CHAPTER 6 HYDRAULIC SYSTEM

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Introduction

1. The hydraulic system operates the alighting gear, wheel brakes, air brake, landing flaps and power-operated ailerons and elevators. High pressure air bottles are provided for the emergency operation of the alighting gear and flaps, whilst the emergency operation of the wheel brakes and power-operated ailerons and elevators is accomplished by means of energy stored in hydraulic accumulators. Provision is made for the recharging of the air bottles and accumulators *in situ*, the procedure being described in Sect. 2, Chap. 2 of this Volume.

2. A description of the majority of the components used in the system will be found in A.P.1803D, Vol. 1. The component part numbers will be found in the master index of A.P.1803A and will enable a direct reference to be made to the applicable section and chapter of A.P.1803D. As the operation of some of the components is initiated

1 EMERGENCY AIR BOTTLES
2 NON-RETURN VALVE
3 EMERGENCY AIR SUPPLY GAUGES
4 EMERGENCY AIR RELEASE VALVES
5 PRESSURE GAUGE BRAKES/SYSTEM
6 CHARGING CONNECTION
7 ACCUMULATOR PRESSURE GAUGE
8 PRESSURE RELAY VALVE
9 PRESSURE SWITCH
10 NON-RETURN VALVE
11 THERMAL RELIEF VALVE
12 BRAKE RELAY CONTROL VALVE
13 BRAKE ACCUMULATORS
14 SHUTTLE VALVE
15 PRESSURE REGULATOR VALVE
16 CONTROL VALVE
17 OIL JETTISON VALVE
18 SHUTTLE VALVE
19 MAIN UNDERCARRIAGE JACKS
20 MAIN UNDERCARRIAGE FAIRING DOOR JACK
21 NOSE UNDERCARRIAGE JACK
22 NOSE UNDERCARRIAGE FAIRING DOOR JACK
23 DOWN SEQUENCE VALVE
24 RESTRICTOR, ONE-WAY
25 UP SEQUENCE VALVE
26 PRESSURE REGULATOR VALVE
27 RESTRICTOR, ONE-WAY
28 NOSE UNDERCARRIAGE SEQUENCE VALVE
29 RESTRICTOR, ONE-WAY
30 CONTROL VALVE
31 PRESSURE RELIEF VALVE
32 SHUTTLE VALVE
33 OIL JETTISON VALVE
34 THROTTLING VALVE, TWO-WAY
35 *Not used*
36 FLAP JACK

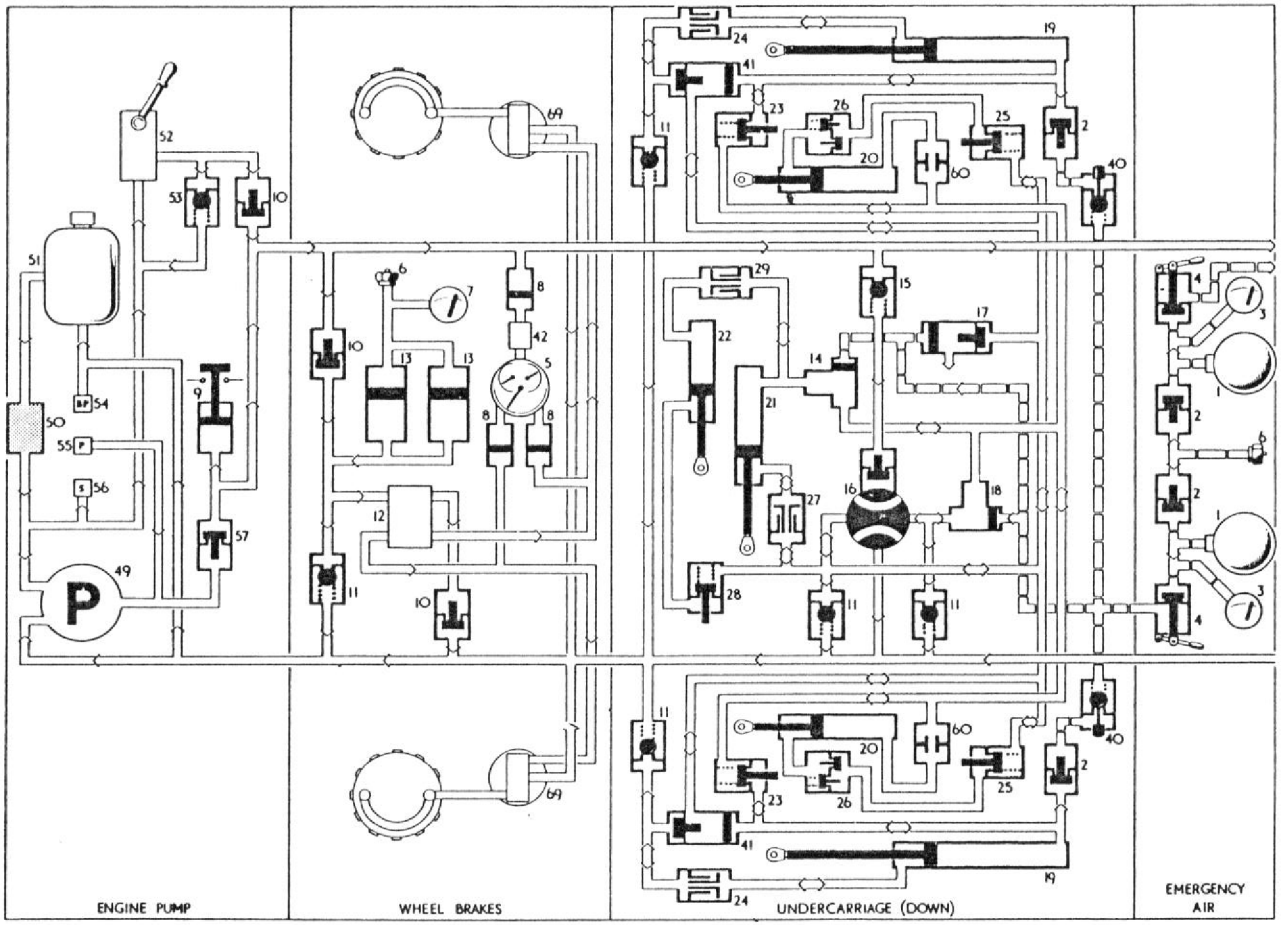

Fig. 1. Hydraulic system diagram (Sheet 1)

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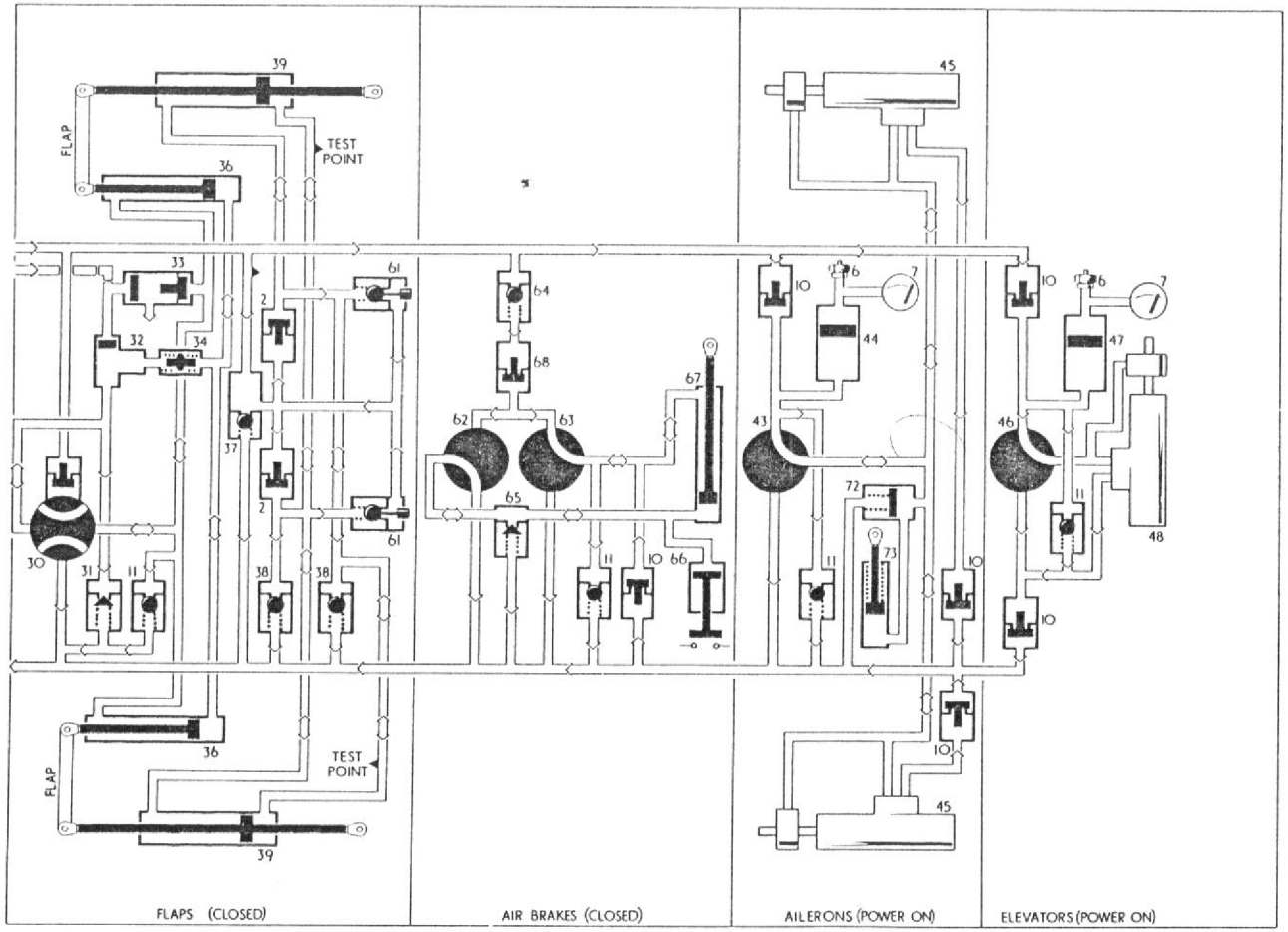

Fig. 2. Hydraulic system diagram (Sheet 2)

37 PRESSURE REDUCING VALVE
38 PRESSURE RELIEF VALVE
39 FLAP SYNCHRONISING JACK
40 PRESSURE RELEASE VALVES (EMERGENCY AIR)
41 SEQUENCE VALVES
42 CHOKE
43 CONTROL VALVE
44 AILERON ACCUMULATOR
45 AILERON HYDRO-BOOSTER
46 CONTROL VALVE
47 ELEVATOR ACCUMULATOR
48 ELEVATOR HYDRO-BOOSTER
49 ENGINE DRIVEN PUMP
50 OIL FILTER
51 RESERVOIR
52 HANDPUMP
53 PRESSURE RELIEF VALVE
54 EXTERNAL SUPPLY COUPLING—BYPASS
55 EXTERNAL SUPPLY COUPLING—PRESSURE
56 EXTERNAL SUPPLY COUPLING—SUCTION
57 NON-RETURN VALVE
58 *Not used*
59 *Not used*
60 RESTRICTOR
61 SELECTOR VALVE
62 MAIN CONTROL VALVE
63 HIGH SPEED CONTROL VALVE
64 PRESSURE REGULATOR VALVE
65 PRESSURE RELIEF VALVE
66 PRESSURE SWITCH
67 AIR BRAKE JACK
68 NON-RETURN VALVE
69 MAXARET UNITS
70 *Not used*
71 *Not used*
72 SHUTTLE VALVE
73 AILERON JACK

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electrically, reference should be made to Sect. 5, Chap. 1 of this Volume for circuit details.

DESCRIPTION

Supply circuit

3. The supply circuit consists mainly of a reservoir, engine-driven pump and filter. For the operation of the system on the ground when the engine is not running, a handpump is incorporated in the circuit. External supply couplings are also provided, these being connected to an external supply trolley when ground testing the system. Both the engine-driven pump and handpump deliver fluid under pressure through their own non-return valves to the main delivery line and thence to the various circuits. The delivery line from the handpump is connected back to the suction line via a pressure relief valve. When off-loaded, the engine-driven pump circulates fluid back to the reservoir. The filter is inserted in the suction line between the reservoir and pumps. The main delivery line branches to a pressure switch which operates to illuminate a warning lamp in the cabin if the pressure falls below 600 p.s.i., thus warning the pilot to reduce speed sufficiently to permit manual operation of the flying controls. An additional warning is provided which generates an aural note in the pilots headphones, this warning note may be silenced by the operation of a cut-out switch in the cabin.

Engine-driven pump

4. The engine-driven hydraulic pump is mounted on and is driven from the engine accessories gearbox which is mounted at the bottom of the engine bay, just aft of the rear spar frame on the port side of the aircraft. Access to the gearbox and pump may be obtained after removing the access panels. To prevent the pump from overheating, a continuous flow of hydraulic fluid is circulated through the pump casing and back to the reservoir. A non-return valve incorporated in the delivery line prevents reverse flow when the engine, and consequently the pump, is not running.

Handpump

5. The hydraulic handpump is mounted in the engine bay and will operate any of the various services after the appropriate selection has been made. The pump, which draws fluid from the reservoir through the same filter as the engine-driven pump, delivers fluid under pressure through a non-return valve. A relief valve, set to blow-off at a pressure of 2,800-2,900 lb. p.s.i., is installed between the inlet and outlet connections of the pump. The pump handle is stowed in clips on the inside of the engine access door.

Reservoir

6. The hydraulic reservoir is mounted in the engine bay on the port side of the aircraft. The filler neck, accessible through an access door in the rear portion of the top wing fillet on the port side of the aircraft, incorporates a sight glass which enables visual inspection of the contents of the reservoir to be made. To facilitate this inspection of fluid level, the inner circumference of the neck below the sight glass is painted white. The filler cap secures a gauze filter element in the neck. Fluid is drawn from the reservoir through an internal stack pipe which is in connection with the outlet connection on the reservoir. From the outlet connection the fluid is conveyed via a pipe to the filter and thence through another pipe which branches to the engine driven pump and the handpump. To relieve excessive internal pressure the reservoir is vented to atmosphere through a pressure relief valve incorporated in a banjo fitting on the reservoir and a drain connection through the aircraft skin. The procedure for replenishing the fluid in the reservoir is described in Sect. 2, Chap. 2.

Filter

7. The hydraulic system filter is mounted on frame 37, access being obtained by removing the access panel in the bottom of the fuselage. In order to avoid spillage of fluid upon adjacent components and structure, the filter must be drained of fluid before it is dismantled, a drain plug with a nozzle end is fitted to the base of the filter body for this purpose. A suitable length of hose, reaching outside the fuselage, must be used for draining. After draining, the plug must be re-tightened and correctly wire-locked.

External supply couplings

8. Three external supply couplings are provided for connection with the hydraulic servicing trolley and testing the hydraulic system on the ground. These couplings are located in the engine bay and are accessible after removing the access panel in the bottom of the fuselage.

Emergency air supply bottles

9. The two high-pressure air bottles for the emergency operation of the alighting gear and landing flaps are mounted side by side below the two Anti-G air bottles just aft of the pilot's seat. All four air bottles are charged in-situ, to the same pressure, simultaneously through a common in-situ charging valve. The procedure for recharging the air bottles is described in Sect. 2, Chap. 2 of this Volume. Two gauges for indicating the pressure in the hydraulic emergency air bottles are mounted in the cabin.

Hydraulic accumulators

10. Hydraulic accumulators are provided for the emergency operation of the wheel brakes and power-operated ailerons and elevators. The two accumulators for brake operation are located in the nose wheel bay, and the one for the powered aileron circuit in the starboard wheel bay, together with its associated pressure gauge. The accumulator for operation of the elevator power controls, which also incorporates a pressure gauge in the circuit, is installed in the dorsal fin just forward of the tail plane, access being obtained through a door in the port side of the fin. This door is provided with a window to facilitate the reading of the pressure indicated on the gauge. The brake accumulator pressure gauge is mounted in the cabin.

Alighting gear

11. Actuation of the hydraulically-operated alighting gear is initiated electrically from a switch in the cabin which energizes a solenoid-operated control valve mounted on the front spar in the starboard wheel bay. Four pipes are connected to this valve, two of these being from the supply and return lines, while the other two direct fluid to and from the undercarriage jacks and fairing door jacks. Fluid flowing to the anchored end of the jacks passes freely through two shuttle valves, these valves having no positive function unless it is necessary to lower the undercarriage by means of the emergency air supply. Mechanically-operated sequence valves are incorporated in the circuit to ensure that the fairing doors and wheel units operate in their correct functional order in relation to each other. Control of the lowering speed is effected by means of restrictors in the pipe lines. A pressure regulator valve is also incorporated in the pressure line between the main supply and control valve to maintain pressure in the power control circuit. A pressure regulator valve in the line to each main door jack ensures that sufficient pressure is maintained in the wheel unit jacks to keep the wheel units fully up while the doors are being closed. A jettison valve, which is operated by high-pressure air when emergency lowering of the alighting gear is effected, permits the fluid expelled from the 'up' side of the jacks to be blown into the atmosphere.

12. When undercarriage DOWN is selected, fluid is directed through the two shuttle valves to the anchored end of the main wheel fairing door jacks, the nose wheel jack and the nose wheel fairing door jack. These jacks then commence to extend, the initial movement of the main wheel fairing door jacks opening the two main fairing door locks (*port and starboard*). Subsequent lowering of the doors operates the leg fairing locks. When these jacks are fully extended, the undercarriage DOWN sequence valves open, permitting fluid to flow to the anchored end of the main undercarriage jacks and at the same time operates a sequence valve which opens the main undercarriage line to permit the main wheel jacks to extend and lower the wheels. The flow of fluid from the wheel unit jacks is impeded by one-way restrictors in the pipe lines, thus preventing the units from extending too rapidly. An internal mechanical lock in each of the main wheel jacks secures the legs in the extended position. In the case of the nose wheel unit, the two doors open together and the wheel forces the fairing door clear as the leg extends. The nose wheel leg is locked down by means of a spring-loaded plunger at the top of the leg.

13. When undercarriage UP is selected, the hydraulic fluid is directed to the piston side of all jacks, except the door jacks to which flow is prevented by their closed sequence valves. Fluid flows comparatively freely into the wheel unit retracting jacks which commence to retract and raise the units. Final movement of the legs, in their upward travel, operate the sequence valves permitting fluid to flow to the door jacks which then retract to close the fairing doors, when spigots on the doors engage with the mechanical locks. During this operation, fluid expelled from the nose wheel door jack is impeded by a restrictor in the pipe line, thus preventing the door, which is assisted by air loads, from closing too rapidly.

Undercarriage control

14. The alighting gear is controlled from the cabin by a selector switch which consists of two inter-locked push-switches, designed in such a manner that the operation of one push-switch automatically ejects the other. The upper push-switch is used to retract the alighting gear and incorporates a solenoid safety lock, which engages when de-energized to prevent the alighting gear from being raised when the wheels are on the ground. This solenoid is controlled by a microswitch on each undercarriage leg, which breaks the circuit to the solenoid when the leg is compressed by the weight of the aircraft when the wheels are on the ground. Release of the load on take-off, or when the aircraft is jacked up with the wheels off the ground as for testing purposes, causes the microswitches to make contact, thus energizing the solenoid to release the lock and permit normal operation of the push-button. It is possible, however, to retract the alighting gear and belly land the aircraft in an emergency by turning the knurled ring, located around the UP button, in a clockwise direction and then depressing the button. *This override of the solenoid lock should not normally be used to retract the alighting gear in flight (Sect. 1, Chap. 3).*

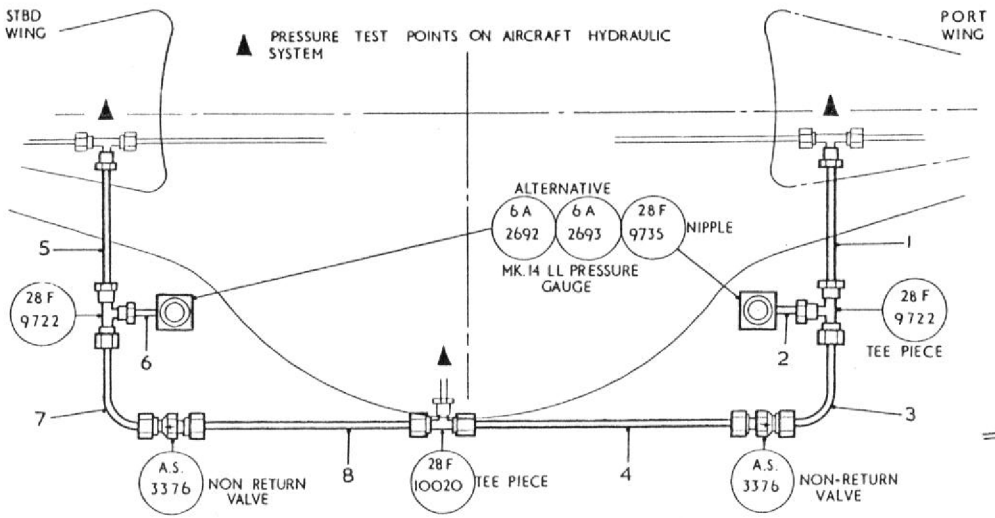
Note . . .

To re-set the solenoid lock override after emergency use, insert the Dowty re-setting tool (Ref. No. 27Q/12407, Part No. S.T.1657) into the small hole in the face of the UP *button, press lightly and turn the knurled ring back to its original position.*

The lower push-button switch of the selector unit is used to lower the alighting gear. Detailed information on the electrical circuit is given in Sect. 5, Chap. 1, ~~of this Volume.~~

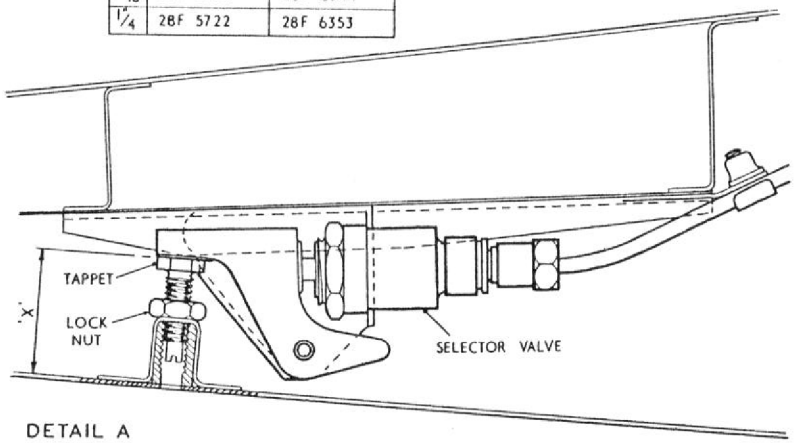
Emergency lowering

15. In the event of hydraulic or electrical failure, the undercarriage legs may be lowered by the admission of high-pressure air into the hydraulic jacks which operate them. The air is obtained from a high-pressure air bottle, installed with the flap and anti-G air bottles in the front fuselage, just aft of the pilot's seat in the cabin. There are two shuttle valves, one for the main wheel units and the other for the nose wheel unit. When the emergency control is operated, high-pressure air is directed to the shuttle valves which operate to cut off the hydraulic supply circuit and at the same time permit air to flow to the anchored end of the nose wheel jack, the nose wheel fairing door jack and the main wheel fairing door jacks. These jacks then commence to extend, the initial movement of the main wheel fairing door jacks opening the main wheel fairing door locks (*port and starboard*). Subsequent



ITEM NO.	DESCRIPTION		MATL		ENDS	O/D
1	TEE PIECE (PORT WING) TO TEE PIECE		TUNGUM D.T.D. 323 A	22 S.W.G.	A-A	3/16"
2	TEE PIECE TO PRESSURE GAUGE	PORT			A-A	3/16"
3	TEE PIECE TO NON RETURN VALVE	PORT			A-A	1/4"
4	NON RETURN VALVE TO TEE PIECE	PORT			A-A	1/4"
5	TEE PIECE (STBD WING) TO TEE PIECE				A-A	3/16"
6	TEE PIECE TO PRESSURE GAUGE	STBD			A-A	3/16"
7	TEE PIECE TO NON RETURN VALVE	STBD			A-A	1/4"
8	NON RETURN VALVE TO TEE PIECE	STBD			A-A	1/4"

O/D	END A	
	OUTER SLEEVE	COLLAR
3/16"	28F 5721	28F 6344
1/4"	28F 5722	28F 6353



DETAIL A

SELECTOR VALVE ADJUSTMENT

1 ENSURE THAT THE TAPPET IS SCREWED FULLY BACK INTO THE CHANNEL SECTION SO THAT DIMENSION 'X' IS A MINIMUM

2 WITH THE FLAP FULLY CLOSED. SCREW THE TAPPET UP UNTIL THE SELECTOR VALVE "BLOWS OFF"

3 LOWER THE FLAP. TIGHTEN THE LOCK NUT AND LOCK THE TAPPET HEAD WITH 22 SWG STAINLESS STEEL WIRE D.T.D. 189 OR 161

TEST INSTRUCTIONS USE THE HAND PUMP ONLY

1 CHECK THAT THE FLAP JACKS AND INTERCONNECTION CIRCUITS ARE CORRECTLY ADJUSTED

2 CONNECT THE TEST EQUIPMENT TO THE HYDRAULIC SYSTEM AS SHOWN ABOVE

3 LOWER THE FLAP

4 CHECK THAT THE PRESSURE GAUGES READ BETWEEN 2000 — 2350 P.S.I.

5 RAISE THE FLAP

6 CHECK THAT THE PRESSURE IN BOTH GAUGES HAS DROPPED TO 450 — 550 P.S.I.

7 IF EITHER GAUGE STILL SHOWS A HIGH PRESSURE (2000 - 2350 P.S.I.) WITH THE WING FLAP FULLY CLOSED, ADJUST THE TAPPET, REFER TO DETAIL A, UNTIL THE PRESSURE DROPS
NOTE:- THE PORT FLAP SELECTOR VALVE RELIEVES THE PRESSURE IN THE STARBOARD GAUGE AND VICE VERSA

8 REMOVE ALL TEST EQUIPMENT AND REPLACE EXISTING BLANKING CAPS

Fig. 3. Flap synchronization test rig

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lowering of the doors operates the leg fairing locks, and these in turn, operate selection valves which pass air to the anchored ends of the main wheel jacks, thus causing them to extend and lower the legs. The air line is also in connection with a jettison valve which opens under the pressure of the emergency air and permits the fluid expelled from the jacks to be blown to atmosphere. The operation of the emergency control is described in Sect. 1, Chap. 3, ~~of this Volume~~

Note . . .

When once the emergency air system has been used, the release valve must be re-set, the system bled of air and the high-pressure air bottle re-charged before next take-off.

Flaps

16. The hydraulically-operated landing flaps are controlled by a selector switch in the cabin. The switch provides for UP, DOWN and six intermediate positions. Between this switch and the electro-hydraulic control valve is a drum switch which directs the current to the UP or DOWN solenoids of the valve according to the attitude of the flaps at the time of selection and breaks the circuit when the selected attitude of the flaps is attained.

17. The flap actuating jacks are mounted in the wings between the undercarriage girder and rear spar. Flap interconnection is by means of double-acting jacks through an independent connective system, fluid flowing to both ends of each jack simultaneously, the fluid displaced from the one being transferred to the other. These synchronizing jacks, which are fed through a reducing valve which drops the pressure to 500 p.s.i. for the synchronizing circuit only, are also mounted between the undercarriage girder and rear spar in the wing. The synchronizing jacks are balanced out by selector valves which are operated every time the flaps are closed. A throttling valve is fitted in the main system to control the rate of movement of the flap and to assist synchronization should the connecting system fail. Fluid to the anchored ends of the main jacks passes through a shuttle valve which has no positive function until the emergency air system is used to lower the flaps in the event of hydraulic failure. A pressure relief valve is incorporated in the circuit between the control valve and flap jack. This valve, which is set to 3,050 ± 50 p.s.i., prevents the flaps from being damaged, by excessive air loads, should they be extended at high air speed. Three test connections are provided for use when checking the synchronizing of the flaps (*shown in fig. 3*).

Emergency operation of flaps

18. Emergency operation of the flaps in the event of hydraulic failure is effected by the admission of high-pressure air into the jacks which operate them, the air being obtained from a high-pressure air bottle mounted adjacent to the air bottle for emergency operation of the alighting gear (*para. 15*). When the emergency control is operated, high-pressure air is directed to a shuttle valve which operates to cut off the hydraulic supply circuit and at the same time admits air to the jacks. The air pressure also operates a jettison valve which permits fluid expelled from the jacks to be blown to atmosphere.

Note . . .

When the emergency air system has been used, the release valve must be re-set, the system bled of air and the high-pressure air bottle re-charged before the next take-off.

Aileron booster system

19. Hydraulically-operated booster jacks provide the power to move the ailerons. The jacks, which are provided with a servo valve and release unit, are fitted, together with their linkage system, in a bay formed by ribs R and S, a diaphragm and the rear spar of their respective wings. Each assembly is carried on two sets of bearing blocks attached to the outboard face of rib R. The linkage consists of an input lever and output lever on one axis pin and a release unit on another, the booster unit being suspended between the levers and release unit. The aileron control tube from the control column is connected to the input lever and the control tube from the aileron is connected to the output lever. A two-position hydraulic jack assembled to the aileron torque tube below the cabin floor serves as a lever to transmit the motion of the torque tube to the control tubes which pass upwards behind the seat and then aft to the ailerons. The jack is fed with pressure oil from the same pressure line that serves the boosters, and consequently the jack is extended when the ailerons are in power. When the aileron control switch is placed to manual, or if hydraulic failure occurs, the jack, being spring-loaded, retracts and the oil trapped in the jack on retraction is by-passed via a shuttle valve to the return line to ensure a rapid change-over. Thus manual operation of the ailerons is effected through a shortened lever so that less effort is required from the pilot to operate them. A spring feel unit is incorporated in the control system. The linkage system and its operation is described in Sect. 3, Chap. 4 ~~of this Volume~~.

20. The hydraulic supply circuit is connected to the control valve through a non-return valve and a hydraulic accumulator (*for operation of the system in the event of hydraulic failure*) is piped into the circuit between the two valves. A branch line connecting the inlet of the control valve to the return line contains a thermal relief valve. From the control valve, fluid is passed to the servo valve and release unit of each jack, the servo valve directing fluid to one side of the jack piston or to the other, according to the position of the valve, movement of which is dependent on the position of the control column. For instance, when the control column is in the neutral position, the valve is also in the neutral position and no fluid is passed to the jacks. When the control column is moved from neutral, the valve position is changed and fluid passes through

one of two orifices depending on the direction of the control column movement. The fluid pressure then acts on the jack piston and the jack body is displaced in the same direction as the servo valve spindle. As the jack body is connected to the ailerons, the air loads are overcome and the ailerons move in the required direction until the linkage returns the valve to the neutral position, thereby cutting off the supply of fluid to the jack until a further movement of the control column is made. The release unit, through the action of hydraulic pressure against a spring-loaded piston, maintains the pawls of the booster jack system in engagement. Should the hydraulic pressure fail, the hydraulic accumulator automatically comes into service to give a limited number of control column reversals before the accumulator is exhausted. When the pressure drops below 300 p.s.i., the spring-loaded piston in the release unit is no longer restrained and the spring extends to move the piston and take the pawls out of engagement and so permit manual operation of the ailerons. Should it be desired, or an emergency render it necessary, the pawls can be disconnected in flight by operation of a switch in the cabin. A magnetic indicator, mounted in the cabin, operates to indicate that the pawls have disengaged. The operation and circuit of the cut-out switch and indicator is described in Sect. 5, Chap. 1 of this Volume.

Elevator booster system

21. The elevator hydraulic booster jack and its linkage system is located between frames 52 and 55, just below the tail plane. The assembly is carried in a channel-sectioned beam bolted to brackets mounted to the frames and consists of a booster jack, release unit, servo valve and operating link, together with an input and output lever. The elevator control tube from the control column is connected to the input lever and the elevator to the output lever. A spring feel unit is incorporated in the control system. In general, the operation of the hydraulic circuit, control valve and release unit is the same as that for the ailerons (*described in para. 20*). The linkage system and its operation is described in Sect. 3, Chap. 4 of this Volume. When the emergency system is used, the hydraulic accumulator provides for a limited number of reversals of the control column.

Wheel brakes

22. The hydraulically-operated wheel brakes are controlled from a lever-operated control, fitted on the control column handgrip. Differential control is obtained by means of a relay valve which is in connection with the rudder bar. In addition, Maxaret units are fitted, one to each main undercarriage leg, which permit the maximum braking efforts to be applied without the risk of the wheel locking. These anti-lock units consist of a valve regulated by a rubber-tyred flywheel in contact with the rim of its respective landing wheel. The units are incorporated in the hydraulic pressure line from the cabin controls to the associated brake units. The Maxaret units are sensitive to angular deceleration consistent with an approaching wheel lock. Under such conditions they off-load the hydraulic pressure applied to the brakes until conditions again return to normal. From the supply circuit, the hydraulic fluid passes through a non-return valve to the brake relay control valve. Two hydraulic accumulators, for emergency operation of the brakes in the event of hydraulic failure, are piped into the line from the non-return valve to the control valve. A branch pipe from this line is taken to a thermal relief valve which is in connection with the return line. From the brake relay control valve, pipes convey fluid to the Maxaret units and on to the brakes. Branch pipes from the brake supply lines connect with two pressure relays, which in turn, connect with two unions on the triple pressure gauge in the cabin. The third union on the gauge is in connection with the main hydraulic system pressure line via a pressure relay. Thus, the gauge registers the pressure existing in each brake unit and also the main system pressure. The accumulators, together with the air charging connection are mounted in the nose wheel bay. The air pressure in the accumulators is shown on the brake accumulator pressure gauge in the cabin. The procedure for charging the accumulators is described in Sect. 2, Chap. 2, and the pressure to which they are to be charged is given in the Leading Particulars.

Air brake

23. The air brake is operated by a hydraulic jack which is anchored at frame 50 and controlled by a thumb switch on the throttle twist grip. Full extension or retraction of the air brake is by selection, using the throttle-mounted switch, and no intermediate position is normally obtainable. The hydraulic circuit consists of a pressure regulator valve, two non-return valves, two single solenoid control valves, a thermal relief valve in the 'in' line, a pressure relief valve in the 'out' line and a pressure-operated switch. The pressure regulator valve is fitted between the pressure supply and the main non-return valve feeding the control valves to maintain sufficient pressure for the supply of the power controls during the period of extension and retraction of the air brake. A magnetic indicator in the cabin gives a white indication when the air brake is extended and black when retracted. On undercarriage DOWN selection (*owing to limited ground clearance*) the air brake control switch is rendered automatically inoperative and the circuit disconnected so that the air brake automatically retracts to the 'in' position, if it is not already in that position. This condition is also obtained on operation of undercarriage emergency lowering by means of a micro-switch operated by the undercarriage emergency air valve. On undercarriage UP selection, the air brake control switch in the throttle lever again becomes operative to permit control of the air brake through the electro-hydraulic control valves in the rear fuselage. The installation may, however, be tested on the ground while the alighting gear is down, by the operation of a spring return test switch in the cabin. Operation of this switch will permit partial extension and immediate retraction of the air brake each

time the switch is moved to the ON position. This gives indication in the cabin by means of the magnetic indicator that the system is functioning satisfactorily.

Note . . .

Air brake IN *must not normally be obtained by selecting undercarriage* DOWN. *On no account is full extension of the air brake on the ground to be obtained by fitting locks to the undercarriage jack and selecting undercarriage* UP.

Operation

24. After the undercarriage has been raised, operation of the air brake switch to the OUT position energizes the solenoid of the main control valve and the circuit is maintained after the switch is released by a hold-on relay (*Sect. 5, Chap. 1*). The jack then extends the air brake by differential action at high speed until the rise in hydraulic pressure due to the load on the air brake causes the pressure switch to operate. Closing of the contacts of this switch energizes the solenoid of the high speed control valve, the circuit being maintained, when once operated, by the pressure switch 'hold-on' relay (*Sect. 5, Chap. 1*). The jack then continues to extend to put the air brake 'out', but now at full power (*normal speed*), until the 'fully-out' position is reached. In the 'out' position, if the air load on the brake produces a hydraulic pressure above the setting of the relief valve, this valve will lift and permit the air brake to retract, oil for the 'in' side of the jack being drawn through a non-return valve from the return line. Retraction of the air brake will cease when pressure drops to the re-seating pressure of the relief valve, and will extend again when the air load is reduced. On the operation of the air brake switch to the IN position, the 'in' relay is energized to break the circuit (*Sect. 5, Chap. 1*) and the jack will retract to bring the air brake to the IN (*closed*) position.

SERVICING

General

25. Scrupulous cleanliness is essential during all servicing of the hydraulic system. Fluid used for topping up the system must be clean and the filter must always be in position in the filler neck when pouring fluid into the reservoir. Fluid drained from the system during bleeding must not be put back into the system. Funnels, containers for holding the fluid, or containers used for the reception of drained fluid, must be clean and preferably rinsed out with clean hydraulic fluid before use. (*The fluid used for this purpose must afterwards be discarded.*) When pipe lines are disconnected, the unions and pipe-ends must be immediately blanked off with blanking caps to exclude the ingress of dirt or moisture. (*Masking tape, rag, or material of a fluffy nature must not be used for this purpose.*) All disconnected pipes must be flushed out with clean hydraulic fluid prior to re-assembly. When drain plugs, or other components are removed, they must be examined carefully to ensure that they are clean before being re-assembled in the system. When using a hydraulic servicing trolley for testing the system, ensure that a micronic filter is in circuit, and that the filter is clean. If the filter is dirty, it should be discarded and a new filter fitted. *This is very important.*

Note . . .

Hydraulic fluid is detrimental to paint, rubber, electrical cables, etc., therefore, great care must be taken to ensure that no fluid is spilled on such parts.

Hydraulic reservoir

26. The procedure for refilling the hydraulic reservoir is described in Sect. 2, Chap. 2 of this Volume. The type of oil to be used is given in the Leading Particulars.

Emergency air cylinders and hydraulic accumulators

27. The procedure for re-charging the emergency air cylinders and hydraulic accumulators, which form part of the hydraulic system installation, is described in Sect. 2, Chap. 2 ~~of this Volume~~.

Lubrication

28. For the lubrication of the rubber sealing rings, gland rings, etc., grease XG-315 is to be used. For all bearings, hinge pins, etc., unless otherwise stated in the appropriate chapter, use XG-275.

Faults

29. Faults in the system may be caused by defects in either the hydraulic or electrical systems. Complete stoppage of the system is unlikely but, if occurring, could be due to:—failure of the pump, obstruction in the pipe line between the pump and control valve, fracture of a pipe line and consequent loss of fluid or a blocked filter. In all cases of unsatisfactory operation, the reservoir should be checked for correct level. Generally, faults can be traced by observing the functioning of the system as a whole and localizing the cause, this procedure should always be adopted before dismantling components for inspection. Investigation of faults should be considered in accordance with the instructions given below.

Loss of pressure

External leakage

30. Keeping the installation clean will facilitate the location of external leakage. Such leakage occurring in a component should be dealt with in accordance with the instructions given in the handbook for the component concerned. In some cases, leakage may occur at a pipe coupling where a metal-to-metal joint is made and may possibly be remedied by tightening the unions, but care must be taken to avoid over-tightening. If normal tightening is ineffective, examine the belling of the pipe, if found faulty, the pipe must be renewed. Where adaptors and plugs are concerned, these must not be tightened unless permitted in accordance with the instructions given in the Handbook for the component concerned.

Note . . .

Tightening will not cure a leak which is due to a defective sealing ring. The only remedy in such cases is the renewal of the defective seal or component.

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31. Generally, pipe leakage is a rare occurrence and would, usually, be the result of external abrasion at points where the pipe passes over structural members. It is essential, therefore, to ensure that all pipes are securely clipped to structure with which they are in contact to eliminate the possibility of chafing.

Internal leakage

32. Internal leakage will cause sluggish or erratic movement in the particular circuit and, possibly, creeping from the selected position. Creeping may also be due to leakage past a non-return valve in the circuit. The remedy is to remove and test any suspected component in accordance with the instructions given in the manual for the component concerned.

Air in the system

33. Air in the system may be detected as follows:—

(1) Sluggish operation.

(2) Backlash at flaps or fairing doors, etc.

(3) Backlash or sponginess when using the handpump.

To expel the air, it will be necessary to bleed the faulty circuit (*para. 34*).

Bleeding the system

34. The complete aircraft hydraulic system must first be primed with clean hydraulic fluid to the specification given in the Leading Particulars, and the handpump operated until all air is expelled from the system through the bleed screws on the components, or by loosening or disconnecting couplings. *The reservoir should be constantly topped up during bleeding operations, otherwise more air will be introduced into the system through the suction line in the reservoir.*

To bleed the system proceed as follows:—

(1) Jack up the aircraft with its wheels clear of the ground.

(2) Inflate all accumulators to the inflation pressures shown on adjacent labels.

(3) Fill the reservoir.

(4) Select undercarriage DOWN and operate by means of the handpump.

(5) Bleed from the undercarriage jacks and then from the fairing door jacks by means of the bleed screws on the components.

(6) Fit locks on the main and nose undercarriage legs. Select undercarriage UP and bleed the undercarriage jacks. The fairing door jacks should then be bled by depressing the plungers of the sequence valves in the wings and nose wheel bay, restraining the doors from retraction by manual pressure on the doors.

(7) Tighten all bleed screws.

(8) Bleed the main flap jacks in both the flaps UP and flaps DOWN position by means of the bleed screws in the wheel bays. The flap interconnection jacks should be bled after they have been adjusted for travel by disconnecting the jacks from the flap lever. To bleed the port down lines, the starboard flap should be raised and vice versa. *It is essential that the flap interconnection circuit is completely free from air, otherwise 'out of balance' will result between port and starboard wing flaps.* Tighten all bleed screws.

(9) To bleed the Maxaret units, the landing wheels should be removed and the return lines disconnected. This procedure enables each unit to be bled through its own return line by rotating the Maxaret wheel smartly by hand in the direction of the arrow on the unit's nameplate and then bringing the wheel to rest. Each time the wheel is stopped, a small quantity of fluid will be released from the exhaust connection. This sequence should be repeated until the fluid expelled is clear and free from air. Re-connect the return line. The brake units should then be bled in the normal manner by means of the bleed screws on the components.

(10) Ensure that no pressure exists in the system. Mount the bleed clamp (*Ref. No. 27VA/3303, Part No. ACO/5928*) on the port hydraulic brake pressure relay in the brake triple pressure gauge line (*clamp about the base of the cylinder and adjacent to the integral connection. The clamp should contact the cylinder in the area between the two shallow grooves*). Using an Allen Key, or Unbrako wrench measuring $\frac{5}{32}$in. across the flats, tighten the two socket-headed clamp screws. (*Excessive torque is not necessary, conventional use of the recommended wrenches producing the necessary clamping force.*) Slacken the pipe coupling in the port brake pressure gauge line at the gauge. Generate main system pressure by means of the handpump and operate the brake lever on the control column to the brakes ON position and lock. Move the rudder bar to port and bleed the gauge line until air-free fluid flows from the loosened coupling. Tighten the coupling whilst the flow is maintained. Dissipate the pressure in the system by operating the brakes a number of times, remove the clamp from the port relay and fit it to the starboard relay. Slacken the pipe coupling on the starboard gauge line at the gauge, build up system pressure again and move the rudder bar to starboard, apply the brakes and lock. Bleed the starboard gauge line until air-free fluid flows from the loosened coupling. Tighten the coupling whilst the flow is

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maintained. Remove the clamp from the relay and check the brakes for correct operation.

(11) The system pressure gauge circuit is the same as the brake gauge circuit, apart from the addition of a choke between the pressure relay and gauge connection. When bleeding the circuit, it will be necessary to open the choke and clamp the relay. To open the choke, first ensure that there is no pressure in the circuit, then unscrew the two halves of the choke, not more than half a turn, in order to allow fluid through the by-pass. Fit the clamp to the relay, loosen the pipe coupling at the gauge and generate system pressure as for brake gauge line, ignoring any leakage at the choke, until air-free fluid flows from the loosened coupling at the gauge. Whilst flow is still maintained tighten the pipe coupling and the choke. Remove the clamp from the relay.

(12) Disconnect the pipes from the power booster units and flush the circuit by continual operation of the handpump and replenishment of the reservoir until fluid flows free from air. Reconnect the pipes, loosen the bleed plugs and operate the circuit until air-free fluid flows from the bleed points. Tighten the bleed plugs. Check the circuit for correct operation.

(13) Loosen the bleed plugs on the air brake jack and operate the handpump until air-free fluid is expelled from the bleed points. Tighten the bleed plugs and check the circuit for correct operation.

(14) When a micronic filter is replaced, the system must be bled through the bleed point at the rear of the hydraulic handpump.

(15) When all bleeding of the system has been satisfactorily completed, the hydraulic reservoir must be finally topped up to the correct level.

Bleeding after use of emergency controls

35. When the emergency high-pressure air system control has been used, the valve must be re-set and the individual system *must* be bled of air before the next take-off. Care must be taken to ensure that the reservoir filler cap is slackened off and the bleed plugs slackened sufficiently to release all pressure before any selection is made. When all pressure is released, prime and bleed the appropriate system (*described in para. 34*).

Testing air brake on ground

Undercarriage down

36. Operation of the spring-return test switch, mounted in the cabin, in conjunction with a microswitch operated by the air brake, permits partial extension (*about 15 deg.*) of the air brake and immediate retraction each time the switch is moved to the ON position. This gives indication in the cabin by means of the magnetic indicator that the system is functioning satisfactorily. *Ensure that the area below the air brake is clear of obstruction and that no personnel are in the vicinity before carrying out this operation.*

Undercarriage up

(*Refer to Warning, para. 38*).

37. Operation of the air brake by means of the normal control on the throttle lever will give full travel at high speed. To check the operation of the high speed control valve short out the pressure switch (*by means of a link across terminals AB.6 and 8 at TB.47 on frame 45, port rear fuselage*) and check that low speed operation is obtained. Remove link after test. To check the operation of the pressure switch, connect a suitable lamp (*24v. 3 watt*) across the above terminals, which lights on selection of air brake OUT. Use handpump to check pressure at which switch operates (*i.e. lamp goes out*).

Operational Tests

WARNING

Before these tests are applied, the aircraft must be jacked up with the wheels clear of the ground.

38. When the system has been filled, each circuit must be tested. For this purpose, a hydraulic servicing trolley will be required, the pipes from the pump on the trolley being connected to the appropriate external supply couplings (*para. 8*). When connection is made, test each circuit for correct operation.

Testing emergency air system

39. At the inspection periods quoted in the Servicing Schedule, and before carrying out the operational tests mentioned in the previous paragraph, the emergency air system must be tested as follows:—

(1) Jack the aircraft clear of the ground.

(2) Connect a ground servicing trolley.

(3) Arrange suitable receptacles under the vent pipes leading from the fluid jettison valves of the undercarriage and flap circuits to receive the fluid expelled from the jacks.

(4) Operate the undercarriage and flaps to the UP position (*after first ensuring that no personnel are in danger from the components being operated*).

(5) Operate the emergency controls for the undercarriage and flaps and see that the fairing doors open and that the main and nose undercarriage and the flaps move smoothly to the full 'down' position. Check that both the nose and main undercarriages are fully locked down.

Note . . .

When the emergency system is used, the flap selector valve is out of circuit. The flaps should, therefore, move down to the full 80 deg.

(6) After the tests have been satisfactorily completed, the controls must be re-set to normal and the system reprimed and bled before carrying out the normal operational tests (*para. 38*).

Pressure tests

40. After servicing or where necessary to localize suspected leakage, the hydraulic system must be tested by use of the handpump. The procedure is as follows:—

(1) Using the handpump, build up the pressure until the handpump relief valve operates and then allow it to stabilize. A subsequent drop in pressure, shown on the triple pressure gauge in the cabin, indicates leakage between the pump and the supply side of each jack for which selection has been made.

(2) To test each circuit separately, make selection in turn and then build up pressure by means of the handpump. Check for pressure drop.

(3) If any circuit is faulty, isolate each unit of the circuit in turn and then apply the pressure test. In this manner, the defective unit is readily indicated.

Note . . .

There is an inherent (permissible) leakage through the pressure reducing valve in the flap synchronizing circuit which must be taken into account when testing. The pressure drop through this valve is from 2,800 p.s.i. to 500 p.s.i.

Pressure settings and adjustment of components

41. The pressure settings for all pressure relief valves is given in the leading Particulars. The adjustment of the various components used in the system is described in the appropriate Air Publications.

Draining the system

42. The bulk of the fluid can be drained from the system by uncoupling unions or connections at the lowest points of the individual pipe runs after the aircraft has been jacked up off the ground and the pressure in the system released by carefully removing the reservoir filler cap. Drainage may be facilitated by operation of the jacks, using the handpump.

REMOVAL AND ASSEMBLY

General

43. In general, the removal of the hydraulic components from the aircraft and their re-installation is obvious. Before attempting any removals, however, the following precautions should be taken:—

(1) Before attempting to remove any hydraulic accumulator, dissipate the fluid pressure by operating the control of the component concerned and deflate the accumulator by means of the Schrader valve.

(2) Ensure that the pipe-ends and unions are suitably blanked off following the removal of any component.

Access to components

44. Access to the main components of the hydraulic system can be obtained as follows:

Reservoir —Top rear fillet of port wing.

Handpump—Handle stowed in clips on engine access door.

Air cylinders—Cabin—aft of ejection seat.

Accumulators:—

Brake	—Nose wheel bay.
Aileron	—Starboard wheel bay.
Elevator	—Spine fairing—rear fuselage

Maxaret units

45. When re-fitting a Maxaret unit, the following precautions should be taken:—

(1) Care must be taken to avoid misplacing the inlet filter of the unit which is a free fit within its inlet connection.

(2) The unit must be fitted so that the Maxaret wheel revolves in the direction of the arrow on the nameplate when the aircraft is moving forward.

(3) *Aircraft Pre-mod. 516*
The Maxaret tyre in contact with the landing wheel must be deflected 0·045 to 0·050 ins. (*approx. 1 in. of flat on Maxaret tyre*), with the aircraft's weight on its landing wheels. This deflection must not vary by more than ±0·020 in. when the weight of the aircraft is removed from its landing wheels. Each Maxaret unit is provided with shims to adjust this deflection.

(4) *Aircraft Post-mod. 516*
The Maxaret is spring-loaded on to the rim of the landing wheel. When changing a landing wheel, therefore, the Maxaret will move outwards past its normal position due to the action of the spring, and precautions must be taken to ensure that the Maxaret is held back to its base when replacing the landing wheel. Failure to do so will result in serious damage to the Maxaret.

Note . . .

The mountings of the Maxaret are interchangeable end for end, but it must be ensured that the Maxaret is always mounted with the fixed pivot end nearest to the rim of the aircraft landing wheel.

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