

4. The Atlantic coast storm of September, 1876.
5. The Atlantic coast storm of October, 1877.
6. The Atlantic coast storm of September, 1878.
7. The Atlantic coast storm of October, 1878.
8. The Atlantic coast storm of August, 1879.
9. The South Atlantic coast storm of August, 1881.
10. The Gulf and Atlantic coast storm of September, 1882.
11. The Atlantic storm of September, 1883.
12. The South Atlantic coast storm of August, 1885.
13. The Texas coast storm of August, 1886.
14. The Atlantic coast storm of November, 1888.
15. The Atlantic storm of September, 1889.
16. The South Atlantic coast storm of August, 1893.
17. The Gulf storm of October, 1893.
18. The Atlantic coast storm of October, 1894.
19. The Atlantic coast storm of September, 1896.
20. The Porto Rico storm of August, 1899.
21. The Galveston storm of September, 1900.
22. The Gulf storm of August, 1901.
23. The Florida storm of September, 1903.
24. The Gulf storm of September, 1906.
25. The South Atlantic storm of October, 1906.
26. The west Gulf storm of July, 1909.
27. The Gulf storm of September, 1909.
28. The Atlantic storm of October, 1909.
29. The Atlantic storm of October, 1910.
30. The South Atlantic storm of August, 1911.
31. The Gulf storm of August, 1915.

ORIGIN OF TROPICAL STORMS.

The causation of tropical storms is somewhat a matter of conjecture and theory. The subject has been more or less fully discussed by many writers, but nothing has been evolved in very recent years that is in conflict with the theory advanced by Prof. F. H. Bigelow,¹ which is as follows:

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 the mathematical analysis.

A very large majority of the hurricanes of which there is record, occurred during the autumn or pre-autumn season, in accordance with the above, but a considerable number occurred in July, and some during the earlier months of the year, even in the winter. These, however, were probably due to some intensification of the usual contributory causation, and were not in conflict with the general idea. Again, the hurricanes of the winter, spring,

¹ Features of Hurricanes, by Prof. F. H. Bigelow. Year Book, Department of Agriculture, 1898.

THE TROPICAL STORM OF AUGUST 10, 1915.

By H. C. FRANKENFIELD, Professor of Meteorology.

[Dated: Weather Bureau, Wash., Sept. 25.]

SOME HISTORICAL DATA.

Records of West Indian hurricanes are available, at least as to time and locality of occurrence, as far back as 1493, and from that year to the present 492 storms were noted, an average of little more than one each year. The great storms that reached the United States were, of course, not very numerous, yet they occurred with sufficient, though very irregular, periodicity to warrant the reasonable expectation of one every few years. Severe tropical storms visited Galveston in the years 1834, 1837, 1847, 1854, 1866, 1867, 1875, 1886, 1900, 1909, and 1915, and those of 1900 and 1915 were by far the most violent. The more severe tropical storms of recent years in the United States were:

1. The Atlantic coast storm of August, 1873.
2. The Atlantic coast storm of September, 1874.
3. The Texas storm of September, 1875.

and early summer are not usually of marked character, although some of the July ones were as violent as those of the autumn.

As to the place of origin of tropical storms, it is probably best to quote again, this time from the late Prof. E. B. Garriott:²

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 definite 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 8° and 20° 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.

Later years have added but little of value to our knowledge of the subject. Those who desire detailed information as to hurricanes and their paths are referred to the publications of Profs. Bigelow and Garriott, earlier mentioned, and also to the works of Prof. Oliver L. Fassig³ of the Weather Bureau, and of Father Benito Viñes.⁴

PATHS OF TROPICAL STORMS.

The paths of tropical storms roughly follow the general atmospheric circulation, from east to west in the Tropics and from west to east in the more northern latitudes. They usually pursue a west to northwest path, recurve, and then move northeastward. Many, of course, do not recurve at all and are dissipated. As to the point of recurving, it appears to be well to again quote from Prof. Garriott:⁵

The recurrence 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.

According to Prof. Fassig's computations the mean paths for June and July originate between latitude 10° and 15° N., and do not recurve until they reach about latitude 27.5° N. in longitude 86.5° W. (east-central Gulf of Mexico), whereas the mean paths for August, September, and October originate north of latitude 15° and recurve

over Florida or the adjacent ocean, the August one on the west coast, the September one over southern Florida, and the October one at a point just touching the extreme southeast coast, but with a movement much more toward the east. It is a fact, however, that some of the most violent storms move as far west as the Texas coast before recurving, notably those of 1900 and 1915, indicating clearly that the probability of recurve and the point of recurving are governed almost entirely by the pressure distribution to the northward.

THE STORM OF AUGUST, 1915.

The meteorological history of this storm was discussed in a special bulletin issued by the Weather Bureau, and the description herewith was copied from that bulletin. Figures 1-12 (XLIII, 92-103), at the back of this REVIEW, show the paths of the storms of 1900 and 1915, and also the pressure conditions that prevailed during the passage of the storm of 1915. Charts for 8 a. m. only, are shown for the period from August 10 to 14, inclusive, while both the 8 a. m. and 8 p. m. charts are reproduced for the period from 8 a. m. August 15 to 8 p. m. August 17, inclusive.

When the storm passed inland from the Texas coast, observations became available giving for the first time the barometric pressure at the approximate center and closely adjacent points. The lowest pressure at Houston, Tex., was 28.20 inches, and it is fair to assume that the pressure at the center of the storm throughout its journey across the Gulf of Mexico was at least as low as 28.5 inches. Isobars in dotted lines have therefore been drawn on the maps on this basis, showing the passage of the storm over the Gulf of Mexico, although only a few scattered reports were available, and they for points at a distance from the center.

This storm proved to be somewhat of an exception to the rule for the pressure conditions that prevailed for a week or two previous were not such as to indicate any probability of the development of a tropical disturbance. It is true that pressure had been quite high over much of the United States and the North Atlantic Ocean during July, and relatively low over the eastern Atlantic as indicated by reports from the Azores Islands, but during the first decade of August these conditions were reversed over the Atlantic States and the western portion of the Atlantic Ocean, although not decidedly so over the ocean where the pressure was still slightly above normal. Thus, as has been said, there was nothing to indicate that conditions were favorable for the formation of a tropical storm, nor, should one form, was there anything pronounced to indicate its direction of progression, whether northwestward to the south Atlantic coast or westward to the Gulf of Mexico, the slight preponderance of pressure over the North Atlantic not having been sufficient to enable this fact to be determined.

The storm was first observed on the morning of August 10 between the Windward Islands of Barbados and Dominica, and at 9:45 a. m. on that date the first warning notice of the storm was sent to West Indian stations. At 2 p. m. similar information was sent to all Atlantic and Gulf stations of the Weather Bureau, and in addition the information was disseminated by the radio station at Arlington, Va. Nothing more definite from the scene of trouble was received during the day, except a special report at 4 p. m. from Roseau, Dominica, which showed a barometer reading of 29.46 inches, with light air from the northwest. On the morning of August 11 the disturbance was apparently near and south of the

² West Indian Hurricanes. Washington, 1900. (Weather Bureau Bulletin H.)

³ Hurricanes of the West Indies. Bulletin X. Weather Bureau, 1913.

⁴ Cyclonic Circulation and the Translatory Movement of West Indian Hurricanes. Washington, 1898. (Weather Bureau No. 168.)

⁵ Summary of International Meteorological Observations. Washington, 1893. (Weather Bureau Bulletin A.)

island of St. Croix, at about latitude 16° N., longitude 66° W. At this time the barometer at San Juan, P. R., read 29.60 inches with a gale of 60 miles an hour from the northeast, indicating a much lower pressure to the southward, and pressure was falling more rapidly to the westward, as indicated by the observations at Santo Domingo, Santo Domingo, and Port au Prince, Haiti. The following information was then distributed over the West Indies generally and to Atlantic and Gulf ports:

Severe tropical disturbance at 8 a. m. apparently central near island of St. Croix, moving west-northwest 18 or 20 miles and hour. Will probably cross Santo Domingo and Haiti, reaching southeastern Cuba about Thursday night or Friday (Aug. 12-13).

On the morning of the 12th the storm was central a short distance south of Haiti at about latitude 17° , longitude 73° . The barometer reading at Port au Prince was 29.60 inches and the highest wind velocity was 32 miles an hour from the east. However, reports of damage over the southern portion of the Republic indicated that a severe gale must have occurred there with much lower pressure. On the same morning the barometer reading at Kingston, Jamaica, was 29.68 inches, and northerly gales were reported east of the island. The wind at Kingston was then light northwest, and pressure was also falling to the westward and northwestward, Songo (near Santiago), Cuba, reporting a barometer reading of 29.80 inches, a fall of 0.16 inch in 24 hours, with light northeast winds. Warnings were again issued at about 10 a. m. to the effect that the tropical storm was apparently central near southwest Haiti, moving a little north of west, and that it would probably reach southeast Cuba that (Thursday) night. Observations taken at 12 noon of the 12th indicated that the storm center was near the east coast of Jamaica, moving a little north of west, and advices were issued accordingly to all Gulf and Atlantic ports, and also to West Indian points that were likely to be affected.

During the night of the 12-13th the storm center passed north of the Island of Jamaica, and at 8 a. m. of the 13th a whole southeast gale was blowing at Kingston. Northeast storm warnings were then ordered at Key West and Miami, Fla., and advices issued stated that the storm would probably reach western Cuba Friday night and Saturday, and that hurricane warnings might be necessary later. All interested, and especially shipping, were advised at the same time to take every precaution necessary for safety. At this time the barometer reading at Key West was 29.92 inches, and the wind velocity 16 miles an hour from the east. Special observations received during Friday, the 13th, indicated that the storm was moving as forecast, and accordingly at 5 p. m., the warnings at Key West and Miami were changed to hurricane, and hurricane warnings were also ordered on the southwest coast of Florida as far north as Boca Grande. The warnings stated that easterly winds would increase that night possibly reaching hurricane force Saturday. All shipping and others interested were warned to take every precaution possible and vessels in port were warned to remain there.

On the morning of the 14th the storm was apparently central near the Isle of Pines, Cuba, with undiminished intensity and moving in a direction a little north of west. Advisory warnings on that morning, which were sent to all interested, stated that the storm would probably pass into the Gulf of Mexico that (Saturday) night. During Friday night the maximum wind velocity at Habana was 56 miles an hour from the east. It was apparent that

during Sunday the storm center would probably reach the north-central Gulf of Mexico, and Gulf shipping was advised to take every precaution. At 5 p. m., Saturday, the 14th, hurricane warnings were continued from Key West to Boca Grande, but were lowered at Miami, as it was apparent that there was no longer any danger of winds of storm force at that station. As the next day would be Sunday, the officials in charge at Weather Bureau stations were ordered to make arrangements for Sunday telegraph service in their districts in order that any warnings that might be necessary could be received and distributed properly. On the morning of the 15th the storm was apparently central in the south-central Gulf of Mexico moving in a more northwesterly direction than before. The barometer at all Gulf stations was falling, and northeast storm warnings were therefore ordered on the Gulf coast from Apalachicola, Fla., to New Orleans, La. All Gulf stations, both regular and display stations, were notified accordingly, with warnings that all interested should take every precaution for safety, and that all vessels should remain in port. The special observations received during Sunday, the 15th, indicated the necessity of hurricane warnings on the west coast, and at 5 p. m. the northeast warning at New Orleans was changed to hurricane, and hurricane warnings were also ordered at all display stations westward as far as Brownsville, Tex. A radio report taken at 2 p. m. on the S. S. *Antilles*, at latitude 27° , longitude 86° , showed a barometer reading of 29.54 inches with wind velocity of 74 miles an hour from the east, and another radio report taken at 8 p. m. on the same date, at about latitude 26.5° , longitude 87.5° , showed a barometer of 29.48 inches, with wind velocity of 64 miles an hour from the east. On Monday morning, August 16, the storm center was apparently approaching the east Texas coast and the warnings from Mobile to Apalachicola were changed from northeast to southeast. At this time the barometer at Galveston read 29.62 inches with maximum wind velocity of 34 miles an hour from the northeast. The conditions continued to intensify, and by noon the barometer at Galveston had fallen to 29.48 inches with maximum wind velocity of 56 miles an hour from the northeast. The tide was rising slowly and the sea was excessively rough. At 5 p. m. the hurricane warnings were ordered continued from Sabine, Tex., to Brownsville, Tex., and the warnings at New Orleans and Morgan City, La., changed from hurricane to storm southeast, as it was apparent that the winds at these places could no longer increase, the maximum wind velocity at Burrwood, La., at the mouth of the Mississippi River, being only 48 miles an hour from the east. At 8 p. m. Monday, August 16, the barometer at Galveston read 29.10 inches with maximum wind velocity of 72 miles an hour from the northeast, and heavy rain was falling. The storm passed into the interior during the night of August 16-17, and at 2:45 a. m. Tuesday, August 17, the barometer at Galveston read 28.63 inches, with maximum wind velocity of 93 miles an hour from the east at 2:37 a. m. At 5:30 a. m. of the 17th the barometer at Houston read 28.20 inches, with a maximum wind velocity of 80 miles an hour (estimated) from the northeast.

Hourly barometer readings were also made by E. F. Roeller at Velasco, Tex., about 40 miles southwest of Galveston and about 14 miles southwest of San Luis Pass, where the storm center first reached the coast. The curve plotted from his readings forms figure 13. It shows that the lowest pressure, 28.06 inches, occurred at 1 a. m. August 17, at which time the wind backed from

north to northwest. The table following gives the pressure and wind direction at frequent intervals during the height of the storm at Velasco:

TABLE 1.—Barometer readings by E. F. Roeller at Velasco, Tex., during August 16 and 17, 1915.

(Correction of +0.08 inch to be applied.)

Date and hour. [90th mer. time.]	Barometer reading.	Wind.	Date and hour. [90th mer. time.]	Barometer reading.	Wind.
Aug. 16, 1915.			Aug. 16, 1915—Contd.		
	Inches.			Inches.	
1:20 p. m.	29.40	ne.	10:00 p. m.	28.66	n.
2:00 p. m.	29.38	ne.	10:20 p. m.	28.60	n.
2:20 p. m.	29.36	ne.	10:30 p. m.	28.56	n.
2:45 p. m.	29.34	ne.	10:50 p. m.	28.50	n.
3:15 p. m.	29.30	ne.	11:10 p. m.	28.48	n.
3:30 p. m.	29.28	ne.	11:30 p. m.	28.40	n.
3:45 p. m.	29.24	ne.	11:45 p. m.	28.34	n.
4:15 p. m.	29.22	ne.	12:00 p. m.	28.28	n.
4:30 p. m.	29.20	n.	12:15 a. m.	28.24	n.
5:00 p. m.	29.18	n.	12:25 a. m.	28.18	n.
5:30 p. m.	29.14	n.	1:00 a. m.	28.14	nw.
6:10 p. m.	29.12	n.	1:30 a. m.	28.18	nw.
6:40 p. m.	29.08	n.	1:50 a. m.	28.30	nw.
7:00 p. m.	29.06	n.	2:15 a. m.	28.40	nw.
7:20 p. m.	29.02	n.	2:30 a. m.	28.45	w.
7:45 p. m.	28.98	n.	2:45 a. m.	28.50	w.
8:10 p. m.	28.94	n.	3:15 a. m.	28.60	w.
8:50 p. m.	28.90	n.	3:40 a. m.	28.70	w.
9:15 p. m.	28.82	n.	7:15 a. m.	28.20	sw.
9:25 p. m.	28.80	n.	12:40 p. m.	29.40	sw.
5:40 p. m.	28.74	n.			

This reading of 28.06 inches was not by any means unprecedented, as numerous readings below 28 inches have been recorded during severe storms in different parts of the world. During more recent years probably the lowest recorded pressure was 27.24 inches. This observation was taken on the schooner *Ponape*, lying at anchor at Wlea, West Caroline Islands, at 10 a. m. March 29, 1907, and was noted by Algué in the Monthly Bulletin of the Philippine Weather Bureau for March, 1907.

a maximum of 60 miles an hour from the north at San Antonio during the day. There was no occasion for further warnings, and those that were still displayed were allowed to expire at 5 p. m. Tuesday, August 17. On the morning of August 18 the storm was central over the northern portion of east Texas, with a barometer reading of 29.50 inches at Fort Worth and Dallas, with northeast gales of 44 to 48 miles an hour and with heavy rains. Warnings of high winds for the interior of east Texas had

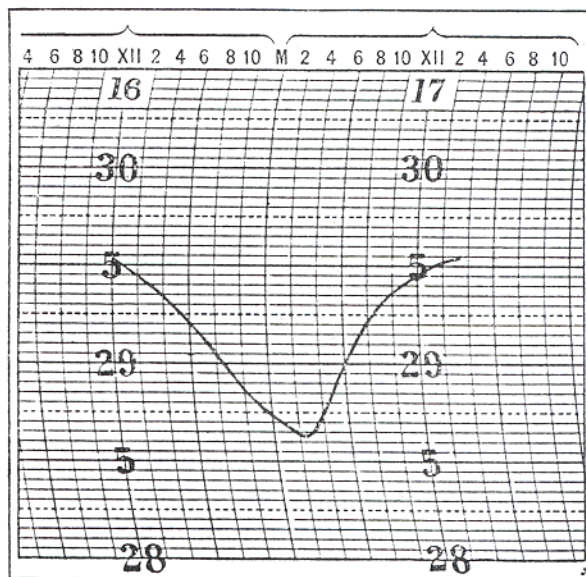


FIG. 14.—Barogram (inches) at Galveston, Tex., noon August 16 to 3 p. m. August 17, 1915.

been issued on the afternoon of the 17th. During the next 24 hours the storm moved very slowly to extreme northeast Texas with somewhat diminished intensity, but with heavy rains continuing in that vicinity and extending into Arkansas. The storm was now moving northeastward, and on the morning of the 20th was central over southeast Missouri with somewhat increased intensity, and heavy rains had fallen in southern and eastern Missouri, the lower Ohio Valley, and west Tennessee, and northeasterly gales prevailed at St. Louis. During the next 24 hours the storm moved slowly to southern Indiana, again with diminishing intensity, but with general rains and some high winds to the southeastward. It then continued its northeastward movement with steadily diminishing intensity, but with general and, in many places, heavy rains, and on the morning of August 24 was passing out into the Gulf of St. Lawrence, with a barometer reading of 29.80 inches at Father Point.

The hourly barometric pressures at Galveston and Houston during the passage of the storm near those stations are shown in the barograms, figures 14 and 15. It will be seen that at Galveston the pressure fell from noon to 6 p. m. on Monday, August 16, was uniform at the rate of 0.06 inch an hour. From 6 p. m. to 10 p. m. the fall was a little more rapid, ranging from 0.08 to 0.12 inch an hour, and the pressure fell below 29 inches for the first time shortly after 8 p. m. From 10 p. m., when the reduced barometer read 28.82 inches, until 2:45 a. m., August 17, at which time the lowest reading of 28.63 inches was recorded, the rate of fall was less than before, averaging a little less than 0.04 inch an hour. From 2:45 a. m. until 9 a. m., August 17, there was a recovery at a much more rapid rate, about 0.11 inch an hour, followed by a much slower rate of rise thereafter.

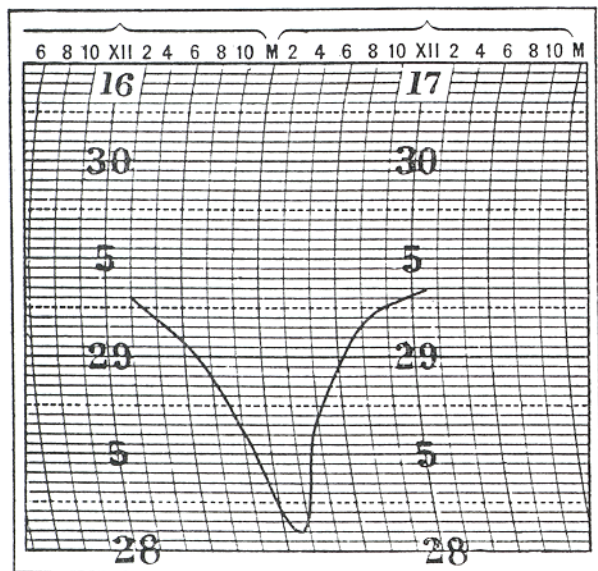


FIG. 13.—Plot of corrected aneroid readings (inches) by E. F. Roeller at Velasco, Tex., August 16-17, 1915.

At 8 a. m. Tuesday, August 17, the barometer at Galveston read 29.12 inches, with the wind blowing 52 miles an hour from the northeast, while at Houston the reading was 28.72 inches, with a wind of 80 miles an hour (estimated) from the southeast. Torrential rains had fallen at both places and were extending into the interior of east Texas. The storm then recovered to the northward, with high winds over the interior of east Texas, reaching

At Houston the barometer fell at the rate of about 0.04 inch an hour from noon until 8 p. m., August 16, and much more rapidly thereafter, falling below 29 inches at about 12:30 a. m., August 17, about four and one-half hours later than at Galveston. The lowest reading of 28.20 inches, or 0.43 inch lower than at Galveston, was reached at 5:25 a. m., August 17, two hours and forty minutes later than at Galveston. From 8 p. m., August 16, to 5:25 a. m., August 17, the total fall in pressure was 1.18 inches, an average of about 0.125 inch an hour. From 3 a. m. to 5 a. m., August 17, the fall was 0.47 inch, an average of 0.235 inch an hour, while the greatest fall during a single hour was 0.30 inch from 4 a. m. to 5 a. m., August 17. At Galveston the greatest fall in any one hour, 9 p. m. to 10 p. m., August 16, was only 0.12 inch. These figures show that the actual storm center passed much closer to Houston than to Galveston, and, according to the wind directions (NE., E., SE., and S.), a little to the southward and westward of both stations.

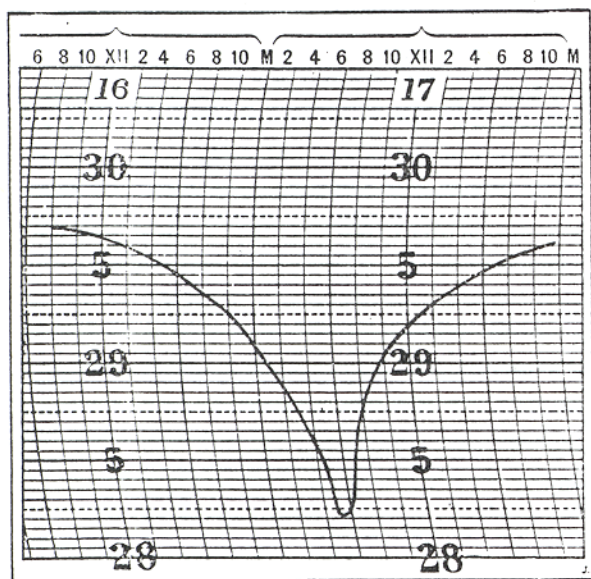


FIG. 15.—Barogram (inches) at Houston, Tex., 8 a. m. August 16 to 12 p. m. August 17, 1915.

As nearly as can be determined the storm center reached the coast of Texas near San Luis Pass, at the end of West Bay, about 26 miles southwest of Galveston, at about 1 a. m., September 17, shortly after which its slow recurve to the northward and northeastward began. The extreme western point of the path was reached between 2:20 and 2:40 a. m., very near and presumably a little to the westward of Sandy Point, Tex. It was next definitely located at about 4:50 a. m. southwest of and very close to Houston, Tex., with a movement slightly east of north.

These deductions are based upon special reports received, mainly, after the passage of the storm, and the center is assumed to have been where the lull, or "calm," that accompanies the shift in wind direction occurred as the storm center passed. At a point about 5 miles northeast of Sandy Point the calm lasted from 2:20 until 2:40 a. m. The time consumed by the storm center in traveling from the coast to Houston, a distance of about 60 miles along the curved path, was very nearly four hours, making the average rate of progression 15 miles an hour. As the calm near Sandy Point lasted about twenty minutes, or one-third of an hour, it may safely be assumed that the diameter of the storm center was one-third of 15, or 5 miles. Some confirmation of this is found in the

official report from Houston in which was stated the fact that in Houston the broken and uprooted trees pointed toward the southwest, while 6 miles southwest of Houston they pointed to the north and northward, indicating violent winds in opposite directions within a distance of 6 miles, from which it may be inferred that the storm center could not have been more than 6 miles in diameter.

The storm center evidently passed over Cape San Antonio, Cuba, about 2:30 p. m. August 14, as at that time a calm prevailed, continuing with heat and mist for about one-half hour. The lowest barometer at the Isle of Pines, Cuba, occurred at 3 a. m. August 14, so that the rate of travel of the storm center between that place and Cape San Antonio was about 13 miles an hour. As it occupied one-half hour in passing over Cape San Antonio, the diameter of the center was apparently about 6½ miles, a very close agreement with the results obtained between San Luis Pass and Houston, Tex.

The following extract regarding the conditions prevailing over the Gulf of Mexico was made from the report of Mr. W. P. Stewart, official in charge of the local office of the Weather Bureau at Galveston:

The recording tide gages of the United States Engineers at Fort Point and of the United States Coast Survey on the wharf at Twentieth Street were carried away by the storm together with their records. There is, therefore, no official record of the tide. A measurement by the United States Engineers at Twentieth and Strand makes the highest point reached 11.965 feet above mean low tide. It appears to be the universal opinion that the water was somewhat higher than in 1900. At 2119 Post office, the highest water in both storms is chiseled on the wall and the record of the recent storm is 3.5 inches higher than that of 1900.⁶

At its highest the water in the retail business district was approximately 5 feet above the street level, the streets being about 6.5 feet above mean low tide. At the American National Insurance Co.'s building it was 5 feet 6.5 inches; at 2110 Avenue E, 4 feet 9 inches; at Tussup Grocery Co.'s store, Twenty-second and Post office, 4 feet 11.5 inches; at Twenty-second and Mechanic, 5 feet 2 inches; at Union Depot, 6 feet. In that part of the town where grade has been raised it was of course not so deep. At Twenty-second and Q it was 2 feet 7 inches; at the county courthouse, 4 feet 11 inches above the street level at the curb.

During the morning of August 15, there was a light southeast swell on the Gulf coming in against a light northeasterly wind. The tide was slightly above normal and it was noticed that it did not fall when it should have done so. During the afternoon it rose slowly and the swells noticeably increased. During the early hours of the 16th the tide rose about 0.3 foot an hour and by daybreak the sea was very rough. At 6:30 a. m. the tide was 4.1 feet and about stationary, but it rose slowly after that time and the sea became increasingly rough. During the afternoon of the 16th and for 36 hours thereafter it was excessively rough. The water began to back in from sewers on down-town streets about noon. At first it rose very slowly and it was 6 p. m. before the streets in the business section were all covered. After that time it rose more rapidly and by 9 p. m. the water was 3 feet deep at Twenty-third and Post office. During the late afternoon the street-car and electric-light services suspended operations and during the early part of the night the gas and water services failed. The tide was highest about the climax of the storm, a little before 3 a. m., August 17. At daybreak it had subsided about 2 feet and the water was again 3 feet deep on the street at Twenty-third and Post office. The tide fell slowly and there was water on some streets until the morning of the 18th.

A curious, although entirely natural, sequence of the storm was the high temperature that prevailed along the southern coast of Texas, beginning with August 15 when the winds first shifted to landward, the fall in temper-

⁶ While the water was 3.5 inches higher at the post office in Galveston than in 1900, the highest tide of 11.965 feet does not appear to have been as high as that of the storm of 1900, assuming that the statements of Dr. I. M. Cline regarding the latter are correct. Dr. Cline said (MONTHLY WEATHER REVIEW, Sept. 1900, 28: 373):

"* * * The water had now reached a stage 10 feet above the ground at Rosenberg Avenue (Twenty-fifth Street) and Q Street, where my residence stood. The ground was 5.2 feet elevation, which made the tide 15.2 feet. The tide rose the next hour, between 7:30 and 8:30 p. m., nearly 5 feet additional, making a total tide in that locality of about 20 feet. These observations were carefully taken and represent to within a few tenths of a foot the true conditions. Other personal observations in my vicinity confirm these estimates. The tide, however, on the bay or north side of the city did not obtain a height of more than 15 feet. It is possible that there was 5 feet of back-water on the Gulf side as a result of debris accumulating 4 to 6 blocks inland."

ature that usually follows the passage of a storm center over or near a given locality having been entirely absent. In this instance the winds blowing from a warm land area brought with them the high temperatures that prevailed over the interior districts, and the condition persisted until the wind again blew from the water surface to the southeastward. The following data show the conditions at Corpus Christi and Brownsville, Tex., from August 15 to 20, inclusive:

Date.	Maximum temperature during day.		Wind direction at 8 p. m.	
	Corpus Christi.	Brownsville.	Corpus Christi.	Brownsville.
Aug. 15.....	° F. 91	° F. 92	ne.	n.
16.....	94	97	nw.	nw.
17.....	97	a 104	nw.	s.
18.....	a 100	a 104	b se.	se.
19.....	98	100	s.	s.
20.....	90	99	se.	s.

a Highest temperatures of record.

b Had been south during day.

CASUALTIES.

The casualties resulting from the storm were of minor character east of Santo Domingo and Haiti and were confined to small shipping. At Fort de France, Martinique, the docks were flooded and merchandise destroyed, while at some of the other islands of the Lesser Antilles there was some damage to small shipping. Over the southwestern portion of Haiti real disaster to crops, etc., was reported, but, so far as is known, without loss of life. Over the Island of Jamaica heavy gales were reported, and the banana crop was said to have been damaged to the extent of several millions of dollars. There were no serious disasters to shipping in the Caribbean Sea reported, and to this fortunate condition the warnings of the Weather Bureau doubtless contributed in great measure.

Over extreme western Cuba, which was in the direct path of the storm, the damage was much more serious, and at Cape San Antonio, on the extreme western end of the island, not a house was left standing. The radio station, the steel tower, and the lighthouse were blown down, and the entire meteorological equipment of the Weather Bureau destroyed. Fourteen lives were lost. The schooner *Roncador* was totally wrecked, but without loss of life, and the schooner *Explorer* was dismantled.

There were no serious disasters in the east Gulf of Mexico, although several disabled vessels came into or were brought into Key West. There was only a moderate gale at Key West, but at Sand Key, 8 miles to the southwestward, there was a 60-mile southeast gale.

The greatest marine disaster was the loss on August 13, probably in the Yucatan Channel, of the American steamship *Marowijne*, of the United Fruit Co., from Belize, British Honduras. Notwithstanding the fact that the steamer was equipped with radio apparatus nothing was heard from her and she must have been lost, together with her passengers and crew, numbering in all 96 persons. The vessel was valued at \$400,000.

The schooner *Lydia M. Deering*, from Sabine, Tex., for Boston, was lost several miles south of Mobile, and the captain and two members of the crew perished. The schooner *Dora Allison*, from Progreso, Mexico, for Mobile, was wrecked in the Gulf, but her crew was saved. The fishing smack *Nettie Franklin*, of Pensacola, was wrecked in the northwest Gulf and two of her crew were lost.

The losses on the Louisiana and Texas coasts and in the interior of east Texas were such as might have been expected from a great storm.

Over southern Louisiana there was no loss of life, while the property loss probably did not exceed \$1,000,000. It was confined mainly to the rice crop and to live stock in the marshes.

The greatest loss of life and property occurred in the vicinity of Galveston, and from thence northward and westward for a considerable distance. The total loss of life was 275, to which the city of Galveston contributed 11; Galveston Island, 42; and the dredges *Houston* and *San Bernard* and the tug *Helen Henderson*, 69. One hundred and two persons were reported as missing, but it is probable that many of these were later accounted for. We quote again from the report of Mr. Stewart:

Of the damage resulting from the direct force of the wind probably the sinking, wrecking, or grounding of vessels of all sizes caused the greatest monetary loss. There are still (August 27) 11 large vessels aground in this immediate vicinity, and several hundred vessels of all sizes were wrecked on the east Texas and west Louisiana coasts. In addition to the wrecking of vessels and the destruction of wharves and sheds along the harbor front, there was an enormous amount of comparatively minor damage due to the direct force of the wind. Windows were broken, and trees, outbuildings, and fences blown down. Of the ornamental, or shade trees, the oaks suffered the most and the palms the least. The leaves on all deciduous trees are withered and dry since the storm, and are falling. The loss from breakage of plate-glass windows in the business district was considerable, as was the loss from damage to roofs, windows, and chimneys in the residence districts.

A large part of the property damage in this storm resulted, not from the direct force of the wind, but from the high tide which flooded the business district to a depth of from 5 to 6 feet and damaged stocks of goods in both the wholesale and retail districts. Great property loss was occasioned by washing of sand from under buildings, causing their overturning or collapse. The seawall which protects the city on the east and south has a height above mean low tide of 17 feet. Reliable observers say that when the waves receded, leaving the sea momentarily calm outside the wall, the water stood about 20 inches from the top. Then, when the larger waves came, an enormous amount of water was projected over the wall. This water washed the sand from under the brick pavement of the seawall boulevard, practically destroying it for 20 blocks. The sand filling or "made ground" inside the seawall boulevard sloped upward toward the center of town. This sand fill had a width of 300 to 400 feet, a depth of 17 to 23 feet and a length of about 2 miles, and was designed to cause the flood waters to flow back into the Gulf. However, it was covered with soil or sod only in a few small patches and wherever not so protected it was washed by the incoming waters back into the town and from under the numerous dwellings that covered it. In this way approximately 200 residences were undermined and more or less seriously damaged. Some were entirely destroyed and nearly all were rendered unfit for habitation. Isolated cases of undermining of houses also occurred in several sections remote from the Gulf front. The sand washed away from near the beach was left farther inland. Some of the street pavements and most of the lawns in the southeastern part of town were covered with sand to a depth of from 2 to 5 feet. About six blocks of single track street railway was undermined and destroyed.

At Fort Crockett the damage is estimated at over half a million dollars. The sand-protected forts were nearly demolished and the sand filling of the military reservation was badly washed. The loss of military equipment was also considerable.

Of the 250 homes on Galveston Island outside the protection of the seawall probably not over 10 per cent are left standing. That there were not more fatalities in that section was due solely to the warnings of the Weather Bureau.

Serious loss resulted from several fires that broke out during the night of the 16th-17th. Along the Gulf front all the structures outside the seawall were destroyed by the storm. The causeway that connected Galveston Island with the mainland was badly damaged. The central part of the structure which consisted of concrete arches did not suffer severely, nor were the dirt and oyster shell approaches at either end seriously damaged, but those portions connecting the central arched section with the shore on either side—each nearly a mile in length—were demolished down to the solid concrete structure that stands slightly above mean tide. It has been estimated that the cost of repairing or reconstructing the causeway will be approximately \$500,000. The practical destruction of the causeway was accompanied by the loss of portions of the water main which brought the city water supply from artesian wells at Alta Loma. There was no city water

from the night of the 16th until the morning of the 26th of August. There was little actual suffering on that account, however, as water for cooking and drinking purposes was obtained from cisterns and several artesian wells in the city.

Post-office inspectors report the destruction of the post offices at Chocolate Bayou, Glen, Kemah, Lynchburg, Quintana, Tomball, Wallisville, and Winfree, Tex., with all contents.

The greater portion of the Marconi wireless station fell across and wrecked the building in which the station was located. The only telegraph service in or out of Galveston from the evening of the 16th of August until the morning of the 21st was by radio from the U. S. Army transport *Buford*.

It has been estimated that the damage from this storm to crops, buildings, railroads, shipping, live stock, and other property will aggregate close to \$50,000,000, but these figures are probably much too large. Of the total amount approximately \$6,000,000 occurred at Galveston.

In the city of Houston the damage amounted to about \$1,000,000, mainly to buildings, railroads, telegraph and telephone lines, and nearly every building shared in the damage. Crops in fully one-half the State of Texas suffered severely. Nearly all open cotton was blown away, and much cotton, late corn and rice was flattened by the wind and rain.

Beyond the State of Texas there was also considerable damage by high winds as far as the lower Ohio Valley, particularly over eastern Missouri, but much greater damage was caused by the severe floods resulting from the torrential rains that extended from Texas northeastward to New York. These floods seriously injured the crops in many localities, while in many others where there were no floods, the heavy rains beat down the standing crops.

COMPARISON WITH THE STORM OF 1900.

Figure 1 (XLIII-92) shows the paths of the storms of 1900 and 1915. An inspection of these paths discloses the fact that the total time occupied from the first to the last appearance of both storms within the field of observation was exactly 14 days, and that the storm of 1900 moved with a slower velocity of progression before reaching its recurve than after, whereas in the storm of 1915 the reverse was true. The two paths are very similar in many respects, although that of 1915 lay a little to the southward of that of 1900 until the St. Lawrence Valley was reached. In previous published reports on the storm of 1900 the storm path shows a strong deflection toward the southwest Florida coast, but reports received from vessels and other sources after those publications indicated the fact that this deflection to the right was not so strong as has been supposed, and the track as here charted is thought to represent more nearly the true conditions. It was carefully plotted from all available observations. As to the comparative intensities of the two storms, it is perhaps idle to speculate. The wind velocities were not greatly different, and the effects of the two storms were much the same, except as modified by artificial conditions in the vicinity of Galveston. The barometer reading of 28.48 inches at Galveston in 1900 was 0.15 inch lower than the lowest reading recorded in 1915, whereas the lowest reading of 28.20 inches at Houston in 1915 was 0.28 inch lower than the lowest barometer reported in Galveston in 1900. Unfortunately there are no records from Houston for the year 1900, and a precise comparison can not be made.

the most complete and successful ever issued by the bureau for a tropical storm. Granting this to be true, it must not be assumed that the thoroughness and efficacy of the warnings were alone due to the work of any particular individual. In very large measure the success in forecasting the path and rate of the movement of the storm was rendered possible by the splendid radio service which has become a valuable adjunct of Weather Bureau forecast work since the last severe tropical storm. While it is true that no reports were received from the immediate vicinity of the storm center, probably because the warnings kept the vessels away, those that were received after the storm passed over extreme western Cuba were sufficiently close to the eastward to afford extremely valuable assistance to the forecaster, while the almost total absence of important marine disasters bears abundant testimony to the efficiency of the warning service by means of the radio distribution. There were no useless warnings. The storm did not reach any locality that had not previously had ample warning, and no warnings were issued for any locality that the storm did not reach.

However, the splendid efficiency of the radio service can not and does not detract from the equally efficient work performed by the Weather Bureau stations along the West Indian and Gulf coasts. The distribution of the warnings was as widespread and complete as human energy could make them, and this service undoubtedly saved many lives and a considerable amount of property. Along the Louisiana coast the cordial and effective cooperation of the telegraph and telephone services and of private individuals enabled the official in charge of the local office of the Weather Bureau at New Orleans to make a wonderful distribution of the warnings, while the official in charge at Galveston and the storm warning displayman at Seabrook, Tex., by supplementing the official warnings by personal service to individuals saved many hundreds of lives. It was fortunate also for all concerned that during the first four days of the storm its center was sufficiently close to the stations of observation to enable the forecaster to indicate its velocity of movement with much greater precision than would have been possible had the storm center been at a considerable distance from land. This is an additional reason for the establishment and operation of many more stations of observation in West Indian waters, especially in the vicinity of Panama, if the Weather Bureau is to be able in the future to forecast the approach, progression, and intensity of West Indian hurricanes for the benefit of the commerce and the military establishment of the United States. This same thought should also be extended so as to comprise a more enlarged radio service in West Indian waters. The radio service now conducted by the Weather Bureau in cooperation with the Navy Department, and commercial organizations is extremely effective and valuable, but it is confined entirely to the waters of the western Atlantic, the western Caribbean, and the Gulf of Mexico. Reports are rarely received from the eastern Caribbean, but with the extension of the commercial activities of the United States in the days to come it is to be hoped that this field will be covered as carefully and as fully as are the adjacent waters.

It is a pleasure also to make grateful acknowledgment here of the services rendered by Señor Luis G. y Carbonell, chief of the meteorological service at Habana, Cuba, while the storm was passing through the Caribbean Sea. Señor Carbonell responded promptly to every request for special observations from various points in Cuba, often at inconvenient hours, and the data were of great assistance to the forecaster.

THE WORK OF THE WEATHER BUREAU IN CONNECTION WITH THE STORM.

If one may judge from press reports and letters received at the Weather Bureau, the warnings issued were

The following press comments relative to the work of the Weather Bureau in connection with the storm are indicative of the uniform character of the large number that was received:

New Orleans, La., Daily States, August 20, 1915 (editorial):

One of the most fortunate phases of the great tropical storm is the small loss of life, relatively speaking, which it left in its wake.

In the storm of 1900, six thousand was the death toll in Galveston alone, and two or three thousand more perished elsewhere, most of them on the Texas mainland. This year, although the storm was of a severity comparable with that of 15 years ago, the total deaths in Galveston, on the mainland and the sea seem likely to run under 300.

In 1900 there was some criticism of the Government, not entirely justified, for its warnings of the storm. But no such criticism lies in connection with this year's storm. If the loss is small, considering the duration and fury of the blow, immeasurable credit is due the Government forecasters for the remarkable accuracy with which they outlined the track of the storm and the ample opportunity they gave not only to shipping but to those on land to protect themselves.

In consequence, shipwrecks have been conspicuously few. Vessels at sea had time to run for cover. Those in ports were enabled to postpone their departure until the actual danger was passed.

Not only at Galveston but all along the coast, even at remote points, messages of the Weather Bureau were received in plenty of time to let the cautious seek places of safety; and no one doubts that, admitting fully the part the seawall played, the exodus of thousands, due to the accuracy of the Bureau's warnings, was one of the factors which held the Galveston fatalities down to such small figures.

Rochester, N. Y., Union and Advertiser, August 21, 1915 (editorial):

Many lives were saved at Galveston by the warning of the approaching storm issued by the Weather Bureau. According to dispatches, the forecaster not only predicted the hurricane, but sent men on motor cycles to various sections, notifying the inhabitants to seek safer places of refuge if they hoped to save their lives. The warning was heeded by the vast majority and they lived to tell the story; by some it was ignored, and they perished because of their heedlessness. Only Galveston's seawall was more effective than the Government Weather Bureau in preventing a repetition of the disaster of 1900, when 4,000 persons were killed.

The incident makes some of the fun that is poked at weather forecasters in all sections of the country sound a little cheap. It puts to shame some of us who have been over zealous in enumerating the mistakes of the forecasters and lax in giving credit to their accuracy. The Galveston incident is the most striking example of the real value of the Bureau that has come up in many years, but not a storm sweeps across the country that is not preceded by property-saving and life-saving warnings. The next time the "weather man" fails to predict a thunder shower that spoils our picnic, let's remember the lives he saved at Galveston.

Galveston, Tex., Daily News, August 17, 1915:

* * * Heralded for two full days in advance by the United States Weather Bureau, the storm did not take Galveston unawares or find it unprepared. Warned repeatedly and thoroughly by the local weather forecaster, W. P. Stewart, every man, woman, and child had ample time in which to seek places of safety in the larger buildings of the business and central residence district, and it was largely due to this fact that none were caught in the wrecked houses on the beach front.

Houston, Tex., Post, August 22, 1915:

In the retrospection after the storm, when the work of searching out the dead and missing is still going on, there remains to be told the story of the part played by the United States Weather Bureau and especially by the stations in Houston and along the coast. When this story is told it will be learned why the loss of life is not considerably greater.

Those who watched the bulletins of the department since the first warning was issued a week before the storm struck Texas, will recall with what prophetic accuracy its direction, its nature, and its violence were heralded to the people of Houston from day to day. Good work was accomplished by the display men in the various substations along the coast, who not only posted the warnings but personally advised the people in the small communities to take the necessary precautions.

An instance of this was the work of W. B. Stearns, the display man at Seabrook, who made the rounds of the flats in that section and urged the people to leave for the high ground. This is simply one example of similar efforts on the part of all the display men in the district.

Probably no more daring feat was performed during the storm than that of two assistants in the office of Dr. Bunnemeyer in the Stearns Building. When the storm was at its height Tuesday morning the anemometer which records the velocity of the wind was put out of commission at 4:35 o'clock. At 5:50 the two men clambered to the roof and replaced the equipment with a new one. The record immediately after showed that the wind was blowing 80 miles an hour, the highest during the entire storm.

**THE TROPICAL HURRICANE OF SEPTEMBER 29, 1915,
IN LOUISIANA.**

By ISAAC M. CLINE, District Forecaster.

[Dated: Weather Bureau, New Orleans, La., Oct. 21, 1915.]

The most intense hurricane of which we have record in history of the Mexican Gulf coast, and probably in the United States, moved northward over southeastern Louisiana and southwestern Mississippi during September 29, 1915. The territory traversed by this hurricane, especially near its center, is well covered by cooperative observing stations, and the records of meteorological conditions from these stations furnish unusually interesting material for study in connection with hurricanes. We have very complete barometer readings from New Orleans, Burrwood, and Morgan City, La., and Bay St. Louis, Miss., and observations of weather conditions and changes in wind direction on and near the path of the center of the hurricane from the time it struck the Louisiana coast until it passed out of the State, a distance of about 150 miles.

We shall first consider the meteorological conditions and special features attending the hurricane, and then take up the issue and distribution of warnings by the Weather Bureau, the action taken to protect lives and property, and the value of the warnings.

GENERAL METEOROLOGICAL CONDITIONS.

Tuesday, September 28, 1915.—Early in the morning a few cirrus clouds were seen at New Orleans spreading over the sky, coming up from the south; by 10 a. m. (90th mer. S. T.) the entire sky was covered with a cirrus veil, below which were about 4/10 strato-cumulus moving rapidly from the northeast. At 11 a. m., there was 4/10 cirro-stratus moving from the northeast and 2/10 cumulus coming from the east, the higher clouds were obscured. By NOON the cirrus had largely disappeared or were not visible, the strato-cumulus had decreased to about 2/10, and the sky was covered by cirro-stratus moving from the south. At 1 p. m., there was 1/10 cirrus and 3/10 cirro-stratus, all from the southwest, and 3/10 cumulus from the east. At 2 p. m., about 3/10 of the sky were covered by cirrus streamers coming up from the south and spreading to the north of the zenith; a few cirro-cumulus were moving from the south, and there was 3/10 strato-cumulus moving from the east. At 3 p. m., there was 4/10 cirrus and 3/10 cirro-stratus, all from the southwest, and there was 1/10 cumulus from the east. By SUNSET the cirrus veil had increased in thickness, merging into thin cirro-stratus and covering the entire sky, which at sunset was a faint brick-dust color, with a heavy bank of cumulus in the east. From sunset to 10 p. m., the sky was covered by a veil of high clouds as shown by observations of the stars, very few of the latter could be seen and those were of a peculiar copper tint. From 10 p. m. to MIDNIGHT the thickness of the clouds gradually increased.

Wednesday, September 29, 1915.—By 3 a. m. of the 29th the cloud cover had increased in thickness and was mainly strato-cumulus moving rapidly from the northeast; occasional heavy rain squalls occurred. By day-break the clouds had increased in thickness, about 7/10 were typical nimbus and 3/10 strato-cumulus andscud moving rapidly from the northeast. This formation of clouds continued all day and into the night, with heavy rain most of the time and excessive [see p. 493, Table II] during the larger portion of the day. After the passage of the storm center the rainfall gradually decreased in intensity and the clouds decreased somewhat in thickness until at MIDNIGHT the rain ceased; but the sky was still covered with strato-cumulus clouds moving rapidly from the west.

Thursday, September 30, 1915.—From midnight until 7 a. m. the clouds gradually decreased in density and the strato-cumulus gave way to alto-cumulus and cirro-stratus covering the entire sky. At 9 a. m. the sky was entirely clear of clouds.

PRESSURE.

From September 22 to 25, the fluctuations of the barometer show nothing more than the ordinary normal diurnal changes. The faint rise in the barometer which is supposed to precede the gradual fall indicating the approach of a hurricane did not occur. A gradual fall in the barometer commenced on the morning of the 25th and the fall amounted to about 0.10 inch in 24 hours until noon of September 28 when the fall became more rapid.

From 7 p. m. of the 28th to 7 a. m. of the 29th the barometer fell 0.18 inch.

During the 29th the barometer fell rapidly from 29.54 inches at 7 a. m. to 28.11 inches at 5:50 p. m., a fall of 1.43 inches in 10 hours and 50 minutes or slightly more than 0.13 inch per hour. From 3:10 p. m. to 5:50 p. m. the barometer fell 0.90 inch, or at the rate of more than 0.33 inch per hour. A trace of the barograph corrected and reduced to sea-level from observed readings of the mercurial barometer is reproduced in figure 5 on chart XLIII-114. Table 1 gives the readings of the mercurial barometer (reduced to sea-level) taken at 15-minute and 5-minute intervals. The readings were taken by Mr. Coberly and Mr. Harder, except that the 5-minute readings were all taken by Mr. Coberly and the instantaneous fluctuations as indicated by the movements of the barograph pen were noted by Mr. Harder, and I took the readings from 10:30 p. m., of the 29th until 12:30 a. m., of the 30th, and Mr. Coberly continued them until 7 a. m., of the 30th. The wind velocity and direction were taken from the triple-register and are given at the time of each barometer reading.

TABLE 1.—Reduced pressure, barometer fluctuations, and wind velocity and direction at New Orleans, La., Sept. 29, 1915, 10 a. m. to Sept. 30, 6:55 a. m.

Time. (90th M. S. T.)	Pressure.	Wind.		Fluctuations in pressure.	Observers.
		Velocity.	Direction.		
<i>1915.</i>					
<i>Sept. 29.</i>					
A. M.	Inches.	Mi./hr.		Inches.	
10:00.....	29.40	37	ne.	.....	Coberly & Harder.
10:30.....	29.33	48	ne.	0.02	Do.
11:00.....	29.30	38	ne.	.....	Do.
11:15.....	29.25	43	ne.	Slight.	Do.
11:30.....	29.24	53	ne.	0.01	Do.
11:45.....	29.19	34	ne.	.....	Do.
12:00, noon.....	29.18	46	ne.	0.05	Do.
<i>P. M.</i>					
12:15.....	29.15	48	ne.	0.03	Do.
12:30.....	29.14	49	ne.	0.01	Do.
12:45.....	29.13	46	ne.	0.01	Do.
1:00.....	29.10	54	e.	0.02	Do.
1:15.....	29.09	50	e.	0.01	Do.
1:30.....	29.08	49	e.	.....	Do.
1:45.....	29.06	44	e.	Steady.	Do.
2:00.....	29.05	44	ne.	0.01	Do.
2:15.....	29.01	50	e.	0.02	Do.
2:30.....	28.98	50	e.	0.02	Do.
2:45.....	28.94	54	e.	0.02	Do.
3:00.....	28.93	53	e.	0.01	Do.
3:15.....	28.90	52	e.	.....	Do.
3:30.....	28.87	54	e.	Steady.	Do.
3:45.....	28.81	48	e.	Steady.	Do.
4:00.....	28.76	52	e.	0.02	Do.
4:15.....	28.68	63	se.	0.03	Do.
4:30.....	28.56	60	se.	Steady.	Do.
4:45.....	28.53	66	se.	0.03	Do.
4:55.....	28.44	72	e.	0.02	Coberly.
5:00.....	28.39	72	e.	0.03	Do.
5:05.....	28.37	76	se.	0.03	Do.
5:10.....	28.34	86	se.	0.02	Do.
5:15.....	28.28	75	se.	0.02	Do.
5:20.....	28.23	70	se.	0.03	Do.
5:25.....	28.17	70	se.	0.02	Do.
5:30.....	28.16	52	se.	0.02	Do.
5:35.....	28.15	44	se.	Steady.	Do.
5:40.....	28.13	42	se.	0.02	Do.
5:50.....	28.11	46	se.	0.03	Do.
5:55.....	28.13	44	se.	0.05	Do.
6:00.....	28.14	50	s.	Steady.	Do.
6:05.....	28.15	50	se.	Steady.	Do.
6:10.....	28.14	60	se.	0.05	Do.
6:15.....	28.15	44	se.	Steady.	Do.
6:20.....	28.17	46	se.	Steady.	Do.
6:25.....	28.17	48	s.	Steady.	Do.
6:30.....	28.17	42	se.	0.02	Do.
6:35.....	28.19	33	s.	0.02	Do.
6:40.....	28.19	34	s.	0.02	Do.
6:45.....	28.23	31	sw.	Steady.	Do.
6:50.....	28.26	32	sw.	Steady.	Do.
6:55.....	28.28	36	sw.	Steady.	Do.
7:00.....	28.31	31	sw.	Steady.	Do.
7:05.....	28.33	33	Variable.	Steady.	Do.
7:10.....	28.35	39	sw.	Steady.	Do.
7:15.....	28.39	39	sw.	Steady.	Do.
7:20.....	28.41	38	s.	Steady.	Do.
7:25.....	28.44	38	sw.	Steady.	Do.
7:40.....	28.54	29	sw.	.....	Do.

TABLE 1.—Reduced pressure, barometer fluctuations, and wind velocity and direction at New Orleans, La., Sept. 29, 1915, 10 a. m. to Sept. 30, 6:55 a. m.—Continued.

Time. (90th M. S. T.)	Pressure.	Wind.		Fluctuations in pressure.	Observers.
		Velocity.	Direction.		
<i>1915.</i>					
<i>Sept. 29.</i>					
P. M.	Inches.	Mi./hr.	sw.	Inches.	Coberly.
7:55.....	28.63	29	sw.	.....	Do.
8:10.....	28.70	26	sw.	.....	Do.
8:25.....	28.77	26	sw.	.....	Do.
8:40.....	28.82	26	sw.	.....	Do.
8:55.....	28.86	23	sw.	.....	Do.
9:10.....	28.91	24	sw.	.....	Do.
9:25.....	28.95	24	sw.	.....	Do.
9:40.....	28.97	22	sw.	.....	Do.
9:55.....	29.01	23	sw.	.....	Do.
10:10.....	29.04	21	sw.	.....	Do.
10:25.....	29.06	25	sw.	.....	I. M. Cline.
10:40.....	29.09	28	sw.	.....	Do.
10:55.....	29.13	29	sw.	.....	Do.
11:10.....	29.14	28	sw.	.....	Do.
11:25.....	29.15	30	sw.	.....	Do.
11:40.....	29.16	28	sw.	.....	Do.
11:55.....	29.17	35	sw.	.....	Do.
<i>Sept. 30.</i>					
A. M.					
12:10.....	29.20	36	sw.	.....	Do.
12:25.....	29.22	29	sw.	.....	Do.
12:40.....	29.22	27	sw.	.....	Coberly.
12:55.....	29.25	27	sw.	.....	Do.
1:10.....	29.27	29	sw.	.....	Do.
1:25.....	29.28	29	sw.	.....	Do.
1:40.....	29.30	30	sw.	.....	Do.
1:55.....	29.32	26	sw.	.....	Do.
2:10.....	29.33	27	sw.	.....	Do.
2:25.....	29.35	30	sw.	.....	Do.
2:40.....	29.37	24	sw.	.....	Do.
2:55.....	29.38	31	sw.	.....	Do.
3:10.....	29.40	26	sw.	.....	Do.
3:25.....	29.41	23	sw.	.....	Do.
3:40.....	29.42	25	sw.	.....	Do.
3:55.....	29.43	23	sw.	.....	Do.
4:10.....	29.45	25	sw.	.....	Do.
4:25.....	29.46	23	sw.	.....	Do.
4:40.....	29.49	21	sw.	.....	Do.
4:55.....	29.49	23	sw.	.....	Do.
5:10.....	29.51	20	sw.	.....	Do.
5:25.....	29.52	19	sw.	.....	Do.
5:40.....	29.53	17	sw.	.....	Do.
5:55.....	29.54	16	sw.	.....	Do.
6:10.....	29.55	17	sw.	.....	Do.
6:25.....	29.57	18	sw.	.....	Do.
6:40.....	29.57	16	sw.	.....	Do.
6:55.....	29.58	16	sw.	.....	Do.

Barometer and wind observations taken aboard the Honduran steamship *Ceiba* were furnished by Capt. Ernest E. B. Drake, and are given in Table 2, the barometer used being the ship's aneroid, Weather Bureau No. 6224.

TABLE 2.—Observations on the *Ceiba*, 3 miles NE. of the Weather Bureau, New Orleans.

Time.	Pressure.			Wind direction and force.
	Observed.	Correction.	Corrected.	
<i>Sept. 29.</i>				
A. M.	Inches.	Inches.	Inches.	
4:00.....	29.71	-0.11	29.60	Fresh to strong east, with frequent heavy squalls and continuous rain.
6:00.....	29.64	-0.11	29.53	
8:00.....	29.64	-0.11	29.53	
10:00.....	29.52	-0.11	29.41	
12:00 noon...	29.31	-0.11	29.20	
P. M.				
2:00.....	29.07	-0.11	28.96	ene. 7.
3:00.....	28.95	-0.11	28.84	e. by n. 7 to 8.
4:00.....	28.87	-0.11	28.76	e. 8.
5:00.....	28.41	-0.11	28.30	e. by s. 9 to 10.
6:00.....	28.15	-0.11	28.04	ese. 11.
6:40.....	28.125	-0.11	28.01	se. by e. 11.
7:00.....	28.22	-0.11	28.11	se. 11 to 10.
8:00.....	28.55	-0.11	28.44	sse. 10.
10:00.....	28.92	-0.11	28.81	s., moderating rapidly and rain clearing.
12:00.....	29.13	-0.11	29.02	ssw.

The above observations were taken at the ship's mooring about 3 miles northeast of the local office, Weather Bureau, and the distance from the center of the hurricane is about the same as that of the local office, Weather Bureau. It is noted that this barometer fell a little more rapidly than the Weather Bureau barometer.

Barometer readings at Burrwood, La., on the east bank at the mouth of the southwest pass of the Mississippi River, have been furnished by Mr. George E. Henderson, special meteorological observer, Weather Bureau, as follows:

TABLE 3.—Barometer readings at Burrwood, La., and on the dredge New Orleans.

Time (90th M. S. T.)	U. S. dredge New Orleans, aneroid.	Burrwood, La., mercurial barom- eter.	Time.	U. S. dredge New Orleans, aneroid.	Burrwood, La., mercurial barom- eter.
<i>Sept. 29.</i>					
A. M.	Inches.	Inches.	A. M.	Inches.	Inches.
2:00.....	29.66		9:45.....	29.00	
3:00.....		29.42	10:00.....	29.04	
3:30.....		29.38	12:00, noon.....	29.05	
4:00.....	29.56	29.38			
4:30.....		29.33	P. M.		
5:00.....		29.30	2:00.....	29.09	
5:30.....		29.27	4:00.....	29.17	
6:00.....	29.27	29.23	6:00.....	29.23	
6:30.....		29.21	7:00.....	29.31	
7:00.....		29.18	8:00.....	29.37	
7:30.....		29.13	9:20.....	29.52	
8:00.....	29.18	29.09	10:00.....	29.54	
8:30.....		29.00	12:00, midnight.....	29.58	

Mr. Henderson and his family, with others in Burrwood, went aboard the U. S. dredge *Benyaurd*, deeming that safer than to remain ashore. This explains why the readings of the mercurial barometer were discontinued after 8:30 a. m. of the 29th.

It is observed that the aneroid barometer on the U. S. dredge *New Orleans* (see Table 3) read 0.24 inch too high at 2 a. m. of the 29th, that it fell more rapidly than the mercurial barometer until 6 a. m., when it was only 0.06 of an inch above the mercurial, but that at 8 a. m. the aneroid showed a more sluggish fall and was 0.09 of an inch higher than the mercurial. The passage of this storm has furnished some interesting features in connection with the ordinary aneroid barometers. Some aneroids which have been checked with the mercurial barometer in this office and found very accurate at ordinary pressures read much too low and others read too high during the passage of the hurricane. The Weather Bureau barometer at Burrwood shows a pressure of 29.00 inches at 8:30 a. m. on September 29, while the aneroid shows the lowest during the storm as 29.00 inches at 9:45 a. m. At New Orleans the barometer fell 0.33 inch during the hour just preceding the occurrence of the lowest pressure, but New Orleans was much nearer the center of the hurricane than Burrwood, and this explains why the fall in pressure was not so great at Burrwood as at New Orleans. Judging from the actions of the aneroid barometer on the U. S. dredge *New Orleans*, it is apparently safe to assume that the lowest barometer at Burrwood was about 28.80 inches. The relation of Burrwood to the center of the hurricane will be taken up later.

The barometer readings given in Table 4 were made at Morgan City, La. (67 miles west of New Orleans), and furnished by Mr. R. A. Squires, of Morgan's Louisiana & Texas Railroad & Steamship Co.

TABLE 4.—Readings of aneroid barometer at Morgan City, La.

[Correction, perhaps +0.02 inch.]

Time (90th M. S. T.).	Aneroid barom- eter.	Time.	Aneroid barom- eter.
<i>Sept. 29.</i>		<i>Sept. 29.</i>	
A. M.	<i>Inches.</i>	P. M.	<i>Inches.</i>
4:30.....	29.58	3:00.....	29.06
7:00.....	29.56	4:00.....	29.05
8:00.....	29.53	5:30.....	29.10
9:00.....	29.50	8:00.....	29.18
10:00.....	29.43	9:00.....	29.24
11:00.....	29.38	10:00.....	29.31
12:00, noon.....	29.30		
		<i>Sept. 30.</i>	
P. M.		A. M.	
1:00.....	29.20	3:00.....	29.50
2:00.....	29.10		

Mr. Squires reports that the wind blew hardest from a direction 2 to 4 points west of north about 4 p. m. to 4:30 p. m., and went to the west about 8:30 p. m. His barometer reads, at ordinary pressures, 0.02 inch lower than the Weather Bureau barometer at New Orleans.

The following barometer readings were taken at Bay St. Louis, Miss., and furnished by Prof. Florian Schaffter, of New Orleans, who was spending the summer at that place:

TABLE 5.—Readings of an aneroid barometer at Bay St. Louis, Miss., by F. Schaffter.

[Correction, see text.]

Time (90th M. S. T.).	Aneroid barom- eter.	Time.	Aneroid barom- eter.
<i>Sept. 29.</i>		<i>Sept. 29.</i>	
A. M.	<i>Inches.</i>	P. M.	<i>Inches.</i>
10:30.....	29.60	8:00.....	29.12
11:30.....	29.48	11:00.....	29.18
		<i>Sept. 30.</i>	
P. M.		A. M.	
3:00.....	29.34	1:45.....	29.26
6:00.....	29.14	8:00.....	29.52

Prof. Schaffter says that the lowest barometer occurred at 8:00 p. m. of the 29th and is represented by the reading given. The aneroid barometer he used is a good one, and at ordinary pressures it reads the same as the Weather Bureau mercurial barometer at New Orleans. I am of the opinion that a mercurial barometer at Bay St. Louis would have shown a pressure of about 28.90 inches. The actual readings given by the aneroid show a barometric gradient of 1 inch in 50 miles. Bay St. Louis, Miss., is east of and a little north of New Orleans.

The following table gives aneroid barometer readings during the hurricane, September 29, 1915, which were made in New Orleans at Stanley Thomas hall, Tulane University of Louisiana, by Prof. W. B. Gregory and Mr. N. C. Curtis:

TABLE 6.—Readings of an aneroid barometer at Tulane University, Sept. 29, 1915.

Time (90th M. S. T.).	Aneroid barom- eter.	Time.	Aneroid barom- eter.
<i>Inches.</i>		<i>Inches.</i>	
A. M.		P. M.	
8:30.....	29.60	2:15.....	29.10
9:05.....	29.55	2:30.....	29.05
9:30.....	29.52	2:35.....	29.02
10:30.....	29.45	2:40.....	29.01
10:50.....	29.38	2:45.....	29.00
11:00.....	29.40	3:00.....	28.97
11:15.....	29.36	3:10.....	28.95
11:30.....	29.30	3:15.....	28.93
12:00, noon.....	29.30	3:30.....	28.90
12:40.....	29.23	4:00.....	28.76
		4:30.....	28.65
		4:45.....	28.35
P. M.		5:15.....	28.25
1:00.....	29.20	5:30.....	28.10
1:20.....	29.17	6:00.....	28.10
1:45.....	29.14		

Tulane University is 7 miles west of the local office, Weather Bureau, and 1 mile north of the sugar experiment station; the grounds of Tulane University and Loyola University are adjacent, hence these records will be of value in connection with the wind directions reported from the sugar experiment station and from Loyola University.

WINDS.

The wind gradually increased during the afternoon and night of *September 28*, the prevailing direction being from the east and oscillating between northeast and southeast; the most frequent oscillations were toward the northeast. From midnight to 2:45 a. m. of the *29th*; the wind was blowing steadily from the northeast with a velocity of from 17 to 18 miles per hour. From 2:45 to 8 a. m. the prevailing direction was east, oscillating occasionally between northeast and southeast; when the wind changed from northeast to east the velocity increased to 25 miles per hour, and a maximum velocity of 34 miles per hour occurred for a period of five minutes at 3:50 a. m. At 8 a. m. the wind backed to northeast and continued from that direction until 1:10 p. m.; from 1:10 p. m. to 4:15 p. m. the prevailing direction was east, oscillating at frequent intervals to the southeast; from 4:15 p. m. to 5:20 p. m. the prevailing direction was southeast, but there were intervals of three to five minutes with the direction from the east. From 5:20 p. m. to 6:30 p. m. the wind was steady from the southeast. The wind shifted from southeast to south at 6:35 p. m. and to southwest at 6:45 p. m., continuing from that direction during the night. The velocity now subsided rapidly, falling below 30 mis./hr. during the hour ending at 9 p. m.; however, maximum velocities of 32 to 36 miles were recorded in each hour from 11 p. m. of the 29th to 3 a. m. of the 30th.

TABLE 7.—Wind velocities and directions at weather bureau, New Orleans, La., Sept. 29, 1915.

Time.	Direction.	Mean velocity.	Maximum 5-min. velocity.
Midnight (28)—2:45 a. m.....	NE.	<i>Mis./hr.</i> 17 to 18	<i>Mis./hr.</i>
3:50 a. m.....	E.		34
2:45-8 a. m.....	E.; ne., se.	25	
7-8 a. m.....	E.	32	39
8-9 a. m.....	NE.	35	43
9-10 a. m.....	NE.	37	45
10-11 a. m.....	NE.	42	48
11-noon.....	NE.	40	53
Noon-1 p. m.....	NE.	48	54
1:10 p. m.....	e.		
1-2 p. m.....	E.; se.	49	54
2-3 p. m.....	E.	50	56
3-4 p. m.....	E.	50	54
4:15 p. m.....	SE.		
4-5 p. m.....	SE.	60	72
5-6 p. m.....	SE.	62	1 86
6:35 p. m.....	S.		
6:45 p. m.....	SW.		
6-7 p. m.....	SE., SW.	41	53
7-8 p. m.....	SW.		

1 E-SE.

The wind velocity was 50 mis./hr. or higher for four hours and was 60 or above for two hours, the maximum velocity, 86 mis./hr., was 20 miles in excess of the highest velocity, 66 miles, previously recorded at New Orleans. The wind attained the greatest velocity when it shifted from east to southeast. The wind subsided rapidly after 3 a. m. *September 30*, and died out almost completely between 5 p. m. and 8 p. m. The wind backed to the west at 8:45 a. m., and to the northwest at 1 p. m., *September 30*. The wind, when at its height, was not steady but

came in a rapid succession of gusts of a few seconds duration, which may be likened to pulsations. The extreme velocity of 130 miles per hour, from the southeast, occurred at 4:58 p. m., while the maximum velocity for five minutes, 86 miles per hour, occurred from 5:11 to 5:16 p. m. The velocity in the pulsating gusts of a few seconds duration was, at times, undoubtedly much greater than the extreme velocity for a whole single mile.

The wind velocity 50 miles distant from the center was evidently much greater than it was at New Orleans. At Burrwood, La., 100 miles south of New Orleans and located at the mouth of the southwest pass of the Mississippi delta, unprecedented high winds for this section of the country were recorded and the velocity exceeded any winds previously recorded on the Gulf coast. In fact, this was the most intense hurricane known to the recorded history of this part of the country. [The automatic record of the anemometer at Burrwood is unusually perfect and distinct, notably so when one considers the abnormally high winds it records; much credit is due G. E. Henderson, the observer, for having maintained his instrument in such perfect condition and for securing such a record.] The wind directions and velocities at Burrwood during September 29 are given below in Table 8.

TABLE 8.—Wind velocities and directions recorded by the Weather Bureau self-recorder at Burrwood, La., Sept. 29, 1915.

Time. (90th M. S. T.)	Direction.	Velocity.		
		Mean.	Maximum, 5 minutes.	Extreme, 1 mile.
		Miles/hr.	Miles/hr.	Miles/hr.
4:45 a. m.—7:20 p. m.		70+		
6 a. m.	ene.			
7 a. m.—6:35 p. m.		80+		
8 a. m.	e. by n.			
10 a. m.	e. by s.			
Noon	ese.			
2 p. m.	se. by s.			
3-4 p. m.		108		
3:31-3:50 p. m.		116		
3:40-3:45 p. m.			124	
3:45 p. m.				140
4-5 p. m.		106		
5-6 p. m.		96		
6 p. m.	sw., s.			

At 6 p. m. of the 29th the wind went to southwest and was southwest or south the remainder of the night; by noon of the 30th it had settled into the southwest. Along the Gulf Coast, from Burrwood eastward to Rigolets, the wind velocity was probably about the same as at Burrwood. From Rigolets the wind probably decreased in velocity toward the center of the hurricane, and there was a rapid decline in the velocity to the eastward of the Rigolets.

Extracts from reports by cooperative observers.

The following extracts from special reports of Weather Bureau cooperative observers at stations in the area covered by the hurricane, furnish valuable material relative to wind changes with the progress of the hurricane. From these and other available material we can determine the exact route over which the center of the hurricane traveled. They also furnish valuable data concerning the conditions of the weather at the center of the hurricane, such as the "eye of the storm," calms, etc. The extracts are given in geographical order commencing on the Gulf coast and thence northward with the progressive movement of the hurricane.

Houma, La.—The wind blew from the northeast on September 29 until between 10 a. m., and 11 a. m., when it began blowing alternately north and northeast, with intermittent periods nearly calm. About 4 p. m. there was a lull, after which the wind blew its hardest from the northwest, finally falling off in that quarter between 11 p. m. and midnight; the wind went from northeast to north, northwest, and west.—*F. X. Zeringer.*

Lockport, La.—The wind began to increase Tuesday night (28th) shortly after dark, but its intensity was not noticed particularly until about 9 a. m. Wednesday, the 29th. During this time it was blowing from the northeast and continued from this quarter with increasing intensity until between 4:30 p. m. and 5 p. m., when it dropped very quickly to a moderate velocity. This lasted for about half to three quarters of an hour when it again began to blow hard from the northwest, or perhaps a little west of northwest. I did not notice any gradual change in the direction from the northeast to northwest, if there was any. There was no period of calm, my observation being that it had changed from a moderate and decreasing northeast wind to an increasing northwest gale. It was also my opinion that our greatest velocity was from the northwest, but lasted only for a very short period. Trees that had withstood the northeast wind snapped off with the northwest wind. By 8 p. m. the wind began to be more moderate.—*Frank H. Adams.*

Avoca Island near Morgan City, La.—After blowing northeast for some hours after the storm began on the morning of the 29th, the wind backed up north by northeast and blew as we estimate at the rate of about 50 miles per hour. It then backed farther and gradually to the north, and I should say blew directly from the north during the highest of the gale, or from about 4 p. m. to 6 p. m. During the night the wind shifted to the west by the way of northwest. We were afraid of a tidal wave here, and the writer noted particularly your wind forecast and saw your predictions verified.—*Eugene A. Pharr.*

Morgan City, La.—The wind was from the northeast the morning of the 29th and continued to increase from that direction until 1 p. m., when it shifted to north-northwest and still increased in velocity until 4:30 p. m., when it blew hardest. From this time until 8 p. m., the wind decreased and backed to the west. There was no period of calm.—*V. E. Kinsey.*

Sugar Experiment Station, New Orleans, La. (7 miles west of local office, Weather Bureau).—During the early hours of the morning of the 29th the wind direction was very uncertain, but as the gale increased it blew more or less north-northeast; toward evening, from about 4 p. m. to 5:30 p. m., the wind had reached its greatest velocity, and it seemed to come directly from the northeast. At 4:50 p. m. it did its worst damage to the station. All during the day there were lulls for a few seconds and then renewed gusts of wind and rain.

Loyola University, New Orleans, La. (1 mile north of the Sugar Experiment Station).—From early morning until about 5:15 to 5:30 p. m., the wind seemed to be steady from the northeast. From 5:30 p. m., until about 6:30 p. m., or perhaps a little later, there was almost a perfect lull, at least it seemed so by comparison with the tremendous disturbance preceding. At the time between 6:30 p. m. and 7 p. m. the wind veered around until it blew strong from a southerly direction, it being difficult to say whether it was from the south, southeast, or southwest.—*Anton L. Kunkel, S. J.*

Reserve, La.—During the recent hurricane the wind shifted from northeast to east, predominating from the northeast. The storm started here about 10 a. m., and blew steadily from the northeast until about 6 p. m., then from that hour it shifted from northeast to east until about midnight; after midnight it turned to the west for quite a time. During the storm there was no period of calm, but the wind blew in gusts most of the time.—*Edward Godchaux.*

St. Gabriel, La.—The wind began from the northeast about 7 a. m. of the 29th, and gradually increased until 9:30 p. m., when it shifted to the northwest and subsided.—*Capt. John B. Murphy.*

Donaldsonville, La.—The direction of the wind in the hurricane of September 29 was northeast from the time of observation at 7 a. m. until 5:30 p. m., when there was a period of calm, after which the wind shifted to north, keeping that direction until 8:45 p. m., when it backed to northwest.—*Alfred J. Landry.*

Cinclare, La.—The wind on September 29 was from the northeast until about 5 p. m., when it shifted to the north and remained from that direction until it subsided. The wind was high from noon until 11 p. m. There was no noticeable period of calm.—*A. W. Wallace.*

Covington, La.—High east wind began on the morning of the 29th: about 6 p. m. the wind increased in velocity and commenced from a southeasterly direction. The velocity increased from 7 p. m. until 10 p. m., when it blew hardest. After the wind shifted to southeast there were lulls of a short duration, then the wind would blow with greater fury than ever.—*Mrs. M. C. Buquoi.*

Baton Rouge, La.—On the morning of September 29 there was a light northeast wind, which increased in velocity as the day passed, and between 5 p. m. and 6 p. m. it shifted to northwest, and about 7:30 p. m. the wind was highest.—*Etmo M. Bott.*

Hammond, La.—The wind started in blowing from the northeast in the morning and gradually increased in velocity as night approached. About 5 p. m. it lulled slightly, but then began to blow harder until about 7 p. m., when it came out of the north, and about this time the storm seemed to reach its maximum.—*C. C. Carr.*

Amite, La.—The winds came alternately high and light from the same direction, northeast. There were high winds from the northwest also.—*Miss Lulu M. Wentz.*

SPECIAL FEATURES SHOWN BY THE WINDS.

An interesting feature brought out by the foregoing reports on the winds in this hurricane is that in the eastern or right-hand segment of the hurricane the highest velocities are invariably reported to have occurred with the change from easterly to southeasterly winds, being as a rule from the southeast, and probably coincident with the passage of the hurricane center. The records at New Orleans and Burrwood show this positively. In the western or left-hand segment, the highest velocities are reported to have occurred at some point between north and northwest, and with a change of the winds towards the west. The highest winds in the right hand segment came from the opposite quadrant from that in which they occurred in the left-hand segment, being almost from directly opposite directions.

At New Orleans with the change in direction from southeast to south the wind velocity fell off to 50 per cent of what it had been with the same barometric gradient when the direction was from the northeast to southeast. A similar decrease in velocity is reported to have taken place in the western or left-hand segment of the

hurricane when the wind shifted from northwest to west and southwest. The progressive movement of the hurricane being about 12 miles per hour (see path and movement of hurricane center) accounts for part of this, viz: The progressive movement would increase the gradient wind by 12 miles per hour in the front segment, and diminish the gradient wind by the same amount in the rear segment, which together would give an apparent difference in velocity, making it 24 miles greater in the front segment than in the rear segment of the cyclonic area. This leaves a falling off in the wind velocity in the rear segment below that in the front segment when compared to barometric gradients of something like 10 miles per hour, which is not explained by the progressive velocity of the cyclonic area.

PRECIPITATION.

Light precipitation began at 2:35 a. m., on the 29th, and with the exception of a heavy shower for a few minutes about 3:40 a. m., soon after the wind veered from northeast to east, very little precipitation occurred prior to 7 a. m., during which time the wind was from the east. Soon after 7 a. m., the wind backed to the northeast and the precipitation increased until 12 noon, 1.59 inches being recorded in the hour ended at 12 noon. The precipitation became lighter again after the wind veered to the east at 1:10 p. m., and it diminished until the fall during the hour ending at 3 p. m., was only 0.30 inch. As the wind veered toward the southeast the precipitation became heavier again and during the hour ended at 5 p. m., also the hour in which the complete change from east to southeast occurred, the precipitation amounted to 1.05 inches. The precipitation then diminished and almost ceased about half an hour before the wind veered from southeast to south at 6:35 p. m., or rather it ceased during the hour in which the change to south was taking place. A light misting rain, however, continued until 11:30 p. m. The total precipitation during the passage of the hurricane amounted to 8.20 inches. A notable feature in connection with the precipitation was the increase in precipitation just prior to the time that the wind shifted from northeast to east near the middle of the day, the falling off in the amount of precipitation both during the early morning hours and again in the afternoon hours during the time the wind was from the east, the increase in the amount of precipitation again as the wind was shifting from the east to southeast, and that the precipitation almost ceased when the wind veered from southeast to south.

The distribution of the precipitation in the area covered by the cyclonic movement of the atmosphere is of special interest. The heaviest precipitation occurred near the center and within a distance of 25 miles to the east of the center, but heavy precipitation occurred over a large area in the eastern segment of the storm, while to the west of the path of the center of the storm the precipitation diminished rapidly and 50 miles to the west of the path of the center of the storm the precipitation was negligible. The distribution of precipitation in relation to the center of the hurricane is shown in figure 7 (XLIH-114).

LIGHTNING AND THUNDER.

The flashes of lightning, supposed to be a special feature in a tropical hurricane, were not present in this one. There was an absence of lightning and thunder, which calls for special comment. About 3 a. m. of September 29 faint sheet lightning was observed a few times in the

northeast, and twice low, distant thunder was heard, but after that time and during the passage of the hurricane the total absence of lightning was commented on in the office. About 9:30 p. m., September 29, four hours after the center of the hurricane had passed, Mr. A. V. Hall, of the Times-Picayune, reported he had observed a peculiar lightning in the southwest a few times. Mr. Hall described it as a light flaring up in sheets not unlike the fire coming out of the mouths of serpents as represented in imaginary illustrations.

NOTE.—In the hurricane of September 8, 1900, at Galveston, Tex., I do not remember to what extent lightning was visible during the day, but certain incidents were revealed by lightning at night which I can never forget. It was sheet lightning to the southeast that revealed to me out of the darkness after the wrecking of my home my brother and my two oldest children floating on wreckage. The lightning enabled me to pick up a strange child about 4 years old floating on the débris of a wrecked house, and occasional flares of lightning enabled us to see buildings, which we would soon hear being ground down and destroyed by the waves and wreckage on which we were floating. This lightning occurred while the wind was from the southeast and ceased quite a while before we landed at 11:30 p. m. In my report on the hurricane of September 8, 1900, I did not go into details relative to meteorological conditions, and I give this here in order to put it of record.

TEMPERATURE.

As the hurricane approached during the night of the 28th, the temperature fell suddenly about 3:40 a. m. of the 29th from 81°F. to 75°, but this occurred with the first heavy shower of rain preceding the hurricane, and the temperature always shows a sudden and decided drop with a heavy shower of rain. After 3:40 a. m. the temperature fell gradually 1 or 2 degrees until noon of the 29th, fluctuating considerably. During the afternoon of the 29th, the sudden fluctuations disappeared, and there were gradual rises or falls of 2 or 3 degrees, the falls occurring with sudden downpours of precipitation and the rises when these would slacken. Temperature conditions during the hurricane were not unlike those found in ordinary heavy rainstorms.

PATH AND MOVEMENT OF HURRICANE CENTER.

The pressure and wind records at New Orleans, Burrwood, and Morgan City, La., Bay St. Louis, Miss., and other places, especially the fact that the barometer remained nearly stationery at Burrwood from 9:45 a. m., the time of the occurrence of the lowest barometer, until 2 p. m. of the 29th, more than four hours, taken along with the wind reports from surrounding stations, indicates that the storm center struck the Louisiana coast about halfway between the mouth of the Mississippi River and Atchafalaya Bay, the center being then about 50 miles west of Burrwood and recurving slowly toward the northeast. The slight change in pressure conditions at Mobile and Pensacola from 8 p. m. of the 28th to 8 a. m. of the 29th also shows that the storm recurved over southeastern Louisiana, and was probably moving toward the northwest up to the time that its northern segment struck the marshes of southeastern Louisiana. The storm center passed near and east of La Rose and Lockport on Bayou Lafourche, where the wind backed suddenly without an intermediate direction from northeast to northwest during the afternoon of the 29th. At Thibodaux, in the northwestern part of Lafourche Parish, the wind backed more gradually from northeast to northwest and west. The prevailing wind at New Orleans being northeast from 8 a. m. until 1 p. m., five hours, east from 1 p. m. until 4 p. m., three hours, southeast from 4 p. m.

until 7 p. m., three hours, then southerly the remainder of the day, indicates that the storm curved to the northeastward around New Orleans.

The lowest pressure at Morgan City, La., 67 miles west of New Orleans, was 29.05 inches and the lowest at Bay St. Louis, Miss., 50 miles east of New Orleans, was 29.12 inches. The gradient between Bay St. Louis and New Orleans, when applied from Morgan City eastward to the path of the center of the hurricane, would bring the 28.11 inches isobar on the west side of the center to within about 25 miles of the local office, Weather Bureau, New Orleans. This would place the center of the hurricane about 12 miles to the west of the New Orleans office. This is also in harmony with the reports of changes in wind direction at the sugar experiment station and Loyola University, just 7 miles west of the local office, Weather Bureau, where the wind was reported by two trained independent observers, 1 mile apart, as shifting from northeast to southeast without any intermediate direction. Further, a complete calm, with the wind shifting from northeast to southeast without any intermediate direction was reported by Mr. C. E. Heckathorn, observer, Weather Bureau, as occurring at his residence from 5:30 to 6 p. m., 1 mile farther west than the above stations, indicates that the eastern limit of the imaginary center, or calm area of the hurricane, passed about 8 miles west of the local office, Weather Bureau, and that the diameter of the comparatively calm area was about 8 miles. The barometer reading at New Orleans probably represented as low a barometer as occurred at any point, even in the center of the hurricane. At Tulane University the barometer at 20 feet altitude was 28.10 inches for 30 minutes and another barometer nearby read 28.09 at 5:42 p. m.

The diameter of the hurricane proper—that is, between points where the pressure was 29.50 inches on the outer rim (this pressure is taken as the outer rim because this hurricane occurred within an area of low pressure of unusually large extent)—may safely be placed at between 250 and 300 miles. The time required for the passage at New Orleans from the front isobar of 29.50 to the rear isobar of 29.50 inches was about 24 hours, which would make the progressive movement of the hurricane about 12 miles per hour. Mobile, Ala., 150 miles east of New Orleans, was on the outer rim of the hurricane proper. The lowest barometer reading reported from the Mobile station was 29.50 inches, and it is assumed that a similar pressure would have been noted about 150 miles west of New Orleans. No observer reports a breaking away of clouds in the center, "the eye," of the storm.

Figure 6 (XLIII-114) gives the directions in which the winds changed at several stations in southeastern Louisiana during the progress of the hurricane, and shows as accurately as possible, from the information available, the path traversed by the center of the hurricane.

TIDE CONDITIONS.

No extraordinary tide conditions appeared during September 28, the day preceding the hurricane, and as late as the morning of the 29th men who had been advised on the afternoon of the 28th to go to their families on the Mississippi coast returned to New Orleans on an early train Wednesday morning and telephoned me that they had left everything comparatively quiet on the Gulf coast and they had noticed no extraordinary tide on the trip to New Orleans. On my advice they attempted

to return to their families by the first train at 11 a. m., but an unusually rapid rise in the tide had submerged the tracks of the Louisville & Nashville Railroad at Rigolets, and the train was annulled. The tide continued to rise as the hurricane advanced and during the afternoon of the 29th covered all low lying lands south of New Orleans and east nearly to Bay St. Louis and around Lake Ponchartrain to the north. The tide and swells topped the levees along the Mississippi River below New Orleans and in places the tide was reported to be as much as 15 to 20 feet above sea level. It was undoubtedly the highest tide of record in this section. At the junction of Harveys Canal with the Mississippi River, just above New Orleans, and 100 miles from the Gulf, the tide was 6 feet in the river. Swells rolled up the river during the hurricane 10 to 12 feet above the high tide. The water was carried into Lake Ponchartrain by the storm, overflowed the protection levees, and flooded a large area in the western part of New Orleans. Over that portion of the city lying between the Old Basin Canal and Broadway and from Claiborne Avenue out to Lake Ponchartrain, the water driven in by the storm ranged from 1 to 8 feet in depth. After the passage of the storm center the tide receded rapidly, except in New Orleans where the water had to be removed by the drainage system and remained for three or four days.

It is evident that the tide came up with the hurricane, because, considering the northeast winds blowing, there were no extraordinary tide conditions, even as late as the morning of the 29th. The long swell on the ocean usually reported as preceding hurricanes had not been observed up to that time. The only noticeable conditions indicating the advance of the hurricane and its probable course was a wind-blown rise of 1 foot in the Mississippi River at New Orleans, and a fall of 0.5 foot in the Atchafalaya River at Morgan City. Had it not been for the fall in the tide at Morgan City there would have been nothing in tide conditions along the coast to attract attention, with the character of winds prevailing.

WARNING SERVICE AND ACTION TAKEN TO PROTECT LIFE AND PROPERTY.

Warnings announcing the appearance of the hurricane in the eastern portion of the Caribbean Sea were received at New Orleans on September 23, and advisory warnings were received daily thereafter until the passage of the hurricane. These warnings gave the location of the storm and its probable direction of movement, and were telegraphed to all coast stations, radiographed to ships at sea, telephoned to ship agents, and published in the daily papers.

September 28 the following warning was distributed by telegraph to all display stations on the Louisiana coast, radiographed to ships at sea, and was widely distributed by telephone and mail:

Hoist northeast storm warning, Louisiana coast, 8:30 a. m. Tropical disturbance will cause increasing northeast winds and probably moderate gales along the Louisiana coast this afternoon and to-night.

(Signed) CLINE.

Warnings for moderate gales were sent with the forecasts at 8:20 a. m. to all telephone exchanges in southern Louisiana. At 9:50 a. m. the following advisory warning was received from the central office, and was distributed by telegraph to all display stations on the coast, radiographed to ships at sea, and telephoned to all interests likely to be affected:

Advisory storm warning. Tropical storm attended by dangerous winds centered this morning over Gulf of Mexico in apparently latitude

24° and longitude 87° and moving northward toward the mouth of the Mississippi River. Its influence will be felt late to-night and Wednesday on the middle Gulf coast.

(Signed) BOWIE.

About 1:30 p. m. the following message was received:

BERWICK, La., September 28, 1915.

Dr. I. M. CLINE,

Weather Bureau, New Orleans, La.

This company has men and boats on the Gulf and we would appreciate advice sent us direct at our expense if storm should head this way.

(Signed) LOUISIANA OYSTER & FISH CO.

The following reply was sent at once:

Hurricane centered about 300 miles off mouth of Mississippi River apparently moving northward. Consider it advisable to call in men and boats. Effects of storm will be felt on middle Gulf coast by Wednesday morning.

(Signed) CLINE.

At 2:40 p. m. the following hurricane warning was received from the central office, Washington, D. C.:

Hoist hurricane warnings 3 p. m., New Orleans to Pensacola. Tropical storm centered near latitude 26° and longitude 88°, moving northward. Dangerous winds late to-night and Wednesday. Center of storm will probably strike coast near or immediately east of the mouth of the Mississippi River. Advise all interests.

(Signed) BOWIE.

An extraordinary distribution of warnings was commenced at once and the following injunction was given those to whom it was sent: "Please reach persons in exposed localities." It was telegraphed to all special storm warning display stations on the middle Gulf coast; was telephoned at Government expense to the telephone exchanges in the threatened area in Louisiana. Mr. T. Barton Baird, district manager of the Cumberland Telephone & Telegraph Co., was called up, the warning read to him, and a list of the telephone exchanges to which the warning had been sent; by our request he instructed the managers at the several exchanges to give the warnings the greatest possible distribution and to endeavor to reach persons in exposed localities. Similar action was taken by Mr. W. A. Porteous, manager of the Western Union Telegraph Co.; Mr. N. E. Church, manager of the Postal Telegraph Co.; Mr. Charles Marshall, superintendent of the Louisville & Nashville Railroad; and by Mr. Isidore Fisher, at Fishers Landing on Harveys Canal, who sent the warning by boat at Government expense down through the Barataria section to Grand Isle. Mr. J. R. Reynolds, superintendent of police, New Orleans, was requested to post the warnings at each police station, and to notify the people on the police rounds that a hurricane with dangerous winds would prevail Wednesday; to advise the people to exercise every precaution against danger; and to reach persons in exposed localities. The fire-alarm department, at my request, sent the warning to all their stations with similar instructions. The commanding officers at Jackson Barracks and at the naval station took similar action. An assistant at the Weather Bureau office telephone, with a list of shipping and others who receive such warnings, called up the chief operator at the telephone exchange and had a special operator assigned to switching from one number to another so that we could get the warning to the greatest number in the shortest time.

The pressure conditions around the Gulf coast Tuesday morning, September 28, and cloud conditions and movements during the day were such that public interests were advised that afternoon that the hurricane would probably be more severe than that of 1909, the most severe storm in the previous history of New Orleans.

Capt. Galbraith, manager of the Western Union branch in the New Orleans local office, Weather Bureau, reported for duty shortly before 7 a. m., September 29. I informed him that wire trouble would soon be experienced and requested him to take such precautions as would enable us to collect reports and get out forecasts and warnings and distribute them early. The following warning, based on pressure and weather conditions along the Gulf coast and on tide conditions at New Orleans and Morgan City, La., was issued at once:

Advisory warning Louisiana coast, 8:20 a. m. Tropical disturbance will move northward over southeast Louisiana. Center will probably pass between New Orleans and Atchafalaya Bay. Easterly gales probably reaching hurricane force in eastern Louisiana and strong northerly winds to moderate gales on west Louisiana coast to-day and to-night. High tides.

(Signed) CLINE.

This warning was given the widest possible distribution by telephone, telegraph, and railroad offices throughout the threatened area and also by mail in New Orleans. Warnings for easterly gales and probably hurricane winds were telephoned to all eastern Louisiana, and for northerly to westerly gales to all western Louisiana. We had just finished distributing forecasts and warnings by telegraph and telephone at 9 a. m. when serious wire trouble set in.

All persons asking were advised to remain at home and stay indoors; the principals of several schools were also advised.

This advice and the distribution of the warnings through the police and fire-alarm departments kept people at home or in their offices and stores and reduced the number of people on the streets during the storm to a minimum, and this unquestionably prevented much loss of life in New Orleans.

When the barometer fell below 28.25 inches and continued falling so rapidly, I began wondering what the result would be. It was a great relief to us when the barograph pen stopped at a reduced barometer reading of 28.11 inches and then began to rise. Every minute during the afternoon of the 29th I had told people coming into the office and over the telephone, that the worst was not over; but after 5:50 p. m., they could be told that the center had passed although dangerous winds would continue for a few hours. Telephone calls came so fast that when we wished to send a message we could not get central and had to go to another telephone. Some one was on the line before we could hang up and lift off the receiver. The strain of anxiety on the part of the public was the greatest I have ever witnessed.

The Daily States, September 30; 1915, in commenting on the storm says:

When the fierce blasts, which in the morning hours came from the northeast, shifted east, then south, and finally, about 10 p. m. south-west, were at their most terrifying height in the late afternoon, hundreds of persons, women, children, and men fought their way through the swirling, blinding mist of rain and flying fragments of roofs and cornices to the substantial stone and marble post-office building in Camp Street, in the top story of which the Weather Bureau is located. Here they felt safer and could get some first-hand information as to what to expect. Among them were some 20 women who lived in the Christian Women's Exchange, the roof of which had already been damaged.

When night came and word still came from the Weather Bureau that, though the center of the storm had passed about 6 o'clock, all danger was not yet over, more than 300 women, children, and men decided to remain in the building all night. Toward midnight, exhausted with anxiety, many of them laid (!) down on the stone floor of the post-office corridor, their heads pillowed on mail sacks supplied them by Assistant Postmaster George V. Fuchs, and snatched such sleep as they might under these hard conditions.

Not until daylight did they leave for their homes.

From many office buildings and stores down town telephone messages came into the Weather Bureau at nightfall asking whether it was safe for other crowds of men and women gathered in them to venture into the streets to go home, but in every case the bureau advised that they remain where they were until daylight on account of darkness and fallen wires.

About 11 a. m., September 29, the chief clerk to the superintendent of the New Orleans & Northeastern Railroad called and asked advice about taking trains over the fourteen miles of trestle and abutments across Lake Ponchartrain. They were advised to suspend trains as the storm would increase in severity during the afternoon. The wind subsided slightly between 1 p. m. and 2 p. m., and the officials of the railroad, being anxious to keep up their train schedules, called again and asked if it would not be safe for them to keep their trains moving. I told them positively that higher winds would occur than had been recorded and that in my opinion there would be winds which would blow trains off the trestle, and they then issued orders for the trains coming in to New Orleans to stop at Slidell on the other side of the lake and they canceled all outgoing trains.

Special observations were telegraphed to the central office every two hours during the hurricane, up to and including 3 p. m. At 5 p. m. all wires out of the city had gone down. Efforts were made to communicate with the Naval radio station in Algiers, the Tropical radio station, and the Marconi station, but all were cut off or out of commission, and New Orleans was absolutely cut off from the outside world. About 10 p. m. of the 29th Mr. Israels, manager of the Associated Press, telephoned that the Marconi Co. had rigged up a temporary wireless station on the American steamship *Excelsior* at the foot of Saint Ann Street, and that they would relay important matter through the American steamship *Creole*, at anchor near the mouth of the river, to Mobile, where it would be put on the land lines. A message to the Chief of the Weather Bureau, giving the regular 8 p. m. observation of the 29th and a brief report on the hurricane was thus sent from New Orleans about 11 p. m. of the 29th. [This message was received at Washington during the afternoon of the 30th]. The regular observations were sent and special reports were transmitted to the chief of the bureau daily through the above channels until October 2, when wire service was established by the Western Union Telegraph Co. into the local office of the Weather Bureau.

The warnings reached every locality in the threatened area, as is shown by press reports and other reports from the storm area, except that the water became so rough that the boat chartered could not make the trip to Grand Isle; however, the previous notices relative to the movements of the storm reached Grand Isle.

People in exposed localities, with a few exceptions, acted promptly on receipt of the warning and sought places where they thought they would be secure. Grand Isle and the Barataria Bay section is practically devastated, nearly all buildings having been destroyed, and all live stock drowned. However, only 23 lives were lost in all this vast region, and 14 of these resulted from the capsizing of boats. At Burrwood the inhabitants went aboard the United States dredge *Benyuard*; fishing boats and other small craft sought refuge in bays and bayous, where they felt secure, but the storm tide of 15 to 20 feet carried many of them from their moorings and left them high and dry on the prairies or far out in the marshes. Weather Bureau warnings held at least 25 ocean-going steamers in the river and at the wharves from the 24th

to 30th. Without definite advice regarding the hurricane the effects on shipping in port would have been disastrous. Vessels which went to sea on the 23d to 26th received the warnings and steered to the westward of the hurricane; no report of an ocean-going vessel being lost has been received.

DAMAGE AND LOSS OF HUMAN LIFE.

The damage to property and the loss of human life were remarkably small when the intensity of the hurricane is taken into consideration. In New Orleans several buildings were totally destroyed and nearly every building suffered injury to some extent, amounting in some cases to several thousand dollars. Four small steamers, or tugs, were sunk in the harbor and several steamers broke from their moorings and were blown ashore. A great many small craft which had sought refuge in the bays and bayous were blown ashore and left by the tide on dry land; several coal barges loaded with coal were sunk. The destruction of buildings was very great in the country surrounding New Orleans. At Leeville on the lower Lafourche, of the 100 houses in the village, only one was left standing, but no one was killed. At Golden Meadow and from that point to Cut Off, 100 houses were demolished, but no lives reported lost. At several places on the Mississippi River below New Orleans and on Lake Ponchartrain 90 per cent of the buildings were completely destroyed.

I have checked the deaths closely and 275 will cover the entire loss of life resulting from this unprecedented hurricane. The loss of life at Rigolets resulted from an absolute disregard of specific warnings and advice to come to New Orleans. Mr. John T. Meehan, of the Times-Picayune, was in the local office, Weather Bureau, when we issued the specific warning at 8:20 a. m., September 29, giving the path which the hurricane would follow and advising that hurricane winds and high tides would prevail over southeastern Louisiana that day and night. He asked me what the result would be at Rigolets, stating that he knew some people there, and I told him he had better telephone them at once, which he did. He spoke with Manuel, the keeper of the club, through his wife, gave him the warning and told him to have everybody come to New Orleans on the next train, which was due to pass that place about 10 a. m. Manuel replied that the train would not stop for them, and Mr. Meehan told him that if the train would not come to a stop for flagging to put a cross tie on the track. The keeper said, "They will put me in jail," to which Mr. Meehan replied, "You would be better off in jail than where you are now and for God's sake stop that train at all hazards and come to New Orleans." It has since been learned that Manuel flagged the train and it stopped, but the people were not there to get aboard, the rising tide was jeopardizing the passengers on the train, which could not wait until the people could be collected from the houses. Manuel returned to his companions and when the storm was over his lifeless body, with 23 others of those who were in the club, were found strewn over the marshes. Mr. Meehan, who went to the Rigolets the morning after the hurricane, with a rescue party, assisted in looking after the burial of the keeper, Manuel, and his companions.

Mr. J. B. FASTERLING, Buras, La., president of the Plaquemines police jury, under date of October 1, says:

It is yet impossible to estimate the number of those who perished, but the death rate has been remarkably low considering the force of the storm. There were 2 feet more water than in the 1903 gale.

The Times-Picayune, October 3, says:

It generally is agreed that the death toll paid the hurricane has been remarkably low along the lower river compared to what the might of the gale led all to anticipate.

The damage done by the hurricane on the middle Gulf coast will probably exceed \$13,000,000, and approximately may be distributed as follows: In the city of New Orleans the damage has been heavy. The damage to municipal property has been appraised at nearly \$500,000. As late as October 13, more than two weeks after the hurricane, the Dealers and Contractors Exchange stated that a survey of the city indicated that 25,000 houses were then in a leaky condition as a result of the hurricane. The total damage to property in New Orleans may be safely estimated as at least ten times the amount of damage suffered by the public buildings belonging to the municipality, and on this basis the damage to property in New Orleans is placed at about \$5,000,000; to shipping and coal interests on the river, \$1,750,000; in the country outside of New Orleans, to buildings, railroads, small craft, crops, and telegraph and telephone systems about \$6,500,000.

VALUE OF WARNINGS IN SAVING LIFE AND PROPERTY.

Much of the success obtained through the warnings in saving human life and property was brought about by the specific statements given on the morning of Tuesday the 28th as to where the hurricane would strike the Gulf coast, and the forecasting Wednesday morning at 8:20 a. m. of the exact course its center would follow, with the character of winds and tides which would prevail, and by the firm and convincing manner in which the people were told what to expect and what to do. We expressed no doubts, but told the people specifically what to expect and advised them without hesitation what action to take. The admonition "Please reach persons in exposed localities," given to every manager of a telegraph and railroad station on the middle Gulf coast, and all telephone stations in southeastern Louisiana and others, with the hurricane warning on the 28th, impressed the people with the seriousness of the impending crisis, and stirred the public to prompt and decisive action to protect life and property such as was never exercised previously. The fact that only 275 lives were lost in all that vast stretch of 300 miles of coast line, including the most populous center in the South, tells the story of the value of the service rendered the people of this section.

The Times-Picayune, Thursday, September 30, 1915, says:

The intensity of the storm, while it did considerable damage in New Orleans and vicinity, proved the worthiness of Dr. I. M. Cline, the district forecaster of the United States Weather Bureau. Never before, perhaps, in the history of the Weather Bureau, have such general warnings been disseminated as were sent out by the local bureau in reference to the disturbance that passed New Orleans Wednesday evening. At 7 o'clock Wednesday morning Dr. Cline said the wind would attain a velocity of 65 miles an hour, or more. At 2 o'clock in the afternoon, when a velocity of 62 miles an hour had been recorded, and when most persons believed the worst had passed, Dr. Cline said the worst was yet to come. He then predicted that the maximum intensity of the storm would be reached here "between 5 and 6 o'clock." As a matter of actual record, the maximum was at 5:30, when a wind velocity of 86 miles an hour for 10 minutes was recorded, and when, for a period of about 20 seconds a velocity of 130 miles was reached.

There may have been much life loss along the coast, but such a catastrophe can not be charged to the Weather Bureau, for the warnings of the approach of the hurricane were sent broadcast before the high winds ever reached the Louisiana coast.

Tuesday afternoon Dr. Cline expressed the belief that the storm would be more intense than that which wrought such damage at New Orleans and along the coast in September, 1909. His prediction came true, although there were many persons in the city who were skeptical

concerning this prediction until the winds actually had recorded a new velocity record for the city.

The New Orleans Item, October 13, 1915, says:

About 20 years ago a West Indian hurricane, far lighter in force and stress than the recent storm, struck the Gulf coast. Over 2,000 lives were lost and many millions in property.

Ten days ago another West Indian hurricane came with tremendously increased intensity. But the loss in life in all the vast stretch of marsh and bayou and sea line is only 275. The property damage is infinitely less.

There is one specific reason for this difference in results: Increased efficiency in the Weather Bureau and an increased and extended service rendered possible by enlarged personnel and extended range of observations.

The News and Courier (Charleston, S. C., Oct. 1, 1915) published the following comment on the Weather Bureau's services:

WEATHER BUREAU MAKES GOOD AGAIN.

For the third time this season [fall of 1915] the United States Weather Bureau has been put to the test and for the third time it has proved its worth. Three great tropical storms have swept upon the shores of this country out of the southern waters where these tempests are brewed. But for the Weather Bureau's good work it is certain that each of these storms would have blotted out thousands of lives along the coasts of the Gulf States.

The News and Courier has already made acknowledgment of its realization of how fine the bureau's work has been. Now that for the third time this year the bureau has been put to the test and has met it admirably, a further acknowledgment is due. Seldom, if ever before, has the bureau been confronted with more important problems than those which it has met and solved this year, and this latest demonstration of its efficiency should not be allowed to pass without remark.

SECTION III.—FORECASTS.

FORECASTS AND WARNINGS FOR SEPTEMBER, 1915.

EDWARD H. BOWIE, District Forecaster.

[Dated: Washington, D. C., Nov. 2, 1915.]

FROST WARNINGS.

A high area that entered the United States from British Columbia moved southeastward to the Ohio Valley and thence northeastward off the New England coast, and in connection with this high pressure area, warnings of frost were issued on September 21, 22, and 23 for portions of the Lake Region, the Ohio Valley, the North Atlantic States, and the northern portion of the Middle Atlantic States, and frosts occurred substantially as indicated in the warnings, although they failed of verification in the southern Ohio Valley and along the north coast of the Middle Atlantic States.

A high pressure area passed from Saskatchewan to Ontario from the 25th to the 30th, frost warnings being issued on the 26th, 27th, 28th, and 29th for the Lake Region, the northern Ohio Valley, New England, and the northern portion of the Middle Atlantic States. These warnings were justified in almost all cases.

STORM WARNINGS.

In connection with the storm that prevailed in the vicinity of the Bermudas from the 2d to the 8th, inclusive, warnings and advices were disseminated to Middle and North Atlantic ports during the 2d and the 3d, and high winds occurred along the Middle Atlantic coast where storm warnings were displayed. As far as indicated by reports, winds approximating gale force occurred off the coast.

For warnings in connection with the storm that crossed the Gulf coast near Apalachicola, Fla., on the morning of the 4th, see other portions of the text.

In connection with a storm that first appeared over Colorado on the evening of the 9th and passed rapidly northeastward, small craft warnings were ordered on the morning of the 10th for Lakes Michigan, Erie, and Huron, and during the afternoon they were supplemented by advisory warnings covering eastern Superior, northern Michigan, and northern Huron. Winds of gale force occurred over southern Michigan and western Erie, and strong winds elsewhere over the Lakes.

A storm passed north-northeastward from eastern Colorado on the 13th to Ontario by the 15th, and small craft warnings were issued on the 14th for portions of the Upper Lakes, and fresh to strong winds occurred.

From the 16th to the 18th there were indications of a disturbance of minor character near the extreme western end of Cuba and in the central Gulf, and shipping interests were advised accordingly. The storm, however, did not advance northward.

A storm advanced from southern Alberta on the evening of the 18th to the Grand Banks by the 23d. On the evening of the 19th storm warnings were ordered for western Superior, and on the following morning storm warnings were ordered displayed over the remaining portions of the Upper Lakes, except extreme southwestern

Lake Michigan, and advisory messages sent to ports on Lake Erie. On the morning of the 21st small craft warnings were issued for the New England coast, and during the afternoon storm warnings were ordered from Sandy Hook to Portland.

Warnings regarding the New Orleans hurricane appear in another portion of the text. Warnings were issued daily from the 22d to 30th, inclusive, in connection with this hurricane.

A storm developed over the Plains States, and on the morning of the 25th it was central over western Minnesota, whence it moved rapidly eastward to the Grand Banks by the 28th. On the evening of the 25th storm warnings were ordered for Lake Superior and northern Lake Michigan, and on the 26th for the Lower Lakes and southern Huron, and also for the Atlantic coast from Cape Henry to Eastport. Gales occurred over the Lake Region generally and along the middle and north Atlantic seaboard.

On the evening of the 26th warnings were continued on Lakes Michigan and Superior, at which time a storm was over Kansas and a marked high area over western Ontario. The low decreased in intensity and storm winds did not materialize. The warnings were accordingly ordered down on the morning of the 27th.

STORM OF SEPTEMBER 1-9 IN THE REGION OF BERMUDA.

On the 1st of the month the 8 a. m. cablegram from Hamilton, Bermuda, showed a pressure of 29.91 inches, the wind north and 26 miles an hour, and the weather cloudy. During the 1st, pressure fell steadily at Hamilton, and at 8 a. m. of the 2d the pressure was 29.46 inches, the wind northwest, 36 miles, and raining. The pressure continued to fall, and at 8 p. m. of the 2d, the barometer reported was 29.18 inches with the wind northwest, 24 miles, and raining. This disturbance remained central in the region of Bermudas until the 8th and much of this time the wind blew a gale from nearly all points of the compass. Without the aid of mail reports from vessels on the western Atlantic, the geographic position of the origin of this disturbance can not be definitely determined, but there is some evidence that it was present during the last days of August to the east-northeastward of the Lesser Antilles, whence it, in all probability, moved northwestward to the vicinity of Bermuda, and there meeting with high pressure in its path was held practically stationary for several days. It is also probable that this is the same storm that was encountered by one of the Royal Mail steam packets during the latter part of August in latitude 22° N. and longitude 47° W. On the 1st storm warnings were displayed on the North Carolina coast northward to Cape May and on the 2d the region covered by the warnings was extended northward to Cape Cod. The advices were to the effect that northerly gales would be encountered off the middle Atlantic and southern New England coasts. The warnings were justified. The highest winds were off the Virginia Capes, Cape Henry reporting a maximum velocity of 48 miles from the northeast at 8 p. m. of the 2d. Advices concerning this storm were disseminated daily

through the naval wireless. On the 9th the storm recurved west and north of Bermuda.

An interesting report of this was received from Capt. D. W. Wilson of the steamship *Kilbride*. The *Kilbride* was at anchor during the period covered by the report in Great Sound, about 3 miles off Gibbs Hill Lighthouse. By comparison with reports from the regular station at Hamilton, it seems that the barometer on board the *Kilbride* reads about 0.20 inch high. No corrections have been made. This report follows:

September 1: It blew fresh all day from the north; 3 p. m., barometer 29.65 inches and thermometer 80°; 9 p. m., wind backed to northwest, barometer 29.30 inches, thermometer 78°; an ugly, threatening appearance of the sky; 11 p. m., let go starboard anchor and paid out on both cables to 75 fathoms on port and 30 fathoms on starboard; very violent rain squalls all night.

September 2: 8 a. m., barometer 29.30 inches, thermometer 78°, wind still blowing hard from northwest; 1 p. m., barometer 29.18 inches, thermometer 81°; 4 p. m., barometer 29.03 inches, thermometer 81°, wind backed to west; strong wind and increasing in force; sky densely overcast, with drizzling rain at intervals.

September 3: 6 a. m., barometer 28.90 inches, thermometer 81°, wind backed to southwest, increasing in force all the time; noon, barometer 28.90 inches, thermometer 81°, gale rapidly increasing in violence with terrific squalls, dangerous confused sea running; 4 p. m., barometer 28.85 inches, wind backed to south, now blowing hurricane force; 8 p. m., barometer 29.05 inches, thermometer 81°, wind backed to southeast, blowing a hurricane with heavy sea, thick and misty, and unable to see any distance; 10 p. m., barometer 29.05 inches, thermometer 82°, still blowing hurricane force with heavy rain, sky densely overcast with very thick atmosphere; 11 p. m., barometer 29.05 inches, thermometer 82°; midnight, barometer and weather the same, using main engines, steaming head to wind and sea and using helm as required to prevent sheering and to relieve strain on cables. Heavy, short, and dangerous sea.

September 4: 1 a. m., barometer 29.05 inches, thermometer 83°, no change in weather; 4 a. m., barometer 29.05 inches, thermometer 82°, wind backed to east-southeast; 8 a. m., barometer 29.06 inches; thermometer 79°, wind backed to east; 11 a. m., barometer 29.10 inches, thermometer 78°, wind backed to east-northeast; noon, barometer 29.11 inches, thermometer 78°, tremendous hurricane, with blinding, heavy rain and densely overcast sky, unable to see any distance; 4 p. m., barometer 29.16 inches, thermometer 76°, wind the same (east-northeast), but less rain; 8 p. m., barometer 29.20 inches, thermometer 77°, hurricane abating a little, weather clear at times; sky overcast, much less sea.

September 5: 4 a. m., barometer 29.33 inches, thermometer 82°, wind the same (east-northeast), but much finer weather; 8 a. m., barometer 29.35 inches, thermometer 82°, wind decreasing, weather inclined to be squally, with heavy rain; noon, barometer 29.40 inches, thermometer 81°, wind backed to northeast, fresh breeze and overcast sky, with a promising appearance of the weather becoming settled; stopped engines; 4 p. m., barometer 29.40 inches, thermometer 82°, strong breeze and overcast sky; 10 p. m., barometer 29.45 inches, thermometer 79°, wind veered to east-northeast, weather improving.

September 6: Noon, barometer 29.50 inches, thermometer 78°, wind east-northeast, freshening and sea rising, heavy rain squalls.

September 7: 6 a. m., barometer 29.47 inches, thermometer 77°, gale, wind veered to east, using main engines and helm again as required; 4 p. m., barometer 29.30 inches, thermometer 75°, whole gale, wind veered to east by south, densely overcast, with continuous misty rain, unable to see any distance; 6 p. m., gale abating, sea falling; 10 p. m., barometer 29.25 inches, thermometer 81°, wind decreasing and veered to southeast, weather improving.

September 8: 2 a. m., great improvement in the weather, barometer 29.25 inches, thermometer 82°, wind veered to south-southeast, rough sea; 2 p. m., barometer 29.26 inches, thermometer 80°, fresh breeze, wind veered to south, weather misty, with drizzling rain; 5 p. m., barometer 29.25 inches, thermometer 77°, wind gradually veered to southwest, fresh breeze all night, with misty rain at times.

September 9: 8 a. m., barometer 29.57 inches, thermometer 78°, wind still southwest, moderate breeze, clear and improving weather; noon, barometer 29.62 inches, thermometer 80°, wind still southwest, weather improving all the time.

TROPICAL STORMS DURING SEPTEMBER.

Between the northeast trade winds of the North Atlantic and the southeast trades of the South Atlantic Ocean there lies a belt of relatively low pressure, light variable winds, calms, and vapor-laden air, commonly referred to as the "doldrums." This belt of calms separates the

general wind circulation of the Northern from that of the Southern Hemisphere, and it shifts northward and southward with the sun, but lags so that the sun reaches its maximum north declination in June, while the "meteorological equator" is farthest north in August. This belt is the birthplace of tropical cyclones or hurricanes, but it is only when this belt lies farthest north that the right-hand deflecting force of the earth's rotation becomes so effective that it gives the air moving toward some local area where the air has become superheated, a gyratory motion. Hence hurricanes are most frequent during the month of August and September. Why they should be more frequent in some years than in others is not yet understood.

Figure 4 (XLIII-113) shows for the West Indian and Gulf of Mexico waters the probable 24-hour movements of cyclones in the month of September. To illustrate: If the center of a cyclone is located in the vicinity of the end of one of the arrow shafts, then 24 hours later its center will be near the head of this arrow. The movements are the averages of all cyclones observed in September in the years 1873 to 1910, inclusive.

Tropical storm of September 2-7.

When a powerful storm is in the region of Bermuda it is uncommon to have a storm of other than minor intensity in southern waters adjacent to the United States. However, a storm of small diameter, but of great intensity, made its appearance near Isle of Pines the afternoon of the 2d and moved thence on a northerly course and crossed the coast line near the mouth of the Apalachicola River during the early morning hours of the 4th, losing its intensity immediately thereafter, but retaining its identity until it reached the region of the Great Lakes. In the forenoon of the 2d the following special advice was received from the official in charge at Key West, Fla.:

Clouds give evidence (of) perfect cyclonic organization central nearly south.

Special observations at 4 p. m., from Habana, were immediately called for and these showed a storm in the vicinity of the Isle of Pines. Storm warnings were immediately ordered displayed on the south Florida coast, and the following advisory message was distributed:

Northeast storm warnings displayed south Florida coast. Tropical disturbance at 4 p. m. to-day, central near Isle of Pines and moving toward the northwest. It will be dangerous for shipping in southern Florida and east Gulf waters during the next two days.

During the morning of the 3d several special observations were received from the steamship *Turrialba*, as follows:

Observations on the *Turrialba* September 3, 1915.

Hour of observation.	Latitude.	Longitude.	Barometer.	Temperature.	Wind direction.	Force.	Weather.
	° ' "	° ' "	Inches.	° F.			
2 a. m.	24 20	84 02	29.62	80	ne.	9	Raining.
4 a. m.	24 18	84 00	29.08	80	sw.	6	Raining.
7 a. m.	24 10	83 50	29.56	82	sw.	8	Cloudy.
8 a. m.	24 00	83 40	29.70	82	s.	7	Cloudy.

These reports, together with that of the *Miami* which follows, enabled the forecaster at Washington to locate quite accurately the center of the disturbance. The following report was received from the U. S. Coast Guard Cutter *Miami* by radio:

Approximate position, latitude 24° 46', longitude 83° 50'. Storm center passed to east of our position about 7 a. m., wind north 80 to 100 miles, barometer 29.38. Wind shifted to west 8 a. m., and moderating.

Hurricane warnings were accordingly issued for the western coast of Florida and thence westward to the mouth of the Mississippi River. In these warnings it was predicted that the storm center would strike the coast between Cedar Keys, Fla., and New Orleans, La. Actually it crossed the coast line about midway between these points. These warnings were as follows:

(Issued Sept. 3, 9:10 a. m.)

Hoist hurricane warnings 10 a. m. New Orleans to Cedar Keys and southeast storm warnings at Tampa. Tropical storm central this morning in Gulf in latitude 25° and longitude 85° , approximately, and moving northwest toward middle Gulf coast. It will probably strike Gulf coast between New Orleans and Cedar Keys, and hurricane warnings are ordered accordingly. Advise all interests.

(Issued Sept. 3, 11:08 a. m.)

Change to southeast storm warnings Boca Grande to Jupiter. Fresh southeast and south gales on the southwest Florida coast and strong southeast winds on southeast Florida coast. Storm apparently moving north-northwestward.

(Issued Sept. 3, 11:52 a. m.)

Hoist hurricane warnings Rockwell to Puntarasa. Storm moving north in about latitude 26° , longitude 84° to 85° . Winds of hurricane force off the coast this afternoon and to-night.

(Issued Sept. 4, 9:20 a. m.)

Advisory storm warning. Center of tropical storm apparently approaching Gulf coast near the mouth of Apalachicola River. Will pass inland late this afternoon or to-night and then diminish in intensity. Hurricane warnings limited to region between Panama City and Cedar Keys, Fla.

After crossing the coast line this disturbance decreased in intensity as it passed northward to Lake Huron and lost its identity by the evening of the 7th.

This storm apparently originated south of Cuba and passed northward near Isle of Pines. A report from the Cuban Meteorological Service states that the barometer at Pinar del Rio on the 2d at 7:30 p. m. was 29.74 inches, wind northeast, 20 miles; and at 10:30 p. m., the barometer was 29.70, wind northwest, 26 miles. The wind having backed from northeast to north-northwest, it may be inferred that the center of the hurricane passed to the east of the city. Comparing these observations with those at Habana, where the minimum pressure, 29.66 inches, was observed at 11:45 p. m. of the 2d, with a maximum wind velocity of 50 miles from the southeast at the same hour, it follows that the center of the disturbance passed in the vicinity of San Cristobal, in Pinar del Rio, and passed to the Gulf near La Mulata. The minimum barometer at the Isle of Pines was 29.52 inches at 5 p. m., to which it had fallen from 29.72 at noon.

Key West report.—No casualties or damage at or in the vicinity of this station. Lowest barometer 29.76 inches about 3 a. m. of the 3d.

Tampa report.—In this vicinity very high tides were reported, some the highest of record. At St. Petersburg, Fla., the tide exceeded by 4 feet 10 inches, the previous high record. Damage from wind and tide is confined to that portion of the coast north of Manatee. The greatest damage was done to the sponge fleet. At Passa Grille the sea wall was considerably damaged by the extremely high seas. An aneroid barometer (recently compared) at Passa Grille showed a reading of 29.60 inches, 0.18 inch lower than at Tampa. The official in charge at Tampa remarks: "This means a gradient of 0.18 inch in 25 miles. The tide was the highest of record at Manatee. At Clearwater there was not much wind, but the highest tides in years."

Every available means was employed to disseminate the warnings—rockets, flags, telephone, telegraph, launches, etc. The storm moved so rapidly that the Weather Bureau warnings were issued hardly 24 hours in

advance. They undoubtedly saved many lives and much property.

Jacksonville report.—The tide was unusually high at all Gulf stations, unprecedented some reports indicate. The loss of life was confined to fishing and sponge vessels at sea which had no knowledge concerning the approach of the storm. The apprehension awakened by the recent hurricane that traversed the Gulf coast striking the coast line of Texas near Galveston, was still much alive and to the fear thus provoked, together with the usual accuracy of warnings, must be attributed the small loss of life and property during the storm of September 3-4. Warnings were heeded by large and small vessels, possibly as never before, all realizing that indifference might exact the penalty of great disaster. Thus again is exemplified the value of the bureau to the marine and industrial interests of the country. At Apalachicola the wind was highest, 60 to 70 miles an hour, from the east-southeast between 4 and 7 a. m. of the 4th, veering to southwest. The loss of timber on turpentine farms will be about 10 to 15 per cent or more. The damage to buildings, small boats, and other exposed property, including telegraph and telephone wires will approximate \$25,000. The tide was highest about 5 a. m., having risen 4 feet above normal within about an hour. No lives were lost in the city, owing to the timely precautions taken by all interests. Small vessels sought harbor, although many small boats and one tug were sunk. From 4 a. m. to 7 a. m. the wind blew from 50 to 60 miles an hour, and for 30 or 40 minutes it was 70 miles. The warnings on the 2d and 3d gave every one ample time to put boats, barges, and all floating property in harbor. The lowest barometer reading was 29.32 inches at 6:40 a. m. At Carrabelle the tide was 7 feet above normal. No lives were lost, but fences, telephone poles and smokestacks were blown down, piers were washed away, several barges and small boats were blown ashore into the marshes and left high and dry after the storm. The highest wind velocity of 60 to 70 miles an hour (estimated) occurred about 6 a. m. from the southeast. The lowest barometer was 29.45 inches at 5:30 a. m. of the 4th. Warnings were received in ample time and highly valued. All interests were prompt in taking protective measures. At Cedar Keys the highest wind velocity, about 40 miles an hour, occurred during the night of the 3d-4th from the southeast. The tide was very high. No lives lost and damage to property small, as warnings were received in time and preparations for safety taken by all. At Panama City the wind was very high and backed from northwest to southwest. The highest velocity occurred at about 7 a. m. Some roofs were blown off and several fishing vessels went ashore. The warnings were received in time, and all shipping and the public were warned to make everything safe. Small boats went into the harbor and the larger ones used every precaution. Everybody appreciated the Weather Bureau advice.

Pensacola report.—The tide was not unusually high. The highest wind velocity was 33 miles an hour from the north at 11:08 a. m. of the 4th. The lowest pressure was 29.80 inches at 10 a. m. of the 4th. There was no damage. At St. Andrews the lowest barometer reading of 29.40 inches occurred at 7:45 a. m. On the morning of the 4th the wind had backed to north, and by 5 a. m. began to increase in velocity and was coming in gusts of 50 to 60 miles an hour. A little before 7 a. m. the wind shifted to northwest and possibly for a moment blew 80 miles an hour. It was then that the most damage was done in the way of uprooting and twisting off of trees.

Tropical storm of September 22-30.

On September 22, in the "doldrums" in about latitude 15° N. and longitude 64° W., the forecaster on duty at the central office at Washington, D. C., detected the first signs of the formation of another hurricane, although he had no reports from that immediate region. This storm began to manifest its presence by the changed wind directions, by the clouds and their peculiar movements that usually occur when a hurricane is somewhere near. Advices on the 22d were sent West Indian stations and shipping bound for West Indian waters. Later reports confirmed the deduction that a storm was in process of formation, and day to day thereafter until the storm passed inland near the mouth of the Mississippi River advices and warnings were issued for the guidance of shipping and the residents of the Gulf coast regions. The track of this hurricane is shown on figure I. M. C. 3 (XLIII-113), which also shows the track of the hurricane that passed near Galveston on August 16, 1915, and the one of lesser importance that passed inland near the mouth of the Apalachicola River on September 4, 1915. It is in fact unparalleled that three hurricanes should reach the Gulf coast within a period of approximately six weeks.

The New Orleans hurricane was equal to and possibly surpassed in intensity the one that occurred at Galveston in August. At New Orleans the lowest pressure, reduced to sea level, standard gravity, etc., was 28.11 inches, which is the lowest reading ever recorded at a Weather Bureau station, and the extreme wind velocity was approximately 130 miles an hour from the east. Figure 5 (XLIII-114) shows the sea-level pressure at New Orleans during the coming and passing of the storm. Figure 1 (XLIII-112) is the weather map of 8 p. m., September 29, or approximately two hours after the center of the storm passed immediately west of New Orleans. The pressure at New Orleans was then rising. The continuous lines on this chart are drawn for each 0.10 inch of pressure, except in the immediate vicinity of the storm center, where the gradient is so very steep that it is not possible to show the lowest closed isobar. The arrows show the direction of the wind at the various stations within the storm area; the number of feathers on the staff of an arrow indicates the force of the wind (Beaufort scale) at the time of the observation.

On the morning of September 28, the following warning was sent Gulf ports, whence it was disseminated by every available means:

Tropical storm attended by dangerous winds central this morning over the Gulf of Mexico in approximately latitude 24° and longitude 87°, moving northward toward the mouth of the Mississippi River. Its influence will be felt late to-night and Wednesday on the middle Gulf coast.

At 3 p. m. of the 28th hurricane warnings were ordered displayed and disseminated on the Gulf coast from New Orleans, La., to Pensacola, Fla. The message read as follows:

Hoist hurricane warnings 3 p. m. New Orleans to Pensacola. Tropical storm center near latitude 26° and longitude 88° and moving northward. Dangerous winds late to-night and Wednesday. The storm center will probably strike the coast near or immediately east of the mouth of the Mississippi River. *Advise all interests.*

Of especial importance and helpfulness to the forecaster in the preparation of the advices and warnings concerning this storm, which from the time of its formation in the eastern Caribbean Sea to the time it struck the mouth of the Mississippi, did not pass close to a land station, were the wireless reports from vessels at sea.

While no one of these vessels reported from the immediate storm center, yet their reports were invaluable in that they permitted the center to be located approximately twice each day.

The following is a record of the more important advices and warnings issued by the Weather Bureau from the time the hurricane made its first appearance over the eastern Caribbean Sea until it passed inland near the mouth of the Mississippi River:

September 22.—There are some indications of a disturbance over the Caribbean Sea immediately west of the island of Dominica. (This information was transmitted to Porto Rico and the Windward Islands.)

September 23.—Some indications of a disturbance central over the Caribbean Sea in latitude 15° and longitude 67°. (This information was sent to all West Indian stations, to important ports on the Atlantic and Gulf coasts, and distributed by United States Radio Service to vessels at sea.)

September 24.—At 4 p. m. to-day the pressure was low over the Caribbean Sea, and there were indications of a disturbance south-southeast of Kingston, Jamaica, where the wind was east, force 2, and the barometer read 29.74 inches. Strong easterly winds are prevailing on the south coast of Haiti. This disturbance will probably move west-northwest. (This information was given a distribution similar to that given the advices of the 23d instant.)

September 25.—Tropical cyclone central this morning immediately southwest of Jamaica and moving toward the Yucatan Channel. Vessels bound for Yucatan Channel and western Caribbean Sea should exercise every precaution. (This information was distributed to all Atlantic ports, Habana, and the vessels at sea by means of the Naval Radio Service.)

September 26.—Tropical cyclone over the Caribbean Sea central south of western Cuba and apparently moving northwest toward the Yucatan Channel. Vessels sailing for the Yucatan Channel and western Caribbean waters should exercise extreme caution. (This information was distributed in a manner similar to the advices of Sept. 25.)

September 27.—The tropical cyclone over the western Caribbean Sea is central near and southwest of the Isle of Pines, and apparently moving northward. It is dangerous for vessels in western Cuban and southern Florida waters and the Yucatan Channel. (This advice was given widespread dissemination to the South Atlantic and Gulf seaports and vessels at sea by means of Naval Radio Service.)

September 28.—Tropical storm, attended by dangerous winds, over Gulf of Mexico in approximately latitude 24° and longitude 87° and moving northward toward the mouth of the Mississippi River. Its influence will be felt late to-night and Wednesday on the middle Gulf coast. At 10 a. m. storm warnings were displayed on the middle Gulf coast, and at 3 p. m. an order to hoist hurricane warnings was sent to the region between New Orleans and Pensacola. This warning read as follows:

Tropical storm center near latitude 26° and longitude 88° and moving northward. Dangerous winds late to-night and Wednesday. Center of storm will probably strike coast near or immediately east of the mouth of the Mississippi River. *Advise all interests.*

September 29.—The following information was distributed on the Louisiana coast:

Tropical disturbance moving toward southeast Louisiana. Center will probably pass between New Orleans and Atchafalaya Bay. Easterly gales, probably reaching hurricane force on eastern Louisiana and strong northerly winds to moderate gales on west coast to-day and to-night. High tides.

Also hurricane warnings were continued on the Mississippi, Alabama, and extreme northwest Florida coasts, east to south gales being forecast for the afternoon and night.

A detailed statement concerning the hurricane, September 22-29, at New Orleans appears elsewhere in this Review. (See pp. 456-466.)

DISTRICT WARNINGS DURING SEPTEMBER.

Chicago district.—There were no special warnings issued during the month with the exception of frost or freezing temperature, and the more important warnings for the various sections were as follows:

12th.—Freezing temperature for North Dakota and Montana (verified at the majority of the stations therein).

20th.—Frost for the entire Northwest from the upper Mississippi Valley westward (fully verified).

21st.—Frost for the western Lake region and the upper Mississippi Valley (partly verified).

A warning was issued on the 20th for the Wisconsin tobacco region, as follows:

Frost indicated to-night in tobacco region of western portion of the State. Conditions a little doubtful in southern and central portions, but frost possible. Frost quite likely, however, Tuesday night.

During the month a number of long-range forecasts covering three days to a week were requested by local Exchanges or State Fair Associations in various sections, as follows: On the 11th, Huron, S. Dak., one week; 13th, Madison, Wis., three days; 17th, Springfield, Ill., one week; 18th, Sioux City, Iowa, two days; 19th, Helena, Mont., one week; 25th, Sedalia, Mo., one week; and on the 27th, Peoria, Ill., five days. These forecasts met with exceptional success and were fully verified in practically every case.

Denver district.—Frost warnings were issued for portions of the district on a number of days during the month.

New Orleans district.—No important warnings, except those in connection with the hurricane, which are given elsewhere (pp. 456-466).

San Francisco district.—On the 10th, 23d, 24th, and 25th warnings of probable showers were issued to the fruit-drying interests, and while the reports from regular Weather Bureau stations in this district show rain in only a few instances, scattered light showers occurred in most sections, especially the mountain and foothill districts, and the warnings were justified.

Portland district.—Not received.