

HISTORY OF THE APPLICATION OF METEOROLOGY TO AERONAUTICS WITH SPECIAL REFERENCE TO THE UNITED STATES.

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With the changes in all lines of industry that have occurred, it has of course been necessary for meteorological service to adapt itself to these changes. Aeronautics, as an industry, is less than 30 years old and the marvelous development in the speed of communications is largely responsible for the changes that have taken place in weather service.

Formerly it was aeronautics that served meteorology. It was early seen that free balloons offered an opportunity for securing information not otherwise obtainable, and it is interesting to find that meteorological observations were made during balloon ascents by Dr. JEFFRIES, an American, as early as 1784 and by B. DE SAUSSURE in 1787. In the century that followed a large amount of data was collected in numerous ascents.

The last quarter of the nineteenth century marks the beginning of really serious effort to secure systematic and accurate information concerning conditions in the upper air. It was during this period that several mountain observatories were established, including Pike's Peak, Colo., and Mount Washington, N. H. It was during this period also that the study of clouds was begun in a scientific way.

Meanwhile other methods of upper-air study were being considered. In 1885 Prof. Cleveland ABBE, pioneer in many lines of meteorological research, urged the use of kites and, following the meeting of the INTERNATIONAL CONFERENCE ON AERIAL NAVIGATION at Chicago in 1893, the project was rapidly developed.

The latter part of the nineteenth century saw also the advent of the sounding balloon; they have made possible the exploration of the upper atmosphere to heights of 20 to 30 kilometers. Their introduction marked an epoch of far-reaching importance in meteorology, since they led to the discovery of the stratosphere, the study of which has led to a complete revision of our conception of the structure of the atmosphere.

Data that are secured by means of kites, airplanes, and sounding balloons include pressure, temperature, and humidity. Observations of wind are also made with the kites and sounding balloons. Comparatively light instruments, called meteorographs, have been designed for recording these elements. Recently considerable work has been done in the development of radio-meteorographs, but these are still to a large extent in the experimental stage.

The method of so-called "pilot balloons" is comparatively inexpensive, but it yields information only regarding winds at various levels and the heights of clouds. Moreover, its use is limited to clear weather or to regions below clouds. Nevertheless, it has added greatly to our knowledge of the upper air. Its value will be vastly enhanced if it can be combined with radio, so that observations can be made in cloudy as well as in clear weather. Pilot balloons are undoubtedly used more extensively than any other method of free-air exploration. In the United States alone, including Alaska, Hawaii, and Puerto Rico, there are nearly 100 stations at which observations are made from two to four times each day.

Within the past 5 years, "ceiling" balloons have been added to the list of devices used in unravelling the secrets of the atmosphere. These are miniature pilot balloons. They serve one purpose only, that of determining the height of clouds, or what is generally referred to as "ceiling".

Ceiling balloons can be used efficiently only in determining the heights of relatively low clouds, chiefly those up to about 2,000 feet above the surface. They are of inestimable value in giving current information for fliers and are also providing an immense body of statistical data regarding the heights of lower clouds in different parts of the country, at different times of the day, in the various seasons of the year, and under varying conditions of pressure distribution. Similar data are obtained at night by means of ceiling lights.

Fortunately, however, the data that were being secured for purposes other than their usefulness to aeronautics were destined later to serve that activity in a very real and vital way.

The entry of the United States in the war marked the first official recognition by this country of the importance of meteorological service to aeronautics. An appropriation of \$ 100,000 was used largely in establishing five additional aerological stations in this country.

During a period of 6 or 7 years after the war, progress was rather more rapid in some of the European countries, where national subsidies made possible the laying out of civil airways and the establishment of meteorological service and other aids for scheduled flying.

Before 1926 there was no Federal regulation of civil aeronautics in this country. Instead there was regulation of various sorts in different States with hopeless confusion resulting. The AIR COMMERCE ACT provided the proper authority for changing this. Machinery was set up for issuance of regulations, licensing of pilots, classifying of airports, and inspection of aircraft. For this work the AERONAUTICS BRANCH was organized, under an additional assistant secretary, in the DEPARTMENT OF COMMERCE.

The work of organizing and maintaining an adequate weather service was naturally assigned to the WEATHER BUREAU, whose already-existing elaborate system of reports and forecasts for general needs made necessary only an extension along similar lines, though in more detail, to meet the requirements of pilots. As authority for this service the WEATHER BUREAU'S organic act was amended to include specifically the furnishing of weather reports, forecasts, and warnings "to promote the safety and efficiency of air navigation in the United States and above the high seas, particularly upon civil airways designated by the Secretary of Commerce under authority of law as routes suitable for air commerce".

In this new activity the factor of danger to life and property is more acute than in ordinary pursuits. It has therefore been necessary to make the service more detailed and intensive. Observations are more numerous and forecasts are for shorter periods. Special attention is given to those conditions which are of chief importance, such as fog, low clouds, poor visibility, and thunderstorms.

Naturally the efficiency of the service depends in large measure on the speed with which the reports and forecasts are made available to pilots. The DEPARTMENT OF COMMERCE, in cooperation with the WEATHER BUREAU, has organized a system of communications which meets the need very effectively. About 13,000 miles of airways now have continuous teletype service. At important terminal airports in these airways and also on about 12,000 miles which do not yet have teletype service, radio stations have been established, partly for exchange of reports but chiefly for broadcasting information and forecasts to aircraft in flight. Thus, to the extent that is possible with appropriations made for the purpose, pilots are provided with up-to-the-minute reports and forecasts based thereon *before* each flight and with supplementary reports and forecasts at frequent intervals *during* each flight.

