can be spared will be welcome, even though they may be of the older dates. The publications should be sent to the Czechoslovak Legation, 1732 N St. N.W., Washington, D. C., from where they will be forwarded to the men and institutions most in need of them through the International Exchange Bureau of the Smithsonian Institution; or they may be sent or delivered to the writer.

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NOTES ON METEOROLOGY AND CLIMATOLOGY

HURRICANES

We have been told by those who have visited the West Indies, that the natives have named the hurricane warning flag, which is displayed by the Weather Bureau, "*el panuelo del Diablo,*" or the devil's handkerchief. Such a name conveys a fair impression of the natives' opinion of the hurricane. We are also told that the various hurricanes are named after saints of the church, and birth-dates, marriage-dates, and death-dates, are reckoned from them. In other words, the hurricane is decidedly an *event* in the lives of those who experienced it. But the native West Indian is not the only one who has a respectful regard for the hurricane, for the vessel masters, whose ships ply the Gulf of Mexico, and those residents of the United States who inhabit the cities along the Gulf Coast have learned by sad experience to betake themselves to places of safety upon the approach of these interesting and destructive storms.

The West Indian hurricane, or tropical cyclone, is an area of low barometric pressure; but it differs in several respects from the extratropical LOWS which cross the United States from west to east in unending procession. The isobars of the tropical cyclone are circular and the distribution of meteorological elements about the storm center is symmetrical, whereas the extratropical LOW usually is elliptical in form and displays a marked lack of symmetry in the distribution of temperature, precipitation and cloudiness. The tropical storm which affects the West Indies and the United States, usually has its origin in the doldrums, or low-pressure calms which in mild-, and late-, summer lie along latitude about 10° N., in the region of the Caribbean Sea and eastward. Its course is first toward the northwest, or west-northwest, and later, usually in about latitude 30° N., curves northward and finally northeast. After entering the mainland the effect of the storm is soon lost; and, while it may be very destructive in the immediate vicinity of the coast, its further progress is characterized by a diminution of intensity and an acquisition of the characteristics of the extratropical LOW.

One of the most troublesome features of the hurricane, from the meteorologist's point of view, is that the main part of its course lies over water, and, since ships make every effort to escape the storm, the forecaster is left in utter darkness as to the exact location of the disturbance and its direction of movement. When a warning is once given of the presence of such a storm in the Gulf, all vessels in port refrain from sailing until the danger is passed. While this is decidedly profitable for the vessels, it makes the meteorologist the victim of his own efficiency, for it deprives him of observations of clouds, pressure, etc., which are so valuable to him in forecasting the part of the coast where the hurricane is most likely to strike. For this reason, it is necessary to utilize whatever observational data can be obtained along the coast, and Dr. Cline, of the New Orleans office of the Weather Bureau, has recently published a paper[1] in which he states his belief that the tides are a reliable criterion of the direction of motion of the hurricane while a considerable distance at sea.

Dr. Cline, after a brief mention of the wave-producing powers of winds, takes up all the hurricanes which occurred between 1900 and 1919. In their chronological order, he

[1] Cline, Isaac M., "Relation of Changes in Storm Tides on the Coast of the Gulf of Mexico to the Center and Movement of Hurricanes," *Monthly Weather Review*, March, 1920, pp. 127–146.

points out the relations existing between the tides at various Gulf stations and the position of the hurricanes in the Gulf. He is enabled by these studies to show the portion of the storm in which the greatest wave-producing winds occur. The quotation from John Eliot's "Cyclonic Storms in the Bay of Bengal" regarding the wave-producing power of the hurricanes is worth repeating here:

> Whatever explanation be adopted of the production of these large waves, there is no doubt of the general principle that air moving over a water surface always produces waves, and that the magnitude of the waves is dependent upon the extent of the water area over which they blow and upon the force of the winds. It is evident that the strength of the swell or the distance at which it will be sensibly felt in the open sea, will depend partly upon the strength of the producing winds and partly upon the distance over which the producing winds act with no considerable change in direction. The rapid movement of the air over the surface of the sea gives rise, by some species of cumulative action to a continuous succession of large parallel waves so long as the winds are fairly steady in character. Waves that are produced in this manner travel steadily onward in the same general direction so long as they meet no obstruction, and if they pass beyond the area of strong winds, they decrease slowly in height and force.

It was noted by Mr. Eliot that in the Bay of Bengal the swells were observed 400 miles from the center of the storm and forty-eight hours before its arrival.

Dr. Cline has given a diagram of the type of waves and swells which emanate from a hurricane, and he finds that the greatest waves are produced in the rear right-hand quadrant of the storm and travel forward through the storm and make themselves felt far in front and mostly to the right side of the line of advance at the time the wave left the storm. These waves travel in the direction of the storm's motion. Waves of lesser amplitude are sent out to the right and left of the center of advance of the storm in the front half, still smaller, weaker waves are sent out to right and left in the rear of the storm; and finally, the weakest waves of all are sent out in the rear.

How intense the winds are in the rear right-hand quadrant of the advancing hurrricane may be seen from the following (indicated) wind velocities observed at Burrwood, La., near the mouth of the Mississippi River, upon the occasion of the hurricane of September 29, 1915:

> Sixty miles per hour or above prevailed for a period of 13 hours.
>
> Seventy miles per hour or above prevailed for a period of 12 hours.
>
> Eighty miles per hour or above prevailed for a period of 11 hours.
>
> Ninety miles per hour or above prevailed for a period of 3 hours.
>
> One hundred and eight miles per hour prevailed for a period of 2 hours.
>
> One hundred and sixteen miles per hour prevailed for one third of an hour.
>
> There was a gust with 1 mile at the rate of 140 miles per hour.

It appears that as these waves begin to reach the coast there is a piling up of water, which is, of course, in excess of the normal predicted tide. By carefully noting and comparing the high water at various stations it is possible, Dr. Cline believes, to detect changes in direction of movement of the disturbance. As an example of this, and also of the fact that the rise of water precedes any change in the barometer, he cites the case of the storm of September 11–14, 1919, in which the "barometer at Burrwood, New Orleans, Galveston and Corpus Christi was either stationary or falling only a few hundredths of an inch, the water, first at Burrwood, later at Galveston, and then at Aransas Pass was rising in feet, telling the story of the movement and of the change in the course of the storm as plainly as could be told."

By this method it is possible to tell whether the storm is shifting its course to right or left by the shifting of the point of greatest rise to right or left. The regular tides are not obscured by these storm tides except perhaps in the last twelve hours before the storm strikes, when there are other features of prognostic value which can be relied upon. The highest water occurs a few miles to the right and at about the time of passage of the center and high water is observed from 100 to 200 miles to the right of the storm, while to the left it is hardly observed at all.

An interesting point is the effect upon the height of the water which may be attributed to the decreased atmospheric pressure in the center of the storm. This of course will allow the water to be raised in that vicinity. In the great hurricane of 1900, which passed inland at Galveston the pressure was low enough to have caused a rise of 1.5 feet in the level of the water. There is no danger of confusing such an effect as this, however, with the main storm-tide, because the amplitude of the storm-tide is much greater; indeed, in this case, it was 15 feet.

The apparent simplicity of this method of forecasting hurricanes must not be overestimated, however. The hurricane is a capricious disturbance and difficulties may be introduced by its unusual conduct either with respect to its rate of movement, or point of recurving. An example of this may be made in the hurricane of September 21–22, 1920.[2] This storm, as indicated by the tides after it entered the Gulf, was moving in the direction of the coast between Corpus Christi and Galveston; but it recurved and with unexpected speed swept northward and inland near Morgan City, La. The difficulty was that, owing to the unexpected late recurving and unusual speed, it was impossible to forecast the actual point of entrance. As a consequence, the warnings were displayed first from Corpus Christi to Port Arthur, Texas, and then extended to include the coast as far east as Pensacola. In retrospect, it is seen that the method worked out well enough; but the peculiarities of the storm's movement preclude a satisfactory application of the method. In this case, the method did not give as great precision as might be required; but it must not be inferred that the method is faulty. Anything that will improve the forecasting of hurricanes is welcomed, and it can not be said that Dr. Cline's paper does not constitute a genuine contribution to this difficult and troublesome question.

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[2] *Cf.* Cline, Isaac M., "The Life History of Tropical Storm in Louisiana, September 21 and 22, 1920," *Monthly Weather Review*, September, 1920, pp. 520–524.

SPECIAL ARTICLES

THE COLLECTION OF RADIUM EMANATION FOR THERAPEUTIC USE[1]

The practise of using radium emanation instead of radium salts for therapeutic purposes is now thoroughly established in this country. Its advantages are so patent that all of the hospitals and clinics, where large quantities of radium are employed, have had their radium salts converted to soluble form, and collect emanation from solution.

It is necessary, however, to separate the emanation from hydrogen, oxygen and other gases which accompany it in the collection, in order to reduce its volume to meet the requirements. This can be accomplished by several different methods: (1) The chemical method of purification by heating copper oxide and other chemicals in a tube through which the gases pass before being confined in small volume over mercury; (2) the method of Professor Duane[2] of passing the gases over an electrically heated partially oxidized copper wire; (3) the method of freezing emanation at liquid air temperature and pumping off the residual gases. This method may also be employed in conjunction with either of the first two.

All three methods require a rather complicated apparatus and manipulations which can be carried out only by a specialist. It occurred to the writer that some simplification might be introduced by collecting emanation from the highly heated or fused radium salts, thus avoiding the presence of water and the consequent large volume of hydrogen and oxygen resulting from its decomposition. It

[1] Published with permission of the director of the United States Bureau of Mines.

[2] *Phys. Rev.* (2), 5, 311, 1915.