Gas Turbine Problems

Dr. Roxbee Cox on Some of the Troubles Encountered in Jet Development and How Solutions Were Reached

THE subject of gas turbines is one of never-ending interest. In the whole history of flying there has been nothing comparable with this spectacular development, which promises to revolutionise many aspects of aviation, both military and civil. Last week we published certain sections from the Wright Brothers lecture delivered by Dr. Roxbee Cox to the American Institute of the Aeronautical Sciences on December 17th, in which were outlined some of the outstanding achievements of the British aircraft industry in this field. This week we deal with some aspects of development and research which have resulted in most of the initial problems being solved. Following are extracts from this section of Dr. Roxbee Cox's lecture.

Bearings were the source of a number of failures. Ball, roller and Michell bearings all had their adherents. It would be dangerous to suggest that a general solution was found, but success is associated with seating designed to withstand mounting distortions, with the correct (and considerable) diametral and axial slackness in ball bearings and limitation of bearing temperatures by careful cooling. The majority of designers incline to ball bearings, some preferring roller bearings at the turbine end of the shaft. Lubrication has proved less difficult than was expected in the early days, and solid lubrication, as distinct from lubrication with an atomised spray, with oil of relatively low viscosity, is the common practice.

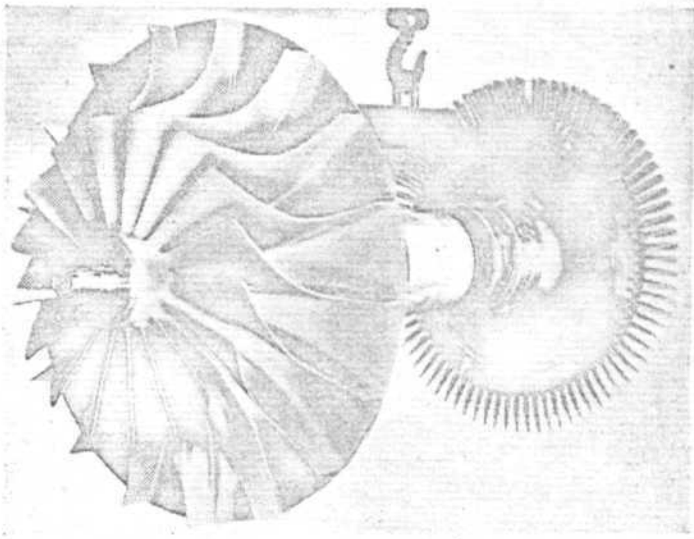
Sheet-metal Construction

All the engines so far have employed sheet metal construction for the bulk of the combustion system, and this sheet metal was at one time a prolific source of failures. These resulted from inadequate experience of resistance welding, from fatigue and fretting due to aerodynamic and mechanical buffeting, and from oxidation through contact with flame or distortion due to bad temperature distribution.

The first type of failure was eliminated by study of and experience in resistance welding, the correct choice of material, and careful attention to finish.

Fatigue and fretting failures have been eliminated by removal or diminution in the sources of vibration, by stiffening or other forms of redistribution of material, by the careful design of corners and junctions, and by locating components to allow freedom for expansion whilst retaining sufficiently accurate positioning. In certain designs, the problem of fretting has been dealt with by arranging small air gaps at the susceptible junctions; this has had no ill-effect on performance.

Failures from flame or poor heat distribution were common in the flame tubes of the early Whittle-type engines, but they have almost disappeared now that combustion chambers have been developed with no thin metal parts in the flame region, and the control of the fuel injection has been improved. The annular combustion chamber is still, however, subject to thermal distortions and cannot yet be regarded as satisfactory.



The rotor of the Halford H.1 engine, which used a single-sided impeller and a "straight-through" combustion system.

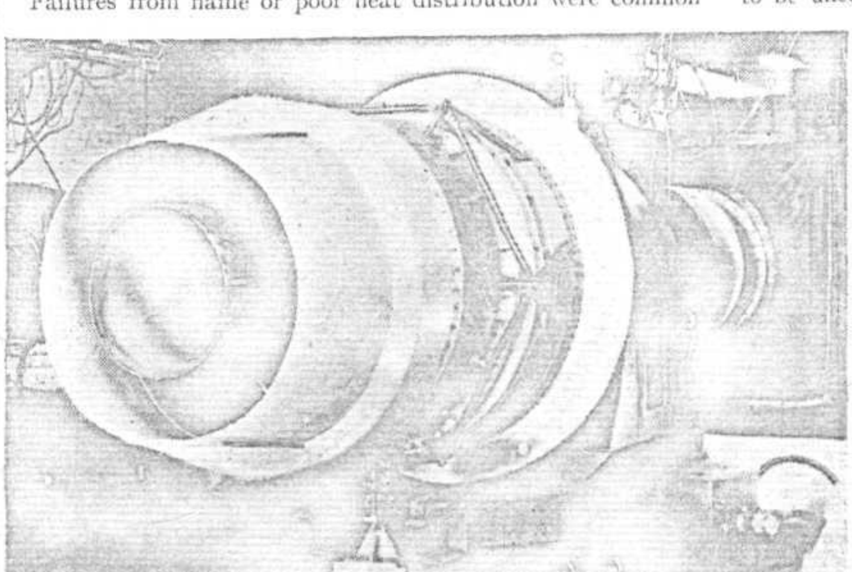
Sources of Impeller Failures

A serious crop of impeller failures was experienced as the engine ratings were increased. Investigation showed that in the early engines these had been avoided more by good fortune than by good judgment, as it was discovered that the failures were attributable to resonant vibrations excited by aerodynamic impulses from the diffusers. After much theoretical and empirical work, designs were evolved which proved to be satisfactory. From these, more precise data have been obtained and impellers can now be successfully designed with confidence. The achievement of a satisfactory impeller was delayed through pilots and test personnel instinctively avoiding the resonant frequencies because they found the corollary noise to be uncomfortable.

The development of the appropriate high-temperature steel for turbine blading at the Firth Laboratories under Dr. Hatfield was one of the major factors which made the aircraft gas turbine possible, and the development of the engine has been accompanied by developments in the materials of construction. At one time, turbine blade failures were unfortunately common. To-day, they are a rarity. Accuracy in manufacture, avoidance of small radii at root junctions, sound stressing methods, understanding of turbine vibration problems as well as improvements in material, have all played their parts in the elimination of failures.

The outstanding blading material developed for the British engines is Nimonic 80. This material was discovered by the Mond Nickel Company in 1940, soon after they had discovered Nimonic 75, which is particularly suitable for combustion parts. Nimonic 80, with its excellent creep and fatigue properties at the working temperature, is sufficiently easily forged at about 1,100 deg. C. to permit blade blanks to be stamped practically to finished size. It is now the standard material for turbine blading in British engines.

A number of failures of turbine discs and rims has been experienced, but now the likelihood of failures of this kind is small. This is due not only to improvements in the design of gas seals and the



The Metropolitan-Vickers F.3 ducted fan thrust augmenter, bench-testing of which has given most promising results.