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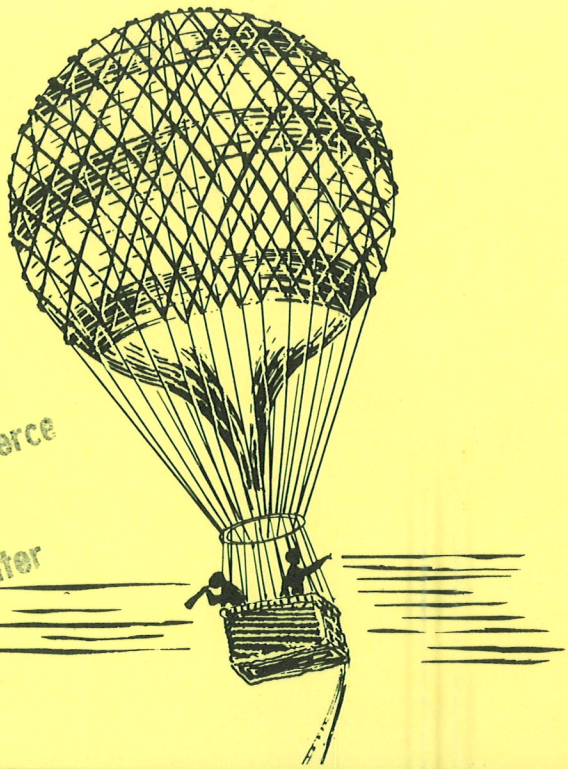
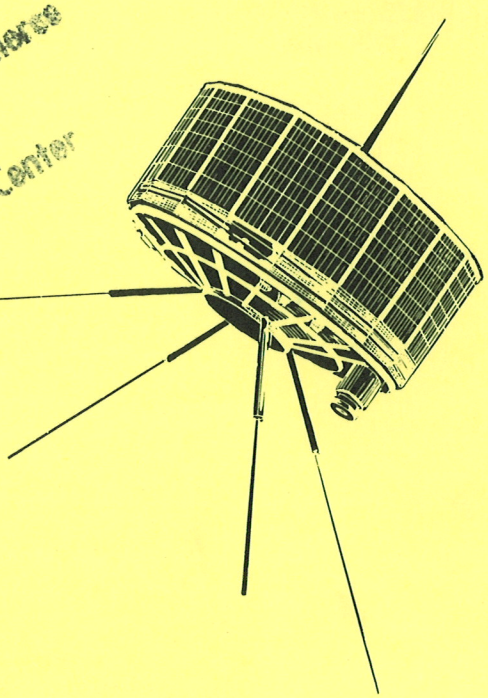


70 YEARS OF PROGRESS 1891-1961

Anniversary Issue



U. S. DEPARTMENT OF COMMERCE
WEATHER BUREAU

preface

The theme that meteorology and the Weather Bureau stand on the threshold of a new era has been printed in many recent articles in national magazines and newspapers. It has been voiced on network radio and television. It has appeared in technical reports, in Congressional hearings, and in speeches made by the President of the United States, the Secretary of Commerce, and by professional meteorologists throughout our country.

We constantly refer to our science as one with a great potential for future growth. We point with pride to the tools that modern technology has given us -- satellites, electronic computers, rocketsondes--to do the job in the future.

The National Meteorological Center, for instance, is indeed a milestone in the progress of meteorology, but it is only one example of our earnest effort to give the nation the best possible meteorological service within available resources.

As the national weather service, we are directed by Congress, through the Organic Act of 1890 and subsequent amendments, to provide all weather services required for the public safety and national welfare.

The job gets bigger and bigger with each passing year, and the demands grow greater and greater.

In the pages of this commemorative issue of TOPICS, there are many articles that should have more than just a passing interest for all Weather Bureau personnel, whether they be the old-timers or the weathermen of tomorrow. They should serve as chest-expanders for the yeoman job that Weather Bureau employees have done in the past, and they should stand as a prologue for the new frontiersmen in the weather science. Time and space do not permit recounting the many examples of heroism and devotion beyond the call of duty by Weather Bureau employees throughout the years.

In no other agency, in no other era, has any group had more reason to feel proud of its accomplishments than the U.S. Weather Bureau. We have truly had 70 years of progress as a civilian agency.

J.W. Osmun
Deputy Chief

Chiefs

of the

National Weather Service

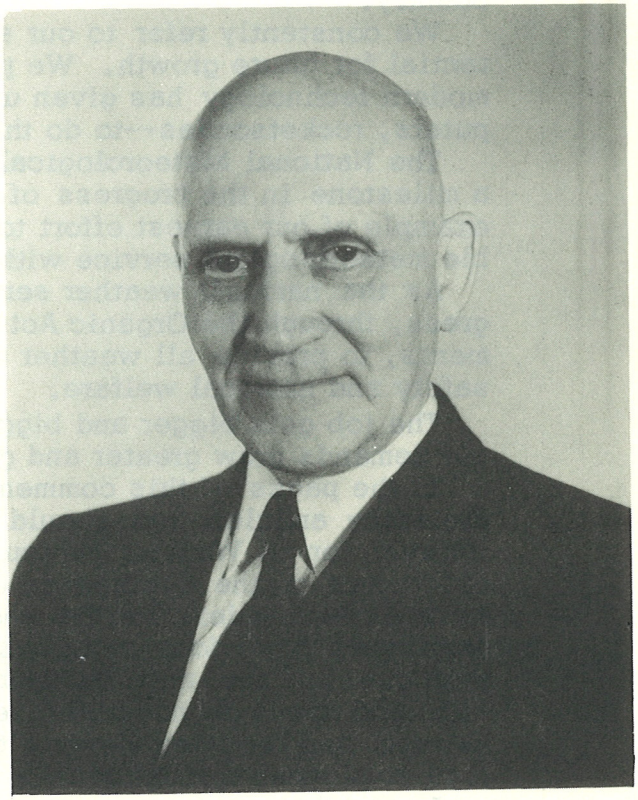
In Signal Corps Days

(1870-1891)

General A.J. Myer

General W.B. Hazen

General A.W. Greely



The Weather Bureau

(since 1891)

Mark W. Harrington

Willis L. Moore

Charles F. Marvin

Willis R. Gregg

Present Chief:

F.W. Reichelderfer

THE NATIONAL WEATHER SERVICE

Its Creation and Its Growth under the Signal Corps

July 1, 1961, marks the seventieth anniversary of the Weather Bureau as a civilian organization. An Act of Congress, transferring the national weather service from the Army Signal Corps to the Department of Agriculture, was passed in 1890 and became effective on July 1, 1891.

Nearly 250 years of weather observation and study in this country preceded the passage of this Act. The first continuous weather records in what is now the United States were kept in 1644 and 1645 by the Reverend John Campanius Holm, near Wilmington, Delaware. Later, other men kept "weather diaries" from time to time, in many parts of the country. The best-known of these was Thomas Jefferson, who was regarded as a weather expert in his day and used his records to answer many inquiries about American weather and climate.

The first government collection of weather observations came during the War of 1812, when Dr. James Tilton, the Surgeon-General of the Army, ordered hospital surgeons to observe the weather and keep climatological records. In the nineteenth century and early in the twentieth, there was tremendous interest in the effects of weather on health. This was the reason for Dr. Tilton's order. By 1853, 97 Army camps were keeping weather records, and many medical studies were based on these observations, including an investigation of the association of yellow fever with climate.

In the same period, other federal and state agencies set up observing networks. In 1817, Josiah Meigs, Commissioner-General of the Land Office, began a system of observations at land offices. From 1825 through the 1850's, New York University collected weather observations from a network of 30 stations. The State of Pennsylvania had a similar, smaller network.

In 1849, Professor Joseph Henry of the Smithsonian Institution established an extensive observation network by supplying weather instruments to telegraph companies. Simultaneous observations were made by local telegraph operators and sent to the Smithsonian. Maps prepared from these observations were displayed in Washington, D.C. Dr. Henry frequently made predictions based on the maps, and these became the first published weather forecasts in the United States.

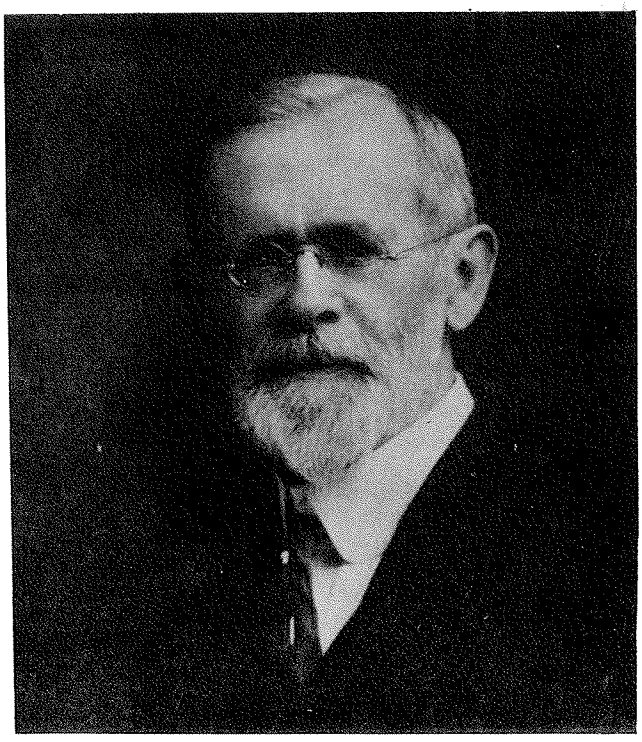
By 1860, Professor Henry had 500 stations making regular weather reports, but the coming of the Civil War broke up his network, and it never returned to its prewar strength.

In his annual report for 1865, Professor Henry advocated the reorganization of all meteorological observations in the United States under one agency as an effective means of predicting storms and warning coastal shipping.

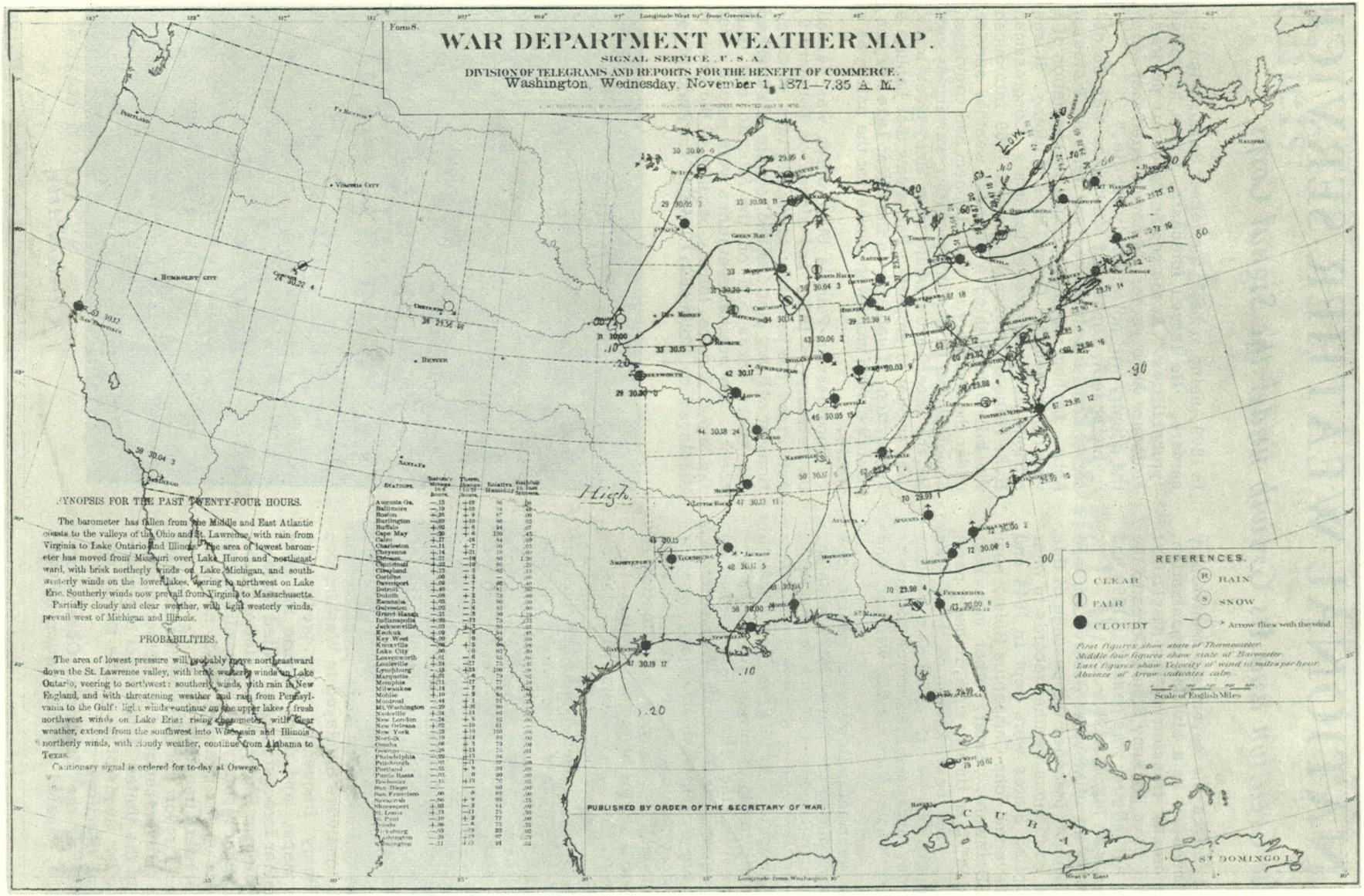
The director of the Cincinnati Observatory, Cleveland Abbe, created an observation network in 1869, using some of the former Smithsonian observers. He issued forecasts, which he called "probabilities." At the beginning of his program, Professor Abbe wrote: "I have started that which the country will not willingly let die."

Increase A. Lapham of Milwaukee was an observer for the Smithsonian and later for Professor Abbe. Lapham repeatedly urged the formation of a warning system for Great Lakes shipping. It was a friend and supporter of Lapham's, Congressman H.E. Paine of Wisconsin, who in 1869 introduced the bill establishing a national weather service under the Secretary of War. Lapham had convinced Congressman Paine that a weather warning system for the Great Lakes would save many lives and a vast amount of property. Paine saw that Lapham's suggestion, if valuable in the Great Lakes region, could be even more worthwhile for the nation as a whole.

Congressman Paine's bill, which was passed on February 2, 1870, and signed on February 9, authorized the Secretary of War to take observations at military stations and to warn of storms on the Great Lakes and on the Atlantic and Gulf coasts. The weather operations were placed under the Signal Service, largely because of the interest displayed by Colonel A.J. Myer, the head of the



Cleveland Abbe


Form 8.
WAR DEPARTMENT WEATHER MAP.
SIGNAL SERVICE, U. S. A.
DIVISION OF TELEGRAMS AND REPORTS FOR THE BENEFIT OF COMMERCE.
Washington, Wednesday, November 1, 1871—7.35 A. M.
SYNOPSIS FOR THE PAST TWENTY-FOUR HOURS.
The barometer has fallen from the Middle and East Atlantic coasts to the valleys of the Ohio and St. Lawrence, with rain from Virginia to Lake Ontario and Illinois. The area of lowest barometer has moved from Missouri over Lake Huron and northeastward, with brisk northerly winds on Lake Michigan, and southwesterly winds on the lower lakes, veering to northwest on Lake Erie. Southerly winds now prevail from Virginia to Massachusetts.
Partially cloudy and clear weather, with light westerly winds, prevail west of Michigan and Illinois.
PROBABILITIES.
The area of lowest pressure will probably move northeastward down the St. Lawrence valley, with brisk western winds on Lake Ontario, veering to northwest: southerly winds, with rain in New England, and with threatening weather and rain from Pennsylvania to the Gulf: light winds continue on the upper lakes: fresh northwest winds on Lake Erie: rising barometer, with clear weather, extend from the southwest into Wisconsin and Illinois: northerly winds, with cloudy weather, continue from Alabama to Texas.
Cautionary signal is ordered for to-day at Oswego.
REFERENCES.
CLEAR
FAIR
CLOUDY
RAIN
SNOW
Arrow flies with the wind
First figures show state of Thermometer.
Middle four figures show state of Barometer.
Last figures show Velocity of wind in miles per hour.
Absence of Arrow indicates calm.
Scale of English Miles
PUBLISHED BY ORDER OF THE SECRETARY OF WAR.
High.
CUBA
ST DOMINGO I.

Signal Service, and also because the Signal Service had a widespread telegraph system to use in weather reporting.

"On November 1, 1870, at 7:35 a.m., the first systematized synchronous meteoric reports ever taken in the United States were read from the instruments by the observer-sergeants of the signal service at twenty-four stations, and placed upon the telegraphic wires for transmission.

"With the delivery of these reports at Washington, and at the other cities and ports to which it has been arranged that they should be sent, which delivery was made by 9 a.m., commenced the practical working of this division of the signal service in this country." (Chief Signal Officer's Report to the Secretary of War for fiscal year 1871)

From its 24 stations of 1870, the Signal Service grew until, by 1890, it had 26 first-order, 118 second-order, and 34 third-order weather stations. The first- and second-order stations were completely equipped and staffed; third-order stations reported only maximum and minimum temperatures and amounts of precipitation.

In the beginning, each station telegraphed its report to Washington three times a day. In 1898, the number of daily observations was reduced to two, at 8:00 a.m. and 8:00 p.m. After the observations were received, forecasts and maps for the various sections of the country were prepared and issued within two hours. The forecasts were then telegraphed to weather stations, railroad stations, and the Associated Press. At Signal Service stations, the forecasts were printed and sent to post offices, reaching them within five hours after the midnight predictions. Copies were then distributed by mail to rural districts.

Until 1881, official weather forecasts were made only at the central office in Washington. In that year and during part of 1882, the New York observer was allowed to make forecasts. The system of local forecasts did not really begin until 1890, when officers at St. Paul and San Francisco began forecasting for their localities.

The first of the daily weather maps appeared on January 1, 1871, and weather predictions were published regularly after February 19 of that year. The predictions were called "probabilities" until 1889, when the term "forecasts" came into use.

The period between 1870 and 1880 was one of rapidly expanding public services. In 1871, observing and reporting river stages became a function of the Signal Service. General weather services were extended throughout the United States by an appropriation act of 1872 providing for "...expenses of storm signals throughout the United States for the benefit of commerce and agriculture."

In 1874, the 383 cooperative observers still remaining in the Smithsonian's network were transferred to the Signal Service. Weather services for producers of cotton and sugar were inaugurated in 1884. Cooperating with the British Meteorological Office, the Signal Service in 1885 began issuing warnings of Atlantic storms. By 1886, 290 locations were equipped with cold-wave warning flags. Forecasts of cold waves were passed along by telegraph, telephone, and railroad, in an effort to give at least 30 hours' warning.

Cleveland Abbe had been made special assistant to the Chief Signal Officer in 1871. Professor Abbe directed most of the research under the Signal Service. Specific investigations undertaken during these years included studies of tornadoes, moisture in the air, atmospheric electricity, use of balloons, thermometer exposure, and wet-bulb temperature conversion tables.

In 1881, the Signal Service disbursing officer, Captain Henry W. Howgate, was indicted for embezzling $90,000, although it was thought that he had actually taken as much as $237,000. The ensuing scandal greatly lowered the prestige of the Service. In succeeding years, the Signal Service appropriations grew smaller and smaller, causing the closing of 18 stations in 1884. The War Department began an investigation of the operations of the Signal Service. Complaints about weather services became increasingly frequent. Employee morale fell lower and lower. There were many people who urged that the weather service should be a civilian agency. A number of bills to this effect were introduced in Congress, but none were passed until the "Organic Act" of 1890. By this time, the new Department of Agriculture was eager to take over the weather service. The transfer to that department was effected on July 1, 1891, with no interruption of observations or forecasts. For the most part, the Signal Service observers were honorably discharged and remained as civilian employees.

At the time of the transfer, General A.W. Greely, the Chief Signal Officer, wrote:

"In parting from the civil employees the Chief Signal Officer feels assured that the new chief in another department will receive from them the same loyal, faithful, and efficient service they have rendered the Government while serving under his orders. The scientific staff have in view important additional duties looking to the extension of the Weather Service in the interests of agriculture and still further development of the science of meteorology. The Chief Signal Officer will follow with deep interest the development on new scientific lines of weather forecasting and the application of meteorology to agriculture, on which grounds this liberal reorganization of the Weather Bureau was planned and carried out."

On June 30, 1940, the Weather Bureau was transferred from the Department of Agriculture to the Department of Commerce. Explaining the reorganization, President Roosevelt said:

"The development of the aviation industry has imposed upon the Weather Bureau a major responsibility in the field of air transportation. The transfer to the Department of Commerce, as provided in this plan, will permit better coordination of Government activities relating to aviation and to commerce generally without in any way lessening the Bureau's contribution to agriculture."

The Weather Bureau administration building, at 24th and M Streets, N.W., in Washington, D.C. was built during 1940-41. The sixth floor has recently been enlarged (upper right).

FORECASTS AND WARNINGS

In July of 1891 when the Weather Bureau took over from the Signal Corps, all of the major activities of a national weather service were already in operation. These programs included forecasts of general weather conditions, cold-wave and high-wind warnings, storm warnings for coastal and inland shipping, river stage reporting and forecasting, recording the climate, and assistance to agriculture.

In 1891, the Bureau performed all these services with only four forecasters. The number of forecasters rose to 40 within three years, and the Bureau was able to decentralize by creating district forecast centers.

National forecasts were prepared in the Central Office and sent to the district forecast centers. From the district centers, the forecasts went to local stations. Local forecasters were authorized to alter the forecasts to suit local conditions, but their efforts were carefully checked. If anyone missed too often, he was reprimanded or lost the privilege of making forecasts.

From 1891 through 1939, public forecasts were issued twice a day. Forecasts covered the ensuing 36 hours. Beginning in 1898, forecasts based on the evening reports were regularly made for 48 hours in advance.

The forecasting procedure in 1891 was similar to that of earlier years and changed very little until the late 1930's. After the data from the two daily observations were collected, various charts were prepared to show areas of changing barometric pressure, temperature, dew point, and wind speed and direction. Isotherms and isobars were drawn to mark lines of equal temperature and pressure. The movement of high and low barometric pressure areas was studied to determine which areas would receive the advancing weather conditions.

The Weather Bureau did not use the air-mass analysis technique until the latter part of the 1930's, and fronts did not appear on many weather maps until 1936.

The Bureau started experimenting with weekly forecasts in 1908 and began issuing them regularly in 1910. The weekly forecasts were prepared each Saturday, based largely on data received from stations in Alaska, and were very general in nature. These early efforts in extended forecasting were designed to aid farmers in planning their operations for the coming week.

In 1940, the weekly forecast was replaced by the more detailed five-day forecast. After several years of experimentation, the Bureau began issuing its 30-day outlook in 1950.

A central analysis center was created in February 1942 to prepare and distribute master analyses of the upper atmosphere. In 1958, this center became a part of the newly established National Meteorological Center.

In addition to the National Weather Analysis Center, the National Meteorological Center (NMC) includes the Extended Forecast Section and the Joint Numerical Weather Prediction Unit. The NMC provides guidance to the field stations by preparing weather analyses and forecasts for the entire Northern Hemisphere. The National Meteorological Center also conducts an extensive research program designed to improve and automate forecast procedures. Computers and other electronic equipment are used in daily operations to speed the preparation of forecasts.

The NMC's analyses and forecast maps are used extensively by military and private forecasters, as well as by Weather Bureau forecasters. Within the Weather Bureau, NMC material is the starting point for the regional guidance forecasts issued by eight guidance centers, for the state and aviation forecasts issued by 28 area forecast centers, and for the general local forecasts issued by upwards of 300 local service offices. Each of

Mark W. Harrington was the first Chief of the U.S. Weather Bureau, serving from 1891 to 1895. He had been a professor of astronomy and director of the observatory at the University of Michigan. It was Professor Harrington's task to reorganize the weather service along civilian lines.

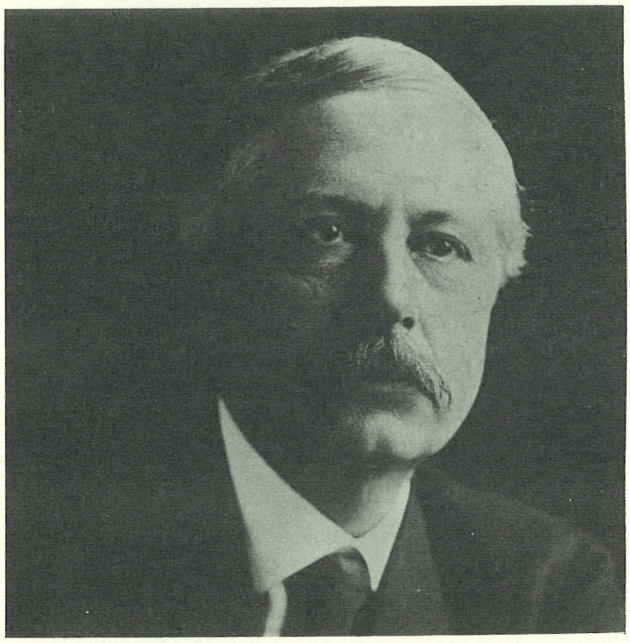
these three groups of offices refines and adapts the NMC material to its geographical area. As the area becomes smaller, the forecasts become more detailed. The field stations are the heart of the Bureau's forecasting and advisory services, disseminating the forecasts to the public and to special interest groups, such as flyers and farmers.

The demand for weather services has expanded many times over since World War II. Aircraft are flying higher and higher, requiring observations and forecasts for greater heights. The coming of the atomic age has created the need for daily forecasts of the fallout pattern in case of enemy attack. The Weather Bureau and the Public Health Service are studying the problems of air pollution created by our industrial society. The beginnings of space exploration have been assisted by special Weather Bureau teams providing forecast services for rocket and satellite launchings.

The Bureau has met these needs and is preparing for the future by enlarging its research program. Intensive studies of the physical processes of the atmosphere will improve methods of forecasting and lead to better services in the years ahead.

Agricultural Services

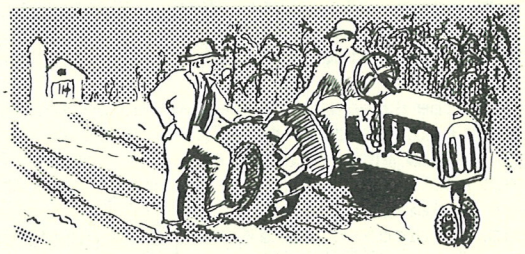
Under the Signal Corps, many weather services were furnished to farmers in addition to general daily forecasts and cold-wave warnings. The Signal Corps provided special information for cotton, rice, corn, and wheat growers and attempted to warn fruit-growers of temperatures lower than 40°.



Willis L. Moore was Chief of the Weather Bureau from 1895 to 1913. He had joined the Signal Service in 1876 and served as a forecaster at Milwaukee and official in charge at Chicago before his selection as Chief.

The Bureau took over and expanded all these programs, adding services for sugar, cranberry, tobacco, alfalfa, truck-farming, and sheep and cattle regions.

The cold-wave warnings were of particular aid to the fruit-growers, even before a special fruit-frost warning service was organized. As early as 1901, a Bureau publication said that "the growers of oranges and other fruits in Florida and California have invested large sums in tents, screens, heating, smudging, and irrigating apparatus for the protection of their groves and orchards, which they put into use when notified by the Bureau of expected occurrence of injuriously low temperatures. The value of the orange bloom, vegetables, and strawberries protected and saved by these means on a single night in February 1901, in a limited district of Florida, through the instrumentality of warnings of freezing weather sent out by the Bureau, was reported at over $100,000."



By 1922, special fruit-frost service was available on the Pacific Coast and in Arizona, New Mexico, New Jersey, New England, Wisconsin, Missouri, Illinois, and Kansas. The service was later extended to Alabama, Florida, and Texas. The fruit-growers take observations from instruments in the groves and send reports to the Bureau, which then issues minimum-temperature forecasts.

In 1958, the Bureau began a special service for farmers in the Mississippi Delta area, providing forecasts tailored to current farming operations and making these available to the press, radio, and TV on a round-the-clock teletypewriter service. The farmers in the Delta region estimated that, during the 1959 crop season, this program enabled them to save more than two million dollars in production costs.

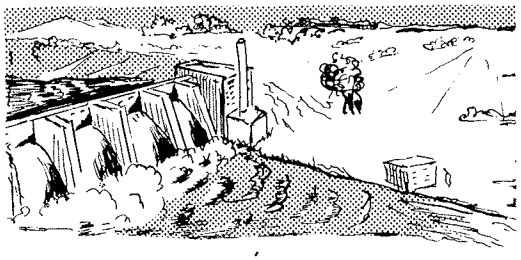
River and Flood Services

In the Bureau's early years, the river and flood forecasting service was greatly expanded. In 1891, daily reports of river stages at 26 places were received in Washington, where forecasters predicted future stages. In 1893, the service was decentralized, and local officials were given forecast responsibility. By 1913, there were 483 stations in the river and flood network.

The early river forecasters did a remarkable job with primitive instruments, no hourly rainfall measurements, and a very thin reporting network.

After the floods of 1903, a Bureau publication reported:

"The flood in the upper Mississippi watershed was the greatest in its history, with the exception of that of 1844, while in many portions of the low-



er watershed the stages were the highest ever known. Yet, notwithstanding the enormous volumes of water, the forecasts and warnings were most specifically accurate, both as to location, stage, and date. Warnings were issued from four days to three weeks in advance, and in no single instance did the forecasted stage differ from that actually recorded by more than four-tenths of a foot. The average difference was about two tenths of a foot."

In these early years, the river forecasting service was confined to the larger, more sluggish streams where reasonably accurate forecasts could be made by rules of thumb. Today, forecasts and warnings are issued for about 1600 localities, including many headwater points with less than 100 square miles of drainage area. Forecasts are now based on reported amounts of rainfall and related factors. After flood waters have collected in headwater channels, the forecasts are revised or confirmed on the basis of reported river stages.

Hurricane Warning Services

In 1896, a destructive hurricane traveled inland from Florida to Pennsylvania. The tremendous losses caused by this storm led to the establishment of our first real hurricane warning service. The headquarters of this service were first in Kingston, Jamaica, then in Havana, and moved to Washington in 1902. The number of stations in the hurricane reporting network was multiplied many times over.

In 1901, a Bureau publication said of the hurricane warning service: "...so nearly perfect has this service become that scarcely a storm of marked danger to maritime interests has occurred for years for which ample warnings have not been issued from twelve to twenty-four hours in advance. The reports from the West Indies are especially valuable in this connection, as they enable the Bureau to forecast with great accuracy the approach of those destructive hurricanes which, during the period from July to October, are liable to sweep the Gulf and Atlantic coasts."

The first hurricane observations radioed from ships at sea were received by the Bureau in 1905. Efforts were made to expand this program to receive observations before storms hit land areas. However, the ships naturally avoided the hurricanes, and the Bureau received few observations until land areas were affected. This problem was never satisfactorily solved until after World War II, when hurricane-hunting aircraft and storm-tracking radar became available.

The hurricane warning system was reorganized in 1935. Forecast centers were established in hurricane areas, and stations in the hurricane network made at least four daily observations and warnings. A teletypewriter network, linking coastal cities, was installed.

The destruction caused by three tropical storms in 1954 provided new impetus for improving the hurricane warning service. Emergency warning centers were established at major Weather Bureau stations along the coast. More frequent reconnaissance flights were made. The Bureau began installation of high-powered radars along the coastline to detect and track hurricanes. A program of education was begun to ensure better public understanding of hurricanes and hurricane warnings.

In 1956, with the establishment of the National Hurricane Research Project, the Bureau began its first major study of hurricanes. This program, which continues to the present day, gives promise of eventual understanding of all the forces involved in hurricanes.

Severe Storms

As early as 1884, Signal Corps forecasters attempted to predict the occurrence of tornadoes, but their efforts do not appear to have been too successful. In the first years of the Weather Bureau, forecasters were not permitted to issue public tornado forecasts for fear of causing panic.

The ability to make accurate forecasts of severe storms had to await the development of modern methods of upper-air observation and air-mass analysis. In 1952, the Weather Bureau established a severe local storm forecast center. The center,

which is now located in Kansas City, is responsible for forecasting such dangerous storms as tornadoes or thunderstorms accompanied by severe lightning, strong winds, or damaging hail. Severe storm forecasts for the entire nation originate in this unit.

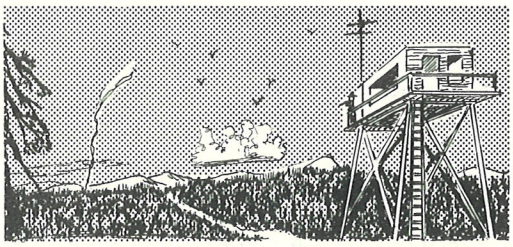
The Bureau makes extensive use of radar in detecting and tracking severe storms and has also

set up 185 volunteer reporting networks to warn of storms' movements in local areas.

An intensive study of severe storms was begun in 1960. The data gathered in this research project will bring greater understanding of these destructive storms and will lead to improved methods of prediction.

Fire Weather Services

The fire weather service was started during the First World War, in an effort to preserve the nation's timber resources. Until 1926, the service was very small, with only two employees assigned to it on a part-time basis. Today, 37 Bureau offices provide fire-weather service. Forest ranger stations are equipped with weather instruments



and make three daily reports to the nearest Bureau station. The forecasters then rate the danger of fire on a numerical scale. The Bureau advises the Forest Service of dry atmospheric conditions and gives special attention to forecasting dry thunderstorms, which have been the cause of many forest fires. Mobile weather stations travel to the scene of forest fires to advise fire-fighters of possible rain or changes in wind speed and direction.

Climatology

In the early years of the Bureau, gathering and studying records of the climate was one of its most urgent duties. Americans were moving westward to establish homes in little-known regions and wanted to know what to look for in the way of heat and cold, rain and snow, and the ordinary run of the weather. Congress asked the Bureau to "establish the climate," thinking perhaps that a record of 20 or 30 years would show climatic conditions presumed to be more or less permanently fixed. We know now that the climate is not fixed, but climatic data are even more useful in the modern era--for business, for agriculture, and for defense.

Records of climate are obtained from the Bureau's own stations and from a network of cooperative observers. The number of cooperative observers has grown from 3000 during the 1890's to more than 12,000.

In 1934, funds received from the Civil Works Administration enabled the Bureau to establish a tabulating unit in New Orleans and to begin the machine-processing of past weather records. In 1936, the Bureau began card-punching surface and upper-air data received from airway weather stations. The activities of the New Orleans tabulating unit were transferred to Asheville, North Carolina, in 1951, when the National Weather Records Center was established there. The National Weather Records Center is the final repository for all weather records collected in the United States.

Aviation Services

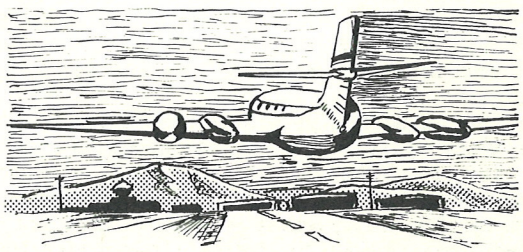
The Weather Bureau's services to aviation began in 1902 when it made a study of the surface winds at Kitty Hawk for the Wright brothers. During the early development of the airplane, the Bureau provided special service for many individual flights.

The Bureau's aerological work was expanded during World War I to aid military flyers and, in 1918, special bulletins and forecasts were issued for military aviation.

Initiation of air mail flights by the Post Office Department brought a continuing need for aviation weather service. In 1919, daily flying weather forecasts were begun for the benefit of the Post Office and military aviation. These forecasts were prepared in Washington at 9:30 a.m. and 9:30 p.m. and covered thirteen separate districts. The brief bulletins included current and expected weather conditions -- cloudiness, visibility, wind direction and speed -- and in many cases suggested the best altitude for flying. No night aviation forecasts were made until 1924, and ceiling and visibility were not included in the forecasts until 1929.

The Bureau established its first flight forecast centers at Chicago, Washington, and San Francisco in 1920.

The Air Commerce Act of 1926 made the Bureau responsible for weather services to civilian aviation. "It shall be the duty of the Chief of the Weather Bureau... (a) to furnish such weather reports, forecasts, warnings, and advices as may be required to promote the safety and efficiency of



air navigation in the United States and above the high seas, particularly upon the civil airways designated by the Secretary of Commerce under authority of law as routes suitable for air commerce, and (b) for such purposes to observe, measure, and investigate atmospheric phenomena,

and establish meteorological offices and stations."

After the passage of this legislation, Weather Bureau Airport Stations were opened along all major air routes. By 1928, there were 18 airport stations. This grew to 50 by 1930, and today there are 247 Weather Bureau Airport Stations providing weather information to the pilot.

In 1929, the aviation weather reporting system was expanded further, and a system of three-hourly synoptic reports was begun. The number of airway stations along flight routes was increased greatly, many providing 24-hour service and others providing only service for scheduled flights.

Forecast centers were established at certain airport stations in 1931. Surrounding stations sent observations to the forecast centers every three hours. Weather maps were constructed in the forecast center, and short-range forecasts were issued. These forecasts were broadcast regularly from Department of Commerce stations along major air routes.

With the approach of World War II, traffic on the major civil airways reached a point requiring control from the ground, and by the end of the war each of the 26 Air Route Traffic Control Centers was supported by a Flight Advisory Weather Service center.

High-altitude service was added in 1959 at seven major forecast centers and integrated with the established international and domestic forecast services. This enabled routine issuance of aviation forecasts for about one-third of the Northern Hemisphere--from Eastern Asia to Western Europe.

Weather briefing services for general aviation have been expanded by the establishment of automatic telephone answering systems at major traffic centers. A nationwide system of continuous aviation weather broadcasts has been started, and 45 broadcasts are now in operation. Recently, closed circuit television briefing systems have been installed at several of the busier international terminals.

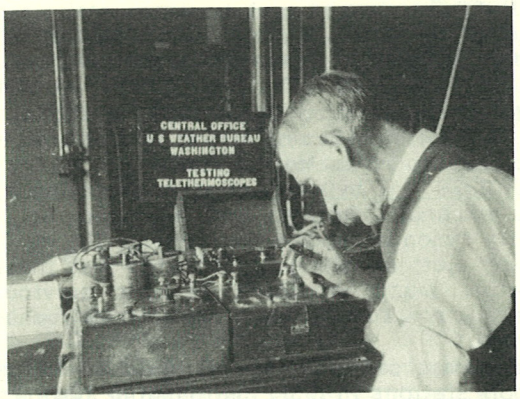
The tremendous growth of the Weather Bureau in the last 35 years has been due primarily to the expansion of aviation. The growth of aviation and the ever-increasing performance capabilities of aircraft have required the formation of new reporting networks, communication networks, and a special forecasting organization. The Bureau's growth over these years is indicated by the increase in appropriations from two million dollars in 1925 to 57 million dollars in 1961, the increase in personnel from 1,023 in 1930 to 4,754 in 1960, and the increase from 210 stations to 314 over the same period.

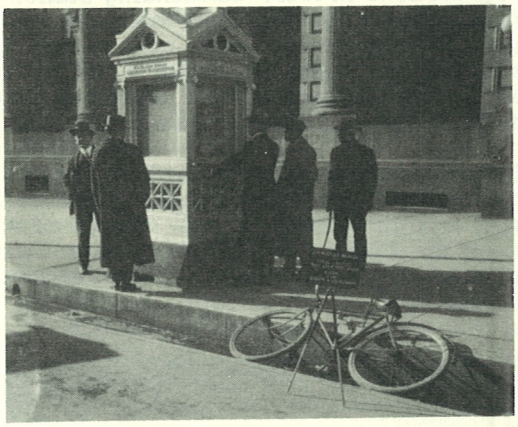
The old Central Office building was acquired by the Signal Corps in 1888 and is still in use today. Its interior decorations indicate that the building may have been intended for use as a Central American embassy.

Weather Bureau Office *Salt Lake City*

A Weather Bureau Office in 1914

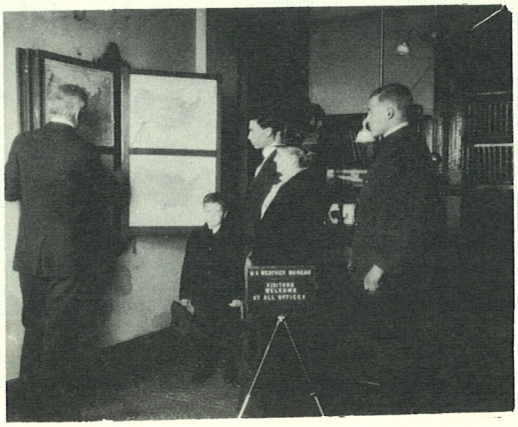
Printing the Daily Weather Map





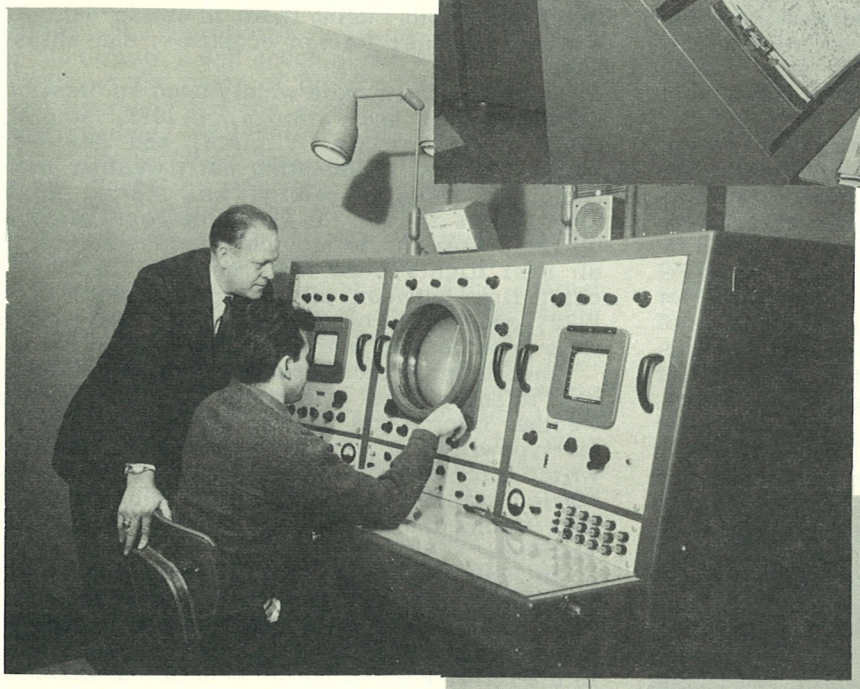
Sidewalk Kiosks Contained Weather Instruments

Forecasting for Visitors



Forecasting and Briefing Room

Radar Console



... and in 1961

Teletypewriters

Two lower photographs
by the Port of New York Authority

COMMUNICATIONS –

From Telegraph to Television

Modern methods of communication are the backbone of any national weather service. Observations must be collected from all over the world and forecasts and maps distributed to the users. The usefulness of the Weather Bureau's services is directly related to the speed of communications, and the advent of radio, telephone, teletypewriter, facsimile, and television has enabled the Bureau to reach more people, faster, with greater effectiveness than ever before.

Under the Signal Corps, weather observations were sent by telegraph to Washington, and the forecasts prepared there were telegraphed to the field. Display flags were flown at Signal Corps stations and in public places to indicate expected precipitation and rising, falling, or steady temperatures. Weather information was also printed in the newspapers, with the first newspaper weather map appearing in 1879.

After 1891, the Weather Bureau continued to use the signal flags, and whistles, searchlights, sirens, and rockets were also employed to warn of severe weather or cold waves. Observations were still collected and forecasts disseminated by telegraph.

A system of telegraph circuits was used for collecting weather observations from all parts of the nation. From 8 to 9:30, morning and evening, telegraph lines in each circuit were held open for weather dispatches. When transmission began, all the men on each circuit were ready with their messages. When one finished, the next began transmitting, until all stations on the circuit had been heard from. Each operator on the circuit took down all the dispatches passing over it.

When one circuit finished its dispatches, another joined it, transmitting its own messages and collecting all the accumulated reports. In this way, weather observations were transmitted to the central office in Washington and to all stations directly connected to the circuits.

A 1901 Bureau publication explained the methods then used to get the forecasts to the public:

"Within two hours after the morning observations have been taken, the forecasts are telegraphed from the forecast centers to about 1,000 principal distributing points, when they are further disseminated by telegraph, telephone, and mail. In this manner the forecasts reach about 80,000 addresses daily, the greater part being delivered early in the day, and none later, as a rule, than 6 p.m. of the day of issue.... The rural free mail delivery system recently inaugurated, and which is being rapidly extended, will afford a means of bringing within the benefits of this system a large number of farming communities heretofore impracticable to reach with the daily forecasts."

In the early 1900's, the use of the telephone was spreading. Forecasts were given to telephone operators who read them to subscribers upon request, thus reaching many agricultural areas much earlier than the mailed forecasts.

Forecasts were displayed in public places by means of the signal flags, and weather maps and bulletins were posted in hotels, stores, office buildings, post offices, and railway stations throughout the nation.

In 1899, Marconi demonstrated the possibilities of wireless telegraphy by sending messages across the English Channel. The Weather Bureau was immediately interested and became the first agency of the United States government to experiment with its use. However, the Bureau continued to rely on the telegraph and telephone for collecting observations, using radio to obtain data from outlying regions, foreign countries, and ships at sea.

Radio has been more widely used in disseminating forecasts and warnings. In 1913, radio stations in Arlington, Virginia, and Key West, Florida, began broadcasting daily weather bulletins, and a similar service was started for the Great Lakes in 1914. In 1920, the Post Office set up radio stations to provide forecast service for air mail flights, and radio has now become the chief link between pilots and forecasters. By 1922, one-fourth of the nation's radio stations were broadcasting weather information.

The Bureau's total dependence on the telephone and telegraph for collecting and disseminating weather information ended in 1928 when its first teletypewriter circuits were installed. Teletypewriter circuits have proved to be the most economical means of transmitting basic observational data among the hundreds of Weather Bureau field stations.

In 1948, the teletypewriter was supplemented by facsimile transmission, a wirephoto technique. Facsimile is used to transmit analyzed maps and charts from analysis centers to weather stations in the field. Prior to the introduction of facsimile, the staff at each field station had to plot and analyze maps before preparing a forecast.

Today, newspapers, telephone, television, and radio are all used to bring forecasts to the public. Automatic telephone weather forecast service began in 1939 and is now available in eleven cities. Automatic telephone answering systems are being installed at 50 airport stations to disseminate weather information to pilots. Americans everywhere hear weather forecasts regularly on radio and watch them on television.

Television has recently acquired two other uses in communicating weather information. The first closed circuit television pilot weather briefing service is now in operation at New York International Airport. And it is television that has given us a new perspective on the weather through cloud photographs from the TIROS weather satellites.

INSTRUMENTS AND OBSERVATIONS

In 1870, when the national weather service was established under the Signal Corps, meteorologists had only surface weather observations to use in forecasting the behavior of an active atmosphere many miles in depth.

The instruments then available for weather observation were the wind vane, anemometer, nonrecording rain gage, thermometer, barometer, maximum and minimum thermometer, and sling psychrometer. The Signal Corps had no self-recording instruments except those for measuring wind movement and some recording rain gages in the central office.

Using these instruments, the weathermen recorded the maximum and minimum temperature, the humidity, the barometric pressure, the rainfall, and the direction and speed of the wind. They also reported the types of cloud present, the state of the weather, and the appearance of the aurora borealis, dew, white frost, the first and last frosts, fog, thunderstorms, hail, tornadoes, landspouts, fireballs, rainbows, and shooting stars. Three daily observations were made until 1888, when the schedule was changed to two observations a day--at 8 a.m. and 8 p.m.

For many years after the transfer of the weather service to the Department of Agriculture, there was little change in the observation program, except that the number of observing stations continued to increase. In 1897, Chief Moore wrote in his annual report to the Secretary of Agriculture: "From a knowledge personally gained by many years service as an official forecaster, I do not hesitate to express the opinion that we have reached the highest degree of accuracy in the making of forecasts and storm warnings possible to obtain with surface readings only."

Under the leadership of Professor Charles F. Marvin, who was later to become Chief of the Weather Bureau, many instruments were developed and improved during the last ten years of the nineteenth century. Marvin worked particularly on the development of self-recording instruments. He perfected the kite meteorograph for recording wind velocity, temperature, barometric pressure, and relative humidity in the upper air. Other Marvin inventions were the weekly float rain gage, the shielded snow gage, and an electrical-resistance thermometer for measuring the intensity of solar radiation in absolute units of heat.

The triple-register recording device, which came into general use during the 1890's, was a means of recording several types of observation simultaneously. The register was connected to the tipping-bucket rain gage, the sunshine recorder, the anemometer, and the wind vane, and observations were recorded on charts driven by a clock.

The great revolution in weather observing came with the growth of aviation. An intensive program of upper-air observations had to be developed to meet the pilot's need for knowledge of the weather above the earth.

The early efforts to probe the upper air were intended only to increase man's knowledge of the atmosphere and not for use in forecasting. Even in 1915, a Bureau publication stated that "the value of this aerological work does not lie so much in the current use of the data, though many of the observations are individually useful, as in the light thrown by these data on the whole subject of dynamic meteorology."

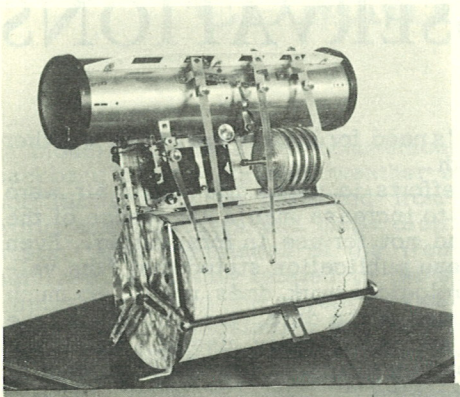
As early as 1784, manned balloons were used to observe the weather, and this method of research was used a number of times by the Signal Corps. The Signal Corps also established weather stations at Pike's Peak and other elevated points to obtain information at high levels.

In 1895, Professor Marvin began using kites to make observations, and within a year he had perfected his kite meteorograph. It was difficult to obtain a continuous record of kite observations, because a wind speed of 10 to 15 miles per hour was needed to raise the kites to 1000 feet. Even so, the kite was more practical than the manned balloon. In 1898, the Bureau made a series of simultaneous kite observations at 17 stations, and a regularly scheduled program of kite observations began in 1907. The program continued until 1933, when it was superseded by airplane observations.

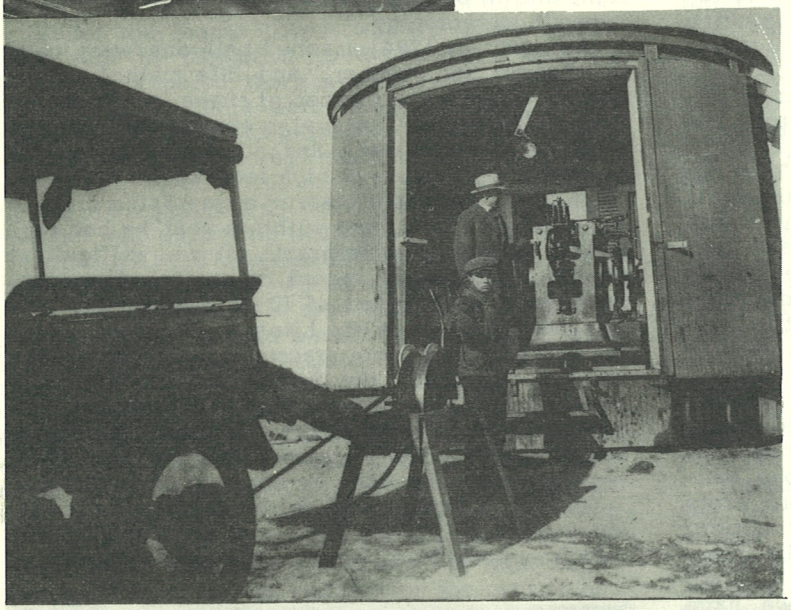
In 1931, a Bureau publication described the kite observations: "Kites (box type) are flown in tandem from steel music wire. The head kite carries

Charles F. Marvin uses a clinometer, one of the many weather instruments he developed. Professor Marvin joined the weather service when it was part of the Signal Corps and was Chief of the Weather Bureau from 1913 to 1934.

KITE OBSERVATIONS

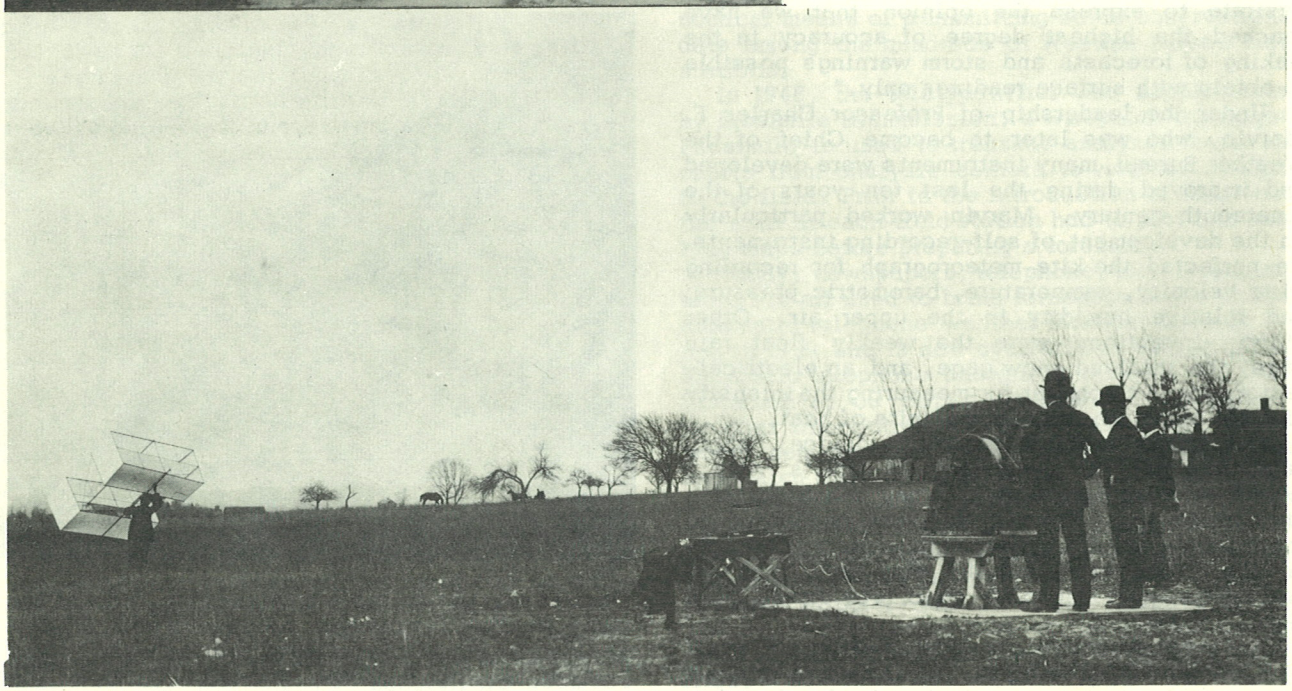


Top: A kite meteorograph



Center: The building at the right was called a reel house and contained a mechanical reel for pulling in the kite. When the kite line broke, a truck was used to chase the kite. A portable reel, such as the one in the center, pulled the kite back to earth.

Bottom: Launching a kite



a meteorograph and by using from six to eight kites, heights of two miles and occasionally four miles are reached." Each flight required four to five hours.

Captive balloons, inflated with hydrogen, were used for probing the lower layers of the atmosphere when winds were too light to lift the kites.

In 1909, the Bureau began a regular program of free balloon observations. Two balloons would be launched at the same time, one in the center of a storm and another to the east of the storm. These were the forerunners of the modern pilot balloon observations. The pilot balloon carries no instruments, but the wind direction and speed at various heights can be quickly determined by following the balloon with a theodolite.

Even before World War I, parachutes and meteorographs were attached to pilot balloons to convert them into sounding balloons. The sounding balloons were described in a 1931 Bureau publication: "Sounding balloons are usually five feet or more in diameter and carry a self-recording instrument (meteorograph). The balloon rises until it bursts, and the meteorograph then descends with a parachute. Continuous records of temperature, pressure, and humidity are thus obtained to a height of 10 to 12 miles and occasionally to 20 miles. The instrument carries a tag on which the finder is requested to send it to the Weather Bureau office.... The chief disadvantage of sounding balloons is that the records are frequently not available until days, weeks, or perhaps months later."

An extensive program for sounding-balloon observations was presented to Congress in 1919, but the necessary appropriations were not passed.

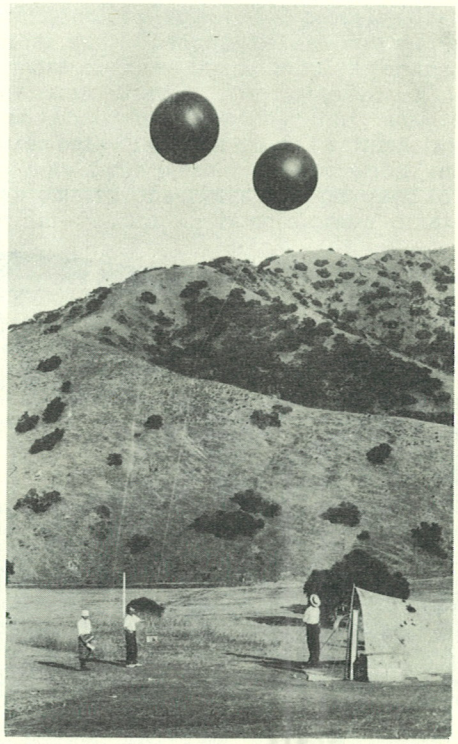
The Bureau's upper-air investigations expanded rapidly during World War I in response to the needs of the War and Navy Departments. In the years following the war, Congress authorized further expansion for the benefit of commercial aviation.

The Weather Bureau began experimenting with airplane observations in 1919. A Marvin meteorograph was attached to the struts of a plane to measure temperature, pressure, and humidity.

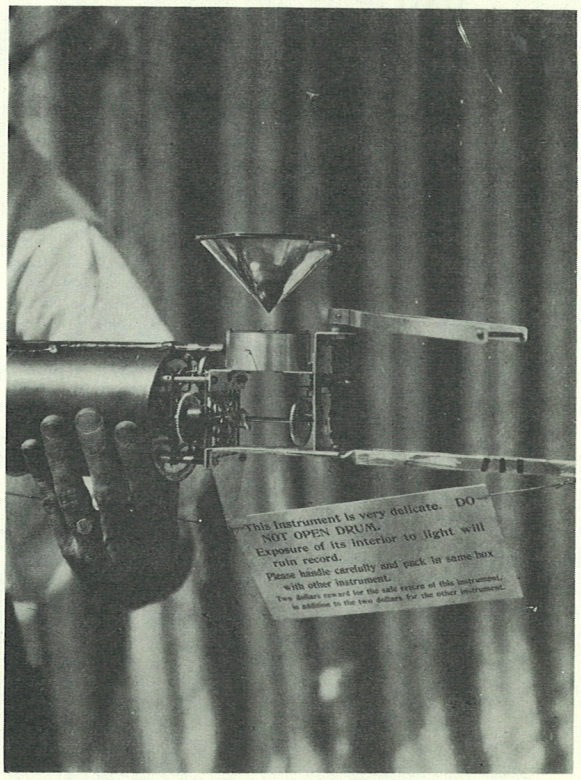
Six years later, with the cooperation of the Navy's Bureau of Aeronautics, daily airplane observations were made at Washington, D.C. In 1931, a regular program of early morning airplane observations was inaugurated at Chicago, Cleveland, Dallas, and Omaha. By 1937, airplane observations were made regularly in thirty places. A complete flight required less than one hour, and the data collected by the meteorograph were almost immediately available for the forecaster. The pilots also observed cloud formation and height, visibility at different heights, and turbulence.

The airplane observations were expensive and dangerous. Between 1931 and 1938, they cost the lives of twelve pilots. For these reasons, and because of the improvement of the sounding balloon, airplane observations were discontinued before World War II.

In 1927, two Frenchmen attached a radio trans-



Launching a sounding balloon



The sounding balloon carried this odd-looking instrument.

Navy pilots make an airplane observation. The meteorograph can be seen between the struts of the plane.

Willis R. Gregg, Chief of the Weather Bureau from 1934 to 1938, attaches an aero-meteorograph to a plane. Mr. Gregg entered the Bureau as an observer in 1902 and spent a number of years in the kite observation program. From 1917 until his appointment in 1934, he was chief of the Bureau's aerological division.

mitter to a free balloon and succeeded in establishing a radio link with the atmosphere. A year later, the Russian meteorologist, Moltchanoff, attached a radio transmitter to a sounding balloon and achieved the first successful flight with what was then called a "radio meteorograph." This designation was changed to "radiosonde" in 1938.

The radiosonde was first used by the Weather Bureau in 1936. It was found to be less expensive than the airplane observation and attained greater heights. In 1938, daily radiosonde observations were started at six Bureau stations.

The radiosonde measures pressure, temperature, and humidity and transmits the measurements to earth by means of radio signals. Wind direction and speed can be determined by tracking the radiosonde with a radio direction finder. A parachute is attached to the instrument to permit recovery after the balloon has burst.

The aviation age also brought an increase in the Bureau's program of surface observations. Many new Weather Bureau Airport Stations were opened, and a network of hourly observing stations was established to report to pilots on the weather along the air routes and at the landing fields.

In 1961, the Bureau's observing network includes 314 regular Weather Bureau stations, 146 upper-air weather sounding stations, 91 radar stations, 20 automatic weather stations, and more than 12,000 cooperative observers who report on river stages and the climate. In addition, there are 229 FAA stations making hourly reports and 256 supplementary aviation weather reporting stations, manned by airline or airport personnel. More than 3000 ships cooperate by observing and reporting on the weather at sea. By international agreement, the Bureau receives regular observations from more than 2000 foreign weather stations.

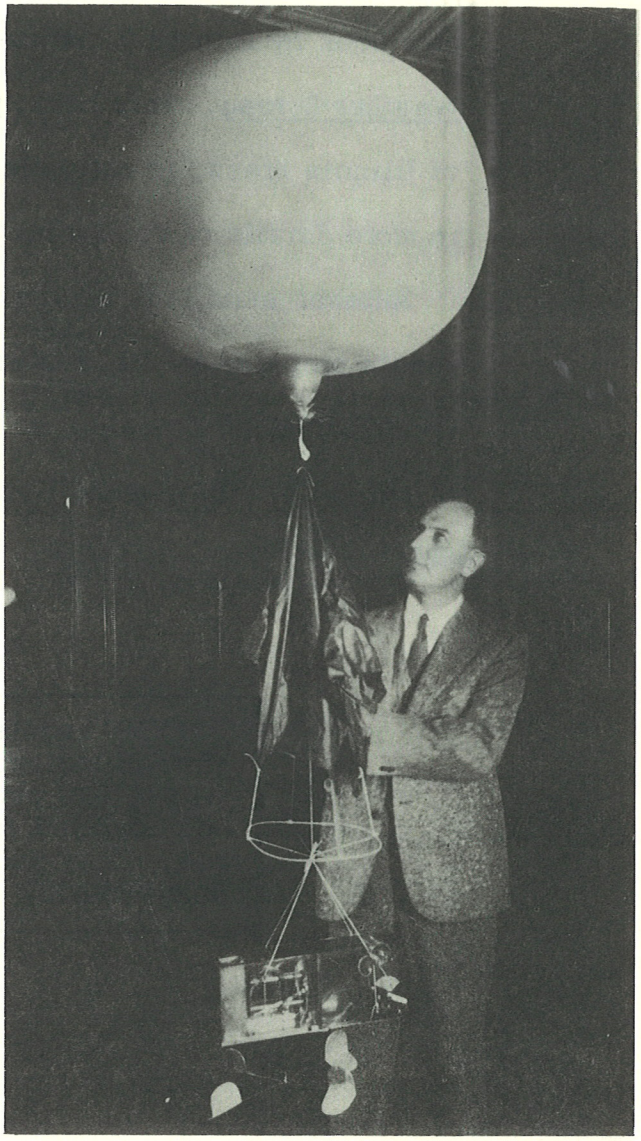
Today, complete synoptic measurements are made four times daily at six-hour intervals, and abbreviated measurements at intermediate three-hour intervals. Surface readings are taken every hour and entered on punched cards for a permanent record. When the ceiling is lower than 500 feet and visibility less than one mile, observations are made every 15 minutes.

In recent years, new instruments have been added to the weatherman's arsenal to improve his ability to observe the behavior of the weather.

After World War II, the Bureau acquired a number of war-surplus radars for tracking the movements of rain areas, storms, and squall lines. Twenty-two additional radar sets, especially designed for weather surveillance, are now in operation, and nine more of these are scheduled for installation in the near future.

An automatic observing station, that makes weather measurements and transmits them by teletypewriter, was first placed in operation in 1954. These automatic observers can be used to obtain weather information in remote areas or at sea.

Rockets are being used to study the upper air, and now the TIROS satellites have inaugurated a new era in weather observing. For the first time, man can view the weather from above. In the future, with a number of satellites operating at the same time, the meteorologist will be able to keep a continuous watch on the weather all over the world.



An early radio-meteorograph of the Moltchanoff type. The old caption on the picture explains that the instrument is "primarily for use in sparsely settled regions where the autographic type of meteorograph is impracticable owing to the unlikelihood of its being found and returned."

Acknowledgments

We wish to thank Miss Marjorie A. Clark of the Weather Bureau Library for her gracious assistance in locating material on the Bureau's history.

One of the most helpful sources of information has been a new book by Donald R. Whitnah, A History of the United States Weather Bureau. This book, published in 1961 by the University of Illinois Press, is recommended reading for anyone interested in more details of the Bureau's history.

Another excellent source of historical material has been a thesis prepared by Mr. Ernest L. Kvam, Chief of the Administrative Operations Division, on "The Evolution of the U.S. Weather Bureau in Meeting the Needs of Radically Changing Times."

TOPICS' regular features--such as Meteorological Readings, Topigrams, and personnel items--have been omitted from this special issue. They will all be continued in June TOPICS.