

SECTION 3 PART 1AIRBORNE AUXILIARY POWER PLANT1. Introduction

To cater for complete alternator failure, a Rover type 13/60 gas turbine driving a 40 KVA 200 volts A.C. 3 phase alternator, is fitted to the aircraft. The unit can also be employed for additional duties as follows:-

- a. Ground servicing of electrical supplies.
- b. Internal engine starting (Nos. 3 and 4 only), (pre Mod. Vulcan 1320).
- c. Cabin air conditioning during ground servicing using the turbine air bleed.

Because the gas turbine has a comparatively short running life, indiscriminate use is not encouraged, and is confined to routine testing, aircraft detached at stations not equipped with 'V' servicing facilities and emergency conditions. An engine running log is maintained in the aircraft F. 700.

Part 1 of this section is concerned with the gas turbine starting system, and a description of components begins in the next paragraph.

2. Turbine Fuel System (A.A.P.P. Installation).

A 10 gallon fuel tank is situated at the rear of the power plant assembly. It is refuelled from the No. 4 tank group system. The tank contains a high and low level float switch connected to a three position magnetic indicator giving the indications 'HIGH' - 'BLACK' - 'LOW'. The indicator is fitted on 70P.

Also fitted to the tank is a low pressure booster pump and a Mk. 9 Flight refuelling transfer valve. An electrically operated low pressure cock is fitted between the tank and the high pressure cock and is controlled by a switch on 70P.

Since the alternator is not provided with a constant speed drive unit the frequency control is determined by the turbine speed. Turbine speed is controlled by fuel/air ratio so it follows, that in this case frequency is controlled by the engine (A.A.P.P.) fuel metering system which confines the turbine r.p.m. within a narrow speed band.

3. Turbine Oil System

Engine lubrication is provided by a gear type pump which draws its supply from a sump formed by the lower part of the compressor casing. The sump is equipped with an electrical heater unit which is operative whenever the engine is switched off. The heater enables the oil to flow more freely whenever the engine is subject to low ambient temperatures. The temperature of the oil is thermostatically controlled by a switch which cuts off the heater supply at a temperature of 50°C.

4. Turbine Oil System Cooling

When the engine is started, the sump heater is automatically switched off by the energising of relay 487. The oil will now absorb heat from the engine itself, so in order to prevent overheating the thermostat will operate to bring in a cooling air supply derived from a mechanically driven blower via an electrically actuated butterfly valve.

5. Methods of A.A.P.P. Starting

Two starting systems are provided and are described in detail in the following paragraphs. The two systems consist of:-

- a. Electric motor start - for normal start conditions.
- b. Cartridge start - for emergency starting.

The cartridge discharges directly on to the turbine rotor and two shots are obtainable, selection being achieved automatically. Oxygen enrichment is provided to assist starting at extreme altitudes and operates with cartridge starting, wind-milling relight, and with certain switch selections motor start. Indication of use is given by a lamp in the starter push.

6. Electrical Equipment

- a. Air Intake Solenoid. This solenoid operates a hydraulic valve controlling the turbine air intake scoop. With the A.A.P.P. master switch 'OFF' the solenoid is energised from fuse 955 via relay 487, the solenoid earth being provided by the master switch. When the master switch is placed 'ON', the earth is broken and the solenoid de-energises causing the intake scoop to open the air intake under spring pressure.
- b. Booster Pump Motor (Low Pressure Pump). The motor is a conventional 28V shunt wound D.C. motor, and drives an impeller type fuel pump. The unit is fitted to the base of the 10 gallon fuel tank. The motor is operated by placing the A.A.P.P. master switch to 'ON' which passes current to the motor via the H.P. cock Override Switch ('NORMAL' position).
- c. High Pressure Cock Actuator. The actuator is a rotary type and consists of a normal split field series motor driving through reduction gearing. It operates a fuel cock to admit high pressure fuel to the turbine burner. Normally closed, the actuator open field energises only on operation of relay 484.
- d. High Energy Igniter Unit. The unit provides an intense spark during the starting cycle to ignite the fuel/air mixture. It is operated when relay 545 energises. The supply to the unit can be isolated by placing the ignition switch to 'ISOLATE'.
- e. Low Pressure Cock Actuator. This actuator is similar in type to the high pressure cock actuator. It is operated by selecting the L.P. cock switch to either 'OPEN' or 'SHUT'. The 'OPEN' circuit is carried through the de-energised contacts of relay 486 thus ensuring that during crash or fire conditions the actuator will be operated to the 'SHUT' position.
- f. Start Panel. The starter panel is fitted to control the electric motor start sequence.
- g. Oxygen and Cartridge Time Switch. The time switch controls the starting sequence when employing cartridge start.
- h. Auto Cartridge Selector. During cartridge starting, the first start is achieved via terminals 5 and 1 of this unit. At the same time, however, a stopping action takes place via terminals 3 or 4 and 2.

i. Starter Motor. The starter motor is of the conventional compensated series type and is fitted to the A.A.P.P. gearbox.

j. Sump and Cartridge Heaters. The sump heater consists of a three phase star connected element immersed in the sump oil. The purpose of this heater is to keep the engine oil flowing freely at high altitudes where the low ambient temperatures cause oil to thicken, thus making engine starting difficult. The element operates from a 200 volts A.C. supply via relay 489.

The cartridge heater is provided to prevent condensation forming on the cartridge firing contacts. The heater consists of two single phase elements working from A and C phases, and the supply is derived from fuses 147 RB via relay 485.

k. Oil Cooler Actuator. This actuator operates a butterfly valve in the engine oil cooling system. Normally 'OPEN' the actuator 'CLOSES' when the engine starts owing to the energising of R.487. Should the oil exceed a temperature of 50°C then the action of the sump thermostat causes the actuator to 'OPEN' allowing air from the blower to flow over the oil cooler. When the temperature falls the actuator closes.

l. 'Firetec' Unit TP.4202. The 'Firetec' Unit type TP.4202 is fitted in the A.A.P.P. compartment for fire warning purposes. It causes a red light on panel 70P to illuminate on receipt of a small e.m.f. (due to a fire) developed in a chain of thermo-couples disposed around the A.A.P.P. turbine.

7. Circuit Operation Motor Start

The aircraft systems must be prepared in the following manner before starting the auxiliary turbine:-

- a. Engine (Olympus) Master Switch - 'NORMAL' (6P)
- b. A.A.P.P. Bleed Switch - 'OFF' (7P)
- c. Check 'Firetec' Thermocouples - Press Test Push - Light 'ON'
- d. All Electrical Loads (especially P.F.C.'s) - 'OFF'
- e. Alternator Switches - 'OFF'
- f. Battery Isolation Switch - 'ON'

The A.A.P.P. may now be started as follows:-

- a. A.A.P.P. Low Pressure fuel cock - 'OPEN'
- b. High Pressure cock override switch - 'NORMAL'
- c. Oxygen and Relight Switch - 'OFF'
- d. Ignition Isolate Switch - 'ON'
- e. A.A.P.P. Master Switch - 'ON' (The Booster Pump starts at this point)
- f. A.A.P.P. Start Switch - Push for 3 seconds maximum

On pressing the button a 28 volts supply from fuse 979 is fed to the terminal 1 of the start panel via B2 and B1 of Relay 560. A supply through No. 1 contacts of the time switch causes the engage relay to energise which allows fuse 859 to feed the starter motor. As soon as the starter motor engages the turbine, the resultant heavy current flowing through the overspeed relay coil closes its contacts this action energising the start button coil thus holding it in, also starting the time switch. 1 second later No. 2 contacts make and 28 volts is fed from fuse 979 to energise relays 484 and 545 causing the high pressure cock to open, initiation of the alternator field and operation of the igniter.

The turbine builds up to a self sustaining speed and the overspeed relay contacts open, the start button coil de-energises and isolates the start circuit from fuse 979. It should be noted that at this stage, the alternator is fully established and its control panel 28 volts will maintain R.484 energised.

8. Circuit Operation Cartridge Start

Normally this would be considered as an airborne operation but it is possible to check the system on the ground. The preparation of the aircraft is as for paragraph 7. For this operation, relay 560 is de-energised:-

- a. A.A.P.P. low pressure fuel cock - 'OPEN'
- b. High pressure cock override switch - 'NORMAL'
- c. Oxygen and Relight Switch - 'OFF'
- d. Ignition Isolate Switch - 'ON'
- e. A.A.P.P. Master Switch - 'ON'
- f. A.A.P.P. Start Switch - Push for 3 seconds maximum

On pressing the button a 28 volts supply from fuse 979 is fed to terminal M of the O and C time switch via B2 and B3 of relay 560. The time switch commences its cycle and after 1 second No. 1 contacts make, allowing fuse 979 to open the oxygen solenoid and energise relays 545 and 484. These operate ignition and open the high pressure cock respectively. The start push lamp illuminates indicating oxygen start in progress. Simultaneously, No. 2 contacts make and 28 volts is fed to pins 5 and 6 of the cartridge selector, and No. 1 cartridge is fired. When No. 2 contacts open the selector steps around to prepare No. 2 cartridge for a further start. The turbine builds up to a self sustaining speed.

9. Relight

Should the turbine 'flame out' provisions is made for a windmilling re-light. The circuit preparation is as for paragraphs 7 and 8 and the starting attempt is as follows:-

- a. A.A.P.P. low pressure cock - 'OPEN'
- b. High pressure cock override switch - 'NORMAL'
- c. Ignition Isolate Switch - 'ON'
- d. A.A.P.P. Master Switch - 'ON'
- e. Oxygen and Relight Switch - 'ON'

Selecting the Oxygen and Relight Switch to 'ON' allows fuse 979 to energise relay 511 causing relay 545 and 484 to energise. At the same time the oxygen solenoid is opened and the lamp in the start push illuminates. The starting cycle is uncontrolled and relies entirely on windmilling speed. When the turbine re-establishes itself the Oxygen and Relight switch is placed to 'OFF.'

10. Motor Start with Oxygen Enrichment

This type of start is carried out in the following manner. The oxygen and relight switch is placed to 'ON' and the starter push depressed, the resultant operation is identical with that described in paragraphs 7 and 9.

<u>Component</u>	<u>No.</u>	<u>Location</u>
A.A.P.P. Start Push B.T. H. Ref. X1.CX.132061	1	70P
A.A.P.P. Master Switch	2	70P
H.P. COCK override switch	1	70P
L.P. Cock switch	1	70P
Ignition Isolate switch	1	70P
Fire Test Push	1	70P
Relays 484 485 486 487 488 489 511 545	8	62P A.A.P.P. comp.
Start Panel Rotax	1	A.A.P.P. Compartment rear of stbd landing gear
Oxygen and Cartridge Time Switch	1	"
Low Pressure Cock Actuator	1	A.A.P.P. Compartment
High Pressure Cock Actuator	1	A.A.P.P.
Auto Cartridge Selector	1	A.A.P.P. Compartment
'Firetec' Unit TP.4202	1	"
Booster Pump Motor P.D.C. 20 mk. 1	1	Base of 10 gall tank - rear of AAPP installation
Air Intake Solenoid	1	Fwd of AAPP installation on air scoop
Starter Motor	1	A.A.P.P.
Sump heater	1	A.A.P.P.
Cartridge heater	1	A.A.P.P.
High energy igniter unit	1	Fwd face AAPP compartment
Igniter Plug	1	A.A.P.P.
Fire bottle	1	A.A.P.P.

SECTION 3 PART 21. Introduction

Part 2 of this section is concerned with the control of the A.A.P.P. alternator. Where necessary, references to the synchronising network can be made in Section 2, Part 3.

2. Type 155 A.C. generator

The type 155 A.C. generator requires a controlled 28V D.C. supply to serve the field rotor and produces a 3 phase 200V A.C. output. This output, when the generator is being driven at 8000 r.p.m. is rated at 30 KVA up to a maximum altitude of 50,000 ft., but a load of 40 KVA may be imposed at altitudes of up to 30,000 ft. The output frequency at 8,000 r.p.m. is 400 c.p.s. The rotor carries the D.C. excitation field which is wound on 6 salient poles keyed to the shaft. The excitation current is picked up by two slip rings at the extremity of the shaft.

3. Transformer Rectifier Unit Rotax Type U.3306

The type U.3306 TRU is used in conjunction with the type 155 alternator to provide a regulated output of 200 volts A.C. at up to 110 amps, the power factor varying from 0.86 to 0.96 lagging. The unit is protected by a system which ensure that in the event of a fault, i.e. line to earth, then should the fault current exceed 25 amps, the unit will be removed from the synchronising network.

The side panels of the unit are detachable and are readily removed when it is required to gain access for servicing. As a further aid to servicing, the voltage regulator is built on its own chassis and can be withdrawn from the main chassis.

a. Voltage Sensing Transformer Rectifier. Line voltage at 200 volts A.C. is transformed and rectified to 28 volts D.C. The latter is applied to the operating coils of the voltage regulator. The generator field being connected in series with the carbon pile it follows that variations in line voltage will reflect in the output delivered to the coils of the regulator, this causes changes in pile compression and hence field strength.

b. Main Transformer Rectifier. During the A.A.P.P. starting cycle, the field of the alternator is initially excited by the field flashing circuit provided by relay 393. Once the alternator has established itself then field current is supplied from the main T.R. at 28 volts DC.

c. Compounding Current T.R. The field rotor of the alternator is supplied from two sources:-

1. The main T.R.
2. The compounding current T.R.

The compounding current T.R. supplies current to the field at a value proportional to line current. When the alternator is supplying current to the synchronising network the compounding current T.R. output assists in keeping the regulator pile current to a safe working value.

d. Field Protection. The bi-metal element of the field thermal unit is connected in series with the field coil. Should field current become excessive, then the element distorts and causes its associated contacts to break the supply to the field relay coil, which in de-energising introduces a field 'slugging' register. The other contacts of the field thermal unit close to lock the field thermal unit out.

e. Earth Leakage Protection. Should the line break down to earth, current will flow through the star point of the alternator. This current induces a voltage in the star point C.T. This voltage is connected to the rectifier of the earth leakage relay and when energised will cause the field thermal unit operating coil to energise, the remaining sequence being the same as in paragraph 3 d.

4. Voltage and Frequency Pick Up Box

During the A.A.P.P. starting cycle, the alternator field is initiated and the line voltage and frequency begin to develop. Once these two values approach 200 volts and 400 cycles respectively, then the voltage and frequency sensitive relays of the Voltage and Frequency Pick Up operate to place the alternator output on the synchronising network, and also remove the supply to the field flashing relay coil, since the alternator will now be self sustaining.

5. A.A.P.P. Instrument Transformer

This transformer enables the alternator output to be checked on IOP.

6. Field Flashing Relay (R.393).

The field flashing relay is provided to convey the alternator field initiation current during the A.A.P.P. starting cycle, the supply being derived from the essential bus bar via fuse 484. As was mentioned in paragraph 4, the relay is de-energised once the alternator output is fully developed.

7. Test Socket

A Plessey Mk. 4 socket is provided for test purposes and is located in the power compartment.

<u>Component</u>	<u>No</u>	<u>Location</u>
Generator Type 155	1	A.A.P.P. Installation (Rear Starboard Landing Gear)
Transformer Rectifier Unit	1	Power Compartment
A.A.P.P. Instrument Transformer	1	82P (Power Compartment)
A.A.P.P. Voltage and Frequency Pick Up Box	1	74P
Field Flashing Relay R.393	1	74P (Power Compartment)
A.A.P.P. Test Push.	1	IOP

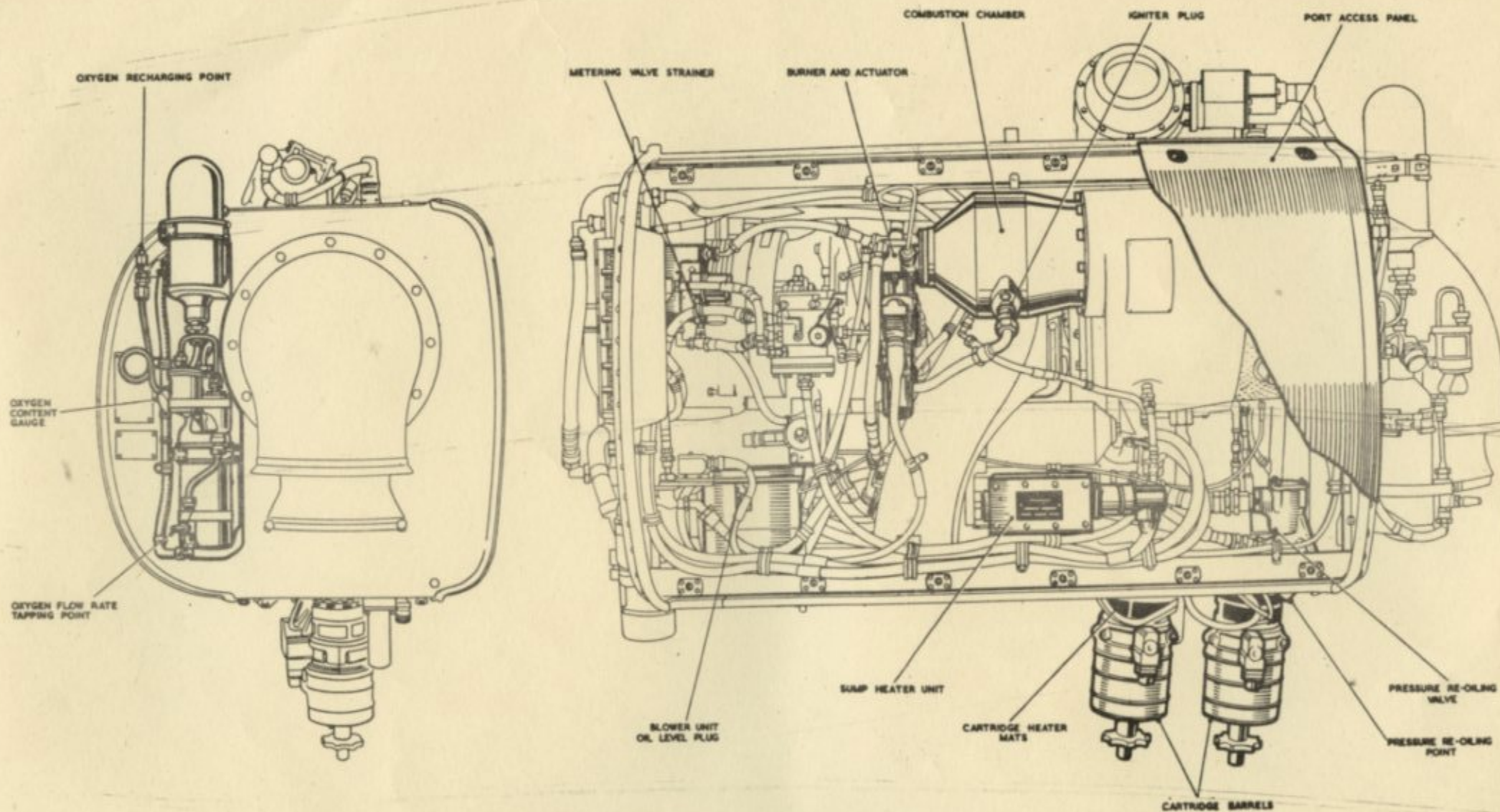
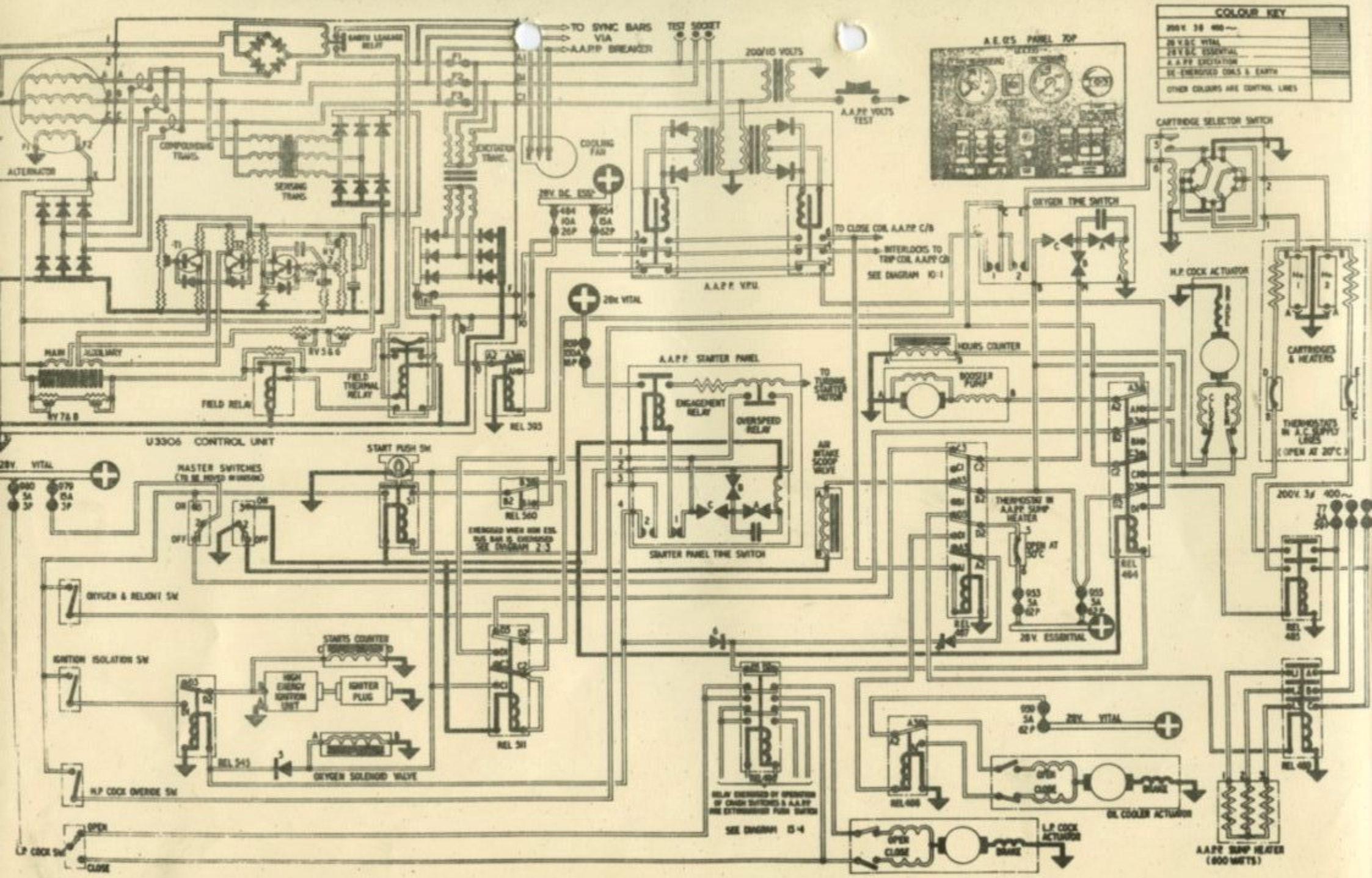


Fig.1. Routine servicing points. (Sheet 1.)

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COLOR KEY

200V 3Ø 400~	
20V AC VITAL	
20V DC ESSENTIAL	
A.A.P.P. EXHAUSTION	
DE-ENERGIZED COILS & EARTH	
OTHER COLOURS ARE CONTROL LINES	



ENGAGED WHEN HIGH EOL
DUE BAR IS CHANGED
SEE DIAGRAM 2-3

RELAY ENERGIZED BY OPERATION
OF CRASH SWITCHES & A.A.P.P.
FIRE EXTINGUISHER PUSH BUTTON
SEE DIAGRAM 0-4

200V 3Ø 400~
77
50

A.A.P.P. SUMP HEATER
(600 WATTS)

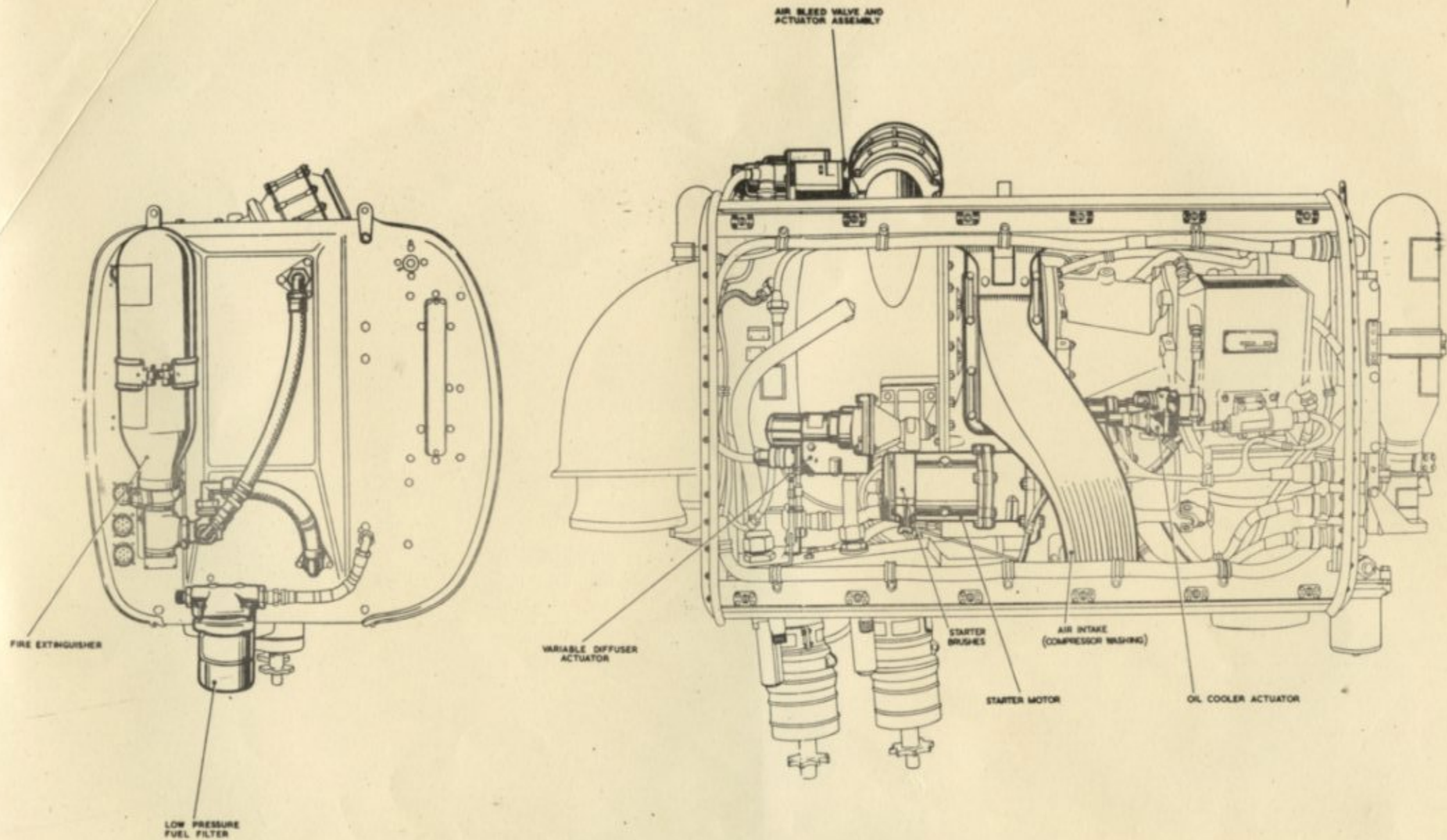


Fig. 2: Routine servicing points. (Sheet 2.)

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