

## **The History of Aerology in the Navy**

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Proceedings Magazine - April, 1934

Proceedings Editor's Note -- The word meteorology comes from the Greek words *meleora* and *logos*, meaning the science of things in the air. The thermometer was invented by Galileo about 1602 and the barometer by Torricelli in 1643.

Naval aerology, a branch of the service which has developed since the Great War, is frequently the subject of interested inquiry and comment. This specialized meteorological section consists of a relatively small group of about twenty-five officers who have received professional training in the subject, twenty-seven chief petty officer aerographers, and forty-nine especially trained enlisted men. A brief survey of the origin and development of this group and its present function may indicate the promising possibilities inherent in this comparatively new arm of the Navy.

It requires no great amount of reflection to realize that the weather is an important matter to most men no matter what their occupation. It is ever-present, and hence must be taken into account in most projects whether in peace or in war. Thus, it is natural that man has been interested in the observation of atmospheric phenomena from earliest days. The first treatise on meteorology, literally a treatise on the super terrestrial, was written by Aristotle about 350 B.C.; but significant progress was not made until the invention of precise instruments for making observations at the end of the sixteenth century. Thereafter, observations increased in number and accuracy, until by 1850 logical explanations for changing temperatures and pressures and other similar meteorological phenomena were set forth. With the establishing of national weather bureaus during the last quarter of the past century and an almost ceaseless activity in gaining and disseminating weather information, the financial saving to society alone has repaid the scientific investment a thousand-fold since timely weather forecasting has prevented countless agricultural, commercial, and marine tragedies.

The development in the Navy of a meteorological service in the modern sense began about the middle of the last century. There was no specific authorization from Congress to initiate such an undertaking, but its potentialities had been glimpsed through such work as that of the naval expedition under Lieutenant Wilkes in 1836, and the cruises, writings, and lectures of Lieutenant Maury. A marine service, based upon thousands of observations from the logs of naval and merchant vessels, was developed by Maury and grew up in the depot of charts and instruments of the Navy Department. This service gradually enlarged into the well-known marine meteorological service which the Navy conducted until 1904. As much as this period was prior to the general development of the radio, the Navy could not collect daily reports from ships at sea or broadcast storm warnings as is done by the United States Weather Bureau today. This early service consisted mainly of general written advice and charts of a climatological nature, together with visual warnings posted in important ports which were connected with the central bureau in Washington by land telegraph.

In 1904 the entire marine meteorological service of the Navy, with the exception of the publication of pilot charts, was transferred to the federal Weather Bureau. This was accomplished by an executive order of July 12, 1904, which was based upon recommendations of an interdepartmental board. According to this order, coastwise radio activities were turned over from the Weather Bureau to the Navy Department and marine meteorological activities were taken from the Navy Department and turned over to the Weather Bureau. It specified that all meteorological reports from vessels of war and other craft, previously sent to the Hydrographic Office, be forwarded directly to the Weather Bureau and that the control of ocean meteorology be placed under the Weather Bureau. Moreover, it stipulated that the Navy should publish no meteorological information save that needed on pilot charts, and that the data for this purpose should be furnished by the Weather Bureau.

The Navy in 1917 had no meteorological specialists and, generally speaking, no meteorological equipment except the common shipboard type barometers, wet and dry bulb thermometers, and masthead anemometers. In the summer of 1917 these instruments were added to the allowance list of naval air stations. Repeated demands from our naval forces in Europe for aerological facilities there as well as from the training squadrons at the Naval Air Station at Pensacola finally resulted, in December 1917, in steps toward establishing a special naval aerological organization. As this new activity was undertaken in all the confusion of war-time expansion and with pressing need for immediate results, many of the early decisions and instructions were made orally. Since naval personnel were unfamiliar with the necessities of an aerological service and since the professional meteorologists who were taken

into the service were unfamiliar with the needs of the Navy, organization developed slowly through the trial-and-error method, rather than according to a preconceived comprehensive plan.

As a first step in supplying the necessary aerological organization the then Assistant Secretary of the Navy, Franklin D. Roosevelt, invited Dr. Alexander McAdie, Director of Blue Hill Observatory, Harvard University, to enroll in the Naval Reserve for the purpose of surveying naval needs and organizing a war-time naval service of aerological information. In January 1918, Dr. McAdie was accordingly enrolled as a lieutenant commander, and attached to the naval aviation organization then under the chief of Naval Operations. Under his direction the most urgent need, namely that for trained aerologists, was met by immediately launching an officer training program in aerography at Blue Hill in connection with the aviation ground school at the Massachusetts Institute of Technology, Cambridge, and a school for the training in aerographical duties of enlisted personnel was established at Pelham Bay, Long Island.

Nine officers and fifteen enlisted men comprised the first aerological detachment which sailed for duty abroad April 16, 1918. After brief additional training at the Meteorological Office in London and at posts of the Royal Navy Aviation Forces, this group was assigned to the various stations administered under the American Naval Forces in Europe. Through the courtesy of the British Admiralty twenty complete outfits for aerographic observations were furnished the Navy contingents, and our aerographers on the coasts of Ireland, England, and France became an integral part of the receiving and distributing network of weather-reporting stations. The aerological stations at U. S. naval air stations in Ireland, England, and Northern Bombing Units were manned and equipped first and by the end of the war 50 officers and approximately 200 men were carrying on aerological work at naval air stations along the French, Irish, and American coasts, and with bombing squadrons in France.

There was throughout this period no separate organization charged with the procurement of aeronautical material, although much of this delicate equipment was handled through the Naval Observatory because of its experience with such instruments. For that reason, the supply of aerological equipment was obtained through the Naval Observatory upon recommendations made by Lieutenant Commander McAdie, senior aerological officer of the Navy. Subsequently graduates of the aerological training course were assigned to the Naval Observatory to handle matters pertaining to aerology and its equipment. The principal items of equipment were thermoscreens, psychrometers, anemometers, thermographs, barographs, hydrographs, Fortin and Kew barometers, theodolites, single register anemobiographs, and sounding balloons.

As rapidly as personnel could be trained and apparatus purchased and shipped, aerological units were installed, in so far as possible, at every naval air station. The amazing speed with which so much organization, training, and equipping was accomplished is best shown in Lieutenant Commander McAdie's report to the Assistant Secretary of the Navy from Paimbouef, France, dated June 10, 1918, or about six months after his appointment:

"The work of organization and equipment has now reached such a point that the officer in charge (Lieut. Comdr. McAdie) feels that the special duty which he was asked to undertake by the Assistant Secretary of the Navy has been essentially completed; and that the Navy now has an efficient aerographic service equal to that of the best foreign service."

The question of the relation of this new activity on the part of the Navy to the established federal agency for collecting and distributing weather information was bound to arise. On September 22, 1919, the President appointed an inter-departmental board to consider the whole question of meteorological service. In brief the conclusions and recommendations of the board were that (a) the primary duty of collecting and disseminating meteorological information devolved upon the Weather Bureau; (b) for naval and military purposes skeleton meteorological organizations were required which could be quickly recruited to full strength and could take the field when necessary; (c) the several groups should co-operate in the location of stations, the making of observations, and the exchange of data and reports to promote efficiency and avoid duplication. This report recognized a situation by that time fully realized by the Secretary of Agriculture as well as the Secretary of the Navy, namely, that naval units, especially in naval aviation, could not always maintain contact with the Weather Bureau Service, that they operated in regions which were impractical for the Weather Bureau to cover, and that the nature of the information demanded was so specialized, so local, and so detailed that the Weather Bureau central offices could not give it, and consequently that special aerological organization was necessary. It became increasingly evident that from the information required by these naval units, naval aerological activities must be de-centralized; that is, each aerological unit must work as part of the station to which it was attached and therefore be as self-contained as

possible. The Secretary of Agriculture realized this fact when he wrote to the Secretary of the Navy, January 14, 1920, as follows:

“It is fully recognized that certain meteorological work and observations must of necessity be conducted by the Navy in connection with its operations at base stations and on vessels at sea, but such work does not involve duplication of effort. In fact, stations so maintained by the Navy will supplement those of the Weather Bureau and be valuable to it.”

In actual practice such co-operation has resulted between the two agencies: naval aerological units contribute their local observations to the general fund of meteorological data from which all daily weather maps are drawn, and at the same time they obtain all the information they can from Weather Bureau sources and then interpret this to meet the particular needs of their own naval ship or station.

With the signing of the Armistice and the following rapid demobilization of armed forces, our aerological work fell off to a minimum except at aviation bases in the United States. The reorganization of the aerological work on a permanent basis was well under way by June 1919, as its value was no longer questioned in the Navy. Answers submitted by the commanding officers of fifteen naval air stations to a questionnaire regarding the desirability of further aerological service were practically unanimous in requesting that the work be continued with increased equipment and facilities.

At first the administrative form of the aerological organization continued essentially as it was during the war; namely, the general supervisory and administrative section was a part of the aviation branch of the office of the chief of Naval Operations, while instrument procurement was carried on through the Naval Observatory, and the various aerological units functioned as integral parts of their respective naval air stations. In October 1919, the aerological section was transferred from Operations to the Bureau of Navigation where it was combined with the photographic and pigeon sections as an auxiliary aviation division. This form of organization continued until September 1921, when the Bureau of Aeronautics was established and the aerological section, as an adjunct to naval aviation, was incorporated within it, although the instrument and equipment work continued as before at the Naval Observatory until 1927 when it too was transferred to the Bureau of Aeronautics.

The most serious problem which faced the aerological section at the conclusion of the war was the lack of personnel equipped to conduct the necessary work in a satisfactory manner. A nucleus of 5 officers and 2 enlisted men of the 50 officers and 200 men who had been actively engaged in this work during the war remained in the Navy, and hence it became necessary to augment this small group as rapidly as possible. As a result, a training program was inaugurated in October 1919. Four naval officers and one Marine Corps officer requested this work and reported November 1 for training at Pensacola. The air station there in co-operation with the U. S. Weather Bureau, offered a brief five-month course of instruction in atmospheric phenomena and forecasting, especially changes in the upper air; and the officers so quickly graduated were sent out to assume charge of the various units which supplied aerological information. As this type of training continued, it became increasingly necessary to draft officers for this course in order to maintain the complement of heads for the established units. The effect of this policy was unpleasantly evident within a few years. Officers not requesting the course were primarily interested in other duties, and since a few months' elementary instruction at Pensacola failed to arouse their interest or enthusiasm in the physics of the air, it was to be expected that they would remain on aerological duty the minimum time possible. This resulted in more or less inefficiency in the aerological units at the various naval stations and a distinct tendency to discountenance this work. If a number of serious incidents, such as the loss of the Shenandoah and the PN-10 Pacific flight, had not revived the demand for a dependable, energetic, and stable aerological service in the Navy it is probable that this type of work might have been abandoned. Aeronautics, however, became increasingly insistent upon accurate upper-air information, and the need for a larger presence and more experienced aerological personnel became imperative. As a result of this situation a two-year postgraduate course in aerology was established for officers who expressed a desire to specialize in this subject and then to assume charge of the various units responsible for supplying weather information. At the same time that this extensive educational program was undertaken, the Bureau of Navigation, acting upon recommendations of the Bureau of Aeronautics, proposed legislation ensuring these officers permanent status as aerological officers, and providing also for warrant aerologists.

In this connection the question of the length of tour of duty for an aerological officer arises and deserves special consideration. It is obvious that the Navy must have the most accurate forecasts possible, and that an unreliable

forecast is worse than none. Moreover, it has been well established that years of experience are required to become an expert forecaster; technical training is essential, but constant practice is even more essential, and daily study of past maps as well as current conditions is also necessary. In this respect aerological duties are somewhat inconsistent with regular line duties. Consequently, the desirability of long experience necessary for the development of an expert aerologist must be weighed against the versatility required in a line officer, and a balance should be reached which is workable from both points of view. This personnel problem is one of the most difficult faced by the aerological section.

The problem of training enlisted personnel for aerological duties was met by establishing a four-month course of training at the Aerological School at Pensacola in December 1919, and the organization of subsequent classes every two months was authorized. The enlisted personnel continued in the quartermaster rating after qualification for aerological work, and consequently they were confused with those performing regular quartermaster duties and were soon lost as especially trained individuals. Hence it was considered advisable to have a distinct aerological rating if a proficient group was to be built up. It was not until 1924, however, that the new aerographer ratings were established through the efforts of the Bureau of Aeronautics, and thereafter many of the difficulties interfering with the maintenance of distinct and well-qualified aerological personnel were eliminated. In May 1924, the aerological school for enlisted men was transferred from Pensacola to Anacostia in order that it might be more closely coordinated with meteorological facilities in Washington. In 1929 this school was transferred to the Air Station at Lakehurst because of the better observatory equipment available there for instruction purposes. This work has become increasingly efficient and popular and there is now a waiting list of applicants for the course.

During 1920 the Lakehurst station was built and the tower feature on administration buildings for use as an observatory was approved by the Bureau of Yards and Docks, and such construction also got under way at San Diego, California. Work was also pressed forward on the improvement of aerological instruments. Also, considerable independent investigation and experimentation was carried on, especially at Pensacola and Hampton Roads, where studies of static disturbances were undertaken in an effort to develop more accurate forecasting of severe lows and tropical cyclones. In addition, arrangements were completed for naval radio stations to broadcast Weather Bureau synoptic reports at night as well as in the morning, so that two synoptic charts could be drawn daily at each station if desired. To meet requests for increased service aerological information was supplied to the national balloon races where there were naval entries, and Lieutenant J. B. Anderson was assigned to the U. S. Navy airship R-38 as aerological officer aboard.

In 1921, in order to stimulate greater interest in and use of aerological facilities among naval air units, and to fix responsibility for utilizing these facilities, a letter of instructions was sent out to all air stations and air units from the Chief of Naval Operations, which read in part:

"Before any long-distance flight is attempted, a copy of a special forecast covering the probable conditions over the area to be traversed will be supplied to each aircraft. This forecast will be made by the aerological officer, based on all information available at the station and supplemented by information from the distant point of the flight and from intermediate points."

After the aerological section was incorporated in the Bureau of Aeronautics at the end of 1921, the policy of expansion continued. Aerological offices were operated aboard all naval vessels carrying aviation units as well as ashore and they have been installed whenever a new air station has been put into operation or an aircraft carrier or tender has been commissioned. Work has been carried forward constantly since this time in developing and perfecting aerological instruments for marine use, especially the marine theodolite. In 1922 regular upper-air observations were inaugurated in the tropics as soundings of the winds aloft were made twice daily at Coco Solo; and similar soundings were made over the Pacific from aboard the U.S.S. Aroostook. The installation of a radio net along the east coast carrying weather reports from all significant Army, Navy, and Weather Bureau stations in the eastern states was put into operation at this time and a similar plan was worked out subsequently for the Pacific coast. This radio service, which has been amplified and improved greatly since its installation, has benefited not only naval aviation, but Army and civilian fliers as well.

By 1925 aerological units were maintained aboard six vessels of the aircraft squadrons in order to give detailed atmospheric advice at sea. This work at sea has presented great difficulties not only in regard to adequate and efficient marine aerological equipment, but also in regard to receipt of weather-map broadcasts when not within

range of Arlington or San Francisco. Constant improvement of existing instruments and the development of new ones, particularly of the new-type mirror theodolite and the aerograph used in making upper-air soundings by airplane, has done much to give increased accuracy in forecasting; and as scientifically trained officer personnel have become more experienced in this work the tactical value of this aerology to the service has greatly increased. There is still, however, a great deal of research necessary to increase the efficiency of the aerological unit; extensive observations and the accumulation and study of data of the upper air, particularly at sea, are necessary not only to improve forecasting methods but also for computation of averages for bombing charts and other strategic studies; further development of static direction recorders and the study of their possibilities in forecasting both local and general storms offer hopeful possibilities; and the problems of gust structure and of fog still challenge the student of aerology. There is still much room for improvement of aerological equipment for the purpose of measuring and recording all of the elements entering into forecasting processes; these instruments must be relatively simple, inexpensive, electrically controlled, and adaptable to use afloat as well as ashore.

Since 1928 aerological units have carried on more extensive activities due to the larger number of trained personnel to direct the work at the various stations. Each operating unit conducts its work as a part of the naval unit to which it is attached and is responsible to the commanding officer for furnishing the atmospheric information required by his particular organization. The complement necessary to carry on this work varies from one or two aerographers on an isolated ship, the U.S.S. Patoka or Chaumont, for example, to an aerological officer, a chief aerographer and three or four rated men at a large air station. The principal routine work of such a unit is to prepare daily two synoptic weather charts or maps. These are drawn from 0800 and 2000 weather signals sent out from Arlington and San Francisco and form the basis for the general weather forecast. Upper-air soundings are taken previously to this, both by pilot balloon and aerograph, obtained on an early morning aerological flight. This flight is made to at least 10,000 feet daily at a constant rate of climb, and while the sensitive instrument records temperature, humidity, and pressure, the aerological observer records cloud formations, visibility conditions, and winds aloft. The data collected on this flight serve as the basis for his local detailed report which includes the state of the weather, direction and velocities of the surface and winds aloft, temperature, visibility, cloud heights and types, thunderstorm risks, and best flying altitudes. In addition, further information is available for cross-country flights and the aerological unit is ready at any time to furnish local atmospheric data upon request of any unit in the service. Telegrams of upper-air observations are sent twice daily to the Weather Bureau in Washington from east coast stations, and to the Weather Bureau in San Francisco from west coast stations, and special reports of current weather or climatological conditions are prepared as required. At air stations where facilities permit, an aerographer is kept on tower or lookout watch during flying hours to protect planes from unexpected squalls or thunderstorms, and a 24-hour watch is maintained at the aerological office or observatory.

A monthly record of observations (surface and upper air) is submitted to the Bureau of Aeronautics, and other reports are made in accordance with instructions.

It is only by constant study, comparison, and analysis of these weather data that more general principles for guidance in forecasting may be evolved, and some part of each aerologist's day is spent at such work. In spite of this application and research, forecasting is only between 65 and 75 per cent efficient, and much thought and hard work are still necessary to increase reliability. Aerology in the Navy is still in its infancy, but its possibilities for vital service, especially in time of war, cannot be overrated. The science must be developed further and the history of the years to come may be even more productive than that of the past fifteen.

