Chapter 6 HYDRAULIC SYSTEM

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DESCRIPTION

1. The hydraulic system operates the nose wheel steering mechanism and the main wheel brakes. The fluid pressure is supplied by two independent electrically-operated pumps. The pump of No. 1 service draws fluid from the outer compartment, and the pump of No. 2 service draws fluid from the inner compartment of the tank mounted on the starboard side in the compartment aft of the pressure cabin.

2. Each pump supplies fluid to the system under the control of a pressure switch and a cut-out valve, and also charges three accumulators, two for the brakes and one for the nose wheel steering. The brake accumulators are initially charged with air to 1,400/1,500 lb/in². The accumulators in the steering circuit are charged with air to 1,700/1,800 lb/in². The pressure in all accumulators rises to 2,300 lb/in. when the accumulators are charged with fluid by the pumps.

3. The pressure control switch starts the pumps running when the pressure in the system drops to 1,900 lb/in², and stops them when the pressure has reached 2,300 lb/in² but in the event of failure of the switch, the cut-out valve cuts in the pump delivery when the pressure has fallen to 2,000 lb/in² and cuts out at 2,500 lb/in², the pumps being kept running continuously.

4. Thermal relief valves are fitted in the supply line to relieve any increase in pressure above the maximum, due to a rise in temperature. A non-return valve fitted in each service prevents the brake accumulator discharging into the steering circuit in the event of a failure in that circuit.

5. A filter and non-return valve are fitted in the return lines from the pumps. The return from pump No. 1 discharges into the tank outer compartment, and the return from pump No. 2 discharges into the tank inner compartment. The return from the brakes system discharges into the outer compartment through a separate pipe but does not pass through a filter.

6. Four air-charging connections and pressure gauges and four pressure-release valves are mounted in the starboard servicing bay. Mod. 1681 introduces two choke valves into the return-to-tank lines from the pressure release valves of service No. 1 and 2. They prevent a transient surge in the pressure system when the pressure release valves are operated. Also fitted in this bay are external connections through which the tank can be refilled and the services operated from a ground-servicing trolley. Pressure test connections are fitted in the lines between the brake control valve and the brakes.

NOSE WHEEL STEERING CIRCUIT

7. The nose wheel is steered by two hydraulic jacks to which fluid is supplied from both services isolated from each other by non-return valves, the feed passing through a control valve mechanically linked to the pilots' steering handwheels. A follow-up gear also connected with the valve, ensures that

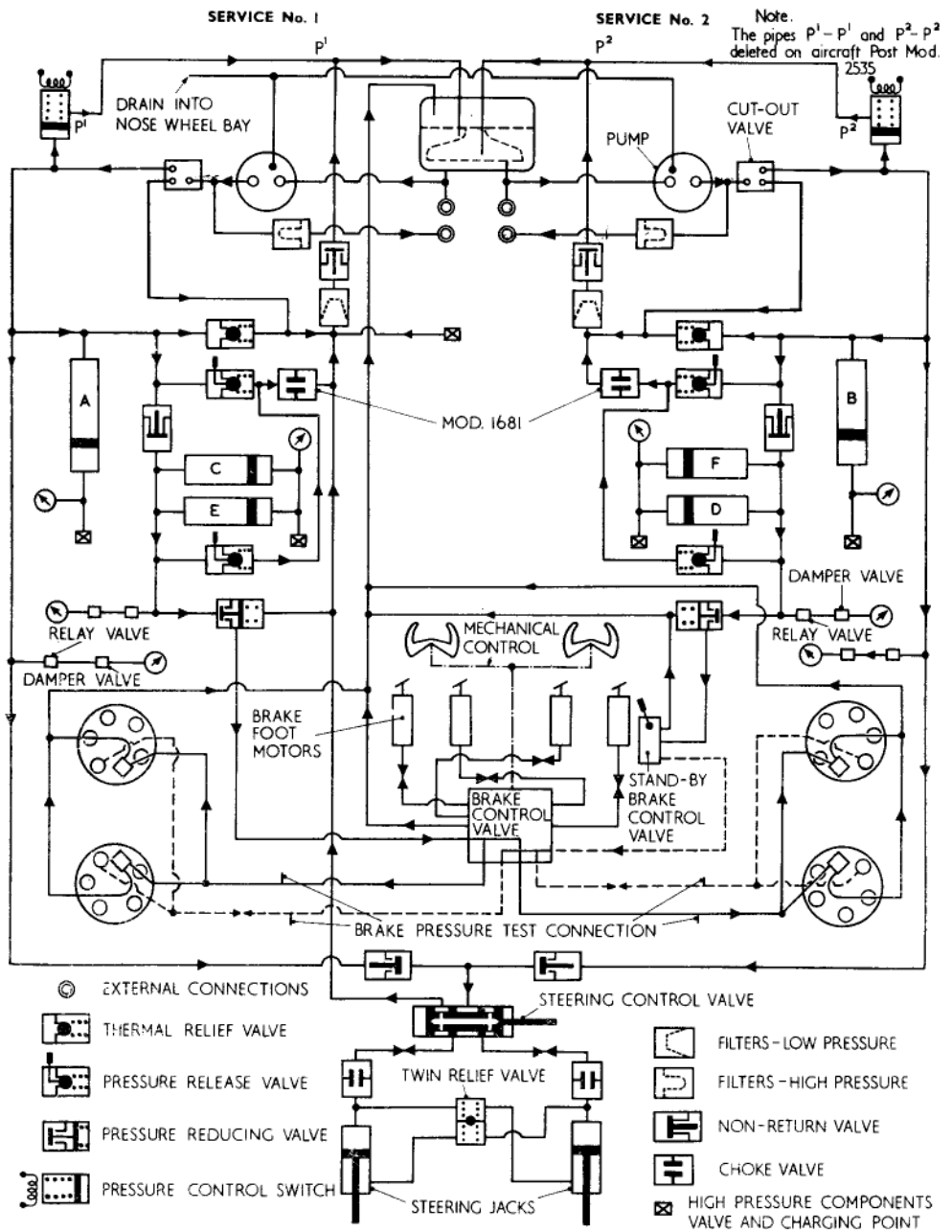

Fig. 1. Hydraulic system diagram

◀ *Note added in respect of Mod. 2535* ▶

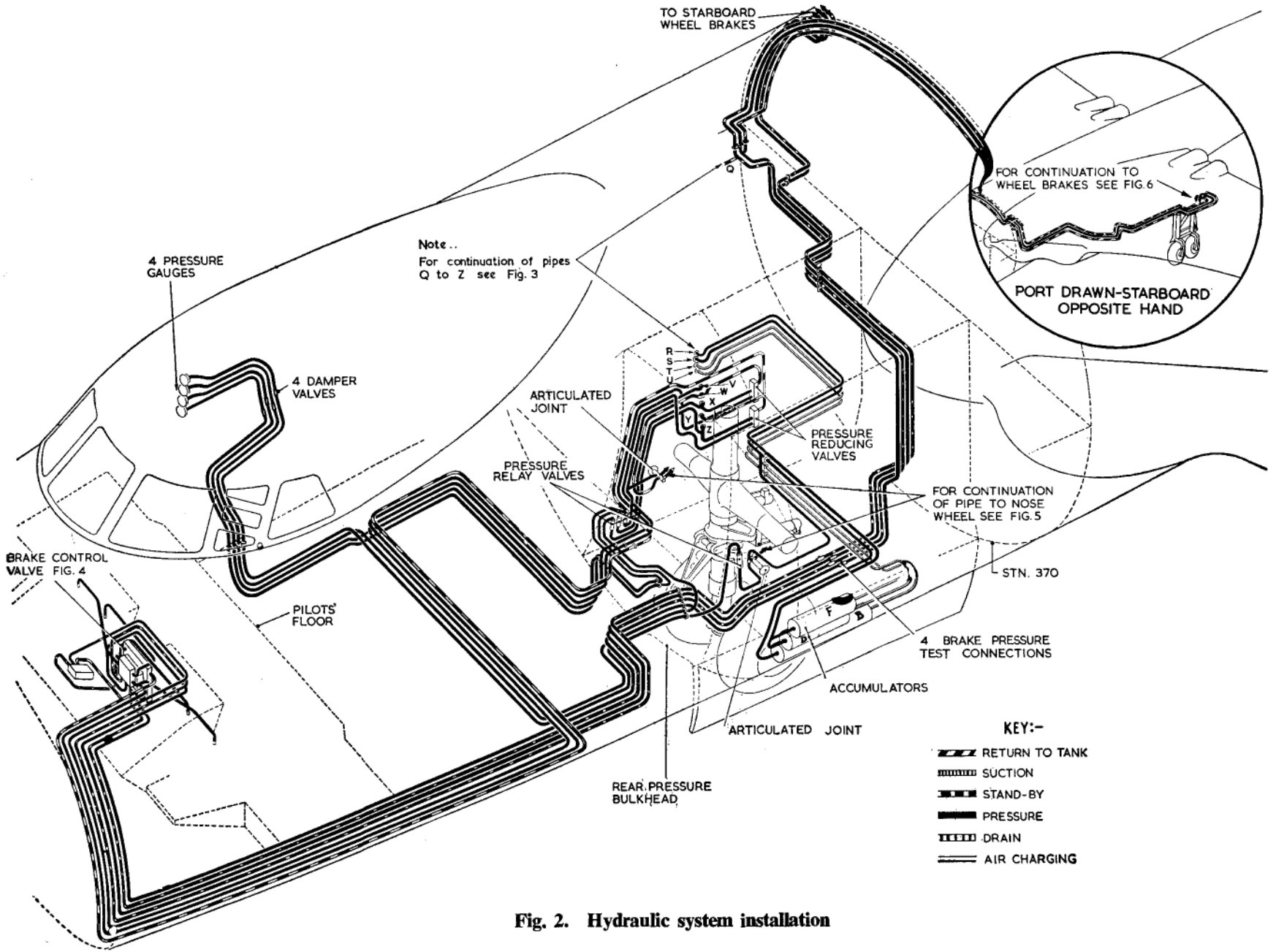

Fig. 2. Hydraulic system installation

the fluid flow ceases as soon as the nose wheel has reached the position selected on the steering handwheel.

8. A choke valve is fitted in each line between the control valve and the jacks to damp the flow. A two-way relief valve is connected across the jacks to allow any excessive pressure to be passed from one side of the jacks to the other.

9. The jacks are connected to the steering head and are mounted in brackets on the oleo cylinder. When either pilot's steering wheel is rotated, the movement is transmitted through the control valve centralizer to the control valve spindle, which permits fluid to flow to the jacks. The fluid flows to the forward end of the jack on one side and to the aft end of the jack on the other side, resulting in the rotation of the steering head.

10. The follow-up mechanism returns the control valve spindle to neutral when the angle of turn is obtained. This is done through cables and chain between the steering head and the control valve centralizer. The maximum turning angle is 50 deg. on each side.

BRAKE CIRCUIT

11. The brake accumulators in Service No. 1 supply fluid to No. 1 inlet connection on the brake control valve, and the accumulators in Service No. 2 supply fluid to No. 2 inlet connection ◀via the stand-by brake change-over valve▶; a pressure-reducing valve is fitted in each line from the accumulators to the brake control valve. The steering accumulators also feed the brakes, but a non-return valve is fitted to prevent the brake accumulators discharging into the steering circuit. The return pipe from the brake control valve is taken to the tank outer compartment.

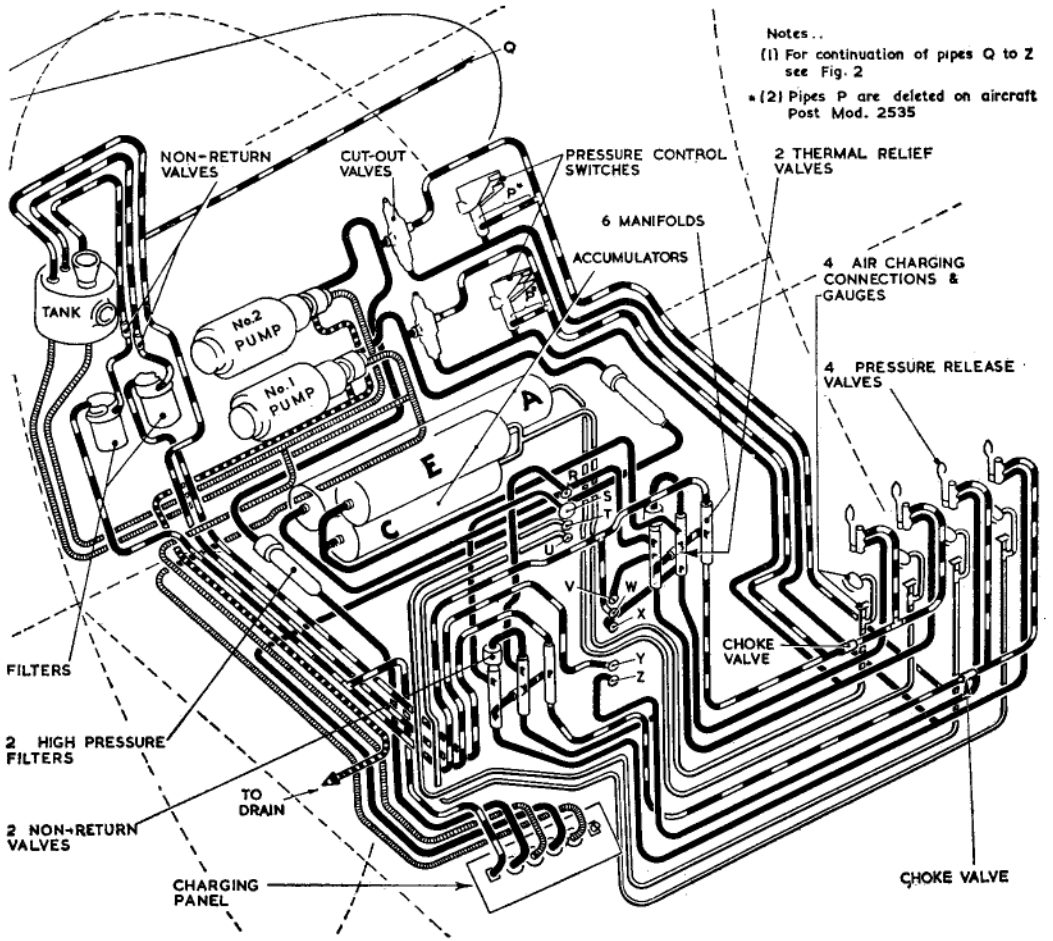

Fig. 3. Equipment in servicing bay

12. The four outlets of the brake control valve supply fluid pressure to the wheel brakes, which are operated by five ◀jack units on each brake assembly, from either No. 1 or No. 2 Service. The normal (No. 1) Service is routed through Maxaret units on each brake assembly to the five jack units; the emergency (No. 2) Service, by-passing the Maxaret units, is connected direct to the jack units. The brake assemblies are fully described in A.P.2337, Vol. 1, Book 2, Sect. 3, Chap. 2, App. 15.▶

13. The brake control valve is actuated by both hand and foot controls. The hand control levers on each pilot's control wheel provide mechanical operation of the brake control valve in such a manner that application of either pilot's hand levers operates port and starboard brakes simultaneously. Control of the brake control valve is by pedals which move pistons acting on closed circuits piped to hydraulic actuators on the valve. The flow from the valve is so arranged that application by either pilot of his left or right pedal will operate port or starboard brakes respectively, thus giving differential braking for steering. Differential braking for steering by the pedals cannot be used at the same time as the hand control is applied.

14. Pressure-release valves are incorporated in the system and pressure gauges on the pilot's instrument panel indicate the pressure in the systems.

Stand-by brake circuit change-over valve

15. ◀The brakes are operated by two independent supplies to the brake control valve. Should the normal supply fail operation of the stand-by brake control allows the supply from No. 2 Service to be used for full braking without anti-skid protection. This valve is controlled by a lever on the rear of the control pedestal; when lifted out of the gate and moved to the left, the lever allows fluid from No. 2 Service to reach the brake control valve.▶ The operation of the change-over valve does not in itself apply brake pressure to the wheels; the normal brake control must be used.

LOCATION OF EQUIPMENT

16. Table 1 shows the location of the various components of the hydraulic system.

17. The layout of the hydraulic system is shown in fig. 2. The fluid used is quoted in the Leading Particulars at the front of this Volume. Reference should be made to Sect. 1, Chap. 1, for location of hydraulic controls and operational details.

18. In all servicing operations absolute cleanliness is essential. Fluid containers and utensils used for filling or draining must be scrupulously clean. The level of the fluid in the tank should be maintained at its correct mark as indicated on the sighting glass built into the side of the tank.

19. Whenever a pipeline is disconnected the union and the end of the pipe must be blanked off to prevent the ingress of dirt. Drain plugs or other components which have been removed during servicing, must be thoroughly cleaned before being refitted. Whenever a pipeline has been disconnected a functional test must be made. Table 1 gives the location of the components in the system. Table 2 will be found useful when tracing hydraulic piping in the aircraft. Where piping passes through a bulkhead, the code denoting its service is painted adjacent to the pipe. All hydraulic piping is identified by a broad white band.

SERVICING

DRAINING

20. If it becomes necessary to remove any component from the system or to disconnect any pipe, as much fluid as possible must be drained off. The normal fluid supply in the tank and most of the fluid in the piping can be drained off by opening the suction connections on the servicing panel and using a draining pipe.

21. Vokes type filters are fitted in the return-to-tank lines from No. 1 and 2 Services; they are mounted together on the starboard side of the fuselage in the compartment aft of the pressure cabin. Provided scrupulous care has been taken to use clean fluid, the filter should not require very frequent attention. When necessary, however, the filter elements can be removed, cleaned and replaced in the authorised manner as described in A.P.1464D, Vol. 1, Part 2, Sect. 3, Chap. 19 (post-Mod. 1243 aircraft). Before removing a filter from the aircraft, drain the system (*para.* 20), and drain the remaining fluid from the filter body, using the drain plug provided.

22. The filter fitted in the neck of the fluid tank should be periodically removed and cleaned. High pressure filters are also fitted in the pressure lines from the charging panel. These should be examined periodically and cleaned when necessary.

23. The tank should normally require no attention, but to allow for cleaning, it is provided with a hand-hole in the top. Before removing the hand-hole cover, drain the tank (*para.* 20) and remove it from the aircraft.

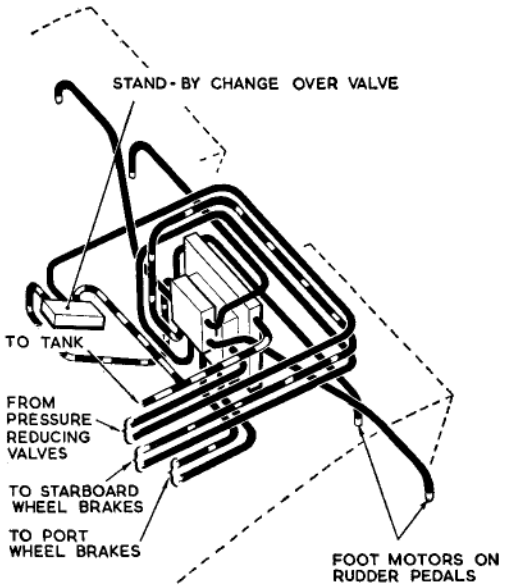

Fig. 4. System at brake control valve

FILLING THE SYSTEM

24. The system must be filled with the correct fluid as detailed in the Leading Particulars. The method of filling is described in Sect. 2, Chap. 2, of this Volume, the tank capacities being as follows : —

Capacity of tank to high level (including 0·97 gall. in inner compartment)	2·9 gall.
Capacity of tank to low level	2·0 gall.
Total capacity of tank (including air space)	4·2 gall.

SUCTION PIPE FLOW TEST

25. Before priming the system, ensure that the tank contains a supply of fluid, then check for freedom of flow in the suction line from the tank to the pump for both No. 1 and 2 Services by disconnecting the suction pipe at each pump in turn and ensuring that a flow of fluid occurs at each pipe.

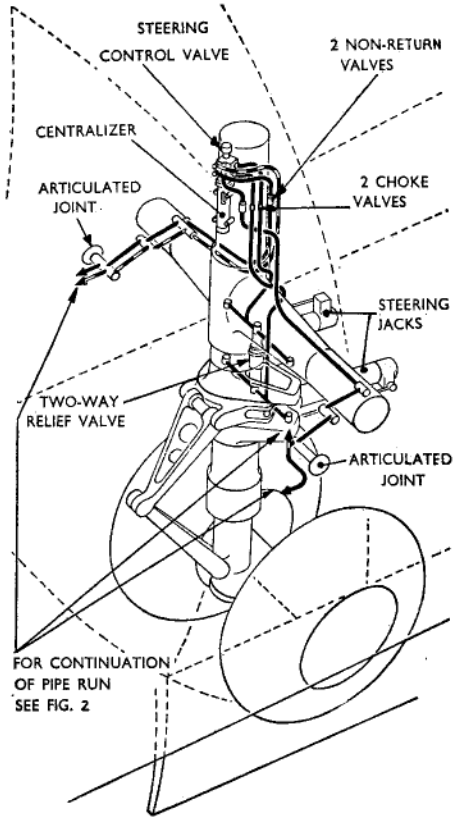

Fig. 5. Piping on nose undercarriage

PRIMING PROCEDURE

Main circuit

26. For a new system, or one that has been drained or partly drained for the removal of any pipe or component, the following action should be taken to bleed the system of air.

Note . . .

During priming, the tank must be kept topped up to the correct level. The pump motors must not be run continuously for more than 20 *minutes on load.*

(1) Charge the accumulators with air to the pressures stated on the instruction plate on the external charging panel.

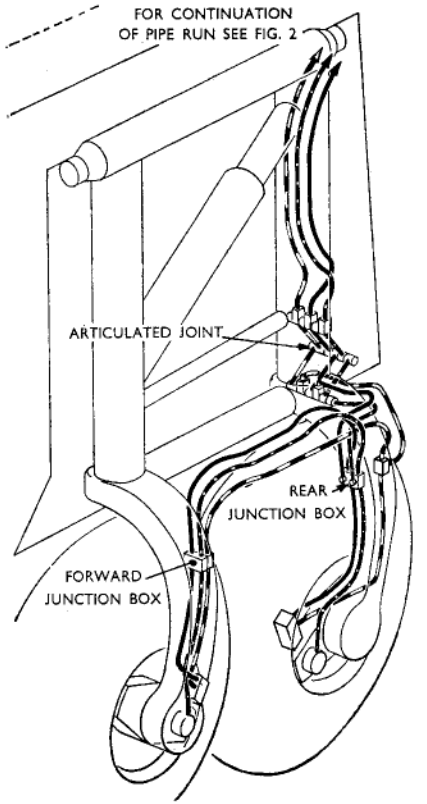

Fig. 6. Piping on main undercarriage

(2) Using an external ground test rig connected to the charging point in the external servicing panel, charge the tank to the HIGH LEVEL mark (*Sect.* 2, *Chap.* 2).

(3) Bleed at the bleed screws on each pump until a clear flow of fluid occurs.

(4) Switch on the pump of Service No. 1 and operate the nose wheel steering approximately 20 cycles and bleed the steering jacks and two-way relief valve. (There is one bleed screw at the top side of each jack and one on the relief valve). Switch off the pump.

(5) Switch on the pump of Service 2 and repeat as in (4).

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(6) To bleed each gauge in turn, first release any pressure in the system by operating the release valves situated on the external servicing panel. Disconnect at the inlet connection to the relay valve and open the connection at the gauge. Fit and tighten the bleed clamps, make good the relay valve joint and, after pressurizing the system, bleed at connections adjacent to the gauges, using a rubber tube to transfer the fluid to a clean container until a clear flow occurs. Disconnect and remove the bleed clamp and make good the connections.

Brake circuit

27. To prime the brake circuit proceed as follows:—

(1) Fit a length of rubber pipe to each bleed screw on each brake unit and run the pumps to charge the accumulators. Switch off the pumps and release the pressure from No. 2 service. Operate the brakes and bleed from each bleed screw in turn until a clear flow of fluid occurs. Tighten and lock the bleed screws.

(2) Run the pumps to charge the accumulators. Switch off the pumps and release the pressure from No. 1 service. Move the stand-by brake lever to the left. Operate the brakes and bleed from each bleed screw in turn until a clear flow of fluid occurs. Tighten and lock the bleed screws. Move the stand-by brake lever to the right, the normal position.

(3) Bleed the gauges as described in para. 26 (6).

Brake control valve operating system

28. The hydraulic system from the foot pedals to the brake control valve is entirely separate from the main hydraulic system and in order to charge it with fluid the following procedure must be carried out:—

(1) Open the two bleed screws on the control valve. Remove the plugs on the port outer and starboard inner pedal cylinders and fill them with fluid. Depress the port outer foot pedal and, keeping it depressed, check that a clear flow of fluid occurs at the relevant bleed screw on the control valve. Close and lock the bleed screw and release the foot pedal.

(2) Top up the pedal cylinders and repeat the procedure as in (1).

(3) Proceed by bleeding the starboard inner cylinder and, when completed, screw down the bleed screw and lock.

(4) The port inner and starboard outer cylinders can be bled in the same way. An indication that all four cylinders are full of fluid is that the foot pedals feel solid and free from sponginess when operated.

GROUND TESTING

29. The four pressure gauges in the cockpit should read 2300±50 with the pumps idling When the system is operating normally the pressure switches are in control, but if the pressure switches fail, the cut-out valves will control the system.

(1) Disconnect the electrical power to the pressure switches and test each service using the cut-out valves as governors. Cut in pressure should read 2 000±50 lb/in², and the cut-out pressure $2\,500^{+0}_{-100}$ lb/in². Reconnect the pressure switches and check the cut-in and cut-out pressures which should be $1\,900^{+0}_{-200}$ lb/in² and 2 300±50 lb/in² respectively.

(2) Test the nose-wheel steering and the brakes by using each service in turn. Fit gauges and Turner adapters at the test connections in the lines between the brake control valve and the brake units. With the change-over lever set to NORMAL, operate the brakes; the gauges should read No. 1 Service, $1\,500^{+150}_{-0}$ lb/in² and No. 2 Service zero. With the lever set to STANDBY, both services should read $1\,500^{+150}_{-0}$ lb/in² when the brakes are operated.

(3) Check all pipe joints and valves, etc., for leaks.

(4) With the pumps off, operate the pressure-release valves and check the air pressure in the accumulators; 12 hours after charging the drop in pressure should not exceed 250 lb/in². This test can be carried out in conjunction with the brake parking test.

Note . . .

The pressure switches and cut-out valves should not operate at less than 5-minute intervals when the system is idling. If they do, then check the valves and the system for internal leaks.

Brake parking test

30. The brake system must be capable of maintaining a hydraulic pressure and not lose more than 250 lb/in² in 12 hours with an initial pressure of 2 300 lb/in² approx.

Brake pad wear

31. Wear at the brake pads is fully dealt with in A.P.2337, Vol. 1, Book 2, Sect. 3.

Table 1

Component location

Component	Ref.	Location	A.P.	Vol.	Sect.	Chap.
Rotax electric motor and gearbox (2)	C.7601	In compartment aft of cabin, starboard side	4343D	1	—	—
Lockheed pump (2)	Pre-Mod. 1468 Mk. 7, AIR.41000 Post-Mod. 1468 Mk. 9, AIR. 68000	Mounted on electric motor	1803B	1	2	2
Lockheed pump adapter (2)	AIR.34524	On Lockheed pump	1803B	—	—	—
Gasket	ADS.33G	On Lockheed pump	—	—	—	—
Gasket	ADS.254B and H	On Lockheed pump	—	—	—	—
Gasket	ADS.32L and U	On Lockheed pump	—	—	—	—
Lockheed cut-out valve (2)	AIR.40020	Forward of hydraulic charging panel	1803B	1	10	2
Lockheed accumulators (2)	AIR.70134	One port and one starboard in compartment aft of cabin	1803B	1	5	1
Thermal relief valve (2)	AIR.41724	One port and one starboard in compartment aft of cabin	1803B	1	10	14
Pressure release valve (4)	AIR.41726	Starboard side of fuselage	1803B	1	7	7
Dunlop accumulators (4)	Pre-Mod. 1432, AC.11698 or AC.12846 Post-Mod. 1432, AC.14046	Two port, two starboard in compartment aft of cabin	1803S	1	4	1
Pressure relay valve (4)	Pre-Mod. 1840, ACM.15698 Post-Mod. 1840, ACM.18570 or ACM.18798	Nose wheel bay	1803S	1	8	2
Bleed clamp	ACO.5928	One stowed in cabin adjacent to gauges	1803S	1	8	2
Pressure reducing valve (2)	AC.12148	Nose wheel bay	1803S	1	8	4
Brake control valve	Pre-Mod. 2632, AC.13706 Post-Mod. 2632, AC.13764	Under pilots' floor	1803S	1	7	3
Foot motor (4)	Post-Mod. 2487, ACM.19302 ◀ Post-Mod. 3207 ACM.22890 ▶	Pilots' cockpit	1803S	1	3	2
Brake assy. (Fwd. Stbd.)	AH.50287	Starboard wheel (front)	2337	1	3	2
Brake assy. (Rear Port)	AH.50287	Port wheel (rear)				Appx. 1
Brake assy. (Fwd. Port)	AH.50286	Port wheel (front)				
Brake assy. (Rear Stbd.)	AH.50286	Starboard wheel (rear)				
Vokes filter	E30L/1/7915	Starboard side of compartment aft of cabin	1464D	—	—	—
Vokes filter	E60L/1/7915					

Table 1

Component location—(*continued*)

Component	Ref.	Location	A.P.	Vol.	Sect.	Chap.
Avery external connection Avery external connection Avery external connection Avery external connection	AVA.58D AVA.64D AVA.55F AVA.64F	Starboard servicing bay	1464D	1, Pt. 2	3	9
High pressure components valve and charging connection	Pre-Mod. 1111 AGS.1200 Post-Mod. 1111 A.57	Starboard servicing bay	4303Z	1	4	—
Pressure gauge 0–3000 lb/in² (4)	6A/2691 and 6A/2775	In pilots' cockpit	1275A	—	—	—
Pressure gauge 0–3000 lb/in² (4)	6A/2991 and 6A/2771	In starboard servicing bay	1275A	—	—	—
Pressure gauge damper valve (4)	6A/1230	Below gauges in cockpit	1275A	—	—	—
Pressure control switch (2) ◄	Pre-Mod. 1695 A.5308 Sht. 1	In starboard servicing bay	1803N	1	7	8
	Post-Mod. 1695 and Pre-Mod. 2535 A.5738 Sht. 1		1275A	1	24	Sub-Sect. A ►
	Post-Mod. 2535 Teddington FPH/A/6					
Non-return valve (2)	A.5179–D	Starboard servicing bay	1803N	1	7	7
Non-return valve (2)	A.5298–C	Starboard servicing bay	1803N	1	7	11
Non-return valve (2)	A.5298–B	On nose oleo leg	1803N	1	7	11
Choke valve (2)	A.5382	On nose oleo leg	1803N	1	7	10
Choke valve Mod. 1681 (2)	A.5368–1	In compartment aft of cabin, starboard side				
Twin relief valve	66026 Sht. 7	On nose oleo leg	1803N	1	7	9
Steering jacks (2)	66026 Sht. 5	On nose oleo leg	1803N	1	8	28
Steering control valve	A.5199 Sht. 1	Nose wheel bay	1803N	1	6	13
Steering control centralizer	66026 Sht. 27	Nose wheel bay	1803N	1	6	12
Hydraulic tank	67385 Sht. 3	On starboard side in compartment aft of cabin	1803N	1	3	11
High pressure filter (2)	A.5071	Starboard servicing bay	1803N	1	5	1
Dunlop Maxaret unit (1)	AC.11512	Starboard rear wheel				
Dunlop Maxaret unit (1)	AC.11514	Starboard forward wheel				
Dunlop Maxaret unit (1)	AC.11516	Port forward wheel	1803S	1	—	—
Dunlop Maxaret unit (1)	AC.11518	Port rear wheel				
Brake test gauge connections (4)	67487 Sht. 23	Nose wheel bay				

Table 2

Hydraulic system piping code

Code	Description	Service No.
B1	Tank to pump and external connection	1
B2	Pump to cut-out valve and external connection	1
B6	Return to tank via cut-out valve and pressure release valve	1
B8	Brake control valve to port brake	2
B9	Brake control valve to port brake	1
B10	Brake control valve to starboard brake	2
B11	Brake control valve to starboard brake	1
B12	Stand-by change-over valve and brake control valve return to tank	2
B15	Cut-out valve to the pressure switch, release valve, thermal relief valve, accumulator A, pressure gauge and steering control valve	1
B18	Steering control valve to steering jack	
B19	Steering control valve to steering jack	
B27	Cut-out valve to the pressure switch, release valve, thermal relief valve, accumulator B, pressure gauge, steering control valve	2
B28	Non-return valve to accumulators D and F, release valve, pressure reducing valve, pressure gauge	2
B29	High pressure components valve and gauge to air side of accumulators A ...	1
B30	High pressure components valve and gauge to air side of accumulator B ...	2
B31	High pressure components valve and gauge to air side of accumulators C and E	1
B32	High pressure components valve and gauge to air side of accumulators D and F	2
B33	Non-return valve to accumulators C and E, release valve, pressure reducing valve, pressure gauge	1
B34	Pressure reducing valve to brake control valve	1
B35	Tank to pump and external connection	2
B36	Pump pressure to cut-out valve and external connection	2
B37	Return to tank via cut-out valve and pressure release valve	2
B38	Pressure reducing valve to stand-by change-over valve and brake control valve	2
B39	◄ Return to tank from pressure switch (pre-Mod. 2535)	1
B40	Return to tank from pressure switch (pre-Mod. 2535) ►	2
B45	1st. pilot's starboard foot motor to brake control valve	
B46	1st. pilot's port foot motor to brake control valve	
B47	2nd. pilot's starboard foot motor to brake control valve	
B48	2nd. pilot's port foot motor to brake control valve	
B49	Return to tank from Maxaret brake units	1

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