and its effects in modifying the catenary may be shown in a more or less satisfactory manner, as follows: Let Fig. 79 represent a catenary subjected to the action of the wind. Along the lower portions of the curve the wind effect is very slight, both because the inclination of the wire is small, and as a rule, the force of the wind near the ground is less than throughout the upper portions of the curve where the effect of the wind pressure upon the wire will be greater, both because of the steeper inclination of the latter and the greater force of the wind. We can not conceive that any appreciable friction arises in the flow of the wind over the wire, and as a result the wind pressure must be normal to the wire at every point. Let the pressure upon a small element of the wire at p be represented by the line $p\,v$. Also let $p\,g$ represent the *weight of the same element.* The effect will then be the same as if the element in question were acted upon by a single force $p\,r$, which is the resultant or combined effect of the two forces of wind and gravity. Drawing in a similar manner the resultant pressure at other points of the curve we see that the curve assumed by the wire must be one that results from the action of a nearly constant force, which tends to press the wire in a direction such as $P\,R$. If we consider only a portion of the catenary $A\,B$, such as might be involved in a partial ascension, we may plainly, with but little error, assume that the combined effects of wind and gravity act in the direction $P\,R$. In such a case the resulting curve will be sensibly the same as would result if we imagine that gravity alone acted, not in a vertical direction, but in the direction of the line $P\,R$. In other words, the general *form* of the curve will be given by the equations we have already deduced, if we imagine the origin of coordinates to be shifted to a new position as $O'\,Y'$, $O'\,X'$, which are parallel and perpendicular to the line $P\,R$. The *tension*, also, will be given approximately by those equations if we imagine w to be increased in proportion to the ratio of the lines pr to pg.

A very simple way of experimentally studying the effects that result from shifting the origin of coordinates in the manner mentioned as applied to kites, consists in laying off on a drawing board an inclined line, $A\,B$, representing the angular elevation of the kite under consideration. Draw $A\,B'$, forming the angle θ' with the horizontal, and representing the inclination of the wire at the reel. Placing the drawing board on edge and suspending a small chain next its surface we may produce in a beautiful manner the curve of the catenary that shall make the angle θ' at the reel, and we may locate its point of crossing the line at B. Fixing these points of the chain by pins or otherwise, it will be found that by raising one edge so that the board stands on its corner, thereby inclining the line $A\,B$ at different angles in a vertical plane we cause important changes in the inclination of the chain at its fixed points. In order to restore the original inclination, preserving still the same length of chain between the points $A\,B$, and the upper extremity of the chain upon the line $A\,B$, it will be found necessary to make the end B approach A as the line $A\,B$ is made more and more nearly horizontal. These suggestions suffice to show a very simple method that has been employed in several ways by the writer to study the wind affected catenary.

Until the experimental observations have given accurate data concerning the magnitude of the wind effect, it will not be desirable to attempt to deduce equations representing the combined action of wind and gravity. This interesting and important branch of the kite problem must be left for solution in the future.

In this discussion of the theory and practice of flying kites for scientific purposes, the writer has aimed to show how the well known forces of nature act in producing the more important effects commonly observed in kite flying and to point out those general and fundamental principles of physics and mechanics pertaining to kites, by the proper application of which principles we may expect to secure the maximum useful results according to the requirements of any particular case. The groundwork we have aimed to lay for this work is not as complete as we could wish, owing to the limited time available for the Weather Bureau kite experiments, but it is hoped to extend the work to more promising forms of kites than those that have thus far been employed.

The Editor of the REVIEW has shown a deep personal interest in both the kite experiments themselves and in the publication of this series of articles in the REVIEW and the writer wishes to acknowledge the benefits that have resulted from his careful revision of the manuscript and proof.

NOTES BY THE EDITOR.

THE ST. LOUIS TORNADO.

The great tornado of May 27, 1896, at St. Louis will long continue to furnish material for interesting articles and reminiscences, and the Editor hopes to select from these such items as may be of value to meteorology. The following is extracted from an excellent article in the Occident, by Prof. E. S. Holden, Director of the Lick Observatory. Professor Holden's remarks as to the forecasting of this tornado by the Weather Bureau are omitted, as these forecasts were disseminated much earlier and more widely than he was aware of.

During the month of May I was in St. Louis and was an eye witness of the destruction caused by the great tornado of May 27. In former years, 1881 to 1885, I was stationed at the Washburn Observatory of the University of Wisconsin (Madison), which lies in a region subject to tornadoes, and made it my business to study the causes and effects of these violent local storms so far as opportunity offered.

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On the afternoon of May 27 I was in Forest Park in St. Louis with one of my daughters, about 3 o'clock, and the aspect of the sky at once reminded both of us of the "tornado-skies" we had been used to see. The upper sky was covered with a faint veil of grayish clouds parted into regular shapes roughly rectangular and some four or five degrees on a side. Between these figures were darker lanes, of gray-blue color. All around the visible horizon, from north, through west, to south, there was a rim of brassy lurid sky. In the west, or a little north of west and also in the southwest, were two heavy, black, towering clouds, roughly rectangular in figure. The aspect of these clouds was carefully watched to see if they sent out fibrous, twisted offshoots downward; and the brassy rim of sky next the horizon was examined to see if the color deepened toward green.

Either of these signs would, so far as our previous experience went, have indicated the coming of a veritable tornado. So long as they were absent the indications were for a severe thunderstorm later in the evening. It was "hurricane weather" and not "tornado weather" at first. A little before 4 o'clock the sky looked decidedly more threatening and I decided to take my daughter to the Southern Hotel, which I knew to be one of the stoutest structures in the city. My rooms were on the eastern side, the safer side, which relieved the slight feeling of anxiety somewhat.

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My own experience was sufficiently exciting. As I have said, our rooms were on the lee side of the hotel facing a street running north and south. Loaded wagons in the street below were blown off their wheels, and the horses thrown down. The heavy iron cornice of a tall building in course of construction was hurled to the street and destroyed; another building was set on fire by lightning which entered by the wires on the roof; the hotel chimney-stack was blown down, causing a damage to glass, etc., of some $5,000 and wounding several employees, etc.

The wind first blew violently up the street (north) and after the center of the storm had passed it suddenly changed direction and blew south, and this change of direction made new wrecks. The winds in such a storm blow circularly round, or toward the vortex, and when their direction is suddenly reversed like this, one recognizes that at least the crisis is half over. I saw very little hail. The occurrence of a violent storm in a city produces any number of strange happenings, freaks, and the published accounts of it usually dwell on these comparatively unmeaning details—freaks—which give no real idea even of the violence of the wind.

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I took the time to visit, personally, the ruined parts of the city. The chief damage was done, not by the direct force of the winds from outside, but by the bursting of the houses from the inside. The barometric pressure in the vortex was very low. The pressure inside the houses was comparatively high. It was usually relieved by the bursting of the walls and windows. When these were uncommonly strong the roofs were lifted and, so soon as the pressure was equalized, dropped down nearly in their former positions. Whole blocks and squares were ruined in this fashion, so that not one house in ten was even habitable. The trees in Lafayette Park were mostly overthrown. The leaves on those left standing were blown into tatters, so that only the midrib with ragged portions on each side were left. This instance will, I think, illustrate the force of the wind as well as any other. The gyratory forces were by no means so well marked in this storm as in others that I have studied. It was not a typical tornado, though it partook of the tornado character.

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Tornadoes are caused somewhat as follows: The atmosphere above a considerable region of country is in unstable equilibrium. The colder and heavier air is above, the warmer below. Anywhere in this large region tornadoes may occur. Tornadoes are local effects caused by the effort to establish a stable equilibrium quickly. They partake of the rotation of the large circular air movement, and revolve, as these do, in a direction counter clock-wise. Such rotations are produced in the large movements by the earth's rotation, but tornadoes are too small to be directly affected by the rotation of the earth. Their rotatory motion is probably determined by that of the general mass of air of which they form a part. The centrifugal force of their rotation tends to produce a vacuum in the center of the tornado. The surrounding air can not enter at the sides of the gyrating column; it therefore rushes in at the bottom and blows towards the center and upwards. In violent tornadoes the barometer may be about three inches below the normal. (At St. Louis it was about an inch lower.) The local tornado, thus inadequately and summarily described, is usually less than three hundred yards wide, and the winds within it and around it blow a hundred or more miles per hour. The storm itself travels in the general direction from S.W. to N.E. seldom more than 40 or 50 miles per hour.

Warning of such a storm can be given by building a telegraph line some 3 or 4 miles outside of a village around the dangerous quadrant (the southwest quadrant).

A little piece of apparatus, a rough pressure-guage, breaks the telegraph wire when the wind blows at a dangerous rate; and the breaking of the wire rings bells wherever one chooses to place them. An arrangement of this sort was in working order at the Washington Observatory for several years, and could be placed so as to warn any small village.

METEOROLOGICAL TABLES.

By A. J. HENRY, Chief of Division of Records and Meteorological Data.

Table I gives, for about 130 Weather Bureau stations making two observations daily and for about 20 others making only the 8 p. m. observation, the data ordinarily needed for climatological studies, viz, the monthly mean pressure, the monthly means and extremes of temperature, the average conditions as to moisture, cloudiness, movement of the wind, and the departures from normals in the case of pressure, temperature, and precipitation.

Table II gives, for about 2,400 stations occupied by voluntary observers, the extreme maximum and minimum temperatures, the mean temperature deduced from the average of all the daily maxima and minima, or other readings, as indicated by the numeral following the name of the station; the total monthly precipitation, and the total depth in inches of any snow that may have fallen. When the spaces in the snow column are left blank it indicates that no snow has fallen, but when it is possible that there may have been snow of which no record has been made, that fact is indicated by leaders, thus (. . . .).

Table III gives, for about 30 Canadian stations, the mean pressure, mean temperature, total precipitation, prevailing wind, and the respective departures from normal values. Reports from Newfoundland and Bermuda are included in this table for convenience of tabulation.

Table IV gives detailed observations at Honolulu, Republic of Hawaii, by Curtis J. Lyons, meteorologist to the Government Survey.

Table V gives, for 26 stations, the mean hourly temperatures deduced from thermographs of the pattern described and figured in the Report of the Chief of the Weather Bureau, 1891–'92, p. 29.

Table VI gives, for 26 stations, the mean hourly pressures as automatically registered by Richard barographs, except for Washington, D. C., where Foreman's barograph is in use. Both instruments are described in the Report of the Chief of the Weather Bureau, 1891–'92, pp. 26 and 30.

Table VII gives, for about 130 stations, the arithmetical means of the hourly movements of the wind ending with the respective hours, as registered automatically by the Robinson anemometer, in conjunction with an electrical recording mechanism, described and illustrated in the Report of the Chief of the Weather Bureau, 1891–'92, p. 19.

Table VIII gives the danger points, the highest, lowest, and mean stages of water in the rivers at cities and towns on the principal rivers; also the distance of the station from the river mouth along the river channel.

Table IX gives, for all stations that make observations at 8 a. m. and 8 p. m., the four component directions and the resultant directions based on these two observations only and without considering the velocity of the wind. The total movement for the whole month, as read from the dial of the Robinson anemometer, is given for each station in Table I. By adding the four components for the stations comprised in any geographical division one may obtain the average resultant direction for that division.

Table X gives the total number of stations in each State from which meteorological reports of any kind have been received, and the number of such stations reporting thunderstorms (T) and auroras (A) on each day of the current month.

Table XI gives, for 38 stations, the percentages of hourly sunshine as derived from the automatic records made by two essentially different types of instruments, designated, respectively, the thermometric recorder and the photographic recorder. The kind of instrument used at each station is indicated in the table by the letter T or P in the column following the name of the station.

Table XII gives a record of the heaviest rainfalls for periods of five and ten minutes and one hour, as reported by regular stations of the Weather Bureau furnished with self-registering rain gauges.

Table XIII gives the record of excessive precipitation at all stations from which reports are received.

Additional information concerning the tables will be found in the REVIEW for January, 1895.

NOTES EXPLANATORY OF THE CHARTS.

Chart I.—Tracks of centers of low pressure. The roman letters show number and order of centers of low areas. The figures within the circles show the days of the month; the letters *a* and *p* indicate, respectively, the 8 a. m. and 8 p. m.,