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BIOGRAPHICAL MEMOIR

OF

GEORGE WILLIAM LEWIS

1882-1948

BY

WILLIAM F. DURAND

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George Lewis,

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The crisis brings forth the man. The significance of aircraft as a means of warfare began to be recognized during World War I. Once the war was over there began to be an insistent demand, on the part of the armed forces, for large expansion of various types of aircraft, both military and naval. This was brought into some form of symmetry and reason by the Coolidge Air Board of 1925.

In the meantime, ten years earlier, in 1915, the Congress had created the National Advisory Committee for Aeronautics with the specific mission "to study the scientific problems of flight with a view to their practical solution."

This body, as then organized, comprised two representatives from the Army, two from the Navy, one representative each from the Smithsonian Institution, the Bureau of Standards and the Weather Bureau, together with five civilians, selected with reference to their training and professional record. The appointments to membership on the Committee were made by President Wilson and the new organization began actively a survey of its problems.

From the first it became evident that progress in the development of new and improved types of aircraft was definitely conditioned on a greatly augmented understanding of the phenomena of aerodynamics, of internal combustion engines and of the materials of aircraft construction. This implied a wide and intensive program of research.

On request the Army, during World War I, had allotted to the Committee an area in its Langley Field, near Old Point Comfort, Virginia, for the construction of a research laboratory. A start had been made comprising an administration and general purpose building, a small wind tunnel with building, an engine research building or shed, and a hangar loaned by the Army with two planes for experimental purposes.

A leader was needed to direct the work of this laboratory, and in 1919 the choice fell on George W. Lewis, a young employe

of the Committee since 1917, whose initiative, energy, tact and winning personality had already strongly impressed all who had come in contact with him.

This was the crisis, and this was the man who appeared, ready and able to undertake the serious responsibilities of the situation.

George William Lewis was born in Ithaca, New York, March 10, 1882, the son of William Henry Lewis and Edith Sweetland Lewis. From Scranton High School he went to Cornell University, graduating in 1908 as a mechanical engineer. He remained at Cornell for two years as Instructor and graduate student, receiving his Master's degree in 1910. He then joined the faculty of Swarthmore College, and in 1917 became Engineer-in-Charge of the Clarke Thompson Research of Philadelphia.

His first contact with the Committee, or the N.A.C.A., as it soon came to be called, was in the summer of 1917 when he appeared at the office of the Chairman, in the Munsey Building, Washington, D. C., with a proposal for a research in connection with the two cycle type of internal combustion engine, which he thought might be of interest to the Committee. The Chairman recognized promise in the project and arrangements were made for carrying it on as a Committee undertaking, with young Lewis in charge.

His handling of this project, together with other matters assigned to him, resulted in 1919, as noted above, in his appointment to take charge of the Committee's laboratory at Langley Field, an appointment which in 1924 was changed to Director of Research for the Committee.

At the time of his appointment in 1919 to take charge of the laboratory, it was only a small organization of some 20 employes, with buildings and equipment as noted earlier. Its growth down through the years has been impressive in the highest degree.

Lewis early recognized that sound progress in aeronautic science and engineering required the fulfillment of four conditions—an adequate understanding of the aerodynamic phenomena involved in flight, a like understanding of the operation of internal combustion engines as a means of propulsion, a

thorough knowledge of the structural materials available and best suited to aircraft construction, with an adequate knowledge of the stresses to which they would be subjected in flight, and finally a definite correlation between the conditions of flight performance as measured in the laboratory, model or full scale, and the actual conditions of flight in free air.

As time went on and he became more effectively adjusted to his job, he advanced boldly and strongly with proposals for new, larger and faster wind tunnels, tunnels for special purposes—for the study of stability and control, for the study of turbulence, for the elimination or reduction to a minimum of the turbulence in the tunnel air stream, thus approaching the conditions of flight in the open air; for studies of gusts and their effect on stability and control, for studies on ice formation and means for its prevention; supersonic wind tunnels for pushing into that great unknown domain lying beyond speeds equal to that of sound in the air through which the plane is flying; equipment for the analysis of engine and propeller performance, combustion and fuels, lubrication and friction, balance and vibration, the materials available for aircraft construction with refined and carefully planned equipment for the study and analysis of stresses and strains in aircraft structures.

And then there was the Instrument Division which concerned itself with the invention, design and construction of a whole line of new and special instruments and appliances for making observations on and measurements of aerodynamic and combustion phenomena.

The proposals made by Lewis for realizing these various purposes met with the approval of the Committee and gained the support of Congress, and the plot of ground originally allotted to the Committee was soon fully occupied with buildings housing new and highly specialized equipment adapted to the study of aerodynamic and combustion phenomena.

With this area fully occupied, a far lying corner of the field was next taken over for extension, and here a considerable number of new buildings was erected and equipment provided, each again intended to meet some special phase of aeronautic research.

Lewis was a pioneer in the design, construction and use of variable density, full scale, refrigerated, free flight, gust and high-speed wind tunnels.

Dr. Lewis lived to see seventeen wind tunnels in operation at Langley Field, of varied dimensions, forms and air speeds, and intended for the exploration of almost every form of aerodynamic problem subject to investigation by such means.

Dr. Lewis found it necessary to concern himself not only with aircraft in the narrow sense of the term, but also with seaplanes and flying boats as well. With such craft there is the water-borne phase and the air-borne phase. The latter could be investigated by the use of the same facilities as for normal aircraft. But for the former, special facilities were required and under his direction there were designed and constructed at Langley Field two seaplane channels, one having a length at first of 2020 feet and placed in operation in May of 1931, later extended to a length of 2960 feet and placed in operation in October of 1931 and a second special purpose channel of length 1800 feet and placed in operation in December 1942.

Here have been carried out long series of investigations and researches relating to the water-borne phases of such craft. They have been of the greatest importance in the development and improvement of such craft and constitute definitely one of the great contributions to aero-hydro science standing to the credit of the N.A.C.A.

The supply of electric power available to meet the demand for power drive at Langley Field was limited and this caused a limitation to needed further expansion. In consequence, in the late years of the decade 1930-40, a serious study was undertaken of the question of another laboratory site away from Langley Field and preferably in the west or on the Pacific Coast. After long and careful investigation, the choice fell on Moffett Field, near Palo Alto, California. The location of the new site at this point resulted from its meeting, adequately, the requirements of the supply of electric power, climate favorable to all-the-year flying weather, and nearness to the great centers of aircraft industry in southern California.

Here a start was made on the construction of laboratory build-

ings and the supply of equipment in the closing years of the decade, and in June of 1944 the Ames * Aeronautical Laboratory was there opened and dedicated to the service of our country, and more widely to the world-wide domain of aeronautic research.

Here is the mammoth full scale tunnel with a throat opening of 40 by 80 feet, a 6 foot by 6 foot supersonic wind tunnel, with eleven others of throat diameters up to 20 feet, and each intended for special phases of aeronautic research.

In the spring of 1939 Lewis made a trip to the chief centers of aeronautic research in Europe. He was especially impressed with the character and extent of the work which he saw there directed toward improvement in the aeronautic engine. These impressions strengthened and confirmed his own feelings on this subject, and on his return to Washington he recommended most strongly to the Committee the development of a laboratory for like purposes in the United States. This important step by Lewis was a natural expression of his earlier training. He was a mechanical engineer by education and naturally sensitive to the part which the aeronautic engine was then playing as the agency for the supply of power for the propulsion of the plane.

He carried the Committee with him in his recommendation and a committee was appointed to consider the question of site. After a careful study of some 72 proposed locations, a site in Cleveland, Ohio, was selected as having the best combination of the following features—proximity to a large flying field; proximity to industrial, technical and scientific centers; living and working conditions; availability and cost of power and water services, and area available for future expansion.

Here in 1940 a start on construction was made and in 1942 the laboratory was opened and work on a wide variety of problems relating to the internal combustion engine for aeronautic purposes was promptly under way.

Here are to be found, among six wind tunnels of varying sizes and wind speeds and for a variety of purposes, an altitude tunnel capable of simulating flight conditions as regards air

*Named in honor of Dr. Joseph S. Ames, President of Johns Hopkins University, and Chairman of the N.A.C.A. for 12 years.

density and temperature up to altitudes of 50,000 feet and where aeronautic engines can be studied in operation under accurately controlled conditions with air stream speeds up to 500 miles per hour.

An 8 foot by 6 foot supersonic tunnel, believed the largest supersonic wind tunnel in the world, is located here. There is also an icing tunnel for research on the icing of aircraft components.

It is appropriate to add at this point that, at a later time, the Committee gave to this laboratory the name "Lewis Flight Propulsion Laboratory," in honor of Dr. George W. Lewis and in recognition of the part which he played in its design and construction.

At each of these laboratories a special feature was made of a Flight Research Division. Lewis held it as a cardinal principle that laboratory results, especially if to model scale, before being turned over for use in the armed forces or in industry, must be proven in the air. In accordance with this principle, at each of the three laboratories he directed the organization of a strong flying division with skilled pilots, scientists, engineers and technicians, for the final checking of laboratory results under the conditions of actual flight in the air.

This required the invention, design and construction of a wide variety of special instrumental equipment for making and recording the observations while in the air. This special activity, it may fairly be said, has led the world of aeronautic research, especially in actual flight, and it traces immediately to Lewis and his strong and enthusiastic support of the instrument division in the various laboratories.

An important feature of the activities of the N.A.C.A. was the policy, fostered by Lewis from the first, of research contractual relations with technical institutions of higher learning. From his background, both as educator and research worker, he was in a position to realize clearly the mutual advantages to be gained by cooperative relations with technical educational institutions. The Government gained the services of talented personnel, not otherwise available, and often of specialized equipment. The institution gained in the extension of its range

of problems for advanced work and in a sense of partnership with the Government in dealing with its technical and scientific problems. A further benefit resulted to the Committee from the interest awakened in bright young students through contact with aeronautics problems, an interest which furnished a field for the selection of additions to laboratory personnel.

The relation was worked out on the basis of a simple form of contract calling for a report at a specified time on a carefully defined problem. This program of educational contracts has grown in magnitude and importance from an annual total of some \$5,000 for four or five contracts to an annual total of \$600,000 for some 35 contracts with the same number of educational institutions. In all a total of some 400 contracts with 50 institutions have produced results of great importance and of definite value. As a less tangible benefit, these contracts have served to bring more closely together teaching staffs and students in aeronautic engineering on the one hand with Government personnel engaged in aeronautic research on the other—undoubtedly to the advantage of both.

A cardinal feature of the Lewis policy in carrying on the work of the Committee was his controlling sense of obligation to serve the needs of the armed services. From the first he developed cordial and cooperative relations with the air branches of the Army and of the Navy. The many problems which arise in the course of the development of a new design were freely submitted to the Committee for study and advice, and the best efforts of the Committee were, through Lewis and his laboratories, brought to bear on these problems. In return, the services furnished to the Committee aircraft and engines for fundamental research, or other materials or equipment to augment their available research facilities. Among such items, the largest was an allotment of \$4,500,000 for the construction of the 6 foot by 6 foot supersonic wind tunnel at the Ames Laboratory.

It may be here noted that the Executive Orders of President Roosevelt establishing the great war research organizations, O.S.R.D. and N.D.R.C., excepted aeronautic research from the fields to be covered by them, thus leaving the N.A.C.A. un-

affected and free to pursue its way without outside interference or direction. This is a striking indication of the confidence in high places enjoyed by the N.A.C.A. and its Director of Research, George W. Lewis.

Two or three illustrative cases may be cited of important results developed by the N.A.C.A. laboratories—for the first, the Low Drag Wing.

It had long been known that the boundary layer of air flowing adjacent to the wing was, during the early part of its flow, laminar in character, becoming more and more turbulent and confused toward the latter part of its contact with the wing. It was also known that the frictional drag due to the turbulent flow was much greater than that due to the laminar flow. It appeared then, as an obvious objective, to extend the domain of the laminar flow and restrict that of the turbulent flow.

Various attempts had been made to realize these ends by varying the shape of the cross section of the wing, but with no satisfying results. Theoretical studies had shown that turbulence in the air first meeting the wing would promptly induce turbulence in the boundary layer. Existing wind tunnels all had turbulence in the air stream, but in free air, in actual flight, the turbulence in the air meeting the wing is usually negligibly small.

The first step in the study was therefore to design and build a wind tunnel in which the air stream should be in a condition, as regards turbulence, as nearly as possible similar to that in free air. This was realized at Langley Field.

Tests of airfoils in this tunnel showed that the extent to which laminar flow could be carried beyond the leading edge was extremely sensitive to the form of the cross-section of the foil. In the meantime, theoretical studies had shown that the change in normal pressure along a wing surface was dependent on the curvature of the surface and this suggested the control of the pressure by the curvature. A wing section was then designed to have a pressure distribution suited to the promotion of laminar flow over the surface. This section was tested in the turbulence free tunnel with most promising results. The drag of the wing was reduced to about one-half its value with turbulent flow.

Before passing on these astonishing results, in view of the unknown effect of the peculiarities of shape in this wing section on stability, control, take-off and landing, Lewis directed the Flight Test group to take over the problem of giving this form of wing section a practical test in flight. This was successfully carried out and showed the new form to be adapted to the conditions of full-scale flight. A wing of this form was given to the Mustang Army Fighter and enabled that plane to attain a speed well beyond anything heretofore considered possible for a plane of that power.

Without detailed description, note may further be made of engine cowling, flapped wings and tricycle landing gear, all of which are now in general use, as further instances of devices and forms of construction tracing directly to the N.A.C.A. and developed under the direction of Dr. Lewis.

Reference has already been made to the cordial and cooperative relations established by Lewis with the armed services. They knew him to be wholly dependable regarding confidential matters, and they had implicit confidence in his caution and good judgment as well as in his untiring zeal in attacking their problems and coming back promptly with effective solutions.

An instance may be given of a specially confidential problem given to Lewis by the Army Air Service during a critical period in the late World War.

Strategic bombing, deep in enemy territory depends on fighter escort for the bombers. The new type of fighter plane counted on for this service seemed on the verge of failure to meet requirements. The situation was put up to Lewis by Gen. H. H. Arnold, Head of the Army Air Service, as one of the highest importance. Lewis immediately organized an all-out plan of campaign to discover the cause or causes of the trouble and find a remedy. This involved aerodynamic research at the Langley and Ames Laboratories with engine investigation at Cleveland and with flight research at all three laboratories, to test out in flight proposed remedial measures. These efforts met with success and the bombing program was laid on as planned.

These are only a few instances of many results of world-wide import, developed by research teams under the inspiration

and guidance with which Lewis effectively directed the members of his organizations.

A special feature of reports on such work, and of all reports on investigation and research, was the modesty and self effacement shown by Dr. Lewis. Literally, hundreds of specific problems relating to military and naval aircraft were attacked and solved by research teams working under his direction. But of all the reports on such work there is no signature by him. The reports themselves were signed by the man actually in immediate charge of the work and were transmitted by Lewis as coming from the Committee. At this point it may be of interest to note that the total number of documents published by the N. A. C. A. during the period covered by the services of Dr. Lewis amounts to 7,826, covering the entire domain of aeronautic science, and constituting what is believed to be an output of material relating to aeronautics unparalleled for any like period elsewhere in the world.

George Lewis was keenly sensitive to the significance and bearing on his own work of closely related sciences. For example, meteorology and aeronautics are both concerned with the atmosphere and its phenomena, and from the start of his work in charge of N. A. C. A. research, he cultivated the most cordial and friendly relations with the Weather Bureau. He was keenly alive to the utilization of meteorological knowledge and the services of the Weather Bureau in the advancement of aeronautic science.

The Chief of the Weather Bureau closes a warm appreciation of Dr. Lewis with the words :

“Dr. Lewis personally was always considerate, stimulating and helpful in his relationships with the Weather Bureau.”

During the 28 years of his supervision of the research work of the N. A. C. A., Lewis saw the birth of aeronautic research and played a major role in its growth to its present commanding importance, as evidenced by the role of aircraft in World War II, and the post-war developments in military and naval aircraft and in civil air transport. Under his direction it may be fairly claimed that the N. A. C. A. has made scientific and tech-

nical contributions of incalculable value to the United States and to the world at large.

As an indication of the magnitude of its growth from its start in 1915 to the present time, note may be made that its first annual appropriation was for \$5,000 while for 1945 it amounted to some \$45,000,000 and for 1949 the budget stands at \$48,000,000, while the number of employees reached a maximum in August of 1945 of 6,829.

The task of carrying on this great work to still higher levels must now be assumed by others, but Lewis will always be remembered as the great pioneer who blazed the way during his direction of the work of the National Advisory Committee for Aeronautics from 1919 to 1947.

In personality, Lewis was in the highest degree friendly, modest and retiring in disposition. He made friends of those about him—of the employes of the laboratories, of his associates in administrative work, of the officers of the Army and Navy with whom he came continuously in contact, and with Members of Congress with whom he had often to deal in connection with questions of Committee policy and appropriations of money to carry out the Committee's plans.

His keen interest in the work of the laboratories led him to make frequent visits to them. On such visits it was his custom to contact the employes in small groups, discuss with them their work, help with suggestions for the meeting of difficulties and above all to commend and encourage them. Such an attitude on his part naturally made warm friends of the employes.

Shortly after his relief as Director of Research (1947) and appointment as Consultant (due to a serious break in health), his associates drew up a fine appreciation, published in the *U. S. Air Service* for September 1947, from which the following extract is made.

"During the past 28 years Dr. Lewis has recruited and trained the research staff of the N. A. C. A. from a handful of workers into the present force of 6,000 people. He planned and carried through the unique research facilities of the Langley Memorial Aeronautical Laboratory, at Langley Field, Virginia, the Ames Aeronautical Laboratory at Moffett Field, California, and the

Flight Propulsion Research Laboratory at Cleveland, Ohio. He is responsible for the introduction, in aeronautic research, of variable density wind tunnels, free-flight tunnels, and high speed wind tunnels, some approaching and some exceeding the velocity of sound. He has led an outstanding technical staff from which have come a succession of advances in aeronautical science resulting in technological improvements in American aircraft of great significance to both civil and military aeronautics."

It was the same with officers of the Army and Navy with whom he was in continual contact in connection with problems on which they wished the help of the Committee. His genial helpful attitude toward them and toward their problems made for warm friendship not only with him, but helped greatly to build up and maintain a friendly entente between the armed services and the Committee as such.

The U. S. Air Service itself closed a most warmly appreciative tribute to Dr. Lewis with the words:

"We know of no man who can exactly fill the place in the American aeronautic picture which Dr. Lewis occupied so capably and entertainingly for three decades."

The professional make-up of Lewis was such that he would not permit himself to make an important decision about personnel or about a problem without exhausting the sources of information regarding the subject matter in question. With laboratories spread from Virginia to California, this resulted in a very great amount of travel and innumerable conferences with leaders and key men, with research teams and with workers individually. He also felt it incumbent on him to keep in intimate touch with the newest trends in the art through visits to military and naval flying centers, to aircraft and engine factories, and, as noted elsewhere, to Europe.

This professional strategy was of definite value to the Committee and to its laboratory as long as the research staff was small or moderate in size. Before Pearl Harbor there were some 600 people at the Langley Laboratory. By V-J Day there were upwards of 6000 in three great laboratories stretching across the country. This insistence on knowing things for himself made it difficult for him to delegate authority

to others, and in the end the burden became too great for human endurance. Without a vacation during the five years of World War II, he drove himself beyond the point of human endurance and in 1945 his heart gave warning of serious impairment. The condition grew no better and in 1947 he was relieved of his task as Director of Research to become a Consultant to the Committee. As such he continued to come to his office regularly for a half day, taking the afternoon for rest, often with a briefcase well stocked with reports for examination or problems for study.

The impairment to his physical stamina was, however, beyond repair and on July 12, 1948 he died at his summer home near Scranton, Pa.

George W. Lewis was a natural leader of men. He was endowed with the qualities of mind and character which admirably fitted him to lead American aeronautical research over the critical period of the years 1919-1947, during which aircraft came into their own as agencies of war, both military and naval, as well as for civil air transport.

As Director of Research for the N. A. C. A. he led an organization which grew from small beginnings to over six thousand people. This great aggregate of research teams in widely diversified fields of applied science and engineering, he largely recruited and trained during the 28 years of his service as director of their work. Likewise the research equipment of the three great laboratories was planned chiefly by him and his plans were presented so persuasively and effectively to the Congress that the money needed for their construction and equipment was promptly appropriated to the aggregate sum of about one hundred million dollars.

On matters of broad policy, Lewis was, of course, under the direction of the Committee. The members of the Committee, non-salaried and giving, for the most part, only a few hours at intervals to the work of the Committee, needed a man of the type of Lewis as their chief executive. He was ready to act in all matters in accordance with the decisions of the Committee, and was tireless and zealous in carrying out the broad programs of action as laid down for him.

He became well adjusted to governmental procedure, budget control, Congressional hearings, etc., and in such hearings and conferences carried himself so well and spoke so clearly and convincingly regarding the significance and importance of the proposals in question that he may properly be credited with a strong influence in determining the generous supply of funds for the needs of the Committee's plans and objectives.

George W. Lewis made for himself a unique place in the development of aeronautic science and engineering in the United States, and more widely in the world at large. His opportunities were great and he measured up to them. His name will live on always as the great leader who organized and directed the operations of the three great laboratories, the work of which has played so important a part in bringing aeronautic science and engineering from its feeble condition at the close of World War I to its commanding status at the close of World War II.

It is a proud record and one in which his family and friends may take just pride.

Dr. Lewis married Myrtle Harvey on September 9, 1908. He is survived by his wife, five sons and a daughter—Arman Kessler, Alfred William, George William, Jr., Harvey Sweetland, Leigh Kneeland, and Mrs. Myrtle Norlaine Senasack.

During the course of his life he was the recipient of many honors and of recognition in high places.

In 1934 he was appointed by Secretary Newton D. Baker to the Special Committee on the Army Air Corps (Baker Board). In 1937 he was appointed by the President a member of the Inter-American Aviation Conference in Peru, and in 1941 to the U. S. National Committee to deal with Inter-American aviation matters. During World War II he served by Presidential appointment on the National Inventors Council. In 1948 he received the Presidential Medal for Merit and O. B. E. (Hon.) from Great Britain.

In 1936 he was awarded the Daniel Guggenheim Medal "for outstanding success in the direction of aeronautical research," and in 1944 the Spirit of St. Louis Medal of the American Society of Mechanical Engineers. In 1939 he was chosen by

the Royal Aeronautic Society of Great Britain to deliver the Wilbur Wright lecture in London.

In 1934 Norwich University conferred on him the degree of Sc. D. (Hon.), and in 1944 the Illinois Institute of Technology, the degree of Eng. D. (Hon.).

He was a life member of the National Aeronautic Association and for many years served on its board to homologate aviation records. He also served on boards or committees to make aeronautical awards; notably for the Brewer Trophy, Collier Trophy, Guggenheim Safe Aircraft Competition, Guggenheim Medal, Wright Medal, Manley Memorial Medal.

He was Past President and Honorary Fellow of the Institute of Aeronautical Sciences, Member of the Society of Automotive Engineers, American Society of Mechanical Engineers and the American Philosophical Society. He was elected to the National Academy of Sciences in 1945. He was a member of the college fraternities Sigma Tau and Sigma Xi.

BIBLIOGRAPHY

For reasons elsewhere noted, the number of signed publications of Dr. Lewis bears no relation to the magnitude of his scientific and productive work. His principal signed publications are as follows:

The Measurement of Viscosity and a New Form of Viscosimeter. Paper presented at the meeting of the A. S. M. E., April 11-14, 1916 by H. C. Hazen and G. W. Lewis. A. S. M. E. Transactions, Vol. 38, 1916, pp. 383-405.

Air Flow Through Poppet Valves, (with E. M. Nutting), N. A. C. A. Technical Report No. 24, 1918.

Research, the Price of Survival, Western Flying, Sept. 1928, pp. 72-73.

Cowling and Cooling of Radial Air-Cooled Engines, S. A. E. paper, April 10, 1929.

The Contribution of the Wright Brothers to Aeronautical Science and Engineering, U. S. Air Service, May, 1938.

The Value of the Wind Tunnel in Aeronautic Research and Design. Address delivered at the dedication of the Wright Brothers Memorial Wind Tunnel at the Massachusetts Institute of Technology. U. S. Air Service, Vol. 23, No. 10, October 1938.

Some Modern Methods of Research in the Problems of Flight. Wilbur Wright Memorial Lecture, 1939. Journal of the Royal Aeronautical Society, October 1939.

Contributions of Wilbur and Orville Wright to Aeronautical Science. Address at dinner honoring Orville Wright on the 40th Anniversary of the first flight of the Wright Brothers at Kitty Hawk, N. C., Dec. 17, 1903. Hotel Statler, Washington, D. C., December 17, 1943. U. S. Air Service, December 1943.