Chapter 6 HYDRAULIC SYSTEM

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DESCRIPTION

Introduction

1. The Hunter hydraulic system operates the alighting gear, wheel brakes, air brake, landing flaps and power-assisted 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-assisted 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 electrically, reference should be made to Sect. 5, Chap. 1 of this volume for circuit details.

Supply circuit

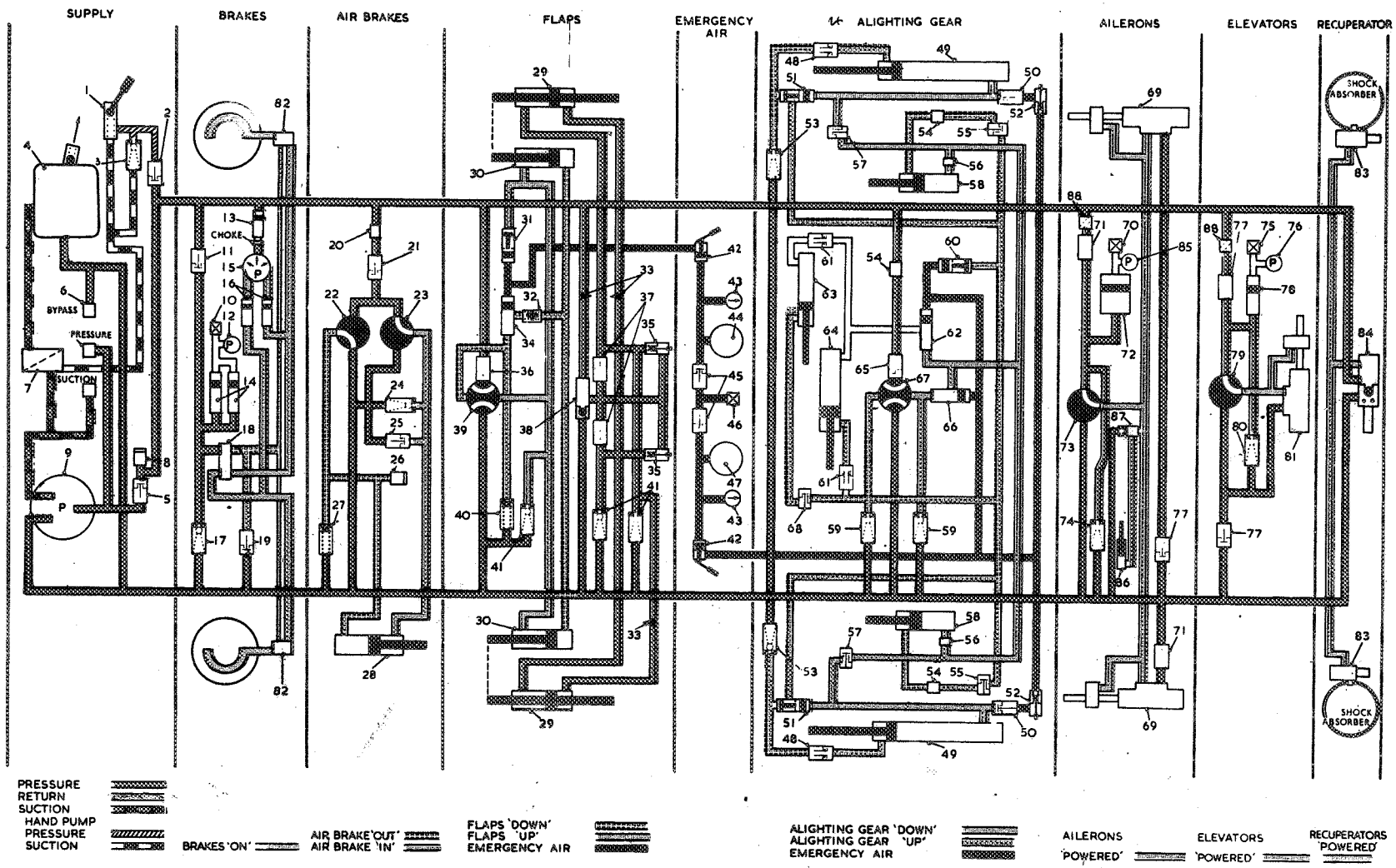
3. The supply circuit consists mainly of a reservoir, engine-driven pump and filter. For the operation of the system on the ground when the engine is not running, a handpump is incorporated in the circuit. External supply valves are also provided, these being connected to an external supply trolley, Mk. 2 (*Stores Ref.* 4F/1685), when ground testing the system. Both the engine-driven pump and the 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 the pumps. The main delivery line branches to a pressure switch which operates to illuminate a warning lamp if the pressure falls below 600 lb. per sq. in., thus warning the pilot to reduce aircraft speed sufficiently to permit manual operation of the flying controls. An additional warning is provided which generates an aural note in the pilot's headphones. A silencing push-switch is provided which, when operated, retains the audio warning in the suppressed condition.

Engine-driven pump

4. The Dowty (*Type* 5050.Y., *RH* 3,000) engine-driven hydraulic pump is a two-stage pump, comprising a low-pressure gear type

KEY TO FIG. 1, 2 AND 3 (HYDRAULIC SYSTEM DIAGRAM AND INSTALLATION)

1 HAND PUMP
2 NON-RETURN VALVE
3 PRESSURE RELIEF VALVE
4 RESERVOIR
5 NON-RETURN VALVE
6 EXTERNAL SUPPLY VALVES
7 OIL FILTER
8 PRESSURE SWITCH
9 ENGINE-DRIVEN PUMP
10 CHARGING CONNECTION (BRAKES)
11 NON-RETURN VALVE
12 BRAKE ACCUMULATOR PRESSURE GAUGE
13 PRESSURE RELAY
14 BRAKE ACCUMULATORS
15 TRIPLE PRESSURE GAUGE
16 PRESSURE RELAYS
17 THERMAL RELIEF VALVE
18 BRAKE RELAY CONTROL VALVE
19 NON-RETURN VALVE
20 PRESSURE REGULATING VALVE
21 NON-RETURN VALVE
22 AIR BRAKE CONTROL VALVE
23 HIGH SPEED CONTROL VALVE (AIR BRAKE)
24 THERMAL RELIEF VALVE
25 NON-RETURN VALVE
26 PRESSURE SWITCH
27 PRESSURE RELIEF VALVE
28 AIR BRAKE JACK
29 FLAP SYNCHRONIZING JACK (PORT AND STARBOARD)
30 FLAP JACK (PORT AND STARBOARD)
31 OIL JETTISON VALVE
32 TWO-WAY THROTTLING VALVES
33 PRESSURE TEST POINTS
34 SHUTTLE VALVE
◀ 35 PRESSURE RELEASE VALVES ▶
36 NON-RETURN VALVE
37 NON-RETURN VALVES
38 PRESSURE REDUCING VALVE
39 FLAP CONTROL VALVE
40 PRESSURE RELIEF VALVE
41 THERMAL RELIEF VALVES
42 EMERGENCY AIR RELEASE VALVES
43 EMERGENCY AIR SUPPLY GAUGES
44 EMERGENCY AIR BOTTLE (FLAPS)
45 NON-RETURN VALVES
46 CHARGING CONNECTION
47 EMERGENCY AIR BOTTLE (U/C)
48 ONE WAY RESTRICTORS
49 MAIN UNDERCARRIAGE JACKS (PORT AND STARBOARD)
50 PRESSURE SEQUENCE VALVES
◀ 51 PRESSURE SEQUENCE VALVES ▶
52 PRESSURE RELEASE VALVES
53 THERMAL RELIEF VALVES
54 PRESSURE REGULATOR VALVES
55 MAIN U/C "UP" SEQUENCE VALVE
56 RESTRICTED NIPPLES
57 MAIN U/C "DOWN" SEQUENCE VALVE
58 MAIN U/C FAIRING DOOR JACKS (PORT AND STARBOARD)
59 THERMAL RELIEF VALVES
60 OIL JETTISON VALVE
61 ONE WAY RESTRICTOR VALVE
62 SHUTTLE VALVE
63 NOSE U/C FAIRING DOOR JACK
64 NOSE UNDERCARRIAGE JACK
65 NON-RETURN VALVE
66 SHUTTLE VALVE
67 ALIGHTING GEAR CONTROL VALVE
68 NOSE U/C SEQUENCE VALVE
69 AILERON POWER ASSISTED HYDRO BOOSTER (PORT AND STARBOARD)
70 CHARGING CONNECTION (AILERON)
71 NON-RETURN VALVES
72 AILERON ACCUMULATOR
73 AILERON CONTROL VALVE
74 THERMAL RELIEF VALVE
75 CHARGING CONNECTION (ELEVATOR)
76 ELEVATOR ACCUMULATOR PRESSURE GAUGE
77 NON-RETURN VALVE
78 ELEVATOR ACCUMULATOR
79 ELEVATOR CONTROL VALVE
80 THERMAL RELIEF VALVE
81 ELEVATOR POWER ASSISTED HYDRO BOOSTER
◀ 82 MAXARET UNITS
83 RECUPERATORS
84 PRESSURE REDUCING VALVE
85 AILERON ACCUMULATOR PRESSURE GAUGE
86 AILERON TWO POSITION LEVER JACK
87 SHUTTLE VALVE
88 MICRONIC FILTERS ▶



F.S./2

FIG.1 HYDRAULIC SYSTEM DIAGRAM

RESTRICTED

(A.L.42, Mar. 57)

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system as a whole and localising 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 in the following paragraphs:—

Loss of pressure

External leakage

30. Keeping the system 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 (care must be taken to avoid overtightening). If normal tightening is ineffective, examine belling of pipe. Faulty components must be renewed. Where adapters or 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 component.

31. Generally, pipe leakage is a rare occurrence and would, if found, 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. When fitting a new or reconditioned pump which has been in store, it should be filled with hydraulic fluid and allowed to soak for at least two hours, to avoid leakage due to the seals drying out.

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 instructions given in the manual concerned.

Air in the system

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

(1) Operational speed below normal.

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

(3) Backlash or sponginess on the use of the handpump.

To expel the air, it will be necessary for the circuit to be primed and bled.

Filling and bleeding

34. The complete aircraft system is to be primed with clean hydraulic fluid to the specification given in the Leading Particulars, using the handpump until all air is expelled from the system through the bleed screws on the components, or by loosening couplings where bleed screws are not fitted. Prior to bleeding, the aircraft should be jacked up with its wheels clear of the ground (*Sect.* 2, *Chap.* 4, *fig.* 4), all accumulators should be inflated to the inflation pressures shown on the labels adjacent to the accumulators and the reservoir should be filled as described in Sect. 2, Chap. 2. (*The reservoir should be constantly topped up during operations, otherwise more air will be introduced into the system through the suction line in the reservoir*).

The operations should be carried out as follows:—

(1) Jack up the aircraft with its wheels clear of the ground (*Sect.* 2, *Chap.* 4, *fig.* 4).

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

(3) Fill the reservoir (*Sect.* 2, *Chap.* 2).

(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 the bleed screws on the components.

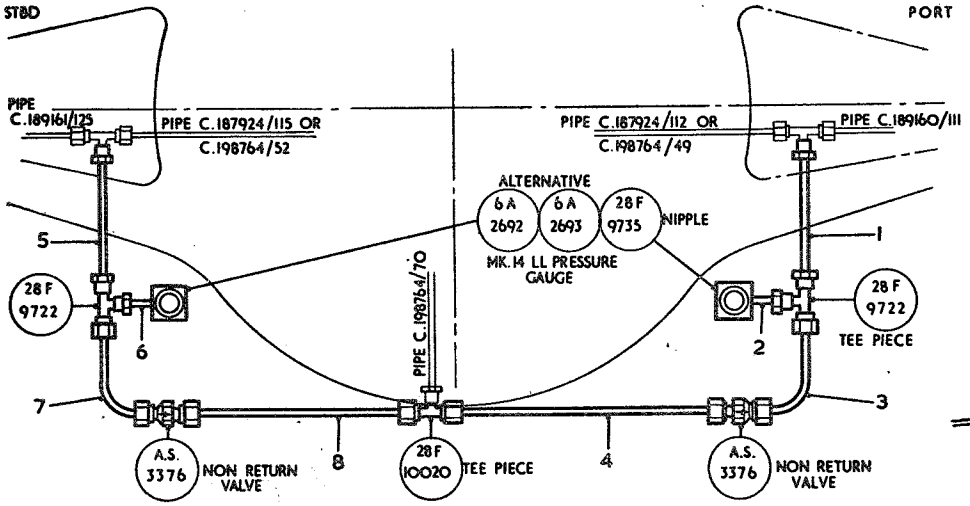
(6) Fit locks on main and nose undercarriage legs. Select undercarriage UP and bleed the undercarriage jacks. The fairing door jacks should then be bled by depressing the sequence valves in the wings and nose wheel bay and restraining the doors from retraction by manual pressure on the doors.

(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 (*Sect.* 3, *Chap.* 4). To bleed the port down line, 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 the bleed screws.

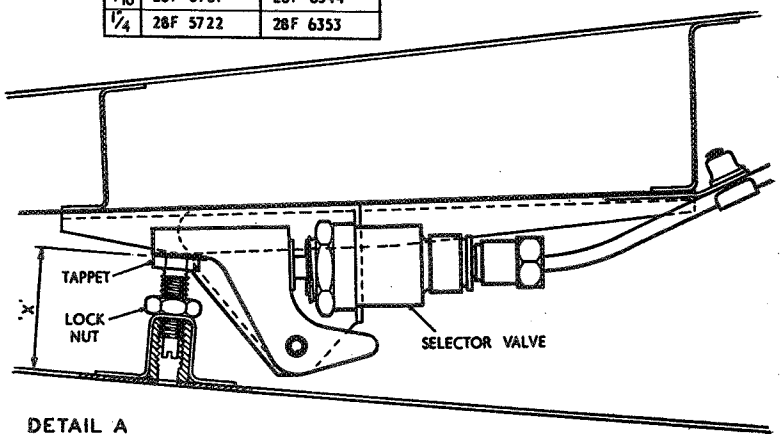
◀(8A) Bleeding of the Maxaret units is important. Where possible, the units should be mounted on the leg and the system bled before fitting the aircraft wheels. This procedure enables each unit to be bled through its own exhaust connection by rotating the Maxaret wheel smartly by hand in the direction of the arrow on the unit's nameplate and then bringing the wheel to rest. Each time the wheel is stopped a small volume of fluid will be released from the exhaust connection. This sequence should be repeated until the fluid expelled is clear and free from air. The brake units should then be bled in the normal manner by means of the bleed screws on the components.▶

(9) Ensure that no pressure exists in the system. Mount the bleed clamp (Part No. ACO.5928) on the port hydraulic brake pressure relay in the brake triple pressure gauge line on the aft face of frame 11 on the port side (about the base of the cylinder and adjacent to the integral connection. The clamp should contact the cylinder in the area between



ITEM NO.	DESCRIPTION		MATL		ENDS	O/D
1	TEE PIECE (PORT WING) TO TEE PIECE		TUNGUM D.T.D.323A	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. 6. Flap synchronization test rig

pump and a seven cylinder radial high-pressure pump in one unit, the two pumps being driven by a common drive shaft assembly. Both high and low-pressure relief valves and an altitude compensator valve are incorporated in the unit. The 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 through the access panels (*items* 84 *and* 85) shown in Sect. 2, Chap. 4, fig. 2. 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 on the bottom face of frame 37 in the engine bay and is accessible through the same panels as is the engine-driven pump (*para.* 4). The handpump will operate any of the 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 is installed between the inlet and outlet connections of the pump, the blow-off pressure of the valve being 2,800–2,900 lb. per sq. in. 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 between frames 35 and 36 on the port side of the aircraft. The reservoir is of welded construction with a fireproof coating. The filler cap, which is 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 cap below the sight glass is painted white. The cap secures a gauze filter element in the filler neck. Fluid is drawn from the reservoir through an internal stack pipe which is in connection with the outlet coupling on the reservoir. From the coupling the fluid is conveyed by a pipe to a filter and thence through another pipe which branches to the engine-driven pump and handpump. The reservoir is vented to atmosphere through a vent valve incorporated in a banjo fitting on the reservoir and a drain connection through the skin. The procedure for replenishing the reservoir is described in Sect. 2, Chap. 2 of this volume.

Filter

7. The hydraulic system filter is mounted on frame 37 on the port side of the aircraft. Access for cleaning the element may be obtained by removing the engine access panel in the bottom of the fuselage (*Sect.* 2, *Chap.* 4, *fig.* 2, *item* 85). To avoid spillage of the 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 retightened and correctly wire-locked.

External supply valves

8. To permit testing of the hydraulic system on the ground, three external supply valves are provided. These are situated adjacent to the engine-driven pump in the engine bay and are accessible through the engine access panel in the bottom of the fuselage (*Sect.* 2, *Chap.* 4, *fig.* 2, *item* 85). Connection between the valves and the ground test pump is made by means of special adapters which consist of a union half coupling, a union nut and blanking cap (*Part Nos.* AVA.57/C/D/F, AVA.62/C/D/F *and* AVA.63/C/D/F *respectively*).

Emergency air supply bottles

9. The two high-pressure air supply bottles for the emergency operation of the alighting gear and flaps are mounted side by side in the front fuselage, just aft of the pilot's seat. Two anti-G air bottles are mounted above them and all four are charged in-situ from a common charging valve located at frame 16 and accessible via the radio access door (*Sect.* 2, *Chap.* 4, *fig.* 2, *item* 77). The procedure for re-charging the air bottles is given in Sect. 2, Chap. 2 of this volume. Two gauges for indicating the pressure in each of the two hydraulic emergency air bottles are mounted on the cockpit port shelf between frames 11 and 12.

Hydraulic accumulators

10. Hydraulic accumulators are provided for the emergency operation of the wheel brakes and power-assisted ailerons and elevators. The two accumulators for brake operation are located in the nose wheel bay, the two for the aileron assister circuit in the starboard wheel bay and the accumulator for operation of the elevator assister, together with its associated pressure gauge, 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 transparent window to facilitate the reading of the pressure indicated on the gauge. (*To eliminate the possibility of air being trapped on the oil side of the piston on full movement, the aileron and elevator accumulators are mounted in such a position that the oil side is uppermost*).

Alighting gear

11. Actuation of the hydraulically-operated alighting gear is initiated electrically from a twin push-button control on the port instrument panel in the cockpit, the control energising a solenoid-operated control valve in the starboard wheel bay. Four pipes connect to this control valve. Two of these pipes are from the supply and return lines. The other two direct fluid to and from the undercarriage jacks and fairing door jacks. Fluid flowing to the anchored ends 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 emergency air supply.

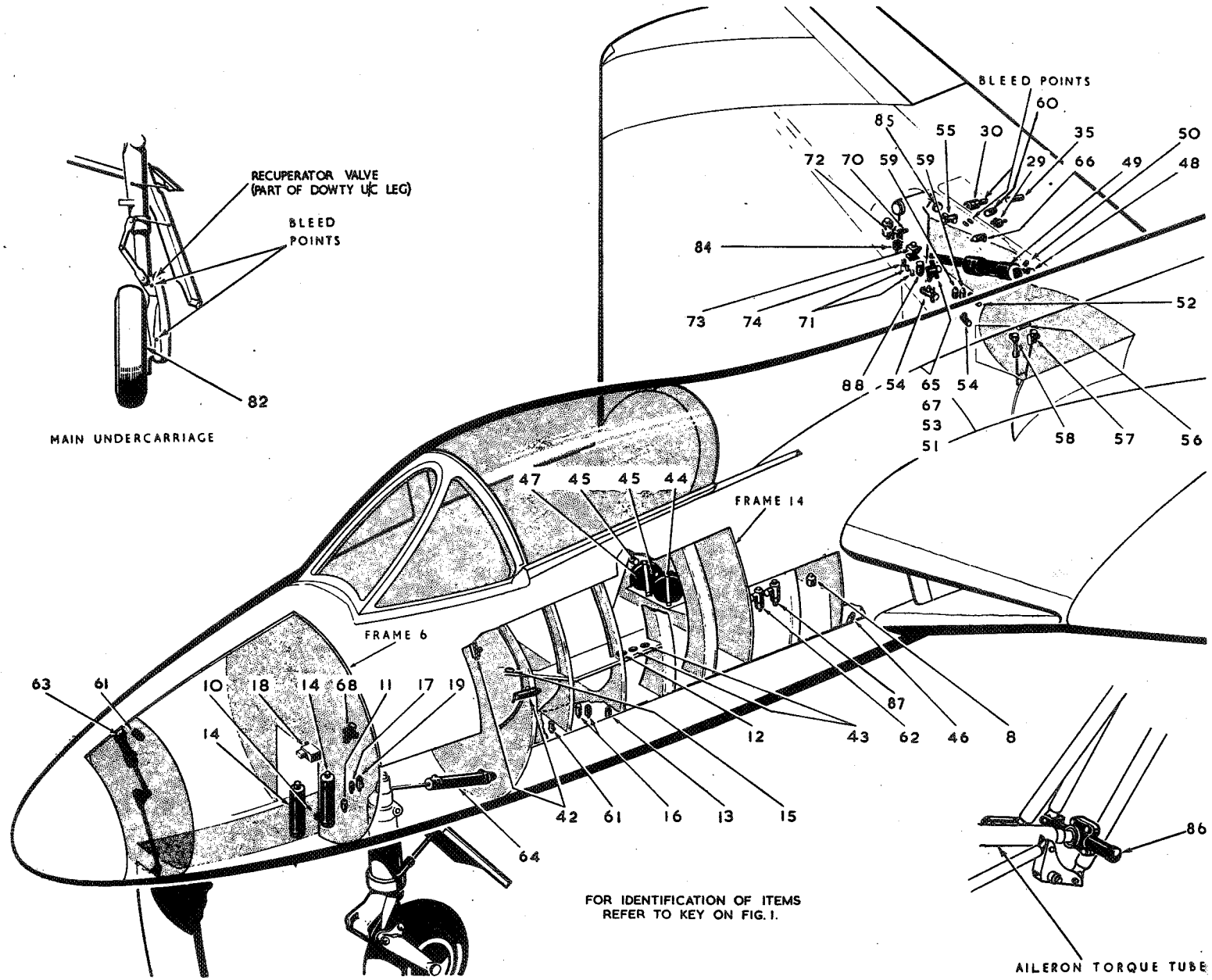


Fig. 2. Hydraulic system installation (1)

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 lowering speed is effected by means of restrictors in the pipe-lines. A pressure regulating 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 regulating 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 clos[illegible] A jettison valve, which is operated by [illegible]gh-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. Each main undercarriage leg is provided with a pressure recuperator, which is attached to the leg in the region of the lower torque link. The recuperators, which obtain their pressure from the main pressure line of the hydraulic system, maintain a minimum charging pressure of 1,500 lb. per sq. in. in the main undercarriage shock-absorber units at all times when the hydraulic pump is running. To ensure that the high pressures generated during landing are contained within the shock-absorber units, each recuperator incorporates a non-return valve.

12. When undercarriage DOWN is selected, fluid is directed through the two shuttle valves to the anchored ends of the main wheel fairing door jacks, the nose wheel jack and the nose wheel fairing door jacks. 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 ends of the main undercarriage jacks and at the same time operates a sequence valve which opens the main undercarriage up 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 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 lowers. There is no sequencing. The nose wheel is locked down mechanically.

13. When undercarriage UP is selected, 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 operates 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 pilot's control consists of UP and DOWN push-button switches situated on the port instrument panel in the cockpit, the control being so designed that operation of the one button automatically ejects the other. These switches energise solenoids which, in turn, operate the valve concerned. The UP push-button is provided with a solenoid-operated lock which engages when de-energised and prevents the alighting gear from being raised when the wheels are on the ground. This solenoid is controlled by a micro-switch on each main undercarriage leg, which breaks the circuit to the solenoid when the leg is compressed on the ground by the weight of the aircraft. 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 micro-switches to make contact, thus energising the solenoid to release the lock and permit normal operation of the UP push-button. The solenoid may, however, be overridden by the pilot twisting the knurled ring on the UP push-button and pressing it, thus providing for retraction of the alighting gear to enable a belly-landing in an emergency to avoid an obstruction during take-off or landing.

Note . . .

To re-set switch after emergency use, insert Dowty re-setting tool (Part No. S.T.1567, or C.2524 Y/50) into the small hole in the face of the UP *button, pressing lightly and turning the knurled ring back to its original position.*

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 which is installed with the flap and anti-G bottles in the front fuselage just aft of the pilot's seat in the cockpit. There are two shuttle valves, one for the main wheel units and the other for the nose wheel unit. When the emergency control (*Sect.* 1, *Chap.* 3) is operated, the 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 ends of the nose wheel jack, the nose wheel fairing door jack and the main wheel fairing door jacks. When the main wheel fairing door jacks have opened, the main door approximately 30 degrees, the leg fairing locks are operated, these, in turn, operating selection valves which pass air freely under pressure 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

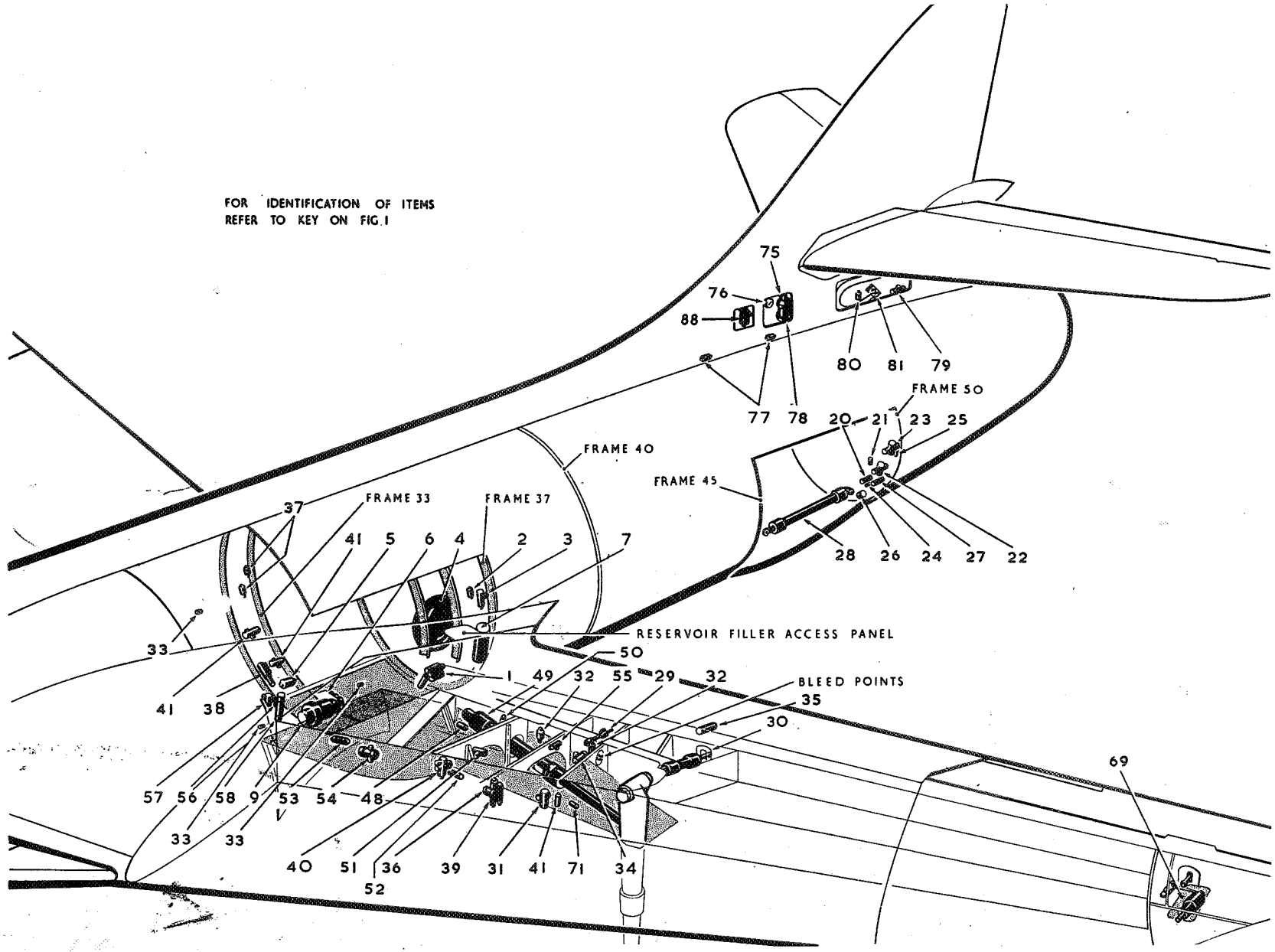


Fig. 3. Hydraulic system installation (2)

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 under the cockpit port shelf 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 extend from just inboard of the ailerons to the wing roots. They are controlled from a switch situated on the port instrument panel in the cockpit. The switch provides 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 magnets 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. The drum-switch is located in the port wing root and its associated Desynn transmitter in the port wheel bay just forward of the undercarriage girder.

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 lb. per sq. in. 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 flap rate and 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 emergency air 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; it is set to 3,050 ±50 lb. per sq. in. and allows the flaps to close to a degree determined by external influences. Three test connections, provided for use when synchronizing the flaps, are accessible through the access doors, items 79 and 87 of fig. 2, Sect. 2, Chap. 4. The use of these is described in fig. 6.

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 behind the pilot's seat, adjacent to the air bottle for emergency operation of the alighting gear (*para.* 15). When the emergency control is operated, the high-pressure air is directed to a shuttle valve which cuts off the hydraulic supply and at the same time admits air to the jacks. The air pressure also operates a fluid jettison valve which permits oil expelled from the jacks to be blown to atmosphere. The disposition of the control in the cockpit and its operation is described in Sect. 1, Chap. 3 of this volume.

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

Aileron booster jack system

19. Hydraulically-operated booster jacks provide additional 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 the 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 hydro-boosters, and consequently the jack is extended when the ailerons are in power. When aileron control is switched to manual, or hydraulic failure occurs, the jack, being spring-loaded, retracts and the oil trapped in the jack on re action 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. This, 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 the two hydraulic accumulators (for operation of the system in the event of hydraulic power failure) are 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 or the other side of the jack piston, 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 valves position is changed and fluid passes through one of two orifices depending on the direction of 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 s

As the jack body is in connection with 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 as long as pressure is applied. Should the hydraulic power fail, the two hydraulic accumulators automatically come into service to give approximately four complete control column reversals. When power drops below 300 lb. per sq. in., 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 renders it necessary, the pawls can be disconnected in flight by the operation of a switch on the port side of the centre instrument panel in the cabin. A dolls-eye indicator, situated on the port instrument panel, operates to indicate that the locks have disengaged. The operation and circuit of the cut-off switch and indicator is described in Sect. 5, Chap. 1 of this volume.

Elevator booster jack 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. The linkage system and its operation is described in Sect. 3, Chap. 4 of this volume. 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, except that a proportion of the power is fed back to give feel to the controls. When the emergency system is used, the hydraulic accumulator provides for 4½ complete reversals of the control column.

Wheel brakes

22. The hydraulically-operated wheel brakes are controlled from a lever on the control column handgrip, differential control being 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 effort to be applied without the risk of wheel lock. These anti-lock units consist of a valve regulated by a flywheel housed in a rubber-tyred shell which is rotated by the rim of its respective landing wheel. The units are connected to the hydraulic line from the pilot's manual control to the associated brake units. The Maxaret units are sensitive to angular deceleration consistent with 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, pipes convey fluid to the Maxaret units and thence to the brakes. Branch pipes from the brake supply lines connect with two pressure relays, which in turn, connect with a triple pressure gauge in the cabin. A third connection on the gauge is in connection with the system pressure line. Thus, the gauge registers the pressure existing in each brake unit and also the system pressure. The accumulators, which are mounted in the nose wheel bay in the region of frame 6, have an air charging connection which is also accessible via the nose wheel bay. 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. This structure, which in the closed position embraces the underside of the rear fuselage, is described in Sect. 3, Chap. 1. It is hinged from structure formed between frames 45 and 46 and is operated by a hydraulic jack which is anchored at frame 50. Operation of the air brake is from a switch on the throttle control lever. Full extension or retraction of the air brake is by selection 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 on the "in" line, a pressure relief valve on the "out" line and a pressure-operated switch. The pressure regulator valve (Maintaining valve) is fitted between the pressure supply and the main non-return valve feeding the control valves to maintain a pressure of 1,000 lb. per sq. in. for the supply of the power controls during the period of extension and retraction of the air brake. A dolls-eye magnetic indicator in the cabin, controlled by a micro-switch, gives a black indication for air brake "in" and a white indication when "out." 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 not already in that position. This condition is also obtained on selection 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 via the electro-hydraulic control valves in the rear fuselage.

Note . . .

Air brake "in" must not normally be obtained by selecting undercarriage "down". On no account is full extension 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 "out" position energises 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 to put the air brake "out" 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 energises 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 full out position is reached. In the out position, if the air load on the air brake produces a hydraulic pressure above the setting of the relief valve, this valve will lift and allow the air brake to retract, oil for the inside of the jack being drawn via 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 energised to break the circuit (*Sect.* 5, *Chap.* 1) and the jack will retract to bring the air brake to the "in" (closed) position.

Note . . .

Air brake "in" selection must not normally be obtained by selecting undercarriage "down".

SERVICING

General

25. Scrupulous cleanliness is essential during all servicing of the hydraulic system. Fluid used for topping up must always be clean and the filter must always be in position when pouring. Funnels and containers for holding the fluid, or containers used for the reception of drained fluid, must be kept clean and preferably rinsed out with clean hydraulic fluid before use. (*The fluid used for this purpose must afterwards be dis-*

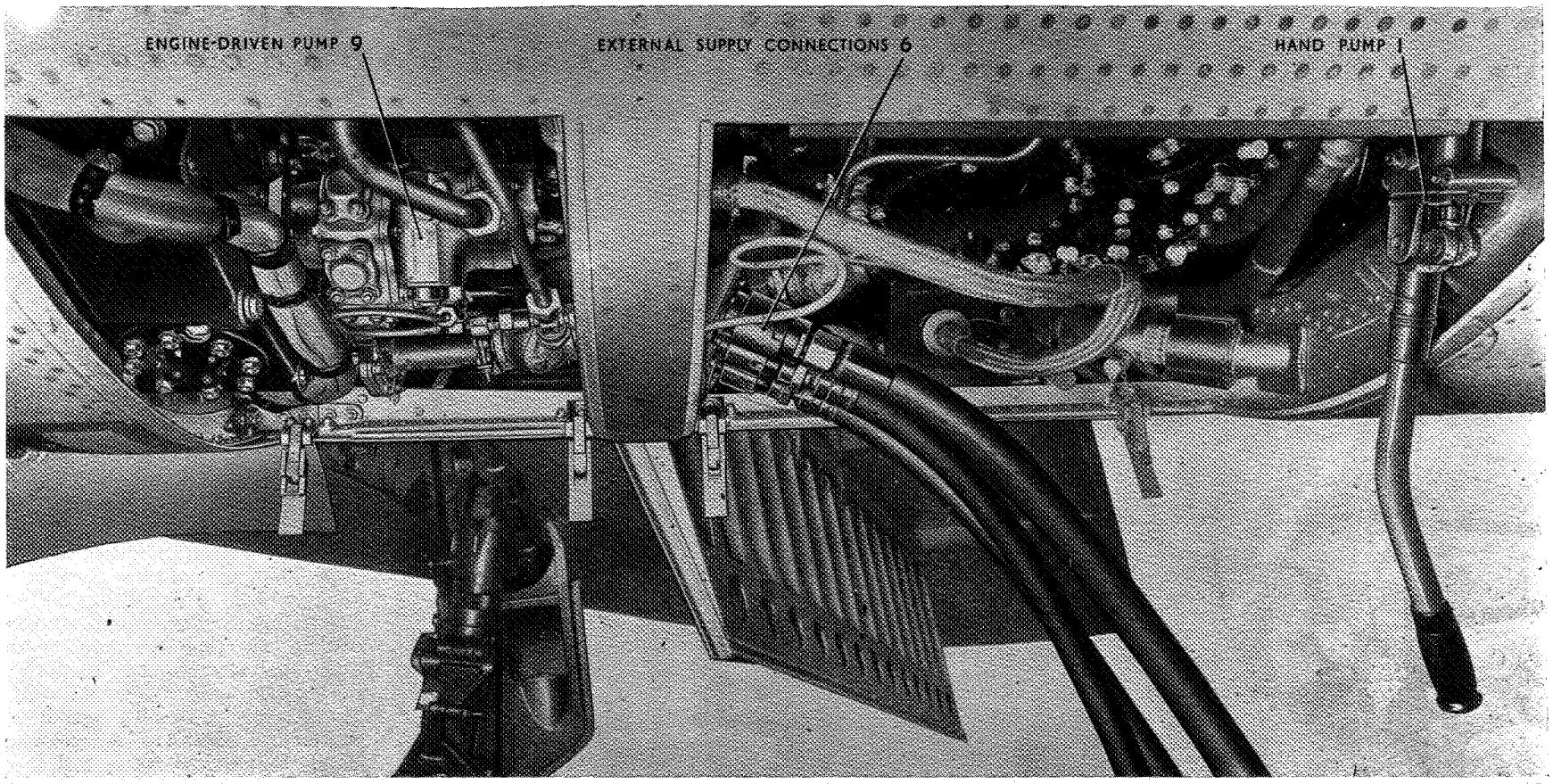


Fig. 4. Hydraulic pumps and external charging connections

carded). When pipe-lines are disconnected, the unions and pipe-ends must be immediately blanked off with blanking caps AGS596 or 505 to exclude the ingress of dirt or moisture. (*Rag or material of a fluffy nature or masking tape 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 re-assembly.

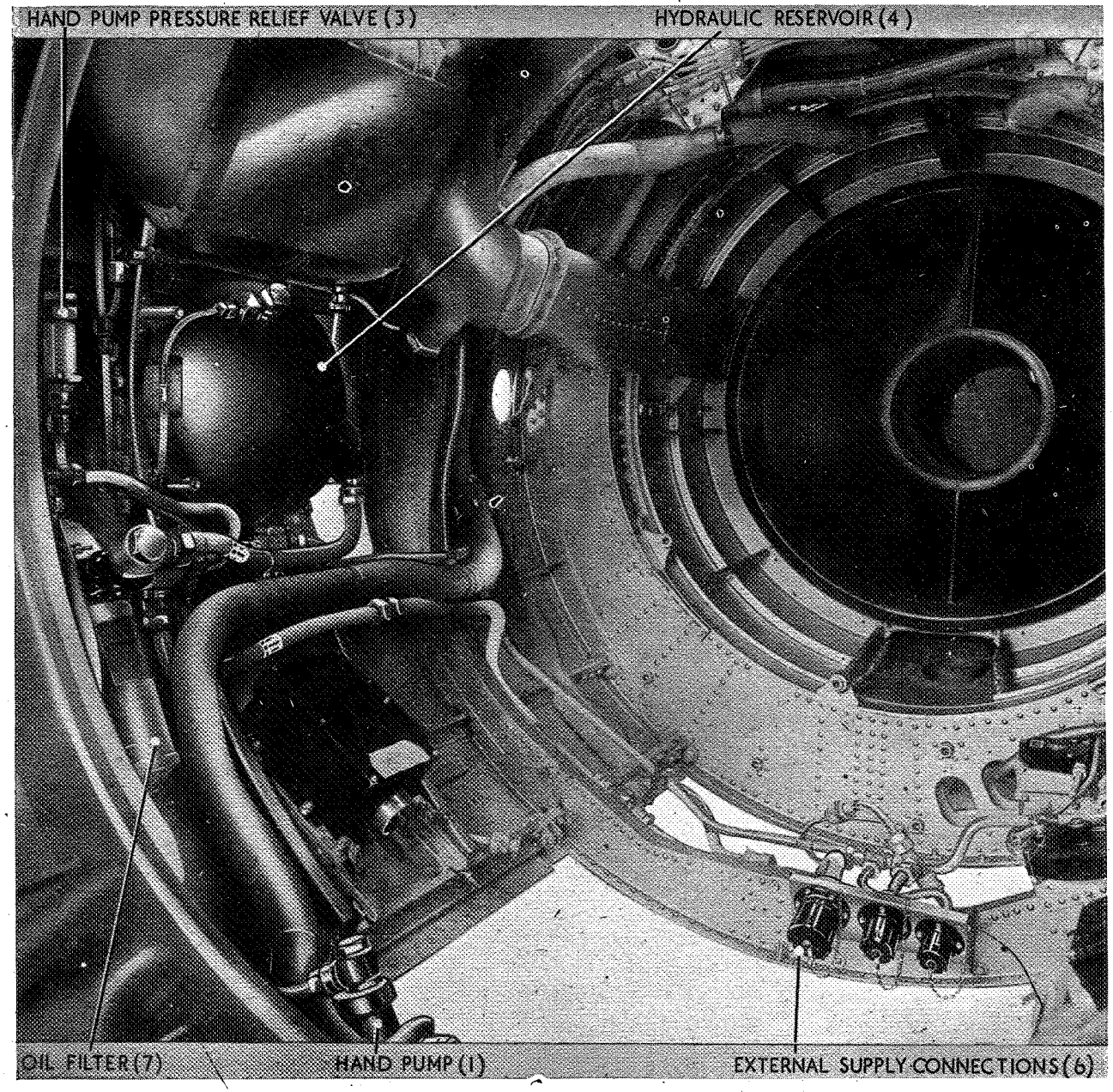


Fig. 5. Hydraulic components in engine bay

Note . . .

Hydraulic fluid has a detrimental effect on paint, rubber, electrical cables, etc., therefore great care must be taken to avoid the spilling of fluid on such parts.

Hydraulic reservoir

26. The procedure for re-filling the hydraulic reservoir is described in Sect. 2, Chap. 2. 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 the hydraulic accumulators, which form part of the hydraulic system installation, is described in Sect. 2, Chap. 2.

Lubrication

28. For the lubrication of rubber sealing rings, gland rings, etc., grease XG–315 (Stores Ref. 34B/237) is to be used. For all bearings, hinge-pins, etc., unless otherwise stated in the appropriate chapter, use a low temperature grease to Specification XG–275 (Stores Ref. 34B/222 or 242).

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, will be due to failure of the pump, obstruction in the pipe-line between the pump and control valve, fracture of the pipe-line and 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

the two shallow grooves). Using an Allen key, or an Unbrako wrench measuring 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 flow is maintained. Dissipate pressure in the system by operating the brakes a number of times, remove clamp from port relay and fit to starboard relay. Slacken the coupling on the starboard gauge line at the gauge, build up system pressure again and move rudder bar to starboard and lock. Bleed starboard gauge line until air-free fluid flows from the loosened coupling. Tighten the coupling whilst the flow is maintained. Remove clamp from the relay and check the brakes for correct operation.

(10) 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. Then fit the clamp to the relay, loosen the pipe coupling at the gauge and generate system pressure as for brake gauge line above, 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.

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

(12) Loosen the bleed plugs on the air brake jack and operate the handpump until air-free fluid is expelled from the bleed plugs. Tighten the bleed plugs and check the circuit for correct operation as detailed in para. 37.

Note . . .

When all bleeding is completed satisfactorily, the reservoir must be topped up finally.

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 next take-off. Care must be taken to slacken off the reservoir filler cap and the bleeder plugs sufficiently to release all pressure before any selection is made. When all pressure is released, prime and bleed normally as described in para. 34.

Testing air brake on ground (undercarriage down)

36. Operation of the spring return test switch, fitted on the port side of the cockpit behind the hood control, in conjunction with a second micro-switch operated by the air brake, permits partial extension (about 15 deg). of air brake and immediate retraction each time the test switch is moved to the ON position. This gives indication in the cockpit by means of the doll's eye indicator that the system is operating satisfactorily.

Note . . .

Air brake check must not be carried out at the same time as check for landing flaps. Air brake "in" selection must not normally be obtained by selecting undercarriage "down."

Testing air brake on ground (undercarriage up)

37. Operation of the air brake by means of the normal control in 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 of rear fuselage) and check that low speed operation is obtained. (Remove the link after test). To check the operation of the pressure switch, connect a suitable voltmeter across the above terminals, which will indicate the battery voltage on selection of air brake "out." Use the handpump to check the pressure at which the switch operates, i.e., the voltmeter indicates zero and the pressure 2,600 ± 50 lb. p sq. in.

Note . . .

The air brake check must not be carried out at the same time as the landing flaps check. Air brake "in" selection must not normally be obtained by selecting undercarriage "down."

Operational tests

WARNING

Before these tests are applied, the aircraft must be jacked up clear of the ground as shown in the illustration in Sect. 2, Chap. 4.

38. When the system has been filled, each circuit must be tested. For this purpose, a hydraulic ground servicing trolley will be required, the pipes from the pump on the trolley being connected to the appropriate external supply valve (*para.* 8). When connection is made, test each circuit for correct functioning in conjunction with their respective control valves.

Testing emergency air system

39. At those inspection periods stated in the Servicing Schedule and prior to carrying out the operational tests mentioned in the previous paragraph, the emergency air system *must* be tested. The procedure is as follows:—

(1) Jack the aircraft clear of the ground (*Sect.* 2, *Chap.* 4).

(2) Connect up the 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 (*Sect.* 1, *Chap.* 3) and see that the fairing doors open and that the main and nose undercarriages and flaps move smoothly to the full "down" position. Check that both undercarriages are fully locked down.

Note . . .

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

(6) After the test has been satisfactorily completed, the ground crew must re-set the controls to normal and re-prime and bleed the system before carrying out the normal operational tests (*para.* 38).

Pressure tests

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

(1) Using the handpump, build up the pressure until the handpump relief valve operates and allow it to stabilise. A subsequent drop in pressure shown on the system pressure gauge in the cabin (port shelf), 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 each 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.

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 listed in the front of this handbook.

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 pressure in the system released by carefully removing the reservoir filler cap. Draining may be facilitated by operation of the jack, using the handpump.

Flap synchronization

43. The method to be used for checking the flaps for synchronization is described and illustrated in fig. 6.

REMOVAL AND ASSEMBLY

General

44. In general, the removal of the hydraulic components from the aircraft and their reinstallation 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

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

Reservoir	Access door in top rear fillet of port wing.
Handpump	Engine access door. Handle stowed in clips on door.
Air cylinders.....	Aft of pilot's seat.
Accumulators	
Brake	Nose wheel bay.
Aileron assister...	Starboard wheel bay.
Elvator assister...	In spine fairing—rear fuselage.

Maxaret units

46. When refitting 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) The Maxaret tyre in contact with the landing wheel must be deflected 0·045 in. to 0·050 in. (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 the following shims to adjust this deflection.

A.H.O. 27450—0·010 in. thick—2 off.
A.H.O. 27451—0·032 in. thick—1 off.
A.H.O. 27452—0·064 in. thick—1 off.