AIRCRAFT

by Evan J. David

Passenger
Freight
mail
agriculture
Seed planting
Fruit tree spraying
Crops

AIRCRAFT

Courtesy of Aerial Age Weekly.

The NC-4 flying-boat, showing the arrangement of the motors.

It is equipped with four Liberty 450 h.-p. engines. It flew from Rockaway, New York, to Plymouth, England, commanded by Lieutenant-Commander A. C. Read, U. S. N.

AIRCRAFT

ITS DEVELOPMENT IN WAR AND PEACE AND ITS COMMERCIAL FUTURE

BY

EVAN JOHN DAVID

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TO

ALL WHO HELPED ME TO OBTAIN
AN EDUCATION

PREFACE

THE object of this book is to explain the fundamental principles of aeronautics and to point out the historic development of both the heavier-than-air and the lighter-than-air craft. The treatment is simple. Technical phrases have been avoided wherever possible. Emphasis has been laid on the changes in the design or construction of aeroplanes and dirigibles, which show the evolution of flight and aircraft from early experiments with balloons and gliders to the transatlantic flights of the NC-4, the Vickers "Vimy" Bomber, and the R-34. Only those things have been singled out which indicated a step forward in the science of aeronautics. Emphasis is placed upon the commercial accomplishments of the aeroplane and the dirigible, and many of the present uses and future possibilities of aircraft as a commercial vehicle have been pointed out.

I am indebted to many sources for the information contained herein. Mr. Henry Woodhouse, the well-known aeronautical authority and editor of *Flying Magazine* and author of the text-books on military and naval aeronautics, has been the source of much of my information, and the volumes of *Flying Magazine* have supplied me with much historic data. *Aerial Age Weekly* and Mr. G. Douglas Wardrop, the managing editor, have also been very helpful. The British periodicals *Flight*, *The Aeroplane*, and *Aeronautics* have furnished me with many facts regarding British aircraft. The articles of Mr. C. G. Grey, the editor of *The Aeroplane*, dealing with the growth of heavier-than-air machines, and of Mr. W. L. Wade on lighter-than-air craft, have been the source of many of the facts regarding the evolution of aircraft. Many other aeronautical authorities have afforded statistics, facts, etc.

EVAN JOHN DAVID.

NEW YORK, August 12.

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AIRCRAFT

CHAPTER I

THE FIRST BALLOONS

THE DEVELOPMENT OF THE FREE BALLOON—THE CAPTIVE BALLOON—THE DIRIGIBLE—THE BLIMP—THE KITE BALLOON

EVER since man first noticed the flight of a bird through the air he has longed to fly. How often, during the countless ages of unrecorded time, he attempted to soar above the earth we cannot know. That he tried often and failed always we have ample proof; indeed, the phrase, "might as well try to fly," expressed the acme of the impossible. That many scientific men for nearly two thousand years believed that eventually a mechanical means could be devised to lift man off the ground like the wings of a bird and to propel him through the air, we have evidence in their writings and the history of their lives.

Ancient mythology is full of stories of the heroes who attempted to imitate the flight of the fowls of the air. The earliest efforts of the aeronauts themselves appear to have been along this line. Naturally many of the experimenters lost their lives. A mere enumeration of their names would take too much space for this volume.

Perhaps these struggles to use wings suggested to the tight-rope walker Allard the possibility of performing a novel stunt. At any rate, in 1660 he successfully made several glides for exhibition purposes in France. Seventeen years later another Frenchman named Bosnier also made spectacular glides. These experiments, however, led to the invention of the glider, which finally developed into the aeroplane or the heavier-than-air machine.

A glider consists of a rigid rectangular plane constructed of frail framework, similar to a kite, and covered with linen or cloth, much like the wing of a modern aeroplane. This plane surface might be a dozen or more feet long and two or more feet wide. The early experimenters jumped off hills with this plane fastened to their arms or shoulders, and balancing themselves in the centre, glided several feet over the ground, keeping their equilibrium by means of their feet. Later two planes fastened together like a box-kite were employed, with the flier stretched out on his stomach on the lower planes. Lillienthal and even the Wright brothers learned most about longitudinal and lateral balance by gliding on gliders of the last type. A great deal of sport can be had with these man-carrying kites even to-day.

The experiments of the two French brothers, Joseph and Jacques Montgolfier, with paper bags inflated with hot air started a new period of development in aeronautics, for the paper bags suggested the silk ones, which were, of course, much lighter. On September 19, 1783, they gave an exhibition before the royal family at Versailles.

The authors of the first ascension, the first actual step in the conquest of the air, were two Frenchmen, Marquis d'Arlandes and Pilatre de Roziers, who made the first ascension near Paris on November 21, 1783. From that time on free ballooning became a very popular sport. The escaping of the hot air or gas, forcing the balloon to descend too suddenly, led to the invention of the parachute as a means of descending slowly from the collapsing bag. The possibility of using this type of balloon for observation purposes was realized by the French, and the first recorded battle that the captive balloon was employed in was at Fleurus June 26, 1794, thus supplying "aerial eyes" for the French army to observe the movements of the Austrians.

The free balloon was, however, entirely at the mercy of the winds, and the captive balloon could not be moved about readily, so that it was thus limited in its sphere of observation, except when attached to some movable conveyance. This showed the necessity of inventing some means of propulsion and steering. The first experiments were attempts to row ordinary spherical balloons, as you would a boat, but the earliest record of any definite progress being achieved in forcing a lighter-than-air craft through the air was the experiment in France of two brothers named Robert in 1784. They constructed a melon-shaped balloon, 52 feet long and 32 feet in diameter, made of proofed silk. The gas employed was pure hydrogen. Underneath this envelope was suspended a long, narrow car, in general idea not unlike that used on some modern airships; and three pairs of oars with blades made like racquet-frames covered with silk, and a rudder of similar material, were the only implements for navigation.

The two brothers and their brother-in-law went up in the apparatus and succeeded in describing a curve of one kilometre radius, which showed, at any rate, that they could deviate slightly from the direction of the feeble wind then prevailing.

The development of the steam-engine was potent with suggestions for aerial navigation of a dirigible. Thus, on December 24, 1852, Henry Gifford, another Frenchman, first ascended in a dirigible balloon. It was spindle-shaped, 143 feet long and 39 feet in diameter. It was driven by a 3 horse-power steam-engine and an 11-foot screw propeller. He went out from the Hippodrome in Paris and made six miles per hour relative to the air and several successful landings. This was the first recorded dirigible flight.

A decade later, Tissandier, with a spindle-shaped balloon, much on the lines of those of his predecessors, succeeded in reaching a speed of eight miles an hour with the aid of an electric motor and a bichromate-of-potash battery.

Captain Charles Renard brought the airship another stage toward realization by building an envelope with a true stream-line. The method of suspending the car was of the type adopted by later builders, namely, to place an enormous sheet over the back of the airship and to attach suspensory cords to its edges. This airship had a cubic capacity of 66,000 feet, and was kept rigid by means of an internal air balloonet or interior gas-bag which was confined to a definite shape by an outer framework or cover. This balloonet was kept full by a fan-blower coupled to the motor.

The car was 108 feet long, and really served as a spar employed in later airships of what became known as the semirigid type.

An electric motor was installed, weighing 220 pounds, which developed 9 horse-power. The battery composed of chlorochromic salts, delivered one shaft horse-power for each 88 pounds, and this great weight seriously handicapped the performance of the airship. The first trials were made in 1884, and apparently within the limits of its propulsive power the airship was an unqualified success, so far as navigation was concerned. On one occasion it flew around Paris at an average speed of 14½ miles an hour.

As early as 1872 Herr Hanlein, in Germany, built an airship of quite reasonable proportions, propelled by a 6 horse-power Lenoir gas-engine. Apparently the engine was run on gas from the envelope. A speed of 10 miles an hour or so was achieved.

In 1879 Baumgartner and Wolfert built an airship with a Daimler benzine motor. An ascent was made at Leipzig in 1880, but owing to improper load distribution the vessel got out of control and was smashed on the ground.

The first rigid dirigible with aluminum framework was built by an Austrian named Schwartz in 1897.

This was the prototype of the Zeppelin, and no practical rigid lighter-than-air ship could now be lifted by hydrogen unless it had an aluminum framework.

The invention of the gasoline engine was another tremendous advantage to the Zeppelin.

M. Santos Dumont built an extraordinary collection of small airships during a period of several years commencing in 1898. His first effort was a cylinder of varnished Japanese silk, 82½ feet long and 11 feet in diameter, with pointed ends, which gave it a capacity of about 6,300 cubic feet. It was fitted with the usual internal air balloonet and a 3½ horse-power motorcycle engine weighing 66 pounds. The engine was fitted to an ordinary balloon basket, which hung beneath the envelope and drove a two-blade propeller. The pilot also sat in the basket. The poise of the vessel was controlled by shifting weights, and steering was effected with a silk rudder stretched over a steel frame. In September, 1898, this miniature airship left the Zoological Gardens at Paris in the face of a gentle wind, and performed all sorts of evolutions in the neighborhood.

M. Dumont's No. 5 was fitted with a four-cylinder, air-cooled motor driving an enormous propeller of 26 feet in diameter, which gave a thrust of 120 pounds at 140 revolutions per minute. There is, however, some difference between this number of revolutions and the 1,400 per minute now generated by all the standard aeronautical motors. Among other novelties water ballast was used and piano wires replaced the old type suspension cords.

No account of the lighter-than-air machine would be complete without mentioning the man after whom the Zeppelins were named. As a matter of fact Count Zeppelin added nothing strikingly new to his airships —he simply made them much larger than any of their predecessors; thus increasing the net lifting power and multiplying the number of engines and the horse-power.

Count Ferdinand von Zeppelin first began to experiment in 1898. His first rigid dirigible was 410 feet and the gas-bags contained 400,000 cubic feet of hydrogen, and the net lifting power, after allowing for the engines, fuel, gear, etc., was about two tons. The framework was of aluminum latticework divided into seventeen compartments, fifteen of which had gas-bags. Two cars were attached and in each was a 16 horse-power German Daimler gasoline motor driving two propellers, and the machine gained a speed of 15 miles an hour, which was far in advance of any airship of that period.

By this time practically all the fundamentals of construction of dirigibles had been incorporated in these airships. Further refinements were made, more engines and balloonets added, and the length of the dirigible and the volume of hydrogen gas used for inflation was increased, as was also the horse-power, but nothing more in the way of radical changes was employed to the end of the Great War. Therefore a description of the Zeppelin which was brought down in England will serve as an excellent idea of the size of these mammoth airships.

The Zeppelin forced to land in Essex measured from 650 feet to 680 feet in length and measured 72 feet across its largest diameter. The vessel was of the stream-line form, with a blunt, rounded nose, and a tail that tapered off to a sharp point. The framework was made of longitudinal latticework girders, connected together at intervals by circumferential latticework ties, all made of an aluminum alloy resembling duraluminum. The whole was braced together and stiffened by a system of wires, arrangements being provided by which they could be tightened up when required. The weight of the framework is reckoned to be about 9 tons, or barely a fifth of the total of 50 tons attributed to the airship complete with engines, fuel, guns, and crew. There were 24 balloonets arranged within the framework, and the hydrogen capacity was 2,000,000 cubic feet.

A cat-walk, an arched passage with a footway nine inches wide, running along the keel enabled the crew, which consisted of twenty-two men, to move about the ship and get from one gondola to another. This footway was covered with wood, a material which, however, was evidently avoided as much as possible in the construction of the ship. The gondolas, made of aluminum alloy, were four in number; one was placed forward on the centre line, two were amidships, one on each side, and the fourth was aft, again on the centre line.

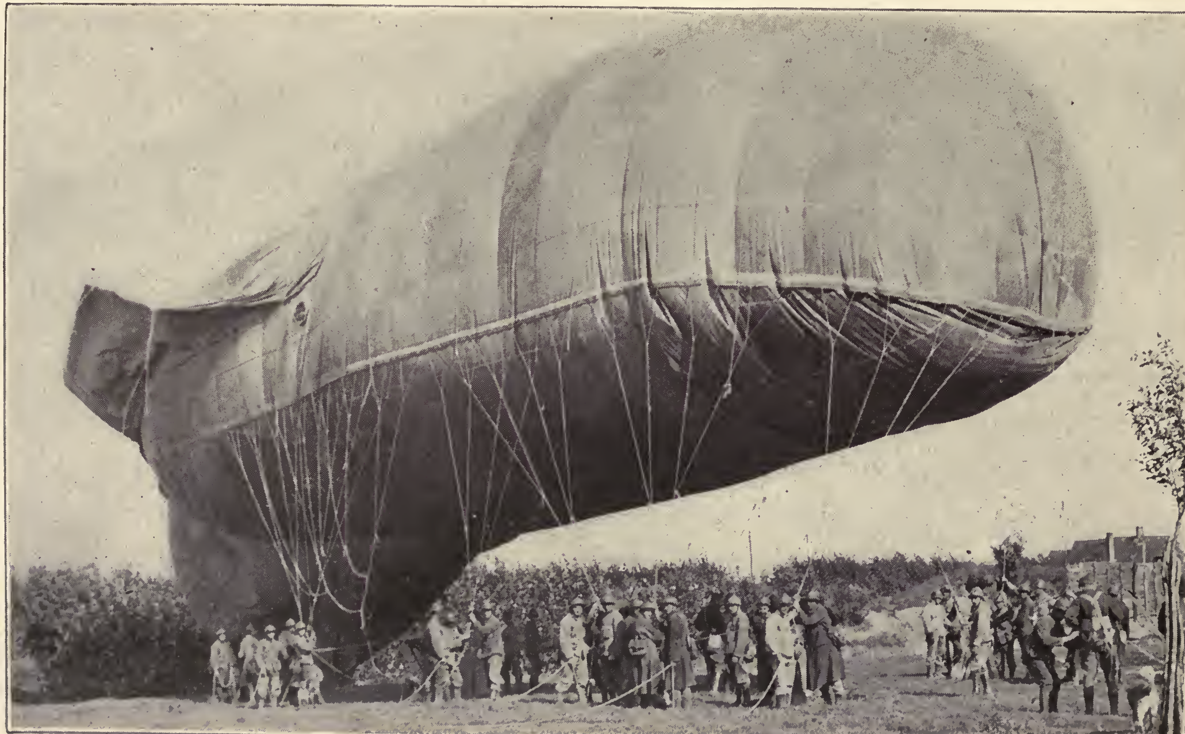
The vessel was propelled—at a speed, it is thought, of about sixty miles an hour in still air—by means of six Maybach-Mercedes gasoline engines of 240 horsepower each, or 1,440 horse-power in all. Each had six vertical cylinders with overhead valves and water cooling, and weighed about 1,000 pounds. They were connected each to a propeller shaft through a clutch and change-speed gear, and also to a dynamo used either for lighting or for furnishing power to the wireless installation. One of these engines with its propeller was placed at the back of the large forward gondola, two were in the amidships gondolas, and three were in the aft gondola. In the last case one of the propellers was in the centre line of the ship, and the shafts of the other two were stayed out, one on either side. With the object of minimizing air resistance the stays were provided with a light but strong casing of two or three ply wood, shaped in stream-line form. The gasoline tanks had a capacity of 2,000 gallons, and the propeller shafts were carried in ball bearings. The date, July 14, 1916, marked on one of them, is thought to indicate the date of the launching or commissioning of the vessel.

Forward of the engine-room of the forward gondola, but separated from it by a small air space, was first the wireless operator's cabin and then the commander's room. The latter was the navigating platform, and in it were concentrated the controls of the elevators and rudder at the stern, the arrangement for equalizing the levels in the gasoline and water tanks, the engine-room telegraphs, and the switchboard of the electrical gear for releasing the bombs. Provision was made for carrying sixty of the latter in a compartment amidships, and there was a sliding shutter, worked from the commander's cabin, which was withdrawn to allow them to fall freely. Nine machine-guns were carried. Two of these, of 0.5-inch bore, were mounted on the top of the vessel, and six of a smaller caliber were placed in the gondolas—two in the forward, one each in the amidships ones, and two in the aft one. The ninth was carried in the tail.

The separate gas-bags were a decided advantage over the free balloon and earlier airships which carried all the gas in one compartment, for if the latter sprang a leak for any reason it had to descend, whereas the Zeppelin could keep afloat with several of the separate compartments in a complete state of collapse.

Since the Zeppelin, like all airships, is buoyed up by hydrogen gas which is .008 lighter than air, the dirigible was sent up by the simple expedient of increasing the volume of gas in the envelope until the vessel arose. This was done by releasing the gas for storage-tanks into the gas-bags. In order to head the nose up, air was kept in certain of the rear bags, thus making the tail heavier than the forward part, which naturally rose first. Steering was done by means of the rudder or the engines, or both, and the airship was kept on an even keel by use of the lateral planes. The airship could be brought down by forcing the gas out of the bags into the gas-tanks, thus decreasing the volume and by increasing the air in the various compartments.

This airship had a flying radius of 800 miles and could climb to 12,000 feet, and could carry a useful load of four tons and could remain in the air for fifty



Courtesy of Flying Magazine.

Observation balloon about to ascend.

These balloons were stationed at intervals along the battle-fronts.

hours. Without a doubt it is one of the largest rigid dirigibles ever built.

Owing to the great amount of material used, the immense cost, and the time necessary to construct a Zeppelin, under the urgent demands of war, the British built and developed a small rigid dirigible measuring between 200 and 250 feet in length, buoyed up by two balloonets, one front and back, and carrying a fuselage and one aeromotor, and propeller situated directly under the cigar-shaped airship. These vessels made about fifty miles an hour, carried two men, were fitted with wireless, and made excellent scouts over the North Sea and waters contiguous to allied territory, looking for submarines. These air-vessels were called Blimps.

The kite balloon was cigar-shaped and non-rigid, with only a basket suspended underneath. It was attached to a rope and was lifted by the gas and the wind which passed under the fins, which extended from the sides near the rear. It combined the principle of the free balloon and the man-lifting kites.

These balloons were used very extensively in the Great War for observation purposes. Suspended at the end of a cable attached to a donkey-engine or a windlass at an altitude of 3,000 feet, they afforded the best observation for artillery-fire, and by means of the telephone in the basket the observer could keep headquarters well informed of troop movements within a radius of many miles.

Naturally it was the special delight of the aeroplanes to dive down on these stationary balloons and by means of incendiary bullets to ignite the gas. It was dangerous work for the heavier-than-air machines, for all the way down the antiaircraft guns blazed away. It was also dangerous work for the observers in the imprisoned balloon, who often had to jump with their parachutes in order to escape.

Thus by 1918 man had devised an aircraft that could propel him through the air faster than the eagle, farther than the sea-gull, and soar aloft higher than the lark! No wonder he felt that no mechanical feat was impossible.

CHAPTER II

THE AEROPLANE

EXPERIMENTS WITH PLANES—LILLIENTHAL'S GLIDER—LANGLEY'S AERODROME—SUCCESS OF THE WRIGHTS—FIRST AEROPLANE FLIGHTS

THE evolution of the heavier-than-air flying-machine, like that of the lighter-than-air, covers a long period of time, and was fraught with many difficulties and dangers. For ages many scientific men played with the idea, but owing to the lack of motive power light enough to be mounted on a glider yet supplying sufficient strength to drive a set of planes through the air at 45 miles an hour, very little progress was made until the perfection of the steam-engine and the development of the gasoline motor. Indeed, such things as lateral and longitudinal balance of planes, as well as steering by rudder, could only be worked out to a successful conclusion by man-carrying gliders moving at a sufficient velocity to keep them off the ground. Since no mechanical device driven by man could supply this want, the science lacked practical development until the last quarter of a century.

Perhaps the acrobatic tight-rope walker Allard, in 1660, was the first to make long glides during an exhibition of his profession. But nothing of material advantage to the science was accomplished.

In 1809 Sir George Cayley, an Englishman, planned an aeroplane with oblique planes, resting on a wheeled chassis, fitted with propellers, motors, and steering devices. The machine was never built.

In 1843 another Englishman, Samuel Henderson, designed and patented an "aerial steam carriage," which was to be an aeroplane of immense size to be used for passenger carrying. Like the former it was never built.

M. Strongfellow, another Englishman, designed a triplane, which he fitted with a tail and two propellers. A triplane differs from a biplane only in that a third plane is superimposed over the second plane at the same distance as the second plane was above the first or monoplane. This model was shown at the exhibition of the Aeronautical Society of Great Britain in 1868. As in the case of previous inventors, nothing in this model indicated that he had any comprehension of the principles of stability or knowledge of the lifting capacity of surfaces, or the power required for dynamic flight.

In 1872 a French inventor, named Alphonse Penaud, constructed a small monoplane. It was only a toy—two flimsy wings actuated by a twisting rubber—but it had fore-and-aft stability. These model aeroplanes, however, aided the science materially by demonstrating the necessity for stability before planes could be steered through space. Subsequently, in 1875, Penaud took out a patent on a monoplane fitted with two propellers and having controlling devices. But this was not built, principally because it would have required a light motor, and the lightest available at that time weighed over 60 pounds per horse-power. To-day most aeromotors weigh less than two pounds per horse-power.

Louis Pierre Mouillard, a Frenchman, who had observed that large birds in flight, while seeming at rest, could go forward against the wind without a stroke of the wings, constructed a number of gliders built on the principle of bird wings, and experimented with gliding. He published a work called "L'Empire de l'Air," which inspired many late experiments with gliders.

The net results of all these designs and experiments of these inventors demonstrated that thin, rigid surfaces of a certain shape, structure, and design could support weights when driven through the air at a sufficient velocity. Further than that they contributed practically nothing to the science of aviation.

As a matter of fact, it was toward the close of the nineteenth century before means were found to make an aeroplane rise from the ground, maintain its equilibrium. These latter-day pioneers of aviation were divided into two schools. The first sought to achieve soaring flights by means of large kitelike apparatus, which enabled them to fly in the air against winds, their machines being lifted up and supported by the inertia of the air as kites are. The second sought to develop power flight, that is, to send their kitelike machines through the air at high speed, being tracted or propelled by revolving screws actuated by motor power.

The most prominent experimenters of the first glider school were Otto Lillienthal, a German, P. L. Pitcher, an Englishman, Octave Chanute, and J. J. Montgomery.

Lillienthal was the first man to accomplish successful flights by means of artificial wing surfaces. In 1894, after much experimenting, he constructed rigid wings which he held to his shoulders. He used to run down hills with them until the velocity he was moving at would catch the air and lift him completely off the ground. By observation of birds he saw that their wings were arched, which suggested reason for failures of previous experiments in this line; so afterward his planes were arched also. He was the first man to be lifted off the ground by plane surfaces, and to demonstrate that arched surfaces were necessary to sustained flight of heavier-than-air craft.

To the rigid wings Lillienthal fastened a rigid tail and this constituted his glider. There were no control levers and the only way he could steer was by shifting the balance, by use of his legs, in one direction or another. By means of an artificial hill he had constructed he could coast downward for some distance without striking the ground. He was unfortunately killed in one of these experiments in 1896.

Chanute's experiments in gliding were similar to Lillienthal's, but they were conducted on the sand-dunes along Lake Michigan, near Chicago. His apparatus was more strongly constructed, of trussed biplane type—a construction suggested to him by his experience in bridge building, and one which persists to-day as the basis of strength in our present military biplanes. In design it was similar to a box kite, and it was the kind which the Wrights adopted for their experiments.

The leaders of the second school were: Clement Ader (1890–97), Sir Hiram Stevens Maxim (1890–94), and Samuel Pierpont Langley (1895–1903).

Clement Ader, the famous French scientist, under the auspices of the French Government, conducted experiments from 1890 to 1897. In 1890 he filled his Arion, a boat-shaped machine with two propellers, with a steam-engine, but the apparatus never flew. He finished his next machine in 1897 after six years of hard work. It was large enough to carry a man, but, like its predecessor, it never left the ground, and the French Government refused to support his experiments further.

While Ader was making his experiments in France, Sir Hiram S. Maxim was at work constructing a large multiplane for the English Government, which he fitted with two steam-engines of 175 horse-power. But like Ader's experiments it toppled over at the first trial and was badly damaged, and the British Government refused further backing.

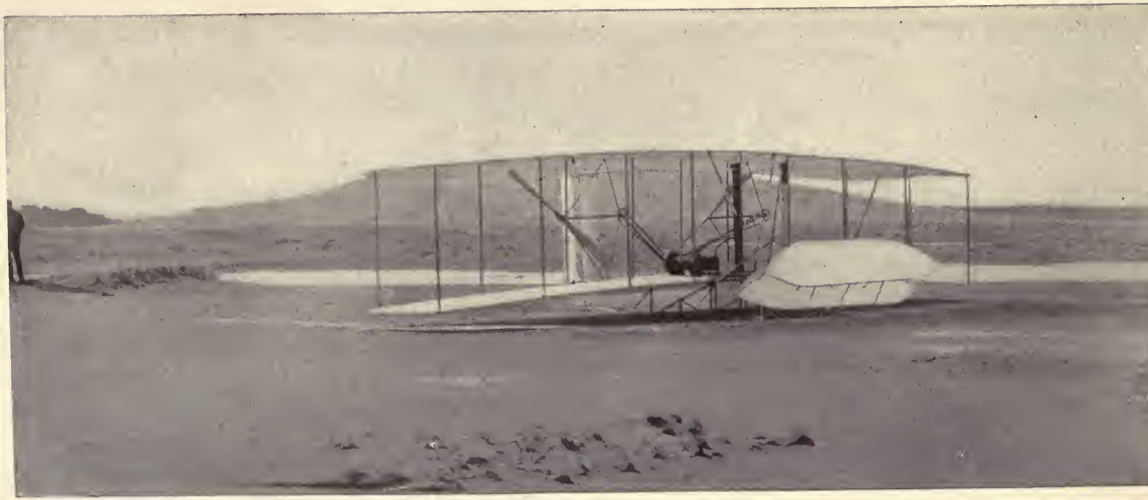
The experience of Samuel Pierpont Langley in America is not unlike the experience of Ader in France and Maxim in England. He was employed by the Board of Ordnance and Fortification of the United States army to construct the "Aerodrome" of his own invention. Congress appropriated $50,000 for the purpose. Langley's machine was a tandem monoplane, 48 feet from tip to tip, and 52 feet from bowsprit to the end of its tail. It was fitted with a 50 horse-power engine and weighed 830 pounds. The trials of this aerodrome, two attempts to launch it, were made on October 7 and December 8, 1903. On both occasions the aerodrome became entangled in the defective launching apparatus, and was thrown headlong into the Potomac River—on which the launching trials were made. Following the last failure, when the aerodrome was wrecked, the press ridiculed the whole enterprise, and Congress refused to appropriate money for further experiments. The Langley aerodrome, fitted with a Curtiss motor and Curtiss controls, flew in 1913–14.

As with experiments of the first school they did not attain practical results. The machines were usually wrecked at the first trial without giving any clew to the nature or whereabouts of the trouble. Although Langley's machines were reconstructed and flown later this should not detract in any way from the fame of the Wright brothers, Orville and Wilbur, who really were the first to construct an aeroplane which was driven by a gasoline motor, lifting a man off the ground, and pursuing a steered and sustained flight through the air.

The experiments of Lillienthal and his death in his glider were the direct incentives to the Wright brothers to conduct their investigations with gliders. The

Lillienthal way of balancing the planes by swinging his legs they judged to be a poor means of controlling the direction of the flight. So they set out to discover another method of controlling the stability of the planes. Their experiments began in the fall of 1900 at Kitty Hawk, North Carolina, as Mr. Henry Woodhouse, the aeronautical authority, has pointed out. They took all the theories of flight and tried them one by one, only to find, after two years of hard, discouraging work, that they were based more or less on guesswork. Thereupon they cast aside old theories and patiently put the apparatus through innumerable gliding tests, ever changing, adding, modifying—setting down the results; after each glide comparing, changing again and again, until they finally constructed a glider which was easy to balance both laterally and longitudinally. But in order to control fore-and-aft balance they had to eliminate Lillienthal's method of swinging his legs and substitute a horizontal elevator. This elevator was raised and lowered by a lever operated by the pilot stretched out on the centre of the lower wing of the glider. This device kept the glider level with respect to the ground. In fact, this elevator was absolutely necessary to prevent the planes from diving up or down, for if the pilot found the glider pitching too much forward, tending to dive, he would tilt the elevator upward by means of the lever, thus pulling the nose of the glider back into its proper position. At first the Wrights built the elevator in front of the planes so that they could see and study its effect. They soon discovered that the control of the glider was much better with the elevator. This elevator has been incorporated as a standard fin on the tail of the fuselage of every aeroplane and is one of the chief factors in steering up or down.

Having completely mastered this most important step, the Wrights next took up the problem of lateral control. The natural tendency of the glider was to flop about like a kite with too light a tail. In order to correct this lateral instability the Wrights determined to make the air itself, rather than gravity, supply this balance, instead of Lillienthal's method of swinging his legs from side to side by observing closely the way in which a pigeon secures its lateral balance by varying the angle of attack with its two wings, whereby one wing would lift more forcibly than the other, thereby turning the bird in any direction around any given axis of flight. In order to accomplish this variation the Wrights made the ends of the glider loose while the rest remained rigid. Then by a system of wires operated from a lever they could warp these wing ends of the glider, one to present a greater angle of attack to the air and the other a smaller angle, just as the pigeon did. In other words, by pulling down the rear edge of the tip of one wing and by pulling up the extreme edge of the other the angles of the wings were varied with respect to the way in which they cut through the air on very much the same principles as the tail elevator on the fuselage. Also, if a flat surface moves through the air horizontal to the ground, if you tipped the rear edge upward the air would strike it on



Courtesy of Flying Magazine.

The Wright flyer after the epoch-making flight at Kitty Hawk, N. C., December, 1903.

This was the first successful motor-driven heavier-than-air craft to lift a man off the ground and carry him over a steered course. It had one 16 h.-p. motor with a chain-drive to two propellers. The elevators were in front of the machine. The plane resembles a glider or a box kite and the wings could be warped for steering.

that edge and have a tendency to force it down, thus forcing the forward edge upward. To pull it in the other direction would cause the opposite effect. The Wrights were first to incorporate this in a glider or aeroplane. They patented it, and although a hinge, called an aileron, was later attached to the end of the wings of an aeroplane to produce the same effect and at the same time to allow more rigid construction of the ends of the wings, nevertheless this idea was distinctly a Wright discovery and innovation.

But that was not all the Wright brothers did to make man-flight over a sustained and steered course in a heavier-than-air machine possible. Directional control or power to steer the glider in a straight line or to vary it had not yet been acquired, so the Wrights installed a vertical rudder which they also operated by lever, just as the rudder on a power-boat is controlled, and the effect on directional steering was the same. Indeed, passage through the medium of the air is in many ways similar to passage through water. Thus the moment the glider swerved from right to left the rudder was pulled in the opposite direction and the planes came back to the steered course.

But this was not invented at once nor installed until after the Wrights discovered that whenever the glider was in flight the effect of warping the wings to control the rolling had a serious unexpected secondary effect, namely, a tendency for the high wing, which they desired to bring down, to advance faster through the air than the low wing, and solely by its higher velocity to develop a higher lifting capacity and thus to neutralize the benefit of the warp. After much experimenting they hit upon the rudder idea and that corrected the difficulty.

Thus the Wrights gained complete mastery of the glider; they could steer it up and down, turn it from right to left, and bring it back safely to the earth. This is the basis of the Wright patents to-day.

The next thing to be done was to install upon an aeroplane a power plant sufficient to drive it through the air fast enough to make the air lift it off the ground and sustain it in the "liquid blue" until the pilot saw fit to glide to the earth again. This was by no means a simple matter, for from 1900, when the Wrights began their glider experiments, to 1903, when they made their first flight, the gasoline motor was in its impotent infancy. They set about building a small light motor, however, to install in their planes.

In the meantime they experimented further with wing surfaces. Langley and Chanute had proved flat wings inefficient and curved wings necessary for lifting capacity. Of course, those early experimenters did not know how much those curvatures affected the climbing angle of a glider, so the Wrights set out to find out by using the wind-tunnel method and testing scale models in the same, with a blast of air generated by an engine-driven fan. This tunnel was cylindrical in form, sixteen inches in diameter. The smaller models of wings were hung in the centre, the air-blast turned on, and the balance arm, which projected into the tunnel and on which the wings were mounted, measured the air forces and the efficiency of the varied wing shapes from the standpoint of rounded wing tips and curvature.

Data acquired in experimenting with their six-inch model biplane in this determined them to build their aeroplane on that scale, even though it was discovered that two wings together were less efficient than one wing by itself. The rigidity of two wings added a safety factor, so they adopted the biplane or two-plane surface rather than the monoplane or one-plane surface.

In these experiments the Wrights also discovered that all surfaces shaped like a fish offered less resistance to the air than blunter obtuse surfaces, so they adopted the stream-line method in construction of struts or supports to the two wings, so that now all surfaces that cut the air in the forward progress of the planes are rounded off so that the air slips off with the least resistance. This was an important discovery, for later when the enclosed fuselage or body in which the aviator sits was constructed it had much to do in determining its shape and design.

Propellers had already been experimented with as a means of propulsion through the air. Because of the low horse-power at which they were driven very little scientific data as to propeller efficiency had been compiled. Because the first motor constructed by the Wrights had only 16 horse-power at maximum speed, which soon fell off to 12 horse-power, the two propellers mounted on their first machine developed a high propeller efficiency. To-day propeller efficiency has reached approximately 70 per cent of efficiency, and much study has been devoted to the propeller.

Because no gasoline motor was in existence light enough to mount on their glider the Wrights built their own in their shops in Dayton. It was a four-cylinder water-cooled upright motor, and it could develop 12 horse-power. The engine was mounted on the rear of the planes of the glider and by a chain drive propelled the two blades mounted in the rear of the two planes, thus making a pusher type of aeroplane. The estimate of the total weight of the machine and the operator was between 750 and 800 pounds.

With this machine, on December 17, 1903, Wilbur Wright made the world's first sustained steered flight of 852 feet in 59 seconds in a heavier-than-air machine. To them really belongs the honor of having invented the aeroplane and of having demonstrated the feasibility of navigating the air in a heavier-than-air machine. It is true that the Frenchman M. Bleriot was the man who covered the fuselage, put the engine in front of the aviator, and constructed a monoplane similar in shape to a bird. Nevertheless, it is the Wrights who built the aeroplane which met all the fundamental requirements of flight through the air.

CHAPTER III

WHY AN AEROPLANE FLIES

THE HELICOPTER—THE ORNITHOPTER—WING SURFACE—FLYING SPEED—LANDING SPEED—EFFECT OF MOTORS—THE SEAPLANE

THE heavier-than-air machines are divided into three classes. The helicopter is a machine which theorists of that school believe can fly straight up into the sky because its air screw propeller works on a vertical axis. This type of aircraft has never been successful, for the reason that the propeller does not lift. It simply pulls a stream-lined surface through the air. The lifting must be done by planes.

The ornithopter is another heavier-than-air craft which seeks to fly by flapping wings like a bird. The effort to build this type of machine is as old as human desire to imitate the fowls of the air and it has been as unsuccessful as the helicopter.

Before we begin to discuss the aeroplane we must remember that before a modern machine leaves the ground it must be moving at least thirty-five miles an hour with respect to the air. This forcing of the edges of these broad-pitching, curved surfaces through the air at such a velocity naturally drives the air downward and these particles of atmosphere react in exactly the same degree upward, thus forcing the planes and the attached apparatus upward. Therefore, as long as the aeroplane rushes through the air at that or greater speed the thousands of cubic feet of air forced down beneath the wings deliver up a reaction that results in complete support. When an aircraft fails to move at that velocity it loses "flying speed" and falls to the earth. The net result of this reaction is called "lift," and as long as the machine sweeps forward at that momentum it has lift. The engine, of course, must supply this forward movement, and when it stalls, the heavier-than-air machine must glide to a landing-place or fall perpendicular to the ground.

To understand why a heavier-than-air machine flies it is necessary to remember that air or atmosphere has many of the characteristics of water. Indeed, like the ocean, its pressure varies at different altitudes. At sea-level a cubic foot in dry weather weighs 0.0807 pounds, but at a mile above sea-level it weighs only 0.0619 pounds, and at five miles 0.0309 pounds per cubic foot and so on up. Therefore machines designed to fly at sea-level often fail to get off the ground at 12,000 feet above the sea in such countries as Mexico.

Air also has motion. Its tendency to remain motionless is called inertia, and its characteristic desire to reoccupy its normal amount of space is known as its elasticity, and the tendency of the particles of air to resist separation is described as its viscosity. Thus we see that air has practically the same characteristics as water, only it is much lighter.

Without going into a technical discussion of all the forces that enter into the flight of an aeroplane we must, however, realize that if the pressure of the atmosphere is uniform in all directions, in order to make the air forced under a wing or plane lift more than the air above forces down, the wing of the plane must be curved in such a way that the forward motion of the edge of the wing causes the air underneath to force any particle of the surface upward, while the upper surface is relieved of the pressure. This is done by curving the surface of the planes so that the under surface is concave while the upper part is almost convex, like the outspread wing of a bird. When this wing is forced horizontally through the air it creates a vacuum immediately behind the upper or convex part, the under pressure is still constant and the surface is lifted upward. That is why a plane covered with a curved surface will fly and a plane with a flat surface will not. In short, a curved surface when moving through atmosphere causes eddies in the air, and if the curvature of the wings is properly calculated, it leaves a vacuum near the rear edge of the surface of the plane and it climbs upward. The smaller the angle the smaller the lift or climbing power of the plane. Thus a 15-degree angle will lift one pound; if reduced to 10 degrees it will only lift two-thirds of a pound, but because a wing is curved a plane could fly at several degrees less than 0 degree, but its "stalling" or critical angle beyond which it is not safe to go is 15 degrees.

It must be borne in mind that the larger the wing surface the larger load the aeroplane can carry, for the lift of a heavier-than-air machine depends entirely on the number of square feet of surface in the plane or wings. The larger the planes the more power is required to force them through the air and the less easy they are to manœuvre and land. The Nieuports, Spads, Sopwiths, and Fokkers, with their small wing spread of less than 30 feet, made them much easier to fly, even though they land faster than the "big busses." Therefore every pound of weight added to an aeroplane decreases its speed proportionately and requires an equivalent increase in horse-power to force it through the air. Of course, an increase of speed gives an increase in lift, so by doubling the speed of a plane you increase the lift just four times.

There are, however, a number of factors which tend to decrease the progress of a machine through the air: the head resistance of the fuselage, the motor, the struts, the wires, the landing-gear, etc. These things do not add to the lift and are described as "dead-head" resistance. Stream-line, or the tapering of all surfaces which resist the air, helps reduce this resistance, so that the design of the plane has much to do with its speed, also as to whether the plane can climb faster than fly straight ahead. Naturally the horse-power of the motor determines the flying speed of the aeroplane as much as any other factor.

To lift a plane off the ground it must be travelling at least 35 miles an hour with respect to the air, as we have pointed out before. So if a gale is blowing 20 miles an hour the aeroplane may be lifted off the ground when moving no faster than 15 miles an hour with respect to the earth. Likewise unless a machine is moving 35 miles an hour it will lose flying speed and fall to the ground.

Machines do not all land at the same speed. The famous Morane monoplane skimmed along the ground at anywhere from 45 to 90 miles an hour. It is manifestly impossible to do more than suggest the fundamental principles of aeroplane flight here. To be sure, the type of aircraft has, as we have indicated, much to do with why and how it flies. Because of its similarity to the bird and owing to the lack of struts, etc., to increase the head resistance the monoplane or single-wing plane is the fastest machine. The absence of struts and the few bracing wires brings a greater strain on the wings and increases its chances of breaking. The biplane, with its two parallel wings separated by struts, is more easily braced and proportionately stronger. The lift is also greater, due to the additional wing surface. The vacuum made over the lower wing is interfered with by the upper plane, and thus neutralizes somewhat the lifting and flying efficiency of the upper wing. Since a plane must reverse all its stresses when looping, the double supports of the biplane make it less susceptible to doubling up and falling. These are some of the reasons for the popularity of the biplane.

The triplane is so called because it has three tiers of wing surfaces set one above the other. This allows for even greater strength in construction, and despite the resistance several very fast-climbing triplanes have been built. The famous Caproni triplanes with three motors have a wing spread of 127 feet. Many biplanes and flying-boats also have approximately 126-foot wing spread. The well-known Handley Page bomber and the NC-1, NC-2, NC-3, NC-4 Naval Flying Boats, which tried the Atlantic flight, had a similar wing spread.

In the war the small aeroplane of the monoplane or biplane type with a small wing spread and equipped with a rotary motor, whose nine or more cylinders revolved with the propeller, or a small V-type motor, was called a scout. These biplanes seldom had a wing spread of over 28 feet and the horse-power of the rotary motors seldom developed more than 150 horse-power, whereas the stationary motors for these same machines generated as much as 300 horse-power, as in the case of the Hispano-Suiza. These machines were used for fighting because they made as high as 150 miles an hour and responded so easily to the slightest movement of the "joy stick" and, consequently, manœuvred so readily. Since trick flying was absolutely essential to air duels these machines were best for this purpose and for quickly getting information of troop movements.

The next larger size, seating two men and driven by the same types of motors or even larger twelve-cylinder Rolls-Royce or Liberty motors, but with a wing spread of from 34 to 48 feet, was used for taking photographs, directing artillery-fire, and general reconnaissance in war. The multimotored machines, with a wing spread of anywhere from 48 to 150 feet, were used for bombing at night or during the day. Owing to the size of these machines and because of their slow-flying speed they were easy to land. Some of the scouts weighed, with petrol and two hours' fuel, less than 1,000 pounds, whereas the four-motored bombers, with 127-foot wing spread, weighed over six tons and could carry a useful load of three tons.

The hydroaeroplane does not differ fundamentally from the aeroplane as regards flying principles. In structure it may be a biplane or triplane, but owing to the supports necessary to carry the pontoons it cannot be easily attached to a monoplane. Structurally, it differs from the aeroplane only in having pontoons or a boat substituted for wheels and landing chassis. Owing to the surfaces presented by the pontoons or the hull of the boat, looping is practically eliminated and the spread of these flying craft is much slower than land machines.

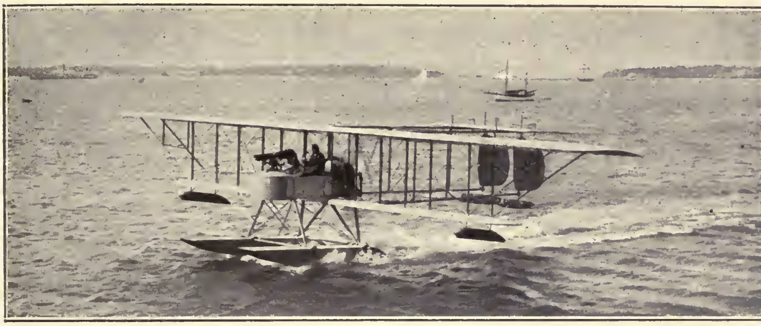
Although M. Fabre conducted experiments with aeroplanes carrying floats instead of wheels, Mr. Glenn H. Curtiss was the first to successfully construct and fly a hydroplane. At the time of his flight down the Hudson River from Albany to New York he equipped his plane with a light boat to protect himself in case of a forced landing on the water. Encouraged by this experiment under the Alexander Graham Bell

Aerial Experiment Association, and by later attaching a canoe, he succeeded in landing and getting off the water. Later he built a hydroaeroplane and flew successfully at San Diego, Cal., thus establishing America as the land which invented and developed the seaplane and flying-boat.

Structurally, the modern seaplane has two small pontoons on the end of each wing and a small boat in the centre, or sometimes only two pontoons in all which are side by side near the fuselage. The flying-boat has one large boat instead of a fuselage, with a small pontoon on the end of each wing. The former is used for fast flying, but owing to the air resistance to the pontoons, and especially to the boats, the speed cannot be compared to that of the scout aeroplanes. Moreover, they are much harder to do stunts with and few are known to have looped the loop. Like the big land bombers the flying-boats may be equipped with as many as three motors. One of these has carried as many as fifty passengers at one time.

Contrary to the accepted notion, these flying-boats are very hard to land on the sea because it is so difficult to calculate the position of the wave when you strike—both are moving so rapidly.

As we have already seen that due to the fact that a heavier-than-air machine must be moving at least 35 miles an hour to get off the ground or water, a strong and powerful motor is absolutely essential to make aeroplane flying possible. We have already discovered that the Wrights had to construct their own motor



A Shortt "pusher" seaplane equipped with a one-and-a-half-pounder gun.

From a photograph by Bain News Service.

British-built Curtiss flying-boat, at Brighton, England.

because none was light enough for an aeroplane. Their 16 horse-power single-cylinder engine weighed over 200 pounds. To-day the Liberty is rated at from 400 to 450 horse-power, and it weighs less than two pounds per horse-power. An Italian aeronautical engine develops 700 horse-power, and one sixteen-cylinder American motor generates 900 horse-power. This shows the tremendous development of the motor for modern flying.

But, aside from the matter of weight and horse-power, the aeromotor has been called upon to perform at altitudes of as high as 30,000 feet as efficiently as on the ground. Since the atmospheric pressure at that height weighs a great deal less than at sea-level the flow of gasoline and lubricants is very much decreased, so that the efficiency of the motor may fall off proportionately. To meet these requirements the aviation motor must be especially designed, and since the vibration of the propeller shakes the frail frame on which the engine is mounted, the materials must have the greatest strength and resistance.

Nevertheless, in both types of motor, the rotary air-cooled and the stationary V type, the engineers have succeeded in making engines that would climb still higher than the 30,500 ceiling already made, if the aviators could stand the cold or have enough hydrogen to keep them from fainting.

The motor then is the heart of the heavier-than-air machine, and when it stops the aeroplane must volplane or fall to the earth, a slave to the laws of gravity.

CHAPTER IV

LEARNING TO FLY

EARLY METHODS—DEVELOPMENT OF SCHOOLS—STUDYING STRUCTURE OF PLANES, MOTORS, THEORY OF FLIGHT, AERODYNAMICS, MAP READING—FRENCH SYSTEM—GOSPORT SYSTEM

FROM the time of the first flight of the Wright brothers in 1903 to the breaking out of the Great War in July, 1914, the art of flying an aeroplane was not taught systematically either in private or military schools, primarily because flying in a heavier-than-air machine was regarded by civilians as a very dangerous sport and by military authorities as hardly more than a dubious scout for locating troop or train movements. For that reason very few civilians were induced to take up aviation except a few of the more daring sportsmen. Consequently, civilian flying on a large scale did not flourish.

It is true, however, that several small schools attached to manufacturing plants did attempt to teach the rudiments of flight and aircraft construction. These schools did not prosper because only a few pupils who wished to give exhibition flights attended, and the art of flying and aircraft development suffered.

In England several schools were started with indifferent success for the same reason as obtained in

America, and in France and Germany, aside from a few aviators who were striving for new world's records, most of the flying training was in the army. Therefore most of the great fliers, like the Wrights, Beachy, Martin, Curtiss, Farman, Bleriot, Garros, Vedrines, Graham-White, Sopwith, A. V. Roe—to mention only a very few—learned to fly themselves. For that reason the toll of lives taken in flying was high. Nevertheless, that did not stop these daring fliers from stunting and exploring all the aerial manœuvres possible with a heavier-than-air machine. As a result Pegout looped the loop; Ruth Law flew at night; Bleriot crossed the channel; Garros the Mediterranean Sea; Vedrines flew from Paris via Constantinople to Cairo; and in July, 1914, Heinrich Oelerich climbed to 26,246 feet altitude in Germany, and in the same month another German flew for twenty-four hours one minute, without stopping.

Meanwhile France had trained several hundred aviators for her army and Germany had five or six hundred trained fliers, including those in the Zeppelin service. The United States army had hardly more than fifty fliers when the Mexican trouble broke out, and only half a dozen aeroplanes to use on the Mexican border.

As soon as the war began and aircraft demonstrated that the side which got control of the air could put out the eyes of the opposing army and that the great struggle might be decided in the air, all the belligerent nations began to train aviators for the war in the air.

France was the first to develop a school of flying, and the French method, with slight variations, was adopted by England and the United States. A description of their method will give a comprehensive conception of the training necessary for a military flier in the war.

Early in the war most of the army, navy, and private aviation schools of the United States adopted the penguin system of learning to fly. That method, invented by the French, consisted of using as a training-machine an aeroplane that had so small a wing spread or so weak a motor that it merely hopped five or six feet off the ground when the motor was wide open. The small wing spread caused it to zigzag along the ground like a drunken man. For those reasons, perhaps, it was named after the penguin, which does not remain long on the ground or in the air and which has an irregular gait.

The first step in learning to fly consists in studying the structure of the aeroplane and of the aeronautical engine, and aerodynamics, or the science of the forces that aid or hinder the flight of heavier-than-air machines. During the last half-dozen years many of the manufacturers of aircraft maintained schools in order to encourage men to learn the art of flying, and have given their pupils the chance to study at first hand the designing, the building, and the assembling of aeroplanes and hydroplanes. That has given the pupils a thorough knowledge of every detail of the aircraft—an invaluable asset to an aviator who has been compelled to make a forced landing far from a repair-shop. In the "ground" schools conducted by the United States Government for instructing aviation officers at the various institutions, like Cornell, Massachusetts Institute of Technology, and Princeton, a great deal of time was devoted to assembling aeroplanes.

Most of the manufacturers of aircraft in this country do not make the motors used to propel their aeroplanes. The aeronautical motor is one of the most difficult machines to build successfully. A motor that runs as smoothly as a watch on the ground may hesitate and sputter at an altitude of a thousand feet, and at three thousand feet may stop altogether. Engineers say that that is because the change in temperature and in atmospheric pressure causes a difference in carburization. All these things the prospective flier had to learn as well as the reasons for the same.

Contrary to the general notion, the construction of the aeronautical motor differs radically from that of the automobile engine. In point of weight the difference is marked. Seldom is any stipulation made that limits the weight of the automobile motor in proportion to the amount of horse-power; a few pounds more or less is not an important consideration in a pleasure-car or a motor-truck. But in an aeroplane every ounce of superfluous weight must be eliminated from the engine, which must nevertheless be strong enough to withstand the most violent strain.

The aeroplane motor is subject to far greater strains than the automobile motor is. Except during a race, one rarely runs the engine of an automobile at its maximum speed; the aeroplane motor, on the contrary, usually runs at full speed from the moment the aeroplane starts until the motor is shut off and begins to volplane down to the earth. It is true that you can regulate the aeroplane engine by the throttle to run from as low as three hundred revolutions a minute to as high as sixteen hundred; but except when testing the motor there is rarely any reason for slowing it up while in the air. The load that the propeller of an aeroplane carries is much less than the load that the shaft of an automobile carries, but, on account of the frail structure of the plane, the vibration is much more violent. A battle plane seldom weighs more than two thousand pounds, and a scouting machine of the Nieuport type tips the scales at not more than one thousand pounds.

For these reasons aircraft require special kinds of motors. The V type is so called because the cylinders are set in the form of that letter; the rotary motor has the cylinders arranged in a circle like the spokes of a wheel, and it revolves on its shaft like the propeller. The rotary motor is used in scouting machines because it is light. The revolving engine also revolves on its shaft, but it has a great many more cylinders arranged side by side like the cylinders of an automobile engine. It is much heavier than the rotary type; it may have as many as thirty-two cylinders.

Of course, a knowledge of the automobile engine was an aid to the prospective aviator; for, except in the process of cooling and the revolution of the cylinders, the principles of the automobile motor and those of the aeroplane are identical.

At aviation schools the pupils went thoroughly into all those things and supplemented their knowledge by continually mounting and dismounting engines and examining their most intricate parts. The schools also kept on hand large aeroplane models, which the students took apart and put together again. In the classroom the prospective aviators studied the mathematics and the theory of aerodynamics. All this work was very important, for an aeroplane is such a nicely balanced machine that if it is not perfectly constructed mathematically it will not fly safely.

For example, if the tail plane or flat, finlike surface that projects from the sides of the tail of the body, or fuselage, has too much "incidence," or, in other words, is slanted at too sharp an angle downward, it has a tendency in flight to lift the rear of the machine and to make it dive. A seaplane, when properly constructed, is so evenly balanced that, when the crane that lifts it off the mother ship holds it suspended in the air, the machine is equipoised like a bird with wings spread in flight. If the plane is heavier on one side than on the other, it will, while "banking," or turning a corner, slide toward the centre of the circle; that sometimes causes a "tail spin," in which the machine whirls round as if it had been caught in a whirlpool. That is a very difficult situation, for an aviator usually ends in a smash at the bottom of the whirlpool unless the pilot has altitude enough to flatten out his plane before it gets too close to the ground. These things were all taught before the novice went up in the air.

Map reading and air navigation were the next studies in military aviation schools. First, the student learned how to judge the height of hills and the size of towns from different altitudes, so that when flying he could tell what part of the country he was passing over. Many of the schools perched the prospective fliers high in the air in a classroom and spread out a miniature landscape made of dirt and sand on a map beneath them so they could get practice in perspective.

Of course, when an aviator is lost in the fog or above the clouds he needs to use all the instruments on board to find his position. For that purpose drift instruments are mounted on aircraft; those tell how much the air-currents, which have the same effect on aircraft as the tide has on a boat, have driven him off his course. A compass indicates the direction in which he is travelling, and other instruments show him whether his machine is climbing, diving, or "banking"; the aneroid barometer indicates the altitude. It is essential, of course, for the aviator to know how to read those instruments correctly. Without the information they give him, he might not know, if flying at night or in a cloud, that his craft was climbing at a dangerous angle until wrenches or other loose implements began to fall out of the machine.

As the next step in the training the student learns the controls. To do that he runs the "taxi" or "lawn-mower," as the training-machine is called, up and down the field. The "hopping" of this machine familiarizes him with "getting off" and landing, and with the noise of the propeller. After he has learned to steer his machine in a straight line, he takes longer "hops" until he is thoroughly familiar with the "joy stick" which pulls the elevators or ailerons up or down or operates the rudder.

Soon afterward the student went up with an instructor for a long flight. The purpose of the flight was to get the pupil used to higher altitudes and to the motion of the aeroplane, and to give him a chance to watch his teacher actually running the machine. Strange to relate, many who have felt an uncontrollable desire to jump off high buildings have no such feeling while in an aeroplane. That is because they sit and look out horizontally instead of perpendicularly downward, and because they move at such tremendous speed.

After several trips of that kind, the instructor let the student handle the controls until he could climb, dive, and "bank," or turn the machine in the air. But the pupil was not permitted to land a machine until near the end of his course; for next to getting out of a tail spin, a dive, or a side slip, landing was the hardest task in flying. Statistics show that more aviators have been killed in making landings than in any other way. Many of the accidents, of course, were caused by the nature of the ground, for when the engine of the aeroplane stops, the aviator has to volplane or glide down wherever he can.

One of the difficulties of landing is owing to the fact that even training-machines cannot land at a slower speed than thirty-five miles an hour. If the wheels of the aeroplane, when they first touch ground, do not skim over the surface of the field, the machine is liable to "nose in" and turn a somersault. Indeed, that is why the pusher type of training-machine, with the propeller in the rear of the pilot, is being abandoned for the tractor machine, which has the propeller in front. If an accident does occur with a tractor the engine does not "climb your back." One of the greatest dangers of flying a seaplane is due to the fact that the engine is installed not in the hull but high above the aviators' heads, upon which it is apt to fall in case of a crash.

The student was next permitted to fly alone. Most machines were so strongly built that accidents were seldom caused by breakage, although, of course, before each flight the aviator and his mechanic critically examined his machine for broken parts. With a reasonable amount of care straight flying by daylight was comparatively safe.

In the French aviation schools, before the military birdman could pass his final examinations, he had to climb twice to an altitude of six thousand feet and spend an hour at a ten-thousand-foot altitude. If he passed that test successfully, he had to fly over a triangular course of one hundred and fifty miles and land at each corner of the triangle.

Before he could fly his machine on the battle-front the French flier had to know how to loop, to fall or dive at such a steep angle that his machine actually dropped through the air for several hundred feet before it flattened out—a tremendous strain on the wings of a machine—to side slip or round a curve with his machine banked at such an angle that it gradually slid toward the centre of the circle, to climb or tail dive at such a pitch that the aircraft actually slips backward tail foremost. Indeed, in the last days of training the student was encouraged to practise all kinds of stunts and tricks, for when an enemy descended on you from the clouds above and was sitting on your tail weaving a wreath of bullets from a machine-gun round you, your only chance of escape was by means of a loop, a dive, a side slip, or a roll.

Another interesting test a pilot had to undergo before he got his license to do battle was to ascend fifteen hundred feet, cut off all power, and volplane down in a spiral to a fixed point. To perform the manœuvre successfully required great skill. All the members of the famous Lafayette Escadrille had to undergo those tests before becoming fighting aviators, and Americans who received their final training in France had to go through the same training.

In our government flying-schools at Mineola in Long Island and the other flying-fields in Texas and other parts of the country, at San Diego in California, the students were put to similar tests of skill. In the private civilian schools, however, instructors rarely attempt to teach their pupils more than straight flying. But most aviators agree that every flyer ought to know the "stunts" in order to meet successfully any extraordinary situation that may confront him.

Of course the training for aerial observers, wireless operators, and photographers was very different from that of the pilots. In each case the instruction was peculiar to the science they were to practise, and it had little to do with aviation, only in so far as it was actually affected by flying. The men who took the pictures had to make a study of the science of photography. The same was true of the wireless operator. The observer, however, had to study topography and the use of the machine-gun, and target practice such as characterized the work of the pilot. In different countries this differed with the methods developed there. In England the pilot often shot at toy balloons in the air while chasing them with his machine or at targets on the ground. The same method was employed by the United States. Nearly all the great aces in the war were very clever shots, and Major Bishop attributed most of his success to his skill with the machine-gun.

Finally the Gosport system of training aviators was adopted by the British and the American armies because it permitted the training of tens of thousands of fliers at the same time. The principles taught were the same as those enumerated above. The system, however, reduces the time spent on each operation to the minimum, specifying the number of hours to be spent on each step in the course. Here is a sample of the outline of the training under that system:

STANDARD OF TRAINING

Part 1. Pilots—Flying Wings

1. *Ground Instruction.*
    1. Buzzing and Panneau
    2. Artillery Observation
    3. Gunnery
    4. Aerial Navigation
    5. Engine Running
    6. Photography
    7. Bombing and Camera Obscura
    8. Air Force Knowledge
    9. Engines and Rigging, Workshops Course
    10. Drill and P. T.

2. *Air Tests.*
    1. Flying Instruction
    2. Formation Flying
    3. Cross Country
    4. Reconnaissance
    5. Photography
    6. Bombing (Camera Obscura)
    7. Ring Sights and Camera Gun
    8. Altitude Test and Cloud Flying
    9. Aerial Navigation

3. *Appendices.*
    - A Flying Instruction
    - B Formation Flying
    - C Cross Country

D Bombing
E Wireless
F Gunnery
G Ring Sights and Camera Gun
H Aerial Navigation
I Photography

To insure a certain amount of continuous practice the following minimum times will be spent on ground subjects. It must be realized, however, that efficiency, and not time spent, is the ultimate passing standard.

Buzzing and Panneau	30	hours
Artillery Observation	20	"
Gunnery	60	"
Aerial Navigation	20	"
Engine Running	3	"
Photography	2	"
Bombing and Camera Obscura	1	hour
Engines and Rigging	12	hours (Workshops Course)
Military Knowledge	3	"

Lectures will be given covering—

(1) All questions on above subjects.
(2) Practical wireless covering knowledge useful to a pilot.
(3) All ground signals as given on new Artillery Observation card, 40–W.O.–2584.

Thus every step in the education of the flier was provided for and thus the United States turned out over 10,000 aviators.

CHAPTER V

AEROPLANE DEVELOPMENT, 1903 TO 1918

ADER'S EXPERIMENTS—MAXIM'S MULTIPLANE—DUMONT'S AEROPLANE—WRIGHTS' 1908 PLANE—VOISIN PUSHER—BLERIOT'S MONOPLANE—AVRO TRIPLANE—FARMAN'S AILERONS—OTHER TYPES

ALTHOUGH the Wright brothers made their first flight in a heavier-than-air machine in December, 1903, it was not until September 15, 1904, that Orville Wright, flying the Wright biplane, succeeded in making the first turn, September 25 before they made the first circle, and October 4, 1905, before they managed to stay in the air for over half an hour. Moreover, it was not until 1908 that they made their first public flights.

Long before the Wrights first flew at Kitty Hawk military men realized the value of observation from the air, and balloons attached to cables had been used for that purpose in the Franco-Prussian and Boer wars for discovering the movement and disposition of troops. Clement Ader, however, was the first to succeed in securing an appropriation for the construction of a heavier-than-air machine which was to fly in any direction like a bird. In 1890 he induced the French Government to appropriate $100,000 for the construction of such an engine. After many experiments his machine failed to get off the ground, and in 1897, after seven years of hard work, the French Government refused to appropriate any more money.

In 1905, however, as soon as the same government heard of the sustained manœuvred flight of 33 minutes, 17 seconds, done by the Wrights, they negotiated for the acquisition of the machine, provided it could attain a height of 3,000 feet. But at that time the Wrights had not flown over three hundred feet, nor risen above one hundred feet, and could not promise to fill the French requirements.

The British Government had also given Sir Hiram Maxim an appropriation for constructing a flying-machine about the same time that the French Government was financing Ader. Maxim built one of the multiplane type, measuring 120 feet, equipped with two steam-engines of 170 horse-power and weighing 7,000 pounds, but like Ader's experiment it never got off the ground.

We have already noted the appropriations made by the United States Government to Samuel P. Langley for his aerodrome. It was the United States Government, upon the recommendation of President Theodore Roosevelt, which first ordered a military aeroplane in December, 1907, giving definite specifications for the same. The machine was required to carry two persons weighing 350 pounds and fuel enough for a 125-mile flight, with a speed of at least 40 miles per hour.

The Wrights were the only persons to submit bids and they delivered a machine which Orville Wright flew at Fort Myer in September, 1908, making a new record of one hour, fourteen minutes, twenty seconds. An accident prevented the fulfilling of the two-passenger-carrying requirement. In August, 1909, however, the Wright biplane, with a wing spread of 40 feet and equipped with a 25 horse-power engine, flew one hour and twenty-three minutes with Lieutenant Frank P. Lahm as a passenger.

The success of the Wrights naturally stimulated the French, Alberto Santos-Dumont, the Brazilian, who had experimented successfully with lighter-than-air craft, first circling the Eiffel Tower, while Louis Bleriot, the Voisin brothers, Captain Louis Ferber, Henry Farman, Leon brothers, Delagrange, and others began to experiment with aeroplanes.

In 1906 Santos-Dumont flew 700 feet in an aeroplane in one sustained flight and in 1908 the Wrights visited France and gave public demonstration flights at Pau and other places. Their machine was a biplane driven by a small four-cylinder water-cooled engine and two large propellers. These were both actuated by chains gearing on the engine-shaft, one chain being crossed so as to make its propeller revolve in the direction opposite to the other, thus giving proper balance to the driving force. Alongside the engine and slightly in front of it was the pilot's seat, and there was also a seat for a passenger in between, exactly in the centre, so that the added weight would not alter the balance.

Unlike present-day aeroplanes, this machine had no horizontal tail behind the main planes, and so it was called the "tail-first" type, or "Canard" or "duck," owing to its long projection forward which resembled the neck of that bird. This type did not steer easily and was abandoned.

The 1908 Wright Plane

The Wright machine had vertical rudders aft, and relied on the two big elevator planes forward for its up and down steering. Its lateral, or rolling, movements were controlled by warping or twisting the wings so that while the angle of the wings on one side was increased and gave more lift, the angle on the other side decreased and gave less lift, thus enabling the pilot to right the machine. The elevators were controlled by means of a lever on the left-hand side of the pilot, the warp by a lever on his right, while by waggling the jointed top of the right-hand lever he also controlled the rudder. This complicated system of control was very difficult to master.

In 1910 the Wrights attached a horizontal tail at right angles to their rudder, and in 1911 they dropped the front elevators entirely. When the United States entered the war, Orville Wright, as engineer for the Dayton-Wright Company, supervised the building of the famous DH4's, making several thousands of them for shipment to France.

Unlike many machines that followed, the Wright 1908 was launched from a carriage which ran on a rail until the planes were lifted into the air, leaving the carriage on the ground. This same principle was used for launching planes from battleships, although it is now abandoned.

Meanwhile Charles and Gabriel Voisin had successfully developed their machine. On March 21, 1909, Mr. Farman flew a little over a mile at Issy, near Paris, successfully turning, and on May 30 Leon Delagrange covered eight miles at Rome, and finally on September 21 he flew forty-one miles without stopping at Issy.

This Voisin biplane differed from the Wrights' in that it followed the box-kite principle. It had a box-kite tail to which the rudders were mounted, while the wings had vertical partitions and the plane had no lateral controls, with the result that it could not fly in any kind of a wind without coming to grief. The first machine had a 50 horse-power Antoinette engine and the latter ones a 40 horse-power Vivinus—an ordinary automobile engine, heavy but reliable.

In 1909 the famous Gnome rotary engine appeared. It had 11 cylinders set like the spokes of a wheel; one was fitted to a Voisin biplane by M. Louis Paulhan. There were several innovations on this machine. The under-carriage and tail-booms and much of the under-structure was made of steel tubing. Its greatest contribution to the modern aeroplane was the steering-wheel. This was operated by a rod or joy stick, which ran from the front elevator to a wheel in front of the pilot which was pushed forward to force the nose of the machine down, and pulled back to force it up. This made steering much easier. The rudders were worked by wires leading to a pivoted bar on which the pilot's feet rested. Pushing the right foot steered to the right, pushing the left foot steered to the left—which was also a very natural motion. This method of construction has been maintained to this day on all machines. The Voisin was the first "pusher" type of machine with single propeller in the rear of the engine and the plane. The Voisin was always heavy, but in 1915 it was built in large numbers for bombing purposes because the forward nacelle or nest which held the observer and gunner afforded such an unobstructed range of vision for the observer.

To M. Louis Bleriot goes the honor of first constructing monoplanes and of putting the engine in the nose of the machine with a tractor screw in front of it. He also first designed the fish-shaped, or stream-line, body, with the tail and elevator planes horizontally and the vertical rudder fixed at the rear end of the fuselage. This was the first successful tractor aeroplane with the propeller in front.

In 1909 M. Bleriot came to the fore with his type X1 machine, the prototype of all successful monoplanes. In this he incorporated the Wright idea of warping the wings to give lateral control, and so produced the first monoplane to be controllable in all directions. With this type of machine, equipped with a 28 horse-power three-cylinder Anzani air-cooled engine, M. Bleriot himself flew over the Channel on July 25, 1909. His type X1 model, with a few structural details, was the first to loop the loop regularly in 1912. After 1909, when fitted with Gnome or Le Rhone rotary engines, the performance of the machine was greatly improved. Since the Bleriot under-carriage, excellent for its purpose, could not be made so as to be pushed rapidly through the air, it was abandoned.

M. Bleriot introduced the stick form of control, so that by moving the control stick forward or backward the nose of the machine moved down or up. Pushing the stick to the right forced the right wing down, moving it to the left pushed the left wing down. The rudder was worked by the feet as in the Voisin. Thus a natural movement was given to all the controls and a great step forward was made.

The 1909 and 1910 Avro

Meanwhile in England Aylwin Verdon Roe was experimenting under strictly limited conditions. In 1908 he had got off the ground in a Canard-type biplane, and in the fall of that year he built a tractor biplane, and in the summer of the next year he had it completed. His engine was a 9 horse-power J. A. P. motorcycle engine, the lowest power which has ever flown an aeroplane. It was also the first successful triplane.

In general lines and plan the machine is the prototype of the modern tractor biplanes and triplanes; it had warping wings, tail elevators, and a rudder astern, while the control was by rudder and stick, similar to the Bleriot.

This little machine was further developed in 1909 and 1910. Later Mr. Roe abandoned the triplane for the biplane, which he fitted with a Green engine of the vertical-cylinder type, which was the first of its kind installed in an aeroplane. Thereafter the triplane practically disappeared till it was revived by Glenn Curtiss, as well as British, French, and German designers during the war.

They are great climbers and attain great speed in flying. The small 1910 Avro, equipped with a V water-cooled engine, was the forerunner of the single-seated fighters of the last days of the war.

Because of its fast-climbing ability the 80 horse-power Avro and the Sopwith Snipe were used for the defense of such cities as London and Paris against Zeps and aeroplanes. The large two-seater Avro, with only an 80 horse-power Gnome, flew over 80 miles an hour. As a war-machine early in the conflict it did excellent work bombing. Later, with slightly higher power, it was a very good training-machine. Among two-seated biplanes it marked as great an advance as did the Sopwith Tabloid. Among single-seaters, for the reason that it had been carefully lightened without loss of strength and all details for stream-line had been observed, the same is true.

The Farman Brothers' Planes

While M. Bleriot was developing his monoplanes, Henry Farman left the Voisin brothers and began experimenting on his own account. The result of his experiments was first seen at the Great Rheims meeting when his Gnome-engine biplane appeared, and on

November 9, 1909, he made a new world record of 145 miles in four hours, eighteen minutes, forty-five seconds! Like the Wrights', his machine had a front elevator stuck out forward, but the vertical partitions had disappeared from the wings, though retained in the tail. The whole machine was built of wood, so that it was very much lighter than the Voisin. Its most remarkable step forward, however, was the use of balancing flappers, usually called ailerons, fitted into the rear edge of each wing. These ailerons were pulled down on one side to give that side extra lift when the machine tilted down on that side. Thus the ailerons had the same effect as warping the wings, and as it then became unnecessary to twist the wing itself, it became possible to build the whole wing structure as a fixed box-girder structure of wood and wire. This was lighter and stronger than was safe with a warping wing. For this reason aileron control is used on all aeroplanes of to-day.

The Farman biplane was fitted with the stick control used by M. Bleriot, the stick working wires fore and aft for the elevator and lateral for the ailerons. A rudder-bar for the feet operated the rudder wires. This was the beginning of the present-day idea of the pusher biplane.

In 1911 Farman abandoned the front elevator and used only the elevator control that was used by monoplanes, and he put the pilot and observer out in front of the machine so that the range of vision was entirely uninterrupted. Later this was covered and called a nacelle or nest by the French. Here the machine-gun was mounted in the days of the World War.

In 1912 Maurice Farman, a brother of Henry, built a machine independent of his brother. He constructed a deep nacelle, giving greater comfort to the pilot. It had a forward rudder, and because long horns supported the rudder, it was called the mechanical cow. When this front elevator was abolished later, it was known as the "Shorthorn." This was the prototype of the "gun busses" and early war training-machines in England.

In 1913 Henry Farman's pusher design began to take on its ultimate form. The whole machine was more compact. The nacelle sheltered the pilot better, and the machine did not look as detached from tail and elevator as formerly. The general effect was more workmanlike and less flattened out. This type was ultimately combined with the "Shorthorn" by Maurice Farman into a machine nicknamed the Horace, a combination of Henry and Maurice. In 1917 it was used as a means of training and aerial travel rather than as a fighting-machine.

The 1909 Antoinette Monoplane

The Antoinette monoplane was evolved from the early experiments of MM. Gastambide and Mangin, and designed by the famous M. Levavasseur, the engine as well as the aeroplane. This is the plane in which Herbert Latham failed to cross the English Channel by only a few hundred yards. At the Rheims meeting in August, 1909, it was in full working order, and during the last few days of the meet there was a continual fight for the distance and duration records between Latham of the Antoinette, Henry Farman of the Farman, and Paulhan of the Voisin. The Antoinette was much the fastest, but its engine always failed to hold out long enough to beat the others. However, the Antoinette proved in other respects to be the fastest flying-machine of the year.

It was the first machine in which real care was taken to gain a correct stream-line form. The wings were king-post girders. The body was largely a box-girder composed of three-ply wood. The tail was separated from the rest of the plane by uncovered longerons.

Unfortunately, the internal structure of later machines of this type was weak, so that there were many fatal results from breaking in the air. The control was also very hard to learn. One wheel worked the warping of the wings, another worked the elevator, and there was a rudder-bar for the feet. In spite of this the plane was very beautiful to look at.

The 1910 Breguet

The first successful machine of this type was designed by M. Breguet, a French engineer, who had begun experimenting in 1908, and it appeared the latter part of 1910. The first of the year he produced a machine which was nicknamed the "coffee-pot," because it was enclosed entirely in aluminum. This was developed later into a bombing-machine which had many interesting features. It was almost entirely constructed of steel tubes covered with aluminum plates, which led some to call it an armored aeroplane, which it was not. The tail, which was one piece with the rudder, was carried on a huge universal joint at the tip of the body, so that it swivelled up or down or sideways in response to the controls. The wings had one huge steel tubular spar, and as a result only one row of interplane struts.

The under-carriage had a shock-absorber of a pneumatic-spring construction, which was highly satisfactory, and was the prototype of the elastic-rubber devices.

The machine was heavy, but it was fast and a great weight-carrier. Because of minor defects in detail the machine never was generally used, but it was the first step toward the big tractor biplane of to-day. The Breguet 1913 seaplane, equipped with a Salmson engine, 200 horse-power, was one of the first to utilize large horse-power and was thus the forerunner of the huge flying-boat of to-day.

The Nieuport

In 1911 the brothers Charles and Edouard de Nieuport produced the monoplane more commonly known as the Nieuport. The fuselage was a very thick body, tapering well to rear. The pilot and passenger sat close together, with only their heads and shoulders visible above the fuselage. All unnecessary obstruction was removed to reduce head resistance. The under-carriage consisted only of three V's of steel tube, of stream-line section, connected to a single longitudinal skid, thus diminishing it to a noteworthy degree.

This made a very fast machine. With only a seven-cylinder, 50 horse-power Gnome engine it travelled 70 miles an hour, and with a fourteen-cylinder, double-row, 50 horse-power Gnome, rated at 100 horse-power but actually developing 70 horse-power, it reached between 80 and 90 miles an hour. M. Weyman, in the James Gordon Bennett race in the Isle of Sheppey, made an average speed of 79.5 miles an hour, so that allowing for the corners, he must have done around 90 miles an hour on straights.

The fast modern tractor biplanes show the influence of the flat stream-lined, all-inclusive body of the Nieuport.

The most remarkable of the small machines of 1916 was the Nieuport biplane, with the 90 horse-power engine and later the 110 horse-power Le Rhone engine. This was similar to the German Fokker, an excellent fighting-machine, and a direct successor of the Sopwith Tabloid. It was noteworthy for the odd V formed by the struts between the wings.

The 1912 B. E. (British Experimental)

In 1912 the British Government, realizing the importance of the aeroplane as a war-machine for scouting purposes, established the Royal Aircraft Factory at Farmborough, with Geoffrey de Havilland, one of the early British experimenters, as designer. Machines of his invention have been called D. H.'s. His 1912 aeroplane contains some of the ideas embodied in the

Avro, Breguet, and the Nieuport. The machine had the lightness of a Nieuport, the stream-line of a Breguet, and the stability of an Avro. It was very light for its size and capacity, and with a 70 horse-power Renault engine it attained a speed of about 70 miles an hour, and it responded in the air and on the ground in a manner never before attained. It was the prototype of a long line of Royal Aircraft Factory designs, through all the range of B. E.'s on to the R. E. series and the S. E. series.

The initials B. E. originally stood for Bleriot Experimental, as M. Bleriot was officially credited with having originated the tractor-type aeroplane. Later B. E. was understood to indicate British Experimental. The subsequent development into R. E. indicated Reconnaissance Experimental, these being large biplanes with water-cooled engines and more tank capacity, intended for long-distance flights. S. E. indicates Scouting Experimental, the idea being that fast single-seaters would be used for scouting. They were, however, only used for fighting.

Another R. A. F. series is the F. E. or large pusher biplane, descended from the Henry Farman. The initials stood originally for Farman Experimental, but now stand for Fighting Experimental, the type being variants of the Vickers Gun Bus.

The 1914 B. E. 2c

Just before the war broke out the British R. A. F. produced an uncapsizable biplane nicknamed "Stability Jane." Officially she was known as the B. E. 2c and was another type of Mr. De Havilland's original B. E. Once it was in the air the machine flew itself and the pilot had only to keep it on its course. It was so slow in speed and manœuvring that it was called the "suicide bus," yet the type was useful for certain purposes.

The 1912 Deperdussin

A very small monoplane, designed by MM. Bechereau and Koolhoven for the Deperdussin firm to compete in the James Gordon Bennett race at Rheims, proved to be the fastest machine built to the close of 1912. It was a tiny plane with a fourteen-cylinder, 100 horse-power Gnome engine. It covered 126½ miles in an hour—the first time a man had ever travelled faster than two miles a minute for a whole hour—and won the race. Allowing for corners, it must have flown well over 130 miles an hour on the straight course.

The little machine was stream-lined, even to the extent of placing a stream-lined support behind the pilot's head. Two wheels, an axle, and four carefully stream-lined struts made up the under-carriage. The plane was remarkable for having its fuselage built wholly of three-ply wood, built on a mould without any bracing inside. It was the prototype of all the very high-speed machines of to-day. In 1916–17 the three-ply fuselage was adopted in all German fighting-machines and this country is gradually appreciating the improvement and has made many fuselages of three-ply wood.

The 1912 Curtiss Flying-Boat

But perhaps the most remarkable achievement of 1912 was the Curtiss flying-boat. Glenn Curtiss, who won the James Gordon Bennett race in 1909, had succeeded in rising from the water in 1911 with a similar biplane fitted with a central pontoon float instead of a wheeled under-carriage. This he made into a genuine flying-boat, consisting of a proper hydroplane-boat, with wings and engine superimposed. All the great modern flying-boats have descended from this, and it is the forerunner of the great passenger-carrying seaplanes of the future. Curtiss is also credited with the invention of ailerons.

The 1912 Short Seaplane

Another type of seaplane was also developed in 1912 when, after many trials, the Short brothers, of Eastchurch, England, built a successful seagoing biplane, equipped with twin floats instead of the ordinary landing-gear. This, with only an 80 horse-power Gnome engine, was the first flying-machine to arise from or alight on any kind of sea.

The 1912 Taube

The German Taube was yet another development of 1912. This plane is so called because the wings are swept back and curved up at the tips like those of a dove. The builders were Herr Wels and Herr Etrich, of Austria, in 1908. Herr Etrich took the design to Germany, where it was adopted by Herr Rumpler.

This machine was designed to be inherently stable, that is, uncapsizable, and it was successful to a great degree. If it had altitude enough it generally succeeded when falling in recovering its proper position before striking the ground. Other builders had striven for inherent stability, but had failed to get beyond a certain point. Owing to the greater financial support obtainable in Germany the 1912 type Taube lasted, with small changes, far into 1915, when it was succeeded by the large German biplanes, which had greater speed and carrying power. Several machines in Britain and the United States have attained a considerable reputation as having inherent stability.

The 1913 Sopwith Tabloid

T. O. M. Sopwith, Harry G. Hawker, the Australian pilot who first went to Newfoundland to fly the Atlantic, and Mr. Sigrist, Mr. Sopwith's chief engineer, turned out early in 1913 an extremely small tractor biplane, equipped with an 80 horse-power Gnome engine, which surprised the aeronautical world by doing a top speed of 95 miles per hour and a climb of 15,000 feet in ten minutes, while it could fly as slowly as 45 miles per hour. It was achieved by skilfully reducing the weight, paying close attention to the designing of the wings, and by carefully stream-lining external parts. All the modern high-speed fighting-biplanes, such as the "Camels," "Snipes," "Kittens," "Bullets," "Hawks," and others, are descended from the original "Tabloid," so called because it had so many good points concentrated in it. Because of its fast-climbing ability it was used for the defense of such cities as London and Paris against the Zeps and aeroplanes.

The 1914 Vickers Gun Bus

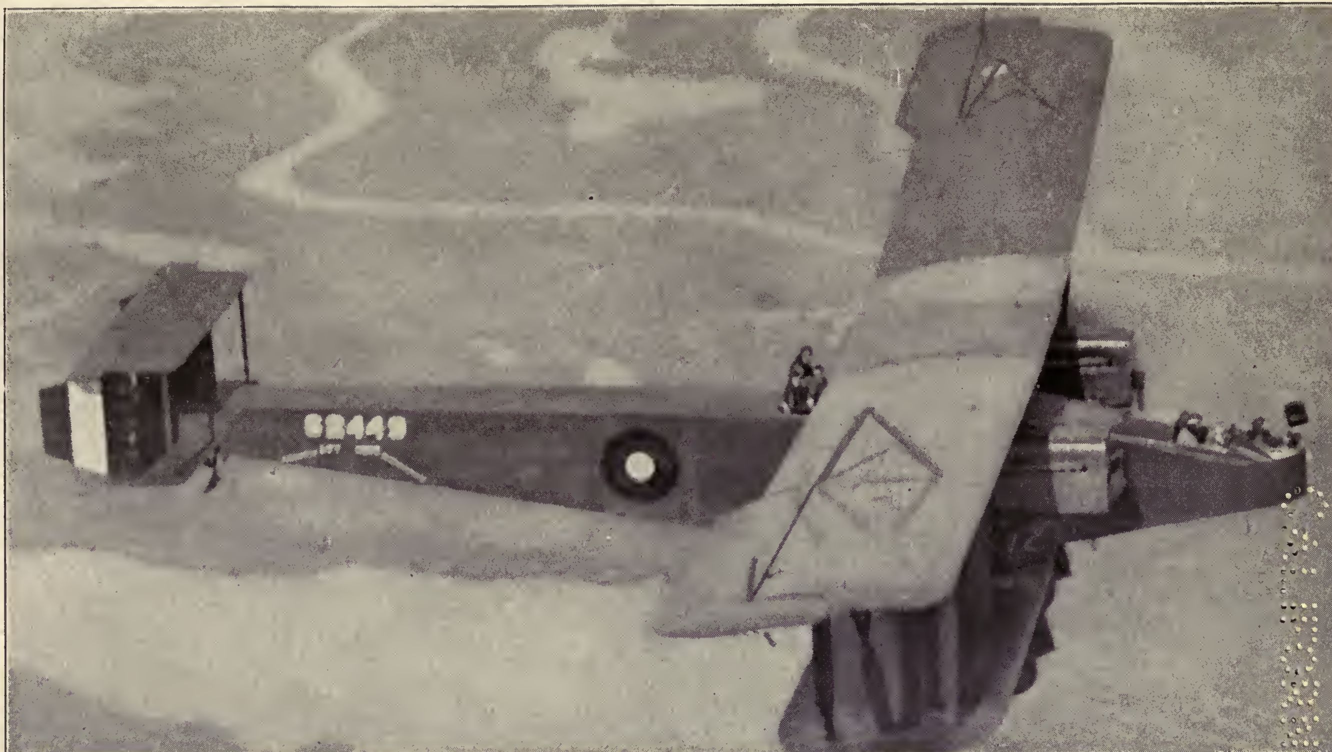
The first genuine gun-carrying biplane, designed and built by Vickers, London, came early in 1914. Clearly of Farman inspiration, it had an especially strong nacelle to stand the working of a heavy gun. Equipped with a 100 horse-power Gnome engine it made over 70 miles an hour. It was known everywhere as the "Gun Bus," and the name stuck to the whole class.

The 1914 German Albatross Biplane

Meanwhile the Germans were busy developing machines, so that another development of 1914 was the Albatross tractor biplane, with a six-cylinder vertical water-cooled Mercedes engine of 100 horse-power. This engine was the ancestor of the Liberty engine and of all the big German tractor biplanes. The plane resembled the French Breguets and British Avros of 1910.

The 1915 Twin Caudron

The first aeroplane to fly with consistent success equipped with more than one engine was the twin-motored Caudron, with two 110 horse-power Le Rhone



The huge four-motored Handley Page bomber.

This machine carried 40 passengers at one time over London and has flown from London, via Cairo and Bagdad, to India. It has a wing spread of 126 feet.

engines. Various other similar experiments had been made and some machines were designed which afterward made good. The French twin Caudron, however, may claim to be the first twin-engined aeroplane. The engines were placed one on each side of the fuselage but inaccessible to the pilot.

The 1916 Twin Handley Page

In 1916 the British Handley Page machine with 100-foot wing spread, driven by two Rolls-Royce motors of 250 horse-power, performed many remarkable bomb-carrying feats for long distance. A later machine, with 127-foot wing spread and four engines, flew via Cairo and Bagdad to Delhi, India, and still another carried a piano over the Channel. A large fleet of these bombers were ready to attack Berlin when the armistice was signed.

The 1917 Spad

The Spad was designed by M. Bechereau, of Deperdussin fame. It and the Albatross D3 model were both descended from the Deperdussin, the Nieuport, and the Tabloid. The Spad superseded the Nieuport as a fighting scout on the West Front because of its superior speed when driven by a Salmson engine.

The 1917 D. H. 4

The 1917 D. H. 4 was designed by De Havilland, and the S. E. 5 was built by his successors at the Royal Aircraft Factory. Both were descendants of the B. E., as is the Bristol Fighter, built by the British and Colonial Aeroplane Company, of British, and designed by Captain Barnwell.

The German Gotha, which bombed London so often, was a descendant of the Caudron and the Handley Page twin-engine planes.

In 1917 Italy produced her famous three-engined Caproni triplane, driven by three Fiat 1,000 horsepower engines. It had 150-foot wing spread and was used for bombing purposes. S. I. A. and Pomilio were smaller fighting-machines, equipped with Fiat engines. All of these machines were exhibited in the United States and many Caproni triplanes were built in this country.

CHAPTER VI

DEVELOPMENT OF THE AEROPLANE FOR WAR PURPOSES

GERMAN AERIAL PREPAREDNESS—PRIZES GIVEN FOR AERONAUTICS BY VARIOUS GOVERNMENTS—FIRST USE OF PLANES IN WAR—FIRST AIRCRAFT ARMAMENT

THERE is no gainsaying the fact that Germany, in her eagerness to develop every engine of war further than any other nation, so that when "Der Tag" came she would be mechanically superior and thus able to quickly crush any adversary, instantly saw the advantage that control of the air would give her.

For that reason, as soon as the Wrights began to demonstrate in France, in 1908, the feasibility of the aeroplane as a scout, the Germans realized the importance of the aeroplane as an adjunct of the dirigible, whose development they had already been committed to since 1900, when Count Ferdinand Zeppelin built his first rigid lighter-than-air craft. Since aeronautic motors had to be used on both types of aircraft, and since the speed and flying radius depended on the efficiency of the engine, the Germans set about to develop them.

The French War Department had in 1910 laid down rules and regulations for a competition to develop aeronautics. They specified that the aeroplane and engine should be made in France, and that the distance of flight must at least be 186 miles, carrying 660 pounds of useful load, or three passengers, and to attain an altitude of 1,640 feet. The sum of 100,000 francs was to be paid for the machine which accomplished this feat, and 20 other machines of the same type were to be bought for 40,000 francs each. In the lists of that year 34 aeroplanes of as many designs were built, but only 8 passed the tests. Weyman's Nieuport with a Gnome engine attained an average speed of 116 miles an hour.

As a result of this contest England, Germany, and Austria established aeroplane meets for 1912. England offered 10,000 pounds in prizes. Prince Henry of Prussia urged the German Government to appropriate $7,000,000 for military aeronautics. On January 27, 1912, the Kaiser offered 50,000 marks in prizes to develop aeromotors. The Aerial League of Germany started a public subscription which brought in 7,234,506 marks. The purpose of the league was to train a large number of pilots for a reserve and to encourage general development of aeronautics in Germany.

This proved to be a great success, for by the end of 1913, 370 additional German pilots had been trained, making a total of over 600. Meanwhile, German constructors increased from 20 to 50 in the same period of time.

The development of aeronautics under the auspices of the Aerial League induced the Reichstag to appropriate $35,000,000 to be expended during the next five years for military aeronautics. This was by far the most liberal appropriation made for war aeronautics by any government in Europe.

Under this encouragement, by the middle of July, 1914, the German aviators broke all the world's records, making a total of over 100 new records of all kinds. The non-stop endurance record of 24 hours, 12 minutes was made by Reinhold Boehm, and Heinrich Oelrich attained a new ceiling at 26,246 feet. Herr Landsman covered 1,335 miles in one day, making the world's record for distance covered by one man in one day. Roland Garros held the world's record of 19,200 feet before Otto Linnekogel made 21,654.

The stream-lining of aircraft and the development of the Mercedes and Benz gasoline motors under the incentive to win the Kaiser's prize was the big factor in this aeronautic progress. Not only did the Germans make new aviation records, but they also won the Grand Prix race in Paris, 1913, with engines the details of which were most jealously guarded, defeating the best English and French machines. Indeed, the Mercedes motor used on Zeppelin, aeroplane, and automobile was the same in fundamentals.

To Americans who are familiar with the difficulties we experienced in the early days of our entrance into the World War in getting quantity production with the Liberty motor, it is evident from the fact that the Germans had three large factories filled with tools, dies, gigs, etc., for quantity production of the Benz, Mercedes, and Maybach engines, that Germany believed that she had control of the air in June, 1914. She had already broken all the world's records in road-racing, as well as in the air, and she had more than a score of Zeppelins and over 500 standardized planes.

Naturally, the preparations of the Germans did not fail to attract attention in France. Races and aeronautic contests at military manœuvres, besides aero expositions, were held by the French, and the success of the Paris–Madrid and Paris–Rome race in 1911 influenced the French Chamber of Deputies to appropriate 11,000,000 francs for military aviation. The Kaiser's prize and Prince Henry of Prussia's recommendation of $7,500,000 appropriation for German aviation caused the Paris *Matin* to start a national subscription by donating 50,000 francs for an aeronautic fund similar to that subscribed by Germany.

In 1911 Mr. Robert J. Collier loaned his aeroplane to the United States Government to be used for scout duty on the Mexican frontier.

In February, 1912, during the Italian-Turkish War, the Italians used one aeroplane for locating the position of the Arabs, and several bombs were dropped without any attempt to do any more than guess at the place where they would land. As a matter of fact, they fell far from their objectives, and served no military purpose further than to frighten the horses. In locating the distribution of troops, however, this aeroplane was most valuable.

For that reason many military men even thought that the aeroplane, because of the velocity at which it moved, could not be of much value other than for scouting, and as no guns had been successfully mounted on aircraft before the World War, the aeroplane was not regarded as an offensive weapon. Indeed, that was one of the developments of the war.

The first attempts to mount a machine-gun on an aeroplane were made in France on a Morane monoplane. In order to shoot over the propeller a steel scaffolding was erected, and the pilot was supposed to stand up to sight his gun. This was impracticable, and the structure retarded the vision of the pilot and the speed of the aeroplane.

In the early days of the war pilots seldom flew over 3,000 feet high, and since there were no machine-guns mounted in a practical way, the pilots could only content themselves with firing revolvers at one another. The only thing they had to fear was rifle-shot and the trajectory of artillery. The few antiaircraft guns had no greater range than 3,000 feet, and, as a matter of fact, most of the reconnaissance work done at Verdun in the first six months of 1916 was at 3,000 feet altitude.

The first historic record of a machine-gun mounted on an aeroplane was in the despatch telling of the death of the French aviator Garaix on August 15, 1914, by the aerobus Paul Schmitt. Garaix had 200 rounds of ammunition. In December of that year the 160 horse-power Breguet piloted by Moineau mounted a machine-gun. The French pusher Voisins, with no obstruction of vision to the gunner in the nacelle, afforded an excellent opportunity for the use of machine-guns. Moreover, most of the aeroplanes brought down in the early days of the war were the victims of engine trouble or shots from rifles on the ground. A staff report of October 5, 1914, of the Germans relates that the French aviator Frantz, flying a Voisin with his mechanic Quenault, shot down a German Aviatic plane with two aviators from 1,500 metres altitude, killing the two Germans. For this feat Sergeant Frantz received the Military Medal, the first decoration given a French flier in the war.

On October 7 Captain Blaise and Sergeant Gaubert, in a Maurice Farman, with a rifle shot down Lieutenant Finger, a Boche who had defended himself with a revolver. Captain Blaise expended eight shots before he got the German flier.

The first recorded equipment of a machine-gun on a German machine was on October 25, 1914, when a Taube near Amiens opened fire on a Henry Farman machine piloted by Corporal Strebick and his mechanic, who were directing artillery-fire. The Germans first used a Mauser gun for their aeroplanes.

Meanwhile, the need for having a machine-gun fixed stationary on the aircraft and armed by manœuvring the aeroplane became more evident. Roland Garros, who was the first to fly across the Mediterranean Sea from France to Tunis, Africa, mounted a gun to shoot through the propeller on February 1, 1915. In order to protect the blades from the bullets, he had the propeller-tip covered with steel. Thus, when the bullets hit, they were deflected. Only 7 per cent hit the blades, however.

This was a crude way of mounting the gun, and it was Garros's mechanician who worked out the method of gearing up the machine-gun so that it shot its 600 bullets between the revolutions of the propeller. This enabled the so-called single-seater scout tractors, with propeller in front, to fly armed with a machine-gun mounted over the hood of the engine, directly in front of the aviator. It was also the beginning of the use of the aeroplane as a fighter in aerial duels and in contact patrol of later days when it descended to attack troops in the trenches and trains on the tracks.

January 1, 1915, was the date of mounting the first Lewis machine-gun on a Nieuport aeroplane to shoot over the propeller. The Germans copied this with their Parabellum light gun, but it was not till July, 1915, that the German Fokker first appeared with a synchronized machine-gun mounted on it. Since a propeller revolves 1,400 times a minute, a blade passes the nose of the gun 2,800 times a minute, and the machine-guns were geared to shoot about 400 shots a minute, so that one shot passes through to every seven strokes of the propeller-blade. Sometimes, however, as many as two guns were synchronized to shoot through the same propeller. A push-button on the steering-bar fires the gun while the pilot keeps his eye on the enemy through the telescope in front of him.

The Lewis gun is an air-cooled, gas-operated, magazine-fed gun, weighing 26 pounds with the jacket and 18 pounds without. The facility with which the gun can be manœuvred into any position or angle makes it a very efficient aeroplane gun. The ability of this gun to function automatically, and the speed with which it operates, is due to the use of a detachable drum-shaped, rotating magazine which holds 47 or 97 cartridges each. When the magazine is placed in position it needs no more attention until all the cartridges are empty, when the magazine is snatched off and another is stuck on. This gun is the invention of Colonel Isaac Lewis, a retired American army officer.

The Vickers is an English gun, belt-fed, water-cooled, recoil-operated. It can shoot from 300 to 500 shots a minute. Since all the shells are in a belt it can be fired continuously until the 500 shots have been used up. Its water-cooled devices were dispensed with on the aeroplanes.

The German Maxim is similar to the Vickers. The Lewis shoots .33 and Vickers and Maxim .30 ammunition. In the beginning of the war the Colt gas-operated gun was also used on aeroplanes, as were also the Hotchkiss and Benet-Mercier. The first gun shooting 400 shots a minute was similar to the Vickers.

Owing to the ease with which the cotton-belts containing the cartridges on Vickers guns jam, it was used only for fixed positions in front, whereas the Lewis was employed in the observer's nacelle and other positions which required sudden change in the aim. As many as half a dozen machine-guns were mounted on some of the large bombers in the last days of the war.

Many attempts to mount cannon on aircraft have been made, but owing to the recoil, the room necessary for mounting and manipulating, and the speed with which the gunner and the target move through the air, not much success was attained.

Captain Georges Guynemer, the first great French flier to down more than fifty Hun planes, is credited with mounting a one-pounder on his Nieuport, single-seater. It could not shoot through the propeller, so it was arranged to shoot through the hub. The gun was built into the crank-case, the barrel protruding two inches beyond the hub. It is said that Guynemer brought down his forty-ninth, fiftieth, fifty-first, and fifty-second victims with this type of gun; but because of the fifty pounds extra weight above that of the machine-gun it was an impediment.

Attempts to use on aeroplanes the Davis non-recoil gun, invented by Commander Davis of the United States navy, have not been entirely successful. The two-pounder is 10 feet long, weighs 75 pounds, and shoots 1.575 shell with a velocity of 1,200 feet a second. The 3-inch Davis fires a 12-pound shell and weighs 130 pounds.

Several other guns have been used, and with the increase in the size of planes there ought to be much increase in the size of aeroplane guns.

CHAPTER VII

DEVELOPMENT OF THE LIBERTY AND OTHER MOTORS

DEBATE IN REGARD TO ORIGIN OF LIBERTY MOTOR—LIBERTY-ENGINE CONFERENCE, DESIGN, AND TEST—MAKERS OF PARTS—HISPANO-SUIZA MOTOR—ROLLS-ROYCE—OTHER MOTORS

THERE has been more discussion of the Liberty motor than any other motor made during the war. This was due to the publicity given to the motor by the publication of a romantic story of the motor, issued from Washington over the signature of Secretary of War Baker, to the effect that the motor was conceived in a few days, and built and perfected within a month. Of course every engineer knows that that could not be done, and it took at least six months before the Liberty engine was perfected, and this was long after the Creel Publicity Bureau in Washington issued its statement.

As we have pointed out elsewhere, if the Aircraft Production Board had taken the patterns of a standard motor like the Hispano-Suiza, which had been flown for nearly three years under all kinds of war conditions, and which was being built in this country, and if they had ordered gigs, dies, and tools, and when we entered the war had requested our engineers to follow Chinese patterns in the making of the same, the dies, gigs, etc., could have been made at once instead of months later, and many American-made aircraft could have been operating over the lines when the Americans began to fight at Château-Thierry, and not months later, as was the case. Undoubtedly this delay cost the lives of thousands of American soldiers, and set back the Allied victory by just so much. The failure to deliver aircraft on schedule was the reason why General Pershing had to demand haste in the production of machines. Regardless of the fact that the aeroplane motor is radically different from the automobile motor, because it must be much lighter, nevertheless automobile men were called in by the Aircraft Production Board to design the Liberty motor, and many of the engine-building companies that had been constructing aeronautical motors were not consulted.

After the Liberty engine was completed a lively debate was instituted as to which of the two companies that was represented at the designing of the engine deserved the most credit for the job. One of the automobile companies advertised the fact that they were responsible for the Liberty motor, and the other company immediately replied, trying to prove that because they had built successful motors before the war that they were the real designers of the motor.

To be sure, no one would have objected to the construction of a Liberty motor on the side, but to delay the construction of motors in quantity until September, 1917, put the United States back just six months in production, for a number of factories were already producing parts for Rolls-Royce engines, and the Wright-Martin Company had been building the Hispano-Suiza motor since January, 1916.

Be that as it may, the facts regarding the Liberty motor appear to be that General Squier, E. A. Deeds, Howard E. Coffin, S. D. Waldon, of the Aircraft Production Board, called in to consultation on May 29, 1918, E. J. Hall, chief engineer of the Hall-Scott Motor Company, builders of a number of 4, 6, 8, and 12 cylinder aeroplane engines, and Jesse G. Vincent, experimental engineer of the Packard Motor Car Company, who had just completed a design and an experimental aeroplane engine, which had never up to that time been in a plane.

Both these gentlemen were in Washington attempting to interest Signal Corps officials in the aeroplane engine each had designed.

Liberty-Engine Conference

A five-day conference between Mr. Hall and Mr. Vincent, called by Mr. Deeds and Mr. Waldon of the Aircraft Production Board to consider aeroplane-engine design and production, was held. The two engineers got together in designing a standardized, directly driven, five-bearing crank-shaft engine of 8 cylinders, and one of 12 cylinders, with a seven-bearing crank-shaft. After a session of twenty hours' work in a room at the New Willard Hotel, in Washington, during which meals were served the two men, and both lived, worked, and slept in the apartments of Mr. Deeds, a new 8-cylinder 230 horse-power aeroplane engine was laid out, described, and drawings of transverse and longitudinal sections were made by Vincent and Hall themselves. This was the first Liberty motor designed.

On the morning of May 30, 1917, near the close of the designing session, Mr. Vincent dictated a joint report to the Aircraft Production Board. The salient points and a rough draft had been agreed upon the night before. It was dated May 31, 1917, and signed jointly by E. J. Hall and Jesse G. Vincent.

WASHINGTON, D. C., May 31, 1917.

AIRCRAFT PRODUCTION BOARD,
WASHINGTON, D. C.

Gentlemen: At your request we have made a careful study of the aircraft motor situation and hasten to submit our report as follows:

In order to get this report in your hands promptly we have condensed it as much as possible and have covered the essentials only.

In view of the fact that there are a number of good motors for training-machines available, we have disregarded this type of motor and have confined our attention strictly to the high-efficiency, low-weight per horse-power type, such as is necessary at the front.

In order that any motors that are built by this country may be of any value when received at the front, it is, of course, absolutely necessary that their efficiency be brought up to or a little beyond the best now available in Europe. This, of course, made it necessary for us to know just what has been accomplished in Europe. The French and English Commission has enabled us to obtain this information by answering our questions very clearly and completely.

From information obtained from these gentlemen and from other sources, we believe that the Loraine Dietrich is the coming motor in Europe. This motor has not been built in large quantities as yet, but some thirty had been constructed and carefully tested out at sea-level and also at about 6,000 feet elevation. The important facts about this motor are as follows:

Eight cylinders: 120 mm. bore by 170 mm. stroke.

Cylinders made of steel with water-jackets welded on. Motor is direct-driven and develops 250 horse-power at 1,500 r. p. m., and 270 horse-power at 1,700 r. p. m. The weight of the bare motor is 240 kilos, or approximately 528 pounds, while the weight of the motor complete with radiator and water is 305 kilos, or 671 pounds. There seems to be a reasonable doubt regarding the exact weight of the bare motor, as while the French Commission gave us the figure of 528 pounds, information from other sources indicates a weight of 552 pounds; probably some intermediate figure is more nearly correct, but in any event the motor gives a horse-power for approximately two pounds of weight when figured at its maximum output of 270 horse-power.

After obtaining this information and considering the matter very carefully, we next investigated the matter of testing such a motor, as we knew that a motor of this type could not be run at full power for long periods of time without developing serious trouble. Here again the French Commission gave us valuable information. They stated that in using a motor of this type it is only run at full power for short periods of time while climbing or fighting, and that all other times it is run at speeds 200 to 300 r. p. m. slower. In view of the fact that the motor is built to run under these conditions, it is, of course, necessary to test it under similar conditions, and they stated when trying out a new model of motor it is their practice to mount a propeller which will just hold the motor down to maximum speed under full throttle. The motor is then run for fifty hours, in periods of six to eight hours each, but the motor is not run up to full speed for more than a total of ten hours during this entire period, nor is it run more than thirty minutes at any single time under this condition. The other forty hours' running is under throttled conditions, turning the same propeller 200 to 300 r. p. m. less than maximum speed.

This information is of the utmost importance, as it enables us to reduce all factors of safety and make possible the light-weight per horse-power now being obtained in Europe.

After obtaining this information we immediately laid down a proposed motor which we believe can be produced promptly in large quantity in this country. Built carefully out of proper materials, this motor will have approximately the following characteristics and be as good, or a little better, than the Loraine Dietrich, which is not as yet really available abroad.

In laying down this motor we have without reserve selected the best possible practice from both Europe and America. Practically all features of this motor have been absolutely proved out in America by experimental work and manufacturing experience in the Hall-Scott and Packard plants, and we are, therefore, willing to unhesitatingly stake our reputations on this design, providing we are allowed to see that our design and specifications are absolutely followed.

The motor is to be of the eight-cylinder type, with cylinders set at an included angle of 45 degrees. The cylinders are of the individual type, made out of steel forgings with jackets welded on. The bore is five inches and the stroke seven inches, giving a piston displacement of 1,100 cubic inches. The crank-shaft is of the five-bearing type with all main bearings 2⅜ inches in diameter, and all crank-pin bearings 2¼ inches in diameter. The connecting-rods are of the I-beam straddle type. This motor is of the direct-driven type with a maximum speed of 1,700 r. p. m. This motor will have a maximum output of 275 horse-power at 1,700 r. p. m. It will weigh 525 to 550 pounds, but we feel very sure of the lower figure. It will have a gasoline economy of .50 pounds of fuel per horse-power hour or better; it will have an oil economy of .04 pounds of oil per horse-power hour or better. Complete with water and radiator, this motor will not weigh more than 675 pounds, if a properly constructed radiator is used and placed high above the motor.

To obtain the above-mentioned weights it will be necessary to use the fixed type of propeller hub which has been thoroughly proved out by Hall-Scott practice. In order to obtain the above-mentioned weights it will also be necessary, as mentioned above, to use the very best material, workmanship, and heat treatment.

Complete detail and assembly drawings, as well as parts list and material specifications, can be completed at the Packard factory under our direction in less than four weeks. We believe that a sample motor can also be completed in approximately six weeks if money is used without stint. As soon as the drawings, specifications, and sample motor have been finished, complete information would, of course, be available so that any high-grade manufacturer could either make parts for this motor or manufacture it complete.

In laying down this design we have had in mind the extreme importance of interchangeability, as a well-laid, comprehensive programme which has for its base interchangeability of important parts, such as cylinders, will speed output and reduce ultimate cost to an astonishing extent. Europe is suffering right now from lack of uniformity of design, but it is too late for them to change their plan. We, however, can take a leaf out of their book and start right.

In the design which we have laid down, the cylinder, for instance, can be used to make four, six, eight, and twelve cylinder motors. As this is the most intricate part to make, immense facilities could be provided to produce them in large quantities for the use of many concerns who could manufacture the balance of the motor. Nearly all small parts and numerous large and important ones would also be interchangeable. This would not only speed up production but would be of the utmost importance in connection with repairs and replacements. A full line of motors made according to this plan would line up about as follows:

Type	Rated Horse-power	Maximum Horse-power	Weight	Weight per Horse-power
4	110	135	375	2.7
6	165	205	490	2.3
8	225	275	535	1.9
12	335	410	710	1.7

Respectfully submitted,

(*Signed*) J. G. VINCENT.

(*Signed*) E. J. HALL.

On June 4 Hall and Vincent finished a layout of an 8-cylinder engine, and presented the drawings and received an order to build ten sample engines, and on June 8 the Packard Company arranged for pattern-making, production work, etc.

This motor after intensive work on detail drawings was put into preliminary production. The first one was delivered to Washington, July 3, 1917. In the making of the sample engine Mr. Vincent's company placed its factory organization at the disposal of the government, and through Mr. Vincent's untiring efforts and enthusiasm the first motor was completed within the sixty days.

The other companies which aided in the work of building this motor were:

The General Aluminum and Brass Manufacturing Company of Detroit made bronze-backed, babbitt-lined bearings and aluminum castings.

The Cadillac Motor Car Company of Detroit made the connecting-rods, connecting upper-end bushings, connecting-rod bolts, and rocker-arm assemblies. The Cadillac Company had perfected the design of connecting-rods of the forked or straddle type, and had been using them for several years in their 8-cylinder engines.

The Parke Drop Forge Company of Cleveland made the crank-shaft forgings. These forgings completely heat-treated were produced in three days, simply because Mr. Hall gave them permission to dig out the Hall-Scott dies which were used in making the first Liberty crank-shaft forgings.

Hall-Scott Motor Car Company of San Francisco supplied all the bevel-gears out of its stock for the standardized line of Hall-Scott 4, 6, 8, and 12 cylinder aeroplane engines.

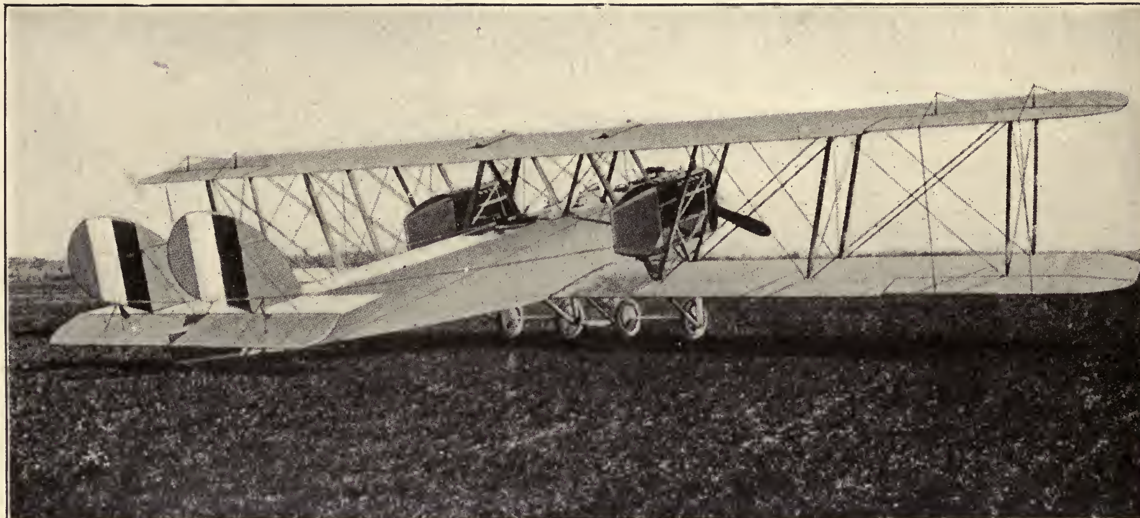
The L. O. Gordon Company of Muskegon made the cam-shafts.

The Hess-Bright Manufacturing Company of Philadelphia made the ball-bearings.

The Burd High Compression Ring Company of Rockford, Ill., supplied the piston-rings out of stock made up for the Hall-Scott line of standardized aeroplane engines, for which it had perfected a piston-ring.

The Aluminum Castings Company of Cleveland supplied the die-cast alloy pistons, and machined them up to grinding, as they had been engaged in making them for several years for the Hall-Scott line of standardized aviation engines.

The Rich Tool Company made the valves.



The Martin bomber.

This plane is equipped with two Liberty engines and has many long-distance records. It flew from Pittsburgh to Washington, a distance of 175 miles, in 1 hour and 15 minutes. It also flew from the Atlantic to the Pacific.

The Gibson Company of Muskegon made the springs.

The Packard Company made the patterns and several dies in order to obtain drop-forgings of the proper quality. It also machined the crank-shafts.

After the preliminary tests passed by the 8-cylinder engine, August 25, 1917, Government Inspector Lynn Reynolds said "that the design has passed from the experimental stage into the field of proven engines." The machine was tested at Pike's Peak, Colorado, for altitude in August, 1917. Reports from the battlefield decided the board to build 12-cylinder engines. Thereupon standardized parts made interchangeable for all types of Liberty engines were detailed, and orders placed with the various firms named to build the same. Production was started on a large scale.

On October 17 the production of the Liberty motor started, over six months after we entered the war.

The delivery of the first Liberty 12 was made on Thanksgiving Day, 1917.

One of the unrecorded incidents of this period concerned the "scrapping" of $400,000 worth of semi-finished parts of an automotive aircraft engine, which was assumed O. K., and parts had been ordered for 250 motors. It was actually in production at the time Hall and Vincent were ignoring practically all its features and "laying out" the designs for the Liberty 8 and Liberty 12. It had never been tested in a plane, and its design and all its parts were rejected.

Owing to the slowness of production due to the new gigs, dies, tools, etc., necessary to build the engines, much criticism was directed at the lack of shipments of Liberty engines for army air service in the winter months of 1917.

Charged with the necessity of protecting the American army transport, the Navy Department had first call on all air-service equipment. As a result it received the first Liberty 12's turned out. These were installed in navy aeroplanes, where they did good work.

The preliminary Liberty 8 was delivered to the Bureau of Standards, Washington, D. C., July 3, 1917, by the group of industrial concerns named. A 54-hour test was made of a Liberty 12 on August 25 by the Bureau of Standards. The Liberty 12 was detailed for quantity production, and the actual work was begun, and the work done by these companies in producing Liberty-engine parts is above praise. It was then that the mighty energies of their splendid organizations demonstrated the ability of American industrial life to fight the battle behind the lines.

War Department Statement

Departing from its policy of secretiveness concerning all things of a military character, the United States War Department on May 15, 1918, issued an authorized statement dealing with the technical features and characteristics of the Liberty 12, then in quantity production. This statement was published in the *Congressional Record* of an early subsequent date.

Secretary of War Baker in his report published elsewhere in this book gives the following account of Liberty motors built:

Production of Service Engines

In view of the rapid progress in military aeronautics, the necessity for the development of a high-powered motor adaptable to American methods of quantity production was early recognized. The result of the efforts to meet this need was the Liberty motor—America's chief contribution to aviation, and one of the great achievements of the war. After this motor emerged from the experimental stage, production increased with great rapidity, the October output reaching 4,200, or nearly one-third of the total production up to the signing of the armistice. The factories engaged in the manufacture of this motor, and their total production to November 8, are listed in Table 21.

Table 21.—Production of Liberty Motor to November 8, 1918, by Factories:

Packard Motor Car Co	4,654
Lincoln Motor Co	3,720
Ford Motor Co	3,025
General Motors	1,554
Nordyke & Marmon Co	433
Total	13,396

Of this total, 9,834 were high-compression, or army type, and 3,572 low-compression, or navy type, the latter being used in seaplanes and large night bombers.

In addition to those installed in planes, about 3,500 Liberty engines were shipped overseas, to be used as spares and for delivery to the Allies.

Other types of service engines, including the Hispano-Suiza 300 horse-power, the Bugatti, and the Liberty 8-cylinder, were under development when hostilities ceased. The Hispano-

Suiza 180 horse-power had already reached quantity production. Nearly 500 engines of this type were produced, about half of which were shipped to France and England for use in foreign-built pursuit planes.

Table 22 gives a résumé of the production of service engines by quarterly periods:

TABLE 22.—PRODUCTION OF SERVICE ENGINES IN 1918:

Name of engine	Jan. 1 to Mar. 31	Apr. 1 to June 30	July 1 to Sept. 30	Oct. 1 to Nov. 8	Total
Liberty 12, Army.......	122	1,493	4,116	4,093	9,824
Liberty 12, Navy........	142	633	1,710	1,087	3,572
Hispano-Suiza 180 h.p...	...	....	185	284	469

Later the Statistical Department of the War Department issued the following. The number of planes and engines shipped by the Bureau of Aircraft Production to depots and storehouses from the date of the armistice to February 14:

Liberty 12 service engines..........................	4,806
OX-5 elementary training-engines....................	1,261
Le Rhone advanced training-engines..................	994
De Havilland-4 observation planes...................	524
Hispano 180 advanced training-engines...............	343
Hispano 150 advanced training-engines...............	254
JN6-H advanced training-planes......................	174
JN4-D elementary training-planes....................	131

The Packard Motor Car Company made the final deliveries of Liberty 12 motors during the week ended March 21, 1919. This completes all contracts. The following shows the number and per cent produced by each factory:

Firm	Number produced	P. C. of total
Packard Motor Car Co..............	6,500	32
Lincoln Motor Co...................	6,500	32
Ford Motor Co......................	3,950	19
General Motors Co..................	2,528	12
Nordyke & Marmon Co..............	1,000	5
Total..........................	20,478	

The Hispano-Suiza

It is evident from the records made by the German Mercedes, which are given in another chapter, that it was the best aviation motor in existence in July, 1914. Naturally, this motor had considerable influence on the aeronautical engineers of the Allies. Mr. Marc Birkright, a Swiss engineer to the Hispano-Suiza Company, automobile builders in Barcelona, Spain, and Paris, designed the aviation motor which now holds the world's record for altitude—28,900 feet. When he designed the motor he had in mind the construction of the machine-tools necessary to build the same.

In the summer of 1915 the first motor of 150 horse-power was delivered to France after a test of 15 consecutive hours. The next two were tested for 50 hours, and proved satisfactory. France placed a large order, and the Hispano-Suiza factory began production at the end of 1915. Before the end of the war three Italian, fourteen French, one British, one Japanese, and one Spanish factory, besides 25,000 people in America, were producing Hispano-Suiza engines.

The motor had great success in the single-seater fighters flown by such men as Captain Georges Guynemer, Lieutenant Fonck, Nungesser, and dozens of other aces.

With the exception of increasing the horse-power from 150 to 180, 200, 300, very few changes were made in this motor in this country.

Four hundred and fifty engines were ordered by the

French Government of the General Aeronautic Company of America early in 1916. When the Wright-Martin Aircraft Company was formed in September of that year, less than 100 motors had been delivered. At the end of July, 1917, 1,000 motors were on their books.

From July, 1917, the American factory concentrated on the 150 horse-power engine. The Wright-Martin Company had to build its own plant for aluminum castings for the engine. In November of that year the company was ordered to build 200 horse-power engines, and later the 300 horse-power was ordered. In May, 1918, the French and British Governments decided to use the 300 horse-power motor in large quantities, and by October the factories of the company in New Brunswick and Long Island City were tooled up to produce 1,000 motors a month, which represented a $50,000,000 order. Early in the spring of 1918, 15 motors a day were produced, and in August of that year the company was committed to a schedule of 30 engines a day.

The Rolls-Royce Motor

"There is no doubt," says *London Motor*, "that the conception of the Rolls-Royce aeronautic engine is extremely good, but no one will gainsay the fact that the care exercised in manufacture and the elaborate operations through which the various parts have to pass are in part the reason for its success. This refinement necessitates the passing of certain parts through fifty or sixty operations that might be easily carried out in a comparatively small number if superfine finish were not desired or required.

"The Rolls-Royce 'Eagle' engine, originally designed as a 200 horse-power unit, developed 255 horse-power on the first brake test. Diligent research and experiment were pursued with extraordinary results, as will be seen in the following record of official brake tests, all made without any enlargement of the dimensions or radical alteration in design. A 12-cylinder engine, 4½-inch bore by 6½-inch stroke, developed in March, 1916, 266 horse-power at 1,800 R. P. M. By July the power was increased to 284 horse-power; nine months from this date, in September, 1917, it had risen to 350 horse-power, and in February, 1918, 10 more horse-power was added, making the total 360 horse-power. In addition to the 'Eagle,' a smaller engine giving 105 horse-power at 1,500 R. P. M. was turned out under the name of the 'Hawk.'

"The 'Eagle' engine was used in the large Handley Page machine, and in the successful long-distance bombing raids into Germany. In 1916 another engine for fighting planes was added to the list, under the name of 'Falcon,' and was almost exclusively used in the Bristol fighting plane. The increase in the power developed by the 'Falcon' engine, which has a 4-inch bore, was as follows: April, 1916, 206 horse-power at 1,800 R. P. M.; July, 1918, 285 horse-power at 2,000 R. P. M.

"From the stamping-plant through the machine, gear-cutting, and grinding shops and welding department, the care with which each engine is turned out is apparent. Take apart a cylinder which has a stamped sheet-metal water-jacket welded externally, and the original billet is found out of which the cylinder was made, but reduced almost by half when it is ready to receive the valve cages, and during the process of removal of the metal and forming into proper shape the piece is subjected to several heat treatments so as to bring the metal to that stage of perfection needed for the work it has to perform. The elbow cages that are fitted to the cylinders might be cast and cored, but the valve cage is an actual solid stamping, and the right-angle bend through the elbow has to be bored out by special machines.

"One point illustrates the care in the choice of metal and the multifarious operations through which each part has to pass. A crank-shaft stamping with extension piece on the rear and about one foot long is cut off, and test pieces of this metal, properly numbered with each crank-shaft, are passed through the same treatment as the crank-shaft itself, and then subjected to minute examination by highly skilled engineers. The actual manufacturing side of the work would naturally be very similar to the manufacture of a car engine, but one obtains a better perspective of what an engine is subjected to by passing from the erecting and manufacturing shops to the engine-testing shop, where the ear-splitting reports from the open exhausts of a number of engines being tested at the same time are heard. Here one sees how dissimilar the aviation engine is from the car engine. It is almost impossible, without having actually witnessed it, to picture to oneself a 12-cylinder engine running at 2,200 R. P. M. against a brake test. As the exhaust ports are on either side of the engine, the cylinders being placed in the form of a V, it is possible, by passing on either side, to look into the combustion-chamber and see the valves rising and the spit of the exhaust, and, what is almost incredible, that the exhaust valves are actually red-hot and run in this condition for hours. Little wonder is it that the valves have to be made of superfine material and of particular form.

"The variation in the color of the flame of the exhaust, due to strong and weak mixtures, makes it quite possible to test the good running of an engine by the color of its exhaust. The strength of the mixture has necessarily to be altered according to atmospheric conditions and the altitude to which the pilot desires to climb.

"No doubt airplane-engine practice of the last four years and the advance that it has made will be reflected in a very marked degree in the automobile, not necessarily by fitting large airplane engines in cars, but by applying to car practice the knowledge that has been gained in manufacture.

"The Rolls-Royce works had in 1907 an area of 5,312 square yards, and during the war this was increased to 67,935 square yards. At the present time the payroll is somewhere in the neighborhood of 8,650."

CHAPTER VIII

GROWTH OF AIRCRAFT MANUFACTURING IN UNITED STATES

THE 1912 EXPOSITION—THE FIRST PAN-AMERICAN EXPOSITION—THE MANUFACTURERS AIRCRAFT EXPOSITION—DESCRIPTIONS OF EXHIBITORS—GROWTH OF AIRCRAFT FACTORIES—NAVAL AIRCRAFT FACTORY

As soon as the Wright brothers demonstrated the feasibility of aerial flight in 1908 a great many companies were organized to manufacture heavier-than-air machines. Naturally, most of the designers and builders were young men who learned to fly, as there was no science of aircraft construction taught in the universities or colleges in the pioneer days. At first little capital was obtained, and as the use of the aeroplane was confined to sporting purposes, the demands for the same were small. Nevertheless, by May, 1912, the manufacturing of aircraft had developed to such an extent that a show was held at the Grand Central Palace, New York, from May 9 to 18. The exposition was held under the auspices of the International Exposition Company. Nine monoplanes and twelve biplanes and one quadriplane were exhibited.

The Wright brothers exhibited a two-seater biplane. It differed little from the regular headless models, the only change being the two long, narrow, vertical planes in front and a larger vertical rudder in the rear and wing-warping. The gasoline-tank is placed behind the passenger-seat, while the radiator was put in the rear of the engine. On the Wright stand was also to be seen for the first time one of their new 6-cylinder 6 horse-power aeroplane motors, as well as a new three-step hydroplane, designed expressly for use on their machines.

CURTISS

The Curtiss Aeroplane Company showed three of their latest biplanes and two motors.

The centre of attraction of the Curtiss exhibit was the new small-spread headless machine. This machine had a spread of only 21 feet 3 inches, and a chord of 4½ feet, and an over-all length of 32 feet. It was equipped with a 75 horse-power 8-cylinder V water-cooled Curtiss motor. A Curtiss hydroaeroplane was also shown.

In addition to the hydro and racer the Curtiss Company showed a two-passenger military-type machine, fitted with a shift control.

BURGESS

The Burgess Company showed three biplanes, one a large two-seater military tractor, a regular Burgess-Wright hydroaeroplane, and the "Flying Fish," the original Burgess.

The military type was a large tractor biplane having the engine and propeller mounted in front of the fuselage. The seats for the aviator and passenger were arranged tandem fashion behind the gasoline-tanks and immediately between the two planes. Near the rear of the fuselage was attached a stationary horizontal stabilizing tail, while at the extreme rear was the horizontal rudder.

The power-plant consisted of an 8-cylinder V air-cooled 70 horse-power Renault motor, which drove through under gearing a large Chauviere tractor propeller.

In addition the machine was equipped with a very complete wireless set for receiving and sending messages, the current being generated by a small dynamo, which was placed underneath the fuselage and was driven by the engine.

The Burgess-Wright shown was of the regular two-passenger type, capable of being started from the seat, and fitted with a 6-cylinder 50 horse-power silenced Kirkham motor in place of the usual 35 horse-power Wright.

Schill

Paul Schill, of the Max Ams Company, exhibited a large Farman-type hydroaeroplane, equipped with a 100 horse-power 8-cylinder Max Ams motor, which could be cranked from the seat. This biplane had a covered-in cabin with seats for three persons. The hydroplanes were fitted to the regular skid struts and were of the single-step type.

Coffyn

Frank T. Coffyn exhibited a hydroaeroplane. This machine was the regular standard Wright pattern, but fitted with Coffyn's own hydroplanes. Coffyn was the first man to successfully fit double hydroplanes to an aeroplane.

Another improvement made by Coffyn was the fitting of a starting-crank to permit starting the motor from the front without having to turn the propellers.

Christmas

The Christmas Aeroplane Company showed a biplane. The wings of this biplane were set at a double dihedral angle, with an opening about two feet wide in the centre of the top plane, to take up the blast of air made by the propeller. The edges of the wings were flexible like a bird's. The controlling-gear consisted of a semicircular wheel, which by rotating worked the ailerons, while a twisting movement of the whole on its axis turned the vertical rudder, and a fore-and-aft movement, operated by warping, the large horizontal rudder in the rear. The motor used was a 7-cylinder 50 horse-power Gyro.

Gressier

The Gressier Aviation Company exhibited a "Canard" type machine which was fitted with a 50 horse-power Gnome. This machine has an elevator in front of the fuselage, while the main planes and motor were in the rear. The seats for pilot and passenger were situated just in front of the main biplane cellule.

The biplane shown was fitted with three skids and six Farman-type shock-absorbing wheels.

Rex

The Rex Monoplane Company exhibited an all-American monoplane. This machine had a long, graceful fuselage, which carried at its front end the motor and gasoline-tank, the wings and the pilot's seat, and at its rear the flat, non-lifting tail plane and elevator flaps with the vertical rudder immediately behind them. The landing-gear was quite novel, and consisted of a single skid and two shock-absorbing wheels. These wheels were attached to the fuselage through telescopic tubes having springs inside them to absorb shocks. The axle also strapped to the landing-skid by rubber bands, the whole forming the first flexible and efficient shock-absorbing landing-gear.

The main planes had a peculiar reverse curve in them, and were pivoted to a centre upright in the fuselage, thus permitting of warping the whole wing instead of only the tips.

Antoinette

Harry S. Harkness exhibited the Antoinette monoplane with which he carried the first war-despatch in the United States, on February 7, 1911. This machine was fitted with an 8-cylinder 50 horse-power Antoinette motor and Normale propeller.

Baldwin

Captain Thomas S. Baldwin showed the biplane with which he has toured in many parts of the globe. This machine was a cross between an early Farman and a Curtiss. The power-plant consisted of a 60 horse-power 8-cylinder Hall-Scott motor.

Multiplane Ltd.

The Multiplane Limited, of Atchison, Kan., showed a large quadruplane built under the patents of H. W. Jacobs and R. Emerson. The machine was of the headless type, having four main planes in front, with four lifting tail planes in the rear, and an elevator immediately behind the two. The propellers were mounted on the same axis and placed midway behind the main planes, and were driven by leather-covered flat steel belts from two 8-cylinder 80 horse-power staggered V-type air-cooled motors. The machine was designed for weight-carrying, and was fitted with a large cabin having a double row of seats, capable of holding five people comfortably. The landing-chassis consisted of one long centre skid, having two large 48-inch wheels in front, and a single swivelling wheel in the rear. These wheels were not fitted with pneumatic tires, but instead had a broad, flat, strip steel rim. The wing spread was 37 feet; length, 29 feet 8 inches; height, 17 feet.

Gallaudet

The Gallaudet Engineering Company exhibited a speed monoplane named the "Bullet."

The fuselage was torpedo-shaped, having a section four feet square at the point where the aviator sat, and tapering sharply to a point in the front, and more gradually toward the rear. The nose of the machine was made up of sheet aluminum, having a series of holes stamped in it to permit of efficient cooling of the 14-cylinder Gnome. The main planes were attached to the centre of the fuselage in a position just behind the engine, while at the rear of the fuselage were the small triangular-shaped elevator and the vertical rudder. A three-bladed propeller was used. The dimensions were: length over all, 20 feet 6 inches; spread, 32 feet; width of wings, 8 feet wide at the body, tapering slightly toward the tips.

Twombly

Mr. Irving W. Twombly exhibited a Bleriot-type monoplane which was fitted with one of his 45 horsepower 7-cylinder air-cooled revolving motors. The planes were covered with transparent celluloid in the vicinity of the body for the purpose of affording the pilot a good view of the ground immediately below and in front of him.

Another exhibit of Mr. Twombly's was a shock-absorbing safety harness of his own invention for strapping aviators in their machines. This harness was so constructed as to prevent the aviator from being lurched out of his seat, and yet at the same time permitting him to quickly detach himself from the harness in case of emergency.

Nieuport

The Aero Club of America exhibited a 50 horsepower Gnome Nieuport aeroplane.

Queen

The Queen Aeroplane Company exhibited two machines, one an aero-boat designed by Grover C. Loening, and the other a Bleriot-type monoplane equipped with a 30 horse-power Anzani motor.

The aero-boat consisted of an aluminum-covered boat, to which were attached in front on an upright structure the main wings, with the motor and propeller just behind them. The power-plant consisted of a 50 horse-power Gnome, which was placed in the boat proper, and drove through a chain the propeller, which was just behind and a little above the main planes. The controlling arrangement was quite novel, and consisted of two horizontal levers resembling the tillers of a boat, which the operator grasped one in each hand.

National

The National Aero Company exhibited a Bleriot-type monoplane which was equipped with a 4-cylinder 40 horse-power Rubel "Gray Eagle" motor and Rubel propeller. The motor was fitted with an acetylene self-starter, which was controlled from the seat.

American

The American Aeroplane Company exhibited a large monoplane with a very low centre of gravity. It was fitted with two 50 horse-power 2-cycle air-cooled revolving motors and self-starters, and was designed to fly with either motor, and to carry six to ten persons.

The First Pan-American Aero Show

It is notable that no engine exhibited at this exposition had more than 80 horse-power, whereas the Liberty motor of 1917 developed 450 horse-power and the Fiat 700 horse-power.

The first Pan-American aero exhibit was held at the Grand Central Palace, February 8 to 15, 1917. By that time the war had demonstrated the value of aircraft for scouting, bombing, reconnaissance, and contract patrol, and because of the exploits performed by famous aces, had attracted the attention of huge numbers of people.

During the five years that had elapsed from the time of the former exhibit the construction of aircraft had advanced fully a decade, due to the intensive acrobatics aircraft had to be put through in aerial fighting. America was, of course, far from the seat of the war, but owing to the orders placed with the Curtiss Aeroplane and Motor Company and other companies by the British and other governments, constructors were kept more or less in touch with developments in Europe. It is true that owing to the rapid changes in designs of motors and aeroplanes, due to the competition between the Central Powers and the Allies for control of the air, the speedier planes like the scouts and battleplanes were built in England, France, and Italy, while the United States manufacturers produced seaplanes for hunting submarines, and training-machines, of which there was a tremendous demand.

The Curtiss Company immediately turned their energies to building J. N. 4 training-machines, and large seaplanes, like the "America," which Captain Porte was to attempt to fly across the Atlantic with for the British Government.

A large number of accessories were also exhibited. President Wilson opened the convention by wireless, and Governor Whitman delivered an address.

The next aero show was held by the Manufacturers Aircraft Association at Madison Square Garden, March 1–15, 1919. This organization had been effected on February 15, 1917. The following were the incorporators of the association: The Aeromarine Plane and Motor Company, John D. Cooper Aeroplane Company, L. W. F. Engineering Company, S. S. Pierce Aero Corporation, Standard Aero Corporation, Sturtevant Aeroplane Company, Thomas-Morse Aircraft Corporation, Witteman-Lewis Aircraft Company, Wright-Martin Aircraft Corporation.

In the meantime the United States had entered the war. At the beginning a great many newspaper editors who did not know the difficulties of constructing aircraft in quantity, and imagining that they could be produced as easily as automobiles, wrote glowing editorials demanding the immediate construction of 100,000 aeroplanes to invade Germany in the air and destroy her manufacturing industries, as well as terrorize the people into surrender. The Aircraft Production Board, however, realizing in a measure the difficulty of constructing aeroplanes in quantity, especially as there were very few aircraft factories in the country at that time which could deliver quantity production, planned to build only one-fourth that number. As a matter of fact, the Curtiss Aeroplane and Motor Company was the only organization that was constructing aircraft on a large scale at Buffalo, N. Y., and the Curtiss plant in Toronto, Canada. Nevertheless, the Aircraft Production Board laid down plans for the production of 22,500 planes. Even this was too optimistical an estimate, although the Aircraft Production Board did not at that time realize it. This, however, has been explained in the official reports of the Aircraft Production Board by General Kenly, Howard E. Coffin, and John D. Ryan.

To get into *production* the Aircraft Production Board had the government take over a number of plants on a cost plus 10 per cent basis, and those companies immediately began to expand their manufacturing capacity to make the new orders the government was placing with them. The Curtiss Aeroplane and Motor Company, Dayton-Wright, Standard Aircraft, Rubay Company, Springfield Aircraft Corporation, Aeromarine Plane and Motor Company, the Fowler Aircraft Company, and a number of others received large orders from the government. Unfortunately, the Aircraft Production Board did not see fit to give orders to the smaller manufacturers in proportion to the size and capacity of their plants. Many of these smaller manufacturers could have produced a few machines for the government, and this would have tended to swell the whole to a greater figure. The inability of some of the manufacturers to increase their plants in proportion to the orders, naturally delayed the manufacture of aircraft.

In the matter of the Liberty motor the same mistake was made. Instead of taking patterns and blue-prints of a good foreign motor, like the Hispano-Suiza, which was already being built in this country, and producing them in quantity, the government stopped to design a new motor—the Liberty motor—which the Aircraft Production Board evidently thought could be built in a day. This was not done—as a matter of fact, it took almost six months to complete the first production motor—whereas a good foreign motor could have been put in quantity production almost immediately, and with the failure of manufacturers of aircraft to turn out the desired number of planes, this caused a tremendous outcry from the disappointed American public, who thought 100,000 aeroplanes could be built as easily as 100,000 automobiles. This led to an aircraft investigation. Judge Hughes was appointed by President Wilson to conduct the investigation. The report failed to find any one libel to prosecution. Indeed, most of the errors were those of judgment or lack of ability. Later President Wilson pardoned those who might have been prosecuted.

Another error was caused by the delay in determining on the type of aeroplane which should be built in quantity in this country. Several types were adopted and then cancelled. Finally, however, the Curtiss J. N. 4's were adopted as the standard training-machine and the standard J. was discarded. The D. H. 4's were turned out in large quantities by the Dayton-Wright; Curtiss produced some Bristol machines in addition to their training-machine and seaplanes. The Standard Aircraft Corporation built a few Capronis and Handley Pages, Curtiss-H-boats. Owing to a failure to adapt the Liberty engine to the Bristol fighter after three pilots lost their lives, the machine was abandoned. If the war had lasted another year these companies would have been in quantity production, and undoubtedly America would have delivered a portion of the thousands of machines which were promised on the West Front.

As nearly every company which had built for the army or the navy was represented at the March, 1919, aero show, a description of the exhibits will give the best idea of the types of machines produced:

Aeromarine Plane and Motor Company

Model 50 flying-boat, similar to the Model 40 except that in the latter machine the cabin is closed in by a transparent hood, and it is driven by an Aeromarine 130 horse-power type-L engine. The Model 50 is a sport machine designed for pleasure flying.

The upper plane has a span of 48 feet 4 inches, lower plane 37 feet 4 inches. Fully loaded the machine weighs about 2,500 pounds. Unloaded the weight is about 2,000 pounds.

Boeing Aeroplane Company

The Type C-1 F. Navy Training Hydroaeroplane was flown from Hampton Roads, Va., to Rockaway, N. Y., for exhibition at the aero show. This machine is equipped with a Curtiss OXX-5 100 horse-power motor. It is an experimental type built for the navy, and has single float instead of the double floats usually employed on Boeing seaplanes.

Span, both planes	43′ 0″
Over-all length	24′ 0″
Speed range	36–65 M. P. H.

Burgess Company

The Burgess Company exhibited a car designed for one of the "C" class twin-motored navy dirigibles. The car is of stremline form, 40 feet long, 5 feet in maximum diameter, with steel tube outriggers carrying an engine at either side. Over-all width of outriggers, 15 feet. Complete weight of car, 4,000 pounds.

Seven passengers may be carried, but the usual crew consists of four.

The engines are made by the Union Gas Engine

Company, and are 150 horse-power each. Fuel capacity, 240 gallons; oil, 16 gallons. Four bombs, totalling 1,080 pounds, are carried at the side.

The dirigible for which the car was designed is 192 feet long, 43 feet wide, and 46 feet high; it has a capacity of 180,000 cubic feet. Its high speed is 59 miles per hour, at which speed it has an endurance of 10 hours. Cruising speed, 42 miles per hour; cruising radius, 12½ hours. Climb, 1,000 feet per minute.

The Cantilever Aero Company

The Christmas Bullet has caused a great deal of comment in aeronautical circles because of its freedom from struts and wires. It is the first heavier-than-air machine built on the Cantilever truss principle, and is the result of years of painstaking investigations and experiments made by the inventor, Doctor William Whitney Christmas.

The wings of the Christmas Bullet are flexible and resemble true bird form. Because of this yielding principle the machine is absolutely immune from all strain and resistance, as are "stiff-wing," parallel-strut machines.

The Christmas Bullet has a horse-power of 185.

Span	28′ 0″
Length over all	21′ 0″
Weight, machine empty	1,820 lbs.
Weight, fully loaded	2,100 lbs.

A Liberty "6" is used, giving 185 horse-power at 1,400 R. P. M.

Caproni Company

The Caproni Company exhibited a giant triplane which has been famous since 1915, when it made its first appearance. This triplane has a spread of 130 feet. It is equipped with three 400 horse-power engines, two of them in tractor position at the nose of the fuselage, and one a pusher at the rear of the central nacelle. This machine has climbed to an altitude of 14,000 feet with a ton of useful load, and with only two of the engines running. The triplane was used as a bomber, and carries a bomb compartment below the lower plane.

Curtiss Aeroplane and Motor Company

Curtiss J N 4 D

The J N 4 D Tractor shown by the Curtiss Company. General specifications are as follows:

Span, upper plane	43′ 7″
Length over all	27′ 4″
Net weight, empty	1,430 lbs.
Gross weight, machine loaded	1,920 lbs.
Useful load	430 lbs.

The motor is Model OX 5, 90 horse-power. Speed range of 75–45 miles per hour. Climb in 10 minutes, 2,000 feet.

The Curtiss M F Flying-Boat

The Curtiss M F Flying-Boat, a sportsman's model, is the smallest of the Curtiss boats, a development of the popular "F" boat, carrying two persons side by side.

Span, upper plane	49′ 9″
Over-all length	28′ 10″
Weight, empty	1,796 lbs.
Useful load	636 lbs.
Maximum speed	69 M. P. H.
Minimum speed	45 M. P. H.
Maximum range	325 miles
Engine, Curtiss OXX	100 H. P.

The Curtiss H-A Hydro

The Curtiss H-A Hydro, a two-place single-float seaplane. The upper wing has a dihedral of 3 degrees and the lower plane a dihedral of 1 degree. Both planes have an incidence of 2 degrees and a sweep-back of 4½ degrees. In official tests by the Navy Department this machine has made a speed of 131.9 miles per hour with a full load. Its climbing speed is 8,500 feet in 10 minutes.

The float is 20 feet long, 3 feet 6 inches wide, and 2 feet 6 inches deep. It has three planing steps.

The engine is a Liberty 12, giving 330 horse-power. It is directly connected to a two-bladed propeller 9 feet 2 inches in diameter, with a 7 foot 7 inches pitch, or a three-bladed propeller 8 feet 6 inches in diameter and 7 feet 6 inches in pitch, depending upon whether speed or quick climb is required.

Upper plane, span	30′ 0″
Over-all length	30′ 9″
Net weight, machine empty	1,012 lbs.
Weight, full load	2,638 lbs.

Dayton-Wright Aeroplane Company

De Havilland 4

The De Havilland 4 Aeroplane, exhibited by the Dayton-Wright Aeroplane Company, was the first De Havilland 4 battle-plane to be built in America, having been completed October 29, 1917, at Dayton, Ohio. This machine has been in continuous service since that time, and has been used in 2,500 flying tests of various kinds.

With this machine a distance of about 111,000 miles has been covered in a time of about 1,078 hours. Twenty-eight cross-country trips have been made in it, including Dayton to Washington, Dayton to New York, Dayton to Chicago, Dayton to Cleveland, etc.

The battle-plane is exhibited with all its military equipment, including two Marlin machine-guns fixed on the front cowling and fired through the propeller at a rate of 750 rounds at 1,650 R. P. M. of the engine, and two movable Lewis machine-guns at the rear cockpit which fire 650 rounds per minute. The wireless carried has a range of eleven miles to another aeroplane and a receiving radius of forty-seven miles by a ground-station. A camera located to the rear of the observer is worked by means of wind-vane. Photographs are taken at the rate of twenty-four per minute, and magazine carries six dozen plates.

A full complement of twelve bombs are carried under the lower wings, and flare-lights for night-landing are suspended from the wing-tips. Red and green guide-lights are carried on the lower plane, and a white light is located on the fuselage deck aft of the gunner. The engine is one of the first Libertys to be built.

The T-4 Messenger

The "Messenger" was designed as a war-machine, but after being modified in small details it makes an ideal machine for commercial and sporting purposes. As a war-machine its use was to have been in carrying messages from the front lines to headquarters and in general liaison work.

The machine is exceptionally light and easy to fly, making it possible to make landings in places that have been heretofore inaccessible.

The fuselage has absolutely no metal fittings nor tie-rods of any sort, strips of veneer being used exclusively for the bracing.

The machine comes within the means of the average sportsman, for its cost is said to be not much over $2,000.

Span, upper plane	19′ 3″
Length	17′ 6″
Weight, unloaded	476 lbs.
Weight, loaded	636 lbs.
Engine, air-cooled De Palma	37 H. P.

The engine is a 4-cylinder air-cooled V type, manufactured by the De Palma Engine Company of Detroit. Its weight is 3.7 pounds per horse-power. The engine consumes 4 gallons of gasoline per hour, and tank has a capacity of 12 gallons. Oil is carried in the crank-case.

Gallaudet Aircraft Corporation

Gallaudet E-L 2 Monoplane

Striking originality in design was shown in the twin-pusher monoplane exhibition by the Gallaudet Aircraft Corporation. Mr. Gallaudet's 1919 Sport Model has a high factor of safety and is easily maintained.

Two stock "Indian" motorcycle engines are located in the nose of the fuselage, connected to a common transverse shaft, and resting on the top of the plane, and driving twin-pusher propellers on longitudinal shafts driven by bevel-gears.

Engines are "oversize" models, giving 20 horsepower each at 2,400 R. P. M. Weight, 89 pounds each. Propellers are 3-bladed, 4 feet 8 inches in diameter, and 7 feet in pitch. Propellers run at one-half engine speed, 1,200 R. P. M.

The plane has a span of 33 feet.

The body is of monocoque construction, 3-ply spruce being used. Two seats are provided, side by side, with single stick control.

Over-all length of machine, 18 feet 7 inches.

Eight gallons of fuel are carried, sufficient for two hours.

Gallaudet D-4 Bomber

The machine is powered with a Liberty motor, driving a pusher propeller attached to a ring surrounding the fuselage.

The L. W. F. Company

The L. W. F. Model V Tractor was equipped with 125 horse-power Thomas engine, is convertible from a land machine to a hydro. The machine exhibited at the show had twin floats.

The L. W. F. Company also exhibited one of the H S 1 L Coast Patrol Flying-Boats, with a 350 horse-power Liberty engine. The machine has a span of 62 feet. Over-all length is 38 feet 6 inches, and over-all height is 14 feet 7 inches. The hull weighs 1,265 pounds. Gross weight, 5,900 pounds, and weight, empty, 4,810 pounds. Fuel and oil, 750 pounds, and crew, 360 pounds.

The L. W. F. Model G-2 Fighter

Model G-2 is a two-place armored fighter, carrying seven machine-guns and four bombs. Guns are arranged to be fired downward through an opening in the bottom of the fuselage.

Span over all	41′ 7½″
Length over all	29′ 1¼″
Total, full load (fighter)	4,023 lbs.
Weight, light (bomber)	2,675.5 lbs.
Total, full load (bomber)	4,879.5 lbs.

The Glenn L. Martin Company

The Martin Bomber

The Martin Twin-Engine Bomber has a speed of 118.5 M. P. H., made on the first trial with full bombing load. The climbing time with full bombing load was 10,000 feet in 15 minutes, and a service ceiling of 16,500 feet was attained. As a military machine the Martin Twin is built to fill requirements of a night-bomber, day-bomber, long-distance photographer, or a gun-machine. As a night-bomber it is equipped with 3 Lewis guns, 1,500 pounds of bombs, and 1,000 rounds of ammunition. A radiotelephone set is carried on all four types. Fuel capacity sufficient for six hours. Full power at 1,500 feet.

As a day-bomber two additional guns are carried, and the bomb capacity cut to 1,000 pounds. The Martin Twin is easily adaptable to commercial uses which are now practical: they are mail and express carrying, transportation of passengers, and aerial map and survey work. As an example of its capacity, twelve passengers or a load of merchandise weighing a ton may be carried.

General dimensions are as follows:

Span, both planes	71′ 5″
Over-all length	46′ 0″

With a ton of useful load, speed of 100 to 150 M. P. H. is made. Two 400 horse-power Liberty engines are used.

Packard Motor Car Company

The Packard two-place tractor was designed around, and made a complete unit with, the Model 1-A-744 Packard Aviation Engine. This machine will make about 100 M. P. H. with full load, on account of its light weight and clean-cut design, and yet its landing speed is as low as the average training aeroplane.

Packard 8-cylinder 160 horse-power at 1,525 R. P. M. Weight, complete with hub starter, battery, and engine water, 585 pounds.

Standard Aero Corporation

Handley Page Bomber

The American-built Handley Page shown at the Garden was similar to the British, except that Liberty "12" 400 horse-power engines are employed in the former, and the Rolls-Royce, or Sunbeam, in the latter. Accommodations are made for one pilot and two or three gunners, and an observer, who operates the bomb-dropping device. Two guns are located at the top of the fuselage, and a third is arranged to fire through an opening in the under side of the fuselage, and a pair of flexible Lewis machine-guns is operated at the forward end of the fuselage. One gunner may have charge of all rear guns, although usually two gunners man them.

Span, upper plane	100′ 0″
Length over all	62′ 10″
Height over all at overhang cabane	22′ 0″
Height over all at centre panel	17′ 6″
Width, wings folded	31′ 0″
Machine, empty	1,566 lbs.
Machine, loaded	14,300 lbs.

Each of the two engines gives 400 horse-power at 1,625 R. P. M.

Speed at ground, 92 M. P. H.

The "E-4" Mail Aeroplane

The "E-4" Mail Plane, built by the Standard Aero Corporation, is particularly adaptable to the work of carrying mail because of the special features of its design. The machine exhibited has seen considerable service, having been brought directly to the show after completing one of its regular mail-carrying trips.

The engine is a Wright-Martin Model L Hispano-Suiza, giving 150 horse-power at 1,500 R. P. M. and 170 horse-power at 1,700 R. P. M. The Model 1 is an 8-cylinder V type, with a bore of 120 mm. (4.724 inches) and a stroke of 130 mm. (5.118 inches).

Span, upper plane	31′ 4¾″
Length over all	26′ 2″
Height over all	10′ 10$\frac{3}{16}$″
Machine, empty	1,566 lbs.
Machine, loaded	2,400 lbs.
Machine, loaded with overhang	2,450 lbs.

The Thomas-Morse Aircraft Corporation

Four aeroplanes shown by the Thomas-Morse Company: the Type S-6, S-7, S4-C Scout, and the M-B-3 Fighter.

The M-B-3 Fighter is equipped with a 300 horse-power Hispano-Suiza engine. It is a single-seater, and is said to be the fastest climbing aeroplane in the world.

The S4-C is an 80 horse-power Le Rhone Scout, used for advanced training. It has been used at most of the army training-schools throughout the United States.

The S-6 is a Tandem two-seater, very similar to the S4-C in general appearance. With an 80 horse-power Le Rhone, this machine has a speed range of 33–105 M. P. H. In ten minutes its climb is 7,800 feet.

The S-7 is a side-by-side Tractor, with an 80 horse-power Le Rhone engine. The side-by-side seating makes it especially desirable for pleasure flying. The cockpit contains numerous comforts and conveniences.

The principal dimensions and specifications of the S-7 are:

Span, both planes	32′ 0″
Over-all length	21′ 6″

The United Aircraft Engineering Corporation

This company is showing a Canadian-Curtiss training-plane, such as used by the Royal Flying Corps for instruction in Canada and England.

A number of Curtiss OX-5 100 horse-power engines are also on display, together with other equipment, which the company has purchased from the Imperial Munitions Board of Canada.

United States Army

Langley Experimental Flying-Machine

The model of the Langley aeroplane is a copy of the original Langley Flying-Machine which is now in the United States National Museum at Washington, D. C. This machine made the first successful flight by heavier-than-air machine driven by its own power. The machine was launched May 6, 1896, at Quantico, Va. It rose to a height of 70 to 100 feet, and travelled half a mile at 20 to 25 M. P. H., with propellers revolving at 1,500 R. P. M.

The total weight of the machine is 26 pounds. It is driven by a single-cylinder engine, using gasoline as fuel.

Foreign Aeroplanes

Among the foreign aeroplanes sent to the aero show by the War Department are the French Spad, French Nieuport, British SEV, and a German Albatross D11.

The Spad is a single-seater scout, with a Hispano-Suiza engine.

The Nieuport Single-Seater is equipped with a rotary Gnome engine.

The SEV, which was put into limited production in the United States, has a Hispano-Suiza engine.

The Albatross Scout was one of Germany's best fighters. It has a Mercedes engine.

United States Navy Department

The F-5-L constructed by the Naval Aircraft Factory at Philadelphia has a span of 107 feet wing, chord of 8 feet, and an over-all length of 50 feet.

Two 400 horse-power Liberty engines are used, connected to tractor propellers 10 feet 6 inches in diameter. Five hundred gallons of gasoline are carried, sufficient for a duration of 10 hours at full speed, near sea-level, and a speed of 102 M. P. H. is maintained.

Fully loaded the machine weighs 14,000 pounds. This weight included a crew of 5 men, 1 Davis and 4 Lewis machine-guns, 4,230 pounds bombs, radio apparatus, telephone system with 6 stations, carrier-pigeons, and 500 gallons of gasoline.

The machine is exhibited with one half covered and the other half exposed to show the interior construction.

In the making of this machine there are 6,000 distinct pieces of wood, 50,000 wood screws, 46,000 nails, braces, and tacks, and 4,500 square feet of cotton fabric. The hull requires 600 square feet of veneer. The 250 pieces of steel tubing total 1,000 feet in length; 5,000 feet of wire and cable, 500 turnbuckles, 1,500 each of bolts, nuts, and washers, and 1,000 metal fittings are necessary in the construction of this flying-boat.

Navy M-2 Baby Seaplane

The M-2 Seaplane designed by the Navy Department, and built by Grover Cleveland Loening, was to have been used for submarine-patrol work. It is easily set up, and occupying so little space, can be stored aboard a submarine.

The machine is a tractor monoplane with twin floats. The plane has a span of 19 feet and a total wing area of only 72 square feet. The wing section is a modified R. A. F. 15. Over-all length of machine, 13 feet.

The floats are 10 feet long and weigh 16 pounds each. They are constructed of sheet aluminum with welded seams. The interior of the floats is coated with glue, and outside is not painted but coated with oil.

The engine is a 3-cylinder Lawrence 60 horse-power air-cooled engine, driving a 6-foot 6-inch propeller with a 5-foot pitch. Twelve gallons of gasoline and 1 gallon of oil are carried, sufficient for two hours' flight. Fully loaded with pilot and fuel, the complete machine weighs but 500 pounds. The maximum speed is about 100 M. P. H., and the low speed is 50 M. P. H.

Helium-Filled Model Airship

The model dirigible exhibited by the Navy Department is inflated with helium. Another item that is of interest is the fact that this model dirigible, 32 feet long and 7 feet in diameter, contains more helium than has ever been placed in an envelope of any kind.

Astra-Torres Dirigible

The dirigible car shown by the Navy Department is from a ship of the "Astra-Torres" type. The airship was built by the French in 1916, and turned over to the Americans in March, 1918, at Paimbœuf, France, the American naval station commanded by Commander L. H. Marfield, U. S. N. It was used until November, 1918, for coast patrol on the west coast of France.

The car is 45 feet long, 6 feet wide, and 7 feet high. The envelope (which is not exhibited) is 221 feet long and 47 feet in diameter, having a capacity of 252,000 cubic feet. Speed, 45.5 miles per hour. With a crew of Americans, this ship has stayed aloft for 25 hours, 40 minutes. At its cruising speed of 45.5 miles the endurance is 10 hours.

The car accommodates a crew of 12. Two 150 horsepower Renault engines with two-bladed tractor propellers are used. They are placed on outriggers. Two Lewis machine-guns are carried.

The ship is one of several large dirigibles purchased by the United States navy and brought to this country for the purpose of development.

B. F. Goodrich Company

The principal exhibit by the Goodrich Company consisted of one of the first dirigibles put into the United States Naval Service. This is a "Blimp" that was completed in August, 1917, and used for seventeen months in coast-patrol work in the vicinity of New York City. The dirigible is 167 feet long, 33 feet in maximum diameter, and contains 80,000 cubic feet of gas. This dirigible held the record for continuous flight.

A Curtiss OX motor is used. The car is arranged to carry a crew of three men. In cruising a speed of from 40 to 50 M. P. H. is maintained.

Other exhibits by the Goodrich Company are a model spherical balloon, relief throttle-valves perfected by the Goodrich Company, and principally the Grammeter valve, shock-absorber cords, special parachute attachments, fabrics and cloths for aeronautical use, etc. Another feature of the exhibit will be a short motion-picture, showing how the balloons are manufactured.

The Goodyear Tire and Rubber Company

The Goodyear Tire and Rubber Company of Akron, Ohio, was the most extensive aerostatic exhibit of the show. The outstanding feature of the booth was the dirigible pusher-car, completely equipped, of a type which has many sisters in service. A 35,000-cubic-foot type "R" military kite-balloon is suspended and equipped complete. Attractive models of the twin-engine navy dirigible and a transcontinental passenger dirigible car are on display. These models are complete in every detail, including full set of instruments and controls, lockers, and upholstery.

A full-sized dirigible car equipped with dual control, indicating devices, including manometers, tachometers, air-speed indicators, incidence and bank indicator, clock, driven by an 8-cylinder OX-2 Curtiss motor, of the type used on the FC training dirigible, having a cubic capacity of 85,000 feet, form an interesting part of the Goodyear exhibit. Models of "R" type kite-balloon, military free balloons, and of the U dirigible are also on display.

Growth of Aeroplane Plants

The growth of the aeroplane factories during the war was enormous. The Aeromarine Plane and Motor Corporation, which was located in a small plant at Nutley, N. J., moved to Keyport, N. J., and on a property of 66 acres erected sixteen fireproof buildings, with a total space of 125,000 feet. Most of the work of this plant was done for the navy. Three types of training-machines were produced, 39-A type, a turn-float hydroplane, 39-B, a single-float machine, and Model 40, a flying-boat.

The Dayton-Wright Aeroplane plant was incorporated on April 9, 1912, to build aircraft for war purposes. In August, 1917, a contract for 400 training-planes was awarded to the company, and later an order for 5,000 De Havilland 4 battle-planes was received from the government.

By November 11, 1918, the 400 training-machines were delivered and 2,700 D. H. 4's, and the 5,000 order was cut to 3,100, which were to be completed. One thousand eight hundred D. H. S-4's were shipped to France. The three plants were located near Dayton, Ohio. Mr. Orville Wright was the consulting engineer of the company. In addition to the three large plants which the company operated at the South Field Experimental Station, which had a total of 65,000 square feet, 8,000 people were employed by the company.

The Curtiss Aeroplane Company were making land-machines, seaplanes, and engines for the British Government when the United States entered the str ggle. Mr. Curtiss, the inventor of the flying-boat, and the winner of many aeronautical prizes and trophies, was the chairman of the board of directors and Mr. John North Willys president.

In January, 1916, the company was incorporated, and in February of the same year the stock of the Burgess Company of Marblehead, Mass., was acquired by the Curtiss Company. It also controlled the Curtiss Aeroplane Motors, Ltd., of Canada and the flying-fields at Miami, San Diego, Hammondsport, Newport News, and the Atlantic Coast Aeronautical Station. The company had nine plants and four flying-fields in 1918. The main plant was at Buffalo, N. Y. The chief plant is now at Garden City, Long Island. The plants consisted of 2,000,000 square feet, and employed 18,000 persons.

The company reached a quantity production of 112 complete machines a week, and 50 a day was to be expected had not the armistice been signed on November 11, 1918. Before and during the war the Curtiss plants manufactured 10,000 aeroplanes and flying-boats and 15,000 motors. The Curtiss plants produced a great variety of machines, including Spads, Bristols, and Nieuports. The famous NC-1-2-3-4, which participated in the transatlantic flight, were constructed for the navy by Curtiss Company at Garden City, Long Island.

The Burgess Company was also doing business when the war broke out. The firm was organized in 1909. The company supplied machines to the United States Government for work on the Mexican border in 1914, and many types of seaplanes were also constructed. In 1913 the company secured the rights to manufacture under the Dunne patents, covering inherent stability.

The Burgess plant at Marblehead, Mass., was one chosen by the navy to build training-seaplanes producing N-9 and N-9-H seaplanes. The company started producing one plane a day, but finally got up to four a day, and employed 1,100 men and women. The company also built turn-engine dirigible cars for the navy.

The Glenn L. Martin Company of Cleveland, Ohio, was organized in the fall of 1917 with the idea of building a gigantic American bomber for work with the Allies in Europe. The first machine was flown in August, 1918. Mr. Martin had been the organizer of the Glenn L. Martin Company of Los Angeles in 1910, and had also been interested in the Wright-Martin Aircraft Corporation of New York and New Brunswick, N. J.

The Martin bomber constructed by this company had a wing spread of 71 feet and length of 45 feet. It carried 11 passengers and pilot, and made several records.

The factory consisted of a single structure of 300 by 200 feet. The war ended before the company got into quantity production of the huge bomber.

The L-W-F Engineering Company, Inc., was organized in December, 1915, and the plant was located at College Point, Long Island, N. Y. The factory has a floor space of 250,000 square feet. The company built training-machines and flying-boats for the government. The L-W-F fuselage is of the monocoque type, which means "one shell" as regards the body. It is of streamline laminated wood.

The Standard Aero Corporation began life in May, 1912. Later it occupied several buildings at Plainfield, N. J. The company was reorganized under the name of the Standard Aircraft Corporation in 1917, and acquired the thirty-four buildings of a manufacturing company in Elizabeth, N. J. The total floor space was 614,190 square feet. The company built several thousand Standard J training-machines, which were bought by the government, but later discarded. The company also constructed the first Handley Page machines in this country, and also the first American constructed Caproni triplanes. Mr. Harry B. Mingle was the president and Mr. Charles H. Day the engineer.

The Standard model J. H. was a hydroaeroplane, and a number of H. S.-1-1 and H. S.-2-1, and D. H. 4's. Flying-boats were made by this company. Model J. R.-1-B. was used by the Post-Office Department for aero mail service between New York–Philadelphia–Washington, making a most excellent record.

The St. Louis Aircraft Corporation was organized in the fall of 1917. The Huttig Sash and Door Company of St. Louis and the St. Louis Car Company facilities were used for making J. N. 4-D training-planes, which were being turned out in quantity in May, 1918. Nine hundred people were employed, and machines at the rate of 30 per week were being produced.

The Springfield Aircraft Corporation came into being on September 27, 1917, and began to manufacture J. N. 4-D and VE-7 type machines. The company leased the Mason Company's plants, with 200,000 square feet capacity, at Springfield, Mass.

The plant reached a capacity of from 5 to 8 machines per day when the war ended. Over 1,000 were employed.

The Wright-Martin Aircraft Corporation was organized in September, 1916, to take over the General Aeronautic Company of America, the Simples Automobile Company, and the Wright Company. The General Aeronautic Company had received an order for 450 Hispano-Suiza engines in 1916, but less than 100 motors had been delivered by July, 1917. In May, 1918, the General Vehicle Company's plant at Long Island City was bought by the United States Government and given over to the use of the Wright-Martin Aircraft Corporation. Fifteen thousand men were employed by the company, and the first production engine was tested in November, 1918. The company also set up a gauge plant at Newark, N. J. The company had orders for delivery of 2,000 motors a month in 1919, totalling $50,000,000. The company reached a production of 30 engines a day in October, 1918. This engine holds the altitude record of 29,500 feet, made by Captain Schroeder in December, 1918. The company produced no aeroplanes during the United States' participation in the war.

In 1915 the Sturtevant Aeroplane Company was organized by Mr. Noble Foss and Mr. Benjamin Foss. The original plant at Jamaica, Mass., had 24,000 square feet. The company built 25 machines before the

United States entered the war. Experiments were made with an all-steel fuselage. The B. F. Sturtevant Company had built many aeroplane engines, and it had been organized by the same two brothers. At the end of the war the company had erected a new three-story building of 35,000 square feet. They had over 1,000 employees at the two plants. The Aeroplane Company was engaged primarily in manufacturing spare parts for the J. N. 4-D and D. H. 4, etc.

The Thomas Brothers Aeroplane Company was organized in 1912 at Bath, N. Y., and built many types of machines, both seaplanes and land-machines, before the war. The Thomas Aeromotor firm came to life in August, 1915. In January, 1917, the two companies were combined into the Thomas-Morse Aircraft Corporation at Ithaca, N. Y., and a factory of three large buildings was constructed. The plant has a floor space of 190,000 square feet. The S-4-E, the S-5 scouts, the M-B-1 and the M-B-2 fighters, B-3 flying-boat, and D-2 hydro are well known as the Thomas-Morse machines.

Other Machines Made

A number of other manufacturers were given orders to construct aircraft. The Packard Motor Company established a department and Captain Le Pere, the French military aircraft engineer, designed a number of machines which were built for the government. Among them was the G. H.-11, an armored plane, the U. S. Le Pere Triplane, and the Le Pere combat machine, which flew from Detroit to New York to attend the aero show at Madison Square Garden, March 1, 1919. None of these machines were put into quantity production.

The Fowler Aircraft Factory at San Francisco had fifteen planes in construction when their plant was destroyed by fire in May, 1918, with a loss of a million dollars.

Other factories which were building aircraft to submit to the government were the Lawson Aircraft Factory at Green Bay, Wis., The Whitteman-Lewis Company at Newark, N. J., The Alexandria Company at Alexandria, Va., to mention only a few.

The S. S. Pierce Company at Southampton, Long Island, had an order for 300 "penguins," as the training-machines were called, but they were not delivered.

The Goodyear and Goodrich Tire and Rubber Companies built a great many kite, observation, and propaganda balloons for the army, and blimps for the navy. Their exhibit at the Manufacturers Aircraft Show, described elsewhere, gives an excellent idea of their product.

The Naval Aircraft Factory

Owing to the fact that the United States Government gave little support to the aircraft industry, despite the fact that we had been on the verge of war with Mexico, and that the Great War was on in Europe, when the United States was finally forced into the struggle the aircraft manufacturers were not tooled up to manufacture seaplanes and flying-boats in quantity, so the navy immediately made plants to establish a naval aircraft factory at Philadelphia.

When war was declared on April 6, 1917, only 93 heavier-than-air seaplanes had previously been delivered to the navy, and 135 were on order. Of the number that had previously been delivered, only 21 were in use, the remainder having been worn out or lost. The seaplanes were of the N-9 and R-6 types, which are now considered as training-seaplanes.

After eliminating types which had been tried and found unsuitable, the Navy Department fixed upon two sizes for war purposes, which had been perfected in the United States in anticipation of the development of a high-powered engine. The engine developed was the Liberty. The flying-boat is an American conception, and it has not been found necessary to copy foreign patterns to insure our flyers being supplied with the best.

With the development of suitable planes and engines the navy was able to select the type of aircraft which was best suited for its service, and to frame a large and complete building programme. As a result over 500 seaplanes were put in use at naval air-stations in the United States, and up to December, 1918, over 400 seaplanes had been sent abroad. Other aircraft at stations, both in this country and abroad, included airships and kite-balloons.

The demand for aircraft necessitated an enormous increase of production facilities, and, as a part of this extension, the Navy Department undertook to build and equip a naval aircraft factory at the Philadelphia Navy-Yard. Within 90 days from the date the land had been assigned the factory was erected and the keel of the first flying-boat was laid down. In August, 1918, the factory was producing 50 per cent more seaplanes than it had been two months previous. In addition, at least five plants were devoted to navy work, and a large proportion of the output of several other factories had been assigned to the navy.

The delivery of seaplanes for training purposes has been sufficient to more than meet the requirements. The training of personnel and providing of stations and equipment to carry out this training had expanded sufficiently so that the output of pilots, observers, mechanicians, and men trained in special branches was keeping abreast or ahead of requirements.

The navy aircraft factory produced aircraft valued at $5,435,000 up to the time the armistice was signed. It had completed, ready for shipment, 183 twin-engine flying-boats, at an average cost of $25,000. It had also produced 4 experimental Liberty-engine seaplanes, carrying the Davis non-recoil gun, at a cost of $40,000 each, and 50 sets of twin-engine flying-boats' spare parts worth $10,000 per set. In addition considerable minor experimental work and overhauling of machines from other stations was done.

The main factory at Philadelphia had a capacity of 50 boats, and could turn out an average of 5 machines a day when the armistice was signed.

On October 1, 1917, the first mechanic was hired at the navy aircraft factory. On November 1, 1918, there were 3,642 men and women employed in building flying-boats for the navy.

About 1,500 Liberty engines were delivered to the navy and assigned to naval air-stations in this country and abroad. Since the number of Liberty engines produced were too small for the needs of the army alone, it had been necessary for the navy to purchase others, to the number of about 700, which were utilized while awaiting a full supply of Liberty engines.

In addition to these a large number of engines of less power were bought for use in training-planes, all of which were distributed to the flying-schools.

One of the very important duties devolving on the Bureau of Steam Engineering was the equipment and maintenance of stations for the generation of hydrogen for use in airships. A number of stations were established, and a full equipment of hydrogen cylinders provided, so that any calls might be promptly met.

CHAPTER IX

THE DEVELOPMENT OF THE AERO MAIL

FIRST MAIL CARRIED BY AIRCRAFT—NEW YORK-PHILADELPHIA-WASHINGTON SERVICE—NEW YORK-CLEVELAND-CHICAGO SERVICE—FOREIGN AERO MAIL ROUTES

As soon as the aeroplane demonstrated that it could travel at least twice as fast as the fastest express-train, even when going in the same direction, and that in addition it could traverse mountains, rivers, forests, swamps in a straight line, its possibilities as a mail-carrier were immediately realized, and steps were taken in most countries to establish aero mail routes.

In the United States the first attempt to carry mail was made by Earl Ovington from the Nassau Boulevard aerodrome near Mineola, N. Y., September, 1911. Postmaster-General Hitchcock delivered a package to Mr. Ovington to be carried to Brooklyn, N. Y. The machine was a Bleriot. The distance of five and one-half miles was made in six minutes. Two trips a day were made by Mr. Ovington—one to and one from Mineola. On Sunday, September 23, 6,165 post-cards, 781 letters, 55 pieces of printed matter were carried. Captain Beck using a Curtiss biplane also carried 20 pounds of mail, and T. O. M. Sopwith, using a Wright machine, also carried some mail.

The first regular permanent aero mail service was started on May 15, 1918, at Belmont Park, New York, and at the Polo Grounds, Washington, D. C. Leaving Belmont Park, New York, at 11.30 in the forenoon with a full load of 344 pounds of mail, Lieutenant Torry S. Webb flew in one hour to Philadelphia, from which point the mail was relayed through the air by Lieutenant J. C. Edgerton, who delivered it in Washington at 2.50 P. M. The actual flying time of the two couriers, deducting the six minutes' intermission in relaying at Philadelphia, was three hours and twenty minutes. This record was considered highly satisfactory for the initial trip with new machines.

Owing to a broken propeller Lieutenant George Leroy Boyle was forced to descend in Maryland with the aero mail bound for Philadelphia and New York. On May 16 Lieutenant Edgerton flew from Washington to Philadelphia with the mail, making the first continuous connection in that direction. President Wilson and official Washington were present at the Polo Grounds to see the first aero mail off.

During the year the aero mail service has been in operation between Washington, Philadelphia, New York, it has demonstrated the practical commercial utility of the aeroplane.

On the anniversary the Post-Office Department released the following summary, which gives us the first complete account of commercially operated air service, dating over the period of a year:

One Year's Aero Mail Service

The two aeroplanes that took to the air to-day, one leaving Washington and one leaving New York, are the same that carried the mail a year ago, and have been constantly in the service, and they are propelled by the same motors. One of these has been in the air 164 hours, flying 10,716 miles, and has carried 572,826 letters. It has cost, in service, per hour, $65.80. Repairs have cost $480. The other plane has been in the air 222 hours, flying 15,018 miles, and has carried 485,120 letters. It has cost, in service, per hour, $48.34. Repairs to this machine have cost $1,874.76.

The record of the entire service between New York and Washington shows 92 per cent of performance during the entire year, representing 128,037 miles travelled, and 7,720,840 letters carried. The revenues from aeroplane mail stamps amounted to $159,700, and the cost of service, $137,900.06.

The operation of the aeroplane mail service every day in the year except Sunday, encountering all sorts of weather conditions and meeting them successfully, has demonstrated the practicability of employing the aeroplane for commercial service, and the air mail organization has been able to work out problems of great value in the adaptation of machines to this character of service. From the inauguration of the service until the 10th of August, the flying operations were conducted by the army, in connection with its work of training aviators for the war. Since August 10 it has been operated entirely by the Post-Office Department, with a civil organization. When the service was started there was great divergency of opinion among aeronautical experts as to the possibility of maintaining a daily service regardless of weather conditions, and the opinion was held by many that it would have to be suspended during the severe winter months. The service has been maintained, however, throughout the year with a record of 92 per cent, gales of exceptional violence and heavy snow-storms being encountered and overcome. Out of 1,261 possible trips, 1,206 were undertaken, and only 55 were defaulted on account of weather conditions. During rain, fog, snow, gales, and electrical storms, 435 trips were made. Out of a possible 138,092 miles, 128,037 miles were flown. Only 51 forced landings were made on account of weather, and 37 on account of motor trouble. It has been demonstrated that flying conditions for such a commercial service as this, which is regulated by a daily schedule regardless of the weather, are very different from those of military flying. Aeroplanes designed wholly for war purposes are not suitable for commercial service, as they lack the strength necessary for daily cross-country work, with its incidental forced landings. Aeronautical engineers have developed for the Post-Office Department a stronger and more powerful plane suitable for commercial service while retaining the excellent flying qualities of the De Havilland machine. The De Havilland 4's, which were transferred to the Post-Office Department after the signing of the armistice, are being reconstructed to fit them for commercial requirements. In specially constructed mail-carrying planes, for the building of which the department has called for bids to be opened June 2, a form of construction is called for which will enable a mechanic to make important minor repairs in flight, making it possible with a multiple motor to avoid forced landings.

Danger Eliminated

One of the lessons learned from the operation of the air mail service during the year is that the element of danger that exists in the training of aviators in military and exhibition flying is almost entirely absent from commercial flying. Second Assistant Postmaster-General Praeger, in reporting to the postmaster-general the operations for the year, says that the record of the air mail service, which includes flying at altitudes of as low as 50 feet during periods of marked invisibility, throws an interesting light on this question. During the year, more than 128,000 miles having been travelled, no aeroplane carrying the mail has ever fallen out of the sky, and there has not been a single death of an aviator in carrying the mail. The only deaths by accident which have occurred were that of an aviator who made a flight to demonstrate his qualifications as an aviator and that of a mechanic who fell against the whirling propeller of a machine on the ground. But two aviators have been injured seriously enough to be sent to a hospital. Other accidents consisted mainly of bruises and contusions sustained by planes turning over after landing. Of the three types of planes operated regularly in the mail service, one type was more given than the others to turning over on rough ground, and it was principally on planes of this type that pilots were shaken up or bruised by the plane turning turtle. One type of machine in the mail service which has performed almost half of the work has never turned turtle. The record of the air mail service with respect to accidents will compare favorably with that of any mode of mechanical transportation in the early days of its operation.

One of the first studies to be taken up by the air mail service was to determine whether visibility is absolutely necessary to commercial flying. The first step necessary was the refinement of the existing radio direction-finders so as to eliminate the liability of 3 to 5 per cent of error. This has been successfully worked out by the Navy Department on an air mail testing-plane. The second problem was that of guiding the mail plane after it had left the field to the centre of the plot for landing. This problem has been solved by the Bureau of Standards in experiments conducted on the air mail testing-plane in connection with the radio directional compass. This device is effective up to an altitude of 1,500 feet, and with the further refinements of the device another thousand feet is expected to be added. Aeronautical engineers are working upon a device for the automatic landing of a mechanically flown plane which would meet the condition of absolute invisibility that could exist only in the most blinding snow-storm or impenetrable fog.

A year's flying in the mail service, with all types and temperaments of aviators, has established the fact that 200 feet visibility from the ground is the limit of practical flying, although a number of runs have been made with the mail between New York and Washington during which a part of the trip was flown at an altitude as low as 50 feet. The objection of aviators to flying above a ground-fog, rain, snow, or heavy clouds with single motor-planes is the possibility of the motor stopping over a village, city, or other bad landing-place, with the radius of visibility so little as to afford no opportunity to pick out a place for landing. It is generally accepted that with two or more motors, forced landings under such conditions can be avoided.

Flying in Roughest Weather

A number of severe gales have been encountered during the flights between New York and Washington. Gales of from 40 to 68 miles an hour have been encountered and overcome. Pilot J. M. Miller, who was formerly a naval flier, made the flight from Philadelphia to New York in a Curtiss R4 with a 400 horse-power Liberty motor, rising from the field against a 43-mile gale and arriving in New York through a blinding snow-storm with a wind velocity reported by the Weather Bureau to be 68 miles an hour and which was 15 per cent greater at the altitude at which he flew.

Mr. Praeger says in his report that from experience it is learned to be useless to send against a 40-mile gale a plane having a top speed of no more than 75 or 80 miles. "The two types of planes in the air mail service of this speed," he said, "are the Standard JR 1 mail plane, having a wing spread of 31 feet 4 inches, and the Curtiss JN 4, having a wing spread of 43 feet 7⅜ inches. Each plane of this type is equipped with a (Hispano-Suiza) 150 horse-power motor, which does not provide enough reserve power to combat the disturbed air conditions at the surface in a wind of more than 40 miles an hour, especially if the wind comes in descending columns or gusts. Under these conditions it is possible to make headway only with a Liberty engine, which has plenty of reserve power. A plane equipped with a 150 horse-power motor, if it succeeds in breaking through the surface winds, can make only slow and laborious headway against a full or a quartered head wind of about 40 miles. There have been many instances where the planes equipped with 150 horse-power motors have been held down to a speed of between 30 and 37 miles an hour; and also many instances where a hundred-mile-an-hour plane equipped with a Liberty motor has been held to between 55 and 60 miles. A few wind-storm conditions were encountered where the planes at the height of the gust were actually carried backward."

The same six planes that were in operation at the inauguration of the service, and have been in continuous employment during the year, are in operation to-day, and the one which made the initial flight from New

York to Washington, May 15, 1918, made the flight May 15, 1919. This is regarded as throwing a new light on the question of the life of an aeroplane and as demonstrating that the mechanical requirements and the operation in commercial flying are more economical and safer and in many instances more practical than in exhibition or military flying.

The fact that there were only 37 forced landings due to mechanical troubles during flights makes a record not heretofore approached in aviation and is creditable in the American-built aeroplane and mechanics who keep them in fine condition. Especially is this record a strong tribute to the American-built Liberty and Hispano-Suiza motors.

The transportation by aeroplane is ordinarily twice as fast as by train, and on distances of 600 miles or more, no matter how frequent or excellent the train service, the aeroplane mail at the higher rate of postage should equal the cost of its operations. Wherever the train service is not as frequent or as fast as it is between Washington and New York the aeroplane operations should show an immense profit on all distances from 500 miles up.

Again, with large aeroplanes and over greater distances, substantial saving in the cost of mail transportation on railroads would be made, besides cutting down the time of transit by one-half.

Boston–New York Pathfinder Aero Mail

Another step in the evolution of the aero mail service was made on June 6, 1918, when Lieutenant Torry S.

Webb carried 4,000 letters from Belmont Park, Long Island, N. Y., to Boston in three hours and twenty-two minutes, the distance being 250 miles.

With R. Heck, a mechanician, as passenger, Lieutenant Webb got away from Belmont Park at 12.09 o'clock.

Two hours later, as the aviator neared Haddon, Conn., he found that his compass was working badly, and he descended at Shailerville and fixed it.

At 3.31 o'clock Lieutenant Webb circled over Saugus, Mass., near Revere Beach and Boston, and then planed down on the estate of Godfrey Cabot, now the Franklin Park Aviation Field.

For some reason or another, presumably lack of funds, the service was not made permanent.

New York-Chicago Aero Mail

September 5, 1918, the Post-Office Department started the first pathfinding mail service between New York, Cleveland, Chicago. Mr. Max Miller was scheduled to leave Belmont Park, Long Island, at 6 A. M., but owing to a storm and the breaking of a tail-skid he did not leave until 7.08 A. M. After flying through a fog he landed at Danville, N. Y., 155 miles from New York City, and after getting his bearings Lieutenant Miller next landed at Lock Haven, Pa., because his engine was missing. At 11.45 A. M. he left for Cleveland. But the fog continued, and he finally was forced to land in Cambridge, Pa., owing to a leaking radiator. After some delay he flew to Cleveland, but owing to the darkness he had to remain there overnight.

At 1.35 P. M. Lieutenant Miller left for Bryon, which he reached and left at 4.35 P. M., and he arrived at Grant Park at 6.55 P. M. The distance was 727 miles in a direct line.

On his return trip he left Chicago on September 10 at 6.26 A. M. with 3,000 pieces of mail, and he landed at Cleveland, and leaving there at 4.30 P. M., reached Lock Haven, Pa., that night. He left there on September 10 at 7.20, and reached Belmont Park at 11.22 A. M.

Mr. Edward V. Gardner left Belmont Park at 8.50 A. M., Thursday, September 5, 1918, two hours after Max Miller had started in a Curtiss R. plane, with a Liberty motor, taking Mr. Radel as mechanic, and carrying three pouches of mail, containing about 3,000 letters.

Gardner landed at Bloomburg, Pa., near Lock Haven. He reached Cleveland before dark, and after spending the night there, on September 6 Mr. Gardner left Cleveland and landed at Bryon at 5.15 P. M., leaving there for Chicago at 5.50 P. M., but was compelled to land at Westville, Ind. He left there the next morning and reached Grant Park, Chicago, at 7.30 A. M. On his return trip Mr. Gardner flew from Chicago to New York in one day, September 10. Leaving at 6.25 A. M., he landed at Cleveland, Lock Haven, and landed at Hicksville, Long Island, in the dark.

The record non-stop for the 727 miles between the two, Chicago and New York, was made by the army pilot Captain E. F. White in six hours and fifty

Courtesy of Aerial Age Weekly.

The pathfinding aerial mail flight, New York–Cleveland–Chicago.

Max Miller starting in a Standard Aircraft plane equipped with a 150 h.-p. Hispano-Suiza motor.

minutes, on April 19, 1919, flying a D. H. 4 army plane.

On May 15, 1919, the postal authorities intended to inaugurate aero mail service between New York and Chicago, but owing to the fact that some of the machines which were being renovated from war-machines to mail-machines were not ready, that branch of the service had to be postponed for a few days.

The aero mail between Chicago and Cleveland and Cleveland and Chicago was inaugurated. The delivery at Cleveland and Boston will be reduced to some sixteen hours, and to New York some six hours. Letters mailed in New York City in time for the train leaving at 5.31 P. M. will reach Chicago in time for the 3 o'clock carrier delivery instead of the following morning carrier delivery, as would be the case if sent all the way by train.

Mail from San Francisco and the entire Pacific coast States put on Burlington train No. 8, mail from South Dakota and northern Illinois put on Illinois Central No. 12, mail from northern Minnesota and northern Wisconsin put on Northwestern train No. 514, mail from Minnesota, North Dakota, and Montana put on Chicago, Milwaukee, and St. Paul train No. 18, and mail from Kansas City and the entire southwest put on Sante Fé train No. 10, will reach Chicago in time to make connection with the air mail eastbound. The air mail from these trains will be taken direct to the air mail field. At Cleveland the air mail will catch the New York Central train at 4 P. M. for the East.

Under this arrangement the air mail will be delivered in Cleveland and Boston on afternoon deliveries instead of the following morning. At Albany, N. Y., and Springfield, Mass., this mail will catch the morning delivery instead of the afternoon following.

The aero mail stamps for this service are the same as for the aero mail service between Washington and New York. It will be recalled that originally the amount necessary to carry a letter was 24 cents. This was reduced to 16 cents, and finally to 6 cents, where it now is.

Without a doubt when large bimotored machines have been put into aero mail service, letters will be carried for 3 cents apiece between New York and Chicago.

One company has already made a proposal to the postal authorities to supplement the mail service between Chicago and New York.

The aero mail service between Chicago and Cleveland started off on schedule. Pilot Trent V. Fry left Chicago at 9.35 A. M., and arrived at Cleveland at 12.48 P. M., in a rebuilt D. H. 4, carrying 450 pounds of mail. The opening trip was made in very good time, with a five-minute stop at Bryon, Ohio.

Another plane with Edward Gardner as pilot left Cleveland at 9.30 A. M., carrying 300 pounds of mail, arrived at Chicago at 1.25 P. M.

Foreign Aero Mail Service

Aero mail service has been started in nearly every country in Europe, and many South American coun-

Courtesy of Aerial Age Weekly.

The reconstructed De Haviland biplane, showing the limousine accommodations for passengers.

The De Haviland 4's were built in large numbers by Dayton Wright Company and equipped with Liberty engines for fighting on the western front. Some of these rebuilt machines are being used for aero mail service between Chicago, Cleveland, and New York.

tries are also making plans for carrying mail by aeroplane. In May, 1919, Mr. Joaquin Bonilla, son of the President of Honduras, visited the United States to see about arranging to use New Orleans as one base and Tegucigalpha as another for the aero mail landing-places.

Mr. V. H. Barranco, of Cuba, is also in this country for President Menocole, of Cuba, to arrange aero mail between Key West and Havana, Cuba.

The French aerial mail service officially started on March 1, 1919, between Paris and Bordeaux, Marseilles, Toulouse, Brest, and St. Nazaire, under the supervision of the director of civilian aeronautics.

The Paris–Lille Mail Service.—The aeroplanes engaged in the Paris–Lille mail service which had been instituted in April, 1919, started from the Le Bourget aerodrome. The machines and pilots engaged had been lent to the postal authorities by the military authorities.

A daily postal service has been started between Avignon and Nice also. An aeroplane carries mails for Nice left at Avignon by the Paris–Lyons train which arrives at midnight. A machine will also deliver mails from Nice at Avignon in time for the midnight train for Paris. A regular postal service by aeroplane is also announced between Rabat (Morocco) and Algiers.

Great Britain.—London–Paris (240 miles). Daily passenger service, weather permitting, by means of twin-engined D. H. 10 biplanes. Now being jointly organized by the Aircraft Transport and Travel (Ltd.), of London, and the Compagnie Generale Transaerienne, of Paris. Average time, two and one-half to three hours.

British aerial highways now in operation: (1) London to Hadeigh (79 miles). (2) London to Dover (65 miles). (3) London to Easteigh (53 miles) to Settenmeyer (152 miles). (4) London to Bristol (95 miles). (5) London to Witney (55 miles) to Bromwich (51 miles) to North Shotwick (72 miles), and to Dublin, Ireland (143 miles). (6) London to Wyton (63 miles) to Harlaxton (41 miles) to Carlton (28 miles) to Doncaster (28 miles) to York (27 miles) to Catterick (38 miles) to Redcar (26 miles). Chatterick to New Castle (42 miles) to Urnhouse, Scotland (95 miles) to Renfrew, Scotland (40 miles). New Castle to Renfrew (124 miles). (7) London to Hucknall (114 miles) to Sheffield (50 miles) to Manywellheights (97 miles). Hucknall to Didsbury (52 miles) to Scalehall (50 miles) to Luge Bay (99 miles) to Aldergrove and Belfast, Ireland (55 miles). Luge Bay to Renfrew, Scotland (72 miles).

Italy.—(1) Civitavecchia–Terranova, Sardinia (150 miles). Daily mail service by means of flying-boats. Inaugurated June 27, 1917; temporarily discontinued during the winter of 1917–18; reopened in March, 1918. Average time, 2 hours. (2) Venice–Trieste (170 miles). (3) Venice–Pola (80 miles). (4) Ancona–Fiume (130 miles). (5) Ancona–Sara (90 miles). (6) Brindisi–Cattaro (150 miles). (7) Brindisi–Valeona (100 miles).

Organized shortly after the signing of the armistice with Austria; operating (8) Genoa–Nice (100 miles). (9) Genoa–Florence (120 miles). (10) Florence–Rome (140 miles). (11) Rome–Brindisi (290 miles).

Air mail lines (8) to (11), now being worked out, will constitute the Italian section of an interallied air mail service to be established between London, Paris, Rome, and Constantinople.

France.—(1) Paris–Mans–St. Nazaire (250 miles). Daily mail service by means of twin-engined Letord biplanes (Hispano-Suiza engines). Inaugurated August 15, 1918. Average time, 3 hours. Postage, 75 centimes (15 cents). (2) Paris–London (240 miles). (3) Paris–Lyons (240 miles). (4) Lyons–Marseilles (165 miles). (5) Marseilles–Nice (140 miles).

Air mail lines (3) to (5), now being organized, will constitute the French section of an interallied air mail service to be established between London, Paris, Rome, and Constantinople.

(6) Nice–Ajaccio, Corsica (150 miles). Daily air mail service by means of flying-boats about to begin operations.

Various air mail lines, operated by the military, are functioning in southern Algeria and Morocco, chiefly for carrying official correspondence. The organization of an air mail line from Marseilles via Algiers to Timbuctoo is now being worked out. The sections Biskra–Wargia (240 miles) and Wargia–Inifel (211 miles) and Inifel–Insala (223 miles) are in operation.

Greece.—(1) Athens–Janina (200 miles). Daily mail service; inaugurated August 8, 1918. (2) Athens–Salonica (220 miles). Daily mail service projected.

DENMARK.—(1) Copenhagen–Odense–Fredericia–Esierg (170 miles). (2) Copenhagen–Kalundborg–Aarhus (105 miles). (3) Copenhagen–Gothenburg–Christiania (330 miles). Daily mail service projected.

AUSTRIA.—Vienna–Budapest (140 miles). Daily mail service; inaugurated July 5, 1918. Postage, 5.10 kronen ($1).

NORWAY.—(1) Christiania–Stavanger–Bergen–Trondhjem (670 miles). Oversea route. (2) Christiania–Bergen (200 miles). Overland route. (3) Stavanger–Bergen (100 miles). Oversea route.

Projected air mail lines to be operated by the Norwegian Air Routes Company.

SPAIN.—(1) Madrid–Barcelona (320 miles). (2) Barcelona–Palma, Balears (170 miles).

Projected air mail lines to be operated by a Spanish company.

GERMANY.—Berlin–Munich (350 miles). Daily mail and passenger service, weather permitting. Average time, four and one-half hours; passage, $1 per mile.

Several other mail and passenger services are operating between the larger cities, but no details are available.

CHAPTER X

KINDS OF FLYING

NIGHT FLYING—FORMATION FLYING—STUNTING—IMMELMAN TURN—NOSE DIVING—TAIL SPINNING—BARREL—FALLING LEAF, ETC.

OWING to the fact that skilful landing is the most difficult thing for a flier to acquire, and because more accidents occur to the novice when he brings his machine to the ground than at any other time except, perhaps, when stunting too near the ground, night flying is especially hazardous. With properly lighted landing-fields in peace-times much of the peril of landing after dark can be eliminated, provided the night is clear and no fog or mist has settled over the aerodrome since the aviators set out. If a mist has settled over the landing-place the flier must take his chances and come down by guesswork, unless his machine is equipped with wireless telephone, for the compass and other instruments cannot tell him exactly where he is with regard to hangars or take-off on an aviation-field. Indeed, if the telephone operator on the ground cannot exactly locate the flier, it is exceedingly difficult to direct the airman to the exact corner of the field in which he should come down.

On a clear night, however, with flambeaux, searchlight flares, etc., a pilot has little trouble in landing, for the straightaway can be as illuminated as it is in broad daylight. Nevertheless, when the aircraft is high in the sky, owing to the vast distances of infinite space, the speed at which an aeroplane moves, and the drift out of its regular course, due to the wind, it is often difficult for the flier to keep his bearings. For that reason aviators try at night to locate the lights on a railroad-track, the reflection of light on a river or stream, and follow them to their destination. The Germans in their raids on London usually tried to locate the Thames River, which they then followed until they reached the metropolis, which they usually succeeded in doing on moonlight nights despite the British long-rayed search-lights, swift-climbing Sopwith Camels, and the barrages formed by the thousands of anti-aircraft guns. As a matter of fact, no adequate means of preventing aeroplane raids was developed by any of the countries involved in the Great War, for the simple reason that there is no way of screening off a metropolis so that those modern dragon-flies cannot fly around, over, or through the screen. That is another reason why a huge commercial aerial fleet will always be a tremendous danger and perpetual threat to any contiguous country or neighboring city, because these aerial freighters can be loaded with inextinguishable incendiary bombs as easily as with passengers, and 10,000 such aeroplanes could drop on a city within a hundred miles of its border enough chemical explosives to raze it by fire.

Considering all the chances taken by the Hun and the Allied fliers during the Great War, and the kinds of machines they flew, and the circumstances under which they flew, it is amazing how successful they both were in their night-raids on one another's territory, and the amount of damage they wrought. Every night, rain or shine, the British and French and Americans dumped from forty to fifty tons of high explosives on German objectives, and it is truly amazing how few machines were lost.

Night flying for commercial purposes, though, might easily be developed into a comparatively safe means of aerial transportation. The machines, however, ought to be constructed like the Sopwith Camel, with a very fast climbing and a very low landing speed, in order to get clear of obstacles quickly and to come to a stop as soon as it reached the earth. The wing-tips should be equipped with lights, and small red and green lights, called navigation lights, should be installed on port and starboard struts. Under the fuselage a signalling light could be used, and Very lights, rockets, parachute flares, or Borse flares could be employed, as in war, to illuminate the fields, give the pilot a clew to his whereabouts, and at the same time reveal to the wireless-telephone operator on the ground the position of the ship in the air. This would also prevent collisions. Care should be exercised so as not to blind the pilot when he makes his landing. An electrically lighted "T" with observation-towers would also aid in the safe landing of an airship at night.

With the growth of flying, lighthouses and captive balloons poised high above the fog or clouds will undoubtedly be established all over the land, equipped with different lights so as to indicate to the flier just where he is located. The French have already developed such a system.

Of course a forced landing at night is very dangerous, and this may happen at any moment. It was reported that a pilot was killed every night patrolling over the cities of Paris and London looking for Boches. It was also reported that every Hun plane brought down during a raid on Paris cost the French Government $3,000,000 in ammunition, aircraft, etc.

With the establishment of municipal aerodromes at regular intervals, equipped with proper lights, signalling devices, wireless telephones, night flying can be made as safe as night sailing along the coasts, and with the increase in the size and number of aircraft, night flying will become as commonplace as day flying.

Stunting

There is no gainsaying that stunt flying, or aerial acrobatics, was absolutely essential to the flying of scout and combat machines in the Great War, for in order to survive in the war in the air it was necessary for the pilot to be able to manœuvre and dodge about in the sky as easily as a fish in the water; otherwise, the flier would be shot down by a more agile machine or clever aviator. Clouds offered such excellent cover for aeroplanes to ambush unsuspecting novices, and decoys were often placed to induce some adventurous

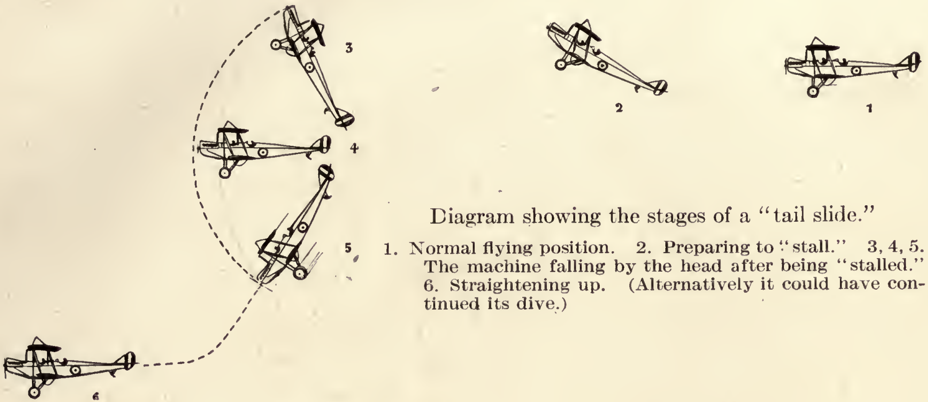
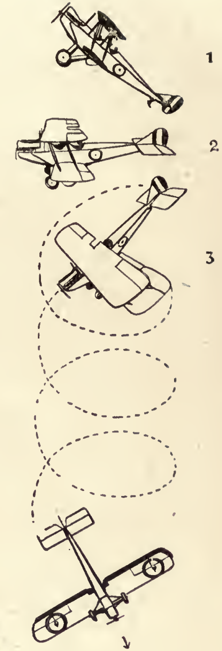


Diagram showing the stages of a "tail slide."

1. Normal flying position. 2. Preparing to "stall." 3, 4, 5. The machine falling by the head after being "stalled." 6. Straightening up. (Alternatively it could have continued its dive.)



The evolution of a "spinning dive."

1. Stalling the machine. 2. The machine falling by the head. 3. Gyrations of a "spinning dive."

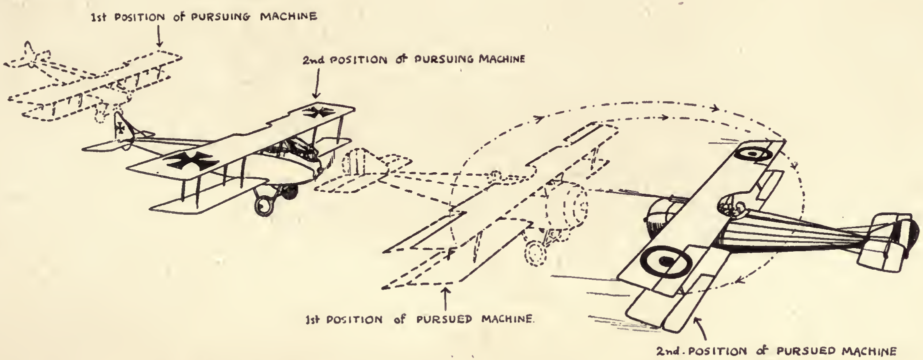


Diagram showing how an "aerial skid" is effected.

combat machine to dive down on the decoy, only to find that a formation of five or more aeroplanes were diving down on him. To escape from such a predicament required knowledge of all the manœuvres an aeroplane could possibly make.

Moreover, every pilot ought to know how to perform these stunts even in peace-time flying, so that, if his engine stalls and he falls into a spinning nose dive, he will know just what to do in order to get out of it. The same is true of banking, side-slipping, etc.

Finally, since an aeroplane moves through the air as a submarine passes through water, it should be designed so as to be able to take stresses from every quarter, so that if the machine loops or flies upside down a vital part will not break because the pressure is reversed.

Stunting should never be performed less than 2,000 feet above the ground. It has been done by reckless pilots in exhibition flights countless times with impunity; nevertheless, many of the most daring and clever pilots have lost their lives just by taking such foolhardy chances. Altitude is absolutely essential to recover equipoise necessary to a safe landing, especially when a forced landing must be made. Eventually a law will be passed preventing, on pain of forfeiting of a license, looping, spinning, etc., below a certain altitude. The result will be a decrease in the number of flying casualties and a proportionate increase in the confidence of the public in the aeroplane as a safe and sane medium of aerial transportation.

A Vertical Bank

This term is applied to all turns or banks made at 45 degrees or over. With proper speed there is no particular danger in this manœuvre, and is performed by putting the rudder and control lever farther over than in an ordinary turn. To come out of a vertical bank is to give opposite rudder and to pull the control lever central again and slightly forward. When the machine continues around the circle it becomes a spiral.

Spiral

A spiral descent is made with the engine cut off, and the pilot should always keep his eyes on the centre of the circle. When the angle becomes too steep, he flattens her out a little so that he does not side-slip or skid, and if the descent is too rapid, he pulls the control lever back slightly. When the bank is too pronounced, the rudder and elevator change functions, and the pilot must bring them back to their proper positions at once.

Zooming

Zooming is really making an aeroplane suddenly jump several hundred feet into the air after flying near the ground. This is essential sometimes in order to clear a hangar or telegraph-pole near the ground. Fliers in the Great War did it when attacking aerodromes. No zoom, however, can be made unless the machine has got up full speed, for it is only this momentum that permits the aeroplane to climb so steeply

The so-called "Immelman turn."

The lower machine is turning on its back, while travelling forward, preparatory to diving.

and suddenly. The stunt is done by jerking the control lever back suddenly, which causes the nose to climb steeply. The control is then pushed forward equally as suddenly, just as the machine has reached the stalling-point and is about to fall over on its side. To avoid that, the control lever must be pushed forward, forcing the nose down, and allowing the machine to gain its velocity, otherwise it will lose its flying speed and crash.

Looping

This stunt is nothing more or less than continuing the zoom until the machine flies upside down and completes a complete circle perpendicular to the ground. It is a very simple manœuvre, and was very necessary in aerial duels. Some machines were built so that they could loop easily. To loop, a machine must always get momentum enough in its descent to complete the circle. To start the loop, the control lever must be pulled far back, so that the nose rears vertically upward and over, and remains in an upside-down position for a few seconds. In this position he must cut off his engine, ease up the stick, slowly centring the control. The engine can be switched on again as soon as the steepness of the circle has decreased.

Before looping, a machine should be carefully inspected because of the reversing of stresses, which may cause the breaking of a vital part. Another danger in looping is the stalling or stopping of the engine anywhere before the first half of the loop has been made, thus causing the aeroplane to fall over on its side and into a tail spin or spinning nose dive.

Nose Dives

Owing to the fact that a pilot must have altitude in order to get out of a nose dive, it is well not to try them near the ground. The pilot should be well strapped in so as not to be thrown forward on the controls. It is made by pulling the nose straight down. The engine should be shut off to minimize the strain on the machine. Many nose dives end in a zoom, and they were very common performances in air duels. A machine whose wings are not sufficiently strong may fold up like a book when levelled out at the end of a dive and crash.

Immelman Turn

This stunt consists of completing the first half of a loop, then turning the machine completely about and facing the other direction. This manœuvre was named after the famous German ace. The engine can be cut out when the machine turns about and dives.

The cart-wheel, boot-lacing, falling leaf, the roll and the barrel are all parts of this same stunt, and are often mistaken for one another. The cart-wheel is done by diving or getting up speed, then making the machine zoom. When the aeroplane is almost standing on its tail, but before it has lost flying speed and controllability, the rudder forces the ship into a

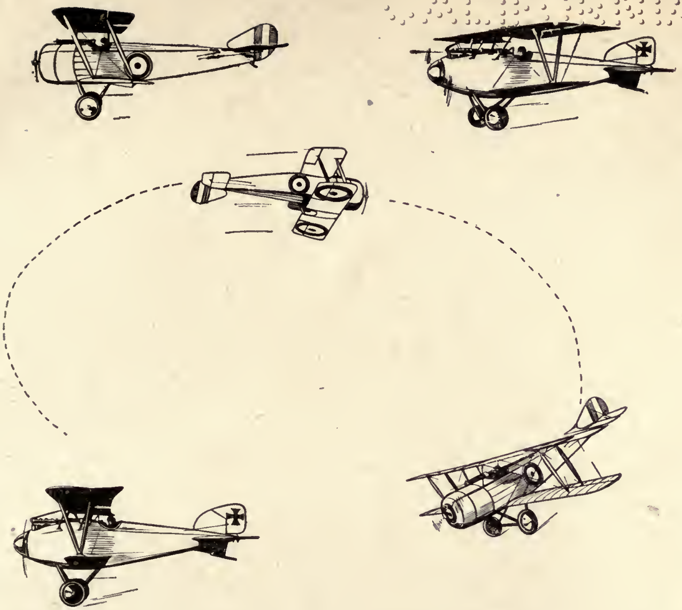


Diagram illustrating the reversal of position effected by a "loop."

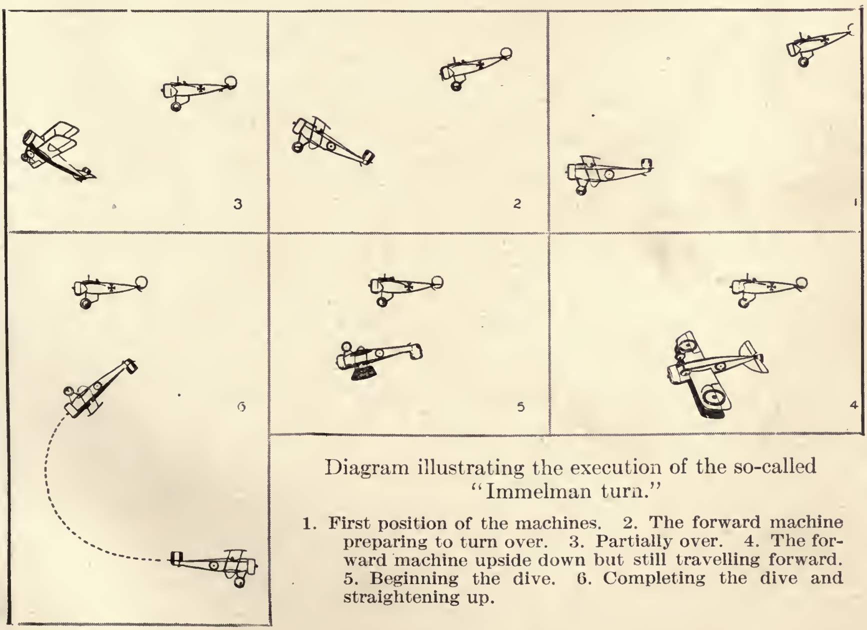


Diagram illustrating the execution of the so-called "Immelman turn."

1. First position of the machines. 2. The forward machine preparing to turn over. 3. Partially over. 4. The forward machine upside down but still travelling forward. 5. Beginning the dive. 6. Completing the dive and straightening up.

bank in the same direction, forming a complete cart-wheel, coming out and facing the opposite direction.

The falling leaf is done by a modification of this manœuvre, causing the machine to fall over on one wing-tip, and then bringing it into control again, thus causing the machine to turn over like a leaf in the air. This is a hazardous manœuvre, and requires pulling the rudder violently from side to side.

Upside-down flying and tail spinning is difficult except to certain types of machines; of course it cannot be done for any length, and usually terminates in a tail spin, when the machine descends like the threads of a screw.

Naturally, there are air disturbances about a machine when performing these stunts, and bumps are frequent owing to that phenomena. They ought never to be tried by a novice close to the ground. They are, however, very spectacular, and for that reason often seen at aerodromes or flying exhibitions. Indeed, Lieutenant B. C. Maynard has a record of 318 consecutive loops.

Formation Flying

Flying like ducks in the form of a spear-head and in groups of from 3 to 300 or more was inaugurated by the German ace of aces, the Baron Von Richthofen, who was credited with shooting down eighty Allied planes in the Great War. Before this, however, it was discovered that flying in pairs was more safe than flying alone. With the development of the wireless telephone the numbers in the formation were increased until, in October, 1918, the Americans made a raid on Waville with 350 machines in formations.

These formations were called circuses, first because of the gaudy camouflage which covered the red baron and his German machines; often they placed decoys beneath clouds, and when an unsuspecting scout descended on the decoy, the circus dived on the scout. This was done by both sides, so that it became very unsafe to fly alone, or even in pairs, on the West Front.

The flight commander's machine was usually marked with a trailing colored streamer, and he usually flew at the apex of the spear-head. The second in command usually had his machine also specially marked, so that if anything happened to the leader he could take command. The commander often signalled by firing Very pistols. These same formations were also used for bombing and reconnaissance. Formation flying was also very useful for strafing the enemy on the ground during the last four drives of the Germans in 1918. Groups of six machines were used for this manœuvre with great effect. Whether or not formation flying will become popular in peace-times remains to be seen. In case of a crash of one machine the others could bring aid quickly, or carry the occupants to their original destination.

CHAPTER XI

AERIAL NAVIGATION

ATMOSPHERIC CONDITIONS—WINDS AND THEIR WAYS—CLOUD FORMATIONS, NAMES, AND ALTITUDES

Just as the navigator must know the sea, so the aviator must have a knowledge of the heavens and the basic principles of aerodynamics in order to become a successful pilot. Although the air is volatile like the water, the aviator flies through it as a fish moves through water. Therefore the aerial navigator must know enough about the medium through which he travels to know what to do in an emergency. Through a knowledge with the fundamental principles of meteorology the fliers may know what to expect in the form of disturbances to the atmosphere, and how to meet those conditions.

For aeroplane flight a calm clear day is the best. Then eddies and storms are not encountered, although the air is never absolutely free from the former in some degree. Even a strong gale is not a hindrance to flying, as the United States aero-mail and hundreds of machines on the battle-fronts have repeatedly demonstrated. Mists, fogs, and low-hanging clouds are the greatest impediments to flying where the machines are not fitted up with wireless telephones or directional wireless. For first flights the early morning and late evening afford the calmest atmospheric conditions.

Air, like water, seeks the level where the lowest pressure exists. It is 1,600 times lighter than water, and it extends to some 50 miles above the earth. One half of its weight is below the three-mile limit. Atmospheric pressure is variable, and the temperature of the air usually decreases with the altitude, so that it is often very cold up in the air when it is comparatively cold on the ground. For that reason electrically heated clothing or cabins, heated from the engine, are used to keep the pilot and passengers warm.

The change in the temperature of the earth sets the air in motion, so that portions that are heated by the sun's rays faster than other portions affect the atmosphere more quickly in that locality than in others, for the heated air rushes up by expansion and the cooler air will rush into the vacated place. With the repetition of this the movement of the air increases. Thus high-pressure areas and low-pressure areas are formed. A glance at a United States Weather-Bureau map will show the location and the atmospheric pressure at various places in the United States, and the intelligent reading of the same will be of infinite usefulness to the aviator. The atmospheric pressure is measured by a barometer. It is measured by a column of mercury necessary to balance it. This same atmospheric pressure is used to operate the altimeter, which tells the aviator how high he has climbed.

A falling barometer indicates the approach of a storm and a rising barometer fair weather. Wind strength is usually indicated by miles at which the storm is raging. In the early days of aviation the aviator used to wet his finger to see if the wind was stirring and what quarter it was from. If it was blowing many miles an hour, he would not venture forth.

In starting or landing a machine it is always desirable to head into the wind. It is true that in forced landings pilots have come down with the wind, but for every foot they must make an allowance.

Atmospheric pressure also has much to do with the flying efficiency of the wings. The heat generated on the surface of the planes used by the United States army in Mexico caused the dope to peal in some cases and rendered the planes unfit to fly.

The flier should, however, know something about the kinds of winds which prevail and the times of the day when the most violent are to be encountered. At the earth's surface the day winds are stronger than the night winds, and the average velocity of the day wind is about eleven miles an hour. Because of the similarity of the movements of the winds to those of water, many of the terms applied to air movements are the same.

When an upward movement of wind rises from barren land or conical hills, it is called an aerial fountain. Sometimes this air rises at a velocity of twenty-five feet per second. Sometimes an aeroplane when caught in one of these fountains will rise like a cork on the top of a water-spout, or the wing will be tilted if it is hit by this column of hot air.

An aerial cataract is caused by descending cold air, and has the opposite effect on an aeroplane flying through the air to that of the fountain. These are encountered in flying over very broken ground.

Aerial cascades are encountered often in flying over narrow valleys or steep hills. The contours of the land cause the air to follow down into the valleys suddenly, thus often making it dangerous for fliers to attempt to land on rivers enclosed in steep banks, unless of course they fly up or down the river.

With aerial torrents the same principle applies, except that the area of disturbance is broader and more powerful. Great velocity is attained near open valleys, due to the cold air rushing to replace the hot air moving upward. A cross, choppy wind will cause choppy air surfaces and bad eddies, and can be discerned on a cloudy day by rips in the surface of clouds.

Over the crests of hills vertical eddies are encountered. They are usually called pockets by fliers. Often the machine drops straight down, and the pilot should immediately head his machine into the current. Sometimes winds will be found blowing in different directions and passing in layers above one another. These have a tendency to turn the ship about, and is one of the reasons why the aviators prefer to get altitude before doing any stunt flying. Except close to the ground these contrary winds are not dangerous. So just as a vessel is safest far from a coast in a storm, so an aeroplane is safest at a reasonable altitude where the wind is not so bumpy.

Clouds and mist are two of the worst enemies of the aerial navigator; first because it shuts off the observer's vision of the terrain, preventing him from knowing exactly where he is, and because it makes it difficult for him to locate his landing-field. Directional wireless and the wireless telephone do help a great deal in giving information about the lay of the land beneath the clouds or mist, but of course it cannot visualize the ground on which the aeroplane is to land for the pilot to see exactly where he should set the wheels down. For that reason a knowledge of clouds is essential to piloting aircraft.

There are many different kinds of clouds, but they are all formed by condension when an ascending volume of moist air mingles with another mass of a different temperature, or when a mass of arising vapor condenses. With a knowledge of the direction clouds are moving in it will reveal certain facts about the weather to the pilot. Clouds take almost every conceivable shape.

A general knowledge of the movement of the clouds is a valuable asset to the flier, for they indicate the air-currents and also the condition of the atmosphere in their neighborhood. Unbroken clouds indicate smooth-flowing air, while the more a cloud is broken the more bumpy the air-currents are in that neighborhood. From the formation of clouds then the atmospheric conditions may be realized by the pilot before he flies into them. In general the following types of clouds indicate certain specific facts to airmen.

A mackerel sky, called technically Cirro-Cumulus, which is formed of small globular masses, or white flakes showing only light shadows, or at most only very light ones, or arranged in groups or in lines, usually at a height of 10,000 to 25,000 feet, denote fine weather, and for commercial flying afford ample opportunity for smooth flying below that altitude.

Very light, whitish wisps of clouds, fibrous in appearance, with no shadows which appear at 30,000 feet altitude, or more, are the highest clouds in the firmament, are called Cirrus or Mare's Tails, because they are scattered like hair over the sky. They indicate wind and a cyclonic depression.

The next clouds in altitude are the Cirro-Stratus, which float 29,500 feet, and look like a thin sheet of tangled web structure. They are whitish, and sometimes completely cover the heavens, giving it a milky appearance. This cloud is one of the most beautiful, and often creates moon and sun halos. It indicates bad weather.

The Alto-Stratus is a thick extensive sheet of bluish or gray cloud, sometimes composed of a thick fibrous structure which is very dense and impossible to penetrate with the eye. They are at an average height of from 10,000 to 23,000 feet, and cause a luminous crown or aureole around the sun or moon.

Woolpack Clouds, or Cumulus, as they are designated, are thick, and the upper surfaces are domeshaped, with many sharp protuberances, and with horizontal bases. They are low-lying and indicate violent disturbances of the air, and are dangerous for any kind of aircraft when passing above them or through them.

Thunder-Clouds, or Cumulo-Nimbus, are formed in heavy masses rising in the forms of turrets, mountains, or animals. They are usually surrounded by a screen or sheet of fibrous appearance, having its base in a similar formation. The highest points of these clouds reach an altitude of 10,000 to 26,000 feet, and they are as low as 4,000 feet at the base. They indicate lightning and terrific gusts of wind, and are very dangerous to aerial navigators.

The whitish-gray globular masses partly shaded, piled up in groups and lines, and often so thickly packed that their edges appear confused, are called Alto-Cumulus. They are arranged in groups at an elevation of from 10,000 to 23,000 feet. They do not look unlike the mackerel sky. The cross-lines indicate strong currents of air.

Strato-Cumulus are dark globular masses of large clouds, often covering the whole heavens in the fall and the winter. They hang as low as 6,000 feet, and always predict changing weather.

The lowest-hanging cloud of all is the Stratus, which is uniform at a height anywhere from 100 to 3,500 feet. It may be either drifting or stationary. It is a uniform layer, and resembles a fog, but, unlike the latter, it does not rest on the ground.

The Nimbus is a thick layer of dark clouds with ragged edges but without shape. Rain or snow usually falls from this formation. There are many rifts in these clouds, and through them many higher clouds are seen. The Nimbus usually occupy altitudes from 300 to 6,500 feet.

CHAPTER XII

COMMERCIAL FLYING

BUSINESS POSSIBILITIES OF THE AEROPLANE—SOME CELEBRATED AIR RECORDS—GERMANY'S INITIAL ADVANTAGE—A HUGE INVESTMENT—CAUSES OF ACCIDENTS—DISCOMFORTS OVERCOME—INEXPENSIVE FLYABOUTS—THE SPORTS TYPE—ARCTIC FLIGHT—NO EAST OR WEST

In the face of the extraordinary development of the aeroplane and what it has accomplished in the Great War, both for the Hun and the Ally, it seems almost incredible that it was only as recent as December 17, 1903, that the Wright brothers made man's first successful sustained and steered flight in a heavier-than-air machine driven by a gas-engine over the sand-dunes of Kitty Hawk, North Carolina! Upon that historic occasion Wilbur Wright flew 852 feet in fifty-nine seconds, and his four-cylinder gas-engine could generate only 12 horse-power!

Since then an aeroplane has carried an aviator from Paris via Constantinople to Cairo, Egypt; a biplane driven by a 300 horse-power gas-engine has climbed to an altitude of 28,900 feet; another with a 450 horse-power engine has ascended with two men to an altitude of 30,500 feet; still another, with a wing spread of 127 feet, propelled by four twelve-cylinder motors developing 450 horse-power each, has lifted forty people to an altitude of 6,000 feet for an hour's cruise over London. Still another machine of the same type, but with only 100 feet of wing spread, and propelled by only two 400 horse-power engines, has transported five men and a useful load of a ton all the way from London to Constantinople and back to Saloniki, a distance of more than 2,000 miles, and has carried six people from London via France, Italy, Egypt, Palestine, Arabia to Delhi, India, a distance of over 6,000 miles. A two-seater, with a pilot and mechanic, has flown from Turin to Naples and back, a distance of 920 miles, without stopping! On April 25, 1919, an F-5 U. S. Naval seaplane, carrying four aviators, flew 1,250 miles in twenty-four hours and ten minutes without stopping. A late report from Italy says that a huge triplane, measuring 150 feet, weighing many tons, and driven by three 700 horse-power engines has taken seventy-eight people up for a ride at one time. A piano has been freighted in another aeroplane from London to Paris. The Alps, the Pyrenees, and the Taurus Mountains have been aerially transnavigated by aeroplane. The Sahara Desert, the Pyramids, the English Channel, the Mediterranean and the Adriatic Seas have been flown over in heavier-than-air machines.

In the war zone the aeroplane has been put to the most astonishing uses. It has spied out the most hidden secrets of the enemy; it has dropped spies behind his lines; it has photographed thousands of square miles of European and Asiatic terrain; it has directed the

Courtesy of Flying Magazine.

Interior view of the Graham White twenty-four-seater aeroplane in flight.

The sound of the motors is shut out by padding. The room is electrically heated.

fire of artillery and the march of hundreds of thousands of troops; it has scattered cigarettes over advancing soldiers; it has dropped cans of tomatoes to thirsty and hungry men in isolated stretches of the desert; it has carried food to besieged camps; it has bombed trains, concentrations of soldiers, ammunition-dumps and ammunition-factories, gas-plants, and innumerable other military and manufacturing objectives. It has performed more manœuvres in the air than the tumbler pigeon. It has fought the most extraordinary battles. It has descended so low as to rake soldiers in the trenches, transports on the highways, trains on the railroads, and even officers in their automobiles. Indeed, by bombing manufacturing cities over a belt of a hundred miles along the Rhine it has done more to break down the morale of the German people than any other factor. Truly this new engine of man has developed, under the intense necessity of war, farther in this short space of time than any other mechanical device—not excepting the automobile—which man has ever invented or fostered.

But with all the wonderful things the aeroplane has accomplished and with all the stupendous advance it has made as a carrier of man and his chattels, even though it does travel the shortest distance between any two points on this planet with the greatest speed, nevertheless, much must yet be done to make the aeroplane a safe, comfortable, popular, and inexpensive means of aerial transportation. Therefore, before we attempt to demonstrate how this fastest engine of flight can be made to do man's will as easily and comfortably as the powerful steam-engine, the mysterious electric dynamo, and the subtle gasoline motor, let us first examine in detail what has already been accomplished in aeroplane transportation. Then, with our feet firmly planted on the ground but with our heads up in the clouds so that we may see over the highest mountains, let us look down the corridors of the ages and discern through the mists of time some of the transportation feats which this new invention of man will most certainly perform.

From the time of the first flight of the Wright brothers till the beginning of the Great War, owing to the lack of commercial incentive, the development in aviation was similar to that of any other science that involved some physical dangers. It is true that M. Bleriot had flown across the English Channel on July 25, 1909; that Jules Vedrines had been carried in an aeroplane from Paris via Vienna, Sofia, and Constantinople to Cairo, Egypt; and that Roland Garros had flown 500 miles across the Mediterranean Sea from St. Raphael, France, to Tunis, Africa; but these facts were regarded as sporting events or stunts that could not be regularly performed by aeroplanes without great loss of life. For that reason practically no commercial interest was taken in aviation, and very little military—except by Germany, which was ready to seize upon and develop anything that would help her to realize *Der Tag* when she would be conqueror of the world.

Indeed, few people outside of those connected with aeronautics know that one of the chief reasons why the Potsdam gang made the Sarajevo murders a pretext for hurling the whole world into war was the firm belief that Germany had at that time the complete supremacy of the air. She had constructed a fleet of twoscore Zeppelins, some measuring 710 feet in length and being buoyed up by over 2,000,000 cubic feet of hydrogen gas, driven by six Maybach gas-engines, each developing 250 horse-power, and carrying a crew of forty-eight men and a useful load of four tons.

What destruction those fleets of lighter-than-air machines wrought upon the open villages, towns, and cities of England, Scotland, France, Belgium, Rumania, and Russia—not to mention the part they played in the naval battle of Jutland—constitutes another chapter in the history of German aerial preparedness and sky-line transportation that is told in the chapter on the commercial Zeppelin. But just as Germany seized on the submarine and developed it for polemic purposes, so she saw the possibilities of the aeroplane as a scout, fighter, and bombing subsidiary to the Zeppelin. With the object of developing the aeronautic branch of the service beyond any other country the German Government gave every encouragement to aviation. In 1914 the Huns offered the sum of $55,000 to be awarded for the best water-cooled and air-cooled aeromotor of 80 to 200 horse-power. Among the points to be avoided in its construction was the "use of material from any other country than Germany." Under the auspices of the Aerial League of Germany the Kaiser also put up fifty thousand marks in prizes for the best altitude, cross-country, and non-stop records made by standardized aeroplanes taken from stock. Subsidized as the German aero manufacturers were by their government, it was not difficult for their flyers to carry off all the prizes at this meet, so that before the end of July, 1914, they had made the following new world's records:

Otto Linnekogel on July 9 climbed to 21,654 feet, breaking Roland Garros's record of 19,032; on July 14 Heinrich Oelrich reached 26,246 feet; and Reinhold Boehm flew for twenty-four hours and two minutes without stopping his engine!

Those who realize how much time, money, and energy have been expended by this country during the time we were in the war in getting quantity production of aeroplanes and aeromotors will appreciate what it meant to Germany in July, 1914, when she declared war on the world, to have all her experimentation done and her aeronautical factories tuned up and nearly a thousand standardized planes equipped with standardized Benz, Mercedes, and Maybach motors while England had barely 250 planes of almost as many different types, and France was in a similar condition with about 300 aeroplanes and engines!

With command of the land and the air Germany felt she could neutralize or overcome Britain's command of the sea by overrunning France, seizing the Channel ports, and by flying over the British fleet land an army in England and conquer the "tight little isle." Indeed, for three years after the first battle of the Marne the fear of just such a contingency compelled England to keep a large standing army at home while Germany with her Zeppelins and aeroplanes, even from distant Belgium, terrorized Scotland and England with almost daily bombing air raids.

But as soon as the war broke out the governments of the world began to appreciate what could be accomplished by these little toys of sportsmen, and to realize that the side which built and equipped the largest and fastest fleet of scouts and fighters could put out the eyes of his opponent and win the gigantic struggle; for an army or a navy cannot feel its way forward like a worm without being destroyed! This precipitated an enormous economic and manufacturing race to make enough aircraft and to train enough skilful aviators to drive the enemy from the air and get control of the third dimension. The fighting and bombing possibilities of the aeroplane were not then fully appreciated; that came afterward. Consequently the two objectives first sought in the actual designing and building of the aeroplanes were manœuvring ability and speed, and later bombing capacity. Inherent stability and sufficient factors of safety, the two chief considerations in peace construction of aircraft, were only secondary or entirely neglected.

For nearly four years this war of tools and this war in the air went on with fluctuating vicissitudes for Hun and Ally. First came the German scouting and fighting Fokkers equipped with motors which owing to their superior horse-power made them faster and more easy to manœuvre than anything the Allies had until the famous French Baby Nieuports with 110 horse-power Le Rhone engines appeared in 1916 and began to equal the Boche in those two prime requisites. Then, owing to the number of machines shot down or forced to land through engine trouble, neither side could long keep any secret of aeromotor construction or aeroplane design from an opponent. Therefore the struggle for quantity production began. In the meantime the huge bimotored Caudrons, Voisins, Breguets, Handley Pages, and Capronis began to be built in large numbers by the French, British, and Italians, and the Gothas by the Germans. Each year saw an increase in the horse-power of the motors and in the size of the aeroplanes; and still, owing to the infinite area of the skies to manœuvre in and the lack of large aerial fleets flying as a unit, neither side could prevent the scouting-machines or the bombing raiders from spying out or bombing any objective within a flying radius of two hundred miles of their aerodromes.

With the advent of the United States into the struggle it became more and more apparent to the German military leaders that they must win the war before the tremendous manufacturing and aviator resources of this country could be felt on the West Front. That, of course, was one of the cardinal reasons for the series of great German drives beginning with March 21, 1918.

The Allies, too, now fully realized that the Great War would be won in the air, so they expended every effort and resource to build aeroplanes to clear the German machines from the skies and to bomb Germany from the air. How much these raids behind the Boche lines had to do with the breaking down of the morale of the German people and Teuton soldier cannot yet be properly estimated. However, to give an idea of the severity of this war in the air and destruction wrought by bombing-machines in Germany we know that the British Independent Air Force sent out over the enemy territory squadrons of five to one hundred aeroplanes, which dumped daily, rain or shine, sixty to one hundred tons of high explosives on military objectives and manufacturing plants scattered over a belt a hundred miles wide all along the Rhine Valley. These raids penetrated as far as Essen and Heidelberg. They destroyed ammunition-dumps, railroad-yards, chemical and gas works. By blowing up railroad communications with the rear they virtually cut the arteries of the German army. Moreover, by their repeated excursions into Holland they disrupted the sleep, the rest, and the working capacity of the people in the manufacturing towns and cities in southern Germany.

In the battles in the air, too, the Allies were rapidly becoming supreme. On October 18, 1918, the British air force alone destroyed sixty-seven Hun machines and brought down fifteen more out of control, losing only fifteen machines themselves. Thus these fliers blinded the German artillery, and in contact patrol swept the Teuton trenches, bombed their motor and rail transports, and dispersed concentrations of their troops. Indeed, the only place to escape these relentless dragons of the air was actually under ground.

Meanwhile, after much delay and many mistakes, American-built aeroplanes were beginning to appear in quantity on the West Front. Here is the record of what the Americans accomplished during the short time in which they had machines: 926 German aeroplanes and 73 balloons were destroyed. The Americans lost 265 aeroplanes and 38 balloons.

Finally, in October, 1918, 350 American-built aeroplanes in one single formation dropped thirty-two tons of high explosives on Wavrille. When the armistice was signed, there were actually engaged on the West Front 740 American aeroplanes, 744 pilots, 457 observers, and 23 aerial gunners. Of these, 329 were pursuit machines, 296 observation machines, and 115 were bombers.

How much damage the French and Italians did to German aerial supremacy and manufacturing efficiency is difficult to summarize. It was very considerable and, taken in conjunction with the others, sufficient to convince the German military leaders that the Allied production of aircraft was so rapid that within less than a year at most the Allies would sweep the Huns from the skies and not even Berlin would escape the fate the Huns had so often visited upon London, Paris, and Bucharest. Finally the plea issued by the

German Government to the Allies, about a month before the end, to confine air raids to within a fifty-mile zone of the fighting-line was a complete confession that the Allied supremacy of the air was one of the most deciding factors in causing Germany to surrender.

But though the primary uses of the aeroplanes during the last four years were polemic, nevertheless, several of the startling new feats demonstrate clearly what may be expected when the same aircraft manufacturers design and construct machines for the avowed purpose of commercial aerial transportation. Here are only a few of the most startling world's records that suggest these possibilities:

On August 29, 1917, Captain Marquis Giulio Laureati flew in an S. I. A. from Turin to Naples and return, a distance of 920 miles, establishing a new non-stop flight world's record, and a month later he and his mechanic flew from Turin to London, crossing the Alps at an altitude of 12,000 feet and negotiating a distance of 656 miles at an average speed of 89 miles an hour. The speed, however, was not remarkable, for 100 miles an hour is the average speed for big machines, and 150 miles was made by scouting-machines on the West Front during the war. On April 19 Captain E. F. White, U. S. A., in a DH-4, flew from Chicago to New York, 727 miles, without stopping, in six hours and fifty minutes.

On April 25, 1919, four naval aviators, in a seaplane of the F-5 type, Serial No. 3589, made a new world's record for an endurance flight when they flew, officially, 1,250 miles in twenty hours and ten minutes. The record was made during a continuous flight from 11.42 A. M. April 25 until 7.52 A. M. April 26. Throughout the entire afternoon and night, and often bucking a strong breeze over the Chesapeake Bay and the Virginia Capes, the F-5 described a great circle, extending northward to the mouth of the Potomac River and then eastward to the Atlantic Ocean, sweeping over the Capes and then inland to the naval station.

The four men in the machine ate three meals during the flight.

The machine left the naval base with 850 gallons of gasoline. When it landed there was scarcely two gallons in its tanks.

The F-5 is an improved type of flying-boat that the Navy Department intended using in patrol duty for war purposes. It has a wing spread of 105 feet. The machine was built by Curtiss, and is known as a "kite boat," equipped with twin Liberty motors.

At Wright Field, near Dayton, Ohio, on September 18, 1918, Major R. W. Schroeder, of the United States Air Service, in an American-built aeroplane driven by an American-made Hispano-Suiza motor, climbed to a new world's altitude record of 28,900 feet, only 102 feet short of the highest peak of the Himalaya Mountains. In December, 1918, Captain Lang and Lieutenant Willets claimed to have ascended to 30,500 feet in a Bristol aeroplane, but the record has not been homologed. On November 19, 1918, an aeroplane flew from Combes la Villa to Paris and return, a distance of eighty miles, carrying thirty-eight passengers. Two days before a Handley Page, with a wing spread of 127 feet and a fuselage measuring sixty-five feet, propelled by four motors and piloted by an American, carried nine women and thirty-one men to a height of 6,000 feet during an hour's cruise over London, England. A year ago another type of this same machine, but with only a 100-foot wing spread and driven by only two 275 horse-power motors and carrying five men, flew across country from London to Constantinople, dropped bombs on the German cruiser *Goeben* anchored there, and then flew back to Saloniki, covering a total distance of more than 2,000 miles and remaining in the air a total of thirty-one hours. The flight was via Paris, Lyons, and Marseilles—in order to avoid the Alps—and from there to Pisa, Rome, Naples, and then across 250 miles of mountainous country, often at a height of 10,000 feet.

Near the close of the year a huge triplane Caproni, with its 150-foot wing spread, driven by three 700 horse-power Fiat motors, developing a total of 2,100 horse-power, has carried seventy-eight people in trial flights at the factory!

A Model F-5 flying-boat, with a wing spread of only 102 feet, driven by two Liberty motors, and lifting a 50-foot boat, has carried 12,900 pounds over many hundreds of miles looking for German submarines, and another flying-boat, with 123 feet of wing spread, carried fifteen officers and a pilot from Washington, District of Columbia, to Newport News, Virginia.

On November 27, 1918, a Curtiss N C 1 carried fifty people for a short flight at Rockaway Beach, New York. It was drawn by three Liberty motors. The flying weight of the machine was 22,000 pounds, and the machine had a wing spread of 126 feet, and the NC-3 and NC-4, which flew from Rockaway, New York, to Halifax, 520 miles for the first leg of the transatlantic, weighed 28,000 pounds, and were driven by four Liberty motors.

The War Department on December 23 also announced that a squadron of four army training-machines flew from San Diego, California, to Mineola, Long Island, a distance of 4,000 miles, in the actual flying time of fifty hours.

The infamous German bimotored pusher Gothas, measuring 78 feet, driven by six-cylinder Mercedes 260 horse-power engines, and carrying three men and five hundred pounds of explosives, flying by night from the aerodromes near Ghent, Belgium, a distance of nearly two hundred miles, have raided London more than a hundred times despite the opposition of fleets of British aeroplanes and seaplanes and thousands of antiaircraft guns.

For some time aerial mail has been carried from London to Paris in two and a half hours. Mail is also being transported by air route regularly between Washington, Philadelphia, and New York, and between Rome and Turin. Mail was carried through the air from Chicago to New York in ten hours and five minutes; and Second Assistant Postmaster-General Praeger says the sky-line mail will be extended to the Pacific coast, and in the year 1919 fully fifty aero mail routes will be in operation.

How many aeroplanes that might be used for peace purposes were completed by all the Allies and in service of some kind at the end of the war is problematic. Judging by the Allied demand that Germany surrender 1,700 aeroplanes, the Allied military authorities surely estimated that Germany must have had far more than that number in active service on the West Front. Counting the training-machines necessary to teach enough aviators to fly and the planes discarded as unsafe for battle flying, Germany must have had 8,000 or more heavier-than-air machines. The British surely had close to 5,000 of all kinds on the different fronts, with possibly 10,000 used for training and other purposes. Indeed, Britain was making over 4,000 a month, or 50,000 a year, when the war ended, according to the statement made by General Seely in Parliament in April, 1919. Perhaps the French and Italians combined did not have so many as the Germans because of the physical limitations on their manufacturing facilities. The Americans, we know, had nearly 2,000 on the front when the war ended. A thousand De Havilland 4's had been delivered up to October 4, and more than 6,000 training-machines had also been constructed. We were just getting into a factory production of about 1,200 a month when the war ended. Indeed, to be exact, on November 11, 1918, a total of 33,384 planes had been ordered; subsequent to that date 19,628 ordered were cancelled, and up to December 27, 1918, a total of 13,241 planes had been shipped from United States factories.

With the exception of the training-machines and the two-seater fighters, like the De Havilland 4's, most of these American machines could hardly be used for anything except aero mail service. The large Caproni and Handley Page bombers will do some passenger carrying. Indeed, the peace planes, unlike the war planes, are constructed with stability, safety, capacity carrying, and comfort as the chief factors.

At the close of the Great War, fortunately for the aeronautic industry, approximately ten billion dollars has already been invested by European, American, and Asiatic countries in aeronautics. Part of this has been expended in constructing aircraft factories, aeronautic engines, aeroplanes, dirigibles, hangars; in obtaining raw materials and landing-fields; in training aviators and mechanics, and in making aeronautic machinery, equipment, and accessories. Thousands of furniture and piano factories, boat-building shops, and similar establishments have been manufacturing propellers, struts, ribs, pontoons, flying-boats, and so on; and hundreds of automobile-makers and engine manufacturers have given over their plants, or a goodly portion of them, to making motors, spars, and tools.

Varnish, linen, cotton, castor-oil, goggles, clothes, and a hundred and one other things have also been used either in the direct manufacture of aircraft or in the equipment of the aviators or mechanics, so that there are to-day tens of thousands of skilled and unskilled artisans, aviators, mechanics, who are wondering how far the aeronautic engine, with its remarkable development from 16 horse-power, which the Wright brothers used, to the 700 horse-power of the Fiat, will be used in commercial aeronautics and how far the frail little Wright glider, which has grown into a machine weighing six tons, can be made a profitable means of aerial transportation.

Moreover, all the scientific knowledge, trained technic, all the enormous investments in fixed property, and the tens of thousands of aircraft built or building is being turned to commercial purposes. They were not, and everything is being done to make the aeroplane do man's bidding as easily and as readily as the steamboat, electric car, steam-engine, and automobile.

Even though the aeroplane does travel the shortest route in the shortest time between any two given points, before a sufficient number of passengers can be induced to travel via the aerial line to make it financially profitable to the transportation company the public must be assured that it is reasonably safe; that they can fly in comfort; and that the price is reasonable. So let us first see what has been done and what is being done to satisfy those three requisites.

The dangers of aeroplane flight have been grossly exaggerated by newspapers, which record only the unusual. Moreover, flying in the war zone was done under the most adverse and dangerous circumstances. Also the machines were built for manœuvring ability and speed, and not for stability and safety factors. Furthermore, all the scouts and most of the reconnaissance and battle planes were driven by only one motor, so that if engine trouble developed they had to volplane to the ground at the mercy of the antiaircraft guns and the aerial fighters. Finally, they often had to land in shell-scarred terrain. Naturally the casualties were high. Indeed, the war in the air was meant to be as perilous and dangerous as it could be.

Nevertheless, in spite of these hazards it is remarkable how many machines, even when shot down with some vital part out of commission, in many cases falling several thousand feet, have righted themselves before reaching the ground and made a safe landing, due to the precision and accuracy of construction with regard to lateral and longitudinal balance. And all in all, judging from the wonderful records already made by aeroplanes, even the single-motored machine is very reliable.

With the bimotored plane, of course, casualties were not so high, for even if one motor was put out of commission the other could bring the aviators back to the aerodrome. Major Salonone, the Italian ace, on February 20, 1916, flew a hundred miles back to his own lines with one of the motors on his Caproni shot out of commission!

On the aviation training-fields, owing to the novices who were learning to fly, the natural recklessness of youth, and sometimes the faulty construction of planes—hastily built and often superficially inspected—the casualties were higher. Stunting too near the ground and in machines constructed primarily for straight flying so that the stresses should come from only one flying angle, enemy treachery, and the absolute necessity of discovering the best manœuvres and newest types of aeroplanes also augmented the honor roll. But stunting eliminated, with machines equipped with two or more reliable aeronautic motors built according to standardized specifications as to materials, methods, stability, and the required number of safety factors, steered by tried and true pilots, flying between regular landing-fields and aerodromes and directed in the dark and in foggy weather from the ground by radiotelephones, such as flight commanders used in giving instruction to the members of the flying squadron, the dangers of flying can be reduced to proportions commensurate with the desire of the public to get from place to place in the quickest and safest vehicle.

Of course, the present high landing speed of an aeroplane is the cause of many accidents. Thirty-five miles an hour, except where the head resistance is great, is the slowest speed now made in landing a heavier-than-air machine. The invention of a device or the discovery of a means of reducing the speed to ten miles an hour when touching the ground, though still only in the realms of the probable, is by no means diametrically opposed to the inherent laws of the aeroplane. This accomplished, the danger of flying in an aeroplane will be reduced to infinitesimal proportions —at least to a degree no more precarious than riding in an automobile.

Already the War Department has ordered flyers to map the country, and large stretches of the United States have already been mapped. The Wilson Aerial Highway, from New York to Chicago and San Francisco, has been laid out. Aerial transportation companies have been formed to provide planes. Thousands of skilled pilots have secured jobs; many chambers of commerce have built landing-places near their towns and cities. Needless to say, aerial laws will be passed to prevent stunting with passengers and requiring machines to fly at the altitude necessary to glide to the nearest aerodrome in case a motor stalls. Already a dozen different aeronautical motors have been developed which will run twenty-four to one hundred hours without stopping. Recently the Caproni biplane at Mineola, Long Island, climbed to 14,000 feet with one of the three motors completely shut off all the way.

On August 9 the Italian poet Gabriele d'Annunzio flew from Venice to Vienna via the Alps with his motor wide open all the way. Indeed, thousands of equally sensational flights have been made, in all kinds of weather and under the most adverse circumstances of a great war. Of the hundred-odd air raids on London by the Gothas some were conducted in broad daylight, when the Germans had to fly through squadrons of British scouts and fighters, through or over three barrages in order to get to the metropolis; and yet seldom more than one or two Hun machines out of the thirty usually constituting the squadron were forced to land or were shot down. The same thing was true of the British Independent Air Force in the raids they made over the German cities, citadels, factories, ammunition-dumps, and other military objectives, though they often flew in fleets of fifty to a hundred.

Of the 350 machines constituting the American air raid on Wavrille in October, 1918, only one aeroplane failed to return, though twelve Hun machines were shot down. The German flying-tank which shot down Major Lufbery, the most famous American ace, was driven by five engines, which were protected, as well as the fuselage, with bullet-proof steel three-eighths of an inch thick. Major Lufbery emptied his machine-gun against this aerial monster from close range and from many angles before his gas-tank was pierced and his machine went down in flames. Therefore a bimotored machine, flying under peace conditions, should be able to make its aerodrome safely nearly every time.

There were three discomforts of air travel—the cold, the noise of the motor, and the lack of room in moving about. Electrically heated clothes eliminate the cold; ariophones, which shut out the noise of the motor but permit the passengers or aviators to converse together, are in universal use on aeroplanes. With the increase in the size of the aeroplanes and the number of motors, the nacelles and the enclosed roomy cabins can be constructed as they were on the famous Sykorsky aerobus, which was built in Russia before the war. This aeroplane carried twenty-one people to an altitude of 7,000 feet. On this trip they had ample room to move about and to observe the sky and the landscape. On Thanksgiving Day, 1917, a half-dozen guests of an American aircraft factory had their turkey dinner served in a huge aeroplane above the clouds.

The Handley Page and Farman aerial transport busses now flying between London and Paris carry the passengers entirely housed in.

It is true that owing to the cost of the aeroplanes and the aeromotors, their upkeep and the number of skilled men required to fly and maintain them, all aerial travel is expensive. The two-seater training-machines, equipped with one motor, cost five to seven thousand dollars, and the huge bimotored bombing-machines averaged forty to sixty thousand dollars. This price was due to the necessity for hurried construction. For everything that went into the building of the aeromotor and the machine itself and also for the labor the very highest price had to be paid. Tools, machinery, factories, fields, hangars, and a thousand other things had to be purchased, and a great body of skilled workmen had to be trained before aircraft could be turned out in quantity.

Now all this skill and billions of money have been invested in the industry so that the plants in this country have the capacity to manufacture nearly two hundred a day. With this nucleus to start a peace-construction programme the price of even the biggest machines must soon shrink to that of a high-priced automobile or private yacht. Plenty of sporting machines with a small wing spread and a two-cylinder motor that will sell for five hundred dollars are now being made; and since these machines can average twenty-two miles on a gallon of gasoline the expense of maintaining one of these will not be out of the means of hundreds of the young flyers who have returned from flying on the West Front. Moreover, since there will be no maintenance of roads, rails, live wires, and so on, such as there is in the railroad and electric road industries, the cost of aero maintenance is infinitely smaller, so that aerial travel may become cheaper than any other known to man.

Fundamentally, the hydroaeroplane is the same as the aeroplane except that pontoons instead of wheels are used to land upon. The cost of these airships over the land machines is noticeable only where boats are used instead of pontoons. Consequently, their price above the aeroplane will depend on the size and the kind of furnishings used in the boat. Owing to the fact that no landing-field has to be bought and maintained and that the flying-boat can come down on a river or a lake with comparative ease, and also the fact that altitude does not have to be maintained in order to glide to an aerodrome or a safe landing-field, this type of aerial navigation bids fair to be fast, cheap, and absolutely safe. Moreover, the size and passenger-carrying capacity of these flying-boats will be limited only by the construction of wings strong enough to maintain them in the air, for the size of the hulls and the number of motors can be increased indefinitely.

Perhaps the best indication of what we may expect of the aeroplane as a commercial carrier is embodied in the present plans of the manufacturers of aircraft. Using the past history of the heavier-than-air machines' performance and their own experience and the experience of tens of thousands of flyers under all imaginable circumstances and conditions as a basis, they are building various types of aircraft. More than a score of American and British firms have already built and are putting upon the market large numbers of sports models. These machines are single and double seaters after the type of the famous Baby Nieuports, Spads, and British Sopwith Pups. They have a wing spread of anywhere from seventeen to thirty feet. The fuselage measures between ten and twenty feet. Some are equipped with one small motor generating from twenty horse-power up to ninety horse-power. Most of these motors are upright, like the ones used on motorcycles, and range from two to four cylinders. The whole machine will not weigh more than five hundred pounds and these models are able to fly at eighty to one hundred miles an hour and make an average of twenty miles or more on a gallon of gas. The price of these will depend on the demand, but most manufacturers believe they will sell for five hundred to a thousand dollars. These machines are so small that they can be landed on any road or field. Besides, the small amount of space they occupy will make it possible to house them inexpensively, and they can be used for any kind of cross-country flying or sporting purposes.

The second type of the sports model has a wing spread of twenty-six to thirty-eight feet. These wings can be folded back so that the aeroplane can be housed in a hangar ten by thirty feet with ample room for the owner to work indoors on the machine. The fuselage is proportionately larger than that on the smaller machine. This aeroplane is equipped with a four-cylinder upright motor or an air-cooled rotary motor of the Gnome style with nine or eleven cylinders, generating up to ninety horse-power. Some also have two small twenty horse-power engines geared to the one propeller so they can be throttled down, or in case one stalls the other can take the flyers to their aerodrome without being forced to land. Some models have two motors on the smaller machines. These aircraft will sell for about the price of a medium-cost automobile.

The two-passenger models are similar in design to the army training-machines. They have more powerful upright and V-type four or eight cylinder motors and generate two to three hundred horse-power. The fuselage is built so that the pilot sits in front of or beside the passenger. The control is dual. The machines are mostly tractors, but in a few cases the nacelle is built in front of the plane like a bomber, and the propeller and engine are behind. These pusher types obviate all the blind angles and afford an excellent unobstructed range of vision. They are especially good for hunters, who desire no obstruction in gunning for birds. In case of a crash, however, there is the added danger of having the motor crush the passengers underneath. The Canadian Government has sold over ten thousand of their training-machines to an American company, which is reselling them at a low price to men who wish to own an aeroplane.

The aero-mail type is about the same as the two-passenger model in wing spread and fuselage, but the motor is a twelve-cylinder V type and generates anywhere from 250 to 450 horse-power. Cost is not so much a consideration here as carrying capacity. Most of the two-seated fighting-machines built for war purposes can be adapted by the Post-Office Department for this purpose, and plans are afoot to extend the service all over the United States.

The big bombing bus type is designed for carrying great numbers of people from one aerodrome to another. These machines are biplanes and triplanes with a wing spread of anywhere from 48 to 150 feet. They are driven by V-type, twelve-cylinder engines generating 400 to 700 horse-power. They have one or two fuselages in the centre but the nacelles are usually forward of the wings, so that nothing obstructs the vision of the passengers. These machines will be sold to transportation companies, which will make a business of carrying people from aerodrome to aerodrome. They are so large and are equipped with so many motors that they are not intended to be landed anywhere except on properly prescribed flying-fields. Several transportation companies are already organized for that purpose.

All the above types of aircraft are so designed that pontoons or flying-boats can be substituted for wheels and landing-gear, and so that most aircraft manufacturers can make both. Of course, in most cases the boats and the motors are made by different manufacturers. Several companies, however, construct aeroplanes complete with motors.

Naturally no manufacturing industry can exist without a potential market. Aircraft manufacturers are sure the majority of the twenty thousand flyers and hundred thousand aero mechanics who have learned their trade in the Great War will want to fly either machines of their own or of somebody else or of some transaerial company. The aeronautical engineers have, therefore, designed the sports type for the young fellows who wish to race in the air, travel from country town to country town, from lake to river, or to commute from country to city. Since these machines fly faster than the fastest bird or the fleetest animal, they will afford great sport for gunners. Indeed, the machines have already been used with such disastrous effects upon the bird that many hunters say it is not good sportsmanship to hunt from them. In that case, perhaps, the farmers will hire the daring young aviators to hunt down the crows and hawks with these dragons of the air.

Be that as it may, this sports type is a great convenience for a person who works in a city located on a large lake or on a river and who wishes to live far in the country. Indeed, he may live a hundred miles up or down that body of water and in less than an hour he can fly to or from his work. If it is cold he can put on his electrically heated clothing and keep as warm as in a limousine. If he has engine trouble he can land anywhere and fix his machine and then fly on. Since air resistance is much less than road resistance he can traverse the distance much cheaper than in an inexpensive automobile. If there is no body of water near his place of business he can land his cross-country flier in the park or flying-field just as easily as on the water. This same machine will lend itself to all kinds of pleasure flying, and no other sport gives so much exhilaration, scenic view, and adventuresome excitement as the aeroplane; and the price will be within the means of many young men.

The two-passenger models are being sold to persons of means who have flown or wish to fly and take up friends. After a few years the manufacturers expect there will be a considerable body of these enthusiasts. The greatest sale of these machines, however, will be to the government for the aero mail service. At first two machines will be necessary for every flier in that service, and one in every aerodrome for every one in the air, so with fifty established routes we shall require several hundred machines. Moreover, the manufacturers expect that these machines fitted with either a fuselage or a boat will be employed very extensively by mining companies for carrying precious metals in South America and Alaska. At the present time llamas are used to carry copper down from the Andes. They are so slow and have to descend to the smelters by such devious routes that valuable time is lost in the transportation. By loading the ore into the hold of a flying-boat, which can land on the lakes and ponds in case of engine trouble, the time will be so materially diminished as to reduce the cost of the metal very considerably. Besides, flying in a straight line as the bird flies, at a speed of not less than a hundred miles an hour, will expedite the work of the engineer and the surveyor over the jungles and unexplored and inaccessible portions of South America and Africa, as well as in other distant countries.

The conditions in Alaska are analogous, though the climate is different. Dogs and sleds are now used, and they, too, have to travel roundabout routes from mine to town. Of course, an aeroplane fitted with skids or runners can be landed on snow or ice as easily as on land. It now takes two days to sled gold down from one mine in the Yukon to Nome, which could be brought out in three hours by aeroplanes flying over the tops of the mountains.

At the time this goes to press Captain Robert Bartlett is so convinced of the feasibility of flying in the arctic regions that he plans to try to fly across the north pole in an aeroplane. During the summer months there are plenty of open spaces on which seaplanes can land in the arctic regions, and flying at 100 miles an hour, it would not take many hours to cross the ice-bound region of the pole itself.

Already on the plains of the West and Southwest this type of aeroplane has been found to be more serviceable than the horse in discovering the whereabouts of lost cattle or sheep, because of the range of vision it gives to the shepherd or cowboy and because of its speed and the short distance it covers in reaching its objective.

The big bombing bus type is being built primarily for companies or clubs intending to carry passengers from city to city or for cruises from the club-houses.

General Menoher, director of military aeronautics, has announced that the army will co-operate with the aero mail department in developing municipal aerodromes in thirty-two different cities in the United States, extending from coast to coast and from Canada to Mexico.

Meantime the aircraft manufacturers are contemplating establishing a line of huge flying-boats between New York and Boston, carrying fifty people each way. The distance of two hundred miles could be covered in two hours, or less than half the time taken by train. Only four machines will be used at the beginning, one leaving Boston early in the morning and the other early in the afternoon. Two will leave New York at the same time. Four more will be kept in reserve, and as the traffic increases more will be added. The total investment will not require a million dollars, and the aero mail between the two cities has already set the pace for this passenger line.

The manufacturers also expect that every life-saving station along the entire coast of the United States and its possessions will be equipped with at least one seaplane with which to carry out a life-line to a ship wrecked on the beach or to rescue any one in distress within a hundred miles of the station, because these flying-boats can be launched in any kind of weather and can travel faster than anything that moves on the water.

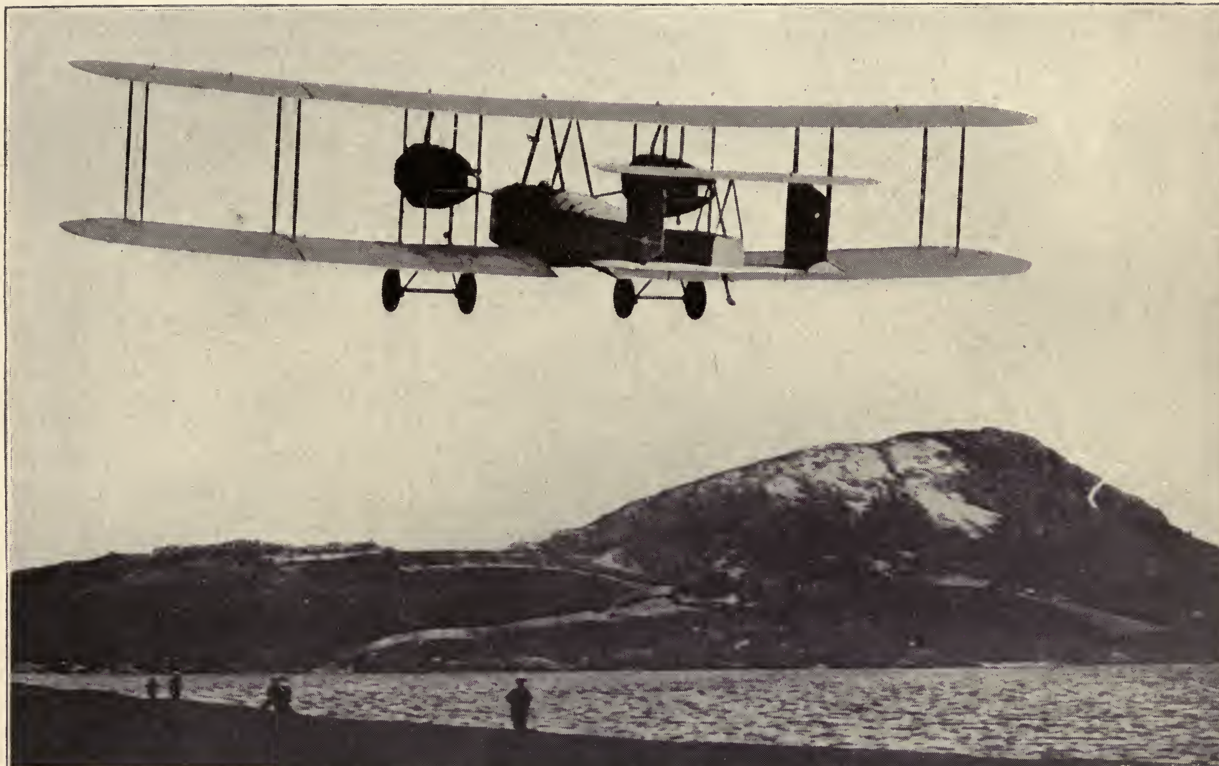
The keenest aeronautic interest at the present time is centred in the aerial crossing of the Atlantic Ocean between America and Europe. Two possible routes are proposed for the flight. Both start from St. John's, Newfoundland, but one stretches from there to Ireland and the other via the Azores to Portugal. The northern route is 1,860 miles from land to land, and the other 1,195 miles to the Flores, which is the nearest one of the Azores. From there to Ponta Delgada to Lisbon is 850 more. The southern route is preferable because the first leg is shortest from land to land. Also, less fog prevails in the south in all seasons of the year. Captain Laureati has already flown in a single-motored machine 920 miles without landing. The United States Naval F-5 flying-boat has flown 1,250 miles. Undoubtedly a flying-boat, equipped with four or more motors, could carry enough gasoline to cover the 1,200 miles on the Atlantic without stopping. Indeed, only half the number of motors need be running at one time if necessary, and since the large bimotored machines make a hundred miles an hour the flight could be negotiated within the twelve hours of daylight in the summer-time.

Just before the war broke out Mr. Glenn Curtiss, the inventor of the flying-boat, was building for Mr. Rodman Wanamaker the seaplane *America* with which

Captain Porte was to try to fly across the Atlantic. The beginnings of hostilities terminated the project. The *America,* however, did cross the Atlantic, but in the hold of another boat, and it performed very good service in British waters chasing Hun submarines.

During the four years that have elapsed since the breaking out of the Great War the construction of aeronautic motors, aeroplanes, and the science of aviation have advanced at least a quarter of a century, so that if the proposition was feasible before the war it ought certainly to be very practicable to-day, as many authorities have testified. The *Daily Mail* prize of $50,000 is still beckoning to the adventurous spirit. The Martinsyde two-seater land-machine and the two-seater Sopwith have already established themselves at St. John's, Newfoundland, to begin the flight to Ireland. The United States Navy NC-1, NC-3, and NC-4 have flown from Rockaway by the southern route to the Azores. Once the first flight is negotiated, the aircraft manufacturers are convinced there will be a greater demand for flying seaplanes than for ocean liners, for they feel sure that most of the people going to and coming from Europe would prefer to travel in that way, and in less than half the time now taken by the fastest ocean greyhounds.

In conclusion, then, it may be safely laid down as an axiom that the conveyance which reduces man's time in travelling from one place on this globe to another will sooner or later be adopted by him. No matter what the discomforts or the dangers or the expense



Courtesy of Flying Magazine.

The Vickers-"Vimy" bomber.

This plane carried Captain J. Alcock and Lieutenant A. W. Brown from Newfoundland to Ireland in 16 hours and 12 minutes.

may be in the beginning, he will eventually find a way to change the inconvenience into the greatest luxuries, the expense will be reduced to within the means of all, and the dangers will be diminished to infinitesimal proportions. It was so in the beginning, it is so now, and it will be so till the end of recorded time. It was so with the recalcitrant camel, the ponderous elephant, the wild horse. It was thus that man transformed the floating log, which he propelled with his feet, into a floating palace, driven thousands of miles across the greatest of oceans. Likewise he metamorphosed the puny stationary steam-engine into a demon that is more powerful than a thousand horses, and that rushes him across the broad spaces of the earth faster than the fastest deer.

Indeed, with the aeroplane, man has already done what was considered for countless ages as the acme of the impossible—he has learned to fly; and in the short space of a decade and a half he has flown faster, farther, and he has performed more convolutions than the noblest birds of prey—yes, it may safely be said that he has made the once marvellous imaginary flight of the magic carpet of the Arabian Nights—when compared with the aerial exploits of the fliers in the Great War—fade into the most diminutive insignificance and the tamest fiction.

Before long then we may reasonably expect that all the capitals of the world will be connected by air lines. Already regular landing-places have been established from London via Paris, Rome, and Constantinople to

Bagdad and Cairo. Peking and Tokio will next be added. The flight from London to New York will also soon be an accomplished fact. Then all the capitals of Central and South America will be joined up. The distance from South America to Africa is about the same as that between America and Europe. By reducing the time of travel between all those places to hours the aeroplane will make mountains dwindle into ant-hills, rivers to creeks, lakes to mud-holes, and oceans and seas to ponds. The globe will be aerially circumnavigated. Tokio and Peking will be as accessible to New York as London now is, and vice versa. Then there will be no east or west and with the new aerial age will come a new internationalism founded on speedy intercommunication and good-will toward all mankind.

Courtesy of Aerial Age Weekly.

The C-5 leaving its hangar at Montauk Point en route to accompany the NC's on their trans-Atlantic flight.

After reaching the vicinity of Halifax the "Blimp" broke away from her moorings and was blown out to sea. The Blimps are equipped with one Hispano-Suiza motor. They measure 200 feet.

CHAPTER XIII

THE COMMERCIAL ZEPPELIN

THE AMBITION OF THE AGES REALIZED—A GIANT GERMAN DIRIGIBLE—ZEPPELIN ACCOMPLISHMENTS—HIGH COST OF ZEPPELINS—SAFETY OF TRAVEL—SOME BRITISH PREDICTIONS—THE FUTURE OF HELIUM—THE LIFE-BLOOD OF COMMERCE

ALMOST daily during the winter of 1918–1919 reports were coming out of Europe to the effect that Zeppelins were being converted into aerial merchantmen to fly regularly between New York and Hamburg.

Because these gigantic lighter-than-air machines, measuring more than 700 feet in length, 70 feet in diameter, buoyed up by more than 2,000,000 cubic feet of hydrogen gas, and driven by six Maybach-Mercedes engines, generating a total of 1,400 horsepower, had carried, in all kinds of weather and under adverse circumstances of war, a crew of forty-eight men and a useful load of four tons from Germany over the British fleet and the North Sea and the anti-aircraft guns and by hostile fleets of Allied aeroplanes, and had successfully raided England and Scotland more than a score of times, returning safely to their home ports, often having flown a total distance of approximately 800 miles—the eyes of the aeronautical world, like search-lights in the night, were sweeping the heavens over the Atlantic seaboard to discover whether these leviathans of the air or the little dragon-flies of aeroplanes were to be the first to appear in the firmament, aerially transnavigating the 1,195 miles of water that separates the Old World from the New.

Indeed, ever since man has learned to fly he has become such an exalted creature that he has ceased to regard any mechanical feat as impossible. This is, in a measure at least, pardonable when we stop to consider that ever since man got up off his hands and learned to walk upright he has longed to be able to fly as a bird through the heavens in any direction he chose, without let or hindrance, boundary or border. Though he expended every effort to accomplish this feat, and often lost his life in the attempt, for countless ages the privilege to soar aloft was denied him.

In point of time it was, as we have seen, September, 1783, before the Montgolfier brothers succeeded in sending up even a paper bag inflated with hot air, and it was November of the same year before two Frenchmen, the Marquis d'Arlandes and Pilâtre de Roziers, made the world's first trip in any kind of aerial vehicle—namely, a free balloon.

But these and most of the attempts to navigate the air in the next century were unsuccessful, primarily due to the lack of power adaptable to propelling a gas-bag through the air. In 1852 Henri Gifford, another Frenchman, made the first successful directed flight in a dirigible 143 feet long and 39 feet in diameter. It was inflated with hydrogen and driven by a three-horse-power steam-engine, an eleven-foot screw propeller, and it made six miles an hour relative to the wind. Owing to the fuel, fire, and weight problems the steam-engine was then impractical as a means of propulsion for lighter-than-air machines.

In 1884 Captain Charles Renard went a step farther in the right direction by installing a 200-pound electric motor, generating nine horse-power. The battery, composed of chlorochromic salts, delivered one shaft horse-power for each eighty-eight pounds of weight, but in spite of such a handicap he flew over Paris at fourteen and a half miles an hour. Nevertheless, the electric motor was also impractical, even for a rigid dirigible. As a matter of fact, every gas-bag was at the mercy of the winds, and could not steer a direct course, until the gasoline motor was invented and developed to generate more than a dozen horse-power.

The first man to build a rigid dirigible with an aluminum framework and drive it with a gasoline motor was an Austrian named Schwartz, but the first man to build, equip, and perform the necessary evolutions with a rigid dirigible was Santos-Dumont, the famous Brazilian. He accomplished this feat in September, 1898, when he set out from the Zoological Gardens at Paris and in the face of a gentle wind steered his airship in nearly every point of the compass. In 1901 he circumnavigated the Eiffel Tower, thus demonstrating the feasibility of the lighter-than-air ship as a practical means of locomotion through the air.

The world's first successful flight in a man-carrying heavier-than-air machine, made by the Wright brothers two years later at Kitty Hawk, North Carolina, only went further to confirm man's belief that the conquest of the air and the age of aerial navigation were at hand.

Since then in a heavier-than-air machine man has climbed to 30,500 feet and has flown 920 miles without stopping. In a free balloon man has drifted 1,503 miles through the air—from Paris to Kharkoff, Russia—and to an altitude of over 38,000 feet. In a rigid dirigible the Germans have transported machinery for making munitions all the way from Austria-Hungary over Bulgaria—while that country was still neutral—to Constantinople, a distance of 500 miles; within a radius of 350 miles of Germany, despite all military and naval opposition on land and sea, the Huns have flown with tons of high explosives and dropped them on London, Paris, and Bucharest. In the last days of the war a super-Zeppelin flew from Jamboli, in Bulgaria, to Khartum, in Egypt, and back, a distance of more than 6,000 miles each way, carrying a crew of twenty-two men and twenty-five tons of medicine and munitions. It was intended to transport the supplies to General Lettow-Vorbeck in German East Africa, but a wireless received when the Zeppelin was over Khartum notified its commander to return, for Lettow-Vorbeck had been captured.

On March 22, 1919, the British Government officially announced that the US-11, a non-rigid type of dirigible, had flown 1,285 miles over the North Sea without stopping, the actual flying time being forty and a half hours. The voyage took the form of a circuit, embracing the coast of Denmark, Schleswig-Holstein, Heligoland, North Germany, and Holland.

The trip was characterized by extremely unfavorable weather, and therefore is regarded as ranking as perhaps the most notable flight of the kind ever undertaken. The airship started from the Firth of Forth, laying a straight course toward Denmark. There was a northwest wind of fifteen to twenty miles an hour, and the night was dark, but the airship was only a mile from her course when she passed the Dogger Bank Lighthouse. After passing the lighthouse the velocity of the wind increased, and calcium flares were dropped into the sea frequently to determine the location.

The airship's troubles began on the return journey. The wind became stronger and more tempestuous. At midnight one engine became useless and the ship was forced a considerable distance to leeward.

The captain contemplated landing in France, but finally decided to hold on in the hope that the wind would abate. The wind abating somewhat, a "land fall" was made at North Forel. At this time the gasoline supply was running low.

In two radically different types of flying-machines man has in the last decade aerially transnavigated great natural and geographic barriers in the form of the Alps, the Pyrenees, and the Taurus Mountains, and the North, the Baltic, the Adriatic, and the Mediterranean Seas. He has made these flights in all kinds of winds, weather, and atmospheric and polemic conditions.

At last he has ascended higher than the lark and flown faster than the eagle and farther than the mightiest bird of prey. Small wonder then that he should consider the flight across the Atlantic by either the aeroplane or the Zeppelin as nothing but a question of time.

As a matter of fact, man does not doubt that eventually not only the Atlantic, the Pacific, and the Seven Seas, but even the globe itself will be aerially transnavigated. His only concern is how soon these feats will be accomplished facts.

Several preparations—but only one real attempt—to fly across the Atlantic had been made up to January, 1919. The first effort to cross the ocean from America to Europe by air was made by Walter Wellman and a crew of five men in the dirigible *America* on October 15, 1910. The airship measured 228 feet in length and 52 feet in diameter, with a lifting capacity of twelve tons. The envelope carrying the gas weighed approximately two tons. Attached to the bag was a car 156 feet long. The nine thousand pounds of gasoline necessary for the trip were stored under the floor of the car. The *America* carried three eighty horse-power gasoline engines, one of which was a donkey, the two others being used to drive the propellers. Beneath the car hung a 27-foot lifeboat that was to be used in case they had to abandon the airship. A 330-foot equilibrator, consisting of a long steel cable on which were strung thirty spool-like steel tanks each carrying 75 pounds of gasoline, and forty wooden blocks, trailed from the cabin. The blocks were about twenty inches long.

The object of the equilibrator was to eliminate ballast. It was intended that the balloon should sail along at a height of about two hundred feet; if it settled close to the water the wooden blocks and the tanks would float on the water and relieve it of some of its weight. The *America* was also equipped with sextants, compasses, and other instruments for locating its position, the same as an ocean-liner.

Besides Walter Wellman, the explorer and writer, were Melvin Vaniman, chief engineer; F. Murray Vaniman, navigator of airships; J. K. Irwin, wireless operator; Albert L. Loud and John Aubert, assistant engineers.

They left Atlantic City in a dead calm and were towed out to sea by a motor-boat. Three days later, on October 18, after many vicissitudes the engines broke down and the huge gas-bag was at the mercy of the winds. Wellman and his crew were picked up by the steamer *Trent* 375 miles east of Cape Hatteras. The dirigible had been carried out of its course because of insufficient power to navigate against the winds and had to be abandoned, a total loss.

A year later, financed by the Chamber of Commerce of Akron, Ohio, and one of the large rubber companies, a balloon called the *Akron*, 268 feet long and 47 feet in diameter, with a gas capacity of 350,000 cubic feet, was built to be flown across the Atlantic by Melvin Vaniman. It had two 105 horse-power engines.

Unfortunately, on July 2, 1912, while making a trial flight over Absecon Inlet, near Atlantic City, the balloon took fire and exploded, killing Melvin Vaniman and the four members of his crew. This disaster put an end to building dirigibles in this country for transatlantic flight.

The preparation for another attempt to cross the Atlantic was made by Glenn H. Curtiss through the generosity of Rodman Wanamaker, who financed the building of the flying-boat *America*. Owing to the breaking out of the war this project was abandoned.

Neither of these two American-built lighter-than-air ships could be compared in size, engine power, lifting capacity, or flying radius with the dirigibles constructed by the German Government and people under the direction of Count Ferdinand von Zeppelin. Indeed, his first airship, constructed in 1900, measured 410 feet and contained 400,000 cubic feet of hydrogen, whereas the super-Zeppelins were many times larger than either Wellman's or Vaniman's airship.

A description of the giant dirigible brought down in the summer of 1916 in Essex, England, will give an excellent idea of the gigantic proportions, the buoyancy, the engine power, and the accommodations of these leviathans of the air.

The airship measured 650 feet to 680 feet in length and 72 feet in diameter. The vessel was of cigar-shaped stream-line form, with a blunt rounded nose and a tail that tapered off to a sharp point. The framework was made of longitudinal latticework girders, connected together at intervals by circumferential latticework tires, all made of aluminum alloy resembling duraluminum. The whole was braced and stiffened by a system of wires. The weight of the framework was about nine tons, or barely a fifth of the total of fifty tons attributed to the airship complete with engines, fuel, guns, and crew. There were twenty-four balloonets arranged within the framework, and the hydrogen capacity was 2,000,000 cubic feet.

A cat walk—an arched passage with a footway nine inches wide—running along the keel enabled the crew, which consisted of twenty-two men, to move about the ship and get from one gondola to another. The gondolas, made of aluminum alloy, were four in number: one was placed forward on the centre line; two were amidships, one on each side, and the fourth was aft, again on the centre line.

The vessel was propelled at 60 miles an hour in still air—by means of six Maybach-Mercedes gasoline engines of 240 horse-power each, or 1,440 horse-power in all. Each had six vertical cylinders with overhead valves and water cooling, and weighed about a thousand pounds. They were connected each to a propeller shaft and also to a dynamo used either in lighting or for furnishing power to the wireless installation. One of these engines with its propeller was placed at the back of the large forward gondola; two were in the amidships gondolas, and three were in the after gondola. In the last case one of the propellers was in the centre line of the ship, and the shafts of the two others were stayed out, one on either side. The gasoline-tanks had a capacity of two thousand gallons, and the propeller shafts were carried in ball bearings.

Forward of the engine-room of the front gondola, but separated from it by a small air space, was first the wireless-operator's cabin and then the commander's room. The latter was the navigating platform, and in it were concentrated the controls of the elevators and rudder at the stern, the arrangement for equalizing the levels in the gasoline and water tanks, the engine-room telegraphs, and the switchboards of electrical gear for releasing the bombs. Nine machine-guns were carried. Two of these, of half-inch bore, were mounted on the top of the vessel, and six of small caliber were placed in the gondolas—two in the forward, one each in the amidships ones, and two in the aft one. The ninth was carried in the tail.

The separate gas-bags were a decided advantage over the free balloon and earlier airships, which carried all the gas in one compartment; for if the latter sprung a leak for any reason it had to descend, whereas the Zeppelin could keep afloat with several of the separate compartments in a complete state of collapse.

Since the Zeppelin, like all airships, is buoyed up by hydrogen gas—which weighs one and one-tenth pounds per two hundred cubic feet as compared with sixteen pounds which the same amount of air weighs—the dirigible is sent up by the simple expedient of increasing the volume of gas in the envelopes until the vessel rises. This was done by releasing the gas for storage-tanks into the gas-bags. In order to head the nose up, air was kept in certain of the rear bags, thus making the tail heavier than the forward part, which naturally rose first. Steering was done by means of rudder or the engines, or both, and the airship was kept on an even keel by use of lateral planes. The airship could be brought down by forcing the gas out of the bags into the gas-tanks, thus decreasing the volume, and by increasing the air in the various compartments.

This airship had a flying radius of 800 miles, could climb to 12,000 feet, could carry a useful load of 30 tons, and could remain in the air for 50 hours.

Because so many Zeppelins were lost to Germany and because so much time and money were necessary to construct the enormous airships, many people have jumped to the conclusion that the rigid dirigible was an absolute failure even as an offensive war weapon. Yet despite its bulk and the fact that it could not fly faster than seventy miles an hour, and though more than a hundred Zeppelins raided England at some time or another during the war, only two were shot down by aeroplanes and only a few by antiaircraft guns. Most of them were destroyed because they ran out of fuel and consequently became unmanageable and were blown out of their course and forced to land or had to descend so low that they came within easy range of aircraft guns of the land batteries or the naval guns.

This record is truly surprising when we stop to consider that the Zeppelin had to navigate entirely by compass and mostly at night over hundreds of miles of hostile sea and land, opposed by the guns of a huge Allied fleet and thousands of antiaircraft guns, without lights or landmarks to aid them and often with untrained and inexperienced pilots to guide them! No wonder that some of these airships met disaster—like the L-49, which had to land in France; or the L-20, which was forced to land on the Norwegian coast near Stavanger; or others, which came down so low over the North Sea that they became easy targets for the British torpedo-boat guns.

But this is judging the Zeppelins purely as offensive weapons of war. Even as such they forced the British Empire to maintain a large standing army and a huge armament of guns and aeroplanes in England by threatening to land a mammoth army of invasion there from Belgium. What they did to spread terror in Belgium and to keep the German army informed by wireless of the conditions behind the British and French and Belgian lines in the first advance to the Marne is a matter of history. Also what they performed in disorganizing the armies and in disconcerting the people of Antwerp and Bucharest, not to mention many Russian cities and Paris itself, during the Hun advance against those cities, is almost too horrible to relate. Over the Rumanian capital alone they descended so low—because there were no antiaircraft guns to defend the city—that they scarcely flew clear of the buildings as they rained down hundreds of tons of high explosives on the frightened inhabitants, and even bombed a part of the imperial palace, where the Queen was nursing the Crown Prince.

This unlawful use of these giant aircraft does not detract from what they demonstrated could be done in the way of aerial navigation and transportation under the frightful opposition of war, and it is only an augury of what will be accomplished when the same vessels of the air will be put to carrying man up and down the aerial highways of the heavens, which know no barriers, obstructions, or hostile opposition.

Their greatest service to the Germans was as aerial scouts rather than as ethereal battleships or cruisers; and if these rigid dirigibles had performed no other feats for the Huns, from the Teutonic point of view at least, their work in planning and directing every move of the German high-seas fleet in the great naval battle off Jutland amply repaid Germany for the time and money and effort expended in building those air cruisers.

On May 30 in the first stage of that battle it will be recalled that Admiral Sir David Beatty was cruising with his scout fleet looking for the Germans several hundred miles east of the British grand fleet, which was under Admiral Sir John Jellicoe, somewhere off the Orkney Islands. Flying out under the protection of a fog-bank that was moving down over the North Sea a German naval Zeppelin discovered the isolated position of Admiral Beatty's scout fleet and sent a wireless message to the German high-seas fleet, which came out under Admiral Von Scheer with the sole object of cutting off and destroying Admiral Beatty's fleet before it could unite with the British grand fleet. Undoubtedly, had it not been for a seaplane launched from the mother ship *Engadine* and flown by Flight Lieutenant Frederick J. Rutland, who discovered the entire German navy coming out, the British scout fleet might have been cut off and completely destroyed before Admiral Jellicoe could come to the rescue.

In the meantime another Zeppelin was hovering over the British grand fleet far to the north and was keeping the German Admiral Von Scheer fully informed by wireless of every ship in the squadron. It was this Zeppelin which finally warned the German admiral to return to the protection of secure fortresses and defenses of the great German naval base of Helgoland. By thus saving the Hun fleet from annihilation in this naval encounter it was possible for the Germans to hold a complete, continuous, and dangerous threat that their navy might again come out to attack England or France and cut off English troops from the Continent. This possibility alone compelled the Allies to maintain, until the close of the war, an enormous fleet at all times in the North Sea.

There is no gainsaying that in time of war the aeroplane has many advantages over the Zeppelin. The heavier-than-air machine can be produced in quantity much more readily than the lighter-than-air craft. Exact figures on the cost of Zeppelins are not available. W. L. Marsh, in the British publication *Aeronautics,* gives half a million dollars as the estimated cost of a superdirigible of sixty tons, having a lift of thirty-eight tons. This high cost is due, among other things, to the enormous building in which the airship must be constructed, for it must be borne in mind that one of these dinosaurs of the air extends its bulk along the ground farther than the Woolworth Building towers in the air. Indeed, it could not descend in an ordinary city street because of its bulk, and if it did it would extend more than three city blocks of two hundred feet frontage! Moreover, the plant necessary to generate the hydrogen gas sufficient to inflate a bag of two million cubic feet capacity would cost fifty thousand dollars alone. The amount of aluminum in the L-49, forced to land in France in the spring of 1918, would make a foot-bridge over the East River as long as the famous Brooklyn Bridge!

To land and house such an elusive and buoyant monster requires many winches and some two hundred men. Even then some have been known to run away. This happened in the winter of 1907, when the *Patrie,* a French semirigid dirigible, which was only a third as large as the German super-Zeppelins, was caught in a gale of wind near Verdun and in spite of the two hundred soldiers who held her in leash she broke her moorings and, flying over France, England, Wales, Ireland, shedding a few fragments on the way, finally disappeared into the sky above the North Atlantic.

On the other hand, a six-ton aeroplane can carry a useful load of two tons and does not cost more than $50,000. Also the wing spread of 150 feet of the largest aeroplane is small compared to a 700-foot Zeppelin. Consequently, aeroplanes can be more readily produced in quantity, can be housed, and require only a half-dozen men to take care of them.

Because of the small size of the scout machine—with only a 26-foot wing spread—and its speed of more than a hundred miles an hour—compared to the Zeppelin speed of 60 or 70 miles—the aeroplane was invaluable for scouting over short distances, for duels in the air, for directing artillery-fire, for contact patrol; and the larger aeroplanes were useful for bombing in huge fleets.

In all other purposes of war the Zeppelin is far superior to the aeroplane. Even the contention that the aeroplanes stopped the Zeppelin raids on England is absurd. It is true that two Zeppelins were brought down over England by aeroplane, but it was September 3, 1916, two years after the breaking out of the war, when young Leefe Robinson brought down the first Hun dirigible over London. It was June 3, 1915, when a Canadian sublieutenant, R. A. J. Warneford, flying a Morane monoplane for the Royal Naval Air Service, got above a dirigible returning to its aerodrome in Belgium from a raid on England and dropped a bomb upon the gigantic gas-bag, blowing it up and killing the crew; but before that came to pass thirteen Zeppelin raids had already been visited upon England, 408 bombs had been dropped, twenty-one persons had been killed and a thousand injured. In both this case and in the case of Lieutenant Robinson, more than a year later, the aeroplanes happened to be in the air above the Zeppelins before they came along, and the aeroplanes in both instances were blown completely upside down by the force of the explosion. Needless to say, a moment later Lieutenant Robinson looped the loop for joy when he saw what destruction he had wrought.

In other words, because the Zeppelins could put out their lights, shut off their motors, and drift through clouds unheard in the night at two thousand feet altitude, and because the dropping of the bombs, like the throwing out of ballast, allowed the dirigibles to jump suddenly up to much higher altitudes, they were as a rule far too elusive for the aeroplanes to get near enough even to shoot incendiary bullets into them.

In point of flying comforts and safety, time that can be spent in the air, flying distances and useful load carried, the Zeppelin is far in advance of any kind of heavier-than-air machine ever built.

Before the war the passenger-carrying Zeppelins *Schwaben* and *Victoria Louise* were equipped with cabins for the accommodation of twenty-four passengers and crew. Meals were served à la carte; two rows of easy-chairs were arranged before the windows, with a passageway between; and there was a wash-room with water-faucets; which will give an idea of the completeness of the appointments for the comfort of passengers. In the super-Zeppelins constructed since then, and now being fitted to fly the Atlantic, there is ample room for a promenade of four to five hundred feet in the keel. Moreover, there is even a greater opportunity for the giant sky-liners to provide luxurious cabins and other comforts for the travellers, such as of course cannot possibly be supplied on a heavier-than-air machine, where even the chief engineer cannot so much as leave his seat to examine the engine once the machine is in flight!

The ability of the airship to cruise at low heights is another comfort the dirigible enjoys over the aeroplane, which, to insure a safe landing in event of engine trouble, usually navigates across country at five thousand feet altitude or more. The most pleasurable height for air cruising is between five hundred and one thousand feet, for from there the perspective of the countryside is not too diminutive.

As regards the safety of travel in lighter-than-air machines, naturally there have been several disasters such as are inevitable in perfecting a new science. The disasters that occur in the air are closely analogous to those of the sea. The greatest dangers to the airship are the wind, storms, and fire. Of these the last is the most dangerous, because hydrogen gas is so highly explosive. That was what caused the destruction of the *Akron*, with Vaniman and his companions. What caused the explosion that annihilated the crew of twenty-five of the L-11 in September, 1913, is not known. Perhaps the absorption of the rays of the sun caused the gas to expand, bursting the gas-bags. Glossed surfaces now deflect the rays and help to avoid that danger.

The extraordinary point in the long experimentation with Zeppelins was the immunity of the actual crews of the airships from death, until the thirteenth year of the Zeppelin's existence. Despite the ever-recurring accidents and the frequent loss of life and serious injury among landing parties and the workshop hands, not a single fatality occurred to any of the navigators until September, 1913, when naval Zeppelin L-1, which was actually the fourteenth Zeppelin to be constructed, was wrecked in the North Sea by a squall, her crew of thirteen being drowned.

Most of the minor accidents to Zeppelins were due to poor landings and high winds. At first this was not to be avoided, because of the huge bulk of these air-liners and their great buoyancy and the ease with which the wind could blow them against their moorings. With experience, though, this was eliminated. Indeed, the officers of the passenger-carrying *Schwaben* never bothered about the weather, and went out when aeroplanes would not dare go up. The *Parseval VI* made 224 trips about Berlin within two years' time, remained in the air a total of 342 hours, carried 2,286 passengers, and travelled a distance of 15,000 miles.

To compare this record with the long list of those who have lost their lives in aeroplane flying and experimentation is impossible and of no avail. The radical differences of construction make it much easier for the balloon to avoid disaster than the aeroplane.

Whenever a wing breaks on an aeroplane or whenever the engine on a single-motored machine stops, the aeroplane must fall down or glide to a landing. These defects will undoubtedly be greatly overcome with standardized construction of aircraft and the establishment of proper landing-fields. The hazard, nevertheless, will always be there in some degree.

Such an accident is not frequent with a lighter-than-air machine, which does not depend on its motor but upon gas to keep it afloat. Indeed, an airship may drift hundreds of miles with the wind with all its motors completely shut off—which, by the way, is another reason why the transatlantic flight with the air-currents, which move from America to Europe, seems to be a very feasible possibility for the lighter-than-air craft. The conservation of fuel under such a condition is tremendous.

"It is unquestionably her long endurance and great weight-carrying capacity which gives the airship her chief advantage over the aeroplane," says W. L. Marsh, the eminent authority on dirigibles previously referred to. "It will no doubt be conceded that in spite of the stimulus of war the airship is little further advanced in development than the aeroplane was at the beginning of 1915; and already airships have visited this country"—England—"which could with ease

Courtesy of Flying Magazine.

The R-34, the British rigid dirigible.

The R-34 flew from East Fortune, Scotland, to Mineola, New York, a distance of 3,300 miles, in 108 hours and 10 minutes, and returned to Pulham, Norfolk, England, in 75 hours and 3 minutes, non-stop flight.

fly from England to America, carrying a considerable load of merchandise. A present-day Zeppelin has a gross lift of sixty-five tons, of which some 58 per cent is available for crew, fuel, ballast, merchandise, and so on. If we take the distance across the Atlantic in a direct line as two thousand miles we get the following disposition of our load of thirty-eight tons:

	TONS
Crew of 30	2.3
Ballast	2.0
Gasoline	12.0
Oil	2.0
Extras [food, and so on]	1.0
Total [say, 20 tons]	19.3

"This leaves eighteen tons available for freight. These figures are based on the ship maintaining a constant speed of fifty miles an hour, at which she would do the journey in forty hours, consuming 650 pounds of gasoline an hour.

"This represents what a rigid airship of slightly over capacity can do to-day, and is given as an indication of what is possible in a comparatively early stage of development.

"No one who has considered rigid airship design and studied rapid strides which aeroplanes have made in the last three and a half years can doubt for a moment that an airship could be built in the course of the next two years which would have a disposal lift—

or, in aeroplane parlance, a 'useful load'—of over two hundred tons, giving it an endurance of anything up to three weeks at a speed of forty to forty-five miles an hour.

"I am endeavoring to state the case as moderately as possible, and am therefore purposely putting the speed at a low figure. I believe I am correct in estimating the full speed of a modern Zeppelin at seventy-five miles an hour. I shall not be too optimistic in claiming eighty miles as a conservative figure for the future. There is little doubt that a ship of some 800,000 cubic feet should be able to carry twenty or thirty passengers, having a full speed of about seventy miles an hour, which it could maintain for two days or more, the endurance at forty-five miles an hour being probably in the neighborhood of five or six days. This ship would be able to cross the Atlantic. A present-day Zeppelin could carry some eighteen tons of freight across to America, and the really big ship—it must be remembered that up to the present we have been talking of lighter-than-air midgets—could transport at least 150 tons the same distance."

But Mr. Marsh is not the only British authority on aerodynamics who has gone on record as to the practicability of transnavigation of the Atlantic. The British Aerial Transport Committee, consisting of some of the most representative men of Great Britain, such as G. Holt-Thomas, Tom Sopwith, H. G. Wells, Brigadier-General Brancker, Lord Montagu of Beaulieu and Lord Northcliffe—to mention only a few—in its report of November, 1918, to the Air Council of the British Parliament, says:

"Airships now exist with a range of more than 4,000 miles, and they can travel at a speed of 78 miles an hour. By running their engines slower a maximum range of 8,000 miles can be obtained. On first speed Cape Town, South Africa, is to-day aerially only a little more than three days from Southampton. This ship could fly across the Atlantic and return without stopping. The committee points out that the airship will soon develop a speed of 100 miles an hour, that it will be fitted with ample saloons, staterooms, an elevator to a roof-garden, and it will be able to remain in the air for more than a week."

Mr. Ed. M. Thierry, Berlin correspondent of the N. E. A., under date of December, 1918, says: "I recently visited the immense works outside Berlin at Staaken. The new super-Zeppelin which is now building has a gas capacity of 100,000 cubic metres. It will have nine engines and eight propellers. This transatlantic Zeppelin is 800 feet in length. It will cost nearly $1,000,000, and it will have a carrying capacity of 100 passengers and forty-five tons of mail and baggage, and thirty tons of petrol, oil, and water and provisions. The first machine for the transatlantic service is to be completed in July, 1919. For maintenance of the service planned, eight active machines and four reserved will be required. As soon as the international situation is clarified it is proposed to establish the service with a hangar in New York."

Major Thomas S. Baldwin, U. S. A. C., considered one of the best authorities in regard to balloons and dirigibles in the United States, said that the Germans had constructed aircraft that could stay in the air for two weeks and could make upward of 75 miles an hour. Major Baldwin stated that the relatively small American Blimps were capable of 60 miles an hour. Only recently one of these flew from Akron, Ohio, to New York without stopping, a distance of more than 300 miles, and the Naval NC-1 flew from New York to Pensacola, Florida, a distance of over 1,000 miles, stopping at Norfolk, Virginia, and Savannah, Georgia.

On December 12 an interesting experiment of launching a plane from a dirigible was conducted at Rockaway Beach, New York. The dirigible rose about one hundred feet above the sand-field near Fort Tilden. An aeroplane was attached to the roof. After discharging ballast and starting the motor the dirigible ascended to three thousand feet and released the aeroplane, which dived about one thousand feet and then flew off to Mineola. Lieutenant George Crompton, Naval Flying Corps, piloted the dirigible, assisted by J. L. Nichols and G. Cooper. The plane was piloted by A. W. Redfield.

In the flight of the British naval dirigible R-23 over the North Sea, in April, 1919, the aeroplane was hung suspended from the keel amidships and launched when near the British coast.

The above experiment is cited only as an indication of what the possibilities are of combining the aeroplane with the dirigible in landing mail or express from dirigibles crossing the Atlantic. Undoubtedly aeroplanes weighing only a thousand pounds, with a flying radius of 600 miles and making 150 miles an hour, will be launched from superdirigibles 500 miles from the journey's end, especially when airships are to be constructed with 10,000,000 cubic feet of gas, with a 60 per cent gross lift for crew, fuel, freight, and so on, as Mr. Marsh says is quite possible in the immediate future.

Experiments for launching aeroplanes from ocean-liners for a like purpose are already under way. The object is to fly the mail for London or New York from the ocean greyhounds as soon as they get within five hundred miles of either coast. This will, of course, cut the flight time from New York to London considerably. As a matter of fact the dirigible might fly over only the great expanse of water from land's end to land's end, while the aeroplanes negotiated the remainder of the distance. It is granted that for short flights over land the aeroplane is twice as fast as the Zeppelin, whereas the latter, because it can stay in the air for weeks, is the best adapted for long cruises over large bodies of water. Moreover, the removal of the weight of an aeroplane from a dirigible six hundred miles from its journey's end would facilitate the remaining flight of the Zeppelin by just so much; it would be equivalent to throwing out ballast to keep a balloon in the air.

Perhaps of all the revolutionary scientific developments of the Great War—especially in the field of chemistry—the one that may perform the greatest service to mankind is the steps taken by the Bureau of Mines to produce helium, the non-inflammable gas which has 92 per cent of the lifting power of hydrogen, in sufficient quantities to be used in floating airships!

A non-inflammable gas with such a lifting capacity as helium has been the dream of the aeronaut and the dirigible engineer ever since the Robert brothers first conducted their experiments in France in 1784 and found that hydrogen had greater buoyancy than any other gas available in large quantities for balloons; for with it they could jump over the highest peaks of the Himalaya Mountains and the broadest expanses of the Pacific Ocean without danger of the gas igniting from the sun or the engine.

It will be recalled that we pointed out that the greatest danger to people riding in dirigibles was the possibility of heat expanding and exploding the hydrogen gas. One of the first airships to experience this fate simply passed through a cloud into the hot sun, whose rays expanded and exploded the gas, blowing the airship and its crew into smithereens before they could open the gauges and release the pressure. The same thing may have caused the explosion of the German dirigible L-2, which killed its crew of twenty-five; and the American airship *Akron,* which blew up, destroying Vaniman and his companions. The substitution of helium entirely eliminates that danger and makes it possible to carry heating devices for the comfort of passengers in high altitudes where it is so cold.

Of course, the lifting power of helium was known to students of aerostatics before the war, but the mechanical difficulties and cost involved in producing this gas on an industrial basis were so great that it would hardly pay to produce it for commercial purposes. Indeed, the largest amount of helium in any one container up to the beginning of 1918 was five cubic feet, and it cost between fifteen hundred and six thousand dollars, whereas under the new system it is expected that one thousand cubic feet can be produced for one hundred dollars!

In war, however, cost is nothing—results are everything. As there was a possibility that helium might be one of the chief factors in winning the war, the joint Army and Navy Board on Rigid Airships in August, 1917, provided the Bureau of Mines with the requisite funds to do the necessary experiment work.

This, however, is not the time or the place to go into a detailed description of this wonderful gas or how it was obtained, further than to state that apparatus had to be designed on entirely new lines for the liquefaction of nitrogen into natural gases, at temperatures as low as -317 degrees Fahrenheit; that the natural gas of Kansas, Oklahoma, Texas, and Ontario contains 1 per cent of helium; that a $900,000 building was constructed for the Navy Department at Fort Worth, Texas, and a ten-inch pipe-line ninety-four miles long was laid, at a cost of more than a million dollars, from the wells at Petrolia, Texas, for supplying the plant with natural gas; and that the first production of it was in operation April 1, 1918.

Within a comparatively short time, then, we ought to see many companies organized in this country for aerial transnavigation of the globe by helium airship! Before the year 1919 has come to a close we ought to see aeroplanes and dirigibles jumping the Atlantic from shore to shore. Who knows, it may even come to pass that man shall become as much a creature of the air as the birds! As a world of exploration and travel the heavens offer him many adventures. It presents to him the shortest distance and the line of least resistance between any two given points on this planet. By the aircraft he has already designed he has penetrated to a height of 38,000 feet and flown a thousand miles in a straight line without stopping.

Is there any reason to doubt that in a very short time man will extend the capacity of these airships or the distance they can travel? The monetary and laudatory incentives are there. For affording to his fellow man and his chattels faster transportation, man's reward has been great and commensurate with his success. In order to win that remuneration he has enslaved and domesticated the beasts of the fields; he has harnessed the river and the streams; he has sought out the secrets of nature and devised ways and means to make her hidden forces transport him up and down the highways and byways of the globe; for that reward he has invented machines and engines to rush him over the land and across the seven seas at an ever-increasing rate. When mountains have raised their ponderous bulk between him and his objective he has climbed over them or tunnelled under them or cut them down; when rivers, lakes, or oceans have intervened he has spanned them by bridges or boats; when isthmus or even continents have injected their lengths between him and his markets he has cut them asunder that his ships might pass through.

In short, transportation is the life-blood of commerce, and by it and through it the perishable fruits of India, Africa, and America are carried from the tropics to the remotest corners of the frigid zone; likewise the foods or minerals or other materials confined by nature to the temperate zone are taken to the balmy tropics. In fact, every instrument and every force in nature is enslaved so that man may enjoy all the blessings of the earth at one time and in one place. Taken all in all, the speed of transportation has increased man's pleasures and years proportionately.

But how many people to-day realize that when aerial transportation of passengers and freight has become an actual accomplished fact in the sense that water and land transportation of man and his goods now is, a complete redistribution and reconcentration of the cities, people, and nations and a new internationalism in the form of customs and language will have become a historic fact! This statement may seem like an absurd phantasy, but if history repeats itself in the future as it has in the past this will take place as surely as the sun rises.

Ever since man transported his goods from one place to another he has followed the lines of least resistance and the greatest speed. For that reason rivers were his first natural highway. At the stopping-places along these routes and waterways he built for himself villages, towns, and cities. The biggest of these, however, have always been located at some favorable terminus or harbor. Nineveh, Babylon, Carthage, and Tyre were ancient cities that grew and flourished because they were either the termini or the harbors of advantageous trade routes or excellent stopping-places on great waterways. With the change in the rivers of commerce those cities decayed and passed away.

The rise of such cities as Venice and Genoa in the Middle Ages, when they afforded the best ports for the sailing-vessels that connected the caravan routes which came across Asia from the East for their distribution of goods to Europe and the West, was due to the same cause. With the changing of those routes those cities lost their importance and prestige and became what they are to-day.

At the present time most of the largest cities of the world are located near inviting harbors or in river-mouths where the great ships of commerce come and go and find refuge. London, Liverpool, New York, Hamburg, Philadelphia, San Francisco, Calcutta, Bombay, Havana, Buenos Aires—to mention only a very few—depend primarily upon their strategic geographic position for their business and their very life.

If in time, then, the nearest points of land between continents and countries become the great landing-places for the new passenger and freight ships of the air, it is quite conceivable that the great centres of population and commerce may grow up themselves round those havens.

Moreover, if, as the British Civil Aerial Transport Committee and most of the world's aeronautical authorities are convinced, Cape Town, South Africa—to take but one example—is only three days' flight by aircraft from Southampton, England, and if all the remotest capitals of the East are only hours or days instead of weeks away from those of the West, there will be such rapid and constant intercommunication that customs practices will become obsolete and one international language may have to be adopted for trade and convenience. Indeed, the only impediment originally put in the way of the Handley Page Company's London-to-Paris air-line was the violation of customs practices, which is delaying the aeroplanes from making the round trip between breakfast and dinner.

Furthermore, with the coming of such rapid intercommunication it is conceivable that foggy and damp countries like the British Isles may be abandoned—save by the workers of minerals—as living and manufacturing places for more beautiful and delightful climates, such as France or Spain. Indeed, the pleasantly located gardens and plateaus of the world—like the one in Mexico, for instance—may be the favorite dwelling-places of the peoples of the world when all the fruits and foods and goods of the earth can be aerially transported to such places in a matter of hours.

Needless to say that when each country possesses a fleet of commercial aircraft numbered by tens of thousands, inherently convertible into bombers large enough to annihilate whole cities entirely—as French aeronautic military authorities have already stated they feared Germany would be able to do with ten thousand aeroplanes and Zeppelins in the next ten years unless she was limited in her construction programme—when many countries can be flown over in a matter of hours without anything to prevent them, then undoubtedly a league of nations will have been organized for self-preservation and war abolished as too horrible to contemplate. Thus by levelling boundaries and borders of nations and countries the aircraft promises to perform the greatest blessing of mankind by abolishing war, destroying nationalism, and establishing internationalism and the brotherhood of man throughout the world.

CHAPTER XIV

THE REGULATION OF AIR TRAFFIC

IMPORTANCE OF SAME—LAWS FORMED BY BRITISH AERIAL TRANSPORT COMMISSION LIKELY TO BE BASES OF INTERNATIONAL AERIAL LAWS—COPY OF SAME

With aircraft flying over cities, towns, countries, continents, and the oceans, carrying passengers, it is becoming absolutely essential that a code of laws for aerial navigation should be adopted by the United States, and an international code should also be adopted by the nations of the earth.

In the United States laws should be adopted to regulate the inspection of aircraft which carry passengers, just as sea and river navigation is now regulated, in order to protect the lives of the passengers, and also to protect the lives of the people living in the cities where these machines are apt to descend, on account of damages that could be collected, etc., in case a machine fell upon and destroyed private property. Unless this is done, with the tremendous increase of the number of aircraft in the United States, there is apt to be a considerable number of lives lost unnecessarily, and a great deal of damage done to private property, for which no compensation can be awarded.

In the matter of international regulation of aircraft it is a great deal more important because of the ease with which commodities could be smuggled in from one country to another, even though mountains or rivers intervene at the borders. Flying at one hundred miles per hour, carrying two or three tons, smuggling could be carried on very extensively between different countries of the world.

The aerial police and aerial navigation laws could restrain and stop such unlawful flying, but an international code is necessary to determine their rights.

It is more important, however, to determine and prescribe the places at which foreign aircraft could cross the border or land for customs inspection. In these regulations should also be incorporated a code of international law. The conditions under which the fleet should pass from one country to another should be prescribed. Unless this was done it would be possible for any country in Europe, operating a fleet of 10,000 or more commercial aircraft, to convert them into bombers, each carrying tons of inextinguishable incendiary bombs, which could destroy a city like Paris, Brussels, or London within a few hours. A menace of this last possibility is so great that the leading aeronautical authorities in Paris and London have asked for a specified written code of aerial navigation laws, to be adopted by the League of Nations. In conformity to that object of controlling all kinds of aircraft, the British Aerial Transport Committee have drawn up a draft of a bill for the regulation of aerial navigation. The principles laid down in this bill are so universal in their application that they could be very well adopted by the United States and other nations of the earth.

Prior to the war, as early as 1905, and forever afterward, the International Aeronautical Federation was organizing laws regulating aerial navigation, and making it the chief topic of discussion.

In 1910 the International Convention held in Paris drew up aerial acts restricting navigation over forbidden zones. There was not at that time sufficient aircraft navigating to make these regulations as important as they are at the present time.

Some of our own States passed some absurd laws to restrict aerial navigation to their own States. These were absurd because of the fact that no limits should be placed on the interstate flying to aircraft because most States in the Union could be flown over in a matter of hours. Federal laws only are sufficient to deal with this situation. The Department of Commerce, which has charge of both registration and inspection, is the logical department to have charge of the regulation of aircraft.

In 1914 the Department of Commerce took charge of regulating aircraft, and Dean R. Van Kirk, Washington, D. C., was fined $550 for disobeying its rules. These regulations should aim to do what the Motor Boat Act does in the case of vessels of not more than sixty-five feet in length. Since the preponderance of aircraft shall be commercial, it is absurd to delegate this power to the Division of Aeronautics.

Herewith follows the draft of the bill regulating aerial navigation submitted to the British House of Parliament and later submitted to the Peace Conference for adoption by that body in Paris.

DRAFT OF A BILL

FOR THE REGULATIONS OF AERIAL NAVIGATION

Whereas the sovereignty and rightful jurisdiction of His Majesty extends, and has always extended, over the air superincumbent on all parts of His Majesty's dominions and the territorial waters adjacent thereto:

And whereas it is expedient to regulate the navigation of aircraft, whether British or foreign, within the limits of such jurisdiction, and in the case of British aircraft to regulate the navigation thereof both within the limits of such jurisdiction and elsewhere:

Be it therefore enacted by the King's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows:—

Power to Regulate Aerial Navigation

1—(1) The Secretary of State may by order regulate or prohibit aerial navigation by British or foreign aircraft or any class or description thereof over the British Islands and the territorial waters adjacent thereto, or any portions thereof, and in particular, but without derogating from the generality of the above provision, may by any such order—

(*a*) prescribe zones (hereinafter referred to as prohibited zones) over which it shall not (except as otherwise provided by the order) be lawful for aircraft to pass;

(*b*) prescribe the areas within which aircraft coming from any place outside the British Islands shall land, and the other conditions to be complied with by such aircraft;

(*c*) prohibit, restrict, or regulate the carriage in aircraft of explosives, munitions of war, carrier pigeons, photographic and radio-telegraphic apparatus and any other article the carriage of which may appear to the Secretary of State to be dangerous to the State or to the person or property of individuals;

(*d*) prohibit, restrict, or regulate the carriage in aircraft of merchandise or passengers;

(*e*) make such provision as may appear best calculated to prevent damage and nuisance being caused by aircraft.

(2) If any person does anything in contravention of any of the pro-

visions of any such order he shall in respect of each offence be guilty of a misdemeanour:

Provided that if it is proved that the contravention was committed with the intention of communicating to any foreign State any information, document, sketch, plan, model, or knowledge acquired, made or taken or with the intention of facilitating the communication at a future time of information to a foreign State any information, document, sketch, plan, model or knowledge acquired, made or taken or with the intention of facilitating the communication at a future time of information to a foreign State, he shall be guilty of a felony, and on conviction on indictment be liable to penal servitude for life or for any term not less than three years, and this proviso shall have effect and be construed as if it were part of the Official Secrets Act, 1889.

(3) Every order under this section shall have effect as if enacted in this Act, but as soon as may be after it is made shall be laid before each House of Parliament, and if an address is presented to His Majesty by either House of Parliament within the next subsequent twenty-one days on which that House has sat next after any such order came into force, praying that the order may be annulled, His Majesty may annul the order and it shall thenceforth be void, without prejudice to the validity of anything previously done thereunder.

Qualifications by Owning Aircraft

2—An aircraft shall not be deemed to be a British aircraft unless owned wholly by persons of the following descriptions (in this Act referred to as persons qualified to be owners of British aircraft), namely:—

(*a*) Natural-born British subjects;

(*b*) Persons naturalised by or in pursuance of an Act of Parliament of the United Kingdom, or by or in pursuance of an Act or Ordinance of the proper legislative authority in a British possession;

(*c*) Persons made denizens by letters of denization;

(*d*) Bodies corporate established under and subject to the laws in force in some part of His Majesty's dominions and having their principal place of business in those dominions, [all of whose directors and shareholders come under one of the aforementioned heads]:

Provided that any person who either—

(1) being a natural-born British subject has taken the oath of allegiance to a foreign Sovereign or State or has otherwise become a citizen or subject of a foreign State; or

(2) has been naturalised or made a denizen as aforesaid;

shall not be qualified to be an owner of a British aircraft, unless after taking the said oath or becoming a citizen or subject of a foreign State, or on or after being naturalised or made a denizen as aforesaid, he has taken the oath of allegiance to His Majesty the King and is during the time he is owner of the aircraft either resident in His Majesty's dominions or a partner in a firm actually carrying on business in His Majesty's dominions.

Registration of British Aircraft

3—(1) Every British aircraft shall be registered in such manner as the Board of Trade may by regulations prescribe:

Provided that an aircraft which is registered under the law of any foreign nation as an aircraft belonging to that nation shall not also be registered as a British aircraft.

(2) Regulations under this section may provide for—

(*a*) the appointment and duties of registrars;

(*b*) the keeping of registers and the particulars to be entered therein;

(*c*) the procedure for obtaining the registration of aircraft by the owners thereof, including the evidence to be produced as to the qualifications of applicants;

(*d*) the issue, form, custody, and delivery up of certificates of registration;

(*e*) the transfer and transmission of British aircraft;

(*f*) the fees to be paid;

(*g*) the application with the necessary modifications for any of the purposes aforesaid of any of the provisions contained in sections twenty to twenty-two, twenty-five, twenty-seven to thirty, thirty-nine to forty-six (except so far as those sections relate to mortgages), forty-eight to fifty-three, fifty-six, fifty-seven, sixty, sixty-one, and sixty-four of the Merchant Shipping Act, 1894.

(3) If an aircraft required under this Act to be registered is not so registered it shall not be recognised as a British aircraft, and shall not be entitled to any of the benefits, privileges, or advantages, or protection enjoyed by British aircraft, nor to assume the British national character, but so far as regards the payment of dues, the liability to fines and forfeitures, and the punishment of offences committed on such aircraft, or by any person belonging to it, such aircraft shall be dealt with in the same manner in all respects as if she were a recognised British aircraft.

(4) If any person required under the regulations to deliver up a certificate of registration fails to do so, he shall be guilty of an offence under this Act.

(5) If the owner or pilot of an aircraft uses or attempts to use a certificate of registry not legally granted in respect of the aircraft, he shall in respect of each offence be guilty of a misdemeanour.

Certification of Airworthiness

4—(1) An aircraft (if not exempted from the provisions of this section by the regulations made thereunder) shall not be navigated unless its airworthiness has been certified in accordance with regulations made by the Board of Trade and the certificate of airworthiness in respect thereof is for the time being in force.

(2) The regulations of the Board of Trade under this section may, amongst other things—

(*a*) prescribe the conditions to be fulfilled (including the equipment to be carried) and the tests to be applied in determining airworthiness;

(*b*) provide for the conduct on behalf of the Board of Trade by other bodies of tests and examinations of aircraft;

(*c*) provide for the issue form, custody, and delivery up of certificates of airworthiness;

(*d*) provide for the recognition of certificates of airworthiness granted under the laws of any British possession or foreign nation which appear to the Board of Trade effective for ascertaining and determining airworthiness;

(*e*) prescribe the fees to be paid in respect of the grant of such certificates and in respect of applications therefor;

(*f*) provide for the exemption from the provisions of this section of aircraft of any particular class or under any particular circumstances prescribed by the regulations.

(3) The regulations of the Board of Trade under this section may in the prescribed manner require the owner of any aircraft in respect of which a certificate of airworthiness has been issued or is recognised under those regulations to submit his aircraft at any time for such tests and examinations as may be prescribed for determining whether the conditions of airworthiness continue to be fulfilled, and may authorise endorsement on any such certificate of the result of such tests or examinations, and the cancellation of any such certificate, or the withdrawal of the recognition thereof, on its being found that such conditions have ceased to be fulfilled, or on failure to comply with any such requirement as aforesaid.

(4) If any person navigates or allows to be navigated any aircraft (other than an aircraft of an exempted class) in respect of which a certificate of airworthiness granted or recognised under this section is not for the time being in force, or navigates or allows to be navigated an aircraft in respect of which such a certificate is for the time being in force, knowing that the prescribed conditions of airworthiness have ceased to be fulfilled, he shall be guilty of a misdemeanour:

Provided that this sub-section shall not, nor shall any proceedings taken thereunder, affect any liability of any such person to be proceeded against by indictment for any other indictable offence.

Certification of Officers

5—(1) Every aircraft when being navigated shall be provided with a navigator duly certificated in accordance with this section, and also, in such cases as may be prescribed by regulations made by the Board of Trade, with such other officers so certificated as may be prescribed.

(2) The Board of Trade may make regulations—

(*a*) as to the issue and form of certificates of competency under this section;

(*b*) prescribing the cases in which officers other than the navigator are to be certificated, and the number and character of such officers;

(*c*) prescribing the qualifications to be possessed for obtaining a certificate as navigator or as officer serving in any other capacity;

(*d*) for holding examinations of candidates for certificates and for such examinations being conducted on behalf of the Board of Trade by other bodies;

(*e*) as to the issue of new certificates in place of certificates which have been lost or destroyed;

(*f*) as to the cancellation, suspension, endorsement and delivery up of certificates of competency;

(*g*) as to the recognition of certificates of competency issued to navigators and other officers under the laws of any British possession or foreign nation which appear to the Board effective for ascertaining and determining their competency;

(*h*) as to the fees to be paid on the grant of a certificate and by candidates entering for examination.

(3) The regulations shall provide for different certificates of competency being issued in respect of different classes of aircraft, and a navigator or other officer shall not be deemed to be duly certificated in respect of an aircraft of any class unless he is the holder for the time being of a valid certificate of competency under this section in respect of that class of craft, and of a grade appropriate to his station in the aircraft or of a higher grade.

(4) If any person—

(*a*) navigates or allows to be navigated any aircraft not provided with a duly certificated navigator, and, in the case of any aircraft which is under the regulations required to be provided with other certificated officers, without such other officers; or,

(*b*) having been engaged as a navigator or other officer required to be certificated, navigates, or takes part in the navigation of, an aircraft without being duly certificated; or

(*c*) employs a person as a navigator or as an officer in contravention of this section without ascertaining that the person so serving is duly certificated;

that person shall be guilty of an offence under this Act.

Collision Regulations

6—(1) The Board of Trade may make regulations (hereinafter referred to as collision regulations) for the prevention of collisions in the air, and may thereby regulate the lights to be carried and exhibited, the fog signals to be carried and used, and the steering and flying rules to be observed by aircraft.

(2) All owners and navigators of aircraft shall obey the collision regulations, and shall not carry or exhibit any other lights or use any other fog signals than such as are required by those regulations.

(3) If an infringement of the collision regulations is caused by the wilful default of the owner or navigator of the aircraft, the owner or navigator of the aircraft shall in respect of each offence be guilty of a misdemeanour.

(4) If any damage to property arises from the non-observance by any aircraft of any of the collision regulations, the damage shall be deemed to have been occasioned by the wilful default of the person in charge of the aircraft at the time, unless it is shown to the satisfaction of the Court that the circumstances of the case made a departure from the regulations necessary.

Alternative for Subsections (3), (4)

(3) If an infringement of the collision regulations is caused by the wilful default of the owner or navigator of an aircraft or of any person in charge of the craft at the time, that owner, navigator or person shall be guilty of a misdemeanour.

(4) If the infringement of the collision regulations is caused by any wilful default, the wilful default shall be deemed to be the wilful default of the navigator. Provided that if the navigator proves to the satisfaction of the Court that he issued proper orders for the observance and used due diligence to enforce the observance of the collision regulations, and that the whole responsibility for the infringement in question rested with some other person, the navigator shall be exempt from any punishment under this provision.

(5) The collision regulations may provide for the inspection of aircraft for the purpose of seeing that the craft is properly provided with lights and the means of making fog signals in conformity with the collision regulations [and the seizure and detention of any craft not so provided].

Identification Regulations

7—(1) The Board of Trade may make regulations providing generally for facilitating the identification of aircraft, and in particular for determining and regulating generally the size, shape, and character of the identifying marks to be fixed under the regulations, and the mode in which they are to be affixed and rendered easily distinguishable [whether by night or day], and any such regulations may provide for the recognition of identifying marks complying with the law of any British possession or foreign nation which appears to the Board of Trade equally effective for facilitating the identification of aircraft.

(2) The regulations under this section may provide for the seizure and detention of any aircraft which is not marked in accordance with those regulations.

(3) If any person navigates or allows to be navigated any aircraft in respect of which any of the requirements of the regulations made under this section are not complied with, he shall be guilty of an offence under this Act [*qu.* he shall be guilty of a misdemeanour].

Aircraft Papers

8—(1) The Board of Trade may make regulations—

(*a*) requiring logs and such other papers as may be prescribed to be carried in aircraft;

(*b*) prescribing the form of such logs and other papers;

(*c*) prescribing the entries to be made in logs and the time at which and the manner in which such entries are to be made;

(*d*) as to the production, inspection, delivery up, and preservation of logs and other papers.

(2) If any person contravenes any of the provisions of the regulations under this section he shall be guilty of an offence under this Act.

Signals of Distress Regulations

9—(1) The Board of Trade may make regulations as to what signals shall be signals of distress in respect of the various classes of aircraft, and the signals fixed by those regulations shall be deemed to be signals of distress.

(2) If a pilot of an aircraft uses or displays or causes or permits any person under his authority to use or display any of those signals of distress except in the case of an aircraft in distress such of those signals as are appropriate to the class to which the aircraft belongs, he shall be liable to pay compensation for any labour undertaken, risk incurred, or loss sustained in consequence of any person having been deceived by the signal [*qu.* he shall be guilty of an offence against this Act].

Customs Regulations

10—The Commissioners of Customs and Excise may, subject to the consent of Treasury, make such regulations as they may consider necessary for the prevention of smuggling and safeguarding the interests of the State with respect to the importation or exportation of goods in aircraft into or from the British Islands, and may for that purpose apply, with the necessary modifications, all or any of the enactments relating to Customs, and may by those regulations, with the consent of the Secretary of State and upon such terms as to payments to police authorities as he may sanction, require officers of police to perform in respect of aircraft all or any of the duties imposed on officers of Customs and may for that purpose confer on police officers all or any of the powers possessed by officers of Customs.

Post Office Regulations

11—The Postmaster-General may make regulations with respect to the conveyance of postal packets in aircraft, and may for that purpose apply, with the necessary modifications, all or any of the enactments relating to mail ships and the conveyance of postal packets in ships.

Trespass and Damages for Injury Caused by Aircraft

12—(1) The flight of an aircraft over any land in the British Islands shall not in itself be deemed to be trespass, but nothing in this provision shall affect the rights and remedies of any person in respect of any injury to property or person caused by an aircraft, or by any person carried therein, and any injury caused by the assembly of persons upon the landing of an aircraft shall be deemed to be the natural and probable consequence of such landing.

(2) Where injury to property or person has been caused by an aircraft, the aircraft may be seized and detained until the owner thereof has given security to the satisfaction of a justice or an officer of police not below the rank of inspector to pay such damages as may be awarded in respect of the injury and any costs incidental to the proceedings.

Salvage of Wrecked Aircraft

13—(1) If any person finds, whether on land or at sea, an aircraft which has been wrecked or lost, he shall as soon as may be communicate with the police or other proper authority, and the police or authority shall communicate the information to the owner of the aircraft if he can be ascertained.

(2) Where any such aircraft is salved then—

(*a*) if the owner of the aircraft does not abandon his right to the aircraft he shall pay to any persons whose services have contributed to the salvage of the aircraft, including any person or authority who has given or communicated such information as aforesaid, any expenses incurred by them for the purpose and five per cent. of the value of aircraft as salved, after deducting from that amount the amount of the expenses of salvage payable by the owner, to be distributed among those persons in such manner as, in default of agreement, the Court having cognisance of the case may think just; and

(*b*) if the owner abandons his right to the aircraft, it shall be sold or otherwise dealt with for the benefit of the salvors.

(3) The Board of Trade may make regulations for the purpose of carrying this section into effect, and in particular may prescribe what authority shall be deemed the proper authority, the manner in which communications are to be made, the manner in which an owner may abandon his right to an aircraft, and the manner in which aircraft may be sold or otherwise dealt with for the benefit of the salvors.

Search

14—(1) If any officer of police has reason for suspecting that an offence against this Act or any regulations made thereunder has been or is being committed on board any aircraft, he may enter and search the craft, and may search any person found therein or who may have been landed therefrom:

Provided that before any person is searched, he may require to be taken with all reasonable despatch before a justice, who shall, if he sees no reasonable cause for search, discharge that person, but if otherwise direct that he be searched, and if a female she shall not be searched by any other than a female.

(2) If any person assaults or obstructs any officer of police in searching an aircraft, or in searching any person in the aircraft, or who may have landed therefrom, he shall be guilty of an offence against this Act, and if any officer of police without reasonable ground causes any person to be searched, that officer shall be guilty of an offence against this Act.

Seizure and Detention of Aircraft

15—The Secretary of State may make regulations as to the manner in which aircraft, liable to seizure and detention under this Act may be seized and detained.

Forgery, etc., of Certificates, etc.

16—If any person—

(*a*) forges or fraudulently alters, or assists in forging or fraudulently altering or procures to be forged or fraudulently altered, any certificate of registration, airworthiness, or competency under this Act or any log or other papers required under this Act to be carried in an aircraft; or,

(*b*) makes or assists in making or procures to be made any false representation for the purpose of procuring the issue of a certificate of airworthiness, or of procuring either for himself or for any other person a certificate of competency; or

(c) fraudulently uses a certificate of registration, airworthiness, or competency which has been forged, altered, cancelled, or suspended, or to which he is not entitled; or

(d) fraudulently lends his certificate of competency, or allows it to be used by any other person; or

(e) forges or fraudulently alters or uses or assists in forging or fraudulently altering or using, or procures to be forged or fraudulently altered or used, or allows to be used by any other person, any mark for identifying an aircraft,

he shall be guilty of a misdemeanour.

Punishment for Offences

17—(1) An offence against this Act declared to be a misdemeanour shall be punishable with a fine or with imprisonment not exceeding two years, with or without hard labour, but may, instead of being prosecuted on indictment as a misdemeanour, be prosecuted summarily in manner provided by the Summary Jurisdiction Acts, and if so prosecuted shall be punishable only with imprisonment for a term not exceeding three months, with or without hard labour, or with a fine not exceeding one hundred pounds, or with both such imprisonment and fine.

(2) An offence against this Act not declared to be a misdemeanour shall be prosecuted summarily in manner provided by the Summary Jurisdiction Acts, and shall be punishable with a fine not exceeding one hundred pounds or with imprisonment for a term not exceeding three months, with or without hard labour, or with both such imprisonment and fine.

(3) Where a person is beneficially interested otherwise than by way of mortgage in any aircraft registered in the name of some other person as owner, the person so interested shall as well as the registered owner be subject to all the pecuniary penalties by this Act imposed on owners of aircraft, so nevertheless that proceedings may be taken for the enforcement of any such penalties against both or either of the aforesaid parties with or without joining the other of them.

Provisions as to Public Foreign Aircraft

18—It shall not be lawful for any aircraft in the service of any foreign State to pass over or land on any part of the British Islands or the territorial waters adjacent thereto except on the invitation of His Majesty [or of some department of His Majesty's Government], and any person carried in an aircraft contravening the provisions of this section shall be guilty of a misdemeanour, and, unless the Secretary of State otherwise orders, the aircraft may be seized, detained, and searched, and the persons carried therein or landed therefrom may be searched in accordance with the provisions of this Act.

Power to Fire on Aircraft Flying Over Prohibited Areas

19—If any aircraft flies or attempts to fly over any prohibited zone or being an aircraft in the service of a foreign State flies or attempts to fly over any part of the British Islands or the territorial waters adjacent thereto in contravention of this Act, it shall be lawful for any commissioned officer in His Majesty's Navy, Army, or Marines [not below the rank of], to cause a gun to be fired as a signal, and if, after such gun has been fired, the aircraft fails to respond to the signal by complying with such regulations as may be made by the Secretary of State under this Act for dealing with the case, to fire at such aircraft, and any such commissioned officer and every other person acting in his aid or by his direction shall be and is hereby indemnified or discharged from any indictment, penalty or other proceeding for so doing.

Jurisdiction

20—(1) For the purpose of giving jurisdiction under this Act every offence shall be deemed to have been committed in the place in or over which the same was actually committed or in any place in which the offender may be.

(2) Where any person, being a British subject, is charged with having committed any offence on board any British aircraft in the air, over the high seas, or over any foreign country, or on board any foreign aircraft to which he does not belong, or not being a British subject is charged with having committed any offence on board any British aircraft in the air over the high seas, and that person is found within the jurisdiction of any Court in His Majesty's dominions which would have had cognisance of the offence if it had been committed on board a British aircraft within the limits of its ordinary jurisdiction, that Court shall have jurisdiction to try the offence as if it had been so committed.

(3) Where any offence is committed in any aircraft in the air over the British Islands or in the territorial waters adjacent thereto, the offence shall be deemed to have been committed either in the place in which the same was actually committed or in any place in which the offender may be.

Supplementary Provisions as to British Aircraft

21—(1) If any person assumes the British national character on an aircraft owned in whole or in part by any person not qualified to own a British aircraft for the purpose of making the aircraft appear to be a

British aircraft, the aircraft shall be liable to be seized and detained under this Act unless the assumption has been made for the purpose of escaping capture by an enemy or by any person in the exercise of some belligerent right.

(2) If the owner or pilot of a British aircraft does anything or permits anything to be done, or carries or permits to be carried any papers or documents, with intent to conceal the British character of the aircraft or of any person entitled under this Act to inquire into the same, or with intent to assume a foreign character, or with intent to deceive any person so entitled as aforesaid, the aircraft shall be liable to be seized and detained under this Act, and the pilot, if he commits or is privy to the commission of the offence, shall in respect of each offence be guilty of a misdemeanour.

(3) If an unqualified person acquires as owner, otherwise than in accordance with this Act or the regulations made thereunder, any interest, either legal or beneficial, in an aircraft assuming the British character, that interest shall be subject to forfeiture.

Application of Foreign Enlistment Act

22—The Foreign Enlistment Act, 1870, shall have effect as if the expression "ship" included any description of aircraft, and as if the expression "equipping" in relation to an aircraft included, in addition to the things specifically mentioned in that Act, any other thing which is used in or about an aircraft for the purpose of fitting or adapting her for aerial navigation.

Extent of Act

23—(1) The provisions of this Act and of the regulations made thereunder shall, except so far as they are expressly limited to the British Islands and the territorial waters adjacent thereto, apply to—

(*a*) all British aircraft wheresoever they may be; and

(*b*) all foreign aircraft whilst in or over any part of His Majesty's dominions and the territorial waters adjacent thereto;

and in any case arising in a British Court concerning matters arising within British jurisdiction foreign aircraft shall, so far as respects such provisions, be treated as if they were British aircraft;

Provided that no such provisions, except those relating to the registration of aircraft and those contained in collision regulations, aircraft papers, regulations, and signals of distress regulations, shall apply to aircraft whilst in or over any part of His Majesty's dominions outside the British Islands or in or over the territorial waters adjacent to any such part.

(2) Subject as aforesaid, nothing in this Act shall be construed as limiting the power of the legislature of any British possession outside

the British Islands to make provision in relation to the possession and the territorial waters adjacent thereto with respect to any of the matters dealt with by this Act.

Exemption of Government Aircraft

24—This Act shall not, except so far as it may be applied by Order in Council, apply to aircraft belonging to His Majesty.

CHAPTER XV

THE TRANSATLANTIC FLIGHT

THE NC'S—THE LOSS OF THE C-5—READ'S STORY—BELLINGER'S STORY—THE GREAT NAVAL FLIGHT—HAWKER'S STORY—ALCOCK'S STORY—THE R-34

EVER since the Wright brothers demonstrated that a heavier-than-air machine could rise from the ground with its own power and carry a man aloft through the air, aeronautical engineers have been ambitious to build an aircraft that would fly across the Atlantic Ocean from the Old World to the New, or from the New World to the Old. Exactly one hundred years to the very month after the first steam-driven vessel crossed the Atlantic, from Savannah, Georgia, to England, NC-4, U. S. naval flying-boat, flew from Rockaway, Long Island, via Halifax, Trepassey Bay, Newfoundland, Azores, Lisbon, Portugal, Ferrol, Spain, to Plymouth, England; and on June 13 the "Vimy"-Bomber, built by the Vickers, Limited, England, made a non-stop flight from St. John's, Newfoundland, to Clefden, Galway, Ireland; and on July 2 the R-34, the British rigid dirigible, flew from East Fortune, near Edinburgh, Scotland, via Newfoundland to Mineola, Long Island, in 108 hours and 12 minutes; and it made the return trip to Pulham, Norfolk, England, in 75 hours and 3 minutes. The NC-4 flew from Trepassey Bay to Plymouth in 59 hours and 56 minutes, and the Vickers Bomber made its flight in 16 hours and 12 minutes. The distance of the first flight from Trepassey Bay to Plymouth was about 2,700 miles; the distance of the one taken by the Vickers was 1,950 miles. The distance covered by the R-34 was 3,200 miles each way.

On May 16, 1919, three U. S. naval seaplanes, the NC-1, NC-3, and NC-4, set out to fly from Trepassey Bay, Newfoundland, to the Azores. The NC-4 alighted at Horta the next day. The NC-1, under command of Lieutenant-Commander Bellinger, did not quite complete the flight owing to fog, and after the crew was rescued by a destroyer, had to be towed into Horta, where it sank. The NC-3, with Commander Towers, was lost for 48 hours in the fog, but finally taxied to Porta Delgada on its own power. Owing to the damaged condition of the boat, it could proceed no farther. On May 16 Commander Read flew the NC-4 to Porta Delgada; on May 27 from there to Lisbon; on May 30 to Ferrol, Spain; and on May 31, to Plymouth, England, thus completing the transatlantic flight in 46 flying hours.

On May 18 Harry Hawker and Mackenzie Grieve flew from St. John's in a single-motored Sopwith, and after 15 hours in the air had to alight on the ocean, 1,000 miles east of where they started and 900 miles from their goal.

On June 14 Captain John Alcock and Lieutenant Arthur W. Brown, in a bimotored Vickers aeroplane, flew from St. John's, Newfoundland, to Galway, Ireland, without stopping, through fog and sleet and rain, in 16 hours and 12 minutes.

Previous Attempts to Fly Across the Atlantic

The first actual attempt to fly across the North Atlantic from America to England was made by Walter Wellman, in 1910, when he set sail in the rigid dirigible *America* from Atlantic City. The engines were not strong enough to force the huge gas-bag against the breeze, and it was blown out of its course and came down in the sea, 1,000 miles off Cape Hatteras, where the balloon was abandoned and the crew was picked up.

During a test flight of a second dirigible called the *Akron*, on July 2, 1912, Mr. Melvin Vaniman and four of his crew were killed by an explosion of the hydrogen gas with which the gas-bag was inflated.

In 1894 Glenn L. Curtiss, through the generosity of Mr. Rodman Wanamaker, constructed a flying-boat, in which Captain Porte was to fly across the Atlantic. The seaplane was completed and tests were being made when the war broke out, and the enterprise had to be abandoned. Nevertheless, the seaplane did go to England, but in the hull of another boat. There it performed excellent service for the British Government hunting Hun submarines.

As soon as the armistice was signed, France, England, and the United States began to lay plans to use some of the airships designed for war for the purpose of flying across the Atlantic. Captain Coli, who flew from France across the Mediterranean, started from

Paris to fly to Dakar on the extreme point of Cape Verde, and from there across the South Atlantic to Pernambuco, Brazil. Owing to engine trouble, he did not reach Dakar.

The NC's

The giant navy flying-boats built for the transatlantic flight were not only of extraordinary size but of unusual construction, and represent a wholly original American development. The design was conceived in the fall of 1917 by Rear-Admiral D. W. Taylor, Chief Constructor of the Navy, who had in mind the development of a seaplane of the maximum size, radius of action, and weight-carrying ability, for use in putting down the submarine menace. Had the German submarines gained the upper hand in 1918, the war would still be going on, and these great flying-boats would be produced in quantity and flown across the Atlantic to the centres of submarine activity.

The first of the type was completed and given her trials in October, 1918, and since that time three more have been completed.

The flying-boats were designated NC, the N for navy, and C for Curtiss, indicating the joint production of the navy and the Curtiss Engineering Corporation. Being designed for war service, the boats are not at all freak machines put together to perform the single feat of a record-breaking flight, but are roomy and comfortable craft, designed and built in accordance with standard navy practice. The NC-1 has been in service seven months, and received rough handling when new pilots for the other NC boats were trained on her, but is still in good condition.

The term flying-boat is used for the NC type because it is actually a stout seaworthy boat, that ploughs through rough water up to a speed of 60 miles per hour, and then takes to the air and flies at a speed of over 90 miles per hour.

The hull or boat proper is 45 feet long by 10 feet beam. The bottom is a double plank Vee, with a single step somewhat similar in form to the standard navy pontoon for smaller seaplanes. Five bulkheads divide the hull into six water-tight compartments with water-tight doors in a wing passage for access. The forward compartment has a cockpit for the lookout and navigator. In the next compartment are seated side by side the principal pilot or aviator and his assistant. Next comes a compartment for the members of the crew off watch to rest or sleep. After this there are two compartments containing the gasoline-tanks (where a mechanician is in attendance) and finally a space for the radio man and his apparatus. The minimum crew consists of five men, but normally a relief crew could be carried in addition. To guarantee water-tightness and yet keep the planking thin, there is a layer of muslin set in marine glue between the two plies of planking.

The wings have a total area of 2,380 square feet. The ribs of the wing are 12 feet long, but only weigh 26 ounces each.

The tail in this craft is unique and resembles no other flying machine or animal. The tail surface is made up as a biplane, which is of the general appearance and size of the usual aeroplane. Indeed, this tail of over 500 square feet area is twice as large as the single-seater fighting-aeroplanes used by the army.

Engines

The four Liberty engines which drive the boat are mounted between the wings. At 400 brake horse-power per engine, the maximum power is 1,600 horse-power, or with the full load of 28,000 pounds, 17.5 pounds carried per horse-power. One engine is mounted with a tractor propeller on each side of the centre line, and on the centre line the two remaining engines are mounted in tandem, or one behind the other. The front engine has a tractor propeller, and the rear engine a pusher propeller. This arrangement of engines is novel, and has the advantage of concentrating weights near the centre of the boat so that it can be manœuvred more easily in the air.

Controls

The steering and control in the air are arranged in principle exactly as in a small aeroplane, but it was not an easy problem to arrange that this 14-ton boat could be handled by one man of only normal strength. To insure easy operation, each control surface was carefully balanced in accordance with experiments made in a wind-tunnel on a model of it. The operating cables were run through ball-bearing pulleys, and all avoidable friction eliminated. Finally, the entire craft was so balanced that the centre of gravity of all weights came at the resultant centre of lift of all lifting surfaces, and the tail surfaces so adjusted that the machine would be inherently stable in flight. As a result, the boat will fly herself and will continue on her course without the constant attention of the pilot. However, if he wishes to change course, a slight pressure of his controls is enough to swing the boat promptly. There is provision, however, for an assistant to the pilot to relieve him in rough air if he becomes fatigued, or wishes to leave his post to move about the boat.

In the design of the metal fittings to reduce the amount of metal needed a special alloy steel of 150,000 pounds per square inch tensile strength was used. To increase bearing areas, bolts and pins are made of large diameter but hollow.

A feature that is new in this boat is the use of welded aluminum tanks for gasoline. There are nine 200-gallon tanks made of sheet aluminum with welded seams. Each tank weighs but 70 pounds, or .35 pounds per gallon of contents, about one-half the weight of the usual sheet-steel or copper tank.

Loaded, the machine weighs 28,000 pounds, and when empty, but including radiator, water, and fixed instruments and equipment, 15,874 pounds. The useful load available for crew, supplies, and fuel is, therefore, 12,126 pounds. This useful load may be put into fuel, freight, etc., in any proportion desired. For an endurance flight there would be a crew of 5 men (850 pounds), radio and radiotelephone (220 pounds), food and water, signal-lights, spare parts, and miscellaneous equipment (524 pounds), oil (750 pounds), gasoline, 9,650 pounds. This should suffice for a flight of 1,400 sea miles. The radio outfit is of sufficient power to communicate with ships 200 miles away. The radiotelephone would be used to talk to other planes in the formation or within 25 miles.

The principal dimensions and characteristics of the NC type may be summarized as follows:

Engines	4 Liberty
Power	1,600
Wing span	126 upper
	94 feet lower
Length	68 feet 5½ inches
Height	24 feet 5⅛ inches
Weight, empty	15,874 lbs.
Weight, loaded	28,000 lbs.
Useful load	12,126 lbs.
Gravity-tank	91 gals. capacity
Fuel-tanks	1,800 gals. capacity
Oil-tanks	160 gals. capacity

First Aerial Stowaway

In connection with the trials of NC-1, the first of the type completed, two significant happenings are recorded.

The first concerns the first aerial stowaway. At Rockaway Naval Air-Station arrangements were made to take 50 men for a flight to establish a world's record; the 50 men were assembled, weighed, and carefully packed in the boat. The flight was successfully made, and upon return to the beach the officer-in-charge counted the men again as they came ashore. He was astonished to find there were 51. An investigation was made at once, which revealed the fact that a mechanic who had been working on the boat before the flight had hidden in the hull for over an hour before the actual departure in order to go on the flight. This man is, no doubt, the world's first aerial stowaway.

Record of the Flight

The NC-1, 3, and 4 left Rockaway at 10 A. M. on May 8 for Halifax. The NC-4, owing to engine trouble, had to land at sea near Chatham, Mass.; the other two continued on their way, and reached Halifax at 7.55 P. M. (6.55 New York time) on May 8; after waiting until the morning of May 10, the NC-1 and 3 left Halifax at 8.44 A. M. After travelling 38 miles, the NC-3 was forced to return to Halifax due to the cracking of a propeller. The NC-1 arrived at Trepassey Bay on May 10 at 3.41 P. M. The NC-3 arrived at 7.31 P. M.

After being refitted with a new engine the NC-4 left Chatham at 9.25 A. M., Wednesday, May 14, and arrived at Halifax at 2.05 P. M. It left there on Thursday, May 15, at 9.52 A. M., and arrived at Trepassey Bay at 6.37 P. M. (New York time 5.37 P. M.).

On the morning of Friday, May 16, the three flying-boats left Trepassey Bay at 6.05 P. M. It was a clear moonlight night, and as 21 United States destroyers were stationed along the route from North latitude 46–17 to 39–40, the airships were in communication with the fleet all the way over.

Because of a thick fog which obtained near the Azores the NC-4 landed at Horta of the eastern group at 9.20 A. M., just 13 hours and 18 minutes after starting. The NC-1 landed at sea and sank, and the NC-3, which flew out of its course, landed at Ponta Delgada.

Time of NC-4's Flight to Lisbon

The NC-4 in its flight from Trepassey to Lisbon covered a distance of 2,150 nautical miles in 26.47 hours' actual flying time, or at an average speed of 80.3 nautical miles. The three seaplanes left Trepassey at sunset on May 16, and the NC-4 reached Lisbon soon after noon on May 27, the eleventh day after its "hop" from Newfoundland. Its record in detail is as follows:

Course	Date	Distance, Knots	Time	Speed, Knots
Rockaway–Chatham (forced landing about 100 miles off Chatham)	May 8	300	5.45	52
Chatham–Halifax	May 14	320	3.51	85
Halifax–Trepassey	May 15	460	6.20	72.6
Trepassey–Horta	May 16–17	1,200	15.18	78.4
Horta–Ponta Delgada	May 20	150	1.45	86.7
Ponta Delgada–Lisbon	May 27	800	9.44	82.1
Trepassey–Lisbon		2,150	26.47	80.3

The total flying time from Rockaway, N. Y., to Lisbon, Spain, was 42.43.

The fastest previous passage of the Atlantic was made by the giant Cunard liner *Mauretania*, which made the trip from Liverpool to New York in four days, 14 hours, and 27 minutes.

Here is the log of the last leg of the transatlantic flight, completed with the arrival of the NC-4 at Plymouth, based on wireless and cabled despatches received at the Navy Department.

1.21 A. M., from Plymouth: "NC-4 left Lisbon 6.23 (New York 2.23 A. M.), May 30, and landed Mondego River, getting underway and proceeding to Ferrol, where landed at 16.46 (12.45 New York time). Destroyers standing by NC-4; will proceed to Plymouth to-morrow if weather permits."

6.50 A. M.—From Admiral Knapp at London: "From the Harding: 'U. S. S. *Gridley* to U. S. S. *Rochester*, NC-4 expects to leave Ferrol for Plymouth at 6 A. M. to-morrow morning, signed Read.'"

7.22 A. M.—From Admiral Knapp at London: "NC-4 left Ferrol at 06.27 (2.27 A. M. New York time)."

8.11 A. M.—From Admiral Knapp at London: "Following received from U. S. S. *George Washington:* 'From U. S. S. *Stockton*, NC-4 passed station two at 07.43 (3.43 A. M. New York time).'"

9.24 A. M.—From Admiral Knapp at London: "NC-4 passed station four at 09.06 (5.06 New York time)."

9.50 A. M.—From Admiral Knapp: "NC-4 arrived at Plymouth at 14.26.31, English civil time (9.26 A. M. New York time)."

11.56 A. M.—From Admiral Knapp: "NC-4 passed Mengam at 12.13 local time."

3.17 P. M.—From Admiral Plunkett, commander of destroyer force at Plymouth: "NC-4 arrived at Plymouth 13.24 (9.24 A. M. New York time) in perfect condition. Joint mission of seaplane division and destroyer force accomplished. Regret loss of NC-1 and damage to NC-3; nevertheless, information of utmost value gained thereby. Has department any further instructions?"

The members of the crews were:

NC-1—Commanding officer, Lieutenant-Commander P. N. L. Bellinger; pilots, Lieutenant-Commander M. A. Mitscher and Lieutenant L. T. Barin; radio operator, Lieutenant Harry Sadenwater; engineer, Chief Machinist's Mate C. I. Kesler.

NC-3—Commanding officer, Commander John H. Towers; pilots, Commander H. C. Richardson and Lieutenant David H. McCullough; radio operator, Lieutenant-Commander R. A. Lavender; engineer, Machinist L. R. Moore.

NC-4—Commanding officer, Lieutenant-Commander A. C. Read; pilots, Lieutenants E. F. Stone and Walter Hinton; radio operator, Ensign H. C. Rodd; engineer, Chief Machinist's Mate E. S. Rhodes.

The Loss of C-5 Naval Blimp

The C-5 naval dirigible, called "Blimp," was 192 feet long, 43 feet wide, 46 feet high, and contained 180,000 cubic feet of hydrogen. It was driven by two 150 horse-power union aero engines.

It left Montauk Point early Wednesday morning, May 14, and was in the air continuously for 25 hours and 45 minutes.

It arrived at Halifax at 9.50 A. M., Thursday morning, New York time.

On Thursday afternoon the C-5 burst from her moorings in a gale and was swept to sea. Lieutenant Little was hurt in an attempt to pull the rip cord of the dirigible in order to deflate her. The cord broke, and he received a sprain when he jumped from the C-5 as she began to rise.

The C-5 arrived at the Pleasantville base, near St. John's, after being in the air continuously for 25 hours and 40 minutes. A perfect landing was made within the narrow confines of the old cricket-field, which was chosen as the anchorage for the airship. Lieutenant J. V. Lawrence was at the wheel at the completion of the voyage, and the manner in which he handled the ship while the landing was being performed evoked a cheer of admiration from the crowd which had gathered.

As soon as she had been secured at her anchorage, a big force, under Lieutenant Little, was set to work preparing the ship for the transatlantic flight. It was not long before the treacherous wind began to play upon the dirigible, and early in the afternoon she was torn from her anchorage, but was recaptured and secured again.

Immediately after arrival, Lieutenant-Commander Coil and his crew got out of the car and prepared to take twelve hours' sleep before continuing their flight across the Atlantic. Before turning in, however, he told the story of the trip to Newfoundland.

In it he gave all the credit to Lieutenant Campbell and Lieutenant J. V. Lawrence, both of whom, he said, were weary "and almost seasick," but stuck to their posts. He also described the period of several hours during which the airship was "lost" over Newfoundland.

"We made a 'landfall' at St. Pierre," he said, "but found ourselves on the west instead of the east shore of Placentia Bay. From this point we attempted to follow the Chicago's radio directions, but they did not work. For the moment we were lost.

"We started 'cross lots' and saw about all of Newfoundland, and I must say that this is the doggonedest island to find anything on I ever struck. Eventually we hit the railroad track and followed it to Topsails, which we identified, and then continued on to St. John's. There was considerable fog, but it did not trouble us.

"Throughout the time we were trying to find ourselves we had difficulty with our wireless set, and part of the time it was out of commission.

"Our troubles started just after midnight, when the sky became overcast. Before then we had been flying under a full moon at an altitude of 1,000 feet. We lost our bearings while approaching Little Miquelon Island, off the south coast of Newfoundland, about 170 miles from St. John's."

Commander Coil praised the work of the landing crew which moored the dirigible. Rear-Admiral Spencer S. Wood, commander of the aviation base, greeted the C-5's commander.

The C-5 is 192 feet long, 43 feet wide, and 45 feet high; it has a capacity of 180,000 cubic feet. Cruising speed, 42 M. P. H.; climb, 1,000 feet per minute.

The car is of stream-line form, 40 feet long, 5 feet in maximum diameter, with steel tube outriggers carrying an engine at either side. Over-all width of riggers, 15 feet. Complete weight of car, 4,000 pounds.

Seven passengers may be carried, but the usual crew consists of four. At the front the coxswain is placed; his duty is to steer the machine from right to left. In the next compartment is the pilot, who operates the valves and controls the vertical movement of the ship, and aft of the pilot are the mechanicians controlling the engines. At the rear cockpit is the wireless operator.

Lieutenant-Commander Read's Story of Transatlantic Flight

(Reprinted from "New York World")

Horta, the Azores, May 18.—"The NC-3 left the water at Trepassey Bay at 10.03, Greenwich civil time, on the afternoon of May 16; the NC-4 at 10.05, and the NC-1 some time later. The Three and Four together left Mistaken Point on the course for the Azores at 10.16, and ten minutes later sighted the One, several miles to the rear, and flying higher.

"We were flying over icebergs, with the wind astern and the sea smooth. Our average altitude was 800 feet. The NC-4 drew ahead at 10.50, but when over the first destroyer made a circle to allow the NC-3 to catch up. We then flew on together until 11.55, when we lost sight of the NC-3, her running lights being too dim to be discerned.

"From then on we proceeded as if alone. Our engine was hitting finely, and the oil pressure and water temperature was right. It was very dark, but the stars were showing. At 12.19 on the morning of the 17th the May moon started to appear, and the welcome sight made us all feel more comfortable.

"As it grew lighter the air became bumpy, and we climbed to 1,800 feet, but the air remained bumpy most of the night.

"Each destroyer was sighted in turn, first being located by star-shells, which, in some cases, we saw forty miles away; then by the search-lights, and finally by the ships' light. All were brilliantly illuminated. Some were apparently in the exact position designated. Others were some miles off the line, necessitating frequent changes of our course so that we might pass near.

"At 12.41, when we were passing No. 4 destroyer, we saw the lights of another plane to port. We kept the lights in sight for ten minutes. After that we saw no other plane for the remainder of our trip.

"So far, our average speed had been 90 knots, indicating that we had a 12-knot favorable wind. At

1.24 the wind became less favorable and we came down to 1,000 feet.

"At 5.45 we saw the first of the dawn. As it grew lighter a llour worries appeared to have passed. The power-plant and everything else was running perfectly. The radio was working marvellously well. Messages were received from over 1,300 miles, and our radio officer sent a message to his mother in the States via Cape Race.

"Cape Race, then 730 miles away, reported that the NC-3's radio was working poorly. The NC-3 was ahead of the NC-1, and astern of us, we learned by intercepted messages. Each destroyer reported our passing by radio.

"Sandwiches and coffee from the thermos bottles and chocolate candy tasted fine. No emergency rations were used. They require too great an emergency to be appreciated. I made several inspection trips aft and held discussions with the radio man and the engineer. Everything was all right.

"At 6.55 we passed over a merchant ship, and at 8 o'clock we saw our first indications of possible trouble, running through light lumps of fog. It cleared at 8.12, but at 9.27 we ran into more fog for a few minutes. At 9.45 the fog became thicker and then dense. The sun disappeared and we lost all sense of direction. The compass spinning indicated a steep bank, and I had visions of a possible nose dive.

"Then the sun appeared and the blue sky once more, and we regained an even keel and put the plane on a course above the fog, flying between the fog and an upper layer of clouds. We caught occasional glimpses of the water, so we climbed to 3,200 feet, occasionally changing the course and the altitude to dodge the clouds and fog.

"We sent out a radio at 10.38 and at 10.55 to the nearest destroyer, thinking the fog might have lifted. We received replies to both messages that there was thick fog near the water. At 11.10 we ran into light rain for a few minutes.

"At 11.13 we sent a radio to the destroyer and could hear Corvo reply that the visibility was ten miles. Encouraged by this promise of better conditions farther on, we kept going. Suddenly, at 11.27, we saw through a rift what appeared to be a tide-rip on the water. Two minutes later we saw the outline of rocks.

"The tide-rip was a line of surf along the southern end of Flores Island. It was the most welcome sight we had ever seen.

"We were 45 miles off our calculated position, indicating that the speed of the plane from the last destroyer sighted had been 85 knots. The wind was blowing us east and south.

"We glided near to the shore and rounded the point. Finding that the fog stopped 200 feet above the water, we shaped our course for the next destroyer, flying low, with a strong wind behind us. We sighted No. 22 in its proper place at 12 o'clock. This was the first destroyer we had seen since we passed No. 16.

"The visibility then was about 12 miles. We had plenty of gasoline and oil, and decided to keep on to Ponta Delgada. Then it got thick and we missed the next destroyer, No. 23. The fog closed down.

"We decided to keep to our course until 1.18, and then made a 90-degree turn to the right to pick up Fayal or Pico. Before this time, at 1.04, we sighted the northern end of Fayal, and once more felt safe.

"We headed for the shore, the air clearing when we neared the beach. We rounded the island and landed in a bight we had mistaken for Horta.

"At 1.17 we left the water and rounded the next point. Then we sighted the *Columbia* through the fog and landed near her at 1.23.

"Our elapsed time was 15 hours and 18 minutes. Our average speed 81.7 knots. All personnel is in the best of condition. The plane requires slight repairs.

"The NC-1 is being towed to port here. Its personnel is on board the *Columbia*, all in fine shape.

"The Three has not yet been located, but will be. We will proceed to Ponta Delgada when the weather permits."

Ponta Delgada, May 20.—"Exceptionally bad weather, which was totally unexpected, was the sole reason for the failure of all three of the American navy's seaplanes to fly from Trepassey, Newfoundland, to Ponta Delgada on schedule time," said Commander John H. Towers to the correspondent of the Associated Press to-night.

"Individually, the members of the crew of the NC-3 virtually gave up hope of being rescued Saturday night, but collectively they showed no signs of fear, and 'carried on' until they arrived in port here Monday and heard the forts firing salvoes in welcome, and witnessed the scenes of general jubilation over their escape from the sea.

"Having run short of fuel and encountered a heavy fog, the NC-3 came down at 1 o'clock Saturday afternoon in order that we might obtain our bearings. The plane was damaged as it reached the water, and was unable to again rise. While we were drifting the 205 miles in the heavy storm the high seas washed over or pounded the plane, and the boat began to leak. So fast did the water enter the boat that the members of the crew took turns in bailing the hull with a small hand-pump, while others stood on the wings in order to keep the plane in balance. Meanwhile we were steering landward.

"That our radio was out of commission was not known to the crew until our arrival here. Communication had been cut off since 9 o'clock Monday owing to our having lost our ground-wire.

"We ate chocolate and drank water from our radiator. This was our only means of subsistence. The crew smoked heavily in order to keep awake while we were drifting. No one of us obtained more than four hours' sleep after leaving Trepassey until Ponta Delgada was reached.

"The hands of all the members of the crew of the NC-3 were badly swollen as a result of their heroic work at the pump; otherwise they did not undergo much suffering. The men have now fully recovered from their trying experience.

"The NC-3 encountered heavy clouds at 1 o'clock Saturday morning. The light instruments on board failed, and we sailed the plane above the clouds in order to get the benefit of a moonlight reading of the instruments.

"We kept in sight of the NC-4 until nearly daylight Saturday, and with the NC-1 until shortly after daylight. All the planes were flying in formation, but the NC-1 and NC-4 were underneath the clouds part of the time because their light instruments were good.

"The NC-3 had no difficulty in being guided by star-shells, search-lights, and smoke from the station ships until we reached Station 14, which was not seen.

"I assumed that we were off our course, but did not know on which side, and began flying a parallel course in what I thought was the direction of Corvo. Shortly after daylight we encountered a heavy fog, rain squalls, and high winds, all of which continued until the NC-3 went down upon the water.

"Before alighting on the surface of the sea my calculations showed us to be in the vicinity of land, but with only two hours' fuel supply on hand and with the weather clearing it was decided to land and ascertain our exact position.

"Our radio kept up sending messages, assuming that the torpedo-boat destroyers were picking them up. We did not know the radio was useless and that the destroyers had not been receiving the messages.

"All the crew thought the sea would moderate, but the plane was so badly damaged in the high billows that we were unable to rise again.

"We were 60 miles southwest of Pico when we alighted, the position being where we had figured we were before coming down.

"The clearing of the weather proved only temporary, for later a storm came up and continued for 48 hours. With both lower wings wrecked, the pontoons lost, and the hull leaking, and the tail of the machine damaged, the plane was tossed about like a cork.

"In order to conserve the remaining 170 gallons of fuel we decided to 'sail' landward, hoping to sight a destroyer on the way. But we did not pass a single ship until we reached Ponta Delgada. Off the port we declined proffered aid by the destroyer *Harding*, which had been sent out to meet us, and 'taxied' into port under our own power.

"During the two days' vigil of seeking land or rescue ships we fired all our distress signals, none of which apparently were seen.

"Without informing the crew of the fear that I had that we would be lost, I packed our log in a waterproof cover, tied it to a life-belt, and was prepared to cast it adrift when the NC-3 sank.

"The nervous strain was terrible while we were drifting, and the men smoked incessantly. This was the only thing that kept them awake.

"I believe a transatlantic flight is practicable without a stop with planes a little larger than the NC type. The engines of all three of the planes worked perfectly, and could have run 6,000 miles more if there had been sufficient fuel on board.

"Wire trouble in the instrument board was the mechanical defect experienced by the NC-3."

Commander Bellinger's Story

(*From "New York World"*)

Horta, Azores, May 22.—"At 22.10 Greenwich time (6.10 P. M. New York time) the NC-1 left the water and took up her position in the formation astern of the NC-3 and NC-4, bound for the Azores, to land at Horta or Ponta Delgada, depending on the gasoline consumption.

"The NC-1 got away with difficulty due to the heavy load she carried. Finally, after a long run on the surface, she reached planing speed and hopped off. The Three and Four were far ahead. We could just make out the number '4' in the distance. When night came we lost sight of the other plane entirely.

"No. 1 station ship we passed on the port hand. It made us feel good to see our solid friend below us, while we were passing over an array of icebergs which resembled gigantic tombstones. The course we followed took us over one iceberg just at dusk. Our altitude then was 1,000 feet, which gave us room and to spare.

"The other station ships, placed 50 miles apart, we passed in their regular order, some on one side and some on the other. We found that star-shells fired by the station ships at night were visible for a much greater distance than were the rays of the search-lights. On one occasion two ships were visible to us at the same time.

"The night was well on before the moon rose, and we wondered whether the sky would prove to be clear or overcast. Luckily it was a partially clear moon that rose bright and full, and though passing clouds sometimes obscured it, the sky could always be sufficiently defined to be of inestimable aid to the pilots controlling the plane.

"We flew along at an altitude of 1,200 feet, and got the air drift during the night from the dropping flares, sighting on them with the drift indicator. The air was slightly lumpy through the night. A station ship full in the rays of the moon was almost passed without being seen by us. Then it focussed its search-light upon us to attract our attention.

"Nobody on board the NC-1 slept during the entire flight. The time passed very quickly, and we found the work of watching for the station ships and checking the air drift very interesting. Hot coffee and sandwiches were available for all hands throughout the flight.

"Finally, the glow of the dawn appeared in the east and soon thereafter the sun arose. The motors were hitting beautifully, and we were making a good 70 miles per hour. Everybody was feeling fine and confident that nothing could stop us making Ponta Delgada.

Plane Runs into a Thick Fog

"But soon we began to encounter thick overcast patches and the visibility became poor. As we went through one thick stretch, station ship No. 16 loomed dead ahead of us. Some of the station ships radioed weather reports to us. We passed No. 17, on the port hand, at a distance of 12 miles at 10.04 (6.04 New York time), and shortly thereafter, while we were flying at an altitude of 600 feet, we ran into a thick fog.

"The pilots climbed to get above the fog, for it was very dense and bedimmed their goggles and the glass over the instruments very quickly. It was almost impossible to read the instruments. Pilots Barin and Mitscher did excellent work and brought the plane to an altitude of 3,000 feet, well above the fog. For a while there the sight was a beautiful one, but none of us could appreciate it. We could not see the water through the fog, and we could not determine how far we were drifting.

"We dodged some fog, but soon encountered more. We continued on, side-slipping and turning in an effort to keep on our course, until 12.50 (8.50 A. M. New York time), when we decided to come down near the water and get our bearings, intending then to fly underneath the fog. We came down to an altitude of 75 feet. The visibility there was about half a mile. The air was bumpy and the wind shifted from 350 to 290 magnetic.

"We changed our course to conform with the new conditions, and sent out radio signals requesting compass bearings by wireless. We decided to land if the fog thickened. A few minutes thereafter we ran into a low, thick fog. I turned the plane about and headed into the wind, landing at 13.10 (9.10 A. M. New York time), after flying a total of 15 hours.

"The water was very rough; much too rough to warrant an attempt to get away again. The outlook was exceedingly gloomy. We realized that we could not go on, and must wait where we were to be picked up. The wind and the condition of the water prevented our taxiing over the sea to windward, and we soon found that radio communication between the plane and the ships was difficult and unsatisfactory.

"We put over a sea-anchor shortly after we alighted, but it was carried away almost immediately. Then we rigged a metal bucket as a sea-anchor, and that did a great deal of good. The wings and tail of the NC-1, however, got severe punishment from the rough sea, and the fabric on the outer and lower wings was slit to help preserve the structure. In an effort to reduce the punishment to the plane, too, I kept one of the centre motors running, but nevertheless both the wings and the tail were badly damaged.

"It looked for some time as if the plane would capsize. All hands realized the danger we were in, but none of them showed the slightest fear. At 17.40 (1.40 P. M. New York time) we sighted a steamer, hull down, and sent a radio message to her. Then we taxied in her direction. The ship proved to be the

Ionia. She had no wireless. After a little she sighted us. Then the fog shut down again and the ship disappeared from view.

"Later, when the fog cleared, we saw that the ship was heading for us. We got alongside at 19.20 (3.20 P. M. New York time), and at 2.20 were on board the *Ionia.* An effort was made to tow the plane, but the line parted. A destroyer came alongside at 00.35 (8.35 P. M. New York time) and took charge of the NC-1. The *Ionia* landed us at Horta. The plane was left at latitude 29 degrees, 58 minutes, longitude 30 degrees, 15 minutes."

History of Navy's Great Ocean Flight

November, 1917—Conference between navy and Curtiss engineers at Washington, D. C.

January, 1918—Working model tested in wind-tunnel. Found practical.

October, 1918—Trial flight of NC-1 at Rockaway Beach, Long Island.

November, 1918—NC-1 makes long-distance trip from Rockaway to Anacostia, D. C., 358 miles, in 5 hours 19 minutes.

February, 1919—NC-2 climbs 2,000 feet in five minutes.

February 24, 1919—Secretary of Navy orders four planes to be prepared for transatlantic flight.

April 3, 1919—NC-2 found to be impractical in design of hull, and is taken out of the flight. NC-3 and NC-4 assembled at Rockaway.

May 7—NC-4 damaged by fire while in hangar. Wings replaced. Elevators repaired.

May 8—Three planes leave Rockaway for Trepassey Bay, Newfoundland.

May 8—NC-3 and NC-4 arrive at Halifax, N. S. (450 miles).

NC-4 forced down by motor trouble. Puts in at Chatham Bay, Mass., for repairs after riding the waves all night.

May 10—NC-1 and NC-3 proceed from Halifax to Trepassey in 6 hours 56 minutes (460 miles).

May 14—NC-4 flies from Chatham to Halifax in 4 hours 10 minutes at 85 miles an hour.

May 16—Three planes leave Trepassey Bay for Azores, 1,250 miles.

NC-4 lands at Horta, Azores, in 15 hours 18 minutes.

NC-1 drops in ocean half hour from Flores. Crew rescued; seaplane a total wreck.

NC-3 lost in storm. Forced to descend 205 miles from destination.

May 19—NC-3 arrives at Ponta Delgada riding waves under own power. Wings and hull wrecked. Engine-struts broken. Out of race.

May 20—NC-4 flies from Horta to Ponta Delgada, Azores, 160 miles, in 1 hour 44 minutes.

May 27—NC-4 flies from Ponta Delgada to Lisbon, Portugal, 810 miles, in 9 hours 43 minutes. Flying time from Newfoundland to Portugal (2,150 miles), 26 hours 45 minutes.

May 30—NC-4 flies from Lisbon to Ferrol, Spain, 300 miles, after a halt at Mondego, 100 miles north of Lisbon, owing to engine trouble.

May 31—NC-4 flies from Ferrol, Spain, to Plymouth, England, 400 miles, without a hitch, thus completing the transatlantic flight as scheduled.

British Efforts to Fly the Atlantic

Captain Hawker, with his Sopwith, was the first to get to St. John's on March 4. He was quickly followed by Captain Raynham and his Martinsyde.

Owing to the constant bad weather which has obtained for seven weeks, the British fliers had not dared to attempt the flight until Sunday, May 18, when Hawker and Raynham started. Everything from snow to the 70-mile gale which blew on April 15 has been experienced at St. John's. The storm continued throughout that and the next morning. The mechanicians at the hangars of the two flying-camps spent the night watching and guarding the aeroplanes. The Martinsyde plane, which was housed in one of the portable canvas hangars used by the British army in the war, was in danger of injury for a time, when the gale ripped up the pegs that anchored the canvas flies of the hangar, and for a time threatened to snatch the whole thing into the air. These storms have made the grounds impossible for taking off, and as the fliers hoped to take advantage of the full moon, which was beginning to gradually wane, the opportunities for flying by moonlight disappeared and a second moon was on the wane before they started.

On March 4 Captain Hawker landed at St. John's, Newfoundland, with his Sopwith plane, and his five mechanics began to assemble the machine, which follows the general lines of construction adopted by the Sopwith war-plane designers. It is 46 feet wide and 31 feet long, with a flight duration of 25 hours at 100 miles an hour. During a daylight-to-dusk duration test Commander Grieve and Pilot Hawker covered over 900 miles in 9 hours 5 minutes, exactly half the distance between Newfoundland and Ireland. The Rolls-Royce engine develops 375 horse-power at 1,800 revolutions of the crank-shaft. A four-bladed propeller is used geared down to 1,281 revolutions. The Sopwith machine weighs 6,000 pounds fully equipped for the transatlantic flight. In the trial test the engine consumed 146 gallons of petrol—slightly over one-third the capacity of the tanks, which are placed behind the engine and in front of the cockpit in which Major Hawker and Commander Grieve sit.

At the end of the 900-mile tryout the engine developed exactly the same power as at the start, which leads Major Hawker to believe the engine will continue to perform the same for the rest of the distance.

Major Hawker proposed leaving St. John's, Newfoundland, about 4 o'clock in the afternoon, and travelling through the night they hoped to pass the south coast of Ireland shortly before noon the following day, English time, arriving at the Brooklands aerodrome, near London, at 4 o'clock, a total flying time of 19 hours and 30 minutes.

In case they were forced to descend into the sea, the "fairing" of the fuselage is so constructed that it forms a boat large enough to support the two men in the water for some time. In addition they wear life-saving jackets. A medical officer in the British Air Ministry made up some scientific food sufficient for forty-eight hours. This includes sugar, cheese, coffee, sandwiches, and tabloids.

Major Harry Hawker

Major Harry Hawker is an Australian, just 31. He is the highest paid flier in the world. He was a bicycle mechanic in Australia when he went to England in 1912 and became an aeroplane mechanic. In 1912 he joined the T. O. M. Sopwith Company, and a year later he came to the United States and flew in "Tim" Woodruff's Nassau Boulevard meet. Hawker returned to England, and about a year later entered the famous "round England flight."

On October 24, 1912, in a Sopwith biplane, designed after the pattern of the American Wright, and driven by a 40 horse-power A B C engine, he put up the British duration record to 8 hours and 23 minutes, thus winning the Michelin Cup for that year.

On May 31, 1913, in a Sopwith tractor biplane, with an 80 horse-power Gnome engine, he put up the British altitude record for a pilot alone to 11,450 feet, and on June 16 of the same year, in the same machine, he hung up a record, with one passenger, of 12,900 feet.

On the same day he took up two passengers to 10,600 feet, and on July 27 took up three passengers to 8,400 feet, all of which were British records.

In 1913 and 1914, in a Sopwith seaplane, Hawker made two attempts to win the *Daily Mail's* $25,000 prize for a flight on a seaplane around Great Britain. The first time he was knocked out by illness at Yarmouth, and the second time he met with an accident near Dublin.

During the last three years Hawker has been test pilot for the Sopwiths, receiving $125 for each flight, and sometimes making a dozen in a single day. His annual earnings in this period are estimated at $100,000.

Commander Grieve

Commander Mackenzie Grieve is 39 years old. He has not been connected with aeronautics for any great length of time, but is an officer of the Royal navy, who has specialized on navigation and wireless telegraphy and telephony. He has been strongly commended by the Admiralty for his work in this direction, and has been chosen as a navigator on the cross-sea trip because he has combined two branches of a naval officer's work, which are not, as a rule, made the subject of specialization by one man, but both of which are essential to such a feat as a transatlantic flight.

Test Flights of the Sopwith

On April 11 Major Harry Hawker made a successful test flight at St. John's.

The wireless station there sent messages to the aviator which he was unable to pick up, but the station at Mount Pearl kept in continual touch with the machine through all the flight. After his flight the flier said that his speed while in the air had been on an average of 100 miles an hour.

The Martinsyde Plane Arrives

On April 2 Captain Frederick Phillips Raynham, the pilot of the Martinsyde aeroplane, and Captain Charles Willard Fairfax Morgan, navigator, arrived at St. John's and began to make preparations for setting up their canvas hangar which was to house their aeroplane. The aerodrome selected was at the Quid Vivi. This site had been selected by Major Morgan about three months ago, and the tent was set up on that field as per the plans and specifications.

The biplane weighs, fully loaded, about 5,000 pounds and carries 360 gallons of gas, while the Sopwith weighs about 6,100 pounds and carries only 350 gallons. Raynham says he has a cruising radius of 2,000 miles with a twenty-mile head wind against him all the way across. But as the prevailing winds are from west to east, he expects to fly with the wind most of the way. The machine was designed by G. H. Handasyde, who has had many years' designing experience in co-operation with H. P. Martin, chairman of Martinsydes.

The reappearance in the transatlantic attempt of a

Martinsyde plane as a competitor for the *Daily Mail* prize recalls that the firm as early as 1914 entered for a transatlantic competition, having completed a monoplane which was to have started from St. John's, the scene of the present venture. This machine was to have been flown by Gustave Hamel, who, it will be remembered, while flying from London to Paris, came down at Calais, ascended again, and has never since been heard of. He is believed to have been drowned in the North Sea, for no trace of his machine was ever found.

Captain Raynham

Captain Raynham is 25 years old. He began to fly at 17, being the possessor of half a dozen of the oldest flying licenses in England. Most of his experience has been in experimental and test flying.

Raynham went with Martinsydes in the early development days of 1907, and was with them when they began monoplane production in 1908. This they continued until the war began, when they turned to building biplanes, the present machine being only a very slight modification of their latest fighting scout.

The Martinsyde biplane was not especially designed for the transatlantic flight, but was taken from stock. It still carries its original fighting equipment, similar to that used during the war. The machine is named the "Raymor," a combination of the names Raynham and Morgan.

The machine has a wing span of 41 feet and a lifting area of 500 square feet; over-all length, 26 feet; height, from ground to top of propeller, 10 feet 10 inches. The engine is a Rolls-Royce "Falcon," which is rated at 285 horse-power. It has a capacity of developing up to 300 horse-power at a speed of 100 to 125 miles per hour. The cruising radius is 2,500 miles.

The Martinsyde machine carries no life-saving apparatus of any kind. Tanks are provided for fuel capacity of 375 gallons, sufficient for a flight of 25 hours at 100 miles per hour. Raynham's idea is to make an ascent at an angle of 3 degrees until an altitude of 1,500 feet is reached. This altitude would be attained in 24 hours, at which time land on the other side would be within planing distance.

Captain Woods's Attempted Flight to America

The aeroplane of the Shortt brothers, one of the entries for the $50,000 race across the Atlantic, was to start from Ireland for Newfoundland. The machine is expected to make the journey in twenty hours, but owing to a defective carburetor the machine fell in the Irish Sea while making the flight from England to Ireland. Captain Woods was rescued, but no further news has been received of the preparations for the flight.

The Shortt brothers had chosen the Limerick section of Ireland for their starting-point. It is considered likely that the Shortt trial will be the only east-to-west attempt, all of the other entries in the

Daily Mail's contest having indicated their intention of flying eastward because of the strong head winds from the west.

The machine entered by the Shortt brothers is the Shortt "Shiel" aeroplane. It is fitted with a 375 horse-power Rolls-Royce engine, developing a speed of ninety-five miles an hour. The machine carries a pilot and a navigator. Of biplane type, the machine, its makers say, is capable of a 3,200 mile non-stop drive.

In their application to the British Air Ministry, the Shortts designated Major James C. P. Woods, of the Royal Flying Corps, as pilot, with Captain C. C. Wylie. In addition to his experience in the air, Major Woods had considerable experience as a navigator on destroyers guarding troop-ships through the Atlantic submarine zone. Major Woods, who has flown more than 10,000 miles, gained fame as a bomber in France.

The latest contestant to arrive at St. John's was the Handley Page Berlin Bomber which was landed on May 10. The biplane is the only one to be compared with the United States navy flying-boats in size. The wing spread is 126 feet, the chord 12 feet. The total weight of the machine is about 16,000 pounds. It carries 3 pilots, 3 mechanics, 2 wireless operators, and 2,000 gallons of gas. The wireless is long enough to keep in touch with both shores all the way. The route is to Limerick, Ireland. The machine has four Rolls-Royce motors of 350 horse-power, and the aeroplane is taken from stock. They expect to travel 90 miles per hour.

One of the pilots is Colonel T. Gran, the Norwegian who first flew from Scotland to Norway in August, 1914. He was a member of the British R. A. F. and also with Captain Scott in the South Polar Expedition.

Major Brackley has had perhaps as much experience in night flying as any living man, and Admiral Mark Kerr is one of the oldest pilots in England. He was the sixth to be granted a pilot's license in England.

Hawker's Story of Atlantic Flight

Thurso, Scotland, May 26.—Harry Hawker and Mackenzie Grieve gave the London *Daily Mail* an outline of their historic flight. Hawker told his story simply as follows:

"We had very difficult ground to rise from on the other side. To get in the air at all we had to run diagonally across the course. Once we got away, we climbed very well, but about ten minutes up we passed from firm, clear weather into fog.

"Off the Newfoundland banks we got well over this fog, however, and, of course, at once lost sight of the sea. The sky was quite clear for the first four hours, when the visibility became very bad. Heavy cloud-banks were encountered, and eventually we flew into a heavy storm with rain squalls.

"At this time we were flying well above the clouds at a height of about 15,000 feet.

"About five and one-half hours out, owing to the choking of the filter, the temperature of the water cooling out the engines started to rise, but after coming down several thousand feet we overcame this difficulty.

"Everything went well for a few hours, when once again the circulation system became choked and the temperature of the water rose to the boiling-point. We of course realized until the pipe was cleared we could not rise much higher without using a lot of motor power.

"When we were about ten and one-half hours on our way the circulation system was still giving trouble, and we realized we could not go on using up our motor power.

"Then it was we reached the fateful decision to play for safety. We changed our course and began to fly diagonally across the main shipping route for about two and a half hours, when, to our great relief, we sighted the Danish steamer which proved to be the tramp *Mary*.

"We at once sent up our Very light distress signals. These were answered promptly, and then we flew on about two miles and landed in the water ahead of the steamer.

Impossible to Salve Machine

"The sea was exceedingly rough, and despite the utmost efforts of the Danish crew it was one and a half hours before they succeeded in taking us off. It was only at a great risk to themselves, in fact, that they eventually succeeded in launching a small boat, owing to the heavy gale from the northeast which was raging.

"It was found impossible to salve the machine, which, however, is most probably still afloat somewhere in the mid-Atlantic.

"Altogether, before being picked up, we had been fourteen and a half hours out from Newfoundland. We were picked up at 8.30 (British summer time).

"From Captain Duhn of the *Mary* and his Danish crew we received the greatest kindness on our journey home. The ship carried no wireless, and it was not until we arrived off the Butt of Lewis that we were able to communicate with the authorities.

"Off Loch Eireball we were met by the destroyer *Woolston* and conveyed to Scapa Flow, where we had a splendid welcome home from Admiral Freemantle and the men of the Grand Fleet."

Commander Mackenzie Grieve, the navigator of the Sopwith, said:

"When but a few hundred miles out a strong northerly gale drove us steadily out of our course. It was not always possible, owing to the pressure of the dense masses of cloud, to take our bearings, and I calculate that at the time we determined to cut across the shipping route we were about 200 miles off our course.

"Up to this change of direction we had covered about 1,000 miles of our journey to the Irish coast."

Vickers "Vimy" Bomber Makes First Non-Stop Flight from America to Europe

Leaving St. John's, Newfoundland, at 12.13 P. M. New York time on Saturday, June 14, the Vickers

"Vimy" bomber, bimotored Rolls-Royce aeroplane, with two four-bladed propellers, and piloted by Captain John Alcock and navigated by Lieutenant Arthur W. Brown, landed at Clifden, Galway, Ireland, at 4.40 A. M. New York time, aerially transnavigating 1,960 miles of the Atlantic Ocean, from the New World to the Old, in 16 hours and 12 minutes, or at an average rate of 120 miles an hour. Although the moon was full, the fog and mist was so dense that the aviators could not see the moon, sun, or stars for fourteen out of the sixteen hours in the air. During the flight they flew through atmosphere so cold that ice caked on the instruments. Nevertheless, the engines functioned consistently throughout the journey, which was, in many ways, as remarkable as the voyage of "The Ancient Mariner," whom Coleridge's poem of that name describes.

Unfortunately, the small propeller which drives the dynamo and generates the current for the wireless radio instruments had jarred loose and blown away shortly after the machine ascended into the air, and the atmosphere was so surcharged with electricity that Lieutenant Brown could not get any radio messages through, and the airship was lost to the world for over sixteen hours. During the flight the men experienced many thrills, primarily because they had no sense of horizon, due to the thick fog which prevailed most of the way over. Under those conditions the navigation was remarkable, and when the aviators saw the aerials at Clifden they were delighted. In landing they mistook the bog for a field, and consequently made a bad landing, for the machine sank into the bog and stuck there badly damaged in the wing.

Captain Alcock's Story

Describing the experiences of himself and Lieutenant Brown, Captain Alcock, in a message from Galway to the London *Daily Mail,* which awarded them the $50,000 prize for making the first non-stop flight across the Atlantic between Europe and America, said:

"We had a terrible journey. The wonder is that we are here at all. We scarcely saw the sun or moon or stars. For hours we saw none of them. The fog was dense, and at times we had to descend within 300 feet of the sea.

"For four hours our machine was covered with a sheet of ice carried by frozen sleet. At another time the fog was so dense that my speed indicator did not work, and for a few minutes it was alarming.

"We looped the loop, I do believe, and did a steep spiral. We did some comic stunts, for I have had no sense of horizon.

"The winds were favorable all the way, northwest, and at times southwest. We said in Newfoundland that we could do the trip in sixteen hours, but we never thought we should. An hour and a half before we saw land we had no certain idea where we were, but we believed we were at Galway or thereabouts.

"Our delight in seeing Eastal Island and Tarbot Island, five miles west of Clifden, was great. The people did not know who we were, and thought we were scouts looking for Alcock.

"We encountered no unforeseen conditions. We did not suffer from cold or exhaustion, except when looking over the side; then the sleet chewed bits out of our faces. We drank coffee and ale, and ate sandwiches and chocolate.

"Our flight has shown that the Atlantic flight is practicable, but I think it should be done, not with an aeroplane or seaplane, but with flying-boats.

"We had plenty of reserve fuel left, using only two-thirds of our supply.

"The only thing that upset me was to see the machine at the end get damaged. From above the bog looked like a lovely field, but the machine sank into it to the axle, and fell over on to her side."

Alcock Has Spent 4,500 Hours in Air

There are few fliers, living or dead, who have passed as many hours in the air as Captain John Alcock, the twenty-seven-year-old pilot of the first aeroplane to make a non-stop flight across the Atlantic. This officer of the Royal Air Force has flown more than 4,500 hours. The one man who is known to have passed more time in the air is Captain Roy N. Francis, U. S. A.

Big, blond, and ruddy, Captain Alcock is typically English in appearance, voice, and mannerisms. His eyes are blue, and his hair, brushed straight back, is almost flaxen. He is more than six feet in height and heavy of frame. Powerful wrists and forearms attest to many hours of tinkering with heavy machinery.

Alcock, who was born in Manchester in 1892, was apprenticed at seventeen to the Empress Motor Works, a firm interested at that time in the development of an aeroplane engine. Alcock helped to build the first aero engine made at that plant, and meanwhile developed the flying fever.

Then he started experimenting with gliders, and in 1911 began to fly. He earned his certificate the following year, and in 1913 won the first race in which he ever had entered. Shortly afterward he took second place in the London to Manchester and return competition, at that time one of the most famous air-races.

In one of those early competitions Alcock beat Frederick Raynham, the pilot of the Martinsyde which was injured in trying to get off for the transatlantic flight with Hawker, whose effort to cross the ocean in a Sopwith ended in mid-ocean a few weeks ago.

From the fall of 1914 to the fall of 1916 Alcock was an instructor of flying at Eastchurch, where he trained some of the best-known fliers of England. One of these was Major H. G. Brackley, pilot of the Handley Page bomber, which has been sent to Newfoundland in the hope that it could get away first on the "hop" across the Atlantic.

From Eastchurch Alcock went to the Dardanelles.

There he won the Distinguished Service Cross as an ace, and it is the gossip of the air force that if he had not fallen prisoner to the Turks his rank would have been much higher. He has seven enemy planes to his credit.

It was his bombing work that attracted most attention, however, for he made a raid on Adrianople and dropped a ton of bombs, destroying 3,000 houses, blowing up an ammunition-train, and razed a fort. Out of the thirty-six bombs he dropped on that expedition twenty were incendiary and sixteen high-explosive. Accurate knowledge of the damage he had inflicted on that September day in 1917 did not come until after the armistice was signed, but Alcock did not have to wait until the armistice to discover that his adventure had been a military success. Ninety miles from Adrianople on his return flight he could still see the glare in the sky from the fires his bombs had ignited.

He was the first man to bomb Constantinople, and it was on his return from his second bombing expedition over the Turkish capital that one of the engines in his twin Handley Page failed him. He managed to fly seventy-six miles on the other engine before he was forced to descend on the island of Imbros, within twelve miles of the home station.

But that twelve miles meant all the difference between friends and enemies, and the aviator was taken prisoner and confined in the civil jail. Later he was removed to Constantinople and then to Asia Minor, where he was held until the armistice was signed. He returned to England December 16, 1918.

Immediately upon his return Alcock joined the Vickers concern as a test pilot. It was due to his persuasion that the conservative directors of the concern, which controls the British Westinghouse works, committed themselves to the enterprise of entering an aeroplane in the transatlantic flight for the *Daily Mail* prize of $50,000 for the first non-stop flight.

America Shares Alcock's Triumph

There is hardly any comparison to be made between Captain Alcock and his navigator, Lieutenant Arthur Whitten Brown. While Alcock is large of frame, Brown is a full head shorter and boyish in build. There are gray threads in Brown's hair, mementoes of twenty-three months in a German prison-camp. His left foot is crippled, too, the result of a crash when he was brought down by German anti-aircraft guns behind the German lines at Bapaume.

Brown is an American born of American parents in Glasgow in 1886. His father was connected with George Westinghouse in the development of an engine. It was that engine that took him to the British Isles, and he took part in the organization of the British Westinghouse Company, now controlled by Vickers, Limited, the concern which built the plane in which the transocean flight was made.

Lieutenant Brown

Lieutenant Brown's mother was a member of the Whitten family of Pittsburgh, and his grandfather fought with the famous Hampden's Battery at Gettysburg. Brown himself has lived in Pittsburgh, where he went to continue the studies at the Westinghouse works that had begun in the works in England.

He enlisted in the university and public school corps in 1914, and in 1915 took his wings. Most of his service was as an observer and reconnoissance officer. One time the machine in which he flew as an observer was shot down in flames. He says of that experience that he "was burned a bit," but was glad enough to escape capture. The machine he was in crashed. He passed nine months in a German hospital and fourteen more months in a German prison-camp, and then was repatriated by exchange. He spent the latter days of the war period in productions work for the Ministry of Munitions.

Lieutenant Brown has never been a navigator in any but an amateur way. Navigation with him is simply a hobby, and on his frequent crossings of the Atlantic, he says, he never failed to persuade the captain of his ship to allow him on the bridge to take a shot at the sun.

The flight across the Atlantic, Brown said, would be his last, for he is engaged to be married to Miss Kennedy, the daughter of a major of the Royal Air Force, and they are planning to pass their honeymoon (and his share of the prize-money) on a trip around the world. After that they are coming to America, and Lieutenant Brown plans to engage in the practice of electrical engineering.

"Vimy" Designed to Bomb Enemy Towns

The twin-engined Vickers-Vimy plane in which the English pilot and his American navigator crossed to Ireland has a 67-foot 2-inch wing spread. The length over all is 42 feet 8 inches; gap, 10 feet; chord, 10 feet 6 inches. It is a bombing-type plane, and its conversion to a peace-time adventure was accomplished by replacing the fighting equipment with tanks of a total gasoline capacity of 870 gallons, weighing more than 6,000 pounds.

The two Rolls-Royce Eagle 375 horse-power engines are mounted between the upper and lower planes on either side of the fuselage.

The outstanding feature of the Vimy is the strength and elasticity of its construction, accomplished by the use of hollow, seamless steel tubing. This type of construction extends from the nose to well behind the planes.

The Vimy has a sturdy double under-carriage, with a two-wheeled chassis placed directly under each engine. Fully loaded the craft weighs a trifle more than 13,000 pounds. Even distribution of eight separate tanks and a cleverly arranged feeding system whereby the fuel is consumed at the same rate from all eight not only insured a well-balanced plane but promised an "even keel" had the fliers been forced down on the surface of the ocean.

A gravity-tank at the top of the fuselage was arranged to be emptied first, so it could serve as a life-raft any time after the first two hours of the flight, which period was necessary to exhaust the load of gasoline contained in that tank.

The Vimy's radio apparatus is the standard type used by the Royal Air Force, and was lent to Alcock by the British Air Ministry. It is similar to that carried by Hawker's Sopwith. The transmitting radius of this type of radio is placed at 250 miles. Messages can be received from a much greater distance.

Vimy Flight Sets New World's Distance Record

The 1,690-mile flight of the Vickers "Vimy" Bomber, carrying Alcock and Brown, establishes a new world's record, breaking the one made by Captain Boehm in a Mercedes-driven Albatross plane, which flew for 25 hours and 1 minute and covered 1,350 miles.

The year 1914, just previous to the war, was the most prolific in long-distance flights. On June 23 the German aviator Basser covered 1,200 miles in a Rumpler biplane in 16 hours and 28 minutes.

The same day Landsmann, another German, drove an Albatross machine 1,100 miles in 17 hours and 17 minutes, and four days later 1,200 miles in 21 hours and 49 minutes.

The nearest approach to Boehm's record was made on April 25 last, when Lieutenant-Commander H. B.

Grow, U. S. N., flew a twin-engine F-5-L flying-boat a total distance of 1,250 miles in 20 hours and 20 minutes.

Lieutenant-Commander A. C. Read, in his hop on the NC-3 from Trepassey Bay to Horta in the Azores, broke no distance records in the 1,200 nautical miles he flew, but shattered the record for speed, making an average of 103.5 miles an hour.

The French pre-war record was on April 27, 1914, by Paulet, who flew 950 miles in 16 hours and 28 minutes. Since the war the French aviators Coli and Roget flew from Villacoublay, near Paris, to Rabat, Morocco, a distance of 1,116 miles without stopping. The engine was a 300 horse-power Renault, and constitutes the longest single-motor non-stop flight on record. Miss Ruth Law holds the record for long-distance flight by a woman. On November 19, 1916, she covered the 590 miles from Chicago to Hornell, N. Y., in 5 hours and 45 minutes.

THE FIRST TRANSATLANTIC FLIGHT OF THE R-34

After a flight of 108 hours, the British dirigible which left Scotland at 2 A. M. July 2, arrived at Roosevelt Field, Mineola, Long Island, N. Y., at 9 A. M., Sunday, July 6, after a flight via Newfoundland and Halifax. Owing to the strong head winds and fog which prevailed the most of the journey the huge airship was delayed two days in its flight, and there was for some time grave doubt that she would arrive on her own gasoline, for the supply was running low, and the aid of destroyers was requested by wireless from the R-34.

As soon as the airship arrived over Roosevelt Field, Major John Edward Maddock Pritchard landed upon American soil, after a parachute drop of 2,000 feet.

This completed the longest flight in history, the distance covered being 3,200 miles, not counting the mileage forced upon the flyers by adverse winds. The time consumed was a few minutes more than 108 hours. The big airship brought over thirty-one persons, one of whom was a stowaway, and a tortoise-shell cat.

A fortunate turn of the wind at about 2 o'clock Sunday morning made the success of the flight possible. Four times on Friday night and early Saturday morning heavy squalls and thunder-storms had threatened to cripple or smash the flying colossus.

During the worst of the storm on Friday night the big airship was suddenly tossed aloft 500 feet and pitched about like a dory in a heavy sea. For a time there was great danger that a vital part would be smashed and a landing forced on the rough water, but the workmanship and material in every part of the 630-foot air giant proved flawless, and Commander Scott got his craft safely through.

In response to calls for aid 200 men were sent from Mineola to Montauk Point, Long Island, where it was at first hoped the R-34 might be towed by the torpedo-boats sent out to aid the airship. The sudden shift in the wind decided Major Scott to continue the flight to Mineola as originally planned.

At 8.35 A. M. the R-34 became visible from Mineola Field, looking at first like a splinter split off from the bluish horizon in the northeast. A thin line of light beneath it made it distinguishable at first at a distance of about twenty miles. Slowly it disengaged itself from the blurring lines where the earth and sky met, and gradually its bulk began to develop. As it approached the field it rose for better observation, and at about 9 o'clock stood out in the sky in its full super-dreadnought proportions, its painted skin responding to the sun, which had become bright a few minutes before, and giving off a dull, metallic gleam between lead and aluminum in tint.

It glided through the air with such smoothness as to give the suggestion that it was motionless and the spectator moving. Like the buzz of a midsummer noontime, the hum of its motors produced no disturbing effect on the quiet.

The ship approached the landing-place at a height of about 2,000 feet, coming from the east-northeast, and passing first over Mitchel Field. It swung around the skirts of Roosevelt Field, while its commanders studied the details of the landing-place. The manœuvres for observation took the dirigible three times around the field before she came to a stop. After 9.11 it shut off its motors, and hovered, like a fixed object, 2,000 feet above the ground.

The time of the R-34 for the transatlantic crossing is slightly greater than the steamship record made by the *Mauretania*, which, in September, 1909, made the trip from Queenstown to New York in 4 days, 10 hours, and 41 minutes. This is better by approximately 2 hours than the time of the dirigible, which took 4 days, 12 hours, and some odd minutes. The R-34, however, starting from Edinburgh, covered a much greater distance. The rate of speed of the R-34 in covering the 3,200 miles was 29⅝ knots per hour.

Airship Landed

The crew sent the cableoon and it made a bull's-eye in the drop, falling squarely over the main anchor. The workmen, who rushed to catch it on the bound, were flung to the ground and rolled about, as if by the lash of a gigantic whip, but they subdued it in a second and rushed with it to the iron ring. An instant later it was dragged through this opening and the gas-bag was secured. A few moments later the crews of men were pinning it down like Gulliver, attaching anchors all along the hull to prepared anchorages of concrete and steel, sunk deeply into the earth.

The British officers, accompanied by their American guest, Lieutenant-Commander Zachary Lansdowne, climbed out of the gondola to receive the official greetings of the government of the United States and the hearty congratulations of brother seamen and flyers in American and British uniforms. Those who expected to find them worn and wan from their unparalleled experience were astonished to see them all in the finest fettle and spirits, ruddy and vigorous, wide-awake, and full of fun.

The crew followed them to land, on which none had set foot for nearly five days, all the members being in good health and spirits, except one man, who had suffered a smashed thumb, the only accident of the cruise.

THE OFFICIAL LOG OF R–34 TRANSATLANTIC FLIGHT BY BRIGADIER–GENERAL E. M. MAITLAND, C. M. G., D. C. O., REPRESENTING THE BRITISH AIR MINISTRY

Atlantic flight by rigid airship R-34, from East Fortune, Scotland, to Long Island, New York, via Newfoundland:

Distances covered were as follows: East Fortune to Trinity Bay, Newfoundland, 2,050 sea-miles. Trinity Bay, Newfoundland, to New York, 1,080 sea-miles.

It was originally intended that this flight should have taken place at the beginning of June, but owing to the uncertainty of the Germans signing the peace terms the British Admiralty decided to detain her for an extended cruise up the Baltic and along the German coast-line. This flight occupied 56 hours under adverse weather conditions, during which time an air distance of roughly 2,400 miles was covered.

At the conclusion of this flight the ship was taken over from the Admiralty by the Air Ministry, and the airship was quickly overhauled for the journey to the United States of America.

The date and time of sailing decided upon was 2 A. M. on the morning of Wednesday, July 2, and the press representatives were notified by the Air Ministry to be at East Fortune the day previously.

Started Ahead of Schedule

At 1.30 A. M. on the morning of Wednesday, July 2, the airship was taken from her shed and actually took the air 12 minutes later, thus starting on her long voyage exactly 18 minutes in advance of scheduled time.

1.42 A. M., Wednesday, July 2.

The R-34 slowly arose from the hands of the landing party and was completely swallowed up in the low-lying clouds at a height of 100 feet. When flying at night, possibly on account of the darkness, there is always a feeling of loneliness immediately after leaving the ground. The loneliness on this occasion was accentuated by the faint cheers of the landing party coming upward through the mist long after all signs of the earth had disappeared.

The airship rose rapidly 1,500 feet, at which height she emerged from the low-lying clouds and headed straight up the Firth of Forth toward Edinburgh.

A few minutes after 2 o'clock the lights of Rosyth showed up through a break in the clouds, thus proving brilliantly that the correct allowance had been made for the force and direction of the wind, which was twenty miles per hour from the east.

It should be borne in mind that when an airship gets out on a long-distance voyage carrying her maximum allowance of petrol, she can only rise to a limited height at the outset without throwing some of it overboard as ballast, and that as the airship proceeds on her voyage she can, if so desired, gradually increase her height as the petrol is consumed by the engine.

An airship of this type, when most of her petrol is consumed, can rise to a height of about 14,000 feet.

15.8 Tons of Petrol at Start

For this reason the next few hours were about the most anxious periods during the flight for Major Scott, the captain of the ship, who, owing to the large amount of petrol carried (4,900 gallons, weighing 15.8 tons), had to keep the ship as low as possible and at the same time pass over northern Scotland, where the hills rise to a height of over 3,000 feet.

Owing to the stormy nature of the morning the air at 1,500 feet—the height at which the airship was travelling—was most disturbed and bumpy, due to the wind being broken up by the mountains to the north, causing violent wind-currents and air-pockets.

The most disturbed conditions were met in the mouth of the Clyde, south of Loch Lomond, which, surrounded by high mountains, looked particularly beautiful in the gray dawn light.

The islands at the mouth of the Firth of Clyde were quietly passed. The north coast of Ireland appeared for a time, and shortly afterward faded away as we headed out into the Atlantic.

The various incidents of the voyage are set down quite simply as they occurred, and more or less in the form of a diary. No attempt has been made to write them as a connected story. It is felt that, by recording each incident in this way, most of them trivial, a few of vital importance, a true picture of the voyage will be obtained.

Time, 6 A. M., July 2.

Early Speed, 38 Knots

Airship running on four engines with 1,000 revolutions. Forward engine being given a rest. Air speed, 38 knots—land-miles per hour made good, 56.7. Course steered, 298 degrees north, 62 degrees west. Course made good, 39 degrees north, 71 west. Wind, north-east, 15⅓ miles per hour. Height, 1,500 feet. Large banks of fleecy clouds came rolling along from the Atlantic, gradually blotting out all view of the sea. At first we were above these clouds, but gradually they rose higher, and we ploughed our way into the middle of them.

7 A. M.—Nothing but dense fog, estimated by Harris, the meteorological officer, to go down to within 50 feet of the water and up to a height of about 5,000 feet.

Suddenly we catch a glimpse of the sea through a hole in the clouds, and it is now easy to see we have a slight drift to the south, which was estimated by both Scott, the captain, and Cooke, the navigating officer.

A few minutes later we find ourselves above the clouds, our height still being 1,500 feet, and beneath a cloud sky with clouds at about 8,000 feet. We are, therefore, in between two layers of clouds, a condition in which Alcock and Brown found themselves on more than one occasion on their recent flight from west to east.

An excellent cloud horizon now presents itself on all sides, of which Cooke at once takes advantage. These observations, if the cloud horizon is quite flat, ought to prove a valuable rough guide, but cannot be regarded as accurate unless one can also obtain a check on the sun by day or the moon and stars by night.

Cooke reckons it is easy to make as much as a fifty-mile error in locating one's position when using a cloud horizon as substitute for a sea horizon.

Breakfast at 1,500 Feet

7.30 A. M.—Breakfast in crew space up in the keel consisted of cold ham, one hard-boiled egg each, bread and butter, and hot tea. We breakfast in two watches, generally about fifteen in each.

The first watch for breakfast was Scott, Cooke, Pritchard, Admiralty airship expert; Lansdowne, Lieutenant-Commander, United States Airship Service; Shotter, engineer officer; Harris, meteorological officer, myself, and half the crew.

Conversation during breakfast reverted to the recent flight up the Baltic, and in the adjoining compartment the graphophone was entertaining the crews to the latest jazz tunes, such as "The Wild, Wild Women."

It might be interesting at this stage to give a complete list of the crew, showing their various duties:

Officers

ship's officers

Major G. H. Scott, A. F. C., Captain.
Captain G. S. Greenland, 1st Officer.
Second Lieutenant H. F. Luck, 2d Officer.
Second Lieutenant J. D. Shotter, Engineer Officer.
Brigadier-General E. M. Maitland, C. M. G., D. C. O., representing Air Ministry.
Major J. E. M. Pritchard (Air Ministry).
Lieutenant-Commander Z. Lansdowne, O. B. E., U. S. Naval Airship Service.
Major G. G. H. Cooke, D. S. C., Navigating Officer.
Lieutenant Guy Harris, Meteorological Officer.
Second Lieutenant R. D. Durant, Wireless Officer.
W. O. W. R. Mayes, Coxswain.

Warrant Officers and Men

engineers

Flight Sergeant Gent.
Flight Sergeant Scull.
Flight Sergeant Riplee.
Sergeant Evenden.
Sergeant Thirlwall.
Corporal Cross.
Lg. Air Craftsman Graham.

Corporal Gray.
Air Craftsman Parker.
Air Craftsman Northeast.
L. A. C. Mort.

RIGGERS

Flight Sergeant Robinson.
Sergeant Watson.
Corporal Burgess.
Corporal Smith.
L. A. C. Foreath.
L. A. C. Browdie.

WIRELESS-TELEGRAPH OPERATORS

Corporal Powell.
A. C. Edwards.

Air Ministry Sends Greetings

11 A. M.—Still ploughing our way through the fog at 1,300 feet. Sea completely hidden by clouds and no visibility whatsoever. Stopped forward and two aft engines, and now running on only two wing engines at 1,600 revolutions. These are giving us an air speed of 30 knots, or 33.6 miles per hour. This is the airship's most efficient speed, as she only consumes on the two engines twenty-five gallons of petrol per hour.

Wind is east, seven miles per hour, and so we are making good forty miles per hour and resting three engines.

Cooke is now on top of the airship taking observations of the sun, using the cloud horizon with a sextant. The sun is visible to him but not to us, the top of the ship being eighty-five feet above us down here in the fore-central cabin.

Our position is reckoned to be latitude 55 degrees 10 minutes north and longitude 14 degrees 40 minutes west, which is equivalent to 400 miles from our starting-point at East Fortune and 200 miles out in the Atlantic from the northwest coast of Ireland.

We are in wireless touch with East Fortune, Clifden, on the west coast of Ireland, and Ponta Delgada, Azores, and messages wishing us good luck are received from Air Ministry, H. M. S. *Queen Elizabeth,* and others.

11.45 A. M.—Lunch—Excellent beef stew and potatoes, chocolate, and cold water.

The talk, as usual, was mainly "shop," dealing with such problems as the distribution of air-pressure on the western side of the Atlantic, what winds were likely to be met with, what fog we should run into, the advantages of directional wireless for navigational purposes, cloud horizons, and the like.

Scott, Cooke, and Harris, in comparing their experiences and expounding their theories, were most interesting and illuminating.

12 NOON.—Watch off duty turned in for their routine four hours' sleep before coming on for their next period of duty—only two hours in this case, as it is the first of the two dog-watches.

The sleeping arrangements consist of a hammock for each of the men off watch suspended from the main ridge girder of the triangular internal keel which runs from end to end of the ship. In this keel are situated the eighty-one petrol-tanks, each of seventy-one gallons' capacity; also the living quarters for officers and men, and storing arrangements for lubricating-oil for the engines, water ballast, food, and drinking-water for the crew. The latter is quite a considerable item, as will be seen from the following table of weights:

	Gallons	Pounds	Tons
Petrol	4,900	35,300	15.8
Oil	...	2,070	.9
Water	...	...	3.0
Crew and baggage	...	...	4.0
Spares	...	550	.2
Drinking-water	...	800	.42
Total			24.32

Life in the keel of a large, rigid airship is by no means unpleasant. There is very little noise or vibration except when one is directly over the power units—a total absence of wind and, except in the early hours of dawn, greater warmth than in the surrounding atmosphere.

Getting into one's hammock is rather an acrobatic feat, especially if it is slung high, but this becomes easy with practice; preventing oneself from falling out is a thing one must be careful about in a service airship like the R-34.

There is only a thin outer cover of fabric on the under side of the keel on each side of the walking way, and the luckless individual who tips out of his hammock would in all probability break right through this and soon find himself in the Atlantic.

It is surprising the amount of exercise one can get on board an airship of this size. The keel is about 600 feet long, and one is constantly running about from one end to the other. There are also steps in a vertical ladder at the top of the ship for those who feel energetic or have duty up there. By the time it becomes one's turn to go to bed one generally finds one is very sleepy, and the warmth of one's sleeping-bag and hum of the engines soon send one to sleep.

3.15 P. M.—Sea now visible at intervals through the clouds—a deep blue in color with a big swell on. Our shadow on the water helps us to measure our drift angle, which both Scott and Cooke worked out to be 21 degrees. Running on the forward and two aft engines, resting the two wing engines. Speed—making forty-nine miles per hour.

Durant, the wireless officer, reports he has just been speaking to St. John's, N. F.—Rather faint but quite clear signals. As we are still in touch with East Fortune and Clifden, and have been exchanging signals with the Azores since reaching the Irish coast, our communications seem to be quite satisfactory.

Remarkable rainbow effects on the clouds. One complete rainbow encircled the airship itself and the other, a smaller one, encircled the shadow. Both are very vivid in their coloring.

3.45 P. M.—Excellent tea consisting of bread and butter and green-gage jam, also two cups of scalding hot tea, which had been boiled over the exhaust-pipe cooker fitted to the forward engine.

SEE LITTLE OF OCEAN

Fruitarian cake was also tried for the first time—rather sickly to taste but very nourishing. The whole assisted by Miss Lee White on the gramophone. We would one and all give anything for a smoke. Greenland, the first officer of the ship, is vainly trying to discover the culprit who used his tooth-brush for stirring the mustard at lunch.

4.30 P. M.—Still in fog and low clouds and no sea visible. We have hardly seen any sign of the Atlantic since leaving the Irish coast, and we are beginning to wonder if we shall see it at all the whole way across.

5 P. M.—Tramp steamer S. S. *Ballygally Head*, outward bound from Belfast, destination Montreal, picked up our wireless on their Marconi spark set, which has a range of thirty miles only. She heard us but didn't see us, as we were well above and completely hidden by the clouds. She gave her position as latitude 54 degrees 30 minutes north, longitude 18 degrees 20 minutes west, and reported as follows:

"Steering south 80 west true, wind north, barometer 30.10, overcast, clouds low.

"(Signed) SUFFREN, *Master*."

They were very surprised and most interested to hear we were R-34 bound for New York, and wished us every possible luck.

5.30 P. M.—Messages were received from both H. M. S. battle-cruisers *Tiger* and *Renown*, which had been previously sent by the Admiralty out into the Atlantic to assist us with weather-reports and general observation. They reported respectively as follows:

H. M. S. *Tiger*.—"Position 36 degrees 50 minutes north, 36 degrees 50 minutes west, 1,027 millibars, falling slowly, thick fog."

H. M. S. *Renown*.—"Position 60 degrees north, 25 west, 1,027 millibars, falling slowly, cloudy, visibility four miles."

Harris's deductions from these reports were to the effect that there was no steep gradient, and that therefore there was no likelihood of any strong wind in that part of the Atlantic.

Set Clock Back Half-Hour

6 P. M.—Scott increases height to 2,000 feet, and at this height we find ourselves well over the clouds and with a bright-blue sky above us. The view is an enchanting one—as far as one can see a vast ocean of white fleecy clouds, ending in the most perfect cloud horizons.

Two particularly fine specimens of windy cirrus clouds, of which Pritchard promptly obtained photographs, appear on our port beam, also some "cirrus ventosus" clouds (little curly clouds like a blackcock's tail-feathers), all of which Harris interprets as a first indication and infallible sign of a depression coming up from the south.

We hope that this depression, when it comes, may help us, provided we have crossed its path before it reaches us. If we can do this we may be helped along by the easterly wind on the northwesterly side of the depression.

It is interesting to note that as yet we have received no notice of this depression coming up from the south in any weather-reports.

6.40 P. M.—Put back clock one-half an hour to correct Greenwich mean time. Time now 6.10 P. M. Position: Latitude 53 degrees 50 minutes north; longitude 20 degrees west.

We have covered 610 sea-miles, measured in a direct line, in 17 hours, at an average speed of 36 knots, or 40 miles per hour. Depth of Atlantic at this point, 1,500 fathoms. At this rate, if all goes well and if that depression from the south doesn't interfere, we should see St. John's—if visible and not covered in fog as it usually is—about midnight to-morrow, July 3.

6.55 P. M.—Wireless message from Air Ministry via Clifden states:

"Conditions unchanged in British Isles. Anticyclone persistent in Eastern Atlantic—a new depression entering Atlantic from south."

This confirms Harris's forecast and is an admirable proof of the value of cloud forecasting.

Sea and Sky Invisible

7 p. m.—The clouds have risen to our height and we are now driving away through them with no signs of the sky above or the sea underneath. Scott reckons the wind is northeast by east and helping us slightly. Airship now very heavy owing to change in temperature and 12 degrees down by the stern. Running on all five engines at 1,600 revolutions, height 3,000 feet.

8 p. m.—We are just on top of the clouds, alternately in the sun and then plunging through thick banks of clouds. The sun is very low down on the western horizon and we are steering straight for it, making Pritchard at the elevators curse himself for not having brought tinted glasses. Ship now on an even keel.

8.30 p. m.—Scott decided to go down underneath the clouds and increases speed on all engines to 1,800 revolutions to do so. Dark, cold, and wet in the clouds, and we shut all windows.

Sea 1,500 Feet Below

We see the sea at 1,500 feet between patches of cloud. Rather bumpy.

We now find ourselves between two layers of clouds, the top layer 1,000 feet above us and the lower layer 500 feet below, with occasional glimpses of sea.

The sun is now setting and gradually disappears below the lower cloud horizon, throwing a wonderful pink glow on the white clouds in every direction. Course steered, 320 degrees. Course made good, 299 degrees. Air speed, 44 knots; speed made good, 55 miles per hour.

All through this first night in the Atlantic the ordinary airship routine of navigating, steering, and elevating, also maintaining the engines in smooth-running order, goes, watch and watch, as in the daytime.

The night is very dark. The airship, however, is lighted throughout, a much enlarged lighting system having been fitted. All instruments can be individually illuminated as required, and in case of failure at the lighting system all figures and indicators are radiomized.

Lights Not Needed

The radium paint used is so luminous that in most cases the lighting installation is unnecessary.

8.20 A. M., Thursday, July 3.—The clock has been put back another hour to correct our time to Greenwich mean time. Position: Longitude 35 degrees 60 minutes west; latitude 53 degrees north.

Cooke got position by observation on sun and a good cloud horizon, and considers it accurate to within thirty and forty miles.

Our position is over the west-bound steamship route from Cape Race to the Clyde and momentarily crossing the east-bound route from Belle Isle to Plymouth.

We are well over half-way between Ireland and Newfoundland and are back again on the great circle route, having been slightly to the south of it, owing to the drift effect of a northerly wind.

Good weather-report from St. John's.

Speaks to Steamship

12.45 p. m.—Durant is speaking S. S. *Canada* on our spark wireless set, so there may be a chance of our seeing her shortly, as the sea is temporarily visible. The second wireless operator obtains his direction on our directional wireless so that we may know in what direction to look for her. All we know at the moment is that she is somewhere within 120 miles.

Captain David, in command, wishes us a safe voyage. We gaze through our glasses in her direction, but she is just over the horizon.

2 p. m.—Slight trouble with starboard amidships engine—cracked cylinder's water-jacket. Shotter, always equal to the occasion, made a quick and safe repair with a piece of copper sheeting, and the entire supply of the ship's chewing-gum had to be chewed by himself and two engineers before being applied.

4.30 p. m.—We are now on the Canadian summer route of steamers bound for the St. Lawrence via Belle Isle Strait and over the well-known Labrador current. There are already indications of these cold currents in the fog which hangs immediately above the surface of the water.

Harris Hurt; Not Seriously

Scott and Cooke spend much time at chart-table with protractors, dividers, stop-watches, and many navigational text-books, measuring angles of drift and calculating course made good.

Aerial navigation is more complicated than navigation on the surface of the sea, but there is no reason why when we know more about the air and its peculiarities it should not be made just as accurate.

5.00 P. M.—Harris unwisely shuts his hand on door of wireless cabin—painful but not serious. Flow of language not audible to me, as the forward engine happened to be running.

6 to 7 P. M.—We are gradually getting farther and farther into the shallow depression which was reported yesterday coming up from the South Atlantic. For the last four hours the sea has been rising and now the wind is south-southeast, forty-five miles an hour. Visibility only a half-mile. Very rough sea and torrents of rain. In spite of this the ship is remarkably steady.

Climbs Through Depression

At 8 P. M. Scott decides to climb right through it, and we evidently came out over the top of it at 3,400 feet.

8.30 P. M.—We have now passed the centre of the depression, exactly as Harris foretold. The rain has ceased and we are travelling quite smoothly again.

To the west the clouds have lifted and we see some extraordinarily interesting sky—black, angry clouds giving place to clouds of a gray-mouse color, then a bright salmon-pink clear sky, changing lower down the horizon to darker clouds with a rich golden lining as the sun sinks below the surface. The sea is not visible, and is covered by a fluffy gray feather-bed of clouds, slightly undulating and extending as far as the eye can reach. The moon is just breaking through the black clouds immediately above it.

On the east we see the black, ominous depression from which we have just emerged, while away more to the south the cloud-bed over which we are passing seems to end suddenly and merge into the horizon.

Valuable Meteorological Data

We are getting some valuable meteorological data on this flight without a doubt, and each fresh phenomenon as it appears is instantly explained by the ever-alert Harris, who has a profound knowledge of his subject.

9 P. M.—One of the engineers has reported sick—complains of feverishness.

A stowaway has just been discovered, a cat smuggled on board by one of the crew for luck. It is a very remarkable fact that nearly every member of the crew has a mascot of some description, from the engineer officer, who wears one of his wife's silk stockings as a muffler around his neck, to Major Scott, the captain, with a small gold charm called "Thumbs up."

We have two carrier-pigeons on board, which it has been decided not to use. Anyway, whether we release them or not, they can claim to be the first two pigeons to fly the Atlantic.

Sunrise

4.30 A. M., Friday, July 4.—Wonderful sunrise—the different colors being the softest imaginable, just like a wash drawing.

7 A. M.—Height, 1,000 feet. Bright, blue sky above, thin fog partly obscuring the sea beneath us, sea moderate, big swell.

The fog-bank appears to end abruptly ten miles or so away toward the south, where the sea appears to be clear of fog and a very deep blue.

Standing out conspicuously in this blue patch of sea we see an enormous white iceberg. The sun is shining brightly on its steep sides, and we estimate it as roughly 300 yards square and 150 feet high. As these icebergs usually draw about six times as much water as their height, we wondered whether she was aground, as the depth of water at that point is only about 150 fathoms.

Another big iceberg can just be seen in the dim distance. These are the only two objects of any kind, sort, or description we have as yet seen on this journey.

8.15 A. M.

Over Large Ice-Field

Fog still clinging to the surface of the water; water evidently must be very cold. Extraordinary crimpy, wavelike appearance of clouds rolling up from the north underneath it. Harris has never seen this before. Pritchard took photograph.

On port beam there is a long stretch of clear-blue sea sandwiched in between wide expanses of fog on either side, looking just like a blue river flowing between two wide snow-covered banks. Cause—a warm current of water which prevents cloud from hanging over it. This well illustrated the rule that over cold currents of water the clouds will cling to the surface.

9 A. M.—We are now over a large ice-field and the sea is full of enormous pieces of ice—small bergs in themselves. The ice is blue-green under water, with frozen snow on top.

A message reaches us from the Governor of Newfoundland.

"To General Maitland, officers and crew, R-34:

"On behalf of Newfoundland I greet you as you pass us on your enterprising journey.

"HARRIS, Governor."

Replied to as follows:

"To Governor of Newfoundland:

"Major Scott, officers and crew, R-34, send grateful thanks for kind message with which I beg to associate myself.

"GENERAL MAITLAND."

12.50 P. M.

LAND SIGHTED BY SCOTT

Land in sight. First spotted by Scott on starboard beam. A few small rocky islands visible for a minute or two through the clouds and instantly swallowed up again.

Altered course southwest to have a closer look at them. Eventually made them out to be the northwest coast-line of Trinity Bay, Newfoundland.

Our time from Rathlin Island—the last piece of land we crossed above the north coast of Ireland—to north coast of Trinity Bay, Newfoundland, is exactly fifty-nine hours.

We are crossing Newfoundland at 1,500 feet in thick fog, which gradually clears as we get farther inland. A very rocky country with large forests and lakes, and for the most part no traces of habitation anywhere.

Message from St. John's to say that Raynham was up in his machine to greet us. We replied, giving our position.

3 P. M.—Again enveloped in dense fog. Message from H. M. S. *Sentinel* giving us our position. We are making good thirty-eight or forty knots and heading for Fortune Harbor.

French Flag Dipped

4.30 P. M.—We have passed out of Fortune Harbor, with its magnificent scenery and azure-blue sea dotted with little white sailing ships, and are now over the two French islands, Miquelon and St. Pierre, and steering a course for Halifax, Nova Scotia. The French flag was flying at St. Pierre and was duly dipped as we passed over.

7.15 P. M.—Passed over tramp S. S. *Seal* bound for Sydney, Nova Scotia, from St. John's, the first we have seen.

8.15 P. M.—Clear weather. Sea moderate. Making good thirty miles per hour on three engines. Northern point of Cape Breton Island, Nova Scotia, just coming into sight. Lighthouse four flashes. We should make Halifax 2.30 A. M. to-morrow.

Saturday, July 5, 2.30 A. M.—Very dark, clear night. Lights of Whitehaven show up brightly on our starboard beam and we make out the lights of a steamer passing us to the east. Strong head wind against us. Making no appreciable headway.

Lansdowne Asks for Destroyer

Lieutenant-Commander Lansdowne, United States Naval Airship Service, sends signal on behalf of R-34 to United States authorities at Washington and Boston to send destroyer to take us in tow in case we should run out of petrol during the night.

The idea is we would then be towed by the destroyer during the hours of darkness, and at dawn cast off and fly to Long Island under our own power. Let us hope this won't be necessary.

It is now raining and foggy, which is the kind of weather that suits us now, as rain generally means no wind.

3 P. M.—Passed Haute Island in Fundy Bay.

3.30 P. M.—For some little while past there had been distinct evidences of electrical disturbances. Atmospherics became very bad and a severe thunder-storm was seen over the Canadian coast, moving south down the coast.

Scott turned east off his course to dodge the storm, putting on all engines. In this, fortunately for us, he was successful, and we passed through the outer edge of it. We had a very bad time, indeed, and it is quite the worst experience from a weather point of view that any of us have yet experienced in the air.

Wonderful Clouds Photographed

During the storm some wonderful specimens of cumulo-mammatus were seen and photographed. These clouds always indicate a very highly perturbed state of atmosphere and look rather like a bunch of grapes. The clouds drooped into small festoons.

7.30 P. M.—We are now in clear weather again and have left Nova Scotia well behind us and are heading straight for New York.

Particularly fine electrical-disturbance type of sunset.

9.30 P. M.—Another thunder-storm. Again we have to change our course to avoid it, and as every gallon of petrol is worth its weight in gold, it almost breaks our hearts to have to lengthen the distance to get clear of these storms.

July 6, Sunday, 4 A. M.—Sighted American soil at Chatham.

4.25 A. M.—South end of Mahoney Island. Scott is wondering whether petrol will allow him to go to New York or whether it would not be more prudent to land at Montauk.

5.30 A. M.—Passing over Martha's Vineyard—a lovely island and beautifully wooded. Scott decided he could just get through to our landing-field at Hazelhurst Field, but that there would not be enough petrol to fly over New York. Very sad, but no alternative. We will fly over New York on start of our return journey on Tuesday night, weather and circumstances permitting.

Landed 1.54 P. M. Greenwich mean time, or 9.54 A. M. U. S. A. summer time, at Hazelhurst Field, Long Island.

Total time on entire voyage—108 hours, 12 minutes.

APPENDIX I

UNITED STATES AIRCRAFT AND ENGINE PRODUCTION FOR THE UNITED STATES AIR SERVICE

The best rapid survey of the organization of the United States Air Service and the part which it played in the Great War, as well as statistics touching upon the materials used in aircraft production, the number of planes and engines made, and also the number of machines used for training purposes, and actually put into service at the front, is contained in the following extracts from the reports of Secretary Baker, Justice Charles E. Hughes, General Pershing, and Major-General William L. Kenly.

SECRETARY BAKER'S AIR SERVICE REPORT

In his annual report for 1918, released December 5, the Secretary of War reported on the Air Service as follows:

Air Service

ORGANIZATION

The Aviation Section of the Signal Corps, which had charge of the production and operation of military aircraft at the outbreak of the war, was created on July 18, 1914. To assist in outlining America's aviation program, the Aircraft Production Board was appointed by the Council of National Defense in May, 1917. In October, 1917, the Aircraft Board, acting in an advisory capacity to the Signal Corps and the Navy, was created by act of Congress. In April, 1918, the Aviation Section of the Signal Corps was separated into two distinct departments, Mr. John D. Ryan being placed in charge of aircraft production and Brig.-Gen. W. L. Kenly in charge of military aeronautics. Under the powers granted in the Overman Bill, a further reorganization was effected by Presidential order in May, 1918, whereby aircraft production and military aeronautics were completely divorced from the Signal Corps and established in separate bureaus. This arrangement continued until August, when the present air service, under Mr. Ryan as Second Assistant Secretary of War, was established, combining under one head the administration of aviation personnel and equipment.

RAW MATERIALS SECURED

One of the most important problems which confronted the aircraft organization from the start was the obtaining of sufficient spruce and fir for ourselves and our allies. To facilitate the work, battalions were organized under military discipline and placed in the forests of the western coast. A government plant and kiln were erected to cut and dry lumber before shipment, thus saving valuable freight space. To November 11, 1918, the date the armistice was signed, the total quantity of spruce and fir shipped amounted to approximately 174,000,000 feet, of which more than two-thirds went to the Allies.

The shortage of linen stimulated the search for a substitute possessing the qualities necessary in fabric used for covering aeroplane wings. Extensive experiments were made with a cotton product which proved so successful that it is now used for all types of training and service planes.

To meet the extensive demands for a high-grade lubricating oil, castor beans were imported from India and a large acreage planted in this country. Meanwhile research work with mineral oils was carried on intensively, with the result that a lubricant was developed which proved satisfactory in practically every type of aeroplane motor, except the rotary motor, in which castor oil is still preferred.

PRODUCTION OF TRAINING PLANES AND ENGINES

When war was declared the United States possessed less than 300 training planes, all of inferior types. Deliveries of improved models were begun as early as June, 1917. Up to November 11, 1918, over 5,300 had been produced, including 1,600 of a type which was temporarily abandoned on account of unsatisfactory engines.

Planes for advanced training purposes were produced in quantity early in 1918; up to the signing of the armistice about 2,500 were delivered. Approximately the same number was purchased overseas for training the units with the Expeditionary Force.

Several new models, to be used for training pursuit pilots, are under development.

Within three months after the declaration of war extensive orders were placed for two types of elementary training engines. Quantity production was reached within a short time. In all about 10,500 have been delivered, sufficient to constitute a satisfactory reserve for some time to come.

Of the advanced training engines, the three important models were of foreign design, and the success achieved in securing quantity production is a gratifying commentary on the manufacturing ability of this country. The total production up to November 11 was approximately 5,200.

PRODUCTION OF SERVICE PLANES

The experience acquired during the operations on the Mexican border demonstrated the unsuitability of the planes then used by the American Army. Shortly after the declaration of war, a commission was sent abroad to select types of foreign service planes to be put into production in this country. We were confronted with the necessity of redesigning these models to take the Liberty motor, as foreign engine production was insufficient to meet the great demands of the Allies. The first successful type of plane to come into quantity production was a modification of the British De Haviland 4—an observation and day bombing plane. The first deliveries were made in February, 1918. In May, production began to increase rapidly, and by October a monthly output of 1,200 had been reached. Approximately 1,900 were shipped to the Expeditionary Force prior to the termination of hostilities.

The Handley Page night bomber, used extensively by the British, was redesigned to take two Liberty motors. Parts for approximately 100 planes have been shipped to England for assembly.

Table 20 shows the status of American production of service planes by quarterly periods.

Table 20.—Service planes produced in the United States in 1918:

Name of plane	Jan. 31 to Mar. 31	April 1 to June 30	July 1 to Sept. 30	Oct. 1 to Nov. 8	Total
De Haviland 4....	14	515	1,165	1,493	3,187
Handley Page....	..	...	100	1	101

A total of 2,676 pursuit, observation, and day bombing planes, with spare engines, were delivered to the Expeditionary Force by the French Government for the equipment of our forces overseas.

Considerable progress was made in the adaptation of other types of foreign planes to the American-made engines, and in the development of new designs. The U. S. D. 9A, embodying some improvements over the De Haviland 4, was expected to come into quantity production in the near future. The Bristol Fighter, a British plane, was redesigned to take the Liberty 8 and the Hispano-Suiza 300 h. p. engines. A force of Italian engineers and skilled workmen was brought to America to redesign the Caproni night bomber to take three Liberty motors, and successful trial flights of this machine have been made.

Several new models are under experimentation. Chief of these is the Le Père two-seater fighter, designed around the Liberty motor, the performance of which is highly satisfactory. Several of these planes were sent overseas to be tested at the front.

PRODUCTION OF SERVICE ENGINES

In view of the rapid progress in military aeronautics, the necessity for the development of a high-powered motor adaptable to American methods of quantity production was early recognized. The result of the efforts to meet this need was the Liberty motor—America's chief contribution to aviation, and one of the great achievements of the war. After this motor emerged from the experimental stage, production increased with great rapidity, the October output reaching 4,200, or nearly one-third of the total production up to the signing of the armistice. The factories engaged in the manufacture of this motor, and their total production to November 8, are listed in Table 21.

Table 21.—Production of Liberty motor to November 8, 1918, by factories:

Packard Motor Car Co.	4,654
Lincoln Motor Corporation	3,720
Ford Motor Co.	3,025
General Motors Corporation	1,554
Nordyke & Marmon Co.	433
Total	13,386

Of this total, 9,834 were high-compression, or army type, and 3,572 low-compression, or navy type, the latter being used in seaplanes and large night bombers.

In addition to those installed in planes, about 3,500 Liberty engines were shipped overseas, to be used as spares and for delivery to the Allies.

Other types of service engines, including the Hispano-Suiza 300 h. p., the Bugatti, and the Liberty 8-cylinder, were under development when hostilities ceased. The Hispano-Suiza 180 h. p. had already reached quantity production. Nearly 500 engines of this type were produced, about half of which were shipped to France and England for use in foreign-built pursuit planes.

Table 22 gives a résumé of the production of service engines by quarterly periods:

Table 22.—Production of service engines in 1918.

Name of engine	Jan. 1 to Mar. 31	Apr. 1 to June 30	July 1 to Sept. 30	Oct. 1 to Nov. 8	Total
Liberty 12, Army..	122	1,493	4,116	4,093	9,824
Liberty 12, Navy..	142	633	1,710	1,087	3,572
Hispano-Suiza 180 h. p..........	...	...	185	284	469

IMPROVEMENT IN INSTRUMENTS AND ACCESSORIES

Few facilities existed for the manufacture of many of the delicate instruments and intricate mechanisms going into the equipment of every battle-plane. The courage and determination with which these most difficult problems were met and solved will form one of the bright pages in the archives of American industry.

One of the most important outgrowths of the research work which the war stimulated was the development of voice command in formation flying by means of wireless devices. The great significance of this invention will be appreciated when it is realized that the leader of a formation has heretofore been dependent on signals for conveying instructions to the individual units of the squadron.

TRAINING OF PERSONNEL

After the declaration of war the construction of training fields proceeded with such rapidity that the demand for training equipment greatly exceeded the output. Since the latter part of 1917, however, the supply of elementary training planes and engines has been more than sufficient to meet the demands, while the situation as regards certain types of planes for advanced training has greatly improved. Approximately 17,000 cadets were graduated from ground schools; 8,602 reserve military aviators were graduated from elementary training schools; and 4,028 aviators completed the course in advanced training provided in this country. Pending the provision of adequate equipment for specialized advanced training, the policy was adopted of sending students overseas for a short finishing course before going into action. The shortage of skilled mechanics with sufficient knowledge of aeroplanes and motors was met by the establishment of training schools from which over 14,000 mechanics were graduated.

At the cessation of hostilities there were in training as aviators in the United States 6,528 men, of whom 22 per cent were in ground schools, 37 per cent in elementary schools, and 41 per cent in advanced training schools. The number of men in training as aviator mechanics was 2,154.

FORCES AT THE FRONT

Early in 1918 the first squadrons composed of American personnel provided with French planes appeared at the front. The number was increased as rapidly as equipment could be obtained. On September 30, the date of the latest available information, there were 32 squadrons at the front; of these 15 were pursuit, 13 observation, and 4 bombing. The first squadron equipped with American planes reached the front in the latter part of July.

LOSSES IN BATTLE AND IN TRAINING

Though the casualties in the air force were small as compared with the total strength, the casualty rate of the flying personnel at the front was somewhat above the artillery and infantry rates. The reported battle fatalities up to October 24 were 128 and accident fatalities overseas 244. The results of Allied and American experience at the front indicate that two aviators lose their lives in accidents for each aviator killed in battle. The fatalities at training fields in the United States to October 24th were 262.

[A later official report gave the total U. S. aviators lost in combat as 171, and those killed by accident as 554.]

COMMISSIONED AND ENLISTED STRENGTH

On America's entrance into the war, the personnel of the Air Service consisted of 65 officers and 1,120 men. When the armistice was signed the total strength was slightly over 190,000, comprising about 20,000 commissioned officers, over 6,000 cadets under training, and 164,000 enlisted men. In addition to the cadets under training, the flying personnel was composed of about 11,000 officers, of whom approximately 42 per cent were with the Expeditionary Force when hostilities ceased. The Air Service constituted slightly over 5 per cent of the total strength of the Army.

GENERAL PERSHING'S REPORT

Secretary Baker's report included a communication received from General Pershing in which he commented on aircraft and the Air Service as follows:

"Our entry into the war found us with few of the auxiliaries necessary for its conduct in the modern sense. Among our most important deficiencies in material were artillery, aviation, and tanks. In order to meet our requirements as rapidly as possible, we accepted the offer of the French Government to provide us with the necessary artillery equipment.

"In aviation we were in the same situation, and here again the French Government came to our aid until our own aviation program should be under way. We obtained from the French the necessary planes for training our personnel, and they have provided us with a total of 2,676 pursuit, observation, and bombing planes. The first aeroplanes received from home arrived in May, and altogether we have received 1,379. The first American squadron completely equipped by American production, including aeroplanes, crossed the German lines on August 7, 1918.

"It should be fully realized that the French Government has always taken a most liberal attitude and has been most anxious to give us every possible assistance in meeting our deficiencies in these as well as in other respects. Our dependence upon France for artillery, aviation, and tanks was, of course, due to the fact that our industries had not been exclusively devoted to military production. All credit is due our own manufacturers for their efforts to meet our requirements, as at the time the armistice was signed we were able to look forward to the early supply of practically all our necessities from our own factories."

THE HUGHES REPORT

The committee appointed by the President to investigate the charges of misappropriation of funds reported in November, 1918, on the number of training planes and engines built. Justice Chas. E. Hughes was chairman of the committee:

Aeroplanes and Engines Delivered During Fiscal Year Ending June 30, 1918

The reported deliveries of Aeroplanes and Engines made prior to June 30, 1918, are as follows:

AEROPLANES

Elementary Training Planes		
JN4-D	2972	
SJ-1	1600	
	——	4572
Advanced Training Planes		
JN-4H		
Training	402	
Gunnery	321	
JN6-HB	100	
S4-B	100	
S4-C	73	
Penguin	50	
	——	1046

Combat and Bombing Planes		
DeH-4	529	
Bristol Fighter	24	
	—	553
Total planes		6171

ENGINES

Elementary Training		
OX-5	5474	
A7a	2188	
	—	7662
Advanced Training		
Hispano 150 H. P.	2188	
Gnome 100 "	209	
Le Rhone 80 "	68	
Lawrence 28 "	114	
	—	2579
Combat and Bombing		
U. S. 12 Cylinder (Army Type)	1615	
U. S. " " (Navy Type)	775	
Hispano 300 H. P.	2	
	—	2392
Total engines		12633

NUMBER OF MACHINES AT THE FRONT

Report prepared by Statistics Branch, General Staff, War Department, March 22, 1919, concerning the 628 De Haviland 4 planes put in service at front before armistice.

The following table and diagram shows the status of production, shipments and use overseas of De Haviland 4 service planes at the date of the armistice:

	Number	Per cent of total production
Produced	3,227	100
Floated	1,885	58
Received at French ports (*a*)	1,185	37
Assembled overseas	1,025	32
Put into service overseas	983	30
Put into service at front	628	19
In commission at front (*b*)	457	14

(*a*) To November 1, 1918.
(*b*) November 3, 1918.

Value of contracts cancelled and suspended exceed $480,000,-000.

The following is a summary of the value of cancellations and suspensions of contracts to March 19, 1919:

	Value	Per cent of total
Engines and spare parts	$250,409,982	52
Airplanes and spare parts	167,554,386	35
Chemicals and chemical plants	19,852,370	4
Instruments and accessories	13,832,902	3
Balloons and supplies	10,071,035	2
Fabrics, lumber and metals	7,968,324	2
Miscellaneous	11,041,132	2
Total	$480,730,131	

THE SIXTY-FOUR AMERICAN ACES

The following official list gives the status of the sixty-four American aces—that is, aviators who had each downed five or more enemies by the time hostilities ceased:

Captain Edward V. Rickenbacker of Columbus, Ohio, famous as an automobile driver, was the premier "Ace" of the American air force in France, having twenty-six enemy planes to his credit.

First Lieutenant Frank Luke, Jr., of Phœnix, Ariz., who was killed in action May 19, 1918, was second on the list of "Aces," with eighteen victories to his credit, and Major Victor Raoul Lufbery of Wallingford, Conn., also killed in action May 19, 1918, was third, with seventeen victories. Before joining the American Army, Major Lufbery was a member of the Lafayette Escadrille.

Captain Reed G. Landis of Chicago, son of Judge Landis, and First Lieutenant David E. Putnam, of Brookline, Mass., who was killed in action, had twelve victories each. The other "Aces," with the number of victories credited to each, follow:

First Lieutenant Fields Kinley, Gravette, Ark., 10.

First Lieutenant G. A. Vaughn, Jr., 341 Washington Avenue, Brooklyn, 10.

First Lieutenant J. M. Swaab, Philadelphia, 10.
First Lieutenant T. G. Cassady, 9.
First Lieutenant C. E. Wright, Cambridge, Mass., 9.
First Lieutenant W. P. Erwin, Chicago, 9.
Captain E. W. Springs, Lancaster, Penn., 9.
First Lieutenant H. R. Clay, Jr., Fort Worth, Texas, 8.
Major J. A. Meissner, 45 Lenox Road, Brooklyn, N. Y., 8.
Captain Hamilton Coolidge (deceased), Boston, Mass., 8.
Captain G. De F. Larner, Washington, D. C., 8.
First Lieutenant P. F. Baer, Fort Wayne, Ind., 8 (captured May 22, 1918).
First Lieutenant F. O. D. Hunter, Savannah, Ga., 8.
First Lieutenant W. W. White, 541 Lexington Avenue, New York City, 8.
Second Lieutenant Clinton Jones, San Francisco, Cal., 8.
Captain R. M. Chambers, Memphis, Tenn., 7.
First Lieutenant Harvey Cook, Toledo, Ohio, 7.
First Lieutenant L. C. Holden, 103 Park Avenue, New York City, 7.
First Lieutenant K. H. Schoen (deceased), Indianapolis, Ind., 7.
First Lieutenant W. A. Robertson, Fort Smith, Ark., 7.
First Lieutenant L. J. Rummell, 798 South 11th Street, Newark, N. J., 7.
First Lieutenant L. A. Hamilton (deceased), Burlington, Vt., or Pittsfield, Mass., 7.
First Lieutenant J. O. Creech, Washington, D. C., 6.
Second Lieutenant Howard Burdick, 175 Remsen Street, Brooklyn, N. Y., 6.
First Lieutenant C. L. Bissell, Kane, Penn., 6.
Major H. E. Hartney, Saskatoon, Canada, 6.
Captain Douglass Campbell, Mount Hamilton, Cal., 6.
Captain J. C. Vasconcelles, Denver, Col., 6.
Captain E. G. Tobin, San Antonio, Texas, 6.
First Lieutenant E. P. Curtis, Rochester, N. Y., 6.
First Lieutenant Sumner Sewell, no address, 6.
First Lieutenant R. A. O'Neill, Nogales, Ariz., 6.
First Lieutenant Donald Hudson, Kansas City, Mo., 6.
First Lieutenant M. K. Guthrie, Mobile, Ala., 6.
First Lieutenant W. H. Stovall, Stovall, Miss., 6.
First Lieutenant J. D. Beane (missing in action), 6.
First Lieutenant A. R. Brooks, Framingham, Mass., 6.
First Lieutenant R. O. Lindsay, Madison, N. C., 6.
First Lieutenant Martinus Stenseth, Twin City, Minn., 6.
Second Lieutenant F. K. Hays, Chicago, Ill., 6.
First Lieutenant H. C. Klotts, no address, 5.
Lieutenant-Colonel William Thaw, Pittsburgh, Penn., 5.
Major D. McK. Peterson, Honesdale, Penn., 5.
Captain H. R. Buckley, Agawam, Mass., 5.

Major C. J. Biddle, Philadelphia, Penn., 5.
First Lieutenant James Knowles, Cambridge, Mass., 5.
First Lieutenant J. A. Healey, Jersey City, N. J., 5.
First Lieutenant Innis Potter, no address, 5.
First Lieutenant F. M. Symonds, 20 West 8th Street, New York City, 5.
First Lieutenant J. F. Wehner (deceased), 124 East 28th Street, New York, 5.
First Lieutenant J. J. Sereley, Chicago, 5.
First Lieutenant E. M. Haight, Astoria, N. Y., 5.
First Lieutenant H. H. George, Niagara Falls, N. Y., 5.
First Lieutenant G. W. Furlow, Rochester, Minn., 5.
First Lieutenant A. E. Esterbrook, Fort Flagler, Wash., 5.
First Lieutenant B. V. Baucom, Milford, Texas, 5.
Second Lieutenant Harold McArthur, no address, 5.
Second Lieutenant J. S. Owens, Baltimore, 5.
Second Lieutenant J. O. Donaldson, Washington, D. C., 5.

OTHER AMERICANS WHO ARE CREDITED WITH BRINGING DOWN ONE OR MORE PLANES

Lieutenant Frank L. Baylies, New Bedford, Mass. (killed June 20, 1918, in the British Air Service), 12.
Adjutant E. C. Parsons, Springfield, Mass., 4.
Lieutenant H. Clay Ferguson, wounded March 12, 1918, 4.
Captain J. Norman Hall, Lafayette Escadrille and A. E. F., Colfax, Ia., wounded and captured, May 7, 1819, 4.
Lieutenant Joseph C. Stehlin, Lafayette Escadrille, Brooklyn, N. Y., 3.
Lieutenant Norman Prince (organizer of Lafayette Escadrille), Beverly Farms, Mass., killed October 15, 1916, 0.
Lieutenant Kiffin Yates Rockwell, Lafayette Escadrille, Asheville, N. C., killed September 23, 1916, 4.
Lieutenant Walter Rheno, Martha's Vineyard, Mass., 3.
Lieutenant Walter Lovell, Lafayette Escadrille, Concord, Mass., 3.
Lieutenant Thomas Hitchcock, Jr., Lafayette Escadrille, Roslyn, N. Y., captured March 10, 1918. He escaped later. 3.
Lieutenant Bert Hall, Lafayette Escadrille, Bowling Green, Ky., retired December, 1916, 3.
George Turnure, Lenox, Mass., third on July 17, 1918, 3.
Lieutenant Hugh Dugan, Chicago, Royal Flying Corps, captured April 6, 1918, 2.
Lieutenant G. de Freest Larner, Washington, D. C., 2.
Lieutenant Andrew C. Campbell, Chicago, missing, 2.

Captain Phelps Collins, Detroit, killed March 18, 1918, 2.
Lieutenant Didier Masson, New York, Lafayette Escadrille, 2.
Christopher Ford, New York, 2.
Lieutenant W. A. Wellman, Cambridge, Mass., 2.
Sergeant James E. Connelly, Philadelphia, Pa., 2.
Sergeant Victor Chapman, Lafayette Escadrille, killed June 23, 1916, 2.
Sergeant Vernon Booth, Chicago, 2.
Sergeant Austin B. Crehore, Westfield, New York, 1.
Lieutenant Willis Haviland, Minneapolis, Minn., 1.
Lieutenant Harry Sweet Jones, Hartford, Pa., 1.
Lieutenant Charles C. Johnson, St. Louis, Mo., 1.
Captain Robert L. Rockwell, Cincinnati, Ohio, 1.
Lieutenant Stuart Walcott, Washington, killed December 14, 1917, 1.
Lieutenant Alan F. Winslow, Rive Forest, Ill., 1.
Lieutenant Edgar Tobin, San Antonio, on July 11, 1918, 1.
Lieutenant Charles T. Merrick, Eldora, Iowa, 1.
Lieutenant Alexander O. Craig, New York, in Italy, on July 5, 1918, 1.
Lieutenant Sumner Sewell, Bath, Me., above Toul, on June 3, 1918, 1.
Lieutenant William J. Hoover, Hartsville, S. C., on July 2, 1918, 1.
Lieutenant Alfred A. Grant, Denton, Texas, on July 2, 1918, 1.
Lieutenant John McArthur, Buffalo, N. Y., on July 2, 1918, 1.
Lieutenant Tyler Cook Bronson, New York, on July 1, 1918, 1.
Lieutenant Charles W. Chapman on May 8, 1918. Both he and victim fell in flames, 1.
Captain Kenneth Marr, on May 15, 1918, 1.
Lieutenant Henry Grendelass, 1.
Lieutenant Edward Buford, Jr., Nashville, Tenn., on May 22, 1918, 1.
Lieutenant William H. Taylor, New York, on May 21, 1918, 1.
Ensign Stephen Potter, Boston, Mass., killed April 25, 1918, 1.
Lieutenant Walter Avery, Columbus, Ohio, brought down and captured Captain Menckhoff, the German ace, who had 34 victories on July 25, 1918, 1.

CITATIONS AND DECORATIONS OF MEMBERS OF THE U. S. ARMY AIR SERVICE

DISTINGUISHED SERVICE CROSS

Gardner Philip Allen, First Lieutenant, C. A. C.
Flynn L. A. Andrew, First Lieutenant.
David H. Backus, First Lieutenant.
Herbert B. Bartholf, First Lieutenant.
Erwin R. Bleckley, Second Lieutenant.
Samuel C. Bowman, Second Lieutenant.

Hugh D. G. Broomfield, First Lieutenant.
John R. Castleman, First Lieutenant.
Weir H. Cook, First Lieutenant.
Hamilton Coolidge (deceased), Captain.
Justin P. Follette, First Lieutenant.
William F. Frank, First Lieutenant.
Harold E. Goettler (deceased), Second Lieutenant.
Andre Gundelach (deceased), First Lieutenant.
D. C. Hunter, First Lieutenant.
John N. Jeffers, First Lieutenant.
Samuel Kaye, Jr., First Lieutenant.
Willburt E. Kinsley, Second Lieutenant.
James Knowles, First Lieutenant.
G. DeFreest Larner, First Lieutenant.
William O. Lowe, Second Lieutenant, U. S. M. C.
Edward Russell Moore, First Lieutenant.
Edward M. Morris, Second Lieutenant.
Stephen H. Noyes, Captain.
Alfred B. Patterson, Jr., First Lieutenant.
Britton Polley, First Lieutenant.
Charles P. Porter, Second Lieutenant.
Clearton H. Reynolds, Captain.
Leslie J. Rummell, First Lieutenant.
Karl J. Schoen (deceased), First Lieutenant.
Richard B. Shelby, First Lieutenant.
John Y. Stokes, Jr., First Lieutenant.
William H. Stovall, First Lieutenant.
William H. Vail, First Lieutenant.
Pennington H. Way (deceased), Second Lieutenant.
Joseph F. Wehner, First Lieutenant.
Chester E. Wright, First Lieutenant.

LEGION OF HONOR—FRENCH

(COMMANDER)

Charles T. Menoher, Major-General.
William Mitchell, Brigadier-General.

CROIX DE GUERRE—FRENCH

Thomas J. Abernathy, Second Lieutenant.
James A. Healy, First Lieutenant.
Arthur H. Jones, First Lieutenant.
Charles T. Menoher, Major-General.
Ralph A. O'Neill, First Lieutenant.

Charles P. Porter, Second Lieutenant.
Kenneth L. Porter, Second Lieutenant.
Joseph C. Raible, Jr., First Lieutenant.
Louis C. Simon, Jr., First Lieutenant.

ITALIAN CITATIONS

James P. Hanley, Jr., First Lieutenant.
George C. Hering, First Lieutenant.
William P. Shelton, First Lieutenant.
Norman Sweetser, First Lieutenant.
Emory E. Watchorn, First Lieutenant.
Frederick K. Weyerhaeuser, First Lieutenant.

FRENCH CITATIONS

Valentine J. Burger, Second Lieutenant.
Alexander T. Grier, Second Lieutenant.
Horace A. Lake, Second Lieutenant.

CROCE AL MERITO DI GUERRA—ITALIAN

James L. Bahl, First Lieutenant.
Raymond P. Baldwin, First Lieutenant.
Arthur M. Beach, First Lieutenant.
Allen W. Bevin, First Lieutenant.
Gilbert P. Bogart, First Lieutenant.
Arthur F. Clement, First Lieutenant.
William G. Cochran, First Lieutenant.
De Witt Coleman, Jr., First Lieutenant.
Kenneth G. Collins, First Lieutenant.
Alexander M. Craig, First Lieutenant.
Herbert C. Dobbs, Jr., First Lieutenant.
Edmund A. Donnan, First Lieutenant.
Norton Downs, Jr., First Lieutenant.
Arthur D. Farquhar, First Lieutenant.
Harry S. Kinkenstaedt, First Lieutenant.
Willis S. Fitch, First Lieutenant.
Donald G. Frost, First Lieutenant.
William O. Frost, First Lieutenant.
James P. Hanley, Jr., First Lieutenant.
Spencer L. Hart, Second Lieutenant.
George C. Hering, First Lieutenant.
Wallace Hoggson, First Lieutenant.
Gosta A. Johnson, First Lieutenant.
James Kennedy, Second Lieutenant.

LeRoy D. Kiley, First Lieutenant.
Herman F. Kreuger, First Lieutenant.
Fiorello H. LaGuardia, Major.
Paton MacGilvary, First Lieutenant.
Oble Mitchell, First Lieutenant.
William H. Potthoff, First Lieutenant.
Aubrey G. Russel, First Lieutenant.
William B. Shelton, First Lieutenant.
Norman Sweetser, First Lieutenant.
Norman Terry, Second Lieutenant.
Emory E. Watchorn, First Lieutenant.
Frederick K. Weyerhaeuser, First Lieutenant.
Warren Wheeler, First Lieutenant.
Alfred S. R. Wilson, First Lieutenant.
Warren S. Wilson, First Lieutenant.

REPORT OF THE DIRECTOR OF MILITARY AERONAUTICS

War Department,

Office of the Director of Military Aeronautics,

November 3, 1918.

Sir: I have the honor to submit herewith the annual report of the Division of Military Aeronautics for the fiscal year ended June 30, 1918. Though the Division of Military Aeronautics was created only on April 24, 1917, it was agreed that the duties intrusted to it and previously carried out by the Signal Corps should be covered in this report in order to present a continuous story of the development of the personnel, training, and organizing phases of the present Air Service. Also it should be pointed out that operations on the front in France have been left largely to whatever report the American Expeditionary Force may deem wise.

The fiscal year 1917–18 saw aviation develop from a wholly subsidiary branch of the Army as the Aviation Section of the Signal Corps to a position of extreme and decisive importance as the Air Service, directly under the Chief of Staff. From the most insignificant beginnings it came within the year to be one of America's major efforts in the war.

This is all the more surprising when America's previous backwardness in aviation is considered. This country has stood practically still in aerial progress, while the war in Europe brought about an extraordinary advance. From all this the United States was entirely shut off up to the time it abandoned neutrality. So little exact knowledge was available that the first American planes to go with the expedition into Mexico in March, 1916, were all rendered useless in accidents within a short time of arrival. There was practically no aviation technique here comparable to Europe's, almost negligible manufacturing facilities, not a hundred trained flyers, and only the most rudimentary facilities for training. Moreover, no one had any adequate appreciation of the intricacy and skill required in the making of either an aeroplane or the training of a pilot.

As against this stagnation Europe's progress in two and one-half years of war had been tremendous. The first planes to go to the front in 1914 had been few in number, unequipped with radio, machine guns, bombs, or photographic apparatus, and entirely unproved in military value. Their extraordinary success, however, in disclosing the size of the German concentration in Belgium at once brought them into a position of great importance. Very shortly radio was installed to replace signaling by dropping tinsel or making curious evolutions; the pistols of the pilots gave way to machine guns; the easy-going system of dropping bombs over the side was replaced by regular bombing planes, and the occasional taking of photographs by an intricate system of picturing every mile of the front. Engine power increased to 200, 300, 400, 500 horse power; huge planes with large carrying capacity were being developed for night-bombing; and operations were taking place by whole squadrons in various air strata—light, single-seater scouts around 15,000 to 20,000 feet, two-seater day bombers around 9,000 feet, and photographic and observation planes around 6,000 feet.

In contrast to all this development the United States at the time of its entry into the war stood very little ahead of where it had been before the world war broke out. Aviation, both in its personnel and its equipment, was included in that part of the Signal Corps known as the Aviation Section, which had been established by Congress July 18, 1914. Its chief was Maj. Gen. George O. Squier, who after four years as military attaché in London, had been put in charge of the Aviation Section in May, 1916, and made Chief Signal Officer on February 14, 1917, continuing to have charge of aviation through nearly the whole of the fiscal year. On April 6, 1917, the total assets on hand consisted of 65 officers, 1,120 men, two small flying fields, less than 300 very second-rate training planes, practically no manufacturing facilities, and only the most meagre technical information as to Europe's startling developments.

The original American war program, based on an army of a million men, made aviation but a relatively insignificant part of the general military forces. This program, which represented the view of the General Staff before the arrival of the foreign missions, was met by two appropriations, $10,800,000 on May 12, 1917, and $43,450,000 on June 15, many times larger than any appropriations ever before made.

The British and French missions, however, arriving the last part of April, completely revolutionized this viewpoint. Supported by an urgent cable of May 24 from the premier of France, calling for 2,000 planes a month and a total of 5,000 pilots and 50,000 mechanicians, the $640,000,000 appropriation, the largest ever made by Congress for one specific purpose, was drawn up, put through the House of Representatives Military Affairs Committee in two meetings, the House itself in one, the Senate Military Affairs Committee in 45 minutes, and the Senate itself a week later, becoming law on July 24, 1917. On this date the present large program was really launched, two months and a half after the outbreak of war, and largely in response to allied appeals.

The rest of the fiscal year was taken up in amplifying and executing the lines of effort here laid down. Toward the end of the year, however, it became obvious that the system of organization of an Aviation Section as a subsidiary branch of the Signal Corps was not functioning efficiently. The British and French, perceiving that we were encountering the same kind of obstacles as theirs, strongly recommended a separate, independent air service similar to the air ministries they had been obliged to establish and which have worked so successfully since. As a result, a first step was taken in a rearrangement of duties designed to effect a greater independence and a greater concentration of authority when, on April 24, the War Department authorized the following statement:

"Mr. John D. Ryan has accepted the directorship of aircraft production for the Army.

"A reorganization of the Aviation Section of the Signal Corps has been also effected, of which the principal elements are as follows:

"Gen. Squier, as Chief Signal Officer, will devote his attention to the administration of signals; a Division of Military Aeronautics is created, under the direction of Brig. Gen. William L. Kenly. The Aircraft Board, created by act of Congress, remains as an advisory body, as it has been in the past, with Mr. Ryan as its chairman. This arrangement is made with the entire concurrence of Mr. Howard Coffin, who remains a member of the Advisory Commission of the Council of National Defense and will render assistance and counsel to the Aircraft Board and Mr. Ryan.

"The Division of Military Aeronautics will have control of the training of aviators and military use of aircraft. The exact division of functions in the matter of designing and engineering will be worked out as experience determines between the Division of Military Aeronautics and the Division of Production.

"This announcement involves no change of personnel in the present Equipment Division of the Signal Corps, of which W. C. Potter is chief, and which will continue under his direction."

This reorganization, however, was admittedly but the first step. The first action taken by the President under the broad powers of the

Overman Act was to effect a still further reorganization by taking aviation entirely out of the jurisdiction of the Signal Corps, where it has been from its inception on July 18, 1914, and to set up two separate bureaus, one for securing and training the large flying and ground forces, and the other for providing planes, engines, and equipment.

The presidential order of May 21 covering this change follows:

"By virtue of the authority in me vested as Commander-in-Chief of the Army and by virtue of further authority upon me specifically conferred by 'An act authorizing the President to coordinate or consolidate executive bureaus, agencies, and offices, and for other purposes, in the interest of economy and the more efficient concentration of the Government,' approved May 20, 1918, I do hereby make and publish the following order:

"The powers heretofore conferred by law or by Executive order upon and the duties and functions heretofore performed by the Chief Signal Officer of the Army are hereby redistributed as follows:

I

"(1) The Chief Signal Officer of the Army shall have charge, under the direction of the Secretary of War, of all military signal duties, and of books, papers and devices connected therewith, including telegraph and telephone apparatus and the necessary meteorological instruments for use on target ranges, and other military uses; the construction, repair, and operation of military telegraph lines, and the duty of collecting and transmitting information for the Army by telegraph or otherwise, and all other duties usually pertaining to military signaling; and shall perform such other duties as now or are or shall hereafter be devolved by law or by Executive order upon said Chief Signal Officer which are not connected with the Aviation Section of the Signal Corps or with the purchase, manufacture, maintenance, and production of aircraft, and which are not hereinafter conferred, in special or general terms, upon other officers or agencies.

"(2) A Director of Military Aeronautics, selected and designated by the Commander in Chief of the Army, shall hereafter have charge, under the direction of the Secretary of War, of the Aviation Section of the Signal Corps of the Army, and as such shall be, and he hereby is, charged with the duty of operating and maintaining or supervising the operation and maintenance of all military aircraft, including balloons and aeroplanes, all appliances pertaining to said aircraft and signaling apparatus of any kind when installed on said aircraft, and of training officers, enlisted men, and candidates for aviation service in matters pertaining to military aviation, and shall hereafter perform each and every function heretofore imposed upon and performed by the Chief Signal Officer of the Army in, or in connection with, the Aviation Section of the Signal Corps, except such as pertains to the purchase, manufacture, and production of aircraft and aircraft equipment and as is not hereinafter conferred, in special or general terms, upon the Bureau of Aircraft Production; and all aeroplanes now in use or completed and on hand and all material and parts, and all machinery, tools, appliances, and equipment held for use for the maintenance thereof; all lands, buildings, repair shops, warehouses, and all other property, real, personal, or mixed, heretofore used by the Signal Corps in, or in connection with, the operation and maintenance of aircraft and the training of officers, enlisted men, and candidates for aviation service, or procured and now held for such use by or under the jurisdiction and control of the Signal Corps of the Army; all books, records, files and office equipment heretofore used by the Signal Corps, in, or in connection with, such operation, maintenance, and training; and the entire personnel of the Signal Corps as at present assigned to, or engaged upon work in, or in connection with, such operation, maintenance, and training, is hereby transferred from the jurisdiction of the Chief Signal Office and placed under the jurisdiction of the Director of Military Aeronautics; it being the intent hereof to transfer from the jurisdiction of the Chief Signal Officer to the jurisdiction of the said Director of Military Aeronautics every function, power, and duty conferred and imposed upon said Director of Military Aeronautics by subparagraph (2) of paragraph I hereof all property of every sort of nature used or procured for use in, or in connection with, the functions of the Aviation Section of the Signal Corps placed in charge of the Director of Military Aeronautics by subparagraph (2) of paragraph I hereof, and the entire personnel of the Signal Corps in charge of the Director of Military Aeronautics by subparagraph (2) of paragraph I hereof.

"(3) An executive agency, known as the Bureau of Aircraft Production, is hereby established, and said agency shall exercise full, complete, and exclusive jurisdiction and control over the production of aeroplanes, aeroplane engines, and aircraft equipment for the use of the Army, and to that end shall forthwith assume control and jurisdiction over all pending Government projects having to do or connected with the production of aeroplanes, aeroplane engines, and aircraft equipment for the Army and heretofore conducted by the Signal Corps of the Army, under the jurisdiction of the Chief Signal Officer; and all material on hand for such production, all unfinished aeroplanes and aeroplane engines, and all unfinished, unattached, or unassembled aircraft equipment; all lands, buildings, factories, warehouses, machinery, tools, and appliances, and all other property, real, personal, or mixed, heretofore used in or in connection with such production, or procured and now held for such use, by or under the jurisdiction and control of the Signal Corps of the Army; all books, records, files, and office equipment used by the said Signal Corps in or in connection with such production; all rights under contracts made by the Signal Corps in or in connection with such production; and the entire personnel of the Signal Corps as at present assigned to or engaged upon work in or in connection with such production are hereby transferred from the jurisdiction of the Signal Corps and placed under the jurisdiction of the Bureau of Aircraft Production, it being the intent thereof to transfer from the jurisdiction of the Signal Corps to the jurisdiction of the said Bureau of Aircraft Production every function, power, and duty connected with said production, all property of every sort or nature used or procured for use in or in connection with said production, and the entire personnel of the Signal Corps, as at present assigned to or engaged upon work in or in connection with such production.

"Such person as shall at the time be chairman of the Aircraft Board created by the act of Congress approved October 1, 1917, shall also be the executive officer of said Bureau of Aircraft Production, and he shall be, and he hereby is, designated as Director of Aircraft Production, and he shall, under the direction of the Secretary of War, have charge of the activities, personnel, and properties of said bureau.

II

"All unexpended funds of appropriations heretofore made for the Signal Corps of the Army and already specifically allotted for use in connection with the functions of the Signal Service as defined and limited by subparagraph (1) of Paragraph I hereof shall be and remain under the jurisdiction of the Chief Signal Officer; all such funds already specifically allotted for use in connection with the functions of the Aviation Section of the Signal Corps as defined and limited by subparagraph (2) of Paragraph I hereof are hereby transferred to and placed under the jurisdiction of the Director of Military Aeronautics for the purpose of meeting the obligations and expenditures authorized by said section; all such funds already specifically allotted for use in connection with the functions hereby bestowed upon the Bureau of Aircraft Production, as defined and limited by subparagraph (3) of Paragraph I hereof, are hereby transferred to and placed under the jurisdiction of said Director of Aircraft Production for the purpose of meeting the obligations and expenditures authorized by said bureau in carrying out the duties and functions hereby transferred to and bestowed upon said bureau; and in so far as such funds have not been already specifically allotted to the different fields of activity of the Signal Corps as heretofore existing, they shall now be allotted by the Secretary of War in such proportions as shall to him seem best intended to meet the requirements of the respective fields of former activity of the Signal Corps and the intention of Congress when making said appropriations, and the funds so allotted by the Secretary of War to meet expenditures in the field of activity of the Aviation Section of the Signal Corps are hereby transferred to and placed under the jurisdiction of the Director of Military Aeronautics for the purpose of meeting the obligations and expenditures authorized by said section; and the funds so allotted by the Secretary of War to meet the expenditures in that part of the field of activity of the Signal Corps, which includes the functions hereby transferred to the Bureau of Aircraft Production, are hereby transferred to and placed under the jurisdiction of the Director of Aircraft Production for the purpose of meeting the obligations and expenditures authorized by said bureau.

III

"This order shall be and remain in full force and effect during the continuance of the present war and for six months after the termination thereof by the proclamation of the treaty of peace, or until theretofore amended, modified, or rescinded.

"Under this order Mr. John D. Ryan continued as Director of Aircraft Production and Maj. Gen. William L. Kenly became Director of Military Aeronautics."

This division of responsibilities and functions gave a clearer conception of the unique duties of the Air Service in production of planes and training of pilots, and is significant, too, of the many tactical reasons which made it imperative for England and France to establish separate and independent air services.

The end of the fiscal year found this problem of higher organization one of the most important to be faced. An early defect discovered in the reorganization developed when there appeared to be inadequate liaison between the Bureau of Aircraft Production and the Division of Military Aeronautics. One was responsible for the production of planes, the other for their operation and military efficiency. The method of selecting a type to put into production and the final decision whether any plane produced was suitable for its military purposes or not, was undetermined. The situation of two sets of officials with equal authority in their respective fields of action, neither responsible to the other, at once demonstrated that neither could be held for the final production of an acceptable plane for the front. This was partially obviated by an agreement between the Division of Military Aeronautics and the Bureau of Aircraft Production that the types of plane to be put into production must first be mutually agreed upon, and that before a plane could be sent to the front it should be given a military test and accepted by the Division of Military Aeronautics. But considerable time was lost before this policy was definitely arranged, a policy which might easily have at once been established by a unified department.

The personnel side of the air service, including the selection, training, organization, and operation of the flying forces, developed within the fiscal year 1917–18 into an educational system on a scale infinitely larger and more diverse than anyone had anticipated. Teaching men to fly, to send messages by wireless, to operate machine guns in the air, to know artillery fire by its bursts, and to travel hundreds of miles by compass, teaching other men to read the enemy's strategy from aerial photographs, and still others to repair instruments, ignition systems, propellers, aeroplane wings, and motors, has required a network of flying fields and schools, a large instructional force, and a maze of equipment and curricula.

None of this, practically speaking, was on hand at the outbreak of the war, neither fields, instructors, curricula, nor, more serious than all, experience to show what was to be needed. This country had never trained an aviator sufficiently to meet the demands of overseas aerial warfare and had not the slightest knowledge of the instruction necessary for radio, photography, or enlisted personnel. Consequently, the first men largely taught themselves before teaching others, and experience led on from one course to the next.

First, in the point of need, was that of flying fields. Two were in limited operation at the outbreak of war, San Diego and Mineola; three more were selected, cleared, equipped, and made ready for flying in six weeks' time, and by the end of the year over a score were in operation all over the country. All were protected by a three-year lease with option to buy, if desired, at a fixed price. During the year also five supply depots, three concentration depots, three balloon camps, two repair depots, one experimental field, one radio laboratory, and one quarantine camp were built.

The selection of men for training as flyers was a complicated task, as the requirements were necessarily rigid. Volunteer examining boards of the highest medical skill were organized all over the country, 36 urban and 30 divisional boards, and a total of 38,777 men were examined to June 2, of whom nearly half, or 18,004, were disqualified. This naturally led to a high grade of personnel, and made the later training both more rapid and more efficient.

The first step in instruction was at one of the new "ground" schools opened on May 21 at the Massachusetts Institute of Technology, Cornell and Ohio State Universities and the Universities of Illinois, Texas, and California, with Princeton and the Georgia School of Technology added on July 5. Here, in eight weeks, under military discipline, the cadets were grounded in all the elements of aviation at a cost to the Government at first of $65 per pupil, and later $10 each for the first four weeks, and $5 weekly thereafter. By June 30, 1918, a total of 11,539 men were graduated to the flying fields and 3,129 were discharged for failure in studies, etc.

Next came the actual flying instruction, divided into two phases, primary and advanced. The former averaged about eight weeks, included ability to execute the simpler evolutions and cross-country flights, and led to an officer's commission and the right to wear the Reserve Military Aviator's wings. To June 30, 1918, 4,980 men had been graduated as Reserve Military Aviators for final training, and about 400 had been disqualified as incapable of becoming flyers.

The advanced training, however, presented infinitely more difficulties. It was not nearly so simple to teach the more complex stunts, formation flying, aerial machine gunnery, bombing, and night flying, while at the same time the highly specialized equipment necessary required considerable time for manufacture. Nevertheless, advanced schools of the three types necessary were opened toward the end of the year 1918, with what equipment was available, and had graduated 110 bombers, 85 bombing pilots, 464 observers, 389 observer pilots, and 131 pursuit pilots by June 30, 1918.

The ideal arrangement in mind at the end of the year was to train each pilot completely on this side of the ocean, where facilities are very good, supplies in abundance, and information and experienced pilots from the front available in ever-increasing numbers. The flyers can then be organized into provisional squadrons and wings and given training as large units with their own administrative officers and enlisted personnel so that they will be able to go immediately to the front, after a month or so of transformation work in France, learning geography and familiarizing themselves with new types of planes. Plans are under way looking to the establishment of such wings and brigades in the United States with the end in view of furnishing complete and fully trained units to the American Expeditionary Force.

The whole training program was considerably held up by lack of equipment. Obviously it required far less time to select men for training than to build the fields, planes, and accessories necessary to train them. Primary training planes, the only type manufactured here before the war, soon became available in increasing numbers, till by the end of the year more were on hand than needed. The advanced training planes, however, presented problems wholly new to this country, so that primary planes had to be fitted with more powerful engines and equipment and made to serve the purpose. The first 16 single-seater pursuit planes were not delivered till January, 1918, the first bombers till March, and the first gunnery late in May.

During this fiscal year a grand total of 407,999 hours were flown by Army aviators in the United States, as contrasted with 745.5 hours in 1914 and 1,269 in 1915. In the single week ending June 30, 1918, a total of 19,560 hours were flown, or 15 times, for that single week, the number of the whole year three years before. This, at 75 miles an hour, is equivalent to over 30,000,000 miles, or 1,223 times around the Equator.

During it there were 152 fatalities, or 2,684 flying hours and 201,000 miles flown to each death. Of these, 86 were caused by stalls, when the plane, usually through some error by the pilot, lost its flying speed and dropped into a straight nose dive or turned into a tail spin, from which the pilot did not have the time or the skill to extricate it. Collisions were responsible for 30 other accidents, often due to failure to fly according to the rules. Side-slips, the only other large cause of accidents, resulted in 10 deaths.

Regrettable as these accidents are, it is felt that, considering the newness of the science, the early state of development of the planes, the inexperience in instruction, and the necessity of teaching stunts in themselves rather dangerous, this number is not large. As a matter of actual statistics, fatalities in American training are less than half as large as those of the other allied countries.

Besides flyers, however, engineer officers to direct the upkeep of the equipment, supply officers to keep sufficient equipment on hand, and adjutants to keep the records and do other military work had to be especially trained. These men, absolutely essential to the maintenance of the Air Service organization, could be secured only after a detailed course of instruction. An engineers' school, opened for a 12 weeks' course at the Massachusetts Institute of Technology on January 12, graduated 590 men and discharged 228 before June 30; a supply officers' school, opened at the Georgia School of Technology, graduated 852 men and discharged 111 from an eight weeks' course before it was closed on May 11; and an adjutants' school, opened at Ohio State University on January 12, graduated 789 and discharged 97 men in an eight weeks' course before it was closed June 22.

A six weeks' course for armament officers and men to care for machine guns and bombs was opened at Fairfield, Ohio, on April 22, graduating 95 officers and 465 men by June 30, all of whom went forthwith overseas. Just at the end of the year a series of special schools in aerial gunnery were opened as the final step in the flyers' training in this country, graduating 102 pilots, 111 observers, and 101 fighting observers by June 30. Also a special course for compass officers was opened at Camp Dick, Texas, on April 10, with 53 graduates, and another course at the same time for a score of navigation officers.

Radio also required very special instruction, with courses and instructors for all flyers through the various stages of their progress, for the receiving force on the ground, and for the men responsible for the upkeep of the radio equipment. At the outset, volunteer civilians, each with his own methods of instruction, stepped into the breach, but by the end of the year two radio officers, and four enlisted men's schools were in operation with 49 and 329 graduates, respectively; radio officers and equipment had been sent to every field and ground school; and the courses for flyers had been standardized all the way through.

Aerial photography, which had developed during the war into an exact science, required similar triple instruction—that for observers to operate the cameras in the air, intelligence officers on the ground to interpret them, and enlisted men to aid in the developing, printing, and enlarging, and to keep the equipment in condition. Where the United States had not even a single aerial camera at the outbreak of the war, by the end of the year there had been opened on March 25 a large school for developers and printers at Rochester, N. Y., with 680 graduates by June 30, an officers' school on January 6 at Cornell teaching map compilation and interpretation, and photographic "huts" with complete personnel and equipment for instruction at each of the flying fields.

One of the most serious problems, and one of late development, was that of enlisted men, the ground force needed to keep the planes and engines always in prime condition, repair minor breaks, tighten up wires, strengthen struts, and make sure that no airman went up in a faulty plane. This was work wholly new to American mechanics, and of a delicacy and carefulness to which they were quite unaccustomed. Moreover, mechanics of the skill required had largely been drained off by the draft, by enlistment, or by other war industries.

Consequently, a whole series of schools was necessary. At first, in the fall small detachments of mechanics were sent to various factories —ignition, magneto, propeller, welding, instruments, sail-making, cabinet work, copper work, machine guns, and motors to secure as much experience as possible. While about 2,000 men were being graduated from 17 courses at 34 different schools of this type, more fully worked out courses were established at five northern flying fields closed for flying during the winter. With 2,500 graduated here, still more detailed courses were opened at four large mechanics' schools, which added another 5,000 men. By the end of the year two large and complete Government schools were in operation at Kelly Field, Texas, and St. Paul, Minn., capable of graduating 5,000 men every three months.

A noteworthy event of the year was the opening on May 15 of the first regular aerial mail service in the United States between New York, Philadelphia, and Washington. The Army furnished six planes and pilots, shortly doubled, for a daily round trip, carrying about 350 pounds of mail each way, and with a record of 50 minutes for the 90 miles between Philadelphia and New York, and 1 hour and 50 minutes for the 135 miles from Philadelphia to Washington. Ninety per cent of the trips were made successfully.

Another vitally important phase of the Air Service is that of ballooning, which during the war has been developing into a system of ever-watchful sentries on guard all the way from the North Sea to Switzerland. Less spectacular, perhaps, than the heavier-than-air work, this branch of the service has a quite indispensable function. The observer, swinging in a captive balloon at an altitude of a mile, 2 to 5 miles from the enemy's lines, and with a range of vision of 8 miles in all directions, can make a far more detailed, minute-by-minute analysis of the enemy's movements than the wider visioned but transitory aviator, and can maintain such a flow of minute information to the staff below that no important movement can take place unobserved within his view.

Here, also, at the outbreak of the war the United States was practically without facilities. The only school was at Fort Omaha, Nebr., recovered from complete abandonment the previous November, with accommodations for 15 officers and 400 men, and equipment of balloon shed, gas plant, two obsolete captive balloons, and some telephone material. The original program of August 13 necessitated a very large expansion, fully comparable to that in the heavier-than-air branch.

To meet the program the Fort Omaha school was enlarged in September to accommodate 61 officers and 1,200 men; on December 28 Camp John Wise was opened at San Antonio with a final capacity of 150 officers and 2,200 men, and special companies were sent to Fort Sill, Okla., for cooperation with the Coast Artillery. By June 30, 440 balloon officers had graduated, of whom 155 were fully qualified observers, and 73 had been sent overseas. The enlisted strength stood at 9,621 with 1,382 abroad.

Thus, by the end of the fiscal year, the Air Service had in operation an educational system complete in all the details necessary to man this intricate service. Fields, curricula, instructors, and equipment were on hand for the most diverse courses, and men were graduating in hundreds trained to all the difficulties of operating aeroplanes and translating their work into effective action. A total of 34,209 men had been graduated from the various courses, with 20,976 men enrolled in 50 schools of 16 different types.

Many outside bodies were called upon to cooperate in this development. Great Britain, France, and Italy all early established large aviation missions in Washington which brought their three years of experience to help solve problems confronted here for the first time. The National Advisory Committee for Aeronautics, the Bureau of Standards, and several joint Army and Navy Boards also added their information on the subject.

Nevertheless the work was carried out under extreme difficulties. Operation and production were not properly coordinated. Much time was lost in having to obtain the necessary authority to build a new field or secure increases in personnel, instead of being able to carry out a main program with full independence and authority. Moreover, experienced and trained personnel was lacking; work had to be done while the actual organization to do it was being built up; much time was lost in the expansion and moving about of offices in Washington, some half a dozen times; while officers were constantly being shifted between Washington, the fields, and overseas.

Meanwhile overseas, work of organization was similarly going on. Hardly six weeks after the United States entered the war, namely, on May 27, the first cadets sailed for France for training in the highly developed French flying schools, till by the end of the year nearly 2,500 men were under instruction in France, England, Italy, and Canada. The collapse of Russia, Italy's serious defeat, and the weight thrown on the allied services made it impossible, unfortunately, for the Allies to meet the schedule of training planes necessary, so that many of these cadets, the most promising of America's material, were in idleness for months. Nevertheless, what facilities were available greatly advanced America's aerial preparation and helped relieve the shortage of equipment here. It was early in May, 1918, however, over a year after America's entry into the war, that the first German plane fell victim to an aviator in the American service. About the same time 468 fully trained American aviators organized into 13 complete American squadrons or brigades with British and French squadrons were actually on the front, taking increasing toll of the enemy.

During the same time an enlisted force of 46,667 men had also been sent overseas. The first to go were sent to France to lay the foundations for the great organization soon to be built up, including training fields, assembly depots for American-built planes, and aerodromes near the front. Others were formed into service squadrons in England and France to be ready as soon as American pilots were trained into their own organizations. Still others went to relieve French skilled labor of unskilled work so that they could go back into aeroplane factories, while others went to England for the construction work necessary to carry out the night bombing program.

Consequently, by June 30, 1918, two large training organizations were in operation, the source of supply in this country training and organizing thousands of pilots and men in all sorts of tasks and the operation end overseas giving the final training in France, England, and Italy the fast moving of fully trained squadrons to the front.

Where, at the outbreak of the war, there had been but 65 officers in the Air Service, there were now 14,230; the enlisted strength, similarly, had jumped from 1,120 to 124,767; the number of men in or awaiting training for flyers from less than 100 to over 18,000. There were 4,872 officers and 46,667 enlisted men overseas. Indeed, the Air Service alone was by June 30, 1918, larger than the American Army at the outbreak of the war. While its development had been infinitely more complicated and much less rapid than expected, there is reason to believe that it is essentially sound.

William L. Kenly,
Major-General, U. S. A.,
Director of Military Aeronautics.

The Secretary of War.

APPENDIX II

RECORDS OF ALLIED AND ENEMY ACES WITH NUMBER OF PLANES BROUGHT DOWN

K—Killed. D—Dead. C—Captured. W—Wounded.

BRITISH ACES

Major E. Mannock (k)	73
Colonel William A. Bishop	72
Major Raymond Collishaw	70
Captain James McCudden (k)	58
Captain Philip F. Fullard	48
Captain Donald E. McLaren (k)	48
Captain G. E. H. McElroy	46
Captain Albert Ball (k)	43
Captain J. I. T. Jones	40
Captain A. W. B. Proctor	39
Major Roderic S. Dallas	39
Captain W. G. Claxton (k)	37
Captain F. R. McCall	34
Captain Frank G. Quigley	34
Major Albert D. Carter	31
Captain Cedric E. Howell	30
Captain A. E. McKeever	30
Captain Henry W. Wollett	28
Captain Brunwin-Hales	27
Major William G. Barker	25
Captain W. L. Jordan	25
Captain John Andrews, (Lieutenant, 9)	24
Captain Francis McCubbin	23
Captain M. B. Frew, (Lieutenant, 8)	23
Captain John Gilmour	23
Captain E. Libby	
Captain Robert A. Little	22
Captain A. H. Cobby	21
Captain G. E. Thomson (k)	21
Lieutenant John J. Malone	20
Lieutenant Allen Wilkenson	19

Captain E. G. McClaughey	19
Captain J. L. Trollope (c)	18
Captain Stanley Rosever (d)	18
Lieutenant Leonard M. Barlow	17
Captain Walter A. Tyrrell	15
Captain P. C. Carpenter	15
Lieutenant Clive Warman	15
Lieutenant Clive F. Collett (k)	15
Lieutenant Fred Libby	14
Lieutenant R. T. C. Hoidge	14
Captain H. G. Reeves (accident)	13
Captain Murray Galbraith	13
Lieutenant Joseph S. Fall	13
Captain Noel W. W. Webb (k)	12
Lieutenant A. J. Cowper	12
Lieutenant Alan Gerard	12
Captain Whitaker (in Italy)	12
Lieutenant M. D. G. Scott	11
Captain Robert Dodds	11
Captain Gilbert Ware Green	9
Lieutenant K. R. Park	9
Lieutenant Rhys-David	9
Lieutenant John H. T. Letts	8
Captain James A. Slater	8
Sergeant Dean K. Lamb	8
Lieutenant Boyd S. Breadner	8
Captain Wagour (in Italy)	7
Lieutenant Edward A. Clear	7
Captain Henry G. Luchford (k)	7
Captain C. A. Brewster-Joske	7
Lieutenant A. S. Sheppard	7
Lieutenant James Dennis Payne	7
Lieutenant Lionel B. Jones	7
Captain Lancelot L. Richardson	6
Lieutenant Cecil Roy Richards	6
Lieutenant Howard Saint	6
Lieutenant Fred John Gibbs	6
Lieutenant C. W. Cuddemore	6
Captain H. T. Mellings (w)	5
Commander R. F. Minifie (c)	5
Lieutenant Langley F. W. Smith	5
Lieutenant Ellis Vair Reed	5
Captain R. W. Chappell	5
Captain G. H. Boarman	5
Lieutenant F. T. S. Menedex	5
Captain Kennedy C. Patrick	5

Sergeant T. F. Stephenson	5
Lieutenant William Lewis Wells	5
Lieutenant E. D. Clarke	5
Captain Fred Hope Lawrence	5
Lieutenant Edward R. Grange	5
Lieutenant W. G. Miggett	5
Lieutenant Lawrence W. Allen	5
Lieutenant William D. Matheson	5
Lieutenant Stanley J. Coble	5
Captain S. T. Edwards	4
Captain A. R. Brown	4
Captain A. T. Whealy	4
Captain T. F. LeMesuries	4
Commander F. C. Armstrong	4
Commander E. L. N. Clarke	4
Commander R. B. Munday	4
Commander G. W. Price	4
Commander R. J. O. Compston	4
Lieutenant V. R. Stockes	4
Lieutenant W. C. Canbray	4
Lieutenant G. T. Beamish	3
Lieutenant E. T. Hayne	3
Lieutenant G. W. Hemming	3
Lieutenant J. E. L. Hunter	3
Lieutenant W. A. Curtiss	3
Lieutenant G. R. Crole	3
Lieutenant Robert N. Hall	3
Lieutenant David S. Hall	3
Lieutenant M. F. G. Day	3
Lieutenant E. G. Johnson	3
Lieutenant M. H. Findlay	3
Lieutenant C. B. Ridley	3
Lieutenant S. B. Horn	3
Lieutenant K. K. Muspratt	3

FRENCH ACES

Lieutenant Rene Fonck	75
Captain Georges Guynemer (k)	53
Lieutenant Charles Nungesser	43
Lieutenant Georges Madon	41
Lieutenant Maurice Boyau (k)	35
Lieutenant Coeffard (k)	34
Captain Pinsard	27
Lieutenant Rene Dorme (m)	23
Lieutenant Guerin (k)	23

Captain Heurteaux	21
Sergeant Marinovitch	21
Lieutenant Deullin	20
Adjutant Ehrlich	19
Lieutenant de Slade	19
Lieutenant Jean Chaput (k)	16
Lieutenant de Turrenne	15
Lieutenant de Meuldre (k)	13
Lieutenant Garaud	13
Lieutenant Nogues	13
Lieutenant Jailler	12
Lieutenant Marcel Hughes	12
Lieutenant Navarre (w)	12
Lieutenant Tarascon	12
Lieutenant de Sevin	12
Adjutant Casale	12
Lieutenant Leps	12
Lieutenant de La Tour (k)	11
Adjutant Maxime Lenoire (k)	11
Lieutenant Sardier	11
Lieutenant Ortoli	11
Sergeant Montrion (k)	11
Adjutant Herrison	11
Sergeant Bouyer	11
Lieutenant Bourgade	10
Adjutant Herbelin	10
Sergeant Quette (k)	10
Captain Georges Matton	9
Adjutant Chainat	9
Adjutant Dauchy	9
Lieutenant Viallet	9
Sergeant Sauvage (k)	8
Lieutenant de Rochefort (k)	7
Captain Rene Doumer (k)	7
Captain Alfred Auger (k)	7
Lieutenant Henri Languedoc (k)	7
Captain Derode	7
Lieutenant Lachmann	7
Lieutenant Flachaire	7
Adjutant Vitallis	7
Adjutant Sayaret	7
Lieutenant L'Hoste	7
Lieutenant Raymond	6
Sergeant du Bois d'Aische	6
Lieutenant Covin	6
Lieutenant Bonnefoy	6

Lieutenant Gond	6
Lieutenant Soulier	6
Sergeant Boyau	6
Adjutant Dhome	6
Adjutant Peronneau	6
Sergeant Rousseau	6
Private Louis Martin	6
Lieutenant de Mortemart (k)	6
Lieutenant Adolph Pegoud (k)	6
Sergeant Marcel Hauss (k)	5
Captain Lecour-Grandmaison (k)	5
Lieutenant Georges Baillot (k)	5
Adjutant Pierre Violet (k)	5
Lieutenant Andre Delorme (k)	5
Lieutenant Borzecky	5
Lieutenant Paul Gastin	5
Adjutant Bloch	5
Lieutenant Regnier	5
Commander Marancourt	5
Adjutant Blanc	5
Lieutenant Marty	5
Adjutant de Pralines	5

HUN ACES

Captain von Richthofen (k)	80
Lieutenant Udet	60
Lieutenant Werner Voss Crefeld (k)	49
Captain Boelke (k)	40
Lieutenant Gontermann (k)	39
Lieutenant Max Muller (k)	38
Lieutenant Bongartz	36
Captain Brunowsky (Austrian)	34
Lieutenant Max Buckler (k)	34
Lieutenant Menckhoff	34
Captain Berthold	33
Lieutenant Loerzer	33
Lieutenant Cort Wolff (k)	33
Lieutenant Koenneke	32
Lieutenant Balle	31
Lieutenant Schleich	30
Lieutenant Schaeffer (k)	30
Lieutenant Almenroder (k)	30
Lieutenant von Richthofen	29
Lieutenant Kroll	28
Lieutenant Prince von Bulow (k)	28

Lieutenant Wuesthoff (k)	28
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Lieutenant Boerr	28
Lieutenant Huey	28
Lieutenant Blume	28
Lieutenant Lowenhardt (k)	27
Captain von Tutscheck (k)	27
Lieutenant Barnett (k)	27
Lieutenant Dosler (k)	26
Lieutenant Arigi (Austrian)	26
Lieutenant Peutter (k)	25
Lieutenant Veltgens (k)	24
Lieutenant Erwin Boehm (k)	24
Corporal Rumey	23
Lieutenant Kirstein (k)	23
Lieutenant Link Crawford (k)	23
Lieutenant Fiala (Austrian)	23
Captain Baumer	23
Lieutenant Jakobs	22
Lieutenant Klein	22
Lieutenant Cluffort	22
Lieutenant Friedrichs (k)	21
Lieutenant Billik (k)	21
Lieutenant Wimdische (k)	21
Lieutenant Adam	21
Lieutenant Grein	20
Lieutenant Buechner	20
Lieutenant Thuy	20
Lieutenant von Tschwibon	20
Captain Reinhardt	20
Lieutenant von Eschwege (k)	20
Lieutenant Bethge (k)	20
Captain Behr	19
Lieutenant Thulzer	19
Lieutenant Baldamus	18
Lieutenant Wintgens (k)	18
Lieutenant Frankel (k)	17
Lieutenant Kissenberth	17
Lieutenant Schmidt	15
Lieutenant Geigle (k)	15
Lieutenant Schneider	15
Lieutenant Immelmann	15
Lieutenant Nathanall	14
Lieutenant Dassenbach	14
Lieutenant Festner	13
Lieutenant Hess	13

Lieutenant Muller	13
Lieutenant Goettsch	13
Lieutenant Pfeiffer	12
Lieutenant Manschatt (k)	12
Lieutenant Hohnforf (k)	12
Lieutenant Muttschaat	12
Lieutenant Buddecke (k)	12
Lieutenant von Kendall (k)	11
Lieutenant Kirmaier	11
Lieutenant Theiller	11
Lieutenant Serfert	11
Lieutenant Goering	10
Lieutenant Mulzer	10
Lieutenant Frickart	9
Lieutenant Banfield	9
Lieutenant Leffers (k)	9
Lieutenant Schulte	9
Lieutenant Parschau (k)	8
Lieutenant Schilling	8
Lieutenant von Althaus	8
Lieutenant Esswein	6
Lieutenant Walz	6
Lieutenant Hehn	6
Lieutenant Koenig	6
Lieutenant Fahlbusch	5
Lieutenant von Siedlitz	5
Lieutenant Rosenkranz	5
Lieutenant Habor	5
Lieutenant Reimann	5
Captain Zauder	5
Lieutenant Brauneck	5
Lieutenant Ullmer	5
Lieutenant Roth	5

ITALIAN ACES

Major Baracca (k)	36
Lieutenant Flavio Barachini	31
Lieutenant Olivari (k)	21
Lieutenant Anchilotti	19
Colonel Piccio	17
Captain, Duke Calabria	16
Lieutenant Scaroni	13
Lieutenant Hanza	11
Sergeant Maisero	8
Lieutenant Parnis	7

Sergeant Poli	6
Lieutenant Luigi Olivi	6
Lieutenant Stophanni	6
Lieutenant Arrigoni	5

BELGIAN ACES

Lieutenant Coppens	30
Lieutenant de Meulemesster	10
Lieutenant Thieffry (k)	10
Lieutenant Jan Olieslagers	6
Adjutant Beulemest	6
Captain Jaquette	5
Lieutenant Robin	5
Lieutenant Medaets	5

RUSSIAN ACES

Captain Kosakoff	17
Captain Kroutenn (k)	6
Lieutenant Pachtchenko	5

TURKISH ACE

Captain Schetz	8

APPENDIX III

NOMENCLATURE FOR AERONAUTICS

BY THE NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

Introduction

The following nomenclature was adopted by the National Advisory Committee for Aeronautics at its annual meeting October 10, 1918.

The purpose of its adoption and publication is to help secure uniformity in the official documents of the government as well as in the technical journals.

Aeronautical Nomenclature

Aerofoil: A winglike structure, flat or curved, designed to obtain reaction upon its surfaces from the air through which it moves.

Aerofoil section: A section of an aerofoil made by a plane parallel to the plane of symmetry of the aerofoil.

Aeroplane: See Airplane.

Aileron: A movable auxiliary surface, usually part of the trailing edge of a wing, the function of which is to control the lateral attitude of an airplane by rotating it about its longitudinal axis.

Aircraft: Any form of craft designed for the navigation of the air—airplanes, airships, balloons, helicopters, kites, kite balloons, ornithopters, gliders, etc.

Airplane: A form of aircraft heavier than air which has wing surfaces for support in the air, with stabilizing surfaces, rudders for steering, and power plant for propulsion through the air. This term is commonly used in a more restricted sense to refer to airplanes fitted with landing gear suited to operation from the land. If the landing gear is suited to operation from the water, the term "seaplane" is used. (See definition.)

Pusher.—A type of airplane with the propeller in the rear of the engine.

Tractor.—A type of airplane with the propeller in front of the engine.

AIRSHIP: A form of balloon, the outer envelope of which is of elongated form, provided with a propelling system, car, rudders, and stabilizing surfaces.

Nonrigid.—An airship whose form is maintained by the pressure of the contained gas assisted by the car-suspension system.

Rigid.—An airship whose form is maintained by a rigid structure contained within the envelope.

Semirigid.—An airship whose form is maintained by means of a rigid keel and by gas pressure.

AIR-SPEED METER: An instrument designed to measure the speed of an aircraft with reference to the air.

ALTIMETER: An aneroid mounted on an aircraft to indicate continuously its height above the surface of the earth. Its dial is marked in feet, yards, or meters.

ANEMOMETER: Any instrument for measuring the velocity of the wind.

ANGLE:

Of attack (or *of incidence*) *of an aerofoil.*—The acute angle between the direction of the relative wind and the chord of an aerofoil; i. e., the angle between the chord of an aerofoil and its motion relative to the air. (This definition may be extended to any body having an axis.)

Critical.—The angle of attack at which the lift-curve has its first maximum; sometimes referred to as the "burble point."

Gliding.—The angle the flight path makes with the horizontal when descending in still air under the influence of gravity alone; i. e., without power from the engine.

ANGLE OF INCIDENCE (*in directions for rigging*): In the process of rigging an airplane some arbitrary definite line in the airplane is kept horizontal; the angle of incidence of a wing, or of any aerofoil, is the angle between its chord and this horizontal line, which usually is the line of the upper longitudinals of the fuselage or nacelle.

APPENDIX: The hose at the bottom of a balloon used for inflation. In the case of a spherical balloon it also serves for equalization of pressure.

ASPECT RATIO: The ratio of span to chord of an aerofoil.

ATTITUDE: The attitude of an aircraft is determined by the inclination of its axes to the "frame of reference"; e. g., the earth, or the relative wind.

AVIATOR: The operator or pilot of heavier-than-air craft. This term is applied regardless of the sex of the operator.

AXES OF AN AIRCRAFT: Three fixed lines of reference; usually centroidal and mutually rectangular.

The principal longitudinal axis in the plane of symmetry, usually parallel to the axis of the propeller, is called the *longitudinal* axis; the axis perpendicular to this in the plane of symmetry is called the *normal* axis; and the third axis, perpendicular to the other two, is called the *lateral* axis. In mathematical discussions the first of these axes, drawn from front to rear, is called the X axis; the second, drawn upward, the Z axis; and the third, running from right to left, the Y axis.

BALANCING FLAPS: See Aileron.

BALLONET: A small balloon within the interior of a balloon or airship for the purpose of controlling the ascent or descent and for maintaining pressure on the outer envelope so as to prevent deformation. The ballonet is kept inflated with air at the required pressure, under the control of valves by a blower or by the action of the wind caught in an air-scoop.

BALLOON: A form of aircraft comprising a gas bag, rigging and a basket. The support in the air results from the buoyancy of the air displaced by the gas bag, the form of which is maintained by the pressure of a contained gas lighter than air.

Barrage.—A small spherical captive balloon, raised as a protection against attacks by airplanes.

Captive.—A balloon restrained from free flight by means of a cable attaching it to the earth.

Kite.—An elongated form of captive balloon, fitted with tail appendages to keep it headed into the wind, and deriving increased lift due to its axis being inclined to the wind.

Pilot.—A small spherical balloon sent up to show the direction of the wind.

Sounding.—A small spherical balloon sent aloft without passengers but with registering meteorological instruments.

BALLOON BED: A mooring place on the ground for a captive balloon.

BALLOON CLOTH: The cloth, usually cotton, of which balloon fabrics are made.

BALLOON FABRIC: The finished material, usually rubberized, of which balloon envelopes are made.

BANK: To incline an airplane laterally—i. e., to roll it about the longitudinal axes. Right bank is to incline the airplane with the right wing down. Also used as a noun to describe the position of an airplane when its lateral axis is inclined to the horizontal.

BANK, ANGLE OF: The angle through which an aircraft must be rotated about its longitudinal axis in order to bring its lateral axis into the horizontal plane.

BAROGRAPH: An instrument used to record variations in barometric pressure. In aeronautics the charts on which the records are made indicate altitudes directly instead of barometric pressures.

BASKET: The car suspended beneath a balloon, for passengers, ballast, etc.

BIPLANE: A form of airplane in which the main supporting surface is divided into two parts, one above the other.

BODY OF AN AIRPLANE: See Fuselage and Nacelle.

BONNET: The appliance, having the form of a parasol, which protects the valve of a spherical balloon against rain.

BRIDLE: The system of attachment of cable to a balloon, including lines to the suspension band.

BULL'S-EYES: Small rings of wood, metal, etc., forming part of balloon rigging, used for connection or adjustment of ropes.

BURBLE POINT: See Angle, critical.

CABANE: A pyramidal framework upon the wing of an airplane, to which stays, etc., are secured.

CAMBER: The convexity or rise of the curve of an aerofoil from its chord, usually expressed as the ratio of the maximum departure of the curve from the chord to the length of the chord. "Top camber" refers to the top surface of an aerofoil, and "bottom camber" to the bottom surface; "mean camber" is the mean of these two.

CAPACITY: See Load. The cubic contents of a balloon.

CEILING: *Service.*—The height above sea level at which a given aircraft ceases to rise at a rate higher than a small specified one, say 100 feet per minute. This specified rate may be different in the services of different countries.

Absolute.—The maximum height above sea level to which a given aircraft can rise.

Theoretical.—The limiting height to which a given aircraft can rise determined by computations of performance, based upon the drawings and wind tunnel data.

CENTER OF PRESSURE OF AN AEROFOIL: The point in the plane of the chords of an aerofoil, prolonged if necessary, through which at any given attitude the line of action of the resultant air force passes. (This definition may be extended to any body.)

CHORD OF AN AEROFOIL SECTION:

For theoretical purposes.—The zero lift line, i. e., the limiting position, in the section, of the line of action of the resultant air force when the position of the section is such that the lift is zero.

Practical.—The line of a straightedge brought into contact with the lower surface of the section at points near its edges. In the case of an aerofoil having double convex camber, the straight line joining the entering and trailing edges.

Length.—The length of the chord is the length of the projection of the aerofoil section on its chord.

CLINOMETER: See Inclinometer.

CONCENTRATION RING: A hoop to which are attached the ropes suspending the basket of a spherical balloon.

CONTROLS: A general term applying to the means provided for operating the devices used to control speed, direction of flight, and attitude of an aircraft.

CONTROL COLUMN: The vertical lever by means of which certain of the principal controls are operated, usually those for pitching and rolling.

CROSS-WIND FORCE: The component perpendicular to the lift and to the drag of the total force on an aircraft due to the air through which it moves.

CROW'S-FOOT: A system of diverging short ropes for distributing the pull of a single rope.

DECALAGE: The angle between the chords of the principal and the tail planes of a monoplane. The same term may be applied to the corresponding angle between the direction of the chord or chords of a biplane and the direction of a tail plane. (This angle is also sometimes known as the longitudinal V of the two planes.)

Dihedral in an airplane: The angle included at the intersection of the imaginary surfaces containing the chords of the right and left planes (continued to the plane of symmetry if necessary). This angle is measured in a plane perpendicular to that intersection. The measure of the dihedral is taken as 90° minus one-half of this angle as defined.

The dihedral of the upper planes may and frequently does differ from that of the lower planes in a biplane.

Dirigible: See Airship.

Diving rudder: See Elevator.

Dope: A general term applied to the material used in treating the cloth surface of airplane members and balloons to increase strength, produce tautness, and act as a filler to maintain air-tightness; it usually has a cellulose base.

Drag: The component parallel to the relative wind of the total force on an aerofoil or aircraft due to the air through which it moves.

In the case of an airplane, that part of the drag due to the wings is called "wing resistance"; that due to the rest of the airplane is called "parasite resistance."

Drift: See Drag. Also used as synonymous with "leeway," q. v.

Drift meter: An instrument for the measurement of the angular deviation of an aircraft from a set course, due to cross winds.

Drip cloth: A curtain around the equator of a balloon, which prevents rain from dripping into the basket.

Droop: A permanent warp of an aerofoil such that the angle of attack increases toward the wing tips. (The opposite of "wash out.")

Elevator: A movable auxiliary surface, usually attached to the tail, the function of which is to control the longitudinal attitude of an aircraft by rotating it about its lateral axis.

Empennage: The tail surfaces of an aircraft. Sometimes the word is limited to the fixed stabilizing portion of the tail—

usually comprising the tail plane and vertical fin, to which are attached the elevator and rudders.

ENTERING EDGE: The foremost edge of an aerofoil or propeller blade.

ENVELOPE: The outer covering of a rigid airship; or, in the case of a balloon or a nonrigid airship, the gas bag which contains the gas.

EQUATOR: The largest horizontal circle of a spherical balloon.

FINS: Small fixed aerofoils attached to different parts of aircraft, in order to promote stability; for example, tail fins, skid fins, etc. Fins are often adjustable. They may be either horizontal or vertical.

FLIGHT PATH: The path of the center of gravity of an aircraft with reference to the earth.

FLOAT: That portion of the landing gear of an aircraft which provides buoyancy when it is resting on the surface of the water.

FUSELAGE: The elongated structure to which are attached the landing gear, wings and tail. A fuselage is rarely used with pushers; and in general it is designed to hold the passengers.

GAP: The shortest distance between the planes of the chords of the upper and lower planes of a biplane, measured along a line perpendicular to the chord of the lower plane at its entering edge.

GAS BAG: See Envelope.

GLIDE: To fly without engine power.

GLIDER: A form of aircraft similar to an airplane, but without any power plant.

When utilized in variable winds it makes use of the soaring principles of flight and is sometimes called a soaring machine.

GLIDING ANGLE: See Angle, gliding.

GORE: One of the segments of fabric composing the envelope.

GROUND CLOTH: Canvas placed on the ground to protect a balloon.

GUIDE ROPE: The long trailing rope attached to a spherical balloon or airship, to serve as a brake and as a variable ballast.

GUY: A rope, chain, wire or rod attached to an object to guide or steady it, such as guys to wing, tail, or landing gear.

HANGAR: A shed for housing airships or airplanes.

HELICOPTER: A form of aircraft whose support in the air is derived from the vertical thrust of propellers.

HORN: A short arm fastened to a movable part of an airplane, serving as a lever arm, e. g., aileron horn, rudder horn, elevator horn.

HULL OF AN AIRSHIP: The main structure of a rigid airship, consisting of a covered elongated framework which incloses the gas bags and which supports the nacelles and equipment.

INCLINOMETER: An instrument for measuring the angle made by any axis of an aircraft with the horizontal, often called a clinometer.

INSPECTION WINDOW: A small transparent window in the envelope of a balloon or in the wing of an airplane to allow inspection of the interior.

KITE: A form of aircraft without other propelling means than the towline pull, whose support is derived from the force of the wind moving past its surface.

LANDING GEAR: The understructure of an aircraft designed to carry the load when resting on or running on the surface of the land or water.

LEADING EDGE: See Entering edge.

LEEWAY: The angular deviation from a set course over the earth, due to cross currents of wind, also called drift; hence, "drift meter."

LIFT: The component of the total force due to the air resolved perpendicular to the relative wind and in the plane of symmetry.

LIFT OF AN AIRSHIP:

Dynamic.—The component of the total force on an airship due to the air through which it moves, resolved perpendicular to the relative wind and in the plane including the direction of the relative wind and the longitudinal axis.

Static.—The vertical upward force on an airship when at rest in the air, due to buoyancy.

LIFT BRACING: See Stay.

LOAD:

Dead.—The structure, power plant, and essential accessories of an aircraft. Included in this are the water in the radiator, tachometer, thermometer, gauges, air-speed indicator, levels, altimeter, compass, watch, and hand starter.

Full.—The total weight of an aircraft when loaded to the maximum authorized loading of that particular type.

Useful.—The excess of the full load over the dead-weight of the aircraft itself. Therefore useful load includes the crew and passengers, oil and fuel, electric-light installation, chart board, gun mounts, bomb storage and releasing gear, wireless apparatus, etc.

LOADING: See Wing loading.

LOBES: Bags at the stern of an elongated balloon designed to give it directional stability.

LONGERON: See Longitudinal.

LONGITUDINAL: A fore-and-aft member of the framing of an airplane body or of the floats, usually continuous across a number of points of support.

LOOP, A: An aerial maneuver in which the airplane describes an approximately circular path in the plane of the longitudinal and normal axes, the lateral axis remaining horizontal, and the upper side of the airplane remaining on the inside of the circle.

MAROUFLAGE: The process of wrapping and winding wooden parts in cloth.

MONOPLANE: A form of airplane which has but one main supporting surface extending equally on each side of the body.

MOORING BAND: The band of tape over the top of a balloon to which are attached the mooring ropes.

NACELLE: The inclosed shelter for passengers or for an engine. Usually in the case of a single-engine pusher it is the central structure to which the wings and landing gear are attached.

NET: A rigging made of ropes and twine on spherical balloons which supports the entire load carried.

ORNITHOPTER: A form of aircraft deriving its support and propelling force from flapping wings.

OVERHANG: One-half the difference in the span of the upper and lower planes of a biplane.

PANCAKE: To "level off" an airplane, just before landing, at too great an altitude, thus stalling it and causing it to descend with the wings at a very large angle of incidence.

PANEL: The unit piece of fabric of which the envelope is made.

PARACHUTE: An apparatus, made like an umbrella, used to retard the descent of a falling body.

PATCH SYSTEM: A system of construction in which patches (or adhesive flaps) are used in place of the suspension band.

PERMEABILITY: The measure of the loss of gas by diffusion through the intact balloon fabric.

PITCH OF A PROPELLER:

(*a*) *Pitch, effective.*—The distance an aircraft advances along its flight path for one revolution of the propeller.

(*b*) *Pitch, geometrical.*—The distance an element of a propeller would advance in one revolution if it were turning in a solid nut—i. e., if it were moving along a helix of slope equal to the angle between the chord of the element and a plane perpendicular to the propeller axis. The mean geometrical pitch of a propeller, which is a quantity commonly used in specifications, is the mean of the geometrical pitches of the several elements.

(*c*) *Pitch, virtual.*—The distance a propeller would have to advance in one revolution in order that there might be no thrust.

(*d*) *Pitch speed.*—The product of the mean geometrical pitch by the number of revolutions of the propeller in unit time—i. e., the speed the aircraft would make if there were no slip.

(*e*) *Slip.*—The difference between the effective pitch and the mean geometrical pitch. Slip is usually expressed as a percentage of the mean geometrical pitch.

PITCH, ANGLE OF: The angle between two planes, defined as follows: One plane includes the lateral axis of the aircraft and the direction of the relative wind; the other plane includes the lateral axis and the longitudinal axis. (In horizontal normal flight this angle of pitch is, then, the angle between the longitudinal axis and the direction of the relative wind.)

PITOT TUBE: A tube with an end open square to the fluid stream, used as a detector of an impact pressure. It is usually associated with a coaxial tube surrounding it, having perforations normal to the axis for indicating static pressure; or there is such a tube placed near it and parallel to it, with a closed conical end and having perforations in its side. The velocity of the fluid can be determined from the difference between the impact pressure and the static pressure, as read by a suitable gauge. This instrument is often used to determine the velocity of an aircraft through the air.

PLANE: One of the main supporting surfaces of an airplane or of a wing. (Thus the upper or lower plane of an airplane or the upper right plane or lower right plane of the right wing.)

PONTOONS: See Float.

PRESSURE NOZZLE: The apparatus which, in combination with a gauge, is used to measure speed through the air.

PUSHER: See Airplane.

PYLON: A mast or pillar serving as a marker of a course.

Race of a propeller: See Slip stream.

Rate of climb: The vertical component of the flight speed of an aircraft—i. e., its vertical velocity with reference to the air.

Relative wind: The motion of the air with reference to a moving body. Its direction and velocity, therefore, are found by adding two vectors, one being the velocity of the air with reference to the earth, the other being equal and opposite to the velocity of the body with reference to the earth.

Right-hand engine: An engine designed to drive a right-hand tractor screw.

Righting moment: A moment which tends to restore an aircraft to its previous attitude after any rotational disturbance.

Rip cord: The rope running from the rip panel of a balloon to the basket, the pulling of which causes immediate deflation.

Rip panel: A strip in the upper part of a balloon which is torn off when immediate deflation is desired.

Roll, A: An aerial maneuver in which a complete revolution about the longitudinal axis is made, the direction of flight being maintained.

Rudder: A hinged or pivoted surface, usually more or less flat or stream lined, used for the purpose of controlling the attitude of an aircraft about its normal axis—i. e., for controlling its lateral movement.

Balanced.—A rudder having part of its surface in front of its pivot.

Rudder bar: The foot bar by means of which the rudder is operated.

Seaplane: A particular form of airplane in which the landing gear is suited to operation from the water.

(*a*) *Boat seaplane* (or *flying boat*).—A form of seaplane having for its central portion a boat which provides flotation. It is often provided with auxiliary floats or pontoons.

(*b*) *Float seaplane.*—A form of seaplane in which the landing gear consists of one or more floats or pontoons.

SERPENT: A short, heavy guide rope.

SIDE SLIPPING: Sliding downward and inward when making a turn; due to excessive banking. It is the opposite of skidding.

SKIDDING: Sliding sidewise away from the center of the turn in flight. It is usually caused by insufficient banking in a turn and is the opposite of side slipping.

SKIDS: Long wooden or metal runners designed to prevent nosing of a land machine when landing or to prevent dropping into holes or ditches in rough ground. Generally designed to function should the landing gear collapse or fail to act.

SLIP STREAM (or *propeller race*): The stream of air driven aft by the propeller and with a velocity relative to the airplane greater than that of the surrounding body of still air.

SOARING MACHINE: See Glider.

SPAN (or *spread*): The maximum distance laterally from tip to tip of an airplane or the lateral dimension of an aerofoil.

SPEED: *Air.*—The speed of an aircraft relative to the air.

Ground.—The horizontal component of the velocity of an aircraft relative to the earth.

SPIN: An aerial maneuver consisting of a combination of roll and yaw, with the longitudinal axis of the airplane inclined steeply downward. The machine descends in a helix of large pitch and very small radius, the upper side of the machine being on the inside of the helix, and the angle of attack being maintained at a large value.

STABILITY: A body in any attitude has stability about an axis if, after a slight displacement about that axis, it tends to regain its initial attitude.

Directional.—Stability with reference to the normal axis.

Dynamical.—The quality of an aircraft in flight which causes it to return to a condition of equilibrium after its attitude has been changed by meeting some disturbance —e. g., a gust. This return to equilibrium is due to two factors: First, the inherent righting moments of the structure; second, the damping of the oscillations by the tail, etc.

Inherent.—Stability of an aircraft due to the disposition and arrangement of its fixed parts, i. e., that property which causes it to return to its normal attitude of flight without the use of the controls.

Lateral.—Stability with reference to displacements involving rolling or yawing, i. e., displacements in which the plane of symmetry of the airplane is rotated.

Longitudinal.—Stability with reference to displacements involving pitching, i. e., displacements in which the plane of symmetry of the airplane is not rotated.

Statical.—In wind-tunnel experiments it is found that there is a definite angle of attack, such that, for a greater angle or a less one, the righting moments are in such a sense as to tend to make the attitude return to this angle. This holds true for a certain range of angles on each side of this definite angle; and the machine is said to possess "statical stability" through this range.

A machine possesses statical stability if, when its attitude is disturbed, moments tending to restore it to this attitude are set up by the action of the air on the machine; e. g., if an aircraft, after an initial disturbance, oscillates with swings of constantly increasing amplitude, it is statically stable but not dynamically stable.

STABILIZER: A fixed horizontal, or nearly horizontal, tail surface, used to steady the longitudinal motion and to damp oscillations in pitch.

Mechanical.—A mechanical device to steady the motion of an aircraft.

STAGGER: The amount of advance of the entering edge of the upper plane of a biplane over that of the lower, expressed as percentage of gap; it is considered positive when the upper surface is forward and is measured from the entering edge of the upper plane along its chord to the point of intersection of this chord with a line drawn perpendicular to the chord of the lower plane at its entering edge, all lines being drawn in a plane parallel to the plane of symmetry.

(*In directions for rigging*).—The horizontal distance between the entering edge of the upper plane and that of the lower when the airplane is in the standard position; i. e., when the arbitrary line of reference in the airplane is horizontal. (This line is usually the axis of the propeller shaft.)

STALLING: A term describing the condition of an airplane which from any cause has lost the relative speed necessary for control.

STATOSCOPE: An instrument to detect the existence of a small rate of ascent or descent, principally used in ballooning.

STAY: A wire, rope, or the like, used as a tie piece to hold parts together, or to contribute stiffness. For example, the stays of the wing and body trussing.

STEP: A break in the form of the bottom of a float.

STREAM-LINE FLOW: The condition of continuous flow of a fluid, as distinguished from eddying flow.

STREAM-LINE SHAPE: A shape intended to avoid eddying and to preserve stream-line flow.

STRUT: A compression member of a truss frame. For instance, the vertical members of the wing truss of a biplane.

SUSPENSION BAND: The band around a balloon to which are attached the basket and the main bridle suspensions.

SUSPENSION BAR: The bar used for the concentration of basket suspension ropes in captive balloons.

SWEEP BACK: The horizontal angle between the lateral axis of an airplane and the entering edge of the main planes.

TAIL: The rear portion of an aircraft, to which are usually attached rudders, elevators, stabilizers, and fins.

Tail cups: The steadying device attached at the rear of certain types of elongated captive balloons.

Tandem: An airplane whose sets of planes are placed one in front of the other.

Tractor: See Airplane.

Trailing edge: The rearmost edge of an aerofoil or propeller blade.

Triplane: A form of airplane whose main supporting surface is divided into three parts, superimposed.

Truss: The framing by which the wing loads are transmitted to the body; comprises struts, stays, and spars.

Undercarriage: See Landing gear.

Venturi tube: A short tube, flaring at the front end, and constricted approximately midway of its length, so that, when fluid flows through it, there will be a suction produced in a side-tube opening into the constricted throat. This tube, when combined with a Pitot tube or with one giving static pressure, forms a pressure nozzle, which may be used as an instrument to determine the speed of an aircraft through the air.

Warp: To change the form of the wing by twisting it.

Wash in: See Droop.

Washout: A permanent warp of an aerofoil such that the angle of attack decreases toward the wing tips.

Weight, gross: See Load, full.

Wing: The aggregate sustaining structure on the right or left side of an airplane, comprising both planes and trussing. (Thus, "detachable wings" and "folding wings.")

Wing flap: See Aileron.

Wing loading: The weight carried per unit area of supporting surface.

Wing mast: The mast structure projecting above the wing, to which the top load wires are attached.

Wing rib: A fore-and-aft member of the wing structure used to support the covering and to give the wing section its form.

WING SPAR OR WING BEAM: A transverse member of the wing structure.

YAW: *Yawing.*—Angular motion about the normal axis.

Angle of.—The angle between the direction of the relative wind and the plane of symmetry of an aircraft.

ZERO LIFT LINE: The limiting position in an aerofoil section of the line of action of the resultant air force when the position of the section is such that the lift is zero.

1. Create an aggressive spirit
2. Reduce efficiency.
3.

[illegible]