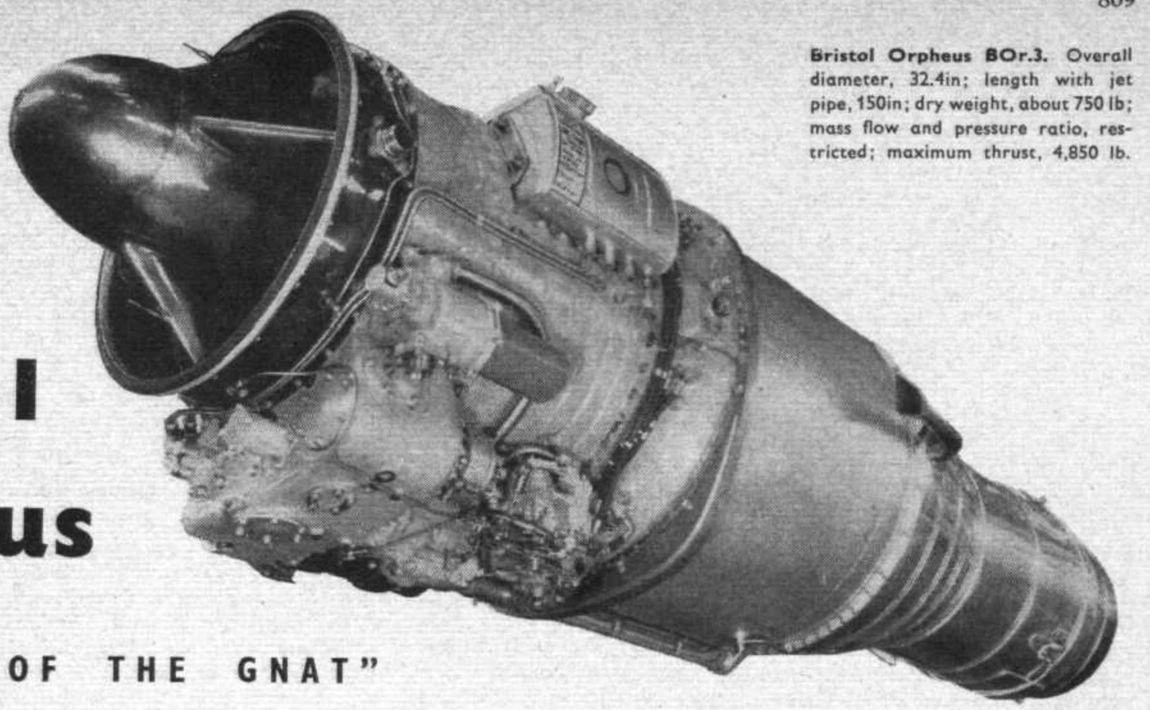

Bristol Orpheus BOr.3. Overall diameter, 32.4in; length with jet pipe, 150in; dry weight, about 750 lb; mass flow and pressure ratio, restricted; maximum thrust, 4,850 lb.

Bristol Orpheus

"THE HEART OF THE GNAT"

FEW aero engines can claim a success record comparable with that already established by the Bristol Orpheus. Within three years of its first run it has been selected as the powerplant of fourteen new types of aircraft, thirteen of which are of foreign design. It is already flying in five different types of aeroplane and has performed superbly during an exceptionally rapid and trouble-free development.

It is now possible to publish a detailed description of all but the most advanced types of Orpheus, and to reveal the singularly ingenious features which make this engine so simple to construct and maintain. At the end of this account is appended the genesis of the design and an account of its current progress and future prospects.

The Orpheus is a single-spool engine, having a single-stage turbine driving a seven-stage axial compressor. The compressor and turbine are coupled by a shaft to form a single main rotating assembly, which is mounted in only two bearings, a ball thrust bearing forward of the compressor and a roller bearing behind the turbine. The following description primarily concerns the BOr.3, although the BOr.1, 2 and 4 are very similar.

The front bearing is mounted in a light-alloy intake casing, the inner structure of which is joined to the outer circumference by four hollow radial vanes. These vanes mate with those of the air intake duct, which is likewise fabricated from light alloy and forms the front extremity of the engine. This duct incorporates a centrally-disposed bullet, which in some types of Orpheus serves as a fairing for a cartridge starter bolted to the front face of the intake casing. The Gnat's BOr.2 has a pneumatic starter mounted in the same position, the fairing being slightly reduced in size. The upper and lower radial vanes of the duct carry pitot heads which measure the air pressure for the barometric pressure control. Also cast integral with the intake casing is the accessory gearbox, driven from the main shaft by means of a bevel drive passing through the lower vertical vane. On the rear face of the gear chamber are mounted the generator on the starboard side, a Lucas swash-plate fuel pump in the centre and a hydraulic pump on the port side. The front face supports the main oil pump, the tachometer generator and, in some installations, a second hydraulic pump.

At its rear end the intake casing houses the entry guide vane assembly. Bolted to the rear of the intake casing are the light-alloy upper and lower compressor casings which carry six rows of stator blades. These half casings are secured at their rear ends to the delivery casing of the compressor, and it is a feature of the design that one of the half casings can be removed without dismantling the remainder of the engine, in order to permit inspection of the complete rotor, which may be turned over by hand. Each of the half casings has six dovetail grooves in which the stator blades are fitted, the latter being retained by simple spring-clips at each joint flange. An external tapping on the lower right-hand side of the casing provides a supply of cooling air for the turbine bearing.

Compressor rotor blades are held by fir-tree roots in discs which, together with intermediate spacer rings, are secured by through-bolts. A stub-shaft bolted to the first-stage disc supports the rotor in the forward thrust-bearing. Bolted to the rearmost compressor disc is the turbine shaft, which is of large diameter and is secured at its downstream end to the turbine disc. The latter also has a stubshaft, attached to its downstream face, which rides in the rear roller bearing.

Surrounding the cannular combustion system is a cylindrical outer casing, bolted to the compressor-delivery casing at the front and carrying the exhaust-cone assembly at the rear. Within are seven flame tubes, and the inner boundary of the pressure space is formed by an inner casing bolted at its front end to the inner section of the compressor-delivery casing and at its rear end engaging the inner face of the turbine-stator segments by means of a piston-type sealing ring. The seven burners are supported in the delivery casing, the inner and outer parts of which are interconnected by integral radial struts. Each flame tube is located at its forward end on its corresponding burner, and is allowed a limited axial float. At the rear, each flame tube changes in section from circular to segmental to form a turbine-entry duct, within which is contained a section of the turbine stator. Each of the seven stator segments has nine hollow blades, and is bolted to the adjacent segments to form a continuous ring. Igniter plugs are provided in Nos. 4 and 7 flame tubes, the flame spreading in the usual way through interconnectors.

There are 125 blades on the turbine rotor, each of impulse section at the root with increasing reaction towards the tip. The blades are mounted in the rim of the disc by means of fir-tree root fixings, located axially by means of a dowel pin driven through a slot to engage a hole in the root of the blade.

As mentioned above, the exhaust-cone assembly supports the rear bearing for the main rotor. The assembly comprises an outer casing from which the inner bullet is carried by means of eight radial vanes; the bullet, which forms a fairing for the downstream face of the turbine, is of truncated form and extends rearwards beyond the rear flange of the outer casing. The rear-bearing support diaphragm is mounted within the front end of this member, bearing-cooling air being supplied through a pipe passing through one of the radial vanes.

The jet pipe, which is secured by a flange on the exhaust-cone outer casing, carries thermocouple bosses for the measurement of j.p.t., and both the jet pipe and exhaust cone are surrounded by a Refrasil heat-insulating blanket. In addition, there is a light-alloy jet-pipe shroud, which is secured to the combustion-chamber outer casing and surrounds the exhaust cone and jet pipe, providing a cooling air space between the two. The shroud has a stainless-steel inducer riveted to its rear end, so that the jet gases induce the flow of cooling air.

Detail design of the Orpheus in its present form began in December 1953, and progress was extremely rapid from the outset. The first material was ordered early in 1954, and all the detail drawings had been issued to the shops by the end of June of that year. Manufacturing progress also went ahead with great speed—largely as a result of the simplicity of the design—and the first engine was assembled and run on the test bench by December. The speed with which the design was completed was due in no small measure to the increasing body of experience on gas-turbine engines, which enabled the design team* accurately to forecast the performance. Moreover, the Engine Division of the Bristol Aeroplane Co. (as it then was) had gained much useful knowledge of the structural design of lightweight turbojets before the Orpheus project began. [contd. overleaf

Dr. S. G. Hooker, chief engineer of Bristol Aero-Engines, directed the work of a design team under Mr. B. S. Massey and a development team under Mr. John Dale.