the winter of 1888–89 the temperature has been decidedly above the normal in the northern United States, and normal or below normal in the Southern States. As a consequence the pressure-gradient in the upper air has been less steep than usual, the movements of the upper-air currents and of storms has been comparatively slow, and the winter over the entire country exceptionally free from sudden changes. The correlation of these facts seems to the writer to promise much; for, when the causes governing the distribution of temperature are better understood, it seems evident that the meteorologist will be able to foretell for considerable intervals the special characteristics of the weather to be expected over large areas.

I trust these few facts may serve to further stimulate the interest which is now being aroused in more exact and detailed cloud-observations. H. HELM CLAYTON.

Blue Hill Observatory, Readville, Mass., March 20.

The Robinson Anemometer Factor.

THIS name has been commonly applied to the earliest expression of the law of relation between the velocities of the centres of the cups of the Robinson anemometer and that of the wind which sets them in rotation. Being a simple ratio between the two velocities in question, or $\frac{w}{v}$ as expressed in *Science* (xiii. p. 227), it is not surprising that subsequent experiments should show, that not only is the original factor, namely 3, incorrect, but that such a simple relation can by no means be made to express with any reasonable accuracy the anemometer law. It is surprising, however, considering the numerous experiments made by Dohrandt as well as others, that writers and investigators of the present day should still adhere to the use of the old anemometer "factor," and group together in a general mean a large number of experiments at different velocities.

The writer of the communication referred to above, in a discussion as to just what constitutes the true anemometer factor, has presented the matter in a form that shows at once how futile it is to use the old factor. Following Dohrandt and others, he assumes that the velocity of the wind, w, and the velocity of the cup-centres, v, bear the following relation to each other: —

$$w = a + bv \quad (1),$$

in which a and b are constants. The anemometer factor then becomes

$$x = \frac{w\,b}{w - a}.$$

We see from this equation, that, when $w = a$, x becomes infinite, which corresponds to the condition when the wind is just too feeble to start the cups. As w increases, x approximates more and more to the value of b; but, even between the small ranges of velocities that occur in ordinary practice, x is entirely too variable to consider constant, as shown by the values given in the above-mentioned paper, and is too troublesome to use in calculation, especially since the very equation from which it is computed is in much simpler form, and, moreover, gives at once the velocity of the wind from the cup-velocity, which is the quantity observed when the anemometer is in use. The facts of the case, however, are not satisfied with even this degree of complication, and the anemometer factor becomes quite out of the question. Dohrandt's results up to 30 miles per hour are only approximately represented by an equation like (1); and as in his experiments, owing to the comparative shortness of the whirling arm, the friction of the anemometer at high velocities, from centrifugal action, was very great, it may be shown that the approximation is even closer than it actually should be. In fact, recent anemometer experiments upon a whirling arm 35 feet long are in most cases represented accurately by an equation of three terms: thus,

$$w = 0\,225 + 3.14v - 0.0362\,v^2 \quad (2),$$

the numerical values being those computed for an anemometer of the Signal Service pattern, the cups of which are 4 inches in diameter on arms 6.7 inches long.

In view of this discussion, and taking into consideration that the experiments just mentioned were made in a closed court under the most favorable circumstances, it would appear that the different conclusions reached by the wind force committee of the Royal Meteorological Society in their open-air experiments are largely misleading and in error, due probably to the serious influence of the outside wind-movement.

It seems that one effect of this wind-movement, outside of the motion of the arms of the whirling-machine, is not clearly understood, or at least receives little attention, and is nevertheless of the greatest importance.

If a uniform wind blows across the path of the anemometer when being carried upon the whirling-machine, every one sees, that, during one half of its motion, the anemometer is going more or less with the wind, and against it during the remaining half. That these effects do not fully neutralize each other, is clearly shown in a mathematical analysis by which it is not difficult to find the correction that should be applied; but this is only small in most cases, and is not very serious. A far greater error arises from the effect this extra wind has in causing a very large and rapid variation in the actual wind-movement experienced by the anemometer, which, if its axis is being revolved on the whirler at the rate of 15 miles an hour, and an extra wind of 4 miles per hour is blowing, is at one point of its path moving through the air at the rate of 19 miles an hour, and at the opposite point at the rate of only 11 miles per hour; the change, moreover, from the maximum to the minimum being accomplished with great rapidity. The mean velocity of the cups in this case may be shown to be such as corresponds to a wind-velocity of nearly 19 miles per hour, the reason being that the inertia of the cups keeps them spinning after experiencing the maximum velocity; so that during the minimum velocity they do not slow up as they should, the only tendency to do this being the air resistance to the backs of the cups; and, as this is considerably less than that felt by the front or concave sides of the cups when the wind tends to increase their velocity, it must follow that the mean velocity of the cups in a variable current is considerably higher than such as would otherwise occur. A more extended statement of this inertia effect, and numerous experiments by which the theory is confirmed, have been already submitted for publication in the *American Meteorological Journal*.

The large and erratic variations in the results obtained by the wind force committee with anemometers of the Robinson type are to be attributed to this cause; and the noticeably more uniform results obtained with the helicoid anemometer were due to the fact that this instrument, being driven by the direct pressure of the wind, and not by the difference of several pressures as is the case with the Robinson anemometer, is not subject to the inertia effect just described. The explanation of this point, given in *Science* of March 22, p. 227, to the effect that the helicoid anemometer was tested with a vane attached to keep it in the wind, is hardly sufficient to account for its seeming better performance.

It follows from the above, that, if two sets of anemometer cups are fitted up exactly alike except in weight, one having paper cups, for instance, the latter will in the open air, exposed to a variable wind, give seemingly less wind than the former, both being reduced by the same formula. Formula (2) given above is also only to be used for perfectly uniform currents.

Some mention was made in a "Note on the Robinson Anemometer Constant," in *Science* of March 15, of the relative merits of the recently invented helicoid anemometer and those of the Robinson type. Judging by the description of the former, its mechanical construction cannot possibly be so simple as that of the latter; and as to what would happen to it and its delicate self-adjusting vanes when exposed to the sleet and frost of a winter season, is by no means difficult to tell. The inventor himself considers the instrument defective or unsatisfactory, owing to the ease with which the readings are altered by bending the vanes.

Robinson anemometers, to give the most satisfactory results in the open air, and variable winds, should have very light cups.

It may be added, in conclusion, that all anemometers acting by direct wind-pressure are subject in much greater degree to variations in their law connected with temperature and pressure changes than are those depending only on difference of pressures.

C. F. MARVIN

Washington, D.C., March 25.