

then rapid, and the subsequent rise was about as fast as the preceding fall. The following barometer readings (reduced to sea-level) were taken:

	Inches.
9:40 a. m. ....	29.73
11 a. m. ....	29.87
1 p. m. ....	29.59
2 p. m. ....	29.53
3 p. m. ....	29.51
5:40 p. m. ....	29.37
6:30 p. m. ....	29.42

Rain fell from 2 a. m. to 9:15 a. m.; 10:50 a. m. to 1:30 p. m. and from 4:03 to 6:37 p. m., being excessively heavy between 6 and 9 a. m. when 2.77 inches fell.

Lightning and thunder were not noticed; residents about 5 miles south of Houston report faint flashes of lightning about 6:30 a. m.

The winds came in characteristic gusts throughout the day increasing in force until 5 p. m. and diminishing thereafter. The direction and force of the wind and other meteorological data are given in the table next below.

The storm moved inland over Matagorda Bay, the center passing in a northerly direction over Palacios, Wharton and Wallis, each of which reported a distinct calm, with wind coming from northwest and west after the calm.

**TROPICAL STORM OF JUNE 22, 1921.**

By B. BUNNEMEYER, Meteorologist.

[Weather Bureau, Houston, Tex., July 1, 1921.]

The storm was of comparatively short duration and of the milder type of hurricane. The sky was overcast throughout the day with nimbus or stratus and scud moving with the surface wind; upper clouds could not be observed.

The barometer fell until 5:40 p. m. and rose thereafter. The fall was slow with strong fluctuations until 9 a. m.,

TABLE 1.—Wind and precipitation data for June 22, 1921.

	A. M.											P. M.											Mid-night.	
	1	2	3	4	5	6	7	8	9	10	11	Noon.	1	2	3	4	5	6	7	8	9	10		11
Wind direction.....	NE.	NE.	NE.	NE.	NE.	NE.	NE.	NE.	NE.	E.	SE.	E.	SE.	SE.	SE.	SE.	SE.	SE.	S.	S.	S.	S.	SW.	SW.
Wind movement.....	11	11	13	13	16	17	23	23	21	23	28	32	44	38	44	47	49	41	37	36	28	19	16	16
Maximum velocities and directions.							29	28	34	26	42	41	49	52	54	53	60	58	42	48	34			
Precipitation.....		T.	0.05	0.15	T.	0.02	1.04	0.27	1.46	0.03	0.01	0.04	0.01	T.			0.01	0.03	T.					

## STORMS AND WARNINGS—WEATHER AND CROPS.

## STORMS AND WEATHER WARNINGS.

## WASHINGTON FORECAST DISTRICT.

On the morning of June 1 pressure was low and falling over the eastern Gulf of Mexico and the northwestern Caribbean Sea, with a disturbance of slight intensity central over the latter region, and advisory warnings were issued daily until the 4th when the disturbance apparently filled up.

At 10:30 a. m. of the 16th the following advisory warning was issued:

Disturbance of moderate intensity over western Caribbean Sea central near coast of Honduras southwest of Swan Island this morning apparently moving slowly northwestward will be attended by fresh and strong shifting winds and rains in northwestern Caribbean Sea next 36 hours.

By the morning of the 17th the disturbance had increased somewhat in intensity and an advisory warning of strong shifting winds and probably gales was issued for the northwestern Caribbean Sea and the Yucatan Channel. During the following night the disturbance passed inland over British Honduras in the vicinity of Belize, continuing its slow northwestward movement, and a maximum wind velocity of 52 miles an hour from the southeast was registered at Progreso, Yucatan, as the storm entered the southwestern Gulf of Mexico during the early morning of the 19th.

No further reports were received giving the approximate location of the storm until the afternoon and evening of the 21st when it was central off the mouth of the Rio Grande. The warnings issued on the 21st and the morning of the 22d are noted below.

A delayed radio report from the S. S. *Sucrosa* (received during the afternoon of the 22d) showed a barometer reading of 29.28 inches and a wind velocity of about 75 miles an hour from the southeast at 10 p. m. of the 21st in latitude 26° 30' N. and longitude 95° W.

During the night of the 21st–22d the storm caused a maximum wind velocity of 68 miles an hour from the northeast at Corpus Christi and a strong northeast gale and high sea at Point Isabel, and by 8 a. m. of the 22d the wind was blowing 42 miles an hour from the east at Galveston, with rising tide. Special observations at 10 a. m. showed rising pressure at Corpus Christi and slowly falling pressure at Galveston and Houston, and the following bulletin was issued at 12 noon:

Tropical storm apparently moving inland over Texas coast vicinity Matagorda Bay. No further danger Corpus Christi southward.

At 5:30 p. m. the following bulletin was issued:

Tropical storm central southwest of Houston moving northward, Gales along Texas coast east of Matagorda Bay will diminish to-night,

The hurricane warnings were ordered down at 9:30 p. m.

The wind reached a velocity of 60 miles an hour from the southeast at both Galveston and Houston, and the lowest barometer reading at a land station was 29.37 inches at Houston at 5:40 p. m. of the 22d. The storm continued to move slowly northward, with diminishing intensity, over the eastern portions of Texas, Oklahoma, and Kansas, thence northeastward over the Lake region.

Another disturbance was apparently forming on the morning of the 24th over the northwestern Caribbean Sea in the vicinity of Swan Island whence it moved slowly westward over southern British Honduras and Guatemala and by the morning of the 28th it was causing

strong shifting winds and heavy rains over the southwestern Gulf of Mexico and also in the Gulf of Tehuantepec on the Pacific side. Advisory warnings were issued daily, based on delayed Mexican reports, until the 29th when the disturbance had apparently moved inland over Mexico. This disturbance was of much wider extent than the preceding one, but it apparently did not develop into a severe storm.

No storm warnings were issued during the month for the Great Lakes or the Atlantic and east Gulf coasts.

Frost warnings were issued for limited areas in the upper Lake region and the northeastern States on several dates during the first week of the month.—*Charles L. Mitchell.*

## NEW ORLEANS FORECAST DISTRICT.

A tropical storm which had traveled from the Caribbean Sea across Honduras and southern Yucatan and thence northward through the Gulf of Mexico moved inland on the Texas coast, with its center passing near Matagorda Bay during June 22, 1921. Small-craft warnings were displayed on the Texas coast 9:30 a. m. on the 20th in anticipation of increasing winds. A 4 p. m. special observation from Brownsville, Tex., June 21, showed a fall in pressure of about 0.08 inch since 8 a. m., with rain falling; small-craft warnings were ordered for the Texas coast, 4 p. m., from Velasco to Brownsville. A 4:40 p. m. observation from Corpus Christi, Tex., showed a somewhat higher barometer than at 8 a. m., but the wind, 48 miles from the northeast, with heavy rain, and the tide high at Point Isabel and a storm tide of 4 feet at Corpus Christi Pass, indicated that the storm was moving toward the Texas coast, and the following warning was issued for the Texas coast, Port Arthur to Brownsville:

NEW ORLEANS, LA., June 21, 1921.

Hoist northeast storm warning, Texas coast 4:30 p. m. Disturbance apparently off mouth of Rio Grande, moving northeast; will cause increasing northeast winds and gales and rising tides.

CLINE.

The following storm bulletin from the central office was distributed to all authorized addresses at 9:40 p. m.:

WASHINGTON, D. C., June 21, 1921.

Storm bulletin: Storm of unknown intensity central off mouth of Rio Grande apparently moving north-northwestward. Shifting gales to-night north to mouth of Colorado River and probably as far as Galveston. Every precaution should be taken. Advise all interests.

MITCHELL.

Hurricane warnings were distributed at 9:25 a. m. on the morning of the 22d, as follows:

WASHINGTON, D. C., *June 22, 1921.*

Hoist hurricane warning 9:30 a. m., Texas coast, Matagorda Bay to Port Arthur, Tex. Tropical storm central off Texas coast east of Corpus Christi apparently moving northward increasing in intensity; it will cause dangerous shifting gales to-day along the Texas coast between Corpus Christi and Port Arthur.

MITCHELL.

Northeast storm warnings were issued for the southwestern portion of Louisiana and the following wind forecast was sent to all stations on the Louisiana coast: "Increasing easterly winds Wednesday afternoon and night; dangerous tides on the coast"; signed, "Cline."

The following wind forecast was telegraphed with the forecast to all authorized points in southeastern Texas:

Strong northeast winds and gales in southeastern portion of Texas this afternoon and to-night, becoming northerly and westerly Thursday and subsiding. High tides on the east coast.

CLINE.

No storms occurred without warning.—*I. M. Cline.*



## STORMS AND WEATHER WARNINGS.

EDWARD H. BOWIE, Supervising Forecaster.

## WASHINGTON FORECAST DISTRICT.

*West Indian hurricane of Sept. 8 to 15.*—This disturbance made its appearance the morning of the 8th to the southeastward of Barbados, traveled west-northwestward and crossed the Grenadines during the night of the 8th and passed on to the Caribbean Sea. Its course from the Grenadines was west-northwest and the afternoon of the 10th it was encountered by the steamship *West Faralon* in approximately Lat.  $17^{\circ}$  N. and Long.  $68^{\circ}$  W., when the barometer fell to 28.38 inches with winds of hurricane force. Passing northwestward from this position its center crossed Haiti and then pursued a northerly course, passing the Bermudas on the 15th and what seemed to be this storm was in the vicinity of Iceland on the 22d. The disturbance was of rather small diameter but of great intensity throughout its course. It is reported to have caused considerable damage to shipping, buildings, and crops and to have caused the loss of a number of lives in the eastern islands of the West Indies and the Bermudas.

On the morning of the 8th, when the signs of the approach of this hurricane were unmistakable, the fol-

lowing warning was issued by the district forecaster at San Juan, Porto Rico:

Tropical disturbance east of the island of Trinidad at 8 a. m., probably moving west-northwest. Caution advised through eastern Caribbean Sea. Further information will issue about 3 p. m.

Based on 1 p. m. special observations from eastern Caribbean stations the following warning was issued by the district forecaster at San Juan, Porto Rico:

1 p. m., tropical storm of moderate intensity with center south of the island of Barbados, moving west-northwest, will probably pass to the south of the island of Porto Rico during Friday, the 9th. Caution advised throughout the eastern Caribbean Sea area. Further information will issue about 10 p. m.

At noon of the 9th the district forecaster at San Juan, Porto Rico, issued the following warning:

Noon broadcast. Tropical storm center about 200 miles southeast of island of Porto Rico at noon, moving west-northwest at rate of 12 miles an hour. Moderate to strong winds with rain probable along south coast of Porto Rico to-night.

At 8 a. m. of the 10th the following information was issued by the district forecaster at San Juan, Porto Rico:

Tropical storm apparently increased in area and extent during the night and continued its movement west-northwestward. This morning the center was about 300 miles southwest of Porto Rico; squalls and heavy rains occurred during the night and early morning in Porto Rico, but the island is now out of the danger zone.



These and other warnings issued by the San Juan station and the Central Office were disseminated to West Indian stations and to stations on the Gulf and Atlantic coasts. They were also sent by Navy Radio to vessels at sea.

On Sunday, the 11th, when there were indications that this disturbance was moving northward over Haiti, the following advisory information was issued from the Central Office:

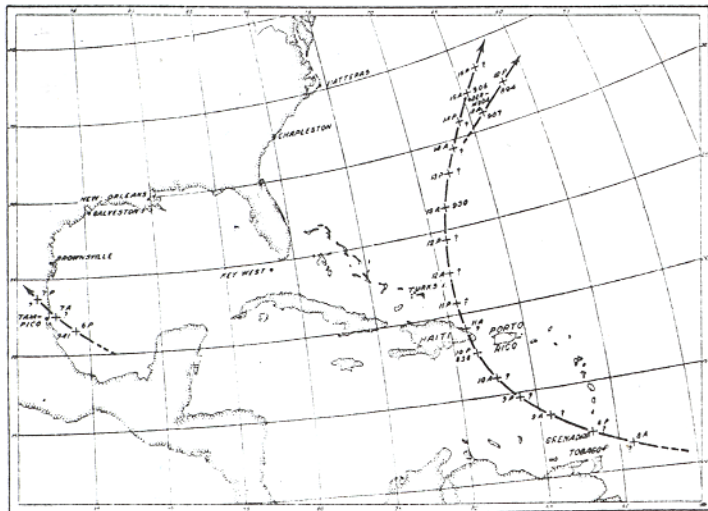


FIG. 1.—Path of hurricane of Sept. 8-15, 1921.

Advisory, 10 p. m. Tropical storm has moved northward and to-night its center is over northwestern Haiti. Future movement uncertain but probably northward. Shifting gales over and to eastward of the Bahamas during the next 36 hours.

This disturbance, as stated in the opening paragraph, moved northward from Haiti, and on the morning of the 14th notification was sent the Bermudas that the disturbance was moving northeastward toward these islands. Its center passed near the Bermudas the morning of the 15th, when the pressure fell to near 29 inches with winds of hurricane force.

The night of the 15th the following communication was sent the Office of Naval Communications, Navy Department, Washington, D. C.:

Please broadcast the following tonight: "Storm of hurricane intensity moving northeastward from the vicinity of Bermudas. It will pass onto transatlantic steamship lanes during Friday and continue to move eastward with unabated intensity."

As previously stated this storm was apparently the one charted over Iceland the morning of the 22d, when the barometer stood at 28.70 inches with wind of gale force. It is a remarkable coincidence that at the time the southern hurricane was centered north of Haiti that the steamship *Capillo* reported by radio having encountered on the 12th a hurricane of small diameter, barometer below 29 inches, near and immediately southeast of the Bermudas, moving rapidly northeast. This disturbance was separate and distinct from the primary disturbance herein referred to. Moreover, immediately preceding the appearance of the tropical storm in the eastern Caribbean Sea, there were signs of a disturbance over the southwest Gulf of Mexico, as indicated by reports by radio from vessels in that region. It passed on to the Mexican coast during the 7th and was dissipated, but there is reason to believe that the phenomenal rains in southern Texas on the 9th and 10th were associated with this disturbance. Conceding that the disturbance that appeared on the 8th southeast of Barbados was in existence previously to that date, it follows that from

the 6th to 14th there were three storms of a tropical nature over the southern waters at approximately the same time.

The paths of these disturbances will be found elsewhere in this number of the REVIEW.

In the Washington Forecast District no storm warnings were issued or required for the east coast of the Gulf of Mexico and for the Atlantic coast south of Cape Henry.

*For the Atlantic coast north of Cape Henry.*—Southwest storm warnings were ordered on the 11th for the coast at and north of Delaware Breakwater, when a disturbance of marked intensity was over the Great Lakes and moving northeastward, and strong winds, at times reaching gale force, occurred over the stretch of coast where warnings were displayed. On the 25th southwest storm warnings were displayed on the coast at and north of Delaware Breakwater when a disturbance of considerable intensity was centered north of the Great Lakes and moving eastward toward the St. Lawrence valley, and it was attended by strong south shifting to west winds during the night of the 25th along the coast north of Sandy Hook. On the 30th southwest storm warnings were displayed on the coast between the Virginia Capes and Eastport, Me., when a disturbance of marked intensity was central over the Great Lakes and moving eastward; the conditions forecast occurred along the coast covered by warnings, the maximum velocity being 56 miles an hour from the south at New York City.

*On the Great Lakes.*—Storm warnings were displayed on one or more of them on the 17th, 20th, 21st, 25th, 26th, 28th, 29th, and 30th. On the 17th the display was that of southwest warnings on Lakes Erie, Huron, and Ontario, when a disturbance of considerable intensity had its center north of Lake Superior. On the 20th the display was for strong south to west winds on Lakes Erie, Huron, Michigan, and Superior except the extreme west portion, the disturbance at the time of the display being central north of Minnesota, and on the morning of the 21st the display of southwest warnings was extended to Lake Ontario. The disturbance on the morning of the 21st was central north of Lake Superior and moving east-northeastward. It was attended by strong south to west winds and gales over the entire region of the Great Lakes. The morning of the 25th northwest storm warnings were displayed on Lakes Huron, Erie, and Ontario, when a disturbance of considerable intensity was central north of Lake Huron and moving eastward. This disturbance produced northwest gales on Huron and extreme eastern Superior, but no winds of consequence elsewhere. On the evening of the 28th northwest storm warnings were displayed on western Lake Superior, and the morning of the 29th southwest warnings were ordered for eastern Lake Superior and for Lakes Michigan, Huron, and Erie, and on the morning of the 30th for Lake Ontario, in connection with a disturbance of the Alberta type. This disturbance increased markedly in intensity during the night of the 29th, and during the 30th it was attended by general gales on the Great Lakes, except western Lake Michigan. The maximum wind velocity reported was 76 miles from the southwest the afternoon of the 30th on extreme eastern Lake Erie.

No abnormally cold weather occurred in the Washington Forecast District during the month, although frosts occurred during the third decade at a number of points along the northern border.



## THE HURRICANE OF OCTOBER 25, 1921, AT TAMPA, FLA.

By EDWARD H. BOWIE, Supervising Forecaster.

[Weather Bureau, Washington, Nov. 28, 1921.]

Like many of the tropical storms of October that pass inland from the east Gulf of Mexico, the one under consideration had its apparent origin over the west-central Caribbean Sea. The first signs of the presence of this disturbance in that region were observed the morning of October 21, although relatively low pressure had been previously reported from bordering stations and from vessels authorized to send meteorological reports by radio. However, on the morning of the 21st when there were signs of the presence of a disturbance in that region, the following advisory information was broadcast:

Advisory 10 a. m. Disturbance appears to be forming over western Caribbean Sea southwest of Jamaica; movement uncertain, but probably northward.

At the time this advice was issued the barometer was high over the United States east of the Mississippi River, low along and off the east coast of the United States, and relatively high southeast of the Bermudas. As to the origin of the storm, little of an authoritative nature may be said, for meteorologists are not yet in agreement as to the forces which bring about their development. It is a matter that is still in the controversial stage. Nevertheless, we do know that they occur along the line of discontinuity which separates the two systems of trade winds—the northeast trades of the Northern, and the southeast trades of the Southern Hemisphere. Perhaps the hypothesis recently stated by Bjerknes to explain the origin of the extra-tropical cyclones will also be found to apply in the case of the tropical cyclones. In connection with the origin of the cyclone under discussion, the following letter from the Chief Hydrographer, Panama Canal, is interesting. It reads as follows:

Reference is made to cabled predictions of the West Indian hurricane of October 21–25. The service on this storm was as satisfactory to shipping here as that of the September 8 to 13, 1921, hurricane.

As usual, we were not detrimentally affected here locally. However, we did have a noticeable effect from it, considerably more than usual. I inclose barometric record, October 12 to 26 (not reproduced). You will note that our barometer, disregarding diurnal fluctuations, was steadily declining from October 13 to 18, preceding the birth of the hurricane. This period was accompanied by heavy daily rains, noticeably on the Pacific half of the Canal Zone; winds prevailing from northward.

On the 18th we had an unusual reversion to a more or less steady southerly wind of dry season intensity and with dry season characteristics except as for direction; virtually no rain; the above conditions obtaining to October 29.

During October 20–22, inclusive, wind movement averaged 19.4 miles per hour at Balboa Heights against a normal October movement of 6.4. That station had maximum five-minute intensities of 35 miles per hour.

Ships tell us of stormy voyages from San Francisco to Nicaragua contemporaneously with the passage of the Caribbean storm.

We infer from the foregoing that there had taken place previously to the birth of the cyclone fundamental changes in the primary wind régime of the Tropics. What this had to do in bringing about the birth of the cyclone we do not know, but it is apparent that something more than purely local forces were in operation.

The diagram herewith gives the track of this cyclone from the time it first made its appearance in the Caribbean Sea up to the time it was lost over the Atlantic Ocean south of Bermuda. Up to the time the storm passed inland near Tampa, Fla., the track may be regarded as normal; after that time, decidedly abnormal, the change from normal to abnormal being brought about by the southward-flowing air from an extensive area of high pressure which moved southward from the Hudson

Bay during the 25th to 28th. This southward-flowing air-stream controlled the movement of all pilot balloons released at pilot-balloon stations in the Atlantic States north of Florida during this period. This but confirms the opinion of the writer and others that the winds flowing out from and around anticyclones very largely determine the movement of tropical cyclones.

Passing north-northwestward from the position southwest of Jamaica, the cyclone passed near and to the east of Swan Islands on the morning of the 22d. The barometer fell to 29.20 inches, and possibly lower, at that station between 10 a. m. and noon and rose rapidly thereafter. During the afternoon of the same day the wind which had been from the north in the morning shifted to south-southwest and reached a speed of

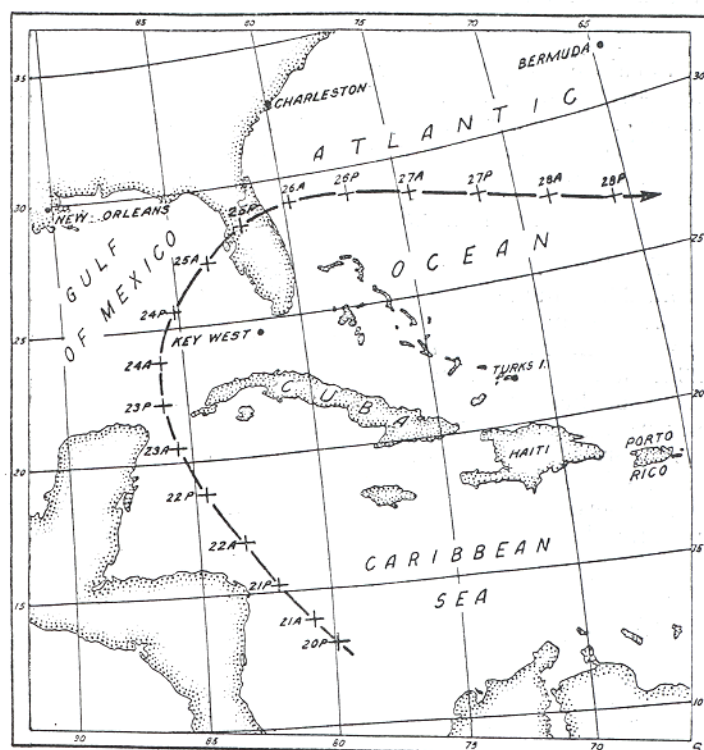


FIG. 1.—Track of tropical hurricane, October 20–28, 1921.

80 miles an hour. Passing Swan Islands the cyclone reached the Yucatan Channel during the 23d, its center passing near Cape San Antonio, Cuba. It seems to have acquired its maximum intensity in this region, as the master of the schooner *Virginia* reported a minimum pressure of 27.80 inches when in the center of the cyclone. The S. S. *El Estero* while in latitude 25° 36' and longitude 84° 24', at 10 p. m. of the 24th, encountered the center of the cyclone, the barometer falling to 27.84 inches. The accuracy of the barometer aboard the *Virginia* is not known, but since the reading is not essentially different from the reading made by the observer at Tarpon Springs, near and north of Tampa, when the cyclone was passing inland north of Tampa, it is presumed to be approximately the true low barometer at the center of the disturbance. At Tarpon Springs the barometer as read by Mr. A. P. Albaugh showed a reading of 28.12 inches and at the same time the wind was a dead calm which lasted an hour or more, following 2:15 p. m. of October 25.



During the time that the cyclone was moving northward advisory information and warnings were issued to the threatened land and sea areas, and it is worthy of note that no report of loss of a vessel carrying radio outfit has come to the notice of the Central Office.

Hurricane warnings were ordered noon of the 24th for the west Florida coast from Key West to Apalachicola. The warning read as follows:

Change to hurricane warning at noon, Key West to Apalachicola. Increasing winds and gales and hurricane velocities along the coast. Emergency; warn all interests. Tropical storm near and northwest of west end of Cuba, moving slowly northward and will change its course to north-northeastward during to-day.

After crossing the Florida Peninsula the storm moved almost due east. The last information concerning it received by radio was supplied by the French S. S. *Montana* which came within the influence of the cyclone during the 27th-28th when in longitude  $69^{\circ} 14'$  west and latitude  $28^{\circ} 22'$  north. The lowest barometer recorded was 29.06 inches.

#### LOCAL DETAILS.

Local details of the storm, abstracted from reports by meteorologists H. B. Boyer, W. J. Bennett, and A. J. Mitchell, in charge of the Weather Bureau stations at Key West, Tampa, and Jacksonville, respectively, are given below.

#### METEOROLOGICAL CONDITIONS.

*Key West, Fla.*—Pressure slowly but steadily decreased from 29.92 inches at 10 a. m. of the 23d to 29.55 inches at 3:30 a. m. of the 24th, while the wind, moderate to fresh from the southeast during the afternoon of the 23d, steadily freshened throughout the 24th, veering from southeast to south between 4 and 5 p. m. and becoming strong. Between 6 and 7 p. m. the force increased to a moderate gale, and between 10 and 11 p. m. to a fresh gale, still blowing from the south. On the 25th the wind veered to southwest at 5 a. m. and 25 minutes later registered its highest velocity of 48 miles an hour. Thence on the force gradually diminished, and during the middle of the afternoon had fallen to fresh and had veered to west.

The rainfall throughout the passing of this storm was light and more or less intermittent, and while the gusty and squally character of the wind invariably accompanying tropical storms was present, this feature was not marked, but during one of these squalls, at 8:06 a. m. of the 25th, the extreme (1-mile) velocity was recorded—54 miles an hour from the southwest.

At the Sand Key station on the Florida reefs, 8 miles south of Key West, the maximum wind velocity recorded was 56 miles an hour from the south at 4 a. m. of the 25th, while the lowest barometric reading was 29.57 inches at the same time.

The heavy seas from the southeast, south, and southwest rolled in over the reef and practically washed away the island that had slowly built up since the hurricane of September, 1919. During the afternoon of the 24th the official in charge at Key West was informed by telephone that the seas were then coming within 5 feet of the recording rain gage. Instructions were given to remove the gage.

Although the employees at Sand Key were assured that violent winds need not be looked for, they were evidently quite nervous in view of the steady encroachment of the heavy seas, and to relieve this tension they were instructed to go to the lighthouse at their discre-

tion. Immediately after the 8 p. m. observation they waded to the lighthouse, where they remained during the night, returning to the Weather Bureau building on the morning of the 25th.

*Tampa, Fla.*—On Tuesday, the day of the storm, hurricane warnings were ordered continued in the early morning, and distribution made as far as possible. Wires were already going down, but warnings of the previous day had been ample. Telephone and telegraph wires went down about noon, but the storm was near its height, and the office force was busy taking special observations, looking after the instruments, and giving information to anxious visitors who, in spite of the fury of the storm, continually filled the office and brought news of the damage and of the brave work of those who were assisting unfortunates to escape from the rising tide.

It began to rain about 4 a. m. Sunday, October 23, and continued with hardly a break until 9:15 p. m. of the 25th. The total recorded rainfall was 8.53 inches, but much more probably fell and was blown out of the gage. The barometer fell slowly at first, more rapidly after midnight of the 24th-25th, slowed down again between 5 and 7 a. m. and then fell still more rapidly until the minimum, 28.81 inches sea-level pressure, was reached at 2:45 p. m. The lowest previously recorded was 28.95 inches in 1910. After this it rose rapidly to 29.34 inches at 10 p. m. and then more slowly. The wind continued from the northeast during the 24th and the early morning of the 25th, increasing to 28 miles at 3:38 a. m. the early morning of the 25th. It shifted between northeast and east until 7:05 a. m., with velocity between 25 and 42 miles per hour. From 7:05 to 9:50 a. m. the wind was east, with velocity occasionally reaching 40 m. p. h. Southeast winds brought increased velocity, and when the wind changed to south about 2 p. m. it increased to 48 m. p. h. and reached a maximum velocity of 68 m. p. h. at 2:18 p. m. The extreme was 75 m. p. h. The wind had decreased to 30 m. p. h. at 3 p. m., but on the rise of barometer increased again, having shifted to the southwest at 3:10 p. m. The highest velocity with rising barometer was 48 m. p. h. The wind was west only 24 m. p. h. at 8 p. m. Occasional very high gusts occurred during the night, but the maximum did not again reach 30 m. p. h.

Tide on the 24th was 0.7 foot, falling at noon; 0.1 foot, falling at 2 p. m.; zero, falling at 4 p. m. During the night it rose and reached 3.6 feet, and rising at 8 a. m. Further reading could not be obtained, tide being over the tide-gage. The highest tide, however, reached 10.5 feet above mean low water at 2 p. m. as calculated afterwards by the United States Engineers. This is by far the highest ever recorded, the previous record being 5.55 feet.

*Jacksonville, Fla.*—Pressure distribution on the 21st over the Gulf and the South Atlantic States was such as to make the future course of the storm problematical, the preponderance of positive factors, however, rather favoring a northeast direction over Florida. This conclusion was shaken somewhat on the 22d when conditions seemingly favored a movement to the westward probably around the periphery of the HIGH, then over the East Gulf and South Atlantic States. The circulation at the morning observation of the 22d showed that the Gulf and lower South Atlantic sections were under the direct influence of the storm as it moved slowly northward, cloudiness having enveloped the lower coast line, with a perceptible increase in wind force at lower coast stations as the result of stronger pressure gradients.



The morning reports of the 23d pointed to a continued northward movement. Cloudiness featured all Gulf and lower South Atlantic stations with the rain area embracing practically all of the Florida Peninsula. The morning reports of the 24th showed falling pressure at all Gulf and South Atlantic stations, most pronounced, however, in Florida, with a fresh southeast breeze at Key West and south wind, force 4, at Habana. Night reports of the 24th accentuated the gravity of the situation and abundantly confirmed previous deductions by the Central Office relative to the future movement and intensity of the storm. Fresh breezes prevailed during the day along the northern coast line of Florida with moderate gales to the southward, attended by a 12-hour pressure fall of 0.22 inch at Key West.

The 24-hour rainfall at regular stations, ending at 8 a. m. of the 24th, was:

Station.	Rainfall (inches).
Key West.....	0.04
Miami.....	0.44
Titusville.....	4.26
Tampa.....	1.00
Jacksonville.....	0.14
Apalachicola.....	0.08

Twelve-hour pressure changes (all negative) for the period ending 8 p. m. of the 24th were:

Station.	Pressure fall (hundredths of inch).
Apalachicola.....	0.14
Jacksonville.....	0.12
Key West.....	0.22
Miami.....	0.12
Tampa and Titusville.....	0.12

An east-west line at the evening observation of the 24th, bisecting the State about Titusville, showed the wind to be east-southeast and south below, and northeast above, the line of demarcation.

The morning reports of the 25th were far from reassuring; in fact, they awakened a keener interest and a deeper concern by the public. Gales were blowing east of the Suwanee River, attended by torrential rains in much of the central and north-central portion of the peninsula. The night of the 24th-25th was altogether a wild one in the central and northern counties.

Barometer readings at 8 a. m. of the 25th, with 12-hour changes, were as follows:

Weather Bureau stations.	Sea-level pressure (inches).	Pressure fall (inches).
Apalachicola.....	29.66	0.14
Jacksonville.....	29.74	0.14
Key West.....	29.60	0.06
Miami.....	29.68	0.10
Tampa.....	29.30	0.44
Titusville.....	29.64	0.16

The 24-hour rainfall for the period ending at 8 a. m. was as follows:

	Rainfall (inches).
Weather Bureau stations:	
Apalachicola.....	0.08
Jacksonville.....	0.34
Key West.....	0.06
Miami.....	0.30
Fort Myers.....	3.30
Tampa.....	5.20
Titusville.....	3.02
Weather Bureau cooperative stations:	
Avon Park.....	5.05
St. Petersburg.....	5.05
Pinellas Park.....	7.81
Tarpon Springs.....	8.70
Brooksville.....	9.50
Ocala.....	5.67
Eustis.....	4.46
Clermont.....	5.00
McDonald.....	7.66
Sanford.....	3.60
Orlando.....	4.45
Glen St. Mary.....	4.10
DeLand.....	3.25
St. Leo.....	11.73

It will be seen that the greatest rainfall occurred near the path and over the upper-right front and the lower-right rear quadrants as the storm center approached the coast and progressed northeastward across the peninsula.

The usual calm prevailed at the center of the storm, one observer stating that "some blue sky was seen, then it (the wind) broke out from the west, blowing to beat the band."

The lowest barometer readings (mercurial barometers) occurred on the 25th and were as follows:

Station.	Lowest sea-level pressure (inches).	Time of occurrence (hour).
Fort Myers.....	29.37	Noon.
Jacksonville.....	29.35	Midnight.
Key West.....	29.55	5:25 a. m.
Tampa.....	28.81	2:45 p. m.
Titusville.....	29.24	8:00 p. m.

The center of the hurricane passed inland just north of Tampa. Fortunately the American S. S. *Truxillo* was able to weather the storm and the master has favored us with the following log for the period midnight of the 24th to midnight of the 25th:

NOVEMBER 22, 1921.

Mr. WALTER J. BENNETT, Meteorologist,  
Tampa, Fla.

DEAR SIR: In complying with your request of November 4, am herewith handing you the following. Clock times stated are ninetyeth meridian time, or six hours behind Greenwich mean time.

Our position while in the storm center, as near as we can reckon, was approximately 24 sea miles due west of Egmont Key.

Oct. 24. 12 midnight. Bar. 29.62 inches. Therm. 72°. Wind east, blowing hurricane force.

Oct. 25. 4 a. m. Bar. 29.27 inches. Therm. 72°. Wind east, blowing force 11, Beaufort scale.

Oct. 25. 6.30 a. m. Bar. 29.00 inches. Therm. 72°. Wind east, blowing hurricane force.

Oct. 25. 8.00 a. m. Bar. 28.90 inches. Therm. 72°. Wind east, blowing hurricane force.

Oct. 25. 10.20 a. m. Entered storm center. Bar. 28.28 inches. No wind, but a terrific cross sea.

Oct. 25. 10.50 a. m. Passed out storm center. Bar. 28.28 inches. Therm. 72°. Getting wind from west, hurricane force. No wind throughout passage through storm center.  
 Oct. 25. 11.30 a. m. Bar. 28.32 inches. Wind west, hurricane force.  
 Oct. 25. Noon. Bar. 28.40 inches. Therm. 72°. Wind west, blowing hurricane force.  
 Oct. 25. 4 p. m. Bar. 29.02 inches. Therm. 73°. Wind west, blowing force 11.  
 Oct. 25. 8 p. m. Bar. 29.36 inches. Therm. 72°. Wind north, force 10, weather and sea moderating.  
 Oct. 25. Midnight. Bar. 29.48 inches. Therm. 71°. Wind north, force 9, weather and sea moderating.

The following barometer readings were taken Tuesday, Nov. 22, 1921, ship lying at Mallory Docks, Tampa, Fla., seventy-fifth meridian time:

8 a. m. Therm. 74°. Bar. 30.17 inches. Tampa station sea-level 30.15.  
 10 a. m. Therm. 76°. Bar. 30.19 inches. Tampa pressure sea-level, 30.17.  
 Noon. Therm. 78°. Bar. 30.14 inches. Tampa pressure sea-level, 30.13.  
 2 p. m. Therm. 78°. Bar. 30.12 inches. Tampa pressure sea-level, 30.09.

Hoping this information will be of benefit to you, I remain,  
 Very truly, yours,

C. S. HYERS,  
 Master S. S. "Truxillo."  
 By S. STANTON,  
 Chief Officer.

*High tides, October 25.*—Tampa: The tide was 10.5 feet, the highest since 1848. Egmont and Sanibel Island: Both were practically covered by water. Fort Myers: Tide was 12 to 18 inches higher than previous records for 30 to 35 years. Punta Gorda: Tide was 7 feet above normal high tide at 3 p. m. of 25th; water was in the streets of the city. Punta Rassa: Tide was 6 feet above normal high water. Boca Grande: Tide 5 feet 4 inches above normal high tide at 7.15 a. m. Clearwater: Tide 5 feet above normal high tide, 1.30–4 p. m. St. Petersburg: Tide 8 feet 5 inches above mean low water at 2 p. m.

Maximum wind velocities, with date and direction: Key West, 25th, 48 miles SW. Jacksonville, 25th, 64 miles NE. Mayport, 25th, 54 miles SW. Tampa, 25th, 68 miles S. Tarpon Springs, Dunedin, Egmont Key, and Safety Harbor, all near the center of the storm, estimated the wind velocity as being 80 to 100 miles an hour.

*Loss of life.*—So far as known the loss of life was small—not exceeding five or six—due, no doubt, to the fact that shipping remained in port.

*Loss of shipping.*—One coast steamer, the *Vann*, plying between Jacksonville and Miami, foundered off the Jupiter coast about 10 a. m. of the 25th. The value of the vessel and cargo was about \$120,000. Several schooners are reported to have capsized off the coast, but definite information is lacking.

*Intrastate loss.*—The citrus crop sustained a loss 800,000 to 1,000,000 boxes of fruit, approximating a monetary loss of more than \$1,000,000. The loss of trees was not great; in fact, the damage from that source was slight. Truck crops adjacent to the coast were greatly damaged—a complete loss in many instances. And the loss of fertilizer and labor greatly augments the disaster, totaling, no doubt, \$1,000,000 or more. Salt water flooded many acres, thereby rendering the soil unfit for cultivation in some instances; heavy rain will, however, soon remove the salt deposit, restoring the soil to normal condition.

*Miscellaneous damage.*—The damage to residences, docks, warehouses, buildings, bridges, and miscellaneous property, at Tampa, Tarpon Springs, St. Petersburg, Sarasota, Punta Gorda, Marco, Caxambus, and Fort

Myers; in short, along the coast from a point near Cedar Keys, southward, will exceed \$1,000,000, and the aggregate of losses will probably total \$3,000,000. The damage on the east coast, while considerable locally, was altogether of little moment when compared with that which befell the west coast.



## SUMMARY OF THE HURRICANES OF 1919, 1920, AND 1921.

BY WILFRED P. DAY.

[Weather Bureau, Washington, D. C., December, 1921.]

Of the storms of tropical origin occurring during 1919, 1920, and 1921, ten have been classed as hurricanes. These storms exhibit some of the variations from type, and also show great divergence in their paths from the average tracks of these disturbances. They bring out a strong relation between the positions and the movements of areas of high barometer and their own subsequent paths. These storms have been fully described in previous issues of the REVIEW, but their importance entitles them to a brief summary. Figure 1 shows the tracks of these hurricanes and another storm of tropical origin which may have been an incipient hurricane.

disturbance was brought to a standstill. It was here on the 6th that the characteristics of a hurricane began to develop; and with the increasing weight of the HIGH to the north the storm was propelled slowly in a new course toward the west, at the same time gaining great intensity. The path followed the southern periphery of the HIGH, which was now nearly stationary, passing over the Florida Keys on the 10th and starting to recurve over the eastern Gulf of Mexico on the 11th. But again the circulation was not strong enough to complete the recurve, and a rapidly advancing HIGH from the northwest reversed the air movement before the hurricane had reached the turning point. Under these new conditions

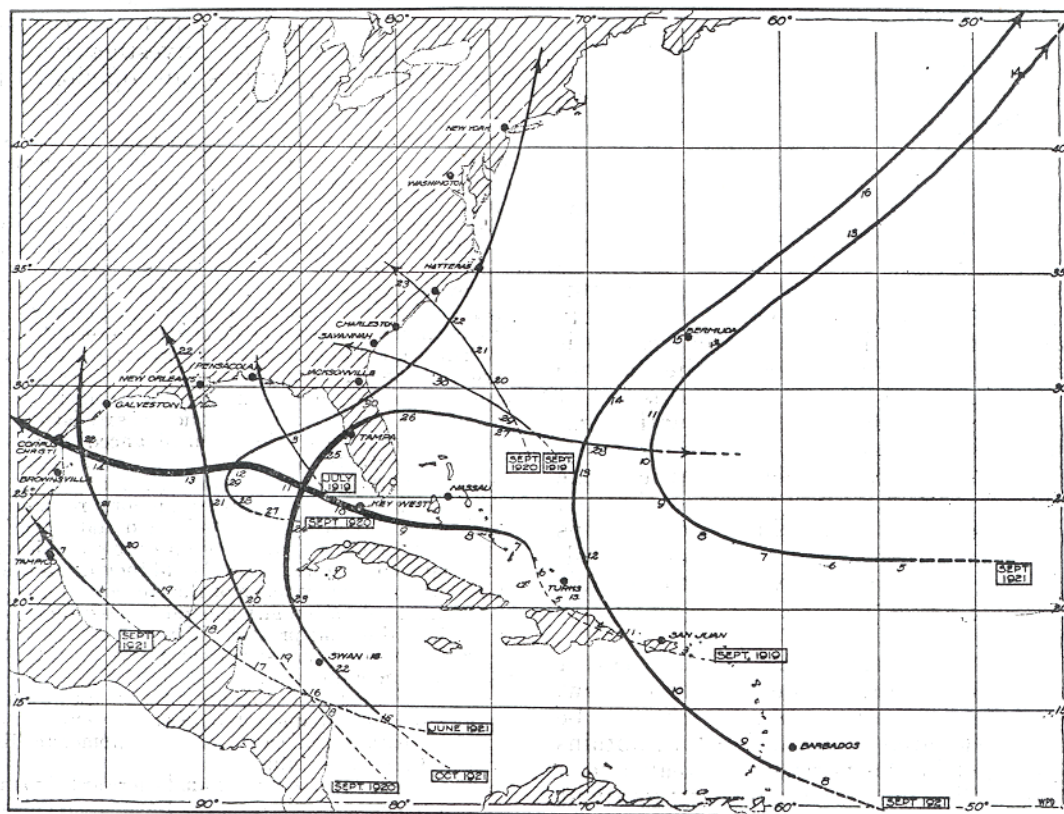


Fig. 1.—Tracks of the centers of tropical storms during the hurricane seasons of 1919, 1920, and 1921 with approximate locations at 8 a. m. (75th meridian time) for the duration of each storm.

*Storm of July 2-4, 1919.*—This storm developed over the eastern Gulf of Mexico on the 2d, was at all times of very small diameter, but with isobars exhibiting the vortex core of the true hurricane. The eastward movement of a trough of low pressure opened up a path and the storm fell into its wake, striking the coast a short distance east of Pensacola, Fla. Some damage was done but storm winds were of short duration.

*Storm of September 3-14, 1919.*—Some indications of a tropical disturbance were noted as early as the evening of the 2d in the vicinity of the island of St. Kitts (in the Leeward group). This low moved slowly (and apparently with no further development) in a northwesterly direction, starting its recurve on the 4th into the southern opening of a shallow trough. It was now in the vicinity of Turks Island, but meanwhile the trough was filling up, and with high and rising pressure to the north the

the storm after apparently remaining stationary for about 12 hours, now (the evening of the 12th) began, at first slowly and then with increasing speed of progression, a new path toward the west, which carried it to the Texas coast during the afternoon of the 14th. The center struck near Corpus Christi, the hurricane being one of the most severe ever recorded. The day to day changes in the general circulation and their effect upon the subsequent path of the storm are more clearly shown than usual on account of the very slow rate of progression and the fairly complete observations which have since been accumulated.

*Storm of September 29-October 1, 1919.*—This was a tropical disturbance which developed and moved nearly westward along the southern edge of a belt of high pressure, passing inland south of Savannah, Ga., but lacked the energy of a hurricane.



*Storm of September 17-22, 1920.*—This storm developed in the vicinity of the Swan Islands, moved north-northwestward with increasing intensity, but retaining its small diameter. It was prevented from making a normal recurve by high pressure to the northeast, and the increasing effect of this HIGH as it spread out toward the southwest caused a further shift of the storm's course toward the northwest. It passed inland on the Louisiana coast, where winds of hurricane force were reported, particularly on the right-hand side, where the isobaric gradients were increased by the proximity of the HIGH.

*Storm of September 20-23, 1920.*—This storm, which was nearly coincident with the preceding, developed off the South Atlantic coast in an area of low barometer which had stagnated there. No low barometer readings were recorded at Weather Bureau stations in the vicinity because of the extremely small diameter of the storm, but the lightship off Smiths Island, N. C., was dragged several miles from its station and a 72-mile wind was reported.

*Storm of September 26-30, 1920.*—The first evidences of this disturbance were noted on the morning of the 26th over the eastern Gulf of Mexico. Under the influence of a ridge of high pressure it was propelled slowly westward. On the 28th it came under the influence of a rapidly developing trough of low pressure, recurved, and moved rapidly northeast. But in crossing Florida it lost its identity as a hurricane, and on the morning of the 30th could not be separately identified in the general trough formation which covered the Atlantic coast region. This large and elongated disturbance developed into a severe coast storm, which should not, however, be confused with the original hurricane. In fact, there is some doubt whether the Gulf disturbance was ever a true hurricane. The heavy north winds which occurred over the Gulf on the 30th, long after the passage of the storm center, were due to the steep-pressure gradient formed as a great HIGH moved down from the northwest in the rear of the trough.

*Storm of June 14-23, 1921.*—This storm apparently developed over the western Caribbean Sea about the 14th and was carried northwestward by the general circulation, pressure being high over the eastern Gulf of Mexico and low over Mexico. This distribution of pressure continued until the 19th, the disturbance meanwhile crossing the Gulf of Honduras, the Yucatan Peninsula, and passing into the Gulf of Campeche. So far, heavy winds had occurred only on the right-hand side of the storm path, in the direction of the normal increase in pressure. No further reports from the vicinity of the storm were received until the late afternoon of the 21st, when special observations indicated its position some distance off the Rio Grande, and later reports showed a north-northwest movement and a fully developed hurricane. The storm center crossed the Texas coast line at Matagorda Bay and moved nearly due north over Palacios, Wharton, and Wallis, Tex., the last-named place being about 40 miles west of Houston, Tex., the nearest approach to a regular Weather Bureau station.

*The three tropical storms during the period September 5-15, 1921.*—From more complete reports which have since accumulated it appears that three important tropical storms were coexistent over southern waters during this period. A small disturbance made its appearance over the southwestern Gulf of Mexico on the 6th and passed inland near Tampico, Mex. The northward movement of the disturbance was evidenced by the torrential rains which fell over southern and central Texas between the 8th and 10th.

On the morning of the 8th a small but very severe hurricane made its appearance to the southeast of Barbados, crossed the Grenadines, moving northwest and with low pressure to the northward the storm turned in that direction, passed through the Mona Passage, and to the east of Turks Island during the 10th and 11th and crossed the Bermudas on the 15th with undiminished intensity.

On the 12th, when the preceding storm was central immediately northeast of Turks Island, the S. S. *Capillo* reported a hurricane of small diameter a short distance southeast of Bermuda. This storm has since been traced back (Tropical Hurricane of Sept. 5-15, 1921, by F. G. Tingley, in this issue, p. 674) and was found to be in existence as early as the 5th in approximate Lat. 22° N. and Long. 54° W. As shown by the accompanying chart, the storm moved slowly west-northwest, recurving near Lat. 27° N., Long. 67° W. These two storms attained great severity over the steamer lanes as they passed into higher latitudes.

*Storm of October 20-28, 1921.*—This was probably the most severe hurricane since the September storm of 1919. A disturbed condition was first noted to the southwest of Jamaica about the 20th. Then followed a very rapid development in area and intensity. Carried along slowly in the general circulation it passed near the Swan Islands, through the Yucatan Channel, and during the 24th, with high pressure breaking down in front and under the influence of a southwest current in the upper air, the hurricane recurved and on the morning of the 25th was centered immediately southwest of Tampa, Fla. A clear path was now apparently open to the northeast, but, meanwhile, a great HIGH was bearing down from the north and under its influence the storm, which had lost considerable intensity while crossing Florida, was forced to take a new path to the east-southeast and was last noted on the 28th south of Bermuda and still in the latitude of Tampa. Some very low barometric readings were made in the path of this hurricane, the schooner *Virginia* reporting 27.84 inches in the Yucatan Channel on the 23d, the S. S. *El Estero*, 27.84 inches at 10 p. m. of the 24th in the eastern Gulf and 28.12 inches at Tarpon Springs, Fla., at noon on the 25th.

#### ADDITIONAL NOTE ON THE WEST INDIAN HURRICANE OF SEPTEMBER 5-17, 1921.

The Weather Bureau recently received from the master of the Danish S. S. *Florida* a report of the weather experienced by that vessel on September 5-7, 1921, during a voyage from Philadelphia to Rio de Janeiro, which showed that the hurricane which passed over the Windward Islands on the night of September 8 was in existence as early as the 5th. The following extract has been taken from the report.

Position at noon of September 5, 13° 15' N., 47° 36' W., barometer 30.37,<sup>1</sup> wind SE., 2; sea SE., 2; 4 p. m., barometer 30.29, wind ENE., 2, sea ENE., 2; 8 p. m., barometer 30.28, wind ENE., 3, sea ENE., 3. At sunset the sky was very red and over the northeast horizon all was dark. The clouds observed comprised A. St., Fr. Nb., and Cu. Nb.; at this time the weather started to get squally.

At midnight of the 5th-6th the barometer was 30.29, wind NE., 4, sea NE., 4. At 4 a. m., barometer 30.17, wind ENE., 6, sea ENE., 6. At this time the same clouds were observed as at sunset on the preceding day but it was darkest over the northern horizon: 8 a. m., barometer 30.14, wind ENE., 6, sea ENE., 6. Noon, barometer 30.11, wind ENE., 8, sea ENE., 6. Position, 10° 10' N., 45° 48' W.

At 1 p. m. (6th) the wind suddenly turned to S., force 9; 4 p. m., barometer 30.11, wind S., 9, sea SE., 7, clouds, A. St. and Fr. Nb.; 8 p. m., barometer 30.23, wind SSW., 8, sea S., 7. Midnight, barometer 30.27, wind S., 6, sea S., 6, clouds Cu. Nb.; 4 a. m. (7th), barometer 30.23, wind S., 4, sea S., 4.

Had the *Florida* been equipped with wireless apparatus and able to send out reports of the hurricane the information would have been of great value, especially to the people of the Windward Islands, who had but very short notice of its approach.—*F. G. T.*

<sup>1</sup> The barometer evidently reads too high but no correction is available.