

ENGINE STARTING1. INTRODUCTION.

This section is concerned with the electrical control of the Olympus engine starting system.

The aircraft engines are started by supplying low pressure air to a Rotax air driven turbine fitted to each engine. The air supply to the turbines is derived from two sources, i.e.

- (a) Palouste air generator (external start)
- (b) Air bottles (rapid start)

Provision is made for relighting the engines in the air should 'flame out' occur and the control is provided by four push buttons, mounted one on each engine throttle lever.

The first pilot has control of the engine starting system from a panel located aft of 6P. This panel contains the engine master, air selector and ignition switches, the four start pushes, a magnetic indicator, the rapid start push and gyro hold off push.

The second pilot has control of the four main engine air cock isolation switches.

2. LOW PRESSURE AIR TURBINE STARTER.

The air turbine starter is a mechanical unit driven by air at a working pressure of 35 lbs. per square inch. Incorporated in the turbine starter is a centrifugally operated switch, the contacts of which open at a turbine starter speed of 36,000 r.p.m.

3. AIR STARTER VALVE (Normal start)

The air starter valve is fitted to control the supply of air to the turbine starter. The valve solenoid which is - energised - VALVE OPEN and de-energised - VALVE CLOSED, is controlled by its associated engine starter relay, which in turn is controlled by the centrifugal switch on the turbine starter. Thus, when the turbine starter has established the Olympus r.p.m. the centrifugal switch opens, causing the starter relay to de-energise, which allows the air valve solenoid to de-energise.

4. AIR BOTTLE VALVE.

The air bottle valve is fitted to control the air supply to the combustion chamber during rapid start. The valve is controlled by its associated time delay unit and engine starter relay which in turn are controlled by the switch on the turbine starter unit.

NOTE:- If Mod. 1615 is embodied a fuel dipper valve is embodied which is connected in parallel with the air bottle valve and is used to reduce the fuel flow to the engine burners during start.

5. COMBUSTION CHAMBER.

The combustion chamber is provided to mix and ignite the fuel/air mixture during rapid start. Air is released from the air bottles into the combustion chamber, via the air bottle valve and a reduction valve. Here it is mixed with fuel and ignited. The resulting ignited mixture is then fed onto the turbine starter unit.

6. ENGINE STARTER RELAY (R.190, 191, 192, 193)

This relay controls the air starter valve and high energy igniter supplies. It is energised by pressing its associated start push or rapid start push and de-energised by the opening of the centrifugal switch, and by the time delay unit during rapid start.

7. AIR CROSS FEED COCK ACTUATOR.

An air cross feed cock is fitted in the air ducting between Nos. 2 and 3 engines. The cock is rotated by the actuator and is controlled by the engine master switch. With the switch in the 'ON' position, the actuator rotates to the open position and indicates OPEN on the cross feed cock indicator.

8. SUPPLIES FOR NORMAL STARTING.

For normal starting the 200 volts A.C. ground truck and a Palouste low pressure air truck are connected to the aircraft. The air supply from the Palouste truck is fed via a delivery hose which is connected to a supply point on the aircraft's air ducting system. The air supply point is located in the A.A.P.P. compartment and access to it is gained by a round detachable panel on the underside of the compartment. In addition, an electrical cable is connected to plug 929 on panel 37P in the starboard main wheel bay.

As mentioned in paragraph 1, the first pilot has control of the engine starting operation. With the Palouste truck running and the appropriate engine start push pressed, a 28V. D.C. supply is fed via plug 929 to open the delivery valve on the Palouste truck. Air is then released into the hose and directed to the air turbine starter on the engine.

9. SUPPLIES FOR RAPID STARTING.

For rapid starting the 200 and 28V ground supplies are connected to the aircraft. The air supply is fed from four H.P. stowage bottles in the aircraft.

10. CIRCUIT OPERATION (NORMAL).

In this paragraph, it is assumed that prior to the start sequence the aircraft has been prepared for starting i.e.

- (a) Palouste truck and 200 volts A.C. ground truck connected to the aircraft.
- (b) All engine controls and fuel cocks positioned for starting. The air selector switch selected to 'NORMAL' and engine master and ignition switches placed to 'ON'.

Placing the master switch to 'ON' will 'prime' the starter pushes and open the air cross feed cock, which when opened will indicate 'OPEN' on the magnetic indicator fitted to the port console. Depressing the engine start push energises its associated engine start relay i.e. in the case of No. 1 engine-relay 190. The start relay in energising opens the turbine air valve, operates the high energy igniters, energises the Palouste air valve Solenoid via plug 929, and forms a hold on circuit for itself. Air now passes from the palouste to the aircraft engine air turbine starter which engages with the high pressure spool of the Olympus. At a speed consistent with self sustaining r.p.m. the air turbine dis-engages from the Olympus and commences to overspeed.

At this stage, a centrifugal switch integral with the starter turbine opens and causes the engine start relay to de-energise, thus closing the turbine air valve, the Palouste air valve and switching off the high energy igniters.

NOTE:- The lamp in the head of the start push indicates 'start in progress' and is operated by the opening and closing of the turbine air valve.

## 11. CIRCUIT OPERATION. (Rapid start)

The aircraft is prepared as per paragraph 10 except no Palouste truck is connected and that the air selector switch is set to Rapid.

Placing the master switch to ON will again open the cross feed cock and 'Prime' the normal start pushes, but will also feed 28 V. D.C. to the rapid start push and energise relays 189 and 317. Energising of relay 189 provides earth for the time delay units and removes the earthing out of the starter relays. Energising of relay 317 changes over the leads from the air starter valves to the rapid start time delay units and air bottle valves.

Depressing the rapid start push will energise all engine start relays via the four diodes. The start relays in energising operate the engine high energy igniter units, feed 28V to pin A of the T.D.U. and forms a hold on circuit for the starter relay.

With the supply on pin A of the T.D.U. it is then fed via relay B of the T.D.U. to energise the starter igniter unit, and via relay A to energise the air bottle valve which allows air to pass into the combustion chamber to mix with fuel and then to be ignited.

After 2 secs. relay B energises and if combustion has not taken place will break the earth of the starter relay and stop the start sequence. If combustion has taken place then the combustion pressure switch will be closed thus maintaining the earth for the starter relay. The other contacts of relay B breaks the supply to the starter high energy igniter, as the fuel/air mixture will now be ignited, and provides an earth for the lamp in the head of the normal starter push to indicate start in progress.

The ignited fuel/Air mixture is fed onto the starter unit which rotates to start the engines. After a successful start the overspeed contacts of the starter turbine will open to de-energise the starter relay which in turn will break the supply to the engine high energy ignition units, time delay unit and air bottle valve, thus ending the start sequence.

If after 12 secs a successful start has not been achieved then relay A energises which de-energises the air bottle valve and starter relay with results as above.

## 12. GYRO HOLD OFF.

To prevent the gyros of the M.F.S., auto stab, and artificial horizon running continuously during stand by, a hold off circuit is used. The hold off circuit also isolates the 28 V D.C. supplies to fuel contents amplifiers.

With the Engine Master switch 'OFF' and air selector at 'RAPID', depressing the gyro hold off push will energise relay 318 which in turn energises relays 319 and 320. On releasing the push relay 318 de-energises but relays 319 and 320 remain energised due to a hold in supply through their own contacts. Relays 319 and 320 break the 115 V 3 phase A.C. supply to the gyro circuits and feeds 28V D.C. to energise relays 479 and 450 which isolates the fuel contents amplifier 28V D.C. supply.

When the Engine Master switch is placed 'ON' prior to starting the engines, relays 319 and 320 are de-energised and all supplies return to normal.

## 13. RELIGHTING.

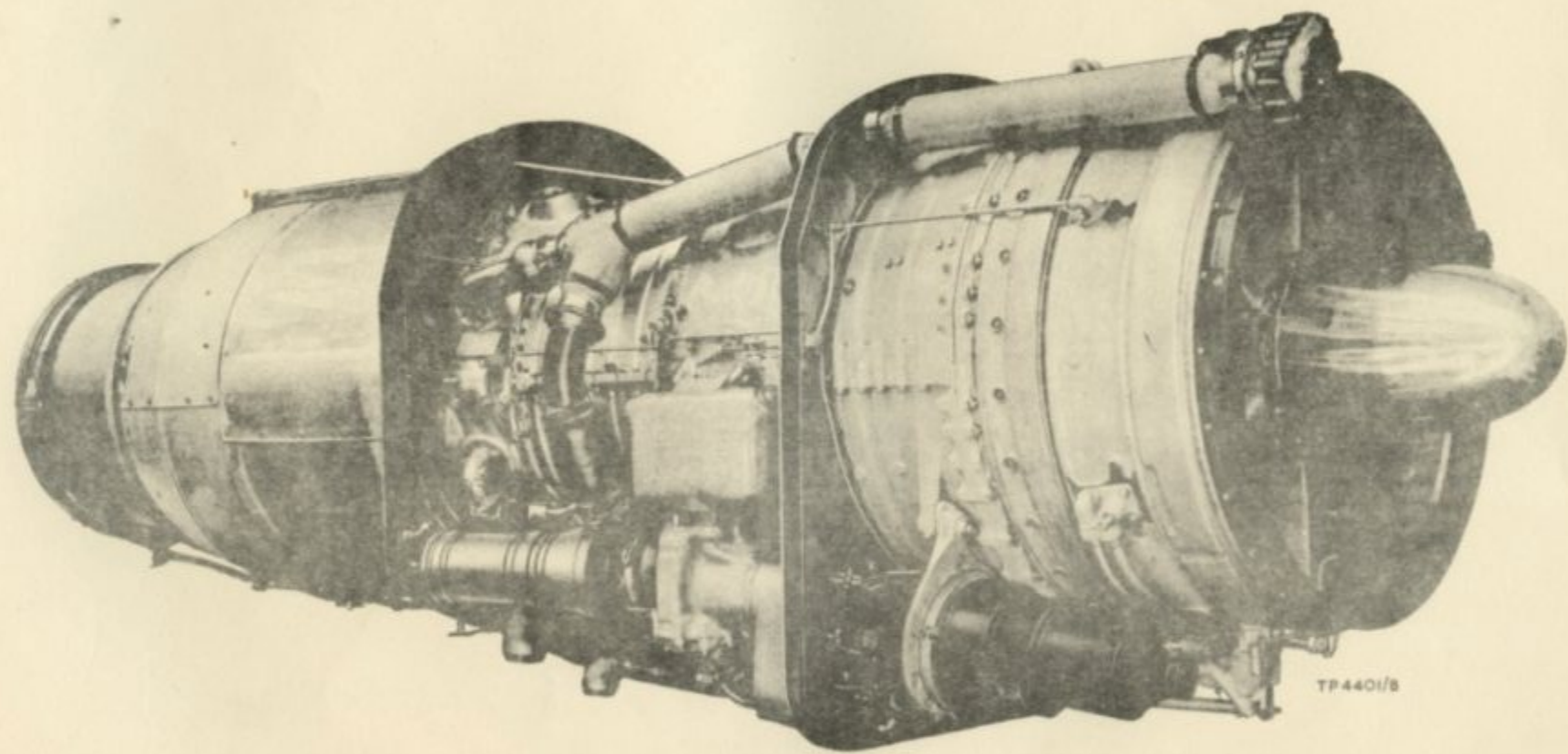
Provision is made for a 'windmilling relight' by relight buttons fitted to the head of each engine throttle. Should a 'flame out' occur then depressing the appropriate button will operate the high energy igniters. The main engine start circuit is not affected since the windmilling r.p.m. of the engine is sufficient to achieve correct ignition.

14. AIR ISOLATION VALVES.

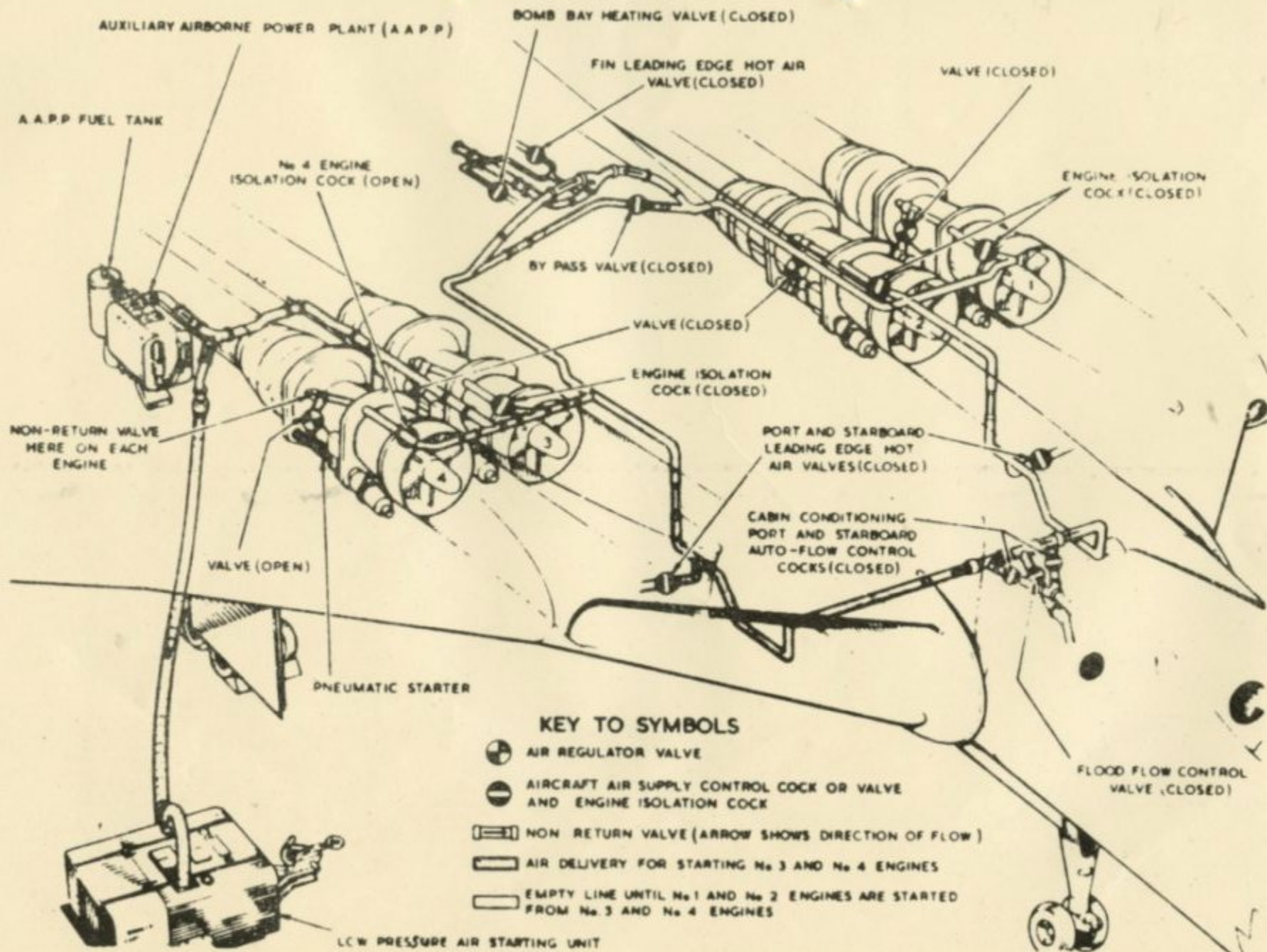
These are four air valves, electrically operated, and form the means of selecting the air duct to the engine starters. These valves must be opened to start the engine during normal start.

COMPONENT	NO.	LOCATION
Air Turbine Starter	4	Starboard side of each engine.
Engine H.E. Igniters	8	Two in each engine bay.
Relay 185 186 187 188 189 190 191 192 193 317	10	73P in nose wheel compartments
Engine Start Push	4	Port Console 6P
Air Selector switch	1	Port Console 6P
Engine Start Master switch	1	
Ignition Isolation switch	1	Port Console 6P
Air Cross Feed Indicator	1	Port Console 6P
Rapid start Push	1	Port Console 6P
Cyrc hold off Push	1	Port Console 6P
Relight Push	4	Throttles
Rapid start time delay units	4	Starboard side engine bay.
Rapid start H.E. igniter units.	4	Starboard side engine bay.
Air Bottle Valve	4	Port side engine bay.
Combustion chamber	4	Starboard side of each engine.
Air cross feed cock	1	Bomb bay roof mid position





OLYMPUS 201  $\frac{3}{4}$  STARBOARD VIEW



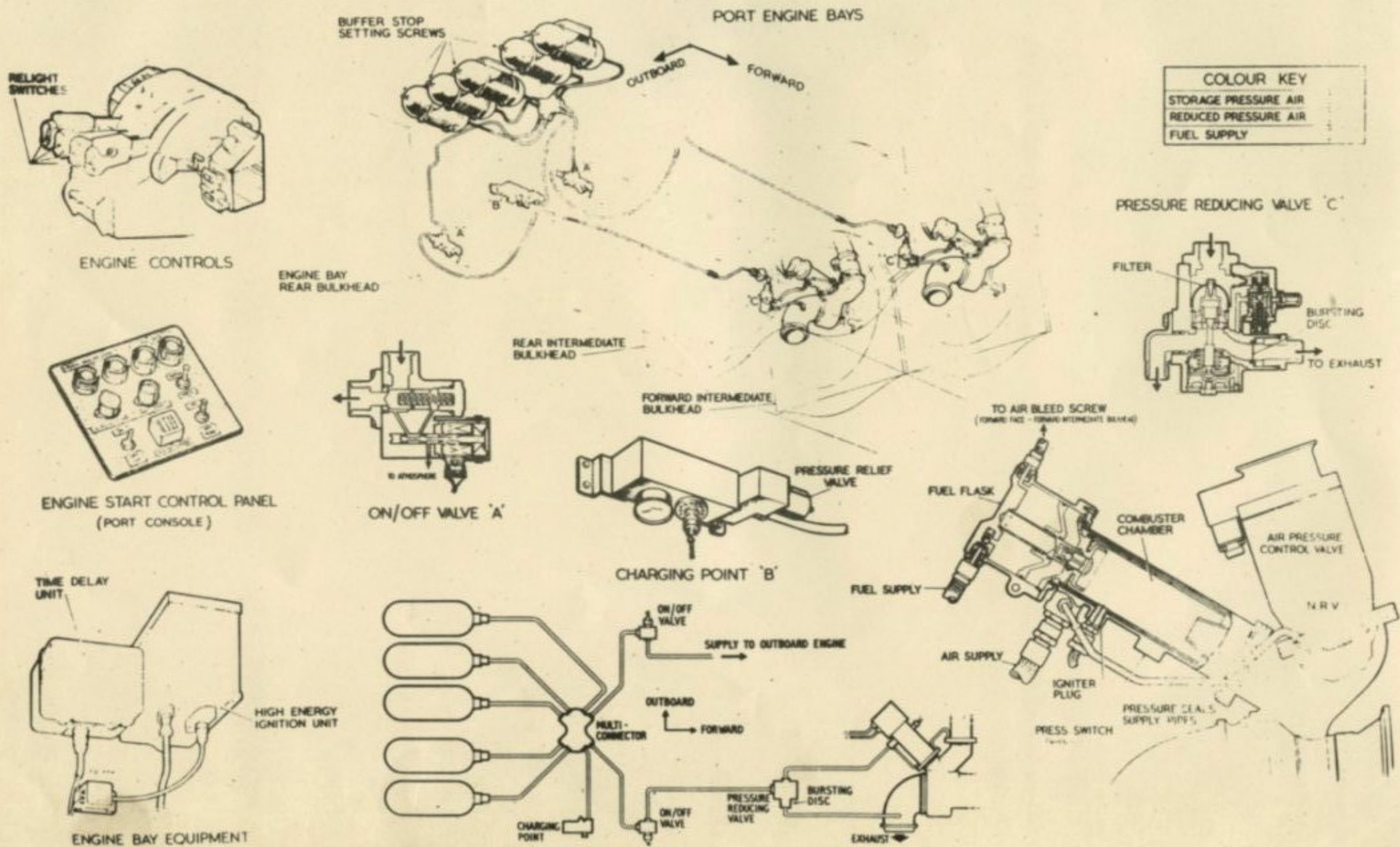
JOB No. 1918  
WAD/8/V2P.

# VULCAN B. MK. 2



# GENERAL ARRANGEMENT

RAPID ENGINE STARTING SYSTEM



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