Exhaust Reheat for Turbojets . . .

decrease the efficiency of the power unit as a whole. The reheat system must be capable of burning at the highest possible combustion efficiency, under all conditions of flight, sufficient fuel to enable a worthwhile thrust boost to be obtained. It will be seen later that this requirement has proved to be one of the most difficult to fulfil and that most of the past work has been associated with this aspect of the general problem.

A two-position, variable-area propulsion nozzle must be provided to cover both the reheated and the non-reheated conditions. It must be capable of withstanding the high gas temperatures which exist in the nozzle when reheating and must be aerodynamically clean both internally and externally to avoid further losses in the exhaust duct and increased aircraft drag. Ample cooling must be provided to protect the aircraft from the hot duct and vibration must be kept to a minimum.

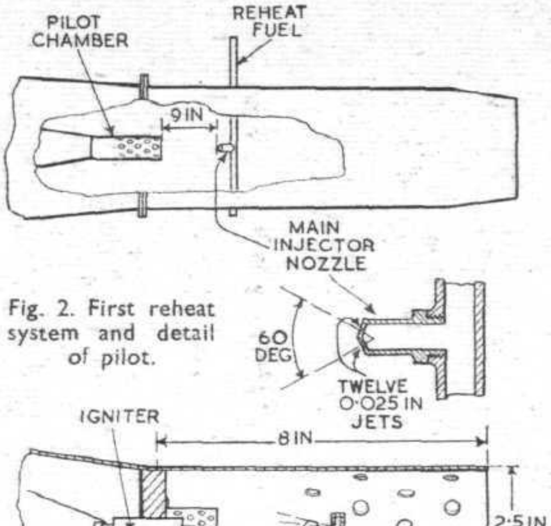

Fig. 2. First reheat system and detail of pilot.

The first reheat experiments in this country were started at the Royal Aircraft Establishment in 1943. At that time the only turbojet available was one of the early Whittle units, W.1.A. No. 3, which was rated at 1,000 lb thrust and 600 C jet temperature at 17,000 r.p.m. These culminated in the development of the burner system shown in Fig. 2. A small pilot chamber was attached to the end of the central bullet in the exhaust cone assembly. This chamber contained a single 0.025in dia. jet which was supplied with P.B.O.* from the turbine fuel system. A spark plug fitted in the base of the chamber served to ignite the fuel, which burnt with a flame some 18in long, starting just inside the mouth of the chamber. When the pilot flame had been lit up the main fuel was injected through a multi-jet rose positioned 9in downstream of the pilot chamber. The main fuel used during the reheat calibrations was lubricating oil to specification D.T.D.472 and it was supplied at a pressure of 400 lb/in² from an auxiliary fuel system. Attempts to burn P.B.O. resulted in severe vibrations and buffeting.

Although not very comprehensive, the results obtained from these tests were sufficient to indicate that a considerable improvement in thrust output could be obtained at great expense of fuel consumption.

At this stage the experimental work was transferred to a Rolls-Royce Welland turbine, and all efforts were concentrated on the further development of the system to burn aviation kerosene throughout. The chief difficulty was to locate the main fuel injection ring in a position where the fuel spray had the least effect on the functioning of the pilot combustion chamber. The most satisfactory arrangement was that shown in Fig. 3.

The pilot chamber was similar to that used in the earlier tests, but in this system the main fuel was injected into the pilot flame from a 6in dia. "halo" ring mounted coaxially and 3in upstream of the pilot-chamber outlet. Once the pilot flame was alight it was not necessary to continue the ignition, but if for any reason the pilot flame was extinguished the main combustion failed also. This represented one of the major faults. The pilot jet diameter lay between 0.015in and 0.020in, and was liable to choke and so lead to failure. A further disadvantage was found in that the size of the pilot had to be varied for different power units. This was due, no doubt, to differences in exhaust gas flow characteristics which resulted in different quantities of air entering the perforated flame tube.

These and other minor defects prompted development which resulted in a modified chamber, shown also in Fig. 3. The principle of a pilot flame in a small flame tube was maintained, but the method of creating it was altered. The pilot jet was abandoned, the holes in the flame tube omitted, and the chamber, still 2.5in dia., shortened in length. The main fuel jet halo was reduced in size and welded to the end of the flame tube. The jets consisted of twelve equally spaced holes, each of 0.025in dia., drilled radially outwards. The halo ring in this position created a reverse flow of air and fuel into the chamber. Spark ignition was required only to start the pilot flame and thereafter the combustion of the main reheat fuel continued to take place independently.

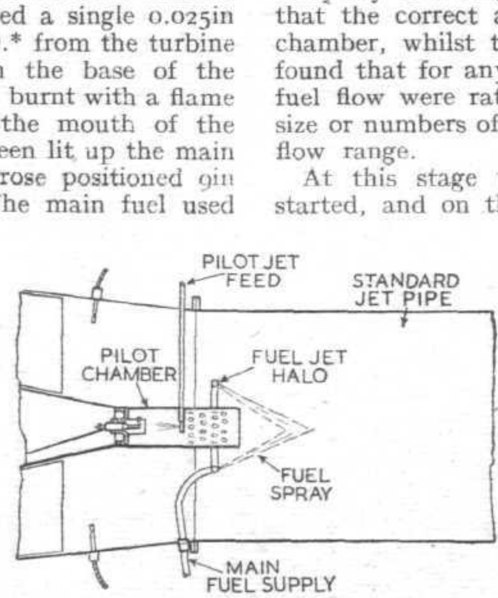

Fig. 3. Original and "halo" burners.

As was the case in the previous design, the main difficulty lay in arranging the fuel injectors in such a manner that the correct air-fuel mixture was maintained in the chamber, whilst the total fuel flow was varied. It was found that for any arrangement of injectors the limits on fuel flow were rather narrow, and only by changing the size or numbers of jets was it possible to cover a wide fuel flow range.

At this stage the V1 bombardment of London was started, and on that account consideration was given to the application of reheat to our Meteor jet aircraft. Bench tests had given good promise and an experimental flight installation was prepared. The flight test programme for this particular system extended over a considerable period, which may be considered here in two main parts. The first part outlines the early flight tests at the Royal Aircraft Establishment using a Meteor I aircraft with Welland units, while the second covers the work undertaken at Power Jets (R. and D.), Ltd., Leicester, and describes the further flight development work carried out on W2/700 units in a Meteor I aircraft.

Initially, this work was intended to provided reheated Meteor aircraft to combat the German flying bomb, but the early repulse of this attack prevented it being used for this purpose. Tests were continued, however, with the object of recording reheat performance at altitude and its effect on aircraft performance. Prior to installing the turbines in the aircraft, bench tests were made to check the reliability and performance of each. In the absence of a suitable variable propulsion nozzle, the

* *Pool Burning Oil.*