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U. S. DEPARTMENT OF AGRICULTURE.

REPORT  
OF THE  
CHIEF OF THE WEATHER BUREAU

FOR  
1909.

BY  
WILLIS L. MOORE.



[FROM ANNUAL REPORTS OF THE DEPARTMENT OF AGRICULTURE.]



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# **National Oceanic and Atmospheric Administration Report of the Chief of the Weather Bureau**

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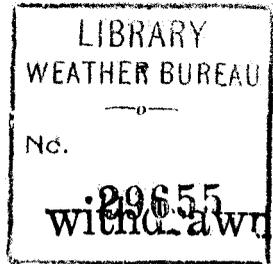
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## REPORT OF THE CHIEF OF THE WEATHER BUREAU.

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U. S. DEPARTMENT OF AGRICULTURE,  
CENTRAL OFFICE OF THE WEATHER BUREAU,  
*Washington, D. C., September 10, 1909.*

SIR: I have the honor to submit a report of the operations of the Weather Bureau during the fiscal year that ended June 30, 1909.

WILLIS L. MOORE,  
*Chief of Weather Bureau.*

HON. JAMES WILSON,  
*Secretary of Agriculture.*

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### RESEARCH OBSERVATORY AT MOUNT WEATHER, VA.

The Sixtieth Congress at its first session authorized the rebuilding of the administration building, destroyed by fire in October, 1907, the construction of a central heating and power plant, and the completion of the physical laboratory and the cottage and office building: The details of progress in construction are given elsewhere.

A part of the office force moved into the physical laboratory building early in March. The principal instruments and machinery for the large workroom have been installed and the greater number of instruments and apparatus for the laboratory have been ordered. Some smaller apparatus have already been received.

As the central heating and power plant and the cottage and office building are located in the uncleared part of the reservation, the roads had to be extended to include those as well as the physical laboratory. In all, 1,200 feet of roads were constructed, and about 2,000 tons of bowlders and smaller stone were removed from the grounds in connection with grading and road making.

#### SCIENTIFIC WORK.

##### AERIAL OBSERVATIONS.

The investigation of the lower layers of the atmosphere by means of kites and captive balloons has been continued throughout the year. Observations of temperature and moisture of the air in a vertical direction, the changes in the speed and direction of the air currents, and the approximate depth of layers of fog and cloud were made daily, except Sundays. The average altitude attained by kites during the year was 2,663 meters (8,737 feet) above sea level; by balloons, 2,004 meters (6,575 feet). The corresponding heights for the previous year were: For kites, 2,388 meters (7,835 feet); for balloons,

1,738 meters (5,702 feet). The height attained by the kites last year, though greater than for the previous year, is somewhat below the ideal altitude for observations in the lower layers of the atmosphere; that is, between the ground and  $2\frac{1}{2}$  miles altitude.

Flights up to and above that altitude are obtained so irregularly as to be of much less value than were they more regular and consecutive. The drift of the air currents is such that it may be impossible for two weeks at a time to get a kite through the zone of still air that overlies the mountain and adjacent valleys. Then, without any preliminary indication, the lower 3 miles of atmosphere will move as a whole with something like uniform speed, and the altitude to which the kites may be sent is a question largely of the strength of the wire and the containing drum.

While the present form of kite is satisfactory for general use, a kind is needed that will withstand the conditions imposed by fog and rain. In a great many cases, probably 100 a year, the mountain is enveloped in fog. Under these conditions the kite sails rapidly take up moisture. This increases their weight, while the shrinking due to the wetting of the fabric often causes the sticks to break, and the kites are precipitated to the ground. Effort has been made to secure material for sails that will not absorb water.

The use of a better quality of material in the constructing of captive balloons has resulted in a greater altitude being reached, and a further increase in the average altitude reached is confidently expected during the coming year.

The kite and balloon observations have been regularly published in the Bulletin of the Mount Weather Observatory, a publication almost wholly devoted to the meteorology of Mount Weather.

#### SOLAR RADIATION.

Measurements of the intensity of solar radiation and the polarization of sky light have been made at Washington and Mount Weather whenever conditions were favorable for this work. At Washington 56 series of observations were obtained, 32 of which appeared to be good enough to justify their employment in computations of the solar constant. At Mount Weather, out of a total of 27 series of observations, 8 were employed in solar-constant computations. The results have been prepared for publication in the Mount Weather Bulletin.

During the past year observations were obtained on a greater number of days than in the year preceding. They indicate a greater intensity of solar radiation at the surface of the earth and a greater percentage of polarization of sky light than was found during the year ending June 30, 1908, which appears to have had a low value for both sky polarization and solar radiation.

The international commission for securing daily weather reports for the globe has recently included a measurement of the intensity of solar radiation in the list of meteorological observations to be telegraphed daily from selected stations located about the centers of action of the atmosphere. This is indicative of the interest now being taken in the relation between the intensity of solar radiation at the surface of the earth and weather conditions. Recent literature also shows an increased interest in the relation between the polarization

of sky light and weather conditions, and the Mount Weather Observatory will cooperate with several foreign observatories in an attempt to determine more definitely the exact nature of this relation. In a paper by Professor Kimball, in volume 2, part 2, Bulletin of the Mount Weather Observatory, it is shown that a relation exists between the polarization of sky light and the transmissibility of the atmosphere for solar radiation. It appears, therefore, that the intensity of solar radiation at the surface of the earth, sky polarization, and weather conditions are phenomena whose relations should be carefully studied.

Extension of this line of research has been retarded by unavoidable delays in obtaining suitable apparatus. Angström pyrheliometers deteriorate with age, and much difficulty has been experienced in replacing defective parts. It has therefore become necessary to devise an instrument that can be manufactured in this country. As stated in my last annual report, such an instrument has been devised in our Instrument Division, embodying some principles not heretofore employed in pyrheliometry. Samples have been tested and defects remedied, and the evolution of a pyrheliometer that will be easy of manipulation and accurate in its indications appears to be in satisfactory progress. With its completion it is hoped to inaugurate an active campaign having in view the study of the intensity of solar radiation in different sections of the United States.

#### MAGNETIC OBSERVATIONS.

At the close of the calendar year 1908 the computation of the hourly values of declination and of horizontal and vertical intensity was temporarily abandoned, as were also the photographic records being made by all the larger instruments. A record of the declination and the horizontal and the vertical force was continued, however. This record has been approximately checked by absolute values obtained from eye readings, and is intended to serve the needs of the future. Data of magnetic storms, auroras, and sun spots have also been collected for publication.

#### NEW WORK PROPOSED.

During the coming year it is proposed to increase the value of kite and balloon flights by making them every day. The first Sunday flight was made July 19, 1909. Two years of active work with kites and captive balloons at Mount Weather have shown that the records thus obtained should be supplemented by others from higher regions of the atmosphere than can be reached with kites, captive balloons, or even manned balloons. Such can be secured by the use of free balloons, or, as sometimes called, "sounding balloons," developed principally by De Bort in France and Assmann in Germany. Kite flights in the center of storm activity are made with considerable difficulty, owing to the unsteadiness of the wind and the increased weight of the kites when wet with precipitation. Preparations are now under way to send expeditions from Mount Weather to two western stations, for the purpose of liberating free balloons simultaneously at the two points—one in or near the storm center and the other some hundred miles to the eastward. The station at Mount Weather can

not be used, owing to its proximity to the sea. Some of the free balloons sent up by Professor Rotch at St. Louis landed 250 miles to the eastward of that city.

Another method of studying the changes in the atmosphere in a vertical direction is that afforded by mountain stations. During the coming year it is proposed to secure a continuous record of the temperature and possibly of other elements at high stations in Nevada and Colorado. While the temperature of the free air is not quite the same as that on a mountain top at the corresponding elevation, the differences are small. Moreover, the mountain temperature record will afford valuable information as to the propagation of temperatures upward or downward due to a horizontally flowing current of definite thickness. Kite observations at Mount Weather have shown at times the existence of a warm horizontal air current on the mountain top nearly twenty-four hours before it appeared in the valley about 300 meters (1,000 feet) below.

Since the foregoing was written preliminary returns have been received from the two sounding balloon parties that it was proposed to send out from the Mount Weather Research Observatory.

Eight ascensions were made, in each of which the altitude attained equaled or exceeded 10 miles. On October 12, at Omaha, Nebr., a height of 15 miles, hitherto unprecedented for this country, was attained, and on October 6, at Indianapolis, Ind., a height of nearly 14 miles was reached. The last-named ascension was made in almost the center of a great area of high pressure. The balloon was observed to move in a southwesterly direction at all altitudes, and was later found in that direction about 30 miles from the city. A similar movement—that is, a drift of the air at high altitudes toward the southwest—was observed at Omaha, Nebr. This would seem to indicate that the control of the general atmospheric movements exerted by areas of high pressure extends upward to greater altitudes than has been hitherto suspected.

In general, the results of the ascensions, so far as available, are in close accord with European observations. The great isothermal layer was reached on eight occasions; its lower limit varied greatly in altitude from day to day and for different surface weather conditions.

#### FORECASTS AND WARNINGS.

Upper air observations have been telegraphed daily from Mount Weather to Washington and utilized in the preparation of the official forecasts. Observations secured at elevations of 8,000 to 10,000 feet and higher have permitted a determination of temperature gradients and normal and abnormal wind currents that bear a definite relation to subsequent weather changes in the Middle Atlantic States. For instance, it has been found that the average wind direction at Mount Weather at about 10,000 feet above sea level is northwest, and that shifts of wind to west and southwest usually forerun by about two days the beginning of rain on the middle Atlantic seaboard. Continued observations and careful studies thereof will doubtless reveal many upper air indications of positive value in practical weather forecasting.

Isobaric charts based upon telegraphic reports received from selected stations throughout the Northern Hemisphere have been pre-

pared daily, and forecasts for about a week in advance have been issued at intervals for publication. The following illustrate the character and scope of these forecasts:

Thursday, July 9, 1908:

A warm wave that will cover the Plains States Friday will extend over the central valleys Saturday and set in over the Atlantic States Sunday. The warm period will be of two or three days' duration in the several sections, and will end with rains in the Plains States on Sunday, in the Mississippi Valley and western lake region on Monday, and in the Ohio Valley, the eastern lake region, and the Atlantic States Monday or Tuesday. The rains referred to promise to be sufficiently heavy to end the existing drought in the Ohio Valley and Middle Atlantic States.

The warm wave was the most intense of the summer of 1908. Its progress and duration, and the movement of the rain and cooler area, conformed to the forecast.

On July 15, 1908:

A barometric depression that now covers the Rocky Mountain districts will move over the Plains States Thursday, cross the central valleys and lake region Friday and Saturday, and reach the Atlantic States Saturday night or Sunday, preceded by rising temperature, attended by local rains and thunderstorms, and followed by two or three days of fair and cooler weather. This depression will cause rains in the wheat and corn belt and also rather copious rains in the Ohio Valley and the Middle Atlantic and New England States.

The depression advanced as forecast, and generous rains fell in the corn and wheat belt. Rainfalls were also heavy in areas in the Ohio Valley and the Atlantic States north of Maryland and relieved the drought that prevailed in those sections. The depression was followed in the interior by two or three days of temperature below the seasonal average.

The Evening Metropolis, Jacksonville, Fla., of July 30, 1908, comments as follows regarding a tropical storm that advanced northward near the Atlantic coast:

The storm that the Weather Bureau has been watching for three or four days has at last shown itself, and this morning is approaching the coast line near Wilmington, N. C. At 7 a. m. the wind velocity at North Carolina stations was between 40 and 50 miles an hour from the east and northeast. No doubt the disturbance has been giving some sailing vessels a hard time. The fact that the storm has at no time been near land, and yet located daily with almost absolute accuracy, shows the exactness with which the Weather Bureau makes its predictions. There are a number of vessels that delayed sailing on account of the display of storm warnings, and they now appreciate the wisdom of their conduct. The Weather Bureau was established to render service. Who will say that it is not doing so?

The Virginia Pilot, Norfolk, Va., of August 2, remarks as follows regarding warnings issued in connection with this storm:

It was due to the magnificent work of the Weather Bureau that there were no wrecks along the coast. Many hours before the storm developed any great strength the Bureau had sent warnings along the coast to notify mariners that there was a blow off the Florida coast and advised caution about proceeding south. These warnings were sent to several wireless stations, which transmitted them to vessels at sea having the wireless apparatus, so that the news was flashed down the line.

The St. Louis Times of August 15 refers editorially as follows to weather forecasts in general, and to a forecast of August 13 in particular:

Close observers of weather conditions have noted in recent months that the department of meteorology at Washington has been indulging in some long-distance and wide-range forecasts.

Time was when the word chiefly employed by the forecasters was "Probably." Now there is a certain note of positiveness in the twenty-four-hour forecast, and the long-distance, wide-range bulletins amount almost to predictions. Several weeks ago, for instance, the department announced that a blanket of rain would begin at the Rocky Mountains and stretch to the Atlantic. The forecast covered a period of a week, gave great cheer to the agriculturist and business man generally, and was fulfilled exactly.

Yesterday the department made a prediction, technically called a forecast, covering a period of five days ending next Wednesday morning. All of the spring wheat and corn States are to have needed hot weather, followed by needed rain, after which it will be cooler. It will be worth while noting the outcome of this prediction.

If the department at Washington finds it possible to make a forecast covering the great growing section of the country for a week, it will have increased its usefulness immeasurably.

A special feature of a forecast issued on the 18th was a prediction of well-distributed rains in the cotton belt, where rain was needed. The rains occurred over the cotton belt as forecast, and in the Atlantic States the rains that set in were exceptionally heavy.

The following from the Daily Picayune, New Orleans, of August 26, 1908, indicates the demand for weather information that increases with recognition of the value of the forecasts:

The weather map issued by the United States Weather Bureau yesterday showed generally settled weather conditions over the greater portion of the country for the first time in several days. These conditions call attention to the special forecast issued by Chief Willis L. Moore, of the Weather Bureau, Tuesday, August 18, and published in the Picayune on the 19th. Looking over the weather map we see that the barometric depression referred to in the forecast crossed the Rocky Mountain districts on the 20th and 21st, the Plains States on the 22d, the central valleys and the lake region on the 23d and 24th, and is now over the Atlantic States. The well-distributed rains forecast by Professor Moore have fallen, and those sections of the cotton belt where rain was needed have received copious showers. The map issued Tuesday shows the comparatively cool and settled weather moving eastward just as forecast eight days ago. Forecasts of this character, when so fully verified as have been the case with the Weather Bureau forecasts, are of great importance to agricultural and commercial interests, and the public will look keenly for information telling a week or more in advance what weather to expect as they look for the daily forecasts covering a period of thirty-six to forty-eight hours. Commercial interests attach such importance to the forecast that request has been made that such forecasts be telegraphed as soon as issued, at the expense of the recipient.

A remarkable period of dry weather set in over the northern half of the United States east of the Rocky Mountains during the latter portion of August and continued well into the third decade of September. In two or three instances during this period indications that as a rule presage rain partially or wholly failed. The rather remote causes of the dry spell are now recognized. It was not possible to detect and interpret them with previous imperfect knowledge of the operative influence of the greater barometric areas.

On September 22 the following forecast based upon radical changes in pressure was issued:

A barometric disturbance will cross the country from about the 24th to 28th, attended by rains that will set in over the central valleys about the close of this week and extend over the Atlantic States by the beginning of next week. Following the rains there will be a sharp fall in temperature, with frost in the central valleys and Eastern States north of the fortieth parallel.

The rains that attended this disturbance occurred as forecast and relieved the drought in northern and northeastern districts. The frosts that followed its passage extended over the Middle Western States and the States of the Ohio Valley and middle Atlantic coast.

The following comment on this storm and cool wave is made by the Market Growers' Journal, Louisville, Ky., of September 30, 1908:

A general area of rain set in over practically the entire Rocky Mountain region the latter half of the week and moved gradually eastward, bringing rain to the Mississippi Valley States by Saturday night. The rain reached the Ohio Valley Sunday night of this week and the indications at this writing are that before this issue reaches our readers the drought in all sections of the country which have been suffering will have been brought to an end. An interesting fact of this rain period is that it was predicted early last week in a bulletin sent out by the Weather Bureau at Washington \* \* \*. The general rains, which marked the end of the drought, are being followed by a period of cold weather which will mark the end of the unusually warm weather of September.

An editorial in the Albany, N. Y., Journal of September 29 reads as follows:

Just now there is in evidence the fulfillment of a forecast made a week ago. Early last week it was announced from Washington that conditions were favorable for the development of a general rain area in this part of the country by about the 28th instant. Because of the long absence of rain, that prediction was of unusual interest, and the arrival of the time appointed for its fulfillment was waited with mingled hope and apprehension.

There was a widespread feeling of relief when the sky became overcast and precipitation began, gradually, as it nearly always does after a long period of dry weather.

The Weather Bureau is to be congratulated upon the accuracy of a "long-distance" forecast, made at a critical time when all ordinary signs, even to that old standby, the sun's "crossing the line," seemed to fail.

The Kansas City, Mo., Star of September 27 remarks as follows:

✓ An interesting fact about the storm area that is now moving across the country is that it was accurately predicted by the Weather Bureau last Tuesday evening (September 22), when a "long-distance" forecast was put out saying that rains would fall in the central valleys about the close of this week, and in the Atlantic States at the beginning of next week, followed by frost north of the fortieth parallel.

The Weather Bureau's forecasts for a week ahead are still in the experimental stage, but they promise to be of great value. They are based on reports of barometric pressures in various parts of the world, indicating the progress of storm areas. Last Tuesday's forecast was based on reports of low barometric pressure at the time in Nome and Sitka, Alaska, and in Honolulu. But the present storm area first appeared over the Rocky Mountain regions with a bank of high barometer all week along the Pacific coast, so that it seemed questionable as to whether it came from the conditions on which the Weather Bureau based its long-distance forecast of last Tuesday.

The forecast was based on reports for several days preceding the date of its issue. On September 17 Pacific pressure was high over Honolulu and low over Nome. Three days later pressure was high over the Bering Sea region and low over the Hawaiian Islands. It has been observed that pressure changes over the Pacific Ocean fore-run by several days certain changes on the Pacific coast and the American continent as a whole. On September 23 a decided fall in the barometer occurred over the middle and south Pacific coast districts, and on the following day the barometric disturbance appeared, as stated, over the Rocky Mountain districts. It is true that pressure continued high over the north Pacific coast. That was expected. The predictions are based, not necessarily upon the progress of individual storm and high barometric areas, but upon a study of atmospheric conditions over the whole Northern Hemisphere and more directly, at this season of the year, on the general circulation of the atmosphere

over the Pacific and Atlantic oceans. In winter the great continental areas of high barometer, and more especially the Asiatic high area, appear to dominate the general atmospheric changes of the Northern Hemisphere. By a study of the association and interrelation of the greater areas of high and low barometric pressure, the forecasting of weather changes for a week or more in advance is made possible.

During the last seven days of September a hurricane advanced from the Lesser Antilles of the West Indies to the Great Bahama Bank. On October 1 the vortex of the hurricane recurved northward over the western Bahamas. The following notes regarding this storm are from the Nassau Guardian, New Providence Island, Bahamas, of October 3, 1908:

The first intelligence that another hurricane had made its appearance reached us late last Saturday (September 26), when we were informed by cable from Washington that a storm was central near and south of Porto Rico, moving west-northwest. This information was confirmed by telegrams from the same source dated the 28th, 29th, and 30th, stating that a hurricane was central near the Great Bahama Bank, moving west-northwest. These statements were entirely borne out by the weather here on September 30, which throughout the day wore an exceedingly threatening aspect. \* \* \* By 8 a. m. of October 1 the barometer had fallen to 28.88 inches, while the wind, southeast, had risen to an estimated velocity of 80 miles an hour—estimated, because at 7.45 a. m. the wind-recording instruments at the observatory were blown away. At this time squall succeeded squall with rapidly increasing velocity from the southeast, the rain falling in continuous torrents, being driven by the wind with a force that the few adventurous persons who were out found positively blinding, \* \* \* Although much damage was done on land, interest centered on the shipping in the harbor, most of which was in sore straits. \* \* \* At 10 a. m. the barometer reached a minimum of 28.68 inches, with wind from the south blowing at an estimated velocity of 60 to 80 miles an hour. At noon the barometer had risen to 29.10 inches.

\* \* \* \* \*

An instance of the value of the storm telegrams is afforded by information obtained from Mr. William Hilton, who arrived this morning from Stanlard Creek. He states that a great many of the sponging craft there had been launched and taken out of the creek to the north side, but that on the receipt by the Rev. Mr. Dinsdale, on Sunday night, of a copy of Saturday's storm telegram, sent by the port officer, the vessels were all brought into the creek again and secured. Had this not been done the damage to shipping there would probably have been very great.

The telegrams referred to were sent by the Chief of the Weather Bureau to the governor of the Bahamas, Nassau. They were begun September 26, 1908, and advised measures to protect shipping.

On Tuesday, October 20, the following general forecast was issued:

The barometer has fallen rapidly over the southern Rocky Mountain region, and a well-defined storm will appear in that section Wednesday morning. This storm will move northeastward, attended by rain in the central valleys Thursday and in the Atlantic States Friday or Saturday. The rains promise to be sufficiently heavy to extinguish the fires in the Allegheny and Adirondack mountains.

The rains set in as forecast, and in the eastern mountain districts, where forest fires were destroying property, they continued several days.

The following are among many comments that were made by the press regarding warnings issued in connection with a severe cold wave that swept the country from the Rocky Mountains to the Atlantic during the first decade of January, 1909:

Kansas Farmers' Star, Wichita, Kans., January 8, 1909:

The weather man gave the farmers of the Southwest plenty of warning. There can't be any very good excuse for not having provided shelter for their live stock.

Market Growers' Journal, Louisville, Ky., January 16, 1909:

\* \* \* This cold wave was forecast in a special bulletin sent out by the Weather Bureau Saturday afternoon, January 2. This forecast indicated the coldest weather of the season for States east of the Mississippi River, and was issued in ample time to warn all growers who needed the warning. \* \* \*

Post-Express, Rochester, N. Y., January 5, 1909:

\* \* \* Hundreds of shippers are holding back shipments on warnings from the Weather Bureau, and many shipments were rushed following the warning sent out last week. The absolute accuracy of the two special forecasts made by the Weather Bureau at Washington has aroused much favorable comment among business men here and in some instances has saved thousands of dollars for nurserymen and brewers.

Daily Times-Union, Jacksonville, Fla., January 11, 1909:

\* \* \* The point of interest involved in the forecast is the fact that nine days ago the Washington office announced the existence of conditions that favored cold-wave formation, and on Monday and Tuesday the same office gave notice that the cold wave actually existed in the Northwest and that the extreme cold would reach the seaboard States during the last of the week, which was exactly the case, for on Friday the temperature in the middle Atlantic section was about 15° above zero and freezing prevailed over the south Atlantic section.

The merit of such long-range weather predictions lies in the fact that they enable shippers to meet contingencies; for instance, the Florida shipper of fish knows that no reicing will be necessary, and the banana shipper from Mobile and New Orleans provides the necessary warmth for his cars. Other commodities to interior points are given the necessary attention.

The Times, Tampa, Fla., of February 1, 1909, refers editorially as follows to warnings issued in connection with this cold wave:

The Weather Bureau gave ample warning, so that persons who desired and were prepared could "fire" their groves and shelter their seed beds and avoid any loss whatever. The value of the Bureau is made more evident every year by the saving it enables people to make in defending themselves against cold and storms.

The following special forecast was issued on Saturday, February 6, 1909, in connection with a storm that advanced from the Pacific to the Atlantic coast from the 6th to the 10th:

A storm that now occupies the north Pacific coast will move southeastward over the Rocky Mountains Sunday, and then eastward over the Plains States Monday and Tuesday, and reach the Atlantic coast about Wednesday, attended by snow in middle and northern districts, and followed by a cold wave that will appear over the Northwestern States Sunday or Monday, advance over the central valleys and Lake region Monday and Tuesday, and reach the Atlantic States about the middle of next week.

The following are among the press comments that have been made regarding this forecast:

The Times, Fort Smith, Ark., February 8, 1909:

On Saturday there was sent out from the Washington Weather Bureau headquarters a general forecast, reporting a storm disturbance on the northern Pacific coast that would advance southeast, followed by a cold wave. They made good. The Monday morning chart indicated that the storm advanced over the Rocky Mountain region, accompanied by snow or rain, which covered the whole Mississippi Basin. Following it, an area of high barometer is sweeping down from the north, accompanied by a fall of as much as 36 degrees in temperature. \* \* \*

**Courier-Post, Hannibal, Mo., February 9, 1909:**

\* \* \* The storm is the one predicted from the Washington Weather Bureau as early as last Saturday, and the prediction has proved remarkably accurate for such a long time ahead. It is central to-day over Iowa, where it is very pronounced. Heavy snows are predicted for the northwestern part of the State, and strong gales. The zero line has been pushed down into northern Kansas. \* \* \*

**Commercial Tribune, Cincinnati, Ohio, February 11, 1909:**

Within a few days the Weather Bureau has come up to all expectations. As early as last Monday the signs indicated rain and snow, and Tuesday morning we were told to look out for rain, snow, and much colder weather on Wednesday. Everything came to pass. The reason for calling attention to this fulfillment of prophecies grows out of the fact that there are countless thousands who find fault whenever there is a little slip up. As a rule, the predictions are quite accurate and there has been a distinct improvement over other years. In short, the business is beginning to rest more nearly upon a scientific basis, and improvements and observations which are to be expected in the future will make this branch of the Government one of the most important, not to the few, but to many millions. \* \* \*

**The following special forecast was issued Sunday, March 14, 1909:**

During the present week a disturbance will advance from the Pacific to the Atlantic coast from about Tuesday to Friday, preceded and attended by rising temperature and by general rains in the middle and southern districts and by snow in the more northern States, and followed by a period of cooler, fair weather that will set in over the Northwestern States Tuesday night and reach the Atlantic seaboard about the close of the week.

The disturbance referred to appeared Tuesday, the 16th, over the Pacific States and its center reached the Atlantic coast Friday night, the 19th. Its passage was attended by snow from the Missouri Valley over the Lake region, and by rain from the lower Mississippi and Ohio valleys over the Southern and Southeastern States. It was followed by lower temperature, that set in over the Northwest Tuesday night and reached the Atlantic and east Gulf States Saturday.

**On April 7, 1909, the following special forecast was issued:**

Several days of comparatively cool weather are indicated for the eastern half of the United States, with frost in the middle and upper Mississippi and Ohio valleys and the Lake region, and thence over the Middle Atlantic and New England States. Frost is also likely to occur in the interior of the Gulf and South Atlantic States.

Following the disturbance of April 5 to 8 an area of high barometer swept south and east from the British Northwest Territory, attended by frost-bearing temperatures that reached the Gulf States the morning of the 9th and covered the east Gulf and Atlantic States the morning of the 10th. On that date frosts were general in the South, including northwestern Florida, and on the morning of the 11th a minimum reading of 26° was noted at Washington, D. C.

On April 21, 1909, a warning of freezing temperature was issued for Colorado, and on the morning of the 23d temperature fell to 27° at Pueblo and in the Arkansas Valley. The Star-Journal, Pueblo, Colo., of April 23, 1909, comments as follows regarding the frost:

The Weather Bureau predicted the frost more than twenty-four hours ahead, and every effort was made to give warning to the farmers. Almost without exception fruit growers whose crops were endangered heeded the warning of the Weather Bureau and protected every early-blooming fruit tree with plenty of smudge fires, and so prevented any loss by frost.

The Record, Fort Worth, Tex., of May 5, 1909, refers editorially as follows to action taken by Colorado fruit growers to protect their crops from the cold wave of April 30-May 1:

There was an illustration in Colorado last week of how man's ingenuity combats the elements and sometimes thwarts the full workings of nature. Colorado fruit growers had been warned of the coming of the cold wave which there was every evidence to believe would blast the fruit crop. The fruit crop in the threatened Grand Valley is estimated to be worth \$3,000,000. Fruit growers immediately got busy with the smudge pot. These oil heaters performed the miracle of heating the whole out-of-doors. The danger point to the fruit crop is 28°, and the smudge pots pushed the thermometer register up to 32°. The orchards were saved. The cost of equipment was an average of \$25 an acre, the cost of running \$5 a night, and the estimate is that not more than three nights a year would such precautions be necessary; hence at a cost of \$40 there was saved each acre's crop, the value of which runs from \$300 to \$2,000.

NEW STATIONS IN ALASKA.—Provision has been made for the establishment of three additional stations in Alaska (Eagle, Tanana, and Valdez), daily telegraphic reports from which are calculated to be of value in foreseeing the approach toward our northwestern borders of severe cold waves that have their origin over the far British northwest.

The application of upper air and world-wide surface observations to the art of weather forecasting for short and long periods is each year becoming more apparent, and progress along lines of useful forecast work will keep pace with discoveries that may be made in these practically unworked fields.

#### THE KEY WEST HURRICANE OF OCTOBER 11, 1909.

During the hurricane season of 1909 the weather was unusually stormy over the Gulf of Mexico and western Caribbean Sea. The first important storm of the season struck the Texas coast south of Galveston, the next two crossed the west coast of the Gulf of Mexico near the mouth of the Rio Grande River, and the fourth advanced northward over Louisiana. The Key West storm moved from a position over the south-central Caribbean Sea northwestward to extreme western Cuba from October 6 to 10, and there recurved sharply to the northeastward over Pinar del Rio Province, Cuba. At 11.30 a. m. of October 11 the vortex of the storm passed over Sand Key with barometric pressure 28.37 inches, and at 11.45 a. m. it passed Key West with minimum pressure 29.50 inches. Moving thence northeastward over the northern Bahamas the storm center passed northwest of Bermuda during the 13th and reached Newfoundland on the 14th, with a gradually expanding area and a rapid loss of tropical intensity.

Notices to shipping regarding this hurricane were begun October 6, when advices stated that a tropical disturbance over the central Caribbean Sea was moving west-northwest. On the 7th the storm advices stated that the disturbance was apparently approaching the Isle of Pines and developing intensity. On the 8th the center was located south of western Cuba and caution was advised to vessels bound for western Cuban waters. Advisory messages of the 9th followed the hurricane center on its northwest course, and on the 10th storm warnings were ordered on the southern Florida coast, and At-

lantic and Gulf shipping interests were informed that the center of the disturbance was west of Habana, moving northwest by north and increasing in intensity. At 6 a. m. of the 11th storm warnings were changed to hurricane at Key West and Sand Key. This action was followed by the following special bulletin addressed to Atlantic and Gulf Weather Bureau stations and the press associations:

The West Indian storm that has been moving westward over the Caribbean Sea during the last week has developed into a hurricane of marked intensity and at 8 o'clock Monday morning was central just west of Key West, Fla. At Sand Key the wind was 60 miles from the east. At 10 a. m. the pressure at Key West was 28.94 inches with a wind velocity of 56 miles from the east and a very high sea swell. Storm warnings were ordered Sunday afternoon from Key West to Mobile and changed to hurricane warnings early Monday morning. Hurricane warnings were also ordered on the Atlantic coast as far north as Charleston. The center of the storm will probably pass northward over Florida to-night and Tuesday and be felt Tuesday off the entire south Atlantic coast. All shipping in the affected area has been warned to seek refuge immediately. Hourly observations will be taken and all ports kept advised of the direction of the storm.

MOORE.

In addition to the above the following was telegraphed to Florida Weather Bureau stations:

Hurricane now central near Key West promises to be destructive to life and property over a large portion of the Florida Peninsula. You are authorized to incur any necessary expense and to adopt every reasonable measure to disseminate warnings to the islands, coast cities, and even the interior of the State.

Advices were issued during the day in which the northeast course of the storm was given and the statement made that there was apparently no further danger in the Gulf of Mexico. On the following morning the advices stated that the storm had passed north-eastward over the Atlantic beyond the region of observation.

At 6 a. m. of the 11th the disturbance was central west by southwest of Habana, Cuba, and over or near the western portion of Pinar del Rio, and its advance over that Province was preceded and attended by torrential rains and winds of hurricane force. The storm struck Habana and raged for several hours, sinking or stranding small craft in the harbor and prostrating trees and wires and flooding the streets with water. The following are notes made by Mr. Dague, observer, Weather Bureau, during the passage of the storm over Sand Key, Fla.:

By direction of the official in charge at Key West the office was deserted at 8.30 a. m., and the barograph and supplies were carried to the light-house. The signal tower fell at 8.45 a. m., and the sidewalk was carried away. A little later outhouses were washed away. When the station was abandoned the barograph had begun to fall rapidly and the wind had reached a velocity of 75 miles an hour. At 9.15 a. m. the anemometer cups were blown away, leaving only the cross arms. At 9.20 a. m. the top door of the roof was blown away. The wind at this time was estimated at 100 miles an hour, with gusts that exceeded that velocity. Heavy rain was falling, obliterating objects more than 50 feet distant. At 9.30 all trees had been blown down, the atmosphere appeared like a white mist, the island was becoming covered with water, and at 9.35 heavy seas swept over the island and a small cistern was blown over and carried to sea. At 9.45 a. m. the tower on the top of the station building fell, and by 9.50 the plank walks were entirely washed away. The large cistern was swept away at 9.52 and at 10 the entire island was covered with water to a depth of about 4 feet, all sand was washed from the island, and many of the steps of the building had been carried away. At 10.05 the foundation of the Weather Bureau building was nearly inundated and at 10.10 all the steps had been carried away. At 10.30 the building went over with a heavy crash

and was immediately washed out to sea. The boathouse was moved from its base.

A heavy swell from the southeast prevailed during the storm. The barometer fell rapidly from 4 to 11.30 a. m., when the minimum reading, 28.37 inches, was registered. A rapid rise then set in that continued until 6 p. m., at which time the weather had moderated. Excessively heavy rain fell until 1 p. m., when it began to decrease and ended at 2 p. m. After the wind had backed to the northwest the swell from the southeast opposed it and caused the water to spray from the top of the swells through the air with the wind. Two windows in the top of the light-house were blown out during the most violent part of the storm and caused a draft through the tower that made it impossible to open the door at the bottom of the tower.

At Key West the barometer at 8 a. m., October 11, stood at 29.42 inches, and fell rapidly to a minimum of 28.50 at 11.45 a. m. This is the lowest barometer reading ever recorded at that station. (See

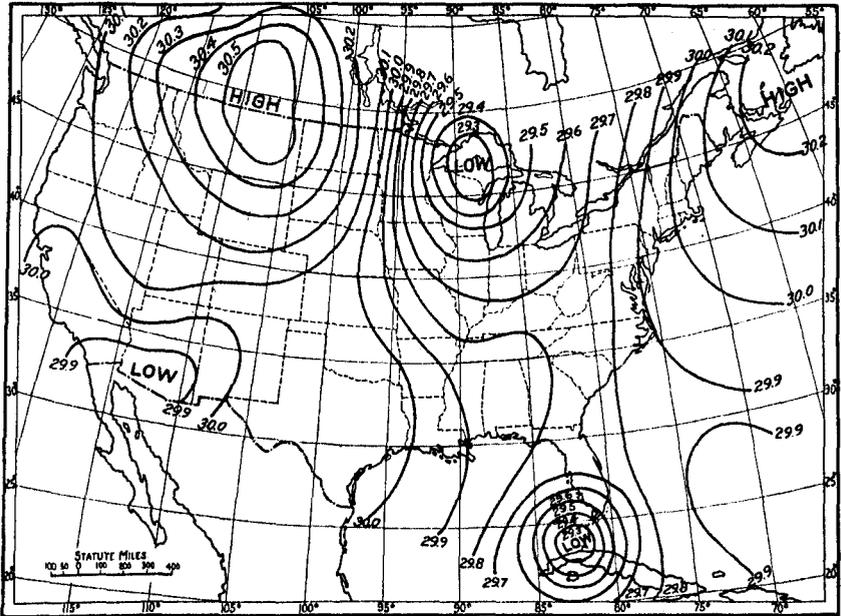


FIG. 1.—Isobars at 8 a. m., seventy-fifth meridian time, October 11, 1909.

figs. 1 and 2.) The wind that at 8 a. m. was blowing from the southeast at a rate of 30 miles an hour, shifted to east by 10 a. m., and at 11 a. m. had reached a velocity of 68 miles an hour from that direction. At noon the barometer had risen to 28.60 inches and the wind had changed to northeast and reached 72 miles. By 1 p. m. the wind had backed to northwest, and it continued from that quarter the balance of the day with velocities reaching 72 to 76 miles an hour until 4 p. m. The rainfall at Key West for the twelve hours ending 8 p. m. was 8.12 inches. Hundreds of buildings in Key West were wrecked by the hurricane and, so far as known, six persons were killed and many injured by flying débris. Many vessels were swept from their moorings and some of these were wrecked. The total financial loss in Key West is variously estimated at \$2,000,000 to \$3,000,000.

After passing Key West the hurricane swept the Florida Peninsula south of Miami. North of Miami the storm was not severe. On the extension of the Florida East Coast Railroad about 3,000 workmen were withdrawn from dangerous points. J. P. Beckwith, vice-president of the line, states:

Positively not a life was lost in the storm. Very little damage was done to the right of way or work on the extension. The road will be open to traffic within a few days to Knights Key. Warning by the Weather Bureau enabled us to fully protect all employees and equipment.

The hurricane loss between Miami and Key West is reported to have aggregated millions of dollars, and so far as known 11 lives were lost. Advices also show that the East Coast Railroad officials acknowledged that the Weather Bureau warnings were their salvation. Profiting from the experience of three years ago, when the lives of

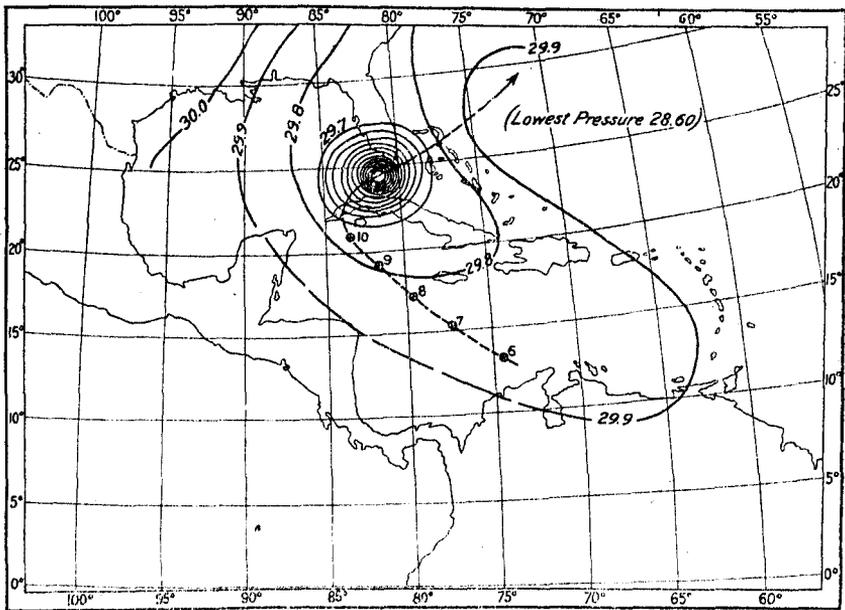


FIG. 2.—Isobars at noon, seventy-fifth meridian time, October 11, 1909.

many men employed on the extension were lost and miles of track were destroyed, the men in charge prepared for the hurricane. The preparations thus made undoubtedly saved hundreds of lives. About Miami the principal damage was to the citrus crops, which were blown from the trees in immense quantities. At Nassau, Bahamas, the storm was felt the night of the 11th, when the barometer fell to 29.37 inches and the wind reached a velocity of 50 miles an hour from the southwest.

While a summary of available information regarding this storm shows that protective measures employed upon the receipt of the warnings reduced losses of life and property to a minimum it appears certain that many fishermen, spongers, and others in small boats, and dwellers on the low-lying islands or keys that fringe the coast of the southern Florida peninsula that were outside the zone of communication were lost.

The storm of three years ago, above referred to, that struck the Florida keys with destructive force apparently originated over the eastern Caribbean Sea early in the second decade of October, 1906, and drifted westward as a shallow depression that covered practically the entire West Indian region. On the morning of the 17th the center of disturbance had reached a position south of western Cuba, where it recurved to the northeastward and passed near and east of Habana, Cuba, at 11.30 p. m. of that date, with minimum barometer at Habana, 28.86 inches. By the morning of the 18th the storm center had reached a position near and to the east of Key West, where at 3 a. m. a minimum barometer reading of 29.30 inches was registered. In its passage over Cuba the storm was of small diameter and great intensity, and caused great damage to crops in the Province of Habana. Crossing the Florida keys the barometer fell to 29.25 inches at Sand Key, with a maximum wind velocity of 75 miles an hour. At Key West the maximum velocity was 54 miles an hour. Although the warnings were given the widest distribution, much damage was done on the keys. The quarter boats of the East Coast Railroad extension were carried out to sea and many lives, probably more than 100, were lost. One hundred and fifty men were picked up at sea on wreckage. It is evident that under similar conditions the severe storm of October 11, 1909, would have caused a much greater loss of life than was caused by the storm of three years ago.

The following are among many newspaper references that have been made in connection with the Key West storm of October 11, 1909:

Editorial, New Orleans Times-Democrat of October 13:

\* \* \* The Federal Government has done all in its power to protect the people and the shipping by timely warnings of the approach of these storms. The Weather Bureau has been signally successful in these forecasts, being now able to follow a hurricane from day to day and give from five to seven days' notice of its coming, so as to enable all to prepare for it. But in spite of these warnings the storms find many persons unprepared and are able to do harm even when preparation has been made for their reception. \* \* \*

Editorial, Boston Daily Globe of October 14:

\* \* \* Had it not been for the timely warning, hundreds of men undoubtedly would have been drowned along the route of that marvelous railroad, the creation of Henry M. Flagler and his engineers, which, when the last spike is driven, will bridge no less than 30 miles of open sea and cross at least 30 miles more of submerged keys and lagoons directly connecting Key West with the mainland of the United States.

The Weather Bureau may make mistakes in some of its predictions (is bound to do so, in fact, in the present state of the science of meteorology); but when the Bureau makes good. It should receive due credit and praise.

Editorial, Washington Post, October 14:

The tropical storm that wrought such havoc at Key West on Monday last might have been productive of much greater damage, especially to shipping, had not the Government Weather Bureau given timely notice of its approach. From its inception in the Caribbean Sea west of Jamaica on October 2 until it passed beyond the limits of observation ten days later, every stage of progress was heralded by daily advices and warnings.

On October 10 an increase in intensity of the storm was reported to all interests needing information, and high winds were predicted for that night throughout central and southern Florida. The Weather Bureau observer at Key West hoisted hurricane warnings at daybreak the next day, some five hours before the fury of the storm was experienced, and ordered the Weather Bureau men at the vessel reporting station on Sand Key to leave their building

and take refuge in the light-house. This warning undoubtedly saved their lives, for the building was washed into the sea.

Until news could be obtained, much apprehension was felt concerning the large number of workmen at the construction camps of the seagoing railroad on the east Florida coast, but there was no loss of life. For this the company officials give all credit to the Weather Bureau, reporting that its warnings enabled them to protect the thousands employed on their extension works in that exposed section.

By such records as this the Weather Bureau establishes its worth and offers the best possible answer to its detractors. It may sometimes predict sunshine and give a rainy day instead, but it is at its best in foretelling these great storms. It is safe to say that the saving of loss of life and property resulting from its successful warnings in this one storm will more than compensate for its annual cost many times over.

#### RIVER AND FLOOD SERVICE.

The protracted drought of the late summer and autumn of 1908 over the watersheds of the great rivers of the eastern portion of the country practically insured immunity from disastrous floods during the following spring unless the rains of the winter and early spring should be more than usually abundant. Fortunately they were not excessive, although in early March conditions became very threatening along the Ohio River and great damage was done along the interior streams of central Kentucky.

The great floods of the year were those of August, in the rivers of the Carolinas and Georgia; of October, in eastern Colorado, Kansas, and Oklahoma; of November and December, in Oklahoma and Arkansas; and of January and February, in California. In South Carolina the stages of water were the highest of record, and the losses and damage in North Carolina, South Carolina, and Georgia amounted to \$3,500,000. In Kansas, Oklahoma, and Arkansas the losses of October, November, and December amounted to nearly \$7,000,000, and those of January and February in California to about \$2,500,000. The floods of March in the Chattahoochee, Alabama, and Tombigbee rivers also caused losses amounting to about \$1,000,000. Including the damage from numerous minor floods, the total losses for the year probably amounted to between \$16,000,000 and \$17,000,000. These losses, though large, were unavoidable.

The forecasting of the floods by the Weather Bureau was characterized by the accuracy that has attended its work in former years, and the value of the property saved by the flood warnings probably equaled the total amount of the losses. The receipt during the year of thousands of testimonials and expressions of commendation is sufficient evidence of the value of the service to the public.

The daily river forecasts for the navigable rivers were also continued with the usual success and with much resulting benefit to the commerce of the watersheds affected.

The service has continued to expand along natural lines, and this expansion must go on in the future if the demands of commerce and agriculture are to be satisfied.

During the year new river districts were established as follows:

- (1) Bismarek, N. Dak., with territory comprising that portion of the watershed of the Missouri River from Bismarek westward. This territory was formerly a portion of the Sioux City, Iowa, district.
- (2) Wichita, Kans., with territory comprising that portion of the watershed of the Arkansas River from Wichita to the Kansas-Colo-

rado line. This territory was formerly a portion of the Fort Smith, Ark., district.

On July 1, 1909, the new district of Evansville, Ind., will be established, with territory comprising that portion of the watershed of the Ohio River from below Louisville, Ky., to the mouth of the Wabash River. This territory now forms a portion of the Cairo, Ill., district.

The equipment of the river stations has been carefully supervised, a special object being to secure river gauges of a substantial and permanent character. During the coming year it is proposed to install several additional automatic gauges of the Marvin pattern, if the necessary arrangements can be made.

The study of the flow of the Ohio River has been continued during the year, and the scheme of forecasting has been completed for that portion of the river between Pittsburg and Louisville. The work on the lower river will probably be completed during the coming year, and the scheme for the Mississippi River commenced.

No definite plans for new field work during the coming year have been determined. Its character and extent will depend largely upon the funds available. Increased service is much needed in portions of Oklahoma and northern Texas, along the eastern tributaries of the upper Mississippi River, and in a few other places. The further prosecution of the snow measurement service at the headwaters of the western streams, as well as the gradual completion of the irrigation projects by the Reclamation Service, will necessitate the establishment of an adequate number of gauging stations along the streams that derive their water supply from melting snows.

The question of river service over the Yukon River watershed is still in abeyance, owing to the continued absence of the necessary facilities for rapid transmission of reports.

#### INSTRUMENTS.

The routine work of the Instrument Division has increased greatly during recent years with the increased number of stations and the introduction of many new forms of apparatus, as has also the work of repairing and reconstructing instruments that become unserviceable through wear and exposure.

The only new station to be completely equipped with instruments during the year was Brawley, Cal., but partial equipment has been furnished nine special meteorological stations during that period.

The new and special work of the past year has been as follows:

- (1) Installation of kiosks.
- (2) Completion of work on installation of automatically recording river gauges at Cincinnati, Ohio, and Hartford, Conn., and the starting of similar work at Parkersburg, W. Va.
- (3) The development of improved apparatus for the observation and study of evaporation and the equipment of a special station for this purpose at Salt Creek Bridge, Cal.
- (4) The perfection of improved apparatus for measuring snowfall.
- (5) The development of new apparatus for the measurement and registration of temperature and solar radiation.
- (6) Seismological work.

The more important details of these different items of work may be thus described:

**KIOSKS.**—As mentioned in my last report, this device consists of an ornamental iron structure devised for installation on public thoroughfares or in parks for the purpose of exhibiting meteorological charts and bulletins and for maintaining certain meteorological instruments showing the temperature, humidity, rainfall, etc. During the past year structures of this character, with their appropriate equipment, have been assigned to twenty-one of the more important cities of the country, and all but five have been installed. The experience thus far has been that the kiosk meets a public need and is an object of general interest wherever located.

**AUTOMATIC RIVER GAUGES.**—The introduction of automatic river gauges at a few of the more important river stations has been of great value to local interests. They indicate in the local offices of the Weather Bureau the stage of the river, although the reading is not at present automatically recorded. These gauges have been especially valuable in flood seasons, enabling the observers to answer promptly all inquiries concerning the stages of the river. The importance of an automatic record of the stages is recognized, and experiments have been made during the past year to devise a suitable recorder, which it is proposed to test at Parkersburg, W. Va., upon the completion of the river gauge equipment at that place.

**EVAPORATION OBSERVATIONS.**—Mention was made in my last annual report of a special form of float for obtaining observations of evaporation by means of dial readings. The structural details of this float were improved during the year. A special form of magnifying burette tube was also devised. Two improved forms of apparatus for automatically recording evaporation have likewise been developed. One of these operates on the principle of the tipping bucket device employed in the measurement of rainfall, the water lost by evaporation from the pans being supplied at intervals by means of a tipping bucket that measures and records the amount. The other operates on the principle of a float, and is designed to record the wind movement in close proximity to the evaporation pan, as well as the amount of evaporation. All of these instruments will be used at the evaporation station at Salton Sea, and at other places where evaporation studies are to be carried on.

**MEASUREMENT OF SNOWFALL.**—The importance of securing precipitation records for the unpopulated regions of the West has led to a study of possible methods by which accurate precipitation measurements, especially snowfall, may be obtained. The measurement of the depth of snow gives but an imperfect idea of the amount of water represented by a given layer. A special form of collector and scale gauge has been devised to enable the water equivalent of the snow to be determined directly by dial readings. It is believed the introduction of this device will greatly increase the accuracy of observations of this character.

**ELECTRICAL MEASUREMENT OF TEMPERATURE AND SOLAR RADIATION.**—Over a year ago we introduced at a number of stations a form of electrical thermometer that would indicate in the Weather Bureau office

at any moment the temperature of the air in the instrument shelter on the roof. The telethermoscope, as the instrument is called, measures the temperature by the variation in the electrical conductivity of a wire. Special pains have been taken to secure instruments of unquestioned accuracy. This has led to repeated tests, through which certain errors and discrepancies in temperature scales have been harmonized and a much more accurate grade of instruments obtained.

**SOLAR RADIATION.**—The apparatus for recording sunshine, and another apparatus for the absolute measurement of solar radiation, procured over a year ago, proved defective in mechanical construction. They were returned to the manufacturers and have only recently been received back. Preliminary examinations indicate that the original defects have been remedied, and it is now hoped to obtain satisfactory records through their use.

**SEISMOLOGICAL WORK.**—The seismological work has consisted in the maintenance of records from the two instruments on hand. The absence of special provision for this work, and the lack of sufficient force to take up these studies actively, make it impossible to carry the work forward in a satisfactory manner. The United States Government is, in many respects, far behind other nations in giving seismological work its proper status, and the progress in other countries, especially throughout Europe, has been very marked during the past few years. Great improvements have been made in instrumental appliances, but much still remains to be done before these instruments can be placed in the hands of any except specially trained observers.

**SEATTLE EXPOSITION.**—The Instrument Division indirectly supervised the preparation of the exhibit made by the Weather Bureau at the Alaska-Yukon-Pacific Exposition at Seattle, Wash., although this work was immediately in charge of the official assigned in charge of the exhibit, who looked after all the details and utilized, as far as practicable, the material remaining available from former expositions. It is believed that a very creditable and interesting exhibit of the Bureau has been realized.

#### CLIMATOLOGICAL DIVISION.

On July 1, 1908, the work of the Climatological Division was largely reorganized. The supervision of forecast distribution was transferred to the Distributing Division, while the preparation of matter for publication in the Monthly Weather Review and Annual Report of the Chief of the Bureau, and the preparation of general climatological data, together with the custody of the completed meteorological records of the Bureau, were carried over from the old Records Division, which was discontinued on June 30, 1908.

The collection and publication of climatological data in the form of monthly and annual section summaries for each of the forty-four section centers and the daily bulletins of the corn and wheat, cotton, and sugar and rice regions, have continued without material change.

The National Weather Bulletin was issued weekly during the crop-growing season, and monthly thereafter, as in the past, as also the weekly summary of snow and ice conditions, and the monthly snow-fall bulletins of the Mountain and Plateau States during the winter season.

At the close of the crop season of 1908 the issue of weekly bulletins during the crop-growing season was permanently discontinued at all the section centers, except Iowa, Hawaii, and Porto Rico.

Inquiries on various subjects, dealing mainly with special climatic features of the various portions of the United States and its dependencies, showed marked increase, more than 2,500 such letters having been received during the year. Many of these included requests for certified data, for use in courts. All were promptly answered, and the information desired furnished as far as practicable.

No effort has been made to increase the number of reporting stations in eastern districts, in view of the large amount of data already available from those regions. In the districts west of the Rocky Mountains the opening up of new territory to settlement has necessitated the establishment of additional observation stations to meet the requirements of home seekers and others as to the prevailing climatic conditions.

Considerable progress has been made in compiling the climatological data collected during the past forty years in form convenient for ready reference. Small bulletins, 106 in number, covering the entire area of the United States, are being prepared, each of which will contain tables showing for a comparatively large number of points in the respective districts the details of precipitation by months and years, and a summary of temperatures, winds, frosts, and other important climatic features. The Water Resources Branch of the United States Geological Survey is furnishing valuable data regarding stream flow and water power where such measurements have been made, for incorporation in these bulletins.

During the year the organization of the climatological service in cooperation with the associated bureaus, namely, the Forest Service and Bureau of Plant Industry of the Department of Agriculture, the Reclamation Service and Water Resources Branch of the United States Geological Survey, and the Office of Indian Affairs, has been perfected, so that the operations are now mutually satisfactory and promise a wide field of usefulness. This cooperation is at present engaged upon two problems, the law of evaporation from large bodies of water and the recording of snowfall in the Rocky Mountain and Pacific coast ranges, from which the waters to supply the irrigation reservoirs are derived.

#### EVAPORATION.

Construction work at the Salton Sea, California, where the principal studies of evaporation will be conducted, has been completed and a camp established at the Salt Creek Trestle, with subordinate stations at Indio, Mecca, Brawley, and Mammoth—all in the Imperial and Coachella valleys of California.

Preliminary evaporation observations at Reno, Nev., and Indio and Mecca, Cal., enabled the campaign to be organized with the direct purpose of attacking certain unsolved features in the problem. It is hoped that the observations made during the next year or two will give the necessary data for a complete discussion of the subject.

In the summer of 1908 arrangements were made for evaporation observations at twelve of the projects of the United States Reclamation Service, as well as at four evaporation stations in charge of the

water resources branch of the Geological Survey in the territory east of the Mississippi River. In this way simultaneous measurements of evaporation will be made in every type of climate, varying from the extremely dry climate of southern California, through the semiarid regions of the Rocky Mountain Plateau, to the humid climates of the Eastern and Southern States.

#### SNOWFALL IN THE MOUNTAIN REGIONS.

In the measurement of snowfall in the mountain regions, stations have been established in the Rocky Mountain and Pacific States, where comparative observations are being made with several kinds of apparatus, namely, a large snow bin, which is a 5-foot cubical box standing on stilts 5 feet above the ground; a standpipe, which is a galvanized-iron pipe 10 feet high and 10 inches in diameter, provided with a movable section at the bottom; a large platform on the ground, about 10 feet square; small vertical scales fixed against posts, tree trunks, etc., in the open; and, finally, the ordinary Weather Bureau snow gauge. It is proposed to vary the attachments on the snow bin by putting louvers on the inside and certain forms of screens or catches near the top of the bin, which will tend to extract from the horizontal sheet of air blowing at a high velocity an amount of snow equivalent to that which would fall vertically into a bin in a calm. This is a mechanical problem, but it must be worked out by actual experiment in addition to what suggestions can be derived from theoretical construction.

The results of experiments thus far indicate that the snow bin is capable of development, but that the long standpipe, the large platform, and the small snow gauge have such serious defects that they are not very promising. The vertical snow scales will be distributed widely in the remote regions of the mountains, where they can be visited on occasional trips, especially during the latter half of the winter.

There are, of course, large areas in these mountains where observers can not be secured, but the districts will be covered as far as possible. About 300 snowfall stations were all that could be established this season, as the campaign did not properly open until some snows had fallen in the early winter, after which it became difficult to make the necessary journeys into the mountain districts.

The associated bureaus are rendering efficient and valuable service in securing observers, installing stations, and making special observations. The Forest Service has submitted numerous interesting suggestions regarding a device for storing the snowfall of a whole season, which it is very desirable to develop, but until the problem of separating the drifting snow from the falling snow is much nearer solution than at present it will not be practicable to put such mechanism into successful operation.

#### NEW METHODS OF PUBLICATION.

With a view to consolidating and unifying the climatological data of the Weather Bureau for their more convenient use by agriculturists, transportation companies, and engineers engaged in the conservation of water resources, and for a study of certain forest problems, it has

been thought proper to remodel the system of publications in the following manner, beginning with July, 1909:

The United States has been divided into 12 large districts, each one covering a natural drainage area as determined by the topographical divides, and these will be made the units of publication. The section directors will contribute their quota to the several divisions, and division editors have been charged with preparing data for publication. Each district will prepare a general summary of the climatic conditions and a series of tables, giving the general climatology for the month, the daily precipitation at a large number of stations, and the maximum and minimum temperatures at a number of selected stations. Two charts, one showing the distribution of the monthly precipitation and the other the temperature changes, will accompany the summary and tables. The division editor will forward the copy to the central office in Washington, where it will be finally edited and printed and incorporated in the *Monthly Weather Review*. This *Review* will contain the usual data for the River and Flood Service and the Forecast and Storm Warning Service, and such strictly climatological articles as may be assigned to it. It may be that the five bureaus associated with the Weather Bureau will make suitable monthly contributions, showing the relation of the climatological and meteorological data to their practical uses from the point of view of the engineer, the forester, and the agriculturist.

The prospective development of the subject of the conservation of the natural resources of the United States, whether of soils, water power, navigation, or forests, would seem to call for some general journal representing the mutual interests that exist between these branches of the Federal Government. Since temperature and precipitation form the two essential features of climate and since the records of the Weather Bureau form an invaluable basis upon which to build scientific and practical studies, it would seem natural that the *Monthly Weather Review* should attempt to cover this field of usefulness. The more strictly scientific papers in the interests of meteorology will be printed in the quarterly bulletin of the Mount Weather Observatory, or in separate form.

The editing of the *Monthly Weather Review* has been transferred to the Climatological Division and it will be amalgamated with the monthly section climatological reports. The Annual Report of the Chief of Bureau will receive some slight modifications, so as to avoid duplicate publication of climatological data.

#### MARINE DIVISION.

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

Twenty-three Weather Bureau stations act as marine centers in the furtherance of this work. All but two have been supplied with a standard marine barometer, model shelter, and thermometers for exhibition and for use in making comparisons with ships' instruments. Upon their arrival at any of these centers, or at any foreign port, vessels are requested to furnish comparative readings of their barometers in order that the proper correction may be furnished.

Marine forms, cloud and ocean charts, pamphlets of instructions, etc., are kept on hand at the marine centers and the American consu-

lates for filling requests from cooperating observers. Under an arrangement with the State Department, 95 American consulates receive marine forms and forward them to Washington with their official mail.

During the last fiscal year 2,201 vessels of all nationalities cooperated with the Bureau, reporting pressure, temperature, wind, and other meteorological data. The data thus obtained are used in the preparation of the monthly pilot charts issued by the Hydrographic Office and the meteorological charts issued by the Weather Bureau.

To increase interest in this work, the Bureau has published a calendar for the use of mariners, which it furnishes to the captains of cooperating vessels, in addition to the usual supply of ocean and cloud charts.

#### DAILY SYNOPTIC CHARTS.

The data placed on these charts are used in determining the storm tracks and in the preparation of the statement of average conditions of wind and weather that appear monthly on the pilot and meteorological charts. Each monthly chart for the North Atlantic Ocean is based on an average of 3,150 reports, and that for the Pacific on 1,020 reports.

#### PILOT CHARTS OF THE OCEANS.

The revision of the meteorological data for the pilot chart of the North Atlantic Ocean, for the Hydrographic Office, has been completed. The chart contains pressure normals covering a period of eighteen years, and temperature normals and wind rose data for twenty-five years, all based on a large number of observations for each 5-degree square of latitude and longitude. Averages of the direction and force of the wind and the percentage of gales and calms cover a period of twenty-five years.

The revision of the meteorological data for the North Pacific Ocean Pilot Chart, for the Hydrographic Office, has been completed, giving new normals of pressure and temperature, wind rose data, averages of the direction and force of the wind, and the percentage of gales and calms for periods of twenty to twenty-five years.

Beginning with the winter season, June, July, and August, a chart for the South Atlantic Ocean, giving the prevailing winds, calms, trade-wind limits, and percentage of gales, together with an inset chart of normal pressure and temperature, was furnished to the Hydrographic Office for publication on the Pilot Chart. The data are furnished forty days in advance of the date on which the chart is issued. This is the first publication of the Pilot Chart of the South Atlantic since the last issue of Lieutenant Maury's chart in 1859.

At the request of the Hydrographic Office, the compilation of the meteorological data for publication on the Pilot Chart for the South Pacific Ocean was taken up, and has been so far advanced that the data will be published for the summer season, December, January, and February. This will mark the resumption of the South Pacific Pilot Chart, not published since the last issue of Lieutenant Maury's chart in 1859.

Some of the data for the Indian Ocean are entered on the charts for the South Atlantic and some on those for the South Pacific. All meteorological reports received from vessels sailing this ocean are

sent every six months to the meteorological office, Simla, India, where they are copied and then returned to this office.

#### FOG.

The revision of the entire fog data for the North Atlantic chart has recently been completed. The necessity for this revision was emphasized by Mr. James White, geographer, department of the interior, Ottawa, Canada, in his request for data relating to the northern route to Europe and the central fog banks of Newfoundland. Mr. White has been furnished with a complete set of fog charts, for which acknowledgment has been made.

#### METEOROLOGICAL CHARTS OF THE OCEANS.

To meet the demands of vessel captains and others interested meteorological charts of the North Atlantic, North Pacific, and South Atlantic oceans have been published, showing pressure and temperature normals, trade-wind limits, storm tracks, percentage of gales and fogs, prevailing winds and calms, and average conditions of wind and weather over each ocean. The storm-warning signals used by all the countries of the world, symbols showing the wireless telegraph and life-saving stations, and much other information of value to seafaring people also appear on the charts. The first issue of 3,000 North Atlantic, 1,500 North Pacific, and 1,000 South Atlantic charts fell short of the demand from marine stations, American consuls, vessel captains, and others, so the next issue was increased to 5,000 North Atlantic, 2,500 North Pacific, and 2,000 South Atlantic charts.

#### WIRELESS TELEGRAPH SERVICE.

Reports of marine observations by wireless telegraph service have been discontinued on the Atlantic. The work has been taken up by the Weather Bureau officials at San Francisco, Cal., and Portland, Oreg., but trouble has been experienced in utilizing these observations on the Pacific coast, on account of the short distance that messages can be sent.

The Weather Bureau official in charge at San Francisco has made arrangements with the Toyo Kisen Kaisha Company, and also with the United States army transports plying between San Francisco and the Philippines, for regular messages. The messages are handled by the United Wireless Company and the naval wireless land stations and delivered without cost. Wireless reports are also received from the steamers of the Matson Navigation Company. These reports are utilized at San Francisco in connection with the forecast work. The Weather Bureau official at Portland, Oreg., has arranged with the manager of the Marine Transportation Company and with vessels of other companies plying between Portland, Seattle, and Alaska, to have wireless messages sent to his station. These reports are received at Cordova or Katalla, Alaska, and transmitted by cable by the wireless telegraph companies free of charge, thus enabling the Portland official to get the reports when the vessels are farther up the coast. During the last fiscal year 177 reports were made, but only 29 were received in time to be utilized in the forecast work at Portland.

## VESSEL-REPORTING SERVICE.

In addition to their meteorological work, the stations at Block Island, Cape Henry, Jupiter, Sand Key, Southeast Farallon, and North Head are required to report all passing vessels, wrecks, marine disasters, and casualties, and to transmit communications between masters, owners, underwriters, and others interested. The stations at Cape Henry, Jupiter, and Sand Key are equipped for signaling by international code, and are prepared to transmit messages by telegraph. Sand Key can also receive messages by flashlight signal—Morse code. Each vessel-reporting station has a list of names of the vessels that belong to the various companies, and immediately upon sighting a vessel a message is sent to the owner and the Maritime Exchange.

At Cape Henry the office is kept open day and night. That station reported 18,093 vessels, received and delivered orders from 853 vessels, reported 17 wrecks, sent regular reports to 89 firms and 5 maritime exchanges, and other reports to 1,424 private individuals during the year. The pilot boats and other vessels off Cape Henry are notified of the noon hour each day by dropping the time flag, similar to the dropping of a regular time ball, the time being sent by the Western Union to the office. This attention is much appreciated by tugboats and other vessels off the capes.

During the year Jupiter sent 586 messages, North Head 1,890, Point Reyes 902, Southeast Farallon 193, Sand Key 1,594, Tatoosh Island 1,664, and Port Crescent 176; in all, including the Cape Henry service, a total of 25,220 messages. In connection with this enormous service only one complaint was received, and upon investigation the official charged with blame was entirely exonerated.

## LIBRARY.

Through the addition of 1,061 books and pamphlets to the library during the fiscal year the total number has reached about 29,000. Important accessions include an extra file of the *Meteorologische Zeitschrift*, 1884–1908, and a file of the *Bulletin of the Imperial Academy of Sciences of St. Petersburg*, volumes 6–25, inclusive.

A large number of purchases were made for the purpose of duplicating the more important works in the library in order to have copies available for lending to stations.

A "Brief List of Meteorological Text-books and Reference Books" was prepared for publication by the librarian and issued toward the end of the year. This compilation was designed to guide the librarians of large general, scientific, and university libraries in the United States in selecting meteorological literature for their collections, and also to provide a ready means of complying with the many requests received by the Bureau from teachers, students, and others for the titles of books dealing with meteorology and its several branches.

The library has recently been made a depository for the printed catalogue cards of the Library of Congress for all publications on meteorology and climatology. Arrangements have also been made whereby surplus publications on these subjects received by the Library of Congress are turned over to the library of this Bureau.

## EXAMINATIONS FOR PROMOTION.

The total number of examination papers received during the year was 223, as compared with 236 during the preceding year. Following is the record in detail:

*Number of examination papers received.*

Subject.	1908.		1909.		Total.	Passed.	Failed.
	August.	November.	February.	May.			
English grammar.....	7	5	14	14	40	23	17
Arithmetic.....	3	7	14	12	36	29	7
Elementary meteorology.....	6	3	9	9	27	24	3
Algebra.....	2	1	8	11	22	22	0
Physics.....	4	4	3	8	19	15	4
Trigonometry.....	3	3	4	5	15	15	0
Essay writing.....	5	3	10	9	27	16	11
Astronomy.....	2	4	2	3	11	11	0
Plant physiology.....	3	4	3	6	16	16	0
Advanced meteorology.....	2	0	4	4	10	10	0
<b>Total.....</b>	<b>37</b>	<b>34</b>	<b>71</b>	<b>81</b>	<b>223</b>	<b>181</b>	<b>42</b>

The examination in English grammar has been put upon a more satisfactory basis by the adoption of a specified text-book as authoritative in rating papers. This action was taken in view of the diversity of opinion among grammarians on many points involved in this examination.

## STUDENTS FROM FOREIGN COUNTRIES.

In November, 1908, the governor of the State of Jalisco, Mexico, sent two young men to Washington to study general meteorology and Weather Bureau methods, preparatory to the establishment in his State of a climatological and forecast district cooperating with the general meteorological service of Mexico, and patterned after the climatological and forecast districts in the United States.

At about the same time the Mexican Government sent two young men from its Central Meteorological Observatory to Washington to study modern meteorology and its practical applications as exemplified in the work of the Weather Bureau, especially as applied to weather forecasting.

The immediate supervision of the meteorological education of these young men was assigned to one of the professors, who arranged a brief course in theoretical meteorology, consisting in part of lectures by himself and other members of the scientific staff, and in part of written work based on a course of reading suggested by him. In addition, the students were given access to the apparatus in the observatory and in the Instrument Division, to the manuscript weather maps in the Forecast Division, and to the meteorological literature and data in the library. Individual students also specialized on lines of work in which they were particularly interested.

Arrangements were also made for visits to the central offices of climatological and forecast districts and to the research observatory at Mount Weather, Va.

The students from Jalisco returned to Mexico after about six months of study. They have already entered upon the work of organizing a meteorological service for their State, and the governor of Jalisco has expressed himself as well pleased with the results of their visit to this country.

One of the students from the Mexican Central Observatory is now at the Mount Weather Observatory, and the other at the station at Burlington, Vt.

#### SCHOOL OF INSTRUCTION.

The work of instructing assistant observers at the central office was begun the 1st of November with a class of 10 young men, all of whom had passed the required civil-service examination and received probationary appointments.

The course of instruction includes the study of Station Regulations and the Weather Cipher Code; practicing typewriting and telegraphy; taking, recording, and telegraphing observations; preparation of meteorological forms; charting weather conditions as reported twice daily from all stations in the United States and Canada; care of meteorological instruments; and the various other duties performed at stations.

Of this class, one was transferred to another branch of the government service and the others were all qualified for station assignment by the 1st of April.

A second class of 9 probationary appointees was formed in March. Four are now ready for station assignment and the others will be ready within a few weeks.

Three Mexican students took most of the course of instruction with the first class.

At such times as it could be done without interfering with their regular work, 9 compositors of the Weather Bureau and 1 probationary appointee were instructed in translating cipher reports, casting chalk-plate weather maps, and the necessary knowledge of presswork in connection therewith. These men are now all thoroughly competent to do station printing.

#### DISTRIBUTING DIVISION.

The Distributing Division came into existence on July 1, 1908. It is charged with the general supervision of weather forecast and special-warning distribution, and has administrative control of the storm-warning display stations of the Bureau. With a few exceptions, it sees to the distribution of all weather maps, forecast cards, and meteorological forms. It has the custody and distribution of Weather Bureau publications and handles all newspaper clippings. The examination and correction of all meteorological forms, except those of the Marine Division, and the examination of station weather maps and forecast cards, also form a part of the duties of this division.

#### DISTRIBUTION OF WEATHER FORECASTS AND SPECIAL WARNINGS.

The daily weather forecasts are sent by telegraph or telephone at government expense to 2,370 places for redistribution by various

means; this number is slightly greater than at the close of the previous year. The distribution by telephone is now the most prompt and effective means employed. In a few States there has been a reduction in the number of telephone companies cooperating gratuitously in this work and in others an increase.

The following table gives in detail the number of forecasts and special warnings distributed in the various States and Territories of the United States.

*Distribution of daily forecasts and special warnings.*

State.	At government expense.			Without expense to United States by—				
	Forecast and special warnings.	Special warnings only.	Emergency warnings.	Mail.	Rural delivery.	Telephone.	Rail-road train service.	Rail-road telegraph.
Alabama.....	33	3	139	1,106	416	4,715	0	96
Arizona.....	8	1	0	203	0	3,204	0	0
Arkansas.....	38	8	102	652	517	24,947	0	13
California.....	121	36	0	1,452	4,059	65,592	0	0
Colorado.....	18	61	39	1,410	1,682	21,400	0	0
Connecticut.....	16	0	49	1,389	50	61,269	141	0
Delaware.....	9	0	0	296	98	4,865	0	29
District of Columbia.....	0	0	0	1,488	0	10,000	0	2
Florida.....	36	113	32	1,056	263	7,406	0	58
Georgia.....	41	31	241	2,071	1,307	23,772	0	214
Idaho.....	19	0	0	710	360	14,542	0	0
Illinois.....	111	0	468	3,065	2,809	319,662	0	17
Indiana.....	115	1	208	2,201	1,620	148,611	0	66
Iowa.....	62	6	400	2,276	3,819	255,185	25	0
Kansas.....	100	1	186	1,337	2,440	126,328	0	15
Kentucky.....	43	32	96	1,693	788	67,289	0	1
Louisiana.....	77	24	61	632	328	17,197	0	16
Maine.....	16	1	40	1,070	877	12,764	0	0
Maryland.....	22	4	42	1,855	980	8,459	0	82
Massachusetts.....	23	12	63	3,173	210	8,650	78	0
Michigan.....	86	1	379	4,089	374	121,650	279	371
Minnesota.....	84	4	196	2,293	4,146	141,000	0	18
Mississippi.....	44	7	118	1,168	958	22,450	0	6
Missouri.....	45	0	240	3,384	2,121	244,705	0	26
Montana.....	11	21	18	480	0	10,424	0	0
Nebraska.....	84	1	221	1,103	408	113,846	0	0
Nevada.....	6	0	0	68	0	907	0	0
New Hampshire.....	20	0	34	902	1,429	2,352	15	0
New Jersey.....	30	18	45	1,198	0	21,762	0	187
New Mexico.....	11	1	0	74	0	4,451	0	17
New York.....	140	45	365	7,063	2,194	321,084	196	158
North Carolina.....	87	12	189	782	2,160	16,978	0	0
North Dakota.....	24	0	99	213	1,889	14,470	0	0
Ohio.....	100	192	312	6,568	1,384	458,644	24	26
Oklahoma.....	33	1	17	665	1,105	7,701	0	192
Oregon.....	10	0	0	500	183	11,456	0	0
Pennsylvania.....	86	11	367	3,918	1,718	154,878	1	499
Rhode Island.....	5	0	12	490	0	908	11	0
South Carolina.....	33	9	109	878	612	4,730	0	40
South Dakota.....	64	11	77	795	250	30,576	0	0
Tennessee.....	55	3	291	1,113	1,050	22,946	0	3
Texas.....	147	53	240	975	2,149	54,443	0	59
Utah.....	8	35	0	111	826	31,806	0	0
Vermont.....	16	0	46	489	701	13,857	12	8
Virginia.....	61	4	96	1,388	1,618	22,931	101	70
Washington.....	24	1	0	760	1,091	2,786	0	0
West Virginia.....	30	7	55	908	7	28,749	0	16
Wisconsin.....	112	7	298	2,520	2,208	51,391	0	0
Wyoming.....	6	4	8	125	0	8,751	0	0
Total.....	2,370	782	5,998	77,563	53,402	3,143,985	883	2,305

STORM-WARNING DISPLAY STATIONS.

Storm-warning display stations on the Atlantic, Pacific, and Gulf coasts and on the Great Lakes have been maintained at 318 places, so distributed as to serve best the needs of the marine interests. The

display of storm warnings has been discontinued at 18 stations, while this service has been established at 10 stations during the year.

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.	1	6	2	0
Baltimore, Md.	3	1	0	0
Block Island, R. I.	1	0	1	0
Boston, Mass.	23	8	3	4
Buffalo, N. Y.	11	2	1	0
Charleston, S. C.	5	1	1	0
Chicago, Ill.	25	1	0	0
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	0	1	0
Erie, Pa.	1	0	0	0
Escanaba, Mich.	2	0	1	0
Eureka, Cal. <sup>a</sup>	0	0	1	0
Galveston, Tex.	4	3	1	0
Grand Haven, Mich. <sup>a</sup>	0	0	1	0
Green Bay, Wis. <sup>a</sup>	0	0	1	0
Houghton, Mich.	2	2	1	0
Jacksonville, Fla.	6	4	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	0	1	0
Nantucket, Mass. <sup>a</sup>	0	0	1	0
New Haven, Conn.	2	0	1	0
New Orleans, La.	4	2	1	0
New York, N. Y.	5	7	1	3
Norfolk, Va.	6	2	4	2
Pensacola, Fla.	4	0	1	0
Philadelphia, Pa.	4	0	1	0
Port Huron, Mich.	4	1	1	0
Portland, Me.	3	4	1	0
Portland, Oreg.	7	4	7	0
Providence, R. I.	1	0	0	0
San Diego, Cal.	0	2	1	0
Sandusky, Ohio <sup>a</sup>	0	0	1	0
San Francisco, Cal.	2	6	4	5
San Juan, P. R.	0	0	0	2
Sault Ste. Marie, Mich.	5	0	1	0
Savannah, Ga.	4	2	1	0
Tampa, Fla.	3	2	1	0
Toledo, Ohio <sup>a</sup>	0	0	1	0
Wilmington, N. C.	3	2	1	0
Total	180	66	57	16

<sup>a</sup> Not centers.

The following table shows the number of publications received and distributed at the central office:

Title.	Received.	Distributed.
Annual Report of the Chief of the Weather Bureau	1,000	865
Annual Summary of the Monthly Weather Review	9,600	9,250
Bulletin of the Mount Weather Observatory	3,300	2,531
Monthly Weather Review	47,800	46,676
National Weather Bulletin	71,865	69,766
Snow and Ice Bulletin	22,225	21,375
Washington Weather Map	474,055	449,530
Special bulletins, etc.	7,500	5,358
Miscellaneous publications		3,928
Total	637,345	609,267

The nearly 4,000 miscellaneous publications distributed during the year represent the action taken upon as many or more letters of request received from various sources.

#### STATION PUBLICATIONS.

Daily weather maps are issued at 112 stations. At 33 stations the maps are printed, and at 79 are issued by duplicating process. The total number of maps issued during the year at all Weather Bureau map stations was about 10,500,000. The Boston station leads in the issue of weather maps, considerably more than a half million copies having been printed and distributed during the year, while Chicago and New York each printed and distributed more than 400,000.

Daily weather bulletins (Forms No. 1038—Met'l) were issued at 12 stations, the total annual output being about 125,000 copies. These bulletins are prepared by duplicating process.

#### TELEGRAPH DIVISION.

The Norfolk-Hatteras section of the Weather Bureau telegraph and telephone lines was maintained in good condition during the entire year, but frequent short interruptions occurred, due to leaks in the submarine cable between Nags Head and Manteo, N. C. In the vicinity of the Duns at Nags Head, lightning is usually very severe and has caused frequent trouble by burning out the lightning arresters, shattering poles, and on two or three occasions escaping into and rupturing the cables at Shallow Bag Bay and Oregon Inlet, North Carolina. A cable from the southern end of Roanoke Island to Chicamacomico, N. C., 20 miles in length, is urgently recommended. It would do away with the trouble that frequently occurs at Oregon Inlet, New Inlet, on the low flat beaches on Bodys Island, and in the vicinity of Nags Head. The new cable and 6 or 8 miles of land line would cost about \$25,000.

The Beaver Island section from Charlevoix to St. James, Mich., was interrupted in St. James Harbor, August 27, 1908, by the screw steamer *Fanny Hart*, of the Green Bay Transportation Company, accidentally fouling and breaking the submarine cable, which was repaired September 9, 1908, at a cost of \$37.

The Southeast Farallon-Point Reyes-San Francisco section has been out of order during the entire year, due to trouble in the submarine cable between Drakes Bay and the Southeast Farallon Island. The cable was first tested on August 7, 1908, and was underrun and tested from ten different places, several miles apart, between the above-mentioned points on March 14, 15, and 16, 1909. It was found defective at all of the ten places, due probably to earthquake ruptures and burrowing of teredoos. Deep water and sandy bottom can be secured all the way for a new cable from 2 or 3 miles north of Point Reyes, excepting the landing in the bight at Southeast Farallon Island, where for one-fourth of a mile rocky bottom will be found. It will cost about \$24,000 to put down a new cable between Southeast Farallon Island and Point Reyes Light. The land line from Point Reyes Light-House to Point Reyes, or Olema railroad station, is about 22 miles in length, and is in poor condition. The official in charge at San Francisco has been directed to report as to the cost of putting the line in first-class order.

The remaining sections of the Weather Bureau telegraph and telephone lines conducted business with little or no interruption, and at small expense for repairs.

#### PUBLICATIONS DIVISION.

The printing of the Washington Daily Weather Maps, Monthly Weather Reviews, Weekly and Monthly National Weather Bulletins, Snow and Ice Bulletins, and the Bulletin of the Mount Weather Observatory has continued during the year. The distribution of the various publications was transferred to the Distributing Division.

Forms, maps, and forecast cards have been supplied to all stations.

The publication of meteorological charts of the oceans was begun, and the Weekly Weather Bulletin, which had been discontinued at the close of the season of 1908, was resumed on May 18, 1909.

The mechanical equipment was enlarged by the addition of a Harris press and a folding machine.

For use in disseminating forecasts there were printed:

Station maps .....	10, 025, 000
Forecast cards.....	21, 978, 316
Rural delivery slips.....	4, 547, 250
Total .....	36, 550, 566

The following statement shows the amount of work done:

	No. of copies.
Monthly Weather Review, May, 1908, to March, 1909, inclusive, and the Annual Summary, 1908.....	57, 175
Bulletin of the Mount Weather Observatory, Nos. 3 and 4, 1908, and No. 1, 1909.....	3, 300
Maps DD and E for station use.....	7, 803, 900
Forecast cards for stations.....	21, 978, 316
Rural delivery slips.....	4, 547, 250
Blank forms for office and station use.....	4, 139, 640
Miscellaneous work.....	960, 071
Daily River Stages, Part VIII (completed during the year).....	500

The following shows the work of the lithograph presses:

Daily weather maps.....	472, 695
Charts for the Monthly Weather Review.....	424, 960
Ocean charts.....	15, 080
Snow and ice bulletins.....	22, 225
National weather bulletins.....	67, 075
Manifold maps.....	19, 460
Maps A for station use.....	50, 335
Miscellaneous charts and forms.....	91, 040
Charts for the Forest Service.....	79, 990

In addition to the above, 2,225,000 Maps DD and E were printed at the office of the Public Printer.

#### DIVISION OF SUPPLIES.

To the usual routine work of the division there was added the issuing of our own bills of lading, except in a few special cases, for all freight shipments of the Bureau, both from Washington and from stations. Prior to the adoption of this method, all bills of lading were issued by the Quartermaster's Department. The change has resulted in expediting shipments two or more days in every instance.

Economy in the purchase of the necessary supplies, without impairment of standard quality, has been kept constantly in view. Material

reductions in the prices of duplicating ink and stencil paper for the coming year have been among the results.

Greater security of our stock of supplies from interference by unauthorized persons was effected by closing the aisles in the main store-rooms with strong wire mesh work fitted with collapsible iron doors or mesh-work sliding doors, that are kept locked during the absence of the storekeeper or his assistant.

#### OBSERVATORY BUILDINGS.

The appropriation bill for the fiscal year 1909 authorized the completion of the cottage and office building and the physical laboratory building at Mount Weather, Va., the erection of a main observatory building to replace the building that was destroyed by fire on October 23, 1907, and the construction of a central heating and power station. The cottage and office building was completed in the latter part of September, 1908, and the physical laboratory building on March 1, 1909. The central heating plant was finished about December 15, 1908; a boiler, engine, and dynamo have been installed therein, and it is now in operation and is supplying all the heat and power required at Mount Weather.

The main observatory building is in course of erection and rapid progress is being made toward its completion. It is built mainly of brick, tile, and concrete, with a view of making it fireproof. Under the terms of the contract this building will be completed about March 1, 1910, but at the present rate of progress it is likely that it will be ready for occupancy at an earlier date.

The appropriation bill for the fiscal year 1909 also provided for the erection of seven observatory buildings, to be located outside of Washington, D. C., at a total cost of \$105,000. These buildings are now under way at Abilene, Tex., Canton, N. Y., Dodge City, Kans., East Lansing, Mich., Northfield, Vt., Richmond, Va., and St. Joseph, Mo., and it is expected that all of them will be completed and occupied not later than February 1, 1910.

The following table shows where the buildings owned by the Weather Bureau are located, and gives the cost of the buildings and grounds:

*Buildings owned by the Weather Bureau.*

Location.	Cost of ground.	Cost of buildings.	Total cost.
Abilene, Tex. ....	\$2,000.00	<sup>a</sup> \$12,879.81	\$14,879.81
Amarillo, Tex. ....	1,255.00	6,503.00	7,758.00
Anniston, Ala. ....	1,799.75	12,920.69	14,720.44
Atlantic City, N. J. ....	(b)	5,991.00	5,991.00
Bentonville, Ark. ....	500.00	5,119.90	5,619.90
Birmingham, Ala. ....	<sup>c</sup> 61.50	15,030.30	15,091.80
Bismarck, N. Dak. ....	(b)	10,085.99	10,085.99
Block Island, R. I. ....	1,034.50	7,068.25	8,102.75
Burlington, Vt. ....	<sup>c</sup> 20.00	10,043.50	10,063.50
Canton, N. Y. ....	<sup>c</sup> 1.35	<sup>a</sup> 13,955.82	13,957.17
Cape Henry, Va. ....		9,222.45	9,222.45
Charles City, Iowa. ....	3,036.75	9,338.47	12,375.22
Columbia, S. C. ....	3,799.00	9,165.00	12,964.00
Dodge City, Kans. ....	2,209.05	7,431.50	9,640.55
Devils Lake, N. Dak. ....	2,050.00	<sup>a</sup> 10,811.89	12,861.89
Dodge City, Kans. ....	2,041.70	7,430.08	9,471.78
Duluth, Minn. ....	<sup>c</sup> 11.35	<sup>a</sup> 12,778.14	12,789.49
East Lansing, Mich. ....	<sup>b</sup> 217.00	4,889.75	5,106.75
Hatteras, N. C. ....		5,087.08	5,087.08
Havre, Mont. ....	1,795.00		

<sup>a</sup> Not completed.

<sup>b</sup> Government reservation.

<sup>c</sup> Donated; figures represent cost of title transfer.

<sup>d</sup> Additional ground purchased.

*Buildings owned by the Weather Bureau—Continued.*

Location.	Cost of ground.	Cost of buildings.	Total cost.
Lola, Kans.....	\$2,241.25	\$9,730.94	\$11,972.19
Jupiter, Fla.....	(a)	6,346.00	6,346.00
Key West, Fla.....	2,020.00	7,994.75	10,014.75
Kittyhawk, N. C.....	(a)	1,616.00	1,616.00
La Crosse, Wis.....	3,523.50	12,276.24	15,799.74
Modena, Utah.....	(a)	4,346.00	4,346.00
Mount Weather, Va.:			
Administration building.....	1,863.15	b 48,035.26	49,898.41
Machine shop and balloon shed.....	650.00	8,107.00	8,817.00
Central heating and power plant.....	(a)	11,964.74	11,964.74
Absolute building.....	(a)	7,000.00	7,000.00
Variation building.....	(a)	8,904.55	8,904.55
Stable.....	(a)	1,900.00	1,900.00
Barn.....	(a)	900.00	900.00
Cottage for workmen.....	(a)	1,300.00	1,300.00
Physical laboratory.....	(a)	37,521.51	37,521.51
Cottage and office.....	(a)	11,246.34	11,246.34
(c)		4,728.53	4,728.53
Nantucket, Mass.....		8,036.50	12,188.25
Narragansett Pier, R. I.....	4,151.75	8,036.50	12,188.25
Northfield, Vt.....	d 101.00	e 12,705.64	12,806.64
North Head, Wash.....	(a)	3,820.13	3,820.13
North Platte, Nebr.....	(c)	3,818.50	3,818.50
Oklahoma, Okla.....	d 38.00	10,520.25	10,559.15
Peoria, Ill.....	d 54.00	7,875.50	7,929.50
Point Reyes Light, Cal.....	(a)	2,875.00	2,875.00
Port Crescent, Wash.....	102.00	730.94	832.94
Richmond, Va.....	d 8.75	e 15,237.05	15,245.80
St. Joseph, Mo.....	5,040.95	e 16,792.40	21,833.35
Sand Key, Fla.....	(a)	5,593.00	5,593.00
Saulte Ste. Marie, Mich.....	(a)	2,994.12	2,994.12
Sheridan, Wyo.....	2,021.75	12,089.30	14,111.05
Southeast Farallon, Cal.....	(a)	5,211.22	5,211.22
Springfield, Ill.....	(a)	10,236.50	10,236.50
Tatoosh Island, Wash.....	(a)	5,000.00	5,000.00
Washington, D. C.....	(e)	174,950.79	174,950.79
Yellowstone Park, Wyo.....	(a)	11,156.00	11,156.00
Yuma, Ariz.....	(a)	1,500.00	1,500.00
Total.....	43,648.95	672,074.88	715,723.83

- a Government reservation.
- b Estimated; not completed.
- c Building and ground purchased as a whole.
- d Donated; figures represent cost of title transfer.
- e Not completed.

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

Station.	Annual rent.	Other items included.
Alpena, Mich.....	\$650	Heat, light, water.
Brawley, Cal.....	300	Water.
Clallam Bay, Wash.....	120	Do.
Del Rio, Tex.....	444	Heat, light, water.
Durango, Colo.....	318	Water.
Flagstaff, Ariz.....	420	
Helena, Mont.....	504	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, and the trimming and care of all trees on the premises.
Kallspoll, Mont.....	360	
Lewiston, Idaho.....	540	
Manteo, N. C.....	144	
Moorhead, Minn.....	600	Heat, light, water.
Mount Tamalpais, Cal.....	420	Heat, light, water, and free transportation of Government employees and supplies.
Pysh, 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.....	10,668	

## PERSONNEL OF THE BUREAU.

The total numerical strength of the Bureau at the close of the fiscal year under consideration was 6,610, against 7,508 at the end of the year preceding. These figures include all classes of employees. The large reduction indicated is due almost entirely to a decrease of more than 1,000 in the number of weather correspondents, whose cooperative services were dispensed with following the discontinuance of the section weekly weather bulletins. In nearly every other branch of work the number of employees was slightly increased.

An analysis of the statement that follows and a comparison of its figures with those for the previous year will show, it is believed, a satisfactory condition as regards the general character of the working force and the discipline of the service.

In the classified service of the Bureau there was a marked increase in the number of promotions over those for the year before, the excess amounting to 145. All promotions but 2 were made to the next higher grade. One of the exceptions was in filling the office of librarian, in which instance the only clerk having the necessary qualifications for the place was advanced from the \$1,400 to the \$2,000 grade, the latter salary being provided by law for the position. In the other case, the clerk was advanced two grades because of his assignment to an isolated station in the Southwest, where it was impossible for his family to accompany him, thus requiring him to maintain two establishments. There was 1 less permanent appointment, 7 fewer temporary appointments, and a decrease of 24 in the number of resignations. The increase of 7 in the number of removals for cause testifies to the maintenance of a high standard of official and moral conduct. Out of 101 probationary appointments during the year only 1 was dropped for unsatisfactory services at the end of the six months' trial period. A record of 42 voluntary resignations during the year, against 68 for the year preceding, signifies a state of general satisfaction on the part of the employees, this indication being further strengthened by the fact that the number of reinstatements was as great as in the preceding year of a larger number of resignations.

For the unclassified service the total of permanent and temporary appointments was slightly decreased, as compared with the previous year. This action has been in conformity with the policy of the Bureau to make up its force as far as possible from the classified lists.

In the distribution of the commissioned employees of the Bureau there has been an increase of 34 in the station force over the number for the preceding year. This has been brought about by the assignment of an additional man at a number of the larger cities where the press of work has become heavy, and by the taking up of new lines of investigation in the field, such as the evaporation experiments that are now being conducted in southern California. At a few stations it has been found possible to reduce the force by one employee, in order to help meet requirements at other places.

At the central office the number of commissioned employees is 14 greater than at the close of the previous year. This number, however, includes 9 student observers, who will be assigned to station duties at the end of their term of instruction. Changes in the duties of some

of the divisions at the central office have altered slightly the number of employees, but in most of the divisions the force has remained much the same, in spite of the gradual increase in the amount of work performed, due to the continued expansion of the Bureau in its various lines of service.

For the Bureau as a whole there was an increase of a fraction of a day in the amount of absence due to sickness, as well as to annual leave, over the record for the year before, the average absence for each employee for both causes being slightly less than fifteen days. There were only 3 deaths among the commissioned employees during the year, as against 12 for the preceding twelve months.

## CHANGES IN THE FORCE OF THE BUREAU.

## CLASSIFIED SERVICE.

## Appointments:

## Probationary—

Printers, at \$1,000.....	7
Clerk, at \$1,000.....	1
Clerk, at \$900.....	1
Copyist, at \$840.....	1
Skilled artisans, at \$840.....	2
Assistant observers, at \$720.....	38
Repairmen, at \$720.....	2
Watchmen, at \$720.....	5
Folder and feeder, at \$630.....	1
Messenger, at \$600.....	1
Fireman, at \$600.....	1
Messenger boys, at \$450.....	6
Messenger boys, at \$360.....	35

101

## Transfer—

Printer, at \$1,000.....	1
Copyist, at \$840.....	1

2

## Reinstatement—

Assistant observers, at \$1,000.....	2
Assistant observers, at \$720.....	2
Messenger, at \$600.....	1
Messenger boy, at \$480.....	1

6

## Temporary—

Compositors, at \$1,250.....	2
Clerk, at \$900.....	1
Watchman, at \$720.....	1
Folder and feeder, at \$630.....	1
Messenger boys, at \$600.....	3
Messenger boys, at \$450.....	2
Messenger boys, at \$360.....	26
Architect and superintendent of construction, at \$180 a month.....	1
Evaporation observers, at \$5 a day.....	2
Evaporation observers, at \$2 a day.....	3

42

## Emergency—

Clerk, at \$1,000.....	1
Folders and feeders, at \$720.....	3
Folders and feeders, at \$630.....	2

6

Promotions (all promotions except 2 were to the next higher grade or by certification for advancement from subclerical positions) ----- 260

**Reductions:**

Causes—

To grant assignment to preferred station-----	2
Neglect of duty-----	3
Disobedience of instructions-----	1
Decreased efficiency due to increasing age-----	2
Unsatisfactory services-----	6
Unsatisfactory services and conduct-----	1
Failure to carry out agreement with the Bureau to settle a just account and unsatisfactory services-----	1
As an offset to the Bureau for allowance of quarters, fuel, and light-----	2
	<u>18</u>

**Resignations:**

Voluntary-----	42
Required because of—	
Unsatisfactory services-----	4
Unsatisfactory services and conduct-----	2
Absence without authority-----	1
	<u>49</u>

Transferred to another Bureau in the Department of Agriculture----- 1

**Removals:**

Causes—

Misconduct-----	2
Absence without authority-----	3
Intemperance and absence without authority-----	1
Drunkenness, disobedience of orders, and use of foul language--	1
Neglect of duty-----	2
Unsatisfactory services-----	1
Failure to answer official communication-----	1
Physical disability-----	1
	<u>12</u>

Dropped from the rolls at termination of probationary period because of unsatisfactory services----- 1

Deaths----- 2

UNCLASSIFIED SERVICE.

**Appointments:**

Permanent—

Unskilled laborer, at \$720-----	1
Student assistants, at \$300-----	5
	<u>6</u>

Temporary—

Student assistant, at \$300-----	1
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Promotions (each to the next higher grade)----- 6

**Resignations:**

Voluntary-----	4
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Death----- 1

## ABSENCE.

*Average number of days per employee during calendar year 1908.*

	Sickness.	Annual leave.
Station (99 per cent males).....	1.5	6.8
Washington, D. C.:		
Males.....	5.2	24.9
Females.....	6.1	26.5
Entire service.....	2.6	11.9

## 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, 1909.*

At Washington, D. C.:		
Classified.....	193	
Unclassified.....	11	204
Outside of Washington, D. C.:		
Classified.....	551	
Unclassified.....	17	568
Total commissioned employees.....		772
Additional employees outside of Washington, D. C.:		
Storm-warning displaymen.....	179	
River observers.....	400	
Cotton-region observers.....	143	
Corn and wheat region observers.....	184	
Rainfall observers.....	87	
Sugar and rice region observers.....	9	
Special meteorological observers.....	22	
Special cranberry-marsh observers.....	2	
Mountain snowfall observers.....	167	
Total noncommissioned employees.....		1,143
Total paid employees.....		<sup>a</sup> 1,915
Persons serving without compensation (except through the distribution of government publications):		
Cooperative observers and correspondents (omitting 351 paid and 6 cooperative observers enumerated elsewhere).....	4,581	
Cooperative storm-warning displaymen.....	82	
Cooperative river observers.....	21	
Cooperative rainfall observers.....	11	
Total cooperatives.....		4,695
Total numerical strength.....		6,610

<sup>a</sup> This total embraces all paid persons connected with the Bureau on June 30, 1909, except 14 commissioned employees absent on that date and who had been granted leaves of absence or furloughs without pay for one month or more.

*Distribution of the commissioned force, June 30, 1909.*

In Washington, D. C.:	
Accounts Division.....	<sup>a</sup> 14
Climatological Division.....	15
Distributing Division.....	12
Executive branch.....	<sup>a</sup> 17
Forecast Division.....	8
Instrument Division.....	10
Library.....	4
Marine Division.....	14
Observatory.....	10
Publications Division.....	36
River and Flood Service.....	2
Supplies Division.....	9
Telegraph Division.....	11
Verification Section.....	<sup>b</sup> 2
Drafting room (under direction of the chief clerk).....	3
Heat, light, and power plant (under direction of the chief clerk).....	<sup>c</sup> 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).....	20
<b>Total</b> .....	<b>204</b>
Outside of Washington, D. C.:	
58 stations with 1 commissioned employee.....	58
51 stations with 2 commissioned employees.....	102
41 stations with 3 commissioned employees.....	123
20 stations with 4 commissioned employees.....	80
12 stations with 5 commissioned employees.....	60
7 stations with 6 commissioned employees.....	42
4 stations with 7 commissioned employees.....	28
2 stations with 8 commissioned employees.....	16
2 stations with 9 commissioned employees.....	18
3 stations with 10 commissioned employees.....	30
1 station with 17 commissioned employees.....	17
<b>201 stations</b> .....	<b><sup>d</sup>574</b>

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 4 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.

<sup>a</sup> One employee devotes a portion of his time at one of the map stations at the United States Capitol.

<sup>b</sup> Heretofore assigned as part of the Forecast Division.

<sup>c</sup> Heretofore assigned as part of the Publications Division.

<sup>d</sup> This represents the normal station force. On June 30, 1909, there were actually on duty 568 employees.

*Salaries paid in the commissioned grades.*

Grades.	June 30, 1909.	
	Stations.	Washington, D. C.
<b>Classified grades:</b>		
Highest salary .....	\$3,000	\$5,000
Lowest salary .....	360	450
Average salary .....	1,041	1,149
<b>Unclassified grades:</b>		
Highest salary .....	720	720
Lowest salary .....	240	240
Average salary .....	374	496

Average salary of all (station and Washington) is \$1,046.

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