gress, held in Vienna in September, 1873; the symbols were slightly modified in Munich in 1892, and were recommended for use to the American observers in a circular issued by the Chief of the Weather Bureau dated January 1, 1894. These symbols are convenient for use in manuscript records and are now almost universally employed in the publications of the various international weather bureaus. They are, therefore, here presented again to the attention of the readers of the MONTHLY WEATHER REVIEW as a matter with which all should be familiar.

The absence of an exponent written above and to the right of the symbol denotes a phenomenon of moderate intensity; the exponent (^{0}) indicates slight intensity; the exponent(^{2}) indicates a phenomenon of great intensity.

The great saving of space and time attained by the use of the symbols is indicated by the following example and translation:

1 ⋖ 9 p — 10 p in E; 3 ◯ 11 p —; 4 ◯ —10 a., ⌜⋖ 3 p — 5 p.

The translation of the above is as follows: "On the 1st, sheet lightning was observed from 9 to 10 p. m., in the east; 3d, rain began at 11 p. m. and continued during the night (a dash indicates the continuance of a phenomenon); 4th, rain ended at 10 a. m. and a thunderstorm prevailed from 3 to 5 p. m.

The international symbols and abbreviations and their explanations are as follows:

1. ◯ RAINFALL—Indicates that an appreciable quantity of rain (one hundredth of an inch or more) has fallen during the day or since last observation; also that the day is a rainy day as distinguished from snowy or clear days.

2. ✳ SNOWFALL—Indicates that an appreciable quantity of snow has fallen during the day. ✳^{0} may be used to denote flurries of snow.

3. ▲ HAILSTONES.—Hard semitransparent ice, whether small or large, crystalline or rounded. ▲^{0} small quantity of hailstones; ▲^{2} large quantity of hailstones.

4. △ SLEET—Or pellets of snow or soft hail without any crystalline structure. This symbol is used by the Germans for *Graupeln*, or snow pellets, and for the semitransparent mixture of snow and ice that in the dry weather of central Europe nearly corresponds to the sleet of the coasts of England and America. △^{0} small quantity of sleet; △^{2} much sleet.

5. ∨ SILVER FROST—(English, "silver thaw," French, *givre*, German, *rauhfrost* or *duft-anhang*); this refers to an accumulation of snow and sleet on the limbs of trees, in which the snow is the main feature, so that the external appearance is silvery white and rough.

6. ∽ GLAZED FROST—(French, *verglas*, German, *glatteis*); this refers to an accumulation of snow and ice on the trees, in which the ice is in excess and the external appearance is smooth and transparent. In using the symbols for "silver frost" and "glazed frost," the Munich Conference requests that these terms be considered as descriptive of the resulting phenomena, no matter how they are brought about, therefore the definitions avoid any statement as to the conditions attending the formation of the depositions. The same rule applies to the use of the symbol for "hoar frost."

7. ← ICE-NEEDLES—(Not yet well defined by international usage).

8. ✛ DRIFTING SNOW—(German, *schneegestober*); this symbol indicates that strong winds are raising the snow from the ground, filling the air with it like dust, and transporting it horizontally; this may occur under a clear sky. The symbol does not refer to snow falling from the clouds, nor to the mere fact that the snow is lying in drifts on the ground. When the air is filled with blinding snow dust, use the symbol ✛^{2}. but for light winds and light snow dust use ✛^{0}.

9. ⊠ SNOW-COVERING—Or quantity of snow lying on the ground; when more than half the soil in the neighborhood of any station is covered with snow this is indicated by ⊠; if the snow covering is thin, use ⊠^{0}; but if it is considered deep for that station use ⊠^{2}.

10. ≡ FOG—Enveloping the observer; ≡^{0} thin fog or mist enveloping and above the observer; ≡^{2} heavy fog or mist, such as the Scotch mist, drizzling down upon the observer. Neither of these fog symbols is to be used when an observer at a high station notices fog in the valley below him; such an observation as this should only be expressed by a note in the daily journal.

11. ∞ HIGH HAZE—Such as makes distant mountains appear hazy, or such as covers the sky in the case of Indian summer haze or prairie fires; German, *moorrauch*. If clouds are also prevalent in connection with this haze, the additional cloud symbol should be given. The intensity, or density, of the haze is expressed by ∞^{0} for light haze and ∞^{2} for dense haze. The symbol ∞ indicates merely the hazy condition, or the optical result, without considering whether the haze is caused by dust or moisture.

12. ⌓ DEW; ⌓^{0} LIGHT DEW; ⌓^{2} HEAVY DEW—As the formation of dew depends upon the nature and exposure of the horizontal surface on which dew is deposited, the observer should use the same horizontal object uniformly throughout the season.

13. ⌐ HOAR FROST; ⌐^{0} LIGHT HOAR FROST; ⌐^{2} HEAVY HOAR FROST, injurious to vegetation—The expression "frosty weather" refers to the low temperature as such; but the expression "hoar frost" to the crystalline ice deposited upon the surface of solids in the open air. Hoar frost is deposited on horizontal objects generally under a clear sky at night.

14. ⟞ STRONG WIND—An arrow with four feathers indicates a wind whose strength is 8, 9, 10, 11, or 12 on the Beaufort scale, or 8, 9, or 10, on the international scale, or anything in excess of 50 miles per hour or 20 meters per second in absolute measures; ⟞^{2} a remarkably strong wind or one exceeding 11 on the Beaufort scale, or 80 miles per hour, or 35 meters per second.

15. ⌜⋖ THUNDERSTORM—Namely thunder, whether with or without lightning, rain, hail, or wind.

16. ⋖ HEAT LIGHTNING—Distant lightning or any form of lightning that occurs without audible thunder, even when it occurs in the zenith, which is sometimes the case (this latter occurrence should be especially described in the journal of the observer); ⋖^{0} infrequent lightning, or lightning that is confined to a small region of the sky; ⋖^{2} lightning that occurs very frequently or extends over a large region of the sky. When distant lightning appears at a definite direction in the horizon, the observer should add the letters indicating the points of the compass, for instance, ⋖^{0} NW. 10 p. indicates that occasional heat lightning occurred in the distant northwest at 10 p. m.

17. ⦶ SOLAR AUREOLA, CORONA, OR GLORY—German, *Kranz, lichtkron*, "Corona," *Sonnenhof*. These are small circles of prismatic colors surrounding the sun, the radii of these circles are usually less than 6°, but in the extreme case of Bishop's ring, its radius was 15°. Several concentric circles are sometimes visible; each circular band of prismatic colors has its red on the outside, and its blue, violet, or purple on the inside, with respect to the sun; such rings are generally formed when the sun shines through a thin cloud and may be seen if the sun is viewed through neutral-tinted glass or by reflection in water. Similar circles surrounding the shadow of the observer's head are called "anthelia," "aureolæ," "glories," or "fog-shadows," (German, *Gegensonne, Brockenspectra*).

18. ⏃ LUNAR AUREOLA OR CORONA—(German, *Mondhof*); circles surrounding the moon similar to the solar corona.

19. ⊕ SOLAR HALO—(German, *Sonnenring*); these are larger circles surrounding the sun whose sizes are quite definite, namely, about 22° and about 40° radius from the sun; they are easily distinguishable from the coronæ by the fact that the colors are feebler, and are so arranged that the red light is inside or nearest the sun, and the blue light is outside; the greater part of the breadth of the halo is white. Complex combinations of halos, parhelia, horizontal circles, and vertical columns sometimes occur, all of which may be indicated in general by the symbol ⊕^{2}, where the figure ^{2} indicates that the display is more brilliant than usual; a detailed statement of the radii or diameters of the rings and columns and of their arrangements should be given in the text.

20. ⏅ LUNAR HALO—(German, *Mondring*); phenomena surrounding the moon similar to the solar halo.

21. ⌒ RAINBOW—Double rainbows and those with adjacent supernumerary bows may be indicated by ⌒^{2}.

22. ⏜ AURORAL LIGHTS—Namely, any display of the Aurora Borealis.

ABBREVIATIONS RECOMMENDED FOR USE.

TIME.

a. antemeridian; p. postmeridian; n. noonday; m. midnight; h. hour. (The hours will be counted from 0 to 12, commencing with midnight.)—[The count from 0 to 24 is now widely adopted.—ED.]

TEMPERATURE.

° degrees of temperature or of a circle; F. Fahrenheit; C. Centigrade; max., maximum of temperature, pressure, or other element; min., minimum of temperature, pressure, or other element.

LENGTHS.

mi. miles; ft. feet; in. inches; kil. kilometers; m. meters; cm. centimeters; mm. milimeters.

CLOUDS.

C. cirrus; KC. cirro-cumulus; CS. cirro-stratus; K. cumulus; KS. cumulo-stratus; S. stratus; Nim. nimbus.

THE FIRST WELLMANN EXPEDITION.

Our readers will remember that in 1894 Mr. W. Wellmann, an American journalist (not a German-American as he is sometimes mistakenly called), conducted an expedition to Spitzenbergen, from which point he intended to make a journey toward the North Pole by sleds and boats. His party included Mr. B. O. French, of the Coast and Geodetic Survey, who served as astronomer; Dr. H. Alme, of the Meteorological Office at Stockholm, who joined the expedition at Tromsoe and served as meteorologist. The general spirit of the expedition was not that of scientific exploration, but the two gentlemen here referred to accomplished all that was possible under the circumstances In 1895 the Chief of the Weather Bureau received from Dr. Alme his report communicating the meteorological results, and on consultation with Mr. Wellmann was assured that there was no objection to the publication of this report, but that he considered Mr. French as responsible for all the work. Accordingly correspondence was opened with Mr. French, who, after unforeseen delays, owing to his absence in the field work of the Coast and Geodetic Survey, has only lately been able to complete the reduction of his astronomical observations and give the proper locations and charts showing the points at which the meteorological work was done. The Editor takes pleasure in being able now to announce that the combined reports of Messrs. French and Alme will be printed as a bulletin of the Weather Bureau. It is always proper and important to publish, in all possible detail, any observations made at an isolated point so far removed from ordinary meteorological stations, and so essential in filling up the daily map for tracing storms and weather over the North Atlantic Ocean.

RAINFALL MEASUREMENTS ON SHIPS.

It has been customary for navigators, in keeping a meteorological record, to express the rainfall only in the most general terms; but, inasmuch as a complete study of the meteorology of the globe requires a positive knowledge of the amount of rainfall, it behooves us to make every possible effort to remedy this great deficiency in our knowledge. In former days it was assumed that the rain gauge must be a fixture with its mouth perfectly horizontal at an elevation of not more than 1 foot above the earth's surface, while a gauge set in a shallow pit so that its mouth is on a level with the surrounding soil was widely adopted as the standard. The invention of shielded gauges by Prof. Joseph Henry, in 1858, and Professor Nipher, in 1878, and of the protected gauge of Bœrnstein, in 1884, together with a better appreciation of the action of the wind upon the gauge, as affecting its catch, have effected a radical change in our views. The height of the gauge above the ground does not materially affect the catch or the apparent rainfall, provided that we adopt some method of annulling the influence of the wind. Shielded or protected gauges give the same rainfall in all open localities, and it seems to be high time that they should be established and used at sea. The errors to which such gauges will then be subject will arise principally from the fact that they are liable to be in the shelter of a sail or bulwark, of a deck house or a smokestack. If established on a steamer near each end of the bridge occupied by the pilot or navigating officer, the average of the two gauges can apparently only be affected by the influence of the rolling of the vessel, and if mounted on gimbals, this latter is reduced to a minimum. If established on a steamship or sailing vessel, the gauge that is to windward of the sail should be employed; but the gauge that is to leeward should be read and recorded, in order to appreciate the amount that it has lost by its sheltered position.

The latest effort in this line of work is that of Dr. W. G. Black, whose paper on this subject, read before the Manchester Geographical Society in October, 1897, is summarized on page 206 of its Journal, Vol. XIII. The complete paper is published, with a chart of ocean rainfall, in the same Journal, Vol. XIV, pp. 36–56. Rainfall tables are given for each ocean, based on observations made with marine rain gauges (generally Dr. Black's pattern of 1870–72), during many voyages between 1864 and 1880, by about twelve steamships or steamers. Dr. Black illustrated his address and explained the use of the large box and small leather rain gauges; the gimbal stand for the rain gauge, with its ring and dish and louvre protection, and, finally, the wind gauge. The following are the conclusions to which Dr. Black has come on the question of oceanic rainfall:

1. More rain falls at sea in the Northern Hemisphere (Atlantic, Indian, and China seas) than in the Southern Hemisphere, by 91.15 inches to 66.33 inches; but there are fewer rainy days, by 162 to 182.
2. The rate of rainfall is heavier in the Northern Hemisphere than in the Southern Hemisphere by 0.562 inches to 0.364 inches per diem of wet days.
3. The percentage of wet days to total days in the Northern Hemisphere is about 24, and in the Southern Hemisphere is 23.
4. Most rain was collected in the month of September in the Northern Hemisphere, and in April in the Southern Hemisphere, both being autumn months.
5. The rate of rainfall per annum in the Northern Hemisphere was 50.56 inches and in the Southern Hemisphere 30.76 inches, or two-fifths less.
6. Least rain was collected in March in the Northern Hemisphere and in October in the Southern Hemisphere, both being spring months.
7. The greatest number of rainy days in the Northern Hemisphere was in September, 33, and in the Southern Hemisphere in April, 25; autumnal months.
8. The least wet days in the Northern Hemisphere were in March, 5; in the Southern Hemisphere, 1, in October; spring months.

We have, unfortunately, no further details of Dr. Black's apparatus, but we have no hesitation in recommending shielded or protected gauges, whether on gimbal stands or not, for general use at sea, as being a great advance over our present absence of rainfall measurements.

CLIMATES OF GEOLOGICAL AGES.

An article by Prof. T. C. Chamberlin in the Journal of Geology for November, 1897, vol. V., p. 653, contains a review of a number of hypotheses bearing on climatic changes during geological ages. In common with all modern geologists, Professor Chamberlin recognizes that the atmosphere is the most active of all geological agencies.

> Its very activity destroys its relics almost as soon as formed and gives them peculiar evanescence. This has invited the neglect of geologists laudably prone to concentrate their attention upon agencies which have left enduring and unequivocal records. * * * All our attempts at the solution of climatic problems proceed on some conscious or unconscious assumption concerning the extent and nature of the atmosphere at the stage involved.

After showing that the carbon dioxide now in the atmosphere would not last ten thousand years at the present rate of consumption, and that we are confronted by the necessity of finding some compensating source of supply, he appeals to the ocean as being an atmosphere in storage, holding in solution about eighteen times as much carbon dioxide as does the atmosphere itself. He finds that the flora and fauna of Paleozoic and Cenozoic times do not imply any great difference between the earlier and the present atmosphere, but that during the Carboniferous period there may have been many thousand times as much carbon dioxide as now. One might assume that our atmosphere has been successively fed and robbed of this gas. After computing from the best data available the power of a hot atmosphere and molten earth to retain the various gases whence it follows that hydrogen, at least, would escape into space away from the earth's attraction quite