

The Royal Aircraft Establishment and the jet engine

One hundred years ago RAE scientist Dr A A Griffith laid the foundation for the design of efficient gas turbines and the work he initiated at the RAE ultimately became realised in the aircraft engines that are commonplace today.

Dr Alan Arnold Griffith joined the Royal Aircraft Factory (RAE in 1918) in 1915. Following his celebrated work on determining the stress in materials using soap films and on crack propagation, his attention was directed to the design of gas turbines suitable for aircraft. From his studies he produced a seminal paper in 1926, "An aerodynamic theory of turbine design", which provided the foundation of compressor and turbine design for almost all subsequent gas turbines. Using a small turbo-compressor he successfully verified his theory in 1929. To fully exploit the potential of the gas turbine, Griffith began to develop the multi-stage axial compressor. From the beginning he pursued the gas turbine with a focus on efficiency and fuel economy. His vision was ultimately realised in the high by-pass turbofan engines common today. However, he was denied further funding, and at the same time, Frank Whittle was also denied funding.

Largely due to the advent of radar, the Air Ministry began to provide funding for aircraft gas turbine projects in 1937 with the expectation that it would eventually result in a high performance engine for a radar directed fighter. Thus the RAE received funding to continue its gas turbine work and the RAE's assessment of Whittle's jet engine project contributed to his company, Power Jets, also being funded.

Contrary to what some journalistic writers would have us believe, the RAE and Whittle's company Power Jets were not rivals. In contrast to Whittle's somewhat expedient approach to building a jet engine, the RAE was pursuing a longer-term approach. Griffith had realised that ultimately the axial compressor would be needed to deliver higher pressure ratios and greater mass flows as engine development progressed, as well as the advantages to be gained from an annular combustion chamber. Consequently, research was aimed at the more difficult task of developing these features, which are now common in modern aircraft gas turbines.

Furthermore, the RAE also realised that the basic jet engine would evolve into the high by-pass turbofan as the need for economy in commercial operations would become paramount. In 1970, some 30 years after Griffith's first high by-pass turbofan schemes, such engines were introduced into commercial service and have since remained the dominant form of civil aircraft engine; surely a manifestation of Griffith's foresight.

In 1938 Griffith was promoted Head of the RAE's Engine Department but his administrative duties inevitably detracted from his theoretical work and the following year he was persuaded to join Rolls-Royce where he continued to develop his innovative ideas. Jet engine work at the RAE was continued under Hayne Constant who had worked with Griffith and became influenced by his ideas. As the RAE did not have suitable facilities to produce gas turbines, it collaborated with Metropolitan-Vickers (Metrovick) for the manufacture and further development of RAE designs and this resulted in several advanced engines. The relation between the RAE and Metropolitan-Vickers was always amicable and their engine projects progressed smoothly; this is in contrast to the drama and recriminations associated with Whittle's involvement with other companies.

Since Metropolitan-Vickers was not an aircraft engine company, in 1948 its work in this field was transferred to Armstrong Siddeley, although the Company went on to pioneer industrial, marine and locomotive applications of the gas turbine.

In addition to its own collaborative work with Metropolitan-Vickers, the RAE provided assistance and technical personnel to Whittle's company Power Jets and helped Frank Halford at de Havilland with the aerodynamic design of the highly successful Goblin turbojet. An axial compressor originating from the RAE featured in Armstrong Siddeley's first aircraft gas turbine that was developed into the Python, which was the first turboprop put into production. The RAE/Metropolitan-Vickers F2 axial compressor design was incorporated in Rolls-Royce's first purpose-built turboprop, the R-R Clyde.

The line of engine development originating from the RAE was completely separate from the work of Frank Whittle and by the late 1940s it had superseded his work. Subsequent events have shown that, despite all the credit and publicity given to Whittle, it has been the approach to aircraft gas turbines pursued by the RAE that has come to dominate aero gas turbine design and development, not only in Britain but worldwide; clearly a testimony to Griffith's and Constant's forward thinking.

With the formation of the National Gas Turbine Establishment (NGTE) in 1946 the RAE ceased its involvement with gas turbines. Hayne Constant was Director of the NGTE in its formative years between 1948 and 1960.

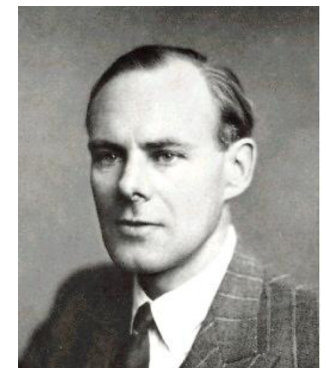
The RAE's two pioneers of the aircraft gas turbine



Dr. A A Griffith

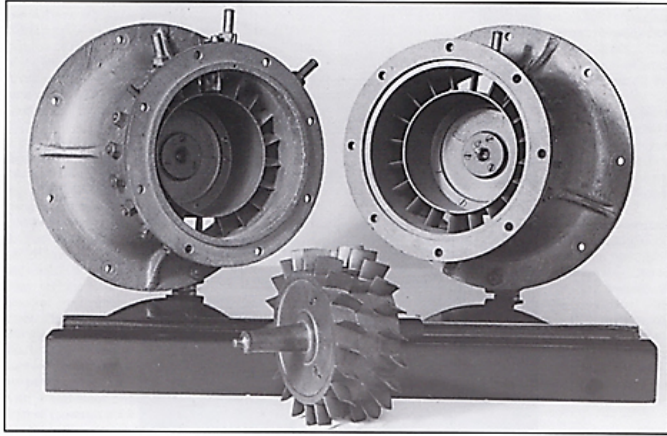
Dr Alan Arnold Griffith (1893 – 1963) was the first to establish the theory which enabled successful axial gas turbines to be built and schemed efficient high by-pass turbofans decades before they became a reality. Later, as Chief Scientist at Rolls-Royce, his system of control by jet reaction made possible vertical take-off and landing (VTOL) aircraft.

Hayne Constant (1904 – 1968) was influenced by Griffith and led the RAE's collaboration with Metropolitan-Vickers, which resulted in a series of advanced engines that pioneered the form aircraft gas turbines would eventually take. He became Director of the NGTE and later a Scientific Advisor to the Air Ministry and Ministry of Defence.



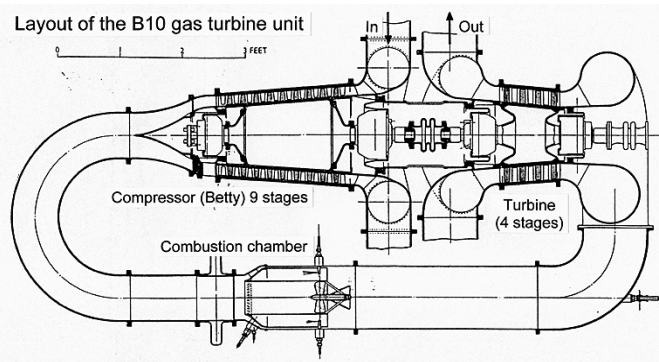
Hayne Constant

The first axial compressor experiments



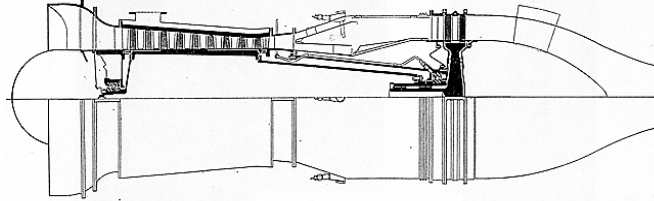
The turbo-compressor rig tested in 1929. The single stage compressor and turbine rotor is shown in the centre, flanked by its casing having inlet and exit guide vanes. The rig was tested by sucking air through it.

The RAE's first gas turbine, the B10

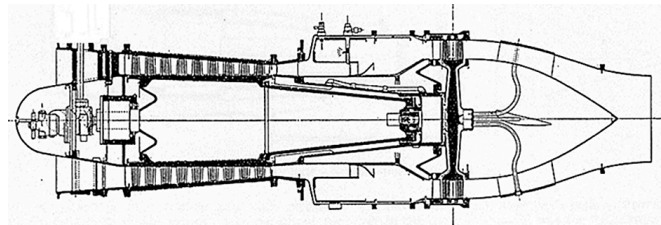


The B10 turbine, built by Metropolitan-Vickers, was a demonstrator unit initially tested in separate parts. It was run successfully as a complete unit in October 1940 and proved invaluable for subsequent gas turbine work.

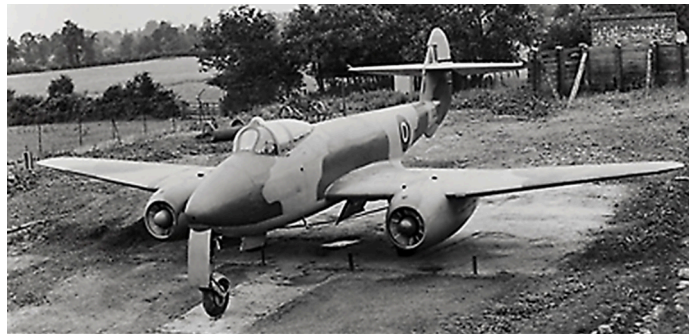
Britain's first axial jet engine



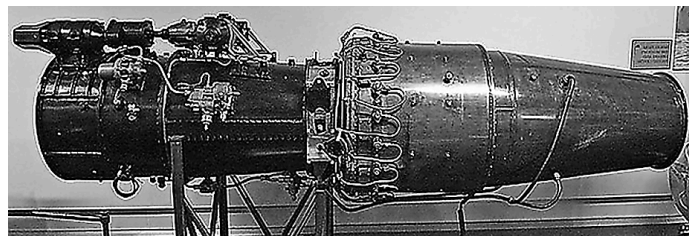
The RAE jet engine design F1A of 1940 that was developed into the Metropolitan-Vickers F2/1.



The Metropolitan-Vickers F2/1 which first ran in 1941



A Gloster F9/40 Meteor experimental prototype (DG204) fitted with two F2/1 engines. It first flew on 13 November 1943.



An F2/1 engine for flight tests in the Gloster F9/40 Meteor prototype.



**The Royal Aircraft
Establishment
and the jet
engine**

www.airsciences.org.uk

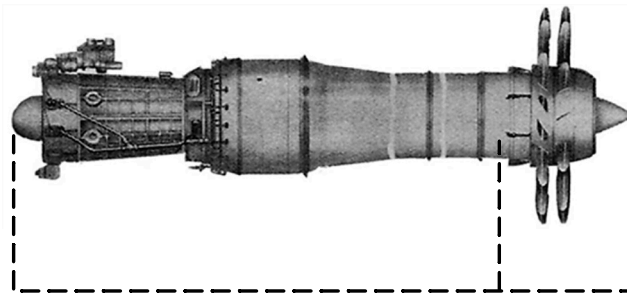
Telephone 01252 375050



The Saunders-Roe SRIA1 jet fighter flying boat was powered by two Metrovick F214 Beryl engines and first flew on 16 July 1947.

Influenced by early RAE schemes, Metropolitan-Vickers adapted the F2/4 engine, by adding a power turbine, to pioneer gas turbines for marine and locomotive use.

The Metropolitan-Vickers F5 unducted fan engine



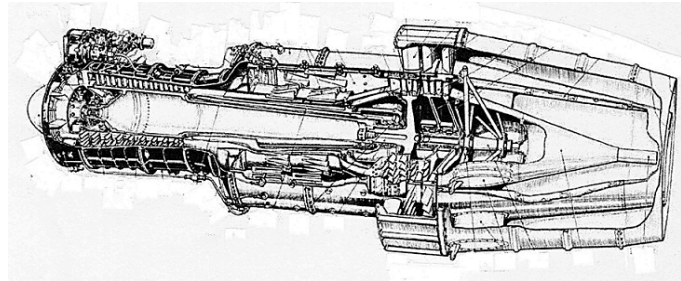
Metrovick F2/4 turbojet with extended jet pipe

Unducted fan

First run in 1945, the F5 basically consisted of a standard F2/4 engine with an extended jet pipe to which was attached a contra-rotating pusher fan unit. This was driven by the exhaust gas from the turbojet via a four-stage turbine to which the fan blades were attached. The F5 gave a total takeoff thrust of 4710 lb (20.95 kN). Compared with the basic turbojet the unducted fan engine gives a much better fuel consumption over flight speeds up to about 500 mph (800 kmh).

Like the F3, the F5 was intended primarily for use in civil aviation but the Government considered that there was no immediate post-war need for such engines and consequently no funding was forthcoming for their further development.

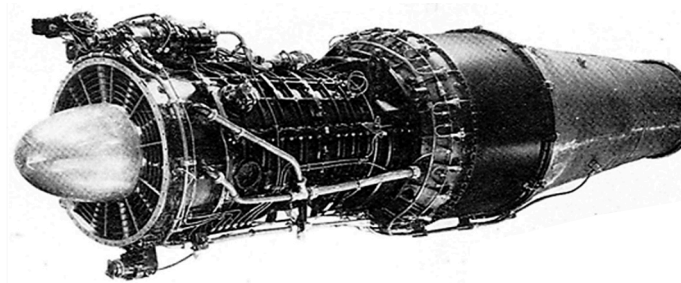
The Metropolitan-Vickers F3 aft-fan



Following experimental work on ducted fans at the RAE, Metropolitan-Vickers produced the first successful turbofan, the F3. It was basically an F2/1 engine with an independent turbine-driven ducted-fan at the rear, the aft-fan originally being called a thrust augments.

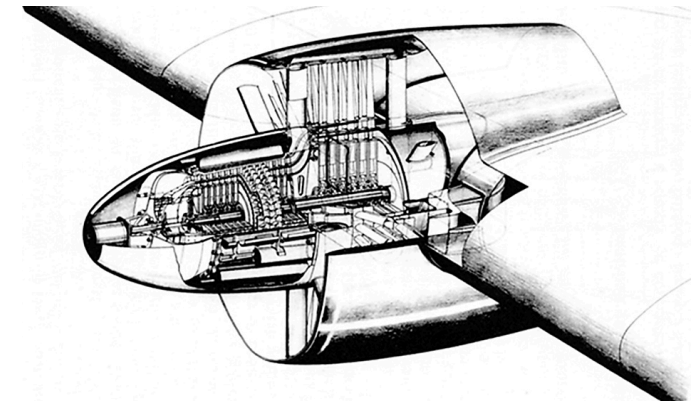
The F3 first ran in August 1943 and was developed to deliver a thrust of 4000 lb (17.8 kN); this resulted in a gain in thrust to weight ratio over the F2/1 of 25%. A substantial reduction in fuel consumption was achieved as well as a significant reduction in noise.

The Metropolitan-Vickers F2/4 Beryl turbojet



The Metrovick F24, which first ran in January 1945, had a 10 stage axial compressor, an annular combustion chamber and a single stage turbine. Its thrust was developed from 3250 lb (14.46 kN) to 3850 lb (17.12 kN).

One of Griffith's high by-pass turbofan schemes of 1940 prepared while he was at Rolls-Royce



A turbofan with a by-pass ratio of 7 to 1 shown installed on an aircraft wing. The scheme is based on an engine core featuring Griffith's contra-rotating, contra-flow arrangement of compressor and turbine, which he devised to counter the difficulties of varying operating conditions. The core of such an engine was tested in 1942 but proved to be beyond the technology of the day and was not developed further.

Suggested further reading:

"The evolution of British Jet engines 1926 - 1966"
by Bill Howard

Available from the FAST museum, Trenchard House,
85 Farnborough Road, Farnborough, Hants.

See Web Site for further details on the museum www.airsciences.org.uk

Tel: 01252 375050

email: secretary@airsciences.org.uk

Office manned: Tue, Thu, Sat, Sun and

Bank Holiday Mondays from 10am to 4pm

Registered Charity No. 1040199

The lineage of early British jet engines

Bill Howard 2025

Axial compressor engine development

Centrifugal compressor engine development

