SECTION 5

HYDRAULIC SYSTEMS - GENERAL

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CHAPTER 1

GENERAL DESCRIPTION

1. Three separate 3,000 p.s.i. hydraulic systems, employing four Integral Type Pumps provide power for operation of the fully power operated flying controls,undercarriage, flaps, and various other services. Supplies to the controls are fully duplicated, guarding against any possibility of complete controls failure. One controls system power supply also caters for Emergency undercarriage lowering, in event of failure of the normal pressure. Provision of this alternative hydraulic power supply obviates the necessity to bleed as in the case of separate systems i.e. gas or air.

2. Control of operation of the various services is in the main by electrically switched selector valves these being of the Dowty Hydel Selector type. Emergency lowering of the undercarriage is by manual remote control. Extensive use of stainless steel is made for rigid pipe runs, and installation details are such that the local manufacture of pipes will be unusual; repairs being effected by standard replacement items. Pipe runs are fully identified to system and service line by sleeving, and where uni-directional flow occurs are arrowed in the direction of MAXIMUM flow. The systemsalso utilise pre-formed P.T.F.E. Hoses and Dowty Swivel Couplings where movement is desired. Self-sealing couplings are provided at each service line for attachment of ground servicing hydraulic trolleys.

3. Hobson power control units (P.F.C.U.'s) are used to operate the flying control surfaces and since these are fully powered, artificial loads are built into each control run. These take the form of spring and hydraulic pressures, a Feel Simulator Control Unit relating hydraulic loads to speed and altitude.

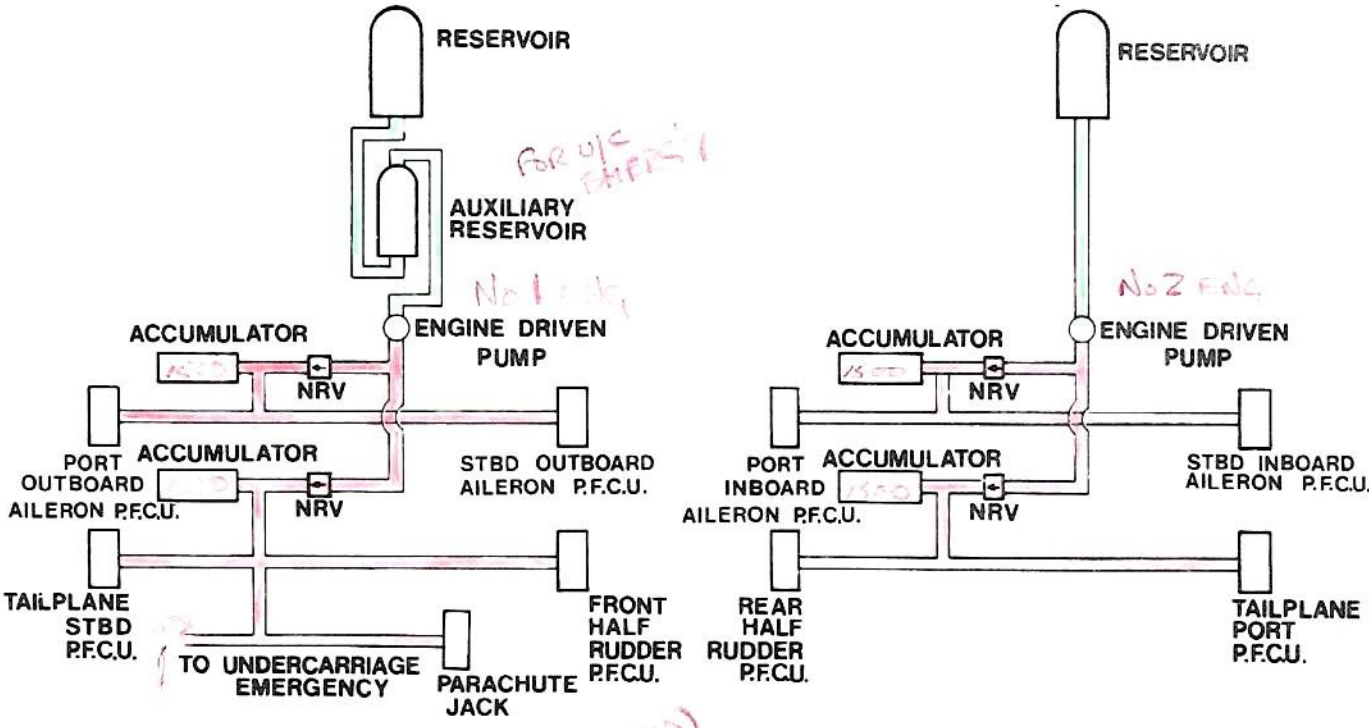
4. Components such as filters, non-return valves, etc., which create uni-directional, or differential flow are manufactured in such a way that incorrect assembly of internal parts is impossible. This irreversibility has been continued in installation details. Such components cannot be incorrectly connected into the hydraulic pipe runs.

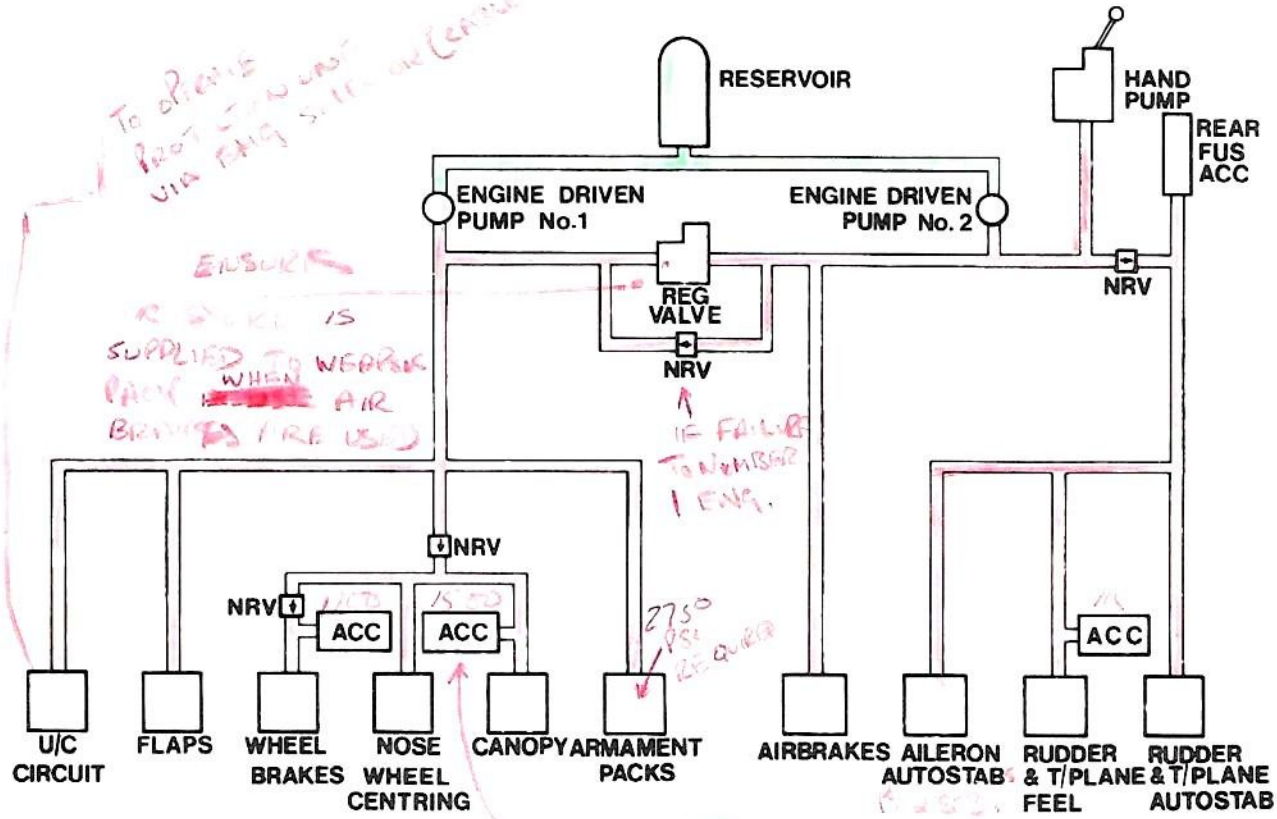
Hydraulic Systems

5. The three systems are :-

Services System providing power for the :-

(a) Alighting Gear
(b) Nose Wheel Centring
(c) Wheel Brakes
(d) Trailing Edge Flaps
(e) Airbrake Doors
(f) Canopy
(g) Hydraulic Feel
(h) Auto-stabilisation/Auto-Pilot
(j) Missile Pack





HYDRAULIC SYSTEM-BLOCK DIAGRAMS

SECTION 5

6. No. 1 Controls System providing power for :-

(a) Aileron P.F.C.U.'s (Outboard)
(b) Tailplane P.F.C.U.'s (Starboard Motor)
(c) Rudder P.F.C.U. (Forward Section)
(d) Braking Parachute Door Jack
(e) Emergency Lowering of Alighting Gear

7. No. 2 Controls System providing power for :-

(a) Aileron P.F.C.U.'s (Inboard)
(b) Tailplane P.F.C.U.'s (Port Motor)
(c) Rudder P.F.C.U. (Aft Section)

8. Certain services in the Services System and all circuits of the Controls Systems are protected by accumulators. Because of the presence of small quantities of oil behind the separator pistons, NITROGEN is used as the pressurising medium.

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CHAPTER 2

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POWER SUPPLIES

ILLUSTRATIONS

HYDRAULIC SYSTEM INTEGRITY

1. Modification 4601, and C.S.T.I. 191, dated 4.2.72 call for certain hydraulic components in the jet pipe bay to receive attention to minimise leakage, due to the failure of bonded seals, in this high-temperature area.

2. Under the terms of these instructions, certain components between frames 55 and 57 have been, or will be, fitted with bonded seals of an uprated specification. These bonded seals must be supported internally by the fitment of PTFE location rings of the specified type.

3. Servicing personnel should be aware of these requirements, in order that, on component replacement, the correct specification of bonded seal and PTFE supporting ring is fitted, and the correct torque loading applied on re-fitment.

4. For identification purposes the uprated seals are marked with one blue spot, and one green spot, on the rubber.

5. In addition, the instructions call for certain specified unions in the same area to be wrapped with fluoro-carbon tape, secured with locking wire, to minimise the spray effect of bonded seal failure.

6. This tape will have to be renewed, in the specified manner, should the joint have been disturbed.

7. The tape wrapping (5, above) is to be applied to the specified unions, which are not necessarily all those fitted with uprated bonded seals (2, above).

8. On leak testing subsequent to re-assembly, any leak must be investigated in accordance with SP.1014, but replacement bonded seal types, and their torque loading figures, are to be in accordance with Mod. 4601 or C.S.T.I. 191, as above.

SECTION 5

CHAPTER 2

POWER SUPPLIES

POWER SUPPLIES CIRCUITS

1. The hydraulic circuit associated with any one engine driven pump is similar to that of the remaining three pumps. In the services system, however, one reservoir supplies both engine driven pumps and a hand pump, the latter being available only for ground servicing, its handle being stowed in the port wing leg well.

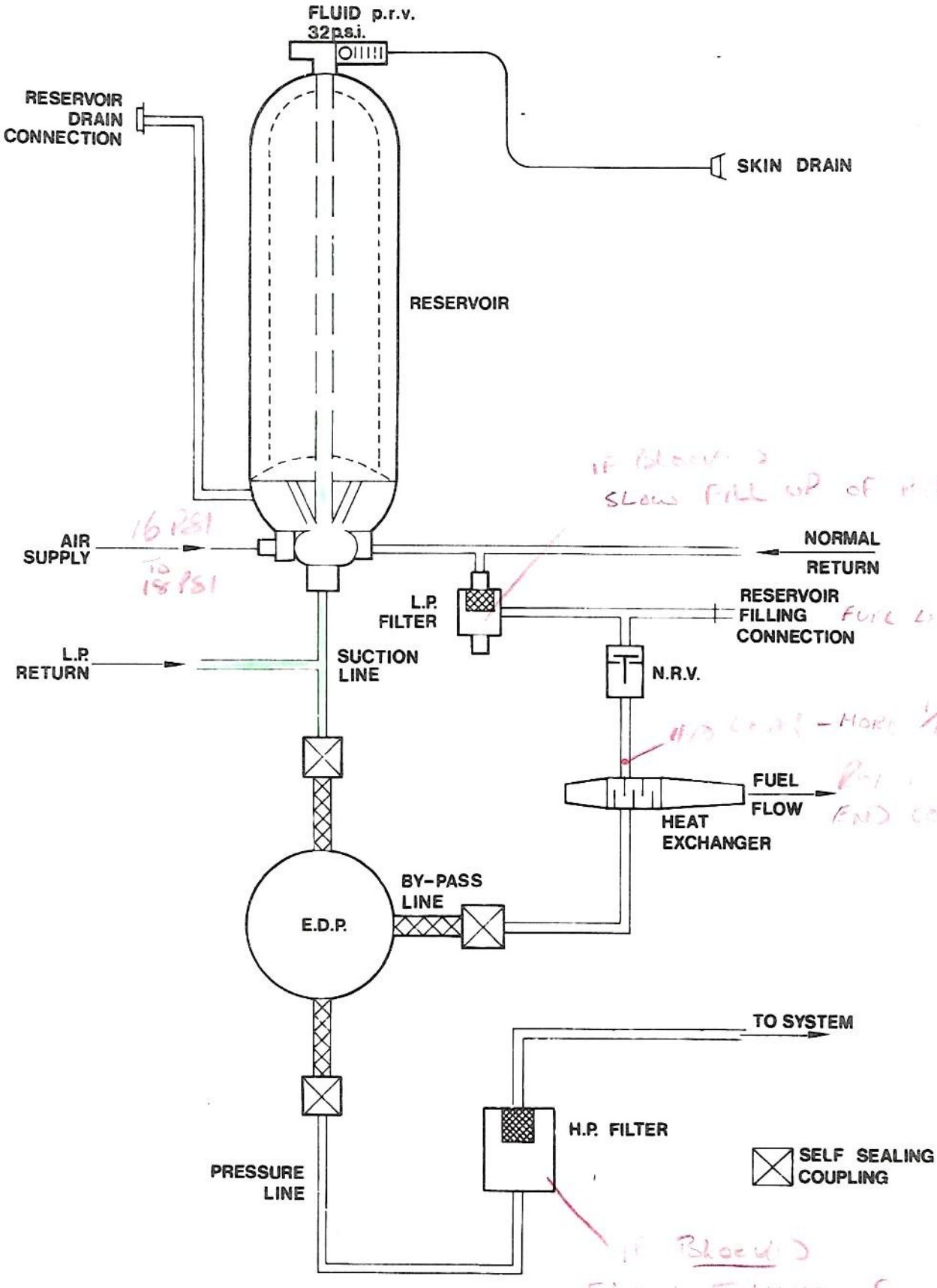
2. A suction line from the reservoir is connected by P.T.F.E. Flexible hose to the pump inlet, the pressure outlet from the pump being connected through a pressure filter to the main pressure line of the system. A by-pass connection on the pump is piped to a heat exchanger where fluid is cooled by fuel, thence via a non-return valve and micronic filter unit to the reservoir. Provision is made for system charging by tapping in a line between the non-return valve and by-pass line filter, thus all fluid entering the system on replenishment passes through the filter, and is prevented from entering the pump by the non-return valve. A normal return line from the circuits is connected direct to the reservoir, and a further low pressure return line tapped into the suction line to the pump.

RESERVOIRS

3. Three separate main reservoirs contain fluid (OM-15) for use in the three systems, and additionally an auxiliary reservoir is fitted in the No. 1 Controls system. The main reservoirs are cylindrical and are mounted vertically in the fuselage. The lower end of each cylinder is closed by a 'junction head', having connections for suction, return, fluid drain and air pressurising lines. The drain line passes up and outside of the reservoir to terminate with a blanking cap near the top of the cylinder.

4. Inside the reservoirs, a perforated delivery tube, seating in the junction head, locates in an externally threaded tube guide at the top of the reservoir. The junction head and tube guide also provide seatage for a rubber bladder. At the top end, the bladder is trapped between tube guide and cylinder wall to form a seal, and a special washer prevents rotation of the tube guide when the securing nut is tightened. At the base the rubber bladder is sealed to the junction head by a sleeve and retaining nut, and the assembly then held in position in the cylinder by a larger threaded outer collar. Ribbing on the bladder prevents pockets of air being trapped during replenishing, thus ensuring maximum content.

5. The junction head is ducted to permit fluid to flow from the delivery tube, through the centre of a special banjo bolt into the suction line to the pump. The return line is coupled to the banjo connection and fluid returns around this, through angled ducts, and a re-inforced gauze filter into the reservoir. Auxiliary air is piped to the junction head and via angled ducts to the space between bladder and body. A 22 p.s.i. relief valve controls maximum air pressure which is normally 16 to 18 p.s.i.



TYPICAL ENGINE DRIVEN PUMP CIRCUIT

6. At the top of the cylinder the tube guide is connected by banjo joint to an oil pressure relief valve, set to limit fluid pressure to 32 p.s.i. The outlet from the valve terminates in a special adaptor in the fuselage skin. A pipe is inserted into the adaptor during reservoir filling and ground servicing.

7. An auxiliary reservoir fitted between outlet from the main reservoir, and inlet to the pump increases the fluid capacity of the No. 1 Controls system. Its construction is basically similar to the main reservoirs except that provision is made only for fluid inlet and outlet and venting air, all other lines being deleted.

ENGINE DRIVEN PUMPS

8. The forward mounted pumps driven by No. 1 and 2 engine are 'Integral' Type 180 Mk. 50 units supplying pressure to the Services system. They feed a common pressure line so that should one engine fail, the remaining pump is capable of maintaining all services. The aft pumps on each engine are Integral Type 220 Mk. 37 units; the pump of No. 1 engine feeding the No. 1 Controls system, whilst that of the No. 2 engine feeds No. 2 Controls system, hence total failure of the power operated flying controls is prevented by full duplication of complete systems and components.

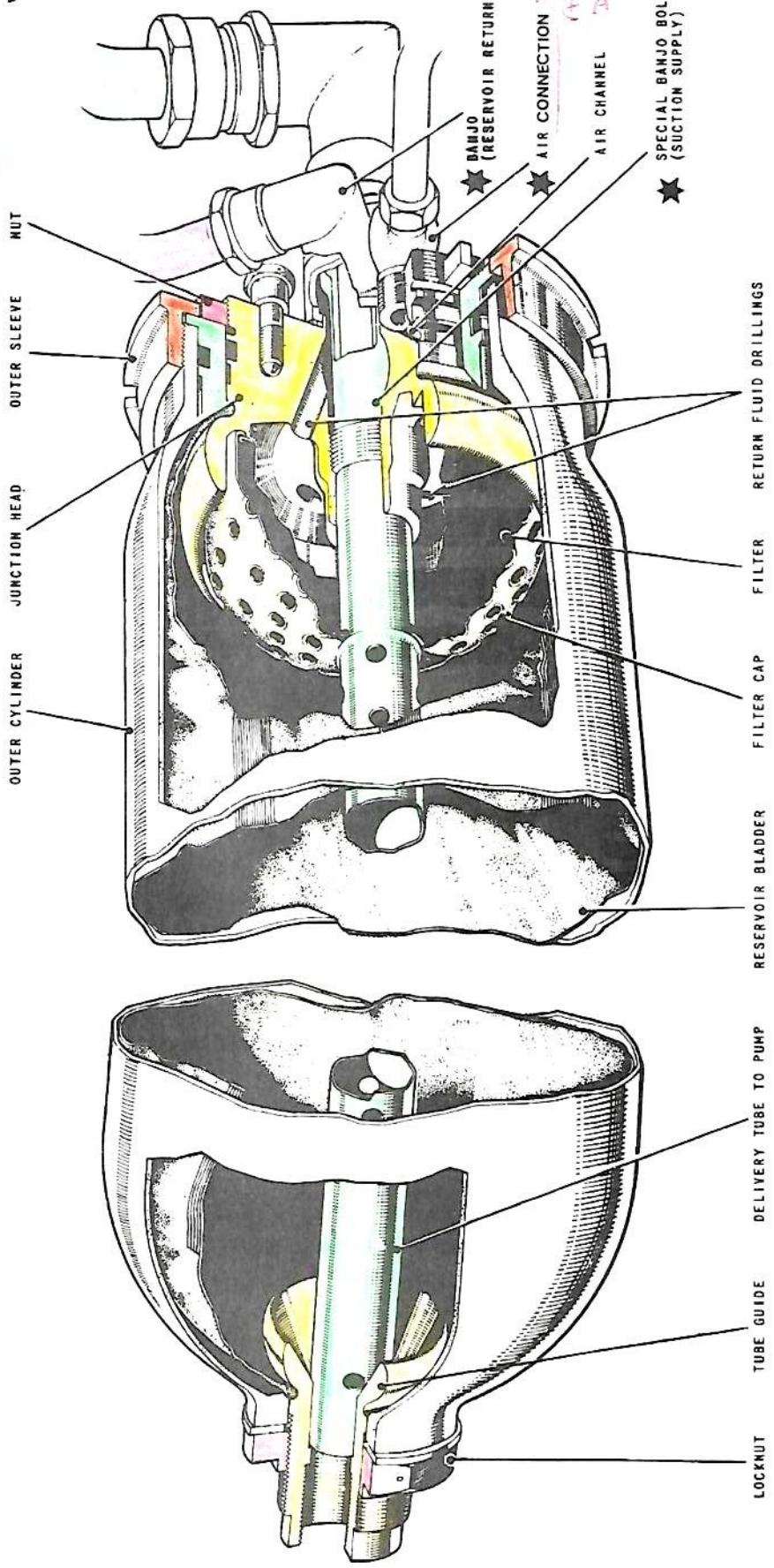
9. The pumps are two-stage type, a spur gear pump and piston type are driven from a common shaft. The gears provide priming for the cylinders of the piston type pump which produce the necessary high pressure for operation of the various services.

10. Control of the high pressure output from the piston stage at 3,000 p.s.i. is by an off-loading valve operating between the two stages. Progressive opening of this valve directs fluid into the by-pass line and back to reservoir. As pressure rises it affects the first stage off-load valve which opens to by-pass a limited amount of fluid, further increase in pressure from the second stage is also sampled by the off-load valve which further opens to stabilise output pressure at 3,000 p.s.i. Spring-loaded restrictors on each cylinder of the second stage pump reduce priming of the cylinders, the degree of restriction being determined by output pressure and amount of off-load.

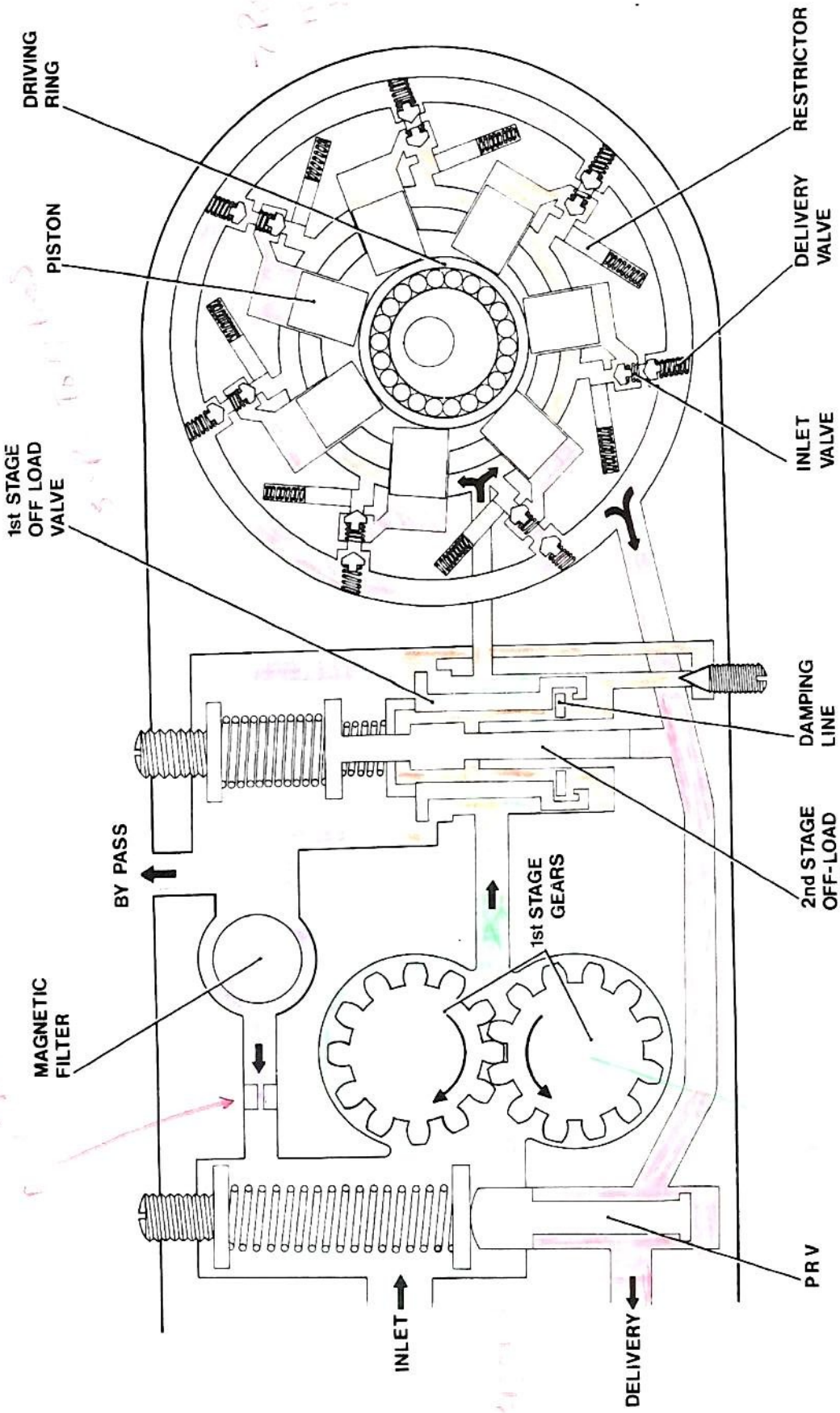
11. A magnetic filter on the outlet side of the off-load valve prevents re-circulation of any ferrous particles, and a pressure relief valve between inlet and outlet ducts opens at a value of 3,100 p.s.i. should the off-load valve fail.

HEAT EXCHANGER

12. Two 'Marston Excelsior' heat exchangers are fitted in the by-pass line to cool fluid being returned from the pumps to the reservoirs. Each consists of two sections, one used in the Services pump line, the other in the Controls pump line. Corrugated aluminium matrix increases the area of contact between the hot fluid and cooling fuel, which passes longitudinally through the unit on the way from the fuel pumps in the wings to the engines.



FLUID RESERVOIR



INTEGRAL HYDRAULIC PUMP TYPE 180/220 FUNCTIONAL DIAGRAM

SECTION 5

FILTERS

13. Pressure and return filters are fitted in each engine driven pump circuit. The micronic elements are stainless steel and must be periodically removed and returned to the makers (Palmers) for cleaning. All elements are easily removable whilst the casings are in-situ. Special spanners are provided to remove the base of each filter casing. Should overheating of fluid in the pump return lines be suspected filtering elements should be removed and examined for contamination. Contaminated elements will increase the length of time taken to replenish the system and where this becomes excessive, elements should be removed, inspected, and if necessary, returned to the makers for servicing.

REGULATOR VALVE

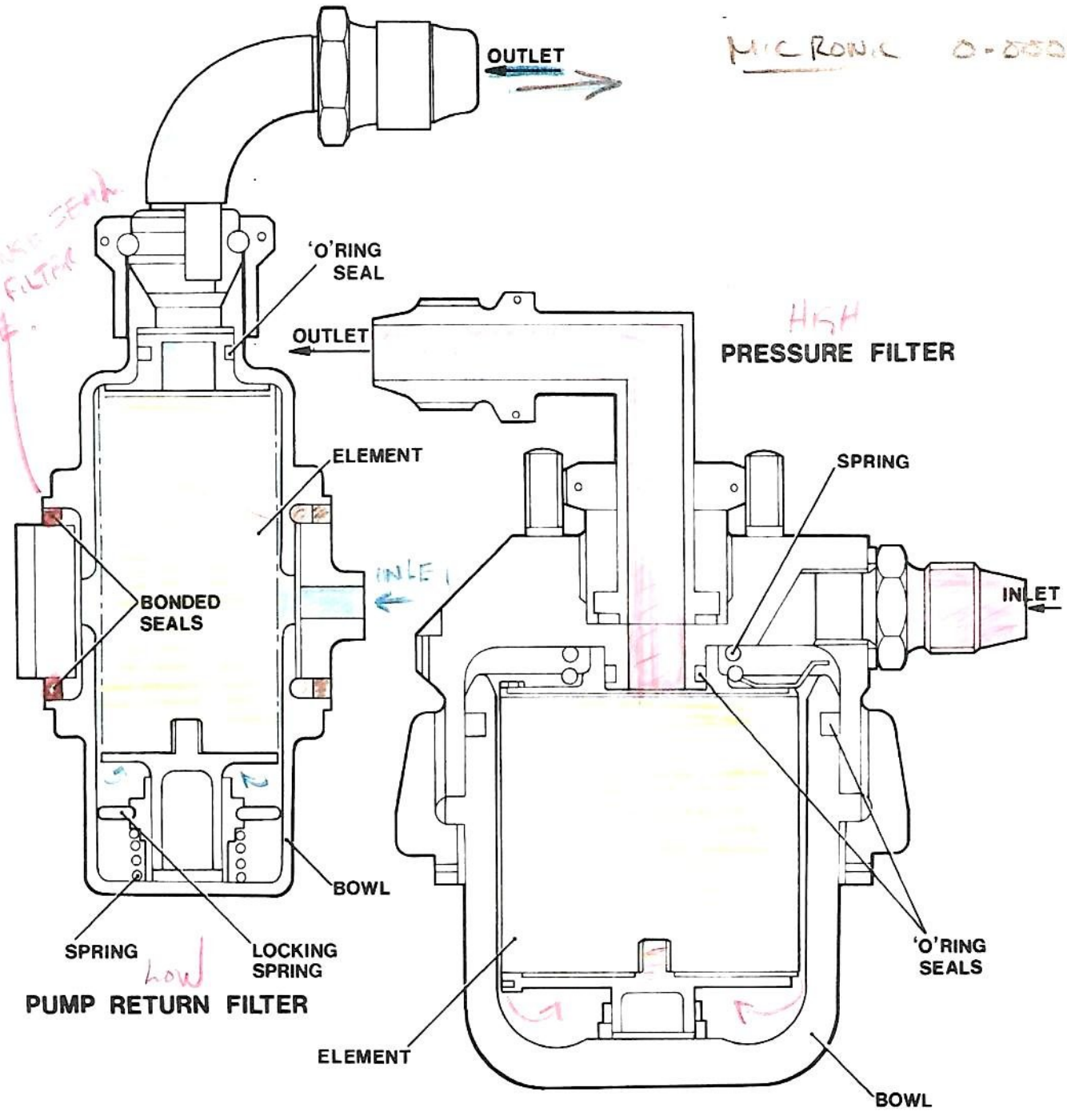
14. A Dowty Pressure Regulator Valve is fitted in the Services system main pressure line between the feeds from the two engine driven pumps. The purpose of the valve is to maintain fluid pressure in the Two-Missile Pack, during operation of the air brakes, which draw fluid from No. 2 Pump side of the line. The air brake operating jacks operated from the No. 2 pump side of the system are of large capacity and may cause a drop in line pressure when operated. The Missile pack operated by the No. 1 Pump side of the circuit is dependent upon a minimum pressure of 2,700 p.s.i. for its efficient operation, and the Regulator valve is set to close at this figure, isolating the two sides of the circuit. A separate line by-passes the regulator valve from No. 2 pump side to No. 1 pump side and a non-return valve in this line prevents reverse flow from the No. 1 Pump side. The regulator valve will open when subject to a pressure of 2,800 p.s.i. felt at the port connected to No. 1 pump side of the pressure line.

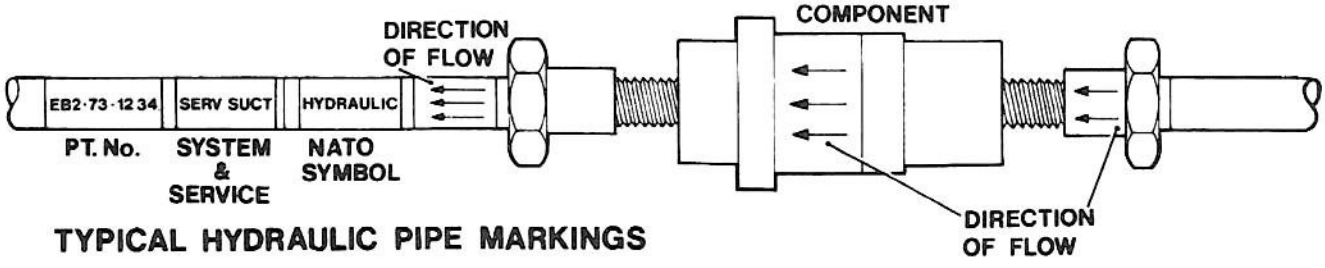
POWER FAILURE INDICATIONS - CONTROLS SYSTEM WARNING

15. Pressure switches tapped into the pressure lines of No. 1 and No. 2 Controls systems, operate warning lights in the Auxiliary Warning Panel. Should line pressure in either system drop to a value below 1,750 p.s.i. operation of the appropriate pressure switch brings on its associated indicator. In the event of a double failure and consequent operation of both pressure switches, indication will be given on the Standard Warning Panel, and will be attended by the flashing alerter light and audio warning in the pilot's headset.

SERVICES SYSTEM WARNING

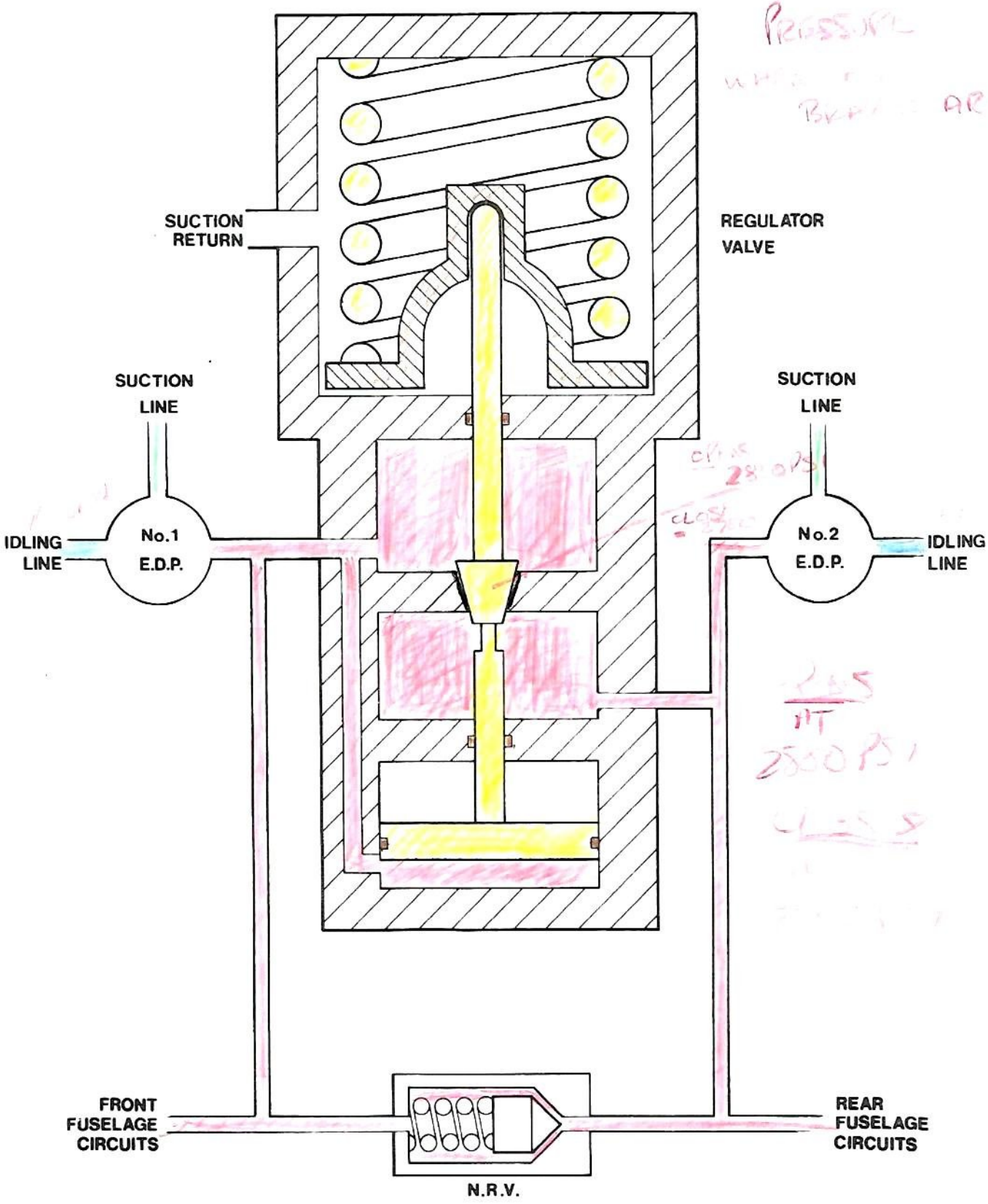
16. An 'Appleby & Ireland' pressure transmitter mounted on the starboard side of the Armament bay is tapped into the Services main pressure line to the packs and an associated gauge is mounted on the Port anti-glare shield in the cockpit. The gauge indicates system pressure being graduated in Thousand pounds commencing at two. Pressures below 1,500 lbs will be indicated when the needle falls to a red segment. Should electrical failure occur the needle falls further to a white segment, thus differentiation between hydraulic or electrical failure to the instrument is possible.



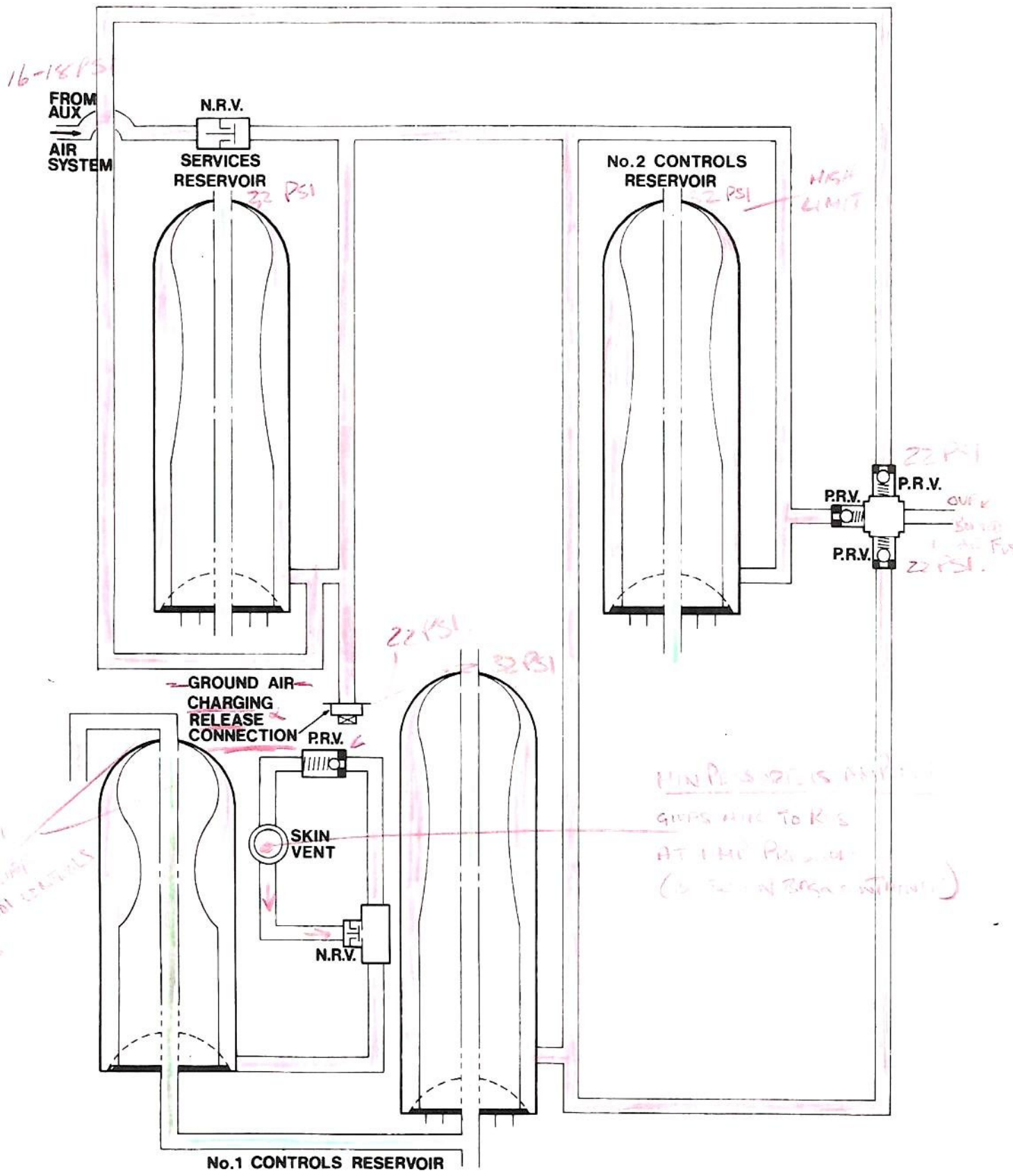


TYPICAL HYDRAULIC PIPE MARKINGS

PALMER FILTER



REGULATOR VALVE/N.R.V. CIRCUIT



RESERVOIR AIR PRESSURISATION AND VENTING (POST MOD.4061)

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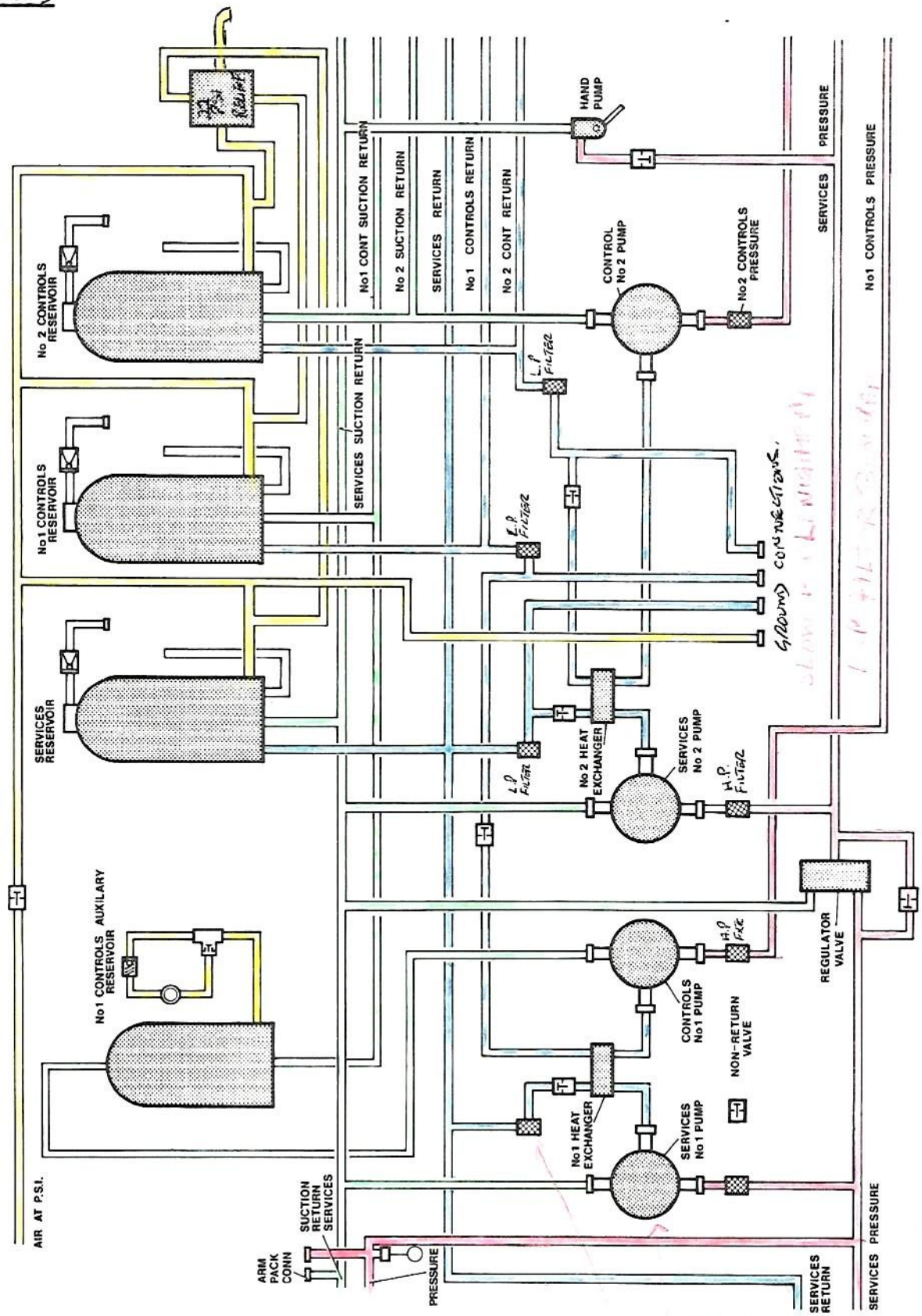

POWER SUPPLY CIRCUIT

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GROUND TEST CONNECTIONS

17. Self-sealing couplings are provided in each of the lines connecting the four pumps to the pipe runs in the aircraft. With the exception of No. 2 Services pump, the aircraft half of the couplings are mounted on brackets accessible through panels in the fuselage. The flexible hoses from the pumps are disconnected from these couplings and the hoses from ground servicing trolleys are then connected. In the case of No. 2 Services pump the couplings are mounted at the pump and the flexible hoses carry the aircraft half of the couplings. Adaptor hoses are therefore necessary when connecting external trolleys to the No. 2 side of the Services system. Location of the ground test connections are as under :-

No. 1 Services System - Panel 45P

No. 2 Services System - Through No. 2 Engine Hatch

No. 1 Controls System - Panel 45P

No. 2 Controls System - Panel 67P

LOCATION OF COMPONENTS

18. SERVICES SYSTEM

COMPONENT	LOCATION	ACCESS PANEL
Filters		
Pump Return No. 1	Pt. Fwd. Fr. 42 in No. 1 Engine Bay (Aft Filter)	H.1
Pump Return No. 2	St. Aft Fr. 47 in No. 2 Engine Bay	56S
Pressure No. 1	Pt. Aft Fr. 23 (Rear Filter)	26P
Pressure No. 2	St. Aft Fr. 47 in No. 2 Engine Bay	58S
Ground Test Points		
No. 1 Pump	Pt. Frs. 29/31 in No. 1 Engine Bay	45P
No. 2 Pump	Pt. Frs. 47/48 at the Pump end of Flexible Hoses	H.2
Heat Exchangers		
No. 1 Pump	Pt. Frs. 36/39 in No. 1 Engine Bay (Fwd. Section)	H.1
No. 2 Pump	Pt. Frs. 46/47 in No. 2 Engine Bay (Aft Section)	H.2
Non-Return Valves		
Air Pressure Line	Pt. Frs. 48/49 in 'tee' connection	-
Hand Pump	Pt. Frs. 51/52 in 'tee' connection inboard of hand pump	-

SECTION 5

LOCATION OF COMPONENTS

18. Continued.

COMPONENT	LOCATION	ACCESS PANEL
No. 1 Pump Return Line	On heat exchanger in No. 1 Engine Bay	H.1
No. 2 Pump Return Line	Ctr, Aft Fr. 46, above fire floor in No. 2 engine bay	H.2
Regulator Valve By-Pass Line	Pt. Frs. 46/47 in 'tee' adaptor	-
Pumps		
Hand Pump	Pt. Frs. 51/52 (Handle in port u/c well)	75P and 79P
No. 1 E.D.P.	Pt. Frs. 29/31	45P
No. 2 E.D.P.	Pt. Frs. 47/48	H.2
Regulator Valve	Pt. Frs. 44/45 in Lower Fuselage	-
Reservoir, Air Release Connection	Pt. Aft Face of Fr. 47 (In refuelling Box)	63P
Air Relief Valve	On bottom of Reservoir Cylinder	71P
Charging Connection	Pt. Fwd. Fr, 48 (Top Connection in refuelling box)	63P
Reservoir	Pt. Aft Fr. 50	69P and 71P
Drain	Aft of Top of Cylinder	69P
Oil Relief Valve	At Top of Reservoir	69P

19. NO. 1 CONTROLS SYSTEM

COMPONENT	LOCATION	ACCESS PANEL
Filters		
Pump Return	Pt. Frs. 39/42 in No. 1 Engine Bay (Fwd. Filter)	H 1
Pressure	Pt. Fwd. Frs. 23 (Fwd. Filter)	26P
Ground Test Points	Pt. Frs. 31/34	45P
Heat Exchanger	Pt. Frs. 36/39 in No. 1 Engine Bay (Aft Section)	H.1
Non-Return Valves		
Air Pressure Line	See Services System	-
Pump Return Line	On heat exchanger on No. 1 Engine Bay	H.1
Pressure Switch	Pt. Frs. 22/23 at Top of Gas Cylinder	26P
Pump, E.D.	Pt. Frs. 31/34	45P
Reservoir,		
Air Release Connection	See Services System	-
Air Relief Valve	On Bottom of Reservoir Cylinder	71P
Charging Connection	Pt. Fwd. Fr. 48 (Bottom Connection in Refuelling Box)	63P

SECTION 5 LOCATION OF COMPONENTS

19. Continued.

COMPONENT	LOCATION	ACCESS PANEL
Reservoir	Pt. Fwd. Fr. 51 (Aft Reservoir)	69P and 71P
Drain	Fwd. at Top of Cylinder	69P
Oil Relief Valve	At Top of Reservoir	69P

20. NO. 2 CONTROLS SYSTEM

COMPONENT	LOCATION	ACCESS PANEL
Filters		
Pump Return Line	St. Fwd. Face Fr. 47, in No. 2 Engine Bay	56S
Pressure	St. Fwd. Face Fr. 49, in No. 2 Engine Bay	60S
Ground Test Points	Pt. Frs. 48/49, in No. 2 Engine Bay	67P
Heat Exchanger	Pt. Frs. 46/47, in No. 2 Engine Bay (Fwd. Section)	H.2
Non-Return Valves		
Air Pressure Line	See Services System.	
Pump Return Line	Pt. Fwd. Fr. 47, above fire floor in No. 2 Engine Bay	H.2
Pressure Switch	St. Aft Face of Fr. 55	72S
Pump E.D.	Pt. Frs. 48/49	H.2
Reservoir		
Air Release Connection	See Services System.	
Air Relief Valve	On Bottom of Reservoir Cylinder	64S
Charging Connection	St. Aft Face of Fr. 48 in No. 2 Engine Bay	60S
Reservoir	St. Aft Fr. 51, Fwd. of Accumulator	66S and 64S
Drain	St. Between Top of Reservoir and Fr.51	66S
Oil Relief Valve	On Top of Reservoir	66S

To Prove Heat Exchanger

1. Open ended adaptor to replenishment point.
2. Battery master S/W 'ON'
3. D.C. Fuel pump ON.
4. L.P. cocks 'OPEN' (S/W ON)
5. H.P. cocks CLOSED, FULLY REAR.

Any fuel out of open-ended adaptor, a leak at heat exchange.