AERO ENGINE SCHOOL
COURSE NOTE
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AVON Mk.205.

WATER/METHANOL INJECTION SYSTEM.

INTRODUCTION.

A gas turbine operating at governed R.P.M. for take-off at high altitude airfields or in high ambient temperatures does not develop its rated thrust because of a reduction in mass flow.

Liquid injection into the combustion chambers of a jet engine can be employed to provide thrust augmentation while still maintaining normal flame temperature. Although water is the simplest and most effective injectant the addition of methanol, to form a water/methanol mixture, lowers the specific heat and gravity, prevents freezing of the residual liquid remaining in the system and gives a more even flame traverse. In addition the methanol content has a calorific value which reduces the main fuel required; the mixture is approximately 70 gallons of distilled water to 30 gallons of methanol to maintain an S.G. of .96 at 15°C or .949 at 45°C.

When water only is injected with fuel flow unchanged the latent heat of vapourisation takes up part of the heat of combustion of the main fuel flow and reduces the flame temperature and engine R.P.M. When the mixture is injected with unchanged fuel flow part of the heat of combustion of the methanol vapourises part of the water content. Increasing the fuel supply to restore the R.P.M. leaves the flame temperature sub-normal but the thrust is slightly increased by virtue of increased turbine mass flow, compression ratio and specific heat. Further increase of fuel supply to restore the flame temperature overspeeds the engine and gives an increased mass flow together with higher jet pipe pressure. This is the augmented thrust condition.

The maximum overspeeding permitted is 300 R.P.M. with the J.P.T. normal. This will restore the loss of thrust at Tropical Summer Ground Level (+45°C) conditions to that of the I.C.A.N. condition. In order to achieve that condition a water/methanol - air ratio of 4.4% is required, this is accomplished by an injection rate of 2,600 G.P.H.

GENERAL DESCRIPTION OF SYSTEM.

Two fuselage mounted tanks, vented to atmosphere, containing 145 gallons supply the mixture by gravity to four turbo pumps. The tanks have high level pressure filling connections and contain low level (6.25 gallons) float switches. The turbo pumps are operated by the aircraft tail de-icing airflow, tapped off from the compressor delivery pressure of the four engines, which is solenoid selected, the solenoid being energised by a pilot operated switch. A 6" gravity head of mixture will maintain a supply to the turbo pumps at pressure altitudes up to 6000 ft. and a mixture temperature of 50°C. The pumps permit a maximum flow of 2,600 G.P.H. and will deliver the 145 gallons to the four engines in approximately 60 secs., in this time the aircraft should have taken off and be at about 50 ft.

The mixture is delivered by aircraft pipes to connection blocks on the port side of the nozzle box of the engines through a combined H.P. filter and shut-off cock. The connection box houses a filter and a non-return valve which permits the mixture flow to be directed through two pipes leading inboard up two nozzle box spokes into a manifold which is welded on to the intermediate casing. The manifold feeds 8 twin-jet injectors bolted to it, which spray the mixture through the tertiary holes of the flame tubes slightly upstream.

/continued.

A third pipe from the connection block upstream of the filter and non-return valve conducts a mixture pressure signal to the overspeed governor of the H.P. fuel pump. This mixture pressure uprates the overspeed governor spring to control the overspeed value at 300 R.P.M. A minimum speed override pressure switch energises the H.P. S.O.C. when the engine compressor delivery pressure exceeds 60 p.s.i. This pressure is an approximate speed signal and ensures that the mixture cannot be injected in the early stages of an acceleration. 60 p.s.i. compressor delivery pressure is reached at the following conditions:-

S.L.	Zero °C	-	6700 R.P.M.
S.L.	+15 °C	-	6890 R.P.M.
S.L.	+45 °C	-	7240 R.P.M.
5000 ft.	+45 °C	-	7500 R.P.M.

A pilot operated switch on the cockpit port coaming panel selects water/methanol operation. When this switch has been selected at an engine speed of 6000 R.P.M. four low pressure warning lamps, adjacent to the switch, light-up.

OPERATION.

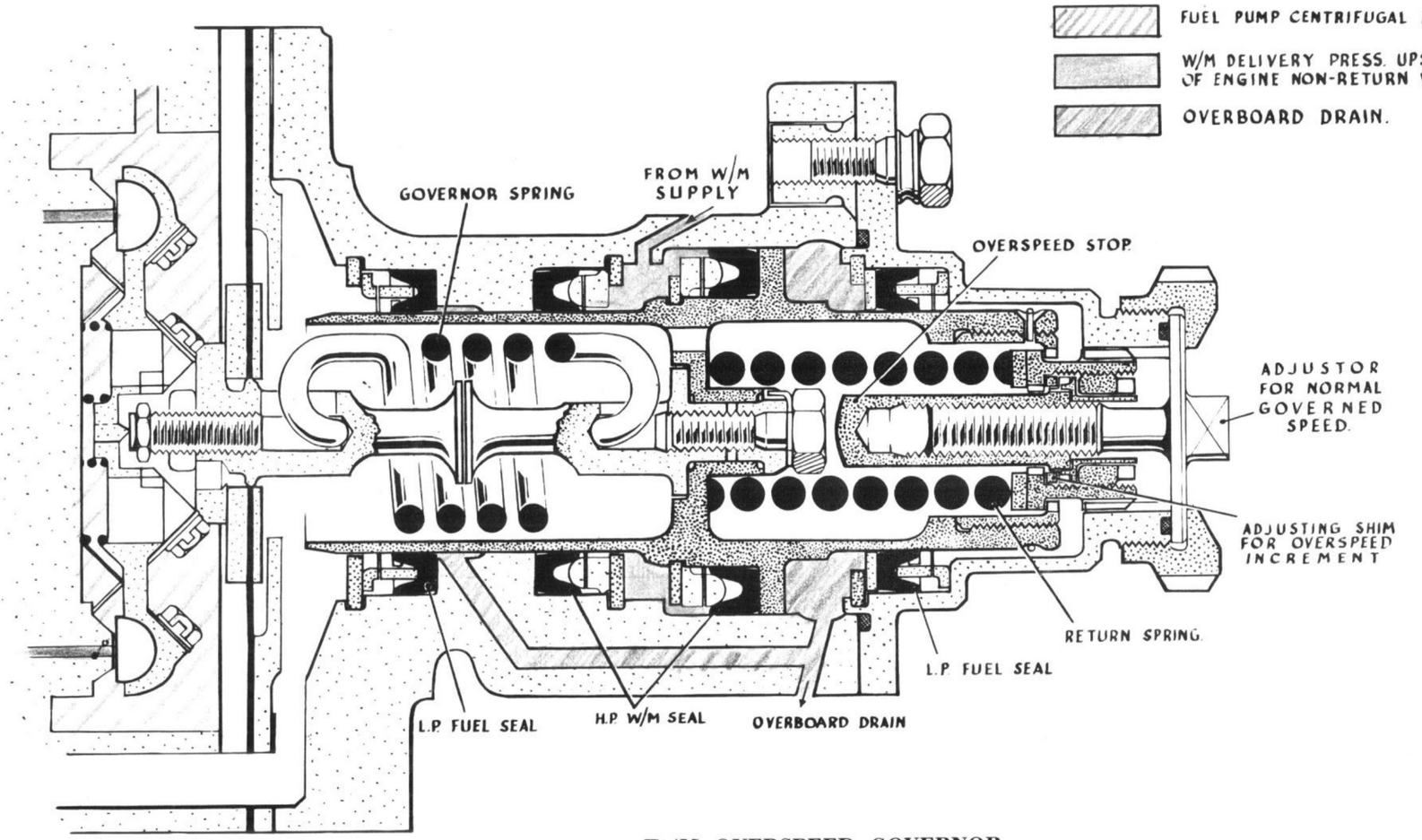
On take-off when 6000 R.P.M. has been attained the water/methanol selector switch is operated. The pilots low pressure warning lamps light-up and the turbo pump air S.O.C.'s are opened. When sufficient pressure is delivered by the turbo pumps the warning lamps 'go out' (they should be on for not more than one second). When 6,500 to 7,700 R.P.M., depending on conditions, is reached the minimum speed switch energises the solenoid of the water/methanol S.O.C. and water/methanol is injected. The H.P. fuel pump overspeed governor is tripped by water/methanol pressure and the engine overspeeds to 300 R.P.M. above governed speed. After approx. 50 seconds the tank low level switches open and both water/methanol and air S.O.C. close. Water/methanol pressure falls to relieve the fuel pump governor and the R.P.M. returns to governed speed and the pilots L.P. warning lamps re-light. Switch off water/methanol selector switch and the warning lamps go out. If any one of the four L.P. warning lamps fail to light-up it may be either a bulb or the low pressure switch that has failed, WATER/METHANOL MUST BE SWITCHED OFF IMMEDIATELY. If either pair of lights fail to light-up, or, go out, the pilot must close both aircraft de-icing gate valves on that side. If either pair of lights blink on and off with attendent engine R.P.M. fluctuations SWITCH OFF the water/methanol selector switch.

SERVICING, ADJUSTMENTS AND FAULT DIAGNOSIS.

No routine servicing of the engine system is necessary.

Although the governed R.P.M. overspeed is adjustable it should not be attempted in the field. If the low pressure warning light goes out but the overspeed does not occur, check that the minimum speed switch operates at 60 p.s.i.; that the airframe de-icing gate valve on the affected engine is opened fully; that the H.P. S.O.C. solenoid is fully opening the cock and that the mixture pressure into the H.P. fuel pump overspeed governor is at least 160 p.s.i. A blocked filter at the engine connection block or a failed turbo pump relief valve may be responsible for low pressure.

If the low pressure warning light remains lit and the overspeed does not occur, check that the airframe de-icing gate valve is fully open; that the turbo pump is functioning correctly and that there is an adequate supply of water/methanol mixture.



W/M OVERSPEED GOVERNOR

FIG.6

Dnl/JF 2488.A

1.5.57

1.4.58

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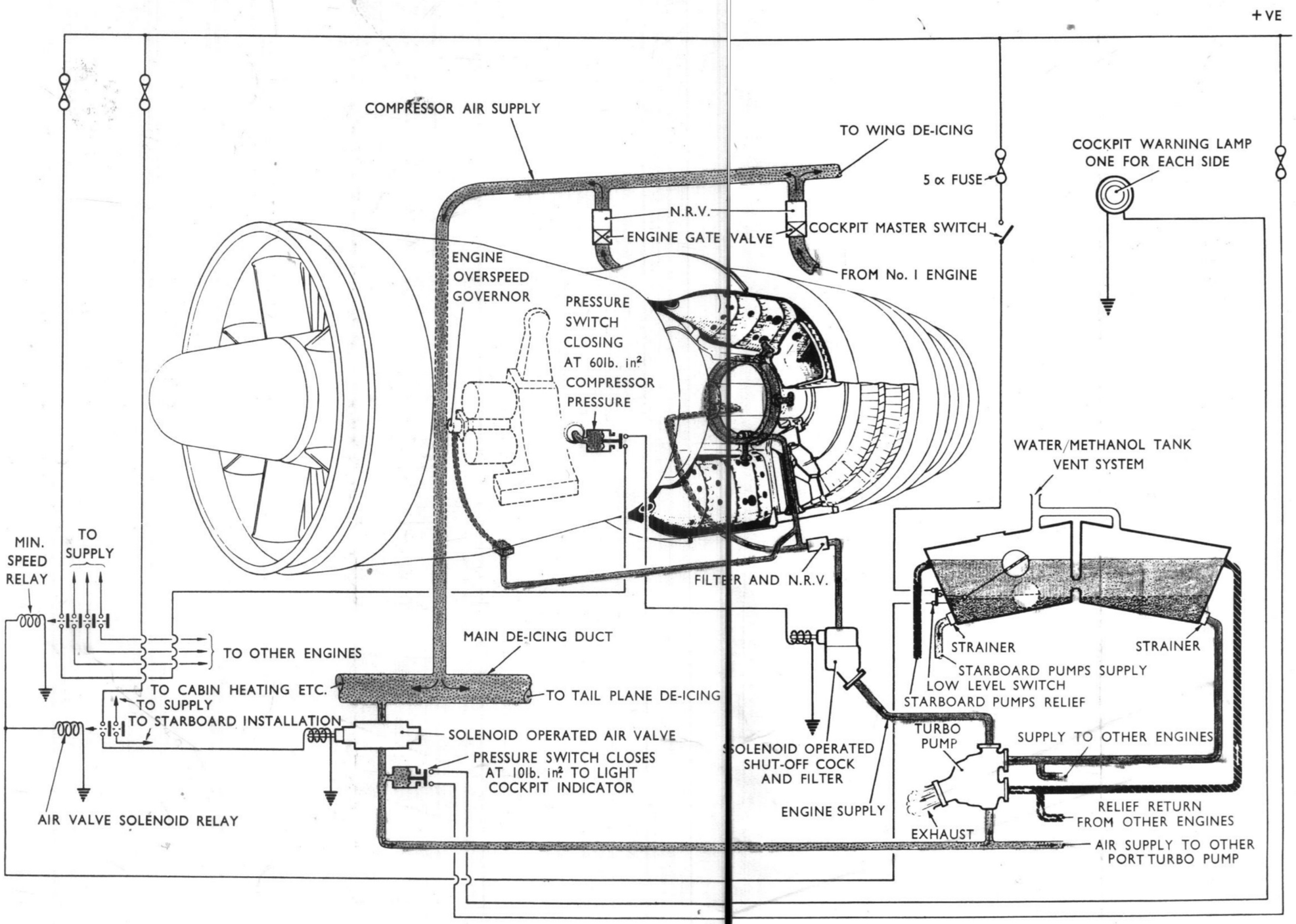

WATER-METHANOL SYSTEM DIAGRAM

1.10.60