Chapter 9

ACCELERATION CONTROL AND METERING VALVE UNIT

TYPE BA36060, BA44983, BA44900, BA98881

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

Introduction

1. Gas turbine design is such that at static throttle settings, or during very slow acceleration, the fuel flow is adequately matched by the mass airflow through the engine to produce a satisfactory fuel/air ratio.

2. During rapid acceleration, however, the normal B.P.C. action causes the fuel flow to increase more rapidly than is necessary to produce the required acceleration, whilst the mass airflow is temporarily inadequate due to inertia of the compressor/turbine assembly.

3. As the above conditions would give rise to over-fuelling, with resultant excessive jet pipe temperature and compressor surge, the acceleration control unit is fitted to limit the fuel flow during the acceleration phase to that necessary to increase momentum and attain the new steady running condition.

4. The unit operates by reducing the servo pressure controlling the H.P. fuel pump stroke during those periods when the fuel flow tends to exceed the acceleration requirement. To achieve this, the unit is made sensitive to compressor delivery pressure as a measure of airflow, and to the pressure difference across a fuel metering valve as a measure of the fuel flow. These two opposed forces, acting on individual diaphragms, influence each end of a rocker lever assembly and control the movement of a half-ball valve which in turn modifies the pump servo pressure.

5. To enable the unit to follow the limiting value of the air/fuel ratio closely under all conditions of operation, the following additional features are incorporated:—

(1) An evacuated capsule is housed in a chamber which is vented to atmosphere. This provides an Absolute datum for the air section of the unit as altitude increases, thus making the unit sensitive at all altitudes.

(2) An upper air diaphragm alters the unit characteristics to compensate for the reduced air and fuel flow at high altitudes in the higher r.p.m. range.

(3) On later types a temperature capsule compensates for the reduction in mass airflow following any increase in air-intake temperature such as occurs when operating under tropical conditions or when the intake anti-icing system is in operation.

(4) A by-pass valve in the fuel metering unit modifies the unit's response to permit faster acceleration at the higher fuel flows where engine response is more suited to sudden increases in fuel flow.

Fuel flow measurement

6. The entire fuel flow from the H.P. pumps passes through a metering unit. The unit contains a metering valve and a by-pass valve which are unequally spring-loaded and through which the pump delivery fuel must flow before passing to the throttle.

7. Pump delivery fuel loses some of its pressure in forcing open one or both valves and tappings taken from upstream and downstream are applied to the A.C.U. fuel diaphragm as a measure of the fuel flow in terms of pressure difference. The more lightly loaded valve controls the pressure difference at all flows up to 240 g.p.h., at which point the second or by-pass valve commences to open, thus permitting the required increase in flow at a reduced pressure difference. This reduces the sensitivity of the A.C.U. at the higher fuel flows and permits a more rapid acceleration.

8. The fuel metering forces are transmitted through pipes to the fuel section of the acceleration control unit where the fuel diaphragm transforms the pressure difference into a force acting on one end of the rocker lever controlling the half-ball valve.

Airflow measurement

9. The pressure difference across the compressor is measured in the A.C.U. by the compressor delivery pressure being fed to the top side of the main air diaphragm which is subject to atmospheric pressure on its lower side. This air force acts on the other end of the rocker lever assembly, opposing the fuel force.

10. The air force is also assisted by the action of a smaller air diaphragm. This small diaphragm is subject to compressor delivery pressure on its underside and to compressor bleed valve operating pressure on its upper side. Bleed valve operating pressure is approximately atmospheric at low r.p.m. when the bleed valves are open, but increases suddenly to compressor outlet pressure when the valves are closed. On engines with mechanically operated bleed valves, a split pressure, i.e. compressor delivery and atmospheric, is used to make the change gradual. This additional air force, acting through the smaller diaphragm, tends to close the A.C.U. half-ball valve, thus permitting more acceleration fuel to be available at the higher r.p.m.

Altitude compensation

11. The A.C.U. is designed to permit an increase in fuel flow sufficient only to achieve the desired acceleration without excessive j.p.t. or surge. As an increase in altitude requires a reduction in the main fuel flow, so must the extra fuel required for acceleration be reduced.

12. At altitudes, reduced atmospheric pressure acting on the underside of the main air diaphragm would allow the compressor delivery pressure to tend to close the half-ball valve, and in consequence increase pump delivery pressure.

13. This tendency is counteracted by an evacuated capsule acting on the end of the air section operating spindle. The effective surface area of the capsule is exactly equal to that area of the main air diaphragm which is exposed to atmospheric pressure. As altitude increases the downward force on the diaphragm is balanced by an equal upward force from the capsule.

Temperature compensation

14. High air intake temperatures, such as those encountered in the tropics or when the anti-icing system is in operation, produce a detrimental effect on acceleration performance. The reduced density of the hotter air, producing a reduction in compressor delivery pressure, results in a smaller downward force on the main air diaphragm opposing the upward force on the actuating rod spring. This reduced force allows the half-ball valve to remain slightly open and thus prevent the fuel pumps from achieving sufficient output for satisfactory acceleration. Compensation is provided by inducing a progressively increased force on the rocker lever actuating rod. Through the action of the temperature sensitive capsule situated above the topmost air chamber and influencing movement of the actuating rod through a spring. A capillary tube connects the capsule chamber to a temperature phial in the engine air-intake. A rise in air-intake temperature compresses the capsule and actuates a rod which increases the tension on the temperature section spring, and so counterbalances the upward force on the actuating rod spring.

15. To prevent the temperature compensating mechanism from over-increasing acceleration time under low temperature conditions a stop plate is incorporated. The temperature section spring carrier rests against this stop plate and allows the capsule contact to lift clear. This stop, therefore, determines the minimum temperature setting at which compensation begins to operate and shims are provided to enable this to be set to the correct value on rig test.

16. Adverse control effects caused by differential expansion between the two types

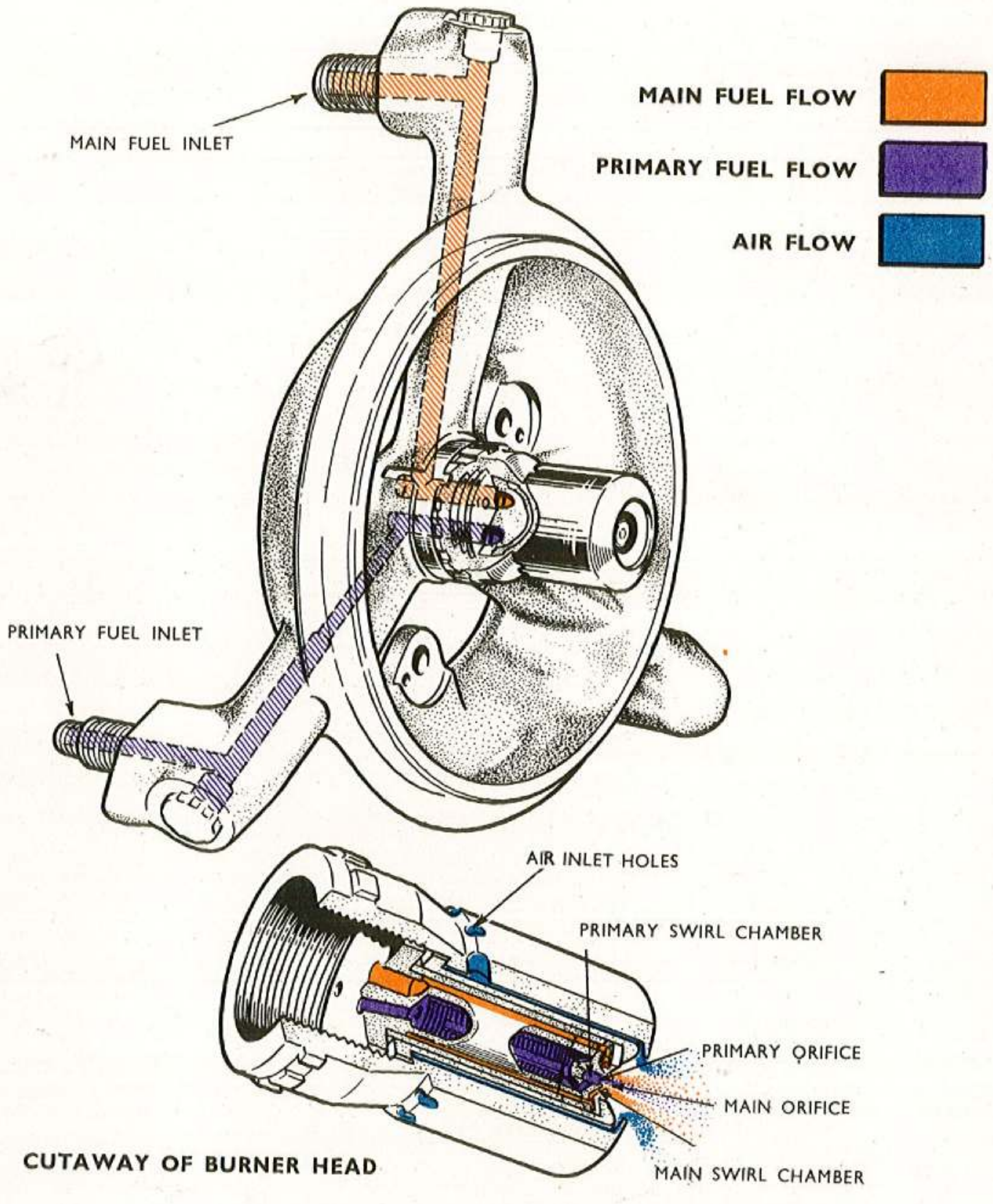

Fig. 2. Duple Burner—Derwent type (cutaway showing flows)

RR 2551

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