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The Navigation of Aircraft

By J. E. BATTERSON, M.E. 2

THE WORD navigation as used here means the act or process involved in the mapping out of a course to be followed for an airplane flight, the act of keeping the airplane on its precalculated course, and guiding it safely to its destination. Emphasis cannot be placed too strongly on the importance of a well-founded knowledge of this subject to the person who desires to make a flight of over one hundred miles. An airplane pilot attempting a long-distance flight without a proper knowledge of navigation can be likened to a city-bred individual endeavoring to find his way through a dense forest for the first time; he has an even chance of getting through by some instinctive means, but it is more than probable that he will end up at some other place than that previously anticipated. To the uninitiated, a flight from one place to another over a long distance may appear to be quite an easy task so far as the actual steering of the airplane is concerned. On the contrary, however, without the necessary equipment, and unless the approximate course to be followed has been calculated and previously studied, the flight may turn out disastrously. From the air the earth looks entirely different than it does from the ground, and it is quite an easy matter to become confused as to the correct path to follow—hence the importance of knowing how to navigate.

There are three principal divisions in the subject of navigation: first, a list and description of the necessary equipment and an explanation of their uses; second, the preparations required for the anticipated flight; and third, the actual flight itself. This theme will be confined to a description of the instruments, preparations, and work necessary for a flight of five hundred miles or farther. It is also assumed that the flight is to be made in fair weather. No mention will be made of the actual operation of the airplane; that is, regarding the various controls and their use in the flying and guiding of the airplane.

The most important piece of equipment used in navigation is an accurate air map. This type of map differs somewhat from the ordinary road map. It is usually drawn to a larger scale, and no highways are shown, while special prominence is given to landmarks such as towns, with a red geometric figure on them to represent their relative size and shape. Rivers, lakes, railroads, prominent elevations together with their heights, air-mail beacons, and airports are also accurately located.

The most important instrument necessary is the compass. This is a device utilizing the attraction of the earth, and enables the pilot to know in what direction he is traveling. It consists of what is known as a card, which is circular in shape, and the degree of a circle marked in white figures on its edge. Zero degrees represents North, 90 degrees for East, 180 for South, and 270 for West. This card is suspended in a liquid, usually alcohol, to prevent it from being affected by the motion of the airplane, and it is free to revolve as the plane changes direction. A magnifying lens is placed in front of the card, and a white vertical line, known as the lubber line, is etched in the center of the lens. Thus, whatever number

on the card is directly behind the lubber line is the heading of the airplane in degrees; that is, the direction in which the airplane is pointed. The compass is located on the airplane dashboard in a position similar to that occupied by the speedometer on the automobile dash. Other instruments used are an accurate watch, an altimeter, which informs the pilot of the height of the airplane above sea level, and an airspeed indicator, which calibrates the speed of the plane through the air.

The first step in preparing for a long-distance flight is to draw a line on the map from the starting point to the destination. On this line a series of short marks should be made at regular intervals of from ten to twenty miles apart.

The pilot or navigator should then study the map very carefully, noting all prominent landmarks within five or ten miles of the line which is the path to be followed by the airplane on its flight. Particular attention should be paid to the regions around the ten- or twenty-mile marks. This part is very important and the degree of success of the flight depends largely upon the previous study of the path to be followed. Colonel Lindbergh has attributed his successful flights to careful study of the map before leaving the ground.

The next step is to measure the angle that the line drawn on the map makes with the nearest meridian. This will give the number of degrees that the compass should read while in flight. However, owing to three conditions, the compass does not read this figure. The first of these conditions is that the direction in which the compass points is toward the Hudson Bay region and not towards true geographical North. Consequently, a com-

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This article on navigation of aircraft is the second of a series of aeronautical articles by John E. Batterson, M.E. 2. The first described, vividly, his experiences in learning to fly. Next month he will tell you about his "barn-storming" tour and some of the interesting incidents encountered thereon.

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—The Editor

NAVIGATION

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pass in California does not point with respect to true North in the same manner as a compass points in New York. This is called variation, and varies by degrees from coast to coast. Hence, it is often necessary to add or subtract a few degrees in order to correct this condition. The lines of magnetic variation are represented on the air map by red dotted lines, together with the number of degrees to add or subtract from the compass reading.

The second condition is that the compass is also affected by electricity generated by the engine of the airplane while it is running, and by the various metal parts of the airplane, depending upon the direction in which the airplane is pointed. This deflection is called deviation. In order to correct this deviation, the compass must be checked with another one that is not close to any metal or electricity. This is done with the airplane headed in different directions, and the number of degrees to add or subtract for each heading should be placed in the space provided beneath the compass.

Shortly before the flight, the pilot should obtain the latest weather information from the place of destination, and from places between it and the starting point. If the wind velocity is not over twenty miles per hour, it need not be considered. However, if the velocity is greater than twenty miles the wind will carry the airplane off its course, unless it be blowing in the same direction as the intended flight. Thus, the third condition is that it is frequently necessary to head the airplane in a slightly different direction than that in which it is actually traveling over the ground. If the wind velocity is known, the approximate number of degrees of difference in the compass reading can be calculated.

The pilot is now ready to take off, and it is highly important that the start be made in the correct direction. However, it may be discovered on the flight that there has been a miscalculation of compass reading, or that the wind has changed. This can be overcome by checking the map with the landmarks visible from the airplane, for example, if a certain landmark, such as a town, is seen from the left side of the plane, when it should be seen from the right side according to the map. The pilot may then change the course until the landmarks appear as they should from the airplane. If the pilot checks the course

in this manner at regular intervals, there will be little difficulty experienced in keeping on the path.

The lapse of time between the start and the sighting of a prominent landmark can be noted, and the approximate speed over the ground calculated. From this, one can estimate whether or not the airplane will need refueling before the end of the flight, and a landing may be made, if necessary, at a convenient airport before the lack of fuel necessitates a forced landing.

The engine sometimes fails, and causes the pilot to seek a landing place immediately, because the airplane is obviously useless without the motor. However, this rarely occurs if proper attention is given to the engine before taking off. Nevertheless, it is advisable that the airplane be kept at an altitude of at least twenty-five hundred feet in order to allow sufficient room to reach a landing place in the event of engine trouble. It is a decidedly good habit to select at frequent intervals a field suitable for landing that is within gliding distance, so that at any time during the flight, if the motor were to fail, the airplane could be headed towards the previously noted spot without delay.

Thus, if one is careful to observe the following points: to supply himself with the necessary equipment, to study the intended course carefully, to use care in calculating the compass corrections, to check the course carefully at regular intervals, and to observe the proper precautions while in flight, one will experience little difficulty in accomplishing a successful long-distance flight.
