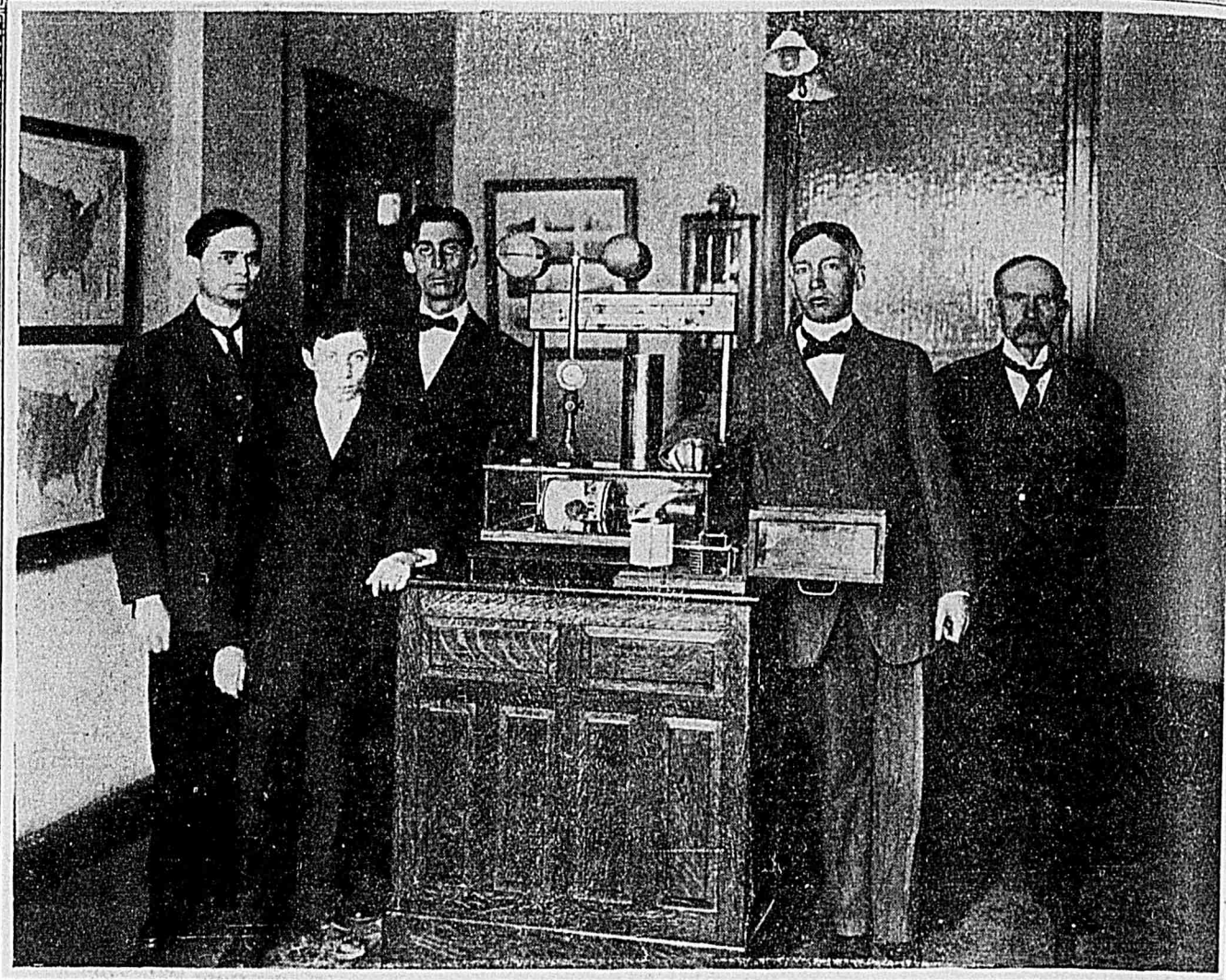
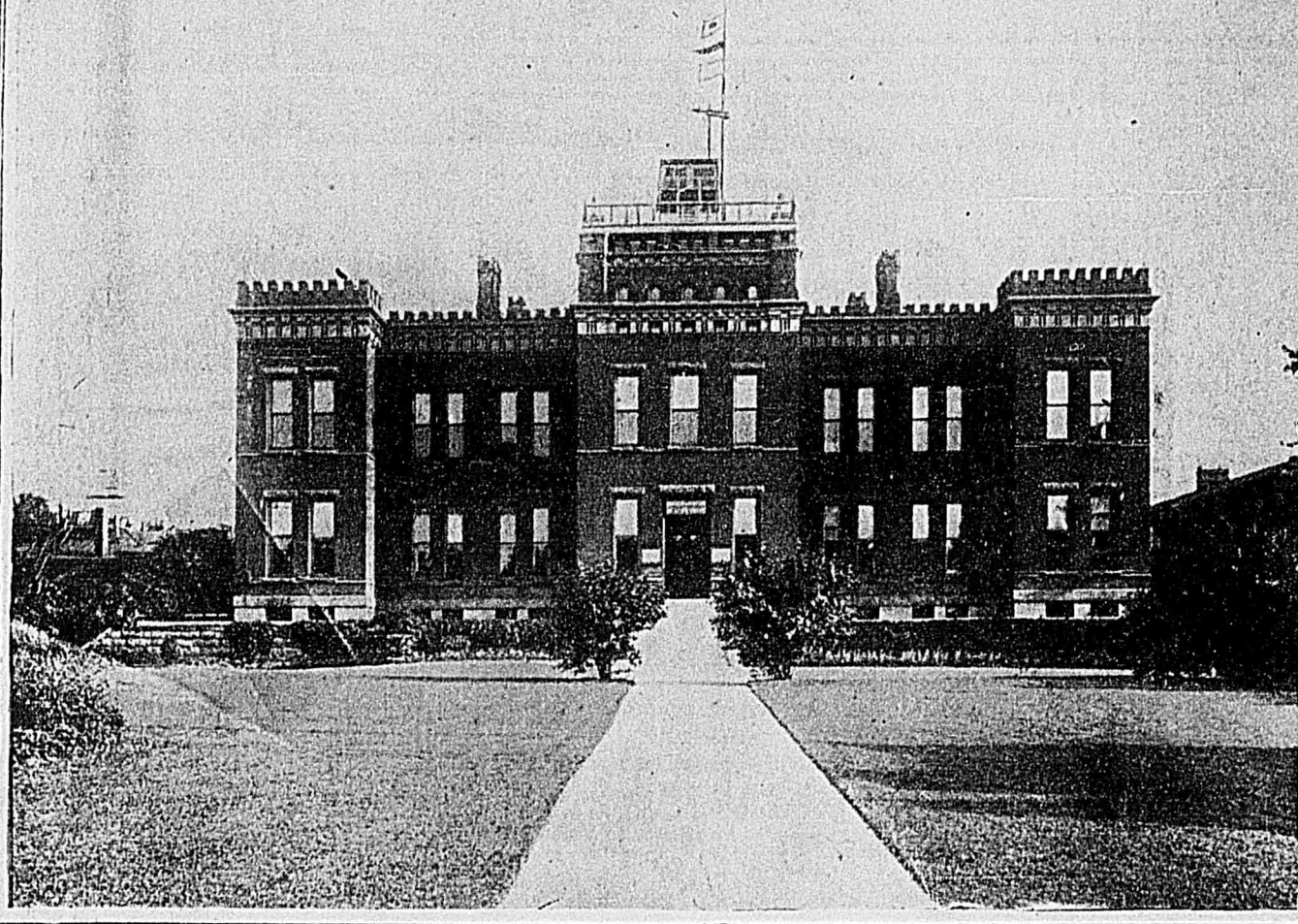


# The Work of the Weather Bureau

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MAN from the beginning has been constantly at strife with nature in his effort to ameliorate his condition, and the various elements of the weather as they affected his comfort engaged his attention from remote antiquity. His earliest studies of the weather were transmitted to us in the form of proverbs. These proverbs were simply the result of the experience of one or many persons.

Meteorology in the old sense embraced the study of not only the air but of the moon and the stars, and in fact everything aerial. The first work on the subject was written probably by Aristotle. In the absence of general physical knowledge and instrumental equipment, the ancients were not able to make scientific inquiry into the laws governing the weather, and meteorology not only did not advance, but in the Middle Ages the weather lore was simply a portion of astrology, and what weather predictions were made were given out by the disciples of this ancient science.

The first attempt to explain the rainbow by reflection in the drops of rain was by a German monk, Theodore, in 1611. This was one of the first efforts to explain in a scientific manner a phenomenon of the atmosphere.

But the general science of meteorology could not advance materially except as the knowledge of general physics advanced and precise scientific instruments were invented.

The first important instrument to be invented was the thermometer. This instrument dates from the time of Galileo who devised the instrument probably in 1587. The form of this early thermometer resembles somewhat the modern barometer with an imperfect vacuum, and was first used generally by a famous physician, Sanctorius, in his lectures 1611-24. Of course varying atmospheric pressure would affect the accuracy of the instrument greatly.

In 1655 the alcohol thermometer was invented, followed by the mercurial in a short time. Fahrenheit made his first thermometer with the definite points at freezing and boiling water in 1714.

The barometer also had its inception at the time of Galileo, although the invention of this instrument is generally attributed to his pupil Torricelli, in 1643.

After this instruments multiplied rapidly, and the study could progress, but the field of observation was so large that a considerable period elapsed before the law of storms was enunciated. There were, however, many observations on hurricanes, typhoons, and cyclones, and many writers published descriptions of them; but it was not until as late as 1831 that Redfield, a naval architect, stated that the winds in a storm had a rotary movement, while the storm itself had a progressive motion. This is now commonly called the law of storms.

There were many guesses regarding the rotary movement of the winds, but it was not until Redfield that it was definitely stated in connection with the progressive motion of the whole storm itself. However the first generalization of the progressive movement of storms was made as early as 1749 by Lewis Evans who said: "All storms begin to leeward." Thus a N. E. storm shall be a day sooner in Virginia than in Boston. And again Benjamin Franklin who in 1752 identified the lightning with electricity stated that storms moved from the west to the east.

## Beginning of the Weather Bureau

Knowing, then, the fundamental principle of the mechanics of a storm, an organization for the express purpose of predicting the weather would naturally follow. Prof. Henry of the Smithsonian Institution made weather reports as early as 1854. Prof. Abbe made weather forecasts in 1869 for the chamber of commerce at Cincinnati.

Congress appropriated \$20,000 in 1870 to inaugurate the first weather service. This has been gradually increased until at the present time over \$1,000,000 is required to meet the expenses of the weather bureau. Since the incumbency of the present chief, Prof. Willis L. Moore, the weather bureau has not only increased in general usefulness, but decided advances have been made in the science of meteorology due to his far-sighted and liberal policy.

The present weather bureau consists of a central office at Washington, D. C., and about 200 stations scattered throughout the entire United States and the possessions. The duties of the weather bureau as defined by Congress are that records shall be kept and forecasts made. To this end about 300 stations are maintained with a force of about 600 people.

Each station is equipped with self-recording instruments which automatically record the direction and velocity of the wind, the temperature, the rainfall, the sunshine, and the barometric pressure. At 8 o'clock a.m. and p.m. an observer takes an observation of all these weather elements, records them and enciphers them in a telegram which is sent to all other stations in the United States where a weather map is made. These observations are then carefully charted on large blank maps, lines are drawn through points having equal barometric pressure, and also through points having equal temperature. This map twice daily reveals to the forecaster an instantaneous picture of the weather conditions over the entire country. Regions of low pressure indicate storm areas, and regions of high pressure indicate the areas of fair or clear weather.

The forecaster by his knowledge of the law of

storms and familiarity with weather maps draws his conclusions regarding the prospective weather for a district and this forecast is telegraphed to very nearly every town and hamlet in the country which can be reached by telegraph.

The forecasts consist of prediction of hurricanes, cold and hot waves, rains and snow and frost. It will be readily seen the importance of a well organized bureau for carrying on this work. There are many millions of dollars' worth of shipping in our ports on the Atlantic and Pacific coasts and on the Lakes. Captains of these vessels attend anxiously to the weather bureau storm warnings, and it is estimated that the loss of life and property has been reduced 75 per cent by the weather bureau system of apprising the vessel masters of the approach of bad storms. These warnings do not in many cases reach the newspapers as it is desirable to hold them until the storm is about 12 or 16 hours away, so that vessels may not be detained in port unnecessarily.

The forecasting of cold waves is also very important. When the cold winds of a broad high area pressure sweep over the country spreading to the east and south and carrying with them immense destruction to perishable articles, forecasts are sent broadcast. Sometimes 100,000 telegrams are sent as warnings of a single cold wave. It has been estimated that in a single cold wave \$5,500,000 of property was saved to the shipper and the farmer.

Frost warnings are also very valuable to the horticulturist and florist. By using protective devices, these men are able to save thousands, yes, millions of dollars every year.

In disseminating these warnings the weather bureau is aided by many persons and organizations. The daily forecast is sent to many addresses daily, the telephone companies disseminating it to their various exchanges which in turn give it to their subscribers, all this free of charge. The newspapers do a tremendous good by freely printing the forecasts and special warnings.

In addition to forecasting purely weather conditions, the weather bureau also maintains a very important branch of the service in the river and flood service. This branch keeps records of the river stages in all the principal streams in the country and forecasts important rises in the rivers and floods so successfully that no important flood has ever occurred without being forecasted.

## Climatological Service

While the 200 regular weather bureau stations referred to above give the necessary knowledge upon which to base weather forecasts, they are insufficient for the minute study of climate in special localities. For the latter purpose the weather bureau maintains about 2,500 co-operative stations at which observations are taken of temperature and precipitation by volunteers or co-operative observers as they are called in this bureau. The data furnished by these observers constitute a most valuable part of the history of the weather in this country.

## River and Flood Service

Another very important branch of the weather bureau is the river and flood service. It is the province of this service to take gageings of rivers, and forecast river and flood stages of all the principal rivers in this country.

The value of this service was even more strongly emphasized during another great flood from March to June, inclusive, in the Mississippi watershed. The flood in the upper Mississippi watershed was one of the greatest in its history, while in many portions of the lower watershed, the stages were the highest ever known. Yet, notwithstanding the enormous volumes of water, the forecasts and warnings were accurately verified, both as to location, stage, and date. Warnings were issued from four days to three weeks in advance, and in no single instance did the stage that was forecast differ from that actually recorded by more than four-tenths of a foot. The average difference was about two-tenths of a foot. The value of the property saved by the weather bureau warnings could not be accurately computed, but probably exceeded that mentioned in the preceding paragraph.

## Special Benefits Derived from Reports

While the value of the bureau's reports and warn-

## APPLICATION OF FORECASTS AND WARNINGS.

Warnings of frosts and freezing weather are valuable to the fruit, sugar, tobacco, cranberry, and market gardening interests.

Warnings of storms and hurricanes are of immense value to marine interests.

Warnings of cold waves are of value to all interests.

River commerce is aided by publication of river and flood stages.

## VALUE OF FORECAST WARNINGS.

\$3,500,000 were saved by warnings issued for a single cold wave of exceptional severity.

\$15,000,000 worth of live stock and other property were, on one occasion, removed from regions in the lower Mississippi River valley that were afterwards inundated.

\$100,000 worth of vegetables, oranges, and strawberries were saved on a single night in a limited district of Florida by a single warning.

ings to many interests is so obvious as scarcely to need more than the brief mention already given, there are numerous special applications of the information to individual pursuits and industries that might not have been suspected. On account of some of these may lead to an increased use of the data in quarters where the possibility of their application has not yet been recognized, and additional details of the manner in which the information is utilized in a number of enterprises will doubtless be found of interest.

The railway and transportation companies make continued use of the forecasts in all of their shipments. Perishable products are protected against temperature extremes by being or heating, as conditions may require. Oftentimes shipments of perishable goods are accelerated when it is found possible to carry them to their destination in advance of the expected unfavorable temperature conditions. An advance notice of a cold wave will often hold up a contemplated shipment until after the freeze has passed, and if the cold is protracted, the companies will refuse to receive consignments of goods likely to be injured by low temperatures. These precautions apply in some instances to prospective temperature changes within comparatively narrow limits. On the other hand, most meats are best shipped in cold weather, although the use of refrigerator cars prevents loss, and the movement of live hogs and cattle by freight is avoided, if possible, when a hot wave is expected. High temperatures are also hurtful to certain other shipments, especially fish and oysters, so that the question of the proper amount of ice to be used is intimately connected with the forecasts issued by the bureau. The daily forecasts and the reports of general weather conditions likewise assist in determining the points to which many shipments of perishable articles are directed, in order to meet the irregular demands that are frequently dependent upon the kind of weather that prevails in a given section. The movement of eggs kept in storage, for instance, is largely regulated by temperature changes, the announcement of a cold wave being usually followed by brisker shipments from western supply districts to the eastern markets, in anticipation of a rise in price.

The uses made of temperature forecasts in the cities are more varied than is generally supposed. With notice of an approaching cold wave green-

houses are closed and boilers fired. Preparations are at once made by heating and lighting plants, whether gas, electric, steam, or hot water, to meet the increased demands that will follow. Fire plugs, exposed mains, and general plumbing are protected. Large stockyards drain their mains. Gasoline engines are drained. Work in concrete is stopped. Brewing companies take care of exposed ammonia condensers and water connections. Street railway companies arrange for more heat in their cars. Merchants curtail advertisements or direct attention largely to cold weather articles. Coal dealers supply partial orders to all customers needing fuel, instead of full orders to a few, and thus please all of their patrons. Ice factories reduce their output. The drying of sand and gravel ceases and iron ore piled up for shipment is placed in the holds of vessels, to prevent the wet masses from freezing solid. Charity organizations prepare to meet increased demands among the poor.

## Pointers for Agriculturists

In the agricultural districts the frost and cold wave warnings are invaluable to the trucker and fruit grower, especially in the spring, when the tender vegetables are protected by covering with paper, cloth, or soil, and fruit is safeguarded by smudging, irrigation, or other methods designed to maintain the temperature above the danger point.

Many crops, such as beans and grapes, are saved by being picked in advance of the freeze. Potato digging is suspended and the dug potatoes removed from the field and sugar cane is cut and winnowed upon receipt of such advice, immense savings having resulted in the sugar districts of Louisiana as a result of such action. The expected duration and severity of freezes govern operations in the ice harvest; if the cold is to be prolonged the ice men await the desired thickness, but otherwise the cutting will be hastened in order to secure the best possible returns under the circumstances. The temperature forecasts are also largely utilized by farmers in the killing of hogs, by sheepsman at lambing and shearing time, and by stockmen in general at critical seasons of the year.

Rain forecasts are also utilized in the large fruit districts to enable picking in advance of rains, so that the fruits can be shipped in better condition than those upon which rain has fallen, after they have been taken from the ground. Broom corn is liable to damage from rain if left in the field. Much saving has resulted from consulting the forecasts in alfalfa cutting, since the alfalfa hay can be baled in the field if dry, but if baled wet it will spoil. The same benefits derivable from rain forecasts, apply to alfalfa cut for seed, since a heavy fall of rain upon the crop, after cutting, ruins its commercial value. Lime, cement, brick, drain tile, and sewer pipe material all require protection from rain during the process of manufacture, and cement work must be protected from rain for 24 hours to 48 hours after the cement is laid. The rain forecasts are used by contractors in their roofing work. Photographic firms working on a large scale find them helpful in planning for panoramic views. City departments determine the number of teams needed in street sprinkling, railroad companies guard against wash-outs and irrigation companies control the output of water by expected conditions of rainfall as given in the forecasts. Physicians use them in advising to patients suffering with tonsillitis or inflammation of the throat, nose, or ear, where it is expedient that the sufferer should keep indoors. They are also used by dentists, many of whom make appointments for bright days and reserve their plate work for days with inclement weather. A knowledge of temperature and moisture conditions in advance is of assistance in blast furnace operations in determining the quality of the output. Warnings of heavy snows are very valuable to railroads by enabling them to organize their snow fighting equipment and to reduce the tonnage of their freight and passenger trains, if considered necessary. They are also necessary on the great western ranches and plains, where the stock is hurried from the ranges to shelter upon notice of blizzards, snows, or heavy rains. Forecasts of bad weather, whether resulting from low temperatures, heavy rains, heavy snows, or a combination of these, are used in regulating advertising, in arranging for automobile, or other outdoor trips, to provide for indoor work on

the farms, and in guarding school children from exposure to the elements.

## Measures to Protect Property

Some special uses of the storm warnings are found in the measures adopted to protect property and crops subject to inundation from high tides or backwaters blown up by the winds. In advance of a predicted storm, rice planters flood their crops to prevent the straw from being broken by the winds. Agents of marine insurance companies refrain from insuring cargoes after a storm has been predicted. Fishermen take steps to protect their boats and nets. Lumbermen make their standing booms secure and regulate their log towing. At like ports vessels load hurriedly if they can get off two to five hours in advance of offshore winds; it was also expected, a start of seven to 18 hours is necessary. Considering the cost of operating a vessel whether standing or moving, a day saved from idleness in the harbor means an appreciable saving in expense.

Flood warnings are indispensable to all river industries, as well as to the operations carried on in the lowlands subject to inundation. Their issue is followed by the removal of cattle from bottom lands and by the saving of such crops as can be cut before the high water reaches the threatened district.

Fishermen in the Columbia river claim that the water stage seems to have some effect on the estimate of salmon from the ocean, and that, by watching the river forecasts, a spur in the run of fish can be predicted with a fair degree of accuracy. Forecasts of low river stages are not without considerable value to some interests. When the stage falls below a given height many water-power plants have their supply cut off; with ample notice, they can have their auxiliary steam plants ready for use, and thus continue their business without interruption.

## Miscellaneous Uses

Among the miscellaneous uses of the various classes of forecasts are their application to the manufacture of certain articles where slight changes in temperature, moisture, and other weather elements have been found to affect the quality of the product. This is true of certain stages in the manufacture of bluing, varnish, oils, cement, lime, bricks, paper, photographic supplies, chocolate candies, and some acids. They also serve usefully the plans of public amusement companies, excursion enterprises, aviation companies, and those engaged in outdoor painting.

The daily maps and bulletins and the general bulletins and reports containing statistical data are utilized in many ways by the public. Data of atmospheric pressure are used in tests of boilers, radiators, and automobiles, and in studies of the amount of fuel required to drive engines under varying atmospheric pressures. Statistics of wind force and direction assist in the installation of water supply systems to be operated by wind mills, in determining the origin of fires resulting from flying sparks, in pressure to which large buildings will be subjected under stress of heavy storms, and the surface movement of lake waters in connection with the disposal of ice sewages. The humidity records are used by silk and candy manufacturers, in tuberculosis investigations, and in studies of the loss of electric current in high voltage transmission. Data regarding rainfall and snowfall are extremely useful in planning irrigation enterprises and selecting reservoir sites, and are studied in connection with the construction of waterworks, bridges, culverts, and sewers. River data are utilized by filtration plants in guiding their methods of chemically purifying the water used for drinking purposes, as the conditions of the raw water supply as regards bacteria content and turbidity are greatly affected by the height of the river and the amount of rainfall. Maps are used by business men generally, by aero clubs in studies of flights, and school teachers in class instruction.

The miscellaneous climatological data are used in medical and scientific studies of the relation of weather to diseases and other conditions of health, life, or human pursuits; by railroad companies in the adjustment of claims and demurrage charges; by homeowners; by invalids in search of health resorts; by irrigation investigators; by contractors and builders in settling labor accounts; by merchants in studies of the relation of the weather to their daily sales; by gas and electric companies in showing their customers the relation of their monthly bills to the varying hours of daylight at different seasons of the year; as adequate testimony in court proceedings; in dry farming investigations; in studies of soil culture, practical agriculture, and the life and migration of insect pests; in plans for the development of the arid regions; in the preparation of historical records; by bond and investment companies in determining the loan values of farm lands in newly opened countries; in short, in nearly every calling in which the weather plays an important part.

Many more uses of the warnings and reports might be cited, but those already given—all of which are taken from personal letters received at the central office of the weather bureau or at its field stations—will suffice to show the extent to which they are utilized by the public in the practical everyday affairs of life.

## From a Small Beginning the United States Weather Service Has Grown.

In 1870 Congress appropriated \$20,000 to inaugurate the first weather service. This has been gradually increased until at the present time over \$1,000,000 is required annually to meet the expenses of the department. This vast sum is but a tithe of what the various industries of the United States are enabled to save through being forewarned by the 200 stations throughout the country of impending changes in temperature and weather conditions.

In addition to the 200 regular weather bureau stations there are maintained about 2,000 co-operative stations at which observations are taken by volunteers of temperature and precipitation.

The river and flood service is another important branch which is responsible for the saving of millions of dollars annually to the country.