

tion effective and valuable. The history of this hurricane is a melancholy one, associated as it is with the tragic ending of nearly 2,000 lives on Lake Okeechobee, whose waters attained a height of 10 to 15 feet as they were forced southward and impinged on the shallow rim of the lake. The damage to property, greatest at Lake Worth and the beaches, approximated millions. The total property loss at West Palm Beach, Palm Beach, and other places in Florida affected and relieved by the Red Cross is given as \$25,000,000, which seems high.

On October 28 Red Cross officials announced their official casualty estimate, placing the number of dead at 1,836, and of injured at 1,870 for the entire storm area in Florida. The detailed casualty list is as follows: West Palm Beach area (from Jupiter to Delray Beach), 26 dead, 1,437 injured; Broward County, one dead, 51 in-

jured; Palm Beach County, 1,700 dead, 265 injured; Okeechobee County, 25 dead, none injured; other territory, 84 dead, 67 injured. A total of 10,172 families had registered with the Red Cross applying for aid up to October 28, about two-thirds of this number being in Palm Beach County.

After leaving Florida the storm decreased steadily in intensity as it moved close to the Georgia and South Carolina coasts and passed into North Carolina the night of the 18th-19th. On the 19th its course again changed to north and later toward the north-northwest, diminishing greatly in intensity and merging with another disturbance over Ontario during the 20th. No material damage has been reported from the Coast States north of Florida.

## SAN FELIPE<sup>1</sup>—THE HURRICANE OF SEPTEMBER 13, 1928, AT SAN JUAN, P. R.

By OLIVER L. FASSIG, IN CHARGE

[Weather Bureau Office, San Juan, P. R.]

On Tuesday morning, September 11, a message was received from the Weather Bureau Office in Washington announcing a tropical disturbance in latitude 15° N. and longitude 50° W. There was no evidence of a disturbance on the morning map of the 11th. At 3 p. m. upon receipt of special reports, changes in wind direction at St. Lucia and Barbados were signs of an approaching tropical disturbance. At the same time a radio report to Barbados from the S. S. *Inanda* was intercepted by the Ensenada radio station indicating that a storm of considerable intensity was raging over the Atlantic about 300 miles east of the Leeward Islands. These were the first indications of the approach of a storm toward Porto Rico. The vessel report was incomplete making it impossible to locate the center of the storm accurately. At the time of the evening observations of the 11th the lowest barometer reading was 29.76 inches at Barbados.

At 8 a. m. of the 12th a well-formed cyclonic disturbance was evidently centered to the east of Dominica, which reported a northwest wind of 20 miles per hour and a barometer of 29.50 inches. At 1 p. m. of the 12th the lowest barometer was 29.32 inches with a west wind of 40 miles per hour, at Dominica.

As September storms usually move in a west-northwest direction at an average speed of 12 to 13 miles per hour, the San Juan radio broadcast of Tuesday evening stated that the storm would move west-northwest and that the center would probably pass south of the Island of Porto Rico Wednesday night or Thursday morning. This information was broadcast from the naval radio station at San Juan every 2 hours from 8 p. m. Tuesday night. The warning was telegraphed to the 75 police districts of Porto Rico and otherwise given general distribution over the island. Observations from the Lesser Antilles on Wednesday morning still indicated that the vortex of the storm would pass at some distance south of Porto Rico. Information contained in the 6 p. m. observations of Wednesday the 12th indicated that the storm was centered farther northward than was anticipated and that the center would probably pass directly over the Virgin Islands and Porto Rico. This information was given prompt distribution throughout the island. At the same time hurricane warnings were ordered up at St. Thomas and at 12 ports along the coast of Porto Rico.

The storm broke over the southeastern portion of the Island early Thursday morning with the center near

Guayama and passed across the island in a west-northwest direction, leaving between Aguadilla and Isabela. The storm center moved across the island in about 8 hours at the rate of 13 miles per hour. The barometer, as the center passed to the south of San Juan at 2:30 p. m., registered the very low reading of 28.75 inches (28.81 inches reduced to sea-level). (See fig. 1). At Humacao on the east coast of Porto Rico a reading of 28.04 inches was recorded at 1:50 p. m. Ponce reported 28.27 inches at 4:30 p. m.; Arecibo on the north coast 28.75 inches at 3:30 p. m.; Isabela on the northwest coast 27.80 inches at 9 p. m.; Mayaguez on the west coast 28.60 inches at 8 p. m. Guayama on the southeast coast reported the lowest barometer (27.50 inches) at 2:30 p. m. (27.65 inches reduced to sea-level). Guayama, Cayey, and Aibonito reported a period of calm or light winds lasting 20 to 30 minutes, indicating that the storm center passed over these towns.

The steamship *Matura* of the Trinidad Line reported a barometer of 27.50 inches (sea-level) about 10 miles south of the island of St. Croix. As a reading of 27.72 inches was reported at West Palm Beach, Fla., it would seem that the intensity of the storm remained about the same from the Lesser Antilles to Florida—a distance of about 1,700 miles. The storm center apparently kept its initial course west-northwest until it reached Florida, with an average progressive movement of 13 miles per hour, when the path turned to the northwest over Florida, then northward and northeastward across New York State on the 20th.

*Rainfall.*—The rainfall of the 13th and 14th was the heaviest ever recorded in Porto Rico during the past 30 years. Unfortunately reports from the special observers of the Weather Bureau showed a high percentage of overturned rain gages. In addition, the great velocity of the winds made it impossible to register more than 50 to 75 per cent of the amounts which actually fell. Along the coast the rainfall was generally below 10 inches. In the regions of greatest normal rainfall—the vicinity of Adjuntas in the Central Cordillera and in the Luquillo Mountains the amounts exceeded 25 inches. The approximate distribution of rainfall is shown in Figure 3. Adjuntas, in the central mountain region, reported the phenomenal fall of 29.60 inches, a record which will have to be examined more carefully before being finally accepted. At San Juan the rain gage was overturned before the height of the storm was reached and probably only 50 per cent of the total amount which fell was recorded. It is estimated that the amount should be approximately 10 inches.

<sup>1</sup> It is customary in Porto Rico to name a hurricane after the particular saint's day on which it happens to occur.—*Editor.*

**Winds.**—At 11:44 a. m. of the 13th the anemometer at the office of the United States Weather Bureau in San Juan lost one of its cups—just after recording a maximum velocity (the greatest velocity in 5 minutes) of 150 miles per hour, and an extreme velocity (the highest velocity in 1 minute) of 160 miles. These velocities probably exceed all official records of the Weather Bureau for similar storms. San Juan was about 30 miles from the storm center when these velocities were recorded. Estimates of 200 miles per hour near the center of the storm appear to be not much overdrawn. At San Juan the storm increased in intensity for 3 hours after the record of 150 miles was made. Most of the damage to property on the Weather Bureau Reservation occurred

San Juan during San Ciriaco was 75 miles per hour on a 4-cup anemometer. The 3-cup anemometer in service at San Juan during the recent storm registers 30 per cent less than the 4-cup variety at velocities in excess of 100 miles. In other words, the 4-cup anemometer formerly used at Weather Bureau stations would have registered not less than 190 miles at San Juan on the 13th at the time the anemometer lost 1 cup.

During the storm of San Ciriaco on August 8th, 1899, it was estimated that fully 3,000 lives were lost during the progress of the storm across the Island of Porto Rico. Most of these fatalities were caused by floods. Loss of life during the recent storm of San Felipe will not exceed 300, due mostly to the fact that the approach of the storm was announced in time to take necessary precautions against loss of life. The lowest barometer reading recorded in 1899 was 27.75 inches at Guayama. The lowest recorded during the recent storm was 27.65 inches at Guayama. The center of the storm passed over the northern portion of the French Island of Guadeloupe in the Lesser Antilles—moved west-northwestward, passing about 10 miles to the south of St. Croix in the Virgin Islands. It entered Porto Rico along the southeast coast and left it on the northwest coast—passed to the north of Santo Domingo and Haiti—doing very little

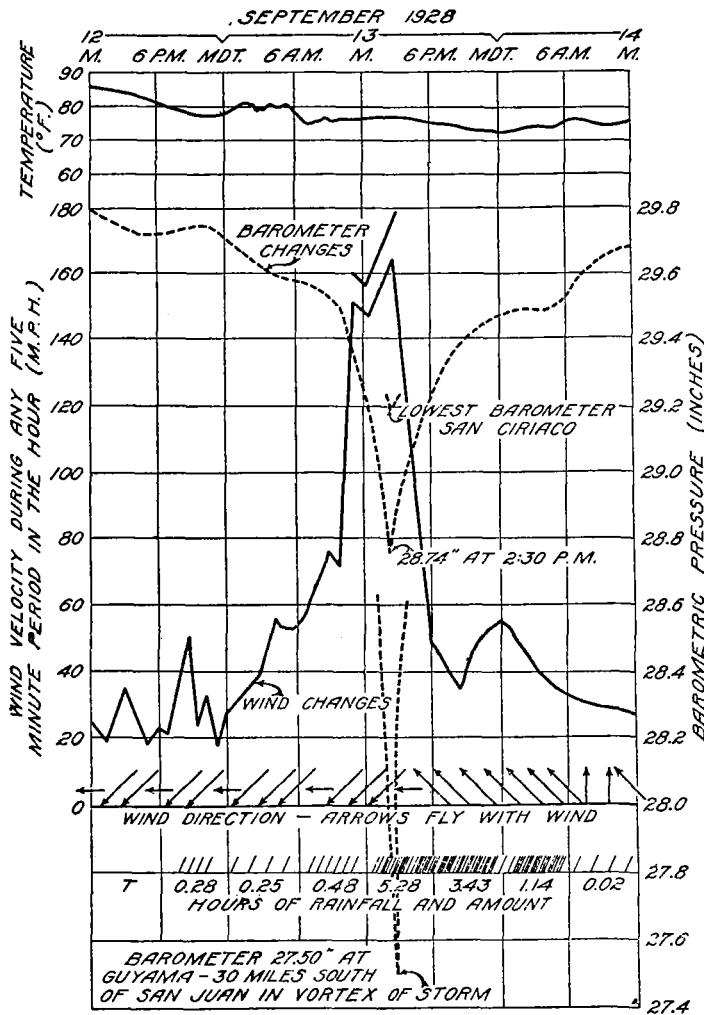


FIG. 1.—Weather elements at San Juan, P. R., hurricane of September 13, 1928

between 2:30 and 3:30 p. m. The balloon shed collapsed at 2:30 p. m. The residence of the official in charge began to lose portions of the roof about the same time and the entire roof and the ceilings were carried away by 3:30 p. m. With only two cups the anemometer still recorded about 75 miles per hour. The second cup disappeared at 12:47 p. m. The arms and the shaft of the anemometer with one cup still attached were blown away at 1:33 p. m.; these parts were later found at San Antonio docks, a distance of a third of a mile to the southwest of the weather bureau wind tower.

The nearest approach to the intensity of San Felipe was San Ciriaco on the 8th of August, 1899. The paths of these two storms across Porto Rico were almost identical. The highest velocity of the wind recorded at

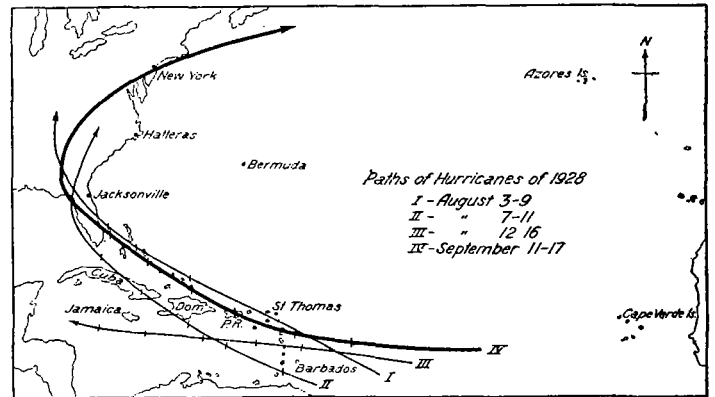


FIG. 2.—Path of hurricanes of 1928

damage in these islands; passed to the south of Turks Islands and Nassau in the Bahamas and entered Florida at West Palm Beach on the morning of the 16th. The French island of Guadeloupe reported heavy loss of life and great property damage. The English islands of St. Kitts and Montserrat, a short distance to the north of the path of the storm also suffered heavy losses. The lowest barometer at St. Thomas, Virgin Islands, 50 miles north of the path, was 29.30 inches, with a maximum wind velocity of 90 miles per hour at 10 a. m. of the 13th. The Island of St. Croix, Virgin Islands, within 10 miles of the center, suffered heavily in loss of life and damage to property and crops.

**Area of winds of hurricane force.**—Guayama, on the southeast coast of Porto Rico, was in the vortex of the storm at 2:30 p. m. of the 13th. Winds of hurricane force prevailed from 4 a. m. to 10 p. m., a period of 18 hours—assuming a progressive movement of 13 miles per hour for the storm, the area of winds of hurricane force east and west, would be 234 miles. At San Juan, 30 miles to the north of the vortex, hurricane winds prevailed from 4 a. m. to 4 p. m., or 12 hours.

Winds of hurricane force were experienced throughout the island to the north of the path; to the south some portions of the coast were apparently free from hurricane winds. The north-south extent of hurricane winds is

a matter of conjecture in the absence of vessel reports either to the north or south of Porto Rico during the storm. A fact worthy of notice is that few vessel reports were received at any time during the progress of the storm, indicating that timely warnings held vessels in port or kept them away from the zone of danger. In San Juan harbor several vessels delayed sailing for 24 to

property losses. Reports of the wreckage of the storm of September 13th (San Felipe) will probably confirm statements made that it was the most destructive storm on record in the West Indies. The extremely low readings of the barometer (27.50 inches) and the unparalleled intensity of the winds experienced will substantiate the claims.

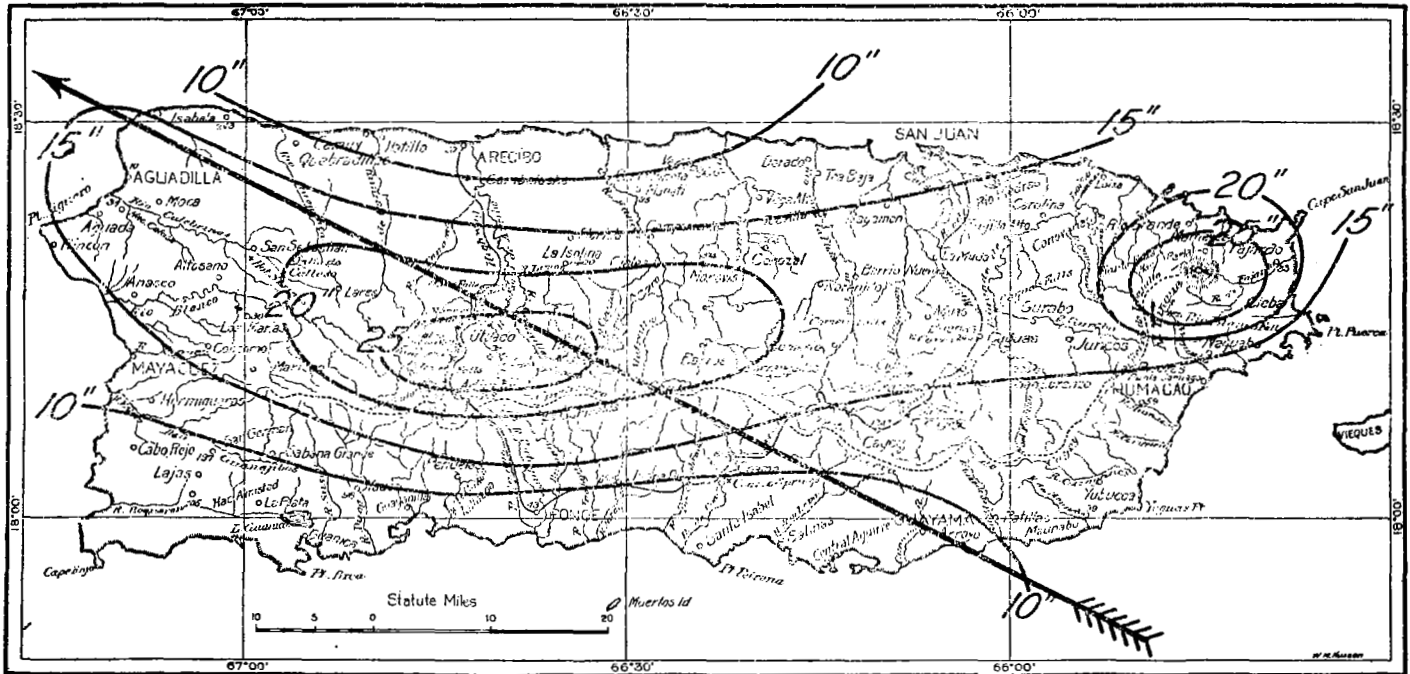


FIG. 3.—Rainfall distribution in Porto Rico hurricane, September 13, 1925

48 hours. In spite of the great intensity and great extent of the storm no reports of loss of vessels in the vicinity of Porto Rico have been reported.

**Storm damages in Porto Rico.**—As stated above the loss of life during the storm will approximate 300. Several hundred thousand people were rendered homeless. Some towns near the center of the storm were practically leveled. The principal crops of the island are sugar, tobacco, coffee, and citrus fruits. Sugar and tobacco interests lost heavily but are generally controlled by large corporations able to take care of themselves. The heaviest property losses were sustained by the coffee growers who had in sight one of the largest and best crops in recent years. In addition to the loss of the crop the shade trees, requiring years to replace, were largely destroyed. The citrus fruit growers lost their entire crop but most of the trees were saved. Property and crop losses are estimated at approximately \$50,000,000.

**Storms of 1928.**—The storm of September 13th was the fourth to pass across the West Indies during the present hurricane season. All of these came into view to the eastward of the Windward Islands. Three of them struck Florida, inflicting a heavy toll of life and great

*San Ciriaco and San Felipe losses compared.*—

	San Ciriaco Aug. 8, 1899	San Felipe Sept. 13, 1928
Loss of life in Porto Rico.....	3, 000	300
Lowest barometer reported at Guayama..... inches..	27. 75	27. 65
Lowest barometer at San Juan do.....	29. 23	28. 81
Duration of hurricane winds at San Juan..... hours..	3	12
Maximum velocity of wind at San Juan..... m. p. h..	75	+150
Advance warnings of storm..... hours..	1 18	36
Property losses.....	\$20, 000, 000	\$50, 000, 000

**Historic storms of Porto Rico.**—Hurricanes of the past 100 years which are most frequently referred to because of their violence:

Santa Ana.....	July 26, 1825.
Los Angeles.....	August 2, 1837.
Santa Elena.....	August 18, 1851.
San Narciso.....	October 29, 1867.
San Felipe (I).....	September 13, 1876.
San Ciriaco.....	August 8, 1899.
The 2nd San Felipe.....	September 13, 1928.

<sup>1</sup> Owing to lack of facilities for prompt distribution of the warning to the rural population, the storm struck them unannounced.