OUR AIR FORCE

Interior of the Chart Room of a Balloon Company, Installed in a Temporary Barrack. The Chart Room Contains a Relief Map of all of the Ground that can be seen from the Balloon's Position, and a Perfect Representation of the Hills, Woods, Houses, Streams, Railroad Lines and Roads

OUR AIR FORCE

The Keystone of National Defense

BY

WILLIAM MITCHELL

BRIGADIER GENERAL, AIR SERVICE

NEW YORK

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THIS BOOK IS DEDICATED

TO THE MEMORY OF MY BROTHER

Lieut. JOHN LENDRUM MITCHELL, Jr.

PILOT, UNITED STATES AIR SERVICE,

WHO WAS KILLED IN FRANCE

IN THE SERVICE OF HIS COUNTRY

ON MAY 26, 1918

EDITOR'S NOTE

Brigadier General Wm. Mitchell, the author of this book, enlisted as a private in the Volunteer Infantry at the outbreak of the war with Spain in 1898; and after serving in the ranks for twenty days, he was made an officer at the age of eighteen. He was the youngest officer in the army during the Spanish War. He later served in the Philippine Insurrection; again in Cuba in 1906 and 1907; and along the Mexican Border. General Mitchell has traveled widely in Asia, India and Europe, studying the military systems in the armies of the various countries. He is a Distinguished graduate of the Army School of the Line, a graduate of the Army Staff College, and he served as a member of our General Staff before the entrance of the United States into the World War. General Mitchell studied Aviation for a great many years; learned to fly at the first opportunity, and has kept it up ever since. He was the first American officer under German fire in Europe, where he was serving as a military observer when the War opened, and was the first American flying officer to cross the Lines in the European War, on April 22, 1917, where he laid the basis for the tactical Air Service in Europe before the coming of the American Expeditionary Forces. General Mitchell later commanded the Air Service of the First Army Corps, the Air Service of the First Army, the Air Service of the Group of Armies, and, when the Group of Armies was discontinued, at the time of the Armistice, he took the Aviation of the Army of Occupation into Germany, and established it along the Rhine River. Since returning to the United States, in the Spring of 1919, General Mitchell has been in charge of the training and operations of our own Air Service, which has been completely reorganized and re-equipped.

General Mitchell was granted the Distinguished Service Cross, with citation as follows:

"GENERAL HEADQUARTERS,

AMERICAN EXPEDITIONARY FORCES,
OFFICE OF THE CHIEF OF AIR SERVICE

M.M.P.
A.S.

France, 7 November 1918.

From: Chief of Air Service, A.E.F.

To: Brigadier General William Mitchell, A.S.,U.S.A.

Subject: Award of Distinguished Service Cross.

1. The Commander-in-Chief of the American Expeditionary Forces in the name of the Presi-

dent has awarded you the Distinguished Service Cross for extraordinary heroism in action, the official citation being as follows:—

> "For repeated acts of extraordinary heroism in action at Noyon, France, 26 March 1918, near the Marne River, France during July 1918, and in the St. Mihiel Salient, France, 12-16 September 1918.
>
> For displaying bravery far beyond that required by his position as Chief of Air Service, 1st Army, American Expeditionary Forces, setting a personal example to the U.S. Aviation by piloting his airplane over the battle lines since the entry of the United States into the war. Some instances being a flight in a monoplane over the battle of Noyon on March 26, 1918 and the back areas, seeing and reporting upon the action of both air and ground troops, which led to a change in our aviation's tactical methods. A flight in a monoplane over the bridges which the Germans had laid across the Marne during July 1918, which led to the first definite reports of the location of these bridges and the subsequent attack upon the German troops by our air forces. Daily reconnaissances over the lines during the battle of St. Mihiel salient, September 12th to 16th, securing valuable information of the enemy troops in the air and on the ground, which led to the excellent combined action by the allied air services and ground troops particularly in this battle."

2. I take great pleasure in handing you this decoration, so well deserved, and wish to add my

own sincere thanks for the magnificent work you are doing and my heartfelt congratulations on the record you have made.

MASON M. PATRICK,
Major General, U.S.A."

He was awarded the Distinguished Service Medal, with citation as follows:

"GENERAL HEADQUARTERS,
AMERICAN EXPEDITIONARY FORCES,
PERSONNEL DIVISION
DECORATION SECTION

By Courier.

France, 27 May 1919.

From: The Adjutant General, American E. F.
To: Brigadier General William Mitchell, U.S.A. (Thru The Adjutant General of the Army.)
Subject: Distinguished Service Medal.

1. Under the provisions of Cablegram No. 2830, received from the War Department, March 1st, 1919, the Commander-in-Chief, in the name of the President, has awarded the Distinguished Service Medal to you for exceptionally meritorious and distinguished services as set forth below:

BRIGADIER GENERAL WILLIAM MITCHELL U. S. A.

For exceptionally meritorious and distinguished services.

As Air Service Commander, first of the Zone of Advance and later of the First Corps, by his tireless energy and keen perception, he performed duties of great importance with marked ability. Subsequently as Commander, Air Service of the First Army, and, in addition, after formation of the Second Army as Commander of Air Services of both armies, by his able direction of these vitally important services he proved to be a potent factor in the successes achieved during the operations of the American Armies.

2. You will be informed later in regard to the time and place of presentation of the Medal awarded you.

By command of General Pershing:

(Signed) F. C. WHITLEY,
Adjutant General."

At the conclusion of the Battle of St. Mihiel, General Pershing wrote the following letter, which expressed his views of the handling of American Aviation in that contest:

"AMERICAN EXPEDITIONARY FORCES,

OFFICE OF THE COMMANDER-IN-CHIEF,
FRANCE, SEPTEMBER 16, 1918.

COLONEL WILLIAM MITCHELL,
Chief of Air Service,
First Army, A.E.F.,
France.

MY DEAR COLONEL:

Please accept my sincere congratulations on the successful and very important part taken by the

Air forces under your command in the first offensive of the First American Army. The organization and control of the tremendous concentration of Air forces, including American, French, British and Italian units, which has enabled the Air Service of the First Army to carry out so successfully its dangerous and important mission, is as fine a tribute to you personally as is the courage and nerve shown by your officers a signal proof of the high morale which permeates the service under your command.

Please convey to your command my heartfelt appreciation of their work. I am proud of you all.

Sincerely yours,

JOHN J. PERSHING."

Besides the American decorations, General Mitchell has been decorated by the French, with the grade of Commander of the Legion of Honor, and War Cross with various citations; by the British, the Order of St. Michael and St. George.

General Mitchell handled the largest concentration of Air Forces, during the European War, that have ever been assembled under one command, consisting of American, British, French and Italian Units; and is therefore an authority on the application and use of an Air Force. He is the only high-ranking flying officer in this country who actually has handled large forces of Aviation against an enemy.

CONTENTS

LIST OF ILLUSTRATIONS

FOREWORD

THE purpose of this book is to bring before the American people an idea of what an efficient organization of our aeronautical resources means to the country, how it can be brought about, and what we already have for doing it. Suitable and adequate preparation of the air arm, and of the personnel required to man the aircraft, manufacture the equipment, and supply such a force, cannot be furnished by the Army or Navy, or by the two combined, as has been the experience in all countries in the recent War. In order that an air force may be developed to the point where it will represent a real safeguard, it is necessary that an organization be formed whose main function will be the employment of aircraft in all their various fields of activity. The importance of this function of the Government is so great, and the interested industries are so large in number, that the governmental organization for the development, control and employment of aircraft in their many phases, both in time of peace as well as in time of war, absolutely requires the formation of an executive department of the Government, which should be known as the Department of Aeronautics.

The aeronautical demands of the late War have so hastened the development and use of aircraft of all sorts, that all nations now regard them as indispensable adjuncts of their national defense. Although the United States was the first nation to demonstrate the practicability of heavier-than-air flight, we allowed ourselves to become so deficient in the development of this science, that we were hopelessly behind when the war in Europe started. Had we not had the bulwark of the European Allies to work behind during the great War, we would have had practically no aviation on the front.

Again we find ourselves largely going backward, instead of forward; and instead of utilizing and putting into effect the aeronautical lessons of the European War, we have allowed the more than 15,000 flying officers that were trained during that great contest to go back to their civil vocations without any serious attempt to organize them, and perpetuate their knowledge of aeronautics as a national asset, or to organize them as a reserve force to be used in any emergency which may come in the future. A paltry 1,000 flying officers have been retained in all the national services, and the places in the national flying forces that should belong to the flying officers, who learned their work in the face of the enemy, are gradually being taken over by officers of superior rank put into the air forces from other branches of the army, such as the Infantry, Cavalry, and Field Artillery, and from the Navy, who know nothing to start with about aviation, and who will never be capable of learning it in the same way as those who have served during the War. The trained flying personnel which this country produced during the War was the greatest aëronautical accomplishment brought about.

The air is a common medium all over the world. It is bounded by no oceans, mountains, rivers or deserts. The aircraft operate in three dimensions up to more than 30,000 feet at the present time. This altitude is being constantly increased. No navies can operate on the seas, nor armies on the land, until the air forces have first attained a decision against the opposing air forces, so as to allow those on the water to operate against their enemy. Therefore, as a prelude to any engagement of military or naval forces, a contest must take place for control of the air. The first battles of any future war will be air battles. The nation winning them is practically certain to win the whole war, because the victorious air service will be able to operate and increase without hindrance.

Under these conditions, it is essential that a nation's air resources be so organized that they can be mobilized and put into fighting condition immediately that war appears imminent, to take the air and protect the country in the way that it deserves.

Navigation of the air is increasing more rapidly in its efficiency and use since the Armistice than it did even during the War. North America is the central point, or meeting place, of all aerial communication between Europe and Asia. The Europeans have splendidly organized air services. Japan is now putting her air forces in a class with her army and navy. Air forces are more difficult to organize and put on a sound footing than either an army or navy, because in this newest arm we have no traditions upon which to build except those developed during the War. The whole system for their operation, the effect which they can produce, their method of supply, their spirit and their characteristics are known only to the personnel that constituted the air forces, and a few students of aeronautics.

Our aviation in the United States is split up between several Government agencies, such as the Army, the Navy, the Post Office Department, Coast Guard, Marine Corps, and Department of Agriculture; and, in addition, all other departments of the Government will need aviation in some phases of their work. It is a matter of common knowledge that whenever an organization is made up of two or more parts, each part must be smaller and less important than the whole. This axiom applies particularly to military and naval organizations, which should be so proportioned as to obtain the maximum efficiency from the entire organization. Neither the Army nor the Navy, nor both combined, can be expected to develop, organize and perfect a flying corps, and its employment, to the greatest possible limit of which that weapon is capable. Considered simply as a military proposition, a very conservative estimate of its capabilities ten years from now is such that it can be definitely stated that, in case of war in which the United States is engaged, if the enemy obtains mastery of the air, he will be able to dictate his own terms of peace at any place within the United States that he may desire. Warfare to-day between first-class powers includes all of the people of the nations so engaged —men, women and children. This inclusion of women and children is not merely a sentimental and economic one, but during the last war was an actual one from a military standpoint. Women and children actually were part of the military and naval forces both at home and abroad, and this inclusion did not stop short of the actual firing line. The entire nations were combatant forces. We must expect, therefore, in case of war, to have the enemy attempt to destroy any or all of our combatant or industrial forces—his attacks being entirely controlled by the dictates of strategy, and the means of bringing the war to a quick conclusion. It may be at times the best strategy to damage and destroy property, and to kill and disable an enemy's forces and resources at points far removed from the field of battle of either armies or navies. The forces that are attacked may be composed largely of women and children and other members of the nation's industrial and economic armies not capable of bearing arms, but extremely important as manufacturers of ammunition, and the many other necessities that are equally as important as carrying rifles in the trenches. A determined enemy, in the future, that gains control of the air will use every means to subjugate the hostile countries. The use of chemical weapons is increasing daily. Fortunately, in Europe airplanes did not drop gas shells during the War. This cannot be expected to be the case in the future when at war with a barbarous foe, who will use every means known to further his end. The personnel of entire cities—men, women and children—can be destroyed by gas attacks from the air.

During the War in Europe, we had a daily example of what explosive airplane bombs were capable of doing. It is always difficult to make people believe what terrific effect these aircraft projectiles have. An excellent example of what could be expected from an air attack occurred on September 16th, 1920, when the explosion occurred in front of J. P. Morgan and Company, in New York's financial district. The building of the J. P. Morgan Company was wrecked; buildings in the vicinity were shattered; thirty people were killed, five missing, and about three hundred injured. The Stock Exchange was closed to business; communicating and transportation systems running through that part of the city were put completely out of order; the excitement of the people affected the whole city. In other words, the heart of the financial center of the Western Hemisphere was paralyzed for a time. This was the result of a single explosion. Imagine what a group of 100 airplanes would do, that carry five bombs apiece, each projectile being much more efficient in its destructive effect than the explosives that were used on September 16th. In case of the attack of a group of such airplanes or airships, 500 explosions would occur, covering the whole of the lower part of New York, which would practically wreck that entire part of the city; and not only paralyze all the business, but would cause a conflagration such as has never been known before. Such a fire occurring in New York, situated on a narrow peninsula between two rivers would make it impossible for the population to get away from it on account of the congestion of the means of transportation that would result when this great population attempted to escape. They would be burned like rats in a trap. New York forms an ideal target for night attack from aircraft, because it is outlined by the two rivers on each side of it, by its high buildings, and by Long Island, which can be used as a reference point and guide directly to it. The only efficient protection against an enemy's aircraft is an air force capable of defeating it.

In the development of national aeronautics, commercial aviation is almost as great an asset as if it were regularly incorporated into fighting units. The commercial equipment and pilots used have an immediate military application, either as training equipment, as bombardment equipment, for the heavy commercial airplanes, or in reconnaissance on account of the knowledge of the country which the pilots possess. In addition, the system of airdromes, air lanes, and aids to air navigation required to handle commercial aviation are exactly those which we would need in case of war. The development of commercial aviation would work "hand and glove" with the protection of the country from air attack.

After having developed a great merchant marine carrying more than 90 per cent of the trade of the world, we let it slip away from us during our Civil War, and never regained it. We worked up a military machine during the Civil War that was the greatest thing which the world had seen up to that time, and let it completely slip away from us, so that in such a small contest as the Spanish War, we were not able to conduct an efficient campaign on this Lilliputian basis. In the European War we worked up a great military system, which we have largely disintegrated and dissolved. While national policies involving expense, and a lack of cause for the use of our military forces, may have required this in the popular mind, there is no reason why we should deliberately throw away the aeronautical position which we had acquired actually at the end of the War, because provision of an adequate air force involves a comparatively small expenditure in men and treasure in accordance with the protection which it gives the nation. It can be employed to the greatest advantage in useful pursuits in time of peace, and is a development, every commercial phase of which has a direct application to national defense. Aeronautics is a new and developing art. We must not prepare for what happened yesterday, but what is going to happen to-morrow, and the day after. We are spending sufficient money at the present time to insure an efficient air service, but we are getting ahead very little with it. Let us not forget the lessons of the past with respect to aeronautics, and again place ourselves in an absolutely defenseless position before the other nations of the world.

OUR AIR FORCE

CHAPTER I

DEVELOPMENT OF AVIATION IN THE WORLD WAR

THE European War proved that Aviation is one of the major arms of national defense, and that without its aid no nation can defend itself, nor can armies or navies in the future bring about an armed decision favorable to themselves. Four and one-half years saw Aviation raised to this pre-eminent position from almost nothing.

Before the great War, Aviation had been regarded more as a science than as a force which constituted an element of power to a State, equal in importance to armies and navies. Its efficacy was questioned by the great majority of the older professional soldiers, and it struggled against prejudice, ignorance, and incompetency in its development.

In spite of all these handicaps, however, within four and one-half years, it has stood out as an arm by itself, supreme in its own power in the air, and bidding defiance to armies on the ground and navies on the water. No other military instrument has ever demonstrated, within such a short time, its absolute necessity, dependability, and power for carrying out military requirements.

In 1914, when the European War began, the airplanes were of the most rudimentary type, and the crews that manned them were even more crude in their knowledge of their use. The problem of aerial navigation had been studied very carefully, particularly by the French and the Germans, and by England. They had not taken into consideration fighting in the air to any extent; nor did they at first regard the great military principle that to gain information one has to fight for it in the air as well as on the ground.

The airplanes which appeared on the battlefields in August, 1914, had engines of from eighty to one hundred horse-power, and a speed of from sixty to one hundred miles an hour. They had no machine guns on them, no large cameras, and had the ability of staying in the air for a couple of hours only. When hostile aviators met, they went ahead about their business, in some cases waving a sign of recognition one to the other as they passed. Nobody took the Air Service very seriously except the aviators themselves at the beginning. In many instances, their reports were disregarded and laughed at.

A notable instance of this, which led to the destruction of a whole army, occurred to the Austrians at the Battle of Cholm, in August, 1914, when, after successful preliminary battles with the Russians, they held that city with the intention of advancing further into Russia. The Russian Army, reinforced, advanced to attack them, and, in doing this, sent heavy columns against the right flank of the Austrian Army. The Austrian aviators immediately reported this move, but the General Staff of the Austrian Army proved conclusively that a column of the size, length, and character of the one reported by the aviators could not possibly be in that vicinity, that the Russians did not have the means of transport for getting these forces there, and even that Russian organizations could not march on the roads indicated on account of the character of their equipment. The Russians, however, were there just as the aviators reported. The result of this was that the Austrians were attacked in entirely unexpected quarters, and their army was completely defeated and practically destroyed. Instances of a similar nature occurred on the Western Front, both in France and in Germany.

By the Autumn of 1914, it dawned on all the contenders in the War that aerial observation was a necessity, and that without it in every operation pertaining to reconnaisance, regulating the fire of artillery, and even finding out where one's own forces were, nothing could be done without the airplane. The Germans particularly saw this very clearly, and, when making up their plans for the Spring Drive of 1915, they considered that, if they were going to be successful, they must drive the French airplanes out of the air so as to surprise the enemy troops on the ground, and render victory to the German armies possible.

The Germans therefore took their fastest and most maneuverable airplanes, and put the machine gun on them to take the place of the pistol and hand rifles with which they had been previously armed. The idea of the German Army was to smash through the French in the vicinity of Verdun, and, as a preliminary to this attack, to seize and hold the air so that the French would not know from which direction their ground attack would come on the battlefield.

The first German attacks took place in February—the ground was covered with snow, and the weather was cold. The arrangements for landing fields on the part of the French, in that locality, were almost nothing, and, although experiments had been made with machine guns on their airplanes, the French equipment was very deficient in this respect. The Germans, on the other hand,

German Airship of the Zeppelin Type

The British Airship R-34, the First to Make the Round Trip Flight Across the Atlantic

came on with their armed airplanes and commenced an era of fighting in the air which will extend and increase for all time. The French replied to this by exerting their every nerve to counteract the air attack, and during the year 1915 pursuit aviation, or that which goes out and fights the enemy aviation for control of the air, was established definitely as a special branch of Aviation. From that time on, primary consideration was given to the fighting of airplane against airplane as a principle—as a prelude to any other air work, whether it be gaining information for the army to which the airplanes were attached, dropping bombs by day or night, or the actual shooting up, or "straafing" as it was called in those days, of troops on the ground. In 1914, the airplane carried a few little grenades weighing less than ten pounds each, steel darts to throw down on their enemies; and one or two light-weight cannon projectiles, made up as bombs, were tried. By 1917, definite organizations of airplanes were carrying bombs weighing up to 500 pounds. By the end of the war, airplanes were carrying bombs weighing upwards of a ton, and the organization in the air forces for this purpose numbered hundreds of airplanes. In fact, during the operations of the American Army in the Argonne, a single aerial formation had over

300 airplanes in it for the purpose of a bomb attack against the Germans.

As things progressed, the combatants began to put armor on their airplanes so as to resist machine gun fire from the ground or other airplanes. They began to machine gun the troops at low altitude and even to mount cannon on the planes, making veritable battleships of the air. A whole new industry sprang up to make all the airplanes, their engines and their accessories, and all the special arms and appliances connected with them. Nothing like this had ever occurred in the world's history.

The tremendous development in aeronautics was not entirely confined to airplanes; but a similar development took place with balloons and airships. Balloons had been used with armies for a great many years. In fact, the French Army operating in Belgium in 1792 had observation balloons as a part of its equipment; Napoleon used them in Egypt; and our own Army of the Potomac in the Civil War was equipped with them. They were used in the War of 1870, both as free balloons, to get messages out of Paris when it was besieged, and also as a means of observation with the troops. The Germans had developed a form of kite balloon called the Drachen, which was much more stable in the air than the former round balloon had been. In fact the Drachen was the first successful type of kite balloon. This balloon was greatly improved and changed by the French engineer, Caquot, who devised a balloon that could be operated in winds up to 30 or 40 miles an hour, which is almost as stable as an observation platform on the ground, and which had a balloon winch actuated by automobile machinery that raised and lowered it with the greatest precision. These balloons are connected to the earth by telephone cables going to telephone centrals, which, in turn, connect it with the batteries and the troops with which they are working.

Early in the War these balloons took their place as an indispensable adjunct with the troops, and their use was continually extended. During the last two years of the War, so many balloons were used around a point under attack, or by the defense to counteract the attack, that they looked almost like an aerial picket fence. While the uses of balloons had been very well worked out before the War commenced, the actual use of airships was still a problem. The Germans had done more with them than any other nation. The first airships—that is, dirigible balloons, as they were called then—appeared many years before a successful airplane was devised. Every sort of a dirigible airship was used during the War, from the little non-rigid gas bags with an engine attached to them, that were employed around harbors to determine the presence of submarines and to convoy surface vessels in and out of roadsteads, to the large Italian semi-rigid airships that were able to carry several tons and rise over the Alps Mountains.

The Germans, however, with their Zeppelins or rigid airships, proved beyond the question of a doubt their great value as military adjuncts. These airships have a rigid envelope made of an aluminum frame work covered with cloth. Inside of the envelope the gas is contained, in a number of small balloons, called ballonets. The Zeppelins are equipped with four or more engines, and are able to stay in the air for several days. These airships were designed originally for reconnaissance purposes. Very early in the War it was found that not only could they reconnoiter, but they had great value as offensive instruments, in carrying bombs for the direct attack of enemy works and formations. The Germans used these ships for this purpose, particularly on the Eastern Front against the Russians. They made repeated bombardment raids over England and France, and were even ready to attack the United States at the time of the Armistice. All of this offensive power was developed during the War, and the loss of these ships from hostile air attack was quite small, because they could remain so high up that airplanes had difficulty in rising sufficiently quickly to head them off.

One German airship, during the War, made a trip of 4,000 miles from Bulgaria to German East Africa and return without landing. This ship had a great store of ammunition on board for the relief of the Colonial troops, and a very comprehensive scheme had been worked out that, in case it landed, its frame work would be used for storehouses, its cloth for tents, clothing and other covering, its nacelles were to be transformed into boats for use on the rivers, its remaining gasoline for motor transport purposes, and its armament for use of the troops on the ground. The airship was guided during its entire trip by wireless from Europe. Through some mistake, when the airship arrived over East Africa it was led to believe that the Allies had taken the Colony. It, therefore, returned to Europe without having accomplished its mission; but giving an example of how great a distance an airship could go.

The development of airships has continued; and it will take its place beside the airplane as a co-ordinate branch of aeronautics. One cannot alone do its full work in a military way without the other.

The use of aviation, both tactically and strategically, was beginning to be understood in its rudiments by all the ground troops at the end of the War. It was known definitely, however, only to the Air officers themselves. The air force had become as specialized in its own work in the air as the armies were on land and the navies on the water. Pursuit, Attack, and Bombardment aviation were just as different as Cavalry, Infantry, and Artillery. The War gave a greater impetus to aviation and air tactics than probably would have resulted from sixty or seventy years of peace-time development, as it was before the War. When the War closed, the air forces were the only thing which all the Europeans hung to tenaciously—the Allies on their side requiring that the Germans cease work on the development of their air forces; the French holding on to theirs as their strongest element of offense against the Germans, not only as a means of defending themselves in future wars, but as a military means of making the Germans comply with the treaty provisions. The British, ahead of all other nations, in their plan of organization of their air forces not only developed their service for fighting over the land but also for fighting over the sea, to contest with hostile air forces the dominion of the waters as well as of the land.

Shortly after the end of the War, the Atlantic was crossed by airplanes and a dirigible. Dirigibles have been built which can go around the world at about the forty-fifth parallel of latitude on one charge of fuel. The progress since the Armistice to the present time, from a scientific standpoint, has been greater than almost for the four years preceding that. The airplane has taken its place in commerce while the airship is developing as a great carrier of the future. So far, aviation is essentially a military instrument of government. It has not arrived at the point where it can with economy support itself in the commercial field. That this is coming, there can be no doubt, and coming quickly. That it is an indispensable part of the national defense, without adequate provision for which the nation cannot succeed in either a defensive or offensive war, is unquestioned.

We should, therefore, investigate the nature of this new power which has come to us in the air, to see what advantages it has over the older arms on the ground and the water, in its principal use for national defense.

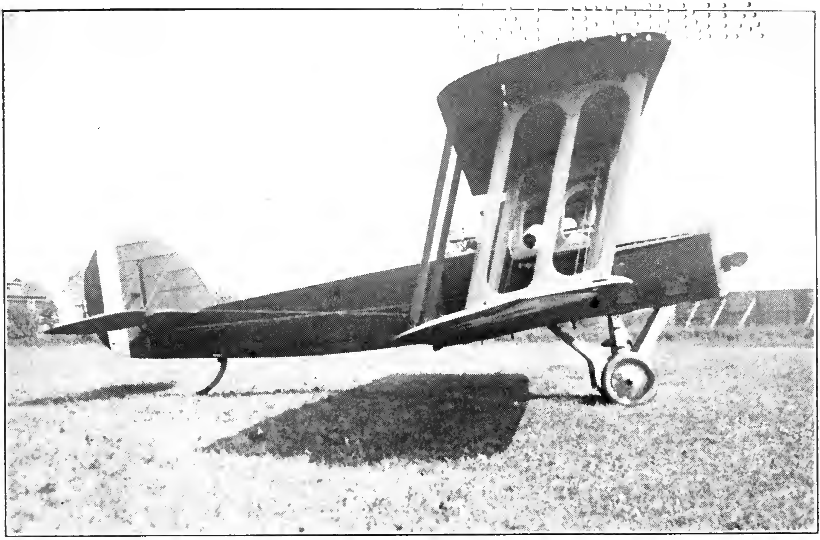
CHAPTER II

Characteristics of Air Power

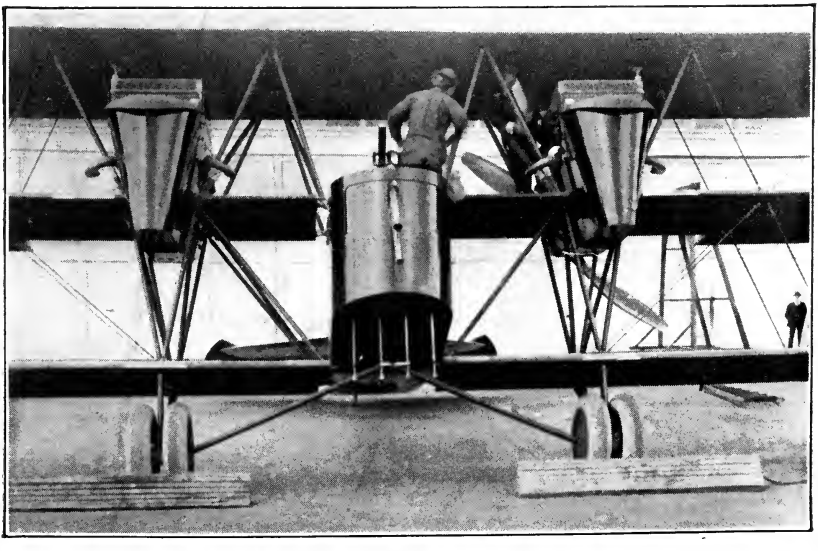
Speed of locomotion is the predominant characteristic of air power.

Armies on the ground move two and a half miles an hour by marching, and about twenty miles an hour on railroad trains. A column of troops on one road, twelve to fifteen miles long (which is the depth of an ordinary tactical division of infantry troops), requires about six hours or more to deploy on a front, that is, to prepare to fight. Navies move at a maximum rate of about twenty miles an hour, and increase this speed about thirty per cent when going into action.

Airplanes move in large bodies at the rate of one hundred miles an hour or over. They fight at speeds around one hundred and fifty miles an hour, while the fastest ones are approaching the two hundred-mile rate. The range of view is almost infinite as compared with troops on the ground or a navy on the water. At a height of fifteen



American Single Engine Attack Airplane. Equipped with Radio Telephone and Telegraph



Type of American Attack Airplane. Carries a Cannon and Eight Machine Guns

thousand feet, a radius of view of fifty miles is possible; in other words, a circle whose diameter is one hundred miles, and one can see much further if the weather is clear. The time of development for battle by airplanes, that is, getting from their traveling formations into their fighting formations, is negligible, because they move in closely packed bodies, communicate with each other by radio telegraph, telephone or visual signals, both of which have the speed of light, and therefore can change from what might be termed a column of route to a formation for battle in one or two minutes.

Their routes through the air are in a straight line—mountains, rivers, deserts and oceans are not obstacles. The State has no air frontiers comparable to borders protected by deserts, coastlines, mountain ranges or deep rivers on the ground. The air permeates the whole world homogeneously, the only change being in its temperature and density. From the standpoint of speed, we may say an air force moves from five to eight times as fast as an army per hour, and from three to six times as fast as a navy. The Atlantic Ocean has been crossed in sixteen hours, while the Continent of North America has been traversed in twenty-five hours' flying time. The size of the air force that may be employed is unlimited, because it has the whole air in which to operate, as distinguished from roads or railroads on the ground, or even an ocean, with its limitations of a single dimension, distance and coastlines. Compared to armies, an air force is not tied down by roads. It can move to any place entirely unhindered. Compared to navies, its speed, power of vision, and maneuverability, are unlimited. The perfection of the means of communication for an air force is an added element in its superiority. From its speed alone, an air force has the power of taking the offensive against either a navy or an army, and engaging these forces under its own conditions. Providing an air force has gained control of the air, it can completely conceal its own movements, or the movements of an army on the ground or a navy on the water, by preventing hostile reconnaissance. It can pick up and follow a ship, or a column of troops and report their exact position during every minute that it is there. It can communicate back to bring up Attack and Bombardment Aviation, and direct these to the objects, or attack them as it sees fit. Consequently, the only defense against an air force is another air force, and as an indispensable prelude to any engagement, whether it be on the water or on the land, there must be an air battle to determine which side shall control this area above the earth and the water.

Our doctrine of aviation, therefore, should be to find out where the hostile air force is, to concentrate on that point with our Pursuit, Attack, and Bombardment Aviation, to obtain a decision over the hostile air force, and then to attack the enemy's armies on land or navies on the water, and obtain a decision over them. Our policy should be to maintain as strong an aviation as is necessary to defend ourselves against the combined attack of our probable adversaries. Our method for carrying this into effect should be to have the necessary air forces always ready at the outbreak of war, because this is the first of our arms that will enter into combat and it is upon a favorable air decision that the whole fate of a war may depend. We should have an air force behind our East Coast that is sufficient for its local protection. We should have an air force behind our Pacific Coast that is sufficient for its local protection; and we should have in the country at large an air force so organized that it could reinforce either coast and insure our defense in the air. In a space which is practically limitless like the air, it is just as impossible to stop entirely the use of a few airplanes or very fast individual enemy ships, as it is impossible for an artillery to entirely silence an enemy's artillery, no matter how great their fire may be. With the proper employment of air units, these isolated enemy patrols have to be so careful in their work, are so harried by the defense, and are exposed to such great danger, that their actual accomplishments are very small in the total. In air work, however, a vigorous attack against any point of the enemy's country which makes it imperative that he defend it with his air force, requires him to concentrate for its defense. This gives a chance to the Air Commander to concentrate immediately against him and to seek a decision with his main air force.

In our operations at Château Thierry, where we were greatly outnumbered by the German aviation and where spreading out or disseminating our air force in small detachments spelled entire defeat for us, we concentrated all the Allied Bombardment Aviation that we could collect, bombarded the town of Fère-en-Tardenois (which was a very important place for the Germans) to such an extent that they had to concentrate their Pursuit Aviation for the defense of this place. We then brought a concentrated attack against their Pursuit Aviation at that place with our Pursuit Aviation, which in the end resulted not only in drawing the German Pursuit Aviation away from the vicinity of our ground troops so that it gave our Observation Aviation an opportunity to work, but also caused a very heavy loss to the enemy, and ended in balancing the air power where the Germans before had entirely dominated. Again, in the Argonne Battle of the First Army, where the congestion of transportation and men behind the center of our front was so great that a well-directed German air attack against our transport trains, which did not move for many hours, would have held up the operation of the whole army, we bombarded German centers of concentration, such as Romagne, Grand Pré, and other places absolutely essential to the Germans for the supply and upkeep of their forces, so that they had to concentrate their Pursuit Aviation for the defense of these places. We had great air battles over these localities between the main force of the German, American, and Allied Pursuit Aviation, because the Germans had to defend these places with their air forces or compromise their whole ground operations. After a series of air battles, we gradually obtained the decision, and it ended by our men shooting down a ratio of eight or ten of their airplanes to a loss of one on our side.

By the first of November, we had obtained mastery of the air in our sector, after a month of heavy fighting for it. The Germans used every art known to aeronautical strategy and tactics to maintain their position, with a constantly decreasing number of effectives. It was indeed an heroic struggle for them, and had they been pitted against a force that was not entirely familiar with their tactics and methods, they would have been successful. Their anti-aircraft defense from the ground was excellent and well co-ordinated with their air force, but this, of course, is merely an auxiliary of the air force itself. It acts as their sentinel and is a means of signaling to the airplanes by the projectiles shot out by the guns, in addition to its positive value of fire attack against aircraft. It has no decisive effect on an air battle. As our predominance over the German air force became greater, just so much more were our airplanes used against the retreating German columns on the ground, their motor trains, marching columns, railroads and military works of all sorts. These ground columns and formations were subjected to concentrated attack, where previously all airplanes had to be used for fighting their aviation.

The air decision gave us the opportunity of entirely concealing our movements, while we knew exactly what the enemy was doing. All the airplanes were used directly in combination with assisting the ground troops to destroy the enemy's forces of all kinds. The decision in the air resulted in giving our forces the complete power of initiative over the Germans—we could attack where, when and how we wanted to.

CHAPTER III

The Application of Air Power

Air Power is applied by means of definite military air units which are organized, armed, equipped and trained for a definite and specific purpose. One kind of airplane or air organization can no more perform all the duties required of an air force than can Artillery, Cavalry or Infantry acting alone form a whole army.

The kind of aviation that a certain nation needs is not necessarily of the same character as that required by another country. For instance, Germany needs a certain line of aviation development to meet her national policy. This is true of England, France and Japan, while our requirements are different from any of them.

On account of the speed of airplanes and the fact that they must occasionally land on the surface of the ground to replenish their fuel, ammunition and personnel, it is necessary first that very efficient means of communication be provided so

Captured German Airplanes Exhibited on the Place de Concorde in Paris

that these air forces can be properly guided for the work that they are required to do.

In the operation of the American Army in Europe, the Air Service had a complete communication system entirely of its own. It consisted of what is known as a radio net. Every airdrome or landing field was connected with every other one by radio; the anti-aircraft artillery with its anti-aircraft searchlights, the aircraft parks and depots; and all of these were connected with the headquarters of the commanding officer of the Air Service. Special telephone lines for the Air Service connected every airdrome, headquarters and supply point, while the headquarters of the Air Service was connected directly with the Commanding General's post of command. It can be imagined how vast a system this had to be, when these airdromes were distributed behind a front sixty miles and more broad, with a depth even greater than this, and where from 1200 to 1500 airplanes operated over the line and an equal number of airplanes were always coming up from the rear to take the places of those destroyed. The telephone, wire telegraph, motorcycle messengers and staff officers in automobiles, carried orders and instructions to their appointed places to supplement the radio telegraph. With a communicating system such as this, the air force could be concentrated at a point anywhere from sixty to one hundred miles away within an hour, or could be shifted across the whole front of sixty miles in half of that time.

The advent of the airplane into warfare has given the commander of a great army a strategical reserve which was never dreamed of before the advent of this wonderful instrument. The old strategical reserves of Infantry troops moved about two and one-half miles an hour on the battlefield. If the enemy made a feint which drew in the main reserves to the fighting line, they could not be extricated in time to effect the decision. At the battle of Mukden, in the Manchurian War, the Japanese directed a very heavy attack against the Russian left, with a view to drawing their reserve in that direction, so as to attack the Russian right wing with their main forces. The Russian commander was deluded by this maneuver, and started his reserve for the left of his line. His front line was about 87 miles long. When the reserve approached the left of his line, the Japanese attacked his right. The reserve was turned around and marched in the new direction, and after three days of marching it never reached its objective, and never entered the fight. A reserve of attack and bombardment airplanes could have covered this whole front in less than an hour. If a mistake had been made, they could have been turned around in the air and applied in a new direction, and covered a hundred miles in the same time that troops on the ground would march two and one-half miles, or in one-sixth of the time that it would take to deploy an ordinary division of troops. The proper application of air power adds tremendously, not only to the offensive ability of a force, but if the air is held, a very weak ground force can retreat with ease before a very much superior enemy. In fact, without air supremacy, an army cannot be pursued even after a tactical victory has been obtained, because the retreating army can completely shield its own movements, and at the same time know every move of the pursuer.

Next, as airplanes land with such great speed, from forty to eighty or ninety miles an hour, it can easily be seen that special landing places have to be prepared for this purpose. To understand how necessary good airdromes are, one may imagine how bumpy it is for an automobile to go at from forty to eighty miles an hour over an ordinary field. The larger the airplane, the more perfect must be the landing place, because the greater the weight placed on the landing gear. The losses from crashes on airdromes themselves are almost as great, or maybe greater, in a campaign than the casualties that occur from actual air fighting. In the application of air power, therefore, it is necessary to have as excellent a system of airdromes as is possible.

Not only should a country have permanent airdromes located in time of peace that are always ready to be occupied in case of necessity, but ample provisions should be made to locate them wherever necessary in time of war. The United States Air Service has traced out all of the routes that are necessary for the use of its air force in case of war, where the airdromes should be located and how they should be handled. This, however, is a paper organization and will require time to put into effect in case of war under the present conditions. The Post Office Department, in the carrying out of its aerial mail projects, is establishing a splendid system of airways throughout the country, which can be used for military purposes. All airways established by the Government, of course, could be made available, if properly regulated, for civil and commercial aviation.

One of the most difficult things to construct rapidly in time of war are airdromes for a large air force. In the operations of the First American Army during the World War, some twenty-five airdromes had to be provided for the air force participating in these operations. These airdromes had to be constructed in a very short space of time, had to be entirely concealed from the enemy during construction, had to be connected with the necessary signal communications, roads, and means of obtaining supplies, and had to be maintained in a suitable condition for use throughout the engagement. Special organizations called construction squadrons of the Air Service were used for this purpose. The plans were so well executed that every airplane that came to the great concentration of aviation knew exactly where it was to go, found everything ready for it in the way of hangars, gasoline, oil and supplies, and all of the communications installed. Not only was it the greatest, but it was the most successful, concentration of this kind that had taken place on the Western Front, and was entirely due to a careful consideration of the problem that had to be solved, and the efficiency of the force that did it.

Next, it is of the greatest importance that the air forces know what the weather is going to be —whether it will rain or shine, snow or hail, or whether the greatest enemy of all air operations

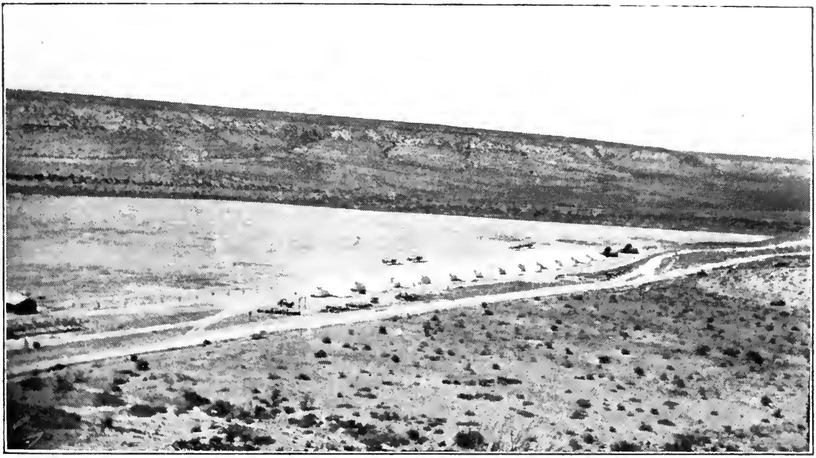
—fog—will be encountered. It must be known in what directions and how strong the winds are in the upper atmosphere, up to twenty or thirty thousand feet, because, if an airplane runs into head winds of one hundred miles an hour at that altitude, it may be entirely stopped from going to its destination in the time required. On the other hand, if it has favoring winds of these speeds, its progress will be very greatly facilitated.

In the World War in Europe where the weather reports were made every hour or half-hour, as the case might be, these reports showed the wind velocity at all altitudes in which the operations would take place, the height of the clouds above the earth; the character of the clouds, whether they were thin, whether there were holes through them; whether it was clear above the first layer of clouds, or whether another layer of clouds were encountered, and whether they contained rain, hail or snow; what the visibility was at various altitudes, that is, how far a person could see, either horizontally, that is, on the same level; obliquely, that is, down at an angle; or vertically, that is, straight up and down. No maneuver was ever ordered by the commander of an air force unless the meteorology was carefully studied. A map was always kept at the elbow of the commanders of the various air units which showed the state of the weather on every part of his front at all times, day or night.

The first thing for us to do in applying air power is to lay out a regularly co-ordinated series of airdromes, as air stations are called, provided with meteorological equipment—that is, everything necessary for telling what the weather is in that vicinity, what it may be in other places, and what weather to expect the following day. A system of wireless telegraph and telephone communication not only will give information and orders to all the airplanes on these airdromes while they are on the ground, but it will give them weather warnings, any necessary orders, and guide them through the rain, hail, snow or fog while in the air. A system of airdromes and airways through the country is almost as necessary in the application of an air force as is a system of gasoline and oil stations, with all their accompaniments of roads and telegraph and telephone lines, for the automobilist, or a similar organization for the railroads.

Taking our country in particular—and it might be mentioned that America naturally is the best suited country in the world for the development of an air force, on account of its climate, people and resources—we might trace in general how these air lanes should be organized. To begin with, we must consider what points are the most important in our defense, and next that the forces which come to attack us must proceed to this continent through the air, or on or under the water. From north to south our most important area lies from Chesapeake Bay to and including Boston, and from east to west, the line from New York to Chicago. Should this area be broken into by an enemy, and any of the great centers destroyed, such as New York, Philadelphia, Buffalo, Detroit or Chicago, or other large cities in this area, our defense would be greatly compromised. In other words, more than two-thirds of our whole industry, population and finances are to be found dependent on this area. It is the keep and heart of the nation. At the same time, it is the most exposed to air attack of any part of our country, because it is immediately next to our land and water frontiers.

The distance from Chesapeake Bay to Boston is about five hundred miles. Giving a slow speed of one hundred miles an hour to an airplane, it can cover this front in five hours. If an air force is stationed midway between these two places, with the distance of two hundred and fifty, or three hundred miles to cover, it can be brought to bear at the point furthest away that is threat-



Airdrome with Temporary Hangars on the Mexican Border

A Squadron of the First Surveillance Group on the Border

ened in from two to three hours, and anywhere between these places in less time. The air distance from New York to Chicago is about seven hundred and fifty miles. Our pilots have actually flown this distance in about five and one-half hours.

We must, therefore, consider the whole country in a similar manner, and organize our airways so that they not only will function rapidly in time of war, but may be useful in time of peace for the civil and commercial aviation which is bound to come in the future. The airways required for military purposes are coincident with those required for commercial aviation, because the great centers of population are both strategical and business centers. Each section of the coast and its interior air communications must be regarded in a similar way, and the centers for the concentration, supply and deployment of our air forces foreseen and provided for.

In the diagram of proposed airways, it may be seen that these routes and places have all been thought out from their strategical, tactical and commercial standpoints. With such a system, air forces could be transferred from New York to San Francisco in twenty-five hours' flying time, and from a central position in the Middle States they could fly to the East Coast in eight hours, to the Western frontier in fifteen hours, or to the Southern Coast and along the Mexican border in ten hours.

Our aviators have recently flown from New York to Nome, Alaska, in fifty-six hours' flying time, without the loss of a ship, man or any equipment, and it must be remembered that this was the first trip of this kind attempted. The airdrome system, meteorological data, and the communicating and supply organizations were very rapidly installed. With a definite and well-planned organization, air forces could be thrown into Alaska with very great rapidity, and would form a most efficient defense in that territory in case of war. Air forces can reach Panama across Cuba and Yucatan in approximately twelve hours, or through Mexico and Central America in approximately twenty hours' flying time. An air force under these conditions would provide the greatest and most efficient strategical reserve which could be used on either the East Coast, the West Coast, the Southern or Northern Frontier, and could be applied against an enemy in one-tenth the time of any other force, such as an army or navy. Due to its speed and its power to move through the air, its whole strength may be brought against an enemy on convergent lines from all directions. In case the United States were attacked on both coasts, it is by no means beyond the realm of possibility that an air force could be used from our Atlantic Coast to our Pacific Coast, and from Alaska to Panama, so as to insure a decision where it was necessary. During the last war, Germany used her Infantry divisions on the ground against the Russians, French and Italians at various times. An air force could be used over the whole expanse of our country, including Panama and Alaska, in fewer hours than it took for Germany to move her ground troops from one of her battle fronts to the other.

In war, it is always difficult to time an attack so that every place will be assaulted at the same instant. If this country were attacked both from the East and West at the same time, the chances are that these assaults might be weeks apart; if they were only days apart, however, an air force on account of its speed could be shifted clear from the Pacific to the Atlantic to meet them.

CHAPTER IV

Branches of Aviation and Their Use in War

Aviation depends for its action on a concentration of air power at the decisive point. Isolated action of any one class of airplanes, or of a few flights or squadrons of planes, is incapable of influencing a decision against a modern air force. An air force has the advantage of being able to bring fire to bear in three dimensions: from above, from underneath, and on the same level; and from any direction—that is, from in front, on the flank, and in reverse or behind. The old saying with ground armies is that one rifle on the flank of an enemy is worth five in front of him. This is for the reason that an enemy fires in line and directs his maximum fire to the front. A rifle shooting into his flank, therefore, is not only free from fire from the enemy, but has as a target the enemy in a deep formation equivalent to a column in front of him, where one bullet may hit a great many military targets successively. One rifle behind him is worth ten in front. An enemy attacked from behind is practically helpless, particularly if the rear attack is combined with a frontal attack, because he has absolutely no means of defending himself without making a complete about-face in the new direction. Fire from the rear shatters the nerve of troops or airmen more than any other kind of fire that can possibly be brought to bear.

This great advantage of a surrounding attack which Aviation holds is utilized to the utmost in its major arm of offense, Pursuit Aviation. All military development, no matter what its nature, has depended on three things—improvement of armament, that is, better rifles, guns and cannon, greater mobility, that is, speed of movement, communications, roads and railways; and last, numbers of effective units at the decisive point. An air force has two of these elements developed to a very high degree, that is, mobility and power of concentration. The armament is being improved constantly.

All military forces must be organized according to a definite system of numbers or hierarchy which ascends in the scale and has appropriate commanders assigned to each unit, so that all organizations may easily be brought under the will of one supreme authority. It is a military axiom that not more than five different things should be directed by one individual, otherwise he will forget something and disaster will result. No organization should have more than five principal parts. This is the result of the experience of the great commanders in all campaigns. The tactical or fighting organization for the different branches of aviation has been worked out by evolutionary changes in actual campaign in the air battles of Europe. This tactical or fighting unit of aviation is the group of one hundred airplanes.

It is divided into four squadrons of twenty-five airplanes each, and each squadron is divided into three flights. The Air Force group corresponds in a way to the battalion which, in an army, is the fighting unit for the Infantry. Two or three groups of airplanes form a wing which corresponds to the Infantry regiment. Two or three wings form a brigade and two or three air brigades form a division.

Air fighting is a thing distinct, and entirely in a class by itself. It bears very little analogy to fighting on the ground or on the water, except that the general principles of strategy, and some elements of grand tactics, are applied. At first an attempt was made during the European War to use one class of aviation for everything, but this soon gave place to specialization, and, at the end of the War, three branches of offensive aviation stood out pre-eminently, which we Americans denominated Pursuit Aviation, Bombardment Aviation and Attack Aviation. The fourth, which is an auxiliary and really is used as an inseparable companion of other organizations, is called Observation Aviation. Observation squadrons and groups are attached to the ground troops, to navies, and to air troops for the purpose of observing everything that is necessary for their own use; that is, to help them fight on the ground, on the water, or in the air.

All branches of aviation depend on each other to a greater or less extent in order that they may be able to carry out their functions in the air. First, Pursuit Aviation has to attack the hostile Pursuit Aviation, and in case it is successful, it attacks the enemy Bombardment, Attack and Observation Aviation. Our own Observation cannot work unless it is adequately protected by Pursuit Aviation, against the enemy Pursuit Aviation; and neither can the Bombardment or Attack Aviation operate alone against a strong enemy force. In the carrying out of each mission assigned to a particular branch of aviation, it is necessary for them to know just what the other branches are doing. For instance, it is necessary that the pursuit commanders know what front of attack has been assigned to the Army Corps, how far the observation airplanes attached to the ground troops must go into the enemy's territory in order to get the necessary information, and what part of the line is the most important from a military standpoint, so that in case they are not able to defend every part of the line, they may concentrate and fight at the most important part of it. Every change of the troops' position must be made known to the Attack Aviation, because otherwise it might shoot up its own troops, instead of attacking the most dangerous of the enemy's elements. At one time in the course of the action, the enemy artillery may be the most dangerous, at another the enemy Attack Aviation, the enemy infantry, or trains bringing up reinforcements.

The Bombardment Aviation also must be constantly informed of the position of the troops so as to make no mistake and hit them with the air projectiles in case the troops make a rapid advance. They must always know where the Pursuit Aviation is, what help can be expected from it, and what its orders of the day are. In fact, Bombardment and Pursuit Aviation always act together when in the face of strong enemy opposition.

The different branches of aviation are grouped into certain organizations, so as to carry out what

One of the Squadrons of the American First Pursuit Group on the Texas Border

they are designed to do. This, of course, depends on the particular military situation which confronts the air force. This organization should always be as simple as possible, and contain in it all the elements necessary for the accomplishment of the mission. A study of our aeronautical needs in this country leads us to the conclusion that offensive aviation should be organized into brigades that will contain about 60 per cent Pursuit Aviation, 20 per cent Attack, 20 per cent Bombardment, a battalion of anti-aircraft artillery, a group of anti-aircraft searchlights, a meteorological section, a communications company, with the necessary air parks for the supply, repair and salvage of the equipment attached to this brigade. These brigades would contain about 600 airplanes, and in turn should be organized into divisions of two brigades, which would give 1200 airplanes. A study of aeronautical conditions in the world indicates that a force of 1200 airplanes might be deployed against us on this continent within two weeks after the beginning of war, which could be greatly increased very rapidly. An air division as indicated above could meet this force on an equal basis. Two divisions would insure its destruction. A French air division organized during the World War, which formed the strategical air reserve for the Western

Front, was organized somewhat along this line. Its effect on both air and ground operations was tremendous wherever it was used. Had the French been able to do so, they would have organized two or more air divisions, but the limitations of personnel and material made it impossible for them to do so. Had the Germans possessed a couple of air divisions when they broke through the Allied lines in March, 1918, the probability is that they would have won the War at that time. All of the great powers intend to organize their aviation according to these principles.

When operations are projected, all the air forces must be instructed in what these are to be. This information is contained in what is known as the aeronautical plan of employment. It is drawn up by the commander of the air forces, submitted to the commanding general of the whole forces, and is published in the form of orders by the headquarters. It is the most important document dealing with the air operations, and its thorough understanding by all the air forces is essential to an efficient performance of their duties. The plan of employment usually provides for three stages in the operations. The first is the preliminary stage, in which all the information possible is found out about the enemy—this includes photographing all of his positions, making deep reconnaissances into his country so as to see where he is accumulating supplies, what capacity his railroad lines have, the condition of his roads and bridges, the amount of motor transport that he possesses, where his great stores of material are located, what they contain, and how long it would take them to be sent to the front. All of this work must be done so as not to bring the attention of the enemy to the increased activity over the sector of operations, because otherwise he would not be surprised. At the same time this reconnaissance is going on, an absolute barrage has to be kept against enemy reconnaissance of the same kind, so as to prevent his gaining information of our own concentrations. This is particularly so at night, when the maximum changes of position take place, to insure greater concealment from airplane observation. As the airplanes operate at night as well as in the daytime, this is very important. Behind the defensive barrage of Pursuit Aviation all the friendly airplane units are brought up without exposing them to view, concentrated, and concealed on their airdromes. In our preparation of the airdromes for the attack in the Argonne, we put up camouflage hangars on the airdromes, and camouflage airplanes out on the ground—moving them frequently so as to make the deception more real. When the time came for the establishing of the airdromes, the real hangars were put up at night, and the camouflaged ones removed; while the actual airplanes took the place of the make-believe ones on the ground. The communicating systems were installed and all the supply points for the airplanes, ammunition, fuel and supplies of all kinds were put in.

The next stage in the operations is the attack. This may be for a limited objective, or may be what is called a penetration—that is, one in which the ground armies attempt to break through and capture the enemy's artillery. The air forces attempt to completely destroy the hostile air force and his airdromes. When acting with an army, this stage of the operations requires that a certain amount of Pursuit Aviation be used entirely offensively against the enemy's Pursuit Aviation far back into his country and that a certain amount of Pursuit Aviation be assigned for the immediate protection of the troops. The front is accordingly divided off into appropriate sectors for pursuit patrolling purposes. In fact, all the enemy territory is carefully gone over and divided into various sectors, to be constantly covered by Pursuit Aviation. The total available pursuit force is assigned for this work, in accordance with the numbers of this arm of aviation that are there. It must be held in mind that an airplane has the power of remaining in the air only from two and one-half to three and one-half hours, in accordance with its gas capacity; then must land and replenish. One must always hold a sufficient reserve to meet any unforeseen emergencies. It can be seen, therefore, that only a very small proportion of the total air force can be in the air at any one time; ordinarily not over one-third of it, unless an action is contemplated which requires a single operation, or maybe two operations, during the day which can take every airplane.

The Bombardment Aviation attacks the most dangerous target which the enemy possesses. This may be large concentrations of supplies, far removed from the lines, communications—such as railroads (particularly railroad yards), bridges, either temporary or permanent, ammunition depots, or cities or towns that have been converted for military use. These bombardment raids have to be protected by Pursuit Aviation, and the plan of employment prescribes the general method by which this will be done. The plan provides for the use of the Attack Aviation, which, ordinarily, is employed to attack enemy troops on the ground, his artillery, and his trains, along an axis which controls the point or points which are most vulnerable, and which assist our own troops the most. In a combined action between air and ground troops, Attack Aviation facilitates the advance of the ground troops by knocking out everything that can be attacked from the air in front of them. It attacks airdromes of the enemy, so as to destroy his airplanes and airships while they are still on the ground; it is especially useful against tanks, automobiles, trains and troops. Again, Attack Aviation has to be protected by pursuit in the accomplishment of its mission.

The plan of employment states when the officers at the various air organizations shall assemble to obtain the orders of the day, how these orders shall be transmitted to the organizations they represent, and what reports shall be made by each organization during the day. Nothing is left to chance, and every phase of the operations is carefully thought out by the air staff officers. A similar method of procedure is employed in air operations against a naval force over the water, or an air expedition acting alone against a hostile air force and country.

As a supplement to the plan of employment of an air force, a complete plan of reconnaissance is drawn up. This is designed to show what must be learned about the enemy. It lays stress on the relative importance of the various communications behind the enemy's positions; that is, his system of roads, railroads, rivers, canals, steamship lines, or any means that he has for moving troops and equipment, all his industrial districts, all his supply points, and even all his mines and factories. Each of these is put down in relative order of importance, so that the most difficult may be reconnoitered first. It must be remembered that all information in war has to be fought for, and the work of the observation squadrons in the accomplishment of these tasks is difficult and requires most excellent handling to be effective.

The Army Reconnaissance Air Group of the 1st Army, A.E.F., under Colonel Reynolds, was the best on the front of any army. The observation squadrons attached to the Army Corps are required to do all the reconnoitering in the immediate vicinity of the troops. They make continuous photographs of the whole area, both from directly above and obliquely. The oblique photographs particularly are used all the way down to the smallest organizations of troops. All the information gained by any observation units which may be useful to other organizations is immediately sent to them.

Another supplement to the plan of employment is the plan of bombardment. This shows all the bombardment targets that may be attacked, what their relative importance is, what size projectiles are necessary for demolishing them, at what height airplanes have to fly in the daytime in order to avoid or counteract the attack of the enemy, what the routes to be followed at night are to be, where the prohibited areas for bombardment are, that is, where airplanes are prohibited from flying, so that our own anti-aircraft defense may be used to its fullest extent. Thus the anti-aircraft cannon, machine guns and balloon curtains may be sure that all aircraft over them are hostile, not being hindered by friendly airplanes. The plan of bombardment also prescribes the general method which will be used in the employment of Pursuit and Attack Aviation as an aid to bombardment operations both by night and by day.

All air forces, therefore, have to be entirely informed of the operations and duty which each part is called on to perform, and in the successful handling of an air force, these are announced every day or several times a day in orders and instructions. Not only does an air force know what each branch of aviation is doing in the air when acting with an army or with a navy, but it

500- and 1000-Pound Airplane Bombs

has to keep in constant touch with everything that is taking place on the ground or the water. The airman, therefore, not only from his position of advantage in the sky looks down on the whole field of battle and surveys the contests between hostile air forces in the clouds, but he knows the particular mission which every distinct part of the force, whether on the ground or in the air, has had assigned to it. He knows a great deal about the general operations and mission of the whole force, so that he can act independently on it in case of necessity. Many times the good judgment of a lieutenant pilot has changed the whole aspect of an air and ground battle. A captured aviator is always very carefully questioned, because he knows more about the general operations than any other officer except the very highest commanders. The individual airman, therefore, bears more responsibility and requires a higher tactical and strategical training than any other individual in the military service.

CHAPTER V

Pursuit Aviation

Pursuit Aviation is that branch of aeronautics which is organized to gain control of the air by air battles. It is equipped with the fastest, the most maneuverable, and the best armed airplanes possible to devise. During the War, the pursuit airplane became obsolete within three or four months after it appeared on the front, its place being taken by the next development, which was a little faster, a little more maneuverable, and a little better armed. Nothing can resist the attack of Pursuit Aviation properly handled, because it utilizes its power of bringing flank, reverse and frontal fire in three dimensions to bear against the air force that it is attacking. Consequently, the only aviation capable of challenging the supremacy of Pursuit Aviation is other Pursuit Aviation. A large lumbering airplane or collection of airplanes, no matter how well armed, cannot resist the surrounding attack of Pursuit Aviation.

The speed of the pursuit plane is one hundred and fifty miles an hour, or more; it climbs to 20,000 feet in twenty minutes or less, and it can outmaneuver, turn quicker, dive faster, and zoom higher than any other airplane. In fact, the modern airplane can zoom for two thousand feet straight up after it has attained its maximum speed. The pursuit airplane is armed with not less than two machine guns, which fire all the way from seven to twelve hundred shots a minute. The guns used in the War were .30 caliber, the same as the Infantry rifle and machine gun, except that they had ammunition especially made so as to prevent jams and, in addition, better suited to the particular work in hand. They utilized incendiary bullets for attacking balloons and airplanes, tracers, which burn a whitish or brown smoke to show where the bullets are going, armor-piercing bullets and the ordinary ones. The .50 caliber machine gun is now largely taking the place of the .30 caliber. This is a great powerful weapon —it is almost a small cannon in a way—which can pierce any armor so far devised for airplanes. It can pierce the armor of tanks on the ground, and no bullet-proof gasoline reservoir in an airplane is immune from its attack. The old bullet-proof rubber covering over gasoline tanks, which prevented fire and leaks, no longer does much good.

The 37 mm. cannon has taken its place permanently as an air weapon. It was used as an experimental arm during the War with very good results. It fires a pound and a half projectile which is made up into high explosive shell, ordinary shell, armor piercing, incendiary and canister projectiles. Its fuse is so sensitive that it explodes on an impact with cloth, for the attack of airships, and its projectiles are so arranged that they will explode themselves after going a certain distance, so as not to fall on the ground among friendly troops and explode. This cannon is particularly useful for attacking large dirigible airships where great holes have to be torn in their structure in order to bring them down. The small machine gun used during the War had little effect on Zeppelins, because the bullet holes were not large enough, and the material of the Zeppelin envelopes largely filled up the apertures made by this small weapon.

In October, 1917, I examined the German airship L-49, which was brought down behind the American area, due to frozen engines. A squadron of French airplanes had attacked it violently for several thousand feet before it landed, and had fired a great many incendiary air projectiles into it. These were of .30 caliber and had little or no effect on this great structure.

As the machine guns have been synchronized to shoot through the propellers of airplanes, so is the attempt being made to do the same thing with airplane cannon. This so-called synchronization is a device for shooting through the area in which the propeller turns, and at the same time avoiding hitting the propeller. The arrangement is very much the same as the cam system on a gasoline motor, which opens and closes the valves or the distributor which makes the contact for the ignition in the various cylinders. Larger cannon are now being tried by all nations for installation in their offensive aviation.

The tactics of Pursuit Aviation may be likened very much to those of Cavalry in the mounted attack in the old days. The elements to be utilized to the greatest extent are surprise, boldness of action and an attack in echelon, that is, successive formations designed to envelop and surround the enemy with a fire attack. This branch of aviation calls for more dash, more quickness of thought, and instant appreciation of tactical situations in the air, than any other military arm. When one appreciates the swiftness of thought that is necessary to handle Cavalry, which, at its very maximum, cannot move, even when charging, more than about twenty miles an hour, then it may be imagined what qualities are necessary in the Pursuit Aviation leader, when the pursuit airplanes move over one hundred and fifty miles an hour, and dive at nearly double this speed, with the enemy coming at approximately the same speed, possibly surprising him or speeding against him from several directions at once.

During the War we had to transmit signals by the personal example of the leader of the subdivision, who made motions with his whole airplane, so as to indicate direction, or swung his wings sideways, or made slight changes of elevation upwards and downwards, to mean prearranged orders corresponding to these motions. Sometimes the rocket signal was employed. Now we are beginning to use wireless telephony between airplanes with considerable success.

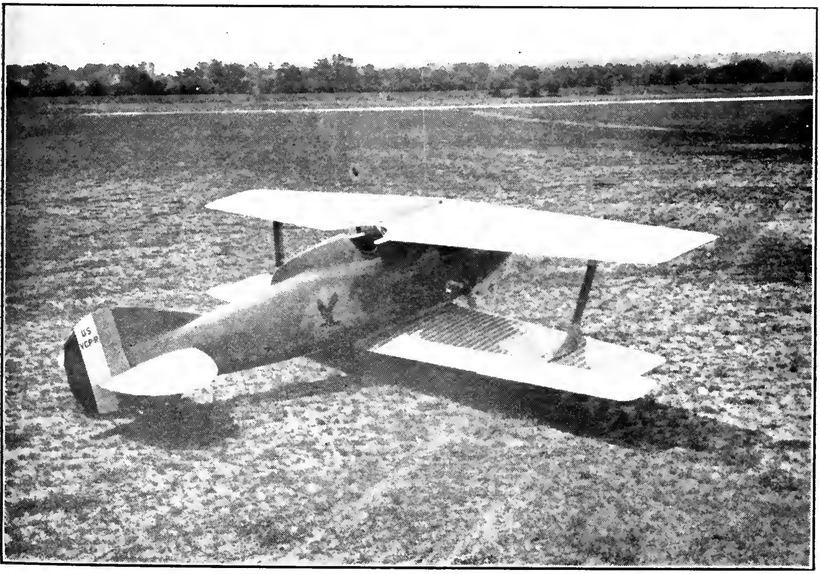
Our Pursuit Aviation greatly distinguished itself in Europe. At Château Thierry, our First Pursuit Group, newly formed, was pitted against the very best pursuit organizations in the German Air Service. It was a question whether our men, new at the business, would have the cohesion, ability of combination, and courage of the individual which the older services had on account of their almost four years of constant fighting on the front.

Our pursuit was carefully trained according to the principles mentioned above—that is, impetuosity of attack in subdivisions, one after another, with a view to surrounding the enemy and bringing reverse or fire from the rear to bear on him; that the last formed reserve thrown into the fight would win; that a flight or unit of five or six airplanes could attack a single enemy unit of three or four times its size which was being maneuvered in one body and throw it into such confusion that succeeding flights could attack them in detail, that is, one, two or three at a time; that it was better to take fifteen pursuit airplanes and fight them in three flights of five ships each than fight all fifteen airplanes in one single mass.

At the time we appeared at Château Thierry, the Germans were using large pursuit formations —fifteen, twenty and thirty airplanes in one group. These large German formations were directed by a single leader, and usually were formed in a "V," both laterally and vertically, so that in a way the whole formation might be likened to a cone of airplanes. Their object was to attack the hostile aviation with the nose of the cone, and at the same time to spread around their enemy with both wings and envelop him. Up to this time, this method of attack by Pursuit Aviation was quite effective, particularly against two-seaters, or against airplanes that could not maneuver with rapidity, or did not have an equal or superior speed. We, however, formed our First Pursuit Group in four squadrons, and each squadron in three flights—the basis of the whole being the flight. These were echeloned or arranged so that each squadron made a "V" formation by flights, each flight having a different altitude from the one ahead of it. A maneuver was always made so as to take advantage of the sun, or any local conditions of wind or clouds that might affect the air battle, so as to allow a surprise and an attack against the enemy's rear, "getting on their tails" as the saying was.

When the attack was launched, it was made with the utmost impetuosity by these formations, one after the other. Success immediately crowned our efforts in spite of the fact that our men were so new at the game. Their excellence as pilots, their remarkable intelligence and their wonderful physical attributes, were a great help. All of our young men in addition had been trained in such games as football, baseball and other exercises calling for team work and cohesion, which, at the same time, required quick thought and decision. This was invaluable as it gave a natural spirit of discipline and combination.

The First American Pursuit Machine Built by the Curtiss Company in 1915



A United States Pursuit Airplane. Speed of 175 Miles an Hour

Although outnumbered and pitted against the best aviation in Europe, at Château Thierry our Pursuit Aviation rendered such a good account of itself and formed such a basis for future development as to leave no question about its excellence. Our tactical system of Pursuit Aviation was also proved to be second to none. This was again manifested in all subsequent operations of the American Army, and the superiority of our Pursuit Aviation in organization, tactics and cohesion was rapidly becoming a model for this branch of the Air Service.

All other branches of military aeronautics are helpless without an adequate, strong, well-trained and well-equipped Pursuit Aviation. Nothing can contest with it for supremacy in the air. All kinds of Bombardment Aviation are completely at the mercy of Pursuit Aviation. Observation Aviation cannot act without its protection, while the heavily armored attack airplanes, no matter how well protected, will be shot down without the assistance of Pursuit Aviation. No one understands the necessity for this kind of aviation as the airmen themselves do. The ground troops think that Observation Aviation is the all-important element, because they are brought more closely into contact with it. They seldom see the battles of Pursuit Aviation, which take place thousands of feet up in the air, and miles into the enemy's country. It is on these contests, however, that the safety and well-being of all branches of aviation rest; whether the enemy will be blinded in his air reconnaissance, which will allow his troops to be informed of every move; whether his Bombardment Aviation can drop the huge projectiles, which are used to-day, on his enemy's troops and strategical centers; or whether his Attack Aviation can shoot up the advancing columns of Infantry on the roads, or destroy the tanks, the motor trains and railroad cars. Without an adequate and efficient Pursuit Aviation, a nation is helpless in the wars of to-day.

CHAPTER VI

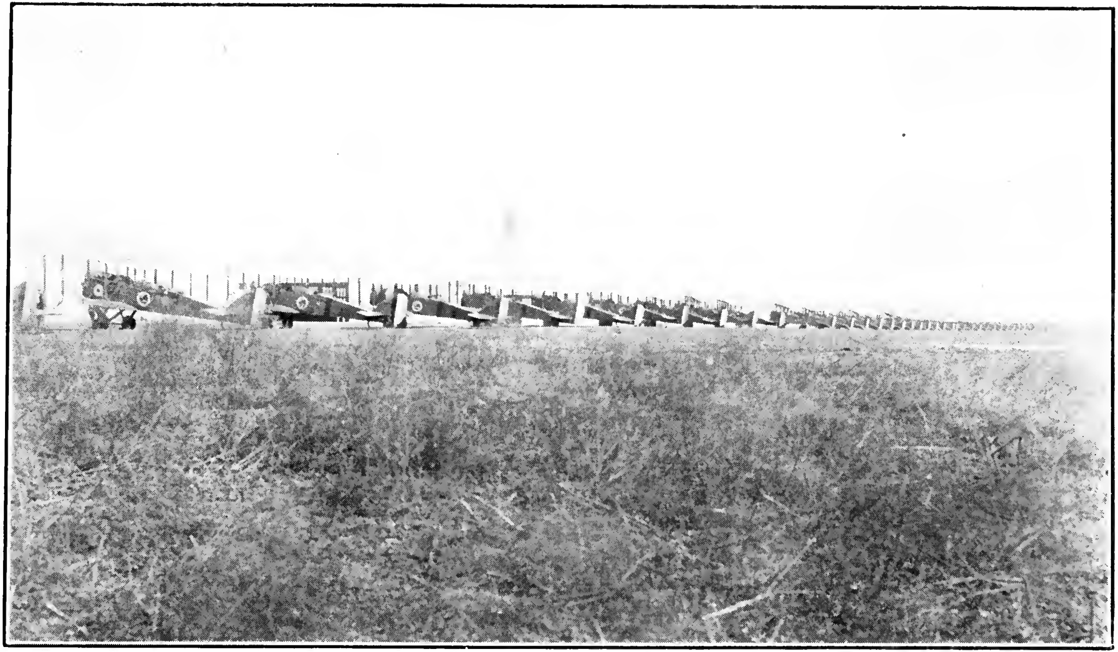
Bombardment Aviation

Bombardment Aviation is that branch which is designed to carry heavy aerial projectiles over enemy targets, and drop them on these places with a view to destroying the material and killing the personnel.

Bombardment Aviation asserted itself more and more as the War developed. Several considerations governed its employment. In the first place, artillery had a useful range of not more than about twenty miles. Aviation had ten times this. In the next place, the War, as it developed on the Western Front of Europe, was not so much a question of whipping the front line troops as it was a question of whipping the reserves, or making it impossible for them to arrive on the field of battle in sufficient time to have an influence on the decision. The effect of interfering by air bombardment with the delivering of supplies along lines of communications was very great, and also of interfering with the manufacture of military equipment. This last amounted to two different things—first, actually hitting and destroying the factories, and, second, causing, by air bombardment, such a nervous condition to obtain among the workers that their efficiency of production would be curtailed.

Bombardment Aviation, therefore, was developed to fulfill these requirements. It gradually divided itself into what was called Day Bombardment and Night Bombardment.

Day Bombardment was used for the purpose of attacking military objects either on or immediately contiguous to the field of operations, such as troop concentration, convoys and railway trains. Its great enemy was the hostile Pursuit Aviation and the fire of the anti-aircraft artillery. To neutralize the last, it had to rise very high in the air, so that the anti-aircraft cannon could not hit it, and to combat the former, or hostile Pursuit Aviation, it had to be supported and at the same time covered by a screen of friendly Pursuit Aviation, because alone it was at the mercy of the hostile pursuit units. As such a high altitude was required (from twelve to sixteen thousand feet or more) to successfully traverse the lines and reach the objects designated for attack, the average Day Bombardment airplane was able to



The United States First Bombardment Group

carry only from about three hundred to five hundred pounds of bombs.

Day Bombardment Aviation was organized into groups of one hundred airplanes divided into four squadrons. In this case the squadron acted as the unit, and consisted of twenty-five airplanes, of which usually about fifteen to eighteen were available for duty. These flew in a "V" formation, very much like the flight of wild geese. This formation had for its object not only its own immediate protection by the fire action of its machine guns against the attack of hostile aviation, but also the necessity for dropping bombs all together so as to get a sort of a shot-gun effect on the target which they were attacking. At the high altitudes necessary in Day Bombardment a single airplane attacking an object would have very little effect, because the ordinary target is so hard to hit. The bombs were dropped by a signal from the leader, that is, the commander of the leading unit had an observer who handled the bomb sights and took all the necessary measures for dropping the bombs at the proper time and place. All the other observers, as the airplanes were two-seaters, watched for the hostile air attack, so as not to be surprised. When the bombs were dropped by the leader, a signal was made, and all the other airplane pilots dropped their bombs at the same time. In this way, a heavy collective effect was obtained.

Day Bombardment, in addition to demolishing objects, had the effect of forcing the enemy to defend with his air forces the areas attacked, and no better indication could be found of its efficiency than the great resistance which the enemy would offer to the Day Bombardment Aviation.

The Day Bombardment branch kept increasing in number of squadrons, groups, wings and brigades. The greatest bombardment attack ever made occurred during our operations in the Battle of the Argonne, when an allied formation of French and American airplanes, more than three hundred in number, attacked an enemy concentration point at a place called Rombevilliers, about twenty miles northeast of Verdun, where the enemy was forming for a counterattack against our troops that had crossed the Meuse River. The enemy troops were concealed in woods and the small villages in that vicinity. This formation arranged in squadrons, groups, wings and brigades, went over the lines in one mass in full view of the whole American Army. In spite of its being engaged by the hostile Pursuit Aviation, the suddenness of the attack of this air force and the quickness with which it went to the objective, made it impossible for the enemy to combat them with success. Thirty-nine tons of bombs were dropped by this one expedition on the enemy concentration. The counter-attack of the enemy ground forces did not take place, twelve German airplanes were shot down in flames which were authenticated, and, in this particular instance, all our own airplanes returned. It might be mentioned that, during the twenty-four hours covered by this day, a total of sixty-nine tons of bombs were dropped on enemy formations opposing the American Army in the Argonne. This was a record for bombardment operations. As these air projectiles held fifty per cent of their total weight in explosive, it will be seen that over thirty-four tons of the highest kind of explosive known were dropped. To shoot the same amount of explosive over the line with artillery more than 700 tons of cannon projectiles would be required.

In addition to the material and personal damage that these air bombardment attacks have on an enemy, the moral effect on one's own troops is tremendous. Most of the time the ground troops cannot see the air troops doing their work, as the air fights necessarily take place at a distance from the troops because the hostile air forces have to be sought out and fought wherever tactical requirements necessitate it. The ground troops consequently get the idea in many instances that they are abandoned by their aviation, and occasional glimpses of a mass of their own aviation such as mentioned above, crossing the lines, and, in spite of being covered by the hostile anti-aircraft artillery fire and attack of the hostile air forces, proceeding on their mission, is indeed a very inspiring sight.

Day Bombardment had to be constantly protected by Pursuit Aviation. Many thought for a long time that Bombardment Aviation could protect itself by its own fire in a manner similar to that employed by battleships on the water. While, theoretically, fire is the best protection, still the battleships maintain themselves more by the thickness of their armor in combination with their fire than anything else; of more importance, however, is the fact that the battleships act in only one dimension, that is, on top of the water. Bombardment airplanes, which have not the maneuvering power of pursuit, cannot resist the rapid attack against them by the pursuit in three dimensions; above, underneath and on the same level, although great loss may be caused to the enemy.

Among the numerous examples illustrating this principle may be mentioned the experience of one of the French Day Bombardment squadrons

A Bombardment Practice Formation. Bombs are Dropped in Formation so as to get a Collective Effect

which was acting under my command during the battle of Saint Mihiel. It will be remembered that, at the battle of Saint Mihiel, we were attacking what we call a salient, that is, the enemy position projected into our position. This gave us the opportunity of attacking it from both sides, and completely crossing over the enemy position. Our aviation, therefore, was so arranged as to hit from one side, and, as that attack diminished in vigor, to attack from the other side of the salient, and, in that way, catch the enemy in reverse, or, while he was engaged in resisting one attack, to come up behind him with the other attack. It might be likened to right and left swings of one boxer against another, while the opponent's guard had been diverted in one direction to hit him from the other.

In the carrying out of their orders, one French squadron of twelve 2-seater Breguet airplanes (the best Day Bombardment machine on the front) and protected by three large 3-seater Caudron airplanes armed with six guns (the most powerful single airplane then in existence) proceeded on their mission to the vicinity of Conflans, about fifteen miles within the enemy's line, at a time when our Pursuit Aviation was not in that vicinity. The squadron was supposed to be with its group but had missed it in the assembly.

The formation of the squadron was in a "V" and the large 3-seaters were used one on each flank and one in the opening of the "V" to guard against flank and rear attack. This squadron formed part of the French Air Division which was a wonderfully instructed corps of seasoned aviators who fought through the whole War and were the reserve of the whole French air force. Wherever a decision was being called for on the front, there would be found the French Air Division. This squadron was attacked in the vicinity of Conflans by a group of German Fokker pursuit airplanes. All three 3-seaters were shot down in flames, and seven of the twelve Breguets met a like fate. The formation was never broken. All the personnel of this famous organization remained at their post fighting in their airplanes until burned up. They accounted officially for twelve German Fokkers. Five planes, manned by the brave crew of this squadron, returned with their airplanes riddled with bullets, witnesses to the fact that the principles of speed, maneuverability and concentration of fire are the things that win in any military operation.

Due to the fact that Day Bombardment Aviation carried only a limited amount of weight because it had to ascend so high and get the maximum speed possible to defend itself, bombardment began to be carried out in the night with slower airplanes, and by the end of the War, specific units of Night Bombardment were organized. On an ordinary clear night, it is almost as easy for the pilot to see the ground at comparatively low altitudes as it is in the daytime. On the other hand, it is extremely difficult for anyone on the ground, or in the air for that matter, to see hostile airplanes. As a result, slow airplanes, which have the ability of carrying great weights of bombs, could be employed, and, as the accuracy of striking an object is directly proportional to the distance you are away from it, great accuracy resulted from Night Bombardment, as they could fly low down, very close to their target. The Germans were especially adept and relied very greatly on this branch of aviation, their famous Gotha airplanes being excellent examples of the Night Bombardment ships. They used no regular Day Bombardment squadrons.

The missiles used ran from 200 pounds up, the 500 kilo or 1200-pound bomb being a favorite one of the Germans. Some projectiles were used weighing a ton. Night Bombardment attacks were particularly severe against the British troops, in which great numbers of men were killed and wounded just back of the actual field of battle.

To illustrate the accuracy of a Night Bombardment attack: the Germans singled out the City of Nancy, which was near the American area in France and contained a great deal of war material, industrial establishments, and railroad facilities. There was an ammunition factory within the city which, of course, was well known to the Germans. One night they attacked this with 1200-pound bombs. The first bomb hit a small house facing the street in front of the factory; the next bomb hit the corner of the factory, demolishing that whole side of it; the third bomb hit the middle of the factory and completely destroyed it. That factory made no more shells during the rest of the War.

A few nights after this, in the same city, a train loaded with gasoline and oils stood in the station. I saw the Germans hit this train directly, blow it up, and cause a fire which burned everything in that vicinity.

The Bombardment Aviation attacks in this vicinity were so severe that they caused the complete evacuation of this great city by the civil population. The working people were in such a nervous state that whenever they heard an airplane or thought they heard one they stopped, looked and listened. I imagine that the productive ability of that area alone was reduced seventy-five per cent by the action of the German Night Bombardment ships.

Corresponding injuries were inflicted on the Germans, and nothing made them cry louder than the bombardment attacks against their centers of production by Allied aircraft. No matter what the propriety of such attacks may have been, it must be taken into consideration that in the World War the Germans adopted and adhered to the theory that with a nation in arms, every man, woman and child of the hostile state is working either on the field of battle, or in factories and fields, to further the object of their armed forces. The Germans having adopted it, the Allies would have suffered a distinct strategical disadvantage had they failed to adopt similar tactics, and on the strength of this precedent of the past war, it is probable that the next war will see the original German theory carried out to a more marked extent.

On one occasion, a Night Bombardment attack against the town of Longuyon, about thirty-five miles opposite the American front in the Argonne, resulted in the hitting of a German ammunition train which happened to be in the station, together with two trains bearing troops—one of the troop trains going to the front and another of troops on leave going to the rear. It caused the ammunition train to blow up which killed 550 men in the station alone, with a corresponding number of wounded.

At this same place, at another time, a Day Bombardment attack which missed the town hit among the troops of a division which was drilling at a short distance from the city, killed over 200 men, and wounded a corresponding number.

The efficiency of Bombardment Aviation, both in its attacks against ground troops and against navies, is increasing rapidly, and, like other branches of aviation, is merely in its development state.

Whenever an attack of a military object depends on an explosive, an aerial bomb attack is the most efficient, because air projectiles carry a greater proportion of explosives than any other missile (roughly, one-half their weight). A 500-pound bomb carries 250 pounds of explosive; a 1000-pound bomb, 500 pounds of explosive; a 3000-pound bomb holds 1500 pounds of explosive. Compared to other projectiles, we find the following: The 16-inch armor piercing cannon projectile carries about 55 pounds of explosive. The projectiles weigh more than one ton. The submarine mines used for harbor defense, weighing from 1200 to 1700 pounds, carry about 200 pounds of explosive. Water torpedoes range from about

200 pounds of explosive with a 1500-pound torpedo, to about 700 pounds with a 3000-pound torpedo. The accuracy of bombing depends entirely upon the distance to the target. If hostile aviation and anti-aircraft defenses can be subdued by the action of Pursuit and Attack Aviation, by being able to fly low, objects on the ground or on the water can be hit with great accuracy. A projectile from a cannon or a torpedo is limited, in the case of the cannon, to something like 60,000 yards; in the case of the torpedo to about one-tenth of this distance. A modern bombardment airplane can go out 200 miles and come back again with its load, and still have a reserve of 200 or more miles of flight.

The Army has recently tested an airplane which shows that it can carry 5000 pounds of bombs with a total flying capacity of about 800 miles.

As to expense, the present bombardment airplane, with all its accessories, would cost about \$80,000, much less if produced in great numbers. Compared to this, the present 16-inch gun, with its mounts, costs \$500,000. The present battleship, with its accessories, costs about \$45,000,000. A single 1000-pound bomb striking in the water within 60 feet of a battleship will greatly injure it or put it out of line so that it will become an easy object for attack. A bomb hitting on the decks of a battleship will put it out of action or completely destroy and sink it.

Many other weapons containing chemical compounds, smoke screens, and brilliant lights, are being used for the attack of shipping. All ships can be sunk with ease, except armored vessels. Up to the present no particularly continuing attempt has been made to complete all the armament arrangements for this purpose. War vessels must be used as targets and a consistent effort made. When this has been done naval vessels will not be able to play the part they have in past wars, unless completely protected by aircraft. No anti-aircraft artillery or searchlight arrangements on war vessels can keep airplanes away, because these defenses either can be made ineffective by smoke screens, neutralized by counter-attacks from the air or totally disregarded. The warship is therefore doomed to certain destruction at the hands of Bombardment Aviation.

CHAPTER VII

Attack Aviation

The third and newest Arm of Aviation is called Attack, in the United States Service. Again we have to give the Germans the credit for initiating this as a separate branch. Its specific mission is to attack troops, trains of automobiles, convoys, railroad trains, tanks, debarkations from trains, ships or vessels, warships, or any military object on the ground or the water which exposes itself to attack from the air by cannon, machine guns, or light-weight bombs.

Attack Aviation works at low altitudes. It is especially developed to scatter and retard advancing columns of troops and tanks, artillery; to wreck deployments of troops; to attack machine-gun nests, hostile airdromes, and anything that it is capable of getting at. A flaming bullet from a .50 caliber machine gun will set the gasoline tank of a truck or a motor car in flames instantly. Artillery in position, and particularly the horses or the motors of this Arm of the Service are very good targets for airplane attack.

The tactics of this Arm of the Service are to determine where the hostile element to be attacked is to be found; then to go there at very low altitudes, one or two hundred feet above the ground, utilizing whatever concealment offers itself in the way of woods, high banks, hills, mountains, smoke clouds, or screens of other airplanes. The attack is made with suddenness and with every element of surprise that is possible. A succession of attacks is necessary, one after the other, for the reason that Infantry on the road, advancing, immediately conceals itself by getting off the road and hiding when attacked in this manner. As soon as the airplanes leave, the Infantry gets back on the roads and proceeds on its march. It is then that it should be pounced on by the next echelon of Attack Aviation. During the war, airplanes completely held up moving columns of troops in many cases. In fact, during one stage of the Battle of Cambrai during a German counter-attack, British Aviation attacking the German troops on the ground held alone and unaided a whole section of front for more than an hour, until reserve troops came up. Motor trains, Cavalry on the march, and other moving objects act in a similar manner while traveling along roads, so that the principle of attacking objects on the ground with this branch of aviation is to cause one flight to attack after the other, successively, and with a sufficient interval of time to enable whatever target they are working against to expose itself again.

In the Argonne Battle of 1918, the Germans had just organized their "battle flights" as they were called. They did not have very many of them, and their last type of armored airplanes was only beginning to come up. When our ground troops attacked, the congestion behind our center was terrible. The roads leading up to Montfaucon were clogged with transportation and all the things that go behind an army to an extent seldom seen on a battlefield. This mass of transport did not move in some cases for thirteen hours, and offered a wonderful target for Attack Aviation. Had these motor trains been destroyed and had the Germans counter-attacked at the same time, the whole position of the American Army would have been critical. The Germans appreciated it at once, and immediately took advantage of it with their aircraft. Our own air forces knew what they would attempt before they tried it, because it was seen from the air as soon as it had happened. They also knew that without pursuit protection, their battle flights could not exist against our pursuit attack. To counter their move, we threw our Day Bombardment and big bodies of pursuit planes into the enemy's territory to fight them on their own ground and keep them back from our territory. In addition to this, we detailed one group of pursuit—the First Pursuit Group—to fly at a low altitude for the specific purpose of engaging the German Attack Aviation when it came over. This system of defense against Attack Aviation had never been tried with success on the Western Front. Our First Pursuit Group made a complete success of it.

As the attack airplanes were painted a color similar to the ground, our own pursuit patrols saw them with great difficulty. They could be seen, however, from the anti-aircraft posts on the ground, and our system was so arranged that the anti-aircraft artillery would fire on them the minute it saw them, to act as a signal for our own pursuit patrols who would immediately assemble in the direction of the bursting projectiles from the anti-aircraft artillery, see the hostile Attack Aviation, and immediately engage it.

During the month of October, our First Pursuit Group, with the aid of the anti-aircraft artillery, worked so successfully that they inflicted a loss of one hundred and ten victories against the Germans to a loss of only ten airplanes in this organization. With our tactics of keeping the German Pursuit Aviation heavily engaged on their own side of the lines, we had made it impossible for them to protect their Attack Aviation, which then allowed our Pursuit Aviation an unhampered opportunity to fight them wherever they found them.

This illustrates again the necessity for the protection of the Attack Aviation against hostile pursuit. Had the Germans been successful with their Attack Aviation against our moving columns and transport on the roads behind our center leading up to Montfaucon and beyond, our movement in this direction would have been stopped.

Modern attack airplanes carry a cannon and six or eight machine guns. They have armor all over their vital parts, sufficient to withstand the fire of rifles and machine guns from the ground. The attack of these airplanes is imposing. Think of a battery of six machine guns firing at once. Say that the machine gun fires only six hundred shots a minute (some fire up to twelve hundred a minute); with six guns you have thirty-six hundred shots per minute. During a minute, the airplane covers about one and a half to two miles of ground; six of these airplanes then will deliver about twenty-one thousand shots per minute, and the cannon, which are able to fire at the rate of one hundred and ten shots a minute divided into groups of ten shots each, will be able to add to this. In addition, these airplanes carry from ten to twenty fragmentary bombs that are particularly useful against personnel, trains and artillery.

Now, take a group of these airplanes, consisting of four squadrons of three flights each, or one hundred airplanes, detailed to attack a column of troops on the road, and one can easily imagine the great effect which Attack Aviation will have.

One German airplane attacked a railway train behind the British lines which was filled with men going to the rear and who had practically no arms with them. It flew along beside the train, and is said to have killed and wounded about two hundred men single-handed. This was an ordinary observation type ship.

These armored airplanes would be especially efficacious against troops debarking from warships, transports, or against a poorly organized enemy that has a weak aviation and a poorly developed system of anti-aircraft artillery. In fact, in some instances, these airplanes, due to their defensive ability, may land on the ground and engage in battle with troops directly.

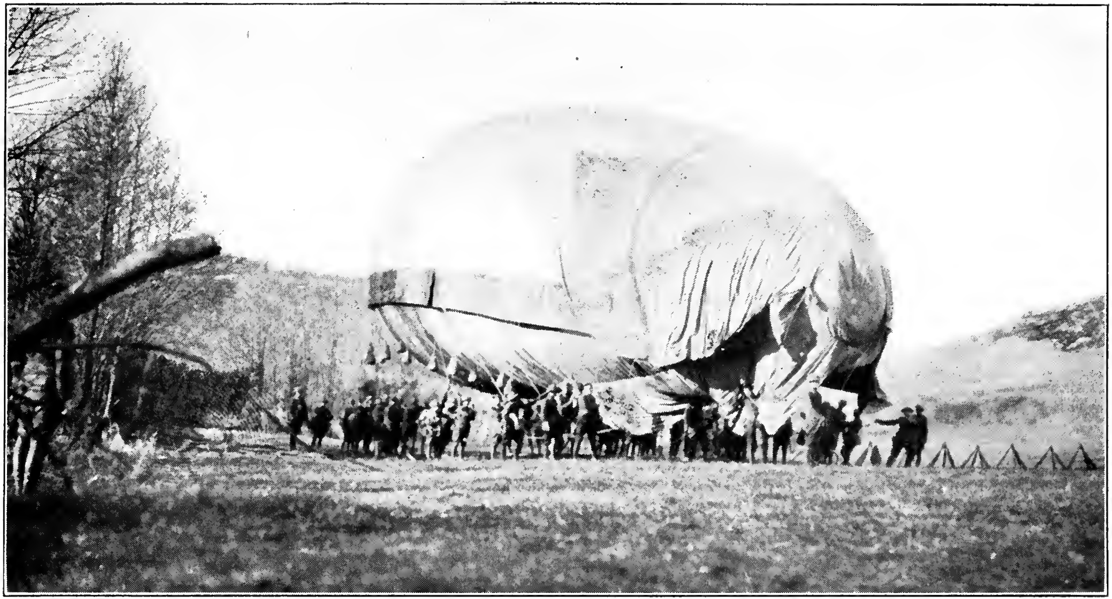
The three branches of Aviation mentioned above constitute the offensive power of an air force. They all work together, and are interdependent.

CHAPTER VIII

Observation Aviation

This title is given to the branch of Aviation that works as an auxiliary of other services, such as an army, a navy, or an air force. There are a great many sub-divisions in Observation Aviation. It is the first branch of aviation which was developed during the War. It is the best known of all branches of aviation, but at the same time, as it requires such an intimate co-operation between the observation squadrons and the ground troops, it is one of the most difficult to bring to the necessary high standard in war, on account of the many elements that have to work together to make it efficient.

The mission of Observation Aviation is to find out and report to the commanding officer of the troops to which it is attached what is in front of him, and in his vicinity. This is done in two ways; first, by visual reconnaissance, where the airplane goes out, looks over the ground, observes what is taking place there, and comes back and



An American Observation Balloon of the Caquot or French Type

reports; and next, by photography. The front of an army is always divided into certain sectors that are kept under the eye of the observer. On account of the fact that airplanes are forced to fly at a great altitude, where it is difficult to see details on the ground, photography has played a more and more important part in this work, so that now each prominent part of a battlefield, every road and cross-road, every wood and ravine, and all entanglements and trenches are immediately photographed and plates are brought back and developed in the photographic section of the observation squadrons, printed, properly marked as to their location on the maps, and distributed to the organizations for whose use they are intended. Ordinarily, in Europe, each plate that was exposed had to have about eighty-five photographic prints made of it instantly for distribution, and before an attack the photographic sections turned out thousands of these negatives and prints every day. They worked day and night. Not only did they take vertical pictures, but also oblique pictures, because the ordinary person, not expert in the interpretation of vertical photographs, does not get the same impression as he does from an oblique picture, which gives the appearance of having been taken from some high building, hillside or tower.

The next duty of Observation Aviation deals with the adjustment of fire of artillery or other missile-throwing weapons. This really is the easiest duty in many ways, of Observation Aviation. Communication is maintained between the air and the batteries of artillery by radio telegraphy. The observers are in constant touch with the artillery organizations with which they work while they are on the ground so that they understand intimately how the artillery works and fights. There are three general conditions under which artillery fire is conducted: where the artillery is in position and the object to be fired at remains in one place; where the artillery is in position and the object to be fired at is moving—a fugitive target as we called it; and where the artillery is moving and the object to be fired at is also changing position—this we called a fleeting target.

The method used of working with the gun is for the airplane to be detailed to work with a certain battalion of artillery. The observer knows where the battalion is located, and the wave length to be used by his radio apparatus has been prescribed. He is furnished with maps and photographs of the area over which he is working. He sees that all his equipment is in proper condition before taking off from his airdrome. As he circles the field at an altitude of a few thousand feet, he calls his own ground station with his radio apparatus to see that it is functioning properly and that it has the proper wave length. He is then told to go ahead by his squadron or group radio station. This is called checking out. When he picks up the target, he calls the artillery battalion and says that he is ready to begin the fire. The fire is then begun, and, if he uses what we call a system of co-ordinate adjustment, he reports whether the shots are falling to the right or the left—over or short of the target. For instance, one hundred yards to the right and fifty yards short; three hundred yards to the left and five hundred yards over, and so on.

Of course, in this work, everything depends on the efficiency of the wireless apparatus, and not only that, but in having the operators constantly at their post. Many amusing and really tragic instances of the neglect of having the operators at their posts occurred during the campaign. In one case, it was reported to me that we had been unable to raise a certain battalion of artillery for a long time, and that the First Sergeant of the battery, which contained a ground station, had put the operators on kitchen police because he said that all they had done for several days was to sit in a little hole in the ground with things on their ears, doing nothing, while the strong men in the battery were doing their work. He could not see that this did any good. Gradually, the feeling of the men was overcome by education and the instruments began to work better.

With the fugitive and fleeting targets, the airplanes cover a certain sector and are relieved one after the other so as to keep the area constantly in view. Certain artillery battalions are detailed for this sort of work, and are supposed to be ready the instant they are called on to turn their fire in the direction indicated by the aerial observer. As a matter of fact, the adjustment of fire means a virtual command of the artillery from the air, as it lies in the hands of the observer to tell what kind of fire is having the most effect, what is the most dangerous target, and when the fire should begin and cease.

Artillery can very seldom see the target that it is firing at. The guns are aimed by means of auxiliary aiming points—that is, a certain object, such as a tree, a church-steeple, the side of a house, or a stake, is selected to aim at for the sights, and the sights are arranged so as to cause the gun to be pointing at the actual target when the auxiliary aiming point is held in the sights of the cannon. The only personnel who can see where the shots are actually hitting, therefore, are the aerial observers, who are really the ones on whom the whole efficiency of artillery work of precision depends.

The third and most difficult class of Observation Aviation is what is called the Infantry or liaison plane. This consisted in flying low over the Infantry during the heat of the combat, through the barrage of both friendly and hostile artillery and often machine gun and rifle fire, to find out and report the position of the troops and indicate to the troops themselves what was in their immediate front, sometimes to carry ammunition and food to them, and, whenever possible, to aid them by firing on the enemy troops from the airplanes themselves.

During the heat of an action, the front Infantry lines cannot communicate back to their commanders or supports on account of the hostile artillery and rifle fire. Oftentimes, it is difficult for the artillery to tell where their own front infantry line is, so that, in many instances, they might fire into their own troops. The only method of keeping track of these lines is by means of the airplane. The infantry airplane was assigned to a certain organization of troops for the day. A certain kind of a rocket would be designated to be the distinguishing call for a specified organization of troops; for instance, three white balls, or two white ones and a red, or some other combination to be fired from the airplane. The airplane usually carried a streamer attached to one of its struts so as to identify it to the infantry. In some cases, the number of the division was painted on the bottom of the airplane. The airplane observer would locate the infantry by actually seeing where the men were, and would fire its rocket, calling for the infantry signals. These consisted of panels or square pieces of cloth, which each infantryman carried, and which were supposed to be spread on the ground, horizontally, in plain view of the airplane. If they were in woods, the infantry was provided with a smoke-producing compound called Bengal fires which they lighted.

A great deal of educational work had to be done among the troops to make them show these signals, because they supposed that, by showing signals to our own air men, they would be disclosing their position to the enemy. This belief was very strong, not only with our troops, but with the French, British and Germans in the beginning, and the way this was overcome was to send the troops to the airdromes, show them how the work was done, and actually take some of them up in the air so as to let them see for themselves what the result was and make them thoroughly understand that, if the panels were not shown, reinforcements could not get to them, our own artillery fire could not help them, and that supplies of all sorts could not reach them. It was especially important to instruct the infantry non-commissioned officers in this respect as the ordinary soldier is brought into much closer touch with them than with his officer. Toward the end of the War, some of our Divisions, notably the First, Second and Forty-second, became very expert in the handling of their panels, and a rocket from an airplane would immediately be followed by a display of a mile or two of panels. In the beginning, many of our commanders called for marking of the lines too often in the day, which made the troops become thoroughly tired of showing their panels every few minutes. Ordinarily, four times a day is a great sufficiency—once immediately after daylight; again about eleven o'clock; about two o'clock, and just before dark.

Another kind of Observation Aviation was attached to the Army Headquarters, and was used entirely for long distance reconnaissance into the enemy's lines. This went thirty and forty miles, and sometimes greater distances, into the enemy's country, photographed their main lines of communication, their centers of supply, their concentration points, ammunition depots, their bridges and railroad yards. By this means a very accurate estimate could be made as to where the hostile army was concentrated. Army Observation became so keen and was such a sure indication of what the enemy troops were doing, in spite of all concealment on both sides, that the end of 1917 marked the end of all troop movements in the European theater during the day. Thereafter all movements of concentration were made at night, and, in their great attack of March, 1918, against the Fifth British Army, the Germans formed their whole position under cover of night, and made a great surprise and caused the destruction of the troops opposed to them.

Aviation was not long to adapt itself to the new conditions of troops moving at night. Night reconnaissance became a set practice by the Summer of 1918. Airplanes covered all parts of the continguous enemy territory, marked down on their map every fire, every movement, and every suspicious looking column they saw. Parachute flares would be thrown down over the hostile moving troops, and their locations discovered. This was so well done by the French Aviation that, in July, 1918, it was told ahead of time exactly where the German attack was going to be

View of a Fort from the Air

in the Château Thierry salient, and it was predicted to within a few hours. Existing records which were made up day by day show the development of the German concentration of troops on each day preceding this attack. Major Paul Armengaud of the French Air Service collected and maintained this record at Marshal Foch's headquarters at Bombon.

Another distinct branch of Observation Aviation is what is called Surveillance. These are the airplanes that remain over hostile positions—or off a coast-line for instance—and report back by wireless what they see. In other words, they pick up the object they are looking for, and remain in observation of it. This is an extremely difficult and hazardous task, and the fastest and highest flying planes have to be used for this purpose.

As is the case with the other branches of Aviation, the Observation Air Service has to act behind an efficient screen of pursuit protection. It is a branch where the most precise methods have to be used in gaining the information, in writing it down, and in reporting it, and the most intimate touch has to be kept with the organizations to which they are assigned, that is, to the Divisions, Army Corps, Armies, Air Forces, or Navies. It is the branch which has to be entirely specialized for these services as distinguished from the offensive air forces that fight in the air and whose tactics are similar, no matter whether they be over the ground or over the water.

CHAPTER IX

Balloons

Balloons of various kinds have been experimented with and tried for many hundred years. They appeared in organized units of troops with the French Revolutionary Army in 1792, filled with hydrogen gas, and used for almost the same purposes that they are now. They have gone through many evolutionary changes in construction, equipment and maintenance, but they all have consisted of a gas bag filled with hydrogen, a rope or cable attaching them to the ground, and winches of some kind for maneuvering them up and down, provisions for communicating with the earth, and a basket for one or two observers.

During our Civil War, the Union Army began using captive balloons with the Army of the Potomac in 1862, in its Peninsula Campaign, and, in fact, it was here that Count Zeppelin, then a Lieutenant of the Prussian Cavalry, and acting as military observer on General McClellan's staff, first obtained his ideas of navigating the air.

During the recent European War, the model of balloon used by all was one developed by a French Officer—Major Caquot. This balloon was very stable in the air, could be used up to 4000 feet in any ordinary weather, and, with the excellent automobile winches, it could be maneuvered at any time. It was a principle with the balloon companies that they needed no shelter for their balloons except what they could erect themselves very quickly from material to be found in the woods or brush, so that they needed no hangars. The balloons were an inseparable companion of the Infantry Divisions. They formed elevated and fixed platforms from which observation could be continued both by day and night if necessary, and, as they were in constant communication with the ground through their telephone centrals, they could be connected with the organizations of troops, both of the Artillery, Infantry and Headquarters. They were especially good in adjusting the fire of the large short range Howitzers, six and eight inch, and were invaluable in observing movements within our own lines, within the lines of the enemy, and immediately behind the enemy's front. Their range of vision in good weather extended from eight to twelve miles. Our balloon companies were the first branch of our own Air Service to appear on

American Air Officer Jumping Out of an Airplane

the Western Front. They were very well instructed, equipped, and rendered excellent service.

The observation balloons are probably the easiest branch of the Air Service to organize, equip and handle. Balloons are used to a great extent in our own service not only with the Infantry Divisions, but in observing the fire of artillery along our coasts, where they have taken their place as an indispensable adjunct.

The hydrogen for inflating the balloons is carried in tubes with the balloon companies, usually enough for one filling, and enough tubes for the daily waste of gas. These tubes were filled by gas compressors at the gas generating plants, which were in the interior of the country. Hydrogen gas, of course, is very inflammable, and the incendiary bullets of the enemy aviation made them catch fire comparatively easily, so that, in addition to the airplane protection which might be in their vicinity, the balloons were equipped with anti-aircraft machine guns varying in number from five or ten to even thirty or forty in some instances. Our balloon companies, under Lt. Colonel John A. Paegelow, during the Château Thierry operations, where we were so greatly outnumbered in the air by the enemy, used from fifteen to thirty-five machine guns to each balloon. The balloon company personnel became very expert in their use, and not only offered great protection to their balloons, but also shot down some enemy airplanes.

The balloon companies can go anywhere that the Infantry Divisions do—no matter what the character of the country may be.

They often tow the balloons right along through the air, attached to the automobile winches. The roads are prepared ahead of them, so that there will be no wires or other obstruction to catch the balloon cables. The troops are often kept in communication with the balloons at all times during marches in this way. Whenever any action starts, the balloons take position off the roads, and go right ahead about their work. Of course, their field of vision is limited by thick woods, abrupt hills, cut banks of rivers, and things of this nature, and when balloon companies are working in conjunction with airplanes, the terrain is carefully studied to see what areas will be hidden from view of the balloon observers at the various altitudes, and these places are particularly watched by airplanes. In fact, the principle of all observation is that, whenever a place can be seen by a terrestrial or ground observer, a balloon is not used; what can be seen from a balloon is not handled by an airplane, and the things that the ground observers and the balloons cannot see are assigned to the airplanes. All balloon companies have their movable chart rooms in which a study of the ground is made immediately a balloon is ordered to a certain position. Maps are prepared showing just what terrain can be seen from 1200 to 3600 feet and the portions that are obscured from view are shaded on the map. Whenever the opportunity offers, a complete relief map showing all hills, woods, roads and even houses are made by the balloon organizations, which give a wonderful idea of the country lying in their front.

These relief maps are of the greatest use for the laying out and execution of all military movements. During the battle of St. Mihiel I had a relief map of the whole area that we were attacking, including the enemy's position to a depth of about ten miles. It was really a wonderful map, and at a glance one could see just where the enemy's advancing or retreating columns were at any time of their march, how they would be concealed by the woods, where two or three columns would cross each other, and how they would be affected by the surrounding country—that is, whether they would be surrounded by flat country where they could get off the road and go over fields, whether marshes or lakes existed on each side of them, or whether they were hemmed in by hills. Many of our bombardment attacks by airplanes were made in accordance with the information that these maps gave us, and with unvarying success. The balloons helped the heavier-than-air units very greatly also, by reporting what the visibility was at the altitude at which they were working, and very often what the enemy aerial activity was also. The balloons have to remain in place and do their work no matter whether they are protected by airplanes or not; and whenever the airplane protection is weaker than is the enemy's Pursuit Aviation, the balloons are exposed to constant attack from the incendiary bullets of the hostile pursuit airplanes. Most strenuous efforts are made to shoot the balloons down, both because of the fact that it stops their observation, and also on account of the effect that it has on the morale of the troops with which they are working. If the troops think that enemy planes can get through the lines and shoot their own balloons down—they are usually from three to five miles behind the line—they become imbued with the idea that the enemy is controlling the air entirely, and that everything they do is seen and reported. During a stage of our operations in Europe, one of our observers was shot down five times during the same day; his balloon being burned each time. In each case he jumped

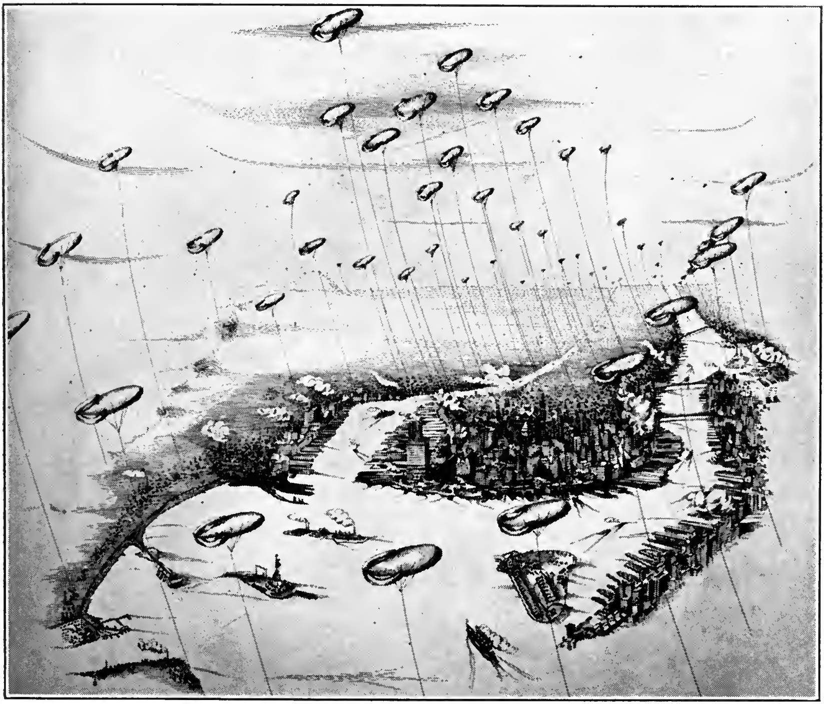


Diagram Illustrating Method of Protecting Large Cities by Barrage Balloons. Three Rings of Balloons Here Shown Surrounding New York City

out in a parachute and landed safely. The method of destroying balloons which was inagurated in our 1st Pursuit Group, and of which Lt. Frank Luke was the principal exponent, was to find the position of these balloons by day, and attack and burn them in their shelters by night. Within seven days Lt. Luke alone burned some ten balloons in this way; and undoubtedly would have burned many more had he not been unfortunately killed. The result was that the Germans moved all their balloons much further back from the front lines, and used dummy balloons with no observers in them to attempt to draw our attack. This was found out at once, however, and had very little effect. Balloon organizations should remain with the troops to which they are attached constantly, know exactly what the troops' work is, and be able to do their own work required at a moment's notice.

The use of non-inflammable helium gas in balloons will render them much safer to operate in, and will make it possible to repair the holes, even if they are torn in the fabric, instead of having the whole balloon go up in flames.

Ordinary bullet holes will not let out enough gas to bring the balloon down, and when the day's work is finished, the balloons can be patched up and the balloons used the next day. With hydrogen balloons, an incendiary bullet will burn up the whole structure.

The use of helium in barrage balloons, that is those balloons which are placed around important points such as cities, ammunition depots, great railroad yards, or accumulations of material, will make them much more effective. These balloons, of course, have nothing to do with observation balloons, and are defensive protection against hostile airplanes in the way that wire entanglements are an obstacle against troops on the ground. Recently barrage balloons have been raised up to 20,000 feet.

CHAPTER X

Airships

From the remotest antiquity, people have wanted to transport themselves through the air from one place to another, and for many years hot air and hydrogen balloons have been used for free balloon flights. These voyages, of course, were entirely dependent on the direction and force of the wind for their power of locomotion. With the coming of the gasoline engine, however, about thirty years ago, attempts were made to construct a balloon which was actually dirigible. Success immediately crowned the efforts of the early experimenters.

The first airships were made with ordinary gas bags, which gradually assumed a cigar or streamline form. In order to keep these envelopes from losing their proper form, due to the escape of gas or pressure of wind against them, interior ballonets filled by wind sails or air pumps, stiffening at various places in the envelope itself, and other expedients were tried. However, in 1900, there appeared the first rigid airship that had been brought out. This was the Zeppelin, built at the instance of Count Zeppelin, who was mentioned as having been in the United States during our Civil War. Although this was a crude affair, it amply proved its possibilities, and Count Zeppelin, although having difficulty in obtaining sufficient funds to begin with, at last obtained enough to keep up this original work, which revolutionized the whole matter of airship transportation. The principle of the Zeppelin is to have a rigid outer frame for the whole envelope or outside of the ship, with separate ballonets inside of this to contain the gas. The stiff envelope maintains its form under all conditions of wind, needs no interior ballonets for wind to keep the envelope in form, and also allows a size to be attained which is impossible in a non-rigid airship. The larger the size the more weight can be lifted. At this time it is hard to tell how large the airship will become.

The German military authorities were not slow to recognize the strategical and tactical value of the airship. From the moment it began to show its possibilities, the interest of the whole German people in its development became very great. In addition to Count Zeppelin, Dr. Schütte brought out his first model of a rigid airship in 1912, and

Sixteen-Inch Gun Used by the French in Their Great Attack of April, 1917. Fire was Adjusted by Balloons that are seen Immediately Above the Cannon.

contributed largely to the development of this new means of transportation. Before the great war, a regular transportation line through the air had been established in Germany. The German Navy had adopted a definite method of using the Zeppelins. The airship stations, consisting of large hangars in which these monsters could be placed, were distributed throughout the length and breadth of the German Empire. Germany had obtained such a tremendous start in this respect that her opponents were entirely unable to catch up to her.

The great reliability of the Zeppelin really was never understood until the War, because, in order to brace up their own morale, the countries at war with Germany that did not have Zeppelins got out a great deal of propaganda to the effect that Zeppelins were no good, that they were easily shot down by airplanes, could not maneuver in a storm, and all sorts of things. As a matter of fact, in the battle of Jutland, German airships practically saved the German fleet. The English main fleet was at Scapa Flow, in Scotland, with a detachment in the south near Rosyth. The English plan was to envelop the German fleet—that is, attack it with the main fleet from the North, while the fleet from Rosyth got in behind them. Twelve Zeppelin airships, however, were on constant patrol between these two points, and each movement of the British fleet was instantly reported to the German fleet. In this way the German fleet was enabled to break off the action with the superior British fleet from the North, retreat, and prevent being completely enveloped by the detachment of the British fleet from the South.

In the Eastern Campaign—that is, in the German Campaign against the Russians—Zeppelins were used a great deal for bombing operations and deep reconnaissance. They executed many bombing missions over England, and demonstrated during these raids that they could remain out in practically any weather encountered, ride out any storm, and that their greatest enemy was the cold if they happened to be forced up to too high altitudes in order to escape the attack of aircraft and anti-aircraft devices of various kinds.

One of the most notable examples of this occurred in October, 1917, when thirteen Zeppelins met at a rendezvous over Belgium, from various parts of Germany, preparatory to a raid on England. These airships were each given a definite mission to accomplish in Great Britain. They were to fly across the North Sea together, distribute themselves over England at various places for their attack, meet at a rendezvous again, and go back to Germany. The airships accordingly met over Belgium. On the way over, two had to turn back on account of engine trouble, leaving eleven which proceeded on their way to their points of attack, London, Sheffield, Birmingham, etc. They had been warned particularly in their orders not to rise above the hail line, that is, the line at which the moisture in the air solidifies into ice, which is found at that time of the year at an altitude of from fourteen to seventeen thousand feet. These eleven Zeppelins proceeded on their mission, which they reported to have accomplished, returned, met again, and started homeward. They encountered a terrific storm over the English Channel. They strove against this all night. The following morning found them over the Northwest coast of France. They were immediately seen and attacked by anti-aircraft fire from all directions, which forced them to ascend above the hail line. Here their engines began to get colder and colder, and as they proceeded toward the East, their engines eventually froze.

I happened to be in Nancy when told that the Zeppelins had just come over with their engines stopped and that they were drifting before the wind. The airplanes had been unable to hurt them at all, on account of the high altitude at which the Zeppelins were traveling, as the airplanes could not get up there quickly enough. The first one that I encountered was hit by an incendiary projectile of anti-aircraft artillery at about 17,000 feet altitude, and came down in flames at St. Clement near Lunéville. Its crew was killed in part, and part escaped by parachute. Shortly afterward, I heard a report that one or two Zeppelins had landed near our Headquarters in Chautmont, and, upon proceeding there, I found that one of the Zeppelins—the L-50—had come down near the earth and hit a tree which had torn the front nacelle away from the ship. It was in this nacelle that one of my officers, Colonel Dodd, a gallant and talented officer, later killed in an airplane accident, obtained the orders which directed the whole Zeppelin expedition. This ship, after losing its nacelle, went straight into the air to a great altitude, was seized by the wind, blown down to the Mediterranean Sea, and there sank with its crew.

The L-49 came down on account of loss of gas and frozen engines, entirely intact, near a little placed called Bourbonne-les-Bains, about fifty miles away from Chautmont. I inspected this ship carefully, and, although it had been attacked all the way down by French Nieuport airplanes, and incendiary bullets, they had practically no

A Formation of Three United States Army Non-Rigid Training Airships

effect on it whatever, because these bullets had to pierce the thick outer envelope of the ship, and then go through the gold beater skin bags which contained the gas. By that time the .30 caliber bullets' power for setting it on fire was very limited. As an illustration of how little the Zeppelins were afraid of airplanes, this great airship had only one machine gun on it with about eight hundred rounds of ammunition.

An interesting thing occurred when the airship landed. One of the crew started up from the front nacelle with a signal pistol with which he intended to fire into one of the gas bags and burn the ship, so that it would not be captured. There was an old man hunting wild boar just at the point where the airship landed. The old men, who could not serve in the Army, in France took advantage of hunting all the time while the young men were away at war. This old fellow, a veteran of the War of 1870, realized immediately what the member of the crew was attempting to do. He held him up with his shot-gun, told him he would kill him if he moved, and calling to his companions he had each nacelle or cabin, of which there were four, watched in the same manner, thereby saving the ship. This was the only modern Zeppelin which the Allies really got hold of intact. It was a tremendous find for them because it contained all the engineering features which they had been unable to obtain before. The British rigid airships, built at a later date, took a great many points from this ship.

Travel by airship is the most comfortable and delightful of any sort of locomotion—superior in every way to railroad trains and away ahead of steamships. There are no particular jars, bumps, heat, cold, or the usual dust, smoke and other discomforts of travel. In the nacelles, the noise can be very greatly eliminated. Distances are covered by the shortest line, and the view and general comfort are remarkable. The modern airship can cruise from ten to fifteen thousand miles, and can carry cargo, besides its fuel and crew, of upwards of twenty tons, is eight hundred feet long, over one hundred feet high, and contains three or four million cubic feet of gas.

The difficulty in handling airships arises when they approach the ground. Up and down currents of air getting under the ship make it extremely difficult to handle, and at first, before the method of handling was well known, resulted in the destruction of several airships.

What is very necessary is an organization of airship stations placed at central locations and so arranged that, if one happens to be in a great storm center when the airship comes in, it will be able to go to another one and make its landing. The expense of constructing these is not as great as that entailed in the building of docks for large steamships. Not only the United States but Alaska and our insular possessions should be immediately equipped with them. Without airship stations no regular communication by airship is possible. It has been very clearly shown that with airship stations properly organized and located, travel by airship is a very safe and sure means of communication. The German Zeppelins have carried some two hundred thousand passengers without a single fatality. As to cost, a very exaggerated idea has obtained heretofore. Naturally, the first few airships to be built cost more than they will subsequently. An airship of the very best class will not cost any more than a vessel of equivalent performance at sea—that is, anywhere from half a million to two or three million dollars.

The United States is more backward in its development of airships than in any other one thing connected with aeronautics. It has never built an airship of the rigid type, or even a semi-rigid. Semi-rigid airships such as the Italians developed during the War are quite interesting from many standpoints. The semi-rigid, instead of having a frame stiffened by beams of various sorts around the whole envelope, has a frame around the lower part of the envelope and around the nose of the airship only. The rest of the airship is entirely of cloth, and holds its shape from the pressure of gas and air in interior ballonets. The advantage of this ship over the rigid ship is primarily on account of its lightness as so many beams and structures have been done away with. This enables it to lift more weight and go to higher altitudes, in accordance with the volume of gas which it holds. It is impossible, however, to make as large an airship according to this system as it is according to the rigid system. The largest semi-rigid so far built by Italy contains one million one hundred thousand cubic feet, and has been purchased by the United States Army for experimental purposes. It will be the first large airship delivered in America, will have a cruising distance of about eight thousand miles, and, in addition, will be able to lift about five and one-half tons, besides fuel, crew and equipment. The semi-rigids, of course, are very much easier to build than the rigids, and correspondingly cheap. In fact, these can be built in Europe for from two to three hundred thousand dollars. They would cost more than double that here.

An airship requires very perfect training for the navigating personnel, and is much more difficult to handle than a vessel on the water, not in taking it from place to place, which is the simplest part of the whole thing, but in actually maintaining it in all sorts of weather and in its landings and getting off the ground.

An interesting development in connection with airships came with the discovery of helium gas. This is a non-inflammable gas which has about ninety per cent of the lifting power of hydrogen. It was discovered by Sir J. Norman Lockyer in 1868, while observing the sun. It was found later that the natural gas in the United States contained anywhere from a trace to two per cent of helium, and, as far as known at the present time, the United States has a monopoly on all helium in the world. It is found in small quantities in other places, but not to a sufficient extent to make it practicable at this time for production in great quantities for airships. The method by which this gas is obtained is to subject the natural gas to high pressure and low temperature which, when it reaches a certain point, solidifies the ordinary natural, or coal gas as it is called, leaving the helium still free. It is then drawn off and put into tubes. This gas may be mixed with about eighteen per cent of hydrogen and still retain its non-inflammable qualities. The United States Government is now experimenting very successfully with the production of this gas, and some civilian companies are projecting its extraction on a commercial basis, being convinced that airship communication is only a short way off.

While helium will be of tremendous advantage for airships in case of war, it is interesting to note that, during the War, not one single instance occurred of a Zeppelin being burned except from hostile attack. In other words, the ship, in so far as its own self is concerned, is perfectly safe against fire, and, of course, as long as we use gasoline for fuel for the engines, an inflammable element remains which will cause fire irrespective of what lifting gas is used in the envelope. As helium has never been tried on a practical basis we do not yet know just what its effect will be. A certain amount of helium has been procured and put into tubes, and was just being sent abroad for use in the captive balloons when the war in Europe ceased.

yeah

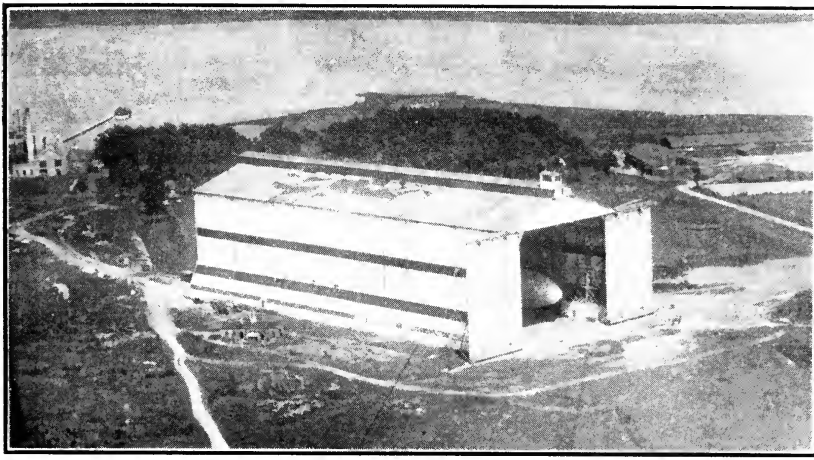
That airships will be a potent factor in all communications in a comparatively few years, there can be no doubt. As the great transporting organizations, either over the water or over the land, will probably not go into this means of transportation, new companies will have to be organized, financed and started, in order to develop this field. This is always a slow process.

The development undoubtedly will be retarded also due to the fact that Germany, that is way ahead in this type of construction, has necessarily been curtailed in her production of these ships by the Allies.

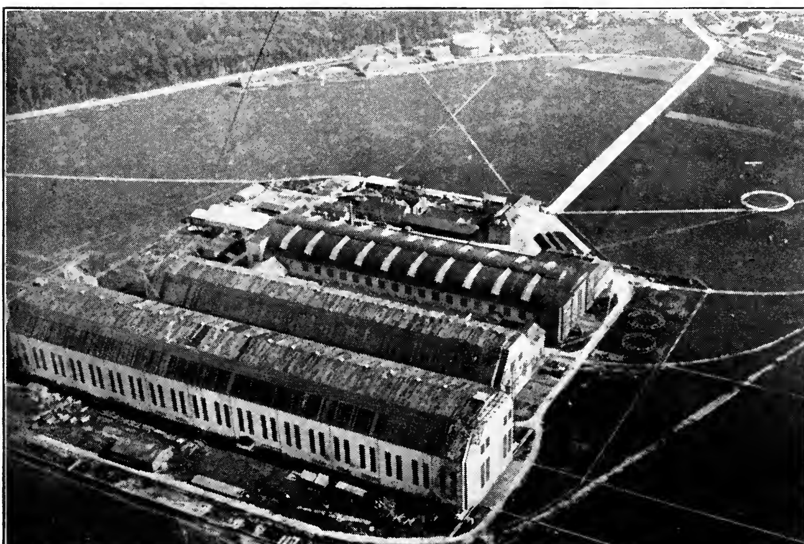
For communication from North to South America, or from America to Europe or Asia, the airship offers very great possibilities, and, as America is a sort of meeting place of these routes, probably their greatest development will take place on this continent, particularly as we have every element necessary for their construction, maintenance and operations.

Airships are a necessity for transporting supplies for other aviation units. In this country with the bad roads and long distances that exist, it would be impossible to supply heavier-than-air groups that have to move rapidly from place to place by means of transportation on the ground. With their speed and ability to carry twenty tons or more in one load the proper use of airships would render an air service independent of other transport.

Airships will play a very prominent part in furnishing supplies for the armies that are operating where the roads are very bad, and where railroad or steamship facilities do not exist. The average man eats about four pounds of food a day, or each company of 250 men will eat about 1000 pounds. A full regiment of Infantry would eat about 12,000 pounds, or 6 tons. Twenty tons then, or the cargo of one of the ordinary Zeppelins, would feed in one trip a brigade of Infantry of three regiments. As these airships can make 70 miles an hour, and as the loading and unloading can be made very quickly, a great number of troops could be easily supplied by a good Zeppelin organization. Twenty tons of bombs form a very formidable weapon against anything that is vulnerable to explosive projectiles. The Panama Canal, for instance, forms an example of this. The military value of this canal to the United States depends on its being kept clear for the passage of our fleets from one ocean to the other. One thousand-pound bomb dropped into a lock, or another vulnerable part of the Canal, would prohibit its use for months. An airship can approach the Canal either from Europe or Asia without landing with its full cargo, and watch for its opportunity to approach under cover of darkness or clouds, and almost certainly hit its objective. If the Allies had possessed Zeppelins they could have done a great deal of damage to the Kiel Canal in Germany during the War. We must expect in the future, therefore, that squadrons of Zeppelins of twenty



United States Army Airship Hangar



German Airship Station Showing Three Hangars, Gas-Plant, and Narrow Gauge Railroad for Supplying Material

or thirty in number will be dispatched immediately at the beginning of war to attack the most vulnerable parts in an enemy's country. It has been thought by many that the use of airships will have its greatest development over the water. This will not be the case, because the only use of military organizations over the water is for the purpose of keeping open and maintaining sea-lanes free for the use of one's own shipping. When this has been assured, the only way that a war can be brought to a successful termination in case of determined resistance is to carry the war into the enemy's country; and in modern times this may mean attacking his whole population, means of production and subsistence. The large rigid airship will be a great element in prosecuting campaigns of this sort in the future.

CHAPTER XI

Flying Personnel

So far we have spoken of the various branches of aeronautics, their employment, the airplanes or airships that are used, and their accessories. The most important element in aeronautics, however, as it is in any other undertaking, is the personnel which must direct the Air Service and operate and construct the airplanes and airships.

No one can know the air except one who works and travels in it, and a thorough air education can only be acquired by long study and experience in this science and art. The greatest handicap under which aeronautics has labored in all countries and particularly in the United States, has been the fact that the Government agencies charged with the development of aviation have, in practically every case, been organized with a non-flying direction at their head, which could not possibly know or appreciate the problems concerned in its development. This was because no corps of officers was especially trained, as a body, to specialize in aviation. Europe is more fortunate, due to the pressure of circumstances. Starting out with a non-flying direction, they soon began to emerge from it so that by 1916 or 1917 flying matters were being handled entirely by fliers. Many officers could be found who could keep papers straight, attend to so-called administrative details, and do everything except fly. They absolutely broke down, however, because they knew nothing about tactical handling and use of aircraft. Whenever a new military branch begins to develop, creative minds must be developed to handle it. Men do not acquire this ability by intuition, but have to learn it by long study and practice. Tactical ability always is the most difficult to obtain—by this is meant the actual art of handling troops in the face of the enemy. Technical ability is an exact science, and can be learned very largely in schools and colleges. The duties of an air force lie in the air, and it is there that all the personnel concerned with its handling must receive the maximum amount of training. Most of the aeronautical engineers, and all of the best ones, appreciated absolutely the necessity of knowing the air and being fliers ahead of anything else, which gave them a great advantage over all competitors in that they combined both the practical and scientific ability necessary for developing new airplanes and their accessories.

So many new elements came into the training of fliers that a whole new system of education has been developed for them. The first characteristic that had to be taken into consideration was that of physique. Rapid changes in altitude, speed with which one left the ground and came back to it, and the necessity for accurateness of vision, rapidity of thought, and certainty of action required an entirely different class of men from those which had heretofore constituted the officers in an army or a navy. In fact, the physical requirements in the American Air Service are such that twenty-five per cent of the officers accepted into the Regular Army between the ages of twenty and thirty cannot pass the aviation physical examination; between the ages of thirty and forty, fifty per cent, and between forty and fifty, seventy-five per cent. So, this new service required a definite organization of the medical authorities to study the physical results which obtained after men had flown a long time in the air, the mental reactions which occurred on the pilots, and the ways in which these could best be determined and handled.

One very erroneous impression gained considerable ground, largely owing to the fact that aviation was such a new art, and this was that no one could be a flying officer except a very young man. Our best pilots in the European War ranged around thirty years of age, and these same flying officers will continue to be more valuable as time goes on unless prevented by some physical disability. This example is very similar to that of officers in various branches of the army. For instance, a Lieutenant of Infantry marches with his platoon and carries his pack on his back; as he becomes older, if he stays with the field army, he rides a horse, until he leaves the regimental organizations and becomes a general—then he goes in an automobile. While he still may be possessed of all the physical requirements necessary in a Lieutenant, he must devote more time with his head to the problems which have to be solved. In a similar way, the air officer starts as a pilot in the flight; becomes a flight commander, squadron commander, group commander, wing commander, and brigade commander. As he goes up and handles his large units in the air, he and his staff act more and more in a directional capacity. Air units cannot be handled from the ground—they must be handled in the air, and great co-ordination can be had now through radio telegraphy and telephony as in the case of any other military organization. In addition to the tactical requirements, all supply officers, technical officers, medical officers, or anybody concerned with the Air Service should have sufficient flying education to enable them to appreciate the problems in hand. This flying must be kept up. Individual morale in the air officer is more important than in any other service, because his duties require a great deal of work to be done absolutely alone, without the support of a companion, and often where no one will see if cowardice is shown or if a battle is avoided. An air officer can very easily say that his motor does not work properly; that his machine guns are jammed; or that many other things have happened, without its being known as easily as the corresponding dereliction of duty would be on the ground. Often, the only way that this can be told is by the intuitive knowledge that one air officer has of another. Most careful instruction has to be given, therefore, in the maintenance of morale among flying personnel. Ninety per cent of the effectiveness of an Air Service depends on the morale and initiative of its personnel. The most injury that can be caused to the morale of an Air Service is to place it under non-flying officers who have not learned their business from the ground up, have not been exposed to the dangers, and have not the point of view of the airmen.

The system adopted by the Army of the United States for the training of its fliers consists in selecting able-bodied young men coming up to the physical requirements and having what is termed "a college education." These young gentlemen come either from the colleges throughout the country, from the Military Academy, or from the ranks; are examined, and then assigned to what are called pilots' schools.

The course in the pilots' schools lasts for about four months. The students are taught, primarily, flying under the most capable instructors obtainable. The American system of flying instruction is what is called dual control. The students are taken up in two-seater airplanes, in each seat of which there is a control for the airplane, all the throttles and instruments for the engines, the rudder bar, and the stick or wheel for the controls. At first the student is taken up and merely allowed to feel the controls. Gradually he is given more and more opportunity to fly the airplane, to make accurate turns, to fly straight, to rise, to climb, and to glide. He then is practiced in landings which, to the novice, is the most difficult undertaking. Judging the speed in the air with the distance to the ground has to be combined in a way required of nothing else, on account of the speed with which the airplane descends, glides, and approaches the ground. There are no brakes on airplanes as there are on automobiles.

Gradually, the student aviator acquires more proficiency, and he is then allowed to take up his airplane for his first solo flight. This is always the great turning point in a flying officer's training. Some "get away with it" well, and some don't. Of course, many are eliminated as the course goes on, as things develop about them which cannot be foretold except by actual test.

When the student pilots have shown that they can handle their airplanes in ordinary straight flight, they are given what is called a course in aerial acrobatics—that is, the airplane is put into all positions, in and out of control, into which it is possible to place an airplane, and they are made to extricate it. This consists of spins of various kinds, stalls in which the ship loses all its velocity and falls, various turns, dives and loops. All of these maneuvers have a direct bearing on fighting in the air, and no flying officer is competent to handle an airplane unless he is thoroughly familiar with all of them.

It is amusing for a flying officer to hear persons unfamiliar with aviation talk about trick flying.

Officers of the 94th Pursuit Squadron, First Pursuit Group, at Rembcourt, France, during the Argonne Battle

There is no maneuver in the air which a flying officer should not know and be entirely familiar with, as they are all necessary in the military use of aviation.

During the time that the flying officer is obtaining his flying training, which amounts to about thirty or forty minutes a day, because more than this tires out the student both physically, mentally and nervously, he is taught the elements which go into the make-up and operation of the engine. This is the most important single thing about an airplane. If the engine does not go, the airplane cannot fly. The old saying is that "if an engine runs one can get away with anything," so that a great deal of instruction is given with the engine. Next, an elementary knowledge of airplane construction and design, and the reason for it, is given; how the airplanes are assembled and put together in the field; how they have to be lined up at the various angles in which the planes have to be set with the fuselage, how the landing gear has to be put on, how the tail surfaces function, and how the inspections of these things are made, to see that the airplane is in condition to fly. Next, how the armament is installed—the machine guns and bombs—and how they work. And last, the radio telegraph and telephone, and the cameras. During this whole time, the greatest attention is given to discipline, guard duty, and to teaching the pilot the responsibility which devolves upon him when he is alone, or with others in the air. There is no place in any service in which individual responsibility has to be exercised to the extent that it does by the airman. His individual action in the presence of the enemy, and the reports he brings back, or his general estimate of a situation, may mean the success of a whole operation in the air, on the ground, or on the water.

The Army now maintains two pilots' schools—one at Carlstrom Field, near Arcadia, in Florida, and the other at March Field, Riverside, California. In these localities, the weather is very equable throughout the year, conditions are favorable for cross-country flying, and for developing map reading and navigation through the air.

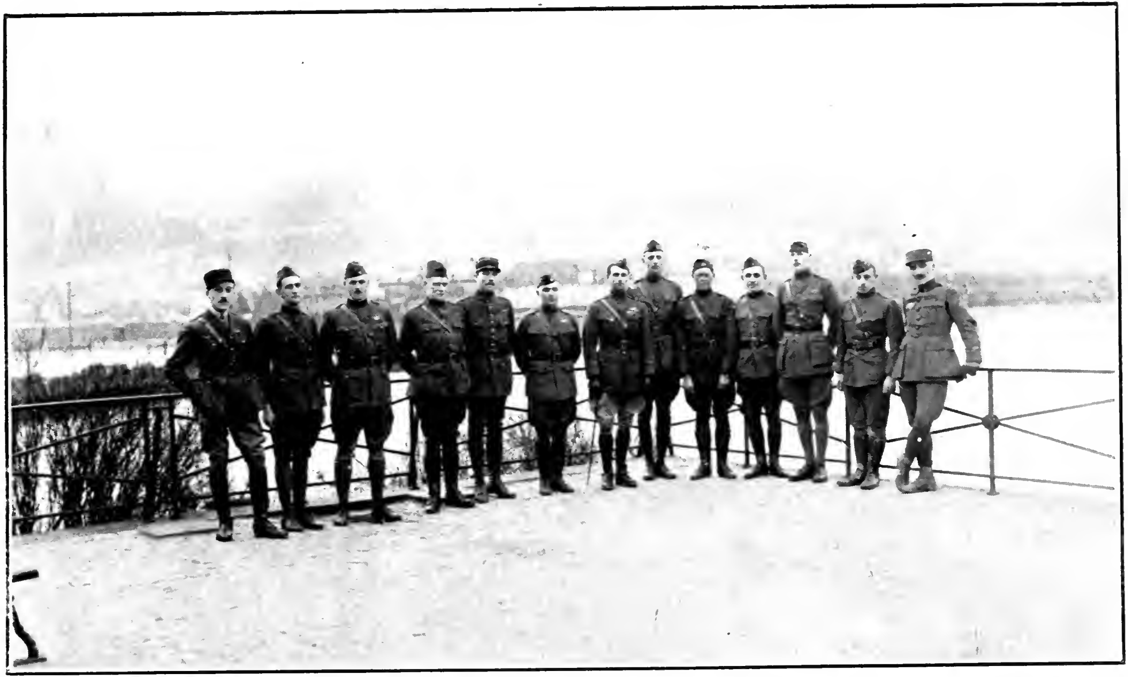
When the students graduate from the pilots' schools, they are ready to take up the study of the special branch of aviation in which they are to serve—that is, Pursuit, Attack, Bombardment, or Observation Aviation. Each one of these specialties requires a training, specialized even more so than do the Infantry, Cavalry, Artillery and Engineers in the Army. The young men are selected for these positions in accordance with the recommendations of their instructors, in which the special characteristics of the individual are taken into account.

In the pursuit school, the students are taught the tactics of Pursuit Aviation, the part which the individual must play in the carrying out of the system that is used in this branch, and each individual is perfected so as to make it possible for him to join a pursuit squadron as a pilot. Pursuit is the branch of aviation that bears more analogy to what Cavalry used to be in an army than any other branch. The student is taught the time, place and method of attacking each kind of hostile aviation. He is taught how the hostile ships look, what their silhouettes are, what formations they fly in, and learns from that to estimate what they may do, and to govern his own actions accordingly. The maximum amount of time is put on shooting, and he is required to fire at targets on the ground, in the water, those towed through the air by other airplanes, on parachutes and on small balloons. The shooting of our aviators has always been one of the very strong characteristics of our Air Service. We are second to none in the world in this respect. The course at the pursuit school takes some four months, and the young men who successfully pass it are sent to join their squadron. The United

States maintains a single pursuit school at San Diego, California.

The young men assigned to the bombardment school learn the tactics and technics of Bombardment Aviation, how the bombs are built, how they are put into the airplanes, what kind of projectiles are necessary for the attacking of certain objects, such as military works, railroad stations, bridges, roads, troops, naval vessels, troops debarking from vessels, or trains, and, in fact, everything that may require attack. The instruction on the ground consists in simulating by various devices how their bomb sights will be used, and how the formations in which their squadrons must fly are handled to get the maximum amount of effect, particularly in the large formations in which Bombardment Aviation now flies. They are trained to fly at night, to find their way accurately across the country during that time, and to land at night by the aid of their own flares carried under their wings. The bombardment school is at Ellington Field, near Houston, Texas, and, upon completion of his course, the young officer joins his squadron for further instruction.

The officers selected for observation work go to the observation school at Post Field, Fort Sill, Oklahoma, where also the Field Artillery School



The Author (Center) and His Staff on the Banks of the Rhine, December, 1918

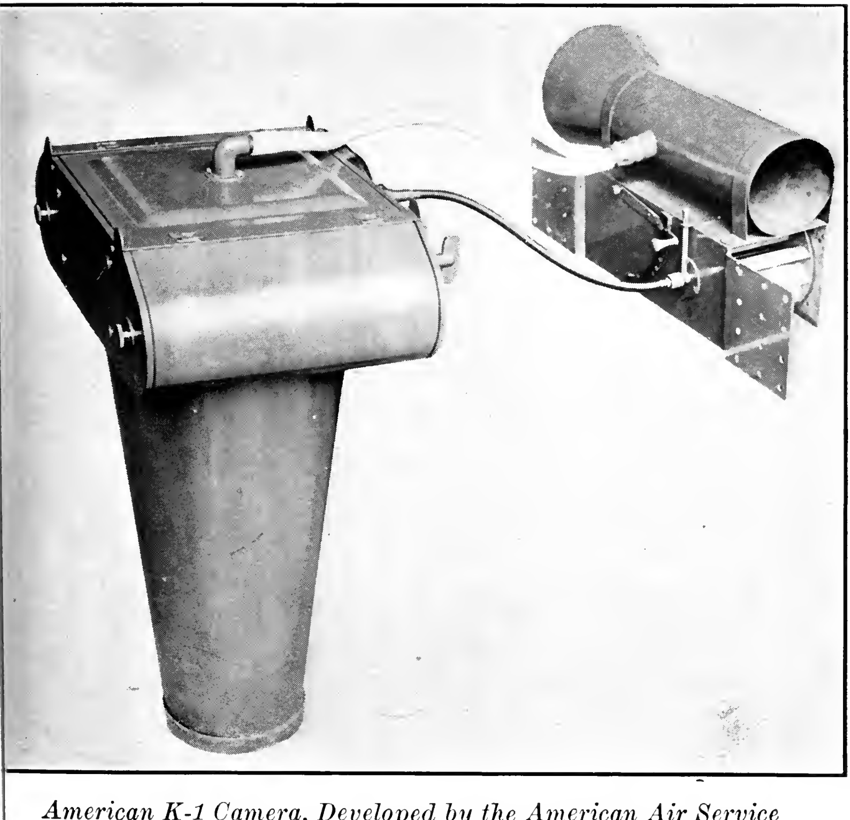
of the Army is located. The observation course consists in studying with great care the formations of troops on the ground, what they do, and how the Air Service co-operates with them. The Observation Air Service is distinctly an auxiliary of troops, and as such has to work and be with them constantly. No artillery can fire accurately now any distance without having observation from the air, and the observers are taught to gauge the fall of the projectiles from the artillery with a percentage of accuracy which amounts to a very few yards' error in each shot. They get a most thorough course in map reading and map making, of flying low over the heads of the infantry so as to find out the exact position of the lines, to deliver messages to them and take messages from them. The signals consist of rockets that are fired by the airplanes, while strips of cloth, or panels as they are called, are laid on the ground by the infantry, messages dropped in tubes, and other means of communication found necessary according to the conditions encountered. The best means of communication from the earth with the air, however, is by radio telegraphy and a great deal of work is done in that line. The radio telephone is now becoming a very potent element in communication with aircraft, and radio is working successfully not only between airplanes in flight, but even between airplanes and submarines when they are submerged.

The ability to find out and report upon all ground objects seen in the vicinity of troops, on roads, railroads, cities, and military positions is studied in the greatest detail in this department. The aerial camera plays a very important part in it. Before the War, we practically had no aerial cameras in America worthy of the name, and it is only during the last year that a good American camera had been developed. The new one, however, is excellent, and works well at high altitudes. On account of the way in which aircraft are attacked, both by anti-aircraft artillery and other airplanes, it is necessary for a great deal of photographic work to be done at extremely high altitudes. During the War we photographed up to an altitude of twenty thousand feet, and from now on we shall have to photograph up to thirty thousand feet. It may be easily seen how the work of aerial photography is a thing entirely special in itself, and, to show the economy of this sort of topographical work not only in photographing specific positions, but in photographing whole areas of country, a recent map was made in the vicinity of Schoolcraft, Michigan, by Captain McSpaden and Captain Stevens of the Air Service, which covered an area in seven hours which would have taken three months or more of extensive work by the old ground surveying methods of triangulation and plane table work, and even then the details of the ground could not possibly have been shown. The advantage of camera mapping over others, particularly in this country, where only forty per cent of the whole United States has been mapped, is invaluable. Here again we have a field for aeronautics which is unparalleled in any other country.

Our Observation Air Service has been used very successfully in the forest patrol and the prevention of fires. The aviators locate and report the fires long before other means are capable of doing so. In this way the fires may be put out before they do much damage. During the year 1919, the Air Service Forest Patrol in the Pacific States saved more money for the Government than the amount of the whole appropriation given by Congress for the Air Service.

In the defense of our coasts, our Observation Air Service will be the first element that gains contact with the enemy, and they are trained to observe and report on all enemy shipping that comes near our shores. The land airplanes, due to their speed, maneuverability, and ceiling, are superior to anything else for this purpose. Flying boats are so slow and are so easily shot down by hostile Pursuit Aviation that they are of little use for observation along a coast. It is very easy to reconnoiter over the seas as compared to over the land, because the vessel on the water cannot be hidden by trees or artificial camouflage. At night, ships on the water are particularly easy to pick up; not only are they easy to see with their lights out, but their wake or the trail left behind them in the water is always bright, either from the white foam or the phosphorescence which always follows them. On the other hand, submarines are very hard to find from the air as was amply proved during the War. Usually when on the surface they lie still and when submerged are quite invisible ordinarily.

In our newest branch of aviation, called attack, which is designed to attack troops, tanks, and other things on the ground, more airplanes equipped with cannon, many machine guns, and also small bombs, are used. The students are taught the tactics of this special arm. The maneuvers of this branch of the service are carried out very close to the ground—in many cases only one hundred or two hundred feet above its surface. This branch of aviation has to approach places to deliver its attacks through ravines, behind a screen of woods, or even behind smoke



American K-1 Camera, Developed by the American Air Service

screens. They have to learn very accurately the difference between friendly troops and hostile troops as they are mixed up in the heat of combat. Attack Aviation flies through the artillery barrages of both sides and is exposed to machine gun and other fire from the ground from all directions. They have to know what the element of surprise means, how to take the utmost advantage of the sun, clouds, and every element which lends to their concealment. This class of aircraft is particularly efficient against tanks on the ground—in fact, only a few days ago, in some tests that I was having conducted at a target of a tank, out of eight shots fired by an attack airplane five hit the target directly. Any one of these shots would have put the tank out of action. The effect of the fire from the machine guns carried by these attack airplanes is tremendous, and will be a decisive element in future battles. Each attack airplane actually carries more than twice as many guns as the average machine gun nests on the ground did in the War.

The attack airplanes have to work in the closest harmony with their own Pursuit Aviation, which has to protect them from the hostile pursuit, and the student officers are taught the interdependence of these two branches of aviation. They are also taught the method of attacking boats and shipping, and how to land and fight other troops or airplanes from the ground. Attack Aviation can almost be compared now to flying battleships or flying tanks. Great development will take place in Attack Aviation.

When the young men have completed their courses in the special schools, they join their squadrons or the actual air troops. After serving there for a period of two years and becoming entirely familiar with the tactics, the supply, and the handling of their organization, certain of those who have shown themselves the most proficient are selected for higher tactical education, and some for higher technical education. Those for a higher tactical education are sent to the Air Service School at Langley Field on Chesapeake Bay. There they are taught how to handle all the air arms in combination, how to work with the ground troops, how to fight other air troops, navies, and ground troops—in other words, it is here that officers are given their education which combines all the different elements of aviation. Those chosen for a technical education are sent first to the School of the Engineering Division of the Air Service, which at present is at Dayton, Ohio. Upon graduation some are sent to the Massachusetts Institute of Technology or other technical institutions, which have engineering courses in aero dynamics and other technical matters pertaining to the construction and development of aircraft.

At the present time, this educational system is all that is given in the Air Service. Beyond this, certain selected officers are sent to the Army School of the Line and the General Staff College for training along strategical and grand tactical lines. When this system, adopted during the last year, has been thoroughly put into operation and allowed to run for a period of five years, a splendid body of aeronautical officers will be the result. We had practically no system before the War, but during the War a great many persons received air training. The air training of 15,000 of our young men is the greatest asset which has been left to us from the War. It takes at least a year to make a man a capable flying officer, so that he is able to be a really good pilot in a squadron. It takes many years to make suitable higher officers for the Air Service. That was our greatest difficulty during the War, as no one knew the duties required of superior commanders in this new branch. It was amply proved in the European War that officers trained in army methods on the ground could handle Infantry, Cavalry, Artillery, or other troops, or all of them in combination, but it was proved more strongly that they could not in any way handle air troops until given a thorough aeronautical education. To put flying troops in the hands of officers not trained in their use is to throw them away.

Another thing which has been conclusively proved is that if a nation is not ready with its flying officers at the beginning of a war, it never will be ready during it, due to the length of time that it takes to train flying officers. The first decision in a war is going to be sought in the air. If this is unfavorable, the nation probably never will recover from it during the existence of the contest. Consequently, it is necessary to have a large reserve of trained aviators. This we are attempting to bring about by taking flying cadets from civil life, putting them through our schools, and allowing them to go in the Reserve Corps. They can then engage more and more in commercial aviation, or keep up their flying in regularly organized reserve units.

The 15,000 trained flying officers which we had at the end of the War were our greatest aeronautical asset. With the exception of a very few, these are all back in civil life. Many of them learned the air business on the battlefields of Europe, in a manner that cannot possibly be learned in any other way. The expansion of any Air Service in this country should include these men in the reserve, who have learned their duty during the War, so that their knowledge may be imparted to the others with whom they come in contact and be not completely lost, as is very apt to be the case at the present time.

CHAPTER XII

Obtaining and Distribution of Material

The most important supplies for an air force are the airplanes, and the engines that impel them. Everything in aviation has to start around an engine. As long as the engine runs the airplanes can fly. When there is constant trouble with this complicated means of locomotion, little can be accomplished. The method which has been found to be the one that gives good results in the obtaining of material for an air force is to have the operating force, that is, the actual squadrons that have to use the airplanes, tell the Technical or Engineering Section just what they want—for example, in the case of a pursuit airplane, how fast it should go, how high it should climb within a certain time, what armament it should carry, and how many hours' gas it should have, that is, how long it must remain in flight. These things are gauged by what the enemy may bring against one's own force. If the estimate of the enemy's power is incorrect, or if the equipment is inferior, disaster is sure to result, because he will have better equipment. The actual pilots who are engaged in the handling of the airplanes, therefore, must be the final judges of whether the equipment is any good for the object that is to be attacked or not.

The Engineering Section of the Air Service obtains the characteristics of the airplanes from the operating force, and causes models to be made of each kind for test. The airplane is one of the most complicated military instruments that has ever been used, and an Air Service, in reality, is harder to create and carry on than is any other arm, harder even than any army or navy. After all these years this is the first year, 1920, in which the American Air Service has actually gotten out its own types of American airplanes for each class of aviation. These have been the result of very close co-operation between the officers that had experience in the European War, and the excellent Technical Section in this country, which was organized during the War. Another thing about the construction of aeronautical material is the time required to accomplish it. After the Technical Section is told to get out a design, it takes four or five months at least to construct the first types. It takes two or three months to test them and make the necessary changes, a month or so to give the orders out for their construction, and about a year to complete any number of them. So that, actually, it takes as long to complete an airplane as it does to produce proper flying officers to handle them.

It takes several years to develop any one type of motor satisfactorily. As so much general development has been done along aeronautical motor types, up to the present, progress along certain lines of motor development is easier than it used to be, but even now the number of airplane engines available for instant use of up-to-date pattern are extremely few in number. It is ordinarily estimated that five men can make one motor in one month, and therefore, if you want to make 7000 motors within a month, it would require about 35,000 men. It will require about five months to make factories ready to begin work on any special motor that is already developed, and for which there are complete construction data. So if we decided to start to-day on the manufacture of a great many motors of new type, it would take at least five months from to-day to properly equip a factory for their construction, and then many months to build them. Five months is too long to wait after a war is imminent, or has been declared, to get motors. Therefore, the proper number must be kept on hand in time

The Crash of a Heavy Bombardment Airplane

of peace for immediate use in time of necessity. About three hundred men can make one airplane in a day, but in the case of the airplane the average factory may be made ready for its production in about one-half the time that is required for motor production, so that, if 20,000 machines are required, say, in 200 working days, 30,000 men will be required to build them. Figuring a 10 per cent loss in personnel during that time, for the programme outlined above, it would be necessary that 35,000 men work on the motors, 30,000 men on the airplanes, and a 10 per cent loss, 6500, or a grand total of 71,500 men. This number of men then could turn out 40,000 engines and 20,000 airplanes in 200 days.

Before these motors and airplanes can be placed in production, as it is called, all the raw materials, such as iron, steel, wood and the necessary cloth and fabrics, and everything pertaining to them, must be assembled and put in condition for work. All of these things were done during the War in the time that it took the factories to get ready to manufacture. No country in the world has the facilities for obtaining and gathering all the materials that go into the make-up of an airplane, that the United States has.

It is necessary at all times to keep track of where these materials can be obtained, wood, steel, wire, copper, rubber, etc., how rapidly they may be moved to the factories, and how quickly each part can be put into an airplane. A military programme, therefore, involving a rapid expansion from a peace to a war basis, must contemplate the keeping constantly on hand of a sufficient number of airplanes to use at once at the beginning of a war, and then a rapid conversion of existing manufacturing plants into production plants for aircraft material when war seems imminent.

The loss of airplanes in war is tremendous. In Europe at certain stages during periods of intense activities, we lost about 100 per cent airplanes per month, so that we had to figure on reserves accordingly. In a future war it would appear that we should have at least 300 per cent reserve airplanes on hand when the war began, which under these conditions should last until our means of production was started, in accordance with our probable needs. The means of production in the United States was well tested out during the War. Starting from nothing at the beginning of the War, it took some time to determine what types of planes, engines, and equipment should be used, so that really serious work was not started on the airplane programme until several months after war began. Notwithstanding this, the production of DH type airplanes arose to 3878 machines per month within fifteen months after the initial order was given. The construction of metal planes will undoubtedly facilitate very rapid construction. But no matter what the deficiencies of this equipment may have been it definitely shows that the airplane production capabilities of this country are very great, when intelligently directed and handled. The airplanes have to be submitted to tremendous strains in the air, and as a defective or weak part may mean a total destruction, great care has to be taken in the inspection of all parts at the factories.

When the airplanes are received from the factories they are sent to depots or receiving points where they are completely equipped with their guns, engines, attachments for cameras and wireless, all their instruments and service equipment, and are forwarded by rail or boat to the point nearest to the air squadrons that are to use them. The packing and delivery of airplanes is an extremely laborious and costly process. Heretofore they have been put up in expensive boxes, loaded on freight cars and sent forward. In the future it would be much more convenient to build special cars for transporting the airplanes, which can be used over and over again. Likewise, special transports for the carrying of airplanes must be provided, because the loading of wing structures, the fuselages, and all their parts into ordinary boats always results in great damage to them. If an expedition is to take place, and it is desired to have the equipment quickly available, all parts of the airplanes, their motors, guns, ammunition, bombs, and everything necessary for them, should go over together at the same time, and be in the same place. If this is not done the different parts that it is necessary to use with the airplane will be separated, and the whole organization will be useless; because guns will be one place, ammunition another, motors another, wireless another, any one of which if lost will render operations impossible. On account of the rapid manner in which airplane material had to be sent from this country to Europe during the War, it all had to be practically rebuilt after it reached the other side.

Once the airplane equipment has been placed in the farthest out supply depots, that are connected by railway or steamships with the bases, very careful consideration must be given to the location of all the supply points which are to follow the fighting squadrons. These points should be selected with a view to having them make just as few moves as possible, and such moves as are made should be made straight to the front or straight to the rear, not to one side or the other. All the material should be sent up by rail just as far as possible and then taken on by truck. All of these means of transportation should be absolutely under the direction of that branch of the Air Service which has charge of the supplying of the planes. As the front is approached the wastage of material increases constantly, and additional methods have to be taken for saving parts of the partially destroyed airplanes and motors that it is possible to repair, and of course, supplying what is needed to take their place.

The supply method which has been found to work the best is that the airplane groups, that is, four squadrons of 100 airplanes, should have what is called an air park with them. These parks had the strength in personnel of about one squadron, that is, roughly, 150 men were divided into salvage, repair and supply elements. The salvage elements had trucks and equipment for going out and picking up smashed airplanes and bringing them back to the points where they could be shipped to the rear or repaired. The supply element kept three days' supplies of all kinds constantly on hand, particularly spare wings, landing gears, spare parts for engines, extra guns, cameras, wireless instruments, and the hundred and one things that go with an Air Service group. The repair element had the movable machine shops, which were mounted on motor trucks, had power-driven machinery, and could be put in operation within a few moments after a stop was made.

The organizations further back, from which the air parks drew their supplies, were called air depots. These kept on hand about two weeks' supplies of all kinds, included a salvage element and a repair element capable of carrying out repairs of quite an extended nature, such as repairing wings, overhauling engines, and considerable overhauling of armament, electrical equipment, and other accessories. The air depot is not as mobile as the park, but is organized so as to have one echelon that can get started within three days and move forward with its supply section, while the whole depot could be moved within two weeks. These depots were organized to supply from 30 to 50 squadrons or from 750 to 1250 airplanes.

The means of supply outlined above has to have the strictest kind of technical direction, that is, the Engineering Department has to watch the state of the equipment, condition of the engines, and how they are handled and run by all concerned in their use. This, it must be held in mind, should be different from the tactical control, which pertains to its use in battle and the method of operating against the enemy, so that we have two elements in an Air Service that have to work side by side—that is, the technical control of all equipment by the Engineering Section of the Air Service, and its tactical use by the fighting forces against the enemy.

A great deal of trouble, inconvenience, and loss of efficiency has always resulted from these two features of control, because they were not well understood by any of the Air Services at first. It has always taken a long time, and the test of war, to work it out thoroughly. What we really have in a supply system is a group of manufacturers who produce the material ordered by the Engineering Section; next a branch of the Air Service that stores it when finished and prepares it to be issued according to the demand of the air squadrons using it, then a group of inspectors that watches the proper issue, use, care, repair and condition of this equipment. Complete lists have to be kept on hand always of what supplies a squadron should have—the probable number of airplanes required in a certain time, under the estimated condition of a campaign, how long it will take for all of this to get to certain destinations, etc. Having worked these things all out, an "automatic system" of supply is put into effect, that is, so much material is sent forward every so many days, no matter whether asked for or not. On account of the complexity and rapidly changing character of air squadrons this work requires a great deal of attention and intelligent study by those who are entirely conversant with the supply of the Air Service, and the greatest harmony and mutual trust and respect must obtain between the head of the fighting aviation and the head of the supply system.

Another important element in a supply system is that airdromes, as they are called, that is flying fields of suitable dimensions, be provided ahead of the coming of the squadrons and groups. This is very necessary because the airplane has to have a field ordinarily about a mile square, so that it may land, or any number of airplanes may land together, no matter what the direction of the wind may be. The airplanes always must land head to the wind. The airplane must be sheltered so as to keep it from destruction by the elements. It must be well concealed so the enemy cannot see it. The airdrome must be fairly dry so as not to fill up with mud when it rains, and have good means of communication by road, railroad, canal or steamships so that sufficient gasoline and oil can be brought to it, together with spare parts

Colombey les Belles Air Depot in France. From this Supply Point the American Airplanes were Issued to the Air Troops

for the airplanes and other accessories. Gasoline weighs about six pounds to the gallon. A 400-horse-power motor at full speed uses about 30 gallons or 180 pounds per airplane per hour. With 20 pounds of lubricating oil added to this, we may say that an airplane eats up at least 200 pounds of supplies per hour. Now 100 airplanes will eat up 20,000 pounds or ten tons per hour, so that it may be easily seen what a tremendous amount of supplies have to be brought up constantly to keep an air force going. In addition, there is all the ammunition, spare parts, food and supplies for the men and motor trucks.

At the battle of St. Mihiel the Air Force assigned to the American Army under my command amounted to, roughly, 1500 airplanes. They required 150 tons per day of gasoline and oil besides all their other supplies. The whole airdrome plan, location of these flying fields, construction of the hangars, smoothing of the ground, and their supplies, was worked out for this, the largest air force ever assembled under one command, by the equipment officer—Major Jerolemon. The system worked perfectly and without a hitch. The airdrome companies that built the flying fields were equipped with all sorts of machinery, trained carpenters for the erection of buildings, camouflage experts for hiding the hangars and other houses, and engineers for grading, draining and otherwise preparing the surface of the ground. All supply formations were connected by telephone so that if an airplane was lost on the front line one was immediately supplied to take is place from an air depot and others came up from the interior of France to the air depot.

A good supply system is always a very difficult element to have running smoothly at the beginning of a campaign, because during a time of peace all the methods and ways of doing things become so stabilized that when a change is brought about, unless very capable men are handling it, a great mix-up occurs.

It is of the greatest importance, in the supply and distribution of aeronautical property in a country, that all of this be done under one direction, instead of having it split up between several different organizations, each competing with the other, such as the Army and Navy, Post Office Department and various other executive departments of the Government. There should be one department of aeronautics for handling the whole thing.

CHAPTER XIII

Civil and Commercial Aviation

The end of the great War in Europe saw aeronautical interest turn from military aviation to the possibility of utilizing aircraft for civil and commercial purposes. During the War, it had been necessary to develop essentially military types which were able to deliver the maximum amount of punitive effect against the enemy, irrespective, very largely, of what they cost or the danger involved in their operation. The commercial use of aircraft, on the other hand, calls for sureness of delivery of whatever is carried to the place it is intended for it to go, and, incidentally, of having it get there safely and in good condition.

Many thought that aircraft could be turned immediately to commercial uses and would, within a short time, supplant automobiles, trucks, and even railroads and steamships for certain classes of transportation. While this undoubtedly will be the case in the future, there are certain limit-ing factors which will necessitate continued development to attain this end.

To begin with, any commercial venture must show a certain margin of profit, or at least pay for operating expenses. When aircraft begin to act as carriers, they come in direct competition with means of transportation which have been developed on the ground through hundreds of years. It might be well, therefore, for us to inquire into the relative cost of operation between the airplane and some of its competitors, and, in this way, see what it is necessary to do to develop the airplane as a commercial carrier.

It is said that the airplanes produced by Great Britain during the War cost more than four dollars per pound of gross weight of the whole airplane and its load, and that the cost of the American airplanes, estimated on the same basis, was from one dollar to four dollars per pound of gross weight. The cost of a railroad freight train is said to be less than five cents per pound. The first cost is from twenty to one, to eighty to one, against the airplane. The cost of maintenance is very high for aircraft. The amount of load which can be carried in proportion to its weight is less than one to two, for an airplane.

On a railroad freight train, more than one-half of the weight can be carried in cargo. The amount of effort necessary to pull an airplane forward through the air is ten times as great per unit of weight as it is for a freight train. A freight train can coast on a two per cent grade, while an airplane requires about twenty per cent angle of descent in order to glide. The crew of a large freight train carrying hundreds of tons is only about five or six men, while the crew of a large airplane requires about the same number, and only carries one or two tons of cargo. In other words, on a basis of ton-miles of cargo transported, the first cost of an airplane is several times as great as that of a freight train, as is the case with the cost of fuel, the cost of crews for operation, and the cost of maintenance. In the most extensive and successful regular service by airplanes, the cost has been on an average of about one-tenth of a cent to one cent per pound-mile; while, on a freight train, the cost is between one-tenth of a cent and one cent per ton-mile. It therefore costs about as much to carry a pound of freight for one mile in an airplane as to carry a ton of freight on a freight train.

These figures have been presented to show airplane transportation in its most adverse way, and the facts taken into consideration in the computation of these figures concern essentially war motors, developed for military purposes, and war airplanes, created to obtain maximum speed. The comparison would be something similar to a racing automobile against a truck, totally out of proportion to the matter in hand. It is therefore necessary to develop reliability of operation and sureness of delivery of the cargo carried to the terminal station. This can be done in several ways.

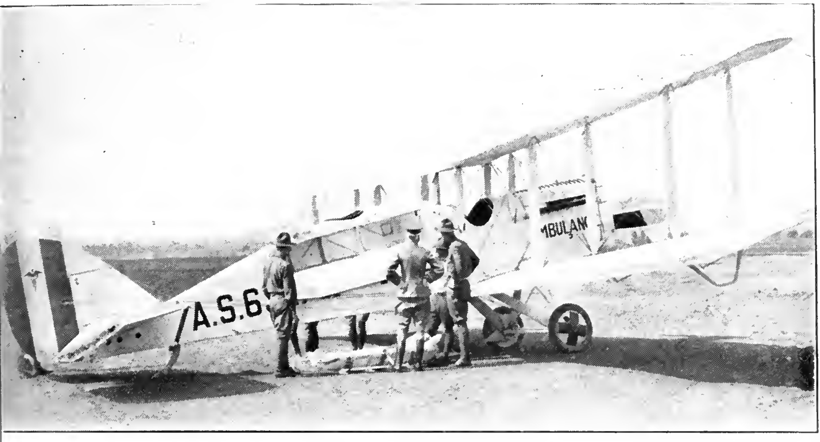
First, by improving the motor. As it is no longer necessary in certain types of commercial airplane motors to obtain the very light weights per horse-power that are necessary in war engines, a slight addition in weight may be given them to bring about greater reliability. The ignition and carburetion systems of engines can be greatly improved, and above all, an airplane can be provided with three or more motors, so that if one is interrupted in its regular work, the other two can sustain the airplane in flight while the one out of order is repaired in the air.

Next, devices for slowing up the landing speed. The average airplane lands at from forty to eighty miles an hour, and it can well be imagined what the effect of driving a motor car over the ordinary fields at such speeds would be. Airplanes are much more fragile than cars. Slowing up the landing speed may be effected by varying the amount of surface in the wing, by the shape of the wing, and probably by altering the form of the wing at certain times. The reversible pitch propeller gives good promise for the future in this respect. This is the propeller in which the pitch can be reversed so that, instead of pulling the airplane, it will push back on it. Many other schemes to insure slow landings are being studied. The scientific development of these things is receiving a great deal of study, which was impossible during the War, because any material that was well understood had to be used instead of experimenting on something new while the fighting was going on.

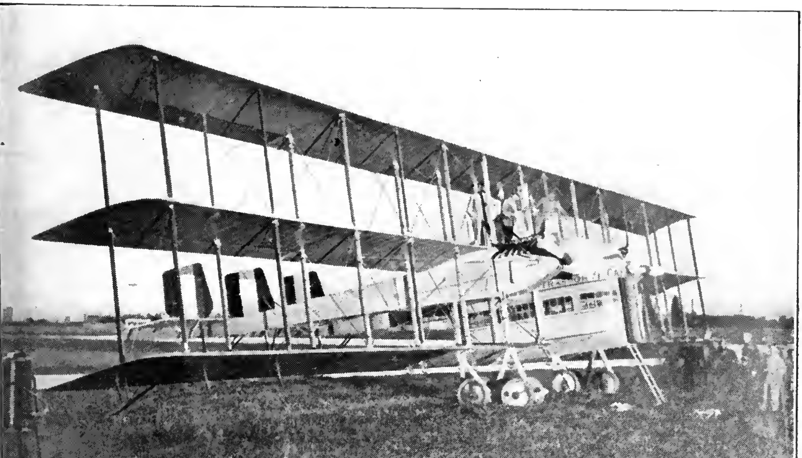
There appear to be three distinct uses for aircraft as cargo carriers—one for local use in and around large cities, where the runs are short and where the facilities for landing are very poor, such as the roofs of buildings, small plots of ground, and places of that kind. A helicopter, or flying machine which is able to ascend vertically and land vertically, seems to be the best solution. Some kinds of helicopters give good promise for the future. The principal trouble about this class of aircraft has been that, if for any reason the engine stopped, the helicopter could not glide to earth but fell when its power of sustentation, derived from the engines alone, was taken from it. Some recent models of helicopters have shown that the vertical propellers may be built in such a manner that they can sustain the aircraft in gliding flight after the engine has stopped. The development of the helicopter, therefore, seems very probable in the near future.

The next class of transport requires that heavy articles be carried between large centers of population, such as from New York to Chicago, Chicago to Omaha, to St. Louis, etc. For this class of work, large airplanes having many motors and slow landing speed, and the ability to get off the fields quickly, are required. Some of the war types of night bombers may act as a start for this sort of a ship. Many types of large airplanes are now being developed for military uses, which, with slight transformation, can be applied to this class of transportation. Wherever the distance is greater than three hundred miles, or where the sea intervenes, such as is the case between London and Paris, which requires a change from railroad to steamship, etc., the airplane will soon make itself a worthy competitor of the railroad train and steamboat.

For this class of aviation, it is essential that a well developed series of airdromes or flying fields be provided throughout the country. These flying fields not only should contain the place where the airplane itself lands, but should have



American Ambulance Airplane



Italian Caproni Passenger Airplane. Carries About Fifteen Passengers and can be Rapidly Converted into a Bombardment Airplane

facilities for the repair of the airplane, proper housing of its crew, medical attendance, gasoline, and oil stations, expert ignition and carburetor mechanics, a system of weather warnings and predictions, wireless direction finders which can guide the airplane to its airdrome and notify it of the weather to be expected while it is in flight, and landing lights, so that in case the voyage has to be made at night, proper facilities exist for getting down on to the airdrome. This whole airdrome scheme should be organized into a system of airways, properly marked, throughout the country. Tops of all railroad stations should be marked with the names of the cities in which they are located, and certain signs should appear even on fences and all sorts of places capable of being painted a distinctive color to mark the particular airway which they are meant to represent.

A system of airdromes of this sort, established by the Government because no commercial company can possibly do so on account of the expense, is the biggest single aid to commercial aviation that can be given.

Fog is a great enemy of aerial locomotion. All sorts of schemes and devices to render airplanes capable of navigating in the fog are being developed—some with considerable success, and others which are still in an experimental stage.

So far, it may be said that an airplane may be guided to the vicinity of an airdrome by radio; it can maintain itself on its course, maintain its speed so as not to stall and fall in the air, and maintain its proper equilibrium. It can be guided even to within a few hundred feet of the ground by radio while still in the fog, but, from that point down, some means must be devised for dispelling the fog in order to make it land. Various means have been tried for dispelling fog, none of which so far have been very successful. Experiments, however, indicate that some success may attend these efforts. At the present time we could make transit through the air, from place to place, as safe as in the case of railroads and steamships if we had the equipment and organization to do it with. For instance, if we had airplanes with six engines, four of which would fly the plane, and all of which could be repaired in the air in case of trouble, three engines would have to be put out of commission in order to bring the airplane down. In other words, six engines would practically insure the airplane staying in the air for the whole time of its fuel capacity. Our last types of large bombers are being built in this way. If these airplanes were put on a run which required ordinarily above five hours' fuel, such as from New York to Chicago, and had a total gas capacity of eight hours, or 350 to 400 miles radius of action in addition to their ordinary trip, if fog or adverse weather conditions were encountered at their point of destination, they could be warned of this by wireless while in the air, and diverted to a landing field that was free from fog, or other adverse weather conditions. In this way crashes would be reduced to a minimum, and aerial transportation would be made very sure. Our contemplated system of airways in this country would be able to carry out this method of handling aerial transport.

The third class of aerial transport involves the most rapid means of transportation we know of for long distances, such as from New York to San Francisco, from New York to Europe, from North America to South America or Asia. Recent experiments have shown that, with the aid of the turbo booster, which is a device that supplies additional air to the carburetor of a gasoline engine, very high altitudes can be obtained, which were impossible formerly, and that, at these high altitudes, on account of the rarefied air encountered, less resistance is offered for the passage of the airplanes through it, which allows the airplane to attain very much greater speeds. Well over two hundred miles per hour have been obtained with an airplane having only a speed of about one hundred and twenty miles near the ground, and it appears probable that speeds of from three to five hundred miles may be obtained before many years elapse. It has also been found through the central part of the United States that, at altitudes of 25,000 feet and over, constant winds blow from west to east with a velocity of over one hundred miles an hour. If, therefore, the airplane speeds at high altitudes, combined with the wind, are utilized to the fullest extent, and the wind currents properly charted in the upper atmosphere all over the world, a means of transportation will be developed which will give from three to five hundred miles per hour as an ordinary thing.

If one thinks how long it took to develop steam and electricity, one is struck by the rapid development which has accompanied airplane evolution since the beginning of the War, and it is possible now to look with great confidence to the future commercial use of airplanes.

The United States Air Mail Service has demonstrated that ninety-three per cent of the trips between New York and Washingon, covering a period of a year, were completed, and that only seven per cent were a failure. They maintained an every-day schedule in all kinds of weather, using obsolescent war equipment. This Air Mail Service is being extended throughout the United States, and will give us splendid data on all sorts of matters concerned with the carrying of freight and passengers by airplane over long distances. It is estimated by the English that it costs about forty dollars to send a cable message of one hundred words from London to Johannesburg, in South Africa, and that it takes about twenty-four hours for the message to get there. If an airplane mail service were established between these two points, it is estimated that a five-thousand-word letter would get through in six days at a cost of sixty cents. Similar estimates have been made over other routes, so that the airplane will act as a rival for the submarine cable in the future.

Military aircraft may be used by the civil departments of the Government to a greater extent than can any other parts of the war machine, such as armies or navies, without impairing their efficiency. One of these very important uses is in the mapping of the country. Recently the United States Air Service mapped an area in Michigan in seven hours, which, for the same work, would have taken a large surveying party from three to four months. Only about forty per cent of the United States has been surveyed so far, and in most places in a very elementary way. The Air Service could photograph all of this country, it is believed, and complete the whole map within three years after the work is started on a systematic basis.

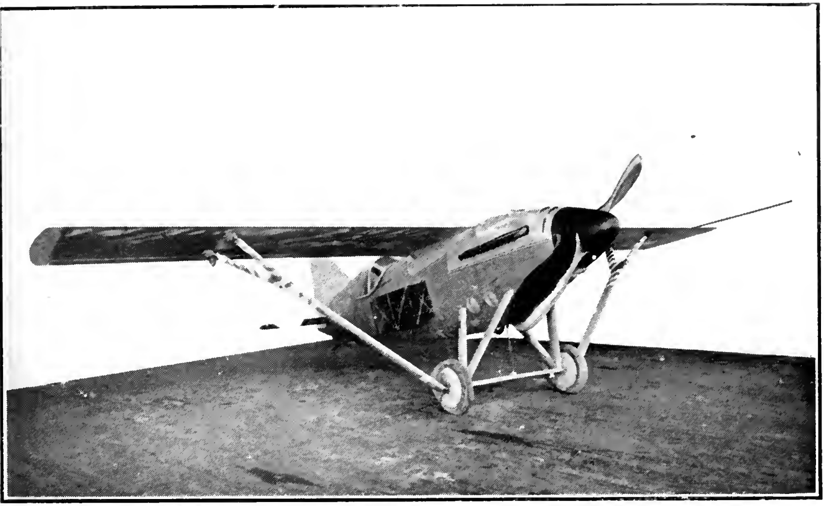
Aircraft have been used to great advantage with the Forest Fire Patrol in the Pacific States, and, during the summer of 1919, the savings resulting from the use of this patrol paid many times over for the whole appropriation made for the Air Service of the Army. An airplane patrol has been maintained along the Mexican border which could be used to prevent smuggling, and to connect the people all along that area where no other means of communication are practicable. Also, aircraft may be used for life-saving work, and for many other things. In fact, there is not one department of the Government which cannot utilize in some way the activity of aircraft.

For both our civil and commercial aviation, therefore, we need constant development along the lines indicated above. The surplus material which the Government has on hand can very well be sold, under proper conditions, to commercial companies who desire to develop aerial routes through the country, or from our own country to other possessions, such as Alaska, Panama, Porto Rico, etc. This is the best use for equipment of this kind, which otherwise becomes obsolescent, and is a positive detriment in case of a war against a first-class power. The same landing fields, and also any airways which are developed for the use of commercial and civil aircraft operations are also applicable to military work. The whole aeronautical development, military, civil and commercial, is inseparably involved in one organization.

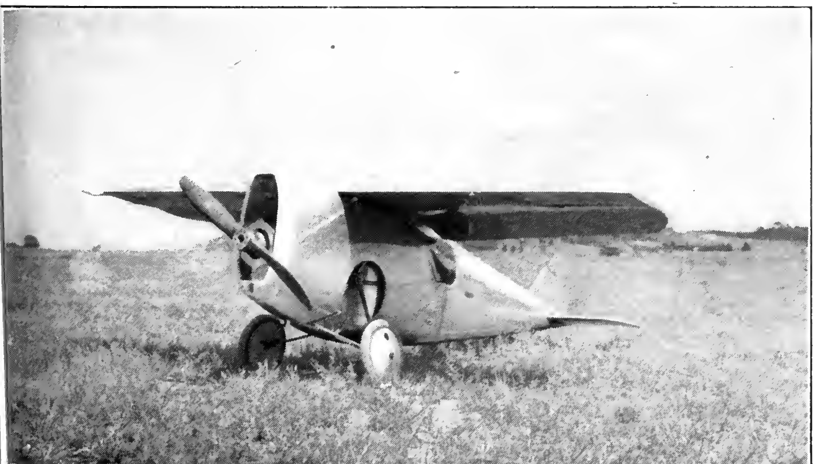
The United States so far has no method of regulating the use of commercial aircraft. It is quite evident that the Government should guarantee that the pilots and operating personnel of all aircraft be sufficiently instructed and capable, to allow them to take up passengers and freight, and that they should be able to direct the airplanes with certainty across the country so as to arrive at their destination and not crash into cities, where many people might be killed by such a disaster. Also that the structure of the airplane itself is proper; that it is equipped with safety devices, and that it is maintained in a good state of repair. All other countries now have rules along that line, with a supplementary law regulating the airways, altitudes at which aircraft shall fly, methods of landing, what they shall do when they meet each other, altitudes at which they will have to fly over cities, towns, and the thousand and one other things relating to aircraft navigation.

In the United States, an interesting local question is presented, because the Government of the United States, being one of delegated power, only has jurisdiction over things especially ceded to it by the States. According to the principles of the common law, the property owners own all the air over their respective plot of ground, and all the earth under it to the center of the earth. A railroad or a road, for instance, is established over a definite right-of-way purchased or taken from its owners by the right of eminent domain; traffic over it is regulated on the basis of international or interstate commerce by the United States. It may be possible that similar things will have to be done in the regulation of air traffic through the United States, and that airways will have to be condemned and acquired by private parties or the Government for the furthering of aerial navigation.

The most important element, however, is in controlling foreign aircraft which may cross the borders, both from a commercial standpoint and a military standpoint. Contraband can be more easily imported by airplane than by any other means, and spying out of our military works, methods of coast defense, and interior communi-



Curtiss Speed Airplane, 1920. Capable of Going About 200 Miles an Hour



Dayton Wright Speed Airplane, Capable of Developing about 180 Miles Per Hour

cations can be more easily done in this way than in any other. The only means by which these things can be regulated is by a definite air organization, and a specific system of rules well known to all and impartially enforced. These should cover the general conditions of flying, how the aircraft should be examined, how the personnel should be registered and where the aircraft should fly; what the prohibited areas are over which they should not go, the class of inspection to which the aircraft will be subjected when arriving from or departing to a foreign country, and the rules which shall be observed on all airdromes when landing on or taking off of them; what safety provisions shall be included as to fire prevention, as to parachutes for personnel, to be used in case of necessity; and appropriate penalties under the law should be attached to all violations of the aerial laws. These, however, should not be so framed as to restrict navigation of the air, but should be so broad and so well applied that they will facilitate it.

So, we may confidently expect that, when a system of airdromes is established through the country, and proper rules for the regulation of aircraft have been prescribed by law and are well administered, which will guarantee to the public safe transit through the air; when we have developed suitable types of aircraft essentially for commercial purposes, we shall see a greater development of commercial aviation in the United States than in any other country in the world. Our country is suited to it; the climate is better; our resources are such that we have all the raw materials necessary for the construction of airplanes; and our people take to it very naturally. We must remember that, as we develop our commercial power in the air, just so much more do we develop our means of national defense.

CHAPTER XIV

Aviation over the Sea

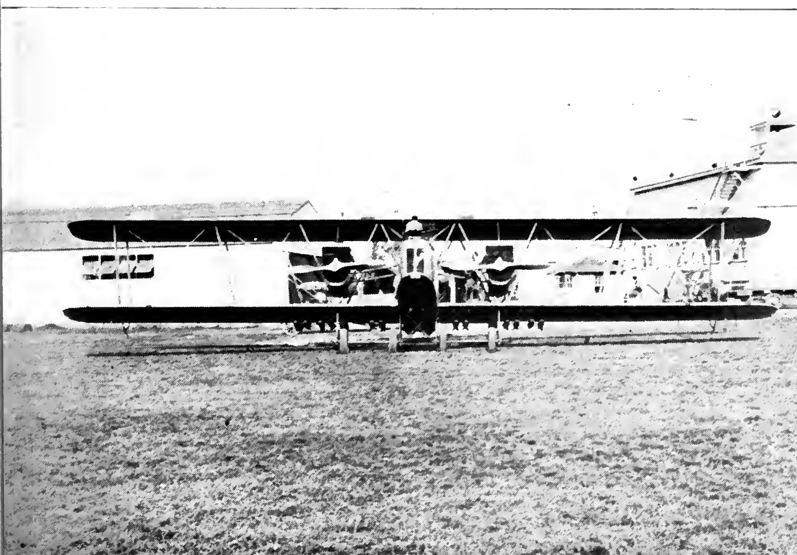
Future control of the seas depends on the control of the air. This is so to an even greater extent than is the case on land, because on the sea, the shipping—using the surface of the water—cannot conceal itself to the same extent that man or his equipment can be concealed on land. On the land it is of first importance that the enemy be prevented from seeing what the movements may be of one's own Army; but on the sea, not only is this the case, but in addition shipping forms an ideal target for air attack. The only thing which it is difficult for air power to destroy at sea is the armored battleship; and this is largely due to the fact that the problem of the attack of battleships has not been studied and worked on to the same extent as has been the application of air power against things on land.

The characteristics of air power, in comparison with sea power, are, first, the predominant feature of speed which air power possesses. Navies move at the rate of 20 miles an hour, and may increase their speed about 30 per cent when going into action; airplanes move in large bodies at the rate of 100 miles an hour, or over. They fight at speeds of about 150 miles an hour; while the fastest ones are approaching a rate of 200 miles per hour. The range of view from an airplane is almost infinite as compared with that from a ship on the water. At a height of 15,000 feet, a radius of view of about 50 miles is possible—that is, a circle with a diameter of 100 miles. The size of an air force that can be employed in the air is unlimited. They communicate with each other by radio telephony, radio telegraphy, or visual signals, which have the speed of light. Airplanes can deploy into battle formations, from their traveling formations, in from one to two minutes. Their routes are through the air, and in accordance with their capacity for covering distances—mountains, deserts, or oceans are no obstacle. An air force moves from three to six times as fast as the fastest ships of the Navy. From its speed alone the air force has the power of taking the offensive against the Navy and engaging it under its own conditions. The only defense against an air force is another air force; and, as an indispensable prelude to any engagement on the water, there must be an air battle to determine which side shall control the area above the water which is to be used by a fleet. Our doctrine of Aviation, therefore, should be to find out where the hostile air force is; to concentrate on it on convergent lines, and destroy it; and then to attack the hostile shipping with aerial weapons, so as to accomplish its destruction.

Many persons are led to believe that flying over the water requires a different kind of aviation, different methods in a military way, different tactics, and different training. This feeling was brought about largely as a result of the World War, where there was practically no air fighting over the water, and where the air forces used were employed merely for reconnaissance for submarines, and in attack against them. They did not have to fight other air forces to get to their destinations, and flew about in an unmolested manner. As a matter of fact, this is an entirely artificial use of aviation, because the Allies held the sea to a greater extent than has any nation, or combination of nations, in any of the wars of the past. Their only menace was the submarine. In a future contest between countries, the control of the ocean lanes will rest on a decisive battle between the opposing Pursuit Aviations; and in order to accomplish this all the air strength which a nation possesses will have to be concentrated at the decisive point. The principal difference between the employment of our airplanes over the water and over the land is in the character of airdrome, or landing place, that has to be used. This landing place may be on the land itself; it may be on the water itself; it may be a floating airdrome on the water, such as an airplane carrier, or a floating landing platform; or it may be even on an airship such as a Zeppelin. The reason that an airplane has a forced landing is either due to exhaustion of its fuel supply, or on account of some accident. The number of forced landings from accidents are now very few, and are becoming fewer as the airplanes and engines are perfected.

Airplanes that are designed to land on the water have permanent floats, or boats, under them. These constructions offer so much resistance to the air, and are so heavy, that they cut down the airplane's speed so much that they cannot compete, as to speed or maneuverability, with airplanes of the land type. As the only reason for having these floating supports under them is in case they land on the water; and as it is well known among airmen that in case of war seaplanes of all kinds are practically helpless, this form of airplane is being abandoned more and more for military purposes as time goes on, because they would unquestionably be destroyed the minute an enemy was met that was properly organized for air fighting over the water. Up to recently, military aviation over the water has been thought of by the ordinary person essentially in connection with navies. At first the development of aviation over the water took place in a manner similar to that which had occurred on land; that is, merely as an auxiliary to the navies, for the purpose of reconnoitering to tell where the enemy fleet, or enemy formations, were, for the adjustment of artillery fire, and for keeping track of parts of their own fleet. This, in theory, is a very simple matter—when no enemy is in the air to stop one's work. The airplanes could go out, find the enemy, report where he was by wireless, wait for the first shots to come from the cannon, tell their own fleet where they were striking, and proceed to adjust the fire in the ordinary way; that is, reporting the position of each shot with respect to the target. When hostile Pursuit Aviation is encountered, however, this will all be changed. There were so few battles between fleets, as compared with the constant battles between armies, in the recent War, that aviation over the water was not developed to as great an extent as it was over the land; and nothing was done to show the absolute identity of the methods required in both cases, and that work in the air was essentially an air matter, no matter whether it was over the water or over the land. Even at the battle of Jutland, neither the British nor German fleets had any Pursuit Aviation with them. In this contest, the German Zeppelins kept up a constant patrol over the North Sea, from north to south, along a definitely established line, and reported to their own fleet the whereabouts of the British Naval detachments. The British planned to send their main fleet out from Scapa Flow, and attack the German main fleet; while a detachment of the British fleet was supposed to come up from the south, get in behind the German fleet, and cut off their line of retreat. The Zeppelins, however, reported all these moves to their own fleet, which made it possible for the Germans to extricate themselves, and at the same time cause the British fleet a great deal of damage. Had the Zeppelins been shot out of the air by Pursuit Aviation, or by other Zeppelins, the German fleet would have been without eyes, and the superior British fleet would have destroyed it. The British themselves, in this battle, sent out a reconnoitering seaplane, which, although its speed was scarcely 100 miles an hour, was able to find the German fleet and report back to the British fleet without being

German All-Metal Seaplane



American Light Weight Bombardment Airplane. Capable of Carrying 1000 Pounds of Bombs.

molested in any way. It is, therefore, evident that if observation is to be carried out in the air for fleets, particularly with the long ranges at which artillery now fires—that is, from 40,000 to 60,000 or more yards—it will be necessary to fight off the hostile aviation before any observation work for a fleet can be done. This, then, requires that Pursuit Aviation be equipped so that it can fight over the water as well as over the land.

The basis of Pursuit Aviation is the flight; that is, the greatest number of pursuit airplanes that can be directed personally by one man in the air. It ranges from not less than five, to not more than seven airplanes; and is the actual fighting unit in Pursuit Aviation. Pursuit Aviation relies for its effect on an enveloping or surrounding attack in three dimensions—that is, from above, from underneath, and on the same level. The squadron, composed of three flights, is organized to bring a surrounding attack in one dimension, the flights attacking successively one after the other. Three squadrons acting together are used for the purpose of attacking the opposing aviation on the same level, from above, and from underneath; while a fourth squadron is put into the formation as a reserve. This is the reason for the group organization of four squadrons of twenty-five airplanes each, or a total of 100 airplanes, and is the fighting unit of aviation. If Pursuit Aviation is not organized according to this system, it cannot cope with an aviation that *is* organized to fight according to these principles. The first nation to see this clearly was England, because her whole existence is bound up in keeping the ocean lanes free to and from the British Isles. The problem, of course, was primarily to equip Pursuit Aviation with airdromes that could move over the water, so that Pursuit Aviation could be kept up with and ahead of her fleets. Early in the European War, she began to equip herself with airplane carriers. The first one of these was merely a large commercial steamer equipped with a deck on which the airplanes could take off and land, with a hangar deck immediately below this in which the airplanes could be kept ready for flight, and with machine-shop facilities, spare parts for the airplanes, and all other accessories for keeping them in condition on the ship. Her first carrier was the "Argus," which had a deck 535 feet long and 68 feet broad. Her hangar held twenty airplanes, or practically a squadron. Her speed was only 20 knots. It was evident at once that any vessel having such a slow speed would not only be a prey to other warships, but also submarines—not to mention destruction by hostile air attack—and there were many other things about this carrier which were not satisfactory, as it was the first attempt in this direction. The next carrier to be built was a warship being constructed for a South American country, which was transformed into a carrier and renamed the "Eagle." This ship is capable of carrying about 40 airplanes in her hangars, or two squadrons. Still another carrier is the "Hermes," with a speed of 25 knots; while more are being built. The British, however, recognized that these vessels could not operate far enough in advance of their fleets so as to go out there and fight for control of the air, but would have to stay near the fleet and be protected, because their speed was not great enough to protect themselves. Consequently, they took the vessels that were most readily available, that had the required speed and at the same time fighting power to ward off other vessels—that is, their battle cruisers—and transformed them into a combination carrier and battle cruiser. They are now reported to have a division of battle cruisers, or four of these high-speed vessels, equipped with airplanes. They all have a speed of about 31 knots, or 35 miles an hour; and have a very heavy gun-power—equal to that of any battleship—and with the airplane carriers attached to them, they have the power of concentrating the equivalent of one or more groups of Pursuit Aviation wherever they desire.

No other navy in the world is so equipped at the present time, and it is perfectly obvious that even with this comparatively crude equipment for handling air units over the water, the British can seize and hold command of the air in the vicinity of a fleet, and render a navy opposed to them not only totally blind—which is well known to be a decisive feature of modern warfare—but can also attack the opposing navy through the air with aerial weapons, so as to destroy it without the assistance of the gun fire of their ships. The air battle, in all probability, would take place from 50 to 200 miles away from the airplane carriers, where hostile gun fire would play no part whatever, and where their own navy would run no risk.

It should be noted that the whole development for the use of aircraft over the water is not in air tactics, in types of airplanes particularly, or in the securing and training of air personnel; but is essentially a development of floating airdromes. It is, therefore, evident that floating airdromes must be made to suit the requirements of the airplanes first—that is, if we are going to fight and drive out of the air an opposing aviation, we must bring to bear against it airplanes that can do the work. Next, the airplane carriers must be able to defend themselves against attack on the water. As to the first requirement, the airplane carriers should be capable of accommodating a complete tactical unit, or one group of 100 pursuit airplanes; and in the second place, in order to be able to defend itself, and be capable of taking the offensive quickly, it should have a speed of at least 40 knots, or around 50 miles an hour, which is entirely possible at this time. To answer these requirements, the airplane carrier should be about 1000 feet in length, with a landing deck of this size. Its width would be over 100 feet, and it could be equipped with all the facilities for handling the airplanes quickly either by day or by night. Even one airplane carrier of this kind would give the side possessing it complete control over the water at the present time, and render an opposing fleet incapable of acting with its Observation Aviation.

The first problem over the water, therefore, as it is over land, is to assure command of the air by Pursuit Aviation; the next problem is to develop aerial means of destroying any enemy battleships that may be on the water. This can be done by airplanes carrying bombs, torpedoes and chemical weapons. As airplanes always have the power of initiative in offense against battleships, it is entirely a question of developing proper weapons for sinking them. Almost nothing has been done along this line. What has been done might almost be described as "playing" with weapons adapted for some other device which has been used by either armies or navies. The bombs and fuses so far used were developed for work on land; the torpedoes that they were trying to use from airplanes are those that were used from ships. These torpedoes were made to be launched at a rate of about 16 yards a second; the speed of the slowest airplane launching them is about 90 yards a second. Their specific gravity is almost the same as that of the water, so that if they are launched from any height they immediately sink; and the airplanes have to get within 20 or 30 feet of the water in order to make them work properly. Torpedoes are launched sideways from surface vessels. They attempt to launch them forward in the air, and have to approach within 1000 yards or so of a battleship in order to be successful in their attempt. All of these things almost amount to making an adaptation of the water torpedo for air work against moving shipping almost useless as a practical proposition. The Italians, among others, have devised torpedoes with wings on them which drop off as they strike the water, thereby allowing the torpedo to be launched from a height. This is the beginning of a solution of this problem. The point is, however, that torpedoes, or any projectiles or armament, must be designed essentially for work in the air.

Airplane carriers to carry Bombardment Aviation should be provided, to accompany the pursuit carriers, which can be done just as it was for Pursuit Aviation. In order to assure close bombardment attack of navies, and to nullify any dangerous effect which anti-aircraft, machine guns, or searchlights might have on these planes our Attack Aviation should be developed for use at very low altitudes against them; that is, the armored attack planes could engage them in single column, so as to keep the battleship under constant machine gun and cannon fire at an altitude not to exceed from 100 to 300 feet. This would keep any observation personnel, anti-aircraft crews, and look-outs on the battleships pretty well occupied in watching this low flying attack, if nothing else. Our experience in the War has shown us that we can nullify searchlights and anti-aircraft equipment to a great extent in this way; so that really the solution of control of the sea lanes is not in a great battleship and its accessories, but in the provision of suitable airplane carriers. These should be provided to carry aviation in the following proportions: about 60 per cent Pursuit Aviation, 20 per cent Bombardment Aviation and 20 per cent Attack Aviation.

For long distance surveillance over the seas (by surveillance is meant going out and remaining in observation of what one sees, and reporting back from the position by radio telegraphy, instead of coming back and making a personal report), airships should be used. The number of the airships should be dependent on the amount of front that has to be covered. To cover our Eastern and Western Coasts, and our North and South Frontiers, no less than 20 airships, constantly in commission, are necessary. It will be remembered that Germany had 123 airships in commission during the War. By airships are meant large rigid cruisers of the Zeppelin type —not the little gas bags that we are used to seeing in this country, which have little value except for training. Again we find England, next to Germany, taking up this important problem and solving it. Airships cannot be provided over night; and no matter what the engineering knowledge may be as to the construction of these giants of the air, and no matter how expert the personnel may be in the handling of smaller airships,

German All-Metal Flying Boat Equipped for Passenger Traffic. Carries About Ten Passengers

a great deal of practice is needed in order to perfect the work of these important elements in aeronautics.

The mission of the airship over the sea, from a military standpoint, is to find out and report the existence, strength, position and probable intention of hostile air forces and shipping; to fight hostile airships; to attack surface craft; and then to be used as a post of command for aircraft with which they are acting. The airship has just as great use over land, if not greater, as over water from the standpoint of reconnaissance, offensive work against enemy elements, and as means of transportation. An efficient Zeppelin service depends primarily on an efficient system of airship stations or docks where these ships can be brought into port, housed under all conditions of climate, and, in case there is a storm where they desire to land, they can have an alternate place to go to, and from which they can leave under all conditions of atmosphere. These stations should be arranged with hangars radiating out from a central turn-table; and the construction and maintenance of such stations by the Government would not only insure their use in case of military operations, but also would encourage the civil and commercial use of these great carriers.

Each nation is solving its air problem in accordance with its particular position and national policy. Germany sees no use in having aircraft carriers in a future war with England, because the distances from England to the Continent are so short that airplanes can operate directly from land bases. The maximum distance from the northern part of the British Isles to the European Continent is about 500 miles; while the minimum distance across the English Channel is only 18 miles. Germany's air policy against England, therefore, would be to construct airplanes capable of sinking the British shipping. Of course, in order to do this, they must be covered by sufficient Pursuit Aviation to insure their action. The air force, therefore, will take the place of Germany's destroyed navy, not only as a means of defense on land and sea, but as her great offensive weapon. France sees an enemy to the north of her as her greatest menace in the future; and knows that these same heavy airplanes designed for work over the North Sea against the British shipping can knock out her centers of production, large cities and railroad lines to a great extent. She also knows that the German nation is much more populous, and will become even more so, than is France; that Germany can concentrate her fighting forces probably quicker than France on the frontier. Her air service is therefore designed to fight the Germans in the air, which means Pursuit Aviation; and to attack the German columns as they march to the front and on the roads and railroads, which requires a sort of combination of Bombardment and Attack Aviation. England, as has been explained before, has to insure her sea lanes of communication; and has really solved the problem to a great extent already. Our problem in America is quite different from what we find in Europe. We have 3000 miles of water to the east of us; we have about twice that distance directly west of us. It is true that in the North Atlantic, by going from Canada from island to island, there is no stretch of water more than about 300 miles; while in the North Pacific, Behring Straits are 52 miles wide, with two islands in the middle, making a maximum distance of 21 miles over the water. At the present moment, no nation is equipped with sufficient means of transport through the air to utilize these routes quickly as a means of supply for her airplane units. Germany could have done it with her airships had they not been dismantled and taken away from her by the Allies. The control of these waters, therefore, resolves itself into a question of aircraft carriers. Aircraft carriers cost far less than the cost of one battleship, and can be produced, equipped, and put in service in a comparatively short time. When this comes about, the air force will constitute the first line of defense of the country. The Navy may be second, or it may be entirely eliminated. Not to recognize this fact is to do the "ostrich act," and to hide our head in the sand while everyone else in the world is progressing along this line. It will not come at once, but by progressive steps. In case of war, the same air organizations that fight over the land will embark on the aircraft carriers, and fight over the water. Directional wireless will bring the planes back to their carriers either by night or by day. The whole force will be handled from the air by radio, and the carriers will move at their great speed wherever they are directed to go. A nation unequipped to concentrate her whole air force over the water, if the decision lies there, can just as well leave her navies tied up to the wharves, instead of sending them out to certain destruction against a hostile country equipped for this purpose. England to-day can hold absolute mastery over the sea against a navy several times her strength, and apparently will soon be in a position where she will need little or no navy to guard her sea lanes in case of danger, as the air force will do it. A contest, therefore, between the United States and a country equipped for fighting in the air would be disastrous at the present time. Having assumed command of the sea, the aircraft carriers could launch their airships against our cities—such as New York, Philadelphia, Boston, Baltimore, and other points further inland—and cause a tremendous destruction, if not paralysis, to our means of communication and production. It is often said, by those unfamiliar with airplane bombardment, that a great deal of damage was not caused by them during the war. These statements often have not taken into consideration the character of equipment that was used at that time compared to what it is now. At that time the airplanes could not carry the heavy weights, nor were they equipped with the heavy bombs that it is now possible to use. One heavy bomb will destroy a whole block of ordinary houses and buildings such as one finds in this country. Whole districts in Europe were denuded of their population entirely, due to airplane bombardment. When industrial districts were attacked, the workers were made so nervous that whenever the buzz of an airplane was heard it made them stop work and think or talk about it during the rest of the day; while at night the constant fear of the bombardment attacks prevented sleep. These districts were kept entirely in the dark for months.

The result was a partial paralysis of all traffic at night, causing a great many accidents, wear and tear on the equipment, and innumerable other serious inconveniences, all as a result of these bombardments.

Our country, therefore, if unequipped with the proper aviation, in case of war, would become exposed to the air attack not only from the carriers, but probably from bases seized and occupied on land. The only defense against it is a proper air organization for the defense of the coast. This should consist of a good airship organization, with some twelve airship stations distributed throughout the country; next, a line of observation airdromes, deployed along the coast at about 200-mile intervals (these would be for the purpose of determining where the hostile air force or airplane carriers were coming from); with airplanes capable of maintaining themselves from eight to twelve hours in constant flight. Behind this line of observation we should concentrate our offensive elements of aviation; that is, our pursuit, attack, and bombardment units, in central positions so that they could be launched together against the hostile forces. A direct attack against the hostile airplane carriers would force hostile Pursuit Aviation to rally for the defense of their carriers, and cause the battle for control of the air to be fought in and around them, instead of over our own territory. In case the hostile air forces were destroyed, the airplane carriers could be attacked directly by the airships; but without equipment of this kind, the airplane carriers could escape without molestation. We can obtain more security from a wise organization of our air forces, dollar for dollar, as a means of coast defense, than from any other one element. While we need every branch of national defense to form the complete chain. we must not lose sight of the fact that our aviation at present is the weakest link in our chain, that we are the one country which can maintain and support an aviation more easily than any other, and that it is more important for our national defense that we maintain a large air force than is the case with any other nation.

CHAPTER XV

How We Should Handle Our Aeronautical Development

We have seen in previous chapters what the characteristics of air power are, what we may expect from it in national defense, and what problems lie before us in civil and commercial aviation. Many are led to believe that a commercial airplane is a thing entirely distinct and different from a military airplane. This is only the case in so far as Pursuit and Attack Aviation are concerned.

The problems confronting commercial aviation are:

First, local aircraft service in and around large centers of population, such as New York, for instance, where the landing fields are very small and where it is necessary to arise almost vertically in the air and land in a similar manner. Airplanes which are suitable for this kind of work are the very best kind that could be obtained for observation work with armies. They could

Thomas Morse Pursuit Airplane. Speed About 150 Miles Per Hour

Airplane Equipped with Air Bags for Floating on the Water

accompany the troops, would need no especially prepared airdromes, would be easy to use at night as well as in the daytime, and could be made very simply so as to require a very low up-keep. This same character of airplane could be used for observation work from battleships, or any floating airdrome having a limited deck space.

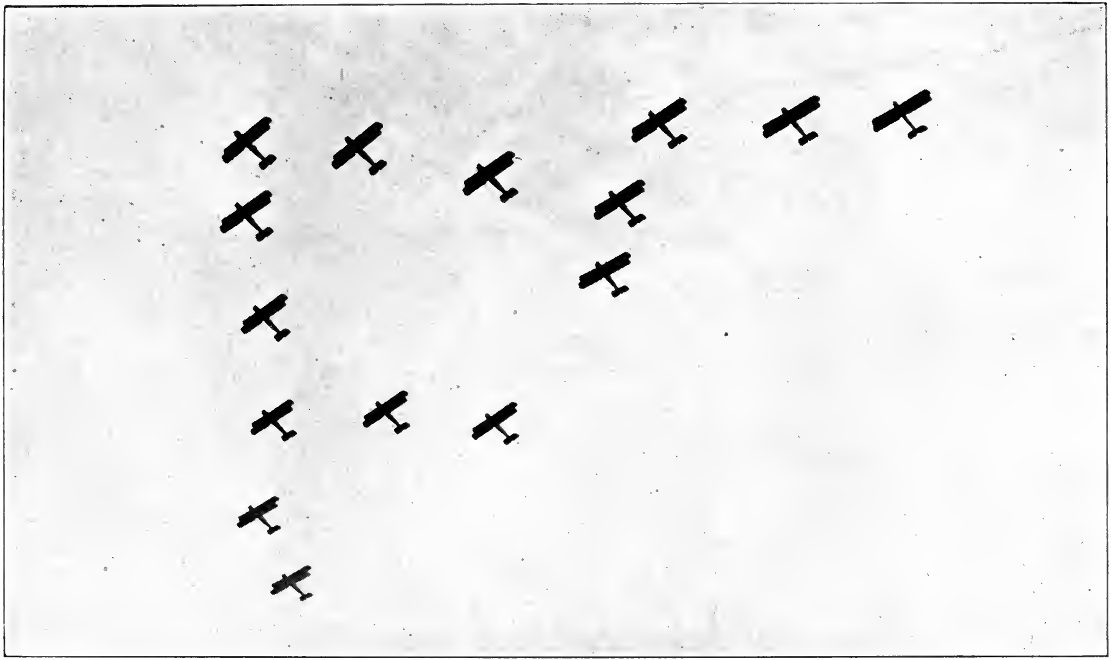
The next class of commercial aviation is that required for carrying heavy weights between cities, such as New York and Chicago, Chicago and San Francisco, or from North to South America. These airplanes should have three or more motors, so that if one ceased to work while in the air, the others would sustain the ship while the unusable motor was being repaired. These airplanes should be completely equipped with wireless appliances, so that they will be kept constantly informed of the weather and meteorological conditions en route to and at the station at which they are desirous of stopping. If for any reason the weather changed en route, they could be notified and could change their airdrome for landing. Most storms are not over two hundred miles in diameter, so that if an airplane of this kind had ten hours' fuel, and could make the trip from New York to Chicago in seven hours, it would always have three hours' fuel, or more than three hundred miles of cruising ability left. Multi-engine airplanes with large gas capacity such as this could fly both day and night. As a matter of fact, conditions are usually better for flying at night than in the daytime. The winds have less velocity; the visibility is very good; and the aids to navigation are automatically in place—that is, the lights in the large cities. These are visible at great distances, and are on the main routes, from east to west and from north to south, which our future airways will follow. The reason that we do not fly more at night at the present time is due to the fact that our airplanes have only one or two motors, which, if they get out of order, force an immediate landing and almost sure destruction of the airplane and its occupants. With multi-motored airplanes, this danger of forced landing will be almost entirely obviated. We have multi-motored airplanes at the present time which carry from three to five thousand pounds of cargo. This, of course, will be very greatly increased in the future. These same commercial airplanes will be of the greatest use in war for bombardment purposes, for carrying troops and supplies, and as ambulances or even temporary hospitals. Very little change would be necessary in order to suit them for immediate military work; and when they are designed, they could just as well be provided with the necessary structural parts on which the bomb-dropping mechanism, under supports for torpedoes, ammunition recesses, parachute holders, and other military accessories are needed. Our latest bombers are designed so that the whole nose of the main fuselage, which holds the majority of the military equipment, can be removed and another nose for civil aviation can be substituted.

In the third class of commercial aviation—that is, the airplanes required to transport passengers for long distances at great speed—we require again the multi-motored airplane, built on speed lines, for high altitude work. The way this high altitude is obtained at the present time is by the use of the turbo-booster. The turbo-booster consists of a turbine, which is actuated by the exhaust from the engine, and revolves at the rate of from twenty-two to thirty thousand revolutions per minute. This, in turn, operates an air pump or compressor, which delivers compressed air to the carburetor, thereby keeping up a proper mixture of air and gasoline for combustion in the engine, which would otherwise be lost at high altitude due to the rarefaction of the air. With this arrangement a 400 h.p. engine is able to deliver as great power at 25,000 feet as a 1000 h.p. engine would be if it did not have the turbo-booster. As we go higher up in the air, the air becomes less dense, and consequently offers less resistance to a body moving through it; and we are therefore able to obtain very much greater velocities. So far, with the very crude equipment that we have used for experimentation at high altitudes—that is around 30,000 feet—we have obtained speeds well over 200 miles per hour. These airplanes also will have to be provided with nacelles or cabins in which a proper mixture of air can be kept for the passengers and crew, with the necessary heating arrangements to guard against the extreme cold of high altitudes, and with electric controls for handling the airplane from within the cabin, so as to get away from the mechanical controls that we use at the present time, which require holes through the outer covering of the cabin and admit the outside atmosphere. These airplanes will very probably be of single wing or monoplane construction, with the motors set in the leading edges of the wings, the landing gears folding up into the body of the airplane, and air chambers inside of the wing so that they will be able to float when they land on the water. This class of commercial airplanes will be entirely suitable for military surveillance work. By surveillance we mean the airplanes that go out to find an enemy and then keep watch over him, and report from where they are, by wireless, what his strength, position and probable intentions are, instead of leaving him and coming back to make a personal report.

In the economical organization of our Air Service, we should take into most serious consideration the classes of aviation that have a prospective use in civil work. It is true that our Pursuit Aviation—that is, the high speed, heavily-gunned equipment that is necessary to pursue and attack an enemy—will have little or no application in commercial aeronautics. Nor will the large armored ships carrying machine guns and cannon. But all other elements of commercial aviation will have a most distinct military use, as will all the pilots, mechanics and personnel concerned in their manufacture, as exactly the same basic training has to be given to all flying personnel no matter what kind of aviation they may be engaged in. It is comparatively easy to teach flying officers everything necessary about troop formations on the ground; that is, the difference between Infantry, Cavalry, Artillery, Tanks and Transport; and it is comparatively easy to teach them what the different formations mean and are intended for. All of our observers during the War learned this within a couple of months after their flying education had been completed. The same is true over the water, except that it is much easier; that is, the different formations of a fleet, and the different kinds of vessels can be very easily learned. Any extended service in either the Army or Navy to learn what these formations are is not only unnecessary, but takes a lot of time away from the flying officer which otherwise should be spent in the air.

What has been said about the military advantages of commercial airplanes can be said with even greater force about commercial airships. Every airship has a most distinct military use, because the very elements of speed, weight-carrying ability, cruising radius, and reliability in flight, are just what we need in military aeronautics. The success of handling airships depends primarily on what we call a ground organization—that is, a system of air-ports and docks for these great ships. As with the large airplanes, so with the airships; we should establish our airship stations in groups which can be used not only for certain lines of airships, but as ultimate landing places in case that the airship station which is the destination of a certain trip is covered by a storm when the airship arrives. One or two airship stations will do little or no good towards the development of commercial airship transportation. It is notable that Germany has equipped her country with a great many airship stations, so arranged that they cover the principal highways of commerce and still give alternate landing places that can be used in case of storms; and on account of this organization, commercial airships have carried over two hundred thousand passengers without the loss of a single life, and with a regularity of schedule that is even better than that of the railroads and steamships.

There are commercial organizations in the United States to-day that would immediately embark on the development of airships as commercial carriers could they be furnished with airship docks, in a similar way for instance, that New York furnished municipal wharves for steamships engaged in trans-Atlantic service. An airship station should consist of the hangars themselves, each of which should be 1000 or more feet long, 300 or more feet wide and 250 feet high. These should be arranged in star shape around a central turn-table or round hangar, equipped with machinery for swinging the airships when drawn into this from the radiating hangars. By this system the airship can always be landed head to the wind, and always taken out of its hangar head to the wind, which makes it doubly easy to handle, and practically eliminates accidents. Most of the accidents occur when an airship is brought in side to the wind, and has to be put into its great hangar in this way. Circular airship stations of this kind have proved their great value in Germany. Airship stations should be located primarily from a strategical standpoint—that is where the greatest number of lines of communication come together. New York, for instance, is such a place. Next, they should be located with due regard to the meteorological conditions—that is, a place with low wind velocities, not subject to sudden storms, minimum variation between heat and cold, and having prevailing winds in the desired direction. The location itself should be sheltered as far as possible to guard against adverse weather conditions. Third, the location of the airship stations should be one easy to defend against attack of hostile guns or air forces, and should be provided with an adequate defense against aircraft. In the United States, we believe that there is a constant current of air blowing from west to east all through the northern part of the country, and increasing in velocity as we go up. Our experience indicates that this wind has a velocity of from one hundred to two hundred miles per hour at altitudes of over 25,000 feet, and it appears that this current keeps up all the way to Europe. It also is apparent that we get a current from



One Squadron of the First Bombardment Group. Each Airplane Carries About 400 Pounds of Bombs

west to east across the Atlantic and through the southern part of the United States. We do not yet know whether this same current crosses the Pacific or not; but we are inclined to think that it does. The same locations for commercial airship stations would be the best locations for our war airship stations, because they offer locations which have the shortest lines to where the enemies' corresponding strategical centers are. In the arrangement of our airship stations, we should therefore contemplate a deployment across the northern part of the country, one across the southern part of the country, and another set of stations through the central part of the country, to act as an intermediate series of stations. Looking at them from east to west, there should be an airship station in the vicinity of New York, one in the vicinity of Chesapeake Bay, one in the northern part of Florida. Airships going from America to Europe could undoubtedly leave from the New York area and avail themselves of the favorable winds in going eastward; those coming from Europe could land at the Southern station, or turn up the Coast and land in the vicinity of the Chesapeake, and avail themselves of the favorable air currents in the South. In the central part of the United States we should have an airship station in the vicinity of Chicago, one in the vicinity of St. Louis and one in the vicinity of New Orleans. These stations would serve both for the east and west, and north and south traffic; and in addition, the station in the vicinity of New Orleans would serve as a point of departure for South America. (The solution of the passenger-traffic problem to South America will come with the airship, primarily, because to establish quick communication from the United States, for instance, to Chile or Argentina on the ground and water requires too devious a route, and too many changes of transportation.) There should be two intermediate stations between the central part of the United States and the Pacific Coast—one in the vicinity of San Antonio, Texas, to cover the Mexican Border and for transportation into Mexico; another one in the vicinity of Ogden, which is the meeting point of the routes from San Francisco, Puget Sound and Southern California. The three on the Pacific Coast should be first in the Puget Sound area, next in the area of San Francisco, and third in the San Bernardino-Riverside Section of Southern California. With a system of airship stations such as this, passenger and mail traffic could be handled from east to west and north to south in about one-third of the time that is possible by any means on the ground; the assurance of delivery of passengers and freight would be even greater than that on the ground; and the comforts of traveling would be incomparably better. The cost of the installation of such stations would be really saved by the benefits which would be derived. For instance, it is maintained by competent naval authorities that one airship saves two battle cruisers to a fleet. A battle cruiser to-day costs about $45,000,000 completely equipped. As a means of supply for aviation units operating where they cannot be supplied conveniently over roads, we would save the services of thousands of motor trucks and would provide a means of transportation that can deliver its cargo where no other can. The saving in time in transmission of mail and passengers would be incalculable. As a matter of fact, each station would not cost more than $10,000,000—only a small part of what terminal facilities, either for railroads or steamships, do in large cities. The Grand Central Station installation in New York is said to have cost $200,000,000; the new railway station in Chicago, $60,000,000; and the one in Washington, $30,000,000. There are correspondingly expensive railway terminals in all other cities. The airships can carry one hundred first-class passengers between New York and Chicago; an average railway express train carries about 150. The cost of the railway train with its tracks is many times greater than the airship. The commercial use of airships is not possible until a development of airship stations takes place as indicated above. A commercial company would have great difficulty, or find it practically impossible to develop such a system. The Government, therefore, should undertake this development, as an element in its national defense system, and allow any commercial airships which pass the Government inspection to use these airship docks on their voyages.

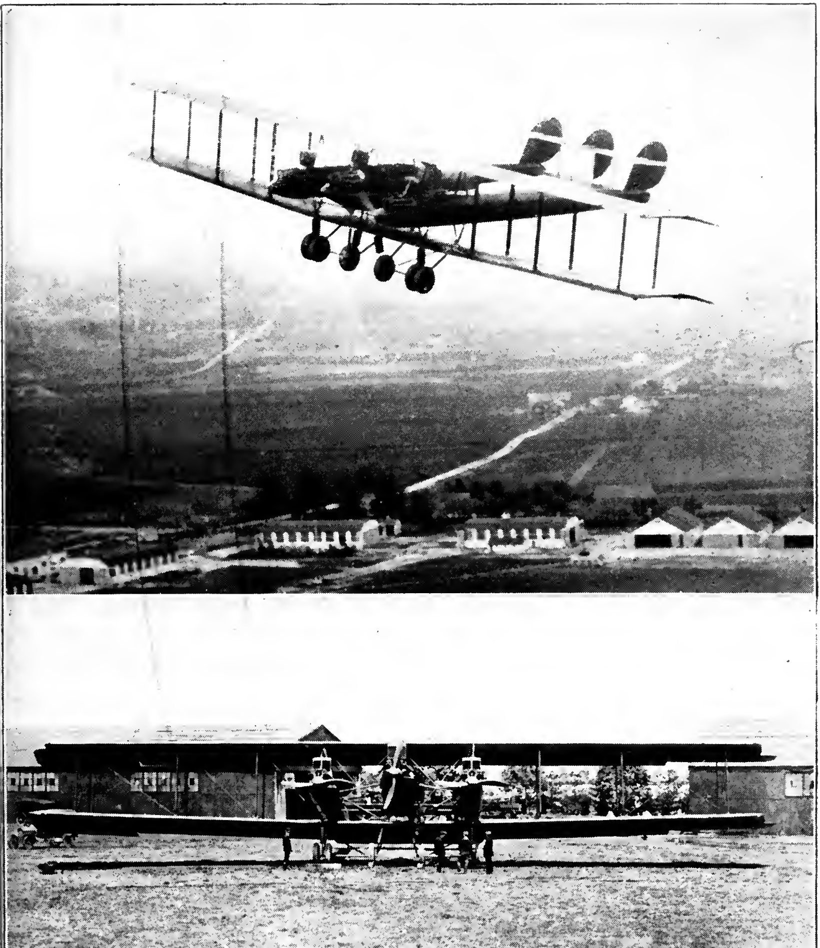
For several years at least 90 per cent of aviation will be military in character; and in the organization of our air resources, we must be concerned primarily with its rapid utilization for war. All the personnel, equipment and methods of work should be modeled along that line. At the same time, the Aviation Service should be run and handled in the most economical manner possible. This may be accomplished, first, by keeping just as few men permanently in the service as possible, but having them in trained and organized reserves, distributed in the great centers of population throughout the country. Next, as many of the airplanes as possible should be used in pursuits that are useful and profitable in times of peace. The Forest Patrol of the Army Air Service alone saved the Government more than the combined appropriations for Air Service cost the Government during the years 1919; and will save even more during the year 1920. These airplanes could be used for mapping the country, which at present (and after 140 years of our Government), is only 40 per cent mapped. We believe that this could be finished, with a proper organization and system, within three years by airplanes. The landing fields and airdromes could be almost made to pay for themselves, by carrying advertising on the fences around them; by giving various exhibitions throughout the year at different times, for which a small fee would be charged; and by giving courses in flying and aeronautics.

We should develop and construct metal airplanes which can be stored for long periods of time without deterioration. At the present time it is almost as costly to put a wood and wire airplane into storage as it is to fly it all the time, because the wood dries out and cracks, or gets mouldy and rots, so that each time the airplanes are taken out of storage they have to be entirely gone over, cloth removed from their wings, wires replaced where rusty, new cloth put on wings, and almost a complete rebuilding of the airplane has to take place. Not only is this costly from the standpoint of material, but from the standpoint of time, if it is necessary to have the airplanes available at once to meet an attack from an enemy, it is extremely dangerous. At the present time, it would take over three months for us to take out airplanes we have in our war reserve and make them available for service with their squadrons and groups. By that time, if we were attacked by a first-class air power, all the fighting in the air would be over; our great cities and strategical centers subjected to the unhindered attack of hostile aviation; and our country overrun by enemy aircraft. Good metal airplanes would do away with many of these disadvantages. We must therefore work up our means of producing suitable metal for airplanes, and of constructing them of that substance instead of wood.

The storehouses where the reserve of aviation should be kept should correspond with the localities where their use will be required to the greatest extent. The most dangerous area, of course, is from Boston to Chesapeake Bay, and from New York to Chicago in the East; and in the West, Puget Sound, San Francisco and Southern California. These places are all coincident with our centers of population, and naturally these same places contain the greatest number of pilots that were trained during the War. These same pilots will soon lose, not only their ability as pilots, but very largely their interest, if they do not see something done to further aviation in their particular vicinity. They have all entered civil life, but are just as much interested in the aviation part of the national defense as they ever were; and in the event of reserve organizations of airplanes being formed in their vicinity, 90 per cent of them would be more than willing not only to join but to do everything they could to further aviation. There is a greater community of feeling among people who go in the air than is the case in any other calling. This is due to the character of the men who have gone into this work, the common danger to which they are all exposed, and the appreciation of these qualities of one by another. We should therefore organize the excellent trained air personnel that we now have distributed all through the country into regular reserve air organizations; not only so as to utilize their own services, but because many of these learned the air business in the War, which gives them an advantage that they could obtain in no other way, and which they will be able to transmit to those with whom they come in contact. If we lose this invaluable asset which we now have, we will never be able to get it again. We have every active element in this country to create a splendid aviation; and we are the only country that has all the personnel, all the raw material, all the factories, and everything necessary to be entirely self-contained in this respect.

It may be asked why we need an Air Service at all. The answer is the same as is the necessity for an army or a navy. As to the size of the Air Service, we must gauge that on the size of an Air Service that may be brought against us, and on the size and extent of our country, because if we are attacked we must protect it at all points. Our land and water boundaries in this country are tremendous. The Atlantic Coast line is 5560 miles long; the Gulf of Mexico line, 3640; the Mexican border, 1744 miles; the Pacific Coast line, 2730 miles; and the Canadian border, 3898 miles; making a total of 17,572 miles. The whole area of the United States is 3,026,789 square miles. This is entirely exclusive of Alaska and our Insular Possessions. Our cities are much more vulnerable to air attack on account of the character of their construction, which is very inflammable, than are the cities of Europe, which have a maximum of stone and masonry in their edifices.

England alone, with her airplane carriers, can transport across the sea 400 airplanes in the hangars and on decks of these ships—set up and



An American Heavy Weight Bombardment Airplane, (above) in the Air, and (below) on the Ground

ready for flight—and an additional 800 as cargo. These can cross the Atlantic in a maximum of seven days' time, while the additional 800, or 1200 in all, can be made available for service within a week after a landing is effected. France has over 3000 airplanes in her units now in service. Were Germany allowed to, she would have a greater number of airplanes than either of these countries. The United States to-day cannot turn out one single squadron equipped with airplanes of the latest design to combat the air forces of a first-class power. What is the reason for this, it may be asked? The answer is that we have had no real air organization in this country. We were plunged into the European War without one, and we have emerged from the War without one. What we have are from ten to twenty different Government organizations, concerned more or less with aviation as an auxiliary to their main activities; with a result that there is no combination of effort worthy of the name, and at least a thirty to forty per cent unnecessary overhead, lost motion, and unpractical direction of aeronautical affairs. Neither is there a single man or a single bureau responsible for aviation and for its complete development in this country. The Army has a part; the Navy has a part; the Post Office Department has a part; all the bureaus of the Government are either using or want to use certain parts of aviation, and each follows its own route more or less in the obtaining and distribution of its duties. There are no laws regulating commercial use of airplanes, no system of inspection of aircraft or aircraft pilots, and no aid or fostering of aviation.

Therefore, as things stand at present, in case of war the United States has not now in being an organization which could develop a national aviation, maintain an aviation or fight an aviation as a national force. This would have to be recreated as it was during the last war. This is a terrible situation to contemplate, in view of the decisive influence of aviation on the wars of to-day. It must be apparent to all. We should organize a department of aeronautics at once, which is the only solution of this important question.

CHAPTER XVI

What the United States Should Do Now to Establish Its Aeronautical Position

The first thing that the United States should do is to establish a Department of Aeronautics, specially charged with the development of all matters relating to the air. This department should be co-equal with the War and Navy Departments in all respects. The person appointed to head this bureau should be held responsible to the President and Congress that aviation is developed and fostered, and that the maximum benefit is derived from every cent that is spent by the people for aeronautics. This organization would make one man specifically responsible that aviation was developed, so that if anything were wrong with it there would be just one man to hold accountable for the shortcomings, and not about fifteen or twenty as is the case at present. In the organization of the department, cognizance should be taken first of our military needs, what the lessons of the European War were regarding aviation, and how these can be applied to our particular position and situation in this country. Our solution of the aeronautical questions involved will be quite different from those that obtain in Europe; and we must not make the mistake of blindly following what others do, but must develop our own resources to correspond to our particular needs. The Department of Aeronautics will give a chance for this to occur, by really fostering our aeronautical, tactical, technical and organizational genius in this country, which I am certain, after contact with all the other Services, to be superior, if it is given a chance.

First, we must take into consideration the military aspects of aeronautics, and constitute a real air force, which can be mobilized with rapidity at the outbreak of a war. The first battles of the future will be held in the air, and the results of these battles will either determine who shall win the war or have a very marked influence on it. Consequently, speed of mobilization is the first requisite. Our air force should consist of some 5000 airplanes, with twice that number in reserve in the storehouses, that would be available for replacements during the first two months of a war. In quantity production, the cost of metal or composite airplanes would be not much more than one-fourth of what we now have to pay for the few wood and wire experimental types of planes that we have. Fifteen hundred (1500) of these airplanes should be assigned permanently to the Army and Navy for their own immediate use in observation, including the observation of the Coast. Twenty-two (22) airships should be provided and distributed at the rate of two to each airship station mentioned in a former chapter. The remaining 3500 airplanes should be organized with 60 per cent of them as Pursuit Aviation, 20 per cent as Bombardment Aviation, and 20 per cent as Attack Aviation. Twenty (20) airplane carriers should be provided for these airplanes when used over the water. (We believe that the provision of these airplane carriers would, in a few years, render it unnecessary to maintain surface battleships, battle cruisers, torpedo boats, or most of the naval surface craft.) These Air organizations should be distributed throughout the country among the centers of population according to their size; for instance the greatest number should be near New York, the next greatest should be near Chicago, etc. About one-sixth of this force should be organizations at war strength, to act first as a model according to which the reserve air organizations could be patterned; second, for use in small expeditionary forces—for instance to Cuba, Mexico, or places of that kind; third, for use in case of domestic disturbances; and fourth, for the purpose of training commanders and staffs for all the air units. The whole thing should be known as the Air Force, and the personnel should be assigned either to an active or reserve status.

The active air force should carry out its peace-time military instruction in combination with the Army and Navy, and also in maneuvers to bring out its own special work. During the period of the year in which it was not engaged in this, it could be used for mapping, forest patrol, or in any way to assist the other departments of the Government.

The reserve air force should be organized definitely into squadrons, groups, brigades and higher units, right alongside of the active air force units permanently in the service. These units should have a small proportion of their personnel constantly on duty to look after their property, keep their airplanes in condition, and attend to the instruction of the reserve personnel. Each reserve pilot should be required to fly for an hour or two each week, and turn out with his organization for a couple of weeks during the year. There will be no trouble at all in maintaining an air force on a voluntary basis by this method on account of the great interest which the American people take in aviation. The cost of maintaining a force of this kind consequently would be cut down to about one-fifth of what would be necessary for a regular force. In fact with a combined air force the cost would hardly exceed what we are spending now for aeronautics.

All the civil departments of the Government which require aviation for their own uses could either employ aviators or obtain the material from the Department of the Air; but in any case, the aviators should be reserve officers, and the airplanes suitable for military purposes so that they could be used in war. For instance in the admirable organization and work contemplated by the Post Office Department, the Department of Aeronautics should assist them in obtaining personnel and then provide the material that is necessary for their work—it being understood that all would be immediately available on the outbreak of a war. They should be left the entire direction and control of the force in time of peace.

Our first division then of the Department of Aeronautics will be an Air Force, with the usual staffs required for such an organization—that is, an Administration Section, which would handle all the correspondence, records of personnel, and see that the methods of paper work and administration through the force were co-ordinated.

Next, a Training and Operations Section, which should make up all war plans for the Air Force, and provide methods and means of training the personnel to meet these conditions.

Third, an Equipment Section to keep track of all equipment which the fighting air organizations have with them, their proper feeding, transportation, clothing, housing, pay, and the upkeep of the airdromes.

Fourth, a Medical Section, which would see to the physical well-being of all the Air Force, and the education and handling of the flight surgeons.

Fifth, a Legal Section that would attend to all courts-martial, methods of discipline, and legal matters pertaining specifically to an Air Force.

As the training of the air personnel in flying and mechanics is common to every use—whether it be with the Army, the Navy, or any other department of the Government—the primary aeronautical schools should be the same. After the fliers are graduated from the primary or pilots' schools, they should be specialized in the particular kind of aviation that they are going into. For instance, an Air Force assigned for observation purposes to the Navy should have its special school, and an Air Force assigned to the Army should have its special school. The offensive units of aviation, such as pursuit, attack and

A Group of American Airdromes near Mineola, Long Island

bombardment, should have their special schools—all of these being fed from the common air force reserve, which could shift the personnel wherever the greatest loss occurred. For instance, in Europe, when the Army was so badly in need of pilots on the front, during the most severe fighting, the Navy had pilots who were waiting for their airplanes who could do nothing against the enemy. With an Air Force organized as a distinct unit, such a thing would be impossible.

All of the Air Force should be organized into appropriate tactical or combatant units, such as squadrons, groups, wings, brigades, and divisions, each with their appropriate staffs and supply elements.

Besides the Air Force there should be two main divisions under the Department of Aeronautics—the Supply Division and the Division of Civil Aeronautics.

The function of the Supply Division would be to devise, obtain, store and issue the flying equipment and all the stores that the Air troops require. This is a very important function. Two things are always necessary in a military organization; one, the personnel, and the other, the equipment. They must be organized into a team so trained that they will drive together; but in driving together, the personnel that has to use the equipment must be the part of the service that prescribes what it shall be. Otherwise the troops will not get what they require, and what is needed to use against the enemy. Whenever a bureau or department is organized so that the troops do not control the material which they are to get, it is sure to end in disaster, because some good-for-nothing thing will be created which cannot and will not function properly against the enemy. We have had many examples of this in our own experience. In fact, this has been one of the most potent lessons that we have learned in aviation. This is the principal reason why a Department of Aeronautics, created merely for the purpose of producing equipment, and not having an air force as a part of it, would never be successful, because a combatant Air Force would be unable to make it supply the equipment it wanted. This has been the result of the experience of every air force. The Supply Department should be headed by a flying officer experienced in this very important duty; and should be separated into the following sections: An Engineering Section, which should attend to all the technical questions involved in devising and constructing new airplanes, engines, guns and cannon, cameras, and wireless meteorological equipment and all their accessories, exactly as the troops want them. They should always have on hand models and complete specifications of airplanes suitable for each branch of aviation—pursuit, attack, bombardment and observation, so as to be able to put them into immediate production in case of war.

Right alongside of the Engineering Section should be the Procurement Section, which should be charged with the construction of the aeronautical material in the factories; and which, in time of peace, should have complete data on where all raw materials entering into the construction of airplanes may be found, how long it would take this to be put into suitable shape to be manufactured, what factories in the country were capable of using this raw material so as to build airplanes, engines and their accessories, and the the tools, jigs and dies necessary for this purpose. They should at all times have available data which would show how many airplanes, and of what type, can be built in a certain time; how this could be increased or decreased so as to meet the necessities of a campaign, and so as to accord and co-ordinate with the construction work required for other activities of the Government, such as the Army, the Navy, the railroads, or any of the other undertakings which have to work together in time of war. The Engineering and

Procurement Sections should be under the same general head, so that their functions could be co-ordinated; and they should also be charged with the inspection of all material that is being constructed in the factories, and all material in the hands of the troops, so that in this way they would be forced to keep in touch both with what the air troops were doing and what the means of production were capable of creating.

When the Procurement Section had obtained the material, it should be turned over to the Section charged with the care of property, and be stored in the depots. Depots should be at strategic centers at which material could be easily collected from the factories, and from which it could be easily sent out to the troops. These depots should be the places where the various parts going into the complete airplane would be brought together and assembled, and made ready for use. The depots should consist of supply sections, repair sections, and salvage sections. All equipment sent to a depot would go through the repair section, be assembled, repaired, rebuilt, cleaned and fixed up as would be necessary, and would be put into the supply warehouse. When it came out of the supply warehouse for issue, it should be checked by the repair station to see that it was in fit condition to turn over to the air troops. If found to be in improper condition, it should be repaired right there; and if in good shape, it should be checked through and delivered to the troops in good condition, when the responsibility of the supply depot would end.

The salvage section should be charged with the recovering of all wrecks, and saving of all parts which could be used in the future. This is a very important matter which it has been difficult to organize and put into working shape in the past, with the consequent loss of a great deal of material and money.

Another section of the supply department should have to do with finance, drawing of proper contracts, payment of obligations, and the distribution of funds throughout the Air Force. In this way, all matters relating to supply of airplanes, engines for them, balloons, dirigibles, armament, signaling and communicating devices, meteorology, photographic instruments, transportation of all kinds, housing and shelter, and all fiscal methods concerned in the handling and use of these things, would be co-ordinated. There is no trouble in properly organizing a supply department for aeronautical needs, and making it work. The difficulty is in getting the proper personnel to handle it. Organization is only a means to an end. It is not the end; and no matter how good the organization may be, if well instructed personnel is not put in it to handle it, it cannot succeed.

The third part of the Department of Aeronautics should be the Division of Civil Aeronautics. The main object of this department should be to foster the development of commercial aviation, by establishing and making available all the airways and airdromes throughout the country, owned by the Government, for the use of properly licensed airplanes; to give advice to those desiring to enter commercial aviation as to what costs of upkeep, cost of maintenance, and prices charged for transportation should be; the dissemination of proper data relating to civil aeronautics throughout the country; and of being charged specifically with the regulating of all air traffic from an interstate and international standpoint. The Division of Civil Aeronautics should have a Law Section under it, which should be charged specifically with the drawing up of projects of law relating to control of air-borne commerce, both from an international and an interstate standpoint; the licensing of pilots; laws relating to license and inspection of aircraft and their accessories; laws for navigation in the air; and for defining and interpreting the laws of other countries relating to civil and commercial aviation. The United States at this time lags way behind in its legal handling of aeronautical matters. No commercial company can go into aviation now, and be sure of what its legal rights are; what its privileges are; where it is trespassing; whether, in case of a forced landing, it is liable for all sorts of damages; or what rights it has in any case whatever. Aircraft have been, and still are, regulated under war-time legislation, which, of course, puts everything into federal power. This will soon cease, however; and good efficient air laws are necessary. These naturally must be federal in their character, otherwise every State will have a special rule of its own, which will greatly hinder the development of aviation, because airplanes due to their speed will be able to cross many States in one voyage.

Next, a section of the Division of Civil Aeronautics should be called the Air Traffic Section, and under it should be the civil air police that would attend to all inspections of foreign aircraft entering our domain; seeing that they did not fly over restricted areas; that they confined themselves to the prescribed elevations and airways; that they landed at the airdromes prescribed; and that they were properly equipped with licenses, safety devices, etc. The air police, in time of peace, would see that the airways are properly used by traveling aircraft; that unauthorized crossing of cities by certain classes of aircraft, or aircraft at low altitudes, is prevented; that all the aids to navigation both for day and night flying are in place and kept in proper condition; that the instructions as to use of landing places and airdromes are strictly complied with; and that prompt information be sent back about any wrecks that might occur throughout the country, so that the crew of wrecked aircraft could be assisted and helped in any way practicable.

A very interesting suggestion has been made in this connection by Asst. Postmaster General Praeger, that the boys along the airways be organized into "Aircraft Troops," somewhat similar to the Boy Scouts; and that these boys' organizations be taught what the different kinds of airplanes are, the sound of the motors, so as to be able to determine whether the airplanes are in trouble or not, what to do in case an airplane is wrecked, how to administer first aid to the pilot and passengers, how to report promptly any mishaps that occur, and how to guard the airplane and its contents when it has had a forced landing and is in need of care. This would be an interesting, profitable and fascinating education for the average American boy; and would result in a great deal of useful aeronautical in-

Shipping Anchored in the James River. Easily Sunk and Destroyed by Aircraft

One of Our American Ship-Yards. An Excellent Bombardment Objective

formation being distributed, which would help in the development of aviation. In short, the Air Traffic Section should handle everything relating to the maintenance and control of civil and commercial aviation throughout the country.

The next section under the Division of Civil Aeronautics should be a Civil Air Development Section; that is, one which obtained all the data relative to the economical use of aviation in commercial pursuits—what it cost to move a pound or a ton of certain kinds of freight or express from one part of the country to another, what times of the year were propitious for this sort of work in various places, where the equipment for doing the work could be obtained, how much it would take to maintain it, where the landing fields would be, where suitable pilots and mechanics could be obtained; and in case that any company desired expert opinion on the effect of a certain project which they intended to go into, that they could be assisted by this department to get the most reliable information on the subject. This department should also encourage the formation of companies for commercial aviation; and wherever they saw an existing organization that could benefit by use of aircraft, to tell them how these could be used to the greatest advantage. They should report promptly the operations of all commercial aircraft throughout the world, so that our own people would be kept constantly informed from a reliable source of just what was taking place. This section also should let it be known what facilities the Government had to offer in the way of airdromes, air lanes, and materials and spare parts for the various kinds of airplanes at the airdromes throughout the country. A commercial Air Development Section should attend to all the publicity necessary in the Division of Civil Aeronautics.

The last section into which the Division of Civil Aeronautics should be divided would be the Operations Section. To this should be referred all the requests of the different departments of the Government that desired aviation for their specific work, whether they wanted to take it and operate it themselves—as the Post Office Department is doing now—and if so, what kind of airplanes and equipment they desire, and what sort of pilots and mechanical personnel. These men could be obtained from a central reservoir and turned over to the department for their use as they desired. In this way, general Government inspection would be applied to the pilots, so that competent men would be obtained who had passed the Government examination, and the airplanes and material would have passed the inspection of the Technical Section for the particular use to which they were to be put. In this way the greatest safeguards on delivering efficient personnel and material would be insured. In case the Geological Survey needed personnel and equipment for mapping, or the Department of Agriculture required certain forest patrols or the expansion of forest patrols, the Operations Section would make all the arrangements ahead of time for obtaining exactly what these organizations desired, and see that they were ready at the proper time and place. If operations in the civil departments of the Government are not co-ordinated by an agency of this kind, each one will have its own complete organization, with the incident overhead for carrying this into effect, which of course is a very expensive and uneconomical manner of doing this work.

The Division of Civil Aeronautics, then, should have four sections, namely: Law Section, Air Traffic Section, Commercial Air Development Section, and Operations Section.

For the formation of any new department, experience is the surest guide to its proper organization; and in suggesting the matters that I have mentioned above, the experience that we have obtained so far, and that of all the European countries, has been taken into consideration.

Such an organization applied to the aeronautics of the United States would allow 30 or 40 per cent more to be done with a given amount of money than is the case at present, where very much the same duty is being done by the Army and Navy, by the Post Office Department, and by other departments of the Government that intend to use aviation in the future.

CHAPTER XVII

A Glance into the Future of Aeronautics

In the development of aeronautics, one has to be careful that the imagination does not run into unpractical channels when a question so unlimited as aviation is considered. Each thing in the development of aviation should be proved to a sufficient extent to warrant the entrance of the Government into it before it is attempted. The development of aviation, however, since the first flights of the Wright Brothers at Ft. Myer, Va., to the present, has been much more rapid and practical than in the time required for a corresponding development of steam engines and electricity, automobiles, the telephone and telegraph, or wireless telegraphy. Even with the instruments that we now have for navigating the air, and with proper arrangement of facilities as mentioned in this book, not only can military protection from attack be obtained, but a great use from a civil and commercial standpoint.

Looking into the not very distant future, we can see the organization of our aeronautical resources so disposed that the minute war starts, our airships can cross the Atlantic Ocean within thirty-six hours, keep the whole area under observation, and report anything that comes across it. They will be able to cross the Pacific in seventy-five hours or less, and do the same thing in that area. Fogs, rains and storms will not impede them, and they will be in constant communication with their own country by radio telegraphy. Airship stations can be provided in Alaska, Panama, Hawaii, Guam and the Philippines, which will give a splendid back-bone for airship communication in that direction to Asia and Australia. Our own country will be organized for air travel, in time of peace, in very much the same way that the automobile roads are laid out at the present time; that is, we get an American Automobile Association Map and it shows a red road, or a yellow road, or a white road, leading to a certain place. All that one has to do is to follow these marks, which are usually painted on the telegraph poles, and a map is unnecessary. Airways will be organized in a similar manner for airplanes, and the tops of buildings, railroad stations, fences—and where these do not exist, as on the prairies, rocks—

painted different colors, or other marks will guide the airplane unerringly from one point to another. Storm warnings will be given to them by wireless telegraphy; and in case their contemplated landing place is covered by fog or storm, they will be able to go to another which is clear. To-day if a road, or even a cleared and smoothed out place 200 feet broad, were built from New York to San Francisco, with a white line along each side of it, airplanes could fly from New York to San Francisco and land any time they desired; and there would practically be no accidents even now. While, of course, this is impracticable, still facilities can be made for landing every 100 miles or so, and all suitable fields marked, so that the aviators will know where they can get down safely in case of trouble. This organization of airways is not very far away in the future. Under these conditions, an Air Service organized with well-balanced units of Pursuit, Attack and Bombardment Aviation, among the civil population as reserve organizations, and having their equipment constantly at their airdromes, could be mobilized in a maximum time of two or three days. They will be able to cross the whole United States from east to west in a maximum of 36 hours' time; and assemble at a threatened point in a manner undreamed of even at present. The airplanes will be able to float on the water as easily as they land on land; and they will be able to attack hostile aircraft or their aircraft carriers 200 miles at sea, so as to keep the enemy completely away from our coast. No navy will be able to exist against air attack unless it obtains an absolute air decision beforehand; and, as an Air Service will eventually be able to sink any warship, there will be no use in maintaining these expensive instruments for national defense. When warships are driven off the surface of the sea, they will go under the surface; and in order to maintain themselves under the surface, they will have to armor themselves to such an extent that again their usefulness will be limited on account of their weight. They will not be able to go fast, and will be very restricted in their field of operations. They will also be very expensive. It, therefore, appears that aviation will cause the abolition of all armored ships, either surface or sub-surface; will cut down the size and weight of armament that is carried on all shipping; and will cause the surface ships to be used entirely as cargo carriers whose military protection will be furnished from the air.

In case an offensive war is necessary, the air organizations will fly across the water to their destinations, and be supplied by airships without

Langley Field, Virginia

any recourse to communications on the ground or on the water. They will be able to force a landing in a hostile country through their own power, protect it and transport enough personnel there to defend the position, and maintain their own aircraft. No part of the country will be immune from attack to the nation having control of the air, as no frontiers exist for air forces, the air being the same the world over. The cost of maintaining a force of this kind, as compared to a navy or an army, will be very much less; and the number of men that will have to be removed from useful commercial pursuits will amount to very little—even with the greatest air force which we can conceive at the present time, not one-twentieth as many would be necessary as for an army, and less than one-fourth of what would be necessary for a large navy. A navy cannot work on land; an army cannot work on the water; an air service can work over both. In time of peace, the same airways can be used for our civil and commercial aviation that are used by the military aviation in time of war. In fact the civil and commercial aviation can be almost entirely transformed into the military aviation in no time. The passenger-carrying airships will be able to take one or more hundred passengers from New York to San Francisco in thirty-six hours; will be able to go to Europe in about the same time; and able to go from San Francisco to Asia in about twice that time. A flight from New York to South America by airship will require only about four days, where it now requires four weeks; and no parts of the mountains, forests, or deserts will be inaccessible to airship travel. Shipments of ore from inaccessible mines will be facilitated. Machinery and other implements will be landed where it is impossible at the present time, and supplies of all kinds delivered for their upkeep. The airplanes, on their part, will map the whole country within three years after they start; whereas only 40 per cent has been mapped during all our existence. Every department of the Government will use them in the execution of some part of its work; the forests will be guarded from fire and destruction by the airplanes; the game and fish laws will be enforced by them; studies will be made of all the rivers and coast lines, harbor improvements, architectural studies in cities, laying out of park systems, and of innumerable municipal improvements. Airplanes will carry passengers to Europe in from six to ten hours from New York; and important dispatches and documents will be sent in a similar manner. The development of aeronautics is infinite. While it is still expensive and somewhat dangerous, this is being overcome every day; and it is increasingly evident that the future national defense, future predominance in commerce, and the future economical development of a country lie in the air.

THE END.