POWERED FLYING CONTROLS

Reference: AP 4505B, Vol 1.
AP 4603 Series.

Introduction

1. The Boulton Paul P.132 and P.135 power flying control units are incorporated in the elevon system of the Vulcan B Mk.2, and the P.138 dual power unit is installed in the rudder flying control system, to assist the pilot in the operation of his controls and, to isolate him from the forces resulting from the varying aerodynamic loads on the control surfaces. Since the pilot is unable to feel any direct reaction from these forces, it is necessary to introduce a suitable degree of artificial feel into the control system which is provided by the aircraft manufacturer.

The P.138 Dual Unit

2. The dual control unit comprises two separate units, a main unit and an auxiliary unit, which are interconnected by a flexible pipe. Each unit is connected by the respective ram ends, to a common rudder actuating arm which is pivoted in its centre.. Under normal conditions the rudder is operated by the main unit with the auxiliary unit idling, but, if the main unit fails, a changeover occurs causing the auxiliary unit to operate the rudder and maintain aircraft directional control.

3. The dual unit is situated in the forward compartment of the rear section with the main unit on the starboard side and the auxiliary unit on the port side.

Description

4. Both main and auxiliary units are electro/hydraulic/mechanical and are basically similar; each unit consisting of an electric drive motor, a servo pressure hydraulic pump and a main ram pressure pump, a hydraulic ram, and a differential lever assembly.

5. The electric motors for the main and auxiliary units are identical and manufactured by Rotax and designed to operate on a 200V AC supply at 2000 rpm.

7. NOTE:-

In the following description, the term "input" refers to movement imparted by the pilot through his control run to the power unit, and the term 'output' refers to the movement transmitted to the control surface by the power unit.

8. The two input rods from the flying control system, which connect with the input levers of the differential lever assemblies of the main and auxiliary units, can telescope, if the loading on them becomes excessive. This can be caused by a differential mechanism seizure on one of the units, therefore, the input rod connected to the ineffective unit collapses or extends as necessary, and allows the rudder controls to impart an input to the remaining serviceable unit.

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9. Because of the similarity between the main and auxiliary units, the descriptions contained in the following paragraphs apply generally to the main unit, specific reference being made to the auxiliary unit only when necessary to differentiate between the two units.

Body Casing

10. The main unit has a casing with a sump tray bolted to it to form the base of the unit. A fabric type fluid filter, through which all the fluid passes, is housed in the lower portion of the casing adjacent to the sump. The majority of the fluid passages interconnection the various components are formed by drillings within the casing, thus reducing the number of external pipes to a minimum. The auxiliary unit casing is very similar, but of opposite hand. The fluid used in the units is OM 15 (DTD 585).

Sump Vent Valves

11. The units are pressurised and take the form of a cushion of air above the fluid in the sump, to ensure a continuous feed of fluid to the servo pressure pump when the unit is operating at high altitudes.

12. The air pressure is controlled by a vent valve which is incorporated in the sump. The valve consists of a spring loaded ball valve which is operated by a double acting cam attached to a spring loaded bellows. The valve is connected by a rigid pipe to the air space above the fluid level in the main casing. This pressure is felt on the outside of the bellows, whilst the inside of the bellows is vented, through the side wall of the sump tray, to atmosphere.

13. At varying altitudes, differences in pressure between the air above the fluid and ambient air pressure, cause the bellows to contract or expand with a consequent outwards or inwards venting of air respectively. In this way a pressure differential of approximately 4 psi. is maintained above the fluid in the main casing.

14. A spring loaded press button valve is incorporated between the rigid pipe and the sump vent valve to allow for venting of the air space above the fluid level in the sump, to atmosphere, during fluid replenishment.

Hydraulic Pumps

15. The pumps consist of a three bank, centrifugal multi-piston assembly of variable flow type. One bank generates servo pressure at 280 to 300 psi for operation of the servo valve assembly. The other two main banks generate main pressure at 2,120 to 2,200 psi for operating the hydraulic ram. Therefore, each pump has an independant output, the volume and direction of flow from the servo pump being determined by the deflection of a track ring concentric about the piston assembly. The flows from the two main pumps are kept in unison by both concentric track ring being operated by a common operating arm.

16. Displacement of the servo bank track ring is effected by a constant pressure assembly, which is governed by the output

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pressure from the pump, and keeps the servo bank output in a constant direction and at a constant pressure. Displacement of the two main banks is by a servo valve and balance piston assembly, and is governed by rudder system control run movement.

Hydraulic Ram

17. The hydraulic ram assembly is housed in the lower portion of the body casing, its purpose being to actuate the control surface when pressure is applied to the ram from the main bank pumps. Bolted to the rear of the casing, about the ram body, is a tail-piece cone which provides a means for mounting the unit to the airframe structure. The fork-end fitting, which connects to its respective end of the rudder actuating arm, is provided on the output end of the ram, and, from the fork-end fitting a rod is connected to the feed back lever of the differential lever assembly.

18. The hydraulic ram for the auxiliary unit is similar to the main unit, but, incorporates between the ram and main bank pumps a control surface lock valve, a damper valve, a manual by-pass valve, and a thermal relief valve.

Control Surface Lock Valve

19. The lock valve is provided to act as a parking lock on the ground, and, in event of failure of both units in flight to lock the control surface. Normally, providing one of the dual units is operating, the lock valve is held in the open flow condition to allow the main bank pumps to supply and operate the hydraulic ram. A micro-switch, connected to a warning light in the pilot's cabin on the port console (Panel 6P) is operated by movement of the lock valve piston to the lock position.

Damper Valve

20. The damper valve is provided between the control surface lock valve and the ram, to allow a controlled leak of fluid across the ram piston when the control surface lock valve is in the locked position. This allows the rudder control surface to move back to the trail position slowly from whatever position the surface failed, dependant on the aerodynamic loads on the surface.

Manual By-Pass Valve

21. The manual by-pass valve is provided between the control surface lock valve and the hydraulic ram, to allow for a by-pass of fluid across the ram piston, so that the control surface may be moved by hand, when the aircraft is on the ground, to enable control surface settings etc to be accomplished without the use of power.

Thermal Relief Valve

22. When the control surface lock valve is closed, and the ram is isolated from the remainder of the hydraulic circuit, the thermal relief valve is provided to relieve any excess pressures which may arise in this closed circuit due to heat expansion.

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Differential Lever Assembly

23. The differential lever assembly is mounted on the forward face of the main casing. The assemblies for main and auxiliary units are similar, but are manufactured in right and left hand form and therefore are not interchangeable between the two units. A trip mechanism is incorporated on both units, to free the differential mechanism in even of seizure. Both trips are similar but the main unit trip operates a trip valve and a micro-switch, whilst the auxiliary unit trip operates a micro-switch only.

24. The differential leverassembly is provided firstly as a means for transmitting an "input" signal from the pilot to the power unit servo valve centre piston, and secondly, to bring about a "feed back" action as the hydraulic ram moves and so return the servo valve centre piston to the neutral position when the ram has reached the desired position.

25. A spring loaded neutral setting plunger is fitted on the input lever, and, when depressed engages in an identation in the mounting bracket to hold the differential lever assembly and subsequently, the servo-valve centre piston in the neutral position.

Control Valve Assembly

26. The trip valve is provided on the main unit only, to effect a rapid change-over to the auxiliary unit, if the servo-valve assembly seizes.

27. The control valve assembly consists of a valve body containing a spring loaded plunger, a spring loaded annular grooved piston sliding in a cylinder bore, and a non return valve assembly. The plunger assembly is connected to the trip mechanism on the top of the body casing with the trip lever of mechanism normally holding the plunger assembly with its spring in compression.

28. A positive leak of servo-pressure to sump is also provided to dispel servo-pressure rapidly in event of failure of the main unit to effect a rapid operation of the control valve piston.

29. When the dual power unit is switched on, servo-pressure from the main unit, via the trip valve, is supplied to the head of the control valve piston head to move it down against its spring. Servo pressure then passes through the non-return valve to the change-over valves of both units.

30. If the servo-valve centre piston seizes, the trip mechanism is released by the force applied from the pilots controls via the input rod. The trip valve is released and moves down under the influence of its spring to make contact with a micro-switch connected to a warning light on the port consol. Movement of the trip valves also diverts the servo pressure to sump thus allowing the control valve piston to move back to its stop under the influence of its spring.

31. Servo pressure holding the changeover valves is now exhausted to the main unit sump, via the annulus of the control valve, and a change-over from main to auxiliary is effected.

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32. In the event of a servo pressure failure only, due either to a motor failure or loss of fluid due to a fractured casing, then this drop in pressure is felt on the control valve only, which moves as previously described in Paragraph 30 to perform the change-over.

Change-Over Valves

33. Three change-over valves are provided in the dual unit, a duplex change-over valve on the main unit (consisting of two annular grooved pistons) and a single change-over valve on the auxiliary unit (consisting of one annular grooved piston). The pistons are all spring loaded and servo-pressure is applied to the piston heads to move the pistons against their springs. Movement of the pistons either cover or uncover ports in the valve casing, to prevent or permit main bank pressure fluid to by-pass. Incorporated in the duplex and single change-over valves is a relief valve set at 250 psi, to relieve excess pressure to the sump during idling conditions.

Make-Up Valves

34. Two make-up valves which are spring loaded non-return valves, are fitted in the end of the distributor stork in the hydraulic pump assembly. Servo-pressure is supplied through the make-up valves to feed the suction side of the hydraulic ram, in event of a loss of fluid in the main bank hydraulic circuit.

Main Pressure Blow-Off Valves

35. The two blow-off valves per unit are located in the forward face of the body casings to prevent fluid pressures exceeding those anticipated in the design of the power units. The relief valves are connected across the main pressure feed channels which are alternatively pressure and return, thus, when the relief valves operate, the excess fluid is transferred to their respective return lines. All the four valves are identical and are set to blow off at 2,120 to 2,200 psi.

Pressure Switches.

36. A pressure switch on each unit, connecting with the servo pressure circuit of each unit are connected to respective warning lights on the port consol. These switches, in conjunction with the micro-switches already mentioned, warn the pilot of the following defects:-

- a. Failure of servo-pressure in the main unit.
- b. Failure of servo-pressure in the auxiliary unit.
- c. Operation of the main unit trip mechanism.
- d. Operation of the auxiliary unit trip mechanism.
- e. Seizure of the control surface lock valve.

Bleed Valves

37. Seven spring loaded valves are incorporated in the dual unit, one to each servo valve, four on the change-over valves, (two on the duplex change-over casing and two on the single change-over casing), and one on the flexible connecting pipe banjo union on the auxiliary unit. A standing bleed screw is provided on both units to bleed the servo-valve balance piston.

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38. A 2 BA csk/hd. screw, together with a bonded seal, is fitted in the end cap of each blow off valve, to allow for bleeding of the main bank circuit.

Level Indicators

39. A filler neck is provided on each unit, and in each instance the filler neck is bolted to the top of the sump filter housing incorporating a standard type charging valve, and two press button fluid level indicators.

Rudder Dual Unit

Principle of Operation

40. As previously stated, the main and auxiliary units are connected to a common rudder actuating arm. The input lever of each unit differential assembly is connected, by a telescopic input rod, to a common pilot's input from the rudder control system.

41. Before the electric drive motors are switched on, the servo-bank track rings in both units are being held in the maximum pumping stroke by the spring loading of the constant pressure assemblies. Immediately the motors start, however, the servo-banks deliver fluid which moves the constant pressure assembly in opposition to the spring loading until a pressure equilibrium is attained and the track rings are held at a 5° deflection to maintain a pressure of 280 - 300 psi.

42. Servo fluid pressure is passed to the servo valve assemblies in readiness for the pilots input, and to the make-up valves. Servo pressure, from the main unit, also passes through the control valve assembly to the duplex change-over valve assembly, to operate the valves to move and close the by-pass circuit in the main unit. The pressure then passes through the flexible pipe to operate the single change-over valve in the auxiliary unit to operate the valve to move and open the by-pass circuit in the auxiliary unit. Servo pressure from both units is also fed separately to two spring loaded plunger assemblies in the control surface lock valve assembly, the movement of which operates a lever assembly to move the control surface lock valve to the by-pass condition.

43. The dual unit is now under power and ready to respond to pilot's rudder control input. In the following paragraphs, the sequence of events is taken stage by stage, when in fact the time lag from the pilots input to operation of the control surface is only 0.8 seconds.

44. Input movement imparted by the pilot through the rudder control run puts input stroke to both units in opposite directions. The main banks of the main unit now supply main pressure fluid to the hydraulic ram which moves in the same direction as input to operate the rudder. The servo valve in the auxiliary unit also displaces its main banks, but, due to the movement of the single change-over valve to the by-pass condition, an idling circuit is formed, the auxiliary unit ram moved purely by its connection to the rudder operating lever. The rudder therefore, under normal conditions, is under the control of the main unit.

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45. Immediately the ram commences to move, a feed back action in the differential lever assembly takes place. This feed back action to the servo-valve centre piston, via the differential lever assembly is in reverse to the one that is required to indicate ram movement and takes the selected stroke off the servo-valves to return them to neutral and so discontinue the fluid supply from the main banks to the ram. The control surface then ceases to move when it attains a position relative to the displacement of the rudder pedals. Until a further input movement is received by the dual unit the rudder will remain in this position. As the time lag between pedal and rudder movement is only 0.8 seconds, for practical purposes therefore, it can be assumed that the rams reach their desired movement simultaneously with the cessation of the pilot's input movement. A resultant failure of the main units whether mechanical, electrical or hydraulic, will result in a change-over from main auxiliary as previously described in paragraphs 25 to 32.

Autostabilizer Operation

46. During normal operation of the rudder dual unit without auto-stabilization, the yaw damper actuators, located back to back, form a rigid link between the flying control run and common input beam lever in the power flying unit compartment in the rear section.

When yaw damping is engaged, yawing oscillations of the air-craft are detected by the rate gyroscope units, to cause the engaged yaw damper motor to extend or shorten the damper according to the "sense" of the gyro signals. (The second motor in the actuator body is acting as a standby in event of failure of the normal motor).

This action causes movement of the beam lever and telescopic input rods to displace the dual unit differential lever assemblies to move the servo-valve centre pistons and operate the dual units to move the rudder control surface in the required sense.

On cessation of yaw damper movement, the input to the dual unit is held and further ram movement causes a feed back action to take place as previously described.

The control switch for selecting the individual actuator motors channels is located on the pilot's port consol.

P.132 and 135 Elevon Units

47. Four P.132 and four P.135 power flying units are incorporated in the elevon flying control system, and are all mounted in the wings to the rear of the rear spar. The four P.135 units are identical.

The four P.132 units are handed left and right, purely for installation purposes and are not interchangeable, but the differences are slight. As all eight units are therefore basic-ally the same, a description of a P.132 will suffice, as the differences between a P.132 and a P.135 are also slight.

48. The elevons are split and each split surface is operated independently by a power control unit. By this arrangement a safety factor is obtained, in that, should one power control unit

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fail, the remaining effective units will continue to function their respective portions of the split elevons and control of the aircraft is maintained.

49. The four P.135 units control numbers 1, 2, 7 and 8 elevons, whilst the four P.132 units control numbers 3, 4, 5 and 6 elevons.

50. The power control unit is electro/hydraulic/mechanical and consists essentially of an electric motor operating on 200 volts AC supply at 2,500 rpm and, servo and main bank pressure pumps, a hydraulic ram, and a differential lever assembly.

51. When mounted in the aircraft, the control unit is supported by its tailpiece to the wing structure and the hydraulic ram fork end fitting is directly attached to its appropriate portion of a split control surface.

52. In place of the feed back link on the four P.132 units only, an electrical actuator is fitted, to enable input signals to be applied to the power unit independent of the pilots input, when the aircraft is being flown with autostabilization, these four actuators are therefore acting as pitch dampers.

Body Casing and Sump

53. The main casing consists of two magnesium alloy castings which are separated by a valve plate. The rear portion houses the servo-pressure pump and the forward portion houses the main pressure pump and a vent valve assembly. The main casing is completely filled with fluid (OM 15 DTD 585) which is pressurised so that all working parts are continually submerged in re-circulating fluid.

A Volkes filter with a fabric element is incorporated in the sump. A standard charging valve is fitted in the base of the sump to allow for filling and topping up of the unit.

Sump Vent Valve and Expansion Chamber

54. A vent valve is locatedin the forward face of the main housing and an expansion chamber, secured by straps to two saddle brackets on the tailpiece of the power unit. The vent valve is provided as a safety precaution and operates only during abnormal conditions, and serves two purposes.

(1) To allow for the relieving of excess pressures in the sump to atmosphere due to excessive thermal expansion.

(2) Should the unit develop an internal leak during flight, to allow for the inwards venting of air to the expansion chamber to replace the lost fluid.

55. The thermal expansion is catered for, under normal conditions, by the expansion chamber piston, but if this expansion causes the chamber piston to reach the limit of its travel, then the increase in pressure is felt on the vent valve bellows. When this pressure increases to 11½ to 13 psi the bellows contract to operate the vent valve and spring loaded plunger to pass fluid to the cavity between the vent valve and the cover plate. Fluid thus vented will seep past the plunger of the venting assembly to issue from the hold in the end cap, to indicate vent valve operation.

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56. If the control unit develops a large external leak during flight, a reverse set of circumstances to those described in Para. 55 will result. Operation of the vent valve under these circumstances will be clearly indicated by the amount of fluid lost.

57. The expansion chamber is provided, to act as an accumulator, to maintain pressurisation of the fluid in the unit at varying altitudes and to allow for thermal expansion and contraction of the hydraulic fluid.

58. It consists of a cylindrical body containing a spring loaded piston and bellows assembly. An indicator rod, attached to the piston, protrudes from the end of the expansion chamber, so that the extent of protrusion of this rod varies accordingly with the fluid pressure and temperature changes in the unit sump.

A circumferential groove machined on the indicator rod is provided to give visual indication of the pressurisation of the unit.

The spring loading on the piston is such that when the circumferential groove is flush with the end surface of the expansion chamber, the fluid in the sump is at a pressure of 5 to 7 psi.

Hydraulic Pumps

59. The pumps consist of two pumping elements, compressing a centrifugal multi-piston assembly of variable flow type operating on a live line principle, which is provided to generate servo pressure, and a swash-plate action main pressure pump for operation of the hydraulic ram.

The volume and direction of flow from the servo pump being determined by the deflection of a track ring concentric about the piston assembly, the displacement of which is effected by a constant pressure assembly, which is governed by the output from the pump, and keeps the servo bank output in a constant direction at a pressure of 320 psi approximately.

60. The displacement of the main pressure pump is determined by the angular relationship of theswash-plate to the drive shaft axis. The larger the angle the larger the fluid displacement.

The direction of flow can be altered without reversing the direction of rotation of the swash-plate cylinder block, by tilting the swash-plate to either side of the axis of rotation. The maximum working pressure from the main pressure pump is 2900-3000 psi and, the deflection of the pump is achieved by a servo-valve assembly, the movement of which is governed by the pilots input from the elevon control system.

Stroke Limiter Assembly

61. The stroke limiter assembly is provided in the main pressure system to limit the fluid horse power of the swash-plate pump and keep it within the capabilities of the electric driver motor. Up to a main pressure of 1200 - 1400 psi the stroke limiters do not operate. As this pressure increases so the appropriate limiter comes into operation to decrease the servo-valve stroke in proportion to the increase in pressure. This progressively decreases the fluid flow from the main pressure pump with a consequent reduction in ram velocity, which, avoids overloading of the electric motor.

Make-Up Valves

62. Two make-up valve assemblies are fitted in the valve plate and each consists of a spring loaded non-return valve, through which servo pressure is fed to the appropriate return side of the main pressure circuit, to compensate for any fluid loss due to leaks in the main pressure circuit.

Servo Pressure Relief Valve

63. This valve, which connects with the servo pressure fluid ways, is also fitted in the valve plate, and consists of a spring loaded ball valve set to operate at 350 - 400 psi and is incorporated to relieve excess servo pressures back to sump if some fault causes servo pressure to exceed the normal working pressure of 320 psi.

Hydraulic Ram

64. The hydraulic ram is attached to the underside of the main casing, its purpose being to actuate the control surface when main pressure fluid is applied. A flat machined on the ram body abuts the lower face of the valve plate and fluid ports, formed in the flat, communicate with the main pressure fluid ways in the valve plate to move the ram in either direction.

Bolted to the rear end of the ram body casing is a tail-piece which provides means for mounting the unit to the fixed aircraft structure. A ⅛ in. diameter drainage hole drilled through the underside of the tailpiece adjacent to the attachment flange. Any leakage past the ram rear gland assembly will readily show as it drains through the hole. The fork end fitting of the ram is attached directly to the control surface. A bracket on the fork end fitting allows the ram to be connected, by the pitch damper (P.132 units only) to the feed back lever of the differential lever assembly.

65. Incorporated in the hydraulic ram assembly are a control surface lock valve, a damper valve, a manual by-pass valve and a thermal relief valve.

Control Surface Lock Valve

66. As each unit is working as an individual controller, then the lock valve operates as soon as the unit starts or stops. The lock valve, when moved by servo pressure, operates a micro-switch to operate a warning light on the port consol. The lock valve is provided to act as a parking brake on the ground, and in event of failure of the unit in flight, to lock the control surface.

Damper Valve

67. Refer back to Paragraph 20 of rudder dual unit as operation of elevon unit valve is similar.

Manual By-Pass Valve

68. Refer back to Paragraph 21 as the elevon unit operation is identical.

Thermal Relief Valve

69. Refer back to Paragraph 22 as the elevon unit operation is identical.

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Main Pressure Blow-Off Valves

70. The two blow-off valves are incorporated in the main pressure feed channels, which are alternately pressure and return, according to the direction and displacement of the swash-plate pump, and are set to blow-off at 2950 psi.

Leak Valve

71. The leak valve, mounted in the hydraulic ram housing, is identical in construction to the damper valve, but is so positioned that a controlled leak is across the main pressure circuit between the swash-plate pump and the hydraulic ram. This valve is set by the manufacturers and must not be disturbed. The purpose of this controlled leak is to make the sensitivity of the pump fluid over ram operation a little sluggish, thereby ensuring that the pilot's input, and control surface resultant movement from the power control unit output is damped, to prevent the flying control system being too sensitive and result in erratic flying control.

Differential Lever Assembly

72. The differential lever assembly is mounted on bearing bolts, on the side of the main casing, and is provided as a means for transmitting an input signal from the pilot's elevon controls to the servo-valve centre piston, and to bring about a "feed back" action, as the hydraulic ram moves to position the control surface, and move the servo-valve centre piston back to its neutral position.

73. The assembly comprises an input lever, a differential lever, a servo-valve operating lever and a feed back lever.

A telescopic spring link connected between the differential and the servo-valve operating lever, prevent the pilot applying more input movement to the servo valve centre piston when either of the stroke limiters are in operation.

A neutral setting plunger is provided on the servo-valve operating lever, to hold the linkage in the neutral position, to enable adjustments to the aircraft control run to be carried out, and ensure that the centre piston relation to controls is in neutral.

P.132 and P.135 Power Unit

Principle of Operation

74. Before the electric motor is switched on, the servo-pump operating arm is held in the maximum pumping stroke by the spring of the constant pressure assembly. The control surface lock valve is being held in the closed position by its spring, thereby blanking off the fluid supply from the swash-plate pump to the hydraulic ram.

75. When the electric motor is switched on, the servo-pump delivers fluid which moves the constant pressure assembly in opposition to its spring loading until a pressure equilibrium of 320 psi is obtained.

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This servo pressure is also present at the two make-up valves, the servo pressure relief valve and to the servo-valve assembly in readiness for the pilots input signal, and to the control surface lock valve to move it in opposition to its spring to the by-pass position, the movement of which operates a micro-switch to extinguish a warning lamp in the cockpit port consol. The unit is now under power and ready to respond to an input signal from the pilot's controls.

In the following description the sequences of response are described step by step, but in practice the time lag between pilots input and control surface movement is in the region of 0.08 seconds. It can be assumed, therefore, that the ram reaches its desired position with the cessation of the pilots handgrip movements.

76. On pilots input, the differential lever assembly is moved at point (A) (refer Fig 2 Stage 2) which moves the input lever about point (B) which is a fixed pivot on the main casing. This in turn, through the rigid link, moves the feed back lever about point (F). The differential lever moves with the feed back lever (which is attached at point (E)) to move the differential lever about point (G) which is a fixed pivot on the main casing. This action causes the differential lever at point (H), which in turn, through the telescopic link, to point (I), rotates the servo valve operating lever and transverse shaft about point (J).

Rotation of this shaft moves the servo valve centre piston and the stroke limiter cam towards its appropriate stroke limiter.

77. Movement of the centre piston causes the servo valve to tilt the swash-plate assembly in the required direction and supply main pressure fluid to the appropriate side of the hydraulic ram, to move the ram in the same direction as pilot's input.

78. Immediately the ram commences to move, a feed back action in the differential lever assembly takes place, to take the selected stroke off the servo valve assembly to return it to neutral. This feed back action is the reverse of one required to initiate ram movement.

During feed back point (A) is being held by the pilot's controls. Point (F) moves with the ram to rotate the feed back lever about Point (D) which in turn, by its connection to the differential lever at Point (E), moves the differential lever about Point (G) in the opposite direction to the input selection, to restore the servo-valve operating lever to neutral, by means of the telescopic link, through points (H) and (I) and pivot (J), thus, discontinuing the supply of fluid to the hydraulic ram.

79. The control surface ceases to move when it attains a position relative to the handgrip deflection and remains there until a further new input signal is received from the pilot.

80. If a fault develops causing servo pressure to fail, the control surface lock valve piston is moved to the closed circuit condition and lock the control surface in the failed position. The micro-switch is operated to illuminate the warning light in the cabin.

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Due to the controlled leak past the damper valve, the control surface will move, very slowly, back to the trail position dependant upon the aerodynamic loads on the control surface.

Alternative failures ie. centre piston seizure, will be indicated by the control surface position indicator on the pilot's centre instrument panel. In this case the failed unit can be switched off and subsequent inputs to the failed unit will merely be a collapse or extension of the telescopic input rod.

Once again, due to the damper valve, the control surface will trail.

Autostabilizer Operation

81. During normal operation of the power flying unit without autostabilization, the pitch damper forms a rigid link between the power unit fork end fitting and the feed back lever.

When pitch damping is engaged, pitching oscillations of the aircraft are detected by the rate gyroscope units cause the movement of the pitch damper motor to extend or shorten the damper according to the "sense" of the gyro signals.

As the input to the power unit is being held by the pilot's controls then pitch damper actuator movement will cause the servo-input lever to be displaced due to the movement of the feed back lever.

Operation of the servo valve causes the swash plate pump to supply fluid to the hydraulic ram to move the control surface in the required sense.

As the casing of the pitch damper is attached to the fork end fitting, ram movement will carry the actuator with it. As soon as pitch damper operation ceases, the further ram movement will cause the feed back lever to return to neutral and restore the servo-valve input lever to return the swash-plate pump to the no-stroke condition, and thereby discontinue fluid supply to the ram.

In this way pitching oscillations of the aircraft are suppressed, independent of the pilot's action.

Cockpit Controls and Indicators

82. A panel attached to the pilots port consol houses, at its rear end, three push button switches for starting the outboard elevon units (Nos. 1, 2, 7 and 8), the inboard elevon units (Nos. 3, 4, 5 and 6) and the rudder dual unit.

Along the lower portion of this panel are ten spring-return push switches incorporating internal warning lamps, one switch for each power flying unit, by means of which, any of the ten units can be switched off independently.

Along the upper portion of the panel are four spring-return push switches incorporating warning lamps, one switch for each pitch damper, by means of which, any of the four dampers can be switched off independently, and a centre- OFF change-over switch for control of the yaw damper motors.

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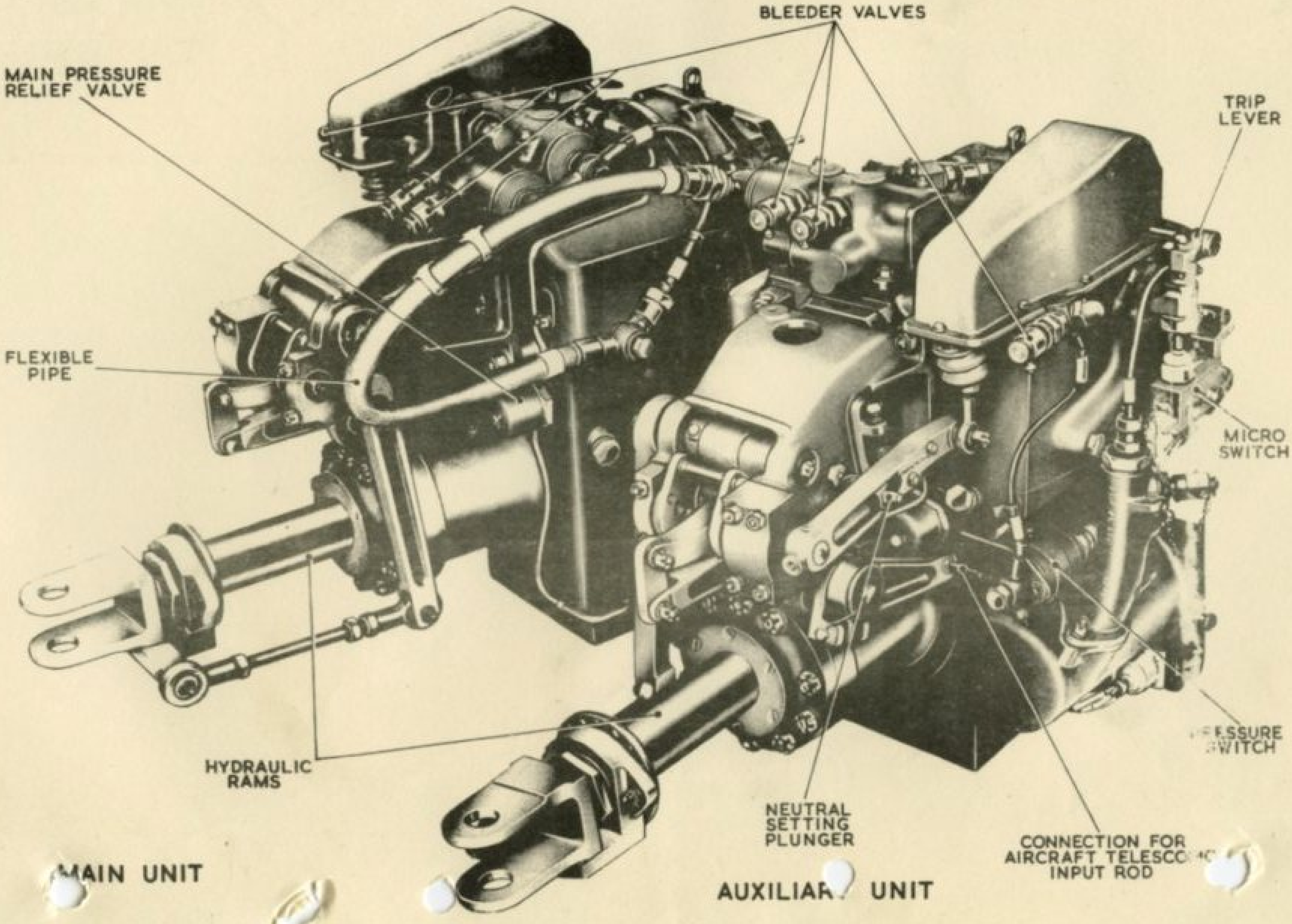
83. Central warning system lights, one at each side, at the top of the pilot's centre instrument panel, energise to amber at the same time as any of the flying controls systems warning lights illuminate on the port console.

Adjacent to the left hand warning lamp are three magnetic "dolls-eye" indicators which serve as reminders, when in the white condition, of a failure of any item in either the power flying system, the articificial feel system and the autostabilizer system.

84. When the faulty channel is isolated by depressing its associatedpush switch, the relative magnetic indicator will show "white" and the two main warning lamps will be extinguished. The warning lamp in the push switch will remain illuminated to identify the faulty channel.

85. A control surface position indicator, in the top centre of the pilot's centre instrument panel, by means of individual needle indicators, show the position of each individual control surface in relation to the aircraft trailing edges.


BLEEDER VALVES
MAIN PRESSURE
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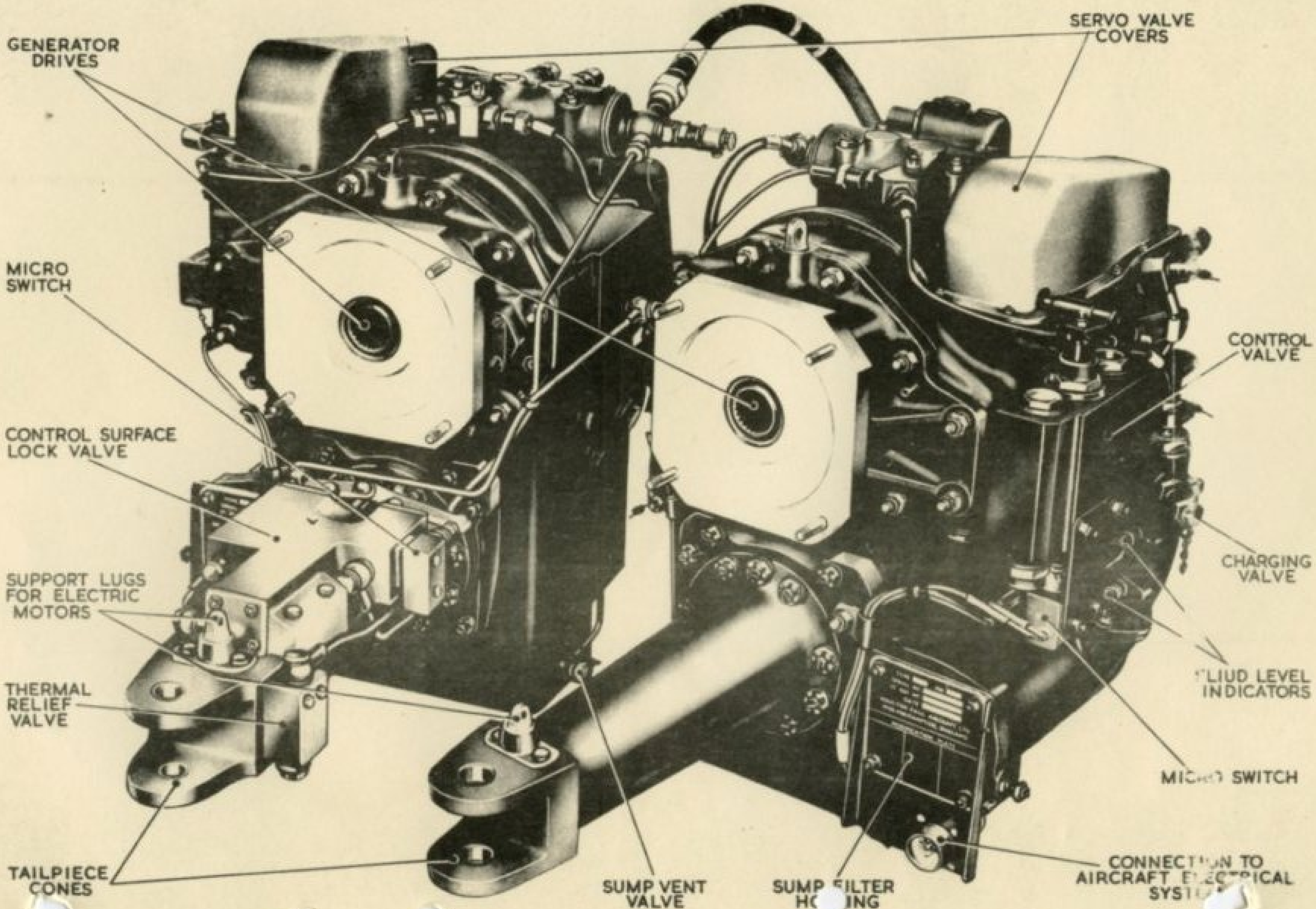
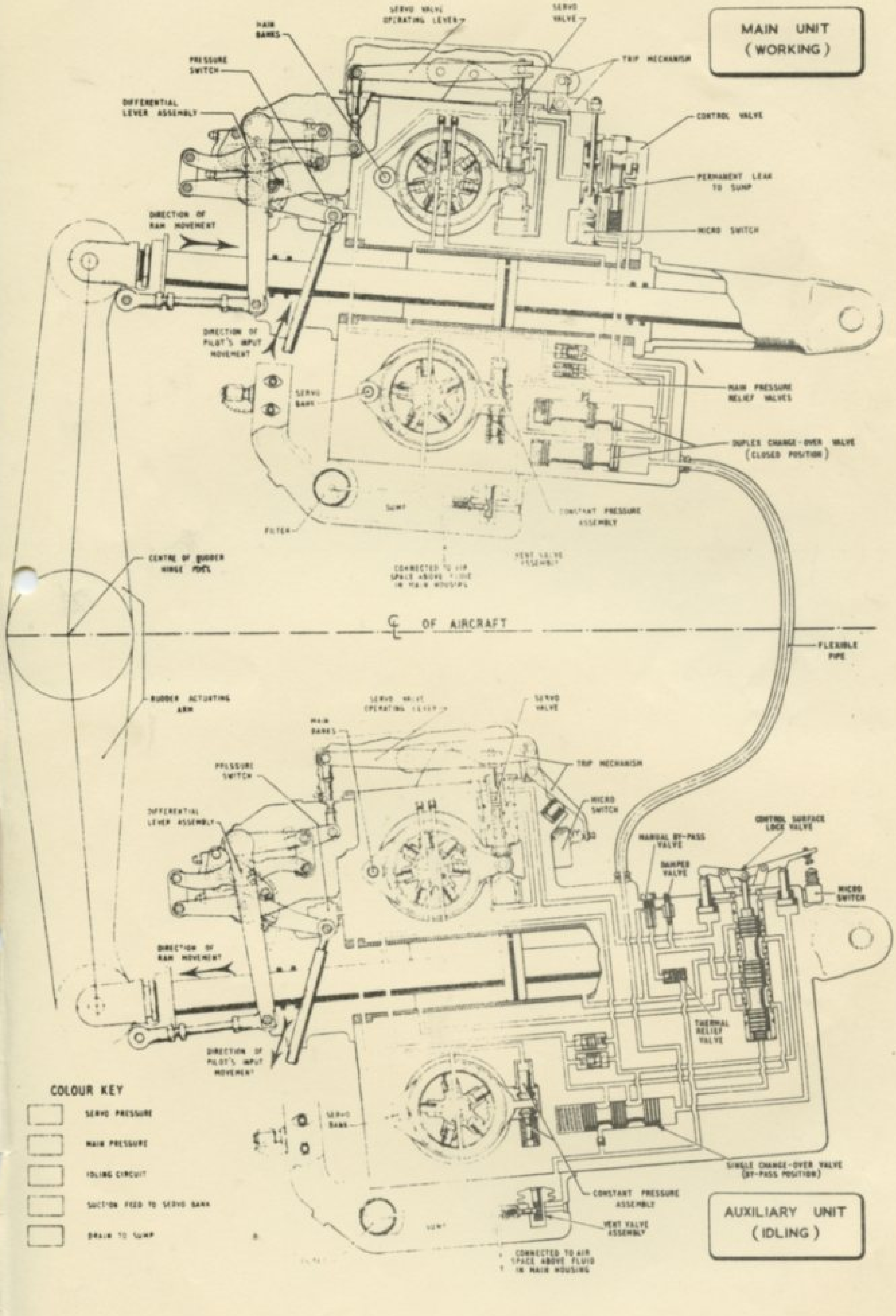
NEUTRAL
SETTING
PLUNGER
CONNECTION FOR
AIRCRAFT TELESCO
INPUT ROD
MAIN UNIT
AUXILIAR UNIT

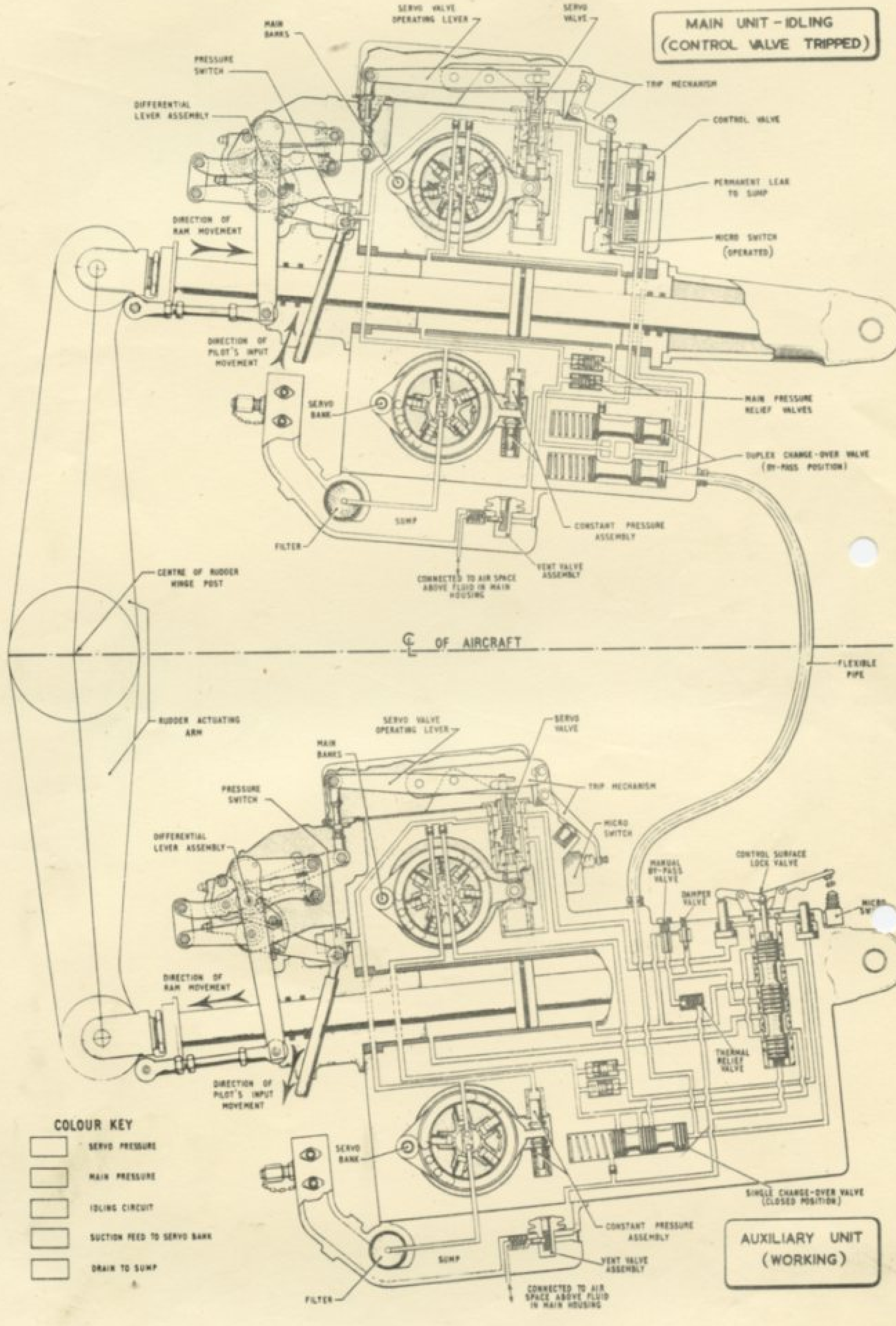


AUXILIARY UNIT

MAIN UNIT



RUDDER DUAL UNIT. P.138



F.138. RUDDER DUAL UNIT. (AUX. WORKING).

JOB No 1919

This Diagram Only

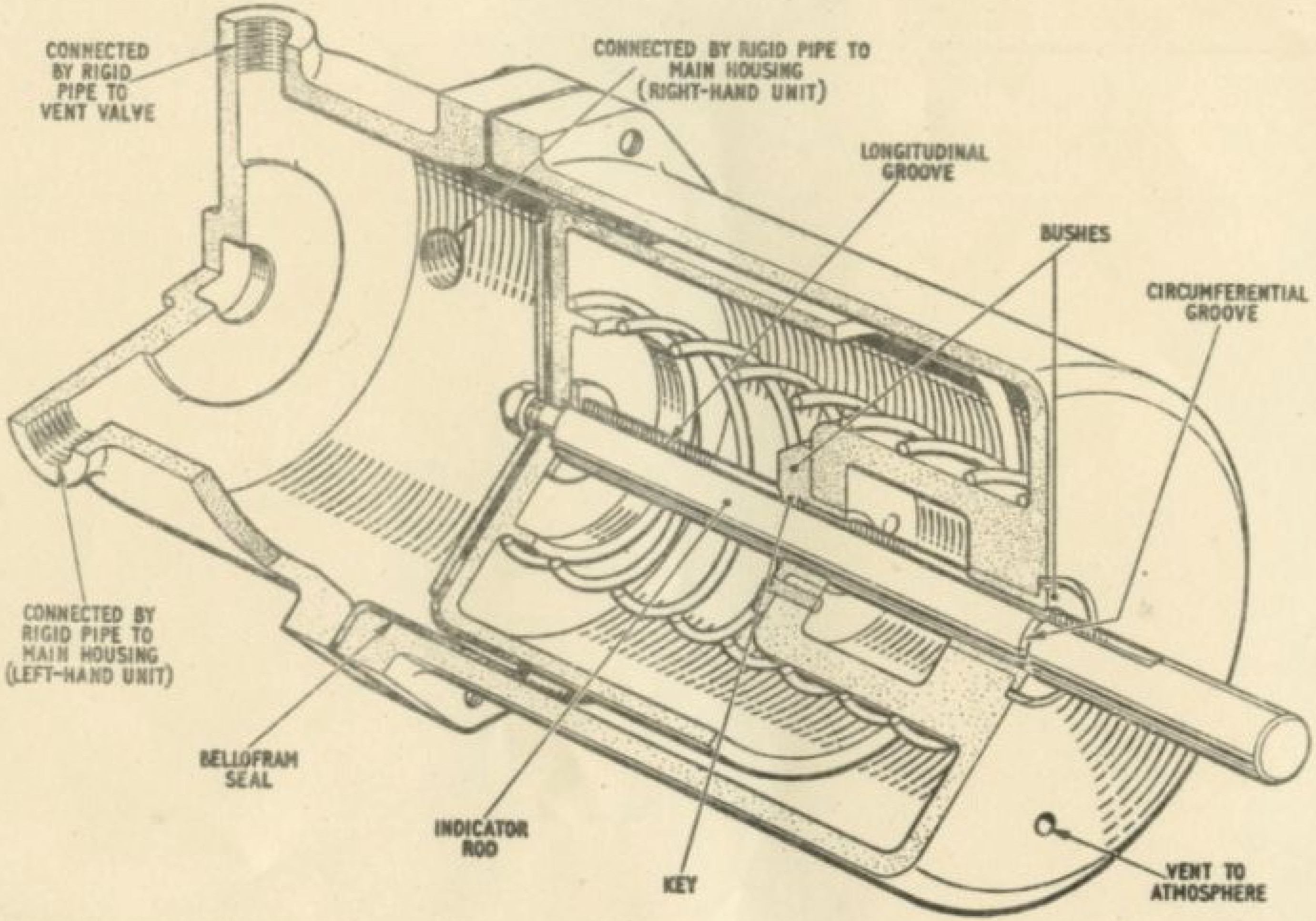


Fig. 1. Expansion chamber

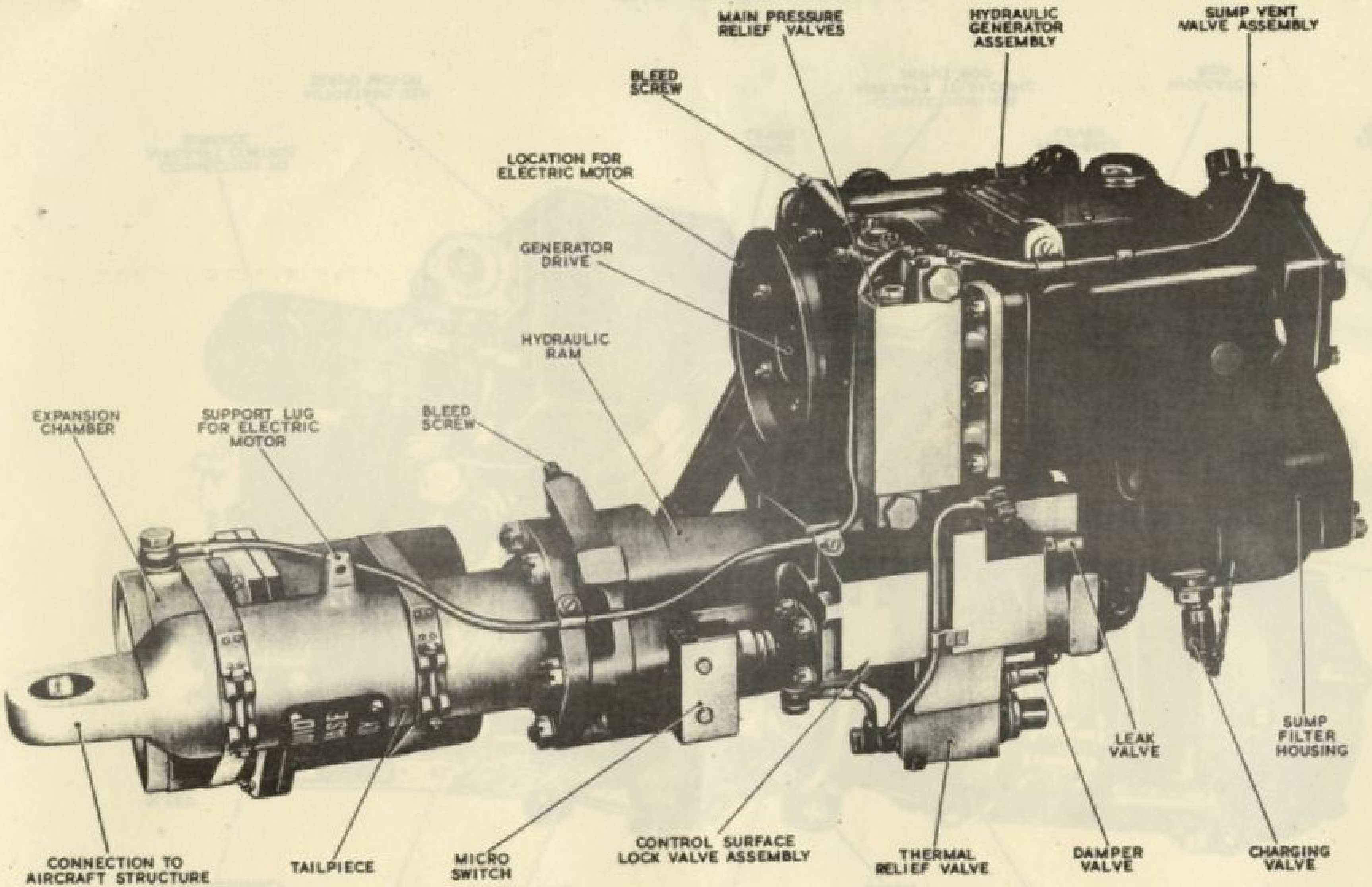


Fig.2. Rear view of left-hand control unit

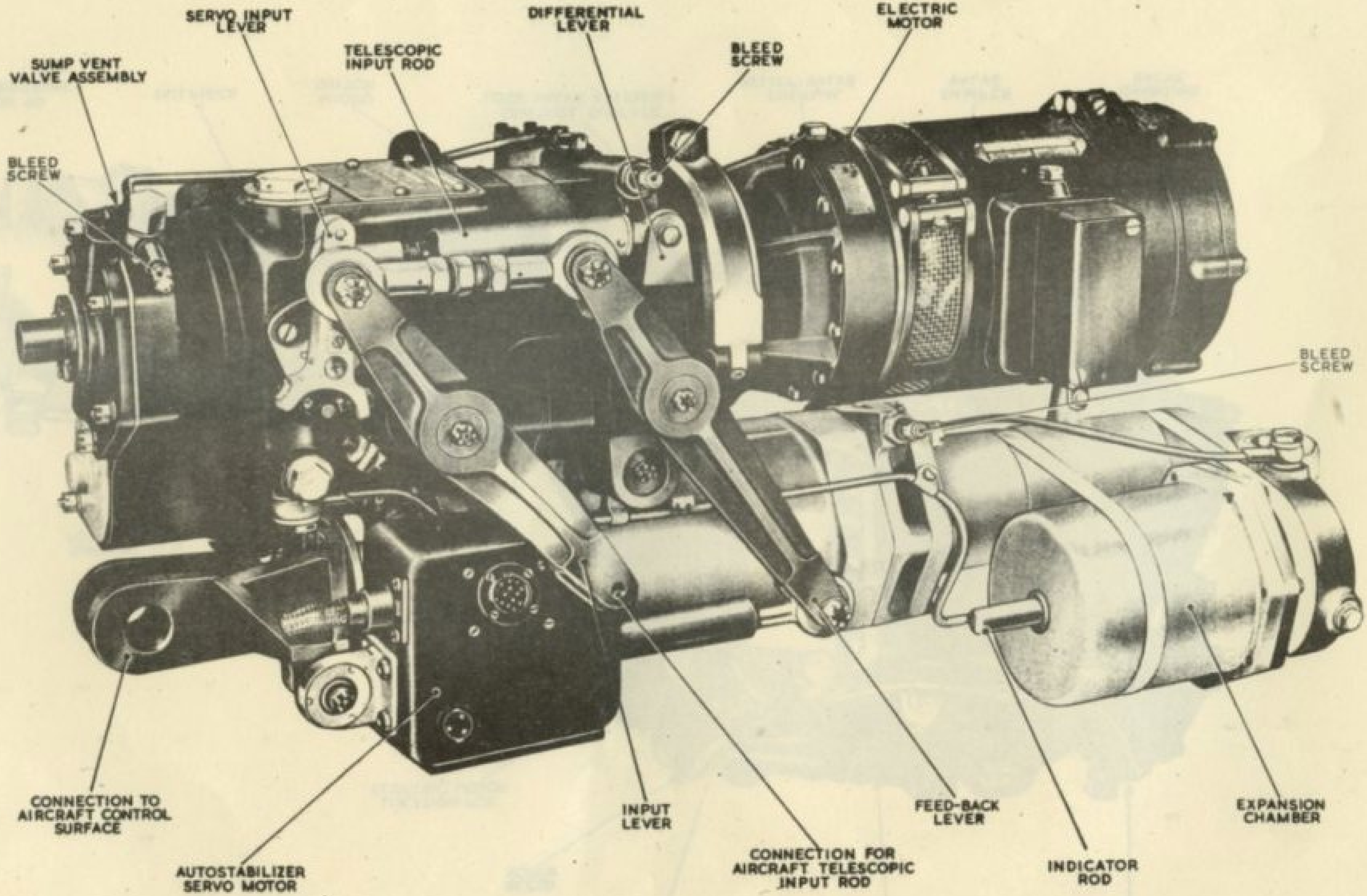


Fig.1. Front view of left-hand control unit

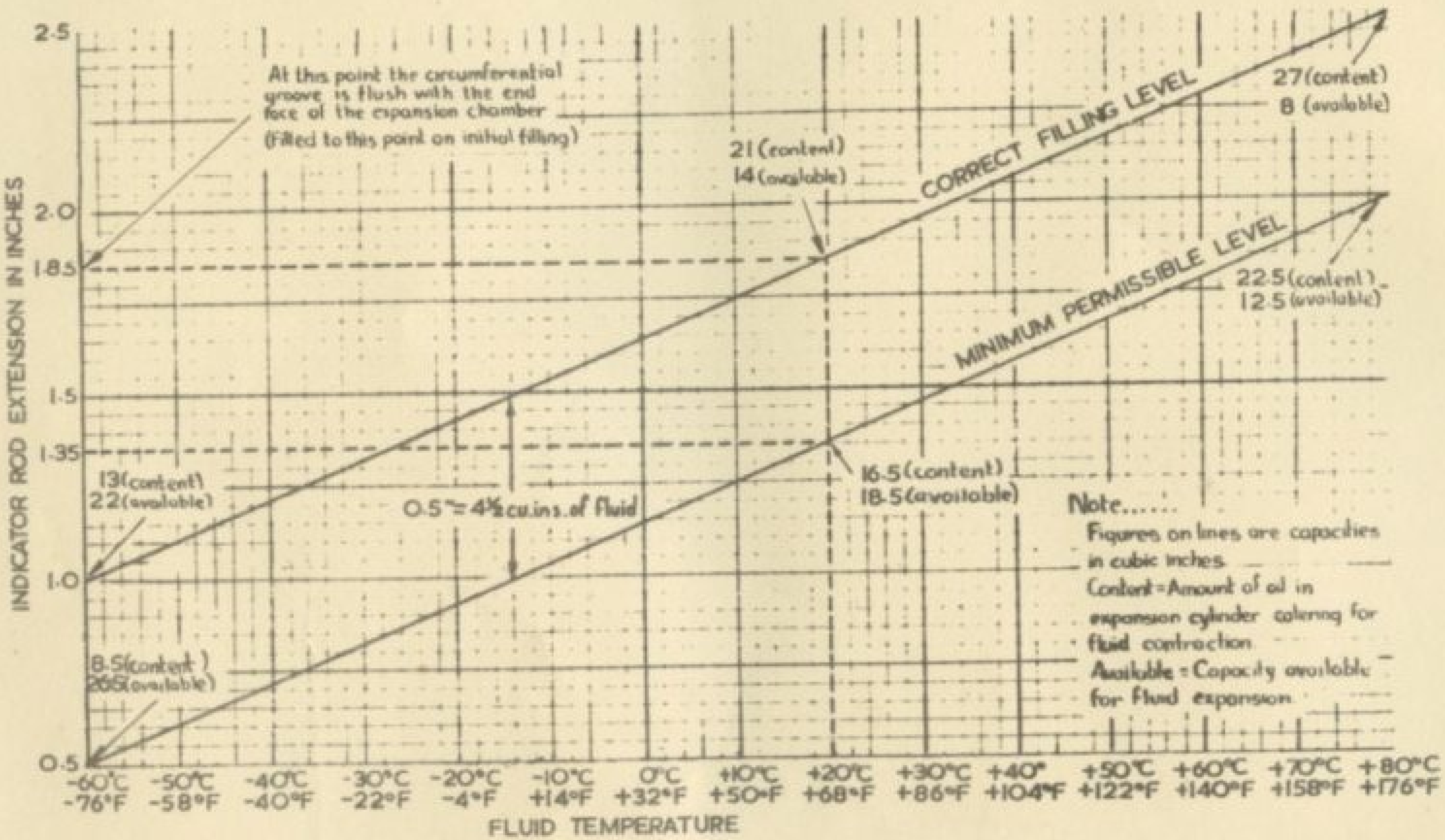


Fig. 3. Filling Details

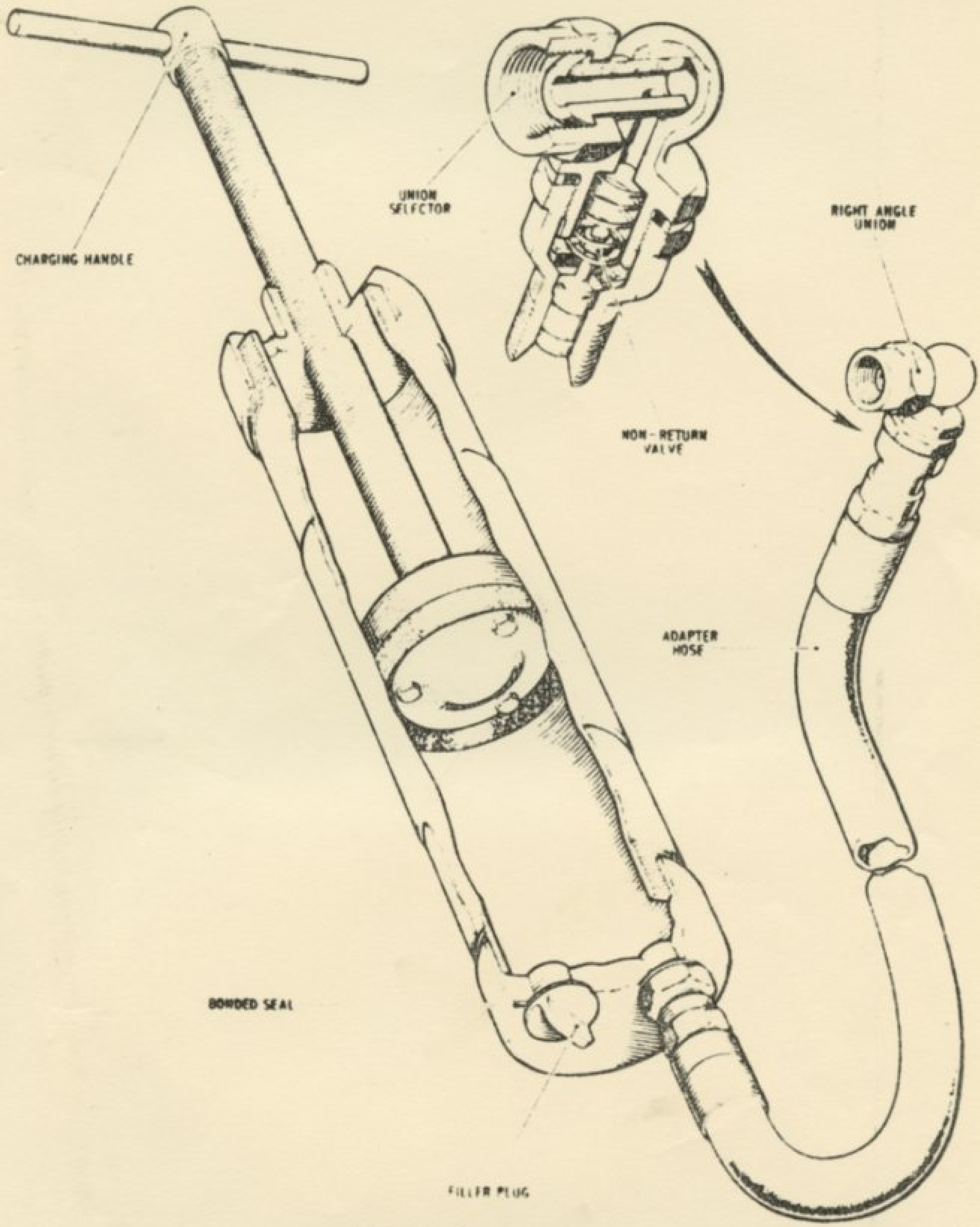


Fig. 4. Special charging gun with adapter

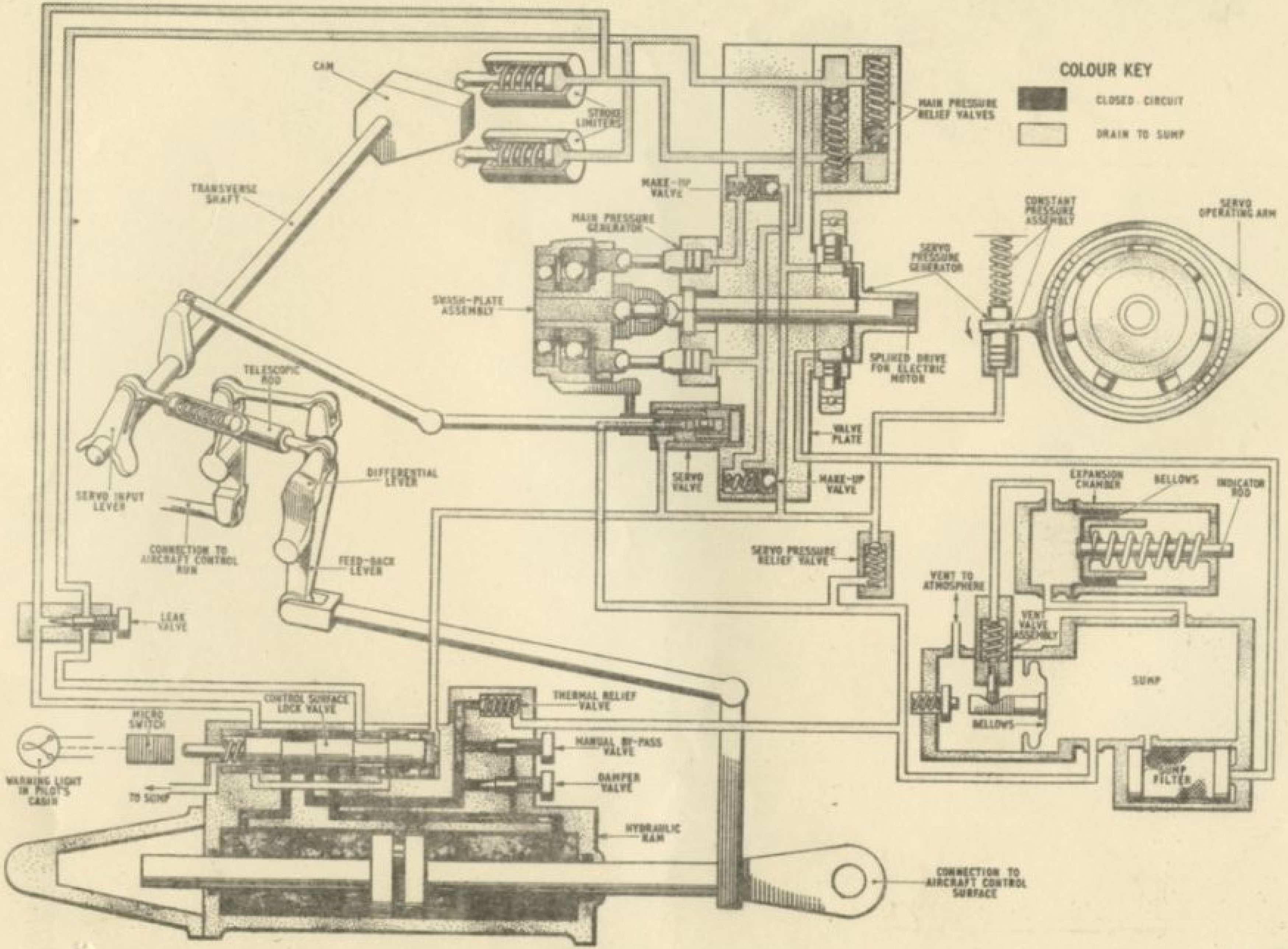


Fig.5. Hydraulic circuit (electric motor switched off)

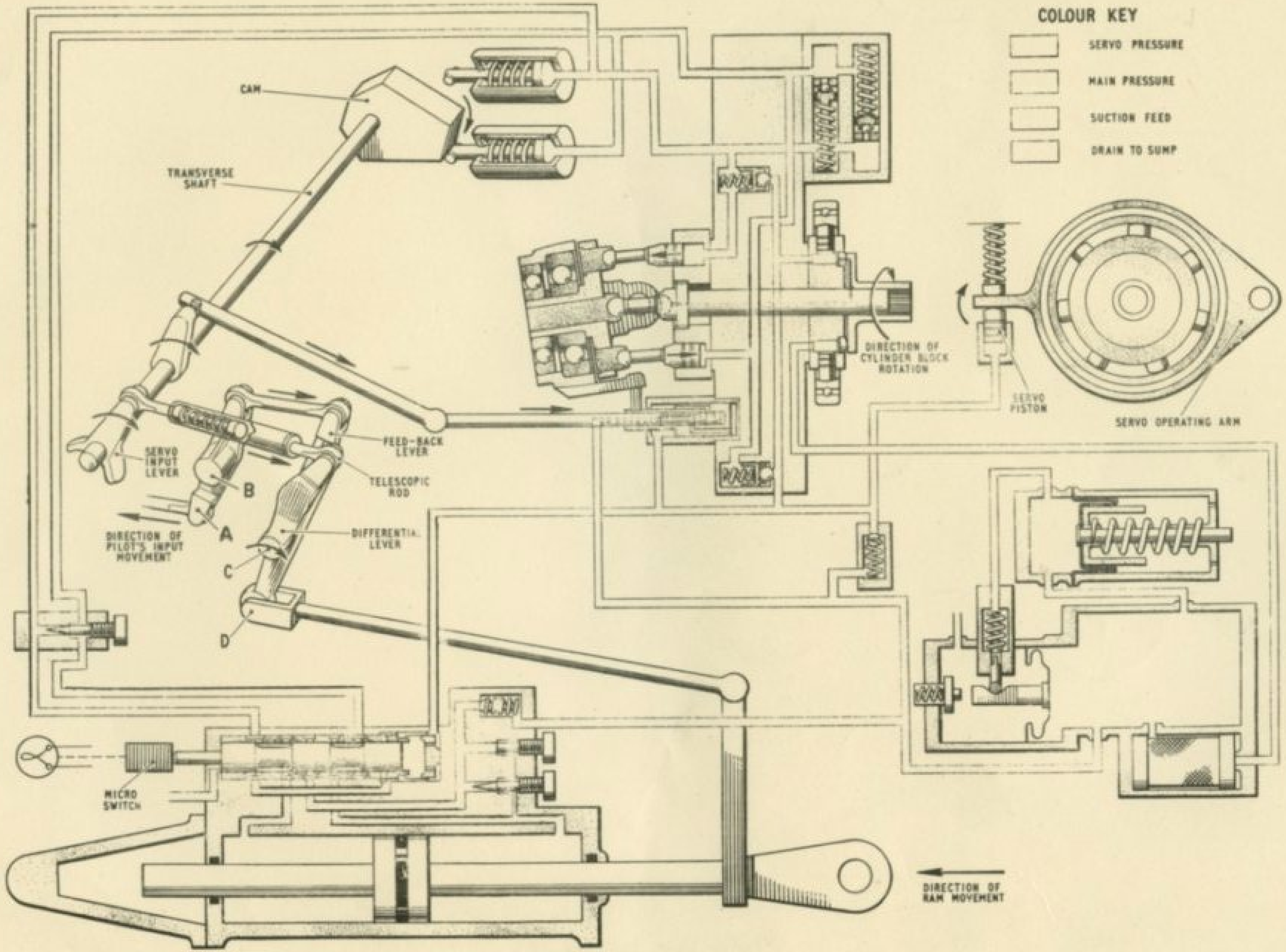


Fig.7. Hydraulic circuit (ram in)

FLYING CONTROLS (AIR BRAKES)

Reference AP 4504B Vol 1, (GENERAL and TECHNICAL INFORMATION VULCAN B MK.2)

INTRODUCTION

1. The air brakes are of the electrically operated slat type, two sets of which are fitted, one port, one starboard, mounted in the centre section above and below the engine air intake structures. Each set consists of two slats above the centre section and one below, no outer slats being fitted on the lower surface.

2. The air brakes comprise of the rotable slats mounted on box section drag posts, the slats being of metal honeycomb construction. Four posts are provided, an upper and lower pair, which when extended or retracted move in opposition to each other in spool type rollers attached to the main structure ribs on either side of the air intake tunnel. Each pair is bolted at its outer ends to a tube which braces the posts together to form a twin post unit, each unit mounting a single slat, hinged and operated by push/pull tubes, and a lever and cam follower housed in each post.

3. This mechanism is functioned by drag post travel, the cam follower travelling in a cam track attached to the rib structure, the drag post extension being controlled by micro-switches.

4. An endless chain assembly is accommodated between the lower and upper pair of drag posts, between an upper drive sprocket and a lower idler assembly. All the drive sprockets are inter-connected by a common drive shaft which extends span-wise in a ball pivoted sections between the sprockets and a motor driven gear box, mounted centrally in the centre section.

5. Operation of the gear box rotates the drive shaft, this movement being transmitted by the sprockets to the chains and drag posts, which are extended or retracted, depending on the direction of sprocket rotation.

CONTROLS

6. Controls for airbrake operation consists of a twin coupled switch on the rear of the throttle pedastel, each switch controlling one of the paired motors mounted in the roof of the bomb bay, forward. These motors operate the airbrakes mechanism via gear boxes located in the bomb bay, on the rib walls, one port, one starboard and extended drive shafts. As the twin switch is coupled simultaneous motor action is ensured, the air brakes moving in accordance with the three positions of the switch, which is marked, IN, - MED. DRAG, - HIGH DRAG. An emergency switch labelled NORMAL - EMERGENCY is also provided and is located on the starboard side of the throttle pedastel, adjacent to the twin switch.

7. A magnetic indicator on the pilots centre instrument panel shows black when the air brakes are fully in.

OPERATION

8. With the airbrake selector switches at the IN position all the drag posts are retracted at the rotatable slats paired into the wing and forming part of the surface contour.

/When MED. DRAG

When MED. DRAG is selected, drag post extension occurs above and below the wing surface and slat rotation occurs, which is tripped by micro-switch action when the slats have rotated through an angle of 35°.

When HIGH DRAG is selected, the motor circuit is restored and the drag posts extended until micro-switch action once again stops the motors when the slats are at an angle of 55°. This angle is achieved when the undercarriage is UP.

If the undercarriage is DOWN when a HIGH DRAG selection is made then the drag posts extend even further, to give a slat rotation of 80°, thus providing maximum braking effect.

9. Extension or retraction of the airbrakes to these positions is effected by the twin selector switch, the initial movement of which causes both motors to drive the airbrakes from the IN position to the drag selected. Further extension or retraction of the airbrakes will be effected by the 'A' motor only, the 'B' motor acting as a standby motor. In event of the 'A' motor failing to operate, changeover to the 'B' motor can be achieved by operation of the emergency switch from the NORMAL position to EMERGENCY.

10. Provision is made for overriding the 80° HIGH DRAG position, when the aircraft if being supported by its undercarriage, by the operation of a switch located in the nose-wheel bay, starboard side, on a small panel bolted to one of the scanner equipment supports.

The operation of this switch, in conjunction with the normal selector switch, will only allow the airbrakes to go to the 55° position, therefore obviating the necessity of having to jack the aircraft and raise the undercarriage to check to 55° circuit. As soon as the switch is released, it is spring loaded back to the 80° circuit condition.