AVDASI 1
AENG 10001

Aircraft Power Systems

Hydraulic and Pneumatics

Aircraft power systems

Electrical Power

Avionics
Commercial
Ventilation
Lights

~230 kW (115 V)

Hydraulic Power

Flight Control
Landing gear
Braking
Doors

~240 kW (20.6 Mpa) *(206 bars)* *(3000 psi)*

Mechanical Power

Engine-driven
Fuel Pump
Oil Pump

~100kW *(variable speed with engine; 1000's rpm)*

Pneumatic Power

Air conditioning
Pressurisation
Icing Protection
Engine start

~1200 kW *peak (3 bars)* *(45 psi)*

Adapted from RAeS presentation by Graham Dobbs

Scales of power

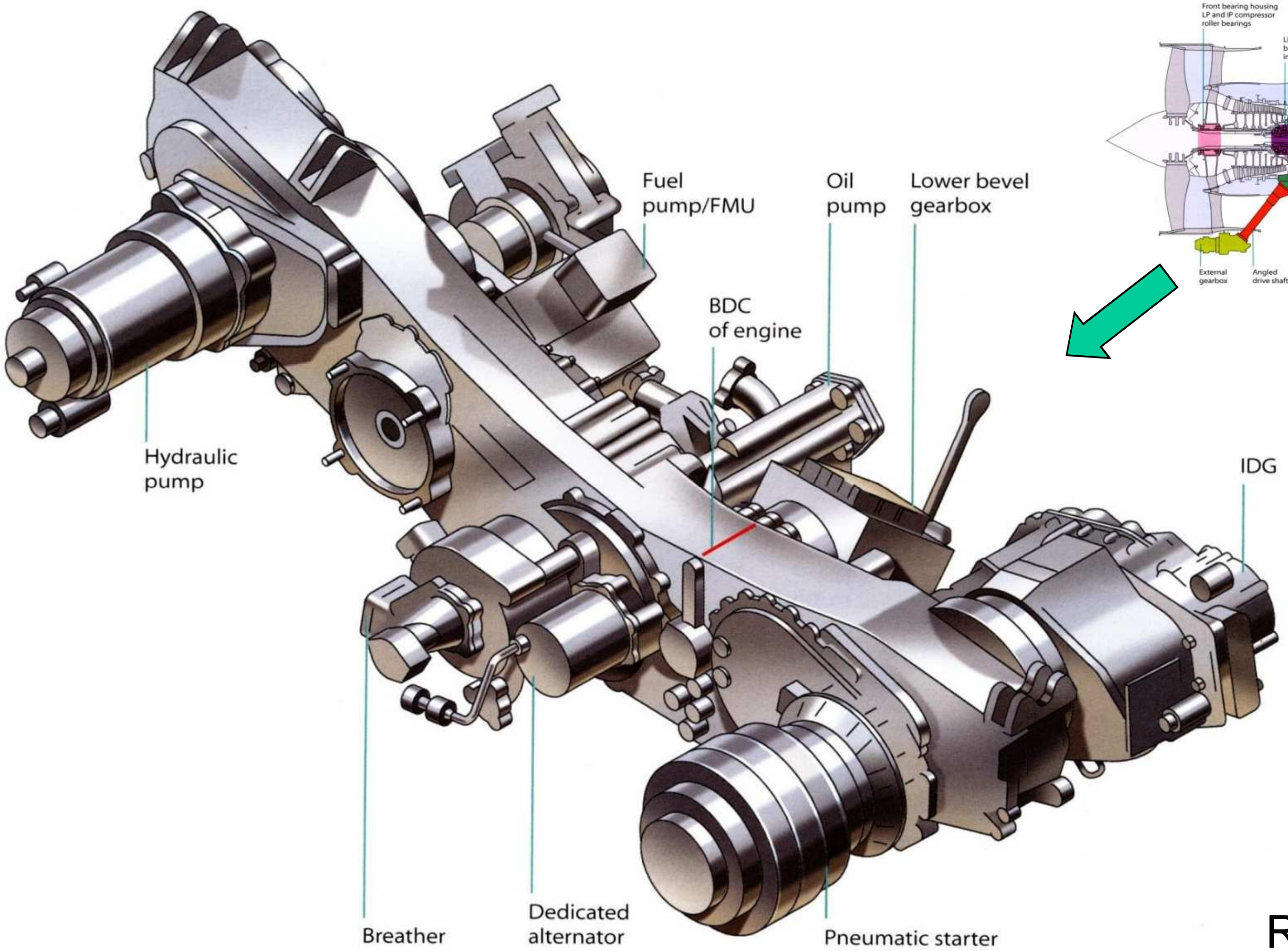
- Pocket Calculator ~ 100 µW (1×10^{-4} W)

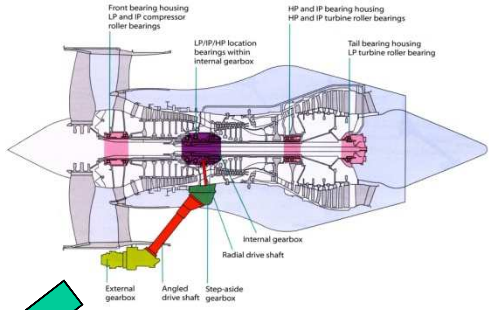
- Light bulb ~ 15 W

- Backhoe loader hydraulics ~ 70 kW (7×10^{4} W)

- 777 engine ~ 75 MW (7.5×10^{6} W)

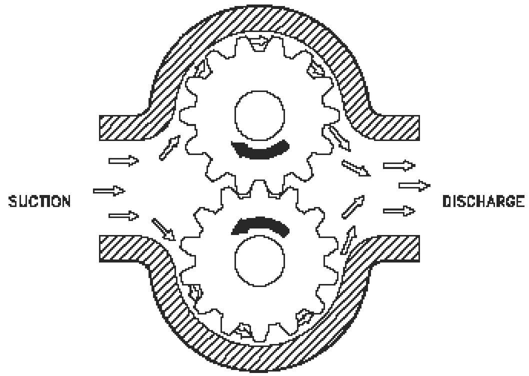
Accessory Gearbox





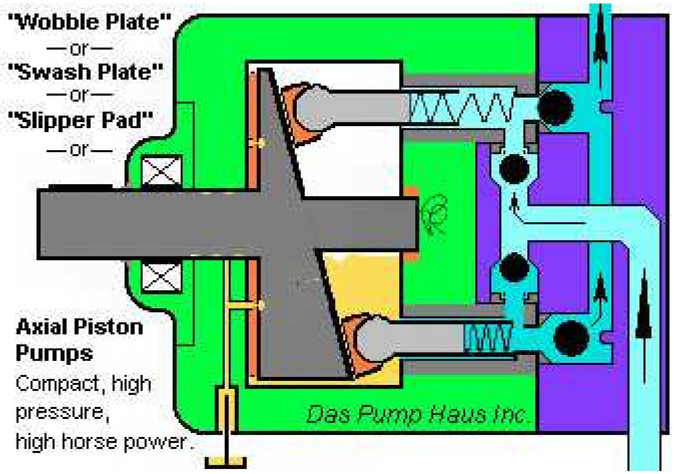
Rolls-Royce

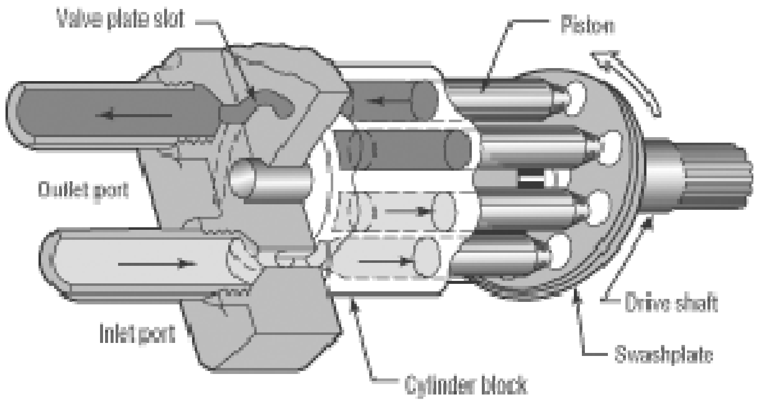
Creating pressure: Hydraulic pumps



- Gear pumps are a simple and reliable.
- They operate by meshing two gears in within a close tolerance housing.
- Oil in the space between the outside teeth is pumped from suction to discharge.
- Gear pumps can be noisy so constant mesh patterns, like the herringbone may be used.

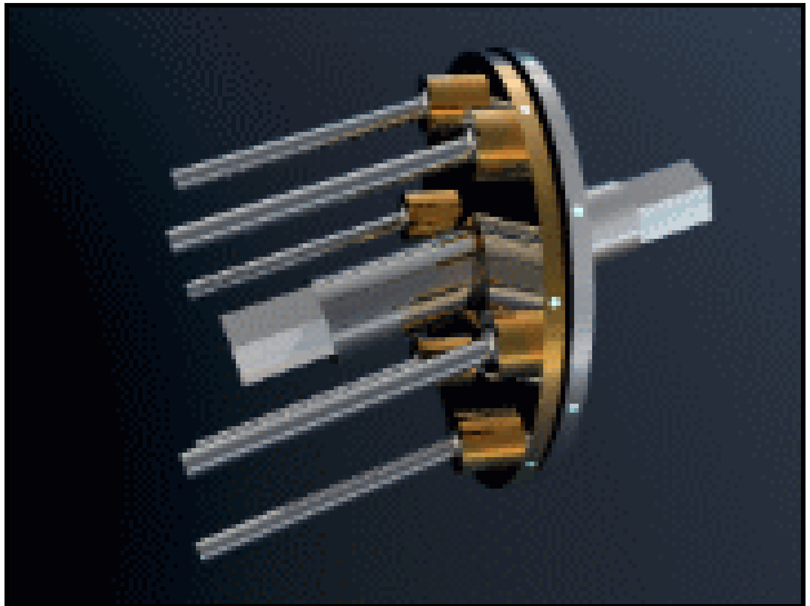
Creating pressure: Hydraulic pumps





- Axial piston pumps use a rotating swash plate to push pistons in and out.
- Check valves (one way) can direct fluid from inlet to outlet side, or one some designs the piston block rotates, aligning with the inlet or outlet port at the correct timing of the piston stroke.

Creating pressure: Hydraulic pumps



Swashplate_anim_metal.avi

Creating pressure: Hydraulic pumps

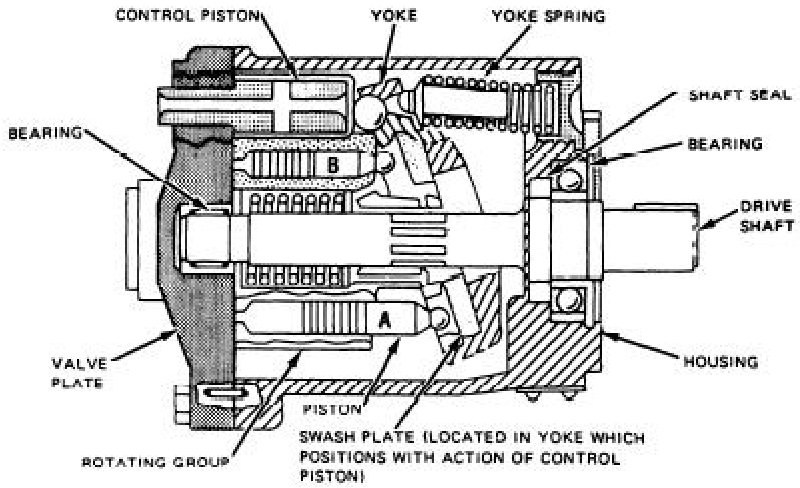
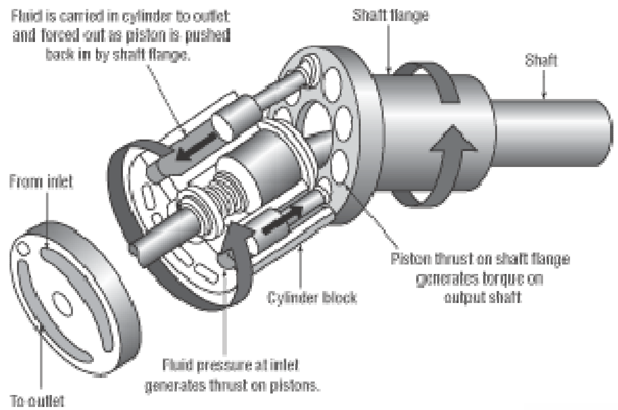
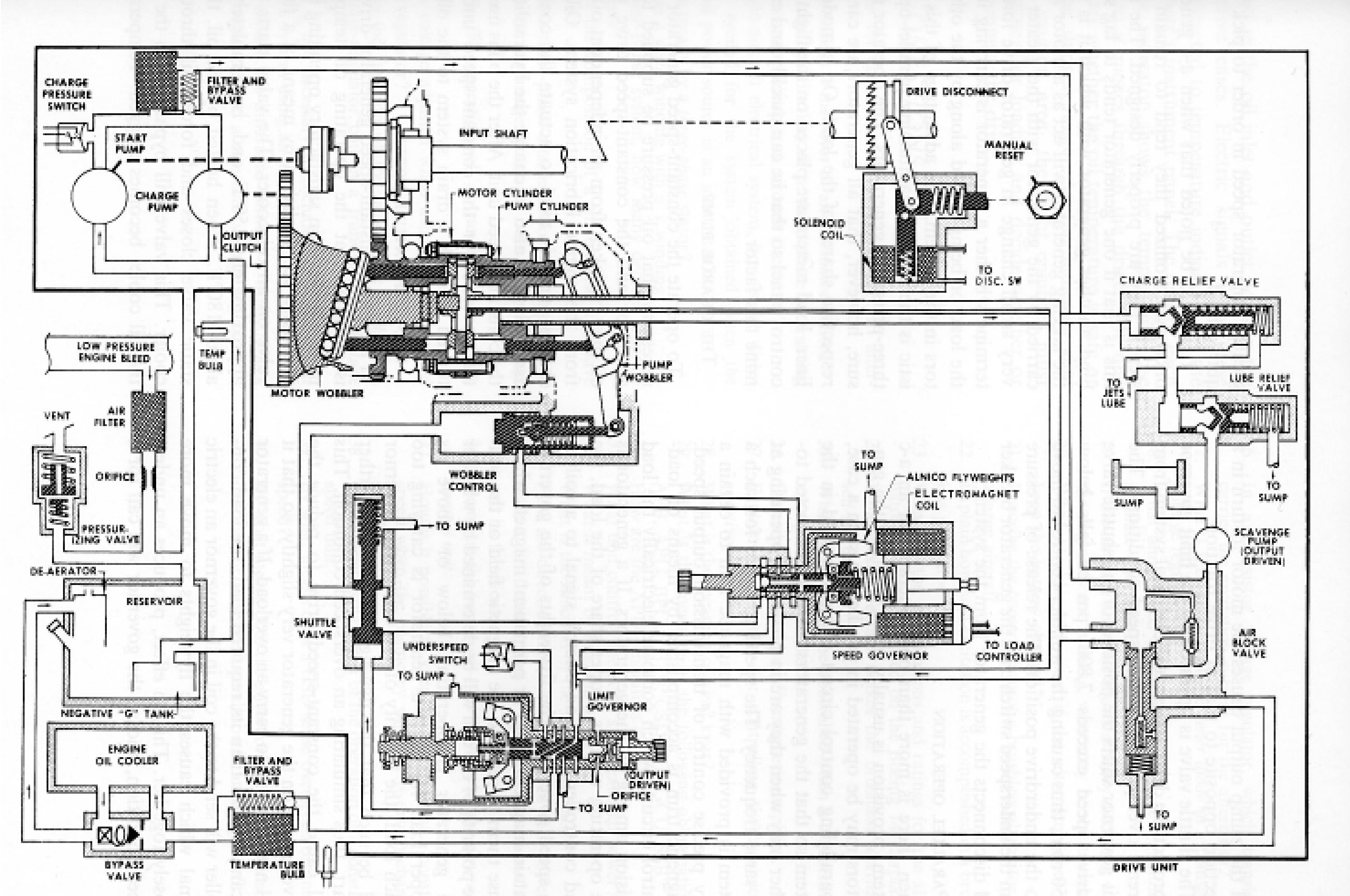


Figure 4-13.—In-line axial piston pump.

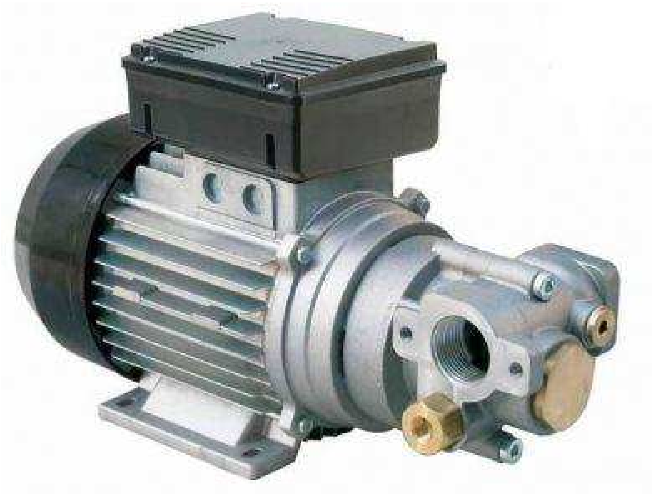


- Variable flow rate can be achieved by varying the swash plate angle
- A variation on this is the bent-axis piston pump.
- Variable rate pumps are used to control power.

The Sundstrand CVG



Creating pressure: Hydraulic pumps

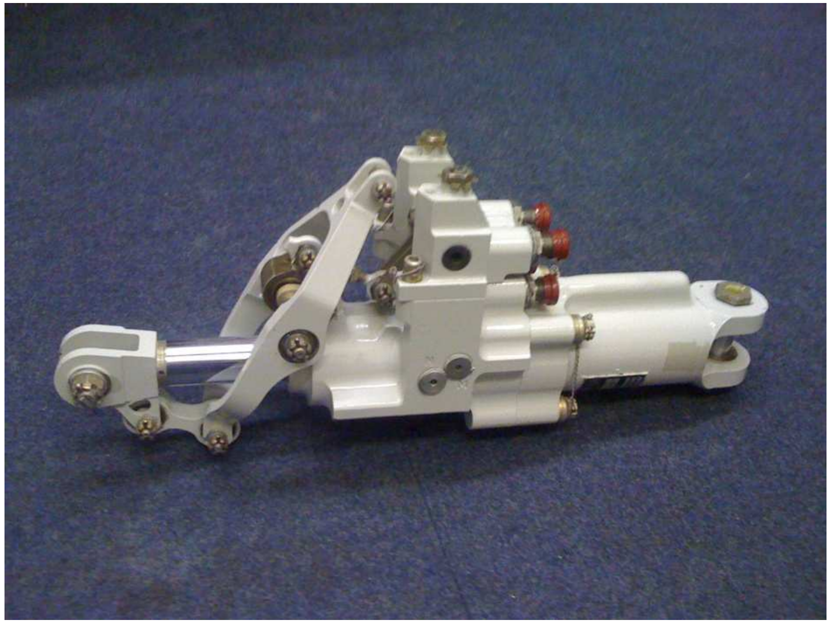


- Hydraulic pumps typically have a higher power density than electric machines.
- In most aircraft systems the pumps maintain a system pressure of around 3000 psi independent of flow rate.

Hydraulic actuators

- One advantage of hydraulic systems is that we can easily produce the linear motion required for flight surface actuation with hydraulic cylinders.

Cut-away of cylinder



Cylinder actuating flight control surface from training jet

Hydraulic control

- Hydraulic fluid is stored in a reservoir that feeds the pressure pump.
- Pressurised fluid directed around the system using a series of valves, these may be mechanical or electrically signalled.
- The fluid exiting the cylinder flows around a low pressure return back to the reservoir. Volume flow is the same around the circuit.

Hydraulic system: power pack

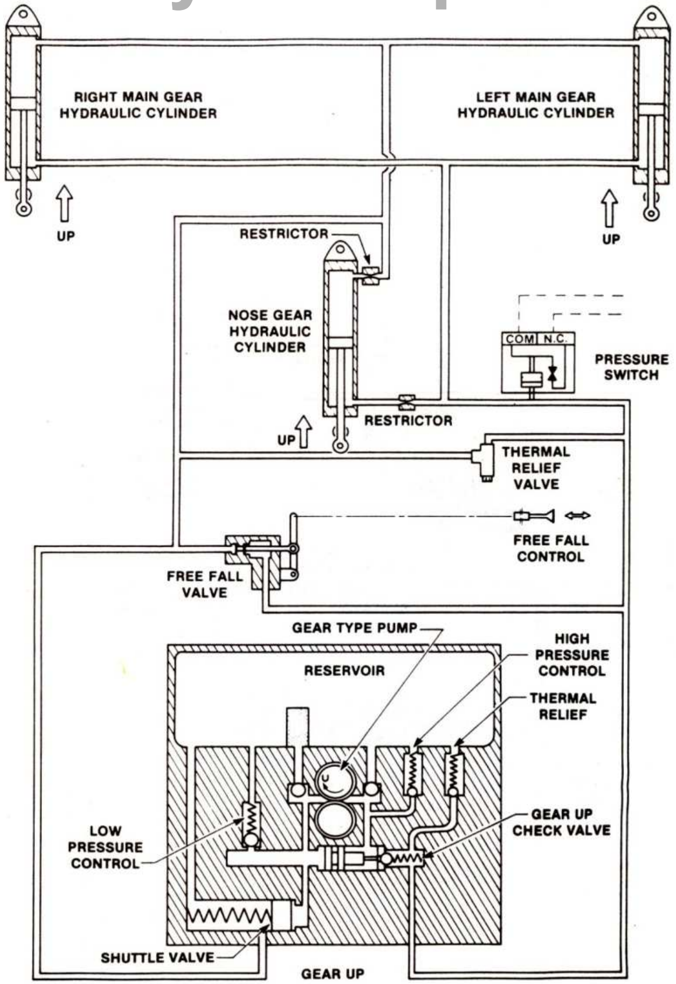


Figure 9.4 Power-pack-type hydraulic system. In this condition, the landing gear is being retracted.

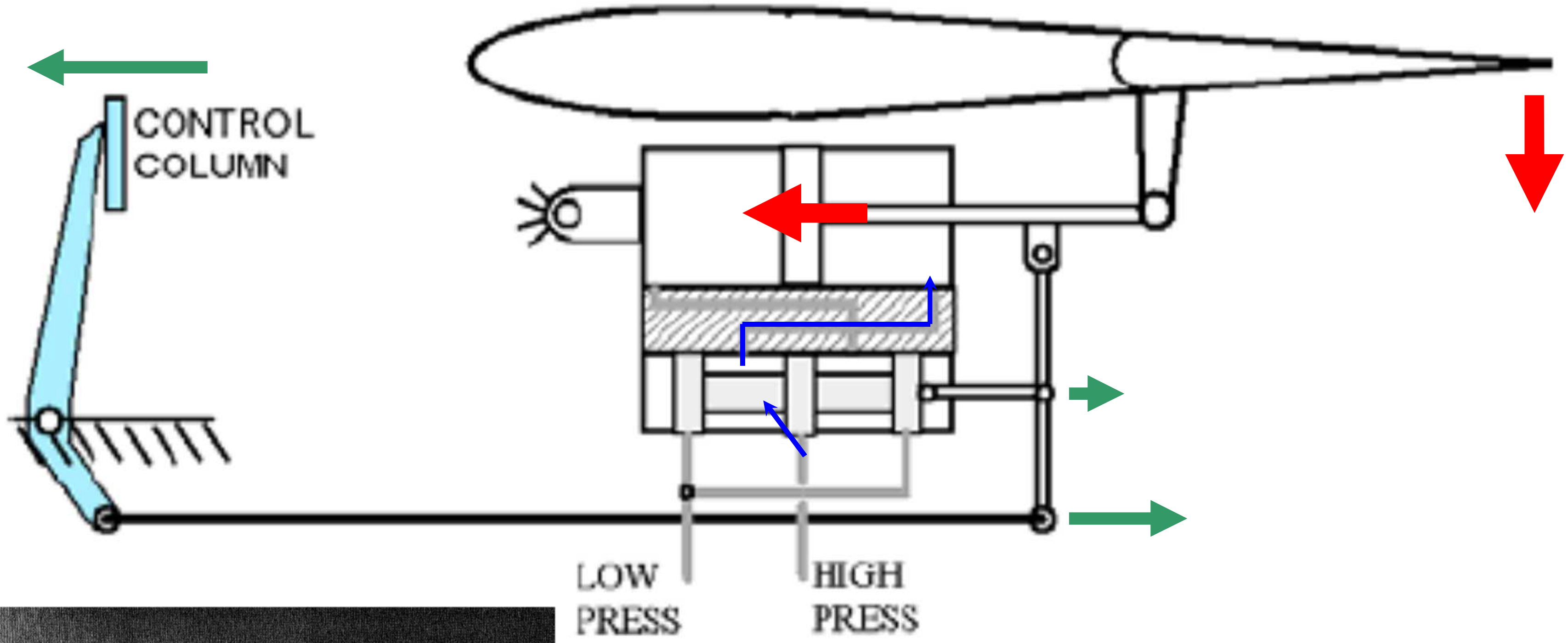
- Light aircraft may make use of a 'power pack' where pump, reservoir and valve gear are in one unit.
- In this example landing gear extension is achieved by reversing the direction of the pump

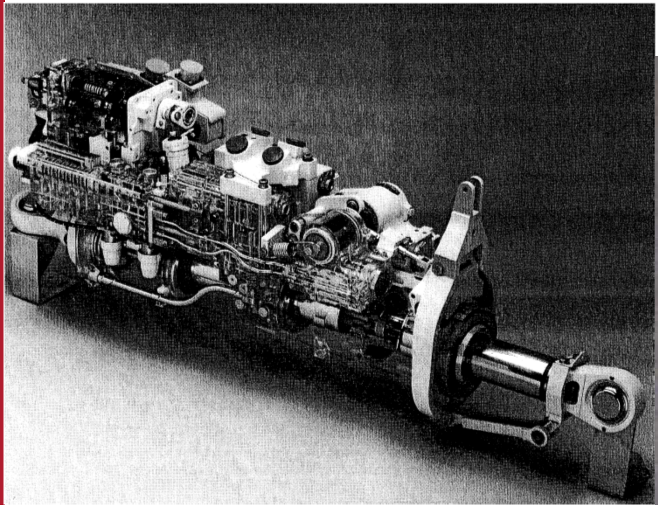
University of BRISTOL

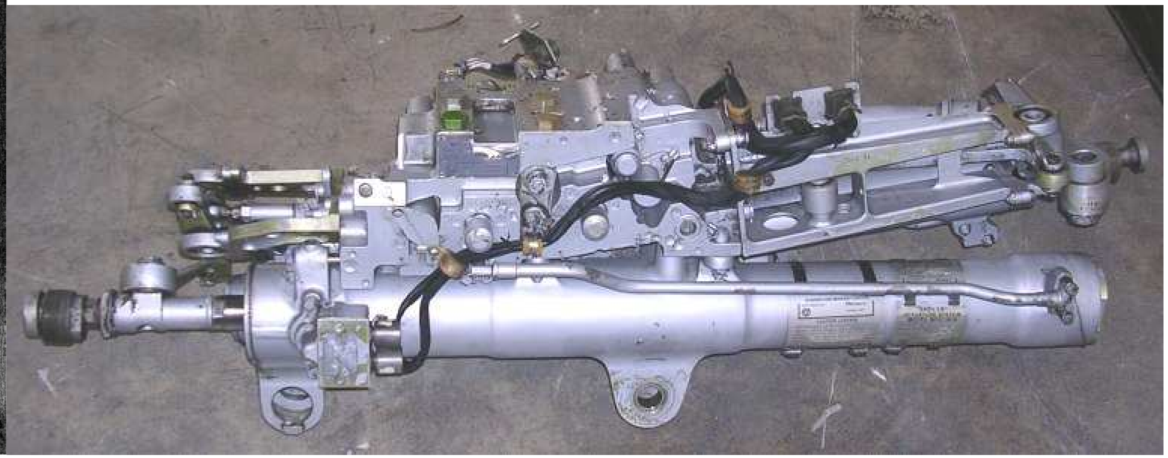
AVADI

DEPARTMENT OF aerospace engineering

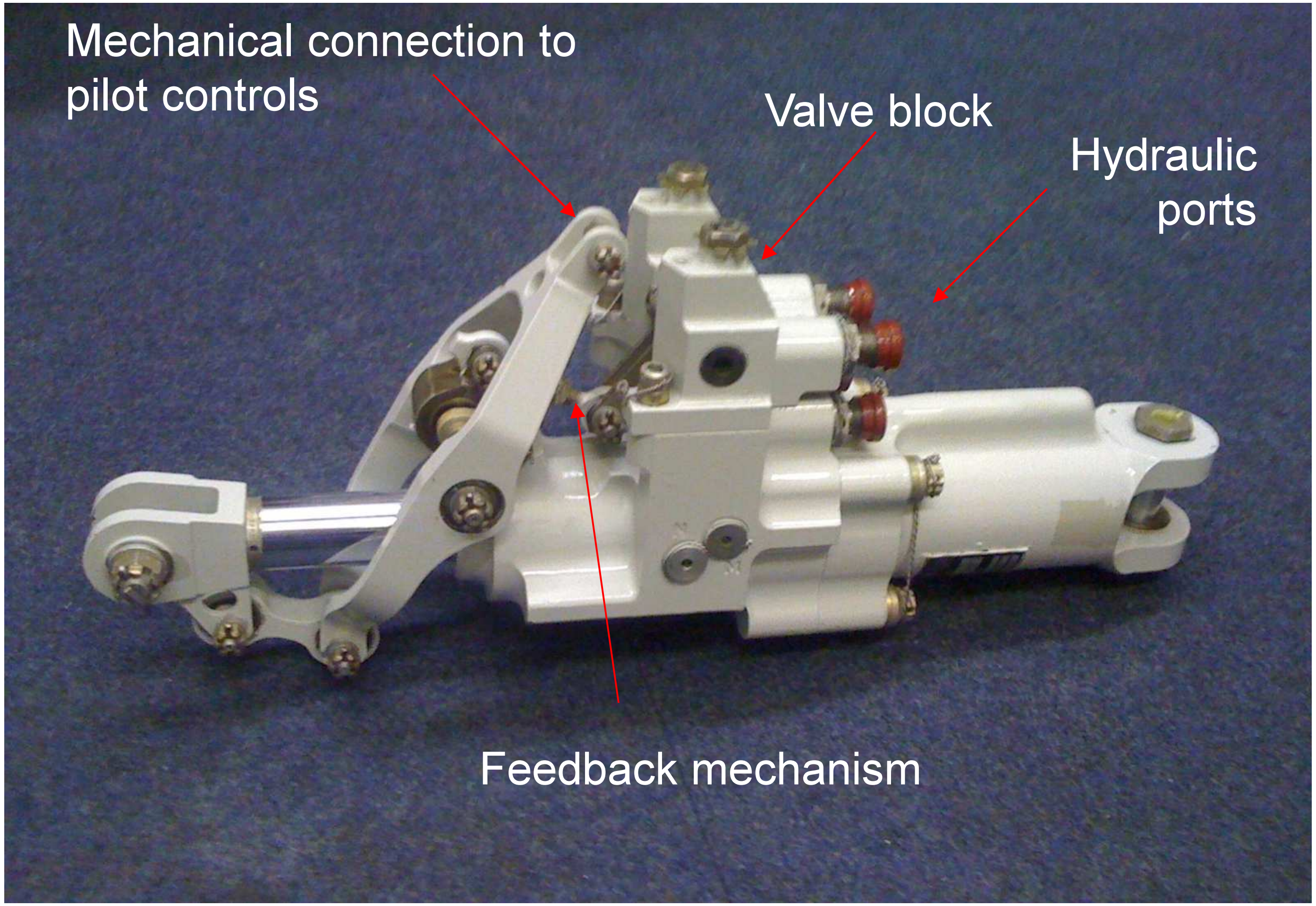
Fully Powered FCS: Hydraulic Servomechanism





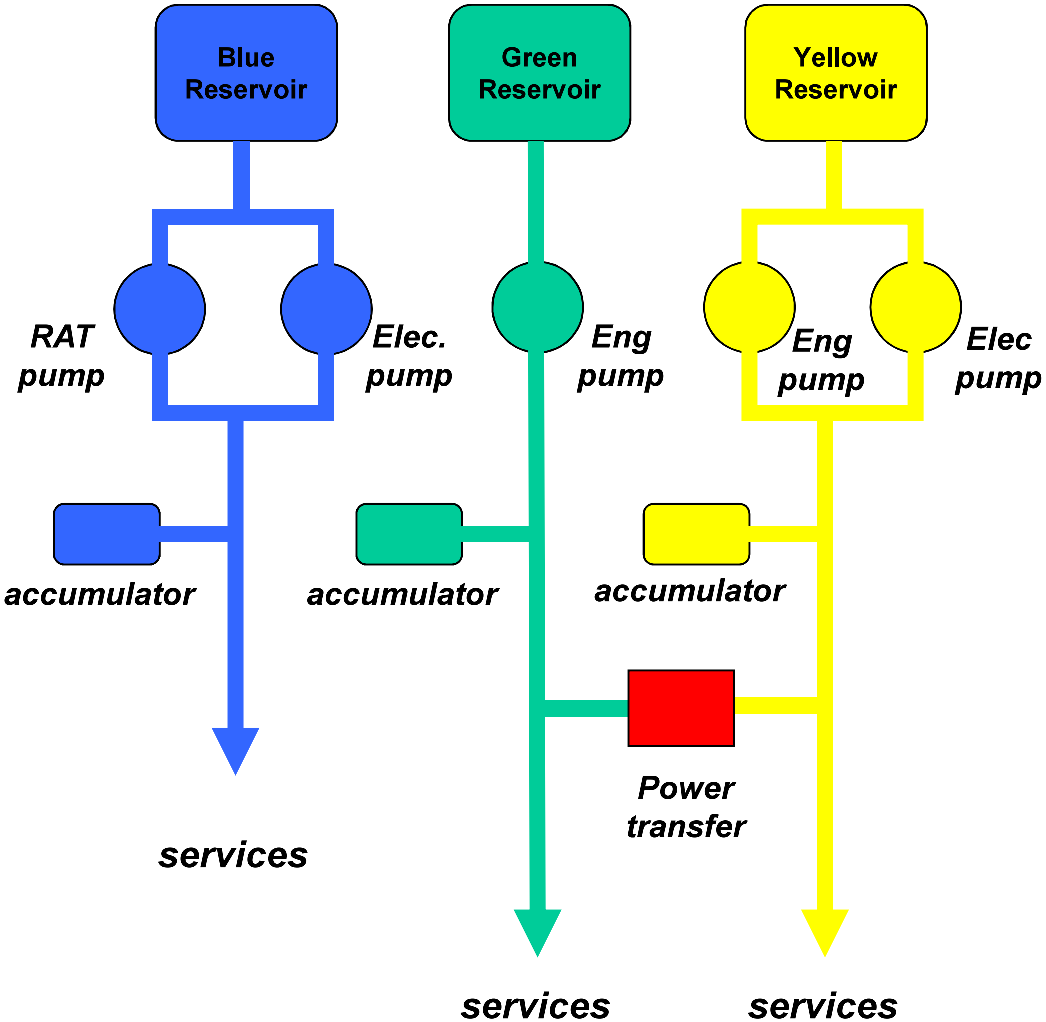


Hydraulic Servomechanism



Hydraulic system

- High power density and instant response makes hydraulic systems particularly good for functions like moving flight control surfaces.
- Primary Source: hydraulic pumps powered by the engine (mechanical or via electrical system). Back up from APU, RAT.
- Multiple hydraulic circuits provide redundancy



Hydraulics

- Hydraulic systems are reliable but are expensive to maintain as they are complex and require a high level of cleanliness .
- The fluid used on aircraft is highly corrosive to many materials.

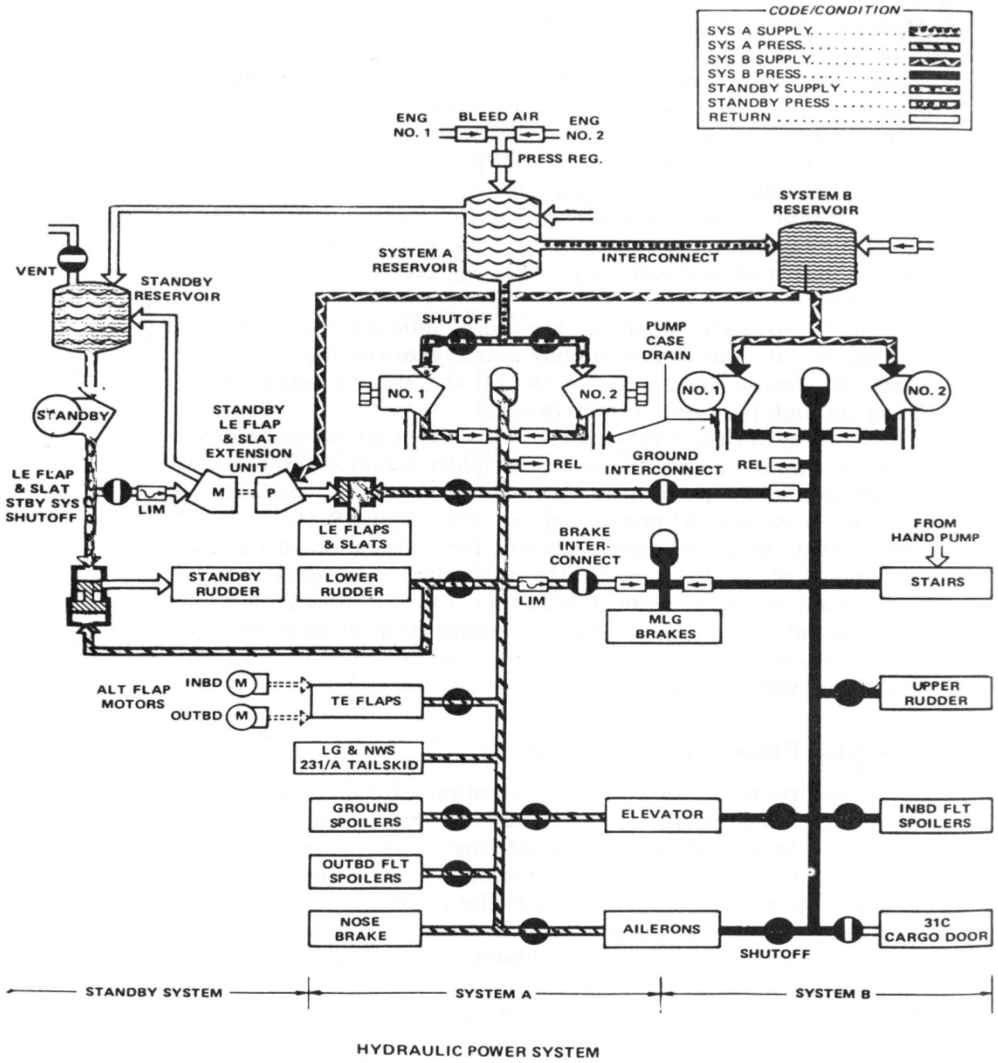
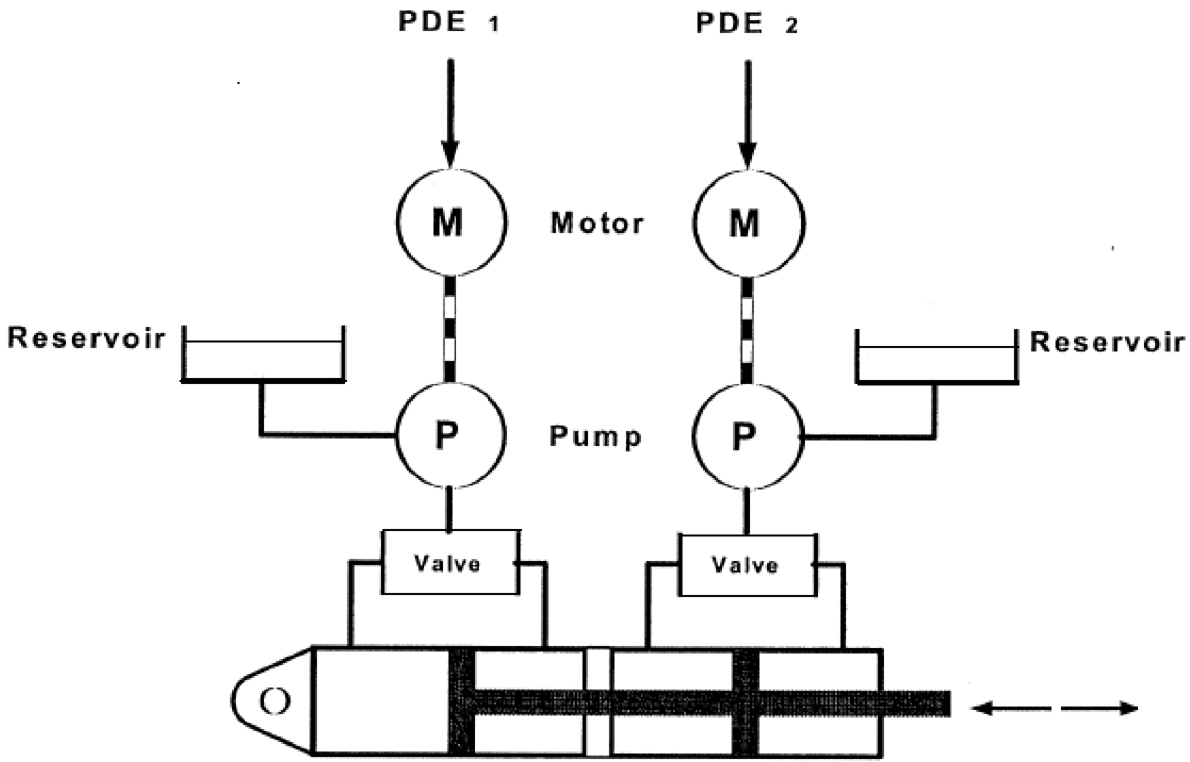


Figure 9.11 Boeing Model 727.

Redundancy



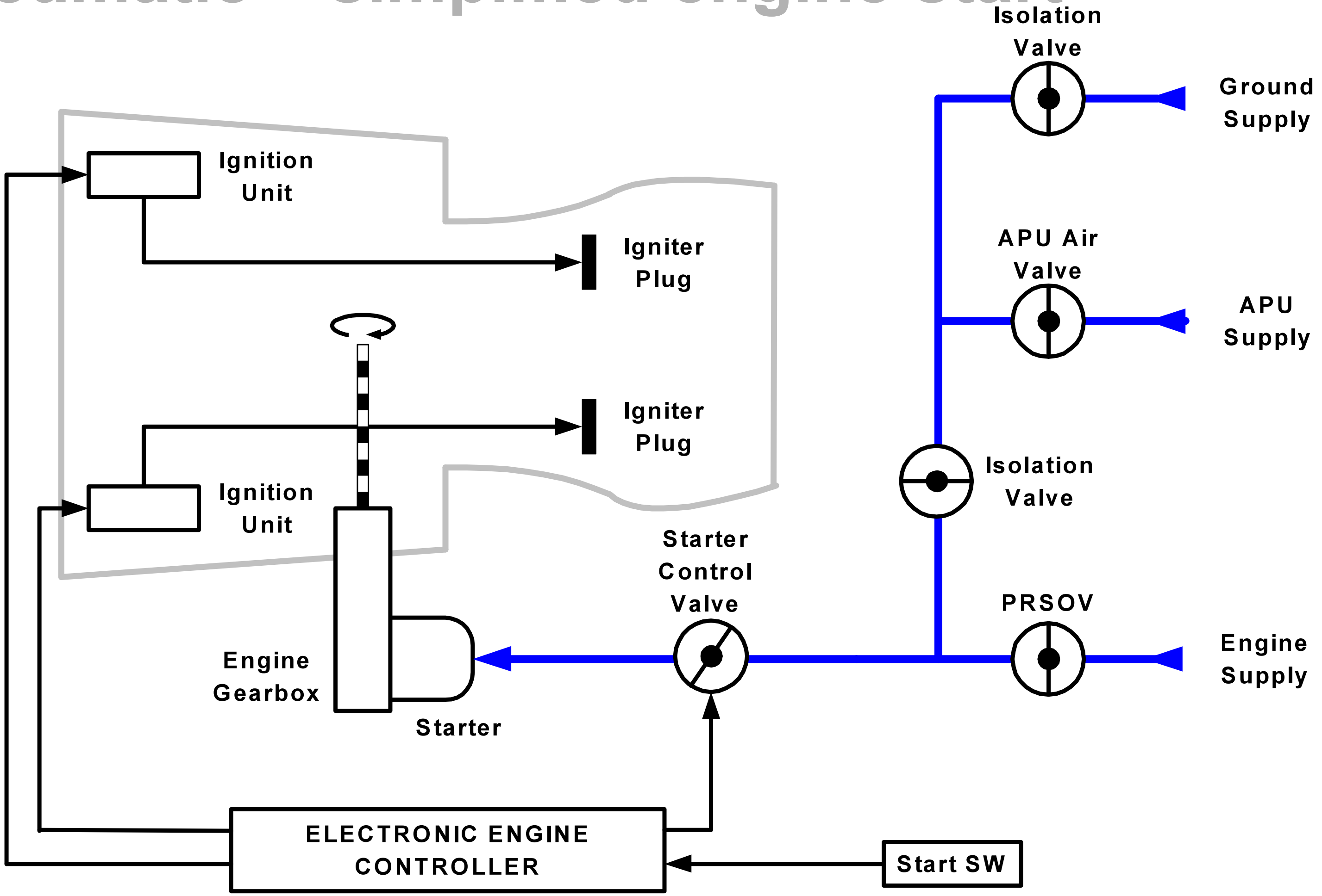
dual-tandem actuator

Pneumatic system

Pneumatic functions

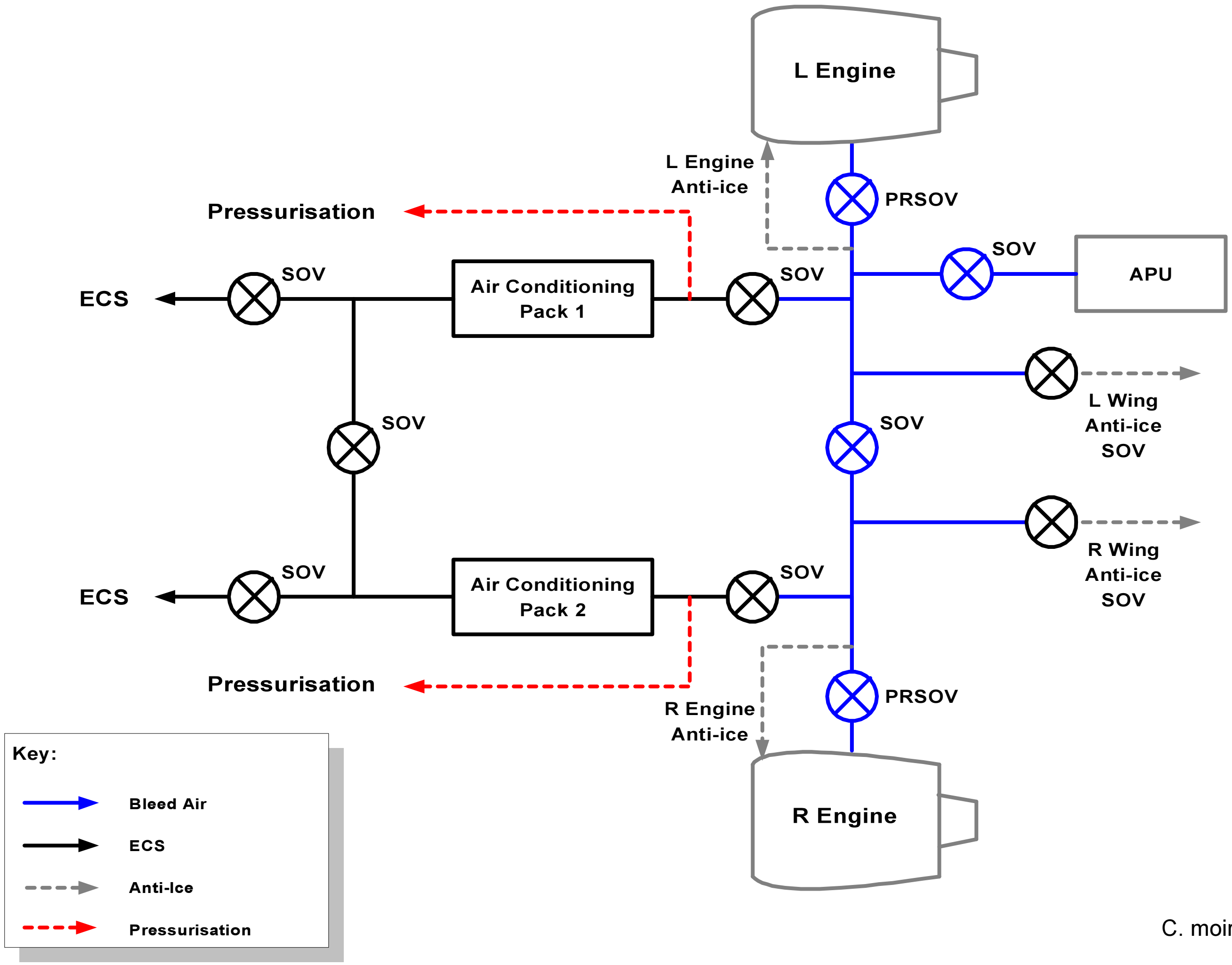
- Engine start
  - Many large turbine engines are started by an air-powered starter motor on the assessor gearbox which mechanically drives one of the engine shafts.
  - Some systems also use a blast of air directly onto the turbine blades
  - Power comes from an engine already running or the APU.
- Bleed Air
  - Hot air under pressure taken from one or more compressor stage.
  - Used for wing de-icing – hot air ducted onto the leading edge
  - For powering the air conditioning system

Pneumatic – simplified engine start



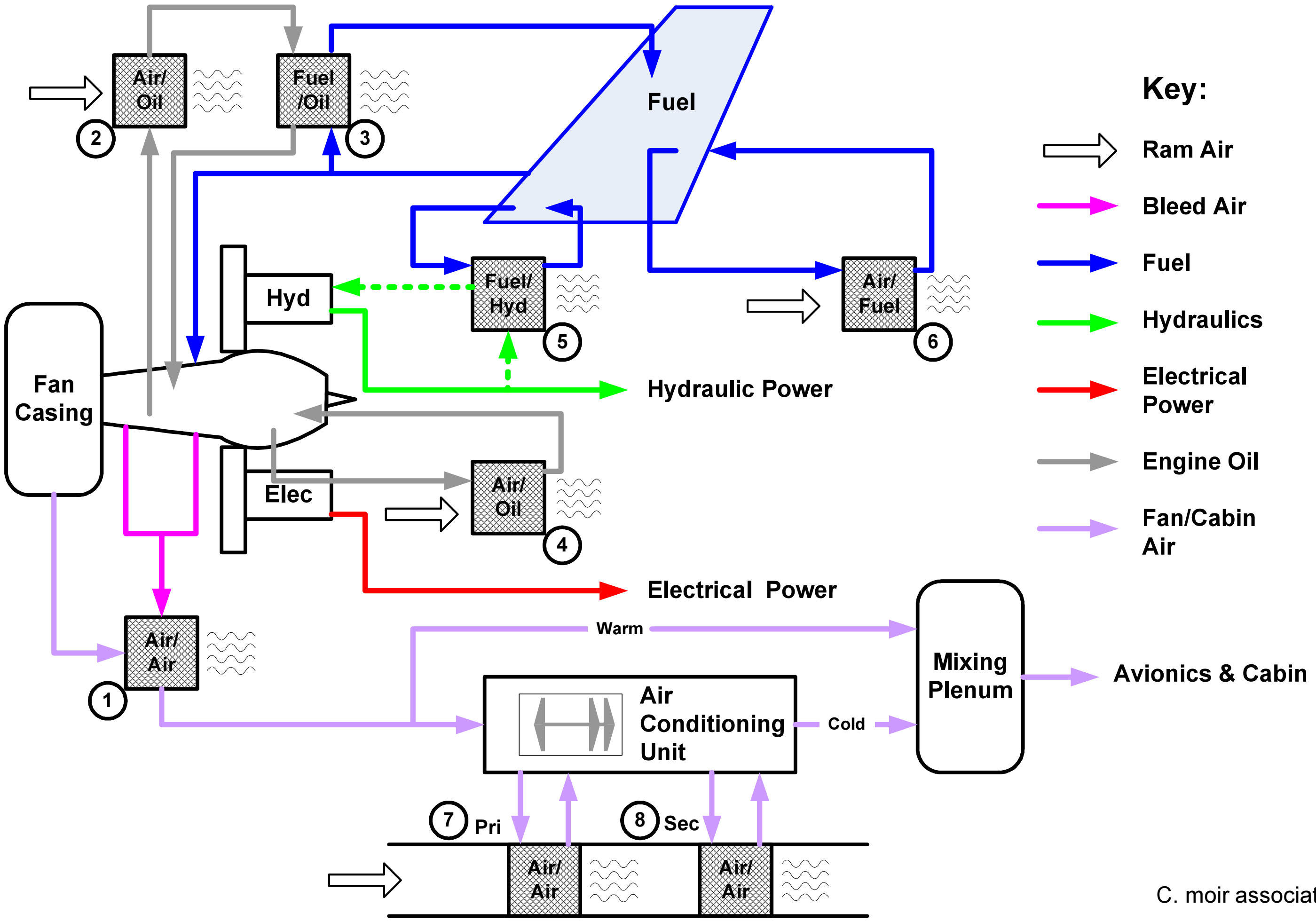
C. moir associates

Pneumatic – simplified bleed air



C. moir associates

Pneumatic bleed air



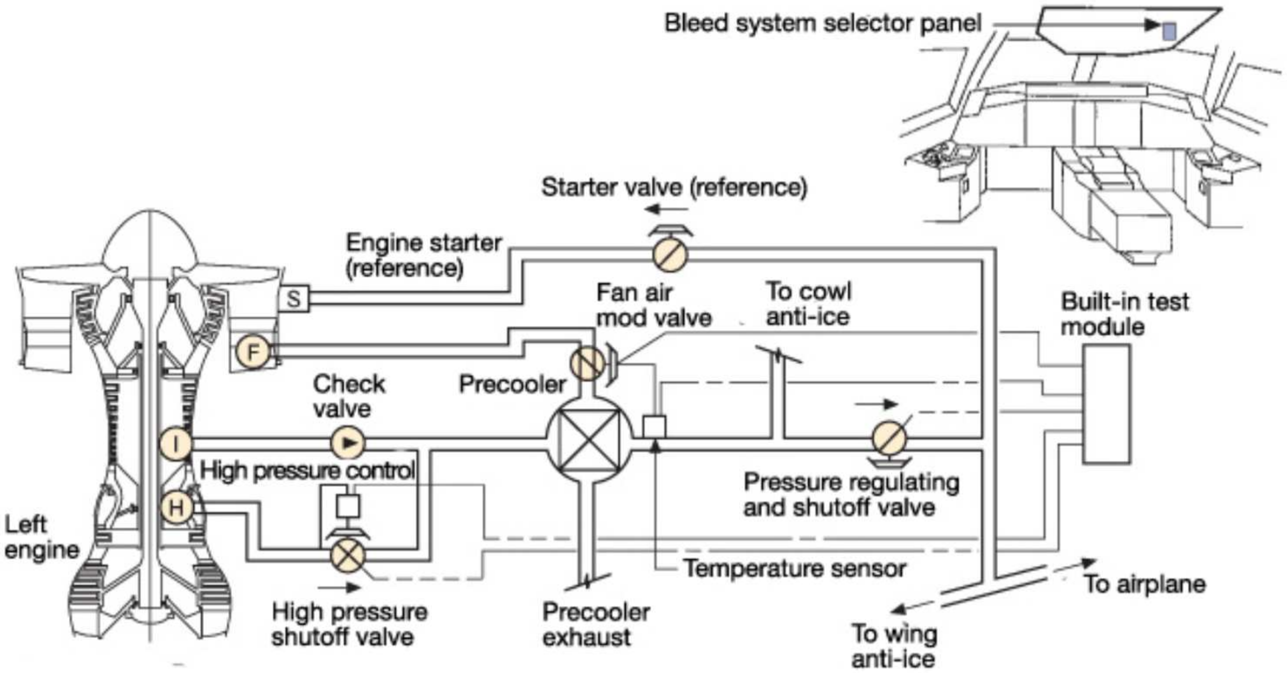
C. moir associates

Heat Exchangers.vsd 220306

Pneumatic Environmental control system

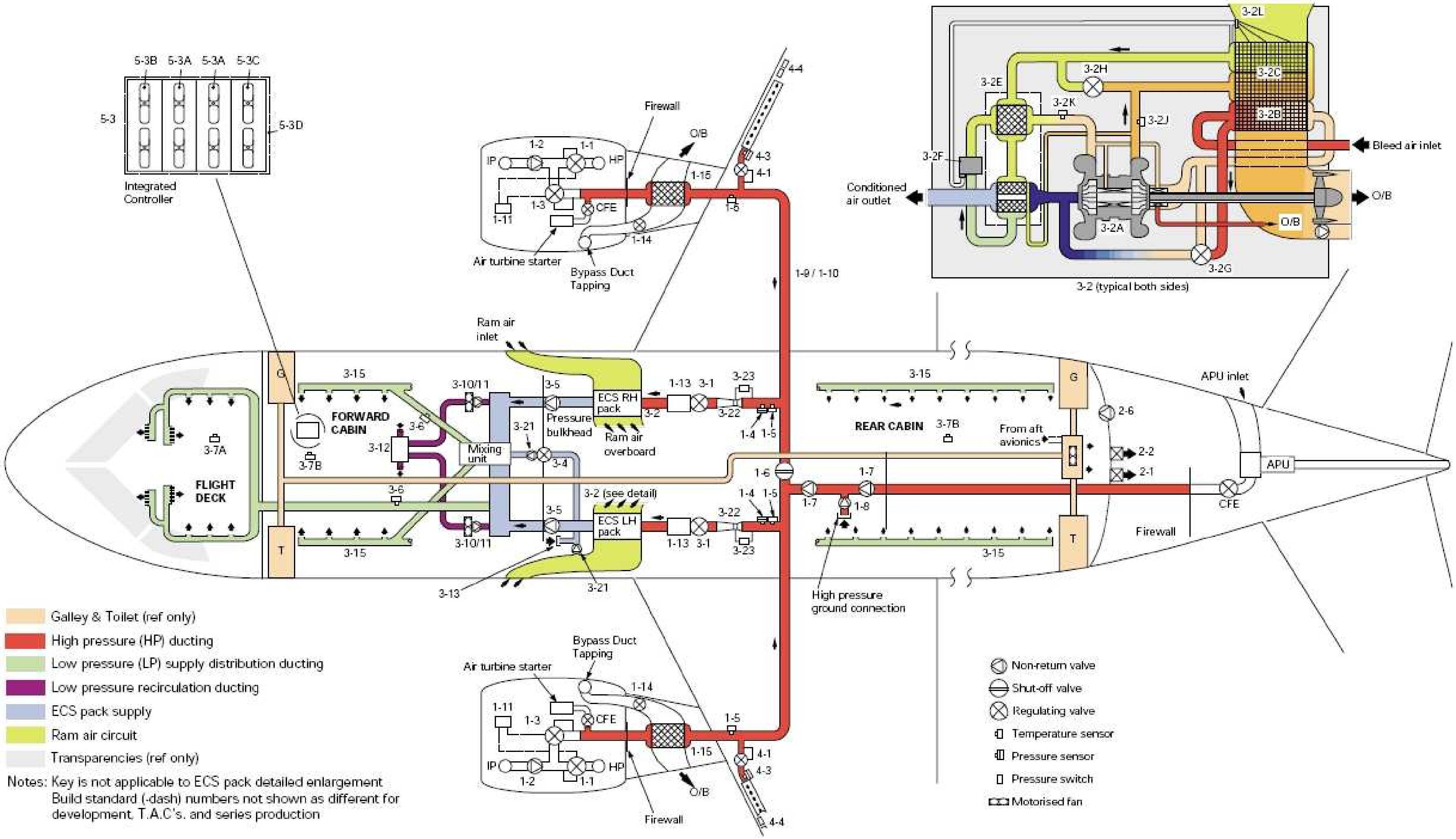
- *The air conditioning system is pneumatically powered from bleed air, which provides cabin pressurisation and heat. Pressurised air bled from the compressor is first cooled in a heat exchanger by air passing through the fan casing. This helps with the wide range of temperatures of bleed air during the flight cycle (often multiple ports on the engine are used to provide different pressures and temperature at different throttle settings). An 'air cycle machine' (ACM) air conditioner (uses air as the refrigerant) then cools the air and removes moisture and filters. To provide the correct temperature of air to the cabin, warm bled air can be bypassed around the air conditioning unit and mixed with the cold air before being fed to the cabin.*

Pneumatic system – engine bleed air



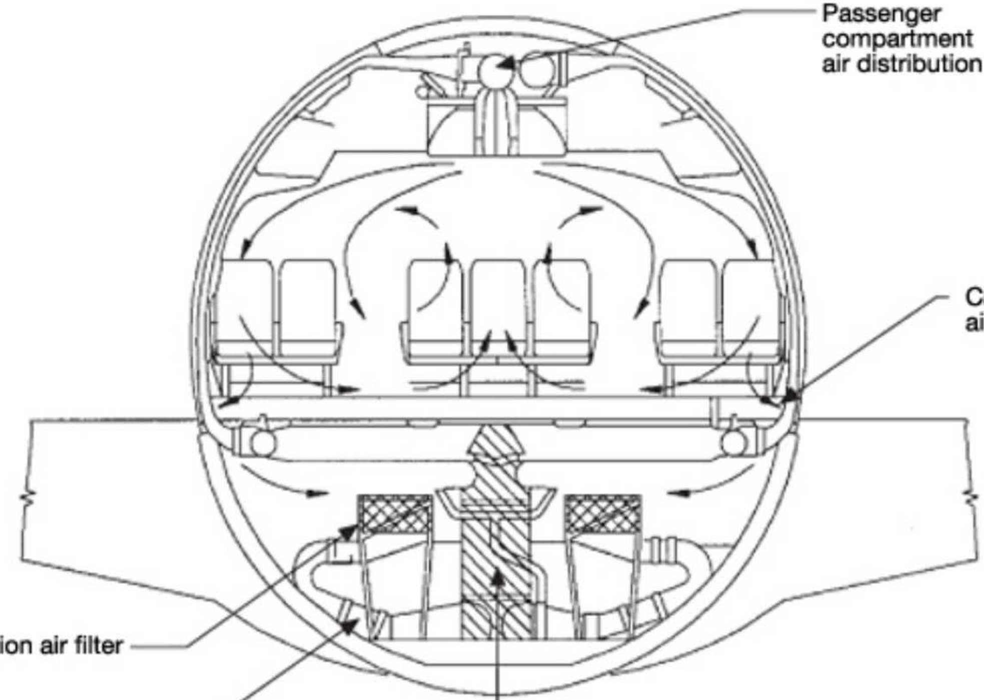
S Starter F Fan I Intermediate stage H High stage

Pneumatic system – full system

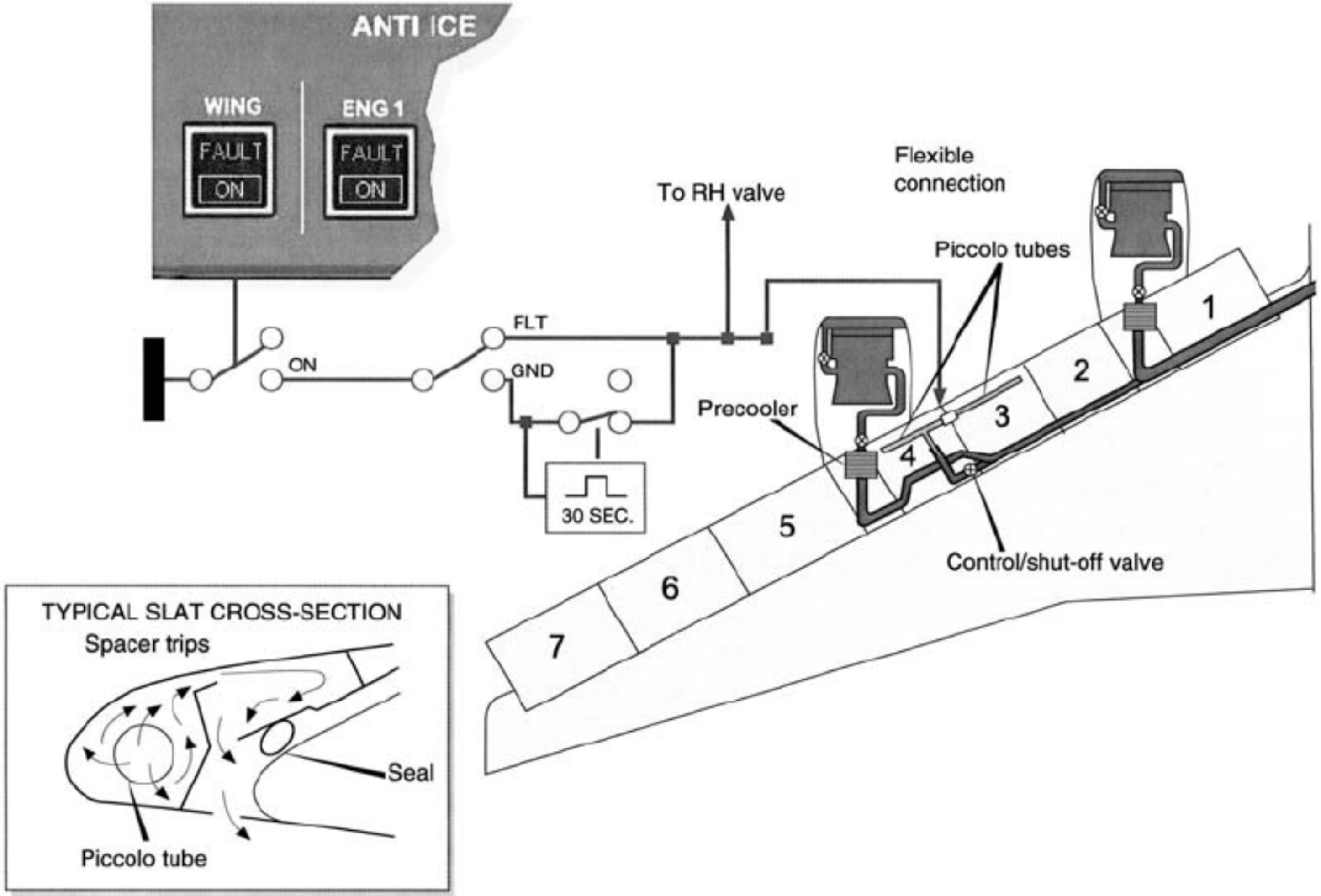


Cabin air

- Cabin air is a mix of fresh external air and re-circulated cabin air that has been passed through HEPA filters
- The total volume of cabin air is replaced around 25 times per hour
- Cabin pressure is controlled to reduce rates of change of pressure without exceeding a differential of 9 psi



Ice protection



Ref. [1]

Summary

- Hydraulic systems;
  - High power density
  - Instant acting (no lag between demand and action)
  - Reliable
  - Expensive to maintain

- Pneumatic systems;
  - Exploit the high pressure/temperature air bled from engine
  - In doing so reduce performance of engine