several types of cold waves and of the conditions which contribute to their development and movement.

A well-defined low area presents a warm and a cold side. In the east or warm side southerly winds are attended by the higher temperature of lower latitudes; in the west, or cold side of the low area west to north winds carry southward the cold of higher latitudes. At any given point in the east quadrants of the low area warm, southerly winds will prevail. As the center of disturbance passes to the eastward the cold, northerly winds of the west quadrants are experienced. When, therefore, abnormally high temperature obtains in the front, and abnormally low temperature in the rear, of a low area, a decided fall in temperature will be experienced within the area of active cyclonic disturbance following the passage to the eastward of the storm center, and in cases where a decided and specified fall to the freezing or frost temperature occurs, a cold wave is noted.

The cold waves of the middle Gulf Coast belong to two fairly well-defined types. They either follow the passage of a low area from the northwestern States to the lower Mississippi Valley, or follow a low area which develops or appears in the extreme southwest. The southwest low area may develop in the southern part of a trough of low pressure which extends southward between the Rocky Mountains and Mississippi River, or it may appear near the west Gulf Coast and move thence over the middle Gulf States. A necessary condition to the southward sweep of the cold waves, whether they depend upon the northwest or the southwest low areas, is an unbroken area of high barometer extending over the Rocky Mountain and Plateau regions. It is also necessary to the verification of a cold-wave signal on the middle Gulf Coast, in cases where a fall of 16° to 42° is required, that a 24-hour fall in temperature of 20°, or more, shall have occurred in the middle-western States, and that a gradient of at least 25° shall appear between the Gulf Coast and the thirty-fifth parallel. When, therefore, the weather maps show a well-defined low area over the lower Mississippi Valley, with temperature 60°, or below, at New Orleans, and an area of high pressure of great magnitude covering the Rocky Mountain and Plateau regions, with a 24-hour fall in temperature of 20°, or more, in States lying between the lower Missouri River and the middle Rocky Mountains, and a temperature gradient of 25°, or more, between New Orleans and Oklahoma, a fall in temperature of at least 16° may be expected along the middle Gulf Coast within twenty-four hours.

SPECIAL CONTRIBUTIONS.

METEOROLOGY AND MAGNETISM.

By Prof. FRANK H. BIGELOW (dated December 15, 1895).

General remarks on the observations for the year, October 1, 1894, to September 30, 1895.

The leading facts regarding the existence at the earth of two systems of deflecting magnetic forces, depending upon solar action as their cause, are now so far developed as to show that there is an intimate connection between them and certain meteorological phenomena. It is evident that the further development of the subject should proceed along two lines, leading (1), to the elucidation of the physical laws involved, and (2), to a practical application to current meteorological conditions, particularly the art of forecasting. Unfortunately neither of these are easy to prosecute satisfactorily, in consequence of the very complex nature of the interrelated phenomena prevailing in the earth's atmosphere, and the obscurity of our information regarding the nature of the ether and the transference of its energy to ponderable matter. Only a slow growth in such knowledge can be looked for, though eventually much may be accomplished, and since close attention is being paid to these topics by physicists, a steady advance will doubtless take place.

For the year October 1, 1894–September 30, 1895, inclusive, certain data regarding the horizontal magnetic force, the pressures and temperatures have been published in the MONTHLY WEATHER REVIEW. The primary object of this publication has been, not so much to establish a connection between meteorology and magnetism, as to exhibit the condition of the practical problem in the simplest possible form, and to gather data from which to judge regarding the proper system of operations to be pursued in connection with forecasting. It is not possible to approach the problem directly, because no magnetic and meteorological observations have ever been taken simultaneously at the seat of the principal transference of energy on the American continent, namely, just east of the Rocky Mountain range in the British Possessions, where the belt of maximum auroral frequency crosses that district; that is to say, at about 115° west longitude and 55° north latitude. A limited knowledge of the operations of the polar magnetic field that emanates from the sun, shows that, as it enters the earth, it is subject to great local variations in direction and in strength at different stations. This differentiation of a field, which is uniform just outside the earth's atmosphere, into local fields of varying vectors will, no doubt, in time, become one of the best means of studying the meteorological conditions of the upper atmosphere, considered as an absorber and transformer of ether energy, but at present it complicates the question under immediate consideration.

The successful establishment and maintenance of first class magnetic observatories requires money and skill, and this need, unfortunately, limits their number to such an extent as to prevent adding one to each of the principal stations of the Weather Bureau. Possibly, however, a few stations can be fully equipped with magnetic instruments, and others may supplement these by using secondary apparatus for relative variations, entirely apart from absolute measurements. During the past two years some attention has been devoted to a consideration of the best form of secondary apparatus for the purpose of recording the relative changes in the impressed solar field from day to day. The features most desired are moderate expense for the instrument, and ease of observation, so that it can be as readily handled as a barometer or thermometer by the observers of the Bureau. My efforts have taken two directions: (1), the construction of a time-integrator by means of a rapidly vibrating magnet; (2), the use of the ordinary bifilar indications unreduced for temperature and instrumental errors. Regarding the former a report may be expected after further observations are secured. Concerning the latter, the data for the present remarks have been presented in this REVIEW.

It is known that the field with which the frequent changes in the meteorological elements of the Northwest are apparently associated, enters the atmosphere of the earth in directions nearly parallel to the magnetic meridians, more definitely in lines normal to the ovals of the distribution of auroral frequency. We may properly call them *auroral meridians*. The concentration of energy in ovals surrounding the magnetic and the geographical poles must be due to such a distribution of the permeable material of the earth as shall make an exflected field in the arctic zone, and an inflected field in the tropics. The southern field is so far absorbed in the heat of the tropical zones as to have no known definite effect upon the weather from day to day; the arctic field, on the contrary, has a persistent though loose tendency to excite the atmospheric circulation to form highs and lows in a peculiar sequence. Hence, it is the variations in the horizontal and vertical components of terrestrial magnetism from day to day that best measure the solar energy involved in the production of northern storms. The systems of force just specified are magnetic, so adjusted as to make mean angles at the surface of the earth, and a constant value for each station, so that the total impressed force is on the average proportional to the horizontal component. Hence, in studying relative variations, this latter can be used as an approximate substitute for the total force, and the bifilar becomes the instrument for useful work. If bifilars could be placed in the zone of the maximum frequency of auroras, they might be a fairly reliable measure of the quantities desired. Unfortunately the observatories available (Toronto, Washington, and San Antonio) are all located in the zone where the exflected and the inflected systems meet together, and there is, in consequence, a very unsteady direction to the impressed field, so that the horizontal component cannot be supposed to hold a very constant ratio to the total vector. Therefore, within this zone the action of the bifilar can only imperfectly record the changes in the solar field, though it is evidently much more valuable than the declinometer or the Lloyd's balance. In the curves published in the WEATHER REVIEW no attempt was made to correct for temperature or other instrumental conditions, because it was desired to see how far the readings of the bifilar could be utilized in their crudest form, such as might be necessary to adopt in any extended use of this form of apparatus. A reasonable steadiness of temperature, and photographic registration of the trace can be secured at very inconsiderable outlay for equipment and maintenance.

With regard to the meaning of the magnetic curves, the following considerations must be mentioned. The primary cause of atmospheric circulation is, of course, the equatorial accumulation of heat from the electro-magnetic radiation of the sun. This maintains a system of atmospheric circulation of warm and cold currents of a very complex character, which are chiefly the source of the highs and lows seen upon the daily maps. My researches show that the magnetic energy of the polar field is added to this as a secondary source of action; it supplements, but does not supersede, the former. The probability is that 25 or 30 per cent of the disturbances in the weather conditions of the region designated as "the extreme northwest" will be traced to this source, from whence the extension and dissipation occurs chiefly in the United States. But it must not be overlooked that prevailing conditions are largely due to tropical convection, and that the synchronism between this and the polar magnetic energy may often become distorted. Such is the case in the summer, when the action due to the polar magnetism of the sun is greatly reduced in effectiveness, and in the winter, when the convectional discharges (*i. e.*, the cold waves) become very violent and disturb the fundamental magnetic pulsation (*i. e.*, the maxima and minima of the 26.68 period).

An examination of the curves of magnetic force and atmospheric pressure and temperature for the year shows that there is a synchronous variation maintained in all three curves for long intervals; that this harmonious beat is sometimes broken up, but soon restored. One should not expect to find such complete harmony as usually exists between the curves of mean daily pressure and temperature; it would be unphilosophical to disregard the well recognized facts that the instrumental conditions are incomplete, and that the effect of magnetic energy is not fully separated from the dominating convectional currents of the atmosphere. As matters now stand we see that (1) 75 per cent of the changes in the curvature of the magnetic curves agree quite well with those of the temperature and pressure curves; (2) that the amplitudes are about as reliable as the phases; (3) that the magnetic force is precedent, and that the highs and lows may lag a little in their formation; (4) that the fact that the magnetic observations are made 2,000 miles away to the southeast of the indicated seat of energy excludes the idea that the variations of atmospheric temperature were the cause of the simultaneous magnetic changes. These practical matters are clearly in a very elementary condition, but the prospects are good that they will be improved. For several reasons there is an increasing demand for better and more magnetic observations, so that it is very much to be regretted that one of our three American observatories has discontinued its operations, and that all three have suffered (especially as to the record of vertical force) by the introduction of electric trolley lines in their neighborhood. The Weather Bureau desires to acknowledge the courteous and generous cooperation it has received from the director of the magnetic observatory at Toronto, the superintendent of the Naval Observatory at Washington, and the superintendent of the U. S. Coast and Geodetic Survey which maintained a temporary observatory at San Antonio.

Beginning with the month of October, 1895, the presentation of the data will be given in a somewhat different form, aiming at greater accuracy in the comparison of the two types of physical elements.

NOTES BY THE EDITOR.

FLORIDA FREEZES FOR A CENTURY AND A HALF.

The following paper, read May 8, 1895, by George R. Fairbanks, is reprinted from pp. 16–20 of the Proceedings of the Eighth Annual Meeting, Florida State Horticultural Society. The data given in it will prove useful for future reference:

The earliest authentic record we have of severe cold weather in this State is in the year 1766, just after the transfer of the Floridas to England.

The night of January 2, 1766, John Bartram, the botanist, says, "was the fatal night that destroyed the lime, citron, and banana trees in St. Augustine, many curious evergreens up the river that were nearly twenty years old and in a flourishing state, the young green shoots of the maple, elm, and pavia, with many flowering plants and shrubs never before hurt."

Bartram, who was then camping on the St. Johns River above Volusia, says: "The morning of the 3d was a clear, cold morning; thermometer, 26°; wind, northwest. The ground was frozen an inch thick on the banks." Bernard Romans, in his Natural History of Florida (1775), says: "On January 3, 1766, a frost destroyed all the tropical productions in the country, except the oranges. The Spaniards called this a judgment on the place for having become the property of heretics, as they never had experienced the like."

In 1774 there was a snowstorm which extended over most of Florida. The inhabitants long afterwards spoke of it as an extraordinary white rain.

In 1799 the temperature was very low. On the 6th of April, 1828, a heavy frost was very destructive to vegetation; the temperature at Picolata was as low as 28°.

The great freeze, par excellence, occurred in 1835 on the 7th of February, when the temperature went as low as 7° above zero. John Lee Williams, writing in 1837, gives the following account of the great freeze of February, 1835:

"A severe northwest wind blew ten days in succession, but more violently for about three days. During this period the mercury was 7° below zero." [This is undoubtedly an error, and should read *above* zero instead of *below*.—G. R. F.] "The St. Johns River was frozen several rods from the shore, and afforded a spectacle as new as it was distressing. All kinds of fruit were killed to the ground. Many of them never started again, even from the roots. The wild groves suffered equally with those cultivated as far south as 28°."