U. S. DEPARTMENT OF AGRICULTURE.

REPORT [administrative]

OF THE

CHIEF OF THE WEATHER BUREAU

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BY

WILLIS L. MOORE.

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Report of the Chief of the Weather Bureau

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REPORT OF THE CHIEF OF THE WEATHER BUREAU.

UNITED STATES DEPARTMENT OF AGRICULTURE,
CENTRAL OFFICE OF THE WEATHER BUREAU,
Washington, D. C., October 10, 1910.

SIR: I have the honor to submit a report of the operations of the Weather Bureau during the fiscal year ended June 30, 1910.

WILLIS L. MOORE,
Chief of Weather Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

MOUNT WEATHER RESEARCH OBSERVATORY.

Upon the completion of the new main observatory at Mount Weather, the necessary instrumental equipment for taking a full set of meteorological observations was immediately installed, and the first observation in the new building was made on February 18, 1910.

Two observations of the surface meteorological conditions are made daily and telegraphed to Washington, D. C. These observations form a part of the general groundwork upon which the daily forecasts of the weather are made.

AERIAL RESEARCH.

In addition to the observations of the surface conditions, there is also telegraphed to Washington each day a brief statement of the observations made in the free air at different heights above Mount Weather.

In the beginning of aerial research by the Weather Bureau, in 1897, it was conceived that a synoptic chart of upper-air conditions, made daily, if possible, would be a decided gain to meteorology. Therefore a network of 17 stations was equipped with kites as the sole means of sending recording instruments into the air. It soon developed that kite flights could be made only on days when there was sufficient wind, and that these formed a smaller percentage of the whole than was expected. For this and other reasons the plan of constructing a chart of upper-air conditions was abandoned.

In planning the upper-air work at Mount Weather, advantage was taken of this earlier experience, and an equipment was installed that promised to insure flights in almost any kind of weather. To a certain extent the equipment now on hand has fulfilled its promise. At times, however, the winds blow over the mountains at almost

hurricane velocity, while at other times the mountain top will be shrouded by a covering of cloud and rain—conditions that baffle any attempt to launch a kite successfully. In the past twelve months there were nine occasions when a kite flight or a balloon ascension could not be made on account of stress of weather or because of other hindering conditions, such as lack of hydrogen gas in winter.

For the first few years flights at Mount Weather were made on week days and holidays, but not on Sundays. The omission of Sunday flights was largely because of the general rule of the institution to suspend activities on the seventh day in order that its employees might get needed rest and recreation. Following a different arrangement of the force and the addition of a storage battery, Sunday flights began on July 18, 1909, and have continued regularly since, except when prevented by adverse weather conditions.

Progress in the exploration of the upper air must of necessity be slow: First, the records obtained are not uniform, either as to the altitude attained or the time of day the ascension is made; second, owing to the varied character of weather conditions met with in the course of a year it is not possible to distribute the flights in such a way that a fair average of each set of conditions will be obtained. In fact, many important changes occur of which no record is possible. Fortunately, the number of days on which adverse weather conditions prevent a kite flight or balloon ascension are few, there having been, as before stated, but nine during the last year. But, on the other hand, there were 10 days on which the altitude attained was only 1,000 meters, or less, above sea level; 97 days when the altitude reached was between 1,000 and 2,000 meters;[a] 112 days when it was between 2,000 and 3,000 meters; 74 days with a record of between 3,000 and 4,000 meters; 45 days with 4,000 to 5,000 meters, and 16 days when a height of more than 5,000 meters was attained. Thus it will be seen that the material for study is composed of many flights up to between 3,000 and 4,000 meters and a much smaller number, about 17 per cent of the whole, above that height. It is obvious that a direct comparison of atmospheric conditions, one day with another, is not possible, except when daily records of approximately the same altitude are at hand.

Since the weather conditions, especially those in an area of low pressure, often preclude the sending up of a kite or captive balloon, and since only that portion of the atmosphere up to about 10,000 feet can be profitably investigated by their use, recourse must be had to free small rubber balloons for sending instruments to greater heights. The small balloons are filled with hydrogen gas, and may be sent up singly or in tandem. When sent up singly a parachute is attached so that when the balloon bursts the instrument will be brought safely to the ground. Sounding balloons, as they are called, were used in Europe as early as 1893. Their first use in this country was at St. Louis in 1904 by Rotch. Their first use simultaneously at two stations in this country was by the Mount Weather Research Observatory in September and October, 1909, at Fort Omaha, Nebr., and Indianapolis, Ind. The party at Fort Omaha obtained hydrogen gas from the Signal Corps plant at that place. The party at In-

[a] 1,000 meters=3,281 feet.

dianapolis used hydrogen gas generated on the ground by the iron filings-sulphuric acid process, using a portable generator. As the gas thus generated did not have the lifting power of that used at Fort Omaha, two balloons instead of one were used at Indianapolis, which necessarily reduced the number of synchronous ascensions. Twelve of the 13 instruments sent up from Fort Omaha and 6 of the 7 sent up from Indianapolis were recovered.

The mean of the highest altitudes reached at Fort Omaha was 13.3 kilometers, or about 8.3 miles. The greatest altitude reached was a little over 24 kilometers (15 miles). The average height of the Indianapolis ascensions was 14.6 kilometers, about 9 miles, and the height of the highest individual ascension at that place was 19.4 kilometers, or about 12.5 miles.

The detailed data of pressure, temperature, moisture, and directions of the wind for all of the flights will be published in a report already prepared by Research Director W. R. Blair.

A sounding-balloon expedition to Fort Omaha was made by a party from the Mount Weather Research Observatory in May, 1910. Fifteen out of 20 instruments sent up on this expedition were recovered. The altitudes attained were not great, owing, apparently, to a poor quality of rubber in the balloons, which permitted the gas to escape.

Notwithstanding the difficulties encountered in aerial research, the work thus far carried on at Mount Weather has disclosed the following new and important facts:

The stratification of the lower portion of the atmosphere, as regards its temperature and moisture, is more extensive than was hitherto suspected. It has been known for many years that the temperature of the air diminished with increasing altitude, but the details remained more or less obscure until revealed by the daily records brought down by kites and balloons. It has been found that there are many exceptions to the rule of decrease of temperature with increase of altitude; thus, a great layer of warm air is sometimes found floating upon a layer of cold air; and furthermore the thickness and horizontal extent of such masses of warm air may vary greatly. Columns of warm air over a mile in vertical extent have been measured. Again, kite ascensions have disclosed temperature inversions of which no trace remained on the descent of the kite a few hours later. These evanescent inversions are probably produced by small masses of relatively warm air flowing across the line of ascent.

The kite flights have also thrown new light upon the direction and the depth of air currents from the surface to the highest altitudes attained. The various strata of air flowing past a place of observation are not of uniform depth and direction from the surface up, as might be supposed, but are at times composed of layers, each differing somewhat in direction from the next adjoining layer. The direction of the surface wind may be from the south, and at the same moment the direction a half mile upward may be from the southwest, and a half mile above that level it may be from the west.

It was known from observations of the clouds that in this hemisphere the wind was deflected to the right with increasing altitude above the ground, but the kite and balloon observations show that at times it is deflected to the left. It has also been found that the depth of easterly winds on this continent is less than over northern Europe.

The data secured by means of kites and balloons point to another equally important conclusion with respect to the time that temperature changes occur at the surface and at altitudes between 1 and 2 miles above, viz, that the changes occur practically simultaneously at both levels. While this conclusion is probably not final, it is in strong contradiction to statements which have been made in this country to the effect that the temperature changes at relatively high levels foreshadow those which take place in low levels twenty-four hours afterward.

The temperature gradient—that is, the rate of decrease of temperature for each 100 meters of ascent—immediately before the so-called heat thunderstorms does not accord with that called for by theory. Likewise in heated terms, or the so-called "heat waves," the unusually high temperatures appear to be confined to the air strata next the earth's surface and up to less than half a mile above. The heat wave does not advance abruptly as a wall of high temperature, but rather builds gradually over the region affected.

ATMOSPHERIC ELECTRICITY.

During the year apparatus was installed by means of which the potential gradient on the kite wire could be read off conveniently. This work, however, should be considered as merely preliminary to a more complete determination of the ionic content and movement in the free air.

No change has been made in the magnetic work during the year. Photographic registers of the declination, the inclination, and the horizontal intensity are made daily, and the photographic sheets are properly checked so that hourly values may be drawn therefrom hereafter.

SOLAR RADIATION.

Measurements of the intensity of solar radiation and the percentage of polarization of sky light have been made at Washington and Mount Weather, as in previous years. A five-year series of observations at Washington was completed on April 30, 1910, and the results have been summarized for publication in the Mount Weather Observatory Bulletin.

In addition to computations of the value of the solar constant, which are necessarily confined to observations obtained on days when the sky is exceptionally clear, all the pyrheliometric measurements made during the five-year period, 7,350 in number, have been utilized in determining the mean rate at which solar radiation is received at Washington, D. C., with a cloudless sky for different angles of the sun and with average solar declination for each month.

These monthly and annual mean rates show greater departures from the normal than do the computed values of the solar constant. The pyrheliometric observations obtained at European observatories during the past twenty-six years also show marked fluctuations. It therefore appears to be desirable to undertake a systematic study of the rate at which solar radiation is received at different points in the United States, and of the variations that occur in this rate from year to year. For this purpose, pyrheliometric records as nearly complete as possible will be obtained at four or five stations, so located as to be fairly

representative of the different climatological sections of the United States. Prof. H. H. Kimball will have charge of the carrying on of these observations, mostly at points west of the Mississippi River, during the coming fiscal year. Preparations are practically completed for equipping these stations with the new form of pyrheliometer developed and partly constructed by Prof. C. F. Marvin. It is hoped to supplement this instrument in the near future with one that records continuously.

THE VAPOR IN THE ATMOSPHERE.

Progress has been made toward the installation of apparatus, especially optical, adapted to the study of the quantity of the water vapor in the atmosphere and the investigation of the radiation and absorption of materials and their varying surfaces.

The amount of water vapor in the atmosphere is of such importance as to justify attempts by all known methods to determine it. At present only the hair hygrometer and the spectroscope are available for measurements in the atmosphere above the surface of the earth, and while both methods are unsatisfactory, they should be used for such results as they can give. The amount of water vapor in the air next to the earth's surface is so strongly affected by purely local conditions that its use in weather forecasting has long since been abandoned.

The spectroscopic observations will be made by Prof. William J. Humphreys.

DISCUSSION AND PUBLICATION OF DATA.

In meteorology, as also in most other natural sciences, the accumulation of data and their discussion from a physical standpoint must go hand in hand; in other words, it would not be wise to go on accumulating data without an attempt at interpretation. To provide a means of publishing the data obtained at the Mount Weather Research Observatory a regular publication, known as the bulletin of that observatory, was established in 1908, as noted in former annual reports. On account of his experience and success as editor of the Monthly Weather Review, Prof. Cleveland Abbe has been assigned as editor of the bulletin.

The field of the new bulletin is technical meteorology and not climatology or education. During the year six numbers have appeared, completing Volume II and including the first part of Volume III. The bulletin contains the detailed records brought down by kites or balloons up to about 5,000 meters in the atmosphere. The results of the first series of synchronous sounding-balloon records made in this country will appear in part 2 of Volume III.

During the year articles discussing the theoretical as well as the practical application of the data obtained at Mount Weather and elsewhere to the problems of meteorology have appeared in the bulletin. The articles on aerial work have been contributed by Research Director Blair; those on the quantity of heat received from the sun by Prof. H. H. Kimball; and those on the changes of wind with altitude by Prof. A. J. Henry, who has also served as executive officer of the observatory.

While the bulletin is devoted principally to the work of Weather Bureau officials at the observatory, its columns are open to eminent scientists throughout the world. Among the latter who have contributed during the year are Prof. R. S. Woodward, president of the Carnegie Institution of Washington; Prof. A. Lawrence Rotch, director of the Blue Hill Observatory; E. Gold, of the meteorological office of London; and Prof. J. H. Jeans, of Princeton University.

FORECASTS AND WARNINGS.

UPPER-AIR OBSERVATIONS AS AIDS TO FORECASTING.

The daily telegraphic reports of upper-air observations from Mount Weather, Va., have been of aid to the forecaster at Washington during the past year, and it is believed that their continued use will further increase the accuracy and range of the forecasts. The following are concrete examples of possibilities in this way:

In this section a storm center sometimes passes eastward or northeastward over the ocean, without being followed by clearing weather on the coast States, as would ordinarily be expected, because of a secondary storm development off the middle or south Atlantic coast. A study of the Mount Weather kite flights shows that north winds occur at high altitudes in advance of the formation of a storm of this character. Thus, it is hoped to be able in future to forecast their development, and thereby increase the accuracy of the forecasts of the weather that follows for the entire coast district.

Again, it has been found that when a low-pressure area is approaching from the southwest, and the winds turn to the right (clockwise) with ascent, the usual warming up in the Atlantic States seems to be retarded about twenty-four hours.

Also, the turning of the winds to the left (counter-clockwise) with increased altitude shows the depth of the cold northwest wind. From this may be drawn reasonably correct inferences as to the fall in temperature that may be expected at the surface of the ground within the next twenty-four hours.

The thickness of the stratum of cold air that advances from the west or northwest with the approach of an anticyclonic area is of the highest importance in determining subsequent temperature conditions. The temperature reports for high altitudes show whether the stratum is shallow or of great depth. When shallow, the cold weather accompanying the high is neither severe nor of long duration; but if the blanket is thick and abnormally low temperatures are reported aloft, the cold will be of marked intensity and will probably last several days. In predictions of sleet, also, it is essential to know what is going on in the upper air. Conditions favorable for sleet are comparatively warm upper air and a thin layer of lower air with its temperature somewhat below the freezing point.

HURRICANES OF THE YEAR.

The hurricane season of the past year was marked by a number of severe tropical disturbances. Warnings were given to shipping and other interests in every instance in time for them to take all necessary precautions.

The Galveston hurricane of July 21, 1909.—The storm was first observed in the Caribbean Sea to the southeast and then to the south

of Jamaica on the 15th and 16th. The center of the disturbance moved northward over the Yucatan Channel into the Gulf of Mexico from the 17th to 19th, thence northwestward with increasing energy during the 20th, reaching the Texas coast just south of Galveston on the 21st. Beginning on the 17th, advices regarding the storm were telegraphed to Havana and southern Florida ports, and from the 18th to 21st Atlantic and Gulf shipping interests were informed daily regarding its probable position and course.

The following is from the report of the official in charge of the Weather Bureau office at Galveston:

The first announcement of the storm's approach was received at this office on the 18th. Advisory messages followed on the 19th and 20th, that of the 20th being to the effect that the disturbance was over the central Gulf, moving northward. Shipping interests and the public were kept thoroughly informed by telephone, bulletins, and the press, and I believe that on July 20 there was not a single news-reading person in the city who was not aware of the storm. It is estimated that the Gulf rose 10 feet above the normal. Volumes of water dashed over the sea wall and flooded the lower portions of the city.

Extract from the Post, Washington, D. C.:

The citizens of Galveston and the residents of the Texas coastal plain owe a debt of gratitude to the United States Weather Bureau for the timely warnings of the tropical storm that recently swept in from the Gulf of Mexico. While the loss was not large from the ravages of the hurricane, yet it probably would have reached an appalling total in death and damage to property had not the storm's destructive path been foreseen by the Bureau many hours before it struck the coast.

Extract from an Associated Press report from Houston, Tex.:

Advices show that damage was done throughout a section of Texas extending on an average 100 miles into the interior. In some counties reports indicate that very few home owners escaped losses of at least a minor sort. While the property destruction has been great, the life loss and serious injury is inexplicably small. This is attributed largely to the fact that storm warnings gave the inhabitants an opportunity to prepare for the expected blow.

Hurricane of August 27, 1909.—This storm, which caused great loss of property at Mole St. Nicholas, was first observed south of Haiti on the 23d. Advices issued on that date stated that the disturbance would move west-northwestward in the region of the Bahamas, and that rough weather would be experienced in Cuban waters, and probably as far south as Jamaica. On the 24th the southern provinces of Cuba were visited by heavy winds and rains that caused considerable damage to property, and in the afternoon a wind velocity of 60 miles an hour from the northeast was reported from Havana. On that date advices were issued that the storm would move west-northwest toward the southeastern portion of the Gulf of Mexico, and vessels were cautioned to avoid those waters. On the 26th the steamer *Cartago* reported the storm by wireless to New Orleans, via Burwood, La., the distance from the ship to the receiving station being about 500 miles. This is the first instance in which a report of an encounter with a storm at sea was transmitted in time to be utilized in current forecast work. The storm struck the coast near the mouth of the Rio Grande on the 27th. Although it was severe, no lives were lost during its passage, due to the fact that the Weather Bureau warnings were timely and enabled the people living on the low islands along the Gulf to reach places of safety.

Extract from the Corpus Christi Herald of August 30, 1909:

The people who were at Tarpon Beach are loud in their praises of the United States Weather Bureau, and say that had it not been for the warnings sent out by the Bureau every one of them might have been drowned. As it was, they received the warnings in time to seek safety in the quarantine station, where they all remained until the storm was over.

Tropical storm of September 17-21, 1909.—This storm was first observed south of Jamaica on the 14th. It moved thence northwestward to the Yucatan Channel, where it was central on the morning of the 17th. Advices were issued to shipping interests at Atlantic and Gulf ports that the hurricane center would probably move northward over the Gulf of Mexico; vessels in extreme south Atlantic and Gulf ports were warned not to leave their harbors, while vessels elsewhere preparing to sail to those waters were told to await the passage of the storm. After a northwestward movement the storm struck the Louisiana coast, about 50 miles west of New Orleans, on the 21st.

The following is taken from the New Orleans Picayune of September 22, 1909:

It must be said to the credit of the Weather Bureau that the excellent work done has proved of incalculable benefit to life and property by the issuance of timely warnings of the storm. On Wednesday of last week the Weather Bureau began to give out bulletins as to the location of the tropical hurricane and its probable trend, and this warning note never ceased from day to day until the crucial moment, Monday morning, when the definite warning was issued telling about the very near approach of the disturbance threatening south Louisiana and probably having some sinister design upon the city of New Orleans. The storm reached this city about the time forecast by the Weather Bureau, and it lasted until nearly midnight Monday.

The following is from the same paper, under date of September 25:

The admirable arrangements made by the weather service insures ample warning of the approach of these West Indian storms, but there is little that can be done to protect property from their ravages. That the timely warnings saved many lives is, however, undoubted, and were the people who live in exposed stretches of the coast to pay greater attention to these warnings the loss of life would be still more reduced. Sailors who go to sea carefully note the weather predictions and are guided thereby, whereas the people living on the low-lying coast, who have actually more to fear than the sailors, usually pay less heed to the storm predictions.

The Key West hurricane of October 11, 1909.—This storm was first noted over the south-central Caribbean Sea on the 2d, and masters of vessels in or bound for southern waters were kept advised daily, beginning on the 6th. On the 10th storm warnings were ordered on the south Florida coast, and at 6 a. m. of the 11th they were changed to hurricane warnings. After passing over Key West the hurricane swept the Florida peninsula south of Miami. On the extension of the Florida East Coast Railroad about 3,000 workmen were withdrawn from dangerous points as a result of the Bureau's warnings. The following particulars are taken from the report of the Weather Bureau official at Jacksonville, Fla.:

The correctness of the warning and the effectiveness of its distribution are indicated in the small loss of life—about a dozen—along the lines of the projected railroad. Those who were drowned paid the penalty of remaining aboard a tugboat, which sank, instead of seeking shelter, as did others. With about 3,000 laborers scattered for many miles over the low islands of the sea along the proposed route of the Florida East Coast Railroad, the fact that the loss of life was so small is an eloquent tribute to the wisdom of the railroad officials in obeying implicitly the information given out by the Weather Bureau. In

1906 many hundreds of laborers were drowned during a tropical storm as a consequence of ignoring warnings. While many tugboats, lighters, and other auxiliary equipment were saved, the losses of the railroad company will reach hundreds of thousands of dollars. It is conceded by the company and by the public press that hundreds of lives were saved through the warnings issued in connection with this storm.

The cooperation of steamship lines has been requested during the coming year as an aid to the forecaster in predicting the direction of movement and the intensity of hurricanes in the Gulf of Mexico, the Caribbean Sea, and West Indian waters. It is hoped to have vessels in those waters report by wireless telegraph to the central office at Washington during the hurricane season of 1910 whenever the meteorological conditions are such as to indicate the presence of a hurricane in the immediate region of the reporting vessel. These reports, in connection with those received from special meteorological stations maintained by the Bureau in the West Indies, will give the forecaster information of the greatest value.

FORECASTS FOR EXTENDED PERIODS.

During the past year forecasts for a week or ten days in advance have been issued from time to time when certain well-defined weather types were shown by reports from selected stations throughout the Northern Hemisphere. These reports are charted daily and show the changes constantly occurring in the great centers of action that control the movements of storms over North America, and as a consequence determine its weather and climate. The conditions existing over western Europe, as shown by the Northern Hemisphere chart of January 26, are typical of the weather over that region during the latter part of January, when heavy rains and resulting floods were experienced in western Europe, and were of particular severity in France. During this period barometric pressure was abnormally low over Iceland and adjacent European districts, and the west-central and northwestern portions of Europe were almost constantly covered by the rain quadrants of a rapid succession of cyclonic areas of exceptional magnitude. These rains were of unprecedented duration and of excessive amounts. It is evident therefore that the floods were caused, not by deforestation, but wholly by the excessive and long-continued rains, extending with hardly any interruption over a period of several weeks.

During the early part of August, 1909, there was a decided lack of rain in the corn-growing States of the Mississippi and Ohio valleys, and in the upper Mississippi Valley the drought had become severe. Rain was also needed in the Middle Atlantic and New England States. On the 10th an announcement was made that the rains over the western portions of the cotton belt during the preceding two or three days would be supplemented during the succeeding several days by abundant rains in that section and generally over the Southern States. The rains set in as anticipated on the 12th and continued through the 13th.

The following special forecast was issued Wednesday, August 11:

Present barometric conditions indicate that the prevailing drought in the Atlantic States from Virginia northward over Maryland, Pennsylvania, New York, and the New England States will be relieved in part by showers by the close of the present week, and that more general rains will fall in the States referred to by the middle of next week.

A period of rainy weather that set in over the Middle Atlantic and New England States during the closing days of the week ending August 14 continued until the middle of the following week, and in areas in those districts the rainfall was excessive.

On January 30, 1910, the following special forecast was issued:

Present barometric conditions over the Northern Hemisphere indicate that during the week beginning Monday, January 31, temperature will be moderate for the season generally over the United States until the close of the week, when a cold wave is likely to appear in the extreme northwest and advance thence to the Atlantic coast by the early portion of next week. In the meantime storms that will reach the Atlantic seaboard about the middle and close of the week will be attended by sharp fluctuations in temperature in Middle Eastern and Northeastern States and by precipitation generally east of the Mississippi. In middle and northern districts the precipitation will be in the form of snow. In the Missouri and western Mississippi valleys and the Plains States precipitation will be comparatively light.

A storm advanced from the Rockies to the Atlantic coast from February 1 to 3, and was attended by precipitation east of the Mississippi and by heavy snow in northern portions of New York and New England. In the Missouri and middle and upper Mississippi valleys the week closed with a cold wave that advanced thence eastward over the Atlantic States during the 6th and 7th, attended in portions of the Middle Atlantic States by the lowest temperatures of the winter. A notable feature of this cold wave was the extremely low temperatures noted in the kite flights at Mount Weather, where, at an elevation above the station of 6,700 feet, a reading of 26° below zero was recorded on the morning of February 7. At the station the temperature at the same hour was 14° above zero.

On February 6 the following special forecast was issued:

The week beginning Monday, February 7, will open with temperature considerably below the average for the season over the eastern portion of the United States. Following the cold period in the East, temperature will rise slowly during the next several days. A disturbance that will reach the Atlantic coast from the Middle West and Northwest about Thursday will be attended by precipitation from the Mississippi Valley eastward; that in more northern States will be in the form of snow and will be followed by a change to colder.

The center of this disturbance reached the Atlantic coast Thursday morning. Its advance from the Rockies was attended by rain in the Southern and Middle States east of the Mississippi and by snow from the Lake region over New York and New England. It was followed by a marked fall in temperature and by freezing weather as far south as the middle Gulf coast.

On Sunday, February 13, the following special forecast was sent out:

During the present week a general storm, followed by a cold wave, will cross the United States. The center of this storm will appear over the Pacific States within the next two days, cross the Rockies, Plains States, and central valleys during the middle days of the week, and reach the Atlantic seaboard by Friday. The cold wave promises to be rather severe. It will overspread the North Pacific States by Tuesday morning, the middle and northern plateau and Rocky Mountain districts by Wednesday morning, the middle and northern Plains States and central valleys by Thursday, and reach the Atlantic seaboard by Friday or Friday night. In the event of warm heavy rains in the near future, the extraordinary depth of snow on the ground in parts of the Lake region and in the mountain districts of the Middle Atlantic and New England States will present conditions favorable for freshets and floods in the streams of those regions. The outlook for the present is that a tendency toward flood conditions in the larger streams about the middle of the week will be checked by cold weather that will arrive later in the week.

The storm referred to appeared over the North Pacific States on the 14th and moved thence southeastward to the West Gulf States, where it recurved eastward and northeastward and passed to the New England coast by Friday morning, the 18th. It was attended by heavy snow from the Middle Mississippi Valley over the Ohio Valley and lower Lakes, by rain or snow in the Atlantic and West Gulf States, and by rains and thunderstorms in the East Gulf and South Atlantic States. Its passage over the Gulf and Atlantic States was attended by gales of unusual strength. The storm was followed by a cold wave that carried the line of freezing temperature to the Gulf coast.

The following editorial regarding the cold wave and storm above mentioned is taken from the Oklahoma Oklahoman of February 17:

The remarkable accuracy with which the blizzard that is now traveling across the country was predicted days in advance of its advent is deserving of most favorable comment. Sunday's newspapers throughout the United States carried a warning from the Weather Bureau to the effect that a storm was approaching the Pacific coast that would traverse the entire continent and reach the Atlantic coast by Friday. In Oklahoma marked derangement of atmospheric conditions was noticeable Monday night. Late Tuesday evening there came a sudden drop in temperature accompanied by high winds. By Wednesday morning the mercury had dropped to 10° above, and the boreal blasts were carrying considerable snow. Thus the story of a prediction and its fulfillment. The advance warning should have been of incalculable benefit to live stock men and to shippers and others engaged in vocations which are affected by meteorological conditions.

In the latter part of March, 1910, it was thought that sufficient advance had been made in the knowledge of general weather types to permit the issue each Sunday of a forecast for the ensuing week. Since that time weekly forecasts for the United States, together with a general résumé of weather conditions throughout the entire Northern Hemisphere, have been issued with gratifying success.

The following is a copy of the first regular weekly forecast:

The vernal equinox inaugurates the rainy season in the Tropics. The autumnal equinox marks the central period of the season of so-called equinoctial storms. When the sun in its annual northward journey crosses the line of the equator the rainy season sets in over the northern equatorial region, and the rain belt keeps pace with the northward movement of the sun until the period of the summer solstice, June 22. About that time the rain belt reaches the northern subtropical regions, like Florida, and the rainy season begins in those regions. Attending the southward movement of the sun, the rain belt again crosses the Tropics, and when the sun has about half completed its return course to the equator the season of severe tropical or equinoctial storms begins in the tropical and subtropical regions of the Atlantic. The North Atlantic season of equinoctial storms extends from August to October, inclusive. On the Atlantic Ocean these storms are called hurricanes, on the Indian Ocean cyclones, and in southeastern Asiatic waters typhoons. In the Pacific area the typhoon season begins earlier and continues later than the hurricane season of the North Atlantic. The vernal equinoctial period of the present year has been attended by exceptionally fine weather over the American continent east of the Rocky Mountains and in western Europe and adjacent waters. Along and south of the transatlantic steamer tracks light to moderate winds and smooth seas have prevailed. Over middle and southern latitudes of the Pacific and adjacent Asiatic coasts no severe disturbances have been reported. Over western portions of the American continent and in eastern Europe and the interior Siberian area marked barometric changes have produced unsettled and stormy weather.

During the present week temperature in the United States will average mild for the season. A disturbance that now occupies the California coast will move eastward and reach the Atlantic coast about Friday. Another disturbance is indicated that should cross the country from about March 31 to April 4. The

disturbance should be attended by rains of increasing area, and will be followed by changes to cooler weather. Atmospheric movements will be more active along the transatlantic routes, and a period of rains is indicated for the British Isles and northwestern Europe.

The following is an extract from a weekly bulletin issued June 12, 1910:

At the close of last week a pronounced disturbance appeared over Iceland, whence it will move eastward and give stormy weather over the British Isles and northwestern Europe during the next three or four days.

The extract next following is taken from the résumé of the following week, and shows the accuracy of the prediction above quoted:

A disturbance of marked intensity moved southeastwardly from Iceland over Europe during the first half of the week, attended by general rains, which produced floods in the rivers of north and central Europe.

The following special forecast was issued Wednesday, June 22:

As forecast in the special bulletin of Sunday, the 19th instant, a break in the hot wave that has prevailed during the past week in Montana, North Dakota, South Dakota, Nebraska, and western Minnesota is now in progress, and the indications are that there will be local rains and several days of normal temperature in those States. Warm weather is forecast to continue in the southern Plains States, the Mississippi Valley, and the eastern districts during the next several days.

The feature of the weather for the week ending June 25 was the hot wave in the Northwestern States during the first half of the week and in the Eastern States from Monday until Friday. Temperatures near or above the highest previously recorded in the month of June occurred Monday and Tuesday in Minnesota, North Dakota, South Dakota, Nebraska, and eastern Montana. Local rains occurred the latter half of the week in the Rocky Mountain region, the Plains States, and the upper Mississippi Valley.

ADDITIONAL ALASKAN REPORTS.

Reports from three additional stations in Alaska during the year have materially aided in the preparation of the weekly forecasts. It is gratifying to learn that the Canadian Meteorological Service will shortly establish two new stations, one at Cochrane and the other at The Pas, thus extending the range of observations northward and enabling the forecaster to predict more accurately the sweep of cold waves and storms from that region.

RIVER AND FLOOD DIVISION.

The administrative work of the River and Flood Division was of the usual description, having been largely devoted to improving the character of the personnel and securing increased efficiency and permanency of equipment. A number of special observers were separated from the service on account of incompetency and neglect of duty, and river gauges were repaired or renewed where necessary. As a rule the spring floods damage or destroy many gauges, necessitating a large outlay for renewals, but during the past spring the absence of severe floods permitted the application of a reasonable amount of money to the work of improvement. During the year a Marvin automatic gauge was successfully installed at Parkersburg, W. Va., and it is proposed to install similar gauges during the coming year

at Des Moines, Iowa, and Sacramento, Cal., if the work of constructing the new bridges at those places shall have advanced sufficiently. A new river gauge of the inclined concrete type was installed at Henderson, Ky., and contracts have been let for similar gauges at Portsmouth, Ohio, and Mount Vernon, Ind. While the original cost of these concrete gauges is considerable, it has been found that their permanency insures a profitable investment.

The uniform success that has attended the forecasting of the disastrous floods that occur at times in the Grand River of Michigan has led to the extension of the river service to the watershed of the Saginaw River in the same State, and it is thought that after the accumulation of some comparative data equally efficient service can be afforded in that section. The river district of Hannibal, Mo., was created during the year by assigning to it that portion of the St. Louis district lying between Hannibal and the mouth of the Des Moines River, and other changes of a minor character were made.

The great floods of the year were those of July in the Missouri River and its tributaries east of Kansas City and in the Mississippi River from Hannibal, Mo., to Chester, Ill.; that of November and December in the North Pacific States; and that of January in Utah and southern California, the last named being one of those rare occurrences known as a "desert flood." The floods of July overflowed about 1,000,000 acres of farm lands, of which two-thirds were under cultivation, with resulting loss of about $7,000,000, of which amount $5,500,000 were in crops. Along the Grand River of Missouri the flood was particularly severe, and the stages of water were the highest of record. The warnings issued by the Weather Bureau during this flood saved property to the value of $1,000,000 that otherwise would have been lost. The north Pacific floods of late November and early December were in the main mountain floods, caused by continuous warm heavy rains and rapidly melting snows, and did damage to the amount of about $4,000,000. As it is not possible to maintain effective flood service along mountain streams, no specific warnings of these floods were possible, but general warnings were issued as soon as the conditions became threatening. The "desert flood" of January was caused by warm rains falling upon the heavy December snows, and the actual losses totaled at least $3,000,000, falling most heavily upon the railroads.

The spring flood in the Ohio River did not assume dangerous proportions, although in January the Wolf Creek ice gorge for a time created a very alarming situation below Louisville.

The daily forecasts for the navigable rivers are still an indispensable adjunct to the successful conduct of river steamboating.

The accuracy and timeliness of the river forecasts and warnings attained during previous years have been maintained, and there is reason for the belief that during the year just ended the groundwork was laid for still further improvement. The comments of the press and interested parties relative to the conduct of the work were uniformly commendatory, and their reproduction here would be but a repetition of those of former years.

The study of the Ohio River was continued, and forecast schemes were completed for the entire river, except for the section from Mount Vernon, Ind., to Cairo, Ill. The schemes for the Cumberland and Tennessee rivers are well under way, and hopes are entertained that

the entire scheme for the Ohio watershed will be completed during the coming year.

There is still need of some further extension in the line of direct flood work, notably in Oklahoma, Indiana, and Illinois, and along some of the upper tributaries of the Mississippi River, but little can be accomplished during the next fiscal year, as projects already under way will consume any funds that might otherwise have been available.

Over a year ago it was recognized that the approaching completion of the irrigation projects in the Far West by the Reclamation Service imposed new responsibilities upon the Weather Bureau, namely, the obtaining of accurate snow measurements at the sources of water supply, the determination of the water equivalent of the accumulated snows of winter, and the gauging of the streams for the benefit of the water users; and it has become a part of the duty of the River and Flood Division to determine as nearly as possible the amount of water that will be available each season for irrigating purposes. A sufficient supply of funds for the entire project has not yet been provided, but it has been proposed to conduct during the coming year at least one series of observations, probably in northern Utah, along certain definite lines. From the experience thus obtained it will be possible to pass intelligently upon the feasibility of the general plan and to prepare reasonable estimates of the annual cost of the entire project for submission to Congress. For a time, at least, this work must be limited to the smaller watersheds.

EFFECTS OF FOREST ON CLIMATE AND STREAM FLOW.

There remains one other problem that will engage the special attention of the River and Flood Division. The widespread discussion during the last two or three years as to the effect of forest cover on climate, stream flow, etc., has developed such differences of opinion in the minds of those chiefly interested as to necessitate a searching inquiry into the subject. After an elaborate research into all available data, the Weather Bureau, in company with many eminent engineers, concludes that on the principal rivers the floods are not higher or longer continued or the low water lower than forty years ago, while other persons hold to the opposite. But there are other questions with regard to which all appear to agree that available data are at best insufficient; consequently, to quote from my report of February, 1910, to the Committee on Agriculture of the House of Representatives on "The influence of forests on climate and on floods:"

> We must therefore reason empirically from the best information at hand, and this insufficiency of data renders less positive the conclusions of all investigators, no matter which side of the question they may be on.

Therefore the Weather Bureau and the Forest Service, with the permission of the Secretary of Agriculture, have agreed to cooperate in an exhaustive study of the entire question of forest effects upon climate and stream flow, and have selected as a suitable field for operation the Rio Grande National Forest, in southwestern Colorado. Representatives of the Weather Bureau and the Forest Service are already in the field making preliminary arrangements, and active work will begin as soon as the Weather Bureau can supply and install the necessary equipment and the Forest Service can provide the necessary

facilities. It is hoped to have the work well under way by August or September, 1910. Two watersheds of similar topography and of limited drainage areas have been selected, and the necessary weirs and instruments for the measurement of stream flow will be located at an approximate altitude of 9,500 feet above mean sea level, the drainage area extending upward to an elevation of about 10,500 feet.

It is proposed to measure the flow of the two streams for a sufficient period, probably eight or ten years, to demonstrate their behavior with equal forest cover. One of the watersheds will then be denuded and streamflow measurements continued on both for another period of eight or ten years, by which time it is probable that the effects of the denudation, whatever they may be, can be stated in positive terms. In order that all the climatic factors that affect or modify stream flow may be considered, a complete equipment of meteorological instruments will be provided and observations will be taken several times daily. Automatic instruments will afford continuous and permanent records of pressure, temperature, wind direction and velocity, sunshine, precipitation, and evaporation.

The proposed period of observations is none too long, and in view of the possible influence of the investigation upon certain questions of public policy, and in the interests of scientific research, it may become necessary later on to extend it.

INSTRUMENT DIVISION.

About 200 stations of the Bureau are now fully equipped with recording instruments, 3,000 cooperative observers are supplied with maximum and minimum thermometers, rain gauges, and instrument shelters, and about 150 stations are provided with steel towers and high-power oil or electric lanterns for the display of storm warnings.

The new stations at St. Joseph, Mo., and Lansing, Mich., at which Weather Bureau buildings have recently been erected, were fully equipped with standard sets of instruments during the year. The regular station at Brawley, Cal., maintained in connection with the observations on evaporation at the "Salton Sea," was closed in May, 1910, and the equipment transferred to the special station at Wagon Wheel Gap, Colo.

The kiosks installed a year ago in some of the large cities have proved very popular, and more requests for these structures have been received than it has been possible to grant. Six kiosks were purchased during the year; three have been erected at prominent points in Hartford, Duluth, and Richmond, but the work of installation at Indianapolis, Salt Lake City, and Atlanta is not yet completed.

NEW WORK AND APPARATUS.

During the year Professor Marvin perfected certain new methods of measuring the intensity of solar radiation in absolute units of heat by the use of the electrical resistance thermometer. So far as known, this method has never been employed heretofore. It seems to possess great advantages over customary forms of the pyrheliometer, owing especially to the fact that the thermal capacity of the apparatus can easily be determined from time to time in the ordinary course of

observation. Such a check is quite impossible with ordinary instruments. The first working apparatus of the new type has been turned over to Professor Kimball and is being installed at Madison, Wis. Additional instruments are under construction for a few other stations where observations of solar radiation are particularly desired.

Last October the Weather Bureau was requested to pass upon a proposed simple plan of renewing and improving the protection of the White House from lightning. Professor Marvin submitted a revised plan, prepared in accordance with the best modern ideas and practice, which elicited the special commendation of the engineer of public buildings and grounds having charge of the execution of the work.

A special form of inverted, astatic pendulum, devised and installed by Professor Marvin in 1907, has since recorded earthquakes at the Weather Bureau in a very satisfactory manner. During the past year detailed drawings of an instrument of this type, adapted to record very destructive earthquakes, and having a possible maximum double amplitude of motion of 3 inches, was supplied to Prof. A. C. Lawson, of the University of California. The instrument is being made up at the shops of the university and will be installed in the special earthquake-proof vault provided for its new seismological equipment.

IMPORTANCE OF SEISMOLOGICAL OBSERVATIONS.

It seems appropriate at this point to renew the recommendations made in previous years that the Weather Bureau be authorized to engage systematically in making seismological observations and publishing the results. People in general, and scientists especially, have become fully aroused to the great importance of this work, and it is now well known that, when full information is available, definite advice can be given as to where to locate and how to erect buildings so as to minimize or even entirely escape disastrous effects of earthquake disturbances. Repeated appeals have been made to Congress to authorize and provide for seismological work, but thus far without avail. The United States is now the only important nation in the world in which seismological studies are not being carried on under the auspices of the Government. This work requires an extensive system of outlying stations from which reports can be procured, and at a limited number of which seismographs can be installed and maintained. The Weather Bureau is the only branch of the Government already having numerous stations widely distributed over the country and maintaining a corps of highly trained observers on duty at all times. It also has a corps of about 4,000 cooperative observers whose services are available for simple reports of earthquake phenomena, such as can be procured without instrumental equipment. By reason of this extensive and fully organized service the Bureau is peculiarly prepared to conduct seismological work in an effective manner, and at far less expense than would be possible through any of the other departments of the Government.

This was fully recognized by the seismological committee of the American Association for the Advancement of Science at a meeting held in Washington April 19, 1907, when it was definitely voted that the Federal Government should be then requested to support

seismological work, and that appropriations therefor should be made through the Weather Bureau. This action of the committee was not only unanimous, but was heartily concurred in by the heads of all Government bureaus either directly or indirectly interested in the questions involved.

CLIMATOLOGICAL DIVISION.

The issue of the Monthly Weather Review in its new form, begun July, 1909, was considerably delayed during the first part of the year, but has since been brought practically up to date. The publication of the National Weather Bulletin was continued as in past years, weekly during the crop-growing season and monthly at other times. Weekly summaries of the snow and ice conditions were issued regularly during the winter, as were also the snowfall bulletins from the mountain States of the West. The latter have been considerably enlarged, owing to the extension of the special snowfall stations into regions not heretofore covered by reports. A special effort will be made in March and April to give the public an idea of the amount and condition of the snow actually lying on the mountains just before warm weather sets it flowing into the streams. Weekly and monthly summaries of climatological data continue to be issued at the Iowa, Porto Rico, and Hawaii centers, as in the past, but the publication of these summaries for the remaining sections was discontinued with the issues for June, 1909.

The current work of preparing data for the Monthly Weather Review and the Annual Report of the Chief of Bureau, the tabulation of the usual data into the permanent records of the Bureau, and the preparation of matter called for by numerous correspondents desiring information regarding the climate in various portions of the country, have been carried forward as usual.

The numerous requests for climatic data show an increasing knowledge of the information available for the public, and indicate the wide diversity of uses to which it is being put. Nearly 4,000 such requests received prompt attention during the year.

No material change has occurred in the cooperative work carried on by the Bureau. Cooperation with other bureaus of the Department and with the Geological Survey and Reclamation Service, in the gathering of information regarding the snowfall in the mountain regions of the West and the study of special problems in forestry and plant growth, has continued with apparently satisfactory results to all concerned.

The changes in the form of some of the current climatological publications of the Weather Bureau were made during the year in order to accommodate more fully than heretofore the requirements both of the public and of the General Government in developing the water resources of the United States, especially in connection with irrigation and transportation enterprises, as well as the many other public interests which have hitherto been served by these publications. Accordingly the material of which the Monthly Weather Review was formerly composed has been separated into two general parts: Technical articles on research problems in meteorology appear in the Mount Weather Quarterly Bulletin, while the more practical papers on engineering and commercial interests are still published in the Monthly Weather Review. Similarly, the data formerly pub-

lished in the monthly section summaries are now arranged with reference to 12 climatological districts, conforming to the natural watersheds of the United States, and a district editor appointed to each district supervises the preparation of the material, which is finally assembled and printed in the Monthly Weather Review.

The Review in its present form is a strictly climatological journal. It contains, in addition to the current climatological history, occasional important papers on the relation of climate to agriculture, irrigation, transportation, and evaporation, the effects of forests on climate, and other similar contributions, but they are presented in a nontechnical manner as far as possible.

The plan of preparing and publishing climatological summaries, giving in some detail the vast amount of material that the Weather Bureau has been for many years collecting, has continued during the year. The entire United States will eventually be covered in these reports, which will be made up for 106 districts in all. Their publication is advancing rapidly and with the completion of the series, which will soon be accomplished, the public will have in form for ready reference the longer records of climatological data for all parts of the country.

MEASUREMENTS OF SNOWFALL.

Since the water used during the summer for irrigation in those western districts where irrigation is practiced depends largely upon the snowfall on the mountains of that region, the importance of measuring the snowfall in remote places which are inaccessible during the winter has made it necessary to discover some means of automatically measuring the seasonal snowfall at places where no permanent observers can be obtained. Experiments have been carried out under the direction of Prof. F. H. Bigelow for this purpose. A large number of stations have been equipped with comparative apparatus, as follows: (1) Snow bins, or cubical boxes, 5 feet on a side, standing on a frame so that the top is 10 feet above the ground; (2) standpipes, 10 inches in diameter and 10 feet high; (3) platforms, 10 feet square on the ground; (4) vertical scales, graduated in feet and tenths; and (5) the ordinary small snow gauge used by the Weather Bureau for many years.

Observations made during the winter of 1909–10 indicate that the snow bins, fitted with a system of louvers on the inside to prevent the wind from blowing out the snow and to insure a level deposit within, catch very nearly the actual amount of fall. The standpipe fails to catch the right amount of snow by 20 per cent to 50 per cent. The wind drifts the snow on or off the platforms, making the measurements wholly unreliable. The catch of the small snow gauges is also rendered imperfect by wind eddies, which blow around the opening of the cylinder and carry a portion of the snow past the mouth without depositing it. The vertical snow scales are placed against trees or posts to show the depth of the snow lying on the ground at a given time. Further experiments will doubtless soon develop the best practical form of apparatus.

EVAPORATION STUDIES.

The evaporation observations and studies, which were begun in 1907, have been continued during the year under the direction of Professor Bigelow, who is now preparing a report summarizing these

observations. A few facts taken from the records of observations at the "Salton Sea" will serve to show the magnitude of the problem under consideration. At tower No. 1, about 1,500 feet inland from the water, pan No. 1, on the ground, gave a total evaporation for the year of about 165 inches, and pan No. 5, 40 feet above the ground, 193 inches. At tower No. 2, 500 feet from the shore, pan No. 1 swings about 2 feet above the surface of the water, it having been found impossible to float the pans successfully without going to great expense. This pan evaporated about 108 inches during the year, and pan No. 5, 45 feet above the water, evaporated 137 inches. At tower No. 4, 1½ miles from the shore, pan No. 1, swinging about 2 feet above the water, evaporated 106 inches, and pan No. 5, 45 feet above the water, evaporated 140 inches. There was therefore a difference of about 30 inches of evaporation near the water surface of the sea and that taking place 40 feet higher.

The records from the United States Geological Survey indicate that the "Salton Sea" has been falling at the rate of about 55 inches annually for the past three years. While it is not known exactly how much water is flowing into the lake through the New and Alamo rivers and from the precipitation on the neighboring country, it may be estimated that it is not over 15 inches, so that the total annual evaporation from the surface of the sea is probably about 70 inches.

Our experiments have shown that pans of different sizes evaporate at very different rates—a 2-foot pan being represented by the coefficient 0.042, a 4-foot pan by the coefficient 0.036, and a 6-foot pan by the coefficient 0.031. The pans on towers Nos. 2 and 4 were each 4-foot pans. It is not now known what the corresponding coefficient of evaporation is for the surface of the sea, but it is probably something like 0.027. If an allowance of 25 per cent is made for the probable coefficient between the 4-foot pan and the large surface of the sea, it would reduce the apparent evaporation to 90 inches. This will be further reduced by computations depending upon the temperature of the water of the sea probably to about 75 inches, which approximates the actual amount observed as above stated. These facts indicate how unsafe it has been to proceed from the observations on a pan placed upon the shore of a body of water to the corresponding water surface, and the necessity of the programme inaugurated by the Weather Bureau has been amply justified. It is hoped that the final report will be successful in clearing up this last part of the problem regarding the coefficient of evaporation on the large water surface. The formula first used at Reno, Nev., by Professor Bigelow has been verified and proved efficient, working equally well in the dry regions of the West and the humid districts of the Eastern States. The wind coefficient is 0.070 instead of 0.0175 as first obtained at Reno. At that time it was not known that the size of the pan was so important in the phenomena of evaporation, and on that account it was not deemed necessary in the preliminary campaign to secure the wind coefficient with such precision. The cooperation with the Reclamation Service and the United States Geological Survey has been very important, and we have now secured corresponding observations at about 25 stations in the United States. These data, when published, will give a very good idea of the amount of evaporation, but it is evident that the entire subject is one that will always need careful supervision. The wind effect is so powerful that in all cases an anemometer must

be placed immediately at the evaporating pan, and the coefficient of evaporation is such that great caution must be used in making the transition from the evaporation on the shore to the corresponding evaporation over a large water surface. It seems probable that the same coefficient of evaporation exists over the entire lake, except within a comparatively few feet of the shore, where land effect merges with the water effect.

It has been found by special experiments that the "Salton Sea" ceases to exercise any influence upon evaporation during the summer at a distance of about 1,000 feet from the shore. This would indicate that there is no effect of the sea by way of changing the climate of the country about its neighborhood.

The phenomena of evaporation should be developed fully in connection with forest and plant growth, and for this purpose the Weather Bureau is cooperating with the Forest Service at the Coconino Forest Experiment Station near Flagstaff, Ariz., and at Fremont, near Manitou, in Colorado.

NEW TEMPERATURE NORMALS.

In Weather Bureau Bulletin S, "Report on the Temperatures and Vapor Tensions of the United States," the monthly mean temperatures reduced to a homogeneous system for about thirty-three years' record have been collected for stations having a long record, about 100 in all.

A series of 481 charts, covering the interval from January, 1873, to December, 1909, inclusive, with corresponding annual charts, has been prepared showing the monthly and annual temperature departures from these long-record normals for the United States. Copies of these charts are being printed, and when assembled will give a complete history of this important phenomenon for more than a third of a century. By using these charts the current short-record normals of any station may be corrected to the corresponding thirty-three-year normal, and this will be undertaken later.

MARINE DIVISION.

This division is charged with the ocean and lake meteorological work, the supervision of the wireless-telegraph weather service, and the work of the vessel-reporting service.

While the collection, compilation, computation, and publication of all ocean meteorological data from vessels traversing the oceans and lakes are by law under the Weather Bureau, a duplicate of the information published by the Weather Bureau has to be furnished to the Hydrographic Office of the Navy Department. The act making appropriations for the legislative, executive, and judicial expenses of the Government for the fiscal year ending June 30, 1911, provides that—

> Hereafter the pilot charts prepared in the Hydrographic Office shall have conspicuously printed thereon the following: "Prepared from data furnished by the Hydrographic Office of the Navy Department and by the Weather Bureau of the Department of Agriculture, and published at the Hydrographic Office under the authority of the Secretary of the Navy;" and all meteorological information received by the Weather Bureau of the Department of Agriculture necessary for and of the character of such information heretofore used in the preparation of the pilot charts shall continue to be furnished with all possible expedition to the Hydrographic Office for use in the preparation of said charts.

COLLECTION AND DISTRIBUTION OF DATA.

The American consuls at 89 of the principal foreign ports have assisted the Bureau in the distribution of marine forms, cloud and ocean charts, and pamphlets of instructions, and in the collection of meteorological observations from vessels.

The Weather Bureau marine centers are equipped with a standard mercurial barometer, thermometers, and shelter, and have a supply of all ocean meteorological forms, cloud charts, gnomonic charts, and meteorological charts. Assistants have been assigned to special duty in connection with marine work at New York, Philadelphia, and Seattle; at the latter point the official will have supervision over the entire traffic entering Puget Sound.

During the year 2,168 vessels of every nationality cooperated with the Weather Bureau in reporting pressure, temperature, wind, and other meteorological data, forwarding to the Marine Division in all about 10,000 weather report books. The data thus obtained are entered in the daily synoptic charts used in making the averages for the meteorological charts issued by the Weather Bureau and in preparing the information for the pilot charts issued by the Hydrographic Office.

Calendars containing useful information for captains and observers were distributed to all cooperating vessels, separate calendars being furnished for the Atlantic and Pacific oceans.

CHARTS PREPARED AND ISSUED.

DAILY SYNOPTIC CHARTS.—The daily observations received from the vessels are entered on these charts, which are used in tracing storm tracks and in preparing statements of average conditions of wind and weather for publication in the pilot and meteorological charts.

PILOT AND METEOROLOGICAL CHARTS.—The entire data for the North Atlantic charts have been revised and are practically complete. These charts contain normals of pressure and temperature covering a period of eighteen years; wind roses for twenty-five years, percentage of gales and calms for each 5° square and of fog for each 1° square of latitude and longitude, and trade-wind limits, all based on a large number of observations. On the back of the meteorological chart for September the origin and course of the West Indian hurricane of September 16–21, 1909, are graphically shown and its history briefly given.

The fog data on the North Atlantic chart have been extensively used by Mr. H. C. Thomson, engineer in charge of the survey for a short-line railway and steamship route to Europe, in his report to the governor-general of Newfoundland and others interested. It is also noted that the English meteorological office has used our fog data and shading to a great extent on their North Atlantic chart.

The South Atlantic charts are published quarterly, and with the charts for the quarter for September–November the data are complete, being based on normals of pressure for ten years, of temperature for fifteen years, and of wind roses (direction and force with percentage of gales and calms) for twenty-five years, and on the average conditions of wind and weather and trade-wind limits.

The revision of the data for the North Pacific charts has been brought up to the year 1909. The charts now contain normals of

pressure for twenty years, of temperature for twenty-one years, of wind roses (force and direction) for twenty-five years, and of the percentage of gales and calms and trade-wind limits, all deduced from a large number of observations for each 5° square of latitude and longitude. These charts will be revised each year and additional storm tracks entered thereon.

Work on the monthly charts of the Indian Ocean is under way. Beginning with the month of January, pilot and meteorological charts will be published containing data similar to that on the North Atlantic charts, including the paths of the more severe storms and the limits of fog.

The compilation of data for a meteorological chart of the Great Lakes is well in hand. With January, 1911, a monthly meteorological chart will be published containing all the meteorological features and the tracks of the more severe storms that have passed over that region each month for the last ten years.

In connection with the storm tracks traversing the North Pacific Ocean, I desire to invite attention to the kind cooperation of the Zikawei Observatory, in charge of Professor Froc, in furnishing the results of the compiled data and study of Père H. Gauthier in portraying the approximate tracks of storms in the middle and higher latitudes of the North Pacific Ocean. The Hongkong Observatory has also given us valued material, while the India Observatory at Simla, India, the Australian meteorological service, the Weather Bureau of the Philippine Islands, and the meteorological service of Canada have kindly furnished all available data. Publications of the other meteorological services have been used for study and reference.

WIRELESS TELEGRAPH SERVICE.

On account of the falling off in the number of vessels leaving San Francisco, very few wireless observations were received there during the year. The service to Portland, Oreg., has been continued throughout the year. From 20 to 75 reports are received each month at that station, but the official in charge states that only about 26 per cent are of benefit in his forecast work, the barometer readings and wind and weather being of most value. More than half of the reports are received too late for use. These messages are sent and received without expense to the Bureau, through the courtesy of the vessel captains, the United Wireless Company, and the naval wireless stations. Many of the reports are received at Katalla or Cordova, Alaska, and forwarded by cable free of cost.

VESSEL REPORTING STATIONS.

In addition to their meteorological work the stations at Block Island, Cape Henry, Jupiter, Sand Key, Southeast Farallon, North Head, Point Reyes, Port Crescent, and Tatoosh Island are required to report all passing vessels, wrecks, and marine disasters and casualties, and to transmit all communications between masters, owners, underwriters, and others interested. The stations at Cape Henry, Jupiter, Sand Key, Southeast Farallon, Point Reyes, North Head, and Tatoosh Island are equipped for signaling by the international code, and are prepared to transmit messages by telegraph.

Sand Key can also send and receive messages by flash light (Morse code). Each station, immediately upon sighting a vessel, sends a message to the owners and the maritime exchanges. All the stations cooperate with the Life-Saving Service in rendering assistance to wrecks and vessels in distress.

Cape Henry has 89 correspondents on its list, the telephone being used in reporting to Norfolk and Newport News. That office also cooperates with the Maryland Pilot Association, and such vessels as do not burn night signals are reported each morning by the pilot boats. All naval vessels are reported to Norfolk, and in some cases to the Navy Department at Washington. A daily list of vessels that pass is sent to the press in Norfolk. The office is kept open day and night. A flag is dropped at noon each day, giving the noon hour to the pilot boats and other vessels in the offing. A new code for communicating with tugboats of the Baltimore Chamber of Commerce that may be in the offing went into use in October, 1909. For night signaling purposes an acetylene plant will shortly be installed at Cape Henry.

During the year Block Island reported 15 passing vessels, Jupiter 542, North Head 1,643, Point Reyes 1,131, Port Crescent 334, Sand Key 1,552, Southeast Farallon 199, Tatoosh Island 2,368, and Cape Henry 19,755, making a total of 27,539 vessels. Often each message is sent to from three to six different interested parties, thus making the work enormous. In addition to this, Cape Henry reported 12 wrecks, and 725 vessel orders were received and delivered.

Only two complaints were made of poor service, and upon investigation they were found to be due to the fault of the vessel captains.

As an instance of the efficiency of the service, the observer at Point Reyes Light noticed that a vessel, the *Charles Wilson*, off the point, was rapidly drifting shoreward and was likely to be dashed against the rocks. He at once signaled the vessel, notified the San Francisco office of the Weather Bureau, and hoisted the distress signal and the signal "want tugboat." The steamboat *Dispatch* recognized the signals and went to the assistance of the helpless vessel.

Letters of commendation of the vessel-reporting service were received from the maritime exchanges at New York, Philadelphia, Baltimore, Norfolk, and Newport News. I will quote one from New York, others being similar in their nature:

> We wish to express our appreciation of the valuable services rendered by the Weather Bureau stations in reporting to us the movements of vessels, particularly the Cape Henry (Va.) and Jupiter (Fla.) stations. The observers at these stations are very capable men and fully understand our needs in the way of prompt and accurate reports of vessel movements.

LIBRARY.

The additions to the library during the year numbered 1,291 books and separate pamphlets, all of which have been catalogued under author and subject. The total strength of the library is now well over 30,000 volumes.

The more important meteorological contents of about 100 scientific periodicals have been regularly catalogued under author and subject. As in previous years, select lists of the current additions to the catalogues of both books and periodical literature have been published

regularly in the Monthly Weather Review, constituting a running bibliography of meteorology, climatology, and seismology.

The following is a retrospect of the more important literary events of the year in meteorology, as reflected in the growth of the library:

The only general treatise on meteorology that has appeared in America for several years was "Descriptive Meteorology," written by the Chief of this Bureau and published early in the spring. The Smithsonian Institution brought out Prof. Cleveland Abbe's "Mechanics of the Earth's Atmosphere—Third Collection," comprising translations and reprints of most of the substantial contributions to this subject in recent years, together with a few earlier memoirs of great interest. The British Meteorological Office published an English version of Hildebrandsson & Hellmann's "Codex of Resolutions Adopted at International Meteorological Meetings, 1872–1907," which places in compendious form the results of international cooperation extending over the past thirty-five years.

One of the most noteworthy publications of the year was the concluding installment of the only large modern treatise on atmospheric optics, viz, "Meteorologische Optik," begun by the late J. M. Pernter and completed by F. M. Exner.

Dr. J. Hann published the second part of the much enlarged third edition of his "Handbuch der Klimatologie." Important climatographic works included many additional parts of the United States Weather Bureau's "Summary of the Climatological Data for the United States, by Sections." Two large works dealing with the climatography of whole countries were G. Roster's "Climatologia dell' Italia," and the text volume of "Das Klima der Schweiz," by Dr. J. Maurer and his official colleagues. Two more parts of the "Klimatographie von Österreich," dealing, respectively, with Styria and with the Tyrol and Vorarlberg, were issued by the K. K. Zentralanstalt für Meteorologie at Vienna. The winds of two countries were discussed, especially with a view to the requirements of aeronauts, in F. Eredia's "I venti in Italia" and R. Assmann's "Die Winde in Deutschland." A valuable contribution to the climatography of South Africa was published by E. Goetz in his "Rainfall of Rhodesia."

The rapid growth of aerology—the exploration of the free atmosphere—was represented by several notable works, including Gold & Harwood's report on "The Present State of our Knowledge of the Upper Atmosphere," presented at the Winnipeg meeting of the British Association; A. Wagner's "Temperaturverhältnisse in der freien Atmosphäre," issued as a double number of Beiträge zur Physik der freien Atmosphäre; a publication of the British Meteorological Office entitled "The Free Atmosphere in the Region of the British Isles;" and A. Berson's "Bericht über die aerologische Expedition des Königlichen Aeronautischen Observatoriums nach Ostafrika."

A work on weather forecasting that aroused much controversy was G. Guilbert's "Nouvelle méthode de prévision du temps." A new method of long-range forecasting was described by S. D. Griboiedov in a memoir published in Russian and presented at the National Congress of Meteorologists held last year in St. Petersburg. Of great interest to students of the history of meteorology was the translation of Seneca's "Quæstiones naturales," by J. Clarke, published under the title "Physical Science in the Time of Nero." A most

useful bibliographic publication was the general author and subject index to the Meteorologische Zeitschrift, volumes 1–25. Bibliographies of special topics included a reprint from the Monthly Weather Review of Mrs. G. J. Livingston's "Annotated Bibliography of Evaporation," and P. Brockett's "Bibliography of Aeronautics," the latter published by the Smithsonian Institution.

During the year the librarian visited several scientific and general libraries in Europe, including that of the Ufficio Centrale di Meteorologia, in Rome; the Laurentian Library, in Florence; and the library of the Royal Observatory of Belgium, at Uccle.

EXAMINATIONS FOR PROMOTION.

The total number of examination papers received and rated during the year was 258, as compared with 223 during the preceding year. Following is the record in detail:

Subject.	1909.		1910.		Total.	Passed.	Failed.
	August.	November.	February.	May.			
English grammar	9	10	14	16	49	37	12
Arithmetic	4	10	14	8	36	27	9
Elementary meteorology	7	12	11	11	41	40	1
Essay writing	7	5	8	9	29	20	9
Algebra	4	4	5	4	17	15	2
Physics	3	3	6	10	22	21	1
Trigonometry	5	5	7	8	25	23	2
Astronomy	4	2	3	5	14	14	0
Plant physiology	1	3	2	4	10	10	0
Advanced meteorology	0	2	8	5	15	13	2
Total	44	56	78	80	258	220	38

SCHOOL OF INSTRUCTION.

The work of instructing probationary appointees has continued along the lines pursued during the previous year, except that more attention has been given to map making, especially the making of stencil or milliograph maps.

By the time they have finished their course of preliminary instruction at the central office, the student observers have a fair idea of the method of handling official correspondence, and a number of them are quite proficient in sending and receiving telegraphic messages. Upon arriving at stations they are already qualified to make maps, take observations, prepare meteorological forms, and perform the various other station duties.

Thirty-six men received instruction during the past year, and all but eight had been given station assignments at its close.

DISTRIBUTING DIVISION.

Owing to lack of funds the extension of forecast distribution during the year was much smaller than it would have been could advantage have been taken of the many favorable opportunities that from time to time were presented. At its close the number of places receiving forecasts at government expense was 2,180. In recent years

the greatest extension of forecast distribution has been made through the cooperation of telephone companies, and it has been mainly through such cooperation that the distribution has been maintained without impairment. In fact, notwithstanding the reduced number of distributing centers receiving the forecasts at government expense, the forecasts have been made available to 537,000 more telephone subscribers than received the service at the close of the preceding year, the total number now being about 3,681,000. Funds not being available, advantage could not be taken of any of the opportunities afforded by the extension of the Rural Free-Delivery Service of the Post-Office Department.

The following table shows in detail the distribution of daily forecasts and special warnings in the several States by the various means employed:

Distribution of daily forecasts and special warnings.

State.	At government expense.			Without expense to the United States by—				
	Forecasts and special warnings.	Special warnings only.	Emergency warnings.	Mail.	Rural delivery.	Telephone.	Railroad train service.	Railroad telegraph.
Alabama	35	3	139	1,232	781	13,195	0	66
Arizona	5	0	0	177	0	7,460	0	0
Arkansas	27	6	107	940	517	22,603	0	14
California	100	44	0	1,265	2,883	101,383	0	0
Colorado	11	62	38	923	914	36,138	0	0
Connecticut	10	0	48	1,401	50	72,300	138	1
Delaware	8	0	16	111	296	4,865	0	27
District of Columbia	0	0	0	1,725	0	20,000	0	1
Florida	35	113	52	1,010	220	8,268	0	69
Georgia	34	31	239	2,161	832	34,350	0	149
Idaho	15	1	0	613	200	13,680	0	0
Illinois	120	1	402	2,386	2,835	376,799	0	17
Indiana	117	1	221	2,347	1,818	175,466	0	71
Iowa	142	5	381	1,993	4,187	171,389	25	0
Kansas	94	1	175	1,015	2,310	306,709	0	51
Kentucky	44	32	84	1,843	806	47,565	0	1
Louisiana	77	23	49	644	143	17,034	0	18
Maine	13	1	39	1,151	802	14,406	0	0
Maryland	20	4	46	1,781	575	7,691	0	65
Massachusetts	16	11	58	3,108	210	9,450	77	0
Michigan	69	1	326	4,974	348	216,796	279	387
Minnesota	75	5	181	2,314	4,100	137,901	0	13
Mississippi	45	6	108	1,205	886	34,611	0	6
Missouri	31	1	146	3,436	2,121	304,347	0	52
Montana	12	21	13	408	50	5,911	0	0
Nebraska	75	1	217	1,141	408	210,717	0	0
Nevada	6	0	0	74	0	967	0	0
New Hampshire	14	0	33	910	1,409	2,397	15	0
New Jersey	23	18	105	1,220	100	27,778	0	179
New Mexico	11	1	0	78	0	3,541	0	8
New York	128	45	351	7,190	2,194	332,505	207	163
North Carolina	81	11	164	777	2,030	27,705	0	0
North Dakota	23	0	93	189	1,919	16,453	0	0
Ohio	81	169	310	5,880	830	540,137	24	34
Oklahoma	32	1	16	722	1,104	6,994	0	130
Oregon	9	1	0	458	183	16,405	0	0
Pennsylvania	86	11	137	3,814	1,718	160,459	1	449
Rhode Island	2	0	12	478	0	1,163	13	0
South Carolina	29	9	105	948	636	10,076	0	38
South Dakota	63	10	76	807	183	49,174	0	0
Tennessee	52	3	285	1,187	1,055	39,344	0	3
Texas	63	46	227	1,460	1,188	71,551	0	63
Utah	5	23	0	300	661	34,277	0	0
Vermont	13	0	44	483	461	20,461	12	0
Virginia	61	4	118	1,283	2,124	31,204	101	72
Washington	25	1	0	787	1,091	11,023	0	0
West Virginia	28	7	51	849	7	34,924	0	17
Wisconsin	108	6	306	2,520	2,110	55,063	0	0
Wyoming	7	2	8	128	0	6,710	0	0
Total	2,180	742	5,526	73,846	49,295	3,680,905	892	2,159

To show the status of the distributing work of the Bureau in recent years, its growth, and by some methods its curtailment, the accompanying table has been prepared. From this statement it will be seen that the telephonic distribution has been materially increased, notwithstanding the decrease of 190 in the number of stations receiving forecasts at government expense. The mail distribution has, however, suffered a slight decrease.

Year.	At government expense.			Without expense to United States by—				
	Forecast and special warnings.	Special warnings only.	Emergency warnings.	Mail.	Rural delivery.	Telephone.	Railroad train service.	Railroad telegraph.
1903–4	2,076	983	6,152	77,605	83,639	152,302	2,423	2,655
1904–5	2,158	973	6,152	77,774	75,602	464,738	2,423	2,443
1905–6	2,150	767	5,998	76,719	82,406	1,014,285	2,514	2,145
1906–7	2,280	734	5,998	78,109	71,300	1,985,905	1,423	2,134
1907–8	2,334	690	5,998	76,154	58,008	3,553,067	852	2,139
1908–9	2,370	782	5,998	77,563	53,402	3,143,985	883	2,305
1909–10	2,180	742	5,526	72,121	49,295	3,680,905	892	2,159

It is estimated that of the $260,000 appropriated for telephone rentals, telegraphing, etc., for the year 1909–10 the Bureau expended in distribution of daily forecasts and special warnings and for storm-warning messages approximately $73,000, or about 28 per cent, of which 25 per cent was used for the daily forecast service and 3 per cent for special warnings of cold waves and frosts and for storm-warning messages.

STORM-WARNING DISPLAY STATIONS.

A storm-warning display station was established at Rockport, Mass., and arrangements were completed for the establishment of two others, one at Grand Marais, Minn., and one at Singers Island, Michigan. Three cooperative storm-warning display stations, viz, Everett, Wash., Neah Bay, Wash., and Vermilion, Ohio, were changed to a paid basis. One paid and nine cooperative stations were discontinued. Those discontinued were stations at which the information could be as readily and conveniently obtained from near-by sources. The station at Rockport, Mass., has supplied an important need, and the proposed stations in the western Lake Superior region will undoubtedly prove valuable additions to the system of storm-warning display stations.

The storm-warning display stations received the usual careful attention, 130 having been inspected during the year.

A circular was issued to all storm-warning distributing centers on the Atlantic and Gulf coasts at the close of the year, having for its object a revival of interest in the plan of disseminating information regarding hurricanes, with special reference to warning people living in districts in which unusually high tides might cause loss of life and property.

The following statement gives the number of stations, arranged under district centers, receiving storm warnings:

Centers.	Paid stations.	Cooperative stations.	Weather Bureau stations.	Naval wireless stations.
Alpena, Mich	6	0	1	0
Atlantic City, N. J	0	4	1	0
Baltimore, Md	3	1	0	0
Block Island, R. I	1	0	1	0
Boston, Mass	24	7	2	4
Buffalo, N. Y	11	1	1	0
Cape May, N. J	1	0	0	0
Charleston, S. C	5	1	1	0
Chicago, Ill	25	2	1	1
Cleveland, Ohio	10	0	1	0
Corpus Christi, Tex	2	0	1	0
Detroit, Mich	0	1	1	0
Duluth, Minn	5	0	1	0
Eastport, Me	0	1	1	0
Erie, Pa	1	0	1	0
Escanaba, Mich	2	0	1	0
Eureka, Cal	0	1	1	1
Galveston, Tex	4	4	1	0
Grand Haven, Mich.[a]	0	0	1	0
Green Bay, Wis.[a]	0	0	1	0
Houghton, Mich	2	2	1	0
Jacksonville, Fla	6	11	1	0
Jupiter, Fla	1	0	1	0
Key West, Fla	0	0	2	0
Los Angeles, Cal	1	3	0	0
Marquette, Mich	1	0	1	0
Milwaukee, Wis	9	0	1	0
Mobile, Ala	4	2	1	0
Nantucket, Mass.[a]	0	0	1	0
New Haven, Conn	2	0	1	0
New Orleans, La	3	1	1	0
New York, N. Y	5	3	2	2
Norfolk, Va	6	6	4	1
Oswego, N. Y.[a]	0	0	1	0
Pensacola, Fla	4	0	1	0
Philadelphia, Pa	3	0	2	0
Port Huron, Mich	4	1	1	0
Portland, Me	3	2	1	0
Portland, Oreg	9	3	6	0
Providence, R. I	1	0	1	0
Rochester, N. Y.[a]	0	0	1	0
San Diego, Cal	0	2	1	1
Sandusky, Ohio[a]	0	0	1	0
San Francisco, Cal	2	5	4	3
San Juan, P. R	0	0	0	2
Saulte Ste. Marie, Mich	5	0	1	0
Savannah, Ga	4	1	1	0
Tampa, Fla	3	2	1	0
Toledo, Ohio[a]	0	0	1	0
Wilmington, N. C	3	2	1	0
Total	181	69	61	15

[a] Not centers.

STATION PUBLICATIONS.

Early in 1910 the policy was adopted of discontinuing the station weather maps wherever the newspapers would undertake their publication. The announcement of this purpose met with a cordial response from the press. The first "commercial weather map," as it has been called, was published in the Minneapolis Journal on March 1. Within the four months following its publication has been extended to 65 morning and evening papers in 45 cities, while 55 additional stations will introduce the method as soon as suitable outfits can be supplied, which will probably be during the coming August. By this plan of publication the weather chart is placed before the public twice daily, and reaches millions of people where

it reached thousands before. Some opposition to the plan has naturally been experienced in a few quarters where special purposes were served by the somewhat more elaborate charts formerly issued, but for purposes of study or for permanent file, the large Washington map remains available to those willing to pay its subscription price. I have no doubt that the change has resulted in vastly increasing the benefits of the map to the public in general, while the saving effected by discontinuing the printing at government expense will permit the extension of the work of the Bureau along other lines of usefulness.

The publication of the daily weather bulletin has been continued at all stations heretofore issuing this form of report, with materially increased editions.

EXAMINATION OF METEOROLOGICAL FORMS.

The principal record kept at Weather Bureau stations and the record kept by cooperative observers are examined, and the accuracy of the data verified or corrected, by the examining force of the Distributing Division. These records were received, examined, and verified or corrected for 195 Weather Bureau stations and more than 3,600 cooperative stations.

TELEGRAPH DIVISION.

The telegraph and telephone lines operated by the Weather Bureau have been kept in good order without any general repairs having been made.

The line from Port Crescent to Tatoosh Island, Washington, worked better than ever before. The line from San Francisco to Point Reyes is in poor condition, but as there is a commercial telephone line from San Francisco to Inverness, which is but a short distance from our station at Point Reyes, it may be cheaper to make some arrangement with the Pacific States Telephone and Telegraph Company to pay them regular tolls on each message sent between San Francisco, Mount Tamalpais, and Point Reyes and do away with the government wire altogether. This would save the rental of leased wires between San Francisco and Mill Valley, as well as the expense of keeping the line in order.

The lines and cables from Charlevoix to Beaver Island, Michigan, and from Glen Haven to South and North Manitou islands, Michigan, have been kept in good working order by the life-saving crews without expense to the Weather Bureau, except for material. The cable between Charlevoix and Beaver Island was broken by the United States dredge *General Gillespie* on August 24, 1909, and was repaired four days later at small cost, the life-saving crew assisting.

The line from Alpena to Thunder Bay and Middle Island, Michigan, has been kept in good working order, but the poles are now seventeen years old and will shortly require cutting off and resetting, and in some places new poles will have to be furnished.

The submarine cable from Key West to Sand Key, Florida, has worked satisfactorily the entire year without repairs.

The line from Norfolk, Va., to Hatteras, N. C., has been kept in good order during the entire year. The life-saving crews, every 5

miles apart from Cape Henry to Hatteras, have rendered prompt and valuable assistance in this work.

The Block Island line has worked excellently during the entire year and has been maintained with slight expense.

The arrangements with the different commercial telegraph companies for handling the daily weather reports throughout the world have been very satisfactory. The average time of transmission to the central office from all points is about one hour.

The work of auditing the telegraph and telephone accounts of the Bureau is well up to date. The government receipts from all lines for commercial messages handled during the year were $1,710.66.

The requests for additional weather reports by telegraph from the various observing stations were unusually numerous, exceeding those for any single year in the previous history of the Bureau. While public requirements in this respect have been met as far as possible by a reorganization of the Bureau's system of "circuit" reports, the demands were more than could be satisfied with the present fund available for telegraphic expenses.

PUBLICATIONS DIVISION.

The Publications Division has continued to print and to supply to stations the necessary blank forms, maps, and cards, and has continued the issue of the regular publications of the Bureau, such as the daily weather map, the Monthly Weather Review, the Bulletin of the Mount Weather Observatory (quarterly), the National Weather Bulletin (weekly and monthly), and the Snow and Ice Bulletin (during the winter season). As heretofore, the Government Printing Office has done all the binding required by the Bureau, and has also printed a few reports that could be more economically handled there.

The material change that was made in the character of the Monthly Weather Review during the year added so largely to its mechanical work that it became necessary to install a larger folding machine and an equipment of type-setting machinery. This permits a more rapid output of the printing office and has improved the typographical appearance of the work.

DIVISION OF SUPPLIES.

In conformity with an executive order effective July 1, 1909, all supplies for the Bureau not covered by special department contracts for articles of a technical nature were purchased, so far as listed, under the contracts prepared by the general supply committee. As this inaugurated a system of unifying and standardizing the miscellaneous supplies used in common by all of the Executive Departments, and involved the setting aside of individual preferences, some friction developed during the first year of its practical application, though in this Bureau to a less degree than might reasonably have been expected. In some instances out-of-town contractors declined to fill small orders; in others the articles under contract were inferior in quality or unsuitable to the purpose for which they were desired; and as no samples were furnished by the committee, it was impossible to determine whether or not such articles were up to their accepted samples. List prices with three or four discounts were also a

constant source of vexation. These and other incongruities were brought to the attention of the committee when occasion offered. It is believed that there will be fewer difficulties of this character experienced hereafter.

Most of the technical supplies heretofore covered by the departmental contracts were included in the general contracts for the coming year.

OBSERVATORY BUILDINGS.

The main observatory building of the Weather Bureau at Mount Weather, Va., has been completed and was first occupied on February 12, 1910. It is practically a fireproof structure, especially designed to meet the requirements of the Bureau for office and living quarters for the investigators and employees on duty at the research observatory. The building replaces the one that was destroyed by fire on October 23, 1907, and it is the last structure that will be required at that point for the present.

The observatory building located on Sand Key, Florida, a few miles from Key West, was completely destroyed by a hurricane on October 11, 1909. Congress has made appropriation for the reconstruction of the building, the plans of which are now in course of preparation, and it is hoped that this work will be completed before January 1, 1911. The proposed building will be composed of concrete, with a foundation of concrete piles driven into the solid rock. It is believed that this type of building will withstand future hurricanes and will involve a minimum cost for maintenance.

Seven observatory buildings were authorized in the appropriation bill for the fiscal year 1909. They were erected at Abilene, Tex., Canton, N. Y., Dodge City, Kans., East Lansing, Mich., Northfield, Vt., Richmond, Va., and St. Joseph, Mo., during the past year and are now occupied.

The following table shows where the buildings owned by the Weather Bureau are located, the fiscal years in which they were erected, and the cost of the buildings and grounds:

Buildings owned by the Weather Bureau.

Location.	Erected.	Cost of ground.	Cost of buildings.	Total cost.
Abilene, Tex.	1909	$2,000.00	$12,841.81	$14,841.81
Amarillo, Tex.	1903	1,255.00	6,503.00	7,758.00
Anniston, Ala.	1907	1,799.75	12,920.69	14,720.44
Atlantic City, N. J.	1902	(a)	5,991.00	5,991.00
Bentonville, Ark.	1906	500.00	5,119.90	5,619.90
Birmingham, Ala.	1907	b 61.50	15,630.30	15,691.80
Bismarck, N. Dak.	c 1899	(a)	10,085.99	10,085.99
Block Island, R. I.	1904	1,034.50	7,668.25	8,702.75
Burlington, Vt.	1906	b 20.00	10,043.50	10,063.50
Canton, N. Y.	1909	b 1.35	14,135.20	14,136.55
Cape Henry, Va.	1902	(a)	9,222.45	9,222.45
Charles City, Iowa	1907	3,036.75	9,338.47	12,375.22
Columbia, S. C.	1905	3,799.00	9,165.00	12,964.00
Devils Lake, N. Dak.	1904	2,209.05	7,431.50	9,640.55
Dodge City, Kans.	1909	2,050.00	10,837.62	12,887.62
Duluth, Minn.	1904	2,041.70	7,430.68	9,472.38
East Lansing, Mich.	1909	b 11.35	12,781.04	12,792.39
Hatteras, N. C.	1902	a d 217.00	4,889.75	5,106.75
Havre, Mont.	1904	1,795.00	5,087.08	6,882.08
Iola, Kans.	1907	2,241.25	9,730.94	11,972.19

a Government reservation.
b Donated; figures represent cost of title transfer.
c Remodeled.
d Additional ground purchased.

Buildings owned by the Weather Bureau—Continued.

Location.	Erected.	Cost of ground.	Cost of buildings.	Total cost.
Jupiter, Fla.	1902	(a)	$6,346.90	$6,346.90
Key West, Fla.	1903	$2,020.00	7,994.75	10,014.75
Kittyhawk, N. C.	b 1902	(a)	1,616.00	1,616.00
La Crosse, Wis.	1907	3,523.50	12,276.24	15,799.74
Modena, Utah.	1903	(a)	4,346.00	4,346.00
Mount Weather, Va.:				
Administration building.	1909	1,863.15	48,035.26	49,898.41
Machine shop and balloon shed.	1904	650.00	8,167.00	8,817.00
Central heating and power plant.	1909	(a)	11,964.74	11,964.74
Absolute building.	c 1906	(a)	7,000.00	7,000.00
Variation building.	c 1906	(a)	8,904.55	8,904.55
Stable.	1903	(a)	1,900.00	1,900.00
Barn.	1905	(a)	900.00	900.00
Cottage for workmen.	b 1905	(a)	1,300.00	1,300.00
Physical laboratory.	d 1909	(a)	37,521.51	37,521.51
Cottage and office.	e 1909	(a)	11,246.34	11,246.34
Nantucket, Mass.	1905	(f)	4,728.53	4,728.53
Narragansett Pier, R. I.	1904	4,151.75	8,036.50	12,188.25
Northfield, Vt.	1909	g 101.00	12,795.64	12,896.64
North Head, Wash.	1902	(a)	3,820.13	3,820.13
North Platte, Nebr.	1906	(f)	3,818.50	3,818.50
Oklahoma, Okla.	1906	g 38.90	10,520.25	10,559.15
Peoria, Ill.	1905	g 54.00	7,875.50	7,929.50
Point Reyes Light, Cal.	1902	(a)	2,875.00	2,875.00
Port Crescent, Wash.	1902	102.00	730.94	832.94
Richmond, Va.	1909	g 8.75	15,489.01	15,497.76
St. Joseph, Mo.	1909	5,040.95	16,882.80	21,923.75
Sand Key, Fla.	1903	(a)	(h)	(h)
Sault Ste. Marie, Mich.	1899	(a)	2,994.12	2,994.12
Sheridan, Wyo.	1907	2,021.75	12,089.30	14,111.05
Southeast Farallon, Cal.	1903	(a)	5,211.22	5,211.22
Springfield, Ill.	1906	(a)	10,236.50	10,236.50
Tatoosh Island, Wash.	1902	(a)	5,000.00	5,000.00
Washington, D. C.	.....	(f)	174,950.79	174,950.79
Yellowstone Park, Wyo.	1904	(a)	11,156.00	11,156.00
Yuma, Ariz.	b 1903	(a)	1,500.00	1,500.00
Total.	.....	43,648.95	667,084.25	710,733.20

a Government reservation.
b Remodeled.
c Begun in 1905.
d Begun in 1903.
e Begun in 1907.
f Building and ground purchased as a whole.
g Donated; figures represent cost of title transfer.
h Destroyed by a hurricane October 11, 1909.

Buildings rented by the Weather Bureau for living and observatory purposes.

Station.	Annual rent.	Other items included.
Alpena, Mich.	$650	Heat, light, water.
Cape May, N. J.	650	
Clallam Bay, Wash.	120	Water.
Del Rio, Tex.	444	Heat, light, water.
Durango, Colo.	318	Water.
Flagstaff, Ariz.	420	
Helena, Mont.	624	Steam heating plant, water.
Honolulu, Hawaii.	1,020	Six rooms; heat, cleaner, light, janitor, and porter service, electric current for fan, storage.
Independence, Cal.	456	Water for domestic and irrigation purposes, and the trimming and care of all trees on the premises.
Kalispell, Mont.	360	
Lewiston, Idaho.	540	
Manteo, N. C.	144	
Moorhead, Minn.	600	Heat, light, water.
Mount Tamalpais, Cal.	420	Heat, light, water, and the free transportation of government employees and supplies.
Pysht, Wash.	144	Water.
Roseburg, Oreg.	550	Heat, light, water.
Roswell, N. Mex.	720	Heat, cleaner, light.
San Juan, P. R.	600	Ten rooms.
Thomasville, Ga.	420	
Tonopah, Nev.	840	
Twin, Wash.	108	Water.
Williston, N. Dak.	510	Heat, cleaner, light, water.
Winnemucca, Nev.	480	Heat, light, water.
Total.	11,138	

PERSONNEL OF THE BUREAU.

The total numerical strength of the Bureau at the close of the fiscal year was 6,895. Of this number more than two-thirds rendered service without compensation other than through the free receipt of government publications. The increase of 285 over the figures given at the close of the preceding year was mainly due to the employment of observers in connection with the extension of mountain snowfall investigation in the Western States, although more than a hundred were added to the lists of special meteorological observers and cooperative observers and correspondents; the number of employees engaged in the remaining lines of work remained practically unchanged.

The distribution of the 792 commissioned employees of the Bureau gave 210 to the central office at Washington and 582 to the stations throughout the country. This represents an increase of 6 and 14, respectively, in the record of similar assignments for the close of the preceding twelve months. At the central office the distribution of the employees among the several divisions remained practically as in the year before, except in the Publications Division, where an increase in the amount of printing necessitated an addition of 5 to the working force. At stations the transfer of the climatological work from Galveston to another point and the curtailment of special evaporation studies at Salt Creek Bridge, California, caused the working force at each of these stations to be reduced by three, while at a number of other points the force was lessened by one man through transfers to stations where the demands for additional help had become imperative. It is a fact that both in the central office and at stations the increase in the number of employees has not been proportionate to the increase in work; in other words, the operations of the Weather Bureau have been so enlarged during the past year as to require more work than formerly from each member of its commissioned force, despite the fact that the number was increased by 20 during that period.

In the classified service of the Bureau there were 4 more permanent appointments, including those effected by transfer and reinstatement, and 7 more temporary appointments than in the preceding year. The promotions during the same period—52 at the central office and 129 at stations—were fewer by 59 than in the year before. All promotions but 5 were made to the next higher grade; of the exceptions noted, 4 resulted through the assignment of especially meritorious employees to charge of important stations in large cities, where the enlarged duties and responsibilities called for appreciable increases in compensation, and the remaining instance was that of a central office employee possessing particular qualifications for the duties to which assigned. There were 53 voluntary resignations in the classified service during the year, or 11 more than in the preceding twelve months. By far the larger part was in the subclerical force, especially among the messengers and messenger boys, which was to have been expected, a less stability naturally belonging to the lower and less remunerative grades than elsewhere. A loss of 8 recently appointed assistant observers through resignation, however, was larger than looked for, and, in view of the time and attention required in their preliminary training, worked to the disadvantage

of the Bureau. In order to better this condition recommendation was made to the Civil Service Commission, and favorably acted upon, that only unmarried men be eligible for appointment as assistant observers, owing to the low entrance salary as well as to the fact that in the earlier years of their service these appointees are liable to be moved from station to station frequently and at short notice. Of the 103 probationary appointments made during the year all but 3 successfully completed the six months' trial period. Nine undesirable employees were eliminated from the classified service during the year and 23 reductions were made by way of necessary discipline or for other sufficient reasons.

In the unclassified service there were 5 permanent and no temporary appointments, as compared with 6 permanent and 1 temporary for the preceding year.

The absence record differed but slightly from that for the calendar year preceding, there having been a fraction of a day less, both for sickness and for annual leave, the average for the entire service considered.

There were 8 deaths in the commissioned force of the Bureau, as against 3 for the year before. The list includes Prof. Edward B. Garriott, through whose death, on May 13, 1910, the Bureau lost one of its most valued officials and the science of meteorology an able investigator and enthusiastic student. Professor Garriott had for years been in charge of the forecast division of the central office.

CHANGES IN THE FORCE OF THE BUREAU.

CLASSIFIED SERVICE.

Appointments:	
Probationary—	
Compositors, at $1,250	4
Printers, at $1,000	5
Skilled mechanic, at $1,000	1
Clerk, at $900	1
Assistant observers, at $720	41
Carpenter, at $720	1
Repairman, at $720	1
Watchman, at $720	1
Firemen, at $720	2
Folders and feeders, at $630	3
Skilled laborers, at $450	3
Messenger boys, at $450	3
Messenger boys, at $360	37
	103
Transfer—	
Engineer, at $1,200	1
Printer, at $1,000	1
Messenger, at $600	1
	3
Reinstatement—	
Printers, at $1,000	2
Assistant observers, at $1,000	2
Assistant observer, at $720	1
Messenger, at $600	1
Messenger boy, at $480	1
	7

Appointments—Continued.
Temporary—

Compositor, at $1,500	1
Compositors, at $1,250	5
Clerks, at $900	3
Repairmen, at $720	2
Fireman, at $720	1
Folders and feeders, at $630	2
Messenger boys, at $600	2
Messenger, at $480	1
Skilled laborer, at $450	1
Messenger boys, at $450	3
Messenger boys, at $360	27
Evaporation observer, at $3 a day	1
	49

Promotions (all promotions except 5 were to the next higher grade or by certification for advancement from subclerical positions) 201

Reductions:
Causes—

To grant assignment to preferred station	3
To grant assignment to preferred work	2
Necessitated by assignment to station duty	3
Necessitated by employee's return to duty from leave of absence without pay	1
Necessitated by civil-service ruling	1
Decreased efficiency due to increasing age	4
Physical disability	1
Absence without authority	1
Unsatisfactory services	7
	23

Resignations:

Voluntary	53
Required because of—	
Unsatisfactory services	6
Unsatisfactory services and conduct	2
	61

Transferred to the office of the Secretary of Agriculture 1

Removals:
Causes—

Absence without authority	1
Unsatisfactory services	1
Unsatisfactory conduct	2
Indecent conduct	1
Gross impudence	1
Theft	1
Physical disability	1
Physical disability and unreliability	1
	9

Dropped from the rolls at termination of probationary period because of unsatisfactory services 3

Deaths 8

UNCLASSIFIED SERVICE.

Appointments:	
Permanent—	
Unclassified laborer, at $480	1
Student assistants, at $300	3
Charwoman, at $240	1
	5
Promotion (to the next higher grade)	1
Resignations:	
Voluntary	3
Required because of—	
Unsatisfactory services	1
Unsatisfactory conduct	1
	5
Removal:	
Cause—	
Position filled by a classified employee	1

ABSENCE.

Average number of days per employee during calendar year 1909.

	Sickness.	Annual leave.
Station (99 per cent males)	1.0	7.2
Washington, D. C.:		
Males	5.4	24.6
Females	7.8	26.0
Entire service	2.2	11.7

STATISTICS OF THE SERVICE.

The following tables show the numerical strength of the Bureau and the highest, lowest, and average salaries paid in the commissioned grades:

Numerical strength of the Weather Bureau June 30, 1910.

At Washington, D. C.:		
Classified	199	
Unclassified	11	
		210
Outside of Washington, D. C.:		
Classified	566	
Unclassified	16	
		582
Total commissioned employees		792
Additional employees outside of Washington, D. C.:		
Storm-warning displaymen	181	
River observers	392	
Cotton-region observers	117	
Corn and wheat region observers	130	
Rainfall observers	107	
Sugar and rice region observers	7	
Special meteorological observers	74	
Special cranberry-marsh observers	4	

Additional employees outside of Washington, D. C.—Continued.		
Special snow and ice observers	4	
Mountain snowfall observers	333	
Total noncommissioned employees		1,349
Total paid employees		[a] 2,141
Persons serving without compensation (except through the distribution of government publications):		
Cooperative observers and correspondents (omitting 415 paid observers enumerated elsewhere)	4,636	
Cooperative storm-warning displaymen	84	
Cooperative river observers	23	
Cooperative rainfall observers	11	
Total cooperatives		4,754
Total numerical strength		6,895

Distribution of the commissioned force, June 30, 1910.

In Washington, D. C.:	
Accounts Division	[b] 14
Climatological Division	16
Distributing Division	11
Executive branch	16
Forecast Division	7
Instrument Division	11
Library	4
Marine Division	13
Observatory	9
Publications Division	41
River and Flood Division	3
Supplies Division	[b] 10
Telegraph Division	11
Verification Section	2
Drafting room (under direction of the chief clerk)	4
Heat, light, and power plant (under direction of the chief clerk)	5
Miscellaneous mechanical work (under direction of the chief clerk)	6
Watch force (under direction of the chief clerk)	6
General messenger and laborer service (under direction of the chief clerk)	21
	210
Outside of Washington, D. C.:	
53 stations with 1 commissioned employee	53
51 stations with 2 commissioned employees	102
43 stations with 3 commissioned employees	129
18 stations with 4 commissioned employees	72
14 stations with 5 commissioned employees	70
10 stations with 6 commissioned employees	60
3 stations with 7 commissioned employees	21
1 station with 8 commissioned employees	8
2 stations with 9 commissioned employees	18
2 stations with 10 commissioned employees	20
1 station with 11 commissioned employees	11
1 station with 22 commissioned employees	22
199 stations	[c] 586

[a] This total embraces all paid persons connected with the Bureau on June 30, 1910, except 18 commissioned employees absent on that date and who had been granted leaves of absence or furloughs without pay for one month or more.

[b] One employee devotes a portion of his time at one of the map stations at the United States Capitol.

[c] This represents the normal station force. On June 30, 1910, there were actually on duty 582 employees.

In addition to the foregoing there are eight special observing (one man) stations in the West Indies, mainly in operation during the hurricane season, and a special repair station in Washington, operated from October to April, inclusive.

The following salary table omits 3 evaporation observers, who receive pay only when they take observations, and persons on duty at special observing and substations where the salaries are $25 a month or less, and where, as a rule, the tour of duty covers but a small fraction of the day and only certain seasons of the year.

Salaries paid in the commissioned grades.

Grades.	June 30, 1910.	
	Stations.	Washington, D. C.
Classified grades:		
Highest salary	$3,000	$6,000
Lowest salary	360	450
Average salary	1,035	1,106
Unclassified grades:		
Highest salary	720	720
Lowest salary	300	240
Average salary	390	502

Average salary of all (station and Washington) is $1,051.