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REPORT OF THE CHIEF OF THE WEATHER BUREAU:

UNITED STATES DEPARTMENT OF AGRICULTURE,
WEATHER BUREAU,
Washington, September 12, 1922.

SIR: I have the honor to submit herewith a report of the operations of the Weather Bureau during the fiscal year ended June 30, 1922.

Respectfully,

C. F. MARVIN,
Chief of Bureau.

Hon. HENRY C. WALLACE,
Secretary of Agriculture.

Another year of progress and growth of the Nation has passed, during which the Weather Bureau has maintained its operations and service in a normal and efficient manner. There is an increasing use made of the advices, warnings, and information supplied by the Weather Bureau to the public and those interested in agriculture, commerce, the industries, and navigation. Use of the Weather Bureau service means preparedness for future conditions and resulting economic benefits which constitute in a high degree the justification for the costs of conducting the work.

The program of the daily routine of service is far from a perfunctory one, founded as it is upon hundreds of twice-daily reports of ever-changing, ever-variable weather conditions and their distribution over a wide extent of territory which, in fact, now includes a great part of the Northern Hemisphere. Alert and intensive mental study of daily weather maps on the part of a corps of many experts is essential to the issue of successful advices, warnings, and information. Under the present unsatisfactory conditions of employment in the Weather Bureau, the conservation and recruiting of its corps of experts trained in this work is a very serious matter. In no way is this more convincingly demonstrated than by the results of the thorough and careful study made by the Bureau of Efficiency of the job schedules of Weather Bureau employees, resulting in the allocation of practically all employees of the bureau to salary grades according to the proposed reclassification, appreciably in advance of the compensation these efficient and deserving employees now receive. It seems appropriate to quote the following passage from my annual report of last year:

The long-promised and long-delayed reclassification of Government salaries is nowhere more greatly needed or justified than in the Weather Bureau. The imaginary economies in withholding urgently needed increases for properly strengthening and recruiting the personnel are not economies, but sap and

withdrawn

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

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injure the vitality of the organization and are certain to be reflected in future inferiority and inefficiency. Another legislative year should not go by without some concrete congressional enactment making the promised reclassification effective.

The outstanding feature of the past year as regards weather phenomena is undoubtedly the flood conditions. The year ending June 30, 1922, will rank as a great flood year for the entire Mississippi River Basin and others immediately adjacent thereto. Occurring at the time of the practical completion of the levee system and made excessive by nearly simultaneous flood stages in its large tributaries, the 1922 flood in the lower Mississippi River tested the efficiency of the levee method of flood protection in a way which is certain to be of great help to its proponent engineers and possibly will aid critics to show the weaknesses, if any, of such protective schemes.

A number of notable storms, some accompanied by heavy losses, are mentioned in later pages of this report, and still more complete and detailed accounts have been published in the current issues of the *Monthly Weather Review*, or will appear in separate bulletins.

FORECAST SERVICE.

A hurricane occurred on September 8 to 15 in the Atlantic, passing near Bermuda on the latter date, and another near Bermuda about the 12th, while a third severe cyclonic storm of tropical character occurred about the same time in the southwest Gulf region and probably caused the torrential rains producing the unprecedented floods in southern Texas of September 9 and 10.

The only hurricane that actually touched continental United States passed over the Florida Peninsula on October 25, 1921, and caused large property damage, mostly from high tides. This storm demonstrated the inestimable value of wireless communication in the hurricane-warning work of the Weather Bureau. It was first detected by a radio report from a ship in the western Caribbean Sea during the afternoon of October 21. Warnings were immediately broadcast to ships in that region. For five days this storm traveled entirely over water areas. Its center, direction of movement, intensity, and rate of progress were determined principally by vessel reports and warnings and advices were radioed four times daily to vessels in the south Atlantic, the Gulf of Mexico, and the Caribbean Sea. The hurricane was approaching the usual course of vessels bound to and from United States and Mexican ports on the Gulf coasts. The observations received from vessels during the progress of the storm clearly indicated that the warnings had been received and heeded. All ships whose courses were in its direction turned back or changed their routes to avoid the hurricane. Only one ship was lost and property amounting to hundreds of thousands of dollars, which could be moved or protected, was saved as a result of the timeliness and accuracy of the warnings.

On June 12, 1922, a tropical disturbance was located in the southwest portion of the Caribbean Sea. It was of moderate intensity but was accompanied by torrential rains in the vicinity of Swan Island. It moved into Honduras and Yucatan, and caused heavy floods in the rivers of Salvador and probably in the adjoining republics. The disturbance passed inland just south of the mouth of the

Rio Grande during the morning of June 16, progressed for some distance up that valley, and was attended by excessive rains which caused the greatest flood on record in the lower Rio Grande. Storm warnings were displayed on the southern Texas coast well in advance of the storm and at the same time advices were issued that heavy rains would occur in that region.

Ice storm in New England.—The most disastrous ice or glaze storm in the "memory of the oldest inhabitants" and within the period of official records occurred in New England during the last few days of November, 1921. It was the result of a cyclone that was central over South Carolina on the 27th and a slight barometric depression that apparently formed over the Atlantic a little to the southward of Nantucket during the night of November 26 and 27. The southern storm moved rapidly northeastward, gained great intensity, and on the evening of the 29th its center was off Cape Cod. It caused gales and high tides on the middle Atlantic and New England coasts and heavy precipitation. In parts of New England, especially Massachusetts, rain fell with air temperatures below the freezing point. Heavy snow had preceded the rain. The latter continued for about three days, during many hours of which period the surface temperatures were several degrees below freezing. The rain froze as it fell and coated trees, telegraph and telephone wires, and other objects. While gales occurred near and off the coast the wind in the ice-storm area was not very high, so that the damage was almost entirely due to the weight of the accumulated ice. Telegraph and telephone poles were broken, communication was paralyzed, and electric light plants were put out of commission. Many thousands of trees were ruined and telephone, telegraph, electric light, and railroad companies suffered heavy losses. Some idea of the accumulation of the ice on objects may be gained from the fact that ordinary insulated electric light wires were in many instances ice-coated 2 inches in diameter and weighed about 1.3 pounds to the foot. It required several days to remove the tangle of broken poles and wires and to restore partial transportation and communication services.

Storm on the Great Lakes.—A storm of extraordinary severity raged in the Lake region on December 17 and 18, 1921. The wind velocity at Buffalo equaled the highest on record at that station, 96 miles an hour, and the high winds continued for an unusually long period. During the three hours from 9 a. m. to noon it averaged 89.3 miles an hour and 75.6 miles an hour for a period of 12 hours. Timely and adequate warnings were issued, but there was large property damage notwithstanding the warnings and protective measures that were taken. Sixty-two vessels loaded with grain were anchored in the breakwater harbor at Buffalo but the high winds tore 27 of them from their moorings and swept them onto the beach. The Buffalo Commercial, in an editorial comment on the storm, said:

It is unlikely that there has been in years a storm of such sustained fury. That there was no greater damage to shipping is due, of course, to the fact that there was ample warning given by the Weather Bureau.

Heavy snowstorm.—One of the heaviest falls of snow on record in some of the Atlantic Coast States occurred during January 27, 28, and 29, 1922. The heavy snowfall was due to a storm that first appeared south of Florida on the 26th and moved up the coast. Its

movement north of Cape Hatteras was extremely slow. It was almost stationary for more than 24 hours. In the eastern portions of some of the Middle Atlantic States snow fell continuously for about 36 hours. Snow was especially deep in portions of North Carolina, Virginia, the District of Columbia, Maryland, eastern Pennsylvania, and New Jersey. At Washington, D. C., the official measurement was 28 inches, 8 inches more than the previous record, which latter was during the memorable storm of February 11 to 13, 1899. However, there was an important difference between the storms of 1899 and 1922. In 1899 the snow was accompanied by extremely low temperatures (a minimum of 15° below zero was recorded in Washington) while in the 1922 storm the temperature was only slightly below freezing. On the evening of January 28, while snow was still falling, the roof of the Knickerbocker Theater in Washington collapsed while a performance was in progress, killing 97 people and seriously injuring many others.

Severe squall in New York.—Squalls of a severity unequaled for many years occurred at several places on the Middle Atlantic and New England coasts during the afternoon of June 11, 1922. They were the result of a cyclone of marked intensity which was central over Lake Ontario on the morning of that day. The squalls attained greatest violence in the vicinity of New York City. Much property damage was caused by the high winds and many persons who were out in small pleasure-craft were drowned. Unfortunately the squall occurred on a Sunday afternoon when large numbers of pleasure boats were in use. On the morning of June 11 small-craft warnings were ordered for the entire Atlantic coast north of Chesapeake Bay and advices issued that squalls would occur during that afternoon and night. Commenting upon the great amount of damage done by Sunday afternoon's storm, and the many fatalities of which it was directly and indirectly the cause, the New York Times remarked that—

* * * all had been warned, first, by the definite prediction of the Weather Bureau in the morning papers, and, second, by the ominously-black clouds that had been gathering in the west for hours.

Cold waves, frosts, and miscellaneous warnings.—Warnings of cold waves in the cattle and stock-raising sections of the country were accurate and beneficial. Warnings of frosts and low temperatures for the benefit of truck and horticultural interests and shippers of perishable products are in increasing demand and use by those who have learned to utilize this important service.

Applications for special forecasts for special functions were numerous and far exceeded any year in the history of the Weather Bureau. During the summer and fall season scarcely a day passed without the forecasters at the five district forecast centers being called on for predictions for lawn parties, State, county, and local fairs, baseball games, social gatherings, etc. Careful consideration is given to all of these requests and in many instances special forecasts in more detail and for a longer period than is covered by the regular daily forecasts are given.

Special forecast service as heretofore was given in connection with airplane and dirigible flights, balloon contests, pigeon races, and for the President's cruises on the *Mayflower*.

Hurricane service.—Some additional funds were provided for this work for the fiscal year beginning with July 1, 1922, and plans were developed for their utilization. Stations of the first order will be established at Brownsville, Tex., and Apalachicola, Fla., and a trained observer will be located at Burrwood, La., during the current hurricane season. It is intended to secure more observations from ships and additional tide reports from points along the Gulf. However, there is great need for more observations from the areas in which these disturbances occur, and especially for more reports from ships.

Prior to the opening of the hurricane season two officials connected with the forecast service made a tour of inspection of all the stations on the south Atlantic and Gulf coasts. As a result of this inspection a number of changes providing for greater efficiency in the distribution of the hurricane warnings were put into effect, especially in the western Gulf coast section. Prompt distribution of all warnings and advices concerning hurricanes to all places within 130 miles of the coast having post office, telegraph office, or telephone communication were arranged. Much of this was made possible by the cordial cooperation of the railroad companies and other local agencies.

Vessel weather reports.—There is much need for more ship reports, especially from the Gulf of Mexico, the Caribbean Sea, and the Pacific Ocean. Ship observations have become an indispensable factor in forecast work and decidedly so in connection with the issuance of hurricane warnings. This is emphasized by the fact that ninety-tenths of the area in which hurricanes occur is water; that the diameter of a hurricane is frequently less than 200 miles, and that many of these storms do not come near land. The Weather Bureau has profited very much by the cordial cooperation of the Shipping Board and several of the large oil companies that operate fleets, from whom, in the aggregate, more weather observations were received from ships at sea than during any previous year.

A portion of the ship reports is furnished by cooperating companies without cost for the observation work, but for the greater part 50 cents an observation is paid. This is insufficient compensation for the time and experience involved in the work, and as a result it has been impossible to interest many ships from which valuable information might be obtained. It is hoped that funds may be provided whereby more adequate payment may be made for ship observations which will go far toward placing this important project on a more efficient and satisfactory basis.

Forecasts in aid of aviation.—The activities in the aid of aviation materially increased during the year. Daily forecasts covering 14 zones into which the country is divided were issued regularly and furnished to Army, Navy, and Post Office officials and to the flying fields. In addition, arrangements were made during the year for broadcasting upper-air forecasts for all the zones, except two, from naval radio stations.

Separate and more detailed forecasts were begun in January, 1922, at the request of the Air Service of the Army for the three air routes from Washington to Norfolk, Va., to Long Island, N. Y., and to Dayton, Ohio. They are issued twice daily and contain advices as to weather conditions to be encountered from the surface

up to 5,000 feet. These forecasts also are published in morning newspapers in Washington and in Dayton. The requests for special forecasts and weather information from individual aviators before beginning flights have largely increased. This latter information for the most part is supplied by the forecasters by telephone directly to the fliers.

Important and extensive cooperative arrangements between the Air Service and the Weather Bureau were established during the year for the purpose of bringing the aviators of the former service and Weather Bureau officials in the field into closer contact to the end that forecasts, warnings, and weather information may be made of the greatest possible benefit to Army aviators. This plan involves the visits by Air Service aviators to the field stations of the Weather Bureau for the purpose of personal acquaintanceship, the discussion of weather conditions peculiar to the various sections of the country over which flights are made, the acquiring of knowledge of the facilities at each station, for the furnishing of forecasts and information desired by aviators, and the perfecting of details for the securing of such information promptly and whenever required.

The Weather Bureau collects at its field stations twice-daily observations of weather from all parts of the country at 8 a. m. and 8 p. m., seventy-fifth meridian time. Each of the Air Service fields calls the nearest Weather Bureau station by telephone every morning and evening when flying operations are being carried out for the purpose of obtaining the weather forecasts and reports. Fliers when away from their stations are authorized to telegraph or telephone any Weather Bureau station at any time for information as to prevailing and expected weather conditions in a particular section and to receive a prepaid reply. This feature of the service is designed to enable fliers who for any reason are forced to land at other than regular flying fields to secure all possible information which will enable them to avoid danger in returning to their home stations or in reaching their destinations.

Knowledge of the science of meteorology is an important adjunct to expert flying and a part of the cooperation between the two services includes the delivery of lectures by meteorologists of the Weather Bureau to Air Service aviators on the general work of the weather service, the climatology of various sections of the country, air currents, the physics of the air, and on other meteorological subjects pertinent to aviation. Already a number of these lectures have been delivered and plans are being developed for a material extension of this work.

Circulars announcing the details of the cooperation were issued to all field stations of the two services, in which the Chief of the Air Service enjoined that the matter is "of most vital importance at the present time in connection with cross-country flying and it is desired that every effort be made to carry out the provisions as outlined."

A similar cooperation exists with the aerological section of the Navy Department. Forecasts and weather reports are furnished with all possible completeness and dispatch to naval bases at which flying operations are conducted. A representative of that service is

given desk space and facilities in the forecast room of the Weather Bureau at Washington, where he prepares each morning a weather map synchronously with the charts used for the issuing of the official forecasts of the Weather Bureau. These official forecasts and weather reports are telephoned by him directly from the Weather Bureau office to the naval bases. In this manner the information and advices are transmitted with the last possible delay and with effective results.

Service was rendered for a number of special airplane flights during the year by furnishing detailed forecasts and extra observations at frequent intervals along the route to be followed. One instance of this kind was the journey of a squadron of 12 seaplanes, much of it over land, from Norfolk, Va., to Pensacola, Fla., by way of the Atlantic coast line to Fernandina, Fla., thence overland across the Florida Peninsula to Cedar Keys and from that point to Pensacola. This journey was undertaken in July, and the various steps in the trips were made in accordance with the forecasts and advices furnished by the Weather Bureau. A seaplane can not land with safety on terra firma, and it was of the utmost importance, both to the success of the undertaking and in safeguarding the lives of the aviators, that no unfavorable weather conditions be encountered, especially for the long overland jump from Fernandina to Cedar Keys. The trip was accomplished without a serious mishap and the commander of the squadron in acknowledging the assistance rendered by the forecaster of the Weather Bureau wrote as follows:

The commander of air squadrons desires to express his appreciation of the excellent cooperation of the Weather Bureau, both of Washington and Jacksonville, in furnishing weather reports to the air squadrons for the recent flight of 12 F-5-L seaplanes across Florida. The safety of the passage undoubtedly was made more certain thereby, as on the receipt of adverse weather reports the passage of 7 planes was delayed two days, during which severe thunderstorms and rain squalls would have been encountered.

RADIO DISTRIBUTION OF FORECASTS AND WEATHER INFORMATION.

In the annual report for last year it was stated that radio telegraphy had reached a stage where it must be recognized as a potential medium for the dissemination of weather forecasts, warnings, and information to agricultural interests. It became a realization during the past year. Although wireless telegraphy has been an invaluable factor for many years in the collection of observations from ships and in the distribution of storm and hurricane warnings and weather information to vessels at sea, it was used only to a limited extent for interior service because all messages were necessarily transmitted in the telegraphic code of dots and dashes. With the introduction of radiotelephony, which makes it possible for anyone to receive messages in spoken words, the broadcasting of information over the interior has increased enormously. A year ago the daily State forecasts were being broadcast from 12 radio stations, representing only 7 States, and principally by radiotelegraphy. On July 1, 1922, 98 stations in 35 States were daily broadcasting weather forecasts and warnings. Weekly reports on the effect of weather on crops and highways, and other information issued by the Weather Bureau for the public benefit, also are disseminated by many of

them. Radiotelephony is now utilized almost exclusively in this work.

The Weather Bureau does not own or operate any wireless equipment. The radio distribution work is accomplished through plants operated by other Government agencies, by corporations and by private individuals, and without expense to the Weather Bureau. An exclusive wave length of 485 meters has been assigned by the Bureau of Navigation, Department of Commerce, for the broadcasting of weather forecasts and market reports. No station can use this wave length unless specifically licensed to do so. In order that unnecessary crowding of the air and interference with schedules may be avoided licenses are granted to only two stations in any city or community. This necessarily eliminates a considerable number of broadcasting stations that otherwise would gladly cooperate in the work. On July 1, 1922, there were about 400 licensed broadcasting stations in the United States. Therefore, about 25 per cent of all the licensed broadcasting stations in the country are already engaged in rendering valuable distribution service to the public. A considerable portion of the remainder would cooperate if sufficient funds were available to provide them with the forecasts and warnings.

The entire project has involved the Weather Bureau in very little cost. For the most part the broadcasting stations are located in or near cities where first-order meteorological stations are maintained. The information to be broadcast is supplied to them by telephone without additional expense. Offers of cooperation by many broadcasting stations have been reluctantly declined because of the expense involved in the telegraphing or telephoning the forecasts and warnings to them. The service could be placed on a much higher basis of efficiency and materially extended if funds were available for the telegraphing of the forecasts, warnings and information to radio stations not now included in the system and for additional employees which would be required in the work.

The great value of radiotelephony as a means for disseminating weather forecasts and warnings to the people already has been demonstrated. Its future usefulness can not be estimated. The Weather Bureau was organized by Congress for the benefit of "agriculture, commerce, and navigation." Heretofore, a large portion of the farmers of the country were so located that they could not be supplied by means of newspapers, telegraph, etc., with the daily forecasts and warnings in time to be of service to them. The extension of telephone lines into rural communities overcame only a part of this difficulty. Radiotelegraphy was of slight help and necessitated learning the telegraphic code. The marvelous advance in radiotelephony has entirely changed this situation. It requires only a limited equipment to receive radiotelephone messages. Thousands of farmers installed such receiving apparatus during the past year and are now obtaining the weather forecasts and warnings, which are so important to their operations, as promptly and effectively as the business interests in urban communities. A great future increase is inevitable.

Another important accomplishment in radio work during the year was the inauguration of a program of broadcasting daily,

Sundays and holidays included, of the regular twice-daily forecasts, cold wave, frost, and other warnings and information issued for the States comprised in the Washington and Chicago forecast districts. On Wednesday during April to November, inclusive, a summary of weather conditions as they affected crops during the preceding week also is included. These disseminations are made from the naval radio stations at Arlington, Va., and Great Lakes, Ill., respectively. This service began June 20, 1922, for the Chicago district and on June 26, 1922, for the Washington district. Radiotelegraphy and high wave-lengths are utilized for these disseminations as telegraphy is more reliable than telephony for long-range transmissions. All the States included in the two districts are within the range of the naval radio stations at Arlington and Great Lakes. Radio receiving stations that are equipped for high wave-length receptions receive direct service thereby. Local radiophone broadcasting stations, most of which are in charge of operators having the required proficiency in radiotelegraph, also are enabled to secure the forecasts, warnings, etc., for localized radiophone broadcasting.

The primary broadcasting of the State forecasts and summaries from the district forecast centers at Washington and Chicago is an immediate adaptation by the Weather Bureau of plans approved by the interdepartmental radio committee, which contemplates the use of a few high-powered Government radio stations for broadcasting official information by radiotelegraphy for the entire country. Plans are now in formation for beginning the broadcasting about September 1, 1922, of the State forecasts, summaries, etc., for the States in the San Francisco forecast district. It is hoped that similar plans for the remaining districts—New Orleans and Denver—will be effected within a few months, thus bringing all the States into the system.

Material extensions were also made during the year in the radio bulletin service for the special benefit of marine and aviation interests. On March 15, 1922, broadcasting of a major bulletin from Goat Island (near San Francisco) was begun, and localized bulletins from Tatoosh Island, Wash.; North Head, Wash.; Eureka, Calif.; San Pedro, Calif.; and Dutch Harbor, Alaska. On April 15, 1922, service of the same character was inaugurated for the Great Lakes regions, the major bulletins being disseminated from Great Lakes, Ill.; and the local bulletins from Alpena, Mich.; Buffalo, N. Y.; Chicago, Ill.; Cleveland, Ohio; and Duluth, Minn., replacing a limited broadcasting service previously conducted at those points. The radio broadcasting work on the Great Lakes and the Pacific coast is on the same basis as on the Atlantic and Gulf coasts. The character of the major and the local bulletins were described in the report for 1921. In all of this work the Weather Bureau is indebted to the Director of the Office of Communications of the Navy Department and the officials in charge of the various naval radio stations for cordial and efficient cooperation.

Exchange of weather reports.—Meteorology is essentially an international science. Cyclones and anticyclones have no regard for boundary lines or 3-mile limits. Exchange of weather reports among all the nations in the Northern Hemisphere is necessary for the de-

velopment of the science and for improvement in forecasting. Navigation of the air, which has advanced to the point where transoceanic and round-the-world flights have been demonstrated as practicable, has emphasized the need for the securing of daily reports of prevailing weather conditions from all parts of the world and the issuing of daily international weather charts. Nearly all countries maintain meteorological services and the observations are available. It is largely a question of providing means for prompt and effective transmission and the publishing of the information. This is a project in which cooperation between the various countries is necessary and naturally involves a proportionate payment of the costs. The depressed financial conditions existing throughout the world prevents any serious consideration of such a project at the present time. However, the United States Weather Bureau has been able to arrange for the collecting of a considerable number of foreign reports for its own needs and purposes and at negligible cost.

Prior to the war a few reports were received from Mexico, Europe, Asia, and from the Far East. These were entirely suspended during the war. Arrangements were made for their resumption during the year just ended, with a material increase in the number of reports. There was no interruption to the exchange of reports between the United States and Canada and in the obtaining of observations from Alaska, Cuba, the West Indies, and from Central American countries.

Including the reports obtained under the plans put into operation during the past year, observations are now received daily from 40 stations in Canada; 9 in Alaska; 22 in European countries, embracing England, Spain, Switzerland, Germany, Austria, Czechoslovakia, Poland, Denmark, Norway, Sweden, Iceland, and the Azores; 36 in the West Indies, Cuba, and Central America; 17 in Mexico; and 12 in the Pacific and the Far East, including the Hawaiian Islands, Guam, Midway Island, the Philippines, Japan, and China. These reports are charted and are utilized in connection with the regular forecast and storm-warning work of the bureau.

Arrangements also were made during the year for supplying to the French meteorological service of a daily radiogram containing observations taken at about 40 stations in the United States and a similar message soon will be sent to the meteorological service of the Philippines and Japan. The reports sent to France are broadcast by radio from the Eiffel Tower for the benefit of the European meteorological services within its range. The United States Weather Bureau receives in exchange a daily message by radio, containing reports from European countries. These exchanges are made possible without cost by the cooperation of the Office of Communication of the Navy Department.

The Amundsen polar expedition started from Seattle on June 1, 1922. The exploring ship *Maud* is equipped with radio apparatus and has a scientific officer on board. It is the plan of this expedition to pass through the Bering Straits, reach the farthest point north that is possible, become frozen in the ice, drift therewith for an estimated period of about three years and come into the open sea to the northeastward of Greenland. The ship expects to maintain radio communications with the United States Signal Corps station at Nome, Alaska, for nearly two years. Arrangements were

made with the expedition to take twice-daily weather observations and transmit them to the Weather Bureau. A number of observations already have been received. This arrangement will provide valuable observations from the most northern points at which observations have ever been taken and transmitted as a daily program. The ship is also equipped with pilot balloons and it is expected that these observations also will be radiographed daily.

Orchard spraying service.—The special forecast service in connection with the orchard spraying activities in the apple-growing sections in the northern part of New York was continued during the past season, and similar work to a limited extent was conducted in localities in Pennsylvania, West Virginia, and Virginia. The forecasts for the New York areas were distributed in previous seasons from the Weather Bureau office at Rochester, but during the past season this work was conducted from Ithaca, where closer cooperation with the State Extension Service and the county agents was obtainable. This arrangement proved more satisfactory and effective work was accomplished.

Damage from frost is not a serious menace to apple growing in northern New York. Serious loss from this cause occurs on an average less than once in 10 years. Scab, a fungous disease, is the worst enemy. It remains dormant so long as the weather is dry. The spores come into activity when moistened and, unless killed by spraying, trees may become infected within 24 hours. The problem is to apply the spray just before a rain because when the rains occur the fungi begin to grow and are killed by the poison in the spray. If the spray is applied and rains do not occur within about three days thereafter the effect of the poison is minimized or lost entirely. There are about 12,000 commercial apple growers in seven counties in New York who are equipped for spraying. At least three applications are necessary each season. It is estimated that the total cost of apple-tree spraying for one season in the seven counties is about \$3,500,000. Therefore, accurate and timely forecasts of the occurrence of rains in the spraying season are of great importance to the growers in determining when the spray shall be applied, and the responsibility placed on the Weather Bureau in giving correct information is apparent. If the forecaster fails to predict a rain and spray is not applied the trees become irremediably affected; if rain is predicted and spray is applied but the rains fail to come the effect of the spray is lost entirely, or considerably reduced, and heavy loss results.

The following is quoted from a report made on this special forecast work during the past season by Professor Crosby, of the Department of Entomology, and Professor Horner, plant pathologist of the New York State Extension, which was based on information submitted by field assistants and county agents:

The special forecasts for the spray service were sent to the following eight counties: Orleans, Monroe, Wayne, Genesee, Onondaga, Chautauqua, and Ulster. They were used constantly by the field assistants in timing their recommendations for spray. In the case of sprays involving fungous diseases these special forecasts are especially important, because it is well known that fungous diseases are vitally affected by the periods of wet weather. Four of the most important counties had a telephone relay system by means of which it was possible to warn the growers quickly when it was time to apply the spray. This system was used throughout the season whenever occasion demanded.

At other times and in counties where the relay system was not used, circular letters and post cards were used to broadcast the information.

The number of fruit growers reached directly by this service was 2,500. It is a well-known fact, however, that nearly every grower who receives the service has at least one neighbor who gets the information from him. This would nearly double the number benefiting by this service.

We feel strongly that these special weather forecasts are of great importance in making the Weather Bureau of real service to our fruit growers and general farmers and that definite provision for the service is essential for getting the full value out of the Weather Bureau.

The New York State Horticultural Society at its summer meeting held at Leroy, N. Y., passed resolutions that "the Government weather forecasts given out in connection with the spray service in New York State has been of great assistance to the fruit growers; we express our appreciation of such service and request its continuance."

The spray forecast work has been conducted as a demonstration of the practicability and value of special forecasts for the benefit of orchardists. The project, although conducted in a limited way, has proved highly successful. It will not be possible, however, to place this project on an adequate and permanent basis and to extend it to other sections, where there is fully as much need therefor, unless additional funds are provided for the work.

RIVER AND FLOOD SERVICE.

The year of 1922 was unprecedented as to the number and wide distribution of floods, especially with reference to the Illinois Valley, the lower Mississippi and Texas rivers, including the Rio Grande. Stages beyond all previous records were attained in many cases and during the month of April almost every stream east of the Rocky Mountains was in flood, entailing heavy demands upon the Weather Bureau for flood service and information, with corresponding increased expenses for operations.

The lower Mississippi River floods.—The river passed the flood stage of 45 feet at Cairo, Ill., on March 16, and did not fall below the flood stage of 35 feet at Baton Rouge, La., until June 12, a total period of 89 days. During the flood the highest stages of record were reached from the mouth of the Arkansas River to the Passes, and had the levees remained intact probably another foot would have been added to the flood crests below Vicksburg, Miss.

There were four important crevasses in the levees, all within the State of Louisiana, and of these the greatest occurred on the right bank near Ferriday, La. The others were at Hamburg, Poydras, and Myrtle Grove, La.

About 13,200 square miles of lands were overflowed, about 4,400 square miles less than in 1912, the deficiency occurring in the Yazoo district.

The total reported losses were about \$17,000,000, of which about one-half were in prospective crops. Many losses, especially those to railroads, were unreported.

There was no loss of human life, as the warnings of the floods were several weeks in advance of their occurrence.

Summary of flood losses.—The Texas floods of September came with a suddenness that in many localities defied any precautionary

measures whatever and caused the loss of 215 lives. Incompletely reported losses of property and crops amount to more than \$19,000,000. This amount actually exceeds the total losses caused by the great floods of the following spring in the Mississippi River and its tributaries. The total reported for these latter floods was \$17,087,790, and approximately 15,000 square miles of land were overflowed, over 13,000 square miles of which were below the mouth of the Ohio River. The reported grand total of flood losses for the year was about \$52,000,000.

In April and May Texas suffered again to the extent of at least \$3,000,000, with the highest stages of record in some of the rivers, and still a third time in June, when the great Rio Grande flood did damage to the extent of about \$3,000,000, making a total for the year for the State of Texas of about \$25,000,000, the major portion of which was in crops, either in hand or prospective.

In April, floods in the Connecticut Valley caused nearly \$1,000,000 damage, and the May floods in the Colorado River also proved destructive by reason of the breaking of a levee on the right bank of the river at Hauser Bend, Calif., in the Palo Verde Valley. The crevasse attained a width of 1,300 feet, and the waters flooded 30,000 acres of land, 10,000 of which were under cultivation. The loss and damage amounted to about \$1,000,000.

Destructive local floods.—An unusual number of destructive local floods occurred in creeks and other small streams, such as those in the State of Washington in December, 1921, at Burlington, Kans., in March, 1922, and in eastern New York, northeastern Pennsylvania, and Wisconsin in June, with estimated total damage of \$5,750,000, excluding that in Wisconsin, of which no report of losses was received.

Flood warnings.—The flood warnings issued by the Weather Bureau were instrumental in saving property to the reported value of \$8,166,500. Growing crops, of course, can not be saved, nor as a rule can houses, roads, bridges, etc., so that the figures given above represent mainly live stock and other portable property, and the statistics received indicate that the losses of property of this kind were very small.

Summary of operations.—Natural expansion of river and flood work has been limited to the addition of a few scattered stations and the inauguration at very small cost of flood service on the Platte River. This service is maintained through cooperation with the department of public works of the State of Nebraska, which supplied the gauges and at two stations the gauge readers. Limited extensions were also made in southeastern Missouri.

A new river district was established at San Antonio, Tex., being simply a portion of the old river district of Houston, Tex. The change was made in the interest of efficiency of operation and without additional charge upon the service as a whole. Another change was that of consolidation of the river districts of Iola, Kans., and Fort Smith, Ark., with headquarters at the latter station.

The compilation of the histories of all the river stations, about 500 in number, has been brought to virtual completion and now serves to bring within a very small compass a large mass of valuable material that was unavailable and liable to loss.

Extensions proposed.—Increased activities in hydrological engineering and the persistent extension of agricultural and commercial interests demand that the river and flood service keep pace with them. More river-gaging stations and much more intensive measurement of precipitation are needed. These things can be accomplished with a very reasonable increase in appropriations and it is hoped that funds will soon be available. As it is, the service is virtually at a standstill so far as field extensions are concerned. One vital need is that of an engineer who can serve as a field man, inspecting stations, making repairs to equipment, and making surveys for the establishment of permanent benchmarks and other measurements of precision. These surveys are of highest importance in their relation to projects involving water supply for irrigation and power purposes.

Snow surveys.—The snow surveys and measurements continued as before. This service is maintained for the purpose of affording each spring to irrigation and hydroelectrical engineers a reasonably accurate forecast of the supply of water that will be available during the coming summer and autumn.

The great importance of such work is obvious, but it requires more intensive local field work in making surveys of snow depths and snow density at the end of each winter, to the end that more accurate forecasts of future water supply may be made. The development of efforts of this character must await further appropriations.

Wagon Wheel Gap, Colo.—The experiment station maintained at Wagon Wheel Gap, Colo., has been continued in accordance with the established program. The whole project will be completed within two or three years and the final results communicated as soon as possible thereafter.

AGRICULTURAL METEOROLOGY.

The usual weekly and daily weather and crop services were continued during the year. The failure of Congress to enact legislation for the continuation of certain publications made it necessary to suspend the issue of the National Weather and Crop Bulletin at the close of November. Beginning with the 1st of January, however, the regular weekly summaries of weather conditions and their effect on vegetation and farm work were resumed, publication being effected through the medium of the new bulletin issued by the Department of Agriculture, known as Weather, Crops, and Markets. The weekly corn and wheat region bulletin was continued at Chicago and a similar bulletin published at New Orleans covering the Cotton Belt, while weekly State summaries have been issued at the various section centers.

Special services.—Daily bulletins were published at various stations throughout the principal agricultural sections of the country, giving in tabular form weather conditions prevailing during the 24 hours preceding. These services were maintained in the interests of the cereal, cotton, sugar, and rice production of the country. In addition weekly cattle region bulletins have been issued showing weather conditions over the range areas of Texas, New Mexico, Ari-

zona, Utah, Wyoming, and Nevada. A demand for an extension of this service to other important western grazing areas continued, while the corn and wheat region service should be extended to some important grain States where the lack of funds has prevented extension.

Fruit-frost service.—A special appropriation of \$9,000 was provided by Congress for the extension of the fruit-frost service of the bureau during the fiscal year, and as a result this service was materially improved. Three special representatives were assigned to this work in the citrus and deciduous fruit districts of the Pacific coast. Active operations were maintained in a number of places in California, at Medford, Oreg., and at Spokane and Yakima, Wash., under the supervision of special employees.

This service was of special value to citrus fruit growers in southern California, where the severest freeze in many years was experienced in January, resulting in enormous loss. Forecasts of minimum temperatures during the period of critical weather conditions were remarkably accurate, and the cooperation of the bureau with the fruit growers was instrumental in saving much fruit that would otherwise have been lost. The appreciation of this service by the citrus interests is indicated by expressions in the following communications received by the bureau:

[From the Pomona Fruit Growers' Exchange.]

Confirming our conversation regarding the value of your service to the citrus industry of this district; we find in the district covered by the Pomona station that there are approximately 7,000 acres equipped for firing and making use of your forecast. The value of the crop in this acreage is fully \$2,800,000. There are within this territory about 9,000 acres not prepared to protect against frost. The crop from the unprotected acreage is practically a total loss, besides injury to the trees of a large proportion of this unprotected acreage.

The growers having equipment and using your service burned about 1,380,000 gallons of oil and we consider the information you have furnished has prevented unnecessary burning of a much larger quantity.

We feel that the investigation of frost prevention being carried on by the Weather Bureau is of great importance and we hope there will be nothing to interfere with the continuation of the work.

[From the Fontana Farms Co.]

In reply to your recent inquiry concerning the value of the special service of the Weather Bureau in this section, I would say that growers hereabouts regard the service as invaluable and indispensable.

The action of this company in voting to subscribe a sum of money at the beginning of the frost season to assist in this work may be taken as a reliable indication that such a service as this is needed.

During the recent freeze that caused so much damage to the citrus industry, authentic temperature records taken in this locality were of very great value as an indication of the degree of cold fruit in this locality was subjected to.

We trust that this service may be continued during future years and assure you of our support in your work.

After the close of the frost season in southern California, special bureau representatives rendered successful services in the central and northern Pacific States, particularly in the vicinity of Fresno, in the Santa Clara Valley, Calif., in the Medford district of Oregon, and in the fruit sections of eastern Washington.

Other fruit-frost activities during the year were as follows:

Ilwaco, Wash.—The cranberry industry has assumed large proportions near the mouth of the Columbia River. Little interest has

heretofore been taken by the growers in the available service of the Weather Bureau, but in the spring of 1922, when heavy frost damage occurred, urgent request for a frost service was made. Action was taken to grant this request in so far as the funds of the bureau would permit.

Roswell, N. Mex.—No effort had been made to protect fruit orchards in this district until the present year when many orchards were heated on a number of occasions on receipt of Weather Bureau advices of probable damaging temperatures. Much interest is now shown in the work of frost protection, and practically all the commercial orchards are equipped with frost-fighting devices.

Yuma, Ariz.—The temperature survey in the Yuma, Ariz., section that was started a few years ago was enlarged by the establishment of a number of additional stations. This survey is being made primarily in the interests of the citrus-fruit industry, which is assuming considerable proportions in that section.

Colorado.—Special services were continued in the Gunnison Valley and in the vicinity of Grand Junction. About 500 acres of orchards are protected in the latter section, and the possibilities of thorough protection by adequate heating were demonstrated at Fruitvale, where an orchard was brought through the cold spell unjured, notwithstanding the minimum temperature fell to 17° F.

New Jersey.—A representative of the Weather Bureau was assigned to New Lisbon during the frost-danger period of the spring of 1922, where a special frost service is maintained in the interest of the cranberry industry in that section.

A fruit-frost service was established during the year at Wichita, Kans. Three special stations were established and frost warnings were distributed to fruit growers over an extended area. In addition, preliminary services were established in Illinois and parts of Florida.

Cooperation.—Quite extensive cooperation has been had during the year with the Bureau of Markets and Crop Estimates in the Great Plains project, an investigation which that bureau is carrying forward in the interest of agriculture in the Great Plains States. Other cooperation with the various bureaus of the department was continued.

Investigations.—Mathematical studies of the relation between weather and crops was continued as the routine duties of the division permitted. Some very close relations were established between the weather and yields of corn and of oats in some important producing areas, and the importance of the establishment of meteorological stations at agricultural experiment stations becomes more apparent as investigations of this character are continued. Papers published during the year are:

HARRICK, A. M. "Fruit Frost Work in the Grand Valley of Colorado" (Monthly Weather Review, October, 1921).

KINCER, J. B. "Relation of Climate to the Geographic Distribution of Crops in the United States" (Ecology, April, 1922).

YOUNG, F. D., and ELLISON, E. S. "Notes on 1922 Low Temperatures in California" (California Citrograph, April, 1922).

STATIONS AND ACCOUNTS DIVISION.

WEATHER BUREAU QUARTERS AT FIELD STATIONS (OUTSIDE OF WASHINGTON, D. C.).

Since the beginning of the United States Meteorological Service in 1870 it has been a uniform policy to secure quarters for its field stations in Federal buildings, whenever such buildings are suitable for the purpose, and it is practicable to do so. Occasionally where Federal buildings were not available Congress has authorized the erection of special observatory buildings and, in several instances, free accommodations have been secured in State colleges or university buildings. Thus far, in a total of 220 stations, 129 are so situated that no rentals are paid for local offices and accommodations, as follows:

Free quarters and accommodations:	
Observatory buildings (owned and controlled by the Weather Bureau)-----	148
State university buildings-----	5
Federal buildings-----	78
Total free of rental-----	129
Rented buildings, etc., owned by individuals or corporations:	
Office buildings-----	90
Buildings with grounds, aerological stations-----	6
Total number of rented buildings partly or wholly occupied-----	96
Total-----	225

Under the program of economy in expenditure of appropriations, it has not been possible to keep the 48 buildings owned and controlled by the bureau in thoroughly good condition, and some of these are urgently in need of repairs and repainting for proper preservation. The more urgent cases, however, are now receiving attention.

At San Juan, P. R., in February, 1922, alterations to the building served to add two rooms to provide needed space for assistant observers for the West Indian Section Center work.

The Weather Bureau building at Narragansett Pier, R. I., still continues vacant and in charge of a caretaker. To avoid continual expense for upkeep, this surplus property should be disposed of by sale or otherwise at the earliest practicable date.

After an exhaustive inquiry by a special commission, no practical use has been found by the branches of the Department of Agriculture or other Government departments for the reservation and buildings on the Blue Ridge Mountains, in Loudoun and Clarke Counties, Va., known as Mount Weather. In harmony with suggestion of members of the Committee on Agriculture of the House of Representatives, this bureau has informally but vigorously prosecuted inquiries in regard to a possible purchaser and offer for this property. In this connection we have communicated with and interviewed the owners of properties near the Mount Weather reservation, others who

¹ Not including those at Mount Weather, Va., and Narragansett Pier, R. I.

² Five stations have quarters in two buildings each, viz.: Cape Henry, Va., 2 Weather Bureau; Cincinnati, Ohio, and Oklahoma, Okla., Weather Bureau and Federal; Columbus, Ohio, 2 rented; and Honolulu, Hawaii, Federal and rented buildings (temporarily).

are familiar with the property and its possible utilization and sale; also realtors having a large clientele who are familiar with the property. In addition, supplementing such inquiries at Washington, a representative of the bureau has visited the reservation and the villages and towns in its vicinity for the purpose of bringing the possible sale of the property to the attention of interested parties who might be prevailed upon to make a preliminary proposal or offer for the purchase of this property. Although prosecuting these inquiries diligently throughout the year, no definite proposals have yet been received, and efforts are still being made to secure some preliminary proposal in more or less definite form in regard to the property.

The buildings and grounds have been inspected by officers of the bureau and repairs necessary for their maintenance in good condition are being made or are planned for in the near future. The property and buildings are in good condition and keepers have been placed in charge of the reservation and buildings for their protection and care. All such expenses of upkeep and necessary repairs amounting to about \$2,000 annually constitute an unprofitable charge upon appropriations and no further delay should occur in the enactment of necessary legislation to authorize the sale and disposal of this property substantially as recommended by the commission appointed to report on the disposition thereof.

Weather Bureau quarters in Federal buildings—Upon completion of new Federal buildings at Santa Fe, N. Mex., and Honolulu, Hawaii, Weather Bureau offices at those places were removed from rented quarters, April 1 and May 1, 1922, respectively, thus effecting a saving of \$1,920 per annum in rentals heretofore paid, part of rented quarters at Honolulu being retained temporarily for special comparative observations.

By reason of expiration of existing leases June 30, 1922, for rented quarters at Weather Bureau field stations, consideration was given changes affecting in all 23 stations at which \$24,179 was paid for rentals during last fiscal year. Of these, Santa Fe, N. Mex., and Honolulu, Hawaii, were moved from rented to free quarters as stated above. At 12 stations no increases were asked in rentals now and heretofore paid, while at the 9 remaining stations the increase demanded was \$4,880 on a total rental involved of \$9,280, or an average of about 53 per cent. Such exorbitant increase could not be paid with limited funds available, and the situation was met by curtailment of needed space at Atlanta, Ga., and Asheville, N. C., and other compromises. The total increased rental required for next fiscal year for the entire field station service of the Bureau was finally reduced to an increase of \$1,077.

New stations.—To meet increasing needs for Weather Bureau information, especially during the hurricane season, a first-order station was established June 1, 1922, at Apalachicola, Fla. Quarters were obtained in the Grady Building, No. 200 Water Street.

In July, 1921, in compliance with instructions from Bureau of the Budget, there was set aside the sum of \$26,000 from the appropriations for the Weather Bureau, 1922, as a "reserve," to be held, if possible, as a minimum unexpended amount to the end of the fiscal year. This was done, notwithstanding urgent demands for the extension of Weather Bureau activities in various directions and for the maintenance and upkeep of existing stations, with result that a further

saving of \$6,701.98 was effected, making a total credit for the year about \$32,700.

TELEGRAPH DIVISION.

Telegraphic conditions, both national and local, were more satisfactory during the past year than for several years previous, except for nearly two months, when there was a shortage of force at the central office, due to resignations.

Maintenance by the Western Union Telegraph Co. of the 23 telegraphic circuits has been conducted in a generally excellent manner and comparatively few complaints of defective or delayed service in transmission of special messages have been received. Reception of cable and wireless reports during the six-months' hurricane season beginning June 1, 1921, was not as prompt as was desired, although efforts in various directions were made to effect improvement. More reports from ships were handled than in any preceding year, the increase being largely due to the cooperation extended by the Shipping Board in transmitting reports from many ships twice daily, without cost for wireless tolls, and the gradual extension of general service.

Examination and audit of telegraph, cable, and wireless accounts, all of which is performed by the division operators, was somewhat delayed during the first part of the fiscal year because of the greatly increased work incident to the six-months' hurricane season and of the operator shortage above mentioned. This work was brought up to date, however, during the spring. But little opportunity has been afforded, unfortunately, for such desirable lines of work as revision and improvement of division records, collecting and compiling data for ready reference—largely used by other divisions—investigation of the possibility of more efficient methods of conducting division work, etc.

Contracts with various wireless telegraph companies, with numerous telephone companies, and with several telegraph companies were renewed for the fiscal year 1923 on terms prevailing in former years. Those with the Western Union Telegraph Co. and the New England Telephone & Telegraph Co. are unexecuted at this writing.

A saving of funds to the extent of about \$1,000 per annum was effected by rerouting certain forecast and crop messages destined to far-western points.

Assignment of an additional operator last fall has enabled the routine telegraph work to proceed in a much more satisfactory manner than previously, permitting, as it did, placing another operator on the early morning and night forces during the hurricane season and thus facilitating reception of the large volume of cable and wireless business transmitted during this period.

Weather Bureau telegraph and telephone lines.—These lines, nine in number, with combined length of approximately 289 miles, including approximately 66 miles of cable and 15 miles of leased wire, worked without serious interruptions and in a generally excellent manner, except the Block Island-Matunuck Beach submarine cable. Over these lines valuable meteorological observations, forecasts and warnings, vessel and wreck reports, and general Government business are transmitted, and five of them carry a volume of commercial business yielding revenue which accrues to the Government.

About 25,000 commercial telegrams were transmitted during the year; about 15,000 Government messages and telephone calls and about 3,000 long-distance telephone calls were handled.

While all these lines are maintained primarily to carry important Weather Bureau reports and warnings where no commercial lines are available for the service, nevertheless the Government derives a significant amount of income from commercial telegrams and telephone calls handled for the public at very small charges.

The following table indicates the receipts for the year:

	Block Island.	Cape Henry.	Beaver Island.	N. & S. Manitouq.	Port Angeles.
1921.					
July.....	\$220.24	\$157.77	\$47.75	\$20.06	\$195.98
August.....	200.00	161.28	62.08	20.06	237.03
September.....	¹ 31.26	145.00	45.18	11.88	185.03
October.....	16.44	146.95	32.15	7.60	132.91
November.....	² 70	171.71	76.00	7.73	124.14
December.....	(?)	230.23	52.40	4.00	132.87
1922.					
January.....	(?)	211.69	35.62	1.75	168.74
February.....	(?)	95.06	33.93	2.28	144.97
March.....	(?)	115.22	36.59	4.75	159.86
April.....	(?)	112.89	63.95	7.72	175.63
May.....	(?)	85.75	70.96	10.28	168.34
June.....	49.11	97.03	64.64	15.71	1202.32
Totals.....	517.75	1,730.64	621.55	114.72	2,027.82

Grand total, \$5,012.48.

¹ Estimated.

² Telegraph communication interrupted.

In addition to the above, \$600 per annum is received from the New England Telephone & Telegraph Co., Boston, Mass., for rental of two conductors in the Block Island cable.

The cost of maintenance and repair to these lines was \$2,500.

Block Island-Matunuck Beach (R. I.) section.—A three-conductor telegraph cable connects the island with the mainland. Two conductors are leased to the New England Telephone & Telegraph Co. for telephone purposes, the third being reserved for telegraph use. This conductor became defective in August, remaining so until June, the Weather Bureau being without sufficient funds to make adequate repairs. During most of this time telegrams were telephoned to and from a telegraph office on the mainland. By cooperation with the Western Union Telegraph Co. repairs were accomplished on June 7, when telegraphing was resumed. For several months in the summer a large number of telegrams are offered for transmission over this cable, the only means of wire communication with the island, a popular summer resort. The interruption above noted seriously interfered with satisfactory conduct of this business, and similar interruptions are liable to occur at any time owing to the age of the cable, which was laid in 1903. It has been repaired numerous times and is subject to gradual deterioration because of electrolysis. The time has come for installation of a commercial cable with adequate facilities to care for the large volume of business now offered. These conditions are recognized by the commercial companies interested, but no action to provide a new cable has been reported to the Weather Bureau.

Norfolk-Hatteras (Va.-N. C.) section.—Extensive reconstruction of certain portions of this telegraph line was undertaken with the co-operation of the Coast Guard and the Chesapeake & Potomac Telephone Co., the operating conditions being materially improved thereby. Cost of these repairs approximated \$1,000.

The great value of this line to the Government and to private interests is indicated by the following data:

Total number of messages handled by Weather Bureau office, exclusive of all Government and radio business handled by the Navy Department:

	Sent.	Received.
Commercial	5,376	5,924
Official messages	8,284	4,702
Total	13,640	10,626

Telegraph receipts at Weather Bureau offices:

	This line.	Other lines.
Cape Henry, Va.	\$1,398.28	\$370.86
Hatteras, N. C.	96.90	189.39
Manteo, N. C.	235.37	407.07
Total	1,730.64	967.32

At the Cape Henry office 16,990 vessels and 17 wrecks were reported by telephone and telegraph.

It is proposed to extend reconstruction work to other sections of the line, where badly needed, during this fiscal year.

Alpena-Thunder Bay-Middle Island (Mich.) section (telephone).—Some damage was done to these two lines, respectively 15 and 12½ miles in length, by ice storms during the winter and spring. An expenditure of about \$1,000 for shortening old poles (set in 1893) is necessary in the near future. Extensive use is made of both lines by the Coast Guard Service, Lighthouse Service, and the Naval Communication Service, and they are of inestimable benefit to marine interests as well as to the Weather Bureau.

Whitefish Point-Vermilion Point (Mich.) section (telephone)—North and South Manitou Islands-Sleeping Bear Point (Mich.) section (telephone)—Beaver Island-Charlevoix (Mich.) section (telephone).—These three worked satisfactorily throughout the year.

Point Reyes-Fairfax (Calif.) section (telephone).—Satisfactory transmission conditions attended the operation of this line of 37 miles excepting for a total period of 400 hours when it was interrupted by storms. The line is maintained by close cooperation with the Coast Guard which service makes large use of the facilities afforded thereby.

Galvanized iron wire is strung for about 13 miles on poles of the Western Union Telegraph Co. It is contemplated replacing this iron wire with copper wire and to change to poles of the Pacific Telephone & Telegraph Co.

North Head-Portland (Wash.-Oregon) section (telegraph).—Interruptions of service, totaling about 344 hours, were frequent but of short duration, caused mostly by improper management of repeaters at Fort Stevens.

Nearly a half mile of the line between North Head and Fort Canby was destroyed by a severe storm December 1. Prompt repairs were accomplished with but slight expense. Telegraphic business consists principally of meteorological and vessel reports, no commercial telegrams being handled.

Tatoosh-Port Angeles (Wash.) section (telegraph).—The course of this line of approximately 90 miles along the southern shore of the Strait of Juan de Fuca is mostly through heavy timber and for a large part along a county road. Extensive logging operations in the vicinity of the line have for a number of years past interfered with continuous communication to a considerable extent, necessitating frequent repairs. Heavy storms during the winter are also a fruitful source of trouble. Less than the usual amount of damage resulted during the past year, the cost of upkeep having been approximately \$1,000. These interruptions totaled 29 days and 2 hours, 10 days of which was due to prostration of the span wire between Cape Flattery and Tatoosh Island.

Extensive repairs, including changes in the course of the line and some reconstruction work, are contemplated during the present fiscal year, which will require an expenditure of about \$1,200.

The line continues to be of benefit to logging, shipping, fishing, and other private interests in addition to its primary use for meteorological purposes. About 11,000 commercial messages were handled during the year, with receipts of approximately \$2,100, Government tolls; also 2,400 Government messages and 1,500 long-distance telephone calls.

AEROLOGICAL INVESTIGATIONS.

Kite stations.—Observations with kites were made regularly at Broken Arrow, Okla.; Drexel, Nebr.; Due West, S. C.; Ellendale, N. Dak.; Groesbeck, Tex.; and Royal Center, Ind. Kite flights are made daily, whenever possible, and, in addition when conditions are favorable, continuous series of flights are made for periods of 24 to 36 hours. Records of air pressure, temperature, humidity, and wind are thus obtained.

Pilot-balloon stations.—Observations by means of pilot balloons were made at the six kite stations, above listed, and at Burlington, Vt.; Denver, Colo.; Ithaca, N. Y.; Key West, Fla.; Lansing, Mich.; Madison, Wis.; San Francisco, Calif.; San Juan, P. R.; and Washington, D. C. The observations are made twice daily at the six kite stations and at Key West, Fla., and Washington, D. C., and once each day at the remaining stations, and the computed wind conditions at various heights are telegraphed to district forecast centers at Washington, D. C., Chicago, Ill., and San Francisco, Calif., where they form the basis for "Flying Weather" forecasts issued to the military, naval and postal aviation services.

Special observations have been made, when requested, for use in connection with long-distance flights, free-balloon races, etc.

Observations with two theodolites have been continued, whenever opportunity afforded, in order to check the accuracy of the formula for rate of ascent of balloons and the behavior of the balloons themselves at high altitudes. These observations have shown that the revised rate of ascent formula gives extremely reliable results, except when there are pronounced vertical movements in the atmosphere. Even then the error is appreciable only in the lower layers.

Cooperation.—Effective cooperation with the Army and Navy meteorological services has been continued throughout the year. Each of these services maintains a number of pilot-balloon stations, whose primary purpose is to furnish data of immediate local interest to aviators at flying fields. These observations are also telegraphed to district forecast centers of the Weather Bureau for use in issuing "Flying Weather" forecasts. They thus supplement, in a very helpful way, the observations made at Weather Bureau aerological stations. In addition to the stations in the United States proper, the Navy maintains one at Santo Domingo, Dominican Republic, and one at Coco Solo, Canal Zone, which, together with those of the Weather Bureau at San Juan, P. R., and Key West, Fla., furnish information of value in connection with the development and movement of hurricanes. A much larger number of stations is necessary, however, to make this service as effective as it should be.

In the autumn of 1921, at the request of the director of the Brazilian meteorological service and in cooperation with a representative of that service, temporarily stationed in Washington, plans for the organization of an aerological service in Brazil, patterned after that in the United States, were outlined and satisfactorily worked out. All necessary equipment was purchased, methods used in this country were studied and adopted, and two trained observers of the Weather Bureau were released, in order that they might be employed by the Brazilian Government to get the service properly inaugurated in that country.

Central office.—All observations made at kite and balloon stations, by the Army and Navy as well as by the Weather Bureau, are forwarded to the central office of the Weather Bureau for final reduction and study. Data based upon these observations are furnished in answer to numerous inquiries not only from other government departments, but from commercial aviation concerns as well. In many cases reprints of special discussions and summaries were issued in answer to these requests.

Work has been continued on the preparation of a summary entitled, "An Aerological Survey of the United States." When completed, this will contain the results of all free-air observations made in this country. Part 1, "Results of Observations by Means of Kites," was completed and published during the past year. It contains tables and figures showing monthly, seasonal, and annual values of pressure, temperature, humidity, density, and wind at various heights up to 5 kilometers. It also includes a detailed study of the behavior of free-air winds, classified by months and seasons, by geographic location and according to different wind directions at the surface. Tables and figures are given, showing the frequency and amount of clockwise and counterclockwise turning of winds, the frequency of

winds from different directions, the average and extreme velocities encountered, and other data of special interest and value to aviators. This "survey" is confined to those portions of the country east of the Rocky Mountains, since free-air observations farther west are too few for the purpose. Additional stations in the West and a few more in the East than we now have are urgently needed, in order to give complete information for all parts of the country.

At the request of the National Advisory Committee for Aeronautics the preparation of a report on "Standard atmosphere" was undertaken and completed. It has been published by that committee as Report No. 147 and will later be included in the annual report. In it are discussed the need of a standard set of values of pressure, temperature, and density at various altitudes, and the desirability of adopting such values as are most in accord with actual average conditions in order that corrections in individual cases may be as small as possible. To meet this need, so far as the United States is concerned, all free-air observations obtained by means of kites and sounding balloons at several stations in this country near latitude 40° north have been used, and average values of pressure, temperature, and density, based upon these observations, have been determined for summer, winter, and the year, and for all altitudes up to 20,000 meters (65,000 feet). These values have been adopted by the National Advisory Committee for Aeronautics for use as "standard" in this country.

CLIMATOLOGICAL WORK.

In the main, the regular work of the division was carried forward as usual and all routine matters were well in hand at the close of the year.

The manuscript tables, charts, and text for the several publications of the bureau, weekly, monthly, and annual, were prepared and placed in the hands of the proper officials on the several dates specified. Likewise the thousands of meteorological reports from the regular and cooperative observers have received increased scrutiny to assure the accuracy required in the material placed before the public through the various reports issued by the bureau.

One of the main lines of work in the division, the furnishing of weather information upon written or other requests from all classes of persons and interests requiring such information, has continued with the usual activity, and this, too, has been met in a satisfactory manner, as indicated by the numerous acknowledgments received, which expressed entire satisfaction with the promptness of the information furnished.

Cooperative work.—The extensive lines of cooperation by which the Weather Bureau secures valuable observations of weather conditions free of charge, save for the necessary observing outfits, have continued as in the past. Hearty interest in this cooperation is manifested in the thousands of reports carefully prepared day after day, month after month, and for indefinite years, and forwarded promptly to this office and to the State section centers.

The number of these cooperative workers has not materially increased over those of previous years. In fact, effort to reduce the number of those reporting temperature conditions has resulted in keeping that class of stations down to a number thought sufficient

for all needs, at the same time arranging for a few new stations at points where temperature observations are considered of value.

On the other hand, effort is being made to increase the number of rainfall measuring stations in sections where local topography causes marked variations in the precipitation at near-by points. It is thought no difficulty will be experienced in securing cooperation along that line at various additional points, and recommendation has been made that appropriation for the purchase of an increased number of gauges be provided for.

Inspection of cooperative stations.—The withholding of travel expenditures for economical reasons and because officials could not absent themselves from their stations due to a general shortage of force has prevented the needed inspection of substations to a considerable extent. As a result some deterioration in the character of reports rendered has undoubtedly occurred, due to agencies not readily apparent to the cooperative observers. The most important of these is the tendency of maximum thermometers to become "re-treaters," a condition of the thermometers not readily apparent to the observer, but easily detected by the inspector. The increasing number of instruments developing this defect has been commented on by several inspectors. The ultimate cause of this is a falling off in the high quality of maximum thermometers as now produced by manufacturers.

Another serious condition to be guarded against is the constant tendency to an improper exposure of the rain gauge. Faults of this kind are not readily noticed by the observer and are most surely remedied by an inspection.

No expenditure of Government funds will render more valuable returns than those providing for the reasonably frequent inspection of cooperative stations, which furnish such a great volume of most valuable data at no cost except those of forms, instruments, and inspections.

Climatological publications.—The material for the Annual Report of the Chief of Bureau and for the Monthly Weather Review has remained practically as during previous years.

The Snow and Ice Bulletin, due to congressional action, was not issued during the first few weeks of the season, but later on it was incorporated in the new department publication, Weather, Crops, and Markets. This soon proved unsatisfactory on account of late issue, and the Snow and Ice Bulletin was therefore issued as an individual publication in nearly the form adopted prior to 1919.

The 45 sections of the Climatological Service are issuing their monthly and annual summaries substantially as last year, save that a few sections have requested permission to increase slightly the number of pages per issue which, for reasons of economy, had been reduced to the lowest possible extent.

The somewhat smaller size of these publications has enabled their printing and distribution at a distinctly earlier date than had been possible for several years past.

The publication of the Alaska Section Summary, which had fallen greatly in arrears, due to certain printing difficulties, was finally

brought up as near to date as can be accomplished, considering the conditions attending its preparation.

The Porto Rico section was enlarged to include the new West Indian Climatological Service, with headquarters at San Juan, and considerable delay in printing the monthly issues resulted from the greatly increased number of stations reporting under the new plan of cooperation inaugurated with the various foreign governments in that region.

To meet the needs of engineers and others in California, who are interested in the seasonal precipitation of that State as affecting stream flow and water supply, the section director was authorized to issue as a supplement to the June, 1922, monthly section report, and yearly thereafter, a statement of the monthly precipitation at all stations in that State for the rain year, July, 1921, to June, 1922, inclusive, together with the total for the season. This permits the bringing together in consecutive order the precipitation for the rainy season and enables a more ready means of studying the water problems of that State.

The snowfall bulletins for the 11 mountain States of the West were issued as usual, and somewhat more data were discussed than in previous years, due to increased facilities for obtaining reports.

Collection and care of meteorological reports.—All reports containing meteorological data usually forwarded to this division were properly checked, filed, and later prepared for permanent binding.

The reports from the 42 climatological sections of continental United States, about 320 copies for each section, were assembled monthly, temporarily bound at the Government Printing Office, and promptly distributed to foreign weather institutions, libraries, or other public repositories, and to subscribers and others making use of the data they contain.

At the close of the calendar year the permanent supply of these reports for file at stations, consisting of about 140 sets, 5 volumes each, a total of 700 volumes, was assembled, permanently bound, and distributed to the more important stations. Altogether nearly 1,800 separate volumes of reports of all kinds, not including those temporarily bound and distributed each month, were assembled in the division during the year, alphabetically and chronologically arranged, permanently bound, and placed in the proper files.

Additional work accomplished.—During the year just closed opportunity was afforded to secure the reprinting of a number of the separate sections of Bulletin W, Summary of the Climatological Data for the United States by sections, many of the sections being entirely exhausted and the editions of others too old to enable their efficient use in answering calls for weather data.

By concerted action between station officials and this division, 26 of the 106 sections were brought down to the end of 1920, with new tables added, and reprinted. Material for 24 additional sections was forwarded to the Government Printing Office and these are in process of completion, and 17 others are now ready, awaiting allotment of necessary funds, while the remaining numbers are in various stages of progress at the respective centers, but will all be ready for printing within a few months.

The preparation of the material for these publications was mainly accomplished at the respective State centers, but the arrangement

of the data and checking the various tables and charts devolved upon the clerical force of the division, where, in order to facilitate the work, much of the proofing, revising, and other details were attended to.

New work.—The preparation of new normals of the daily maximum, daily minimum, and daily mean temperatures, the details of which were outlined during the preceding year, was carried forward as rapidly as the press of other work permitted. At the end of the year nearly all the stations having 40 or more years of record, some 75 or more, had been practically completed and most of them forwarded to stations for current use.

Considerable progress was made on a proposed new system for maintaining the summarized weather data accumulated at the various State section centers, but on account of prospective world-wide changes in the calendar, now being discussed, it was deemed best to delay any extensive changes at the present time.

The preparation of new normals of daily maximum, daily minimum, and daily means of temperature for the short-record stations of the bureau will be the principal extra work in the division during the present fiscal year.

Loyal support has been given by each member of the division's clerical force.

PRINTING.

The mailing lists of the bureau have all been revised and brought up to date, resulting in the discontinuance of a number of subscriptions. The demand for Weather Bureau publications from the general public, especially libraries, schools, and colleges, continues to be large. All applications are receiving prompt, careful, and favorable consideration where possible. In case the publications can not be supplied the writer is so advised, and if possible the source from which the publication may be secured.

Under a provision of the sundry civil act of March 4, 1921, Government departments were required to suspend the publication of all periodicals not otherwise specifically authorized by law. The National Weather and Crop Bulletin and the Monthly Weather Review were therefore suspended with the issue of December, 1921. Later the Weather and Crop Bulletin was combined with the Market Reporter and the Monthly Crop Reporter on January 7, 1922, and is now issued weekly throughout the year by the Department of Agriculture under the title, "Weather, Crops, and Markets." The resumption of the issue of the Monthly Weather Review was also authorized.

Under the deficiency bill passed by Congress for printing and binding of the Department of Agriculture, the Weather Bureau was enabled to effect the printing of a considerable amount of back climatological statistics, river stages on the principal rivers of the United States for 1920 and 1921, and the binding of official records. A large amount of this important data had accumulated during the war and since, and the amount of printing and binding accomplished under this appropriation has materially facilitated the work of the bureau.

In accordance with existing regulations the utmost economy was practiced in the issuance of publications and the purchase of paper, ink, and other printing materials. No new or additional machinery or equipment was installed during the year.

THE MONTHLY WEATHER REVIEW.

The Monthly Weather Review presents under a single cover fairly complete statistics and a discussion of the weather in all parts of the United States and to a lesser extent of the adjacent oceans. This purely statistical record alone is highly prized and extensively used by various marine, commercial, and agricultural interests. The Review also serves as an important aid in the teaching of meteorology in primary and secondary schools; also as a medium of exchange for workers in the field of theoretical as well as applied meteorology. It is now in the fiftieth year of publication, the first issue having appeared in the early part of 1873.

The early numbers were devoted to a résumé of the storms of the month, accompanied by charts showing the path followed by each, with short paragraphs upon the distribution of temperature and precipitation. All of these original features have been carefully preserved and greatly amplified with the passage of years, and many new topics have been added.

The forty-ninth volume contained 745 pages of text and tables and about 120 charts. The fiftieth volume will contain a somewhat smaller number of pages, about the same number of full-size charts, but with the addition of three small inset charts which add considerably to the information graphically presented.

Three contributions to meteorology have been printed during the year as supplements to the Monthly Weather Review, and the manuscript of a fourth is awaiting final action previous to being sent to the Public Printer.

INVESTIGATIONS IN SEISMOLOGY.

The important work of collecting and publishing earthquake data, begun December 1, 1914, has been continued during the year.

Instrumental records have been obtained by instruments owned and operated by the bureau itself at Washington, D. C., Northfield, Vt., and Chicago, Ill., and similar data secured from various seismic observatories distributed from Panama to Canada and from the Hawaiian Islands to Porto Rico.

The noninstrumental reports rendered by the regular and cooperative observers of the bureau recorded 83 separate earthquakes strong enough to be felt by the unaided senses in the continental United States during the calendar year 1921. The great majority of these resulted in little or no damage, but the widespread shocks which took place in Utah in September, the latter part of October, and first of November caused moderate damage. No important earthquakes occurred in our outlying possessions.

VOLCANOLOGY.

The funds available for the conduct of observations of the glowing lava beds of the Kilauea Volcano have remained the same as heretofore and have barely sufficed to maintain the program of work as in the past. Some additional investigations by borings supported by funds from the Hawaiian Volcano Association were made during the year.

LIBRARY.

During the fiscal year 1,130 books and pamphlets were added to the library, the total strength of which is now well over 41,000 volumes. Most of the gaps in periodical publications occasioned by the war have now been filled, the chief exceptions being Russian publications. A nearly exhaustive bibliography of the climatology of South America was published in October. The various catalogues have been kept up to date. One of these, not mentioned in any previous report, is a catalogue of portraits of meteorologists. This has been in progress for several years and is probably the only one of its kind in existence. At least one additional trained assistant is greatly needed, in order to enable the library to undertake important work outside of routine.

MARINE METEOROLOGY.

The marine meteorological work progressed satisfactorily during the year. A larger amount of data was furnished the Hydrographic Office for publication on the Pilot Charts, and at the same time an increased volume of material of value to marine interests was supplied through publications of the bureau.

During the year arrangements were perfected for an interchange of marine reports with the French meteorological service.

The amount of data furnished for use in admiralty cases was about the same as in previous years.

It was possible near the end of the year to augment the force engaged on the marine work at Washington, where a reduction had been necessary during the preceding year. A further increase of this force is needed to make greater use of the material now being reported by observers, and which supplies the fullest record we have of detailed weather conditions over the Northern Hemisphere.

The volume of reports reaching the bureau still reflects the depressed state of shipping, but shows, nevertheless, the continued interest of seamen in the marine meteorological work.

Reference to the increasing use of radio at sea and its influence on the transmission of weather information will be found elsewhere.

INSTRUMENT DIVISION.

The maintenance of the instrumental and storm warning equipment of the Weather Bureau, which has an estimated value of \$700,000, together with the purchase of necessary new equipment, has been accomplished at an expense of about \$26,000. Station officials have cooperated with the division by making diligent effort to keep down expenses without permitting the equipment to deteriorate.

The major portion of the work of repairing instruments, including the rebuilding of special thermographs for fruit-frost investigations, has been performed in the instrument shop, and important progress has been made in the development of new forms of apparatus and instruments.

A new form of solar radiation receiver, utilizing the principle of thermo junctions, was worked out with the joint efforts of several

members of the technical staff of the bureau and is now being successfully used in recording solar radiation intensities.

The evaporation program inaugurated in 1916 has been continued. Regular reports are being rendered by 47 stations, and the results are published in the State Section Reports. An annual summary for all stations appears in the statistical section of the annual report of the Chief of the Weather Bureau.

Investigations of the relation between anemometer cup movement and actual wind velocity, begun more than 20 years ago by Prof. C. F. Marvin and limited in scope at that time by the difficulty of obtaining high velocities, have been resumed, and as a result the relations are now known up to 113 miles an hour actual velocity. This investigation has been conducted jointly by Messrs. Fergusson and Covert of the instrument division, using the wind tunnel of the Bureau of Standards, which was primarily constructed for the study of problems in aviation, and in which high velocities under control are easily produced. Many other forms of anemometers, different sizes of cups, and lengths of arms, were also made subjects of experiment, with a view to the early design of an anemometer to record true wind velocities, and the preparation of corrections applicable to the records of the Weather Bureau, which are all on a uniform basis of indicated velocities.

Exhibits.—An exhibit to show the activities of the Weather Bureau has been prepared for the Brazilian Centennial Exposition, also three self-demonstrating exhibits and one instrumental exhibit to accompany the Government exhibits sent over circuits routed to State fairs in the United States. This work is carried on cooperatively with the Office of Exhibits.

As a result of the wide distribution of Farmers' Bulletin No. 842, Modern Methods of Protection Against Lightning, the Weather Bureau is being called upon with increasing frequency to answer letters of inquiry in regard to methods to be used in particular instances. R. N. Covert has been named Weather Bureau representative on a committee to formulate a code whose purpose is to specify safe practice in lightning protective measures.

INVESTIGATIONS IN SOLAR RADIATION.

Continuous registration of the quantity of heat received from the sun at the surface of the earth from day to day has been maintained at Washington, D. C., since 1909; at Madison, Wis., since 1911; and at Lincoln, Nebr., since 1915. In addition, on clear days the intensity of direct solar radiation has been measured at the above stations and also at Santa Fe, N. Mex. At the latter station these measurements were discontinued at the end of March, 1922, when the Weather Bureau office was moved to the new Federal building, which does not afford suitable exposure for pyrliometers; and at Lincoln, Nebr., the registration of the heat energy received from the sun has been discontinued temporarily on account of a defect in the recording pyrliometer. It is expected that the early completion of a recording pyrliometer of improved design will make it possible to replace this defective instrument in the near future.

In addition to heat measurements, the intensity of direct sunlight and of diffuse skylight has been measured on almost every day at

Washington during 12 months ending with April 6, 1922, except that for about four weeks in July and August, 1921, and for a like period in January, 1922, the measurements were made at Chicago, Ill.

From the sky brightness measurements thus obtained charts have been prepared showing the resulting illumination on vertical surfaces, such as the walls of buildings, facing the eight principal points of the compass, for each hour of each day throughout the year for latitude 42° north, with the sky free from clouds and also completely covered with clouds. The charts are based on the measurements made in practically smoke-free atmosphere in a suburb of Washington, but the percentage of diminution in illumination resulting from a smoke cloud such as usually prevails at Chicago has been determined.

Even with skies entirely free from clouds the brightness and the resulting illumination may vary by as much as 50 per cent from the mean value represented by the charts. This is due principally to the presence of haze or dust in the atmosphere to a greater or less degree. A clear blue sky, which is rare at Washington, is dark as compared with a white, hazy sky. Thin clouds increase the brightness of the sky markedly, and especially in the vicinity of the zenith.

A preliminary report on the sky brightness measurements has been published in the Monthly Weather Review, and also in the Transactions of the Illuminating Engineering Society. A more complete report is now in preparation.

These results are of practical importance to illuminating engineers and others having to do with questions of natural lighting, especially as applied to school rooms, office buildings, and industrial plants.

There yet remain to be considered the effect upon interior illumination of substituting for skylight the daylight reflected from the walls of neighboring buildings, and, also, the interior illumination from skylight when the so-called saw-tooth roof construction is employed. It is hoped to solve these two problems during the coming year.

It is also the expectation to take part in an international investigation of the dust content of the atmosphere that has been planned by the meteorological section of the International Geodetic and Geophysical Union.

The official in charge of solar radiation investigations took advantage of a trip to Europe as a delegate to the International Institute of Agriculture and to the International Geodetic and Geophysical Union, both meeting in Rome in May, 1922, to consult with European meteorologists on various topics, more particularly those relating to solar radiation studies.