identical with that which exerts its influence on the secular variations. As regards the nature and origin of this force, there is a wide field for speculation.

The Editor is not yet prepared to recognize the force of the demonstrations that have been adduced by Dr. Halm. Coincidences between sun spot frequency and various other phenomena have been made the basis of innumerable memoirs and have led to a host of most suggestive hypotheses as to the connections that must, or at least may, exist between most diverse phenomena within the solar system. As we know nothing about the nature of the force of gravitation it is perfectly proper for us in our ignorance to acknowledge that it is a plausible hypothesis that gravitation may be affected by the same cause that produces the sun spots and may vary simultaneously with them. But in order to give this hypothesis a satisfactory basis, we need either better astronomical work or a profounder insight into the interaction of the physical ether and the ordinary molecules of matter. We need to know something more as to what sun spots are and what causes them or what is that physical connection between the sun and the earth by virtue of which we receive not only light and heat, but chemical and electrical influence. After many centuries philosophers discovered how the ocean tides are caused by the solar and lunar gravitation. Clerk Maxwell made the profound suggestion that electrical and magnetic phenomena might be traced back to the so-called viscous tides and strains within the earth's crust; recent electricians seem to have shown that the electrified condition of the upper air is due to the chemical action of the solar radiation. There is reason to expect further progress in this direction and it will be proper for us to publish in the next MONTHLY WEATHER REVIEW the views advocated by Prof. Ernest W. Brown as to the nature of the sun spots and the plausibility of further connections between the sun and the earth.

THE STORMS OF MARCH, 1888 AND 1900.

The newspapers of New England contain many comparisons between the blizzards of 1888 and 1900, the general conclusion being that the famous storm of the former year still holds its own as the severest of the century. The snowfall varied from 2 to 4 feet in depth during the first two days of the current March; the wind was severe; ordinary roads were entirely blocked, owing to the quantity of snow already on the ground; the railroad service was severely disorganized, but telegraph and telephone service was not affected to so great an extent. The Montpelier papers say:

> It takes something more than 3 feet of snow to stagger the managers of the Montpelier and Wells River Railroad, which is one of the hardest in the State to keep open." * * * "The great blizzard of 1888 began in Vermont on Monday morning, March 12, and it continued snowing heavily until Thursday night, while the wind piled it up into immense drifts. There was no communication, even by wire, with New York and Boston for two days and a half, and no trains or mails reached Burlington, Vt., between Monday morning and Wednesday evening.

The storm of March 1, 1900, throughout New England and New York was, in general, slightly inferior to that of 1888. In some cases, however, as in Rochester, the snowfall was decidedly the largest on record. The Rochester Democrat and Chronicle says:

> The longest drawn out snowstorm on record for this city was that of January, 1889, when it snowed from the 2d to the 4th of January, but only a small quantity of snow fell. The average snowfall for February is 17 inches; the greatest for one is 90 inches; and thus Rochester in two days got a third as much as the record for the season. But there was on the ground in 1893 29 inches of snow, some 2 or 3 inches more than there is now. During the winter of 1847–8 there was on the ground, it is said, 35 inches of snow about 100 miles southeast of Rochester. Buffalo at one time had 9 feet of snow—the fall for the month. This was in 1879. Arches were constructed of the snow, and people walked under them in the street.

Buffalo and Toledo report that the snowfall was not so heavy as in the storm of 1894, but that the drifts were worse than on that occasion.

At Portland, Me., the maximum easterly wind is said to have occurred about 10:30 to 11:30, March 1, at which time the water in the harbor had risen to a point unequaled in recent years. At this time also vivid flashes of lightning were observed. In general the storm of wind and high water on the coast of Maine was the severest for twenty-five years past. At St. John, N. B., it is called the severest since "the Saxby gale."

From Ohio westward the storm was, in general, the most severe that had been experienced during the past fifteen years.

FROST PROTECTION BY HOT WATER.

According to the Citrograph, published at Redlands, Cal., Mr. E. A. Meacham, of Riverside, has been experimenting on a method of protection against frost by the use of hot water. The plan is to heat water and spread it over the orchard in the usual way of irrigation. The water is heated in a large boiler under which is burning an oil jet. The water is distributed in furrows between the trees of the orchard to be protected. Water, which stood at a temperature of 60°, was heated in a short time to 94° F. The cooling of the water, after it had flowed in the furrows, was carefully measured; it was found to have a temperature of 58° at a distance of 20 rods from the boiler, and of 52° at 40 rods distance. While the heated water was flowing a decided amount of vapor rose from it and from the land that was wetted and warmed by it. Mr. Meacham's plant cost about $200, and the cost of operating it is about 60 cents per hour. The observations of temperature were made by Mr. A. G. McAdie, Forecast Official, who has made a full report on the matter which will be published in Weather Bureau Bulletin No. 29. The plant consisted of a 12-horsepower horizontal boiler and a secondary 6-horsepower boiler, which is used to generate the steam that is mixed with the burning oil so as to consume it entirely without smoke. The temperature of the air was about 34°, and the temperature of the unheated water in the open fields about 41°.

THE TOTAL ECLIPSE OF THE SUN MAY 28, 1900.

In the MONTHLY WEATHER REVIEW for September, 1899, will be found an article by Prof. F. H. Bigelow and a chart showing the path of totality as it passes from New Orleans, La., to Norfolk, Va. In addition to the many astronomers who will attend to observations that interest the astronomical world, there will, it is hoped, be some physicists and meteorologists who will look after the important matters that relate to the earth's atmosphere. Having been requested to state what observations are of special interest to meteorology, the Editor would suggest the following:

1. The solar corona consists of a bright interior portion which undoubtedly represents the sun's atmosphere and will be carefully studied by the astronomers. Outside of this are to be seen streamers of great delicacy and sometimes bright isolated spots. The general belief is that these relate to the space outside of the sun and not to the earth's atmosphere, but there is still a possibility that some of these may be due to the reflection of sunlight from particles of vapor or crystals of ice floating in the earth's atmosphere. Any observations that will elucidate the character of the outer corona will interest meteorology. The corona may be sketched by some as seen by the naked eye; by others it may be photographed

with an ordinary camera and sensitive plates; by others the character of the light may be studied by the use of the polariscope or its brightness by the photometer, or its color by some form of colorimeter. In rare cases, it may be that the air will be still enough to allow crystals of ice, or snow, to arrange themselves systematically as they descend toward the earth, in which case delicate coronal streamers will assume symmetrical positions about the sun, very much as in the ordinary halos.

2. The amount of heat received from the sun per minute is measured by some form of pyrheliometer of which the best are those devised by Pouillet, Langley, Crova, Violle, Chwolson and Angström. When such observations are made frequently from sunrise to sunset on any clear day we obtain the coefficient of absorption for the earth's atmosphere and, also, the amount of heat received at the outer surface of the atmosphere, which is, of course, much larger than that received at the ground. But the heat absorbed by the atmosphere, with its dust and moisture, must also be radiated in all directions, so that the earth's surface receives both the direct radiation of the sun and the diffuse radiation from the atmosphere, which latter is a very important item when the whole hemisphere of sky is considered. Now, during the few minutes of totality, when the direct rays are cut off, we have an opportunity of measuring the sum total of the atmospheric radiation and, thus, determining a point that is very important for climatology and agriculture. The same measurement enables us also to calculate the average temperature of the atmosphere during the total eclipse and thus obtain some idea of the thermal disturbance that pervades the atmosphere at that time. The fact that on many occasions, in a very moist air, the reduction of temperature is sufficient to allow the formation of fog or haze or cirrus clouds shows that this thermal disturbance is by no means unimportant.

3. The regular meteorological observations of temperature, cloudiness, and wind generally show a slight change as a solar eclipse advances toward totality. Observations of the barometer do not show any influence. In general these meteorological observations have not yet been utilized to elucidate any important point, still it is well to make hourly observations during the whole day, and 10-minute records during the eclipse, and minute records during the totality, if it seems likely that the records will be utilized for future study. Of course, the barometers and thermometers must be of extreme delicacy in order to catch the fleeting eclipse effect.

4. It is well known that the blue skylight has a peculiarity called polarization that does not belong to the sunlight itself. This polarization is supposed to be the result of the process of reflection by which the blue skylight is formed. Perhaps it is more proper to say that the sky would be perfectly black and the stars would be visible by day as well as by night, were it not for the fact that a minute percentage of sunlight is reflected to us from every atom of dust and vapor and every molecule of gas in the atmosphere. The smallest or finest particles send us the blue light, while the largest send us white light, and intermediate sizes may send us each color of the spectrum, respectively. The blue light from points in the sky at right angles to the sunlight is almost perfectly polarized, but being mixed with other light from larger particles the resulting mixture is neither perfectly blue nor perfectly polarized. The percentage of polarized light indicates, approximately, the quantity of small particles, or haze, that exist in the line of sight. The observations of polarization of skylight should undoubtedly form a prominent part of the work of every well equipped meteorological observatory, and they may, eventually, be found to be of sufficient practical importance to demand attention at every regular Weather Bureau station. During an eclipse of the sun we have an opportunity of examining whether the percentage of polarization varies with the varying total light from the sun. There is no known reason why it should be so, but if it is found to be the case, then, certainly we must be stimulated to further investigations.

5. During totality observers have frequently noticed, when looking at a uniform surface of wall or ground, that little shadows appear to flicker or move rapidly over the surface. Sometimes these are described as shadow bands, at other times they are bright and dark spots of lenticular shape moving in parallel lines, and with the speed of from 5 to 20 feet per second. Some excellent suggestions as to the observation of these shadow bands have been made by Prof. R. W. Wood of the Physical Laboratory of the University of Madison, Wis., and we copy the following from Science of April 27.

They can be observed to the best advantage by laying a large piece of white cloth on the ground. * * * They move quite slowly for the minute before and after totality. * * * They move in one direction before the eclipse and in the opposite direction after. * * * The only half-way plausible explanation that I have ever heard offered for the shadow bands is that they may be due to striæ in our atmosphere. This would bring them under the head of the scintillation phenomena, treated of somewhat extensively in advanced works on optics, but I am unable to see how any such regular and symmetrical distribution of light and shade can result in this way. That the distance between the bands varies on different occasions lends some plausibility to this explanation, but it is not impossible that the width of the bands is a function of the location of the point of observation, that is to say, of its distance from the center of the eclipse track. This can only be determined by numerous and extensive observations covering a wide tract of country, and it is to secure as many data as possible on this subject that I desire to secure the cooperation of all who are interested in the subject. Observations just outside of, and just within the track of totality will be of especial interest. The observations can be made without any apparatus, and as the bands are not visible during totality their observation will not inconvenience any who are more interested in the spectacular than in the scientific side. At the end of this article I shall outline, as clearly as possible, just how the observations should be made and what data recorded. It has occurred to me that the stroboscopic disc may be of use in determining the cause of the bands. If a source of light produces in any way moving bands of light and shade, it is obvious that if the eye be directed toward the source it will receive more light from the source while a bright band sweeps across it, than during the transit of a dark band. If the alterations are not too rapid a fluctuation in the brilliancy of the source should be observed.

As a matter of fact, citing a special case, the bands are about 3 inches wide, and move with a velocity of about 10 feet per second. This means that 40 bands cross the eye every second, too many to cause any flickering effect. By means of a stroboscopic disc, which is merely a circle of cardboard with equidistant radial slits arranged to be rotated at varying speeds, it is possible to keep the eye in a dark or light band as long as we choose.

Suppose we are looking at the source of light through the slits of the revolving disc, and suppose that the speed of rotation is such that the slits cross the eye at the same rate that the dark and light bands do. This is practically keeping the eye continually in a dark or light band. If the rotation is a little faster or a little slower, the slits will alternately get into, and out of step with the bands, and the eye will be in a bright band one moment and in a dark one the next. In this way we may make the speed of the fluctuations as slow as we please, and if we look at the sun's crescent through such a device we may possibly detect a flickering in whatever part of the source of light is operative in producing the bands. The disc should be about a foot in diameter with about 8 slits in it, distributed uniformly. I should advise that 3 or 4 concentric rings of slits of different width be made, the eye being moved from one to another. In this way the apparent brilliancy of the sun can be varied at will, which would increase the chances of detecting the flickering if it existed. The location of the flickering is to be carefully noted, that is, whether it is of a portion, or the whole of the crescent, or whether it is in the air close to the edge of the sun's limb. The disc can be rotated by hand by means of a whirling table, to be found in every physical laboratory. This simple arrangement will, I think, be found more satisfactory than a more complicated rotator, as the speed is more immediately under one's control.

I am planning to use such an arrangement myself, and hope that some of the other eclipse parties can arrange for the simple experiment also. The speed and width of the bands could also be determined by means of the stroboscope. If we receive the bands on a white cloth on which a scale is marked, and view them through the revolving disc, by carefully adjusting the speed of rotation, it is obvious that the bands can be made to appear stationary. Their width can then be accurately determined by counting the number in a given distance, and the speed with which they move calculated, if the speed of the disc at the moment is recorded. In this way any change in width could be measured.

While these observations can only be made by persons who have had some training in work of this nature, valuable data may be secured by any who are fortunate enough to live within the eclipse belt. I desire to secure, if possible, a complete record of the appearance of the bands over the entire country, together with statements regarding the direction of the wind, condition of the air, etc. The bands can be best observed by spreading a sheet or other large white cloth on the ground. As soon as the moving shadows appear, which will probably be about a minute before totality, lay a lath on the sheet parallel to the shadows, with as great accuracy as possible. Then try to estimate the width of the bands and the velocity with which they are moving, also the direction in which they are going, that is whether from east to west or west to east. The width of the bands can be best determined, I imagine (I have never seen them), by estimating the width of a group, say five or six, or as wide a bunch as the eye can grasp and follow, with certainty as to the number of dark bands in it. A scale for reference, preferably a white board with feet and half-feet marked with strong black lines, will be of assistance. It should be laid perpendicular to the shadows, that is at right angles to the lath. The speed can be estimated by trying to keep up with the moving shadows, and may be recorded as slow walk, fast walk, slow run, etc. Those who are accustomed to counting quarter seconds, can probably make a fair estimate of the speed by noting the time of transit of a band across the sheet. The shadows will disappear at the moment of totality, but will reappear again as soon as the sun's edge emerges from behind the moon. A second lath should be laid on the sheet, parallel to the bands unless their direction is the same, and the same observations repeated, noting whether the direction of motion is reversed. After the eclipse is over, determine the direction of the two laths as accurately as possible with the compass, and measure the angle between them. Note the direction of the wind before and after the eclipse, and record the general atmospheric conditions.

Tabulate the data as follows:

BEFORE TOTALITY.

1.—Direction of the bands.
2.—Width of bands. (Give all data, that is number of dark bands in given width of the system.)
3.—Estimated speed. State how estimated.
4.—Direction of motion. Whether from east to west, or west to east.
5.—General appearance. Whether sharp or lazy, whether contrast between light and shadow is considerable. If possible estimate relative intensity of illumination in dark and light areas.
6.—Direction of wind. Temperature and general atmospheric conditions.

AFTER TOTALITY.

Repetition of the above.
Actual angle between the laths.
General remarks and location of point of observation.
Reports should be sent to Prof. R. W. Wood, Physical Laboratory of the University of Wisconsin, Madison, Wis.

STATIONS OF THE MEXICAN TELEGRAPH COMPANY.

In the March number of the Texas Climate and Crop Bulletin, Mr. I. M. Cline, Local Forecast Official and Section Director, publishes the monthly summaries for the three regular stations of the Mexican Telegraph Company, viz, Coatzacoalcos, Tampico, and Vera Cruz. The apparatus at these stations has been carefully established by Dr. Cline. The stations are maintained entirely at the expense of the telegraph company, and as they are quite independent of the official Mexican system conducted by the superintendent of the state telegraphs, it is proper that the records should be published by the Weather Bureau. Observations are daily sent by cable from these three stations to Galveston, and therefore, appear in the regular daily bulletins and charts published at Washington and elsewhere. These accurate observations, so far south on the Gulf coast, combined with those at Merida, give us a very comprehensive view of atmospheric conditions over the Gulf of Mexico when northers or hurricanes prevail, and the Weather Bureau is greatly indebted to the Mexican Telegraph Company for its hearty cooperation in this matter.

INFLUENCE OF THE WIND AND OF RYTHMIC GUSTS ON THE LEVEL OF LAKE ERIE.

In the MONTHLY WEATHER REVIEW for April, 1898, page 164, the Editor has calculated the outflow of the Great Lakes into the St. Lawrence River, and has shown the need of further data relative to the rainfall and evaporation. Similar calculations, as revised in the light of the most recent data, have lately been published by the United States Board of Engineers on Deep Waterways in its preliminary report on the regulation of the level of Lake Erie (House Doc. No. 200, Fifty-sixth Congress, first session). In the course of this report it is shown that a serious source of irregularity affecting the navigation of the lakes is the great variation of level at the outlet and inlet of each lake due to the influence of the wind. On this point the report says:

> From the head of Lake Erie to the islands (about 30 miles) the depth of water is only about 35 feet, and through the channels between the islands the depth is from 25 to 35 feet.
>
> Heavy westerly winds force the water through these passages into the main body of the lake, causing a lowering of the water level at the head of the lake and a corresponding rise at Buffalo, N. Y. The amount of this change of level depends upon the stage of the lake, the velocity and direction of the wind, and the duration of the storm, and in extreme cases, with wind velocity of 60 to 80 miles lasting for several hours, the change of level reaches 6 to 7 feet at each end of the lake.
>
> The change of level at Cleveland, Ohio, is generally less than one foot, showing that the wind effect is mostly at the two ends of the lake, and is due to the depth of water being so small that return currents are not generated sufficiently to equalize the effect of wind on the surface, until considerable difference in level is produced. The deeper the water the less will be the head necessary to produce any given volume of flow in return current, and it is probable that the elevation to which the water will be raised by wind of any given velocity and duration will be approximately the same, whether the lake be at extreme low or medium high stage when the storm occurs. Storms of sufficient force to change the water level 3 feet or more at the head of the lake are very infrequent, and can only be provided for by making the depth of channels at the head and foot of the lake that amount deeper than through other portions of the waterway system.
>
> The length of time which these changes would be in excess of 1 foot is so small that, with the level of the lake regulated above mean stage, the detention from this cause would not seriously delay commerce.

In this connection the student should consider the influence upon the water level of changes in atmospheric pressure. If the barometer should be higher at one end of the lake than at the other by one-tenth of an inch, and should continue so for a sufficient length of time, it would cause a difference in level of over one inch of water. Barometric differences of several tenths frequently occur. An interesting article upon this subject, by Prof. A. J. Henry, will be found in the MONTHLY WEATHER REVIEW for July, 1899, page 305.

An important cause for the occurrence of differences of level at the two ends of a lake consists, not so much in the temporary differences of barometric pressure or in the temporary influences of gusts of wind, as in the regularity with which these temporary pressures and gusts act upon the water. There is always a natural period which is called the free oscillation of a water surface. By experiment in a basin or tub, we may easily find what depth of water allows of a rythmic oscillation from side to side throughout the whole mass of water. For this depth the water rises on one side of the tub while it is falling on the other side. If we depress the water on one side by blowing upon it, or by pushing it, or by tipping the basin, and do this systematically while the water is itself falling on that side, but do not do it when the water is rising, we quickly observe that we have so timed our artificial impulses as to force the waves to grow larger and larger. This is also the principle elaborated by Dr. R. A. Harris in connection with the local tides of the ocean, and, indeed, of the Great Lakes also. The influences that come from the sun