W. B. No. 232.

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U. S. DEPARTMENT OF AGRICULTURE,

WEATHER BUREAU.

BULLETIN H.

WEST INDIAN HURRICANES.

BY

E. B. GARRIOTT,

PROFESSOR OF METEOROLOGY.

Prepared under direction of WILLIS L. MOORE, Chief U. S. Weather Bureau.

WASHINGTON:

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE, WEATHER BUREAU,
Washington, D. C., April 12, 1900.

Hon. JAMES WILSON,
Secretary of Agriculture, Washington, D. C.

SIR: I have the honor to transmit herewith a paper on the subject of West Indian hurricanes, prepared by E. B. Garriott, Professor of Meteorology, and to recommend its publication as a bulletin of the Weather Bureau.

This paper reviews the writings of the more prominent meteorologists of the nineteenth century, so far as they refer to the tropical storms of the North Atlantic, and presents a chronological list of West Indian storms for four hundred years. It graphically illustrates and describes the more important hurricanes that have occurred during the last twenty-five years, and contains accounts, based upon local records and observations, of historical storms of the West Indies. It presents in a concise form information, obtained from many sources, which is necessary to a practical understanding and appreciation of the character of the storms which visit the territory over which the work of the Weather Bureau has been recently extended.

Very respectfully,

WILLIS L. MOORE,
Chief U. S. Weather Bureau.

Approved.
JAMES WILSON,
Secretary.

WEST INDIAN HURRICANES.

Conceived in the mind of Benjamin Franklin in 1747, the law of storms was in an incubative state for more than fifty years. Referred to by Colonel Capper in 1801, and formally introduced to the world by William C. Redfield in 1821, this law evolved a system of meteorology which at the close of the nineteenth century is a recognized but undeveloped member of the scientific family.

The part taken by Franklin in this creation was the discovery that the northeast storms of the Atlantic coast of North America came, with shifting winds, from the southwest. The position was somewhat similar to that assumed by him in the electrical field, wherein he proved that atmospheric electricity and lightning were identical. Colonel Capper, of the East India Company's service, asserted that hurricanes were whirlwinds whose diameter could not be more than 150 miles, and that these whirlwinds sometimes had a progressive motion. William C. Redfield, of New York, independently announced the discovery, based upon detailed observations taken along the Atlantic coast of the United States, that the whole of the revolving mass of atmosphere which composed the whirlwinds, or hurricanes, of the West Indies advanced with a progressive motion from southwest to northeast, and drew the conclusion that the direction of the wind at any particular place forms no part of the essential character of the storm, and is in all cases compounded of both the rotary and progressive velocities of the storm in the mean ratio of these velocities. He found that while the average diameter of West Indian hurricanes was 150 to 250 miles, their active influence extended over a tract 500 to 600 miles in width; that the duration at any point of the most violent portion of the storms was seven to twelve hours; that they rotated from right to left, and that their average rate of progress from the time they appeared over the eastern islands of the West Indies until they disappeared beyond Nova Scotia was 15 to 20 miles an hour. He remarked that their axis of revolution, or "gyral axis," probably inclined in the direction of their progress, and he ascribed the retardation of the lower part of the revolving mass to the greater resistance at the surface of the earth, in consequence of which the more elevated parts inclined forward and overrun to a very considerable extent the more quiet lower atmosphere. He ascribed the fall in the barometer at places toward which the hurricanes approach to the centrifugal tendency of the immense revolving mass of air which constitutes a storm. He stated that this centrifugal action must expand and spread out the stratum of atmosphere subject to its influence, and toward the vortex or center of rotation must flatten and depress the stratum so as to diminish the weight of the superincumbent column, which presses on the mercury of the barometer. He also conceived that, whatever the upward limit of the revolving mass, the effect of its depression must be to lower the cold stratum of the upper atmosphere, particularly toward the more central portions of the storm, and, by thus bringing it in contact with the humid stratum of the surface, to produce a permanent and continuous stratum of clouds, with abundant precipitation of rain. He speculated on the cause of the hurricanes which visit the Atlantic coast, and conceived that—

> They originate in detached and gyrating portions of the northern margin of the trade winds, occasioned by the oblique obstruction which is opposed by the islands to the direct progress of this part of the trades, or to the falling off of the northerly or eddy wind from the American coast upon the trades, or to both these causes combined.

Additional investigations by Redfield regarding hurricanes were summarized in the United States Naval Magazine as follows;

1. The severest hurricanes originate in tropical latitudes to the north or east of the West Indian Islands.

2. They cover simultaneously an extent of surface from 100 to 500 miles in diameter, acting with diminished violence toward the exterior and increased energy toward the interior of the space.

3. South of the parallel of 30° these storms pursue toward the west a track inclined gradually to the north till it approaches 30°, when their course changes abruptly to the north and eastward, their track continuing to incline gradually to the east, toward which they advance with an accelerated velocity.

4. The duration of a storm depends on its extent and velocity, and storms of smaller extent advance with greater rapidity than larger ones.

5. The direction and strength of the wind in a hurricane (for the most part) are found *not to be in the direction of its progress.*

6. In their *westward* course the direction of the wind at the commencement is from a *northern* quarter and during the latter part of the gale from a *southern* quarter of the horizon.

7. In their *northward* and *eastward* course the hurricane begins with the wind from an *eastern* or *southern* quarter and terminates with the wind from a *western* quarter.

8. North of 30°, and on portions of the track farthest from the American coast, the hurricane begins with a *southerly* wind, which, as the storm comes over, *veers gradually* to the westward, where it terminates.

9. Along *the central portion* of the track in the same latitude the wind commences from a point near to *southeast*, but after a certain period *changes suddenly* to a point almost directly opposite to that from which it had been blowing, from which opposite quarter it blows with equal violence till the storm has passed. Under this central portion the greatest fall of the barometer takes place, the mercury rising a short time previous to the change of wind.

10. On the portion of the track nearest the American coast, or farthest inland, if the storm reaches the land, the wind begins from a *more eastern* or *northeastern* point, and afterwards veers more or less gradually by *north* to a *northwest* or *westerly* quarter, where it terminates.

11. From these facts it follows that the great body of the storm whirls in a horizontal circuit round a vertical or somewhat inclined axis of rotation, which is carried onward with the storm, and that the direction of this rotation is from *right to left.*

12. The barometer in all latitudes sinks under the first half of the storm in every part of its track except, perhaps, its northern margin, and *thus affords the earliest and surest* indication of the approaching tempest. The barometer again rises during the passage of the last portion of the gale.

In the vortex or axis of the revolving storm violent *flaws* or *gusts* of wind alternate with *lulls* and remissions of its violence; and here Mr. Redfield conceived *that the vortex or rotating axis of a violent gale or hurricane oscillates in its course with considerable rapidity in a moving circuit of moderate extent near the center of the hurricane;* and he conjectured that such an eccentric movement of the vortex may be essential to the continued activity or force of the hurricane.

In his third paper Mr. Redfield delineated on a chart the route of several storms and hurricanes, and made the following remarks regarding the results of his investigations:

It will hardly escape notice that the track of most hurricanes appears to form part of an elliptical or parabolic circuit, and this will be more obvious if we make correction in each case for the slight distortion of the apparent course in the higher latitudes which is produced by the plane projection. We are also struck with the fact that the vertex of the curve is uniformly found near the thirtieth degree of latitude. In connection with this fact it may also be noted that the latitude of 30° marks the external limit of the trade winds on both sides of the equator; and perhaps it may not prove irrelevant to notice even further that by the parallel of 30° the surface area as well as the atmosphere of each hemisphere is equally divided, the area between this latitude and the equator being about equal to that of the entire surface between the same latitude and the pole.

Finally Mr. Redfield deduced the following rules for the guidance of mariners which, even in the light of our present knowledge of the law of storms, are not subject to sweeping modifications:

1. A vessel bound to the eastward between the latitudes of 32° and 45° in the western part of the Atlantic on being overtaken by a gale which commences blowing from any point to the eastward of southeast or east-southeast may avoid some portion of its violence by putting her head to the northward, and when the gale has veered sufficiently in the same direction may safely resume her course. But by standing to the southward, under like circumstances, she will probably fall into the heart of the storm.

2. In the same region vessels on taking a gale from southeast, or points near thereto, will probably soon find themselves in the heart of the storm, and after its first fury is spent may expect its recurrence from the opposite quarter. The most promising mode of mitigating its violence and at the same time shortening its duration is to stand to the southward upon the wind as long as may be necessary or possible, and if the movement succeeds, the wind will

gradually head you off in the same direction. If it becomes necessary to heave to, put your head to the southward, and if the wind does not veer, be prepared for a blast from the northwest.

3. In the same latitudes a vessel scudding in a gale with the wind at east or northeast shortens its duration. On the contrary, a vessel scudding before a southwesterly or westerly gale will thereby increase its duration.

4. A vessel which is pursuing her course to the westward or southwestward in this part of the Atlantic meets the storms in their course, and thereby shortens the periods of their occurrence, and will encounter more gales in an equal number of days than if stationary or sailing in a different direction.

5. On the other hand, vessels while sailing to the eastward or northeastward, or in the course of the storms, will lengthen the period between their occurrence, and consequently experience them less frequently than vessels sailing on a different course. The difference of exposure which results from these opposite courses on the American coast may in most cases be estimated as nearly two to one.

6. The hazard from casualties and, of consequence, the value of insurance is enhanced or diminished by the direction of the passage, as shown under the last two heads.

7. As the ordinary routine of the winds and weather in these latitudes often corresponds to the phases which are exhibited by the storms as above described, a correct opinion, founded upon this resemblance, can often be formed of the approaching changes of wind and weather, which may be highly useful to the observing navigator.

8. A due consideration of the facts which have been stated will inspire additional confidence in the indications of the *barometer*, and these ought not to be neglected even should the fall of the mercury be unattended by any appearance of violence in the weather, as the other side of the gale will be pretty sure to take effect, and often in a manner so sudden and violent as to more than compensate for its previous forbearance. Not the least reliance, however, should be placed upon the prognostics which are usually attached to the scale of the barometer, such as *set-fair*, *change*, *rain*, etc., as in this region, at least, they serve no other purpose than to bring this valuable instrument into discredit. It is the mere rising and falling of the mercury which chiefly deserves attention, and not its conformity to a particular point in the scale of elevation.

9. These practical inferences apply in terms chiefly to storms which have passed to the northward of the thirtieth degree of latitude on the American coast, but, with the necessary modifications as to the point of the compass which results from the westerly course pursued by the storm while in the lower latitudes, are for the most part equally applicable to the storms and hurricanes which occur in the West Indies and south of the parallel of 30°. As the marked occurrence of tempestuous weather is here less frequent, it may be sufficient to notice that the point of direction in cases which are otherwise analogous is, in the West Indian seas, about ten or twelve points of the compass *more to the left* than on the coast of the United States in the latitude of New York.

Vicissitudes of winds and weather on this coast which do not conform to the foregoing specifications are more frequent in April, May, and June than in other months.

Easterly or southerly winds, under which the barometer rises or maintains its elevation, are not of a gyratory or stormy character; but such winds frequently terminate in the falling of the barometer and the usual phenomena of an easterly storm.

Mr. Redfield stated it as his opinion that—

The great circuits of wind, of which the trade winds form an integral part, are nearly uniform in all the great oceanic basins, and that the course of these circuits, and of their stormy gyrations, is, in the Southern Hemisphere, in a counter direction to those in the northern one, producing a corresponding difference in the general phases of storms and winds in the two hemispheres.

In referring to general storms, Redfield, in 1834, ascribed—

The ordinary routine of the winds and weather to the passage of rotary storms.

And in 1846 he stated that—

The greater variations of winter temperature are shown to result from the passage of rotary storms with warm southerly winds in their front and cold northerly winds in their rear.

Here we find the first expressed knowledge of the mechanism of cold waves.

In defining cyclones, he wrote, in 1854:

The term cyclone was first proposed by Mr. Piddington to designate any considerable extent or area of wind which exhibits a turning or revolving motion, without regard to its varying velocity or to the different names which are often applied to such winds. Thus all hurricanes, or revolving storms, may perhaps be considered as cyclones, or revolving winds. But it by no means follows that all cyclones are either hurricanes, gales, or storms. The word is not intended to express the degree of activity or force which may be manifested in the moving disk or stratum of rotating atmosphere

to which it is applied. It often designates light and feeble winds, as well as those that are strong and violent. The more inert and passive cyclones, which seldom gain attention, but which constantly occupy in their transit the greater portion of the earth's surface, appear to move in orbits or courses corresponding with those of the more active class which have been traced on the storm charts. In a broad view of the case, the constant occurrence and progression of the cyclones in various degrees of activity constitutes the normal condition of the inferior or wind stratum of the atmosphere, at least in the regions exterior to the trade winds of the globe.

Following in the footsteps of Redfield, Lieut. Col. William Reid, of the Royal Engineers, London, issued in 1849 a volume on The Progress of the Development of the Law of Storms and of the Variable Winds, with the Practical Application of the Subject to Navigation. In reviewing the work of Colonel Reid, the author of a pamphlet, Statistics and Philosophy of Storms, remarks as follows :

His attention was first directed to the subject in consequence of his having been employed officially at Barbados in reestablishing the government buildings, blown down by the hurricane of 1831, in which 1,477 persons lost their lives in the short space of seven hours. In order to learn something of the causes and modes of action of these violent gales, he searched everywhere for accounts of previous storms, and was fortunate in meeting with the memoirs of Mr. Redfield. Impressed with the belief that Mr. Redfield's views were correct, Colonel Reid determined to verify them by making charts on a larger scale and laying down the different reports of the wind at points given in Mr. Redfield's memoirs; and the more accurately this was done, the more did the tracks approximate to those of a progressive whirlwind. But Colonel Reid was not content with thus revising, in a more accurate projection, the labors of his predecessor. He obtained from the admiralty the logs of British ships that had been navigating the hurricane region, and by combining the observations which they contained with those made on land, he was thus enabled to group the varying phenomena of different storms; to place beyond a doubt their rotary and progressive character, as described by Redfield; to ascertain that they derive their destructive power from their rotary force, and to confirm the sagacious conjecture of the American philosopher that the storms in the southern latitudes would be found to revolve in a contrary direction (namely, from left to right) to that which they take in the Northern Hemisphere.

Colonel Reid concludes his observations with the following rule for laying ships to in a hurricane:

That tack in which a ship should be laid to in a hurricane has been hitherto a problem to be solved, and this one which seamen have long considered important to have explained. In these tempests, when a vessel is lying to and the wind veers by the ship's head, she is in danger of getting stern way, even when no sail is set, for in a hurricane the wind's force on the masts and yards alone will produce this effect should the winds veer ahead; and it is supposed that vessels have often foundered from this cause. When the wind veers aft, as it is called, or by the stern, this danger is avoided, and a ship then *comes up* to the wind, instead of having to *break off* from it.

If great storms obey fixed laws and the explanation of them given in this work be the true one, then the rule for laying a ship to follows like the corrallary to a problem already solved.

In order to define the two sides of a storm, that side will here be called "the right hand semicircle" which is on the right of the storm's course as we look in the direction in which it is moving, just as we speak of the right bank of a river.

The rule for laying a ship to will be: When in the *right hand* semicircle to heave to on the *starboard* tack, and when in the *left hand* semicircle on the *larboard* tack, in both hemispheres.

Espey made many valuable deductions in connection with the phenomena of the atmosphere. He maintained that the tendency of the winds in a storm is centripetal, because the primary cause of the movement is the low pressure at the center of the storm; and Redfield showed that the winds of a cyclonic system must have a whirling movement, because the rotation of the earth will inevitably cause such a whirl in any system of centripetal winds. Espey established "A qualified central tendency of the air in both the general storms and smaller tornadoes," and admitted that the deflective force arising from the earth's rotation is called on to cause and maintain a whirlwind :

Upon the same principle, the tornado, the typhoon, and the widespread storm of the Atlantic, if the currents move toward a central point, must have a rotary character. In every such case the incoming of air must be regarded as a succession of rings taken off the surrounding atmosphere and moving slowly at first but swifter as they proceed toward the center. Each ring is affected by the law of deviation during its passage, and hence the ring begins to revolve when far from the center, turns more and more as it draws near it, and, finally, as it gathers about the central spot, all its forces are resolved into a simple whirl.

Following these pioneer discoverers and investigators of the character and nature of the new meteorology come Henry, Loomis, and Maury on the sea; and Ferrel, Blodget, Viñes, and Abbe have

added valuable material by their studies and researches. The actual development of the science along useful lines began in 1843, when a grant of $4,000 was made by the legislature of Pennsylvania to the Franklin Institute for the purpose of establishing meteorological observing stations throughout the State. This was the first appropriation of public money made in this country for the collection of weather information. Referring to this work, the Philadelphia Bulletin of September 26, 1899, remarks as follows:

> The committee on meteorology of the institute, acting in conjunction with a similar committee from the American Philosophical Society, organized and equipped stations throughout the State and began the collection and preservation of data concerning weather phenomena. This work, it must be remembered, was carried on without the aid of the telegraph; but it was so thoroughly done that from the data thus gathered was formulated a theory of storms which is substantially the same as that which is generally accepted to-day. This work was carried on for a number of years by the Franklin Institute; in fact until, through the efforts of Prof. Joseph Henry, of the Smithsonian Institution, the attention of the Government was drawn to the matter. The interest thus aroused finally resulted in the organization of the Weather Bureau as it exists to-day.

The reports thus collected, with rather meagre telegraphic advices, made it possible to locate, plot, and determine the character of well-defined storms that traversed the region of observation. This system of reports was continued from the early fifties until the beginning of the civil war. In the meantime, and beginning with the introduction and attending the extension of the electric telegraph lines, the fact was noted, in the operation of the wires, that certain types of weather which were observed in the interior of the country usually passed eastward and were experienced in the Atlantic seaboard districts within periods which varied in length from one to three days.

After the war, interest in the subject of the weather was revived, and late in the sixties Prof. Cleveland Abbe, who has been associated with the Weather Bureau at Washington, D. C., since its organization, prepared daily weather forecasts for the Cincinnati Board of Trade, by aid of reports furnished through the courtesy of the Western Union Telegraph Company. The late Prof. I. A. Lapham, of Milwaukee, Wis., became actively interested in the subject, and, largely through his efforts, a bill, presented by the Hon. H. E. Paine, member of Congress from Wisconsin, was passed in the United States Congress in the early part of 1870, which provided for the establishment of stations of observation at a number of the more important cities upon the seacoasts and the Great Lakes, in the interior, and at military posts throughout the country. The act further provided that observations should be regularly taken at each of these stations, and that notice should be given by telegraph to lake and seacoast ports of the approach of storms of a destructive character. This work was assigned to Gen. Albert J. Myer, Chief Signal Officer, United States Army.

From the small beginning afforded by an annual appropriation of $15,000, the weather service rapidly assumed larger proportions and greater importance. The first marked advance in the direction of securing a more extended system of observations was, however, made in 1873, when, upon a proposition made by General Myer, the Meteorological Congress at Vienna adopted a plan which provided for simultaneous daily observations at noon, Greenwich mean time, in all the countries and upon all the navigated oceans of the world. These observations were continued from 1875 to 1887, inclusive, and were supplemented by a series of magnetic and meteorological polar observations from 1882 to 1884, taken by expeditions sent to the polar regions by the United States and the several European countries. The United States expeditions were sent to Lady Franklin Bay and Point Barrow, the Lady Franklin Bay expedition being under the command of General (then Lieutenant) A. W. Greely, Chief Signal Officer, United States Army, and the other under the command of Lieut. P. H. Ray. In addition, the cooperation of the regular naval and merchant marine services of the principal countries was secured.

In the fall of 1886 the writer, under the direction of General Greely and Col. H. H. C. Dunwoody, began the preparation of charts and tabulated and text matter summarizing the observations of this series. In 1893 this work was published as Weather Bureau Bulletin A, Summary of International

Meteorological Observations. A number of the charts of this bulletin, which present tracings of West Indian hurricanes from 1878 to 1887, inclusive, and additional data regarding the hurricanes charted, are herein reprinted and extended to include all hurricanes which have occurred since 1887.

During what may be termed the second period in the growth and development of this science many valuable contributions were made to the literature of meteorology. Conspicuous among the contributors were Prof. Elias Loomis, whose papers were issued from early in the forties until late in the eighties, and Prof. William Ferrel, who was probably the greatest of mathematical meteorologists. To Ferrel, in particular, are we largely indebted for our present knowledge of the phenomena of the atmosphere. He presented a masterful explanation of the planetary circulation of winds, and applied mathematical methods to the solution of the problems of the air. In his Essay on the Winds and the Currents of the Ocean, published in 1856, he wrote:

> The earth is surrounded on all sides by an exceedingly rare and elastic body called the atmosphere, extending with a diminishing density to an unknown distance into space, but pressing upon the earth with a force equal to that of a homogeneous atmosphere five and one-half miles high. It is also partially surrounded by the ocean, which is of a varying depth, and known to be, in many places, more than four miles deep. If the specific gravity of the atmosphere and of the ocean were everywhere the same, all the forces of gravity and of pressure which act upon any part of them, would be in exact equilibrium, and they would forever remain at rest. But as some parts of the earth are much warmer than others, and the air and water expand and become rare as their temperature is increased, their specific gravities are not the same in all parts of the earth, and hence the equilibrium is destroyed, and the system of winds and currents is produced.

Referring to the effects that are produced by this disturbance of equilibrium due to differences in heat, he remarked:

> All storms are produced by an ascending current of warmer atmosphere saturated with moisture, and this current is kept in motion by the continual rarefaction of the atmosphere above by means of the caloric given out of the water which is condensed as it ascends to the colder regions above. Therefore, as long as this ascending current can be supplied with air saturated with vapor this continued rarefaction must take place, and also the ascent of the air in the middle of the storm, and the consequent rush of air from all sides to take its place. If, then, all the lower stratum of atmosphere over a large district were saturated with vapor, without some disturbing cause, it might remain undisturbed; but if, from any cause, an ascending current is produced, either by local rarefaction of air by means of heat, or by the meeting of two adverse currents, which produce gyratory motion and consequent rarefaction in the middle on account of the pressure being taken away by centrifugal force, as soon as the air below, saturated with vapor, ascends to the colder region above, the vapor is condensed and the caloric given out continues to rarefy it so long as the ascending current is supplied with moist air. The surrounding cold air presses in below from all sides, and thus a storm of more or less violence is produced, moving with the general direction of the motion of the atmosphere where it occurs. The violence, then, of a storm, and also its duration, depends upon the quantity of vapor supplied by the currents flowing in below. Hence it is that the tropical hurricanes which originate in the Atlantic east of the Caribbean Sea do not abate their violence until they reach a high northern latitude where the atmosphere is cold and dry.

Aside from the investigations of Colonel Reid the literature of West Indian hurricanes is deficient in working facts until the last quarter of the nineteenth century. Preeminent among the workers of this period was the late Rev. Benito Viñes, S. J., formerly Director of the Magnetic and Meteorological Observatory of the Colegio de Belin, Havana. The investigations of Father Viñes are embodied in a paper published as Weather Bureau pamphlet No. 168, 1898, entitled Cyclonic Circulation and the Translatory Movement of West Indian Hurricanes. The conclusions of Father Viñes may be summarized as follows:

LAWS OF CYCLONIC CIRCULATION.

> The aerial currents in a cyclone constitute a vast whirlwind around a central space of calm, of relatively small extent, called the "vortex" of the cyclone. It is an established fact that the direction of the rotary motion is always alike in the same hemisphere (northern or southern). In our own the cyclonic rotation is invariably from right to left, in the direction from east to north to west to south, or as commonly expressed, in a contrary direction to that of the hands of a watch placed upon a horizontal plane, face upward. In the Southern Hemisphere the cyclonic rotation follows an opposite direction.
>
> In the West Indian cyclones the rotation and the cyclonic circulation takes place in such a manner that the infe-

rior currents, as a rule, converge more or less toward the vortex; at a certain altitude the currents follow a nearly circular course, and higher still their course is divergent. It is particularly to be noted that this divergence is all the greater as the currents occupy higher altitudes until a point is reached where the highest cirrus clouds seem to move in a completely divergent radial direction.

The writer is prompted to question the accuracy of the conclusion of Father Viñes regarding a divergent radial direction of cyclonic currents in high altitudes. That the lower currents converge toward the vortex is an established fact; that the high upper currents have a divergent radial direction has not been established. Upper air cyclonic observations have been made only through an observance of cloud forms and cloud movements. These observations have shown that the different forms of cirrus clouds are carried by the controlling upper main current to the front, or in advance, of a cyclone; they have not shown that the clouds are projected *back* from the vortex. As a matter of fact the vortex acts as a chimney for the inflowing lower currents, and the moisture of these currents which is condensed into cirrus clouds in high altitudes, is carried forward like smoke which emerges from the top of a chimney.

The following rules are given for the approximate determination of the bearing of the vortex of a hurricane by using the direction of the wind:

1. When the vortex lies at a greater distance and the cyclonic winds are not yet well established, their convergence is apt to be greater and they are liable to many irregularities and to local influences.

2. The first squalls in front of a storm give divergent gusts. The squalls in fact proceed from the left-hand extremity of the cloud bank and their gusts are directed outwardly, as happens with the ordinary thunderstorm; hence, during such squalls the wind veers to the right, that is to say, toward the cloud bank, by four, six, and sometimes by eight points.

3. In the interior of the storm the gusts of the squall always bring the wind round to the right and therefore tend to lessen the convergence of the wind and sometimes almost to annul it.

4. As the wind increases in violence in the neighborhood of the vortex its direction becomes less convergent, owing to the centrifugal force developed in that part of the storm, and probably also to the influence of the incessant squalls which, in that part of the hurricane, continually occur.

5. In the Island of Cuba cyclonic winds blowing from north to north-northeast present scarcely any divergence at all; hence, in this particular case the law of storms[1] may be applied without notable error.

6. The trade wind, reinforced by the cyclone, modifies considerably the convergence of the cyclonic winds, sometimes (as in the above instance) suppressing it completely, and at others increasing it, so that the vortex may be lying to the south while the wind is from the northeast.

CLOUD MOVEMENTS.

The low clouds move in a direction nearly perpendicular to the bearing of the vortex.

The alto-cumulus, the dense cirro-stratus, and the light cirro-cumulus move from divergent directions, forming, with the bearing of the vortex, acute angles that are smaller in proportion as the currents to which they belong occupy a higher position; that is to say that the smallest angle is formed by the cirro-cumulus and the widest by the alto-cumulus; the intermediate angular magnitude corresponds to the cirro-stratus or the dense veil of cirrus clouds.

The light cirrus clouds constituting the highest current that falls under our observation move, as a rule, in a completely divergent or radial direction, forming with the bearing of the vortex an angle equal to zero, or practically inappreciable. This current is one of the most regular, and generally forms a right angle with that of the low clouds.

To sum up briefly, we find that the cyclonic currents which exhibit the greatest regularity and point out best the bearing of the vortex are those of the cirrus and of the low clouds. The current of the cirrus clouds is that which should be selected in preference when the first indications of the approach of a cyclone are seen and the vortex is still far distant. In the interior of a storm the observer must be guided principally by the movement of the lower clouds. In the absence of cirrus clouds, the currents of the cirro-cumulus and cirro-stratus may guide one, and when there are no lower clouds the wind and the high cumulus may be resorted to instead, always bearing in mind, however, that these indications are less reliable and the approximate inferences less satisfactory. In a well-developed cyclone of considerable intensity we can generally observe the following gradation and disposition of currents. If the vortex lies to the south-southeast, the cirrus clouds will move from south-southeast, the cirro-cumulus from southeast, the dense

[1] The author refers to the circular rule of the older cyclonologists, according to which the bearing of the vortex is eight points or 90° to the right if one faces the wind.

cirrus-veil from east-southest, the alto-cumulus from east, the low clouds from east-northeast, and the wind from northeast.

In the rear of the storm and, in general, when the prevailing winds are from the south, or from the points of the compass between east-southeast, south, and west-southwest, it is observed that all the currents in general form wider angles with the bearing of the vortex than in the previous case, the gradation between them, however, remaining the same. So that in the rear of the storm the inferior currents are more convergent and the superior ones less divergent than in the front. Thus, if the vortex, for example, lies to the northwest, the wind comes from south-southeast or south, the low clouds come from south or south-southwest, the alto-cumulus from southwest, the cirro-stratus from west-southwest, the cirro-cumulus from west, and the cirrus approximately from west-northwest.

Reference to the laws of cyclonic translation given in Father Viñes work can be omitted in favor of the very complete data regarding the movement of hurricanes which form a part of this paper. From the laws given, Father Viñes deduces, however, the following interesting conclusions:

That while every cyclone in August crosses the twenty-third parallel, the laws do not tell us that none of these cyclones pass near Havana, which lies precisely in latitude 23°. From them we also infer that, generally speaking, every cyclone in October crosses the eighteenth parallel in a certain direction, but they do not inform us that it very rarely happens that an October cyclone passes near Puerto Rico, which lies in that very latitude. Nevertheless, the fact exists, and is of such ancient belief that the ecclesiastical authority, from time immemorial, wisely ordained that priests in Puerto Rico should recite in the mass the prayer "Ad repellendat tempestates" during the months of August and September, but not in October, and that in Cuba it should be recited in September and October, but not in August. All of which proves that the ecclesiastical authority knew by experience that the cyclones of October are very much to be feared in Cuba, but not those of August, and that in Puerto Rico, on the contrary, the hurricanes of August are disastrous, while those of October are rare. This constant and well-established rule, proved by experience, implies a general law which connects the geographical position of the tracks on the map of the West Indies with the circumstance that the season is more or less advanced.

The formation of hurricanes is discussed by Father Viñes as follows:

It must, of course, be admitted that the tropical cyclones do not form indefinitely at any point within the tropical zones, but that they single out, in preference, for their formation and development particular and definite regions in those zones. The following geographical conditions generally, and in a more or less perfect degree, distinguish the cyclonic regions within the tropics: Large continents lie to the west, indented by numerous gulfs and bays whose coasts run more or less northward and southward, with vast and extensive seas to the east, overspread commonly with numerous islands. Such, at any rate, are the features that in a more or less perfect degree concur in the cyclonic regions of the Philippine Isles and in the China Sea, in the seas of India, and also in the Southern Hemisphere in the region situated east of Africa, in the vicinity of the islands of Madagascar, Mauritius, Reunion, Rodriguez, etc. But of all the cyclonic regions within the intertropical zone the one which more perfectly and grandly combines all these conditions is the great Bay of North America, with its wide Atlantic Ocean extending to the east as far as the coast of Africa, and to the northeast as far as the coast of Europe and the northern seas. In my opinion this contributes much to the grandeur and regularity of the immense paths of the West Indian cyclones. A cyclone of August or September may form in the vicinity of the Cape Verde Islands, near the coast of Africa, or to the east of the Lesser Antilles, cross the Atlantic along the first branch of its track, and recurve either in the Gulf of Charleston or on the coast of Texas. In the latter case it may cross the United States in the direction of Cape Hatteras, sweep, with renewed strength, and velocity, a second time across the Atlantic, in a northeastward direction, and enter Europe or be lost in the northern seas. We have, then, a series of cyclones which describe immense tracks over many thousands of miles with admirable regularity and normality, and subject to general laws. This is truly surprising and astounding. I do not believe that on the face of the globe there is another region where cyclones are met with that can compare with those of the West Indies, or, rather, I should say, with those of the great Bay of North America. Neither is there within the whole intertropical zone a grander bay than this one, nor one which offers more favorable conditions for the development and onward progress of gyratory storms.

The Bay of North America comprises, as I understand, that part of the Atlantic to the west of the fifty-fifth meridian (longitude west of Greenwich) from Newfoundland to Dutch Guiana. It is bounded on the east by the said meridian, and on the north, west, and south by the coasts of Newfoundland, Labrador, and Gulf of St. Lawrence, by the coasts of the Atlantic, Gulf of Mexico, and Caribbean Sea from Yucatan to Dutch Guiana. It embraces the West Indies, the Carribbean Sea, the Gulf of Mexico, the Bahamas, the Bermudas, and the gulfs of Charleston and of the St. Lawrence.

Now, it is in the southern part of this great bay, that is to say, in the Carribean Sea, and in that portion of the Atlantic which extends to the east of the West Indies, that hurricanes are formed and developed, with this peculiarity, that according to the position occupied by the equatorial zone of calms, by the Atlantic anticyclone, and consequently

by the southern limit of the trade wind, respectively, the cyclones form either more to the south, and above all more to the east or west. The point of origin and formation of the hurricane depends, therefore, on the more or less advanced season of the year. Now, as the variations in the point or region where cyclones originate during the hurricane season principally affect the positions in longitude extending across the Atlantic from the Cape Verde Islands to the coasts of Honduras and Yucatan, and to the eastern portion of the Gulf of Mexico, it results that the region where the cyclones originate during two months and a half, that is to say, from the middle of August (maximum of cyclonic activity and of the recurving latitudes) to the end of October, or from the beginning of June to the middle of August, will move in the space between the Cape Verde Islands and the western portion of the Caribbean Sea.

According to my opinion this seasonal change of origin takes place in the following manner: In the middle of August, when the anticyclone of the Atlantic is about latitude 30° or 35°, the trade winds of the Northern Hemisphere and those of the Southern (converted into southwest monsoon) generally meet somewhat to the south of the Cape Verde Islands, where lies the area of low barometer, and in this vicinity it is that the August cyclones are formed. At this time the isobars of the Atlantic anticyclone extend to the southwest of the Island of Cuba and Caribbean Sea, and on this side no cyclones are formed. In the month of September the Atlantic anticyclone draws near Africa, its isobars invade the eastern part of the Atlantic east of the West Indies, and leave the Caribbean Sea free; at this time the cyclones are formed somewhat to the east of the Lesser Antilles or in their vicinity. In the first decade of October the state of things varies but little. Some cyclones, however, form rather more to the west in the eastern part of the Caribbean Sea. In the second and third decades of October the 30-inch isobar, which surrounds the Atlantic anticyclone and that of the American Continent, only leaves free the western portion of the Caribbean Sea south of Cuba and part of the Gulf, the depressions or low barometric areas move to this region, and it is here that the hurricanes originate which prove so disastrous to the western half of the Island of Cuba at this season of the year.

The months of June and July in this particular do not quite agree with those of September and October. In some years the anticyclonic isobars of July invade the Carribean Sea, and in those years there are usually no cyclones in July. In other years the anticyclonic curves lie rather farther north and leave the Carribean Sea free; in such years the cyclones are apt to form in those regions and follow the same laws as those of September, with the exception that they move in somewhat lower latitudes.

The hurricanes of the second and third decades of June agree with those of the first and second decades of October, respectively. Those of the first decade of June are very few; they come from the windward, move in very low latitudes, penetrate Mexico, and dissolve without recurving. Many years pass without cyclones in June; nevertheless, cyclonic purturbations following the same laws sometimes occur to the south and southwest of Havana, causing great inundations in the western provinces of Cuba.

In a pamphlet issued in 1890, Father Viñes gives the following interesting description of the characteristic phenomena of tropical cyclones, or West Indian hurricanes:

In a measure, as the barometer in its decided and continued fall announces the approach of the hurricane, and long before the cirro-strata appear there is a notable change observed in the atmospherical regions. The higher layers lose their extreme transparency and the blue of the sky is not so pure as before. A thin veil, scarcely visible, covers the celestial arch and it darkens by degrees; this hazy veil has the property of decomposing rapidly the solar light, giving passage in preference to the red and absorbing almost entirely the remaining rays whenever these solar rays, striking obliquely, are compelled to cross a large portion of the atmosphere. From this decomposition of the light there arises during this phase a singular and characteristic appearance of the sky during the rising and setting of the sun.

The atmosphere in the upper region takes on such occasions a uniform, reddish tint, which covers the whole hemisphere, and which, during the twilight and while the crepuscular rays are fading, merges into the dark red and somewhat violet color, which color remains a long time after sunset, as if this dim and prophetic light tried to prolong the evil omen in the longer duration of the twilight.

The head of the cumulus and strato-cumulus appear crowned with vivid and dazzling reflections, the violet color predominating at the base; objects appear colored with flaming reflections and the sky presents, as a whole, magnificent contrasts and beautiful pictures impossible to describe. Later, at the time when the cirro-strata begin to appear and the opaline veil becomes each moment more defined and transformed by degrees into a milky, semitransparent veil, these reddish tints take a character somewhat alarming as they obscure the sun; the whole atmosphere then simulating the glowing reflections of an aurora borealis which resembles an immense fire; and while the sun is dropping toward the horizon the colors gradually diminish in vividness, and I should compare them in this case to the dark red color of incandescent metal. The heavens acquire at this moment an appearence truly threatening and foreboding evil. These characteristic tinges have been compared by some authors to red copper colors and by others to red brick dust.

This phenomenon, as it is seen, is a constitutional physical result of the hurricane, a characteristic phenomenon, and as such it is never missing nor can ever be missing in a hurricane, and in a greater or less degree will also be

observed in whirlwinds at various points of the globe and in very different latitudes, so that there can hardly be found a meteorological author who does not attempt a description of this phase.

Dr. Enrique del Monte, member of the Havana University, has furnished for the exclusive use of the Weather Bureau a very interesting paper on the Climate of the West Indies; and West Indian Hurricanes, their Origin, Courses, and Indications of their Approach. That portion of the paper which relates to West Indian hurricanes is as follows:

Hurricanes, in the general sense of the word, have always belonged to the number of those physical phenomena that have most attracted the attention of men, both vulgar and scientific—the former because they find themselves overtaken and terrified by the awful magnificence of the storm, and the latter, because to these and natural causes, they unite chiefly the sentiment of philanthrophy, and their perpetual ambition of the absolute control of the science.

In the scale of power or destructive strength of these phenomena, one of the most conspicuous places, beyond doubt, belongs to cyclones, which, as it is well known, are gigantic eddies of extraordinary violence. Furthermore, among those, the typic tropical cyclone, or West Indies hurricanes, are the most terrible and severe.

Hence, the activity displayed in Cuba in the last twenty years, leading to the practical study of this phenomenon and the advancing of its theory, and hence, too, the valuable works published by the late Professor Halkzenbrich, of Havana, member of the Royal British Meteorological Society, and a correspondent in Cuba of the Observatoire Meteorologique de Montsouris, France, the late Rev. Father B. Viñes, S. J., of the Royal College of Belen, at Havana, and those, more modest, but no less enthusiastic, of the author of this pamphlet.

And if the practical knowledge of the phenomena, invariably preceding by two, three or more days, the passing of a cyclone through a place, is always useful, it becomes necessary in the tropics, and chiefly so in the *autumnal equinox*. So that in the brief review we intend to make of such phenomena, we shall describe them to the reader in the same order of succession as they appear to the observer. This is called, in technical language, *different phases of a cyclone at a distance*. These phases follow one another with more or less rapidity, according to the position and velocity of translation of the hurricane.

What a cyclone means.—Before entering upon the description of the phases above referred to, we will say something about what may be called the *structure of a cyclone.*

What is a cyclone, aside from its origin?—The cyclone, and especially the tropical cyclone, is characterized by a vast eddy, on an average 300 miles in diameter, of extraordinary violence in the gusts of wind (90 miles per hour, and sometimes more) and carrying, necessarily, with it a *relative vacuum*, which increases from the periphery to the center or vortex. This rarefaction of the air in so large an area implies a lack of equilibrium in the atmosphere, which, by the *law of compensations*, represents affluence of air in one or more isolated places surrounding the hurricane.

Therefore, if we suppose the barometer (which is only a delicate balance, enabling us to weigh the atmosphere at any moment), to be situated in any place embraced from the periphery to the center or vortex of the eddy, the nearer it is to the vortex the lower its column will be.

On the other hand, let us suppose the barometer situated beyond the body of the hurricane, but as near as it can be without the observer being able to perceive any sign of the storm, there, in compensation for the relative vacuum that makes an integral part of the neighboring hurricane, will be, as stated above, an affluence of air, and, consequently, the barometer will rise more or less, but higher than the normal, and in some places it reaches an extraordinary maximum.

The above-cited affirmation that the hurricane is characterized by a relative vacuum seems a paradox at first, since the testimony of our senses tends to evince to us the contrary, in the unusual impetuousness of the winds, to such an extent that the existence of a hurricane is physically impossible without the wind having at least the velocity of a strong gale. This contradiction disappears if we have in mind what the wind means. In fact, the wind is only a mass of air that runs with more or less violence to a point in which, by any cause, a relative vacuum has been formed. From the gentle breeze, walking two miles an hour, to the furious gale, running 100 miles, all the wind velocities are subordinate to the above-cited general cause.

In order to explain to ourselves graphically the physical reason existing between the velocity of a gentle breeze and that of the furious gusts in a tropical hurricane, let us suppose an extent of ground 60 miles long, and let us suppose, too, five observers, provided with standard barometers and situated 12 miles apart, respectively. Now, let them take simultaneous observations at a preconcerted hour (10 o'clock a. m., for instance), and correct them for temperature and elevation. Everyday experience demonstrates that the larger the difference between the readings of the barometers at the stations, the greater is the velocity of the wind at that moment. These differences of readings in simultaneous observations are called in meteorological language barometrical gradient. The lines on the surface of the globe connecting places that present the same barometrical pressure at any moment are called isobarometric.

And now a very interesting point here arises: Is there any constant relation between the magnitude of the barometrical gradient and the wind's velocity all the world over? In other words: To a given gradient—for example, 0.10 millimeters per mile—does the same velocity of the wind always pertain, regardless both of the latitude of the

place and the season? We firmly believe that latitude has a very notable influence in this matter, as well as topographical conditions and seasons.

Barometrical gradients and their features in Cuba.—Regarding the Island of Cuba, which has for a long time been the field of our investigations in everything leading toward the knowledge of its climatology, we can affirm, by reason of repeated experiments, that whenever the barometrical gradients amount to 0.04, 0.05, and 0.07 millimeters per mile, the *mean* velocities of the wind, approximately, are 15, 30, and 45 miles per hour, respectively. We say approximately, because the given numbers are the average of the different months, the velocities of the wind corresponding to every gradient being a little higher in summer than in winter.

During the passage of tropical hurricanes through the island, when the *mean* velocity of the wind is generally 65 miles per hour, we have always endeavored to investigate the relation between the barometrical gradients and the wind velocities, without ever being able to find any satisfactory result; owing, in our opinion, to the irregular and rapidly variable isobarometric distribution. This irregularity, more or less apparent, always exists in the dominions of the hurricane; occasioned by the intermittent, frequent, and copious condensations of the aqueous vapor, affecting locally in this way the vertiginous and powerful ascending currents.

Herefrom arise the two following, and nearly insuperable, difficulties, hampering greatly the measurements of the gradients:

1. Rough and frequent oscillations in the barometric columns, ranging from 0.50 to 0.80 millimeters, (every five seconds on an average), thus making it impracticable to take an exact reading of the pressure of the air.

2. A continuous variation in the wind velocity, that passes, in a few seconds, from a fresh breeze of 25 miles per hour, to the most violent and furious gale of 90 and 100 miles.

So that in order to be able to find in such an anomalous condition, any relation between the gradients and the wind velocities, it would be necessary to have the stations located at very short distances, respectively, perhaps no farther than one mile apart, and also to have all the barometers and anemometers connected with the central station by means of the electrical registers at a distance, where the indications of all of them should be taken simultaneously on a special *Chronographic* cylinder.

As a valuable proof of the exactness of this affirmation, we will cite a practical case which occurred during the passage of a cyclone through the island.

On the 21st of October, 1895, at 10 h. a. m., the vortex of the hurricane was, approximately located, in latitude 23° 00′ N., and longitude 79° 00′ W. from Greenwich; that is to say, about 30 miles to the northeast of Sagua La Grande. At that moment the barometrical pressure at Havana was 752.30 millimeters, or 29.62 inches; and at Matanzas, (practically the nearest station in the line of the gradient; situated about 55 miles E. ¼ southeast from Havana), at the same moment, (10 h. a. m., 82° 21′ meridian time), the pressure was 748.45 millimeters, or 29.47 inches. We had, therefore, a *gradient*, amounting to 0.07 millimeters per mile, approximately. To this *gradient*, according to repeated experiments, should pertain in normal weather conditions in October, a velocity of the wind of about 48 miles per hour. Notwithstanding this, the anemometer in Havana showed a mean velocity of 56 miles an hour. Such an anomally we can only attribute to the above-cited causes.

In several previous hurricanes, of different destructive strength, all attempts to compute the gradients have been thus far unsuccessful.

We shall now begin to examine the different phenomena, all closely connected, which always indicate the existence of an atmospheric disturbance. The careful observation of these phenomena will not only enable the observer to detect the disturbance, where its vortex is on an average 1,500 miles away, but will also, in most of the cases, allow him to judge about its magnitude and intensity.

As we said in the introduction, in this brief review we shall present them to the reader in the same order of succession as they appear to the observer; saying then, also, that in technical language they are called: *different phases of a cyclone at a distance.* We also pointed out in the introduction above referred to that by what may be called the mechanism of the hurricane itself, the great rarefaction of the air, attending the eddy, implies a fault of equilibrium in the atmosphere; which, by the law of compensations, represents affluence of air, more or less perceptible, in the vicinity of the hurricane; the barometer reaching in two or more isolated places an extraordinary maximum.

First phase of the hurricane: the anticyclone.—Hence, we have already the first phase of the hurricane; and when its vortex is on an average 1,500 miles off. This phase is called the *anticyclone.* As its name indicates, it is the reverse of the cyclone. In fact, the meteorological elements follow in it a course different from the normal, and quite different, too, from that in the dominions of the hurricane.

Its distinctive features are the following:

1. An anomalous rising in the barometer. It reaches sometimes an exaggerated maximum.

2. Fine and rather cold weather. The temperature goes, on an average, 14° F. below the normal.

3. Cloudless sky, and of a decided indigo blue. Consequently in this kind of weather, the dew-point and relative humidity are always far below the normal.

4. Persistency of the *anticyclonic winds.* That is to say, the daily shiftings from the land to the sea breezes, and vice versa, disappear entirely, or at least, are greatly disturbed.

5. Different order in the circumgyration of the atmospheric currents from those in the hurricane. In the anticyclone the gradation is from right to left, beginning from the lowest current.

Summing up we will say, that all the anticyclones that may appear to the observer, presenting the features above referred to, always indicate *á priori* the existence of an atmospheric disturbance. In the Island of Cuba, when they appear in the months of cyclonic activity, they must be always carefully observed and studied, as their subsequent positions may furnish the observer with valuable information regarding the hurricane. On the other hand, when their appearance takes place in the months of *calm in the cyclonic activity*, they pertain to hurricanes of high latitudes, although in some instances, as we shall see in the next section, they may offer some dangers to navigation, through the northern Cuban coasts.

Some features of the anticyclonic weather in Cuba.—We will now refer to some weather features in the Island of Cuba, when it happens that the anticyclones bear in some peculiar positions in relation to the island. As these features of anticyclonic weather, of which we are about to speak, are very different from those described in numbers 2 and 3 of the last section, we may properly assign them as exceptions to the general rules.

FIRST EXCEPTION.

Regarding Havana and its vicinity, the only exception we know to the characteristic features of anticyclonic weather, described in numbers 2 and 3 of the last section, arises when the anticyclones bear northeast from the city, in the months of November, December, January, February, March, April, and May. In these cases the weather is cloudy and showery, owing, we believe, to the collision of the anticyclonic upper winds (in the months very dry and cold), with the upper atmospheric general current, that all this time, invariably comes from the west-southwest, always abounding with the heat and dampness of those regions. This class of anticyclones never precede the tropical hurricanes in the Island of Cuba, as the above-mentioned months are those of calm in the cyclonic activity. So that when they appear northeast from Havana they always pertain to hurricanes crossing the Atlantic, and whose vortices lie between forty-five and fifty degrees of latitude. On the other hand, when the anticyclones bear northeast from Havana, in the hurricane season, namely: June, July, August, September, and October, then the weather appears, as has been described in numbers 2 and 3 of the last section, owing, in our opinion, to the following causes:

In the months of cyclonic activity the upper general current goes higher than in the remainder of the year. The average altitude of the upper cirri in these months is a little higher than the figures given by Dr. Vettin, of Berlin. Therefore, the intrusion, or interchange, of this current with those of the anticyclone, is very difficult if not impossible. But assuming such an interchange not to be so difficult as we believe, the thermic and hygrometrical conditions of both currents are not so different in these months as in the others.

Besides this, in the months of cyclonic activity, the upper general current is subjected to the interesting changes fully described in the first part of this work. Those changes tend also to render difficult the collision of this current with those of the anticyclone.

SECOND EXCEPTION.

Here we wish to refer to a noteworthy feature, occurring in one section of the north coast of the island, embracing from Sagua la Grande to Bahia Honda (and singularly remarkable in Havana), when it happens that the anticyclones bear north-northwest, north, or north-northeast from that section.

It is a well known fact that this section of the Cuban coast is generally subject to high winds and ruffled seas.

The daily maximum velocity of the wind in Havana takes place between noon and 4 h. p. m., being on a yearly average 11.5 miles per hour, (mean velocity); and the daily absolute maximum velocity, counting the revolutions of the anemometer in one record of time, averages yearly 17.5 miles per hour.

In order to have the daily absolute maximum velocity accurately determined, the Central Observatory was furnished with an anemo-cinemographe, of the manufacture of Richard Frères, of Paris. This instrument is carefully described in the pamphlet "Notice sur les instruments enrégistrés construits par Richard Frères; Paris, 1889," page 51.

But in the particular case of which we are speaking, namely, when the anticyclones bear north-northwest, north, or north-northeast from that section of the coast, the trade wind (whose daily absolute maximum velocity is, as above said, on an average 17.5 miles an hour), often increases to 40 and 45, and sometimes to 50 miles an hour. These high winds and gales are always attended by very heavy and dangerous seas, so that the captains in those waters must be always watchful and ready, as this rough weather, in many cases, cannot be accurately forecast so long as the island lacks valuable information regarding the weather on the American Continent. This kind of weather is the most awful to the seamen, as it is apt to appear and wage destruction, notwithstanding the high barometer and cloudless sky.

Many ships are driven ashore every year by this kind of weather, and in some instances with fatal consequences, resulting in their total destruction. Three miles eastward from Morro Castle, in Havana, along the rocky shore, lies the iron hull of the American steamer *Hutchinson*, of the New Orleans Morgan Line. A gale drove her ashore five years ago, and her hull remains there as a silent warning to the seamen. A few months after this disaster the big Spanish steamer *Cadiz* met the same fate not far off from the *Hutchinson*. Again, three years ago, the Spanish gunboat *Christobal Colon* went ashore, and was completely wrecked, one mile from Bahia Honda. We could refer to many

accidents of this kind to big ships. To number the casualties among the smaller vessels would be almost impossible.

Second phase of the hurricane: Mean zones or intermediate spaces between the anticyclone and the cyclone.—Soon after the observer is getting rid of the influence of the anticyclone, while on the other hand the approaching hurricane is still far enough away to prevent its detection, the following phenomena are generally noticed:

1. The barometer begins to fall slowly. Irregularities and fluctuations in its column are always noticed owing to the antagonizing influences exerted on it.

2. The appearance of the sky is highly changeable, passing sometimes, in a few minutes from entirely clear to cloudy, and vice versa.

3. Consequently the temperature and moisture of the air are also very fluctuating.

4. The wind directions in the different atmospheric strata are singularly unstable. We have frequently observed the passing of those currents, in a very short time, from anticlyclonic to cyclonic, and vice versa.

All the above weather features are always more or less perceptible under atmospheric cyclonic conditions, and after the gradual recession of the anticyclone. The brightness of this phase obviously depends on the power exerted by both the anticyclonic and cyclonic systems as well as in their relative position to the observer.

Third phase of the hurricane: Changes and phenomena to be observed in the upper strata of air.—This phase begins when the anticyclone in its progressive motion is so far away as to be imperceptible to the observer, while the hurricane is gradually approaching him.

Hitherto we have examined what may be called deductive methods of ascertaining the existence of the hurricane. We will now study what may be called inductive methods. In fact, under the heads "First and second phase of the hurricane," we have examined those phenomena whose operations, if closely connected with the hurricane, take place beyond its limits. On the contrary, the phenomena upon whose study we now enter are originated in the body of the hurricane itself.

Alteration of the light in the upper strata of air. Reddish and ruby skies.—This phenomenon is always noticeable when the outermost part of the hurricane begins to invade the place of observation. The unsettled weather, described in the last section, gradually disappears and the barometer falls now steadily but rather slowly. By this time the transparency and blueness of the sky, characteristic of the past anticyclonic weather, is succeeded by an opaqueness or veil called cirrhose veil, so extremely subtle in the beginning as to render it almost imperceptible. Notwithstanding its subtlety this veil exerts a very great dispersive power on the solar rays; its principal feature being the almost entire absorption of all the prismatic colors, except red. These dispersive and absorptive powers are singularly remarkable when the solar rays are compelled to pass through a great portion of the atmosphere. Consequent upon this the sun's rising and setting are attended by an anomalous reddish coloration in the sky ending or beginning, accordingly, when the sun's altitude is, on an average, 15°, the coloration increasing as the altitude decreases.

B.—Precursory cirri and their magnificence. Invaluable data to be derived from their appearance.—Just here the observer is confronted with the most splendid phenomenon to be observed in tropical meteorology.

Soon after the reddish coloration is noticed the tribe of cirri makes its appearance. These clouds are oftentimes called "Pele's Hair," "Mare's Tails," etc., on account of their fibrous or filiform structure. As is well known they resemble in their form a feather or plume of highly variable dimensions.

The appearance of these clouds shows an organization whenever pertaining to tropical hurricanes, seldom noticed, if not unknown, in those attending high latitude storms. In fact during our long stay in New York, N. Y., we have had ample opportunity to watch a good many specimens of cirri in connection with storms of very different energies, having utterly failed in detecting any similitude with those frequently observed in the West Indies hurricanes.

The shape of the typical tropical cirrus is that of a most perfect and remarkably beautiful feather or plume snow-white, in which the shaft or stem is of a fibrous structure, great density, and averaging 80° in angular length. The vanes are equal and closely distributed on both sides of the stem, being of filiform structure, divergent, and of marked outward curvature.

It is also noticeable in connection with these clouds that when there are two or more, as is usually the case, all of them agree in their directions, converging to a given point on the horizon. This point is called divergence focus.

Whenever these cirri are carefully observed a great activity or instability is always detected as taking place in their masses. So their longitudes are frequently seen, increasing or diminishing, in a short space of time.

In spite of this instability the cirrus is never deformed nor deflected from its primitive direction.

By this phenomenon positive evidence is obtained that whatever may be the operations going on in the clouds, the facts remain:

1. That the powerful streams made transitorily visible through the condensing vapor are of very great steadiness in their directions.

2. That these streams are subjected to rather rapid changes in their energies.

3. That these changes are always accomplished with remarkable regularity as long as the cirrus is neither distorted nor deformed.

Such are, in brief, the characteristic features of the typical tropical cirri.

Let us see, now, the invaluable information to be derived from them regarding the coming hurricane.

Early in 1877, the Rev. Father Benito Viñes, S. J., from the Belen College, Havana, advanced the two following theories:

1. That the cirri crowning a hurricane show exactly, or very closely, to the observer, the direction of the radius of the hurricane; so that the divergence focus shows him the bearing of the vortex.

2. That in every hurricane the structure, appearance, and magnitude of the precursory cirri are always in close relation to the magnitude and energy of the hurricane.

Regarding these theories, we can only say that after having been, both of them, subjected to a most exhaustive series of observations, by Professors Halkzenbrich, Theyer, and ourselves (embracing more than fifteen years), we do not know of a single case in which the theories were not fully confirmed.

Tropical meteorology is thus in possession of a most valuable source of information regarding threatening hurricanes, while their vortices are, on an average, 600 miles off.

Father Viñes, purporting to bring into practical application his second theory, divided all the cirri into two groups, and then, selecting from each group its most characteristic form, obtained two specimens calling them extreme types.

Let us now examine the distinctive features of these types.—First type.—The shape of these cirri, often called the typical cirrus, is carefully described in this section.

This kind of cirri always pertain to the typical tropical hurricane: cyclone of short diameter, sharp barometrical gradient, and consequently, powerful ascending currents and extreme destructiveness. In these cases, the appearance of the precursory cirri takes place when the vortices are, on an average, 350 miles off.

Second type.—According to Father Viñes, this cirrus is characterized by its filiform structure, belt shape, and great extensiveness. It is frequently the case that the observer loses sight of it in opposite horizons.

When there are two or more of these cirri they appear like belts or zones parallel to their longitudes. M. Ch. Martins, in his translation into French of the Kaemtz's work, Paris, 1858, says: "La tendance qu'ont les cirrus à se disposer suivant des bandes paralleles entre elles est remarquable, et prouve que la cause qui dirige leurs filaments, suivant tel azimuth, plutôt que suivant tel autre, au lieu d'être simplement locale et accidentelle, s'étend à de grande distances."

According to Viñes, "The constituent matter of this cirrus is extremely attenuated, inasmuch as its appearance is always of a slight opaline color, dimming the sky in some degree without reducing at all its transparency." In fact, the appearance of this cirrus is like gauze or muslin, of a very subtile texture, resembling to that extent the tail of a comet. We have had ample opportunity to see through these clouds stars up to the sixth magnitude.

These cirri always belong to the upper general current, sometime called antitrade current. They pertain to the highest strata of air, where the currents, as shown by the shapes of these clouds, are of remarkable regularity, though subjected to the most interesting changes, which are fully described in the first part of this work.

Being already familiar with the two leading types of Viñes classification, the first of which belongs, as has been said, to the typical tropical hurricane, and the second to the perennial cyclonic tendency in the equatorial doldrums, we will now make a brief examination of the intermedial or transitional types from the first to the second, having in mind (and here lies the chief feature of Father Viñes' theory) that as the shape, appearance, and structure of the precusory cirri of a hurricane depart from the first type and approach the second in the same relation the hurricane's energy will always be minor, and sometimes no more than a slight cyclonic disturbance.

According to Father Viñes, the intermedial types are characterized by the following features:

1. Want of perfection and harmony in the whole of the cloud.
2. Greater length in the feathers, being only generally partially visible.
3. Lesser condensation in their masses.
4. Greater fineness and delicacy in their parts.
5. Augmentation of nebulosity in their middle.

In fact, the derivations of the first type generally appear assuming the shape of an imperfect feather, in which the lower part of the shaft is invisible, possibly because of its nonexistence or perhaps on account of its being located at a greater altitude than the vanes, and thus concealed behind the cirro-pallium. Sometimes these cirri appear in a still more anomalous shape, viz, a feather without shaft, the vanes being distributed at each side of the central empty space. Possibly, too, the shaft bears at a greater altitude, being also hidden by the cirro-pallium. But whatever may be the form, more or less perfect, of the intermedial types, they are always larger than those of the first type, of a minor condensation in their masses, and consequently less whiteness and reflecting power, filiform structure, and semitransparent vanes.

Summing up all the statements concerning the precursory cirri of a hurricane, we now derive the following conclusions:

1. Cirri of the first type on a blue sky, extraordinary whiteness and perfect shapes, great condensation and reflect-

ing power, lively activity in their masses, and strong divergence focus at a given point on the horizon; these cirri always belong to the typical tropical hurricane, viz., cyclone of short diameter, moderate altitude, sharp barometrical gradient, and extreme destructiveness. This kind of cirri generally appear to the observer while the vortices are 350 miles off.

2. Cirri of the intermedial types. These cirri always appear on a faint blue, nebulous sky, and always pertain to hurricanes of a greater diameter than the typical cyclones, greater altitude, moderate gradient, and consequently less destructiveness. The shapes of the intermedial types being so numerous and almost indescribable, it is very difficult to state here the precise relation between what may be called appearance and energy. Nevertheless, the following rule, we believe, may lead us far toward some practical results: *The magnitude and force of every hurricane is always proportional to the magnitude and perfection of the precursory cirri, as well as to the greater or lesser diaphaneity of the atmosphere attending their appearance.* Thus large cirri of truncated or irregular shapes, hardly discernible through a dense opaline veil, are always followed by cyclonic disturbances of a great diameter and altitude, gentle gradient, copious rains, and moderate winds from 40 to 50 miles per hour. In these cases the precursory cirri appear to the observer while the vortices are 700 to 800 miles off.

As a good practical illustration of the invaluable data to be always derived from the positions and appearances of the precursory cirri, we will mention a case occurring in the last hurricane investigated by our observatory: On the evening of October 18, 1895, we detected a hurricane bearing south-southeast from Havana, the only sign of it hitherto being a weak *focus of cirri* diverging from that point, very near the horizon, and attended by a slightly opaline sky, promptly turning into gay ruby colorations at sunset. By the structure, size, and appearance of the *cirri*, openly differing from those of the *first type* of Viñes, we concluded the hurricane was of moderate energy and common features. The position of the vortex at that moment (on the Caribbean Sea) was such as to prevent direct information regarding the storm. In fact, it was afterward verified that its vortex on that day was bearing south-southeast from Havana toward 16° north latitude. The track was directed to north-northwest, according to the normal tracks for that date; recurved between 21° and 22° latitude, in observance, also, of the recurving laws; and, after crossing through the central section of the island, gained the Atlantic at a point not far from Sagua la Grande. The absolute maximum velocity of the wind in Havana was 37 meters per second, or about 83 miles an hour, the barometrical minimum (reduced to sea level and 0° Centigrade) being 751.60 millimeters, or 29.59 inches.

In this hurricane the preceding anticyclone crossed at some distance from Havana, and we could not detect it, the first noticeable phase being the appearance of the precursory cirri on the 18th.

Solar and lunar halos, parhelia and paraselene, threatening skies.—Shortly after the appearance of the precursory cirri it is always noticeable that the subtile opaqueness, or veil, has gradually acquired density, and now resembles a light curtain of a milky appearance. During this phase the delicate filaments of the cirri are almost imperceptible, owing to the interposition of the veil.

Solar and lunar halos are always phenomena attending this kind of weather, the parhelia and paraselene being seldom noticed. At the beginning the halos are of a weak appearance; but later, and when the veil is still denser, they usually display extraordinary brilliancy, which afterwards gradually declines as the veil is changing to a dark cinereous color.

The reddish colorations attending the sun's rising and setting are now of a most indescribable and threatening appearance, resembling the resplendence of a bright polar aurora. The ruby color is gradually turning into crimson as the sun is reaching the horizon, and shortly after its setting the whole sky has the appearance of an enormous conflagration.

Cirrhose arc: its appearance.—While the cirrhose veil is increasing in density, as we have seen in the last section, it is always noticeable that at a given point in the horizon the condensation of the veil is greater. There the veil has the appearance of a segment of a circle at first, tangent to the horizon, but gradually rising to a maximum of perhaps 10° above. This arc is generally called the cirrhose arc. Its color at the beginning—that is to say, during the phase of which we are now speaking—is the same as that of the veil covering the whole hemisphere, only that the accumulation of vapors being greater where the arc appears, its reflecting power is necessarily greater; so that, in spite of the identity of colors between the cirrhose veil and the arc, the latter seems perfectly detached, a similar phenomenon to that always noticed in the tail of a comet, where the tail is brighter near the borders than along the middle, in spite of the uniformity in its color.

The point in the horizon at which this arc is formed always coincides with the divergence focus of the observed cirri, and therefore with the bearing of the vortex to the observer. In fact, the arc is but the visible upper part of the approaching hurricane.

Seamen navigating in tropical seas in the hurricane season must carefully observe if, after the appearance of the precursory cirri, the cirrhose arc is formed, attended by halos and reddish colorations, with falling barometer. In this case there is no time to be lost. Let them consult without delay the charts of normal tracks for the different months of cyclonic activity, and if they find themselves to be in a dangerous zone adopt immediately the measures they may deem necessary.

While the phenomena described have been taking place, the different atmospheric currents, of an unstable nature at the beginning, have been gaining regularity, and they are now quite cyclonic. These currents, in every tropical hurricane, appear to the observer to be making different angles with the bearing of the vortex, according to the height of the different currents, the gradation being expressed in the following table:

Different currents.	Angles with the storm radius, or bearing of the vortex.
	°
1. Wind direction or superficial current	112
2. Lower clouds (nimbus)	90
3. High cumulus	68
4. Cirro-stratus	45
5. Cirro-cumulus	22
6. Cirri	0

So that, assuming the vortex as bearing southward from the observer, the wind blows, approximately, from east-northeast; the *nimbus* come from the east; the *high cumulus* from east-southeast; the *cirro-stratus* from the southeast; the *cirro-cumulus* from south-southeast, and the *cirri* from the south.

It is to be noticed further that the angles assigned in the preceding table are only on an average, and pertain to the typical hurricane. Therefore, whenever the currents in the coming hurricane present exactly, or nearly, the above tabulated relation, the hurricane will be a typical one—short in diameter and of extreme destructive violence. On the other hand, if the currents make angles lesser than those expressed in the table, this being the general case, then the hurricane will be of usual or moderate violence. If it is noticed that currents 1st, 2d, and 3d, or 1st and 2d, or 2d, and 3d agree in their directions, then the hurricane is of defective organization and great diameter, sometimes being no more than a slight cyclonic disturbance.

Bar of the hurricane: its appearance. Data to be derived from its observation.—The cirrhose arc, described, gradually changes as the hurricane is approaching. At the beginning its color is of a whitish-milky appearance, but now its color is rather dark and opaque, soon to be turned into black. After this change in its appearance the arc is called the bar of the hurricane.

The bar has the appearance of an arc whose altitude in the horizon is generally from 10° to 15°. It is formed in its upper section by cumulo-stratus, and in the lower one by a nimbus of great size and black color. The base of the bar is always concealed below the horizon, so that *solution of continuity* is never detected between the bar and the horizon.

Showers and squalls: their phenomena.—Shortly after the bar is formed in the horizon the nimbus of the hurricane begin to overrun the skies with inexhaustible succession and high speed. Showers of short duration begin, and the wind velocity increases from that moment. The barometer that has been slowly falling since the beginning of the second phase, now drops abruptly.

It may be well to notice here that in every perfect hurricane of great or relative moderate intensity, the rain, at the beginning, is of a showery nature, attended by squalls from 55 to 65 miles an hour, while the mean velocity of the wind is from 35 to 40 miles. On the contrary, as the vortex approaches the rain is always continuous, although highly irregular, the showers succeeding each other at shorter intervals, and always attended by furious gusts of 100, 110, and sometimes 120 miles an hour.

As is well known, the energy of every tropical hurricane is always in close relation with the frequency and fury of the attending showers. It being always the case that the hurricanes *are fed*, and their *activity* maintained unabated by the characteristic showers which accompany them, by reason of the fact that this rapid upward convection contributes largely to a more and more severe precipitation.

The principal features accompanying the showers are the following:

1. Extraordinary increment in the wind's velocity at the beginning and during the shower. The mean velocity of the wind in the body of the hurricane is, on an average, 65 miles an hour, increasing then to 100, 110, and sometimes 120 miles, in the form of gusts, their duration ranging from 3 to 4 seconds. As the shower relaxes the wind abates, the duration of the showers being from 60 to 120 seconds.

2. At the beginning of, and during the shower, the wind's direction always shifts to the right (supposing the observer facing toward the wind) from 45° to 90°, so that if the wind was blowing before the shower, say from the north, during the shower, it will blow from northeast, east-northeast, or east, oscillating greatly in its direction, according to the frequency of the gusts, the greatest elongation corresponding *always* to the greatest fury of the wind.

3. During the continuance of the intermittant gusts (forming, as we have seen, a part of the shower), the barometrical column oscillates greatly, the amplitude being from 0.02 to 0.03, and sometimes 0.04 of an inch. This renders it very difficult to take accurate readings of the instrument.

Passing now to an examination of the characteristic features of the rains in the tropical hurricanes, we have the following results, derived from observations of a large number of cases.

1. In every tropical hurricane the area of rain extends *forward* to 150 miles from the vortex; while *backward* it only embraces 100 miles from the vortex, both distances being averages. Nevertheless, instances are on record in which the area of rain extended itself farther *backward*, or to the *right* or *left* of the vortex.

2. In cyclone disturbances of great diameter and large altitudes, the area of rain generally extends around the vortex, from 500 to 700 miles. In this kind of storms the rain is always copious and continuous, a procedure widely opposed to that followed in the typical hurricane, where the rain is always of a showery nature. Floods are the principal dangers and immediate results of these cyclonic disturbances.

The theory in favor with many conspicuous meteorologists, that *storm centers move toward the region where the greatest precipitation takes place, does not seem well confirmed in the process of tropical hurricanes.* As we have already seen, the tracks of the tropical hurricanes are in close relation with the course of the upper atmospheric current, and its periodic changes, the existence of what may be called *traced tracks* for the hurricanes (changeable with this current) for every period of the hurricane season or cyclonic activity, seeming thus a demonstrable fact. It is true that in most of the *tropical* hurricanes the area of precipitation extends itself more toward the front of the storm, and this fact seems to be a confirmation of the above cited theory; but there are the two following, and in our opinion powerful reasons, tending to embarass that theory, at least so far as the tropical hurricane is concerned.

1. Instances are on record in which the area of rain extended itself farther *backward*, or to the *right* or *left* of the vortex. 2. In cyclonic disturbances of great diameter and large altitude, the area of precipitation generally extends to equal distances around the vortex. In this, as well as in the former case, the storm centers always follow their normal routes.

Besides this, the deflection of the hurricanes of September 4–5, 1888, seems to confirm the theory advanced by Father Viñes, that tropical hurricanes are directed, or impelled in their tracks, by the upper atmospheric current.

The fact that in the tropical hurricanes the area of precipitation extends itself more toward the front of the storm, is in our opinion, purely a result of the mechanism of the hurricane itself. In fact, it is easy to conceive that inasmuch as the ascending currents come first in contact with the upper strata (always cooler than the lower strata) at the forepart of the eddy the upward convection of vapor thus accomplished, occasions the more copious and showery condensations at that point. In this way the forepart of the storm operates as a huge condenser, in which the ascending air frees itself of the greater part of its vapors. Continuing, the spiral ascending of this air comes in contact with still higher layers in the *rear* portion of the storm, and condensing there another part of its remaining vapors, occasions an area of showery precipitation, necessarily less abundant, and the area less extensive than in the forepart of the storm. Ascending still more, this air in the eddy comes again to the front, and the new condensing vapors occasion there the continuous drizzling rain, always attending the forepart of the hurricane, independently of the characteristic showers. Still continuing, the ascending air reaches again the rear of the storm, and there the condensing vapors result in the abundant formation of cirro-stratus and cirro-cumulus clouds, the drizzling rain being seldom noticed in this part of the hurricane. Coming again to the front, and reaching now a great altitude, the vapors of the air occasion the formation of the splendid cirri, crowning the hurricane. And a very interesting feature in connection with the cirri is that those at the rear of the hurricane always reach a greater altitude than those in the front, the former being detected about 410 miles from the vortex, while the latter are only discernible at 357 miles, both distances being averages. This seems to be conclusive evidence that the operation of the ascending air is as we have stated above.

The long and tedious procedure described in the last number may, we believe, be simply represented in the following table:

Phenomena occasioned by a volume of air ascending through the spirals of a tropical hurricane.

Passages by the front of the hurricane.	Passages by the rear of the hurricane.
First passage: Showers of great intensity. Second passage: Continuous drizzling rain. Third: *Cirri.*	First passage: Showers of moderate intensity. Second passage: Abundant formation of cirro-stratus and cirro-cumulus. Third: *Cirri*, at a greater altitude.

Observation of many tropical hurricanes leads us to conclude that the above-cited operation is either rigorously exact or, at all events, is not too far from the truth.

The fact that in some hurricanes and at some points of their tracks the area of precipitation extends itself farther *backward*, or to the *right* or *left* of the vortex, may be due (though this is not well established) to the *nutation* or oscillatory motion of the axis of the hurricane, a phenomenon always existing in every hurricane, but in most of the cases so slight as to escape detection. In fact, when the nutation is small, the axis then being nearly perpendicular to the track, all the sections of the whirlwind will be about horizontal (disregarding the spiral shape of the storm), and, in consequence of this, the ascending air will produce the phenomena referred to. But when the nutation, owing to

causes which will be explained farther on, is greater than usual, then the greater will be the obliquity of all the sections of the whirlwind, and in this way the precipitation will be more abundant toward the place opposite to the inclination of the axis.

The nutation of the axes in the tropical hurricanes was discovered by Father Viñes in September, 1876. The hurricane of October 19 of the same year had a greater inclination in its axis than that of September. Contrary to the usual process, the hurricane of October had the mildest winds in the so-called dangerous semicircle, or right side of the storm. In the passage of this hurricane through the island the fact could be well established that the winds on the right side ran at a great altitude, damaging only the royal palms and other tall trees, while sugar cane, tobacco, and other shrubs remained intact. On the contrary, on the left side nothing escaped the fury of the storm, the gusts there being generally like small whirlwinds of terribly destructive violence.

Consequent upon the great nutation of the axis in this hurricane, at least as far as the first part of its track was concerned, the precipitation was highly irregular around the vortex.

A careful examination of delineated tracks of tropical hurricanes will always show the nutation of their axes. The shape of the tracks is that of an undulating curve.

We regard the nutation of the axes in tropical hurricanes as a new and strong argument favoring the theory that tropical hurricanes are directed or impelled in their tracks by the upper atmospheric current. In fact, however regular and steady the current may appear in its course (owing to the defective means of observation of which we can avail ourselves for its study), such regularity and steadiness are more apparent than real. It is hardly conceivable that an atmospheric current (and especially during the months of cyclonic activity, when the atmosphere is so turbulent), may be not subjected to continuous and rather rapid changes in intensity, and, as the hurricanes run along with it, they can not escape its disturbing influence; and hence the nutation of the axes and the irregularities ever existing in their progressive motions.

Position of the observer in relation to the track, and how to ascertain it by observations of the bar.—The attentive observation of the *bar*, will always furnish the observer with the following interesting results:

1. If after a series of observations, embracing six hours as a minimum, he finds that the *bar* has been moving to his *right* (supposing the observer is facing the bar), he is on the right side of the track, or dangerous semicircle. The wind, of course, will move to the right also, that is to say, from north to east, south, west, and north.

2. If the movement of the bar and wind takes place with rapidity the vortex will pass not far from the observer. On the contrary, if the changes take place slowly, then either the vortex will pass at some distance from the observer, or the hurricane will be recurving. The latter assumption will be strengthened if the barometer ceases to fall.

3. If, after a series of observations, performed in the above-cited manner, the observer finds that the bar has been moving to his *left*, then he will be on the left side of the track. The wind will also move to the left: from north to west, south, east, and north.

The deductions from the rapidity or slowness of the movement of the bar and wind are the same as recited in paragraph 2.

4. If after a series of observations the observer finds that the bar remains stationary on the horizon, while the barometer descends rapidly, and the wind velocity and showers continually increase, then he will be situated in the same track as the hurricane, and sooner or later will be in the middle of the vortical calm.

Approximation of the vortex; phenomena to be observed in its vicinity, and before its crossing the point from which it is observed.—It has already been stated that the stability of the bar at the same point on the horizon, attended by continuous and rapid falling of the barometer, and progressive increase in the wind velocity and frequency of the showers, was conclusive evidence that the observer was situated in the track of the hurricane.

In this case, as we have had ample opportunity to verify, the bar is slowly growing in altitude, until reaching about 20° on the horizon. Simultaneously with this increase in the bar, the wind velocity increases largely; the absolute maximum velocity of the gusts being generally from 90 to 100 miles an hour, while the mean velocity averages 65 miles per hour. Showers fall unabated, darkness and mist shut out the horizon, and the barometer descends with unusual rapidity. As the vortex approaches, the moment comes when the wind begins to abate, and the showers gradually to relax in copiousness, notwithstanding the still increasing fall of the barometer. It is easy to see then how the bar has been spreading on the horizon, and now looks like an enormous ring, 20° in altitude, inclosing the observer in its center.

The elapsed time from when the wind and showers begin to abate until the vortical calm is settled and the barometer stationary, is highly variable with different hurricanes, being necessarily dependent upon the diameter of the storm itself and the velocity of its translation.

Vortical calm; phenomena to be observed therein.—The abatement in the wind velocity and force of the showers, to which we have referred in the last section, goes on slowly but steadily, so that the transition from the fury of the hurricane to the relative vortical calm is always accomplished in a gradual and progressive manner.

In passing now to examine the so-called vortical calm and the phenomena to be observed therein, we have—

1. That in the tropical hurricanes this calm is only relative, owing, it may be, its name of calm to the notable disparity between the lull and the tumult of a few hours before, which is to be repeated a few hours later. In fact, in

the so-called vortical calm, the wind velocity is seldom less than 6 miles an hour, though it never goes beyond 10 miles. In spite of this, it is often the case that this relative calm is suddenly broken off by an unexpected gust of 25 to 30 miles an hour, and the approximated duration of which is limited to a few seconds.

2. That the gentle winds of the vortical calm are highly variable or unstable in their direction. It is frequently the case that these winds, within a few minutes, shift around the entire compass.

3. That during the vortical calm the zenith is always clear, stars up to the sixth magnitude being easily discernible.

4. That the barometer remains stationary for a time, highly variable in different hurricanes, the minimum reading during any given hurricane being indicated at the period of vortical calm.

5. That the bar of the hurricane, appearing as an enormous ring, incloses the observer in its middle.

6. That the case is frequent when the bar of the hurricane appears as an ellipse of great eccentricity, whose transverse, or major axis, bears variably during different hurricanes. During the passing of the vortex of the hurricane of September 24, 1894, through Havana, the track of this hurricane, and the observed pressure fall, at the Vedado Park Observatory, the bar of the storm had an elliptical shape, whose major axis extended notably from west to east. Consequent upon this elliptical shape of the bar the space of the vortical calm in these cases extends itself more in the direction of the major axes. This phenomenon is ascribed to the nutation of the axes.

Phenomena to be observed after the passage of the vortex through the point of observation.—These phenomena are—

1. Differing from the procedure observed before the passing of the vortex where the wind is gradually abating, until the vortical calm is settled, after the passing of the vortex, the transition from the calm to the new storm winds is generally accomplished in a sudden and violent manner, so that those gentle winds running from 6 to 10 miles an hour are unexpectedly substituted by gusts of 80 and 90 miles per hour. These winds are always terrible, and especially so on the seas, on account of their unexpected arrival.

2. The observer must ever bear in mind that these awful gusts *always blow from a quarter diametrically opposed* (180° departure) *to that from which the last violent gusts were blowing before the relative vortical calm was settled*, and he must disregard the wind direction during the vortical calm, which is highly variable, as we have said in paragraph 2 of the last section.

3. Shortly before the appearance of the new stormy winds (though sometimes simultaneously), the barometer begins to rise rapidly. This rising goes on unabated until the hurricane has fully passed.

4. Soon after the beginning of the new stormy winds the showery precipitation is again resumed. This precipitation is generally less abundant than that in the forepart of the hurricane.

5. Sometimes the winds blowing in the rear of the hurricane are more violent than those in the front. For instance, in the hurricane of September 24, 1894, before the passing of the vortex through Havana, the absolute maximum velocity of the wind was 43 meters per second, or 95.5 miles per hour. On the contrary, shortly after the vortical calm was over, the absolute maximum velocity recorded in our anemo-cinemographe was 50 meters per second, or 111 miles per hour. In this hurricane, owing to the nutation, the axis of the storm was remarkably inclined from west to east.

6. In the progressive recession of the vortex all the phenomena previously described as taking place during its approaching, come again to sight, with only the difference of being now in a quite reverse order of succession.

Velocities of translation at different points of the track.—1. From the time the hurricane is formed until it reaches the vicinity of the vortex of its parabola, or recurving point, the velocity of translation increases moderately, the average (derived from the observation of many cases) being 15 miles an hour.

2. On the vortex of the parabola, or recurving point, the velocity of translation only averages 6 miles per hour. Sometimes this velocity is limited to 1½ mile per hour.

3. Shortly after recurving, the velocity of translation increases anew, reaching on an average a maximum of 35 miles an hour.

The foregoing review or summary of writings regarding the law of storms, as it applies to West Indian hurricanes, will be concluded with a discussion of the Features of Hurricanes, by Prof. F. H. Bigelow, of the Weather Bureau, in the Yearbook of the Department of Agriculture for 1898:

Hurricanes occur in the southeastern parts of the United States and adjacent waters during the season of the year when the cooling of the Northern Hemisphere takes place as the sun retreats toward the Southern Hemisphere. At this season the calm belt of the Tropics and the heated, moist condition of the air in the region known as the doldrums are at their farthest northern limit. The South Atlantic permanent anticyclone, which lies over the subtropical ocean, is in its fullest vigor. Now, superposed upon these states of the lower atmosphere, the colder temperatures of the upper atmosphere, caused by the approaching autumn, on account of the more rapid circulation higher up, overspread the tropic strata near the surface. As the polar air cools first, it flows gradually above the warmer air at the south of it near the ground, and covers it with a circulating sheet of temperature cool or low for the time of year. The effect of all this is to make the atmosphere unstable, that is to say, too warm at the bottom, compared with that above it, to be able to maintain the usual equilibrium. The tendency is, therefore, for the lower air to rise vigorously

and burst its way upward by convection, in order that the normal equilibrium may be restored. Of course, this action is favorable to the formation of cyclonic gyrations and the development of severe storms. Hurricanes seem to generate in some such way as this, though our observations are as yet inconclusive on that point, since there is always observed to be a stagnant, warm condition over the ocean at the time the incipient cyclonic action begins. It is to be especially considered that the isotherms in hurricanes do not show any very decided differences in temperature on opposite sides of the center, such as always prevail in the cyclones of the north. There are no counter-flowing currents here, and no source is known from which these can arise in the equatorial region to produce the marked temperature gradients found in cyclones. Furthermore, hurricanes are much more circular in shape and conform more exactly to the pure theory of cyclones as derived from mathematical analysis.

There is another feature of great interest to be considered. It was stated that in the case of common cyclones, even those having very great strength, the deflection or distortion of the eastward drift at the 3-mile level is only moderate. In the case of hurricanes, which are centered in the east Gulf States, so that the wind directions can be observed on all sides, it is proven that the circulation is not only more rounded, but also that it penetrates the upper strata very much farther, and twists even the cirrus level entirely out of its ordinary shape. The circular components are, therefore, very strong up to 6 miles in hurricanes, while they are equally pronounced in the cyclones only to a height of 3 miles. This is a very marked characteristic, and indicates that hurricanes depend largely upon vertical convection for their power, while cyclones depend almost exclusively upon horizontal convection, that is, upon the counterflow of very long branches of horizontally moving atmosphere, having their bases several thousand miles apart. As hurricanes move northward, out of the Tropics, they gradually assume the nature of true cyclones, since vertical convection is finally superseded by horizontal convection in the North Atlantic districts.

The physical features of hurricanes are well understood. The approach of a hurricane is usually indicated by a long swell on the ocean, propagated to great distances and forewarning the observer by two or three days. A faint rise in the barometer occurs before the gradual fall, which becomes very pronounced at the center; fine wisps of cirrus clouds are first seen, which surround the center to a distance of 200 miles; the air is calm and sultry, but this is gradually supplanted by a gentle breeze, and later the wind increases to a gale, the clouds become matted, the sea rough, rain falls, and the winds are gusty and dangerous as the vortex core comes on. Here is the indescribable tempest, dealing destruction, impressing the imagination with its wild exhibition of the forces of nature, the flashes of lightning, the torrents of rain, the cooler air, all the elements in an uproar, which indicate the close approach of the center. In the midst of this turmoil there is a sudden pause, the winds almost cease, the sky clears, the waves, however, rage in great turbulence. This is the eye of the storm, the core of the vortex, and it is, perhaps, 20 miles in diameter, or one-thirtieth of the whole hurricane. The respite is brief and is soon followed by the abrupt renewal of the violent wind and rain, but now coming from the opposite direction, and the storm passes off with the several features following each other in the reverse order.

By the laws of vortex motion the winds approach the center in spirals, the circular and the centrifugal movements increasing every moment. At the core within the walls of the columnar vortex the air circulates about the calm central part, gradually rising to the cloud stratum, just above the inflowing disk. Here the air flows out suddenly on all sides, the circular motion decreasing, the air cooling by expansion, causing a great, thin sheet of rain 200 to 300 miles from the center. At this distance the vortex sheet turns up suddenly (not down as usually stated) and discharges the expended matter into the high upper currents of the atmosphere. The feeding wind lines are more nearly parallel to the ground than the upper discharge lines, but they all form a columnar vortex of unusual configuration. There is probably no feature of nature more interesting to study than a hurricane, though the feelings of the observer may sometimes be diverted by thoughts of personal safety.

The discoveries and researches reviewed herein cover all available knowledge which is necessary to a practical understanding of West Indian hurricanes.

It will be observed that at the beginning of the three-quarters of a century period, during which these researches have been made, the world possessed no knowledge of the mechanism of storms, and the history of West Indian hurricanes prior to the second quarter of the century is made up solely of local descriptions of their visitations. Toward the middle of the century the paths of hurricanes were successfully traced over the West Indies and adjacent waters and along the Gulf and Atlantic coasts of the United States. During the last quarter of the century hurricanes have been not only accurately traced, but their paths and character have been forecast for the benefit of land and maritime interests which are affected by this class of storms.

The following table, which is taken from Table de Quatre Cents Cyclones by Andreas Poëy, covers the occurrence of three hundred and fifty-five hurricanes which visited the West Indies from 1493 to 1855.

Hurricanes in the West Indies from 1493 to 1855.

Dates.	Localities.
1493, Feb. 12	North Atlantic.
1494, May 19–21	Cuba (between Cape Cruez and Manzanillo).
1494, June 16	Santo Domingo.
1495	Santo Domingo.
1496, Mar.	Atlantic.
1498	Cuba.
1500, Aug	Caribbee Islands.
1502, July 1–2	Santo Domingo.
1502, Dec. 5	Porto Bello; Santo Domingo.
1504, Oct. 19	Atlantic.
1508, Aug. 5	Santo Domingo.
1509, Feb. or Mar.	Gulf of Mexico.
1509, July 29	Santo Domingo.
1510, July	Santo Domingo.
1526, Oct	Santo Domingo.
1527	Cuba.
1530	Porto Rico; Cuba.
1548	Santo Domingo.
1557	Cuba.
1565	Caribbee Islands.
1588	Cuba.
1591, Aug. 10	Latitude 35° north.
1625, Sept. 19	St. Christopher.
1642	Windward Islands; Martinique.
1642	Martinique.
1642	St. Christopher; Martinique; Guadeloupe.
1650	St. Christopher.
1651	Martinique.
1652	Martinique; Guadeloupe; St. Christopher.
1655, July 13	St. Vincent.
1655, Oct. 1	St. Vincent.
1656	Guadeloupe.
1656	Antilles.
1657	Guadeloupe.
1658	Antilles.
1660	Antilles.
1664, Oct. 22, 23	Guadeloupe; Antigua.
1665, Oct	Caribbee Islands.
1666, Aug. 4, 5	Guadeloupe; Martinique; St. Christopher.
1667, Aug. 19	Barbados; Nevis.
1667, Sept. 1	St. Christopher.
1670, Aug. 18	Ninety leagues off Barbados.
1670, Oct. 7	Jamaica; Barbados.
1674, Aug. 10	Barbados; Jamaica.
1675, Aug. 31	Barbados.
1680, Aug. 14	Santo Domingo.
1681	Antigua.
1688, Mar. 1	East of Jamaica.
1691	Antilles.
1692, June 7	Jamaica.
1692, Oct. 24	Cuba.
1694, Aug. 13	Fort James; Barbados.
1694, Oct 17	Barbados.
1695, Oct. 2	Martinique.
1700	Barbados.
1701, April 3	Antilles.
1702	Barbados.
1705, Feb. 7	Antilles.
1707	Nevis; Antigua.
1712, Aug, 28	Jamaica.
1712, Oct	Cuba.
1713	Guadeloupe; St. Thomas.
1714, Aug. 13, 14	Guadeloupe.
1714, Aug. 29	Jamaica.
1714	Cuba.
1718, Mar. 6–7	St. Vincent.
1718, Sept	Nevis.
1720	Barbados.
1722, Aug. 28	Jamaica; Carolina, U. S.
1722, Aug. 31	Antilles.
1725	Martinique.
1726, Oct. 22	Jamaica.
1728, Aug. 19	Antigua.
1728	Carolina, U. S.
1730	Cuba.
1731	Barbados.
1733, June	St. Kitts.
1733, July 16	Cuba.
1734, Sept. 1	Jamaica.
1737, Sept. 9	Santo Domingo; St. Kitts; Montserrat.
1738	Guadeloupe; St. Thomas.
1739, Sept. 9	Antilles.
1740, Aug	Antigua; Martiuique; Dominica.
1740	Porto Rico.
1742	St. Thomas.
1744, Oct. 20	Jamaica.
1744, Nov	Cuba.
1745	Caribbee Islands.
1746, Jan	Latitude 40° N.
1747, Sept. 21	St. Christopher; Leeward Islands.
1747, Oct. 24	St. Christopher; Leeward Islands.
1751, Mar. 7	Jamaica.
1751, Aug. 10	Jamaica.
1751, Sept. 2	Jamaica.
1751, Sept. 15	Santo Domingo.
1751, Oct	Jamaica; Dominica.
1752, Sept	Charleston, U. S.
1753, Sept. 15	Charleston, U. S.
1754, Sept	Santo Domingo.
1756, Aug. 25	Barbados.
1756, Sept. 12	Martinique.
1757	From Florida to Boston, U. S.
1757, Aug. 29	Barbados.
1758, Aug. 25	Barbados; South Carolina, U. S.
1759, Sept	Gulf of Mexico.
1761, May 4	Charleston, U. S.
1761, June 1	Charleston, U. S.
1762, Dec. 31	Martinique; St. Eustatius; Guadeloupe.
1765, Sept	Martinique; Guadeloupe, St. Christopher.
1765, Nov. 13, 14	Santo Domingo.
1766, Aug. 13	Martinique.
1766, Aug. 16	West of Jamaica.
1766, Sept. 11	Virginia, U. S.
1766, Sept. 13–15	St. Christopher; Montserrat.
1766, Sept. 21	St. Eustatius; Tortugas.
1766, Oct. 6	Dominica; St. Eustatius; Guadeloupe.
1766, Oct. 22	Pensacola, U. S.
1768, Aug. 12	Grenada.
1768, Oct. 15	Cuba.
1768, Oct. 25	Havana, Cuba.
1769, Aug. 30	West of Florida,
1769, Oct. 29	East of Florida.
1770, June 6	Charleston, U. S.
1771, Aug. 4	Santo Domingo.
1772, Aug. 4	Santo Domingo.
1772, Aug. 16	Santiago, Cuba.
1772, Aug. 17	Antigua.
1772, Aug. 28	Porto Rico; Jamaica.
1772, Aug. 31	Leeward Islands; Virgin Islands; Antigua.
1772, Sept. 1, 4	Dominica; Santo Domingo.
1772, Nov. 22	St. Christopher; St. Eustatius.
1773, July	St. Thomas; Cuba.
1773, Aug	Boston.
1774, Oct. 2	Jamaica.
1775, July 30	St. Croix; Martinique.
1775, Aug. 25	Martinique.
1775, Aug. 27	Santo Domingo.
1775, Sept. 14	Cuba; Santo Domingo.
1775, Oct. 16	St. Christopher.
1776, Sept. 4	Antigua; Martinique; Guadeloupe.
1776, Sept. 5, 6	Martinique; Guadeloupe; St. Kitts.
1778, Oct. 28	Cuba.
1779	New Orleans, U. S.
1780, Aug. 25	St. Kitts; New Orleans.
1780, Oct. 3–12	Jamaica; Cuba; Martinique; Barbados.
1780, Oct. 10–18	Barbados; Dominica; Antigua; Tobago; Grenada; St. Vincent; Santo Domingo.
1780, Oct. 16	Cuba.
1780, Oct. 31	Barbados.
1781, Mar. 15	West Indies.
1781, Aug. 1	Jamaica.
1781, Aug. 10	North Carolina, U. S.
1781, Sept. 5	Santo Domingo.
1782, Apr. 12	North Atlantic.
1782, July 25	Latitude N. 45° 33′, longitude W. 4° 40′.
1782, July 31	Kingston, Jamaica.
1782, Aug. 1	Jamaica.
1782, Sept. 16	North Atlantic.
1784, Mar. 8	Cuba.
1784, July 10	Jamaica.
1784, July 30	Jamaica; Santo Domingo.
1785, July 6	West Indies.
1785, July 25	St. Croix.
1785, Aug. 25	Guadeloupe.
1785, Aug. 27	Jamaica.
1785, Aug. 31	Guadeloupe; Barbados; Santo Domingo.
1785, Sept. 22–24	Carolina and Virginia, U. S.
1785, Sept. 27	Santo Domingo.
1786, Aug. 11	Santo Domingo; St. Eustatius; Barbados.
1786, Aug. 29	United States.
1786, Sept. 2	Barbados.
1786, Sept. 10	Guadeloupe.
1786, Oct. 5	Barbados; Grenada.
1786, Oct. 20	Jamaica.
1787, Apr.	United States; Bermudas.
1787, July 30	United States.
1787, July	Guadeloupe; French Islands.
1787, Aug. 5	Dominica.
1787, Aug. 15	Florida.
1787, Aug. 25	Dominica.
1787, Aug. 29	Dominica.
1787, Sept. 2	Honduras.

Hurricanes in the West Indies from 1493 to 1855—Continued.

Date.	Localities.
1787, Sept. 19	United States.
1787, Sept. 25	Belize.
1787, Dec. 1	West Indies.
1788, Jan.	Honduras.
1788, Mar. and Apr.	St. Croix.
1788, July 22	United States.
1788, Aug. 14	Martinique.
1788, Aug. 16	Porto Rico; Santo Domingo.
1788, Aug. 19	United States.
1788, Aug. 29	Dominica.
1788, Sept. 19–20	United States.
1790, Aug.	Nevis.
1790, July 31	Jamaica.
1791, June 21	Cuba.
1791, Sept. 27	Cuba.
1792, July 15	West Indies.
1792, Aug. 1	Antigua.
1792, Aug. 6	Bermudas.
1792, Sept. 10	Antigua.
1792, Oct. 29	Cuba.
1793, Aug. 12	St. Christopher; St. Eustatius; St. Thomas.
1794, Aug. 27–28	Cuba.
1795, Aug. 10	Jamaica.
1795, Aug. 18	Antigua.
1796, Oct. 5	Bahamas.
1796, Oct. 24	Cuba.
1796, Nov. 2	Cuba.
1799	Cuba.
1800, Nov. 2	Cuba.
1801, July 22	Nassau.
1802, Feb. 21, 25	Charleston; Nova Scotia.
1802, Sept. 16	Cumana.
1803, July 10	Bahamas.
1803, Sept. 3–9	Martinique; Caribbee Islands; United States.
1804, Aug. 29	Jamaica.
1804, Sept. 3–6	Leeward Islands.
1804, Sept. 22	Jamaica; latitude N. 20° 18′
1804, Oct. 4	Savannah, Ga.
1804, Oct. 9	United States.
1805, July 27	Jamaica.
1805, July 29	Latitude 26° 17′, longitude 60° 2′, north of Barbados.
1806, Aug. 30	Bahamas; Eleuthera.
1806, Sept. 9	Dominica.
1806, Sept. 24	Dominica.
1806, Sept. 27	West Indies.
1806, Oct. 5	Bahamas.
1806, Oct. 27	Bahamas.
1807, July 25–28	St. Christopher; Montserrat.
1807, Sept. 5	Cuba.
1809, July 27	Dominica; Guadeloupe.
1809, Aug. 1–5	Dominica; Guadeloupe.
1809, Sept. 2	Guadeloupe; Porto Rico.
1809, Oct. 15	Martinique.
1809, Oct. 18	Trinidad.
1810, Aug. 12	Trinidad; Barbados.
1810, Aug. 28	Barbados.
1810, Sept. 28	Cuba.
1810, Oct. 25, 26	Cuba.
1812, Aug. 14	Jamaica.
1812, Aug. 19	New Orleans, U. S.
1812, Oct. 12	Jamaica.
1812, Oct. 14	Jamaica.
1812, Oct. 14	Trinidad; Cuba.
1815, July 20	Bermudas.
1815, July 22	Barbados.
1815, July 22, 25	Dominica; Martinique; St. Christopher.
1815, July 26	Bermudas; Bahamas.
1815, July 31	Jamaica.
1815, Aug. 1	Jamaica.
1815, Aug. 5–9	North Atlantic.
1815, Aug. 25	Dominica.
1815, Nov. 19	Nova Scotia.
1815	Belize.
1815, Aug. 9	Gulf Stream, latitude 40°, longitude 62°.
1815, Aug. 31, Sept. 1	North Atlantic, latitude 39°, longitude 58°; Bartholomew.
1815, Sept. 20	Turks Island.
1815, Sept. 29	Barbados.
1815, Oct. 18	Jamaica.
1816, Sept. 15	Barbados; Martinique; Dominica.
1816, Oct. 16	Dominica; Martinique.
1817, Sept. 15	Dominica.
1817, Oct. 21	Little Islands; St. Vincent.
1817, Oct. 25	Barbados; St. Lucia; Martinique.
1818, Aug. 28	Bermudas.
1818, Sept. 10, 12	Cayman Islands; Campeche.
1818, Sept. 10	Santo Do. ingo.
1818, Sept. 22–25	Antigua.
1818, Sept. 27–30	Barbados.
1818, Oct. 7	Port Royal (Jamaica).

Dates.	Localities.
1818, Oct. 21	St. Lucia.
1818, Nov. 17, 20	Jamaica.
1819, Aug. 25	Dominica.
1819, Sept. 21–22	St. Lucia; Barbados; Virgin Islands; Porto Rico.
1819, Oct. 13, 15	Barbados; St. Lucia.
1819, Oct. 28	Cuba.
1821, Sept. 1	Guadeloupe.
1821, Sept. 1	Turks Island; Long Island, U. S.
1821, Sept. 9	Antigua; St. Bartholomew.
1821, Sept. 25	New Haven, U. S.
1821	Cuba.
1822, Mar. 11	Jamaica.
1822, July 11	Mobile, U. S.
1822, Dec. 18	Barbados.
1824, July 26	West Indies.
1824, Sept. 7, 8	Guadeloupe.
1825, July 25, 26	Dominica; Martinique; Guadeloupe.
1825, Oct. 1	Cuba.
1826, Aug. 18	Antilles.
1826, Nov. 6–9	Atlantic; Teneriffe.
1826	Cuba.
1827, July 30	North Carolina, U. S.
1827, Aug. 17–28	Windward Islands.
1827, Aug. 28	St. Thomas; Virgin Islands.
1827, Sept. 7	North Atlantic.
1827, Oct. 11	Bahamas.
1827	Belize.
1828, Mar. 15	Gulf of Mexico.
1828, Sept. 19	North Atlantic, northwest of Bermudas.
1829, July 24	Boston, U. S.
1830, Apr. 24, 25	Vera Cruz.
1830, Aug. 7	Jamaica.
1830, Aug. 11–18	Dominica; St. Thomas; Barbados.
1830, Aug. 19–24	Martinique; United States.
1830, Aug. 22–26	Turks Island; north of Bahamas.
1830, Sept. 29	Caribbee Islands, north coast.
1830, Dec. 5, 6	Coast of America, latitude N. 50°.
1831, Apr. 27	United States.
1831	Belize.
1831, Jan. 13–15	Florida.
1831, June 10	Florida.
1831, June 25–27	Trinidad; Tobago; Antigua; Grenada.
1831, Aug. 10–17	Barbados.
1832, June 3–6	Cuba; Bahamas; Bermudas.
1832, Aug. 7	Jamaica.
1833, Aug. 14	Guadeloupe; Antigua; Bermudas.
1833, Sept. 20	Dominica.
1833, Oct. 16–19	Cuba; Gulf of Mexico.
1834, Sept. 20	Dominica.
1834, Oct. 20, 21	Martinique.
1835, April 28	Coast of the United States.
1835, July 26	Barbados.
1835, Aug. 12–18	Antigua; Cuba; Galveston.
1835, Sept. 5	Barbados.
1835, Sept. 18	Matamoras; Gulf of Mexico.
1835, Nov. 10	Nova Scotia.
1836, Nov. 30 and Dec. 21	United States.
1837, July 9	Barbados; St. Lucia.
1837, July 26	Barbados; Cuba; Martinique.
1837, July 31	Antigua; St. Thomas.
1837, Aug. 2–4	Antigua; St. Thomas; Barbados.
1837, Aug. 6	Lesser Antilles.
1837, Aug. 12	Northeast of Caribbee Islands.
1837, Aug. 18–21	Latitude N. 32° 45′, longitude E. 79° 47′.
1837, Aug. 12–23	Turks Island.
1837, Aug. 31	St. Mark.
1837, Aug. 31 to Sept. 3	Apalachicola, U. S.
1837, Sept. 27 to Oct. 10	Gulf of Mexico.
1837, Oct. 1–5	Yucatan Channel, in the Gulf of Mexico.
1837, Oct. 26	Cuba.
1838, Sept. 10	Bahamas.
1838, Nov. 1	Vera Cruz.
1838, Nov. 26	Vera Cruz.
1838, Nov. 26–28	Atlantic coast of Europe.
1839, June 9	Antigua.
1839, Sept. 8–14	Bermudas.
1839, Nov. 5	Galveston, near Island of St. Louis, Gulf of Mexico.
1839, Dec. 15–17	United States; North Atlantic.
1840, May 25	Madeira.
1840, Sept. 16	Porto Rico.
1841, Oct. 3–6	Nantucket, U. S.
1841, Oct. 6	Barbados; St. Lucia.
1841, Oct. 21–28	Bermudas.
1841, Nov. 28	Cuba.
1842, July 12	Cape Hatteras, U. S.
1842, Aug. 30 to Sept. 2	Atlantic and the coasts of Mexico.
1842, Sept. 4	Cuba.
1842, Oct. 2–10	Bermudas.
1842, Oct. 24–29	Madeira.

Hurricanes in the West Indies from 1493 to 1855—Continued.

Dates.	Localities.	Dates.	Localities.
1842, Nov. 5	Latitude 56° 40′, longitude 65° 20′.	1850, Aug. 21	Cuba.
1843, Oct. 13	Florida.	1850, Sept. 2	St. Nicholas; Cape Verde Islands.
1844, Feb. 22	Martinique.	1850, Oct. 14	Latitude 24° 59′, longitude 49° 50′.
1844, May 12	Latitude N. 37° 47′, longitude W. 67° 42′.	1850, Oct. 18	Latitude 25° 58′ N., longitude 43° 39′ W.
1844, Oct. 5	Cuba.	1851, Aug. 16–28	St. Mark; Florida; St. Christopher; St. Thomas; Cuba.
1845, Oct. 12	Straits of Florida.	1851, July 10	Barbados; Santo Domingo; St. Christopher.
1845, Oct. 22	Bermudas.	1852, Jan. 12	Vera Cruz.
1845, Oct. 27	Bermudas, east coast.	1852, Sept. 22–26	St. Christopher; St. Eustatius; Porto Rico.
1845, Nov. 9	Bermudas.	1852, Oct. 9	St. Mark; Florida.
1846, Sept. 11–21	Barbados; Guadeloupe; Antigua.	1853, Aug. 30	Cape Verde.
1846, Oct. 6–18	Cuba; United States.	1853, Sept. 11	Hatteras, U. S.
1847, Feb. 21	Atlantic.	1853, Sept. 27	Latitude 35° 19′, longitude 58° 56′.
1847, Oct. 10	Tobago; Trinidad.	1853, Sept. 28	Latitude N. 15°, longitude 37° 10′.
1848, Aug. 22 to Sept. 3	Antigua.	1854, Oct. 21	Bermudas.
1848, Sept. 19	Barbados; St. Christopher.	1855, Jan. 20	Baltimore, U. S.; Halifax,
1848, Dec. 16	Atlantic.	1855, Feb. 10	Bermudas.
1849, Mar. 27	Latitude N. 48°, longitude W. 22°.	1855, May 24	Trelawny.
1850, Mar. 30	Nassau.	1855, Aug. 25–26	Martinique; Santo Domingo.
1850, July 14–16	Islands of the south and west.		

The distribution of these hurricanes during the different months was as follows:

Month.	No. of hurricanes.	Month.	No. of hurricanes.
January	5	August	96
February	7	September	80
March	11	October	69
April	6	November	17
May	5	December	7
June	10		
July	42	Total	355

From 1856 to 1877 the occurrence of twelve hurricanes was noted by various writers, and the storms of that period complete an inexact record of hurricanes for nearly four hundred years.

From 1878 to 1900, inclusive, observations and data collected by the United States Weather Bureau permitted accurate tracings and descriptions of hurricanes that occurred over the Caribbean Sea, the West Indies, and adjacent waters, and the hurricanes thus described and traced will be made a base for determining facts regarding the movement and characteristics of storms of this class.

Movement of West Indian Hurricanes, 1878 to 1900, Weather Bureau records.

Date.	Latitude north.	Longitude west.	Appeared.	Latitude north.	Longitude west.	Recurved.	Disappeared.
May, 1889	22	65	North of Lesser Antilles	30	75	Off south Atlantic coast	Off south New England coast.
June, 1886	24	87	Off western Cuba	25	87	Gulf of Mexico	Middle Atlantic coast.
June, 1886	17	80	Caribbean Sea	25	89	Gulf of Mexico	Off middle Atlantic coast.
June, 1889	20	85	Caribbean Sea	23	86	West of Cuba	Off New Englaud coast.
July, 1886	19	83	Caribbean Sea	25	88	Gulf of Mexico	Mid Atlantic Ocean.
July, 1886	25	85	Gulf of Mexico	25	87	Gulf of Mexico	Mid Atlantic Ocean.
July, 1887	14	61	Windward Islands	21	89	Yucatan	East Gulf States.
Mean	20	80		24	88		
August, 1878	15	78	Caribbean Sea			No recurve	West Gulf.
August, 1879	16	65	Caribbean Sea	20	78	Cuba	South of Newfoundland.
August, 1879	20	90	Yucatan	25	95	Gulf of Mexico	South of Newfoundland.
August, 1880	15	80	Caribbean Sea			No recurve	Texas.
August, 1880	27	69	East of Bahamas			No recurve	East Gulf States.
August, 1880	18	58	East of Windward Islands	21	79	Cuba	Northeast of Bahamas.
August, 1880	26	61	Southeast of Bermudas	32	65	Near Bermudas	North of Bermudas.
August, 1881	20	63	North of Windward Islands			No recurve	Mississippi Valley.
August, 1883	22	58	Northeast of Windward Islands	33	70	West of Bermudas	Northwest of British Islands.
August, 1883	28	68	North of Windward Islands	34	70	West of Bermudas	Mid ocean.
August, 1886	11	59	East of Windward Islands			No recurve	Gulf of Mexico.
August, 1886	26	92	Gulf of Mexico			No recurve	Southeastern slope of Rocky Mts.
August, 1886	12	59	East of Windward Islands	22	80	Cuba	South of Iceland.
August, 1887	21	67	North of Porto Rico	28	79	North of Bahamas	North Sea.
August, 1887	17	58	East of Windward Islands	27	79	North of Bahamas	Mid ocean.
August, 1887	17	72	Caribbean Sea			No recurve	South of Cuba.
August, 1888	25	79		30	93		East of Newfoundland.
August, 1890	18	57		30	70		South of Nova Scotia.
August, 1891	14	59				No recurve	West Gulf of Mexico.
August, 1892	20	65		25	70		Northeast of Newfoundland.
August, 1893	22	57		27	77		Northeast of Newfoundland.

Movement of West Indian Hurricanes, 1878 to 1900, Weather Bureau records—Continued.

Date.	Latitude north.	Longitude west.	Appeared.	Latitude north.	Longitude west.	Recurved.	Disappeared.
August, 1893	21	61		28	75		North of Newfoundland.
August, 1893	15	66		30	75		Northeast of Newfoundland.
August, 1895	15	70				No recurve.	Rio Grande Valley.
August, 1899	16	60		27	80		South of Nova Scotia.
Mean	19	67		27	77		
September, 1878	11	60	East of Windward Islands	24	81	Florida	South of Iceland.
September, 1878	15	71	Caribbean Sea	19	73	North of Haiti	Northeast of Bahamas.
September, 1878	14	49	East of Windward Islands	25	60	North of Windward Islands	North Sea.
September, 1879	15	68	Caribbean Sea	23	87	Gulf of Mexico	Mid ocean.
September, 1881	25	70	North of Haiti	33	76	North Carolina coast	New England coast.
September, 1882	21	72	North of Haiti	25	88	Gulf of Mexico	Near Iceland.
September, 1883	15	66	Caribbean Sea	30	79	South Atlantic coast	South of lower Lakes.
September, 1884	14	47	East of Windward Islands	20	58	Northeast of Windward Islands.	Northeast of Windward Islands.
September, 1885	27	56	Northeast of Windward Islands.			No recurve	South of Nova Scotia.
September, 1885	24	89	North of Yucatan	25	93	Gulf of Mexico	Mid ocean.
September, 1885	23	97	West Gulf	23	97	West Gulf	Northwest of British Islands.
September, 1886	22	66	North of Porto Rico			No recurve	West of Bermudas.
September, 1886	14	62	Windward Islands	22	97	Gulf of Mexico	Middle Mississippi Valley.
September, 1887	13	57	East of Windward Islands			No recurve	Northern Mexico.
September, 1888	20	65				No recurve	Central America.
September, 1889	14	57		22	67		North Carolina coast.
September, 1889	14	69		25	92		New England.
September, 1894	16	60		23	82		Southeast of New England.
September, 1896	23	85				No recurve	North of St. Lawrence Valley.
September, 1897	25	83				No recurve	Texas.
September, 1897	22	85				No recurve	Newfoundland.
September, 1898	13	57		25	74		Bermudas.
September, 1899	15	64		21	74		Mid ocean.
September, 1899	17	61		25	67		Mid ocean.
September, 1900	13	63		24	95		Mid ocean.
Mean	18	67		24	80		
October, 1878	25	50	Northeast of Windward Islands.	32	52	Northeast of Windward Islands.	Mid ocean.
October, 1878	17	41	Northeast of Windward Islands.	18	55	Northeast of Windward Islands.	East of Bermudas.
October, 1878	25	72	East of Bahamas	25	73	Northeast of Bahamas	North of Europe.
October, 1878	17	81	Caribbean Sea	21	81	Cuba	South of Newfoundland.
October, 1879	16	71	Caribbean Sea	33	89	Mississippi Valley	Lake region.
October, 1880	25	61	North of Windward Islands	30	63	Southeast of Bermudas	Northeast of Bermudas.
October, 1881	25	60	North of Windward Islands	30	63	Southeast of Bermudas	Southern Europe.
October, 1882	20	83	Caribbean Sea	23	83	Cuba	Near Iceland.
October, 1883	30	65	South of Bermudas			No recurve	South Atlantic coast.
October, 1883	27	79	Bahamas	27	79	Bahamas	South of Iceland.
October, 1884	22	72	North of western Cuba	24	76	Bahamas	South of Newfoundland.
October, 1886	21	84	Caribbean Sea	30	95	West Gulf States	Middle Mississippi Valley.
October, 1886	17	70	Caribbean Sea	19	70	Santo Domingo	East of Newfoundland.
October, 1887	19	44	East of Windward Islands	20	58	Northeast of Windward Islands.	Mid ocean.
October, 1887	17	52	East of Windward Islands	25	56	Northeast of Windward Islands.	South of Newfoundland.
October, 1887	18	80	Caribbean Sea			No recurve	Gulf of Mexico.
October, 1887	15	78	Caribbean Sea	24	97	West Gulf	Northeast of Iceland.
October, 1889	15	61		28	68		Southeast of Newfoundland.
October, 1891	23	58		35	70		Northeast of Newfoundland.
October, 1891	16	63		18	70		Newfoundland.
October, 1891	20	83		21	83		Northeast of Newfoundland.
October, 1892	25	91		28	91		Newfoundland.
October, 1893	21	54		27	79		North of Newfoundland.
October, 1894	23	63		25	75		East of Newfoundland.
October, 1894	12	64		25	67		East of Newfoundland.
October, 1894	14	78		24	88		North of Newfoundland.
October, 1895	16	80		23	80		Bermudas.
October, 1895	23	83				No recurve	East of Newfoundland.
October, 1897	22	83		23	85		Off New England coast.
October, 1898	20	70		35	86		Newfoundland.
October, 1899	21	82		26	84		Newfoundland.
October, 1899	19	78		22	81		Newfoundland.
Mean	20	70		26	76		
November, 1878	13	51	East of Windward Islands			No recurve	Caribbean Sea.
November, 1879	15	68	Caribbean Sea	24	78		Mid ocean.
November, 1888	22	57		24	78		South of Newfoundland.
Mean	17	59		24	78		
December, 1885	15	76	Caribbean Sea	18	77	Jamaica	East of Iceland.
December, 1887	19	54	Northeast of Windward Islands.	33	62	East of Bermudas	South of Iceland.
December, 1887	25	62	North of Windward Islands	29	65	South of Bermudas	East of Bermudas.
Mean	20	64		27	68		

The following table shows, by months, the number of West Indian hurricanes that appeared, the average position in which they were first located, and the region in which they disappeared during the twenty-three years, 1878 to 1900, inclusive:

Month.	No. of hurricanes.	Appeared.		Recurved.		Disappeared.
		Latitude north.	Longitude west.	Latitude north.	Longitude west.	
May	1	22	65	30	75	Off south New England coast.
June	3	20	84	24	87	2 off middle Atlantic coast; 1 off New England coast.
July	3	19	76	23	88	2 off middle Atlantic coast; 1 over east Gulf States.
August	25	19	67	27	77	9 no recurve; see charted tracks.
September	25	18	67	24	79	6 no recurve; see charted tracks.
October	32	20	70	26	76	3 no recurve; see charted tracks.
November	3	17	59	24	78	See charted tracks.
December	3	20	64	27	68	See charted tracks.

The above table shows that 76 of the 95 West Indian hurricanes traced during the last twenty-three years had a recurve to the northward; that during the principal hurricane months, August to October, inclusive, the hurricanes generally recurved east of the Gulf of Mexico; and that, during these months, the mean track of the hurricanes was farther west in September, when it approached very near the east Florida coast. The figures in the table which summarize the mean courses of the hurricane for the several months can, however, be given but little weight, and a reference to the charted tracks will show that during the principal hurricane months these storms are liable to appear in any part of the region lying between the tenth and twenty-fifth parallels and east of the eightieth meridian, and to recurve from far to the eastward of the Bahamas to the west coast of the Gulf of Mexico. It is apparent, however, that the tracks run farther south and west in September, and hurricane visitations are, therefore, more probable on the Island of Cuba and on the United States coast in September; and this is equally true as regards the frequency of hurricanes on the more eastern islands of the Greater Antilles. The belief, founded upon local experiences, that the hurricane tracks shift farther west as the season advances, is doubtless well grounded; and it is safe to assume as a fact that the more severe storms of the West Indies usually occur over the Lesser Antilles and the eastern islands of the Greater Antilles in the early part of the hurricane season, and over the western parts of the Greater Antilles as the season advances.

The table, which summarizes by months the number of hurricanes which occurred during the 23-year period, 1878 to 1900, inclusive, shows a total of 95 storms, of which number 82, or about 90 per cent, occurred during the months of August, September, and October. The month of greatest hurricane frequency was October, with a total of 32, or about 34 per cent of the entire number. August follows with 25, and September with 25 hurricanes. The greatest number that occurred in any of the remaining months was 3, in June, July, November, and December. But one hurricane is noted for the month of May, and no storms of this class have appeared within the region of observation during the months of January, February, March, and April.

While the foregoing tables and accompanying charts show the individual and mean tracks of West Indian hurricanes it will be profitable to again briefly refer to the conditions and causes which appear to control the movements of these storms. These conditions and causes are outlined in Weather Bureau Bulletin A in part, as follows:

> The recurve of storms in the West Indies and over the Gulf of Mexico is dependent upon general meteorological conditions, and more especially upon the distribution of atmospheric pressure. The anticyclonic or high pressure area of the North Atlantic Ocean lies northeast of the West Indies, and causes east to northeast winds over the southern part of the ocean and the Caribbean Sea. The storms that develop in the region east of the West Indies, and also those of a more western origin, have a tendency to follow the course of the main equatorial current over the Caribbean Sea. This course is doubtless largely influenced by the general drift of the atmosphere in that region, and, following the anticyclonic circulation of winds, the hurricanes skirt the western quadrants of the Atlantic high area, and, carried by the general drift of the atmosphere, follow paths which recurve north and northeastward near the southeastern coasts of the United States. As a majority of the hurricanes traced followed the course indicated, it may be considered the usual course of West Indian storms when the usual meteorological conditions obtain over the southern and southwestern North Atlantic Ocean and the eastern part of the United States. Some of the more important storms that originate near the West Indies do not recurve to the northward but move westward over the Gulf of

Mexico and dissipate over Mexico or the Southwestern States. In such cases high barometric pressure to the northward apparently prevents a recurve.

Observation has shown that storms are commonly more violent in the region where they recurve or attempt to recurve. Observation has also shown that when the advance of a storm is obstructed, and it is forced or held back by an area of high pressure which persistently occupies the region through which the storm would pass with the prevalence of usual conditions, the storm acquires greater intensity before dissipating or assuming an abnormal course. Among notable storms of this class may be mentioned the hurricane of August, 1886, which totally destroyed the City of Indianola, Tex., and the hurricane of September, 1888, which raged with destructive violence over Cuba. These storms were apparently unable to recurve, owing to high barometric pressure to the northward. Forced westward they developed intense energy and dissipated, one on the southeast slope of the Rocky Mountains, and the other over eastern Mexico.

Aside from the fact that they commonly emerge from the region of equatorial rains, which lies between the Lesser Antilles and the African coast, little is known regarding the place of origin of West Indian hurricanes. It has seemed allowable in instances to assume that storms which have been encountered by vessels far to the eastward of the Lesser Antilles have subsequently visited the West Indies, but owing to the very meager amount of data which has been received from the tropical ocean such assumptions are not susceptible of proof. It is not improbable, however, that some of the West Indian hurricanes originate over the mid-Atlantic Tropics and even well over toward the Cape Verde Islands. The latitudinal limits of the region within which these storms originate may be safely represented by the parallels of eight and twenty degrees north, and it is believed that they have their origin along the line of the southern limit of the northeast trades. As the summer advances the North Atlantic area of high barometer settles southward over the eastern Atlantic, forcing the limit of the trade winds southward, and causing hurricanes to form farther and farther to the westward until October, when they develop or originate, over the eastern Caribbean Sea, or but a little distance east of the Lesser Antilles.

The manner of their origin is a matter of speculation and theory. The writer in an article published several years ago in the American Meteorological Journal stated that "Storms are incubated by heat and nourished by moisture." In the region of equatorial rains from whence these storms emerge are found all of the known and recognized elements which contribute to a storm's formation and subsequent intensity. The northeast trade winds strike an almost quiescent mass of exceedingly moist and warm air which possesses an initial upward or rising motion. The striking of the trades into this mass is calculated to cause atmospheric whirls or eddies, and when these whirls become sufficiently pronounced they develop into well-marked cyclonic disturbances, which, under the most favorable conditions, acquire hurricane intensity and are carried westward over the West Indies by the prevailing general wind currents.

The remainder of this paper will be devoted to descriptions of the more important hurricanes that have occurred in the West Indies, over the Atlantic Ocean, and along the North American coasts. A number of these descriptions, from 1873 to 1896, have been collected by Prof. A. J. Henry, of the Weather Bureau, and the record has been continued throughout the year 1899. Following these descriptions reference is made to some of the great and historical hurricanes which occurred prior to 1873.

AUGUST HURRICANES.

1. *Hurricane of August 14–27, 1873.*—The most destructive that ever visited the Atlantic coast, charted in Memorandum of Useful Information for Shipmasters, 1885, as Hurricane No. 1, of August, 1873. First reported by bark *Crest of the Wave* in latitude 14°, longitude 27°, August 13; in latitude 22°, longitude 60° on the 18th, noon; on the 19th, noon, latitude 22°, longitude 63°; 20th, latitude 27°, longitude 66°; 21st, latitude 30°, longitude 65.5°; 22d, latitude 35.5°, longitude 68.5°; 23d, in latitude 37°, longitude 67°; at midnight of the 24–25th the storm believed to have been in latitude 44°, longitude 56°; on 25th, at noon, central in latitude 44.5°, longitude 54.5°; noon of the 26th, latitude 44.5°, longitude, 50°; twenty-four hours later, in latitude 49.5°, longitude 54.5°. Proceeding

in a northwesterly course, it recurved between the islands of Bermuda and Cape Hatteras, taking a northeasterly course, its center at no time touching the coast line. Between sunset and sunrise of the 24th and 25th occurred the greatest destruction in the region of Halifax, Sydney, Charlottetown, and the coast of Nova Scotia, due to a terrific easterly wind, which, within twenty-four hours, backed from southeast to to northwest.

The marine losses from this storm amounted to 1,223 vessels, with 223 human lives. The region of coast which suffered most included Cape Breton, Gaspe, Labrador, Magdalen Island, New Brunswick, Nova Scotia, Newfoundland, and Prince Edward Island, where the damage and destruction affected breakwaters, wharfs, docks, bridges and railways, buildings, particularly churches, and to some extent, growing crops. A total of 897 buildings was reported destroyed, and a total money loss of $698,000 was reported, though in many instances the money losses were not estimated, the damage being stated as "great," "immense," or "incalculable."

2. *Hurricane of August 16–20, 1879.*—A severe Atlantic coast storm, most severe at Cape Lookout, with very high wind and high seas. Charted in Memorandum of Useful Information for Shipmasters, 1885, as Hurricane No. V, August, 1879. Course from about latitude 18.5°, longitude 60°, on 13th. On the 15th, latitude 20°, longitude 69°, north of Haiti; on the morning of the 17th about latitude 25.5°, longitude 76°. Storm center off the South Carolina coast the same date; Wilmington, N. C., on the 18th, then up the coast in a north-northeasterly direction, reaching the region of Nova Scotia on the 19th.

On the 18th the gale commenced at Wilmington, N. C., and at 5 a. m. was blowing west, 68 miles. At the same hour, at Cape Lookout, the wind had increased to southeast, 80 miles, with torrents of rain, and a fearful sea. At 6:30 a. m., at Cape Lookout, the barometer had fallen to 29.15 and the sea was increasing, the wind blowing 138 miles; the anemometer cups were carried away; at 7:30 the wind had reached its greatest velocity, estimated at southwest, 165 miles.

At Portsmouth, N. C., 6:30 a. m., the wind was southeast, 49 miles, and at 8:45 was southeast, 97 miles, when the recording apparatus was temporarily disabled. At Cape Hatteras the wind reached its maximum recorded velocity, southeast, 74 miles, when anemometer cups were blown away. At Kittyhawk, N. C., 9:30 a. m., the wind was southeast, 100 miles; Norfolk, Va., 10:45 a. m., barometer, 29.16, wind northeast, 48 miles; Cape Henry, Va., 11 a. m., wind north, 66 miles, when it moderated, then shifted to northwest, and increased to 70 miles; Atlantic City, N. J., 3 p. m., northeast, 60 miles, and at Barnegat, N. J., 5 p. m., north, 64 miles, with 5.39 inches of rain in nine hours.

In New England heavy rains and east and northeast winds prevailed during the preceding day. The storm commenced at New Haven, Conn., about noon, and had extended from New Bedford, Mass., to Portsmouth, N. H., by 8 p. m. At Easport, Me., 10:30 a. m., on the 19th, the barometer registered 29.20; wind northeast 34 miles. On the afternoon of the 19th the storm passed into New Brunswick.

The amount of damage could not be estimated. Inland property in the track of the storm was damaged extensively, while the marine losses must have been enormous, as 100 large vessels and 200 small craft were wrecked or injured, not a few of the latter being pleasure yachts. Highest wind velocity in New England, as reported, 54 miles at Thatchers Island, Mass., and Eastport, Me. The storm was especially interesting on account of the rapid and extreme fluctuations of pressure, with attending phenomena, near the immediate center.

3. *Hurricane of August 22–26, 1881.*—A destructive hurricane which was very general in extent, striking the coasts of Georgia and South Carolina, and passing inland in a northwesterly direction; it finally crossed Minnesota and entered the British Possessions.

The center of the storm was reported at St. Thomas at 3 a. m., August 23, and at Turks Island, W. I., 3 p. m., on the 24th. The first indications of the storm on the United States coast were noted on the 26th, the greatest violence being manifested on the 27th, in many localities there being no abatement until the morning of the 28th. In the Charleston, S. C., report it was stated to be "the most violent since the great storm of August, 1874," and Savannah, Ga., reported that "the memor-

able storm of 1854 was not so violent or prolonged." (See close of account of September hurricanes, in this article).

The storm was unusually severe all along the coast line from Georgia to North Carolina, extending as far north as Cape Fear, the sea islands in many instances being submerged with great loss of life, and destruction to property and crops, while all islands in the track of the storm were devastated to a more or less extent.

The damage to property in Savannah, Ga., was estimated at $1,500,000, with a loss of 335 human lives. Lives were also lost at other points along the coast, and cattle, horses, and other stock destroyed. The terrible destruction was due to unusually high winds and high water, and to the long continuance of the winds at hurricane force. The storm was accompanied by torrents of rain. There were a few reports of losses in the interior, particularly at Montgomery, Ala.

On the morning of the 29th the storm center was near Memphis, Tenn., heavy rain having fallen along the path of the cyclone. The next morning the center had moved into Iowa and thence to the northeast.

Five storms during this month are noted in the Jamaica Meteorological Observations, Vol. I, this storm being No. 3 of the Jamaican account.

4. *Hurricane of August 23–24, 1885.*—Another destructive hurricane which particularly affected the coasts of Georgia and the Carolinas, the reports showing that it was also violent at sea, from the 23d to the 26th.

On the 23d the schooner *E. B. Conwell* encountered a hurricane off the Florida reefs. The midnight map of the 24th showed the center of cyclone near Savannah, Ga. At 7 a. m. of the 25th it was near Charleston, S. C., and west of Smithville, N. C. At midnight it was northwest of Wilmington, N. C., and west of Hatteras, N. C., and on the 26th had passed off the North Carolina coast. The winds attending the cyclone were terrible in their force along the south Atlantic coast, and high winds (25 miles) were mentioned at all stations on the coast from Florida to Massachusetts. The following high velocities are noted: Savannah, Ga., 56 miles; Tybee Island, Ga., 75 miles; Smithville, N. C., 98, miles, estimated 125 after anemometer cups were blown away; Hatteras, N. C., maximum velocity of 52 miles.

The greatest destruction occurred at Charleston, S. C., where the damage was estimated at $1,690,000, and the loss of life was placed at 21 persons. At Smithville, N. C., the damage to town and county amounted to $100,000. At Savannah, Ga., it was said to be the most severe storm since August 27, 1881.

5. *Tropical hurricane of August 13–20, 1886.*—The first appearance of this storm was over the eastern portion of the Caribbean Sea on the 13th. It then moved north of west into the Gulf of Mexico on the 18th. The storm passed over Cuba on the 17th, where it was very severe. On the 19th it had appeared on the Gulf coast at several points in Texas, notably at Indianola, where at midnight the wind was blowing northeast, 40 miles, and in eight hours had increased to 72 miles. The storm was raging at 7 a. m. on the 20th. The wind was at that hour northeast, 49 miles, at Galveston, and northeast, 20 miles, at San Antonio. At 2:40 p. m., at San Antonio, the barometer registered 29.03, with a wind velocity estimated at over 80 miles per hour. The storm center was over San Antonio at 3 p. m., and the storm passed away with southeast winds.

The damage was most severe at Indianola, where no house remained uninjured, and many were swept away. Those which remained standing were generally in an unsafe condition. Among the buildings destroyed was the Signal Office, the observer losing his life in attempting to escape. More than 20 other lives were lost at Indianola. In Galveston the damage to property was estimated at $150,000, and more than 160 houses were damaged or destroyed. At Victoria 40 buildings, including 6 churches, were totally destroyed, and a loss of $100,000 was reported. Other towns in this region suffered to a more or less extent, and some interior towns felt the force of the storm to the extent of considerable losses.

6. *The Martinique cyclone of August 18, 1891.*—One of the most disastrous of West Indian cyclones, but which was confined to the region south of latitude 25°.

The storm continued four hours at Martinique, from 6 to 10 p. m. During the day there was a fresh northeast breeze, with a rapidly falling barometer, the wind steadily increasing in force. The storm struck the island at 6 p. m., the wind veering from east-northeast to south-southeast, and was most severe from the latter point; it was accompanied by thunder and lightning, and at its conclusion there were two distinct shocks of earthquake at intervals of five seconds. Two immense waves were noted in the vicinity of Caraval Rock (from a calm sea), passing from the direction of St. Lucia. The storm is charted in the Monthly Weather Review for August, 1891, as follows:

18th, Martinique.—Passing in a north-northwesterly course it was midway between Martinique and Porto Rico on the 19th; north of Grand Turks Island, West Indies, about midnight of the 21st; over Crooked Island, Bahamas, evening of 22d, and on the 24th was south of Cape Florida, latitude 24.5°, longitude 60°.

This storm did not affect any portion of the coast of the United States, though the reports at hand indicate that it moved westward with diminished energy over extreme southern Florida on the 24th, passing thence into the Gulf of Mexico. Its greatest severity was felt on the Island of Martinique at sea level, the elevated plains escaping with the minimum of damage. Seven hundred lives were lost at Martinique, and property to the value of $10,000,000 was destroyed. Some 50 vessels were wrecked, including sail of all classes. At Grand Turk 3 persons were drowned, the property losses being confined to small houses and sailing vessels.

7. *Hurricane of August 25–30, 1893.*—This was the very destructive hurricane which devastated the sea islands off the coasts of Georgia and South Carolina on the 27th and 28th, and which passed into Canada on the 30th.

The depression was felt as early as the 22d in north latitude 22°, west longitude 56°, where an uncommonly low pressure, 28.70, was reported, the storm being already fully developed. In the Weather Review account for the month it was stated that "its earlier history is yet quite problematic, but it is likely to be similar to that of the great Nova Scotia hurricane of August, 1873, started by a flow of dry air from northern Africa westward into the ocean."

The storm followed the general track of West Indian cyclones, save that it was developed in a higher latitude. The center had reached the Bahamas by the morning of the 26th, passing 100 miles northeast of Nassau, although the heavy waves which extended outward in all directions, from a hurricane center, were noticeable on the 25th at Savannah, Ga. On the 26th, at 8 p. m., the storm was central northeast of Jupiter Inlet, and on the afternoon of the 27th the center had reached the Georgia coast, the storm carrying death and destruction in its path. By 3 p. m. of the 28th the center was northwest of Charlotte, N. C., and on the morning of the 29th was near Oswego, N. Y., having moved 450 miles in twelve hours. Twelve hours later it was a little east of Quebec, possibly within the borders of Maine, and the next morning had moved into the St. Lawrence Valley; it was probably broken up in the vicinity of Newfoundland on September 1.

This was one of the most destructive storms to life and property that has visited the South Carolina and Georgia coasts in many years. The storm struck the islands in the vicinity of Charleston, S. C., and Savannah, Ga., on Sunday, the 27th, and from the fact that it was accompanied by a tremendous wave which submerged the islands, the loss of life was appalling, while the value of property destroyed ran into millions. Beaufort and Port Royal, S. C., felt the effects of the storm probably to a greater degree than other localities, although the destruction between Tybee Island, Ga., and St. Helena Island, S. C., was general. The money loss first and last, doubtless, amounted in the aggregate to $10,000,000, and at least 1,000 people, largely negroes, lost their lives.

Harper's Weekly for September 16, 1893, contains the following statements which are interesting:

The best built houses in Savannah were drenched inside and shaken without. * * * Savannah was severely hurt, but her distance from the sea, the fact that she is landlocked 18 miles up the river, closely built, resting upon a bluff 45 feet above the water level, gave her some immunity from the ravages inflicted upon Charleston and

Port Royal. Her parks and shade trees were damaged; roofs along the bay were torn away; the Tybee Railroad (17 miles) was almost a total wreck. * * *

Port Royal harbor is broad and exposed. That city, with the beautiful residence town of Beaufort, was swept and battered, and the work of repair must be long and costly. Port Royal received the full shock of the storm. It was off Port Royal the steamer *City of Savannah* was wrecked. The Government dry dock is a wreck. Phosphate works are dismantled and the sea rolled over railroad tracks and piers.

The ravage at Charleston was terrific. The loss to shipping off Tybee Island was greater than elsewhere, because Savannah's shipping is larger than all southern ports combined. * * *

Hundreds of corpses were strewn along the farms, unknown save to the vultures which flocked about them. Whole families are wiped out in some places. The coroner has sworn in an army of deputies and these are hunting for the dead.

8. *Hurricane of August 7, 1899.*—This hurricane appeared east of Martinique on the morning of August 7, 1899, and during the afternoon and night of that date devastated the more southern of the Leeward Islands of the Lesser Antilles. During the 8th the storm caused the loss of hundreds of human lives and destroyed millions of dollars worth of property in Porto Rico. Moving thence north of west the disturbance crossed the Bahama Islands during the 11th and 12th, attended by a considerable loss of life and property, and from the 13th to the 17th skirted the South Atlantic coast of the United States, after which it disappeared in the direction of Newfoundland. At Porto Rico and at Hatteras, N. C., where its vortex passed near regular reporting stations of the Weather Bureau, the hurricane was of exceptional severity, and at Hatteras, N. C., it was the most severe storm within the recollection of the oldest inhabitants.

SEPTEMBER HURRICANES.

1. *Cyclone of September 26 to 27, 1874.*—Very generally compared to the hurricane of 1854, described on another page.

On the 25th the storm center was reported south of Louisiana, possibly nearer Yucatan or Mexico; during the night of the 27th and 28th the center passed in a northeasterly direction over upper Florida to the coast of Georgia, pursuing a track medial between those followed by storms Nos. VI and VII of September, 1873, as charted in the Weather Review for that month.

The track of the storm followed a generally north-northeasterly direction. As charted it was south of Lake City, Fla., on the 27th at 11 p. m.; the morning of the 28th it was north of Jacksonville, Fla.; on the afternoon of the 28th it had passed into North Carolina; on the morning of the 29th was west of Norfolk, Va., when it crossed Chesapeake Bay, and on the afternoon of the 29th had passed New London, Conn.; on the morning of the 30th the center was in Maine at a point due east from Mount Washington, and by the afternoon of the 30th had passed over Canada and was lost sight of at the mouth of the St. Lawrence. The highest winds were: Savannah, Ga., northwest, 36 miles; Tybee Island, east, 60 miles; Charleston, S. C., east, 51 miles, and northwest, 48 miles; Cape Hatteras, southeast, 75 miles; Wilmington, N. C., southeast, 45 miles, and southwest, 50 miles; Cape Henry, 50 miles. Lowest barometric pressure: at Charleston, S. C., 1 p. m., 28th, 29.06; at Portland, Me., 7:35 a. m., 30th, 29.05; at Boston, Mass., 4 a. m., 29.13, and at Eastport, Me., three hours later, 29.20. The amount of losses on account of the destruction of property was not reported.

2. *Hurricane of September 15, 1875.*—Referred to in the Weather Review as "the most severe which has occurred in the United States since the establishment of the weather service."

First observed in latitude 13°, longitude 17°, thought to have originated east of Barbados, where a severe storm occurred on the morning of the 9th. On the 12th the storm had reached the eastern portion of Cuba. Violent hurricane raged at Santiago de Cuba on the 13th; on the morning of the 14th the center of the disturbance had passed to the westward of Key West, Fla., and Havana, Cuba. At Indianola, Tex., the wind had increased to a gale at noon of the 15th, and by midnight was blowing north-northeast, 60 miles. Hourly observations taken from 1 a. m. to 5 p. m. showed the wind fluctuating, but gradually increasing, from 56 miles to 82 miles. About 5:15 the registry

was 88 miles, when anemometer cups were carried away. The tide rose rapidly through the night of the 15th, the water breaking over the beach, and on the morning of the 16th was rushing in torrents through the streets. The local reporter states that by the night of the 16th "the volume and immense velocity of water pouring through the streets was truly terrible." The rain and wind increased up to midnight, when the wind velocity was estimated at 100 miles. The tide began to abate soon after midnight, the wind gradually backing to north and northwest, and a little later was sweeping out to the bay with irresistible force from the overflowed country extending miles inland. This was a new source of danger, as the buildings which had withstood the effects of the northeast storm, though racked and weakened, were unable to stand against the terrific force, in a cross direction, now brought to bear upon them. The morning of the 17th opened cool and cloudy, with a gale still blowing from the northwest, when it was known that three-fourths of the houses in the town had disappeared, with a loss of 176 human lives.

By the afternoon on the 17th the storm center was north of Galveston, Tex., when its course changed to easterly. On the morning of the 18th it was in the vicinity of the Mississippi River, when its course again changed to northeast, cutting the coast line on the morning of the 19th just above Norfolk, Va. During the easterly movement the center of the depression gradually changed to an elongated ellipse and the velocity of rotation was materially retarded, while the center remained on the continent.

3. *Hurricane of September 12–17, 1876.*—The storm center of this cyclone approached the Windward Islands from the southeast on the 12th; passed over Porto Rico on the 13th, with great destruction to property and crops; barometer at San Juan, 8:30 a. m., 29.49; wind north-northeast. Light hurricane reported at Santiago de Cuba on the 14th, which struck the Bahama Banks on the 15th, passing close to the east coast of south Florida. On the 16th it was about due east of Savannah, Ga., striking the North Carolina coast on the 17th in the early morning, though its near approach was perceptible late in the afternoon of the 16th. The anemometers at Wilmington, N. C., and Cape Lookout at the height of the storm, when both were disabled, recorded, respectively, north, 60, and southwest, 73 miles. At Hampton, Va., the lowest reading of the barometer was 29.10 at 1.20 p. m. of the 17th, the wind veering from northeast to southeast, and about three hours later, to south. At Washington, D. C., the barometer registered 29.15 at 4:35 p. m. One hour later the wind shifted from east to west, with a maximum velocity of 36 miles. In the passage of the storm along the south Atlantic coast, especially from the 16th to the 18th, very heavy easterly gales prevailed from Hatteras to Cape Cod. A peculiarity of this storm was its deflection to the northwest instead of the northeast, after striking the Atlantic coast, accounted for by an area of decidedly high pressure north of the Alleghenies on the 17th, and consequent heavy rains over the Middle States, with northwest winds.

4. *Tropical hurricane of September 21 to October 5, 1877.*—On the 21st the storm passed over or near Barbados, St. Vincent, and Grenada; 22d and 23d was 250 miles south of Porto Rico; 23d over Buen Ayre and Curaçao, where destruction to the extent of $2,000,000 and large loss of life was reported. In the City of Curaçao the most solid buildings were swept down by the waves. On the 28th it passed, in a northwesterly course, about midway between the west end of Cuba and the coast of Honduras. The vortex of the storm struck the coast of Florida near St. Marks at 11 p. m. on October 2, showing very slow progress. The wind reached a velocity of 66 miles per hour at 5:15 a. m. of the 3d at St. Marks, the tide rising 12 feet above the mean; barometer at 6:15, 29.17, wind southeast, gradually veering to southwest. High water was reported at Jacksonville, Fla., on the 2d. The storm passed northeastward over Georgia on the 3d, with the barometer at Augusta at 11 a. m. 29.35. On the night of the 3d and the morning of the 4th it passed over the Carolinas and Virginia, southeast gales prevailing along the coast. The storm was terrific in the vicinity of Albemarle Sound, the attending floods carrying away all the bridges and wharfs; crops were severely damaged along the James River. It passed Chesapeake and Delaware bays on the 4th, wrecking several vessels. The night of the 4th it appeared along the north shore of Long Island, and on the morning of the 5th the storm

center was about two degrees south of Cape Cod; at midnight it was four or five degrees southeast of Cape Breton.

In southeastern Pennsylvania, northern New Jersey, and along the Hudson River passenger trains were wrecked by washouts, resulting in great loss of life and property. In the region of Long Island the storm was very severe, several vessels having been wrecked. The damage in the Southern States traversed by the storm resulted largely from freshets and high tides, which were particularly destructive to cotton and rice crops.

5. *Tropical cyclone of September 1–13, 1878.*—This storm is particularly interesting, not only on account of its unusual track, but on account of its force and the attendant destruction of property throughout its course, which began near the Island of Trinidad, traversing the south Atlantic coast States, and proceeding almost due north to the Great Lakes, where it was very severe, finally disappearing in Canada.

It originated considerably to the eastward of Trinidad (probably near the Cape Verde Islands) and was central over that island at midnight of the 1st and 2d, when the storm began about 7 p. m. of the 1st and continued over twenty hours. Lowest reading of the barometer, 29.05, wind veering from northwest to southwest, and 7 inches of rainfall recorded; earthquake shocks also reported. On the night of the 2d and 3d it was central in latitude 15° north, longitude 68.5° west; on the 4th passed over Haiti and Santo Domingo; entered Cuba the night of the 4th and 5th near Guantanamo, leaving it near Cardenas. Although the center of the storm passed Cuba on the night of the 6th and 7th the barometer continued low until the 11th. On the 7th the storm entered Florida east of Key West, and during the next three days, up to the 10th, it slowly moved in a northerly course over the middle of the State. The gale was at its height at Jacksonville on the 10th, with the wind northeast, 40 to 48 miles. The vortex probably moved over Tybee Island on the 11th, though the gale lasted at this point from the 7th to the 12th. The total movement of air from the 8th to the 12th, inclusive, was 3,474 miles, and the total rainfall 5.61 inches. The center of the storm was located in South Carolina on the afternoon of the 12th. At 11 p. m. of this date a belt of low pressure extended from the Carolina coast to Lake Erie, the lowest pressure on the morning of the 13th being recorded at Buffalo, N. Y. The following wind velocities were reported at cities in the Lake region: Sandusky, Ohio, northeast, 48 miles; Cleveland, Ohio, west, 48 miles; Erie, Pa., west, 48 miles; Buffalo, N. Y., southwest, 45 miles; Rochester, N. Y., west, 30 miles. The storm passed off into Canada on the 13th.

This cyclone was particularly destructive in Trinidad where it destroyed buildings, bridges, and other structures, wrecked all vessels in the harbor and swept away entire plantations. Severest storm in forty years. Similar destruction was recorded in Haiti and Santo Domingo, where there was considerable loss of life, particularly in the towns, and where entire coffee and cocoa crops were destroyed in some localities. In Cuba the storm was attended with great and destructive inundations and remarkably heavy rainfall.

In Georgia and South Carolina there were likewise floods and inundations, attended with great destruction of property. The Georgia rice crop was damaged to the extent of $400,000. In the cities streets were flooded and business was suspended.

To the northward, over a wide extent of country, rivers and streams were dangerously swollen, resulting in washouts and damage to embankments, bridges, and railway trestles, and to docks and wharfs on the water front, while the farmers suffered everywhere. Stock, lumber, hay in the stack, and crops, generally, were washed away; and in town and country alike all kinds of property was destroyed by the terrible floods. The same widespread destruction attended the passage of the storm through Canada, as shown by the reports from Canadian observers.

6. *Hurricane of September 2–15, 1882.*—The movement of this storm was first noted at 10 a. m., September 2, at Grand Turk Island, with the barometer indicating 29.79, and wind strong northeast, shifting on the 3d to strong southwest. The center passed south of Isabella de Sagua, Cuba, during the evening of the 4th; at Cienfuegos, 11:30 a. m., on the 5th, the barometer had fallen to 29.13; wind,

west-southwest, blowing with great force; vortex went south of Havana between 12:30 a. m. and 2 a. m. of the 6th, wind east-northeast, 67 to 85 miles. After leaving the Island of Cuba the hurricane began to recurve toward the north and was encountered by the ship *City of Alexandria*, between 6 and 7 p. m. of the 6th, in latitude 22.5° north, longitude 85.4° west. The *City of Alexandria* on the 10th, 11th, and 12th, became again involved in the storm after it had recurved to the northeast. From the 6–10th the storm was encountered by many vessels while recurving to its north-northeast course before striking the coast of the United States. On the 9th the storm center was not far distant from Port Eads, La., where, during the day, the barometer fell to 29.39, with the wind northeast, 92 miles; the vortex passed just east of Pensacola, Fla., at midnight, with barometer 29.35. By the 10th the storm had increased in size, but decreased in energy, and had moved in a northeasterly track over Alabama, Georgia, and South Carolina. At Savannah, Ga., the barometer stood 29.56, and at Charleston, S. C., 29.60. The storm crossed North Carolina on the 11th in a northeasterly path, and still showed great energy. While the storm track left the coast on the afternoon of the 11th, the northern coast cities felt its influence by high winds, resulting in considerable damage to shipping. The storm track was about two degrees east of Cape Cod on the morning of the 12th, and by afternoon had again struck the continent near Halifax.

Considerable damage was reported in Cuba, particularly at Villa Clara and Cienfuegos. In Tuskeegee, Ala., 1,000 trees were blown down and crops damaged to the extent of $50,000. At Port Eads, La., the railway was destroyed and the jetty walls badly damaged, and New Orleans, La., likewise felt the force of the storm. The damage was slight at Savannah, Ga.; at Athens, Ga., many trees were blown down and some property washed away. The losses at Cedar Keys, Fla., footed upward of $100,000, and in other portions of Florida there was more or less destruction to property and to crops, particularly cotton. In South Carolina some buildings were destroyed and crops injured, chiefly in interior towns. Similar reports come from Virginia, the losses being considerable along the James River, which broke over its banks. In New England, coast cities reported high winds, with torrents of rain and some damage to shipping. Timely warnings had been sent out from the Signal Office, however, through which a vast amount of destruction to shipping was prevented by the vessels remaining in harbor. This saving was estimated by the office to have amounted to $13,000,000, as was afterwards reported by station observers.

7. *Hurricane of September 4–5, 1883.*—Referred to as the September northern cyclone (Jamaica Meteorological Observations, Vol. I).

First observed at St. Pierre, Martinique, afternoon of the 4th, and by the morning of the 5th had entered the Caribbean Sea. Passed over Dominica 1 a. m. of the 5th, with barometer 28.98, wind north-northeast and south-southwest; was accompanied by a shock of earthquake; was encountered by vessels in the Mona passage on the 5th. During this date the center moved slowly westward south of Porto Rico and by midnight the vortex was near Santo Domingo; on the morning of the 6th had crossed north latitude 20°, and was just eastward of Cuba; on the 7th was in the Bahamas, on a line a little south of east from Havana. The cyclone passed over Nassau at 2 p. m. on the 8th, with the barometer 28.87, wind north-northwest and west, and on the 9th was probably central near Abaco Island. During its progress from the Bahamas the center did not appear to deviate from a northerly course as its violence was not felt on the coasts of Florida, Georgia, and South Carolina, nor by vessels that were east of the seventy-fourth meridian, though the storm was very disastrous to vessels between Hatteras and Wilmington, N. C. The storm showed considerable force along the North Carolina coast on the 9th, and at Fort Macon and Cape Lookout, N. C., the wind was blowing from northeast, 60 miles an hour, on the morning of the 10th, and by afternoon of that date was blowing 75 miles an hour. Other coast cities also reported high winds, high tides, and heavy surf. Central near Cape Hatteras on the 11th, when it passed north to Nova Scotia. After the 10th, 11th, and 12th the winds remained high over the ocean from west longitude 75° eastward to the sixtieth meridian, but the pressure increased to 30.00 and above. While not a very destructive storm it did great damage to shipping in

Martinique and considerable land damage at Dominica. In the Bahamas over 100 vessels were wrecked or disabled and at least 50 lives were lost. In North Carolina there was some damage to buildings and crops and some vessels were driven ashore, many having been saved, however, through the timely warnings of the Signal Office. Immense damage was reported at Halifax.

8. *The great Cuban cyclone of September 1–7, 1888.*—This storm did not enter the United States, but pursued a westerly course from latitude 20° north to longitude 63° west, striking the northern coast of Cuba in longitude 77° west, passing to the southwestern end of the island, and pursuing a nearly west-southwest direction, swept the northern coast of Yucatan, striking the Mexican coast between Vera Cruz and Coatzacoalcos about two degrees south of latitude 20°, and the same west of the ninety-fifth meridian. The chronology of the storm is as follows: First indications were noted in the northeast trade wind belt east of the sixtieth meridian on the 30th and 31st of August; noon of September 1 found the hurricane center north of the western end of Porto Rico; on the 2d it was over Turks Island, and by noon of the 3d to the northward of Great Inagua Island, with the barometer 28.70. At noon of the 4th the center was off the coast of Cuba just east of Sagua, the barometer registering 28.90 at 9 o'clock in the morning. The center left the western extremity of the island during the 5th, and on the 6th was over northern Yucatan, reaching the Mexican coast by the night of the 7–8th. This storm was remarkable both on account of its exceptional energy and by reason of the abnormal path it pursued after having advanced toward the eightieth meridian.

At Turks Island more than 250 houses were destroyed, with other valuable property, including 400,000 bushels of salt; and 21 human lives were lost. The greatest destruction was reported from Cuba, where the losses to property ran up into millions of dollars, and the loss of 800 lives was recorded. The principal buildings in the cities were destroyed, and whole towns near the seaboard swept out of existence by the gigantic seas which overwhelmed them. In Mexico, particularly along the coast, there was also great damage.

9. *Tropical storm of September 6–14, 1888.*—The great Cuban cyclone was immediately followed by a depression which was central over the Bahamas September 4. It was observed near Jupiter, Fla., afternoon of the 7th, moving slowly northwestward, recurving near latitude 30°, in the vicinity of Cedar Keys on the night of the 8th. On the afternoon of the 10th, central near Norfolk, Va., after which it followed the Middle Atlantic and New England coasts, attended with dangerous gales, and proceeded as far as Boston, Mass. From New England it moved directly northward to the St. Lawrence. Lowest pressure, 29.50, at Cedar Keys, Fla., on the 8th, with the wind 60 miles. The Jamaica Meteorological Observations for September, 1888, says "that this storm vanished midway between Newfoundland and Ireland." No special damage was reported.

10. *The St. Thomas-Hatteras hurricane of September 3–12, 1889.*—From the reports of vessels sailing to the eastward of the Windward Islands, this storm is thought to have been central September 1 in latitude north 14° and longitude west 57°. Passed over St. Christopher during the night of the 2d; barometer 29.50, wind northeast. The storm was central near St. Thomas on the 3d, and near to and north of Porto Rico on the 4th, while on the 5th it had moved about two degrees in a northwesterly curve away from Porto Rico. Marine observations on the 6th indicated two centers of disturbance, one passing northward from north latitude 22°, west longitude 67°, the other passing west-northwesterly from the same point. The latter depression was central in north latitude 28°, west longitude 77°, on the 6th, but was traced no farther, while the easterly disturbance was central in north latitude 29°, west longitude 66°, on the 6th. It now recurved to the northwest, and was one and one-half degrees farther north and two degrees farther west on the 7th. On the 8th it appeared in north latitude 32° and west longitude 68°, and on the 11th the center had reached north latitude 38°, west longitude 67.5°, being charted eastward of Chesapeake Bay. The storm track at this point recurved sharply to the southwest, apparently forced to this course by the area of high pressure to the northward, and was some distance off Hatteras, N. C., on the 12th, its course being traced no farther. Considerable disturbance was noted all along the coast from North Carolina to New England, with

violent storms and high tides. The losses footed up between two and three million dollars, falling heavily upon the railroad and ship owners. The storm was especially severe in the West Indies, and there were reports of great damage to crops over many of the islands lying in its track.

11. *Hurricane of September 26–30, 1896.*—First reported from the northwest of Cuba on the 26th. By the morning of the 28th the center had moved to the Florida coast, wind southeast at Key West. By the 29th it had entered southwestern Georgia and was increasing rapidly in intensity. By 8 p. m. of the same date it was central over Lynchburg, Va., barometer 29.30, the storm reaching the District of Columbia about three hours later. On the morning of the 30th the storm center had moved to Lower Michigan, when its course was deflected and it passed to Lake Ontario and the St. Lawrence Valley, in a northeasterly direction. Its passage from Key West to Canada occupied twenty-four hours, showing a uniform rate of progression of 46 miles per hour. The path of its destruction did not extend more than 50 miles in width in any part of its course. The greatest violence was manifested in Florida during the early morning of the 29th. A second period of violence began in Virginia about 9 p. m. and lasted until midnight in Pennsylvania. Following a lull, there was a third renewal of intensity during the early morning hours of the 30th in Cayuga and Cortland counties, N. Y.

The loss of life and property in the States traversed by the storm is given in the following table from the Monthly Weather Review for September, 1896:

State.	Loss of life.	Loss of property.
Florida	68	$2,225,000
Georgia	25	933,000
South Carolina	5	25,000
North Carolina	0	20,000
Virginia	5	695,000
District of Columbia	1	443,000
Maryland	8	500,000
Pennsylvania	2	2,140,000
New York	0	50,000
Total	114	$7,031,000

This storm is remembered as one of the most severe of the West Indian hurricanes that has swept the country, its severity being specially marked in Florida and Pennsylvania, while in the District of Columbia it was one of the worst storms on record.

Hurricane of September, 1854.—Several hurricanes of unusual violence, during the part of two decades, have been compared to the hurricane of 1854. Several such references are found in the Monthly Weather Review. Authorities for the 1854 hurricane are Baldwin, Pasey, and Blodgett (page 400, —— Climatology).

The storm extended from September 6 to 14. First noted off Cape Florida on the 6th; at Jacksonville, Fla., on the 8th; appeared at Charleston, S. C., on the 9th; Norfolk, Va., on the 10th, and Boston, Mass., on the 11th. The central line was doubtless some distance off the coast, though the interior was visited with tremendous rainfall. Terrific gales marked its passage in the Gulf Stream. Barometer at Savannah, Ga., 29.04. The general direction of the wind was northeast. At sea the series of gales continued to latitude 54° and longitude 35°, with many wrecks of vessels. Washington, D. C., Philadelphia, Pa., and New York, N. Y., felt the effects of the storm, and in Philadelphia many buildings were prostrated. At Charleston, S. C., and Savannah, Ga., it was more destructive, as regards inundation, than any previous storm for many years:

> The wind was strong and constant from the northeast through the 6th and 7th and the morning of the 8th, when it changed to southeast with equal severity. The waters subsided on the 8th and 9th, with strong southwest winds. It was a hurricane at northeast through the whole of the 8th at Savannah.—*Blodgett.*

No accounts showing losses of life and property are available, though reference is made to a paragraph in the Monthly Weather Review for August, 1881, relating to the hurricane of that month and year, in which a comparative reference is made to the 1854 storm:

Damage to property in the city (Savannah) is estimated at $1,500,000. On the morning following the storm there was presented the most terrible scene of wreck, ruin, and death that was ever witnessed within the memory of the oldest inhabitant. The memorable storm of 1896 was not so violent or prolonged.

12. On September 10 and 11, 1898, a hurricane visited the Windward Islands of the West Indies. This storm was particularly destructive throughout the Island of Barbados, where 83 persons were killed, 150 injured, and property to the estimated value of $2,500,000 was destroyed. At St. Vincent and St. Lucia the violence of the hurricane during the 11th equaled, or exceeded, that manifested at Barbados the night of September 10. After the 11th the hurricane center moved northwestward with a very marked loss of strength, and finally disappeared east of the Bahamas during the 14th of September.

13. On the morning of September 8, 1899, a storm of pronounced energy appeared east of the Island of St. Kitts, from which position it moved northwestward until the 10th, when it began to recurve to the northward. During the 11th and 12th the recurve changed to the northeastward and the storm passed over the Bermuda Islands during the night of the 12–13th. This storm was quite severe over the more eastern islands of the Leeward group of the Lesser Antilles during the evening and night of the 8th, and also over the Bermudas during the night of the 12th.

14. *The Galveston, Tex., cyclone of September 8, 1900.*—This was the severest and most destructive hurricane in the storm annals of the Western Hemisphere. It apparently originated in the vicinity of the Windward Islands of the West Indies August 31, and from that region moved westward over the Caribbean Sea during the first three days of September without evidence of marked energy. During the 4th it recurved northward over Cuba, passing just east of Havana, and during the 5th advanced slowly toward the extreme southern point of Florida. During the day and night of this date the storm acquired marked strength and caused the loss of a number of vessels, mostly small sailing craft, on the keys and coast of southern Florida. It did not, however, attain hurricane intensity until the 6th, when it began its westward course across the Gulf of Mexico. Only one vessel is known to have encountered the hurricane during its course over the Gulf and this vessel was the Cromwell Line steamship *Louisiana*. The captain of the *Louisiana* reports that he passed through the center of the storm at 1 p. m. of the 6th when about half way across the Gulf, on a course from New Orleans to the southern point of the Florida Peninsula. At that hour his barometer showed a reading of 28.75 inches, and he estimated the wind velocity at over 100 miles an hour. The gales along the middle coast of the Gulf of Mexico, while severe, were not especially destructive, and it was not until Galveston was reached, during the evening of the 8th, that the full force of the storm was again experienced. The center of the vortex of the hurricane passed some miles south and west of Galveston shortly after 8 p. m., seventy-fifth meridian time, attended at Galveston by a barometer reading of 28.48 inches. This is the lowest reading of the barometer ever reported in the United States. After having registered a wind velocity of 100 miles an hour the anemometer cups were blown away at 6:15 p. m. Between that time and 8 p. m. the wind reached an estimated velocity of at least 120 miles an hour.

In Galveston, out of a population of about 40,000, fully 6,000 were drowned or killed, $20,000,000 worth of property was destroyed, and not a building in the city escaped injury. The loss of life and property was caused principally by a storm wave which, in connection with the high water blown in by the wind, flooded the city and island of Galveston to a depth of 6 to 15 feet. Thousands of lives were saved through the action of the local Weather Bureau officials in disseminating, by every possible means, warnings of the character of the impending storm. At the risk of their own lives—and one of their number perished with his family—they warned the population to seek the higher parts of the city. After all that human endeavor could accomplish in this direction had been done the official in charge, Dr. I. M. Cline, reached his own home, which was an uncommonly strong structure, and gathered therein neighbors to the number of about 50 whose houses were less substantially built. A final wave 4 feet in depth, aided by the debris which was hurled by the wind and rushing waters, swept his house from its foundations and it collapsed, drowning or killing 32 of the 50 people

who had gathered within its walls, one of the number being Dr. Cline's wife. The balance were storm tossed on the wreckage of buildings for three hours. That no vessels were wrecked, so far as is known, in the Gulf of Mexico can be ascribed to the fact that all ports and shipping interests were warned of the approach of the storm two days before it entered the Gulf from Florida and three to four days before it reached the central and west portions of the Gulf.

After passing inland from Galveston the storm lost strength rapidly and did not again acquire destructive force until it approached the Great Lakes. Crossing the Lake region it was attended by gales of great violence. Ample warnings of its approach, however, reduced the damage to a minimum. Moving eastward over the Canadian Maritime Provinces the storm gathered further strength and caused considerable destruction to land property and also to shipping in Nova Scotia and Newfoundland waters.

OCTOBER HURRICANES.

1. *Hurricane of October 21–24, 1878.*—This storm was developed south of Cuba, though little is known of its early history. Was noted at Havana on the night of the 21st. At 4:35 p. m., Havana, the barometer showed pressure at 29.67, wind northwest, 24 miles. Lowest barometer at Key West, Fla., 29.53, at 2 and 4:19 p. m., wind 54 miles during the morning. From a. m. to p. m. wind backed from northeast to northwest. Severe gale from east-northeast, backing to north, was reported off St. Johns Bar during the 21st and 22d, though the wind at Jacksonville, Fla., did not exceed 17 miles. During the 22d the vortex of the storm moved northward from the east coast of Florida to the coast of North Carolina, and at 11 p. m. the cénter was midway between Wilmington, and Cape Lookout, N. C. The storm began at Kittyhawk, N. C., 6:30 p. m., on the 22d, and the wind reached its maximum registered velocity of 88 miles, southeast, at 2 a. m. of the 23d, when the anemometer was carried away; barometer 29.06, wind shifting suddenly to southwest. Cape Henry and Norfolk, Va., wind shifted from southeast to southwest, during the night, maximum velocities 84 and 44, respectively. The storm center passed into New York State about noon of this date, when its northerly course was deflected to the eastward, and it passed into New England during the latter part of the day, and morning of the 24th, its severity being somewhat modified, it then disappeared into the ocean at a point between Boston, Mass., and Portland, Me.

The storm did considerable damage in Cuba, particularly at Havana, where buildings were blown down and shipping destroyed. It was particularly severe on Chesapeake Bay, especially between the mouth of the Patuxent River and Barren Island, where a steamer was sunk with loss of life, and several vessels were driven ashore. On Delaware Bay the storm was said to have been the most severe ever experienced, vessels of all kinds being driven ashore with loss of life. The wind blew 72 miles an hour in Philadelphia, Pa., injuring or totally destroying 700 substantial buildings; 8 vessels were sunk, and 22 badly damaged; the losses were estimated at one to three millions of dollars. High tides and inundations occurred all along the New Jersey coast, and in the interior, particularly in eastern Pennsylvania, there was great damage to property, and some loss of life. At New London, Conn., severest storm in forty years. Wind at Portland, Me., 70 miles, and anemometer cups carried away. Very high tides noted along the New England coast, with considerable damage to wharfs and shipping. The influence of the storm extended to the lower Lake region and the cautionary signals ordered on the 22d were justified.

2. *West Indian cyclone of October 8–12, 1882.*—The earliest notices of the development of this storm were received from scattered vessels indicating its presence in the Caribbean Sea from the 5th to the 7th, and probably near north latitude 15°, west longitude 82°, although it developed little energy until the 8th, when the center was near Grand Cayman Island, southeast of Havana. On the 8th the diameter of the cyclone greatly increased, and its presence was felt over the entire Island of Cuba and westward to the coast of Yucatan and the Gulf of Mexico. The center was passing over the western portion of Cuba on the morning of the 9th. At Pinar del Rio the violence of the storm was

first felt about 2 p. m. of the 8th, when the wind increased to hurricane force. The vortex passed over this point at 7:15 p. m. At Key West, Fla., 9 a. m. of the 9th, southeast gale and heavy rain were reported. At Jacksonville, Fla., on the 10th the wind reached a velocity of 44 miles per hour. The gale began at 4 p. m. on the 10th at Cedar Keys, Fla., though the first disturbance was felt on the 9th. On the morning of the 10th the wind was veering from northeast to east, gradually shifting during the day to southeast and south, with a velocity of 56 miles. The center passed into southern Georgia on the morning of the 11th, and by the afternoon was near Savannah, Ga. From this point the course of the storm followed the coast line to Cape Hatteras and passed off to the eastward on the 12th.

The storm was very disastrous in western Cuba, where the town of Pinar del Rio was almost destroyed. At San Juan and Martinez, Cuba, 1,500 warehouses and dwellings were destroyed. In the district of Guane the destruction of houses and tobacco storage buildings reached 2,000, and thousands of cattle were swept away. Similar reports of disaster and loss of human life were received from many other towns and localities.

The losses in the United States were comparatively light, and were confined to the extent of damage which usually follows the advent of high winds and flood, such as the prostration of trees, the destruction of growing crops, washouts on the railways, injury to water fronts in coast cities, and damage to unprotected shipping.

Through the timely warnings of the approach of this storm, sent out by the Signal Office, vessels to the value of over six millions of dollars were prevented from sailing.

3. *So-called Gulf hurricane of October 1–6, 1893.*—A small, violent whirl in the Gulf of Mexico on the 1st, the early history of the storm not being known. It developed rapidly, striking the Gulf coast on the same date, its destructive influence being felt from New Orleans, La., to Pensacola, Fla. It had reached the southwest corner of Alabama on the morning of the 2d, and was central in the northern portion of Alabama on the 3d. On the morning of the 4th it had reached the Atlantic coast line in North Carolina near Hatteras, and was dissipated in the Atlantic on the 5th.

Violent wind, heavy rains, and local storms attended its progress through the South Atlantic States, though the greatest amount of destruction and loss of life occurred in Louisiana, where the track of the storm passed between Port Eads and New Orleans. As the instruments used in the weather service were blown away, or destroyed, only an estimate of the maximum force of the wind was made, which placed the velocity at 100 miles an hour near Pointe a la Hache. The storm was accompanied by a tidal wave which engulfed everything before it, explaining the great loss of life reported, one local account placing it as high as 2,000. The canning interests suffered severely, and there was immense destruction to shipping, the property losses in the aggregate footing up millions of dollars. There was great suffering among the living in many localities, and in some instances, as on the islands, it was necessary to use for food dead animals and poultry that had perished in the storm. In the vicinity of Mobile, Ala., the storm was very severe, though unattended with the terrible loss of life recorded in Louisiana. In the marsh truck farm region nearly every house was swept away and the crops destroyed; 7 lives were lost. At Pensacola, Fla., considerable damage was done to the water front, and there were bad washouts on the railways. The influence of the storm extended to Savannah, Ga.

4. *West Indian hurricane of October 1–13, 1894.*—While this storm developed winds of hurricane force, reports of destruction are conspicuous by their absence, the storm being chiefly interesting on account of the great length of its course, with a very flat trajectory, and because it swept the Atlantic coast line from western Florida to the New England States. Its development was traced from a point off the coast of Colombia, South America. Following a northwesterly course from north latitude 14°, west longitude 78° on the 2d, it passed midway between Cuba and Yucatan on the 4th and 5th. It was in north latitude 27°, west longitude 88° on the morning of the 7th, when it swerved to the northeast and entered the United States at the western extremity of Florida on the morning of

the 8th, crossing South Carolina on the 9th, reaching the coast of New Jersey on the morning of the 10th, and by the evening of this date the severity of the storm was felt at Portland, Me. From this point its course was almost due north, and the morning of the 11th found it above north latitude 50°, west longitude 67°, in Canada, when it again swerved to east-northeast, and on the 13th was in north latitude 52°, west longitude 45°, in the Atlantic Ocean. Recorded wind velocities in Southern States, 30 to 80 miles; in New England States, 60 to 84 miles; very severe at Narragansett and Block Island, R. I. Timely warnings kept many vessels in port along the entire coast line.

5. *Hurricane of October 19–24, 1895.*—This was the only destructive hurricane that developed in the West Indian Islands during the month of October, 1895. The track of the storm at no time touched the Atlantic coast line in the United States, although the influence of the storm was felt at southern points in high winds.

On the 19th the storm was central south or southeast of Cuba. On the night of the 20th it crossed Cuba, and on the 21st was between Cuba and Nassau. Pressure at Havana, 29.74, and at Nassau 29.84 in the morning, and 29.62 at Key West, Fla., in the evening. On the 22d the center was between Nassau and the mainland, the pressure being well marked over Florida. Wind velocities of 55 miles per hour were reported from Jupiter and Key West, Fla., and 80 miles at Havana. Very high tides occurred on the south Atlantic coast, but no special destruction in the United States was reported. Timely warnings were given and many vessels remained in port that otherwise might have found themselves in positions of danger.

A NOVEMBER HURRICANE.

This record is not complete without reference to the destructive West Indian hurricane of November 17, 24–29, 1888. It was first noted on the 17th northeast of the Windward Islands, from whence it proceeded westward almost on the line of north latitude 23°, making its appearance in the Bahamas on the 22d. On the 22d its influence extended to the fortieth parallel, and after its recurve over the Bahama Islands it augmented in energy until the 26th, when minimum pressure falling below 29.00 was reported. On the morning of the 27th the center was just off the New England coast; on the afternoon of the same date it had passed into Maine, and by the 28th was in the British Possessions.

As early as the 25th the gale had developed a force of 66 miles an hour at Hatteras, N. C., and northwest 50 miles on the 26th at Norfolk, Va. At Atlantic City, N. J., on the same date, high winds prevailed with high tides, barometer 28.96 at 2 p. m. At New York, N. Y., the wind was northwest, 40 miles, on the 26th. The storm continued at New Haven, Conn., up to noon of the 27th, wind northeast, 51 miles. At Block Island, R. I., 3:25 a. m., on the 26th, the maximum velocity of the wind was 84 miles per hour. At Woods Hole, Mass., the storm continued until the evening of the 27th, with a maximum wind velocity at 2 p. m., northwest, 48 miles. High winds prevailed at Portland, Me., on the 25-27th; maximum velocity on the 26th, northeast, 36 miles. At Boston, Mass., the maximum velocity was northeast, 60 miles, at 1:35 a. m. of the 27th, but moderated to 36 miles at 8 a. m., then increased during the day to northeast and north, 48 miles. The storm was particularly severe on the Atlantic Ocean as reported by the vessels which felt its force. The damage to shipping was very severe all along the Atlantic coast from Hatteras, N. C., to Eastport, Me., and many vessels were wrecked or disabled. Norfolk, Va., suffered from both winds and floods, the damage to property in the city being considerable. In and around New York, N. Y., the damage was general, and it was stated that the losses would foot up millions of dollars. In New Haven, Conn., two houses were destroyed and telegraph and telephone wires wrecked. Similar reports came from Rhode Island and Massachusetts coast towns, vessels in the harbors dragging anchors, and, in some instances, smaller craft being driven ashore. In Portland and Eastport, Me., buildings, fences, trees, and shipping felt the fury of the storm, which, in the last-named city, was accompanied by snow, sleet, and heavy rain.

LOCAL DESCRIPTIONS OF HISTORICAL WEST INDIAN HURRICANES.

PORT OF SPAIN, TRINIDAD.

The only hurricane that has visited this island during the present generation, if I have been informed correctly, was in 1847, but I am unable to obtain any data bearing on the same.

ERNST T. GIERS,
Observer, Weather Bureau, Port of Spain, Trinidad.

THE BARBADOS HURRICANE OF AUGUST 10, 1831.

There was no premonitory sign of this hurricane observed, except by one individual, which will be referred to later on, other than an extreme redness of the sky on the evening of the 10th. This appearance was not unusual, as it is frequently seen at this season of the year. The heat, however, had been very oppressive and intense for some days previous, but that was to be expected at the approach of the equinox. Rains set in early in the spring and had been quite general during the three months preceding the hurricane, July being especially wet. The weather, altogether, had been totally unlike that which preceded the storm of 1780.

The electric action during the storm was very unusual, at times being in the form of a livid flame and at others it came in the form of alternate sheets and forks. The hurricane lasted in its utmost fury from about midnight of the 10th until 8 a. m. of the 11th.

Calamitous as were the many tempests from which Barbados had suffered, the aggregate destruction produced by the whole combined was probably unequal to that effected by the hurricane of 1831. The hurricane of 1675, according to historical account, very much resembled it in appearance, duration, and fury, but the extent to which human life then suffered is not on record. The hurricane of 1780, fearfully tremendous as it was, is admitted to have been far inferior in force and less destructive to property.

Sunrise on the 10th was clear and at 10 a. m. a gentle breeze which had been blowing died away. After a temporary calm, high winds sprang up from the east-northeast, which also subsided. For the most part calms prevailed, interrupted by occasional sudden puffs from between north and northeast. At noon the heat increased to 87°, and at 2 p. m. to 88°, at which time the weather was uncommonly sultry and oppressive. At 4 p. m. the temperature was 86°, and at 5 p. m. the clouds seemed gathering densely from the north, the wind commencing to blow freshly from that point; then a shower fell, followed by a sudden stillness, but with a dismal blackness all round. Toward the zenith there was an obscure circle of imperfect light, subtending about 35° or 40°. From 6 to 7 p. m. the weather was fair and wind moderate, with slight puffs from the north, the lower and principal stratum of clouds passing fleetly toward the south, the higher strata, a scud, rapidly flying to various points. At 7 p. m. the sky was clear and the air calm, tranquility reigning until a little after 9 p. m., when the wind blew again from the north. At 9:30 p. m. it freshened and moderate showers fell at intervals for an hour. Distant lightning at 10:30 p. m. in the northeast and northwest. Squalls of wind and rain from the northeast, with intervals of calms succeeding each other until midnight. The thermometer in the meantime varied with remarkable activity; during the calms it rose as high as 86°, and at other times it fluctuated from 83° to 85°, this high stand of the thermometer near midnight under the tropics being without record.

After midnight the continued flashes of lightning were awfully grand and the gale blew fiercely from between the north and northeast. At 1 a. m. of the 11th the tempestuous rage of the wind increased, shifting suddenly from the northeast to the northwest and intermediary points. The upper regions were from this time illuminated by incessant lightning, but the quivering sheets of blaze were surpassed in brilliancy by the darts of electric fire which were exploded in every direction.

At a little after 2 a. m. the astounding roar of the hurricane, with wind from the north-northwest and northwest, can not by language be described. About 3 a. m. the wind occasionally abated, but intervening gusts proceeded from the southwest, the west, and northwest with accumulated fury. The lightning also having ceased for a few moments, only, at a time, the blackness in which the town was enveloped was inexpressively awful. Fiery meteors were presently seen falling, one in particular, of a globular form and deep red-blue hue, was observed to descend perpendicularly from a vast height and fell in Beckwiths square. A few minutes after the appearance of this phenomenon the deafening noise of the wind sank to a distant roar; the lightning which from midnight had flashed and darted forkedly, with a few and but momentary intermissions, now for a space of nearly half a minute, played frightfully between the clouds and the earth. The vast body of vapor appeared to touch the houses and issued downward flaming blazes which were nimbly returned from the earth upward. The moment after this singular alternation of lightning the wind began again to blow from western points with a violence beyond conception, hurling before it thousands of missiles, the fragments of every unsheltered structure of human art. The strongest houses were caused to vibrate to their foundations and the surface

of the very earth trembled as the destroyer raged over it. The horrible roar of the wind, the noise of the tumultuous ocean, whose frightful waves threatened the town with destruction if all other elements might spare it, the clattering of tiles, the falling of roofs and walls, and the combination of a thousand other sounds, formed the most hideous din, which appalled the heart and bewildered, if not alienated, the mind. No adequate idea of the sensations which then distracted the mind and confused the faculties can possibly be conveyed to those distant from the scene of terror.

This unparalleled uproar continued without intermission until half past 4 in the morning, when the raging blast veered from the west and other points to the southward, with avalanches of rain accompanying. After 5 a. m. the storm now and then for a very few moments abated, the falling of tiles and building materials, which by the last dreadful gust had been carried to a considerable height, the shrieks of suffering victims, the cries of the terrified inhabitants, were clearly audible, awakening the mind to a distressing apprehension of the havoc and carnage which had been, and still were desolating the island.

At 5:30 a. m., after a dreadful gust from the southwest, the wind suddenly chopped around to the east, from whence it blew a moderate gale, changing to southeast in a few minutes after and blowing with hurricane force, but unaccompanied by those fatal gusts which from the western quarter had inflicted so much destruction. Torrents of rain fell at this time. At 6 a. m. the wind blew steadily and tremendously from the south, driving sheets of rain horizontally before it. This continued until 7 a. m., when the wind then from the southeast, was more moderate, but floods of rain still deluged the ruins of the town. Strong breezes from the east-southeast at 8 a. m.; after that hour the dense body of cloud began to break up, and at 10 a. m. the sun for a few moments darted its rays over a prospect of wretchedness and woe, more replete with real misery and sickness to the heart than the field of battle (after a sanguinary conflict) ever presented.

This hurricane came from the southeast of Barbados, the center passing slightly to the north of the island. It produced great damage in St. Vincent and St. Lucia, and slightly touched Martinique. On the 12th it arrived at Porto Rico; the Aux Cayes, Hayti, was nearly destroyed by its force, and Santiago de Cuba much injured. On the 14th it was at Havana, and on the 16th and 17th on the northern shores of the Mexican Sea. It blew a dreadful gale in New Orleans, La., on the 17th. The duration was six days from the time it commenced in Barbados until reaching New Orleans, La., a distance of 2,100 nautical miles.

The ships in the harbor were totally destroyed, being either blown out to sea or sunk at their moorings, 12 at least were driven high on the beach, total wrecks.

No portion of the island escaped the ravages of the storm, and, without particularizing, its effect can best be studied by consulting the value of the property destroyed, which is estimated at $7,397,532. This does not include the value of the government property and principal shipping destroyed.

According to official returns the total number of persons killed outright is, 1,477; wounded, 310, of which 114 died afterwards. To this should be added 48 soldiers killed, and 242 wounded in the ruins of the garrison barracks. It is thought that the total number killed and wounded was not reported to the government, and it is estimated that at least 2,500 were killed or died from results of wounds.

Freaks of storm.—A piece of lead weighing 150 pounds was carried to a distance of more than 1,800 feet, and another piece, 400 pounds in weight, was lifted up and carried 1,680 feet. Many instances are reported of shingles and pieces of tin being forced by the wind into trunks of hard wood trees.

Generally the surface of the ground was denuded of vegetation, appearing as if a fire had passed over it. The few trees left standing were stripped of all foliage.

It is stated that an earthquake accompanied this storm, but nothing authentic can be found on the subject, other than a statement that many walls were covered with cracks and fissures.

Mr. Benjamin Gittens, Barbados, appears to have been the only person to observe any premonitory signs of the approach of this hurricane, and these were: 1st. The darting forward of the clouds in divided portions with fleet irregular motion, not borne with the wind, but driven as it were before it. 2d. The distant roar of the elements, as of wind rushing through a hollow vault. 3d. The motion of the branches of trees, not bent forward as by a stream of air, but constantly whirled about.

While this storm was passing over the West Indies on the 11th, 12th, and 13th, objects which were of whitish color appeared to be of light blue, so marked as to attract the attention of all the inhabitants.

From Schomburgk's History of Barbados. Reid on Storms, was also used, these being the only authorities from which a descriptlon of this storm could be obtained here.

P. McDonough, *Observer, Weather Bureau.*

HURRICANE AT ROSEAU, DOMINICA, W. I., 1834.

In the history of Dominica about twenty hurricanes are recorded since the year 1765. Among these, four stand out preeminently as very destructive visitations. They occurred in 1806, 1813, 1834, and 1883. Concerning the first two nothing authentic can be learned, except that in 1806 the Roseau River overflowed, inundated the capital and

131 persons were killed. Much information can of course be obtained of the last one mentioned, as it is of comparatively recent occurrence, and many eye witnesses are alive.

It is found, on inquiry, that the storm of 1834 is generally accepted as the most destructive one that ever visited the island. Unfortunately, there are no intelligent living witnesses of this storm, and the only record which can be found is contained in some notes left by the Hon. John Imray, M. D., who was government medical officer of the island at the time, and a man of reputed high scientific attainments. From his notes the following description is made:

"This terrible hurricane happened on the night of September 20, 1834. The sun had set very red that evening, but the day had been cool, with occasional showers, and nothing appeared remarkable in the weather previously to lead to the supposition that so tremendous a visitation was at hand. As soon as the sun had set the wind veered round to the north and northeast, with light showers until 10 o'clock. It then suddenly increased in violence, and the people were obliged to have their houses shut up immediately. Each gust came with greater force than the preceding one, until it blew a complete hurricane, and really frightful it was—the wind roaring and rattling over the house with a deafening noise, making the solid stone building shake to its foundation. A little after 12 o'clock the wind moderated and soon afterwards it was almost a dead calm—a treacherous calm it proved." Dr. Imray went out during the calm and by the moonlight could see, though dimly, trees and houses blown down. In his own yard a beautiful mango tree had been torn up by the roots, and a large silk cotton tree (believed to be the largest on the island, and which is standing to-day) was a branchless trunk. Two of his windows had been blown in and part of the roof ripped off. Everything was in the direst confusion and the rain pouring in in torrents. The wind by this time had again begun to blow, this time from the opposite direction—the south. In a few moments on the hurricane came again, from the south and southwest, with greater fury than before; it continued to rage until near daylight. As soon as the wind would allow, he again went out to see what further damage had been wrought.

The scene of desolation that daylight disclosed was awful. The streets were flooded with water and strewn with shingles and rafters, and the parts of roofs of houses, trees blown down and lying across the streets, houses entirely turned upside down and shifted into the middle of the streets, many of them in ruins. All the houses along the bay side were injured, partly by the surf which rolled up in tremendous waves. There were many hairbreadth escapes from death. The next day it blew a heavy gale, with rain, and the people were in expectation of having another blow but it did not come.

The accounts, as they came in from the country, were distressing. The vessels that were at anchor in Prince Ruperts and Soufriere bays were driven ashore and 11 sailors in all drowned. An American schooner went ashore at Grand Bay and not a soul was saved.

Here follows some detailed accounts of the destruction wrought by the storm and the number of people killed in different parts of the island, which was omitted.

Continuing, Dr. Imray says:

"The country is ruined—irretrievably ruined. The island is devastated—absolutely laid waste from one end to the other, and I am afraid will never be able to rise from its ruins. The crop of sugar cane is totally destroyed; sugar works, proprietors' and negroes' houses leveled to the ground, and the provision grounds utterly ruined. The town has not suffered to as great an extent as the country, but still great damage has been done. More than a hundred people have been killed. The appearance of the country is altogether changed. Instead of being covered with verdure, it now looks as if fire had passed over it—scarcely a leaf to be seen. The trees left standing have quite the same appearance as in winter. The roads are completely impassable. Many estates are entirely ruined and must be abandoned. The negroes will be starving in a few weeks. The port has been opened for twelve months."

Unfortunately for our purpose, Dr. Imray's notes deal more with the destruction wrought by the storm than with the storm itself. It is hardly probable that any barometer, temperature, wind, or rainfall observations were made of the storm by anybody, and diligent inquiry has proved fruitless to obtain any further description of it.

Dr. H. A. Alford Nicholls, C. M. G., has kindly given the following very good description of the hurricane of 1883, including some reliable data from observations taken by himself during the storm. Although they may be of no value for the present purpose, they are forwarded as a matter of general interest, hoping they may be worth filing for future reference:

THE DOMINICA HURRICANE OF 1883.

"DOMINICA, *September 10, 1883.*

"During the afternoon of the 4th of September the sky was overcast, but there was nothing in the weather to excite suspicion that the island was to be devastated by one of the circular storms that sometimes occur at this season in these latitudes. Being much occupied, I did not, as is my custom, look at the barometer throughout the day, but I am informed on reliable authority that the mercury stood at 30.00 inches at 10 a. m., and this is about the usual height in ordinary weather. Toward evening rain set in, and it was raining heavily when I parted with your excellency at

10:30 p. m. On walking home I found the wind was blowing with some force from the northeast, and my suspicions became aroused as to possible danger.

"On reaching home at about 10:35 p. m., I examined the barometer carefully and found it to register nearly two-tenths below 30.00. The wind was now blowing in strong gusts from northeast by north, the rain was falling heavily, and the night looked very wild.

"I set to work at once to make my house secure, and, being thus occupied, I was unable to examine the barometer, again until 11 p. m., by which time the mercury had fallen to 29.764, and the storm had commenced to rage furiously, the wind coming with great velocity from the north-northeast. The barometer now fell rapidly; at 11:15 p. m. it registered 29.710, at 11:30 it stood at 29.598, and by midnight it was down to 29.362. It was now blowing a full hurricane from the north-northeast, and the noise occasioned by the rattling of the doors and windows and the crushing down of broken limbs of trees and debris of houses was terrific. At 12:30 a. m. on the 5th the height of the mercury was 29.212, and the wind blew, if anything, with increased force and velocity. The extraordinary atmospheric disturbance was plainly evidenced by the agitation and rapid descent of the column of mercury. Later on the wind fell. At 12:40 a. m. the barometer registered 29.026 and there was a dead calm, which lasted thirty-one minutes and which showed that the center of the storm was passing over us. At once I seized the opportunity of opening one of the doors of the house in order to look out on the night, and never shall I forget the scene that lay before me. To the north, close to the earth and apparently within a quarter of a mile of the town, was a large globular[1] mass of intense light, with forked lightning issuing from it in various directions; then, all at once, the whole ground appeared flooded with a sheet of lightning, which lasted sufficiently long to give one a glimpse of the destructive effects of the wind, The trees round about were wrecked, none but the larger branches remaining, and these bereft of leaves. There was no thunder, but the lightning came again and at short intervals, thereby showing the vast amount of electrical force present.

"At 12:45 a. m. the barometer stood at 29.010, and at 12:53 a. m. I read off 28.984, which was the lowest point reached. For a few minutes the mercury remained stationary, and then it commenced to rise gradually, and the wind set in from the south-southwest in gusts. The fastenings of one of my hurricane shutters now gave way, and, as there was much difficulty in securing it, I was unable to resume the observation of the barometer until 1:25 a. m., by which time the mercury had risen to 29.092; but the hurricane was still blowing in full force, and a shock of earthquake which then occurred made the howling of the winds to appear more terrific. The mercury now rose steadily and rapidly. By 1:49 a. m. it stood at 29.501, and by 2:03 a. m. it reached 29.588. At this hour I recorded in my notes that the wind came from the south-southwest "in fearful gusts," and every moment those in the house expected that the roof would have been blown off. Indeed, had the wind continued much longer with unabated fury most of the houses in the town must have been destroyed. By 2:15 a. m. there were frequent lulls in the wind and the mercury had risen to 29.672. By 2:34 a. m. it reached 29.752, and the wind began to abate, for the hurricane was passing away. At 2:53 the register shows 29.786, with the following note: "Wind falling, but occasional strong gusts." At 3:45 the mercury was up to 29.862, and there was no further danger. I was so exhausted with battling with doors and shutters, and with keeping an accurate record meanwhile, that I now fell asleep, and I regret to say that I have no barometrical reading until 5 a. m., when the mercury was at 29.972.

"I now opened the door and looked out on the country, and found the extent of the destruction astonishing. The day before the Roseau Valley and the surrounding hills looked lovely in the rich and magnificent clothing of tropical vegetation; now all vegetable life was blasted, and the scene was likened to a bleak winter morning in a northern clime. In my garden one large tree had disappeared. Another large one—I believe the largest silk cotton tree in the country—had branches as large round as a man's body torn off and thrown to a distance. But, strange to say, on the stone steps in front of the house stood my rain gage unbroken, and not even overturned. A child might have pushed the instrument off the steps with ease, for it was not secured in any way; but the hurricane had not shifted it an inch. Similar circumstances that have come under my notice led me to believe that the circular storm was composed of smaller circular storms, each with its central calm, for it seems impossible for me to account otherwise for the escape of flimsey houses while stronger structures within a stone's throw were utterly demolished. On seeing the rain gage intact, I measured the rainfall and found it to be 2.79 inches.

"I need not in this letter enter on a consideration of the destructive effects of the hurricane and the loss to life and property occasioned thereby, for as honorary secretary of the relief committee I have already placed your excellency in possession of all the particulars that have come to my knowledge.

"Before concluding, however, I may mention that the barometrical readings I have given may be considered to be scientifically accurate. They were read off from a Hick's standard barometer (No. 334) which was verified at the Kew Observatory less than two years ago. In the midst of the storm the instrument remained in an immovable position 60 feet above sea level close to one of the stone walls of my house, and during the night the average temperature, as read by the thermometer in contact with the barometer, was 85° F. The barometrical readings are uncorrected for elevation or temperature."

CHARLES E. ASHCROFT, JR., *Observer, Weather Bureau.*

[1] This globular lightning rolled slowly down the Goodwill Ridge eastward to the sea.

The following notes relative to some of the most remarkable and destructive hurricanes of the West Indies, chronologically arranged, have been collected by Mr. W. H. Alexander, Observer, Weather Bureau, Basseterre, St. Kitts, W. I.:

1492—While coasting along the north coast of Cuba Columbus was driven by violent gales 56 leagues to the northeast. He was also compelled to remain in harbor off Espanola some days because of "stress of weather."

1493—On returning to Spain, Columbus and his fleet were overtaken by a severe storm which lasted three days and threatened them with certain destruction, so much so that Columbus wrote an account of his discoveries and threw it overboard.

1494—While on his second voyage Columbus anchored at Cape Santa Cruz, and while there "upon the 16th July a violent hurricane occasioned the admiral to declare that nothing but the service of God and the extension of the monarchy should induce him to expose himself to such dangers."

1498—When 480 miles southwest of the Cape Verde Islands, Columbus found that "the altitude of the north star was 5°." Here, in a calm, he expected that the heat would set the vessels on fire; the men were alarmed and dared not go below, though the stores were spoiling. This weather lasted eight days; the first only was clear, the seven following it rained; had all been as hot as the first, Columbus says, nothing could have saved them.

1502—While searching for a passage to the South Sea Columbus arrived off Santo Domingo, and asked permission to enter the harbor which was refused. His object in entering the harbor was to exchange his vessel and also for shelter from a hurricane which Columbus thought was approaching. The fleet sailed July 1, and within twenty-four hours 20 sail with all on board perished. Columbus said: "The gale was terrible, and in that night my vessels parted company, every one expecting death, and each considering it certain that the others were lost. With the exception of Job there never was a man who would not have died in despair. When to save my life and that of my son, brother, and friends, I was at such a time forbidden the harbors, which, by God's permission, I had gained for Spain, sweating blood. The vessel in which I was, weathered the gale marvelously; it pleased God that she received no damage whatever. My brother was in the unsafe vessel, and, next to God, was the means of saving her. In this gale we made Jamaica.

1508—On the 3d of August all the thatched houses in Santo Domingo, and several of those built with stone, every house in Bonaventura, and 20 sail of vessels, were destroyed by a hurricane. At first the gale blew from the north, then shifted suddenly to the south.

1509—On July 10 Admiral Don Diego Columbus arrived at Santo Domingo with his bride, and a few days later almost the entire city was destroyed by a hurricane. These visitations were considered marks of Divine displeasure.

1526—In October a violent hurricane did great damage in the Island of Espanola; rivers overflowed their banks. No such had been experienced in that island for many years.

1530—There was great distress among the inhabitants of San Juan because of a hurricane, which was followed by rain storms, so that the rivers were overflowed, crops, trees, and herds were washed away; the works at the gold mines and other undertakings were suspended.

1591—On July 17 a fleet of 77 sail left Havana for Spain and on August 10, in latitude 35° north, they were overtaken by a gale and the commander of the fleet with 500 men perished. Three or four days later, in another gale, 5 or 6 ships, with all their crews and the vice-admiral, were lost. About the end of August, in latitude 38°, they experienced another gale, during which 22 sail perished. September 6 the remaining 48 arrived within sight of Flores, where they were separated by another gale, so that of the 123 sail that were expected in Spain this year from the West Indies but 25 arrived.

1623—On September 19 a hurricane destroyed the tobacco crop on the Island of St. Christopher, this being the first crop planted and raised by the newly-arrived colonists.

1635—Du Pont, while on his way from Martinique to St. Kitts to bear the news of a treaty of peace between himself and the Caribs to D'Enambuc, was driven by a violent gale to the coast of Espanola, where he was taken prisoner by the Spaniards and closely confined for three years.

1642—During this year there were three hurricanes in the West Indies; the second lasted twenty-four hours, during which, at St. Kitts, 23 fully laden vessels were wrecked upon the coast, all the houses blown down, and the cotton and tobacco crops completely destroyed, and the salt ponds overflowed and rendered unproductive for some time.

1656—The Island of Guadeloupe was desolated by a fearful hurricane. Most of the houses were destroyed, all the domestic animals were killed, and all the plantations laid waste. Every vessel at anchor in the roads was wrecked and most of their crews drowned.

1664—The crop of potatoes was destroyed by a violent hurricane at Guadeloupe.

1666—On August 4 a hurricane began at Guadeloupe at 6 p. m., the wind blowing from the north. It continued with great violence until midnight when there was a calm of a quarter of an hour, the wind then shifting to the south and driving everything before it with irresistible force. Every vessel and boat on the coast of Guade-

loupe was dashed to pieces, all the vessels in the Saints were driven on shore, and of Lord Willoughby's fleet (consisting of 17 sail with 2,000 troops) only two were ever heard of afterwards. An armee-en-flute of 22 guns got to Montserrat with only the stump of her mizzenmast standing, and a fire ship got to Antigua dismasted. The bottom of one ship was washed on shore at Capesterre, Guadeloupe, and another at the Saints; the whole coast was covered with wrecks of masts and yards; a figure from the stern of Lord Willoughby's ship was recognized among the ruins. The hurricane lasted 24 hours; houses and trees were blown down and a great number of cattle killed. The sea rose and was driven to an unusual height. All the batteries, walls of six feet thickness near the sea, were destroyed and guns, 14-pounders, were washed away. The storm was felt at St. Christopher and Martinique, but with less violence.

1667—September 1, a tremendous hurricane devastated the Island of St. Kitts; it began at 9 a. m. and lasted until 5 p. m. from the north, then shifting to the south, blew with such violence that all the houses and buildings were thrown down. The inhabitants sought shelter from its fury by throwing themselves upon the ground in the fields.

M. Laurent, the governor, in a letter to Mr. Colbert, says: "There has blown here the most violent hurricane ever known, and I hold myself obliged to inform you that this island is in the most deplorable state that can be imagined, and that the inhabitants could not have suffered a greater loss, or been more unfortunate, except they had been taken by the English. There is not a house or sugar works standing, and they can not hope to make any sugar for fifteen months to come. As for the manioc, which is the bread of the country, there is not one left, and they are more than a year in growing. I can not describe to you, sir, the misery of this poor island without wounding my heart. It is as a place over which fire has passed. I assure you that if peace is not made, or men of war sent into this country to facilitate the bringing of cassava from the other islands, that the inhabitants and troops will die of famine. I shall do everything in my power to keep up the spirits of the inhabitants, who are stunned like men that are totally ruined; and I shall not spare either pains or trouble to maintain the island and remedy the evil, which is irremediable except succor arrive from without."

1674—At Barbados, on the 10th of August, a hurricane blew down 300 houses, killing 200 persons, wrecked 8 ships in in the harbor, and so damaged the plantations that very little sugar was made the two succeeding years.

1675—The Island of Barbados was again devastated by a hurricane in August of this year. The crops were destroyed and the people asked the British Government to relieve them of an impost duty of 4½ per cent on exports. This was refused.

1681—The Island of Antigua was desolated by a tremendous hurricane.

The following account of two hurricanes which occurred at St. Kitts in 1681 is from a letter written soon afterwards and published in the first volume of A Young Squire of the Seventeenth Century. It seems so quaint and interesting that its reproduction verbatim et literatim is justified in this connection.

"Saturday the 27th of August, about one or two in the morning, the winds blew very hard at northeast, which did small damage. Before day, the weather broke up with appearance of fair weather; but before nine of the clocke, it was overcast and proved a rayney, blustering day. About eight or nine o'clock at night the wind, veering more to the north and from the north to the northwest, increased till midnight; at which tyme it blew so vehemently hard, and so continued with small rayne and frequent lightnings, until within less than an hour of daybreake (when the storm began to cease), that I had not a house standing upon my plantation, in which I could shelter myself from the weather.

"It was a little after midnight, when a great part of the roof of my dwelling-house began to fly away; several of my out-houses being allready downe. Then I thought it tyme to shift for myselfe; which I did. Turning my people out before (who had been driven to my house by the insufficiency of their houses) I locked the door, and tooke the key in my pocket.

"I could not goe against the winde; and with no small difficulty could I goe with it, for fear of being driven away by it. At last we got (all but one of our company) to a little hut, which, we had agreed upon before, to make our rendezvous in; which sheltered vs from the violence of the storme, but not of the raine, the thatch being partly blown away. But to be wet was then no news to vs. Wee were in continual feare oure little cottage should have beene blowne away; which rocked like a cradel. As soone as the storme began to cease, I went up to my house whiche I found miserably torne, and flat with the ground. My sugar-worke, in like manner, and all my buildings. I walked downe to my new sugar-worke, which I had built not long before, about a quarter of a mile or more from my house, towards the sea, to make my tenants' sugar canes; to whom I had leased fifty acres of land, and had newly begun to make sugar at it, and was then boiling at it, when the storme began. I found *that* likewise flatt with the grounde, the stone wall overturned, and the timber scattered in divers places farre distant from the house.

"I must confesse, I did wonder more to see my house standing, than to see what was destroyed, considering the impetuosity of the weather. I had scarce time to view this losse, when the winde being shifted into

the south, the storme began afresh. I made what diligence I could (the pathes beeing all spoyled), to get to the place where my dwelling-house did stand; to whiche the winde assisted me, being in my back, but veering to the southeast.

"It blew a frett of winde, and continued with suche violence for severall hours, that it did much more damage in some partes of the island than the fore-part of the storme. But it was not comparable to the former with vs. I stoode for shelter behinde that part of the wall of my house, which was left standing, till I feared it would fall upon me, and then shifted to another shelter, little better than the former.

"About ten or eleven of the clocke, the winde ceased; but most part of the day was wet and rayney, very uncomfortable for those that had neither victuals to eat, dry cloathes to put on, or a house to shelter in, or fire to dry themselves by—which was the condition of most people. It was a deplorable sight to see the spoyle that was done in the canes and provisions, in comparison of which the losse of all our houses and workes is as nothing.

"That day, although Sunday, I got up a little house, in whiche to secure myselfe and the best of my goods from the wet; and I used all diligence to gett up a couple of rooms, and one of my sugar-workes, and to put some Indian provisions in the ground, having thirty-two negroes, besides whites to feed every day (for which I blesse God). I was now indifferently well at my ease for the present; my two rooms being built, and everything indifferently well in order, towards the repaireing of my buildings and my other losses. When on Tuesday, the fourthe of October, after a very tempestuous night, about breake of day, a second hurricane began, which lasted until two or three in the afternoone. I used all the endeavours I could to secure my new house, where I was lodged. But all my endeavours were not sufficient, but that, about ten or eleven of the clocke, the roof was blown away over our heads all at once and carried many yardes from the house—and *that* in a very instant of time. But I thank God none of vs were hurt, but one who had a small hurt with a nayle in a board.

"I made what haste I could out, and passed the remainder of the storme at the side of a wall, which afforded me some small shelter. This and the other hurricane were more fierce here and in another quarter, than in any other part of the island, as appeared by the effects of them. The damages done by this second storme, were very great, and would have been much more, had not the great spoyle wrought by the former hurricane deprived it of matter to worke upon. Though this was not so tedious, or exceedingly fierce as that, yet it hath destroyed our provisions, and hath occasioned a sickly and scarce time amongst vs. It was most violent at Antegoa, where several ships were cast on shoar."

1689—A dreadful mortality swept away one-half the inhabitants of Nevis.

1690—The Island of Antigua was almost desolated by an earthquake.

1692—Jamaica suffered from a dreadful earthquake on June 7 between 11 and 12 o'clock, noon. The town of Port Royal was almost completely destroyed in less than three minutes. About 3,000 of the inhabitants, with their houses, found one common grave. The sinking of the wharfs was but a prelude to that of the town. Those nearest the water first disappeared; and next in succession followed. In the meanwhile the streets began to gape, "opening those dreadful fissures into which the miserable remnant of the inhabitants fell, who had escaped the previous ruin, and were fleeing for shelter in the open air." The water began to roll where the town had flourished and swept from the sight the devastations which the earthquake had made. Several of the inhabitants were swallowed up and returned again to the surface of the earth through distant apertures which had no visible connection with those which first yawned to receive them. Some were returned alive and even without material injury. The waters rose and filled the houses, which had survived the shock, to the upper story, "a preternatural tide that was to ebb no more." Several of the streets were laid several fathoms deep under water; the harbor was agitated as in a storm. The ships parted their cables. The frigate *Swan* lay by the wharf and was forced over the tops of the sunken houses, and saved some hundreds of the inhabitants. The fort and about two hundred houses escaped; but part of the neck of land, about a quarter of a mile in length, was entirely submerged with all the houses, which stood very thick upon it. A general sickness ensued which, with the other miseries, left the island about destitute. The assembly ordered a perpetual anniversary fast in commemoration of this calamity.

1722—The town of Port Royal, Jamaica, was visited by a severe hurricane on the 28th of August, in which 26 merchant vessels were wrecked and 400 persons killed. An eye witness says: "The hurricane began at 8 in the morning, two days before the change of the moon; it gave at least forty-eight hours' notice by a noisy breaking of the waves upon the keys, very disproportioned to the breeze, a continual swell without reflux of the water; and the two nights preceding, prodigious lightning and thunder; which all the old experienced men foretold would be a hurricane, or that one had already happened at no great distance. The wind began in flurries from the northeast and flew quickly around to southeast and south-southeast, where it continued the stress of the storm, bringing such quantities of water that our little island was overflowed four feet at least; so that with the fierce driving of shingles about our ears, and the water floating boats, empty hogsheads, and lumber about the streets, those without doors were every moment in danger of being knocked on the head or

carried away by the stream. Within it was worse; for the waters sapping the foundations gave continual and just apprehension of the houses falling, as in effect half of them did, and buried their inhabitants. * * * The whole rise of the water was computed at 16 or 18 feet at a place where it is not ordinarily observed to show above one or two. At 5 in the evening the waters abated, and so quickly as to leave the streets dry before 6. * * * Wrecks and drowned men were everywhere seen along shore; general complaints of loss on land which made it a melancholy scene, and to finish the misfortune, the slackness of the sea breeze, calms, lightning, stagnating waters, broods of insects thence, and a shock or two of earthquake that succeeded the hurricane, combined to spread a baneful influence, and brought on a contagion fatal for some months through the island.

B. Edwards says that as upon the same day of the month ten years before another hurricane had shaken the island the anniversary of the day was, by an act of the assembly, set apart for fasting and humiliation.

1737—On September 9 the town of St. Louis, Santo Domingo, was destroyed by a hurricane. All the sugar cane and cotton trees were destroyed and all the ships in the harbor were thrown upon the coast. This hurricane did great damage at St. Kitts and Montserrat. At the latter island it blew down all the windmills and houses and carried away mules, negroes, and cattle into the sea. The sugar canes were all destroyed.

1744—On the 20th October, at Jamaica, a dreadful hurricane began at 6 p. m. and lasted until 6 the next morning; the wind was all that time due south. Mosquito fort was demolished; eight English ships and vessels and 96 merchant vessels were stranded and foundered. Out of 105 vessels only one, the *Rippon*, rode out the gale, and she without masts. One hundred and eighty-two men were drowned.

1747—There were two violent hurricanes this year, one on September 21 and the other on October 24. They did great damage among the Leeward Islands. Fourteen sail were lost at St. Kitts and 36 at the other islands.

1754—A hurricane in September did great damage at Santo Domingo to the sugar and indigo plantations. Twelve ships were driven ashore and 1,700 hogsheads of sugar lost.

1759—"In the month of September of the year 1759 a heavy gale of wind from the northeast so greatly impeded the current of the Gulf Stream that the water forced, at the same time, in the Gulf of Mexico by the trade winds, rose to such a height that not only the Tortugas and other islands disappeared, but the highest trees were covered on the Peninsula of Larga, and at this time (so says Wm. Gerard de Brahm, Esq.), the *Litbury*, John Lorrain, master, being caught in the gale, came to an anchor, as the master supposed, in Hawke Channel, but to his great surprise found his vessel the next day high and dry on Elliotts Island and his anchor suspended in the boughs of a tree."

1761—On the 31st of March, at 4 p. m., the sea at Barbados began to flow; at 8 it appeared to ebb, but at 10 it increased considerably, and continued so until 6 the next morning. A similar agitation in the water was observed there at the time of the earthquake at Lisbon in 1755.

1762—A storm from the southward, followed by an earthquake, destroyed a great part of the walls surrounding the town of Carthagena on December 9; wrecked many houses, among them the castle of Santa Maria; drove two Spanish men-of-war on shore.

1766—This year seems to have been marked by an unusual number of direful calamities in the West Indies. An earthquake at Santiago de Cuba, killed 40 persons, and at Grenada the same or another threw down the sugar works and hills in several places, so that it was impossible to ride round the island on horseback.

At 10 p. m. of August 13 a strong northwest gale set in at Martinique, and about midnight the shock of an earthquake added to the horrors of the increased hurricane. At 3 a. m. the storm abated, and daylight revealed a scene of desolation and woe; wrecks and dead bodies covered the shore at St. Pierre; the streets were covered with ruins, while the roads were blocked by trees uprooted by the storm and enormous stones brought down by the rivers. At 5 a. m. a waterspout burst upon Mount Peleus, overwhelming the neighboring plains. By 6 o'clock it was quite calm and the sea was smooth. As many as 90 persons are said to have perished, many of these under the ruins of their own houses, while twice that number were wounded. Seven English and 28 French vessels were wrecked; also 12 passage canoes.

On the 13th, 14th, and 15th of September such violent gales raged at St. Kitts and Montserrat that 13 vessels were wrecked at the former and all at the latter. At Montserrat half the town was destroyed and upward of 200 persons reduced to distress by the torrent from the mountains.

St. Eustatius suffered severely from a hurricane on September 21; the provision grounds and cane plantations were destroyed; several vessels lost. The salt works at Tortuga were destroyed by the hurricane, also, and 3 French and 5 Newfoundland vessels driven on shore.

On the 6th of October 5 vessels were driven on shore at Dominica in a gale of wind, and upward of 50 sail at Guadeloupe.

On the 22d and 23d of October a violent hurricane did considerable damage in the harbor of Pensacola. The Spanish fleet from Vera Cruz for Havana and old Spain, consisting of 5 large ships of register richly laden, were driven ashore at the Bay of St. Bernard,

1768—On the 25th of October a brief but violent hurricane occurred at Havana. The storm began from the south and died away from the north, having continued not more than two hours; nevertheless, in that short time 96 public buildings and 4,048 houses were destroyed and about 1,000 persons killed almost instantly.

It was this year that the snow *Rodney*, carrying convicts to Maryland, was forced by stress of weather into Antigua. It is also stated that there was great distress among the convicts; as many as eleven died from want, and the survivors had to eat their shoes and the like to sustain life.

1770—On the 3d of June, in the afternoon, the Island of Santo Domingo suffered from a fearful earthquake. The City of Port au Prince was entirely destroyed; not one house was left standing, and more than 500 people were buried beneath the ruins. La Croix de Bouquet, a small town, with the greater part of the inhabitants was swallowed up. The sea rose a league and a half in the island.

1771—The great calamity of this year came in the form of a famine at the Bay of Honduras, caused, as it is said, by locusts. They ate up every green thing, and in some places covered the ground a foot thick. It is estimated that as many as 8,000 Indians died from starvation because of this awful visitation.

1772—During the last days of August and the first days of September a hurricane passed over the West Indies, causing frightful havoc among the Leeward Islands. At Dominica 18 vessels were driven ashore and lost. Several war ships were driven ashore at Antigua. At Montserrat and Nevis nearly every house was blown down. The hurricane passed over St. Kitts on August 31, beginning at daylight. At noon the storm abated to such an extent that the people thought that it was over, but the wind suddenly shifted from the northeast to the southwest by south, and blew with increased violence, destroying almost every house, sugar mill, tree, and plant, killing several and wounding many persons. The damage was estimated at £500,000 sterling. At St. Eustatius 400 houses were destroyed or rendered untenable, and the Dutch church blown into the sea. At Saba 180 houses were blown down. At St. Martins nearly all the houses and all the plantations were destroyed. The disastrous effects of this storm were felt nowhere more forcibly than at Santa Cruz, where, it is said, the sea rose 72 feet above its usual height, carrying every ship at the island on shore, some as far as 100 yards inland. Large stones were brought down from the mountains, and there was a terrific electrical display. Four hundred and sixty houses were thrown down at Christianstadt, and all but three at Fredericstadt. The magazines and stores were quite ruined. The total damage was estimated at $5,000,000. The damage at St. Thomas was placed at $200,000.

1779—This year was marked by a drought and famine at Antigua. The water supply became quite insufficient and the stock and negroes perished in the greatest agony. A malignant fever raged at the same time, threatening all with death. Mr. Baxter, a Methodist preacher, appointed the 28th day of May as a day of fasting, and he says: "It is remarkable that while we were assembled for prayer, the Lord granted our request by sending an abundance of rain."

1780—The hurricanes of this year were characterized by such unusual violence, and were attended by such appalling disasters that accounts of them may be found in many works on the subject, hence an extended account is not necessary in this place. As to the hurricane which swept over the Island of Jamaica, we reproduce the account given in Southey's West Indies, Vol. II, page 472.

"Upon the 3d of October the inhabitants at Savanna-la-Mar were gazing with astonishment at the sea swelling as it had never before; on a sudden, bursting through all bounds and surmounting all obstacles, it overwhelmed the town and swept everything away so completely upon its retreat as not to leave the smallest vestige of man, beast, or habitation behind. The sea flowed half a mile beyond its usual limits, and so sudden and unavoidable was the destruction, although it took place at noonday, that of the inhabitants of one gentleman's house, consisting of 2 whites and 40 negroes, not a soul escaped. Where the sea did not reach the destruction was nearly as effectual by the succeeding earthquake and hurricane; between both scarcely a house or building of any sort was left standing in the parishes we have named (Westmoreland and Hanover).

"The gale began from the southeast at 1 p. m.; at 4 it veered to the south and became a perfect tempest, which lasted in full force till near 8; it then abated. Forty of the inhabitants who had sought shelter in the courthouse were killed by the house falling upon them. At 10 there was a smart shock of an earthquake and the waters subsided. All the vessels in the bay were dashed to pieces or driven on shore."

We now come to the consideration of what is commonly and very properly called the great hurricane. A full history of this hurricane is not difficult to get and is worth the effort. In this connection we reproduce an account of this hurricane, found in a work entitled The Atmosphere, by Flammarion, beginning on page 377:

"The most terrible cyclone of modern times is probably that which occurred on October 10, 1780, which has been specially called the great hurricane, and which seems to have embodied all the horrible scenes that attend a phenomenon of this kind. Starting from Barbados, where trees and houses were all blown down, it engulfed an English fleet anchored before St. Lucia and then ravaged the whole of that island, where 6,000 persons were buried beneath the ruins. From thence it traveled to Martinique, overtook a French transport fleet and sunk 40 ships conveying 4,000 soldiers. 'The vessels *disappeared;*' such is the laconic language in which the governor reported the disaster. Farther north Santo Domingo, St. Vincent, St. Eustatius, and Porto

Rico were devastated, and most of the vessels that were sailing in the track of the cyclone were lost with all on board. Beyond Porto Rico the tempest turned northeast toward Bermuda, and though its violenee gradually decreased it nevertheless sunk several English vessels. This hurricane was quite as destructive inland. Nine thousand persons perished in Martinique and 1,000 at St. Pierre, where not a single house was left standing, for the sea rose to a height of 25 feet and 150 houses that were built along the shore were engulfed. At Port Royal the cathedral, seven churches, and 1,400 houses were blown down; 1,600 sick and wounded were buried beneath the ruins of the hospital. At St. Eustatius 7 vessels were dashed to pieces on the rocks, and of the 19 which lifted their anchors and sailed to sea only one returned. At St. Lucia the strongest buildings were torn up from their foundations; a cannon was hurled a distance of more than 30 yards, and men as well as animals were lifted off their feet and carried several yards. The sea rose so high that it destroyed the fort and drove a vessel against the hospital with such force as to stave in the walls of that building. Of the 600 houses at Kingston, on the Island of St. Vincent, 14 alone remained intact, and the French frigate *Junon* was lost."

From the Gentleman's Magazine for 1780: "Alarming consequences were dreaded from the number of dead bodies which lay uninterred, and the quantity of fish the sea threw up, but these alarms soon subsided." (Compare this hurricane with that of 1666.—*A.*)

1781—On the 1st of August a gale of wind from the south at Jamaica sunk 2 loaded vessels and drove 24 others on shore, besides wrecking or driving on shore 73 light vessels.

1784—A hurricane began at Jamaica at 8:30 p. m., and continued up to 11 p. m. or later of July 30, sinking, dismasting, or driving on shore every vessel in the harbor except 4, causing the loss of numerous lives, The barracks were blown down killing 5 soldiers. The workhouse was destroyed and 10 of the inmates killed or wounded.

During the first three days of August the Island of Santo Domingo experienced a storm.

1785—A hurricane visited Jamaica on the 27th of August.

1786—The first storm of this year was in August, doing most damage at St. Eustatius where all the shipping was driven to sea and most of the small craft destroyed. It also swept the southern coast of Espanola. Another hurricane swept over Guadeloupe on September 10, doing much damage.

From Southey: "On Saturday, the 2d of September, an alarming hurricane threw the inhabitants of Barbados into the utmost consternation. At 11 p. m., when the storm was at its height, a meteor in the southeast issued from a dark cloud, and spreading its diverging rays to a vast circumference, continued, with unabated splendor, nearly forty minutes.

On the morning of the 3d Carlisle Bay was a scene of desolation, not a vessel had ridden out the storm. In the country great damage was done to houses and crops; many persons killed in the ruins of their own houses.

Jamaica came for her share this year on the 20th of October. The trees were stripped of their leaves and appeared as if fire had passed over them. The shores were covered with aquatic birds killed by being dashed against mangroves.

1787—According to the record there were three gales at Dominica this year, all in August; one on the 3d, one on the 23d, and one on the 29th. A number of houses, all the barracks, and all the vessels in the harbor were wrecked. In September, on the 23d, Balize experienced a severe hurricane, attended by heavy rains, and as the sea rose the land floods could not flow off, hence great damage was done by the overflow. It is stated that more than 500 houses were thrown down and 100 persons perished. Dead carcases and logs of mahogany were floating about in every direction. As many as 11 square-rigged vessels, besides the smaller ones, were totally lost.

1790—The little Island of Tobago is brought into notice this year by destruction wrought there in August by a hurricane, which, among other things, wrecked 20 vessels on the coast. As illustrative of the marvelous things sometimes performed by the hurricane we reproduce an account of what occurred on Mr. Hamilton's estate during this gale. "His new mansion, which had been built upon pillars, was lifted by the tempest and removed to some distance, but being well made did not go to pieces. Mrs. Hamilton, two ladies, and five children, were in the house and suffered little or no harm. Mr. Hamilton being absent from home knew not what had happened, but returning in the night, which was excessively dark, and groping for his door, fell over the rubbish left on the spot, and so far hurt himself that he was confined for a week."

1791—At daybreak, the 21st of June, it began to rain near Havana and contiued until 2:30 in the afternoon of the folday, with such force as to cause the greatest flood ever remembered in that country. The royal tobacco mills, and the village in which they stood, were washed away and 257 of the inhabitants killed. In the spot where the mills stood the water, or a partial earthquake opened the ground to the depth of 45 feet, and in one of the openings a river appeared of the purest water. Where the Count Baretto's house stood was a cavity more than 60 feet deep, from which a thick smoke arose. Four leagues from thence the torrent was so great that none of the inhabitants within its reach escaped. All the crops of corn and growing fruits were carried away. Three thousand persons and 11,700 head of cattle are said to have perished in the flood.—*Southey.*

1792—St. Kitts experienced a terrific flood which caused the loss of many lives and the destruction of much property. In August of this year a tremendous hurricane swept over the West Indies, causing great loss of life and property.

1793—About 30 vessels were lost or stranded by a hurricane in August at St. Kitts.

1803—On the 3d of September 13 vessels were wrecked by a hurricane. Among the vessels was the *Aurora* with cargo costing £46,000 sterling.

1807—The Bahama Islands were so desolated by hurricanes that the inhabitants suffered great hardships in procuring the necessaries of life.

1812—October 14, a hurricane devasted Trinidad, Cuba, wrecking 500 houses, and very much damaging the Pope's Convent and the hospitals, besides driving on shore or sinking many of the vessels in the harbor of Casilda.

1815—The West Indian Islands, especially the Leeward Islands, desolated by a hurricane which swept over them on August 31 and September 1. It is said that 30 sail were driven on shore at St. Bartholomew alone and 14 totally lost.

A hurricane on September 20 blew down or unroofed about half the houses in Turks Island, besides destroying about 400,000 bushels of salt. A number of vessels were wrecked, and one American vessel lost 22 of her crew and passengers.

On the 28th of October, Jamaica suffered very great damage from a hurricane. Several vessels with their crews were lost and others damaged.

1819—In September of this year a hurricane swept over the Leeward Islands, the Virgin Islands, and the Bahamas. It was first noticed near St. Lucia, passed over or near Antigua, St. Kitts, St. Barths, and St. Martins. It was most destructive in the Virgin Islands.

1825—On July 26 of this year a hurricane did very great damage to Guadeloupe. The Bishop of Guadeloupe was among the killed. It blew with considerable force at Dominica, Martinique, and Porto Rico.

1859—On September 2, a hurricane of rather mild form passed over St. Kitts, that is the center passed right over the island. It wrecked a number of boats besides other damage. It passed over St. Croix after leaving St. Kitts.

1871—A dreadful hurricane occurred this year in August. The center of the storm passed over St. Kitts. The barometer began to fall about 1 a. m. of the 31st, at which time the wind was from the east-northeast. By 6 a. m. the barometer had fallen to 29.60, and the wind had shifted to the north; at 8:40 the barometer stood at 28.50, and there was a calm lasting twenty-two minutes, after which the wind came from the southwest and the barometer began to rise. The damage done was quite general. The center passed right over Antigua and Statia also.

1876—In September of this year there occurred a severe storm. It passed to the north of St. Kitts on the 12th. The storm passed to the northwest at 7 p. m., and the lowest barometer reading recorded was 29.35. The wind shifted to west-northwest, west, west-southwest, southwest, and, finally, east-southeast. There was no thunder, but some lightning in the northwest and west-southwest at intervals.

1899—The great hurricane of this year was the one which occurred in August between the 7th and 14th. It was so violent and caused such widespread destruction that it will certainly be ranked as a historical hurricane, for which reason it is mentioned in this place. Entering the West Indian regions in the vicinity of Guadeloupe, it included in its majestic sweep the Leeward and Virgin islands, Porto Rico, and the Bahamas, not to mention the damage along the coast of the United States. The desolation and ruin wrought by this monster in the West Indies are fresh in the minds of all and need not be repeated here. Suffice it to say, then, that the wreckage along its path is comparable only to "the gambols of a bull in a china store." This hurricane was peculiar, in that it maintained a distinct organized existence for more than a month, finally dissipating in the region of the Mediterranean Sea.

In regard to the above notes on historical hurricanes it is not offered as a complete list of West Indian hurricanes, not even of *severe hurricanes;* but being forced to make selections for the sake of economy of space, the above were selected for reasons unnecessary to point out.

Most of the data are taken from Southey's Chronology, B. Edwards's West Indies, and Handbook of the Hurricane Season, by Westerly. The writer is also indebted to Dr. W. J. Branch, of Basseterre, St. Kitts, for data relative to the hurricanes of 1819, 1825, 1859, and 1871.

THE VIRGIN ISLANDS HURRICANE OF OCTOBER 29, 1867.

The following notes regarding this great storm are found in the Nautical Magazine, Vol. XXXVI, December, 1867:

It appears that the center of this hurricane, traveling in the usual west-northwest direction, passed immediately over the Virgin Group. On the 29th of October, at 11 a. m., at St. Thomas, the wind is reported as blowing a fearful hurricane from north-northwest half west, the wind all the morning having been from the northward. By 11 a. m., the wind at north-northwest half west, the barometer was down to 27.95. At 12:15 the wind had lulled, and at 12:30 it

was almost calm, and at 12:40 it was almost dark. Shortly after, a most fearful rush of wind from south-southeast half east set in, and it continued to blow (how not said), but with gradually diminishing force, until 4 p. m. During this period a great deal of mischief was done. The storm appears to have traveled on an east-northeast and west-southwest line, the focus passing over Tortola and the harbor of St. Thomas, with the usual lull. The mention of two hurricanes is evidently by an inexperienced person, who seems to be quite uninformed on the principle of the rotary gales. In point of duration it was a mere transient gale (a day and a half or two days being not unusual with these hurricanes, while this lasted not half a day). However, the violence of it seems to have made up for its brevity.

It is estimated that upward of 600 persons were drowned at St. Thomas during the hurricane, the loss of life occurring mainly among the crews and passengers of vessels. Within forty-eight hours 300 bodies were washed ashore, recovered, and buried. The leading features of this calamity appear to be confined to the great loss of shipping and the destruction of houses in the islands of St. Thomas and Tortola. On shore many persons were killed by the falling of houses. Considerable damage was done along the shores of the harbors by the high seas, but the loss of life through the waves among the people on shore was very small. Amid the confusion of wrecks there was slight chance for identifying about eighty vessels which were known to have suffered more or less from the hurricane in the harbor. * * * After the hurricane had lasted some time there was a lull for about half an hour. It then recommenced with redoubled fury and lasted altogether three hours. The *Rhone* parted amidships and the waves ripped the gigantic steamer up just as if she were made of brown paper. * * * Seventy-five vessels were wrecked or seriously damaged; property to the amount of a million and a half or two millions pounds sterling was lost and about 500 persons perished. * * * All the islands appeared as if fire had passed over them. The town of St. Thomas looked exactly as if an explosion had taken place; roofs, doors, and windows having been blown away, and the streets were filled with tiles, trees, and rubbish. The harbor was filled with wrecks. * * * The hurricane occurred after the season was supposed to be over as the first full moon in October was on the 13th. * * * All the vessels that tried to go to sea were lost, with nearly all hands. * * * The wharfs which lined the shore were gone and every street was blocked up with broken rafters and debris of every conceivable description. Houses even were to be seen standing erect which had been lifted from their foundations many yards distant and dropped into some of the lanes running seaward out of the main street. A bombarded town could never have presented a worse picture of desolation and ruin. Plantations of whitened sticks covering the hills alone indicated that trees had at one time grown there. * * * The hurricane appears to have commenced at 12:10 and to have lasted with one break—at 1 o'clock, lasting thirteen minutes—till half past 3. The barometric indications of its coming were feeble until it had absolutely broken, then the downward progress of the mercury could be plainly seen. One or more shocks of earthquake were experienced, and in a moment the awful conflict had begun. At 1 o'clock the storm blowing from the northwest had ceased and the thirteen minutes lull took place. Again it broke forth with more dreadful energy from the opposite quarter and tore away many vessels which had until then rode securely. * * * The houses on the island appeared to have suffered more from the earthquake than the hurricane, destructive as the latter was. The particulars of the earthquake wave are so colored that it is difficult to arrive at the truth of them. An eyewitness stated that it swept directly over Brush Island, which is tolerably high, and advancing thence on the harbor was only prevented from visiting the town by the check it received from the overlapping points which in somewise shelter the entrance to the port. However, it appears pretty certain that vessels which were lying in four fathoms of water were left dry for a short time as the wave receded, but the subsidence must have been very gradual as none were wrecked from its effects, although at Santa Cruz an American frigate was deposited *in the market place*, where she was abandoned.

It is interesting to note that the almost completed negotiations for the purchase of the Danish West Indian Islands by the United States were ended closely following the occurrence of this hurricane and the earthquake of November 18.

SAN JUAN, PORTO RICO.

Porto Rico has been devastated by many hurricanes, but the records beyond the mere statement of the facts, are very incomplete and inaccessible. Four, however, stand out prominently as having committed terrible ravages. These are the hurricanes of Santa Ana on July 26, 1825; Los Angeles on August 2, 1837; San Narciso on October 29, 1867; and San Ciriaco on August 8, 1899.

Owing to the paucity of records it is almost impossible to say which of these four was the most severe, but it is the generally conceived opinion that that of the Los Angeles was the worst. There being no meteorological data available, however, it can probably be said that the hurricane of San Ciriaco was very nearly as severe as regards the velocity of the wind, and very much more so as regards the destruction of property and life. This is probably due to the fact that in 1837 the population of the island and the number of buildings was very much less. The latter hurricane having also occurred while a station was in operation in San Juan, we are enabled to present meteorological data which is entirely wanting in the former.

The rainfall during San Ciriaco was excessive, as much as 23 inches falling at Adjuntas during the course of twenty-four hours. This caused severe inundations of rivers with which Porto Rico is so liberally endowed, and the deaths from drowning numbered 2,569, as compared with 800 killed by injuries received from the effects of the wind. This number does not include the thousands who have since died from starvation. The total loss of property was 35,889,013 pesos (dollars).

For several days previous to the hurricane the meteorological conditions had been peculiar. On the 3d calm was recorded at both the morning and the evening observations. Between midnight of the 3d and 8 a. m. of the 4th but 4 miles of wind were recorded. The barometer showed no rise such is usually anticipated immediately preceding a hurricane, the mean of the 5th being 29.96, and that of the 6th 29.98. During the afternoon of the 7th the sky was unusually hazy, and the lower clouds were moving rapidly from the northeast. About 3 p. m. the sky was covered with thick alto-stratus and stratus clouds, the former moving from the southeast and the latter from east-northeast. At this time the barometer registered 29.865. At 10 p. m. the barometer began its downward movement, which did not cease until the lowest reading, 29.23 inches was reached, at 8:30 a. m. of the 8th, at which time the mercury in the tube was oscillating violently.

The storm passed to the south of San Juan, and striking the island on the southeastern part, passed in a direction north of west until it passed the northwestern part, the time consumed in its passage being from 7:00 a. m. until 1 p. m. The wind reached no very high velocity until 2 a. m. of the 8th. At 10 p. m. of the 7th, however, it came in puffs, some of them of considerable violence. At 5 a. m. of the 8th it was raining and blowing furiously, both increasing until between 7 and 9 a. m. the hurricane was at its height, the wind reaching a registered velocity of 66 miles an hour from the northeast. The wind shifted during the progress of the hurricane from northeast to southeast.

There was noted in the case of this hurricane, as has been noted in subsequent ones, a decided lowering of the relative humidity immediately preceding.

The total loss of life caused by this hurricane was 800, and 2,569 persons were drowned.

R. M. GEDDINGS,
Section Director, Weather Bureau.

THE "PADRE RUIZ" HURRICANE, SANTO DOMINGO, W. I., SEPTEMBER 23, 1834.

The most severe and destructive hurricane on record that passed over this city is the one generally known as the "Padre Ruiz" storm, which occurred on September 23.

It derived its name from the fact that it began when the funeral services were being held over the body of the priest of that name in the church of Santa Barbara.

The loss of life and property was appalling. Everything was laid waste before its fury. Large tracts of timber on both sides of the Ozama River were torn up by the roots; many vessels were lost, and the suffering of the people was something terrible. Hundreds of houses in the city were unroofed or blown down and many lives and thousands of head of all kind of stock were lost.

The stone church at San Antonio was unroofed and then demolished. Its ruins are still standing as a monument of the fury of the storm. The downpour of rain was so great that a fisherman by the name of Jose Ramon was drowned in the principal market space of the city, as no one dared to go out on the street to render him assistance.

(Translated from Historia de Santo Domingo.)

LOUIS DORMAN,
Observer, Weather Bureau, Santo Domingo, W. I.

JAMAICA, W. I.

Vol. 11 of the Jamaica Weather Reports, by Mr. Maxwell Hall, Government Meteorologist, contains the following descriptions of noteworthy hurricanes which have visited that island:

August 28, 1722.—This great hurricane damaged the whole island; the center passed over Port Royal, where the water rose 16 feet above its usual level. "It began at Port Royal," writes Long (Vol. 11, p. 145), "at 8 in the morning, and lasted fourteen hours, during which time the rain was incessant and the storm veered all around the compass. In Kingston most of the buildings were thrown down or much shattered. The day preceding was perfectly calm, but so great a swell at sea that the waves broke over the breastwork at Port Royal and laid all the streets under water. The fort suffered very much; several guns were dismounted and some washed into the sea. The church and row of houses in the east part of the town were so battered that there remained very little appearance of buildings. In short, about half the town was laid in ruins, and the houses and plantations in all parts of the island suffered considerable

damage, except in St. Jago, where the Spanish buildings stood the shock unhurt. Very few of the inhabitants lost their lives, but in the harbor it proved more fatal." Part of the squadron was at sea, but out of 50 vessels in port only 4 men-of-war and 2 traders were saved, with the loss of their masts. About 400 lives were lost. After the hurricane there was a calm, and the air was poisoned by the smell of decaying bodies, and an epidemic broke out.

October 20, 1743.—"Another furious hurricane," writes Long, "arose at 6 in the evening (at Port Royal) and continued until 6 the following morning. A new fort begun at Mosquito Point (Fort Augusta) was entirely razed; many houses were blown down in the towns and other parts of the island, and all the wharfs at Port Royal, Kingston, Passage Fort, and Old Harbor were destroyed and most of the goods swept away. The inhabitants of Port Royal expected every moment to be swallowed up by the inundation, the streets being all laid several feet under water; but, happily, their wall withstood the shock and saved them from utter ruin. Their dangerous situation may be imagined, for the wind, setting the whole time from the south, drove the surge full against this part of the town with such fury that immense loads of stone and sand were poured over the wall. Sir Chaloner Ogle, who then had command of this station, was fortunately at sea with the major part of the fleet; but there were 9 men-of-war and 96 merchant ships in harbor, 104 of which were stranded, wrecked, or foundered, so that only the *Ripon* rode it out, with the loss of her masts, and a great number of marines were drowned." A pestilence followed, which proved fatal to a still greater number of lives.

WILLEMSTAD, CURACAO, WEST INDIES.

Leon J. Guthrie, Observer, Weather Bureau, submits the following regarding Curaçao's most severe storm:

The hurricane of September 23, 1877, is the only destructive storm on record here. As no records were kept by the government at that time it is impossible to obtain entirely reliable data, therefore the report is confined to desultory observations by sea captains and private individuals and to extracts from consular reports and newspaper files.

The day preceding the storm was unusually calm, with light gusts of wind. From 4 a. m. until midnight the pressure remained stationary at about 29.80. Shortly after noon a few swiftly-moving cirrus clouds were observed but their direction was not remembered. Early in the afternoon the sky became overcast, presenting a dark greyish color, and the sea swell was long and increasing in height. During the evening the wind increased to almost a gale from the northeast and dark, heavy clouds formed along the eastern horizon. The barometer read 29.80 at 4 a. m., 8 a. m., 2 p. m., and midnight, but began to fall shortly after midnight—slowly until 3 a. m., then more rapidly. Light drizzling rain fell at intervals during the afternoon. After midnight the wind increased steadily from the northeast and the swell was very heavy. Heavy rain began about 3 a. m., and the pressure at that time was 29.75, a fall of but .05 in three hours. At 5 a. m. a tremendous sea was running; the wind changed to north, increasing to hurricane velocity, and rain fell in torrents. From 5 to 9 a. m. the storm increased in violence, reaching its maximum strength about 8 a. m., when "In the city proper many houses were totally destroyed, and many others partially, both by the force of the wind and by the waves which rolled inward from the sea, washing the most substantially built houses away as if they were built of paper" (extract from United States consular report). The pressure continued to fall until 11 a. m., when it began to rise; the wind changed to east, but continued to blow with great violence. At 2 p. m. the wind changed to southeast, becoming considerably lighter. The barometer had risen rapidly and by 4 p. m. the weather cleared, the wind and waves had greatly diminished in force, and the storm had passed.

There were no temperature readings taken, and the only barometer readings were taken by some private person and published in the Curaçao Courant. They were as follows: September 22, 4 a. m., 29.80; 8 a. m., 29.80; 2 p. m., 29.80; midnight, 29.80. September 23, 3 a. m., 29.75; 5 a. m., 29.70; 9 a. m., 29.60; 9:30 a. m., 29.55; 10:30 a. m., 29.45; 11 a. m., 29.45; 11:45 a. m., 29.50.

It is generally believed that the center of the storm passed some distance south of Curaçao, moving from southeast to northwest. The captain of a small sailing vessel reported a barometer reading of 29.20 at some distance south of the island. The lowest recorded reading on the island was 29.45.

The number of lives lost was never known, but it is thought that it was no more than 16. The damage to property approached $800,000.

SANTIAGO, CUBA, W. I., *April* 10, 1900.

Mr. Mason, British Consul at this place, has given me a statement which I inclose herewith. Mr. Mason informs me that he was appointed a Voluntary Observer for the United States Signal Corps in 1878, and reported the storm he refers to in his statement.

"Since the year 1866 I know of no very violent storm striking this vicinity. The first storm which I saw was in 1878, and since then I have seen three more, including that of last year, which have caused some damage in this vicinity, but the damage has been chiefly caused by excessive rain, even to the buildings in town, many of them being built of cujes or adobe.

"When I came here I frequently heard reference to a severe hurricane felt in the early fifties, I think in 1852 and in August, but I have not been able to find any data.

"On the other hand, from one or two quite old gentlemen, I have gotten some particulars of a severe hurricane which did much damage in this vicinity in the year 1831. One of them says it occurred on Saturday, the 13th of August, that he was living in the country about thirteen miles from Santiago, and can remember that the wind began to blow quite gently about 7 a. m., but by 9 a. m. it was blowing hard, and that it blew from all directions until 5 p. m., when it began to abate; that it blew so hard that they could not go out of the houses, and that it was impossible to pass along the road. He remembers that branches of trees flew through the air like feathers, that all rivers overflowed and could not be crossed for four or five days; also that the roads were completely spoiled."

I see in Miguel Roderigues Ferrer's book that he cites Poey and others as describing a hurricane in that year.

I have so far been unable to find here any printed data with regard to any hurricane.

A. V. RANDALL, *Observer Weather Bureau.*

PUERTO PRINCIPE, CUBA.

From the fact that details are meager and stories conflicting, it is evident that, for a good many years, no storm great enough to impress itself upon the memories of the people, has visited this place.

The most reliable source of information tells us of three storms whose accompanying phenomena have been noticeable here. One of these passed south of Santa Cruz in 1878; the one which most nearly approached this place passed through Santa Cruz in 1894, while the third one referred to passed north of the island in 1895.

The storm of 1894 was accompanied by high winds and heavy rains, which raised the Hatibanico River to the greatest height recorded. Very little damage was done, and it is believed that no lives were lost. Other details are conflicting, even contradictory, and there seems to be a controversy regarding the exact date.

PAUL DEGRAW, *Observer, Weather Bureau.*

CIENFUEGOS, CUBA.

During the latter part of the year 1825 the Colony of Cienfuegos, which had been founded about six years before, was almost completely destroyed by a severe hurricane, only three or four houses being left standing. A subscription was made throughout the island large enough to restore to each homeless colonist the value of one-third part of what he had lost. Apparently these first houses had been little better than huts, as the historian states that those built after the storm were of a more substantial character, some being of wood and others of masonry.

On October 13, 1877, the influence of a hurricane began to be felt in Cienfuegos. The barometer reached its minimum, 744.7 mm., during the 18th and 19th, and oscillated between 745 and 746 mm. for twelve hours, during which period the vortex of the storm being to the west of the city, very high and steady winds were experienced from the southeast, south-southeast, and south, a maximum velocity of 72 miles per hour being attained. The water in the harbor rose 4 feet above its ordinary level, flooding many streets in the lower part of the city, and also the houses, so that the dwellers therein had to abandon them, some families being rescued in boats by the police, firemen, and others. The high houses especially suffered from the wind, and the wharfs were much damaged by the sea. Many vessels in the harbor were dragged from their anchorage, and some were wrecked outside the harbor, one, an English bark, the *M. E. Chapman*, while trying to enter. No loss of life is mentioned, but it was found necessary to issue rations to many of the poor who had lost their homes, and on the 22d more than 1,000 people visited the mayor's office to solicit food.

The approach of the hurricane of 1882 was first indicated in Cienfuegos on the 4th of September by a falling barometer. Little notice was taken of this, however, as it was unusual for this section to be visited by hurricanes at this season of the year. At 11 p. m. of the 4th the barometer marked 760 mm.; the sky was threatening and there was much heat. The pressure continued decreasing slowly to 758 mm. at 4 a. m. of September 5, with showers and light gusts of wind from the north-northwest. The wind increased in strength. At 7 a. m. the barometer stood at 756 mm., and at 9 a. m. at 752 mm., with occasional violent gusts of wind from the northwest. After this latter hour the barometer fell rapidly, the gusts of wind and the rain increasing, until at 11 a. m. the barometer marked 742 mm., with furious gusts of wind from the west, which did not cease until 1 p. m., and destroyed whatever was in their path. The barometer reached its minimum, 741 mm., at 12 noon amid a general tumult of elements. At 12:30 p. m. it marked

741.10 mm., the wind backing toward south-southwest, but still blowing very heavily. At 1 p. m. the wind was southwest, with barometer 742 mm.; at 1:15, 743 mm., with heavy gusts from the south-southwest; at 1:30 p. m., 744 mm., and at 1:45 p. m., 745 mm. From 2 to 3 p. m. the wind was backing to the south, and the pressure increased to 748 mm. At the latter hour the gusts from the south increased in force and continued until 4:30 p. m., with the barometer rising slowly. After 5 p. m. the wind began to die down, although rain still fell abundantly. At 9 p. m. the barometer had risen to 756 mm.

This hurricane, of a diameter of more than 100 leagues, and whose vortex cut the meridian of Cienfuegos at noon of September 5, from 5 to 9 leagues north of the city, caused great damage and loss throughout this section. One boy was drowned and many persons suffered slight injuries. There was scarcely a house in the city that was not more or less damaged. Some were broken down completely, while parts of the roofs and walls of others were blown to the ground. The signal staff belonging to the captain of the port was blown down. The gas plant was partially wrecked. Nearly all the trees in the city, except the palms of the Plaza de Armas, were uprooted. All of the wharfs suffered considerable damage. In some of the small surrounding towns nearly all of the dwelling houses were destroyed. The vortex of the storm appeared to pass directly over Cartagena (a small village 15 to 20 miles to the north) and at that point scarcely a house or tree was left standing. Crops of all kinds throughout this section also were greatly damaged.

Mr. J. S. Murray, an American civil engineer, who was living in this city at the time of the hurricane of 1882, states that a wind gage at Central San Lino, a sugar plantation some miles to the north of Cienfuegos, recorded a maximum velocity of 92 miles from a westerly direction; also that all but one of the vessels in the harbor here were blown ashore.

In the summer of 1888 another severe hurricane passed near this city and caused much damage. During the passage of this storm Mr. Murray took a number of barometric readings and notes, which he has offered to furnish me copies of, but up to this time he has not succeeded in obtaining them for me.

JAMES L. BARTLETT, *Observer, Weather Bureau.*

HAVANA, CUBA.

Years in which hurricanes occurred on the Island of Cuba; also monthly date of occurrence; and lowest barometer reading, when given.—*Marcos T. Melero, Diario de la Marina, October 9, 1873.*

1494. May 19–20.
1498. Hurricane which damaged the naval fleet of Spanish Admiral Colon, en route from Cuba to Spain.
1527. Hurricane which destroyed the naval fleet of Spanish Admiral Panfilo Narvaez, in Casilda Harbor.
1557. A furious hurricane throughout the island.
1588. A furious hurricane; more destructive than that of 1557.
1679. February 11.
1692. October 24. Storm of San Rafael, in Havana.
1712. October. Storm in Havana.
1714. Strong hurricane throughout the island.
1730. Storm in Havana which destroyed the Paula Hospital.
1733. Strong storm throughout the island.
1744. November. Storm; after which a plague of worms appeared among the cattle.
1755. November 1. Storm; through which the city was inundated by the waters of the Gulf of Mexico.
1756. October 2 and 3.
1766. June 11.
1768. October 15.
1778. October 28.
1780. October 17.
1784. March 8. Strong storm, attended with hail; named "Storm of San Juan de Dios."
1791. June 21–22. The river Las Puentes overflowed, inundating the country as far as Cerro.
1792. October 29.
1794. August 27–28.
1796. October 3.
1796. October 24.
1799. Storm on the southern coast.
1800. October 14–15.
1800. November 2. Hurricane in Santiago de Cuba, with rain and earthquake.
1807. September 5. Lowest barometer, 29.79.
1810. May.
1810. June.
1810. September 28.

1810. October 24–25. Lowest barometer, 29.35. Storm in Vuelta-Abajo, Pinar del Rio Province, called the "Salty storm."
1812. October 14. Big storm in Trinidad, Cuba.
1819. Big hurricane over the southern coast.
1821. Big storm in Havana. Lowest barometer, 29.31.
1825. October 1. Hurricane in Trinidad and Cienfuegos.
1826. Hurricane throughout the island.
1831. August.
1832. Big storm throughout the island.
1833. October. Big storm in Vuelta-Abajo, Pinar del Rio Province.
1835. August.
1837. July 26. Big storm in Trinidad.
1837. October 25 to 26. Lowest barometer, 28.06.
1841. November 28. Lowest barometer, 29.55. Storm in Havana, called the "Mercurial storm."
1842. September 4. Lowest barometer, 28.93.
1844. October 4 to 5. Lowest barometer, 28.84.
1846. October 10 to 11. Lowest barometer, 27.06.
1850. August 21–22. Lowest barometer, 29.52 to 29.37.
1856. August 27. Lowest barometer, 28.62.
1859. October 2.
1865. October 22. Barometer 29.00; lowest barometer, 28.78.
1870. October 7–8. Lowest barometer, 29.38.
1870. October 19–20. Lowest barometer, 29.32.
1873. October 6. Lowest barometer, 29.56.

HURRICANES AT HAVANA OF WHICH DATA ARE OBTAINABLE.

1. *October 15, 1768.*—Wind of hurricane force blew for a little more than one hour from the southeast, backed to northeast, and later to northwest. The maximum force of this hurricane was experienced from the northeast and north; the wind decreased and weather cleared when the wind backed to northwest.

The damage to vessels in the harbor was as follows: Blown on the beach and their hulls, masts, and rigging injured: (Men-of-war) 2 line-of-battle ships, 3 frigates, 5 schooners, 5 sloops, and 1 pontoon; (merchant vessels) 10 frigates, 2 barks, 5 packet boats, 5 sloops, 5 settees (lanteen-sailed boats), and many of the small boats that ply the harbor.

2. Occurred during six hours of the night of the 27th and 28th of October, 1794. The hurricane began with southeasterly winds, then they backed to the northeast, from which direction the maximum wind force was experienced; then backed to the northwest, when the wind diminished and the weather cleared.

Considerable damage was done to shipping in the harbor and to the wharfs. The following vessels were blown on shore: (Men-of-war) 1 line-of-battle ship, 1 frigate, 1 brigantine, 2 sloops, 1 schooner, and 6 small boats belonging to the arsenal; (merchant vessels) 7 frigates, 7 brigantines, 8 sloops, and 42 schooners; besides these, all the small harbor boats were either totally destroyed or so severely damaged as to require very great repairs.

3. Occurred during three hours of the night of October 2–3, 1796. The hurricane began with east-northeast winds, which backed to north, and later to northwest, when winds began to decrease in force and the weather to clear.

The following vessels were lost: 1 brigantine and 2 schooners of the Spanish Navy and 1 brigantine of the American Navy. The following were blown on shore and injured: 1 bark and 2 brigantines of the Spanish Navy and 2 brigantines of the American Navy, also 6 schooners of the Spanish merchant marine. Some cables (ship?) were broken and other minor damage done.

4. Occurred on September 4, 1842. At the break of day the wind began to blow very strongly from the northeast and increased in force until 2 p. m.; it was of great violence, attended with heavy rains. At 4 p. m. the wind backed to northwest and continued to blow with great violence until 10 p. m., after which hour it began to diminish in force. The loss caused by this hurricane was some damage to buildings, inundation on Animas and Trocadero streets, the washing away of boilers by the waves at the Punta, and great damage to crops and trees in the country.

5. Began with a southeast wind at 6 p. m. of October 4, 1844; backed to northeast and north and continued with hurricane force until 9 a. m. of the 5th, the hurricane attaining its maximum force at daybreak; after 9 a. m. the winds backed to northwest and decreased in force.

All the vessels of the navy (number not given) in the harbor were damaged in hull, masts, and rigging, and the schooner *Ligera* was carried away from her moorings by the steamer *Congress*, which was being blown toward the arsenal. The following coasting vessels were blown on the shore: 76 schooners, 1 steamer, 2 sloops, 10 lighters, 8 supply boats, and many of the smaller harbor boats. Of the vessels of the seagoing merchant marine 4 brigantines were blown on shore, others lost their masts, and many were severely damaged.

In Havana many doors and windows were blown out, and all the trees in the city were blown down. In the territory between the meridians of Havana and Cardenas all of the villages were almost totally demolished, and the plantations destroyed.

The following information regarding this hurricane was received from the various sources quoted below:

Mail boat *No. 3* sailed from Havana on October 4, 1844. At 6 a. m. of the 5th very violent winds were blowing; at 1:30 p. m. the wind backed to west-northwest, and blew with hurricane velocity; at 4:30 p. m. the wind veered to northwest and weather cleared.

Batabano, October 2, 1844.—Northerly winds began to increase in force, and by the 3d they had attained the intensity of a hurricane. The winds decreased on the afternoon of the 5th. Some ships were lost at sea and some blown on shore and wrecked; one vessel was carried by the waves one-half mile inland, and left there when the water receded.

Matanzas, October 6, 1844.—Yesterday, the 5th, was a day of horror and destruction. A terrific hurricane, which lasted eighteen hours, destroyed the majority of the wooden warehouses along the river banks, and the rivers overflowed, destroying everything in their paths. The Yumuri River for six hours inundated the territory as far inland as the printing office of the Aurora, seven blocks from its banks, and families in this district were driven from their houses and forced to seek shelter and safety elsewhere; many had to wade through water waist-high. The San Juan River overflowed and inundated the territory as far as the Pueblo Nuevo, and then flowed along the roadway. It is impossible to estimate the loss suffered by Matanzas, as not a single house has escaped injury. It is believed that between 4,000 and 5,000 boxes of sugar have been lost. Of the 15 or 20 vessels in the harbor only one could ride to its anchors; the others were blown against the wharfs. It is thought that the steamer *Cardenas* has been damaged beyond repair.

It is learned that Aguacate, Madruga, and Lazuna de Palos suffered as severely as Matanzas by the ravages of the hurricane. Alquizor also suffered very greatly, and there is not a single tree standing in that territory, excepting the palms. From Tapaste and Madruga reports are received to the effect that not a single house remains on the coffee plantations, and the coffee trees have been greatly injured.

6. *Hurricane of October 10–11, 1846.*—On October 10 the barometer fell rapidly from 10 a. m. to 4 p. m. At 10 a. m. the barometer read 29.68 and the thermometer 80°, and at noon barometer read 29.50 and thermometer 80°. The wind blew very strong from the northeast, with frequent rain squalls. At 4 a. m., October 11, the barometer read 29.24, and thermometer 80°; the wind blew with hurricane velocity from northeast and north, attended with excessively heavy showers of rain. At 6 a. m. barometer read 29.14, thermometer 80°, with furious northeast to northwest winds blowing; at 9 a. m. barometer read 28.50, thermometer 79°. The wind continued blowing with hurricane force until 10:30 a. m., when it reached its maximum velocity from the north, at which time (10:30 a. m.) the barometer read 27.74 and thermometer 79.5°. At 11 a. m. the wind was steady from the west-northwest, attended with heavy rain squalls, and a tendency to rising barometer. At 12 noon the barometer read 28.35 and thermometer 79.5°; wind very strong from the northwest and west-northwest, with frequent rain squalls. At 2 p. m. the barometer had risen to 28.91, and heavy and frequent rain squalls from the west-northwest and west had occurred. At 4 p. m. the barometer read 29.23 and thermometer 80°; the wind continued to blow very strong, but the rain squalls were becoming less frequent and with decreased rainfall. At 5 p. m. the barometer read 29.30 and thermometer 80°.

Very great damage was done to buildings throughout the city, and several lives were lost. The roof of the principal theater was blown off, the front wall was blown down, and the building presents the appearance of a pile of rubbish. Many families were compelled to abandon their houses and seek shelter in more secure places. The roof of the Cathedral was in a very bad condition; the cupola of the Sacrista Chapel was blown down and the upper windows blown out. The upper story of the Seminary College was rendered uninhabitable and most of the partitions on the second and third floors collapsed. The tower and a part of Angel Church building were blown down. The roof of Montserrate Church was blown off and the doors and windows blown out. The parish churches of Jesus del Monte and Guanabacoa were ruined. All the buildings of the tannery belonging to Señor Xifre were greatly damaged and one negro killed. The Liceo Building was greatly damaged and all the doors and windows were blown out. The gas plant was seriously damaged by the blowing down of the big smokestack of the factory; a big stone turret was blown over on the roof of the secretary's office and broke in the roof of the office. The railway station suffered great damage. In Havana Harbor the damage was greater than that caused by the hurricane of 1844, and many vessels were wrecked and blown on shore.

Matanzas, Cuba, October 10, 1846.—After having blown very fresh from the east-northeast, the wind diminished somewhat, but the weather remained dark and drizzly; barometer read 29.80 (time not given). At 9 p. m. the wind began to increase in force and the barometer to fall. At 11 p. m. the wind still continued to increase, with heavy gusts, until 4 a. m. of the 11th, when wind veered to southeast and blew with the velocity of a severe hurricane, carrying the steamer *Cardenas* from its moorings. At daybreak on the 11th the harbor presented a sad prospect, being covered throughout by wrecks, some blown on shore and others sunk in the harbor. At 6 a. m. the wind backed to east-southeast and diminished somewhat in force, but occasional strong gusts continued until 10 a. m., at which time barometer read 29.30 and wind veered to south and south-southeast and again increased and became of great violence, and so continued; at 1 p. m. the barometer read 29.80. The wind began to decrease at 2 p. m.—but rain squalls con-

tinued—and veered to south-southwest, and continued to decrease until 4 p. m., when it veered to southwest and became calm.

Of all the vessels in the harbor only the American frigate *Ranger* and the coastwise schooner *Antonia* held to their anchors, 10 vessels in the over-sea trade and 25 vessels in the coasting trade being either very severely damaged or entirely lost. This hurricane also caused the loss of many lives and destruction of, or damage to, much property. Many houses, both in the city and country, were destroyed, together with all crops, and a great number of trees; railway cars were blown over, and many heavy ox carts were carried by the wind several yards from where they stood.

On the plantation Alejandro, Guines, the negroes had taken shelter in the owner's house. The house was blown down, killing many of the negroes, 56 bodies having been recovered from the ruins up to noon of the 11th. A later dispatch, dated the 15th, reported the number of bodies recovered from the ruins of the plantation house as 84.

On the plantation Providencia, in the same locality, only a very few of the negroes escaped death. Number not given.

It was thought that the number of deaths in Guines amounted to 100.

At Cardenas the hurricane was not so severe as at Havana and Matanzas.

7. *August 21–22, 1850.*—From 4:30 p. m. of August 21, 1850, the winds were variable, shifting between northeast and northwest. At midnight they shifted to southwest and increased in intensity, and from 7 to 10 a. m., August 22, they were of great force, diminishing after 10 a. m. At 6 a. m., August 22, the barometer read 29.37 and the temperature 80°.

Crops were destroyed and many trees blown down. At the gas house the roofs of two houses were blown off, and a man who exposed himself to the wind was knocked down. The rivers overflowed, causing an extraordinary inundation, and some wooden houses were destroyed.

8. *August 27, 1856.*—At 8.54 p. m. on August 27 the barometer read 29.70; at 9.05 p. m., 29.57; at 9.25 p. m., 29.52; at 9.45 p. m., 29.49; remained at that height until 12 midnight, after which hour it began to rise.

9. *October 22–23, 1865.*—At 4 p. m., October 22, the barometer read 29.39, wind, east; at 8 p. m., 28.96, east-southeast; at 9 p. m., 28.81, south; at 10 p. m., 28.79, south-southwest; 10:30 p. m., after a period of calm, the wind again increased and blew very strong; 12 midnight, 29.05, wind west-southwest, and beginning to diminish in force. At 5 a. m., October 23, the barometer read 29.80, wind west.

Of the vessels at the Caballeria wharf 30 or 40 were destroyed, with their cargoes, and many others greatly injured. Most of these vessels were lighters loaded with assorted merchandise, sugar, etc. Some houses were damaged, and banana plantations and all crops destroyed. There were but few lives lost.

Between 10 and 10:30 p. m., October 22, a brilliant light, which resembled a fire, was observed in the direction of Reina street.

10. *October 7–8, 1870.*—The flag indicating very bad weather has been displayed since this morning, October 7. At 1 p. m., October 7, the barometer read 29.66, and at 6:30 p. m. 29.45, and heavy gusts of wind, frequently shifting, some of great violence, continued until 9.30 p. m., at which time there was a marked decrease in the velocity of the wind, and attended by a heavy downpour of rain. The rain continued with more or less severity until 10:30 p. m., at which time the wind again increased in force to a storm of great intensity, attaining its maximum force between 12 midnight of the 7th and 3 a. m. of the 8th. At 4.30 a. m. of the 8th the barometer indicated a rising tendency, and at 12 noon read 29.67. The barometer at 3 a. m. read 29.30, indicating that the blow was a severe storm, but not a hurricane; however, it was the most severe storm since October 22, 1865.

On the morning of October 7 the wind was northeast, with a tendency to veer toward the east, which indicated that the storm center was to the southeast. The winds continued northeasterly all day, with falling barometer, indicating that the storm center was moving northwest by north. As the center approached the winds increased in force. During the afternoon the wind backed to north-northeast, indicating the storm center was to the east-southeast, having shifted its course more toward the north than during the earlier portion of the day. From sunset of the 7th to 2 a. m. of the 8th the wind backed to the north and blew with its maximum force, showing the center to be east at 2 a. m., and as at that time the barometer registered the lowest pressure, the indications were that the storm center was nearing Havana. After 2 a. m. the barometer began to rise; at 12 noon the wind backed to north-northwest and diminished in force. From the action of the barometer and winds, it would appear that the storm center moved to the northwest and to the eastward of Havana.

After 2 p. m., October 7, the ferryboat service between Havana and Regla was suspended. Considerable damage was reported to trees and banana plants in the vicinity of this city. At the Reina battery a small wooden garret was blown down. In Havana, on San Luis Gonzaja (Reina) street, and in Isabel la Catolica, Rodas, and Colon parks many trees were blown down, and some of them, including roots, were blown out of the ground. In the Plaza de Armas, in front of the Captain-General's palace, many public lanterns (street lights) were broken, as also was the lantern in front of the Tacon Theater. Some small wooden buildings were blown down. A portion of the tramway between this city (Havana) and the Vedado (a suburb)—that portion of the tracks beyond Torreon—was washed away. One of the cars was washed off the track by the waves and all the passengers drenched.

In the harbor the sloop *Zarramplin* was blown against the wharf and sunk. She was loaded with brick and petro-

leum the cargo was saved. Two lighters, loaded with old iron, were sunk alongside the Spanish brigantine *Patriarca San Jose.* The British frigate *Sea Gem* broke her cables and was blown against the Machina naval station wharf. A brigantine and an American schooner were riding out the storm off the Tableros, the Gulf coast to the northward of Cabaña Castle, when their anchor chains parted and they were blown on shore, but were not damaged.

In Guanabacoa, Vibora, and Arroya Apolo some damage reported to houses and trees.

In Nueva Paz 110 houses destroyed.

In Bejucal 50 houses and many trees blown down and all plantings and crops destroyed.

In Colon some houses and walls blown down; some suburbs inundated, compelling the people to abandon their houses; telegraph lines down and the roads impassible.

Reports received at Guines state that a vast amount of damage was done to Nueva Paz and San Nicolas.

In Jaruco, Bainoa, and Tibarca houses destroyed.

In Madruga more than 100 of the houses occupied by the poor people were destroyed.

In Matanzas the destruction was terrible. The districts of Ojo de Agua and Puebla Nueva have suffered great and sensible losses.

At the railway station at San Luis a landslide occurred, into which the train from Havana ran and was wrecked; very few of the passengers escaped; probably killed.

The rivers San Juan and Yumuri overflowed, their waters intermingling and inundating the country to a considerable depth. It was reported that about 40 persons were drowned and it is expected that many more cases of drowning will be reported. At the railway station at Garcia the level of the water reached the chapiters of the columns. The Pailen Bridge was destroyed. It was reported that the houses of a small sugar plantation near the San Juan River were carried away and 40 of the workmen drowned or killed; also that some employees of the Bahia railway were killed.

Another report regarding the inundation of Matanzas states that the flood carried away all the buildings of the railway station at San Luis and everything it encountered in its path; submerged a train that had remained at the station on account of the tempest, drowning 26 employees of the railway company and 30 passengers.

In the harbor of Matanzas some vessels were blown on shore and seriously damaged and the brigantine *I. N. Nicholas* totally destroyed. All crops in the territory between the meridians of Sagua and western Havana were destroyed.

11. *October 19–20, 1870.*—October 19, 2 p. m., barometer 29.67, moderately fresh east by southeast winds; 5 p. m., wind fresher, barometer 29.63; 10.30 p. m., east-southeast wind, with rain squalls, barometer 29.55; 11 p. m., barometer 29.45; 11:30 p. m., very heavy rain, southeast wind, very fresh, barometer 29.33.

October 20, 12:30 a. m.—Heavy wind, with rain squalls, barometer 29.34; 1 a. m., very heavy south-southeast wind continued with rain squalls, barometer 29.34; 1:30 a. m., strong squalls from southeast, with heavy rain, barometer 29.28; 2:30 a. m., barometer 29.25; 3 a. m., barometer 29.25; 3.30 a. m., heavy wind, with gusts, from south-southeast to southeast, barometer 29.24; at 4:30 barometer began to rise. From 4 to 4:30 a. m. wind blew very hard from the south, with gusts; 5:30 a. m., wind continued blowing from the south with less intensity, barometer 29.25; 6 a. m., barometer 29.26; 7 a. m., south-southwest wind, with squalls of heavy rain, barometer 29.27; 8 a. m. southwest wind, with rain squalls, barometer 29.30; 8:30 a. m., wind west-southwest and heavy rain, barometer 29.34; 9 a. m., barometer 29.37; 10 a. m., wind blew from south by southwest, barometer 29.42; 11 a. m., barometer 29.42; 12 noon, south-southwest wind and dark weather, heavy sea from west, barometer 29.42.

Damages are reported to houses and crops in San Cristobal and Guanajay.

At Wajay the water rose to a level of 3 feet on the streets during the night of 19–20th. Trees were broken off and blown through the air.

At Batabano the sea inundated the city, compelling the inhabitants of the lower portion to move, some using boats, to the higher portion of the city. Many houses were damaged and some destroyed, and some vessels were blown on shore.

At Cienfuegos some trees which had withstood the preceding hurricanes were blown down.

At Nueva Paz the wind veered from east-southeast to west-southwest during the evening of the 19th. During the night of 19–20th an odor like sulphur was observed.

The ravages of this hurricane covered the territory between Cardenas and Pinar del Rio, extending farther to the westward than the preceding one, and it is estimated that there will be a shortage of 50 per cent in the sugar crop, caused by these two hurricanes.

12. *September 30–October 7, 1873.*—Caimanera, at 7 p. m., September 28, the barometer read 28.66; at 10 p. m., 28.95, with a hard northwest wind and heavy sea from the southeast; after that hour the wind backed to south, with gusts of hurricane force.

October 3.—In my opinion we are under the influence of a hurricane which should form near the southernmost of the West Indies and pass to the southward of Jamaica, recurving between latitudes 20° to 21° north, near Yucatan, and it is probable that its effects will be felt on the north coast and parts of the interior of the west provinces. (Signed) *S. D. A.* [Name of writer of above unknown.—*W. B. S.*]

October 6.—A storm is approaching from the south-southeast; the barometer is falling. Should the storm be a cyclone it will probably pass to the westward of Havana toward Pinar del Rio Province, and the wind attain its greatest intensity as it veers toward the south, south-southwest, and southwest, and diminish when wind veers to the northwesterly quadrant.

During the afternoon and the night of the 6th and 7th a heavy north-northwest sea was running, reaching its greatest violence at 2 a. m. of the 7th. The interiors of nearly all of the houses at the northern end of San Lazaro street have been destroyed by the fury of the waves. The neighborhood has never experienced such heavy waves, and two or three walls that withstood the hurricanes of 1844 and 1846 have been destroyed. Some doors on the south side of San Lazaro street have been battered down. The beach at Marianao was flooded and many houses destroyed. Some trees in this city were blown down.

In the Vedado, a suburb, some houses were damaged. Morro Castle was also damaged to some extent.

Batabano was inundated.

Meteorological record at Havana, September 30–October 7, 1873.

Date.	Hour.	Barometer.	Temperature.	Wind.	Miles per hour.
			°		
September 30	4 a. m.	29.70	81.5	east-northeast.	.....
October 1	4 a. m.	29.69	85.5	east.	.....
October 2	4 a. m.	29.71	84.6	south-southeast.	.....
October 3	4 a. m.	29.72	75.6	east by southeast.	.....
October 4	4 a. m.	29.72	75.0	east.	20.1
October 4	4 a. m.	29.70	77.9	east-southeast.	20.1
October 5	4 a. m.	29.68	78.1	east-southeast.	22.4
October 5	4 a. m.	29.65	83.8	south-southeast.	26.8
October 6	4 a. m.	29.55	80.1	south-southeast.	29.1
October 6	4 a. m.	29.56	80.8	south.	33.6

13. *September 13–14, 1875.*—Lowest barometer, 29.40; at 4 a. m. of the 14th the barometer began to rise. Time of lowest barometer unknown, also place of observation, but suppose it to be Havana.—*W. B. S.*

Cardenas, September 13.—At 3 p. m. the barometer read 29.46; 4 p. m., 29.40; 5 p. m., 29.26; 6 p. m., 29.29; 7 p. m., 29.25; 8 p. m., 29.18; 9 p. m., 29.11; 10 p. m., 28.95; 11 p. m., 28.90. October 14, 2 a. m., 29.00; 6 a. m., 29.25; 8 a. m., 29.31; 9 a. m., 29.36; 10 a. m., 29.37; 11 a. m., 29.42. From 6 p. m. of the 13th to 3 a. m. of the 14th the winds were hard northeast, veering to southerly. Doors were blown in and trees blown down, but no damage was done to vessels in the harbor.

Havana, September 13, 1875.—At 5 a. m. the barometer read 29.81; 6 a. m., 29.82; 7 a. m., 29.83; 8 a. m., 29.85; 9 a. m., 29.85; 10 a. m., 29.85; 11 a. m., 29.83; 12 noon, 29.81; 1 p. m., 29.79, and continued falling until 2:20 a. m. of the 14th, at which time it read 29.29; at 2:40 a. m. it read 29.31, and centinued to rise.

Portillo, Santiago Province.—At 11 p. m. of the 12th the wind blew down the majority of the houses of this town. Heavy rainfall on the night of the 11–12th, being heaviest on the morning of the 12th, caused the river to overflow, washing away the few houses that had withstood the violence of the wind. At 4 a. m. on the 13th the barometer read 29.00.

Rev. Father Viñes says that this cyclone (?) was of mild intensity. He states that its center entered the island somewhat to the east of Cape Cruz, passing near Manzanillo and Santa Cruz, then passed to the southward of Puerto Principe, Santa Clara, Colon, Cardenas, and Matanzas, and to the north-northeast and north of Havana. The districts in which the greatest damage was done were Portillo, Mazanillo, and Santa Cruz.

14. *October 12–13, 1876.*—A cyclone passed St. Thomas and Porto Rico and continued moving west-northwest, passing through and off the north coast of the Island of Cuba.

During the forenoon of October 19 the vortex passed Havana; the lowest barometer was 28.68, between 11:30 and 11:40 a. m. The area of calm reached Havana 11:40 a. m. and continued for some time, after which the wind blew from the northwest, west-northwest, and west, and at 1:13 p. m. became steady from the west-southwest, which was the opposite direction (east-northeast) from which it was blowing during the first part of the hurricane. After the wind backed to northwest the barometer began to rise rapidly. Hard gusts of wind and very frequent rain squalls have occurred since the storm's effects began to be felt, and the clouds, which were from the same direction as the wind, were very low and near to the house tops, and shifted their direction with the wind as it backed to northwest, west-northwest, and west-southwest, and continued moving from the latter direction until 10 p. m.

The damage done by this hurricane was as follows: Some damage to vessels in the harbor and also to the wharf at the office of the captain of the port. In the city some buildings and many trees were blown down. In the country the devastation was much greater, and houses and crops were destroyed.

In the harbor of Mariel 1 Spanish gunboat, 7 merchant schooners, and 1 sloop were blown on shore. In the City of Mariel the wind greatly damaged many houses, principally the roofs, and blew down many trees.

Damage to bulldings was reported from Mantanzas, where many trees were blown down; in the harbor 2 schooners and 1 launch were greatly damaged, a bark lost one mast, and 7 fishing boats were totally destroyed.

In Cienfuegos some houses were blown down, and the river overflowed, the inundation extending as far as Corales street, between Santa Cruz and Santa Elena streets, and some vessels at anchor in the harbor were damaged.

In Gura de Macuriges the river overflowed, inundating the village. The current of the water in the inundated district was so swift that persons could not cross the streets. Houses were severely damaged, but no person suffered injury.

At Artemisa it is reported that never before has a hurricane occurred attended with such violent winds at this place. All that portion of the island (Cuba) between the meridians of Santa Clara and Pinar del Rio have suffered greatly; much damage was done to the canes; small crops were destroyed; trees were blown down; rivers overflowed; and many buildings, both in the city and country, were more or less damaged and some totally destroyed. No loss of life has been reported.

15. *September 5–6, 1882.*—The center of the cyclone (hurricane) passed Havana shortly after midnight of the 5th, moving toward the west-northwest, with moderate velocity of progression. The diameter of the storm center was small and its force of moderate intensity, less than that attained at Cienfuegos. The lowest pressure, 29.60, occurred at 1:30 a. m. The hardest gusts of wind occurred between 1 a. m. and 2 a. m., attaining a force of 38 to 40 meters per second (85 to 89.5 miles per hour), while the average velocity during that time was 19.5 meters per second (43.6 miles per hour). The heaviest winds at Havana were from the northeast and east. After passing Havana the rate of progression was greatly increased; the direction was continued toward the west-northwest, indicating that the center was still a considerable distance from the latitude of recurve, which possibly would not occur until it had approached near to the Texas coast; then cross the United States toward Cape Hatteras (to the southward of Cape Hatteras). At 1 p. m. telegraphic communication was possible with Matanzas, Bejucal, and Guanajay, but impossible with other points. Very little damage was reported to vessels in the harbor; the floating dock broke away from its anchors and was blown into the center of the channel, where it was sunk, by order of the dock superintendent. On account of being insecurely anchored, 1 American brigantine and 2 Spanish schooners incurred some small damages.

At Batabano the wind blew very hard from the north, veered to north-northeast, and during the night to the east. Some fishing schooners were blown on the beach.

Cienfuegos, September 5.—At 1:30 p. m. south-southwest winds blew with hurricane velocity; weather totally cloudy and dark; barometer 29.36; hurricane moving west-northwest, in which direction the center lies. The maximum velocity of the hurricane was experienced at 10:30 a. m., when the barometer read 29.13, and the winds were westerly. Much damage was done to buildings; no loss of life reported.

In Santa Clara many houses were blown down. The vortex of the hurricane passed that city between 8 and 8:45 a. m., September 5, preceding which, very violent northwest winds, with gusts of hurricane velocity, blew. At 8 a. m. the wind died to a calm and so continued until 8:45 a. m., when it shifted to the east, and blew with increasing velocity, attended with frequent rain squalls. At 2 p. m. the wind still continued blowing very hard, with a tendency to veer to the south. Almost all the houses in the country and crops were destroyed.

In Sagua la Grande some damage was done to houses, and in the harbor four lighters loaded with sugar were sunk, and an English schooner was blown on the beach.

At Cardenas some minor shipping was blown against the wharf and damaged.

Reports have been received from other towns between the meridians of Santa Clara and Havana, stating that the hurricane caused considerable damage to houses, some of which were blown down, and crops were very much damaged.

16. *October 8, 1882.*—Batabano, 7:30 p. m., barometer 29.90; state of weather, raining; winds fresh and variable between east-southeast and east.

Cienfuegos, October 7.—Bad weather; heavy sea from the south. October 8, 10 p. m.: Since 4 p. m. yesterday the barometer has been falling, now reads 29.78; temperature 77°; weather cloudy; light northeast wind.

Bejucal, October 8, 8:15 a. m.—Heavy weather continues, with strong gusts of wind and heavy showers; barometer falling very slowly and slightly; now thundering and lightning,

Santiago de Cuba, October 8, 3:05 a. m.—Guantanamo reports barometer reading low. Here the weather is threatening, with rain squalls; wind southeast.

"This storm was of very great diameter, and its influence was felt over extensive areas on the 8th, from Guantanamo to Vera Cruz. Its center passed the western portion of the island and recurved over the Tropic of Cancer, and is at present, 2 p. m., October 9, toward the west-northwest. The majority of the gusts of wind experienced in this city were from 22 to 25 meters per seeond (49 to 56 miles per hour) in force, while the average velocity of the wind during the blow was 14 meters per second (31 miles per hour). (Signed) *Benito Viñes, S. J.*"

17. *August 21–26, 1886.*—Trinidad, Cuba, August 26, 1886, reports received here by mail state that great damage was done by a hurricane in Jucaro, and many coastwise vessels were severely damaged, while several others are still missing. No lives lost so far as known. (Signed by the captain of the port of Casilda.)

Ciego de Avila.—At 2 p. m. of August 22 the wind began to blow very hard, with gusts of hurricane force, blowing the tiles from the house roofs, and attended with heavy rain. At 4 a. m. the wind and rainfall were terrific; houses were

blown down, crushing many of their inhabitants; the streets were flooded, in places to a depth of 80 centimenters (2.6 feet). The maximum intensity of the hurricane was experienced during the two hours from 7 to 9 a. m., during which time roof tiles and zinc plates were carried through the air with extraordinary velocity. The majority of the large trees were uprooted, and houses were blown down with a terrible crash. At 9 p. m. the wind began to decrease, but the rain continued falling in excessive amounts. About 150 houses were blown down, rendering more than 200 families homeless; and the remaining buildings of the town, more than 400, were more or less damaged. In Jucaro only two buildings in the town withstood the violence of the hurricane. All the banana plants and other crops in this territory were destroyed. Of the corn crop, which was ready to be harvested, not one cob remains, having been blown to, no one knows where; forest trees were uprooted and roads destroyed.

Jucaro, August 21, 9 a. m.—Barometer, 29.61; thermometer, 71.6°; hard northeast wind; weather, cloudy; 9 p. m., barometer, 29.68; thermometer, 71.6°; hard northeast wind; state of weather, raining. 22d, 5 p. m., barometer, 29.61; thermometer, 68°; north winds with hurricane velocity; 9 p. m., barometer, 29.72; thermometer, 66°; winds veering to northwest, to southwest; storm over.

Caibarien.—On the 22d, at 1 a. m., the winds began to increase in force, with some hard gusts, from the east-northeast, attended with rain squalls; barometer falling. The waves began to inundate the wharf. Very hard east-northeast and northeast winds blew until 2 p. m., at which time they backed to north and began to diminish in force. The weather did not present the aspect of a hurricane, rather that of a severe cyclonic storm; the clouds were high and divided.

18. *Manzanillo, September 20–22, 1886.*—The lowlands throughout this district and a part of Bayamo were inundated by the storm of September 20, 21, and 22. All crops were destroyed; more than 350 cattle and a great number of sheep and pigs and some horses were drowned. In some of the country districts the people had to seek shelter on the house tops, from which they were rescued by means of boats.

19. *Isabella, harbor of Sagua, September 3, 1888.*—At 9 p. m. barometer was 5.5 mms. (.216 inch) below the normal; winds northeast, 15 meters per second (33.6 miles per hour); weather cloudy; eastern horizon dark; rain squalls occurred between 6 and 8 p. m.; wind increased in intensity after 8 p. m. (Signed) *Captain of the Port.*

Caibarien, September 3, 1888, 9:15 p. m.—Barometer 4 mms. (.158 inch) below normal and falling; weather bad, with rain squalls from the north. (Signed) *Captain of the Port.*

Jucaro, September 3, 6 p. m.—Barometer 5 mms. (.197 inch) below the normal; thermometer 18° C. (64.4°); north-northeast winds, 14 to 20 miles per hour; weather bad. (Signed) *Captain of the Port.*

In Havana, since the morning of September 4, the winds have backed slowly from north-northeast to north to north-northwest. During the afternoon the winds were steady from the north and north-northeast, with very little shifting of direction; gusts of wind, increasing in force each moment, attended by rain squalls and rapidly falling barometer, which indicate that the hurricane is moving toward Havana. After sunset the wind veered to north-northeast, and after midnight September 4, at which hour the pressure recorded its lowest readings, it rapidly veered to east and east-southeast, and the gusts diminished in intensity.

From the telegrams received it appears that the center of the hurricane passed to the northward of Gibara and entered the island to the eastward of Sagua; moved across the island, passing to the southward and near to Havana. The minimum barometer reading, 731.91 (28.82 inches), occurred between 12 midnight, 4th, and 12:30 a. m., 5th; the maximum force of the gusts of wind was 42 mms. per second (94 miles per hour), and the total rainfall 8.63 mms. (3.40 inches).

At 4 p. m., 4th, a boat, under sail, from the man-of-war *Jorge Juan* was overturned and two sailors drowned. The tug *Valador* was sunk at the gas company's wharf; many vessels in the harbor suffered more or less injury; railway and ferryboat traffic was stopped; many buildings were seriously damaged, some of them having their roofs blown off, and many trees blown down.

Marianao reports considerable damage to houses.

Batabano, September 4, 1888.—From daybreak until 12 noon fresh, gusty north-northwest winds blew and in consequence the level of the water in the harbor was lowered. At 9 p. m. threatening weather continued, with indications of a hurricane; barometer 29.70, thermometer 80.6°; constant heavy rains, with occasional rain squalls; weather dark and lowering. At 12:30 p. m. the wind backed to southeast and south-southeast and drove in the water from the sea, inundating the town. At 6 a. m. of the 5th all of the houses were flooded, the water reaching to the height of a man's waist in the houses and still higher in the streets. The Spanish gunboat *Lealtad* was capsized when, at 11:30 p. m. of the 4th, the wind backed to northwest and west and increased to hurricane intensity, and the captain, a second lieutenant, and 8 men were drowned.

Guanajay reports that some of the houses in the country were blown down and all crops destroyed and that the hurricane was something terrific.

Matanzas reports that the maximum force of the hurricane was felt at 9 p. m. of the 4th. Some damage reported to the roofs of houses and to lanterns of the city lighting service; very heavy seas damaged the houses along the beach; some vessels were blown on shore and seriously damaged. The captain and two passengers of the sloop *Antonio Saurez* were drowned and the sloop *Almirante*, with her entire crew, has disappeared.

In Sabanilla some houses damaged and one person killed.

At Sagua the river overflowed and many persons were killed by the hurricane. The suburb of Pueblo Nuevo, located at the mouth of the river, was totally destroyed. At Isabella, harbor of Sagua, numerous houses were carried away and the harbor was filled with floating doors, furniture, etc. The office of the captain of the port was entirely surrounded by the sea and the iron tanks for holding fresh water were carried into the house by the violence of the hurricane. A railway train was overthrown upon its arrival at the station and the passengers more or less injured; the rails were carried away. When the steamer *Adela* sailed from Isabella at 2 p. m. on the 5th, 45 bodies had been recovered, and it is thought that double that number perished by the inundation. From Sagua to Cape San Antonio the loss to houses, crops, and trees in the country has been considerable. Sixteen persons perished by the capsizing of a boat, in which they had endeavored to cross from Salto, near Sagua, to a nearby beach.

In Cienfuegos from midnight of the 3d until midnight of the 4th the barometer fell, reaching its minimum, 29.32, at the latter time. At midnight of the 3d the wind began to increase in force from the northwest. At noon of the 4th it backed to west and in the afternoon to southwest, from which direction the maximum intensity was experienced. From 10 p. m. of the 4th to 2 a. m. of the 5th the wind blew from the south, then backed to southeast and diminished in force. In the early morning of the 4th a drowned fisherman's body was found on Santa Elena street. Great damage was done in the country and all crops were destroyed.

Two hundred head of cattle were drowned in the Santo Domingo district.

In the Paula municipality 92 families were rendered homeless.

Batabano reports many fishing schooners capsized and others blown on shore.

In Caibarien a falling wall killed an old man and injured other persons, and on the cayos two families of fishermen, each lost three sons.

In Vueltas the loss is estimated at $400,000.

In Sancti Spiritus banana plantations and corn and rice crops were destroyed.

All tobacco seed plots in the Vuelta Abajo were destroyed. In Pinar del Rio 75 houses were damaged.

20. *Havana, September 24, 1894.*—At 1 p. m. the barometer began to fall slowly, attended with rain squalls from the north and northeast, and the weather becoming darker and darker. At 4 a. m. of the 25th the barometer began to fall more rapidly, with very hard gusts of wind from the north-northeast. At 8 a. m. the barometer continued falling, with violent north and northeast winds, steady rainfall, and dark weather. At 10 a. m. the wind began to diminish somewhat, but the barometer continued to fall until 4 p. m., reading at that hour 29.35, attended with light rain and moderate gusts of west-northwest wind. At 6 p. m. the barometer showed indications of rising, and at 8 p. m. it began to rise.

At Matanzas the banana plants were blown down, and some damage was done to houses in the country.

In Cardenas some wooden partitions in the courts of houses were blown down.

In Marianao the public baths were destroyed, and some small houses occupied by fishermen were somewhat damaged.

In Cienfuegos great damage was done in the suburbs by the storm; 3 persons killed and crops greatly damaged.

In Santa Clara no serious damage was done by the storm to buildings, but some cattle were killed and crops greatly damaged.

At Sancti Spiritus the river Zaza overflowed, carrying away the wharf and doing some damage to buildings.

In Sagua ugly weather began on the 23d and continued through the 24th; gusts of wind and rain squalls did considerable damage to cane and banana plantations. The Sagua and Yabucito rivers overflowed; the plantation Salvador was inundated and the canes blown flat by the wind totally destroying the crops, so that the central will not be able to grind this year. It is believed that 6 or 7 of the plantations in this vicinity have been flooded, and that the cane crop will, therefore, be about 50 per cent short. At 4 a. m. of the 25th the waters reached the city and inundated it. The waters continued to rise until noon, after which hour they fell. The overflowing of the rivers created three currents in the city, along Muras, Oriente, and Progreso streets, through which the entire city was inundated, except Tacon street, between Sol and Aurora. The flood reached a maximum height of 7 to 9 meters (23 to 29.5 feet) along the river bank; 1.5 meter (4.9 feet) at the railway station; 2 meters (6.6 feet) at the post office, and 2.5 meters (8.2 feet) at the Telegraph Hotel. The Spanish Club was flooded to a depth of 3 meters (9.8 feet), and all the furniture therein was carried away by the waters; the house of the French consul and that of Notary Montero were totally destroyed. The flood reached to a distance of 7 kilometers (4.3 miles) to the eastward; 5 kilometers (3.1 miles) to the eastward, and an unknown distance to the southward. There were 8 persons drowned, also a family living on the Santa Teresa plantation. The schooner *Vistona* was wrecked at the caballeria of the civil guards. The loss is estimated at $500,000. Over 7,000 persons saved themselves by climbing to the roofs of the houses, and 400 to the tops of the churches.

In Trinidad the cross on the church of Santisima Trinidad was blown away by the wind, and some houses considerably damaged. All crops were totally destroyed. The river Agabama overflowed, causing a very serious inundation.

In Santa Cruz del Sur 46 houses were destroyed, and considerable other damage done.

W. B. STOCKMAN,
Forecast Official Weather Bureau.

THE HURRICANES OF 1780.

Colonel Reid, in the Law of Storms, gives exhaustive descriptions of the great hurricanes of 1780:

Three great storms occurred in that year nearly at the same time, and these have been frequently confounded together and considered as but one. The first destroyed the town of Savannah la Mar, Jamaica, on the 3d of October; the second, and by far the greater one, passed over Barbadoes on the 10th and 11th of October, and the third dispersed and disabled the Spanish fleet, under Solano, in the Gulf of Mexico after it had sailed from Havana to attack Pensacola. The Savannah la Mar storm has been described in this paper.

THE GREAT HURRICANE OF 1780.

This storm, coming from the southeast, passed over Barbados on the 10th and 11th of October, and the ships of Admiral Hotham's squadron experienced the hurricane, each in turn, according to the place she was in, and it passed on until it reached the ships of Sir Peter Parker at Jamaica.

The *Deal Castle* was wrecked at Porto Rico. The *Ulysses* and *Pomona*, with the fleet under their convoy, were in the Mona Passage and suffered greatly, being almost in the center of the storm. The *Diamond* and *Pelican* had been sent to Honduras, convoying merchant ships, and had felt nothing of the first hurricane, but on their return toward Jamaica, though on somewhat different courses, both ships came within the influence of the great hurricane of the 15th of October. The *Thunderer*, on her way to Jamaica from St. Lucia, foundered in one of these storms, but where and on what day has never been ascertained.

The *Berwick* had separated from this fleet after the hurricane of Savannah la Mar and was proceeding to England under jury masts. She had reached north of the latitude of Bermuda when the second hurricane overtook her, and, by her track and log book, we are enabled to ascertain the direction taken by this storm. On reading the logs of these ships and the various accounts of this hurricane, and comparing the different reports of the wind, it will be found that no storm yet described more strongly proves than this the rotary nature of hurricanes, and, after attentive consideration of this tempest, in addition to the details of so many others, it seems difficult to refuse belief to this being their mode of action. The center of the circle would appear to have passed just to the north of Barbados and thence over the Island of St. Lucia, so that Admiral Hotham's ship, the *Vengeance*, which remained in the careenage, to ride out the gale, was in the right-hand semicircle of the storm, whilst the ships which cut or parted their cables, and ran first to the southward, were for a while in the left-hand semicircle. These last appear to have been dismasted and the *Vengeance* drove on shore just as the center of the storm was passing between them. The three ships to the eastward of Martinique, being in the right-hand semicircle, had the gale from the eastward and were therefore upon a lee shore. By the log of the *Endymion*, it will be seen that ship just cleared the northeast point of the island, but the *Andromeda* and *Laurel* were wrecked and 25 men of the crew alone were saved. These men, of course, were made prisoners, but were sent by the Marquis de Bouille to the British Governor of St. Lucia with a letter expressing that he could not detain them as prisoners from the chances of a catastrophe common to all.

A Danish report was made by Captain Stockfleth, who commanded the frigate *Christiana*, to the Danish Admiralty. This ship met the hurricane on the 13th of October, 1780, when southwest of Porto Rico, but the direction of the wind is not given. The report states that only six or seven ships of the French convoy at Martinique were saved, and from Sir Peter Parker's report we learn that there were 5,000 troops on board. From St. Lucia the center of the storm appears to have passed over or very near to the Island of Mona on the morning of the 15th of October, and when we take up the logs of the *Venus* and *Convert*, which were on one side of the storm at that date, and those of the *Diamond* and *Pelican*, which were on the other side of it, we find the wind blowing in contrary directions. On referring to the logs of ships lying in the harbor of Antigua we there find the wind blowing in squalls, at first coming from the east-northeast, then veering by the east to the southeast, in strict accordance with the apparent law of storms in the Northern Hemisphere.

The squadron of Admiral Rowley, being in latitude 26° 30′ (about which latitude we find hurricanes so frequently change their direction and set toward the eastward), first received the storm easterly. As the gale proceeded toward the northeast this squadron was in its left-hand semicircle.

By referring to the log books of His Majesty's ships *Strewsbury* and *Resolution*, it appeared that they were under weigh off Long Island on the 18th of October, 1780. The weather had been fine for some time, both before and after, and the only exception was that day, when it blew in squalls so as to make these ships strike their top-gallant masts, and the *Shrewsbury* split a topsail, the wind becoming north. At Bermuda 50 vessels were driven on shore on the 18th of October, and we have here the log of the *Berwick* for that day, when she was to the northward of that island, from which we get the direction of the wind. The wind, as laid down from the *Berwick's* log book, accords with the reports of living witnesses (1839) at Bermuda, and this storm is there still referred to as the greatest ever experienced in their latitude. Thus, the great hurricane is traced beyond Bermuda, moving in the direction of the Azores; and if this same storm was really the cause of the *Shrewsbury* and the *Resolution* striking their top-gallant masts, and they increase in diameter as they proceed toward the poles, this storm, on reaching the latitude of Great Britain, may have given a circular direction to the wind over an extent equal to the width of the Atlantic from the British Islands to Newfoundland.

Copy of an account of the hurricane of the 10th of October, 1780, which was sent to Lieutenant-General Vaughan, Commander-in-Chief of the Leeward Islands, and by him transmitted to Lord G. Germaine. Copied from the Gentleman's Magazine of 1780:

The evening preceding the hurricane, the 9th of October, was remarkably calm, but the sky surprisingly red and fiery. During the night much rain fell. On the morning of the 10th much rain and wind from the northwest. By 10 a. m. it increased very much. By 1 p. m. the ships in the bay drove. By 4 p. m. the frigate *Albemarle* parted and went to sea, as did all the other vessels, about 25 in number. By 6 p. m. the wind had torn up and blown down many trees, and foreboded a most violent tempest. At government house every precaution was taken to guard against what might happen; the doors and windows were barricaded, but it availed little. By 10 p. m. the wind forced itself a passage through the house from the north-northwest, and the tempest increasing every minute, the family took to the center of the building, imagining, from the prodlgious strength of the walls, they being three feet thick, and from its circular form, it would have withstood the wind's utmost rage; however, by half past 11 they were obliged to retreat to the cellar, the wind having forced its passage into every part and tore off most of the roof. From this asylum they were soon driven out; the water, being stopped in its passage, having found itself a course to the cellar, they knew not where to go. The water rose four feet, and the ruins were falling from all quarters. To continue in the cellar was impossible; to return to the house equally so. The only chance left was making for the fields, which at that time appeared equally dangerous. It was, however, attempted, and the family got to the ruins of the foundation of the flagstaff, which soon after giving way, every one endeavored to find a retreat for himself. The governor and the few that remained were thrown down, and it was with great difficulty they gained the cannon, under the carriage of which they took shelter. Their situation here was deplorable. Many of the cannon were moved, and they had reason to fear that the one under which they sat might be dismounted and crush them by its fall, or that some of the ruins which were flying about might put an end to their existence; and, to render the scene still more doubtful, they were near the powder magazine. The armory was leveled to the ground, and the arms scattered about. Anxiously did they look for break of day, flattering themselves that with the light they would see a cessation of the storm; yet when it appeared little was the tempest abated. Nothing can be compared with the terrible devastation that presented itself on all sides; not a building standing. The trees, if not torn up by the roots, were deprived of their leaves and branches, and the most luxuriant spring changed in this one night to the dreariest winter. It is yet impossible to make a calculation of the number of souls that have perished; whites and blacks together, it is supposed to exceed some thousands. Many were buried in the ruins of the buildings, many fell victims to the weather, and a great number were driven into the sea and there perished. The troops suffered inconsiderably, though their barracks and hospitals were early blown down. What few public buildings there were are fallen in the wreck; the fortifications have suffered considerably. The buildings were all demolished, for so violent was the storm here, when assisted by the sea, that a 12-pounder gun was carried from the south to the north battery, a distance of 140 yards—on its carriage, of course, which had wheels. The loss to this country is immense; many years will be required to retrieve it. Alarming consequences were dreaded from the number of dead bodies which lay uninterred, and from the quantity of fish which the sea threw up; but these alarms soon subsided.

At St. Christopher many vessels were forced on shore. At St. Lucia all the barracks and huts for His Majesty's troops, and other buildings in the island were blown down and the ships driven to sea, and the *Amazon,* Captain Finch, miraculously escaped foundering. At Dominica they suffered greatly. At St. Vincent every building was blown down and the town destroyed. At Grenada 19 sail of loaded Dutch ships were stranded and beat to pieces. At Martinique all the ships were blown off the island that were bringing troops and provisions. On the 12th, 4 ships foundered in Fort Royal Bay and the crews perished. The other ships were blown out of the roads. In the town of St. Pierre every house is blown down, and more than 1,000 people have perished. At Fort Royal the cathedral, 7 churches, and other religious edifices, many other public buildings, and 1,400 houses were blown down. The hospital of Notre Dame, in which were 1,600 sick and wounded, was blown down, and the greatest part of these persons buried in the ruins. The number of persons who perished in Martinique is said to have been 9,000. At St. Eustatius the loss was very great. On the 10th of October, at 11 in the morning, the sky on a sudden blackened all around; it looked as dismal as night, attended with the most violent rain, thunder, lightning, and wind ever known before. In the afternoon the gale increased. Seven ships were driven on shore near North Point and dashed to pieces on the rocks, and their crews perished. Nineteen vessels cut their cables and went to sea, and only one is yet returned. In the night every house to the northward and southward was blown down or washed away, with the inhabitants, into the sea, a few only escaping. The houses to the east and west were not so much hurt till the afternoon of the 11th, when the wind on a sudden shifted to the eastward, and at night it blew with redoubled fury and swept away every house. The old and new forts, the barracks, and hospital, the cathedral, and 4 churches stood. Between 4,000 and 5,000 persons are supposed to have lost their lives in St. Eustatius.

Extract from Sir George Rodney's official report of the hurricane of the 10th of October, 1780, at Barbados:

No naval stores of any kind can be got at Barbados or St. Lucia, owing to the dire effects of the hurricane which happened on the 10th of October. It is impossible to describe the dreadful scene it has occasioned at Barbados, and the condition of the miserable inhabitants. Nothing but ocular demonstration could have convinced me that it was possible for the wind to cause so total a destruction of an island remarkable for its numerous and well-built habitations, and I am convinced that the violence of the wind must have prevented the inhabitants from feeling the earthquake, which certainly attended the storm. Nothing but an earthquake could have occasioned the foundations of the strongest buildings to be rent; and so total has been the devastation that there is not one church, nor one house, so I am well informed, but what has been destroyed. I leave their lordships to judge how much my concern must have been heightened upon the report made to me of the loss His Majesty and the public had sustained in the destruction of ships of war, and the gallant officers and men belonging to them, a list of which I have the honor to inclose. But I hope some of them have escaped and arrived at Jamaica, to which island I shall dispatch an express, acquainting Sir Peter Parker with the great disaster which has happened, and request and demand his assistance, in not only hastening such of my squadron as may have escaped the hurricane and arrived at Jamaica to rejoin me, without loss of time, with the *Thunderer* and the *Berwick*, in pursuance to the orders he received by Commodore Walsingham.

SOLANO'S STORM, 1780, AND THE WINDS CALLED "LOS NORTES."

This third storm, like that which destroyed Savannah-la-Mar, has generally been confounded with the great Barbados hurricane which disabled Rodney's fleet, although it appears to have been a distinct one. It will serve to show that the gales of the Gulf of Mexico are sometimes at least of the same rotary nature as those which have been described. It is possible that the Spaniards may apply the term nortes, or norths, to more than one phenomenon, but the violent north winds in the neighborhood of Vera Cruz are frequently no other than the left-hand side of rotary storms in their northerly progression across the Gulf of Mexico, just as Redfield's storms, in their northerly progression, have been clearly shown to be in reality identical with Franklin's northeast storms.

I am indebted to Lord Clarendon, formerly British Ambassador at Madrid, for copies of documents relative to Solano's storm, extracts from which are here printed. These records show that the Spanish Admiral's flagship was in the northern half of a circular storm, for the wind commenced at northeast, veered to southeast, and ended at south-southeast. It is possible that this storm may have had its origin near the west end of Cuba, for the weather at this period was moderate and fine at Jamaica; and we find no trace of it in any of the log books of Sir Peter Parker's squadron. The British frigate *Phœnix*, just before she was wrecked, had come from Pensacola, and she had looked into Havana Harbor and seen Solano's fleet lying there. On the morning of the 15th the wind at Havana was southeast; on that day Solano, having first consulted the pilots, called together the captains of the fleet, when it was determined to sail the next day, provided the wind did not veer from the southeast quarter to south. Next morning, the 16th of October, the wind being light and more easterly, the signal was made to weigh, and 58 ships out of 74 got out of the harbor before night, and they were all out at 9 p. m.

Extract from the journal of the Spanish Admiral, Don Jose Solano, having his flag on board of the *San Juan*, commanded by Pereda:

"October 16, 1780.—At daybreak, after a moderate land breeze from east and east-southeast, the scud moving in the same direction, it fell calm. The wind afterwards sprung up again from the east-southeast quarter and freshened, and at 6 a. m. the signal was made to heave short. The wind appearing settled in the east, the signal was made to weigh anchor, and the *Caiman* ordered to wait to see all the vessels out of port. By half past 9 the Admiral was a league from the land, standing on under topsails only, in order to unite his fleet. In this manner he stood on a northerly course with the same sail during the rest of the day, with the wind varying from east to northeast. By sunset the *Velasco*, *San Genaro*, and *San Ramon*, with 7 transports, had not got out of port. The Admiral kept the same sail upon his ship during the night. October 17: At dawn it was calm in shore; by 8 o'clock a breeze sprung up from the northeast; 58 ships and vessels were in sight out of 74, the *Velasco* and *San Genaro* being among the missing ships. At 7 o'clock the *Caiman* made a signal that all the vessels had got out of port by 9 o'clock the night previous. The Admiral, concluding that the missing ships were either covered by the haze or that they had got ahead of him during the night, made sail in the course north 10° west. By noon the wind freshened at northeast, scud and heavy clouds closing in upon us, the *San Juan* carrying her foresail and topsails, lowering and raising the latter occasionally in order to keep the fleet together. At 9 p. m. the breeze freshened; took in the topsails; toward evening we could only just see the vanguard owing to the density of the clouds. At 6 p. m. reefed the foresail. By 10 at night the wind increased and was then at northeast-quarter-east, with torrents of rain and some hard squalls, shifting as far as east-northeast. October 18: At daybreak heavy clouds, rain, wind, and sea; 2 ships and a brig of the convoy in sight. At 9 a. m. the wind was east-northeast. At 10 a. m. a ship near us, which we took to be the *Guerrero*, made a signal that she was leaky. A squall coming on we could make out no more, and we then lost sight of all ships; furled the close-reefed foresail and lay to under a mainsail, the ship laboring very much. From the 18th to the 20th, continued lying to in the fourth quadrant; the weather still dark and increasing; the wind at northeast; continued rain, with a heavy sea; kept two pumps constantly working. At 10 p. m. on the 20th our tiller broke; secured the rudder; the ship sustained heavy and repeated squalls, whilst she came up from the east-northeast as far as east, as the wind

veered round from the southeast to the south-southeast. October 21: By half past 4 in the morning the wind changed, making the ship come up head to sea. The ship then pitched away all her masts as well as her bowsprit, and with it lost the greater part of the cutwater. By the exertion of the officers and crew the wreck was cleared up by 6 o'clock; at this hour it began to clear up from the south-southeast. Lightened the decks of everything we could. The sea ran so high that we were still unable to ship another tiller. At 11 a. m. set topgallant-sails on the stumps of the main and fore masts and the sail of the launch on the stump of the mizzen, keeping her head to the northeast. At noon, latitude 26° 42′ north, longitude 86° 11′ west of Greenwich. October 22: Commenced with less sea and wind. At daylight saw a large vessel; we fired three guns, but she did not answer our signals. Got another tiller shipped; prepared jury masts and sails, but the ship would not wear and we could not set them. At noon fell in with the brig *Industria*, which had received no damage, and we were the only vessel, excepting one (name unknown), that she had fallen in with since the 17th; she had laid to all the time. The *Industria* was ordered to keep along with the Admiral. In the evening spoke the transport *St. John the Baptist;* she had not suffered much. October 23: At daybreak found ourselves close to the frigate *Rosalia*, the captain of which came on board. During the first four days of the storm the *Rosalia* lay to, but on the fifth she scudded with her spritsail for a foresail. Toward the end of the storm, for eight hours, she was in a complete hurricane; her seams had opened and she leaked both through the decks and sides. By the assistance of her boats we were enabled to wear the *San Juan*, after which we got up the jury-rigging. The Admiral calling a council, it was determined upon returning to Havana; orders were therefore given to Captain Pereda (captain of the *San Juan*) to proceed to that port and to conduct thither all the ships he should fall in with. The Admiral shifted his flag on board the *Rosalia*, leaving the *San Juan* rigging jury-masts in latitude 27° 20′ north, longitude 89° 21′ west of Greenwich. The Spanish Admiral then sailed for Pensacola; after cruising in that neighborhood for some time, without finding any of his ships, he left it, and on the 16th of November he reached the Tortuga soundings, which had been ordered as a point of rendezvous; finding no vessels there, he sailed for Havana and arrived there on the 19th, and there found his fleet."

Chart I. Tracks of West Indian Hurricanes. May, 1878-1900.

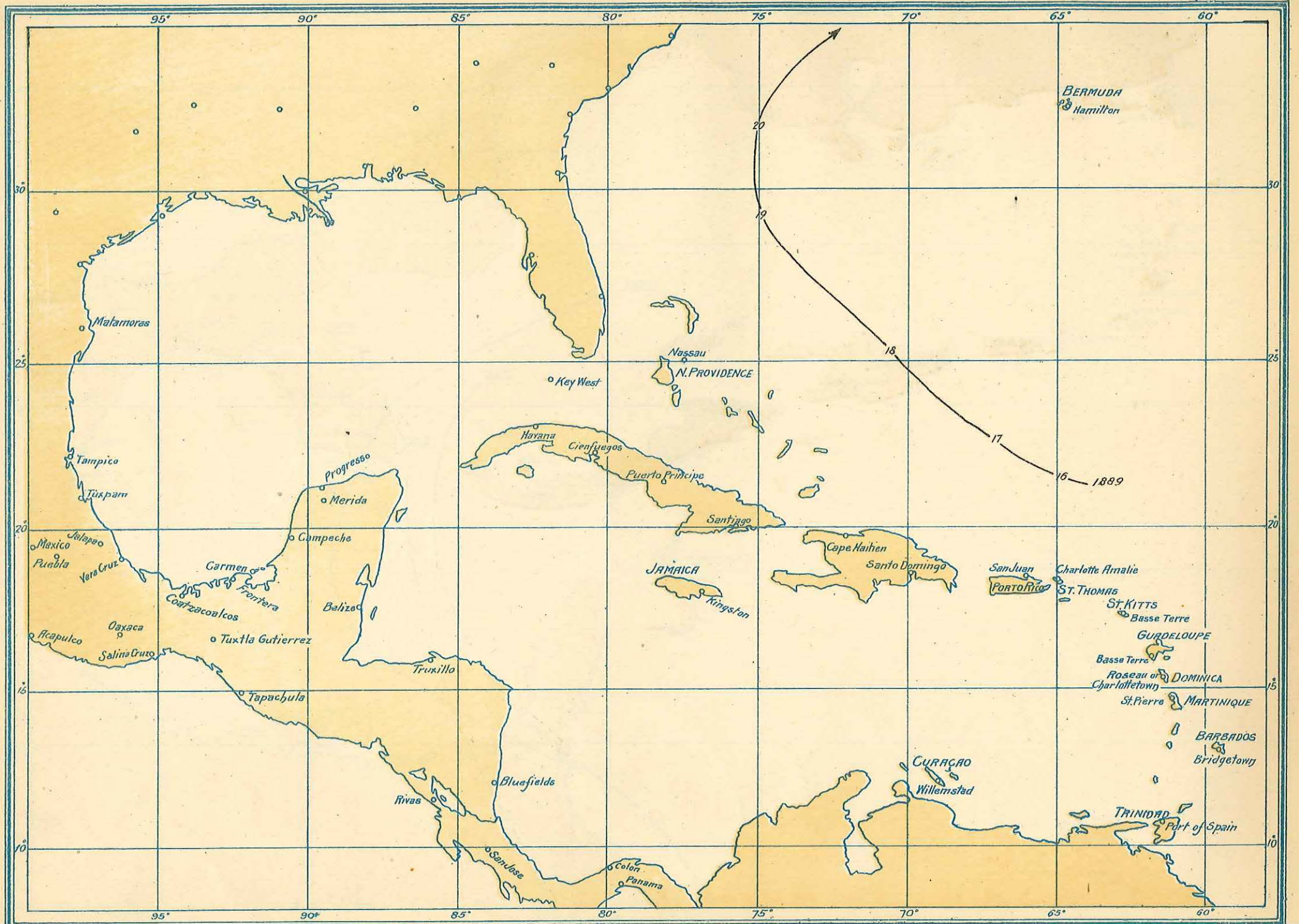

Chart II. Tracks of West Indian Hurricanes. June, 1878-1900.

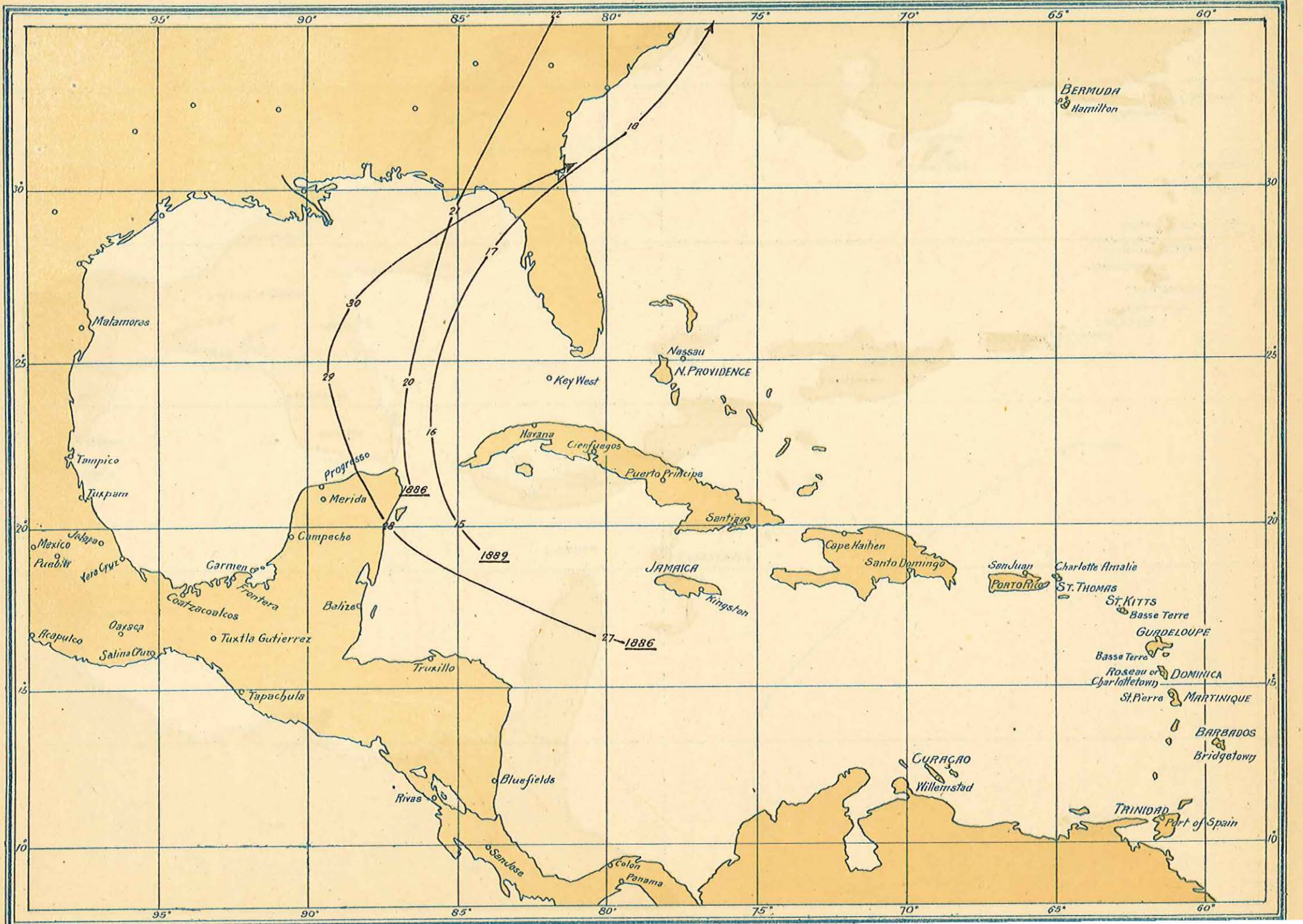

Chart III. Tracks of West Indian Hurricanes. July, 1878-1900.

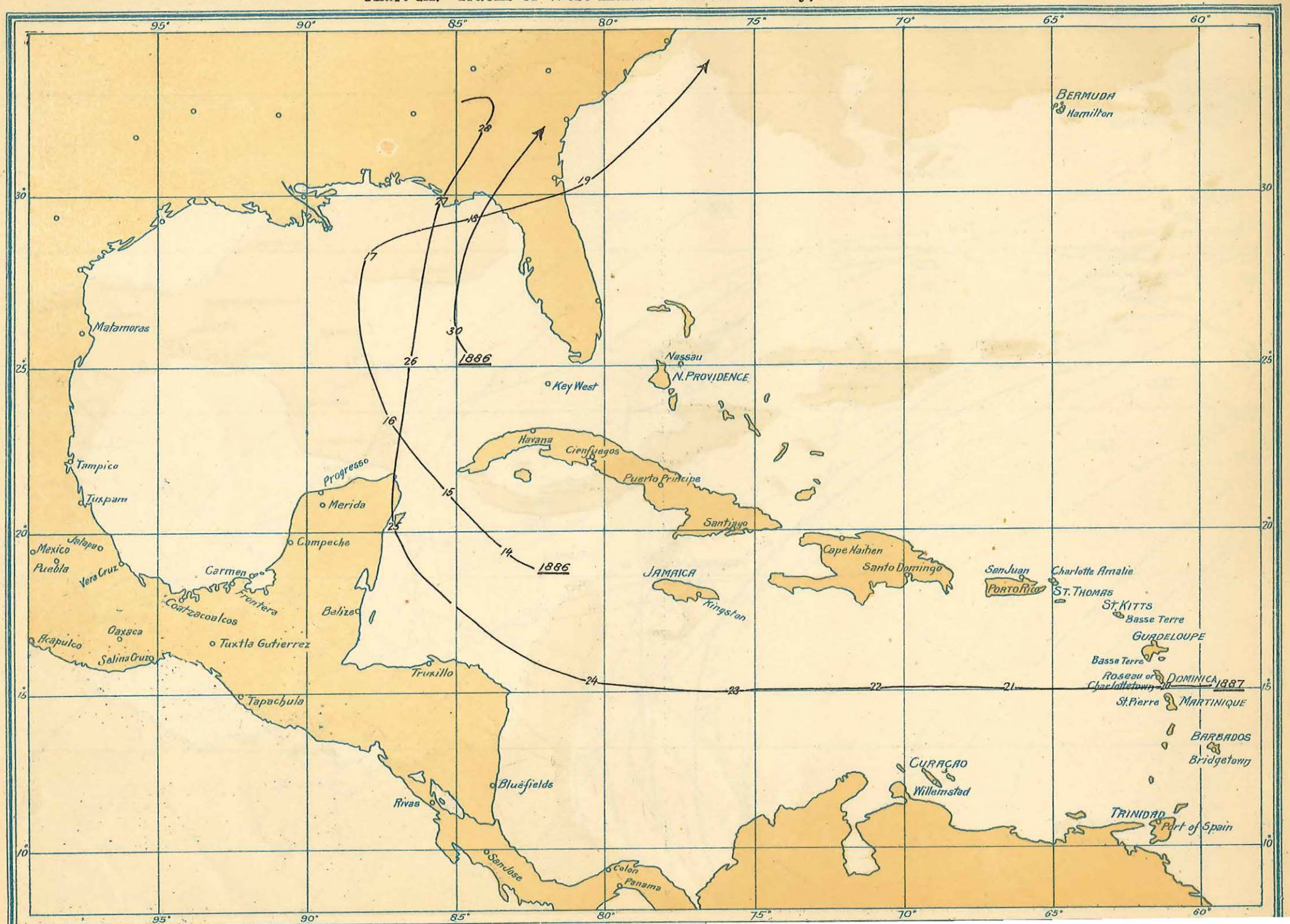

Chart IV. Tracks of West Indian Hurricanes. August, 1878-1900.

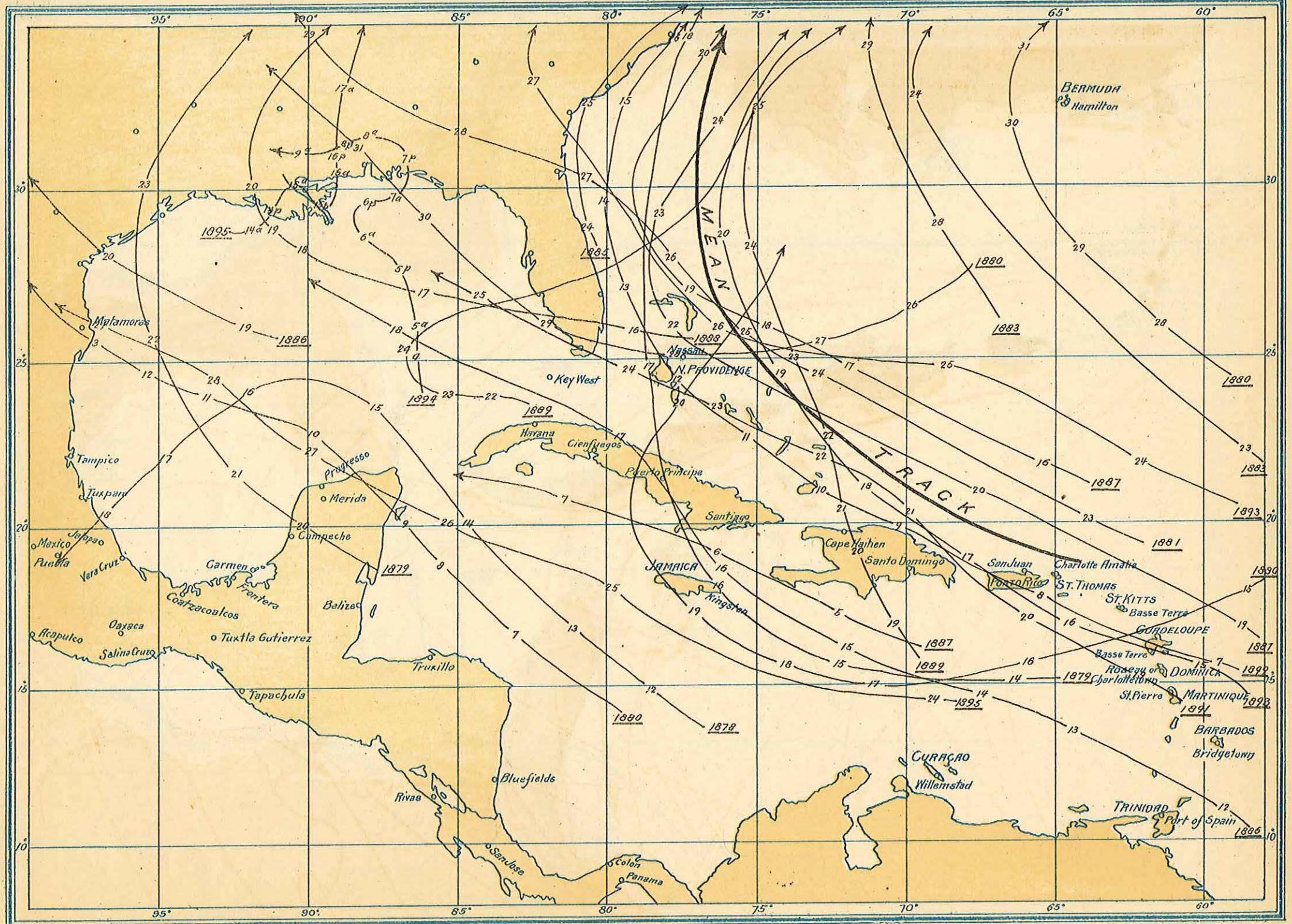

Chart V. Tracks of West Indian Hurricanes. September, 1878-1900.

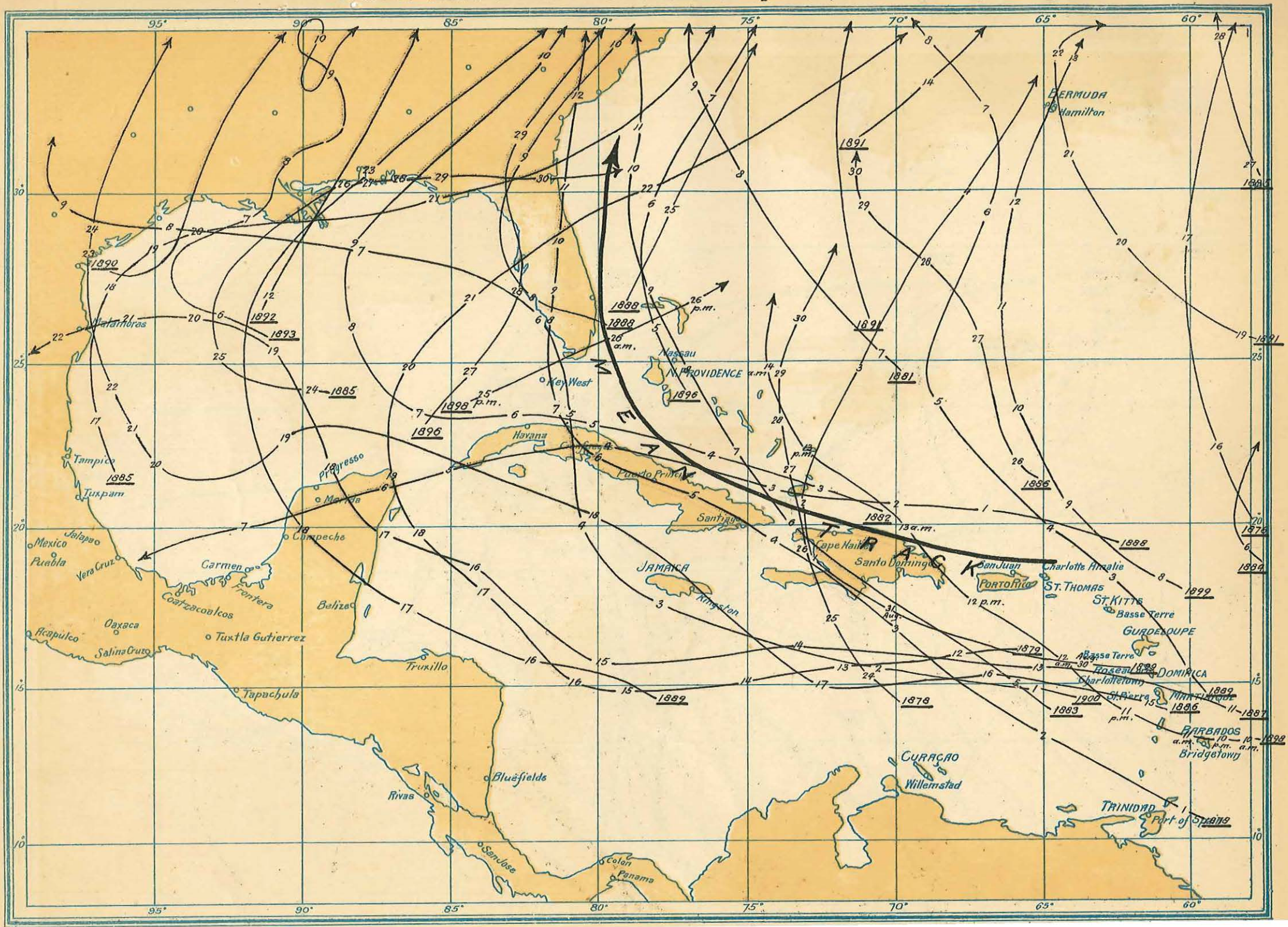

Chart VI. Tracks of West Indian Hurricanes. October, 1878-1900.

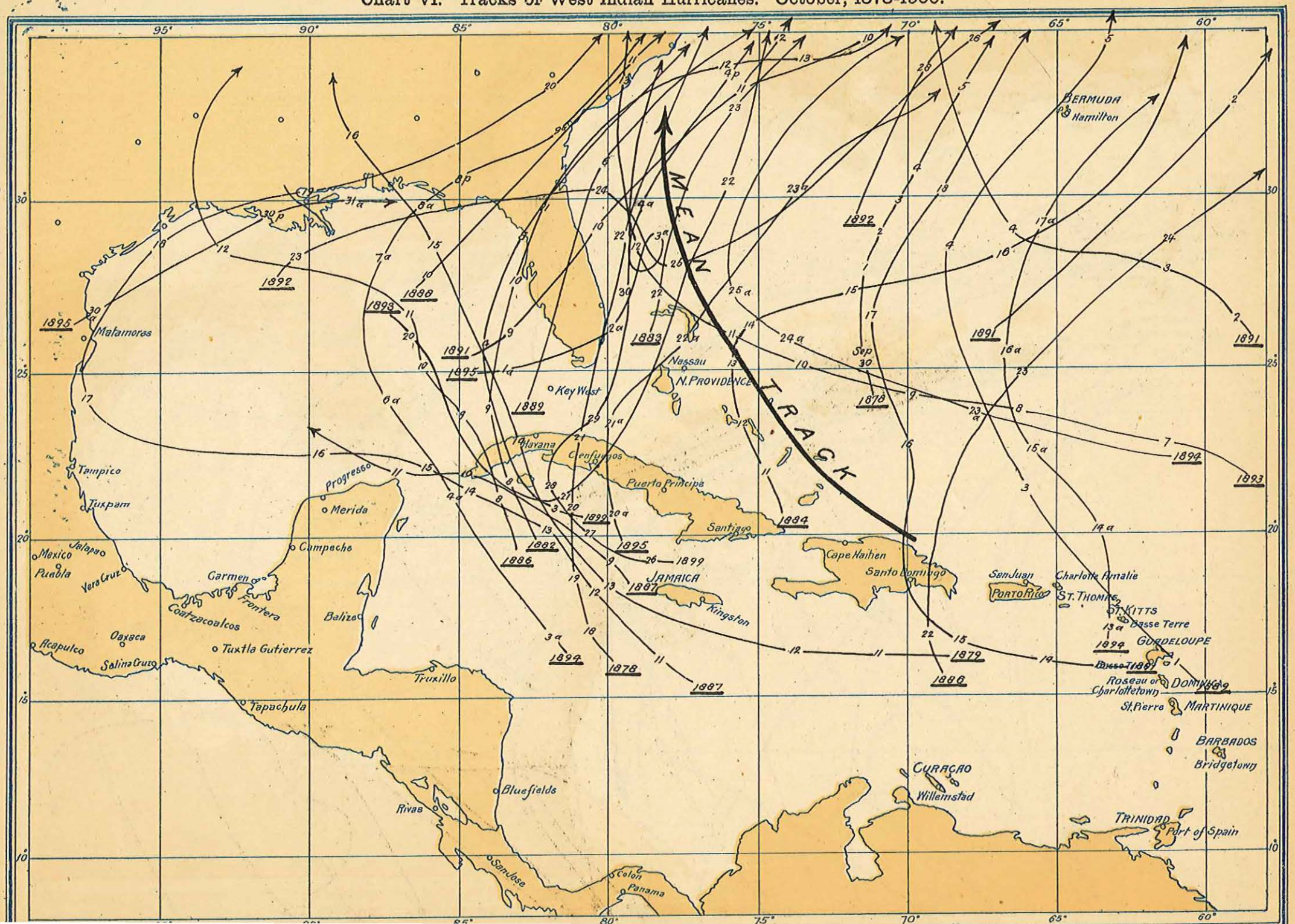

Chart VII. Tracks of West Indian Hurricanes. November, 1878-1900.