Each of the outer windscreens is heated by air which is drawn from the port or starboard twin duct and piped direct to the windscreen.

OVERHEAT SWITCH

55. Should the temperature in the ducting rise to above 70°C a thermal overheat switch in the ducting, interrupts the electrical supply to the heater unit. When the temperature falls to 60°C the switch "makes" and the heater comes into operation again.

SILICA - GEL SYSTEM

56. The centre three panels of the pilots windscreen are of sandwich type constructions and to prevent internal misting of the inner and outer window and air drying system is installed, connected to the space between the windows.
/DEHYDRATOR

DEHYDRATOR VALVES.

57. Fitted in the upper portion of each of the three windscreen panels is a Vickers self sealing dehydrator valve. These valves effectively seal the space between the windows until they are connected to the pipe lines of the system dehydrator valve connectors which maintain the valves in the open position, thus ensuring that only dry air is admitted to the interspace.

58. Each valve is connected through a short length of rubber tubing to an aluminium pipe and to the silica-gel container. The three silica-gel containers are located under the 1st pilots floor.

BASIL BLADDERS

59. As the system is contained completely within the pressure cabin, it follows that the air in the windscreen interspace is at the same pressure as the cabin air at all times. Should the cabin be depressurised in an emergency, it is necessary that the pressure in the interspace be reduced at approximately the same rate as the cabin pressure, in order to avoid possible damage to the inner screen through differential pressure.

60. To obtain this condition, three small basil bladders are connected to the system, one in each pipe line. These bladders permit rapid expansion of the air in the system when, during a decompression, the cabin pressure is below the interspace pressure.

SILICA-GEL

61. When refilling air drying cartridges, silica-gel crystals Ref No 33C/1454 only must be used. The silica-gel is blue when dry and slowly changes to pink as it absorbs moisture.

RELIEF VALVES

62. To prevent excess pressure from building up in the windscreen interspaces, pressure relief valves, one in each of the three windscreen systems, are fitted.

AIR VENTILATED SUIT SYSTEM.GENERAL

63. Under certain conditions of aircraft operation, such as aircraft stationary or taxiing, especially in warm climates or low altitude high speed flying, it is an advantage to use a system which allows direct and individual bodily air ventilation to all crew members when dressed in normal or special flying clothing.

A special suit, the air ventilated suit is worn; this is a fabric garment rather like an overall, fitted with a network of flexible tubes terminating in small jets which discharge air directly over the skin near the main sweat glands. Body heat is therefore removed by evaporative cooling.

The air ventilated suit has certain advantages; it cools the wearer at source and nullifies the insulating effect of the various layers of flying clothing.

The air supply can be taken from a ground conditioning trolley or tapped from main engine compressor, so that the suit can be used under all circumstances.

SYSTEM

64. The system which conditions the air supply for suit ventilation is an automatic adjunct to the cabin air conditioning system and obtains its air supply from the same basic source.

Air is taken from the cabin main pressurisation system before the flood flow valve, and flows through an electrically operated ON/OFF cock into the suit ventilating air conditioning system.

PRIMARY COOLER.

65. From the ON/OFF cock, the charge (supply) air, which is hot and possibly humid, is passed through an air to air cooler (Heat Exchanger). The cooling medium for this cooler is ram air ducted from the ram air intake at the boundary layer fence on the port side centre section.

COLD AIR UNIT

66. After passing through the cooler and giving up most of its heat, the partly cooled air is expanded across a cooling turbine to further reduce its heat and cause the water content to form into controllable droplets.

The cooling system turbine drives a fan coupled to it which draws ram air through the cooling surface of the primary air to air cooler; after passing around the fan this cooling air is discharged to atmosphere.

WATER EXTRACTOR

67. Cold air on leaving the turbine is ducted to a water extractor where the water content is reduced and the air emerges as cold and dry. At temperature sensing element at the outlet of the water extractor, operates the underheat control valve to by-pass warm engine air into the water extractor to mix with the cold moist air from the cold air unit, and thereby prevent the moisture particles from freezing. The sensing element operates to open the underheat control valve when the water extractor outlet temperature drops to 2°C.

HEAT EXCHANGER

68. The air now flows through a heat exchanger to be warmed and leaves as warm dry air. This heat exchanger receives its supply of heat from the initial tapping of hot air, this air passes through, and is controlled by, a temperature control valve.

FILTER AND NON-RETURN VALVE

69. After being re-heated the warm dry air is filtered and passed through a non-return valve at the rear pressure bulkhead to a manifold fitted inside the cabin aft of rear crews floor.

MANIFOLD

70. The manifold consists of five main components, i.e. sonic venturis, pressure relief valve, pressure controller, temperature sensing unit and an overheat switch. It serves as a distribution point for the supply of air to individual crew stations, the six sonic venturis ensure that the flow of air to each suit is limited to 1 lb/min.

MANIFOLD PRESSURE CONTROL AND RELIEF

71. During normal operation, the flow of air to the manifold is in excess of that required for the suits. Pressure in the manifold is prevented from rising above 18 p.s.i. absolute (3.3 p.s.i. at ground level) by a relief valve which is held open at the correct setting by a pressure controller.

MANIFOLD TEMPERATURE CONTROL

72. A temperature sensing element projecting into the manifold operates the overheat control valve should the air temperature in the manifold rise to above 15°C. Operation of this allows the overheat control valve to cut off the supply of hot engine air to the heat exchanger.

MANIFOLD OVERHEAT CONTROL

73. An overheat switch is located on the manifold casing directly below the temperature sensing element. This switch prevents an uncontrolled temperature

rise in event of a fault in the system.

If the temperature in the manifold rises to 70°C the overheat switch operates the relay to cause the shut off cock to close and render the complete system inoperative.

REHEAT

74. At each crew members position a manually controlled electrical heater is fitted so that each crew member may adjust heating to his individual requirements.

MANUAL FLOW CONTROL

75. A manual control to enable each crew member to adjust the flow of ventilating air to his own need is fitted at each position.

SYSTEM FLOW AUGMENTOR

76. To compensate for the adverse effect of high altitude, when available supply pressures and flows are reduced and the cold air unit goes out of action a flow augmentor comes into action; a by-pass upstream of the cold air unit allows air to flow through the augmentor to the re-heat exchanger and onwards to the ventilated suits.

EXHAUST

77. After use the air from the suits is exhausted into the cabin and is discharged from the cabin with the normal cabin air.

GROUND OPERATION

78. With aircraft static, suit ventilation may be effected by connecting the 2" ground conditioning connection on the port underside of centre section forward of front spar to a ground conditioning trolley supplying the necessary air supply.

CONTROL SWITCH

79. The ON/OFF cock is controlled by a master switch in the cabin, manually operated, mounted in the aft position on the starboard console, or the fully automatic overheat switch incorporated in the manifold.

BOMB BAY HEATING SYSTEM

INTRODUCTION

80. Provision is made for heating the bomb bay, as the temperature of the bay must not fall below freezing point, when certain stores are carried. The system which can be operated under automatic or manual control draws hot air from the engine air supply system, mixes it with cold ram air from a cold air intake on the dorsal fin, and circulates it throughout the bomb bay.

DUCTING

81. The resultant mixed air is ducted forward and aft in the bomb bay. Eighteen branch ducts of reducing diameter from the main trunking distribute the heating air evenly throughout the length of the bomb bay, exhaust air passes to atmosphere through an exit louvre in the rear of the port bomb door.

HOT AIR VALVE

82. The hot air supply from the engines is fed to the bomb bay hot air valve. A branch duct also takes hot air to the fin leading edge anti-icing hot air valve. The flow of air into the bomb bay via the hot air valve, is electrically controlled, together with a flap type cold air valve, in the bomb bay roof. An amplifier wired to four temperature sensing elements dispersed in the bomb bay, causes an actuator to open or close the hot air valve as necessary to maintain a bomb bay temperature of between 10°C to 25°C.

/COLD

COLD AIR VALVE

83. Two flush type air intakes, mounted in the dorsal fin supply cold ram air to the cold air valve. This valve is controlled by an inching unit, the operation of which is governed by a capillary tube inserted in the duct downstream of an injector barrel, and maintains a duct temperature of 100°C at the injector outlet.

INJECTOR

84. Hot air from the hot air valve passes to the injector, mixing with the cold air from the cold air valve. Swirl vanes in the injector nozzle ensure that efficient mixing of the air takes place. The final temperature depends on the proportion and initial temperature of the two air supplies.

OPERATIONAUTOMATIC

85. When the main control switch is placed in AUTO, the following actions take place.

(a) The hot air valve is governed by the temperature sensing elements to maintain the correct bomb bay temperature.

(b) The cold air valve is governed by the inching unit to maintain the correct duct temperature.

MANUAL When the main control switch is placed in MANUAL the following actions take place.

(a) The hot air valve comes under the control of the manual INCREASE/DECREASE switch.

(b) The cold air valve is fully opened and remains open until system is shut down.

OVERHEAT SYSTEM

86. If the temperature of the heating air in the ducting downstream of the injector, rises to 130°C, an overheat switch operates to move the hot air valve to the closed position, overriding any other form of control at that time. When the duct temperature drops to 120°C, the switch returns the hot air valve to manual or automatic control.

CONTROLS AND INDICATORS

87. These are mounted on the starboard upper portion of the rear crews panel, and consist of :-

(a) Main control switch. Three positions AUTO-OFF-MANUAL

(b) Manual Heat control switch. Three positions INC-OFF-DEC, spring loaded to the OFF position.

(c) Temperature selector. Enables the operator to set the desired bomb-bay temperature under automatic control.

(d) Bomb bay temperature indicator.

SWITCHING OFF

88. When the main control switch is returned to the OFF position the hot air valve closes, then the cold air valve closes, This sequence ensures that an uncontrolled temperature rise is avoided.

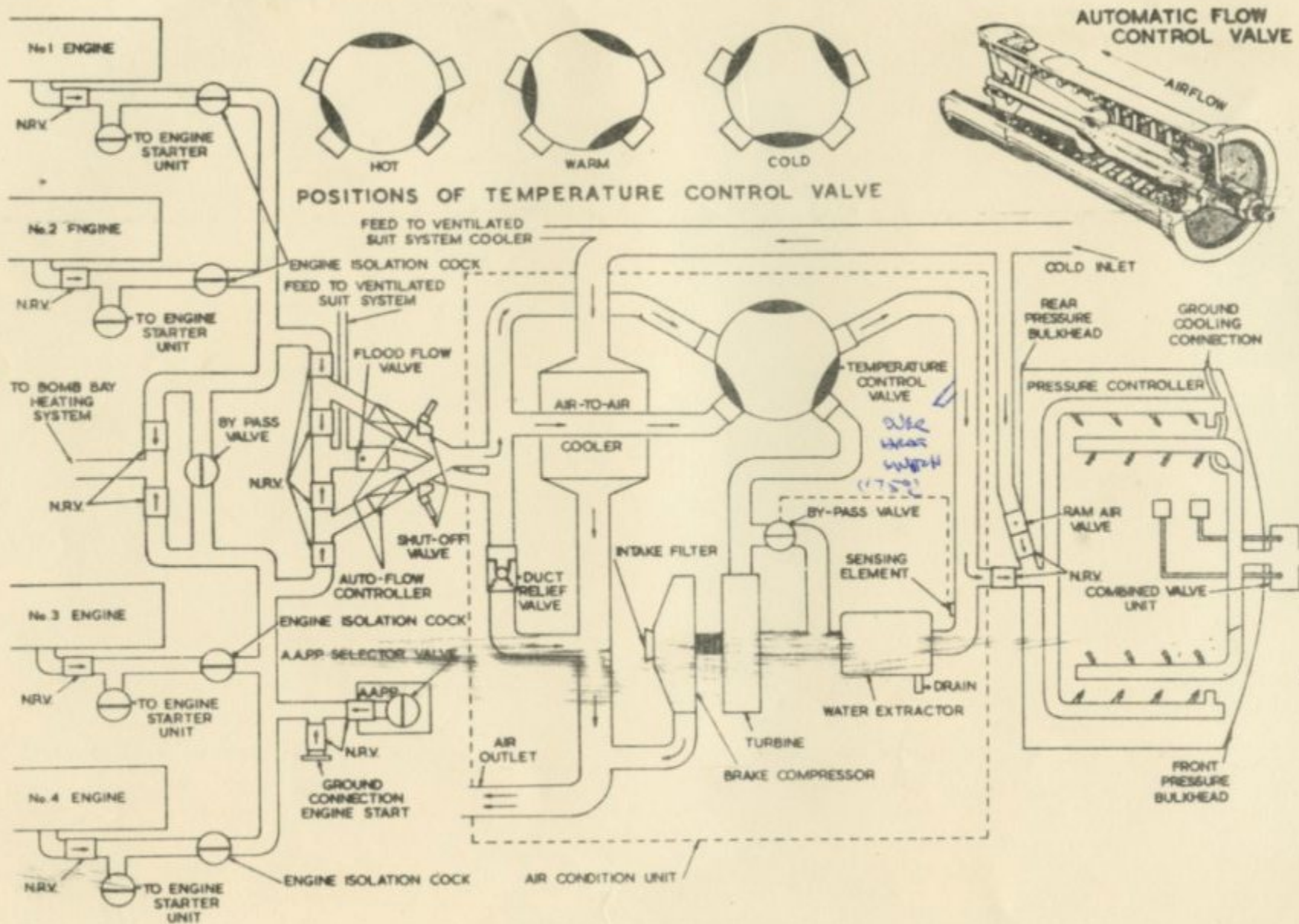


Fig. 2. Air conditioning system diagram.

RESTRICTED

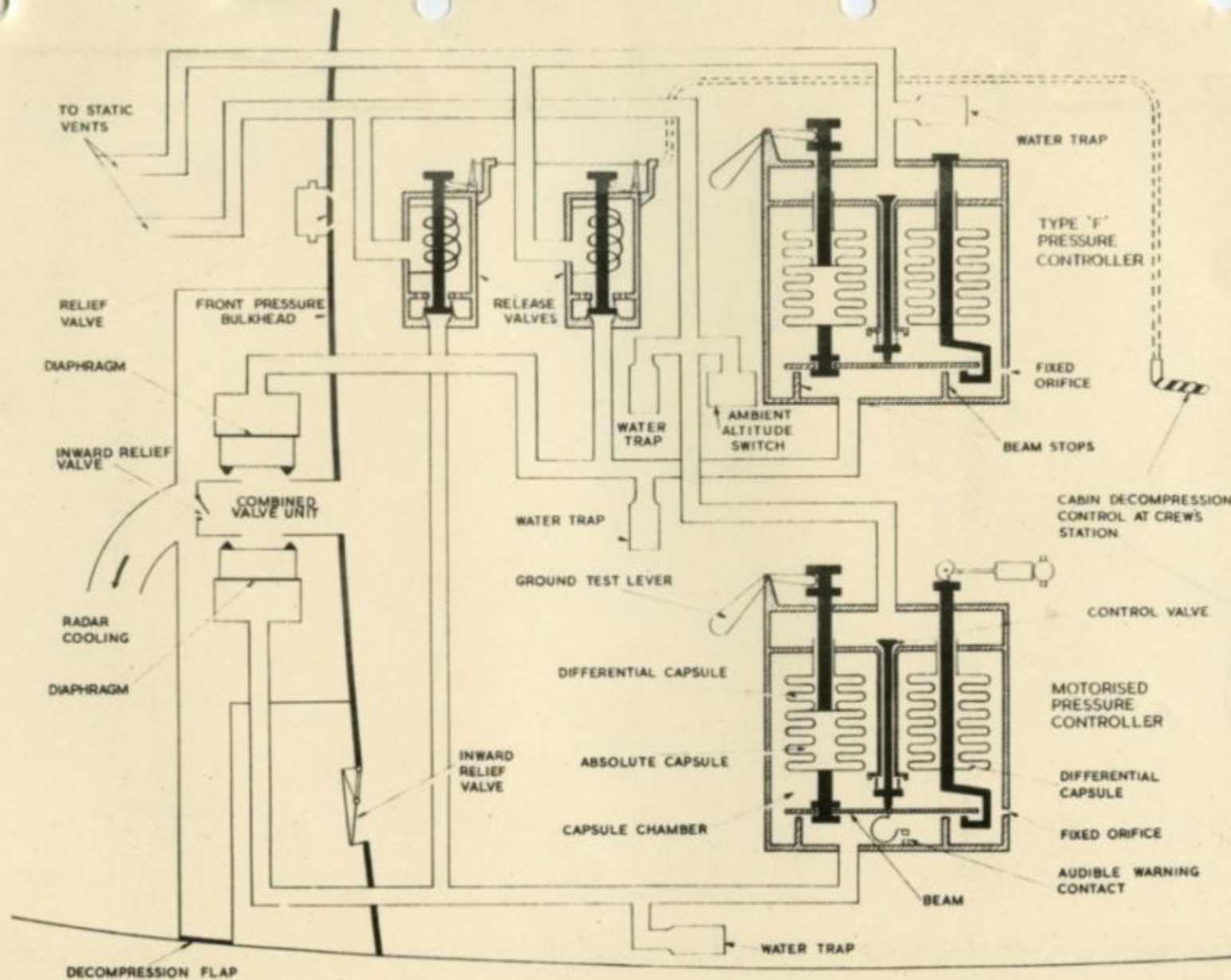


Fig. 4. Cabin pressure control diagram

RESTRICTED

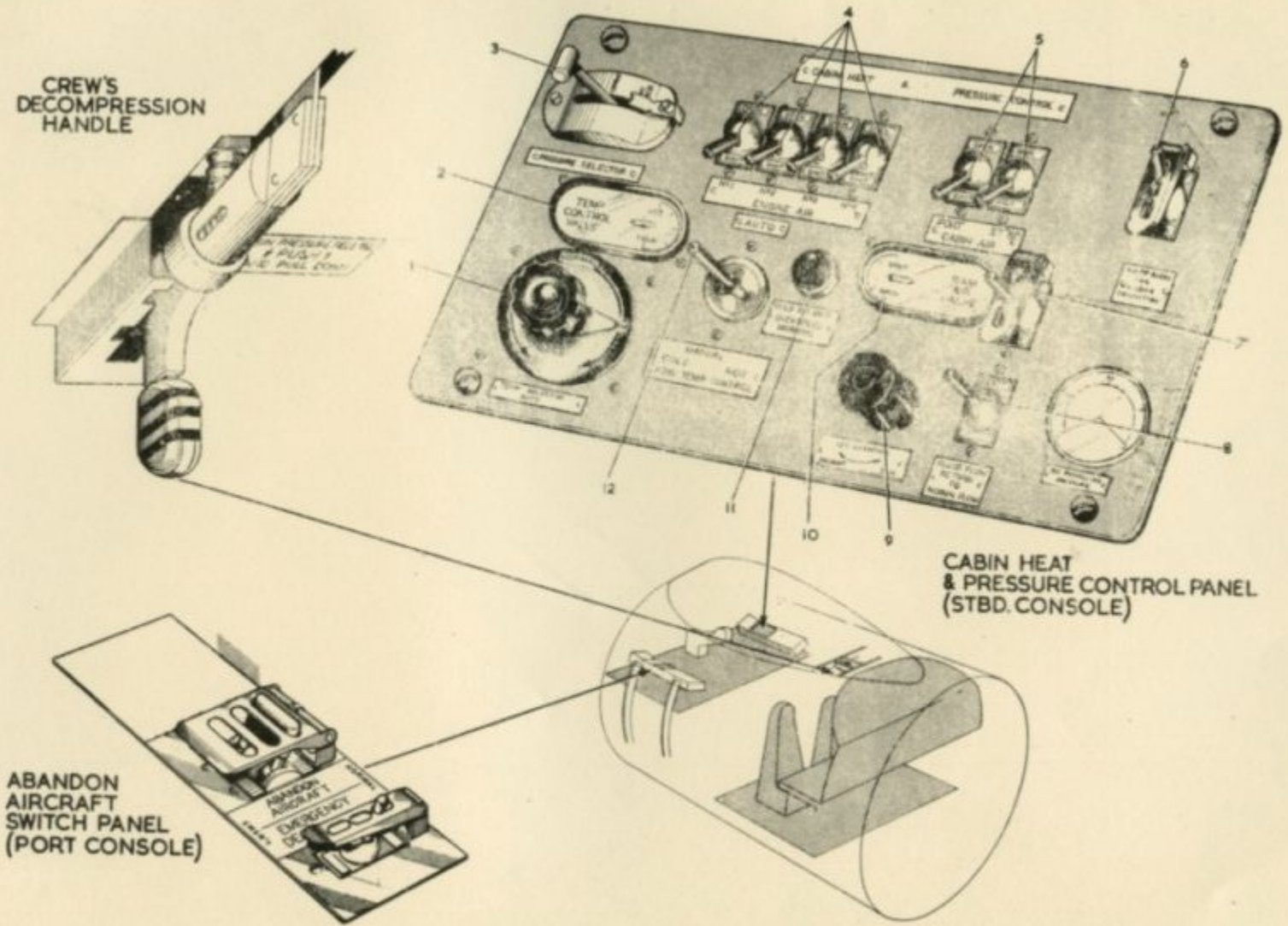


Fig. 1. Controls, air conditioning system.

RESTRICTED

AIRFRAME THERMAL ANTI-ICING

Reference: AP 4505B Vol 1 (GENERAL and TECHNICAL INFORMATION)

INTRODUCTION

1. The thermal de-icing installation provides a means of keeping the temperature of the air in the regions of the inner surfaces of the wing and fin leading edges within predetermined limits. The required heat is provided by air tapped from the engines and, mixing it with a suitable quantity of cold air to control its temperature, passing the resultant temperature of air along the inside of the leading edges of the mainplanes, the engine air intake lips and splitter wall, and the fin leading edge.

The installation is divided into three separate systems, one for the port wing, one for the starboard wing, and one for the fin system, each having its own injector barrel and hot and cold air valves. The three systems are controlled electrically, three distinct circuits being employed.

Normally automatic control is used, but manual control can be used in an emergency such as failure of the automatic controls.

WING LEADING EDGES

2. Warm air enters a wedge shaped duct, which runs the whole length of the leading edges, at the transport rib junction. The forward edge of the duct is open to admit warm air to flow to the inside of the leading edge skin and then rearwards between the outer skin and a corrugated inner skin, which is part of the duct. The warm air gives up its heat to the skin, and exhausts into the space between the rear of the wedge shaped duct and the front spar. Outboard of the tank bays, a series of holes in the front spar web allows the exhaust air to flow rearwards to an exit louvre on the underside of the main-plane just forward of the rear spar.

ENGINE AIR INTAKE LEADING EDGES

3. The warm air junction at the transport ribs taps off air inboard to the top and bottom lips of the intake structures, to ducts passing along the inside of each lip, and then rearwards between each lip and a corrugated inner skin as in the wings. The used air exhausts into the space around the air intake tunnels and the ribs, and then out through an electrically operated extractor flap on the lower skin of the centre section just forward of the front spar.

SPLITTER WALLS

4. A branch pipe, prior to the transport rib junction, feeds warm air to a small duct along the inside of the splitter walls leading edges, and then rearwards, between the splitter skin and an inner skin and finally exhausts with the leading edge intake lips used air, through the extractor flap.

FIN LEADING EDGE

5. Warm air enters a wedge section duct which runs the length of the fin leading edge, and is similar in construction to the wing systems. The warm air gives up its heat to the skin, then passes rearwards between the skin and a corrugated inner skin, and

/exhausts

exhausts to the space formed between the rear of the duct and the front fin post. A series of holes in the front and rear fin posts, allows the exhaust air to flow rearwards, to an exit louvre in the form of vertical slots, near the top of the fin, on both sides.

HOT AIR SUPPLY

6. Hot air at a temperature and pressure of up to 350°C and 200 psi, is tapped off the delivery casings of the engines through the engine isolation cocks. A common duct from each valve runs inboard, under the engine bay roofs, to divide into two branches at the bomb-bay rib, the hot air being ducted rearwards for bomb-bay heating and fin thermal anti-icing, and to run forward for wing anti-icing and cabin conditioning.

As the ducting on each side of the aircraft approaches the front spar, it descends down the rear face of the spar to pass through the spar into the lower air intake lip structure.

Immediately afterwards, the ducting divides into two branches, one going forwards to the cabin conditioning equipment, and the other going outboards to the wing and intake structure thermal anti-icing systems.

The ducting running rearwards in the inboard engine bay roofs, passes through the bomb bay ribs at the rear of the engine bays, and provides a common feed through non return valves in the roof of the bomb-bay, to the fin anti-icing and bomb-bay heating systems. The non-return valves can be by-passed, by a branch duct from the intake sides of each valve, for the purpose of starting numbers 1 and 2 engines by low pressure air supply. An electrically actuated butterfly valve is situated in this branch duct and is operated by the engine start controls.

The flow of hot air into each system is controlled by electrically actuated carbon slide valves.

COLD AIR SUPPLY

7. Cold ambient air is supplied to each system from separate flush intakes.

The wing and intake lips ambient air intakes are in the form of electrically actuated flaps (one port, one starboard), the amount open determining the cold air supply. These flaps when closed, form part of the surface contour, and are located under the lower engine air intake lip structure forward of the front spar.

The fin supply enters by twin fixed flush ambient air intakes, back to back, in the dorsal fin, the cold air flow being controlled by an electrically actuated butterfly valve in the throat of the cold air ducting. These intakes also supply cold air to the bomb-bay heating system through a separate cold air valve in a branch duct.

INJECTOR BARRELS

8. In this paragraph the operation of one injector is described, the others being similar.

Hot air from the engines passes through the hot air control valve to the nozzle of the injector barrel. It then leaves the

/nozzle

nozzle at a considerable velocity and passes through the barrel, mixing with, and imparting some of its velocity, to the cold air which enters the barrel around the hot air nozzle. Swirl vanes in the hot air nozzle induce efficient hot and cold air mixing. At the outlet of the barrel, complete mixing has taken place, and the final temperature depends upon the proportion of cold air allowed to mix with the engine air.

CONTROLS AND INDICATORS

9. A panel on the starboard console at the rear, houses the control switches and indicators, which are:-

- a. Three Main control switches, one for each system, labelled AUTO-OFF-MANUAL.
- b. Three manual heat control switches, one for each system, labelled INC-DEC. (Spring loaded to "OFF" position).
- c. Three temperature indicators, one for each system, calibrated 0-200°C to register the temperature at the injector outlet.

NOTE:- Before the de-icing systems can function, the ENGINE AIR switches on the pressurisation and cabin conditioning control panel must be "ON".

OPERATION

10. The following paragraphs describe the operation of one of the wing systems, the other systems being similar, apart from the fact that the fin system has no extractor flap.

AUTOMATIC

11. With the ENGINE AIR switches on, the main control switch is placed to AUTO. The variable cold air intake and the extractor flap are opened fully.

When the cold air flap is one third open a micro-switch is operated to open the hot air valve fully. The hot air valve is now under the control of a sensing element, flush fitted in the wing root leading edge. The sensing element ensures a constant leading edge skin temperature of 10°C, and, through a magnetic amplifier re-adjusts the hot air valve accordingly.

The cold air flap actuator is controlled by an inching unit. This unit senses changes in temperature at the injector outlet by means of a fluid filled capillary tube fitted to the barrel outlet duct. A rise in injector outlet temperature will cause the fluid to expand, the expansion being felt via a flexible pipe, to a capsule operated switch in the inching unit. This will cause the cold air flap actuator to operate to further open the flap to admit more cold air into the system. A mechanical follow up connection between the actuator and the inching unit switches off the actuator when the flap has moved to the correct setting.

When the system was initially selected to AUTO, the cold air flap opened fully, which resulted in too much cold air supply so, the inching unit will close down the supply, to the setting determined by the mass of hot air from the hot air valve. Therefore
/any changes

any changes in temperature by the wing sensing element on the hot air valve will cause the inching unit to re-adjust the cold air setting via the capillary tube, to the correct mixture proportion.

TEMPERATURE INDICATION

12. The injector barrel outlet temperature is recorded on the 0-200°C temperature gauge on Panel 7P by a temperature bulb in the outlet ducting from the injector.

OVERHEAT CIRCUIT

13. If the temperature of the air on the outlet side of injector exceeds $165 \pm 5^{\circ}\text{C}$, an overheat switch in the ducting operates and the hot air valve is disconnected from AUTO or MANUAL control and closed. When the duct temperature drops to 160°C the overheat switch returns to normal and the hot air valve is placed back under control to AUTO or MANUAL.

ICE DETECTORS

14. Provision is made for the installation of automatic ice detectors in each circuit. This ensures that when the main control switch is placed to AUTO the system will be placed under the control of its ice detector and, when conditions of icing occur, i.e. the combination of humidity and airframe skin temperature, contacts in the ice detector will close and the operations previously described will take place.

MANUAL OPERATION

15. With the ENGINE AIR switches "ON" the main control switch is placed to MANUAL. The variable cold air intake and the extractor flap open fully, and applies a positive supply to the MANUAL HEAT CONTROL SWITCH.

A holding of MANUAL CONTROL SWITCH to the INC position opens the hot air valve until the temperature indicator registers $150 \pm 5^{\circ}\text{C}$.

Opening or closing of the hot air valve can now be controlled by operating the INC/DEC switch as required. The cold air valve and extractor flap will remain at the open position whilst the main control switch is at MANUAL.

Wiring Diagram Only.

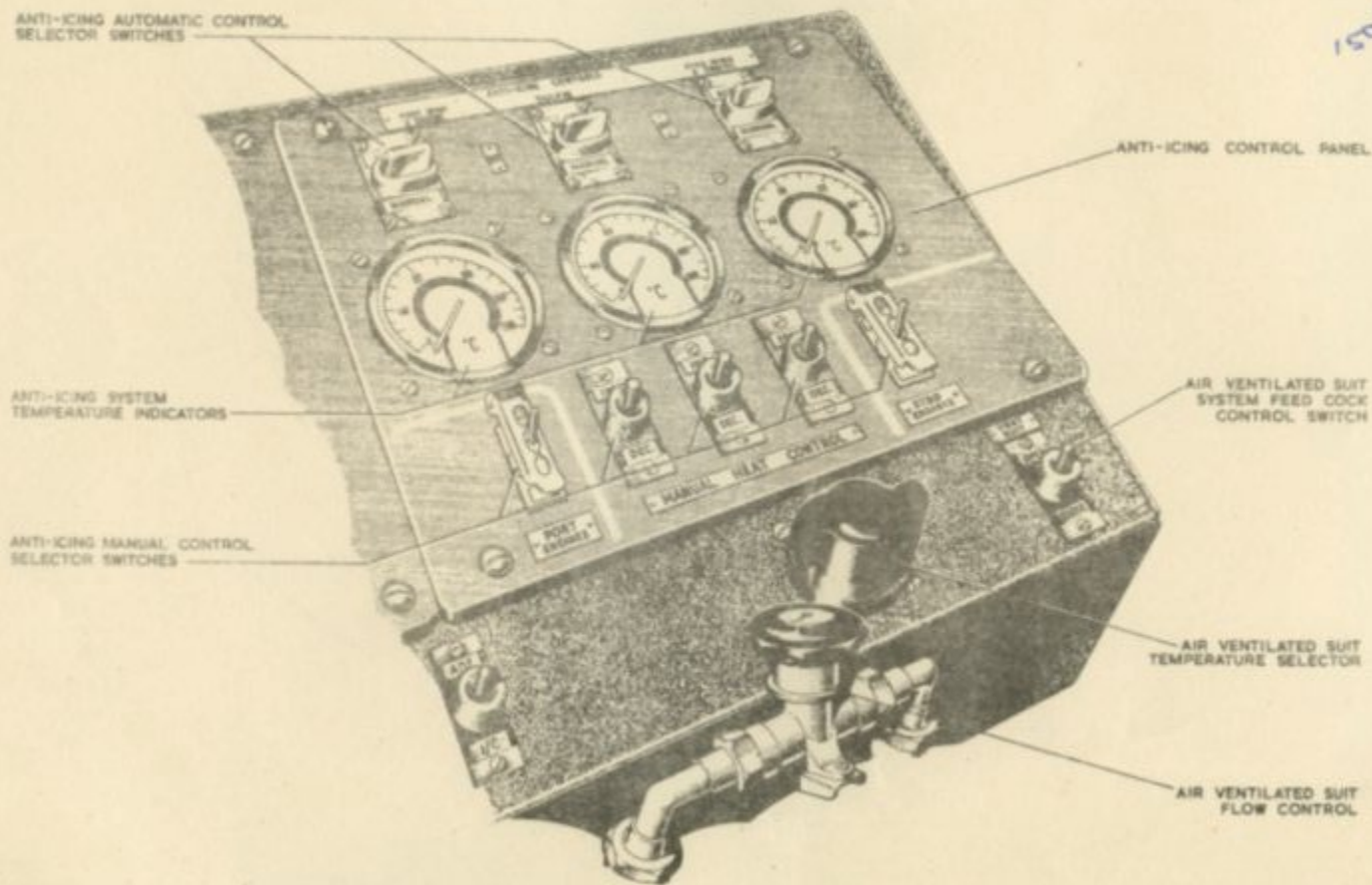


Fig. De-icing system control panel

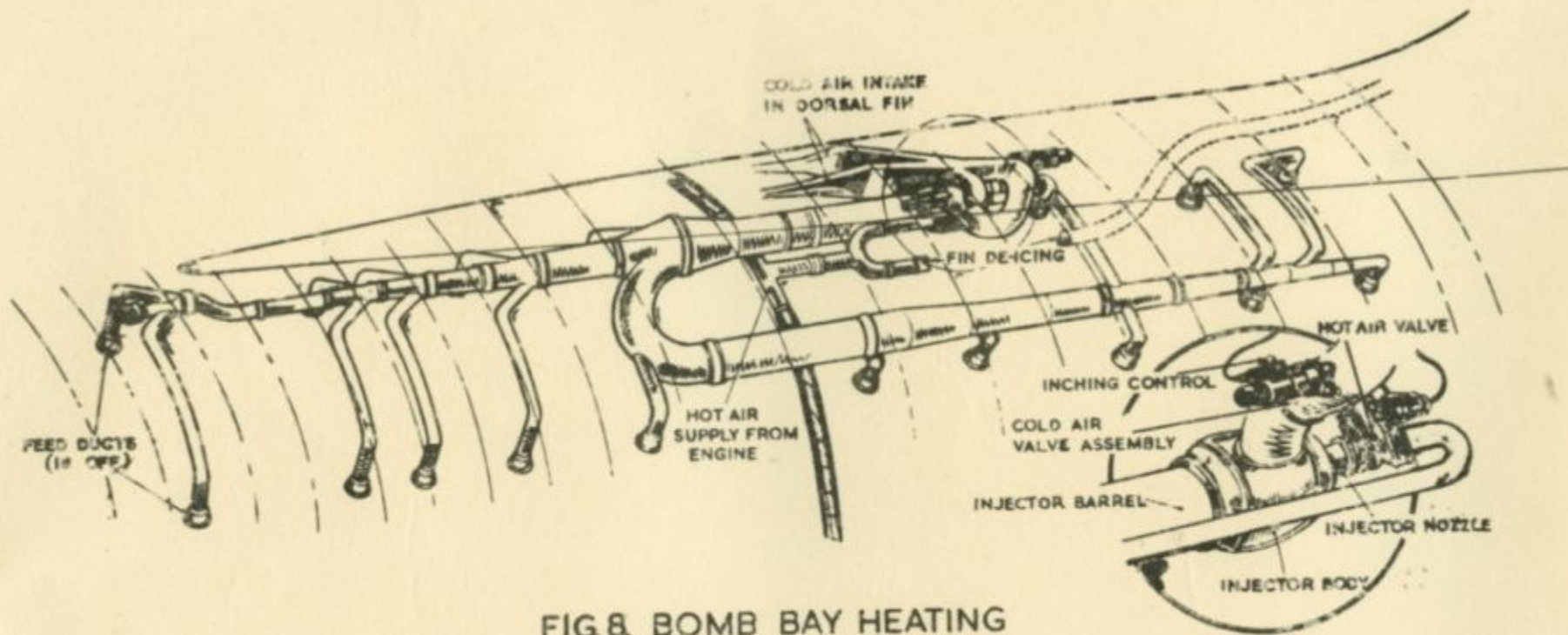
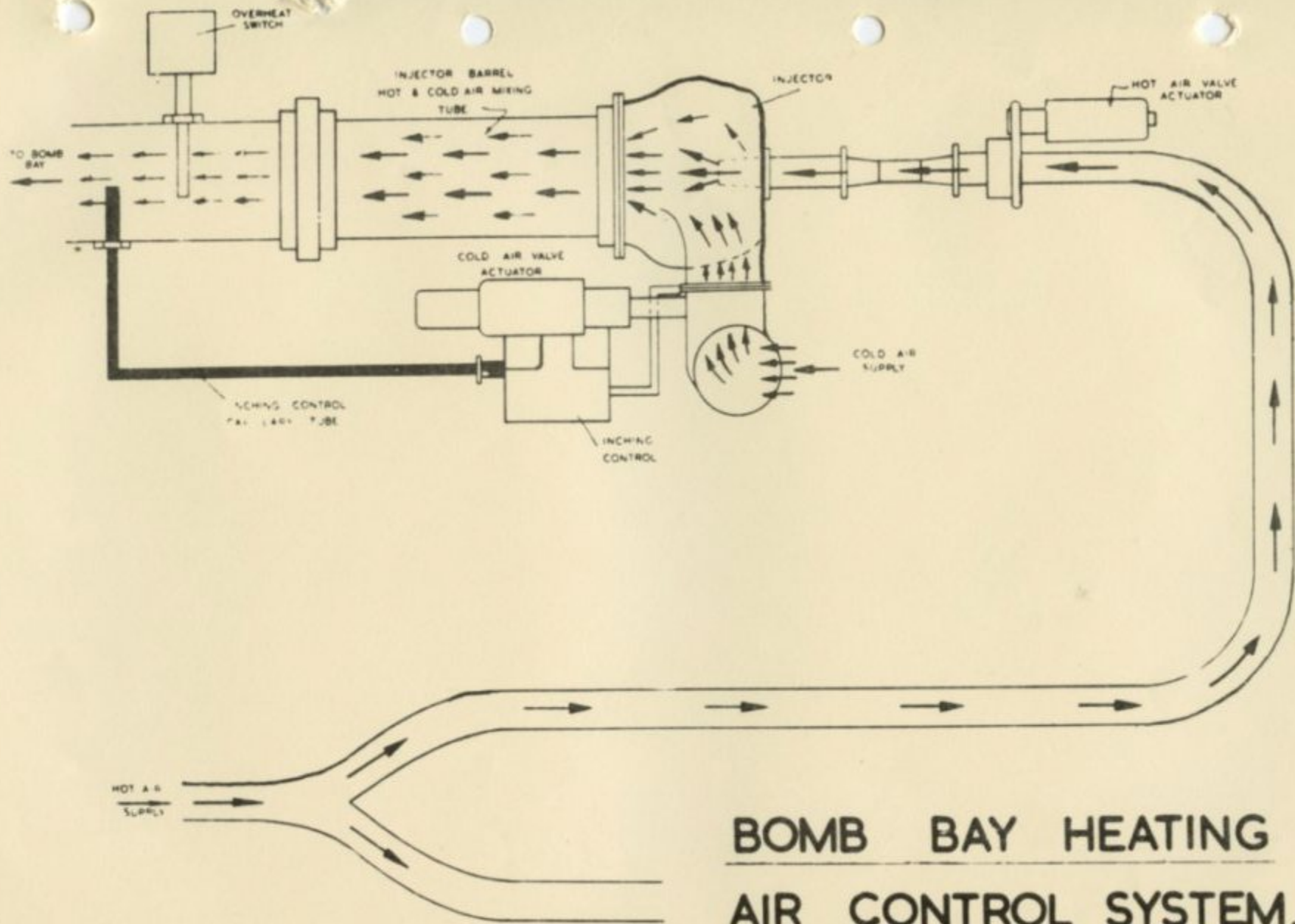


FIG. 8. BOMB BAY HEATING



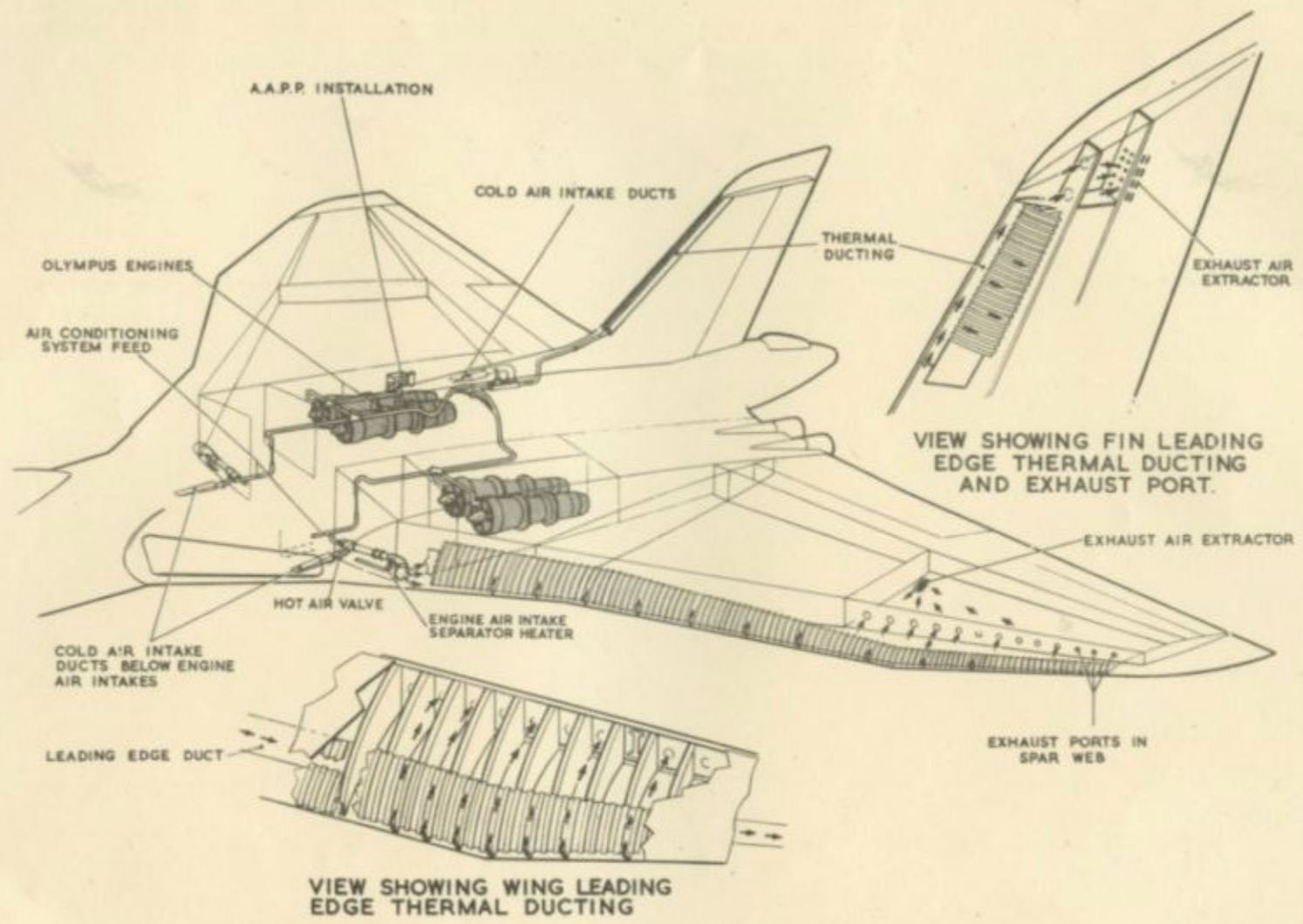


Fig.2. Thermal de-icing system installation

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