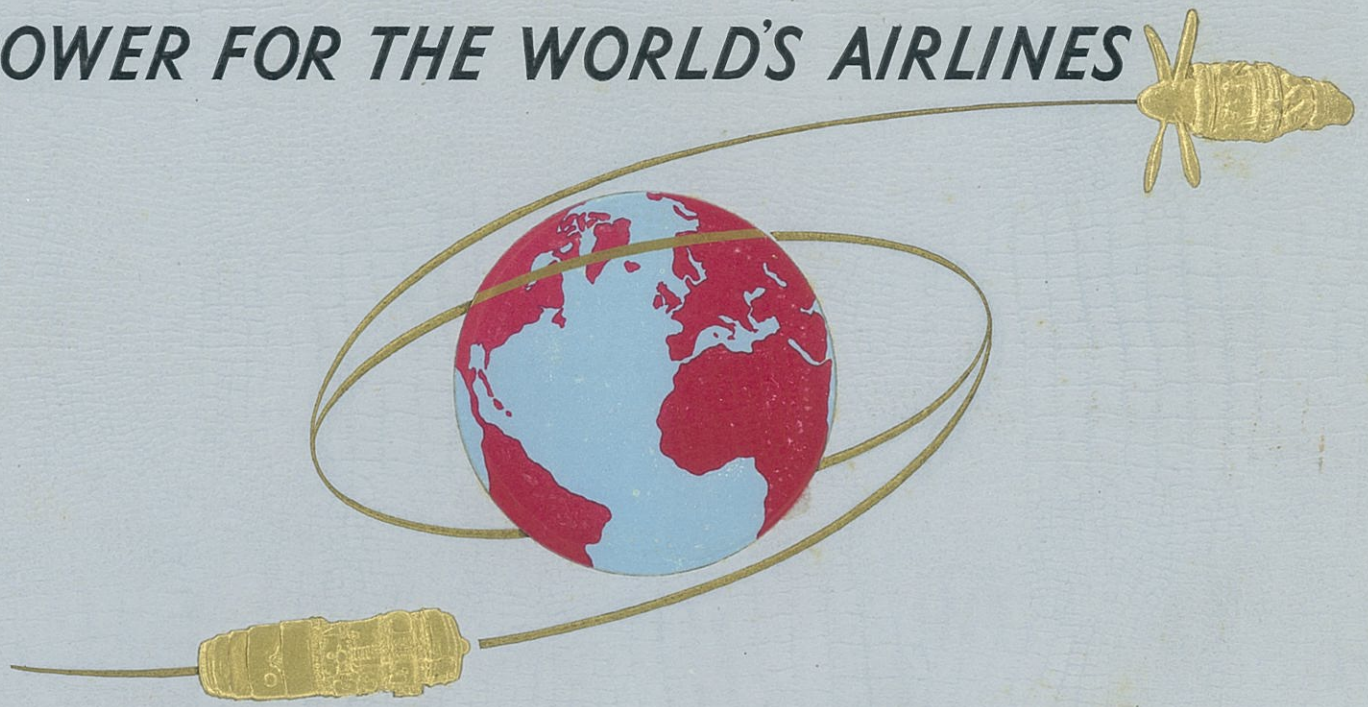
POWER FOR THE WORLD'S AIRLINES



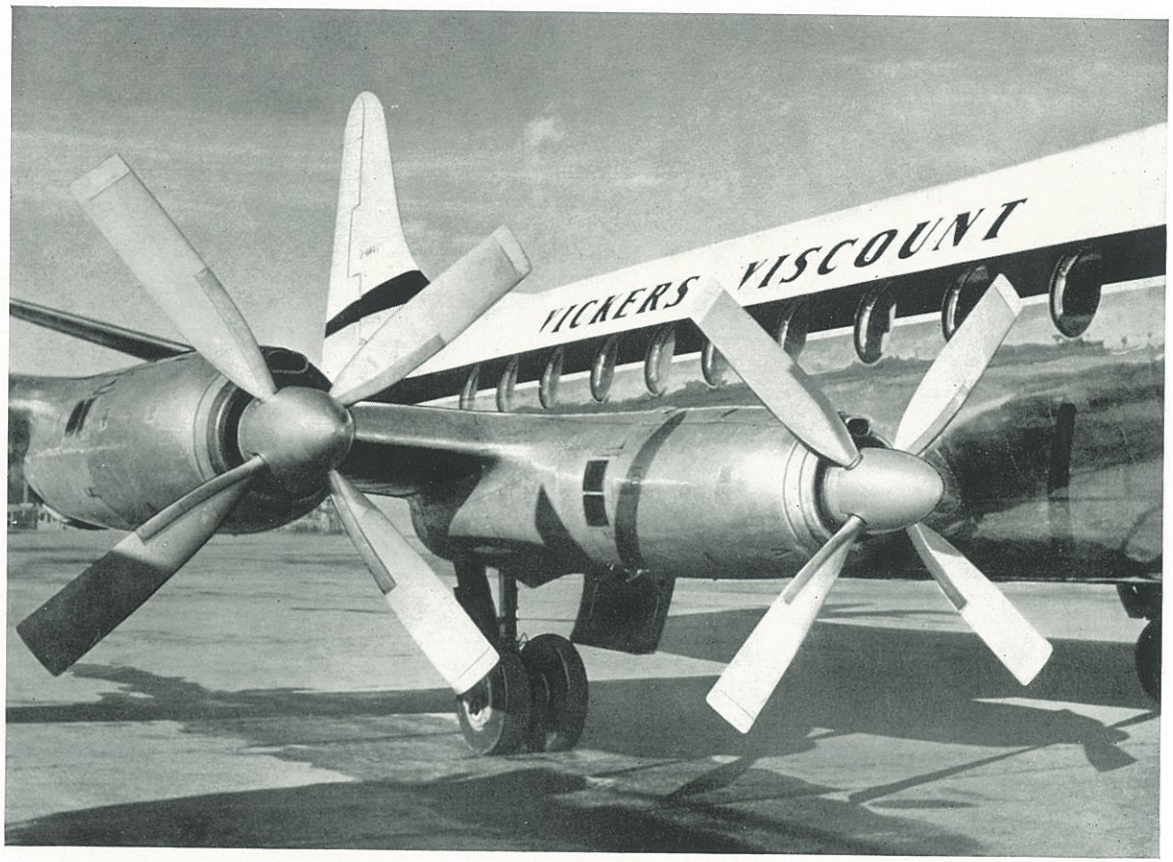
POWER FOR THE WORLD'S AIRLINES

An account of Rolls-Royce achievements in providing the engines for civil aircraft operators

by

MAJOR OLIVER STEWART, M.C., A.F.C.

ROLLS-ROYCE LIMITED · DERBY · ENGLAND



Rolls-Royce Dart engines for the World's Airlines

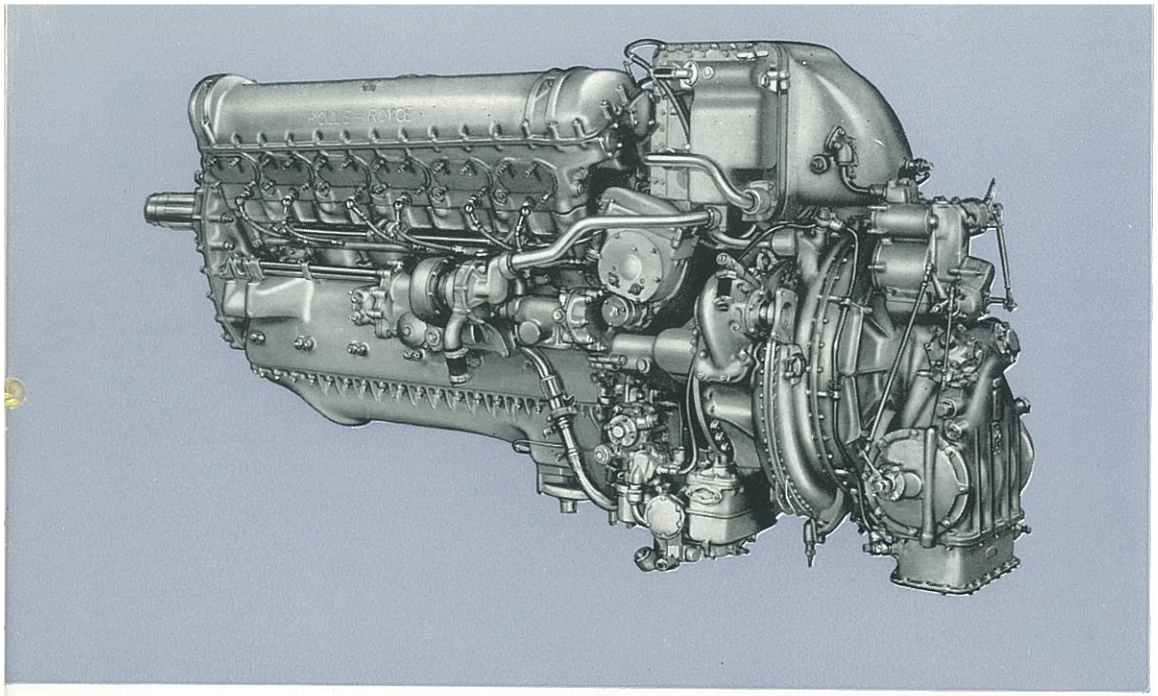
The de Havilland Comet powered by Avon engines

POWER FOR THE WORLD'S AIRLINES

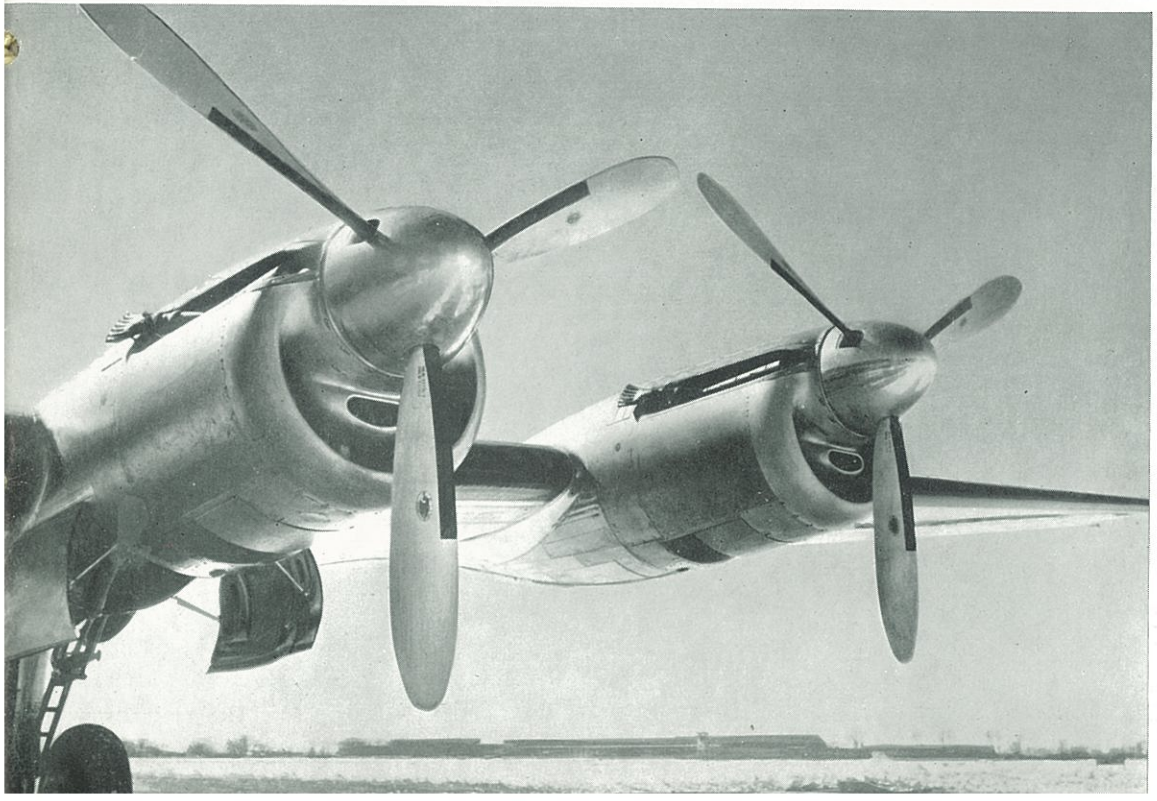
FOUR distinct and different aero engines for civil aircraft have been created by the Rolls-Royce Company and are available for sale throughout the world. They are the Dart, the Tyne, the Avon and the Conway. Their development, whether with or without military background, has been pointed at civil aircraft and they will all be certified under United States and British conditions. They offer, for this decade of air transport, a wider selection than can be found elsewhere. They are a measure of the progress made since design work started on the civil version of the Rolls-Royce Merlin more than twelve years ago.

At that time the Rolls-Royce Company enjoyed a rich military inheritance, but it had no direct experience in the manufacture and development of civil aero engines. In two world wars it had lavished its technical and industrial resources upon engines which were basically different from those favoured by airline operators, but, by an absolute concentration upon the new problems, the company succeeded in solving them in a short space of time and in becoming the producer of the first turboprop power unit to go into general employment with the leading air transport companies. It is the Dart.

The Vickers Vanguard powered by Tyne engines



The two-stage, two-speed civil Merlin engine



The Starting Point

In July 1945, the civil transport version of the Merlin made its formal entry into the world, for on that date it successfully completed the British Air Registration Board's newly formulated civil aero engine test. The Series 620 Merlin may fairly be described as the first specifically civil transport aero engine made by Rolls-Royce. It was a two-speed, two-stage, supercharged unit with means of controlling more precisely charge temperature and with fuel injection.

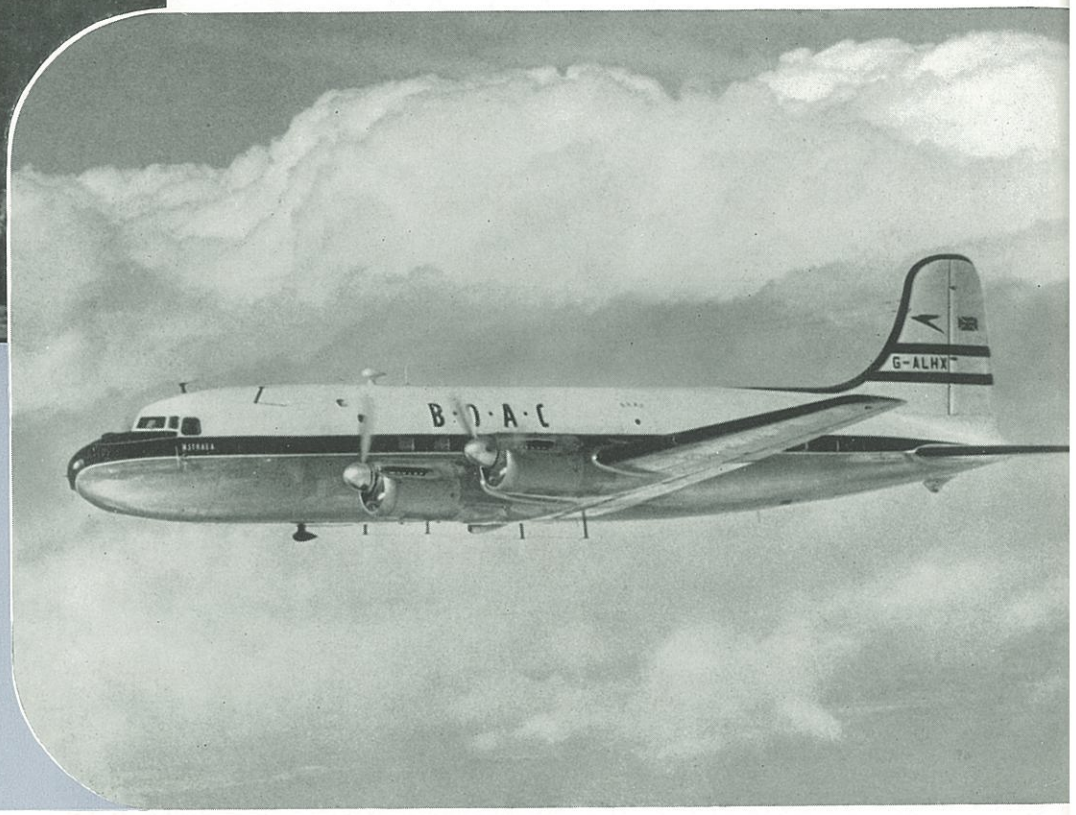
When it settled down to a period of extended operation it came under continuous supervision and development. It established the sequence, now paralleled in the four gas turbines, of mounting power and improving economy. A 27.3 litre engine, the Merlin had started at under 1,000 horse power and had reached 2,000 on military service.

As engine-miles rose on civil transport service it became possible to obtain the information upon which civil development could be continued. In 1946 eight million aircraft-miles were flown by Merlin-engined machines and in 1948, the figure rose to 25 million aircraft-miles, all on scheduled services. In addition there were charter operations with Merlin-engined aircraft, bringing the total for 1948 to 40 million aircraft-miles.

An aircraft now appears on the scene which has borne and is bearing a large load in the transport operations of the world. It goes under three names, according to the operator. Its airframe originated as the American Douglas DC-4. Built in Canada and fitted with Rolls-Royce Merlin engines, this aircraft is known as the Canadair Four to its Canadian manufacturers, the Argonaut to the British Overseas Airways Corporation, and the North Star to Trans-Canada Air Lines. With Merlin 620 engines, it first flew on the 12 July, 1946.

The Merlin power plants relied upon for so many years by B.O.A.C. and T.C.A.

The first orders came from the Royal Canadian Air Force, but the aircraft were switched to Trans-Canada Air Lines. The British Overseas Airways Corporation and Canadian Pacific Airlines placed orders. At the time when the Canadair Four was being brought into airline operation, a number of other Merlin-engined aircraft were in service, including the Avro York and Tudor.



Trans-Canada Air Lines North Star, British Overseas Airways Argonaut, both powered by the Merlin

The Pattern of Continuing Responsibility

In 1947, to ensure that Canadian customers, and, in particular, Trans-Canada Air Lines, received all the technical assistance needed, Rolls-Royce Montreal Limited, was formed as a subsidiary company. This was established at Dorval Airport and consisted of a large stores and a technical office. A Rolls-Royce engineer from Derby represented the Technical Service Department and a senior engineer supervised the field service and the repair engineers in Canada. In 1952 this company was superseded by Rolls-Royce of Canada Limited.

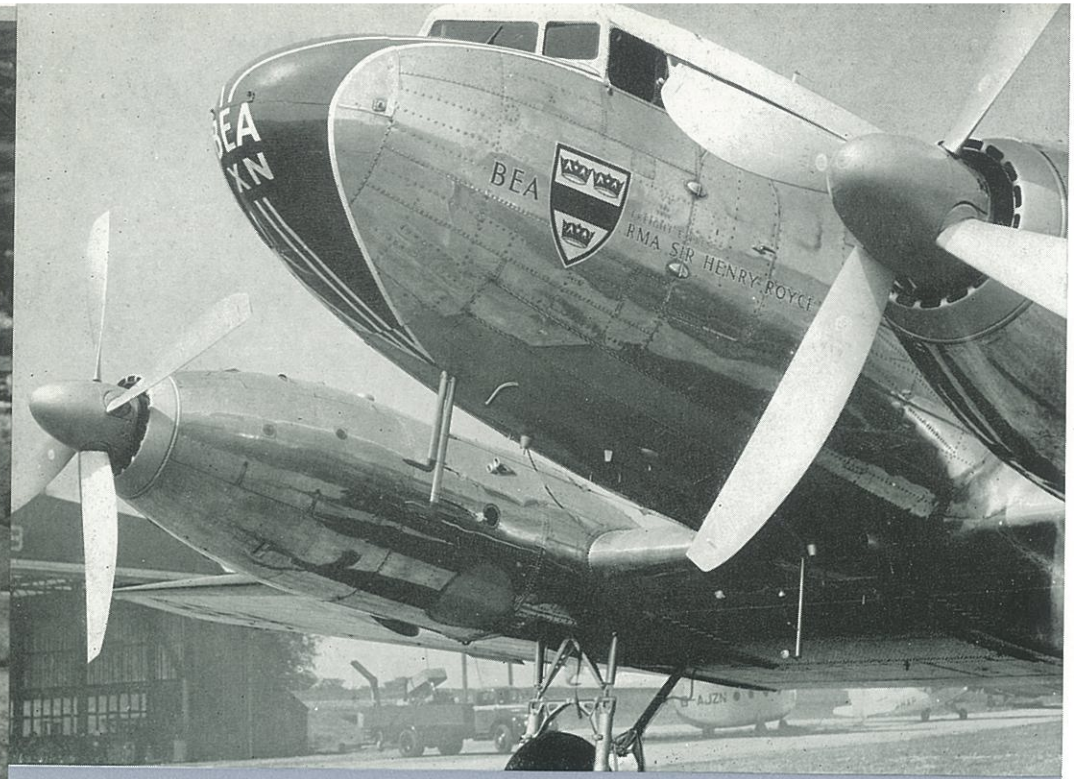
By these and other means Rolls-Royce Limited was gradually imposing upon civil aviation a pattern of service which it had originated in its dealings with motor cars and which it had continued in its military aviation activities. It was the pattern of continuing responsibility.

T.C.A.'s Merlin powered North Star greets T.C.A.'s Dart powered Vickers Viscount over Montreal

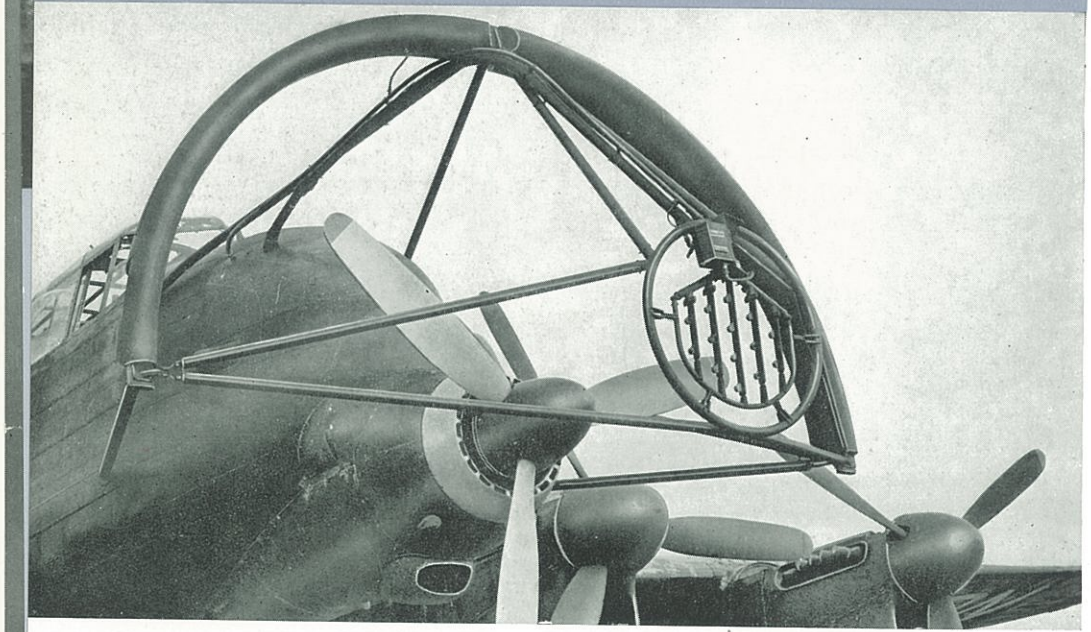
A famous Military Transport, the Avro York, powered by four Merlin engines

Merlin overhaul life was improved at the same time as power output. It rose from 400 hours to 1,000 hours, and the horse power was increased to 1,760. So far as Rolls-Royce Limited was concerned, the company's objective was fixed and invariable: it was to satisfy the user and to give him all possible assistance, without delay and without argument. The whole knowledge and experience of the company were thrown into the support of Trans-Canada Air Lines with the result that a link was forged between manufacturer and operator.

In the present era of the gas turbine, to which we shall now turn our attention, that link has become stronger even than it was in the pioneering period of the piston engine.



B.E.A. Dakota freight carrier fitted with Dart engines



De-icing test rig

THE GAS TURBINE

Rolls-Royce had first taken an interest in jet propulsion in 1938 and had done a number of theoretical and practical studies of gas turbines for aircraft. In 1941 the manufacture of a Whittle type engine was begun; but this work was specifically directed at military needs. In 1943 a propeller turbine was built, the Trent, and in September 1945, two of these units were mounted in a Meteor. They were the first propeller turbines in the world to fly.

While development of the Trent was proceeding, work began on a larger propeller turbine, the Clyde. Rated at over 4,000 horse power, it was the first high-powered propeller turbine to obtain approval for civil operation. Its design was begun in 1943 and, before it was abandoned, in 1949, because of the lack of any suitable aircraft for it, it had completed 3,300 bench and flight hours.

Concurrently with the design work on the Clyde went the design work on a small, centrifugal compressor turboprop, intended to give 1,000 horse power. It ran for the first time in July 1946. This is the engine now known to the airline services of five continents as the Rolls-Royce Dart.

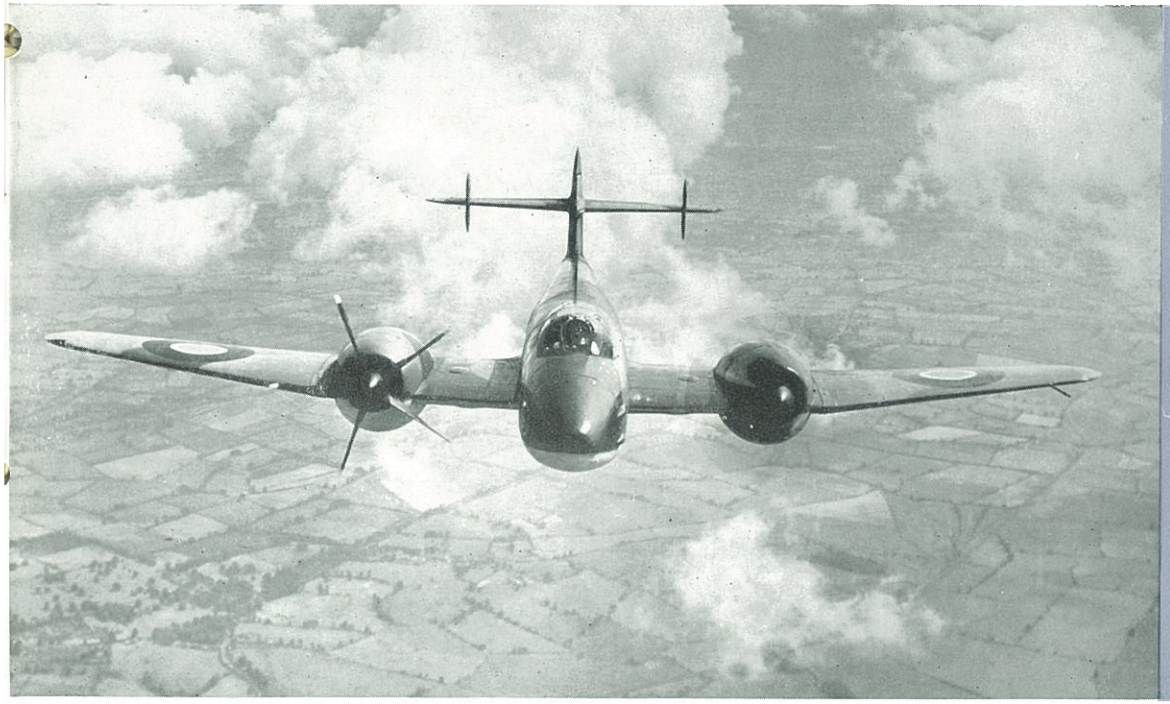
It began airline operations in Vickers Viscount aircraft at 1,400 take off shaft horse power. In various developed forms it is now used in the Viscount series 700 and 800, and its power has been progressively increased together with its overhaul life. It is specified for the Fokker Friendship and for the United States built Fairchild Friendship. The Aviation Traders Accountant will also be powered by the Dart. The Trent, the Clyde and the Dart were thus representative of the opening phase of Rolls-Royce's propeller turbine activities. But these activities were, inevitably, linked with progress with straight jet engines.

The beginning of the transition from piston engine to gas turbine had a significance greater than that of any previous advance in the prime movers used for flight. At every stage

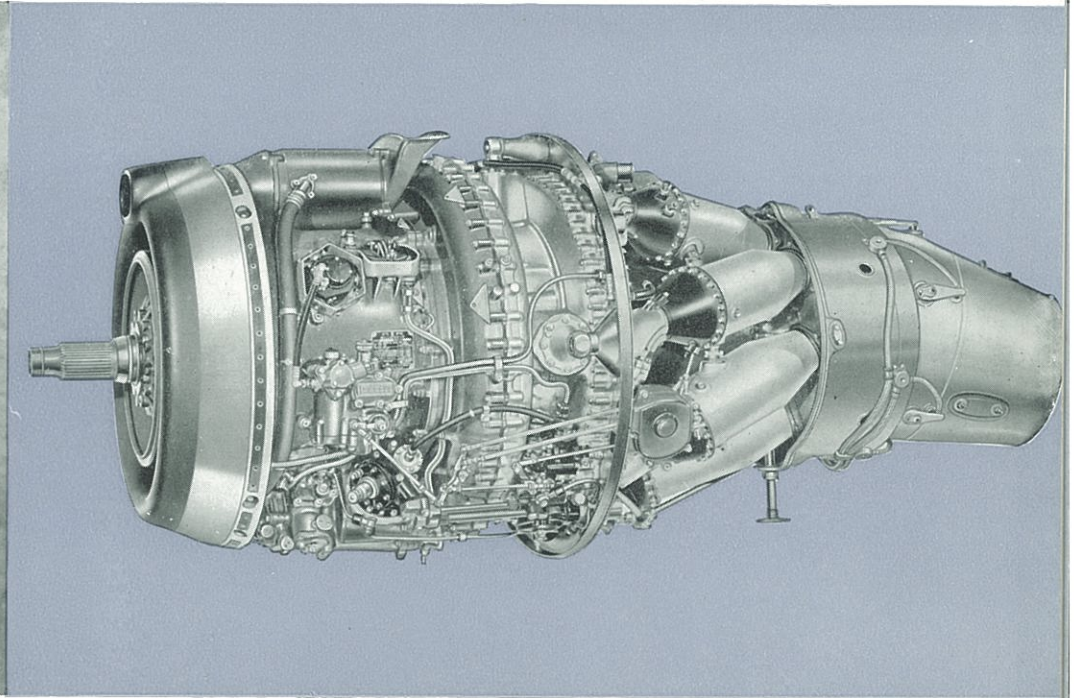
in the augmentation of power and the extension of overhaul life of turbines intended for military use, their potentialities for civil aviation became more evident.

We may select three events as preliminaries to the first attempts to use gas turbines in passenger-carrying aircraft: the type test of a Rolls-Royce turbojet in April, 1943, the 500 hour test and 180 hour overhaul period of 1944 and the first turbojet world speed record of 1945. The implications were clear enough and, in the following year, 1946, Rolls-Royce fitted an Avro Lancastrian with two Nene turbojets in the place of the outboard Merlins. This was an experiment; but it was an experiment whose purpose was plain from the outset.

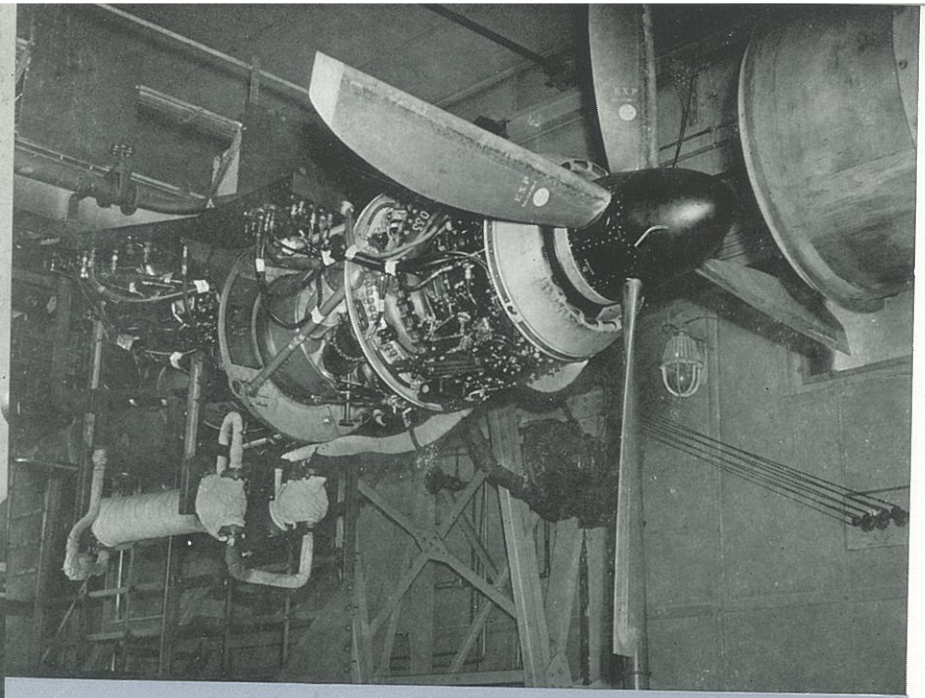
The first prototype Vickers Viscount flying with two engines feathered



The first propeller turbine aircraft in the world to fly—The Trent Meteor



The first propeller turbine engine in airline service in the world—The Rolls-Royce Dart



1949, *an early 500 hour type-test of the Dart engine*

Dart Development

The Nene Lancastrian was followed by a gas turbine engined aircraft designed from the outset as a standard commercial transport vehicle. Powered by four Rolls-Royce Dart propeller turbines, the Vickers Viscount made its maiden flight from Wisley aerodrome, in southern England, in July, 1948. The developed version made its maiden flight in August, 1950 and the production version followed it two years later.

British European Airways put the Viscount on the regular London-Paris and London-Edinburgh services in July, 1950 and so operated the first turbine-engined, scheduled passenger flights in history. By April, 1953 the Corporation had 26 Viscount V701's in service and by 1960 it expects to have

The Viscount 700 which has made airline history

a total fleet of 83 Viscounts. In 1960-61 the Rolls-Royce Tyne engined Vickers Vanguard will come into service.

By the summer of 1956 thirty-three airline operators in different countries of the British Commonwealth and other parts of the world had placed orders for 342 Viscounts, and Rolls-Royce Dart engines had completed more than one million hours in air line service. Among the Dart operators is Capital Airlines, the United States company which successfully pioneered the turbine-engined passenger aircraft on the United States domestic routes.

As the Viscount was attracting more attention, so the Dart engine was responding to development with the result that the engines delivered to airline operators were often an advance in power and overhaul life upon those ordered. Thus the Dart's 150 hours test of January, 1948, was at 1,200 shaft horse power; but, by May of the same year, a similar test was completed at 1,400 shaft horse power. The Ministry of Supply's 500 hours endurance test was done in March, 1949,

The Vickers Viscount. The first propeller turbine airliner in the world to go on schedule service

One of B.E.A.'s fleet which introduced the Viscount to the world

and, in 1950, the full Certificate of Airworthiness was granted to the Dart-engined Viscount.

The 1,400 shp Dart for the first production Viscount was the 505 series. The 506 Dart permitted increased power to be used for the climb and offered an improvement in fuel consumption, while the 510, in full series production, gives 1,600 horse power for take-off with still further improved specific fuel consumption and, as a consequence of changes in the reduction gear ratio, a lower noise level.

Basically the Mark 520 and 525 Darts (the R.Da.7 and R.Da.7/1) are the same as the 510, but they have three-stage turbines and the increased power which goes with increased mass flow. At the same time their specific fuel consumption is diminished as a consequence of improvements in component efficiency. The Total Equivalent Horse Power given by the 525 at take-off is 1,992 (1,800 shaft horse power). Cruising at 20,000 ft. and 345 miles an hour the engine gives

Air France

1,325 tehp and the specific fuel consumption in pounds/to the tehp/to the hour is 0.57. The 520 and the 525 are derated engines. A fully rated version, the R.Da.7/2, for which production is planned in the late 1950s, will give 2100 tehp at take off.

Still higher powers and lower specific fuel consumptions will be offered by the R.Da.7's successor, the R.Da.10. Component testing for this engine is in progress and an increase of 23% in power and a diminution of 3% in specific fuel consumption are expected at a take-off power of 2,500 tehp.

This engine will give the Viscount V840 a cruising speed of 400 miles an hour. As the engine will maintain take-off power up to 25 degrees C. above International Standard Atmosphere at sea level, water methanol will no longer be needed.

Dart Applications

The procedure which sustained the Merlin during the formative years and which still sustains it, is being followed and amplified in the Dart and the other gas turbines. But there is now a much wider experience of civil aviation and there are technical, maintenance and advisory services much more precisely adapted to present operating requirements. The policy of continuing responsibility, however, remains exactly as it was when the Rolls-Royce company was first formed.

Aer Lingus

While the Dart was on the initial steps of its performance climb a variety of opinions was being expressed about propeller turbines for civil aircraft. It is accurate to say that the Dart's success coincided in time with the swing of operating opinion in favour of turbines and that the Dart was responsible for that swing. It had shown itself as amenable to development as any reciprocating engine and it had suggested greater potentialities.

The success of the Dart in the Vickers Viscount has induced other aircraft manufacturers to specify it for their new designs. The Fokker Friendship, a twin-engined, high-wing, medium range transport, is powered by Darts as is its United States counterpart, the Fairchild Friendship. Eight operators have placed orders for the Dart-engined Friendship which made its first flight in 1955. Delivery dates are from 1957. The aircraft can be fitted as an executive transport or as a

Trans-Australia Airlines

The first Trans-Canada Air Lines Viscount leaving for North America

British West Indian Airways

Cubana

tributary transport seating up to 40 passengers and cruising at 280 miles an hour. The normal stage length is 300 miles and the aircraft's range is 2,250 miles. The Mark 511 Dart, specified for the Friendship, is the same as the 510 apart from installation details.

The Aviation Traders Accountant is also a twin-engined medium transport for which Rolls-Royce Dart propeller turbines are specified. This is a low wing monoplane embodying a novel form of construction. Before we turn to the other Rolls-Royce gas turbine engines now offered for civil aircraft, we will tabulate the air line operators who, up to the summer of 1956, had placed orders for Dart-engined aircraft. If all aircraft for delivery up to 1959 are included they are:

The first Viscount with Dart 510's, Capital Airlines

Central African Airways

VISCOUNT

Aer Lingus
Air France
British Overseas Airways Corporation
British West Indian Airways
Capital Airlines
Continental Air Lines
Deutsche Lufthansa
Hunting Clan
Iranian Airlines
K.L.M.
Middle East Airlines
Misrair
Olsen
South African Airways
Trans-Australia Airlines
Union of Burma Airways
Air Austria
British European Airways
Braathens
Butler Air Transport
Central African Airways
Cubana
Hong Kong Airways
Indian Airlines
Iraqi Airways
L.A.V. (Venezuela)
New Zealand National Airways
Philippine Air Lines
Transair
Trans-Canada Airlines
Pakistan International Airlines
Linee Aeree Italiane

FRIENDSHIP

Aer Lingus
Bonanza Airlines
Frontier Airlines
K.L.M. Airlines
Mackey Airlines
Trans-Australia Airlines
West Coast Airlines
Piedmont Airlines

These figures are representative of the Dart's achievement. We now turn to another Rolls-Royce propeller turbine, the Tyne.

Trans-Canada Air Lines

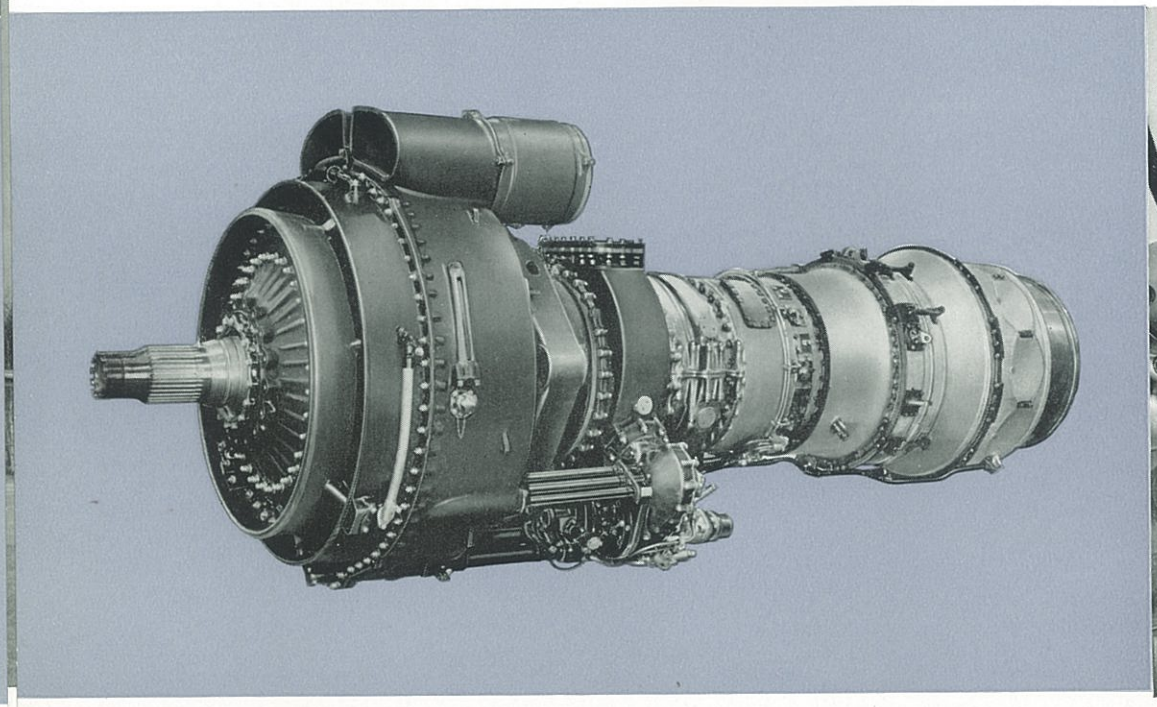
Misrair

The Tyne

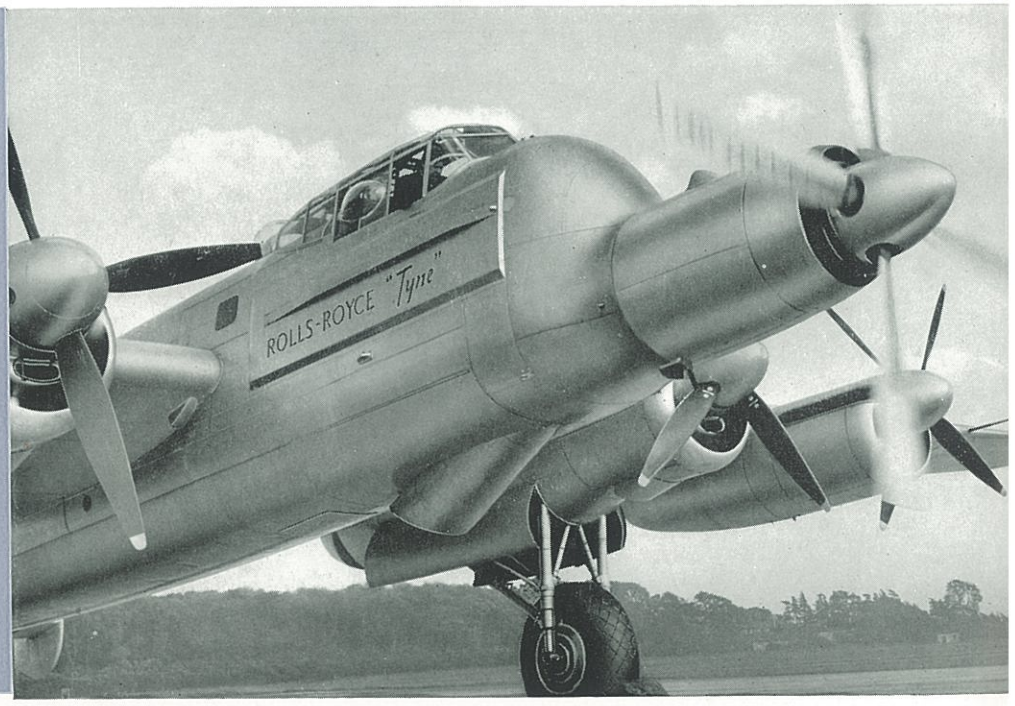
Beginning in April 1959 and overlapping deliveries of the later versions of the Dart, production deliveries will be made of the RB.109 Tyne propeller turbine. It is a projection of the Dart into a higher power bracket. Three distinct stages of development are at present envisaged. In the first the Total Equivalent Horse Power will be 4,470; in the second it will be 5,075 and, in the third, 5,500. The stage 2 engine will incorporate an improved turbine disc cooling system and improved turbine blade materials, while the stage 3 engine will have improved high pressure turbine blade cooling. Stage 1 engines will be convertible to stage 2.

The Tyne is a two-shaft engine with axial compressors and it expresses in its general conception the latest design thought. The high compression ratio of 13:1 is of assistance in giving a specific fuel consumption figure better even than that of the fully developed Dart.

Design of the Tyne was begun in June 1953 and the engine was first run in April 1955. Within a year it had completed a 150 hour type test scheduled at design flame temperature. The first aircraft designed to use the Tyne is the Vickers Vanguard. In the standard version it will seat 93 passengers and in the high density version 115. Its calculated cruising speed will be over 400 miles an hour. Another aircraft which is offered with the Tyne engine is the Lockheed Electra. The Lockheed company has ordered two Tynes for evaluation.



The Tyne propeller turbine



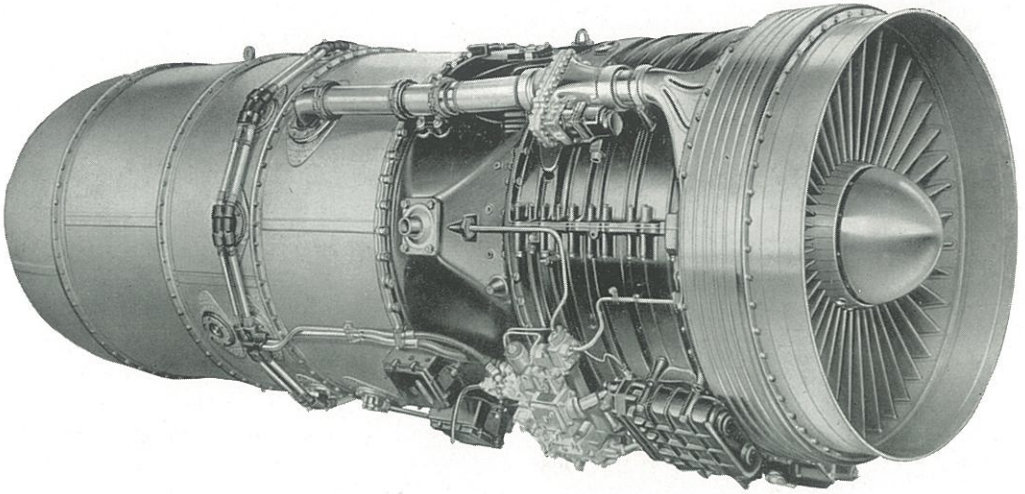
The Lincoln flying test bed with the Tyne in the nose

The Conway

In broad and general terms the by-pass engine may be described as an intermediary between the plain turbo-jet and the propeller turbine. It is not a fundamentally different type from the straight jet. It differs from the ducted fan, however, in that it enjoys a larger measure of flexibility. The augmentation ratio, or ratio between the air going into the engine and that being by-passed around it, determines whether the engine is tending towards the turbojet or towards the turboprop.

The Rolls-Royce Conway is offered in two new long range jet airliners, the Douglas DC-8 and the Boeing 707. The Trans-Canada Air Lines order already mentioned is for four Conway-engined DC-8s with an option on two more. Mr. H. Seagrim, Operations Manager of Trans-Canada Air Lines, has stated that the application of the Conway to the DC-8 gives, according to his company's calculations, a lower operating cost and a range increase of from 300 to 400 miles.

In all preparations to introduce long range jet airliners into the main routes of the world, attention must be paid to the effects of noise. At the airports serving many great cities there are regulations to limit the disturbance caused to people living in the district by the noise of aircraft. These regulations place restrictions upon what can be done with plain jet power units.

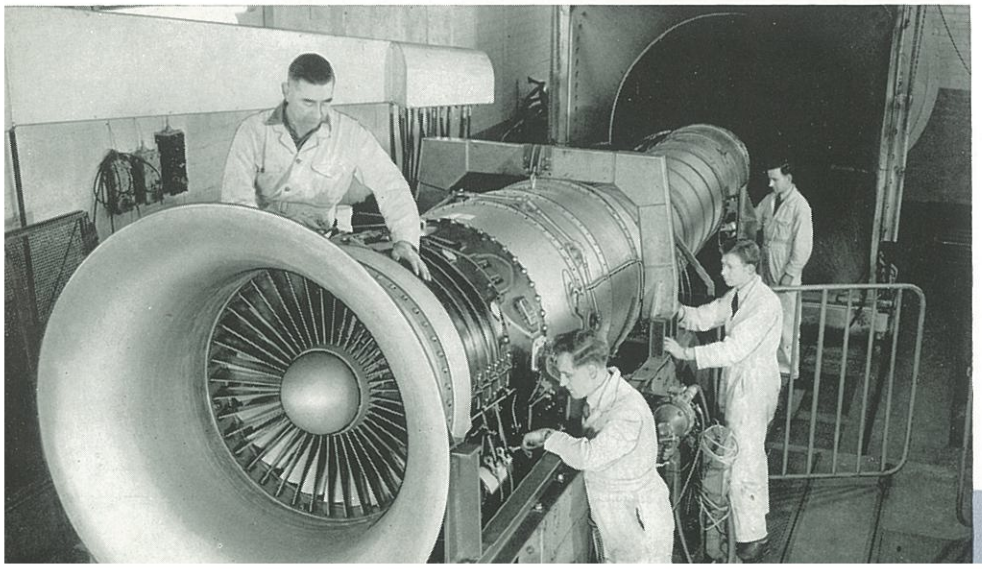


The Conway by-pass turbo jet

It has been shown that the by-pass engine is quieter than a comparable jet. One measurement setting the Conway against a straight jet at the same thrust showed an improvement of 9 decibels for the by-pass. Another merit of the by-pass is that the exterior of the engine is maintained at a lower temperature than that found in a plain jet. This is because of the sleeve of cooler air surrounding the engine itself.

In direct performance the by-pass has an advantage of at least 5% in range while the installation advantage of the lower surface temperature reduces the drag and weight penalty of engine compartment ventilation and fire precautions. The by-pass, therefore, offers advantages in three directions: range, simpler installation and lower noise level.

The Rolls-Royce Conway will be seen in military aircraft and in civil aircraft. It will be the most advanced instrument for providing power for the world's air lines.



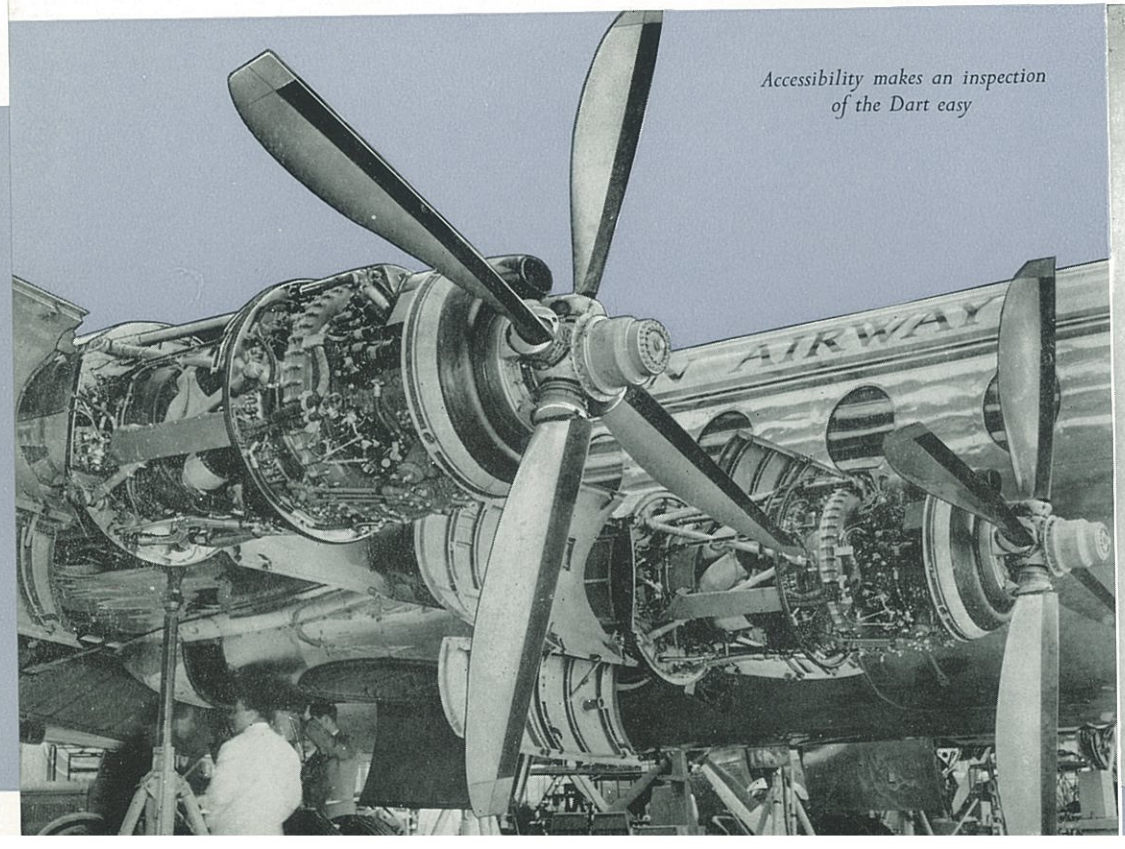
The Conway being prepared for a test run

SERVICE ORGANISATION

Attention may now be directed to one of the most important aspects of all civil aviation work: the service and maintenance side. As has been indicated already, the first step which is taken by Rolls-Royce Limited, when an airline decides to buy its engines, is to form a direct link by personal representation with the operator. Satisfactory operation of the engine is regarded as part of the pattern of continuing responsibility.

The Rolls-Royce Service organisation consists of the Technical Service Department and the Aero Service Department with repair and overhaul factories in England and Scotland; the Publications Technical Department and the Aero-Engine School, all of which are the technical responsibility of the General Manager, Sales and Service.

The Technical Service Department controls the life development of the engine, and a watch is maintained on all parts and their performance in service. They are made the subject of statistical analysis and defects reported are investigated so that comprehensive information may be available on which to base modification and future design detail. This department also maintains a constant survey of maintenance and overhaul requirements, including shop layouts and tooling, equipment for stripping and cleaning, standards of fitting and inspection, and re-assembly and testing procedure.



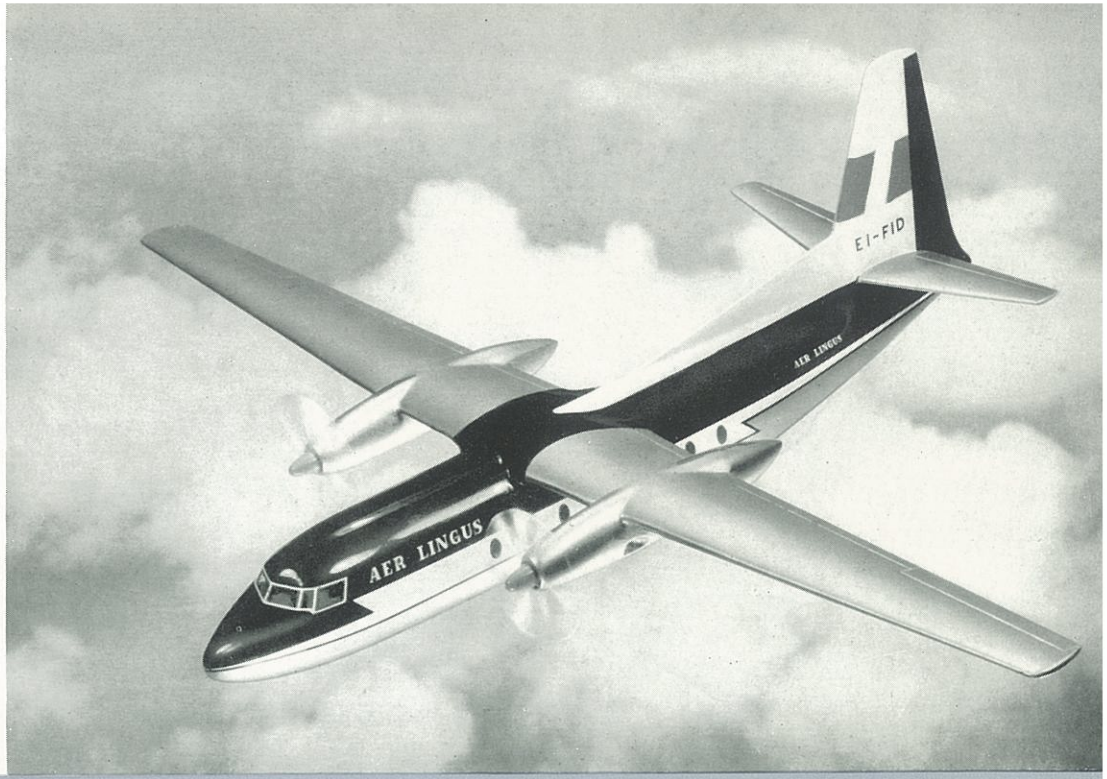
Accessibility makes an inspection of the Dart easy

Rolls-Royce Technical Publications

Airline requirements are studied and it is an integral part of this technical service that there should be systematic circulation of information to all departments.

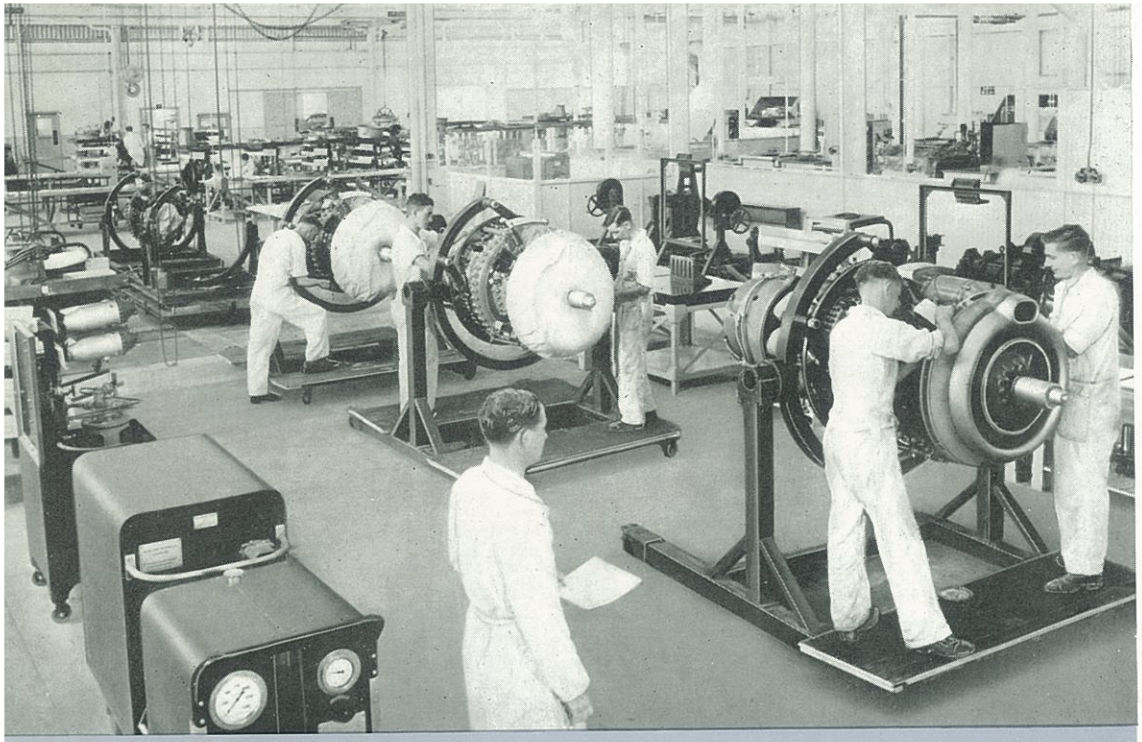
The Aero Service Department maintains Service Engineers in all the major airports where Rolls-Royce engines are in use. They are attached to the airline operators so that they may be available for consultation on the spot and are able to direct the operators own personnel in the servicing of engines. These service engineers maintain a close contact with headquarters and are kept fully informed on all the latest developments. They are also the link that supplies the day-to-day information on the behaviour of each engine in use to headquarters and, in particular, to the Technical Service Department.

Darts on Arctic trials



Fokker Friendship in Aer Lingus livery

Rolls-Royce Limited considers the after-sales service so important that it has set up permanent establishments in Canada and Australia. Overhaul bases are in existence for Air France, Trans-Canada Air Lines, L A V (Venezuela), Capital Airlines (Washington) and Central African Airways. Bases are projected for Indian Airways, Continental Airlines, Pakistan Airlines, K L M, New Zealand National Airlines and Hong Kong Aircraft Engines. A base is being considered for Cubana Airlines. Rolls-Royce of Canada Limited is a self-contained manufacturing and repair unit keeping stocks of spares for operators in Canada and the U.S.A. It is also responsible for technical and field service in Canada and the United States.



Overhauled Darts at Rolls-Rovce of Australia

L.A.V. Darts are overhauled in Venezuela

Similarly at Mascot, in New South Wales, a repair and overhaul base for gas turbines in Australia has been completed by Rolls-Royce of Australia (Pty) Limited. All the Dart engines used by Trans-Australia Airlines are overhauled at this factory.

Rolls-Royce Limited also maintains, at London Airport, service engineers and mechanics available at all times to give advice and assistance to operators. This after-sales service is of assistance to the British Corporations with their Viscounts and to Air France and other companies using these aircraft.

Documentation plays a large part in after-sales service. It begins when the first contacts are formed between operator and manufacturer. A questionary is then presented to the operator and care is taken that he has a complete appreciation of all his needs before he buys the aircraft. Regular technical meetings take place and the spares situation is worked out so that supplies may be put in hand to be available to match engine utilisation. The Rolls-Royce advisory service is at the call of purchasers of the engine and the aim is to look forward two years in provisioning and planning.

The written side of this work finds its main expression in the sets of manuals which are given to all purchasers of engines. The Rolls-Royce policy is to supply customers and service representatives with information and facilities unique in scale. Special emphasis is given to keeping the holders of these manuals advised of technical changes and new maintenance and overhaul techniques. To achieve this the manuals are designed both for quick reference and for quick amendment. Advance information leaflets are issued to operators within days of a change. As the manuals are printed by Rolls-Royce there is a high degree of flexibility which benefits the customer directly.

No operating problem is overlooked and the user enjoys, from the moment of purchase, the massed engineering experience of Rolls-Royce Limited. Before concluding this survey of the company's practices, some facts must be given about the Rolls-Royce Aero-Engine School.

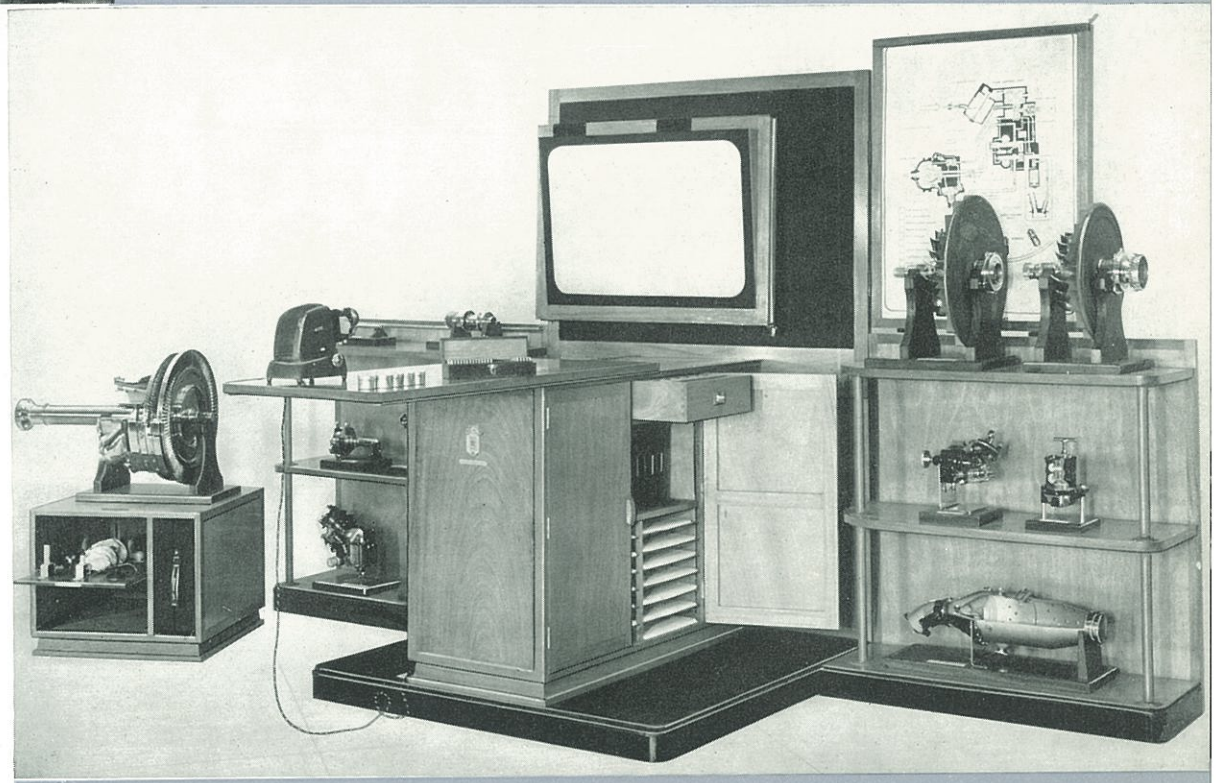
The Rolls-Royce Aero-Engine Instruction School

Technical Training

The Aero-Engine School was started in 1938. Its object is to provide customers' representatives with organised training facilities free of charge. It is the longest established customers' engine school, and it is regarded as a means of giving initial training and of providing a background for the training establishments of airline operators. It seeks to reinforce, never to supplant, those establishments.

Situated in Derby, about two miles from the main works, the School has lecture rooms, workshops, permanent exhibitions dealing with manufacture, inspection and test techniques and with manufacturing processes and production methods, as well as a small theatre and the usual lecture facilities. It has already been said that the dissemination of information is an important feature of the technical service department and as a further guarantee that the School keeps up-to-date in its teachings, two senior members of the staff maintain contact with the technical side of the main works.

As a supplement to the main work of the school, training kits have been designed for use in customers' own training establishments. The basic kit includes such items as instructional diagrams, manuals, sectioned components and notes, slides and films. Instructional engines and trestles and tools may also be included. The basic kit is regarded by the School as its permanent link with the engine user.



A training aid kit

RESPONSIBILITY SPELLS RELIABILITY

After-sales service has been developed by Rolls-Royce Limited until it has attained a unique position and now offers a comprehensive, direct and energetic background for transport operations, comprehending the fields of the propeller turbine, the plain jet and the by-pass. The classified information and the massed experience behind the Dart, the Tyne, the Avon and the Conway form a guarantee of satisfactory service.

The Viscount carries a paying load for B.E.A.

The Rolls-Royce Company entered civil aviation without previous experience and achieved a high rate of learning in the early stages. It has since made a point of continuing to learn and continuing to assemble knowledge which shall be at the disposal of future users of Rolls-Royce engines.

Direct representation; technical service; spares arrangements; advisory facilities; training arrangements: all arise from the central, stable policy of continuing responsibility towards the user and of the philosophy that the delivery of engines, however well-built and well-designed, is not an end, but a beginning. It is a beginning of a co-operative effort engaging the full capabilities of both manufacturer and operator.

It has never been the practice of Rolls-Royce Limited when points of criticism are raised by those who buy and use its engines, to devote time and energy to proving that the criticisms are unjustified; on the contrary the whole effort of the company is thrown into seeking to meet the criticisms and to satisfy the user.

It may be that this Rolls-Royce ideal has been the chief stimulus to the creation and development of the manufacturing and servicing prestige which the company enjoys. Testimony to that prestige is found in the fact that eight of the new main line aircraft now in process of development throughout the world are offered with Rolls-Royce engines. Operators in all countries recognise the lead that Rolls-Royce Limited has acquired in the provision of power for the world's airlines.

Sir Winston Churchill, K.G., arrives by Viscount

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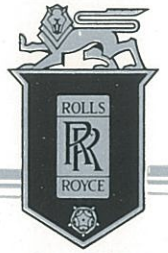

ROLLS-ROYCE

Aero

ENGINES

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