The Skycraft Book

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FOREWORD

Where the youth of yesterday dreamed of a romantic career in the fields of railway and maritime transportation, the youth of today looks forward longingly to an interesting and lucrative career in the field of aviation.

The demand for literature upon this subject has, therefore, been great; probably it has been most insistent in the classrooms and libraries of our public schools.

To meet this need the author has prepared this book, the scope and content of which will appeal singularly to boys and girls of school age. Its accuracy and loyalty to detail are vouched for by the fact that the author is a licensed airplane pilot of several years' experience, a well-trained and experienced teacher in the public schools, and a person trained in modern methods of research. This book presents the limitations of aviation as well as its glorious possibilities. It will provide a sane experience as well as an inspiration to those who read it.

Roland H. Spaulding

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CHAPTER I

CREATIONS OF THE BEGINNERS

Long ages ago when semicivilized man was pursued by some huge wild beast, he must have gazed upward at the creatures of the air and longed for wings like theirs, whereby he might climb into the sky and escape his hungry enemy.

In the myths and folk tales of early peoples reference is made to supernatural beings floating through the air, or to men who attempted to use wings for flight.

An oft-heard story is that of Daedalus and his son, Icarus, who, according to Greek mythology, found themselves confined in a strange, roofless structure on the island of Crete. Daedalus had an inventive mind, and he set to work fashioning wings for himself and his son. These wings were fastened on with wax, and by their aid father and son took off and sailed high above the prison walls. Icarus, gaining confidence in his new adventure, forgot his father's advice not to go too near the sun lest the wax melt and his wings fall off. Onward he soared to new altitudes, when lo, the wax melted and he lost his wings and plunged headlong into the sea below. Daedalus, bemoaning the fate of his son, flew on, however, until he came to Sicily. Not caring to use his wings for future flights, he placed them in the temple of the great god Apollo.

Of Bladud, mythical king of Britain, it was written that

> "From a towre he thought to scale the sky.
> He brake his neck because he soared to high."

Another legend tells of a Saracen who in a desire to please his emperor gave an exhibition flight — a flight which, however, ended with fatal results to himself and his ambitions.

Downward through the centuries one finds vague stories of the magical flights of witches and wizards. Even today a familiar symbol of Halloween is the old witch, sailing through the sky astride her broomstick.

Early Theories Regarding Flight

Then, too, from time to time there appears the account of some one whose imagination far surpassed that of his fellows. Even in the thirteenth century the inquisitive friar, Roger Bacon, set forth an idea that there could be made "some flying instrument so that a man sitting in the middle and turning some mechanism may put in motion some artificial wings which may beat the air like a bird flying." The good friar lived in an age of superstition; so, lest he be denounced for favoring some black art, he never tried to put his ideas into practice.

About the time that Columbus was discovering new lands there lived the famous artist, Leonardo da Vinci, whom the world remembers as the painter of beautiful pictures, but who was also an architect, an engineer, and a scientist. One may read his *Treatise on the Flight of Birds* and discover that this man of the fifteenth century had figured out a great many principles of flight which designers of airplanes put into practice in this, the twentieth, century. His drawings, based upon his keen observations of birds and showing the essential ideas of the helicopter and the parachute, are still of considerable value.

Two men of the sixteenth century, a painter, Guidotte, and a Venetian architect, Veranzio, seem to have been sufficiently interested in da Vinci's theories to attempt to put them into practice; but both were unsuccessful in doing so, and da Vinci's ideas on flying were neglected for nearly four hundred years.

In the seventeenth century there were several men worthy of mention in the history of flight; two of them were Giovanni Borelli and Francesco Lana.

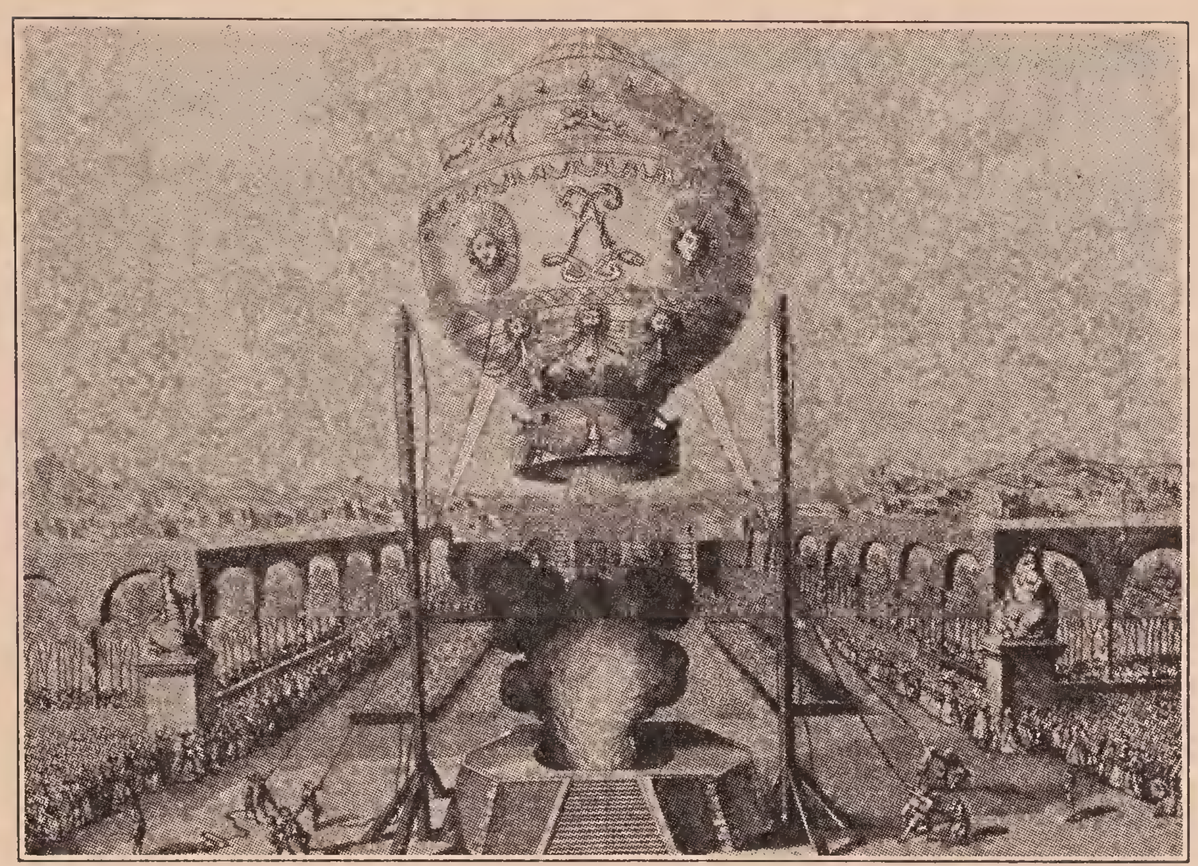
Borelli, like da Vinci, was a keen observer of birds. He figured out the relation between the power of the bird's muscles and the weight of its body and applied the same ratio to the power of a man's chest muscles and the weight of his body. He came to the conclusion that in order to sustain himself in flight with wings attached to his arms, man's chest muscles would have to be many times larger than they are, or if they were to remain the same size, his body weight would have to be very much less. His conclusion was, "It is impossible that men fly craftily by their own strength."

But man was determined to get into the air by one way or another, and his imagination led him into devising some means of getting there other than the flapping of wings. Francesco Lana was one such man with a novel idea for flight. He would build a kind of platform and attach vacuum globes on each corner. These globes, devoid of air, would be so much lighter than the surrounding air that they not only would rise, but would also take the platform along with them. Sails and oars would be used to control the direction. Lana was a monk whose vows of poverty prevented him from using funds to carry out his project.. If he had put his theory to the test he would have found that his copper globes, with no air or gas of any kind inside, either would have collapsed or, if strong enough to withstand the outer pressure of 14.7 pounds per square inch, would have been too heavy to rise at all.

Early Experiments with Balloons

It was not, indeed, until the eighteenth century that the first balloon was contrived.

In Annonay, France, there lived a paper manufacturer who had two sons, Joseph and Jacques Montgolfier. Both boys were interested in science. Much of their reading in this subject was about the nature of the atmosphere and the gases of which it is composed. They experimented with paper bags filled with heated air and found that the bags would rise in the air. Then they made larger devices for holding hot air. Their creations began to at-



Brown Brothers

THE MONTGOLFIER BALLOON

tract attention, and on June 5, 1783, they gave a public demonstration. When they were summoned to the French Court at Versailles to repeat their experiment, they placed in their gayly painted balloon, made this time from waterproof linen, three occupants — a sheep, a cock, and a duck. After an ascent of 1,500 feet, the balloon came down safely with two of the voyagers none the worse for their unusual trip. The cock seemed to be suffering discomfort which was thought at first to be an effect of the 'tremendous' altitude to which he had been carried. Later it was found, however, that his wing had been broken, probably by a kick from the sheep.

The next step was for some human being to take an air voyage. At first it was planned to select a convict from the prison and give him his freedom if he came down alive. But a man named Pilâtre de Rozier argued that great honor would be due such a person — honor too great to be bestowed upon one convicted of a crime — and he begged to be allowed to take the trip himself. At first he ascended in a captive balloon, and a month later, on November 21, 1783, he and Marquis d'Arlandes sailed over Paris in a free balloon, the first men in the history of aëronautics to invade the region above the earth.

A few days later a certain Professor J. A. C. Charles, who had been experimenting with balloons filled with hydrogen, and his companion, Mr. Roberts, made a notable 25-mile flight from Paris to Nesle in a balloon filled with this 'inflammable gas,' as hydrogen was then called.

Ballooning became the craze of the time, and interest spread over Europe and across the channel to England. The first aërial voyage in that country was made by an Italian, Lunardi, who won great fame as a balloonist. Women, with as keen an interest in air flights then as now, became spectators at the assemblages to witness balloon ascensions. On June 4, 1784, seven months after De Rozier had taken his first balloon trip, it is recorded that a woman, Madame Thible, made an aërial flight with a French aëronaut which lasted for forty-five minutes and which was witnessed by Gustavus, King of Sweden.

The first 'over-water' hop was made by Jean Pierre Blanchard and an American doctor, John Jeffries, of Boston, when in 1785 they took off in a balloon from Dover and landed near Calais, in France, having crossed the English Channel.

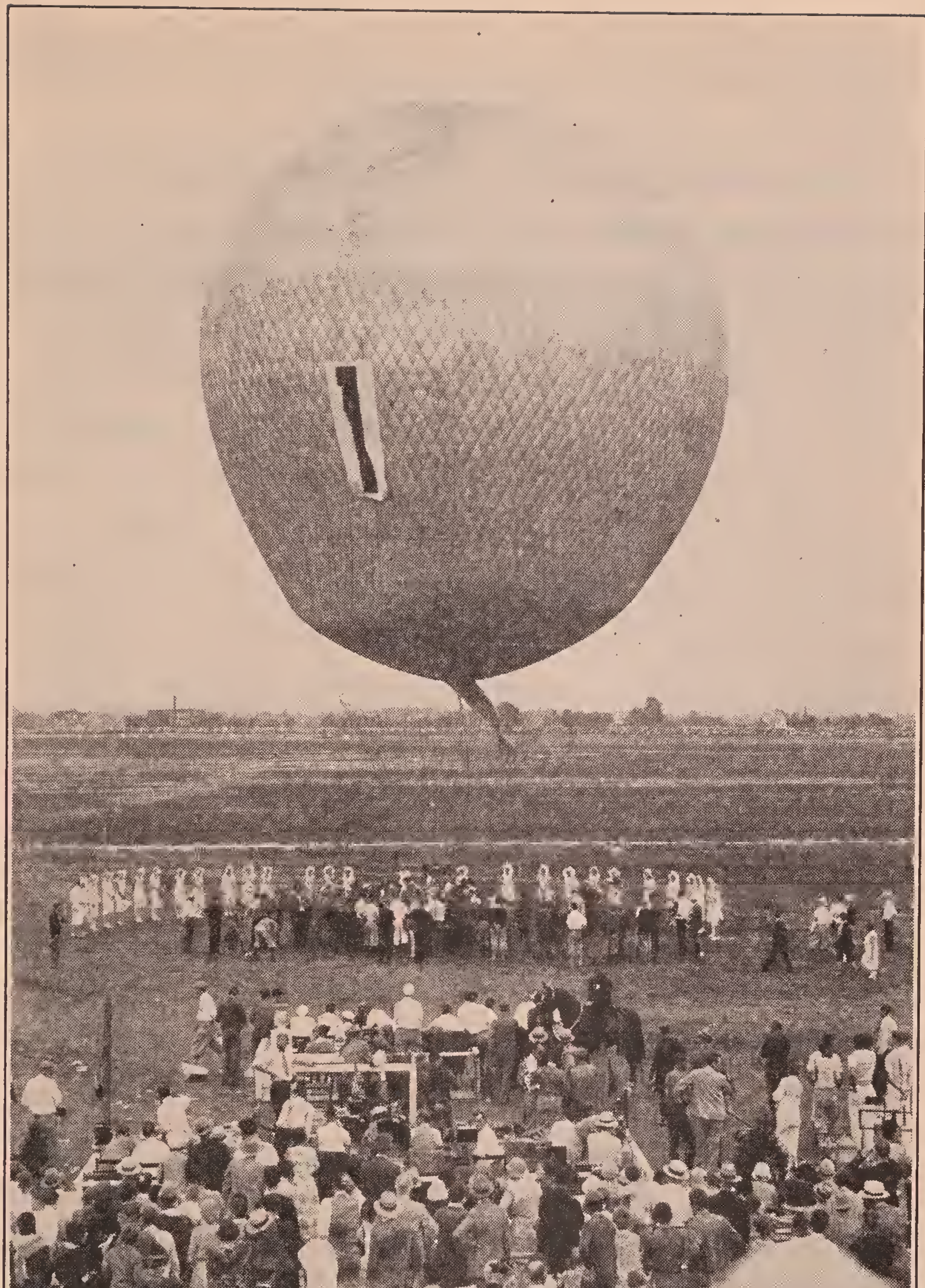
These European balloon flights attracted the attention of Americans, and on the invitation of Benjamin Franklin, Blanchard came to America. He started from Philadelphia one cold January morning in 1793 on an air flight over America. He carried an American flag and a passport presented to him by George Washington, who was then President of the United States. After six hours in the air he landed near Woodbury, in New Jersey. Here he loaded his deflated balloon on a farm wagon and carried it back to Philadelphia.

From 1804 to 1850 nothing important occurred in ballooning. Since balloons were wholly dependent upon the air currents for speed and direction, they were not of much use except as attractive spectacles at pleasure resorts or as a source of daring pastime for the adventurous.

The French were the first to make use of a balloon in warfare, when they built one and used it in a campaign against the Austrians in 1794.

During the American Civil War balloons were used. Professor F. S. C. Lowe, an enthusiastic aëronaut, made an "official ascent on July 24, 1861, and had the satisfaction of watching the movements of the Confederates after the battle of Manassas (Bull Run) and of being shot at." Descendants of Professor Lowe have presented to the Smithsonian Institution at Washington a copy of a note which Lincoln wrote to General Winfield Scott directing him to grant an interview to Lowe to discuss the use of balloons in warfare. A telegram, said to be the first message from a station in the air to one on the ground, was sent to President Lincoln by Mr. Lowe, June 18, 1861. In this message he thanked the President for the encouragement he had received in "demonstrating the availability of the science of aëronautics." These documents have proved that Lincoln was 'air-minded,' that he was personally interested in the early development of aëronautics in America. It is said that the Confederates, recognizing the value of balloons but handicapped by lack of materials, sent out an appeal to their fair ladies for a contribution of silk articles from their wardrobes. Without doubt these patriotic ladies responded generously, and when the balloon was finished it must have rivaled the earliest model in color and design. When it was captured by the North, General Longstreet wrote, "With it went the last silk dress of the Confederacy."

Today, interest in free ballooning centers around the Gordon Bennett International Balloon Race. In 1930 the nineteenth race was held, when contestants from Belgium, France, Germany, Canada, and the United States left the Municipal Airport at Cleveland, Ohio. The Gordon Bennett Trophy and one thousand dollars in cash went to Ward T. Van Orman, an American entrant, who covered over 550 miles. This, however, did not better the record which was made in October, 1910, when Alan R. Hawley and Augustus Post covered 1173 miles from St. Louis to the wilds of Labrador in their free balloon.



Edwin A. Vorpe

AN ENTRANT IN THE GORDON BENNETT BALLOON RACE, 1930

The First Dirigibles

It was in 1852, when Henri Giffard, experimenter with steam engines, constructed a small engine and installed it in a cigar-shaped balloon, that the way was prepared for the development of the modern dirigible.

Germany gives credit to Paul Haenlein for having constructed and successfully flown the first rigid type of airship. Accompanied by several friends, Haenlein piloted his dirigible over the city of Bruenn in December, 1872. This airship was propelled by engines fed with illuminating gas, and its shape was very similar to that of dirigibles built many years later. Lack of funds prevented Haenlein from carrying on his experiments.

An Austrian named Schwartz built the first all-metal rigid dirigible, which, however, proved unairworthy and was destroyed on its first landing.

At the end of the nineteenth century, with the development of the gasoline motor, came notable advances in dirigible construction.

The Experiments of Santos Dumont

Alberto Santos Dumont, a wealthy young man from Brazil, began his aërial exploits in Paris. His striking personality and his good fortune in escaping disasters aroused the enthusiasm of all France about his "picturesque and spectacular performances in the air." He had a venturesome disposition and was keenly interested in all mechanical devices. Like the Wright brothers, the new sport of motorcycling appealed to him. He took one of his motorcycle engines and fitted it into a balloon. The experiment proved to be successful. From that time on he built and flew one airship after another. He is given credit with having built at least fourteen airships. His book, *My Airships,* tells of his eight years' work on lighter-than-air craft. It was in 1905 that he turned his attention to airplanes.

Origin of the Zeppelin

While Santos Dumont was attracting attention in France, there was a man in Germany, Count Ferdinand von Zeppelin, who was building rigid airships and to whose perseverance and ceaseless labors the modern dirigible owes its successful development.

It was during the Civil War that Count Zeppelin, then a young man and a friend of Mr. Lowe, served as a balloon officer with the Union Army. It was over thirty years later in his own country that he completed his first dirigible. Despite the success of his aircraft, neither the German government nor individuals would have anything to do with helping to finance the little Zeppelin Company. For five long years this man traveled far and wide seeking capital. Finally the government agreed to buy an airship if one could be made to remain in the air for twenty-four hours. On July 11, 1908, Count Zeppelin startled the world by flying over the Swiss Alps to Lucerne and back again to the little town of Friedrichshafen on Lake Constance, a place where airships are still being built.

Count Zeppelin was no longer a young man. When his struggling company faced financial disaster, the people of Germany, whose sympathy was aroused for him, raised a million and a half dollars and gave it to him to use as he wished. But the inventor took only enough for his personal needs; with the rest he established the Zeppelin Endowment for the Propagation of Navigation.

A short time before his death in 1917 he said, "My invention belongs to the people, and even today many capable men are working to further its development. We still have far to go, but I know that they will eventually be joined by the best minds all over the world. That is why I feel perfectly assured that my ideas will live."

His ideas have lived and are being carried out in many different countries of the world.

Aircraft Heavier than Air

During the seventeenth and eighteenth centuries little progress was made in the development of machines heavier than air. During this period, flight, for the most part, was confined to rude types of gliders, to the use of the free balloon, or to the unsuccessful trial of devices for propulsion of aircraft which were dependent upon the muscular power of the operator. Some few students of the theory of flight, however, did make accurate calculations as to the properties of the air and its effect upon objects moving through it.

Such a one was Sir George Cayley of England, who lived between 1774 and 1857, and who has been called the 'Father of British Aëronautics.' As a boy, he became interested in the problems of flight, and at an early age he was able to work out many sound conclusions concerning the resistance of air. He figured, for example, the area of surface necessary to support a given weight, and discovered the peculiar advantages of the curved, or cambered, wing. He wrote articles on aëronautics for magazines, and it is said that he never made claims which he could not support.

Two Englishmen of the middle nineteenth century, W. S. Henson and John Stringfellow, not only had theories on flight, but constructed crude airplanes in which engines were to be installed. They took out patents protecting their inventions and went so far as to attempt to organize a company in 1843 called 'The Aërial Steam Transit Company.' Their scheme for raising funds failed. Henson married and came to America. Stringfellow continued his experiments. He built a small model which, with the tiny steam engine included, weighed only eight pounds. When tested in a long room, the model actually flew, the first engine-driven airplane ever to do so. This was in 1848.

Another, a triplane model, was exhibited at the First Aëronautical Exhibition held at the Crystal Palace in 1868. Today Stringfellow's models may be seen in the Victoria and Albert Museum in London.

Men could not forsake the idea of motion through the air with wing-flapping devices, and after the invention of the steam engine and its application to model planes, attempts were made to perfect wing-flapping airplanes. The helicopter with its rotating propeller occupied the minds of inventors, especially those of France.

Otto Lilienthal

In the history of aëronautics in the latter half of the nineteenth century the name of Otto Lilienthal, a German, stands forth. Like the Montgolfier brothers, the Roberts brothers, and the Wright brothers, Otto and his brother Gustave were enthusiastic about flying.

The Lilienthal family had made plans to come to America, when their father died. Otto was just thirteen years old, and he and Gustave had already begun their experiments with gliders. To the wings of one of their first gliders they planned to attach bird feathers. Their early models were flown indoors in a large room. Their first real glider had a wing spread of only about six feet and a depth of three feet. These wings were fastened on their backs by ropes, and their flights were taken secretly on moonlight nights to avoid the ridicule of their playmates.

Gustave's interest in flying waned, but when Otto went to Berlin to study engineering he took his materials with him and continued work on his gliders. In 1889 he wrote a book on his observations of birds and on the results of his experiments — a book which is read today with much interest.

At first Lilienthal used a spring board for his take-off, but later he built an artificial hill about fifty feet high. On a good flight he could land three hundred feet from the center of this hill. The hill was hollow like a cave, and it was in this space that he kept his gliders.

Lilienthal had made over two thousand successful glides by 1896 and was about to try out a power-driven machine which he had constructed. He believed that "a cylinder of compressed carbonic-acid gas released through a hand-operated valve would keep the machine in the air for four minutes." On the very day that he had planned to test his power machine he went for a long flight in a glider on which he had installed a new form of rudder. When he had reached the height of fifty feet, in an attempt to gain speed, he let the glider nose down so far that it crashed to earth. He was so severely injured that he died the next day.

Lilienthal is considered one of the great pioneers in aviation. His enthusiasm and his careful scientific records of his work inspired his followers to carry it on after him.

Percy Pilcher

In England Percy Pilcher became interested in aviation through reading the accounts of Lilienthal's successful flights in Germany. By the time that Pilcher was nineteen he had completed six years of service in the British

Navy. He then resigned, studied to be an engineer, and began his work on gliders. After completing his first glider, which he called the *Bat,* he visited Lilienthal and made several glides in a biplane glider which Lilienthal had constructed.

After returning to England he made a second glider, which he called the *Beetle* because he said it looked like one. His third he named the *Gull,* and the name of a fourth was the *Hawk.* The *Hawk* was a sturdy craft with a very simple form of undercarriage consisting of two bamboo rods from which wheels were suspended on steel springs to support the glider when it was resting on the ground. To a horizontal tail surface there was attached a vertical surface, and from the upper part of this vertical surface guy wires ran to the main frame. Pilcher intended to install an engine in the *Hawk.* He had trouble in finding one light enough; so he started the construction of one himself. It was never installed in the glider, however, for in September, 1899, while he was doing some exhibition gliding in unsuitable weather, one of the guy wires broke and his machine fell to the ground. Pilcher received severe injuries from which he died two days later.

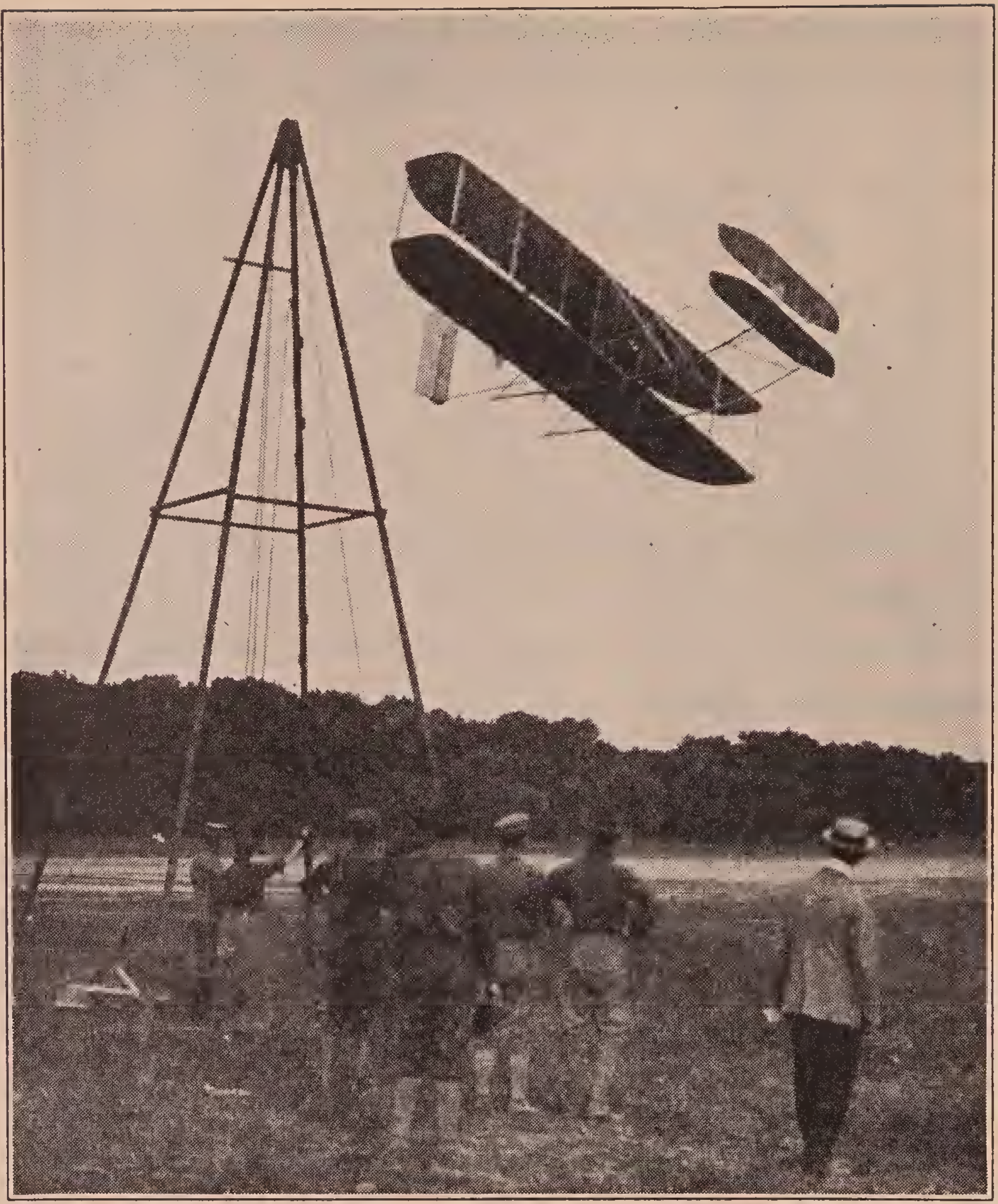
Instead of suspending his body from his machine and running along to take off, he had employed a method similar to that in use today. By sitting in the glider and having some boys pull his craft along with a rope, he was carried upward; then the rope was cut loose. Though Pilcher's experiments covered a period of only four years, he ranks as one of the great men in the history of glider flight.

Other Early Airmen

Even the tragic deaths of Lilienthal and of Pilcher could not discourage the enthusiasts in their belief that the era of controlled and extended human flight was near at hand. In America, too, there were men whose enthusiasm for flying was leading them to glider construction and flights.

Professor J. J. Montgomery is reported to have begun his experiments with gliders in 1884. It was he who added to the glider such control surfaces as warped wings, elevators, and rudder. He also employed a novel method of launching his glider. He would attach it to a hot-air balloon and, ascending to any desired altitude, would take off and glide to earth. Wilkie and Defolco were two other pilots who took off from hot-air balloons and gave equally striking exhibitions.

Octave Chanute was a civil engineer of French descent who lived in Chicago. His first experiments were conducted with a machine similar to Lilienthal's, but with only one pair of wings. Later he used one having five wings with a sixth pair for a tail. With the help of Mr. A. M. Herring he constructed his biplane glider and by 1896 was launching it successfully from sand dunes on the shores of Lake Michigan. He made more than seven hundred glider flights.



Underwood and Underwood

THE WRIGHT BROTHERS' AIRPLANE AT FORT MYER, VIRGINIA

THE WRIGHT BROTHERS

From Chanute the Wright brothers received courteous answers to their many inquiries about gliders and flying. Wilbur and Orville Wright were fortunate boys in having parents who were always alive to the interests of their children. Perhaps the boys' enthusiasm for flying was kindled when their father brought home to them a flimsy little toy made of white paper and shiny strips of bamboo. When it was released it shot to the ceiling, where it bounced along until it finally settled to the floor. The boys called it a 'bat,' but their father said its correct name was a French term, a *helicoptere.* When the original toy was worn out, the boys constructed another, using for motor power rubber bands exactly like those that boys use today in making their advanced flying models.

Wilbur was eleven years old and Orville seven when they first played with this toy, but they never forgot the curiosity its performance aroused or their efforts to find out the reasons why it flew.

The brothers entered the business world through the publication of a newspaper and a weekly magazine. They next became interested in bicycling and opened a repair shop in Dayton, Ohio, their home town. Later they manufactured bicycles. The death of Lilienthal in 1896 and the account of his achievements in gliding renewed their interest in flying.

They began a systematic study of all the material they could find relating to aviation. They observed the flight of birds. They learned a great deal about air currents and how they are affected by every slope, every house, every little stream, and every dusty roadway. They read what other men had done and what still others were doing whose interest was similar to their own. They read of Sir Hiram

Maxim's extensive experiments on a huge steam-driven biplane; they studied the theories of Montgomery; they listened to the stories about Dr. Langley and his successful flying model airplanes; they corresponded with Octave Chanute; and they began experimenting on gliders of their own. Then one day they moved their glider paraphernalia to Kitty Hawk, North Carolina, where, the United States Weather Bureau in Washington had informed them, they would find a hilly place with steady and moderate winds suitable for further experiments.

Here they worked and labored on their machines, with which they made numerous glides from Kill Devil Hill, four miles from Kitty Hawk. Here they learned the advantages of twisting, or 'warping', a part of the wings. These warped wings, together with the rudder, would give them control over their glider, so that it could be maneuvered in the air.

For three summers they continued their experiments at Kitty Hawk, but when they returned to Dayton in the fall of 1902, their minds were full of ideas about a power plane which they had decided to build the coming year. The greatest difficulty was to get an engine light enough, but with sufficient power to drive the propeller and keep the machine in the air. They made an engine of their own, which they installed in their plane.

At this same time Professor Langley was completing a machine which he called an *aërodrome,* for the building of which Congress had appropriated $50,000. On December 8, 1903, Langley's machine made its second unsuccessful attempt to get into the air. The public had assembled to witness the flight, and being disappointed, it had been bitter in its ridicule of flying in general and of Dr. Langley's apparent failure in particular.

It is little wonder that the Wright brothers wished secrecy to attend their first attempts at flight. On December 14, Wilbur had actually got this machine into the air, but being overanxious, he had nosed it up too steeply, and after only three and one-half seconds it had stalled and made a poor landing, injuring some minor parts of the framework.

But undaunted, the brothers had repaired the damage, and on December 17, 1903, Orville took his turn at flying. He started the motor and took his place in a prone position in the open framework of the plane. Lo! The machine arose and carried him through the air for twelve seconds, landing 120 feet from the starting place. The flight had been witnessed by only a few persons, who little realized at the time that they had been the spectators at a scene that would go down as an epoch-making event in aviation history.

Wilbur and Orville Wright soon realized that they were real contributors to the progress of science, but their path upward to recognition was as tedious and wearisome as the one up the sandy hills at Kitty Hawk over which they had dragged their early gliders. They continued their experiments on a level plain a few miles from Dayton. They took out extensive patents on planes which they built and flew. For five years neither the public nor the press showed much interest in the Wrights. After building a machine that had remained in the air for thirty-eight minutes and that had covered over twenty-four miles, the Wright brothers felt confident enough in their success in flying to hope that their government would become interested and perhaps buy their inventions. Their spirits must have sunk low, indeed, when a delayed message came from a government clerk saying, "We cannot consider your suggestion that we buy your inventions or that we send a commission to investigate them. We have neither time nor money to waste on a couple of Ohio cranks. We are not interested." You must recall that the government had received a great deal of adverse criticism when Professor Langley's machine, on which it had spent thousands of dollars, had been proclaimed a failure in 1903. The French government, however, became interested and invited the Wrights to give flight demonstrations in France. It was to Kitty Hawk that they went again in 1908 to try out their new planes. But this time newspaper men followed them, and the stories of their exploits filled the news columns. The Wright brothers became the most talked-of men in the world. Wilbur took his invention to France, where he became the hero of the hour and established an unheard-of record for those days by remaining in the air two hours and twenty minutes. At last the United States government awoke to the realization of the importance of aviation. It offered $25,000 for a machine that would carry two men ten miles at a speed of forty miles an hour. For every extra mile of speed per hour an extra $2,500 was to be paid. Orville Wright brought his plane to Fort Myer and entered the contest.

A large crowd was assembled — President Taft and members of Congress were there; men, women, and children from far and near had come to see Orville Wright fly. He appeared wholly oblivious to the crowds. Had he not been making flights for over five years? He and Lieutenant Benjamin D. Foulois, his companion, took their places. The plane slid forward on a monorail, a single rail which in those days was used to make the take-off smoother and faster. It rose in the air. As the crowds watched, it sailed away. For a few minutes it became lost to view; then it appeared again and after a graceful circle over the field landed safely. It all happened in 14 minutes and 42 seconds, but the plane covered the distance at a speed of over 42 miles an hour; accordingly Orville Wright received the government prize of $25,000 plus $5000 for the extra two miles in rate of speed.

But money was not the greatest reward to these men from Ohio. They had proved to their government that its sons were capable of teaching the world how to use wings in the air.

The Wright Company for the manufacture of airplanes was formed with Wilbur Wright as president and Orville Wright as vice president. They ceased to take part in public flights and were eagerly looking forward to the time which money and leisure now afforded to develop some of their ideas on flight. But in May, after returning from a trip to Boston, Wilbur became ill with typhoid fever. Early on Thursday morning, May 30, 1912, the great partnership of Orville and Wilbur Wright, founded upon a common interest which had taken them through trials, poverty, and finally to success and fame, was ended, for Wilbur passed away, leaving his brother with a heavy heart to carry on alone the great work which both had undertaken.

Orville Wright still lives in Dayton, Ohio. His interest in aëronautics has never waned, and whenever he accepts one of his numerous invitations to attend any meeting in the interests of aviation, his quiet, unassuming presence adds distinction and dignity to the occasion.

CHAPTER II

SOME FIRST FLIGHTS

The offer of prizes always stimulates activity in any field of endeavor. Those offered in aviation have done much to speed the progress of flight.

In 1910 the New York *World* offered a prize of $10,000 to the person who would make the first flight either from New York to Albany or from Albany to New York.

Glenn Curtiss

Glenn Curtiss, one of the pioneers in aviation in this country, had won, by his flight in the *June Bug* on July 4, 1908, a cup presented by the *Scientific American,* the first prize offered in America in connection with an airplane flight. He now took one of his flying machines to Albany and waited for suitable weather to begin his flight in an attempt to win the prize offered by the New York publishers.

His delay became so extended that people began to criticize him and to say that he must know that such a flight could never be made. But finally, early on Decoration Day, 1910, he left Albany, and the people along the Hudson

Aëronautical Chamber of Commerce of America

THE CURTISS *June Bug*

were startled by the sound of a noisy motor as he steered his plane over that river, following its course to New York. A stop was made at Poughkeepsie for oil and gas and an inspection of his engine. The flight was continued; he reached his objective and won the $10,000.

His plane had a wing spread of only 30 feet, and his instruments, he said, were his five senses. What a difference twenty years later, when, on the same day in 1930, the twentieth anniversary of that first flight, Mr. Curtiss as co-pilot in a giant 18-passenger twin-motored Curtiss-Condor biplane, with a wing spread of 92 feet, flew over the same route! His first flight took 2 hours and 51 minutes, but this time he flew from Albany to Governors Island and circled the Statue of Liberty in only 80 minutes.

A few weeks after this celebration, Mr. Curtiss died suddenly on July 23, following an operation for appendicitis. A Congressional Medal of Honor was awarded him because of the following accomplishments, among others:

1907. He built the first dirigible motor for the Army and with Capt. T. S. Baldwin constructed, flew, and delivered to the Army its first airship.

1909. He brought the first international air races to the United States by winning the famous Gordon Bennett Trophy race in France.

1910. He made the first demonstration of bomb-dropping from an airplane.

1911. His planes were first to land upon and to rise from the decks of battleships.

1914. He designed and built the famous *OX* motor and the *JN* airplane, which became world-famous as the 'Jenny.'

1918. In the World War the Navy adopted Curtiss designs for nearly all its flying equipment, and practically all Army and Navy flyers were trained in Curtiss planes.

Flights across the English Channel

A little less than a year before Glenn Curtiss made his first flight down the Hudson, the feat of flying over the English Channel was claiming the attention of two Frenchmen, Lathan and Bleriot. In 1909 both were rivals for a $5,000 prize offered by an English newspaper for the first crossing of the English Channel by airplane. Lathan had made an unsuccessful attempt in July of that year.

Both he and Bleriot were on the coast of France only a few miles apart waiting for favorable weather. Fortune, it seemed, favored Bleriot, for having discovered at half-past two on the morning of July 25 that no wind was blowing, he prepared for his start, and an hour later he took off with his monoplane, crossed the Channel, and landed near Dover, flying the 21 miles in 37 minutes. His name appeared on the front pages of all the world's newspapers, and he received cables and telegrams of congratulation from every country.

Three years later, on April 16, 1912, a young American woman, Harriet Quimby, performed the same feat by flying from Dover, England, to Hardelot, France, in a light, low-powered monoplane. Miss Quimby had obtained a pilot's license in 1911, the first woman to receive one in America. She had given a number of exhibition flights in the United States and in Mexico, but her flight across the English Channel made her world-famous.

The next year an Englishman, flying a Wright plane, crossed from Dover to Sangaette, near Calais, dropping greetings to the French Aëro Club there, and returned to England, making the first non-stop flight over the Channel and back.

Transcontinental Flights

The first transcontinental flight across America was made in September, 1911, by Calbraith P. Rodgers. He reached Los Angeles 49 days after he had left New York, though his actual flying time in covering his course of 4,231 miles was 82 hours. Numerous forced landings had made necessary so many repairs to his plane that it was said that he used material enough in repairing his machine to construct four new ones.

The first non-stop flight across the continent was made in 1923 by Oakley G. Kelly and John A. Macready, of the American Army Air Service. They took off from Mitchell Field, Long Island, in a Fokker *T–2* army transport plane with a 400-horsepower Liberty motor at half-past twelve, Eastern time, on May 2, and landed in San Diego, California, the next day a little after twelve, Pacific time. Their 2,500-mile flight was accomplished in 26 hours and 50 minutes.

This same distance was covered in August, 1930, in less than half that time, when, including three stops, a flight was made in 12 hours, 25 minutes, and 3 seconds (actual flying time 11 hours and 40 minutes) by Captain Frank M. Hawks. He flew his Whirlwind-powered Travel Air from the Glendale Airport, Los Angeles, to Curtiss Field, Long Island, lowering, by 2 hours and 20 minutes, the record made on the preceding Easter Sunday by Colonel and Mrs. Charles A. Lindbergh. No man had ever flown a like distance in so short a time. Imagine eating breakfast in California, climbing into the cockpit of your plane, taking off as the hands of the clock point to sixteen minutes after six, speeding through the sky at a rate never below 200 miles an hour (except in landing and taking off), whizzing across the continent, dropping down and landing for a 15-minute stop for fuel at airports at Albuquerque, New Mexico, at Wichita, Kansas, and at Indianapolis, Indiana, and then shooting over the Allegheny Mountains, reaching the Atlantic coast, and swooping down at the airport in Long Island in time to wash your face and hands, comb your hair, and sit down to a seven-o'clock dinner that evening.

In December Miss Ruth Nichols of Rye, New York, made a transcontinental record for women. With a single stop at Wichita, Kansas, she arrived at Roosevelt Field, Long Island, in 13 hours, 21 minutes, and 43 seconds, flying time from Los Angeles.

First Transatlantic Flights

The year 1919 was a great year in the history of aëronautics. Three types of aircraft crossed the Atlantic.

Three large seaplanes of the United States Navy, the *NC–1*, with three motors, the *NC–3*, and the *NC–4*, each equipped with four motors, left Rockaway, Long Island, on May 8, 1919, planning to fly to Plymouth, England, by stages from Nova Scotia: to Newfoundland, to the Azores, to Portugal, and then to England. The longest flight would be over the ocean from Newfoundland to the Azores, and on the ocean along this route there were to be stationed destroyers and other vessels to act as rescuers in case the planes were obliged to make a forced landing on the ocean.

The *NC–3*, the flag ship of the expedition, was forced down in a heavy sea. For over 52 hours without food and with the only drinking water that which was drained from the radiators, the crew succeeded in remaining afloat and finally in reaching the Azores. The plane was too seriously damaged to continue the flight.

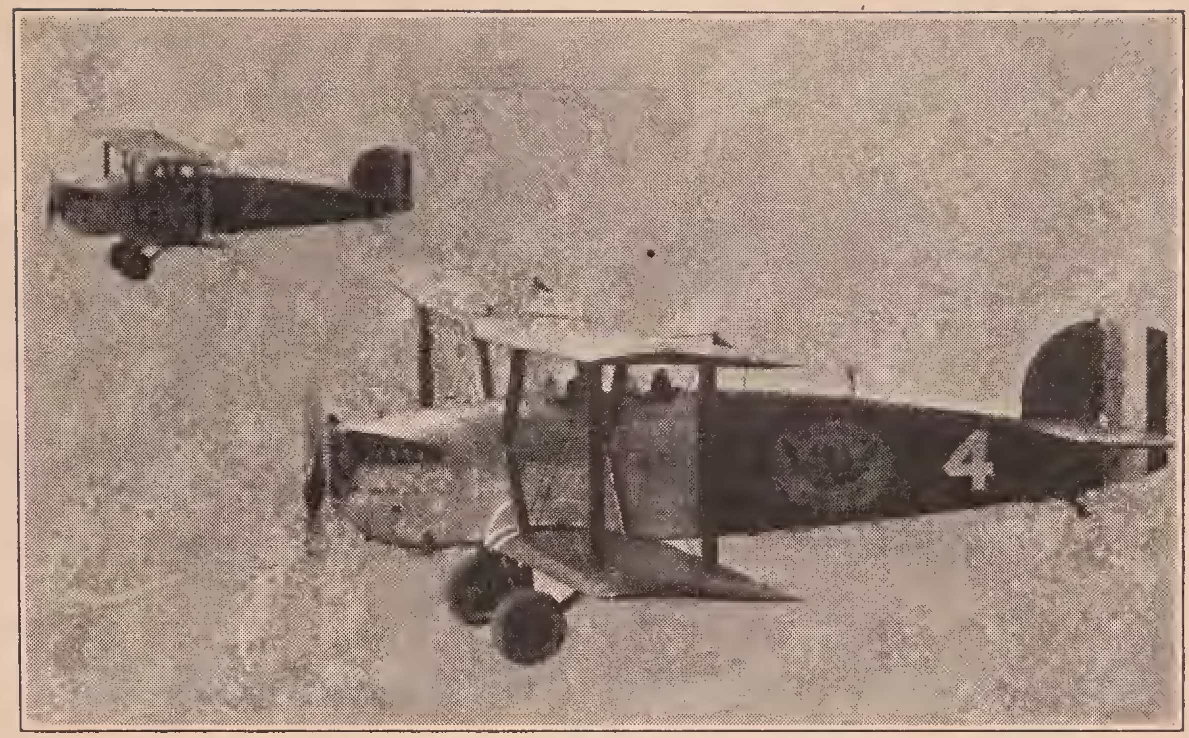
The *NC–1* was also forced down by bad weather, and its crew was picked up by a steamship. But the *NC–4,* under the command of Lieutenant Commander Albert C. Read, with a crew consisting of pilots, Walter Hinton and Elmer Stone; radio operator, Lieutenant H. C. Rodd; engineer officer, Lieutenant J. L. Breese; and mechanic, Eugene Rhoads, reached Plymouth fifteen days after it had left New York (actual flying time 24 hours and 42 minutes). The *NC–4* was the first aircraft ever to cross the Atlantic.

Two plucky Englishmen, Harry Hawker and Kenneth Mackenzie-Grieve, had hoped to bring this honor to Great Britain and also to win a prize of £10,000 (nearly $50,000) offered by the London *Daily Mail* for the first transatlantic flight. They had taken off from Newfoundland two days after the *NC–4.* Their plane was a land plane with a detachable undercarriage and was so constructed that it could land in water if necessary. When about half way across, their motor began to fail, and they were forced to alight on the water. Fortunately they had attracted the attention of the Danish steamer *Mary* and were taken on board. But the *Mary* had no radio, and it was six days before the world knew that they had been rescued. Reaching England, the fliers were much surprised to find themselves world heroes.

The second successful transatlantic crossing by air, and the first one by aircraft lighter than air, was made by the *R–34,* a British dirigible which left Dublin, Ireland, on July 2, 1919, and arrived at Mineola, Long Island, July 6, flying 3,200 miles in 108 hours and 12 minutes. Three and a half days later the return voyage was successfully made in 74 hours and 56 minutes.

On June 14 to 15, the first non-stop transatlantic airplane flight was made by two English war pilots, Captain John Alcock and Lieutenant A. Whitten Brown. On June 14, they started from St. Johns, Newfoundland, in their heavy bombing plane with its two Rolls-Royce motors. Their flight proved their endurance and pluck. For hours they flew through fog and sleet, coming down in spins to the very ocean's crest, barely leveling off in time to avoid a dive into the salty waters, then climbing upward thousands of feet in a vain effort to get above the cloud banks, and dropping back down again and flying dangerously low in order to get a little better visibility. All through the night they flew, with only an occasional opportunity to take observations; but Brown proved a good navigator, for in the morning they caught sight of islands off the Irish coast, and at 8:40 o'clock they made a landing, their plane turning over as the wheels sank into a miry bog at Clifden, Ireland.

The world could hardly believe that these two men had safely crossed the great Atlantic. They were given a splendid reception in England. At a luncheon in their honor, Winston Churchill, an English statesman, said that



United States Army Air Corps

THE DOUGLAS WORLD CRUISERS
The *New Orleans* is in the foreground.

he did not know which to admire most, the audacity, the determination, the skill, the science, the Vickers-Vimy airplane, the Rolls-Royce engine, or the good fortune of these first non-stop Atlantic fliers.

THE FIRST ROUND-THE-WORLD FLIGHT

To the United States Navy went the honor of the first flight across the Atlantic, and to the United States Army went the honor of the first round-the-world flight.

It was on April 6, 1924, that four Douglas transport planes started from Seattle to fly around the globe by way of Alaska, Japan, China, India, Persia, Iraq, Turkey, Austria, England, Greenland, and Newfoundland, and then back to Seattle. Think what a test such a journey meant at that time to both man and machinery — flying over snows and icy seas, over oceans, over jungles and hot desert regions!

Only two planes, the *Chicago,* piloted by Lieutenant Lowell W. Smith, with First Lieutenant Leslie P. Arnold as mechanic; and the *New Orleans,* piloted by Lieutenant Erick St. Nelson, with Second Lieutenant John Harding, Jr., as mechanic, completed the trip 175 days after starting. They had covered 27,553 miles in a total flying time of 371 hours and 11 minutes.

Charles A. Lindbergh and the *Spirit of St. Louis*

It was half-past five o'clock by New York daylight saving time on May 12, 1927, when there appeared on the western horizon of Curtiss Field, Mineola, Long Island, a single-motored monoplane. It glided down to the field and made a perfect landing. Across the fuselage was printed the name *Spirit of St. Louis,* and from the cockpit there climbed out a tall, slim, blue-eyed young pilot. Yes, he was Charles A. Lindbergh, who had come from the West to attempt the realization of a long-thought-of dream to fly across the great Atlantic ocean. Few Americans could have told you much about him; not many persons then knew that the father of this young man had been elected to Congress from Minnesota and before his death had served for ten years as a member of that body at Washington, D. C. Not many knew that his mother was a teacher of science in a large technical high school in De-

Underwood and Underwood

THE *Spirit of St. Louis*

Colonel Lindbergh making a trial flight in the Ryan monoplane before receiving news of favorable weather conditions over the Atlantic.

troit, Michigan. His arrival at Curtiss Field, which then adjoined Roosevelt Field, seemed no occasion for great headlines in the daily papers. People were more concerned about the tragic fate of those two brave French fliers, Captain Charles Nungesser and Captain Francois Coli, who had attempted to cross the ocean from Paris to New York by way of the air and who, missing for the past four days, had been given up as lost. More interest was shown in the preparation being made by Commander Richard E. Byrd, and more confidence was felt that this

Aëronautical Chamber of Commerce of America

A Few of Lindbergh's Medals and Trophies

These are on display at Jefferson Memorial, Forest Park, St. Louis, Missouri.

experienced polar flyer would be the one to fly to France.

But the *Spirit of St. Louis* was receiving complete and careful inspection while its pilot was eagerly studying the weather reports.

Seven long days went by with reports from land stations and ships still unfavorable. It was May 19, and a misty rain was falling from an overcast sky. It seemed that such days as these would lengthen into another week of waiting. But about six o'clock that night there came a special report from Washington, saying that the weather was clearing over the entire North Atlantic. With such welcome news, Lindbergh hastened to Curtiss Field and transferred his plane to Roosevelt Field, where he left it in the hands of mechanics until he should return at daybreak. On the morning of May 20, not more than five hundred persons were about the field as this young mail pilot raised his plane from the muddy runway at 7:52 A.M. and waved his farewell to his friends below.

In his book *We* he tells of his flight across the ocean, but he did not know as he was flying that he was arousing the admiration of all the world and that the hearts of all America were beating with ardent hope and pride as he was reported now to be making good progress along the New England coast, now to be flying over St. Johns, Newfoundland, now to be heading over the Atlantic into the silent evening twilight to meet the unknown dawn of another day. Prayers for his safety were murmured from a million lips while he and his plane were speeding high above some great cloud bank at eleven thousand feet, or skimming through the cushion of air over the ocean white caps at barely ten feet.

Then word came that he had reached the Irish coast, had passed over the English Channel, had circled over Paris, and had landed safely at Le Bourget Field.

It then was 5:00 P.M. in New York, May 21. Newspapers, radios, telephone and telegraph wires were announcing the fact that this American pilot had been the first to fly alone the 3,620 miles across the Atlantic, from New York to Paris, in 33½ hours.

The result of this flight and the unassuming manner in which he has met world-wide acclaim have made Colonel Lindbergh the idol of his countrymen, and have inspired a new confidence everywhere in air travel. His silent partner, the *Spirit of St. Louis,* now hangs with outspread wings in the Smithsonian Institution at Washington, D. C., proudly proving to the admiring thousands who view it that a good airplane, with a good pilot, is the modern vehicle for safe and speedy travel. Lindbergh had shown the way, and others made successful crossings that same year.

Other West-to-East Flights across the Atlantic

Clarence D. Chamberlain and Charles A. Levine flew a single-motored Bellanca-Wright monoplane, the *Columbia,* from New York to Germany, making the flight of 3,930 miles in 42 hours.

In August, William Schlee and William Broch crossed the Atlantic from Harbor Grace, Newfoundland, to Croydon, England, in a single-motored monoplane on their way to Japan.

A few weeks after Lindbergh's memorable flight, Byrd navigated a tri-motored Fokker, the *America,* from New York to France, June 29–July 1, 1927. With him were three others, Acosta, Noville, and Balchen. Owing to the dense fog, they were unable to land at Le Bourget Field, Paris, and were compelled to make a landing on the water near the coast. It was the clever handling of the controls by Bernt Balchen that prevented serious accident in their emergency landing. This exhibition of skill no doubt

International News

THE *Columbia*

Clarence Chamberlain leaving Roosevelt Field for his transatlantic flight.

influenced Byrd in selecting him as his chief pilot on the South Polar Expedition.

The first woman to cross the ocean by air was Miss Amelia Earhart, who, with Wilmer Stultz as pilot and Louis Gordon as co-pilot, left Trepassey, Newfoundland, on June 17, 1928, in a tri-motored Fokker landplane, *Friendship,* fitted with pontoons, and landed in Burryport, South Wales, England, the next day, flying 2,140 miles in 20 hours and 49 minutes. In her book *20 Hours, 40 Minutes* Miss Earhart tells the interesting story of her previous flying experiences and of her trip over the waters of the Atlantic.

Aëronautical Chamber of Commerce of America

THE *Friendship*

Amelia Earhart's plane landing off the coast of England after its flight across the Atlantic.

FIRST EAST-TO-WEST FLIGHT

The first east-to-west non-stop flight in a land plane was made in April, 1928, by Baron G. von Huenefeld, Captain Hermann Koehl, and Major James Fitzmaurice. They left Baldonnel, Ireland, on April 12 in a Junker-Junkers 310–horsepower metal monoplane, named the *Bremen,* with the hope of landing in New York. They met unusually strong head winds, their fuel supply became exhausted, and they were forced to land on the lonely Greenely Island off the coast of Newfoundland, after being in the air 37 hours.

In attempting their rescue, the brave pilot, Floyd Bennett, sacrificed his life. Leaving a sick bed to pilot a plane, he was stricken with pneumonia and was taken to a hospital in Quebec, where he died just after his great friend Richard E. Byrd had reached his bedside.

One of Colonel Lindbergh's most spectacular overland flights was made when, laying aside his usual precaution, he left New York in unfavorable flying weather conditions and flew to Quebec with the serum which was used in a vain effort to save Floyd Bennett's life.

Bennett's successor in the attempt to rescue the *Bremen* pilots, as well as his successor as chief pilot on Byrd's Antarctic Expedition, was that stalwart Norwegian pilot, Bernt Balchen. The *Bremen* was brought to New York City, where it hung suspended from the dome of the Grand Central Station until it was taken to the Smithsonian Institution.

The Flight of Coste and Bellonte

On September 1 and 2, 1930, the first non-stop flight from Paris to New York was completed by Captain Dieudonne Coste and Maurice Bellonte. It had been the dream of French airmen, before and after Lindbergh landed in Paris, to fly the Atlantic from east to west. Through three years of hard effort and heart-breaking disappointment, Captain Coste had waited for the time to come when he could realize his great desire to reach the New World by flying over the Atlantic.

His plane, the *Question Mark,* now equipped with a new

650-horsepower Hispano-Suiza motor, was the same one in which the year before he and Bellonte had broken a world's cross-country distance record by flying 4,877 miles from Paris to Tsitsihar, Manchuria.

These airmen left Le Bourget Field, Paris, at 5:54 A.M. on September 1 and landed at Curtiss Field, Long Island, at 7:12½ P.M. on September 2, covering 4,030 miles in 37 hours, 18½ minutes. This was one of the best-prepared flights ever made. And what need there was for preparation when great cloud banks blocked the way by day and the sullen darkness became the barrier at night! Can you imagine two lone men flying on and on in that complete darkness, with the only sound the song of the motor, as a steady watch was kept on the numerous instruments on whose accuracy rested the fulfillment of the dreams of a lifetime? How welcome was the first faint gleam of morning light, and what a relief it must have been when the friendly shore line of North America came in view! How the news flashed around the world telling of the scarlet plane's successful crossing and keeping thousands posted on its speedy progress along the New England coast and its arrival at Curtiss Airport.

About the airport had gathered thousands of spectators who soon picked up the French words of greeting and who shouted, "Vive la France!" "Vive Coste et Bellonte!" as the *Question Mark* glided down to a landing on Curtiss Field. A flying stork etched in white on the red background of the fuselage attracted special attention. It was the war insignia of the flying squadron in which Coste had served during the World War.

Associated Press

COSTE AND BELLONTE LANDING AT CURTISS FIELD, LONG ISLAND

An interesting piece of baggage was the altimeter which had been lost from Byrd's plane, the *America,* when it had made the emergency landing at Ver-Sur-Mer, France, and which had been found by a fisherman and taken to Paris. It had been brought to America by Coste to be returned to its owner, Admiral Byrd.

Coste and Bellonte were welcomed in New York with the wildest enthusiasm of its cheering millions. Mayor Walker, who had been a guest of Captain Coste in Paris, formally welcomed the fliers and complimented them upon their valor and the scientific accomplishment of the non-stop flight from Paris to New York.

One notable gathering took place when the French fliers sat down to a dinner in New York with Captain

Gronau and his three companions, students from a German flying school of which he was chief. A few days before, on August 26, they had landed their Dornier-Wal seaplane in the harbor of New York, after a successful flight from List, Germany, by way of Iceland, Greenland, Labrador, and Nova Scotia. On this occasion, in a room draped with American, French, and German flags, the German naval flier, Captain Wolfgang von Gronau, and the French ace, Captain Dieudonne Coste, combatants in the World War, clasped hands and congratulated each other upon the success of a common undertaking. What an instrument the airplane has become for promoting good will and universal understanding!

Coste and Bellonte did not remain long in New York. They left on Thursday morning, September 4, for Dallas, Texas, where a $25,000 prize awaited them for having flown from Paris to Dallas with the only stop at New York.

After a good-will tour of the United States over the same route which Colonel Lindbergh had taken when he returned from his flight to Paris, the French flyers sailed for their homeland. They reached Paris on October 25, where great honors and affection were bestowed upon them by their countrymen.

The Italian Flyers

One of the most spectacular flights from the Old World to the New was made by a squadron of Italian seaplanes, with Italy's air minister, General Italo Balbo, as leader. This experiment in group flying was begun December 17, 1930, when fourteen Savoia-Marchetti flying boats, each with two 500-horsepower Fiat engines arranged in tandem above the wings, left Orbetello, near Rome, Italy, on a four-lap flight to Bolama, Africa, whence twelve of the seaplanes were to fly the South Atlantic to Brazil. Two of the twelve were crashed on the take-off at Bolama with the loss of five lives. Two other planes were substituted, so that the original number of twelve left Bolama, on Monday, January 5, 1931. Two of these, however, were forced down at sea, without loss of life or injury to the crews, and were taken in tow by some of the Italian destroyers which were stationed along the route. After a long dark night with only their instruments to tell them of their location, the remaining ten planes reached the harbor of Natal and settled down on its waters at 2:15 Tuesday afternoon, January 6, 1931.

What a sight it must have been for the crowd at Natal as these gaily decorated, black, green, red, and white giant flying boats, with their 79-foot wing spread, emerged from the dark rain clouds that January afternoon. What a picture the forty members of the crews and their leader, dressed in the Fascist black shirt and white trousers, must have made as they climbed from their flying boats after being in the air for 17 hours and 15 minutes. From Natal the 'flying rainbow' continued the flight for 1,440 miles to Rio de Janiero. Eleven of these swift Italian seaplanes completed the flight of more than 6,000 miles when they arrived at the Brazilian capital on the afternoon of January 5.

In speaking over the radio from that city, General Balbo said in part, "Ours is an achievement of civil rather than military aviation because it will be possible in the future to fly commercial fleets between the two continents as we have done with the military planes." In his speech he also thanked his friends and countrymen in North America for their keen interest in the flight.

First Flights across the Pacific

By this time you will be wondering about the first flights across the Pacific.

Various prizes had been offered for a flight from California to Hawaii. James D. Dole, of Honolulu, had offered a first prize of $25,000 and a second prize of $10,000 for the first and second uninterrupted flights from the mainland of the United States to Hawaii. During the early summer of 1927 fourteen entrants in the race for the Dole prizes were preparing for the flight.

Before any of the contestants got away, however, a flight was completed by two lieutenants of the Army Air Corps, Lester J. Maitland and Albert F. Hegenberger, who, after displaying splendid application of the knowledge of navigation, reached this small mid-Pacific group of Hawaiian Islands and landed their tri-motored Fokker on Wheeler Field near Honolulu on the morning of June 29, flying 2,400 miles over open ocean in 25 hours and 50 minutes.

This flight was one of the early demonstrations of the value of the radio-beacon beam as a check on a course for airplane flights.

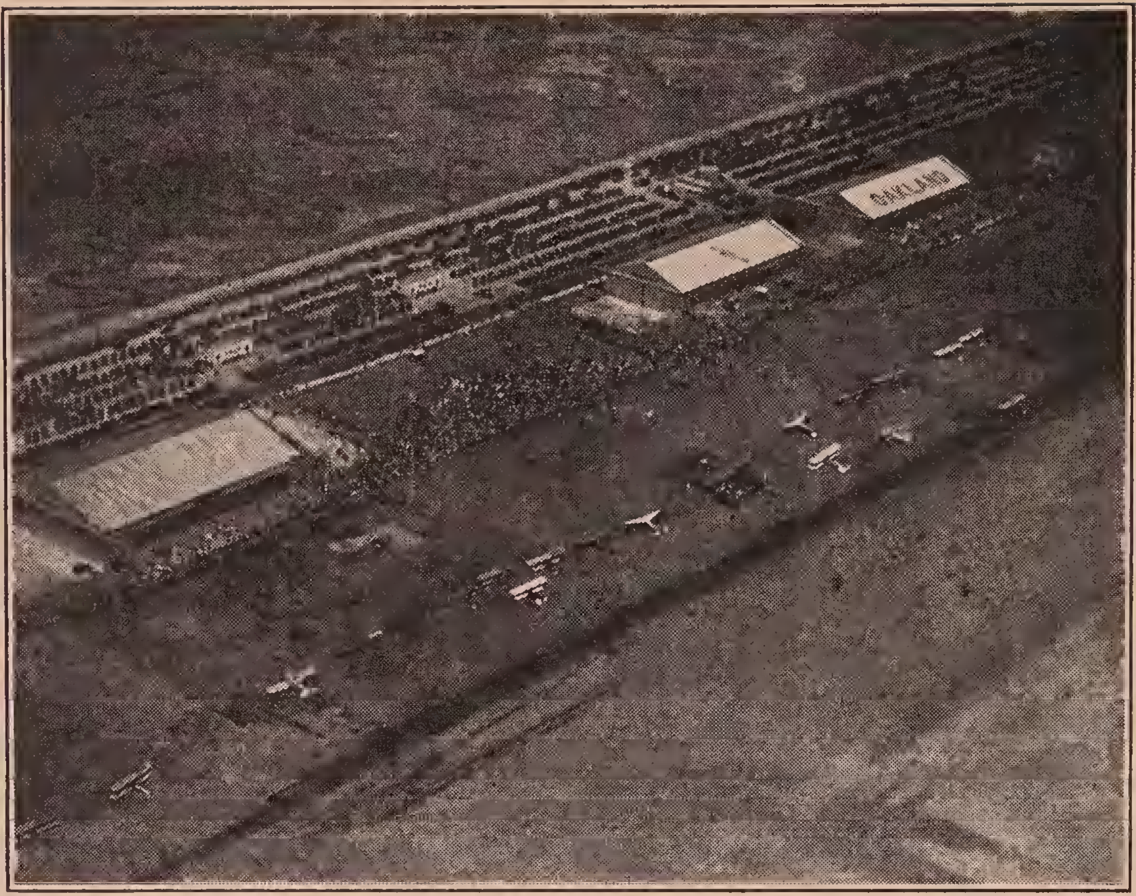
The next month Ernest S. Smith and Emory B. Bronté flew a Travel Air with a Wright Whirlwind motor for 2,340 miles above a fog-covered ocean, reaching Molokai, an island of Hawaii, where in making a landing their plane was wrecked. They had been in the air 25 hours and 36 minutes.

In August only eight of the fourteen entrants in the Dole airplane race crossed the starting line, at the airport in Oakland, California. Four of these turned back; two were lost at sea; two reached Honolulu and landed at Wheeler Field within two hours of each other. Arthur Goebel, pilot, with Lieutenant William Davis, won the first prize, their flying time being 25 hours and 17 minutes; and Martin Jensen and Paul Schluter won the second prize, their flying time being 28 hours and 16 minutes. Each of the planes was powered with a single Wright Whirlwind engine.

One of the most remarkable flights of 1928 was the flight from California over the Pacific Ocean to Brisbane, Australia, only two stops being made, one at Honolulu and one at Suva, Fiji Islands.

It was on the morning of May 31 that the *Southern Cross,* a tri-motored Fokker monoplane, with its load of 15,807 pounds, took off from the Oakland Airport.

Charles E. Kingsford-Smith and Charles T. P. Ulm, the pilot commanders, were Australians; Harry W. Lyon,



Clyde Sunderland Studios

COMMANDER CHARLES KINGSFORD-SMITH LANDING THE *Southern Cross* AT OAKLAND MUNICIPAL AIRPORT

navigator, and James W. Warner, radio operator, were Americans. They reached Honolulu after flying 27 hours and 25 minutes. Early the next morning, after getting a supply of fuel on Kauai Island (about one hundred miles from Wheeler Field), they started on the most perilous part of their trip. Black tropical storms forced them upward to an altitude of a mile and a half. Then, because in the high altitudes the hungry motors were eating away the fuel supply so fast, down they would come to a height of 400 feet, flying through rain which, seeping through the wind shield, made them soaking wet. You can imagine how frightened they were at one time when along a fuel-supply pipe they saw drops of liquid falling and thought their precious fuel was leaking away. It proved to be the condensation of the water vapor in the warm air, as it came in contact with the colder gasoline pipes. Their supply of fuel proved more than sufficient, for they reached Suva, Fiji, at 3:50 P.M. on June 5, with a 4-hour gas supply left in the tanks. They had performed the remarkable feat of flying over water for 3,144 miles in 34½ hours.

On the morning of June 8 they left Suva, and the next forenoon they landed in Australia, having spanned the Pacific in 83 hours, 15 minutes, actual flying time.

This was not the last journey for the *Southern Cross*. Two years later, in June, 1930, this plane, said to be the second oldest tri-motored plane in the world, with its same three motors brought Kingsford-Smith and his three companions across the Atlantic from Port Marnoch, Ireland, to Harbor Grace, Newfoundland, and then by way of Halifax to Roosevelt Field, Long Island.

His genial personality and his exceptional ability as a pilot have given Charles Kingsford-Smith a place among the most popular and able flyers of the world.

The first successful flight across the North Pacific from west to east was made in October, 1931, by Clyde Pangborn and Hugh Herndon, Jr., who had hopped off from New York, July 28. After a successful Atlantic crossing and a victorious battle with storms over Siberia the fliers found themselves in trouble as they landed in Tokio. They had innocently violated the Japanese espionage act by flying over fortified zones in half-a-dozen places and had taken about one hundred feet of photographic film. For this offense their plane and they themselves were held by the Japanese authorities. Upon payment of a fine, however, their plane was released and they were given permission by the Japanese Aviation Bureau to undertake their flight across the Pacific, provided a start could be made not later than October 15. Happy at last, they took their plane to Sabishiro Beach, where they awaited good weather. The morning of October 4 dawned clear and windless with favorable weather reports coming in from the east. They lifted their Bellanca monoplane with its load of 900 gallons of gas and 40 gallons of oil, sufficiently fueled to enable it to fly for 45 hours, and waved farewell to their Japanese spectators.

Over the North Pacific they cut loose their 300-pound landing gear. Without it, landing would be a hazardous feat, but the load would be lightened and air resistance reduced by about 17 per cent. On they flew 4500 miles over the great Pacific Ocean. Then after 41 hours they reached America and made a landing with only a minor shake-up at Wenatchee, Washington, on October 5.

Two representatives of a Japanese newspaper came forward and handed them $25,000, a prize offered for a non-stop flight from Japan to the United States.

They ended their globe-circling flight when they set their red Bellanca plane down at Floyd Bennett Field on October 18.

But the speediest round-the-world flight was made by Wiley Post and Harold Gatty on June 23 to July 1.

In their flight Pilot Post and Navigator Gatty had lifted their big White Lockheed monoplane, the *Winnie Mae,* from the runway at Roosevelt Field early on the morning of June 23. Leaving Harbor Grace that afternoon, they crossed the Atlantic Ocean, arrived safely in England, and, continuing across Germany and Russia, reached Siberia. Then they dashed through the sky across the Bering Sea for 2,100 miles and landed without mishap in Nome, Alaska. A flight over the Canadian Rockies and across the Eastern United States brought them back again in 8 days, 15 hours, 51 minutes to Roosevelt Field.

Some of these aircraft may be seen in the Smithsonian Institution in Washington, D. C., which contains the largest collection of famous aircraft in the world. Of particular interest are:

Models

Da Vinci's machine	1490
Henson's projected airliner	1840
Chanute's biplane glider	1896

Originals

Stringfellow's triplane (Reconstructed, with some of the original parts)	1868
Lilienthal's glider	1896
Langley's aërodrome (restored)	1903 (1914)
Wright's airplane	1908

War Planes

First American training plane, *JN–4* type
French *Caudron*
French *Voison*

Spad–13	
German Fokker *D–7*	

Post-War Planes

Berliner helicopter	1924
Pulitzer Trophy and Schneider Race winner. Hull of the *NC–4*	1925
T–2 (plane of Macready and Kelly)	1919
Chicago (round-the-world flight)	1924
Spirit of St. Louis	1927

Here there are also many other models and originals of craft heavier than air and of craft lighter than air, besides exhibits of flying equipment, propellers, airplane engines, and other accessories.

CHAPTER III

ARCTIC EXPLORATION

What a challenge to the physical fitness, the courage, and the daring of man does exploration in the polar regions offer! What a thrill one feels as he reads of the hardships overcome, and the obstacles surmounted, by these intrepid men who have brought back knowledge of those vast, far-away, icebound spaces! Or what a feeling of awe and reverence one has for those who, unable to contend with polar blizzards and with starvation, have been forced to take their last sleep amid the storms and snow and ice in those frigid lands!

You may ask, "But why do men risk and sacrifice their lives on such perilous journeys?" And these are some of the answers: to seek adventure, to gain fame for one's self or for one's country, to gain knowledge and promote science, or to seek wealth. Are not these the very reasons for which the knights of old set out, for which the earliest explorers sailed away in frail boats on unknown waters?

Before the birth of Christ, Greek sailors had brought back from their voyages strange tales of far-away, ice-strewn seas. You may read the legends of adventure and bloodshed of those giant Vikings of Norway who sailed the raging northern waters and who in the year 1000 probably reached the shores of America. Then came the humble Genoan who proved the earth was round, and history tells us how the countries of Europe tried to find a northwest route to India around the continents that barred their passage westward.

Attempts of Various Countries to Reach the North Pole

The nineteenth century ushered in the attempts of England, Norway, Denmark, Sweden, Russia, France, Germany, Japan, Holland, Portugal, and Austria to reach the North Pole or to hold the record of 'farthest north.'

The disappearance of Sir John Franklin and his company of 138 men in 1814 into the Arctic snows, which remained a mystery for over a dozen years, furnished the impetus for exploration for many years, and resulted in the establishment of over seven thousand miles of coast line. The English government offered rewards for news of the Franklin party. Men everywhere became interested. American sympathy was awakened, and rescue parties were organized which aroused American interest in Arctic exploration.

You may read of the tragic suffering of the men of these expeditions who fought such desperate battles with snow, ice, and frigid temperatures — some to return, many to die — but whose courage took them farther and farther north.

You should read the story of the young Lieutenant, Adolphus Greely, whose unconquerable spirit took him in

1892 farther north than any human being had ever been before, where he unfurled an American flag made of silk by his devoted wife. Then, too, you will want to read about the adventures of that world-famous Viking, Dr. F. Nansen, whose Arctic explorations covered nearly half a century, and of how, among other exploits, in 1888 he crossed Greenland from east to west on skis.

Today over this same territory explorers are studying conditions to see whether a suitable landing place for airships sailing between Britain and Canada or the United States can be established, and meteorologists are acquiring data in regard to wind conditions, for scientists are led to believe that cold winds of the Northern Hemisphere originate in the interior of Greenland.

It was Dr. Nansen who wrested the world's record of 'farthest north' from America and who planted the Norwegian flag within two hundred miles of the North Pole. In April, 1900, the record passed to Italy, when a member of an expedition led by the Duke of Abrussi reached a point about thirty miles beyond that reached by Nansen.

But now another American, Robert E. Peary, whose Arctic experiences covered a period of almost twenty-five years and for whom the Esquimos had great reverence, sailed from New York in July, 1908, for a third attempt at the Pole. A year later, with a Negro companion, Matthew Hensen, and four Esquimos, Peary reached the coveted '90° north' and the world acclaimed him as the discoverer of the North Pole.

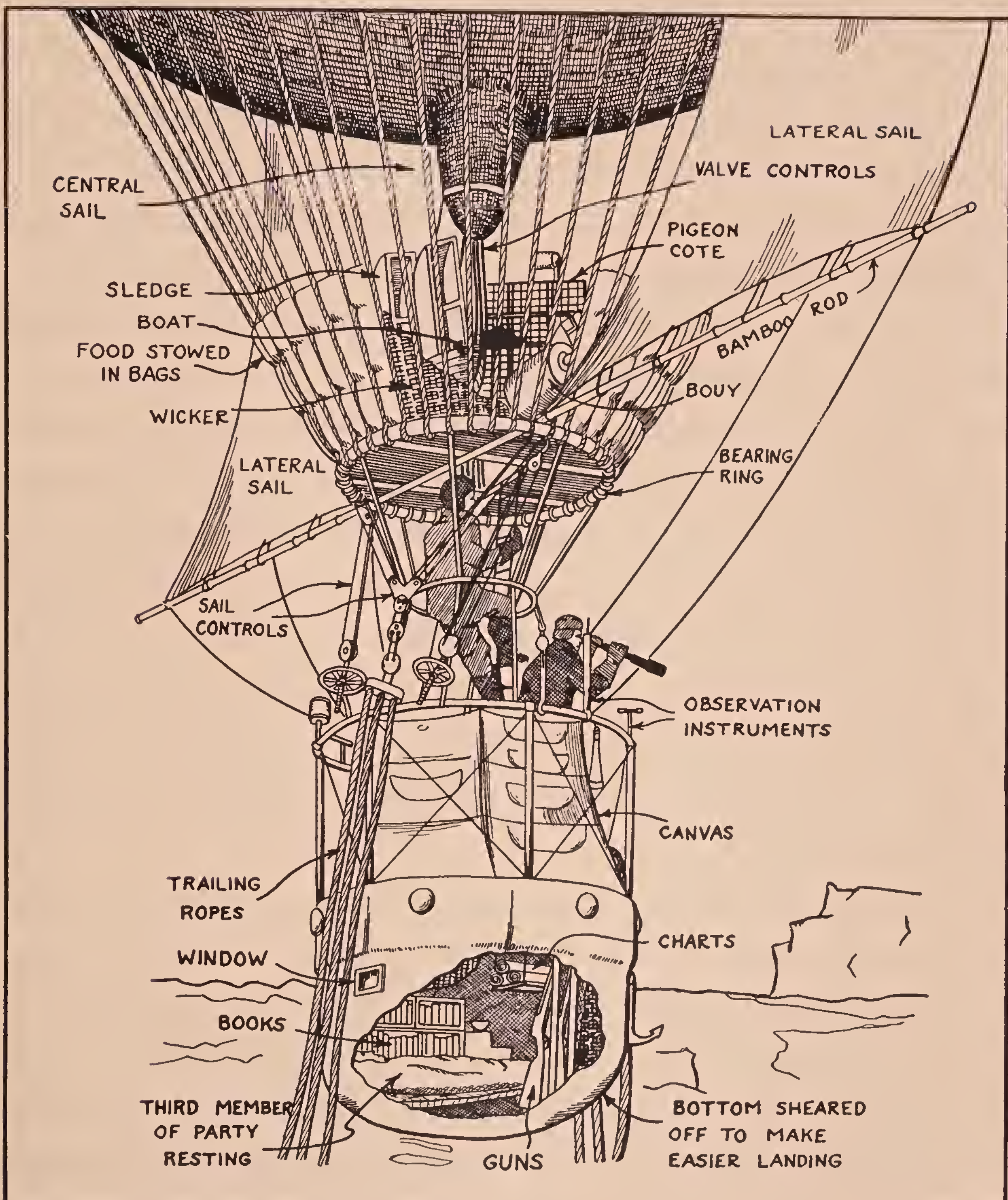
Explorations in the polar regions continued. Then came the development of aircraft as a successful method of transportation over long distances.

Andrée's Attempted Flight over the Pole

Before the first flight of an airplane, however, there was a man whose knowledge of air currents in the northern latitudes led him to believe that a successful flight could be made over the North Pole in a balloon. He was the expert Swedish aëronaut, Solomon Auguste Andrée. He was a graduate of the Royal Institute of Technology in Stockholm and had studied weather conditions and wind directions. He had learned that about midsummer there is always a strong current of air blowing northward. He believed that a balloon once caught in this air current could be carried over the North Pole in a few days.

A proposed flight in 1896 was given up on account of the lateness of the season and unfavorable weather conditions. Albert Nobel, whose will provided funds for the Nobel prizes given each year to men or women contributors in the field of science and in other fields, must have been convinced of the merit of Andrée's undertaking, for he gave a large amount of money toward it. But Andrée as the leader of such an expedition was subject to considerable ridicule. One European newspaper called him "simply a fool or a swindler."

However, in 1897 a large balloon named the *Ormen,* the Swedish name for 'eagle,' was fitted out for the journey, the equipment including specially arranged sails. In the



ANDRÉE'S BALLOON

This drawing shows the care with which Andrée's expedition was planned. Note the extent to which emergencies were provided for, and the completeness with which the balloon was fitted out.

big basket were charts, books, guns and ammunition, a sledge, a boat, a pigeon cote, and food sufficient for four months. Everything was in readiness for the start, which was to be made whenever the direction and strength of the wind were favorable. At this time Andrée seemed rather sad and quiet. He questioned Knut Frankel and Nils Strindberg, his companions, about the start and received the answer, "We ought to try it." So on July 11 they climbed into the basket and gave the command, "One, two, cut." The balloon whizzed upward, became a mere gray speck in the sky, and finally disappeared from view, never to be seen again, for their flight and its tragic ending remained an unsolved mystery for thirty-three years.

Then one day in August, 1930, some members of Dr. Gunnar Horn's exploring expedition came unexpectedly upon the remains of the Andrée party, on White Island, a spot of land northeast of Iceland and only ten degrees from the North Pole.

A diary and other notes have been deciphered, and camera films taken then have been carefully and successfully developed which tell of their three days' flight, of their landing within 475 miles of the Pole, and of their slow laborious trek across the snow and ice in an attempt to reach Spitzbergen. They reached White Island, but the increasing cold caused them to make preparations for spending the winter there.

They laid in a stock of polar-bear and seal meat and enough game to last them until the following spring. But a few days later a severe storm struck their camp and swept away a part of their supplies, leaving them huddled together in their little shelter where they may have been overcome by monoxide poisoning or may have died from sheer exhaustion. However it was, the great Ice King claimed them for his own three months after their departure from Spitzbergen.

On September 2, 1930, the remains of Andrée and Nils Strindberg were brought to Tromso, where each was laid in a coffin and placed in the little cathedral to await their comrade, Knut Frankel, whose remains reached Tromso two weeks later. Then with impressive services the three coffins were escorted to the quay and taken aboard the ship *Swensksund* en route to Sweden. In the early Sunday afternoon of October 5, this ship, escorted by several Swedish destroyers, was moored at the harbor of Stockholm. Five airplanes circled overhead and church bells rang out as the funeral procession took its way from the quay to St. Nicholas' Church in that city, where the coffins, draped in the nation's flags, lay in state for four days.

Byrd's Successful Flight over the Pole

The successful air flight over the North Pole was accomplished nearly twenty-nine years after Andrée's attempt, when, on May 9, 1926, Richard E. Byrd and Floyd Bennett flew their Fokker airplane, the *Josephine Ford*, from Kings Bay, Spitzbergen, to the Pole and back.

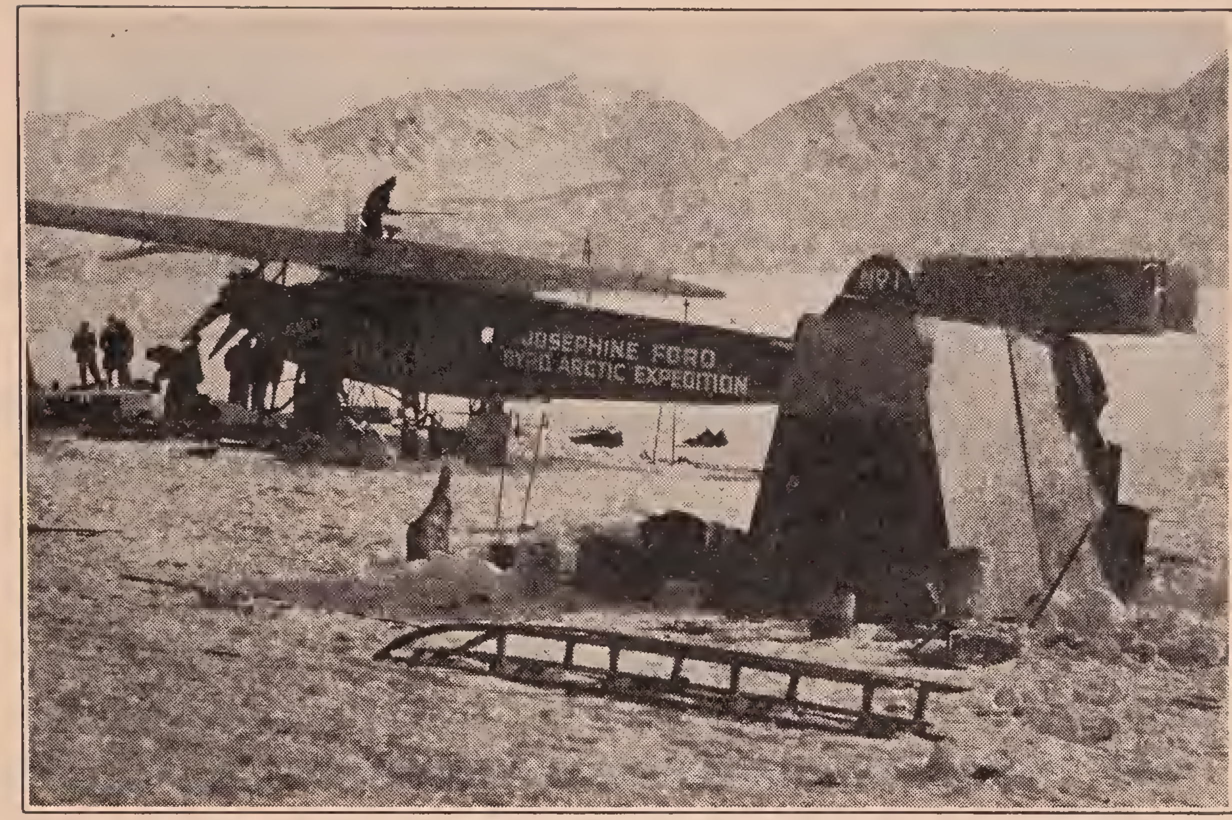
The life of Richard Evelyn Byrd is an inspiration to the youth of any country, but especially so to the young people of America. His ancestors were among the early settlers of Virginia, and their pluck and gallantry may be traced down through the generations to the three brothers who today bear the names of Tom and Dick and Harry Byrd, of old Virginia. Dick's first adventure came at the age of twelve when he crossed the continent all alone and boarded a ship for the Philippines to visit a friend of the family.

He returned by way of the Indian Ocean, the Suez Canal, and the Mediterranean Sea, and then across the Atlantic to New York. You may be sure that this boy of twelve who had circumnavigated the globe alone was considered most unusual. But his love of adventure did not gain supremacy in his early years, for he entered school and became a keen student of mathematics.

It is said that his father wished him to take up law, but realizing that Richard's interest lay in the engineering field, he secured an appointment for his son at the National Naval Academy at Annapolis. Here the science of navigation attracted him, and he became one of the honor students in his class. Athletics appealed to his fearless nature, and he became a star on the football field.

It was during the World War that he learned to fly. It was after only seven hours' dual instruction that he took his first solo flight, which he still maintains gave him one of his greatest thrills. The Armistice brought an end to his plans for flying navy planes across the Atlantic.

His determination to fly over the North Pole came in 1925, when, in company with Donald B. MacMillan and the young navy flier, Floyd Bennett, he flew over 2,500



Byrd's Monoplane, the *Josephine Ford*

miles in the region of Greenland. When Byrd and his friend Bennett returned to the United States, they asked for a leave of absence from the Navy Department. This being granted, they began to make preparations for their polar flight.

It takes a surprising amount of money to finance such an expedition. But the character and experience of these men inspired confidence, and over $100,000 was raised. Among the contributors and supporters of the expedition was Edsel Ford. In appreciation of his support, his little daughter's name, *Josephine Ford,* was placed in large letters on the side of the tri-motored Fokker airplane.

The party sailed by boat from New York and anchored in Kings Bay, Spitzbergen, on April 29, 1926. The *Josephine Ford* was taken ashore, and on May 8, Commander

Byrd and his pilot, Floyd Bennett, climbed into the cabin. It was an anxious moment. Would the plane, with its load of five tons, be able to take off? With the throttle opened for full speed the plane raced down the runway and rose like a great gull, eager to see what fate had in store for it as it winged its speedy flight northward.

But airplanes, unlike birds, have no instinct to direct them. The accuracy of their flight depends upon the navigator who sits in the cabin. It is he who interprets the readings of the many instruments and who signals to the pilot the correct course to pursue. This came easy to Commander Byrd — he was only putting into practice the knowledge of mathematics and navigation which he had so thoroughly mastered during his school and college days.

In fifteen and one-half hours the great plane had flown as straight as an arrow to the top of the world and back again, a distance of over sixteen hundred miles.

Byrd returned to New York, June 22, 1926, amid a storm of applause such as few Americans had been accorded.

He had now flown over the North Pole and had crossed the Atlantic. The next great adventure would be the attempt to carry the American flag to the South Pole. How that was done we shall soon see.

Roald Amundsen

When Byrd returned to Kings Bay from his North Pole flight, one of the first men to greet and congratulate him was Roald Amundsen, the 'Splendid Norseman.'

During the long snowy winters of Norway, Amundsen at an early age became an expert in skimming over the snow and coasting down the hills on his skis and sleds. The howling north winds seemed to him the voices of his Viking ancestors calling him to the adventurous life of an explorer, and the lives of the great English explorers, especially the life of Sir John Franklin, aroused in him the desire to do some discovering for himself.

After a two years' voyage as member of an expedition to find the South Magnetic Pole, Amundsen decided to try to sail through the Northwest Passage and locate the North Magnetic Pole, the exact position of which had never been established. The success of these attempts brought him into public notice.

His experiences in the Arctic prompted him to look forward to the discovery of the North Pole, but when Robert Peary had won this honor, Amundsen made up his mind that the Norwegian flag should be the first to fly over the South Pole. Before the world became aware of his intention, he had landed at the Bay of Whales and was making necessary preparations for the trip southward. On this expedition Amundsen used Esquimo dogs which he had brought with him from Greenland and upon which he relied so much for Arctic travel. It was on December 14, 1911, that he and his four companions raised the flag of Norway from the top of a little tent over the spot which he had found to be the South Pole. The weather was in their favor on the return trip, so that, after making over nine hundred miles in forty-two days, they stalked into the camp at the Bay of Whales on January 25, 1912, as the discoverers of the South Pole.

Now, before the World War, Amundsen had thought of using an airplane for a polar flight, and in 1914 had purchased a machine mounted on skis. Then the war broke out, and he presented this plane to his government. After the war, in an attempt to secure a flying boat for an Arctic flight, Amundsen found himself deeply in debt and unpopular both with his own countrymen and with his family. A lecture tour in the United States unfortunately proved a failure. Here was the greatest living explorer of the day seemingly without money, friends, or an opportunity for carrying on his marvelous work. But at this stage of affairs, an American, Lincoln Ellsworth, offered his financial support to Amundsen's scheme of reaching the Pole by way of the air.

Two flying boats were purchased and sent to Kings Bay, Spitzbergen, in 1925. In these two planes, the *N–24* and *N–25,* the Amundsen-Ellsworth party started off. Within one hundred thirty-six miles of the Pole both planes were forced to make emergency landings. One was wrecked. After days had lengthened into weeks, by united and heroic efforts the men from both planes finally succeeded in packing the snow into an icy runway some five hundred yards long, from which the capable pilot, Riiser-Larsen, got the plane into the air and, after one more landing, reached Spitzbergen.

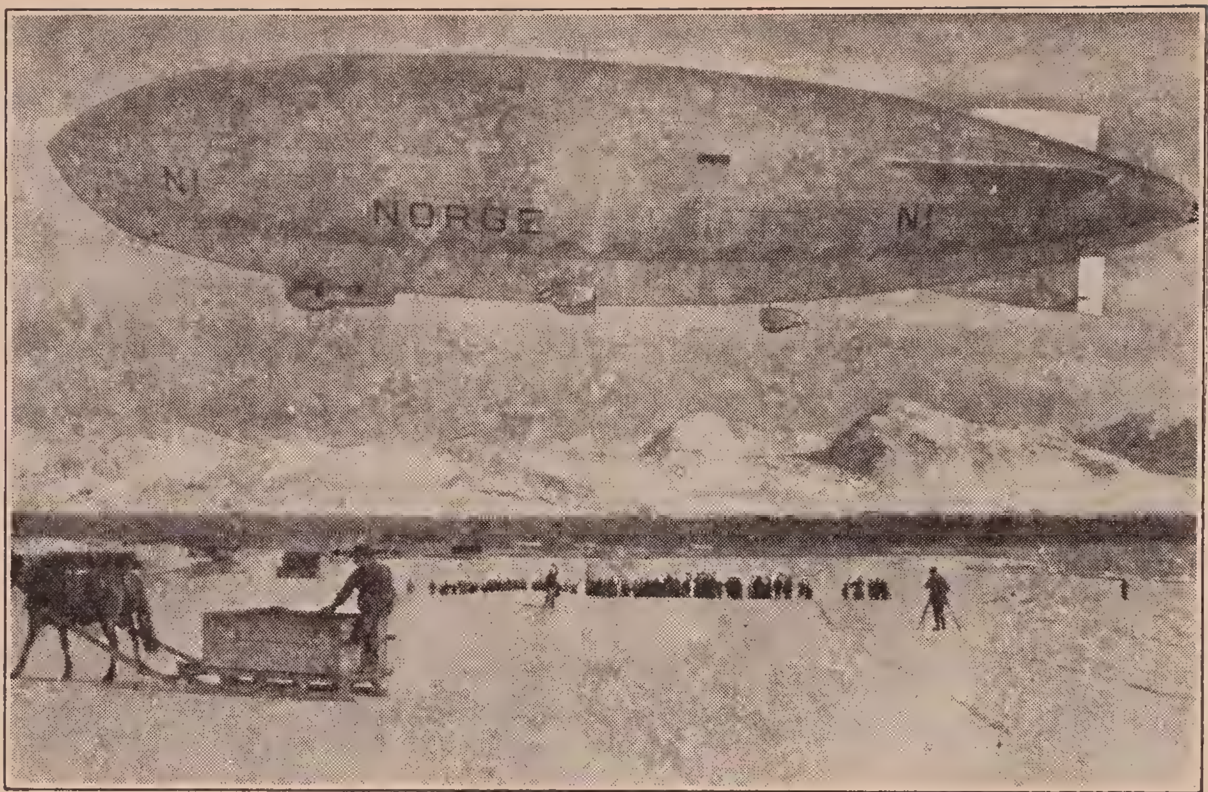
The *Norge*

Amundsen and Ellsworth now began to bargain with the Italians through Colonel Nobile for the purchase of the *N–1,* a semi-dirigible airship. This bargaining resulted in the combined Amundsen-Ellsworth-Nobile flight.

The *N–1* was a semi-rigid dirigible; that is, it was stiffened by a framework of steel tubing. Its length was 348 feet, or less than half that of the *Graf Zeppelin,* and its gas capacity was 650,000 cubic feet, or only one-tenth that of the new American airships built at Akron, Ohio. There were three engines of 250 horsepower each, two on each side just back of the cabin and one in the rear near the tail. These engines gave the ship a cruising speed of fifty miles per hour and a maximum speed of a little over seventy miles per hour. To fit this airship for its polar trip a good many changes were made. First its name was changed to the *Norge,* meaning 'Norway.' The luxurious cabin was made over, and the necessary equipment for the trip was installed. Sufficient gas tanks were provided for a flight of 4,350 miles without refueling.

On April 10, 1926, under the command of Colonel Umberto Nobile, the dirigible left Rome, Italy, for Kings Bay, Spitzbergen, where it arrived safely on May 7.

It was at this very time that Commander Byrd was also preparing for his flight to the Pole. The happiest relations existed between the leaders of the competing expeditions. Byrd won the race on May 9, in his airplane, the *Josephine Ford.* As for Nobile, it was 9:55 A.M., on May



THE *Norge* AT SPITZBERGEN

11, when the *Norge* lifted itself into the air with its company of sixteen men and the motors began their steady hum. At midnight, Ellsworth, the American, became a year older, and all on board were wishing him a happy birthday when Riiser-Larsen, the second in command, announced, "Now we are there." At 1:25, Greenwich time, the radio flashed the news that the Norwegian, the American, and the Italian, each had dropped his country's flag over the spot on the earth's surface known as the North Pole. As the Norwegian flag floated downward, two staunch friends grasped each other by the hand. They were Roald Amundsen and Oscar Wisting, for had not these same two, fifteen years before, planted their country's flag far away at the South Pole on the other side of the globe?

But the *Norge* did not return to Kings Bay as the *Josephine Ford* had done. Its objective was Alaska. On it sailed through dangerous fogs and over perilous Arctic seas. The ship had been seventy hours in the air carrying its human cargo 2,700 miles from Spitzbergen, Europe, to Teller, North America. Teller, however, was ninety miles northwest of Nome, which was the original point of destination. The dangerous ice and fog had made it seem best to land at Teller. Here the ship was deflated and taken to pieces for shipment to Europe while the explorers went to Seattle by boat. As the train carrying the explorers crossed the United States, it was met with cheers and public demonstrations at all the stations. Then on July 3, the Norwegians sailed from New York for their native land, where a great welcome awaited them.

General Nobile and the *Italia*

Two years later Nobile, who in the meantime had been made a general, planned another Arctic flight in the *Italia,* a semi-rigid dirigible similar to the *Norge*. On May 24, 1928, another Italian flag floated downward from the air as the *Italia* passed over the North Pole. But ill fortune overtook the ship on its return. It was forced down during a dense fog, and in an attempt to land, the cabin gondola was wrecked. Ten of the company were thrown out. One man was killed; Nobile and another were badly injured. The seven who were in the main part of the ship were carried away, their fate one of the unsolved mysteries of the

Pacific and Atlantic

SURVIVORS OF THE NOBILE DISASTER BEFORE THEIR RESCUE, LIVING IN THE 'LITTLE RED TENT'

Arctic. Fortunately some food supplies and the radio had been thrown out also. The radio was set up, and messages for help were sent out. However, before these messages were picked up, three of the party, Dr. Malmgren, the Swedish scientist, and two Italians, set out on foot for North Cape to bring assistance.

Finally the radio messages were picked up, and communication was established with Kings Bay. Rescue parties were formed. It was not until June 20 that the 'Little Red Tent' was discovered by an Italian plane and supplies were dropped to the little group. A few days later a Fokker plane piloted by two Swedish pilots made a successful landing near the wreck. It was decided that General Nobile should be the one to return and with his comrades' help he took his place in the rear compartment of the plane with his little dog, Titina, at his feet. The Fokker rose in the air and reached Russian Island, off the coast of Norway, safely.

Then Captain Lundberg returned alone to rescue the other members of the party, but in landing, his plane was wrecked and he became a member of the stranded party for two weeks before he was rescued by a plane flown by a brother officer of the Swedish air corps. (Captain Lundberg was killed on January 27, 1931, when a new plane, which he was testing for the Swedish army, crashed to the ground.)

During this time a Russian steamer, the ice-breaker *Krassin,* was forcing its way northward. Two planes sent out from her were forced down in an attempt to reach the Nobile camp. However, planes were successful in dropping food and supplies to the men marooned on the ice until the *Krassin* finally reached them all, picking up those from the *Italia* on July 12 after their forty-nine days' imprisonment on the ice. One of the most unfortunate circumstances attending the whole rescue was the loss of Malmgren, who perished on the ice, although his two Italian companions were afterwards rescued by the *Krassin.*

When the fate of the *Italia* became known, one of the first to give his services in organizing a rescue party was Roald Amundsen, who headed a Norwegian flying expedition, using a French seaplane. When three days passed with no word from Amundsen, anxiety was felt, but it was not until after a month had gone by that Russia, France, and Norway sent fliers out in an organized effort to locate the French plane. But to no avail. The only moving objects were the shadows of the planes; the only sound, their drumming motors as the searchers scanned the Arctic wastes. Amundsen, like the Vikings of old, had reached Valhalla in "the fulfillment of a high mission."

Sir Hubert Wilkins in the Arctic

There is another man who has flown many miles over the regions near the poles and whose past experiences and whose expectancy to reach the North Pole by submarine will interest every boy or girl. He is Sir Hubert Wilkins, an Englishman, whose friends in America have made possible his many flights over the Arctic and Antarctic regions.

With Carl Ben Eielson as his pilot he took off from Fairbanks, Alaska, one March day to fly across the country to Point Barrow. From that point he was to attempt a trans-Arctic-Ocean flight to investigate the possibility that there existed an area somewhere in the Northland devoid of snow and ice. The big Lockheed plane, built especially for him for such flights, was loaded to capacity with gas and oil and, he tells us, "with food and equipment to last for thirty days' travel over mountains or tundra in case we should be forced down on the way to Barrow."

Eielson was a competent pilot. The plane successfully climbed the eleven thousand feet needed to fly over the

Endicott Mountain Range. Then keeping a steady course for two hundred miles over the flat land to Point Barrow, the plane was brought in for a landing.

It is interesting to read of the curiosity with which the Esquimos, a simple, friendly people, viewed such scenes and of their eagerness to be of some assistance. Sir Hubert was on friendly terms with the Esquimos of Alaska, and they were employed by him at Barrow to prepare the runway necessary for his take-off on his non-stop flight across the Arctic. He says, "They worked with a will as I was able to pay them six dollars a day and an occasional meal."

Then one morning in April Sir Hubert decided that the weather was suitable, and, climbing into the navigator's cabin, he gave Eielson the signal "Let go." They were in the air on their non-stop flight across the Arctic seas. Twenty and one-half hours later they landed in Spitzbergen, having flown 2,200 miles, 1,300 of which were over areas which had never before been seen by man. The following November, Pilot Eielson responded to a call for help from a fur-trading ship frozen in the far Arctic, and set out in his own plane. He never returned alive. Three months later a rescue party found his broken plane and brought back his remains to Alaska.

Sir Hubert Wilkins later transported his airworthy plane to the Antarctic. Here in December, 1928, and January, 1929, he flew over 600 miles, locating 300 miles of coastline and gaining the distinction of being the first man to fly over this region in an airplane.

CHAPTER IV

IN THE ANTARCTIC

Exploration is a more difficult undertaking in the Antarctic than in the Arctic regions. Suppose you think of the Arctic as the area covered by the 60° circle drawn about the North Pole and the Antarctic as an area of the same size around the South Pole. Within this area about the North Pole there live over one million human inhabitants. There are countless land animals. Lumbering, mining, and fishing are carried on. But in the same-sized area about the South Pole there is not a single permanent human inhabitant. Neither is there a single land animal except that peculiar bird creature, the penguin. There are no trees and very few plants. The only industry is whaling, and that is carried on along the coast. Within this area, however, lies a large body of land known as *Antarctica,* equal to the United States and Mexico combined, over which spreads a vast sheet of snow and ice. This territory exceeds in land area and in altitude the region about the North Pole; thus it is colder and the polar blizzards rage with more terrific fury and disastrous results. On the Pacific side, indenting the coast of Antarctica, is the Ross Sea with its great ice barrier, a sheet of floating ice from 300 to 1,500 feet thick, extending above the water from a few feet to 200 feet. Because this part of Antarctica is nearest the South Pole, it has been from it that the polar expeditions have started.

Men have sailed from the ports of many different countries to venture forth into the perilous Antarctic seas. It has been through the knowledge that they have gained that each subsequent voyager has got nearer his goal.

Early Attempts to Reach the South Pole

As early as 1838 America sent a sea captain, Charles Wilkes, with a corps of scientists on an organized expedition into the far southern waters. One of the ships was called the *Flying Fish,* a name suggestive of the mode of travel one hundred years later. Captain Wilkes was the first man to sight Antarctica. You will find the coast line on the Australian side of this continent now bears the name of Wilkes Land in his honor.

Sir Ernest Shackleton was a brave Englishman whose superb courage and endurance had taken him in 1909 to a point less than two hundred miles from the South Pole. He made many voyages into Antarctica. While on his last, in 1922, he suddenly died. He was buried under a cairn of stones on South Georgia, a desolate island about 35° from the Pole which he had made such a desperate attempt to reach thirteen years before.

Roald Amundsen was the first man, as you know, to reach the South Pole. He started from the Bay of Whales, which was the site of 'Little America,' the base from which Admiral Byrd made his flight.

While Amundsen, with his Eskimo dogs that he knew so well how to use, was traveling toward the Pole from the Bay of Whales on the east side of the Ross Ice Barrier, Captain Robert F. Scott was braving the elements and urging his Manchurian ponies onward from his base on the west side in the hope that the English flag would be the first to fly over the South Pole. But his ponies did not prove so successful as he had anticipated. They all died on the trip, and it was not until thirty-five days after Amundsen had reached the goal that Scott discovered the heart-breaking fact that others had preceded him. He and his four companions began their homeward trip, weary and disappointed. With unfavorable weather conditions they made slow progress. Within only eleven miles of a base of supplies a terrible blizzard came upon them, leaving death behind. Their tragic end, their loyalty to each other, their last hours are told in Captain Scott's notes and diary, which were found with their remains in November, ten months later.

The Byrd Antarctic Expedition

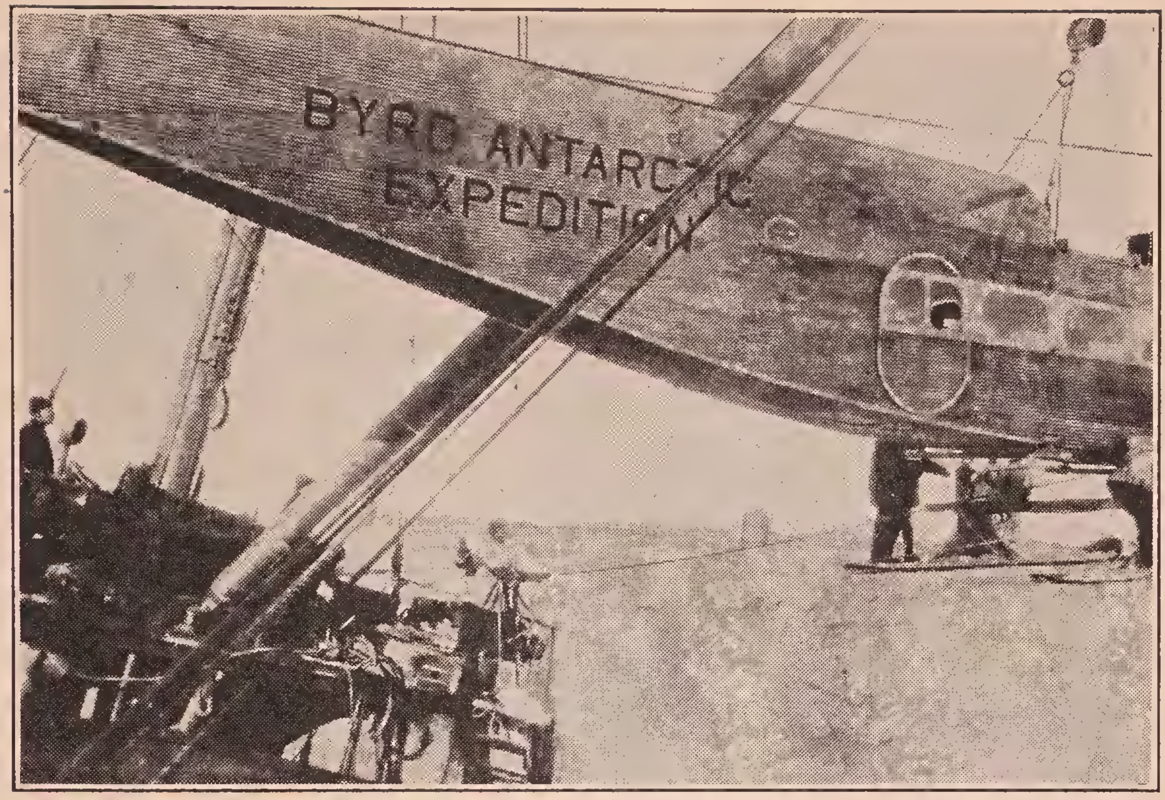
The success which accompanies great adventurers does not just happen, is not just a lucky ending. Days, months, and years lie behind the successful attainment of a goal. The great Byrd Antarctic Expedition was led by a man who said, "For years I had read every record of Antarctic exploration and every scientific discussion of Antarctic problems." The time came when this man was ready to attempt his flight to the South Pole, not planned, however, just for the great honor such a flight would give to himself and his country, but as a great scientific undertaking: to learn about weather conditions, air currents, wind velocities at different altitudes; to determine ocean currents; to study the composition of the mountain rocks; to see whether these ranges were the continuation of the great Andes range of South America; to observe the habits of animal life; to bring back for future study records made by weather instruments; and to take moving pictures of those desolate ice-covered regions to be shown for the instruction and entertainment of the millions who would never be able to visit that part of the globe.

Think of the responsibility which rested upon the leader of such a great endeavor. Richard Evelyn Byrd had the happy faculty of choosing wisely those companions upon whom he relied so much to carry out his plans. There were engineers; geologists, men whose business it was to study rock formations; surveyors; meteorologists, who studied and recorded weather conditions; physicians; radio operators; photographers; newspaper men; mechanics; ski experts; dog trainers and dog drivers; carpenters; airplane pilots; seamen, sailors, and cooks; and the Boy Scout who was privileged to be one of the party. Enough food of the right fuel and vitamin value was to be taken to last the company three years. The proper kind and quantity of clothing had to be selected. Instruments which were to record scientific data had to be carefully packed. Medical and surgical supplies had to be taken. There were outfits and material for repair work on every kind of equipment. There was a library containing technical books, books on exploration, and books for recreational reading. Then there were the tons and tons of coal, and barrels and barrels of gasoline and oil — nothing must be overlooked.

Four ships were used to carry all these necessary supplies. Room also was provided for the huge crates containing the three airplanes which were a very important part of the expedition. It is interesting to learn that one of the ships of this little fleet, now renamed the *City of New York,* had been built in Norway over forty years before and that it had weathered many trips through Arctic ice. Its construction was such that instead of being crushed by the ice packs it would be pushed above them.

On August 25, 1928, this ship put out to sea from the harbor of New York, bound for Dunedin, New Zealand, the place from which the expedition would set sail for Antarctica, 2,300 miles to the south.

The departure from Dunedin was made on December 2, and on Christmas Day, 1928, the ice walls about the Great Ice Barrier loomed into view. A few days later a landing was made at the Bay of Whales, and Little America was established a few miles inland, near the site where nineteen years before the Norwegian camp had awaited Amundsen and his companions, who were trudging along with their dog teams over the snows from the South Pole. But the trip this time was to be taken by way of the air.



Aëronautical Chamber of Commerce of America

UNLOADING THE BIG PLANE AT LITTLE AMERICA

A large all-metal tri-motored Ford monoplane, named the *Floyd Bennett* in honor of Byrd's companion on his flight over the North Pole, was to carry the explorer and his companions on the perilous polar flight. There were two other planes, the *Stars and Stripes,* a Fairchild, and the *Virginian,* a Fokker plane, each with a 425-horsepower Pratt and Whitney Wasp engine. These later were to be used for scouting flights and to explore uncharted areas about Little America.

In the early part of March the *Virginian* had taken Professor Lawrence Gould, Bernt Balchen, and Harold June to the far-away Rockefeller Mountain section, where it had been staked out while they were examining land formations and obtaining specimens. A terrific blizzard swept over their little camp. The *Virginian* was torn loose from the stakes and dashed, a miserable wreck, against the snow. The men were left in the mountains with no way of returning except by foot. The winter was approaching and flying days were few, but Byrd insisted on going to their rescue. With two companions he headed the *Stars and Stripes* toward the mountains. The wrecked *Virginian* was discovered, and a large 'T' made of orange flags, indicating a landing space, was visible on the snow. The rescue plane was landed safely. Byrd anxiously looked about and found the three members of his expedition well though "disconsolate after their battle with the storm which had wrecked their plane." Like a true hero, Byrd sent Balchen and June back in the plane while he and the other members waited for two days, with the temperature 25° below zero, for the return of the rescue plane. This ended exploration trips, for the winter was near at hand and every one was busy preparing for the long polar darkness which would soon be upon them.

The two remaining planes, with their engines snugly covered, were placed deep in their dugout snow hangars. On April 18, the sun disappeared from view, not to become visible again until the following August.

It is interesting to read about the busy life of the men in their home under the snow, lighting their way through the tunnels with flash lights and lanterns, as they went from one 'building' to another, while outside the thermometer went down, down, 50° below zero, 60°, 64°, and on a mid-July day while New York City was sweltering in

Aëronautical Chamber of Commerce of America

THE STARS AND STRIPES FLYING OVER LITTLE AMERICA

the heat, even registering 71° below zero. How happy they must have been when Old Sol appeared again! What a celebration as the Stars and Stripes, followed by the British and the Norwegian flags, was unfurled and mounted on the flagpole!

September came and went. October saw the preparations for the polar flight nearly completed. On October 15, a supporting party started south with its line of loaded dog-drawn sledges to lay a base of supplies over three hundred miles away. Then came November. Motors were tuned up daily. In the big Ford plane, the central engine, a 525-horsepower radial air-cooled Wright Cyclone, and the 225-horsepower side engines, gave forth their steady regular hum which satisfied the trained ear of the mechanic. Everything was ready now. Would the day ever come when visibility would make possible the success of one of the greatest adventures ever attempted by man?

On Thanksgiving Day, November 28, 1929, the great leader decides to wait no longer. Bernt Balchen, Harold June, Ashley McKinley, and Richard Evelyn Byrd enter the cabin of the big tri-motored monoplane, heavy with its load of over seven tons. Bernt Balchen is at the controls; June at the radio. McKinley is busy with his camera, and the skillful navigator who is to direct the pathway through the skies is seated where he can watch the many instruments. The plane slides along on its trusty skis, rises in the air; the thirty-eight men left behind shout Godspeed and toss their hats in the air from the very joy their unselfish hearts feel in their part in this marvellous adventure.

The plane gains altitude, is lost to view. For five hours it speeds southward as straight as an arrow. Mountains still a hundred miles away are visible in the distance. Then the bare, vertical, snow-bound rocks appear. A quick decision and a course is taken up an opening in the mountains made by a time-old glacier; a huge high-humped peak is ahead! Balchen, fighting the changing air currents, forsees disaster unless the load is lightened. Overboard is strewn three weeks' supply of food. Better food than the precious gasoline without which they could never fly back! More food is sacrificed, and then still more, until a bare five hundred pounds are left. But now a shout of joy from Balchen as the plane rises over the mountains, and a level polar plateau lies ahead. It is straight flying now. Midnight comes, not a dark midnight, but with the sun's rays across the horizon. Then another hour goes by and at 1:25 A.M. Commander Byrd passes a message to June, who clicks out these words by radio to those anxious men at Little America and on to all peoples of the world: "My calculations indicate that we have reached the vicinity of the South Pole." Then a trap-door in the plane is opened. In Commander Byrd's hand is a silk American flag weighted with a small oval stone brought with him from the grave of Floyd Bennett. A salute is given as the American emblem, with its token in memory of a courageous comrade, floats to the whiteness below. The flags of three other nations follow: one for that splendid Norseman, Roald Amundsen; one for the immortal Englishman, Robert F. Scott; and a French flag in honor of the people of France. The plane circles the spot where all meridians come together and then starts on its return flight. Clouds begin to show their fleecy masses along the horizon in the rear. The plane is light and it slides through the mountain passes, following the same glacier over which it had flown on its southward flight. A landing is made at the mountain base where gasoline has been previously stored. The plane is refueled here, and food is left for Gould and his party of geologists.

Within an hour the plane again heads northward and on November 29, 1929, at 10:10 Arctic time, the *Floyd*

Bennett comes to earth again, amid the joyous shouts of the men at Little America. In eighteen hours and forty-one minutes, less than one day, the airplane had made possible a trip of sixteen hundred miles over a route which Amundsen had needed ninety-seven days to cover! It had carried the American flag a thousand miles farther south than it had ever been before. Congratulations poured in from everywhere, keeping the radio busy. Then on Christmas Day came the news that Commander Byrd had been promoted to the rank of a rear admiral in the United States Navy.

Busy weeks followed. Exploring trips some hundreds of miles away occupied the time and attention of the little group. Then came the preparations for leaving this polar country. Fear was felt lest the *City of New York* could not weather the ice pack and reach the Bay of Whales. But on February 18, sheathed in a coat of frozen spray weighing over 200 tons, she reached her goal. By 9:30 o'clock the following morning everything was ready for a speedy departure from Little America. But there was no room to take the victorious plane on board. It had served its purpose, and there it was left, silhouetted against the sky — an appropriate monument to the accomplishment of a great task.

A splendid welcome was given to the expedition at Dunedin, New Zealand, whence it had sailed over fifteen months before. It was not until June 19, 1930, that Rear Admiral Byrd reached New York to receive his third official welcome, greatest and heartiest of all, exceeding those he had received for flying over the North Pole and for flying across the Atlantic. Admiral Byrd paid high tribute to the services and loyalty of his comrades on the expedition; for himself he said, "It is good to be back again."

Sir Douglas Mawson

Another man whose explorations have added thousands of square miles to the known area of Antarctic lands and whose information gained on weather conditions will be of valuable aid to aircraft visiting these areas, is Sir Douglas Mawson, the Australian scientist.

He is commander of the British, Australian, and New Zealand Antarctic Research Expedition which has explored the coast of Antarctica opposite to that traversed and viewed by air by Wilkins and by the Byrd Expedition. He is convinced that the airplane is a convenient and safe method for transportation over polar areas and has made use of one in his recent explorations in the Antarctic regions.

PART II

AIRCRAFT LIGHTER THAN AIR

TYPES OF BALLOONS AND DIRIGIBLES
SOME GREAT AIRSHIPS OF GERMANY AND ENGLAND
UNCLE SAM'S AIRSHIPS

CHAPTER V

TYPES OF BALLOONS AND DIRIGIBLES

A balloon leaves the ground because it is filled with a gas that is lighter than the air it replaces.

Balloons trace their ancestry backward over a long period. You have already read how the Montgolfier brothers, the brothers Charles, De Rozier, Blanchard, and others amazed the people of their times with the ascensions of their gayly colored balloons, filled at first with hot air and later with hydrogen.

Hydrogen was first investigated in 1766 by an English scientist named Henry Cavendish, who called it 'inflammable air.' It is 14½ times lighter than air, is the lightest known gas, and is therefore specially fitted to give the needed buoyancy to balloons and dirigibles. It has one great disadvantage, however — it takes fire easily and this inflammability may bring about violent and destructive explosions.

In 1895 another British chemist discovered helium. This gas is not so light as hydrogen, but it has the decided advantage that it does not burn. Helium is present in mineral springs and in natural gases that rise from wells in many parts of the United States. It is from such wells that our government is obtaining its supply for use in its balloons and airships.

At certain intervals helium must be removed from the ship, purified, and replaced. The plants for doing this work are under the jurisdiction of the Federal Bureau of Mines.

Balloons for ordinary observation and those which individuals use for exhibition purposes at country fairs are filled with ordinary illuminating gas.

There are two distinctive types of balloons — those which float in the air without mechanical means for directing them and those which have special mechanical devices, such as motors and propellers, for direction and control. The former are known as *free balloons;* the latter are called *dirigibles.* An *airship* is a dirigible balloon.

Unmanned free balloons, small balloons not intended to carry passengers, are used by the Army and Navy in observations at their weather stations. Instruments which register the air pressure (barometers), the temperature (thermometers), and the relative humidity (hygrometers) are placed in these balloons. These instruments are packed very carefully in cases, so that no harm comes to them when the balloon finally reaches such an altitude that it bursts and the instruments fall to the ground. The results of such observations supply accurate and useful data on weather conditions of the upper regions of the atmosphere. Of course, this method is expensive, for the instruments are costly, many of them are lost, and

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FLEET OF SIX SMALLER GOODYEAR AIRSHIPS ON 'DRESS PARADE'

some are found but not returned to the government station where they were sent up.

Other free balloons which do carry passengers are used in the effort to gain altitude or distance records or to make meteorological observations.

Free balloons have been used frequently during war times for making observations. Many hundreds of curious-looking, kite-shaped and sausage-shaped balloons were used during the World War. These were called *captive balloons* because they were anchored to the ground by a strong rope and could be rapidly hauled down to earth by a windlass. Captive balloons were also anchored to ships, because from the high-vision points they reached, submarines could be better located than from the decks or mastheads of the ships.

Controlled balloons, or dirigibles, were first conceived as aërial rowboats. As the years passed, many primitive types of propellers were designed. At first these propellers were manually operated; later crude efforts were made to apply steam power. At last came the internal-combustion engine to solve the problem of propulsion.

Modern dirigible balloons, or airships, are of three sorts: non-rigid, semi-rigid, and rigid. Non-rigid airships rely upon the interior gas pressure to preserve their shape, and are relatively small in size. They are familiarly called *blimps*. France may be considered the home of this type.

Italy, in particular, has developed the semi-rigid type. The Italian ship *Norge*, which, you will remember, flew over the North Pole in 1926, was a semi-rigid dirigible. In this type the shape is partly maintained by a framework, or keel structure.

It was through the vision and perseverance of Count Zeppelin, a German army officer, that the rigid types of airship were developed. These are now officially known as *Zeppelins*. These rigid dirigibles are so important a development that it is desirable to learn something of their history, their design, and their construction.

CHAPTER VI

SOME GREAT AIRSHIPS OF GERMANY AND ENGLAND

THE *Graf Zeppelin*

The *Graf Zeppelin,* the 127th airship to be built in Germany, is one of the largest dirigibles which has ever flown. It well illustrates the remarkable progress that has been made in conquering the air by lighter-than-air machines.

The framework of the *Zeppelin* is made of duralumin, an aluminum alloy which is nearly as strong as steel. This frame is covered with a special fabric coated with an aluminum powder compound. Fabric treated with this compound reflects the heat waves and reduces the risk of fire.

Within the framework there are seventeen cells which contain hydrogen gas. These cells are made of tightly woven cloth lined with goldbeater's skin. The goldbeater's skin is prepared from the intestines of the ox. Though it is very thin, it does not permit any of the gas to escape. To each of these cells are attached valves which may be operated to release any desired amount of gas, thus making the ship less buoyant and enabling it to descend.

On the under side of the main body of the ship, a short distance from the nose, the main car is located. This contains the navigation rooms and the passenger accommodations. The apparatus for steering the ship is located in the foremost cabin, called the *control room*. The large glass windows give an unobstructed view to all sides as well as downward. In this cabin are also located the controls that operate the gas valves, the ballast tanks, and the electric telegraph for communication with the engine cars. Here also are the compass, the navigating instruments, and the switchboard which controls telephonic communication aboard the ship.

Just back of the control cabin and adjoining it is the chart room. Here the maps are kept, and here the navigator checks constantly on the ship's direction. To the left of the chart room is the radio room, where powerful radio sets can transmit and receive messages from long distances.

On the right of the chart room is the kitchen, where the chef prepares the food on electric stoves for the passengers and crew.

The next cabin is the combination dining and lounge room. It occupies the full width of the cabin structure and is tastefully and comfortably furnished. There are four tables with upholstered chairs, made of surprisingly light wood. A radio brings music or other entertainment from any broadcasting station that is picked up. The two wide windows on either side are set at an angle to improve the view earthward.

From a central corridor leading to the rear, open the passengers' staterooms. There are five of these on either side, and each one is equipped to accommodate two persons. Each room has a large window, a table, a clothes closet, and comfortable berths. Next to the staterooms are the lavatories for men and for women.

From the end of the main-cabin car there is a ladder which leads to the inside of the airship. A long passageway extends all the way from the nose to the tail of the big ship. Along this passageway are the sleeping quarters of the crew, the gasoline tanks, the water ballast tanks, and space for mail and baggage.

From this corridor there extend 'cat walks' to each of the five separate 'gondolas' which are suspended from the main framework of the ship. In each of these gondolas is a propelling engine. These engines are designed so that they can run on either gasoline or *Blau Gas* (a special gas invented by a German named Blau). The interesting thing about this gas is that it has the same weight as air. The ship, therefore, is no heavier when it takes on a supply of this fuel, nor is it lighter after this gas is consumed. A quantity of gasoline is carried to serve as an emergency ballast.

The interest of the world was centered on Dr. Hugo Eckener as he piloted the *Graf Zeppelin* around the world in 1929. About midnight on the eighth of August the sky was clear, and the weather reports were favorable as the giant airship was towed out of the hangar at Lakehurst, New Jersey. It rose into the air and headed for

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THE *Graf Zeppelin* AT FRIEDRICHSHAFEN, GERMANY

New York City. It circled the city, passed the Statue of Liberty, and turned its silver nose eastward into the darkness of the Atlantic.

It reached Friedrichshafen 55 hours and 22 minutes later, on the first lap of its journey around the world. After four days in Germany it again pointed its nose eastward to sail for 6,800 miles to Tokio, Japan. The flight for hours over cold Siberia was filled with danger. Two severe storms were encountered, one of them over uncharted regions of that great territory; but no mishap occurred, and the airship made a safe landing at the Kasumigaura Airport, Tokio. Four days were spent here in the preparation for the crossing of the Pacific Ocean, the first ever attempted by an airship.

Commander Eckener navigated the giant dirigible safely into the Los Angeles Airport on August 26, 1929. The next day the ship started on its transcontinental flight and reached Lakehurst just a few hours over twenty-one days from the day it had begun its globe-circling flight of 19,500 miles.

Germany has a new airship under construction which is even larger than the *Graf Zeppelin.* It will probably be used when the German-American Company, being organized by Dr. Hugo Eckener, establishes a commercial air line from the Old World to the New.

The *R–100*

The *R–100,* which was built in England, differs somewhat from the German type of dirigible. In length it is 709 feet, or 63 feet less than the *Graf Zeppelin,* but in diameter it is 133 feet, or 33 feet more. It is designed to fly 82 miles an hour, a very fast speed for an airship of this size.

The passenger quarters on the *Graf Zeppelin,* you recall, were arranged in a cabin suspended from the framework of the ship. In the *R–100,* passenger quarters are inside the ship and may be compared with those of a steamship.

There are three floors, or decks, connected by a staircase ladder on each side. On the lowest deck are the mess deck and cabins for the crew. On the second deck there are a dining room and cabins for passengers. The dining room seats fifty persons and the two-berth and fourberth cabins, accommodating fifty persons in all, are similar in size and furnishings to those on an ocean liner. On the top deck are cabins for fifty more persons, a smoking room, and toilet facilities similar to those provided in a Pullman car.

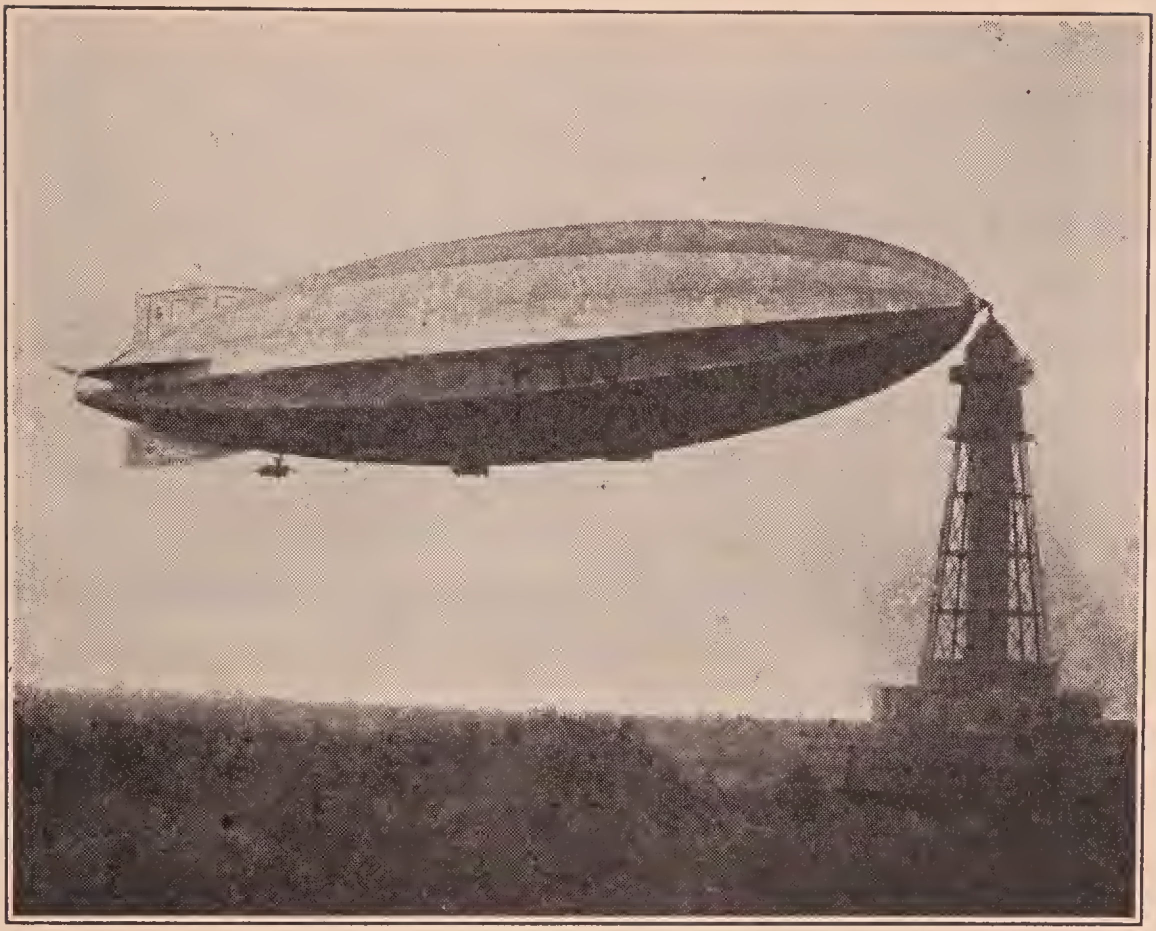
Around the outside of the middle decks are wide verandas, or 'promenade decks,' to talk in the language of the sea. These are built strong enough to allow dancing. Many of the cabins on the top deck open on to narrow balconies which run along the side of the ship; here passengers may sit and gaze through the windows at the scenery below.

You will be amused to learn that, on account of the common superstition about the number *13,* the cabin which bears that number has in it a little wooden mouse, the mascot of the ship.

Electricity, which is generated in the motors in the gondolas suspended from the ship, is used for lighting the ship throughout and for cooking.

The flight of the *R–100* from Cardington Airport in England to St. Hubert Airport at Montreal has proved again to the world not only that transatlantic flights by airship are possible but even that within a few years aircraft will be the regular means of quick transportation across large water areas.

Sir C. Dennistown Burney, the designer of the *R–100,* believes that a regular service will be established between England and North America, taking upon the average two and a half days for the westward passage and a day



Wide World

THE *R–100*

She is moored to her mooring mast at St. Hubert Airport, Montreal, Canada.

and a half to two days for the return flight. He points out that the airship has one decided advantage over the ocean ship in its quicker 'turn around'; it would be able to make thirty-six trips across the Atlantic to every ten trips of the ocean liner.

The *R–100* was the fourth airship to cross the Atlantic. Another English dirigible, the *R–34,* was the first one to make such a voyage, in 1919. Two years later this airship was almost cut in two by a windstorm at Hamden, England. After the *R–34* made its trip, the *ZRS–3,* now the *Los Angeles,* was flown from Germany. The *Graf Zep-*

pelin, the third ship to cross, has made several voyages to America.

The sister ship of the *R–100,* the *R–101,* the largest ship of its kind at that time, met with disaster in a great explosion while flying over France en route to India.

It was the only airship of its kind in which a smoking-room had been provided. This was deemed safe because Diesel engines had been installed which used a heavy non-explosive fuel oil. The only gasoline on board was the small amount necessary for the small engines used to start the large ones.

A special 'breathing' apparatus was installed whereby any excess pressure within the big outer envelope could be automatically released. A current of fresh air circulated constantly throughout the ship to sweep away any dangerous gas fumes. With these precautionary measures it was thought that the *R–101* could safely make its trip over the hot, tropical regions. Many different reasons have been given for the accident. Dr. Hugo Eckener, who went to England as a member of the investigating committee, said that probably some of the gas tanks in the front end had sprung a leak, causing the ship to nose over and to descend so rapidly that it struck the hillside where it met its grim fate.

One of the great problems in the development of airships has been that of handling them in port. The mooring mast at St. Hubert's Airport at Montreal is an example of a modern structure built for this purpose. When the *R–100* reached Canada after its transatlantic voyage, it was moored to this mast in only twenty-seven minutes after the first landing line had been dropped. Three large cables, one attached to the nose of the ship and one to each side, were reeled in so that the nose came directly into that part of the mast called the mooring bell, where it was fastened. The passengers and crew were brought downward from the ship in the twelve-passenger elevator which runs through the center of the 205-foot tower. This mooring mast was built by the Canadian government, aided by American specialists, at a cost of $750,000.

CHAPTER VII

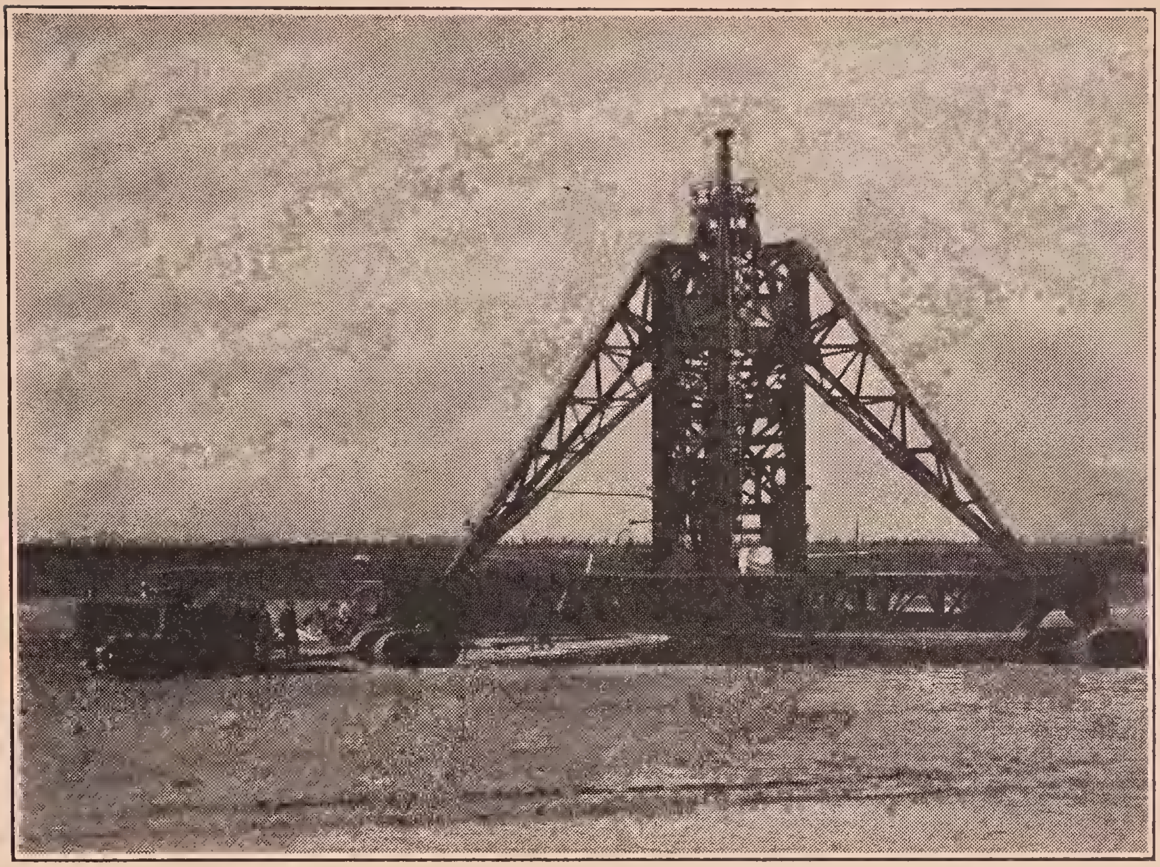
UNCLE SAM'S AIRSHIPS

Even before we entered the great World War, our government had become interested in the idea of building rigid airships. Samples of materials from Zeppelins wrecked in Scandinavia were received and analyzed, and the development of similar materials was urged by the Navy Department. Sample aluminum girders for airships, for example, were made and tested.

In the fall of 1916 a board of Army and Navy officers was appointed to recommend a policy for the development of rigid airships. It was left to the Navy Department to develop them in this country or to acquire them abroad.

Congress appropriated $1,500,000 toward the construction of one rigid airship, $2,500,000 for the purchase of one abroad, and $3,000,000 for the construction of sheds, or hangars, large enough to house two large airships. The *R–38*, which was the ship purchased from England, unfortunately met with disaster in 1921, while on a test flight.

The hangar, which was erected in 1919, at Lakehurst, New Jersey, was the world's largest airship shed. From the inside it gives the impression of several blocks of



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A Mooring Mast at Lakehurst, New Jersey

This mast may be towed by tractors.

fifteen-story buildings. It is large enough to accommodate two 5,000,000-cubic-foot ships. When the *Graf Zeppelin* visits this country, it finds comfortable space beside the *Los Angeles* and several 'blimps.' A mooring mast is located at this naval base.

The *Shenandoah*

The U.S.S. *Shenandoah* was developed by the lighter-than-air technical staff of the Navy at the Naval Aircraft Factory at Philadelphia, and assembled at the Lakehurst Station. It went into service in October, 1923, and made

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THE *Los Angeles*

Notice the airplane hooking on.

many notable flights, including one to the West Coast and back. In September, 1925, it was destroyed by a severe storm over Ohio. Fourteen men lost their lives in the disaster.

THE *Los Angeles*

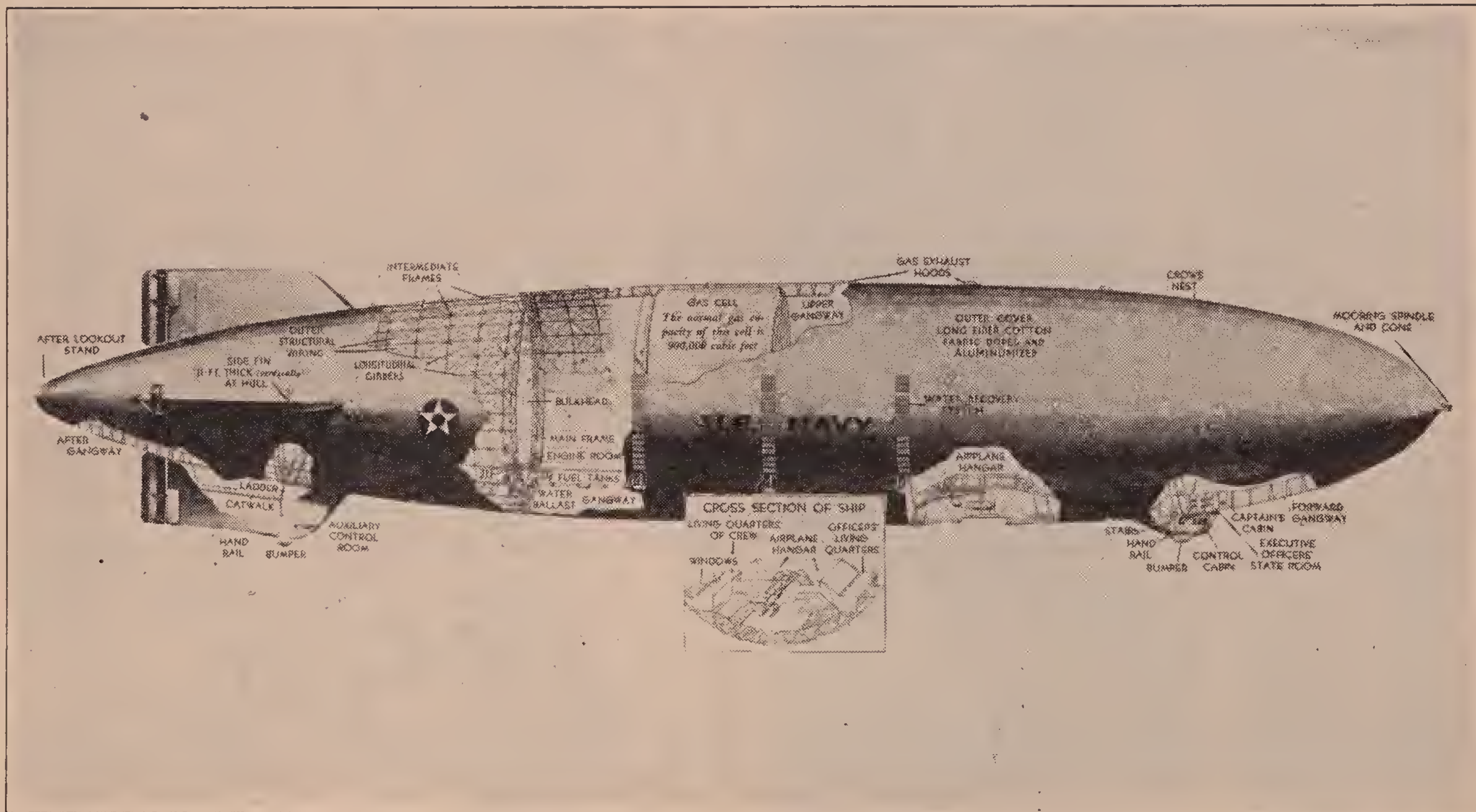
The *Los Angeles,* which the Navy men call 'the big silver pig,' was built at Friedrichshafen, Germany, under the direction of United States inspectors. It was completed in September, 1924, and after several successful trial flights was flown across the Atlantic in October under the command of Dr. Hugo Eckener, of the Zeppelin Company. On that voyage it flew 5,066 miles in approximately 81 hours. On November 25 it was christened *Los Angeles* by Mrs. Calvin Coolidge.

This dirigible is 656 feet in length and has a gas capacity of 2,625,000 cubic feet. Its five propellers, each driven by a 525-horsepower Mayback engine, give it a speed of about 70 miles an hour. The *Los Angeles* no doubt has been seen by many who read this book, for the ship makes frequent short trips and has made notable transcontinental flights.

The *Akron*

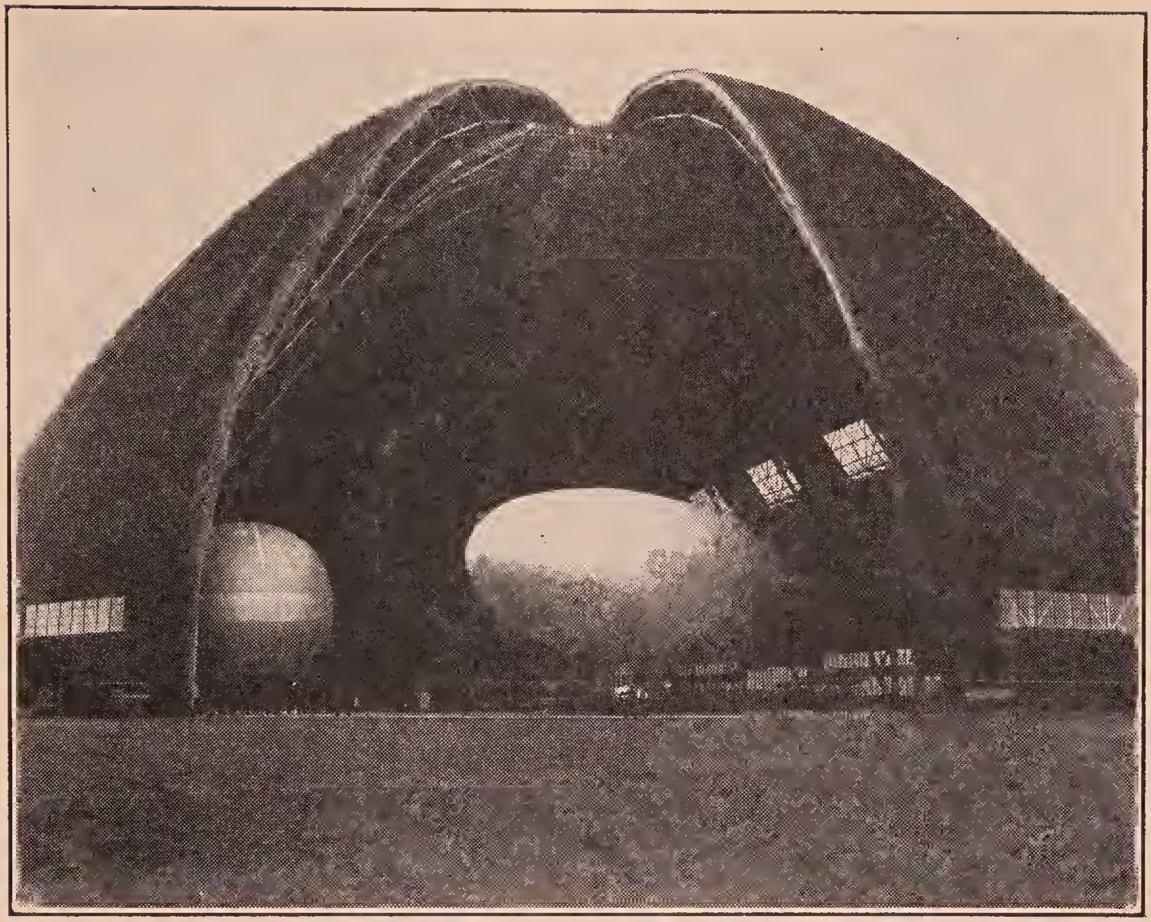
In October, 1928, the United States contracted with the Goodyear Zeppelin Corporation of Akron, Ohio, for the building of two new airships, one to be completed in 1931, the other in 1932.

The first of these ships, the *Akron,* was christened August 8, 1931, by Mrs. Herbert Hoover. It is the custom in Europe to christen an airship by breaking a bottle of liquid air on it. But since liquid air is really quite dangerous — for on account of its extreme temperature it freezes instantly any flesh that it may touch — Mrs. Hoover at the proper moment cut a silken string which opened a cage and released forty-eight beautiful pure white pigeons — one for each state. It is the largest lighter-than-air craft in existence, being nearly twice the size of the *Graf Zeppelin.* Powered by eight motors, it has a maximum speed of 84 miles per hour. At a cruising speed of 50 miles per



THE *Akron*

Cut-away drawing showing compartments in the ship.



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THE EVOLUTION OF THE AIRSHIP

Just inside the orange-peel doors of the Goodyear-Zeppelin dock at Akron are seen a free balloon, a blimp, and the duralumin framework of the airship *Akron,* recently completed for the United States Navy.

hour it can travel over 10,000 miles, or more than twice as far as can the *Los Angeles,* without refueling.

A unique and outstanding feature is the provision of a complete airplane hangar within the hull of the ship. Here may be housed five high-performance airplanes. These planes are raised or lowered on a trapeze swinging through large doors in the bottom of the hangar. Special hooks on the wings of the airplanes are used to attach them to the trapeze.

The *Akron* looks different from the other dirigibles as it glides through the air; it is fuller, or plumper, than the *Los Angeles,* as the figures in the accompanying table show; then, too, its engines do not swing in gondolas, as they do in the *Graf Zeppelin,* but are housed within the hull to reduce air resistance.

The longitudinal and transverse girders for the framework are made of duralumin; they are stronger and more efficient than any ever used before and are braced with steel wires. Indeed, the strength of the hull is so great that it can withstand the wrenches of storms and squalls twice as severe as the *Los Angeles* could successfully encounter. Eleven separate cells of gas-tight fabric, containing the non-inflammable helium gas, give the necessary buoyancy. Over the huge framework is drawn smooth and tight the aluminized fabric which gives the lovely silvery effect. At the rear, as in all dirigibles, horizontal and vertical surfaces are attached. On the vertical fins there are movable rudders, and on the horizontal fins there are elevators. These surfaces act as stabilizers; that is, they help to keep the ship steady. The vertical rudders steer the ship to the right or the left; the elevators nose it up or down.

Construction has been begun in the Goodyear dock at Akron on the second of these airships, to be as large as, if not larger than, the *Akron.*

WORLD'S SIX RIGID DIRIGIBLES

(From the Yearbook of the Aëronautical Chamber of Commerce)

NAME OR DESIGNATION	*Los Angeles* (ZRS*–3)	*Akron* (ZRS–4)	*Graf Zeppelin*	*R–100*	*R–101* (Destroyed 1930)
Nationality	American	American	German	British	British
Nominal gas vol., ft.	2,470,000	6,500,000	3,708,000	5,000,000	5,000,000
Length over-all, ft.	658.3	785	776.2	709	724
Max. diameter, ft.	90.7	132.9	100.1	133	131.8
Height over-all, ft.	104.4	146.5	110.6	141	139
Kind of gas	Helium	Helium	Hydrogen and fuel gas	Hydrogen	Hydrogen
Gross lift, lbs.	153,000	403,000	262,000	343,000	340,000
No. of engines	5	8	5	6	5
Total horsepower	2,000	4,480	2,550	3,600	3,250
Kind of fuel	Gasoline	Gasoline	Fuel gas and gasoline	Gasoline	Oil
Max. speed, knots	63.5	72.8	69.0	69.5	65.0

* Zeppelin Rigid Scout

PART III

AIRCRAFT HEAVIER THAN AIR

PERIODS IN THE DEVELOPMENT OF THE AIRPLANE
SOME TYPES OF POWER CRAFT
THE POWER PLANT
INSTRUMENTS
FORCES ACTING ON A PLANE
FEATURES IN DESIGN
THE WEATHER AND ITS EFFECT ON AIR NAVIGATION

CHAPTER VIII

PERIODS IN THE DEVELOPMENT OF THE AIRPLANE

Some one has aptly divided the development of aircraft and air transportation in this country into four periods — the Pre-War period, the War period, the Pre-Lindbergh period, and the Post-Lindbergh period.

The Pre-War Period and the 'Barnstormers' *

It is difficult for any one today to believe that in the first decade of this century there was little if any news of aviation to be found in the daily newspapers and that to most people the idea of being propelled through the air was ridiculous and foolhardy. But even though no newspaper men were present to witness and report it, the Wright brothers did prove in 1903 that flying was possible, for their man-carrying, motor-powered machine rose from the ground and remained in the air for twelve seconds. Their subsequent flights in America and other

* The term 'barnstormer' was originally applied to a member of any small wandering troupe of actors who played in barns in the country districts where there was no available theater or hall.

successful attempts abroad, especially those of Santos Dumont in France, aroused public interest and the history of modern aviation may be said to date its beginning from that time.

When the United States government purchased a Wright airplane in 1908, the first airplane to be bought by any government, there was awakened the idea of flight for commercial purposes. But its development was handicapped by the lack of money available for research in design and for construction. Financing was done by companies whose sources of income were prizes or the sales of their products to rich sportsmen or exhibitors. Aircraft competitions both here and abroad and the exhibition of aircraft throughout the country aroused interest in flying, but afforded meager opportunity for the development of aëronautics as a science.

While the Army and Navy were carrying on experiments and inventors were busy taking out important patents, the interest of the public in aviation was kept alive by individuals who singly or in groups traveled about the country on 'barnstorming' tours.

It is said that in 1916 Frank M. Hawks, one of our most brilliant airmen, got his first airplane ride by false pretense. He pretended to be a newspaper reporter and promised a barnstormer, a Mr. Christopherson, in Long Beach, California, that he would give him a good 'write-up' for a 'ride up.' He got the ride, but he was not a reporter and could not keep his end of the bargain. It bothered him so much that he returned to his newly made friend, told him the truth, confessed that he did not have the fifteen dollars, the price of the ride, but offered to 'work it out.' Mr. Christopherson consented to this, and the young man set to work. He not only paid for his first ride but earned many more trips in the sky and learned many things which were of value to him in his student days at Brooks Field and in his own barnstorming days after the War, before he won national fame by flying across the continent in a little over twelve hours.

Exhibitors were so frequently employed to attract visitors to county and state fairs that by 1914 no such exposition was considered up-to-date unless on its program there appeared a notice of some more or less spectacular demonstration in flying. Most of those who saw had no ambition to learn about aviation. They were there to be entertained, and got their money's worth in witnessing daring feats, even though these feats might cost the life of some youth who went aloft in an airplane which would never be approved by the Department of Commerce today and whose only test of airworthiness lay in the fact that it could be flown this time if not the next one.

To these barnstormers much credit is due after all, because they did make a valuable contribution to aviation in acquainting the people of the times with the performance of the airplane and in stirring their imaginations as to its possibilities.

The War Period

Then came the World War. Few governments had given much thought to the possibilities of aircraft as weapons of war, as aids to the movement of armies in observation, in photography, in fighting, and in bombing.

With the rapid adoption of trench warfare, the cavalry of the armies, so useful in previous wars, became ineffectual as a means of obtaining information, so that the airplane became literally the 'eyes of the Army.'

The planes in use at first were of the same type that the Wright brothers had flown a decade before. They were of open, flimsy construction with small power plants. But their importance was speedily recognized. Improvement was necessary to enable them to carry observers, bombs, or other equipment for warfare. A new era opened; designers who had been previously handicapped by the lack of funds were now given every facility and financial aid necessary to produce practical aircraft.

With the coöperation of the automobile industry, which was in position to manufacture motors suitable for airplanes, it is small wonder that the airplane went through a development so rapid that at the end of the war, airplanes were being produced so far improved in design and construction as to compare quite favorably with those of even a decade later.

The motors that proved most reliable and that became favorites during the war were the French rotary types, the Gnome and Le Rhone; the German Mercedes; and the American Liberty.

During this short period of hasty experiment and rapid development, when so many of the fundamentals of aëro-dynamics had to be discovered and conquered, it is no wonder that many mistakes were made which cost the lives of thousands of brave young men. Many of them, fine types of young manhood from the college campuses throughout the land, were eager and willing to try their hands at flying. Some took to the art as the proverbial duck takes to water. Sometimes with only an hour's instruction from a pilot who himself had perhaps less than fifty hours in the air, they were able to solo. Training days were hectic days and the death rate both in America and abroad was heavy. But when countries are at war, heroic measures become necessary. What a challenge to the adventurous spirit of youth enlistment in the aviation corps afforded! The pluck and daring of these knights of the air, were they friends or foes, merited admiration as they courted death in their conflict for the supremacy of the sky.

A famous German pilot who struck terror to the hearts of all Paris was Lieutenant Max Immelmann, who appeared regularly every afternoon at five o'clock to drop bombs over that city. The familiar sound of his whirring motor sent people scurrying to their cellars, but when the explosion of the bombs announced the end of his day's work, they would hurry forth in time to gaze skyward at their intrepid enemy, who seemed to escape in some miraculous fashion the thousands of bullets sent toward him from the guns below. It was he who invented the 'Immelmann turn,' which he used many times to escape the Allied planes, only to lose his life later in the war.

But Germany, whose superiority in the air had to be acknowledged in the earlier days, soon began to realize that America, England, France, and Italy had equal engineering ability and that the sons of these Allied countries were no less skillful and no less brave than her own.

Even before America entered the war, many of her airmen had already joined the French service. A number of them organized the *Escadrille Americaine,* the American air squadron, which eventually stood third in all France in number of victories over the enemy. Those pilots who had brought down five of their opponents in these air duels were known as 'aces.'

The American ace of aces, who had twenty-five confirmed victories to his credit, was a young automobile racer from Columbus, Ohio, Captain Edward U. Rickenbacker. His experience on automobile speedways had accustomed him to danger and had trained his mind to quick decision in moments of peril, both characteristics being indispensable to an army flier. He showed more than average ability in 'sizing up' a situation and in foreseeing the intentions of an opponent. He studied the tactics of successful maneuvers and held it advisable to avoid, if possible, any unnecessary risk. A stubborn tenacity, coupled with good judgment and possibly sprinkled with an element of good luck, carried him through encounter after encounter with the enemy planes and brought him at last through the war for future service to his country.

The Pre-Lindbergh Period

After the war most of the American pilots left the military service and became 'Q.B.'s,' 'quiet birds.' Not a few of them, however — and their number was increased by youngsters who had been thrilled by the exploits of war-time maneuvers and who had learned in one way or another to fly — took up aviation as a means of earning a livelihood.

Our government found itself in possession of a large amount of aviation equipment of no further value to it. This equipment was auctioned off at but a fraction of its cost. These war-time planes and engines enabled many hundreds of civilians and ex-service pilots to establish themselves permanently in towns throughout the country, where they took up passengers for short rides, gave instruction in flying, did aërial photography, took passengers on emergency cross-country flights, or went on barnstorming tours, thus contributing much toward developing the commercial air service peculiar to the United States.

It was in one of these war-time training ships, the *JN–4*, affectionately called the 'Jenny,' that Colonel Lindbergh took his first solo flight and made his barnstorming trips before being enrolled as a flying cadet at Brooks Field.

By the end of 1926 the surplus of war aircraft became exhausted, and new types of equipment with improved design and higher-powered engines were developed.

Air meets and air races took on a different aspect. Spectators became more interested in aviation from a commercial standpoint. The prevention of accidents became a common topic of conversation.

After the war, the use of the parachute gave confidence to fliers and enabled them to conduct experiments with new types of aircraft without risk of life in case the airplane failed to make a safe descent.

Although the government has not given money directly to aid the aviation industry, it has indirectly stimulated its progress by fostering races and competitions, by purchasing equipment for experimental purposes, by steadily increasing the number of airmail routes, and by spending money in establishing and maintaining weather stations, radio stations, lights, and other means for safety in air travel over many thousands of miles of airways.

The Post-Lindbergh Period

The great event that awakened renewed interest in aviation, that stirred the imagination of people everywhere, that quickened the pulse of the airplane industry, took place when a young air-mail pilot came out of the West and spanned the Atlantic alone in his single-motored monoplane. Charles A. Lindbergh was the ambassador of progress. His intense interest in his chosen profession and the high faith he had in its future gave him courage to prove to the world its possibilities. His extraordinary achievement, coupled with the program for active, but sane, progress which he has consistently advocated since his transatlantic and other epochal flights, has been an outstanding factor in the fourth period of development in which we now find American aëronautics.

The growth of aviation in America since Lindbergh's flight has been spectacular, until today America leads the world in air transport over airways well equipped for day and night service.

CHAPTER IX

SOME TYPES OF POWER CRAFT

With the invention of mechanical motor power and especially with the development of the internal-combustion engine, came many attempts to apply these forces to sustain machines heavier than air and to give them motion through the air.

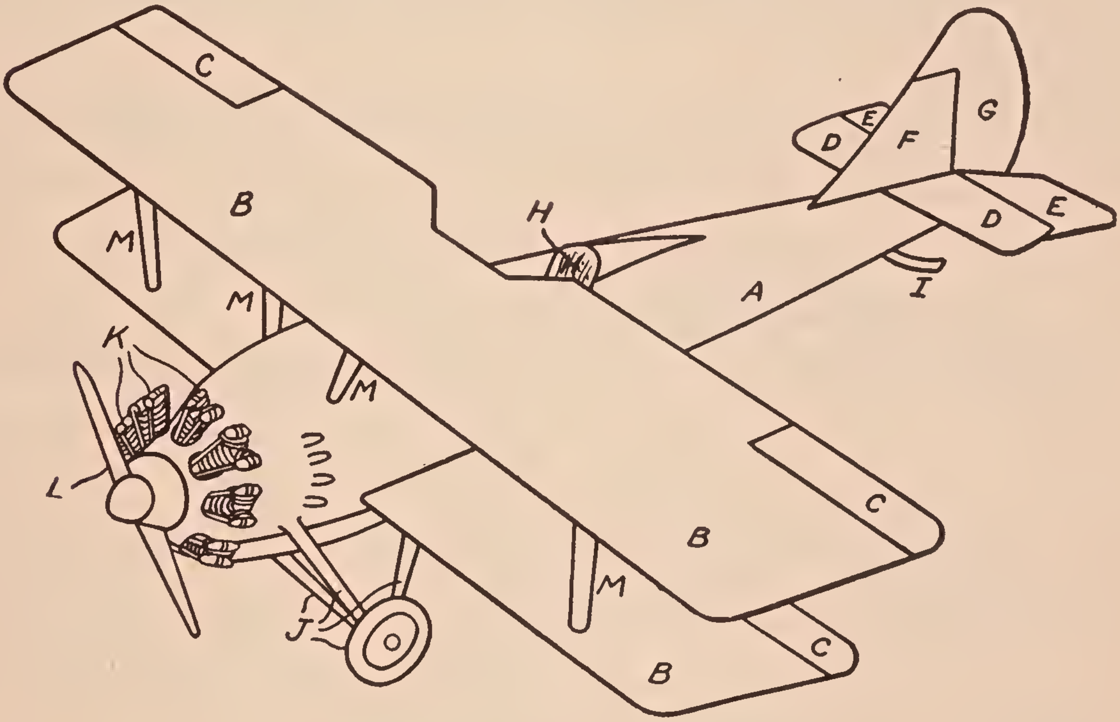
The various types of machine that have been developed, like the ornithopter, the helicopter, the autogiro, the amphibian, and so forth, can best be understood if we first get familiar with the different parts of the modern flying machine, know their names and what they are designed to do.

The Essential Parts and Their Purposes

An airplane may be divided into the following parts: (1) the wings, or airfoils, (2) the fuselage, (3) the empennage, (4) the landing gear, and (5) the control system. By examining the accompanying drawing you will be able to understand clearly the descriptions of these parts that follow.

The *fuselage* is the body of the plane. It contains the necessary space for the pilot and passengers, the instruments for navigating, the fuel tanks, and the extra baggage or accessories. The part of the plane which houses the power plant, or motor, is sometimes called the *nacelle.*

On the rear part of the fuselage are attached those



THE PARTS OF THE AIRPLANE

A—Fuselage
B—Wings, or Airfoils
C—Ailerons
D—Horizontal Stabilizers, or Fins
E—Elevators, or Flippers
F—Vertical Stabilizers, or Fins
G—Rudder
H—Cockpit
I—Tailskid
J—Front Landing Gear
K—Power Plant
L—Propeller, or 'Prop'
M—Struts

horizontal surfaces called the *horizontal stabilizers,* or *fins,* and those vertical surfaces called *vertical stabilizers,* or *vertical fins.* To the horizontal stabilizers are attached the movable *elevators,* or *flippers,* and to the vertical fin is attached the movable *rudder.* This entire group of stabilizing surfaces is known as the *empennage.*

There is also attached on the bottom of the fuselage near the tail that part of the landing gear called the *tail skid.*

The main parts which give shape and strength to the fuselage are (1) the longerons, (2) the vertical compression members, (3) the diagonal bracing struts, and (4) the bracing wires.

The *longerons* run horizontally from front to back. The *vertical members* give height to the fuselage. The *diagonal struts* act as braces, as also do the *bracing wires.* The floor of the fuselage is made of plywood.

Attached to the under part of the fuselage is the *landing gear* in the form of wheels fitted with rubber tires for landing on land, or skis for landing on snow. On amphibians, *pontoons* like small boats are added to the landing gear for landing on water. To lessen the strain on the plane in landing, shock absorbers are installed.

To the upper part of the fuselage are attached the *airfoils,* or *wings,* by special metal fittings, struts, and wires. The wings are the most interesting of all the parts. It is through their design and construction that speed and lifting power are given to the plane. Just back of the front edge, or *leading edge,* of the airfoil there is generally a main spar. From this main spar to the rear edge, or *trailing edge,* of the wing are attached ribs. To hold the ribs firm, there is another spar about two-thirds of the distance back.

There are two kinds of ribs: the *skeleton rib* and the *compression rib.* The skeleton rib has portions of it cut away to give lightness. The compression rib is heavier and gives the necessary strength. Between the compression ribs wires are strung to give additional strength and to hold the wing firm in landing and taking off, as well as in flight. The shape of the ribs determines the shape of the airfoil. The wing may be 'thin' or 'fat.' This curved shape is spoken of as *camber;* thus we may say one wing has more camber than another. On the back, or *trailing*

Cross Section of a Cambered Wing

edge, of the airfoil are movable parts called *ailerons.* The horizontal and the vertical stabilizers are similar in construction to the airfoils, or wings.

A set of strong steel cable wires runs from the ailerons and the elevators to the stick in the pilot's cockpit which he moves with his hand. Another set of wires runs from the rudder to the rudder bar in the cockpit which he moves with his feet.

Over the skeleton of the whole airplane is stretched closely woven linen or cotton cloth. This fabric is made air-tight and water-tight by the application of four or five coats of a chemical preparation known as 'dope.' The dope also gives tautness and strength to the fabric.

To hold the fabric in place and to keep it from tearing, light strips of cane, wood, or fabric tape are placed along the edge, through which tacks are driven. The dope, which penetrates the cloth, also sticks it to the parts. Sometimes the fabric is stitched with flax cord over both the upper and lower wing ribs.

Some planes are now made entirely of metal. The tri-motored Ford monoplane is an example. One advantage of using metal lies in the possibility of testing its strength. After a given kind of metal has been tested, the designer can figure the strength of his entire structure. This is not true of wood. The fact that one piece stands up under a certain test is no guarantee that another piece will do so. Although metal covering for planes is heavier than fabric covering, its strength and durability make its use seem logical.

Types of Powered Aircraft

The preceding description of the various parts of the airplane was illustrated by showing how they were assembled in the type with which every one is familiar. But not all planes are of this type.

There have been developed many interesting variations of a type of aircraft called the *ornithopter.* In this type an attempt has been made to install flapping wings in imitation of the wings of birds. But, though man has profited greatly from his study of the principles upon which the flight of birds depends, so far the application of these principles has never proved successful.

Another type, called the *helicopter,* has wing surfaces

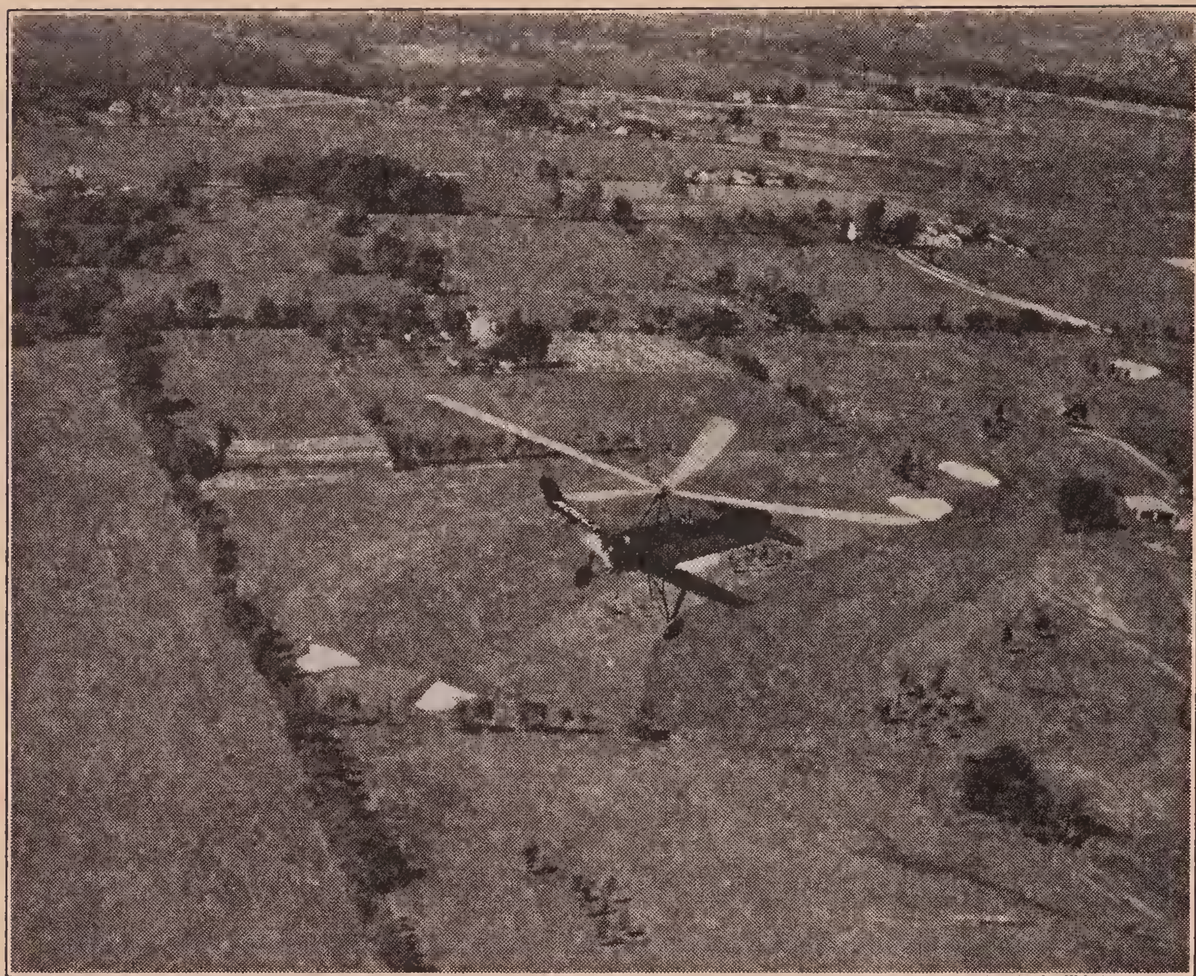
THE CURTISS HELICOPTER

Note the difference between the wings of the helicopter and those of other types of airplane.

which are revolved by power in such a way as to lift the plane and at the same time to give it forward motion.

It is interesting to know that three official Federation Aëronautique Internationale records were established in 1931 by Marinello Nelli, an Italian flyer, with his Ascanio helicopter: duration with return to starting point, 8 minutes, 45 seconds; distance in a straight line, 3539 feet; altitude above point of take-off, 59 feet.

Another, and a decidedly interesting, type is the *autogiro,* as it is called by Juan de la Cierva, a Spanish inventor, whose study and development of this type of machine began in 1920. The first successful autogiro flight was at Getofe Airdrome, Madrid, Spain, in 1923. It was in the



Aëro Service Corporation

AN AUTOGIRO

fall of 1928 that Mr. Harold F. Pitcairn, whose active interest in aviation dates back to 1914, brought an autogiro to America. Later that year, on December 19, it was flown at Pitcairn Field, Willow Grove, Pennsylvania, the first one of its kind to be flown in this country. This plane is now among other historic aircraft in the Smithsonian Institution at Washington.

It is the rotor system of hinged blades that gives the autogiro its name. These blades furnish approximately 80 per cent of the lift at a high forward speed of more than 100 miles per hour, and 100 per cent of the lift in its slow, almost vertical descent, a descent slower than that of a parachute.

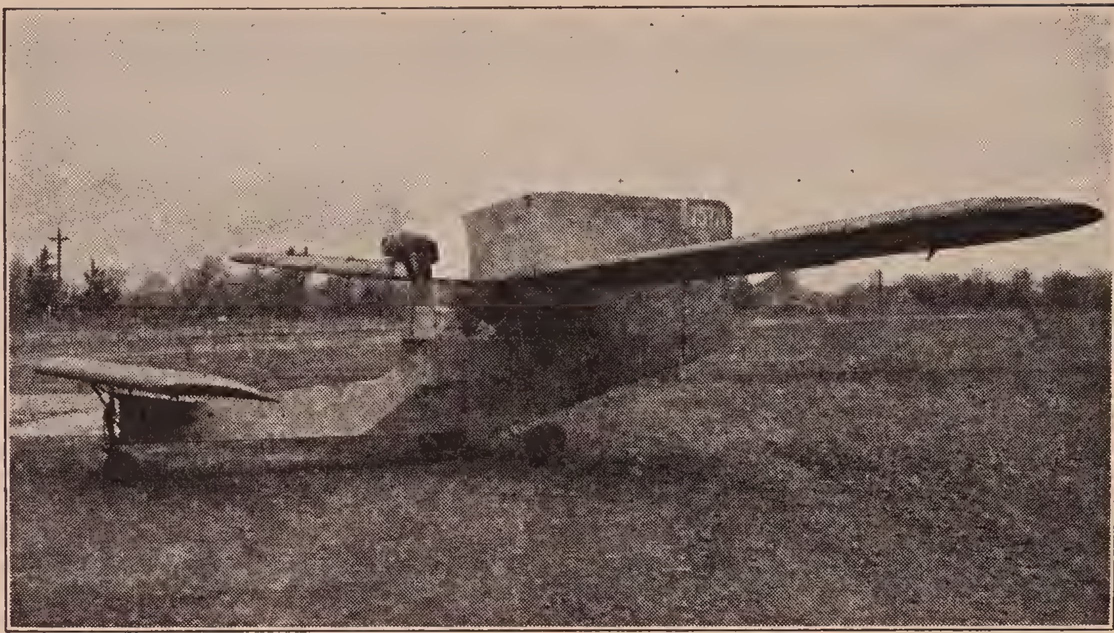
In the most common type this rotor system consists of four hinged blades which are mounted on a hub set on a pylon structure on the top of the fuselage. These surfaces are free to move at a speed independent of the machine as a whole. Their specially constructed attachment to the rotor hub by means of articulating joints is the secret of this machine's ability to keep stable and steady in taking off and in landing in very small areas.

The two small wings with upturned wing tips serve to carry the ailerons and to provide a mounting for the rather wide undercarriage. A motor-driven propeller gives forward motion, as in other planes.

When Thomas A. Edison saw one of these machines take off after a run of fifty feet, zoom directly from the ground, and then land with hardly a turn of the landing wheels, he exclaimed, "That's the answer!" and he added that he believed that the autogiro represented a great advance in aviation.

At Pitcairn Field, Willow Grove, Pennsylvania, on December 18, 1930, Miss Amelia Earhart took one of these planes aloft, the first woman ever to fly solo in an autogiro. In April, 1931, she established in one an altitude record of 18,415 feet. In June she used one on a 'friendly' flight across the continent. It was the second 'wind-mill plane,' as it is sometimes called, to be seen west of the Mississippi River.

On April 22, 1931, President Hoover presented Mr. Pit-



Springfield Union

THE GRANVILLE ASCENDOR

This craft is a modification of the German 'duck.' It seems to fly backward, because the elevator, which is at the rear end of planes of the standard type, is here attached to the front end of a shoe-like fuselage.

cairn with the Collier Trophy. This trophy, donated by the late Robert J. Collier and awarded the first year to Glenn H. Curtiss in 1911, goes each year to the person or persons deemed to have accomplished "the greatest achievement in aviation in America, the value of which has been demonstrated by actual flying during the preceding year."

The *Ascendor,* as is shown clearly in the photograph, is another type of airplane that looks very different from the ordinary type. The empennage, or tail structure, lies in front of, instead of behind, the wings and the main body of the plane. The effect is curious, because the machine seems to be flying backward. The machine shown in the picture was designed by Z. D. Granville and first flown at Springfield, Massachusetts, in November, 1931. It is a modification of a German type of plane called the *Ente,* or "duck." The idea in this design is to give greater visibility, greater stability, and freedom from the danger of stalling and tail spins. This Ascendor is only 16 feet long, has a wing span of 38 feet, weighs about 700 pounds, and is driven by a 28-horsepower engine.

The *airplane* is the name given to the heavier-than-air machines with which we are most familiar. A plane that is built to take off and land on water is called a *seaplane,* a *flying boat,* or a *hydroplane.* When wheels are added which may be lowered so that it may also make a landing on the ground, it is called an *amphibian.*

Then again, airplanes are designated according to the number of wings. A *monoplane* has only one wing, a *biplane* has two, and the name *multiplane* indicates that there are more than two wings. The wings may be attached above the body, or fuselage, of the plane, or they may be attached below it.

CHAPTER X

THE POWER PLANT

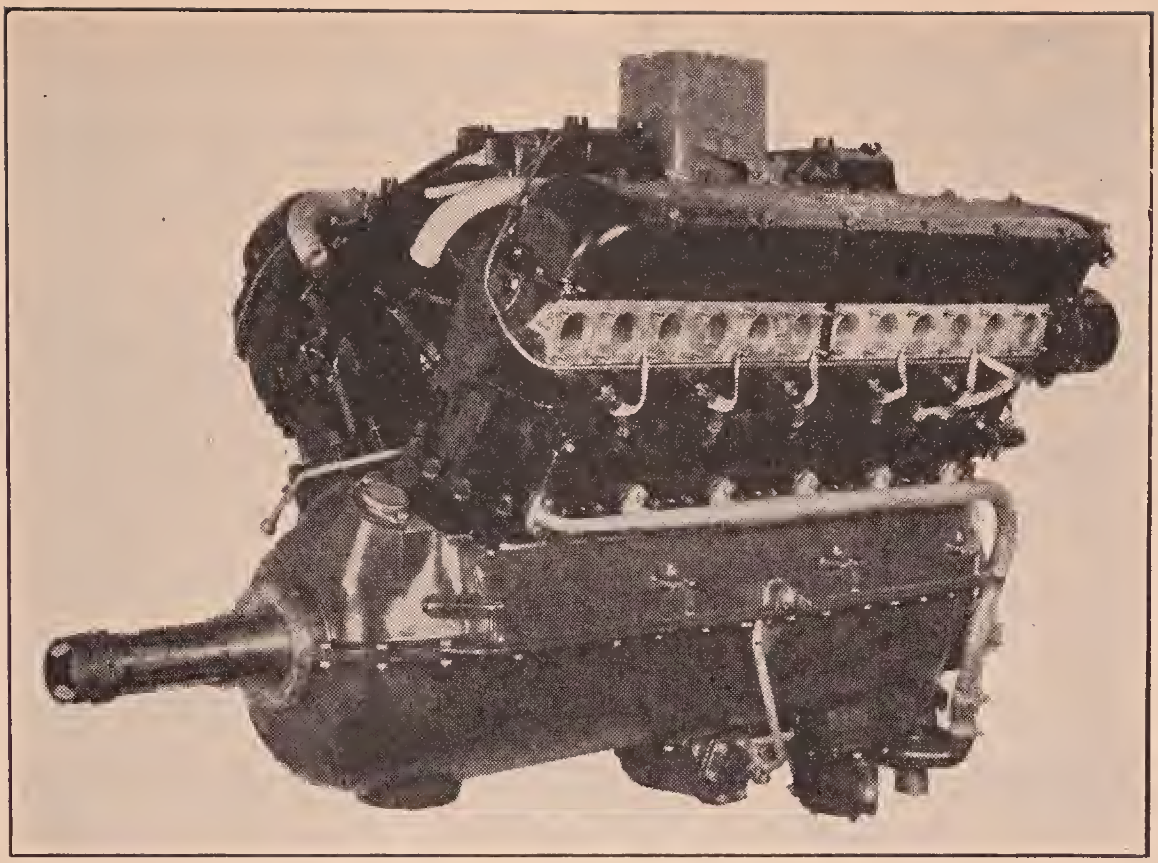
The most vital part of an aircraft is its motor plant, or engine.

Types of Aircraft Engines

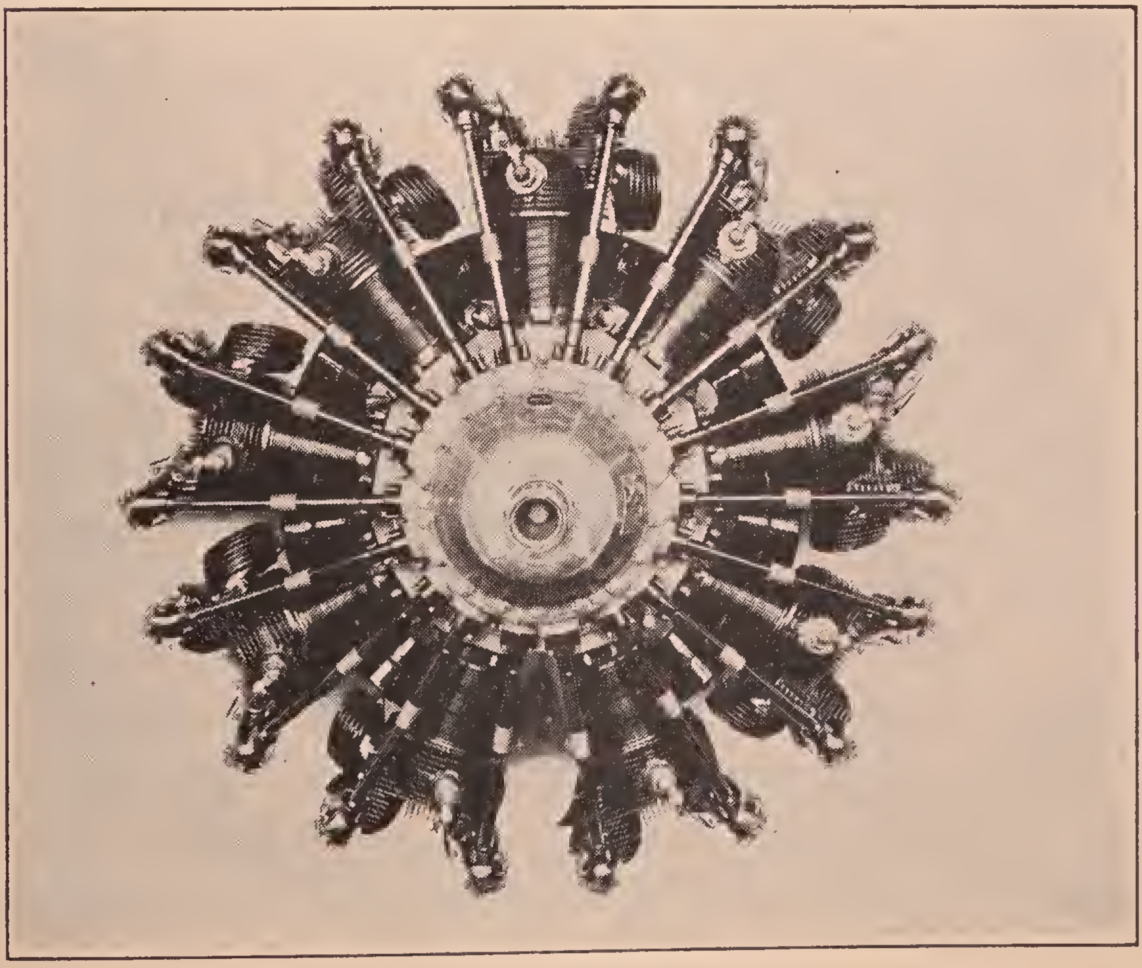
In general, the aircraft power plant is similar to the automobile power plant, but there are certain types of engines that have been developed for aircraft that are not ordinarily used for automobiles.

The commonest type of automobile engine is the *vertical*, or *in-line*, engine. The cylinders, whether four, six, or eight in number, all stand vertically in a row. This type of engine is also used in some airplanes, especially in smaller planes requiring smaller amounts of power to drive.

A second type of engine has several cylinders in a row, like the in-line engine, but there are two or more rows of them. These engines are usually named from some letter of the alphabet that describes the arrangement of the rows of cylinders, as for example, the *V-type*, the *inverted V-type*, the *X-type*, or the *W-type*. The V-type engine is frequently found in automobiles, like the Cadillac V-type 8. The picture of the Curtis Conqueror shows an airplane engine



In-Line V-Type 600-Horsepower Airplane Engine
(Curtiss Conqueror)



Air-Cooled, 9-Cylinder, 575-Horsepower Radial Engine
(Wright Cyclone)

of the V-type, having a set of six cylinders in each leg of the V. The inverted-V and other types just mentioned have been developed for use in aircraft.

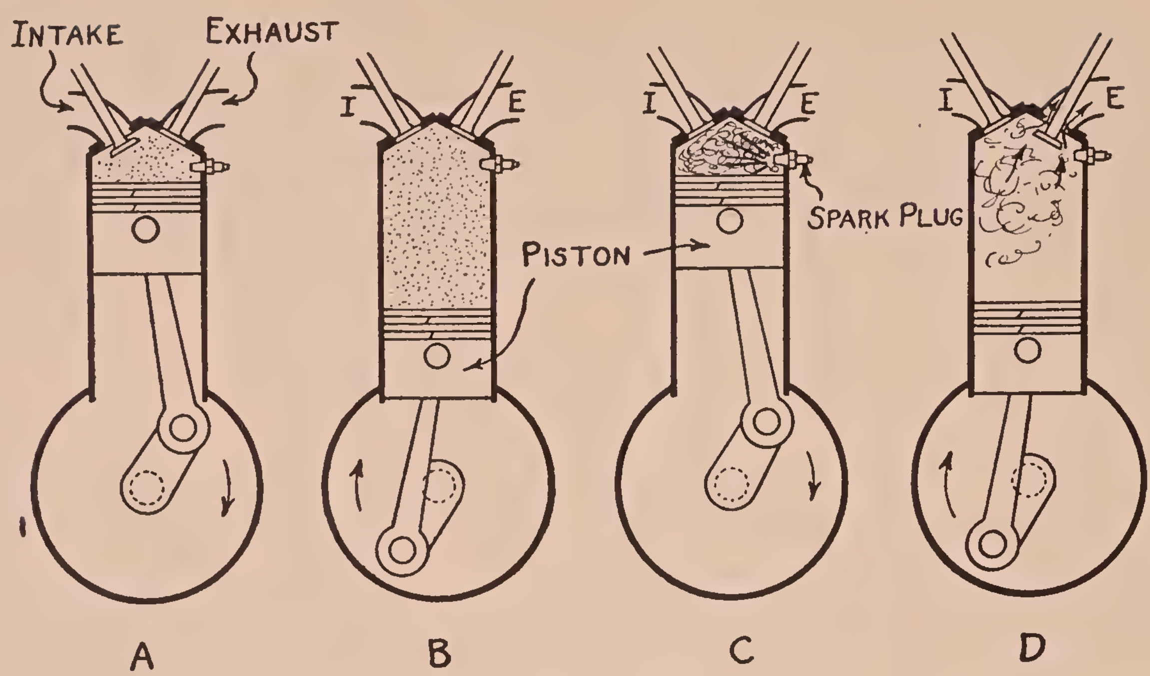
In aircraft power plants, especially in engines of high horsepower, there is often seen another arrangement of the cylinders. They are set around the propeller shaft like the spokes of a wheel around its hub. This is the *radial type* of engine. Sometimes the whole set of cylinders is attached to the propeller and spins about with it, as in the Gnome engine. This kind of engine, called a *rotary engine,* was frequently used in French planes during the World War, but is seldom seen in America. More commonly, in this country, the radial engine is made with the cylinders stationary, standing around the revolving shaft on which the propeller is fastened. A good idea of this type of engine is given by the picture of the 9-cylinder, 575-horsepower Wright Cyclone engine.

If you compare this tremendously powerful engine with any ordinary automobile engine of perhaps 16 to 35 horsepower, you will understand that the aircraft engine must be much larger to give so much more power. At the same time, since weight must be cut down as much as possible in any aircraft, it must be much lighter in terms of pounds of weight per horsepower developed. For these reasons, modern aircraft motors are truly wonderfully developed engines, and are now being built to display extraordinary endurance. If you will remember that an airplane engine is running all the time at almost full load (like an automobile climbing fast up a heavy grade with open throttle), you will understand how remarkable are the endurance airplane records in which, with refueling and minor adjustments during the flight, an engine has driven the plane continuously for over six hundred hours.

How the Engine Works

Whether the aircraft engine is an in-line engine, or a V-type, or a radial type, it must be built by making a series of cylinders with a moving piston closely fitting within each cylinder. The to-and-fro motions of the piston must turn the crankshaft to which the propeller is fastened. Now, what makes the piston move back and forth? Above the piston there is a valve, called the *intake valve,* which lets in the fuel mixture composed of about fifteen parts of air to one part of gasoline. As the piston moves down on the *intake stroke,* as it is called, there is a space left without air. The fuel mixture pushes in to fill up this space. The intake valve is arranged so that it closes as the piston starts upward. You can see what happens. The mixture is squeezed and pressed into a small space. This is called the *compression stroke* of the piston. Now something happens, and it happens with great force. A pulse of electricity comes in through the spark plug. It makes a flash of fire as it jumps across from one wire end to another wire end at the bottom of the plug, where it projects within the cylinder in the compressed fuel mixture.

This little flash of light is like a match and it sets the fuel on fire. The fuel was very hot from being compressed,



A. Intake Stroke:
Piston moving downward; intake valve open; fuel mixture entering.

B. Compression Stroke:
Piston moving upward; both valves closed; mixture being compressed.

C. Power Stroke:
Piston moving downward; both valves closed; mixture ignited by spark from spark plug.

D. Exhaust Stroke:
Piston moving upward; exhaust valve open; waste products escaping.

and now, when afire, it is still hotter. You may know that things expand with heat. The molecules in the fuel must have more room to move; so with great pressure the piston is forced downward on the *power stroke,* as it is called.

When combustion, or burning, takes place, waste products are formed. Now another valve, called the *exhaust valve,* opens, letting out the waste products as the piston comes again to the top on the *exhaust stroke.* The exhaust valve closes as the piston moves downward. In comes the fuel again, and the process is repeated. The same thing happens in every other cylinder at just the right time. Thus the crankshaft is turned rapidly and steadily so long as the fuel mixture comes into the cylinder and the electric current enters the spark plug at just the right moment. This process is called a *four-stroke cycle.* In one such cycle the crankshaft is revolved twice.

The Fuel System

The little chamber to which fuel flows from the storage tanks is called the *carburetor.* Here the fuel supply is regulated and mixed with air. From the carburetor the mixture goes through the *intake manifold,* as it is called, to the cylinder. For flying in high altitudes where the air is less dense, devices have been added to the carburetor to supply more air, and hence more oxygen, to the fuel mixture. The throttle regulates the amount of the mixture fed to the cylinders.

The Ignition System

The ignition system manufactures the electric current which flows to the distributor, which in turn distributes it to the spark plug of each cylinder. The fuel system and the ignition system are so important that most airplane engines now have two sets of each. If something should prevent one set from working, the cylinders would not be deprived of their fuel or their electric spark.

In the Diesel type of motor there is no ignition system.

The cylinders are built of superior metals which will stand great pressure and heat. Air is admitted through an intake valve to the cylinder. It is compressed so compactly on the compression stroke that it becomes extremely hot. At this moment fuel oil is forced in and combustion occurs instantly, sending the piston down on the power stroke.

The Oiling and Cooling Systems

Other very important parts of the engine are the oiling, or lubrication, and the cooling systems. The machinery in an engine working so fast needs a constant supply of oil to keep the parts from sticking together or wearing out from heat, expansion, and friction.

There are two kinds of cooling systems. In one, liquid is circulated about the cylinders. Water is the most common fluid used. Most automobile engines are water-cooled. In the air-cooled motors there are fin-like projections extending from the sides of the cylinders. The heat is dissipated, or taken up by the air, as it rushes by them. In the radial type of engine all cylinders are equally exposed to the air; therefore this type is an example of a successfully air-cooled motor. The air-cooled motor has the advantage over the water-cooled motor that there is no danger of its freezing in higher altitudes. There are no water-supply lines to get out of order, and the weight is lessened, which is always an important factor.

Recently important improvements have been made by the perfecting of liquids far superior to water in cooling capacity and in resistance to freezing and boiling.

The Number of Cylinders

There is always some vibration in a motor as its cylinders fire, or when combustion takes place, sending the pistons downward on the power stroke. The greater the number of cylinders, the shorter interval of time there is between the power strokes; and the less the vibration is felt, the more smoothly and quietly the engine runs. You have noticed the difference, yourself, between a four-cylinder and a six- or eight-cylinder engine in an automobile.

Then, too, the greater the number of cylinders, the greater the power developed and the more work an engine can do. The amount of work the whole engine can do is measured in terms of horsepower. Horsepower is the amount of work necessary to lift 33,000 pounds one foot high in one minute, or 550 pounds one foot high in one second. Now you can see why engines are spoken of as being such-and-such horsepower. Of course, you can also see that the more horsepower an engine develops, the heavier it must necessarily be. The great problem in making airplane engines is to get a reliable engine with the least possible weight and the greatest possible horsepower.

On large commercial planes two or more engines, each capable of developing many hundred horsepower, are used.

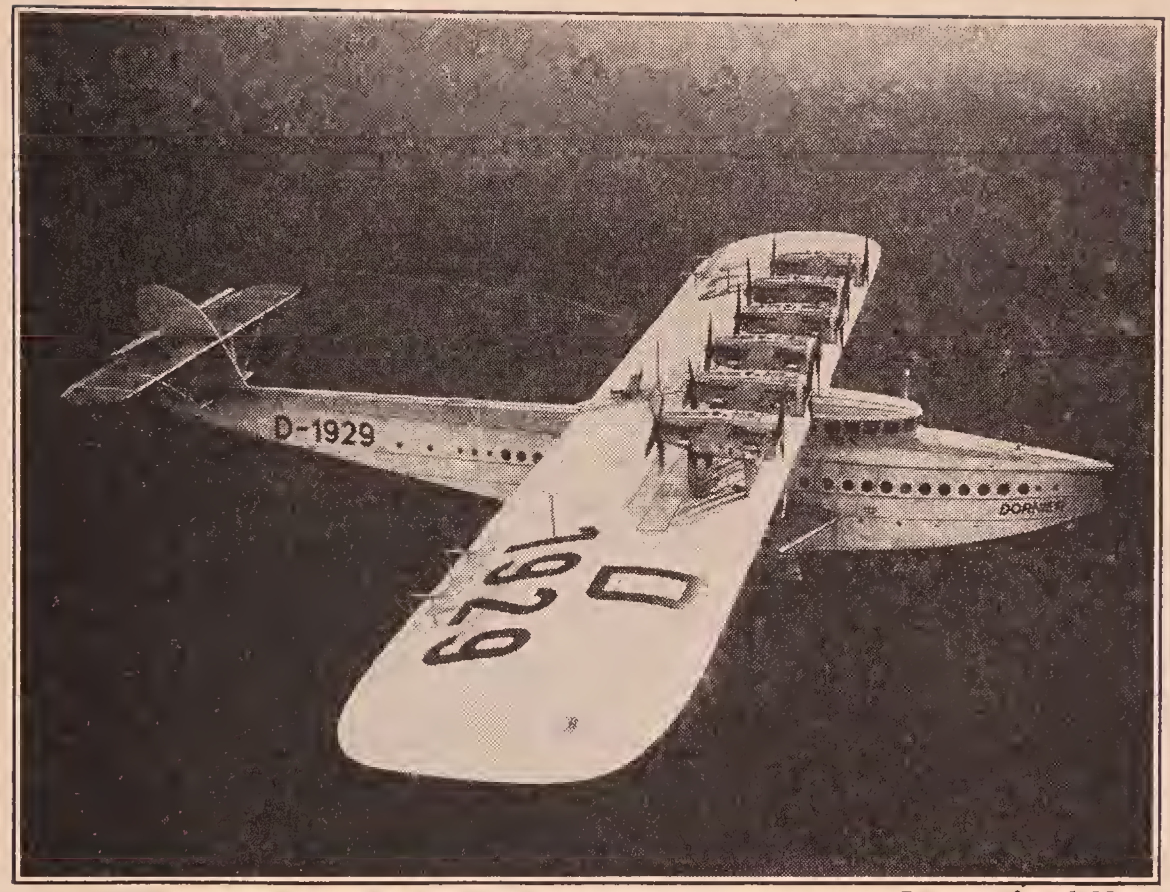
Testing the Motor

Before any type of motor is approved for airplanes, it is placed on a stationary block, where for hours at a time it is allowed to run at different speeds and its performance closely watched and recorded. Then it is taken apart and each separate piece is examined closely for any possible irregularity in the composition of the metal.

The Work of the Propeller

The propeller by its rapid turning either draws the plane through the air, as in the tractor type, or pushes the plane through the air, as in the pusher type. In the tractor type the propeller by the set of its blades has the same effect in the air that a screw has in a piece of wood; it pulls, or draws, through the air much as the threads on a screw pull the screw into the wood. But air is a light, gaseous form of matter, so that in order to be effective the propeller must cut into the air at a very great speed, turning many times per minute. The path the blades travel through the air in one revolution will be in the form of a spiral, or *helix,* as it is called. But since the air is so thin, a good deal of it slips by, lessening the distance that the propeller would actually travel were the air much thicker. This loss of air is called the *slip-stream.*

The peculiar twist which is noticed in the blades of the propeller makes it difficult to construct. A propeller must be very strong to withstand all the forces acting on it as it travels at such speed through the air. Propellers



International News

THE *DO–X* OVER THE RHINE COUNTRY, GERMANY

at first were fashioned out of a solid piece of wood. Later a number of layers of wood, called *laminations,* were glued together and then the propeller was made from this laminated piece. Now most propellers are made from light metal which is tested and forged into shape. The designing of propellers to fit them for the most effective service in different altitudes is a problem upon which aëronautical engineers are constantly working.

MULTI-MOTORED PLANES

The *DO–X* is an example of a multi-motored all-metal plane. This enormous plane, with its length of 131 feet and its wing spread of 157 feet, is driven by twelve motors arranged tandem along the top of the wing. These developed enough horsepower so that on one of its first flights 169 passengers were given nearly an hour's air ride over Lake Constance, in Switzerland. The original 525-horsepower motors have since been replaced by an equal number of American water-cooled ones, each developing 650 horsepower. These were the motors which brought this gigantic flying boat on the 12,000-mile flight to America. Motors must be efficient indeed when they can furnish the power necessary to carry a plane weighing (fully loaded) 48 tons through the air at a cruising speed of 120 miles per hour and a maximum speed of 133 miles per hour.

A striking example of a large multi-motored plane built in this country is the *American Clipper* (the Sikorsky *S–40*), a 43-passenger, 17-ton amphibian, 76 feet long, with a wing spread of 114 feet—the largest amphibian airplane in the world. It has four Pratt and Whitney Hornet engines of 575 horsepower each, and its maximum speed is the same as that of the *DO–X*, 133 miles per hour.

It was christened by Mrs. Hoover in November, 1931, and was piloted on its maiden voyage to Miami by Colonel Lindbergh. This plane and another like it are in use over an international air-mail and passenger route between Miami, Florida, and Panama, Canal Zone.

CHAPTER XI

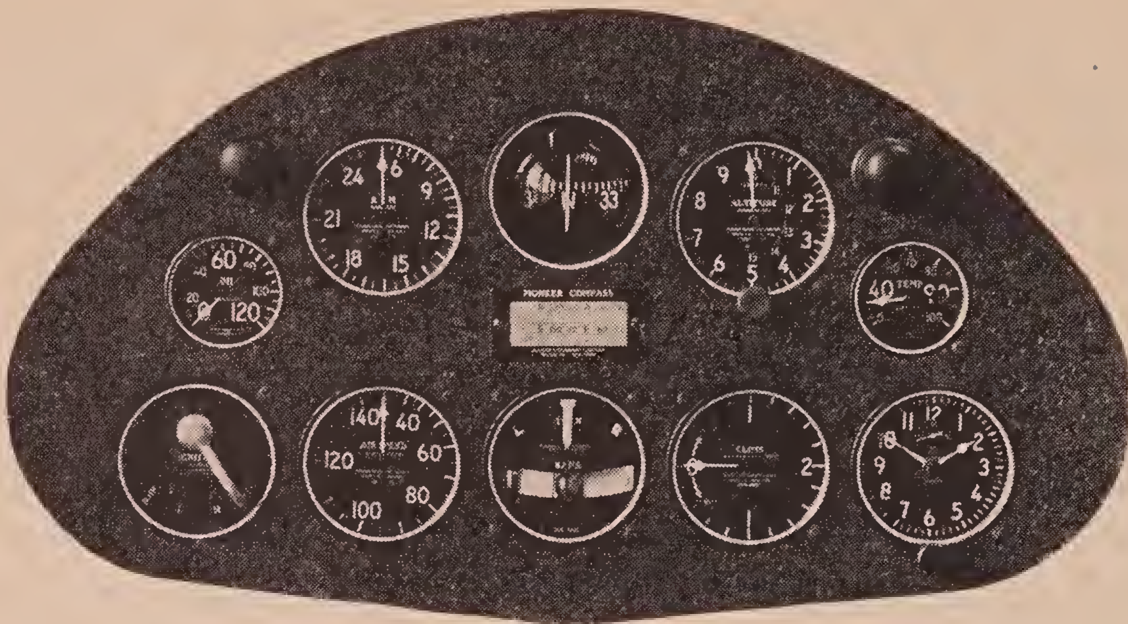
INSTRUMENTS

More and more as the accuracy of instruments has been perfected, pilots have come to rely upon them for safe flying. Indeed all transport companies demand that their pilots be skilled air navigators. These pilots must be able by the use of instruments to steer the aircraft accurately enough to reach their destination and make safe landings under the most adverse weather conditions.

Although aërial navigation is not unlike nautical navigation, the air navigator must be more rapid in calculation than the ocean pilot. All great flights which have culminated successfully have depended upon the flyer's knowledge of aërial navigation and his ability to make rapid calculations.

There are two groups of aircraft instruments mounted on a board in front of the pilot; namely, flying instruments and power-plant instruments.

The following are some of the useful flying instruments. The *air-speed indicators* tell the speed of the plane with respect to the air through which it is passing. Planes have a minimal and maximal air speed. Allowing the speed to drop below this minimum may result in disaster. So,



A TYPICAL INSTRUMENT BOARD

for efficiency, the plane is flown at some speed between the two. The airspeed indicator does not tell the ground speed; that is, how many miles over the ground the plane has covered.

The *altimeter* tells how far above sea level the plane is. It does not tell how high above the ground the plane is, and adjustments have to be made in flying over mountainous country.

The *climb indicator* tells how many feet per minute the airplane is ascending or descending.

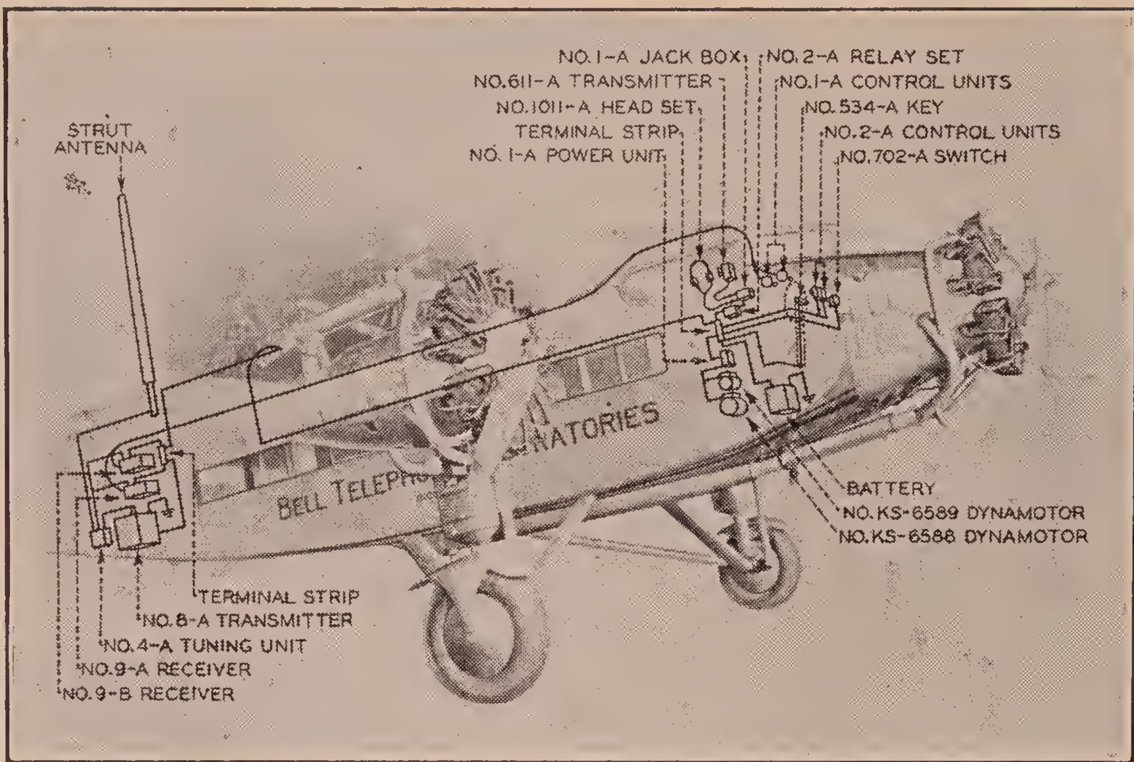
The *bank and turn indicator* helps the pilot to make correct turns in the air and to level off afterward.

The *magnetic compass* shows the direction in which the plane is headed. Sometimes the plane has metals in its structure which attract the compass. This factor must be taken into consideration and adjustments made.

And, of course, a watch is always rated as an important and necessary flying instrument.

Pilot Using 'Silencer' Type Transmitter and Phonette Head Set

Graphic Illustration of Radio-Telephone Plane-to-Ground Communication



Bell Telephone Laboratories

Diagrammatic View of Two-Way Radio-Telephone Equipment as Mounted in Large Cabin Planes

The second group of instruments records the condition of the power plant. Important ones are as follows:

A *tachometer* indicates the revolutions per minute the crankshaft is making. A loss of R.P.M. generally indicates some irregularity in the power plant that needs immediate attention.

Thermometers show the pilot whether the power plant is operating normally or overheating.

Pressure gauges show whether the engine and its parts are getting the proper amount of oil for lubrication and the proper amount of fuel mixture for combustion. *Fuel gauges* inform the pilot as to the amount of fuel on hand.

There are other instruments installed in planes which are used on long trips. Colonel Lindbergh used an *earth-*

inductor compass and a *drift indicator* on his transatlantic flight. Rear-Admiral Byrd used an especially designed instrument called a *sun compass* on his North Pole flight which was slightly revised for his South Pole flight. Wing-Commander Kingsford-Smith used the radio, which in spite of a dense fog insured a safe landing on the coast of Newfoundland after his air flight from Ireland.

The *Question Mark,* flown by Captain Dieudonne Coste and his co-pilot, Maurice Bellonte, on the first non-stop flight from Paris to New York, was fitted out with every conceivable instrument.

There are three methods whereby the navigator can determine his position when he cannot see land.

The first is called 'dead reckoning.' This refers to calculation by means of the air-speed indicator and the compass.

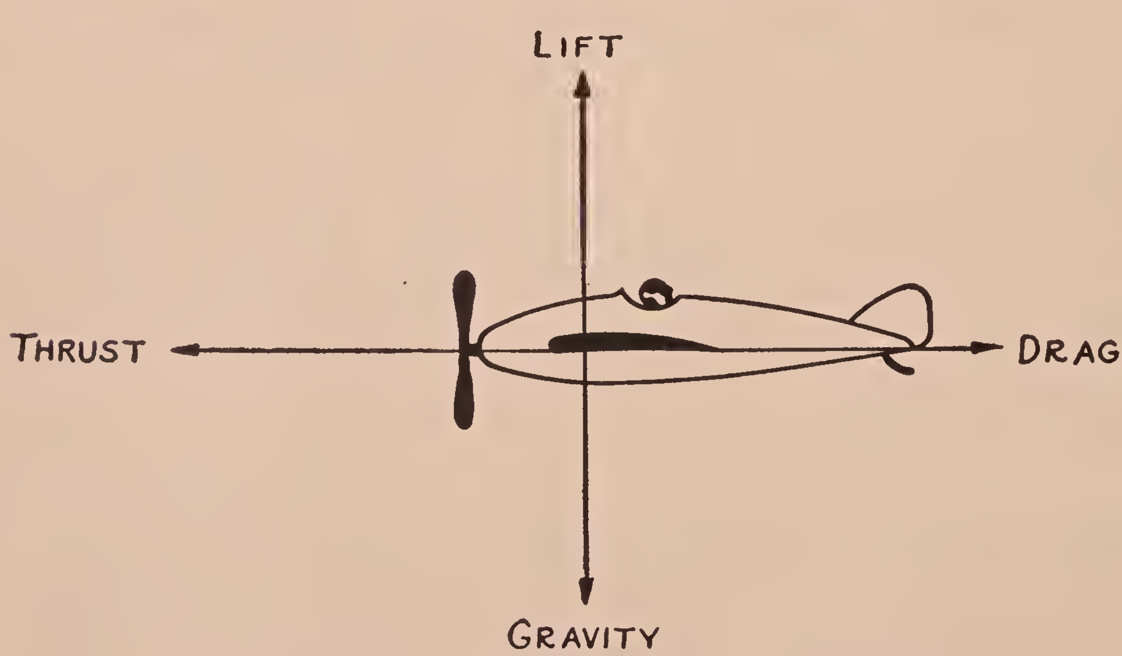
The second, or 'celestial navigation,' is by using the sextant in a series of observations of the sun, moon, and stars. The result may be translated into latitude and longitude by the aid of tables.

The third method is by means of the radio. Radio beams or beacons are particularly useful in fogs and are the only device which can be used under practically any weather conditions. Of course, the plane itself must be equipped with a special type of receiving set.

CHAPTER XII

FORCES ACTING ON A PLANE

There are four forces which act on a plane when it is in the air. First, the force of gravity tends constantly to pull the plane earthward. Second, overcoming this force is the 'lift,' which is given to the plane through the design and arrangement of the wing surfaces, or airfoils (liter-



THE FORCES ACTING ON A PLANE IN FLIGHT

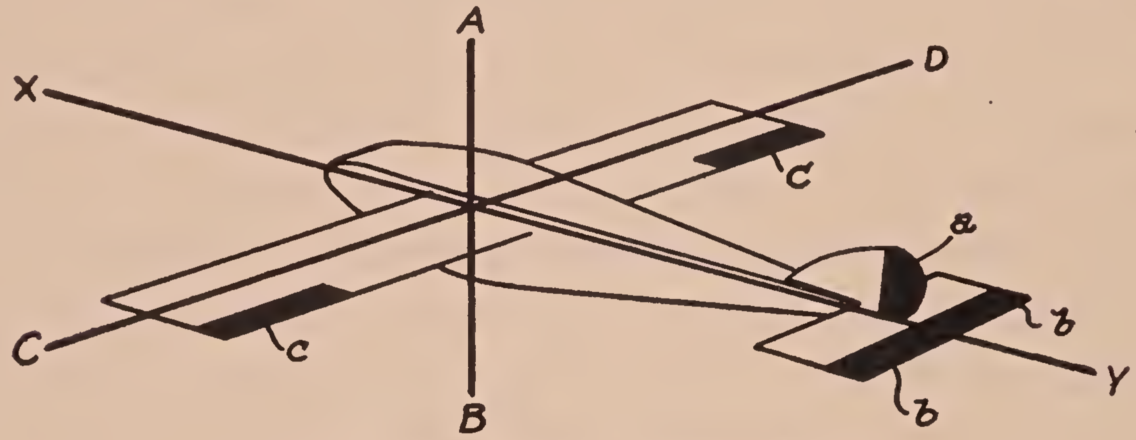
ally, air-leaves). Third, the revolving propeller blade pulls or pushes the plane through the air; this force is the 'thrust.' Then, fourth, as the plane is thus pulled through the air, it meets the impact of the air on all its parts, and that causes resistance, or 'drag.' To keep the plane in sustained flight, the lift must be at least equal to the force of gravity, and the thrust must overcome the drag.

In finding out the amount of drag, or resistance, the air opposes to a body moving through it, men have made some accurate and definite observations which are called *laws of air resistance.* Air, as you probably have already learned, has weight, takes up space, and like every other kind of matter is composed of tiny particles called *molecules.* When the molecules are packed close together, the air is heavier and denser. The air near the surface of the earth is densest, for the molecules are packed close together by the weight of the air on top. Then the higher one goes away from the earth's surface, the less dense the air becomes. The less dense it becomes, the less resistance it offers; so it may be said that *the resistance of air is in proportion to its density.*

The larger the surface passing through the air, the greater is the number of molecules encountered; so it is said that *air resistance is in proportion to the area of the surface.* The faster the surface travels through the air, the greater the number of molecules encountered; and the faster the surface travels, the harder those molecules strike against that surface. If the speed or velocity of a surface were doubled, there would be twice as many molecules hitting the surface twice as hard; so it is said that *air resistance is in proportion to the square of the velocity, or to the velocity multiplied by itself.*

These are three of the laws of aërodynamics — or the laws which govern the resistance that the air offers to a moving object.

In flight an airplane moves about three axes. Suppose you balanced a rectangular block of wood on the end of a small round rod. You could keep the block level and



Axes about Which a Plane Moves

AB — Vertical axis, about which a plane moves in changing direction — controlled by the rudder *a*.

CD — Lateral, or horizontal, axis, about which a plane moves in nosing up or down — controlled by the elevator *b*.

XY — Longitudinal axis, about which a plane tips to one side or the other, as in banking — controlled by the ailerons *c*.

still spin it around on this point. If this rod extended through the block of wood, the block would be turning on its 'vertical axis.' Now suppose that you pushed the rod through the block from one side to the other. You could tip the block forward and back on the rod, which would represent the 'horizontal' or 'lateral' axis. Finally, you could push the rod through the block endways from tip to tip perpendicular to the horizontal axis and rock it from side to side. It would then be moving around its 'longitudinal axis.' An airplane has the same three axes. The vertical axis passes through the center of weight and is the axis around which the plane revolves as it changes direction. The horizontal, or lateral, axis passes from side to side, or from wing tip to wing tip, and is the axis about which a plane moves as it noses up or noses down. The horizontal, or lateral, axis passes from nose to tail and when the plane rolls from side to side it moves on its horizontal axis.

In learning to fly, one has to learn how to adjust or move the 'control surfaces' of a plane so that it moves about one of these axes, although one may move the controls so that the plane will move about all three axes at the same time.

An aëronautical engineer or any one who designs a plane must always bear in mind the law of forces which act upon it in the air. He must provide means for maintaining stability of the plane as it moves about its axes. The properties of speed, lightness, durability, and use must also be considered in its design. Some of the details the designer considers are described in the next chapter.

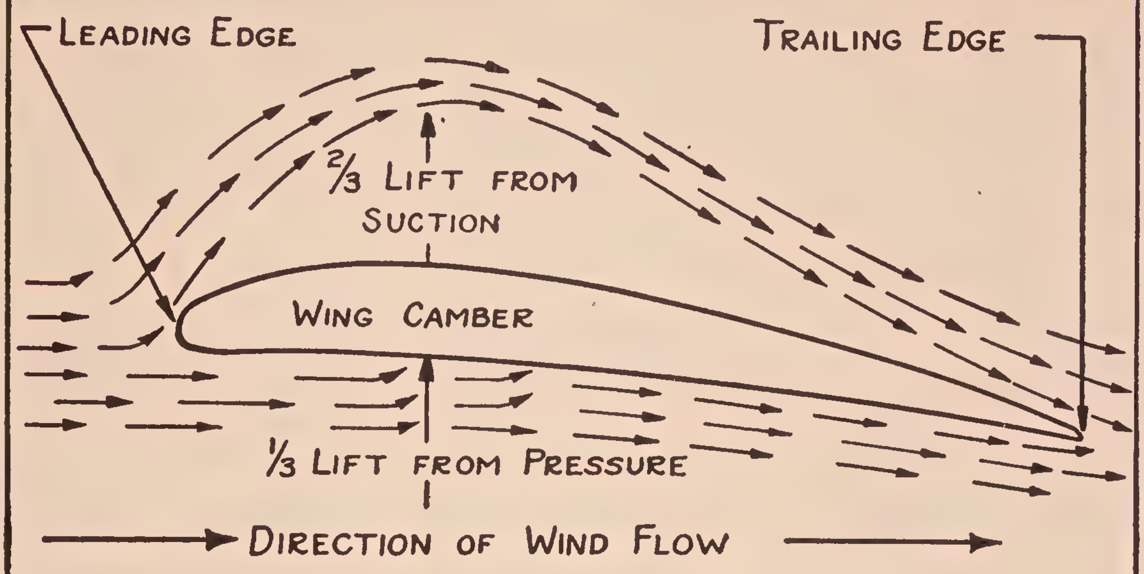
CHAPTER XIII

FEATURES IN DESIGN

In order to reduce the resistance, or drag, a plane is 'streamlined.' Notice how smooth the fuselage appears, how few, if any, projections of any kind there are, how it tapers off toward the rear. It resembles the fish, whose body Nature has streamlined so well. The same feature of design is evident in automobiles, especially those intended for speed. Examine the struts of the airplane. They too are streamlined. Even the construction wires take on this shape.

See how the power plant is housed, so that it will offer as little resistance as possible. The covering closely fitted about the cylinders is called the *cowling*. In some planes the cowling is in the form of a wide band encircling the head of the engine. Colonel Lindbergh's speedy plane has this kind of cowling. Streamlining was carried out in every feature in his new plane (even the landing gear may be drawn up into the wings), for the less resistance, or drag, there is, the greater the flying speed.

The airfoil surface gives the lift to the plane. The leading edge of the wing cuts the air current asunder, so

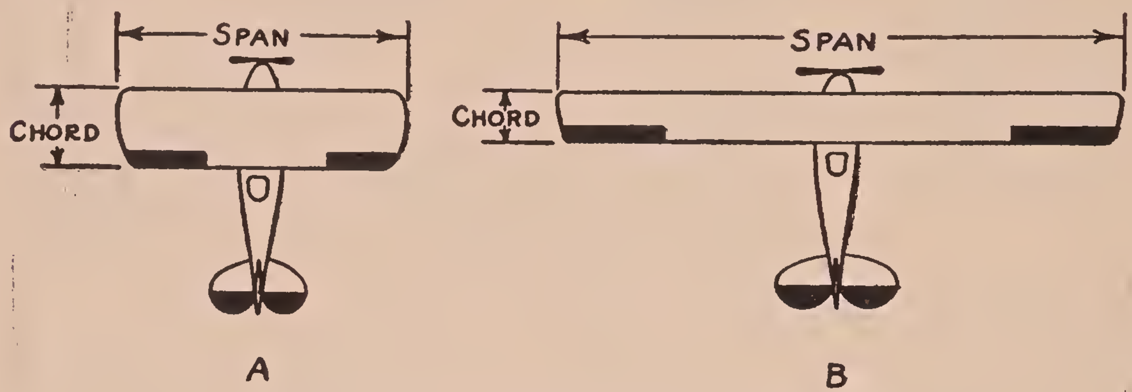


TWO-THIRDS OF WING LIFT IS A RESULT OF SUCTION FROM ABOVE THE WING, AND ONE-THIRD IS A RESULT OF THE LIFT FROM PRESSURE BELOW THE WING.

that part of it goes above and part of it goes below the wing.

The camber of the upper surface directs the stream of air upward and over in such a fashion that an unfilled space is left on the top of the wing. This space is a partial vacuum, and it gives an upward suction effect to the wing. In fact this gives the wing about two-thirds of its lifting power. Then too, on account of the camber, the air molecules under the wing do not have so far to go as those over the top of the wing. So they travel along closer together. This makes the air more dense underneath, and therefore it has more pressure. This pressure pushes the wing upward into the less dense air above. About one-third of the lift comes from this upward pressure.

A large camber gives more lift to a wing, but on the other hand, it increases the wing's weight and air resistance. The greater the amount of airfoil surface the greater the amount of air passing over it and the greater is the lift. The 'chord' of the wing, or the distance through the airfoil



PLANES WITH DIFFERING ASPECT RATIOS

A — A wing with small aspect ratio; the span of the wings is short compared with their chord.
B — A wing with large aspect ratio; the span of the wings is long compared with their chord.

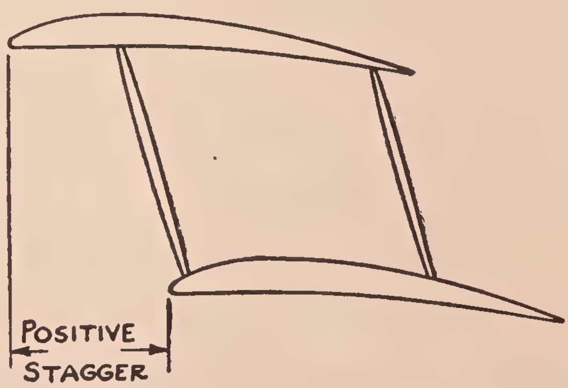
from the leading edge to the trailing edge, must not be too great, for the air currents must flow smoothly over and under the airfoil, so that they can unite at the trailing edge without interfering with the progress of the plane.

It must also be borne in mind that there must be surface area. If we decrease the chord, we must increase the length of the wing from tip to tip, or its 'span.' The ratio of the span to chord is called *aspect ratio.* In giving good lifting power with minimum drag the proper aspect ratio is always an important factor.

Lift is also given a wing if its leading edge is tilted upward. This angle, which is formed by the chord of the wing and the longitudinal axis of the plane, is called the *angle of incidence.*

The angle between the chord of the wing and the horizontal plane of the earth is called the *angle of attack.* This angle is changed as the plane is nosed up or down, but when the plane is in exactly horizontal flight the angle of attack and the angle of incidence are the same. When the angle of attack is increased beyond a certain limit, however, the air currents do not flow over the wing smoothly. They set up a turbulent, or burbling, motion which greatly increases the drag. When this point, called the *burbling point,* has been reached, the plane loses its flying speed and it is said to 'stall.' This term *stall* is not used in reference to the engine, as it is in an automobile, but in reference to the motion of the plane. The plane loses its flying motion, by which the necessary lift is given to overcome the force of gravity.

If you stand at the side of a biplane, you will notice that one wing projects beyond the other — generally the upper beyond the lower. Drop an imaginary line from the top wing and another from the bottom wing. Now measure the distance between these lines and you get the 'stagger' of the wings. Stagger increases lift by increasing surface and also by influencing the air currents to flow more smoothly. Positive stagger (lower wing set back) gives the pilot better visibility.



POSITIVE STAGGER

Upper wing projecting beyond the lower wing.

Thrust is developed through the propeller, which in turn receives its power from the engine. An engine must be installed which develops sufficient power to pull the plane through the air at sufficient speed to give lift to the wings. The faster the plane travels against the air molecules, the more resistance, or drag, is encountered; but also, the faster the plane travels, the more lift is given to the wings.

The lighter the plane, the less it suffers from the force of gravity and the faster it can go, other things, like power and strength, being equal. It must be structurally capable of housing the motor power and resisting the force of the air.

Since lightness combined with strength and durability is such an important factor, great care is used in the selection of wood, and many difficult problems have been solved in the manufacture of metals. The framework of the earlier types of plane was made of wood. Now a light metal known as *duralumin* is used. This metal is an aluminum alloy nearly as strong as steel but only one-third as heavy.

Before a new feature is built into a plane, its particular qualities are put to a rigid test. Scale models are built and set up in a huge wind tunnel. Powerful fans blow through the tunnel a current of air which corresponds to any desired wind velocity. The effect is the same as though the plane were flying at the same speed in still air. For instance, if the current in the tunnel is giving a velocity of eighty miles an hour, it would have the same effect as though the plane were moving at an air speed of eighty miles an hour in still air, or the same as though it were moving sixty miles an hour against a twenty-mile wind.

If the scale model then behaves in a satisfactory manner, the 'life-sized' plane is built. If no errors are made in calculating the ratio of the measurements of the model to those of the large plane, the latter will behave in the air exactly as the model behaved in the tunnel.

There are, also, wind tunnels in which full-sized airplanes are tested. The world's largest tunnel of this sort, and a seaplane-testing basin in which full-sized floats are studied were completed in 1931 at the Langley Memorial Aëronautical Laboratory of the National Advisory Committee for Aëronautics at Langley, Virginia.

CHAPTER XIV

THE WEATHER AND ITS EFFECT ON AIR NAVIGATION

So important to the success of flying is the weather that it has become an outstanding problem for research in the field of aëronautics.

Although the weather is as yet beyond man's control, he may anticipate its condition and govern his activities accordingly. The science which treats of weather, its changes and their causes, is called *meteorology*.

The Atmosphere

It has always been an interesting problem to scientists to determine the height of the atmosphere which surrounds the earth and to learn its conditions. A great deal of information has been gained by means of instruments sent up in small free balloons which fall to earth uninjured after the balloons have burst.

Such balloons have reached heights of over twenty-two miles.

Thermometers have shown that the air temperature decreases to a height of five to ten miles, the altitude depending upon the latitude of the place. After that height has been reached, there is no decrease in temperature, but even a slight increase.

Barometers show that the pressure of the air decreases as one ascends, and it is supposed that at a height of 50 miles there would be practically no pressure, although an exceedingly thin envelope of air might extend outward about 150 miles farther.

Air is a gaseous form of matter; and since it is matter, it has weight. The total amount of air which envelops the earth is said to weigh about 58,000,000,000,000,000 tons. It exerts a pressure at sea level of 14.7 pounds per square inch, which is enough to hold the column of mercury in a barometer — the instrument used to measure the pressure of the atmosphere — to a height of about 30 inches. It has at all times a greater or lesser amount of water vapor and dust.

The atmosphere is divided into two layers. The layer which envelops the earth to a height of 10 miles at the equator and 5 miles at the poles is called the *troposphere*. This layer contains about three-fourths of the weight of all the atmosphere. As storms occur here there are both vertical and horizontal air currents. It is in this region that all flying is done at the present time.

Outward from the troposphere another layer of air extends for nearly 200 miles which is known as the *stratosphere*. This contains only one-fourth of the air, has a constant temperature, only horizontal air currents, and probably no storm areas. The division between these two layers is called the *tropopause*.

With these differences in mind, you can understand why some persons have had the idea that if the stratosphere could be reached, very different, and perhaps much better, flying conditions could be obtained.

As a matter of fact, a new world record was established on May 27, 1931, when Professor Auguste Picard and Paul Kipfer ascended to a height of 51,775 feet in a flight between Augsburg, Germany, and Glacier d'Obergurgl, Switzerland, in their 'stratosphere' balloon.

One important thing to the pilot is visibility. If he is able to see vertically downward from an altitude of 5000 feet and horizontally for a distance of 7 miles the visibility is reported "Good" for flying. Visibility depends upon the conditions of the air; namely, temperature; pressure; humidity; clouds — type and distribution; wind — direction and velocity; and the forms that water vapor assumes after it has been changed from a gaseous to a liquid form — in other words, precipitation in the form of rain, mist, clouds, dew, hail, frost, or fog.

The Winds

It goes without saying that those who guide aircraft need to be thoroughly familiar with the winds. In order to understand some of the principles at work here, we need to remember that air, like any other object, has weight and that the weight of a given quantity of air varies with its temperature. As the air gets warmer, it gets also thinner and lighter, and expands; while as it gets colder, just the opposite happens: it gets heavier and tends to fall toward the surface of the earth.

The winds are caused in this way by changes that take place in the temperature of the air over different areas of the land and water that make up the surface of the earth. Some of these winds blow steadily and for long periods of time over large areas of the earth's surface; others of them are local and are felt only over small areas and for short periods of time.

The explanation of the important big currents of air that flow rather steadily over large areas of the earth is found particularly in the effects of the sun's rays upon different parts of the earth's surface. William Ferrel, an American meteorologist, in 1856 made the first clear explanation of these important *wind belts,* as they are called.

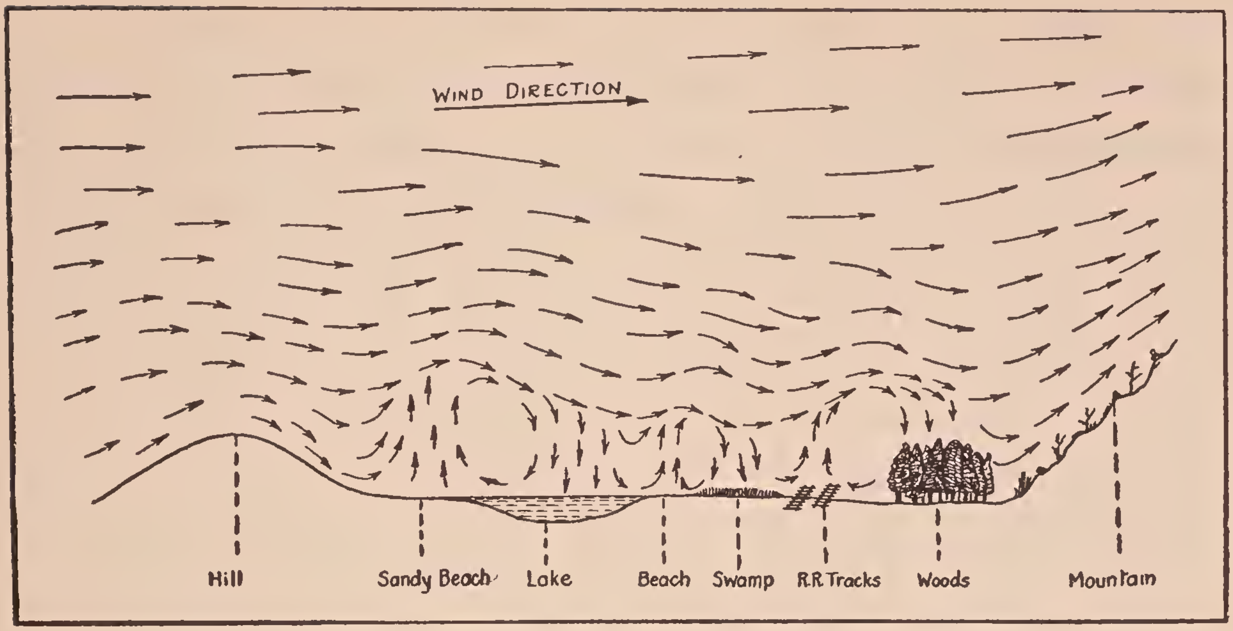
When the rays from the sun strike through the earth's atmosphere upon the surface of the earth, they warm the earth. In a wide belt around the earth at the equator these rays of the sun strike directly down upon the surface and make the land and water decidedly warm. That causes the air above this land and water to expand, as it is warmed and becomes thinner and lighter, so that it rises from the surface toward the upper atmosphere. On the other hand, the rays from the sun that strike the land and water about the North Pole and the South Pole are so slanting that they do not warm the land and the water as they do near the equator. Air over the polar regions is cold and heavy and tends to settle down toward the surface of the earth.

The general result of this condition is that at the surface of the earth on either side of the equator large quantities of air are pushing in toward the equator to fill the space left by the ascending warm air. These currents do not actually blow directly north and south toward the equator because the turning of the earth on its axis deflects them. North of the equator they blow from the northeast, and south of the equator they blow from the southeast. These important winds on either side of the equator are known as *trade winds,* because before the use of the steamships, trading vessels depended much upon them for making their way across the oceans.

Near the equator, where the warmed air is rising toward the upper atmosphere, there is not much wind on the surface of the earth. This area of calm is known as the *doldrums.*

The warm air that rises over the equator flows along from the equator toward the poles in the upper layers of the atmosphere above the surface trade winds. As these upper currents of air get about to the regions of the tropic of Cancer on the north and the tropic of Capricorn on the south, they have lost most of their warmth; so they sink toward the earth to join the trade winds blowing along the surface back toward the equator. This belt around the earth north of the northeast trade winds and south of the southeast trade winds is called the *horse latitudes.*

Another important wind belt is formed in this way. On the surface of the earth the winds blow from the horse latitudes not only toward the equator but also toward the



THE EFFECT OF TOPOGRAPHY ON AIR CURRENTS

poles. Like the trade winds, these winds are also deflected by the rotation of the earth, so that they flow northwesterly in the northern hemisphere and southwesterly in the southern hemisphere. In addition to these winds there are other winds not so general and steady that are caused by special conditions on the earth's surface, as will now be explained.

Since water heats more slowly and cools more slowly than land, the distribution of land and water areas in the heat belt affects the direction of winds. During the summer months, when the water is cooler than the land, the wind blows from the sea; and in the winter, when the water is warmer, the wind blows from the land. Such seasonal winds are found especially on the southern coast of Asia, where they are called *monsoons*. A similar condition, but not so pronounced, exists along the coast of Mexico.

Local conditions, such as bare rock, sandy areas, and even small buildings which radiate heat very rapidly, and streams, rivers, and small bodies of water which absorb the heat more slowly create up currents and down currents of air. Hills and mountain ranges deflect the air currents, which may flow up one side and down the other.

All these facts about the winds are important to navigators of the air, as they are to navigators of the sea. A transatlantic airplane or dirigible flight, for instance, demands careful planning to take the best advantage of the winds. Again, knowledge of the effect on the wind of local conditions is absolutely essential for successful soaring in the big gliders called *sailplanes.* And in ordinary airplane trips the flyer often feels the effect on the air of local conditions below as his plane suddenly rises with an up current or drops with a down current. This latter effect often erroneously, is spoken of as 'hitting an air pocket.' While the air may be 'bumpy,' especially near the surface, on account of these local currents of air, of course there can never be a pocket, or hole, in the air any more than there could be one in the water of the ocean.

Water Vapor and Precipitation

When water is changed from its liquid form into water vapor, a gaseous form, it is said to evaporate. Heat aids and hastens this process.

The capacity of air to contain water vapor depends upon its temperature. The warmer it is, the more water vapor it will take up. On hot days one speaks of the air as being 'heavy.' What he means is that it is full of the light water vapor and is really light. The amount of water vapor the air contains is known as its *absolute humidity.*

The *relative humidity* is the ratio between the amount of water vapor that air actually contains at a certain temperature and the amount of water vapor it could contain at the same temperature if it were saturated. For instance, if a cubic foot of air at a certain temperature contains five grains of water vapor but at the same temperature could, if saturated, contain ten grains, the ratio of five to ten, or the relative humidity, would be one-half, or 50 per cent. When the relative humidity for a given temperature reaches 100 per cent, it has reached the 'dew point' and if the temperature then falls, some of the water held suspended in the air is squeezed out, is precipitated, in the form of mist, rain, or snow. Thus, as hot moist surface air rises into cooler altitudes or is carried in winds over cooler areas, the water-vapor molecules condense into drops of rain, or if the temperature is cold enough they become flakes of snow. It may happen that as they fall earthward they pass through a layer of warm air and change, by evaporation, into gaseous water vapor again. It is quite possible for an aviator to pass through a rainstorm or a snowstorm which never reaches the earth.

Fog and Clouds

Mist and fog are other forms of the condensed water vapor. Fogs greatly handicap flying. Heavy fogs, sometimes called *advection fogs*, are caused when air rising from warm-water areas is borne over colder land or colder water areas and is condensed. This happens especially often along the Newfoundland coast. The air over the warm Gulf Stream blows over the cold Labrador current and causes heavy fogs around Newfoundland. Sometimes aviators must wait several days before a rising temperature and a change of wind clear the fogs away.

Clouds are also fog, but, being higher, are carried along with wind currents.

It is not an uncommon sight to see some masses of clouds floating along in one direction, while others at a higher altitude are being carried along in another.

Aviators make use of the different layers of horizontal currents. When flying in one direction they may benefit by a tail wind, and upon the return trip, by flying at a different altitude, they may profit by a wind current from another direction.

The thunder storm, with its violent upward and downward vertical currents of air, its lightning, its sudden rain, and frequent hail, is a source of danger to the pilot. Under no condition should he attempt to fly up and through a thundercloud. The best course to adopt is to make a landing at once in the most suitable spot and to wait there until the storm passes, for a delay is better than a crash and certainly less expensive.

One peculiarity of thunderstorms, of interest to a pilot, is the fact that they rarely cross large rivers.

Air Pressure and Its Effect on the Weather

Air pressure, as will be clear from what was said about winds, is a great factor in determining weather conditions. The instrument which measures the atmospheric pressure is the *barometer.* You have already read how the pressure of the upper regions of the atmosphere may be determined by installing this instrument in free balloons which reach great heights before bursting and letting the instruments return to the earth, attached to a little parachute.

For a long time the scientists did not understand air pressure. For this reason they were at a loss to know why, with a lift pump, water could be made to rise only about 32 feet in a vacuum tube.

Galileo (1546–1642) had advanced the theory that air has pressure, but it was Torricelli, his pupil, who found that mercury, which is 13.6 times heavier than water, would rise in a vacuum tube about 30 inches, and that the air exerted a pressure of almost 15 pounds per square inch. This lead to the invention of the *mercury barometer.*

The mercury barometer is in use today, but the *aneroid barometer* is the one used on aircraft. The aneroid consists of a small metal box exhausted of air. Atmospheric pressure causes the top of the box to rise and fall. Through a set of springs and levers this motion is magnified and transferred to the index needle on the face of the barometer. The barometer works much as does the oil-pressure gauge on an automobile, except that it is much

An Aneroid Barometer

more delicate. A change of only 1/200 of an inch on the wall of the box will cause the index needle to move three inches.

The barometer measures the weight, or pressure, of the atmosphere. As the pressure increases, there is a 'rising' barometer; as the pressure decreases, there is a 'falling' barometer. A rapidly falling barometer generally indicates the approach of a storm.

If you look at the weather map, you will see how all the meteorological elements have been pictured. Those places where the barometer reading is the same have been connected with a line, and the groups of lines show the location of low-pressure or high-pressure areas. Another name for a low-pressure area is *cyclone*. In the center of this region the air is warmer and lighter than the surrounding air, and as it rises the heavier air rushes toward the center of the 'low' from all directions in an anti-clockwise movement.

In the high-pressure areas, or *anti-cyclones,* as they are called, the heavier air in the center falls downward, crowding out the warmer air in all directions in a clockwise movement. The wind directions about the cyclone and anticyclone centers are reversed in the southern hemisphere, where the winds blow in a clockwise fashion in the cyclones and anti-clockwise in the anti-cyclones.

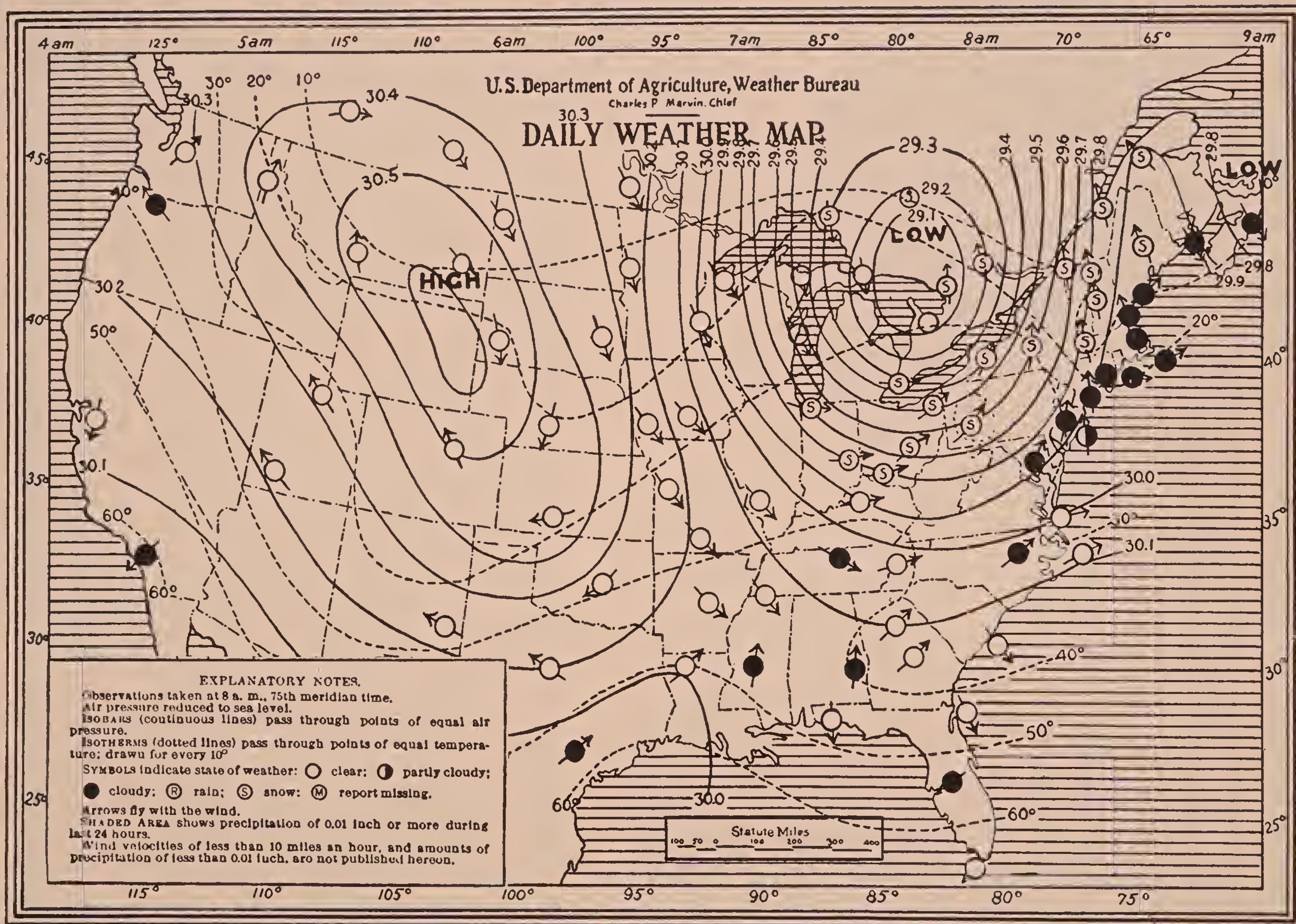
These regions of low and high pressure, or cyclones and anti-cyclones, travel around the earth in a general west-toward-east direction and carry with them distinctive weather conditions that are more or less influenced by the topography of the country over which they pass.

These great whirling eddies of air are the cause of all our changes of weather, and since they travel at a fairly uniform rate of speed, several hundreds of miles a day, it is possible by reading the weather map to determine quite accurately the kind of weather the advancing 'low' or 'high' will bring.

The Service Provided by the Weather Bureau

Records of the weather are kept from year to year. Although one often hears older people say that the weather conditions were different when they were young, by consulting the records one finds very little, if any, radical change in weather from one year to the next.

It was not until 1891 that the entire weather service for the United States was centralized in the Weather Bureau of the Department of Agriculture, Washington, D. C. At this Bureau, daily weather maps are prepared. Over two hundred stations in this country, Canada, Mexico, and the West Indies coöperate in sending information to the Bureau at Washington.


U.S. Department of Agriculture, Weather Bureau
Charles F. Marvin, Chief
DAILY WEATHER MAP
HIGH
LOW
LOW
EXPLANATORY NOTES.
Observations taken at 8 a. m., 75th meridian time.
Air pressure reduced to sea level.
ISOBARS (continuous lines) pass through points of equal air pressure.
ISOTHERMS (dotted lines) pass through points of equal temperature; drawn for every 10°
SYMBOLS indicate state of weather: clear; partly cloudy; cloudy; rain; snow; report missing.
Arrows fly with the wind.
SHADED AREA shows precipitation of 0.01 inch or more during last 24 hours.
Wind velocities of less than 10 miles an hour, and amounts of precipitation of less than 0.01 inch, are not published hereon.
Statute Miles

Each day at 8:00 A.M. and 8:00 P.M., Washington time, trained scientists from each of these stations send reports of their weather conditions in code by telegraph to the central office at Washington. The messages giving information concerning pressure, temperature, rainfall, sunshine, and direction and force of the wind are decoded and the data placed upon blank maps. All places of equal pressure are connected by a line called an *isobar*. Places of equal temperature are joined by *isotherm* lines. Other symbols found on a weather map indicate clouds, rain, snow, and thunderstorms. Arrows fly with the wind, whose velocity is given in miles per hour, except on Navy and Marine reports, where the Beaufort scale is used.

Besides the central station at Washington, there are other forecast centers at Chicago, New Orleans, Denver, and San Francisco.

Weather reports are now sent out from central stations by radio to flying fields, so that a pilot anywhere may know what kind of weather to expect.

No experienced flyer now takes off for any cross-country flying without first getting information about weather conditions. Very careful analysis and scientific study of weather charts and bulletins are made by those who are planning any long-distance flights.

Three flying altitudes are registered on weather charts: 2,500 feet, 5,000 feet, and 10,000 feet. Each is identified by a different color, and the condition and direction of the air currents in each level is recorded.

The information is obtained by releasing an ordinary

THE BEAUFORT SCALE OF WIND FORCE

Beaufort Number	Description of Wind	Characteristic Effects	Speed in Miles per Hour
0	Calm	Smoke rises vertically	Less than 1
1	Light air	Smoke drifts gently	1– 3
2	Light breeze	Wind felt on face. Leaves rustle	4– 7
3	Gentle breeze	Wind extends light flag. Leaves and small twigs move	8–12
4	Moderate breeze	Raises dust and paper. Small branches move	13–18
5	Fresh breeze	Small leafy trees sway	19–24
6	Strong breeze	Large branches move. Whistling in telegraph wires	25–31
7	Moderate gale	Whole trees in movement	32–38
8	Fresh gale	Twigs broken off trees. Wind impedes movement	39–46
9	Strong gale	Damage to buildings. Slates and shingles blown down	47–54
10	Whole gale	Trees uprooted. Much damage done to buildings	55–63
11	Storm	Widespread damage. Rarely occurs	64–75
12	Hurricane		Over 75

sounding balloon which carries nothing and which is known to have a definite rate of ascent. The observer on the ground takes sights on it with an instrument called a *theodolite*. With this instrument he is able to tell the force and direction of the wind at different altitudes. This is called taking a sounding of the upper air. Such soundings are taken at least daily at every Army airport, every Naval air station, and at those airports where weather bureau offices are located. By studying these charts the pilot can decide at what altitude it would be most advantageous to fly.

Advanced methods of weather forcasting, improvement in the accuracy of flying instruments, and the means of constant communication afforded by the radio will probably make flying in the future possible at all times.

PART IV

MOTORLESS CRAFT

THE PARACHUTE
GLIDERS

CHAPTER XV

THE PARACHUTE

Perhaps you have been attracted to some public place — a fairground, an amusement park, or an airport — because one of the features of entertainment was a 'parachute jump.'

You have seen an airplane take off and have watched it as it circled over the field in order to gain altitude for the jumper to make his descent.

Then your heart almost stopped beating as you saw a dark object drop from the plane and you knew that the jumper's life depended upon less than one hundred square yards of silk, some silken cords, and his own clear head in manipulating this device so that it would open at just the proper time and he would land in an unobstructed place.

For an instant a dead silence spread over the gazing spectators; then there were many exclamations of, "See, it is opening!" Out above the body of the jumper floated a long wriggling stream of white, not unlike a huge white caterpillar crawling through the sky. Then the leading end began to bulge, and the yards of silk spread out in a beautiful flower-shaped form, from the stem of which swung the figure of the jumper. The parachute had performed its function faithfully. Within a few seconds a person had safely descended from an altitude of probably three thousand feet.

But the main use for the parachute is not for exhibition purposes. It is a veritable 'life preserver of the air.'

Early Experiments

The idea of parachutes was born in the minds of men centuries ago. The Chinese are credited with being its inventors far back in the age of broadswords and armored suits.

Then you have read how Leonardo da Vinci experimented with them in the fifteenth century. Toward the end of the eighteenth century and especially after ballooning became a craze in the nineteenth century, parachute jumping furnished a new way of satisfying the demand of the public for thrills. Parachute jumpers swung from balloons in spectacular style; they jumped into clouds of smoke; they hid the chute in a pack to make believe they were falling without one; they frantically pulled on the cords to deceive the spectators into thinking something was wrong; or they fell an amazing distance before they landed.

After such spectacular exhibitions it seems strange that it was not until the last six months of the World War that parachutes were employed to lessen the death toll of war pilots and that the practice of adding this safety device to a pilot's equipment was employed only by the Germans even then.

A story is told of a French pilot who on a reconnoitering flight sighted a German Fokker plane. A stream of bullets was sent toward the German plane. A burst of flame from the petrol tank enveloped the Fokker. Just as it shivered downward in a fatal spin, the figure of the German pilot plunged outward into space as though he preferred to meet his death outside the burning plane. To the amazement of the Frenchman the German's descent was suddenly halted as a parachute opened, and the German made a safe landing in the fields below.

The French also had experimented with parachutes, but with meager success. It was in America, after the war, that the 'free' parachute was finally perfected and then not until after brave men had sacrificed their lives in the testing of different types.

Modern Types of Parachute

It was due to the diligent service of Leslie Irwin, a member of the Army Air Corps, that the present types owe their principal features of design.

Records show that no Irwin parachute has ever failed to open if the jumper was at an altitude of at least 150 feet, if he was free from obstructions, and if he had not failed to pull the rip cord to release the chute.

Other standard types are the Russell Lobe, the Floyd Smith, the Swatlik and the triangular parachute.

Irvin Air Chute Company

Quick-Connection Air Chute Showing Chest Pack — Form-Fitting Back Pack — Seat Pack

Parachutes are made in three sizes — 28 feet in diameter when open, 24 feet, and 22 feet.

The largest one is used for exhibition and for training purposes. Under ordinary circumstances its average rate of descent is 12 feet per second.

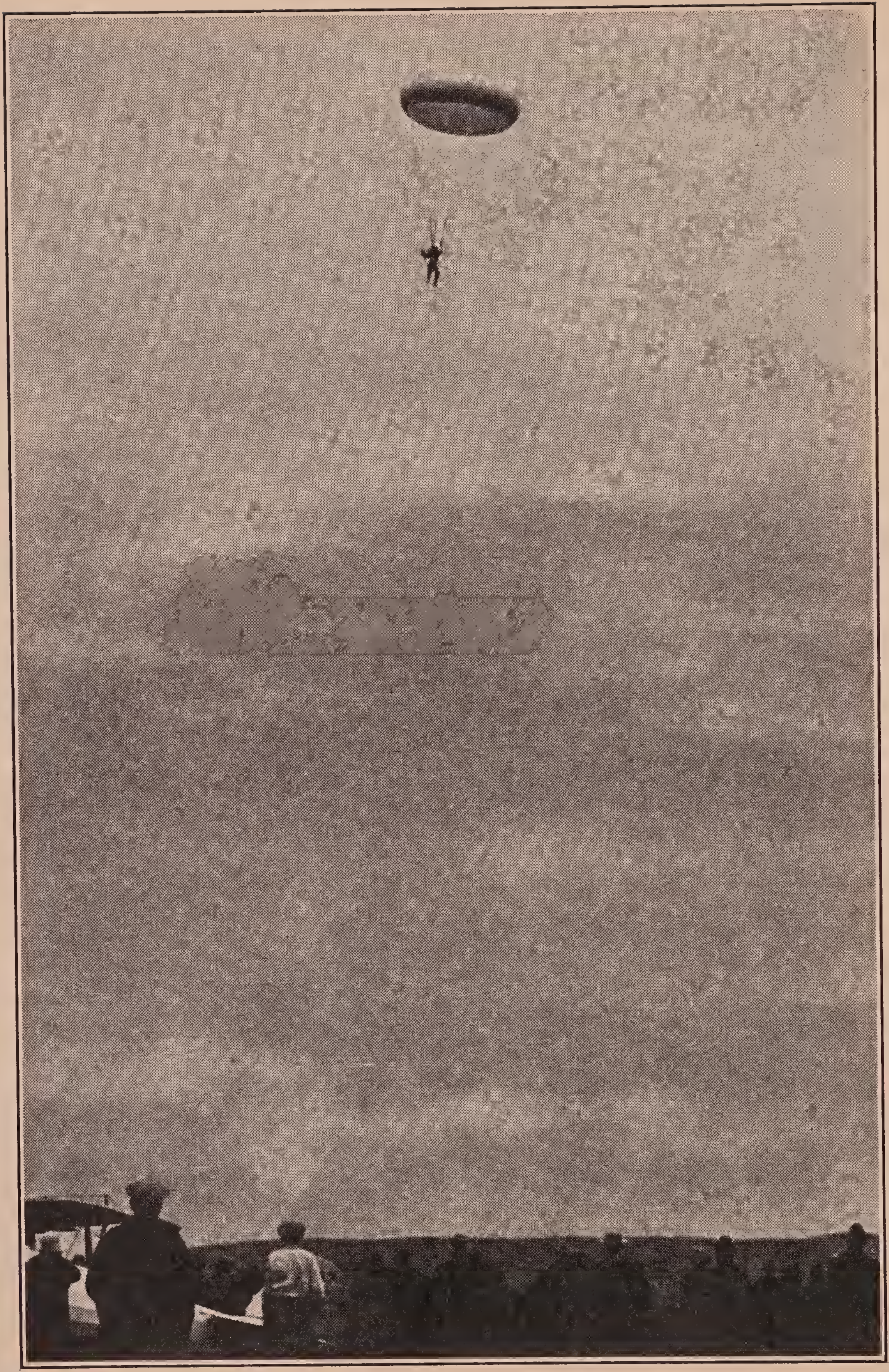
The 22-foot chute, carried on the chest, is used as an auxiliary to the large one in government training equipment for aviators.

The 24-foot chute is the standard for general service. Its weight, complete with harness, is approximately 18 pounds and the average rate of descent is 16 feet per second.

A specially woven linen-webbing harness attaches the parachute to the wearer and may be adjusted to fit him perfectly and comfortably.

In the Irwin parachute an important feature is the 'pilot chute.' This diminutive chute is only about 30 inches in diameter. It is put into the case after the main chute has been packed. Elastic bands pass around the pack and are hooked to a flap. The flap is fastened in place with the pins on the ends of the rip cord. When this cord is pulled, it releases the flap, which is pulled open by the elastic bands. Out springs the little 'pilot chute,' which opens up like an umbrella, dragging out the main parachute. It only takes about 1⅗ seconds from the time the rip cord is pulled before the whole parachute is filled with air.

The chute is attached to the harness on the wearer by twenty-four lines. As the chute opens, the wearer feels



A Russell Lobe Parachute in the Air

a sudden jerk, but it generally affords only a happy sensation, for he knows that the parachute has opened and that a safe descent is certain. An experienced jumper can handle the ropes so that he spills out some of the air and gives direction to the parachute; this is called 'slipping' the parachute.

In the service parachute certain standards in quality and strength are met. The harness has a tensile strength of 3000; that is, it will withstand a pull of that many pounds. The buckles and snaps are made of chrome-nickel steel, zinc or cadmium plated and subjected to a 2500–pound test. The canopy is made of Japanese habutai silk. This fabric has been chosen because it withstands the great impact of wind pressure when the chute opens so quickly. The twenty-four suspension lines are made of silk cord neither knotted nor spliced. Each has tensile strength of 400 pounds. They are continuous from one side of the harness, up over the canopy, and down to the other side. The rip cord is a flexible cable with pins on one end and a handle on the other. It takes only a pull of ten pounds on the handle to detach the pins that release the pilot chute.

Tests and Experiments

Parachutes must now be approved by the Aëronautics Branch of the Department of Commerce. They must be packed by a licensed packer and subjected to severe tests.

TESTING A PARACHUTE

A wind tunnel motor being used in parachute instruction at the Boeing School of Aëronautics, Oakland Municipal Airport, Oakland, California.

They must open in every one of twenty-five trial drops with a 200-pound dummy.

It is a fascinating sight to watch these tests. The air seems literally filled with these great white blossoms as one after another is released from the whirring planes above. Sometimes after landing, the wind drags the dummy over the ground for some distance, or until some one can grab the cords and spill the air.

Many lives have been saved by the use of the parachute. Engines have gone wrong in mid-air, tail surfaces have parted company with the fuselage, or wings have been unable to withstand sudden shock of air pressure in air maneuvers. It is then that the aviator is either forced out of the plane or deliberately makes a jump. The thing he has to remember is to be sure that he is far enough from the plane to be free from any of its parts before he pulls the rip cord. Then he must remember to give the cord a good pull. Some sad instances are on record in which a person through fright failed to do this. On landing, the feet should be kept close together and the landing taken much as an athlete lands in the pit after a pole vault.

Persons who have made descents to earth in parachutes have been asked to give their impressions of their downward trips. They say that the most exciting and breathtaking moment is just before they land, when the earth seems literally to jump up to meet them.

In order that the radio public might listen in, an airplane carrying a parachute jumper installed a broadcasting set. A spool of wire, attached to a microphone and fastened to the mouth of the jumper, unwound as he made his descent. It didn't take long for him to broadcast his speech.

Colonel Lindbergh has used the parachute on four different occasions to save his life.

There is a club called the 'Caterpillar Club' to which admittance is gained only when a person has used the parachute to save his or her life. The club received its name because the silk is made by that little animal, the caterpillar.

Experiments are being made with parachutes large enough to land a plane. In one test a giant parachute brought a plane and pilot safely to earth from an altitude of 2500 feet. Perhaps these planechutes may some day become common equipment for all aircraft.

CHAPTER XVI

GLIDERS

Have you ever watched a sea gull or a hawk as it floated along in the air and with only an occasional flap of its wings kept the same altitude or seemed even to soar higher and higher? Men throughout the ages have watched the flight of birds and have longed to be able to sail, as they do, through the air. You have read the interesting stories of the attempts to get into the air that men have made during the past centuries.

Pioneers in the Art of Gliding

There is a story of a Chinese general who, in 200 B.C., used kites to elevate a man so that he could look down and observe the movements of his opponent's army.

You have read about the great painter, sculptor, and architect, Leonardo da Vinci, who, in the sixteenth century, created the design for a man-carrying glider. Although he died before he ever built and experimented with his craft, his writings show that he had thought out many of the fundamental principles of flight.

Otto Lilienthal of Germany became one of the outstanding pioneers in gliding, between the years 1890 and 1896.

He made many successful flights with gliders, covering distances as great as one thousand feet from the point of take-off.

Before Lilienthal's experiments, a certain French sailor, Captain Le Bris, made some remarkable flights in a boat-like glider with wings shaped like those of an albatross, but his flying was done more by natural instinct than by any scientific skill; so he made no substantial contribution to the science of flight.

Another Frenchman, Henri Farman, who, like the Wright brothers, was interested in bicycle racing, became an aviator of some note. He established a school of aviation in 1908. His early experiments on gliders finally led him into the airplane business, so that he and his brother were able to supply planes to different countries during the World War.

Octave Chanute, J. J. Montgomery, A. M. Herring, and later the Wright brothers were early Americans, as you know, who became interested in glider construction, but the development of power planes in America diverted attention from the glider until 1922, when a glider club was formed at Massachusetts Institute of Technology. One of the members of the club that year, Mr. E. T. Allen, became qualified to take part in the Rhöen glider and soaring-plane contest which is held every year in Germany.

Germany's Leadership in Glider Flying

German glider enthusiasts have been interested in the development of gliders since the days of Lilienthal. In

1909, during the International Airship Exposition at Frankfurt-am-Main, there was a German glider competition.

Even during the World War, gliding experiments were made from time to time; and after the War, when Germany was restrained by the Treaty of Versailles from building high-powered planes, her pilots and designers turned their attention to the development of high-type gliders and soaring planes. The development of the movement which has placed Germany in the lead in this fascinating method of flight may be said to have started in 1920 with the Rhöen soaring-flight race on the Wasserkuppe Mountain in Germany. There were only ten machines competing, of as many different makes and all more or less poorly constructed.

The following year, 1921, a new glider, which had established three new world records in endurance and speed, made its appearance. It was designed by a Mr. Martens and a Mr. Hensen of the Hanover University group. In the meet in 1922 there were approximately forty gliders on the Wasserkuppe, all of which quite closely resembled the Hanover type of glider. Heretofore, flights had been comparatively brief in duration, but at this competition the time in the air was extended into hours.

Soaring-flight schools were started in Germany. A very successful one, established in 1924 by Mr. Martens, was eventually taken over by the Rhöen — Rossitten Company.

This company has the character of a public utility and is an important institution for the promotion of the German soaring-flight movement. It supervises glider schools and arranges competitions. It fosters clubs and for a small fee supplies designs and materials for glider construction.

National contests are held in August at the Rhöen Wasserkuppe in southwestern Germany and at Rossitten in northeastern Germany.

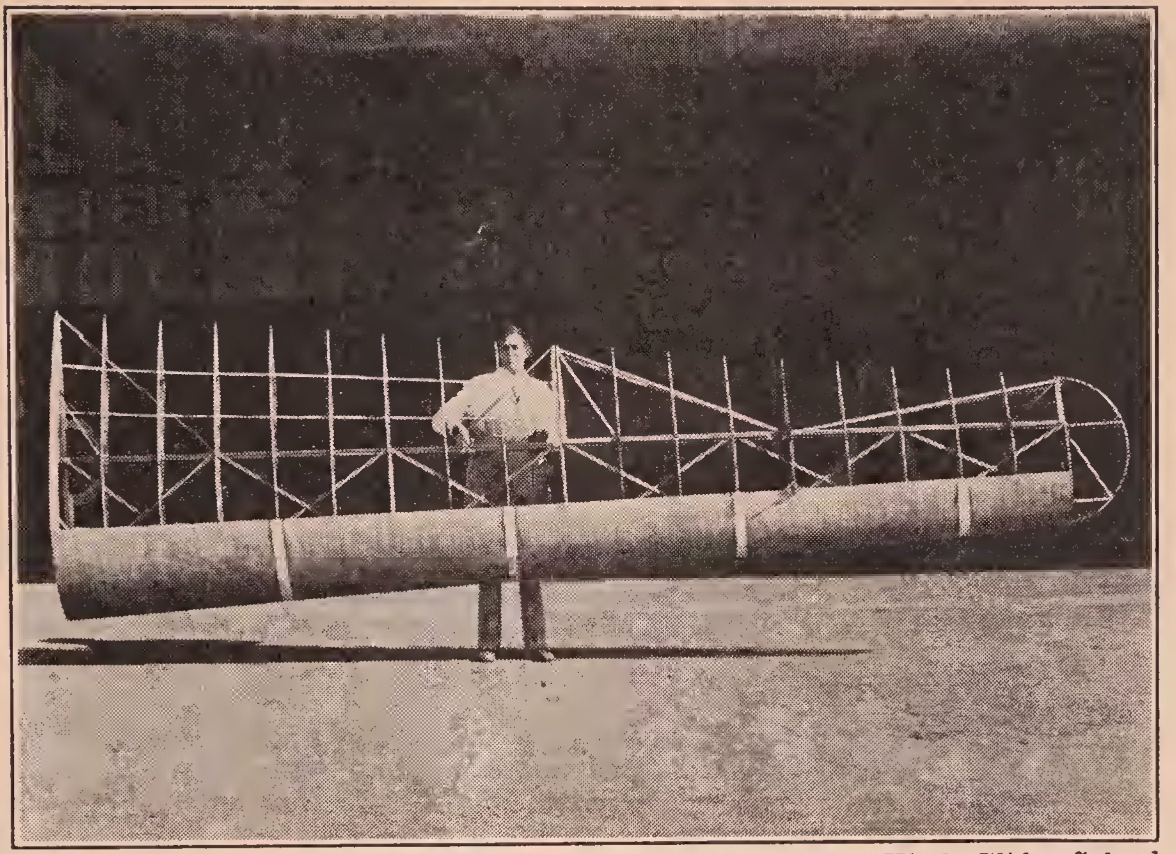
German glider pilots have made some notable records which have been a challenge to pilots throughout Europe and America.

At the meet on the Wasserkuppe in August, 1930, Robert Kronfeld, an Austrian, defeated thirty-three other glider pilots by a 39-mile circuit flight, thereby winning one thousand marks (about $240). His flight carried him across difficult country to a neighboring mountain, over which none of his competitors was able to soar.

The day after he won the prize, he took his glider aloft again and 'hooked on' to a thundercloud. Taking advantage of the strong currents which always exist in such clouds, he was carried 94 miles, bettering his record of the previous day.

Glider Flying in America

It was in 1928 that interest in glider flying was again revived in America when three German glider pilots came to this country, one of whom, Peter Hesselbach, established a duration record of more than four hours, breaking the Wright record of 1911. It was through their experiments



Bowlus-Hirth Glider School

MR. HAWLEY BOWLUS WITH A WING SECTION OF ONE OF HIS GLIDERS

that the flying field at Cape Cod was found and tested. This field has become the base for the location of a school for teaching glider flying.

Williams Hawley Bowlus, who has been flying gliders since 1910 and building them since 1914, became renowned when he flew a sailplane which he had built for over nine hours and broke the record that Hesselbach had established at Cape Cod.

Then there appeared on the front of every newspaper the announcement that Colonel Lindbergh had become a glider enthusiast and that his wife, Anne Lindbergh, had also remained aloft long enough to qualify as a glider pilot.

A glider launched from the *Los Angeles* created attention. Then Captain Hawks attached his monoplane glider, *Eaglet,* which is now in the Smithsonian Institution beside other historical aircraft, to an airplane and was towed across the continent. Every city and community en route became 'glider-minded.'

It seemed that every one wanted to glide. Memberships in college glider clubs increased. Regular flying clubs forgot their powered planes and set to work constructing gliders. Boys and girls who had built elaborate airplane models assembled their odd bits of balsa wood and Japanese tissue into dainty little models which sailed through the air, with a double-headed tack attached to the fuselage to keep the nose down. Then the high-school students began the construction of real gliders under the supervision of their shop teachers. School authorities and parents realized that this was a safe means of letting boys and girls in their teens have an outlet for their heretofore suppressed desire to get into the air.

But motorless aviation is not confined to high-school students or to college youths. It has caught the imagination of men and women in every part of the country, who have formed glider clubs either independently or fostered by Chambers of Commerce, newspapers, country clubs, or industrial organizations. Besides offering a training valuable for flying engine-driven aircraft, gliding affords great entertainment and excellent sport. When used for sport, however, gliders should be flown only when the weather is suitable. If you are planning a pleasure trip in your automobile, you wait for pleasant weather; you should do so when you fly your glider.

Some Principles of Glider Flying

Properly conducted there is a minimum risk and a minimum cost to gliding. A beginner is not disturbed by speed and by the roar, vibration, and fumes of a motor. There is no fuel tank and consequently no fire hazard. Instead of coming in contact with the ground at express-train speed as in an airplane, a glider drifts down into the wind at a rate of only a few miles an hour and lands as lightly as a bird.

The glider is not a toy, however. It commands a good deal of respect, as many a licensed pilot is ready to admit after his first real flight in one, for no matter how long one has flown an airplane, he is advised to start at the beginning in learning to fly a glider.

Since in gliding one makes use of the air currents to keep the glider in the air, one must understand how air currents are affected by the topography of the country, or, in other words, by the mountains, hills, valleys, rivers, and plains.

In the chapter on meteorology you noted that currents of air flow upward over the side of a hill or mountain and perhaps downward on the other side. You also read that air is unequally heated over land and water areas, so that the cool heavier air over water flows downward to push up the warm lighter air over land areas. You were

Colonel Lindbergh Looks It Over

And Takes a Flight

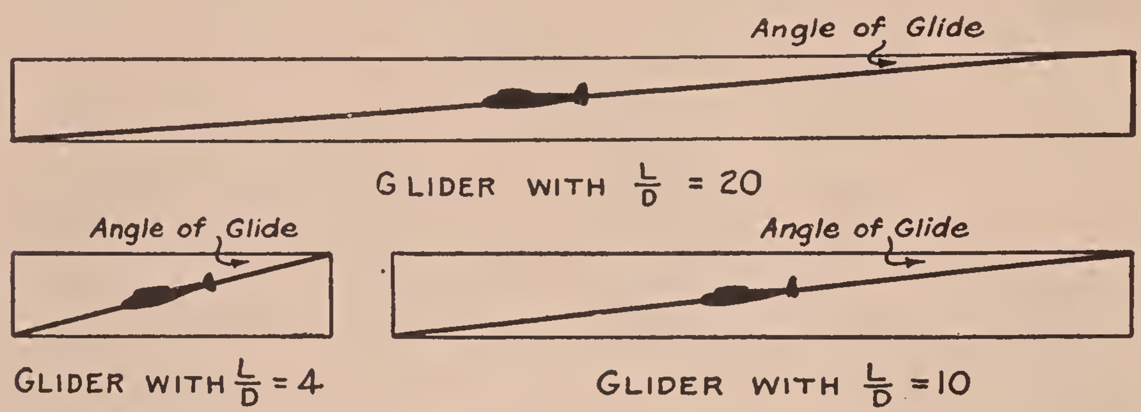
also told that even buildings, clumps of trees, and railroad tracks affect the air currents above them.

The glider pilot must make note of all these things so that he may take advantage of the up currents to gain altitude and be able to manage his craft by nosing down as he glides through a down current.

One of the important factors in gliding is the selection of the field. You recall that the Wright brothers wrote to the Weather Bureau at Washington for information about a suitable location for their experiments and were advised to try Kitty Hawk in North Carolina. In general, there should be some low elevation, as a hill, embankment, or sand dune. Gliding should not be undertaken from house tops, precipices, quarries, or the like. The flying field should be free from obstacles within the gliding range. Walls, trees, high bushes, telegraph wires, or high tension wires must not be within the flying area.

Certain principles must be carried out in the construction of gliders, and certain rules followed in flying them. A glider is acted upon by the same forces that act on an airplane, except that it has no motor to give it forward motion, or thrust. The reason that a glider does not fall downward in a straight vertical line, but takes an inclined path, is that there is a lifting force to the wings just as there is to the wings of an airplane.

The amount of opening between a horizontal line and the line representing the path of the glider is called the *gliding angle,* or the *angle of glide.* Some gliders are constructed so that they need a small gliding angle, and some are constructed so that they need a large gliding angle, to make a safe descent. The angle that a glider must take for a safe descent is determined by the relation of the



Gliders with Differing Angles of Glide

Note that the larger the $\frac{L}{D}$, the smaller the angle of glide and the longer the glide.

lifting power of the wings and the resistance the glider feels as it passes through the air. When the lifting power of the wings has been carefully figured by mathematical rules, it is divided by the air resistance, or drag, which has also been figured by mathematical rules.

This division is represented by L (for lift) over D (for drag), or L/D. If the lift is great and the drag small, the ratio of L/D is large. When the L/D is large, the glider will not need to be nosed down so much — it will have a small gliding angle. If the L/D is small, the glider will need a larger gliding angle and its path will need to be steeper.

The three types of gliders might be classed on the basis of their L/D ratio. Those with an L/D of less than 10 fall into the primary training type, those of 10 to 15 into the secondary type, while soaring planes, sometimes called *soarers,* or *sailplanes,* may have an L/D of over 15.

It is plain to see that when the angle of glide is small, the glider will be able to cover, in a normal glide, a long distance before landing. In the soarers, which are finely constructed and extremely light in weight, the craft can sail along covering 20 feet in a horizontal line to every foot they lose in altitude. In the secondary-type glider the gliding angle is larger, and the glider covers about 12 feet horizontally for every foot it loses in altitude, while in the primary type the gliding angle is about 8 to 1, or 8 feet covered horizontally for every foot lost in altitude. Birds have a very small gliding angle. A condor, starting from an altitude of 2000 feet could glide for 100 miles without flapping his wings.

Because so many engineering problems must be solved in the construction of gliders in order to make them airworthy and safe, it is always wise for individuals or clubs that are planning to build one to use plans which have met the approval of the Department of Commerce.

Training for Glider Flying

If you entered a school as a glider student, you would begin your training on a primary glider. The control stick would be tied a little forward from neutral, so that the elevators would be held down, keeping the glider from nosing up and rising from the ground. While the glider was stationary, you would be instructed in the operation of the controls. Then as you were pulled along the ground, you would try to keep the glider level and straight. If you did well at this, the rope attached to the control stick would be changed enough to permit the glider to rise off the ground. Then as the glider was launched, you would become quite excited as you felt yourself in the air. It might seem to you that you were rather high, but you would only be about three feet off the ground and your first flight would cover only a distance of about seventy-five feet. The next step would be to take the rope on the control stick off altogether.

After you have shown that you can fly smoothly along level ground and make fairly good landings, you will begin your glides from a small hill with a gradual incline free from any obstructions. After you have mastered straight flying, you will practice making turns. After fifteen or twenty advanced hops in the primary glider, you should be able to take off in a 15-mile wind from an altitude of about 70 feet and fly for 30 seconds over a distance of 2000 feet.

The secondary glider is for those who have been taught on the primary glider. This glider is similar to the primary one, but it has a better gliding angle, is of lighter construction, and will not stand the abuse that the primary glider often has to stand during the training periods.

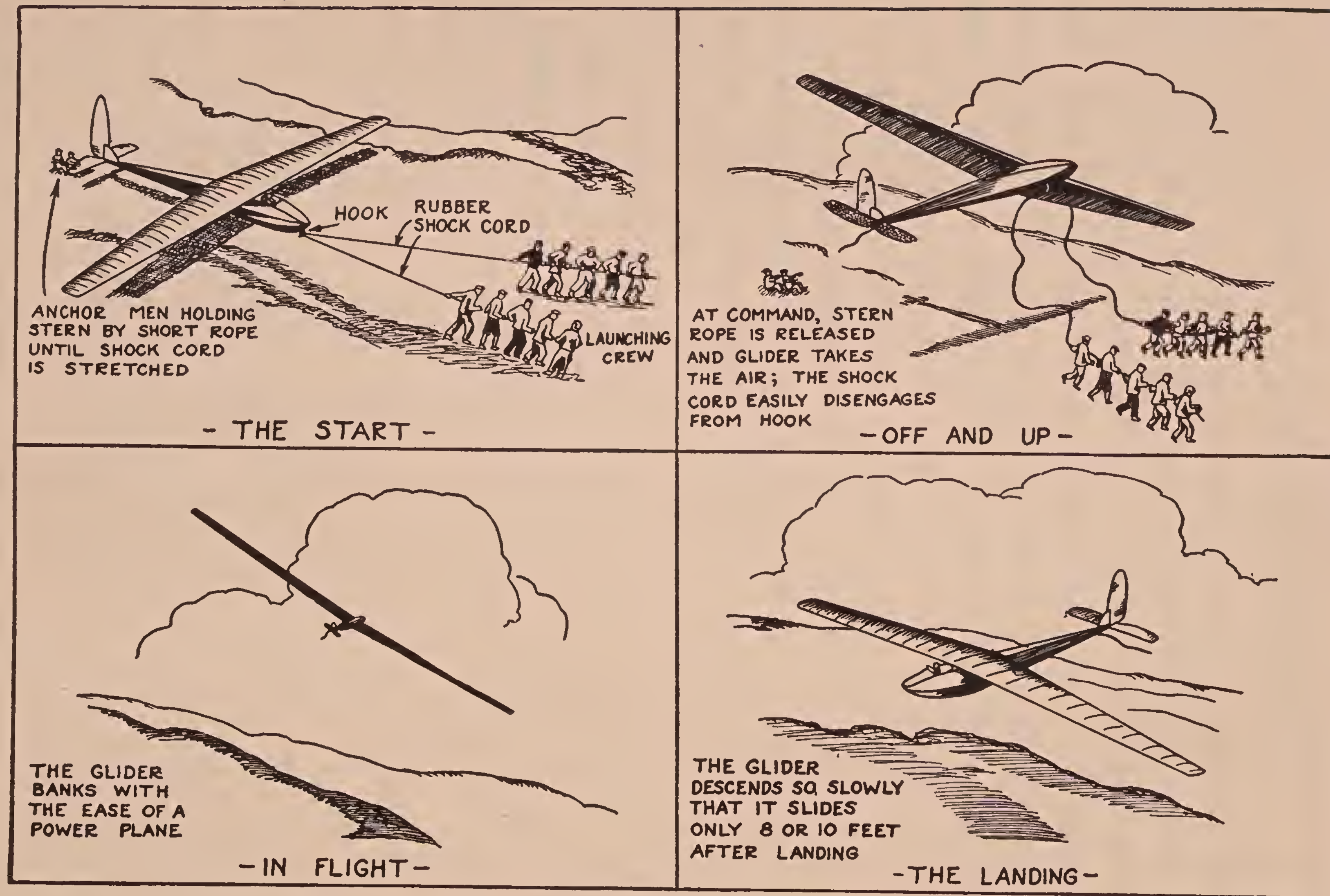
Then comes the soaring plane for advanced flight with an expert pilot. This is the type used in the record-breaking attempts for duration and altitude. They are beautifully streamlined and appear like huge birds with far-flung, slender wings.

Methods of Launching a Glider

The question arises as to how the glider is got into the air. Since a glider has no motor to pull it into the air, it must be launched. The launching of gliders from a slight elevation by the 'elastic-cord' method is the most elementary way and is considered by some to be a most satisfactory method for beginners. This is the method that is used in Germany, where they have had only three or four major accidents in ten years of glider training. To launch a glider by this method requires the services of several persons. To the nose of the glider, the center of a long cord is attached. Not fewer than three persons take each end of the cord and stretch it out in the shape of a V, the apex of the V being attached to the nose of the glider. The rear of the glider is held down by man power, or it may be tied to a post in the ground with a snubbing device from which it can be quickly released. As the men in front walk away from the glider, stretching out each end of the elastic cord, the person in charge of the flight says "Run!" and the men run forward. The rear of the glider is then released, the glider is shot into the air over the heads of the men, and the glider flight is begun.

The 'sling-shot' method is one in which the elastic cord in front is made fast and the glider is pulled back and suddenly released, so that it shoots out as your pebble flies out of a sling shot.

A common method in some schools is one in which an automobile is used to tow the glider. At first, the speed



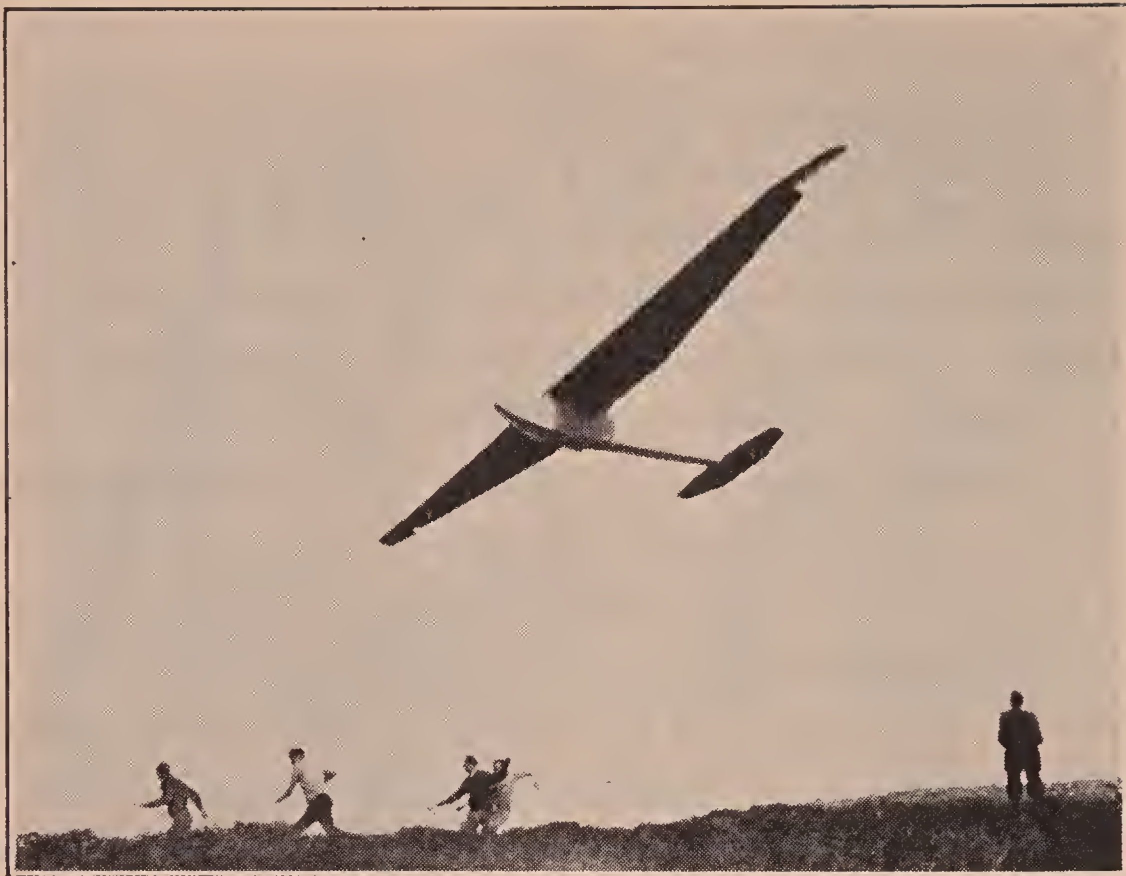
THE 'ELASTIC CORD' METHOD OF LAUNCHING A GLIDER of the automobile is just enough to keep the glider not more than three to six feet above the ground. Then the automobile slows down to give the student practice in landing. When the student gets the feel of flying and landing and gets more efficient at the controls, the speed of the automobile is increased, so that he gains more altitude, and by degrees he can make a longer and longer glide. Great care must be observed in towing a glider, and the automobile driver should be some one who has had experience, for he bears much the same relationship to the glider student that the airplane instructor does to the student pilot. In some types of gliders the fuselage is built large enough and strong enough to accommodate both the instructor and student. Towing gliders from an airplane without special permission has been forbidden by the Department of Commerce.

Regulations Governing Glider Flying

Without competent supervision in building gliders and without proper instruction in flying them, gliding may become exceedingly dangerous. This has been recognized by the Department of Commerce, and new federal rules and regulations pertaining to the construction, maintenance, and operation of gliders, have been made.*

There are three classes of gliders which are considered

* Bulletin on *Gliders and Gliding* may be obtained free of charge by writing to United States Department of Commerce, Aëronautics Division, Washington, D. C.



Bowlus-Hirth Glider School

A Glider Launched for Its Powerless Flight

eligible for license upon passing an inspection by the Department of Commerce. The first are gliders which have been manufactured under approved-type certificates or those built according to specifications and designs which have been approved by the Department of Commerce. The gliders of the second class are those not manufactured under the approved-type certificates, but which meet the requirements of such a certificate. The third class includes gliders manufactured prior to October 1, 1930, which have passed a visual inspection by the Department of Commerce as to "design, materials,. workmanship, and flight characteristics." The last-named class includes gliders built by individuals or clubs with or without previously approved designs, but which have been inspected and approved by the Department of Commerce. However, gliders so constructed after October 1, 1930, "will not be considered eligible for license."

The Department of Commerce has also provided for the following types of glider-pilot licenses: the student, the non-commercial, and the commercial.

The student permit gives the student the privilege of receiving instruction and of making solo flights with licensed gliders while under the instruction of a licensed glider pilot. No physical or written examination will be required.

The non-commercial license is for those persons who wish to operate a glider "only for sport and pleasure." To earn such a license, one must pass a flight test consisting of "a minimum of three flights, including moderate banks in either direction."

The applicant for a commercial glider-pilot license must pass the same examination as the one given for a private airplane-pilot license. There are no written examinations, but "in addition to normal take-offs and landings," he must include "a series of general and moderate banks, 360° turns and precision landings." Any holder of an airplane license who can satisfactorily complete the glider tests may receive a glider-pilot license.

It is a strange fact that most of the accidents in gliders have happened when they were being flown by airplane pilots. It seems that these pilots are often overconfident of their ability or overestimate the performance of which a glider is capable. The best advice is to learn from the ground up. Captain Hawks took this advice. He started out to fly a glider as though he were a novice and has become a very successful glider pilot.

Present Interest in Gliding

Scattered from coast to coast throughout the United States are hundreds of glider clubs, and other countries are becoming more and more enthusiastic over the possibilities of glider flying as an aid to aviation. Throughout Europe the German types of gliders and methods of flying are used mostly. Gliding is receiving attention in Italy, Belgium, Poland, Russia, England, and Australia. In Canada there is wide interest in gliding as a sport.

The first national soaring contest in America was held September 21 to October 4, 1930, at Elmira, New York. Of the fourteen machines entered in the contest only four were of the soaring, or sailplane, type, and two of these were made in Germany. The others were the so-called 'secondary type' of glider. Quite remarkable were the results of this contest. There were flights of 7 hours' duration and altitudes of 1500 feet were reached. Landings were made within a few inches of the take-off mark, but the most interesting spectacle was that of a pilot reaching for the sandwich suspended from the end of a fish pole held out to him by a pilot in another glider.

Even the birds showed their interest in the graceful soaring planes with their long slender wings through which the light shone with lace-like effect. They must have imagined them to be some sort of huge kin with whom they would like to become better acquainted, for they flew around not in the least afraid!

The German pilots were enthusiastic over the air conditions found at Elmira, and named it 'the Wasserkuppe of America.'

A glider is sometimes fitted out with a small engine and propeller and called a power glider. It is difficult to draw any sharp distinction between such a glider and a light airplane. A sixteen-year-old schoolboy from Long Island reached an altitude of 11,800 feet in a glider powered with a two-cylinder engine. On account of its lower cost and upkeep the power glider may become a popular type of aircraft.

Colonel Lindbergh's interest in gliding has increased the popularity of gliding. He says that, "It places flying within the reach of the great majority of people who never expect to become professional aviators and cannot afford the time and money required to learn to fly and operate a power plane of the present-day type."

PART V

RULES AND REGULATIONS

SOME AIR-TRAFFIC RULES
EARNING A PILOT'S LICENSE
AN AIR FLIGHT
MANEUVERS

CHAPTER XVII

SOME AIR-TRAFFIC RULES

In 1926 an Air Commerce Act was passed by Congress. It is the foundation upon which the Department of Commerce bases its Air Commerce Regulations.* These regulations come under eight heads: namely, licensing of aircraft, inspection of aircraft, operation of aircraft, marking of licensed and unlicensed aircraft, licensing of pilots, licensing of mechanics, air-traffic rules, and miscellaneous.

These may be supplemented by additional rules and regulations to meet such needs as arise in the rapid development of aëronautics. For instance, when gliders became so popular, the department forestalled danger by making new rules which would apply specifically to this type of aircraft and to this method of flying.

Identification

All aircraft must have some mark of identification. When you see a large Roman 'S' on aircraft, you may know it is used solely for governmental purposes and belongs to states, territories, possessions, or political subdivisions

* Copies of air-traffic regulations in full may be obtained free of charge upon request to Aëronautics Branch, Department of Commerce, Washington, D. C.

of the government. There will also appear numerals and perhaps a symbol representing some particular department. On all other licensed aircraft you will see a large Roman 'C' followed by numerals. This means that it was built according to design that had been approved by the department and that it has been tested and found airworthy. The letter 'N' must precede the license symbol and numerals on licensed aircraft if it is engaged in foreign air commerce.

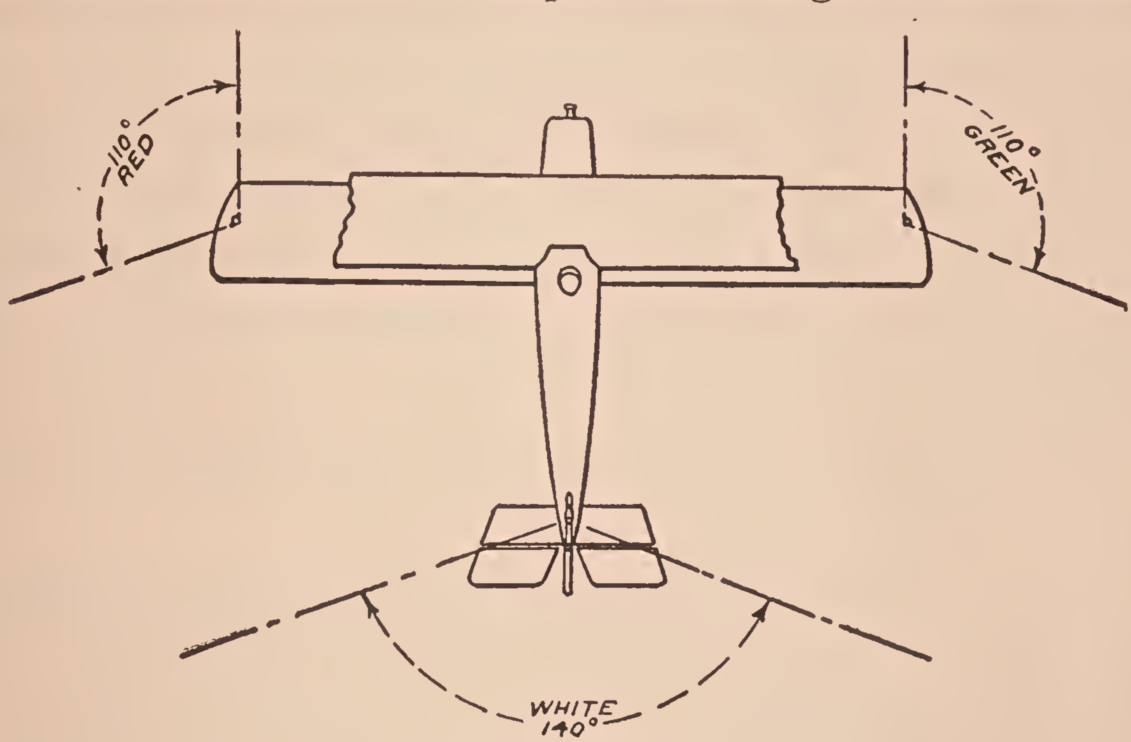
Aircraft which is unlicensed must always bear some mark of identification assigned by the Secretary of Commerce, but this alone is no guarantee of its airworthiness. Except with the approval of the Secretary of Commerce, "no design, mark, character, symbol or description" which "modifies, adds to or subtracts from, or confuses the assigned mark or destroys its visibility" shall be placed upon aircraft.

Inspection

Within twenty-four hours preceding each flight the aircraft must be given a line inspection by a licensed airman. After each 100 hours' flight it must be given a "periodic inspection" by a licensed mechanic. Then after 300 to 350 hours, the motor plant is removed and completely overhauled. All minor repair work on damaged aircraft must be inspected and approved by a licensed mechanic, but if the aircraft was seriously damaged, all repairs must be approved by a Department of Commerce inspector before it is flown again with passengers for hire.

Lighting

The matter of lights on aircraft is becoming increasingly important, and rules have been made in regard to them. Between one-half hour after sunset and one-half hour before sunrise, all airplanes in flight must show a



Airplane Lights

Airplanes in flight at night must show red, green, and white lights, each showing unbroken light as indicated.

green light on the right side, a red light on the left side, and a white one in the rear. These lights must be set according to specific rules and those on the sides must be visible for two miles, while the one in the rear must be visible for three miles. A special regulation governs color and arrangement of lights on balloons and airships. In addition to the rules governing navigation lights, aircraft carrying passengers for hire must have additional electric landing lights.

Some Flying and Landing Rules

It might seem that there would be plenty of room in the air to maneuver aircraft, or that they were not numerous enough to require special attention to traffic rules, but accidents occur from time to time which could have been avoided had rules been properly observed.

If you were riding in an airship and a balloon appeared, according to traffic rules your pilot would have to give it right of way, but if you were riding in an airplane, your pilot would have to give way to either a balloon or an airship.

In taking off or in landing, a pilot, whenever it is possible, heads his aircraft into the wind.

When in flight, aircraft must keep to the right in passing each other and must maintain a distance apart of at least 300 feet. In flying over cities, towns, or settlements, the pilot must maintain an altitude of at least 1000 feet. Over open country and when carrying passengers for hire, he must at all times maintain an altitude of at least 500 feet. If weather conditions prevent this, he must effect a landing at once either by returning to his point of last departure or by going to the nearest landing field or any other area where he can make a suitable emergency landing.

By special permission of the Department of Commerce a pilot may deviate from the traffic rules. One illustration is the flying of an industrial pilot at low altitudes over agricultural areas, distributing dust to kill injurious insects.

Air Acrobatics

Special rules apply to intentional maneuvers not necessary to air navigation, so-called 'air acrobatics.' All persons in planes performing acrobatics must wear parachutes whose type and design has been approved by a government official, but a pilot is prohibited from stunting any aircraft in which there are paid passengers. No acrobatics may be performed over or within 1000 feet horizontally of any airport, or over any congested area of any city, town, settlement, or below 2000 feet over any established civil airway. Over other areas the acrobatic maneuver must be concluded at a height greater than 1500 feet.

Aviation and the Law

To help in making the skyways safe, the government maintains a corps of trained inspectors. They are the cream of the nation's flyers, combining flying skill, experience, and engineering qualifications. These aëronautical experts inspect aircraft, examine pilots and mechanics, rate flying schools, investigate accidents, and report violations of air traffic. State legislatures have enacted laws pertaining to aviation within their boundaries. In December, 1930, Mr. Robert Lamont, Secretary of Commerce, invited the governors of the states or their representatives to a meeting in Washington, D. C., to discuss plans for unifying federal, state, and municipal laws for aviation. Persons connected with the aircraft industry and with various business organizations, as well as some who were especially interested in the problem, were also invited to attend.

Great precaution is taken in the settlement of all cases pertaining to aëronautics. It is said that at present all the laws on aviation could be printed in two volumes. Since 85 per cent of all law is based upon custom and precedent rather than on statutes that are made by legislative bodies, it is easy to see that the terms of settlement in some particular case may be the basis upon which all subsequent cases of similar nature are settled. This is particularly true in the settlement of cases where different nations are involved. As aircraft travel becomes more extensive between the United States and other countries, circumstances will arise which will need a new interpretation of existing laws or an entirely new set of international laws. Development of commercial aviation will demand uniform flying regulations observed by all nations.

Aëronautical law is in the making. It would be a most interesting research problem for the boy or girl who has a flair for legal matters or for those interested in law as a profession to watch the daily papers and to note the settlement and terms made in all cases pertaining to any phase of aëronautics.

CHAPTER XVIII

EARNING A PILOT'S LICENSE

Perhaps you have just taken your first airplane ride or your friend has just received a pilot's license. You may have been thrilled by some new air feat, or perhaps you may be looking upward at the bird-like object high above with its whirring motor, when your enthusiasm for aviation suddenly transforms itself into the idea that you, too, will learn to fly.

If you are young and can receive your parent's consent and financial support, you are favored indeed. There are many young people today who have earned their private pilot's licenses at sixteen, the minimum age requirement of the Department of Commerce for such licenses.

Boys eighteen years old have flown across the continent, and a girl in Omaha, Nebraska, had more than two hundred hours in the air before she became sixteen years old and eligible for a pilot's license.

The Medical Examination

Every one who decides to fly must pass a medical examination. The tests given to applicants for the government schools are very rigid, since a military pilot must learn to fly under all conditions and must be able to perform all sorts of acrobatics. He is trained so that he can maneuver his aircraft in all possible war-time combative emergencies. But the examinations for the civilian and the commercial pilot are not so exacting. They are given by physicians appointed by the Department of Commerce.

It is an anxious moment when you await your turn in the doctor's office. You wonder if perchance you may have some ailment unknown to yourself which will prevent you from passing the test. Your heart seems to be beating at an unusual rate of speed this morning. Probably it is due to suspense — you will find out soon, however. The nurse appears, and you are ushered into an office where there are some queer-looking pieces of apparatus.

You are seated, and the eye test, one of the most important tests, is given. One part is similar to the one you took when you were in school. Then the leaves of a book are turned, and you tell the numbers that appear on a page thickly covered with all sorts of colored dots and dashes. This is to see whether you can distinguish colors quickly and whether you are color blind. You look straight ahead while the nurse, holding up fingers at one side and the other for you to count, tests your 'perimeter' of vision. Then you look at an object far away and at one near by to test the ability of the eyes to change their focus rapidly.

Now you are given two strings which lead across the room to a little movable post on an oblong platform on which there is a similar stationary post. You can see only the top of the posts, but you pull the strings to bring the movable post forward or backward so that it appears to you to be exactly beside the stationary one. On three trials your average error should not be more than 1 3/16 inches. This tests your 'depth perception' and your judgment of distances.

You listen to the tick of a watch as a test for hearing.

Some other tests follow, but at the conclusion the nurse assures you that you are normal or above the average; so when you stand before the doctor for the physical examination you are quite yourself.

He finds your heart regular and your other organs in good condition. A test proves that your blood pressure is normal for your age. You have to stand a certain number of seconds first on one leg then on the other with your eyes closed, to test your sense of balance. You feel rather wobbly, but your performance must have been satisfactory, for he nods his approval as you open your eyes. You sit and cross your legs and he gives a little whack just below one of your knees. Up flies your foot, and he assures you that your reflexes are all right. Probably the physician has been testing your 'temperament' by the answers you have given to apparently random questions. Finally he fills out a paper which states that you are eligible, from a medical standpoint, to enroll as a student flyer. You pay the fee and leave the office.

Selecting a Flying School

Now you select a flying school. Time was when the would-be flyer must either join the Army or the Navy to receive aëronautical education, or else risk his life in some worn-out plane while receiving instructions from a pilot whose qualifications rested upon his barnstorming experiences. Now flying schools are approved and rated by the Department of Commerce.*

An amendment to the Air Commerce Act passed in February, 1929, authorized the Secretary of Commerce to provide for the examination and rating of flying schools. Although nothing can be done to compel schools to meet certain standards, those that do fulfill the requirements and become 'approved' by the Department of Commerce have a decided advantage over competing schools which do not have such a rating.

If an approved flying school is in your vicinity, you will doubtless choose it as the one where you will enroll as a student. Such a school will have met a certain standard as to size of field available for take-offs and landings, and type of plane and number available for flying instruction. There will be hangar and shop facilities for proper maintenance and repair of the school's planes. Then there will be satisfactory classroom facilities for ground-school courses.

* A list of aviation schools having approved school certificates may be obtained from the Department of Commerce, Aëronautics Branch, Washington, D. C.

Ground School

The ground-school courses will be given by a teacher licensed by the Department of Commerce to teach each subject. Your courses in ground school will include instruction in Air Commerce Regulations; in aviation engines, including principles of internal combustion, carburetion, ignition, lubrication, cooling, construction, inspection, maintenance and repair; airplanes, including history of aviation, theory of flight, nomenclature, aërodynamics, construction, rigging, inspection, maintenance, and repairs; meteorology; aërial navigation; aircraft instruments, including radio and its use in aëronautics; and the care and use of parachutes. The number of subjects, and the required time to be devoted to each varies with the type of license, the transport ground course being the fullest and most complete.

In the Air

The flying instructors are transport pilots who have passed satisfactorily the prescribed Department of Commerce tests. Many such instructors hold college degrees. You will be assigned to one with whom you probably will remain as a student until your 'check' flights are taken with the chief instructor of the field before you 'solo.'

One day he tells you that the chief instructor is to fly with you. This flight disturbs you somewhat, for you certainly do not make your landings so well as you did with your instructor. Once you leveled off too soon and 'pancaked' pretty badly. The chief looks out over the cockpit on this side and that as if to see if the landing gear is still intact. Another attempt and you land on the front wheels. Up you bounce, but before you strike the ground again you have 'given it the gun' and are away for another trial. This time and the next you do better, but not so well as you feel you should. You 'taxi' across the field to the line. You do not dare ask any questions; you feel pretty humble at your bad performance. You notice your instructor and the chief instructor talking by themselves, and you wonder what they are saying about you.

You feel rather discouraged, but you return the next day. Nothing has been said about your soloing, and you certainly do not mention it yourself after yesterday.

The day is perfect; you cannot remain depressed. As you take off into the clear atmosphere you almost forget that your instructor is sitting in the front cockpit. Somehow a sense of mastery over this mechanical thing comes over you. You bank your turns just right, you come down at just the right gliding angle, and your three-point landings are smooth. On the third one you receive the signal to remain on the ground. The instructor is getting out. He looks about him and waves for you to go alone.

With a little prayer on your lips you are rising over the field. Almost before you know it you are around and have landed again, not just where you had planned, but safe, sound, and 'soloed.'

Days with check flights and solo flights follow. It is with a good deal of pride that you receive a card from 'contact' and take a plane from the line without a check flight. But you know that it is said, "Pride goeth before a fall," and you hope never to feel overconfident of your ability. In ground school you have studied some of the principles of aërodynamics, and you know many things about airplane engines. You know that you must be on the alert every instant, especially during this early period of your flying experience, and that you must always have your mind on your plane rather than on the people who may be watching you.

A Private Pilot's License

Since you have chosen an approved school, you will be ready for your private pilot's license after eight hours of solo flight. In this time you will have learned to make gentle and steep figure-eight turns, to spiral from two thousand feet with engine throttled, and to make good three-point landings within five hundred feet of any particular spot.

Perhaps you may be rather nervous as you perform these feats before the Department of Commerce inspector. You may not have answered the questions in the written test as completely as you might have done. But you passed, and you now possess a private pilot's license. This certifies that you are "a private pilot of aircraft of the United States." You may pilot "all types of licensed aircraft, but may not for hire, transport persons or property, nor give piloting instructions to students."

Other Types of License

Other types of license are the limited commercial, the industrial, and the transport. To earn a limited commercial license or an industrial license, one must be able to pass a more extensive written examination, have more solo-flying experience, and be able to accomplish satisfactorily certain air maneuvers and as many others as the Department of Commerce inspector deems necessary. The transport license is the highest type of license, and when one has earned such a one, he may feel that he has reached one of the high goals in aviation.

Other types of license which will eventually be included in the transport license are given for a certain number of hours' experience on seaplanes and on motorless aircraft.

The time necessary for earning a pilot's license depends upon the ability of the student to learn the art. New methods of instruction are decreasing the amount of dual instruction necessary before solo flying, after which the student's progress depends upon the actual solo time he can put in. Weather conditions may retard progress for the student, since he must gain his early solo-flying experience under favorable weather conditions. There is not, as formerly, any set time in which he must actually complete his course, but generally the student who is devoting all his time to training may secure a transport license in less than a year. Many secure it in six months.

Expense Involved in Earning Licenses

The cost in an approved school ranges from $600 for a private license to $4000 for a transport license. To this one must add living expenses and probable transportation to the flying field.

Although the money involved is a large item, if one considers flying as a profession, it is far less costly than the required preparation for such professions as law, dentistry, or medicine. The Department of Commerce survey, April 1, 1930, of 84 per cent of approved schools is as follows:

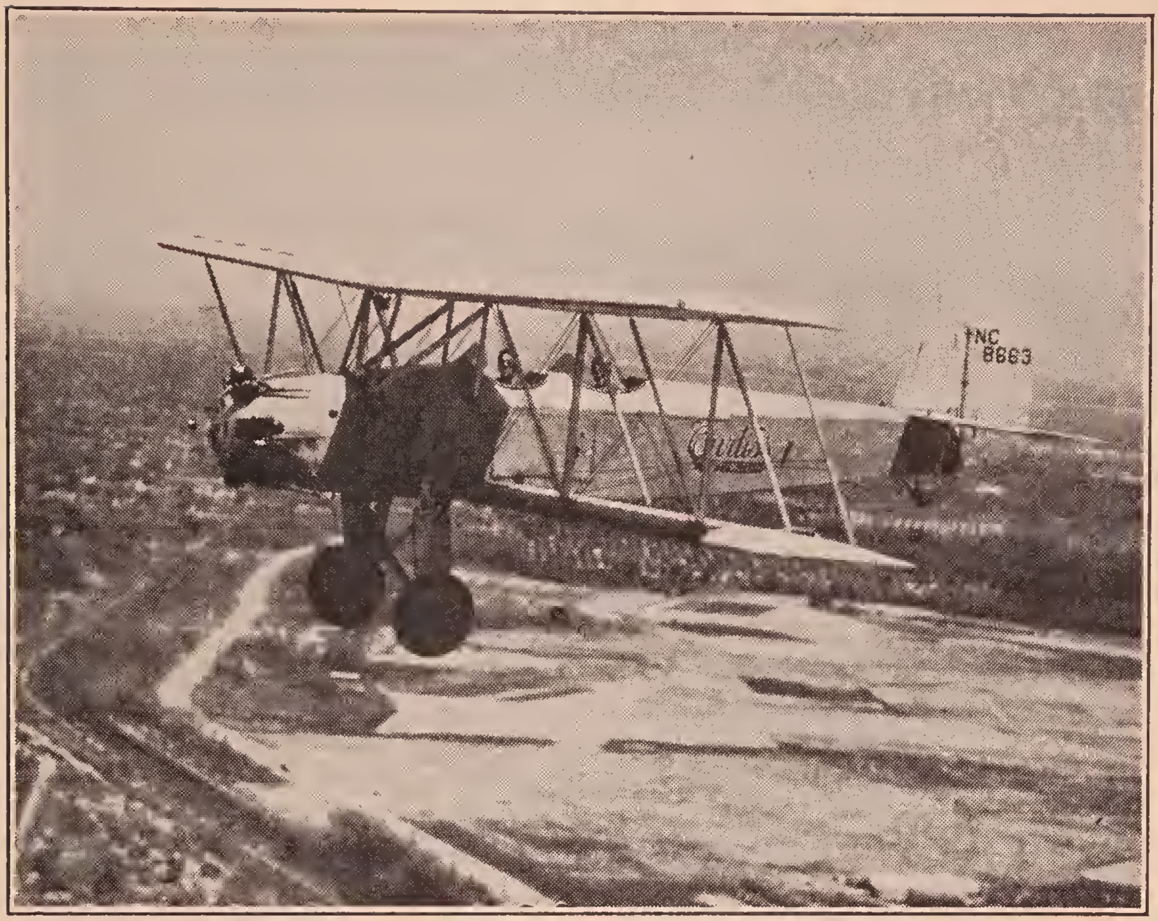
Type of License	*Average Cost*	*Average Time*
Private	$ 345–$ 650	7⅙ weeks
Commercial	$1050–$1500	5⅘ months
Transport	$3075–$4618	8⅛ months

CHAPTER XIX

AN AIR FLIGHT

One of your most interesting experiences will be, or perhaps has been, your first ride in an airplane. Before going up in an airplane you should always make sure that its safety and airworthiness have been approved by the Department of Commerce. A licensed plane will have the license given it by the Department, inside the cockpit or the cabin. It will have a number assigned to it which will be printed on the wings and on the rudder. The number will be preceded by a 'C,' which shows that it is a commercial plane and that it may be used to transport or carry passengers. Your pilot must hold either a commercial license or a transport license. The former allows a pilot to operate planes with paid passengers within an area ten miles distant from an airport; but since the transport license is given only to those who have had at least two hundred solo hours in the air, you will feel safer when a transport pilot is at the controls.

You will doubtless take your first air trip from some approved airport on a fine day when there are not many, if any, clouds in the sky. Although practically every passenger plane is of the cabin type, most of the student



STUDENT PILOT (REAR) WITH HIS INSTRUCTOR (FRONT) IN A TRAINING PLANE

planes are of the open-cockpit style. From the latter one gets a better idea of the use of the controls. It will be in this type that you, as a prospective student, will take this demonstration flight. After you have donned a flying suit, a helmet, and a pair of goggles, and fastened on a parachute by snapping the strap fasteners across your chest and around your legs, you will take your seat in the rear cockpit of a sturdy biplane, while the instructor, a transport pilot, will climb into the forward seat.

He will warn you to fasten your safety belt, a belt which holds you securely in your seat, but which may be unfastened very readily by merely flipping over a piece of the metal part of the buckle. A mechanic is on hand to help get the motor started. Notice that the ignition switch is turned off. In an automobile this is often done by turning a key, but here a little lever is used. It is kept turned off while the mechanic winds the starting crank or else turns the propeller around and around. Then as he jumps back and says "Contact!" the pilot shouts back "Contact!" as he turns on the switch and pulls the gasoline throttle part way back. The engine starts its steady roar. While it is warming up, you will have a chance to study the instruments. If the field is at sea level, the hand on the altimeter will point to zero. A compass may be attached in front, perhaps on the underside of the center wing section. Notice the tachometer; it now registers about fifteen hundred, which means that the crankshaft with the attached propeller is making that many revolutions per minute, spoken of as R.P.M.'s. Then there are the oil-pressure gauge, the oil-temperature gauge, and the speed indicator. You are not moving yet; so the air-speed indicator points to zero.

Of course for cross-country or long flights there doubtless would be several other instruments, but these will keep you acquainted with the way your motor is performing, an important point for every flight, no matter how limited in duration or distance.

The pilot is going to let you 'follow through' on the controls. Place your feet on the rudder bar to keep the rudder in the rear straight; place your right hand on top of the control stick, sometimes called the 'joy stick'; place your left hand on the throttle. The mechanic removes the chocks, or blocks, from the front of the wheels. The throttle is moved forward and the stick held back as your pilot taxies across the field and turns to face the wind. This is done to decrease the ground speed and lessen the length of run, as well as to give the plane a quicker lifting force. It is easy to see that if one took off with the wind, the ground speed would be so great that some obstacle might be encountered before sufficient lift could be obtained. Did you notice how the elevators, or flippers, in the rear are pulled upward as the stick is held back in taxiing? The air is packed up against these surfaces; this keeps the tail down, preventing the heavy nose from tipping forward when the plane goes over any bumps on the ground. Now the pilot looks backward and around to see if any plane is about to land, for landing planes, as you recall, always have the right of way. Everything is clear. The throttle is pushed forward as far as it will go, to give the engine flying speed. The stick, too, is forward now; see how it changes the elevators to a downward position, so that the air pushes up the tail of the plane. You race across the field with your feet holding the rudder straight. Gradually the stick is pulled back again, lowering the tail, so that the plane is nosed up on the climb. You have left the ground, and with a steady climb you are up 1000 feet, yes, 2000 feet, in a few short seconds. The stick is now just straight or in neutral; the throttle, too, is pulled back to reduce the R.P.M. to about 1500, so as not to race your engine.

You look over the side but feel no dizziness at all;

you have the same sensation that you may feel when you look over the side of a tall building.

You do not realize the speed, either, at which you are flying; yet the air-speed indicator registers eighty miles an hour. That does not mean, however, that you are actually passing over the ground at that rate, for you have been flying into the wind, the velocity of which, say, fifteen miles an hour, retards you just that much, to say nothing of the effect of the upward climb. But see now what is happening. The pilot is pressing on the left rudder to steer the plane left, but at the same time he is pushing the stick to the left. Notice the left aileron is up and the right one is down. The air pushing against these surfaces forces the left wing down and the right wing up, tipping the plane sideways. This is called *banking.* Your pilot, through his experience in the air, knows how to use the combination of the rudder and the stick to bank the plane at just the right angle in proportion to the speed, so that the plane neither skids toward the outside nor slips toward the inside.

Unlike an automobile, in making turns a plane cannot slacken its speed, for if there is not sufficient speed there will not be sufficient lift given to the wings; and when the lift is decreased, 'Old Man Gravity' starts working to pull you down. You observe how easily your pilot makes the turns, how smoothly he operates the controls, how he keeps the nose on the horizon, and how straight he can fly. You have no fear and know that you could learn quickly the feel of the air, while keeping an eye on the instruments. You gain confidence in the ability of your motor, for you remember having read that accidents very seldom occur through defects in a plane or engine, but rather through the thoughtlessness or recklessness of some pilot. You have confidence in yours, and you know that he will not attempt any maneuvers which may be dangerous. But listen, the noise of the motor has decreased, and the throttle is all the way back. Notice, too, that the horizon comes above where it was before. The plane is gliding downward into the wind toward the field; it loses altitude; you are nearing the edge of the field, sinking lower and lower. Now the stick is gradually pulled back as the plane levels off; and before you are aware that you have touched the ground, your pilot has set the plane down easily and smoothly on wheels and tail skid in what is called a 'three-point landing.'

You observed by the wind indicator on the hangar and by the small flags on the field in which direction the wind was blowing. The pilot took notice of these things and flew into the wind as he landed, for the force of the wind retards the ground speed of the plane and makes a landing in a small area safer. It also shortens the length of the run after landing. Did you notice how careful he was to hold the rudder bar rigid and straight so that no surface wind or rough spot on the ground would cause the plane to pivot around rapidly in what is known as a 'ground loop.' This landing error sometimes tips the plane over on the wing, causing damage to that member. Notice, too, that after landing he still holds the stick back, which keeps the tail down, and drags it along on the tail skid, thus bringing the plane to a dead stop. He looks around and sees another plane gliding in on the right; so he waits until it has landed before he taxies back to the line.

You have had your first air ride and can tell all your friends how delightful it was and advise them all to try it for themselves.

CHAPTER XX

MANEUVERS

The Department of Commerce characterizes any intentional maneuver not necessary to air navigation as 'acrobatic flying.' As you already know, one has to be able to perform some maneuvers in the air in order to earn a license to fly, but there are many kinds of acrobatics which pilots are able to perform. The use of the plane during the war brought out the necessity of the pilot's being able to handle his plane in many spectacular ways in order to evade his enemy or to conquer him. It is always a debatable question just where useful knowledge of air maneuvers leave off and where 'stunting' maneuvers begin.

The Department of Commerce requires a candidate for a transport pilot's license to pass a flight test which includes the following maneuvers: "From fifteen hundred feet with engine throttled make a 360° turn and land in normal landing attitude, by wheels touching ground in front of and within two hundred feet of a line designated by examiner for the Department of Commerce. Fly in emergency maneuvers such as spins, spirals side slips, climbing turns, and recovering from stalls, and such others as the Secretary of Commerce deems necessary. Fly over a rectangular course at least one hundred miles, landing at place of take-off within five hours. This flight shall also include two obligatory landings, not at point of departure, when craft must come to rest. The course will be designated and the candidate will be furnished with route information by the examiner for the Department of Commerce at time of departure and the examiner for the Department of Commerce will determine whether the course was correctly followed and whether obligatory landings were satisfactory. Upon the presentation of satisfactory proof that the candidate has engaged in solo cross-country flights at a distance of at least one hundred miles within one year preceding the date of his application the flight specified in this subsection will be omitted. Cross-wind landings and take-offs must be effected."

The same flight test must be passed by candidates for a commercial license except for the cross-country flight; for industrial pilots "the cross-country flight shall be sixty miles." The flight test for the private pilot is more simple and consists of "a series of five gentle and three steep figure eight turns from eight hundred to one thousand feet respectively." "Spiral in one direction from two thousand feet with engine throttled and land in normal landing attitude by wheels touching ground in front of and within five hundred feet of a line designated by examiner of Department of Commerce and three satisfactory landings."

Stunt Flying

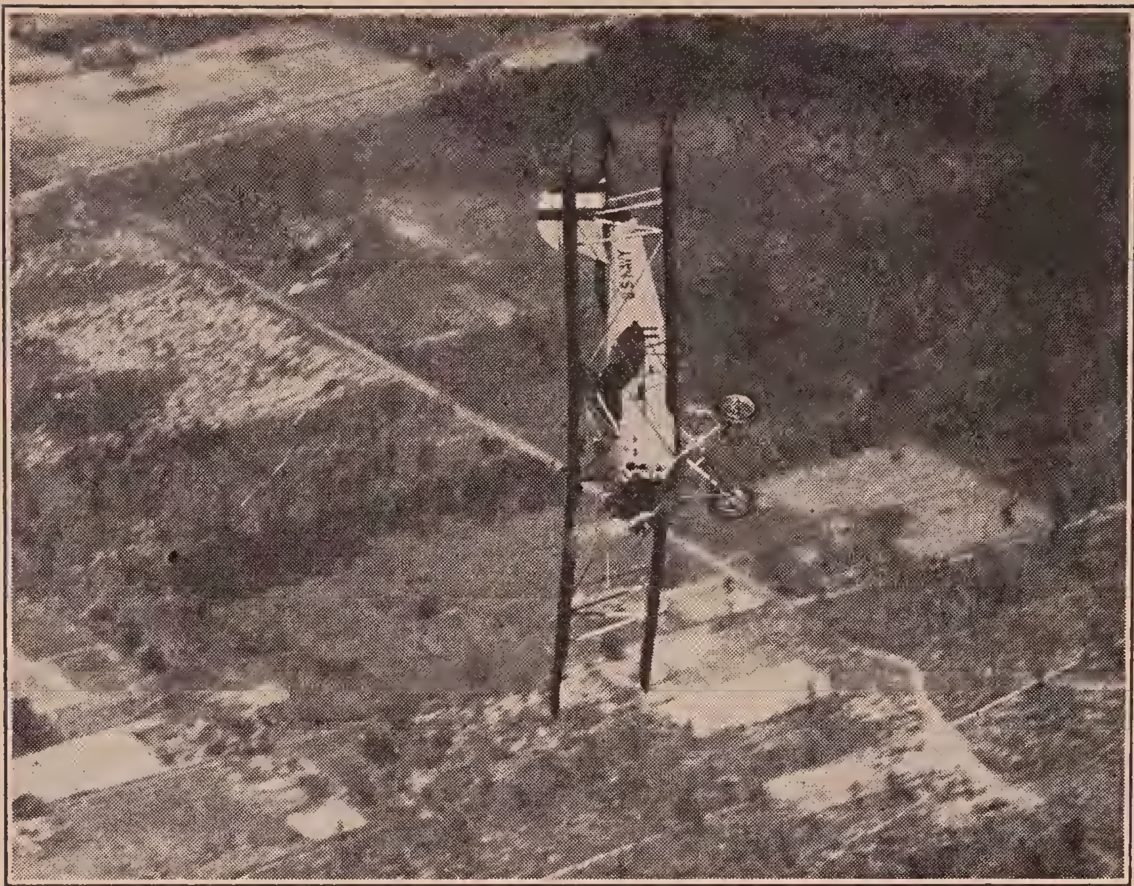
The performances of the stunt pilot always meets the ardent admiration of the public. Every one likes to be admired, and this urge in younger and inexperienced pilots often leads them to attempt that which their training and experience do not warrant. Then, too, fatal accidents sometimes occur because an ambitious pilot attempts to do maneuvers in a plane whose structural design was not at all intended for such uses.

Aëronautical engineering has done much toward the development of safe aircraft for all purposes. There are men who design aircraft who themselves do not even fly, yet their mathematical solutions to the problems of air flight are so accurate that their product performs just as they had planned that it would.

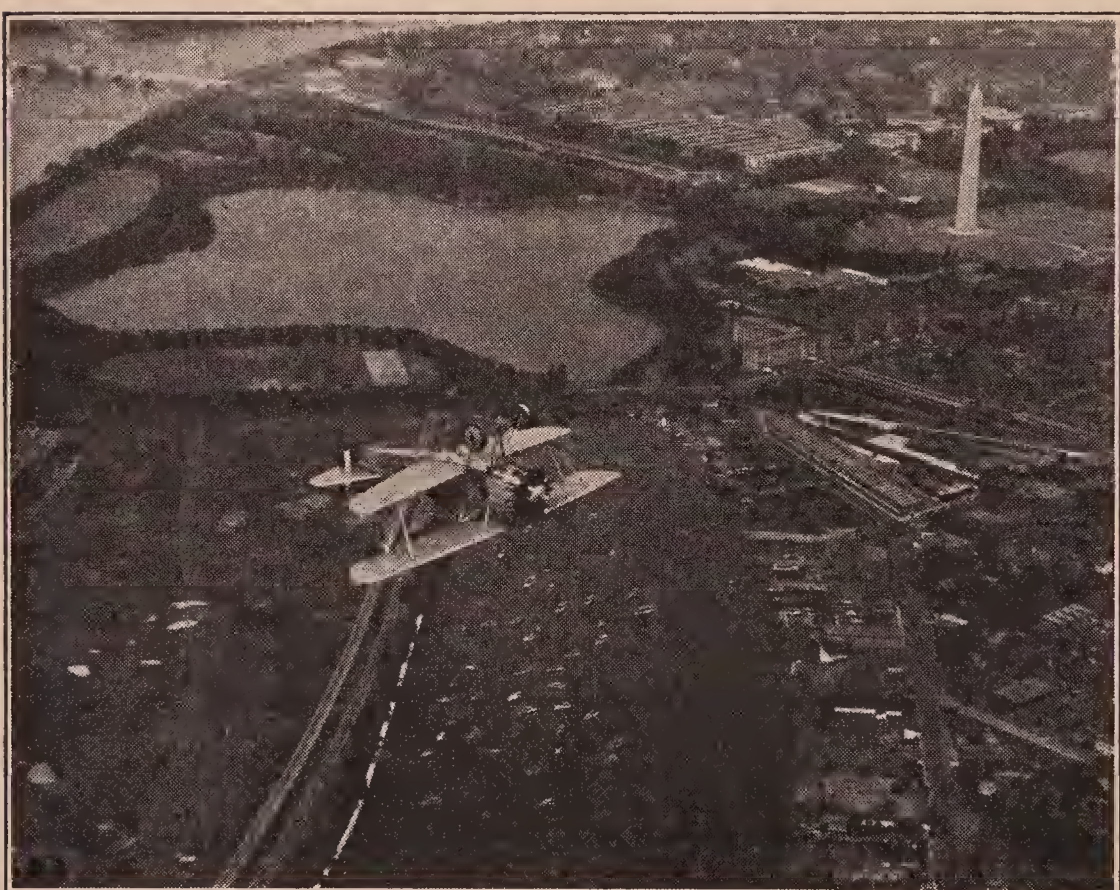
The qualities required for the ideal airplane are "strength, rigidity, plenty of reserve power, compactness and responsive controls."

One marvels at the speed with which an experienced pilot can take a reliable plane aloft and that he can put it through such startling maneuvers.

There are many persons today who believe that sensational stunt flying does not promote the interests of aviation, and that the pilot skillful in getting out of a tight place should use his skill in avoiding such situations. The opinion of a majority of pilots with long experience seems to be that if a pilot, other than one in the Army or Navy Air Corps, can spin and recover from a spin and can



Plane Flying in Vertical Bank Position



Aëronautical Chamber of Commerce of America

Plane in Inverted Flight

do side-slips and stalls, vertical banks and turns at various angles, he has learned the necessary maneuvers for safe flying and emergency landings in small areas.

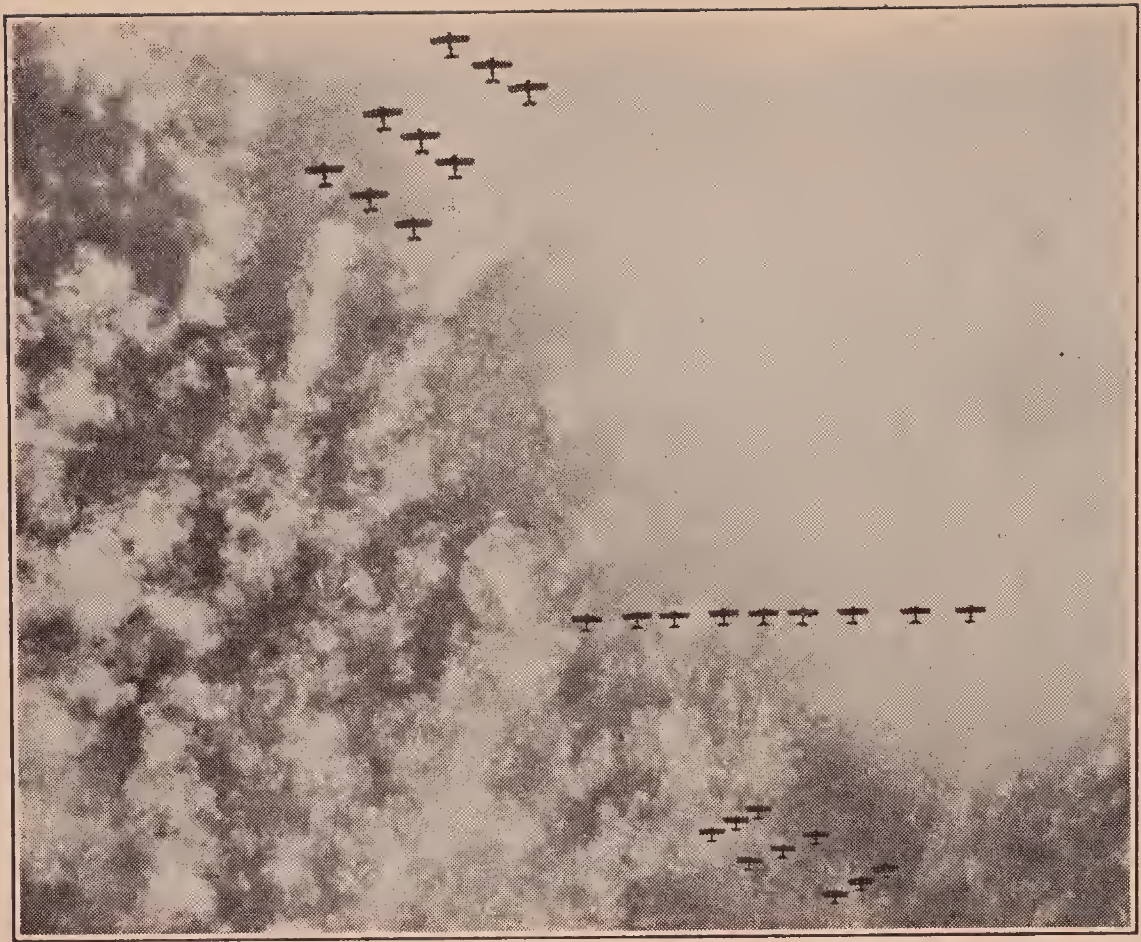
Perhaps you would like to know what happens in some of these maneuvers.

Let us consider 'spinning.' You have read that when a plane stalls, it loses flying speed and the necessary lift to overcome the force of gravity. In all falling bodies, the heaviest part leads in the rotating descent. It happens so in the case of a plane: the heavy nose falls forward and the plane descends vertically with a whirling or spinning motion, the tail describing the larger circle. Thus, the descent is spoken of as a *tailspin*.

When a pilot purposely makes a tail spin, he noses the plane upward into a stall and applies the rudder in the direction of rotation. As the plane falls, the rapid forward motion creates enough lift to the wing surfaces to bring the plane again in normal flight. Of course, such a maneuver must be done at sufficient altitude so that a plane can right itself before crashing into something or hitting the ground.

The manner in which an airplane spins; that is, the number of times it will spin around in, say, 1000 feet, depends upon its design and upon its rudder setting.

'Looping' is another favorite acrobatic stunt. In this maneuver the plane is flown at such speed that as it is nosed upward and the throttle pulled back, there will be sufficient impetus to carry it over the top of a loop.



Aëronautical Chamber of Commerce of America

PLANES OF AIRCRAFT SQUADRONS IN FORMATION FLIGHT

Clyde Sunderland

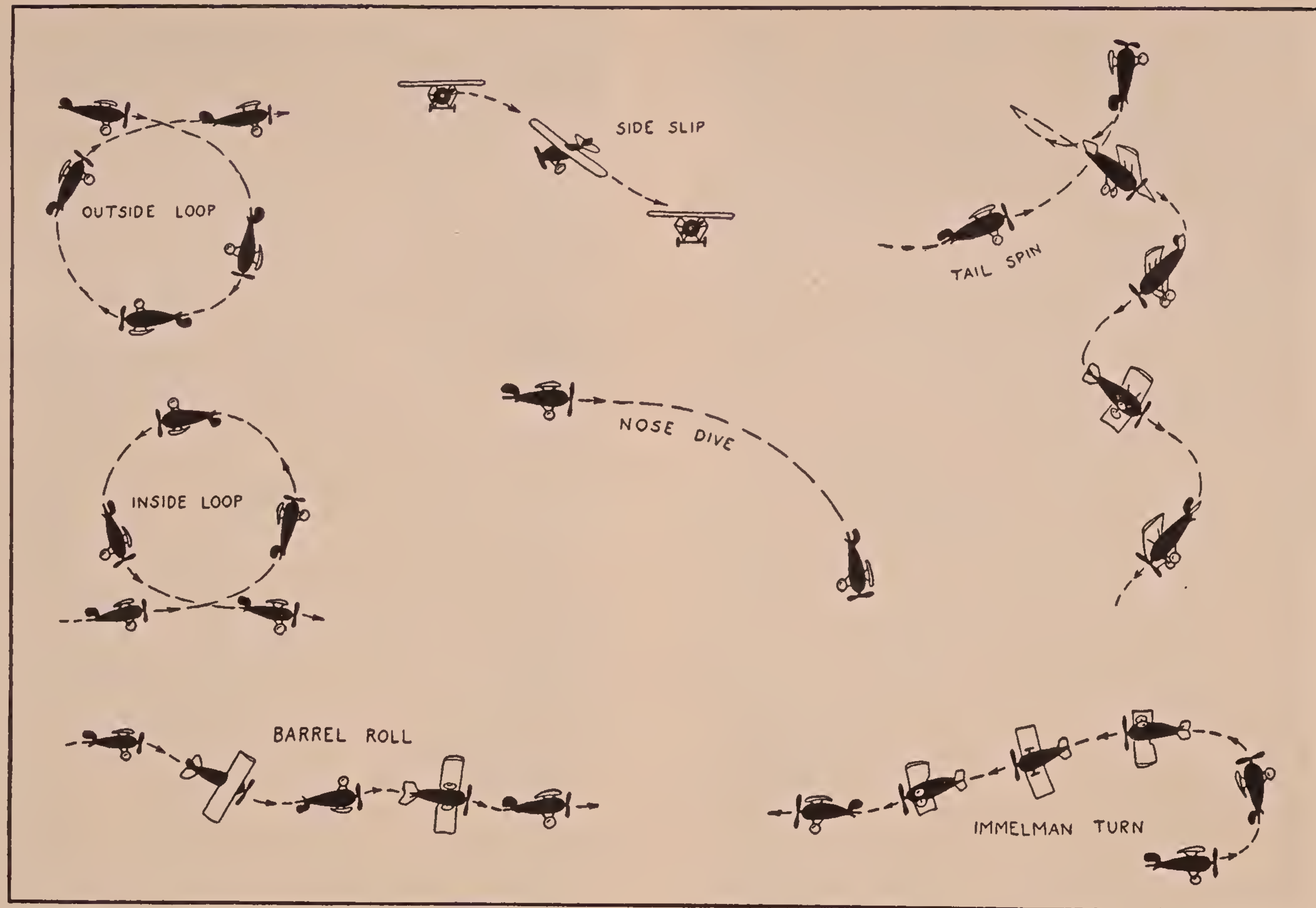
ARMY CONDOR BOMBING PLANES IN MANEUVERS

As the plane takes the path of the elliptically shaped loop, it literally turns over on its back and comes around in the same direction in which it was headed before looping.

The first man to do this stunt in this country was Lincoln Beachy. In 1913 he learned that Adolphe Pigoud, a French flyer, had looped the loop and a year later Beachy had not only done the same thing once but a thousand times. Before the World War, Ruth Law had the distinction of being the first woman flier in America to loop the loop. Today it is not considered a difficult stunt at all, and there are experts who have even made outside loops. In an outside loop the plane noses downward, around and back to normal flight. The reason why this is so much more difficult is that the pilot is on the outside of the loop. The centrifugal force affects him physically, making it difficult for him to keep his senses clear for the proper handling of the controls.

The 'side-slip' is a maneuver that is used to lessen altitude. The occasional stopping of a motor in flight makes a knowledge of this maneuver most gratifying. It enables the pilot to land in a small-sized field. By banking the plane with the stick, applying the opposite rudder, and keeping the nose forward in a normal gliding position the plane slips sideward, losing altitude rapidly. Recovery is effected by raising the low wing to horizontal and changing the rudder control.

The 'wing-over' is a pretty maneuver. It consists of a steep climbing turn, followed with a diving turn, both to-



SOME OF THE MORE COMMON MANEUVERS

gether making a half circle. It is a quick way to change direction of flight.

The necessity during the World War for pilots to be able to make quick 'get-aways,' to deceive the enemy planes as to methods of attack, and to get into a position for machine-gun effectiveness, developed many acrobatic stunts.

These have been perfected, and new ones added by careful calculations of well-trained and daring pilots. One of our country's greatest acrobatic pilots is Alford J. Williams.

PART VI

SOME FACTS AND FIGURES

AIRPORTS
AIR-MAIL AND AIR-TRANSPORT LINES
OPPORTUNITIES IN AVIATION
GROWTH AND FUTURE OF AVIATION

CHAPTER XXI

AIRPORTS

There are not many boys or girls living near a city or large town who have not made a visit to an airport and while there watched the many types of planes landing and taking off, for practically all cities of 100,000 population, as well as scores of less populous towns, have their port.

Occasionally a boy living many miles from any airport has an unexpected opportunity to watch some plane make a forced landing on his father's farm. A university professor, flying solo to fill a speaking engagement on aëronautics at a national meeting of educators, gave such a boy this opportunity.

Having successfully navigated his plane, first to the north and then to the south, to avoid flying into electric storms the flying professor, on the sudden approach of a third storm, decided to make a landing. He leveled off and made a good three-point landing on a smooth spot which proved to be in the middle of a farmer's oatfield. After the storm passed, the farmer and his young son came to discuss the situation with the professor. The boy, no doubt, received his first instruction in 'ground school' as he listened to the answers given to his many questions on air and airplanes. He at least felt compensated for the loss of his father's oats in that part of the field.

Some European Airports

If you were traveling in Europe, you would be amazed at some of the outstanding airports there. You would visit Croyden Field in London and Templehof Field in Berlin, which was once a parade ground of the Emperor's soldiers. Of course, you would want to see Le Bourget Field where Colonel Lindbergh landed in Paris, and if you went to Italy you would visit the field in Rome. The airports of Europe are always the marvel of American tourists. But you will see that architects and engineers in America are planning and building airports in which every convenience and service possible is offered the flying public.

Kinds of Airports

Airports may be placed in four classes: those municipally owned, which are under the jurisdiction of the town or city; those owned and operated by flying or transport companies; those which are controlled by clubs for private flying and sportsmen pilots; and the government fields where the Army and Navy flyers are trained.

Government Fields

One of these fields was dedicated at San Antonio, Texas, in June, 1930, and is the largest aviation field in the world. It embraces 2,362 acres, about half of which is grass-covered flat land. It is named Randolph Field after a native Texan who was known for his military service and his interest in the advancement of aviation, but it is popularly called 'The West Point of the Air.'

Randolph Field is one of the greatest construction projects ever undertaken by the United States Army. It was started in November, 1928, and required about three years for its completion and an expenditure of over $30,000,000.

Think of a flying field within which there will be 18 miles of graded roads, 12 miles of water mains, 11 miles of sewers, and 10 miles each of gas, electric light, and telephone lines.

The buildings are arranged in a central hexagonal area, leaving all the space outside available for flying lines. The plans provide for administration buildings; operations buildings; a school of medicine for training flight surgeons; cottages for married officers and their families; bachelor officers' quarters, mess building, and club; and a barracks, headquarters, mess building, and recreation building for cadets. There are a chapel, a hospital and a school for children. There are shops, warehouses, and a store. There will be 22 steel hangars, each 110 feet by 120 feet. Every type of airplane, from the simple primary flying machine to the giant bomber, will be included in the field equipment. A modified Spanish type of architecture will prevail, and the government is giving careful consideration to the landscaping of the whole area.

But there is a type of government airport in a class by itself, one on which it takes the most skilled pilot to land.

These 'fields' are on the decks of the Navy's aircraft carriers. The *Lexington* and the *Saratoga* are the largest vessels of this class in existence. Some 80-odd naval aircraft, varying in size from single-seater fighting planes to huge bombers, are operated from the deck of each of these carriers. Although the total deck length is 888 feet, only about one-third of that distance is available for landing, and it takes a pilot with a 'smooth' stick and steady nerves to bring his plane at rest in exactly the right spot, where the arresting landing gear on the deck will retard the roll of the plane. Especially this is true if an emergency should require a landing after nightfall. This is the ultimate test for skillful flying.

A gentle breeze is amplified into a gale as the fast-moving carrier, with the propellers of its eighty planes whirling, heads into the wind just before the take-off. Then, only a few seconds apart, one after another the planes roar straight up the deck and into the air.

A deck crash is uncommon, and although the Navy's carriers have been in operation for several years, no accident has ever resulted in more than minor cuts or bruises to the pilots.

Municipal Airports

Cities are aware that their prosperity depends in a great measure upon transportation facilities. You have read in history of a city whose site at a crossroads or at a junction of two rivers or whose good harbor was the reason for its rapid growth and development. So, today, cities are selecting space for, or have already completed, a modern airport.

In 1927 the Kansas City Airport was a cornfield. Now it is one of the best fields in the country for night flying.

At Louisville, Kentucky, you could find space at the airport for parking your car along with 3,000 others.

The Detroit city airport has a hangar capable of housing 175 airplanes and costing $1,000,000. You could land at night at Grosse Isle airport near this city on a 'dotted line' of lights buried in the ground. The lighting of these runways is controlled automatically by a wind vane.

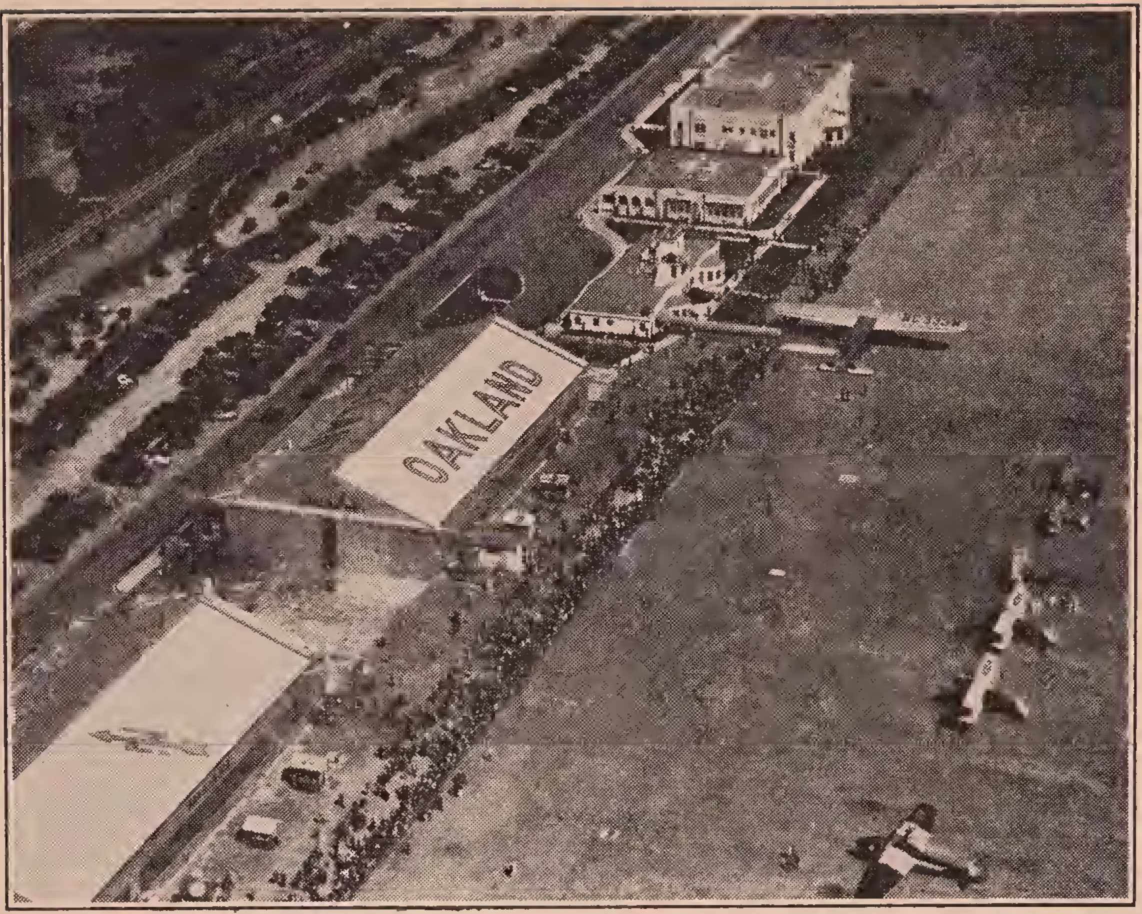
At the municipal field at Oakland, California, you would find a 37-room hotel, and you could eat at a restaurant capable of serving 185 persons at the same time.

Miami, Florida, has a dirigible field, one of the first in the country.

A swimming pool and complete recreational facilities are found at Central Airport, Camden, New Jersey.

One of the largest municipal airports in the world is located at Cleveland, Ohio.

Newark Airport, Newark, New Jersey, is located 'where airways, railroads, waterways, and highways meet.' An



Clyde Sunderland

MUNICIPAL AIRPORT, OAKLAND, CALIFORNIA
Notice size of lettering and direction sign.

Fairchild Aërial Surveys, Inc.

BOSTON MUNICIPAL AIRPORT

elevated highway miles long leads directly from this airport to the Holland Tunnel.

New York City spent $4,500,000 to convert the swampy waste land of Barren Island into a municipal airport which is called the 'Floyd Bennett Field.' In addition to commercial aviation, departments of the city government have hangars here. Even the Board of Education has a hangar where boys and girls of New York can go to supplement their courses in aëronautical education with observation and practice. This field was officially dedicated on May 23, 1931, the day that New York City's millions turned their eyes skyward as more than six hundred Army airplanes roared overhead, 'saving' the city from an imaginary invading enemy air fleet.

The 'Aviation Country Club'

The field at Hicksville, Long Island, is an example of the aviation-country-club idea. Here the 'elite' from the Metropolitan area learn to fly their own planes from their own airport. It was within the privacy of this club field that Anne Lindbergh made her first solo flight while her distinguished husband was an intensely interested spectator.

The country flying club is not a new idea. Such clubs have been popular in England for the past ten years. One has a membership of over four hundred and during its existence has trained over a thousand English sportsmen. The Prince of Wales, who became a fully qualified air pilot in October, 1929, has his own private landing field at Smith's Lawn, Windsor Great Park, London. Here in his hangars are dressing rooms for him and his pilots. His own machines are available at a moment's notice, and he fills many engagements by plane.

The country-club idea is developing rapidly in Canada, Australia, and the countries of Europe. The Aviation Country Club, Inc., with offices in New York City, is organizing a nation-wide chain of clubs in the United States. One of its members is a woman who has been flying for several years and who holds the coveted transport license. In the interests of the movement she took a transcontinental airplane tour, flying 12,000 miles and visiting 92 cities.

Commercial Airports

Commercial flying organizations are anticipating the needs of the future and are investing millions of dollars in their airports.

On July 1, 1930, the Curtiss-Wright Flying Corporation had 36 bases in 25 different states. Its airport at Chicago was built at a cost of $3,000,000.

One located at Valley Stream, Long Island, New York, covering 320 acres, is nearing completion. When the author first visited the field, the students, while awaiting their turn for a 'ship' were housed in a one-story two-room building called 'The Student's Roost.' Busy tractors and steam shovels rumbled away all day leveling knolls and hills on one side and filling depressions on the other.

The slightest breeze caught up the loose earth and filled the air with clouds of dust. Landing was doubly difficult as one peered through the dust to judge his distance and at the same time selected a spot to land his plane out of the path of those ever-moving vehicles of progress. But a year later what a difference! Four of the nine concrete hangars are all complete, surrounded by concrete 'aprons' and grassy lawns. There are spacious offices for the field personnel and artistically furnished lounging rooms; a women's department with rest room, telephone, lockers, showers, and lavatories; a terrace, one flight up on Hangar Number 2, where guests may sit under gaily colored porch umbrellas and watch the activities on the field.

Not far away one may be served at the field restaurant, and the plans include a hotel and dormitories.

A part of this field is occupied by the Navy for a Naval Reserve aviation base. It was here that some 140 planes of the Navy Air Fleet made their headquarters while for two days they made spectacular mimic air attacks on New York. It was an interesting spectacle the morning the scores of planes left the field. Taking off in formations of three, within 45 minutes they were in the air and on their way to the Naval Air Station at Anacostia, D. C. Here they were reviewed by officials of the Navy Department and then proceeded to Hampton Roads.

Features of an Approved Airport

Every field aims to receive a favorable rating from the Aëronautics Division, Department of Commerce. On one that meets the minimum basic requirements you will find a firm, smooth, well-drained landing area, approximately level, without obstructions or depressions presenting hazards in taking off or landing, and with suitable approaches. Within this landing area you will see a 100-foot circle whose circumference 4 feet wide will always be kept whitewashed if not painted with chrome yellow. No lettering must appear in the circle, but on one or more of the buildings you will see the name of the airport or the city, in letters large enough to be read from an altitude of 2,000 feet. They, too, will be in chrome yellow against a dead black background, for this color combination is the one most easily visible from the sky.

Then you will see a wind-direction indicator, commonly called the 'wind sock.' It is a tapering, cylindrical, muslin bag 12 feet long, open at both ends, 36 inches in diameter at the throat and 12 inches in diameter at the tail. Perhaps also there will be a black and yellow marker in the form of an airplane. When you land, you will expect to find facilities for supplying fuel, oil, and water for your aircraft. There will be dependable communication and transportation facilities to the nearest city or town. Airport personnel are required to be in attendance during the day or available on call by telephone.

There are certain additional features which would enable an airport to enjoy a higher rating. The landing area would be conspicuous with its fencing posts of yellow and black or white and black. There would be a large hangar, sleeping quarters, additional repair equipment sufficient to permit changing of engines and landing gear and making major engine and plane repairs. You would find more wind-direction indicators and weather instruments. On a bulletin board there would be the latest report of weather conditions. If the station was within 400 miles of Department of Commerce Airways, it would be equipped with a radio receiving set and loud speaker, over which hourly weather reports could be broadcast. A first-aid equipment and ambulance accommodations would be available. There would be waiting and rest rooms, a restaurant, adequate fire-fighting apparatus, and sufficient personnel in attendance to give proper operation to the airport.

Darkness always presents a problem to the aviator. As night overtakes him and as he strains his eyes for some guiding light, how welcome are the beacon lights along the airways, as they flash red to tell that there are no landing fields near or flash the friendly green that tells that one is in the immediate vicinity. How welcome, too, is the well-lighted airport.

An approved field will have a long-range beacon light of not less than 100,000 candlepower. About the field itself there will be a row of low boundary lights. Then there will be one or more flood lights operated at a central control point, which illuminate the buildings and field. An illuminated wind-direction indicator shows the pilot the direction of the wind, so that he may head his plane into it as he makes his landing.

All obstructions on the field or in the vicinity of it will be clearly marked with red lights. There will be a ceiling projector in the form of an incandescent searchlight to determine the height of the 'ceiling' above the airport at night.

The most brilliant air beacon in the world is installed atop the Palmolive Building in Chicago. It is a rotating light shaft of 2,000,000,000 candlepower and visible for 500 miles. Below this main beacon is another fixed ray pointing toward the Municipal Airport.

Need for More Airports

At a recent airport conference a strong plea was made for small-town airports. If every city, town, and village of the United States made provisions for airport facilities, America could boast its supremacy in the air. It is the small city, where land can be obtained near the business section at a comparatively reasonable price, that has a ready opportunity to provide itself with an airport. Such a port would attract airlines, make rapid transportation possible, create publicity, invite tourists, increase business, and promote the interest of aviation.

Look about the vicinity of your city or town for the acreage necessary for an airport. Perhaps you may be the young pioneer upon whose vision the future prosperity of your community may depend.

CHAPTER XXII

AIR-MAIL AND AIR-TRANSPORT LINES

When one reads of endurance flights, stunt and exhibition flying, and the frequent long-distance flights, one is likely to think that these are the important phases of aviation. But America to-day is doing a prodigious amount of other kinds of flying. There is a great transcontinental system of air-mail, air-express, and passenger service, which is rapidly growing.

Air Mail

Before the World War there were no such regular routes in operation. However, a four-pound sack of mail had been carried five miles by a small Bleriot monoplane from the old Mineola Field, Long Island, and dropped near the Mineola post office five miles away on September 23, 1911. But the first experimental air-mail route was started in May, 1918, between Belmont Park, Long Island, New York, and Washington, D. C. It was operated by the Army as additional training for Army pilots. After three months, or in August of the same year, the Post Office Department took over actual operation. Army training planes were first used, but after the war ended, in November, 1918, many of the surplus De Haviland planes were remodeled and put into use.

In 1919 the Post Office Department started plans for a transcontinental air-mail route between New York, Chicago, and San Francisco. By September, 1920, there was completed a combination daylight air-mail service and night train-mail service across the continent. The mail was flown out of New York and put on a train in the evening at Chicago, then taken off the train the following morning and flown the rest of the route to San Francisco. Eastward the procedure was reversed. Through service by air alone was begun July 1, 1924, after the section over which the mail was carried by rail had been lighted.

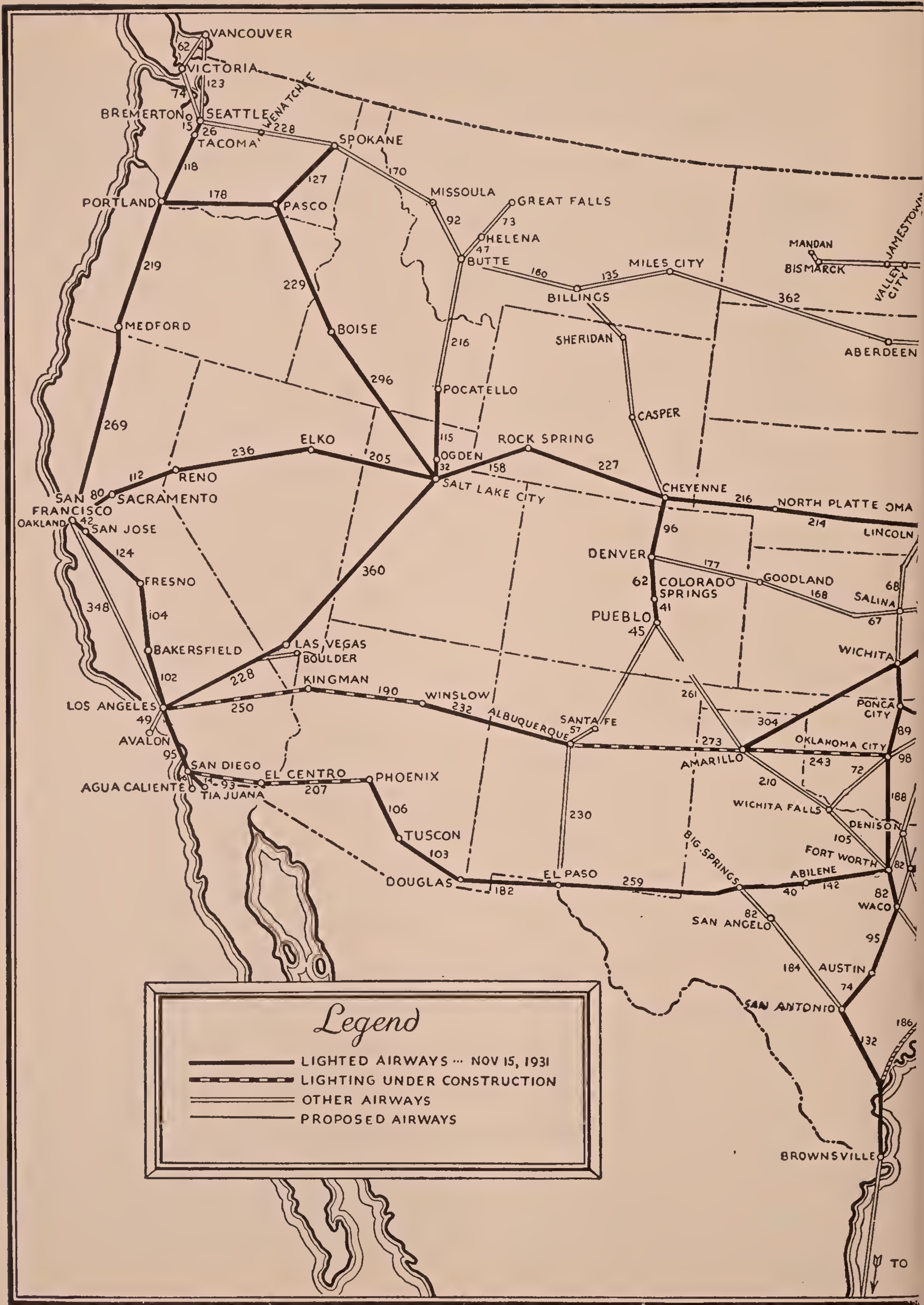
During 1926, contracts were let to civil transport companies to carry mail by air. With the exception of a contract opened between Fairbanks and McGrath, Alaska, February 1, 1924, the first air route under contract to the government began operations in February, 1926, between Detroit and Cleveland, and Detroit and Chicago. By the end of the first half-year nine more contracts were let for air-mail service.

During 1929 nearly 4,000 tons of mail were carried by air, for which the transport lines received over $13,000,000. Out of that vast amount of mail carried only about one pound in a ton was lost by fire. To prevent even this slight loss, the Post Office Department, in September, 1930, put into service fireproof bags. This new bag is slightly larger than the pouch formerly used by the air-mail service, which was 24 inches wide by 41 inches long. The pouch is made of asbestos, lined with high-grade canvas. It is steel-riveted on sides and bottom and has a triple-closing device which prevents the flames from penetrating the bag through its neck. It was subjected to an actual fire test and withstood the heat perfectly. It weighs 15 pounds.

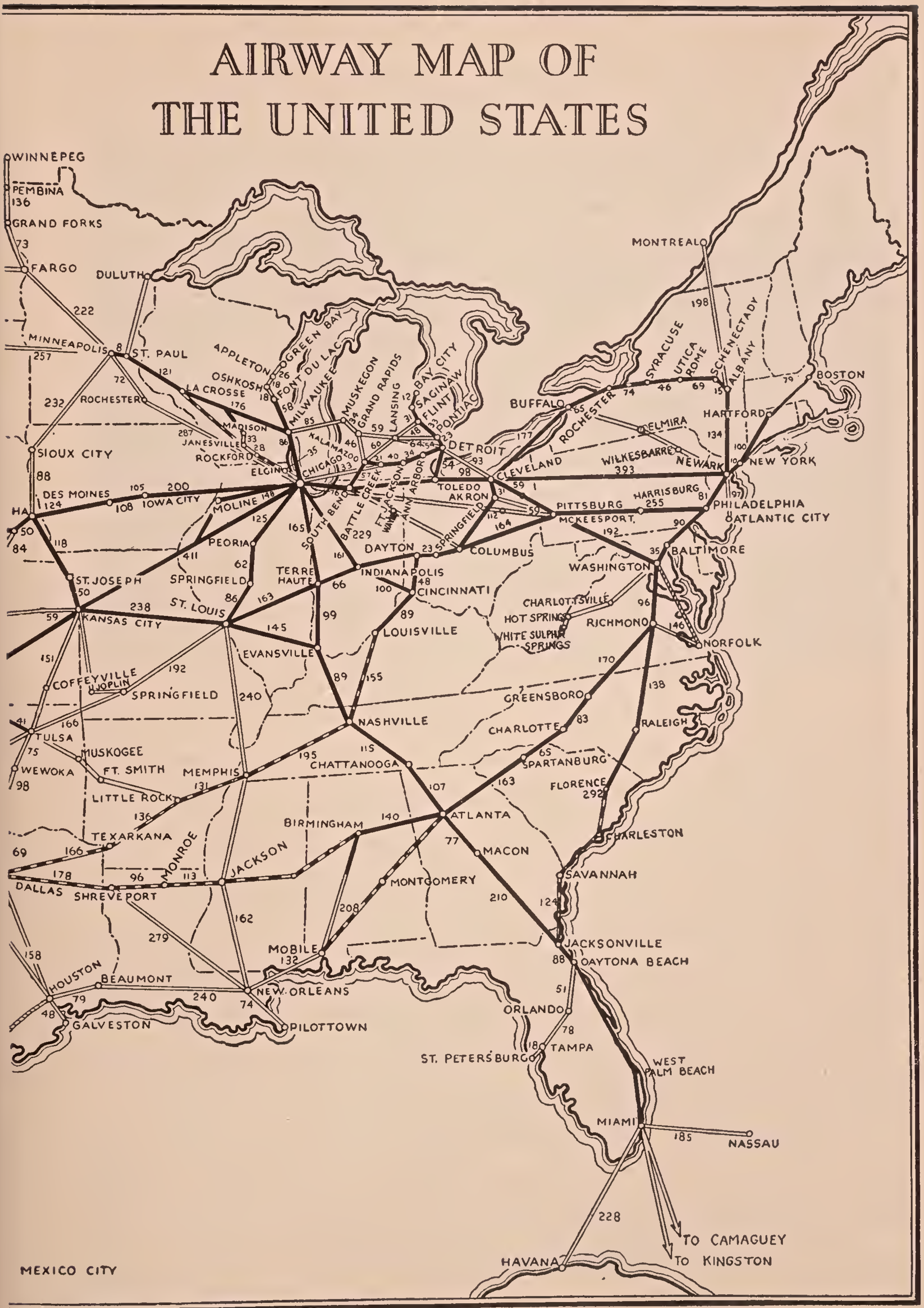
The first foreign mail flown by air was carried between Seattle and Victoria, B. C., in October, 1920. Now air-mail service extends to Cuba and other islands of the West Indies, to Canada, Mexico, the Canal Zone, and South American states. It was Colonel Lindbergh who opened the air-mail route between Miami, Florida, and the South American cities of Buenos Aires and Montevideo, by a twelve-hour flight across the Caribbean Sea to the Canal Zone, on the first leg of this new air line.

Mail has been taken from incoming steamers and delivered hours ahead of schedule time. As an example, the incoming steamship *Bremen* sent a radio message to Boston that a seaplane carrying air mail would be released from its deck some 350 miles from shore. Just 4 hours and 32 minutes later thousands of spectators saw the plane land safely at the East Boston Airport.

The Air Commerce Act of 1926 gave authority to the Department of Commerce "to furnish air traffic those aids which will result in the greatest degree of flight efficiency." Now the government-improved airways exceed 25,000 miles, more than half of which is lighted and equipped for night-flying operations.


VANCOUVER
VICTORIA
BREMERTON
SEATTLE
WENATCHEE
TACOMA
SPOKANE
MISSOULA
GREAT FALLS
HELENA
BUTTE
PORTLAND
PASCO
BOISE
MEDFORD
BILLINGS
MILES CITY
SHERIDAN
CASPER
MANDAN
BISMARCK
JAMESTOWN
VALLEY CITY
ABERDEEN
POCATELLO
OGDEN
SALT LAKE CITY
ROCK SPRING
ELKO
RENO
SAN FRANCISCO
SACRAMENTO
OAKLAND
SAN JOSE
FRESNO
BAKERSFIELD
LOS ANGELES
AVALON
SAN DIEGO
AGUA CALIENTE
TIA JUANA
EL CENTRO
PHOENIX
TUSCON
DOUGLAS
LAS VEGAS
BOULDER
KINGMAN
WINSLOW
ALBUQUERQUE
SANTA FE
EL PASO
CHEYENNE
NORTH PLATTE
OMA
LINCOLN
DENVER
COLORADO SPRINGS
PUEBLO
GOODLAND
SALINA
WICHITA
PONCA CITY
OKLAHOMA CITY
AMARILLO
WICHITA FALLS
DENISON
FORT WORTH
WACO
ABILENE
BIG SPRINGS
SAN ANGELO
AUSTIN
SAN ANTONIO
BROWNSVILLE
TO
Legend
LIGHTED AIRWAYS ··· NOV 15, 1931
LIGHTING UNDER CONSTRUCTION
OTHER AIRWAYS
PROPOSED AIRWAYS

AIRWAY MAP OF THE UNITED STATES



Air Express

Another exceptional development of air transport is the air-express service. The many different air lines delivering express to over eighty-two American cities are constantly enlarging their services.

The transportation of jewels, securities, and other valuable cargoes by air is nothing new in Europe. During nine days an air-express shipment of $25,000,000 was made across the English Channel from London to Paris. In the United States, money, jewels, wearing apparel, sporting goods, small machine parts, fruit, perishable merchandise, and a host of other things are being shipped every day by air express.

One of the most unusual air shipments was made when 105 queen bees were sent from Florida to California. Each bee was inclosed in a small box and the boxes were then wrapped in one package. The queens were only two days on the trip from their old home in Florida to their new owners in California. Six refrigerator planes carry about 3000 pounds of fish packed in dry ice each trip from the Gulf of Mexico to Brownsville, Texas, where they are packed for shipment to northern cities. In a Chicago restaurant you can eat a fish that only a few hours before was flapping its tail in the briny waters of the Atlantic.

An example of the possibilities of air transport was demonstrated at the Newark Airport in February, 1931, when an airway luncheon was served which consisted only of such food as had been brought by air. Caviar came

LOADING EXPRESS ON TO AN AIR-EXPRESS PLANE

from the Great Lakes over Colonial Airways, beef bouillon from Chicago via National Air Transport, pork sandwiches from Kansas, and strawberries for mousse from the Ozarks via Transcontinental and Western Air, Idaho potatoes and onions from Denver via United Aircraft and Transport, and Virginia ham sandwiches from the South via Eastern Air Transport. Butter came from Oklahoma. In the salad were pineapples from Panama, avocados from California, apples from Oregon, oranges from both Florida and California, grapefruit from Texas. There was even candied cactus from Arizona.

Today in New York City you can buy cut roses which were nodding on their bushes in the Midwest at noon the day before. At the annual flower-shows in that city there are flowers and plants which come by air from many parts of the country.

One company gives a flat-rate service between New York and Boston. If you live in New York and wish to send a birthday gift to a friend in Boston all you need do is to phone for a Western Union messenger boy and hand him your package. Just four hours later your friend will be unwrapping your gift.

Unless special arrangement is made in advance, no single piece sent by air express may be more than 60 inches long or more than 19 inches wide, and if it is over 40 inches long it shall not be over 4 inches deep. The combined length and girth may not be over 106 inches.

Air Passenger Service

The most fascinating phase of commercial aviation, that of air-passenger service, is developing very rapidly in this country. The first service was maintained daily, but passengers rode in open-cockpit planes designed to carry air mail. Now thousands of passengers are carried yearly over millions of miles.

Everything is being done to add to the safety, comfort, and convenience of the passenger. You may now take a taxi from a hotel in any large city and be whisked away to an airport where with several other passengers you take your place in the cabin of a large airplane. Your chair is deeply cushioned, and it may be adjusted to make you still more comfortable if you become sleepy and wish to take a nap. The rug harmonizes in color and design with uphostery, curtains, and wall covering. Windows extending the full length of the cabin give proper ventilation in summer and winter. Wall lights and ceiling lamps light the cabin at night. A little kitchenette with refrigerator and electric grill is part of the equipment on the large planes. Here a full-course dinner may be prepared and served you on long flights, or a tasty little 'snack' on shorter hops. In the rear you will find the conveniences of a typical rest room, with a washbowl supplied with hot and cold water, soap, towels, and mirror.

Devices are installed to reduce the noise, so that you may converse with your companions or be entertained by radio programs. On some of the planes there are motion pictures. You will not need to worry about fire, for a valve-controlled fire extinguisher operates to put out fires in any one of the two or more motors. An instrument will show you how high you are traveling and at what rate of speed, which in one large transport plane is from 115 miles per hour cruising speed to 150 per hour high speed.

Your companions may be vacationists who want the experience of air flight, business men and women to whom speed means dollars added to their bank account, or individuals whose presence is urgently needed at some distant place.

The man who pilots your plane has had thousands of hours in the air. His co-pilot or assistants are well trained, cool-headed, and efficient. Stewards and attendants often are college men.

If you prefer not to fly at night, you may take advantage of the combination air-mail service. You may fly from dawn to dusk, and during the night ride in a sleeper on a railroad train. The list of railroads connected in some way with air-transport lines would fill several pages.

The airplane is recognized as a reliable method of transportation, and man is flying faster, higher, and farther every year.

The following table shows the growth of air transportation in the past six years.

Year	*Lines in Operation*	*Number of Transport Planes*	*Miles Flown Daily*	*Passengers Carried*	
1926	19	95	12,627	5,782	
1927	24	144	14,363	12,594	
1928	32	294	28,690	52,934	
1929	33	619	55,460	165,263	
1930	35	685	73,997	385,910	
1931	45	700	134,066	176,143	(first 6 months)

CHAPTER XXIII

OPPORTUNITIES IN AVIATION

Perhaps you would like to know what are the opportunities in aviation for those who hold licenses to fly or for those whose interest is in the technical or the commercial development of this great method of transportation.

Positions may be classified under four heads according to the minimum training required.*

Department	*Classification*	*Training*
1. Engineering	Engineer	University
	Draftsman	Vocational School or College
	Computers	Vocational School or College
2. Mechanical	Mechanics	Trade School
	Apprentices	Trade School
3. Executive	Business	Business College
4. Piloting	Pilots	Ground School
	Civilian	Flying School
	Military	Army–Navy–Marine Air Corps

* From a bulletin prepared by the Guggenheim Fund for the Promotion of Aëronautics.

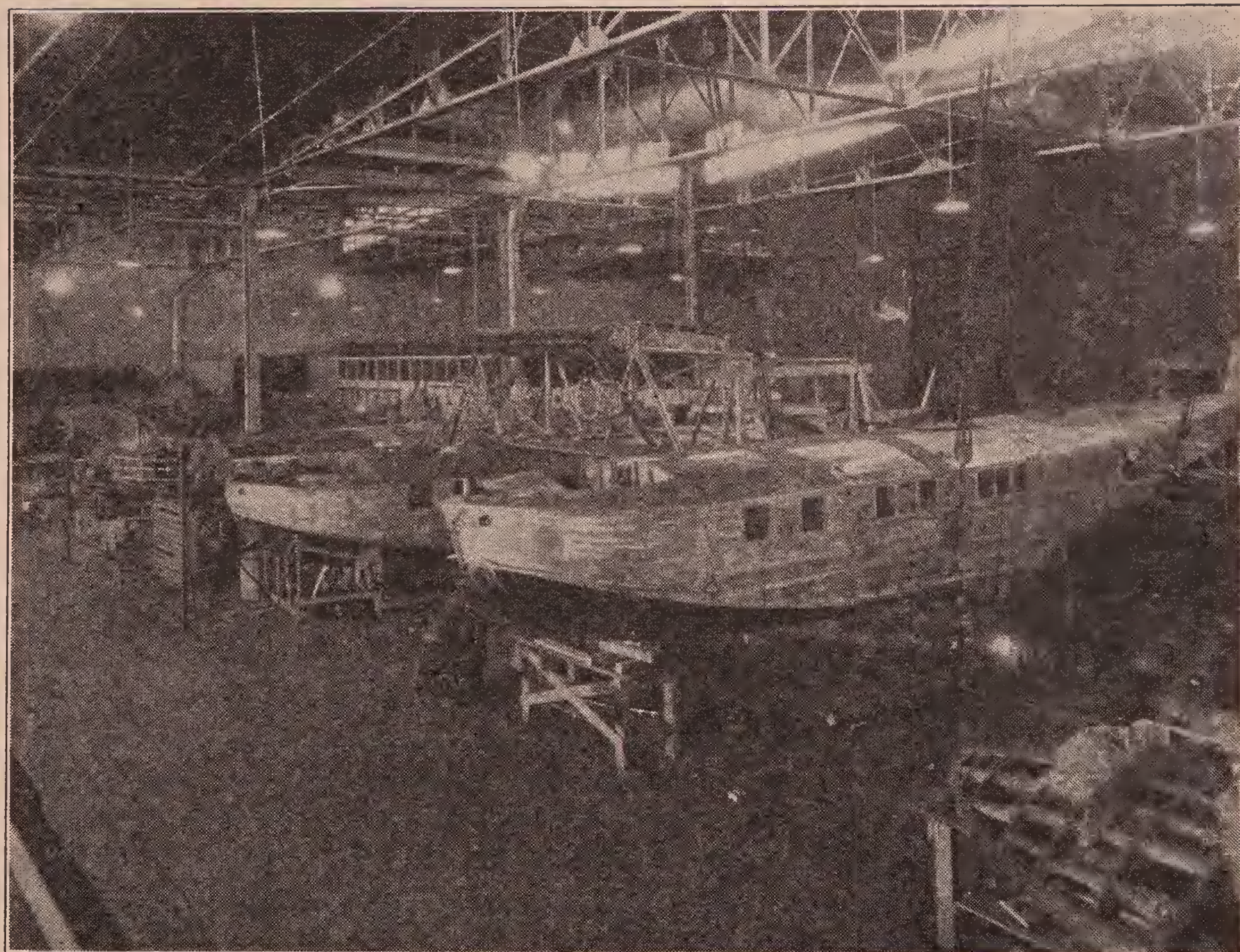
The future of aviation depends largely upon meeting problems that can be solved only by men with engineering education. Aëronautical engineering demands special aptitude in mathematics, physics, and mechanics, with more than average ability in the power of concentration and close application in research work. The freshman enrolling today for such a course in engineering must complete four years of college work, after which he will have to have two or three years' practical experience before he can be considered a useful aëronautical engineer. It is evident that it is a long and expensive course, but as the aviation industry develops, manufacturers will more and more employ college-trained men to fill positions in their engineering departments.

Although the most highly paid men will be found in the research and experimental laboratories, other positions will demand the services of those with engineering training. The airport designer is another specialist who will be called upon more and more as fields are opened up throughout the country. The study of the location of airports and airfields with regard to such factors as weather conditions, drainage, surfacing, and probable expansion, is an engineering problem, as is the installation of equipment for weather stations, for radio receiving and broadcasting sets and signal beacons, for fire protection, and for traffic control. There are positions open to aëronautical meteorologists with college degrees and practical experience. Aëronautical draftsmen are needed in every aircraft manufacturing plant.

For the air-minded young men or women who lack the education, qualification, or financial support necessary for technical courses, there is an opportunity to fit themselves for good positions by attending first-class vocational schools or good trade schools. In these schools a high-school education is supplemented by actual shop practice. An airplane mechanic must, before receiving a license from the Department of Commerce, have had at least one year's actual experience maintaining or repairing aircraft. The applicant for a position as airplane-engine mechanic must have had at least two years' experience on gas engines, one year of which must have been on airplane engines.

Then there is an almost unlimited variety of mechanical jobs in a typical airplane factory, including those of metal-workers and tool-makers. Here many opportunities arise for promotion to inspector, foreman, supervisor, or shop superintendent.

The positions open for both men and women in the business side of aviation are unlimited. Companies manufacturing aircraft, like any other industrial companies, must have the typical personnel — presidents, vice presidents, treasurers, secretaries, managers, publicity men, salesmen, and others whose executive ability and training along aëronautical lines are valuable. Many a young man who may be filling a minor position today will, through application to business, tact, and personality, find advancement sure, for the aviation industry is expanding very rapidly.



Making Commodore Planes at the Consolidated Aircraft Corporation Factory, Buffalo, New York

Opportunities for positions with airline and transport companies are rapidly increasing. This method of transportation is expanding as railroad travel did some years ago, making increases necessary in the personnel of traffic departments. In fact every phase of the business of dealing with the traveling public offers new opportunities for employment. Think of the men needed at the airline terminals and at points between them to keep the fields in condition, lights and radio equipment functioning, and to answer any calls from pilots who have been forced to make emergency landings. Then there is the operations office, where men are employed to take care of scheduling the regular trips or to arrange for extra planes for special trips. Women, too, are employed as ticket-sellers, information clerks, stenographers, and hostesses.

For the actual flyer there are varied types of positions.

The private pilot is limited to flying his own or another's plane for pleasure only or on business for which he does not receive any pay.

The commercial license enables a pilot to engage in flying his own plane or another's for pay within a restricted area. He may act as co-pilot on a transport line or an air-mail route.

The industrial pilot may receive pay for various kinds of useful work. Control of insects is an important work. This is done by flying low over cotton or grain fields, orchards, or forest areas, and spraying a cloud of insect powder which destroys the insects themselves or settles down on the foliage on which the larvae feed, and poisons them. Other interesting types of aërial work include mapping, surveying, mineral prospecting, locating forest fires, sky writing, or aërial advertising, carrying food or medical supplies to isolated or devastated regions, and photography.

All these, as well as every other phase of aircraft flying, are open to the transport pilot. He may qualify for a pilot of an air-mail or an air-transport line. He may pilot private airplanes for their owners across the continent on pleasure, sight-seeing, or business trips. The greater the number of flying hours he has had, the more valuable he will be. Test pilots for experimental aircraft must have nerve, experience, and exceptional ability. A transport pilot may accept a position as an instructor in a flying school. In such a position he must add to his other qualifications a vast amount of patience.

Another important position that also demands actual flying is that of navigator, the person who reads the instruments and tells the pilot what course to take. The navigator will be a more and more important figure in flying; indeed many flights have ended successfully because the pilot himself was a good navigator or because a good navigator was a member of the crew.

A navigator who also understands radio ought to be able to secure a good position at any time. Since radio is becoming such an important means of directing flight, trained men in this field will be needed to accompany aircraft, and others will be needed at the ground stations to send out and receive messages.

Positions open to men pilots are always open to women flyers who possess the same grade of license. The woman flyer may transport passengers, demonstrate planes, compete in races, strive for records, and take part in pageants and in formation or stunt flying.

Opportunity is offered a limited number of young men to receive aëronautical education at government expense at the Army Air Corps flying schools. Candidates must be male citizens of the United States between twenty and twenty-seven years of age, of good character, sound physique, and excellent health. Before being accepted, candidates must pass an examination consisting of three parts: physical, educational, and psychological.

The physical examination is very rigid, particular attention being paid to the eye tests. The educational examination covers two years of college work, but may be omitted if the applicant can furnish proof of having satisfactorily completed two years of work at an approved college or university. The psychological test is the hardest to pass. It is said that only about 75 per cent of all candidates pass. It is given by specialists who test how quickly one's mind responds in sending out messages for bodily movements — it shows whether one has natural ability for flying, and it analyzes one's personality traits.

Those who pass the three examinations are accepted as flying cadets. Flying cadets receive $7 a month and an allowance for food. Their uniforms are furnished without cost. The courses start on July 1, November 1, and March 1 of each year.

The first eight months of the heavier-than-air training is given at a primary school. Besides the time in the air, students are trained in airplane engines, navigation, machine guns, radio, and other academic subjects necessary for a military pilot.

On the completion of the primary training the students are transferred to the advanced flying school at Kelly Field, San Antonio, Texas, for the remaining four months of the course. Here training consists of flight in service-type airplanes, cross-country flying, aërial gunnery, and special training in pursuit, attack, bombardment, or observation aviation.

The successful completion of the course includes about 250 hours in the air, and graduates receive the rank of second lieutenant. They are allowed to return to civilian life, but if they wish they may report for active duty for two weeks each year, when they are permitted to fly government airplanes at government flying fields without any expense to themselves.

The Naval air-training center is at Pensacola, Florida. The Naval Aviation Reserve draws students and graduates from certain approved colleges and universities. An applicant must be between eighteen and twenty-eight years of age. He must qualify under strict Navy rules. Government training in balloons and airships is given at the Balloon and Airship School, Scott Field, Belleville, Illinois.

Many outstanding pilots, among whom are Colonel Lindbergh, Lieutenant Doolittle, Lieutenant Soucek, and Alford Williams, are government-trained.

CHAPTER XXIV

GROWTH AND FUTURE OF AVIATION

The future of aviation is a challenge to the most imaginative mind. You could let your imagination conjure up what would seem the most novel aircraft, flying at terrific speeds, at impossible altitudes, and for unknown destinations, and perhaps within a few years you would see at least some of your fancies being put into actual practice.

When, on the twenty-fifth anniversary of their first flight, Orville Wright was asked if he and his brother thought, when they made that flight, that aviation would reach the development of today, he replied, "Yes, but it has reached, in twenty-five years, the place that Wilbur and I dreamed it might reach in a hundred years." What development will the next twenty-five years bring?

It is said that the future of aviation lies in the hands of the engineer. Certainly he has been very busy in the past years. The rapid growth of air-transport lines has increased the building of larger aircraft and specially designed flying boats and amphibians. Great attention is paid to the specific purpose for which the transport plane is to be used, whether for mail, passengers, or express, and whether for short hops or long transcontinental voyages. This just reverses the old order, in which the operator had to adapt to his special needs the planes that were available.

Some of the giant transport planes of Europe and America weigh from seven to fifty-six tons when loaded. You know how a motor truck 'chug-chugs' up a steep grade with a load of perhaps five tons. Think of a set of wings strong enough and motors powerful enough to carry eleven times such a load through the air.

You know that it is difficult for you to lift and carry a person your own weight. But in our own country experiments are successful with flying boats which carry one pound of useful load for every pound of their own weight.

Some persons believe that the future airplane will be a huge flying wing with motors along its top developing thousands of horsepower, and quarters inside for hundreds of passengers. Perhaps it would be interesting to study some types already in operation.

Some Modern Types of Airplane

A type of aircraft familiar to German engineers is the Junkers G–38. It is made of all-metal duralumin. Passengers are accommodated partly in the mono-wing section and partly in the fuselage.

The Rohrback Romar is an all-metal flying boat. It established a record when its three 550-horsepower motors took it to an altitude of 6500 feet with a 7-ton load. This would be about the same as carrying 86 passengers or over 300,000 ordinary letters.

The Fokker F–32 has a fuselage, tail surfaces, and landing gear of tubular steel construction. Two engines are mounted tandem on each side of the fuselage, those in front having two-bladed propellers and those in the rear having three-bladed ones. As a day plane it can carry thirty passengers, and at night half that number find sleeping comfortable in full-sized berths.

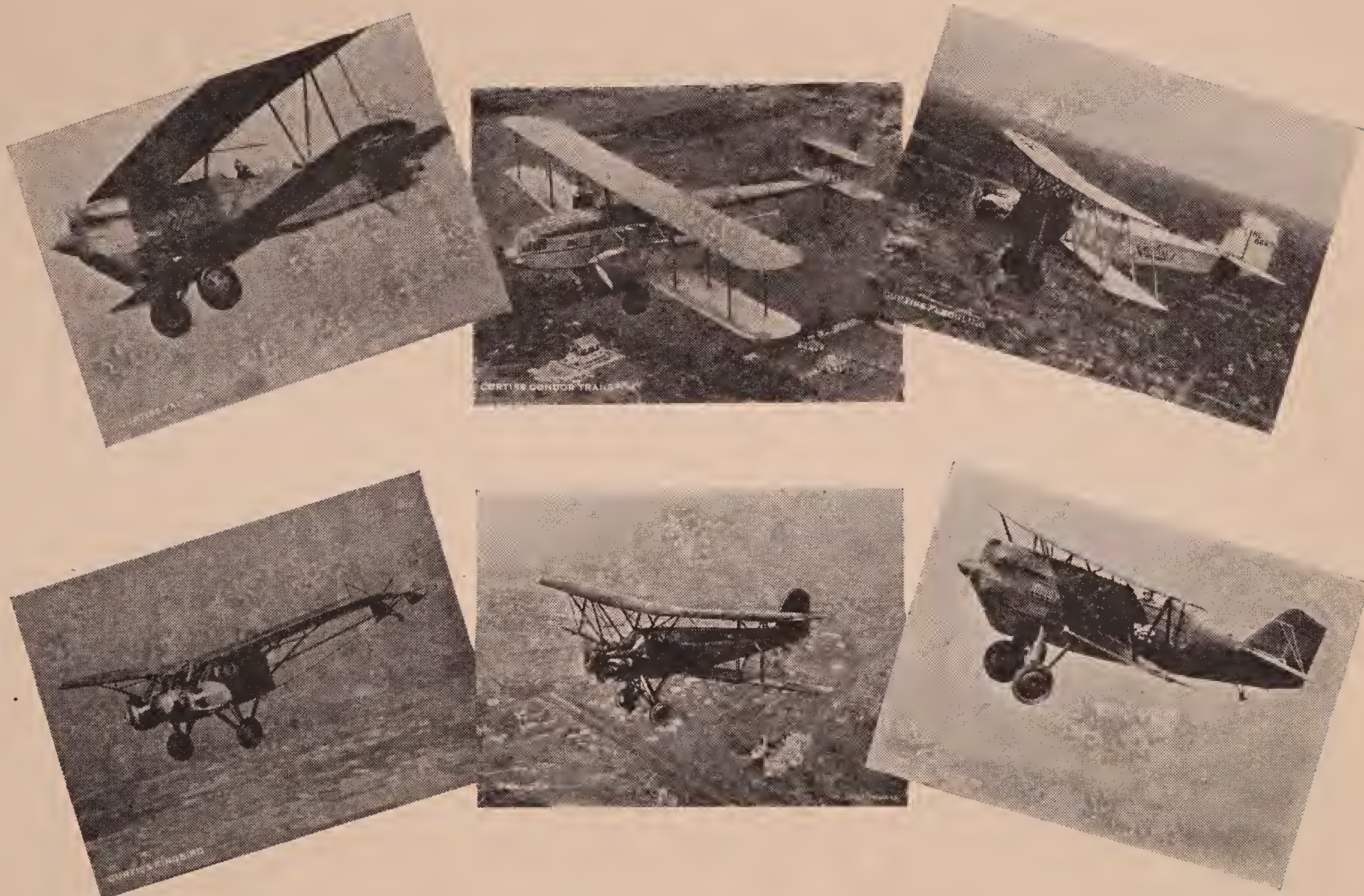
The Consolidated Commodore, a flying boat, is intended to furnish the design for giant flying boats for seven-day service between New York and Buenos Aires.

The Curtiss Condor is a land transport biplane carrying eighteen persons besides two pilots. It has two powerful water-cooled motors either of which is designed to support the total weight. The cabin, with luxurious chairs, is soundproofed by a three-inch air space between inner and outer walls double-lined with sound and shock-absorbing material.

The Boeing 80A is another type of biplane. It also has soundproofed walls and ceiling. In eleven seconds it can take off and one minute later be over 800 feet in the air. A transport company operates a fleet of these for passenger service between Chicago and San Francisco.

The Keystone Patrician is another type of large transport monoplane in service between New York and Boston.

The flying boat and its closely related type, the amphibian, have offered interesting problems to the designer. They are serviceable for the sportsman-pilot who can hop



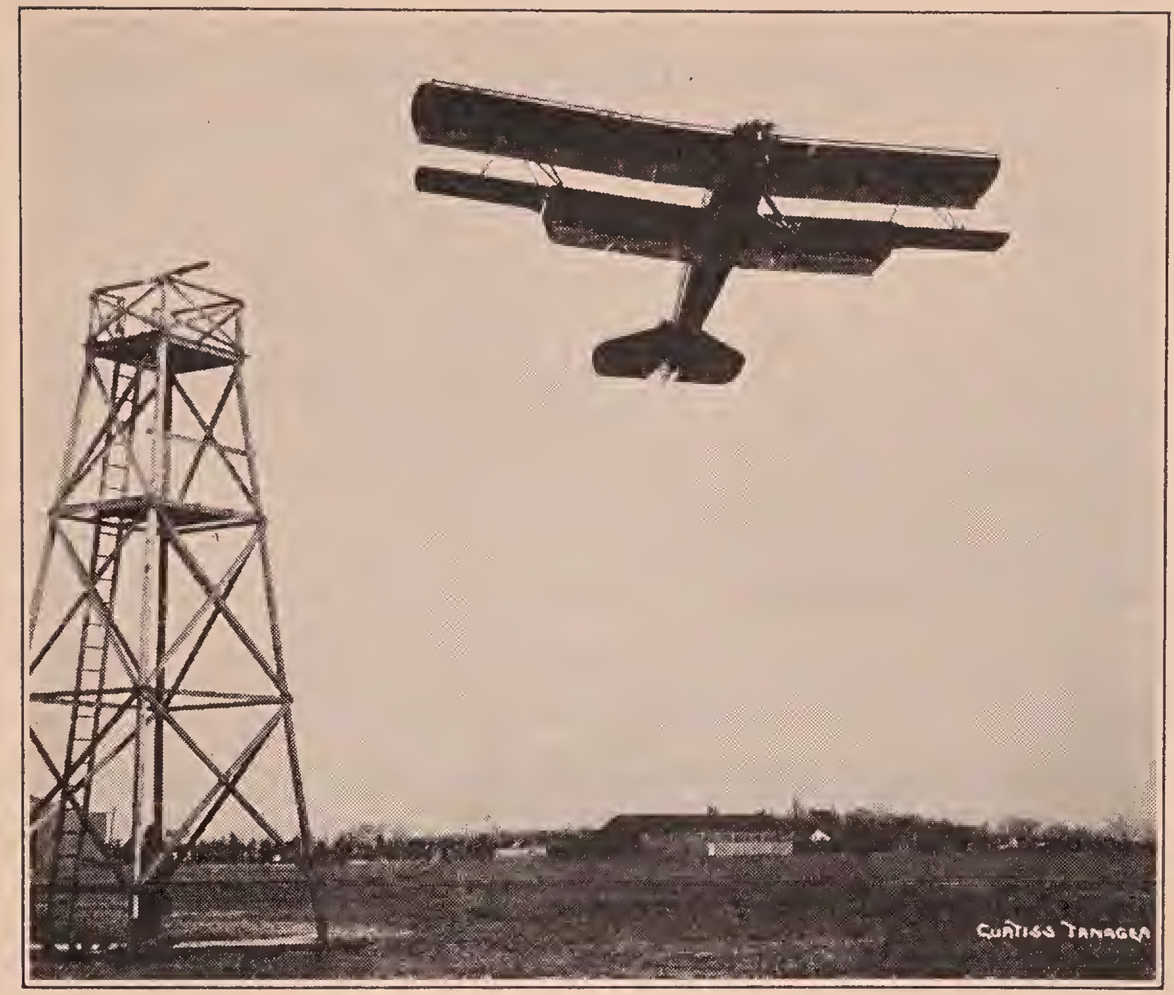
Some Modern Types of Airplane

Some Modern Types of Airplane

to his seashore home or his camp on a mountain lake and use these waterways for his airport. A big forty-passenger Sikorsky amphibian is in service between New York and Bermuda. A seaplane has in an emergency glided down to safety on land, its all-metal bottom skidding along on the ground.

To stimulate competition among aircraft manufacturers, the Daniel Guggenheim Fund for the Promotion of Aëronautics offered a prize of $100,000 for a plane with special safety characteristics. Twenty-seven companies entered the contest, but one by one they dropped out until only fifteen machines were left for the final tests. Two, the Tanager and the Handley-Page, an English machine, scored highest in all the points. When the final decision of the judges was reached, the Curtiss Tanager had equaled or exceeded all requirements, and on January 6, 1930, Mr. C. M. Keys, then president of the Curtiss Aëroplane and Motor Company, was handed a $100,000 check by Captain E. S. Land, vice president of the Fund.

This ordinary-looking biplane has several novel features which make its landing and flight performance really remarkable. On the tips of the lower wings are full-floating ailerons which enable the pilot to control the plane for a low-speed landing, which was one of the requirements of the competition. They also give stability when the plane is in flight. Along the full length of the wings at the trailing edge are flaps. These are operated from the cockpit to increase the camber of the airfoil and give it increased lift. Along the leading edge, slots open automatically as



Aëronautical Chamber of Commerce of America

THE TANAGER, A PRIZE-WINNING PLANE

the plane is tipped up on a climb. This gives lifting power to the plane and at the same time keeps it from stalling (losing flying speed) and going into a spin.

The Tanager has a wing span of 43 feet, 10 inches, and a chord of 5 feet. Its maximum flying speed is 111 miles per hour, cruising speed 95 miles per hour, with a landing speed of only 37.1 miles per hour. Slow gliding speed makes landing possible in a very small space because it lessens the length of the run after the plane has landed. In the test the Tanager literally hopped over a 35-foot obstacle only 50 feet away from the beginning of the take-off, and landed only 293 feet from it on the other side.

As the confidence of the public is gained by the application of such safety measures in airplanes, it is plain to see how bright the future is for aircraft manufacturers. The airplane will rival the automobile as a means of travel.

Some Present and Future Uses of the Airplane

The great source of profit for commercial aviation in the future will probably be in the transportation of express rather than passengers. Express of equal weight can be carried more cheaply, for an express package needs no attendants or conveniences to make it comfortable, it needs no extra weight in the form of loud speakers or motion pictures to entertain it, nor does it need food at regular intervals. It can be packed closely, with low liability for its damage or loss.

It is apparent that hundreds of large transport planes will be required to take care of even a small portion of the nation's total express.

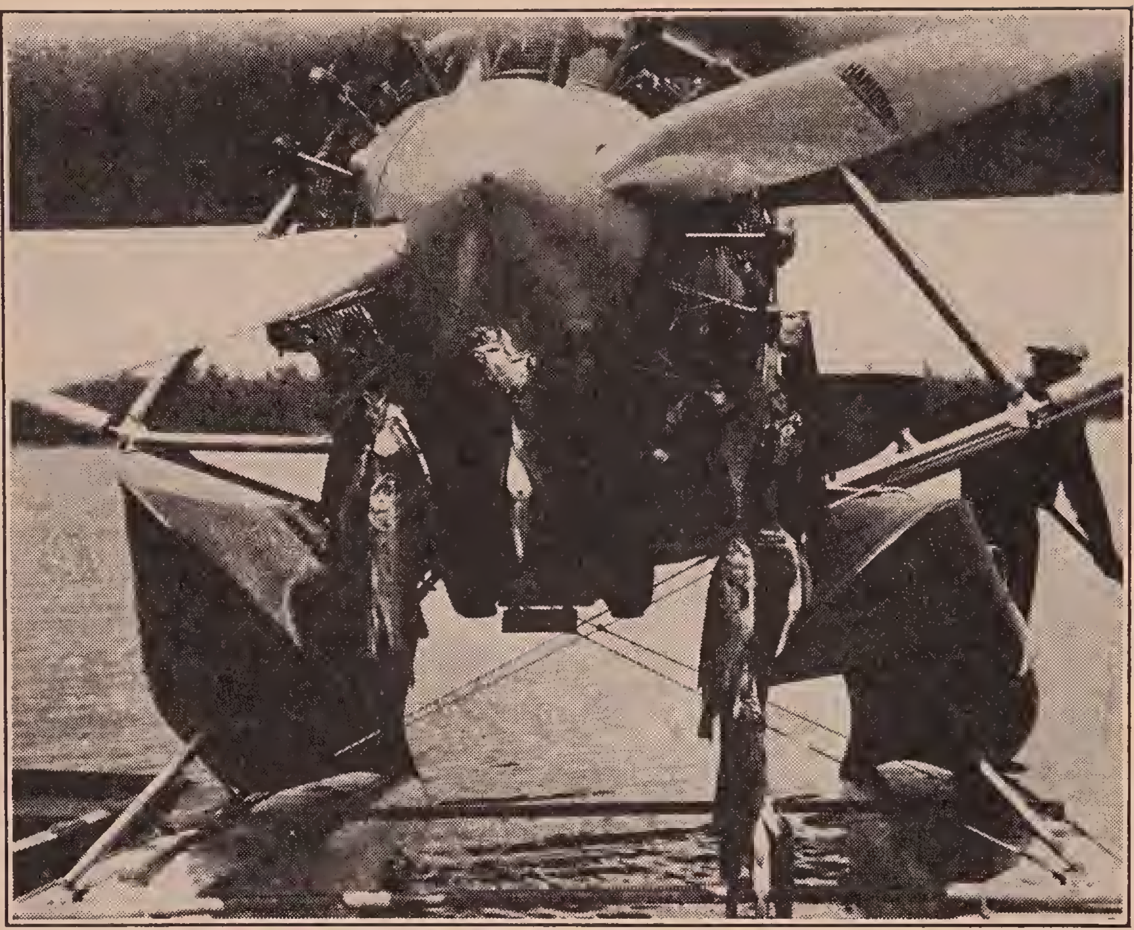
Millions of dollars are being carried from place to place for big banks. Money is not earning interest when it is being carried from one place to another; so the more quickly it reaches its destination, the more quickly it can be set to work. Since air express will transfer this money five times as fast as any other means, bankers will take advantage of such service.

More fragile merchandise will be carried in the air because there will be no vibration and less rough handling. Furthermore, heavy crating and extra packing will not be necessary; so the cost of preparing shipments will be lessened.

All sorts of merchandise will be shipped by air express. Already radios, typewriters, and machine parts have been safely dropped to places of delivery from flying planes. Flying grocery stores, fruit stores, and fish markets will carry fresh food supplies to people living inland or in isolated regions. Stores will not need so much space for surplus stock. A long-distance call to the manufacturer telling him of one's immediate needs will bring the merchandise by plane within a few hours.

You are familiar with sky writing, and you have perhaps picked up some circular dropped from an advertising plane. Probably you have listened as a radio installed in a plane has broadcast an advertising program, advised you to buy some particular kind of toothpaste or eat some special kind of bread. New devices will be developed to attract attention and stimulate buying.

Newspapers are being delivered on regular routes from a city press to mountainous regions or prairie towns. One pilot from an airport in a western state collects 'funnies' from all the Sunday papers, and taking an hour's ride in his plane, drops them for some eager little children living miles from the railroad. An air-mail pilot flying over a desert region near the Utah-Idaho state line played Santa Claus to the school children of a tiny community located in the midst of a monotonous stretch of sagebrush, when he flew downward to an altitude of 500 feet and released a Christmas tree. Looking back he saw the delighted chil-



Aëronautical Chamber of Commerce of America

THE RYAN SPORTSMAN'S SPECIAL

This plane carries two canoes, fishing rods, camping equipment, and special containers for keeping the catch fresh. It can land on lakes never reached except by air. The fisherman can fish from the pontoons or use the canoes.

dren and their teacher dragging the tree into their little schoolhouse.

There are vast unexplored and unmapped areas on the earth over which planes will fly, taking photographs. Scientific societies, newspapers, and individuals have already financed many flights over areas which it would take years to explore by any other means. It was in 1924–1925 that the value of the airplane for this kind of work was recognized. A group of men spent months making flights over the jungle regions of South America, taking pictures, making maps, and gaining a vast amount of valuable information. Since that time flights have been made and pictures taken in the Arctic and Antarctic over regions never before viewed by man. Hazards and obstacles are always a challenge to the adventurous spirit. Perhaps aërial exploration may furnish opportunity for unthought-of development or wealth in what now appears only vast waste areas.

Real-estate companies will use planes to survey lands which they intend to develop. Prospective buyers will be taken by plane to get a bird's-eye view of the development, thus making it easier and quicker for them to decide where they wish to locate. Oil companies are using planes to determine the best routes for their pipe lines, and to transport their high-salaried experts quickly from one place to another.

The possession of polar regions takes on new significance as possibility becomes evident of their affording important landing fields where aircraft en route from one continent to another could be repaired or refueled. The development of such industries as seal fishing and whaling has been made easier and will be more profitably carried on in the future by the use of aircraft. A great part of the Arctic region is claimed by Canada, the United States, and Russia, but there still remain extensive areas unknown and unclaimed. These parts appear on the maps as 'white spots.' According to the requirements set down by Charles Evans Hughes when he was Secretary of State in 1924, "The discovery of lands unknown to civilization, even when coupled with a formal taking of possession, does not support a valid claim to sovereignty unless the discovery is followed by an actual settlement of the discovered country." If such lands become important and settlement becomes necessary, think what the airplane could do to make such areas more inhabitable and living more comfortable.

Some Predictions

No one can foretell just what the motor plants of aircraft of the future will be, but four of the characteristics will be slow speed, reliability, perfect balance, and such construction as will use a fuel four or five times as powerful as the present fuel. The metal engineer, or metallurgist, is busy with his research in producing light metals which may be used for engines. New ways of cooling have brought out the use of new fluids. Four and one-half gallons of some of these liquids may be substituted in water-cooled motors for as many as eighteen gallons of water. Such a substitution reduces the weight and also reduces drag by lessening the frontal radiator area of the engine. Propellers will be adjustable both in pitch and diameter, which will make them more efficient in high altitudes.

Space for landing and taking off will be another problem. It is said that 3 per cent of the area devoted to railroads and roads in this country would provide sufficient landing fields for aviation. If airports could be located throughout the country at intervals of ten miles in each direction, an airplane flying at an altitude of four or five thousand feet would rarely be out of gliding distance from a landing field.

Since roads receive state aid for their upkeep, it is quite possible that airports may receive financial support from the same sources. Already cities have their own municipal airports.

It is predicted that one will be able to make the trip to Europe by air for $350 when the big seadromes are in use. These floating landing fields will be like huge floating islands of several acres, weighing thousands of tons. A string of them across the Atlantic would make possible regular scheduled flights from America to Europe in thirty to forty hours. They will be anchored by cables over three miles long to reinforced concrete blocks weighing hundreds of tons. Landing decks will be above the highest wave. An up-to-date hotel will have overnight accommodations for a hundred guests. There will be service stations where aircraft may be repaired and tanks filled with fuel. Radio broadcasts from these seadromes will guide aircraft in flight.

Dr. Hugo Eckener, who has been so successful in navigating the *Graf Zeppelin* on its long trips, is an advocate of airship travel for long distances. He believes that heavier-than-air machines must be confined to overland routes, while airships are well adapted to over-water flights. With good weather-forecasting service airships can avoid storms and safely make regular trips across the Atlantic or the Pacific. He foresees such a service over a San Francisco-Honolulu-Tokio route within a few years. Already the *Graf Zeppelin* has made several trips on schedule between Germany and South America.

If one said that one out of every twenty-five junior-high school students today would be piloting his or her own plane five years after completing a college course, the statement would sound extravagant, but the prediction has been made that within fifteen years there will be a million privately owned planes flying over this country. The gentleman who made this statement * came to such a conclusion after a six months' flying survey of the nation's aviation industry. In 1914 he made a similar survey of the automobile industry, and the accuracy of his report at that time gives weight to his forecast regarding the future of aviation. It seems quite possible that, as the public gains confidence in the safety of air flight, many more persons will own their own planes.

Aviation and Education

Aviation is influencing every branch of education. Technical colleges are enlarging their scope to prepare students for degrees in aëronautical engineering. Schools of education are discussing problems of aëronautics with respect to elementary and secondary education.

New York University, in coöperation with the Daniel Guggenheim Fund for Elementary and Secondary Educa-

* Mr. Charles Coolidge Parlin, head of the Division of Commercial Research of the Curtis Publishing Company.

tion, is giving, under the leadership of Professor Roland H. Spaulding, courses by means of which men and women are preparing to meet the requirements of the Department of Commerce for teachers of aviation ground schools. This University is unique in a new method employed whereby professors from its faculty are transported by airplane to different parts of the state to deliver lectures or to meet classes for the discussion of educational problems.

High-school students are being guided in their enthusiasm for aviation. Subjects pertaining to the industry are being added to the curriculum, and regular courses are given in many schools throughout the country.

Perhaps one of the first high schools to start work in aëronautics was Galt High School, Galt, California. The interest in aëronautics started in 1925. The pupils in this high school have the unusual opportunity of having actual flight instruction, along with ground-school education. Most school authorities feel, however, that the hazards are too great to give more than ground-school instruction.

St. Louis, Los Angeles, San Francisco, Seattle, Detroit, and Atlanta are only a few of the cities where an opportunity is provided for students to gain some aëronautical education in one way or another.

Aviation Clubs

Probably the most popular method in junior high schools is that of the organization of aviation clubs. These

The Aëronautics Club of the Washington Junior High School, Mount Vernon, New York

This club is working under the author's direction. The five charts on the wall at the right are a display of air-mail envelopes.

are conducted by the students themselves as an extra-curricular activity.

One club in Elizabeth, New Jersey, is composed of boys and girls who call themselves the Lafayette Air Cadets. They are divided into four squadrons with a cadet captain in charge of each squadron. The squadrons rotate, so that each spends a two-week period in each of four divisions. At the end a test is given covering all the instruction, and each cadet who passes successfully is given his 'wings.' The club has accumulated some aëronautical equipment, and members have made visits to airports, air shows, and airplane factories.

Another example of a junior-high-school club is one at Washington Junior High School, Mount Vernon, New York. This club, composed of boys and girls, divides itself into committees according to the interests of its members. The correspondence committee carries on correspondence with other clubs and societies and arranges for speakers for special meetings. A historical committee plans a report for each meeting on the history or progress of some phase of aviation. Construction work on models is taken care of by the construction committee, and the excursion committee makes arrangements for visits to factories, fields, or interesting places. Members of the club have constructed models, entertained speakers of note, visited shows, fields, and factories. They carried out an interesting project in the form of a 'Junior Aviation Show' at which some fifty members exhibited airplane models, scrapbooks, and aviation-career books. There were collections of bulletins, charts, maps, catalogues, pictures, and a large display of aëronautical magazines. A collection of air-mail envelopes, started three years before by a twelve-year-old boy and including specimens from dedication exercises and trips of practically every mail route in the United States, besides those carried on famous flights, received special commendation from visitors, among whom was the mayor of the city.

Playground and recreation commissions are setting aside space where boys and girls may construct models of aircraft, and are providing them with materials free or at a small cost. Tournaments are held where models are flown and exhibited. A national model-airplane contest under the auspices of the Airplane Model League of America, whose honorary president is Rear Admiral Richard E. Byrd, attracts boys and girls from all over the country. The Model Aircraft League of Canada, the junior branch of the Aviation League of Canada, is rendering a similar service to boys and girls of Canada.

It is surprising to note how much knowledge of aërodynamic principles young people acquire in the construction of models which remain in flight with only rubber bands supplying the motor power. Elsewhere in this book are directions for making airplane models with drawings and photographs of them.

A project worthy of mention was completed by eight high-school students in a small steel-milling town near Pittsburgh. These boys, aided by the local Boy Scout organization and the public schools, painted the name of their town, Midland, Pennsylvania, on the roof of their school. The letters were laid out and the painting was executed according to the specifications of the aëronautics division of the Department of Commerce. Chrome yellow was used for the letters and for the arrow pointing north, marked 'N.' Flyers and pilots are most appreciative of such markings, and the pioneer efforts of these boys could well be duplicated by junior- and senior-high-school boys throughout the country.

Growth of Interest in Aviation

Newspapers, magazines, motion pictures, and radio broadcasts have given facts about aviation to millions of people. Libraries have set aside special sections for the display of aëronautical subjects and book collections. Nationally known artists lend their talent in the portrayal of illustrative work relating to aviation. Aircraft shows, receiving aid and support from the Aëronautical Chamber of Commerce, have attracted millions of people, young and old, who have in this way been given an opportunity to obtain first-hand information about airplanes, engines, and aëronautical equipment. At air races, airplanes have demonstrated the fine art of flying in formation or in air maneuvers.

Long ago there were many persons whose views on flying were determined by their views on religion. They were convinced that if God had intended man to fly he would have provided him with wings, and therefore to experiment with devices which would take one into the air would be an act against Divine Providence.

How science explodes old theories and superstitions! Today man is carrying the messages of faith, hope, charity, service, and brotherhood to humanity by the very means that were so disparaged in earlier times. For today clergymen are using airplanes to take them to many different parts of the world to conduct religious services.

Aviation and International Relations

The greatest benefit of all to be derived from the development of aëronautics will be in international relations. The invention of the telegraph, the telephone, and the radio have all been contributing factors in breaking down prejudices of one nation against another. But nothing in the history of the world has ever held the common interest of peoples of all nations like the development of air transportation. How France and the other countries of Europe welcomed Charles A. Lindbergh when he conquered the elements and crossed the Atlantic! How like one great family did all nations pause to watch the progress of the *Graf Zeppelin* as it circled the globe!

The opening of air-transport lines between the states of Latin America and the United States will encourage communication and travel, and stimulate a common interest in each other. Aircraft will bring the continents of Europe and Africa on the east, and Asia on the west in closer contact with the Americas and with one another. Through the indorsement of Colonel Charles A. Lindbergh, the League of Nations has started a plan for an international system of markings and signals and weather and radio reporting. The famous aviator says, "Every problem in transportation has stimulated commerce and brought people of the world into closer contact with one another."

PART VII

MAKING MODEL PLANES

NATURE'S MODELS
HOMEMADE MODELS AND HOW TO BUILD THEM

CHAPTER XXV

NATURE'S MODELS

Many of nature's model aircraft have never been surpassed by man's productions. Fossils which have been dug up show that ages ago there were huge flying birds. The great winged lizard, called by scientists the Pteranodon, must have been "monarch of all he surveyed," in the sky at least, with his wing spread of over twenty feet. Of modern birds the great condor of South America has the largest wing surface, but the albatross has the longest wing spread, over eleven feet. No wonder the albatross, the bird which Coleridge tells about in *The Ancient Mariner,* is a great long-distance flyer.

The humming bird is tiny, indeed, compared with the condor and the albatross, but it, too, is an example of feathered perfection; it can poise at one place in the air, yet dart away with amazing rapidity when it is discovered hovering above some flower.

The soaring birds have long baffled learned scientists and have long defied the most careful study as to how these winged creatures can cover so much distance, yet expend apparently so little energy. The recently developed methods of high-speed photography, however, now give us a better idea of the way in which these birds take advantage of air currents.

But birds are not the only creatures making use of air pressure and air currents for flight. There are the flying insects. Many of these have two sets of wings — one set for support, which may be adjusted to different angles of incidence; another set for furnishing the propelling force. Not unlike modern airplanes, are they?

Then there is the flying squirrel. How well he uses that fold of furred skin between his legs, stretching it out and controlling it in such a way that he glides with safety for 60 feet from one tree to another. Indeed, in California and in Alaska there is a less-known squirrel that glides from the tops of trees 200 feet high. In East India there are flying lizards that are said to be able to make long gliding leaps like those of the flying squirrels.

Then, in the warm seas there are flying fish, some as long as 18 inches. They leap from the water and fly for over 100 yards, sometimes as high as 15 feet above the surface.

You may see other types of nature's model aircraft any day in the fall as fluffy seeds or thin flat ones go sailing and gliding up and down or gliding long distances, carried along on air currents.

CHAPTER XXVI

HOMEMADE MODELS AND HOW TO BUILD THEM

For a long time inventors of aircraft have put to use facts learned from observation of nature's models and have experimented with small model planes. As long ago as 1871 the idea of using a rubber band for the power plant of a model plane — the same power plant used now — was introduced by a Frenchman, Penaud.

Boys and girls are forming clubs all over the country; they build models and compete with one another to see whose product can fly longest or highest or farthest, or which one shows the finest workmanship. Many of these youthful builders of today will be the aëronautical engineers of tomorrow.

In this chapter exact directions are given for building two fairly simple models. This will give you what you need to make a beginning in this fascinating field, for to fly airplane models that you have built yourself is thrilling sport. The take-offs, the flights, and the landings are all of breath-taking interest.

Types of Model Planes: Tools and Materials

It is well to familiarize yourself with the standard types of airplane models that are flown in contests and generally made by experienced model-makers. These types

United States Army Air Corps

BOYS AT CHICAGO AIR RACES WITH THEIR MODEL RACERS

are the single pusher, the indoor endurance tractor, the twin pusher, and the R.O.G. models. The simplest of all these planes are the small R.O.G. models; they are easy to build and offer interesting possibilities for improvement. The most remarkable flyer of all is the twin-propelled pusher, which has flown for twelve minutes and sometimes over two miles. A record of twelve and one-half minutes was made at one of the National Playground Contests which are held every year.

In addition to these power models, a model glider is easy to build, and, in fact, a good model to start with.

The general tools and supplies necessary for model-building are inexpensive and simple. A good assortment consists of:

A ruler
A soft (No. 2) pencil
A sharp pocket knife
A pair of small round-nosed pliers
A pair of small flat-nosed side-cutting pliers
A pair of shears
A drawing board (or other flat wooden surface)
A safety razor blade and holder
A pencil compass
Thumb tacks
Stout pins
Sandpaper, No. 00
Banana oil
Acetone

There are certain materials that enter into the construction of nearly every model. Most of these materials you will have to purchase of stores or model-supply houses that make a specialty of providing them. These are:

Balsa wood (various dimensions as specified)
Japanese tissue paper
Piano wire (usually .014″ and .016″ diameter)
Rubber (in flat strips)
Bamboo
Ambroid (a special airplane cement, or glue)

The knife is used for carving the propeller blades and cutting the wing frames and ribs. The pliers are used for cutting and bending the piano wire into the different fittings necessary for the models. The drawing board is used when making drawings or laying out surfaces for wings, rudders, etc. The shears are handy for cutting balsa wood. The razor is used to trim the excess paper from the wings and other surfaces of the models. A simple holder for safety-razor blades can be bought at local hardware or five-and-ten cent stores.

For wing spars, longerons, and braces, balsa wood is the best material, unless one is building a scale model, when heavier material is used. Ribs, skids, and outline pieces are often made of bamboo, bent to the required shape by heating over a candle.

I. A Model All-Wood Glider

If you want to get results from flying models, it is best to start with model gliders.

A primary-type glider is very easy to build. You can do many things with it by launching it from your hand. You can even have it towed behind a larger model airplane, when it certainly will give you a realistic performance, if not a real thrill.

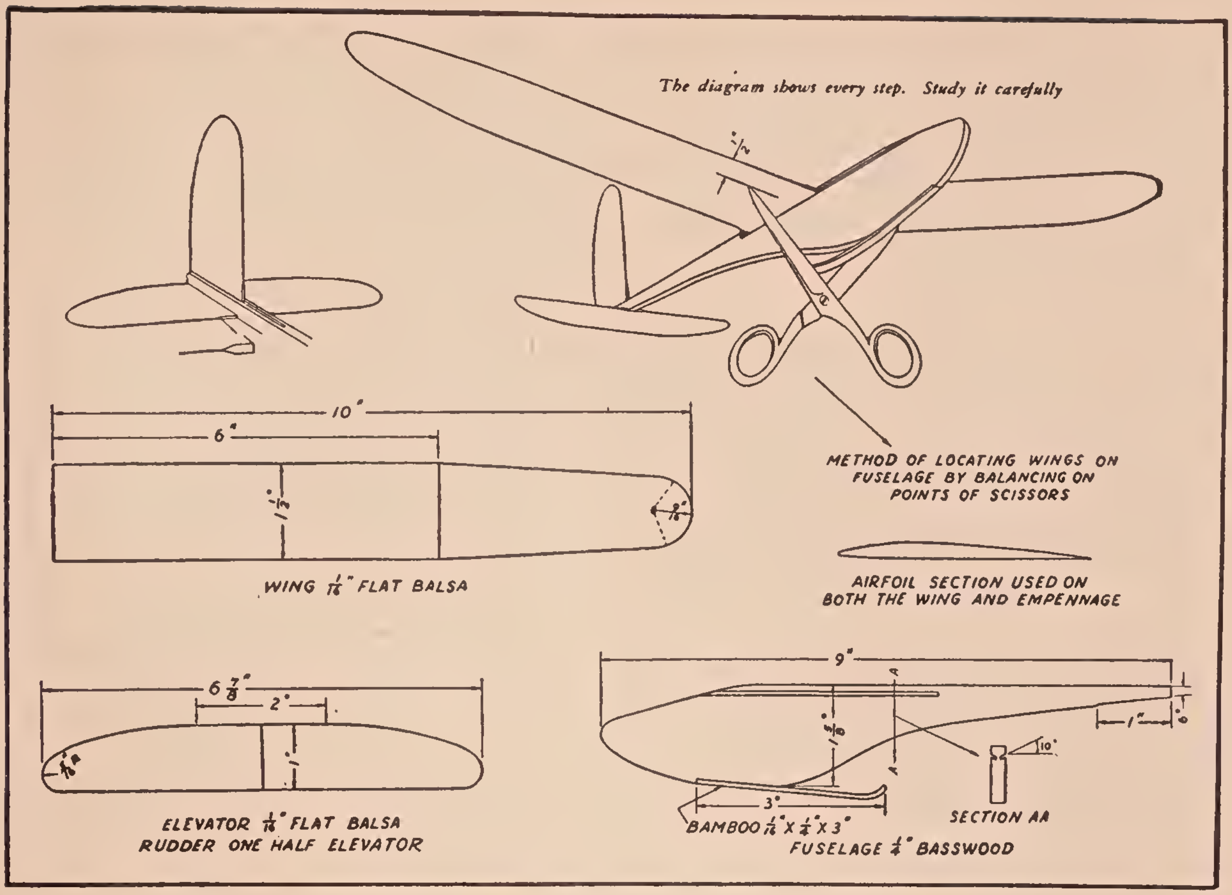
Special Materials Needed

1 piece basswood, 1/4″ x 1 3/4″ x 9 1/8″
1 piece balsa, 1/16″ x 4″ x 10 1/2″
1 piece bamboo, 1/16″ x 1/4″ x 3″
Airplane cement (Ambroid)

Your tools are a pencil compass, a razor blade, and a jackknife, with some sandpaper.

Making the Fuselage

Your first job is the basswood fuselage. You may use balsa instead of basswood for this, but you will then need to add a weight on the nose to balance it better for gliding.



Working Drawing of the All-Wood Glider

(Adapted from an article by Merrill Hamburg in *The American Boy Magazine.*)

The drawing shows you the shape and dimensions of the fuselage. Its widest point, 1⅝", is just 2⅞" back from the nose.

Section AA, ⅞" in width, is 4⅝" back from the nose. The tail tapers to a width of 3/16" at the very rear.

With a pencil, outline the whole fuselage on one side of the basswood board. Then cut it away with your jack-knife. Smooth the edges down to the outline, first with coarse, then with fine, sandpaper.

Note that at the rear of the fuselage you must cut away underneath a section 1" long and 1/16" deep to permit attachment of the balsa tail, or elevator. The angle between the top edge of the fuselage and this cut-away section along the bottom is six degrees, as shown in the illustration. This angle determines the slant of the elevator; so work it out carefully, coming as close to it as you can by observation of the drawing.

Now the grooves for the wings are to be cut. This is a delicate job, and you'll have to handle it carefully and expertly. Each groove is $\frac{1}{16}''$ wide and just about as deep. You must be extremely careful not to make the grooves too deep; if you do, you will cut all the way through the fuselage. Take extreme care, too, to cut the grooves at precisely the same angle — approximately 10 degrees. If they differ, that will wreck the setting of your wings and throw your model out of balance. Study Section AA of the drawing.

Finish the bamboo skid as shown in the working drawing by bending up the last half-inch of it slightly. To do this, heat it over a candle flame or near a hot soldering iron; bend it to the desired angle, and hold it bent until it cools. Then it will retain the angle. Cement it to the bottom of the fuselage with Ambroid, as shown in the diagram.

Making the Wings

Next come the wings. They are cut from the 10-inch piece of $\frac{1}{16}''$ flat balsa. Both edges are straight (retain their $1\frac{1}{2}''$ width) for $6''$ out from the center; then they taper toward the end. To get the rounded end, find the exact center of the wing at a point 9/16″ from the tip of the wing and with your pencil compass draw a circle of 9/16″ radius. Taper the edges from the 6-inch point to the side of this circle, and sandpaper the whole wing down to a smooth, properly shaped surface.

The drawing shows a suggested airfoil section for both wing and tail members. It isn't absolutely necessary to work out this detail, but a model with cambered wings will perform better than one with perfectly flat wings; so you will probably want to do it.

The amount of curve in the wing is a little exaggerated in the drawing. The chief point to remember is that the thickest place in the wing should be one-third of the distance (half an inch in this case) from the leading edge to the trailing edge. Here are two 'don'ts' to be observed in making the airfoil: first, don't attempt to carry the camber all the way to the ends of each wing, because a stronger joint may be obtained between the wings and the fuselage if the wings are left flat at the point of joining; second, don't make both wings rights or lefts. Remember that their wide square ends are brought together at the fuselage and that the leading edge must be the heavier edge when they are assembled in this position. If you lay them out in flying position before you start work, you will avoid making this error.

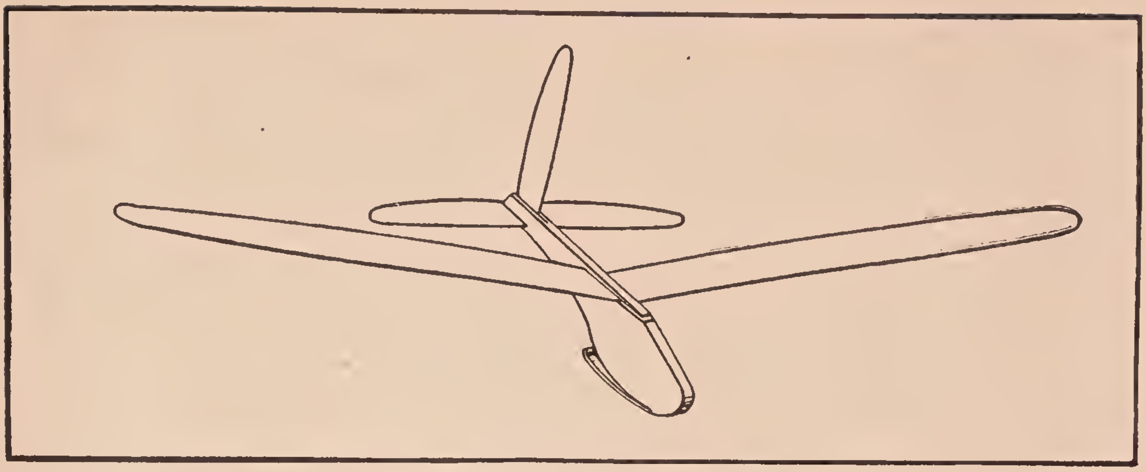
The Elevator and the Rudder

You make the elevator and rudder by the same procedure used in making the wings. The rudder is just like one half of the elevator. You should not camber the rudder, however, the way you did the wings, because you want the two sides of it to have the same curve. Make the thickest point of the elevator and the rudder about one-third of the way from the leading edge to the trailing edge, then streamline both sides of each of them in the same curve. Don't thin the edges of elevator and rudder where they are to meet the fuselage.

The Assembly

Now comes the assembly job. It is easy to cement the elevator and the rudder to the fuselage (you have left their leading edges square where they meet the fuselage, for ease in joining). The rudder fits squarely and solidly into the groove in the top of the fuselage, and is not to be set at an angle. (If you have built flying models, you have been accustomed to twist the rudder in order to turn the model in flight. Don't do it with this glider model!) And don't be sparing with cement; you need plenty of it for firmness.

Fitting the wings into place is a little harder. First, you must find their exact setting. Do this by forcing them into the wing grooves, then balancing them on the points of a pair of shears as shown in the drawing. Draw lines on their lower surfaces parallel to the leading edge and ½″ from it, as shown in the illustration. These show the points at which the shears should support the model. If it tips forward, tail up, move the wings forward; if it tips backward, nose up, move the wings backward. It will be properly balanced when the top of the fuselage remains



The Assembled Glider

in a horizontal position. Be sure that the wings are now inserted evenly, then on the fuselage mark with a pencil the exact places for them to be set and have the glider balance.

Now remove them and squeeze cement into the grooves. Reset the wings exactly where you had marked places for them. Check the model again for balance on the shear-points, and make sure that they have formed the same dihedral angle with the fuselage. You can do that in the following manner:

Place the side of the fuselage against the edge of a desk or table, with one of the wings just at the table top. With a ruler, measure the height of the wing tip above the table top. Reverse the model, and measure the height of the other wing tip. If the heights are not exactly even, you may change the angle of one or the other before the cement hardens. While the cement is drying, the glider should rest on the table in a flying position, tail up, with supports under it. The wings also should be supported to prevent them from sagging. Small blocks, paper weights, books, or any similar objects may be used for this purpose. You will find that your glider is going to be subject to more strains than any power model you have ever built; so don't rush the drying. Let it set overnight. It takes some time for the cement in the grooves to harden thoroughly.

Now the cement is set, and the glider is ready for action. It will probably be well to select a favorable place outdoors where there is less danger of a crash against obstacles. Take it between thumb and forefinger, holding it just below the wing; be sure that it is horizontal; then launch it directly forward. After a few trial launchings you'll be an expert. You'll learn to make it loop, glide straight, or make a big circle, all by varying the manner in which you launch it.

Performance

If it has a tendency to 'hunt' — that is, to dive in a long curve, stall, and dive again — you'll need to add a pin or so, or maybe as much as a thumb tack, to the nose of the fuselage. Your wing is too far forward, and nose weight will remedy the difficulty; but don't add any more than you have to, for weight will reduce its gliding ability.

Once it's set just right and you know how to handle it, you can do many things with your model glider. You can hold it over your head in a stiff breeze and see it rise right into the wind. You can launch it from the hilltop — remember that the wind should be blowing up the hill, and that you must always launch it against the wind — and watch it soar far above your head. You can hold a glider contest with other members who have built similar models.

And maybe you will be setting new model glider records. Whether you do or not, you will be learning many things about gliding angles, lift, and so forth that will help you when you build your flying models.

II. The Baby R.O.G.

The Baby R.O.G. ("Rise Off the Ground") is the simplest and easiest power model to build. It can be made to dive, zoom, loop, and barrel roll, and, if properly constructed and adjusted, it will sail for at least one minute.

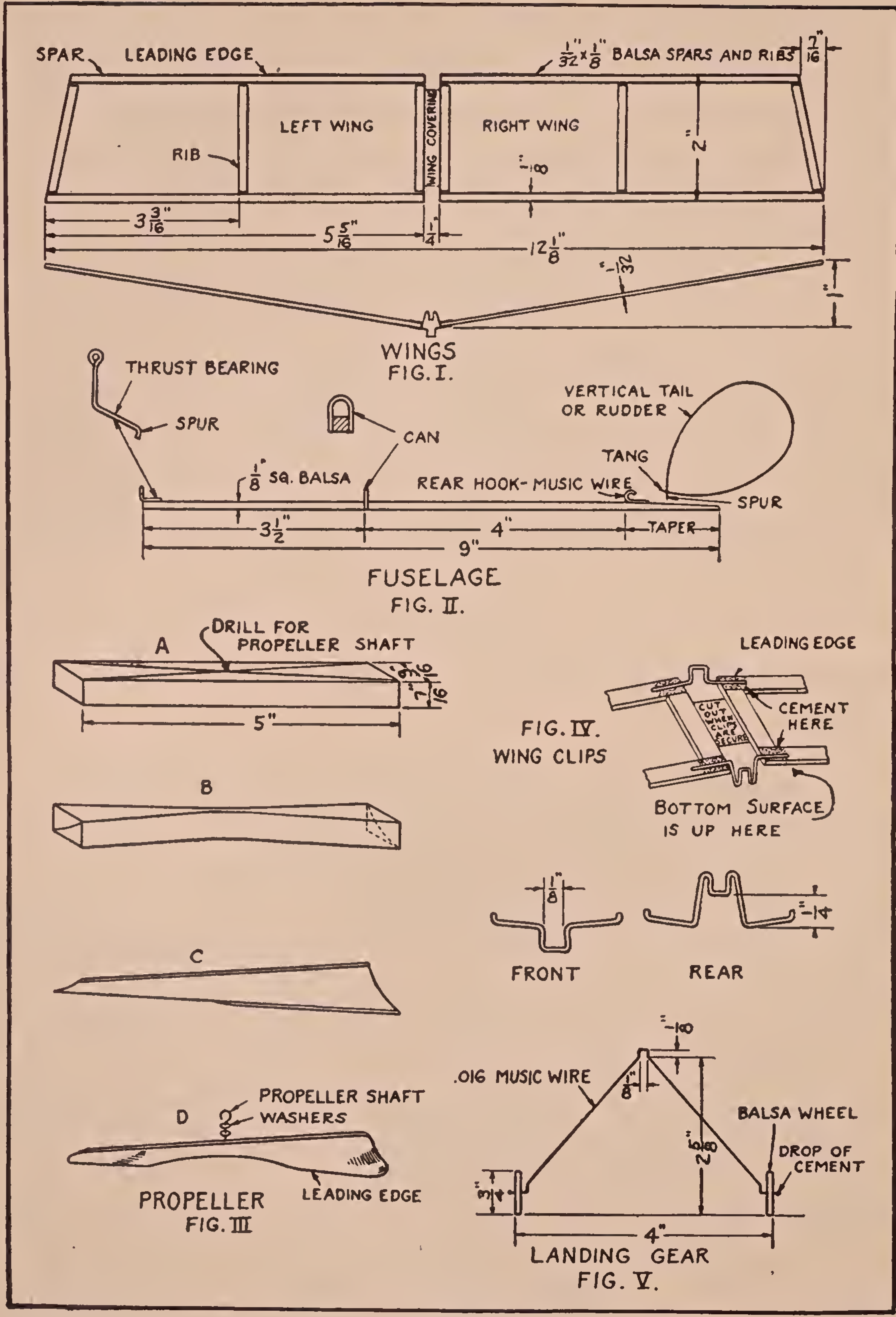
Materials

The materials necessary to build the Baby R.O.G. are as follows:

1 pc. balsa $\frac{1}{8}''$ x $\frac{1}{32}''$ x 36″ (for wing spars and ribs)
1 pc. balsa $\frac{1}{8}''$ x $\frac{1}{8}''$ x 9″ (for fuselage)
1 pc. balsa $\frac{3}{4}''$ x $\frac{1}{2}''$ x 6″ (for propeller block)
2 pc. balsa $\frac{1}{16}$ x 1″ x 1″ (for wheels)
1 pc. Japanese tissue paper (for covering wings and tail surfaces)
18″ piano wire .014″ diameter (for frames of rudder and tail surfaces and can)
20″ piano wire .016″ diameter (for landing gear, wing clips, rear hook, and propeller shaft)
2 feet of $\frac{1}{8}''$ flat rubber (for motor)
2 small washers

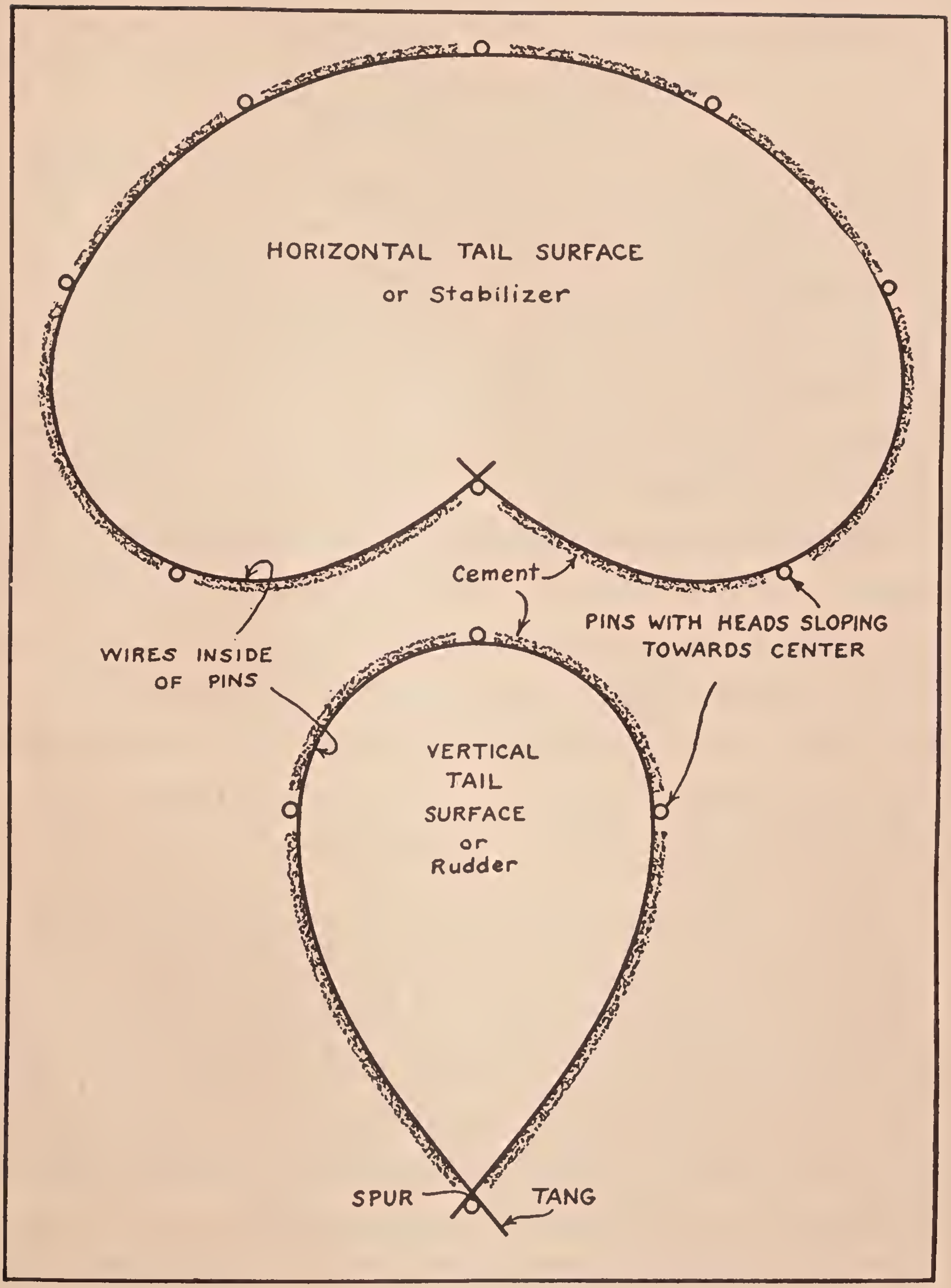
Making the Fuselage

Start with the fuselage. Take the piece of balsa $\frac{1}{8}''$ x $\frac{1}{8}''$ x 9″ and at a point $1\frac{1}{2}''$ from one end taper it down to



Working Drawing of the Baby R. O. G.

(Adapted from an article by Merrill Hamburg in *The American Boy Magazine.*)



FULL-SIZE DRAWINGS OF THE TAIL SURFACES OF THE BABY R. O. G.

(From an article by Merrill Hamburg in *The American Boy Magazine.*)

one-half the thickness of the stick. (See section of fuselage, Figure II, marked "taper" in the drawing.)

Making the Landing Gear

Take the two pieces of balsa 1/16″ x 1″ x 1″. With the ruler draw light diagonals on the face of each piece. Where the diagonals intersect will be the center of the wheel which is to be made. With a pencil compass make a circle with 3/8″ radius, then trim to the circle, making a wheel 3/4″ in diameter. Lay a sheet of paper on your drawing board and with pencil and ruler draw to full size the lay-out of the landing gear shown at Figure V in the diagram. From the piano wire .016″ in diameter cut a piece twelve inches long. Bend this piece of wire into shape so that it will lie exactly on the line of your drawing. Put the wheels in place with the wire passing through the center marks. Then put a drop of glue on the end of each axle. Set the landing gear aside until the glue has hardened.

Making the Thrust-Bearing, Rear Hook, and Can

Make the thrust-bearing by bending a piece of .016″ piano wire with the round-nosed and the flat-nosed pliers. The small loop takes the propeller shaft. Note that the flat section that lies along the fuselage ends in a tiny spur than can be pushed into the balsa wood.

Cut off a one-inch piece of the .016″ piano wire. Bend one end of this into a hook to form the rear hook, as shown on the drawing of the fuselage. Make a spur on the tip of the flat section.

Cut off a one-inch piece of the .014″ piano wire. Bend this into a loop to form the can. Notice that this can is to fit over the fuselage to make a guide for the rubber motor.

Mounting the Thrust-Bearing, Rear Hook, and Can

Glue the thrust-bearing to the thick end (front) of the fuselage (motor stick) after pushing the short spur into the wood. At a point 1½″ from the tapered end (rear) of the stick, push the spur of the rear hook into the wood and glue the hook in place. At a point 3½″ from the front end of the stick, glue the can in place. Set the motor stick aside until the glue has hardened.

Making the Horizontal Tail Surface and the Vertical Tail Surface

With the thumb-tacks pin the sheet of Japanese tissue paper upon the drawing board. On this tissue paper trace an exact-size drawing of both the horizontal tail surface and the vertical tail surface, as shown in the drawing. Drive pins into the board along the outlines drawn as shown. Cut two pieces of the .014″ piano wire so that one piece is 10⅜″ long and the other is 6⅝″ long. Bend the pieces of wire to the shapes drawn on the paper. Be careful not to kink the wire, and see that the wire conforms to the drawings. Finally, glue the wire to the paper, placing the glue outside the wire only. The point to remember is to get the Ambroid glue under the wires without using too much. When the glue has dried well, remove the pins and glue the places where they were. After these spots of glue have dried, trim off the extra paper with the razor.

Assembling the Vertical Surface, the Horizontal Surface, and the Landing Gear on the Fuselage

Insert the short end (marked "spur" on the drawing) of the rudder, or vertical tail-frame, wire into the end of the motor stick next the rear hook and glue the other end (marked "tang") to the fuselage. Put glue on the under-side of the rear end of the fuselage and glue the horizontal tail surface to this under side of the stick, taking care that the stick is exactly centered above the tail surface. Then mount the landing gear about 1½″ from the front end of the stick. Set aside until the glue has thoroughly dried.

Making the Wings

With thumb tacks, fasten a piece of Japanese tissue paper, 14″ x 3″ or larger, upon the drawing board. Then, with a soft pencil, very carefully draw full size the right and left wings and show the exact position of the four spars and the six ribs. Follow the wing dimensions shown at Figure I in the working drawing.

Now, to construct the wings, with shears or a sharp knife cut the four spars of the proper lengths from the strip of balsa ⅛″ x $\frac{1}{32}$″ x 36″. Give one side of each spar a light coat of the Ambroid glue and glue all four of them to the drawings you have made on the tissue paper. Next, cut and fit the six ribs. Give one side of them a light coat of glue and glue them to the proper positions on the wing drawings. Apply an extra drop of Ambroid at every place where the spars and rigs are joined. Put weights on the spars and ribs while they are drying, so that there will be no chance of their warping.

Making and Attaching the Wing Clips

The next step is to make the wing clips. These are made from the .016″ piano wire. To make the front wing clip, cut a piece of wire 1⅞″ long and bend it into the shape shown in Figure IV, being careful to include the short spurs (at each tip of the clip) that are pushed into the wood of the wing spars. To make the rear wing clip, cut a piece of wire 2⅝″ long and bend it into the shape shown in Figure IV. (For exact dimensions see the two drawings marked "Front" and "Rear" in Figure IV of the working drawing.)

When the glue on the wings is perfectly dry, trim off all excess paper and then glue the wing clips in place. Glue the small clip to the front, or leading, edge of each wing and the larger clip to the rear of each wing, as shown in Figure IV. Notice that, to show better the method of attachment, this figure is shown bottom side up in the working drawing; that is, the surface of the wing spars to which the clips are glued will be the under surface when the wings are attached to the fuselage stick. Notice also that the rear wing clip, made of a longer piece of wire, and bent with longer sides, sets the rear edge of the wings off from the fuselage; that is, the rear edge of the wing will be lower than the front, or leading, edge. This shows clearly in the photograph of the completed model.

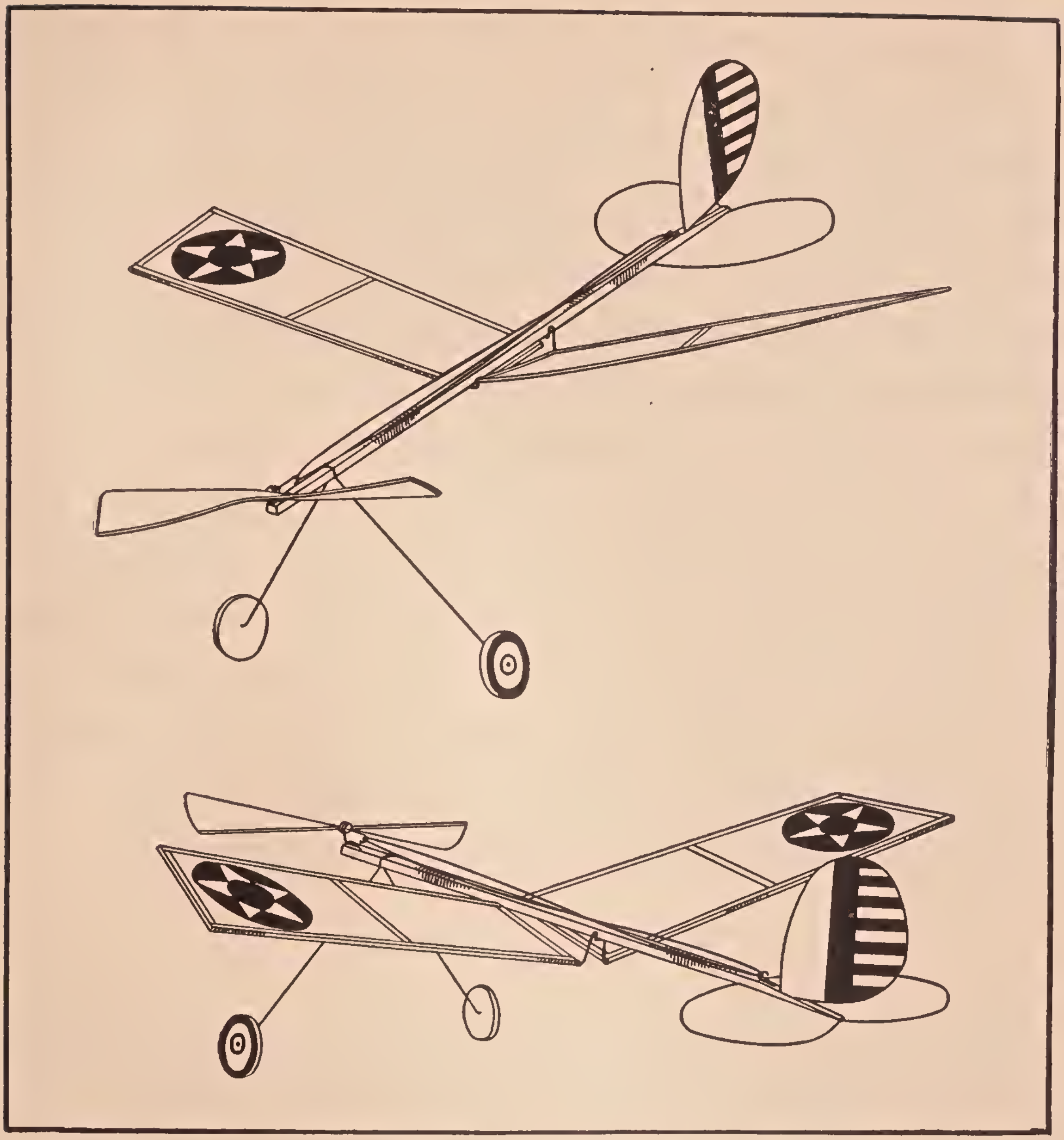
The wings not only slope upward from rear to front, but also slope upward from the fuselage to the wing tips. This slope amounts to one inch vertically (see lower part of the wing drawing, Figure I and also the front and rear wing clips in Figure IV) and is made by bending the two wing clips very carefully with flat-nosed pliers before the wings are attached to the motor stick.

Making the Propeller

On the broad surfaces of the balsa propeller block, ¾″ x ½″ x 6″, draw diagonals as shown in Figure III, A. At the intersection of these diagonals drill a hole through the block to take the propeller shaft. Use a drill smaller than the .016″ wire, and be sure to hold the drill exactly perpendicular to the block. Now with a sharp knife carve out the center sections, as shown in Figure III, B, leaving the middle about ⅛″ thick.

Next draw a diagonal across one end of the block, as shown in Figure III, B. On the other end draw a diagonal in the opposite direction. Carve the block away above the two diagonals, as shown in Figure III, C.

The wood below the diagonals is next cut away until the blades are about 1/16″ thick. After that use fine sandpaper, instead of a knife, very carefully dressing down the blades until they are about 1/32″ thick and the hub is about 1/16″ thick. The 'prop' is a delicate job. On some models made



Two Views of the Baby R. O. G.

Here are some suggestions for decorating your assembled model.

by expert model-builders, the blades are scarcely thicker than a sheet of paper.

Finally round off the tips of the blades (see the drawing of the assembled model) and cut away the hub sections, so that the blades are wider at the tip than at the center.

For the propeller shaft take the remaining piece of .016″ diameter wire, which should be approximately 1½″ long.

With the flat-nosed pliers bend one end into a square-cornered L, with a short spur on the tip of the L. Put the long, straight end of the wire through the hole of the propeller from front to back, pushing the spur into the balsa wood. Then glue the L arm of the wire to the face of the propeller. Put Ambroid around the hub also to strengthen the propeller at that point.

After this glue is thoroughly hard, put the two small washers on the wire, run the wire through the hole in the thrust bearing, and with your round-nosed pliers bend the end of the wire into a loop (propeller shaft hook shown in Figure III, D) to take the front end of the rubber motor. The washers are tiny thin metal pieces with holes not much bigger than a needle would pass through. Tiny beads are sometimes used instead of brass washers.

The Final Assembly

Attach the two-strand rubber motor to the propeller shaft hook, pass it through the can, and attach it to the rear hook. The rubber should be just long enough to keep the propeller pulled up against its thrust bearing before the motor is wound up.

Clip the wings on to the under side of the fuselage about two-thirds of the way from the front end of it.

The exact point to clip on the wings you will have to find out by gliding the model. If the wings are properly adjusted, the model will level off when you glide it and come to the floor in a three-point landing. If the wings are too far forward, the plane will stall; if they are too far back, it will dive to the floor. Experiment until it glides smoothly and evenly.

Now you can make your first trial flight 'under power.' Wind the propeller clockwise for about 150 turns and then launch the plane for its maiden flight. With a little patience and practice you can make the R.O.G. loop, barrel roll, and fly on a straight-away for as long as one minute.

GLOSSARY

(Adapted from a *Dictionary of Aëronautical Terms,* by permission, and with the endorsement, of Roland H. Spaulding, of New York University.)

ACROBATIC FLYING—Intentional maneuvers with an aircraft which are not necessary to air navigation. (See Chapter XX.)

AËRODROME—An extensive tract of level ground suitable for, or devoted to, the take-off, landing, and evolutions of aircraft; a flying field.

AËRODYNAMICS—The branch of dynamics which treats of the air and other gaseous bodies under the action of force, and of their mechanical effects.

AËRONAUTICS—The science and art concerned with the flight of aircraft, both lighter-than-air and heavier-than-air.

AILERON—A hinged movable surface of an airplane, usually part of the trailing edge of a wing near its outer tip, which is used to rotate the airplane about its longitudinal axis. (See Chapter IX.)

AIRFOIL—A surface, like a wing or rudder or elevator, designed to produce a lifting or directional effect. The words 'control surface,' 'lifting surface,' and 'stabilizing surface' are often used to indicate special forms of airfoil. (See Chapter IX.)

AIRPLANE—A mechanically driven aircraft, heavier than air, fitted with fixed wings, supported by the dynamic action of the air, and controlled by movable airfoils.

AIRPOCKET—The name erroneously applied to a down current of air. (See Chapter XIV.)

AIRPORT—A locality, either of land or water, that is adapted for the landing and taking off of aircraft and that provides for their shelter, supply, and repair; or a place used regularly for receiving or discharging passengers or cargo by air. (See Chapter XXI.)

AIR SPEED—See SPEED, AIR.

AIRWAY—An air route between air-traffic centers which is over country best suited for emergency landings of either land planes or seaplanes. (See Chapter XXII.)

ALTIMETER—An instrument for measuring the height of an aircraft above sea level. (See Chapter XI.)

Amphibian—An airplane designed to rise from and alight on either land or water. (See Chapter IX.)
Angle of Attack, Critical—The angle between an airfoil and the air, which, if increased, will result in a stall. Also called the 'burble point.' (See Chapter XII.)
Angle of Incidence—The acute angle formed between the wings and the body of an airplane, or more exactly, between the chord of the airfoil and the longitudinal axis of the plane. (See Chapter XII.)
Apron—A hard-surface area of considerable extent, immediately in front of the entrance of a hangar, that is used for the handling of aircraft.
Autogiro—The name given to a heavier-than-air craft in which the lift is obtained from four equally spaced airfoils rotating about a vertical axis. The blades are not driven by an engine, as in the helicopter, and the forward speed is obtained by the thrust of an engine-driven propeller, as in an airplane. (See Chapter IX.)
Aviation—The science and art of operating heavier-than-air craft.
Axis, Lateral—An imaginary horizontal line extending in the same direction as the wings and perpendicular to both the longitudinal and the vertical axes.
Axis, Longitudinal—An imaginary line extending fore and aft in an airplane, intersecting the lateral axis at right angles.
Axis, Vertical—An imaginary perpendicular line running through the center of an airplane where the lateral and the longitudinal axes intersect. (See Chapter XII.)

Balloon—Lighter-than-air aircraft without any propelling system. There are various types, such as 'captive,' (held to the earth by a cable), 'free,' 'pilot' (sent up to show the way the wind is blowing), 'sounding' (carrying recording weather instruments but no passengers). Captive balloons have various forms, such as 'kite' (with fins or lobes to head it toward the wind), 'observation' (carrying a person to observe), 'sausage' (shaped like a sausage). (See Chapter V.)
Balsa—An extremely light, easily worked wood, grown in Central America and the West Indies, and much used in making model airplanes. (See Chapter XXVI.)
Bank—To incline an airplane by tipping a wing up or down; *i.e.*, to rotate it about its longitudinal axis. 'Right bank' is to incline the airplane with the right wing down. (See Chapter XIX.)
Barograph—An instrument for recording the pressure of the atmosphere, and hence serving as one means of recording height above sea level. A barometer indicates, but does not record, this pressure. (See Chapter XI.)
Barrel Roll—See Roll.

Biplane—An airplane with two main supporting surfaces placed one above the other. (See Chapter IX.)

Blimp—A small non-rigid dirigible. (See Chapter V.)

Bumpy Air—A condition of the air in which there are numerous up-currents and down-currents. These give an up-and-down motion to an airplane flying through them not unlike the motion given to a boat by waves.

Camber—The amount of curve in an airfoil section. (See Chapters IX and XXVI.)

Ceiling—The height of the clouds above the ground or the highest point above the ground at which the aviator can see well enough to fly without the aid of instruments.

Ceiling (of an Airplane):

Absolute—The maximum height above sea level at which a given airplane would be able to maintain horizontal flight.

Service—The height above sea level at which a given airplane ceases to be able to rise at a rate higher than a small specific one (100 feet per minute in the United States and England).

Chocks—Blocks placed on the ground in front of the wheels of an airplane to prevent its moving forward while the engine is being warmed up.

Chord (of an Airfoil Section)—A straight line connecting the leading and the trailing edges of an airfoil.

Climb Indicator—An instrument used in an aircraft to indicate the pitch of the path taken during a climb or a dive. (See Chapter XI.)

Cockpit—The open space in which the pilot or passengers are accommodated. When the cockpit is completely housed in, it is called a 'cabin.' (See Chapter IX.)

Compass, Earth Inductor—A special type of compass that operates by means of a coil revolving in the earth's magnetic field. (See Chapter XI.)

Contact—Making an electrical connection that will switch on the ignition system of an airplane motor. The pilot shouts "Contact!" when he is about to throw the switch, to warn the mechanic who is turning over the propeller by hand.

Controls—A general term applied to the means provided to enable the pilot to control the speed, direction of flight, altitude, and power of an aircraft. (See Chapter IX.)

Air Controls—The devices used to operate the control surfaces of the aircraft.

Engine Controls—The devices used to regulate the power output of the engine.

Control Stick—The vertical lever by means of which the longitudinal and lateral controls of an airplane are operated. Pitching is controlled by a fore-and-aft movement of the stick; rolling, by a side-to-side movement of the stick. (See Chapters IX and XIX.)

Cowling—A removable cover that extends over or around the engine and sometimes over a portion of the fuselage or the nacelle as well. (See Chapter XIII.)

Cross-Country Flight—Any flight starting at one field and ending at another that is not within gliding distance of the first field.

Cross-Wind Landing—Landing an airplane with the wind blowing against its side. This is often necessary in small or one-way fields.

Dead-Stick Landing—A landing resulting from engine failure.

Dirigible—A balloon that can be directed or steered; *e.g.*, a zeppelin. (See Part II.)

Dive—A steep descent, with or without power, in which the air speed is greater than the fastest speed the airplane can make in horizontal flight. (See Chapter XX.)

Dope—The liquid material applied to the cloth surfaces of airplanes to increase strength, to make the surface taut by shrinking, and to act as a filler for maintaining air-tightness.

Drag—That part of the total air force on an aircraft or airfoil which acts parallel to the path of the relative wind. (See Chapter XII.)

Drift—The sidewise deviation in the flight of an aircraft which is produced by crosswise currents of air.

Duralumin—An alloy of aluminum that is much used in aëronautics, especially for the structure of airships and airplanes. It is much stronger than aluminum and considerably lighter than steel.

Elevator—An airfoil control surface placed horizontally, usually hinged to the stabilizer. Its movement causes the ship to climb or to dive. (See Chapter IX.)

Empennage—All of the tail group of airfoils, including the rudder, elevators, vertical stabilizer, and horizontal stabilizer. (See Chapter IX.)

Engine, Inverted—An engine having its cylinders below the crankshaft. (See Chapter X.)

Engine, Radial—An engine having stationary cylinders arranged like the spokes of a wheel around a crankshaft. (See Chapter X.)

Engine, Rotary—An engine having revolving cylinders arranged radially around a common fixed crankshaft. (See Chapter X.)

Engine, Supercharged—An engine in which the cylinder charge, or intake of fuel, is increased by some mechanical device.

Engine, Vertical—An engine having its cylinders arranged vertically above the crankshaft. (See Chapter X.)

Engine, V-Type—An engine having its cylinders arranged in two rows, forming, in the end view, the letter 'V'. (See Chapter X.)

ENGINE, W-TYPE—An engine having its cylinders arranged in three rows, forming, in the end view, the letter 'W'. Sometimes called the 'broad-arrow type.' (See Chapter X.)

FIGURE EIGHT—A maneuver in which the airplane is flown in a course which produces a horizontal figure 8. Flying in 8's is one of the requirements of the Department of Commerce examination for a pilot's license. (See Chapter XX.)

FIN—A fixed surface attached to the tail of an airplane, parallel to the longitudinal axis, to enable the plane to keep its direction better. Same as 'vertical stabilizer.' Fins are sometimes adjustable. (See Chapter IX.)

FLIPPER—A slang term for 'elevator.'

FLOAT (OR PONTOON)—A completely inclosed, water-tight structure attached to an aircraft to give it buoyancy and stability when in contact with the surface of the water.

FUSELAGE—The body of an airplane of approximately streamline form, to which are attached the wings and the tail unit. In general, it houses the power plant, passengers, and cargo. (See Chapters IX and XXVI.)

GLIDE—A descent with the airplane flying at a normal angle but without engine power sufficient for level flight in still air.

GLIDER—A form of aircraft similar to an airplane but without motive power. It depends upon gravity and wind currents for its flight. (See Chapter XVI.)

GRAVITY—The force that tends to draw all bodies toward the center of the earth.

GROUND LOOP—The movement made by an airplane if, when taxiing, control is lost and it makes a quick turn on its wheels. Frequently a wing tip then digs into the ground and is broken. A wheel or a tire may also give way.

GUN—A slang name for the airplane engine throttle. "Give her the gun" means "open the throttle"; "cut the gun" means "close the throttle."

HANGAR—A shelter for housing aircraft; more properly applied to airplanes than to dirigible shelters.

HELICOPTER—A form of aircraft whose sole support in the air is derived directly from a vertical thrust produced by rotating airfoils. (See Chapter IX.)

JENNY—A slang name for the Curtiss JN–4 airplane, used in the war, now obsolete.

JOY STICK—The control stick, really a nickname for Joyce stick, from the name of its inventor. (See CONTROL STICK.)

Laminated Wood—(See Wood, Laminated.)

Landing Field—A field of such a size and nature as to permit of aircraft landing and taking off in safety. It may or may not be part of an airport.

Landing Gear—The understructure that supports the weight of an aircraft when in contact with the land or water and that reduces the shock on landing. There are five common types—boat type, float type, skid type, wheel type, and ski type. (See Chapters IX and XXVI.)

Landing 'T'—A large marker, shaped like a capital T, laid out on a landing field or on top of a building to guide flyers in landing and taking off.

Landing, Three-Point—A landing such that the two wheels and the tail skid touch the ground at the same instant. (See Chapter XIX.)

Leading Edge—The foremost edge of an airfoil or propeller blade. Also called 'entering edge.' (See Chapter IX.)

Lift—That part of the total air force on an aircraft or airfoil that tends to push the plane upward against gravity. (See Chapter XII.)

Load, Useful—The crew and passengers, oil and fuel, ballast and portable equipment.

Load, Pay—That part of the useful load from which revenue is derived, usually passengers and freight.

Longeron—A part of the framing of an airplane fuselage or nacelle that extends fore and aft. (See Chapter IX.)

Loop—A maneuver in which the airplane describes a circle in a perpendicular plane; the lateral axis of the plane remains horizontal. (See Chapter XX.)

Monoplane—An airplane which has but one main supporting surface, sometimes divided into two parts by the fuselage. In a high-wing monoplane the wings are placed well above the center of gravity; in a low-wing monoplane the wings are attached at the lower longeron, usually below the center of gravity; while in a middle-wing monoplane the wings are attached to the fuselage near its middle, vertically, at approximately the center of gravity. (See Chapter IX.)

Multiplane—An airplane with two or more main supporting surfaces, placed one above the other. (See Chapter IX.)

Nacelle—An enclosed shelter for passengers or for a power plant. A nacelle is usually shorter than a fuselage and does not carry the tail unit. (See Chapter IX.)

Nose Heavy—The condition of an airplane in normal flight such that, if the longitudinal controls were released, the nose would drop. (See Chapter XXVI.)

Ornithopter—A heavier-than-air aircraft, driven by flapping wings. (See Chapter IX.)

Pancake—To level off an airplane at a greater altitude than normal in landing, thus causing it to stall and to come down flat.

Parachute—An apparatus, usually umbrella-shaped, used to slow the descent of a person or an object. (See Chapter XV.)

Petrol—Word used by the French and English for gasoline.

Plywood—A material formed by gluing together two or more layers of wood to secure strength with lightness.

Pontoon—(See Float.)

Power—The rate of doing work. One horsepower is the power that will lift 550 pounds one foot in one second.

Prop—Common abbreviation for 'propeller.'

Propeller, Adjustable Pitch—A propeller with blades that may be set to any desired pitch when the propeller is stationary.

Propeller, Control Pitch, or Variable Pitch—A propeller with blades that may be set at any desired pitch while the propeller is rotating.

Propeller, Pusher—A propeller mounted to the rear of the engine or propeller shaft. It is usually behind the wing cell or nacelle.

Propeller, Tractor—A propeller mounted on the forward end of the engine or propeller shaft. It is usually forward of the fuselage or wing nacelle.

Rate of Climb—The number of feet per minute an airplane gains altitude.

Rev—A slang term for 'revolutions' or 'revolve.' 'Revving up' is running the motor to warm it or test it before taking off.

Rigging (Airplane)—The assembling, adjusting, and aligning of the parts of an airplane.

Rip Cord (Parachute)—A device that holds the pack cover to the cones on the pack frame. The pack cover is opened by pulling a ring at the end of the rip cord. (See Chapter XV.)

Roll—Movement of an airplane about its longitudinal axis; that is, turning over so that, while continuing to fly forward, it is now right side up, then upside down, then right side up again. (See Chapter XX.)

Rotor—The name given to a group of airfoils revolving about a vertical axis from which heavier-than-air craft, like the autogiro and the D'Ascanio helicopter, gain the greater part of their lift. The rotor may be revolved by an engine or by the force of the relative wind. (See Chapter IX.)

R. P. M.—Revolutions per minute. (See Chapter XIX.)

RUDDER—A movable airfoil that guides an aircraft the way a rudder guides a boat.

RUDDER BAR—The foot bar by means of which the control cables leading to the rudder are operated.

RUNWAY—A long, smooth area on a landing field especially prepared for the take-off of airplanes.

SAFETY BELT—A belt used to hold the aviator or passengers in their seats. It has a special clasp that permits quick release. Safety belts or an equivalent for pilots and passengers are required by the Department of Commerce in all airplanes.

SEAPLANE—An airplane designed to rise from and alight on water. This general term applies to both boat and float types, though the boat type is usually designated as a 'flying boat.' (See Chapter IX.)

SHIP—A term used for an aircraft, either lighter than air or heavier than air.

SHOCK ABSORBER—A device fitted to the landing gear of airplanes for the purpose of reducing the shock of landing. In a common type oil is forced slowly through a small hole in a piston that slides in an oil-filled cylinder.

SIDE-SLIPPING—Flight in which the lateral axis is tipped and the airplane slides in the direction of the lower wing. The opposite of skidding. (See Chapter XX.)

SKID—A runner used as a part of the landing gear and designed to aid the aircraft in landing or taxiing. (See Chapter IX.)

SKIDDING—Sliding outward while making a turn. The opposite of side-slipping.

SKY WRITING—A trail of smoke or similar substance left in the air by an airplane. The pilot guides the ship along a path that will form letters from the trail of smoke.

SLIPSTREAM—The stream of air driven astern by the propeller. (See Chapter XX.)

SPEED, AIR—The velocity of an aircraft relative to the air through which it is passing. It is recorded by the air-speed indicator. (See Chapter XI.)

SPEED, GROUND—The horizontal velocity of an aircraft relative to the earth.

SPEED, LANDING—The lowest speed at which an airplane can maintain itself in level flight and still be under control.

SPIN—A maneuver consisting of a combination of roll and yaw, in which the longitudinal axis of the airplane is inclined steeply, and the ship descends, nose first, in a long spiral with the upper side of the ship on the inside of the spiral; also called 'tail spin.' (See Chapter XX for diagram.)

STABILITY—That tendency of an aircraft, when thrown out of equilibrium or steady motion, to return to its original condition.

STABILIZER—An airfoil, usually located at the rear of an aircraft and approximately parallel to the longitudinal axis, to lessen the pitching motion and give longitudinal stability. It is sometimes called the 'tail plane.' (See Chapter IX.)

STAGGER—The amount of advance of the leading edge of an upper wing of a multiplane over that of a lower wing. It is expressed in inches or in degrees. (See Chapter XIII.)

STALL—The condition of an airplane when, from any cause, it has lost the air speed necessary for support or control.

STREAMLINING—The designing of airplanes and their parts in such a way as to lessen the resistance met in passing through the air. (See Chapter XIII.)

STRUT—A part of the framework of an aircraft; *e.g.*, the vertical supports between the two wings of a biplane. (See Chapter IX.)

TACHOMETER—In an aircraft, an instrument to indicate the speed of the motor in R.P.M. (See Chapter XI.)

TAIL—The rear end of an aircraft, including control surfaces. In the case of a dirigible, it is more often spoken of as the 'stern.'

TAIL-HEAVY—A condition in an airplane such that, in normal flight, the tail sinks if the longitudinal control is released by the pilot. Opposite of nose-heavy.

TANK, SERVICE—A fixed fuel tank near each power unit into which fuel from other tanks is pumped and from which the fuel supply for the engine is directly drawn.

TANK, SLIP FUEL—A fuel tank fitted with a device to permit the quick dropping of the fuel or of both tank and fuel in case of emergency.

TAXI—To run an airplane along the ground or a seaplane along the water under its own power.

THREE-POINT LANDING—See LANDING, THREE-POINT.

THRUST—The push created by a revolving propeller. (See Chapter XII.)

WIND SOCK—A funnel-shaped piece of canvas or similar cloth, usually fastened at the top of a mast, or tall pole, to show which way the wind is blowing.

WING RIB—A part of the framing of an airplane wing that runs from the leading edge to the trailing edge. Sometimes called 'form rib' or 'camber rib.' (See Chapters IX and XXVI.)

WING SPAR—The main part of the framing of an airplane wing to which the ribs are attached. (See Chapters IX and XXVI.)

WOOD, LAMINATED—A piece of wood formed by fastening together a number of strips, or laminations, of wood with the grain running parallel. It differs from plywood in that in the latter the grain of alternate plies is usually crossed at right angles.

YAW—Movement of an aircraft about its vertical axis; that is, a movement to right or left, such as would be produced by the action of the rudder.

ZEPPELIN—A dirigible, power-driven, rigid, lighter-than-air ship, named after Count Zeppelin, who first developed this type successfully. (See Chapter I.)

ZOOM—To climb an airplane for a short distance at an angle greater than that which can be maintained in steady flight. This term is sometimes used as a noun to denote any sudden increase in the upward slope of the path of flight. (See Chapter XX.)

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