after effect, or creeping, is in the corrugated aneroid vacuum boxes themselves, as distinguished from the tempered steel springs that are employed to keep the box from collapsing under the pressure of the air. This conviction was forced upon my mind after reading Mr. Whymper's valuable paper on the errors of the aneroid, and in 1892 I made the following simple experiment, which greatly confirmed this supposition: The vacuum box of an old aneroid was removed, and a heavy weight (a trifle over fifty pounds was required) was applied directly to the steel spring, thereby straining it as nearly as possible to the same extent as did the air pressure exerted through the medium of the corrugated vacuum box. Any desired changes in the position of the index were made by appropriate changes in the weight. No after effect comparable in magnitude with that exhibited by ordinary aneroids was ever observed. In other words, this tempered steel spring behaved to all intents and purposes as if it were a *perfectly* elastic body. Readings of the pressure scale could be made corresponding to about 0.005 of an inch on the barometer. A careful or full investigation was not attempted. I believe, nevertheless, that the tempered steel springs employed in all aneroids are, or may easily be made to be, highly trustworthy. On the other hand, the process of constructing the vacuum boxes is well calculated to develop therein irregular and imperfect elastic properties in the highest degree. The top and bottom surfaces are each formed of a thin circular sheet of metal, with a narrow rim bent up around the edge. In order to give flexibility, several concentric corrugations are formed over quite the whole face of the disk. The crimping and bending operations necessary in the manufacture of these corrugated disks have a marked effect upon the elastic qualities of the metal, which, to make matters worse, is generally of brass, german silver, or some similar alloy well known to be only imperfectly elastic under the most favorable conditions. The metal must originally be, more or less, in a soft and annealed condition in order to withstand the corrugating and bending operations. Those portions which are stretched and compressed by the process become stiffer and more elastic, and a most complex and irregular system of internal stresses and strains exists within the finished disk. The arrangement of molecules is undoubtedly a highly unstable one, and it is not surprising that large, discontinuous, and unexpected changes take place in the readings of the finished instrument.

A careful examination of the theory of the weighted aneroid will show that the massive weight does not counterpoise all the air pressure upon the vacuum chambers. These latter, of themselves, offer an additional elastic reaction which increases in amount with greater distension and diminishes as the chambers close together. The fixed, invariable, weight of the suspended mass can exactly counterpoise the air pressure on the cells for only one particular barometric pressure. A greater pressure will lift the weight and a lower pressure would permit it to fall by an indefinite amount, if the elastic restraint of the chambers themselves, or some equivalent effect,[2] does not operate to counterbalance the excess or deficit in pressure and thus establish a system which is in stable equilibrium.

We find, therefore, that in this weighted aneroid the real variations in air pressure are measured and registered entirely by the elastic reactions and deformations going on in the material of the vacuum chambers themselves. It is quite certain that the elastic properties of the chambers can not be so nearly perfect as those of finely tempered steel springs, and the writer is compelled to conclude that the barometric records by means of the weighted aneroids will still be found subject to appreciable, if not serious, errors of the kind so characteristic of all aneroids yet employed.

[2] An automatic variation of the area upon which the air pressure is operative would be perhaps an ideal way to attain the desired end provided no frictions or elastic reactions were involved, but nothing of this character is comprised in the present instrument.

## SNOW ROLLERS.

By Mr. WILSON A. BENTLEY. Dated Jericho, Vt., June 26 and July 5, 1906.

During the night of January 18, 1906, there occurred at and in the vicinity of Jericho, Vt., the very interesting and somewhat rare phenomenon of the formation by wind action of vast numbers of snowballs, or snow "rolls" or "rollers". A brief account of them, and of the weather conditions that prevailed before and while they were being formed, may possibly be of interest to the readers of the WEATHER REVIEW.

About five inches of very light, fluffy snow fell during the twenty-four hours immediately preceding the phenomenon. During this time the temperature ranged from 14° to 22° F. But during the night of the 18th, when the snow rolls were formed, the temperature slowly rose from 24° to 34° F., and the lower wind shifted from westerly to southerly points and blew at times in a very strong but intermittent and peculiar gust-like manner. The snow rolls were formed during the latter part of the night, after the rise to 34° was accomplished. This rise in temperature operated to cause a slight superficial melting of the upper layers of the snow and to make it slightly damp, so that the individual snow crystals tended to cling to one another.

So far as the writer was able to observe, and to learn from others in adjoining towns, the phenomenon occurred only over a quite limited and narrow strip of foothill country perhaps one mile wide, lying alongside and parallel to, but at a little distance from, the western side of the Green Mountains. The winds that produced the phenomenon blew across the valleys and foothills rather than parallel to their greater length. The topography of the region in question is such as to cause the winds that reach the valleys, or at least some of them, to flow or pour downward into them in descending order from foothills of considerable height.

In many cases the gusts of wind evidently had a strong descending motion, such as just described, for they actually scooped up considerable masses of the light, damp, fluffy snow and formed it into ridges or hollow snow arches, and rolled many of these up into snow rolls of various sizes.

The forms and structures of the snow rolls were such as to indicate that, at least in many cases, the wind that scooped up the fluffy snow masses into ridges or open arches, got in behind such ridges and arches (which may be termed "cores") and blew them over upon themselves or upon the snow directly in front and to the leeward of them, thereby imparting both rotary and forward motions to the snow core ridges or arches, blowing and rolling them along in this manner for some distance. Fresh layers of damp surface snow collected upon them as they rolled along upon the surface of the snow, and operated rapidly to increase their size and specific gravity. Eventually the rolls became so large and heavy that the winds were unable to roll them farther and they came to rest. Variations in exposure to winds and surface topography operated to cause some rolls to be blown along much farther than were others, hence some became of much greater size and weight than others. The individual snow rolls varied in size one with another, from tiny rolls but a few inches in diameter to huge ones 18 by 24 inches in size. In most cases the diameters of the rolls were much less than were their lengths.

Perhaps the most interesting rolls thus scooped up and modeled by wind action were those whose "cores" were of an open, hollow character. Such came into existence in the form of hollow snow arches, as previously described, and were so substantial, or were rolled along so gently by the winds, that their hollow cores were preserved intact, i. e., were not filled in as a result of collapse or of their rotary experiences. Figs. 1 and 2 show snow rolls of this character.

Unfortunately, the day following the formation of the snow rolls was a dark, cloudy day, unfavorable for photographic work, hence our original photographs of the snow rolls failed to show them with sufficient plainness, and it became necessary to increase their sharpness by recopying so as to produce extreme contrast effects. This explains why the trees, etc., show up so very darkly in these photographic prints.

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The wind came from the right-hand side of these figs. 1 and 2. They show the paths of some of the rollers, and their beginnings on the right-hand side. The accumulation of snow occurring on the right-hand, or windward, side of each roller was, I am certain, not blown there from a distance by the wind, but is, in each case, a partly detached layer of snow, that adhered to and was partly lifted up by the roll while that was revolving, but that settled back to earth at a later time, owing to the continuation of the process of partial melting that was going on at a temperature of 34° to 36° F. In case the roller had undergone another revolution such windward layer would doubtless have gone with it, and been incorporated within the mass. Many of the rollers formed on a practically level surface, and some were actually rolled up a slight incline.

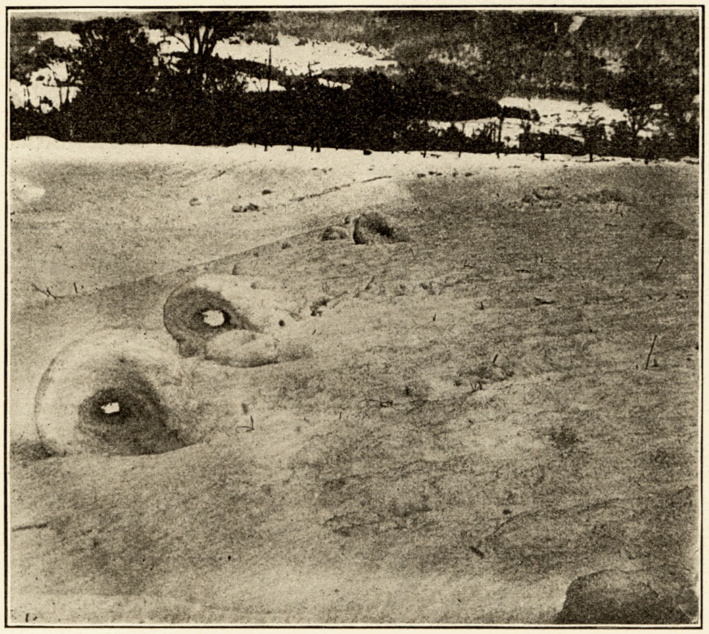

FIG. 1.—Snow rollers at Jericho, Vt.

FIG. 2.—Snow rollers at Jericho. Vt.

## SNOW ROLLERS AT MOUNT PLEASANT, MICH.

By Prof. R. D. CALKINS. Dated Central State Normal School, Mount Pleasant, Mich., June 27, 1906.

On the evening of January 17 [1906], the wind at Mount Pleasant, Mich., was northeast, and a light flaky snow was falling. During the night the wind backed through north and northwest to the southwest. In the morning we found that at the northwest corner of the Normal School Building snowballs, or snow rolls, to the number of fifty or seventy-five had been formed. They varied in size from three inches in diameter to twelve inches. They were rolls of snow rather than snowballs, for most of them had square ends. They were spiral in structure when viewed from the end. Behind each roll was a path where the snow had been taken up, and the depth of snow removed from this path corresponded very closely to the thickness of the layers forming the roll. These paths became narrower as the corner of the building was approached, where they all disappeared, as indicated in the diagram, fig. 1. The rolls were very light and would hardly hold together sufficiently to preserve their shape when lifted. Some boys from the country on the same morning reported similar balls two feet in diameter. The wind has a long, unobstructed sweep from the southwest. There were no tracks of children about the balls, and there can be no doubt that they were windformed. Can you give me any more information concerning the origin of such balls or rolls? Just why, and how, do they start?

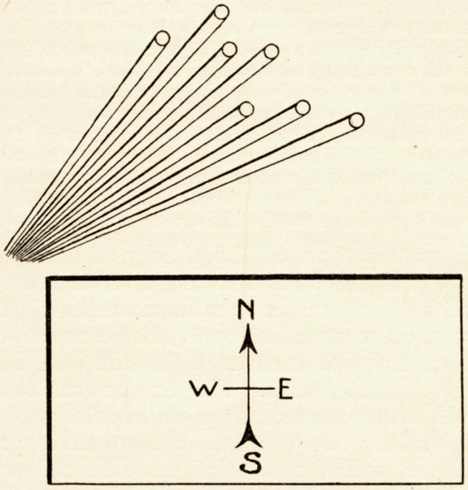


FIG. 1.—Paths of snow rollers at Mount Pleasant, Mich.

*Note.*—The initial step in the formation of snow rolls seems not yet to have been observed. They appear generally to be formed at nighttime, or in the very early morning, and the diagram by Professor Calkins suggests that they are formed by or among the eddies in the strong wind at the corner of a building or other obstacle.

We note that in the Meteorologische Zeitschrift, May, 1895, p. 198, Prof. K. R. Koch, of Stuttgart, mentions three ways in which snow becomes hardened after it has fallen:

1. A warm snowfall is followed by cold west winds that favor compression, the wind in descending gusts forcing or pressing it into a hard, solid mass.
2. Hard surfaces are formed by melting and freezing and become hard enough to support the mountain climbers in the Alps and Black Forest.
3. In March and April in the mountains, before thawing weather begins, the insolation is powerful, and snow crystals exposed in the sunshine are evaporated and the vapor is actually recrystalized; thus very large crystals are formed and the layers of snow become quite solid; it is not impossible that large nuclei may thus be formed.—*C. A.*

## MONTHLY REVIEW OF THE PROGRESS OF CLIMATOLOGY THROUGHOUT THE WORLD.

By C. FITZHUGH TALMAN, U. S. Weather Bureau.

THE ASIATIC RAILROADS AND THE PROGRESS OF METEOROLOGY.

This is emphatically an era of railroad building throughout Asia. It may be but a few years before we witness in Asia a