

OLYMPUS 202/301 SERIES

SECTION 7

ENGINE AIR SYSTEMS

INTRODUCTION

The engine air system fulfils the following purposes:-

- Pressurisation fo constant speed unit oil tank and bulkhead seals.
- Pressurisation of fuel tanks and fuel recuperators
- Hot air supply to aircraft services
- Engine cooling system
- Inducer cooling air to the alternator, constant speed unit oil cooler and zone 2B
- Engine breathing system
- Engine bay ventilation
- Engine anti-icing.

1. Pressurisation of Constant Speed Unit Oil Tank and Bulkhead Seals

Mk 301

L.P. compressor delivery air enters an aperture in the front face of the intermediate casing diaphragm and flows through No. 1 vane to an air supply connection which locates two external pipes.

One pipe supplies air to pressurise the constant speed drive unit oil tank, the air entering the tank through a banjo union on the valve housing. The other pipe supplies air to a connection on the bottom of the L.P. compressor casing from which it is piped to the front and rear bulkhead seals.

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L.P. compressor delivery air enters an aperture in the front face of the intermediate casing diaphragm and flows through No. 1 Vane to the banjo of the air supply connection. Air is utilised from this banjo union to pressurise the front and rear bulkhead seals; it is piped to the seal inlet valve at the base of each seal. The C.S.O.U. oil tank is pressurised by air tapped from the fuel heater pipe.

2. Pressurisation of Fuel Tanks and Fuel Recuperators

H.P. compressor delivery air enters the apertures in the delivery casing diaphragm and flows through No. 3 vane into the inducer elbow of the alternator, and constant speed drive unit cooling ducts. The fuel tanks and recuperators are pressurised from a tapping on the inducer elbow.

/3. Hot

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3. Hot Air Supply to Aircraft Services

H.P. compressor delivery air passes through apertures in the delivery casing diaphragm, into No. 2 vane and then into the duct elbow from which it is ducted forward through a non-return valve to the hot air valve fitted on the starboard side of the intake casing. When the valve is open it allows hot air to flow to the aircraft for the following services:-

- Cabin pressurising and air conditioning
- Wing and fin anti-icing
- Bomb bay heating

Portions of this ducting are also used for conveying air to the engine starter unit.

Eng Cooling System

4. (i) Turbine discs

The front and rear faces of the 1st stage turbine disc and the front face of the 2nd stage turbine disc are cooled by H.P. delivery air. The air enters apertures in the seal housing support of the delivery casing and flows through three turbine air feed pipes to the bearing diaphragm; it is then piped through the turbine bearing support drum to discharge, through three apertures, on the front face of the 1st stage turbine disc.

The outer portion of the 1st stage turbine disc rear face is cooled by air from the annulus in front of the disc, flowing through ports in the disc into the chamber enclosed by the disc rear face and the inter-stage diaphragm. This air flows outwards across the disc face and exhausts into the turbine.

To cool the inner portion of the 1st stage turbine disc rear face and the 2nd stage turbine disc front face, air passes through ports in the 1st stage turbine shaft hub and into the space between the turbine shafts to pass into the annular chamber between the faces of the turbine discs. The air flows outwards across the 2nd stage disc front face and exhausts into the turbines.

The supply of air used to pressurise the 2nd stage turbine rear bearing seal is also used to cool the rear face of the 2nd stage turbine disc and the front face of the bearing housing. The air flows through the bearing housing and the wheel hub air cover on to the rear of the 2nd stage turbine rotor disc and exhausts into the jet stream immediately after the 2nd stage turbine. A smaller supply of air from the same source is directed between the rear face of the bearing housing and the diaphragm cone, passes through ports in the rear face of the diaphragm cone into the vanes of the exhaust annulus and is then exhausted through holes in the trailing edge of the vanes into the jet stream.

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(ii) Combustion chambers, casings and turbine casings

Compressor delivery air flowing through the annulus of the combustion system cools the skins of the combustion chambers and casings, flows rearwards through ports in the turbine casing and exhausts into the jet stream at the rear of the 2nd stage turbine wheel.

5. Pressurisation of Bearing Seals

To minimise the loss of oil from the main bearings the seals are pressurised; L.P. compressor delivery air tapped from the intermediate casing is utilised to pressurise these seals, with the exception of the No 8 bearing seal which is supplied from the 3rd stage of the H.P. compressor.

6. Inducer Cooling

H.P. Compressor delivery air enters apertures in the delivery casing diaphragm and passes through No 3 vane and the inducer elbow to the inducer control valve. When opened, the valve causes jets of high pressure air to flow in the outlet ducting of the alternator and C.S.D.U. oil cooler and Zone 2B cooling outlet to induce a flow of cooling air during ground running or taxiing.

The valve is controlled from the aircraft under carriage circuit; i.e.

U/C Up - valve CLOSED

U/C Down - valve OPEN

7. Engine Breathing System

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Pressurised oil and air mixture from the engine oil tank is vented to No 7 vane of the intermediate casing. At the outer end of the vane is the tank pressurising valve; when the pressure in the tank exceeds 2 p.s.i. the valve opens and allows the mixture to flow through the vane to the gear chamber.

The air is then vented to atmosphere via the main engine breather outlet. The mixture of oil and air from the intermediate casing gear chamber, delivery casing coupling chamber, compressors and intershaft bearings, flows through port into the hollow L.P. compressor shaft and passes to the front of the engine into the oil separator, it then flows through Nos. 1 and 12 vanes of the intake casing and is ducted rearwards to be discharged to atmosphere through the main engine breather outlet at the propelling nozzle. The oil and air mixture from the 2nd stage turbine bearing passes into the hollow 2nd stage turbine shaft and flows forward to the end of the shaft in the delivery casing where it is ducted via the coupling to the intershaft bearing and through the L.P. compressor shaft to be vented to atmosphere with the other mixtures.

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Air from the seals of the 1st stage turbine bearing, the 2nd stage turbine air seal and the 1st stage turbine shaft coupling seal discharges into the turbine bearing support drum; the air then passes through the apertures of the delivery casing diaphragm to augment the air from the H.P. compressor rear seals and the H.P. compressor rear bearing seal; the whole volume of air from these seals then passes through No 5 vane of the delivery casing to a vent pipe on the casing which directs the air to atmosphere.

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Pressurised oil and air mixture from the engine oil tank in the nose bullet is vented to No. 6 vane of the intake casing. At the outer end of the vane is the tanks pressurising valve; when the pressure in the tank exceeds  $21\text{lb}/\text{in}^2$  the valve opens and allows the mixture to flow through a second passage in the vane to the oil separator. The air is then vented to atmosphere via No 1 vane and ducting at the propelling nozzle. When the pressure is less than  $21\text{lb}/\text{in}^2$  the mixture by-passes the pressurising valve via a vent hole in the valve housing and enters the second passage in the vane to the oil separator and then to atmosphere.

The mixture of oil and air from the intermediate casing gear chamber, delivery casing coupling chamber, compressors and inter-shaft bearings, flows through ports into the hollow L.P. compressor shaft and passes to the front of the engine into the oil separator; it then flows through No 1 vane of the intake casing and is ducted rearward to be discharged to atmosphere. The oil and air mixture from the 2nd stage turbine bearing passes into the hollow 2nd stage turbine shaft and flows forward to the end of the shaft in the delivery casing where it is ducted via the coupling to the inter-stage bearing and through the L.P. compressor shaft to be vented to atmosphere with the other mixtures.

Air from the seals of the 1st stage turbine bearing, the 2nd stage turbine air seal and the 1st stage turbine shaft coupling seal discharges into the turbine bearing support drum; the air then passes through the aperture of the delivery casing diaphragm to augment the air from the H.P. compressor rear seals then passes through No 5 vane of the delivery casing to a vent pipe on the casing which directs the air to atmosphere via the main engine breather.

8. Engine Anti-icingMk 301

H.P. compressor delivery air is used to prevent icing of the air intake, the intake vanes, the nose fairing and entry guide blades.

Hot air passes through No 7 vane of the delivery casing and is piped to a hot air valve mounted on the L.P. compressor casing. The valve is operated by an electrically operated actuator controlled from the cockpit. When the valve is open, hot air passes to the anti-icing air duct inlet and the adapter ring inlet. The anti-icing air in the duct passes into the entry guide blades then

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through internal passages to the air intake vanes, while the air in the adaptor circulates around the ring and then into the leading edge of the intake vanes. Air is ducted from the leading edge of the vanes, to the multi-skinned nose fairing from which it is exhausted via the passages in the centre of vanes No 2 to 11 inclusive. (The passages in the centre of vanes Nos 1 and 12 are used to duct air away from the oil separator.

The anti-icing air is ducted away from the air intake through five outlets as follows:-

- (i) No 3 vane is connected to No 2 vane by a duct in the periphery of the intake casing. The air passing through these two vanes is exhausted through an outlet at the outer end of No 2 vane from which it is piped to the rear bulkhead to exhaust into zone 2B.
- (ii) Air passing through No 11 vane is piped from an outlet at the outer end of the vane to zone 2B as described in (i).
- (iii) No 5 and 6 vanes and Nos 8 and 9 vanes are connected to No 9 by a duct in the periphery of the intake casing. Air passing through these vanes is exhausted through an outlet at the outer end of No 7 vane. The outlet mates with a connection in the engine bay doors from which air is exhausted.
- (iv) The air passing through No 4 vane is exhausted from the vane outlet into the engine bay. A perforated plate and a deflector plate is fitted over the outlet to prevent hot air impinging directly upon the engine bay walls.
- (v) The fifth outlet is on No 10 vane and is identical to the outlet on No 4 vane.

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H.P. compressor delivery air is used to protect the air intake nose bullet and its integral oil tank, the intake vanes, pitot and entry guide blades from icing. The hot air passes through No 6 vane of the delivery casing and is then ducted externally to a hot air valve mounted on the l.p. compressor casing. This valve is operated by an electrical actuator controlled from the aircraft cockpit; when it is in the open position, hot air passes into the anti-icing collector manifold and through the entry guide blades to the annulus at the rear of the inner casing. The air then flows through the internal passages of the casing to the nose bullet then forward between the bullet and the oil tank and through an aperture at the leading edge of the bullet inner skin to heat the outer skin on its rearward journey to the bullet rear face. Ports in the air intake inner casing front face receive the hot air which then flows into the intake vanes from which it is exhausted into the engine air intake.

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The pitot head, situated in front of the leading edge of No 4 intake vane is heated by air tapped from the air pipe between the valve and front bulkhead; this flexible pipe carried air to the pitot head base through the pitot head to vent, through holes into the air intake.

9. Engine Bay Ventilation

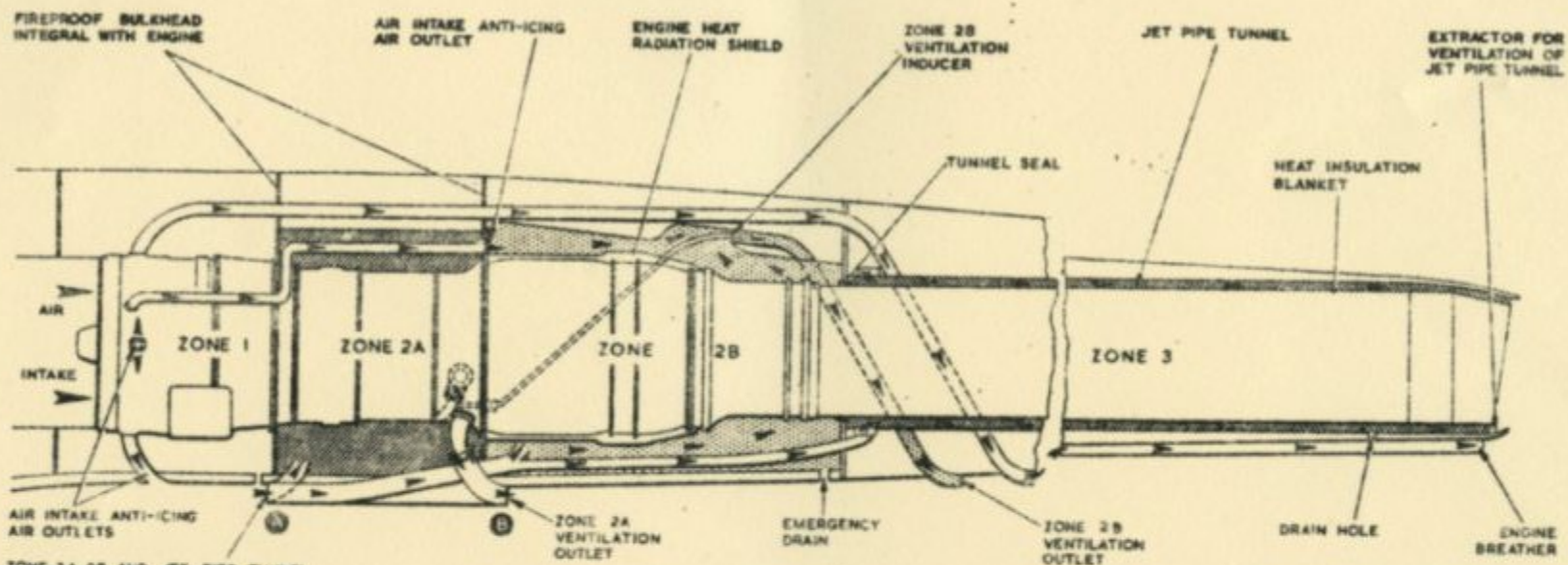
Zone 1 forward of the front bulkhead contains the intake casing and L.P. compressor casing. The cooling air inlet ducts of the alternator and constant speed drive unit oil cooler pass through the bottom of this zone. Air from the separator is ducted from the outlet on the top of the intake casing through the aircraft to the trailing edge of the main plane where it is discharged to atmosphere.

Zone 2A is the compartment between the two bulkheads which contains the fuel system. This zone is ventilated by ram air, ducted from an intake fitted beneath the zone 2A engine bay door, being directed to the top of the zone and discharged to atmosphere by the inducer action of the main engine breather through an aperture in the rear of the door. Ventilation is assisted by ram effect in flight.

Aft of the rear bulkhead, zone 2B contains the combustion chambers, turbines and exhaust annulus. Ventilation of this zone is by ram air, ducted from an intake fitted beneath zone 2A engine bay door, entering the base of the compartment and is directed to the top where it enters a duct which carries it to the outlet aperture beneath zone 3. An inducer fitted in the outlet duct ensures efficient ventilation of zone 2B during ground running and taxiing.

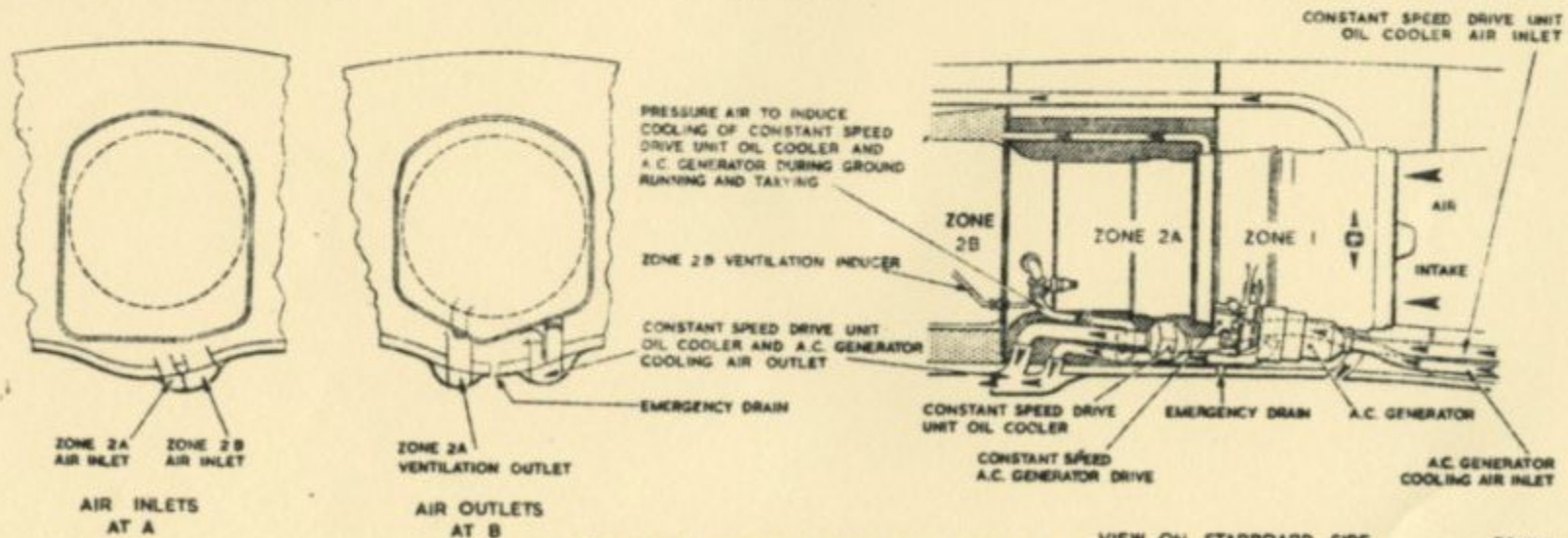
Zone 3 is the zone containing the jet pipe tunnel. It is ventilated by ram air, ducted from an intake fitted beneath zone 2A engine bay door, directed around the circumference of the jet pipe and exhausted at its rear end. To ensure a flow of air during ground running or taxiing the outlet end of the jet pipe is shaped to give extractor action.

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ZONE 2A, 2B AND JET PIPE TUNNEL VENTILATION AIR INLETS, AIR TO BE DEFLECTED TO TOP OF ZONES 2A AND 2B

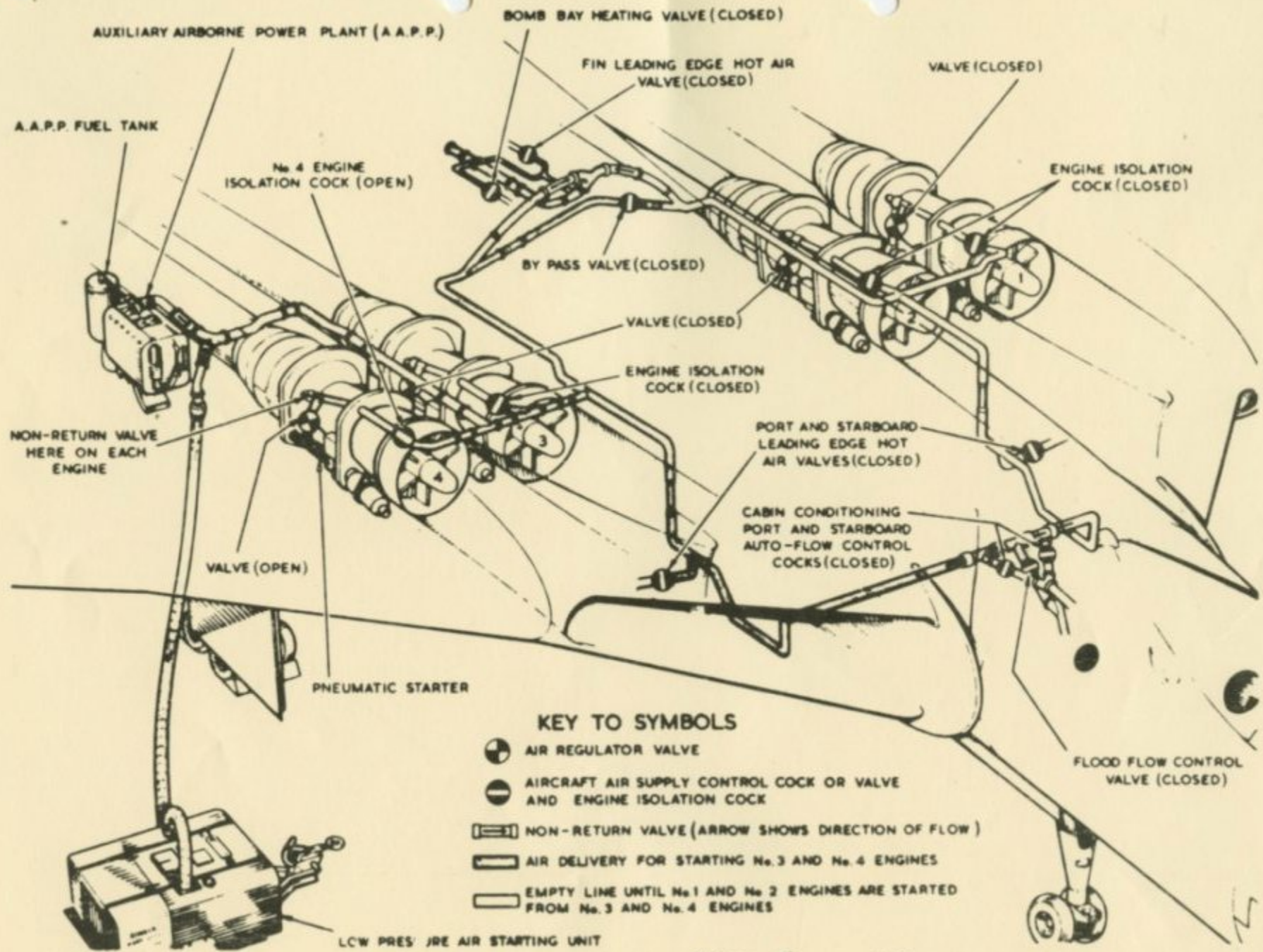
VIEW ON PORT SIDE



ENGINE VENTILATION DIAGRAM

VIEW ON STARBOARD SIDE

TR 6149



MASS FLOW CIRCUIT DIAGRAM.

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