station, the altitude of the barometer above sea level and the existing pressure. So far as latitude is concerned its influence for 30 inches of mercury is given by the figures printed on the right hand side of each map of isobars and the correction varies from plus 0.027 inch at latitude 55°, to minus 0.061 inch at latitude 20°. The correction has its full value, just given, at any station when the pressure is 30 inches and increases or diminishes exactly in proportion as the pressure departs therefrom; it has, therefore, two-thirds of its value when the pressure is 20 inches and it has one-thirtieth more than its full value when the pressure is 31 inches. As concerns altitude, the correction increases algebraically but slowly with altitude. If the force of gravity were determined at every station, as it easily could be, a somewhat more correct value of the influence of this source of error would be known.

3. The isobars depend upon pressures that "have been reduced to a sea level." This reduction is made for the purpose of, at least approximately, annulling the influence of the height of the station, thereby making the reduced pressures more nearly comparable than are the actual station pressures. This would be unnecessary if the stations were all at the same altitude, and it becomes a very uncertain hypothetical quantity when the stations vary in altitude from sea level up to 7,000 feet, as is the case in the present American system. Other things being equal, the uncertainty of the reduction to sea level must increase with altitude. For the averages of a month or a year the methods or systems of reduction used by conservative students will differ 0.10 inch for an elevation of 5,000 feet, and 0.01 for an elevation of 1,000 feet.

4. Besides the uncertainty due to methods, the reduction to sea level is also uncertain because of unknown errors in the adopted elevations of the barometers at the stations. The greater part of the elevations used by the Weather Bureau depend upon levelings made with spirit levels by railroad and canal engineers. Many discrepancies occur among these levels; very few of our altitudes are considered reliable to within 10 feet, and an uncertainty of 20 feet in the elevation, or 0.02 inches in the reduced barometer is considered a fair index to the accuracy of the elevation in the interior of the country; in a few special cases it far exceeds this.

5. In view of the preceding it is not proper to publish reduced observations to a greater degree of refinement than the nearest 0.01 of an inch, although the preliminary calculations are all made to the nearest thousandth, consequently the published figures even at the low stations have an uncertainty of plus or minus 0.005 due to the adoption of the nearest whole hundredth, whereas they might agree to within one or two thousandths if the third decimal had been retained on the charts.

In view of the preceding the student who has charted his pressures reduced to sea level and is about to draw the isobars for every 0.05 of an inch of pressure may well ask how closely his pencil must follow the figures that his eye interpolates between the charted numbers. As he wishes to show the narrow belt over which the pressure is 30.05 and as his pencil traces accurately the 30.05 line in among the maze of figures a little larger or smaller than this, he is perpetually oppressed by the conviction that a little wavering to the right or left can do no harm because the figures are slightly uncertain. When he finally has traced upon his map several loops or bights, such as those shown in the annual maps for 1896, there is a strong temptation to wipe them out and replace these by a smoother generalized line; a temptation that is intensified when he perceives that the winds, which, according to our preconceived ideas ought to have a simple relation to these isobars now appear to be entirely independent of them.

Now the well-recognized proper way of presenting any data that results from observation is to follow the numerical results strictly, but to accompany them with some indication of their probable reliability. Thus in the present case the isobars represent closely a rigorous interpolation between the charted numbers, but the lines thus interpolated have different degrees of reliability depending upon the several sources of uncertainty above enumerated: this uncertainty can be best represented on a chart by a shaded area extending equally on either side of the isobar to a distance representing the supposed uncertainty of 0, 1, 2, 3, etc., hundredths of an inch. Such shading would probably not look well on the published maps, but can easily be supplied by any special student. When the shaded areas approach each other closely, or overlap, then we know that the reduced pressures within the shaded region are too uncertain to justify reliance upon the isobar drawn within it. In such cases we must seek to combine the pressures at several neighboring stations into one normal that shall be more reliable than any one of the individual pressures. By using several such normals isobars may be drawn that shall give some idea of the distribution of pressure at sea level. In respect to the bights and loops on the annual chart in the MONTHLY WEATHER REVIEW for 1895, the shaded areas do sometimes overlap in the Rocky Mountain Region, where the isobars on Chart I show dotted lines, but the bights in the Missouri Valley, on Charts I and IV, still remain, although they might plausibly be made less pronounced. We conclude, therefore, that in the study of isobars and isotherms, as in the study of every other matter that results from observation, one must always present the figures correctly, but guard against drawing conclusions finer than are warranted by the reliability of the data.

THE FIRST ATTEMPT TO MEASURE WIND FORCE.

Meteorological observers, especially those who have studied the development of anemometry, will recall the fact that the most simple and direct measurement of the velocity of the wind is made by observing the speed of light bodies, such as feathers or soap bubbles carried along by it. The first piece of apparatus applied to the measurement of the wind was the pendulous plate anemometer introduced by the Royal Society about 1665 on the recommendation of Sir Christopher Wren, Robert Hooke, and others, who constituted a committee on meteorological observations. This instrument gave a measurement of the effect of moving air on a resisting plate from which the velocity can perhaps be calculated. In using this and almost all other apparatus which measures some definite effect of the wind it is assumed that the wind blows upon the apparatus long enough to bring its moving parts into a steady condition, either of motion or of resistance, so that we measure the maximum effect that a given wind is capable of producing. Prof. C. F. Marvin has called our attention to the fact that meteorology owes another ingenious method to Sir Isaac Newton. This eminent philosopher was for many years engrossed in the study of forces; he it was who first saw that the proper method of measuring and comparing forces among themselves is to measure the amount of energy that each force when acting continuously can communicate in a unit of time to a unit mass of freely moving matter. It seems to have occurred to him to apply this idea to the resistance of the wind. When a body is falling freely through the air the resisting force of the air sometimes erroneously called friction is brought into play; this resistance can be expressed by the amount of retardation experienced by a falling body whose mass and resisting area are, respectively, unity. Newton also applied this same idea to an ingenious method of determining the relative strength of the various winds. His experiments in this line are narrated at page 15 of Sir David Brewster's Memoir of the Life, Writings, and Discoveries of Sir Isaac Newton, whence we take the following:

It was about this time, also, that he seems to have paid some attention to the subject of the resistance of fluids, to which his experiments with water wheels would naturally lead him. Mr. Conduit, apparently on the authority of Mrs. Vincent, informs us that even when he was occupied with his paper kites, he was endeavoring to find out the proper form of a body which would experience the least resistance when moving in a fluid. Sir Isaac, himself, told Mr. Conduit that one of the earliest scientific experiments which he made was in 1658,[1] on the day of the great storm [September 3] when Cromwell died, and when he himself had just entered into his sixteenth year. In order to determine the force of the gale he jumped first in the direction in which the wind blew, and then in opposition to the wind; and after measuring the length of the leap in both directions, and comparing it with the length to which he could jump in a perfectly calm day, he was enabled to compute the force of the storm. Sir Isaac added, that when his companions seemed surprised at his saying that any particular wind was a foot stronger than any he had known before, he carried them to the place where he had made the experiment, and showed them the measures and marks of his several leaps. This method of jumping to a conclusion, or reaching it *per saltum*, was not the one which our philosopher afterward used. Had he, like Coulomb, employed a shred of paper instead of his own person, and observed the time it took to fly through a given distance, he would have obtained a better substitute for an anemometer.

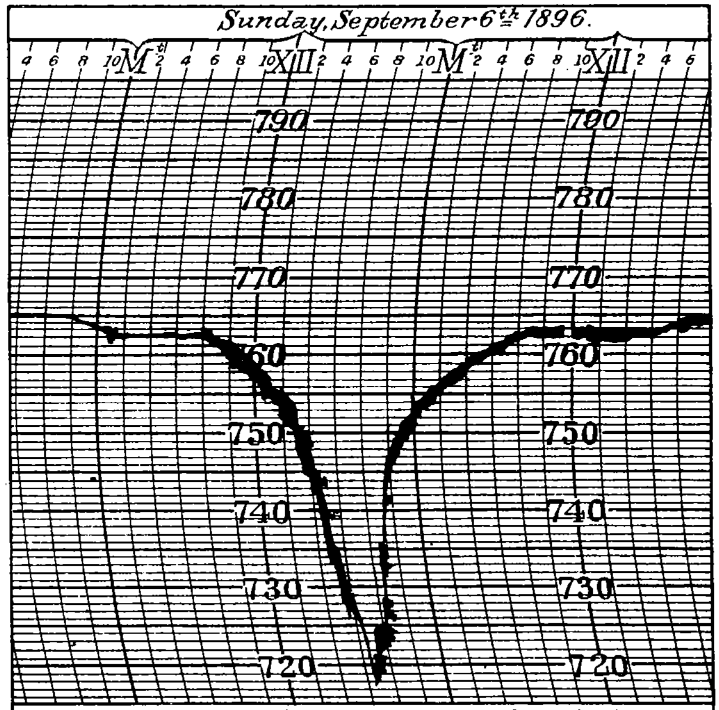
The reader will perceive that provided one jumps with the same force first with and then against the wind he may take half the difference of the two distances as being the effect of the wind in carrying him along while he is in the air. The wind acts upon him continuously during this brief interval just as gravity acts continuously upon any falling body. If, indeed, the observer simply jumps vertically upward or, still better, if he lets an inanimate spherical ball fall vertically downward and observes the amount of horizontal movement he has a direct measure of the force or pressure whence he may calculate the velocity of the wind. There are several reasons why such calculated velocities are rather rough compared with the results given by other methods, but it is certainly of the highest interest to find that Sir Isaac Newton in his boyhood, and before he could have known anything of Galileo's work, devised this simple method of estimating the energy and velocity of the wind.

BAROGRAM NEAR A HURRICANE CENTER.

Mr. A. Rouilliard, engineer in charge on the S. S. *Francois Arago*, has kindly sent the Weather Bureau a photograph of the Richard barograph curve for the time when the steamer crossed the hurricane center northeast of the Bahama Banks on September 6; a similar copy was sent by Captain Tissier to the Hydrographic Office and is published on its Pilot Chart. Mr. Rouilliard says:

> We have been right in the center of the hurricane and suffered considerable damage; two boats carried away, one man overboard, steam steering gear and hand steering gear both broken. In order to get out of the center we had to make our rudder fast with blocks and ropes in such a way that the helm was hard on port, this to keep the wind on the starboard bow, steering only with the engine which we kept more or less slow.

The following diagram, showing the barometric pressure during the 6th, apparently has its original time scale adjusted to the local time of some meridian a little to the eastward and Mr. Rouilliard says that time data should be increased by one hour and thirty minutes, probably, in order to get correct local mean time, or by one hour and thirty-one minutes to get seventy-fifth meridian time, or subtract three hours and twenty-nine minutes to get correct Greenwich time.



The time-scale is to be increased by 1h. 30m.

The first signs of a hurricane appear on the barometric sheet by the rapid fall beginning at 10 p. m. September 5, and the vessel had completely left the influence of the hurricane by 10 a. m. September 7. The position of the center of the hurricane at 9 p. m. September 6 was latitude 28° 50′ north, longitude 77° 0′ west of Paris, or 74° 40′ west of Greenwich, at which time the center was about 220 nautical miles distant from the vessel; this location is based upon an estimate of the position of the steamer at noon of September 7. The lowest pressure was recorded at 6.30 p. m. of the 6th, viz, 717.3 mm. (28.24), which must, therefore, have been very near the center of the hurricane. Nothing is stated as to the corrections to the barograph at this pressure. If we assume that the navigator was sailing northward, while the hurricane center was moving toward the northeast, we find that the vessel was in the southeast quadrant of the storm and approaching the center up to 6 p. m. of the 6th, and that after 8 p. m. it was in the northwest quadrant and receding from the center. This explains the fact that the accompanying barogram shows a somewhat more rapid fall in the course of the eight or ten hours preceding the center than during the same interval of time after the center had passed.

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 indi-

[1] Sir Isaac was born in 1642, December 25, old style.