MONTHLY WEATHER REVIEW.

Editor: Prof. Cleveland Abbe. Assistant Editor: Frank Owen Stetson.

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The Monthly Weather Review is based on data from about 3500 land stations and many ocean reports from vessels taking the international simultaneous observation at Greenwich noon.

Special acknowledgment is made of the data furnished by the kindness of cooperative observers, and by Prof. R. F. Stupart, Director of the Meteorological Service of the Dominion of Canada; Señor Manuel E. Pastrana, Director of the Central Meteorological and Magnetic Observatory of Mexico; Camilo A. Gonzales, Director-General of Mexican Telegraphs; Capt I. S. Kimball, General Superintendent of the United States Life-Saving Service; Commandant Francisco S. Chaves, Director of the Meteorological Service of the Azores, Ponta Delgada, St. Michaels, Azores; W. N. Shaw, Esq., Secretary, Meteorological Office, London; H. H. Cousins, Chemist, in charge of the Jamaica Weather Office; Señor Anastasio Alfaro, Director of the National Observatory, San José, Costa Rica; Rev. L. Gangoiti, Director of the Meteorological Observatory of Belen College, Havana, Cuba.

As far as practicable the time of the seventy-fifth meridian, which is exactly five hours behind Greenwich time, is used in the text of the Monthly Weather Review.

Barometric pressures, both at land stations and on ocean vessels, whether station pressures or sea-level pressures, are reduced, or assumed to be reduced, to standard gravity, as well as corrected for all instrumental peculiarities, so that they express pressure in the standard international system of measures, namely, by the height of an equivalent column of mercury at 32° Fahrenheit, under the standard force, i. e., apparent gravity at sea level and latitude 45°.

SPECIAL ARTICLES, NOTES, AND EXTRACTS.

THE INTERNATIONAL SYMBOLS.

By Mr. Henry Helm Clayton. Dated Blue Hill Observatory, Hyde Park, Mass., May 8, 1906.

In the excellent article by Mr. Miller, in the December, 1905, Weather Review, Vol. XXXIII, page 524, on the international definitions and symbols, he uses the expression "Silver thaw" as an equivalent of the symbol V. The expression "Silver thaw" is a meteorological term used in England, but not in the United States, and I did not know its exact meaning until I had occasion to look it up recently. In the English edition of the report of the Vienna Congress, where the symbols originated in 1874, the expression "Silver thaw" is given as the equivalent of the German "Rauhfrost", indicated by the symbol V. "Glazed frost" is given as the equivalent of the German "Glatteis" and indicated by the symbol ∞. Mr. R. H. Scott, in his "Elementary Meteorology", p. 115, 1887, gives "Silver thaw" and "Glazed frost" as equivalent expressions, and defines them as follows:

> The frozen surface which is occasionally produced at the beginning of a thaw, if a warm wind suddenly sets in. The damp air, passing over the ground, of which the temperature is exceedingly low, has its moisture deposited in the solid form, and all objects on which this deposit takes place are covered with a sheet of ice. This phenomenon is intensified if a fall of rain occurs at the time.

Wind blowing against cold objects does not produce a "sheet of ice"; this is brought about by the second method suggested by Mr. Scott, namely, the falling of raindrops against objects cooled below the freezing point. Mr. William Marriott in his "Hints to Meteorological Observers", 1902, is more specific and defines "Silver thaw", on page 59, as "Rain falling when the air is below the freezing point and congealing when it falls". I find also that Mossman and other English writers use "Silver thaw" in this sense. It is evident from the above that "Silver thaw" is not the equivalent of the German "Rauhfrost". Doctor Hann defines "Rauhfrost" as "a rich, frost-like, rough deposit of ice particles which forms over the irregularities of the earth's surface, on edges, corners, and on the branches and twigs of trees. It is distinguished from frost by the conditions of its formation. Ordinary frost forms on clear nights like the dew, but "Rauhfrost", however, in foggy weather; the latter is formed from the fine fluid fog particles which are cooled below the freezing point, and therefore turn to ice by contact with solid bodies.

It seems evident, from these quotations, that the American term "Frostwork" is equivalent to the German "Rauhfrost", but that the English term "Silver thaw" is equivalent to the American term "Ice storm" and should be defined by the symbol ∞. I write this to prevent, if possible, the expression "Silver thaw" coming into use as the equivalent of the terms "Frostwork", "Rauhfrost", and "Givre", and thus causing confusion in terminology and description.

THE METEOROLOGICAL OPTICS OF PROF. J. M. PERNTER.

By Prof. R. W. Wood. Dated Johns Hopkins University, Baltimore, Md., September 15, 1906.

The subjects treated in this volume[1] comprise the various types of halos, parhelia, rainbows, etc.; in fact the entire list of phenomena due to the reflection, refraction, and diffraction of light by clouds, snow crystals, and raindrops suspended in the air. It is doubtful if any type of halo with its accompanying parhelia, and there is a large number of them, has ever been observed which is not explained in this very comprehensive treatise.

The value of Doctor Pernter's book is somewhat marred, in the writer's opinion, by a very peculiar mistake which the author, in common with some other writers on this subject, makes almost at the outset. As is well known, a large number of these optical phenomena can only be explained by assuming an orientation of the ice crystals or spiculæ floating in the air. These may roughly be divided into two types, elongated hexagonal prisms or spiculæ, fig. 2, and flattened hexagonal laminæ, fig. 1, the form usually observed in the case of snowflakes. The author states, on page 318, that a body falling through a resisting medium (the air) orients itself in such a way that the resistance offered by the medium is a *minimum*, i. e., the long spiculæ stand vertically, while the flat plates take a position such that the diagonal of the hexagon points up and down, in other words, stand on end; whereas the true positions are perpendicular to these and are shown in figs. 1 and 2. It seems odd that such a mistake could have been made, since we have so many examples of the principle that a falling body takes the position of *maximum* resistance, mica flakes settling in water, falling leaves and pine needles, an unfeathered arrow, etc. It is evidently not a slip of

[1] Meteorologische Optik von J. M. Pernter. Theil III. Wilhelm Braumueller. Wien und Leipzig.

the pen for, from this point on, the author always considers his spiculæ and plates as standing vertically in the air. The same error was made by Bravais and his predecessors in treating parhelia. It must not be supposed, however, that this error invalidates in any way the author's admirable treatment of the optical problems involved, for in each case we may substitute a horizontal hexagonal plate for a vertical hexagonal prism, and vice versa, without affecting the orientation of the angles. It is well to bear this in mind, as the formation of plates or spiculæ of ice seems to depend upon the temperature, and it is possible that approximate estimates of the temperatures of the clouds could be made by considering whether the parhelia observed were of the type due to hexagonal crystals with the principal axis vertical (i. e., flat plates), or with the axis horizontal (i. e., spiculæ). Erroneous conclusions would of course be drawn if the mistake here pointed out were not corrected.

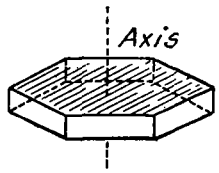

FIG. 1.

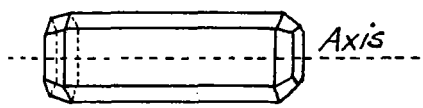

FIG. 2.

The luminous rings often seen surrounding the sun or moon are divided by the author into two classes—halos and coronæ.

(1) The "halos" or large rings, due to ice crystals floating in the air, are commonly seen with a radius of 22° or 46°, rarely with 90°. There are in addition a large number of related phenomena—the horizontal ring, which passes through the sun and runs parallel to the horizon; arcs of circles with their concave sides turned away from the sun; the parhelia (neben sonnen), or brightly luminous spots seen on the halo, to the right and left of, or above and below, the sun. A very complete list, illustrated with diagrams, is given, followed by explanations of each type. As an introduction to the theoretical treatment the author gives us a very complete and profusely illustrated list of the various types of snowflakes and ice spiculæ, and the temperature conditions under which they are formed. Bentley's valuable work[2] on the micro-photography of snow crystals is alluded to, and it seems a pity that some of his beautiful pictures could not have been included in this volume, as they are superior in definition to those used by Pernter to illustrate this section.

The smaller rings, which are more commonly seen, and which are due to diffraction either by water drops or by ice crystals, the author calls "Kränze" [or coronæ or small circles]. They are more often observed around the moon, as the overpowering brilliancy of the sun is usually sufficient to drown them out. When seen surrounding the point opposite the sun, as when the shadow of the observer's head is thrown upon a cloud, they are spoken of as "glories." These latter are to be classed as diffraction phenomena seen in reflected light. Following the glories comes a brief description and explanation of the "Heiligenscheines", a luminous halo seen surrounding the shadow of the observer's head when it is thrown upon dew covered grass, and the so-called iridescent clouds, which are explained in the same way as the smaller halos and glories. I have looked with some interest for some mention of an extremely beautiful and brilliant phenomenon which I once saw upon the surface of a large lake at Madison, Wis. The sun was well up, and the surface of the water appeared to be covered with a very shallow layer of fine mist. About half a mile from shore appeared a long, very narrow, and extremely brilliant straight spectral band, the colors being vivid and arranged in proper order. There were, if I remember rightly, two or more spectra, the appearance being strikingly like the reflection of an arc light in a plane metallic diffraction grating. I have never seen the phenomenon described elsewhere, but quite recently a letter was published in "Nature," describing a very similar appearance seen also upon the surface of a lake[3].

Doctor Pernter's admirable treatment of the rainbow, which is largely his own, is the best, most complete, and most easily understood that has ever been given. There is more variety in rainbows than is commonly supposed. Teachers who are in the habit of contenting themselves with the theory of Descartes will have difficulty in explaining why certain colors are sometimes nearly absent in the rainbow while at other times they may predominate. The difficulty lies in attempting to explain the phenomenon by geometrical optics and rays—wave-front methods are always safer. A plane or flat wave, incident upon a transparent sphere (raindrop), can be shown by very elementary methods to acquire, after two refractions and one reflection, the peculiar shape shown in *b*, fig. 3, where the curved line 1, 2, 3 represents the wave-fronts, the elements of which are traveling in the direction of the arrows. The portion 1, 2 is convex in the direction of propagation, and will of course go on expanding; the part 2, 3 is concave, and converges to a focus. The curvature varies as we pass along the wave-front, being greatest at 3, zero at 2 (where the front is plane) and having a large value again at 1. The element at 3 comes to a focus first, passes through it and becomes convex instead of concave, forming a "cusp" on the wave as shown at *c*. Successive elements of the wave-front above 3 pass in turn through foci and build the rear front of the cusped wave. A fuller treatment of the propagation of cusped waves will be found in my Physical Optics (The MacMillan Co., 1905) where I have shown that the caustic surfaces (i. e., the curved lines of light seen, for example, when light is reflected upon the table cloth by the inside of a napkin ring) are the surfaces traced out by the cusps on the wave-front, where there is of course a concentration of radiant energy. We may thus regard the least deviated ray in the Descartes theory as the path traversed by the cusp on the wave after its emergence from the raindrop.

Now the caustic surfaces are always bordered by interference fringes, for we are dealing with two sets of wave-trains, formed by the front and rear surfaces of the cusped waves. If we draw the surfaces, as in fig. 3, representing the crests of the waves by solid lines, and the troughs by dotted lines, we find that crests intersect troughs along the arrows 1, 3, and 5, consequently these represent the positions of the interference minima. This method of looking at the phenomenon is more elementary than that given by Pernter, who integrates the effect of the whole wave at a given point in front of it, as in diffraction problems. We thus see that in addition to the least deviated ray of Descartes, indicated by the arrow 0, there will be other directions (arrows 2, 4, etc.) in which there is considerable illumination. With a monochromatic sun we should, therefore, have a number of concentric bows, as can be shown experimentally with a spectrometer and glass cylinder or ball. The distance between these bows will vary with the size of the raindrops, and since with white light we have, theoretically, an infinite number of bows, it is clear that the color of the actual rainbow at a given point can only be determined by computing the "mischfarbe" due to the superposed bows. This is not an easy problem, or one that can be described briefly, but the author handles it most skilfully. The variation in the color is of course due to the fact that secondary bows (the interference maxima) are differently spaced in different cases, the distance between them

[2] Monthly Weather Review, Annual Summary, 1902, Vol. XXX, p. 627.

[3] The rainbow as seen in the dewdrop is described by L. J. Briggs, Science, September 19, 1902.

being a function of the size of the drops. A curiously distorted bow, observed by Linhart (Pernter, page 494), is explained by refraction by an intervening bank of mist. This appears to be a wholly inadequate explanation, as the presence of small drops of water in the air [or saturated air] can only affect its refractive index to a very slight degree, if at all. The masts of ships never appear distorted when seen through wisps of fog. A more reasonable way of regarding the phenomenon seems to be to consider the distorted portion as a part of a halo seen upon the cloud bank, the actual rainbow being invisible through the mist.

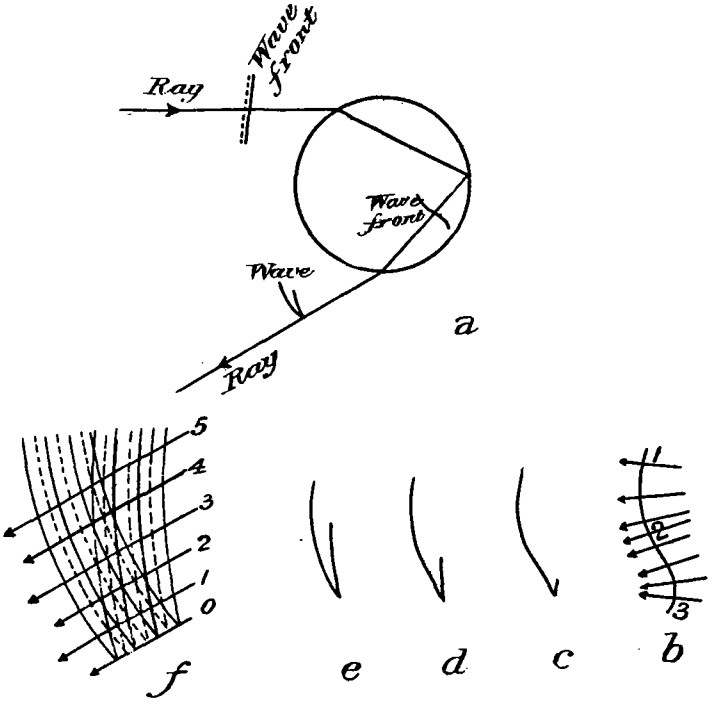

FIG. 3.

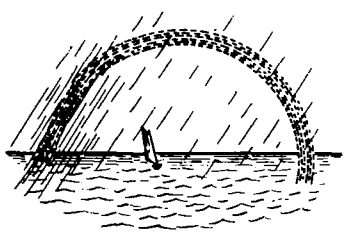

FIG. 4.

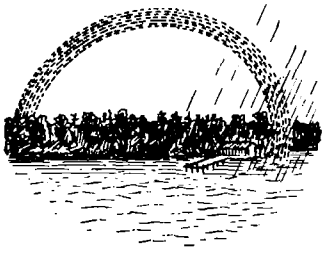

FIG. 5.

Two years ago, while discussing rainbows with Alexander Harrison, who has made an elaborate study of them from the artist's point of view, I was asked for an explanation of why the bow sometimes departed from a true circular arc. Never having observed a case of this kind, or seen any description of one, I expressed some doubt as to whether it were possible. Mr. Harrison assured me, however, that he had frequently seen the lower end of the bow slope off in a nearly straight line (as I have roughly sketched in fig. 4), and had attributed it to the fact that the rain curtain forming this portion was at a greater distance. Only a few weeks ago I observed a magnificent bow at Annisquam, Mass., which showed an unmistakable anomaly of this sort, the left half appearing pulled out into an arc of greater curvature, as shown in fig. 5. The right part cut across a distant bank of trees and well down upon the intervening water, the drops being not over 100 yards distant, while the left portion did not do so, and was evidently formed by a wall of rain at least half a mile away. I have been unable to find any case of this kind mentioned by Pernter. Possibly readers of the MONTHLY WEATHER REVIEW may have observed similar cases. The case which I saw this summer was so marked that it was at once noted by several people, whom I questioned as to whether the bow seemed peculiar in any way. It may be an illusion, similar to the apparent increase in the diameter of the moon when seen on the horizon, but I am inclined to regard it as real. It may be due to the fact that the cusp on the wave does not travel in a straight line, or in other words that the direction of the "least deviated ray" varies with the distance of the drop. It becomes noticeable, however, only when large distances are involved, for I have found that two jets of spray, one 60 feet from the eye and the other three, gave superposed rainbows. I have delayed this review in the hope of having a chance to throw up a jet of spray close to the eye and compare its bow with the one formed by a distant shower, but no more rainbows have appeared as yet.

EIFFEL'S "ETUDES PRATIQUES".

[Translation of a letter from M. Eiffel, dated Paris, France, April 12, 1906.]

In extending you my thanks for the very complete account [by the Editor] of my work, "Practical Studies in Meteorology", which you have been kind enough to publish in the October number of the MONTHLY WEATHER REVIEW, Vol. XXXIII, p. 442, I permit myself to make the following remarks:

1. In reference to the reading of thermometers to the tenth of a degree, I am of the opinion that in the observation of natural phenomena as complex as those studied by meteorologists it is not desirable to seek the precision necessary for the physicist and the chemist in investigating phenomena which are largely of their own creation in their own laboratories, for the reason that such precision would be purely illusory. We may convey an impression of accuracy by calculating, if we will, monthly means to the hundredth of a degree, but this does not constitute any real progress in science. Moreover, in the American observations, tenths of degrees are not observed in reading the maximum and minimum thermometers, from which eventually the mean monthly temperatures are determined.

2. The author of the article does not give my reason for preferring the meteorological year, commencing with December, to the civil year, commencing with January. It is simply in order to enable us to group the months by seasons. In our climates these seasons possess such distinct characteristics that it is advantageous to group the months accordingly, and this can be accomplished only by considering as winter the months of December, January, and February. December must not be classed an an autumn month, nor March as a winter month. It appears to me that such a grouping is useful; that by years combines elements which exhibit wide discrepancies.

3. The division into decades appears to me advantageous because it permits the deduction of means that are not too comprehensive, whereas those for a whole month include elements that are very unequal. In such means the irregularity of the final decades is of scarcely greater importance than that due to months of 31, 30, and 28 days.

4. There must be some misunderstanding as to what is said about mean solar time and the note in reference thereto. I have nowhere considered *true* solar time, but *mean* solar time, either civil or local.

5. I think it a duty to recommend the use of diagrams, especially the last that I have constructed, and two of which refer to the reading of the psychrometer, inasmuch as, when traveling, they replace the more or less voluminous tables, and even for the final reductions made at the office they are more rapid than the tables, as has been found by M. Moureaux, Director of the Observatory of St. Maur, who has made actual time tests. Moreover the diagrams furnish direct solutions