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The Aviator and the Weather Bureau

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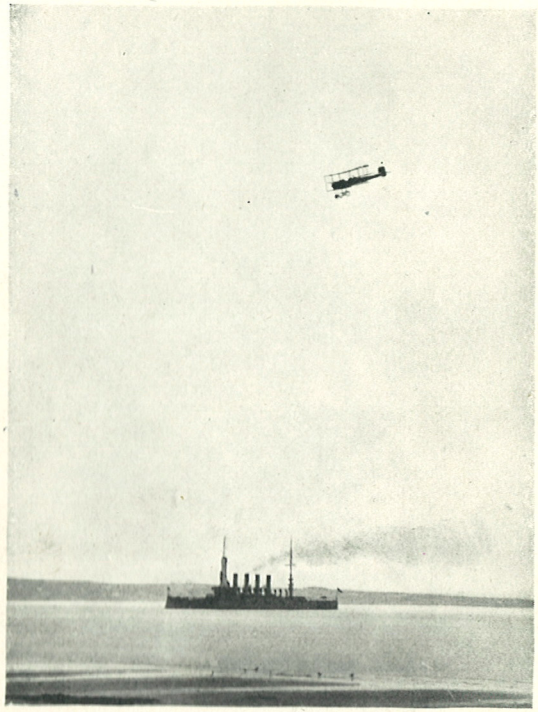

Army Airplane Gliding to North Island over U. S. Cruiser "San Diego"

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(1917)

The Aviator and the Weather Bureau

BY

FORD A. CARPENTER, LL.D.

Meteorologist

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Introductory Note

THIS is a brief but general account of the history of aviation as it is associated with southern California, a description of the War Department school of aviation at San Diego, a syllabus of the course of lectures delivered there on the subject of practical meteorology as applied to aviation, a narrative of weather-study from an airplane, and a recital of subsequent active coöperation between the aviators and the U. S. Weather Bureau.*

Much of the material in the following pages was obtained by the writer while detailed as Lecturer in Meteorology to the Signal Corps, War Department Aviation School at San Diego, in 1915–1916, also when detailed in the same official capacity to the U. S. Army Military Training Encampment, Monterey, 1916; and at the summer sessions of the University of California during 1914–1916.

LOS ANGELES, CAL.,
February, 1917.

*It may be remembered that the weather service of the United States originated with the Signal Corps of the Army and that the Weather Bureau was created from it by Act of Congress, June, 1891, and made a bureau of the U. S. Department of Agriculture. As a former member of the Signal Corps the writer enjoyed the renewal of old friendships among the officers at the Aviation School. Col. W. A. Glassford, Signal Corps, U. S. Army, Commandant of the War Department Aviation School at San Diego, kindly read the manuscript of the following pages and the writer gratefully acknowledges his valuable suggestions.

To
J. S. A.

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The Aviator and the Weather Bureau

CHAPTER I

THE SIGNAL CORPS AVIATION SCHOOL AT SAN DIEGO

History.—The year 1911 marked the beginning of the United States aviation school at San Diego. There is no finer tribute to the equability and general excellence of the climate of southern California than that given in the history of aëronautics. It was here, in 1900, that Chanute completed his early and epoch-making observations of the flight of gulls and pelicans. These contributed largely to the success of the Wright brothers a few years afterward. It was in southern California, six years ago, that Harkness, in an Antoinette, made his record monoplane flight to Tia Juana. San Diego witnessed the flying of the first seaplane, by Curtiss, five years ago. It is in this district that not only the War Department aviation school and a number of commercial flying schools are located, but also one of the large airplane* factories in this country.

Location of the School.—Whatever the final action may be as to permanent location, it has been con-

*The National Advisory Committee for Aëronautics in its report of October 17, 1916, on Nomenclature for Aëronautics, the name *airplane* is substituted for "Any form of aircraft heavier than air which has wing surfaces for sustention, with stabilizing surfaces, rudders for steering, and power-plant for propulsion through the air."

ceded by all authorities that the situation of the aviation school on North Island, San Diego Bay, is ideal. (See Fig. 21.) The so-called island is connected with the peninsula of Coronado by a narrow sand-spit, and it comprises many hundred acres of level land free from buildings and any sort of overhead wires. The island fronts the ocean on the south; Point Loma on the west with the narrow entrance to the bay between; to the north is the city of San Diego across the bay; and Coronado just beyond Spanish Bight on the east. This natural arrangement gives good air conditions for beginners, and also enables them to use the smooth waters of the bay as well as the rough ocean water for the seaplanes. The proximity of this location to San Diego is also a distinct advantage. (See Fig. 11.) All of the structures of the aviation school on North Island are temporary, the buildings consisting of a scattering array of huge sheds.

Character of Instruction.—Officers from all branches of the army volunteer for this service. The qualifications of an aviator are caution, judgment, and technical skill. Deficiencies in caution and judgment being temperamental are rarely remedied, while technical skill is largely a matter of acquirement. Less than ninety days are allowed for qualification as a junior aviator, and if in that period the officer's deficiencies are found to be inherent, he returns to his company.

The school is a place for hard work and quick thinking. Detail in the repair shop is part of the course, as is also the use of the gasoline engine in motor trucks as well as in aircraft. (See Fig. 22.) Theory and practice are closely united: the former is

carried on by means of bi-daily lectures, while the early morning hours are devoted to flying. Pilot-and-observer machines equipped with double control are used in instruction. The aviation instructor ascends with the student and allows him to manipulate the controls, only resuming the management of the airplane in an emergency. Needless to say, the life of an instructor is a most hazardous one and full of thrills. His duty is to be on the alert to correct errors in the manipulation of the machine. After every trip the instructor reviews, point by point, the features of the flight, showing the pupil his deficiencies and explaining how he may avoid them in the future. The instruction is terse but kindly, and the manner of imparting this information leaves nothing to the imagination. After watching student and instructor, and closely studying the finished work of an aviator, it is my opinion that in no other occupation must there be such perfect coördination between mind and muscle: the perfectly qualified aviator is the modern super-man.*

Results of a Year's Work.—During the year 1915, the students of the aviation school made 3,652 flights with a total time aloft of 1,516 hours, and a mileage of 95,000. As regards weather conditions affecting flights, it will be found interesting to note Chart No. 5 giving number of flights and duration for the fourteen months ending August, 1916, which shows that work progressed regardless of

*The army aviator of today is picked for his quickness of mind and body, and the first thing that strikes you about him is a sort of feline, wound-up-spring alertness. Then you note his reticence, the cool reserve of a man whose lot is to express himself in deeds rather than words. And, lastly, there is the quiet seriousness, verging almost on sadness, of a man who must hold himself ready to look death between the eyes at any moment and yet keep his mind detached for other things.—Lewis R. Freeman in the *Atlantic Monthly*.

weather, and at an increasing rate.* In February, a military tractor-seaplane (an all-California product), 125-horsepower motor, with twenty-six gallons of gasoline, four gallons of oil, and three passengers, making a total weight of 3,100 pounds, reached an altitude of 12,362 feet. This was the world's record, the previous altitude under the same conditions having been 9,000 feet.

*"It is estimated that the average cost to France of training each pilot is five thousand dollars . . . no less than from four to six months are devoted to the training of finished pilots. Although I have just come from France, the progress of aviation is so rapid that much of my own knowledge may be out of date before I again return to the front."—C. D. Winslow, "With the French Flying Corps," 1917, 4-5:N. Y.

CHAPTER II

APPLIED METEOROLOGY FOR THE AVIATOR

Activities of the Weather Bureau in Relation to Aëronautics.—Naturally the progress of aërial navigation has at all times been rather closely connected with the Weather Bureau. For over a decade the Bureau has not been content with surface observations but has maintained laboratories for the study of the upper air. The results of its observations are considered a mine of information for the student aviator. Prof. Charles F. Marvin, the Chief of the Weather Bureau, is a member of the National Advisory Committee for Aëronautics, and chairman of a subcommittee engaged on the determination of the problems of the atmosphere in relation to aëronautics.*

The first official coöperation between the Weather Bureau and the War Department aviation school was inaugurated in the year 1914 by Dr. W. J. Humphreys, Professor of Meteorological Physics, when he was detailed to give a course of lectures. It was during this course that he lectured on "Holes in the Air."† This paper has been reprinted as a textbook for the aviation school.

Early Studies in Aëronautics.—Unofficially, however, the coöperation extended back some fifteen years prior to that time, when the writer was in charge of the local office of the Weather Bureau at San Diego, and assisted the aëronautical engineer,

*Monthly Weather Review, 1915, 32:500, Washington.
†Popular Science Monthly, 1914, 44:18-34, N. Y.

Octave Chanute, in his observations and experiments on San Diego Bay.* At this time hundreds of photographs of sea-gulls, pelicans, and other soaring birds were made, and both birds and photographs studied and analyzed. Ever since then more or less interest has been taken by the writer in aërial navigation. During an assignment to the Central Office the work of the Wright brothers was observed and studied. The association with the late Octave Chanute and his friends, the Wrights, during their experimental flights at Fort Meyer, Virginia, in September, 1908, is counted among the many pleasant memories of the Washington visit. It was here that was witnessed the first flight with a passenger (see Fig. 4), Mr. Orville Wright taking up with him Major (now Colonel) George O. Squier, the present head of the aviation branch of the army. Such was the infancy of the flying-machine that at that date no fatalities had occurred. A few years later the writer had the pleasure of accompanying Mr. Glenn Curtiss while he was determining a site for his school, which was finally located on North Island. (See Fig. 6.) Shortly afterward, from this place, Harry Harkness made record amateur cross-country flights in an Antoinette monoplane.

Active Work of the Weather Bureau.—During the score of years that the writer has been in charge of the San Diego and Los Angeles stations of the Weather Bureau, interest in flying has been cumulative. Efforts have been made to furnish aviators with available data so that at the present time a day seldom passes without conference with officials or

*"Climate and Weather of San Diego, "Carpenter, 1913, 57–59, San Diego.

students of Government or private flying schools in this vicinity.

Lectures on Meteorology as Applied to Aviation.—Through the War Department, October, 1915, on request of the commanding officer of the Signal Corps aviation school, at San Diego, the writer was directed by the Chief of the Weather Bureau to deliver two lectures of which the following are outlines:

"What the Weather Bureau Offers the Aviator"

(Illustrated by 37 lantern-slides from photographs by the author)

Introductory:
- Weather service once part of the Signal Corps, U.S.A.
- Transfer in 1891 to the Department of Agriculture.

Distribution of weather stations in the United States:
- Character of data obtainable:
  - Advance data from the daily map such as
    - Position of high and low areas.
  - Weather conditions from sub-stations in vicinity.

The weather map:
- How constructed.
- How distributed.
- Specimen maps showing differing conditions in California.
  - Winds, velocity and frequency:
    - On-shore.
    - Off-shore.
  - Discussion of air conditions December 20–22, 1914.
- The international weather map.
  - Relation to weekly forecasts.

Cardinal climatic features:
- Ascending winds and types producing them:
  - Cloud, fog, precipitation.
- Descending winds:
  - "Northers" and dust-storms.
  - Thermograph and hygrograph traces.

Factors in the meteorology of southern California:
- Influence of latitude:
  - Sea.
  - Mountains.
  - Desert.
- Path and distribution of storm areas.
- Knowledge of local climatology necessary in flying.
- Local winds discussed:
  - "Woollies" (descending wind eddies).
  - "Chubascos" (south coast thunder squall).
  - "Santa Anas" (northeasterly and desiccating).
  - "Wilmingtons" (northwesterly line-squall).

"Practical Meteorology for the Aviator"

(Illustrated by 72 lantern-slides from photographs by the author)

Historical:
- Original work begun in Scotland, year 1749.
- Characteristics—
  - English work; Dines' minute meteorograph.
  - French work; Dr. Berson's balloon ascent of 6½ miles.
  - German work; detailed data in low altitudes.
  - American work began with Franklin.

The Upper Air:
- Definition:
  - "Stratosphere" is (according to some authorities) the dynamical laboratory of the atmosphere where the main causes of pressure originate.
- Results in America:
  - Balloon meteorograph (Fig. 3).
  - Charts showing rate of increase in wind velocity with elevation (Chart No. 4).
  - Wind, temperature, pressure, humidity at maximum airplane height of 26,242 feet.
  - Stratosphere:
    - Lower level in winter than in summer.
    - Lower temperature in summer when surface pressure is high.
- Definition:
  - "Troposphere" is the physical laboratory where cloud and rain are produced by local causes and induced by the effect of the dynamical changes in the upper air.
  - Conditions within 6 or 7 miles of the earth's surface.

Clouds and their Meaning:
- Cirrus:
  - Height and composition.
  - Formation:
    - Perpendicular shafts of clouds indicate rapid changes in weather.
    - Horizontal layers, no change and clouds will dissipate.
- Cirro-stratus, threatening in winter.
- Cirro-cumulus, fair and foul varieties differentiated.
- Cumulus with strong uplift.
- Alto-cumulus, cause of parallel rows.
- Fracto-cumulus, wind indicator, Point Loma "woolly."
- Stratus.
- Alto-stratus, favorable for flying.
- Strato-cumulus, long shallow rolls, threatening in winter.
- Cumulo-nimbus, unsafe air conditions for flying.
- Fracto-nimbus, waterspouts and their causes.
- Velo cloud, examples, cause, effect, distribution, density.
- Fog, examples of great fog-belts.

CHAPTER III

NARRATIVE OF WEATHER OBSERVATIONS FROM AN AIRPLANE

In order to qualify as meteorologist competent to confer with aviators, it seemed desirable to become personally acquainted with some of the conditions that confronted them. As a matter of professional acquirement therefore, I was glad to accept an invitation to go aloft after the necessary official arrangements had been made with Washington.

This trip was in line with the previous endeavors of applying practical meteorology to the science of flight and appropriately extended the work which was begun in San Diego with Chanute and the sea-gulls fifteen years before.

Object of Flight.—I wished to put myself in the student's place and learn at first hand the practical facts he demanded from weather observations and to acquaint myself with everything possible that might be of value to an aviator. There were two definite things of which I desired knowledge: first, to determine the height of the upward trend of the sea-breeze over Point Loma which causes the mysterious "woolly" of a score of years' acquaintance from a yachting standpoint; second, to observe the extent, form, and composition of the velo cloud which is the characteristic sun-cover of California.

Preparations for the Ascent.—Aviator Instructor Oscar Brindley (the 1915 winner of the Curtiss trophy), in military tractor No. 50, was assigned

as pilot. It may be stated here that the accepted definition of aviator is a pilot of a flying-machine heavier than air. The airplane used in my first flight (see Fig. 13) was made in Los Angeles and is the present standard army model. This tractor has an 80-horsepower engine and 8-foot propeller. It is 21 feet long, has a wing-spread of 38 feet, supporting area 364 square feet, and a flying radius, with two persons, of 300 miles. The maximum altitude attained with this model at San Diego was 13,000 feet. Before being placed in service the machines are thoroughly gone over at the repair shop (see Fig. 22), and the motors are run at full speed for twenty-four hours, after which they are taken down and subjected to scrutiny for possible defects. All of the struts, guys, and wires are closely examined; the boltheads are all drilled, wired, and soldered so that no amount of vibration will loosen them. Regardless of the length of the flight, each machine, before going up again, is given a rigid inspection and not until the mechanicians have tested every part is it pronounced ready.

Not being prepared with a regulation aviation suit, I was loaned a leather jacket by one officer, face-goggles and safety helmet by others. I then took my place in the observer's seat forward and was strapped into it with the safety belt (see Fig. 12). I was cautioned to let my body give way as the waist-controls were moved from side to side and not pay any attention to the steering rudder wheel which had a way of mysteriously revolving, advancing and receding.

In cranking an airplane, a certain formula is always gone through. The mechanician at the pro-

peller calls out, "Close!" The aviator closes the switch and repeats the word. This short-circuits the ignition apparatus so that no spark occurs in the cylinders. The propeller is turned in order to introduce explosive mixtures into the cylinders. When ready to start the mechanician says "Open!" The aviator opens the switch and repeats the word. The charges in the cylinders then fire when the propeller is turned.

After the engine starts, the machine is "trimmed" by helpers and jockeyed for a favorable "take-off" into the air. (See Figs. 14, 15.) This model of airplane climbs on a gradient 1 to 7; its minimum speed is 41 miles per hour. In other words, if the speed is less than 41 miles per hour the machine will not fly horizontally.

The Ascent.—The tractor was headed into a 30-mile northwesterly wind so that the "take-off" was quick and easy; there were only a few seconds spent rolling over the field, when the airplane left the ground and I felt the never to be forgotten cushioning feeling of the air. For ten seconds there was experienced a decidedly weakening nervous chill, which occurred to me once before when making a high dive from a spring-board. It was the sort of physiological disturbance that can only be counteracted by immediately pulling one's self together saying, "*Well, here goes nothing!*" The momentary depression was immediately followed by a corresponding elation of feeling which strange to say did not leave me during the trip and is always associated with thoughts of the journey. There was no dizziness, although I am peculiarly susceptible to the least change in balance. The earth did not recede as we progressed steadily

upward; we seemed part of the earth, but not of it. Although the airplane reached an altitude of 3,000 feet in a comparatively few minutes, the barometer falling from 30.0 to 27.0 inches, the decreased bodily pressure was not at all noticeable.*

Next to the supporting quality of the atmosphere I had noticed the 70-mile blast of air as the airplane pushed its way steadily onward and upward. Naturally, the exhaust of the motor in addition to the roar of the wind made conversation impossible. Some airplanes have telephone communication between observer and pilot. (See Fig. 9.) During one flight in a machine not so equipped, the passenger noticed the breaking of some apparatus. Knowing that it was impossible to make himself heard he hastily scribbled the word "Accident!" on a bit of card, whereupon the pilot shut off his engine and glided to earth.

Two-thousand Feet above Point Loma.—Carrying out my suggestion as to investigating the "woolly," the pilot drove the machine straight for Point Loma and those unseen aërial breakers. Suddenly there were two distinct "wallops" and I felt the fuselage beneath me respond as if struck by a stuffed club. There was evidently first a surge then a drop, and it was the descending current of air that deprived the airplane of the supporting medium, hence the shock. Point Loma itself, from this altitude, and seen directly from above, looked very like a barracuda's backbone—long, low, and ugly. Although this peninsula (see Fig. 21) is less than 500 feet high it so effectively deflects the prevailing northwesterly wind that the upward surge has been noticed by aviators

*Trans-American Climatic Association, 1915, 31:20, Hot Springs, Va.

at an altitude of 4,000 feet. It is no wonder then that these descending winds, called "woollies" (from their churning the water into isolated masses which look like tufts of wool), are dreaded alike by yachtsmen and birdmen. They have been known to carry away topsails from too closely venturing schooners and student aviators always give the vicinity of Point Loma a wide berth.

No Winds Aloft.—We had not changed our direction since leaving the ground, but after passing over Point Loma the airplane was put sharply on a port course. I had been expecting this and must confess, somewhat dreaded it, innocently thinking that a 30-mile wind added to our 70-mile rate of speed would "heel" the craft to an uncomfortable angle when the course was changed from northwesterly to southerly. What was my astonishment to find that the putting about was unaccompanied by any of the nautical motions such as tilting or canting. Theoretically one may be ever so well grounded in physical laws but it seems to take actual experience to bring their truth home to us. Of course there can be no wind *in* the air; when we entered the air it was moving 30 miles an hour in relation to the earth but as soon as we were free from the earth the velocity of the wind had no effect on our flight. No matter how strong the gale, so far as it concerned the airplane, if the wind be steady no difficulty is experienced; the aviator is concerned only by windshifts.

The Velo Cloud Seen from Above.—In kindergarten days I remember that one of the first questions I asked was "Are clouds smoke?" And this early query was really first answered in the air. Fog on a mountain

top may be cloud, but somehow cloud free from close proximity to the earth seems different.

The machine was put through the cloud blanket much as a horse takes a hurdle; it seemed unlike fog and more of a palpable substance. As we emerged, the sun was shining on it like a silvery sea with gently undulating surfaces and it looked for all the world as supportable as layers of cotton-wool. Many times have cloud-banks from mountain tops been observed, yet the upper side of the velo cloud from a flying-machine looked very different. The cloud was only four or five hundred feet thick and extended inland a few miles in irregular outline. The seaward edges of the velo cloud were not ragged, and apparently paralleled the coast for 10 or 15 miles.

Such was the exhilaration and confidence the air gave that I can understand how parachute jumpers confidently step off into space, for to them the air is a supporting medium no more terrible than a transparent sea to a good swimmer. I believe that the record parachute drop was made in 1916 by Colonel Maitland, of the English Royal Flying Corps, who descended in a parachute 10,000 feet from an airplane. Fifteen minutes was occupied in the descent.

Ease of Vision at 3,500 Feet Altitude.—At this altitude the ease of vision is most remarkable. At this height, *with perpendicular vision,* the eye is possessed of wonderful powers. In those "solitudes august with stars" men not only "mount up with wings as eagles" but are given the eagle's unobstructed vision. Birds have been credited with much too keen vision. From this height of several thousand feet every object stood out with remarkable distinct-

ness. Automobiles racing along the El Cajon boulevard to Lakeside were readily picked up with the unaided eye although 20 miles away. Looking down over the aviation field the long compass mark and the wind-direction pennant (Figs. 19 and 20) were easily distinguished. The bay and ocean, however, gave the most remarkable revelation, for the bottom of the bay and the shallow ocean shore were plainly discernible. The absence of water as well as air refraction explains why submarines cannot hide from an airplane: one of the army aviators told me that a submarine cannot ordinarily sink so low that it cannot be seen from an airplane.

Color of Landing-ground Important.—Owing to the absorption and reflection of sunlight, there is a distinct variation in the character of otherwise similar landing-ground. A field, dark from recent plowing (or burning), will heat the air over it faster than will a field of stubble, hence over the former field there will be the greater air disturbance, and this will affect the ease of landing. Air is heated by contact and convection. One of the aviators said that recently he was descending, and had all but reached the ground when a localized convectional current hurled his machine upward some distance but immediately afterward deposited him on the ground without damage.

Spiraling Down 3,000 Feet.—Speeding ever in wide circles the course lay southeast over the upper part of San Diego Bay. The city of San Diego presented the usual checkerboard appearance (Fig. 16), and even at this altitude it would seem easy to drop an orange at almost any point. The velo cloud was lifting and we could see the gradual disappearance

as it melted rather than drifted from North Island. (See Fig. 17.)

The gliding descent was made from an altitude of 2,500 feet, starting above San Diego. As the aviation school was approached, we could see a number of machines in the air, three below and two above us, circling about like hawks. And, like soaring birds, these machines had their air-lanes, designated courses and levels being devoted to the different classes of machines. The landing was made without incident and the hour's flight was ended.

Outline of Meteorological Work at the Aviation School.—At the close of the lecture detail, the attention of the student aviators was called to the importance of their having as thorough knowledge as possible of the fundamentals of meteorology. The application of these fundamentals to the analysis of air conditions met with in their daily flights was shown to be essential. Investigations as to varying wind direction were taken up by one of the staff instructors by the use of small parachutes to be dropped at different altitudes. (See Fig 8.) Through the coöperation of the local official in charge of the San Diego Weather Bureau station, duplicate signal sheets were available from which the student officers made their local weather maps. From these maps and their own flights, they could arrive at some relationship between the actual and the theoretical 3,000- and 10,000-foot level maps prepared from the Bigelow formula, as used by the Bureau. Lectures were given on temperature and its distribution; winds, moisture, and clouds were also made part of the course, one of the papers of the Bureau* being re-

*"Clouds of California," Carpenter, 1914, 24, 2d ed., Ft. Leavenworth (U. S. Army Press).

printed by the aviation school by permission of the Chief of the Bureau and used as a textbook. The Weather Bureau furnished the station with a standard set of meteorological instruments so that the student officers could become perfectly familiar with the regular equipment at the Weather Bureau stations.

Extending the Usefulness of the Bureau to the Aviators.—Practical utilization by the aviators of this district of the information possessed by the Bureau has received considerable impetus during the past six months. During the cross-country flights of April and May, 1916, the Los Angeles station was directed by the Chief of Bureau to furnish weather and flight conditions between San Diego and Los Angeles. With the aid of the general weather-map data from the regular stations, and special observations of wind, weather, and fog conditions on the immediate coast near Los Angeles, and on Mount Wilson, it was possible to issue satisfactory forecasts of flying conditions. The eye-observations of fog-heights as determined by the Weather Bureau co-operative station at the Mount Wilson Solar Observatory were especially valuable. From this mountain (6,000 feet elevation) it is possible on a good day to see the whole length of the coast from Point Firmin, San Pedro harbor to Point Loma, San Diego Bay. Knowing different levels, the observer at Mount Wilson was able to give actual thickness and extent of the fog-belt and its past twenty-four-hour history.

CHAPTER IV

INVESTIGATING THE UPPER AIR

Balloon Soundings into the Stratosphere.—It was the writer's privilege to be present when some highly interesting and instructive experiments made by the Weather Bureau in coöperation with the Smithsonian Institution, in sounding the upper air were made at Avalon, Santa Catalina Island, off the coast of southern California in July and August, 1913.* The results of this work were in close agreement with similar soundings of the upper air throughout other surveyed portions of the earth's atmosphere, and a record ascension for this country was made on July 30—32,643 meters or 20½ miles. In common with other observations of temperatures in the stratosphere, the minimum temperature of these soundings (–90 F., August 3) was registered within the first 10 miles.†

Of especial interest to the aviator is the table on the next page which shows wind velocities increasing with elevation as determined by observations of the Avalon balloons.

*University of California Chronicle, 1915, 17:1–25, Berkeley.
†Monthly Weather Review, 1914, 42:410, Washington.

RECORD OF AVALON ASCENTS, JULY–AUGUST, 1913

Table showing Theodolite observations of wind velocities (meters per second) at elevations of 1,000 and 5,000 meters

Meters	Meters per second 5 p.m. July 24	Meters per second 5 p.m. July 27	Meters per second 10 a.m. July 31	Meters per second 10 a.m. Aug. 1	Meters per second 10 a.m. Aug. 2	Meters per second 5 p.m. Aug. 3	Meters per second 4 p.m. Aug. 7	Meters per second 5 p.m. Aug. 8	Mean
1,000	2.5	1.0	5.6	6.6	2.3	5.8	7.1	1.9	4.1
1,500	6.2	0.8	6.2	8.1	3.3	5.0	6.4	1.5	4.7
2,000	8.0	1.2	5.8	7.0	4.1	4.5	6.5	6.0	5.4
2,500	10.0	1.8	10.8	5.7	5.2	4.2	4.7	3.6	5.8
3,000	12.0	2.3	9.4	6.1	7.2	5.2	3.5	4.1	6.2
3,500	12.8	2.5	8.0	6.7	7.4	6.1	4.6	4.6	6.6
4,000	13.6	3.8	11.2	7.4	9.2	5.2	6.4	3.2	7.5
4,500	14.3	5.2	14.6	8.5	11.2	1.8	7.8	3.0	8.3
5,000	21.2	6.2	12.8	10.3	10.4	2.3		3.4	9.5

Charts Showing Upper-air Weather Conditions.—It is believed that the following charts when examined in connection with the accompanying explanation in the text will give the reader something of an outline as to the conditions existing in the upper regions of the atmosphere.

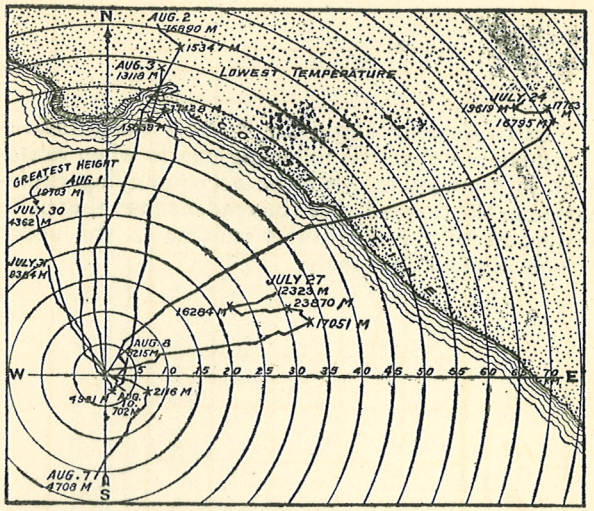

CHART NO. I

Horizontal Projections of the Paths of the Sounding Balloons Liberated at Avalon, California, July 23 to August 10, 1913

Reproduced from the *Monthly Weather Review*, 42: 423

This figure shows the horizontal projections as far as the balloon was observed, not the entire distance traveled until it landed.

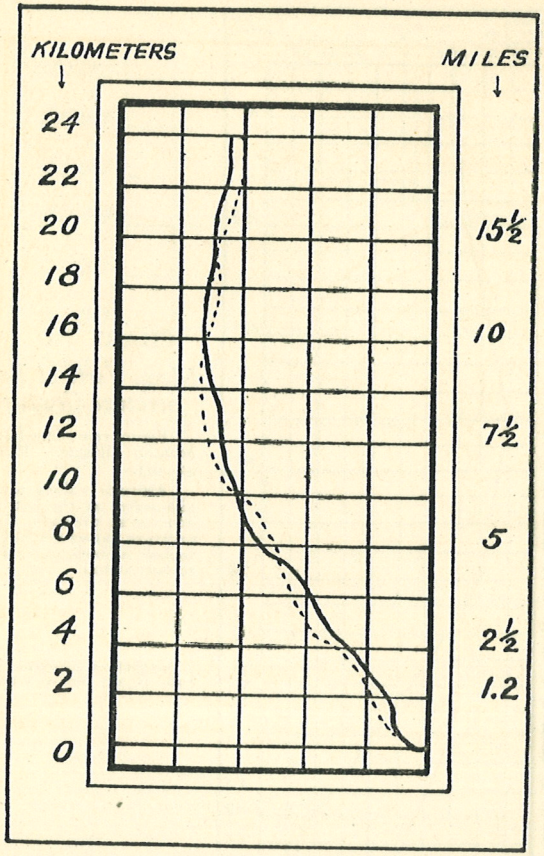

CHART NO. 2

Vertical Temperature Gradient, Avalon, California, July 27, 1913

Solid line represents the ascent of the recording apparatus, the dotted line the descent. (Verticals 25° C. or 45° F.)

Reproduced from the *Monthly Weather Review*, 42: 412

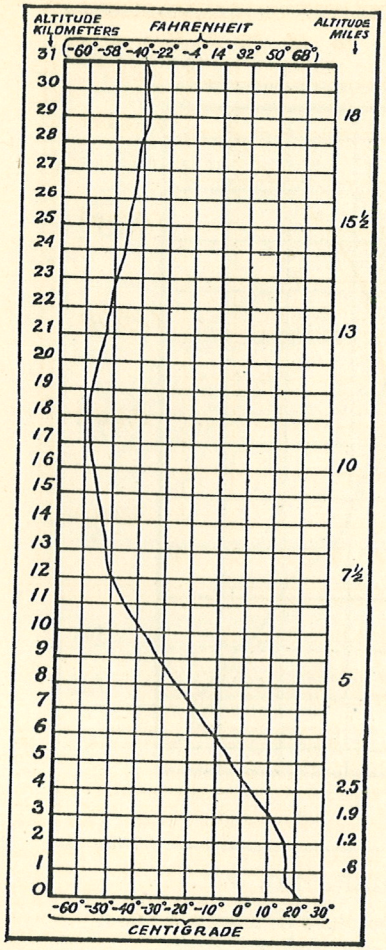

CHART NO. 3

Mean Vertical Temperature Gradient

Figure reproduced from *Monthly Weather Review*, 42: 413.

Altitude values are in kilometers at the left, and in miles at the right. Temperature values are in Centigrade at bottom, in Fahrenheit at top.

Maximum airplane altitude 26,242 feet or 5 miles.

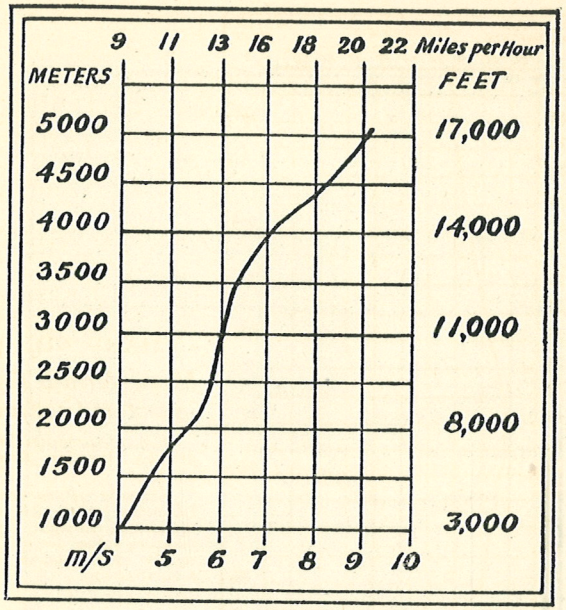

CHART NO. 4

Diagram Showing Increase of Wind with Elevation Data from Eight Meteorographs

From the article "Free Air Data in Southern California, July and August, 1913" by Dr. Wm. R. Blair, Professor of Meteorology, in the *Monthly Weather Review*, for July, 1914, it is learned that the wind shifts from west to east rather abruptly at 16 to 20 km. (10 to 12 miles); below this level down to about 5 km. (3 miles) it is quite uniformly from the west. Extremes: Maximum wind velocity 21.2 miles, 5,000 meters elevation, 5 P.M., July 24; minimum wind velocity 0.8 miles, 1,500 meters elevation, 5 P.M., July 27.

The table shows a steady increase in velocity of the wind with elevation, the data being obtained from the eight meteorographs. There were four morning flights (July 31, August 3, 7, 8) and five afternoon flights (July 24, 27, August 3, 7, 8, 1913), and elevations were computed for nine heights, 1,000 to 5,000 meters. Beyond the 5,000 meters the records show that from 2 to 7 miles altitude the wind increases at approximately the same rate that the density of the air decreases.

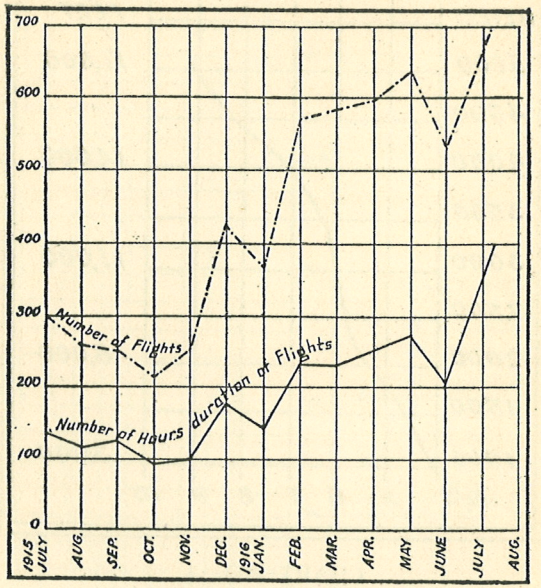

CHART NO. 5

Chart Showing Number of Flights and Duration in Hours for the Months of July to December, 1915, and January to August, 1916

Prepared by the War Department, Signal Corps Aviation School, San Diego, California, and furnished through the courtesy of Col. W. A. Glassford, Signal Corps, U. S. Army, Commanding Officer, September 14, 1916.

FIG. 1. CONGRESSIONAL MEDAL AWARDED WRIGHT BROTHERS

(Designed by Morgan)

This medal was awarded Orville and Wilbur Wright by resolution of Congress, March 4, 1909. Bronze replica in possession of the writer.

Photographed May 31, 1916, by permission of the Director of the Mint, Philadelphia

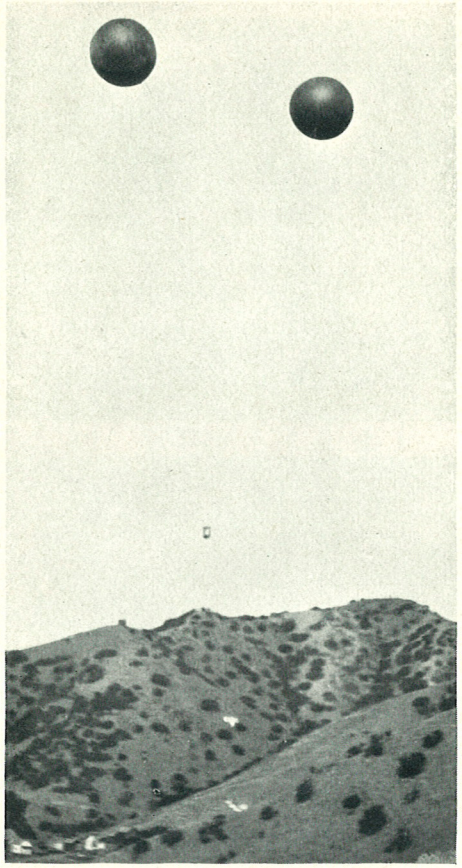

FIG. 2. ASCENT OF SOUNDING-BALLOONS AT AVALON

Photographed July 27, 1913

This set was liberated from the base of the U. S. Weather Bureau, Avalon, Catalina Island, California, at 4.57 P.M., July 27, 1913, and rose to a height of 23,870 meters in one hour and three quarters when one of the balloons burst and the descent began. This was observed by Carpenter at the theodolite.

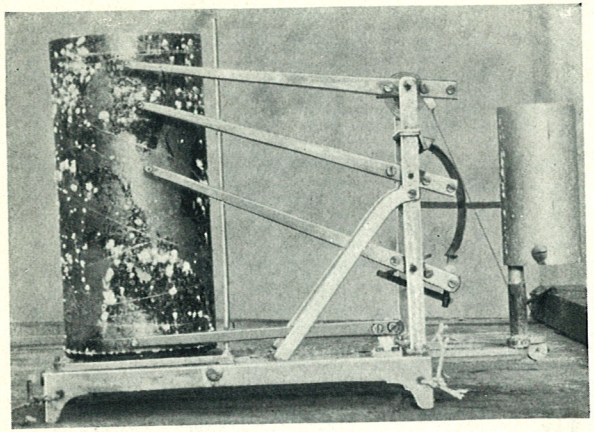

FIG. 3. METEOROGRAPH WHICH MADE THE ASCENT OF JULY 27, 1913

Photographed August, 1913

This meteorograph rose to a height of 23,870 meters (94,716 feet), at which height the pressure was 23 mm. (0.906 inches), temperature −52.1 C (−58 F.), relative humidity 21 per cent, wind E. (or more precisely S. 79 degrees E.), velocity 6.1 m.p.s. (14 miles per hour), but the minimum temperature was registered at 15,228 meters (49,960 feet) when the thermometer showed −64.7 C. (−85 F.), at which time the pressure was 89 mm. (3.504 inches of the barometer), relative humidity 19 per cent, wind N.W., 3.4 m.p.s. (8 miles per hour).

The basket was picked up at sea off Oceanside, San Diego County, about 90 km. (145 miles) east of Avalon.

For the first 6 miles of ascension the balloon moved upward at the rate of 8 miles per hour.

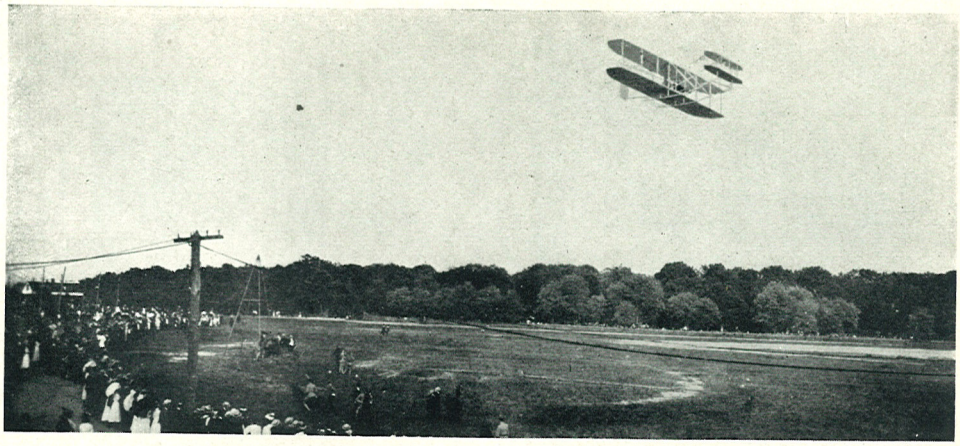

FIG. 4. FIRST FLIGHT OF AIRPLANE CARRYING TWO PERSONS

Photographed September 10, 1908

This photograph was made at Fort Meyer, Virginia, of the original Wright biplane, piloted by Mr. Orville Wright with Colonel G. O. Squier, U. S. A., as first passenger.

When this photograph was made no fatalities in airplane flight had occurred; the first victim, Lieutenant Selfridge, U. S. A., was killed while riding with Mr. Wright in the same biplane shown above, on the Tuesday following the Saturday this photograph was made, the machine falling to the ground at a spot which is practically the center of the picture, but near the trees which are part of Arlington National Cemetery.

FIG. 5. MOUNT WILSON OBSERVATORY

Photographed December 24, 1915

A special meteorological station of the Weather Bureau was established on Mount Wilson, December 25, 1915, and on April 1, 1916, daily reports of temperature, weather, precipitation, relative humidity, fog and other conditions were first telegraphed to the local office of the Weather Bureau at Los Angeles for publication and distribution.,

The photograph shows the location of the meteorological observatory (*) and the valleys below. From the elevation of the observatory (6,000 feet above sea-level), it is possible for the observer to determine the thickness and extent of fog as it is feasible to see as far southwesterly as Point Loma on a clear day, and southerly to Santa Catalina Island. Such observations and reports have been made and forwarded without interruption to date. They have proven of incalculable value to the aviators making cross-country flights.

The station on Mount Wilson is maintained through the coöperation of the Carnegie Institute of Washington.

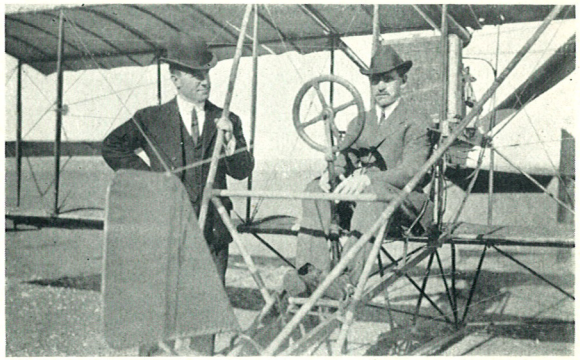

FIG. 6. TYPE OF AIRPLANE USED IN 1911 ON NORTH ISLAND

Photographed October, 1911

This photograph of Mr. Glenn Curtiss in his "pusher" airplane was made shortly after the Curtiss School of Flying was established in 1911, on North Island. At his right is Local Forecaster Carpenter.

Comparison of this machine, which four years ago was the last word in airplanes, with the tractor shown on the opposite page, indicates the rapid progress in design.

FIG. 7. DISCUSSING A FLIGHT

Photographed October 18, 1915

Aviation Instructor Oscar Brindley discussing a flight with Captain Clarke, U. S. A., and other officers at the U. S. Aviation School at San Diego.

Mr. Brindley is standing by the side of Captain Clarke in the group at the right. After every flight the Instructor reviews, point by point, the features of the flight, showing the pupil his deficiencies and explaining how he may avoid them in the future.

The officer at the left, Lieutenant Brown, has the regulation leather leggings, coat and helmet, and is ready to go up as soon as the mechanicians (who may be seen at the extreme left) finish inspection and pronounce the airplane fit for the next flight.

FIG. 8. CAPTAIN CULVER AND PARACHUTE

Photographed October 21, 1915

Captain C. C. Culver, U. S. Cavalry, Adjutant, Aviation School, with a parachute in his hand, having word with Captain L. W. Patterson, U. S. A., before the latter's flight. The object of the parachute is to determine changing wind-direction at different heights.

The airplane wireless record is now held by Captain Culver. In October, 1916, he sent a message 119 miles from Santa Monica to San Diego, California, while flying at an altitude of 1½ miles. He received a radio message from a distance of 11 miles while flying 7,000 feet aloft. He is also the first military aviator to rig up two airplanes so that they could exchange messages while in flight. The radio set used weighed less than forty-five pounds.

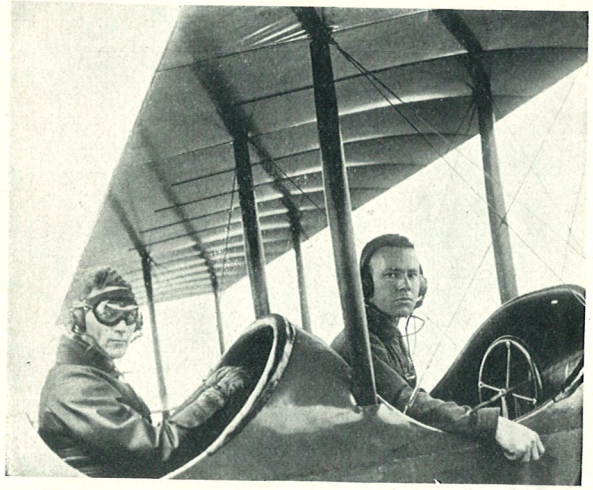

FIG. 9. LIEUTENANT GORRELL, U. S. INFANTRY, AS OBSERVER

Photographed October, 1915

The noise of the motor, together with the terrific blast of air, makes conversation impossible between the pilot and observer; for that reason telephones are sometimes installed as noted in this photograph.

Lieut. Edgar S. Gorrell is shown as the observer in this photograph. He has since qualified as an aviator and made a brilliant record in the Mexican activities in 1916.

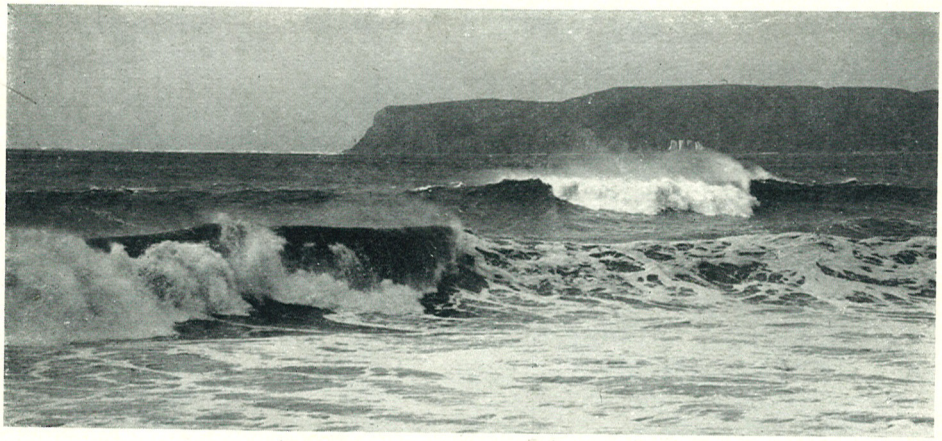

FIG. 10. POINT LOMA FROM THE EASTERN SHORE OF NORTH ISLAND

Photographed October, 1915

The peninsula of Point Loma rises to an elevation approximating 500 feet, and as it lies approximately north and south, it interposes a considerable barrier to the prevailing westerly winds. The eastern side of Point Loma is very precipitous. These factors tend to produce winds called "woollies" which are a distinct menace to all small boats and air-craft, unless the air-craft have an elevation exceeding 3,000 feet on a normal windy day.,

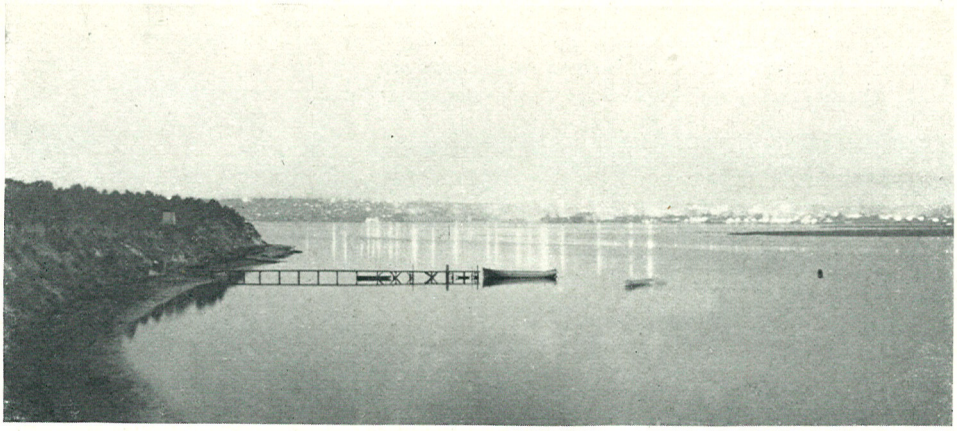

FIG. 11. SAN DIEGO, ACROSS SPANISH BIGHT, AS SEEN FROM THE U. S. AVIATION SCHOOL AT TWILIGHT

Photographed October, 1915

Contrasted with the photograph of Point Loma on the opposite page, this picture shows the ideal water conditions for trying out seaplanes. Shortly before this picture was taken, one of the pilots of the Curtiss Aviation School, also on North Island, drove a big seaplane 100 miles per hour barely skimming the surface of the water.

FIG. 12. INSTRUCTOR BRINDLEY AND METEOROLOGIST CARPENTER IN MILITARY TRACTOR NO. 50

Photographed October 20, 1915

Instructor Oscar Brindley and the observer, Meteorologist Ford A. Carpenter, U. S. Weather Bureau, leaving the ground for a flight. In the military tractor used generally by the Army, the observer sits forward while the pilot occupies the after cockpit. This machine, like all others used in the military service, has dual control.

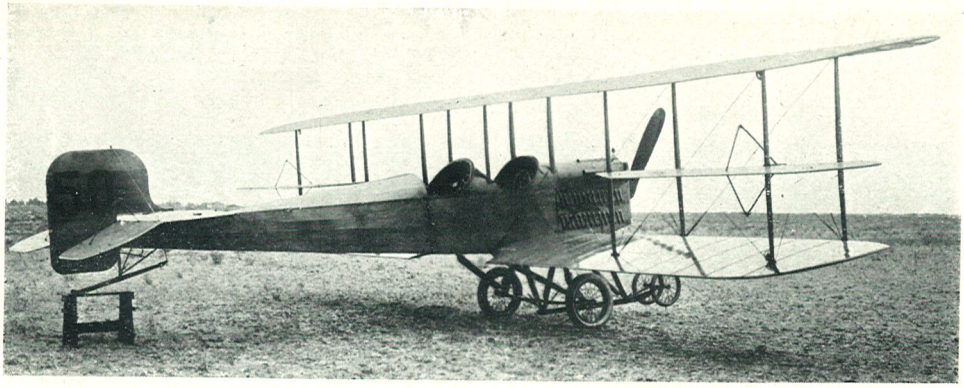

FIG. 13. MILITARY TRACTOR NO. 50. TYPE OF BIPLANE USED IN U. S. ARMY SERVICE; MADE BY GLENN MARTIN, LOS ANGELES, CAL.

Photographed October, 1915

Motor, horsepower, 80: revolutions per minute, 1,277.
Diameter of propeller, 8 feet.
Load of 39 gallons gasoline, 2½ gallons oil.
Flying radius with normal equipment, two persons, 300 miles.
Maximum altitude obtained with this model at San Diego, 13,000 feet.
Wing-spread, tip to tip, upper, 38 feet, 10 inches; lower, 34 feet, 10 inches.
Supporting area, upper, 139 square feet; lower, 165 square feet; total, 364 square feet.
Length of fuselage from rear of propeller hub, 21 feet, 6¾ inches.
Data from Major F. P. Lahm, Signal Corps, U. S. A.
Dated May 9, 1916.

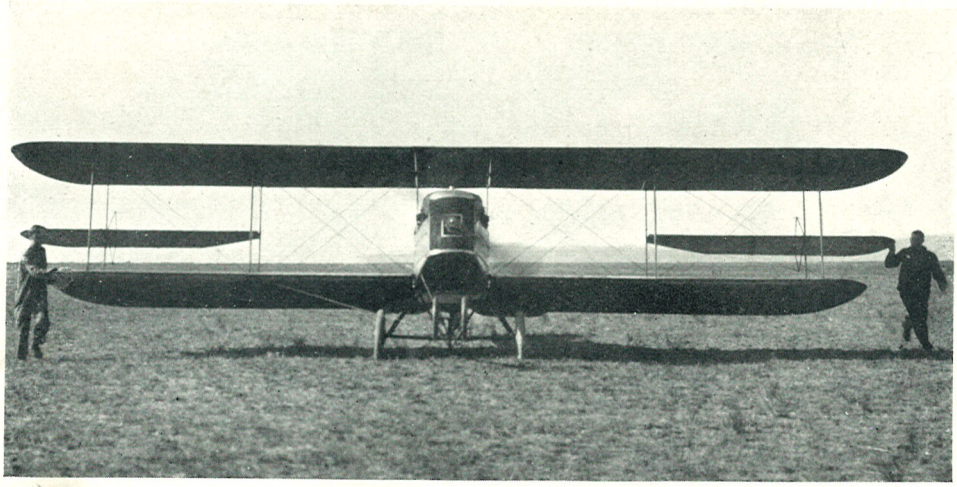

FIG. 14. "TRIMMING" A TRACTOR IN LEAVING THE GROUND

Photographed October, 1915

Military Tractor No. 50 just before leaving the ground. In gusty weather the mechanicians steady the ends of the lower planes, sometimes turning it by holding one edge and pushing the other. In the photograph the mechanicians are giving the airplane steerageway to the right.

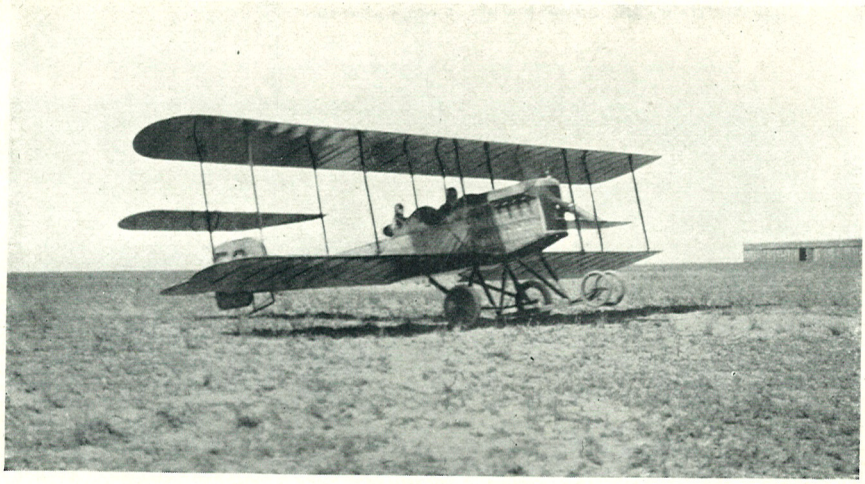

FIG. 15. MILITARY TRACTOR NO. 50 JUST LEAVING THE GROUND

Photographed October, 1915

Before attempting to leave the ground there is always considerable jockeying for a favorable headwind, and the photograph shows Instructor Brindley maneuvering for a favorable pointing.

After leaving the ground, the wind, so long as it is not gusty, makes no difference to the pilot.

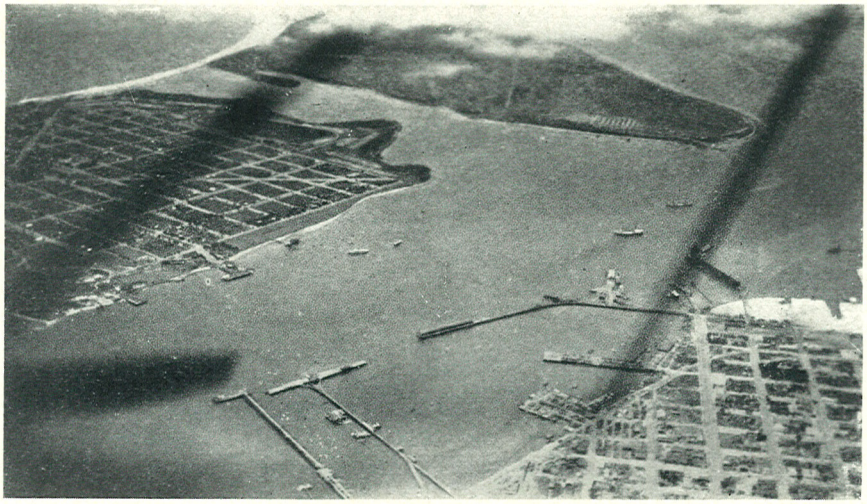

FIG. 16. SAN DIEGO HARBOR AT OVER 2,000 FEET ALTITUDE

Photographed October, 1915

The new municipal wharves are in the middle foreground and to their right may be seen the Santa Fé station. Part of North Island is obscured by cloud.

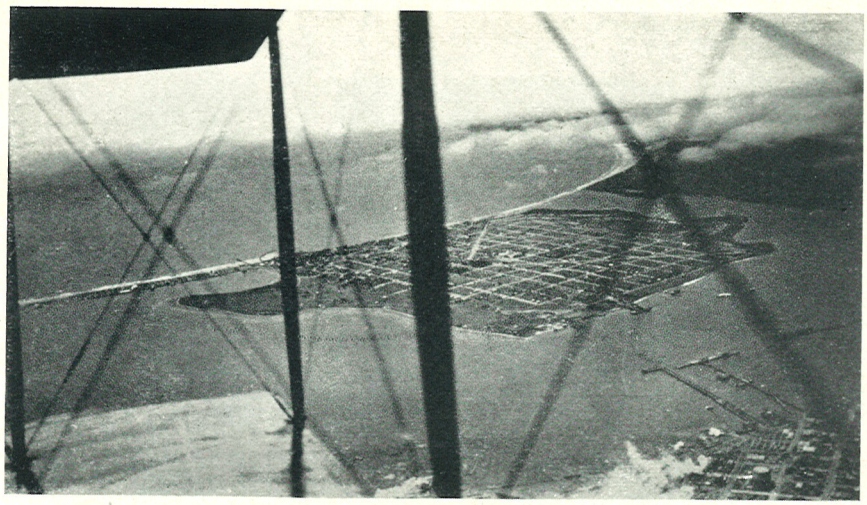

FIG. 17. THIRTY-FIVE HUNDRED FEET ABOVE SAN DIEGO

Photographed October, 1915

This photograph was made 1,000 feet above the clouds. The wharves of San Diego and Coronado may be seen in the foreground and in the middle distance.

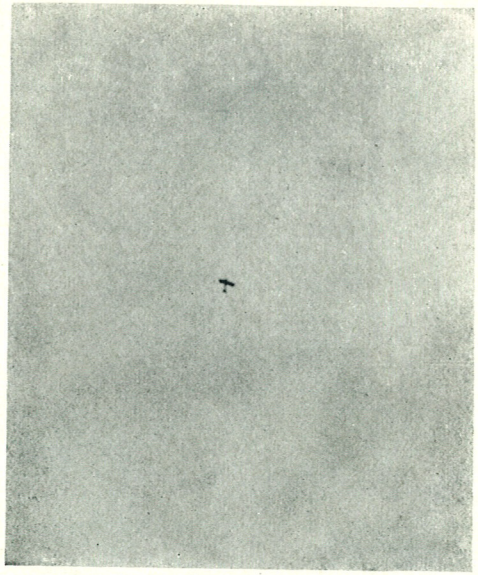

FIG. 18. MILITARY TRACTOR NO. 50 AT 3,500 FEET ALTITUDE

Photographed October 20, 1915

The airplane, in which the pilot, Oscar Brindley and the observer, Meteorologist Carpenter, made their flight, was photographed at the maximum elevation, 3,500 feet above the aviation field.

FIG. 19. FLYING SQUAD'S WIND-DIRECTION PENNANT ON TOWER

Photographed October 5, 1915

The regular observation tower from which all observations and notes on every flight are made is just back of the headquarters building. The station anemometer is on the tower, and the portable anemometer is to the left.

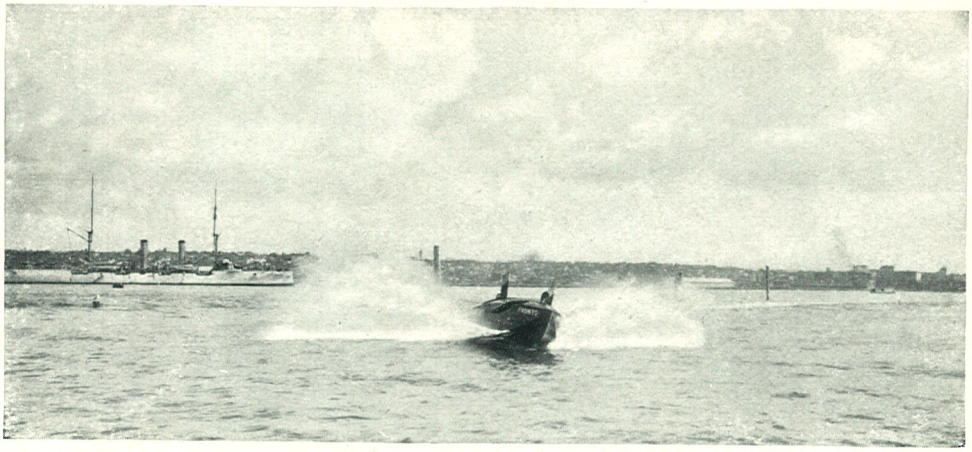

FIG. 20. THE AVIATION SCHOOL MOTOR-BOAT "PRONTO"

Photographed October, 1915

During the flying periods, the motor-boat of the U. S. Aviation School is kept ready for instant service in order to work in conjunction, if needs be, with the Medical Corps emergency truck on land.

Such is the speed of this boat (exceeding 40 miles per hour) that the water no longer has resiliency, and it is about as comfortable as riding in an old-fashioned stone-boat over rocky pastures.

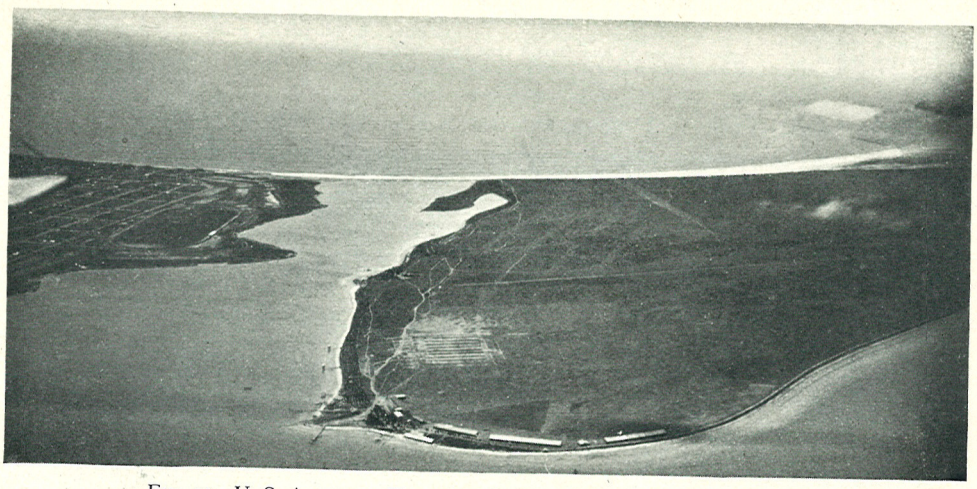

FIG. 21. U. S. AVIATION FIELD AT THREE THOUSAND FEET ALTITUDE

Photographed October, 1915

Part of Coronado and the portion of land called North Island, separated by Spanish Bight. Point Loma may be seen at the extreme upper right-hand corner of the photograph. The flying-machine sheds, buildings of the Aviation School, etc., may be seen in the immediate foreground. The U. S. Cavalry camp is the white splotch in the center foreground.

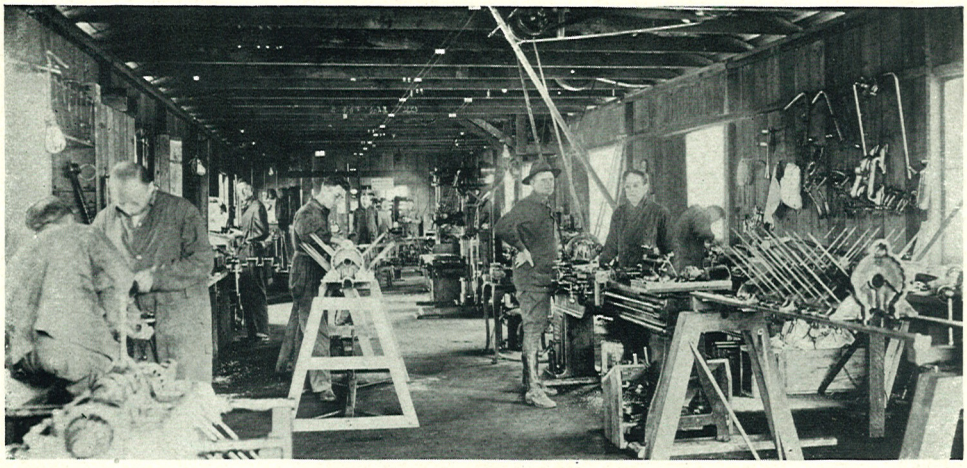

FIG. 22. REPAIR SHOP U. S. AVIATION SCHOOL, SAN DIEGO, CAL.

Photographed October, 1915

In the repair shop of the U. S. Aviation School at North Island the motors are given a gruelling test, being run twenty-four consecutive hours at a speed greater than that given them in actual practice. After this run they are taken down and each part is spread out on a large drawing-table and is subjected to close scrutiny so as to show any defect. Several airplanes as well as seaplanes have been reconstructed in this shop.