The voluntary observer at Wauseon, Fulton County, states:

A heavy thunderstorm, with high wind, struck here just after noon, filling the air with sand so I could not see 15 rods. Some trees were broken down and two barns unroofed, one two miles east of here and the other four miles northwest. It was not a tornado, but a straight wind.

Wauseon is about 17 miles southeast of the schoolhouse mentioned above.

At Toledo the wind was 44 miles an hour from the northwest.

At Cleveland the maximum on that day was 58 miles from the west.

The observer at Green Spring, in Seneca County, writes:

Its path was about three-eighths mile wide at some points; one-half mile at others.

Mr. W. F. Miller, of Siam, Seneca County, writes:

The storm struck here at 2 o'clock. A number of barns were unroofed at a point three miles east of Bloomville. The wind was a straight blow, with no hail. The clouds were of a light yellowish green; lightning accompanied the storm.

He incloses a diagram which showed that the storm moved southeasterly, and that there were points of greatest severity at irregular distances of from one to five miles apart.

Prof. H. V. Egbert, voluntary observer at Bouchtil College, Akron, Summit County, writes as follows:

The storm was not of a tornado character. It had been raining a little, with light wind from the southwest, when it suddenly shifted so as to come from the north 60° west. It reminded me very much of the wind which frequently springs up after a thunderstorm when the low has passed and the northwest wind sets in vigorously. There were low clouds and some darkness therefrom, but they were clouds of smoke which had settled over the city and as soon as they blew away it was lighter. The nimbus were at an average height and they disappeared with the approach of the wind, leaving the higher stratus, from which no rain fell. In other words, the wind was not accompanied by rain. There was no joining of clouds, as is supposed to exist in a tornado. I saw the whole affair from the third story of the college building, which stands on the highest ground in the city. There was no lightning, though in the night following a thunderstorm occurred. It was simply a good old-fashioned straight blow, though a severe one.

Reports from voluntary observers in Portage, Mahoning, and Columbiana counties show considerable local damage, Mr. T. R. Snowden, postmaster at Wellsville in Columbiana County, writes:

The damage done in this section was caused by the wind alone. The wind had a twisting movement, uprooting trees and catching up great quantities of water from the river and scattering it in spray.

Newspaper reports indicate that the west gable of a schoolhouse which stood in the Keefer District near Canal Fulton, Stark County, was blown in and several of the pupils seriously injured. This occurred at 3:15 p. m.

Other damaging thunder and hailstorms occurred later in the afternoon and evening over the same district. In southern Wayne and northern Holmes counties, hail destroyed much glass, broke slate, perforated iron roofs, and killed some sheep.

Some interesting facts in connection with this storm are:

(*a*) The storm occurred in the northeast quadrant of a cyclonic area, yet had the characteristics of a "line" squall, such as occur near the western edge of a sirocco wind area, where the overrunning colder winds cause the most unstable condition of the atmosphere.

(*b*) The absence of the generally-accepted characteristics of the tornado, although most newspapers and some observers gave it that name. A study of its course shows that it was widespread, covering much more territory than is ever covered by a tornado.

(*c*) The apparent rising from and dipping down to the earth of the severest winds.

(*d*) The meteorological conclusions announced by the newspaper reporters and the universal exaggeration of accounts of damage were more remarkable than usual.

BALLOON ASCENSIONS ON MARCH, 24, 1899, IN FRANCE.

[Abstract from L'Aerophile, April, 1899, by Prof. F. H. BIGELOW.]

On March 24, 1899, five balloons were sent up in France, three, unmanned, under the direction of M. Teisserenc de Bort; one, unmanned, in charge of M. Gustave Hermite, and one, manned, carrying MM. Bezançon et Le Cadet. The results of these ascensions were interesting on account of several practical experiences, which it will be well for those planning such voyages of exploration in the upper air to bear in mind.

(1). The first unmanned balloon was of 100 cubic meters. It was launched by M. Raymond, at Trappes, about 8:30 a. m. It drifted east-northeast and landed at Treves, in Rhenish Prussia. At the altitude of 14,000 meters, when the surface temperature was —1.9° C., the balloon thermometer recorded —52.9° C., a fall of 0.364° per 100 meters.

(2). The second balloon, of the same size, was launched by Teisserenc de Bort, near Limoges, at 9.27 a. m. It moved north-northeast 59 kilometers and landed at Péroles (Corrize). At the height of 8,600 meters, for a surface temperature of +0.3° C, the temperature —44.0 C. was registered at the balloon, a fall of 0.515° per 100 meters.

(3). The third unmanned balloon, also 100 cubic meters in size, was launched by Teisserence de Bort, at 3.45 a. m., from the same place, and it moved 121 kilometers east to Meix-Saint-Epoin (Marne). For a surface temperature of —3.0° C. the temperature at the height of 8,600 meters was —52.6°, a fall of 0.570° per 100 meters. The last balloon was sent up before sunrise, in order to determine what influence the sun's rays would have upon the registering thermometers as compared with the similar instruments sent up at 9.27 a. m. The latticework used to protect the thermometers was quite sufficient for this purpose, and the conclusion is drawn that no complicated mechanism is required to agitate the air near the thermometers at high altitudes.

(4). The fourth unmanned balloon, the Aerophile, No. 3, 460 cubic meters capacity, had a disastrous experience. It was sent off by M. Gustave Hermite, from the Champ-de-Mars, but was only *one-third* filled with gas, thus saving expense. It was supposed that the gas would expand at high altitudes enough to completely expand the balloon. It ascended 4,000 meters, meanwhile taking on the form of a parachute, resisting the movement of the balloon upward. It was subjected to violent swayings and shocks, and at that height burst into a thousand pieces, as if the covering had been made of brittle glass, falling near Bagneux (Seine). It is supposed that the low temperature froze the material and made it very fragile, or that possibly a rope became twisted about the globe, preventing its proper enlargement. This experience is considered conclusive against the idea that an unmanned or sounding balloon may profitably be started up only partially filled with gas. On recovering the instruments, it was found that with a surface temperature of 0° C., the temperature at the height of 4,338 meters was —33° C., a fall of 0.700 C. per 100 meters.

(5). The manned balloon was the "Balaschoff," carrying M. M. Besançon and Le Cadet, which left Paris at 8:15 a. m. and landed at Loiret (Seine-et-Marne) at 11:15 a. m. For a surface temperature of —3.4° at the height 4,014 meters a temperature of —31.6° was observed, being a fall of 0.732° per 100 meters. They had a mercurial barometer, but it was found impossible to read it very accurately on account of the incessant oscillations of the balloon, and they conclude that this difficulty is so persistent in balloon voyages that either the aneroid or self-registering instruments must always be employed. The ventilated Assmann psychrometer was suspended at the end of an arm, 12 feet from the balloon, and it was read by a telescope. The self-register thermograph which agreed with the Assmann at the ground recorded

about 4° lower at the high altitudes. This lag of the self-register is a serious defect in all ascensional operations, and it should be carefully considered before drawing conclusions from such data. In this ascension the wet-bulb thermometer seems to have ceased to operate at the temperature —22° C., and after that it actually read warmer than the dry-bulb thermometer. This shows the extreme unreliability of all direct measures of humidity at very low temperatures in the free air.

Besides giving us some interesting low temperature readings at several high elevations, these experiences show what should be avoided in several particulars, especially in starting up with a partially inflated balloon.

CLIMATOLOGY OF THE ISTHMUS OF PANAMA, INCLUDING THE TEMPERATURE, WINDS, BAROMETRIC PRESSURE, AND PRECIPITATION.[1]

By HENRY J. ABBOT, Brigadier General, U. S. A. (retired).

In his note on this subject dated Paris, June, 1882, Monsieur Cugnin enumerated the astronomical and physical conditions which produce important consequences as to local climate. The following are some of these conditions:

General considerations.—The geographical position of the Isthmus of Panama is about 9° north latitude. From this position it follows that at noon the sun is in the zenith twice a year; it is on the northern side between the 13th of April and the 29th of August. Its altitude above the north horizon on the day of the summer solstice is 75° 41′ and its altitude above the south horizon at the winter solstice is 57° 24′. It transmits to the surface of the earth the maximum possible amount of heat on April 13 and August 29. The amount of heat coming from the sun is in proportion to the sine of the angle made by the solar rays with the horizon; that is to say, to the numbers 1.00, 0.97, and 0.84 at noon at the time of the maximum and at the two periods of summer and winter minima, respectively. This shows the very small differences in the quantity of heat received day by day during the entire year.

But the temperature of the air does not depend solely upon the quantity of heat coming from the sun, it is also necessary to consider the amount lost by radiation and the effects of many local conditions, and these may vary according to place and from one day to another. Among these conditions the motions of the atmosphere and the quantity of aqueous vapor are general and powerful factors.

Aqueous vapor is the great regulator of temperature, as it is less permeable than dry air to the waves of energy from the sun and still less so to those that radiate from the earth. Its influence in this direction is very important on the Isthmus of Panama because there is only a narrow strip of land between two great oceans, and consequently the relative humidity is always very high. By combining high temperatures with this high humidity there results an excessive absolute amount of moisture in the atmosphere.

In regard to the general motions of the air, it is well known that in consequence of the high temperature in the equatorial regions the air ascends; in consequence of this we should have constantly in the lower atmosphere north winds from the north, and south winds from the south, seeking to fill up the vacuum; but on account of the rotation of the earth from west to east, these directions become northeast and southwest. Nevertheless, there are circumstances, as we shall see further on, which modify this general law on the Isthmus of Panama. Thus, the observations made daily at Colon, during the year 1881, at 6 a. m., 1 p. m. and 9 p. m. (fig. 1), show 55 per cent of winds from northeast and

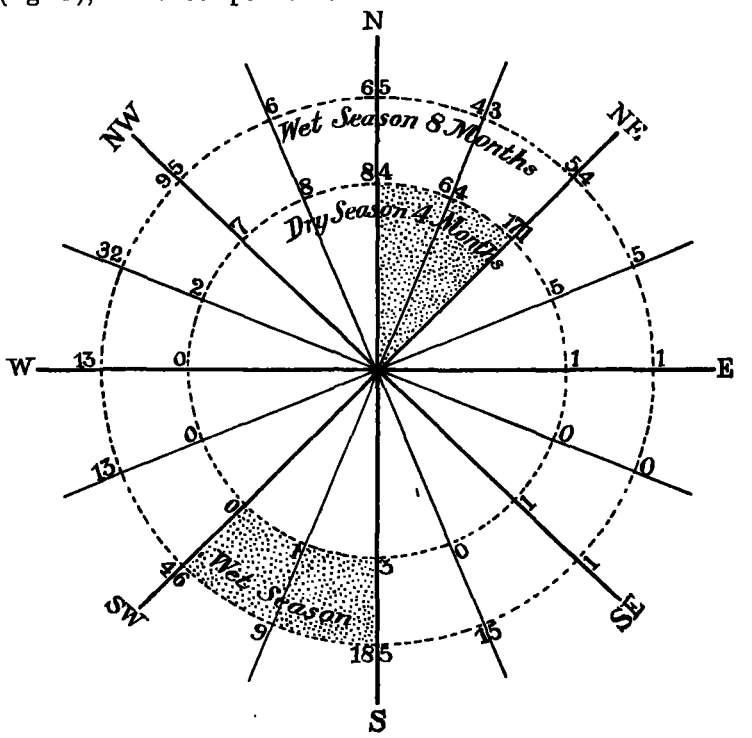

FIG. 1.—Wind rose at Colon for the year 1882. The figures give the total number of times each wind is recorded during the dry and wet seasons, respectively, at the 3 hours of daily observation. During the dry season 91 per cent of the recorded winds are from north and northeast. During the wet season 33 per cent of the recorded winds are from south and southeast.

northwest; 35 per cent between southeast and southwest, and 10 per cent from all other directions, including 1 per cent of calm. Nevertheless these percentages become, during the dry season (January, February, March, and April), 95 per cent from northeast and northwest, 91 per cent between northeast and north, 2 per cent southeast and southwest, and 3 per cent from all other directions, respectively: during the rainy season 36 per cent from the northeast and northwest; 91 per cent from southeast and southwest, of which 33 per cent between southwest and south, and 13 per cent from all other directions. That is to say, at Colon north winds prevailed during the dry season, but south winds were strongest during the rainy season; thus, these winds follow the sun as it carries northward the axis of the ascending layer of air.

In order to elucidate these facts one must remember that the geographic equator does not coincide with the thermal equator, which is the term applied to the curve that connects the points on all meridians where the annual maximum temperature is found (generally from 26° to 30° Centigrade). This thermal equator passes very near to the Isthmus of Panama, but a little to the south, on account of the great ocean current which carries thither the equatorial waters of the Atlantic, and consequently increases the temperature of the whole of Central America, commencing with the Isthmus. This is not to say, however, that the temperature there is ever very high, as we shall see later on. In a great measure, so far as concerns temperature, this ocean current neutralizes the effect of 9° of north latitude.

The axis of the ascending layer of air moves toward the north and retrogrades toward the south with the sun, oscillating in the course of a year, day by day, symmetrically across the thermal equator. This layer varies in thickness, from one place to another, according to the diverse local conditions, such as the configuration of the land, the dura-

[1] The original text of General Abbot's paper has, with his permission, been slightly modified by the Editor, so as to restrict this paper to the presentation of the climate of the Isthmus of Panama. The original data in metric measures has been compared as far as possible with published data, and has been converted into English measures by Mr. A. J. Henry, Chief of Division, who has also added an appendix containing figures not accessible to General Abbot.