SECTION II.—GENERAL METEOROLOGY.

AIR CHIMNEYS OF ICE BELOW A WATERFALL.

By ROBERT E. HORTON, M. Am. Soc. C. E.

[Dated: Albany, N. Y., Feb. 5, 1918.]

On the morning of December 12, 1917, the writer observed an unusual formation of ice below a waterfall created by a dam on the Oswegatchie River, near Gouverneur in northern New York. The air temperature on the morning when the observations were made was about −25°F. There had been freezing weather at this location for sometime preceding. The dam is of timber [fig. 1 not accurate in this] and is located at the crest of a natural rapid in a rough but shallow granite gorge. There was a slight depth of water wasting over the spillway of the dam in places. This depth ranged from zero to perhaps 6 inches. Owing to projecting rocks and piles of pulp wood below the dam (*C* in fig. 1) the flow of water away from the toe of the dam was greatly obstructed and there was opportunity for shore ice to build out from some of these obstructions, starting at a distance of about 20 feet below the dam and reaching out over the pool to within, say 10 feet, of the toe of the dam. In several places there were vertical chimneys of ice of circular cross section built up on this shore ice. (*A*, *B*, in fig. 1.) Where, owing to a higher crest, water did not flow over the dam, shore ice had also built out from the toe of the dam and here again the ice chimneys were formed. The tallest of these chimneys was about 4 feet high and 6 or 7 inches inside diameter, the walls apparently being ½ inch to 1 inch in thickness. The largest ice chimney was 10 or 12 inches in diameter, but this one was not over 2 feet high.

Apparently the overflow from the dam carried air down with it into the pool. The turbulent water rising under the shore ice permitted the escape of this air, first through air holes. Mist and drops of water expelled with this escaping air froze around the margin of the air hole, gradually building up an ice chimney. In the case of the shorter chimneys, mist and particles of water could still be seen escaping.

Although the writer has been around northern streams much of the time for 20 years, this is the first occasion when he has observed this phenomenon, although it would seem natural from the simple conditions under which it is produced that it must be of rather common occurrence.

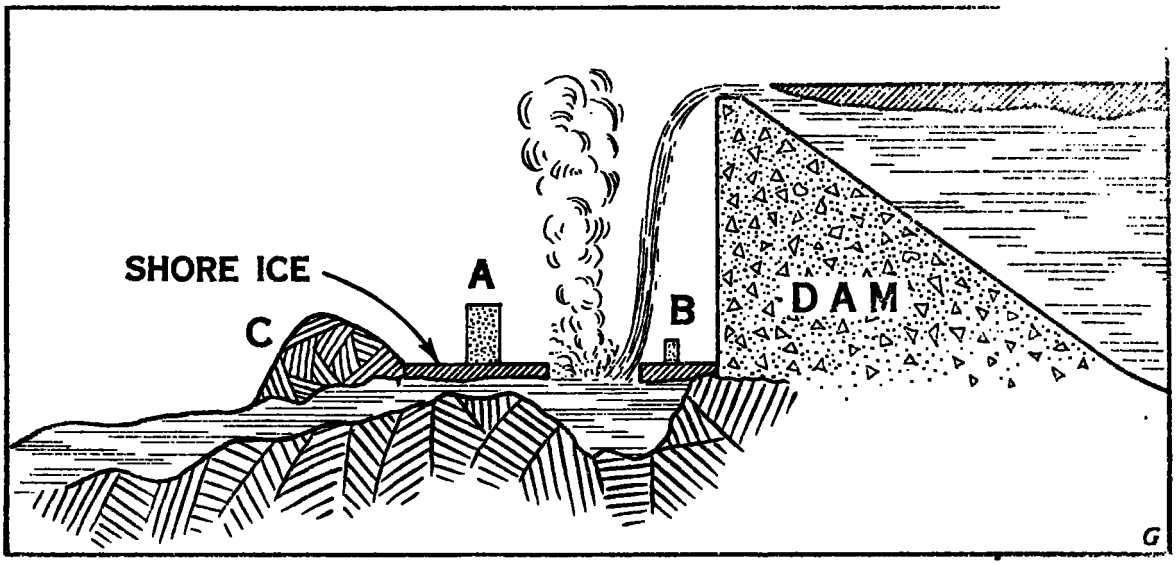

FIG. 1.—Illustrating formation of air-built ice chimneys, *A* and *B*, on shore ice below a dam on the Oswegatchie, near Gouverneur, N.Y., December 12, 1917. Obstructions of rock and pulp wood at *C*. Dam should be of timber.

CYCLONES, TORNADOES, THUNDERSTORMS, SQUALLS.

By ALFRED J. HENRY, Meteorologist.

[In response to a query from an honored correspondent the Weather Bureau recently submitted the following elementary remarks on cyclones and on tornadoes, with the purpose of clearing away once more the usual misconceptions regarding the distinctions meteorologists make between these storms. As all our stations repeatedly encounter the kinds of questions here brought up and answered, the remarks are published *in their entirety* that all may use them when needed.—EDITOR.]

What is a tornado? Students of weather phenomena define a tornado as a violent windstorm accompanied by rain, hail, thunder, and lightning, in which the air masses whirl with great velocity about a central core while the whole storm travels across the country in a narrow path at a considerable speed. These storms have a destructive diameter of from a few hundred feet to half a mile and sometimes more. When seen from a distance the tornado has the appearance of a dense cloud mass with one or more pendant funnel-shaped clouds which may or may not reach to the earth. In the larger tornado clouds east of the Mississippi the funnel cloud may not be noticeable unless the observer be situated in a favorable position for observing it, but the whirling motion of the air is the same whether the funnel is visible or not.

(1) Tornadoes almost invariably occur in the southeast quadrant of a cyclone, that is the barometric con-

figuration marked LOW on the daily weather map. The cyclone or area of low pressure or simply LOW of the daily weather map, indicates certain atmospheric conditions essential for the generation of tornadoes. However, many cyclones occur without tornadoes, but a tornado does not occur without a cyclone.

(2) On the average about 120 "cyclones" pass across the United States in the course of a year, moving in a general way from the west to the east. The characteristics of a cyclone are: Cloud and rain. The temperature of the air constituting the front or advancing air masses is warmer than that of the air masses in the rear. The surface wind circulation in a cyclone is spirally inward toward the region of lowest pressure, counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere. A complete statement of the wind circulation in "cyclones" would far exceed the limits of this paper but it may be found in any standard treatise on meteorology.

(3) It will suffice for our purpose to say that cyclones, after crossing the Rocky Mountains and entering the Plains States in their eastward movement, induce a movement of the surface air from the south and southeast. When this circulation persists for a day or so, the following result is commonly experienced, viz, an increase in the temperature and moisture of the air. This condition is a natural concomitant of cyclones and it is a very beneficent one because the rainfall that makes the great interior valleys a rich agricultural region is dependent on these southerly, moisture-bearing winds.

(4) The cyclones of Winter differ from those of Summer in that the winds of the former are stronger and the precipitation in northern districts is mostly in the form of snow, but with the coming of summer, the surface winds become weaker and the weaker energy of the summer cyclone is generally accompanied by the development of *violent local winds, thunderstorms, and tornadoes.* All of these occur within the area covered by the cyclone. That area generally embraces several States, while the track of a tornado may be but a few rods wide and 25 to 50 miles in length. This is one of the very essential points of difference between a cyclone and a tornado. The former is a widespread storm which moves across the country at a rate probably not exceeding 15 or 20 miles an hour, in summer attended by cloud and rain and at times thunderstorms, hailstorms, and mostly without violent general winds.

(5) Practically all cyclones of the warm season are attended at some time and at some place by one or another of the following-named phenomena: (*a*) a simple, harmless thunderstorm, with more or less brilliant electrical display; (*b*) a part of the precipitation of the thunderstorm may occur in the form of hail, and then we have a hailstorm; (*c*) violent winds may occur, blowing in a straight line. These winds may be of sufficient violence to unroof houses and destroy frail structures; many of the storms of this class are *improperly called* tornadoes.

(6) Finally, *the real tornado* is to be distinguished by several unmistakable characteristics, first, the whirling columnar of air and pendant funnel-shaped cloud, whose lower end is always in physical contact with the earth when it causes destruction. Whether or not the funnel cloud can be seen depends somewhat upon the size of the storm, on the viewpoint of the observer and also the time of day. In the dry regions of the Great Plains the funnel cloud is often plainly visible miles away across the prairies, but in the more humid districts east of the Mississippi River, where the cloud mass is much greater, it is sometimes impossible to perceive the funnel cloud in the darkness and rain produced by the general rain cloud. The second characteristic is a very significant roar that has been likened to the rumbling of distant thunder or the approach of a train of heavy cars; and finally, after the storm has passed, the lay of the débris will generally indicate whether there has been a twisting or whirling motion of the winds. If the débris lies parallel with the course of the storm, then the winds have been straight-line rather than spiral or curving and the storm was not a tornado.

Tornadoes almost invariably travel in an easterly direction. The *prevailing* direction is from the southwest to the northeast. The width of the path of great destruction varies from a few rods to half a mile; in extreme cases a width of as much as a mile has been reported. The average length of the path of great destruction is about 25 miles, although here again individual cases vary greatly from the average. Great destruction is not always continuous throughout the entire path of the storm, but occurs only where the funnel cloud is in contact with the earth. The funnel cloud sometimes rises and passes over considerable distances before again descending to earth.

(7) The weather conditions associated with tornadoes are very similar to those which commonly occur in the southeast quadrant of the cyclone, namely: (a) southerly winds, mostly gentle; sometimes no appreciable wind; (b) high temperature and humidity. These conditions are quite common and probably exist every day in some part of the land. But tornadoes occur only rarely, nevertheless they are much more frequent some seasons and some years than in others.

Questions and answers.

A correspondent has asked the following questions regarding tornadoes. Both the questions and answers are given.

Q. What weather conditions prevail prior to a tornado?

Ans. A cyclone, with unusually high temperature and high humidity in its southeast quadrant, a condition of weather often described as "sultry," "sticky," "oppressive," etc. These conditions are usually found in the southeast quadrant of a LOW whose center overlies any one of the great interior valleys.

Q. Does rain follow or precede a tornado?

Ans. It may precede, accompany, or follow, and on rare occasions it may be absent.

Q. How long before a tornado sets in will a barometer record its coming?

Ans. The barometer does not indicate the coming of a tornado, although, as above stated, tornadoes occur with the greatest frequency in an area of low barometer at certain seasons.

Q. Can a barometer be depended on?

Ans. Not to indicate the approach of a tornado; but a recording barometer, if within the influence of a tornado, may give a valuable and interesting record.

Q. During what months of the year can tornadoes be looked for in the Mississippi Valley?

Ans. Tornadoes may occur in the Gulf States in winter. As the season advances the region of greatest frequency is found in the Plains States and the Mississippi Valley, May being the month of occurrence of the greatest number, April coming next. East of the Appalachians tornadoes occur rarely until after July. The

season of tornadoes in the Mississippi Valley extends from April to September, inclusive.

Q. In case a cyclone cellar is not available, what, in your estimation, would be a safe place?

Ans. The southwest portion of the cellar of a frame house.

Q. What about cellars in brick buildings during such storms; are they safe?

Ans. That depends entirely on the severity of the tornado. Some tornadoes merely destroy the roof of brick houses; some cause the walls to crumble or fall outward. The cellar of a brick house is probably safer than any other place in that particular structure. In the Omaha tornado of March, 1913, very few brick houses were seriously damaged.

Q. What time of day do these storms occur?

Ans. Generally from 3:30 to 5 p. m.

Q. Have there been any at night?

Ans. Yes.

Q. Have the municipalities any way of notifying the people, and how?

Ans. The place where a tornado will form can not be foretold. Tornadoes, like thunderstorms and hailstorms, occur, for the most part, on warm, sultry afternoons, in the late spring and in summer. While the precise path of these storms can not be accurately foretold, the weather maps show when the conditions are favorable to their generation.

The local signs of the approach of a tornado are ominous clouds, first in the southwest and then almost immediately in the northwest and north. The appearance of a pendant funnel-shaped cloud may be taken as conclusive evidence of the presence of a tornado. If a funnel cloud can not be observed, its existence can be known by a peculiar roaring noise, somewhat like the rumbling of distant thunder or the approach of a train of heavy cars.

If one can see the tornado cloud and gain an idea of its direction of motion, then the zone of safety is in a line at right angles to the direction of motion. If the tornado is moving toward the northeast, then one should run toward the northwest, provided, of course, the storm is about to move a little to the south of the observer's position.

The southern margin of a tornado is more dangerous than the northern, and one should take advantage of this fact in the endeavor to reach a place of safety, remembering that usually the width of the path of great destruction does not cover more than a couple of city blocks and that comparative safety may be found only a short distance at right angles to the line of advance of the tornado.

DETERMINATION OF OZONE AND NITROGEN OXIDES IN SOUTHERN INDIA.[2]

By F. L. USHER and B. S. RAO.

[*Reprinted from* Science Abstracts, Sect. A, Oct. 31, 1917, §1094.]

The more rapid decay of rubber articles and textile fabrics in the Tropics generally is ascribed to the intense light and heat, and the supposed higher percentage of ozone, hydrogen peroxide, and nitrogen oxides in the tropical atmosphere. As there are hardly any reliable data concerning these percentages, the authors undertook this determination at Bangalore College in southern India (Mysore). Rothmund and Burgstaller have shown that the potassium iodide method of estimating ozone and hydrogen peroxide is untrustworthy, they rely on the oxidation by ozone of alkaline or neutral sodium nitrite to nitrate, and they let the air to be analyzed replace water, instead of bubbling it through water. The air is sucked through tubes charged with chromic acid (which destroys H_2O_2) and MnO_2 (neither of these two reagents attack nitrogen peroxide).

Only 14 complete determinations have been made so far, and in 12 of these none of the three gases were found; twice nitrogen peroxide was observed, 1 part in 4,000,000 or 5,000,000 of air. Conclusions are not yet drawn, but it is pointed out that apparently ozone and nitrogen peroxide never occur together in the atmosphere, probably because they would react with one another under formation of nitric acid.—*H. B[orns]*.

[2] Trans., Chem. soc. J., Aug., 1917, 111: 799–809.

PITFALLS OF METEOROLOGICAL PERIODICITIES.

By W. W. B[RYANT].

[*Reprinted from* Nature, London, Nov. 29, 1917, 100: 246–7.]

There is a real danger that some meteorologists, resenting the accusation frequently made against them of accumulating masses of data without making any real use of them, may be tempted to apply the processes of mathematical analysis to any and every set of observations, regardless of the considerations which limit the suitability of the method for the particular data proposed for analysis. This may easily be the case when hunting for periodicity. There is a great temptation, especially for anyone accustomed to the regularity of so many cosmic phenomena, such as eclipses, comets, planets, etc., to expect to find such periods recurring in the weather, but the work before us, consisting of the essential portions of a dissertation by Dr. Ryd—fortunately thought worthy by Capt. Ryder, director of the Danish Meteorological Institute, of a wider publication and so included in the Communications of the Institute and done into intelligible English—should be studied before much time is spent in the search.[1]

Dr. Ryd sets out clearly certain characteristics of meteorological data, wherein they differ essentially from e. g., astronomical data. One of these is the impossibility of eliminating some forms of "systematic" error, which are too likely to be variable to be strictly systematic, such as the difference between the indications of a thermometer, under various conditions of exposure, and the real temperature of the air. Another is an error neither accidental nor systematic, but due to the fact that the data are meteorological; a good example of this is afforded by the mean diurnal variation of air temperature as shown on (*a*) overcast or (*b*) cloudless days.

Dr. Ryd regards harmonic analysis applied to such data as an excellent interpreter, but a very untrustworthy probe. The known periods—the day and the year—are unexceptionable, and the variation from hour to hour in one case, and from day to day, or preferably from "pentad" to "pentad," in the other, are obviously fit subjects for analysis. Dr. Ryd prefers to use both sine and cosine terms instead of the usual transformation, because the determination of mean error is more direct when two constants enter similarly. This is clearly important, as the mean error is a vital consideration. Analysis for testing a real period, such as one of the lunar periods, on the meteorological data is not quite so risky as tentative fishing for an unknown period, in

[1] Publikationer fra Det Danske Meteorologiske Institut Meddelelser. No. 3, "On Computation of Meteorological Observations, by *V. H. Ryd* (Copenhagen, 1917).