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## FORECASTS AND WARNINGS.

By Prof. E. B. GARRIOTT, in charge of Forecast Division.

### WEST INDIAN HURRICANE OF SEPTEMBER 1-12, 1900.

Measured by losses of life and property and the depression of the barometer at Galveston, Tex., the hurricane of September 8, 1900, was the severest storm that ever occurred in the United States. On Galveston Island upward of 6,000 human beings were drowned, or killed by falling buildings or flying debris, and property to the estimated value of \$30,000,000 was destroyed. Enormous losses of life and property were also reported in the inland coast country. The barometer, which reached a verified minimum of 28.48 inches at Galveston, was lower by .10 inch than any reading previously made at a station of the Weather Bureau. The maximum wind velocities registered in this and other great storms are not comparable for the reason that the apparatus employed to record wind force can not, as a rule, withstand velocities which approach 100 miles an hour. At Galveston the greatest recorded wind velocity, for a five-minute period, was 84 miles an hour at 6:15 p. m., and 2 miles were registered at a rate of 100 miles an hour. At that time the anemometer was blown away. It was estimated that a velocity of at least 120 miles an hour was attained between 6:15 and 8 p. m. These velocities, both recorded and estimated, have been exceeded at other stations of the Weather Bureau. Excepting Mount Washington and Pikes Peak, the record for high winds in the United States was established at Cape Lookout, N. C., August

18, 1879, where a velocity of 138 miles an hour was registered before the anemometer was blown away, and the wind reached an estimated velocity of 165 miles an hour. During the tornado of May 27, 1896, at St. Louis, Mo., an extreme velocity of 120 miles an hour was recorded.

The devastation at Galveston was caused principally by a storm wave, which swept in from the Gulf in advance of the hurricane's vortex. This wave, 4 feet in depth, struck the already submerged island with almost irresistible force, and entirely destroyed the south, east, and west portions of the city for a distance of two to five blocks inland. In other parts of the city many houses were destroyed and none escaped injury.

There are a number of instances on record in which storm waves have caused appalling losses of life. In the sixteenth century the Lincolnshire coast of England was swept by a storm wave which caused a loss of thousands of human lives. On October 5, 1864, a storm wave, 16 feet deep, caused the loss of 45,000 lives on the Ganges delta. On October 31, 1876, a storm wave, 10 to 50 feet high, swept the eastern edge of the Ganges delta, destroying over 100,000 lives. Many of the most fatal tidal waves have been accompanied by earthquakes. The Lisbon earthquake of 1755 was accompanied by a wave which destroyed thousands of lives. Islands of the East and West Indies and some of the Japan islands have suffered severely from tidal waves which have attended earthquakes.

All low-lying coast districts which face the line of advance of severe storms are subject to overflow by storm waves of greater or less magnitude. The danger from these waves lies in the power of the rushing water, rather than in the depth of the overflow. During the last twenty-five years the Texas coast has been the scene of three storm-wave disasters. On September 15, 1875, Indianola was nearly destroyed by a wave from the Gulf, which caused a loss of 176 lives and over \$1,000,000 worth of property. During August 19-20, 1886, Indianola was entirely destroyed. Many other instances might be enumerated to illustrate the destructive power of hurricanes and the attendant tidal and storm waves.

The record of the barometer at Galveston during the passage of the hurricane is shown by the following copy of the barograph tracing at that station. This tracing shows that Galveston was within the area of the storm's vortex for about one hour, and as the estimated progressive movement of the vortex at that point was about 8 miles an hour, the diameter of that part of the vortex which passed over Galveston was about 8 miles. It is evident from the shifts of the wind at Galveston and at the mouth of the Brazos River, which is 40 miles southwest of Galveston, that the center of the storm's vortex passed between Galveston and the mouth of the Brazos and moved northwestward some miles west of Galveston, and it follows that in the center of the vortex the barometer was lower, and that the vortex had a greater diameter, than was indicated at Galveston.

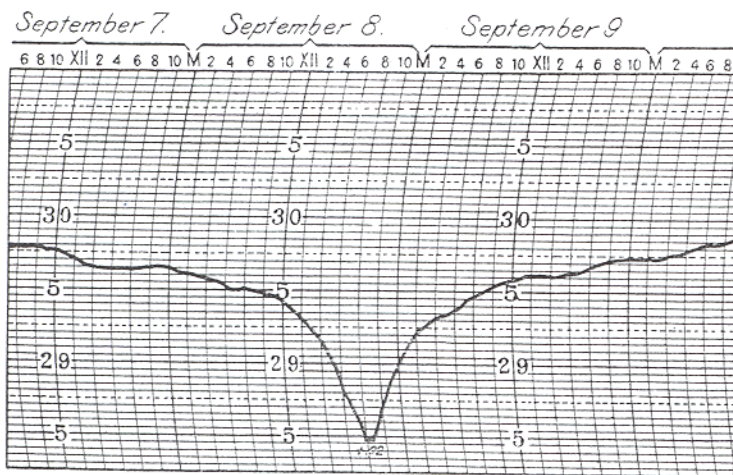


Fig. 1.—Barograph tracing.

The following description of the storm at Galveston has been prepared by Dr. I. M. Cline, official in charge of the Weather Bureau office at that place. In this description Dr. Cline presents an official report on the hurricane which embodies the general meteorological features recorded and observed by himself and his assistants, and recites the means employed in disseminating warnings. He also views the storm from the point of view of a resident of Galveston who underwent the most harrowing experiences:

SPECIAL REPORT ON THE GALVESTON HURRICANE OF SEPTEMBER 8, 1900.

The hurricane which visited Galveston Island on Saturday, September 8, 1900, was no doubt one of the most important meteorological events in the world's history. The ruin which it wrought beggars description, and conservative estimates place the loss of life at the appalling figure, 6,000.

A brief description of Galveston Island will not be out of place as introductory to the details of this disaster. It is a sand island about thirty miles in length and one and one-half to three miles in width. The course of the island is

southwest to northeast, parallel with the southeast coast of the State. The City of Galveston is located on the east end of the island. To the northeast of Galveston is Bolivar Peninsula, a sand spit about twenty miles in length and varying in width from one-fourth of a mile to about three miles. Inside of Galveston Island and Bolivar Peninsula is Galveston Bay, a shallow body of water with an area of nearly five hundred square miles. The length of the bay along shore is about fifty miles and its greatest distance from the Gulf coast is about twenty-five miles. The greater portion of the bay lies due north of Galveston. That portion of the bay which separates the island west of Galveston from the mainland is very narrow, being only about two miles in width in places, and discharges into the Gulf of Mexico through San Louis Pass. The main bay discharges into the Gulf between the jetties; the south one being built out from the northeast end of Galveston Island and the north one from the most southerly point of Bolivar Peninsula. The channel between the jetties is twenty-seven to thirty feet in depth at different stages of the tide. There are channels in the harbor with a depth of thirty to thirty-five feet, and there is an area of nearly two thousand acres with an anchorage depth of eighteen feet or more. The mainland for several miles back from the bay is very low, in fact much of it is lower than Galveston Island, and it is so frequently overflowed by high tide that large areas present a marshy appearance. These are in brief the physical conditions of the territory devastated by the hurricane.

The usual signs which herald the approach of hurricanes were not present in this case. The brick-dust sky was not in evidence in the smallest degree. This feature, which has been distinctly observed in other storms that have occurred in this section, was carefully watched for, both on the evening of the 7th and the morning of the 8th. There were cirrus clouds moving from the southeast during the forenoon of the 7th, but by noon only alto-stratus from the northeast were observed. About the middle of the afternoon the clouds were divided between cirrus, alto-stratus, and cumulus, moving from the northeast. During the remainder of the 7th, strato-cumulus clouds prevailed, with a steady movement from the northeast. A heavy swell from the southeast made its appearance in the Gulf of Mexico during the afternoon of the 7th. The swell continued during the night without diminishing, and the tide rose to an unusual height when it is considered that the wind was from the north and northwest. About 5 a. m. of the 8th Mr. J. L. Cline, Observer, called me and stated that the tide was well up in the low parts of the city, and that we might be able to telegraph important information to Washington. He having been on duty until nearly midnight, was told to retire and I would look into the conditions. I drove to the Gulf, where I timed the swells, and then proceeded to the office and found that the barometer was only one-tenth of an inch lower than it was at the 8 p. m. observation of the 7th. I then returned to the Gulf, made more detailed observations of the tide and swells, and filed the following telegram addressed to the Central Office at Washington:

Unusually heavy swells from the southeast, intervals one to five minutes, overflowing low places south portion of city three to four blocks from beach. Such high water with opposing winds never observed previously.

Broken stratus and strato-cumulus clouds predominated during the early forenoon of the 8th, with the blue sky visible here and there. Showery weather commenced at 8:45 a. m., but dense clouds and heavy rain were not in evidence until about noon, after which dense clouds with rain prevailed.

The wind during the forenoon of the 8th was generally north, but oscillated, at intervals of from five to ten minutes,

between northwest and northeast, and continued so up to 1 p. m. After 1 p. m. the wind was mostly northeast, although as late as 6:30 p. m. it would occasionally back to the northwest for one or two minutes at a time. The prevailing wind was from the northeast until 8:30 p. m., when it shifted to the east, continuing from this direction until about 10 p. m. After 10 p. m. the wind was from the southeast, and after about 11 p. m. the prevailing direction was from the south or southwest. The directions after 11 p. m. are from personal observations. A storm velocity was not attained until about 1 p. m., after which the wind increased steadily and reached a hurricane velocity about 5 p. m. The greatest velocity for five minutes was 84 miles per hour at 6:15 p. m., with two miles at the rate of 100 miles per hour. The anemometer blew away at this time, and it is estimated that prior to 8 p. m. the wind attained a velocity of at least 120 miles per hour. For a short time, about 8 p. m., just before the wind shifted to the east, there was a distinct lull, but when it came out from the east and southeast it appeared to come with greater fury than before. After shifting to the south at about 11 p. m. the wind steadily diminished in velocity, and at 8 a. m. on the morning of the 9th was blowing at the rate of 26 miles per hour from the south.

The barometer commenced falling during the afternoon of the 6th and continued falling steadily but slowly up to noon of the 8th, when it read 29.42 inches. The barometer fell rapidly from noon until 8:30 p. m. of the 8th, when it registered 28.48 inches, a fall of pressure of about one inch in eight and one-half hours. After 8:30 p. m. the barometer rose at the same rapid rate that had characterized the fall. The barograph trace sheet during this storm, from noon September 6 to noon September 10, is inclosed as fig. 1. On account of the rapid fall in pressure, Mr. John D. Blagden, Observer, took readings of the mercurial barometer as a check on the barograph, and his readings are as follows:

Time.	Readings.	Time.	Readings.
5:00 p. m.	29.05	6:40 p. m.	28.75
5:11 p. m.	29.00	6:48 p. m.	28.70
5:30 p. m.	28.95	7:15 p. m.	28.69
5:50 p. m.	28.90	7:40 p. m.	28.62
6:06 p. m.	28.86	8:00 p. m.	28.55
6:20 p. m.	28.82	8:10 p. m.	28.53

These readings confirm the low pressure shown by barograph and indicate the great intensity of the hurricane.

Mr. Blagden looked after the instruments during the hurricane in a heroic and commendable manner. He kept the wires of the self-registering apparatus intact as long as it was possible for him to reach the roof. The rain gage blew away about 6 p. m., and the thermometer shelter soon followed. All the instruments in the thermometer shelter were broken, except the thermograph which was found damaged, but has been put in working order.

Storm warnings were timely and received a wide distribution not only in Galveston but throughout the coast region. Warning messages were received from the Central Office at Washington on September 4, 5, 6, 7, and 8. The high tide on the morning of the 8th, with storm warnings flying, made it necessary to keep one man constantly at the telephone giving out information. Hundreds of people who could not reach us by telephone came to the Weather Bureau office seeking advice. I went down on Strand street and advised some wholesale commission merchants who had perishable goods on their floors to place them 3 feet above the floor. One gentleman has informed me that he carried out my instructions, but the wind blew his goods down. The public was warned, over the telephone and verbally, that the wind would go by the east to the south and that the worst was yet to come. People were advised to seek secure places for the night. As a result thousands of people who lived near the beach or in small houses moved their families into

the center of the city and were thus saved. Those who lived in large strong buildings, a few blocks from the beach, one of whom was the writer of this report, thought that they could weather the wind and tide. Soon after 3 p. m. of the 8th conditions became so threatening that it was deemed essential that a special report be sent at once to Washington. Mr. J. L. Cline, Observer, took the instrumental readings while I drove first to the bay and then to the Gulf, and finding that half the streets of the city were under water added the following to the special observation at 3:30 p. m.: "Gulf rising, water covers streets of about half city." Having been on duty since 5 a. m., after giving this message to the observer, I went home to lunch. Mr. J. L. Cline went to the telegraph offices through water from two to four feet deep, and found that the telegraph wires had all gone down; he then returned to the office, and by inquiry learned that the long distance telephone had one wire still working to Houston, over which he gave the message to the Western Union telegraph office at Houston to be forwarded to the Central Office at Washington.

I reached home and found the water around my residence waist deep. I at once went to work assisting people, who were not securely located, into my residence, until forty or fifty persons were housed therein. About 6:30 p. m. Mr. J. L. Cline, who had left Mr. Blagden at the office to look after the instruments, reached my residence, where he found the water neck deep. He informed me that the barometer had fallen below 29.00 inches; that no further messages could be gotten off on account of all wires being down, and that he had advised everyone he could see to go to the center of the city; also, that he thought we had better make an attempt in that direction. At this time, however, the roofs of houses and timbers were flying through the streets as though they were paper, and it appeared suicidal to attempt a journey through the flying timbers. Many people were killed by flying timbers about this time while endeavoring to escape to town.

The water rose at a steady rate from 3 p. m. until about 7:30 p. m., when there was a sudden rise of about four feet in as many seconds. I was standing at my front door, which was partly open, watching the water, which was flowing with great rapidity from east to west. The water at this time was about eight inches deep in my residence, and the sudden rise of 4 feet brought it above my waist before I could change my position. 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 five feet additional, making a total tide in that locality of about twenty 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 backwater on the Gulf side as a result of debris accumulating four to six blocks inland. The debris is piled eight to fifteen feet in height. By 8 p. m. a number of houses had drifted up and lodged to the east and southeast of my residence, and these with the force of the waves acted as a battering ram against which it was impossible for any building to stand for any length of time, and at 8:30 p. m. my residence went down with about fifty persons who had sought it for safety, and all but eighteen were hurled into eternity. Among the lost was my wife, who never rose above the water after the wreck of the building. I was nearly drowned and became unconscious, but recovered through being crushed by timbers and found myself clinging to my youngest child, who had gone down with myself and wife. Mr. J. L. Cline joined me five minutes later with my other two children, and with them

and a woman and child we picked up from the raging waters. We drifted for three hours, landing 300 yards from where we started. There were two hours that we did not see a house nor any person, and from the swell we inferred that we were drifting to sea, which, in view of the northeast wind then blowing, was more than probable. During the last hour that we were drifting, which was with southeast and south winds, the wreckage on which we were floating knocked several residences to pieces. When we landed about 11:30 p. m., by climbing over floating debris to a residence on Twenty-eighth street and Avenue P, the water had fallen 4 feet. It continued falling, and on the following morning the Gulf was nearly normal. While we were drifting we had to protect ourselves from the flying timbers by holding planks between us and the wind, and with this protection we were frequently knocked great distances. Many persons were killed on top of the drifting debris by flying timbers after they had escaped from their wrecked homes. In order to keep on the top of the floating masses of wrecked buildings one had to be constantly on the lookout and continually climbing from drift to drift. Hundreds of people had similar experiences.

Sunday, September 9, 1900, revealed one of the most horrible sights that ever a civilized people looked upon. About three thousand homes, nearly half the residence portion of Galveston, had been completely swept out of existence, and probably more than six thousand persons had passed from life to death during that dreadful night. The correct number of those who perished will probably never be known, for many entire families are missing. Where 20,000 people lived on the 8th not a house remained on the 9th, and who occupied the houses may, in many instances, never be known. On account of the pleasant Gulf breezes many strangers were residing temporarily near the beach, and the number of these that were lost can not yet be estimated. I inclose a chart, fig. 2, which shows, by shading, the area of total destruction. Two charts of this area have been drawn independently; one by Mr. A. G. Youens, inspector for the local board of underwriters, and the other by myself and Mr. J. L. Cline. The two charts agree in nearly all particulars, and it is believed that the chart inclosed represents the true conditions as nearly as it is possible to show them. That portion of the city west of Forty-fifth street was sparsely settled, but there were several splendid residences in the southern part of it. Many truck farmers and dairy men resided on the west end of the island, and it is estimated that half of these were lost, as but very few residences remain standing down the island. For two blocks, inside the shaded area, the damage amounts to at least fifty per cent of the property. There is not a house in Galveston that escaped injury, and there are houses totally wrecked in all parts of the city. All goods and supplies not over eight feet above floor were badly injured, and much was totally lost. The damage to buildings, personal, and other property in Galveston County is estimated at about thirty million dollars. The insurance inspector for Galveston states that there were 2,636 residences located prior to the hurricane in the area of total destruction, and he estimates 1,000 houses totally destroyed in other portions of the city, making a total of 3,636 houses totally destroyed. The value of these buildings alone is estimated at \$5,500,000.

The grain elevators which were full of grain suffered the smallest damage. Ships have resumed loading and work is being rushed day and night. The railroad bridges across the bay were washed away, but one of these has been repaired and direct rail communication was established with the outside world within eleven days after the disaster. Repairs and extensions of wharfs are now being pushed forward with great rapidity. Notwithstanding the fact that the streets are not yet clean and dead bodies are being discovered

daily among the drifted debris, the people appear to have confidence in the place and are determined to rebuild and reestablish themselves here. Galveston being one of the richest cities of its size in the United States, there is no question but that business will soon regain its normal condition and the city will grow and prosper as she did before the disaster. Cotton is now coming in by rail from different parts of the State and by barge from Houston. The wheels of commerce are already moving in a manner which gives assurance for the future. Improvements will be made stronger and more judiciously; for the past twenty-five years they have been made with the hurricane of 1875 in mind, but no one ever dreamed that the water would reach the height observed in the present case. The railroad bridges are to be built ten feet higher than they were before. The engineer of the Southern Pacific Company has informed me that they will construct their wharfs so that they will withstand even such a hurricane as the one we have just experienced.

I believe that a sea wall, which would have broken the swells, would have saved much loss of both life and property. I base this view upon observations which I have made in the extreme northeastern portion of the city, which is practically protected by the south jetty; this part of the city did not suffer more than half the damage that other similarly located districts, without protection, sustained.

From the officers of the U. S. Engineer tug *Anna*, I learn that the wind at the mouth of the Brazos River went from north to southwest by the way of west. This shows that the center of the hurricane was near Galveston, probably not more than 30 miles to the westward. The following towns have suffered great damage, both in the loss of life and property: Texas City, Dickinson, Lamarque, Hitchcock, Arcadia, Alvin, Manvel, Brazoria, Columbia, and Wharton. Other towns further inland have suffered, but not so seriously. The exact damage at these places can not be ascertained.

A list of those lost in Galveston, whose names have been ascertained up to the present time, contains 3,536 names.—*Isaac M. Cline, Local Forecast Official and Section Director.*

In tracing the hurricane from Galveston back over the Gulf of Mexico, reports from Gulf stations only are available during the early part of the 8th and on the 7th. On the 6th the Cromwell Line steamer *Louisiana* passed through the center of the hurricane in the middle-eastern part of the Gulf. The fact that this is the only vessel that is known to have encountered the storm in the Gulf of Mexico indicates that the Weather Bureau warnings and advices were generally observed at Gulf ports. It is apparent, from the following description by Captain Halsey, of the *Louisiana*, that the storm acquired hurricane intensity immediately after leaving the Florida coast, and it is equally evident that sailing vessels could scarcely escape serious injury or total loss in a storm of the character experienced by the *Louisiana*.

We left New Orleans at 9:20 a. m. of September 5, and passed the bar at 5:22 p. m. that afternoon. The warning flag was up at Port Eads as we ran out. The wind was hard from the east-northeast, and the barometer was at 29.87. By 6 o'clock the next morning the barometer was at 29.60 and falling, and the wind was blowing a gale from the north-northeast and circling to the north. At 10 o'clock the wind was north and the barometer marked 29.25, and at 1 p. m. the barometer had fallen to the remarkable figure of 28.75 and we were in the storm center.

I do not like to speak of anything outside of the log record, but I think the wind was blowing at the rate of more than 100 miles an hour. It went rapidly from the north to north-northeast, then to north-northwest, west, and south. We were about half way across the Gulf when the storm center passed us, and the sea which it raised was so severe that we heave to from 12 to 3 o'clock. The gale held until about 12 o'clock that night, when it began to moderate.

The most probable course of the hurricane from the 6th to 9th is shown on charts Nos. IX to XII of this REVIEW. We also give in tabular form the cloud data that were available

Amount, kind, and direction of clouds from September 6-9, 1900.

Stations.	September 6.						September 7.						September 8.						September 9.					
	A. M.			P. M.			A. M.			P. M.			A. M.			P. M.			A. M.			P. M.		
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.
Port of Spain, Trinidad....	1 few	ci. s. a. s. cu.	e. e. e.	1	ci. cu.	e. e.	8 few	ci. cu.	ne. e.	few	cu.	e.	few	ci. cu.	se. e.	9 few	ci. cu.	s. e.	2	ci. cu.	calm. se.	few	ci. cu.	s. e.
Bridgetown, Barbados.....	4	cu.	e.	2	cu.	e.	6	ci. cu.	ne. e.	2	cu.	e.	4	cu.	e.	1	cu.	e.	7	cu.	e.	6	s. cu.	se.
Roseau, Dominica.....	1	cu.	ne.	9 few	ci. a. cu.	calm. e.	few	ci. cu.	calm. e.	2	ci. cu.	calm. e.	1	ci. cu.	calm. e.	2	cu.	e.	few	ci. cu.	calm. e.	5	cu.	e.
Baseterre, St. Kitts.....	1	ci. s. cu.	n. s.	9	a. s. s. cu.	e. e.	4	ci. a. cu.	n. nw.	1	cu.	e.	4	cu.	e.	1	cu.	e.	4	cu.	e.	4	cu.	ne.
San Juan, Porto Rico.....	1	a. s. cu.	nw.	2	a. cu. s.	s.	1	a. cu.	nw.	6	a. s. s.	calm. s.	1	ci. a. s. n.	ne. n.	8	a. s. n.	n.	1	s. cu.	e.	5	s. cu.	e.
Santo Domingo, San. Dom. ....	few	ci. a. cu.	n. s.	3	cu. s.	se.	few	s. ci.	n.	10	s. cu.	sw.	few	s. cu.	se.	1	ci. cu.	w.	2	ci.	w.	4	a. cu.	e.
Kingston, Jamaica.....	3	a. cu. n.	s. se.	10	s. cu. s.	se.	10	n.	e.	10	s.	se.	4	a. cu. s. cu.	nw. ne.	2	a. cu. s. cu.	ne. n.	4	a. cu. s. cu.	w. w.	10	s. cu.	e.
Grand Turk, Turks Island .	3	ci. cu.	se.	4	ci. cu.	se.	4	ci. cu.	se.	5	a. s. cu.	se.	5	a. s. cu.	se.	2	s. cu.	se.	3	cu.	se.	10	n.	s.
Santiago de Cuba, Cuba....	10	cu.	se.	10	cu.	s.	10	n.	s.	10	cu.	nw.	10	n.	s.	10	n.	s.	3	a. s. cu.	calm. s.	10	n.	s.
Puerto Principe, Cuba.....	3	a. s. s.	s. s.	10	s.	s.	10	s.	s.	10	s. cu.	s.	5	a. s. s. cu.	calm. ne.	10	n.	nw.	3	a. s. cu.	calm. sw.	10	n.	ne.
Cienfuegos, Cuba.....	10	n.	s.	10	a. s. se	se	few	a. cu. w.	9	a. cu. n.	9	a. s. n.	10	s. cu. ne.	few	s. cu.	calm. s.	10	s. cu.	calm. s.	10	s. cu.	n.	
Havana, Cuba.....	5	ci. s. cu.	w. sw.	3	a. s. cu. n.	s.	2	ci. a. cu. s.	8	a. s. w.	6	a. cu. w.	5	s. cu. ne.	1	ci. a. cu. n.	calm. ne.	1	ci. a. cu. n.	calm. ne.	1	ci. a. cu. n.	calm. ne.	
Key West, Fla.....	9	s. cu.	s.	9	s.	s.	10	n.	s.	3	s. cu.	s.	2	a. s. s. cu.	sw.	1	a. s. s. cu.	calm. ne.	1	ci. s. cu.	w.	5	s. cu.	e.
Jupiter, Fla.....	10	n.	e.	10	s.	s.	8	s.	se.	10	s.	s.	8	s. cu.	se.	3	s. cu.	se.	3	s. cu.	se.	7	s. cu.	se.
Tampa, Fla.....	10	n.	calm.	9	s.	se.	1	a. cu. se.	7	cu.	se.	9	s. cu.	e.	1	a. s. cu.	calm.	7	ci.	n.	few	a. s. cu.	calm.	
Jacksonville, Fla.....	2	ci. cu.	s.	10	s. cu.	e.	1	ci. s. cu.	calm. e.	3	a. s. s. cu.	se.	2	ci. w.	few	cu.	e.	2	cu.	e.	2	cu.	e.	
Savannah, Ga.....	5	s. cu.	e.	4	a. s. cu.	sw.	6	s. cu. se.	5	ci. s. cu.	n.	5	ci. s. cu.	w.	2	ci. s. cu.	nw.	2	cu.	se.	1	cu.	e.	
Montgomery, Ala.....	1	ci.	se.	6	ci. s. cu.	e.	4	cu. n. e.	2	cu.	se.	2	cu.	e.	3	a. cu. e.	2	cu.	se.	few	s. cu.	calm.		
Mobile, Ala.....	5	ci. s. a. s.	ne. ne.	4	a. s. a. cu.	ne.	few	s. cu. e.	3	s. cu. e.	3	ci. s. cu.	3	ci. s. cu.	e.	6	ci. s. cu.	se.	2	ci. cu.	calm.	1	ci. s. cu.	w.
New Orleans, La.....	4	ci. s.	e.	9	a. s. s.	sw.	2	ci. s. cu.	se.	10	n.	ne.	10	s. cu. se.	10	s. cu. se.	10	s. cu. se.	1	ci. s. cu.	calm.	10	s. cu. s.	
Vicksburg, Miss.....	0	0	calm.	6	a. s. a. cu.	ne.	3	ci. se.	6	s. cu. e.	5	ci. s. cu.	7	a. s. cu.	8	a. s. cu.	8	a. s. cu.	4	ci. s. cu.	e.	4	ci. s. cu.	e.
Galveston, Tex.....	0	0	calm.	4	a. s. s. cu.	ne.	6	ci. n.	10	s. cu. ne.	10	s. cu. ne.	10	s. cu. ne.	10	s. cu. ne.	10	s. cu. ne.	10	s. cu. ne.	10	s. cu. ne.	10	s. cu. ne.
Palestine, Tex.....	2	cu.	e.	0	0	calm.	10	ci.	ne.	8	ci.	nw.	1	cu.	ne.	10	s.	ne.	10	n.	ne.	10	n.	se.

during the progress of the storm. The chief interest in the latter lies in the fact that there is an absence of suggestion or positive information in them as to the exact location of the center of the hurricane.

At New Orleans, La., advisory messages on the 4th and 5th were followed the afternoon of the 5th by an order to hoist the storm warning. During the 6th many inquiries were made at that office by owners and masters of outward-bound vessels, and in each case the advices were to delay departures until after the passage of the storm. The effects of the storm began to be felt at New Orleans the morning of the 7th, and a wind velocity of 56 miles an hour was recorded at Port Eads at that time. At New Orleans the Shell Road to West End was rendered impassable by the rising waters of the canal, and nearly all other canals and bayous were bank full with water backing from Lake Pontchartrain. The 8th was one of the windiest and stormiest September days ever experienced in New Orleans, and the maximum wind, 47 miles an hour, was within 1 mile of the highest wind ever recorded at that station in September. The local New Orleans press commented upon the storm as follows:

Times-Democrat, September 8, 1900:  
Of yesterday's storm we had, as usual, ample notice. The Weather

Bureau hung out storm warnings on Thursday, and as a consequence no vessels have put to sea of late. It was impossible to do more than this, but the people were put on their guard and waited to see at what point the storm would strike, for, like lightning, it seldom strikes twice in the same place.

Daily States:  
Had not the blow been so well advertised by the Weather Bureau there might have been considerable damage done to shipping. As it was all the men of the sea were on their guard, and, so far as can be ascertained at this writing, there were only two vessels in this immediate vicinity lost, etc.

At Mobile and Pensacola the warnings were given an equally effective distribution, and they were universally heeded by shipmasters.

At Tampa, Fla., all shipping remained in harbor, except the schooner *Olive*, 135 tons, bound for Biloxi, Miss., which left while the warnings were flying. This vessel is reported missing. During the day and night of the 5th the gales which attended this storm scarcely attained hurricane force; they were sufficiently strong, however, to wreck a number of vessels on the keys and coasts of the southern Florida Peninsula. The captain of the steamship *Comal* felt the storm off Jupiter, Fla., and made no headway for twenty-four hours. He reports that sailing vessels could not stand the gale and were

driven ashore. Mr. A. J. Mitchell, Official in charge of the Weather Bureau station at Jacksonville, Fla., reports that—

The warnings were of great value to the large fleet of small sponge and fishing vessels on the lower coast, particularly from Cedar Keys south, and, so far as can be ascertained, 131 vessels, valued, with their outfits, at about \$200,000, with crews numbering 235 men, delayed sailing on account of the display of the warnings.

During September 4 the influence of the storm extended over Cuba and the northwest Caribbean Sea. It had at that time developed but little force, but had caused torrential rains at many places. At Santiago de Cuba 12.58 inches of rain fell in twenty-four hours, of which amount 10.42 inches fell from noon to 8 p. m. of the 3d. During the first three days of the month the disturbance possessed but slight intensity, and is traced to the vicinity of the Windward Islands, where there was evidence of its development on the last day of August.

Returning to a consideration of the storm from the time its vortex passed Galveston, we find that, according to the custom of storms of this class, it experienced a rapid loss of energy after it had passed inland from the coast. Moving northward during the 9th and 10th as a disturbance of small strength, the center reached Iowa on the morning of the 11th, where it manifested considerable energy. During the ensuing twenty-four hours the storm passed eastward over the Great Lakes, attended by gales of unusual violence. Along this part of the storm's track ample warnings had also been sent, and a general observance of the warnings by the shipping interests reduced to a minimum the damage it caused in the Lake region. On the morning of the 12th, when the storm was central in the St. Lawrence Valley, a special bulletin issued by the Chief of the Weather Bureau at Washington contained the following:

There is little doubt that severe and dangerous gales will be encountered to-night and to-morrow over the Banks of Newfoundland and along the west part of the trans-Atlantic steamship routes.

Reports of incoming vessels show that unusually severe and especially destructive gales prevailed over and near the Grand Banks during the period specified.

The widespread interest which has been taken in this storm and in the work of the Weather Bureau in determining and forecasting its position, character, and course is indicated by the following press comments, which have been selected from a great number of articles of a like character which have been published by representative newspapers of the United States.

Editorial from the New York Evening Sun, September 20, 1900:

Meteorology is so complete a science that it can usually be depended on to give warning of the approach of dangerous storms. The value of the Weather Bureau's forecasts of what was destined to happen at Galveston can not be overestimated. According to Texas papers the Government indications did not leave that city or any part of the adjoining coast in ignorance of the prospective magnitude or violence of the storm. The people of Galveston read in the papers at their breakfast tables on Saturday that they were directly in the path of the disturbance, which had been working westward over the Gulf for nearly two days. The danger was upon them at that very hour, for the first burst of the gale struck the city between 8 and 9 o'clock a. m. Dr. Cline, the chief of the local weather station, was then at his office. From that hour until 3 o'clock in the afternoon he kept a man at the telephone, who called up every town and hamlet and all country residents within reach, informing them that there were signs of an inundation, and answered hundreds of calls for reports from the city and country, by which the news was spread on every hand.

The warnings which were sent out by Dr. Cline are said to have saved thousands of lives along the coast. The Texas papers show that in some towns and villages and at many plantations and farms the force of the wind and the rise of water were as necessarily fatal to

life as at Galveston, but that the inhabitants and residents profited by their information to escape inland. The actual signs of the approach of the tempest were correctly read by Dr. Cline, and he was supplied with still further information from Washington. The difference between the heights of the barometer at Galveston and New Orleans and points north and west of the Texas city was the best prophecy of what might take place, and all through Saturday morning and until the weather station was closed the pressure showed that the worst was yet to come and would probably be some hours in arriving. The steady increase of the force of the wind and the gradual rise of the water on both sides of the city, the breakers on the Gulf beach rolling high, the rush of the sea into the bay, easily seen on the water front, and the backing up of the flood in the bay under the violent northeast gale, which soon made canals of the streets, left no doubt in the minds of cautious citizens that a catastrophe was imminent. Had the impression these facts created been more generally extended by a proper use of the information obtainable from the weather station, some thousands of lives which were lost might have been saved.

The idea may be dismissed as purely scientific, theoretical, and academic by very many intelligent persons. But none, except a fatalist, or one who does not believe in the uses of modern science, can neglect the lesson of the warnings. It seems that perhaps the largest number of lives were lost as a result of a refusal to accept them. The oldest residents were not thrown into a panic even when the water had flooded the whole city. They remembered the height reached by the tide in the storm of 1875, and as most of them, having built their houses after that event so that the first floor was above the level of danger then, were dwelling in such residences or had friends who occupied them, they repaired to these refuges. But the water climbed above its old mark and the wind, reaching a maximum at times of 100 miles an hour, assisted it in destroying nearly all of the stoutest houses. Dr. Cline occupied such a building, and was confident that the water would not reach his first floor, but his home was utterly demolished. He spent all the late afternoon in carefully watching the advancing height of the water and he did not give up his hope that his place would withstand the storm until the 1875 water mark was passed. In that last hour he waved warnings from his porch to his neighbors, telling them to fly to higher ground. Some could heed his warnings, but by far the most of the people were caught in the same way that he was.

Other proof of the value of the Weather Bureau's warnings is not wanting. Thousands of persons dwelling along the beach and east and west of Galveston fled to places of safety in spite of the fact that many persons far inland were drowned. Almost all of them had news from the weather station which told them of their danger. The beach residents fled, and the islanders were confident, like Dr. Cline and other residents of Galveston, that the storm could not bring the flood high enough to eat away the foundations of their houses. These people could nearly all have been alive at this moment. All this goes to show that the inhabitants of this country, especially those who are residents of districts liable to floods, should under no circumstances and at no time refuse to heed the warnings of the Weather Bureau. They would do well to observe and obey these with a degree of prudent caution equal to that displayed by the ship's master who takes note of the cautionary warnings at the Government's stations when it comes time to put to sea.

From the Boston Herald, September 17, 1900.

The excellent service rendered by the Weather Bureau during the recent storms, which carried havoc in their path, is deserving of recognition. It was not through any lack of attention on the part of the forecasters that the victims of the hurricane on the Texas coast were overtaken by such a terrible disaster. The weather office sent out its hurricane warnings both for the Atlantic and Gulf coasts, and when the storm turned from the north of Cuba westward the Bureau turned its attention to Texas, and on the morning of the 7th, nearly thirty-six hours before the disaster, warned the people of Galveston of its coming, and during that day extended its warnings all along the Texas coast, thus preventing vessels from leaving. Furthermore, the weather officials were remarkably successful in anticipating the coming of the hurricane, with less force, up toward the lakes, and thence in this direction. That such horrible disasters followed in the storm's path must be taken as showing either that the warnings were unheeded or that the havoc wrought was something inevitable.

From the Buffalo, N. Y., Courier of September 16, 1900:

The accuracy with which the coming and the course of the recent great storm were predicted, and the promptness with which warning was furnished to the mariners of the Gulf coast and the Great Lakes, afforded reason for noting the advanced efficiency of the United States Weather Bureau.

Editorial from the Marine Record, Ohio, September 13, 1900:

The Weather Bureau, also the officers in charge of lake stations,

gave full and ample warnings of Tuesday night's gale which swept over the lakes with such sad results to life and property. There can be no doubt but that this one warning alone has repaid the country for the outlay of the entire annual appropriation granted by Congress for the maintenance of the service. Too much credit can not be given to the Chief of the Weather Bureau and the officers in charge of lake stations for the energetic and well advised measures taken to warn vessels of the approach of the late gale and its probable severity.

Editorial from the Inter-Ocean, Chicago, Ill., September 14, 1900.

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 Simple justice demands public recognition of the efficiency of the Chief of the Meteorological Bureau and his staff. They have demonstrated their usefulness in such manner as to set at rest all doubt with regard to the wisdom the Government has displayed in maintaining the weather service against all opposition and all ignorant prejudices.

The heated period which prevailed almost continuously over the eastern part of the United States during July and August was permanently broken by the tropical storm described herein, and advices to this effect were given in a special bulletin which was issued the morning of September 12, 1900.

From the 15th to the 18th a cool wave, which produced the first frost of the season, extended from the Northwestern States over the Lake region, and frost occurred in the Northwestern States from the 25th to the 27th. Warnings of these frosts were distributed over the districts visited. In the north Pacific coast States the occurrence of frost on the 19th, 24th, 25th, 27th, and 28th was, as a rule, predicted.

On the 23d and 24th snow fell in the mountains and hills about Salt Lake City, Utah. The Weather Bureau observer at Cheyenne, Wyo., reports that snow fell as far west as Evanston, and that a depth of 13 inches was measured at Sherman the morning of the 25th. On the 24th railroad contractors working on a big contract on Sherman Hill were specially informed by the Weather Bureau observer at Cheyenne of the approaching storm.

Toward the close of the month damage was caused by a rapid rise in the Colorado, Brazos, and Trinity rivers, Texas. Towns on the Colorado, south of Austin, were warned of the impending flood, and the inhabitants of the bottom lands of the Trinity were warned in time to escape. Interests along the Brazos River were also warned, on the 27th, that the rise would continue during the next few days and overflow low land.



## Movements of centers of areas of high and low pressure.

Number.	First observed.			Last observed.			Path.		Average velocities.	
	Date.	Lat. N.	Long. W.	Date.	Lat. N.	Long. W.	Length.	Duration.	Daily.	Hourly.
<b>High areas.</b>										
I.....	1, a. m.	47	123	5, p. m.	42	70	2,950	4.5	655	27.3
II.....	4, p. m.	53	114	8, a. m.	45	64	2,475	3.5	707	29.5
III.....	7, a. m.	52	114	11, p. m.	46	60	2,575	4.5	572	23.8
IV.....	12, a. m.	52	114	16, a. m.	46	60	2,650	4.0	665	27.7
V.....	14, a. m.	54	114	21, a. m.	48	52	4,285	7.0	612	25.5
VI.....	19, p. m.	41	124	21, p. m.	48	122	530	2.0	260	10.8
VII.....	20, a. m.	43	109	26, a. m.	45	52	3,625	6.0	604	25.2
VIII.....	24, p. m.	53	114	29, a. m.	46	60	3,885	4.5	641	26.7
IX.....	29, a. m.	52	114	3, a. m.*	48	52	3,000	4.0	750	31.2
	29, p. m.	41	88							
Sums.....							27,125	43.5	6,081	253.3
Mean of 10 paths.....							2,712	.....	608	25.3
Mean of 43.5 days.....									624	26.0
<b>Low areas.</b>										
I.....	1, a. m.	15	67	12, p. m.	46	60	5,200	11.5	452	18.8
II.....	1, a. m.	44	103	2, a. m.	48	89	725	1.0	725	30.2
III.....	3, a. m.	45	118	7, a. m.	48	52	3,295	4.0	824	34.3
IV.....	10, a. m.	21	82	17, a. m.	46	60	3,150	7.0	450	18.8
V.....	13, a. m.	51	120				3,250	4.0	812	33.9
VI.....	11, a. m.	54	114	15, a. m.	48	52	2,935	4.0	734	30.6
VII.....	14, a. m.	22	60	19, a. m.	48	52	2,575	5.0	515	21.5
VIII.....	15, a. m.	44	116	24, a. m.	48	52	3,975	9.0	442	18.4
IX.....	17, a. m.	33	115				3,825	7.0	546	22.8
	22, a. m.	51	120	25, p. m.	48	86	2,130	3.5	609	25.4
	26, p. m.	54	114	30, a. m.	49	88	1,220	3.5	349	14.5
Sums.....							32,280	59.5	6,458	269.2
Mean of 11 paths.....							2,935	.....	587	24.5
Mean of 59.5 days.....									543	22.6

\* October.

*Lows.*—With the exception of those of tropical origin, none of the low centers appeared south of the forty-second parallel except the lower section of No. VII, which was first noticed in southwestern Arizona. In fact they were for the most part limited to that portion of the country north of the forty-fifth parallel. Their mean direction of movement was almost due eastward or east-southeastward, and three of them, Nos. II, VIII, and IX, disappeared to the northeastward after leaving Lake Superior. No. II was a depression that had remained practically stationary over the extreme northwest since the morning of August 28, and it was not until the morning of September 1 that any progressive tendency developed. There was also a depression over the northwest from the evening of the 6th until the evening of the 10th, or until the tropical storm charted as No. I had turned eastward while leaving northern Kansas.

Of the three tropical storms—Nos. I, IV, and VI—No. I stands forth most prominently as the destructive hurricane of the early days of the month which created such terrible devastation and destruction at Galveston, Tex. A full history of this storm appears in another portion of this REVIEW. No. IV was a moderate disturbance, without destructive energy, which first appeared south of Cuba on the morning of the 10th. It reached the Louisiana coast by the evening of the 12th, and then recurved to the northeastward, reaching the southern New England coast on the morning of the 16th; it then moved northward to eastern Ontario, where it was joined by another depression of nearly equal intensity; it continued eastward in the track of the latter through Cape Breton Island into the Atlantic. No. VI was first reported by the captain

of the steamship *Hungaria* in latitude 21°, longitude 60°, on the 13th. It moved slowly northward, apparently passing westward and close to the islands of Bermuda on the evening of the 17th. It moved more rapidly during the night of the 17th, and on the morning of the 18th was evidently central a short distance southeast of the southern New England coast, from whence it turned northeastward along the coast, passing off the Newfoundland coast on the morning of the 19th. This storm caused only moderately high winds on the New England and middle Atlantic coasts, but was evidently much more severe in its effects over its ocean path.—H. C. Frankenfield, Forecast Official.



rior it was the combination of three different sections that had originated, one in Alberta, one in western South Dakota, and the third in the Texas panhandle. The two latter sections merged into one in the middle Missouri Valley, to be joined two days later by the first section over northwestern Lake Superior. No. X was a tropical disturbance of moderate energy, which was first noted on the morning of the 23d over the southern portion of the Windward Islands. It moved very slowly northwestward to the Bahamas, and then recurred to the northeastward. It was finally noted while passing Bermuda. Another tropical disturbance, No. V, originated over southeastern Cuba, moved northwestward off the west Florida coast, and then turned northward along the coast to Maine, finally passing out beyond the Gulf of St. Lawrence. No. III was first observed at Bermuda; moved northwestward to the Massachusetts coast, and thence northeastward along the coast to Cape Breton Island. Nos. VII, VIII, XII, and XV originated on or near the north Pacific coast and dissipated in from twenty-four to thirty-six hours in the British Northwest.

There was a low, which was not charted, over the west Gulf of Mexico from the morning of the 4th to the evening of the 5th. It was evidently a tropical disturbance of minor character that moved in from the Caribbean Sea. There was also a stationary depression over the middle and northern Plateaus and Pacific coast from the morning of the 1st to the evening of the 4th, and another over the south Pacific coast and southern Plateau from the morning of the 9th to the morning of the 11th. During the 11th the latter moved to the middle California coast and disappeared.

There were lows over the British Northwest from the evening of the 10th to the evening of the 13th, and from the morning of the 23d to the morning of the 26th. The former began to move eastward during the night of the 13th, and is charted as No. VI.—*H. C. Frankenfield, Forecast Official.*

*Movements of centers of areas of high and low pressure.*

Number.	First observed.			Last observed.			Path.		Average velocities.	
	Date.	Lat. N.	Long. W.	Date.	Lat. N.	Long. W.	Length.	Duration.	Daily.	Hourly.
<b>High areas.</b>										
I.....	6, a. m.	51	114	9, p. m.	48	68	3,095	3.5	884	36.8
II.....	8, a. m.	43	110	14, a. m.	46	60	3,125	6.0	521	21.7
III.....	14, a. m.	35	90	15, a. m.	38	80	650	1.0	650	27.1
IV.....	14, p. m.	51	114	18, a. m.	38	80	1,825	3.5	521	21.7
V.....	17, a. m.	53	109	24, a. m.	46	60	3,425	7.0	489	20.4
VI.....	23, a. m.	44	116	26, a. m.	45	64	2,625	3.0	875	36.5
VII.....	23, p. m.	41	124	28, p. m.	46	60	3,625	5.0	725	30.2
VIII.....	26, a. m.	46	123	2, p. m.†	32	65	3,950	7.5	527	22.0
Sums.....							22,320	36.5	5,192	216.4
Mean of 8 paths.....							2,790		649	27.0
Mean of 36.5 days.....									612	25.5
<b>Low areas.</b>										
I.....	30, a. m.*	44	116	2, a. m.	41	96	1,100	2.0	550	22.9
II.....	4, p. m.	45	123	8, a. m.	49	68	2,825	3.5	807	33.6
III.....	10, a. m.	32	65	11, p. m.	46	60	1,350	1.5	900	37.8
IV.....	8, p. m.	54	114	11, a. m.	48	89	1,125	2.0	562	23.4
V.....	10, a. m.	20	76	15, p. m.	49	68	2,700	5.5	491	20.5
VI.....	14, a. m.	45	110	18, a. m.	48	54	2,900	4.0	725	30.2
VII.....	18, a. m.	50	120	19, a. m.	51	104	825	1.0	825	34.4
VIII.....	19, a. m.	45	123	20, p. m.	53	105	1,175	1.5	783	32.6
IX.....	20, a. m.	44	103	23, a. m.	48	89	1,175	3.0	392	16.3
X.....	20, p. m.	35	102				1,250	2.5	500	20.8
XI.....	21, a. m.	54	114				1,400	2.0	700	29.2
XII.....	23, a. m.	15	62	30, a. m.	32	65	2,150	7.0	307	12.8
XIII.....	24, a. m.	46	106	27, a. m.	43	77	2,125	3.0	708	29.5
XIV.....	27, a. m.	49	123	28, a. m.	54	114	550	1.0	550	22.9
XV.....	27, a. m.	44	103	28, p. m.	48	87	1,050	1.5	700	29.2
	28, p. m.	38	114	3, a. m.†	48	54	3,445	5.5	626	26.1
	30, a. m.	49	122	31, p. m.	53	108	720	1.5	480	20.0
Sums.....							27,965	48.0	10,606	442.2
Mean of 17 paths.....							1,639		624	26.0
Mean of 48 days.....									580	24.2

\* September.

† November.

*Lows.*—The movements of the fifteen lows were extremely erratic, and were remarkable for the fact that none was over the eastern half of the country south of Canada, except three of tropical origin, Nos. III, V, and X, that passed up the Atlantic coast. The majority originated either in the British Northwest or first appeared on the north Pacific coast. The paths, as a rule, were quite short, only three, Nos. II, VI, and XIV, moving across the country. When No. IX passed beyond the field of observation to the northward of Lake Super-