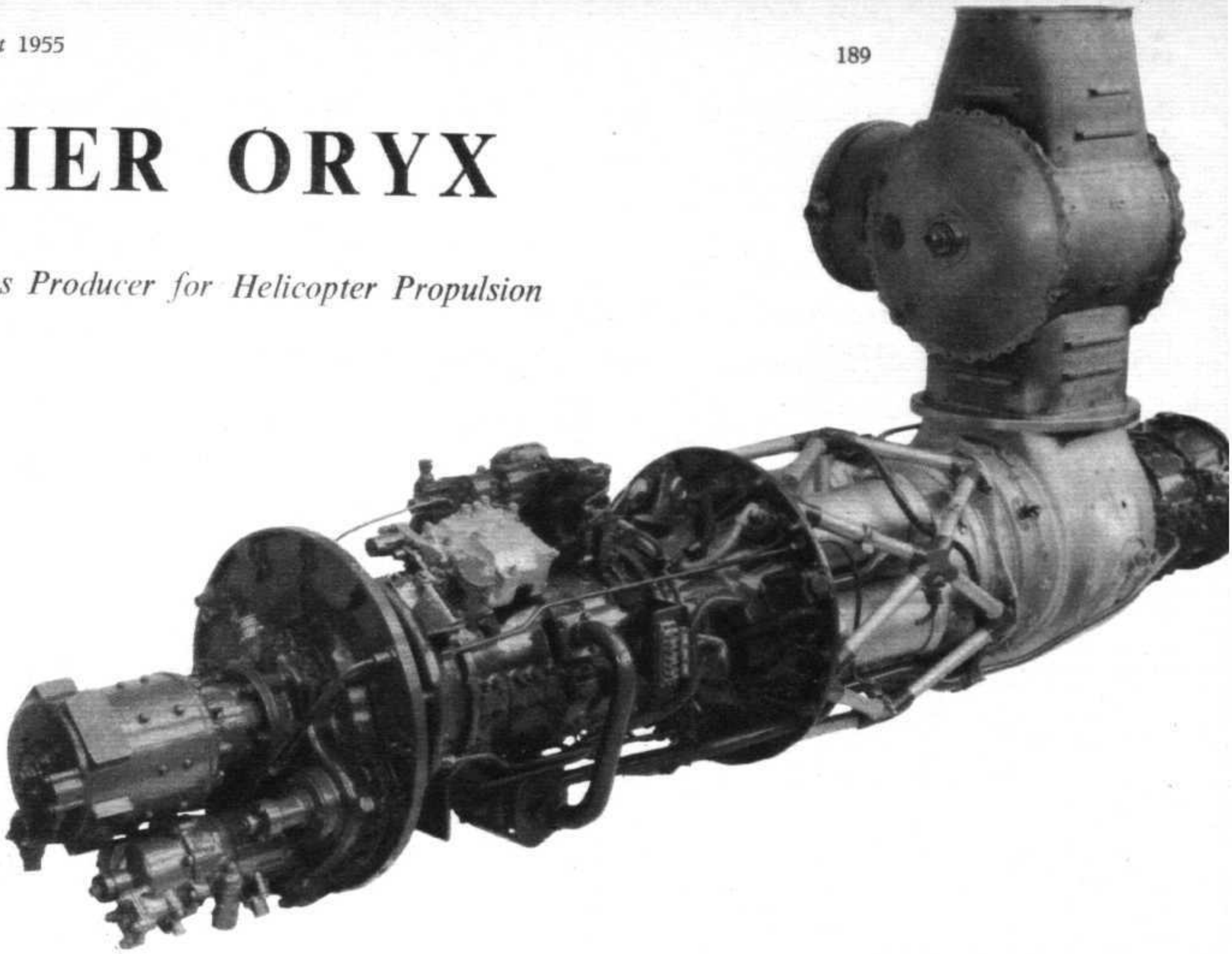
NAPIER ORYX

A Unique Gas Producer for Helicopter Propulsion



IT is now generally known that D. Napier and Son, Ltd., are paying particular attention to the propulsion requirements of rotary-wing aircraft. It is, in fact, the company's ultimate intention to market a range of engines suitable for installation in most types of helicopter; units producing shaft power and a gas delivery for tip jets are included in the programme. The engine now to be described is at present equipped solely for the latter function and it can therefore be described as unique in many respects.

The Oryx, which bears the Napier works number E.146, arose as a result of a helicopter project which was planned by Hunting Percival Aircraft, Ltd., early in 1951. Under their technical director, Mr. L. G. Frise, the latter company investigated the possibility of a single-rotor machine for which a tip-drive gas flow would be provided by a pair of small gas turbines. Reference to a curve of "power required" against forward speed for a helicopter shows that, at cruising speed, the power needed is no more than 70 per cent of that required for the hovering case at the same weight, so that, with two engines, flight could be continued even in the event of failure of one of them.

At that time the Aero Gas Turbine Division of Napiers (chief engineer, Mr. A. J. Penn) had already acquired a wide reputation for the development of high-quality small axial compressors and it was to this company that Hunting Percival turned for a small turbo gas-generator for the then-projected P.74 helicopter. A joint exploratory programme by both firms continued throughout 1951 in order to establish the design parameters.

Owing to limitations on the gauge of the material of the rotor gas-ducts, Napiers had to keep the delivery gas temperature below 400 deg C. Obviously, there were many possible arrangements for the engine, ranging from a simple turbojet (gas delivery from which would have been on the hot side) to a variety of by-pass engines. The first of the latter units to be investigated in detail would have employed an axial compressor with extended early stages of blading to provide the required flow of cool air which could later be mixed with the jet from the turbine discharge duct. It was found, however, that great difficulty attached to the efficient extraction of the by-pass flow through the shallow duct surrounding the main compressor—a problem which was aggravated by the small size of the engine.

It was accordingly decided to develop an engine with a separate auxiliary compressor handling atmospheric air for mixing with the main jet. Initially, a layout was studied in which the flow through this second compressor was in the same direction as that in the remainder of the engine, but such a layout inevitably called for bifurcated turbine exhaust ducts and auxiliary-compressor inlets. In order to keep the length of the engine within reasonable limits, a considerable compromise in duct efficiency had to be accepted and it was accordingly decided to turn the auxiliary compressor back to front, so that air could be drawn in at both ends of the engine and the mixture of cooling-air and hot gas drawn off between the auxiliary compressor and the turbine section. From this happy solution grew the present Oryx.

Development of the Oryx was carried out against a Ministry of Supply contract. By the end of 1951, the gas delivery and the layout and size of the engine were settled and actual detail design started early the following year. Scale effect has a profound influence on the best attainable efficiencies in an engine as small as this, and it seems to be a fair conclusion that, in the present state of the art, an axial gas turbine cannot be made significantly smaller than the Oryx without loss of efficiency throughout the engine.

As the illustrations indicate, the Oryx is an engine with a high "fineness ratio"—a logical outcome of its unusual number of major sections attached one after the other. This is, however, no handicap, for in the P.74 the two Oryx will occupy long and narrow engine bays outboard of the main fuselage keel members beneath the floor. Ram effect is usually of slight importance in helicopter installations and it was, therefore, decided to draw air through louvred side intakes into a plenum chamber surrounding the forward part of the engine. The air then enters the Oryx through a truly annular intake behind the engine-accessory drive-face (the accessory arrangement is described later), and so passes to the compressor. The intake (together with all other aerodynamic components) was flow-tested at the company's large research station at Liverpool to ensure good velocity distribution around the periphery. At the outset the large back-plate behind the accessories was not circular, and the change to this shape was made in order to smooth out the flow and obtain the required quality of distribution. The intake itself is cast in RZ5 magnesium-zirconium alloy.

The Oryx compressor is fitted with variable-incidence inlet guide vanes, basically similar to those employed on the Eland turboprop (*Flight*, July 23rd 1954). These vanes—which, like all the compressor blading throughout the engine, are made of aluminium-bronze alloy to specification D.T.D. 197A—sit on large-diameter circular platforms at their outer ends. These platforms act as pivots, a small pip on each platform locating in a socket in a circumferential actuating ring moved by a servo (again as in the Eland). Full details of the actuating system may not yet be published, but the guide-vane angle is responsive to actual engine speed.

Twelve stages of compression are used, the aerodynamics of the compressor being based on those of a Napier research unit which gave very satisfactory performance on test. Overall efficiency is highly creditable for a unit with an overall diameter of under nine inches. There is no central shaft; the 12 discs are through-bolted end to end by nine tie-rods which have push fits in appropriate holes through the periphery of each disc. By this means, the effective "shaft diameter" and hence rigidity, is made exceptionally large