Britain's Influence on World Aviation — Past, Present and Future

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1. Introduction

It is indeed an honour to have been asked by the Council of the Royal Aeronautical Society to deliver this lecture on the occasion of the Society's Centenary Celebrations. The subject suggested to me was: 'Britain's Influence on World Aviation—Past, Present and Future.' I suppose the Council wanted to get an assessment from a non-Briton in order to get a view that, favourable or unfavourable, would come from someone outside these Islands.

The January issue of the Society's *Journal*, covering in general this same subject, displays 297 pages. I am to do this job in 40 minutes. This obviously means a condensation of heroic proportions causing, I fear, many important omissions, especially in the oral presentation. It will, however, show what items in this tremendously impressive record strike me, a foreigner, as being outstanding. I would like to begin by quoting the opening sentence of the late Sir Sydney Camm in his piece entitled 'A Lifetime of Design' appearing in the Centenary issue of *The Journal* of January 1966:

> Although it is only the future that matters, the Centenary of this Society justifies a glance at the past — but what is one to look at? So much has happened.

Indeed, there has been a great record of achievement for Britons in aviation in research, theory, design, development and production.

Although the future is all-important, to fulfil my task I must look back. One might symbolise the scheme of the paper in terms of a tree. The roots are the great work of Sir George Cayley carried on by Henson, Stringfellow and Wenham. Then the trunk represents the contributions of a number of pioneers in theory, in concepts of flying machines, in founding an aeronautical society, in gliding, in designing and in writing throughout the one hundred odd years up to about 1908 — from Cayley to Lanchester.

Then the branches appear, some representing the work of the giants of British aeronautics, many of whom found their inspiration for aviation roughly during the 1908 to 1920 period. Other branches may be symbolised as fields within aeronautics such as aerodynamics, structures, materials, powerplants, equipment, air transport and systems concepts (military and civil), to many of which the giants made substantial contributions. The impacts of both reached the world by the winds of publication, lectures, demonstrations, contests and personal contacts. In this, the part played by the Royal Aeronautical Society has been most important.

My lecture is to deal with aviation, the heavier-than-air field. The broader subject, aeronautics, encompasses all forms of aerial locomotion including lighter-than-air. For completeness, I will say something of the latter, because in the early days there were ardent champions of both.

2. A Great History

I preface this section of my lecture, probably also applicable to the whole paper, by a quotation from R. E. G. Davies as the opening to his article in the January *Journal* dealing with air transport:

> A chronicler of history can easily be carried away with enthusiasm for his chosen subject and as a consequence, lose impartiality.

Now, following our tree analogy, may we start with the roots, the work of Sir George Cayley. He was a man of great breadth of interests and achievements. He was a scientist, in the sense that he applied the scientific method of concept, research, experiment and conclusions; an engineer, in that he developed actual devices based on his scientific studies; and with all, a man of great vision. And much of his work was conducted before 1809 when he published his findings on aerial navigation in *Nicholson's Journal*. What he developed was fundamental to aeronautics. He wrote, and how true it is, 'The whole problem is confined within these limits, viz. To make a surface support a given weight by the application of power to the resistance of air.'

But he accomplished far more than this simple statement of fundamentals. Time will not permit a discussion of each of his many developments, but their importance is such that I will list them as summarised in the excellent book *The Aeroplane, An Historical Survey of Its Origins and Development* by Charles H. Gibbs-Smith. The list of Cayley's accomplishments is:

(*a*) to lay down the scientific principles of heavier-than-air flight;

(*b*) to carry out aerodynamic research for flying purposes, on the pressure on surfaces at various angles of incidence (he used a whirling arm machine);

(*c*) to use models for flying research;

(*d*) to make the first proper aeroplane (the 1804 model glider);
(*e*) to draw attention to the importance of streamlining, and to outline the shape of the body of least resistance;
(*f*) to show and discuss the movement of the centre of pressure of a surface in an air stream;
(*g*) to discuss the problem of stability in an aeroplane, and to indicate methods of obtaining stability; to draw attention to the effects of the dihedral angle for aeroplane wings, and of a movable tailplane (elevator) and rudder;
(*h*) to suggest the use of superposed wings (*i.e.* biplanes or triplanes) to provide maximum lift with minimum structural weight;
(*i*) to draw attention to the great importance of weight control;
(*j*) to design a light undercarriage wheel for aeroplanes (this was the tension wheel which led to the bicycle wheel);
(*k*) to build and fly a full-size man-carrying glider;
(*l*) to point out that curved surfaces give a better lift than flat surfaces: and that there exists a region of low pressure ('vacuity') on the upper surface which provides a powerful lift;
(*m*) to suggest an internal combustion engine for aircraft (he made a model gunpowder motor); to draw attention to the importance of the power/weight ratio, and the need for a light prime mover;
(*n*) to suggest jet propulsion for aircraft (he described it in reference to airships);
(*o*) to suggest the convertiplane (published designs in 1843) which would have four helicopter screws, for vertical lift, that closed to become wings, with two propellers for forward propulsion.

One notes the great breadth of his aeronautical investigations of which I spoke above. I also referred to him as a man of great vision. To show this, I quote from his published works:

> I am well convinced that Aerial Navigation will form a most prominent feature in the progress of civilisation (1804).
>
> I may be expediting the attainment of an object that will in time be found of great importance to mankind; so much so, that a new era in society will commence from the moment that aerial navigation is familiarly realised (1809).

In addition to the research into Sir George Cayley's life and work by Mr. Gibbs-Smith, one notes the substantiating findings of the late J. E. Hodgson and of J. Laurence Pritchard. But in the context of my paper it is most desirable to find what men of aeronautical competence outside Britain have felt. With this in view, I quote from two Frenchmen. Alphonse Berget, President of a Société Française Aérienne, wrote, 'The incontestable forerunner of aviation was an Englishman, Sir George Cayley' (*c.* 1909) and much later, Charles Dollfus the well-known French historian, named Cayley, 'the true inventor of the aeroplane and one of the most powerful geniuses in the history of aviation.'

Cayley's experiments and developments continued after his important publications in 1809–10 (he died in 1857) so that he could influence his successors, William S. Henson (1812–88) and John Stringfellow (1799–1883). Henson drew up plans and specifications for an 'Aerial Steam Carriage'. He secured a patent in 1842 which, following most of Cayley's precepts, describes a remarkably modern configuration. He was aided throughout by Stringfellow. Gibbs-Smith writes that this 'was a work of true genius, and presented for the first time a reasoned, formulated, and detailed design for a powered aeroplane; the mechanical drawings being masterpieces of their kind.'

The over-enthusiasm of the inventors prompted them to promote an 'Aerial Transit Company'. This amounted to practically nothing other than through its publicity 'to spread over the entire civilised world that such a venture was actually conceived'. It provided a powerful incentive to Continental inventors.

Stringfellow carried on after Henson departed to America, and developed an aeroplane along the lines of the 'Ariel', but no important results from its tests materialised.

However, 'in fifty years Cayley, Henson and Stringfellow had taken heavier-than-air flight out of the hands of "tower jumpers" and ornithopter enthusiasts and established it on a sound basis of science and technology'. All that seemed now to be needed was the development of lateral control, more knowledge of stability (Cayley had seen the contribution of dihedral to lateral stability) and above all an engine of far better power-over-weight ratio than the steam engine.

I now embark on a discussion of a most important event in this early history of aviation, one involving another group of men. This event was the founding of the Aeronautical Society of Great Britain, to become the Royal Aeronautical Society in 1918. The founders were all aware of the work of Cayley, Henson and Stringfellow. What a pity that Cayley passed away nine years before the founding, as he had indeed unsuccessfully striven to form an aeronautical society some 50 years before! The great date, which is the reason we are assembled here on its Centenary, was 12 January 1866. The men of vision principally involved in the founding were the eighth Duke of Argyll, elected first President; F. W. Brearey, Secretary; and James Glaisher and F. H. Wenham, members. All, except Brearey, were men of attainment in several fields of science and engineering. Others participated in the founding and others joined during the next few years. But to these four must go the credit for instilling continuing vigour in the new enterprise, which was looked at askance by many, and its objectives held up to ridicule.

Then on 27th June, 1866, Wenham read his classic paper before the Society, 'On Aerial Locomotion and the Laws by which Heavy Bodies Impelled Through the Air are Sustained.' This paper, widely copied in other countries, clarified and substantiated many of Cayley's earlier findings, portrayed in engineering terms the fundamentals of mechanical flight and added several new concepts to the whole subject. Octave Chanute, the great American experimenter in gliders and a friend of the Wright Brothers, met Wenham in 1875 and on Wenham's death in 1908, wrote in the American paper *Aeronautics*:

> On 27th June 1866, Mr. Wenham read before the Aeronautical Society of Great Britain, then recently organized, the ablest paper ever presented to that Society, and thereby breathed into it a spirit which has continued to this day.

I wish to record here my view that the Royal Aeronautical Society has indeed exerted a profound influence on world aviation. *The Journal* of the Society has a continuous record of publication since its founding and has always been widely read. Its contents have been uniformly of the highest quality.

The Society's impact has been made, not only through the pages of *The Journal*, but also by means of the many lectures sponsored by it, influential both by the scientific and technical content presented and also by the opportunity on occasion of rubbing 'international shoulders' and by participation in joint meetings, such as the Anglo-American (and Canadian) Conferences held for many years bienially in our two countries. And so, both in substantive material and availability of interchange, one must, I feel, place the Society in a high place as an influential force in world aviation. Viewed in this light, the founding of the Society in 1866 was indeed an event of great moment.

Next in this early historical section of my paper, I will list a few other people and events which made contributions having impact beyond Britain herself. However, first I should mention the Aeronautical Society's early venture in displays, the Crystal Palace Exhibition of 1868. It contained exhibits of steam engines, kites, balloons and models of various sorts, including a triplane designed by Stringfellow. Altough this was unsuccessful in later trials, it apparently had an influence in subsequent developments of biplanes. Octave Chanute was one who was so influenced.

Now a few paragraphs on *lighter-than-air*. The first successful ascent of a hot air balloon was made in France in 1783. James Sadler was the first Englishman to ascend, in 1784. Other names associated with ballooning were Charles Green and strangely, James Glaisher, who, although participating in several balloon ascensions (one coming near to disaster), announced to the Council of the Society that he considered ballooning a stunt, a daredevil undertaking. He protested that lighter-than-air was not the path to air navigation.

Before leaving lighter-than-air, I would like to mention an occasion in which balloons were used in an interesting manner. In 1870 Paris was under seige by the Germans. To gain contact with the outside world, the Parisians resorted to the use of balloons. A considerable number were released carrying passengers, mail and homing pigeons. The idea in the latter case was for the pigeons to return bearing information in capsules containing messages attached to their legs. Many did not make the return flight due to storms, German shotgun fire and German-released hawks. I could contend that this might well be the background for the current opposing contention of two groups in America described as the 'doves and the hawks!'

Steerable and power-driven balloons were developed with more streamlined shapes and with both semi-rigid and rigid structures. And then, of course, the Zeppelins of the First World War were used by the Germans quite extensively. From hot air as the contained gas, came hydrogen and then, in the United States, helium. The intensive development of large dirigibles in England was in the period 1918 to 1930, paralleling work in Germany and the U.S.A. However, disasters occurred to the airships of each country, due to weather, navigational difficulties and fire. And so, the great enthusiasm of the lighter-than-air advocates was dampened, and development ceased. There remain now only the relatively small blimps and kite or captive balloons in the development of which Britain played an important role. Incidentally, the Army took great interest in this and one should mention J. L. B. Templer, the moving spirit who moved the initial operation at Woolwich to Farnborough, later to become the Royal Aircraft Establishment.

My own contacts with lighter-than-air (aside from witnessing balloon ascensions) was observing a flight over my home town of Galesburg, Illinois, by Captain Tom Baldwin (inventor of the limp-canopied parachute) in a powered dirigible whose longitudinal control was achieved by the pilot walking fore or aft on a triangular 'fuselage' mounted under the gas bag. This must have been in about 1905. Then in 1919, my wife and I were thrilled by the sight of the R34 flying low over our house on Long Island, N.Y. We drove the two miles to Mitchell Field to arrive in time to see the mooring lines thrown out and the airship drawn down by 50 or so soldiers on each of several lines. This was the first leg of a dirigible two-way crossing of the Atlantic and the second direct crossing by an aircraft. So much for lighter-than-air work in Great Britain. It had some influence, if for nothing else than showing that it should be investigated, but as indeed James Glaisher had forecast, it was not an air navigation contender with the aeroplane.

In the field of *gliding*, it should be recalled that Cayley did much work early in the 19th century with model gliders and later constructed a man-carrying glider which successfully flew with a man aboard in 1852. The greatest progress in glider design and operation was made by Percy S. Pilcher. He built a monoplane glider and then, influenced by Lilienthal, improved his first one and successively (1895 and 1896) built three biplanes, and then a triplane configuration. All were successful, contributing much in this field. Pilcher looked forward to powered flight and in fact, designed and built his own oil engine of four horsepower. He intended to mount this engine in a new glider, thus producing a powered glider (about 1899). However, before this was accomplished, he was killed in one of his gliders because of a structural failure.

Next I will mention Lawrence Hargrave (1850–1915) from Sydney, Australia. This generous man of genius (he gave the results of his work freely to the public) made his contribution to world aviation in the field of gliding by operating his fixed-wing model aeroplanes (monoplanes and multiplanes) by power from clockwork, rubber bands and compressed air, driving propellers or small up-and-down beating surfaces. Then in 1887, he invented a rotary engine, driven by compressed air, operating much as did the rotaries of The First World War. He also invented the box kite, in many forms. Far from the stream of work in Europe, he did, however, bring the results of his investigations and developments to world notice in a lecture to the Aeronautical Society in London in 1899.

I am constrained to submit the comment — how strangely small was aeronautical progress in Britain, from the great achievement of the Wright Brothers on December 17, 1903, to 1909. Only a few important events occurred which I will list chronologically.

1 In June 1908, A. V. Roe tested a biplane at Brooklands.
2 In October 1908, Griffith Brewer became the first Briton to be a passenger in a powered aeroplane (with Wilbur Wright in France).
3 Samuel S. Cody on the 16th of October, 1908, made the first powered flight in England in British Army Aeroplane No. 1.
4 In December 1908, the late Moore-Brabazon qualified as the first Briton to become a pilot and early the next year, J. A. D. McCurdy, a Canadian, became the first Commonwealth pilot to fly his own design, Silver Dart.

This year, 1908, in Europe was what Gibbs-Smith calls the 'annus mirabilis'. The Wrights who, in 1903, made the first powered sustained and controlled flight of an aeroplane in history, crossed the Atlantic to demonstrate in Europe their great superiority as pilots and the great controllability and performance of their aeroplanes. As the Patent Office always requires, they had 'reduced to practice' the science and art of flying. Scarcely credited in their own country, as well as in Europe, their exploits forced the world to recognise that aviation was really here to stay.

My final section under 'the first hundred years' is now concluded with comments on the great contribution to the science of aerodynamics by the publication in 1907 of F. W. Lanchester's book, *Aerodynamics*, to be followed the next year by *Aerodonetics*. The importance and great influence of these books is best shown by quoting a passage cited by Gibbs-Smith from the *Journal of the Royal Aeronautical Society:*

> These two books form the foundation of flight as we know it today. They revealed an insight into aerodynamic problems which was all the more astounding when so little was known . . . he first put forward the now well-known conception of the vortex or circulation theory of sustentation in flight. Professor Sutton says that 'Lanchester made an advance as notable as that of the Wrights, although less spectacular. He laid the foundations of modern aerofoil theory, that is, he found the origin of the all-important lifting power of the fixed wing. . . . He also attacked the difficult and intricate problem of stability.' The German mathematician Ludwig Prandtl finally confirmed and developed the circulation theory, and today it bears the name of the 'Lanchester–Prandtl Theory'.

It is interesting to note that although published in 1907–8, the research and experimental investigations involved in their preparation was started in 1894 using, among other devices, flying models.

Let us now look into British world-wide aviation influence in the modern era which it is reasonable to select as beginning in 1909.

3. Distinguished Men

The eleven years following 1909 include the First World War; this was a period that was characterised by an influx into the field of great personalities, of giants in British aviation, whose impact was world-wide. The war period brought about substantial advances in aviation, particularly in the use of the aeroplane for observation missions and for pursuit combat — the dogfight. Subsequent to 1920, many more men of eminence have taken their place among these 'greats'. Many of these will be mentioned in special connections hereafter and I am sure many others deserving of recognition because of their contributions may be omitted. My apologies to these latter.

Those pioneers I list now have been selected because of their outstanding place as industrialists, scientists, engineers, designers or pilots, with several of them possessing eminence in two or more of these categories. Here one must emphasise that British influence in world aviation has been through people as well as by great aircraft, important scientific findings or products of industrial firms. These men by their competence in these, plus character and personality, have added much to the pre-eminence of British aviation. My list of these early pioneers is the following, most of whom were either knighted or were created Lords in later years:

J. T. C. Moore-Brabazon	Melvill Jones
Sydney Camm	Frederick Handley Page
Geoffrey de Havilland	Alliot Verdon Roe
Roy Dobson	The Short Brothers, Eustace, Horace and Oswald
Sholto Douglas	John Siddeley
Richard Fairey	Thomas O. M. Sopwith
William Farren	Richard V. Southwell
Roy Fedden	Geoffrey I. Taylor
Arthur Gouge	Henry Tizard
Frank Halford	
Ernest Hives	

Most of these I have known personally and one notes with regret that about three-quarters of them have passed away.

Before closing this section of my paper, I would like to pay tribute to a few Britons who, I feel, should receive special mention because of the particular nature of their impacts on world aviation. Such a list must surely include several presidents of the Society not mentioned in other connections in this lecture, such as Major B. S. F. Baden-Powell, Lord Sempill, Sir John Buchanan and Major Bulman. And then by all means, Capt. Laurence Pritchard to whom the Society owes so much throughout the long period of his secretaryship. Also to Dr. Archie Ballantyne who has carried on so well subsequently; and as one from abroad, the late Miss Florence Barwood who for many years tended so helpfully and graciously to our needs when visiting your fair country.

And finally, a very special appreciation and tribute to Sir Roy Fedden, an engineer of great ability, a man of great integrity, a leader in his technological field of aircraft engines, a prolific writer, a leader in advocacy of aerospace engineering and education and, above all, a great lover of his country, his constant concern being her retention of leadership in aviation. Let me put in a personal note. In 1934 my wife and I visited Coventry from which my ancesters on my mother's side stemmed. On a wall of the Cathedral — the old Cathedral — we found a plaque to Ann Sewell, wife of William Sewell, Mayor of Coventry in 1606 and Member of Parliament 1620–21. After giving the vital statistics, the plaque read, 'a stirrer up of others'. I thus claim some affinity to Sir Roy in this quality I myself have and that he possesses to marked degree, 'a stirrer up of others'. In so doing in the matters in which he feels so deeply, he has performed a great service to the Society and to his country.

4. Notable Aircraft

Next let us consider those aircraft which it seems to me have, at the time of their development, been so outstanding as to have influenced world aviation, by design innovation, by wartime success, by example or by competition.

I would like to stress a point here which applies to this and subsequent sections of my lecture. My subject deals with great *British* contributions to world aviation and her influence. It is not my intention nor desire by so doing in any way to diminish the lustre and influential contributions to world aviation of the men, aircraft, exploits and innovations of other countries.

My list of notable British aircraft includes Folland's SE5a, the Sopwith Camel, and the DH4 in the First World War. These three aeroplanes did yeoman service, the first two as fighters and the DH4 as a bomber; the Camel was used as both fighter and bomber and also for ship deck use. The DH4 was used most extensively as a bomber and was selected, with Liberty engine powerplant, for production in the U.S.A.

de Havilland Moth. This private venture, personal aircraft, designed in 1925 by Sir Geoffrey de Havilland and Charles Walker, was the first really fine personal aeroplane. Proof is the very large production and sales which it enjoyed. Its Cirrus engine was developed by Frank Halford.

Fairey Fox. About 1926, Fairey developed the Fox whose lines were so clean and wing design so refined as to surpass contemporary fighters in speed by a considerable margin. The model was purchased in substantial numbers for the R.A.F. and was accepted by the Belgians as their standard fighter, being constructed in a Fairey-operated factory in Belgium.

Handley Page 42. This transport aeroplane was used for a really *de luxe* service between London and Paris. I well recall a flight my wife and I made in the Hannibal in 1934. Speed was not very great ('built-in headwinds' of C. G. Grey) but comfort and cabin service were superb.

Hawker Hurricane. First flown in 1935, this design of Sydney Camm with Merlin engine was a large factor in winning the Battle of Britain. Any factor that contributed to the winning of the Second World War which saved western civilisation can be said to have been the ultimate as an influence in world progress. Great Britain contributed most to this end in the first years of the war, standing alone against the Hitler menace. The Hurricane played a part in achieving this success.

Supermarine Spitfire. In 1936, this aeroplane appeared, also with Merlin engine, with performance well ahead of any other aircraft in the fighter field. Its contribution to the winning of the Battle of Britain was of the same high order as the Hurricane and its performance was such that it went into extremely large series production throughout the war.

Bristol Blenheim. Coming out in 1936, this twin-engined bomber served effectively in the Second World War and was produced in large numbers.

de Havilland Mosquito. This all-wood aircraft with excellent speed was designed by Geoffrey de Havilland's team, including R. E. Bishop and Charles Walker, to carry out high-altitude reconnaissance and later other missions in the Second World War. Throughout the war its high performance was its chief protection and it gained an enviable reputation because of its many successful exploits.

Avro Lancaster. Coming out about the middle of the war and designed by Roy Chadwick, it soon became the best of the four-engined night bombers and was produced in large quantities.

Vickers Viscount. This admirable turboprop design of Sir George Edwards (four Rolls-Royce Darts) was a great success from the first. Started in 1948, it went into airline service in 1953, forming a large part of the fleets of many airlines throughout the world, the first British ship to go into extensive use on a U.S. airline. It brought great prestige to Britain because of its worldwide use, and was the first turboprop airliner to go into service.

de Havilland Comet I through IV. The Comet I, started in 1949, went into service with B.O.A.C. in 1952, the first turbojet air liner in the world. Powered by four de Havilland Ghost jet engines, buried in the wing roots, it represented a quantum jump in sleekness of appearance, in speed and all-around efficiency. The most unfortunate fatigue failures occurring in service were in an area of design not related to its fundamental contribution to its jet age transport pioneering. Modifications resulted in the successful Comet IV, with Rolls-Royce Avon engines. de Havilland received the Elmer Sperry Transportation Award for the design and development of the Comet, and inaugurating the era of jet transportation.

English Electric Canberra. In 1949 this aircraft appeared, again a two-engined (Rolls-Royce Avons) design of remarkable cleanness. This was the first jet bomber made in Britain, establishing several world records. It was accepted for use in the U.S. Air Force with license to build in America in quantity by the Martin Company.

Hawker Hunter. This jet fighter designed by Sydney Camm was brought out in 1954; in all, almost 2000 being built for the R.A.F. A swept wing jet fighter, it was standard for the Service for a number of years. It was powered by a Rolls-Royce Avon and flew at subsonic speeds.

Handley Page Victor. This was one of the three V-Bomber class (Avro Vulcan and Vickers Valiant were the others) which were the mainstay of Britain's bomber strength in offense after 1957. Powered by four Rolls-Royce Conway engines, the Victor possessed fine performance and was noteworthy for its Lachmann-designed crescent wing and high tail unit.

English Electric Lightning. This is the latest interceptor in the R.A.F., flying at supersonic speeds.

I now turn to two special types of aircraft namely *Flying Boats* and machines capable of *vertical take-off and landing*. The *former* have had a magnificent history in the U.K. which has easily been the leader in their development throughout the forty years of ascendency from T. O. M. Sopwith's Bat Boat of 1912 to the flight of the Princess flying boat in 1952. I have a warm place in my heart for the flying boat as my own first assignments in aviation were involved with them — first in 1918 in preparing an inspection manual for the H16 flying boat, somewhat similar to the F series (known as F5L with Liberty engines in the U.S.A.); then in inspecting parts and assemblies of a series of 50 in Garden City, Long Island (these were crated for overseas use in Britain's coastal defence); and then as Chief Inspector of the N.C. flying boats and their preparation for the U.S. Navy's successful trans-Atlantic flight venture.

One should give credit here for the first flight in a Commonwealth Nation by J. A. D. McCurdy who flew the Silver Dart off ice at Baddeck Bay in Canada on 23rd February, 1909. This was the fourth of the series developed by the Aerial Experiment Association, consisting of Dr. Graham Bell, Glenn Curtiss, Lieut. T. Selfridge, F. W. Baldwin and McCurdy.

It seems altogether logical that Britain should lead the world in flying boats as a sort of extension of her rule of the seas and her vast overseas empire. The great names in maintaining this leadership were Manning, the Shorts, Saunders, Knowler, Mitchell and Sir Arthur Gouge, with Commodore John Porte contributing much to the First World War developments at Felixstowe. Just to list a few of the names in Britain's great flying boat period must bring a thrill to many in this audience. Supermarine Southampton (Coastal Command standard for ten years); Short Calcutta (first air-cooled engine installation starting service on Imperial Airways, 1928); the Empire Flying Boats (serving Imperial and B.O.A.C. for years); the Sunderland (military version of the Empire class); and other notable models, such as the Singapore, Cutty Sark, Lerwick, London, Stranraer and Shetland. Then finally, the Princess, (designed for 8 coupled Proteus propjets and 2 single engine installations) with gross weight of over 300,000 lb. By the time the engines were ready after a long delay, decisions had been made which removed the flying boat from contention as an over-water air transport vehicle. Availability of concrete runways at most population centres, coupled with greater efficiency of land-based aeroplanes and possibly more ready susceptibility to pressurisation of the cabins, were a few reasons for the transition. In any event, 1952 closed the era of the flying boat, a period in which Britain had a predominant role, influencing design in many countries.

Vertical take-off and landing aircraft

It will be recalled that the concept of VTOL aroused interest from very early times, going back in Britain to experiments of Sir George Cayley in 1796 and later in 1843, with a convertible helicopter idea. In 1842, W. H. Phillips conceived a jet-driven rotor, tried out in a 49 lb. model. Tethered helicopters were tried successfully in France, Italy and Austria and in 1859, Henry Bright took out a patent on a contra-rotating, coaxial rotor helicopter.

But nothing much came of all this until the Cierva Autogiro concept, first flown in 1923, using flapping blades. (This, of course, was not strictly a VTOL.) This was demonstrated at Farnborough in 1925 and struck the imagination of many engineers in both Britain and the U.S.A. where, in each case, construction rights were acquired. I recall an autogyro air mail service between Washington and Philadelphia where the landings and take-offs were made from the roof of the Post Office. This was indeed a thrilling sight. My own first flight was in 1931. However, even the 'jump' take-off feature (made possible by pre-rotating the rotor to high rpm's and then suddenly increasing pitch) did not bring about really wide acceptance of the autogyro.

Then came the true helicopter utilising the Sikorsky tail rotor balancer and progress was rapid both by British licensees and by designers. Great contributions to the theory were made by Glauert, Hafner, Weir and Bennett; Hafner in his ARIII introduced the concept of cyclic and collective pitch control. The continuing writings of Raoul Hafner have done much to influence theory and design in this field.

After the conclusion of the Second World War, many proposals for helicopter development were made and Air Marshal Sir Ralph Sorley had the task of co-ordinating a plan for new developments. A number of companies had sprung up and designs were undertaken by about nine. Leaders seemed to be Bristol (models 171 to 192), Westland (Sikorsky types) and Fairey. The first two created successful types, produced in considerable quantity. Fairey, however, embarked on his novel Gyrodyne and Rotodyne concepts which possessed great promise for speed and economy. In 1945, Fairey installed small engines at the sides to counteract torque and by 1955 had developed the concept of pressure jet drive at the rotor tips in a Gyrodyne to serve as a prototype for the Rotodyne. The latter flew in 1957 with stub wings for unloading the rotor and with engines for forward thrust, and the type progressed from a 33,000 lb. vehicle, which set a world's speed record for rotorcraft of 192 m.p.h., to 60,000 lb. for the final model.

Then in 1960, the Government's merger plan resulted in all rotary wing aircraft companies merging in Westland including, of course, Bristol and Fairey as well as a group of smaller firms. A comprehensive study of what should be done resulted in decision to proceed with three types: first, a 60,000 lb. class Rotodyne; second, the Westland-Sikorsky type Westminster for stage lengths of over 100 miles and third, the Bristol 194 for stages of over 200 miles for civil transport. (This was a tandem rotor configuration with stub wings.) Unfortunately, it then appears that both civil and military authorities got 'cold feet' so that at present, the question of the next generation of transport helicopters remains unanswered, eliminating the considerable advance in helicopter development which it is reasonable to suppose Britain might have made. World influences for Britain in the helicopter field must therefore be assigned to theoretical studies and to novel developments of much promise, not pushed forward to the final stage of proof and production.

Further along in this paper under Power Plant Innovations, I discuss two developments which may indeed prove of greatest significance and worldwide influence in the VTOL field, namely, the Rolls-Royce direct lift jet engine and the Bristol vectored thrust jet power plant. Von Kármán said not many years ago that we are moving from the field of the aerodynamicist to the field of the motorist. This I believe is the sort of thing he had in mind.

Brief mention will next be made of a remarkable development related to aviation in certain respects although not truly part of it. Nevertheless, it is to aviation people that development is entrusted. This is the *Hovercraft* or called in America the Ground Effect Machine or Air Cushion Vehicle. Christopher Cockerell's RN1 blazed the trail for this amphibious transport. Progress is now so great that a 150-ton passenger vehicle ferry Hovercraft is on the verge of reality and a considerable number of intermediate sizes are under development or consideration. British progress and design innovation is leading the world in this development, with many countries, notably Russia, convinced of the utility of these craft and with an American firm recently taking out a license.

5. Famous Flights

So far, we have discussed British influence in world aviation through the media of her great early history, her distinguished men and her notable aircraft. A nation also influences the world by the important records and pioneering flights that her people and aircraft make. It is not practicable to list all records nor even all flights that might have been an influence throughout the world, but a number of them seem to me to demand attention. Great flights not only show the world the calibre of a nation's pilots and aircraft and her general progress in aviation, but also stimulate determination to 'go out and do likewise', in short, stimulate competition. From a considerably longer list, I select the following:

1909 Moore-Brabazon, the first Briton to fly in Britain; later, in an all-British aircraft, won the *Daily Mail* prize for one mile circular course.

1919 Alcock and Brown in Vickers Vimy converted bomber in first direct Atlantic crossing (Newfoundland to Ireland). Later, this type of aeroplane was flown from England to Cape Town by Ryneveld and Brand.

1919 Ross and Keith Smith — also in a Vickers Vimy — London to Australia.

1925 Sir Alan Cobham flying the de Havilland 50 made a series of pioneering flights charting future routes of Imperial Airways. These, starting in London, included separate flights to Cairo, India, Australia and South Africa.

1926 Sir Alan Cobham in a Short Singapore III flew the 20,000-mile trip around Africa.

1927 Cave-Browne-Cave led a formation of four Southampton Flying Boats from England to Singapore, then around Australia to Hong Kong, some 28,000 miles.

1928 Kingsford-Smith made first trans-Pacific crossing, United States to Australia.

1931 Bert Hinkler in a DH Puss Moth made first South Atlantic crossing.

1931 The Supermarine S6B (with Rolls-Royce R engine) designed by R. J. Mitchell and flown by Boothman won the Schneider Trophy race, thus placing the Cup permanently in British hands. Subsequently, the World Speed Record of 407·5 m.p.h. was achieved by Stainforth, placing Britain well ahead in clean, high-speed aircraft design. This race experience, 'improving the breed', led directly to the famous Spitfire of the Second World War, also designed by R. J. Mitchell and using Rolls-Royce Merlin engine. I well recall discussing aircraft design matters with Mitchell at his home in 1936.

1932 Mollison in Puss Moth made first east-west solo Atlantic flight.

1933 Mollison in Puss Moth made first east-west solo South Atlantic flight.

1933 Fairey Long Range Monoplane with Reed metal propeller established records of 5,309 miles in 57 hours and 25 minutes from Cranwell to Walvis Bay, South Africa.

1934 The de Havilland Comet Racer, a specially designed twin-engined all-wood monoplane, won the MacRobertson England–Australia race. The aeroplane was conceived, designed and built in a few weeks' time. The pilots were Scott and Black. The engines were two Gipsy Six's. This was the first aeroplane to combine in one aircraft a retractable undercarriage, flaps and a variable pitch propeller. In many respects it was the forerunner of the Mosquito of Second World War fame. I recall seeing the Comet Racer fuselage in its jig when visiting de Havilland's factory at Hatfield with its designer Charles Walker.

1938 Vickers Wellesley long-range record of 7,162 miles in just over 48 hours from Ismailia to Darwin, Australia.

1941 First turbojet engine (Whittle) flown in Britain in the Gloster E28/39.

1949 First turbojet air liner flown (DH Comet with four DH Ghost engines).

One also should record the view that the S.B.A.C. Display static and flying, has contributed to world aviation. The famous caravans of the several constructors have provided fine facilities for international interchange as well as an excellent place for viewing the always sensational flying.

6. Advances in Scientific Theory

The world is influenced in aviation matters by books and scientific papers and also by technological innovations in design. The successful development of an aeroplane such as those heretofore listed is usually the end product of the evolutionary work of many designers and engineers; however, there are every now and then innovations, some of breakthrough proportions, that have application to any aeroplane and are used by other designers. Also, new theory and scientific research often lead to innovations in design available to anyone who may study such results for the purpose of conceiving new applications. Thus, influence in one country is disseminated to others. In this section, I deal with these matters, subdividing the treatment into aerodynamics structures, power plants, equipment and military concepts.

First then, let us deal with *aerodynamics*. One must surely start with the contributions of F. W. Lanchester, with whom I closed the discussion of the first century of British aeronautical history. He dealt with almost all subsonic aerodynamic principles and the development of wing theory. Next, I would list the book by Sir Leonard Bairstow, *Applied Aerodynamics*, published in 1920. I have a warm spot in my heart for this book as it formed the foundation of my own introduction to aerodynamics. In 1921, at the conclusion of my duty in the U.S. Naval Reserve Flying Corps, I asked a friend what books I should study to prepare myself for a career in aviation. Without hesitation, he listed three: Bairstow's *Applied Aerodynamics*, Pippard and Pritchard's *Aeroplane Structures*, and Watts' *Screw Propellers*. I obtained them all and studied them assiduously. I have never regretted the choice. This personal manner of how I was influenced is only mentioned as an indication that if one 'foreigner' was so greatly influenced by British writings, many others in the world must also have been so influenced.

Other British works of importance that had great influence in America were the A.R.C. R and M series of reports dealing with research findings or theory. During the 1920s, I recall the care with which these were studied in my own design office and the great credence given their conclusions. I would like especially to pay tribute to those written by Hermann Glauert. Others we admired were written by Farren, Goldstein, Taylor and Miss Bradfield (who on the occasion of my many visits to Farnborough in the 1930s, acted as my guide when inspecting wind tunnels and other aerodynamic laboratories).

But possibly the greatest influence came from the works, and the contacts (both at Cambridge and in the U.S.A.) with Sir Melvill Jones. In a series of three lectures he gave us the conception and ideal of the Streamlined Aeroplane (1929); the reduced skin friction aeroplane (1936 — because by then there had been considerable progress towards achieving his first objective); and finally, achievement of a greater proportion of laminar flow over all wetted parts and particularly the wing, involving controlling the transition point. He described two important pieces of test equipment, namely, the Pitot Traverse Method and the wind tunnel of non-turbulent flow. One is amazed at Sir Melvill's vision and the scientific as well as practical effectiveness of his research undertakings.

Others whose research, writings and lectures contributed to British influence abroad were E. T. Jones, Southwell, Collar and Relf. And, as a great leader in instilling a spirit of research among all who came within his many areas of work, on committees and in government councils, was Sir Henry Tizard.

7. Influential Technological Innovations

Now I list a few innovations in design which contributed to improvement of aeroplanes.

The aerofoil studies and experiments made by Horatio F. Phillips, leading to his patent of 1884, described what came to be known as the 'Phillips Entry'. This was the start of present subsonic aerofoil shapes to create optimum aerodynamic flow and resultant increased lift and reduced drag. Incidentally, Phillips developed a usable wind tunnel to aid him in his experiments.

During the First World War, Richard Fairey took out a patent for a wing flap gear.

In the mid-1920s, L. G. Frise invented the aileron control surface balance that bears his name. I recall using this exclusively for aileron balance, finding it most effective, not only for achieving low stick force, but also for inhibiting certain kinds of wing and aileron flutter by adding weight in the leading edge.

The Townend (of N.P.L.) ring was the forerunner of the fuller NACA cowling and did much to bring the air-cooled engine into contention at higher speeds by reducing drag more nearly to that of the liquid-cooled power plant. (We built hundreds of these rings in the U.S.A., standardised to each air-cooled engine model, under the name of Anti-Drag Rings).

Then Meredith of Farnborough discovered the possibility of so designing radiator cowling that the unit acted as a heat engine giving a force that substantially counteracted radiator cooling drag.

The jet or blown flap was first used on the Hunting 126.

Two developments of far-reaching importance stemmed from the invention and experiments of Handley Page and his associate, Gustav Lachmann. These were the Handley Page slat and slot, frequently in association with flaps, and boundary layer control. The former has been used successfully on many aircraft in many countries and the latter holds out a potential for drag reduction unmatched by any other innovation. Great credit is due to H.P. for his research into practical as well as theoretical problems and his vision in recognising this potential.

There are two more aerodynamic achievements of a different kind that influenced world aviation — complete aeroplane developments. These were the design by Mitchell of the Spitfire, using several concepts stemming from the work of Melvill Jones (streamlined shapes, elliptical wings, 'clean' surfaces) resulting in the production of this most refined aircraft that did so much to win the Battle of Britain. This aeroplane possibly more than any other gave the R.A.F. the equipment which permitted its pilots to do the job. Churchill rightly said, 'Never in the field of human conflict was so much owed by so many to so few'. Also should be mentioned in the present context, the de Havilland Comet, with its buried jet engines and over-all cleanness — a truly beautiful aeroplane.

Britain also contributed considerably in the development of the slender delta configurations, one built by Handley Page, the 115, and the other the B.A.C. 221.

Let us now consider British influence in the field of *structures*. As in the case cited under Aerodynamics, I was also influenced by a book on structures with the title, *Aeroplane Structures*, by Pippard and Pritchard. By studying this book, I was able to supplement my civil engineering type of training to permit its application effectively to structural problems associated with the design of aeroplanes. During the subsequent years, I have felt that G. Lachmann's writings on structural design (as well as on aerodynamics problems) had substantial influence in clarifying several current problems.

The Society's 'Stressed Skin Data Sheets' had their influence and usefulness. In the field of aeroelasticity, substantial contributions were made by Pugsley and Roxbee Cox at a time when these problems, frequently of catastrophic proportions, were causing great concern to designers throughout the world. Professor Collar prepared a classic paper which shed much light on this whole matter. The problems of fatigue in aeroplane parts became increasingly menacing, particularly after the Second World War (and still are) and good basic work was accomplished both from the standpoint of design and of materials. One of the greatest contributions in this regard was the pattern of testing performed on the Comet stemming from her most unfortunate fatigue failures. This procedure for accelerated service test programmes (which establishes substantial assurance of structural integrity throughout an aeroplane's life) has been widely accepted.

Good work on determining the actual loading on aeroplane wings and tail surfaces was done by Air Marshal Sir Roderic Hill and others at a time when load factors were not sufficient because of lack of knowledge of air loads applied during manoeuvres and in gusts.

From the design office standpoint, it has always been difficult to get designers to visualise stress paths in many fittings and joints. The photoelastic work which makes such visualisation possible in a very beautiful way was undertaken at University College, London, and the resulting findings added much to dissemination of this important technique.

There were two noteworthy departures from convention in structural design I should like to mention. First, Rex Pierson's Vickers geodetic used in the Wellesley and Wellington, deriving from concepts of Barnes Wallis. This short column principle used both in wings and fuselage required fabric covering and resulted in substantial weight savings. Consequently, record-breaking, long-range flights were made in the Wellesley and the Wellington bomber achieved a good war record. Higher cost was, however, an adverse factor and the stressed skin design won out in the long run. Second was the design effort made by J. D. North on stainless steel strip structures. Many difficulties were encountered but the development, as in the case of the geodetic, was useful in the evolution of structural design.

All in all, Britain made important contributions to structural design and materials research and development. In the latter, there seem to have been parallel developments in several countries in the long road from the fabric-covered stick and wire construction of the First World War, through welded steel tubes, wooden monocoque and special concepts described above, to present-day metal monocoque.

Engines

And now comes the big subject of *powerplant development* in which Britain has perhaps made her greatest contributions to world aviation. However, at the time of the First World War, she got off to a slow start. At the Olympia Display of 1914, only two of the 16 aircraft shown had British engines. However, after that First World War, the great engine people who were to lead their companies to pre-eminence were becoming involved. Included were such men as Hives, Feddon, Halford; and in government and university service, Bulman, Tizard, Taylor and Griffith. The great leadership qualities of Hives and Fedden and their assembling and holding together of fine teams of engineers and designers, has been an important factor in their subsequent success. Many important names appear in this early period such as Siddeley, and Napier. But during the First World War and the immediate post-war period, certain French-designed engines were built in Britain.

Some important work of an innovation-type was done on superchargers (Roots blower, exhaust-driven and gear-driven centrifugal) and also on fuel development and the C.F.R. standard test engine for determining octane rating; but by and large, the worldwide contributions in engines coming from Britain were not impressive until about 1930. To tell this story, one may well take up the work of the leading companies and designers from their beginnings to the jet era.

I will begin with Rolls-Royce. The early Rolls engines, Falcon and Eagle, were good 12-cylinder, V, water-cooled engines and the company stayed with liquid cooling throughout. Hives started with excellent associates, such as A. G. Elliott, and through the years built up a magnificent team including Olley, Livesey, Rubbra, Dorey, Greatrex and Lombard. Rolls-Royce came much to the fore in 1929 because of its great engine for the Supermarine S6 Schneider Cup winner of that year and again in 1931 when the S6B retained the Cup for Britain. A truly remarkable job was done in constantly boosting power, and all in the span of a few months. Air Commodore F. R. Banks helped a great deal in the area of fuel mixture to permit proper operation at these high powers.

The Merlin engine of deserved Second World War fame, derived in many respects from the racer engine, again, 'improvement of the breed' stemming from racer impetus. The Merlin-powered Spitfires and Hurricanes flown by Britain's famous fighter pilots were, I repeat, the deciding factors in winning the Battle of Britain and also the War.

Mention must be made of the unique and outstanding Rolls-Royce operation at Hucknall, the engine installation works of this company. Here the company at its own expense designed and made engine installations in many aircraft, thus assuring the elimination of the frequent 'buck-passing' of engine and airframe designers for power plant difficulties. Installations of Merlins in the Lancaster at Hucknall assured a leading place among Britain's bombers for that aeroplane.

I well remember going out to Hucknall early several mornings in 1942 with Tommy Hitchcock, U.S. Air Attache, to witness progress and flights of a Merlin engine installed in the North American P51 Mustang. The final speed improvement over the aeroplane with original U.S. engine installation was about 40 miles per hour. Transmittal of this news caused great commotion in Washington and resulted in the Merlin-powered Mustangs that served so outstandingly as fighter cover for U.S. B24 and B17 bombers later on. Rolls-Royce's own production for these were augmented by a large Merlin output by Packard in the U.S.A.

A Merlin installation was also developed successfully for a Canadian DC-4.

In Britain, Rolls-Royce set up factories in Derby, Crewe and Glasgow, preferring direct management control as opposed to the shadow factory concept. Other larger engines than the Merlin came out of Rolls-Royce's up to the time when gas turbines took over.

In 1920, Roy Fedden had a staff of 31 and an order for 10 Jupiter air-cooled radial engines. These were difficult times for Bristol, the situation being saved by a license to build Jupiters in France and an added order of 81 from the British Government. Fedden was a great team leader, as was Hives, assembling through the years such eminent engineers and designers as Rowbottom, Ninnes, Butler, Newport, Owner, Nixon, the Mansells and Stammers. Fedden always had a philosophy of bringing in and training young engineers of promise. He was also a great contributor to world aviation by his many visits abroad to the U.S.A., France and Germany. Some visits were individual, on the occasion of giving a technical paper, others as leader of a group on some type of official mission.

Bristol was dedicated to air-cooled radials throughout, first a line of poppet valve types and then engines using sleeve valves (9–14 and 18 cylinder). The many initial problems associated with the latter were met patiently by design changes, by application of new materials and testing. Early in the war, Bristol engines powered over 50% of all R.A.F. aircraft. Some of the last engines of the sleeve valve type, up to the gas turbine era, were the Perseus, Hercules and Centaurus.

In the matter of expansion of productive capacity to meet war-time needs Fedden favoured and, to a considerable extent, initiated the Shadow Factory scheme. Also, he was instrumental in inauguration of the underground factory idea with a successful unit at Corsham.

In any discussion of British influence in the engine field on world aviation, mention must be made of the outstanding contributions of Frank Halford. In all, he was a designer for several firms, including Beardmore, de Havilland and Napier. His contributions in developing the Cirrus engine for the Moth of de Havilland, and then the Gipsy were important. It will be recalled that the MacRobertson race winner was the (first) Comet powered by two Gipsy Sixes. He continued his fine work into the gas turbine era.

Sir Richard Fairey, although never an engine designer or producer, made a unique contribution in the field. As I was to some extent involved, I will relate the matter as I recall it.

In 1924, Mr. Fairey made a trip to the United States, prompted by the reports he had of the substantial success of the Curtiss Aeroplane and Motor Company with which I was associated, in producing winning racers powered by the D12 engine. A reciprocal arrangement for exchange of technical information was made. For example, one item disclosed to Fairey was the latest racer wing section ordinates. The wing, the C62, had a very high ratio of maximum lift to minimum drag and was, I understand, used on a subsequent Fairey aeroplane design.

Fairey also made a license agreement to build the D12 engine and purchased a number, with the intention of producing the model in Britain. The idea was frowned upon by government people and came to nought, except for design details presumably of considerable value, as the engine was torn down and minutely inspected, having possibly some influence on later Rolls-Royce designs.

However, the incident was to some extent related to the decision to set up an aeroplane factory in Belgium which proved to be an important undertaking, both from the standpoint of the Fairey Company and the Belgians.

Fairey certainly appreciated the potential of the D12 and designed the Fairey Fox fast day bomber around it.

As a conclusion to this section on pre-gas turbine development, a word is in order on propellers. Here again, I originally obtained such knowledge as I may have from a British book, *The Design of Screw Propellers for Aircraft*, by Henry C. Watts, published in 1920. I read and studied this book with great care and corresponded with the author about it quite extensively. One of the most important developments in the late 1920s and early 1930s was the variable pitch propeller from which stemmed the controllable pitch, reversible pitch, constant pitch and constant speed variations. Britain played an important role in these with the Hele-Shaw and (from Canada) the Turnbull electric-driven controllable pitch configuration. My company had a license from Mr. Turnbull and developed the device successfully, later licensing Bristol and Rotol in Britain. Aluminium alloy blades were also developed by Curtiss and arrangements for use of the Reed propellers were effected with Fairey.

Gas turbines

Now we come to the gas turbine era where British developments not only influenced world aviation, but completely revolutionised it. Here the name of Air Commodore Sir Frank Whittle predominates. His enthusiasm, inventiveness and drive brought about the successful inventions, developments, testing and flight demonstrations of this remarkable prime mover in Britain. His original concept was an engine configuration of the centrifugal type, developed at Power Jets, Ltd. (R. & D.). Roxbee Cox (now Lord Kings Norton) was associated with this and also the National Gas Turbine Establishment. The axial flow configuration was brought out by Metropolitan Vickers. A final development of theirs, the Sapphire, was licensed to the Curtiss Wright Corp. in the U.S.A.

The extent of the revolutionary nature of the jet engine is evident in its almost complete usurping of power plants in military and transport aircraft today.

Rolls-Royce got into gas turbine development during the war, shifting their piston engineering teams smoothly into this new development field. Their first gas turbine engines were the Welland, Derwent and Nene. Then the smaller propjet, Dart, which powered the Vickers Viscount, of which more have been produced than any other propeller jet transport. The engine has a remarkable record for its long period between overhauls. Well over 5000 have been delivered, powering Viscounts in all parts of the world, accumulating over 35,000,000 hours of flying.

I recall on one visit to Derby, Hives showing me the first Conway by-pass engine, running on a test stand. This was a development of great importance as the by-pass or similar turbo fan engine is the preferred configuration for modern, efficient transport aircraft. Rolls-Royce also developed the Spey and Avon, the latter — a pure jet — being the basis of an early arrangement made between Rolls-Royce and Pratt and Whitney in the U.S.A.

Important contributions were made by Rolls-Royce in the fields of thrust reversal and noise suppression for jet engines, on which Colley and Greatrex were intimately involved and on which they have both given excellent technical papers. The great Lord Hives of Huddleston is succeeded in Rolls-Royce leadership by Sir Denning Pearson.

Another important Rolls-Royce development in the gas turbine picture is the direct-lift engine of high thrust-over-weight ratio. Starting at a figure around 10 in this respect with the model 108, it is now over 16 in the 162 and is going up steadily. Recently, much worldwide interest has been shown in this engine and the potential of this concept and an arrangement with Allison Division of General Motors in the U.S.A. for collaborative development has been made.

Work on gas turbine aircraft engines got under way at de Havillands as a result of a request by Sir Henry Tizard that the company, in association with Major Halford, enter the field, pointing to the use of the engine in a fighter. The Goblin was the engine and the Vampire the fighter. Also, the first flight of the Meteor was with two Goblin engines. From the Goblin came the Ghost, four of which were used, buried in the wing roots of the D.H. Comet I. Halford was chairman and technical director of The de Havilland Engine Co. Ltd., to be succeeded after his death by Dr. Eric Moult as Technical Director. As a personal aside, I might mention the privilege I had in 1942 of being shown the Goblin in its early development stages by Halford in a revamped garage, I believe, on the Great North Road to Hatfield. I was tremendously impressed and after returning to America, urged the two major engine companies and government officials in the Air Force to obtain licenses and information on these developments, which seemed to me to be destined for a role of great importance in the future of aviation.

Bristol got into jet development during the war and in 1946, the Theseus turboprop passed its 100-hour type test at 2,450 e.h.p. as the first successful turboprop engine. Next came the Proteus, rather late in development because of difficulties from the curious reverse flow arrangement. Later, the Olympus, first run in 1957 at 11,000 lb. thrust, developed finally to over 30,000 lb. under Hooker. The 593B model will power the Concorde. The latest Bristol development, of great potential importance, is the vectored thrust Pegasus. This powers the late Sir Sydney Camm's 1127 fighter, of which more anon.

Equipment

In dealing next with the broad category of *equipment*, I find a parallel development in many countries making it difficult to assess innovations first developed in any one. This is the case for many instruments; landing gears as to shock-absorbing means and retraction; brakes; tyres; ancillary power units; safety fuel tanks; inflatable dinghies; and others. In all of these, it appears that Britain contributed her full share in the development and interchange of acquired knowledge. In several important developments having worldwide impact, Britain clearly was the innovator. Let us list some of these.

In the military field, I include the gyro-stabilised gunsight and particularly, the power-operated gun turret, using electro-hydraulic means. J. D. North of Boulton and Paul was an early designer of this equipment, later further developed and manufactured by Bristol and Frazer-Nash. This development gave British bombers a potent means of defence, later adopted in the U.S.A. I recall conferences in Washington during the War at which need for immediate action was emphasised, resulting in sending U.S. manufacturing representatives to Britain to arrange for rights, drawing and 'know-how' to produce in America. U.S. bombers were equipped with these in a remarkably short time. All helped to win the War.

Other important items were the early development of the distance reading gyromagnetic compass and radio altimeter. Of particular interest was the Martin-Baker ejection seat, also adopted in the United States. Its development story is most interesting and was fraught with considerable danger. I recall witnessing a test using the tower equipment, along with several other Americans, in 1944 or possibly 1945. A U.S. volunteer experienced the ejection (Robert Stanley) and later produced this type of equipment for the U.S. Government in America. Many British-built units were purchased for U.S. use both before and after the Stanley Aviation Co. got under way.

Britain has been a leader in the field of development of electronic systems for various air navigation and landing systems. In such a list would appear Loran, Decca and recently Dectra, and of course the work of B.L.E.U. In the area of landing aids from the standpoint of direct reading information for the pilot, is the so-called Head-Up Display.

Military concepts

In my final section under Innovations, I will discuss unique military concepts conceived and developed in Great Britain. First, let us consider the concept of the eight-gun fighter appearing in the specifications prepared by Air Marshal Sir Ralph Sorley and exemplified by use in the Spitfire and Hurricane. The fire power thus provided in these magnificent fighters was also an important contributor to winning the Battle of Britain. In the bombing field, the Radio Controlled Proximity Fuse played an impoıtant role, as did the night-bombing techniques used so effectively during the war. I recall the controversies during the war between the advocates of day and of night bombing. My own view, expressed at a dinner in 1942 tendered by the government to a group of us from the U.S.A. then visiting Britain, at which Sir Stafford Cripps presided, was: 'Why argue? It seems to me the best policy embraces hitting the enemy the full 24 hours each day rather than during only half that time.'

The British Pathfinder technique for guiding bombers to target and the low altitude bombing scheme used at the Möhne and other dams attacked in 1943 were also important.

The 'probe and drogue' refuelling technique developed in the early 1930s by Sir Alan Cobham proved of major importance in military tactics and is now commonplace for many operations.

Several British innovations in naval equipment for air warfare utilisation have been widely adopted, most important among which are the angled deck aircraft carrier, greatly enhancing carrier operational capacity and safety; the early development of the steam catapult; and the mirror sight for deck landing.

Finally, I come to one of the greatest of inventions and developments — radar. During the Battle of Britain, radar detection of enemy aircraft held a position of importance alongside and complementary to their interception and destruction by fighter command pilots and aeroplanes. And, I reiterate, winning this battle was of overshadowing importance in saving our civilisation. In the late 1930s, Sir Robert Watson-Watt conceived of the potential in the application of radio pulse reflection and received support from H. E. Wimperis, Director of Scientific Research for the Air Ministry, to proceed with certain critical experiments. Resulting from success in these investigations, after several years of development, the warning ground radar chain (essential to the system of detection, interception and destruction of enemy bombers described above) was developed. Sir Henry Tizard also participated even more actively in the system's development. Radar, of course, found many other important applications in the prosecution of the war on a worldwide basis, as well as playing an essential role in civil aviation for air navigation and landing.

8. Air Transport Services

Britain got off to an early start in air transport, from air mail flights of the Grahame-White Aviation Co. between London and Windsor in 1911 to the formation of Imperial Airways in 1924. There were many companies, all private ventures (with a few military lines during the First World War), and all of relatively short life. One was the Air Transport and Travel Co. formed during the war but really starting in 1919 when G. Holt Thomas, its owner, appointed Sefton Brancker as Managing Director. For the most part, converted bombers were used (de Havilland and Handley Page). Handley Page himself formed Handley Page Transport with runs to Paris and Brussels. Others were Supermarine Aviation, Blackburn, North Sea Aerial.

Then a period of mergers took place. George Woods-Humphery came into the picture in 1922 and then in 1924, Imperial Airways was organised, combining all others as a government corporation with subsidy payments envisioned. With it a determination to use all British aeroplanes and engines was made. This date, 1924, was two years ahead of the forming of Lufthansa and eight to ten years ahead of the flag airlines of France, Italy and Russia. However, KLM was in operation then and was actively planning its eastward routes. Shortly after this, Sir Alan Cobham made his trail-blazing British Empire flights and the race to the Far East was on.

The great expansion period started in 1929 when the Short Calcutta flying boats came into service and from then on, flying boats formed the backbone of Imperial Airways operations, a most natural manner of operation considering British maritime tradition, the nature of the operation and of the location on water of the cities to be served. However, the Dutch throughout operated landplanes. Certain high landmarks appear — the no-surcharge air mail in 1935; the opening of routes to South Africa and Asia in 1936 with Short S23s; joint service with Pan American, New York to Bermuda in 1937 (as a sidelight, I made a trip to Bermuda with my family on the first Pan American flight); flight refuelling trans-Atlantic service in 1939; and the formation of another merger in 1939, Imperial Airways and British Airways to form B.O.A.C., British Overseas Airways.

Then came the Second World War. Services were greatly altered with military necessity prevailing. Certain landplane developments for air transport (Fairey was one) were cancelled and in general, aircraft manufacture in Britain, of necessity, was concentrated on military aeroplanes. Incidentally, in the U.S. in the early years of the war, American transport aeroplane production was curtailed, but soon it became evident that the war effort required transports as well as fighters and bombers and the restrictions were removed and production of DC-3s, C46s and DC-4s greatly increased. I know of no definitive agreement that Britain should build only fighters and bombers whereas the U.S.A. should go all-out for transports. The requirements of the war effort as decided by the Joint Aircraft Committee (U.S. and Britain) simply dictated production as it best contributed to winning the war.

After the war, it became evident that flying boats would not serve air transport, whether domestic or overseas, so well as landplanes. Air transport was in for a great boom as was forecast with the formation of the International Civil Aviation Organisation (ICAO) in Chicago in 1944 at which Sir Frederick Tymms played an important role. Many international agreements were made to facilitate such expansion.

British European Airways (B.E.A.) was formed in 1946 and operated most successfully with DC-3s and Vikings (developed from the Wellington bomber) and then using Airspeed Ambassadors in the Elizabethan class. The company was ably managed by Lord Douglas, assisted by Peter Masefield.

A word should be given to a rather significant service inaugurated in 1948 — by Silver City Airways — a car-passenger service from Lympne to Le Touquet, using Bristol 170s. This is, I think, an important concept and one that will expand in importance as aircraft with greater economy for the service are developed.

The findings of the Brabazon Committee report of 1944 could not be implemented until almost ten years later — two of these resulting in the de Havilland Comet and the Vickers Viscount. The former went into service in 1952 and the latter in 1953. Both were highly successful in service. Alas, the Comet disasters of 1954 were a terrible blow to de Havilland, to B.O.A.C. and to Britain. Remedial corrections were made to permit the Comet IV to resume service in 1958 on trans-Atlantic runs, a little ahead of Pan American. The Viscount was most successful, forming the backbone of many services throughout the world. The turboprop Britannia (1957) first so-equipped in Atlantic service, has served well although its tardy start greatly limited its market.

The Vanguard turboprop came out in 1961 and supplemented Viscounts as a larger design with B.E.A. and other airlines. The contributions to success of these latest aeroplanes by the Rolls-Royce designed engines have been noteworthy.

Local service flying in Britain has apparently been plagued by too much private enterprise and competition. More orderly procedures from a British CAB (one writer has said) would appear desirable. Nevertheless, good service is available on Cunard Eagle, British United Airways and others.

Britain has a good supply of new aircraft in the Trident, BAC One-Eleven, Herald and Avro (Hawker Siddeley) 748, with VC10 performing so excellently to South Africa and the Super VC10 to New York. Here, I understand it commands load factors considerably higher than its competition.

Britain thus has made very great contribution to the advancement of air transport and may well be proud of the record; I believe she will continue to do so.

9. Present and Future

As the present is but prologue of the future, I will place these two together. Both are dependent on how well a nation has built in the past and this I have tried to show. Britain contributed much to world aviation in the Cayley to Lanchester century and then rose to great heights between the First World War and the end of the Second. Subsequently, she has held her own well against shattering odds of war exhaustion, economic depletion, empire liquidation and plain bad luck. But all these can be counteracted and the situation at present gives a good base from which to work.

Let us see how things now stand on the basis of the principal criteria used in making an assessment of Britain's position in the period 1916 to 1946. First then, there are a number of outstanding men, younger by twenty-five years than that great group of 'giants' who have led the nation in aviation since 1909. These also have among them able leaders in the fields of science, engineering, industry and design. They too have character and determination. My list is, of course, incomplete, including for the most part only those I know personally. To be added to these are others whose age lies between the first and second groups who have made great contributions and will make more. For the present purpose, I list the following younger men:

Professor A. R. Collar	David Keith-Lucas
Handel Davies	Robert L. Lickley
A. Valentine Cleaver	Adrian A. Lombard
Sir George Edwards	Peter Masefield
Ferdinand B. Greatrex	Sir Denning Pearson
Sir Arnold Hall	Walter Tye
H. H. Gardner	

The in-between age group, but still active, includes:

Air Commodore F. Rodwell Banks	A. C. Livesey
Stuart Davies	Dr. Eric Moult
Sir George H. Dowty	N. E. Rowe
Sir George Gardner	A. A. Rubbra
Dr. John J. Green	Dr. A. E. Russell
Raoul Hafner	Beverley S. Shenstone
Dr. Stanley G. Hooker	

There is no lack of talent in British aviation with which to face the future.

Now let us take a look at the 'stable' of aircraft which must serve the present and tide over through the immediate future, say five years. Excellent civil aeroplanes now in service on a world-wide basis that will carry on for a while are the Vickers Viscount and Vanguard, the de Havilland Comet IV and Bristol Britannia; and in the military field, the English Electric Lightning and Hawker Hunter fighters, the Hawker Blackburn Buccaneer for strike missions; and possibly the HS801, based on the Comet IV, as a maritime reconnaissance aircraft.

Of more recent vintage in the air transport field are the Vickers VC10 and Super VC10, the latter an outstanding trans-Atlantic contender for B.O.A.C. For the smaller air transport mission, the B.A.C. One-Eleven has been purchased in quite large numbers by airlines both at home and abroad. Both are developments by Sir George Edwards.

There are a considerable number of other civil aircraft; possibly from the standpoint of the market and of their quite similar characteristics, too many. In the transport field are the Handley Page Herald, Hawker Siddeley 748 (with the Andover as a military version), and the Hawker Siddeley Trident.

In the field of business and executive aircraft are the Hawker (DH) 125 (R.A.F. Dominie), the HS(DH)Dove, and the Beagles, really personal aeroplanes. In the area of cargo and freight carriers are the Hawker Siddeley Argosy and the Short Brothers and Harland Belfast and Skyvan. Mention should also be made of the good conversion performed on a DC-4 as the Aviation Trader Carvair, successor to the Bristol 170 for the unique car-passenger ferry service. The service performed by the Scottish Aviation Pioneer and Twin Pioneer for use in terrain requiring STOL characteristics has been excellent.

The multiplicity of models listed stems largely from the continuation after the mergers of competitive types developed by the merged companies. They do, however, now being in production, represent a potential source of supply should the domestic and world market continue to expand during the next ten years, as it is forecast it will do.

There are, no doubt, versions of many of these, projected to meet specialised needs as with the VC10; and there is, I understand, a projected development for a feeder line aircraft by Hawker Siddeley, the HS136. The cancellation of the almost developed TSR2 in favour of purchase of a comparable fighter (the F111) from the U.S.A. put an end to a most promising development. Other purchases from America are understood to be the Lockheed Hercules C130 cargo aircraft and a Rolls-Royce Spey-powered Phantom jet fighter. This matter of foreign purchases will be discussed further in the next section of my paper.

Britain is in fine shape for engines, well able to hold her pre-eminent position. At Rolls-Royce, there are the famous Dart turboprop, and also in this category, the Tyne; for Turbo-fans, Rolls has the Conway and Spey; for jets, the Avon and the RB162 lift jet. In the field of gas turbine engines, Bristol Siddeley has the Olympus series headed by the 593 for the Concorde; the Orpheus series of intermediate thrust; and the Pegasus vectored thrust model; in lower thrusts are the Viper series.

I will now discuss the present situation concerning important *innovations* of world-wide impact invented or developed in Britain. In the area of engines, I want to re-emphasise the importance of the vectored thrust Pegasus of Bristol and the small lift jets of Rolls-Royce. The former has great promise for VTOL military aircraft and possibly civil, and the latter has similar promise with a real possibility in the longer term future of the Griffith conceived multi-lift jet-engined supersonic transport. The vectored thrust Pegasus powers the Hawker Kestrel 1127 now under trial in Britain and America and one regrets the cancellation of the supersonic P1154 development. The Rolls-Royce lift jet is used in aircraft under development in Europe. An arrangement has been made for further collaboration in development between Rolls-Royce and the Allison Division of General Motors in the United States.

At the top of my list in the innovation category for aircraft is the British Aircraft Corporation Concorde being developed in collaboration with the French Sud Aviation. Dr. A. E. Russell leads the able development team at Bristol. From the standpoint of timing, the situation is comparable to the initial head start enjoyed by the Comet, some three years ahead of its competition. In 1960 when asked by a British friend what I conceived to be the most important step Britain could take to boost her world-wide aviation standing, I unhesitatingly said that early development of a successful supersonic transport to me appeared to be the answer. I still think this is so as, in air transport, both for flight equipment and air transport services, this giant step can possibly be compared to that taken in the development of the gas turbine as a prime mover, compared with the piston engine. The good reports of progress I hear indicate the development of both aeroplane and engine are now proceeding smoothly and on schedule. The characteristics of the Concorde are, I believe, soundly conceived. Its contributions to the coming supersonic age of air transport will be very great indeed.

I had intended originally to omit reference to rocketry, satellites and space programmes, their implications and Britain's contributions, present and future. However, for the sake of completeness, I will include several paragraphs and give a few quotations, more to stimulate thought than to attempt real coverage. Although there was some very early work on the potential of rockets, such as that of Sir William Congreve in the first part of the 19th century, a wider interest started with the founding of the British Interplanetary Society in 1933 about the same time as its counterpart, the American Rocket Society was formed in the U.S.A. It has consistently urged speeding up work in this field.

In 1946 the Rocket Populsion Establishment was created as an independent organisation at Westcott; and in 1957, the Astronautics and Guided Flight

Section was formed in the Royal Aeronautical Society. Britain has developed rockets using both liquid and solid propellants. Among these are Black Knight, Skylark (for the International Geophysical Year in 1957), short-range Sea Slug, Bloodhound and Thunderbird, and Blue Streak. This latter was to be a large development built in co-operation with the U.S.A. and utilised by it. Cancellation of the project involving the favoured emphasis in Polaris submarines was, of course, a discouraging event for Britain.

A. V. Cleaver, in the forefront in this field in Britain, has written: 'British contributions to this technological adventure have so far been relatively modest' (compared, of course, with this effort in Russia and the United States) . . . 'and do not compare with the great pioneering achievements by British scientists and engineers in almost every other branch of technology.' Along the same line, the late M. N. Golovine, then President of the BIS, has written, 'We cannot yet become as professional a Society as we would like, for there is precious little profession.'

In 1961, ELDO (the European Launcher Development Organisation) was formed. This organisation is composed of the following nations with indication of the development field of each: Britain (Blue Streak); France (2nd stage); Germany (3rd stage); Italy (test satellite); the Netherlands (telemetry); Belgium (down-range guidance); and Australia (the Woomera or other launch site). The schedule calls for use of the complete Europa I vehicle to send a satellite into orbit during 1968. It is to be hoped that neither politics, economics nor indecision will hold back the venture.

One may well ask whether or not the effort in Britain, from the long view, is enough. Possibly not, but probably, with the overshadowing NASA effort in the U.S.A. and the tremendous effort in Russia, and in view of economic considerations, much more would not have been feasible. As to a space programme in general, one notes the accomplishments in the satellite portion in the U.S.A. as making real contribution in areas of weather prediction and monitoring, air pollution surveys and warning, storms and climatic hazard detection, global weather circulation phenomena identification, and assessment of synoptic weather patterns. The whole gambit of U.S.A. satellite programmes (not here including man in space) have dealt with discovery, exploration, navigation, meteorology, communications, reconnaissance, astronomy and space probes. As well as in these specific missions, there has been some 'fall-out' of scientific and technological findings of direct benefit to man on earth.

Another aspect to consider is voiced in a recent issue of 'Looking Ahead', a publication of the National Planning Association in America, '. . . the space program may be stimulating the whole process of technological innovation by serving as a highly successful model. The continuing, visible technical accomplishments of the space program may be modifying attitudes toward technological innovation among those who previously have been hostile or neutral to innovation. To the extent that this is so, the very existence of the space program as a model of technological achievement may prove more important to the economy than either the multiplier effect of its investment or the "spillover" of its technology.'

My own conclusion is that the space effort of the U.K. should be somewhat larger than it is now. Again, M. N. Golovine wrote, 'However, we must prepare for the day when the UK has a significant space effort engaging the attention of a significant scientific community.' In 1961, I delivered a lecture to the Cranfield Society on the subject, 'Space-Investment or Luxury — Reflections on Aerospace Developments.' I concluded then as I do now in this section of the present paper:

> Regarding research and development in the space fields, I will say this: I do not believe that the nation that has accomplished such outstanding achievements in the science of aeronautics and the arts and techniques of aircraft design and development; the nation that has Jodrell Bank and Calder Hall to attest to her pre-eminence in radio astronomy and nuclear power reactors, respectively, will not also achieve a leadership position in many important aspects of space science and technology.

10. The Future of the Industry

The future of the industry and indeed of aviation in general in Great Britain is, it seems to me, very closely associated with the larger economic problems of the nation. The problem resolves itself into striking a proper balance between what Britain can afford to do and (to put it crudely), what Britain cannot afford *not* to do. This first involves the short-term view, the latter encompasses the long-range future well-being of the country. It seems to me that above all, research and development must not be stifled as in these lies the hope of encouraging innovation in design and, as well, the training of men.

A second factor greatly influencing the future is politics, including need for clearcut and timely decisions on the government level. I must say that when writing this in mid-July, the picture is blurred. From the long-range point of view, I remind you of what Lanchester said in 1908 in *Aerodynamics* regarding aeronautics as the foremost of the applied sciences, and one demanding study in the universities: '(It) . . . ranks almost as a national obligation, for the country in which facilities are given for the proper theoretical and experimental study of flight, will inevitably find itself in the best position to take the lead in its application and practical development. That this must be considered a vital question from a national point of view is beyond dispute.'

The over-all solutions to the great political and international discussions of the present seem to involve several co-operative developments of Britain in association with the nations of Europe — France, West Germany and possibly others, and co-operation with the U.S.A. through purchase of the more complicated aircraft from America, equipped to the maximum extent practicable with British engines and equipment, to supplement research and development and manufacture at home.

The first of the above policies (co-operative developments with European countries) is typified by the Concorde venture in association with France and negotiations centred on the Jet Strike Jaguar fighter and trainer, some type of variable geometry aircraft and discussions of a Counter Insurgency type (COIN), an air bus, a Spey-engined Mirage IV, and a possible V/STOL type with Dornier. Very recently, Anglo-French mergers or close associations are being discussed as possibilities. Mention in the press included Rolls-Royce–Turbomeca and Bristol Siddeley–SNECMA, and in the aircraft field, B.A.C.–Avion Louis Breguet.

In the second of these policies (purchase from U.S.A.) are the F111A (to acquire the range of characteristics envisioned for the abandoned TSR2), the Spey-powered Phantom jet (for R.A.F. and Navy) and A7A Corsair II and the Lockheed 130 cargo aeroplane (for the R.A.F.) with four turboprop power plants. These, of course, are in the area of requirements for military use. One must not neglect, however, the possibly larger potential of civil needs, governed by economic factors of airline operation, of timing to meet competition, and of government attitude on matters of subsidy, exchange and probably other considerations.

Another question bearing on the future is the size of the British industry, both as to number of companies or groups and the attendant degree of competition within the country itself. I have always felt that some competition within a nation is important to development, in addition to competition from outside. This, then, implies that one can go too far in the direction of mergers. It seems to me the present degree of contraction is as far as should be undertaken. This I understand to be two main airframe groups, one containing an engine design and production company, another large independent engine company, a minimum of independent airframe companies and a single helicopter designer and manufacturer.

I have studied the Plowden Report quite carefully and have found some passages with which I agree, such as its analysis of the past and its affirmation of the great national value of the aircraft industry. But on the whole, it does not advocate the steps which it seems to me are so greatly needed to create stability, both for industry and government policy. The latter is, of course, made difficult by frequently encountered changes in key government officials to whom aviation matters are entrusted, a particularly important problem in the announced reorganisation plan.

I do not feel it is appropriate to say much more, other than may be implied in what I have written in general terms. I must record, however, my unqualified agreement with the views of the Council of the Royal Aeronautical Society which it sent to the Minister of Aviation on the 18th of January 1966 and which is given in full in the February 1966 issue of the *Journal*. Here I would emphasise, if I may, the importance of forcefully following up and pressing for adoption of recommendations of this kind. This will be the case especially with the Government officials in the four departments responsible for aviation matters in the new reorganisation scheme.

If one compares Britain, Europe (including Britain), the Soviet Union and the United States on the basis of their populations, gross national product and exports, the conclusion is reached that, on a realistic basis, the great development and production groups are Europe (with Britain), Russia and the U.S.A. Therefore, the co-operative programmes previously mentioned, where Britain joins with France or West Germany, are sound. I understand the Concorde progress is good. The comparison also inclines one to the scheme of some British purchases from the U.S.A. of certain large, complicated, expensive aircraft, now in quantity production, using British engines and substantial U.S. purchases from Britain, as the co-operating factors. But this is not to say (and I emphasise this as strongly as I can) that a sound research and development and manufacturing industry must not be encouraged and maintained in Britain. It surely must. Innovation and technological advancement in the aerospace industry, which has always led in these characteristics, is essential to the future of Britain. It sets the tone of the nation. The all-important by-product of leadership can only be achieved by this means.

What is most needed is timely and decisive action by government and industry. There is nothing so debilitating as indecision. I am indeed pleased that the Society has taken a leading role in these matters, a course so ably advocated by Sir Roy Fedden. The establishment of a highly professional Aerospace Planning Authority, part of the response of the Council of this Society to the Plowden Report, seems to me sound and essential. Presumably, such an Authority would deal with such matters as initiation of design and of feasibility studies, market research, prototype development, assessment of international developments in aviation, and co-operative undertakings. The background for these considerations would be announced requirements for defence, for the air carriers and for general aviation. Planned, long-term programmes are essential.

The Society itself has contributed a great deal to world aviation as I have said already. It should now continue to take a leading role in advising the Government of Great Britain. The efforts of its so-called Working Party and of the report of the Council to the Minister of Aviation are excellent starts. The world will change much in the decades just ahead. The Working Party and Council have wisely said: 'We believe that given the essential environment of wholehearted government encouragement, and the promotion of efficiency in the right way, it is not too late, although nearly so, to re-establish a British initiative which will greatly ease many of the difficulties relating to finance and markets, so depressingly commented upon in the Plowden Report.'

Here I insert two notes occuring to me after attending the dinner of the Society of British Aerospace Companies held on 7th September, 1966, and since viewing the exhibits of the S.B.A.C. Farnborough Display.

One notes with pleasure the favourable economic comparisons with former years made, at the dinner, by the Minister of Aviation dealing with present British aviation production and exports; also the assertions of confidence and determination to achieve continuing progress made by the President of the S.B.A.C.

However, at Farnborough one noted that the aircraft exhibited on the aerodrome were models brought out some five years ago, with the exception of the Britten-Norman Islander and in the static display of the Handley Page 137 executive model now under development. These should hold the line for another five years. But this does emphasise the need to get new models under way in development at once, it seems to me, to forestall a hiatus in deliveries in the 1970–73 period.

11. Conclusion

I count myself among those who view Britain's future in aviation as bright. This is predicated on my hope and belief that the British Government will make the sound decisions needed to warrant this optimism; decisions involving the several points recommended by the Council of the Society and including the continuation of an effective research and development industry. The road has been a rough one for your country. Your tremendous contributions to the winning of two world wars has been shatteringly costly in men and wealth. Your talents and products are at present such as to form a sound basis for continued effectiveness in all areas of aviation — research, development, manufacture, sales and air transport. You have an unsurpassed history in aeronautics, including pioneering achievements, men of stature, aircraft of great utility, introduction of important innovations in many areas and flight achievement records.

Whatever discouragements and tribulations have occurred, and they have been many, I believe the inherent moral fibre of the British people will reassert itself and make it possible to surmount them. I close with excerpts from Tennyson's *Ulysses*:

> I am part of all that I have met
> Yet all experience is an arch wherethro'
> Gleams that untravell'd world whose margin fades
> Forever and forever when I move.

How dull it is to pause, to make an end
To rust unburnish'd, not to shine in use . . .
We are not now that strength which in old days
Moved earth and heaven, that which we are we are,
One equal temper of heroic hearts,
Made weak by time and fate, but strong in will,
To strive, to seek, to find, and not to yield.

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