REPORT OF THE CHIEF OF THE WEATHER BUREAU.

UNITED STATES DEPARTMENT OF AGRICULTURE,
WEATHER BUREAU,
Washington, D. C., October, 11, 1919.

SIR: I have the honor to submit herewith a report of the operations of the Weather Bureau during the fiscal year ended June 30, 1919.

Respectfully,

C. F. MARVIN,
Chief of Bureau.

Hon. D. F. HOUSTON,
Secretary of Agriculture.

POST-WAR CONDITIONS.

With the close of the fiscal year and the passing of war conditions the Weather Bureau finds itself face to face with post-war conditions of more serious character even than the difficulties imposed by the war. It seems appropriate at this time to state briefly the status and functions of the Weather Bureau because applied meteorology as never before in history has come to be recognized as a highly important factor and guide in the conduct of almost every activity of any consequence of the Nation. Never before in any previous war did the science of meteorology play any important part or have a place in the program of military and naval organizations and operations. Now it is regarded as indispensable and is destined to become a permanent feature of each arm of the service.

Created in 1870 as a part of the Signal Corps of the United States Army by a joint resolution of Congress "to provide for taking meteorological observations at the military stations in the interior of the continent and at other points in the States and Territories of the United States and for giving notice on the northern lakes and on the seacoast, by magnetic telegraph and marine signals, of the approach and force of storms," its network of stations soon embraced the entire United States.

Subsequently the designation of the service was changed to the Weather Bureau, which, by act of Congress approved October 1, 1890, was transferred from the War Department to the Department of Agriculture and its duties and functions defined in the following language:

> The Chief of the Weather Bureau, under the direction of the Secretary of Agriculture, shall have charge of forecasting the weather; the issue of storm warnings; the display of weather and flood signals for the benefit of agriculture, commerce, and navigation; the gaging and reporting of rivers; the main-

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

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tenance and operation of seacoast telegraph lines and the collection and transmission of marine intelligence for the benefit of commerce and navigation; the reporting of temperature and rainfall conditions for the cotton interests; the display of frost, cold-wave, and other signals; the distribution of meteorological information in the interest of agriculture and commerce; and the taking of such meteorological observations as may be necessary to establish and record the climatic conditions of the United States, or are essential for the proper execution of the foregoing duties.

This organic act, with interpretations and extensions by subsequent annual appropriations, assigns to the Weather Bureau the entire domain of meteorology, including the duty of preparation and issue of forecasts and warnings of weather, storms, cold waves, heavy snows, floods, and the stages of rivers, all in the interest of commerce, agriculture, and navigation. At present it maintains over 200 fully equipped meteorological stations, and about 1,400 substations classified as special meteorological, river, storm-warning, hurricane, marine, cotton-region, corn-and-wheat-region, fruit, cranberry, and fire-weather warning stations. In addition to these the Bureau maintains, in connection with its climatological work, about 4,500 stations known as cooperative stations, the equipment being furnished by the Bureau and the observations being taken by public-spirited citizens who render gratuitous service. Its cooperative work extends to practically every ocean of the globe, and the masters of many vessels (the number was greatly reduced by the war, but is now on the increase) fill out our forms of daily meteorological observations on every voyage, to be forwarded on arrival in port. Before the war daily observations received by cable and otherwise from selected stations over the entire Northern Hemisphere were collected and published. Negotiations to restore this exchange are under way. A highly trained, efficient, and experienced personnel of over 800 commissioned employees, helped by about 1,400 who receive a small compensation for the regular performance of specific duties, conducts the work of the Bureau, and in addition the marine and cooperative observers constitute a host of nearly 6,000 public-spirited individuals who serve gratuitously. Such, in brief, is the machinery and organization of the Weather Bureau.

While the Bureau is best known to the public through the issue of its daily forecasts, maps, and bulletins, there is no doubt that its greatest value in an economic sense consists in the immense saving effected by its special warnings, as of storms and hurricanes for the benefit of marine interests, warnings of floods that occur on the principal rivers, warnings of cold waves which accomplish protection to property and food stuffs liable to damage by injuriously low temperatures, and warnings of frost and freezing weather for the benefit of the fruit, sugar, tobacco, cranberry, market gardening, and other interests.

Its duties and authorities by law are broad and comprehensive, and post-war conditions bring it new and important obligations and responsibilities which it is fully alert to recognize and eager to discharge. With the experience and traditions of nearly 50 years to its credit, the Bureau is in a position to render practically every service of a meteorological nature which may be required of such an agency and at an economy of expenditure of public funds which can not be surpassed, or even equaled, by any new agency.

A few only of the post-war problems and demands in the administration of the affairs of the Weather Bureau will be mentioned here.

METEOROLOGY AND AERONAUTICS.

From a phenomenal development under the stimulus of war necessities the navigation of the air is rapidly extending to its civil and commercial or industrial stage. Flying in ignorance or disregard of meteorological conditions and warnings is at times suicidal and destructive of costly property. Even before flying increased so greatly within the United States the Weather Bureau inaugurated a service of flying forecasts, effective December 1, 1918, which is conducted in cooperation with the Chief Signal Officer of the Army and for the benefit at first of the Army training posts and the aerial mail service of the Post Office Department, and later destined to be extended to all flying in general. Much development work is needed to make this service the most effective possible, all of which may be accomplished, as flying develops, through existing agencies and channels of cooperation between the public and the branches of the Government concerned.

METEOROLOGY FOR MILITARY OPERATIONS.

Closely allied to meteorology for aeronautics, the experiences of the war have created a demand for a service to supply information for artillery, gas warfare, and other kinds of military operations, each in its way different. The influence of winds upon the flight of projectiles has long been recognized, but in the past methods of observing the actual motions of the free air in the various altitudes were little known and less used, consequently the allowance for wind in the older formulæ of the artillerists were largely academic or mere approximations, whereas nowadays the ballistic wind is not a matter of guess or estimation, but of definite and direct observations by meteorologists employed for the purpose and using pilot-balloons or other aerial apparatus which meteorologists have developed and employed in the advancement of their own science.

On a peace-time basis these needs are being met by cooperative work and arrangements existing between the Chief of the Weather Bureau and the Chief Signal Officer of the Army, as a result of which a limited number of stations are maintained by the Army, while others constituting a useful coordination of points are established and maintained by the Weather Bureau. Observations at these stations consist chiefly of the flight of small rubber pilot-balloons. The results are used locally as required and telegraphed to the central office of the Weather Bureau for the use of the official forecasters in the issue of flying advices and other information.

MARINE METEOROLOGICAL OBSERVATIONS.

The submarine menace brought on with the war soon terminated the program of observations which merchant vessels plying the several oceans of the globe were long accustomed to furnish with the object of supplying data and information concerning the climate and meteorology of the oceans for publication as aids to navigation (marine) on the pilot charts of the Hydrographic Office. This serv-

ice is being restored gradually, and its importance is enhanced on account of the policy of extending the merchant marine of the United States, and also extensive navigation of the air over the oceans, which the future is sure to see accomplished.

Details of the major activities and work of the Bureau follow:

FORECAST SERVICE.

The general forecast service continued in operation as in the past several years. This plan consists of: (a) The Supervising Forecaster at the central office, Washington, D. C., who has general charge of the forecast work of the Weather Bureau and regularly makes the day-to-day forecasts and special warnings for the Washington forecast district and warnings of storms and dangerous winds for the Great Lakes, the Atlantic and Gulf coasts, and the West Indian waters; (b) district forecasters at the Chicago, New Orleans, Denver, and San Francisco forecast district centers, who have to do with the preparation and dissemination of forecasts and warnings for their respective districts; (c) a district forecaster at San Juan, P. R., who has charge of the issue of forecasts and warnings for that part of the West Indies lying east of longitude 70° west; (d) a district forecaster at Juneau, Alaska, who issues daily forecasts for the Juneau district of southeastern Alaska throughout the year, and for the lower Tanana Valley during the period of low temperatures; and (e) local forecast officials located in many cities of importance who prepare forecasts of weather, temperature, and wind for their respective limited regions. The forecast districts with headquarters at San Juan and Juneau were organized during the fiscal year ended June 30, 1919; otherwise there was no change in the general plan of organization.

FORECAST OFFICIALS.

The officials assigned to forecast service are selected only after long preliminary training and through competitive tests that extend through one or more years. It is necessary that the officials engaged in this work have a fundamental training in the laws of atmospherics and also that they be temperamentally fitted for the work, which, at times, is extremely arduous and requires the constant attention of the one engaged therein. In addition to the officials that are actually engaged on this work, there are of the younger men of the Bureau approximately 40 who engage in what is termed "practice forecasting," fitting themselves to later become local forecasters and yet later, in the event of special aptitude and success, to become assistants to district forecasters. This system of training forecasters must necessarily rest in the Weather Bureau, for there is no outside institution of learning where one might perfect himself in the art of weather forecasting.

FORECASTS AND WARNINGS.

The forecasts that are regularly issued by the Bureau are adapted to the many varied demands for them. In general, they consist of the following:

(*a*) Day-to-day forecasts, for 36 to 48 hours in advance, of the general weather, temperature, and wind conditions for the various

State units. These forecasts are issued twice each day, a. m. and p. m., at approximately 9:30 o'clock. The morning forecast is given general distribution through the display of weather and temperature flags, the telephone, printed cards and bulletins, and the afternoon press; the evening forecast is distributed mainly through the various press associations for appearance in the morning press.

(*b*) Weekly forecasts, that are issued Saturday of each week for larger areas than the day-to-day forecasts, and set forth the expected general conditions of the weather for that period in advance. These forecasts are disseminated largely through the press, but also through mailed cards and bulletins.

(*c*) Local forecasts, that are issued daily by the officials of the more important Weather Bureau stations for their respective regions. These include a statement as to the probable weather, temperature, and wind, and, during the winter months, the probable minimum temperature is made a part of the forecast.

(*d*) Shippers' forecasts, which are regularly made during the months when temperatures likely to be injurious to shipments of perishable goods and produce occur. These forecasts are prepared and issued by the local forecasters at many of the regular Weather Bureau stations.

(*e*) Special forecasts that are issued from time to time as occasion requires, and some of these are given special designations, as, for example: "Fire-weather warnings," for the forest regions of the West; "Orchard forecasts," for the guidance of spraying operations for insect pests and fungi, and of heating operations to prevent frost injury. Moreover, special forecasts are regularly issued for the cranberry industry of Massachusetts, New Jersey, and Wisconsin; and for various other industries that are partially or wholly dependent on accurate forecasts of weather and temperature changes.

(*f*) Day-to-day forecasts of the weather and winds along the trans-Atlantic steamship lanes eastward from the Atlantic ports to the Grand Banks of Newfoundland are issued for the guidance of vessel masters.

(*g*) Day-to-day wind and weather forecasts for the Atlantic and Gulf coasts are issued each day and transmitted to vessels at sea through naval radio. In addition to the forecast there is included in this daily message the prevailing weather and wind conditions at ports along the Atlantic and Gulf coasts and a statement as to the position of any atmospheric disturbance and its direction and speed of movement and intensity.

(*h*) Aviation forecasts are made regularly each day for the Post Office Department and the United States Army Air Service and the United States Naval Air Service. This service is conducted in a rather limited way as yet, but the general plan of the Weather Bureau aims to effect its development as rapidly as funds and the extension of aviation justify.

(*i*) Warnings are obviously issued only at specified times, but many of them are so important that when conditions arise which require their issue other lines of work give way in order that the warnings and advices may be placed before commercial and other organizations that may be benefited thereby. Warnings are issued for cold waves, heavy snows, gales, frosts, local storms, floods, winds dangerous to

navigation on the Great Lakes, the oceans, the Gulf of Mexico, and the Caribbean Sea, and for hurricanes. There can be no question but that this service saves many lives, and that property to the value of millions of dollars has been protected and saved through the prompt issue of these warnings by the Weather Bureau.

FUTURE DEMANDS.

With the wider recognition now accorded applied meteorology, increased demands are being made for information and forecasts. Advices of various kinds and forecasts are already being supplied the Air Services of the Army and the Navy and the Post Office Department, and it seems altogether probable that the growing demands for information and forecasts of a meteorological character will soon make necessary a new branch of forecasting planned to care primarily for the interests of aerial navigation.

RECENT EXAMPLES.

During 1919 there were two notable cases of the importance of accurate meteorological information and forecasts in connection with aerial navigation. The one was that of the trans-Atlantic seaplane flight by the United States Navy in May, and the other that of the visit of the British dirigible, the R–34, to our country during July. In both these instances the fullest cooperation on the part of the Weather Bureau was requested by the United States Navy. Complete synoptic meteorological reports were placed at the disposal of the officials of the Navy, and in addition the forecaster on duty prepared and issued forecasts based on the 8 a. m. and 8 p. m. regular observations for the commanding officers of these operations.

THE TRANS-ATLANTIC SEAPLANE FLIGHT IN MAY, 1919.

The start of the trans-Atlantic seaplane flight (United States Navy) was made from Rockaway the morning of May 8, two of the planes, the NC-1 and NC-3, reaching their destination, Halifax, the afternoon of the same day. The NC-4 developed engine trouble and put into Chatham, Mass. The forecast issued the morning of the 8th was as follows: "Moderate northwest and west winds. Fair weather to-day. Friday; fresh north to east winds, cloudy weather with rain over southern half of course." The evening of the 9th the following forecast was made for the seaplanes between Halifax and Trepassey Bay, Newfoundland: "Weather favorable for flight Saturday. Gentle variable winds. Fair weather. Wind velocity less than 15 miles an hour." The morning of the 10th the forecast for the same course read: "Fair weather Halifax to Newfoundland. Gentle variable winds, except moderate west and northwest off south coast of Newfoundland." The flight from Halifax to Trepassey Bay was made on the 10th and the two seaplanes making it reached their destination the afternoon of the same day. In the meantime the seaplane NC-4, at Chatham, Mass., had made ready for a renewal of the flight to Halifax, but it was held there for several days because of adverse wind and weather conditions. On the evening of the 13th the following forecast was sent the commander of the seaplane NC-4 at Chatham, Mass.: "Conditions favorable for start from Chatham

for Halifax Wednesday morning (the 14th). Moderate to fresh westerly winds and fair weather." The flight was made to Halifax on the 14th under favorable conditions, and from Halifax to Trepassey Bay on the 15th, the advices sent to the commander of the NC-4 assuring him of favorable wind and weather conditions. On the 15th (Thursday) the following forecast was sent to the commander of the seaplanes at Trepassey Bay, Newfoundland: "Wind and weather conditions over the course (Newfoundland to the Azores) will improve during Friday and Saturday. Wind will be west and fresh and possibly strong. Weather will be fair. Above based on incomplete reports from the ocean. Advise start by Friday night." On Friday the following forecast was sent: "Surface winds fresh and possibly strong west-southwest and upper winds fresh to strong west over course between Newfoundland and the Azores; some clouds, fair visibility, and rising pressure. Conditions favorable for start." The seaplanes left Trepassey Bay the afternoon of the same day for the Azores. The NC-4 reached the Azores the late forenoon of the following day, while the NC-1 and the NC-3 landed in the vicinity of the Azores, but were unable to rise from the water and resume their flights

THE VISIT OF THE BRITISH DIRIGIBLE, THE R-34, JULY, 1919.

The Weather Bureau was called on for detailed information and forecasts before, during, and after the visit of the R-34 to the United States in July, 1919. The first call for information and forecasts was from the R-34 by radio when she was in the vicinity of Newfoundland, and then and after, until she had reached midocean on her return to Great Britain, the latest meteorological information and forecasts were always at the disposal of the commander of this craft. The following letter, addressed to the Chief of the Weather Bureau, was received from the Secretary of the Navy concerning the work of the Weather Bureau in connection with the visit of the R-34 to our country:

> The work done by the Weather Bureau before, during, and after the visit of the British dirigible R-34 has been keenly appreciated by the Navy Department, and by the British officers connected with this flight. The reports were most reliable and the last report sent by Maj. Bowie on the evening of July 10, undoubtedly was the prime agent in the safe departing of the ship.

Also there was received the following letter from the British air attaché in appreciation of the work of the Weather Bureau in connection with the flight of the R-34:

> Permit me to thank you, on behalf of the Air Ministry for the very distinguished part you played in the success which attended the visit of the R-34. It is claimed that meteorology is the handmaiden of aeronautics, but I think that does not show the science enough respect. At any rate, you, by your assiduous attention to, and reading of, the weather during the visit contributed more than a fair share to the success attained.

TROPICAL STORMS.

Only one tropical storm of sufficient importance to justify the display of hurricane warnings occurred during the year, namely, that of August 1–6, 1918. This storm moved northwestward across the Caribbean Sea and Gulf of Mexico, and struck the Louisiana coast

about 30 miles east of the mouth of the Sabine River, moving thence inward about 80 miles to northwestern Louisiana, where it was dissipated. It passed over Lake Charles and Gerstner Field, La., developing considerable violence, the wind attaining a velocity of about 100 miles an hour. Thirty-four deaths were reported as being due to the storm and the number of persons injured as more than twice that number. The damage to property was roughly estimated at $5,000,000. Hurricane warnings in advance of the storm were ordered for the Louisiana and Texas coasts from Galveston east.

SPECIAL METEOROLOGICAL STATIONS.

As an aid to the forecast service in Alaska arrangements were made for the establishment of three special meteorological stations at Atka, Akiak, and Noorvik, Alaska, to report twice daily by radio.

HIGHWAYS WEATHER SERVICE.

A new project, designated "Highways weather service," was formally authorized during the year. In the carrying out of this project certain central stations receive reports of the conditions of the roads in the surrounding region or over certain main highways, and publish the same on their bulletins and in the press. In cases where the stations are centers of a corn-and-wheat or cotton-region service the reports of road conditions are obtained by telegraph without additional expense by the addition of a word indicating the conditions of the road to the daily report from the substations. In other instances they are obtained by mail by means of franked postal cards furnished to persons who are willing to cooperate with the Bureau in this service. Projects were in operation during the past winter at some 15 stations in 11 States, but at all but four of these it was a winter service only and was discontinued in the spring, to be resumed the coming winter. Although still in a tentative stage the service has great possibilities and is likely to be largely extended in the future. It has proved very popular where it has been in operation, the official in charge at one station stating that he has as many calls for road data during the day as for the weather forecasts.

RIVER AND FLOOD WARNINGS.

The flood service of the Weather Bureau functioned properly, not only as to the issue of timely notices of the coming of floods but also in the daily statement of river conditions throughout the country.

The floods of the year were largely local and much less severe than in many previous years.

During threatening conditions which obtained for a time along the Mississippi River from Keokuk, Iowa, southward to Louisiana, Mo., information was furnished that proved to be of great practical utility in the organized effort to strengthen the levees along that section of the stream.

In the drainage investigations of the department and in many private enterprises in connection with river improvements the river and flood service has contributed valuable information both to agricultural and commercial interests along the great rivers of the country.

INSPECTION OF RIVER STATIONS.

Owing to the unprecedented demand for engineers, it has not been possible to obtain from the outside persons having the necessary skill and experience to correct irregularities which invariably creep into the work of river-gaging stations unless the work is frequently inspected.

As a temporary expedient an employee of the Washington office was detailed for a part of his time to field work in connection with the installation and upkeep of river gages. It was not possible in this way, however, to care for more than the most pressing cases. A return to the prewar basis of having persons of engineering ability available at central points for service in keeping the system of river-gaging stations up to standard is urgently needed.

CHANGES IN DISTRICT CENTERS.

No new river districts were organized during the year, but the charge of the Kansas River was transferred from Kansas City, Mo., to Topeka, Kans., largely for administrative reasons.

SNOW SURVEYS IN HIGH ALTITUDES.

The activities of the Bureau in determining the depth and density of the snow cover of high altitudes in certain drainage basins of the West were naturally restricted to the most urgent and promising cases. These were the White Mountain region of Arizona draining into the Roosevelt Reservoir and on the headwaters of the Walker River of Nevada.

FORMULÆ FOR FLOOD FORECASTING.

Studies leading to the formulation of rules for forecasting floods almost wholly from the physical data of rainfall have been completed during the year for the Asheville (N. C.) district.

COOPERATION.

Progress was made on the following-named specific projects during the year:

1. The collection of rainfall measurements in the mountains of Los Angeles and San Bernardino Counties, Calif., in cooperation with the local county officials.

2. The Wagon Wheel Gap Experiment Station in cooperation with the Forest Service of the department. This important project has now run for eight years, and a mass of unique data has been collected to establish, if possible, hitherto unknown facts concerning the relations between weather conditions and stream discharge on forested watersheds. The experiment has reached its second stage, in which one of the two watersheds will be denuded of its forest and observations continued for a further period of years under the changed conditions. A detailed study of the data for the first stage of the experiment is far advanced, and the future observations are looked forward to with great interest.

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STATIONS AND OBSERVATIONS.

NEW WEATHER BUREAU BUILDINGS.

After considerable unavoidable delays due to war and unsettled business conditions, the new Weather Bureau observatory and telegraph office building at Cape Henry, Va., was completed and accepted under date of September 8, 1918. This station was fully equipped with steel towers and lanterns for storm warning displays, and a small electric light plant to provide illumination for displays, vessel-signaling, and office purposes has proved very satisfactory. The new building was erected on the Weather Bureau reservation comprising 15,000 square feet of ground on beach front at the foot of Forty-third Street, where the location is much more advantageous than that previously had for many years on the lighthouse reservation. The old building is retained for use of the assistant observers.

CHANGES AT REGULAR STATIONS.

Narragansett Pier, R. I., station discontinued August 17, 1918. Weather building and reservation placed in hands of a caretaker.

Buildings and reservation at Mount Weather, Va., also remain in possession of caretaker.

On October 1, 1918, the important meteorological city substation, Central Park, New York, in the Army Building, near Sixty-fifth Street, East, maintained continuously for about 50 years past under local supervision, was removed to, and installed in the remodeled Belvidere Tower building, near the Eighty-first Street, West, entrance to the Park, and re-equipped as a permanently established substation of the Bureau.

Completion of a Federal building at New Haven, Conn., in which accommodations were provided by the Treasury Department, enabled the Bureau to effect removal thereto February 15, 1919, and save rental heretofore paid for quarters in a private building.

Notwithstanding the general increase in rentals throughout the country during the last two or three years, it has been possible to effect a considerable saving to the Government by reason of the 5-year renewal clause in leases whereby the Bureau was able to retain occupied quarters at prewar prices. Leases involving $6,466 at the old rate, which now expire by limitation at seven stations where increase is demanded, required renewal at a total increased cost to the Bureau of $1,556 for the next fiscal year, or about 24 per cent of the total amount paid for such rentals. One serious incident of exorbitant increase in rental compelled the Bureau reluctantly to move its station at Topeka, Kans., to quarters in a new rented building. The following statement shows the present status of Weather Bureau offices at field stations outside of Washington, (not including Narragansett Pier or Mount Weather):

Free quarters and accommodations:	
In Observatory buildings, owned and controlled by the Weather Bureau	45
In State University buildings	5
In Federal buildings	72
Total free of rental	122

Rented buildings, etc., owned by individuals or corporations:		
In office buildings	80	
In buildings with grounds, aerological and special meteorological stations	19	
Total number rented buildings partly or wholly occupied	99	
Total		221

COOPERATION.

The Weather Bureau is always ready to cooperate to the fullest extent possible, and during the war, at Springfield, Ill., the entire second floor of its building was turned over for extended use by the Internal Revenue Service. At Parkersburg, W. Va., Weather Bureau quarters in the Federal building were changed to better accommodate additional employees of the Treasury Department. At Sand Key, Fla., at the request of the Secretary of the Navy, the station and equipment were transferred to that department October 26, 1918, by order of the President, under the authority of the Overman Act, and returned to the control of the Weather Bureau July 1, 1919.

TELEPHONE SERVICE.

In connection with its prompt and wide dissemination of storm warnings and general meteorological information, the Weather Bureau probably is the most extensive user of telephones of any branch of the Government, and at its more than 220 central field stations has direct wire connections with local telephone exchanges. An authorized allotment of about $14,000 was made for this local telephone service for the fiscal year ended June 30, 1919, and the increased local rates promulgated in the Postmaster General's Order No. 2940, effective May 1, 1919, called for an almost complete readjustment, together with an added and wholly unexpected charge against our appropriations for 1918–19. For next fiscal year the total cost of this service is likely to reach $17,000.

TELEGRAPH CONTRACTS.

For the prompt handling of meteorological reports and weather information over the greater part of the Northern Hemisphere the Weather Bureau has necessarily maintained for many years past formal annual contracts, arranged under special authority of law, with all of the more important telegraph, telephone, and submarine cable companies, including also wireless commercial companies, through cooperation with the Naval Communications Service. By order of the Postmaster General, dated June 7, 1919, Weather Bureau contracts for next fiscal year and during Federal control were made exempt from increase of rates, but this affects only contracts entered into by the central office at Washington. An opinion was also obtained that increased rates were not applicable for wire and battery service leased for maintenance of local recording river gages and similar self-registering equipment used by the Weather Bureau.

INVESTIGATIONS IN VOLCANOLOGY.

The act making appropriations for the Weather Bureau for the fiscal year ended June 30, 1919, contains authority for investigations in volcanology and appropriates $10,000 therefor. Provision for

this project was included in a supplemental estimate submitted to Congress for the fiscal year 1917, but was not allowed. The estimate was not repeated for the fiscal years 1918 and 1919, but was inserted on the initiative of Congress itself for the current fiscal year. The primary purpose of the appropriation is to conduct investigations in volcanology at Kilauea Volcano, on Hawaii Island, of the Hawaiian group, with the expectation that they may be extended later in Alaska and other places in the United States possessions where active volcanoes exist. The site of the volcano and extensive adjacent territory has recently been included in a national park.

Investigations have been conducted at Kilauea since 1912, first under the auspices of the Massachusetts Institute of Technology, and since 1913 by the Hawaiian Volcano Research Association, which is composed principally of prominent citizens of Honolulu.

The Weather Bureau took formal control of the work at Kilauea on February 15, 1919. Prof. Thomas A. Jaggar, jr., formerly of the Massachusetts Institute of Technology, who has been in charge of the investigations since their inception, has been appointed volcanologist and will continue in immediate charge.

The buildings, grounds, instruments, and equipment belonging to the Hawaiian Volcano Research Association were transferred to the control of the Weather Bureau under the terms of a long-time lease. Prof. Jaggar and his assistants will reside in the observatory buildings, and the major part of their work will be conducted at the Kilauea Volcano, although simultaneous studies of the activities of near-by volcanoes, especially Mauna Loa, will be made as far as practicable.

The program of work at present contemplates little more than the maintenance of the systematic observations of the volcano, with some possible extensions in the way of a seismic survey of the vicinity. No more than this can be undertaken with present funds, but as national affairs become more stabilized under peace-time conditions the opportunity offered here of conducting extensive investigations in the field of volcanology will no doubt be fully supported and important results secured.

AEROLOGICAL INVESTIGATIONS.

Free-air observations by means of kites were obtained throughout the year at Drexel, Nebr., and Ellendale, N. Dak. Installation of equipment was completed for similar work at Broken Arrow, Okla., Groesbeck, Tex., Leesburg, Ga., and Royal Center, Ind. Regular observations were begun at those stations before January 1, 1919. These observations, as well as those at Drexel and Ellendale, include daily kite flights and, whenever possible, continuous series of flights covering periods of 24 to 36 hours. The records have been reduced at the central office, and the results published in aerological supplements of the Monthly Weather Review. Moreover, brief summaries are telegraphed daily to the central office and other district forecast centers.

The pilot-balloon work that was organized and conducted during the war by the meteorological section of the Signal Corps at Broken Arrow, Okla., Ellendale, N. Dak., Groesbeck, Tex., Leesburg, Ga., Royal Center, Ind., and Washington, D. C., was transferred to the

Weather Bureau during the latter half of the year. Similar work has been organized at regular Weather Bureau stations at Ithaca, N. Y., Lansing, Mich., and Madison, Wis. Observations are made twice daily, and the indicated wind conditions at various heights are telegraphed to the central office for use in furnishing advices to the military, naval, and postal aviation services. The Weather Bureau observations are supplemented by similar reports from several military and naval air stations where work with pilot balloons is regularly conducted. All of the free-air records thus obtained are furnished to the central office for final reduction and study.

Both during and after the war there was close cooperation with the Army and Navy meteorological services. Special data were furnished also to the ordnance departments and to the military intelligence and aviation services. Advices were given to the United States Navy in connection with its trans-Atlantic flight project, further details of which are stated under the section on forecast service.

TELEGRAPH SERVICE.

The prompt collection and dissemination of weather reports and warnings require an extensive network and use of commercial telegraphic facilities. Various elements of a disturbing nature contributed generally, and in some phases in an aggravated form, to a continuance of the difficulties experienced during the preceding year in maintaining the telegraphic circuits at a high standard of efficiency, although some improvement was noted during the last half of the year. Chief among the causes were shortage of experienced operators in the commercial companies, necessary employment of untrained forces, substitution of machine for manual transmission of telegrams over trunk lines, the epidemic of influenza, abridgment of the hours of labor, late opening of telegraph offices at numerous small but important points, preventing dispatch of observations at usual times, and, latterly, the prevalence of minor strike conditions.

Effectual means were promptly taken by the commercial companies as a rule, however, to remedy unsatisfactory conditions upon presentation of complaints, and, on the whole, the telegraph service was performed as efficiently as could have been expected.

Changes in telephonic rates, effective January 21, and in telegraphic rates, effective April 1, imposed additional difficulties in examination and passage of accounts for service, necessitating a large volume of correspondence to effect proper adjustment.

A complete revision of forms showing distribution of forecast messages throughout the country, approximately 1,100 daily, was accomplished, resulting in much improved record lists.

During May and June a large number of telegrams was handled in connection with the trans-Atlantic flights in which the Weather Bureau cooperated with the Navy Department, additional telegraphic loops having been installed for the purpose. As this business was filed during the rush hours of the morning and evening, its handling, coupled with the other routine work, taxed the operating facilities to the utmost.

The services of another clerk-operator are much needed to properly handle the telegraphic and auditing work throughout the crop and

hurricane seasons, and the need is much accentuated at times of increased work similar to the above. Should there be further increases of telegraphic work consequent upon the contemplated extensive cooperation with the Army and Navy, a corresponding enlargement of the telegraphic force will become imperative.

WEATHER BUREAU TELEGRAPH AND TELEPHONE LINES.

These lines have been maintained and operated generally in a satisfactory manner, considerable necessary reconstruction work having been accomplished on several. The Navy Department, the War Department, and the Coast Guard have made increasing use of them, the Coast Guard Service having cooperated largely in cable repair and other work.

BLOCK ISLAND-NARRAGANSETT PIER SECTION.

[Telegraph.]

Closing of the Weather Bureau office at Narragansett Pier on July 31, 1918, necessitated other land terminal arrangements. To meet this situation the cable was permanently connected in the office of the Providence Telephone Co. at Narragansett Pier with the Western Union wire running to Boston, thus affording a satisfactory channel of communication between Block Island and the mainland. Large use is made of this cable by the naval base on Block Island, which enjoys direct wire connection.

One mile of new three-conductor cable, costing $2,312.64, was bought during the spring to replace a defective portion which had interfered seriously for most of the year with transmission through two of the conductors used by the Providence Telephone Co. Repairs made by the Coast Guard Service produced very satisfactory results, the cable now being in first-class condition, although laid in 1903.

NORFOLK-HATTERAS SECTION.

[Telegraph.]

Extensive repairs became necessary on the southern portion of this line, due to prostration of about 10 miles of poles resulting from effects of a severe storm on August 25–26, 1918. These repairs were completed early in the summer.

The 3-mile submarine cable connecting Manteo, on Roanoke Island, with the mainland became so defective as to seriously impair its further use for telegraph purposes. To insure continued communication with this isolated but important point 4 miles of new four-conductor cable were purchased, nearly 3 miles of which were successfully laid in June, the remainder being stored for emergency use. Two sections of land line necessary to connect the cable with the office at Manteo and the main line were rebuilt.

Four important naval stations which transact a large volume of business enjoy direct connection with the main line through to the naval base at Norfolk. Extensive use is made of the facilities of the Weather Bureau office at Cape Henry by the Navy and the Coast Guard Service, the latter effectively cooperating in the maintenance of the line. Two telephone lines belonging to that service are carried on the Weather Bureau poles between Virginia Beach and Hatteras.

KEY WEST-SAND KEY.

[Telephone.]

Nine miles of submarine cable connects these two stations. This cable was laid in 1903, and in the early part of the year became so defective as to call for a new cable to protect the naval interests in the gulf which had assumed great importance on account of war conditions. As the Sand Key station had been taken over by the Navy Department during the period of the war, a new 4-conductor cable was purchased and laid by that department.

ALPENA-THUNDER BAY-MIDDLE ISLAND SECTION.

[Telephone.]

During the year communication was interrupted 23 hours on these two lines owing to damage by thunderstorms. The poles are beginning to fail from age and will doubtless need renewing soon.

WHITEFISH POINT-GRAND MARAIS SECTION.

[Telephone.]

NORTH AND SOUTH MANITOU ISLAND-SLEEPING BEAR POINT SECTION.

[Telephone.]

BEAVER ISLAND-CHARLEVOIX SECTION.

[Telephone.]

These three lines worked continuously and smoothly throughout the year.

SAN FRANCISCO-POINT REYES (CALIF.) SECTION.

[Telephone.]

For several years past much difficulty has been experienced in communicating between these points. Arrangements were made during the winter with the Coast Guard Service for reconstruction of the line, which provided for a metallic circuit from Point Reyes to San Anselmo, where the Weather Bureau wire now terminates in an exchange, thence operated to San Francisco at established rates. The former method of communication involved rental of a wire from San Francisco to Mill Valley which connected at that point with the Weather Bureau single-grounded wire running to Point Reyes. Communication with the Mount Tamalpais station had been carried on by the use of a loop on the main line. This portion of the line now terminates in the Mill Valley exchange where connection is made with either Point Reyes or San Francisco. Approximately two-thirds of the cost of the reconstruction work was borne by the Coast Guard, and the remaining third by the Weather Bureau. Annual cost of service between the new and old systems differs but little. The new system was placed in operation on March 5, with satisfactory results. A portion of the line will need renewing with copper wire before long. Three test stations were installed on the line, which are found valuable in locating trouble.

NORTH HEAD-PORTLAND SECTION.

[Telegraph.]

Fairly satisfactory and continuous communication was maintained between these two points through the successive use of several con-

ductors in the Army cable connecting Fort Stevens and Fort Canby on opposite sides of the Columbia River. Serious and unlooked-for difficulties were encountered in putting into effect the project of purchasing and laying a new cable from funds authorized by Congress for cable and line repairs. Prolonged but unsuccessful efforts were made to determine a proper route to connect with existing land-line facilities. Utilization of the route of the abandoned cable was highly inadvisable. The selection of a new and longer route entailed construction of new land lines or unsatisfactory cooperation with other services in the use of present system. The greatly increased expense of cable and aerial material was prohibitive in view of the small amount of funds remaining after expenditures necessarily incurred in emergency repairs on the lines above mentioned. As continued use of the Army cable is permissible as long as a conductor can be spared, consummation of the project of a new cable has been deferred pending future action by the Congress.

TATOOSH ISLAND-PORT ANGELES SECTION.

[Telegraph.]

A large amount of reconstruction work was accomplished during the year. This was made highly desirable, and in places necessary, by the extensive logging operations along the route of line, railroad construction work, private road building, activities of the Spruce Production Division of the Signal Corps, and heavy storms.

The Weather Bureau station at Pysht was closed on August 31 and the repair work formerly done by the official divided between the stations on either side.

A temporary office was opened at the military camp at Joyce, Wash., August 29, and a large volume of telegraph business was carried over the line in connection with the spruce production operations at that point. The office was closed on December 25. During these four months approximately 3,100 commercial messages were handled at this station.

WORK IN CLIMATOLOGY.

No important changes occurred during the year in the work in climatology, and the several important lines were carried forward as usual, despite many general enlargements in most of the items making up the duties and some decrease in the clerical force available.

All material prepared for the several publications of the Bureau was submitted as per schedule and the final reports printed at the time designated. The weather data for the Monthly Weather Review, Annual Report of the Chief of Bureau, and the monthly and annual climatological reports for the several States were subjected to the usual careful scrutiny, and effort has been made to maintain the standard of accuracy heretofore required, although, as stated above, there has been a steadily increasing number of reports to be examined and a constant diminution of the effective working capacity of the clerical force.

COOPERATIVE REPORTS.

The work of the cooperative observers of the Bureau has been maintained in a highly satisfactory manner despite the additional duties imposed on the observing force by the unsettled world conditions and

the lessened opportunities for such work in view of the shortage of labor in general.

More changes in the observing force were necessary than usual, owing to a large shifting from the usual lines of work to those pertaining to the war, but the continuity of the work was usually provided for and the records as a whole were remarkably complete, and continued improvement in practically all features of the work was noted.

INSPECTION OF STATIONS.

The policy of inspecting cooperative stations once in each three years, temporarily suspended during the early portion of the fiscal year just closed, was vigorously taken up toward the latter part and is being continued whenever feasible for officials to absent themselves from their stations. These visits of inspection impress the cooperative observers with an added sense of the importance of their work, establish a spirit of sympathetic cooperation, and encourage them to renewed effort in case they have become discouraged at the prospective amount of work without financial remuneration or an apparent lack of appreciation by the Bureau or the public of the value of the records they are at such pains to make.

During the year most cordial cooperation was maintained with other Government bureaus in collecting meteorological reports from points that would naturally be without representation but for the willingness of the officials to take up this special duty in addition to their regular lines of work.

OCEAN METEOROLOGY.

As was pointed out in previous reports, the work of the marine section was seriously interfered with by the war, the loss of reporting vessels and censorship restrictions together having the effect of greatly reducing the number of reports available for charting and study. So far as possible, however, the work of the section proceeds along the usual lines.

Upon the close of the war attention was centered upon a program for the restoration and extension of the marine work, and plans have been formulated which will result in a material advancement of our knowledge respecting meteorological conditions of the great ocean areas.

Progress in this direction is necessary to enable the Bureau to meet the increasing demands for information regarding weather conditions over the oceans resulting from the expansion of our merchant marine and commercial development associated therewith, as well as those arising from experiments in trans-oceanic flight.

MISCELLANEOUS ITEMS OF WORK.

The usual work incident to the receipt, examination and filing of the meteorological reports of the Bureau went forward as usual. The section publications were assembled and prepared for distribution and the sets of these intended for station files for the year 1918 were bound and distributed. The binding of the original records of the preceding year was accomplished as usual and all reports put in shape for permanent preservation. The tabular matter usually extracted from the original records has been entered in the books pre-

pared for such data and all are as nearly up to date as it is practicable to keep them.

Many data on the temperatures of the country have been accumulated during the year, particularly with regard to the maximum and minimum values. Extensive compilations of the daily and weekly means of these factors for the 40-year period ending with 1918, have been obtained from the various stations. It is hoped opportunity will be afforded during the present year to properly analyze and interpret these data and present them to the public.

Near the close of the year steps were taken to present to the public in general, but particularly for the benefit of the engineering professions, through the press, more information on the daily state of the moisture in the atmosphere, and at this writing these data are being published for the three principal observations in practically all the leading papers in the country. At the same time a revision of the local station forms intended for public distribution was being considered by which similar data will be presented to the public in much greater detail than heretofore.

The extensive utilization of our accumulated records by nearly every class of our population has continued during the year, and the fact that practically every request for information has been promptly and fully met indicates the extensive character of the data we are collecting. The reputation of the Bureau for prompt service has been fully maintained, as indicated by the many acknowledgments of appreciation received for early and complete responses to requests for information.

AGRICULTURAL METEOROLOGY.

The activities under this section include the supervision of special services maintained in the interests of agriculture in the principal grain, cotton, sugar, rice, alfalfa seed, cranberry, tomato, tobacco, fruit, and potato-growing districts, as well as in the great grazing districts for the benefit of those interested in stock production; all maintained for the collection anl dissemination of information relative to current weather conditions throughout the country, and their resulting effects upon the development of crops and the progress of agricultural operations.

In addition to the above, studies are conducted on the influence of weather on the development of crops, and the relation of weather and climate to agricultural activities and crop yields, including the supervision and distribution of forecasts of minimum temperatures during critical periods in districts where protective methods are extensively practiced. The fruit frost-work was very successful during the year, particularly in the Northwestern States, and gratifying progress was made during the year in studies of special mathematical methods of forecasting minimum temperatures that may be injurious to fruit.

Weather is a dominant factor in the success or failure of agricultural or horticultural operations, and special effort was made during the year to apply the information collected, through the vast organization of special and cooperative services of the Weather Bureau, to the important problem of food production in its various aspects.

SPECIAL SERVICES.

Few changes were made during the year in the special crop services maintained by the Bureau and described sufficiently in the last annual report. The cotton, corn, and wheat services were improved during the year by the inauguration of a new system of making observations whereby the minimum temperatures experienced during the preceding night were reported instead of the 24-hour minimum.

A new method of issuing reports weekly, instead of daily, in the cattle region service, has proved very satisfactory, and resulted in a material reduction of expense. There is an insistent public demand for the extension of this service over some important grazing districts not yet covered, which it is hoped to meet in the near future.

Special studies were made during the year in the development of a mathematical hygrometric formula to aid in making more accurate minimum temperature forecasts.

The special forecast and warning service was extended, with good results, in connection with spraying operations in some important fruit growing districts. So far as the depleted personnel of the bureau would permit, trained officials of the Weather Bureau were detailed to special field duty in fruit districts during critical periods for the purpose of giving advice as to the best time to conduct spraying operations. It is hoped that, when more normal conditions prevail, the Bureau may be in position to enlarge and improve this branch of its activity.

Cooperation.—By request of other departments of the Government, and for the use of the recent Peace Conference at Paris, the Weather Bureau prepared, during the fall and early winter, a general summary of the climate of Africa, with special attention to that of the former German colonies. A vast amount of climatic data was compiled, and a number of charts were prepared showing graphically the annual and monthly distribution of precipitation and temperature over the continent, together with a discussion of its climatic characteristics.

The Weather Bureau continued its cooperation with other bureaus of the department in maintaining special meteorological stations at various points in different sections of the country as an aid to research and investigation of the many agricultural problems in which weather is an important factor.

INSTRUMENTATION.

The instrumental equipment of the various stations of the Bureau has been maintained at the high standard of former years. The practical cessation of European supply and the difficulties attending American manufacture of instruments have made it less simple than heretofore to obtain suitable supplies, particularly when such supplies involved the labor of highly skilled artisans. Prices of instruments and of parts have increased greatly, and we have been able to maintain the equipment of the Bureau with the appropriation available only by working over a considerable stock of apparatus available. The instrument shop of the Bureau has been availed of to salvage instruments that under ordinary conditions would hardly be worth repair. Naturally a time will soon come when further opera-

tions of this character will not be possible, and, unless prices recede, a substantial increase in the allotment for instrumental equipment must follow.

STORM-WARNING EQUIPMENT.

The three-lantern system was completed on the Atlantic coast during the fall of 1918, and work on the Pacific coast was about half completed at the end of the fiscal year. The entire installation will be finished by October 1, 1919. It is a pleasure to report that there has been very little expense for repairs at stations equipped with this new system, and while the initial expenditure of making the change is somewhat high, it is believed that the total cost to the Bureau through a period of, say, 10 years will be no greater than would be the cost of maintaining the former less effective equipment.

NEW INSTRUMENTS.

A form of thermograph, intermediate in size between our present long- and short-range instruments, has been adopted as standard for future purchases and will eventually replace all thermographs now in use in the Bureau.

A minimum thermometer of larger index, so as to obtain increased visibility and thereby retain to the Bureau the services of cooperative observers who must now give up the work because of failing eyesight, has been worked out with the cooperation of the manufacturers, and it is hoped to obtain a quantity of these in the near future.

A nephoscope of rugged construction and simple form has been designed for general use in the Bureau, and a contract for 100 of these has been awarded.

EVAPORATION WORK.

Extensions of the Class A evaporation stations have been made only where satisfactory and continuous observations were to be expected. Thirty-eight stations well distributed over the country now render regular reports.

PRINTING AND PUBLICATIONS.

War conditions at the beginning of the year continued to embarrass the work of this division through the loss of employees and the impossibility of replacing them with efficient substitutes. Thus the lack of skilled press feeders necessitated keeping idle some of our presses much of the time and compelled us to use some of our scant printing allotment for having work done at the Government Printing Office that would otherwise have been taken care of by own own printing plant. However, no delays or interruptions were allowed to occur in printing and distributing the daily weather maps, weekly crop bulletins, and other periodical publications of the Bureau, whose value depends entirely upon the promptness and regularity with which they are placed before the public. Since the close of the war conditions have gradually become more satisfactory, and the early installation of automatic press-feeding machines will prevent a recurrence of some of the troubles experienced during the past year.

The demand for Weather Bureau publications relating to meteorological and allied subjects maintained its usual high level, especially as regards requests received from military and naval sources for

meteorological data in the aid of aeronautics and ballistics. Public schools and other educational institutions also showed continued interest in the work and publications of the Weather Bureau.

At the end of the year there were 546 paying subscribers to our various periodical publications, exclusive of the Monthly Weather Review, and the total receipts from that source amounted to $697.17. An additional amount of $117.90 was received from the sale of blank weather maps for school use. Subscriptions for the Monthly Weather Review are received and filled by the Superintendent of Documents, Government Printing Office, who requires 125 copies each month for that purpose.

To guard against an improper use of information regarding crop conditions in advance of the time set for its release to the public, all copy for the National Weather and Crop Bulletin is now set up by our printers in a locked room of the Division of Agricultural Meteorology, and the advance sheets are printed on a proof press in the same room for distribution to the press and telegraph companies at the appointed hour.

The principal publications issued during the year included the Monthly Weather Review and Supplements; Daily River Stages for 1917; Climatological Data for the United States, by Sections; Instructions to Cooperative Observers; Daily Washington Weather Map; National Weather and Crop Bulletin; Snow and Ice Bulletin; Forecast cards, daily except Sundays and holidays; Weekly Forecasts; and Monthly Meteorological Summary for District of Columbia.

Some of the more important features of the publications of the past year are mentioned in the following:

Station annual summaries with comparative data forming very full local histories of the weather have continued to be published at the larger stations, and some heretofore without such summaries have been enabled to have them printed through courteous cooperation with officials at stations having printing facilities. These local climatic histories have a wide circulation and afford convenient means for the distribution of important information needed by the public.

The snow and ice bulletins were issued as usual, and some improvements were possible in the extent of the information heretofore obtainable in the remote mountain sections of the West, by the hearty cooperation of the Forest Service, and other agencies of the Government whose officials are required to make occasional visits in the high mountain districts forming the headwaters of important streams that supply the great irrigation systems. Reports on the snowfall during the past winter showed at the close a marked deficiency in the usual supply of well-packed snow over several important drainage systems. Later advices show a serious shortage of irrigation water in these regions, and much loss to crops in areas dependent thereon is reported. These bulletins have a large circulation and are in constant demand, particularly by the irrigation interests.

Several reprints of the sections of Bulletin W, "Climatology of the United States by Sections," were provided for during the year. The editions of many other sections are rapidly becoming exhausted, and it is hoped that practically the entire set can be brought down to date, more important data included, and all reprinted in the near future.

These publications afford a most satisfactory means of giving to the public important information of climatic conditions in all parts of the country and are invaluable in the work of this Bureau, which consists so largely in supplying weather information to all classes of individuals.

A rather full history of the cold winter of 1917–18, with a liberal display of charts showing some of the more important features of the pressure distribution and the resultant wind, temperature, and snowfall conditions over the North American Continent and the adjacent waters, as far as observations would permit, was issued during the year and given a wide distribution through the Monthly Weather Review.

Weather and Crop Bulletin.—The National Weather and Crop Bulletin was issued as in previous years without material change in policy. In addition to current weather and crop information, the bulletin contains, from time to time, charts and discussions bearing on the relation of climate to crops and agricultural operations. The value of this publication is evidenced by the popular demand for it, which has grown to such proportions as to severely tax the printing facilities of the Bureau in its issue.

During the active agricultural season a weather and crop summary is published at each section center, 42 in number, which is disseminated by bulletins and through the public press.

Pacific coast weather and crop service.—A special weather and crop service, covering seven of the far Western States, was continued during the year, with San Francisco as the district center. The bulletin issued at that point conforms in both scope and time of issue to the National Weather and Crop Bulletin and has proved of great value.

Monthly Weather Review.—Contributions to the Monthly Weather Review increased rapidly after the signing of the armistice, which liberated much material previously held as confidential and also allowed former contributors to turn from their war-time activities.

Beginning with the January, 1919, issue, the make-up of the Monthly Weather Review was consolidated by dividing the contents into two groups—Contributions and Bibliography and Weather of the Month—and some improvement was made in the attractiveness. The contents of the weather section were rearranged and some new features added, the most important being the current weather of the Atlantic and Pacific Oceans instead of that for the corresponding month a year before.

LIBRARY.

During the year 890 books and pamphlets were added to the library, bringing the total strength of the collection up to about 38,000. A considerable amount of bibliographic work has been done during the year, including the preparation of a nearly exhaustive bibliography on the climatology of South America. A new edition of the publication "Brief List of Meteorological Textbooks and Reference Books" has been prepared for the printer. Several of the more important foreign periodicals, whose receipt was interrupted during the war, are now being received and have been indexed to date.

INVESTIGATIONS IN SOLAR RADIATION.

The necessity of employing untrained observers led to the suspension of radiation measurements at Santa Fe, N. Mex., between September 12, 1918, and April 23, 1919, and to a marked reduction in the number of measurements at Lincoln, Nebr., during July and August, 1918. By the end of April, 1919, measurements were being obtained as heretofore at both these stations, and also at Madison, Wis., and Washington, D. C.

The assignment of the official in charge of solar-radiation investigations to the editorship of the Monthly Weather Review greatly curtailed his opportunity for research work. However, apparatus was tested and an observer trained in its use for the measurement of nocturnal radiation in orchards at Pomona, Calif., and at Medford, Oreg., in connection with the frost-protection investigations of the Weather Bureau. Measurements were also made of the rate at which heat is radiated from different types of oil heaters employed in orchard heating.

At the end of the fiscal year the work of computing from the radiation measurements available the diurnal and annual variations in radiation intensity with geographical position in the United States, and those which depend principally upon latitude, altitude, and the vapor content of the atmosphere, was well advanced. One of the by-products of the computation has been the determination of the relation between radiation intensity, expressed as a percentage of clear-sky intensity, and the percentage of cloudiness and of the possible hours of sunshine, as observed by eye and recorded automatically, respectively, at most Weather Bureau stations. The results of the computation, which will be shown graphically, will soon be ready for publication.

From the relation between the sun's total, or heat radiation, and the luminous solar radiation, heretofore determined, charts and tables are also being prepared showing the intensity of direct solar illumination on a surface normal to the solar rays, on a horizontal surface, and on vertical surfaces in the plane of the meridian and the prime vertical, respectively, and also the intensity of diffuse sky illumination on a horizontal surface. The illumination data are furnished in response to repeated and urgent requests from illuminating engineers and architects, and must be considered preliminary in their character, as the investigation has disclosed the need of extensions in the observational work, especially on the Pacific and Gulf coasts and in the northern tier of States.

INVESTIGATIONS IN SEISMOLOGY.

The important work of collecting and publishing earthquake data, begun December 1, 1914, has been continued during the year. These data are of two kinds, noninstrumental reports of earthquakes felt and instrumental records, often of quakes imperceptible to the senses and even originating at a great distance. The noninstrumental reports are rendered by all the regular stations of the Bureau, nearly 200 in number, and also by nearly all the Bureau's 4,500 cooperative observers. The instrumental records published by the Bureau have been obtained in part by instruments owned and operated by the

Bureau itself, one at Washington, D. C.; one at Northfield, Vt.; and one at Chicago, Ill., and partly through the cooperation of a number of additional stations distributed from Panama to Alaska and from the Hawaiian Islands to Porto Rico.

During the calendar year 1918, 127 separate earthquakes strong enough to be felt were reported from different parts of the continental United States. The great majority of these did no damage whatever; a few, however, were strong to severe. One of these, occurring on April 21, destroyed the business sections of Hemet and San Jacinto, in southern California. An equally severe quake occurred on May 28 in New Mexico, but did very little damage.

The chief earthquake damage in our outlying possessions occurred in Porto Rico on October 11 and 12. The records of this series of quakes obtained at Washington and Chicago were used by the commission especially delegated to study these disturbances.

In addition to the above regular work certain studies of meteorological phenomena have been made and several brief papers published.

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