The TRIUMPH of the NC's

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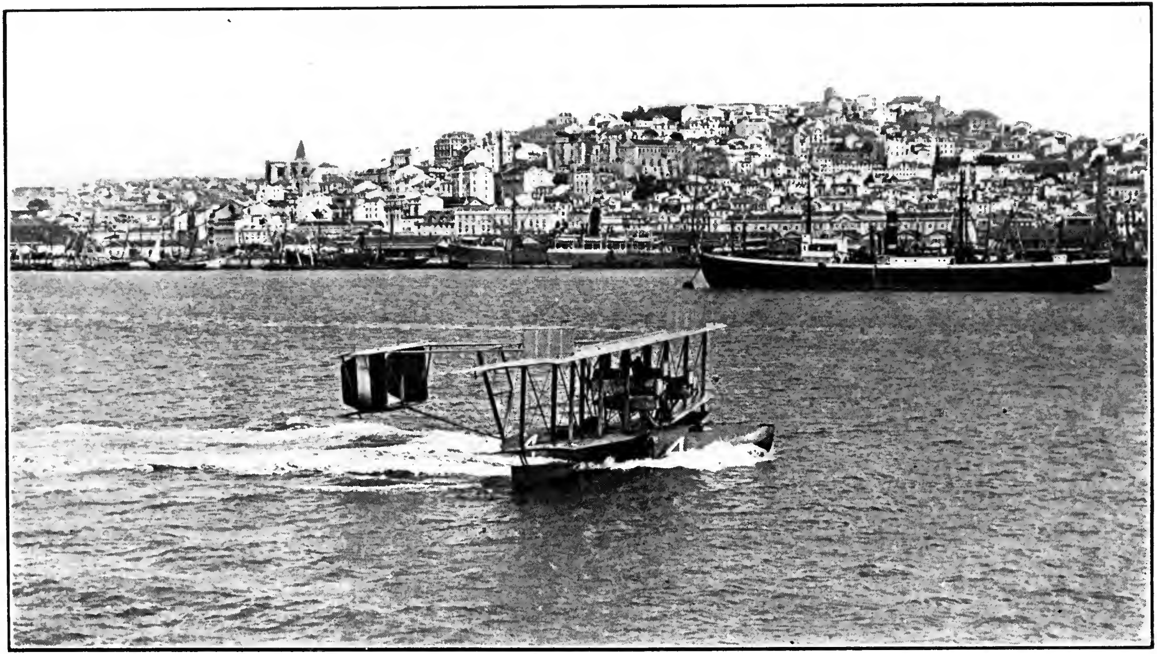

THE *N.C. 4* TAXIES ALONG THE LISBON WATERFRONT

"The biggest thrill of the whole trip was experienced as we passed over the beach line of Portugal and realized that the trans-Atlantic flight, the first one in the history of the world, was an accomplished fact."—*Commander Read's Narrative*

THE TRIUMPH OF THE N.C'S

BY

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COMMANDER H. C. RICHARDSON
AND
LIEUT.-COMMANDER A. C. READ

DOUBLEDAY, PAGE & COMPANY
GARDEN CITY NEW YORK LONDON
1920

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HOW THE FLYING BOATS WERE DESIGNED AND BUILT

By
Commander G. C. Westervelt

The Triumph of the N.C'S

CHAPTER I

ORDERED TO PERFORM AN IMPOSSIBLE BUT NECESSARY TASK

EARLY in September, 1917, Rear-Admiral D. W. Taylor called Naval Constructor Hunsaker and me into his office, and took our breaths away by giving us terse instructions to begin the design of a seaplane that could cross the Atlantic under its own power. The longest non-stop flight that had then been made was only about 1,200 miles, and that had been accomplished under ideal conditions, in the immediate neighbourhood of a flying field where any ordinary mishap would have resulted merely in an enforced landing. The shortest route across the Atlantic required one hop under very difficult conditions of at least 1,330 miles. And here was the Chief Constructor of the United States Navy calmly commanding us to bridge that gap, and, if possible, the full 1,933 miles from Newfoundland to Ireland—to do what the combined genius and resources of France, Italy, and Great Britain had not achieved in three years under the desperate stimulation of war.

I had just returned from a trip to England, France, and Italy, where it had been stated by thoroughly practical and experienced men that airplanes of such a size and of such a radius were as yet beyond our reach. Much investigation had pointed in the same direction, and Naval Constructor Hunsaker, who was the head of the Aeronautical Division of the Bureau of Construction and Repair, and had had a great deal of experience in such matters, felt the same way about it. We presented the objections that were in the way, and Admiral Taylor, after listening patiently to them, waved his hand as if to close the conference, and turning in his chair ended the discussion by ordering us to, "get busy and produce results."

The two of us left the Admiral's office together, and as the door closed behind us we paused, as if by mutual inspiration, and looked at each other.

"What do we do now?" asked Hunsaker, after a moment.

"I wish I knew," I replied.

From the time of our entry into the war until the middle of June the War and Navy Departments had been endeavouring to secure information regarding the air services of our military associates sufficient to make possible the adoption and carrying out of an effective programme, but conclusive information had not been forthcoming. Though much information had been obtained from many sources, though numbers of British, French, and Italian officers had come to the United States with sample planes and with advice, and though definite recommendations had been received from the War Departments and Admiralties of Great Britain and France, the recommendations were so various and contradictory that it had not been possible to base our actions upon them.

Because of this, on the 16th of June, 1917, a somewhat hastily formed joint Army and Navy Commission, composed of Major R. C. Bolling, Captain V. C. Clark, Captain E. S. Gorrell, Captain Howard Marmon, and Captain Hughes, for the Army, and Lieutenant W. G. Child and myself for the Navy, sailed for England, in order to secure first-hand information on which to base a programme.

The investigation carried out took us through various airplane factories in England, France, and Italy, and on August 20th, I sailed from Liverpool in order to lay before Admiral Taylor the information that had been gathered concerning airplanes to be used by the Navy.

On the date of our arrival in London there was around the American Embassy, where all our naval activity in Europe was centred, a most remarkable and profound atmosphere of apprehension. The seriousness of the submarine menace had become apparent. Small progress, only, had been made in defence measures; and there were not lacking officers in our naval service who were most frank in their statements that disaster was being postponed from day to day only by the most remarkable good fortune, and that the margin preventing it was of the narrowest. It was impossible to enter this atmosphere without feeling the chill which comes from the possibility of a disaster seemingly almost impossible to guard against.

I immediately devoted my attention to the subject of aircraft defences against submarines. The officers of the British Admiralty connected with the Naval Air Service, or with the British Air Board, dealt with me in a spirit of the most absolute frankness and openness, and placed at my disposal all information bearing on the subject. It was easily seen that, of the Allies, only Great Britain had developed a naval air service to the point where it could be regarded as having any effect on submarine activities. It was practicable, therefore, to report to Admiral Sims within a few days, for cabling to the United States Navy Department, the preliminary conclusions of the naval representatives regarding the steps the United States Navy Department should take in connection with air matters, and the direction in which it was believed results could be earliest obtained. It was our recommendation, and in this recommendation Admiral Sims concurred, that we should proceed immediately to the development of both lighter-than-air and heavier-than-air craft. Of the former, our state of manufacturing preparedness made it seem possible that kite balloons, for towing by surface craft, must be our principal contribution. Of the latter, those seaplanes known commonly as of the "flying boat" type must be the result of our activities.

It was fortunate that a decision could be made in favour of flying boats, as in this one type of flying craft alone was progress in the United States up to the best made elsewhere. For this progress, Mr. Glenn Curtiss, the celebrated developer and manufacturer of seaplanes, must be thanked. His interest has always been mainly in water flying craft, and, in addition to being the originator of the type, the inspiration for most of the development has come from him and from his work.

It will be shown by photographs how flying boats are differentiated from hydroaeroplanes. Briefly, a flying boat is a boat hull with wings and tail surfaces attached to it which is capable of flight; a hydroaeroplane is an airplane of conventional type in which the ordinary landing carriage of wheels and struts has been replaced by one of pontoons, or floats, and struts. A brief summary, giving the advantages and disadvantages of each type, will further develop the subject. In this connection, however, it must be said that this summary is largely my own summary, and that concerning this subject considerable controversy rages. There is the flying boat school, and the hydroaeroplane school, and the more determined of the followers of each of these schools will yield little to each other. In my opinion, flying boats are more seaworthy than hydroaeroplanes; they are able to land upon, and get away from, seas of greater height; more comfortable quarters for the pilots and crew can be provided; and greater gasoline capacity, more uniformly distributed, can be arranged for. Hydroaeroplanes possess the advantages of being somewhat faster for equal power, and of being somewhat more manœuvrable in the air. As airplanes for fighting purposes they would also be superior since they would permit of better arrangement of guns for defensive or for offensive purposes. This latter, however, is probably true only of small craft, as on large ones it is possible to arrange guns so as to secure fire into all portions of the air.

Fundamentally, all water flying craft are seaplanes, but it is necessary to adopt some method for definitely defining the kind of seaplane meant. That adopted by myself, and the one I shall follow throughout this account, is this: When seaplanes are spoken of in the plural, water aircraft in general will be meant; a seaplane spoken of in the singular will mean a hydroaeroplane or airplane of the float type; a boat or flying boat, spoken of in the singular, or boats and flying boats, spoken of in the plural, will mean a seaplane or seaplanes of the boat hull type.

In recommending types of flying craft for use against submarines many things had to be taken into consideration.

First of all to consider was the engine. At the time of which I am speaking there was not built in the United States an engine of sufficient power or reliability to make possible its consideration in connection with an aircraft programme. There was under development, however, the Liberty engine. Since then this has proven to be an engine of wonderful success, but it was necessary, then, in a large degree, to take it for granted that this engine would turn out successfully, and that our flying boats could be motored with engines of this type. In order to avoid an entire reliance on this work of development, though, we recommended the immediate undertaking of the manufacture of Rolls-Royce engines of 300 to 400 horsepower.

During the time I was abroad, the first Liberty engine had been built and run. The results of this first test were unexpectedly favourable. By the time I returned to the United States this engine, originally designed for 330 horsepower, was showing continually increased power, and its reliability had been proven to be such that practically all thought had been dismissed of manufacturing Rolls-Royce motors. The United States, in its air problem, had decided to plunge entirely on the Liberty, and to sink or swim with its success. At that time I considered this decision one involving great hazard, and I still consider it so. It is true the outcome was successful, and that the Liberty developed gradually into the premier airplane engine of its type in the world. Had the outcome failed to be successful, however, the United States would have been practically inert so far as its air forces were concerned, and would have been able to contribute little or nothing, in this direction, toward winning the war.

The great outstanding accomplishment of the aeronautical endeavour of the United States, during the World War, was the Liberty engine. Starting almost from a standing start, this engine was developed in something less than a year into the leading aviation engine of its type of the entire world. Its simplicity of construction and its suitability for American manufacturing methods are such that in about a year the output of these engines became equal to the entire output of the rest of the world of engines of nearly the same horsepower. During the final thirty days before the signing of the Armistice, there were produced of this engine more than had been produced by all other nations of all other engines of similar type and comparatively equal horsepower in any twelve months.

Mark Twain once said, in essence: If an intellectual giant can be found holding an opinion, another intellectual giant can be found who holds directly to the contrary; if an intellectual pygmy can be found holding an opinion, another intellectual pygmy can be found who holds the contrary opinion; and thus through the entire range of intellectual strata. From this he concluded that nobody's opinion is worth anything. When we were confronted with the necessity of arriving at conclusions regarding the proper sizes of aircraft for counter-submarine measures, this opinion of Mark Twain's was frequently in our minds. On one hand, we were advised that numerous small seaplanes should be provided for carrying one or two small bombs—on the other hand, that seaplanes of large sizes were necessary for carrying bombs of the greatest power. It sometimes seemed that as many of our advisors held to one opinion as to the other. It was, therefore, as much by instinct as by reason that we came to believe that those who advised in favour of craft of considerable size were more nearly fundamentally correct than those who advised in favour of smaller craft.

Advice against aircraft of the largest sizes was, however, nearly unanimous. Only here and there a voice was raised in defence of such craft. As we examined the attempts which had been made to produce larger flying boats than two-motored ones, we were forced to admit that the success attained had hardly justified the effort. The effort, however, had not been entirely consistent, and it lacked the support of enthusiasm, except on the part of its immediate backers.

Commander Cyril Porte of the Royal Navy, who will be mentioned again, stood almost alone as a champion of great flying boats. His own efforts, or the efforts due to his inspiration, such as those resulting in the production of some of the Curtiss boats of large size, were the only ones consistently devoted to developments in this direction. Those efforts, it must be confessed, had not been productive of great success. From this fact, it is quite certain, had resulted, in considerable measure, the lack of confidence felt in these larger flying craft. This lack of success was due to the fact that though designs grew larger practically the same type of construction was maintained. This resulted in an increase in weight out of proportion to the increase in engine powers. Engine powers had not increased sufficiently, and engine weights per horsepower had not decreased rapidly enough, to meet this weight increase, and the result was flying boats over-weighted, under-powered, and of small cruising radii.

With large sizes in aircraft there go inevitably all of the disadvantages of this size. Manufacturing facilities must be great, and buildings enormous; sheds must be much larger and handling arrangements more extensive and more complicated; the members of handling crews must be more numerous; and expenses of maintenance are largely increased. Unless advantages of very great value can be secured from this larger size, such size cannot be justified. From the several larger boats built by Commander Porte, or on his initiative, these advantages had not, it seemed, been obtained. I did not have the opportunity of meeting Commander Porte, or of discussing with him the reasons for or against large size in naval flying craft; or the reasons for a lack of the expected success in the craft built by or for him. I secured, instead, all of the arguments made me, either for or against, from sources less inspired, or from those less experienced in the many details involved.

Back in the United States, the aeronautical industry was a starveling. It had suffered severely from malnutrition, and, with the exception of the Curtiss Aeroplane and Motor Corporation of Buffalo, N. Y., no company had facilities for manufacture worth a moment's consideration. Among the personnel of this industry were few men of real manufacturing experience, and outside of Buffalo the total personnel engaged was only a few hundred. These were the foundations we were forced to regard as those on which, overnight, enormous organizations must be built. Thought must be given a building programme which took into consideration these conditions.

If we decided upon the building of flying boats of the largest sizes then in being, factory buildings of the greatest dimensions must be put up; two or three manufacturers, only, would be able to undertake the necessary work; and small output at the best, and only after nine months to a year, could be expected. If the decision were for boats of smaller size, the material difficulties would be greatly reduced; more manufacturers could put up plants and undertake the work; deliveries would commence within a few months; and boats could be obtained by hundreds as compared to tens of the larger ones.

Under the insistence of the American Navy the convoy system for cargo ships and for troopships was being put into operation. It was still during its early days. Previously, ships had taken their way alone through waters rendered as safe as possible by the ceaseless patrol of such vessels as were available for the purpose. The ocean is enormous; patrol vessels were few for the tasks set them; and the patrol system was gradually being given up for the convoy system.

In the convoy system ships leave their ports in groups under the escort of one or more vessels of war, or else rendezvous at an appointed place distant from the usual cruising grounds of submarines. Later, before entering these cruising grounds, they are met by a group of destroyers, or other vessels, and are escorted through submarine waters to their appointed destinations. Submarines are free to roam at large as they desire, except for the dangers they encounter in passing through the mine fields strategically placed, and from hostile submarines patrolling near their ports of entry and exit. If they will leave the convoys alone, they are themselves left alone, as patrol vessels exist in quantities insufficient for both convoy and patrol work. Attacks on convoys, however, were welcomed. These attacks exposed the submarine to the attack of a group of destroyers under conditions much to the disadvantage of the submarine, and, after a few attempts, became a venture only the boldest, or the most reckless, would attempt.

We were considering aircraft activities against submarines on the patrol basis. The intention was to establish upon the coasts of France and of the British Islands a number of air stations so close together that their patrol activities would interlock, and there would be created in this way sea areas off these coasts of as great an extent as possible, free from submarines, and safe at any point for slow-moving ships. It is instantly obvious that these intentions required for their fulfillment very large numbers of flying craft. This need for numbers, and for numbers with the least possible delay, determined our recommendation. We recommended, with the strong approval of Vice-Admiral Sims, flying boats by the hundreds, motored with single Liberty engines, and as many of the large two-motored boats as could be built without interfering with the building of the smaller ones.

It is sufficient to state that the actual airplane building programme of the Navy was along the direction discussed. The development of this building programme was one of the romances of the war, which, to my regret, has no further place here. One of the buildings erected for constructing some of the flying boats ordered was started in the latter part of July, was completed in October, and was turning out boats in January. It was 900 feet wide by 1,300 feet long, and, with equipment, cost more than $6,000,000.

As I look back on it, I must admit that, upon my departure from London for the continent, I was of the opinion that reasons against very large flying boats, so far as this term was understood in July, 1917, were of considerably more weight than the reasons for them. During the remainder of my time in Europe nothing occurred nor were any opinions presented to modify materially these conclusions. Upon my return to London in August, shortly before my departure for the United States, I again canvassed the situation, and discussed with a number of people the proper naval flying craft of the heavier-than-air type for counter-submarine defence. Opinions and conclusions were generally as I had found them before.

On the first of September I landed in New York, and on the second of that month reported to my Chief, Rear-Admiral D. W. Taylor, in Washington. On that day and on the following days, as his engagements permitted, I gave him the opinions and conclusions arrived at as a result of my visit to Europe. During the time I was in Europe I had, of course, by letter, kept him fully informed of developments there. I had given him my impressions of the drift of opinion regarding anti-submarine air measures, and of my conclusions regarding these opinions. To some extent, I discussed the subject of flying craft larger than anything at that time in successful use, and the reasons why these were considered desirable or undesirable. His interest in much larger flying craft than any the Navy was contemplating was immediate, and he required all possible information I could supply regarding this subject. This, as a matter of fact, was not a new interest with him. One of his final injunctions to me before my sailing was to examine carefully into the work which had been done in this direction. The reports I was able to give him were far from encouraging. To how great an extent he was discouraged by these reports may be judged from what I have already recorded.

It has been told how Admiral Taylor ordered the design of a transatlantic flying boat. He amplified his order by specifying a large depth bomb carrying capacity, sufficient protection against smaller and faster craft, and a rapidity and simplicity of design making possible their early completion for war service.

The reason for this imperative command was plain enough. The cry from Europe was for aid in overcoming the submarine. Ships were being sunk faster than they were being replaced, and the Allies were straining every nerve to overcome the menace that threatened. Many things were being tried, and few were yet accomplishing much, while the enemy was becoming more and more proficient, and more and more daring in the use of his underwater weapon. Patrol boats were being sent over by the score. Submarine chasers were being built by the hundred, and destroyers were being constructed in every available shipyard.

It had become the practice, more and more, to equip all surface craft operating in submarine waters with depth charges of trinitrotoluol, generally known simply as TNT, a most powerful explosive, and one of great disruptive effect when exploded at a sufficient depth below the surface of the water. All ships were fitted for dropping bombs set to explode at regulated depths below the surface of the water. Some were fitted, in addition, with methods for throwing these bombs to limited distances in the attempt to place them nearer a position in which a submarine was possibly submerged.

As soon as aircraft began to be employed for anti-submarine purposes, these aircraft were equipped with depth charges of this TNT, and with means whereby these charges could be dropped as near as possible to the submarine attacked, or to the submerged position in which the submarine was thought to be. These aircraft charges were, at first, very small and of a very limited radius of action. As aircraft grew in size, however, chiefly due to increase in engine power, these charges increased in weight until they became sufficient to be of positive menace to submarines within 75 to 100 feet of their points of detonation. The limit in the size of these charges, due to the limit in the size of aircraft, of which I have spoken, seemed to have been reached.

Other elements also were of great importance. As aircraft had grown in size, space required for shipping purposes had increased enormously. As a shipload of large flying boats would mean a most uneconomical utilization of space so far as weight was concerned, the problem of providing sufficient cargo space, out of the rapidly decreasing tonnage available, was a most serious matter. Later on, the Navy actually sent an entire shipload of two-motored flying boats to England, and though the ship in question was a large one the cargo carried on this occasion consisted of only twenty-five flying boats with accessories.

The factors which limited the weights of the depth charges carried by aircraft limited the weight available for gasoline for cruising purposes. Six hours was the limit of time a flying boat with its depth charges could keep the air. If necessary to seek submarines on operation grounds 100 miles from shore, this would mean, at the most, that these boats could spend only three hours patrolling against submarines, as they would require the other three hours for going from and returning to their stations. For distances farther out than 100 miles, or for convoying purposes for a slow convoy, aircraft of the heavier-than-air type must be regarded as practically useless.

Naval Constructor Hunsaker and I had our orders. So ominous was the submarine situation that nothing of possible use must be neglected. Hopes were entertained that aircraft could help, but decreasing shipping was available for transporting them. It might be impossible to produce a flying boat which could fly across; it seemed quite impossible then; but if one could be produced the gain would be great. The submarine menace, and not any conscious intention of being the first to fly across the Atlantic, was the immediate reason for the undertaking of a seemingly impossible task.

CHAPTER II

GLENN CURTISS IS CALLED TO ASSIST—HIS CAREER AND PERSONALITY—SUGGESTIONS OF THE CURTISS TRIO—DECISION TO TRY FIRST THE THREE-MOTOR MACHINE

LIFE is largely a question of a man's reactions to the circumstances which surround and often circumscribe him. If a person has been set an absolutely impossible task he cannot react to it. From whatever direction he may approach it, it looms up ever larger, more dispiriting, more forbidding, more terrifying. Since it is impossible, no approach gets him anywhere, and, presently, he has tried them all and is beaten. If it be not quite impossible, he may eventually open a path nearer to its centre, and, bit by bit, get on his way to complete penetration.

The seemingly impossible task set on Monday seemed on Wednesday not quite impossible. Two days had been devoted to a discussion of the problem—a flying boat for anti-submarine operations capable of flying across the Atlantic—and the problem no longer seemed entirely beyond human capacity, as this capacity stood at that instant. It was decided to call in as soon as possible other men with knowledge of airplanes, to talk with them, to hear their views, and to compare ideas. The first man whose name suggested itself was Mr. Glenn H.

Curtiss, president of the Curtiss Aeroplane and Motor Corporation, and he was invited by telegram to Washington for a discussion of the problem up for solution.

As the name of Curtiss will appear very frequently in these pages, and as the engineering organization built up by the man from whom this name was obtained will be referred to with increasing frequency, this is an appropriate place in which to detail, as briefly as possible, the history of that remarkable man, and the incidents and events which led to his occupying a place in the aeronautical history of the United States of glory less only than that of the Wright brothers and of Langley.

Glenn Hammond Curtiss was born in Hammondsport, New York, on the 21st of May, 1878. With worldly possessions his parents were not well supplied. When he was four years of age his father died, and it became necessary for him, in a very few years, to work for a livelihood and to assist in the support of his family. When twelve years old, he was engaged in the assembling of cameras at the works of the Eastman Kodak Company in Rochester, and for the first few weeks during which he was engaged in this occupation, received the weekly pay of $4.00. He continued at work of this nature at increasing compensation for several years.

We are assured by his biographer that at school he was particularly proficient in mathematical subjects. It seems certain, however, that the demands of poverty made his pursuit of school learning a brief one, and that his excursions in the fields of mathematics during this period were limited, and over rough ground. As has been the case with so many other men who have risen superior to the disadvantages of early environment or circumstances, Glenn Curtiss's knowledge was acquired in small degree within the limited spaces enjoyed by village schools. Rather than in this way, this knowledge came to an intensive mind, not subject to the discouragements of limited opportunity, through exercise in that university which is the whole field of human knowledge and of scientific endeavour.

After a few years in Rochester, family affairs drew him back to Hammondsport. His natural mechanical adaptiveness asserted itself, and he very shortly was engaged in the general work of bicycle repair, or, when that failed, due to the winter weather and the impassability of the roads, he did odd jobs of tinkering with machinery, of wiring houses for electric lights, or in some similar undertaking. This was in the late nineties when all the world was awheel, and he, naturally, rode bicycles as well as repaired them. He went far beyond the usual run of his associates, however, and developed the ability to obtain speed from a bicycle in a degree which made it possible for him to win a number of the local races in which he entered. This is a matter of some importance. It will be found throughout the career of this man that he has always been desirous of moving as rapidly through the air as the possibilities of the day have made practicable. There is no record of his ever having been a particularly fast rider on a bicycle. More than to speed, his victories were due to ability to analyze the situation and to out-think his opponents. It would have been most phenomenal had he ever held records for a man-driven bicycle, as he has always been a slight and slender man, without the necessary weight or physical vigour for the propelling force of a vehicle of this nature. In power-driven vehicles, however, it may be noted that, from time to time, he has held world records for speed on motorcycles, in speed boats, and in airplanes. He has never been attracted by speed possibilities of motor cars. This, it is safe to say, is the only reason he has not held records for this type of power-driven vehicle as well as for the others.

At the age of twenty-two, he started his own bicycle repair shop. There he very shortly became interested in the application of the gasoline motor to the bicycle, and is probably the first man to combine the two successfully. This led him, during favourable times of the year, into motorcycle racing, and in such races his defeats were so few as to be almost negligible. His motors were built by himself in a small factory erected in Hammondsport, and they very shortly attracted such favourable attention throughout the country that the enterprise of building them enjoyed some degree of financial success.

During the several years in which he rode as a professional motorcyclist, a number of the premier records of the world were established by him. On the 28th of January, 1904, on a motorcycle driven by a two-cycle engine, he made a record of 10 miles in 8 minutes and 54 seconds—which was far beyond anything previously accomplished. A few years later, on a cycle driven by an eight-cylinder motor, he made a mile in $26\frac{2}{5}$ seconds, or at a speed of 137 miles per hour. This established a speed record for a power-driven vehicle unbeaten for several years by any type of motor-driven, man-carrying appliance.

Two years after the establishment of this motorcycle record, he had already progressed far enough in aviation, and in the development of airplanes, known at that day as flying machines, to win the James Gordon Bennett International Cup Race in Rheims, France. This was on August 29, 1909. In this race he was opposed by all of the best-known flyers of that day, and by the best-known airplanes at that time manufactured. His most redoubtable opponent was Monsieur Blériot, the famous French aviator and airplane manufacturer, who was just fresh from his triumph of flying across the British Channel. In this race Monsieur Blériot used one of his well-known monoplanes, motored with an 80-horsepower motor, whereas Mr. Curtiss relied upon a biplane, designed and built by himself, motored with an eight-cylinder, 50-horsepower motor, of very much the same type, though of very much less power, as the well-known Curtiss motor of the present day. On this day, Quentin Roosevelt, at that time a boy in his teens, was an interested spectator of the flight at Rheims, and was among the first to congratulate Mr. Curtiss when his victory was announced. From the inspiration of seeing this international race won by an American in Rheims may have come the determination which later led that Young Crusader to take to the air as his element, and, from this, to the laying of his life as a sacrifice on the altar of Liberty within a few miles of this historic spot.

Mr. Curtiss's first interest in motors for aircraft was stirred by Captain Thomas Baldwin, the famous balloonist, parachute jumper, and dirigible pilot. Captain Baldwin was attracted by the remarkable qualities of the motorcycle motors built by Curtiss in his Hammondsport plant, and travelled from California to Hammondsport to discuss with him the building of a motor suitable for his dirigible. This motor was built, and was used by Captain Baldwin in successful flights made by him during the World's Fair in St. Louis in 1904. From this association grew a friendship which has continued to the present day. Its first immediate fruit was the successful building by Curtiss and Baldwin, in combination, of the first dirigible ordered by the War Department, and the first airship of any type built by Curtiss and his organization. This was a small, non-rigid dirigible, required to have the modest speed of 20 miles an hour. At that time this was considered by no means modest.

In 1905, in New York City, Mr. Curtiss became acquainted with Dr. Alexander Graham Bell. This acquaintance may be said to mark the definite entry of Mr. Curtiss into the fields of activity in which he very shortly became so eminent. It was, indeed, a most fruitful one, and, judged by its results, must be regarded as one of the epochal meetings of modern times. Doctor Bell was, at that time, interested in experiments with weight-lifting tetrahedral kites. He was concerned with the possibility of installing a motor in one of these kites, and invited Mr. Curtiss to visit him at his summer home in Nova Scotia to discuss the project.

Mr. Curtiss visited Nova Scotia, and very shortly there was formed at the home of Doctor Bell an association known as, "The Aërial Experiment Association." This association was very largely financed by Mrs. Bell, and consisted, besides Doctor Bell and Mr. Curtiss, of Mr. F. W. Baldwin and Mr. J. A. D. McCurdy, young Canadian mechanical engineers, and Lieutenant Thomas Selfridge, of the United States Army. This association immediately interested itself in the question of power-driven flight, and, after a short time, moved its headquarters to Hammondsport, where the facilities for work were better. At Hammondsport their first experiments were with a glider. From this, however, they very quickly passed on to power-driven airplanes, and built in succession three of these of increasing merit.

The first flight of an airplane, designed and built by this association, was made on March 12, 1908, by Mr. Baldwin, and ended, as might be expected, after a flight of 318 feet 11 inches, in a crash which badly smashed the machine. This flight, however, was remarkably successful from the viewpoint of the experimenters. To them it demonstrated the truth of the axiom that, "All which goes up must come down," but it also demonstrated the fundamental soundness of the theories on which their work was based, and the breaking of the plane, due to the inexperience of the man flying it, was of no importance compared to this greater fact.

Increasing experiments, breakages, repairs, and tests, with the building of additional airplanes, carried the knowledge of airplane design and manufacture much farther, and there was, eventually, developed an airplane possessing many of the well-known characteristics of the Curtiss airplanes used so successfully for training purposes since that time. On May 22, 1908, Mr. Curtiss, in one of these airplanes, flew a distance of 1,017 feet, and landed without damage. For that particular time and for an organization of so little experience, this was a remarkable accomplishment. On the 4th of July of that year, in the third machine designed by the association, and named by them the *June Bug*, he won a trophy offered by the *Scientific American* for a one-kilometer flight in public. On this occasion he flew a distance slightly in excess of one mile, and landed only because he was approaching woods, and had not yet had sufficient flying experience to make it desirable to attempt a turn.

Shortly after the winning of the *Scientific American* cup, the association had their first great misfortune. This was met in the death of Lieutenant Selfridge, who was killed while flying with Orville Wright, at Fort Meyer, Va. The accident resulting in the death of Lieutenant Selfridge was caused by the breaking of one of the propellers of the Wright airplane, and was the first airplane accident in this country to result in the death of a flyer. This was a severe blow to the association, to whom the untiring activity and the great technical ability of Lieutenant Selfridge had been of the greatest assistance, and to Mr. Curtiss personally, as between himself and Lieutenant Selfridge there had developed a very warm attachment.

The most spectacular of the personal flight achievements of Mr. Curtiss was that made by him on Sunday, May 31, 1910, from Albany, N. Y., to New York City. This flight won a $10,000 prize offered by the New York *World*.

The distance was slightly over 150 miles, which, at that time, was a very great distance for an airplane to fly. Of more importance than the distance, however, was the fact that the route over the gorge of the Hudson River is one of the worst air routes in the entire world. To-day, even, with all uncertainty eliminated regarding the behaviour of airplanes, and with powerful engines of a large reserve of power, few flyers voluntarily essay this flight. If forced to do so, they fly at altitudes generally greater than the world's height record of that date so as to avoid the diverse air currents invariably met with on this route.

From whatever direction the wind may blow, it tumbles into the Hudson gorge, over hills and through valleys, and there it boils, surges, rises, and falls, to such an extent that at any level above this river up to 500 to 2,000 feet, the air is disturbed to a most surprising extent. Any one flying through it is beaten and buffeted, and maintains his course and his level with difficulty, and only by the exercise of the greatest amount of skill. Mr. Curtiss, flying over a greater portion of this distance at a very low altitude, was subjected to many of the worst conditions of this course. This was a new, and must certainly have been a disquieting, experience. He was successful, however, and after a stop near Poughkeepsie, and another stop near the Harlem River, he continued on to Governor's Island and made his final landing there.

Very shortly after the winning of the *Scientific American* trophy there developed on the part of Mr. Curtiss an active interest in the subject of flying from water. There followed the experiments which resulted in making Mr. Curtiss the leading developer of watercraft, and which had the further happy effect of preserving for the United States, the original home of aviation, in this one direction of aeronautical development the distinction of being, if not preëminent, at least abreast of the development in any other portion of the world.

The first results of this interest were of very little promise. The late *June Bug* was fitted with floats, was rechristened the *Loon*, and, under this discouraging cognomen, made an attempt to fly from the water. Due to the added weight, and to the fact that it is more difficult to obtain necessary speed on water for flying purposes than it is to obtain this speed on land, it was impossible to get this first seaplane into the air.

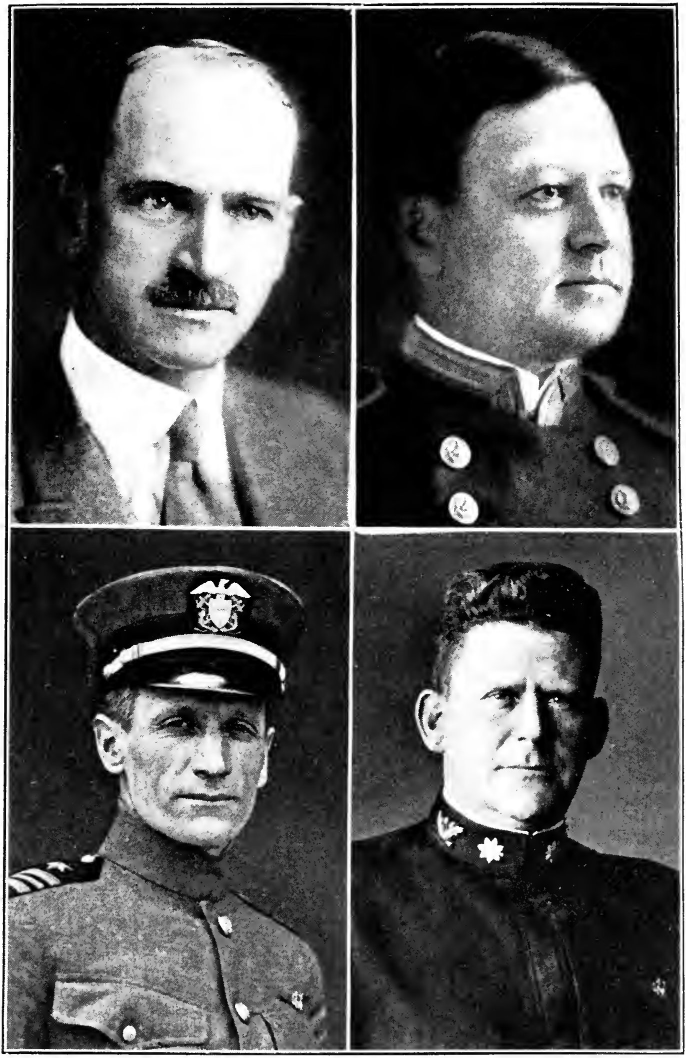
It seems quite probable that the attempted flights with the *Loon* were the first actual attempts made to support an airplane on the water by means of floats, and to fly it therefrom. The idea involved, however, is claimed by more than one man, and is one concerning which there has been considerable patent litigation. Most of the developments secured at Hammondsport were made the subject of patent applications, and the fitting of pontoons to aircraft in order to fit them for flying from the water was so covered.

Continued experiments gave better results. These experiments had been transferred to North Island, San Diego, California, where weather conditions were such as to make flying the year around practicable. This island has, of late years, been used by both the Army and Navy for training purposes, and on it, at the present time, is located one of the large aviation training stations maintained by the Navy Department. It was Mr. Curtiss who first saw the suitability of this island and of this locality for the training of flying men, and his good judgment has been proved by the expenditure on the part of the military departments of millions of dollars in the building up of their stations there.

One of Mr. Curtiss's first ideas after securing an encouraging degree of success in his airplane experiments was the possibility of training Government aviators for the military purposes of the Government. In response to his offer to the War and Navy Departments to undertake this work, there were sent to San Diego officers of both military departments. Since that time, there have been trained under the direct supervision of Mr. Curtiss, or in airplanes designed or built by his company, fully nine tenths of the Army, Navy, and Marine Corps aviators of the United States Forces.

With his military students, Mr. Curtiss took in hand his further experiments on water flying craft, and on the 26th of January, 1912, accomplished the first successful flights with an airplane of this character. This airplane was of the float type, and in it Mr. Curtiss and his flying students made many flights. It gave way rapidly, however, to the idea of the flying boat which Mr. Curtiss originated; and the result has been that this type of flying craft has been associated, and will continue to be associated, with the name of Curtiss. Rapid improvements in engines and in the design of the details of the seaplanes themselves, perfected these flying boats, and in a comparatively short time Curtiss boats, as well as the ordinary biplanes of the typical Curtiss design, became known over a considerable portion of the world.

The Wright brothers, to whom the credit belongs for the fundamental developments which have made modern flight possible, seemed to have done their life work, and from them little other development of promise had been secured. They had given flight to the world and apparently had then settled back in some degree of contentment to take their ease and to enjoy their own quiet scientific investigations. Little or no advance in airplane design or construction came from them, and the result was that the name of Curtiss became synonymous with the progress in aviation being made in the United States. After the death of Wilbur Wright on May 30, 1912,



(*Upper left*) Glenn Curtiss, Father of Aquatic Aviation
(*Upper right*) Commander G. C. Westervelt, U. S. N., who supervised the designing and building of the N.C. craft (*Photo by Marceau*)
(*Lower left*) Commander A. C. Read, U. S. N., who commanded the *N.C. 4* on her epoch-making flight. (*Photo © by Paul Thompson*)
(*Lower right*) Commander H. C. Richardson, U. S. N., who commanded the *N.C. 3* on the trans-Atlantic flight, and who had much to do with the designing and building of the four N.C's.

the Wrights practically disappeared as airplane developers or manufacturers. Orville Wright, a particularly gentle, sweet-tempered, and lovable man of quiet tastes, is by nature an investigative physicist. At his home in Dayton he has provided himself with an experimental laboratory and being, happily, of sufficient means for his simple tastes, has devoted himself to calm, untroubled, and unhurried pursuit of the answers to certain unsolved questions. From him, from time to time, are received bits of scientific knowledge of use to the Fellows of his profession, but outside of that limited circle the business of the world proceeds and knows not of him, except that, with his brother, he belongs to history as one of the Great.

Glenn Curtiss, on the contrary, has with his greater business instinct invaded the world, and has spread his flying craft around wherever civilization is and men are interested in the conquest of the air. For this fact, the United States owes to him a debt of gratitude. With almost no encouragement from the Government of this country, and frequently under circumstances of the utmost discouragement, he held aloft the banner of American determination. It results that, throughout the world, where aeronautical development before the World War was discussed, Curtiss was discussed, and wherever aeronautical achievements were dwelt upon, it was possible to cite those of Glenn Curtiss and his organization, and to avoid the humiliation of an acknowledgment of complete inertia.

Up to the outbreak of the World War in 1914 there had not, it is probable, been placed in this country an order with an airplane manufacturer for more than six airplanes of any one type at any one time. Up to this time the total expenditures of the War Department and of the Navy Department for aeronautics in all its phases had certainly not been in excess of $4,000,000. Under such discouraging circumstances courage and tenacity were required to carry on. Except for the fact of popular interest in airplane tests and in airplane exhibits, it would have been impossible for the airplane industry to exist at all in this country. On this foundation of sand the Curtiss organization was built. In his ability to keep this organization together, to expand it gradually, and even to pay the members of it from time to time, as funds became available, Mr. Curtiss showed himself a financial genius of ability at least equal to his mechanical ability. There were many times when the last dollar must have been in sight, and when all work was being continued on the basis of hope and of such credit as could be obtained.

When the Great War came, the Curtiss Aeroplane Company was, in reality, the only airplane company in this country deserving of such a designation. To them there applied, naturally, purchasing agents of the British Government, scouring the world for every possibility of securing the necessary military appliances. With the same degree of optimism which had made it possible for him to win over almost insurmountable obstacles, Mr. Curtiss accepted from these purchasing agents contracts for hundreds, and even thousands, of airplanes, of various types. In some way the money was found to finance the enterprise; the organization built up by him was moved from the sleepy little village of Hammondsport to the industrial city of Buffalo, and there the first real plant of the Curtiss Aeroplane and Motor Corporation was erected.

To a certain extent, there slipped from Mr. Curtiss's hands control of his own affairs when this larger field was entered. He is not a man who gets his happiness from the campaigns of large business undertakings, and it was, undoubtedly, with the greatest degree of satisfaction that he was able to capitalize his past experience, and to secure for himself, and for the faithful associates who had stuck by him through thick and thin, the rewards made possible by the enormous amount of business now offered. Upon other shoulders he unloaded most of the burdens of manufacturing activity, and withdrew himself more and more into the quieter, calmer atmosphere of experiment and engineering development.

Among Mr. Curtiss's associates it is a well-known fact that the harsh climatic conditions of Hammondsport and of Buffalo were not to his liking. In his mind there had formed the determination to escape from them, and from the cares and troubles of large manufacturing activities, when the opportunity presented itself. To these facts are due the construction of the plant of the Curtiss Engineering Corporation at Garden City, N. Y.; and to them must be ascribed the fact that a plant of this nature was constructed at a location so little suited for such a purpose.

His biographer has recorded, in discussing the activities of his early life, "Thus Curtiss went ahead with his work to construct and improve his motors, and improvement came with each successive one. Meantime, Curtiss began to receive inquiries and even some orders, and business took a decidedly favourable turn. Half a dozen fellow townsmen became interested enough in Curtiss's motorcycle experiments to put money into the business, and within a short time a little factory was built on the hill back of Grandma Curtiss's house. It was an inconvenient place to put up a factory, and all the heavy material was hauled up to it with some difficulty. In spite of these little obstacles; in spite of the fact that Hammondsport is located at the end of a little branch railroad, which seems to the visitor to run only as the spirit moves the engineer—in spite of every handicap, the business grew rapidly." So may it be with the plant at Garden City! The factory built by Curtiss, the boy, behind Grandma Curtiss's house, was built there without any special business reason, but because Curtiss, the boy, wanted it there. Due to the genius of the boy it prospered. For all we know there may be no better reason for the location of the factory built by Curtiss, the man, on the pleasant plains of Garden City May the genius of Curtiss, the man, cause it also to prosper.

Glenn Curtiss is a man beloved of his associates. He has that rare quality of leadership which breaks the path loyal, unquestioning followers keep with him. Men who started with him in Hammondsport are with him yet. The appraisal put on the ability of these men is Curtiss's appraisal, and they have been rewarded accordingly. It may be that some have been rewarded beyond their actual deserts, but, almost without exception, they have given loyalty and support, and the affection which one man feels for an admired and trusted leader. These are among the things one cannot buy and which are beyond any price.

Mr. Curtiss is of medium height and slender. Prosperity has brought to him no increase in girth. His face is keen, his head of medium size, and his features sharp. In general, he has the lean, keen, falcon-like look one associates in one's mind with a man of the air. He is quiet, gentle, and without self-assertiveness. His manner is just the least bit embarrassed, and his opinions are given somewhat hesitatingly, as if by one who waits for agreement from time to time, and for the encouragement which comes from this agreement.

In all great developments the pioneers who have first achieved success, after the patient plodding of their many forerunners, seem to have moved for a time with seven-league boots. After them come the plodders who move a few inches at a time. These speeds often are relative only. The development of the fundamentals is the great work, and carries the human race centuries in advance in a few moments of time. After that, progress is won only by steps, and no further great advances—except by the step-by-step method—seem possible.

It has been Mr. Curtiss's good fortune to progress for a while in his seven-league boots, and to accomplish in a few months the work of years. At the present time, however, he is an inch-by-inch plodder with the rest of us, but liable at any time, perhaps, to break once more into his natural stride, to leave the plodders still plodding on behind.

The airplane built by Professor Langley, but not flown successfully until years afterward when Mr. Curtiss himself flew it at Hammondsport, the first airplane built and flown by the Wright brothers, the first seaplane built and flown by Mr. Curtiss, all weighed less than a thousand pounds. The N. C. boats as they took the air for the flight to the Azores weighed about twenty-eight thousand pounds. Pound by pound the sizes grew from the first to the latest of the series. From each one something was learned. The N. C. boats embody the knowledge gained from all of their forerunners, and a number of these forerunners are shown here so that appreciation may be had of the steps through which this development has been secured.

In reply to a telegram from Admiral Taylor, Mr. Curtiss arrived at the Navy Department on the following morning with two of his designing staff, Mr. W. L. Gilmore and Mr. Henry Kleckler. After a preliminary discussion with Mr. Hunsaker and myself, an appointment was made with Admiral Taylor. In the discussion which followed there was laid down the broad precept of the design aimed at.

Into this discussion there entered definitely the proposition that the seaplane produced should, if possible, be capable of sustained flight from Newfoundland to Ireland. If this proved impracticable, it, at least, should be capable of a sustained flight from Newfoundland to the Azores, and its characteristics should, in general, be those outlined in the first chapter.

After the conference with Admiral Taylor, the Curtiss representatives, Hunsaker, and myself, discussed the general characteristics of a flying boat of the type aimed at, the engine horsepower available, and the size of the craft which it might be necessary or desirable to attempt. Mr. Curtiss and his assistants returned to Buffalo to prepare, as rapidly as possible, for early discussion, general suggestions as to type, sizes, powers, and general arrangements, in accordance with the tentative conclusions at which we had arrived.

Two or three days later, the Curtiss trio returned to Washington with general arrangement plans of two suggestions. One suggestion was for a five-motored boat of roughly 1,700 horsepower, the other for a three-motored boat of roughly 1,000 horsepower. Both were biplanes, and were similar in general except for the differences in size made possible by the differences in power.

The boats for which these outline plans were submitted differed from the conventional type of flying boat in that the hulls were considerably shorter, and the tails, instead of being supported on these hulls, were supported on booms carried from the hull and from the wings. In general, there was employed in these rough suggestions an idea embodied by the Curtiss Company in a flying boat which they designated a "flying life boat." In this boat the hull was very short, the tail planes were carried on extension booms, and an arrangement had been made whereby, if desired, the wings and the tail could be dumped overboard, and the boat could proceed under the power of the engine, which was mounted in the hull, and drove the propellers through chains and gearing. In this larger design no such arrangement with regard to the wings or to the location of the engines was proposed. There was, in general, a similarity in the two types, however, though the flying life boat was a triplane and the proposal for the larger boats called for biplanes.

General dimensions only, estimated weight and horsepowers, were submitted with these proposals. It hardly can be said that any definite or concrete design was presented. The drawing of a picture indicating what an airplane will look like is the smallest part of the work of design. There had been made, at least, a definite suggestion that the craft designed be either a three-motor or a five-motor flying boat, and certain guesses, based on extensive experience, as to the general sizes and weight characteristics of these boats. With no more than this as a basis of discussion, another conference was arranged with Admiral Taylor, and the result of the labours of the several preceding days was presented to him.

Admiral Taylor is used to thinking in terms of 150,000 to 200,000 horsepower, as the latest ships designed by him were for such powers, and was, perhaps, a bit inclined to turn up his nose at the paltry thousand horsepower proposed for the three-motored seaplane. The one of 1,700 horsepower was a bit more impressive and in line with his ideas of what real size should be.

After consideration, however, of the greater difficulties involved, the greater uncertainties which would be introduced by this larger size into a problem already difficult enough, the smaller, three-motored design, was decided upon.

The Liberty engine, although of the greatest promise, was certainly not such a proved instrument at that date that we could afford to gamble upon it to an unnecessary extent. It was feared that the result of undertaking the larger development would be a delay in completion of such seriousness that we could hardly have a finished craft ready for use during any period for which the war might be expected to extend. In the conclusion reached these considerations were given much weight.

Whether we were right in this or wrong, no one could now say with authority. Certainly, with the knowledge gained since that date, it would be possible to design and build much larger, and somewhat more efficient, flying boats, but it is possible we might have failed had we tried it then.

CHAPTER III

MR. LANCHESTER'S DICTA—USEFUL-LOAD PERCENTAGES —HANDLEY-PAGE AND LIBERTY MOTORS—THE NAVY DEPARTMENT ORGANIZATION—CURTISS CORPORATION TAKES OVER THE TASK

THE noted English authority on aeronautics, Mr. F. H. Lanchester, proved, to his own satisfaction, some years ago, that there is a limited size beyond which heavier-than-air craft cannot be constructed. Fortunately for his own reputation, and for the future of the science, he found it possible to make the reservation that his discussion and proof applied merely to methods of construction at that time in general use. The basis of his demonstration was a simple one. The sustaining power of an airplane depends on the area of its wings and the square of its speed, whereas its weight, being a question of the volume of its members, is a function of the cube of its dimensions. It is quite evident from this that increasing size would rapidly bring about a state of affairs which would make flight impossible.

Mr. Lanchester did not, of course, suppose that engineers would rest content with the methods of construction already adopted, but was merely pointing out as an interesting discussion the limit in size imposed by the types of construction in use at the time of his discussion. This discussion accepted engine weights as they were, and did not, of course, attempt to argue that the future would see no reduction in such weights.

Since the publication by Mr. Lanchester of the article referred to, there had been very pronounced improvements in aeronautical engines. Powers had risen rapidly and weights per horsepower had fallen. This had made possible building of materially larger airplanes of the same type of construction as those previously built. It was quite evident, however, that the limits of this type of construction, although these limitations were above those established theoretically by Mr. Lanchester, had been very nearly reached. As a matter of fact, Commander Porte's lack of the fullest success with the large flying boats built by himself was due to his adherence to conventional methods of design. The result had been increased weight of such an amount that the increasing size brought little advantage beyond the mere ability to carry the greater structural weight of the airplane itself. In one large airplane only, of the period of which I speak, had there been any consistent engineering investigation of structural modifications. In this one, the Handley-Page, it had been demonstrated that the adoption of new methods of construction made possible larger sizes without the increase in weight of structural members which an adherence to conventional construction would have involved.

The measure of the success of an airplane, whether of land or of the water type, is found in what is conventionally designated as its "useful load." This is the portion of the weight of an airplane, in full-load flying condition, not contained in the structure itself. It comprises, for an ordinary machine, the fuel, lubricating oil, the cooling water for the engines, the members of the crew with their clothing, and all of the small, unattached accessories required for the general operation of an airplane. In military machines this useful load would also comprise guns, ammunition, bombs, and the necessary accessories such as sights, direction indicators, etc. Ordinarily, this measure of effectiveness is indicated by a percentage, and among aeronautical designers you will hear that such and such a machine has a useful load of 30 to 40 per cent., or of any percentage it may happen to have, this being the percentage of the total load represented by the useful load as above described. With decreasing weight per horsepower and with increasing horsepower, this useful load has been steadily, though not rapidly, on the increase. Progress in the design of heavier-than-air craft can be made only if this percentage of useful load can be still further increased.

So far as our information extended, the useful load of the Handley-Page night bombers, those famous British machines which were the cause of so much annoyance to our late enemies, the Germans, exceeded that of any other machine of any weight-carrying ability. It was, roughly, in the neighbourhood of 40 per cent., and this percentage set the standard at which we must aim. If we could equal this percentage, our design would be considered reasonably successful. By the extent to which we fell below this, it must be considered as less successful, and by the amount to which we reached above it, an improvement on the best yet produced. The Handley-Page night bombing airplane of that period was motored with two 275-horsepower Rolls-Royce motors, and was of a full flying load of about 11,000 pounds. As we started our design on the basis of 1,000 horsepower, and a full flying load of approximately 25,000 pounds, it was evident that improvements over the engineering structure of the Handley-Page must be made if a useful load percentage equal to the one of that craft was to be obtained; and that very material improvements in structure must be secured if this useful load ratio was to be exceeded.

In the Liberty engine there was available motive power of less weight per horsepower than in any equally powerful engine in existence. It may be noted at this point that, since the date treated of, this engine has undergone various modifications which have increased its power without a corresponding increase in weight. To-day this engine is materially lighter per horsepower than any other equally powerful engine known. At the time of the commencement of our design, this lightness was of material value; since that time the greater power which has been obtained, without a corresponding increase in weight, has been of increasing value.

In designing the structure of a large airplane, certain inescapable dead weights, such as those of the engines, propellers, radiators, gasoline tanks, etc., must be accepted. In addition there must be accepted the weight of a minimum crew, and of other items of this nature. It will be found in the final weight analysis that the weight of the final structure is roughly three to four times the weight of the inescapable items. If, therefore, due to the greater lightness of an engine per horsepower there appears in this inescapable dead weight an advantage of, say, one hundred pounds over some other engine, there will appear in the finished airplane as a whole a final advantage of from three hundred to four hundred pounds over an airplane designed for the heavier engine. This was an advantage we enjoyed from the Liberty engine in undertaking the design of this large flying boat, and one which has worked in our favour with every increase in the power of this great engine which has not involved a corresponding increase in weight.

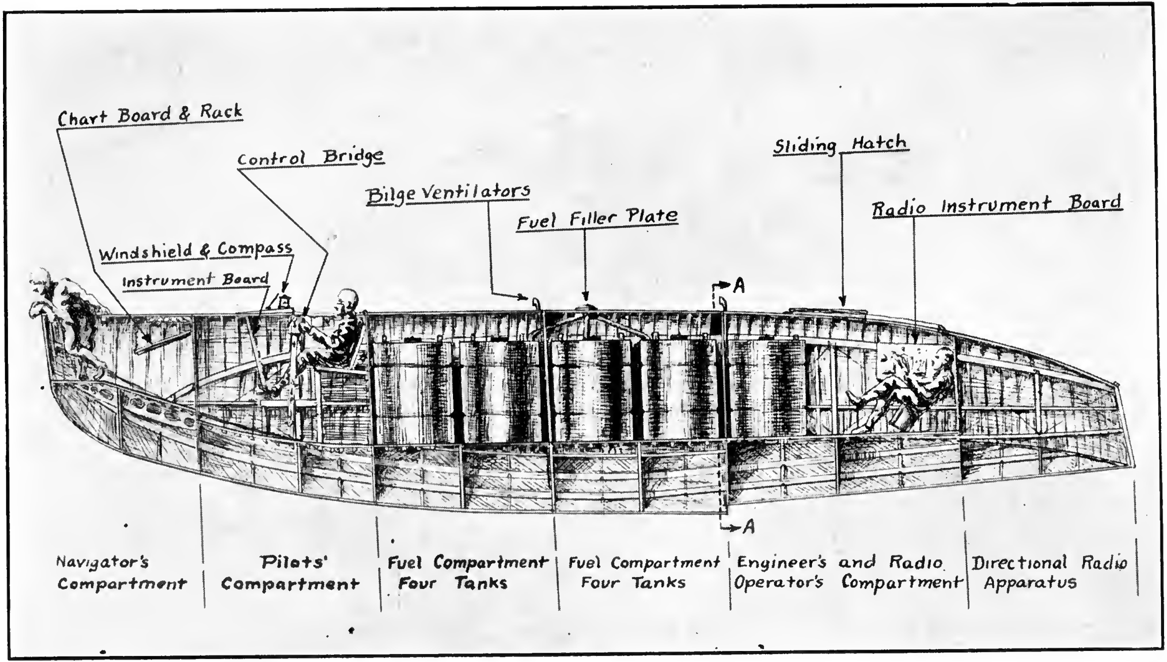
There were, in September, 1917, about twenty draftsmen in the aeronautical design force of the Bureau of Construction and Repair. The majority of these draftsmen were immediately put to work in connection with certain important details of design of the three-motored flying boat, on which it had been decided to embark.

All structural elements such as wing beams, the ribs, wing struts, tail booms, and the compression struts in the wings, required many investigations. It was found, very shortly, that these investigations must be so extensive that the technical force of the Bureau of Construction and Repair, under Naval Constructor Hunsaker, would be quite insufficient for undertaking them. There were, at this time, many aeronautical problems requiring immediate investigation, and the burden upon the technical department of the Bureau was as great as it could carry. It was necessary to adopt some other basis of investigation of structural details and of design of the boat to be built.

Admiral Taylor determined to transfer the design, and the major portion of the investigations in connection with it, to the engineering department of the Curtiss Aeroplane Company in Buffalo. The Bureau, under an arrangement of this sort, would maintain a close control over the work, and would exercise supervision of such a nature that the design itself would be one largely representing the detailed opinions of the Bureau and of its representatives. This was a decision promising many advantages, due, among other things, to an inherent feature of Navy Department organization. The Navy Department is organized into bureaus dealing with certain definite functions. The Bureau of Construction and Repair, for example, deals with the design of the structures of ships, or of aircraft, and of the structural accessories; the Bureau of Steam Engineering deals with the design of propelling machinery, and of accessories of the propelling machinery; the Bureau of Ordnance deals with the design of guns, ordnance materials, and their general accessories. These bureaus are independent of each other, a common control of them being exercised by the Secretary of the Navy. In a design undertaking of the nature of the one under discussion, three bureaus, at least, would be involved, and the common control of these details would be encountered at no place short of the Secretary of the Navy. Carrying out a design of this nature at the Curtiss plant would place all details under one organization. Although subject, to some extent, to the same divided authority commented on, this division of authority would be much less important than if experienced in the Navy Department, since all details would, in any event, be under the one employee of the Curtiss Company appointed to general supervision of the work.

Up to the point reached, the work done had been performed on the initiative of Admiral Taylor, under his authority as Chief of one of the Navy Department bureaus. To continue it beyond this point, and into a field requiring work of other Navy Department bureaus, involved approval and coöperation of these bureaus. This approval and coöperation Admiral Taylor now sought.

The organization of the Navy Department, when understood, is logical and fairly simple. For the uninitiated, it is not always easy to understand. A project of the nature of the one referred to can be conceived of and initiated by any one of the Navy Department bureaus concerned in any of its details. After such conception and initiation, it must, first of all, be approved by the Division of Operations. This is a division which for the Navy Department takes the place of the General Staff in the Army. It is responsible for the general conduct of operations; for the proper military application and use of all military instruments and appliances; for the proper military coördination of different departmental divisions; and for the inclusion under the military



Longitudinal Section of the N.C. Boat Hull, Showing Tanks, Construction, Bulkheads and Interior Arrangements

requirements of all military instruments needed for operations under contemplation. The actual provision of such instruments is left to the technical departments specializing in such matters; the use of these instruments and, to a large extent, the forethought which decrees their provision, lie with the Division of Operations. The approval, by this division, therefore, of the design and building of this large flying boat was necessary.

The Division of Operations approved of the proposed design as a military project; the Bureau of Steam Engineering, which would be concerned in the technical work of the design in a very great degree, added its recommendation; and with the approval of Operations, and the joint recommendation of Rear-Admiral Griffin, of the Bureau of Steam Engineering, and Rear-Admiral Taylor, of the Bureau of Construction and Repair, it was ready for submission to the Secretary of the Navy.

The reference of this project to the Secretary of the Navy secured very promptly his enthusiastic approval. All necessary steps had now been taken to go ahead, and it was possible to make arrangements for the actual work of design. This involved a contract with the Curtiss Aeroplane and Motor Corporation for the work to be done by them.

To meet the difficulties of the cost uncertainties, a contract was worked out on a modified basis of cost, plus a certain profit on the determined cost. Here difficulties were met with in definitely drawing the terms of the contract. There was arrived at, after consideration, a contract in which the Curtiss Company undertook the work of design on the basis required of it by the Navy Department, and was to be compensated as follows: All labour and material charges ordinarily made directly against a job of this nature were to be directly charged; to this amount was to be added a charge of 100 per cent., or an amount equal to the direct charges, for certain intangibles and indirect expenses; and to the sum of these two amounts there was to be added a profit of 10 per cent. The total amount thus obtained would represent the cost to the Navy Department.

Among the items referred to as intangibles were considered to be a number of elements, the value of which, or the relation of which to the cost of work of this nature, could not be definitely ascertained. The existence of the Curtiss Aeroplane and Motor Corporation as an organization had been brought about as the result of a number of years of effort and expenditure. The momentum of this organization was of value, and in a portion of the 100 per cent. for intangibles this was to be taken into consideration. The engineering experience and suggestions of Mr. Glenn Curtiss, and of the engineers under him, were also of value, and would be utilized in connection with this design. No possible measuring device, however, could determine the extent to which the cost to the Curtiss Company for their services and experience could be proportioned to any one project as compared to the others, and in the 100 per cent. for intangibles it was the intention of the parties to the contract that an allowance be included for such services. In addition, there were represented in this 100 per cent. the ordinarily understood items of overhead expenses commonly distributed in commercial organizations, such as power, rent, heat and light, depreciation, insurance, etc., items accurately determinable in their totals, but impossible of definite distribution to individual items in progress.

CHAPTER IV

CHARACTERISTICS OF THE CURTISS CORPORATION PERSONNEL—EXPERIENCE OF THE NAVY EXPERTS—FIRST PLANS TOO AMBITIOUS WITH MEANS THEN AVAILABLE

THE city of Buffalo, on Lake Erie, has been identified with the development of large flying boats. It was in Buffalo that the Curtiss Company built their factory very shortly after the outbreak of the World War. Up to this time flying boat sizes attempted by them had not been very great. In their plant located at Hammondsport, New York, they had constructed, for Lieutenant Cyril Porte's projected attempt to cross the Atlantic, the flying boat *America,* which represented the largest flying boat design up to that time. At the Buffalo plant, however, they very soon produced flying boats of a much larger type, although there were no engines at that time available in this country for power. These boats were, accordingly, shipped to England without engines, and were there fitted with Rolls-Royce engines. In one type of aircraft alone did the United States, up to the time of our entry into the World War, possess designs of equal merit with those developed on the other side. This was in flying boats. As a matter of fact, Mr. Glenn Curtiss's work in the development of water flying craft was of such a nature that the result has been that the United States, if anything, has been ahead of the remainder of the world in the development of such craft. It is some small satisfaction to know that the country which first developed the airplane at least held as much priority in progress as this, and with this progress Glenn Curtiss and the Curtiss organization are indissolubly associated.

In Buffalo the Curtiss Company was located in various buildings in several portions of the city. Only one of these buildings had been built especially for the Curtiss Company, or for airplane construction work. The others had been rented for their availability, or because they could be secured for low rentals.

The Experimental Engineering Department was located in an old building on the Niagara River at the foot of Austin Street. This building had, at one time, been the power station of an electric lighting concern, supplying light and power to that section of the city. It had been vacant for years and, as may well be imagined, was in disrepair and little suited to the purpose for which it was employed. In it, however, had been assembled the personnel of the Experimental Engineering Department, and in it was done the experimental engineering work for the Curtiss organization.

The Curtiss organization has been a never-ending source of wonderment to most persons connected with the Navy Department who have come into contact with it. Up to the outbreak of the World War, when a sudden expansion took place in its activities, it was founded very much on the basis of a particularly congenial family. Mr. Curtiss was the head of this family. He was the undoubted head—the fountain of inspiration and the provider of all good things. When times were hard, which they have often been, all suffered together. When times improved, they all benefited together. When it became possible to provide good things for this family, Mr. Curtiss was unquestionably a "good provider" and stinted his family for nothing. It is probable that, at all times, the wages and salaries in the Curtiss Company have been considerably higher than those which would have been enjoyed by the recipients elsewhere. Often, it is probable, they did not receive these wages or salaries, but this was a misfortune, and in no sense any one's fault, and was due, merely, to the absence of funds, and certainly not to anybody's disinclination to disburse them. Some fell by the wayside under this rise and fall of family fortune; but those who stuck came into their reward when the Great War broke out and their organization was given large contracts by the British Government. As a result of these contracts, their organization immediately became the object of considerable solicitude on the part of financiers who were engaged in the laudable enterprise of spoon-feeding war babies. It grew accordingly. A plant of considerable size was built in Buffalo; the other buildings referred to were taken over; they embarked on large and profitable contracts for the British Government; and, if signs do not fail, made money. The head of the family is as shrewd as he is kindly. He looked out for the interests of his associates as he did for those of himself. Those who had been loyal to him through thick and thin, and who had found him loyal to them, found that this loyalty was not one of degree only, but was a temperamental characteristic. His associates found themselves with real salaries even further raised, and with considerable quantities of stock in an organization quoted on curb exchanges at rapidly increasing values. The small group of associates held together by a common interest, common affection, and by the genius of their family head, now found themselves financiers and the possessors of real liquid assets.

One other effect, however, sprang from the sudden development of the situation. The organization building two airplanes, or a half dozen, may whittle them out by hand and build them as an individual or family matter. The organization with an order on its books for a thousand airplanes must manufacture them. A difference is introduced as great as that from the North to the South Pole, or as that of the temperament of two men. Under the strain of manufacturing airplanes, the Curtiss family showed weaknesses. There were then called in manufacturing experts. The experts took charge and decided, to their own satisfaction, that the members of the Curtiss family were not manufacturers, and must not be allowed to become such. Something, however, must be done with them. They were the real owners and controllers of the organization and could not be calmly and blandly invited to get out. Accordingly, there was developed for them, as one by one they were displaced from positions in the manufacturing organization, an experimental engineering plant where they could experiment and develop to their hearts' content, hold their family organization intact, and continue on the same old status they had found so attractive in the past. From this grew and developed the engineering department in the old power house on Austin Street. Mr. Curtiss was still the head of the whole organization and his office was in the main plant. His heart and his mind, however, were in the Austin Street plant with Harry, and Henry, and Carl, and the rest of the boys.

Into the midst of this happy family was introduced the waif of whom I have been speaking. To their tender mercies it was to be, in a great degree, committed.

The first difficulty encountered was in connection with the name. Upon the few plans presented by the Curtiss Company, indicating their ideas of a big flying boat design, the name of the design had been given as TH. These letters were chosen from the Curtiss series, whereby designs are indicated in sequence, and had no other significance. It seemed to me that a design of such size and of such ambitious intentions should be dignified by a name more definite than two meaningless letters and I changed this name to D. W. T. These were the initials of Rear-Admiral David W. Taylor's name. I had not, however, consulted Admiral Taylor regarding this matter, and upon discussion with other men in the Construction Corps, I decided that such a name would fail to find his favour. Once more the name was changed. This time I chose the name of N.C.1. Under this name the design has developed and grown; the flying boats have been built and flown. In this name, the N is for Navy, the C for Curtiss, and the 1 indicates the first of a series of joint Navy-Curtiss designs. This name, changed since to simply N.C., has stuck and has given general satisfaction, and may be accepted as permanently indicating the type.

Up to the time the design of this three-motored boat was undertaken by the Curtiss Company, it is probable no design prepared by them had been worked out in the amount of detail desirable for a design of N.C. dimensions.

It was desired that this design should be worked out in complete detail so we would know as definitely as can be known from previous calculations what to expect from seaplanes built to it. This entailed control of the Curtiss design work by the Navy Department, and required a thoroughness of preliminary design foreign to practice at that time. The way they adapted themselves to the unusual conditions under which the work was done was creditable and helpful in the extreme.

There were times, of course, when things seemed to be progressing not any too well, when some members of the organization would gently complain that their ideas were not allowed full liberty of expression. They were right. No one's ideas were allowed such expression. No one of the Navy Department or of the Curtiss organization possessed sufficient experience in the fields we were exploring to be entitled to such confidence, and the Navy Department was compelled to pursue the matter in its own way. With these methods the Curtiss personnel assigned to the job were always in loyal and earnest coöperation. At times there was a lag in effort, but this always results when men are being driven as hard as were those working on this design. For the men actually rubbing noses with the details no hours of labour were too long, and many a one of them has worked often all day and most of the night in clearing up a difficult point.

From first to last there were many of the officers of the Navy Department who made important contributions to the design and construction work necessary in these boats. As the aeronautical assistant to the Chief of the Bureau of Steam Engineering Rear-Admiral Griffin, Commander A. K. Atkins had supervision of all work related to power plant, gasoline supply, etc. Immediately subject to his division of the Bureau of Steam Engineering were Commander H. T. Dyer, Lieut.-Commander H. W. Scofield, of the Navy, and Captain N. M. Hall, of the Coast Guard, under whose supervision many details were solved. The work performed by these officers was of the greatest importance and upon its success, of course, was dependent the success of the boats. From the nature of the design as a whole, however, their work must stick largely to practice already common, whereas that of the designers of the structure must depart almost entirely from the common, to branch out into new and unexplored fields. If in a description of this work the men who did the power plant work may seem to be neglected, these facts, and in no degree any lesser importance of their work, must be held responsible. It happens that this new work came mainly under the control of the Bureau of Construction and Repair, since it was, in a major degree, connected with the structure and, as a result, fell to the supervision of Naval Constructor H. C. Richardson, Naval Constructor J. C. Hunsaker, and myself. Since these are the facts it may be of interest to examine, briefly, the aeronautical experience brought by ourselves to this work of supervision of design carried on in territory until then unexplored in the aeronautical development of the United States.

In 1914, while I was stationed in Seattle, Washington, in connection with naval shipbuilding work in progress there, I became interested, with Mr. W. E. Boeing, of that city, now the head of the Boeing Airplane Company, in aeronautical matters. We took a few flights in a small Curtiss type flying boat then near that city, and Mr. Boeing became so enthusiastic that he decided to buy a seaplane for his own use, and asked my opinion regarding the type it should be. I made inquiries of the various manufacturers of airplanes then attempting to develop the aeronautical industry in this country, regarding the seaplanes built by them. I could find none I was willing to recommend, and, to my astonishment, Mr. Boeing one day stated that if I would design a seaplane he would have two of them built in a boat-building shop he owned. I knew so little about the subject, so little of the difficulties involved, that I agreed to undertake it.

To all of my acquaintances who knew anything of seaplanes, to everyone else of any knowledge of the subject on whose courtesy I could presume, I wrote for information, and, having collected all I could get, designed a seaplane with two pontoons, for a 140-horsepower, six-cylinder, Hall-Scott motor. In this seaplane there was little original: I had picked here and there the features of airplane design which seemed to me simplest and soundest, and, combining them, had developed a design from them. Mr. Boeing built two of them and, impossible as it undoubtedly seems, they were remarkably successful. After using these two seaplanes for a year and a half Mr. Boeing sold them to the Government of New Zealand.

This had two results: Mr. Boeing decided to become a manufacturer of airplanes, and built a plant in Seattle for the purpose; when the naval aviation programme was expanded shortly before our entry into the war, I was placed by Admiral Taylor in general charge of all aircraft inspection and construction coming under his Bureau of the Navy Department. In this position I became connected with the N.C. boats when the World Drama brought them on the stage.

Of Naval Constructors Richardson and Hunsaker the tales are quite different from my own.

The interest of Commander H. C. Richardson in aeronautics dates back a number of years, and in several respects he is the pioneer of the Aeronautical Fraternity of the Navy.

As far back as 1890 he was interested in, studied, and designed parachutes, and even built one of these devices for easing his descent from the ridge of the family barn. In 1895 he designed and built several light canoes, a type of structure definitely a forerunner of the pontoons used for seaplanes.

His transfer from the line of the Navy to the Construction Corps was partly due to his desire to take up the study of aeronautical design and construction. After his graduation from the special course for naval constructors at the Massachusetts Institute of Technology, in 1907, his interest in such matters rapidly crystallized into definite forms. He worked on design questions; took every opportunity presented in those early days of aviation to make flights; and, in 1911, built and tested a glider at the Philadelphia Navy Yard.

This glider was one of the first to be built without front elevators. With this glider, however, his experience was far from encouraging. When it was completed, he hitched it to a motor car, took his place in it, and gave the word. Nothing unusual happened until the speed of the car was about 25 miles per hour, and then the glider shot up in the air at an angle of about 45°, changed its mind, and returned to the earth at a similar angle, but with considerably greater velocity. It is possible to mention this occurrence in such a cheerful style as, happily, in the ensuing total wreck none of Commander Richardson's bones were broken, and he was damaged in a very minor degree only.

In 1913, Commander Richardson qualified as a naval aviator, and since that date his services have been employed entirely in an aeronautical capacity. At the Washington Navy Yard he had a valuable experience with tests of airplane floats and airplane boat hull models in the towing tank, and laid firmly the foundation for his future success in the design of elements of this nature. There, too, in 1914, he designed and built a twin-engined seaplane, which, at that time, was the largest plane of this type in the world.

From Washington he was transferred to the Air Station at Pensacola, Florida. There he continued the work, commenced in Washington, in connection with boat hulls, pontoons, general airplane designs, and devices for launching planes from shipboard, and was, in addition, charged with a very important proportion of the upkeep work of that training base. It was from Pensacola that he went to Buffalo and afterward to Garden City, to do his very important part in the designing of the N.C. boats. Later he was stationed in Buffalo in charge of the work of the Bureau of Construction and Repair at the Curtiss Aeroplane Company's plants in that place.

In addition to his work in the design field, Commander Richardson has done much valuable test flying, both in craft of his own design and in those designed by others. The ability to pilot a plane has been of great assistance to him in the working out of problems with which he has been confronted.

Naval Constructor Jerome C. Hunsaker, while engaged on post-graduate work at the Massachusetts Institute of Technology, in Boston, after his graduation from the Naval Academy, became so much interested in aeronautics that he was encouraged to take up specialization in that field; and he has continued in it ever since. While still a post-graduate student, he translated from the French the fundamental work of Monsieur Eiffel, "The Resistance of the Air, and Aviation," on which much of the progress in aeronautics in this country and abroad has been based. This was published both in this country and in England.

In 1913, shortly after completing his post-graduate course, he was sent abroad by the Navy Department to investigate and report upon the state of the aeronautical arts and sciences in England, France, and Germany. Upon his return to the United States he was detailed by the Navy Department, at the request of the Massachusetts Institute of Technology, in Boston, to organize there a course for post-graduate students in aeronautical engineering, and to install there and place in operation an aerodynamic laboratory. In this work he continued until 1916, and his influence upon aeronautical development in the United States while at the Institute, and since leaving it, has been of the greatest importance.

His contributions to the literature of aeronautics, his investigations and discussions of difficult problems, have been numerous and valuable. They have comprised such subjects as:

Aeroplane Design.

Theory of Similitude of Aërial Propellers.

Aerodynamics of the Triplane.

Dynamical Stability of Aeroplanes.

Reports on Wind Tunnel Experiments in Aerodynamics.

Stable Biplane Arrangements.

It may be of interest that the Boeing Airplane Company, of Seattle, designed and built a number of airplanes based on this last paper, and that they are remarkable in the ease with which they may be flown, and in the extent to which they can fly and control themselves, if the pilot desires to permit this.

In 1916, Mr. Hunsaker was detailed for duty in Washington, where he was placed by Admiral Taylor in charge of the aeronautical activities of the Bureau of Construction and Repair of the Navy Department centring in that city. This section of the Bureau expanded rapidly from five to one hundred and fifty men, and had charge during the war of all matters affecting design and construction of lighter-than-air and heavier-than-air craft for which the Bureau of Construction and Repair was responsible.

Up in Buffalo, where work was soon proceeding, the men working on the job soon became fired with an ambition which was partly hope, and permitted themselves to day-dream a bit. Results, however improbable, ceased to be impossible. We could see flying boats doing as we had been told they must—flying from Newfoundland to Ireland, and ready, able, and, as far as a flying boat can be, willing the next day to blow a submarine to perdition.

We were determined that a craft should be produced which could do the job. This called for one weighing 26,000 pounds. Of this amount, approximately

12,000 pounds would be required for oil and gasoline. A useful load slightly in excess of 50 per cent. was hoped for. This is very much better than the Handley-Page night bomber, and represented optimism of a high order. With the decreasing consumption of gasoline as the weight fell off greater radius per unit consumption of gasoline could be obtained, and it was estimated that it would be possible to cover with this boat the 1,933 miles involved without placing any reliance upon the wind for assistance. Accordingly, the dimensions were laid out on this basis.

We estimated a load of eight pounds per square foot, which would require a wing area of 3,250 square feet. A wing chord of fourteen feet was chosen; and other general dimensions of the craft were decided upon as follows:

Upper wing span	140 feet
Lower wing span	110 feet
Length, over all	82 feet

With these dimensions, the preliminary details were worked out.

When this preliminary design was about half completed, Naval Constructor H. C. Richardson arrived from the Naval Air Station at Pensacola for temporary duty in connection with this work. He expressed immediate doubts of the possibility of accomplishing the result aimed at with the horsepower to be employed, but the design was proceeded with. In a week or ten days more it was far enough advanced to make possible the estimates of performance. Naval Constructor Hunsaker came up from Washington, bringing with him all the latest coefficients of resistance, just received from the National Physical Laboratory of Great Britain, and we fell to work on the estimates.

Richardson was right! The result was most disappointing. Instead of a cruising radius of 1,933 miles, necessary for flight from Newfoundland to Ireland, there was indicated one of 1,300 only, barely sufficient for a flight to the Azores. The resistance of the seaplane would be so great that its speed and consequent radius of flight would be small. Further estimates indicated that we could do quite as well with a smaller boat, and that the "all-the-way-across" flight was probably impracticable with three "direct-drive" Liberty engines.

In the carrying of this design as far as it had gone there had already been encountered many of the difficulties expected from work of this nature undertaken with so little information and so little previous experience. It appeared most undesirable to embark on a design of even greater dimensions than the one undertaken, in which even the uncertainties with which we were being confronted were of such great proportions. To a certain extent we were whipped and had to admit it. Though I was responsible for the insistence which had caused us to spend several weeks chasing an impossibility, Richardson and Hunsaker generously shared with me in the downfall. To Washington we went, and told Admiral Taylor of our plight.

Doubtless, the Admiral was expecting us, had wondered, perhaps, what had kept us away so long, and was ready with his answer. He relieved us vastly by letting us off with a problem only half again as difficult as any one had yet been able to answer. "Build the smaller design, and we'll go by way of the Azores." With this smaller design, it seemed practicable to make a flight to the Azores, and refuelling there, to continue the flight to Portugal, one of our allies. And so it was necessary to dismiss the idea of a Newfoundland-to-Ireland flight, except on the basis of a stop in mid-ocean for refuelling from a ship.

We had in sight, at that time, no engine of sufficient power so constructed as to permit of a smaller number of revolutions of the propeller than were given by the engine itself. An engine of this type is referred to briefly as a "geared-down" engine. Over the other type, referred to as a "direct-drive" engine, it has, throughout the greater portion of the flying range of an airplane, a marked advantage. We realized that geared-down engines, of similar power to the direct-drive engines we were contemplating using, would improve greatly the performance of the design being produced, but it appeared unlikely that any would be available soon enough for our needs and we could not consider them at all.

In these few weeks we had been forced to accept the practical certainty that the target aimed at by us was too distant for us to hit. We had to admit, very reluctantly, that, so far as our knowledge could carry us, the art of airplane design had not yet reached a point permitting us to accomplish completely the task set. With the experience we have gained since then, and the knowledge we have acquired from the design produced, we could have adopted certain fairly simple modifications of the first design, which would have added very materially to its flight radius, and might even have made it practicable for it to accomplish an "all-the-way-across" flight. This would have been, briefly, the maintenance of the size as originally decided upon, and the addition of one more engine. The uncertainties were so considerable, however, and the amount of weight we had decided upon as capable of being carried by each square foot of wing surface was already so far beyond contemporary practice, that it did not seem practicable, from such a modification, to accomplish the object aimed at. As will be seen later, the addition of another engine was the very modification which was adopted finally for increasing the flight radius of these craft. From the resulting improvement, with a wing loading enormously increased beyond anything which had been experienced when this design was started, it seems quite certain that, with the greater wing area provided in the original tentative design, even better results would have been obtained had it been considered practicable to install an additional engine, and to continue the design on the basis of the dimensions originally laid down.

With enthusiasms somewhat dulled, for the time being, by our unexpected setback, we again went to work to produce the details for a flying boat of a total weight of 22,000 pounds and an estimated flight radius of at least 1,300 miles.

We may now survey the general dimensions of the design resulting from the labours just described:

Wing span, upper	126 feet
Lower wing	94 feet
Wing chord	12 feet
Gap between wings	13 feet 6 inches at centre
	12 feet at outer wing struts
Over all length	67 feet 3½ inches
Length of boat hull	45 feet 9 inches
Beam of " "	10 feet
Wing area	2,380 square feet
Weight, empty	11,500 pounds
Weight, full load	22,000 "
Engine power	1,000 horsepower

CHAPTER V

IMPORTANCE OF LOW WEIGHT PER HORSEPOWER AND OF STREAMLINES—WING SECTION DESIGN—STRUT EXPERIMENTS—HULL AND TAIL DESIGNS—USE OF ALUMINUM—POWER PLANT INSTALLATION—A SAFETY FACTOR OF FOUR

AN AIRPLANE looks like a very simple thing; but do not be misled by looks, it isn't! If I tried to tell you how complicated it really is, and to describe the calculating and designing of each portion, you would drop this book very quickly, and in no friendly spirit. Things one would bother about very little in other types of construction, in airplanes make the difference between flying and not flying.

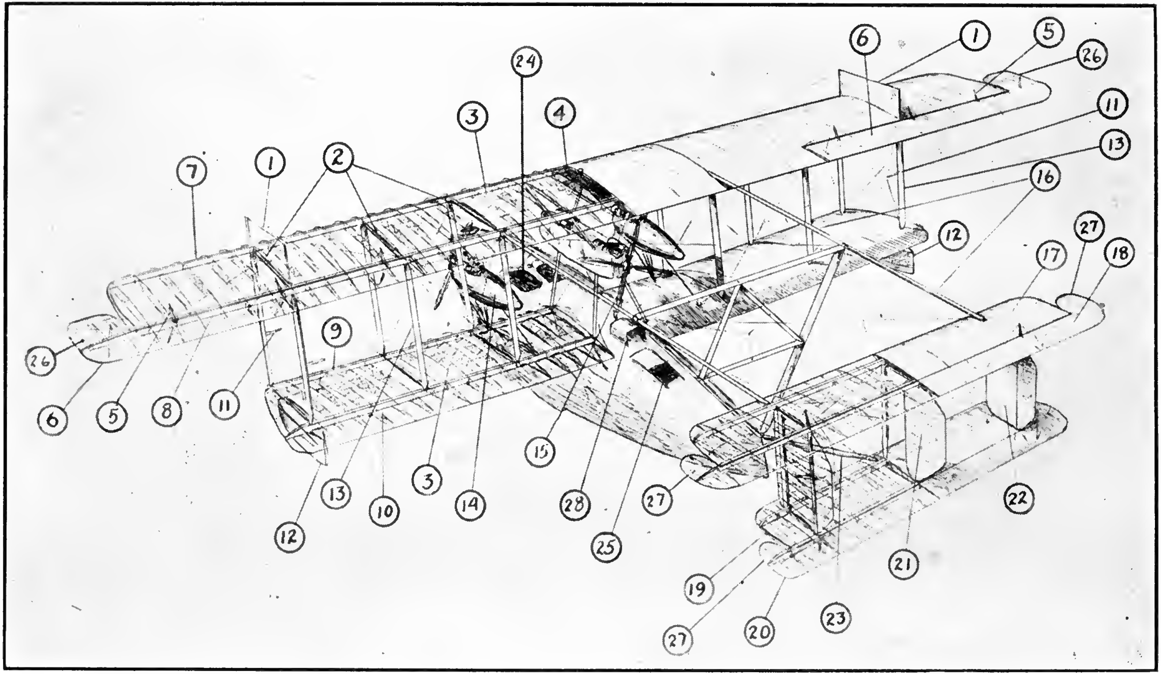
Take weight, for example. In a house, or a ship, or a motor car, weight is important, but nobody wastes sleep over a few pounds here and there. But in an airplane it is so important to avoid all unnecessary weight that designers try and try again, design and re-design, test this and that, investigate every practicable material they can think of, until every part of the plane is as light as it can possibly be for the strength required. It was weight which kept man from flying for so many centuries; and until he learned to build engines which weighed only a few pounds per horsepower, and the rest of the structure in harmony, he was tied down to the earth.

When the Wrights first started their experiments with flight they used gliders, very lightly built, for which the motive power was the force of gravity, as they would fly these gliders from low hills, and really coast down the air. But when they began to think about power-driven flight they had to consider the weight of the engine, and then much more real trouble began. When they attempted to secure an engine to fly with, of a weight of not more than 20 pounds per horsepower, they were told by gasoline engine manufacturers that their order was unfillable. It was not unfillable, but they had to become gasoline engine designers and manufacturers, and fill it themselves. Two poor, young bicycle mechanics solved, first of all, the principles of flight on which scientists had worked for centuries, and then, invading the entirely strange field of gasoline engineering, designed and built, on the first trial, the lightest engine for its power the world had known. In all records of man's superhuman accomplishments there is none any greater.

The first power-driven airplane in which man flew weighed about 45 pounds per horsepower. It had a speed of little more than 30 miles per hour. To-day there are airplanes which weigh not over 6½ pounds per engine horsepower, and which have a speed of 160 miles per hour. This has been made possible by a reduction in the weight of airplane engines from the 12 to 14 pounds per horsepower of the first Wright engine to the 1¾ pounds per horsepower of the Hispano Suiza, and the 2 pounds per horsepower of the Liberty engine of the present day. Design

Nomenclature of the N.C. Planes

1—Skid Fins
2—Compression Struts
3—Wing Ribs
4—Gravity Tank
5—Aileron Control Horns
6—Ailerons
7—Upper Forward Wing Beam
8—Upper Rear Wing Beam
9—Lower Forward Wing Beam
10—Lower Rear Wing Beam
11—King Posts
12—Wing Tip Pontoons
13—Wing Panel Strut
14—Outer Nacelle
15—Pusher Propeller
16—Outriggers for Tail Support
17—Upper Stabilizer (horizontal)
18—Upper Elevator
19—Lower Stabilizer (horizontal)
20—Lower Elevator
21—Balanced Rudder
22—Vertical Stabilizer
23—Tail Boom
24—Pilots' Cockpit
25—Hatchway, Engineer's Compartment
26—Aileron Balancing Section
27—Elevator Balancing Section
28—Access Tunnel



Nomenclature of the N.C. Planes. *(See opposite page for explanation)*

and construction details of the planes themselves have, of course, been refined, but these followed as a natural consequence of the reduction in engine weights and of the increase in engine powers.

Nothing could be clearer than the fact that a certain amount of power can drive a weight of 6½ pounds through the air much more rapidly than it can drive a weight of 45 pounds; and nothing could be more certain than the fact that future development must depend upon a further reduction in weight per horsepower, or that from such a reduction will come greater speeds.

The weight per horsepower of a fully loaded N.C. boat, with a transatlantic flight engine installation, is about 17½ pounds; the speed with this full load is about 93 miles per hour.

Success in airplane design and construction is in such a superlative degree the reward of an untiring consideration of weight, that an entire chapter devoted to the explanation of the weights of the N.C. boats would not be wasted. Bitter, indeed, will be the experience of the designer who allows any other element of design to assume in his mind an aspect of more importance. The soldier bound for the front may do as all soldiers entering their first campaign inevitably do, load himself up with non-essentials, with items chosen without due regard to weight, and no great harm will follow. As the weights on the first long marches become irksome, he can discard unnecessary items one by one, to be left at the last with the irreducible kit of necessities of the veteran. Designed into or built into the structure of an airplane the unnecessary or excess weight is there forever, and its elimination entails a new design.

With all of these things regarding weight in mind, we figured and designed the parts of the N.C. boats. We considered aluminum, and high-tensile steels, and woods of various kinds, but generally we found that when all the points had been considered, good, old reliable spruce was the material adopted for large members. For fittings, of course, steels were used; for tanks, aluminum; for pipes in the gasoline system, copper, but the main structure was of spruce. It was not always absolutely the lightest thing we could have used, but it was generally the most satisfactory. Aluminum would have been a little lighter, but aluminum deteriorates very badly in the presence of salt water, and, of course, we could not take any chances on such a thing in strength members. The framing of German Zeppelins is built of aluminum, and on several shot down in England and France marked deterioration has been found. The Germans have been using aluminum for such purposes for many years and have not yet learned how to prevent this action, so we decided to take no chances with it. For a few things, like long wing struts, high-tensile steel worked out lighter for equal strength, but it would have been so thin as to have no local strength. When you see an N.C. boat flying through the air, if you ever do, it is a portion of the spruce forests of Maine or of Oregon out for a joy ride.

Then resistance has to be considered. In our ordinary daily lives we do not give much attention to the resistance the air opposes to passage through it.

Even those of us who move fastest do not move fast enough to have it make any appreciable difference. In the motor cars in which we ride we give it little heed, and only the very high-speed cars used for racing purposes take it into consideration and adopt shapes with a reduction in resistance directly in mind. In airplanes, however, resistance is the thing most fought against. It is even more important, when high speed is to be considered, than weight, as the effect of a bit of unnecessary resistance is greater than that of a bit of unnecessary weight. This comes from the fact that resistance to passage through the air increases with the square of the speed. The resistance at 50 miles an hour is only one fourth that at 100 miles an hour.

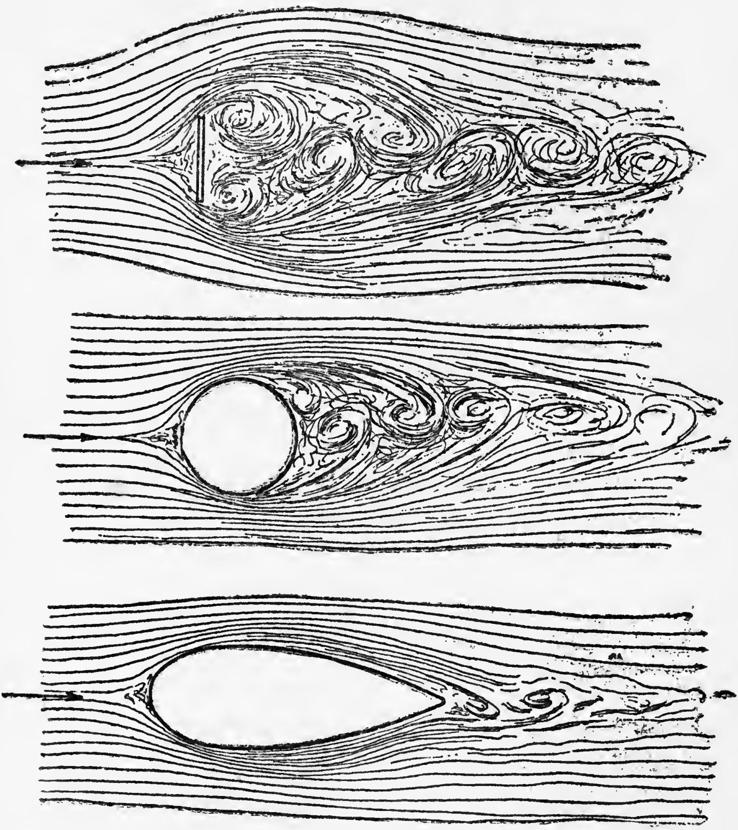
An airplane designer tries to keep down resistance by designing the members of the airplane exposed to the air of such shapes that they will have as little resistance as possible. One may easily, if interested, try a few experiments bearing on this subject. If a block of wood is held stationary in a stream of water, the effect upon the moving water is shown very clearly by the lines which it assumes around the sides of, in front of, and behind the block. It will also be seen that the effect upon the flowing water depends upon the velocity of flow, and that the strength required to hold the block stationary increases rapidly with an increase in velocity. Now, by varying the shape of the block, keeping the velocity of flow constant, changes may be produced in the effect upon the stream. Experiments have shown that by a careful choice of the shape of the block, although its width be kept the same, the disturbance of the stream may be reduced to the point where the effect is hardly visible, and where the strength required to hold it in position is small.

If the body be completely submerged in the water, the flow will take place above the body as well as at the sides and below. Here again, by the careful choice of the shape of the submerged body, the disturbance produced in the flowing water may be reduced to the point where it is hardly visible.

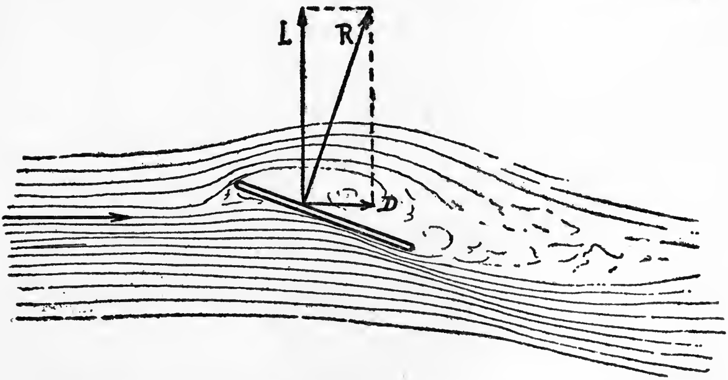
A body suspended in a flowing stream of air affects the air in exactly the same way as the body submerged in water affects the water. To reduce the effect to a minimum, methods similar to those explained above must be followed, and when minimum resistance is obtained, the body is said to be of "streamline" form. The more nearly the form becomes a perfect streamline form the smaller the resistance becomes. Were it possible to develop a perfect streamline form this resistance would be zero, and there would be no pressure against the body.

The flow of the air around this suspended body will depend upon the shape of the body. It is quite probable that it has often been noted while in a motor car that the wind blows on the back of the head instead of on the face. This is because the air in striking the wind shield is deflected upward over the head, but eddies are produced at a point just back of the head, giving the effect mentioned above. By a slight change in the height of the wind shield, or in the position of the wind shield with respect to the seat, this effect may be entirely overcome.

The accompanying sketches show in a visual form the effect on the air stream of the change in shape of the body suspended in the stream.



Consideration must also be given to the wing sections, for it is on the wing section that the lifting power of the wings depends. Wing sections are of many and of peculiar shapes. They have not developed accidentally, but from the fact that people who have experimented with them have, little by little, found the shapes that give the best results. Some wing sections are best for high speed, some are best for low speed; some for a heavily loaded, and some for a lightly loaded, plane; and if the average individual, who is not interested in airplane design except in a general, sketchy way, were to try to find out all a designer has to consider before he decides upon the wing section for his airplane, it would make him dizzier than a flight in the plane itself.



Here again it is necessary to mention the Wright brothers. The simplest conversation regarding the development of flight nearly always involves some mention of the Wright brothers, for they seem to have overlooked very little. It was they who first put the examination of airplane wing sections on a sound basis. In order to fly with the great handicap they experienced from their high engine weights they had to do this, for it was necessary for them to use a wing section from which they could get the very greatest amount of lift at the slow speeds at which they would be able to fly.

To find these things out they developed the wind tunnel. This is a device of a generally circular section through which air is drawn by means of a fan. In the stream of air created small models of the wings considered were tested, and by means of special scales the lifting effects were determined. As this lift increases, just as resistance does, with the square of the speed, it is easy to determine from such tests on small models, even with moderate speeds of the air stream passing through the tunnel, just what may be expected of the full-sized wings.

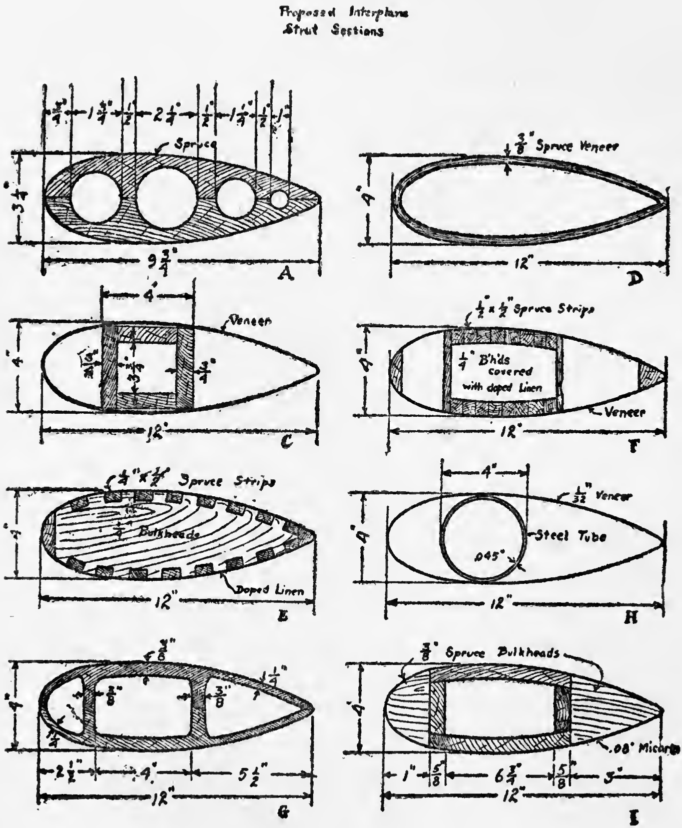
To-day there are wind tunnels large enough to take models of a span of more than seven feet, in which an air speed of more than a hundred miles per hour can be developed, but the Wright brothers could afford nothing of such magnitude. Their finances were inadequate, and their wind tunnel was small, and, perhaps, inefficient, but, nevertheless, their work was remarkably exact, and the methods developed by them are those now in use the world over. Wherever one turns in his examination of the achievements of these two remarkable men he is confronted by development work of astounding merit, and must conclude that their success was that of sheer, hard-working genius, unrelieved by any contribution of luck whatsoever.

The wind tunnel developed by the Wright brothers, primarily for the measurement of the lifting effect of airplane wings, is now employed for numerous purposes. In it are treated the resistances of different forms; models of complete airplanes are tested out in advance of building the large planes, and complete data may be secured of the performance to be expected of the large plane before any considerable amount is spent on it; and, most important of all, it may be definitely determined whether the large plane will be a safe one in which to fly, so that no brave lives need be sacrificed unnecessarily in taking into the air airplanes which have no business being there.

Never losing sight for an instant of the things we have just been considering, it was necessary for us to proceed with the design work. We could not produce a boat capable of flying all the way across, and of doing the necessary things to German submarines after they got there, so it was our task to do the best we could, and at it we went.

The wing section chosen by us for the N.C. boats was one developed by the British at their Royal Aircraft Factory in England, and named by them the R.A.F.6. This is a very excellent wing section, particularly suitable for load-carrying airplanes of moderate speeds. It is deep, so it can contain the large wing beams heavily loaded airplanes require, and is of as simple a form as any.

For several months 20 to 25 draftsmen were constantly employed working out and drawing the details, and there were very few solutions of the different problems of structural details we did not try. In connection with the wing ribs, the wing posts or struts, the tail booms, the compression struts, the wing beams, dozens of designs were sketched, cal-



culated, and in many cases built and tested. Ounces were fought for in the attempt to save weight as fiercely as if they were ounces of gold. The fever of invention seized everyone, and men would appear in the mornings with new designs they had thought up as they lay in bed.

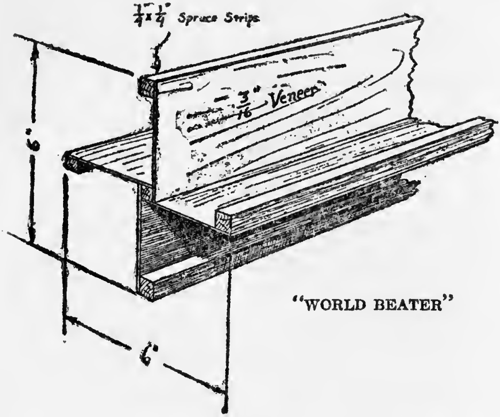
Some rather grotesque things were taken seriously, and several times designs were constructed and tested which in any other condition than the one of intense devotion to the saving of weight and resistance in which we then were we would have recognized at once as impracticable.

Numerous wing ribs were built and tested, each one a little stronger and a little lighter, until, finally, we got one weighing less than two pounds which supported a distributed load of 600 pounds for 24 hours without being permanently deformed. On a comparative basis a man of 160 pounds could hold up 48,000 pounds.

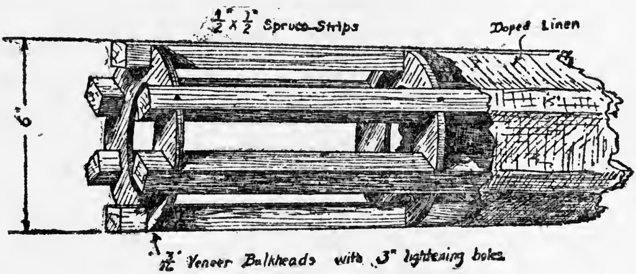
In our designs of compression struts for the wings we were particularly fluent. Something was wrong with the day on which two or three were not thought of. Finally one was produced seven feet long, weighing 3½ pounds and capable of supporting vertically a weight of 7,000 pounds. This strut was a simple, hollow, tapering strut of square section. Before it, however, many less successful ones had gone through the mill.

Almost every day, one or another of the many men working on the design of this boat would contribute to the designs of compression struts a new one of boasted qualities, and it would be patiently detailed, and calculated, and, occasionally, built and tested. From the first I had advocated the compression strut of square section, and had taken the attitude that it would be impracticable to develop one which would be more satisfactory from consideration of strength, lightness, and ease of manufacture. This, by the way, was a conclusion arrived at by Mr. Handley-Page, and we had already found how sound several of his conclusions had been. In common with the other persons working on this design, however, I suffered from the fever of invention, and produced one day a strut that all referred to as "the fish pole." In this strut were intended to be combined ease of manufacture, strength, and the absolute minimum of weight. When two of these were brought to test, however, instead of supporting the 7,000 pounds it was confidently expected they would be capable of, they assumed, when the weights placed upon them were still less than 1,000 pounds, remarkable postures, proving, beyond a doubt, that the name with which they had been christened was well deserved. Upon this, we all discovered, as we would have sooner done had each one not been blinded by the extent of his own inventive fervour, that in this strut no torsional strength of any amount had been provided. The fact was that any load off-centre by the slightest degree whatsoever caused torsional stresses against which no resisting ability had been provided, and when deflection once commenced it continued in a most remarkable and amusing fashion. The provision of torsional strength would have involved such manufacturing complexity as to make this type of compression strut impracticable, and it was, to the amusement of all concerned, laid on the shelf.

Proposed Compression Struts



"WORLD BEATER"



"FISH POLE"

Then appeared Commander Richardson with his "world beater." Like "the fish pole," this strut should have told on itself immediately, but two of them were built and tested. Having had my experience, and having returned to my advocacy of the strut of square section against the field I pointed out, not without some decree of sarcasm, that any one should be able to see that the material in Commander Richardson's strut was incorrectly disposed, and that this strut would inevitably be heavier for corresponding strength than the simpler strut of square section. Pained by my jibes at this child of his inventive faculties, and driven by them into a reckless course he probably would not have otherwise adopted, he took the typical American method of settling an argument by betting on his judgment. Four bets were made and duly recorded. The stake in each case was an ice cream soda. First, Commander Richardson bet me that his strut would be lighter per pound supported than the one advocated by me. Second, I bet Commander Richardson that without any relation to the weight of the two struts, the one advocated by myself would support more weight than the one advocated by himself. Third, in order that Naval Constructor Hunsaker might have some interest in the proceedings, I also made in his behalf, and with the same stakes, bets similar to those made by myself. As any one with the remotest nodding acquaintance with that mathematical conception known as "The Moment of Inertia" will appreciate, Commander Richardson forfeited four 24-karat ice cream sodas. At the same time, also, it was decided to adopt the strut of square section, and to proceed no farther with experiments being made.

It must be recorded that we found, when inventiveness had been exhausted, and decisions had been made, the wing beams, the ribs, the wing struts, and the compression struts to be practically identical with those employed by Mr. Handley-Page in his bombers. We could have accepted those at first and saved much work, but were hopeful of improving on them, and in some minor degrees did improve on them. As a result, we duplicated much of the work most probably done by Mr. Handley-Page before us in arriving at his excellent conclusions.

In the design of the very numerous fittings of metal, each one special to itself and requiring most careful strength calculations, much time, work, and ingenuity were involved. In this Commander Richardson's experience was of considerable value.

The system of wires is not so straightforward as it looks. For all of these wires exposed to the air we arranged streamline covers of wood. These streamline covers have a much less violent effect on the air than the round wires, and, though the several hundred feet required weigh many pounds, reduce the resistance of these wires to such an extent as to increase the high speed by three to five miles per hour.

The areas of the different surfaces, the wings, the stabilizers, the ailerons, the elevators, the vertical stabilizers, the non-skid fins, were determined by comparisons with other successful airplanes, and by proportioning the auxiliary surfaces to the area of the wings.

The N.C. machine is of the flying boat type. The boat hull on which the wings are mounted, and from which the rest of the structure is supported, carries the gasoline tanks, the crew, and many of the weights connected with the ship. It must be very light yet enormously strong. Of the total weight of the flying boat only about one tenth could be claimed by the boat hull. On it depends the ability of the plane to get off the water with large loads, its ability to land on the water without injury, and to rest upon the water with the crew in security and safety. Of all the portions of the structure it is the most important and the one most difficult to design. Upon Commander Richardson was thrown the burden of this design. If any one should be capable of doing it successfully it should be he, as he had specialized in connection with seaplane floats and flying boat hull designs, and was probably better posted regarding the subject than any one else in the world.

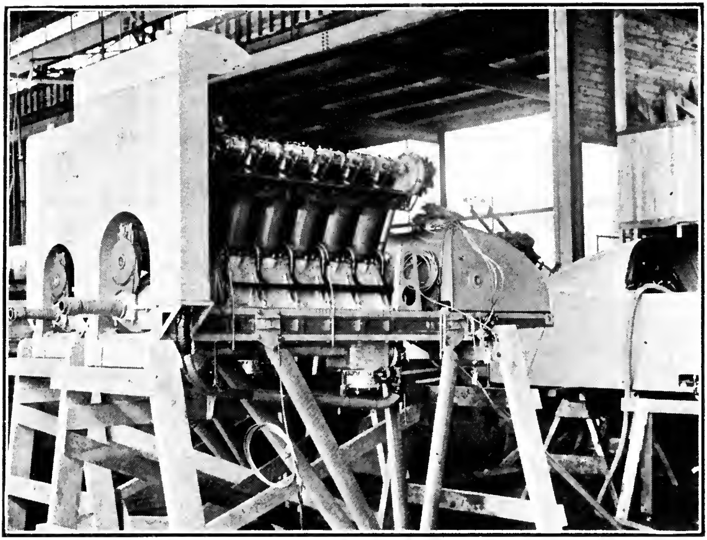
In the early days of the boat hull problems, Commander Richardson and Mr. Gilmore of the Curtiss Company worked together on them. They produced a design based partly on Commander Richardson's experience and partly on that of Mr. Gilmore, as embodied in a flying boat called "the flying life boat" recently constructed by the Curtiss Company. In this boat, too, was a trifle of the design found in the latest of the flying boats being built by the Curtiss Company, largely according to the ideas of Commander Porte of the Royal Naval Air Service of Great Britain. To this design a small scale model was built.

When tested in the Washington Navy Yard towing tank, however, this model gave very poor results. Commander Richardson thereupon changed it radically in several respects, retested it, and presently came back to Buffalo with the lines of the boat hull afterward built for the N.C. boats, and found to be wonderful.

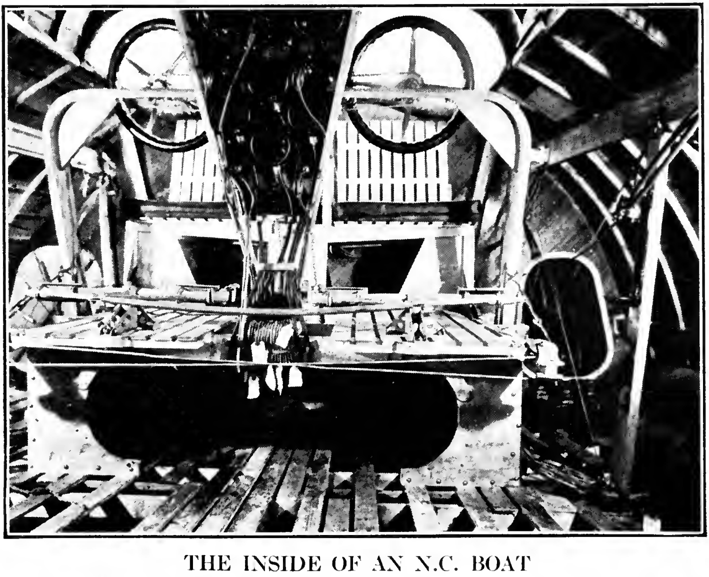
In working out the simple and sturdy details of construction Commander Richardson and Mr. Gilmore coöperated, and with the happiest results. Months afterward, as he will tell you in his account of the attempted transatlantic flight of the *N.C.3*, Commander Richardson's life depended for many hours on the integrity of the boat hull, on the correctness of the assumption of strength made when he had worked on it, on its ability to withstand the fierce onslaught of stormy seas; and it brought him and his four companions back to port in safety.

To Commander Richardson was given, also, the responsibility of designing the wing tip floats which prevent the ends of the wings from dragging in the water and the seaplane from upsetting. In the experiences of the *N.C 3*, of which you will later read, you will find mention of these floats. You may judge for yourself of their success.

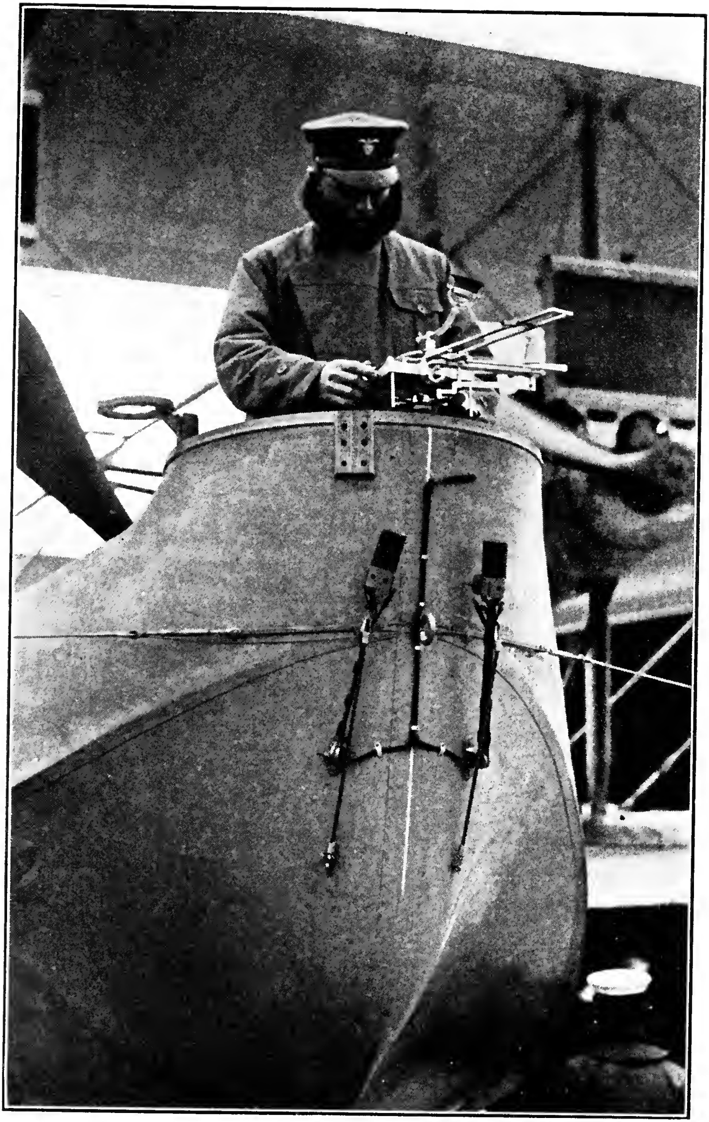
Of the features of the N.C. boats the two radical ones are the boat hull and the tail. Of the hull we have just heard. Of the tail little description other than sketches of the different arrangements of tail and of tail supports, shown in the next chapter, seems necessary. Many combinations were investigated and it may, of course, be questioned whether we got the best. We did do this, however, we got one which, through wind and weather, stayed where it belonged, content to be always last provided it got there eventually.



A WING ENGINE MOUNTING
Showing Liberty engine and radiator, as used on the *N.C. 3* and *N.C. 4*



THE INSIDE OF AN N.C. BOAT
Looking aft toward the instrument board and the pilots' control arrangements



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THE BOW OF AN N.C. PLANE

Lieut.-Commander Bellinger is adjusting the navigating instruments. Below may be seen the rockets used for night signalling

The N.C. boats were designed for a power plant of three Liberty engines driving tractor propellers, and the *N.C. 1* was constructed in accordance with this design. Of the Liberty engine it should not be necessary to include any description. Few things have been better advertised, and its origin and development are familiar and threadbare tales. Combined with this engine installation as a part of the power plant was the entire oil, gasoline, and engine control system.

One very radical departure, at least, from previous American practice was introduced in working out the power plant installation. Aluminum was employed more extensively than on any plane of our experience, and probably more extensively than on any other airplanes built as yet. The gasoline tanks, the lubricating oil tanks, and much of the gasoline distribution system were designed of this material. During construction and tests some of the piping and valves of the distribution system were changed to copper or to brass, and the gravity tank for gasoline feed was changed to a lead-covered steel plate, known as tern plate; but elsewhere aluminum has been retained, and has been found very satisfactory. The saving of weight was great, amounting to several hundred pounds, and it is most doubtful whether these craft would have been successful if aluminum had not been employed.

Gasoline is fed to the engines through a gravity tank set in the upper wing directly over the centreline of the boat, which is kept constantly full by two wind-driven propeller pumps. Through a very complete system of piping these pumps can draw from any or all of the nine 200-gallon gasoline tanks. Any one of these tanks can be shut off from all the others so that gasoline leakage, in the event of injury or failure of a tank, can be limited to the tank affected. Overflow from the gravity tank passes through a sight chamber with front and back glass sides, mounted just below the deck of the boat hull, and any failure of the wind-driven gasoline pumps to deliver gasoline can be instantly detected by the engineer. In the event of such failure a hand pump connected to the gasoline manifold system is available in the engineer's compartment.

Throughout, except for the large use of aluminum, the power plant installation is straightforward and in accordance with the usual best practice.

As has already been pointed out, we were unfortunate in having to employ direct-drive engines because no suitable geared-down engines were available.

Except in a few elements of the structure where special conditions held, every portion of these planes was designed for four times the strength required for support of the loads of normal flight. This margin of strength is designated in engineering structures as the "Factor of Safety." It had been customary in airplanes to make it at least six and often seven or more. Our decision to cut it down so radically was based on the certainty that in planes as large as the N.C's there would be no erratic or "stunt" flying, and none of the unusual strains produced by such flying. By this reduction in the factor of safety we were enabled, of course, to reduce the sizes of structural members and to save much weight.

The most important of the constructional elements for which a factor greater than four was employed were the flying wires. These were given a factor of six, and this factor was distributed to three wires. These planes were for war purposes, and subject to attack by hostile fighting planes, and, in the event of the cutting, by a bullet, of any one of the numerous flying wires, would be in a dangerous condition if the factor were only four divided among two wires. As soon as peace came, one of the flying wires was removed, so in the N.C. boats, when flying at designed load, there was, almost throughout, a factor of safety of four.

CHAPTER VI

SLOW PROGRESS—DOUBTS ABOUT THE HULL—MANY DESIGNERS LEND A HAND—MR. HANDLEY-PAGE AND HIS BOMBING MACHINES

IN DECEMBER, 1917, the Curtiss Engineering organization moved from Buffalo to their new plant near Garden City, Long Island, New York. By agreement with me this move was so made as to involve almost no delay in the work on the N.C. boats. Work stopped one afternoon in Buffalo; the Curtiss engineers and draftsmen went aboard special Pullman cars that night, and were in Garden City the following morning. Living arrangements had already been made for them, and most of them were at work again that day.

This move to the more kindly climate of Long Island was a welcome one to the Curtiss Engineering organization. After it, the work on the N.C's progressed unbrokenly for many months. For the Curtiss Company this work was under Mr. W. L. Gilmore, assisted by Mr. J. A. Christen. The progress, however, was less rapid than I had hoped, and its slowness contained in it many disappointments. I have no doubt that more was expected by us than could be accomplished in work of this nature, and my urgings for increased effort and for increased design output seemed to me, often, as not entirely unfruitful.

I have had sufficient experience with work of this nature to know that it is almost impossible to hurry it, and that the men who do the best work of this kind cannot be driven. The output of work appeared not overgreat, and there have been times when I feared the design would never be completed.

Shortly after the move to Garden City, Naval Constructor Richardson returned to Pensacola. All the main elements of the design had been formulated, and the general nature of smaller details had been decided upon. There remained for completion the innumerable small details of design, requiring the ceaseless plug, plug, of the draftsmen detailed to cover the work, and the careful and observant oversight of the engineers in charge of the preparation of these plans.

Regarding a new design of such dimensions and of such unusual features it must be expected that much doubt would exist. It is probable that little confidence was felt in the work being done by persons cognizant of it but not themselves engaged upon it. It was no uncommon thing, as the design approached completion and the construction of certain elements were taken in hand, to hear frankly expressed criticisms of the whole design or of specific features of it. This, not unnaturally, had a disturbing effect upon those connected with it whose fortunes were to some extent, and whose hopes and expectations were completely, tied up in it. After a bit, when a boat hull being built by the Curtiss Company at Garden City was sufficiently completed to attract attention, it was made the subject of more than one jest, and served to point the moral of more than one gloomy forecast.

As the first one of these flying craft approached completion, these forecasts became, if anything, gloomier, and few could be found who would speak with enthusiasm of the probable outcome. Of the boat hull, in particular, much doubt was felt. Its design, compared to previous flying boat hull designs, was radical in the extreme. Its width, compared to the amount of load to be carried, was small, and on more than one occasion my nights had been disturbed by the recollection of the confident forecasts of men of experience that it would never get off the water. Though I never have discussed this matter with Mr. Curtiss, and so cannot quote him, I feel that he was among the number who doubted the performance anticipated from this boat hull. I base this belief on the fact that, without securing my approval, he had arranged to have incorporated in the boat hull built at his plant a structural feature which would make possible the addition of side fins for the increase of the bottom or the planing surface. These fins, as can be seen from Curtiss flying boat photographs in Chapter II, had been an inherent feature of Curtiss flying boats almost since the first. They had, in fact, come to be considered as indispensable, and the design of a boat hull without these features, or without the proportion of planing surface previously considered necessary, seemed almost heretical.

Commander Porte of the Royal Navy, the greatest foreign authority on the subject of flying boats and flying boat hulls, had an opportunity of examining the boat hull for the *N.C. 1.* He discreetly refused to commit himself, merely stating: "It is very interesting." However, in England, I later heard from various sources doubts of this boat hull, and of the design in general, which could hardly have been inspired by any one else than the Commander himself, and it is fairly safe to conclude from these remarks, and from the probable source of their inspiration, that he, too, was, not unnaturally, among the doubters. There can be no question that the design had the appearance of being a radical one. The boat hull, in particular, had so widely departed from previous practice that it is not surprising that incredulity should have resulted. The boat hull suggested by the Curtiss Company had possessed the general appearance, looked at from the side, of the one constructed, but the ideas of this company regarding the dimensions of this boat hull and, in particular, the area and distribution of the planing surface, were fundamentally different from the ideas embodied in the design itself.

In July, 1918, there visited this country a British Aviation Commission. The principal technical member of this commission was Colonel Sempill, a most talented officer, formerly of the Royal Navy. This commission was given the fullest possible opportunity for examination into all phases of our aircraft efforts, and at Garden City was shown the *N.C. 1,* at that time far enough advanced in construction to afford some fair idea as to what it might look like finally. Colonel Sempill's opinion of the craft was briefly summarized in his report regarding American activities, and was as follows:

"The hull of this machine was examined, and is the design of a naval constructor. The machine is impossible, and is not likely to be of any use whatever."

It happens that in airplane design, the thing which does not look well is very likely to be unsound. It does not follow, however, that the design which looks unusual is also unsound. In judging the N.C's, numerous people have been led astray by the fact that the design is unusual, have forgotten that different problems must be solved in different ways, and have condemned the design without going to the trouble of inquiring into its different features and the reasons therefor.

At the time of the move to Garden City, with headquarters in Buffalo, I had charge for the Bureau of Construction and Repair of all aeronautical work at factories, with the exception of that at the Naval Aircraft Factory in Philadelphia. With more than a dozen branch offices scattered about the country, from Akron, Ohio, east to Marblehead, Mass., requiring frequent visits, most of my nights were spent in Pullman cars, and my visits to Garden City were not quite so frequent as I would have desired. Always one day of the week, however, was spent there; occasionally it was possible to work in two days there. Everything was of surpassing importance, for everything we were doing was for counter-submarine work, but the N.C. design seemed always just a little more important than anything else, and as requiring a bit more personal attention and personal shove, and, accordingly, it was to Garden City I went oftener than to any other place.

My visits could not have been very welcome. I was always disappointed by less progress than I had expected, and was, perhaps, a complaining visitor. The pressure under which this work was done never relaxed until the three boats left Rockaway Beach for the transatlantic flight. The fact that the men of the Navy and of the Curtiss Company who were connected with the designing and building of these boats came through the experience in fair shape is testimony to the endurance of the human animal.

One thing we discovered was that everyone underestimated the time required for the design work, and that we were certain to be several months longer in completing the first boat than we had anticipated.

There have been many inquiries as to the specific control of the design of these great flying boats. Time and time again I have been asked: "Well, now, who did design the N.C. boats?", and I have replied, "That is impossible to answer. They were designed by many people." It may, then, be explained in more detail what is meant by this.

The final supervision over structural design details was, of course, retained by the Bureau of Construction and Repair. This meant, ordinarily, Naval Constructor Hunsaker. In the event, however, of a matter of importance regarding which his opinions might have been divergent from those of Naval Constructor Richardson and myself, the decision would have rested with Admiral Taylor. It may be said, however, there was not carried to the Admiral a single difference of design opinion of this nature for his final decision. In no case were we unable to reach a harmonious conclusion. In few cases, and in few instances, in fact, was it even necessary to refer to the Bureau for decisions on points concerning which any considerable differences of opinion existed among the persons working immediately in connection with the design. In many cases, however, where various solutions of a problem could be adopted, these solutions were thoroughly considered by those actively engaged on the design, and then Naval Constructor Hunsaker was called in for the final discussion at which the decision was made as to the solution to be chosen.

Details of the design of the power plant installation required the approval of the Bureau of Steam Engineering. Ordinarily, this meant the approval of Commander A. K. Atkins who was the head of the aeronautical division of that Bureau. On occasions, as necessity developed, Commander Atkins, or one of his immediate assistants at the Bureau, would visit the scene of actual work, for conference with the Curtiss representatives, or with those of Construction and Repair, and for decisions of power plant matters. In Buffalo, during the time work was carried on there, Lieut.-Commander H. W. Scofield supervised the work for Steam Engineering and in Garden City, after the transfer of the work there, it was under the supervision of Captain N. B. Hall of the Coast Guard, Aeronautical Inspector in the New York district for the Bureau of Steam Engineering.

At the plants of the Curtiss Company, the supervision of the work of design for the Bureau of Construction and Repair was under myself. A few of the features were contributed by myself. In general, however, I exercised, in connection with this design, the same type of supervision the head of an architectural firm would exercise over the numerous designs being worked up by the personnel of his firm, with the exception that final decisions could always be made by the Bureau of Construction and Repairs. First of all, there were arrived at the larger characteristics of the design. These characteristics were thoroughly discussed by the Navy Department's representatives and the Curtiss Company's representatives, and were then divided into their component elements. These component elements were distributed among the drafting personnel for the working out of the details.

As to individual responsibility or credit for certain details, it is exceedingly hard to be definite. One never can know, even of his own accomplishments, where the original idea came from. The boat hull, for example, the most important of the large elements of this design, as well as the most unusual in its departure from previous practice, is in a very large measure the contribution of Naval Constructor Richardson. Its successful working out was made possible by his several years of experience in seaplane pontoon design and building, and by his knowledge of resistance secured as a result of his connection with the towing tank of the Washington Navy Yard. The general dimensions and the structural arrangements were largely suggested by him, and may be said to be almost entirely the fruits of his experience. As a matter of interest, however, it may be mentioned again that the short hull, necessitating an auxiliary structure for the support of the seaplane's tail, was the original suggestion of the Curtiss Company, and was taken from a flying boat previously constructed by them. This flying boat was, in my opinion, almost entirely the product of ideas of Mr. W. L. Gilmore of that company.

To a boat of this nature Naval Constructor Richardson was at first opposed. He was, as a matter of fact, in favour of a construction somewhat more conventional, with a long tail, and the tail members of the airplane supported thereon. It may also be noted that the fundamental idea of the bottom of this boat hull was furnished by the shape of the boat hull of the *H-16* for the design of which Commander Porte of the Royal Navy was largely responsible. In the *H-16*, however, were contained one or two features which prevented the full success of that design, and these features were eliminated by Naval Constructor Richardson in the model tests made by him and Naval Constructor McEntee in the towing tank in Washington.

As to the tail, arguments arose. Naval Constructor Richardson was, and still is, an advocate of monoplane tails. To me the size of the required tail was somewhat staggering, and I was in favour of a biplane tail. Involved in the question of the tail was the method of support to be adopted, and in connection with this there was also much argument, discussion, and investigation. After such discussions and investigations had run their courses, however, the tail decided upon was the biplane tail. The fundamental decisions arrived at, the design details were immediately taken in hand, and to these design details, as well as to those for practically every other portion of the plane, great and valuable contributions were made by Naval Constructor Richardson. We tried to have no pride of opinions. Ideas were pooled —our own, as well as those uncovered by designs of other men—and wherever we could find a good one we took it and used it.

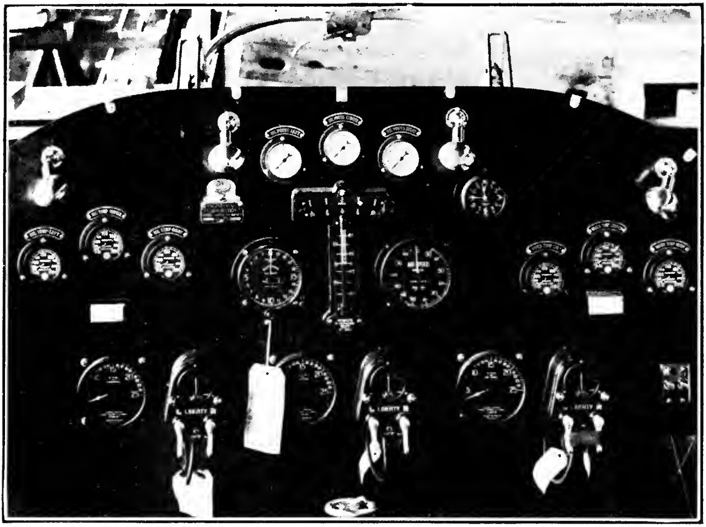
Working intimately with Naval Constructor Richardson, and at all times in direct control of the Curtiss design personnel engaged, were Mr. W. L. Gilmore and Mr. J. A. Christen of the Curtiss Company. Their ideas, opinions, and experiences are so interwoven in all the results accomplished that there cannot and should not be any attempt at identifying those pertaining to each individually.

Before a satisfactory rib could be worked out, many less satisfactory, as has already been stated, had been tried. The one finally chosen was, essentially, the rib used in the Handley-Page airplanes of 1917, though, in its construction, certain improvements had been made, and a lighter, stronger design had been secured. We were fortunate in having definite information regarding the Handley-Page rib. This information was no less definite than an actual portion of one of these ribs brought back by me, in September, 1917, after a visit to London. In London, I had the pleasure and good fortune of becoming well acquainted with Mr. Handley-Page, the designer of the great night bombing machines which bear his name, and of being permitted freedom of access to his manufacturing plant. On one of my visits to this plant, he gave me a section of one of his airplane ribs, and this souvenir I brought back with me on my return to the United States.

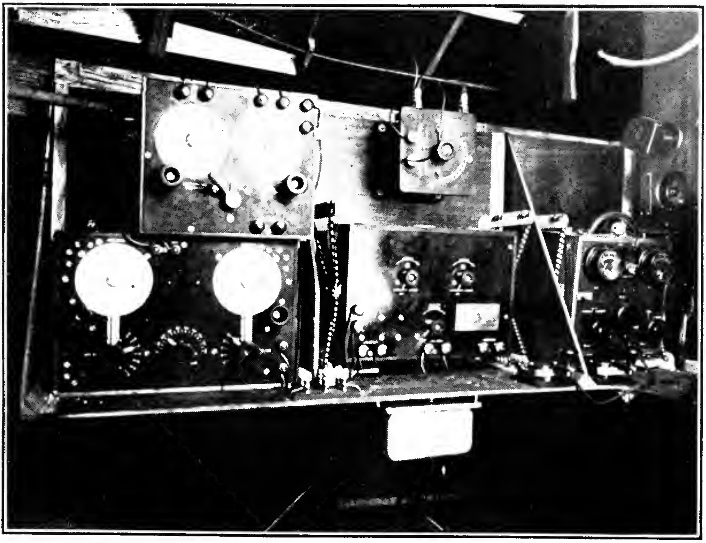
Connected with this bit of an airplane rib is an amusing little story. Mr. Handley-Page is a genial, hearty, and an entertaining man. During the time I was in London in July, prior to my departure for the Continent, I saw much of him. With several other officers of the Aeronautical Commission mentioned previously, I was domiciled at one of the London hotels, and, either there or at other places, we enjoyed, not infrequently, the very pleasant company of Mr. Handley-Page. In addition to the facts that we were representatives of the newest of the Allies, and of a most welcome addition to the fold, and that, with the exception of some differences in accent and in pronunciation, we spoke the same language as himself, the fact that we represented the future aeronautical development of the United States gave us sufficient importance from Mr. Handley-Page's point of view to afford us the good fortune of becoming well acquainted with him. In his dealings with the British Air Service he had suffered many disappointments. Even as late as July, 1917, there was in Great Britain a powerful voice against the adoption of airplane bombing, and, even in the air service itself, a powerful element doubted the merit of airplane bombing operations. Mr. Handley-

Page, having devoted some years of his life to the development of bombing craft, believed, not unnaturally, that of all military instruments the airplane bomber was the most important, and, baffled for the time being in his efforts to have large numbers of these planes built for the British Government, turned to us in the hope that the United States might be induced to take up the manufacture of this bombing plane. We shortly discovered, to our pleasure, that he was somewhat sensitive, personally, regarding the very large amount of advertisement being secured by Signor Caproni, the great Italian designer, and the large planes designed and built by him for purposes somewhat similar to those for which the Handley-Page planes were intended. We also found that he was quite a bit gullible, and we secured much amusement by discussing with him the comparative merits of his own craft and those manufactured by Signor Caproni. We always took care to convey somewhat definitely the impression that we considered the Caproni as the only real bombing plane in existence. We never failed, I believe, in our intention of starting him on a series of explanations, and out of this innocent sport secured no little amusement. After we returned from Italy, and from a personal investigation of the Caproni airplanes, and of the plant in which they were built, and a delightful acquaintance with Signor Caproni himself, we were in a much better position to secure more harmless amusement at the expense of Mr. Handley-Page, and took advantage of it. He knew he was being imposed upon, but the subject was one too intimately a portion of his fibre, and too near his heart, to make it possible for him to avoid the harmless pitfalls we were ever setting for him.

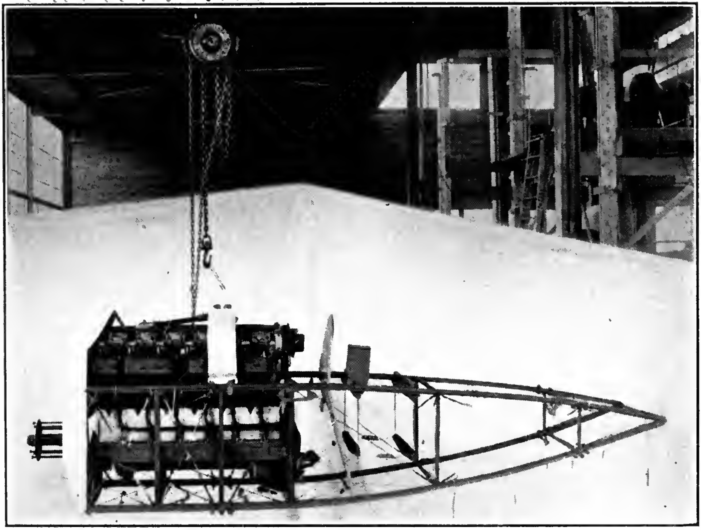
On the evening on which I quit London for Liverpool, and a steamer home, Mr. Handley-Page was thoughtful enough to drop into my hotel to say good-bye. There he found my luggage piled up in the lobby, and resting on top of it the airplane rib he had given me. The sight was too much for him. When I returned to the hotel he was on the point of leaving, as he had concluded my return might be too long delayed. He walked back with me into the lobby, and there I found a message, pasted around one of the sections of the airplane rib, which he admitted was his own handiwork. This message was the simple legend: "The thing that made Caproni jealous." It was this rib, adorned with this message, which served as the foundation on which the ribs of the N.C's, shown in Chapter VII, were designed and built.



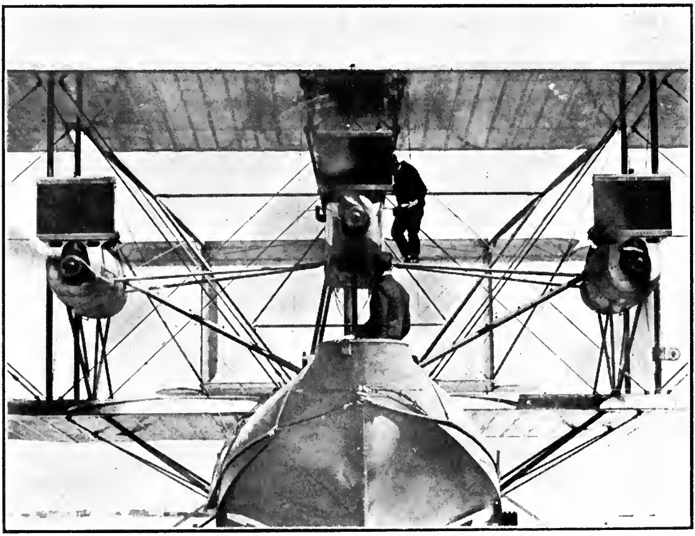
Instrument Board, Centre Nacelle, *N.C. 3*



Wireless Control Station in the After Cockpit, *N.C. 1*



Liberty Engine, in Place on a Wing Nacelle, *N.C.-1*



THE BOW OF THE *N.C. 1*
All the propellers are in motion, and she is ready for flight

CHAPTER VII

THE ACTUAL BUILDING—PLACING OUT PARTS OF THE WORK—MR. GILMORE'S SHARE IN THE N.C'S—HIS NAVAL ASSISTANTS—MOVING THE BIG PANELS OUT TO GARDEN CITY—THE ASSEMBLING—ENGINE INSTALLATION PROBLEMS

BY THE middle of January, 1918, we were far enough advanced with the design to give consideration to building. Our weight estimate indicated that we would be within 5 per cent. of the amount allowed; our estimates of performance were encouraging. Much detail design, particularly on the tail, which had been delayed, was necessary, but most of the major construction work could be taken in hand.

I estimated the boats, exclusive of engines, would cost over $50,000, and not more than $75,000, each. Actually, they cost very much more than the larger figure, about twice as much, in fact, but this was due to the great number of changes made in the design after the completion of the first boat. Duplicates of the last boat, the *N.C. 4*, could now be built in groups of four for about one hundred thousand each.

Admiral Taylor, with the concurrence of the other Navy Department bureaus concerned, recommended the building of four of these craft, and the Secretary of the Navy immediately ordered the work taken in hand.

Uncertainties regarding the type still existed in a very active degree, and in the department of the Navy charged with the operation of aircraft it was feared the work on the N.C. boats might interfere with work considered more pressing and more important. To prevent such interference, it was definitely ordered that it must be avoided.

As there was no experience to guide us in estimating the cost of flying boats of this nature, it was decided to place the contract for the construction work with the Curtiss Engineering Corporation, without considering any other airplane builder, and to base the contract on the actual cost to that company of the work involved, plus a profit of 10 per cent. on this cost.

In connection with the contract for the N.C. flying boats, the Navy Department reserved to itself the right of placing sub-contracts for any portions it might elect so to handle. Actually, the only structural parts purchased directly by the Navy Department and supplied to the Curtiss Company, for incorporation in the completed structure, were three boat hulls. Two of these boat hulls were built by the celebrated boat building firm of Lawley & Sons, Neponset, Mass., and one was built by the Herreschoff Manufacturing Company, the famous boat builders of Bristol, R. I. The fourth boat hull was built by the Curtiss Company itself, as an item under the regular contract.

When the details of the boat hull design were sufficiently advanced to make construction practicable, Mr. Fred Lawley, of Lawley & Sons, visited Garden City to examine these plans, and to arrive at a basis on which his firm could undertake the construction of two of them. This basis was rapidly arrived at. Mr. Lawley's attitude was most helpful, and there was no difficulty in reaching an agreement satisfactory to both sides. On this basis, a contract was placed with them for two boat hulls for these boats. The Herreschoff Company, of Bristol, R. I., were offered a contract for one of these boat hulls on the same terms, and accepted it.

There were definite reasons for placing these contracts with three builders rather than with one only. It was hoped to secure some competition in speed of building, as well as in cost. It was considered probable that the ideas of different boat builders, regarding the structural details of these boat hulls, would be of value. Primarily, however, it was desired, in the event of additional boats of this nature being required, to have at least three builders, sufficiently experienced with the design and with the details of construction, as sources of immediate supply.

Even before the move from Buffalo to Garden City, a definite procedure for building the N.C's had been decided upon. The size of these boats is such that large quantities of space are required in their construction. The facilities of the Curtiss Engineering Corporation were insufficient for this purpose, and other contracts already secured by them were such as to require a considerable part of such space and facilities as they had. It had been decided that expedition in building could be obtained only if these boats were built on the "assembly" principle, rather than at one plant.

Full use would be made of the Curtiss Company's facilities, but care would be taken not to overload them; and such work as could be efficiently and quickly performed elsewhere would be placed elsewhere. The work peculiar to airplane construction, and requiring experience gained in such construction, would be performed by the Curtiss Company. This work would include the provision of the flying and landing wires, the layout and building of the gasoline system, of the flying controls, engine controls, and the nacelles, the covering of the wings, and, most important of all, the complete final assembly and adjustment of all the parts.

A survey had already been made of the facilities existing in the vicinity of New York City, to determine where the portions of the flying boats to be built outside the Curtiss plant could be most effectively and expeditiously constructed. This was at a time, of course, when few organizations not engaged in the production of war materials could be found in the country, and when the majority of these manufacturing concerns were being pushed to the utmost limit of their capacities. There were, however, some manufacturing plants which, before the war, were engaged on work found at the outbreak of the war to be unnecessary for the purposes of war, and which, accordingly, had almost ceased to operate. Many of these manufacturing plants were of such a nature as to be fitted for the work of building portions of the N.C. flying boats, and it was among manufacturing plants of this type that the survey referred to was especially made. It was certain that plants of this character would be able to proceed with little delay upon the work placed with them. A difficulty of some importance was anticipated on account of the weakened organization of most of these plants, due to lack of work, but this was a disadvantage which must be accepted. In addition, no one of these plants could claim familiarity with work of the exact nature of that for which their facilities were being examined. This, however, was not a matter of any great seriousness, as the work would be in any case of a somewhat similar nature to that on which the plant had previously been engaged.

As a result of the survey made, it was possible, very shortly after a contract had been placed with the Curtiss Company for four of these flying boats, for that organization to place sub-contracts for various parts of these craft within reasonable distances of New York City, or actually within that city itself. These sub-contracts, which were in addition to those placed directly by the Navy Department for the three boat hulls, were for metal fittings, for gasoline and oil tanks, for wings, ailerons, non-skid fins, and all tail surfaces; for wing struts or posts; for tail booms; for gasoline system valves and fittings, and for the wing tip floats. This list will strikingly show the extent to which the Curtiss Company was relieved, by the procedure adopted, of many onerous manufacturing details.

Among the buildings comprised in the plant of the Curtiss Engineering Corporation, at Garden City, there was not one of sufficient size, or of sufficient truss height, for the work of assembly. For such work a special building was constructed. This building, naturally and justly, was paid for by the Navy Department with the understanding that, at some future date, it would revert to the Curtiss Company, on the basis of an agreement to be arrived at by that company and the Navy Department.

The early steps preceding the start of assembly of the *N.C. 1* were filled with many small sorrows and difficulties, formidable and often disheartening when they came several at a time. Many drafting details were incorrect or incomplete and the subcontractors were often clamouring for correct information, or were delayed by having to make over again things incorrectly made; many intricate and expensive metal fittings were destroyed in heat treatments, and valuable time was lost in replacing them; many small parts needed for the complete parts were forgotten, and were not ordered until the necessity for them actually existed, and delay was the result; in fact, all was bad luck and no good luck. In airplane building it seems that optimism is never justified, that things are always worse, never better, than we expect, that unexpected happenings always hinder and never help. Nevertheless, in the latter part of May the necessary parts of the *N.C. 1* had been delivered to Garden City, or had been built there, and assembly was started.

In describing delays, there is danger that an unnecessarily critical attitude may develop, and that criticisms, spoken or implied, may become personal. Such a result would be entirely unintentional. It is desirable, however, to record freely and frankly such incidents relating to the construction of these boats as may be of interest, and, in such records, facts must be stated as they existed.

The Curtiss Engineering Corporation, as originally organized, was for the carrying on of experimental work only. It had much of the strength and much of the weakness usually existing in an aggregation of stars. Mr. Curtiss's inclinations run naturally in the direction of development work rather than in that of production work. Due to the demands of war conditions which this organization had not fully anticipated, it was called upon to become more of a production organization than a developing one, and the addition of four N.C. boats to these production demands increased greatly the burden being carried. The result at first was a decided lag in effect. The transforming of an engineering organization into a production organization is a matter of difficulty and one requiring, usually, much more time than is available while a war is in progress.

As was to be expected from the conditions outlined, results, at first, were far from happy, and progress was much retarded. To meet the situation existing, there was created within the Curtiss organization a special organization, known as the N.C. organization, for duties solely in connection with the building of these boats. Until the creation of this special organization, the work on the N.C. boats had been practically without a head divested of other interests. To Mr. W. L. Gilmore, of the Curtiss organization, working under the supervision of the general manager of that company, had been assigned the oversight of the construction of these boats. Upon the shoulders of Mr. Gilmore, however, were borne such an amount of the weight of the work of the whole organization that the time he was able to devote to N.C. affairs was but a small portion of any one of his days. Duties of much complexity in connection with design were assigned him. In addition, he had indefinite but extensive duties in connection with the manufacturing activities in general. If any time was left him from such manifold and difficult demands, he was able to devote it to the handling of the numerous, difficult, and increasing details connected with these flying boats.

Mr. Gilmore is by preference a designer. Work of manufacturing and the pursuit of the details involved do not hold his affection in any degree comparable with that he feels for development work. His abilities in the direction of manufacturing or production work are great, however, and fate decreed that he must so employ them. It was possible for the Curtiss Company to relieve him from the major portions of his other duties and assign him to the overlordship of the N.C. boats, and his efforts devoted to speeding the progress of these craft had excellent results.

As the work of the sub-contractors progressed, and the work of assembly of the first one of these boats was taken in hand, the details increased in their complexity, in number, and in difficulty. The personnel of the Curtiss organization became unequal to the demands made upon them. It was impossible to expand this personnel sufficiently. All over the country, and, as a matter of fact, all over the world, there was a dearth of men with manufacturing experience. It was becoming more and more pronounced as manufacturing enterprises increased, and a greater and greater number of men were drafted into military service. In the organization immediately under my command, however, there were a number of young officers of some manufacturing experience, and of the highest degree of intelligence. I detailed five of these officers for duties exclusively in connection with the N.C's, and placed them on this work to all intents and purposes as assistants to Mr. Gilmore of the Curtiss Company. With the assistance of Mr. Gilmore, an organization chart was prepared, a copy of which is considered as sufficiently interesting for inclusion here. In this organization these officers reported directly to Mr. Gilmore and received from him instructions as to the carrying out of their duties. As members of my official family, and, therefore, as responsible to me for work considered by me to be the most important of that coming under my supervision, it was natural that they should have exercised a very close liaison between the Curtiss Company and my office, and that elements were occasionally introduced into the work in progress which required considerable forbearance on the part of all concerned. In such good faith did this arrangement proceed, however, that, notwithstanding its many very evident difficulties, it was practicable to carry on with it on terms of the best understanding, and with excellent results. To

Mr. Gilmore much credit is due for his conduct throughout a situation of many difficulties.

The plant of the Locke Body Company, where all wing and tail surfaces were built, is located in the heart of New York City. The upper outer wing panel of an N.C. boat is twelve feet wide by forty-five and three quarters feet long. It may be appreciated that the hauling of a fragile construction of this nature through the streets of New York City, and over the roads of Long Island to Garden City, a distance of about twenty-three miles, would require the greatest amount of care, and would be of the greatest difficulty. To Lieutenant W. C. Wetherill, of my office, was assigned the responsibility for the arrangements for transporting these wing sections, and for the entire supervision of this work. He was so convinced of the difficulty of the undertaking, and of the necessity of successfully carrying it out without injury to the wing panels, that he assured me, when on the point of starting to move the first one, that, if anything happened to it on the way he, "Would jump overboard, and not go to the trouble of coming to the surface again."

The route from the Locke Body Company's plant to the plant of the Curtiss Engineering Corporation, at Garden City, is over much-travelled streets and highways, and it was decided by Lieutenant Wetherill to move the wing panels at night, during hours when little traffic would be encountered. This enterprise was carried out with the utmost seriousness, and if any of the inhabitants of Long Island along the route followed went to the trouble of remaining long enough awake, they must have seen an exhibition well paying them for their unusual exertion. The dimensions of the longer wing panels are such that no wagons available in New York City, other than one or two used by a theatrical scene hauling company, could transport them. When the first of these wing sections started on one of these long, broad wagons to Garden City, in the dead of the night, it was preceded by Ensign Hutchins, of my office, in a motor car, vigorously waving a red lantern whenever an attack from any vehicle threatened from ahead, and was followed by Lieutenant Wetherill in another automobile, also vigorously waving a red lantern whenever an attack from the rear threatened. To further safeguard this precious freight, the wagon containing it was fringed with four red lanterns; and it is safe to say that any pedestrians or vehicles encountering this strange cavalcade gave it a wide berth.

The methods of transportation, while, perhaps, somewhat bizarre, were effective, and of the numerous wing panels, tail surfaces, and ailerons, moved from the Locke Body Company to Garden City, amounting in all to sixty-eight, not one suffered a mishap or an injury of any proportion.

From the various sub-contractors the elements ordered were collected in the assembly building at Garden City. By the middle of August, the first one of these boats was approaching completion. Assembly was in progress on the second, and much of the work for the completion of the remaining two had been accomplished. The work of the sub-contractors had been done with the greatest degree of accuracy, and it was gratifying, though somewhat surprising, to discover that the assembly in the first flying boat, of the divers parts built by so many manufacturers, could proceed with practically no hitches whatever. In this assembly no discrepancies of any real seriousness were encountered, and the results obtained in this respect were far more favourable than had been expected. In the work of the sub-contractors, many inaccuracies in the plans prepared by the Curtiss Company had, of course, been discovered. These inaccuracies were mostly in dimensions, errors in which had been overlooked by the checkers when making their corrections. The sub-contractors had checked these dimensions with such accuracy, however, and the Curtiss Company, through Mr. J. A. Christen, had maintained such a close relation with the sub-contractors, that errors most likely to occur in the work were almost entirely absent, and were not in many cases such as to make necessary the rejection of the parts, or to prevent their inclusion in the final assembly. Upon Mr. Christen, of the Curtiss Company, fell the responsibility for eliminating errors of this nature. In this work he was indefatigable, and to him is due in a large measure the credit for the preparation of plans so complete and so accurate that an assembly job of a greater degree of complexity, and of required accuracy, perhaps, than any assembly job previously attempted, proceeded with so few delays, and with so few mishaps.

In designing the engine mountings for the first of the N.C. boats, we had permitted ourselves to be nervous regarding the power of these engines. The most powerful airplane engine any of us had previously dealt with was of 230 horsepower. The Liberty engine, before we completed the design of the N.C. boats, was rated at 400. This caused us to adopt a mounting of such rigidity and weight that a proper balance of the plane could be secured only by mounting the three engines near the leading edge of the wings, for the driving of tractor propellers. This was the least efficient propeller arrangement which could be adopted, but seemed inescapable. Best of all would have been three pusher propellers, but the weights would have been thrown so far back in such an arrangement that flight would have been impracticable.

While the *N.C. 1* was building, tests were made of other airplanes carrying Liberty engines, and it was found that the balance of these engines was so good that mountings much less rigid and heavy than those we had adopted would be sufficient. Our calculations showed us that we could mount the central engine far enough aft to use it for driving a pusher propeller, and that its effect on the balance of the seaplane could be overcome by mounting the other two engines on bearers extending well forward of their previous positions and supported by hollow steel tubing. This engine installation was decided upon for the *N.C. 2*, the *N.C. 3*, and the *N.C. 4*.

By the latter part of August, when it became necessary for me to go abroad, the *N.C. 1* was approaching completion and the others of her tribe were "coming along."

CHAPTER VIII

COMMANDER RICHARDSON'S ALARMING "HUMP"—"N.C. 1" READY FOR FLIGHT—ARRANGEMENTS AT ROCKAWAY—HANDLING METHODS AND DIFFICULTIES—THE FIRST TRY-OUT TESTS AND ADJUSTMENTS—THE FLIGHT TO WASHINGTON—FIFTY-ONE PASSENGERS—THE FIRST AIR STOWAWAY

JUST prior to my sailing for Europe on the 25th of August a bomb of proportions had exploded under me, and some of the confidence I had felt in the outcome of the design and building of the N.C's was, temporarily, very seriously shattered. I know of no one, outside of the immediate personnel engaged on this work, who expressed unqualified confidence in the accomplishment of even the estimates we were counting on. I, however, regarded, and still regard, Commander Richardson as the leading authority of the world on airplane pontoons and flying boat hulls, and the fact that the design of the N.C. hull had been under his supervision, and that he vouched for it, was sufficient for me. Then one day he appeared unexpectedly in my office in New York City, and waved some papers at me. I had thought it a beautiful day, unusually cool and crisp for August, and life was less strenuous than it had been at any time for many months. The *N.C. 1* was approaching completion; all factories turning out seaplanes were humming; and we had shipped so many abroad for our naval patrol stations that we could view the future with some confidence. The submarine menace was a bit less fearful; ships were being launched almost as fast as they were being sunk; and the Huns were retreating. Added to all of this was the excitement due to the fact that in a day or two I was sailing for the theatre of war on some special aeronautical duty for my Bureau.

Richardson changed it all between heart beats! He had been drawing some more curves of the resistances shown in the towing tank by the boat hull model. On these curves he had found, at the speed necessary for leaving the water in flight, a sudden increase in resistance which he designated a "hump." "With luck," said he, "we may get into the air with 22,000 pounds."

"Crash," went many of the remaining props under my confidence. As doubters increased I had bet on Richardson against them all, and suddenly, unexpectedly, he had left me supported by nothing but hope, and by very little of that.

It was in this state of uncertainty that I left this country and went to Europe, and in it I continued for several weeks until the cable brought news to London of the flights of the *N.C. 1*, which proved that Richardson had spoken too soon.

Something happened to the "hump" and it wasn't where it was expected to be. When the *N.C. 1* flew, it disregarded it, and was soon taking more weight into the air than we had dared to hope for.

The first portions of the *N.C. 1* were moved to Rockaway Beach, Long Island, N. Y., to the U. S. Naval Air Station, on September 11th. By the 23rd of the month the entire plane had been delivered there, and by the end of the month it had been assembled, and, except for a few finishing touches, was ready for flight.

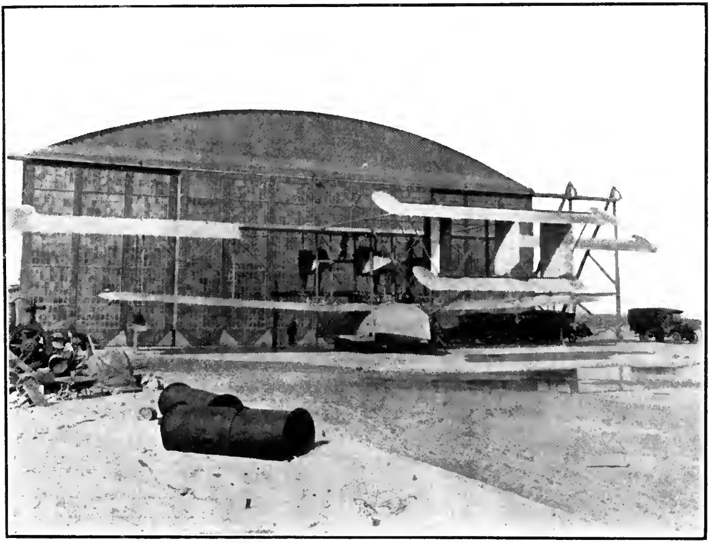
The Rockaway Beach Naval Air Station, which was chosen as the location of the N.C. hangar, is built on a narrow neck of land extending between Jamaica Bay and the Atlantic Ocean. This property belongs to the city of New York and was loaned by that city to the National Government for wartime purposes. For the erection and flights of the N.C. flying boats, it is remarkably well located. It is about twenty-one miles from the Curtiss Engineering Corporation's plant at Garden City, and between the station and that plant there are no obstructions to the transportation of airplane members of the size of those used in these seaplanes.

On one side of this point is the ocean in which rough-water tests can be made; on the other side are the waters of Jamaica Bay, well protected from all directions, so that at practically all stages of weather there may be found in this bay smooth-water landings and smooth-water getaways.

For some reason or other, not definitely known to myself, but probably tied up to a considerable extent in the lack of confidence felt by the responsible authorities in Washington in this design, a hangar was authorized of sufficient size for two of these boats only, and sometime in May the construction of this

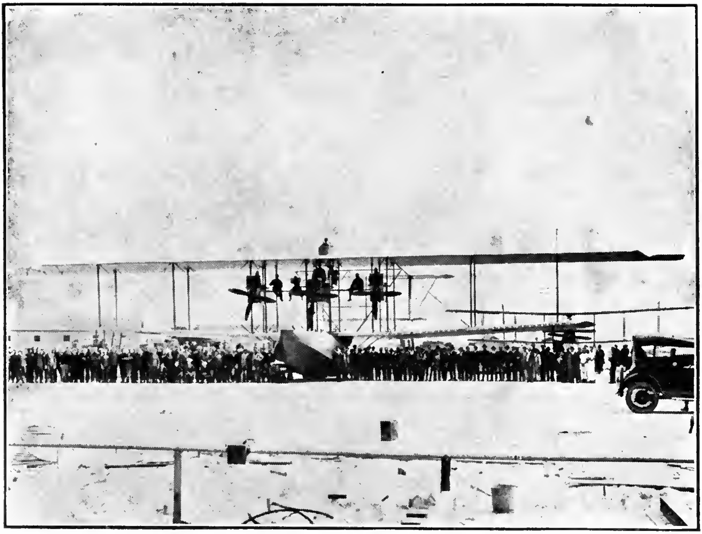
A BIRDSEYE VIEW OF THE ARRANGEMENTS AT ROCKAWAY

The N.C. hangar at the left, in front of it the concrete handling platform. *N.C. 1* is on the marine railway ready for launching. The *HS-2* hangar is at the right, and an *HS-2* flying-boat stands ready to be launched



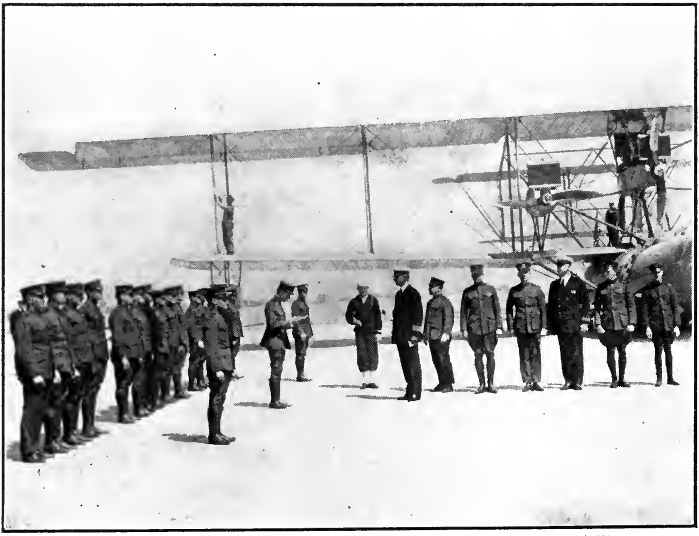
N.C. 1 IN FRONT OF THE HANGAR

Four N.C.'s were built, but there was room in their hangar for only two



FIFTY-ONE PASSENGERS

The *N.C. 1* has just returned from a record-breaking trial spin with fifty-one passengers. She intended to carry only fifty, but unwittingly carried also the kneeling gob at the right—the first aërial stowaway.



COMMISSIONING N.C. DIVISION ONE

Captain Powers Symington turns over the completed plans to Commander John T. Towers, commanding officer of the Division. His "flag-plane" was the *N.C. 3* hangar was commenced. The dimensions of this hangar are approximately 165 feet by 110 feet. The 110 feet is in the clear and the height to the truss is approximately 30 feet. This building is of sufficient size to accommodate two completely assembled N.C. flying boats. In front of this hangar is a pavement of concrete approximately 160 feet square, of sufficient extent to make possible the handling of the boats in and out of the hangar and in and out of the water.

Under ordinary conditions, without a crew on board, one of these boats will weigh in the neighbourhood of ten tons. Its dimensions are such as to make impossible its simple pickup by crane or by some other means and moving from one place to another. To meet these conditions, a special handling truck, mounted on four wheels, has been designed. This truck is of sufficient surface to prevent undue concentration of weight on the necessarily fragile boat hull, and to further safeguard this boat hull the bearing surface of the truck is padded with felt.

Due to the great over all dimensions of this craft, 126 feet by 67 feet, it is necessary to be able to manœuvre it with very little forward or rear motion. Accordingly, the wheels of the truck have been so installed as to permit their setting at various angles, so that a turn-table effect can be obtained and the flying boat may be rotated in either direction without any movement of translation whatsoever. This rotation has proven easy of accomplishment, and a few men shoving against the wing tip floats can quite easily rotate the machine at as high a degree of speed as is desired.

Movements into and out of the hangar are accomplished by gasoline-driven caterpillar tractor trucks, one of them of 60 horsepower. The larger of these trucks also pulls the boats up the inclined marine railway in getting them from the water to the land.

This docking arrangement is in all essentials similar to that made for small yachts. A regular marine railway of two steel rails has been built at a proper inclination from the sea wall, of sufficient length to carry the boats into water deep enough to float them from their handling trucks. On this railway is a special handling car so built that its platform is horizontal notwithstanding the fact that its wheels run on rails inclined to the horizontal at an angle of about 15°. There is a departure from ordinary marine railway practice in the provision at each side of our railway of a handling platform which runs parallel to it and is of equal length. These are required due to the great area of one of these planes exposed to the wind, and to the necessity for having men hold the craft steady while it is being landed in its handling truck.

When the railway car is at the upper end of its travel its platform is flush with the concrete area in front of the hangar, and the handling truck carrying the seaplane may run from this car to the concrete area. It may be appreciated how simple it is to get one of these boats in or out of the water during good weather. In bringing it in the railway car carrying the handling truck is run out into water of sufficient depth; the boat is floated into place and is held there; a small movement of the car up the railway lands the boat hull in its cradle, and the remainder of the operation is an obvious one. Launching is even simpler. The truck with its freight is run on to the railway car with the nose of the boat pointing seaward; then engines are started and run slowly; the car is lowered slowly down the railway incline until in water of enough depth for the flotation of the boats, when an increase in the engine revolutions will carry the plane free and ready for flight.

Due to a circumstance of some seriousness, however, this simple operation is not always practicable. In laying out this marine railway, the grade was placed a few inches below the beach line. In addition to this, certain side structures running well out into the water, and used as platforms for handling and guiding the boats into their handling trucks when they are being taken out of the water, have been so constructed as to cause the beach to build up. The result is that large quantities of sand are deposited on the marine railway, and it is not infrequent that these deposits are so great as to interfere seriously with, or even prevent, the launching of these boats.

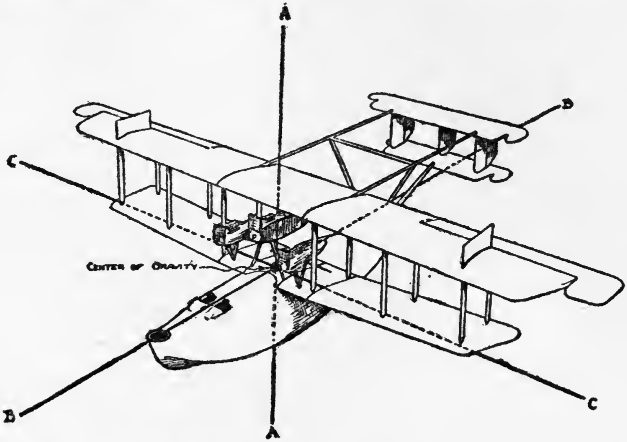
When the marine railway is lightly covered with sand, it is frequently possible, by starting the engines and permitting the boat on its truck to run down the marine railway, to cut through this sand and reach the uncovered railway beyond. When this is not possible, sand must be shovelled out laboriously, and a passageway prepared through which the marine railway truck can make its way. Under the suggestion of Naval Constructor Richardson, there were placed in front of the forward wheels of the marine railway truck steel ploughs, and these ploughs, contrary to the expectations of a number of scoffers, myself among the number, proved most effective, and made it possible to launch these craft under conditions which would previously have entailed several hours' work at sand dredging on the part of the entire handling crew.

On the first of October, the motors of the *N.C. 1* were started for the first time. The two outside motors were equipped with electric self-starters, whereas the centre motor was started by hand starter only. Since that time all motors have been equipped with electric starters on all of the boats of the N.C. type, and hand starters are no longer used.

In determining the relative locations of the centre of gravity of the *N.C. 1* and the centre of lift of all its lifting surfaces we discovered the centre of gravity was so much farther back than we had anticipated that the craft in flight would be tail heavy. Our figures showed that this condition could be corrected by a weight of 1,750 pounds in the bow. The adoption of such a method for correcting balance could, of course, be a temporary expedient only, as the carrying of useless dead weight could not be tolerated. It was desirable to try the general qualities of the plane as soon as possible, and 1,200 pounds of sand in small bags was placed in the nose of the boat. The total weight was then 16,200 pounds.

All was ready on the 4th of October for the momentous determination. Would she fly, or wouldn't she?

Would she fly well enough to give us encouragement, or would there be some terrible fault of proportion, of balance, of control, which would prove her the impossible craft many believed her?



AA Axis about which Weathercock Stability is Determined.
BB Axis about which Lateral Stability is Determined.
C C Axis about which Longitudinal Stability is Determined.

At Rockaway Beach the entire personnel of the air station gathered as spectators; as many of the members of the personnel of the Curtiss Company as could find excuses for being present were there; the officers from my New York office, and from that of Captain Hall, the representative of the Bureau of Steam Engineering, found duty had called them to Rockaway Beach. As for myself, I was in Queenstown, Ireland, aware, of course, of the imminence of the event, and wondering just when it would be and what would happen.

Commander Richardson was in charge of the test.

He had come down from his office in Buffalo several days before to see to the finishing touches. He and Lieutenant Dave McCulloch of the Reserve Force, afterward with him one of the pilots of the *N.C. 3* on her trip to the Azores, were the pilots. The others of the crew were Machinist Philo H. Danly of the Reserve Force, and George Robinson and Van Sicklen of the Curtiss Company.

They took their places. The engines were started, and warmed up with the steady, healthy roar of thirty-six cylinders "hitting" perfectly. Richardson waved a hand, and a line from the marine railway carriage to the beach was slacked away. Down the inclined railway, off from their cradle, they went. Back and forth for a while they ran to give the pilots a chance to feel out the controls. Then they turned and headed into the gentle wind from the west which was hardly flecking the surface.

The roar of the engines increased; the spray flew from the bow of the boat hull; the speed increased; and all on the beach knew that the *N.C. 1* was at last determined to try her own element.

Would she make it, or would some 59th minute mishap spoil the show?

Almost before the question could be asked, the wake on the water narrowed to a ribbon, and then ended. She was in the air, she was flying! A cheer vented the tenseness of those on shore—many cheers blending in one. The largest flying boat in the world was in the air.

After an instant she began to settle. The spectators held their breaths. Down, down she dropped, nearer the water, then on to the surface in a perfect landing. Something was wrong evidently, but no mishap had resulted. Back to the beach she came, and all gathered to meet her.

Nothing whatsoever was wrong. They had returned simply to take on board Captain Parker of the Coast Guard, the Commanding Officer of the Rockaway Beach Naval Air Station, whose assistance in connection with the work carried on at his station had been so helpful that he was considered as entitled to an early ride. Two more short "hops," each of a duration less than a minute, were made, and to the great satisfaction of everyone it was evident that the *N.C.1* would be successful. How successful could not be told until the ability as a weight lifter had been determined, but it was certain that as a flying craft it would be satisfactory.

These flights showed, however, that the plane was still tail heavy. To correct this, an additional weight of 555 pounds was added, bringing the total weight up to the amount previously estimated as necessary for balance. An additional passenger was taken on board, which brought the total weight of the machine up to 16,930 pounds. At this weight, three more hops were made.

There had now been made six hops, giving a total time in the air of $4\frac{3}{4}$ minutes. The operation of the plane, though not entirely satisfactory, was excellent. It was evident that the designers had developed an airplane different in many ways from any machine previously built, but which, on the whole, fulfilled expectations and promised excellent results.

The weights added for the correction of the tail heaviness had not accomplished their purpose. The effect of the powerful blast from the propellers on the tail surfaces was greater than anticipated, and other methods were necessary to remedy this tail-heavy condition. Of an airplane's structure, the member of the tail surface known as the stabilizer is one of the most important. Upon the relation between this stabilizer and the wings of the airplane depends in almost important degree the ability of the airplane to carry out an ordered flight. It was evident that in the *N.C. 1* this relationship was not a correct one, and a procedure was adopted, a usual one in airplane construction, of so changing the position of the stabilizer as to vary the relationship.

There followed now a series of tests with constantly increasing loads, and with constantly increasing confidence on the part of the flyers in this boat. It was found that at normal angles of flight and at weights ordinarily to be expected, within range of flying weights, the airplane handled very easily, was remarkably stable inherently without having lost its controllability, and that flight with it was, in reality, very little more difficult than with a much smaller boat. This ease of flight was contributed to, in a pronounced degree, by the fact that the three control surfaces, the ailerons, the elevators, and the rudders, were each of what is known as the balanced type. That is to say, a portion of the surface of each of these control surfaces was placed forward of the axis around which these surfaces work. The result is that the air, striking these surfaces forward of the axis itself, assists in turning these control surfaces in the direction desired. The proper proportioning of these surfaces is a matter of great difficulty. An airplane flies at so many different speeds, and under such different conditions of propeller revolutions and flight angles, that the degree of balance satisfactory for one condition may be entirely unsatisfactory for another condition. The determinations in the case of the surfaces of the *N.C. 1*, however, have proven to be remarkably satisfactory, and have given this large boat an ease of flight and of control highly gratifying to its designers, as well as satisfactory to its pilots.

There also followed the inevitable process of changes. One change after another was made, some important, some unimportant, and there would be little interest in describing these changes in detail or the reasons therefor. The effect of them, taken as a total, was beneficial, and it may be said that the performance of these boats has been improving so constantly, due to changes, modifications, and knowledge of their characteristics, that, even yet, it is impracticable to state definitely what they are capable of. Among the most important changes made were an increase in the fuel capacity of the boat, a change in the gasoline fittings from aluminum to bronze, and a change in the nature of many of the valves in this system.

Naval Constructor Richardson had been so much encouraged by the performance of the *N.C. 1* that he determined on a more ambitious project than the simple tests this boat had been engaged upon. On the 7th of November, with Commander Richardson as officer in charge and acting as assistant pilot, and Lieutenant Dave H. McCulloch as pilot, a start was made from Rockaway Beach for the city of Washington, for the purpose of exhibiting this large bird to the interested officials in that city. In addition to these officers there were on this flight, as passengers, or as members of the crew, Lieutenant Harold Wesson, Ensign G. N. Gregory, Ensign C. J. McCarthy, Ensign H. B. Sanford, Machinist P. H. Danly, Chief Special Mechanic E. H. Howard, and Chief Machinist's Mate Rhodes, a total of nine. The weight of the flying boat at getaway was 20,272 pounds. Six hundred and ninety-one gallons of gasoline were carried, and the oil tanks and radiators were filled. The getaway from Rockaway Beach was made at 10:50 A. M., after a run on the water of forty seconds. The day was fair and clear. A light west wind was blowing and the sea at Rockaway Beach was practically smooth.

After taking the air and rounding the point at Rockaway Beach, the course was set parallel to the New Jersey and Delaware coasts to Metomkin Bay. It was the intention to cross the peninsula at this point to Pocomoke Sound on Chesapeake Bay, and to proceed up Chesapeake Bay and the Potomac River to Washington.

For the first half hour everything proceeded smoothly; then a leak was discovered in the water connections of the central radiator. The central motor was shut down and the flight was continued with the two outer motors, an attempt being made to repair the leak while in the air. This was found impracticable, and it was decided to land and repair the leak before proceeding. In the event of necessity, the flight could have been continued with the two motors, but as it was intended to cross the peninsula for a considerable distance, it was considered inadvisable to continue the flight without the repair necessary, as in the event of the stoppage of another motor a landing would have become imperative and, if made on land, would have destroyed the machine and seriously endangered the lives of all on board. At 11:25 a landing was made on the ocean, just north of Barnegat Inlet. The leak was repaired, and the radiator was filled with sea water, since no provision had been made for such a contingency, and no spare water had been taken. The element of a flying boat is the air, and little provision is ordinarily made for contingencies which may happen on the water. No provision had been made for the present one, and the process of dipping water from the sea for the filling of this radiator was a difficult one. It was finally accomplished by means of one of the boat bilge pumps, by pumping from the sea into an ammunition box placed on the deck, and from the ammunition box to the radiator above, by means of the other bilge pump. At the time, the swells in the ocean at that point were very high, and added to the difficulty of work of this nature on a light structure which bobbed around like a cork, was the fact that several of the passengers and crew were seasick. After an hour, however, repairs were completed, all radiators were filled, and a new getaway was made.

The landing off Barnegat has been spoken of at considerable length as it was of great importance. The swells were of the ordinary ocean type and were about ten feet high. Almost no breeze was blowing. Notwithstanding these swells and the absence of a breeze to assist in landing and in getting away, the landing was made without any sensation of shock, and the getaway was accomplished after a run of one minute, and without any appreciable difficulty. As has been said before, the element of a flying boat is the air. It rests upon, or runs upon, the water purely as a matter of necessity and is not at home there. Its home is in an element less than 1-800 the density of water, and it must be built of a lightness fitting it for this element. When, therefore, the *N.C. 1*, built for this lighter element, had been able to accomplish with such success a landing and a getaway from the heavier element, at that time engaged in no small degree of its usual turbulence, it was considered that a further merit of this seaplane and of its peculiar type of boat hull had been strikingly demonstrated.

The remainder of the trip was passed without any particular incidents. In crossing the peninsula from Metomkin Bay to Pocomoke Sound, the flight was made at a height of about 2,000 feet. Instead of following the Potomac for its full course, as had been originally intended, it was decided, on account of the unexpected delay caused by the leaking radiator, to fly across land from Mathias, Va., to Marshall Hall, Md., a distance of about eighteen miles. For this flight, an altitude of 2,500 feet was obtained. Alexandria, Va., was passed at 5 P. M. These were the short days of the year and dusk was approaching. No attempt was made to fly over the city of Washington, as it was necessary to land and to tie up before dark. At 5:10 P. M., a landing was made at the Anacostia Naval Air Station, a short distance from the Washington Navy Yard, and the *N.C. 1* was taken in tow by a motor launch and towed to her mooring.

On the following morning, she was visited by Admiral Taylor, Chief of the Bureau of Construction and Repair, the officer most responsible for her construction, since it was he, as has been described in considerable detail in a former chapter, who decreed the design and building; by Rear-Admiral Griffin, Chief of the Bureau of Steam Engineering, and by many other officers connected with the Navy Department in Washington. On the part of the unofficial portion of Washington society, great interest was also shown, and there would have been little difficulty in having the boat thronged with visitors during the entire time of its stay in Washington. This stay was brief. At 1:40 P. M., the anchor was weighed and the return trip was commenced. On this trip, a flight was first made to the Naval Air Station at Hampton Roads, Va. On board were the personnel who had joined at Rockaway Beach, with an added passenger in the person of Commander A. K. Atkins, of the Bureau of Steam Engineering. The inevitable moving-picture operators were on hand, and all operations from the weighing of the anchor to the instant of getaway were filmed.

During the brief stay of the *N.C. 1* in Washington there was invented a name for this type which has come more and more into popular use. A newspaper reporter, in getting his notes for an early edition, apparently got the substance and not the meaning of the pronunciation of the two letters N C, and in the article from his pen, published in the afternoon paper, referred to the *N.C. 1* as the *Nancy*. The "patness" of this designation was apparent, and these boats are now very often referred to simply as the *Nancies*.

The flight to Hampton Roads followed the course down the Potomac to Monroe, Va., thence across country to Lloyds, Va., on the Rappahannock, down the Rappahannock to Chesapeake Bay, thence down the bay and across the mouths of the York and James rivers to Hampton Roads Air Station, on the site occupied years ago by the Jamestown Exposition. At the beginning of the flight the atmosphere was very hazy and the air very rough. It was found difficult to keep the Potomac River in sight unless the boat was maintained at a very low altitude. When Monroe was reached, however, the atmosphere had cleared, and the cross-country flight to the Rappahannock was made at an altitude of about 2,000 feet.

Just before Newport News was reached, the course lay directly over Langley Field. At that time the altitude was about 2,000 feet, which seemed a considerable distance above the field. In the air above, however, a single Army plane flew at such an elevation as to be barely visible, and it seemed like a mere speck in the sky. Landing at the Naval Air

Station at Hampton Roads, Va., was made at 4:29 P. M.

On the following morning the boat was made ready for the return trip to the Rockaway Beach Naval Air Station. Commander Atkins left at this point, and the personnel of the crew were those who had joined on the start from Rockaway Beach. At 10:57 A. M., a start was made, but before going any distance carburetor trouble developed in the centre motor and it was necessary to land and clean this carburetor. About an hour later the final getaway was made, and the course was set across the entrance of Chesapeake Bay, and up the coast to Rockaway Beach without any special incidents of interest. The trip was completed and the landing was made at the Rockaway Beach Air Station at 4 P. M.

On this round-trip flight 1,024 gallons of gasoline had been consumed. The total miles traversed were 819; the total time of operation of the motors was 12 hours and 13 minutes. The gasoline consumption was 83.8 gallons per hour, or 1.25 gallons per mile.

It may be said with certainty that from the seeds of this trip budded the confidence which later flowered into the plans for the adventure of the N.C. boats on the transatlantic flight. By it many of the chief doubters of the success of the design were convinced of their error, and were converted into advocates of the type.

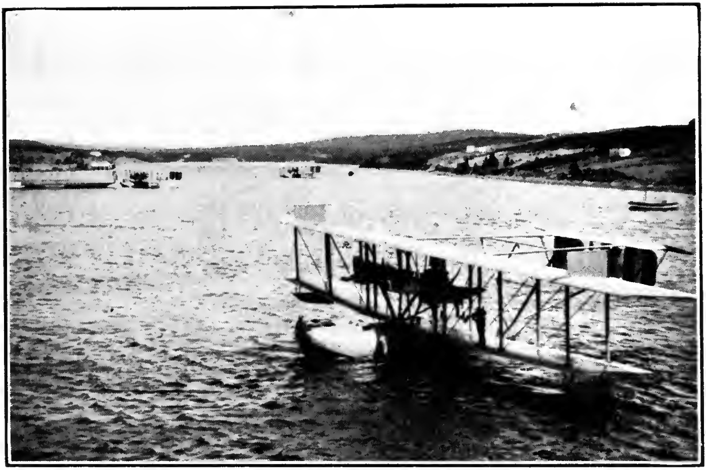
Ordinary routine flights for test purposes were made from the time of this return until the 27th of the month—the day before Thanksgiving. On this day the *N.C. 1* was taken out for the purpose of breaking a world's record. Shortly before this a Super-Handley-Page airplane had made a flight in London carrying 40 passengers, and it was desired to exceed this performance. Into the hull of the *N.C.1*, and into the centre nacelle, there were packed 50 persons, mostly officers and enlisted men on duty at the Rockaway Beach Naval Air Station, and the flight was made. This flight was, in reality, of little more than a half minute's duration, as it was not desired to take any greater risk with so many lives. The amount of weight, however, was considerably less than this seaplane has flown with, and it could have made a flight of several hours' duration without any difficulty.

Upon returning to the landing, the passengers were disembarked, and were counted, and it was found that instead of the 50 expected, there disembarked 51. One of the men attached to the Rockaway Beach Air Station, Machinist's Mate, 2d class, Harry D. Moulton, being possessed with an overwhelming desire to have a ride on this boat on that historic occasion, had stowed himself away beside the gas tanks in a narrow passageway, in such a space that he must have been most uncomfortable. He had remained in this space for an hour and a half before the flight began.

There have been occasions before when unexpected passengers have been taken into the air. Workmen engaged on the interior of large flying boats have found themselves involuntary companions of pilots who have gone aloft without a sufficiently thorough examination of their craft; earnest individuals,

THOSE WHO GO UP IN THE AIR IN SHIPS

Three flying sailors of the *N.C. 1*, two of them in their air clothes. They are, left to right, Lieut.-Commander Bellinger and Pilots Mitscher and Barin



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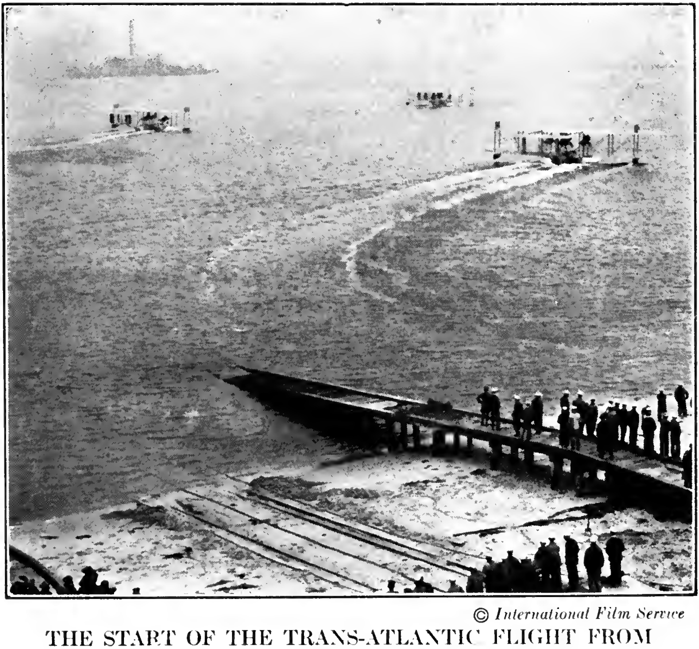
READY TO START FOR THE AZORES

The "Lame Duck" has caught up with the others and all three are ready to start the long "hop" which she alone was destined to make in safety



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THE START OF THE TRANS-ATLANTIC FLIGHT FROM ROCKAWAY BEACH mostly of the German race, failing to let go of lines attached to dirigibles or to kite balloons, have soared aloft with them, generally to their undoing. There has not previously, in all probability, been a case where a man deliberately crawled into the structure of a flying boat, and, without the permission or knowledge of the pilot, stowed himself away in order that he might be a party to the flight in contemplation. To Moulton, therefore, belongs a dual record: that of having assisted in breaking a world's record, and that of having done so uninvited, as the first aërial stowaway.

On January 17th, it was decided that the tests of this craft were completed; that its period of growth and training had ended and that it could be turned over to the operating branch of the Navy for active service. On that day it was delivered by the Bureaus of Construction and Repair and Steam Engineering into the custody of the Division of Operations, and was by that Division assigned for operating purposes to the Rockaway Beach Naval Air Station.

CHAPTER IX

NUMBERLESS ALTERATIONS STOP PROGRESS—THE REPORT TO THE PLANNING COMMITTEE—OTHER OFFICIAL CORRESPONDENCE—SPEEDING UP PREPARATIONS—CHANGES—"N.C. 2" GIVES HER WINGS TO "N.C. 1"—ACCIDENTS—THE DELIVERY OF THE BOATS

AFTER the first flights of the *N.C. 1* there began to be, on the part of a number of officers of the Navy Department, an active interest in the subject of the transatlantic flight. In spite of the technical continuation of the war, everybody realized that, as a matter of actual fact, it was completed. The N.C. boats, built originally for strictly war purposes, would no longer be required for such purposes, and it was in order to consider to what useful purpose they could be put at the earliest date. It was natural and logical that as soon as the *N.C.1*, in its trials, developed the possibilities of this type, thought should turn to flying the ocean with them as a peace-time accomplishment instead of as the purely military purpose for which these flights had originally been contemplated.

Reports reached me in Europe of the consideration being given the transatlantic flight, and after my return to this country, on December 16, 1918, this was one of the things of interest concerning which inquiry was first made by myself. It was found that a "Planning Committee" of the Division of Operations had been appointed to consider and report upon this project, but the demobilization duties, thrown on that division by the "blowing up" of the war, were so great that this committee had been physically unable to devote any time to extraneous subjects, and had done little or nothing regarding a flight across the ocean.

Down on Long Island, where the N.C. boats were building, it was found that progress on them had been almost entirely stopped while improvement suggested by the trials on the *N.C.1* were being incorporated. Commander Richardson had had charge of practically all of the flight trials of the *N.C.1*, and it was under his direction that the changes and modifications in the later boats, suggested by these trials, were being made. As there was no longer any urgency felt in connection with the completion of these boats for anti-submarine purposes, it was distinctly the logical thing to proceed with beneficial modifications in the later boats to develop a type as nearly perfect as possible. The inescapable effect of starting these changes, however, was that work had to be held up on the other boats and that, with the exception of the *N.C.2*, no work at all, except engineering work and the preparation of plans, was in progress. The *N.C.2* was too far advanced to make the inclusion of the major portion of these changes desirable and was, therefore, being proceeded with, and was very nearly completed.

Consideration of the requirements of the transatlantic flight gave a different aspect to the situation. It was evident that the completion of these boats in time for the flight would involve a curtailment of the process of change and the building of the boats very much in accordance with the plans already developed. From the plans, which it was presumed were being made by other countries or by individuals, for the transatlantic flight, it seemed certain that if the United States Navy was to be first across, the start from this side must be made some time in the late spring. It was decided, therefore, to discontinue immediately the programme of changes, and to proceed with the completion of the boats as originally decided upon with the inclusion of only such changes as could be made incident to this completion, and without holding up entirely the progress on the boats. This plan was, accordingly, immediately proceeded with, and in a short time construction work was again in full blast. Of Commander Richardson's suggestions, and of the suggestions made by the officers connected with the power plant installation, for improving the N.C. boats, it was possible during construction to adopt many, and practically all of them have been found to be of the greatest merit, and to have the effect of improving the design as a whole.

Shortly after Christmas, it was possible to discuss, in Washington, with Captain Tompkins of the Division of Operations, the head of the Transatlantic Flight "Planning Committee," the question of this flight. We discussed the flight itself, the condition of the N.C. boats at that time, the many things remaining to be done, and the many steps to be taken in connection with them and the other plans of the flight. A very great amount of work remained to be done during the comparatively short time remaining available, and it was evident that the project must be immediately started with the greatest amount of energy by all of the branches of the Naval Service who would be connected with it, if possibilities of success were to be a maximum. At Captain Tompkins' request I prepared for him a few days later the report now quoted:

No. 3109 *January 15, 1919.*

From: Commander G. C. Westervelt, Construction Corps, U.S.N., New York City.

To: Captain John P. Tompkins, U.S.N., Operations, Navy Department, Washington, D.C.

Subject: Transatlantic Flight—Discussion of details.

1. Consideration of the subject of a transatlantic flight by an airplane indicates that the project is one which for its success will probably depend, so far as the first flight of this nature is concerned, on Governmental backing. The first accomplishment of this feat will give to the organization of the Government accomplishing it a considerable amount of deserved prestige. It is, naturally, my desire, as I have no doubt it is that of the majority of the officers of the Naval Service, that this flight be first accomplished by craft built and flown under the control of the Navy Department.

2. There can be no doubt that several governments, or, in any event, organizations in several countries receiving the approval and support of their

governments, are making active preparations for attempting this flight during the coming spring and summer. A careful consideration of the elements involved indicates that the chances of success are considerably more than even. If, therefore, the United States Navy is to have the opportunity of accomplishing this flight before it has been accomplished by any other country, or by an individual, or a syndicate formed for the purpose, and acting under Governmental encouragement, steps should be taken toward an immediate organization of the project along lines which will reduce the elements of failure to an absolute minimum. It is necessary, also, that the arrangements to be made should be completed as soon as practicable, in order that the flight might be started with very little delay should it be found that arrangements of any other persons contemplating such a flight had already progressed to such a point as to endanger the priority of our contemplated flight. As an accompaniment of this, the greatest degree of reticence should be preserved regarding all of the arrangements made, or to be made, and the contemplated date at which the flight would start.

3. As is well known, there are two routes for this flight which promise in varying degrees, depending on the circumstances under which the flight is undertaken, a successful outcome. One route is from St. Johns, Newfoundland, to the coast of Portugal, via the Azores. The other is from St. Johns, Newfoundland, to Bantry Bay, Ireland, direct. It has not, as yet, been practicable to examine thoroughly enough into the elements of these two courses to advance a definite opinion as to which one, if either, offers a definite advantage. It may be said, however, that to the large type of flying boat now under construction by the Navy Department, the *N.C.-1* type, either route offers a very fair degree of success, provided the undertaking be properly organized, and

as many of the elements of doubt as practicable be eliminated before starting.

4. The *N.C. 1* type of flying boat is capable of a flight of at least one thousand miles with a crew of five men. This means, whether the northern route or the southern route be adopted, it must be with the certainty that one landing, at least, for replenishment of gasoline must be made on the ocean on the way. With the probability of receiving some assistance from the wind on the northern route, one landing, only, will be required on this route, placing this route on an equality with the southern route. As no flight would be started unless the condition of the ocean was such as to make practicable landing and getting away, it seems fairly reasonable to presume that landing near a ship detailed for the purpose, taking on a supply of gasoline, and again getting away for the continuation of the flight, would be entirely practicable. Dismissing, therefore, the inescapable necessity of landing on the ocean as one productive of no great handicap, consideration may immediately be given to the other elements of the project.

5. As a definite accomplishment, carrying with it all of the prestige related to an accomplishment of this nature, it would, I believe, be advisable, provided the chances of success seem sensibly equal, to attempt the northern course in preference to the southern. This would involve a fairly straight-away flight, on a course somewhat north of east, of slightly less than two thousand land miles. Presuming that the motors run successfully for the length of flight involved (approximately thirty hours of flying, at the speed which would be chosen, counting no assistance from the wind), this flight, as a flight, reduces itself largely to a question of successfully hitting the objective at the far end. In order to eliminate the possibility of failure in this direction, stake boats should be located at definite intervals, probably somewhere

in the neighbourhood of one hundred miles apart, across the ocean on the course to be flown. These boats, presumably destroyers, or small craft of some nature, would be a definite part of the project, and would be counted upon for several days in advance of the flight for weather reports on which, combined with the weather reports from other sources, the hour of starting the flight would be based.

6. St. Johns Harbour, Newfoundland, is, as mentioned above, the logical starting point for such a flight. A seaplane attempting this flight must be in that harbour a number of days in advance of the contemplated flight in order to take advantage of the most favourable moment for starting. In reaching this harbour a flight of seven to eight hundred miles from Rockaway Beach, the present location of *N.C. 1*, is involved. In addition, it may be necessary for seaplanes attempting this flight to lie at St. Johns for a considerable length of time, during which the up-keep of the craft, and the maintenance of crews and up-keep gangs, would be necessary. To provide for all contingencies, there should be delivered in advance to this location spare engines and spare parts for the power plant and for certain portions of the plane, as well as a complete supply of the very many items for which necessity may be found. There will be several hundred of such items, as it would be unwise to rely upon the local markets for the provision of any of them. The gasoline supply should be arranged for. If practicable, facilities should be provided for getting these seaplanes out of the water, in order to keep the hulls as light as possible, and all necessary facilities for the housing of the crews and up-keep gangs should be provided.

7. Arrangements will be required at St. Johns for receiving weather reports from all localities, the weather of which might have a bearing on the flight. Coöperation of the authorities controlling wireless

and of those controlling cables would be necessary, since hourly weather reports across the Atlantic from the stake boats, from the Azores, from the north of Scotland, and, if practicable, from Iceland, would be invaluable. It appears to me also that it would be exceedingly desirable to provide St. Johns, as well as the stake boats, with a large number of sounding balloons and necessary tubes of hydrogen for testing the movement of the air up to five thousand feet.

8. So far as the stake boats are concerned, each of these vessels should be provided with some efficient type of signalling apparatus by means of which the passing seaplanes can be easily and surely communicated with by day or by night. Each vessel, of course, will report to the vessel astern and the vessel ahead the hour of the passing of the seaplane, and should be prepared to furnish the plane with information regarding the direction of the wind and the strength of the wind at the next stake boat ahead, in order that any variation in the wind from that existing at the hour of its departure might be taken advantage of. Each stake boat should also be provided with some means of creating a smoke column, and of thereby increasing its visibility as greatly as possible. Stake boats in areas in which a landing for a replenishment of fuel will be made should also carry sufficient gasoline in easily transportable containers for replenishment purposes, and should also carry boats suitably arranged for carrying this gasoline and for going alongside the seaplane with the minimum danger of injury to the plane.

9. So far as I know, no trials have been made to determine the effect of oil on the water as of assistance in the getting away of a seaplane from water too rough to negotiate otherwise. It appears to me probable, however, that a destroyer ploughing through the sea at high speed and releasing at the same time

a considerable quantity of oil might possibly flatten out the sea sufficiently to make practicable the getaway of a seaplane which could not otherwise negotiate a getaway. I would suggest the desirability of experimenting in this direction, and, if this be found of assistance, the provision of the necessary means for oiling the water in the event the wind should increase, during the time of flight to a landing place, to such an extent as to make impracticable otherwise the getting away of a seaplane after landing.

10. It is evident that an all-night flight will be necessary. Presuming that the flight in question will take place some time after the first of May and before the end of June, it is evident that in these high latitudes a comparatively short period of darkness will be encountered. If chance should make it desirable to start this flight during periods of moonlight, this period of darkness will be still further reduced. In any case, there are two events which should be so arranged as to fall during daylight: One is landing near a stake boat for fuel replenishment; the other is the arrival and landing at destination in Bantry Bay. It seems evident that the starting time can be over several hours in the very early morning, or over several hours in the late afternoon, and that, therefore, a considerable portion of the day is available for starting, and the necessity of flying all night will not impose any material difficulty. On account of the necessity of flying at night, however, stake boats should be provided with powerful flares which they can use, in addition to their searchlights, for indicating their positions, provided they lie within the passing areas at night.

11. With regard to airplanes of the *N.C. 1* type, the present situation is as follows:

(a) Four flying boats of this type are under construction. Two have been completed, and the third one will be completed about the first of February. The fourth boat will be completed about the middle of March. The first of these boats has had sufficient trials to indicate its suitability for the service proposed, and to indicate that the remaining boats will also be suitable for such a project.

(b) Unless unexpected casualties overtake the *N.C. 1* flying boats, it seems reasonable to presume that at least three of them will be available for this transatlantic flight by the first of May, which, it is presumed, would be the earliest date on which the flight in question could be started. It is, therefore, suggested that all four of these boats be flown at the proper time to St. Johns, and that of these four, the three in best condition, from every consideration, be started on the transatlantic flight when the hour arrives for the starting of this flight.

(c) It appears to me that there is at least an even chance of getting all three of these boats across; better than a two-to-one chance of getting two of them across; and considerably more than a three-to-one chance of getting one of them across.

12. In the event of the failure of any one or all of these boats to complete the distance, the chances are, of course, that the boat itself must be sacrificed. This does not, however, follow absolutely, and, under favourable circumstances, it might be possible to tow one of these craft back into port. In the event of failure to cross resulting in a forced landing of any one or all of these boats, total destruction upon landing being very unlikely, there seems little reason to doubt that the members of the crews would be saved. These boats should be provided with wireless sufficiently powerful for signalling to the nearest stake boat; should carry navigational ap-

pliances sufficient for the location of their positions; and even if unable to rise again after a forced landing will probably have two engines left in working order, and be able with these engines to taxi to the nearest stake boat. Any one boat dropping out of formation and landing, would, of course, be reported by the others to the next stake boat passed, so that rescuing operations could be immediately undertaken.

13. Although, as stated above, a considerable number of flights have been made already with the first of these boats, much data remains to be accumulated, and many flights should, if possible, be made before the transatlantic flight in contemplation is attempted. I do not consider that the most satisfactory propellers have been installed, and believe that a series of tests should be carried out for the determination of the most satisfactory propellers for use on this flight. Although much data has been collected during the last year regarding the running of courses at sea, it is believed that further experiments should be undertaken with various winds, running courses marked by stake boats at least one hundred miles apart, so that definite data may be secured as to the methods of running these courses, and the use which can be made of the information received from the stake boats regarding the direction of winds on the surface, and in the upper air. Drills should be carried out on fuelling at sea, in order to determine the best sizes of containers to be carried by the stake boats, the best methods of handling these containers, and the lengths of time which should be allowed in the schedule of the trip for fuelling operations. Trials should be made in fairly rough water to determine the effect, if any, of running a high-speed destroyer ahead and oiling the surface of the sea, in order to assist in getting a boat into the air. Several sustained flights, of at least

eight hundred to nine hundred miles, should be carried out with each one of the craft possibly to be entered in this flight, in order that the probable points of weakness may be indicated and strengthened.

14. Upon the arrival of these boats at St. Johns, preliminary to the starting of the transatlantic flight, they should be equipped with new engines, carefully tested, and inspected for every possible defect.

15. It is presumed that the crew for each boat will be five men. All of these men should be naval pilots, two, at least, of them skilled in connection with the Liberty motor. Two men, at least, of each five should be skilled as aërial navigators. At least four of the pilots for each boat should, as soon as possible, be assembled at Rockaway Beach, or at Hampton Roads, and immediately trained in connection with the flying of these boats, and, in particular, in matters of detail connected with the Liberty engine and with the power plant of these craft, and in aërial navigation and seamanship. It is not regarded as necessary for the commanding officers of these craft to report for this duty more than six weeks in advance.

16. These officers should, of course, be volunteers; should be in the most perfect possible physical condition; and, other things being equal, should be of average weight. In order to provide for casualties of any sort during this preparatory period, two or three additional officers should be detailed with the specific understanding that they are additional, and that they will start the flight only in the event of some other officers dropping out.

17. There should also be detailed, as soon as boats are completed and delivered to handling stations, about twenty men of various ratings, in accordance with lists previously submitted to Operations, Avia-

tion, by the Commanding Officer, Rockaway Beach Air Station, as a permanent handling and up-keep gang for each boat. These men should be carefully trained from now until the time of flight in their duties, and should be sent sufficiently ahead of the date of the flight to St. Johns, Newfoundland, to be ready for immediate work on these boats upon their arrival there. This work will involve the removal of the engines installed, installation of new engines, and the general overhauling, truing up, and testing of all features of the craft. With these men should be sent complete equipment of all items found necessary in the handling and up-keep of these craft. These items are several hundred in number, and data regarding them is now being accumulated at Rockaway Beach. The provision of these items and their delivery at St. Johns, with the handling and up-keep crews, will require most careful attention, as, it is safe to say, they are, with few exceptions, of such a nature that they cannot be obtained in that port.

18. Many special articles, like Thermos bottles, water containers, condensed foods of various kinds, chronometer watches, eiderdown sleeping bags, etc., etc., must be provided and installed. In addition, provision must be made for water flares for use in connection with navigation, for sounding balloons, and for hydrogen bottles, as well as for other things which will undoubtedly be found necessary.

19. The subject has by no means been exhausted, but enough points have, I believe, been brought out to indicate the fact that very careful attention will be required from some organization working specifically on the details of this project, to prevent the oversight of some very important detail. As I told you several days ago, I have for some months had this project in mind, and have had my organization working on it. We are favourably located to con-

tinue the problems involved; are being rapidly relieved of the major portion of our duties, due to the completion of aircraft contracts on which we have been engaged; and are, for the reasons cited, in a position to undertake, under the direction of a central planning committee in Washington, the organization of this project, and the carrying out of the multitude of details involved. I shall be very happy to coöperate with you in anything, and to any extent, in making this project a success. I believe the fact of our location in New York, outside the somewhat distracting atmosphere of Washington, would make it possible for us to carry out necessary arrangements with less interruption than would be experienced in Washington. I shall be glad to supply office space and office facilities to any one you care to connect with the project. Many of these details are of such a nature that a considerable amount of time will be required for their successful solution, and it is my opinion that no more time than is absolutely necessary should be lost before attacking them. Progress in airplane tests and experiments, and in the provision of special articles required by aircraft, is so slow and tedious that very careful conservation of the time remaining before the date at which this flight would become practicable should be exercised.

20. If you should care to call on me for assistance, I shall visit Washington at any time you elect, to discuss with you and your planning committee the details of the project, and the portion of these details you would care to have our attention for.

/s/ G. C. Westervelt.

About two weeks later the project was placed before the Secretary of the Navy in the following communication from the Planning Committee. The

Secretary's enthusiasm was immediately aroused, and his approval was promptly forthcoming. His support and encouragement of the project from then until its successful conclusion were unfailing.

2-AH Q1

Op-Air SECRET
068-A-25 *February 4, 1919.*
From: Chief of Naval Operations.
To: All Bureaus.
Commander-in-Chief, Atlantic Fleet.
Subject: Transatlantic Flight.
Enclosure: (A) Copy of recommendation of Planning Committee on above subject with Secretary of the Navy's endorsement of approval.

1. Enclosure "A" is forwarded for your information and compliance.

2. It is especially desirable, in view of the many uncertain elements which may affect this project, that it be considered as "secret."

/s/ J. M. McKEAN
Acting.

NAVY DEPARTMENT Q1
OFFICE OF NAVAL OPERATIONS
WASHINGTON

Op-35 SECRET

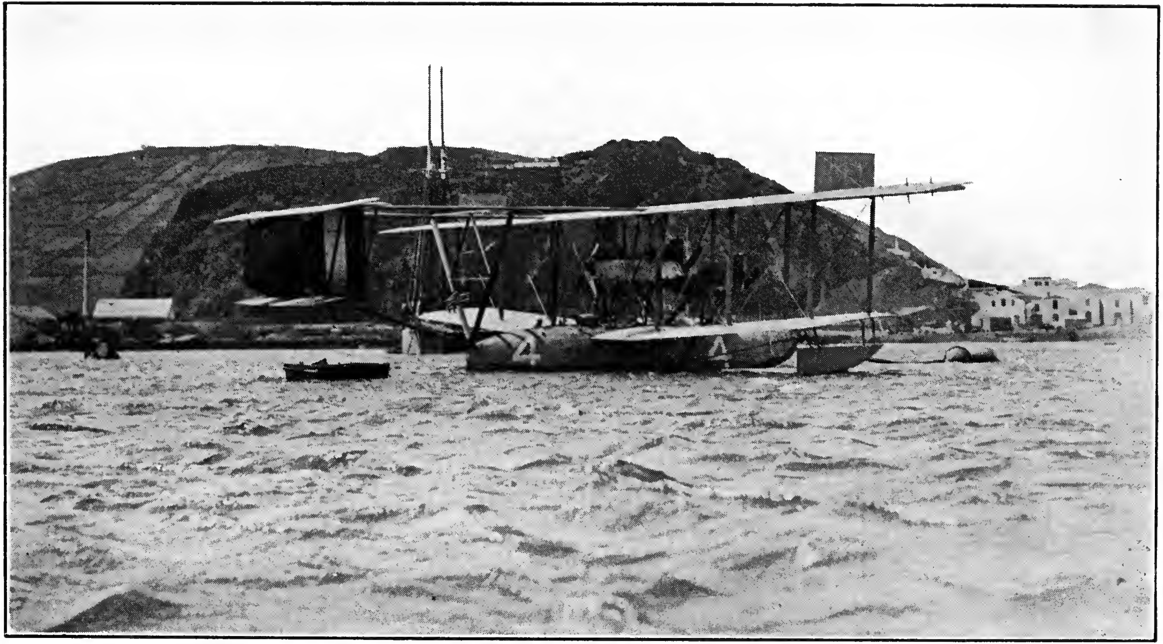
From: Planning Committee.
To: Chief of Naval Operations.
Subject: Transatlantic Flight.

Foreword

As early as 1914 a transatlantic flight was seriously contemplated and Commander J. H. Towers,

THE LANDFALL OF THE ROCKY COAST OF THE AZORES

"On approaching the water we found the fog stopped nearly two hundred feet above it . . . A peaceful farmhouse came into view in the midst of cultivated fields on the side of the hill. That scene appeared far more beautiful to us than any other ever will"



N.C. 4 ARRIVES AT HORTA, AZORES

This was the first Old World point reached after the successful long jump from Newfoundland (then Lieutenant) was ordered by the Navy Department to observe the preliminary tests and experiments and to report upon the feasibility of the project. The war put an end to this special undertaking, but it had a marked effect in causing developments in aviation, which have resulted in the construction of machines far superior to the original *America*.

Now that the war operations have ceased, the attention of the aeronautic world has again turned to the transatlantic flight. It is known that the British have been considering this project for some time and have had experts studying the problem with the purpose of attempting its solution upon the conclusion of peace. The British have developed larger airplanes than any other nation, and it is believed that they are prepared to undertake the first transatlantic flight. As it seems probable that Great Britain will make every effort to attain the same relative standing in aërial strength as she has in naval strength, the prestige that she would attain by successfully carrying out the first transatlantic flight would be of great assistance to her in attaining the supremacy desired in aviation matters.

It is understood that France and Italy have also considered this project, and it is known that at least four independent efforts are being developed by private parties in this country. In view of the fact that the first successful airplane was produced in this country, and that the United States developed the first successful seaplane, it would seem most fitting that the first transatlantic flight should be carried out upon the initiative of the United States Navy. The accomplishment of this feat would give to the organization of the government accomplishing it a considerable amount of deserved prestige.

It is considered most desirable in every way that this flight be accomplished in craft developed by the Navy Department and flown under the direction of officers of the United States Navy. The facilities at the disposal of the Navy Department are such as to insure the proper carrying out of all plans so essential to the successful accomplishment of a project of this nature. The successful accomplishment of this flight by the Navy will have an important effect in stimulating the progress of commercial aviation endeavour. It will have the effect of calling up for settlement many important international questions involving aërial matters.

Routes

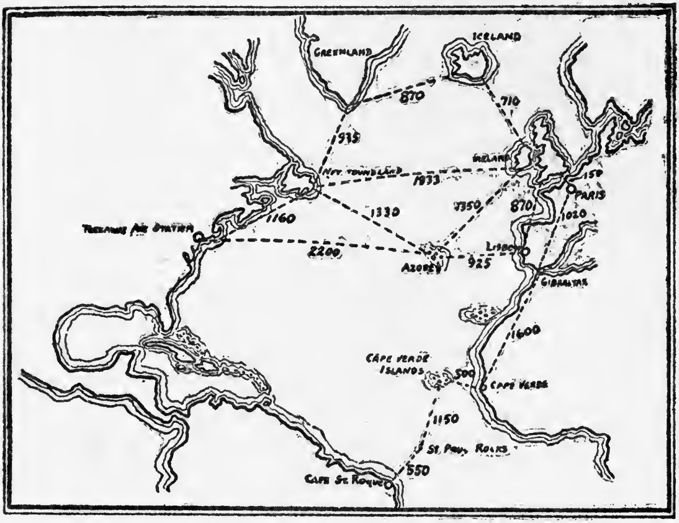
In view of the limited equipment and cruising radius of the planes available, only four possible routes are considered, as follows:

1. United States, Newfoundland, Greenland, Iceland, England.
2. United States, Newfoundland, Ireland.
3. United States, Newfoundland, Azores, Portugal.
4. South America to Africa.

The first route is rejected owing to unsettled weather conditions and the inability to predict the conditions in these areas, the difficulty of basing patrolling forces, and the lack of suitable ports of call.

The second route offers many advantages in that it will be a non-stop route across the Northern Atlantic, which is the real problem involved; but in view of the fact that it necessitates an over-sea flight of 1,675 nautical miles (great circle distance from Cape Broyle Harbour to Bantry Bay) it is not considered practicable to cover this distance with the planes available without refuelling at sea. This would introduce many complications which would render it unwise to adopt this route, unless developments in seaplanes permit an extension of cruising radius.

The third route offers the easiest solution, as its distances are shorter, areas of uncertain weather conditions least, it lends itself admirably to basing patrols, and is well within the zone in which the weather bureaus can make accurate predictions.



The fourth route is rejected on account of the inaccessibility of the point of departure.

Facilities

There are available under the Navy Department several seaplanes capable of carrying sufficient fuel and equipment and with engines of sufficient reliability to offer excellent chances of success on the Azores route. The planes available at this time are the *N.C. 1* type and the *F-6-L* type.

The *N.C. 1* is the largest seaplane developed by the Navy, and is equipped with three Liberty engines and has an estimated cruising radius of more than 1,400 miles. Its wing span from tip to tip is 126 feet, and its over all length 68 feet 3½ inches. This plane recently made a flight with fifty-one men aboard. It is designed to carry a crew of six men, and has a speed of 80 miles per hour.

The *F-6-L* is a twin engine (Liberty) flying boat, 103 feet 9¼ inches span, 49 feet $3\frac{11}{16}$ inches length, with an estimated cruising radius of more than 1,350 miles. It is designed to carry a crew of four men and has a speed of 87 miles per hour.

The cruising radius of each of these types can be improved by stripping them of all unnecessary gear and increasing the fuel supply.

Patrol

By the establishment of a proper patrol of the course, the danger to personnel can be practically eliminated. For this purpose there would be required a number of destroyers, in order that they could be stationed a distance of about 100 miles apart to mark the course, and in order that at least one of them may be within helping distance in the event of emergency.

By making a smoke column during the daytime and using searchlights during the night, these patrols would largely overcome the difficulties of aërial navigation.

Additional Equipment

In addition to the patrol vessels, mother ships would be required at the ports of call in order to furnish fuel, spare parts, personnel, etc., for the planes. The assignment of mother ships for this purpose is advantageous, as it does away with necessity for elaborate shore establishments at ports of call.

In order to permit of repairs upon arrival at bases, seaplane lighters will be required, unless beaching facilities are available.

Weather Conditions

From a study of weather conditions prevailing over the North Atlantic during the various months of the year, and after a discussion of the project with officials of the Hydrographic Office and the Weather Bureau, it appears that the only suitable months for this flight are from April to September, inclusive. In view of the desirability of being ready to make this flight as soon as conditions are favourable, and in order to forestall independent projects of this nature, it is believed that plans should be made to start the flight about May 1st. Officials of the Weather Bureau believe that with the assistance of the patrol vessels and with the observations available from their own stations, it will be practicable to make very accurate predictions regarding weather and winds.

General

By installing four K-12 engines in an *N.C. 1* type of seaplane, a computed radius of action of 2,100 miles can be obtained.

These engines are built by the Curtiss Company, but up to this date have not passed a sufficient test to insure their reliability in a project of this nature. It is believed that these engines could be developed satisfactorily if proper action were taken. The successful development of engines for this equipment of tried reliability would make it practicable to attempt the direct flight from Newfoundland to Ireland, with excellent chances of success.

Geared Liberty engines would give a much better performance in both types of planes and largely increase their radii. Proper development, however, has not been carried out on the geared Liberty motor, and its reliability for this purpose is not assured.

The distances involved are as follows:

Rockaway to Halifax . . .	540 nautical miles
Halifax to Cape Broyle Harbour, Newfoundland . .	485 nautical miles
Cape Broyle Harbour to St. Miguel, Azores . . .	1,320 nautical miles
St. Miguel to Lisbon, Portugal	780 nautical miles
Cape Broyle Harbour to Bantry Bay, Ireland . . .	1,675 nautical miles

Recommendations

The following definite recommendations are submitted:

(a) That the transatlantic flight be undertaken by the Navy Department.

(b) That full preparations be made as soon as practicable, in order that the flight may begin about May 1, 1919.

(c) That the route chosen be from Newfoundland to Portugal, via Azores.

(d) That the detachment making the flight consist of four of the best seaplanes available.

(e) That a line officer of the Navy be detailed to command this expedition. That this officer, under the direction of the officer in charge of Aviation Operations, be authorized to select the personnel for this expedition, collect all data, assemble all material, direct experiments, and carry the entire project to completion.

(f) That immediate action be taken to obtain reliable data from actual performances of the types of planes selected for this flight, in order that accurate information may be available upon which to base the plans of operation.

(g) That the coöperation of the Commander-in-Chief of the Fleet and all bureaus concerned be directed in the expedition and completion of this project.

(h) That intensive experimental development work be carried out immediately with K-12 engines and the geared Liberty engines, in order that information may be available regarding the reliability of these machines.

(i) That if the results of these developments demonstrate the practicability of equipping naval seaplanes with engines of great reliability sufficient to give them largely increased radius of action, the possibility of making a direct flight from Newfoundland to Ireland be further considered.

(j) In view of the fact that the only logical point for the beginning of the flight is a port of Newfoundland, which is a British Colonial port, and in view of the possibility that Great Britain contemplates an expedition of this nature at about the date recommended above, an awkward situation may result from the independent preparations being carried out by the two countries at the same port. In order to avoid any complications of this nature, and also in view of the fact that the United States and Great Britain have coöperated to a great extent in the development of the latest types of seaplanes, which has made this project practicable, it is recommended that information regarding the proposed flight be furnished the proper British authorities, and it be suggested to them that if they contemplate an expedition of this nature, arrangements be made to start both expeditions simultaneously, in order that the patrols and other facilities may be utilized conjointly.

(k) In view of the important rôle being taken by the United States in international affairs, and of the necessity of avoiding any possibility of giving offence to any of the great nations with which we are associated, attention is invited to the desirability of supplying information in regard to this flight to governments of France and Italy also, in order that both or either of these countries may have planes to participate if desired. It is believed that the prestige obtained by the United States Navy in thus initiating and making possible a great international flight of this nature will equal or exceed that obtained by attempting the flight alone and all chance of international jealousies will be avoided.

/s/ J. T. TOMPKINS,
Captain, U.S.N.
/s/ J. H. TOWERS,
Comdr., U.S.N.
/s/ G. D. C. CHEVALIER,
Lt. Comdr., U.S.N.

1st Endorsement

From: Chief of Naval Operations,
To: Secretary of the Navy.

1. Forwarded, approval recommended.

/s/ J. L. MCKEAN,
Acting.

NAVY DEPARTMENT

1. Approved.
2. Commander-in-Chief of the Fleet and the Bureaus of the Navy Department are authorized and directed to take such action as may be necessary to carry out the provisions of this plan for a transatlantic flight. /s/ JOSEPHUS DANIELS.

The injunction to secrecy contained in these papers was not observed. This was due to a peculiar little slip in one of the cogs of the Navy Department machinery. Although during the war secrecy had been maintained regarding all orders to officers, this policy had recently been reversed, and the before-war policy of allowing the newspapers to publish summaries of these orders had been reëstablished. When Commander Towers was given duty in connection with the preparation for this flight, immediately upon the approval by the Secretary of the project, the issuance of his orders in secret was overlooked. Even a newspaper reporter knows when something falls on him. Orders for duty, "in connection with preparations for transatlantic flight," had some significance. They flocked to the Secretary's office: the cat was already out, concealment was impossible, and the Secretary told them the whole story.

On February 17th, Admiral Taylor, in the letter quoted, directed the completion of the N.C. boats for the specific purpose of the earliest practicable transatlantic flight.

NAVY DEPARTMENT
BUREAU OF CONSTRUCTION AND REPAIR,
WASHINGTON, D.C.

February 17, 1919.

O-Z-4 (A)

To: Commander G. C. Westervelt, Construction Corps, U. S. N.
Subject: Transatlantic Flight.
Enclosures (herewith):
(A) Copy of letter from Chief of Naval Operations

dated February 4, 1919, No. Op-Air: 068-A-25 with its enclosures.

1. Your attention is invited to enclosure (A), outlining a proposed transatlantic flight which has been approved by the Secretary of the Navy.

2. The present intention is to use the *N.C. 1* type of flying boat for these flights. It is probable that a number of experimental changes will have to be made in the *N.C.1* boats already produced and in those now coming through production before the most satisfactory installation for making the transatlantic trip can be determined. The limited time remaining before the flight should be started makes it imperative that the heartiest coöperation of Bureau representatives and all others concerned be obtained, in order that the flight may be a success and reflect honour and credit to the Navy. The Bureau expects and requires this coöperation from its representatives.

3. At the request of the Director of Naval Aviation, the Bureau is requesting orders for Commander H. C. Richardson, Construction Corps, U.S.N., detaching him from his present duties and ordering him to report to the Chief of Naval Operations, Washington, D. C., for further assignment in connection with the proposed transatlantic flight. While on this assignment Commander Richardson will be detached from the technical duty he has been performing under this Bureau.

4. Anticipating that a number of changes must necessarily be made, and that considerable pressure must be exerted on the contractors to have the work on the *N.C.1* boats expedited, the Bureau hereby designates you as its official representative in New York and other points outside of Washington to handle matters concerning this project coming under cognizance of this Bureau.

5. You are empowered to make changes in the

N.C.1 boats, or to authorize trials to be conducted, reporting to the Bureau what changes have been made and the results of trials. The Bureau wishes to make it plain that no changes under its cognizance are to be made on *N.C.1* boats, unless the change is authorized by the Bureau or by yourself acting for the Bureau.

6. The Bureau should be kept fully informed by weekly reports, in triplicate, of the status of work and trials of the *N.C.1* boats, with particular reference to their being prepared for the transatlantic project.

7. It is understood that the Bureau of Steam Engineering desires to have collected considerable data on various power plant installations. This data will necessitate a number of trial runs before the boats are finally accepted from the contractor. The Bureau desires that the wishes of the Bureau of Steam Engineering in this matter should govern, and that the trials and collection of this data be expedited in every possible way.

/s/ D. W. Taylor.

Very great amounts of work remained to be done in completing these craft. They had been greatly advanced since work under pressure had been resumed on them, but there was much to do. The *N.C.2* had been completed and flown, and, as anticipated, the engine arrangement gave much advantage over that in the *N.C.1*. The *Three* and the *Four* were far from completion. If we could be certain of anything it was that much unexpected work would develop and that many unanticipated changes would be made. Immediate steps were taken, accordingly, to secure permission for overtime work, as it was certain that the date on which we hoped to have everything ready, May 1st, could not be met on any other basis. From the date this permission was secured until the boats left Rockaway Beach on their flight, work never stopped before midnight, except, occasionally, on Sunday. The men of the Curtiss Engineering Corporation, who had a tremendous interest in the project, and a determination to see America first across, and who stuck to the job under most wearing conditions; and the men of the Navy, of the Bureaus of Steam Engineering and Construction and Repair, who spent the long hours with them, in order that difficulties when met might be immediately surmounted, will always have the satisfaction of having "finished in time"!

In changes and improvements on the *N.C.1* much weight had been added, and it was found, when accurate determination of gasoline consumption was made, that her flight radius was insufficient for a non-stop flight from Newfoundland to the Azores. It had also been found that the boat hull was much more efficient than we had anticipated, and we decided that an increase in engine power would increase the lifting capacity of the seaplane and the radius of action.

This we determined immediately to try in two ways. On the *N.C.1*, engines with high-compression pistons were substituted for those of low compression—resulting in increased horsepower to the extent of at least 125, and in an increase in weight-lifting ability of about 2,000 pounds. Experiments with propellers had also made available a more efficient propeller, and radius of flight was so increased that a non-stop flight to the Azores was practicable.

The second method to be tried was the installation of an additional engine in the *N.C.2*. In order to make this installation as quickly as possible, and without disturbing other arrangements, these engines were placed in the wings in two tandem sets, an arrangement the accompanying photograph will make quite clear. Our estimates indicated that this fourth engine would raise the flying weight of these boats to about 28,500 pounds, and the radius of flight to 1,550 or 1,600 miles.

It soon became evident that we could not make the installation of a fourth engine in the other boats wait the trials of the *N.C.2*. We must decide without such trials whether or not to equip all boats in this way. At a conference in Washington this—with other radical and extensive changes, the greatest of which was removing the pilots from the centre nacelle to the boat hull—was decided upon. As the engine arrangement, however, we decided upon single wing engines and two central engines in tandem. This arrangement has a great advantage over a three-engine arrangement because of the fact that immediately after getting into the air flight can be continued on three engines, if necessary, whereas with three engines only, the boat would not for several hours be sufficiently lightened, due to gasoline consumption, for flight with two engines.

Gasoline tankage was increased from six 200-gallon tanks to nine; wireless telegraph and telephone apparatus and wireless direction-finders were provided and installed; many items of special application to the flight only were introduced.

Our difficulties were many. As always in aircraft work, as has been mentioned previously, everything hindered, nothing helped. Late in March the *N.C.1*, at anchor in the bay, was driven ashore by a violent gale which buffeted her for three days. The wings on one side were practically destroyed. We had no spare ones; the time was insufficient for their construction; and our hope that we could start the flight with four boats was dashed. In this lay the doom of the *N.C.2*. It was decreed that she should lose her wings for the *N.C.1*.

Except for delays, which always result in aircraft construction, and for the injury to the *N.C.1* by the storm, and to the *N.C.1* and the *N.C.4* by fire, as will be described in a later chapter, the N.C. boats have been remarkably lucky. Under the press of insufficient time, when they were being completed for the transatlantic flight, it was necessary to incorporate important features on very scanty consideration. We had grown, however, to consider these boats lucky and took some very long chances. The engine arrangement is a case in point. This engine arrangement is absolutely unique and has never before been employed on a flying boat. Its details were worked out in a few days, and it was then installed. If it had proven unsatisfactory, or its details had not been effective, serious delay imperilling the whole project would have been occasioned. This chance had to be taken, and the luck of the N.C. boats held. Except for one or two changes of a minor nature this difficult installation, worked out in such a short time, and with no possibility of having sufficient time for thoroughly testing it, was all that could be desired.

In all of the flights of the N.C. boats, no crashes were experienced, no lives were lost, and only one man was seriously injured. Here again luck played an important part. In February, the *N.C.1*, while on the handling platform, was very seriously buffeted by a furious gale which eventually tore the control column loose, due to the flapping of the control surfaces, and injured the plane itself in a minor degree. This occurrence uncovered the fact that the principal bearings of the double control yoke, which were supposed to be one and one half inches in length, were, in reality, due to a series of remarkable mischances of manufacture and inspection, only one eighth inch in length. They had projected into metal plates to this depth instead of to the depth of one and one half inches as was intended, and upon this frail support had depended the safety of the *N.C.1* on the flights it had made up to this time. It may well be imagined how great would have been the catastrophe if these insufficient supports had failed when fifty-one persons were on board. The storm which tore them loose and exhibited them to the gaze of the world, with no damage other than the few slight injuries to the plane itself, was good luck of the first order.

On another occasion the *N.C.2*, this time with thirty persons on board, was skimming along the water just on the point of taking to the air. From an altitude of 1,500 feet a smaller flying boat from the Air Station was practising the dropping of 220-pound depth charges against a target anchored in the bay. As the *N.C.2* with its freight of humans passed this target, the bomb dropper of the other boat let fall a depth charge which struck the water within less than 150 feet of the *N.C.2* and very severely shook up everyone on board, though without doing them any actual injury. If this depth charge had fallen 25 to 50 feet nearer, it would almost certainly have destroyed the plane and would have caused the loss of a considerable number of the men on board. This occurrence was due, of course, to the carelessness of the bomb dropper, but good luck was with the *N.C.2* in her successful passage through the ordeal. From descriptions of the flights across the ocean made by the *N.C.1*, *N.C.3*, and *N.C.4*, will be realized the fact that the good luck which had attended these boats to such an extent was still with them. It may appear that the Goddess was nodding when they ran into fog and rain, but the experiences of the *N.C.1* and the *N.C.3* after landing, the happy outcome so far as the crews were concerned, will prove that she awoke in time and again took charge of the circumstances.

The things we had expected to do, the changes we had contemplated making, were few in number compared to those we did do and did make. From the directors of the flight operations came innumerable requests, all of them entirely reasonable, for items no one had contemplated before. Captain Hall of the Coast Guard, who had charge of work for the Bureau of Steam Engineering, and I had most of them incorporated and, of course, paid the penalty in being unable to complete the "Nancies" by May the first.

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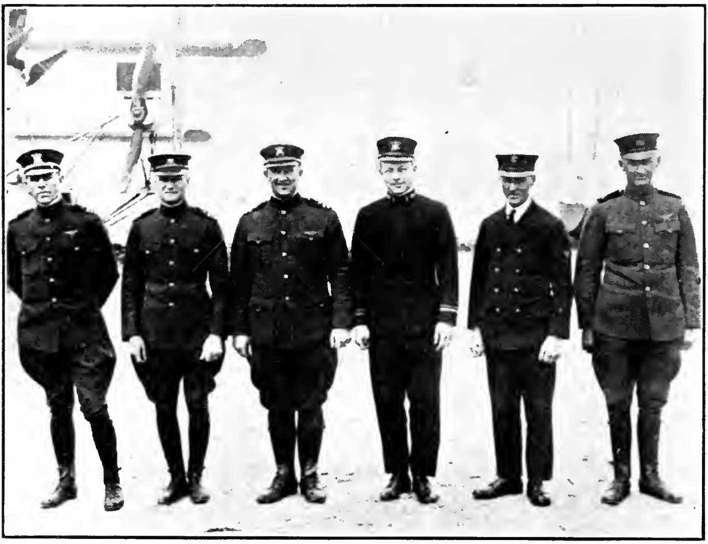
THE CREW OF THE *N.C. 4*

Photograph taken immediately after their arrival in Plymouth while they are still in their flying clothes. Commander Read stands in front; behind, from left to right, are Lieut. J. L. Breese (reserve pilot engineer), Lieut. Walter Hinton (Pilot), Ensign Charles Rodd (Radio Operator), Lieut. E. F. Stone (Pilot), and Chief Special Mechanic, E. C. Rhodes



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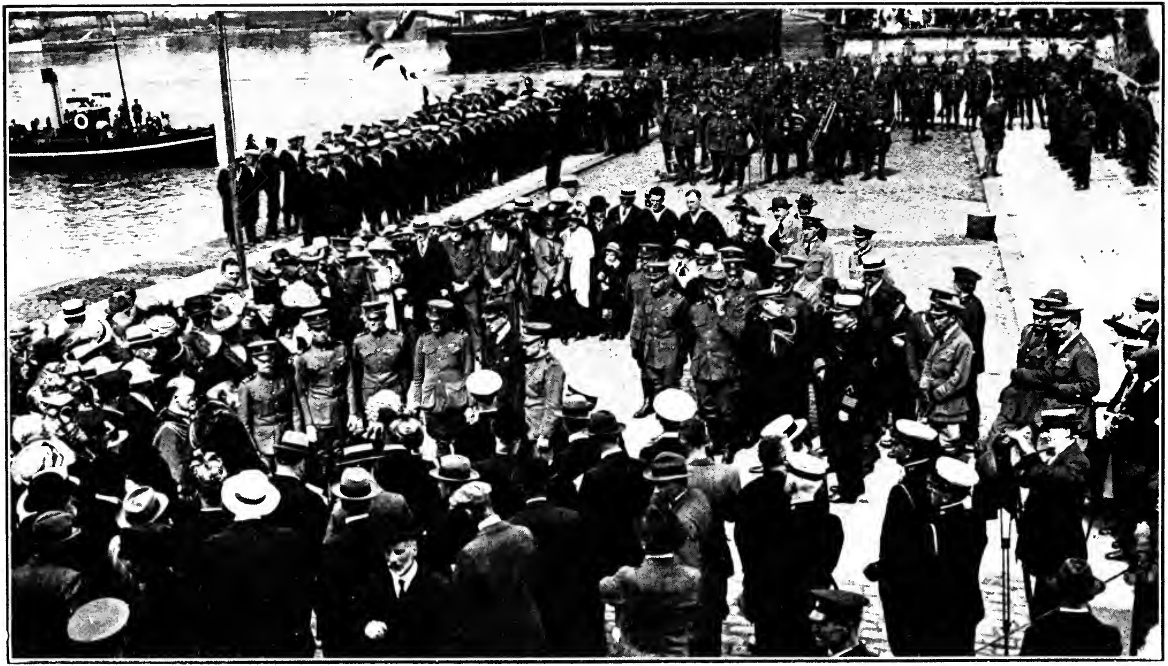
THE CREW OF THE *N.C. 1*

From left to right they are Lieut.-Commander Bellinger, M. A. Mitscher and L. F. Barin (Pilots), Lieut. H. Sadenwater (Radio Operator), Chief Machinist Engineer C. I. Kessler, and Reserve Pilot Engineer R. Christensen



THE WELCOME TO THE N.C. MEN AT PLYMOUTH, ENGLAND

The Lord Mayor of Plymouth addresses the triumphant Americans from the spot whence the Pilgrim Fathers sailed three hundred years ago

Some time previously to that date, however, we had been compelled to report that as the details required of us were so much more numerous than we had contemplated when our original date was set that we would need an extra week. Actually the boats were completed on May the 3rd, and on that day the *N.C.1*, the last to be completed, was turned over to Commander Towers. If some "Jinks" a night or two later had not tried to burn the *One* and the *Four*, our labours would have ended then.

With the delivery of the boats to the flyers, the story of the design and building of the N.C. boats comes to an end. What happened then and afterward let Commanders Read and Richardson relate.

PART II

THE LAME DUCK WINS

BY

LIEUTENANT-COMMANDER A. C. READ

CHAPTER I

THE PRELIMINARIES

THE work of preparation for the Navy's attempt at a transatlantic flight can be divided into two parts—first, the preparation of the seaplanes themselves, and, second, the preparation of plans for conducting the actual flight. The first of these tasks has been described at considerable length, and the description conveys some idea of the immense number of details that had to be worked out, the numerous tests that had to be conducted, and the many troublesome features that had to be corrected. The result was a type of seaplane that embodied the best characteristics of smaller flying boats and one that filled the crews with confidence that they would be able with ordinary luck to cross the ocean safely.

We can take up now the second proposition, that of the preparation of plans for conducting the flight. These plans were made with a view to providing every practicable means of enabling the planes to keep their course and of aiding them in case of a forced landing at sea. This was to be no "do-or-die" effort. Though there must be, in a project of this kind, some doubt about the "doing," no one considered the "dying" as more than a very remote possibility—any more than there would be in a flight from Chicago to New York.

The plans were so complete and so carefully laid that all of us were sure that we would be well looked out for in case of misfortune. In the first place, the choice of routes—Newfoundland to the Azores and to Lisbon, Portugal—was made because it appeared to be easiest of accomplishment, and therefore safest. The Newfoundland-Ireland route could not be followed, taking into consideration the fuel capacity of the N.C's, without favourable winds. The route chosen could be.

Another route proposed was that from Rockaway to a point at sea at the limit of the flying radius; refuelling there from a ship and then continuing on to the Azores and Lisbon. There were several arguments against this route; doubt was expressed as to the practicability of replenishing gasoline and oil at sea except under ideal conditions, and the point was made that the longest leg would be started first, while to jump off from Newfoundland would allow an opportunity to eliminate defects that might show up on the comparatively short "hops" from Rockaway to Halifax and from Halifax to Newfoundland. The northern route, via Greenland, Iceland, and Ireland, was not considered very seriously, because it is practicable for only a short period in the year.

Three classes of ships were used: "Base ships," to be at the different stopping places, in order to provide temporary quarters for the crews, to provide extra aviation mechanics, to assist in any repair work found necessary, and to carry gasoline, oil, and numerous tools, spare parts, and supplies that might possibly be needed; "patrol" or "escort" vessels (destroyers) to be stationed at intervals of fifty miles along the course, to aid the seaplanes in keeping track of their positions and to render assistance if necessary; and "meteorological" ships (battleships, five in number) equipped with powerful radio outfits and stationed at points about four hundred miles off the track to take and report weather observations in order to assist the official weather prophets in telling us what to expect, especially in regard to the wind.

A great amount of detail work was entailed in getting all the odds and ends of special equipment and supplies together, in distributing them to the various ships and, in some cases, in fitting the ships so that they could take the materials. For this some of them had to go to a navy yard. Two small flying boats were sent on the Newfoundland base ship, *Aroostook*, in order to give the pilots a bird's-eye view of the rather restricted area in which the getaway would have to be made and to try the air while making the same course that would be used later in starting off the big fellows.

This was a comparatively small matter, but navy yard work was necessary before the planes could be received on deck, for although they are "small" when compared with the N.C's, they were "big" when resting on the *Aroostook's* narrow deck, and are most unwieldy to handle.

Besides the strictly aviation spare parts and supplies furnished the "base ships," all of the 68 destroyers used in connection with the flight had to be supplied with special apparatus for day and night signalling and with special radio apparatus for purposes of communication to and from the planes.

Each destroyer that might be in the "night zone" of the Newfoundland-Azores leg was given star-shells to fire in its anti-aircraft guns. With the help of these shells, which are designed to be fired high in the air and then explode and ignite a parachute light of approximately 800,000 candle power, and with searchlights, it was believed that the planes would be able to pick up the ships at night with little difficulty unless the weather was thick. Then each meteorological ship (including every fourth destroyer) required a special outfit for obtaining detailed information necessary for the weather men to form their estimates of the situation.

In order that the "air" navigator could obtain the best information as to his progress and his position at any time, he was furnished not only with a compass and the greater part of the equipment of a "sea" navigator, such as chronometers, sextants, charts, etc., but with other special devices—for example, drift indicators to obtain the effects of the wind on the course being steered and on the speed; ground flares to drop into the water, which gave off a bright flame for night work or a heavy smoke for day work, in order to furnish a stationary point to sight on in using the drift indicators; and, finally, special short methods of working out positions by observations of the sun and stars.

In taking these observations it is necessary to obtain the vertical angle between the horizon and the heavenly body observed—easy on a ship in ordinary weather, but quite another matter from a seaplane, as the horizon at an altitude of only a few hundred feet disappears entirely, lost in the haze. Therefore, our sextants were fitted with "bubble levels" and then they furnished their own horizon. It took many weeks before a satisfactory "bubble" was obtained which would give accurate results.

Two radio sets were carried, one good only for short-distance work when on the water or when flying very low, and the other for longer distances, up to two or three hundred miles. As a matter of fact, it was found that this set was able to work at much longer distances, as will be described later. The "short-distance" set obtained its power from a storage battery carried in the hull and had a fixed antenna strung along the upper wings. The power for the "long-distance" set came from a small "streamline" generator clamped to one of the wing struts and fitted with a small propeller. This propeller was kept turning by the rush of air caused by the onward speed of the seaplane, in a manner similar to a windmill. The antenna was a wire two hundred and fifty feet long with a weight on the end; this wire was wound on a reel mounted in the after cockpit and was let out to trail astern only when sufficient altitude was attained to insure its not touching the water. The shutting off of the motors at the commencement of a glide to the water was necessarily a signal to the radio officer to "reel in," and as it proved later on, it was the only signal necessary.

Besides the functions of the "battery" set, that is to say the sending and receiving of ordinary radio messages, telephoning could also be carried on between the planes, as this set used the "continuous wave." Then there was a telephone system connecting each member of the crew, and one of our radio experts had the bright idea of switching this system on with the interplane radio telephone, so that one skipper could talk directly with another skipper in another plane without having to depend on relaying through the operators. This scheme was found to be of not much practical value, however, during the flight, owing to the difficulty of shutting out the roar of the motors sufficiently to understand what was being said. I did use it very successfully in getting the time "tick" from Arlington for determining the chronometer's error; there was, of course, no talking involved in this.

The contingency of a forced landing at night was considered. Experiments were conducted, and flares to be set off by pushing a button on the pilot's "dashboard" were mounted under the bow in order to illuminate the surface of the water in time for the pilot to "level-off" and effect a safe landing. The principal fault in this installation was the fact that the dashboard button was placed in such a prominent position that the "I-didn't-know-it-was-loaded" type of man just couldn't resist the temptation to press it to see if anything would happen. This occurred several times, once in the Azores while filling up with gasoline, with the filling hose less than two feet over the flares. Fortunately a quick use of fire extinguishers prevented serious trouble.

For food, coffee in vacuum bottles and sandwiches were provided, and in addition a number of "emergency rations." In trying the latter we came to the unanimous opinion that, while they undoubtedly had the theoretical food value required, with the minimum of weight and space (the label said so), it would require a decided emergency before the containers would be opened.

Our clothes were the standard Navy one-piece leather suits worn outside of anything the individual might choose to wear. One officer favoured wearing two of these suits, on the theory that if he was too warm he could "shed," but if too cold he would only "shiver." Most of us wore our forestry green Naval Aviation uniform under the leather suit supplemented with as much underwear as each thought desirable.

Thus far I have touched only lightly upon the general disposition and movements of the assisting ships. This was all arranged by the commander of the destroyer force, Admiral Plunkett, the same officer who did such excellent work when in charge of the Navy "railroad guns" on the western front in France. He sent his Chief of Staff, Captain Laning, to Washington to arrange the details. Captain Laning arrived, obtained from Commander Towers the general outlines of what was wanted, rolled up his sleeves, and plunged into the work with a vim that set the pace for the rest of us.

The first thing he did was to give us twice as many destroyers as we had asked for. All the ships connected with the transatlantic flight project, of whatever type, were to be turned over temporarily to the commander of the destroyer force. It was therefore necessary to arrange for the movements of all of them. Not only was it necessary to allot each ship to its particular position, but dates of departure of each individual ship must be arranged so that it should arrive in its position in plenty of time. Arrangements had to be made for refuelling some ships that did not have sufficient steaming radius to make their stations and return, and, finally, very careful instructions were issued to cover exactly what each ship was to do and how and when.

All probable contingencies were covered. As an example of this there is quoted below a few paragraphs from the "operation orders" issued to all concerned:

"When a station ship receives a report that a plane has passed the next station to the westward it will commence 'smoking' in daytime and continue to 'smoke' until the last plane passes or is accounted for. [This is done on oil-burning ships simply by restricting the supply of air admitted to the boilers.] At night ships will 'torch' [a brilliant flame, at the top of the smoke pipes made by improper firing of boilers], 'and searchlights will be turned on at once and kept on, trained directly into the true wind' [knowledge of the direction of the wind at night is of great value to the flyer] until planes have passed or been accounted for.

"In case of mist or thick weather searchlights shall sweep the heavens in a vertical plane into the true wind until plane reports that the vessel has been sighted, when the beam will be steadied level. At night ships will also commence to fire star-shells from

3-inch guns at five-minute intervals and continue firing until plane reports sighting. Star-shells to be fired to north on maximum elevation with fuses set for five seconds, unless plane requests otherwise.

"Should a station ship be 'off station' during the flight, due to answering an S.O.S. or some other emergency, it will make smoke or 'torch' and fire star-shells, as above directed, but will inform planes as directed in special 'communication instruction,' that ship is out of position.

"When an S.O.S. call is received from a plane the two station ships nearest the indicated position of the plane shall proceed to her assistance with all possible speed, unless notified otherwise. Upon arrival, if repairs are possible, lend all assistance. If repairs are not possible group S.O.P. [senior officer present] shall designate one destroyer to take the plane in tow and proceed to the nearest port. If the plane is too damaged to be towed, the destroyer, after rescuing the personnel, shall use every effort to salvage the engines and equipment.

"Utilize destroyers to the best advantage in an S.O.S. emergency. If an S.O.S. call comes at night destroyers will keep brilliantly illuminated while proceeding to the plane, will 'torch,' will keep searchlight sweeping the heavens, and will keep a bright lookout for Very signal, the colour of which will indicate the character of the forced landing and the condition of the plane. [Very signals are coloured stars fired from a special pistol. They give a light somewhat similar to those given off by Roman candles, except that they are brighter and travel farther.]

"If while off station for any purpose a destroyer sights a plane in the air, it will signal the duty it is on and if requested will send to plane the true bearing and distance from the destroyer's then position to the nearest station," etc.

The problem of getting all the reports through, especially those of meteorological observations, was worked out to the minutest detail. Practically all reports were by radio; and, as is pretty well known in these modern days, only a very few messages can be sent through at the same time in any certain area. To do even this requires a different "tuning" of the radio sets. Therefore, it was necessary that the instructions include means of preventing the possibility of one ship "outtalking" another ship which might have an important message to deliver.

Not to go further into details, it took seventeen pages of closely written official-size paper to tell the whole story of "radio communications" instructions. As the weather information desired was far more extensive than the ships had ever before obtained, special instructions were issued to cover the operation of the meteorological apparatus and the codes necessary to transmitting in a few words the complicated data recorded. This alone took thirteen pages.

The plan of the formation of the planes themselves, the rules for manœuvring and for action in case of emergency, etc., were made as simple as possible. Events in the air happen quickly, and hampering the skipper and pilots with complicated orders would be worse than giving no orders at all. In a nutshell, the idea was to follow the leader and, when necessary to do otherwise, to do it first and report afterward. The seaplane flagship would lay the course and set the speed, the others, on each side, adjusting their movements accordingly.

The contingency of suddenly running into fog without warning had to be provided for, and to eliminate any chance of a collision all planes were to start to climb out of it, and those on the flanks would shift their course slightly away from the "flag" to obtain a more comfortable distance from her.

Thus, from the foregoing, some idea may be gained of the extent of, and the care employed in planning for, the project of crossing the Atlantic Ocean in a "heavier-than-air" craft. As it appeared to be the first effort of its kind by any government, the problem was to make the crossing with every safeguard provided against the loss of personnel or of material. In time of war a great deal would have been omitted and very few ships employed to assist. But in peace times the Navy always pursues the policy of "safety first."

If the flight were successful, not only would an immense amount of valuable and much-desired information be obtained concerning long-distance oversea flying, but Naval Aviation, the Navy Department, and the whole country would receive the plaudits of the entire world for accomplishing a notable feat in the progress of the science; the mass of the people would be made to realize the importance of aviation as a valuable arm of the naval service; and the way would be blazed for others to follow and thus act to promote a commercial transatlantic service.

To those who might say that no commercial company would ever go to the expense of keeping such an extensive patrol, or of providing such complicated equipment, we would agree. We did not think it would be necessary after something was learned by actual experience. For instance: Several different methods were provided for finding and keeping the correct course to steer, but no one knew by experience which one would be most suited to the purpose. That was one of the things to learn on this trip. A second flight across would see a much simpler layout, with the elimination of all the safeguards except those found to be best and most reliable. The attitude of all concerned with the first transatlantic flight was fairly well expressed in an article written before starting the flight, from which the following paragraph is quoted:

"Some flyers might say there was no sportsmanship in flying across after making such thorough preparations and that anybody could jump from ship to ship when they are but fifty miles apart. Well and good, and all honour to any one who tries it alone, if he gets there or even if he makes an attempt. But we say that accomplishing a transatlantic flight in a two-seated, single-engine machine proves no more that it is a practicable proposition than a hit obtained from a blind shot in the dark proves the practicability of obtaining results with that method of target practice."

The three seaplanes *N.C.1, N.C.3,* and *N.C.4,* were finally placed in regular commission by the commandant of the District on May 2, 1919. The ceremony was short but impressive. With the crews who were to make the flight drawn up in line the Chief of Staff read his orders from the Navy Department and gave the order to hoist the colours. To the music of the bugle the United States ensign, the jack, and the commission pennant were run up. Then Commander Towers read his orders, saluted, and assumed command of the N.C. Seaplane Division One. This was the first time in the history of the Navy Department that any seaplane had been placed in regular commission.

The seaplanes were even then not completely ready for a start. Day and night work was still going on. Up to the time of the commissioning ceremony none of us knew in which seaplane we were to fly. Everybody worked for the common cause. Soon after commissioning, however, the detail was made, Commander Towers to command the *N.C.3*, which therefore became the "flagship" of the division; Lieutenant-Commander Bellinger to the *N.C.1*, and myself to the *N.C.4*. The reason for my assignment to the *N.C.4* was because it was thought that she was slightly heavier than the others and my crew weighed about one hundred and fifty pounds less than either of the other two. As a matter of fact, I think it probable that the *N.C.4* was somewhat lighter, in view of the getaway made later at Trepassey Bay when we left the water very easily while the others had great difficulty.

The matter of determining the comparative weights may seem to be a simple problem, but with such large weights involved, our crude methods for obtaining them and the difficulty of weighing the seaplanes under like conditions, a hundred pounds or more error might very easily creep in.

All three planes were nearly ready when one night a fire broke out in the hangar housing *N.C.1* and

N.C.4, caused by the ignition of gasoline by a spark from an electric pump. A little fast work with extinguishers by the men still working there and the fire was put out, but not until the entire left wing of the *N.C.1* was burned beyond all hope of repair and a portion of the tail of the *N.C.4* was badly scarred. If any one of several things had happened both of those seaplanes would have been permanently out of the running. As it was the Curtiss Company put every available man on the job, and some time during the following night both seaplanes were again ready, having had repairs that had been variously estimated to require from three to ten days! It was a remarkably fine piece of work, probably the most remarkable single event in the whole rather hectic period of preparation or in the flight itself.

The day before the flight was started, just as the *N.C.4* was preparing to leave the beach for a trial flight, the second in its existence, and the first with its regular crew on board, the mechanician, Chief Special Mechanic Howard, had his left hand cut off by our pusher propeller. His nerve and grit were really marvellous. Scorning all assistance he jumped to the ground and, holding on to the stump, walked to the dispensary and reported for treatment. Of course he had to be left behind; he had our deepest sympathy, for he had been with the N.C's from the start, had worked tirelessly in whipping the motor installations into shape, and his whole heart and soul had been wrapped up in the transatlantic project.

I have mentioned above the fact that the *N.C.4* had been flown but once previously. The lack of sufficient time in the air for the purpose of working out small but possibly important defects and for the training of the crew in team work was the only unsatisfactory feature of the period of preparation. But all of us without exception wished to start at the earliest possible date, for we wanted to be the first across, and we thought that the flying time necessary to get us to Newfoundland would be a sufficient "shaking-down" period.

CHAPTER II

THE FLIGHT BEGINS—"N.C. 4" GOES LAME—REPAIRS AT CHATHAM—THE "HOPS" TO HALIFAX AND TREPASSEY BAY

THE actual start from Rockaway of the three seaplanes *N.C.1*, *N.C.3*, and *N.C.4*, was made on May 8th, at 10:02 A.M., local time, under an overcast and dismal sky. A large crowd had assembled, composed of personal friends, well-wishers from the Curtiss Company, and the usual number of reporters and camera men. These latter had for many days been following our every move with close attention.

The *N.C.3*, the division "flagplane" took off first. The *N.C.4* was planing by the time the *N.C.3* was in the air and the *N.C.1* followed close behind. After gaining a few hundred feet, heading west, the *N.C.3* made a wide turn to the left and headed on a course to clear the southern coast of Long Island. The *N.C.4* and the *N.C.1* cut in and gradually assumed their positions in formation.

As we passed by the Naval Air Station at Rockaway all of us bade them a mental "good-bye" and fervently hoped that our comparatively untried motors would not let us down and force an ignominious return.

We started a gradual climb, following the "flag," until about 2,000 feet altitude had been attained, which was then held for a while. The formation was as follows: The *N.C.3*, flagplane, with Commander Towers, acting as guide; the *N.C.1*, with Lieutenant-Commander Bellinger on the right flank, not less than 400 yards nor more than three miles distant, maintaining about the same altitude; and the *N.C.4*, with myself in command, in a corresponding position on the left flank.

The planes were not required to keep closely in position, but to endeavour to maintain steady courses and speeds as far as was possible, in order to simplify navigation. It can readily be seen that continuous changes in course and speed, in order to maintain a definite relative position with the flag, would cause a navigator an immense amount of work in keeping track of his exact position. Each boat must be navigated independently, for any time the necessity might arise of proceeding "on its own," or it might be necessary to make a bee-line to some position too far away to see.

The formation, therefore, was elastic and the exact relative positions varied according to the circumstances and as the judgment of the commanding officer dictated. On the stretch from Rockaway to Vineyard Sound it appeared that the commanding officers had considerably varying ideas, for the formation was extremely wabbly. However, between Vineyard Sound and Monomoy Point the three planes started to act more as a unit, and maintained a fairly accurate formation. We slowly left Nantucket Sound behind us ("slowly," for in spite of the great speed of an airplane, it always seems slow except when flying at very low altitudes) and passed over Monomoy Point at 1:20 P.M., headed for Nova Scotia. We were now started on our first real over-sea trip.

We were then at about 2,500 feet altitude, climbing gradually, following the *N.C.3*. Visibility was good, with a slight haze, and there was a slight wind against us. It was about one and a half hours later when the troubles of the *N.C.4* began. The engineer reported that the oil pressure on the after centre engine had dropped to nothing and the spark had been cut. We were therefore proceeding under the power of the remaining three engines but making good speed at that. This incident made us a little uneasy, as now, if one of the other engines gave us trouble, a landing would be necessary. And that is what happened.

The first of the "station" destroyers was sighted at 2.05 P. M. well off the port bow. I changed course to pass over her and *N.C.3* and *N.C.1* were soon lost sight of. Shortly after passing over this destroyer the other two planes were again sighted ahead and to starboard; they had also apparently shifted their course somewhat to the left. While gradually overhauling them and when a little more than halfway to the next destroyer fifty miles farther along, a shower of water and steam was suddenly seen leaving the forward centre engine. That meant one thing—a punctured crank case and only two good engines left. We could not hold up under the power of two engines, and so came down to the surface. The other two planes kept right on; afterward they said they had seen us turn (which was done to head the plane into the wind for a landing) but did not see us land and had thought we were heading back in order to land near the destroyer recently passed.

The water was slightly rough but not so bad. We hoped then to locate the oil leak in the after engine, repair it, and get under way once more. After two hours' work this idea was given up; it was just as well, for there was no leak to find in that motor. We found out later that the oil pressure had failed on account probably of the chilling of certain oil pipes and that the oil had been lost when the forward engine had let go, for the oil systems of these two centre engines were linked together. So there we were with two good engines, out at sea, somewhere off Cape Cod. We had no success with the weak battery radio set. No destroyer heard us. Apparently they were too busy talking to each other to "listen in" for us. They were asking if we had been sighted, venturing opinions as to where we were, suggesting areas to search, and so forth. During the two-hour period of investigating the trouble I took an observation of the sun which indicated that our position was twenty miles farther out than I had figured by my reckoning, or eighty miles from the nearest shore. That was a little discouraging.

At about 5 P. M. we started to "taxi" (making headway on the water by means of the motors), hoping to sight a destroyer, or, failing that, to continue on to Cape Cod and make the Naval Air Station at Chatham. Two hours and a half after commencing the long, tiresome journey, a destroyer was sighted about ten miles to the north, and we headed that way, but the destroyer was looking for us in another direction and soon drew away. There was nothing to do but resume our westward course.

It soon got dark, but it was a beautiful night, with the moon nearly full, and the sea had smoothed down, so that after the first hour or two we made about ten knots. We were not much worried, for if the engines held out we were bound to make shore. They did hold out all through the night.

The engineers and pilots relieved each other and took cat-naps in the bottom of the hull. The radio officer and I got an occasional wink of sleep. In fact, this was the only time I slept at all on board the *N.C.4* during the entire trip.

Along toward morning we tried to intercept a steamer, the lights of which were sighted some distance away. But she also was too fast for us and we gave up the chase.

At one time both engines suddenly stopped and remained so for more than twenty minutes; then the starboard engine was started again and we turned circles for twelve minutes more, trying to start the port engine. That one finally listened to reason, not to mention the flowing tributes of the crew, and consented to continue its work. We sighted our first lighthouse on Cape Cod at 5:25, then another one, and just as it grew fairly light we arrived off the Naval Air Station at Chatham. Two seaplanes from that station were just starting out to look for us. Their mission was accomplished almost before it had begun.

Just as we arrived off the entrance to the narrow and winding channel to wait for a tow, the oil pressure in one of the engines that had been running all night dropped down, but we did not care. That good old engine had done its work. That same engine took us later all the way to Halifax and Trepassey, then to the Azores, and finally to Lisbon and Plymouth.

It was not long before we were tied up at the Chatham station. The officers and men of that station turned to with a will and fixed us up finely, both as regards our personal comfort and the welfare of our ship. They took out our broken-down motor, gave us a good one they had, and installed it for us. They did numerous other necessary small jobs and by the afternoon of the second day, the 10th, *N.C.4* was ready once more to battle with the elements. Unfortunately, however, the elements were not ready. A forty-mile gale set in blowing directly from Halifax to Chatham, and worse than that it kept on blowing. It did not stop until the afternoon of the 13th. During this tedious wait we were encouraged from time to time by despatches, stating that weather conditions on the Newfoundland-Azores leg were unfavourable; that meant that *N.C.1* and *N.C.3*, which had made quick trips to Halifax and then on to Trepassey, would not leave immediately. We would not have blamed them if they had, for ideal weather conditions for the long stretch between Newfoundland and the Azores were so unusual that it would be unwise to let a good chance slip by.

On the 13th, with good weather promised, a daylight start was planned for the 14th. Then a starter on one of the motors broke in testing out. There were no spares at Chatham. The Rockaway Air Station was called on the 'phone and within three quarters of an hour had a seaplane headed for Montauk with two starters on board. Meantime Chatham started another seaplane to Montauk as a relay; unfortunately, before getting into the air, this plane ran full tilt on a sand bar. Then a blimp was gotten ready and started out. Twenty minutes after the blimp had left, a call came in from New York that the Rockaway seaplane had arrived at Montauk and was very anxious to come right on through to Chatham! I replied: "Fine, go to it." It was then dark but with a fine moon and I knew that one of the pilots was well acquainted with Chatham's winding channels. After getting the plane all ready to receive the starter, we turned in to await developments. The seaplane arrived at 12:30 A.M., and in went the starter. At daylight we were ready. The poor old blimp returned from its wild-goose chase at about the same time.

Due to minor troubles developing we did not finally get started until 8:14 A.M. But we left with a good strong wind in our favour. We picked up each of the three destroyers in turn that were stationed between Chatham and Nova Scotia and finally hit Seal Island square, then skirted the coast and arrived at Halifax after a run of three hours and fifty-four minutes from Chatham Bar, at an average speed of eighty-six knots. The first leg was at last accomplished and the *Baltimore* received us with open arms. They told us the cheering news that *N.C.1* and *N.C.3* were still at Newfoundland. "Now for a quick run to Trepassey and perhaps we shall catch them yet," was our thought.

On this first leg the radio officer enjoyed himself by listening to messages from all around and by sending some on his own account. Before making Seal Island a message of inquiry was received from Assistant Secretary Roosevelt. I replied immediately with our position and speed. A few minutes later we received word that it was exactly three minutes from the time of Mr. Roosevelt's filing the message in Washington to the time of his receiving my reply, which constituted a world's record—the first pat on the back, most welcome after our discouraging delays.

We were greatly encouraged as a result of this trip. We were now out of the United States and much nearer the "jumping-off" place in Newfoundland. The power plant had functioned so well and we had picked up the station destroyers with such regularity and with so little trouble that our confidence in the machine and ourselves was considerably increased, and we thought that at last our bad luck, which had gained us the name of the "lame duck," was over.

It had been a very easy and comfortable passage thanks to the roominess of the hull. I generally sat in the extreme bow on a small box with a soft life preserver as a cushion, in such a position that I could look ahead or to one side, but at any time I could shift my position to a seat rigged in the bottom of the hull just aft of the box and could stretch out or even lie down if the spirit so moved. The others, too, had plenty of room; there was no occasion for having an arm or a leg fall asleep.

At Halifax, the weather still held good and we planned to start early the next morning for Trepassey. The structure of the plane and the power plant were given careful attention. The "low-compression" motor installed at Chatham had vibrated considerably and the two wing motors had done some "missing" due to dirt in the carburetors. The missing was easily corrected, but if we were to take the time necessary to replace the Chatham motor we were afraid that word would be received from Newfoundland that the other planes had started for the Azores. We therefore did what could be done in the short time available, refuelled and re-oiled, and set out the next morning with the blessings of the *Baltimore's* officers and men.

Things went well for a few minutes, then the oil pressure in that same centre forward engine started to fall. We headed for the smoother water near shore and landed eighteen miles from Halifax to investigate. The oil trouble was corrected, but when about to start again we found more jobs to be done. In such a new installation as this it was to be expected that more or less dirt and foreign matter would have collected in the gasoline lines and not had opportunity to work out thoroughly. A piece of rubber was found in one of the gas leads to a motor that had been starving, carburetor jets were cleaned out, and a new spark-plug was found necessary for a cylinder that had refused to fire.

At last, at 12:45 P.M., Halifax time, we once more took off, and much to our delight found every cylinder hitting as it ought to hit. This time we made no other stop until Trepassey appeared beneath us.

The run was uneventful, varying winds were obtained sometimes of greater velocity, but fortunately mostly in our favour as the weather forecaster on the *Baltimore*, who was Professor McAdie (also Lieutenant-Commander in the Naval Reserves and Superintendent of the Blue Hill Observatory), had predicted. During the 170-mile run from Cape Breton Island to St. Pierre off Newfoundland the wind blew strong and sent us along at a speed of about 95 knots or 109 miles per hour at times. Our friends, the destroyers, were picked up regularly. I exchanged messages of greeting with several of the skippers who were classmates of mine at the Naval Academy. It was a comforting feeling to realize that Uncle Sam's most efficient men were standing by, ready to extend a helping hand in case of trouble. We were maintaining about 3,000 feet and once or twice passed over and through light, fleecy lumps of clouds, but these never lasted longer than a few minutes; for the most part, visibility was very good.

After passing St. Pierre the change of course necessary to head us for our destination brought the wind almost directly astern, and we fairly burned the air to Trepassey. The temperature had been gradually falling and icicles were forming on the struts. Whenever I stood up and leaned forward in order to get a reading from the "drift indicator," the icy blast that stung my face and hands was a temptation to abandon the instrument and guess at our drift. I was wearing two suits of heavy flannels, a flannel shirt, a jersey, the regulation aviator's uniform, and over all our heavy-lined leather flying suit—it was none too much even when sitting down in the hull out of the wind.

Some of the others later said that they were becoming chilled through, but this condition did not last long as we soon rounded the point to the south of Trepassey and headed up the bay.

As we were manœuvring for a landing *N.C.1* and *N.C.3* were sighted on the water taxiing into the inner harbour. They were caught at last! They had planned to start for the Azores without us but failed to get off. We were saved by a hair from being left behind. It was found afterward that too much gasoline had been put in, which increased the weight so much that the planes refused to lift.

Congratulations were showered on us and we were very happy to be with "the crowd" once more and for the chance to go along. No longer the "lame duck," all of us were again on an equal footing.

Rapid work was done on *N.C.4* and good work, as was evidenced by the remarkable run to Horta. A fine new motor replaced the centre forward one that had been installed at Chatham and that had given us so much anxiety. The whole oil and gasoline systems were carefully cleaned, three new propellers were put on, and we were ready just in time to make the big hop with the others.

Most of this work was done by the detail that had been sent up with the *Aroostook*. The *N.C.4* crew took a good night's rest in order to be ready for the next day's start.

CHAPTER III

THE BIG "HOP"—NEWFOUNDLAND TO THE AZORES

I HAD been privately hoping for one more day in which to work on the plane in order to assure ourselves that all parts were functioning as they should. But the aerographic officer—in plain English, the weather forecaster—informed us that conditions all the way to the Azores would be unusually good, and that a change would probably occur if the start were postponed for another twenty-four hours. He was right, except that, as will be seen later on, the change came sooner than expected—a storm sneaked in from a quarter unguarded by any one of our "meteorological" battleships.

In starting out on the next leg, the longest of all, about 1,350 nautical miles to Ponta Delgada with a sub-fuelling station at Horta, 1,200 miles away, the fact that we had a new and untried motor just installed gave us some uneasiness. The start was delayed somewhat by trouble in getting that motor going, but finally, in the late afternoon, all three planes, *N.C.3*, *N.C.4*, and *N.C.1*, were taxiing around Trepassey's sheltered waters allowing the motors and complicated systems of piping to warm up. This was on the 16th, the day after the *N.C.4's* arrival. Then *N.C.3* started out, and *N.C.4* immediately shot on full power. We soon saw that *N.C.3* had given up the attempt to get off, but by that time *N.C.4* was planing on its step, very evidently ready to take the air, and it struck me as a fine opportunity to give our new motor, and, in fact, the entire power plant, a preliminary try-out during the time necessary for *N.C.3* to return for another attempt. I therefore gave the pilots a signal to keep going and in a few more seconds we were bouncing along the nearly spent swells entering the harbour, then with one final, easy leap we stayed in the air. To the great delight of the whole crew, everything functioned perfectly and the new motor ran smooth and sweet and delivered its full quota of power. For eighteen minutes we flew over Trepassey and Mutton bays and then, as *N.C.3* appeared to be waiting for something, we again landed and once more stood by for a start. We had a new feeling of confidence now in our plane. The chance of having to land soon after starting, as had been done outside of Halifax, seemed quite remote. A landing outside here would have been most unpleasant, as the thirty-mile wind had kicked up a fairly rough sea, and a forced landing in that water did not mean simply the effecting of minor repairs and another getaway. It meant to us a probable abandonment of the whole project.

At last *N.C.3*, having put out one of her crew and certain weight-producing material, made a second attempt, this time a successful one. *N.C.4* followed, and at 10:05 G. M. T., or about 6:00 P. M. local time, of May 16th, she again took the air, this time to stay. *N.C.1* was still plowing the water of Trepassey Bay when lost to sight behind a hill, but she succeeded in taking off, and later I saw a speck high up in the western sky indicating that all three of us were on our way, with the hope and expectation of sighting a small island sometime the following day, more than a thousand miles away and across a white-capped sea.

It was cool, but, dressed warmly, most of us were comfortable; the wind appeared to lessen in strength somewhat and the sea, dotted with icebergs, did not look very rough. *N.C.3* kept very low on the water for a half hour or so while we maintained about 600 feet. As the light faded she was hard to see against the dark background of water; then she climbed a little, and the two planes were soon flying on the same level, with the outlines of each appearing distinctly to the other. *N.C.4* slowly drew ahead of the "flagplane" in spite of throttling down as much as the pilots dared, for we had to keep up a good speed in order to maintain our altitude and to retain good control in the rather uneasy air. All sailors know how much more quickly a boat responds to the rudder when its speed is increased. It is the same with an airplane; an airplane becomes very sluggish in answering the controls when travelling slowly, and the manual labour of operating them in order to keep the plane straight and on an even keel is increased considerably, especially when "bumpy air" is encountered. When near the first destroyer marking our course, *N.C.4* made a complete circle, rounded up near *N.C.3*, and from then until she was lost in the dark we managed to hold our correct relative position. A little later we turned on our running lights, a white light at the leading edge of the upper wing on the centre line, and green and red lights on the starboard and port outboard struts. A radio was sent to *N.C.3* requesting that her lights be turned on; later we learned that they would not work. I could catch only occasional glimpses of a faint light which must have been on the instrument board.

As the outlines of our "flagplane" grew dimmer and more indistinct, I began to realize what a hopeless proposition it would be to attempt to maintain contact with either of the other planes all through the night. *N.C.1* had long since been lost sight of. Up to this time I had merely followed, and changed altitude, speed, and course to conform to the movements of the leader, leaving it to him to direct our movements in order to pass near the destroyers. Now it was evident that we would soon be "on our own." Well, we had made the runs from Chatham to Halifax and from Halifax to Trepassey alone, thanks to our troubles and delays; why shouldn't we make this alone? At 11:55, one hour and fifty minutes from Trepassey and while still able barely to distinguish the silhouette of *N.C.3*, course was changed slightly to the left as my reckoning had put us to the south of the line. *N.C.3* was immediately lost to view, and *N.C.4* was to all intents and purposes acting singly with 1,185 miles yet to go.

At this time it was very dark except for the stars. These, however, were of great assistance to the pilots in keeping the plane level and on its course. The engines were hitting on every cylinder. There were no mufflers fitted, so that the exhaust flame could be seen, and it was most reassuring to see the flame shooting out regularly from each exhaust valve without missing a stroke. The oil pressure, which was normally at thirty to forty pounds by gauge and which had given us trouble at intervals previously, held up perfectly. The water temperature of the four radiators could not be improved. In short, everything about the big machine seemed to be on its best behaviour, and as time went on our confidence increased to such an extent that our entire thoughts were centred on our own individual duties. The pilots took turns at the controls for stretches of thirty to forty-five minutes; the one off duty sometimes remained in his seat, sometimes squirmed down in the fairly roomy space forward of the seats and aft of the bulkhead on which my chart board was slung. He would occasionally catch a few winks of sleep; the "off" engineer also slept a little. The radio man had no relief—he had to stick to his job; but he found his job of such absorbing interest that the thought of sleep never entered his head. The Commanding Officer and navigator, myself, felt not the least inclination to sleep, even had there been an opportunity. There were too many changes of course to be made on account of slight changes in wind currents and on account of the varying ideas of the destroyers as to their correct positions. They were never very far out, but there was bound to be a considerable variation from the straight line extending from off Trepassey to Corvo in the Azores; a fresh breeze, unknown currents, and no opportunity of verifying position since twilight made that inevitable.

Then, too, there was always the possibility of being forced to make a landing. For this contingency I was not depending entirely on the bow flares described before, for we had had no opportunity to practise landing the N.C's at night by means of the flares, and there was a certain element of doubt as to their efficiency. Therefore, it was my intention at any sign of trouble to grab a Very pistol kept right at my hand and, when the altimeter showed our near approach to the water, to shoot stars downward and forward. By this means a very close estimate of our height could be obtained. Happily, however, neither the flares nor the stars had to be called into action.

At 12:19 G. M. T. (Greenwich mean time will be used hereafter except when otherwise stated) in the morning of the next day, the 17th, the first faint signs of the rising moon were seen. As it grew lighter the nervous tension relaxed even more—the pilots' work was less difficult, and a forced landing in case of necessity would be easier of accomplishment. About this time the air, which had at no time been very quiet, increased in bumpiness. We were then at about 1,000 feet. A slow climb was started to 1,800 feet, but the air at that altitude was as turbulent as that lower down, and as our speed appeared to have dropped considerably (obtained by checking times of passing destroyers) we later returned to our former altitude of 800 to 1,000 feet. The air remained rough all through the night and our machine continued its wallowing, plunging course.

At 12:41, before the moon had had a chance to add much light to the situation, another plane was sighted close aboard on the port side. It was in sight nearly ten minutes and came too close for comfort. A veer to the right, a few minutes' climb, and they were again lost to view. This was our last sight of any of the other planes of the division, until *N.C.3* was later seen in the harbour of Ponta Delgada in a half-wrecked condition.

The destroyers marking our course were checked off on the chart one after the other. The star-shells which they fired from their anti-aircraft guns were always sighted at great distances. In several cases a shell of one destroyer would be seen when we were passing over the next destroyer to the westward, fifty miles away. Then after an interval the search-light would be seen, and finally, as we approached at a speed of about eighty-five knots, the ship's deck lights would appear. If the lights were nearly ahead a sufficient change in course would be made to pass directly above, but if too great a change would be required, I would assume that the destroyer was in its exact position, estimate our distance from her, and lay a new course direct for the next one. All destroyers had large, illuminated figures on their decks to indicate the number of their station, but as all of the ships were sighted one after the other it was never necessary to verify these numbers. The searchlights, laid directly into the wind at the surface, showed that the breeze was still with us at each successive station.

In this manner the night passed. At 5:45 came the first indications of dawn. The motors were still thundering on with not the least appearance of ever wishing to stop. The radio officer was having the time of his life, picking up messages from places as far distant as Bar Harbour; the last one received was distinct at 1,330 nautical miles. He talked with Cape Race, Newfoundland, and sent, via the operator there, a message of greeting to his mother in the States when we were 730 miles away. He reported that *N.C.1's* radio was working very well, but that *N.C.3's* was weak. From intercepted messages it appeared that *N.C.1* was still behind us but that *N.C.3* was ahead. Later it developed that we were leading the procession; the mistake had been made on account of *N.C.3* calling destroyers considerably ahead of her own position instead of the nearest one. Each destroyer would broadcast our passing. This message was flashed to the base ship in the Azores and relayed to the Navy Department at Washington so that the Department was kept in touch with the progress of the flight.

As the light was increasing I suddenly remembered that I had eaten nothing since lunch of the day before. A swig of hot coffee from our vacuum bottle hit the right spot, and the sandwiches were excellent, but one of them was enough. A small piece of chocolate for dessert, and my first transatlantic air meal was finished. We all find that on these long trips we are neither hungry nor thirsty; we throw most of the sandwiches away at the end of a trip, and, although a five-gallon tin of water is always carried, the tin remains practically full until our arrival in the next port. The absence of hunger and thirst and of any desire to sleep is probably an effect of the continuous nervous tension under which we undoubtedly labour, although as a rule we do not realize we are under any tension at all except when unusual and dangerous conditions are met. In fact, it became rather monotonous flying hour after hour over waves that look exactly alike and never seeing anything except an occasional destroyer.

The intercommunication set between members of the crew was not very satisfactory. The pilots had given it up entirely and donned more comfortable helmets. As my telephone helmet fitted well, I still retained it, and occasionally "Radio" and I could make each other understand messages of a simple nature. If there was anything unusual, however, we would exchange notes, using one of the engineers as messenger, and occasionally I would squirm aft along the passageway, by the gasoline tanks, to the after compartment, where we would converse by means of paper and pencil. The engineer, too, would report by note and his messages were always cheering—all parts functioning properly with a normal consumption of gasoline.

At about 6:45 a ship was sighted which at first was mistaken for a destroyer but which proved to be a freighter. She was crossing our course, and without any change we passed directly over her. Only one other merchant ship was sighted during this run. The ocean wore its usual deserted look. If it had not been for the destroyers we would probably have felt lonesome.

Up to this time, after passing Number 13, the flight had proceeded so satisfactorily, and so nearly in the exact manner planned (except that we were alone instead of in formation), and the destroyers had been passed with such clocklike regularity, that it appeared now only a matter of time and ticking off the remaining seven ships, picking up Corvo, then running by Destroyers 21 to 23, passing between Pico and San Jorge and by Destroyers 24 and 25, and finally picking up San Miguel. Fate had other things in store for us.

Numbers 14 and 15 were checked off in regular turn, the latter at 7:45. Ten minutes later there seemed to be a rain of considerable area ahead. Course was changed to port for a few minutes to dodge the thickest part, but we soon saw that instead of rain, light lumps of fog were forming and blowing along in the same direction that we were making. Our former course was resumed and we passed through the foggy area at 8:12. This did not impress us very strongly as we came again into nearly clear air and easily picked up Destroyer 16 a little later. We passed her at 8:30. She was the last one to be sighted until we picked up Number 22 sometime later on. Visibility grew less and less and we missed Number 17, although little fog was encountered until about 9:40. Then it began to show us what real fog was like. At 9:45 we entered an impenetrable layer as thick as pea soup. The sun disappeared entirely. I motioned the pilot to climb, hoping to get above it, but the pilot was just beginning to have troubles of his own. In endeavouring to watch too many instruments he had allowed one wing to drop. I immediately sensed that something was wrong but was helpless to tell just what it was or how to correct it. We had lost all sense of direction. The wind increased in my face, which meant that the speed of the plane had increased correspondingly. We were going twenty miles an hour faster than we should be. An occasional momentary glimpse of the sun revealed the fact that we were in a sharp turn. I glanced first at the compass—it was spinning like a top; then at the altimeter—1,200 feet. At least we were still holding our altitude. Was the pilot never going to get control, or were we going to spin more and more and finally end in a nose dive for the water? Then the sun and patches of blue sky appeared once more, the big machine straightened, and as the pilot pulled her back we shot up out of the fog bank into clear, warm air, once more masters of the situation.

Immediately our former course was resumed, and we flew on, keeping just above the layer of white, billowing fog, which, with the sun shining on it and streaks of blue sky in the distance, was strikingly beautiful. The sky above us became more and more cloudy; at the same time the fog bank below was rising, so that it was necessary to climb almost continuously to keep in clear air.

We were sandwiched in between the fog underneath and the clouds overhead. Occasional rifts appeared through which the water could be seen, and the drift meter indicated that we were being set to the south. Our course was corrected accordingly but favouring slightly a course south of the one originally laid down. The Island of Corvo was very small, but there was Flores, a bigger one to the south of it; it seemed better that any error in our direction should not be to the north, as there was nothing but the broad ocean in that direction. Several times it became necessary to change course or reduce altitude to pass around or under a thick cloud in our path, but an average altitude of about 3,000 feet was maintained all the latter part of the time.

I then began to wonder how we were going to come out of all this uncertainty. Was this fog going to last indefinitely? The islands of the Azores were high and perhaps we might sight one of them over the fog. Pico was more than 7,000 feet; I did not know then that Pico is always covered with thick clouds except in the clearest sort of weather. We still had several hours of gas and the motors were running beautifully, but they could not keep on going forever. Would we pick up some one of the islands and find shelter in smooth water to leeward, or were we in for another experience like that off Chatham, only very much worse?

At 10:40 the fog was just under us at about 3,000 feet, and thinking that it might have lifted from the water inquiry was made by radio of Destroyer 19 concerning visibility conditions at the surface. The reply came in "thick fog." Then Number 20 was called; his reply was "heavy mist." Then we tried 21, which was some distance ahead; he came back with "10 miles visibility." At last we had something to encourage us. Perhaps, if we kept on going, we could get out of this mess. A light, stinging rain was encountered for a few minutes, but that soon passed or rather we passed by the rain, and the air again was fairly clear. The minutes ticked by. It had been getting thicker to the left of our course, but to the right there was still a streak of blue sky showing between the fog layer and the cloud layer.

Then suddenly, at 11:27 or nearly three hours after passing the last destroyer sighted, while flying at 3,400 feet altitude, we saw down and on our port hand a tide rip through one of the rifts in the fog that had of late become less frequent. The water on the far side was slightly darker than that on the near side. Tide rips do not occur far away from land, therefore land must be somewhere near by. As more and more of the white line on the water was revealed I followed it with my eyes. Then just where it ended the outlines of a rock loomed large. Instantly the thought flashed: "this is no tide rip, it is a line of surf, the darker portion is land, and it must be the southern end of Flores." It took about two seconds to signal the pilots to come down. While they were spiralling down through the rift, being very careful not to enter the surrounding fog, I ducked down to my chart and laid a course to the next destroyer which would be Number 22. As I had hoped, on approaching the water we found that the fog stopped nearly two hundred feet above it. As we rounded the point a peaceful farmhouse came into view in the midst of cultivated fields on the side of the hill. That scene appeared far more beautiful to us than any other ever will. If the worst happened now we could land in a lee somewhere, and get ashore, somehow.

But now things seemed to be breaking our way.

The friendly shores of Flores were soon left behind but we could now see for about ten miles all around. Soon the smoke of Number 22 was seen and we passed over her at 12:08. We were feeling quite cocky; we had passed through the fog and were again on our line with visibility now about twelve miles. The engineer assured me that there was sufficient gas and oil left to make Ponta Delgada about 250 miles away. Why stop at Horta then? The pilots had the same idea; we flew on, and soon left the destroyer astern.

Then it started to thicken up once more; we passed streaks of thick fog, and by the time Number 23 was due, we could hardly see a mile in any direction and we missed her. Soon the fog became dense, but keeping fifty feet above the water we could still keep it in sight. No Ponta Delgada for us to-day; we would be perfectly satisfied to make any port. I figured keeping on our course until 1:18; then make a right-angle turn, and, allowing any speed between seventy and eighty-five knots from Destroyer 22, we should sight land somewhere between the western end of Fayal and the eastern end of Pico with some margin to spare.

Before it became necessary to execute this manœuvre, however, land was again sighted—this time the northern end of Fayal Island. There was a region of comparatively clear air to leeward of the island which enabled us to see it. Again we breathed more easily—Horta, where one of our base ships was at anchor, must be just around the corner. We lost no time in heading for the beach, rounded the island through the very rough air tumbling down from the mountains, and then headed for a landing. It was too thick ahead to determine whether Horta was there or not, but as soon as we had landed and taxied in a few minutes, it was evident that we were in the wrong bight. Again we took the air, rounded the next point, and caught sight of the *Columbia* less than a mile away just before the fog swept in and hid her completely from view. It was only a matter of a few seconds' time to pick her up again and to land close by the stern. The landing was made at 1:23.

We were safe in a snug harbour at last, fifteen hours and eighteen minutes from Trepassey Bay, Newfoundland, or fifteen hours and thirteen minutes actual flying, counting out the time on the water after our first landing in the wrong bight. Our average speed for the entire run was about seventy-nine knots, or ninety statute miles per hour.

The crew needed sleep, but nothing else; the plane was in excellent condition except for a few very minor repairs required.

As we ascended the gangway of the *Columbia* the crew gave us a hearty cheer. It was quite a surprise to us, as it was our first realization that people at large considered the flight as a great feat.

The skipper insisted on my taking his bed while he slept on a cot; we were all treated like kings. Bands from Horta were serenading us, bouquets of flowers were sent out from the city, and many congratulatory messages were received by radio and by cable.

CHAPTER IV

TO PONTA DELGADA—TO LISBON—AND TO PLYMOUTH

AFTER a good night's sleep, the trip to Ponta Delgada, about 150 miles, occupied our attention; but our experience at Chatham was repeated—the crew and the *N.C.4* were ready long before the weather allowed a start.

Our stay at Horta from the 17th to the 20th was pleasant enough but all hands were champing at the bit to be on the way. Then, too, we were much worried about the fate of *N.C.3* with Commander Towers and his crew. *N.C.1* was picked up in a few hours so that their safety no longer gave us any anxiety; but it seemed as though *N.C.3* never would be located. When they were finally reported off Ponta Delgada under their own power our gloom disappeared at once. The water cruise of *N.C.3* was a triumphant demonstration of courage, expert seamanship, and the seagoing qualities of the seaplane hulls. Sixty hours in a gale of wind and thirty to forty foot waves, adrift in a machine designed for entirely different surroundings, the *N.C.3* overcame all difficulties and arrived at port safely! I was very thankful that we had been fortunate enough to get that glimpse through the fog of the rocky surf-bound beach of Flores.

While waiting at Horta the report came in of the attempt of the two airplanes to make an ocean flight by the Newfoundland-Ireland route. One smashed, the other got away—then silence. Nothing was heard except wild rumours. We were fervently hoping that the pilot and navigator would be picked up by some ship. Of course we were hoping against their successfully effecting the first transatlantic flight; but men that will embark on an enterprise like that knowing that weather conditions were unfavourable are too brave and courageous, even if perhaps foolhardy, to be otherwise than admired.

The weather settled finally on the afternoon of the 19th and preparation was made for a daylight start. At daylight, however, rain squall chased rain squall over the mountains and all around us. More patience was required. Incidentally, I have never heard "patience" mentioned as one of the requisite qualities of an aviator's make-up. It should be. That quality has to be more frequently exercised and for longer periods than any other.

The weather at Horta and along the course to Ponta Delgada ceased "squalling" later, and at 12:39 G.M.T. on the 20th we were once more winging onward, again with a strong favouring wind. We found the air so rough along the southern side of Pico that the course was laid about eight miles off shore where it was smoother but none too comfortable. For the third time this trip we passed over the destroyer *Robinson;* the first time on the Halifax-Trepassey leg as a regular station ship, the second while she was on her way to the Azores; this time bound from Horta to Ponta Delgada. She left about one half hour ahead of us and we beat her to the latter place by about five and a half hours, a distance of 150 miles.

The flight was uneventful. We left Pico and San Jorge behind; Terceira lingered in sight a little longer. Visibility was excellent from 1,000 feet; the destroyers' smoke was sighted twenty-five miles away. As soon as they sighted us the smoke would be discontinued and we would lose sight of them until very close. Their wake was lost in the white caps of a fairly rough sea and their colour blended in with the background of water. San Miguel soon loomed in sight and with our ninety-knot gait it was a few minutes only before the town and harbour of Ponta Delgada, with many ships lying at their moorings, spread itself beneath. A wide circle to meet the wind, a gusty descent, a pretty landing, and we were soon safe in the smooth water behind the breakwater.

As the exhaust of the engines subsided we heard a new noise, one that brought back memories of New Year's Eve in New York. Whistles were blowing, all ships were full-dressed, and as we approached our buoy we could see thousands of cheering people lining the rails and the seawall and the shore. It dawned on us that this was all a welcome to us. Somebody said: "These people must think we have done something." Events following immediately afterward deepened that impression. Rear-Admiral Jackson, Commander of the U. S. Naval Forces in the Azores, greeted us at the landing, took us in hand, and we were presented to the Governor;

then the movies had their turn, and I had my first experience of "greeting the cheering populace" from a balcony.

After a late lunch the crews of the battered *N.C.3* and the *N.C.4* attended a beautiful reception given by the Governor. There was a fine-looking body of men there, and speeches and wine were in order, but as the former were all in Portuguese, we could really appreciate only the latter. After reading the translation of the Governor's speech it was agreed that we were fortunate in not understanding any of it (except "President 'Weelson'") at the time, for it saved us considerable embarrassment. It was couched in such complimentary terms that we could not have helped blushing.

The Admiral put us up in the "Admiralty" and treated us royally. After dinner he gave a reception and dance attended by all the notables. We managed very well with Ponta Delgada's fair ones; they danced surprisingly well.

The following day one of the motors shirked its duty in attempting a getaway and a postponement of our start on the fourth leg, Ponta Delgada to Lisbon, was necessary. In order to make Lisbon during daylight it would be necessary to start early in the morning. Therefore this meant a twenty-four-hour delay. The offending motor was coerced into a better line of behaviour and the machine was carefully groomed, but the following morning the roughness of the sea prevented even an attempt at a start.

In fact, we were in Ponta Delgada five days more before the weather and the sea were sufficiently favourable to permit our leaving. Once or twice during that period it might have been possible to get off the water without damaging the plane, but we were too near our goal to take foolish chances with the Navy's "last hope" for the sake of completing the flight a day or two sooner. This was one of the most anxious times of the entire trip. We were not worried about our next flight, but were afraid that some small boat might run into the plane at its moorings and damage it badly.

At last, on the 26th, conditions looked favourable for a start on the following morning.

The start was planned for 6 A. M., but was delayed on account of dirt in the gasoline and in the carburetor, and was not finally made until 10:18. The swells were quite high, but as *N.C.4* was two thousand pounds under her "full-load" weight she took the air with but a few jolts. The area in which a getaway was possible was so small that we had been rather anxious about it all, and it was a great relief to find ourselves in the air with the machine intact.

A favouring wind of about twenty knots was blowing and visibility was good, but thick clouds were covering the mountains.

After leaving Ponta Delgada and the Island of San Miguel behind, the first destroyer on our line was sighted dead ahead, but just why it was picked up in that position I have never understood, because at the time we were making some seven or eight degrees to the right of the proper course. On account of this error Number 2 destroyer was barely visible when abeam, about fifteen miles away, and Number 3 was missed altogether.

I could not figure out the cause of this wandering away from the line, but headed more to the northward with the hope of seeing Number 4. The thought came to me that in case we saw no more destroyers at all, the coast of Portugal stretched a long way to the north of Lisbon, and to the south, if we missed Portugal, there was Africa which, with our gasoline supply, we should be able to reach, so that if the motors held out we ought to be able to make some port.

The radio compass then showed its usefulness. A bearing taken on Number 4 indicated her to be twenty degrees off our port bow. Some minutes later another bearing indicated her as forty-five degrees off the port bow.

We then changed course still more to the left or toward the north, and it was not long before Number 4 was sighted off our port bow. It was a great relief to be back on our line once more. The rest of the crew had been too busy to notice whether we were picking up destroyers or not.

Later on I discovered that the compass had been jarred out of its position an amount equal to the original error in our course. This had probably occurred when we were bouncing on top of the swells in making the getaway from Ponta Delgada, although it was not noticed at the time.

A little later a rain squall of considerable area appeared directly in our course, and it was necessary to head forty degrees to the left for about eight minutes in order to pass around it; but with another change to bring us back to the line the next destroyer was picked up exactly where it was supposed to be. Then while passing over No. 7, which was our old friend the *Robinson*—this making the fourth time the *N.C.4* had passed over her on the transatlantic flight—there were two rain squalls, one off the starboard and one off the port bow, but we passed between them without having to change our course.

The visibility became very poor, and our altitude, which had been about one thousand feet, was reduced to six hundred feet. Up to this time the speed made had been about eighty-eight knots, thanks to the wind, and the air had been comparatively free from bumps.

As we continued eastward the wind gradually dropped, the whitecaps disappeared, and no disturbance of the water could be seen except the long groundswell. Smooth water is much to be preferred to a strong even if favouring wind, because the ever-present possibility of having to land keeps a flyer more or less at a tension.

In other words, it is more comfortable to fly over water on which you know an easy landing can be made than to fly over water so rough that there will be a probability of breaking something in case of a forced landing, and a certainty of not being able to rise again.

Number 10 destroyer was missing and Number 9 and Number 11 had been moved together to equalize the interval. This made the run about sixty-seven miles between 8 and 9, 9 and 11, and 11 and 12. That, however, was a small matter with the compass functioning properly once more.

At last Number 14, the last destroyer in the line, was passed, and a few minutes later we picked up the rocky coast of Portugal. Everything about the seaplane was functioning perfectly. Our speed had slowed down, but eighty-eight knots was too much to expect for the entire run. During the latter part, in order to make up for the falling wind, we speeded up the engines from fifty-nine knots, air speed, to sixty-five knots. We preferred not to reach Lisbon after dark although the pilots were perfectly ready and felt confident of landing without mishap.

From questions asked after the completion of the flight it would appear that most people are under the impression that the entire flight was one "grand thrill" from start to finish. As a matter of fact, a good deal of it was really monotonous as has been stated before. Perhaps the biggest thrill of the whole trip was experienced as we passed over the beach line of Portugal and realized that no matter what happened—even if we crashed on landing—the transatlantic flight, the first one in the history of the world, was an accomplished fact.

During this run we had become so accustomed to travelling long distances through the air that I drew up my report to the Navy Department before landing, and the engineer shaved in readiness for the reception which we heard was going to be held on the *Rochester*, flagship of the destroyer force. On the strength of this the company manufacturing the particular brand of razor used for the operation, sent me a razor later on as a gift.

At 7:50 we were nearing the entrance of the Tagus, still carrying a slight westerly wind. Then a few minutes later we circled and landed astern of the *Shawmut* at 8:01. The time elapsed during the flight from Ponta Delgada was nine hours and forty-three minutes. Our average speed had been about eighty knots.

A scene greeted us similar to that at Ponta Delgada except on a much larger scale. In addition the men-of-war anchored off the city gave us a 21-gun salute, a salute ordinarily rendered only to the President or to the flag of a foreign country.

Immediately after securing the seaplane we were taken on board the *Rochester* and with great ceremony were decorated by the Portuguese Government. The personnel of the *N.C.4* were a little tired but otherwise in fine shape. In fact, some of us decided to go ashore and see the town, as it might be our last chance. The *N.C.4* was in its usual tiptop condition, ready for another all-day run.

The Portuguese were very enthusiastic about the flight, and desired to do a good deal in the way of entertaining, but it was necessary to push on to Plymouth. When we left, on the morning of the 30th of May, it was necessary to cancel several official engagements that had been made for that day.

The start for Plymouth was made at 5:29. Before heading out for the mouth of the Tagus we circled over the city as a parting compliment to the people who had treated us so kindly, and sent a farewell message of thanks by radio to the American minister.

The weather was favourable except for small rain squalls. We skirted the coast, flying about ten miles off, and everything went along normally until 7:05, when we discovered a water or a gasoline leak in the port engine, and it became necessary to make repairs.

There was a fair-sized swell running, and to land in that would endanger our chances of getting off again after making whatever repairs were found necessary. Therefore we headed for shore to find smooth water. We found it in what we discovered was the Mondego River and landed just above the town of Figueira, Portugal, at 7:21.

The river was full of sand bars and while taxiing about, the plane ran aground but was got off into deeper water with no damage. Meanwhile, the leak had been repaired—it was a water leak which was stopped by merely putting some "radiator preparation" into the circulating system.

Having been forcibly reminded of the choked condition of the river when we ran aground, and having come to a realization of the danger of damaging the hull on one of the small bars, it was decided to secure the plane temporarily to the bank of the river and to search for sufficient depth of water and sufficient room in which to make a getaway. The Captain of the Port arrived on the scene and very cordially assisted us by furnishing boats, and in other ways. He spoke Portuguese and French, we spoke English. However, the engineer boasted a very limited vocabulary of French words, and with my still more limited

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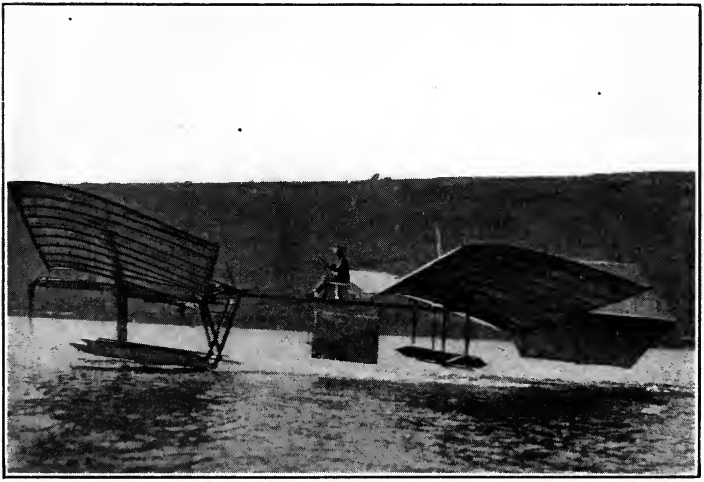
THE *N C. 4* MEN ARE CONGRATULATED BY THE PRINCE OF WALES

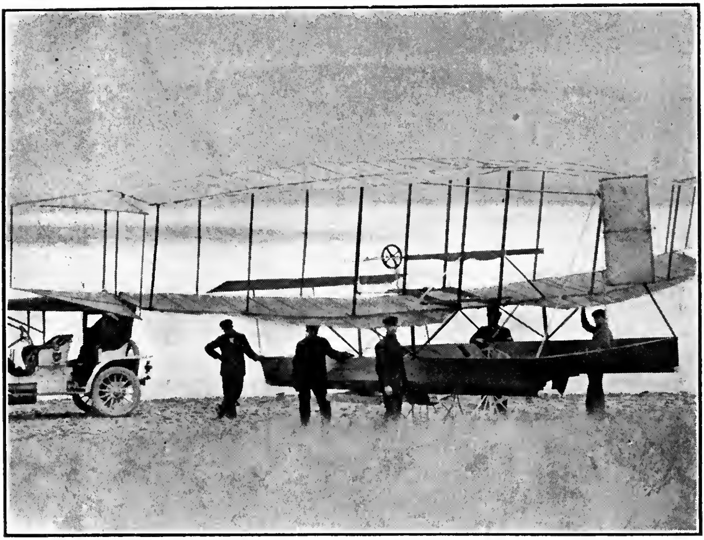
The British had hoped to be the first to fly across the Atlantic. But their welcome to the Americans was none the less hearty on this account. This reception committee on the terrace of the House of Commons includes the Prince of Wales, the Earl of Reading (Special Ambassador to the United States), Rt. Hon. Winston Churchill (Secretary of War and of the Air Ministry), Admiral Sir Rosslyn Wemyss, and other distinguished men.



THE DEVELOPMENT OF NAUTICAL AVIATION—I

(*Above*)—Commander Richardson and other investigators have studied pictures like this very closely in their attempt to formulate the basic principles of the new science.

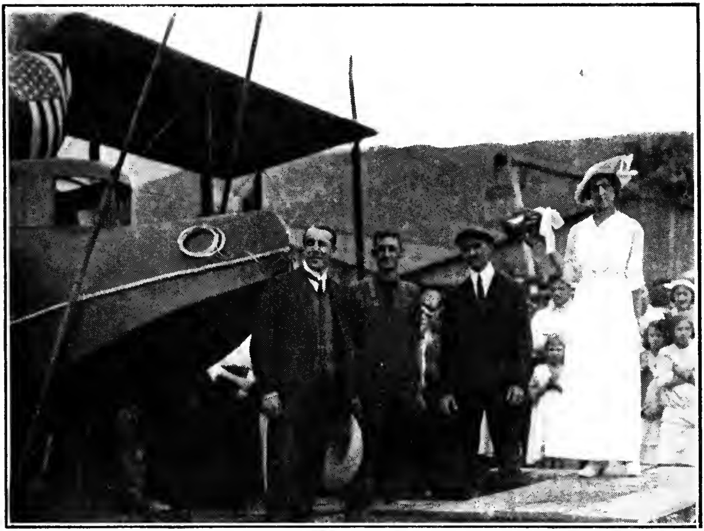
(*Below*)—Professor Langley of the Smithsonian Institution came to grief when he tried to fly in this machine, which came to be known as "Langley's Folly." Years after the death of the disappointed inventor Curtiss vindicated his ideas by actually flying in the old machine at Hammondsport.

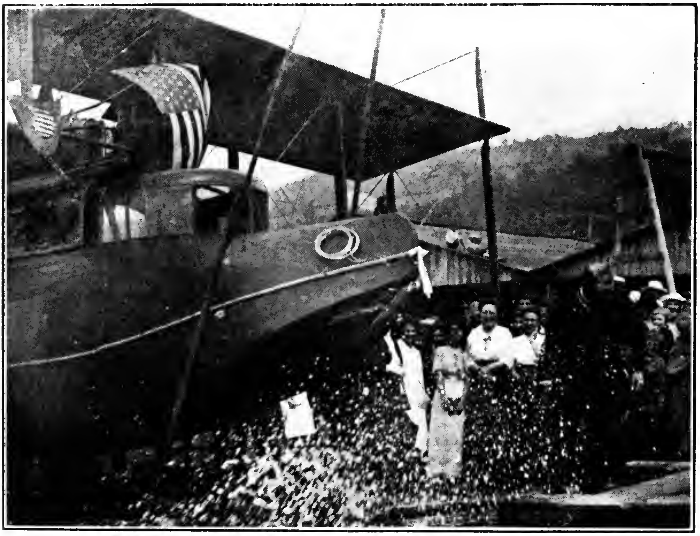


THE DEVELOPMENT OF NAUTICAL AVIATION—II

(*Above*)—Glenn Curtiss won the *Scientific American* Trophy by flying this machine for one mile, July 4, 1908. It was then called the *June Bug*. When fitted with floats, as shown, and re-christened the *Loon*, she was unable to fly.

(*Below*)—The first successful hydroaeroplane, flown at San Diego in 1912.





CHRISTENING THE *AMERICA*, ASPIRANT FOR TRANSATLANTIC HONOURS

(*Above*)—Miss Masson stands sponsor with a ribbon and horseshoe-decked bottle of wine. Mr. Glenn Curtiss stands, at her right and Lieut. Porte of the Royal Navy, the prospective pilot, stands, hat in hand, at the *America's* bow

(*Below*)—The bottle is broken and Lieut. Porte dodges, to the amusement of the spectators command of the language we managed to get along.

From our investigation of the river and from the the general tenor of the Captain of the Port's verbose explanation it was apparent that a wait for high tide, which would occur at about 2 P. M., was necessary.

We were the guests of that same Captain of the Port for lunch. He presented us to the "President" of the town, who congratulated us most heartily and then offered to turn over to us the whole town or any portion of it if we had any use for it.

Two destroyers had arrived off the mouth of the river in response to our radio calls; one of the skippers came ashore in his small boat through a breaking surf—the natives had assured us that the passage could not be made at that stage of the tide. This was another exemplification of the fact that destroyer officers delight in doing things ordinary mortals find impossible.

We discussed with this officer the details of the remainder of the trip and decided to make a stop for the night at Ferrol, Spain, as it was clearly impracticable to reach Plymouth before dark.

The tide having risen sufficiently high we finally left the water at 1:38 P. M.; there was a light breeze in our favour and the weather was beautiful except for numerous squalls of small area which required an occasional change of course. We kept near the coastline where the air was generally clearest and where the scenery was much more enjoyable. Our power plant was in excellent condition, the leak having been entirely stopped. Our radio apparatus was functioning finely as usual, and we intercepted many air conversations, most of them in Portuguese or Spanish.

Off Cape Finisterre we encountered a strong, favouring wind and were able to beat our estimated time of arrival at Ferrol, made two hours before, by fifteen minutes. Ferrol is surrounded by high hills, and though the harbour is very beautiful the air is decidedly troublesome. We circled over thousands of the townspeople, who had flocked to the docks and seawall, then landed and secured to a convenient buoy to wait for a destroyer.

One arrived a few minutes later and the personnel bunked on her for the night. No repairs to the seaplane were necessary. The Spanish officials were very polite, making calls of courtesy and offering us every assistance. The weather forecast for the next morning was slightly unfavourable, but we decided to proceed in spite of it.

We left at 6:27, on the morning of May 31st, and after clearing the harbour encountered rain for forty minutes, the thick weather and frequent squalls requiring many changes in our course. In fact, at one time the squalls were coming so thick and fast that the pilots started to take matters in their own hands and to steer their own courses. For a while I allowed them to do this and endeavoured to keep track of their twists and turns until I finally gave it up as a bad job and made them follow the courses given to them in spite of rain and "bumps."

Visibility was poor all the way across the Bay of Biscay and we missed four of the six destroyers stationed between Ferrol and Plymouth. But the water was smooth and the French coast not so far off our starboard hand that there was any occasion to worry over not sighting the destroyers.

We edged off to the right of the course in order to be certain of not missing Ushant, the northwestern corner of France, and eventually sighted Ras Point which is to the southward of Brest. And then as a compliment to the Commander of U. S. Naval Forces in France who had sent us several congratulatory messages we flew over the harbour of Brest, circled, then came out and continued on to Plymouth.

The country we saw below us was very picturesque, but the weather outside was so thick that we came down to within a few feet of the water for better visibility.

Leaving France behind we ran into an increasing head wind while crossing the Channel, the thick haze clearing somewhat as we reached mid-channel. Then, nearly two hours after leaving Ushant, the hills around Plymouth were sighted dead ahead. Several British seaplanes had gone out to meet us but we missed them on account of the fog.

A quick climb was made to 1,500 feet in order to pick out a suitable landing place, then we landed in smooth water at 1:26 and taxied up to our buoy.

The job was finished.

CHAPTER V

CONCLUSION OF THE TRIP—GLAD HANDS—SOBER THOUGHTS

WE HAD a wonderful reception from the officials, which made a fitting climax to the entire trip. The heartiness of the congratulations showered upon us proved the sportsmanship of the British. The crew of the *N.C.4* was in better health than at the time of the start from Rockaway Point, and the good condition of the seaplane proves the excellent serviceability of that type of flying craft. Our Liberty motors had given a marvellous performance. Three of them were the same ones first installed at Rockaway; the fourth had been put in at Trepassey Bay.

Immediately upon landing we were taken to the *Rochester* which had preceded us from Lisbon and were presented to several notables. Then we went ashore in order to be received officially on the "Plymouth Rock" by the city officials.

Up to this time I had been under the impression that our own Massachusetts town boasted the only Plymouth Rock in existence; but here there was another one, a slab of rock laid down on the spot from which the first Pilgrims embarked on the *Mayflower* in 1620.

The ceremony was very dignified and impressive.

After this they escorted us on a sort of triumphal parade through the city, and then we were guests of honour at a beautiful luncheon.

The next morning all of us, including the crews of *N.C.1* and *N.C.3*, who had come from the Azores by sea instead of by air, left Plymouth for London. I will not attempt to describe the many banquets and other honours that were tendered us. Perhaps the two most important of these were a luncheon at the House of Commons where we had the honour and pleasure of meeting H. R. H. the Prince of Wales and many other famous men whom we had heard of but never seen, and the ceremony of being decorated with the Royal Air Force Cross. Although the King awarded the decorations he himself was not present.

After a week of gaieties in London we were ordered to Paris. Although it could not be discovered by a mere reading of the orders, our verbal instructions were simply to have a good time until we were tired, then to proceed home by way of a steamer sailing from Brest.

These orders were carried out. The French people were very enthusiastic about our flight and entertained us royally, but strange to say all of us were ready to leave even before the week was over which we had agreed upon as our limit. To go home seemed the most desirable thing that could happen to us. I could not help thinking how much more anxious to go home must the people be who had been over there for many months, nor help feeling a deep sympathy for those who were still being held on the other side.

While in Paris we met President Wilson. He congratulated us but warned us "not to get too high for the higher you get the harder the fall will be." We also had the good fortune to meet the others of the "Big Four," Clemenceau, Lloyd-George, and Orlando.

We counted ourselves in luck in getting passage in a comfortable steamer and finally arrived back in New York on the 27th of June, exactly one month after the *N.C.4's* arrival at Lisbon. Here we ran once more into a regular barrage of entertaining. The celebrations at present writing have not yet ceased. And we appreciate it all; more so even than the many honours showered on us abroad, for no matter how much one is entertained and fêted by strangers in a strange land the plaudits of one's own countrymen in one's own native land have a far greater appeal. They carry with them the feeling that something worth while has really been accomplished and that our own people approve of us.

Since the *N.C.4* landed in Lisbon innumerable questions have been asked us concerning all features of the flight. The answer to most of them can be found in what has been said above. Some of the queries have not been covered and I will put them down here and endeavour to give the correct answers.

"Is the N.C. type of seaplane suitable for trans-oceanic flying?"

It is not. Seaplanes must be built of far greater size before a regular service across the Atlantic could meet with any success. The hulls were very seaworthy as *N.C.3* demonstrated, but during her 200-

mile trip on the water the crew were far from comfortable and were continuously in danger of capsizing.

"How do you like the Liberty motor?"

After the experiences of this flight and particularly after the long night passed through between Trepassey Bay and the Azores, when every exhaust valve was spouting out its flame without a miss, my faith and confidence in the Liberty is higher than in any other motor of anything approaching its power.

"Did your radio outfit work successfully?"

Something has already been said of the distances of sending and of receiving messages. We undoubtedly broke many previous distance records established by seaplane sets. When one takes into consideration the small space and the small weight allowed for such an installation on a seaplane, the performance was really remarkable. The radio compass, or direction finder, also proved itself of great assistance, and indicated its immense value for future long-distance flights when it has been more fully developed. In fact, I look to the radio compass for the easiest solution of transatlantic navigation problems.

"Was the flight worth while?"

The answer is decidedly in the affirmative. The information obtained concerning over-sea flying and concerning the big machines themselves was of inestimable value for future operations and future development. The few who still doubt that the expense was justified are those who always believe that the more tangible things that can be turned to present use are to be preferred to research work for future benefit. Still more difficult to estimate is the value to Naval Aviation of the advertisement received. The flight brought home to the people all over the country that aviation in the Navy is a force to be considered, and one capable of planning and accomplishing difficult enterprises—an asset greatly appreciated in time of war.

"What were your general impressions of the flight?"

Perhaps the chief impression obtained during the actual flight was the apparent smallness of the Atlantic Ocean—it appeared to have shrunk in size. We passed over it so quickly that it was impossible to realize the great distance actually travelled.

The chief impression received at Lisbon was the great friendliness of the Portuguese people for anything and everything American. This was noticeable at the Azores as well as in Portugal itself.

We were impressed in England by the hearty sportsmanship of the British. They had hoped to capture the prize of making the first ocean flight themselves but they did not let that interfere in the least with the heartiness of their reception and congratulations.

In France, the people showed great enthusiasm for all things connected with flying. In England also the same sort of feeling existed—shown not only in the interest exhibited in aviation matters but in the way big things are being accomplished toward the future development of the art. It was depressing upon our return to this country to find that, although considerable interest was manifested, that interest did not extend to the point of furnishing financial backing sufficient for the needs of aviation. It is not an art that can advance by itself, any more than the development of the submarine could have taken place by itself after the *Holland* made its first successful plunge.

"Are you going to make another flight across the Atlantic?"

Yes, I expect to do so inside of a few years and I will take my wife and baby with me. Before that, however, there will be great improvements effected. Few people realize what improvements can and will be brought about in the near future, or realize what an enormous field of development lies before us.

While at luncheon in Paris, I had the pleasure of meeting some of the foremost designers and engineers of aircraft. Some of the prophecies they made appeared at first rather visionary even to me. But any one in the present age of new and startling inventions who says positively that we will never attain an altitude of 60,000 feet, will never fly at 500 miles an hour, or will never be able to cross to Europe in the forenoon and return in the afternoon, is a most courageous person, with a courage similar to that of those doubters in the olden days who proclaimed that iron or steel ships would never be successful.

"In view of the interest everywhere manifested in flying why are not the people as a whole squarely behind aviation and willing to push?"

There are two main reasons: ignorance and fear. People are inclined to think of flying only in terms of looping, side-slipping, barrel-rolls, and tail-slides. They forget the possibilities of the big machine in carrying tons of bombs and guns or of cargo and passengers. To my mind it would be far better to divert much of the energy now expended in hair-raising stunting exhibitions to efforts toward the development of safe and sane and useful flying. The people, too, do not realize the very rapid changes and improvements in design, which make it imperative for this country to keep at least abreast of the others, unless we are content to remain hopelessly behind and be in a far worse state of unpreparedness in the next war than we were in the last.

The reason for their fear is easily understood. Accidents in airplanes are always featured in the papers—if one occurs in Texas, in Norway, or in Australia, we hear of it. If automobile accidents were given the same prominence, there would be room for little else in the news columns. There are some pilots with whom I would refuse to risk my life. But, given a modern machine with the proper attention paid it, and a skilful but conservative flyer, it is as safe a means of rapid transit as an automobile travelling at less than half the speed. Think over that statement, for it is absolutely true. Nowadays there is scarcely ever an accident in an airplane of standard type due to fault of material—they are all due to the inexperience or to the dare-devil stunting proclivities of the pilot—the pilot who "takes chances."

PART III

THE LOG OF THE *N.C.3*

BY

COMMANDER H. C. RICHARDSON

CHAPTER I

PREVIOUS ATTEMPTS AT TRANSATLANTIC FLIGHT

PRIOR to this attempt at a transatlantic flight by the Navy Department, various efforts had been made for a trip by air across the Atlantic Ocean. The earliest actual attempt was made by Walter Wellman on the 18th of October, 1910. Mr. Wellman at that time was a special correspondent for the Chicago *Record-Herald*. One of the assignments which had been given him was a trip by airship to the North Pole, for the purpose of concluding explorations which had been made by him some years previous when he had been one of the parties on an unsuccessful attempt to reach the Pole by boat and by sledge. An unsuccessful effort to reach the Pole had been attempted in May, 1894, and another in the fall of 1898. Mr. Wellman was not discouraged by these failures and set about preparations for a third trip, but before these preparations could be completed he was beaten to the goal by Admiral Peary.

In the preparation for the transatlantic flight Mr. Wellman was assisted by Mr. Melvin Vaniman, an engineer who had taken a great interest in balloon construction and in experimental work in connection with balloon flights. The airship designed for this flight was a non-rigid dirigible type, 228 feet in length by 52 feet in diameter. The total lifting capacity was twelve tons. Plans called for the start of this flight from Atlantic City, N. J.

Mr. Wellman, Mr. Vaniman, two assistant engineers, a navigator, and a wireless operator made up the crew. Unfortunately for the success of the undertaking, it was very foggy at the time of starting and the gas envelope became soaked with water. In order to make flight possible it was necessary to throw out a large quantity of the gasoline. Due to the heavy fog it was impossible to see far enough ahead to distinguish approaching vessels, and a very narrow escape from collision occurred off the south shore of Long Island.

The balloon was fitted with an equilibrator made up of steel cable and drums containing gasoline, interspersed with wooden blocks to provide buoyancy. The equilibrator trailed from the car and took the place of additional ballast. During the flight, it was intended that this equilibrator should control the altitude of the balloon. Unfortunately, it produced a motion of gas bag and car which was exceedingly unpleasant and caused seasickness among the members of the crew. The winds, which had been expected to help the machine in its passage, soon became contrary and they were finally thrown out of their course so that it became necessary to head for the Bermudas instead of for Ireland.

One of the motors became inoperative and when the steamship *Trent* was sighted and offered assistance it was decided to abandon the ship. This was effected with difficulty, as it was necessary for all members of the crew to place themselves in the lifeboat, and as the gas bag rose and fell, to choose the proper instant to cut the supporting cables and allow the boat to drop into the sea. In spite of the hazards this was accomplished successfully and the crew picked up by the *Trent*. The balloon had to be abandoned and was a total loss.

The trip was a failure as far as accomplishing the desired object, but a new world's record was established for balloon travel. The balloon was in the air a total of 71½ hours and had covered in that time a distance estimated at 1,008 miles. The principal cause of the failure was lack of power to navigate against unfavourable winds, due to the insufficiency of the fuel supply.

In 1912, preparations were made for another transatlantic flight. Mr. Melvin Vaniman was responsible for this effort. Funds for the construction of the balloon for this flight were supplied by the Chamber of Commerce of Akron, Ohio, and by the Goodyear Tire and Rubber Company. The balloon was considerably larger than the one used by Wellman in his effort. The total length of the gas bag was 268 feet, the maximum diameter was 47 feet, and the total gas capacity was 400,000 cubic feet. The car was placed in close contact with the bottom of the envelope. The balloon was fitted with two 100-horsepower gasoline engines estimated to provide a speed of thirty miles per hour.

The machine was assembled in June, 1912, and tests were made at Atlantic City on July 2, 1912. In the final test the balloon caught fire and Mr.

Vaniman and four members of the crew were killed. The cause was never determined, but it was due probably to sparks from the motor exhaust.

Mr. Vaniman's purpose in attempting this flight was to call attention to the possibilities of the dirigible as opposed to the airplane.

Interest in transatlantic flight was next stimulated by means of a prize of £10,000 offered by the London *Daily Mail* and published April 1, 1913. The *Daily Mail* had previously offered similar prizes to stimulate efforts to cross the English Channel and flights from London to Paris. These flights had been successfully accomplished, and the next big and spectacular flight would be the flight across the Atlantic.

The next project for transatlantic flight to be started in America was financed by Rodman Wanamaker. Mr. Wanamaker furnished the funds with which Glenn Curtiss constructed a flying boat called the *America*, which was to be piloted by Lieut. J. C. Porte of the British Navy.

The machine was of biplane construction with an over all length of 37⅔ feet. The span of the upper wing was 75 feet 10 inches. The total load to be carried was 5,000 pounds, and the estimated speed was 65 miles per hour. The power plant was of two Curtiss OX-2 motors, arranged to drive tractor propellers. The pilots and all controls were located in a small cabin in the boat hull. It is interesting to note that this was the first two-motor flying boat attempted in this country.

The *America* was built at the Curtiss plant at Hammondsport and was christened by Miss Katherine Masson. The first test was made in June, 1914. The machine got away very rapidly with a light load, but it was found impossible to leave the water with the designed load. The hull of the boat, which is of standard Curtiss construction, was developed from the lines of boats which had previously been constructed; but it had a stubbier bow, and the tail from the step aft was of elliptical form. These modifications made it drive hard and as a result attempts at further modifications were made to improve its behaviour. Various methods were used. Planing fins were built at the sides of the hull. Submerged plates were tried both at the step and at the stern. Additional floats were added under the wing motors, and finally a third motor was attached. On July 10th, a flight was made with ten men on board, making what was then a world's record for passenger carrying. On July 22nd, tests were made with the three-motor arrangement and the machine got away with a load of 4,500 pounds. Fuel consumption tests were made at the time which showed a gasoline consumption of about 1½ times the estimated consumption. It was therefore decided to postpone the flight which had been planned for August to some time in October, to allow additional experiments. Shortly after this decision was made the World War started and Lieutenant Porte was recalled to take up his duties with the British Navy. This resulted in an indefinite postponement of the entire project.

Probably the principal cause of the failure of the *America* to get away with the designed load was the change of the hull aft of the step. While the elliptical sections improved the flying qualities, they reduced the buoyancy abaft the step, making the hull trim by the stern. This in turn gives the bottom at the bow too steep an angle for efficient planing. Also the elliptical lines undoubtedly produced a certain amount of suction. The stubbiness of the bow also permitted this hull to sink deeply into the water, which aggravated the difficulty. The hull was later re-designed, using a flat bottom aft of the step, and this made it possible to get away with two motors at practically the desired load. After these changes had been made the *America* was purchased by the British Navy and was used in connection with training of pilots for the Royal Naval Air Service. The *H.16* and *F.5*, developed by the British, were undoubtedly the outgrowth of these trials, in which the fins at the side of the hull became a prominent feature.

At about the same time of the experiments with the *America*, preparations were being made in England for competition for the *Daily Mail* prize. The only experiments to gain any headway whatever were with a Martinsyde monoplane, which was to have been flown by Gustave Hamel, a well-known English aviator who had made several record trips between London and Paris. This monoplane was to have a span of 66 feet with the chord of 14½ feet, at the centre, tapering to 10½ feet at the wing tips. The total supporting area was 750 square feet. Power was to be supplied by a 250-horsepower Sunbeam engine. Unfortunately, Hamel was killed in a trip from Paris to London when a Martinsyde monoplane in which he was flying fell into the English Channel. The Martinsyde machine was not completed and remained for some years in the Martinsyde factory.

When the World War began and all effort was concentrated on the production of airplanes and airships for war purposes, the *Daily Mail* prize was withdrawn. The development of machines, both lighter-than-air and heavier than-air, since that time has been exceedingly rapid, although no machine has been built for the express purpose of attempting a flight of the length of the transatlantic flight. But there seems to be little doubt that if the war had not intervened machines would have been developed before this which would have been able to accomplish a flight of this length.

About the time the *America* was undergoing tests, a German aviator by the name of Rheinold Boehm made a flight in an Albatross biplane, remaining in the air twenty-four hours and twelve minutes and covered a distance of approximately 1,150 miles. It would have needed only a small increase in fuel capacity to fly from Newfoundland to the Azores in such a machine, assuming that a suitable landing field could be found at the Azores.

During the period of the war it was found that delivery of American planes in Europe could be greatly expedited if they could be taken across under their own power. It was because of the delay in shipment of planes, due to congestion of freight and supplies and to the bulk of the planes when packed for shipment, that Admiral Taylor reached his conclusion that delivery by air was necessary.

General interest in the transatlantic flight was again obtained by the renewal of the offer by the London *Daily Mail* on November 18th, immediately after the Armistice had been signed. After that date many European and American manufacturers took up the project, and special planes were constructed to be used for this flight. However, the Navy Department's effort was, as previously stated, not a separate effort, but the development of a war project, and the Navy Department's interest was in the information to be gained from such a flight and not in the prize which had been offered.

CHAPTER II

THE AZORES ROUTE CHOSEN—COMMISSIONING THE PLANES—EQUIPPING THEM

A NUMBER of routes for the transatlantic flight were possible, but the final decision depended on the amount of fuel required and the amount which could be carried.

The route from Newfoundland to Ireland direct involved about 1,670 nautical miles, 1,933 statute miles, traversing a region in which there were almost always storms at some part of the route, and also traversing an area in which the percentage of fog is high. It was early found that the N.C's would have to refuel at sea unless a gamble was made on the assistance of the wind. After due consideration this was considered to involve too many uncertainties and was given up.

The route from Rockaway direct to the Azores appeared more favourable, because the weather conditions are generally better, and fog is less likely than in the vicinity of Newfoundland, but the run of 2,200 statute miles is longer than that to Ireland, and would also involve refuelling at sea. It was much favoured by nearly all the pilots, but wiser heads prevailed.

The route from Newfoundland to the Azores is, excluding the Newfoundland, Greenland, Iceland, Ireland, or Scotland route, the shortest possible land to land, and even in a calm was in striking distance for the N.C's. Weather conditions are generally good along this route and the wind favours if the time is selected with due regard to the location of high and low barometer, as under favourable conditions the wind blows down the lane between them in a favourable direction and the weather is generally good along the lane. Thus a non-stop flight to the Azores appeared entirely feasible, and the leg from the Azores to the mainland at Lisbon is shorter and weather conditions are generally good.

The cruising radius of the N.C's depended on many factors which had to be determined as definitely as possible prior to May 1st, the principal ones being fuel consumption, propeller designs, and the best flying speed.

Very careful studies were made in detail and these factors were carefully estimated. Based on these estimates it appeared that the most favourable results would be obtained if these planes were flown so that the "angle of the wings" was 7° to the path of the seaplane through the air. It appeared that the greatest radius of action would be obtained in this way. However, it was also found that almost as good results would be obtained using 5° or 6°, and these angles involved greater speed, less time on the run, and in rough air might be even more efficient than 7° because the power of control would be increased, thus making it easier to hold a steady course.

Another important factor is the propeller efficiency, for this determines the brake horsepower required of the engines. This problem is very complex. It depends on the revolutions of the engines, the speed of advance, the form of the propeller and its location on the airplane. A propeller that would be eminently satisfactory at flying speed might be less efficient when getting away from the surface at a lesser speed, than another which might be less efficient at flying speed. The second might be able to lift more additional load of gasoline than it would eat up on the run as compared with the first. The time available, particularly because of unfavourable air conditions, prevented a complete or exhaustive determination of this difficult problem, but sufficient tests were made to arrive at a fairly approximate solution and a fairly exact determination of the brake horsepower required. Therefrom, by computation from the engine characteristics and also from runs over known distances, it was finally determined that the average fuel consumption would run about eighty-two to eighty-five gallons per mile at seventy to seventy-five miles per hour, mean speed. This determination depended upon experimental work at Dayton and Washington with high-compression engines and different combinations of jets and chokes for the carburetors.

From these determinations and also the maximum load which four engines could get off, 28,000 pounds, it appeared the flight from Newfoundland to the Azores, Trepassey to Horta, 1,200 miles (nautical), could be made in a calm.

Lieutenant-Commander P. N. L. Bellinger and

Lieutenant E. F. Stone were sent to Newfoundland to determine the best point for starting, and after examining a number of harbours reported that Trepassey was most favourable but far from ideal.

Toward the end of April, it appeared that the earliest start could be May 4th.

Toward the end of April the Navy Department officials took the greatest interest in the preparation and everyone was most solicitous that we should have every assistance possible. The Secretary of the Navy was in Europe, but the Assistant Secretary, Mr. Roosevelt, represented him and made a personal trip to Rockaway, acquainting himself with the state of the preparations and personally making a flight under about as rough air conditions as were experienced in any of the flights at Rockaway. He did not know that had he not been there the flight would not have been made, nor did he realize from his position in the plane just how rough it really was, although as the flight was made in the *N.C.2*, in which he was seated directly behind the pilots, he did note that both McCulloch and I were busy with the ailerons. He talked to each of us personally, showing the greatest interest in all phases of the flight, and giving us needed encouragement. We were nearly worn out with the constant work and worry of the preparations.

On May 3rd, at 10:00 A. M., the *N.C.1*, *N.C.3*, and *N.C.4*, were regularly placed in commission.

This was an historic event for it was the first case in the history of the United States Navy in which seaplanes had been formally placed in commission and in which they had formed a definite division of the Fleet.

Commander John H. Towers, U. S. N., was placed in command of N.C. Seaplane Division One, by authority of Bureau of Navigation telegram to the Commandant of the Third Naval District.

Captain Powers Symington, U. S. N., Chief of Staff to the Commandant, in the presence of the assembled crews of the seaplanes, the Commanding Officer and Executive Officer of the Naval Air Station, Rockaway, the Superintending Constructor and his assistants in charge of the construction of the N.C. seaplanes, and many others, read the telegram and gave orders to "hoist the colours." The bugle sounded "colours." All hands stood at salute until "colours" was finished.

Commander Towers then read his orders placing him in command of N.C. Seaplane Division One, and giving him the status of a Commander of a division of the Fleet.

This formal commissioning of the planes definitely determined the crews of the planes, which information the reporters, of which there were a great many at Rockaway, had been trying in every way to get advance information. They had made many amusing conjectures and had played up one pilot after the other attempting to pull the Department's leg. These reporters were all very fine men and patiently met the rebuffs of Commander Towers who, under Departmental instructions, was able to give them only limited information.

All officers attached to the division were given the status of officers attached to seagoing ships.

The crews of the seaplanes were as follows:

N.C.3 Flagship.

Commander John H. Towers, U.S.N., Commanding and Navigator, and in Command N.C. Seaplane Division One.

Pilots—Commander H. C. Richardson (C. C.), U.S.N.; Lieutenant David H. McCulloch, U.S.N.R.F.

Radio Operator—Lieutenant-Commander R. A. Lavender, U.S.N. Pilot Engineer—Boatswain L. R. Moore, U.S.N. Reserve Engineer—Lieutenant Brenton Rhodes, U.S.N. *Reserve Navigator—Lieutenant-Commander R. A. Byrd, U.S.N.

N.C.1:

Commanding Officer and Navigator—Lieutenant-Commander P. N. L. Bellinger, U.S.N.

Pilots—Lieutenant-Commander M. A. Mitscher, U.S.N.; Lieutenant L. T. Barin, U.S.N.R.F.

Radio Operator—Lieutenant (Junior Grade) Harry Sadenwater, U.S.N.R.F.

Pilot Engineer—Machinist R. Christensen, U.S.N.

Reserve Engineer—C.M.M., R. Kesler, U.S.N.

*Special Observer: Ensign C. J. McCarthy, U.S.N.R.F.

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*To Trepassey only.

N.C.4:

Commanding Officer and Navigator—Lieutenant-Commander Albert C. Read, U.S.N.

Pilots—Lieutenant Elmer F. Stone, U.S.C.G.; Lieutenant Walter Hinton, U.S.N.

Radio Operator—Ensign Herbert C. Rodd, U.S.N.R.F.

Pilot Engineer—Lieutenant J. G. Breese, U.S.N.R.F.

Reserve Engineer—C. M. M. E. C. Rhodes, U.S.N.

*Reserve Engineer—C. Special Mechanic, E. H. Howard, U.S.N.R.F.

The equipment of the seaplanes was very complete. Each member of the crew was provided with a soft helmet and goggles, a special one-piece leatheroid suit, water and airproof, lined with fleece, a pair of fleece-lined gauntlets, and if he desired a pair of soft leather fleece-lined boots, lacing high outside of regular shoes and leg of suit. According to their like, each member of the crew wore light or heavy underwear. Each wore his one-piece suit over his regular uniform. Each was also allowed five pounds for toilet articles and spare clothing. Additional clothing was placed on the *Aroostook* for use on arrival at Trepassey and at Plymouth.

The pilots were provided each with a vertical card compass and an inclinometer on the hood immediately in front of him. On a central instrument board were located in full view of each pilot a com-

*Lost left arm day before started.

bined lateral and longitudinal inclinometer, an air speed meter, an altimeter, tachometers, and oil pressure gauges, one for each engine, and a clock.

Between the pilots' seats were Liberty switches and voltage regulators for each engine, also lighting switches for dash and compass lights, for side lights, and for range lights.

To avoid confusion and necessity for labels the tachometers and Liberty switches were arranged in plan form so that their position indicated the engines they applied to.

The hand pulls for the electric starters were located in the bulkhead back of and between the pilots' seats.

The engine throttles were located under the deck between the pilots. The forward throttle controlled the forward engine, the rear throttle the rear engine, and a differential throttle controlled the wing engines, permitting both to be accelerated or retarded simultaneously by a direct movement, or independently by a twisting movement for manœuvring on the water or in the air.

A master switch for cutting in or out all engines could be operated by the feet; it was located at the bottom of the instrument board on the centre line.

A turn indicator was mounted on deck on the centre line where it was readily seen by both pilots.

The pilots' seats were provided with "Kapok" cushions for the seat and back rest. The edges of the cockpits were upholstered.

Dual control was provided so that either pilot could take complete control or assist the other.

Two hand wheels, interconnected, controlled the ailerons. These were mounted on a single bridge operating the elevators.

Two foot bars, interconnected, controlled the rudders.

The navigator was provided with a boat compass, a special drift indicator, a specially designed "bubble" sextant, devised by Lieutenant-Commander Byrd, requiring no horizon, chronometers showing Greenwich Mean Time and Greenwich Sidereal Time, charts, plotting sheets, navigation tables, nautical almanac, and a chart board and all necessary instruments required in navigation work. He was also provided with a stop watch for recording time of astronomical observations.

The seaplane engineers were provided with special tools and spare parts and materials, also a lineman's belt for security when working in the open under-way.

The radio operator was provided with complete sets of radio apparatus for telegraph and telephone and radio compass, and carried limited spares for the more fragile parts.

Special antennæ were rigged between the skid fins for operation when afloat and a trailing antenna was provided for greater range in flight.

All members of the crew except the reserve pilot engineer were also provided with telephone head gear for inter-communication in flight, and by a special connection it was also possible for the Commanding Officer to switch in on the radio 'phone to communicate with other planes, vessels, or stations in range.

CHAPTER III

THE START OF THE FLIGHT—ROCKAWAY TO HALIFAX

THE original date for completion of the N.C's was set as May 1st, but as this date approached and the manifold modifications developed, it was apparent that the earliest possible date for completion of the three planes to enter the flight would be May 4th. This, however, was satisfactory as there was still sufficient leeway to make the flight to Newfoundland and leave there by May 14th. In the last days of the preparations all hands were working under high tension and work was going on night and day. The nervous strain on all hands was high and it finally became necessary for Commander Towers to issue instructions that none of the pilots should participate in the night work, as he appreciated that it would not do for them to enter the first leg of the flight if they were physically and mentally exhausted.

The *N.C.1* and *N.C.4* were finally completed on the night of May 4th, and the Curtiss workmen left that night proud and happy that they had completed their work on time. During the night about forty officers and men carried on the work of preparation for the flights in the morning, and among these preparations was the filling of the tanks of the *N.C.1* with gasoline. About 2:00 A. M., in some manner a spark from the motor driving an electric pump ignited the gasoline, blowing the hose off the pump and throwing a stream of gas on the concrete floor directly under the right wing of the *N.C.1* and the tail of the *N.C.4*. In an instant the wings of the *N.C.1* and the tail of the *N.C.4* were in a blaze, and inside of six minutes the right wing of the *N.C.1* was hopelessly damaged although the fire was put out. The men who fought this fire deserve the greatest credit for, realizing that it was impracticable to save the right wing, they exerted all their efforts to hold the damage to it, and flooded the rest of the machine with their fire extinguishers so successfully that the damage was practically limited to the portions of the wing outboard of the engine mountings. They succeeded in limiting the damage to the *N.C.4* to part of the lower elevator and the lower horizontal stabilizer.

Many barrels of gas were on the deck of the hangar and in spite of the danger to themselves the men rolled these tanks out of the hangar clear of the fire, a number of the men suffering burned hands and sprained wrists as a result.

The Curtiss factory was immediately notified and calls were sent out to their workmen to be back on the job the next morning. Fortunately, the right wing of the *N.C.2*, whose left wing had previously been damaged in a storm, remained intact. As soon as the fire was out the men at the station proceeded to dismantle the right wing and to remove the damaged elevator from the *N.C.4*, so that in the morning when the Curtiss workmen arrived preparations were already under way to substitute the undamaged right wing of the *N.C.2* for the damaged wing. The Curtiss workmen arrived before working hours, but did not wait for the whistle to blow and, though many of them were ready to cry when they saw the condition of the plane, they got into their working clothes as rapidly as practicable and work was diligently started, so that late that evening the *N.C.1* was again in flying condition, and the damaged tail of the *N.C.4* repaired. It was only their indomitable spirit which made this possible.

From now on until May 8th, the weather conditions interfered and the time thus gained was used to tune up and adjust the planes.

On the morning of May 8, 1919, everything was in readiness; *N.C.1* and *N.C.3* had had early morning workouts proving everything in good order and *N.C.4* had been tried out the preceding day.

About 8 A. M. local weather conditions appeared favourable, but reports had not all come in yet as to conditions near Halifax. About 9:30 these reports arrived as well as the synoptic reports from Washington. Conditions seemed favourable and the decision was made and instructions issued to get under way.

At last the time had arrived to which we had all been looking forward for months. We had each and every one of us given serious thought to the work on which we were engaged, and had attempted to foresee all contingencies. In carrying on the work we had given the most minute inspection to every detail, fully appreciating the importance of the integrity of our planes and their power plants. We had developed many devices to insure that we should make no mistakes in handling the planes. We had taken particular care to see that we ourselves were in the proper physical and mental condition to undertake the important task which had been assigned us.

The *N.C.1* and *N.C.3* were already overboard and *N.C.4* was on the marine railway.

Each plane was now supplied with a package of about two dozen sandwiches, a two-quart thermos bottle of coffee forward and a one-quart bottle aft, and five gallons of drinking water.

Each plane carried about 800 gallons of gasoline, 1,000 pounds of oil, a heavy ground anchor and sea anchor and line, and towing gear, besides excess spare parts over and above those to be carried on "the long leg," for due to the small quantity of gasoline there was considerable reserve left. In addition, the members of the crew carried cigarettes, cigars, and chocolate candy.

Having said our farewells, the crews climbed on board, the engineers primed the engines, and stood by with fire extinguishers in case of a back fire. All engine switches were thrown to contact, then the master switch, and finally the starting switches were pulled, and in less than a minute all four engines in each plane were running. A few minutes' delay to warm up and insure oil pressure in each engine and the signal to start was given. The lines holding the *N.C.3* to the beach were released and she headed out into Jamaica Bay. *N.C.1* followed, and *N.C.4* came down the marine railway, took the water, and gracefully followed the others which had headed N. E. across the bay. The *N.C.3* left the beach at 10:07 A. M. local time. After a short run toward Barren Island the *N.C.3* turned and headed west followed by *N.C.1* and *N.C.4*. All planes being in position opened out, *N.C.3* "planed" quickly and at 10:15 took the air, followed in quick succession by the others, and the flight was "on."

The *N.C.3* headed for Roamer Shoal Light till it was evident that the others could take their assigned positions, then turned at about 500 feet altitude and headed east on her course about three miles south of Rockaway for Montauk Point. The *N.C.4* was to the north well in shore and the *N.C.1* to the southwest well off shore.

The sky was cloudy and the horizon hazy, but visibility was good. The air was smooth and we soon settled down to our cruising gait.

By noon Montauk Point was abeam, and we set our course for Block Island which was clearly visible ahead. The New England shore was just visible in a dark haze to the northward. At an altitude of about 2,300 feet we passed Block Island at 12:15 P. M. and headed for Vineyard Sound. Block Island showed up clear and beautiful. The houses, roads, and fields looked like a Christmas tree garden. We could see the surf breaking on the rocky beach, and the smoke of steamers passing below showed us the direction of the surface wind.

As we entered Vineyard Sound *N.C.4* had gotten well ahead and made a complete circle to regain position. Here we got a few mild bumps from the wind coming over the land to the northwest. Buzzard's Bay was visible over the islands.

Passing Wood's Hole our course was changed for Monomoy Point, which we passed about 1:30 P. M., getting a few bumps crossing Nantucket Shoals. Massachusetts Bay was clearly visible almost as far as Cape Cod. The course was now changed to head for Cape Sable. About 2:00 P. M., sight of land was lost in the haze astern. About this time we sighted the first patrol vessel making smoke well to our northward, though *N.C.4* must have passed close to it as she was farther north. Shortly after this *N.C.4* reported she was having oil trouble with one engine and was proceeding on three engines. She slowly dropped behind and we soon lost sight of her in the dark sky to the north.

N.C.3 and *N.C.1* continued toward Halifax. We did not sight Number 2 patrol though we saw her smoke coming down wind. We picked up Number 3 on our starboard hand. Shortly after we saw a heavy wind squall coming down from the north and as we could not avoid passing through it, came down from about 2,500 feet to 50 feet to meet it. The gusts were sharp and strong, and tended to roll us though they did not affect our longitudinal trim or our direction seriously. By sharp work on the ailerons, both pilots working together, we were able to keep right side up and on our course. I had made a tour of the plane and had just returned to my seat when we saw the squall. As the squall hit us Towers looked back at us anxiously for a few seconds, for none of us had experienced such weather in the N.C's before, but it was soon evident that the plane was well balanced and satisfactorily controllable and he returned to his navigation to correct our course for the new wind. This squall lasted probably twenty minutes.

On my tour around the plane I had to wriggle out of my seat to the side passage, and crawl on hands and knees to the rear compartment. There I found Rhodes stretched out on the floor resting. "Dinty" Moore was watching the engine gauges, seeing that gas was overflowing from the gravity tanks, watching the gas pumps, and from time to time looking over the engines and listening to detect any mechanical troubles or irregularity in firing.

Lavender was busy with his radio, and I did not disturb him. I then crawled forward through the starboard wing passage and went to Towers. He showed me on the chart where we were, and then told me that he preferred running at not more than 1,000 feet, as it was easier to determine the drift; that is, how much the wind set us off our heading, also that at higher altitudes this drift was stronger and made our speed slower over the ground.

Moreover, at higher altitudes, though we could still detect the smoke from the destroyers, it was more difficult to find them, and the destroyers themselves were almost impossible to see more than five or ten miles, even though the point of the smoke trail indicated their position. Under certain conditions white smoke was more visible than black against the sea background. This we discovered when passing one patrol, which according to instructions, started to steam toward the destroyer as we passed. When they changed the fires to stop making black smoke, they overdid it and made white smoke for a short while, and this was clearly visible.

After passing the squall the visibility steadily improved. We passed directly over patrol Number 4, soon sighted Seal Island, and then shaped our course to pass to the leeward of the Nova Scotia coast. This coast is high, rocky, and broken by gulleys and headlands and rocky islands.

From the time we got to leeward of this land until we landed in Halifax, we encountered very bad air and were in it for close to three hours. Vicious squalls continuously rushed down the gulleys and over the headlands, and mixed hot and cold air joined in giving us a battle to keep on our course and to keep from rolling down first one wing and then the other. At first it was quite a strain, but shortly, through unremitting practice, we learned how to anticipate effects and the best way to meet the puffs whose tracks we could see on the surface of the water.

McCulloch and I agreed to take half-hour tricks at the wheel, and this worked very well until we struck the squall above referred to and until we got under the lee of the land. In these puffs a wing would go down and it would take the efforts of both pilots to regain control, and though we divided up responsibility approximately half an hour at a time, we were both on the job most of the last three hours.

We had never expected to encounter such weather in these large seaplanes and were delighted to find that they responded splendidly to their controls.

Although we had hard work they never really assumed a dangerous attitude on this run.

As we approached Halifax we were alarmed by the report that we had but two hours' gas to do two hours' flying, and more so when two hours passed and due to the strong cross wind we were still some distance from Halifax. For each leg of the flight careful computations had been made as to the quantity of gas which would be needed to complete that leg with certainty. We had figured out that about 650 gallons would carry us to Halifax, allowing a safe margin in still air, and we had added 200 gallons reserve over this figure, and it was therefore hard to comprehend why our gas supply was so nearly exhausted. We later found out that the gauge readings were incorrect under way because the gasoline pumps drew off the same lead as the gauge. Later on, when we wanted gas estimates, we stopped the pumps to get true readings.

Approaching Halifax a beautiful rainbow column appeared over the land dead ahead. It extended in a broad band of brilliant colours from the hilltop to the clouds which were at about 6,000 feet elevation. The band of colours was about one third as broad as it was high.

Swinging into Halifax harbour we headed straight into the wind and though the gusts were still strong they were less troublesome then when nearly abeam. Descending easily we made a smooth landing about 7:00 P. M., abreast the stern of the *Baltimore*, surprising those on board who were watching the *N.C.1*, as we suddenly appeared from behind McNab Island.

We had lost sight of the *N.C.1*, but they had sighted her first coming in at much greater altitude.

About one minute after we landed we sighted the *N.C.1* while we were taxiing to our moorings. She made a pretty landing about ten minutes after us and almost on the same spot.

Skimming on the surface of the water at high speed, we frightened the captain of a schooner which was in our way. He put about to avoid us just as we changed course to avoid him, and it was only by sharp manœuvring that we prevented a collision.

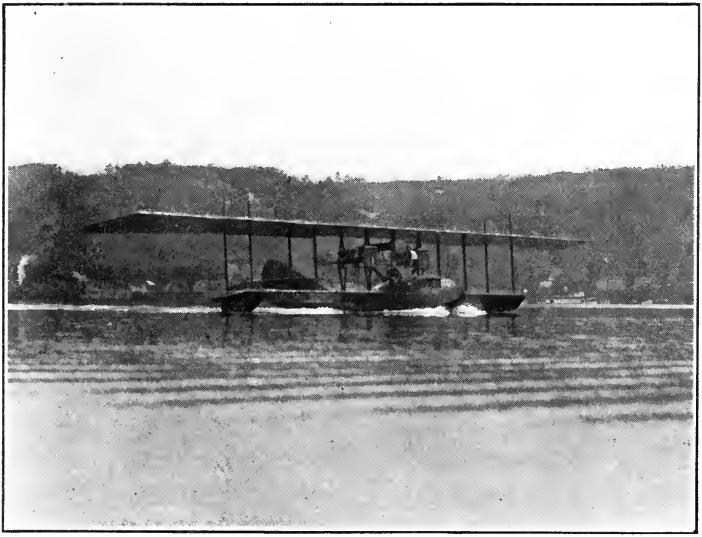
As soon as we moored the crews of the *N.C.3* and the *N.C.1* went on board the *Baltimore*. Here Captain Cluverius and Captain Hines and the officers of the *Baltimore* made us heartily welcome.

The *N.C.1* had had much the same experience as we had had, and all hands, particularly the pilots, were tired and ready to turn in after we had satisfied our lusty appetites with the fine warm meal which awaited us. However, as we had had no news of the *N.C.4* since she reported engine trouble, we were anxious concerning her and waited a while to hear from her. We could not understand why the *N.C.4* was in trouble. We had received no reports from her by wireless. If she had landed, why had no destroyer picked her up? We felt confident that in the condition of the sea near Chatham, when she fell behind, there should be no difficulty in her landing and taking care of herself. If she had landed right side up it was hard to understand her silence. We did not like to feel that the expedition had already been reduced to two planes, aside from our personal anxiety for the members of her crew. A false report of a plane over the city had us looking at a low red star which showed red and green through binoculars. For a short time it was mistaken for the plane. Later another star to the south was also thus complimented.

Coming into the harbour we had viewed it under unusual conditions. The full red sunset tinted the lower tufts of clouds with a rich crimson. This mingled with the lights of the city and the fading colours of the landscape, making a wonderful picture in which the citadel was a prominent form.

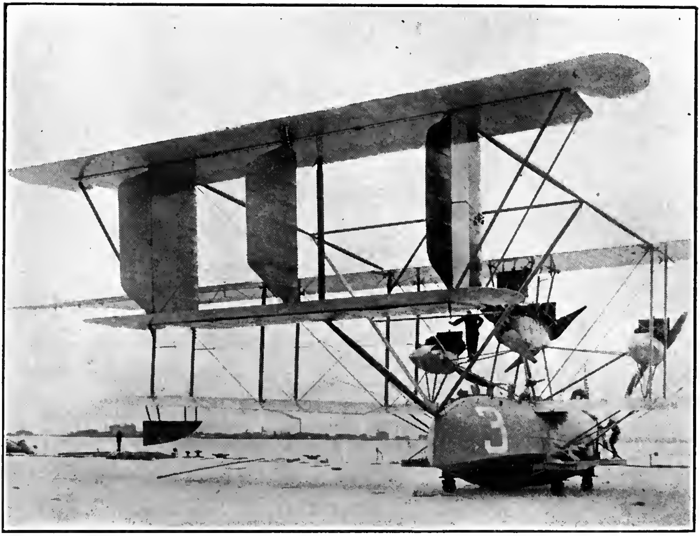
Crowds lined the docks, the tops of buildings, and the hilltops; and steamers and factory whistles added to the noise of the cheering crowds. But we heard none of it till we throttled our engines for the glide to the landing.

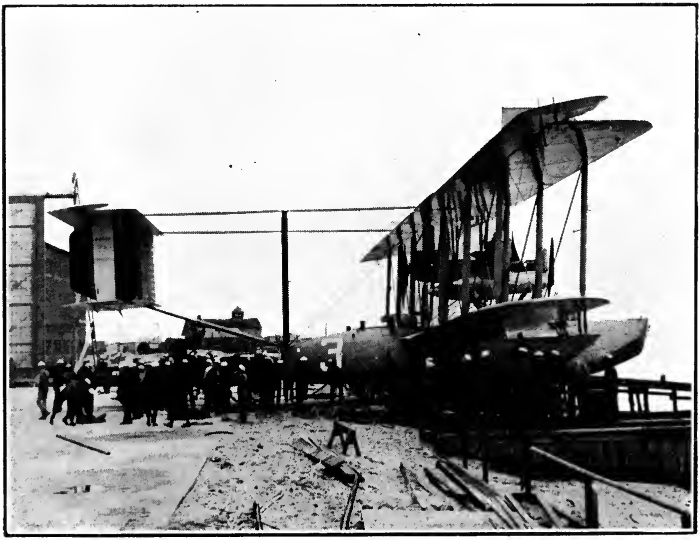
THE IMMEDIATE ANCESTOR OF THE CURTISS FLYING BOAT



THE *AMERICA* ABOUT TO TAKE THE AIR

She got away very rapidly with a light load, but could not leave the water with the load she was built to carry across the Atlantic. She was purchased by the British navy, however, and used in the training of pilots for the Royal Naval Air Service





© *International Film Service* (*lower photo*)

THE *N.C. 3* AT ROCKAWAY

(*Above*)—View from astern, showing the construction of the tail, the arrangement of the engines, and the four-wheeled handling truck

(*Below*)—A beam view, showing the big boat on the marine railway ready for her start

CHAPTER IV

THE SECOND "LEG"—HALIFAX TO TREPASSEY BAY

REFUELLING and overhaul were started at once under the direction of the regular plane crews, but the bulk of the work was carried on by plane crews trained at Rockaway and transferred to the *Baltimore* for the purpose. All base ships were similarly supplied with trained personnel and also with adequate spare parts, to provide for almost any normal contingency.

For the purpose of refuelling, the planes were brought one at a time to the stern of the *Baltimore*. This ship had been modified as a mine planter, and the large open port at the stern was almost ideal for the purpose.

The two planes had reached Halifax without any mishap, travelling 540 nautical miles in nine hours elapsed time. All the engines had run perfectly and the planes had been proved in very rough air.

As soon as we awakened the next morning we received the glad news that the *N.C.4* had been sighted making her way in over Chatham Bar. This was a great relief to us, and we now proceeded cheerfully toward preparations for the next leg of the flight.

The next morning the engines were tried out, but due to dirt and water in the gasoline supply difficulty was found in starting; and a final inspection showed that the tips of one propeller were cracked. The *N.C.1* had similar propellers, and although she was already taxiing we warned her of the danger and on inspection she also found the same difficulty. It therefore became necessary to change all propellers of this particular type. On investigation it was found that there were not enough spare propeller hubs to replace the special hubs used with the faulty propellers. For a few minutes we were stumped, but Lieutenant-Commander Byrd, who had had charge of the Halifax station during the war, remembered that at the time of transfer of this station to the Canadian Government spare hubs for Liberty engines had been transferred with other equipment.

We had no difficulty in arranging with the Canadian officials for the use of the necessary hubs, and preparations were continued though not completed in time to get away that day. Late in the afternoon both planes made trial flights to insure that everything was in order. The *N.C.1* did not get off till after sundown, and then made a moonlight flight over the city and harbour. Her running lights were brilliant objects in the sky and she presented a most beautiful spectacle, with her engines spitting flame as she sailed above the lights of the city in the late twilight.

May 10th we were up bright and early, but the night had been cold and there was some delay in getting the engines started. Finally, the *N.C.3* got the three tractors going, but the rear starter carried away and had to be replaced. In the meantime, the *N.C.1* got under way and warmed up her engines, and when we found that we would have to delay to change starters Towers ordered her to proceed to Trepassey.

Bellinger was glad of this for it gave him a chance to navigate on his own. The *N.C.1* took the air at 8:47 A. M. (N.Y. time), and climbing steadily soon passed out of sight at about 500 feet altitude beyond McNab Island.

About twenty-five minutes later the *N.C.3* got under way. We found the air rough, the wind being off shore, but not so bad as when we came in. Much to my annoyance and McCulloch's also, I found my arms muscle-bound from the unusual exertion of two days before, and I was sluggish to reaction on the controls to meet the bumps. About thirty-five miles out, when near Egg Island Light, oil pressure failed on the rear engine. McCulloch shut down this engine and we decided to land to note its condition. We landed easily, head to the wind, and ahead of a moderate ground swell from the south a few miles off shore. On examination we found the rear engine in satisfactory condition, but inspection of our propellers showed the starboard propeller tips damaged. We decided to return to Halifax and replace it. The return flight was uneventful except that McCulloch and I tried to turn in at every cove thinking we had reached Halifax. We used all four engines to get into the air, but immediately throttled the starboard engine to "idling" and made the run back on three engines. Because of lack of propellers to match our damaged starboard propeller, we had to change the centre propeller to the starboard engine and replace the centre one by one of the type that had failed. To save time we "radioed" the *Baltimore* to be ready to make this change. The change was completed about noon, and after our early lunch on the *Baltimore* we again got away at 12:40, taking the air at 12:45. This time I was in good condition for I had limbered up on the run back to the harbour.

Outside the harbour the wind had changed and, coming off the sea, was smooth till we had gone about thirty miles. Here it changed to an off-shore wind, and for the rest of the trip we encountered rough and bad air till in the vicinity of Newfoundland. Just before we reached Guyon Point Light we ran into contrary wind and the drift suddenly changed from 10° to port to 10° to starboard. We passed just inside Guyon Point Light. From this point we headed for St. Pierre. We sighted Number 1 patrol well to the south of us and evidently off station. As we proceeded the wind increased to an intensity of forty miles per hour across the course. About four o'clock we passed out of sight of the American continent, crossing the mouth of the St. Lawrence. We continuously fought through very rough air until St. Pierre was sighted about 4:30 P.M. Visibility was good and we picked up the patrols regularly. We tried various altitudes to get out of rough air, but with only minor success below 2,500 feet. Before we reached this altitude we found the wind much stronger across the course and unfavourable, and it was also more difficult for the navigator to determine the exact course we were making, and our progress became seriously reduced. Once we sighted land, however, navigation difficulties were reduced and, as the wind direction became more favourable on the new course, we climbed to 3,000 feet, where we found the air smooth but cold. To be certain of maintaining smooth air to the lee of the land we also worked well off shore. As a consequence, we could not see as far as the head of Placentia Bay, but we kept the point to the east in sight, and we sighted the patrol in the mouth of Placentia Bay. By the time we arrived off Trepassey we had worked thirty miles off shore. About twenty miles west of Trepassey we sighted a fleet of four large icebergs in line along a tide rip. At first these looked like sound steamers, but soon their intense whiteness and their odd shapes revealed what they actually were.

These icebergs, even from our altitude of 3,000 feet and at a distance of approximately one mile to our north, were of such size as to be prominent objects in the wide field exposed to our view. Their appearance was majestic as they moved on to the westward. The water in the vicinity of their margins appeared to be illuminated by the reflected light from the submerged portions, presenting a peculiarly beautiful appearance like that of the sun shining through the back of high breakers running in on the beach. It is probable that the peaks of these icebergs stood 150 feet or more out of the water, and as only about one ninth of the iceberg itself is exposed above the surface, the depth to which they projected can be imagined.

We arrived off Trepassey about 6:00 P. M. and then headed in for the harbour, making a détour in order to approach the landing headed into the wind, as we expected rough air under the lee of the land. It was now very cold and the radiators showed only 98°. We did not feel the cold except on our chins which were unprotected unless we ducked below the wind shields.

Approaching the harbour we started to descend. At about 2,100 feet, while McCulloch was forward consulting the navigator to get the lay of the harbour, we caught a vicious puff which sent the left wing down. I used all my strength on the aileron to recover, but got no response. I then used strong rudder to assist the left wing to rise but again no response, and I finally had to head down sharply, going down after the wing, in order to regain control. This manœuvre succeeded. It all happened in less time than it takes to tell it, and in another moment McCulloch was back in his seat ready to assist me. A long glide for the harbour of Trepassey was now started, throttling the engines only partially to stretch out the glide and to keep them warm. From time to time on the glide the engines were let out to clear them of oil, so they would not "die" when we wanted them again.

All the way down from 2,000 feet we struck vicious puffs which grew sharper and more frequent as we neared the surface and came closer under the lee of the land.

At one time we got a sharp drop, and Rhodes and a box he was seated on were tossed off the deck in the rear compartment. Heading into the wind, however, there was little difficulty with the ailerons and rudder; but we had to keep a sharp watch on the elevator and head down frequently to keep from being lifted sharply or to maintain full flying speed as the puffs would kill our headway.

We finally got down to from thirty feet to fifty feet of the water where strong swells were running, and at this altitude approached Powells Point Light, fighting all the way. At Powells Point we ran on the water until we reached mid-channel and then turned at right angles up the harbour, running at high planing speed across an avalanche of wind rushing across the harbour from the bluffs on the west side. Running this way it took all the strength of both pilots to keep the right wing up. We were frequently lifted clear of the water by squalls, each time being carried sharply to leeward and skidding strongly as we would again make contact. On our way in we had sighted icebergs in Mutton Bay and to the eastward toward Mistaken Point. Byrd had noted and reported broken ice in the sea outside. With our goggles befogged with spray we could not see clearly. Consequently when I sighted a cloud of spray from a speed boat racing in ahead of us, I thought it was a berg ahead and had visions of ice cakes floating in the harbour, and would not have been surprised if one had come crashing through the bottom of the hull at any moment.

Passing astern of the *Prairie* and the *Aroostook*, we soon saw the *N.C.1* at her mooring and rapidly approached our own mooring about 7:30 P. M.

The *N.C.1* had had practically the same experience we had had on each part of the run, but had entered the harbour flying in over the causeway and getting a nasty jolt doing it. On the way to her mooring she was slightly damaged by a sailing launch fouling the tail and breaking an elevator horn. She had arrived about 4 P.M. Leaving Halifax, Barin had tripped and plunged a hand through the deck. It was painful at the time, but the run to Trepassey made it worse and on arrival it was badly swollen and very painful from a sprain. Fortunately, under the doctor's care it was in good condition before we left Trepassey.

We at once went aboard the *Aroostook*. Captain Tomb and his officers, together with Captain Crenshaw of the Destroyer Force, Captain Ghent of the *Prairie*, and the crew of the *N.C.1*, met us and made us welcome. We were soon cleaned up and enjoyed a nice warm meal which was ready for us. We did justice to it.

During the meal and all the evening the wind continued to blow in such sharp gusts that we had grave fears lest the seaplanes would drag their moorings and be driven on to the rocky beach.

Every effort was made to get ready for the next leg of the trip. We all hoped that the *N.C.4* would arrive in time to join us on the trip to the Azores, but the weather was so uncertain that we felt we could not afford to wait if good weather should turn up first.

Trepassey Harbour is a narrow bay just to the west of Mutton Bay. On the west side are steep hills rising to about 300 feet elevation, with a steep bluff all along the western side of the entrance. A river valley forms a gulley on the west side which points for the main harbour at its broadest point in line with the causeway on the east side which connects Powells Point with the mainland. The inner harbour is too small to permit taking the air and crossing the causeway, and about the only way for seaplanes of large size to get away is to start in the broad part of the inner harbour and head straight out through the entrance. With northerly winds Mutton Bay is well suited for a getaway, but during our stay, except the first few days, a heavy ground swell from the south made it impracticable to taxi or tow out through the entrance. Even had that been practicable, the swells were so strong that it is doubtful if a getaway would have been made without serious danger of damage to the planes.

The town of Trepassey is a village of scattered frame houses on the east side of the harbour. The inhabitants were very cordial. They were proud of the fact that one of the officers of the *Aroostook*, Lieutenant James, was a Trepassey boy. He had not been there for thirty years, and he particularly enjoyed a flight with Ensign Talbott in a small flying boat.

This flying plane was a small two-passenger 100-horsepower plane. Two of them had been placed on the *Aroostook*, in order that by exploring the air in that vicinity we should know what conditions to expect on arrival there and when starting for the Azores. They served this purpose admirably. While at Halifax we received a report, as a result of such flights, that at practically any time of the day around Trepassey the air was decidedly rough and bumpy. It was for this reason that, on approaching Trepassey, we got so far leeward in order to bring these bumps dead ahead.

During our stay at Trepassey the local weather conditions were surprisingly good, though conditions on the Azores route were unfavourable, and on the route to Ireland were especially bad. The days were pleasant, but the nights were cold, and twice on calm nights the harbour was covered with a scum of ice. Because of the cold weather special steamlines were rigged on the sterns of the *Aroostook*, *Prairie*, and *Hisko*, so all the planes could warm up their oil before shoving off, to avoid possible damage to the engines due to cold oil.

A number of reporters from the States had come to Trepassey. They had converted an antiquated dining car to their uses, utilizing cots at night. This car was dubbed the *N.C.5*, and while at Trepassey it carried the Stars and Stripes on a flagpole at one end.

Sunday, May 11th, we inspected Mutton Bay and found conditions satisfactory for a getaway into a northerly wind, though long ground swells were running in from the south.

Overhaul went on rapidly. We carefully revised downward our spare parts lists and tool lists and equipment, eliminating everything practicable in favour of gasoline. We dispensed with the ground anchor, towing gear, and miscellaneous tools and spares; substituted a spare elevator wire for the sea anchor line; reduced our emergency rations to one per man, and put half our life preservers ashore. Some of us left our fleece-lined boots behind. We tore out about fifty pounds of floor slats and bulkhead doors and fittings, and even reduced some of the navigating equipment. We decided to attempt the trip with 1,700 gallons of gasoline, 800 pounds of oil, 5 gallons reserve radiator water, and to carry the reserve engineer if we could get off with this load.

In February the date for the start from Newfoundland had been set for May 14th. By the afternoon of May 12th, the *N.C.1* and *N.C.3* were ready at Trepassey, and the *N.C.4* was still weatherbound at Chatham.

We were now held up by unfavourable weather along the route to the Azores. By the evening of the 15th conditions improved except that locally a strong wind blew across the harbour and a strong swell was running in at the entrance.

We were loaded close to 29,000 pounds, which was greater than we had ever succeeded in getting off with in the trials at Rockaway, but we counted on some assistance from the wind though its direction was bad as it came over the hills with a strong down trend into the harbour.

Though the *N.C.4* had reached Halifax the night before she had been held by fog and had not yet reached Trepassey. On the morning of the 14th we had received new oak propellers, and all tractor propellers on the *N.C.1* and the *N.C.3* had been changed. We had much more confidence in the workmanship and material of the new ones than in those previously provided. They were of the type with which we had achieved the heaviest weight-lifting at Rockaway.

We therefore attempted to start, but the cross winds caused the pilots to become drenched with ice-cold spray, we were unable to get planing in the inner harbour, and in the outer harbour the swells were too strong to risk a getaway. The pilots felt that they needed a change of clothing and it was doubtful whether a fresh trial would be any more successful. As we turned back to the inner harbour the *N.C.4* came in. This settled the question, and we decided to wait till the next day so that the *N.C.4* could join us.

We were delighted to have the *N.C.4* with us again and proud that she had overcome the obstacles in her way. We could now start from Trepassey in full force. On returning to the ship, we found that the weather conditions predicted for the next day were as good if not better than those for that day. We now made an important decision, which was seriously to change the fate of the *N.C.3* and the *N.C.1*. We knew that the *C.5* had arrived at St. Johns and was standing by for an attempt at a transatlantic flight.

From the *N.C.4* we got the first news of the loss of the *C.5* as they had sighted her adrift about two hundred feet off the water to the south of Trepassey.

By strenuous work the *N.C.4* was ready the next afternoon.

Friday, May 16th, we again scanned our weights and decided to reduce our fuel to 1,600 gallons, as careful computations showed this to be sufficient to reach Horta in a calm, estimating conservatively. Ensign Barrat, our aerographer, assured that us we could also expect real assistance from the wind so that we should have more than an even chance of making Ponta Delgada without stopping at Horta. We decided that if we sighted Horta inside of seventeen hours we would not stop there as we should still have sufficient gas to reach Ponta Delgada.

In the morning a strong wind was blowing directly across the harbour so that it looked as if we should have to get away in Mutton Bay. To settle this all pilots were detailed to go in a launch, examine and report on conditions. We found a heavy ground swell running into the harbour and in all parts of Mutton Bay, and reported that it was impracticable to attempt towing or taxiing to Mutton Bay, to get off outside the harbour, or even inside the harbour with the wind blowing across it.

As the afternoon wore on the wind changed direction, making getaway conditions more favourable, and the weather reports indicated favourable conditions on the Azores route. If the getaway was delayed another day it might be several days before conditions would again favour. Finally, although it was reported that the sky was overcast and there was fog and rain at the Azores, we were assured these conditions would clear up before we arrived. Our weather forecaster in Washington advised us to "go."

CHAPTER V

THE THIRD "LEG"—TREPASSEY TOWARD THE AZORES

THE *N.C.4* was expected to be ready at any minute, so the *N.C.1* and the *N.C.3* got under way and warmed up their engines, waiting for the *N.C.4*, and taxiing around the harbour. We were delayed so long that we decided we could not wait and finally proceeded to attempt to get off. About this time the *N.C.4* shoved off and finally got her centre engine going. This had had no previous running since coming out of the crates.

Three attempts of the *N.C.3* to get off were unsuccessful. We had foreseen the contingency and decided that if necessary we could leave our reserve engineer and the radio converter behind.

In the meantime, the *N.C.4* got away easily. She circled over Mutton Bay for a try-out of her new engine and then returned to the harbour to wait for the flagship to start. She got away between our second and third trials and in the third trial we made desperate efforts to get off. We nearly made it, but failed again. Much to our regret, therefore, we put Rhodes, the radio generator, stool, and a few tools in the *Aroostook* and again attempted to get off—this time successfully.

(In the continuance of this narrative I shall give time as Greenwich Mean Time, which is four hours ahead of New York Summer Time. Local time changes too fast with longitude to afford any comprehensible record.)

By getting well back into the bight of the inner harbour, starting near the main wharf at Trepassey, we had about a half-mile run into the wind, and then had to turn and head out of the harbour with the wind almost abeam, to avoid getting under the down trend over the bluffs. By strenuous efforts we nearly got to planing as we reached the turn; by constant work on the controls we got to jumping before we struck the swells in the outer harbour, and finally we were able to "keep the air" as we passed Powells Point. We were quickly followed by the *N.C.4* and later by the *N.C.1*. The *N.C.3* got off at 22:06 G.M.T., the *N.C.4* at 22:07, the *N.C.1* at 22:09.

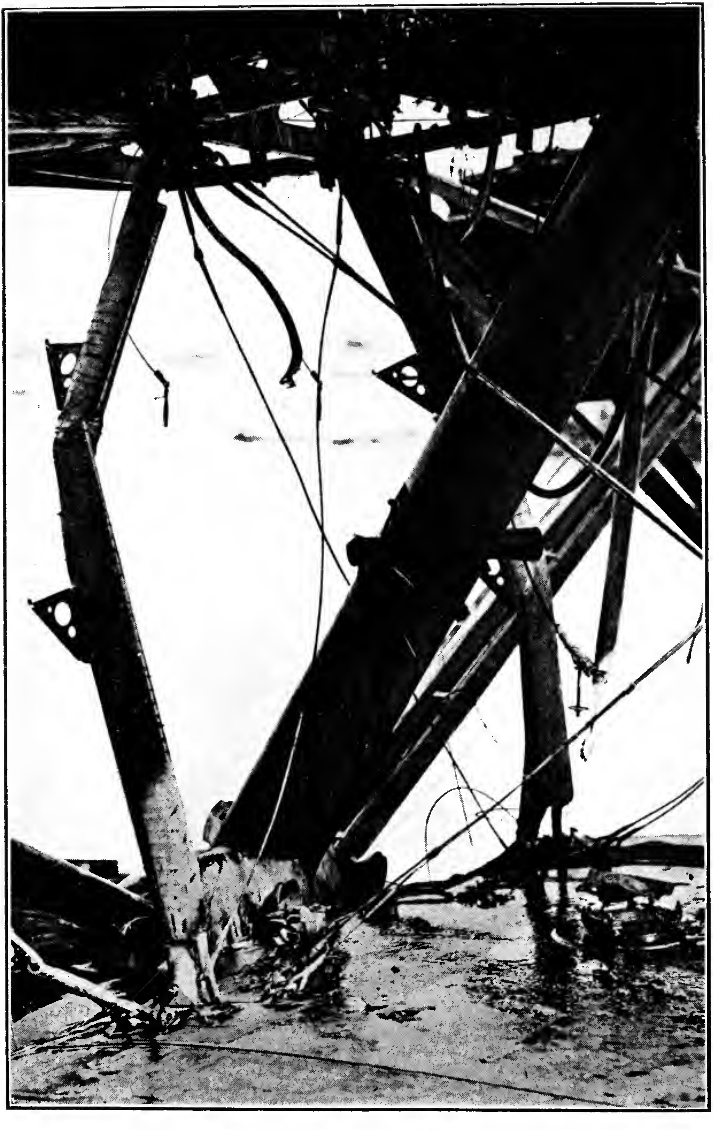
We were now off on the most important leg of the flight and one which was to prove extremely eventful. We had no fear of results as we had been through such bad weather on the way to Trepassey that we had confidence in the planes and their power plants. Practically all of our air stations had noted that when the wind came off the sea it was smooth and the air conditions were best except in advance of a big storm, when for days before the storm the air would become restless. We therefore expected that after we had gone one or two hundred miles from the coast that we should get away from the currents of the air coming off the land and find flying as smooth as a mill pond. But we were mistaken, as it will be seen as the narrative continues.

The air at the harbour entrance was rough, so we climbed slowly, turned, and headed for Mistaken Point. This brought the wind astern and we wallowed around a bit as we overtook the puffs.

We passed Mistaken Point at about three hundred feet at 22:15 and a few minutes later lost sight of land in the haze astern. We were off on what was to prove an eventful trip, sailing into the night with the land ahead nearly 1,200 miles away. We had every confidence of success.

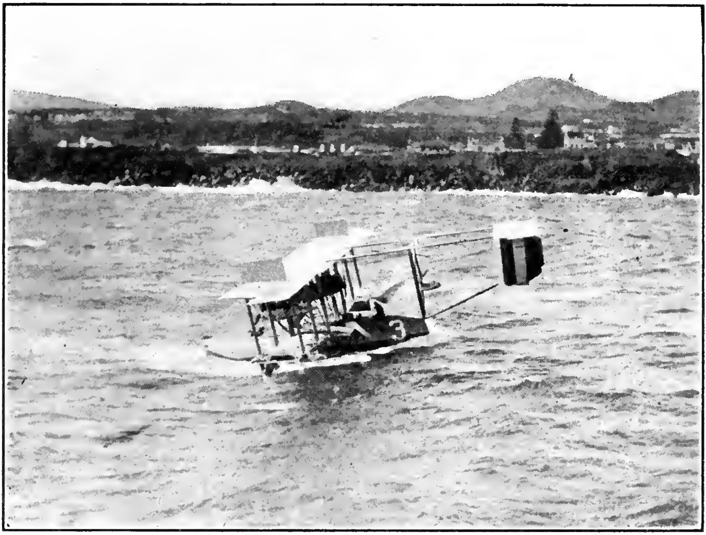
The sun set about 23:00 G.M.T., in heavy cloud banks, and it rapidly grew dark. Just before dark we passed close to a large iceberg and found the air rough in its vicinity. Fifteen minutes after passing Mistaken Point we passed a reserve destroyer specially posted and set our course down the lane of destroyers which at fifty-mile intervals marked our way to the Azores. The sky was heavily overcast, and there was practically no horizon to the south of us, while to the north the horizon was fairly clear.

We soon picked up the lights of Number 1 patrol on our port bow and from then on followed the patrols regularly and easily till Number 13 was sighted and passed. At one time we encountered the wake of another plane, probably the *N.C.4*, and got some good jolts from her propeller blast. Throughout the night the *N.C.3* found the air restless, and we tried different altitudes searching for better conditions. Due to grounding of the running-light circuits by salt spray, our running lights would not work and we had no lights on our pilots' compasses or inclinometers. The luminosity of the compass cards was very faint

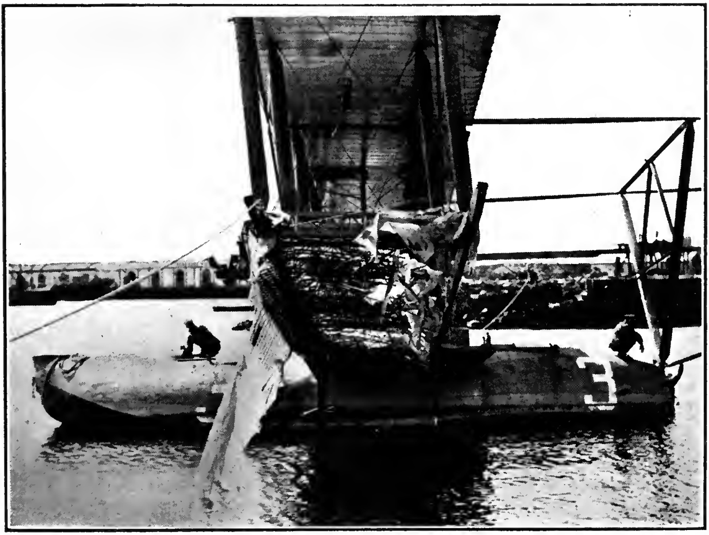


WHEN THE *N.C. 3* LANDED ON ROUGH WATER

"We were surprised and chagrined to find the forward engine struts buckled like a bull-dog's legs." Showing the damage to the forward engine struts and the slack in the flying wires attaching at the heels of these struts. An attempt was made to smooth the seas by the use of the oil with which the deck and wreckage is smeared



THE CRIPPLED *N.C. 3* BLOWING INTO PONTA DELGADA STERN FOREMOST



N.C. 3 AT PONTA DELGADA

The damage to the left wing may be closely studied. The wing ribs are practically all detached from the rear wing spur, but the internal wing trussing remains intact.

except when we would revive it with a pocket flash. They would then become brilliant only to fade out in about three minutes.

McCulloch and I had again agreed on half-hour tricks at the wheel, but the air was constantly so bad that even when off watch we had to stand by to assist and frequently had to work together for considerable intervals to maintain our course and balance. At times, in unusually turbulent conditions, we would divide the control. I would handle the ailerons and watch the wing tips and, by keeping the horizon line between the tip float and the lower wing tip, was able to anticipate effects of puffs and more easily keep in lateral balance. McCulloch would handle the rudder and elevator and keep on the course. This was necessary, for we found that the compasses were erratic and would swing with the plane unless we kept her from turning or from heeling. In this manner and with the assistance of the turn indicator we were able to make decent courses even in bad air. Even when the horizon was obscured, by the aid of the inclinometers we were able to avoid getting into dangerous attitudes.

Very few stars were visible, and until the moon was well up we had to depend principally on the instruments.

In daylight the handling of a big seaplane in rough air is reasonably easy because, with a visible horizon and objects on the surface to guide us, we can instantly recognize the attitude and movements of the plane and make corrections if necessary; but on this night the horizon was seldom clearly defined and at times the air was very rough so it became trying work to keep the plane properly trimmed by the aid of the instruments alone. About 00:03 G.M.T. the moon was dead ahead, blood red behind banks of cloud. Its form was much distorted and at first it showed about three layers. Instead of helping us, at first, it was a menace for it made our compasses and inclinometers almost impossible to read. Because of peculiar atmospheric conditions a brownish haze horizon line appeared on our starboard bow and confused us as to the true attitude of the plane. While passing Number 3 patrol we sighted two steamers brilliantly lighted up. At one time when near Number 5 patrol, because our running lights were not burning, we were nearly run down by the *N.C.1.* We warned her off with a pocket flash lamp. Her own lights showed up brilliantly.

Conditions got better as the moon rose higher, but we frequently had to change altitude to avoid layers of cloud and several times ran into wind squalls near the surface. Passing patrol Number 6 we were at 2,100 feet, but the air got so rough we descended to 1,400 feet where we found it better. We finally descended to about fifty feet between Number 7 and Number 8, but found the air very rough and started climbing again. We passed Number 9 about 4:10. We were now above the clouds and found smooth air for the first time. From now on the pilots were able to relax while off watch.

The navigator was constantly busy checking drift and position and keeping our track on the charts. The frequent shift of wind made this a continuous job.

Cruising along above a thin layer of clouds, we had another plane (*N.C.4*) in sight almost directly below us for the run from about Number 8 till we passed Number 13. At one time we climbed to avoid danger of her coming up under us. We could see her running lights plainly as she passed beneath open patches in the clouds.

About 4:00, as we sailed above the clouds, we appeared to be passing over a new country filled with enormous hummocks and billows of white as far as the eye could see. We were running about four hundred feet above the tops of the clouds. Looking down I frequently noted our shadow chasing madly over the hills and hollows below and saw that the shadow was surrounded by a rainbow, forming a complete ring just touching the tips of the shadows of the wings. This moonlight rainbow was weak, but the colours were distinguishable. I had heard of this phenomenon occurring in daytime, but had not expected to find it by moonlight.

We could now see the sky on our port beam steadily becoming brighter, and about 5:00 G.M.T. it was nearly full daylight.

Throughout the night run we could pick up the searchlights of the patrols at long distances and the star-shells even farther away. They would come up in a brilliant burst of greenish-white light arching over and falling even above cloud level.

Throughout the night wireless operators were constantly on the job, and although the air conditions had become such that we had become separated, each of us seeking better air conditions, we were still in wireless touch with each other and with the destroyers.

As daylight came we could still communicate with *N.C.1* and *N.C.4*. In order to keep above the clouds we had to keep climbing, so that finally, as we passed Number 13 at 6:23, we were up about 4,300 feet and just above the clouds, which were steadily getting thicker and higher. They finally became so thick that we seldom saw the surface, and it became more and more difficult for the navigator to keep track of our true course. While above the clouds I noticed that the hummocks seemed to move relatively to each other as if agitated by a ground swell. At first I thought it was because my eyes were tired, but after repeated observation concluded that the motion really existed and I later confirmed this as Towers had also observed it.

About the time we passed Number 13 I sighted the searchlight and a star-shell from Number 14 about two points on our port bow. Both were clearly visible though fifty miles off at the time. Shortly after this, as the clouds became thicker and higher and the sky was almost completely overcast, we decided to go down the better to check our course. Choosing the first opportunity we went down through a large hole in the clouds. Through this hole the surface of the sea appeared a blue black, and even in the half light of dawn waves were distinguishable at this altitude. The sun had not yet risen. We descended nearly 2,000 feet before we got below the clouds and there found ourselves in a sort of half-lighted room of enormous size having a bright silvery rim all around which were numerous squalls and patches of fog. The air was very restless. We searched the horizon for Number 14, fully expecting to sight her easily, but she was nowhere to be seen. Coming down through the clouds we even had some fears we might run foul of *N.C.4*, but as it turned out later it is probable that while above the clouds and after passing Number 13 we were set strongly to the south of our course.

For six hours we now ran into fog and rain squalls at frequent intervals. Sometimes we would dodge them, but often were unable to avoid them. Once we were caught in a fog so thick we could hardly see the bow of our own plane; another time we were almost blinded in a rain squall and started to land from about 600 feet, but before we got turned into the wind we ran out of the squall. Somehow, principally by the aid of our instruments, we managed to keep right side up though the air at times was very rough. We steadily approached closer to the surface to get better drift observations. We sighted only one more vessel that day. This was shortly after we came down below the clouds. Later we learned it was probably the *Marblehead*. It was well to our southward, so it only helped to confuse our position.

About 11:00 G.M.T., Saturday, having had only a short nap on Friday, the almost constant exertion on the controls seated in one position and the steady strain on my eyes caused them to become very heavy; and I suffered greatly from the mental effort to overcome my drowsiness, fully realizing my condition and my responsibility, driving a ten-ton seaplane at eighty miles per hour through bad air.

During the night I had had some coffee, but the coffee was now almost gone and was cold and did not help to keep me awake. Fortunately, before leaving Rockaway the medical officer, Doctor Schade, had explained the use of the first-aid kit and, anticipating just this effect of a prolonged strain in one position, had provided strychnine and caffein for the emergency. Remembering this I went forward and asked Towers for the first-aid kit and took a dose according to instructions. Temporarily I gained relief, possibly because of my exertion in crawling around the hull, but after about a half hour I was worse than ever and McCulloch, noting this, signalled Towers to give me another dose. This time the desired effect was obtained and I had no further trouble.

It now was evident that we were off our course, and at about 9:30 G.M.T. Towers reported that we were between Number 17 and Number 18, off our course, and asked for compass signals.

Later on Towers got a sight of the sun which indicated our position as well to the south of the line, and at about 13:00 G.M.T. he changed course to 90° magnetic. As nearly as we could determine we had already gone far enough to make the islands, but had had no sight of land or of any patrols since Number 13, and the visibility was so bad that we did not know but that we might pile up in some vineyard in the fog without warning. It became essential to know our position for we had only two hours' gas left, and we had to know how to use it to advantage. At the time of taking the sight the air conditions were so rough that Towers did not have complete confidence in it. We later found that the sight was substantially correct, and, had we held our course less than one hour more, would undoubtedly have found Pico.

Under these conditions, Towers asked McCulloch and me if we did not think we could land as he wanted to get a radio compass bearing. We both looked at the sea and decided it was possible; though as we were up about 500 feet we decided to look again closer to the surface. We swung down in a spiral to head into the wind. Closer inspection indicated conditions O.K. We had landed off Barnegat in seas nearly as rough as those we now saw, so we throttled down to make a landing. We struck the first crest rather hard and then found a long, deep hollow ahead. We dropped into this and "zoomed" to the crest touching easily and expecting to stick to the surface, but the swell dropped from under us sharply and sat us down very hard on top of the next crest, making contact forward of the step almost under the pilot's heels. This time we stuck, at 13:30 G.M.T., May 17th.

We were surprised and chagrined to find the forward engine struts buckled like a bulldog's legs. The engine had settled at least eight inches. The flying wires were slack, the aileron wires very slack. Further examination showed that the hull was leaking and several longitudinals and frames buckled and cracked. One hull truss wire had carried away, and the truss attachments to the bulkheads were strained as well as the connections of the tubular struts from the wing engines to the hull.

It was manifest that we could not resume flight even had the sea been smooth. The seas were running eight to twelve feet high at the time, and there was superposed a ground swell which added four to five feet at times. The wind was about twenty-five miles per hour.

CHAPTER VI

A SMALL CRAFT ON A LARGE OCEAN

AS WE sized up the situation we now realized that the Atlantic Ocean was very large and that we were very small. Moreover, we were in a not-much-travelled portion of the ocean, and to the southward of the usual steamer track. We did not yet know how serious the leakage was, nor did we anticipate that conditions were going to grow worse.

As we had placed the radio converter ashore at Trepassey we were without means of radio sending until we could relocate the radio generator in a propeller blast. We at once proceeded to do this, placing the generator on the diagonal strut to the port engine. As soon as this was done we started the port engine, but found we dared not run it more than 1,000 revolutions per minute as the engine foundation was damaged in landing. We did not dare run it long at a time for it drove us diagonally across the seas, and this endangered the starboard tip float and also produced dangerous pounding of the weakened hull. However, we were able to radiate about 2½ amperes which should cover a radius of 100 miles. For some reason, however, although we could hear destroyers working not more than forty-five miles away, they did not hear us. We also heard the *Columbia* and later got a radio compass bearing from her which fixed our position as about forty-five miles southwest of her when we landed. We later learned that the *N.C.1* was down with damaged left wing and that the search was "on" for her.

It was most annoying to be practically gagged, to be able to hear without it being possible to be heard. Still later we learned that the *N.C.4* had arrived alongside the *Columbia*, and was ready to proceed to Ponta Delgada the next morning.

Yet later we learned that the crew of the *N.C.1* had been rescued by the Greek ship *Ionia*, Norfolk to Gibraltar, and that efforts were being made to save the *N.C.1*. This was good news to us and we expected soon to see destroyers searching for us. Next we got the disheartening news that the search was "on" for us to the west of Corvo. This was based on the fact that we had last been reported as between Number 17 and Number 18 when we reported that we were off our course.

We were riding comfortably, head to the wind and seas, with an improvised sea anchor from the bow. The wind was sending us toward the islands.

We had landed after 15.5 hours in the air having covered 1,200 nautical miles or 1,380 land miles, enough to have reached Horta and still had two hours' gas left, more than enough to reach Ponta Delgada in the air.

We now proceeded to take account of stock and found our provisions amounted to a few dry jelly sandwiches, a few wet ones, some chocolate almond bars, and one emergency ration apiece. I did not learn until later that we had left our drinking water at Trepassey, but supposed I was getting rusty, greasy radiator water in order to save the fresh water.

We thoroughly realized our predicament, but as we were riding fairly easily except for the frequent jerks of the loosened wings, and the leaks were under control, we were not yet deeply worried and fully expected to sight a destroyer at any time, particularly after dark when their searchlights should be visible a long distance and we could attract their attention by Very's stars.

As we were all pretty well exhausted and conditions appeared favourable, about 20:00 G.M.T on the 17th we decided to stand two-hour watches. I took the first watch during which nothing was sighted and nothing unusual happened. I was relieved by McCulloch, and from then on in turn by Lavender, Towers, and Moore. The next morning about 6:00 G.M.T. I was aroused from a half-sleeping condition by a noise which made me think the hull had broken in two. Investigation showed that the seas had increased during the night and had grown so steep that the lower elevator had dipped into the wave astern wrenching the tail surfaces badly, and the noise had been made by the whipping of the control column. My next watch was from 6:00 to 8:00 G.M.T. Just as I was going off watch the rear edge of the left wing caught in the water, carrying away the trailing edge up to the rear wing spar. The wind continued to increase in strength and the waves grew larger. The contact of the tail with the water became more frequent and progressively increased the damage to the tail.

The wing damage also increased. We finally decided to cut off the trailing edge. Moore and I crawled out on the rear spar and after about twenty minutes' cutting and hauling managed to get it clear. Several times while doing so seas rushed over the lower wing and as they came up under the wing they would give it heavy jolts, breaking the wing ribs, and then sucking at the cloth on the lower surface tearing it away from the ribs with a sound like the rattling of a tin roof. This action was caused by cross seas which formed peaks which would rise between the hull and the tip floats. Ultimately, with the ribs broken, the cloth on top sagged; and the seas, rushing over, would fill it with pools of water which greatly increased the danger of rolling over, so we had to slice the wings. The wing cloth in this wet condition was very tough and not easy to cut. At 11:30 G.M.T. on the 18th, just twenty hours after landing, the left wing tip float broke away without warning and we rapidly drifted away from it.

This brought us face to face with the danger of rolling over and made it necessary to man the controls, working the ailerons to keep balanced, and the rudder to keep us square to the seas so that we should not also lose the right tip float.

We again attempted to broadcast an S.O.S. call, giving our position and asking for assistance, and then hoisted our ensign inverted as a signal of distress. We got no acknowledgment. By manning the controls and placing one of the crew on the right wing tip we were able to keep the left wing clear most of the time and to prevent yawing.

From now on the two pilots, assisted at times by the pilot engineer, stood watch and watch until we tied up at Ponta Delgada. McCulloch was seasick enough to prevent his taking any food, but not enough to stop him from taking his turn at the controls.

All day Sunday we kept one of the crew out on the wing tip; and as all members were busy taking turns on the wing tip, at the controls, pumping, or tightening up the tip float or main float wires, or cutting away damaged portions of the wings as they continued to disintegrate (the right lower wing had also lost its trailing edge), there was no opportunity for any one to get much sleep or rest. The radio operator kept listening in and from time to time we continued efforts at sending, but always without any acknowledgment.

When resting we would place cushions on the slats in the pilots' compartment and, with a life preserver for a pillow, get such rest as we could, but the swashing of water in the hull was a constant reminder of danger. The hull would settle and the wing tips would land with a thud on the wave crests, giving blows to the hull fastenings which they could not stand indefinitely, and jerking us as we tried to sleep. Our most disquieting thoughts concerned those at home. We could not tell them how things were going with us, yet there we were well and uninjured though we were in danger.

About mid-day we sighted what appeared to be "land" clouds, and as they opened up slightly we saw a part of Pico. At first we were not certain as we saw only a small portion of the slope, but as this line did not change while the contours of the clouds did change we were almost certain of it. By bearings and a sun sight we now located ourselves as forty-five miles southeast of Pico. We still had two hours' gas left and debated whether we should attempt to taxi to land. This, however, looked impracticable in the heavy seas then running, and would almost certainly have involved the loss of the right wing tip float and probably would have increased the damage to the hull. Moreover, our probable headway across the seas and wind would hardly have brought the land within reach with the fuel available, nor was it likely we could have reached land before dark. The idea was therefore abandoned with great reluctance in favour of continuing to sail to leeward, trusting the wind would remain favourable in direction and that by steering we could make a course which would carry us to the northward of San Miguel and through the line of patrol set for the *N.C.4* between Horta and Ponta Delgada. Should we pass the patrol line this course would take us into the route of shipping. At this time the wind was not sufficiently favourable for us to make San Miguel direct, even though we could steer safely about 10° to either side of the wind.

Our decision was arrived at after serious misgivings for it involved another night at sea and it was hard to give up the sight of land. At this time the seas were running very high, at times as high as thirty feet, and a forty- to forty-five-knot wind at least was blowing. (I base this estimate on the air speed meter reading twenty-eight knots, and our speed astern averaging more than twelve knots. The meter would read highest on the wave crests when we were travelling faster than our mean speed.)

Constant vigilance was necessary on the controls, not only to keep the left wing from going under, but to limit the punishment of the right wing, and also to keep from yawing which would almost certainly have meant rolling over, or at least losing our remaining tip float. The danger was very real, because some waves were curling and at times we would coast like a surf board at speeds close to twenty-five knots and at one time certainly thirty knots astern. This stern board reduced the velocity of the wind relative to the ailerons and rudders, taking away much of our power to control our course and balance.

The lower elevator was catching frequently and ever more frequently as its hinges carried away and it hung lower. Every time it caught it would jerk violently at the wires connecting it to the upper elevator, and this in turn was wrecking that elevator. We feared that when it carried away it might tear holes in the hull, so Moore and I cut the lower elevator wires adrift. We debated crawling out into the tail, but it appeared to involve too much risk so we gave up the idea.

About sundown by trial we determined that we could maintain balance just as well without keeping one of the crew on the right wing. We also found that with the ailerons neutral we could steer with much less effort and still have reserve control to keep the left wing from catching. This was important, for all hands had had very little sleep or rest that day, and it was dangerous for the man on the wing tip if he should fall asleep, for at times, in spite of our efforts on the controls, seas would wash over the wings and, should he be washed overboard in his flying togs, there would be almost no chance of recovering him, for as I said before we were averaging about twelve knots at this time. As a matter of fact, McCulloch was so exhausted that, while standing his watch on the wing tip, he used a safety belt to fasten himself to the wing strut and went to sleep for some time leaning against a stay wire.

We got such sleep as we could off watch, but seldom more than an hour or two at a time. It was so disappointing to come off watch and not be able to go below and get something to eat or have something else to do, that several times I stayed on watch over my time. In fact, part of the time the work was really fascinating, and if a destroyer had been within reach it would have been a real pleasure to have gone through some of our experiences.

On watch, through our exertions, we would become overheated in our flying togs, and off watch we would get chilled, due to the dampness of perspiration.

We had plenty of radiator water to drink, but didn't drink much as it was too unpalatable. None of us suffered from hunger, thirst, or exposure. The sandwiches were uninviting, though a bite of chocolate candy now and then and a cigarette or cigar afforded relief and helped us materially.

Sunday evening I felt quite fresh and stayed on watch till about eleven. It was more difficult fighting the seas at night for we could not see them much before they got to us and it was more difficult to hit them square to the crest which we had learned was necessary. The pilots had been to school and through compulsion had learned to "fly" backward and still steer a course, so that only once in a while were we caught in cross seas which put the left wing under, and only once or twice did it go under so badly that we had to call for help and send a member of the crew out in the right wing to assist in recovering balance. Cross chop was most difficult to handle and did the most damage to the lower wings. At times the seas were so steep that we would be supported by the peak of a wave which extended only from the front to the rear of the wing along the main hull, but in no case did we ship any seas in the main hull.

The right tip float constantly got severe punishment and it was frequently necessary to tighten up the float-bracing, as it slacked due to rocking. This nearly always meant that Moore would get drenched, though we tried to keep the float clear while he was on it. We found each wave crest had to be tackled individually nearly square to the crest and, because the wind frequently shifted in squalls and cross seas were running, this meant unremitting manœuvring. It was surprising how quickly the seas would change direction as the wind shifted and how quickly they would build up as the squalls came.

On Sunday we saw a number of gulls playing over the waves. It was wonderful to see them skimming the surface, never touching the water, and taking advantage of the changing velocities to bank and soar and maintain flight without apparent effort or beating their wings. They were the only signs of life we saw on our entire run excepting a few Mother Carey's chickens.

That night our eyes were strained and tired and several times we thought we saw searchlights, particularly after the moon rose, only to find that it was a spouting wave peak, the phosphorescence of a whitecap, or the moonlight on a wisp of cloud. After I came off watch I went back to the stern of the hull to see how the elevator was making out. While standing there I looked down into the water and saw what appeared to be a sort of sea serpent swimming along with its head about abreast the stern of the hull. It wove its way along like a monster eel. On closer inspection its body appeared much larger than its head which seemed quite small in proportion. After watching it for several minutes I found it was the elevator wire dragging in the water and making a phosphorescent streak as we rushed astern.

Early Monday morning we had heavy wind squalls with driving rain and about 18:00 G.M.T., the wind changed direction so that the best course we could make good was southeast. This was very discouraging for during the night we had been making a course which would take us close to Ponta Delgada, and the new course would take us clear of the islands. Fortunately, after two hours of this we were able to resume our course, which Towers had determined, by a moon-and-star sight, would carry us almost direct to

Ponta Delgada. Another sight of the sun about 9:00 G.M.T. showed us that San Miguel should be sighted shortly and while Towers was communicating this news to the pilots, Moore sighted land dead astern at 10:23 G.M.T. We soon made it out to be San Miguel. The effect of this discovery was remarkable.

All hands had fully realized our serious situation and the consequences that might at any time ensue from the loss of the right tip float, or the opening of the bottom under the severe racking of the hull, but aside from making preparations to have fresh water and emergency rations available in case of capsizing, and providing lashings of interior communication wire to lash us to the hull, we had none of us spoken of our thoughts to the others. Now all hands, except McCulloch, who was dozing, cheered up and came on deck. McCulloch overheard us in his half-sleeping condition, but, instead of getting up, rolled over and got a snatch of real sleep. Our spirits steadily rose as the land became plainer, and as it became possible to make a course for Ponta Delgada with certainty. We had not yet touched our emergency rations, but now became inquisitive and sampled one. We found it rather unpalatable and decidedly salty. It seemed to contain beans, dried eggs, dried fish, probably beef extract, and perhaps some cornmeal. It looked like plum pudding or brown bread, in the form of cakes about the size of a dollar and about three eighths of an inch thick. Besides these the package contained sweet chocolate. This was very good and refreshing. We once more attempted to radio, again unsuccessfully, though we could still hear the *Columbia* at Horta and now learned that the destroyers had been ordered to search to the east with despatch, but there was no likelihood that they would pick us up, and in our present situation this didn't worry us. We had learned that the *N.C.4* was not to join the search though previously it had been suggested she do so.

Shortly after we landed we had put over two canvas buckets as sea anchor, to prevent too much sternboard and yawing. This worked well and at the time much reduced the frequency with which the tail dipped into the water. We also tried oil on the water, but we were running too fast to leeward for it to be effective. Sunday, at one time, we tried out the sea anchor. In doing so I narrowly escaped injury through a loop in the anchor line around my leg. We finally got the anchor overboard, but its action was intermittent and too violent and it carried away in less than three minutes. For a while we rode without any sea anchor, but made too much sternboard to manœuvre satisfactorily. Monday morning we tried setting sail to make better speed, but this also was abandoned because we lost manœuvring power.

About 15:00 G.M.T. it was apparent that we should arrive at Ponta Delgada about two hours later. By tossing pieces of wreckage overboard and noting the time it took to drift past the hull we determined we were making about six knots. Shortly after, a rain squall overtook us and in a sharp shift of wind the bucket drag let go as we crossed the crest of a wave and made us yaw badly. The left wing went down sharply but finally came up again. Land was steadily getting plainer. The lighthouse, radio station, sugar factory, houses, and trees became visible. Farms, vineyards, roads, and buildings took on form and colour. It was manifest that we should soon be sighted. We were first sighted about seven miles from Ponta Delgada at about 16:12 G.M.T.

We had to keep well off shore as it was very probable that a sea breeze would be encountered close to the island which might drive us ashore on the rugged coast to the west of Ponta Delgada. On the other hand, we did not want to get too far off shore when it came time to taxi into the harbour.

As we got nearer we could make out the breakwater and shipping and a vessel at anchor in the entrance to the harbour. These were the first vessels we had sighted from the time we landed. A few minutes after we were observed we sighted the *Harding* coming out at high speed, shooting spray clean over her bridge as she raced to us. We at once signalled by Aldis lamp (electric flash) for her to stand by as we ran in under power.

The seas were too rough to attempt towing and we could manage more certainly under our own power when the time came. In the meantime, about the time we expected to be sighted, we had hauled down our distress signal and hoisted our colours right side up.

As we arrived about four miles west of the harbour, we found it increasingly difficult to maintain a course clear of the shore and had to work more and more across wind. This could be done only at considerable risk. That this risk was real was proven shortly, for as we arrived off the breakwater our right tip float let go. Dragging by two wires with its deck broken it nearly made us capsize by dragging the wing down. We at once started the rear engine. Moore went out on the wing, let go the turnbuckles on the two wires, and the second float was gone. Our danger was now so great that we asked the *Harding* to have a lifeboat ready at a moment's notice and to stand close by. We also asked the *Melville* to have two boats ready to place under the wings as we came up to our mooring.

Fortunately the wind was so strong that the ailerons remained effective, particularly with the help of the centre engine. Several times we rolled dangerously on to the right wing. We started the two wing engines next, and with Moore on the port wing we were able to keep balanced fairly well. Once more the wing went down, and Lavender started to go out to the opposite wing from aft, passing the rear propeller. Towers let out an unearthly yell which Lavender "got" just in time to save himself from the propeller.

McCulloch and I both had to work fast on the ailerons. We found it was most difficult to keep the right wing up as we were now heading into the harbour, and the wind was on our port side. Moore was out on the left wing. As soon as we found McCulloch could get along without my assistance I converted myself into portable ballast and relieved Moore on the left wing and with Lavender on the right wing, by running in and out on the rear wing spars we were able to keep from serious rolling until we got into the harbour and had boats under the wing tips.

As we entered the harbour of Ponta Delgada it was a perfect bedlam of noise and motion. Whistles shrieked from every craft in the harbour, the crews of the ships were cheering, and the shores were lined with cheering crowds. Ships, boats, and shore-boats charged about the harbour, the launches from the war-ships vying with each other to see which should be the first to take our lines. Thus two launches got foul of each other and of us as we neared the mooring buoy and both got their propellers fouled by the antenna wire we had used in making an improvised sea anchor. Two speedy motor-sailing launches came rushing along with punts in tow to go under our wing. The one to port passed by in seeming doubt as to what was expected of him. The one to starboard came up nicely. Then the man in the punt grabbed the right wing tip. He hung on until he was lifted about five feet into the air, when he decided to let go, and was lucky enough to drop back into his punt without capsizing. The port launch had swung around for another try and this time came charging up with its punt submerged.

Mack Sennett could not have staged a better roughhouse than was afforded by the efforts of these boats to be of assistance to us.

The sun was still high over the hills at the head of the harbour. All craft in the harbour had "dressed ship," and the colours in the bunting stood out brilliantly as the flags whipped in the stiff breeze.

The harbour is naturally beautiful with its tropical colouring. Pink, white, blue, yellow, and brown houses with red-tiled roofs in the foreground, were set against a background of variegated fields and tropical foliage under a brilliant sky. Add to this the relief from tension now that we were out of danger and our feelings may be easier imagined than described.

CHAPTER VII

ARRIVAL AND RECEPTION AT PONTA DELGADA

WE WERE tired and dirty, but happy, for all hands of the N.C. Division were accounted for. Though we had met with misfortune, we had had a wonderful adventure, and were not unmindful of the favouring winds which had made it possible for us to sail to our destination unassisted. We had had three days to get used to the idea that we were "out of it" so far as completing the flight was concerned. We had worked so hard, some of us for more than a year, with the trip in view; we had dared so much that the disappointment was a bitter one that we could not go on through the air.

If the damage had been confined to that existing at the time we landed, it is possible that we should have been able to make repairs and continue, but the loss of the lower wings, tip floats, and lower elevator, and the damage to the upper elevator put this out of question.

As soon as the *N.C.3* was secured at her moorings we went ashore where we were tendered a reception by Admiral Jackson and his staff. There were present the U. S. Consul and his wife, the Civil Governor and Military Governor of the islands and their staffs, the President of the City, and others.

On landing we found we had sea legs on, and reeled our way up the steps to the Admiral's quarters.

After being officially welcomed and very much photographed we repaired to the ballroom. We then were called to the balcony facing on the square, to satisfy a local demonstration of a crowd which had formed an impromptu parade, following a native band to the plaza in front of the Admiral's quarters. On our appearance the band played the "Star Spangled Banner" and the crowd gave a round of cheers, with a "Heap, Heap, Whoo-rrrah."

We each then cabled home.

After a good hot bath and making ourselves as presentable as possible with our limited outfit, we very much enjoyed a fine dinner which was awaiting us, prefacing the dinner with a trifle of six scrambled eggs apiece.

As soon as we could decently do so we then found our way to real beds and thoroughly enjoyed a good night's rest, knowing that those at home would also sleep well with the knowledge that we were safe and sound.

The next morning we got word that the *N.C.4* was coming from Horta. She came over the hills to the west at good altitude, making a long, easy spiral and landing in the harbour entrance. Coming through the air she made a great impression on the natives. Her reception was a repetition of that accorded us on our arrival. Shortly after, a destroyer arrived with the *N.C.1* crew. It was a happy reunion for us, tempered only with regret that we could not all continue, yet proud and hopeful that the *N.C.4* was still fit in every way and almost certain to succeed.

We now learned that the *N.C.1* had encountered fog at 11:10 G.M.T. at Number 18, and like us after travelling about 200 miles without sighting any patrols had descended at 13:10 G.M.T., also for the purpose of getting a radio bearing. She had landed without injury of any kind, apparently in even heavier seas than we had encountered, but found these seas too heavy to attempt a "getaway." Shortly after landing, a heavy sea rolled one wing down so deep that the upper wing entered the water, and the overhang of the aileron carried away, also the wing tip float let go. They tried out the sea anchor, but it carried away quickly. They then used a galvanized bucket as a sea anchor with better success, but the damaged aileron was a heavy handicap and they finally decided to taxi and use one engine. Even so they found it almost impossible to maintain control. After about three hours they sighted the smoke of a steamer and started to taxi toward it, but lost it in a short while. A little later they sighted another steamer, the *Ionia.* She appeared to be heading to one side and wireless failed to connect, for the *Ionia* had no wireless. They then headed for her as she appeared to be getting nearer; but they lost her in a fog. All hands were seasick and discouraged by this, but the lookout on the *Ionia* had discovered the tattered wing flapping in the wind and took it for a signal of distress. So she changed her course before the fog set in. About six hours after the *N.C.1* landed, the *Ionia* came out of the fog close aboard. With a fine display of seamanship the captain placed the *Ionia* across the sea close aboard the *N.C.1* and lowered a lifeboat, which also by excellent seamanship succeeded in getting to the bow of the *N.C.1.* By this time, though right side up, she was so badly damaged that Bellinger decided to leave her, but carried a line to the *Ionia* in an effort to tow her to port. The rescue of the crew was no easy matter, as the men had to come over the bow and the bow rose and fell with each sea so that one instant the boat was level with the bow and the next was twelve to fifteen feet below. Only expert work on the oars made the rescue possible, and the captain and crew of the *Ionia* deserve the greatest credit.

Efforts at towing were unsuccessful and the line soon parted. The position was noted and the *N.C.1* was then abandoned. The captain of the *Ionia* did everything possible to make the crew of the *N.C.1* comfortable and then headed for Gibraltar.

Bellinger informed him of the search that was "on" and how necessary it would be for the search vessels to know that the crew was safe. So, as the *Ionia* had no wireless, the captain changed his course and headed back toward Horta. Contact with a destroyer was soon made and the crew was transferred to the destroyer after expressing their gratitude to the captain of the *Ionia* and his crew.

To the crew of the *N.C.1*, elimination from the flight was just as bitter a disappointment as it was to the crew of the *N.C.3*. This disappointment was also shared by the crew of the *N.C.4*. But all hands were glad indeed to be saved, and pleased that one of our planes, which had been the lame duck at the start, was still ready and able to carry on the work of the division and ultimately win the honour of being the first aircraft in the world to cross the Atlantic.

The afternoon the *N.C.4* arrived at Horta the crews of the three boats were tendered a reception at the Governor's palace. It was a most impressive spectacle. On one side of the room Admiral Jackson, his staff, and Captain Wortman of the *Melville* were lined up with the crews of the planes, and were received by the Governor and his staff. On the other side were all the military and naval officials of the islands together with prominent civilians. Following the formal reception, the Civil and Military Governors gave enthusiastic and laudatory addresses of welcome, the first in Portuguese and the second in French. Admiral Jackson replied in Portuguese on behalf of the plane crews. After this there was general mingling of all hands and refreshments were served. The reception room was handsomely decorated and furnished, and made a wonderful setting for the occasion of the first of many receptions to be tendered the plane crews, in Ponta Delgada, Lisbon, London, and Paris.

It is interesting to note that the *N.C.3* sighted nothing after passing Number 13, encountering fog, squalls, and rain from then on, and she landed at 13:30 G.M.T. She would have sighted land in less than an hour if she had held her course.

The *N.C.4* encountered similar conditions after passing Number 17, but had the good fortune to sight land at Flores at 11:27 G.M.T., making her way to Horta and landing at 13:23 G.M.T. alongside the *Columbia*.

The *N.C.1* encountered similar conditions at Number 18, at 10:14 G.M.T., and sighted nothing else from then on and landed at 13:10 G.M.T. She must have passed near Corvo just before landing. Though abandoned in badly damaged condition on the 17th, she remained right side up until 13:00 G.M.T. on the 18th when she capsized, finally breaking up and sinking on the 19th.

The power plants of all planes were in excellent condition after fifteen hours of flying. There was fuel to spare. All planes had encountered bad air conditions which proved their airworthiness.

Except for the unusual combination of wind, fog, and heavy seas, all occurring in spite of favourable forecasts, all these planes would easily have accomplished this longest leg of the flight. In spite of these conditions the *N.C.4* did accomplish it.

Due to the foresight of the Navy Department, however, just such chances were discounted, and the flight was not agreed to until more than one plane was ready. Thus was its wisdom vindicated.

THE END

THE COUNTRY LIFE PRESS
GARDEN CITY, N. Y.