mometer or the rotating blades of Combes' wind meter or the curved plates of the Richard anemometer, or of Dine's helicoid anemometer. On the other hand the wind pressure is observed by exposing a plane plate, normal to the direction of the wind, or sometimes a sphere is substituted for the plate; in Wild's pendulum anemometer the plane plate swings like a pendulum out of the vertical position for calms, up to as high an angle as the force of the wind requires. This latter form of apparatus gives us some idea of the force of the gust of wind, the gust may be but momentary, being only the front of a "pulse of pressure," or of a revolving eddy; its force is due to the very rapid motion, through a very short distance, of a small mass of air. When such a gust strikes the cups of the Robinson anemometer they are whirled about with great speed, and retain that speed for some time after the gust has ceased. The sum total of the movement shown by this anemometer is distributed over a longer time than the gust itself endures, and the extreme velocity attained is less than that of the gust at its maximum intensity, but the average velocity shown by the cups is greater than belongs to the gust as a whole. If, therefore, we compare the records of the maximum pressure and the maximum velocity recorded in the open air we find that the velocity seems to be less than is appropriate to the pressures.

If, on the other hand, the velocity and the pressure anemometers are set up side by side in a current of perfectly uniform wind, or failing that, if they are established on a uniformly revolving whirling arm in a room with still air, then, for this case of uniform motion, the pressures and the velocities harmonize perfectly. This latter is the ordinary method of comparing anemometers in order to deduce figures necessary to reduce the indications of one instrument to that of another. Nearly all kinds of anemometers will agree very closely when they are compared in a perfectly uniform stream of air, but they will show wide differences in gusty winds. These differences will increase in proportion to the friction within the apparatus, and especially in proportion to the inertia, or more properly the moment of inertia.

This gusty nature of the atmosphere has of course been known from ancient times. In fact the motion of the air in what we call a steady wind is not linear but a mass of whirls and eddies, as may be seen by any one who will watch the gyrations of a snowflake. Professor Marvin seems to have been the first to perceive that the presence of these gusts explains the discrepancy between the action of the anemometers in the open air as compared with their behavior in the steady wind of the whirling machine. He has explained this matter and given accurate determinations of its amount in numerous publications between February, 1889, and December, 1890. In order to show the effect of gustiness most clearly Professor Marvin employed some very light anemometers of paper of the same size as the regulation Robinson anemometer, having previously used others of much smaller size. The sluggishness of these anemometers depends upon the moment of inertia, viz, the mass multiplied by the radius of gyration, and his smallest anemometers had not one one-thousandth part of the sluggishness of the regulation apparatus. The latter being set into rapid motion by the gusts showed slightly larger average velocities than the smaller instruments which showed higher maximum velocities, but stopped their rapid motion as soon as the gusts went by.

Professor Marvin concludes that after determining the error of an anemometer in a steady wind by means of a whirling apparatus, one must then still further determine its errors in gusty winds; but this latter is well nigh impossible, or rather useless, because the gusts are of such infinite variety, as to severity and lengths and vacillation. It would seem possible to establish side by side in the open air several anemometers of very diverse moments of inertia, in order, by the comparison of their records, to determine the general influence of the gustiness of any particular location or wind. In general, Professor Marvin finds for the average character of the gusts at Washington a set of corrections that are embodied in his pamphlet on anemometry. His last report on this subject, dated October 4, 1890, is published on pages 691–698 of the Annual Report of the Chief Signal Officer of 1890, and as his results are frequently called for, we quote from that report the following:

The formulæ derived for the Signal Service anemometer having cups 4 inches in diameter on arms 6.72 inches long are—

(*a*) $V = 0.225 + 3.143\, v\, 0.0362\, v^2$—(for whirling machine.)

(*b*) $V = 0.263 + 2.953\, v\, 0.0407\, v^2$—(*a*, reduced to open air.)

V is velocity of winds in miles per hour; v is velocity of centers of cups in miles per hour.

Equation (*b*) may be considered as the equation of the regulation Signal Service anemometer when exposed to the variable wind of the open in Washington, while equation (*a*) is for the same anemometer exposed to perfectly steady winds.

[and a moment of inertia of about 117,000 grammes centimeters.]

In order to overcome certain defects in this quadratic equation which would prevent its being applied to very high velocities, Professor Marvin deduced and recommends the following logarithmic form:

$$(c) \qquad \log V = 0.509 + 0.9012 \log v$$

With this formula he computed a table of wind velocities as indicated by Robinson anemometers, converted into true velocities especially applicable to the gusty winds of Washington, from which we make the following abstract:

Weather Bureau anemometers. Indicated velocity.	True velocity.
Miles per hour.	*Miles per hour.*
10	9.6
20	17.8
30	25.7
40	33.3
50	40.8
60	48.0
70	55.2
80	62.3
90	69.2

The importance of inertia in gusty air is also dwelt on by Professor Langley in his memoir On the Internal Work of the Wind, published in 1893, in the prosecution of which he was assisted by Mr. G. E. Curtis, formerly of the Signal Office, and made use of the paper anemometers constructed by Professor Marvin.

The last volume of the Archives of the German Marine Observatory at Hamburg, contains an elaborate memoir by Dr. George Neumayer, on anemometer studies, in which he reviews the whole subject, and concedes the correctness of Professor Marvin's results, which have also been further confirmed by the investigation of Dr. C. Chree, Director of the Kew Observatory.

NOTES FROM THE AUGUST REPORTS OF THE CLIMATE AND CROP SECTIONS.

ALABAMA.

The regular meteoric shower of August will frequently bring large meteors, and this seems to be especially the case in Alabama, where especially brilliant meteors were observed on the 9th at 8:40 p. m., at Selma, and on the 16th at 9.30 p. m., at Montgomery. The latter was so brilliant as to outshine the public electric lights.

ARIZONA.

The voluntary observer at Fort Mojave reports that on the 28th there was a heavy rain and furious wind, but the latter upset his rain gauge; other measurements gave rainfall of about 8 inches in forty-five minutes. May not the Editor make this unfortunate upset of the rain gauge the text for an urgent appeal to all observers to reexamine and strengthen the defenses of the gauges. Here was a rare phenomenon lost to accurate measurement by over confidence in the firmness of the gauge, and it was merely good luck that the observer happened to have a wash tub set out on the mesa, clear of everything, which caught 8 inches of rain. Is it not remarkable that the rain gauge, although firmly secured was upset, while the wash tub, without being secured, was undisturbed?

FLORIDA.

The Section Director, Mr. A. J. Mitchell, has been fortunate in securing from Judge Richard some account of the freeze of 1833. The Judge says that it was not very severe; the ground being frozen about one-half inch on freshly plowed land. The correct date of the freeze was the 27th of April, and not February or March as sometimes erroneously stated.

GEORGIA.

Mr. Marbury, Section Director, reports a remarkable meteor observed at Atlanta at 10:15 p. m. of the 30th. As this meteor was not reported from any other station we must infer that cloudy weather hid it from most of the observers. Yet, on the other hand, as its course, as seen at Atlanta, was within 45° of the zenith, and as its height when it disappeared might not have exceeded 10 miles, it may well be seen that very few observers, except those close to Atlanta, could have had any chance to see it. A meteor like this might fall simultaneously into every circle of 10 miles radius throughout the world, and yet each would only be observed by two or three observers within the respective circles.

LOUISIANA.

The relation of the climate and crops is a matter of great complexity and ordinary statistics of the climate and crops do not generally show clearly any specific relation between them, but in an article in the Louisiana report Mr. Alexander McAdie quotes from the Louisiana Planter an item of great importance, viz:

In 1890 the rains on the sugar plantations of Louisiana *fell so nearly when and where they were wanted* that the sugar crop of 1889 of 144,000 tons was followed by a crop in 1890 of 252,000 tons. The distribution of rainfall was ideal. Every sugar planter seemed to have just the rains he wanted and the results showed up in an immense crop; black clay lands that ordinarily do well to yield 20 tons of plant cane, having given that year 35 tons. It is apparent therefore that not only the amount of rain falling in any year but also the distribution during the growing and maturing seasons are important factors in determining the crop yield.

We shall look with interest for the discussion upon this subject from Mr. McAdie, promised by him. In fact we are not sure but that it is about time to publish portions of a memoir on the relations between the climate and crops that was prepared by the editor in 1891 for the use of the Weather Bureau.

NEW MEXICO.

The successful cultivation of most crops depends upon the soil and the water quite as much as it does upon the meteorological climate. In New Mexico, where there is a superfluity of sunshine and heat, there is not sufficient rainfall at the proper time of the year, and the report in this section for August calls attention to the great advantage of the absolute control over the water supply that is afforded by artificial irrigation.

The large amount of sunshine and small amount of rainfall make it possible to harvest crops of hay and small grain with much more certainty than is possible in regions where the rainfall is more abundant and the sky is overcast with clouds a greater portion of the time.

On account of the abundant sunshine and dryness of the air and the absence of extreme sudden changes New Mexico offers conditions favorable to the relief of those suffering from diseases of the lungs.

It is a climate suited to the case before the destructive stage has arrived. * * * Our observations are such that we would recommend the Pecos Valley of New Mexico to those persons who have not yet reached the stage of disintegration.

PENNSYLVANIA.

During the summer season our notes from the section reports inevitably include a large number of severe local storms, but especial interest will attach to one that passed over Philadelphia on August 3. This seems to have been the severest storm on record for over a century, and it was moreover remarkable for its restricted local character. It lasted between 10:15 a. m. and 12:35 p. m., being nearly stationary over the city. Lightning flashes occurred in rapid succession. A large number of buildings, towers, flagstaffs, etc., were struck by lightning, "but probably owing to the heavy downpour of rain no serious fires occurred with a single exception of the destruction of the oil tanks at Point Breeze." Incipient fires may have been extinguished by the downpour of rain, as Section Director T. F. Townsend suggests, or else the lightning may have been conducted harmlessly to the ground through the thin layers of water which covered the roofs, a view known to harmonize with experience. But may we not go even farther and infer that the flashes, coming down with abundant rain in the midst of the storm, are really not so powerful from an electrical point of view as those that strike through the clear air from a thunder cloud at a considerable distance? This storm, in Philadelphia, after passing a short distance north of the station seems to have circled toward the northeast and returned directly over the station before resuming an easterly course. The total rainfall at the Philadelphia Weather Bureau station, 9th and Chestnut streets, during this storm, was 5.43 inches and was practically the same at the Pennsylvania Hospital station and at that of the voluntary observer in Camden, N. J. A station maintained by the Department of Surveys, at the corner of 5th and Wharton streets, reported 5.17 inches in three hours and thirty minutes, while another station maintained by the same department, at the corner of Frankford avenue and Orthodox street reported only 1.75. Occasionally we meet some one who is incredulous as to the necessity of having so many rainfall observers, but instances like this serve to emphasize the importance of the general principle that the Weather Bureau ought to encourage the establishment of just as many rain guages as possible. We need to study not only the extent of local storms, but also the peculiarities of specific locations. Not only does every hillside and valley have its own rainfall, but every storm and cloud has its own limitations. If ever, in the future, the student of atmospheric electricity succeeds in proving that rain can not fall without some kind of electrical discharge, either by lightning flash or otherwise (that in fact rain drops can not be formed without electrical influences), then, of course, the quantity of rain and the quantity or quality of the electricity will stand in some important relation to each other, so that knowing one we shall be able to infer the other.

The retrogression of this storm, by reason of which it remained so long over the city of Philadelphia, is a matter of much interest in the mechanism of thunderstorms. It is very much to be hoped that the observers in southeastern Pennsylvania may be increased in number and pay increased attention to the location of every thunderstorm that passes within the range of their respective horizons, so that we may be able to draw numerous charts of storm tracks as a preliminary step in the prediction of thunderstorms for that city.

TENNESSEE.

Showers of extremely brilliant meteors were observed at a number of places on the 10th, 11th, 12th, and 13th.

The observer at Greeneville reports a waterspout on the 10th in Green and Hawkins counties. We presume that he means a cloud-burst, namely, a heavy downfall of rain. In the genuine waterspout the water ascends rather than descends.

The observer at Lewisburg records a cloud formation at sunset of the 31st which consisted of branches extending upward from a base, but all intersecting at some point in the horizon. We presume that this is a form of illusion due to perspective. If these branches were really clouds parallel to each other and extending away from the observer, they would by perspective all seem to meet at a point in the horizon (which the draughtsman calls the vanishing point). This is illustrated every day when one observes carefully the rows of houses in a street or the parallel rails of a railroad. But it is barely possible that these branches were not clouds, but were simply the shadows of clouds. After sunset there will often be seen beautiful bars or streaks of light rising up from the western horizon. These are the effect of cloud shadows, or, sometimes, even mountain shadows. The original lines are all perfectly parallel with each other, but, by reason of perspective, they appear to converge, intersecting at the sun. A similar illusion will be noticed even when the sun is high in the heavens and when cumulus clouds shade a part of the hazy, gusty air, while the spaces between the clouds are brightly lighted up by the sun. The latter will then appear as bright beams converging upward toward the sun. Some call them Jacob's Ladder, others say that the sun is drawing the water, but the real phenomenon is simply one of shade and shadow, and perspective.

TEXAS.

The August report contains mean temperatures and pressures for three Mexican stations contributed by the Mexican Telegraph Company. Mr. Cline has done good service to meteorology by stimulating the cooperation of this influential cable company with our West Indian system. He has inspected its stations, and will consider them as part of the Texas section. It looks very much as though one of the three reported pressures at sea level were slightly erroneous. An error of a hundredth is more important in the tropical regions than in the extreme north temperate zone.

UTAH.

Mr. Isaac J. Elkington, the voluntary observer at Tooele, reports that on the 30th, at 4:10 a. m., he saw a perfect, white rainbow. It began to disappear in the southeast, but was visible in the northeast until 4:30 a. m., when it vanished.

The white rainbow is really a halo formed in mist or clouds, whose globules are too small to allow the formation of the regular colored rainbow. The rainbow is due to interference, not to dispersion of light, and requires full-sized raindrops to form it in perfection.

WISCONSIN.

The Section Director, Mr. W. M. Wilson, reports the heaviest rainfall on record for one hour at Milwaukee on Tuesday afternoon, August 23. He says nothing about attendant thunder and lightning, but adds that the storm was very local and that "unlike the local thunder storms noted in the July report the self-registering barometric trace showed no mark of oscillation before or during the progress of the storm. There was a gradual increase of pressure and a noticeable condition of instability, but no marked rise which usually indicates the approach of severe local thunderstorms and wind squalls."

In the early part of the century, and in fact up to 1871, there was probably no one except Prof. William Ferrel who had divested himself of the old fashioned error that when the rain falls the atmosphere must be lighter and therefore the barometer should fall. He, however, as it is now universally recognized made it clear that the fall of the barometer in our general whirling storms was not due to the rainfall but to the whirl, and he applied this same principle to the formation of the central core of a waterspout. On the other hand in thunderstorms and ordinary local rains which descend from small clouds high above us, there is no apparent general whirl, or if it exists it is small and confined to the region of the cloud, so that it does not seem to affect pressures at the earth's surface. In these cases the rain may fall and produce a very different class of phenomenon; whatever the pressures may have been in the cloud region, we at the earth's surface come under the following different conditions: (*a*) The falling rain must have a tendency to drive the air down before it, producing a pressure at the surface of the ground, where the air being checked in its descent, begins to flow out from under the rain. This increase of pressure may sometimes be appreciable, but generally it is small because pressure gives way as soon as the air moves away. (*b*) The falling rain cools the air, and if thereby a thick layer of cool air replaces the former warm air and allows other air to overflow it, the total weight, and therefore the pressure, is increased. (*c*) But more important than either of these is the consideration that the rainfall is usually a result of the ascent of air, which is cooled by the necessary expansion as it rises. Now this air would not rise if it were not pushed upward by an under flowing and uplifting mass of denser air, which is usually denser because it is both drier and colder. Oftentimes the thin layer of denser air does not at first descend to the earth's surface; it generally comes in as a wedge, inserted as it were between the cloud overhead and the air near the ground below. It brings with it a change of temperature and almost always a change in the direction of the wind; it is pushing its way forward like the nose of a plow under ground, and that push means pressure, and the moment its influence is felt at any station up rises the barometer, oftentimes without any rain at all, but more generally with temporary cloudiness and short rains. This is the process that goes on at the clearing up side of any storm; in extended storms the horizontal distribution of low pressures, rain, clouds, clear sky, and high pressure, covers so large a region that we can easily separate one from the other. The same process also goes on in the smallest local storm and in a thunderstorm, where the phenomena are all crowded close together.

Between every thunder cloud there is undoubtedly a mass of descending dry air, equal in volume to the ascending air within the clouds. We, at the earth's surface, are unconscious of the descending movement until the air strikes the ground, just as in the case of a man holding out his hand while a baseball is descending toward it, the hand like the barometer gives no indication of this special weight or inertia of the descending mass until the mass strikes it and is resisted. At first the inertia or vis viva of the moving mass is overcome; this is the blow or impact; then the added weight must be sustained, and then it is that the barometer rises permanently. It is the extra pressure, due to the extra weight of the descending masses of air that makes the barometer rise steadily after our local storms when they occur in the front of an advancing area of high pressure.

WYOMING.

The voluntary observer at Basin, Mr. Jas. I. Pattin, notes a remarkable display of lightning from a dark cloud.

Remarkable display from a dark cloud hanging over Bald Mountain, in the Big Horn, on the evening of August 3, when many varieties of