ANNUAL REPORT BY WILLIS L. MOORE, CHIEF OF THE WEATHER BUREAU, FOR THE FISCAL YEAR ENDING JUNE 30, 1908.

[Dated September 28. Extract from the report of the Secretary of Agriculture for 1908.]

I have the honor to submit a report of the operations of the Weather Bureau during the fiscal year that ended June 30, 1908.

RESEARCH AT MOUNT WEATHER.

As stated in my last report, the administration building was totally destroyed by fire October 23, 1907. The destruction of the living quarters made it imperative to shelter the employees in such places as could be temporarily adapted to living purposes. Accordingly, portions of the farm cottage, hitherto occupied by the laborers, and of the power house, the barn, and the stable were utilized for sleeping, eating, and cooking purposes. With one exception, these buildings were not suitable for living quarters, especially during the inclement weather that prevails at Mount Weather in the winter season. Notwithstanding this fact, the work of the observatory was carried on without complaint and with no material curtailment. Under the circumstances, however, it was impossible to enlarge the scope of the work.

The activities of the year may be classified under the following heads:

DAILY METEOROLOGICAL OBSERVATIONS.

Regular twice-daily observations of pressure, temperature, humidity, wind, and weather were made. These observations were telegraphed to the Central Office in Washington for the use of the Forecast Division.

UPPER-AIR RESEARCH.

During the year that ended June 30, 1908, records of pressure and temperature were obtained daily, except Sunday, by means of kites and captive balloons. These records were computed for each day so as to show all peculiarities or changes in the temperature gradient or air currents, altitudes of clouds, depths of cloud and fog layers, and the highest points reached. The tabulated results, together with observations and conclusions deduced from them, have been published in the Bulletin of the Mount Weather Observatory. Two numbers of this publication have already appeared, the third is nearly thru the press, and the manuscript of the fourth is about ready for the printer. Daily upper-air data are also telegraphed to Washington for the Forecast Division.

The records are for the most part obtained by means of kites. On occasional days, when the wind is insufficient for kite flying, captive balloons are used. The mean altitude obtained during the year with captive balloons was 2,357 meters (7,732 feet). With the installation of the new kite reel, designed to carry 15,240 meters (50,000 feet) of wire and to run at rates of speed varying from 0.45 meter to 4 meters per second (1 to 9 miles per hour), the observatory will be well equipped for kite flying. The balloon ascensions during periods of very light winds are of great importance, in that they make the upper air records continuous. Their need will justify the equipment of the observatory with the means of making and repairing its own balloons, and with a gasometer suitable for storing the gas that has been used in an ascension. At present this gas is wasted, and the capacity of the gas plant is insufficient to permit the use of more than one balloon in an ascension, while two could often be used to great advantage.

The only records now obtained are those of temperature, pressure, and wind direction. Instruments have been ordered, however, which will record the relative humidity also, and plans are being made to secure a record of the wind velocities in the upper atmosphere and to make the kites and balloons a means of studying the electrical conditions obtaining at similar heights.

The observatory also cooperates with the International Commission of Aeronautics in its endeavor to secure on fixt days upper-air data for a number of stations in the Northern Hemisphere.

WORK OF MAGNETIC OBSERVATORY.

The work in terrestrial magnetism was interrupted and seriously set back by the burning of all its records in the fire that destroyed the main building. In beginning anew, advantage was taken of the opportunity to rearrange and improve the operation of the Wild magnetographs. In particular, the two horizontal intensity magnetographs of that type were oriented to register the east-west and north-south components of the horizontal intensity, as recommended by the international committee.

All of the magnetographs have now been provided with electromagnetic coils for determining their scale values at frequent intervals. These coils are of the types used on the magnetographs designed by Ad. Schmidt for the new magnetic observatory at Seddin.[1] The work of standardizing the magnetometer and the magnetographs has been taken up and the constants for the Wild magnetometer have been determined with sufficient accuracy for the current reduction of the absolute observations. More accurate determinations will result as the new apparatus just received is put into use and the number of observations increases. The temperature and distribution coefficients are being determined from the regular weekly observations, and a higher degree of accuracy will accrue from an increased number of observations.

The scale coefficients of the magnetographs have been accurately determined. Preparations are now being made to obtain the temperature coefficients of these instruments by subjecting them to artificial variations of temperature in an air bath, the temperature of which can be controlled automatically.

An account of the methods and the instruments used in these experiments and a summary of the results obtained are being prepared and will probably appear in the Bulletin of the Mount Weather Observatory.

The tabulation of the hourly values of the magnetic elements from the photographic records has been begun and will be carried forward to such a point that it will only require the application of the temperature correction to obtain the true values.

Action has been taken to secure from the magnetic observatories of the Coast Survey and from a number of foreign observatories data for the investigation of the time relation of the beginning of magnetic disturbances of the different places on the earth, from which it is hoped to obtain results that will throw light on the nature and mode of progression of those disturbances that are believed to proceed from the sun.

SOLAR PHYSICS.

The work in solar physics as conducted at the present time consists in the measurement of the amount and intensity of solar radiation, the degree of absorption of the earth's atmosphere, and the polarization of blue sky light, and in the determination, by means of these data and an empirical formula developed by Prof. H. H. Kimball, of the solar constant or the heat received at a point just outside of the earth's atmosphere. The instrumental equipment includes two Ångström pyrheliometers and a Pickering polarimeter, together with a storage battery, a mil-ammeter, and a rheostat. Values of the solar radiation are obtained, which, with other data, including the

[1] Zeitschrift für Instrumentenkunde, May, 1907, p. 137.

vapor pressure, may make it possible to compute the solar constant and, finally, the amount of absorption by the earth's atmosphere. The work is facilitated by the use of reduction tables and especially by the employment of a diagram that shows the air masses thru which the sun's rays pass at different hours of the day and for different declinations of the sun.

This work was begun at Mount Weather in September, 1907, and observations have been taken every day since, with the result that up to July 1, 1908, thirty determinations of the solar constant had been made. An extra pyrheliometer is used in making comparative readings to detect any changes that may be taking place in the constant of the station instrument. Readings with the Pickering polarimeter have been made on every day, but thus far these have not been reduced.

During the ensuing year it is planned to continue observations along the same lines as heretofore.

SOLAR RADIATION.

Atmospheric conditions of temperature, moisture, and sunshine may be said to control almost completely the growth of vegetation in general.

Observations of temperature and moisture have been made by meteorologists for many years, but measurements of solar radiation have been almost entirely restricted to laboratory investigations, and even then nothing has been attempted on a scale sufficiently comprehensive to show the radiation available during the entire day or during the growing season. Heretofore apparatus capable of giving in reliable form the data required have not been available, and instruments designed to meet the requirements can be used successfully only by observers of exceptional training.

An instrument that promises to give good results and which records continuously the total radiation received from the sky, as well as from the disk of the sun when not obscured, has been procured and will be tested by the Instrument Division to determine its reliability.

The records from this instrument will show day by day the total radiant energy upon each unit of area of the surface of the earth, and such data summarized for different regions should be of value when used in connection with studies of the growth and development of plant life.

SOLAR CONSTANT.

A phase of this problem of the measurement of solar radiation has been the subject of several years' study by Professor Kimball—namely, the determination of the total heat that reaches the outside limits of the earth's atmosphere. It is only within recent years that scientists have been able to demonstrate that the solar radiation is variable. One outcome of the studies conducted at the Weather Bureau has been to make plain the errors of the apparatus heretofore employed in these investigations. At the suggestion of Professor Marvin arrangements have been made to use a special type of electrical pyrheliometer, with which it is hoped to attain greater accuracy and to avoid the deterioration with age that is characteristic of the older apparatus.

STUDY OF APPARATUS.

In July, 1907, a series of comparative readings was obtained from the Ångström pyheliometer and the Smithsonian actinometer. In December following two additional instruments were received from Ångström, the constants to one of which he had determined with care, and in accordance with his suggestion this instrument has been preserved as a standard. In February, 1908, a second series of comparative readings from Ångström and Smithsonian instruments was obtained, and the fact established that the reduction factors for Ångström pyrheliometers change slowly with age. Effort has been made to obtain an instrument not subject to these changes, and an order has been placed for a new pyrheliometer, the essential features of which have been suggested by Professor Marvin.

At present eye readings of the pyrheliometer are made at frequent intervals whenever the sky is free from clouds, and the data obtained are tabulated, so as to show the relative amounts of solar radiation received at different seasons of the year and in different years. It is not possible by this method to obtain continuous records of the quantity of solar radiation received under all sorts of atmospheric conditions. A Callendar recorder, designed for use in connection with a special form of pyrheliometer, is now being tested, and it is hoped that with it the desired continuity of records may be obtained. In its present form the instrument records the radiation received from the entire sky.

NEW FORMULA FOR COMPUTING THE SOLAR CONSTANT.

An equation has been developed by means of which the atmospheric transmissibility for solar energy of different wavelengths may be computed with reasonable accuracy from pyrheliometric observations, most conveniently from observations with the sun from 20° to 30° above the horizon, provided the water-vapor content of the atmosphere at the same time is also known. This formula has been applied to pyrheliometric observations obtained at Washington on 69 different occasions between December 22, 1905, and June 30, 1908, and to observations obtained at Mount Weather on 26 different occasions between September 21, 1907, and June 30, 1908. The mean value of the solar constant as computed for both stations is in close agreement with the mean value obtained by Abbot on Mount Wilson in 1905 and 1906.

The results of instrumental comparisons, the reduced pyrheliometer observations, and the computed values of the solar constant have been published in the Bulletin of the Mount Weather Observatory, Vol. I, parts 2 and 4.

Considerable discrepancies exist in the values of the solar constant computed from observations on different days, and even from observations at Mount Weather and at Washington on the same day. In most cases these are traceable to the unsteadiness of the atmosphere. The formula employed, in common with all formulas with which we are familiar, assumes that atmospheric conditions are uniform during the period of observation, which usually lasts two hours. Such conditions probably do not occur in the eastern part of the United States more than ten or twelve times during the course of the year, and almost never during the summer months. It is therefore hoped that, if the new apparatus ordered proves satisfactory, arrangements can be made to obtain observations at some point in the arid Southwest, where it is believed favorable conditions prevail on a majority of the days thruout the year.

The headquarters for solar radiation investigations were transferred from the Central Office to Mount Weather, Va., on July 1, 1908.

UPPER-AIR OBSERVATIONS AND WEATHER FORECASTS.

In previous years upper-air observations for the study of the forecaster were telegraphed from Mount Weather to Washington at irregular intervals. During the year that ended June 30, 1908, they were telegraphed daily. The character and special value of these observations in their application to practical weather forecasting and the manner of utilizing them are illustrated by the following extracts from the general forecasts issued at Washington:

May 1, 1908.—The cold weather of the last few days has reached its climax, and will doubtless be followed within the next few days by considerably higher temperatures east of the Mississippi. The kite observations to-day at Mount Weather at an elevation of about a mile above the station showed a temperature of only 10° above zero, or a fall of 25° in the last twenty-four hours. This would seem to indicate a slow rise on the surface during the next twenty-four hours.

May 6, 1908.—Since the beginning of the present rainy spell it has been impossible to get the kites at Mount Weather more than 3,200 feet above the mountain, thus indicating the existence at that level of a considerable stratum of calm or light winds and a temporary suspension of the characteristic west-east movement of the upper air in these latitudes. This is the probable explanation of the failure of the Mississippi Valley storm to advance eastward. To-night's reports show, however, a well-developed storm center in southern Indiana, with a tendency to move northeastward by way of the St. Lawrence Valley. Should it move as indicated, the great cloud blanket that has covered the country east of the Mississippi since Monday last will be lifted by Friday morning, and higher temperatures will prevail.

May 18, 1908.—The kite flights at Mount Weather during the last few days have reached only small elevations above the mountains, thus indicating, as on a previous occasion during the month, the existence of a considerable stratum of calm or light winds about 2,000 feet above the mountains, thru which the kites can not pass. The surface winds in both cases were from the east.

A return of the stagnant conditions that prevailed during the latter half of May was noted on June 3. In each instance unsettled and rainy weather was experienced over the eastern portion of the country and the surface winds were from the eastern quadrants.

June 15, 1908.—The kite flight at Mount Weather to-day reached an altitude of nearly 2 miles above the station, at which elevation the temperature was 31°, while at the surface it was 65°. High northwest winds and heavy rain followed the flight.

The rains and cooler weather that reached the Atlantic States on this date were in accord with a forecast issued June 9.

June 22, 1908.—To-day the kite at Mount Weather past thru a warm warm stratum of air at an elevation of 1,500 feet above the station, where the temperature was 75°, or 7° higher than at the surface. The warm air did not extend much above 1,500 feet, and from that elevation up to 5,700 feet above the station the temperature fell 15°.

On this date a warm wave covered the country east of the Mississippi. On the following date, June 23, there was not sufficient wind to fly a kite and it became necessary to use a captive balloon. The latter showed an almost uniform decrease in temperature from 84° at the surface to 61° at an elevation of 7,800 feet.

June 20, 1908.—During the kite flight at Mount Weather to-day an altitude of 16,300 feet was reached, at which elevation the temperature was 20°, while at the surface it was 74°, with westerly winds.

The weather map to-night is of the hot-weather type—high pressure in the southeast and low over the north and northwest. As a consequence temperatures are much above the seasonal average over the entire country east of the Rocky Mountains, except where local thunderstorms have afforded temporary relief.

July 3, 1908.—The vigorous circulation of the air in the higher levels above Mount Weather that characterized the closing days of June has now given way to stagnant conditions that make it necessary to use captive balloons instead of kites in sounding the air. The ascension to-day showed a uniform fall in temperature from 76° at the surface to 58° at an altitude of 6,400 feet above sea-level.

July 15, 1908.—The kite flights on Mount Weather to-day showed, as on a previous occasion under similar conditions, a marked temperature inversion about 1,500 feet above the earth's surface. At that level it would seem that nocturnal radiation is not effective in lowering the night temperature as on the earth's surface.

The outlook is for slowly moderating temperature over the eastern half of the country during the next two days. There are no present indications of another period of excessive heat.

July 17, 1908.—Since the breaking up of the warm spell the upper air currents have been unusually active. On the 15th the kites at Mount Weather broke away in high winds at an elevation of 8,400 feet above sea-level. On the 16th an elevation of over 17,000 feet was reached, with brisk northwesterly winds and a temperature of 15° above zero. At the surface the temperature was 65°.

On July 22 a zone of light variable winds was again shown at an altitude of about 1,000 feet above the station, the first condition of this character observed in about ten days. A captive balloon that past thru the calm zone indicated the prevalence of westerly winds at an altitude of 1 mile above the station and a temperature of 57° as compared to 77° at the surface. As in previous cases noted, the presence of a stratum of light winds or calm at an elevation of 1,000 to 1,500 feet above the station attended generally unsettled and rainy weather over the eastern portion of the United States.

July 30, 1908.—Hitherto the kite flights at Mount Weather have uniformly shown that easterly winds over that region are quite shallow, none of them extending more than a mile above the mountain. On Thursday, for the first time, at an altitude of about 2 miles above the station, rather strong easterly winds were found, thus indicating a suspension of the ordinary west to east drift in these latitudes.

At this time a storm that had moved slowly northward from the subtropical region of the Atlantic was central near the North Carolina coast, with reported barometer 29.22 inches at Wilmington. The unusually strong and high drift of easterly winds referred to was doubtless due to the exceptional strength of the air currents in the northern quadrants of this storm. The high winds that followed the northward movement of the storm center carried away three kites at an altitude of more than 3 miles on August 1.

August 20, 1908.—The kite flights on the 18th, 19th, and 20th reached an altitude of about 3 miles above sea-level. The temperature at that height on the 18th was 30°, falling on the 19th to 28°, and on the 20th to 24°. The fall at the upper level was felt nearly forty-eight hours before it reached the surface.

August 27, 1908.—On the 25th the kites at Mount Weather past into a dense layer of cloud and fog, which enveloped the mountain and probably extended more than 6,000 feet above it. The air temperature at the upper level was nearly the same as at the surface. The winds were north-northeast at the surface, shifting to northeast aloft, such as would be required with a storm center off the south Atlantic coast.

Beginning August 23, a barometric depression had occupied the Gulf States, and on the 25th the center of disturbance was over the east Gulf States and the low area extended thence over the south Atlantic coast. To the north and northeast was an area of high barometer. This distribution of pressure extending over a two or three-day period caused a prolonged drift of northeasterly winds over the Middle Atlantic States, and, as shown by the Mount Weather observations, equalized temperatures in the air currents to an elevation of more than 6,000 feet. This was a period of exceptionally heavy rains that gradually extended from Georgia northward to New England.

The daily observations that have been secured during the past year at a nearly uniform altitude of about 1 mile above the Mount Weather station and the occasional surroundings of the atmosphere to much greater heights have been of particular interest to the forecaster. A study of data that have been obtained, and that will be secured by improved apparatus, will undoubtedly reveal elements of cause in the practically unexplored regions of the upper atmosphere that will account for many phases of weather and climate that observations taken at the surface of the earth do not indicate or presage.

FORECAST AND WARNINGS.

Attention has been given during the past year to isobaric charts based upon telegraphic reports received daily from selected stations thruout the Northern Hemisphere. Forecasts for periods of about a week in advance were begun experimentally, and during the last three months of the year they were prepared for publication. The following of these forecasts are presented for the reason that they dealt with notable abnormal conditions:

WASHINGTON, D. C., *Saturday, April 18, 1908.*

Forecast for the week beginning Sunday, April 19, 1908.

For the States of the Missouri, extreme upper Mississippi, and Red River of the North valleys, where little or no rain has fallen, a season of showery weather will be inaugurated by the middle of the week. In the Gulf States and lower Mississippi Valley the excessive rains of the past week will give way to a period of more settled weather.

Heavy showers set in over the north-central districts referred to during the night of Wednesday, April 22, and precipitation continued in that region during the following three or four days. In the South Central States the prolonged period of rain ended on the 21st.

The Cheyenne Tribune of May 4, 1908, had the following editorial concerning the forecast of May 2 for the following week:

The weather man down at Washington has made an excellent guess. Saturday he gave to the Associated Press the following:

"The rains of the week beginning Sunday, May 3, will cover the principal agricultural districts from Canada to the Gulf of Mexico. From May 3 to 5 an area of general rains will advance from the Pacific to the Atlantic coasts, reaching the Atlantic coast Monday night or Tuesday * * *."

The storm Cheyenne is now enjoying arrived very promptly on schedule, and is worth more to Laramie County than can be measured in dollars and cents. The precipitation is probably general over Wyoming.

The rains referred to broke a drought in Wyoming and eastern Colorado that was rapidly becoming serious.

On Monday, June 15, the following was issued:

The period of persistent heavy rains of the last two weeks that have caused destructive floods in the Middle Western States will end by Thursday. Temperature will rise in the Plains States and central valleys after Tuesday and the warmer weather will reach the Atlantic States about the close of the week. Next week will open warm over the eastern portion of the country.

The heavy rains of the Middle Western States practically ceased Thursday. Following the termination of the rain period the first well-defined warm wave of the season set in over interior districts and extended to the Atlantic coast by the close of the week. A forecast dealing especially with this warm wave was issued on the morning of Monday, the 22d:

The warm wave that now covers the country generally east of the Rocky Mountains will break over the Plains States Tuesday, over the Mississippi Valley and the western Lake region Wednesday, in the Ohio Valley and eastern Lake region Wednesday night, and in the Atlantic States Thursday. Local rains and thunderstorms will attend the advent of the cooler weather in the several sections named. Moderate temperature will be experienced over the eastern portion of the country during the closing days of the week.

This forecast, like preceding ones, was closely verified. The value of accurate forecasts for this period to agricultural and business interests can not be measured, and the success that has attended the experimental and published forecasts will justify this office in making weekly forecasts a regular feature of its work. Their inauguration will mark a most important advance in the practical application of meteorological science. Using as a basis of calculation isobaric lines of the Northern Hemisphere, forecasts may, on occasions, be safely made for periods greater than one week. The next advance in the art of forecasting will be marked by a still further extension of the forecast period.

All severe storms on the American coasts and lakes and severe cold waves and frosts that visited any portion of the United States during the year were successfully forecast. No important storms of tropical origin visited the United States coasts. The following dispatch from Kingston, Island of St. Vincent, British West Indies, dated September 20, 1907, indicates the character of disturbances that occur in that section during the prevalence of low barometric pressure over the tropical regions of the oceans:

Recent advices from the Weather Bureau at Washington were verified in a remarkable manner. A disturbance east of the Windward Islands, which had been announced as probable, developed yesterday into a thunderstorm of great severity. Exceedingly low thunder clouds hung over St. Vincent, and the lightning was fearfully vivid. Several casualties occurred. Similar storms have been experienced in the northern islands.

The association of upper-air observations made at Mount Weather with the practical work of weather forecasting is receiving special attention, and progress is being made in determining the relation of cause and effect that exists between conditions observed in the upper strata and certain types of normal and abnormal weather.

INSTRUMENTS.

For many years the operations of the Instrument Division have been governed by a fixt policy of slowly bringing the instrument equipment of all regular stations up to a certain uniform and high standard. This work was practically completed a year ago, as stated in my last annual report.

No new stations were established during the year closed June 30, 1908, and the ordinary resources of the Instrument Division thus became available for the betterment of station outfits that had been in service for many years.

Partial equipments consisting of barometers, thermometers, rain-gages, and shelters, have been issued to special observers at Greenville, Me.; Leadville, Colo.; Wallace, Idaho.; Jackson, Miss.; Sitka, Alaska, and Marshfield and Siskiyou, Oreg., from each of which daily telegraphic reports are rendered at the nominal compensation of $25 per month.

SEISMOGRAPH AND EARTHQUAKE RECORDS.

The seismographic records were constantly maintained during the year. A new instrument of high magnification (120 times), designed by Professor Marvin, was installed in November and has since been in successful operation. A detailed description of this seismograph was published in the MONTHLY WEATHER REVIEW for November, 1907.

In the latter part of the year a seismograph of European manufacture for recording vertical motion was purchased and temporarily installed. This instrument, however, is so seriously disturbed in its action by variations of temperature, air currents, etc., that its installation requires exceptional surroundings, which are not now available. It is hoped Congress will favor the extension of seismological work along the lines indicated in my last annual report. In the meantime these important studies are restricted to the simple maintenance of the daily records from the instruments now installed.

NEW WORK.

The work of inventing new apparatus to meet the ever-increasing demands of the Bureau may be summarized under the following items:

(1) *Chart and instrument kiosk.*—A suitable means of taking meteorological observations, especially of temperature and humidity, near the street levels, and thus representing more nearly the conditions experienced by pedestrians and the public generally, has long been needed. To meet this need it seemed practicable to expose instruments, accompanied by climatic charts, weather maps, and forecast cards, in a shelter of appropriate design, located at some favorable point or points in the business and news centers of every large city. Prof. C. F. Marvin, in charge of the Instrument Division, was instructed to work out the details of such a scheme. The problem involved not only the design for the kiosk itself, which must provide proper exposure for the instruments and charts and protect them from molestation, but also new instruments of a construction adapted to satisfy conditions. The instruments comprise special forms of maximum and minimum thermometers, air thermometer, hair hygrometer, thermograph, and a special type of tipping-bucket rain-gage with dial indicator. All of these have been successfully devised by Professor Marvin.

(2) *Recording hygrometers for stations.*—The moisture content of the air constitutes one of the most important meteorological elements requiring observation, yet its automatic registration in an accurate manner has thus far baffled the genius of inventors. An American manufacturer has made important improvements to an instrument for this purpose. A few have been tried at stations selected for the purpose of securing the most satisfactory tests. Gratifying results have been obtained, but a longer test is necessary.

(3) *Tele-thermoscopes.*—The local offices of the Weather Bureau in large cities are called upon by telephone or otherwise many times daily for temperature data, especially during periods of exceptional weather conditions, and for many years, a type of instrument has been in demand that would record or indicate in the main office room the true temperature outside. In the absence of such an instrument observers have been obliged to make frequent trips to the roof, which is often at a

considerable distance. Within the past year a type of apparatus capable of showing but not recording the air temperature has been introduced to meet these needs; it is of such a character that it gives promise of meeting the exacting requirements of the Bureau with regard to accuracy. The thermometer is a protected coil of wire, the electrical resistance of which varies with temperature. The indicator, which is located in the office, is a device that determines the electrical resistance of the coil and indicates the corresponding temperature. Ten of these instruments have been installed.

(4) *Automatic river-gages.*—Among the newer types of instruments that have been introduced in recent years, mention has been made in previous reports of automatic gages for recording or indicating river stages. The installation of one of these at Pittsburg was completed during the past year, and work was begun on the mounting of a similar gage at Cincinnati, Ohio, on the north pier of the Covington and Cincinnati suspension bridge. The introduction of this gage will give us what we have been unable to obtain heretofore, namely, the extreme flood stages of the river. The extreme range of the Ohio River at this points amounts practically to about 75 feet. The new gage will automatically indicate in the office of the observer, no matter what its distance from the river, all stages above 18 feet.

RIVER AND FLOOD SERVICE.

The months from February to June, inclusive, of the present year were characterized by frequent floods, some of them of grave character, taxing to the utmost the resources of the Weather Bureau to deal successfully with them.

The Ohio Valley was the chief sufferer, with floods of marked character during each of the four months from February to May, inclusive. The floods of May were not limited to the Ohio River, but extended thruout the entire Mississippi watershed above the mouth of the Ohio River. In the month of June general and destructive floods occurred over the same watershed, except the Ohio River portion, and the fortunate failure of the Ohio simultaneously to be in flood stage prevented the greatest flood in the history of the lower Mississippi River. As it was, the river at New Orleans reached a stage of 20 feet on June 19 and 22, only 0.4 foot below the great high-water stage of April 6 and 7, 1903. At the close of the year the river stood at 19.6 feet on the gage, having been above the flood stage continuously since March 9.

The most destructive floods of the year occurred in the Red and the lower Arkansas rivers and their tributaries in the State of Oklahoma, and in the Trinity and Brazos rivers of Texas, the losses in Texas alone amounting to not less than $5,000,000.

These floods were forecast with the same accuracy that attended those of former years, and in some instances with an exactness much beyond that ever before attained. Particular attention is invited to the work along the Red and lower Mississippi rivers, where the warnings, given in detail two weeks in advance, were so exact as to leave practically no percentage of error. Numerous newspaper editorials and several resolutions of thanks from representative bodies testified to the public appreciation of the work of the Weather Bureau.

With each succeeding year the development of agricultural operations and the extension of business interests, more or less dependent on river stages, necessitate some broadening of the field of activity of the River and Flood Service, and during the present year new work has been undertaken as follows:

(1) The establishment of a continuous flood-warning service, operating day and night in times of flood, in that portion of the State of West Virginia bordering on the Ohio River.

(2) The establishment of a new river district center at Binghamton, N. Y:, with territory comprising that portion of the watershed of the Susquehanna River at and above Binghamton. This territory was formerly a portion of the Harrisburg, Pa., district.

(3) The opening of new river stations in the watershed of the upper Cumberland River, in the interest of navigation and the lumber industries.

(4) The opening of several new stations at scattered places thruout the country, in order to secure increased efficiency in the flood-warning service.

Realizing the fact that the art of river forecasting is dependent upon the intelligent use of data of diverse kinds, and that the exigencies of the Weather Bureau service frequently render it impossible for officials in charge of river districts to systematize and preserve for future use their knowledge of the regimen of the rivers in their districts, the river and flood branch of the Central Office at Washington has begun, in cooperation with the district officials, an exhaustive study of the problem. The Ohio River and its principal tributaries as far south as Cincinnati, Ohio, have thus far been studied and the results in elaborate form have been transmitted to the officials in charge of the various districts for actual use in river forecasting. It is hoped that the scheme for the entire Ohio River, and possibly a portion of one for the Mississippi River, can be completed within another year. The work is necessarily slow, as it involves the discussion of a large amount of data.

The new field work contemplated during the coming year is largely suggested by the flood problems of the present year, as well as by requests for increased service from Members of Congress, citizens, corporations, and associations of various kinds. Should our resources permit, it is proposed to introduce flood-warning service along the Oklahoma tributaries of the Arkansas River, and to extend somewhat the present service on the Red and Neosho rivers, and possibly the upper Arkansas River. In connection with the latter project, it may become necessary to establish a new river district center at Wichita, Kans. Request has also been made for additional service along the upper Missouri River and its tributaries, and the matter will be given attention during the coming low-water season.

No definite suggestions can be made at this time regarding proposed work during the fiscal year ending June 30, 1910. It may be possible by that time to take up the question of river service over the Yukon River watershed in the interest of navigation, and also the expansion of the service that will be necessary on the Ohio and lower Mississippi rivers in order to meet the requirements of inland water transportation.

CLIMATOLOGICAL DIVISION.

During the year ended June 30, 1908, the Climatological Division was charged with (1) the collection and publication of climatological data, and (2) the distribution of forecasts and special warnings. Under the first-named heading may be classed:

(a) Cooperative stations, of which there are more than 3,700.

(b) Cotton, corn and wheat, and sugar and rice region stations, and the publication of the daily bulletins (Forms Nos. 1045 and 1046–Met'l) at district centers and other selected Weather Bureau stations for the period from April to October.

(c) The monthly and weekly publications of the several sections of the climatological service, including the monthly snowfall bulletins of the States of the Rocky Mountain and Plateau regions for the period from December to March.

(d) The preparation of the national weekly and monthly weather bulletins, and the weekly snow and ice bulletins issued during the winter months.

COOPERATIVE STATIONS.

At the close of the year there were 3,761 stations of this class in operation, an increase of 77 over the number in opera-

tion at the end of the preceding year. Most of the newly established stations are in the semiarid regions of the West, special efforts having been made to place stations at the higher altitudes of the drainage basins of the streams whose waters are used in irrigating. Two hundred and sixty-three cooperative stations, the majority of which were in the eastern portions of the country, were for various reasons discontinued. During the year 237 stations were visited by section directors for the purpose of inspection. The number of stations inspected was considerably greater than during the previous year.

COTTON, CORN AND WHEAT, AND SUGAR AND RICE REGION STATIONS.

The number of cotton region stations at the close of the year was 143, or 1 less than at the close of the preceding year, 2 stations having been discontinued and 1 established. There are 137 corn and wheat region stations, 4 more than at the close of the year ended on June 30, 1907, 7 having been established and 3 discontinued during the year of 1907–8.

CLIMATOLOGICAL PUBLICATIONS.

The publications of the 44 section centers of the climatological service have continued without change. The monthly reports of all the sections have been issued with promptness, the majority making their appearance before the 20th of the month succeeding that to which they pertain. With the installation of a number of additional printing plants, the number of sections having their reports printed by contract has been reduced to 2, namely, Idaho and Hawaii, against 7 at the close of the previous year. The average date of issue of the annual climatological reports was earlier than in the year before. The weekly weather bulletins issued during the crop-growing season have been regularly published by all the sections, including Porto Rico and Hawaii. A reduction in the edition of these bulletins is noted, the total number being more than 3,000 below that of the previous year.

The foregoing table shows for each section the number of cooperative observers, the number of weather correspondents, and the editions of the weekly weather bulletins and monthly climatological reports.

Cooperative observers, weather correspondents, and edition of climatological publications.

Section.	Number of—		Publications issued.	
	Cooperative observers.	Weather correspondents.	Weekly bulletins.	Monthly climatological reports.
Alabama	38	128	500	500
Alaska	45	0	0	0
Arizona	80	55	700	700
Arkansas	65	58	525	665
California	350	50	500	700
Colorado	95	42	300	700
Florida	60	75	750	475
Georgia	42	150	650	625
Hawaii	151	53	396	458
Idaho	65	76	600	450
Illinois	90	90	780	430
Indiana	58	140	650	725
Iowa	121	700	1,900	1,800
Kansas	93	91	1,500	1,250
Kentucky	39	39	350	325
Louisiana	42	75	450	700
Maryland and Delaware	51	60	300	325
Michigan	115	124	389	750
Minnesota	81	42	600	425
Mississippi	63	85	400	715
Missouri	78	110	368	381
Montana	81	85	600	600
Nebraska	140	404	760	585
Nevada	40	42	150	300
New England	150	55	350	700
New Jersey	51	55	400	325
New Mexico	78	70	450	870
New York	123	117	900	825
North Carolina	66	114	420	900
North Dakota	80	50	500	550
Ohio	96	109	650	575
Oklahoma	70	190	700	650
Oregon	93	93	300	540
Pennsylvania	87	65	320	600
Porto Rico	45	33	182	375
South Carolina	32	47	480	480
South Dakota	65	98	575	637
Tennessee	50	88	250	450
Texas	148	150	800	900
Utah	88	154	500	600
Virginia	54	94	325	950
Washington	85	45	600	850
West Virginia	55	65	900	500
Wisconsin	84	84	350	500
Wyoming	73	20	275	350
Yellowstone National Park	10	0	0	0
Total	3,761	4,570	24,345	27,661

DISTRIBUTION OF WEATHER FORECASTS AND SPECIAL WARNINGS.

Diligent efforts have been made to increase the distribution along all lines, but, as in the previous year, the principal part of this work has been directed toward the dissemination of forecasts thru the medium of the telephone companies, and they have responded almost unanimously to the invitation to cooperate for the benefit of their subscribers. During the year several States of the Middle West and on the Pacific slope were canvassed, and as a result a large number of telephone companies in those States are now cooperating with the Bureau in this important work.

Distribution of daily forecasts and special and emergency warnings.

State or Territory.	At Government expense.			Without expense to United States by—				
	Forecasts and special warnings.	Special warnings only.	Emergency warnings.	Mail.	Rural free delivery.	Telephone.	Railroad train service.	Railroad telegraph.
Alabama	33	2	139	1,124	661	4,715	0	96
Arizona	8	0	0	152	0	5,911	0	0
Arkansas	27	7	102	636	666	15,837	0	15
California	124	12	0	1,379	4,086	52,986	0	9
Colorado	19	60	39	896	1,748	32,830	0	0
Connecticut	16	0	49	1,401	50	71,292	181	0
Delaware	10	0	0	95	1,025	4,865	0	30
District of Columbia	0	0	0	1,419	0	5,700	0	1
Florida	30	131	32	1,068	268	5,329	0	58
Georgia	43	33	241	1,782	1,307	21,197	0	214
Idaho	23	0	0	533	255	13,559	0	0
Illinois	121	0	468	4,801	2,808	457,052	0	17
Indiana	114	1	208	2,117	1,935	154,279	0	76
Iowa	143	6	400	1,996	3,522	107,484	25	0
Kansas	87	1	186	1,266	1,915	202,415	0	15
Kentucky	40	34	96	1,648	720	25,038	0	1
Louisiana	36	36	61	680	340	2,224	0	9
Maine	16	1	40	1,009	877	12,146	0	0
Maryland	25	4	42	2,131	1,096	6,546	0	80
Massachusetts	23	10	63	3,262	210	8,950	77	0
Michigan	86	3	379	5,484	378	408,759	279	239
Minnesota	83	5	196	2,417	4,300	144,601	0	18
Mississippi	41	7	118	1,061	958	35,555	0	6
Missouri	37	0	240	3,318	2,231	306,329	0	26
Montana	13	19	18	441	50	10,311	0	0
Nebraska	82	2	221	1,170	406	155,465	0	0
Nevada	6	0	0	64	0	413	0	0
New Hampshire	20	0	34	794	1,429	2,285	14	0
New Jersey	30	18	45	1,218	0	7,215	0	195
New Mexico	8	0	0	125	0	5,361	0	17
New York	143	46	365	7,778	2,392	272,332	176	143
North Carolina	74	14	189	712	2,795	24,421	0	0
North Dakota	21	0	99	194	2,009	31,616	0	0
Ohio	100	96	312	6,378	1,474	500,909	24	26
Oklahoma	36	1	17	661	1,151	7,313	0	116
Oregon	11	0	0	482	435	5,457	0	0
Pennsylvania	78	11	367	4,088	1,718	153,210	1	534
Rhode Island	2	0	12	471	0	898	12	0
South Carolina	35	8	109	914	672	3,990	0	40
South Dakota	61	13	77	784	415	31,221	0	0
Tennessee	36	5	291	1,391	1,676	16,811	0	3
Texas	133	49	240	1,158	2,961	52,651	0	60
Utah	9	35	0	387	1,041	32,333	0	0
Vermont	16	0	46	471	466	10,428	12	8
Virginia	61	3	96	1,512	1,848	29,535	101	71
Washington	26	0	0	777	1,421	2,600	0	0
West Virginia	28	7	55	906	7	29,049	0	16
Wisconsin	116	7	298	2,542	2,296	54,809	0	0
Wyoming	5	3	8	111	0	6,835	0	0
Total	2,334	690	5,998	76,154	58,008	3,553,067	852	2,139

One of the largest telephone companies operating in the Southern States, which had heretofore declined to take up the work of distribution, has fallen into line and is now giving its subscribers the benefit of the daily forecasts, thru a

large number of exchanges, particularly in the States of Mississippi and Tennessee.

In the States of the Middle West the telephone is largely used for transmitting forecasts, and the weather information is much appreciated. The officers of the companies state that the number of calls that come into "central" daily for the weather reports is surprising. They say that it is an advantage to them to have the opportunity of distributing the information free, as such action aids in securing more subscribers. Some officials, in fact, are enthusiastic in their commendation. A special correspondent of the New York Evening Post writes from Kansas City, Mo., as follows:

> Little wonder that every day's weather predictions are awaited with interest. Early in the morning in the central telephone stations of the grain counties the calls come in to know "What does the weather man say?" The farmers' lines are kept busy answering these calls until nearly noon. So insistent is the demand for this news that many of the companies send out a general call for all subscribers at 9 o'clock, and read the bulletins.

The greater portion of the telephone companies are now publishing in some prominent place in their directories the following notice:

> Subscribers of this company may obtain the daily forecasts and special warnings of the Weather Bureau of the United States Department of Agriculture from their respective exchanges after 11 a. m., eastern time. These forecasts usually cover the thirty-six hour period ending at 8 p. m. of the following day.

The foregoing table gives, in detail, the distribution of forecasts and special warnings for the various States and Territories.

MARINE DIVISION.

This division collects meteorological information pertaining to the oceans from naval and merchant marine vessels, plots the data (pressure, temperature, wind, and weather) on daily synoptic charts for study and for the preparation of monthly summary charts, and compiles in tabular form meteorological data for the use of the Hydrographic Office of the Navy in the preparation of the Pilot Charts.

The normal pressure and temperature inset charts, tables showing the percentage of fog and gales, and wind roses showing the direction and force of the prevailing winds, are printed monthly for all coast stations and each 5° square of latitude and longitude on the Pilot Charts of the North Atlantic and North Pacific oceans.

The metorological data are obtained thru a system of cooperation on the part of vessel owners and captains and the United States naval vessels, the Bureau furnishing in lieu of other compensation such available publications as may be of service. During the last year 1,608 vessels, hailing from every port and flying the flag of every nation, cooperated with this Bureau. Meteorological reports and publications were distributed to all such cooperating vessels, to local Weather Bureau offices and to American consulates. A number of the forms and charts used are kept on hand at local stations and American consulates for filling requests.

Twenty-five local Weather Bureau offices are equipped to assist in the marine meteorological work. The stations at Portland (Me.), Boston, New York, Philadelphia, Baltimore, Norfolk, Wilmington, Charleston, Savannah, Jacksonville, Tacoma, Seattle, Portland (Oreg.), San Francisco, San Diego, Honolulu, and Washington are supplied with marine barometers.

PILOT CHART, NORTH PACIFIC OCEAN.

Beginning with the month of January, 1908, the meteorological data for this chart have been entirely revised, the averages or normals for pressure, temperature, wind (direction and force), percentages of gales, trade-wind limits, and storm tracks being given. These data have been computed for each 5° square of latitude and longitude, and the result of this work is published on the Pilot Chart issued by the Hydrographic Office, Navy Department.

PILOT CHART, NORTH ATLANTIC OCEAN.

The revision of the meteorological data for this chart commenced with the month of July, 1908, and has been continued for each succeeding month.

A chart giving the prevailing winds and calms, with gale percentages, is furnished to the Hydrographic Office forty days in advance of the date of publication, while the inset chart (pressure and temperature), trade-wind limits, storm tracks, percentage of gales and fog, and a statement of average conditions of wind and weather, are delivered thirty-five days in advance. It will be necessary to make a revision of the wind-rose data, prevailing direction and force of the wind, for the North Atlantic and North Pacific oceans for the months prior to August.

INDIAN OCEAN.

All meteorological data received from vessels sailing this ocean are dispatched every six months to Simla, India, where they are copied for the use of the Indian meteorological department and then returned to this Bureau.

FOG.

At the request of Mr. James White, geographer, Department of the Interior, Ottawa, Canada, made on March 24, 1908, a chart for each month, showing the frequency of fog in the Gulf of St. Lawrence and on the great circle route between Belle Isle and the north of Ireland, was prepared and furnished for the period 1901–1907.

WIRELESS TELEGRAPHIC WEATHER SERVICE.

On September 20, 1907, the Marconi Wireless Telegraph Company, and the foreign and American agents of the vessels cooperating with this Bureau, by transmitting meteorological observations made at sea, were informed that this service is suspended for the present.

The official at San Francisco has arranged thru this Bureau and the Quartermaster-General of the Army to have the Army transports plying between that port and Manila send wireless messages containing weather reports to that station. This work will be taken up by the transports as rapidly as wireless equipments are installed. It is the purpose to utilize the reports in forecasting the weather conditions for the coast.

The official at Portland, Oreg., has completed arrangements with Mr. W. J. Smith, manager of the Marine Transportation Company, to receive each morning and evening observations of pressure, temperature, wind, and weather from the following ships plying between Portland, Seattle, Alaskan ports, and San Francisco, viz, *Humboldt*, *President*, *Governor*, *Rose City*, *G. W. Elder*, *Roanoke*, and *City of Pueblo*.

VESSEL-REPORTING SERVICE.

In addition to the meteorological work, the officials in charge of the stations at Block Island, Cape Henry, Jupiter, Sand Key, Southeast Farallon Island, North Head, and Tatoosh Island are required to report all passing vessels, wrecks, marine disasters, and other casualties, and transmit all communications between masters, owners, underwriters, and others interested. The stations at Cape Henry, Jupiter, and Sand Key are equipped for signaling and receiving messages by the international code and for transmitting by telegraph all messages received from passing vessels. Sand Key is also prepared to receive and transmit messages at night by flash-light signals. During the last fiscal year these stations received, and transmitted to the vessel owners and others, 24,319 messages. During this time but two complaints were received, and these upon investigation proved unfounded. The Cape Henry station reported the passing of 17,624 vessels without an error being charged to it. The work done at this station was highly commended by the Maritime Exchange of New City and by Commander B. M. Berry, commandant of the navy-yard at Norfolk.

LIBRARY.

Attention is called to the fact that the Weather Bureau has gradually collected a meteorological library that is probably unrivaled thruout the world. The accessioned books and pamphlets number about 28,000, including nearly complete files of the publications of all the meteorological services and independent observatories of the world (including the foreign daily weather maps); files of all scientific journals that devote more or less attention to meteorology, and a large collection of meteorological and physical memoirs, text-books, and reference books. Every effort is made to obtain promptly, by gift, exchange, or purchase, a copy of each new publication bearing on meteorology. Current catalogs and bibliographies are carefully searched for the titles of such publications, and an extensive correspondence is maintained with authors and publishers.

All works in the library are fully catalogued by authors, and about half (comprising all the additions of recent years) are also catalogued by subjects. A very important part of the work of the library consists in cataloging, under both author and subject, the meteorological articles contained in the current numbers of nearly a hundred scientific periodicals, including the transactions and proceedings of societies. This task is justified by the value of the bibliography that is thus accumulating, and that is now more frequently consulted than the catalog of books.

At least two-thirds of the publications received in the library are in foreign languages, in about the following order of frequency: German, French, Spanish, Italian, Russian, Dutch, Portuguese, Roumanian, Swedish, Dano-Norwegian, Magyar, Polish, Czech, Finnish, Japanese.

In addition to the general library of the central office, the Bureau maintains small libraries at 191 stations. All of these libraries are under the supervision of the library at Washington, which purchases and issues all books for stations. During the past year there has been a marked increase in the number of highly technical works issued to stations, including the more important works in foreign languages. This applies especially to the stations at which educational work is carried on and to the research observatory at Mount Weather. The latter now has the nucleus of an excellent meteorological and physical library, and receives a large list of scientific periodicals.

The library prepares for each number of the MONTHLY WEATHER REVIEW a list of current papers bearing on meteorology and seismology, a list of recent additions to the library, and a column of meteorological news, notes, and abstracts. The duties of the supervising examiner, referred to elsewhere, form a considerable part of the work of the librarian.

During the past year the librarian, Mr. H. H. Kimball, has been occupied with important researches on solar radiation, and most of the duties of librarian have been performed by the assistant librarian, Mr. C. F. Talman, who also assumed the duties of supervising examiner on May 22, 1908, and became librarian by promotion on July 1, 1908.

EXAMINATIONS FOR PROMOTION.

The transfer of the examination in essay writing from the first to the second group of examinations, referred to in my last report, has made possible the advancement of many of the younger employees who would otherwise have been retained for an indefinite time in the lowest grades. The ability to write a satisfactory essay, conforming to the rules of good taste as well as grammar, does not depend upon the study of a text-book, but is a question of general education and culture. This examination is too severe a test to impose upon the younger men, whose duties are generally performed in comparative obscurity, under the supervision of others, but is an excellent means of ascertaining the fitness of employees to fill the more important and independent positions.

The total number of examination papers received during the year was 236, as compared with 158 during the preceding year. Following is the record in detail:

Number of examination papers received.

Subject.	1907.		1908.		Total.	Past.	Failed.
	Aug.	Nov.	Feb.	May.			
English grammar	4	8	13	12	37	30	7
Arithmetic	7	9	8	16	40	33	7
Elementary meteorology	6	10	5	13	34	30	4
Algebra	4	7	5	10	26	15	11
Physics	3	2	6	9	20	19	1
Trigonometry	3	5	5	5	18	15	3
Essay writing	3	1	7	6	17	13	4
Astronomy	1	2	3	4	15	12	3
Plant physiology	2	5	4	6	17	16	1
Advanced meteorology	2	2	4	4	12	12	0
Total	35	51	65	85	236	195	41

METEOROLOGICAL RECORDS.

The regular work of the Division of Meteorological Records has been carried on in the usual way thruout the year. It consists of checking the meteorological reports and discussing the same, and preparing reports for publication in the MONTHLY WEATHER REVIEW and the Annual Report of the Chief of Bureau. Nearly 2,000 letters of inquiry on various topics received from the public have been answered, the matter furnished including many certificates of official data for use in the courts. A new series of climatological papers is being prepared, in which the records of precipitation, temperature, dates of the first and last killing frosts, and prevailing wind directions are collected, the precipitation tables including all available data since the year 1871. These reviews are made comprehensive for small sections of the United States, which it is intended gradually to cover in this manner. The papers will be of value to agriculturists, engineers requiring data on water resources, and other citizens who seek information regarding the climate of the several sections.

WATER RESOURCES.

A demand for a better knowledge of the water resources of the United States has become so urgent as to make it advisable to put forth special efforts to supply the necessary data to the public. In the arid and semiarid regions of the West these consist primarily in securing the amount of precipitation from rain and snow in the high levels of the mountains, from which are derived the waters that are used in the storage basins and the irrigation projects now undergoing rapid development. It is a difficult problem to secure regular and accurate observations of the amount of snowfall in the remote regions of the mountains where there are very few inhabitants, but a special effort will be made by the Weather Bureau to extend the range of observations into the high levels of the mountains. A plan has been perfected to cooperate with the Forest Service of the Department in securing these observations. The field work of that Service is of such a nature as to render the cooperation of its officers of value in executing this extension of meteorological observations.

The action of the forests on the conservation of the water resources of the West has so many features of a strictly meteorological character in connection with it, that it seems desirable to cooperate with the Forest Service in the scientific problems which arise in this connection. The Forest Service is planning to establish several high-grade laboratory stations for the study of such problems, and the meteorological conditions in relation to precipitation, evaporation, and the storage of water will have an important place in its program. The Weather Bureau proposes to supply the necessary meteorological apparatus and give what assistance it can of a more technical nature regarding the problems under consideration

It is furthermore proposed to cooperate with the Bureau of Plant Industry in determining the locations of habitats most favorable for the growth of valuable plants, as the date or fig, and other selected types, in the arid and semiarid regions of the West. It will be an economical plan to determine the exact meteorological conditions in selected places, where it is proposed to try the several types of plant life, in order that suitable information may be obtained before undergoing the expense of plant cultivation. A small amount of preliminary work has been begun at the Government date farms at Indio and Mecca, southern California, in cooperation with the Bureau of Plant Industry, and it is expected that such work will be extended as appears to be advisable.

EVAPORATION STUDY.

In addition to measuring the water resources of the mountains, it is necessary to determine the amount of evaporation in the lower levels, where the storage basins are located. The amount of evaporation in the driest portions of the country, as in the Colorado desert, may amount to as much as 8 feet of water annually, altho it differs greatly according to circumstances. The process of evaporation in nature is very complicated, and especially over a body of water in the open, swept by various winds and subject to great changes of temperature, as between day and night, cloudy and fair weather, winter and summer, the laws are so complex as to have hitherto baffled the researches of many investigators. The importance of securing much more reliable information on this subject has made it desirable to renew the attack upon the problem. The formation of the Salton Sea in the Colorado desert, by the overflow of the Colorado River during the year 1906, affords a favorable laboratory on a large scale at which to make the proposed research on evaporation. A preliminary study on this subject was conducted by Professor Bigelow in the summer of 1907, at Reno, Nev., for the purpose of securing sufficiently adequate knowledge of the phenomena to permit a proper planning of the campaign at the Salton Sea. It was shown that pans evaporate at very different rates over the same body of water, and that the rate of evaporation is dependent on the characteristics of the blanket of invisible vapor that overlies every large body of water.

It is not proper to infer that the evaporation over a lake is the same as that over an isolated pan away from the water. The blanket of vapor tends to conserve the water in the lake, and it may be that the lake evaporates at only five-eighths the rate of an isolated pan. While a pan in the Colorado desert may evaporate at the rate of 8 feet a year, it now seems as if the Salton Sea were avaporating at the rate of only 5 feet a year. The necessary plant will be installed at the Salton Sea during the summer of 1908, and it is hoped that by continuing the observations for two or three years a satisfactory law covering evaporation generally may be secured. The problem is one of unusual difficulty from several points of view, but its practical value is such as to justify a serious effort to solve it. The plan of cooperation with the other Bureaus of the Government has been enlarged to include the Reclamation Service, and the water resources branch of the Geological Survey, which are especially interested in evaporation at the reservoirs, not only of the arid west but in the eastern districts of the country. During the summer of 1908 several plants for the measurement of evaporation will be installed at the reservoirs of the Reclamation Service, and if practicable some other reservoirs in the central and eastern districts will be included. It is important to measure the evaporation in different climates on a uniform plan in order that a comprehensive law may be deduced.

Professor Bigelow, who is in charge of the Records Division, has made some studies on the laws of vortices that are applicable to the explanation of the phenomena of tornadoes, waterspouts, hurricanes or typhoons, and land and ocean-cyclones. It is especially important that the theoretical side of meteorology be developed, because the interpretation of the observations must remain less fruitful until the laws controlling the physical process in the atmosphere are correctly understood.

THE MONTHLY WEATHER REVIEW.

The MONTHLY WEATHER REVIEW has continued to be published regularly within about six weeks of the close of the month to which its data refer. It contains the fundamental climatological averages of the month for all Weather Bureau stations, together with eight charts illustrating the geographical distribution of storms, temperature, sunshine, wind, rain and snow, and river floods. The chapters contributed by the Forecast Division and the Records Division give further details relative to these subjects. The discontinuance of the semiannual chart of the Great Lakes has rendered it appropriate to publish in the MONTHLY WEATHER REVIEW some of the data formerly given on that chart. The remarks furnished by the Forecast Division relative to long-range weather forecasts have been especially appreciated. The opening chapter of the MONTHLY WEATHER REVIEW has always given a general summary of the weather of the current month, but this review now takes a wider range. The introduction of the map showing international weather reports has called attention to the persistent relations between American phenomena and those of Europe and Asia, which relations have justified general forecasts for a week or ten days in advance, the accuracy of which is stimulative to further work along that line; articles on this subject in the MONTHLY WEATHER REVIEW have excited wide attention.

The Chief of Bureau has acknowledged the kind cooperation of numerous meterologists thruout the world who have sent important articles to the columns of the MONTHLY WEATHER REVIEW.

THE TEACHING OF METEOROLOGY.

In pursuance of the policy of the Bureau to aid in eradicating the superstitions everywhere prevailing with regard to the weather, the officials of the Bureau are encouraged in giving popular lectures or explanations, and, when practicable, offering systematic courses of instruction. The minor courses for the benefit of high schools have been numerous and are recorded in detail in the successive numbers of the MONTHLY WEATHER REVIEW. The colleges at which regular courses of instruction were given by Weather Bureau officials, in addition to their regular station duties, were as follows:

Seattle, Wash., University of Washington, G. N. Salisbury.
Syracuse, N. Y., Syracuse University, M. R. Sanford.
Raleigh, N. C., Agricultural and Mechanical College, A. H. Thiessen.
Peoria, Ill., Bradley Polytechnic Institute, D. A. Seeley.
Northfield, Vt., Norwich University, W. A. Shaw.
New Haven, Conn., Yale University, L. M. Tarr.
Madison, Wis., University of Wisconsin, J. L. Bartlett.
Ithaca, N. Y., Cornell University, W. M. Wilson.
Columbia, Mo., University of Missouri, Geo, Reeder.
Columbus, Ohio, Ohio State University, J. Warren Smith.
Cincinnati, Ohio, Cincinnati University, S. S. Bassler.
Canton, N. Y., St. Lawrence University, M. L. Fuller.
Burlington, Vt., University of Vermont, W. H. Alexander.
Berkeley, Cal., University of California, C. Abbe, jr.
Baltimore, Md., Johns Hopkins University, O. L. Fassig.

A method of instruction that is greatly valued consists in the exhibits and local talks at the numerous expositions that have been held during the past twenty years. The work of this nature done at the recent Jamestown Exposition has been highly spoken of. These exposition exhibits involve a heavy expense to the Weather Bureau and much work on the part of its officials, but thousands of citizens are thus reached who would never be able to visit a regular Weather Bureau station.

A novel educational feature has been introduced by the Department of Education of the State of New York, under the general title of "visual education." As a part of this system a popular lecture on meteorology, prepared by Mr. J. R. Weeks,

of Binghamton, N. Y., has been adopted. This lecture, with the accompanying slides, is loaned for repetition before any school or academy.

Translations of special technical articles on the mechanics of the atmosphere, collected for the use of students, have been prepared for publication by the Smithsonian Institution.

The new edition of the Smithsonian Meteorological Tables, as revised by Professors McAdie, Marvin, and Abbe, was published at the beginning of the present fiscal year and copies have been furnished to such Weather Bureau stations as desire them. These tables are widely used by surveyors, meteorologists, and physicists.

The admirable collection by C. F. von Herrmann (now section director) of problems for advanced students of the physics of the atmosphere, published in the MONTHLY WEATHER REVIEW for December, 1906, has been supplemented by a still larger collection that will be published during the coming year. These problems have received many encomiums; they illustrate the character of the instruction in higher meteorology that should be given in our colleges and universities.

The Handbook of Laboratory Experiments leading up to research in meteorology is being amplified by the editor, who expects to complete it during the coming year. It elaborates the idea of a systematic course of instruction for post-graduate students who are working on theses that should bring them the degree of master of science, or doctor of science, or doctor of philosophy, under the regulations that now obtain in all American colleges and universities.

At the present time the tendency of American educational institutions appears to be to assign meteorology to a subordinate position under geography, geology, physics, or other analogous department of learning. This radical error is not committed with regard to astronomy, chemistry, etc., and should be rectified. I wholly agree with the views exprest by my colleague, W. N. Shaw, esq., director of the Meteorological Office, London, in his comments on the life and influence of Alexander Buchan:

> Meteorology, or the physics of the atmosphere, is to be regarded as a separate scientific subject entitled to separate academic recognition. The physics of the atmosphere has its geographical aspect, but it is not a branch of geography; it has its mathematical aspect, but it is not a branch of mathematics; it has its experimental aspect, but it is not a branch of experimental physics.

TELEGRAPH DIVISION.

Extensive general repairs were made to the Port Crescent-Tatoosh Island line during the first part of the fiscal year, and the line is now in excellent order.

On November 6, 1907, the cable between Marthas Vineyard and Nantucket became grounded within 2½ miles of Nantucket. After exhaustive tests it was concluded that it would be impossible to underrun and repair the cable, as it was 23 years old and was heavily sanded all the way. Permission was given to the Western Union cable ship to attempt to do so, without expense to the Government, and in the month of May, 1908, several trials were made by her, but without success. As the Marconi Wireless Company had by this time been handling all the Nantucket telegraph business for a period of more than six months, it was decided to dispose of the defective cable and short land lines at public auction to the highest bidder, which was done on June 30, 1908.

The number of miles of telegraph and telephone lines now operated by the Weather Bureau is 460, inclusive of 110 miles of submarine cables.

The receipts from commercial telegrams handled during the year amounted to $2,781.57.

PUBLICATIONS DIVISION.

As in previous years, the principal work of this division has been the printing and distribution of the Washington Daily Weather Map, MONTHLY WEATHER REVIEW, Weekly and Monthly National Weather Bulletins, and, during the winter months, the Snow and Ice Bulletin. To the above list of regular publications there has been added since last report the Bulletin of the Mount Weather Observatory, a pamphlet containing about 100 pages and issued quarterly. The division has also supplied the observing stations with the requisite blank forms, maps, and forecast cards, and has directed such binding and miscellaneous printing as was authorized for the several divisions of the Bureau. In compliance with executive orders, the mailing lists of all regular publications have been thoroly purged and revised.

OBSERVATORY BUILDINGS.

The observatory buildings reported in my last report as being in course of construction at Anniston, Ala., Birmingham, Ala., Charles City, Iowa, Iola, Kans,, La Crosse, Wis., and Sheridan, Wyo., have been completed and are now in use.

An appropriation of $75,000 has been made for the rebuilding of the main observatory building and for the erection of a central heating and power station at Mount Weather, Va. It is the intention to make these buildings as near fireproof as practicable. As heat and power for all the principal buildings will be supplied from a central station, the danger from fire will be reduced to a minimum.

Buildings owned by the Weather Bureau.

Location.	Cost of ground.	Cost of buildings.	Total cost.
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	(a)	5,991.00	5,991.00
Bentonville, Ark.	500.00	5,119.90	5,619.90
Birmingham, Ala.	(b) 61.50	15,630.36	15,691.86
Bismarck, N. Dak.	(a)	10,085.99	10,085.99
Block Island, R. I.	1,034.50	7,668.25	8,702.75
Burlington, Vt.	(b) 20.00	10,043.50	10,063.50
Cape Henry, Va.	(a)	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
Devils Lake, N. Dak.	2,209.05	7,431.50	9,640.55
Duluth, Minn.	2,041.70	7,430.68	9,472.38
Hatteras, N. C.	(a) (e) 217.00	4,889.75	5,106.75
Havre, Mont.	1,795.00	5,087.08	6,882.08
Iola, Kans.	2,241.25	9,730.94	11,972.19
Jupiter, Fla.	(a)	6,346.90	6,346.90
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)	4,346.90	4,346.90
Mount Weather, Va.:			
Administration building (including tower and tank)	1,863.15	20,971.12	22,834.27
Power house and balloon building	650.00	8,167.00	8,817.00
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)	27,083.89	27,083.89
Cottage and office	(a)	6,800.00	6,800.00
Mount Washington, N. H.	(c)	300.00	300.00
Nantucket, Mass.	(d)	4,728.58	4,728.58
Narragansett Pier, R. I.	4,151.75	8,036.50	12,188.25
North Head, Wash.	(a)	3,820.13	3,820.13
North Platte, Nebr.	(d)	3,818.50	3,818.50
Oklahoma, Okla.	(b) 38.90	10,520.25	10,559.15
Peoria, Ill.	(b) 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
Sand Key, Fla.	(a)	5,593.00	5,593.00
Sault Sainte 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.	(d)	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	34,485.55	523,301.29	557,763.84

a Government reservation. *b* Donated—figures represent cost of title transfer.
c Leased. *d* Building and ground purchased as a whole. *e* Additional ground purchased.

The building for the central heating and power station has been completed, and an effort will be made to install the boilers and apparatus therein, so that the station may be put into operation by December 15, 1908.

Congress made an appropriation of $15,000 for the completion of the physical laboratory building and the office and

cottage building at Mount Weather, work on these structures having been suspended, as stated in my last report, by reason of a decision by the Comptroller. Work on these buildings was begun promptly on July 1, 1908, and the cottage and office building was completed and occupied September 1, 1908. It is expected that the physical laboratory building will be completed by February 1, 1909.

The appropriation bill for the fiscal year beginning July 1, 1908, also provides for the erection of seven new observatory buildings outside of Washington, D. C. These buildings will be located at Abilene, Tex., Dodge City., Kans., Fort Wayne, Ind., Lansing, Mich., Northfield, Vt., Richmond, Va., and St. Joseph, Mo., and sites have been selected except at Fort Wayne and at Richmond. It is expected that these buildings will be completed and ready for occupancy on July 1, 1909.

The foregoing table shows where the Weather Bureau buildings are located, and gives the cost of the buildings and grounds.

Rented buildings occupied wholly by the Weather Bureau.

Station.	Annual rent.	Other items included.
Alpena, Mich	$650.00	Heat, light, water.
Brawley, Cal	300.00	
Del Rio, Tex	444.00	Heat, light, water.
Durango, Colo	440.00	Do.
East Clallam, Wash	120.00	Water.
Flagstaff, Ariz	300.00	
Helena, Mont	504.00	Steam heating plant, water.
Honolulu, Hawaii	1,020.00	Six rooms; heat, cleaner, light, janitor and porter service, electric current for fan, storage.
Independence, Cal	360.00	Water.
Kalispel, Mont	360.00	
Lewiston, Idaho	540.00	
Manteo, N. C	144.00	
Moorhead, Minn	600.00	Heat, light, water.
Mount Tamalpais, Cal	420.00	Heat, light, water, free transportation of Government employees and supplies.
Pysht, Wash	144.00	Water.
Roseburg, Oreg	550.00	Heat, light, water.
Roswell, N. Mex	720.00	Heat, cleaner, water
San Juan, P. R.	684.00	Four rooms; light, water.
Thomasville, Ga	420.00	
Tonopah, Nev	1,200.00	
Twin, Wash	108.00	Water.
Williston, N. Dak	510.00	Heat, cleaner, light, water.
Winnemucca, Nev	360.00	Heat, light, water.
Total	$10,898.00	

CHANGES IN THE FORCE OF THE BUREAU.

CLASSIFIED SERVICE.

Appointments:
- Probationary—
  - Observer, at $1,200 ... 1
  - Printer at $1,200 ... 1
  - Printers, at $1,000 ... 5
  - Assistant observers, at $720 ... 20
  - Repairmen, at $720 ... 2
  - Watchman, at $720 ... 1
  - Folder and feeder, at $720 ... 1
  - Folders and feeders, at $630 ... 3
  - Skilled laborers, at $600 ... 2
  - Messenger, at $480 ... 1
  - Messenger boy, at $480 ... 1
  - Messenger boys, at $450 ... 4
  - Messenger boys, at $360 ... 60

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- Transfer—
  - Assistant observer, at $1,000 ... 1
- Reinstatement—
  - Assistant observer, at $1,000 ... 1
  - Repairman, at $840 ... 1
  - Assistant observers, at $720 ... 3
  - Messenger boy, at $480 ... 1

  6
- Temporary—
  - Compositors, at $1,250 ... 3
  - Copyists, at $840 ... 4
  - Repairmen, at $720 ... 2
  - Watchman, at $720 ... 1
  - Skilled laborer, at $660 ... 1
  - Folders and feeders, at $630 ... 4
  - Messenger, at $480 ... 1
  - Messenger boy, at $480 ... 1
  - Messenger boys, at $360 ... 32

  49
- Emergency—
  - Clerk, at $1,400 ... 1
  - Folder and feeder, $630 ... 1
  - Skilled laborer, at $600 ... 1

  3

Promotions (all promotions were to the next higher grade or by certification for advancement from subclerical positions) ... 115

Reductions:
- Causes—
  - Inability to perform satisfactorily work assigned ... 3
  - To grant assignment to preferred station ... 2
  - To grant assignment to preferred work ... 1
  - Neglect of duty ... 2
  - Decreased efficiency due to increasing age and ill health ... 1
  - Maintaining disrespectful attitude toward official superior 1
  - As an offset to the Bureau for allowances of quarters, fuel, and light ... 1
  - Necessitated by employees' return to duty from leave of absence without pay ... 5
  - Because of being permitted to receive compensation regularly from a State ... 1
  - To equalize salaries ... 1

  18

Resignations:
- Voluntary ... 68
- Required because of—
  - Unsatisfactory services ... 3
  - Unsatisfactory services and conduct ... 2

  73

Transferred to the office of the Secretary of Agriculture ... 1

Removals:
- Causes—
  - Misconduct and neglect of duty ... 1
  - Absence without authority ... 1
  - Absence without authority, and insubordination ... 2
  - Defrauding the Government by false vouchers and forgery 1

  5

Dropped from the rolls at termination of probationary period because of unsatisfactory services ... 2

Deaths ... 10

UNCLASSIFIED SERVICE.

Appointments:
- Permanent—
  - Unskilled laborers, at $450 ... 2
  - Student assistants, at $300 ... 2
  - Unclassified laborer, at $240 ... 1

  5
- Temporary—
  - Unskilled laborer, at $660 ... 1
  - Unskilled laborer, at $450 ... 1
  - Student assistant, at $300 ... 1
  - Charwoman, at $240 ... 1

  4

Promotions (each to next higher grade) ... 3

Resignations:
- Voluntary ... 1

Removals:	
Causes—	
Unsatisfactory services	1
Unsatisfactory conduct and services	1
Unsatisfactory conduct and failure to reply to an official communication	1
	3

ABSENCE.

Average number of days, with pay, per employee, during calendar year 1907.

	Sickness.	Annual leave.
Station: (99 per cent males)	1.6	6.3
Washington, D. C.:		
Males	5.1	26.4
Females	4.9	28.7
Entire service	2.5	11.4

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, 1908.

At Washington, D. C.:		
Classified	179	
Unclassified	11	
		190
Outside of Washington, D. C.:		
Classified	520	
Unclassified	14	
		534
Total commissioned employees		724
Additional employees outside of Washington, D. C.:		
Storm warning display men	181	
River observers	381	
Cotton region observers	143	
Corn and wheat region observers	137	
Rainfall observers	88	
Sugar and rice region observers	9	
Special meteorological observers	9	
Cranberry observers	2	
Total noncommissioned employees		950
Total paid employees		[a] 1,674
Persons serving without compensation (except thru the distribution of Government publications):		
Cooperative observers and correspondents (omitting 87 paid and 4 cooperative river and rainfall observers enumerated elsewhere)	5,734	
Cooperative storm warning display men	74	
Cooperative river observers	16	
Cooperative rainfall observers	10	
Total cooperatives		5,834
Total numerical strength		7,508

Distribution of the commissioned force, June 30, 1908.

In Washington, D. C.:	
Accounts Division	[b] 13
Climatological Division	7
Editor Monthly Weather Review	[c] 3
Executive branch	[d] 18
Forecast Division (including River and Flood Service)	[e] 10
Instrument Division	10
Library	[c] 5
Marine Division	14
Division of Meteorological Records	16
Publications Division	43
Supplies Division	9
Telegraph Division	11
Miscellaneous mechanical work (under direction of the Chief Clerk)	5
Captain of the Watch (under direction of the Chief Clerk)	6
General messenger and laborer service (under direction of Chief Clerk)	18
Total	190
Outside of Washington, D. C.:	
56 stations with 1 commissioned employee	56
57 stations with 2 commissioned employees	114
35 stations with 3 commissioned employees	105
20 stations with 4 commissioned employees	80
10 stations with 5 commissioned employees	50
8 stations with 6 commissioned employees	48
2 stations with 7 commissioned employees	14
3 stations with 8 commissioned employees	24
2 stations with 9 commissioned employees	18
2 stations with 10 commissioned employees	20
1 station with 15 commissioned employees	15
196 stations	[f] 544

[a] This total embraces all paid persons connected with the Bureau on June 30, 1908, except 8 snow and ice reporters who report under certain conditions during the occurrence of snow and ice, and 16 commissioned employees absent on that date and who had been granted leaves of absence or furloughs without pay for one month or more.

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

[c] One employee temporarily assigned.

[d] Two employees temporarily assigned and another devotes a portion of his time at one of the map stations at the United States Capitol.

[e] The River and Flood Service, including two of the commissioned force heretofore assigned as part of the Forecast Division.

[f] This number represents the normal station force. On June 30, 1908, there were actually on regular duty but 534 employees.

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

The following salary table omits persons on duty at special observing and substations where the salaries are $25 a month or less, and where, as a rule, the tour of duty covers but a small fraction of the day and only certain seasons of the year:

Salaries paid in the commissioned grades.

Grades.	June 30, 1908. Station.	Washington, D. C.
CLASSIFIED GRADES.		
Highest salary	$3,000	$5,000
Lowest salary	360	450
Average salary	995	1,189
UNCLASSIFIED GRADES.		
Highest salary	600	720
Lowest salary	240	240
Average salary	343	469

Average salary of all (station and Washington) is $1,022.