Chapter 6

FUEL TANK PRESSURISATION

LIST OF CONTENTS

	Para.
DESCRIPTION	
Introduction	1
General	2
Controls and indicators	6
System installation	7
Tank pressurisation ground test panel	12
System components	13
Master control valve	14
Air valve	17
Vent valve	19
Filter/restrictor unit	23
Servo pressure-reducing valve	24
Air drier	25
Fuel traps	26
Solenoid depressurisation valve	27
Cycle of operations	
Static conditions	28
Tank pressure rising	32
Balanced tank pressure	33
Climb conditions	34
Inward venting conditions	37
Failure of air supply	41
SERVICING	
General	42
Filters	43
Air drier	44
Fuel traps	45
Pipelines and connections	46
Functioning tests	47
Ground test connections	49
Functioning test with engines running	50
Functioning test using ground test connections	51
Component checks	52
Outward venting check	53
Inward venting check	56
Pipe pressure tests	
General	58
Low pressure	59
High pressure	60
Fault finding	62

LIST OF ILLUSTRATIONS

	Fig.
Main fuel tank pressurisation and venting system diagram	1
Main fuel tank pressurisation and venting system installation	2
Ground test panel	3
Main tank pressurisation control panel	4
Tank pressure building up	5
Tank pressure balanced	6
Outward venting	7
Inward venting	8
Tank pressurisation	9

LIST OF TABLES

	Table
Tightening pipe unions	1
Fault finding chart	2

LIST OF APPENDICES

	App.
Test rig - fuel tank pressurisation	1

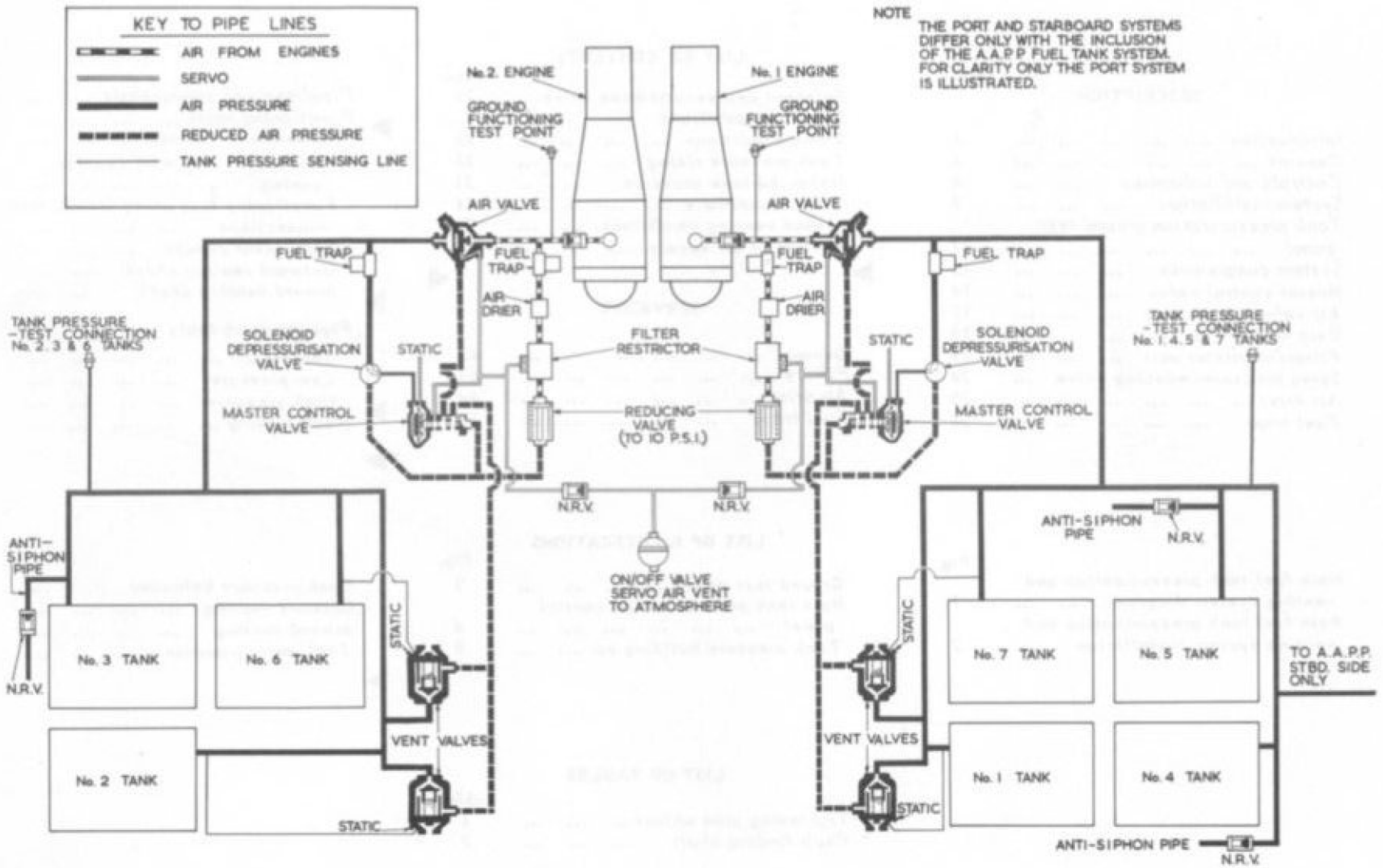


Fig. 1. Fuel tank pressurisation and venting system diagram

DESCRIPTION

Introduction

1. This chapter contains a description of the fuel tank pressurisation system, gives details of servicing operations and recommends the method of removal and assembly of certain components. Should it be necessary to service or bench test a system component, reference should be made to A.P.4303E, (Aircraft Pneumatic Equipment - Teddington Controls).

General

2. The pressurisation system enables a predetermined air pressure of approximately 1·82 - 2·3 p.s.i. above ambient to be maintained in the fuel tanks throughout the altitude range of the aircraft.

3. Primarily the reason for pressurisation is to prevent loss, by boiling off fuel, due to high altitude and high temperature particularly when using fuels of high Reid Vapour Pressure, i.e., AVTAG R.V.P. 3 p.s.i. Note that the Reid Vapour Pressure is the absolute pressure at which fuel at 100 deg. F. begins to boil. For example, should the aircraft be parked in high surrounding temperatures and then be flown in a rapid climb to 38,000 ft. at which altitude the ambient pressure is 3 p.s.i., i.e., coincident with the fuel R.V.P. Under these conditions without a pressurisation system, the fuel would rapidly boil off.

4. In addition, the system prevents negative differential pressure in the tanks which could damage or even collapse the tanks during diving conditions.

5. A diagrammatic arrangement of the system on the port side of the aircraft is shown in fig.1, the starboard side installation is similar but contains additional pipes and components for the A.A.P.P. fuel tank pressurisation.

CONTROLS AND INDICATORS

6. A control switch, mounted on the flight refuelling panel in the cockpit starboard console, operates the solenoid depressurisation valve directing the air flow through the master control valve either at full or reduced pressure (para.27).

SYSTEM INSTALLATION

7. Reference to fig.1 will show that engine compressor air is delivered to the system in two ways; main supply to the valve for delivery to the tanks, and a secondary tapping to be applied as servo pressure to the system components as required.

8. Compressed air is supplied at pressures, depending upon the engine and aircraft speed, up to 200 p.s.i. from ½ in. tappings at the last stage of each engine high-pressure compressor to the valves on the control panel (fig.4). An air flow tapped from the main supply line, passes through a fuel trap, an air drier and the filter of a filter-restrictor to a pressure-reducing valve. After the pressure is reduced to 9 - 12·5 p.s.i., the flow is either fed direct to the master control valve to be applied as servo pressure to the system components or via the solenoid depressurisation valve to the master control valve to depressurise the system. From the filter a further servo line supplies restricted air for the operation of the air valve and two vent valves. The functions of the feed and servo lines may be seen on fig.5 and succeeding figures.

9. The servo air piping arrangement between the system components, i.e., master control valves, air valves, and vent valves, is shown on fig.4, the static air supply to the master control valves is taken from the common supply in the No.2 tank bay above the nose-wheel bay.

10. Vent pipes from the fuselage No.1 and No.2 tanks lead to forward facing outlets in the fuselage roof skin plating, one on the port and one on the starboard side of the aircraft. A further outlet for the wing tanks is on the under side of each wing inboard of the inner elevons centre hinge rib. This outlet is branched, each branch being connected through a vent valve to the associated tank group pressurisation system. The No.1 tank and, on the starboard side only, the A.A.P.P. tank are interconnected to the No.4, 5 and 7 tanks via the tank pressurisation pipes and two vent valves, similarly the No.2 tank is connected to the No.3 and 6 tanks and two further vent valves. Therefore, the pressure in all tanks of one group will normally be equal with both vent valves operating together.

11. If the emergency fuel level switches failed during the refuelling of No.3, 4 or 5 fuel tanks, overfilling would create an effective siphon action via the pressurisation lines. The internal depression resulting from this would be sufficient to tear the tank colletted studs from the bay skin and damage the tank. To prevent this, pipes, tapped into the tank pressurisation/vent lines, lead through anti-

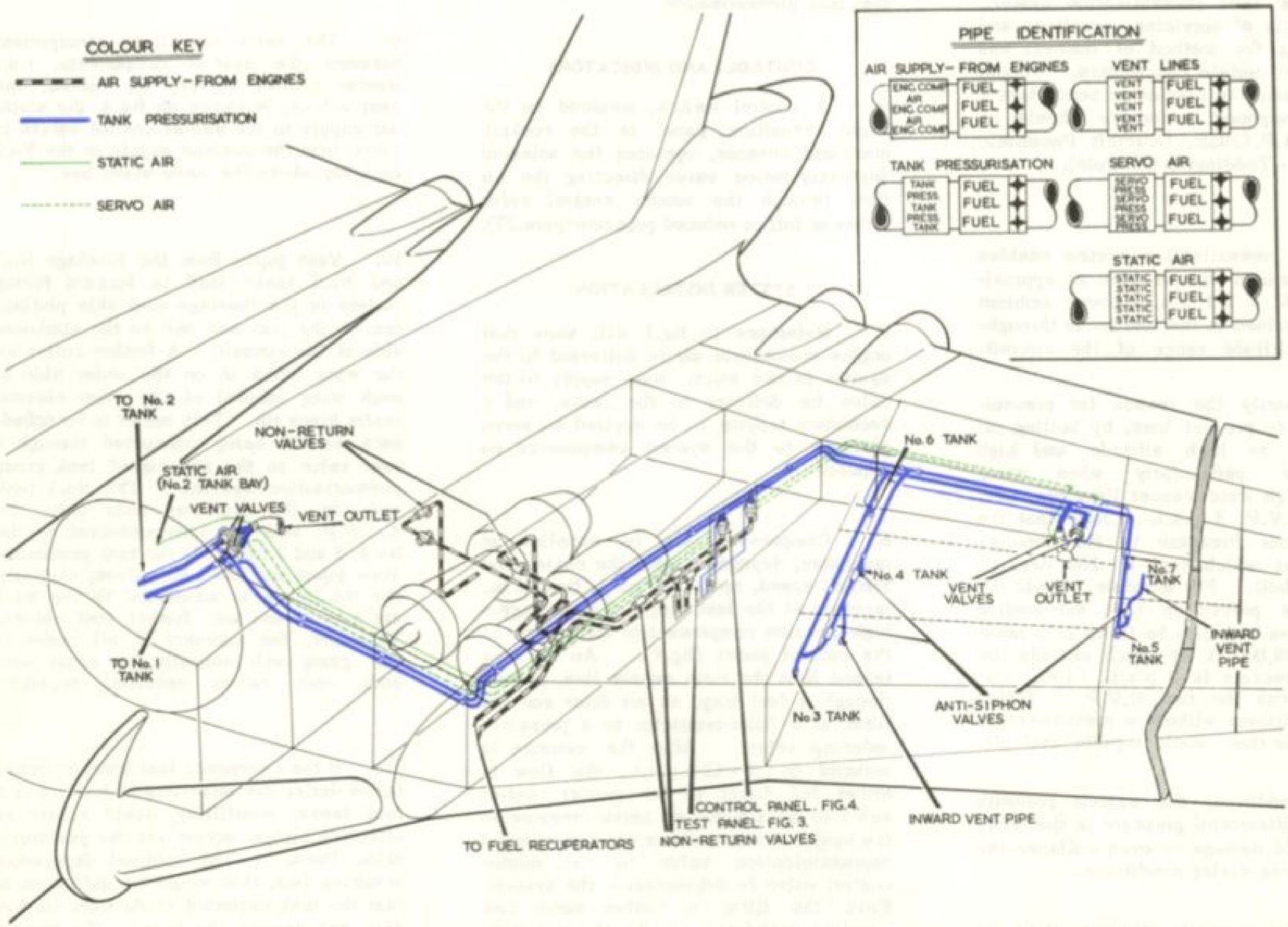


Fig. 2 Main fuel tank pressurisation and venting system insallation

siphon non-return valves to air vents in the under side of the wing. The valves are set to prevent the pressure in the pressurisation/vent lines falling below -0·25 p.s.i. (-6 in. W.G.). When the valves open, tank pressure will rise to atmospheric and internal and external forces acting on the tank will equalise.

TANK PRESSURISATION GROUND TEST PANEL

12. The ground test panel (fig.3), situated on the inner rib in each main wheel bay, houses the test points to which pressure gauges and external air supplies are attached during ground checks of the system. Four points are provided, two for the compressor air pressure and two for the fuel tank pressure. In addition, a control valve is provided to exhaust servo air pressure during ground testing. The function of this servo air pressure is explained in para. 18 and 19.

SYSTEM COMPONENTS

13. Nine major units are employed in the system. Eight of these are duplicated on the tank pressurisation control panels (fig.4) in the main wheel bay. They consist of:-

(1) Master control valve (M.C.V.) Type FLE/A/6.

(2) Air valve FLA/A/4.

(3) Vent valve (V.V.), Type FLB/A/12.

(4) Servo pressure - reducing valve, Type FLD/A/14.

(5) Filter restrictor unit, Type FLC/A/7.

(6) Air drier, Type X/FOD/A5.

(7) Solenoid depressurisation valve, Type ES/A/390.

(8) Fuel trap, Part No. 1/Z9214.

(9) Fuel trap, Part No. 1/Z9010.

Master control valve (M.C.V.)

14. The master control valve, as the name implies, is the initial controlling influence of the pressure in the fuel tanks, since it governs the opening and closing of the vent valves and the air inlet valve in order to maintain the tank pressure within the accepted limits under all conditions.

15. Referring to fig. 5 it will be seen that a spring-loaded diaphragm at one end of the M.C.V. is subject to tank pressure on one side and, via the No.2 tank static pipe, to atmosphere on the other. Variations of tank pressure cause movement of the diaphragm and the landed control spindle to which it is attached. The complete sequence of operation may be seen on fig.5 and succeeding diagrams.

16. It will be noted that the air and vent valve servo lines are each connected to the central bore of the M.C.V. at three different points and immediately opposite these are three exhaust ports communicating directly to atmosphere.

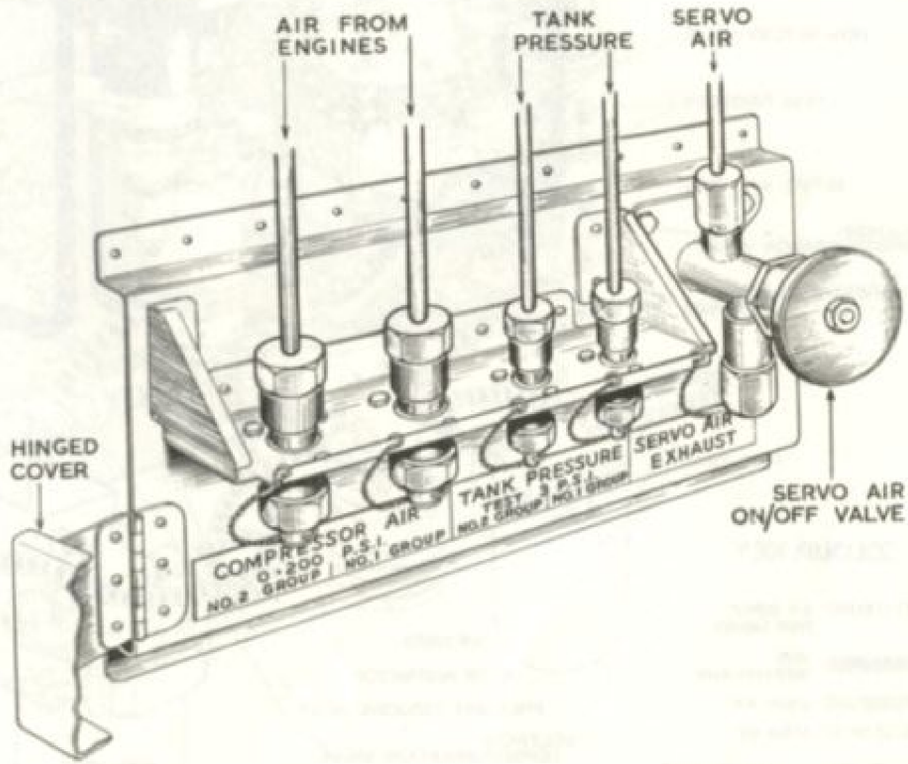


Fig.3. Ground test panel

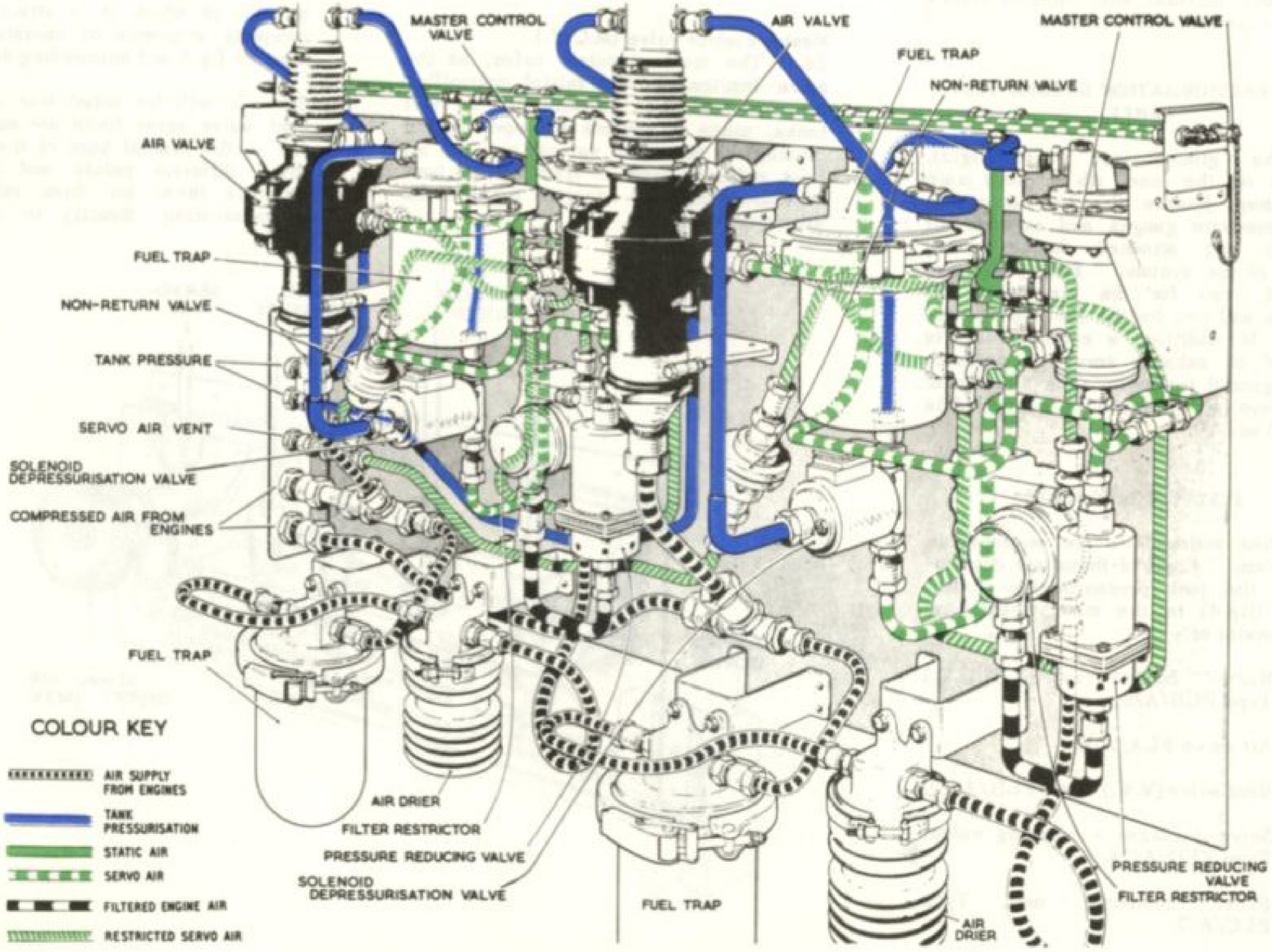


Fig. 4 Tank pressurisation control panel

Suitable positioning of the lands on the control spindle and the placing of the restrictions in the servo supply line inside the M.C.V., enable the latter to release or supply pressure for the various servo lines and thus control the operation of the air and vent valves in strict sequence. The nominal tank pressure setting of the valves, that is the figure at which the vent valve servo pressure begins to vent is 2·65 p.s.i. above ambient. It will be appreciated from the description of the valve that a certain travel of the control spindle is required between the point at which the air inlet is closed off and the vent valve is opened as tank pressure rises; in the case of the M.C.V. the air valve is open until pressure reaches 1·82 to 2·3 p.s.i., at which point it closes, and the vent valve is open for outward venting over the pressure range of 2·65 to 3 p.s.i. The M.C.V. opens the vent valves for inward venting at a tank pressure of 0 to -4·5 in. W.G.

Air valve (A.V.)

17. Reference to fig.5 will show that the air valve unit consists of two diaphragm-operated valves, an air valve in tandem with a controlling diaphragm and an inlet valve operated by a pivoted lever. (This inlet valve is only required when the aircraft is fitted with a nitrogen system).

18. The air valve is lightly spring-loaded to the close position and held shut by servo pressure on the diaphragm chamber. This pressure is tapped from the engine supply line and is fed through a restrictor in the filter/restrictor unit directly into the diaphragm chamber.

Vent valve (V.V.)

19. Two vent valves are connected to each group of tanks and are dependant upon servo pressure for their operation; the servo pressure supply is controlled by the master control valve in the system. Operation of the vent valve is governed by an internal bellows chamber upon which the rubber seated main valve is assembled. When the chamber is not pressurised by servo air, the main valve seat is spring-loaded to the open position. Application of the servo pressure to the interior of the chamber will close the valve against the compression of the internal spring. The minimum servo pressure required to hold the valve closed is at present 5 p.s.i.

20. Provision is made within the vent valves for emergency inward and outward venting, control of which is by a diaphragm operated valve assembly, housed in a small chamber at the outlet end of the vent valve. The diaphragm responds to tank pressure (via the tank pressurisation sensing lines) and operates the valve assembly to vent the main valve bellows to atmosphere. The emergency pressure settings are 2·75 to 3·25 p.s.i. (outward) and minus 4 in. W.G. at 23 deg.C. (inward).

21. When tank pressure exceeds the emergency high pressure setting figure, the diaphragm is moved inwards and, by means of the pressure pin and ball assembly, depresses the valve disc off its seating. This movement allows control air to escape from the main valve bellows, through the outer passages of the valve disc past the ball through to atmosphere, via the static connection. Contraction of the bellows, under the influence of the main spring, opens the vent valve and allows the tank system to vent to atmosphere.

22. Should the tank pressure fall below the emergency low pressure figure, the diaphragm is drawn outward away from the valve disc. This movement allows the ball to lift off its seating and open the centre orifice in the valve disc. Control air inside the bellows then escapes through the orifice and through the static connection to atmosphere. The bellows again contract, under the influence of the main spring, and the vent valve opens to admit air at atmospheric pressure to the tank system.

Filter/restrictor unit

23. This unit is included in the system to filter the supply of air from the engine, for subsequent use as servo air, and to provide a secondary supply of air from a restricted output tapping. It has one inlet and two outlets; one outlet goes to the servo air pressure-reducing valve, and the other in which a restrictor is interposed, goes to the operating diaphragm chamber of the A.V. and to the M.C.V.

Servo pressure-reducing valve

24. This valve reduces engine compressor output pressures, varying between 15 and 180 p.s.i., to provide a servo air supply of 9 to 12·5 p.s.i. An emergency relief valve, incorporated in the unit downstream of the reducing valve seat, relieves at 14·5 p.s.i. thus preventing the supply of excessive pressures to the servo system in the event of failure of the reducing valve.

Air drier

25. An air drier is interposed in the servo air bleed line to the system components and consists of a cylindrical fluted body housing a container. Inside the container there is 0·2 lb. of silica gel (Ref. No.33C/1454). The air drier removes moisture from the servo air applied to the system components and thus prevents malfunctioning.

Fuel traps

26. Two fuel traps are included in each group, one in the servo air feed line between the air drier and the main supply line connection, the other in the tank pressure sensing line upstream of the solenoid operated depressurisation valve.

The fuel traps are mounted on the control panel, one adjacent to the air drier, the other between the A.V. and the M.C.V.

Solenoid depressurisation valve

27. When the tank pressurisation switch is in the ON position the tank pressurisation line is connected through the solenoid depressurisation valve to the master control valve; fluctuation of the tank pressure will then automatically control the system through the master control valve. If the switch is in the OFF position, the tank pressurisation line is shut off and air at reduced pressure fed into the master control valve. This pressure, acting on the diaphragm, moves the landed spindle until the air port is closed and the vent valve ports opened; thus the air supply is cut off and the vent valves opened to depressurise the system.

CYCLE OF OPERATIONS

Static conditions

28. Under static conditions but with engines running, compressed air is applied directly to the air valve which at this stage is lightly spring-loaded to the closed position. The force of the compressor air is sufficient to open the valve and permit some flow into the tanks.

29. At the same time, air passes via a small diameter pipe line, through a fuel trap and an air drier, to the filter/restrictor unit and thence through a pressure-reducing valve (set at 9 - 12·5 p.s.i.) to the master control valve.

30. Initially the master control valve air valve port is open and the vent valve ports are closed due to the M.C.V. spring-loaded diaphragm.

31. Servo air from the filter/restrictor unit will pass through the reducing valve to the vent restrictor orifice (M.C.V.) and, being diverted by the closed port, will pressurise the vent valve bellows to close the main vent valve (V.V.).

Tank pressure rising (fig.5)

32. As tank pressure rises to 1·82 - 2·3 p.s.i. so the pressure on the M.C.V. diaphragm is increased and since there is a static air supply on the other side of the diaphragm, the differential pressure is sufficient to move the landed spindle attached to the diaphragm within the M.C.V. The movement of the spindle closes the servo air port and the diverted pressure is applied to the air valve diaphragm chamber, closing the air supply to the tanks. The vent valve remains closed.

Balanced tank pressure (fig.6)

33. Shortly after starting the engines a state of equilibrium is reached with the tank pressure balanced at 2·4 p.s.i. This is achieved by the sensing action of the M.C.V. When the tank pressure falls below 2·4 p.s.i. due to consumption of fuel or from any other cause, the M.C.V. spindle will be moved by the lowering of pressure on the M.C.V. diaphragm, opening the vent port (M.C.V.) and allowing servo air to exhaust from the air valve. This will allow the valve (A.V.) to open and pressure will be built up until the M.C.V. spindle regains its equilibrium position.

Climb conditions (fig.7)

34. As tank pressure rises due to climbing, so the pressure on the M.C.V. diaphragm is increased until the pre-setting of 3 p.s.i. differential is exceeded. At approximately 2·9 p.s.i. tank pressure the M.C.V. diaphragm will move its associated spindle far enough to open the vent port (M.C.V.) allowing servo air to escape. This collapses the bellows (V.V.), opening the vent valve and allowing excess pressure in the tanks to pass to atmosphere.

35. The sequence of operation is now straightforward in that only the vent valve and the master control valve are involved. The resultant fall in tank pressure will cause the M.C.V. diaphragm to return sufficiently to move the spindle and close the servo air vent to atmosphere when the vent valve will close.

36. Any further increase in tank pressure will again open the vent valve and the tanks will vent in a series of pulses if the climb is continued.

Inward venting conditions (fig.8)

37. When the aircraft descends, the tank pressure relative to ambient air pressure will obviously fall and a reversal of the climb sequence will occur, and at 1·7 to 2·0 p.s.i. the air valve will open.

38. Should the pressure continue to fall, which would occur during a dive, the differential pressure across the M.C.V. diaphragm will be increased, and at approximately 1 p.s.i. differential the M.C.V. spindle will move to the extreme inward venting position, eventually opening the servo air ports of the vent valve bellows and the air valve diaphragm to atmosphere.

39. Removal of the servo air supply from the vent valve bellows will allow the valve to be opened by its light spring-loading; similarly, the air valve diaphragm is deflated and air passes into the tanks.

40. When the differential pressure across the M.C.V. diaphragm has been sufficiently reduced, the M.C.V. spindle will regain its equilibrium position.

Failure of air supply

41. Should the air supply from an engine fail, the emergency valve of the vent valve will operate irrespective of the state of the

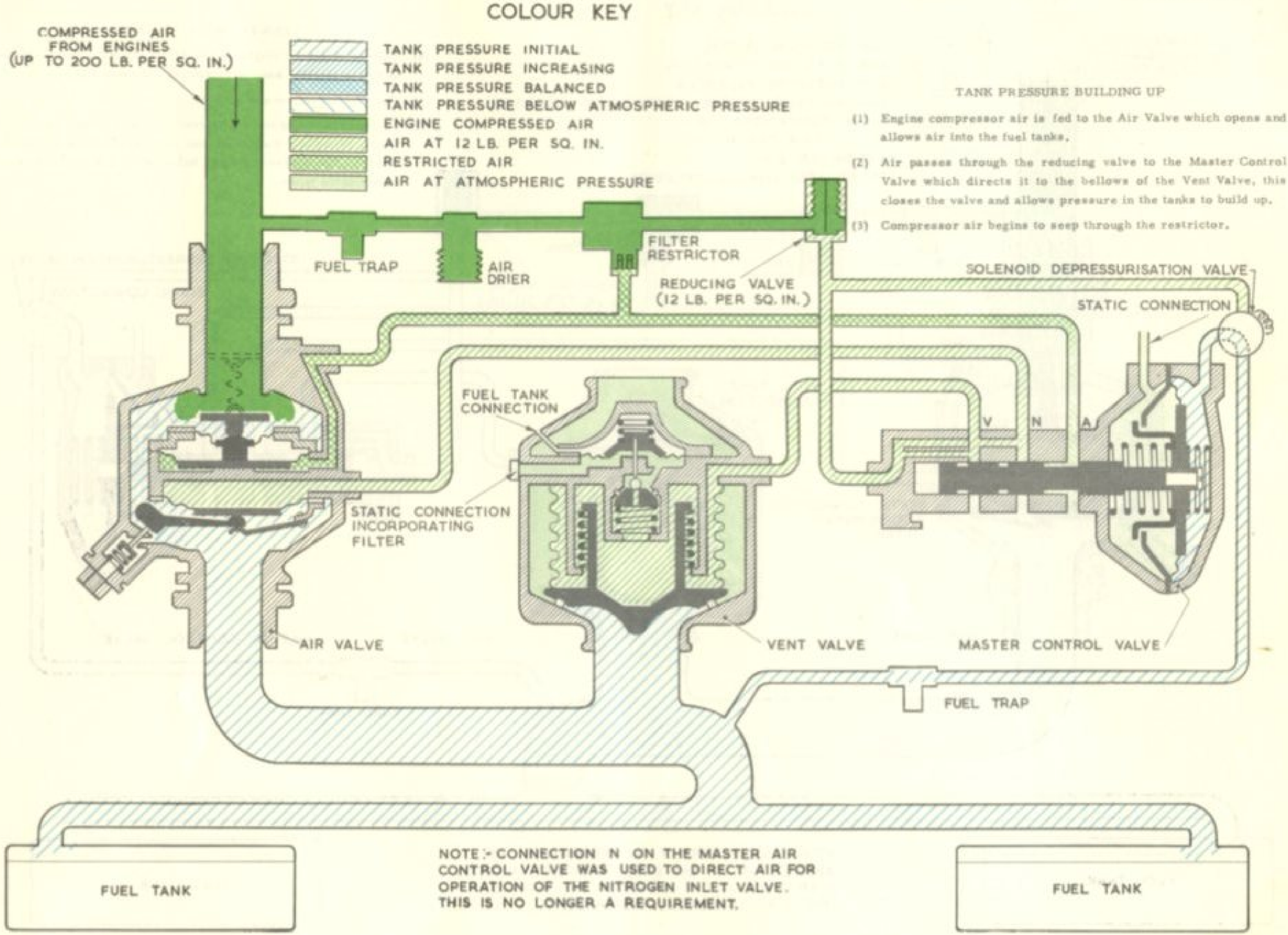


Fig. 5 Tank pressure building up

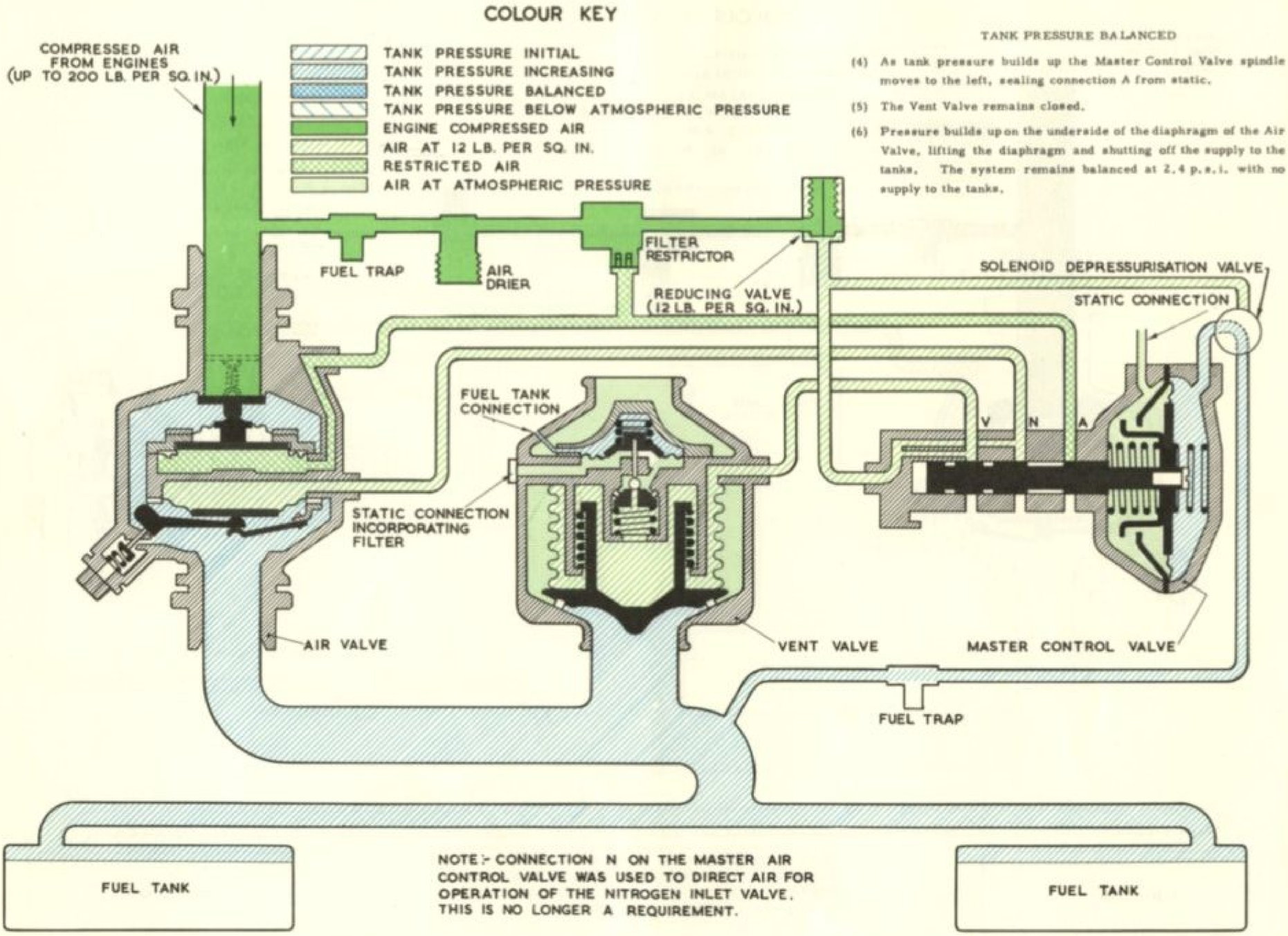
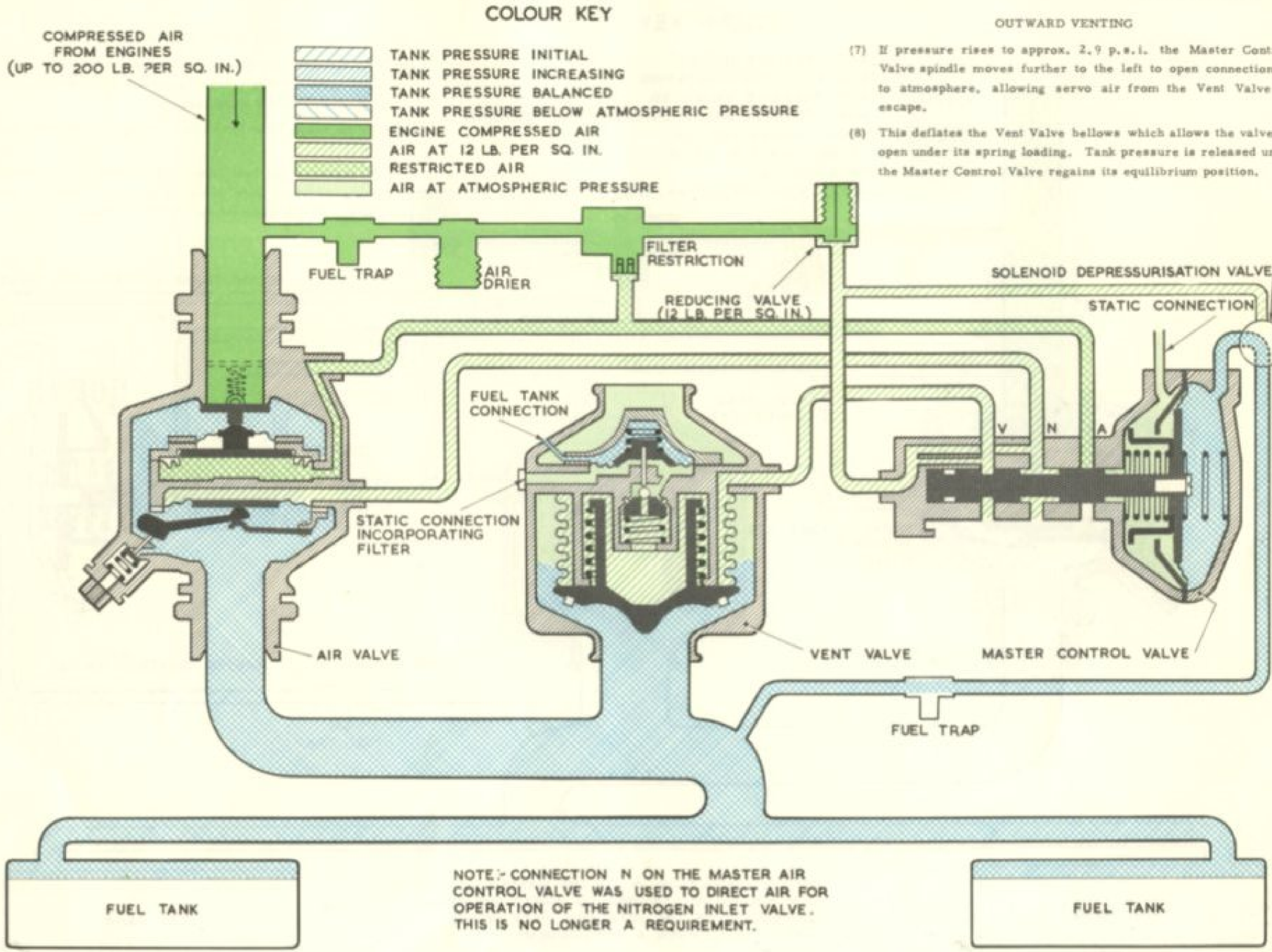


Fig. 6 Tank pressure balanced

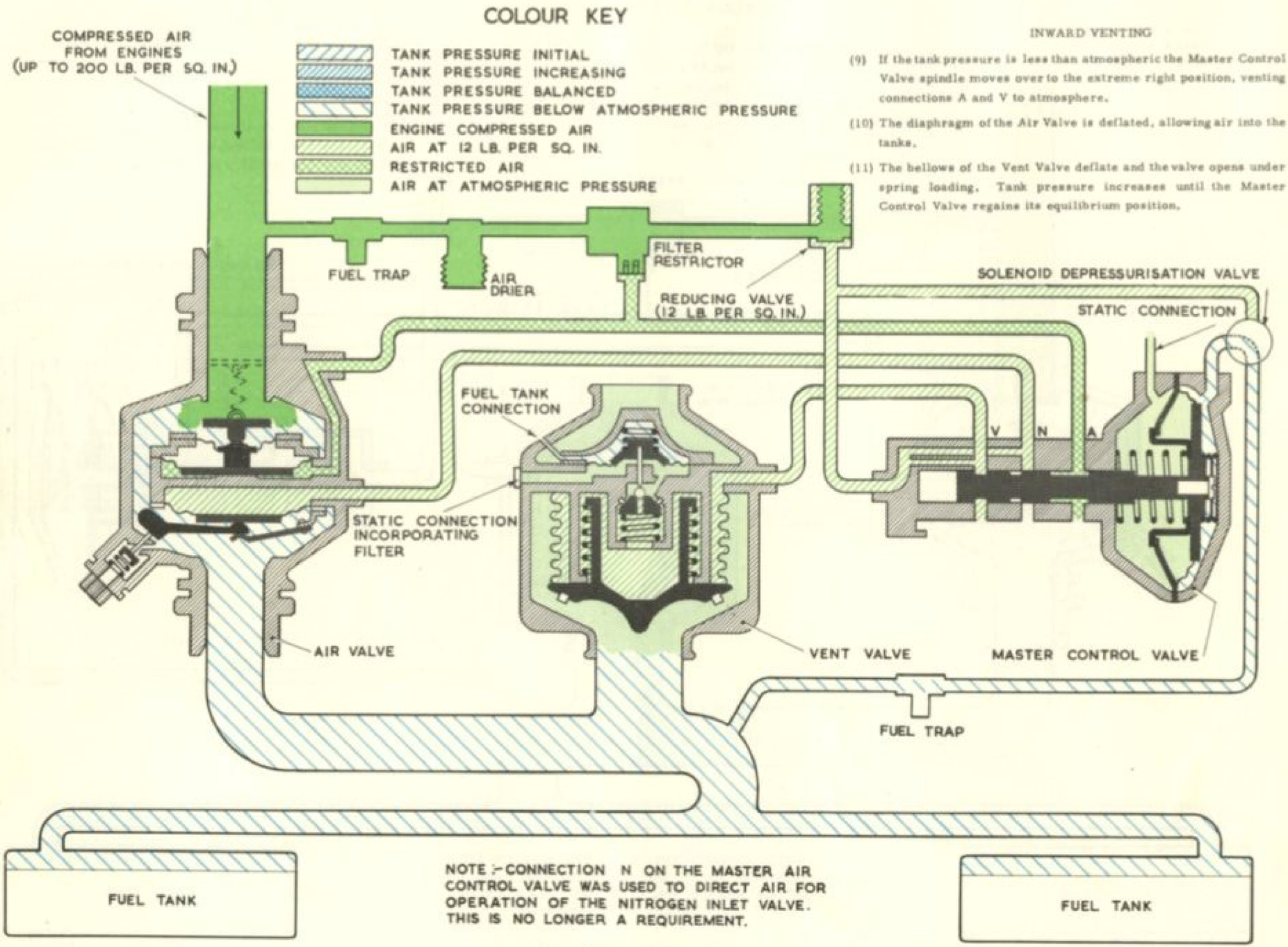


OUTWARD VENTING

(7) If pressure rises to approx. 2.9 p.s.i. the Master Control Valve spindle moves further to the left to open connection V to atmosphere, allowing servo air from the Vent Valve to escape.

(8) This deflates the Vent Valve bellows which allows the valve to open under its spring loading. Tank pressure is released until the Master Control Valve regains its equilibrium position.

Fig. 7 Outward venting



INWARD VENTING

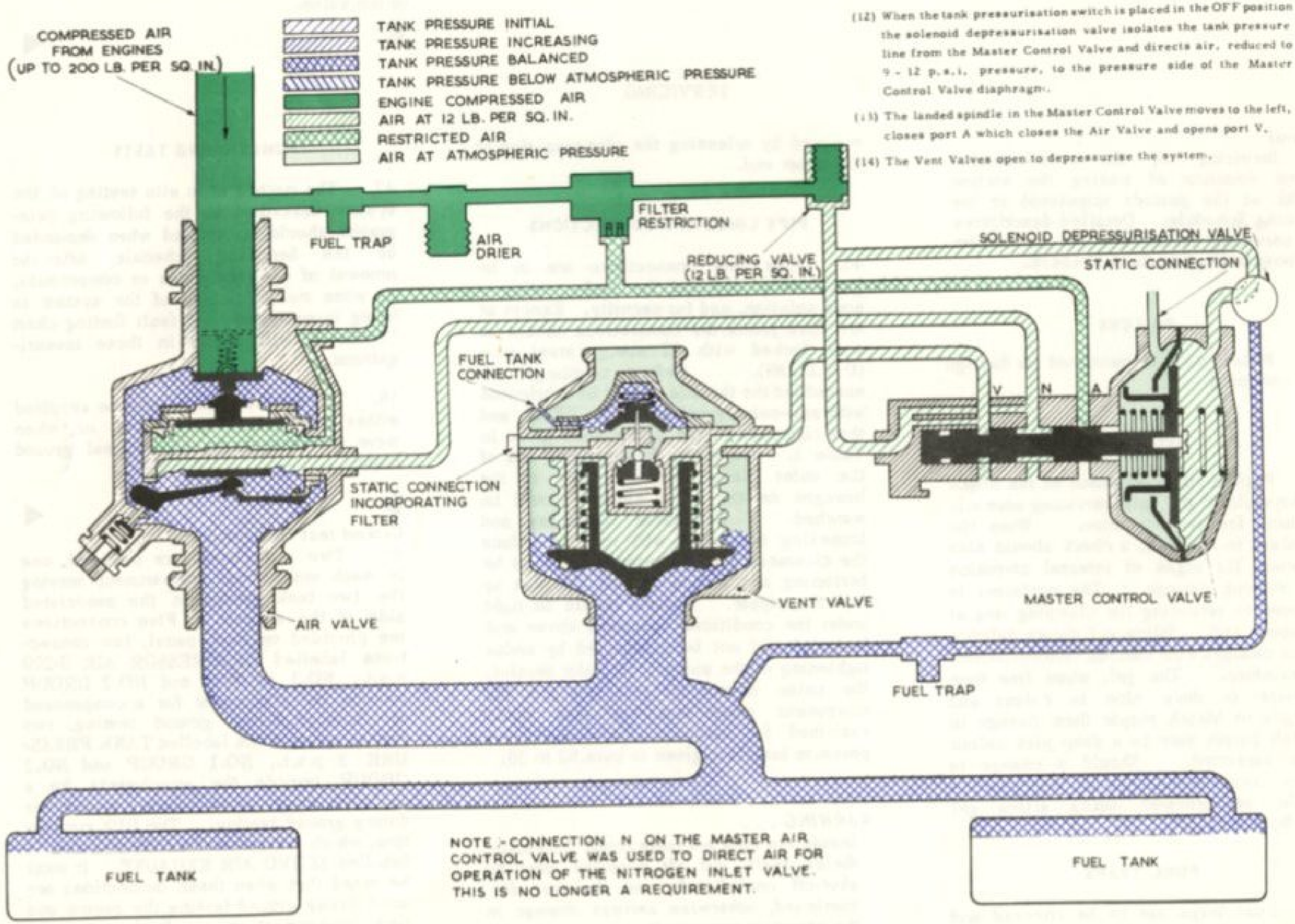
(9) If the tank pressure is less than atmospheric the Master Control Valve spindle moves over to the extreme right position, venting connections A and V to atmosphere.

(10) The diaphragm of the Air Valve is deflated, allowing air into the tanks.

(11) The bellows of the Vent Valve deflate and the valve opens under spring loading. Tank pressure increases until the Master Control Valve regains its equilibrium position.

NOTE :- CONNECTION N ON THE MASTER AIR CONTROL VALVE WAS USED TO DIRECT AIR FOR OPERATION OF THE NITROGEN INLET VALVE. THIS IS NO LONGER A REQUIREMENT.

Fig. 8 Inward venting



TANK DEPRESSURISATION

(12) When the tank pressurisation switch is placed in the OFF position the solenoid depressurisation valve isolates the tank pressure line from the Master Control Valve and directs air, reduced to 9 - 12 p.s.i. pressure, to the pressure side of the Master Control Valve diaphragm.

(13) The landed spindle in the Master Control Valve moves to the left, closes port A which closes the Air Valve and opens port V.

(14) The Vent Valves open to depressurise the system.

Fig. 9 Tank depressurisation

V.2.1A. 1992

remainder of the system, opening the vent valve when the tank pressure falls to a predetermined pressure below the ambient atmosphere. This preset pressure is minus 4 in. W.G. at 23 deg.C. The outward venting has been set to 2.75 to 3.25 p.s.i. Reference should be made to para.20 and subsequent paragraphs for an explanation of the emergency operation of the valve.

SERVICING

General

42. Servicing of the pressurisation system consists of making the routine checks at the periods stipulated in the Servicing Schedule. Detailed descriptive and servicing information on the system components is given in A.P.4343E.

FILTERS

43. Filters must be examined for damage and corrosion.

AIR DRIER

44. Periodical examination of the silica gel crystals is the only servicing normally required for the air drier. When the container is removed, a check should also be made for signs of internal corrosion and obvious damage. The container is removed by releasing the clamping ring at the upper end. Silica gel shows definite colour changes with various concentrations of moisture. The gel, when free from moisture is deep blue in colour and changes to bluish purple then through to reddish purple then to a deep pink colour when saturated. Should a change in colour have taken place, the crystals should be renewed using silica gel (Ref.No.33C/1454).

FUEL TRAPS

45. Fuel traps are to be checked and drained periodically. The container is removed by releasing the clamping ring at the upper end.

PIPE LINES AND CONNECTIONS

46. Pipe line connections are to be periodically checked for leaks, using a soap solution, and for security. Except at the hose joints, the connections should be wire locked with 22 s.w.g. steel wire (D.T.D.189). Before couplings are assembled the threads should be lubricated with anti-seize graphite grease ZX-13, and then tightened to the instructions given in Table 1. Clearance between the end of the outer sleeve and the face of the hexagon on the inner sleeve should be watched. Excessive tightening and loosening of unions will tend to reduce the clearance and the outer sleeve may be bottoming and failing to pull the pipe up into the nipple. Unions should be tight under the conditions specified above and leaks should not be eliminated by undue tightening of the union. If leaks persist, the union should be released and the component parts and the pipe flares examined for faults. Details of pipe pressure tests are given in para.52 to 55.

WARNING . . .

Should the tank pressure reach 3-35 p.s.i. during tests, all air supplied must be shut-off immediately and the test discontinued, otherwise serious damage to the structure may result.

FUNCTIONING TESTS

47. The method of in situ testing of the system described in the following paragraphs should be applied when demanded by the Servicing Schedule, after the renewal of damaged pipes or components, or when malfunctioning of the system is being investigated. A fault finding chart (Table 2) will assist in these investigations.

48. Air for the system, may be supplied either by running an engine or, when more convenient, by an external ground supply.

Ground test connections

49. Two test panels are provided, one in each main-wheel compartment serving the two tank groups in the associated side of the aircraft. Five connections are provided on each panel, two connections labelled COMPRESSOR AIR 0-200 p.s.i., NO.1 GROUP and NO.2 GROUP provide the attachment for a compressed air supply during ground testing, two further connections labelled TANK PRESSURE 3 p.s.i., NO.1 GROUP and NO.2 GROUP provide the attachments for a pressure gauge or a mercury manometer during ground testing. The fifth connection, which incorporates an on/off valve is labelled SERVO AIR EXHAUST. It must be noted that when these connections are used during ground testing the engine and tank pressurisation air feed pipes and their associated non-return valves are not

included in the tests and will have to be checked during a subsequent engine run.

Functioning test with engines running

50. One or more groups may be tested at any one time by running the appropriate engines. The procedure is as follows:-

(1) Attach a gauge (Ref.No. 26DC/95096) to the appropriate TANK PRESSURE connection on the test panel in the main-wheel bay. Remove the blank from the SERVO AIR EXHAUST on/off cock also located on the test panel.

(2) Run the appropriate engine or engines and select the fuel tanks pressurisation switch to ON.

(3) Raise the engine r.p.m. to 80 per cent to initiate tank pressurisation. Once pressure has been built up it can be sustained by running the engines at 45 per cent r.p.m. Check that the tank pressure, as indicated on the gauge fitted in op.(1), builds up to a maximum of 1·82 to 2·3 p.s.i. A slow hunt will occur as fuel is used.

(4) Switch the fuel tank pressurisation OFF and check that the tank pressure exhausts and falls to atmospheric.

(5) Switch the tank pressurisation ON and when tank pressure has built up, open up the appropriate engine to take-off r.p.m. for 20-30 seconds, tank pressure should not be effected.

(6) Drop the engine speed to 45 per cent r.p.m. and check that tank pressure is maintained. Failure to hold tank pressure at 45 per cent r.p.m. indicates restriction in the engine air feed pipe or associated non-return valves.

(7) Switch the pressurisation OFF, increase engine speed to 80 per cent r.p.m. then repressurise. When pressure has built up, reduce engine speed to 60 per cent r.p.m. Open the SERVO AIR EXHAUST on/off valve on the ground test panel just sufficient to cause a slow build up of tank pressure.

NOTE...

The servo air exhaust cock must not be open further than that required to cause a slow build-up of pressure. Full opening of the on/off valve may cause a false low reading or entire loss of servo air and tank pressure.

(8) Check that tank pressure rises and that outward venting occurs at between 2·65 and 3·0 p.s.i. Venting will continue in a series of slow hunts.

(9) After repeating the tests three times, shut down the engine, remove the gauge fitted in op.(1), close the SERVO AIR EXHAUST on/off valve, and fit the blanks to the test connections.

Functioning test using ground test connections

51. As the air flow requirements of the ground test equipment are dependant on the quantity of fuel present in the tanks whilst the tests are in progress, the tanks should be at least 80% full to keep the amount of air required to a reasonable limit. If storage bottles are used for the air supply, at least 200 lb. of air must be stored, this is equivalent to about 60,000 litres of air at normal temperature and pressure. Note that the standard charging cylinder Mk.7A (Ref.No. 71A/29) has a capacity of 15,850 litres when charged to 3,600 lb. per sq.in. Air flows of up to 30 lb. per min. will be required for short

TABLE 1 - TIGHTENING PIPE UNIONS

Outside diameter of pipe (in.)	Approximate number of turns after finger tightening		Approximate clearance between end of outer sleeve and face of hexagon on inner sleeve (in.)
	New Joint	Remade Joint	
3/16	2/3	1/3	1/16 -1/8
1/4	1/4	1/6	1/8
5/16	1/4	1/6	1/8
3/8	1/4	1/6	1/8
7/16	1/4	1/6	1/8
1/2	1/4	1/6	1/8
5/8	1/3	1/6	1/4
3/4	1/3	1/6	1/4
7/8	1/3	1/6	1/4
1	1/3	1/6	3/8
1.1/4	1/3	1/6	3/8
1.1/2	1/3	1/4	3/8

periods, this flow decreasing considerably as the tanks become pressurised. An external power supply should be plugged in to the aircraft to deliver 28 volts for operation of the solenoid de-pressurisation valve.

Component checks

52. To check the operation of the air valve, vent valves and master control valves proceed as follows:-

(1) Remove the blank fitted to the COMPRESSOR AIR test point of the group to be tested, located on the ground test panel situated in the main wheel bay. Connect a source of clean, dry air, incorporating a pressure gauge, reading 0 - 300 p.s.i. and an ON-OFF control cock, and capable of delivering air at a rate of 30 lb. per min. at 20 to 200 p.s.i. for short periods.

(2) Remove the blank from the TANK PRESSURE TEST connection on the ground test panel and attach a 0-4 p.s.i. pressure gauge (Ref.No. 26DC/95096) or a mercury manometer calibrated in p.s.i.

(3) Ensure that the servo air exhaust cock on the ground test panel is closed.

(4) Place the fuel tanks pressurisation switch on the starboard console in the ON position, and turn on the control cock of the external air supply.

(5) Check that air pressure builds up and then remains steady 1·82 to 2 3 p.s.i. This shows that servo air from the M.C.V. has closed the vent valves, allowing pressure to be built up, and that the M.C.V. has directed servo pressure from the reducing valve to the diaphragm of the A.V. This closes the A.V. when the maximum required pressure is reached, so keeping the system pressure stable. A very slow hunt in tank pressure is permissible but if the rate exceeds once in 30 seconds an excessive air leak from the tanks or piping is indicated and it is important that any such leaks are found and rectified.

(6) Switch the tank pressurisation OFF and check that the vent valves allow all pressure to escape.

(7) Switch the tank pressurisation ON, the tank should pressurise. Check that the tank pressure is 1·82 to 2·3 p.s.i. as before.

(8) After the test has been repeated three times, remove the external air supply and the gauges fitted in (1) and (2) and fit blanks as required.

Outward venting check

53. To check the outward venting of the system proceed as follows:-

(1) Use an external air supply and gauges connected as in para.59 op.(1) and (2).

(2) Switch the tank pressurisation ON. Turn on the control cock of the external air supply.

(3) When pressure has stabilised at 1·82 to 2·3 p.s.i. open the servo exhaust cock just sufficient to cause a slow build up of pressure in the tanks (see Note para.57 (7) (8). Air will be introduced into the tanks and, when pressure reaches 2·65 - 3·0 p.s.i., the vent valves will open and outward venting will occur. Venting will continue until the tank pressure has dropped to approximately 2·5 p.s.i. when the vent valve will close allowing pressure to build up again. Outward venting will continue in a series of slow hunts as long as extra air is introduced to the tanks.

NOTE...

Tank pressure should be carefully watched during this test and if it rises to 3·35 p.s.i. the tanks should be de-pressurised immediately by selecting the tank pressurisation switch OFF and by turning off the external air supply.

(4) Close the servo air exhaust cock and switch the tank pressurisation OFF. The tanks should de-pressurise.

(5) After the test has been carried out three times, close the control cock of the external air supply and disconnect the air supply and gauges fitted in (1). Fit blanks to panel test points.

It should be noted that in these tests it will not be known whether (a) the vent valves are opening under the control of the M.C.V. or (b) the emergency valves within the vent valves are opening, since the operating limits overlap. It is assumed that the complete panels and vent valves will have been pre-tested (App.1, of this chapter) thus clearing the individual operation of these functions. If, however, this has not been done, individual operation of these valves may be checked as detailed in para.54 and 55.

54. To check (a) the tank pressure sensing pipes to the vent valves should be blanked off. With the servo air exhaust cock slightly open the tank pressure should build up to 2·65 to 3 p.s.i. At this figure the M.C.V should open the vent valves and allow pressure to drop to approximately 2·5 p.s.i. Tank pressure

will then rise again and outward venting will continue in a series of slow hunts between these pressure settings. Reconnect the sensing pipes and test for air leaks at the completion of checks.

55. To check (b) disconnect the pipe between the M.C.V. and the vent valves and apply an external air supply of about 15 p.s.i. to the vent valves to keep them closed. This prevents the M.C.V. from opening the vent valves as pressure is built up. With the servo air exhaust cock slightly open the pressure in the tanks should build up to 2·75 to 3·25 p.s.i. and at this pressure the emergency valve in the vent valves should open and prevent further rise. Reconnect the pipe from the M.C.V. to the vent valves and check for air leaks at the completion of the test.

Inward venting check

56. It is very difficult to test satisfactorily the operation of the system on the ground for inward venting, as this condition arises only during a rapid aircraft descent. A test to check the inward venting depression can however, be made by creating the required conditions in the tanks of any one group; i.e., by defuelling, with the pressurisation air supply shut off. The test is carried out in the following manner:-

WARNING...
During refuelling, defuelling and draining operations, the fire precautions detailed in A.P.4177, Vol.1, Sect.1, Chap.2 are to be strictly observed.

(1) Connect a ground electrical supply to the aircraft.

(2) Ensure that fuel tanks are at least 80 per cent full.

(3) Remove the blank from the COMPRESSOR AIR test point of the group to be tested and connect an air supply, as in para.52(1).

(4) Remove the blank from the TANK PRESSURE TEST connection of the group to be tested and connect a water manometer.

(5) Disconnect the union to the connection marked 'AIR' on the M.C.V. and blank off the end of the pipe. On a port side control panel this connection is inaccessible and it will be found more convenient to disconnect and blank off the pipe at the four-way union.

NOTE...
The blanking of this pipe has the effect of maintaining a pressure in the air valve bellows of the air/gas valve and prevents air flowing through the valve to the tanks. Servo air supply is maintained to the vent valve bellows so that the valves will operate in the normal manner.

(6) Ensure that the servo air exhaust cock on the ground test panel is closed.

(7) Place the fuel tanks pressurisation switch (starboard console) to the 'ON' position and turn 'ON' the control cock of the external air supply. Tank pressure should remain at atmospheric.

(8) Connect a receiving bowser to the normal defuelling point (See Sect. 4, Chap.2), and begin to defuel by switching 'ON' the booster pumps of the appropriate group.

(9) As fuel is removed, a negative pressure will be created in the tanks and, before this pressure reaches -4 in. water gauge, inward venting should occur. If defuelling is continued, inward venting will be repeated.

NOTE...
Tank pressure must be carefully watched during this test and if it reaches -5 in. water gauge, defuelling must be stopped immediately and the tank pressurisation system switched OFF.

(10) Three inward vent checks should be made.

(11) At the completion of inward venting tests, remove the blanks and connect the pipes to the M.C.V. and/or four-way union.

(12) Remove the water manometer fitted at (2) and fit a mercury manometer or a 0-4 p.s.i. pressure gauge in its place ready for the next check.

(13) Ensure defuelling cocks are closed and secure, then disconnect and remove the defuelling bowser. The tanks should now be refuelled to at least 80 per cent full to facilitate any further tests.

NOTE...
If the control panel has not been checked (App.1) prior to installation in the aircraft, it will not be known whether inward venting is occurring under control of the M.C.V. or the emergency valve in the V.V.

57. Tests are now required at full 200 p.s.i. air pressure to ensure correct normal functioning and to prove the pipe connections which have been re-made. Repeat the test detailed in para.52.

PIPE PRESSURE TESTS

General

58. At periods laid down in the Servicing Schedule or when a pipe has been refitted or renewed, the following tests must be carried out on the part of the system affected. Each tank group must be tested separately. The engine feed piping from the engine compressor to the non-return valve, must be tested with the recuperator system. It must be noted that these tests do not include the pipes from the solenoid depressurisation valve to the master control valve and to the reducing valve, since these are short length pipes, joined by a T-piece on the control panel.

Low pressure

59. To test the air supply pipes from the A.V. to the tanks and vent valves, and the static pipes proceed as follows:-

(1) Disconnect the vent pipe connections at each fuel tank of the group to be tested and blank off the pipes.

(2) Disconnect the tank pressure sensing connection from the solenoid depressurisation valve to the M.C.V. at the M.C.V.

(3) Disconnect the static pipe from the M.C.V. and connect it to the pipe disconnected in op.(2).

(4) Disconnect the tank pressure sensing pipes at the vent valves and blank off the pipe ends.

(5) Disconnect the main vent pipes from tanks to vent valves at the valves and blank off the pipe ends.

(6) Disconnect the A.A.P.P. fuel vent pipe from the tank and blank off the pipe.

(7) Blank off the end of the static pipe in the tank bay.

(8) Disconnect at the T-piece, just upstream of the fuel trap in the main air supply pipe, the pipe leading to the A.V. and blank off the end of the pipe.

(9) Fit a 0-10 p.s.i. pressure gauge to the TANK PRESSURE test connection on the test panel in the main-wheel bay.

(10) Plug an external power supply into the aircraft to deliver 28-volts for operation of the solenoid depressurisation valves.

(11) Switch the tank pressurisation switch to ON (starboard console).

(12) Connect and apply a pressure of 5 p.s.i. to the COMPRESSOR AIR connection on the test panel. There must be no loss of pressure over a period of 30 minutes.

(13) Remove all pipe end blanks and connect all pipes disconnected in op.(1) to (8) inclusive.

(14) Remove the pressure gauge and external air supply and fit the blanks to the test panel connections. Select the tank pressurisation switch to OFF and disconnect the external electrical supply.

High pressure

60. To test the engine air supply pipes and the servo pipes to the servo air on/off valve, the A.V., and the M.C.V., proceed as follows:-

NOTE...

Ensure that the pipe disconnected in para.59 op.(8) has been connected, otherwise this portion of the system will not be tested at its correct pressure.

(1) Disconnect and blank off, at the M.C.V. end, the servo pipe running from the filter restrictor to the M.C.V.

(2) Disconnect the main engine supply pipe at the inlet to the A.V. and blank off the end of the pipe.

(3) Disconnect the servo pipe from the filter restrictor to the A.V., at the A.V., blank off the pipe.

(4) Disconnect the main servo pipe at the inlet to the pressure-reducing valve, blank off the pipe.

(5) Ensure that the servo air on/off valve on the ground test panel is closed.

(6) Connect an air supply to the COMPRESSOR AIR connection on the test panel and apply a pressure of 200 p.s.i. There must be no loss of pressure over a period of 30 minutes.

(7) Connect the pipes disconnected in op.(1) to (4) inclusive. Disconnect the air supply and fit the blank to the test panel connection.

61. To test the servo piping from the M.C.V. to the vent valves.

(1) Disconnect the servo pipe at the inlet to the vent valves and blank off the pipe.

(2) Disconnect the servo piping from the M.C.V. to the vent valves at the M.C.V. end. Connect an air supply, incorporating a pressure gauge, to the pipe and apply a pressure of 12 p.s.i. There must be no loss of pressure over a period of 30 minutes.

(3) Disconnect the air supply and connect the pipes to the vent valves and the M.C.V.

FAULT FINDING

62. The only indication of a fault occuring in the system during flight is the sound of outward venting in level flight or in a shallow dive. When a fault is being traced on the ground, the air driers and fuel traps must first be checked for any moisture or fuel. If moisture is present, the dessicant in the air driers will have changed from blue to pink, or if large quantities of fuel are found in the fuel traps, the components of the system may have been affected. In either case ground tests must be carried out, although the faults enumerated in the table apply only when the air driers are satisfactory. To avoid prolonged running of the engines, an external air supply with a 0-3,000 p.s.i. pressure gauge must be connected to the COMPRESSOR AIR test point of the group to be checked, on the test panel in the main-wheel bay, and a 0-4 p.s.i. pressure gauge connected to the TANK PRESSURE TEST connection. Temporary blanking of the vent outlets may be required, should the external supply be of low capacity. When the outlets are blanked off, on a correctly functioning system, servo pressure will build up and the vent valves will remain closed after the blanks are removed. The following table gives a list of the most likely faults to be encountered together with their symptoms and remedies, and the methods of detection must be carried out in the order given. Listed below are faults which are highly improbable and not covered in the table.

(1) Failed vent valve bellows.

(2) Seized pressure-reducing valve.

(3) High control pressure from the pressure-reducing valve.

(4) Blocked filter restrictor.

(5) Blocked static pipes.

TABLE 2 - FAULT FINDING CHART

SYMPTOMS	FAULT & METHODS OF DETECTION	REMEDY
1. Tanks do not pressurise and no pressure is recorded on a gauge attached to the COMPRESSOR AIR point of the test panel.	Flow from engine compressor blocked due to:-	
	(a) Faulty non-return valve in undercarriage bay or engine bay.	(a) Renew N.R.V.
	(b) Blockage in pipe from engine compressor to control panel.	(b) Locate and rectify.
2. In flight, outward venting is audible except when the aircraft is in a steep dive. On ground test the tanks vent continually with TANK PRESSURE gauge reading 2·65 -3 p.s.i. When pressurisation is switched OFF air continues to issue from vents and the gauge at the COMPRESSOR AIR point reads lower than maximum supply pressure.	Air valve (A.V.) not closing due to:-	
	(a) Air leak from the pipe which runs from the M.C.V. to the bellows of the A.V.	(a) Locate leak and rectify.
	(b) Faulty non-return valve in the servo line in the group adjacent to that being tested. (Only applicable when the adjacent group is inoperative and denoted by a leak from the exhaust of the M.C.V. of the inoperative group).	(b) Renew the N.R.V. in the adjacent group.
	(c) Leaking A.V. bellows. Denoted by an air leak from the static hole in the centre of the A.V. body.	(c) Renew A.V.
	(d) Faulty valve seat (A.V.) confirmed by disconnecting a pipe on the outlet side of the A.V. and testing for excessive leak when pressurisation is switched OFF.	(d) Renew A.V.
3. Tanks do not pressurise due to vent valve failing to close. Air issues from vent valve outlet when pressurisation is switched ON.	(a) Emergency inward venting ball valve, in the vent valve, unseated. (Denoted by excessive leak at static connection).	(a) Renew the affected vent valve.
	(b) Emergency outward venting valve in the vent valve, unseated. (Denoted by excessive leak at static connection).	(b) Renew the affected vent valve.

FAULT FINDING CHART - continued

SYMPTOMS	FAULT & METHODS OF DETECTION	REMEDY
	(c) Leak in piping from the pressure reducing valve on the control panel to the control connection on the vent valve. Disconnect the piping to the control connection of the vent valve and fig a 0-20 p.s.i. pressure gauge to the end of the pipe. The reading should not be less than 9 p.s.i.	(c) Locate leak and rectify.
	(d) M.C.V. remains in "inward venting" position due to sticking of the spindle at the end of its travel (Denoted by excessive air leaking through the exhaust of the M.C.V. and may be confirmed by applying suction at the disconnected static connection of the M.C.V., the system should then pressurise).	(d) Renew M.C.V.
4. In flight, outward venting is audible except when the aircraft is in a steep dive. On ground test the tanks vent continually with TANK PRESSURE TEST gauge reading 2·65-3 p.s.i. in a series of pulses. When pressurisation is switched OFF the system depressurises satisfactorily.	(a) M.C.V. remaining in the "A.V. open" position due to its spindle sticking or a leak in the tank sensing line, in which the solenoid depressurisation valve is situated.	(a) Check for leaks in the tank sensing line to the M.C.V. If none is found, renew the M.C.V.
	(b) Punctured diaphragm in M.C.V. (Detected by disconnecting the static pipe line to the M.C.V. and checking for air leaks from the connection, when the system is switched off).	(b) Renew M.C.V.
5. Tanks pressurise but excessive hunting is indicated on the gauges fitted to the COMPRESSOR AIR and TANK PRESSURE TEST points on the test panel. Air does not issue from the outlets of the vent valves.	Leak from tank, vent pipe, engine supply pipe or tank sensing line.	Locate and rectify.
6. Tanks will not depressurise.	Solenoid not operating.	Check electrical circuit and renew solenoid if necessary.

V.2.1A. 2000

Appendix

TEST RIG - FUEL TANK PRESSURISATION

LIST OF CONTENTS

	Para.
DESCRIPTION	
Introduction	1
Construction	4
Test rig control panel	7
Air system	9
Vacuum system	14
Electrical power supplies	15
Installation	
General	17
Temperature control	18
Manometer filling	20
Operation	
General	21
Fitting aircraft control panel	23
Fitting vent valves	24
SERVICING	
General	26
Manometers	27
Vacuum pump	28
Electric motor	29
TESTS	
Pre-test requirements	30
Test procedure	34
Initial pressurisation (level flight)	35
Normal outward venting (climbing)	36
Emergency outward venting	37
Normal inward venting	38
Emergency inward venting	39

LIST OF TABLES

	Table
Schedule of parts	1

LIST OF ILLUSTRATIONS

	Fig.
General view (showing connections)	1A
Front view of test rig	2A
Rear view of test rig	3A
Test rig control panel	4A
External connections and pressure gauge recess	5A
Arrangement of pressure reducing and relief valves	6A
Electrical circuit	7A

LEADING PARTICULARS

Type	Avro Part No.U.1383
Ref. No.	26DC/95218
Electrical supply	230-250 volt, 50 c/s, single phase

DIMENSIONS

Length	4ft. 6in.
Width	3ft. 7in.
Height	6ft. 0in.
Weight	6 cwt.

V.2.1A. 2001

DESCRIPTION

Introduction

1. The Fuel Tank Pressurisation Test Rig (Ref.No.26DC/95218) has been designed to facilitate ground servicing of the fuel tank pressurisation system which is described in the chapter.

2. The test rig enables the fuel pressurisation control panel and associated vent valves to be tested for correct functioning after removal from the aircraft and bay servicing. The following control functions may be found for each tank group.

(1) Initial pressurisation (level flight conditions)

(2) Normal outward venting (climbing conditions)

(3) Emergency outward venting

(4) Normal inward venting (diving conditions)

(5) Emergency inward venting

3. The following paragraphs contain a detailed description of the test rig, give the recommended installation, operating and servicing procedures together with the tests to be carried out on the fuel tank pressurisation control panels.

CONSTRUCTION (Fig. 1A and 2A)

4. The test rig is intended as a static rig to be installed in a servicing bay. It has a welded angle-iron framework covered with panels of mild steel sheet secured by rivets and self-tapping screws. The panels completely cover the framework with the exception of the back, which is left open to give access to components.

5. The front panel is of stepped construction to facilitate pipe connections to

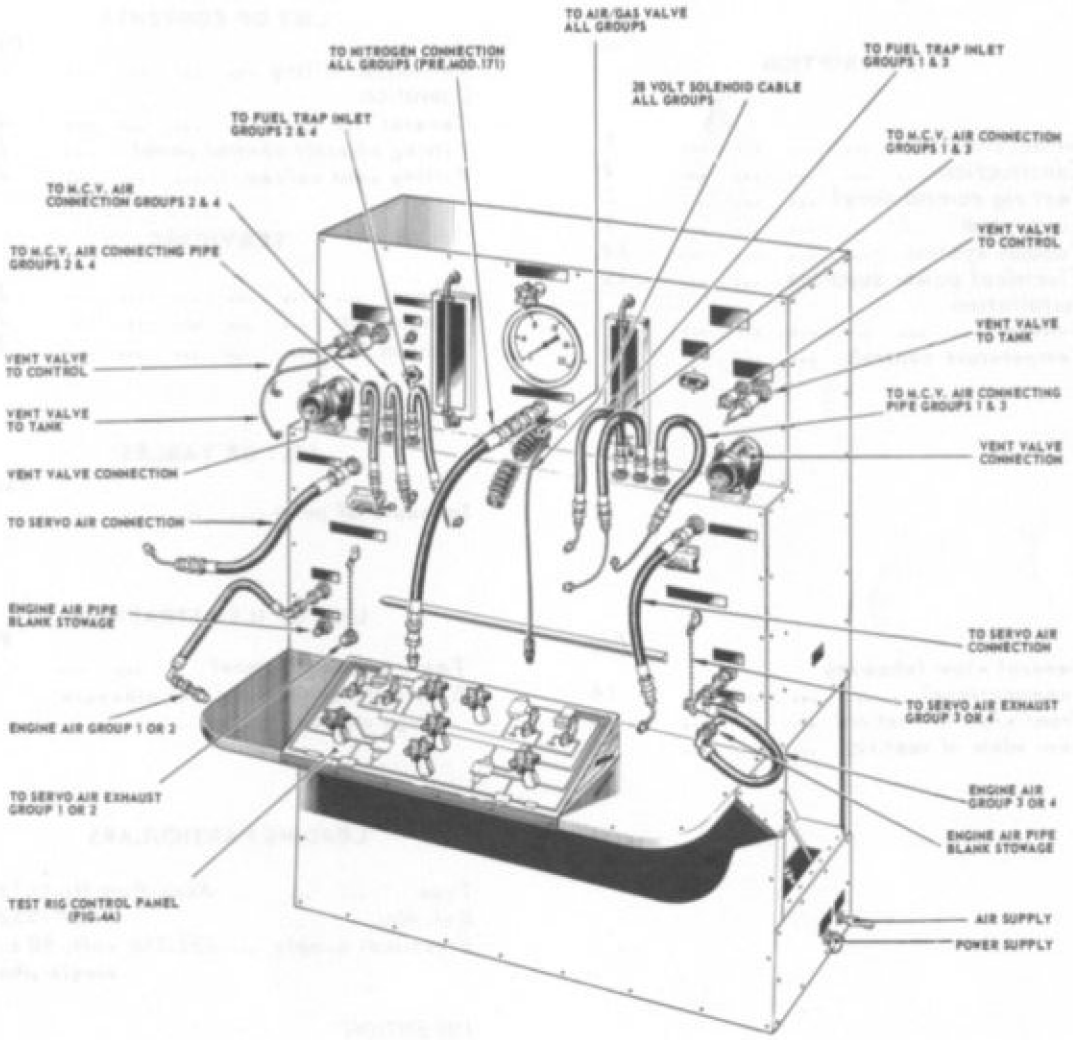


Fig. 1A General view (showing connections)

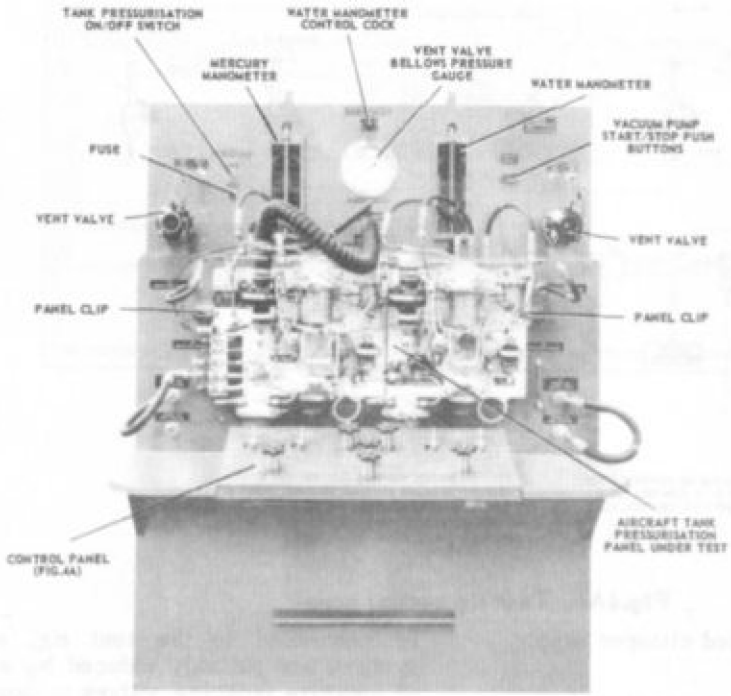


Fig.2A. Front view of test rig

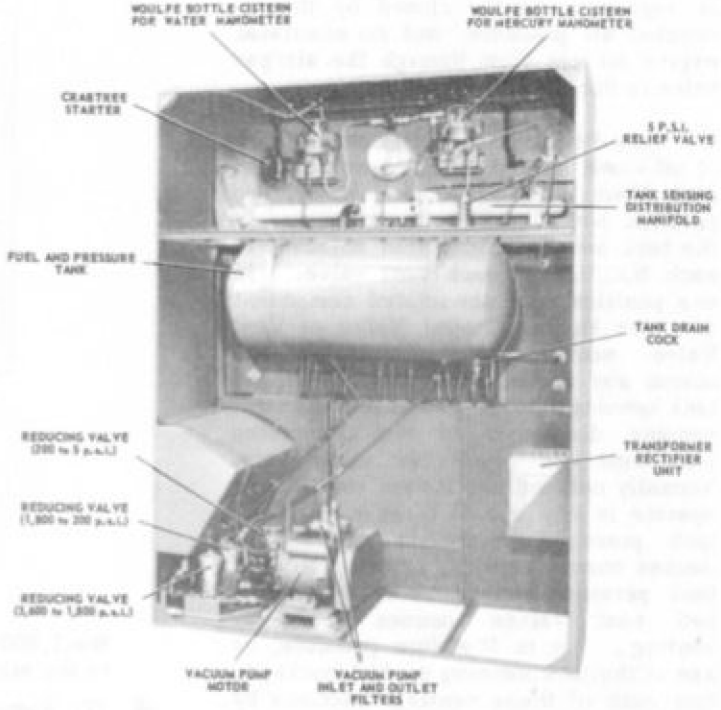


Fig.3A. Rear view of test rig

the aircraft pressurisation panel, and a shelf is fitted at normal desk height to accommodate an inclined rig control panel. Provision is made for mounting the aircraft panel under test, immediately above the control panel and in the centre of the front panel. Appropriate connections are arranged around this central position so that they can be readily coupled to either a port or starboard pressurisation panel.

6. The upper front panel accommodates pipe connections and mountings for two tank vent valves. These are mounted on the extreme right and left of the panel respectively with spring clips on the step to support them. Also mounted on this panel are electrical components (para.15); a mercury manometer for reading normal tank pressures; a water manometer and control cock for indicating negative tank pressures, and an air gauge for the vent valve bellows pressure.

TEST RIG CONTROL PANEL (Fig.4A)

7. The test rig control panel is fabricated from a light alloy sheet suitably stiffened and secured in an inclined position at desk height. The panel has a dark grey anodic finish engraved with a line diagram of the tank pressurisation system. Hand operated control valves are mounted in their correct relative positions on the panel and all components are identified in white engraved lettering.

8. The following valves are fitted on the control panel:-

(1) Air Valve Control Cock (2 off - one for each Master Control Valve). Each valve is interposed in the line between the air connection of the M.C.V. and the four way union, and when closed, prevents restricted air from bleeding away

regardless of the position of the M.C.V. piston. When this valve is closed therefore, the air valve of the air/gas valve is kept permanently closed by the restricted air pressure and no simulated engine air can flow through the air/gas valve to the tank.

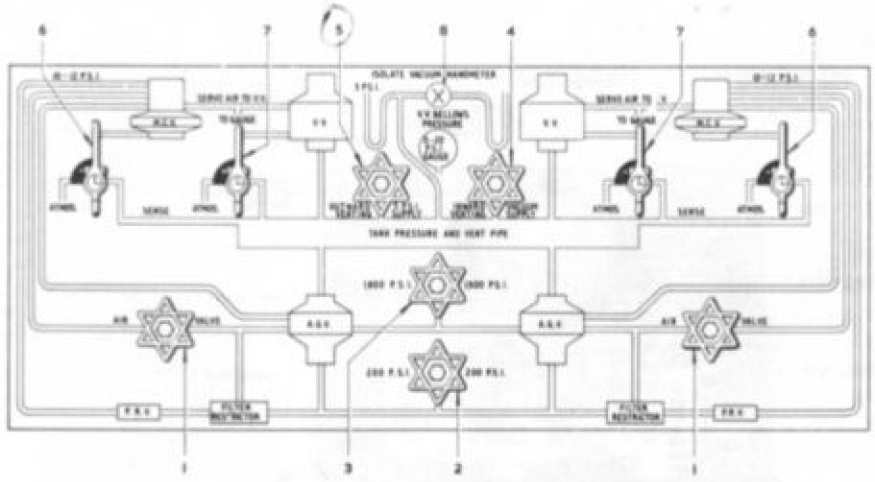
(2) Tank Pressure Sensing Control Cock (4 off - one for each M.C.V., and one for each Vent Valve). These items, two position 3-way cocks, are interposed in the tank sensing connection adjacent to each M.C.V. and each vent valve. In one position, the associated component i.e., the Master Control Valve or Vent Valve senses tank pressure in the normal way and in the other position, the tank sensing line is closed and the tank sensing diaphragm of the associated component is open to atmosphere. Normally outward and inward venting can operate in any one of three ways i.e. tank pressure sensed by the M.C.V. causes normal venting, or alternatively, tank pressure sensed by either one of two vent valves causes emergency venting. It is therefore possible, by use of the tank sensing control cocks, to test each of these venting functions by isolating consecutively two components at a time.

(3) Inward Venting Control Cock - Controls the vacuum supply to the tank to simulate inward venting conditions. May also be used as a leak source from the tank (without the vacuum pump running) to simulate the usage of fuel in level flight.

(4) Outward Venting Control Cock - Controls the 5 p.s.i. supply to the tank and vent manifold and is used to regulate the rate of change of tank pressure.

(5) 200 p.s.i. Control Cock - Controls the 200 p.s.i. engine air supply to the air/gas valve and associated servo lines.

(6) 1,800 p.s.i. Control Cock - Controls



1. AIR VALVE CONTROL COCK
2. 200 P.S.I. CONTROL COCK
3. 1,800 P.S.I. CONTROL COCK
4. INWARD VENTING CONTROL COCK
5. OUTWARD VENTING CONTROL COCK
6. MASTER CONTROL VALVE, TANK SENSING COCK
7. VENT VALVE, TANK SENSING CONTROL COCK
8. WATER MANOMETER CONTROL COCK

Fig.4A. Test rig control panel

the 1,800 p.s.i. simulated nitrogen supply to the air/gas valve.

◀ (7) Water manometer control cock - Used to connect the manometer to tank pressure when negative pressures are being used for inward vent testing.

NOTE...

The water manometer control cock must be kept closed except when inward venting testing is being carried out. ▶

AIR SYSTEM

9. Provision is made on the right hand side panel (fig.5A) for connecting a ground air supply. Originally a high pressure air bottle of 3,600 p.s.i. was necessary in order to obtain a simulated nitrogen pressure of 1,800 p.s.i., but on control panels, post Mod.171, a workshop air supply of 200 p.s.i. is acceptable. This means that either method of air supply may be connected to the test rig, as both systems are suitably reduced by a series of pressure reducing valves to accurately simulate air/gas supplies.

10. Air pressure indication is provided by three pressure gauges recessed into the right hand side panel (fig.4A). These show initial air supply pressure, simulated nitrogen pressure and engine supply pressure, respectively.

11. Three pressure reducing valves, mounted on the base of the test rig, immediately below the pressure gauge recess, are accessible from the rear (fig.3A). The arrangement is shown diagrammatically in fig.6A and the three reduction stages are as follows:-

(1) 3,600 p.s.i. to 1,800 p.s.i. (for nitrogen simulation).

(2) 1,800 p.s.i. to 200 p.s.i. (simulated engine air).

8222 2175 500 10,63 AVR 1354

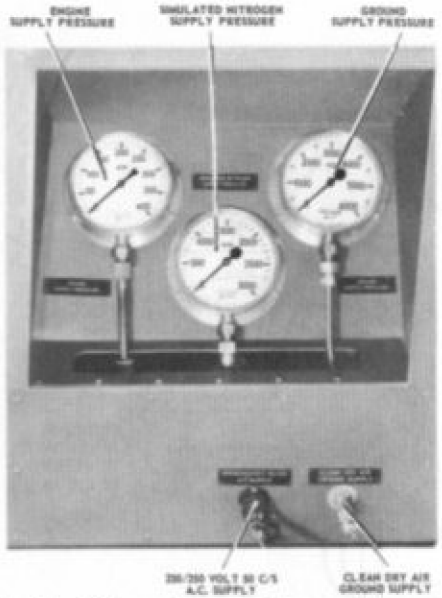


Fig.5A External connections and pressure gauge recess

(3) 200 p.s.i. to 5 p.s.i. (tank supplies).

Provision is made on all three reducing valves for hand adjustment so that pressure reduction figures may be accurately set prior to each test.

12. A light alloy fuel and pressure tank is installed centrally in the rear of the test rig, and although termed as such, does not require fuel for testing purposes. The tank takes the place of a normal aircraft tank group and under the influence of either a ground air supply (suitably reduced), or a vacuum pump depression, can be made to accurately simulate the normal rise and fall of tank pressures during flight. A safety valve, set to 5 p.s.i., is fitted to the top of the tank, and a moisture drain cock is fitted at the lowest point. Positive tank pressure indication is provided by a mercury manometer, mounted in the upper front panel.

13. To facilitate connection of aircraft control equipment and rig instrumentation a distribution manifold is connected to, and is mounted directly above, the fuel and pressure tank.

VACUUM SYSTEM

14. An electrically driven vacuum pump, mounted on the base of the test rig, is accessible from the rear. On selection, the pump can be started and connected to the test tank in order to simulate negative tank pressures. Negative Pressure indication is provided by a water manometer mounted on the upper front panel.

ELECTRICAL POWER SUPPLIES

15. A 230-250 volt, 50 c/s, single phase a.c. power supply socket is provided on the lower right hand side panel. A ground supply connected to this point provides power for the electrically driven vacuum pump. A Crabtree starter unit, incorporating START/STOP push buttons is mounted on the upper right hand front panel.

16. Tank pressurisation is controlled by a 28-volt d.c. solenoid operated valve, one to each tank group. On the test rig a supply for these valves is obtained from a transformer rectifier unit installed in the left hand rear of the rig. A mains control switch for the transformer rectifier unit, together with a 28-volt output fuse are mounted on the upper front panel and a 28-volt supply cable of sufficient length to connect to either a port or starboard pressurisation panel, is available at the lower centre top panel. A theoretical wiring diagram for the test rig is shown in fig.7A.

INSTALLATION

General

17. The test rig must normally be installed in a component servicing bay on a steady and level base. The appropriate air supply and a 230-250 volt, 50 c/s single phase power supply must be available at the right hand side panel.

Temperature control

18. Ideally some degree of temperature control in the servicing bay is desirable, but is not essential. Temperature is only critical in the case of the emergency inward venting range which tends to drift with temperature changes.

19. The vent valves control emergency inward venting and this should normally occur over the range 0 to minus 4 in. water gauge. This figure depends on the valve setting tolerance and the ambient temperature, which under laboratory setting conditions should be 23 deg.C. However, because of the comparatively large tolerance on this type of valve it is normally not necessary to insist on laboratory temperature conditions when carrying out tests in service, but it is important that before rejecting any vent valves which appear on, or below the minus 4 in. water gauge limit, to first ascertain that the test temperature is not less than 23 deg.C.

Manometer filling

20. For storage and transit purposes both the mercury and water manometers are drained and must be refilled before the rig is brought into use. Fill the mercury manometer with clean mercury (preferably from a sealed container) and fill the water manometer with distilled water containing a few drops of a suitable wetting agent. Use the following procedure:-

Set the manometer scale to the appropriate mid position.

In the case of the water manometer only, remove the vacuum pipe rubber connecting tubing.

Remove the clamp which secures the Woulfe bottle.

Carefully invert the Woulfe bottle with bungs and manometer tubing still connected.

Remove rubber tubing from the glass adapters which fit through the rubber bungs.

NOTE. . .
Do not remove the glass tubing or rubber bungs, as leaks can develop if disturbed.

With the Woulfe bottle on a bench, approximately half fill with mercury or distilled water, as appropriate. This operation may be accomplished quite easily if a paper funnel is made with the end rolled small enough to engage inside the lip of the glass tube.

Carefully invert the Woulfe bottle with one finger held over the normal outlet tube. The vent or inlet glass tube has a stack-pipe and with care no liquid should be lost from this connection during the turning operation.

Reconnect the manometer tube, releasing the finger from the outlet tube as connection is made.

Secure the Woulfe bottle in the inverted position, with the two rubber bungs resting on the wooden support block.

Check the zero setting on the manometer scale. (With the bottles half filled, the liquid level should be on the high side). Bleed back to zero mark by partly disconnecting the rubber tube at the bottle. Slight inaccuracies can be adjusted on the manometer scale.

In the case of the water manometer only, replace the rubber tubing on the vacuum connection.

OPERATION

General

21. On completion of the installation, the test rig is ready to receive either a port or starboard tank pressurisation control panel, together with two vent valves.

22. To avoid rejecting control panels and/or components unnecessarily, it is important that aircraft panels are maintained in their normal upright attitude as removed and carried from the aircraft to the servicing bay and that the following components in each tank group are serviced prior to carrying out rig tests:-

Fuel traps (2 per group)
Air drier (1 per group)
Filter restrictor (1 per group)

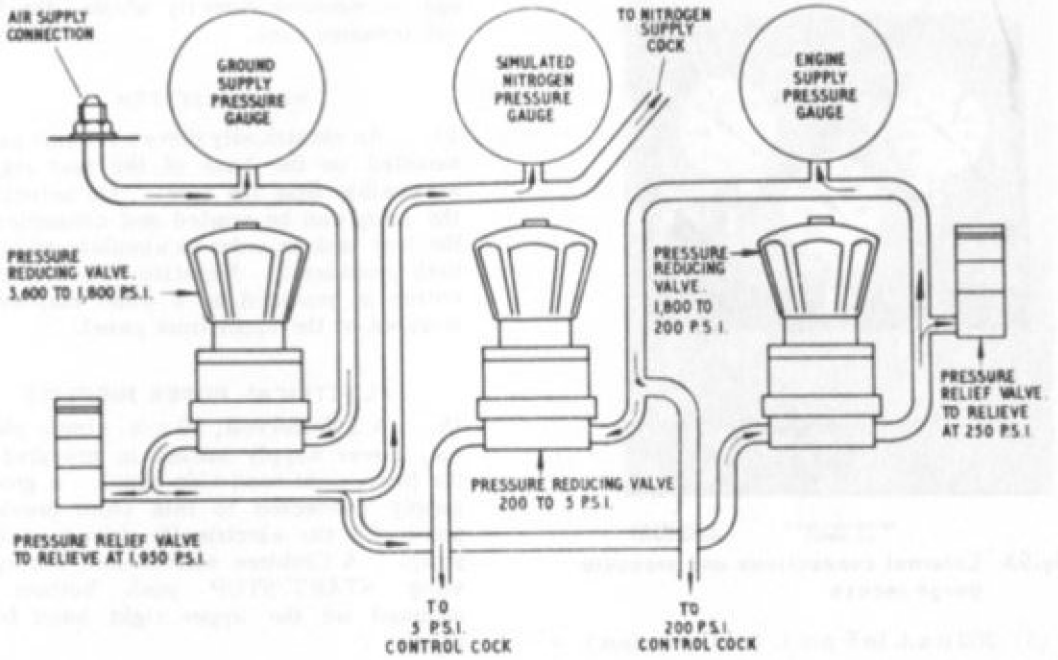


Fig.6A Arrangement of pressure-reducing and relief valves

Fitting aircraft control panel

23. To avoid crossed or incorrectly positioned pipes it is recommended that the following fitting procedure is followed whenever an aircraft control panel is connected to the test rig:-

(1) Secure the control panel to the test rig by panel retaining cleats.

(2) Connect flexible hose marked TO AIR/GAS VALVE, to the air/gas valve of the group under test.

(3) Disconnect pipes marked AIR at both master control valves.

(4) Connect the two pipes on the test rig marked TO M.C.V. AIR CONNECTION to the union marked AIR on each group master control valve.

V.2.1A. 2004

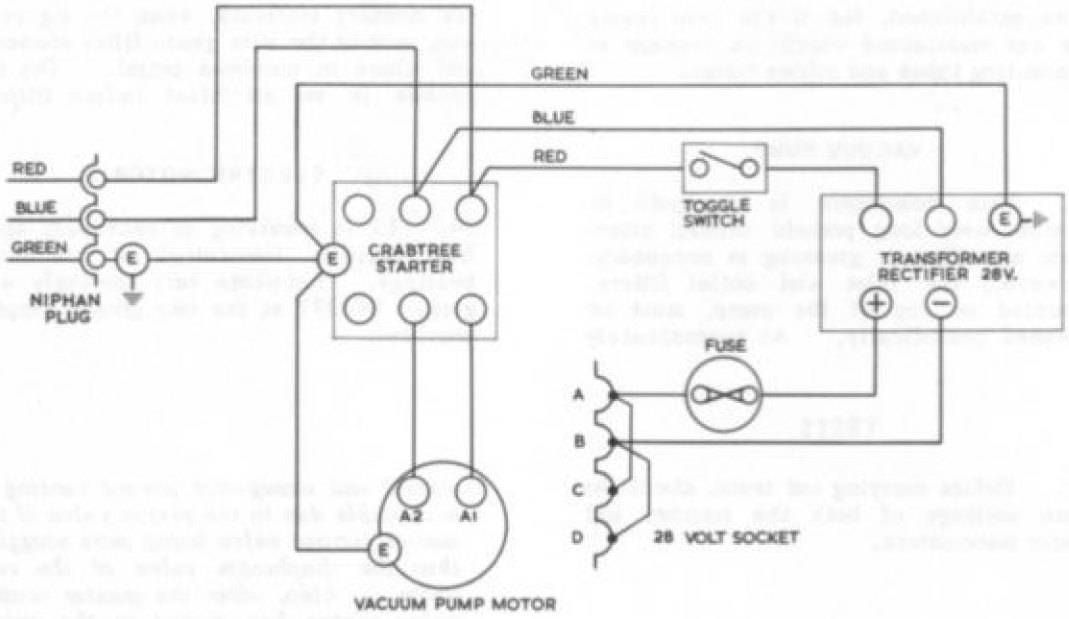


Fig.7A. Electrical circuit

(5) Connect pipes on test rig marked TO M.C.V. AIR CONNECTING PIPE, to the pipes disconnected in item (3).

(6) Connect the test rig hoses marked TO FUEL TRAP INLET to the open end of the fuel traps in both groups, in the FLOW direction.

(7) Connect the test rig hoses, marked TO SERVO CONNECTION to the servo-pipes of the group under test (i.e., SERVO 1, SERVO 2, SERVO 3 or SERVO 4, as appropriate).

(8) Connect the test rig hose marked TO ENGINE AIR GROUPS 1 and 2 (or 3 and 4 as appropriate) to the corresponding engine air supply union on the aircraft panel.

(9) Connect the test rig hose marked TO ENGINE AIR, GROUPS 3 AND 4 (or 1 and 2 as appropriate) to the adjacent blanking stowage on the test rig marked ENGINE AIR PIPE STOWAGE.

(10) Connect the blanking union which is held on a short chain and marked TO SERVO AIR EXHAUST to the adjacent union on the aircraft panel marked SERVO AIR EXHAUST.

(11) Connect the test rig 28-volt electrical lead to the solenoid valve supply socket on the aircraft panel.

NOTE...
The following additional item is only applicable to aircraft control panels pre Mod.171.

(12) Connect the test rig hose marked TO NITROGEN CONNECTION to the nitrogen pipe tee-connection on the aircraft control panel.

Fitting vent valves

24. Each of the four tank groups must be tested separately with a pair of vent valves in position. It is not necessary to selectively fit vent valves from the particular group in which they are connected on the aircraft, but each pair of vent valves should be changed before testing the next group. Thereafter serviced and tested vent valves may be fitted to any location in the aircraft.

25. Vent valves may be fitted to the test rig, as follows:-

(1) Fit a vent valve into a retaining clip and connect the large bore tank sensing pipe.

(2) Connect the test rig pipe marked TO CONTROL, to the CONTROL connection on the vent valve.

(3) Connect the test rig pipe marked TO TANK to the tank connection on the vent valve.

(4) Repeat items (1) to (3) for the second vent valve.

SERVICING

General

26. To ensure efficient operation of the test rig a periodic check must be made of all H.P. and L.P. valves and pipes for air leakage. If leakage is suspected a comprehensive check must be made using a soap solution.

MANOMETERS

27. The manometers should give little trouble once filling and zero levels have been established, but if the zero levels are not maintained check for leakage at connecting tubes and rubber bungs.

VACUUM PUMP

28. This component is designed to operate over long periods without attention; no oiling or greasing is necessary. However, the inlet and outlet filters, mounted on top of the pump, must be cleaned periodically. At approximately six monthly intervals, when the rig is in use, remove the wire gauze filter elements and clean in non-lead petrol. Dry the gauzes in an air blast before fitting.

ELECTRIC MOTOR

29. Little servicing is necessary apart from periodic lubrication of the motor bearings. Lubricate very sparingly with grease XG-271 at the two grease nipples provided.

TESTS

PRE-TEST REQUIREMENTS

30. To prevent the possibility of damage occuring to the test rig on the aircraft control panel, through crossed or incorrectly positioned pipes, it is important that all connections are visually rechecked before conducting any tests.

31. The water manometer control cock must always be in the fully closed position except for inward vent testing. Failure to observe this precaution will result in a positive pressure being applied to the water manometer which will force water from the manometer tube.

32. When connecting external air and electrical supplies to the test rig, carry out the following procedure:-

Tank pressurisation switch	- set to OFF
Air supply cock, 1,800 p.s.i.	- set to CLOSED
Air supply cock 200 p.s.i.	- set to CLOSED
Ground air supply	- connect to test rig
External electrical supply	- connect to test rig

TEST PROCEDURE

33. Before carrying out tests, check the zero settings of both the mercury and water manometers.

34. In order to ensure accurate results it is recommended that the tests detailed in the following paragraphs be repeated three times for each tank group.

Initial pressurisation	- Air valve closing 1·82 to 2·3 p.s.i.
Normal outward	- Master control valve limits 2·65 to 3·0 p.s.i.
Emergency outward venting	- Vent valve limits, 2·75 to 3·25 p.s.i.
Normal inward venting	- Master control valve limits 0 to minus 4·5 in W.G.
Emergency inward venting	- Vent valve limits 0 to minus 4·0 in.

NOTES...

The variation in the limits quoted for normal and emergency inward venting is acceptable due to the piston valve of the master control valve being more sluggish than the diaphragm valve of the vent valve. Also, after the master control valve piston has moved to the inward vent position the vent valve bellows pressure has to bleed away through approximately 30 ft. of piping, while the vent valve, as well as responding more quickly, bleeds the bellows pressure direct to atmosphere through its own gauze covered static outlet. Therefore, at fast rates of descent, the vent valve will operate before the master control valve and for safety the limits must be tighter.

The 9 to 14·5 p.s.i. pressure controlling range given in these tests cover the full 'flow' and 'no flow' conditions as measured on the test rig only and must not be expected when the P.R.V. is installed in the aircraft.

To carry out the tests, an aircraft fuel tank pressurisation control panel and two vent valves must be installed in the rig.

V.2.1A. 2006

Initial pressurisation (level flight)

35. Air valve closing limits 1·82 to 2·3 p.s.i.

(1) Air valve control cock	Set valve of group not required for test to CLOSED.
(2) Master control valve tank sensing cock.	Set valve of group not required for test to ATMOSPHERE.
(3) Master control valve tank sensing cock.	Set valve of group in use to NORMAL.
(4) Vent valve tank sensing control cock (2 off)	Set to NORMAL.
(5) Water manometer control cock.	Set to CLOSED.
(6) Ground air supply	Ensure reading on engine supply pressure gauge is 200 p.s.i.
(7) Ground air supply cock (200 p.s.i.)	Set to OPEN and wait for the air valve of the air/gas valve to close. NOTE... *This is indicated when air ceases to flow from the vent valves.*
(8) Tank pressurisation switch	Set to ON.
(9) Air valve control cock (group under test) NOTE... *The air valve of the air/gas valve should open and the vent valves close. This is indicated by a reading of 9 to 14·5 p.s.i. on the vent valve bellows pressure gauge and a tank pressure of 1·82 to 2·3 p.s.i. on the mercury manometer when the system has settled.*	Set to OPEN
(10) Tank pressure switch	(a) Set to OFF and ensure that the tank pressure falls to zero and the bellows pressure to 4 p.s.i. or less. (b) Reset the switch to ON.
(11) Inward venting control cock	(a) Open slightly to allow air to escape from the tank to simulate usage of fuel, and check that the air valve opens at 1·7 to 2·0 p.s.i. (b) Check that the air valve closes when pressure reading of 1·82 to 2·3 p.s.i. is shown on mercury manometer. (c) Set the inward venting control cock to CLOSED.

NOTE...
The following items 12, 13, 14 and 15 are only applicable in the case of early type pressurisation panels (pre Mod.171), incorporating a nitrogen supply to the gas valve:-

(12) Simulated nitrogen supply	Ensure nitrogen pressure gauge is set to 1,800 p.s.i. maximum.
(13) Control cock (1,800 p.s.i.)	Open slowly, and check that the tank pressure builds up, until at 2·02 to 2·5 p.s.i. the gas valve closes.
(14) Inward venting control cock	(a) Open slowly to allow air to escape from the tank to simulate usage of fuel and check that tank pressure slowly hunts between a minimum of 1·9 to 2·2 p.s.i. and a maximum of 2·02 to 2·5 p.s.i. (b) Set inward venting control cock to CLOSED.
(15) Control cock (1,800 p.s.i.)	Set to CLOSED.
(16) Tank pressurisation switch	Set to OFF.
(17) Air valve control cock	Set to CLOSED.

Normal outward venting (climbing)

36. Master control valve, limits 2·65 to 3·0 p.s.i.

(1) Vent valve tank sensing control cocks (2 off)	Set both cocks to ATMOSPHERE
(2) Inward venting control cock	Set to CLOSED.
(3) Air valve control cock	Ensure air valve control cock of group not required for test, is set to CLOSED.

(4) M.C.V. tank sensing control	Ensure cock of group not required for test is set to ATMOSPHERE.
(5) M.C.V. tank sensing control cock.	Set cock in use to NORMAL
(6) Water manometer control cock.	Set to CLOSED
(7) Tank pressurisation switch	Set to ON
(8) Simulated engine air supply	Ensure reading on gauge is 200 p.s.i.
(9) Control panel supply cock (200 p.s.i.)	Set to ON and wait for air valve of the air/gas valve to close
	NOTE... *This is indicated when air ceases to flow from the vent valves.*
(10) Outward venting control (5 p.s.i.)	(a) Open slowly to give a rate of change of pressure of 1 p.s.i. per minute, as shown on the mercury manometer.
	(b) Check tank pressure reading on mercury manometer which should now read between 2·65 and 3·0 p.s.i.

NOTE...
When the above pressure is reached both vent valves should outward vent, and rising and falling of the tank pressure should continue in a series of slow pulses. This condition should be maintained for several minutes in order to conduct a satisfactory test.

(11) Outward venting control cock 5 p.s.i.	Set to CLOSED
(12) Tank pressurisation switch	Set to OFF

Emergency outward venting

37. Vent valve limits 2·75 to 3·25 p.s.i.

(1) Vent valve tank sensing control cocks (2 off)	Ensure both valves are set to NORMAL.
(2) M.C.V. tank sensing control cock	Set to NORMAL
(3) Tank pressurisation switch	Set to ON to allow tank pressure to rise to 1·82 to 2·3 p.s.i.
(4) Air valve control cock	Set to CLOSED in order to prevent the air valve from opening, when the tank sensing control is removed from the M.C.V.
(5) M.C.V. tank sensing control cock	Set to ATMOSPHERE
(6) Vent valve tank sensing control cock left hand side (1 off)	Set to ATMOSPHERE
	NOTE... *The vent valve, now left with NORMAL tank sensing, is the valve under test.*
(7) Outward venting control cock (5 p.s.i.)	(a) Open slightly to give a rate of change of pressure of 1 p.s.i. per minute as shown on the mercury manometer.
	(b) Observe tank pressure rises and outward venting occurs at a pressure of 2·75 to 3·25 p.s.i., as shown on the mercury manometer.

NOTES...
When the above pressure is reached the vent valve should outward vent and rising and falling of the tank pressure should continue in a series of slow hunts.

In the case of some valves it may be found that the first outward vent occurs within the correct limit of 2·75 to 3·25 p.s.i. but the valve then remains feathered partially open, maintaining a steady bellows pressure of 6 to 8 p.s.i. and a tank pressure at, or below, the normal outward venting pressure. In such cases the 5 p.s.i. air supply to the tank should be reduced to allow the tank pressure to fall and if the bellows pressure recovers to 9 p.s.i. minimum before the tank pressure drops to 2·3 p.s.i., the valve is satisfactory.

A change over to the vent valve not yet tested may be accomplished as follows:-

(8) Vent valve tank sensing control cock of vent valve not yet tested (i.e., left-hand side).	Set to NORMAL
(9) Vent valve tank sensing control cock of vent valve tested (i.e., right-hand side).	Set to ATMOSPHERE

(10) Carry out checks as detailed in item (7) (a) and (b), for the second vent valve, and outward venting should occur once again between 2·75 and 3·25 p.s.i.	
(11) Outward venting control cock (5 p.s.i.)	On completion of tests, set to CLOSED
(12) Tank pressurisation switch	Set to OFF to depressurise the system

Normal inward venting

38. Master control valve, limits 0 to minus 4·5 in. water gauge.

(1) Vent valve tank sensing control cocks (2 off).	Set both valves to ATMOSPHERE
(2) M.C.V. tank sensing control cock.	Set to NORMAL
(3) Air valve control cock	Set to CLOSED
(4) Tank pressurisation switch	Set to ON
(5) Mercury manometer	Check reading is ZERO

NOTE...
If any pressure is showing on the mercury manometer, select the pressurisation switch to OFF and then ON again. If pressure is still showing this may be due to the tank temperature being lower than ambient because of depressurisation after earlier tests. In these circumstances the tank temperature should be allowed to return to normal before selecting the tank pressurisation switch to ON again.

(6) Vent valve bellows pressure gauge.	Check reading; this should be between 9 and 14·5 p.s.i.
(7) Water manometer isolation cock.	Open, slowly
(8) Vacuum pump	Select ON
(9) Inward venting control	(a) Open slowly and adjust to give a rate of change of pressure of 1 in. W.G. per 20 sec. (b) Observe that inward venting relieves the tank depression before it exceeds minus 4·5 in. W.G.

NOTE...
Inward venting should take place in a series of hunts for as long as the vacuum pump is running.

(10) Vacuum pump	Select OFF and ensure that the vent valve bellows pressure rises to between 9 and 14·5 p.s.i.
(11) Water manometer control cock	Set to CLOSED
(12) Inward venting control cock	Set to CLOSED
(13) Tank pressurisation switch	Set to OFF

Emergency inward venting

39. Vent Valve, limits 0 to minus 4·0 wage gauge.

(1) Vent valve tank sensing control cocks (2 off)	(a) Set control cock of one vent valve to ATMOSPHERE and the other vent valve to NORMAL

NOTE...
The vent valve left with NORMAL tank sensing is the valve under test.

(2) M.C.V. control cocks (2 off)	Set both valves to ATMOSPHERE
(3) Air valve control cock	Set to CLOSED
(4) Control cock (200 p.s.i.)	Set to OPEN
(5) Tank pressurisation switch	Select ON
(6) Mercury manometer	Ensure reading ZERO
(7) Water manometer cock	Set to OPEN
(8) Vacuum pump	Select ON
(9) Inward venting control cock	Open slowly to give a rate of change of pressure of 3·5 in. W.G. per sec.
(10) Vacuum pump	(a) Select OFF and allow the vent valve bellows pressure to build up between 9 and 14·5 p.s.i. (b) Select ON and note the maximum negative pressure reached on the first inward vent. This figure must not exceed minus 4·0 in W.G. (c) Select OFF

NOTE...
If the vacuum pump is left running, subsequent inward vent depression will be lower, as the bellows pressure does not fully recover. It is therefore the first inward vent from full bellows pressure which is important, and this must not exceed minus 4·0 in. W.G.

(11) Vent valve tank sensing
(a) Set control cock of vent valve just tested to ATMOSPHERE.
(b) Set control cock of valve to be tested to NORMAL.

(12) Repeat test items (2) to (9) inclusive for the second vent valve.

(13) Water manometer cock — Set to CLOSED

(14) Inward venting control cock — Set to CLOSED

(15) Tank pressurisation switch — Select to OFF

(16) Control cock (200 p.s.i.) — Set to OFF

NOTE...
The above sequence of operations represents the tests on one tank group and one pair of vent valves only. A second pair of vent valves should therefore be fitted and all applicable connections changed over to the other group on the panel. The second control panel may then be fitted and tested in a like manner, making sure to change the two vent valves after each group is tested.

TABLE 1
SCHEDULE OF PARTS

Main components and some consumable items only:-

A.V.Roe Part No.	Description	Qty.
7b/U.1383	Spring clip, 4 in. dia.	2
119/U.1383	Rubber bung 15 mm. 3/8 in. dia hole	2
120/U.1383	Cork bung, size 5	2
131/U.1383	Woulfe bottle, 500 c.c.	2
125/U.1383	Tank assembly	1
132/U.1383	Manometer tube, glass 3/8 in. o/d. x 12 in. long 3.285	2
133/U.1383	3/8 in. needle valve	7
135/U.1383	Pressure gauge 0-20 p.s.i.	1
136/U.1383	Pressure gauge 0-400 p.s.i.	1
137/U.1383	Pressure gauge 0-6,000 p.s.i.	1
138/U.1383	Pressure gauge 0-300 p.s.i.	1
139/U.1383	P.80 Press. controller 3,600-1,800 p.s.i.	1
140/U.1383	P.40 Press. controller 1,800-200 p.s.i.	1
141/U.1383	L.1. Press. controller 200-5 p.s.i.	1
134/U.1383	Flanged plug and cover 3 pin 5 amp.	1
143/U.1383	Vacuum pump unit R.B2 Mk.1V, 65 Plant	1
165/U.1383	Switch 250v x 10 amp.	1
116/U.1383	Starter Type D.6	1
174/U.1383	Flexible pipe	8
175/U.1383	Flexible pipe	1
176/U.1383	Flexible pipe	2
177/U.1383	Flexible pipe	1
190/U.1383	Fuseholder L.356	1
191/U.1383	Fuse H.R.C. 3 Amp. L639	1
195/U.1383	Relief valve, blow-off 2,000 p.s.i.	1
196/U.1383	Relief valve, blow-off 250 p.s.i.	1

7 14729 625 2/71 H.S.A.1354