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Since Duplicate and Compass Whist have come into fashion there has been an unprecedented revival of interest in the game, due to the fact that mere *luck* is to a large extent eliminated by a comparison of the scores made in the play of the same hands by different players.

The one thing needed to perfect the new method has been a convenient device by means of which the score made on the first round can be concealed until after the replay of the hands, as a knowledge of the first score often enables a good player to make a decisive gain, and matches are lost and won on just such little chances.

A Washington player has at length invented and put upon the market at a very low price a little device which admirably answers the purpose, and at the same time serves as a pretty and useful table ornament, marker, and pencil rest. It is called the "Cosmos Counter," and consists of a little polished wood tablet with a metal keyboard that can be clamped down on the score in such a way as to bring 24 little metal plates over the 24 spaces in the "score" column of the card, for use in concealing each first score as soon as recorded and until the hand is replayed (in duplicate whist) or the entire series finished (in compass whist).

Whist players will at once see the advantage of this new method of keeping the score, as it effectually prevents their opponents at the same or another table from taking advantage, either by accident or design, of a knowledge of what the hand is capable. The trouble with duplicate whist, especially, is that the replay is liable to be influenced by memory of the cards and score, and anything that helps to confuse such recollection is a great gain to fair play.

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S	W

HAND	COMPASS WHIST					HAND
	SCORE	TOTALS	TRUMP	OPPONENTS		
	DUPLICATE WHIST					
	SCORE	GAIN	TRUMP	GAIN	SCORE	
1						1
2						2
3						3
4						4
5						5
6						6
7						7
8						8
9						9
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11						11
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22						22
23						23
24						24
TOTALS						TOTALS

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THE
National Geographic Magazine

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STORMS AND WEATHER FORECASTS

By Professor Willis L. Moore,
Chief of the United States Weather Bureau

While the practical application of meteorological science to the making of weather forecasts will never reach the degree of accuracy attained by theoretical astronomy in predicting the date of an eclipse or the return of a comet, meteorology has made during the last century such substantial progress as to seriously engage the attention of thoughtful man and cause him to make special effort to apply the knowledge gained to the commerce and industry of the world.

Comparing meteorology with astronomy, we may say that it passed through the Chaldaean and Ptolemaic periods with the invention of the barometer and thermometer early in the 17th century; that it reached the Copernican stage with the discovery of the rotary and progressive motion of storms, and that it now awaits the genius of a Kepler or the magic intuition of a Newton to unravel the mysteries that still baffle the student.

But it is doubtful whether any other branch of science, unless it be electricity, has shown more wonderful progress during the past quarter-century. Where man but a few years ago, on account of his limited range of vision, thought that chaos reigned supreme, we are now able, by the aid of daily meteorological observations and the wonderful telegraph joining our cities by an electrical touch, to trace out the harmonious operations of many physical laws that previously were unknown.

Practical meteorology is to some extent a tentative work. It may be placed upon a plane with the theory and practice of medicine and surgery. The forecaster is in a degree guided in his calculations by symptoms, and he is able to diagnose the atmospheric conditions with about the same degree of accuracy that the physician is able to determine the bodily condition of the patient. He is able to forecast changes in the weather with rather more certainty than the skilled physician can predict the course of a well-defined disease.

As to the genesis of weather forecasting, it must be said that to the immortal Franklin belongs the credit of divining that storms have a rotary motion and that they progress in an easterly direction. To be sure, without the aid of the telegraph and of simultaneous observations his discovery was little more than a speculation; nevertheless it was one of those sagacious anticipations of coming knowledge which mark the true scientific genius. Grand as a patriot, able as a statesman and diplomat, he was no less great as a student in the broad domain of science; he was one of the isolated figures that stand so far in advance of the knowledge of their day as often to be imperfectly understood. His idea of drawing the lightning from the clouds and identifying it with the electric currents of the earth was capable of physical demonstration, but his contemporaries did not appreciate his philosophy of storms, written in a fragmentary manner before 1750, and so it remained for Redfield, Espy, Henry, Loomis, Maury, and other Americans, 100 years later, to gather the data and completely establish that which the great Franklin so accurately had outlined. American meteorologists can justly take pride in the achievements of these their countrymen.

In 1855 Professor Joseph Henry, of the Smithsonian Institution, collected, by telegraph, observations from a number of stations and displayed a large map showing the meteorological conditions at these points, but the breaking out of the civil war caused him to suspend his reports. He made oral forecasts and used his charts for the purpose of demonstrating the utility of a government meteorological service and the feasibility of making forecasts from daily, telegraphic, synchronous observations. If there were no other achievements to the credit of this great institution, the work of Professor Henry in connection with practical meteorology would alone be sufficient to command the admiration of all who love knowledge because of the benefits it confers upon man. As we glance into the past and hastily note the mileposts along the highways of science, the lives and actions of those who gave new thoughts, or who by their discoveries opened up useful and diverging paths, stand like lofty beacon towers, marking the rugged pathway pursued by advancing civilization.

Professor Buys-Ballot, of Utrecht, induced Holland to establish a weather service, with telegraphic reports and forecasts, in 1860; England followed with a similar service in 1861, and France in 1863. The United States was the fourth government to establish a permanent weather service, although its scientists were the pioneers in discovering the progressive character of storms and in demonstrating the practicability of weather services. In 1869 Professor Cleveland Abbe published a weather bulletin and forecast at Cincinnati, based upon simultaneous observations secured by telegraph from about 30 stations.

From the introduction of the electro-magnetic telegraph in 1844 down to 1869 intermittent and desultory advocations for a government weather service were made by many in this country. Finally Dr Increase A. Lapham, of Milwaukee, student, scientist, and philanthropist, so aroused the property and industrial interests of the country by the facts that he presented relative to the destruction of life and property by storms on Lake Michigan that Congress, under the provisions of a bill introduced by General Halbert E. Paine, was induced to appropriate money to initiate such a service. To General Albert J. Myer, Chief Signal Officer of the United States Army, was intrusted the duty of inaugurating a tentative weather service by deploying over the country as observers the military signalmen of his command.

The system by which the United States Weather Bureau collects meteorological observations and makes weather forecasts may be briefly described as follows. This morning at 8 o'clock, Washington time—which, by the way, is about 7 o'clock at Chicago, 6 o'clock at Denver, and 5 o'clock at San Francisco—the observers at about 150 stations scattered throughout the United States were taking their observations, and, from carefully tested and standardized instruments, noting all the elementary conditions of the air at the bottom of the great aerial ocean in which we live, and which, by its variations of heat and cold, sunshine, cloud, and tempest, affects not only the health and happiness of man, but his commercial and industrial welfare.

By 8.25 a. m. the necessary mathematical corrections have been made, the observations have been reduced to cipher, and each has been filed at the local telegraph office. During the next 30 or 40 minutes these observations, with the right of way over all lines, are speeding to their destinations, each station contributing its own observations and receiving in return, by an ingenious system of telegraph circuits, such observations from other stations as it may require. The observations from all stations are received at such centers as Washington, Chicago, New York, and other large cities, and nearly all cities having a Weather Bureau station receive a sufficient number of reports from other cities to justify the issuing of a daily weather map.

Before examining the accompanying charts, it may be well to glance at the Central Office in Washington, while the observations are coming in, so as to get an idea of how the charts are made for the study of the forecast official. From these he gets a panoramic view, not only of the exact conditions of the air over the whole country at the moment of taking the observations one hour before, but of the changes which have occurred in those conditions during the preceding 24 hours. As fast as the reports come from the wires they are passed to the Forecast Division, where a reader stands in the middle of the room and translates the cipher into figures and words of intelligible sequence. A force of clerks is engaged in making graphic representations of the geographical distribution of the different meteorological elements. On blank charts of the United States each clerk copies from the translator that part of each station's report needed in the construction of his particular chart. One clerk constructs a chart showing the change in temperature during the preceding 24 hours. Broad, red lines separate the colder from the warmer regions, and narrow red lines inclose areas showing changes in temperature of more than 10 degrees. The narrow lines generally run in oval or circular form, indicating (as will be shown subsequently) that atmospheric disturbances move and operate in the form of great progressive eddies; that there are central points of intensity from which the force of the disturbance diminishes in all directions.

A second clerk constructs a chart showing the change that has occurred in the barometer during the past 24 hours. As in the construction of the temperature chart, broad, heavy lines of red separate the regions of rising barometer from those of falling barometer. Narrow lines inclose the areas over which the change in barometer has been greater than one-tenth, and so on.

Here, for instance, throughout a great expanse of territory, all the barometers are rising—that is to say, the air cools, contracts, becomes denser, and presses with greater force upon the surface of the mercury in the cisterns of the instruments, thereby sustaining the columns of liquid metal at a greater height in the vacuum tubes. Over another considerable area the barometers are falling, as increasing temperature rarefies and expands the volume of the air, causing it to press upon the instruments with less force. This chart is extremely useful to the forecaster, since, in connection with the general weather chart, it indicates whether or not the storm centers are increasing or decreasing in intensity, and, what is of more importance, it gives in a great measure the first warning of the formation of storms.

A third clerk constructs two charts, one showing the humidity of the air and the other the cloud areas, with the kind, amount, and direction of the clouds at each station. It is often interesting to observe at a station on the cloud chart high cirrus clouds composed of minute ice spiculæ moving from one direction, lower cumulo-stratus composed of condensed water vapor moving from another direction, and the wind at the surface of the earth blowing from a third point of the compass. Such erratic movements of the air strata are only observed immediately before or during rain or wind storms.

A fourth clerk constructs a chart called the general weather chart, showing for each station the air temperature and pressure, the velocity and direction of the wind, the rain or snow fall since the last report, and the amount of cloudiness. The readings of the barometer on this chart are reduced to sea-level, so that the variations in pressure due to local altitudes may not mask and obscure those due to storm formation. Then lines, called isobars, are drawn through places having the same pressure. By drawing isobars for each difference in pressure of one-tenth of an inch the high- and the low-pressure areas are soon inclosed in their proper circles. The word "high" is written at the center of the region of greatest air pressure and the word "low" at the center of the area of least pressure. Under the influence of gravity the air presses downward and outward in all directions, thus causing it to flow from a region of great pressure toward one of less. The velocity with which the wind moves from the high toward the low will depend largely on the difference in air pressure. To better illustrate: If the barometer read 29.5 at Chicago and 30.5 at Bismarck, North Dakota, the difference of one inch in pressure would cause the air to move from Bismarck toward Chicago so rapidly that after allowing for the resistance of the ground there would remain a wind at the surface of the earth of about 50 miles per hour, and Lake Michigan would experience a severe "northwester."

The forecaster knows that high-pressure and low-pressure areas drift across the country from the west toward the east at the rate of about 600 miles daily, or about 37 miles per hour in winter and 22 miles per hour in summer; that the highs are attended by dry, clear, and cooler weather, and that they are drawing down, by a vortical action of their centers, the cold air from great altitudes above the clouds and causing it to flow away laterally along the surface of the earth in all directions from the center, and that the high-pressure areas sometimes become so intense in their vortical motion as to draw down such vast volumes of cold air that we call them cold waves.

In the downward movement of the air in cold waves we must concede that the loss of heat by radiation through a cloudless atmosphere is much greater than that dynamically gained by compression, or else we must assume that the air possesses such intense cold at the elevation from which it is drawn that notwithstanding the heat gained by compression in its descent it is still far below the normal temperature of the air near the surface of the earth.

The forecaster knows that although these intense high-pressure areas first appear in the extreme northwest, they do not depend on the land of their birth for the cold they bring to us, and that cold waves are not simply immense rivers of air which have been chilled by flowing over the great snow and ice fields of the Arctic regions, as was once thought. He is also familiar with the fact that in the low-pressure areas the conditions of the air and its various movements are exactly the reverse of what they are in the high; that the air is much warmer and moister, and that it is drawn spirally inward from all directions instead of being forced outward, as in the high; that it ascends as it approaches the center of the depression, sometimes causing rain or snow as it cools by expansion during its ascent, or as it encounters and mixes with air strata of lower temperature than its own.

We know that while our atmosphere expands upward to an altitude probably of 50 miles, it is so elastic and its expansion is so rapid as it recedes from the earth that half of its mass lies below the 3-mile level, and that our storms and cold waves are simply great swirls or eddies in the lower stratum of probably not more than 5 miles in thickness; that the air above the 6-mile level probably flows serenely eastward in these latitudes without being disturbed by our most severe storms.

The forecaster is further aware of the fact that our high-pressure and low-pressure areas alternately drift eastward in periods that average about 3 days each; that they are not in any sense the product of chance, but are part of that great divine economy that provides for seed-time and harvest, for by the action of the lows the warm, vapor-bearing currents are sucked inland from the Gulf and the ocean and carried far over the continent, so that their moisture is condensed and scattered over the plains, rendering them tillable and suitable for the habitation of man; that the highs, in drawing down the cool, pure air from above, scatter and diffuse the carbonic-acid gas exhaled by animal life and the fetid gases emanating from decaying organic matter; that the cold waves created by these high-pressure areas are among the most beneficent gifts of nature, for their clear, dense air not only gives us more oxygen with each inspiration of the lungs, but the abnormally high electrification that always accompanies such air invigorates man and all other animal life; that the cold, north wind, if it be dry, as it usually is, brings physical energy and mental buoyancy in its mighty breath; that four-sevenths of all our storms come from the north plateau region of the Rocky mountains and pass from this arid or subarid region easterly over the Lakes and New England, producing but scanty rainfall; that the greater part of the remaining three-sevenths have their inception in the arid region of our southwestern states, and that as they move northeastward they can nearly always be depended on to give bountiful rainfall, and that many of them cross the Atlantic and affect the continent of Europe; that a few, and by far the most severe, wind and rain storms that touch any portion of our country originate in the West Indies and travel in a northwesterly direction until they touch our Gulf or South Atlantic coast, when they recurve to the northeast and sweep along our Atlantic seaboard.

During the prevalence of droughts in the great central valleys all the low-pressure or storm conditions form in the middle or north plateau region of the Rocky mountains. When such droughts are broken, it is usually accomplished by lows that form in Arizona, New Mexico, or Texas.

From many years spent in daily watching the formation, progression, and dissipation of storms, the forecaster well knows that at times, by an accretion of force not shown by observations taken at the bottom of the ocean of air, storms suddenly develop dangerous and unexpected energy or pursue courses not anticipated in his forecast, or that the barometer at the center of the storm rises without any premonition and gradually dissipates the energy of the cyclonic whirl.

These are a few of the generalizations of which the forecaster takes cognizance and which guide him in his deductions. In brief, he carefully notes the developments and movements in the air conditions during the preceding 24 hours, and from the knowledge thus gained he makes an empirical estimate of what the weather will be in the different sections of the country the following day. By preserving the weather charts each day and noting the movements of the highs and the lows, any intelligent person can make an accurate forecast for himself, always remembering that the lows, as they drift toward him from the west, bring warm weather and sometimes rain or snow, and that as they pass his place of observation the highs following in the tracks of the lows will bring cooler and probably fair weather.

We will now examine the accompanying charts and, after a brief review of the Weather Bureau river service, will endeavor to trace the inception and progression of the different classes of storms.

The stations from which the Weather Bureau issues and rapidly distributes forecasts and flood warnings are shown on Chart I. Small radial lines are drawn to each central station from up-river points in the various watersheds; from these points daily telegraphic measurements of rainfall and temperature are sent to their respective centers, in addition to observations from many of the full meteorological stations of the Bureau not shown on this chart.

With our many thousands of miles of navigable rivers flowing through one of the most extensive and fruitful regions of the world, daily forecasts of the height of water in the various sections of each river are of enormous benefit to navigation, and the warnings issued when the precipitation is so heavy as to indicate the gathering, during the next two or three days, of flood volumes in the main streams, are often worth many millions to navigators and to those having movable property on low grounds contiguous to the streams.

The feasibility of making accurate forecasts as to the height of water several days in advance at any station of the system is

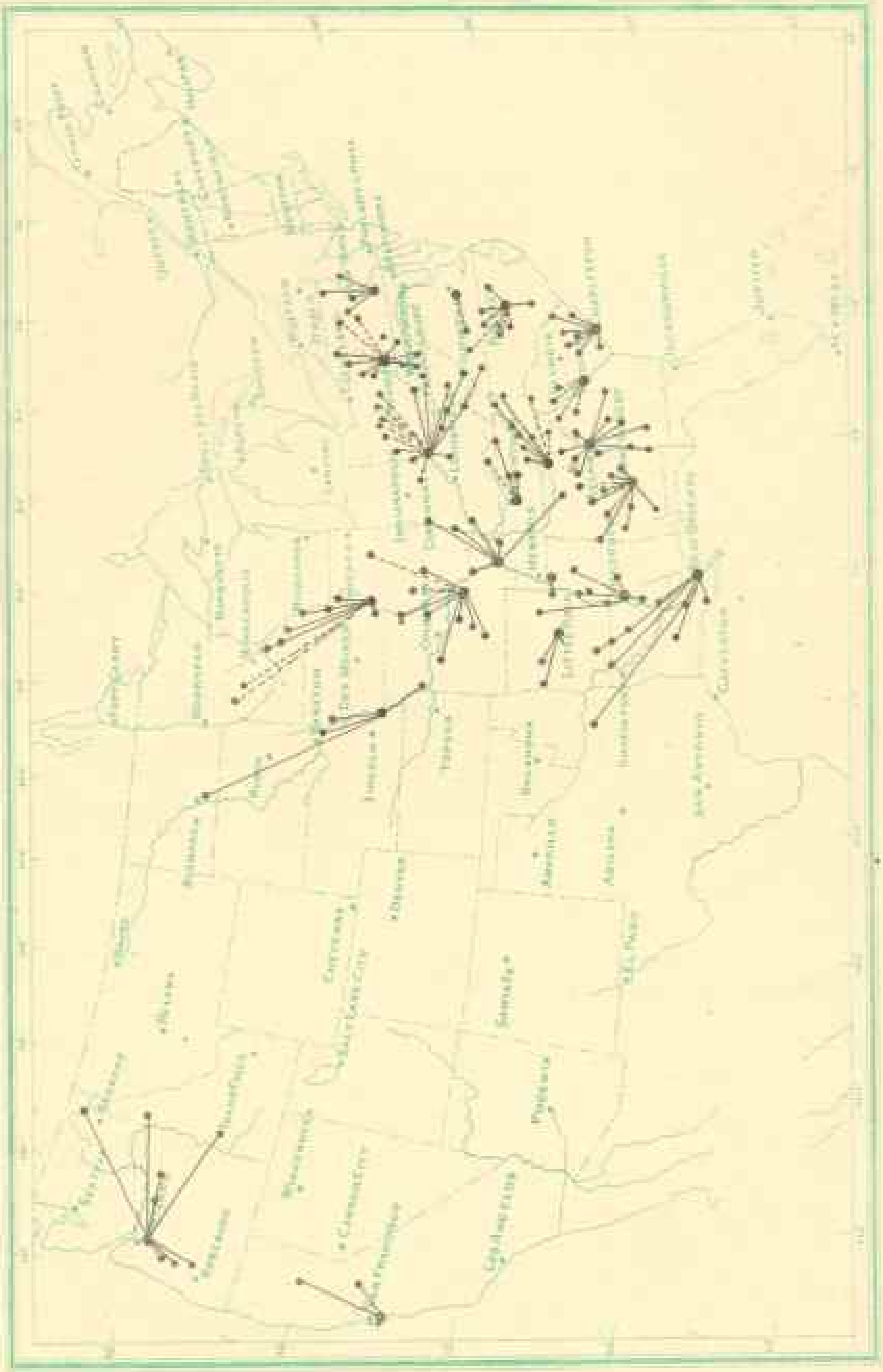
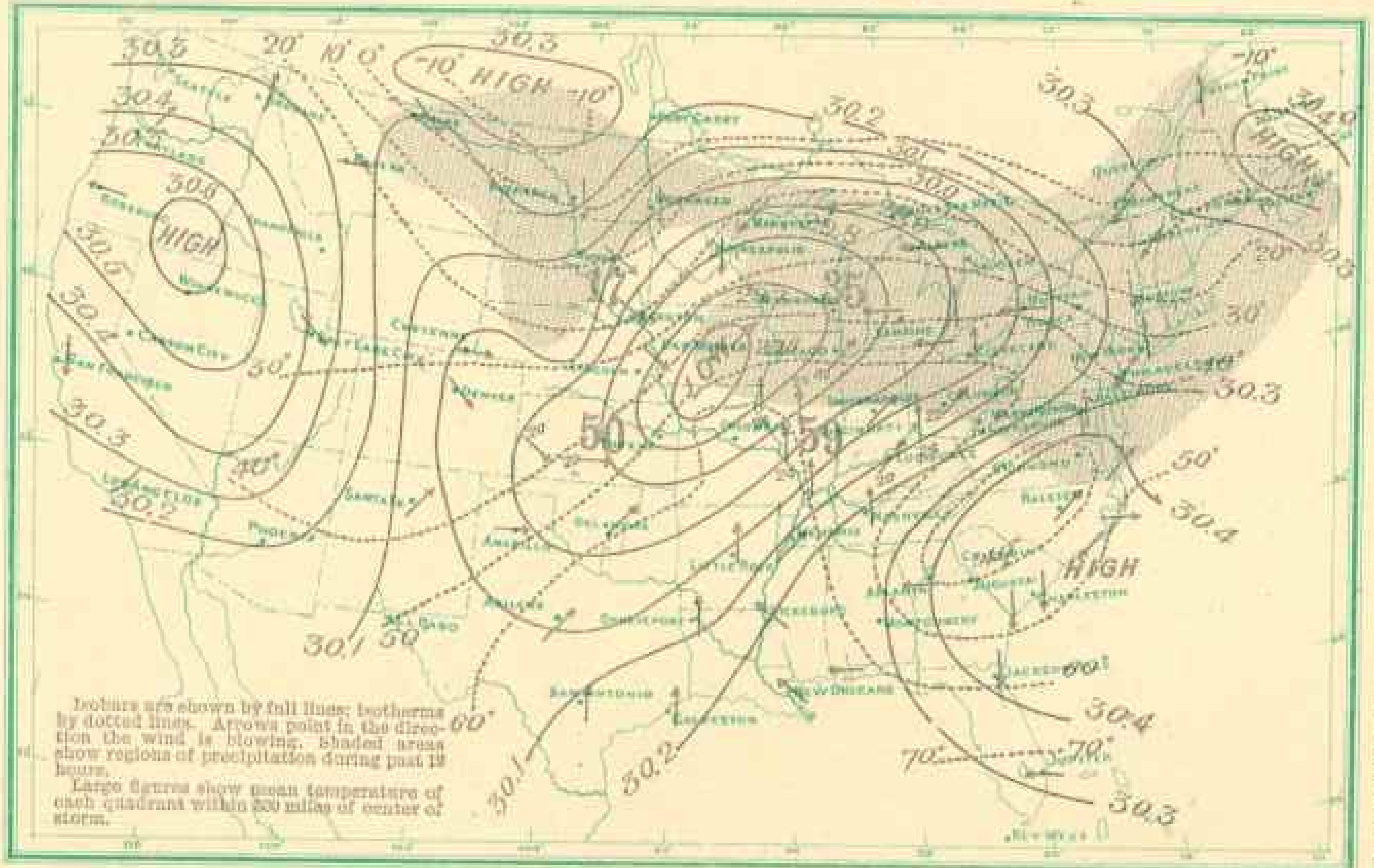


Chart I. River Stations.

Chart II. Winter Storm, December 15, 1893, 8 a. m.



Isobars are shown by full lines; isotherms by dotted lines. Arrows point in the direction the wind is blowing. Shaded areas show regions of precipitation during past 12 hours.

Large figures show mean temperature of each quadrant within 500 miles of center of storm.

no longer questioned. The forecaster at each river center considers the rainfall, the temperature, the melting of snow, if there be any, the area and slope of the watershed, and the permeability of the soil. From a study of floods in former years, he knows the time necessary for the flow of the water from the tributaries to the main stream and the time required for the passage of the flood-crests from one city to another. The forecasts are, of course, empirically made, but still they are sufficiently accurate to possess great value to the people of the river districts. Some idea of the vast destruction of property due to floods may be gathered from the statement that the floods of 1881 and 1882 caused a loss of not less than $15,000,000 to the property interests of the Ohio and Mississippi valleys. There was also a loss of 138 lives. In 1884 the region about Cincinnati alone suffered a loss of over $10,000,000 in property.

Chart No. II shows a winter storm central in Iowa at 8 a. m., December 15, 1893. The word "low" marks the storm center. It is the one place in all the United States where the barometer reading is the lowest. The heavy, black lines, oval and nearly concentric about the low, show the gradation of air-pressure as it increases quite uniformly in all directions from the storm center outward.

The arrows fly with the wind, and, as will be seen, are almost without exception moving toward the low or storm center, clearly demonstrating the effect of gravity in causing the air to flow from the several regions marked high, where the air is abnormally heavy, toward the low, where the air is lighter. As the velocity of water flowing down an inclined plane depends both on the slope of the plane and on the roughness of its surface, so the velocity of the wind as it blows along the surface of the earth toward the storm center depends on the amount of the depression of the barometer at the center and the resistance offered by surfaces of varying degrees of roughness. The small figures placed at the end of the arrows indicate high wind velocities. At Chicago, where the wind is blowing at the rate of 40 miles per hour, the anemometer is 270 feet high, while at Minneapolis, where the instrument is so low as to be in the stratum whose velocity is restricted by the resistance encountered in flowing over forests to the northward, the rate is not great enough to be marked by a special figure.

Now picture in your mind the fact that all the air inside the isobar (heavy black line) marked 30.2 as it moves inward is rotating about the low in a direction contrary to the movement of the hands of a watch and you have a very fair conception of an immense atmospheric eddy.

Have you ever watched the placid water of a deep running brook and observed that where it encountered a projecting crag little eddies formed and went spinning down the stream? Well, our storms are simply great eddies in the air which are carried along by the general easterly movement of the atmosphere in the middle latitudes of the northern hemisphere. But they are not deep eddies, as was once supposed. The low marks the center of an atmospheric eddy of vast horizontal extent as compared with its thickness or extension in a vertical direction; thus a storm condition extends from Washington to Denver in a horizontal direction and yet extends upward but four or five miles. The whole disk of whirling air four or five miles thick and 1,500 miles in diameter is called a cyclone or cyclonic system. It is important that a proper conception of this fundamental idea be had, since the weather sequences experienced from day to day depend almost wholly on the movement of these traveling eddies, cyclones, or areas of low pressure.

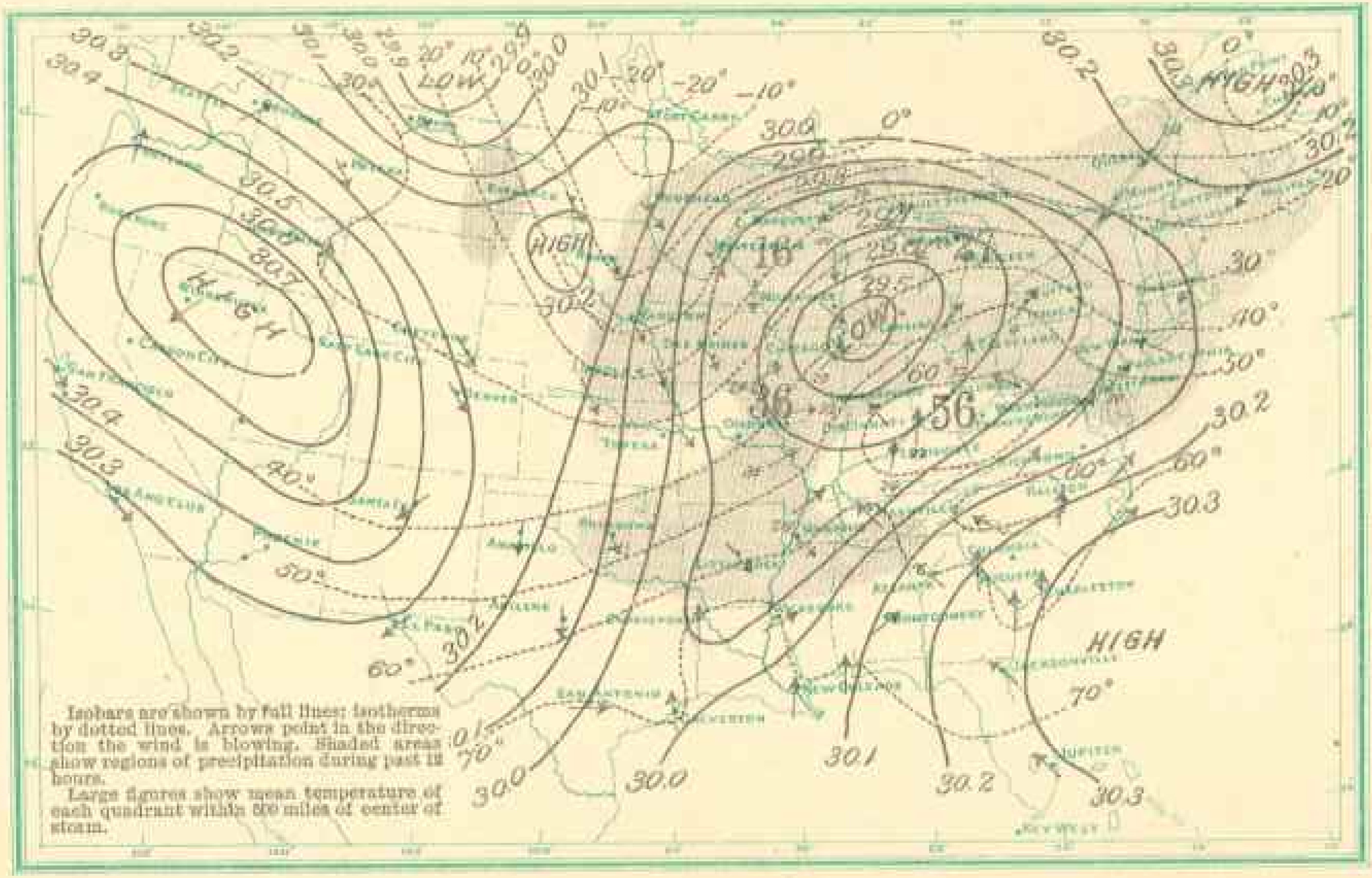
The large figures in the four quarters of the cyclone show the average temperature of each quadrant. The greatest difference is between the southeast and northwest sections. This is due in part to the fact that in the southeast quadrant the air is drawn northward from warmer latitudes, and in the northwest quadrant the air is drawn southward from colder latitudes. The shaded area shows the region of rain or snow fall during the preceding 12 hours. Unfortunately for the science of forecasting, precipitation does not show that relation to the configuration of the isobars that temperature, wind velocity, and wind direction do.

Chart III, constructed from observations taken 12 hours later, shows that the storm or cyclonic center, as indicated by the word "low," has moved from central Iowa since 8 a. m. and is now, at 8 p. m., central over the southern point of Lake Michigan. The shaded areas show that precipitation has occurred during the past 12 hours in nearly the entire region covered by the cyclone.

Chart IV, 12 hours later, shows that the precipitation has been general throughout the entire area swept by the cyclonic whirl.

Chart V is quite dissimilar, in the information it conveys, to any other of the charts accompanying this paper. From July 28 to August 10, inclusive, 1896, there was a remarkable hot wave in the United States, extending from the Rocky mountains to the

Chart III. Winter Storm, December 15, 1893, 8 p. m.



Isobars are shown by full lines; isotherms by dotted lines. Arrows point in the direction the wind is blowing. Shaded areas show regions of precipitation during past 12 hours.
Large figures show mean temperature of each quadrant within 500 miles of center of storm.

Chart IV. Winter Storm, December 16, 1893, 8 a. m.

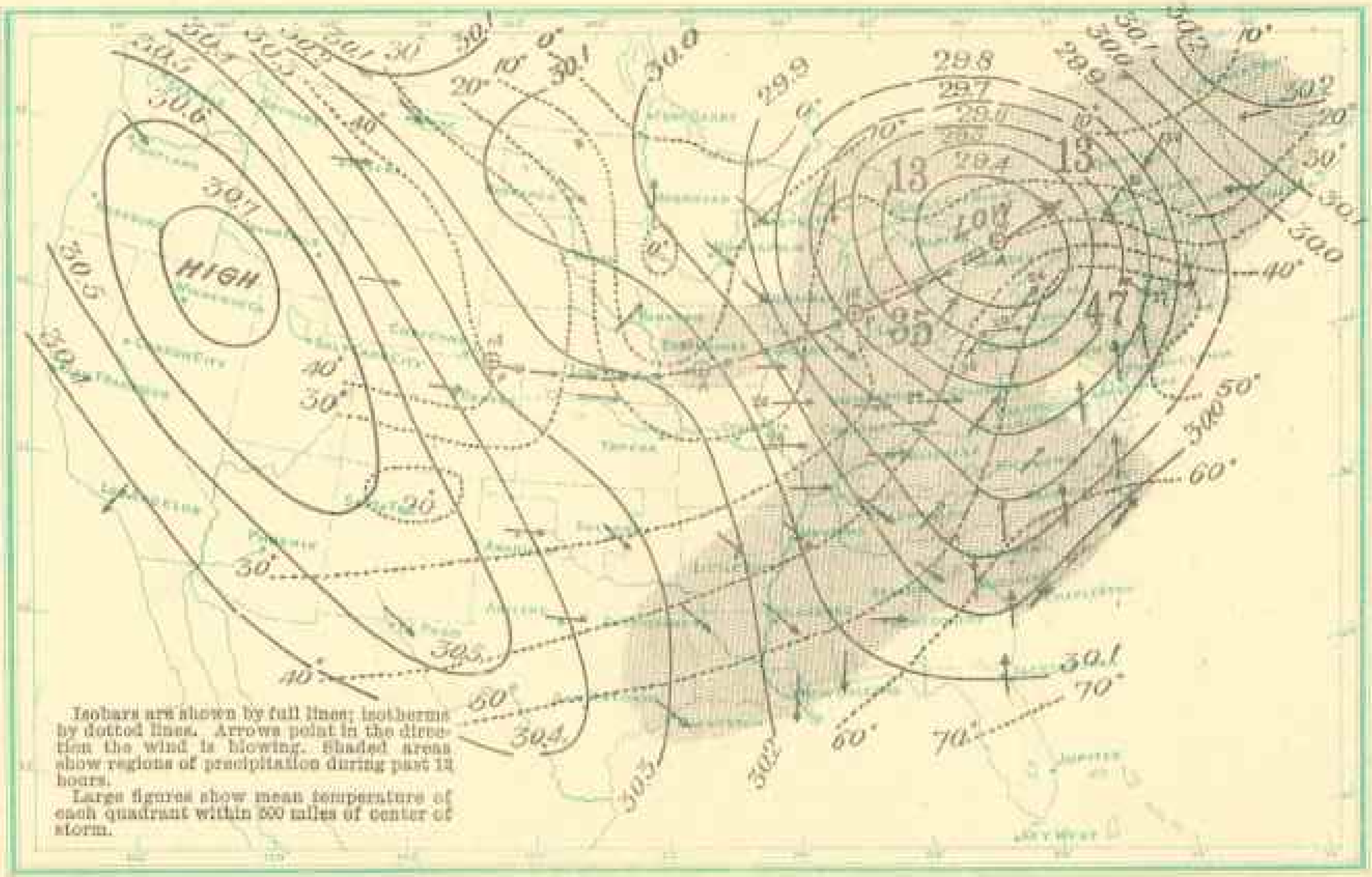
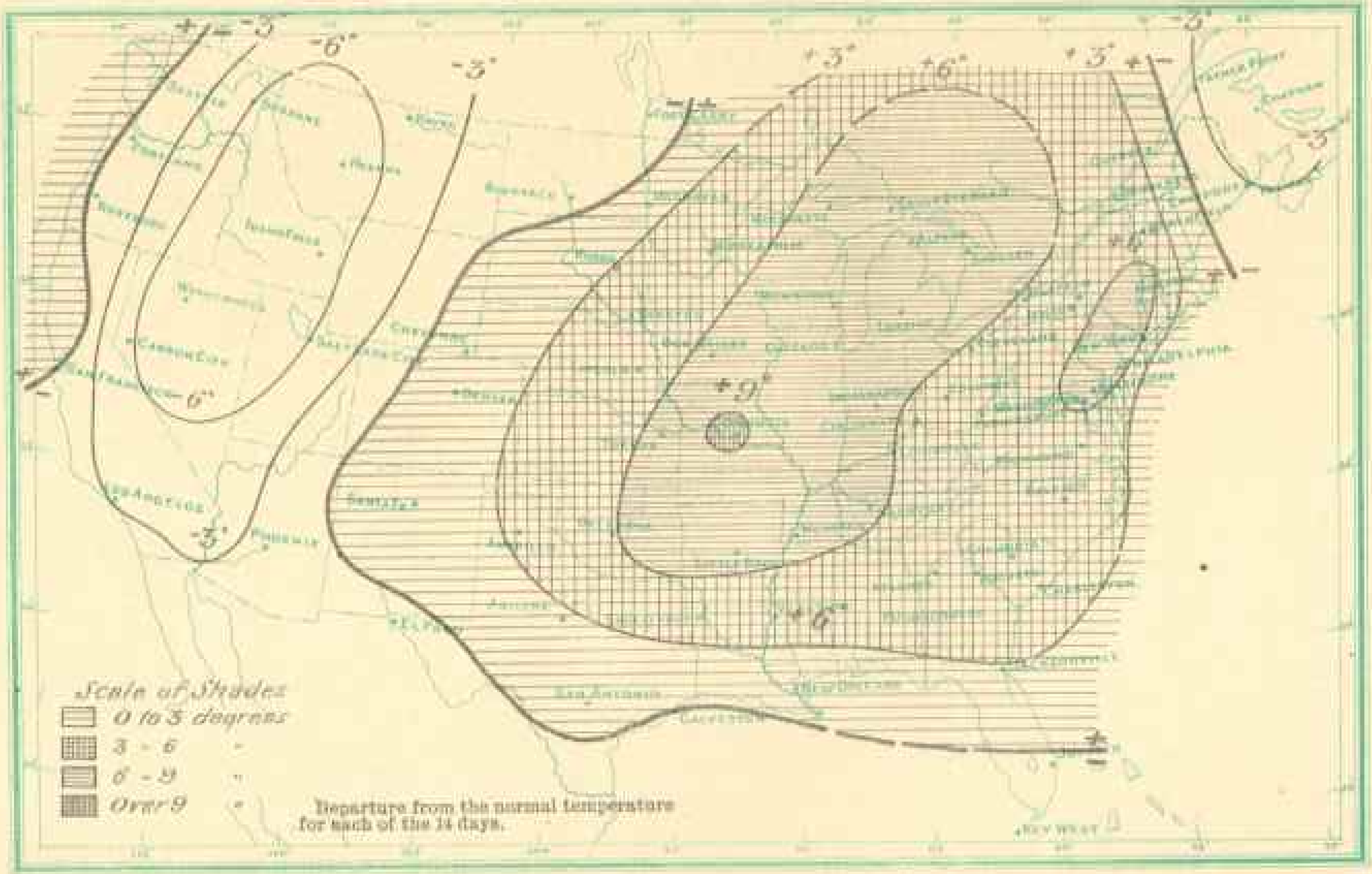


Chart V. Hot Wave, July 28 to August 10, 1896, inclusive.



Atlantic ocean. The mortality from this cause amounted to many thousands. The hottest region, as shown by the dark shading, was in the middle Mississippi and Ohio valleys and the Lake region, where the temperature averaged from six to nine degrees above the normal for each one of the 14 days. During this same period, strange as it may seem, the temperature over the vast Rocky Mountain plateau was markedly below the normal, and the cold was not due to altitude, for often we find these conditions geographically reversed. The weather charts showing the movements of highs and lows during the period of this abnormal heat are not shown in this paper. Chart V is simply intended to show graphically the area and degree of the heat.

For some unexplained reason there come, in summer, periods of almost absolute stagnation in the drift of the highs and lows. At such times if a high rest over the southeastern part of the country and a low over the northern Rocky Mountain region, there will result what is popularly known as a warm wave, for the air, on account of its slightly greater specific gravity, will slowly and steadily flow from the southeast, where the pressure is greater, toward the northwest, where the pressure is less, and receiving constant accretions of heat from the hot, radiating surface of the earth, without any whirls or eddies to mix the upper and lower strata, will finally attain a temperature almost unbearable to animal life. This superheated condition of the lower stratum in which we live continues until the low-pressure area in the northwest begins to actively gyrate as an eddy and move eastward, mixing in its course strata of unequal temperatures and precipitating the cool and welcome thunder-showers.

It is a pertinent inquiry whether such adjacent areas of abnormal heat and abnormal cold can possibly be due to cosmic influences. The only cosmic influences that meteorology is sure of are the radiation of heat from the sun to the earth and the reception, by space, of the heat that is radiated back by the earth and atmosphere. In the long run, these two balance each other. It is inconceivable that solar insolation, passing outward from the sun along true radial lines, could fall so unequally upon the United States as to cause excessive heat on one side and extreme cold on the other. It follows from the preceding that we must be slow to ascribe any of the local peculiarities that are observed in terrestrial weather to cosmic influences. Weather variations, irregular, annual, and diurnal, all probably have their causes at the earth's surface or in the earth's atmosphere, and depend wholly on the mechanics of the latter. The problem, however, is so complex that it would be hazardous to undertake to explain the great differences in temperature shown on this map of departures for July and August, 1896.

Think of the atmosphere as a mass of air about 50 miles deep, whose upper surface maintains nearly the same configuration and temperature and is almost entirely without motion relative to the earth's surface. The solar radiation and the terrestrial radiation penetrate this upper region without appreciable absorption, and the ascending and descending currents of air rarely or never disturb this region, but cease before they reach it. Our weather and climate depend on the changes going on in the middle and lower atmospheres, and among these changes that which affects our surface temperature most is the *motion* of the atmosphere. The great contrast in temperature between two regions lying close together, as shown by Chart V, is therefore probably not due to any special cosmic influence, but to the flow of air as determined by the distribution of air pressure day by day.

Chart VI shows the beginning of a cold wave in the northwest on the morning of January 7, 1886. Observe that the heavy, black isobar passing through Montana is marked 30.8, while the isobar curving through southern Texas is marked 29.8, a difference of one inch in the air-pressure between Montana and Texas. The dotted isothermal line in Montana is marked 30 degrees below zero, while the isotherm on the Texas coast indicates a temperature of 50 degrees.

Chart VII is auxiliary to Chart VI, and by varying degrees of shading shows the fall of temperature during the preceding 24 hours attendant on the high-pressure area of the northwest. A considerable area covered by the darkest shade indicates a fall of 40 degrees in temperature during the past 24 hours.

The people of the Gulf states, with a morning temperature of 40 to 50 degrees, knew nothing of the great volume of extremely cold air to the northwest of them; but from the distribution of air pressure shown by Chart VI, the forecaster anticipated that the very cold air of the northwestern states would, on account of its great weight, be forced southward to the Gulf and eastward to the Atlantic ocean; or, more accurately speaking, that the conditions causing the cold in the northwest would drift southward and eastward. He therefore issued the proper warning to the threatened districts.

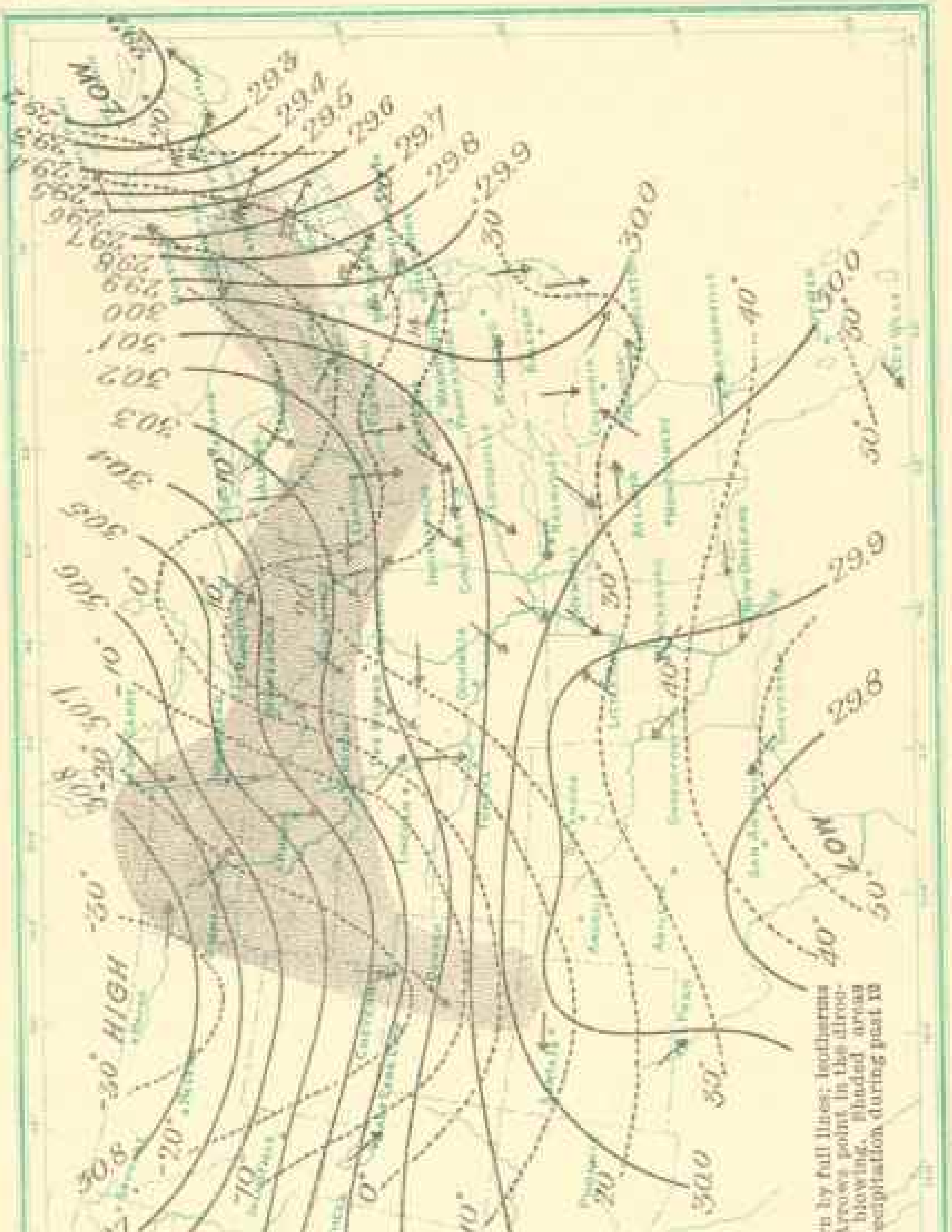


Chart VI. Cold Wave, January 7, 1886, 7 a. m.

Chart VII. Cold Wave, January 7, 1886, 7 a. m. Temperature Change in Preceding 24 Hours.

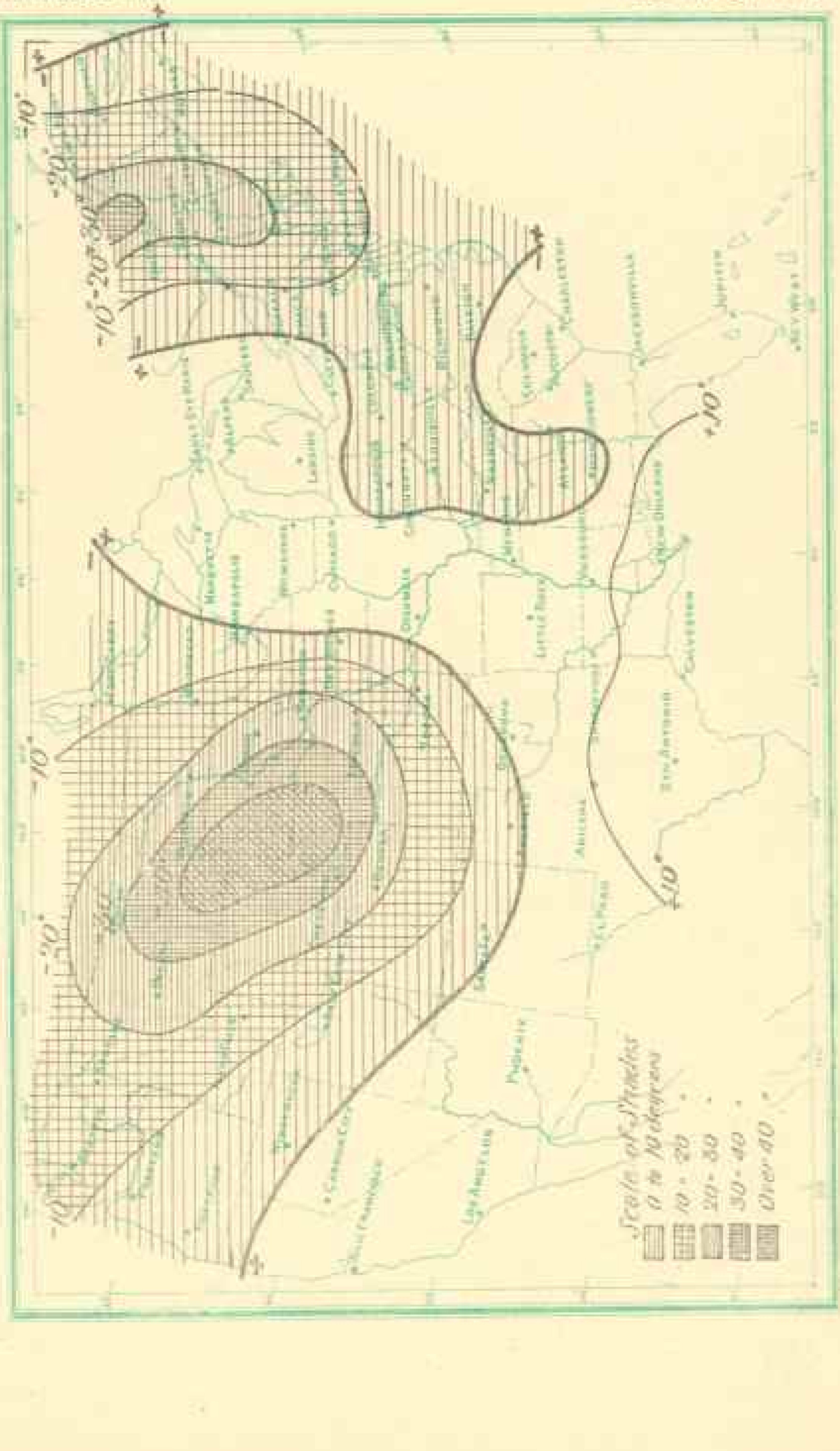
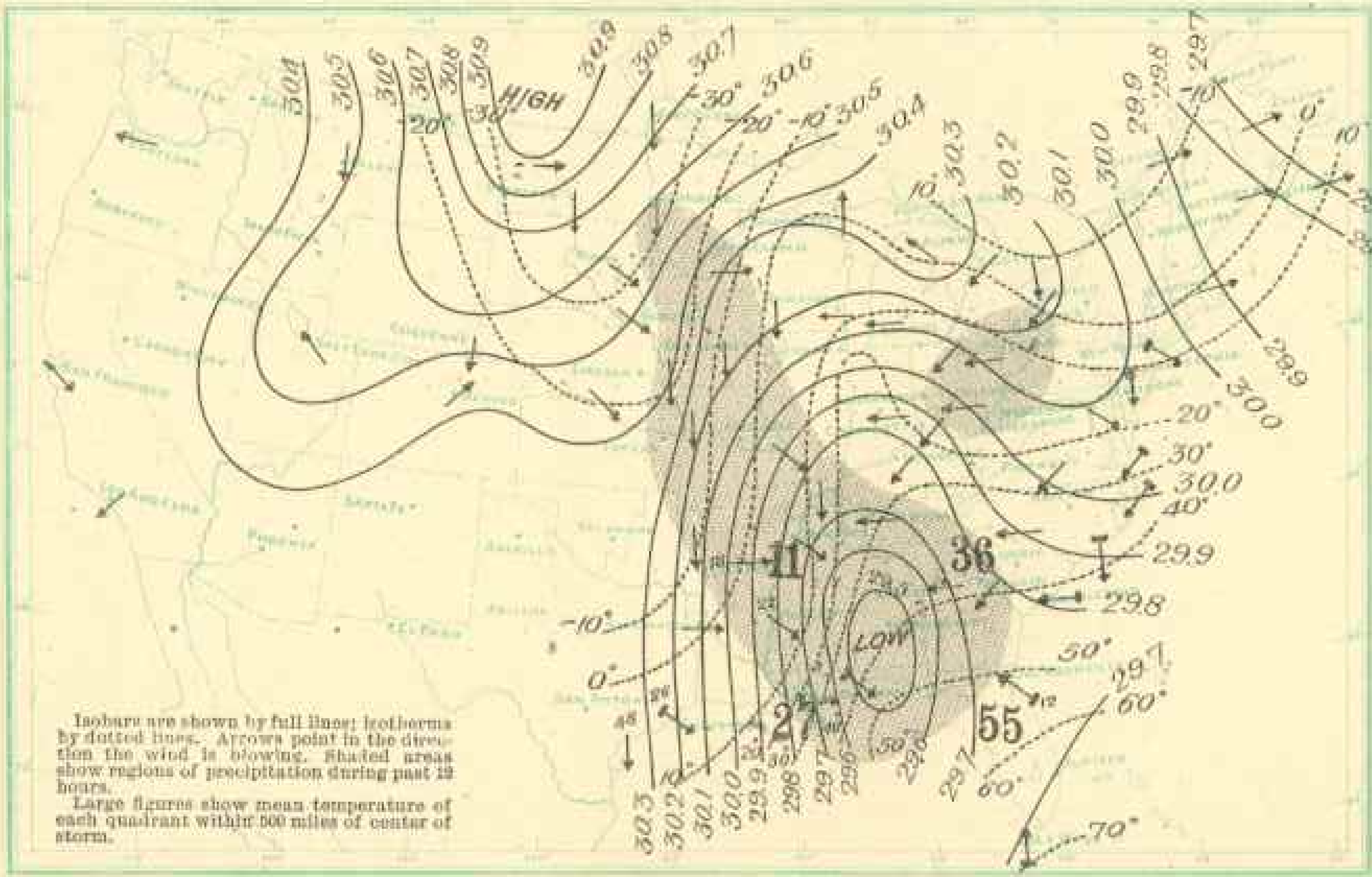


Chart VIII.

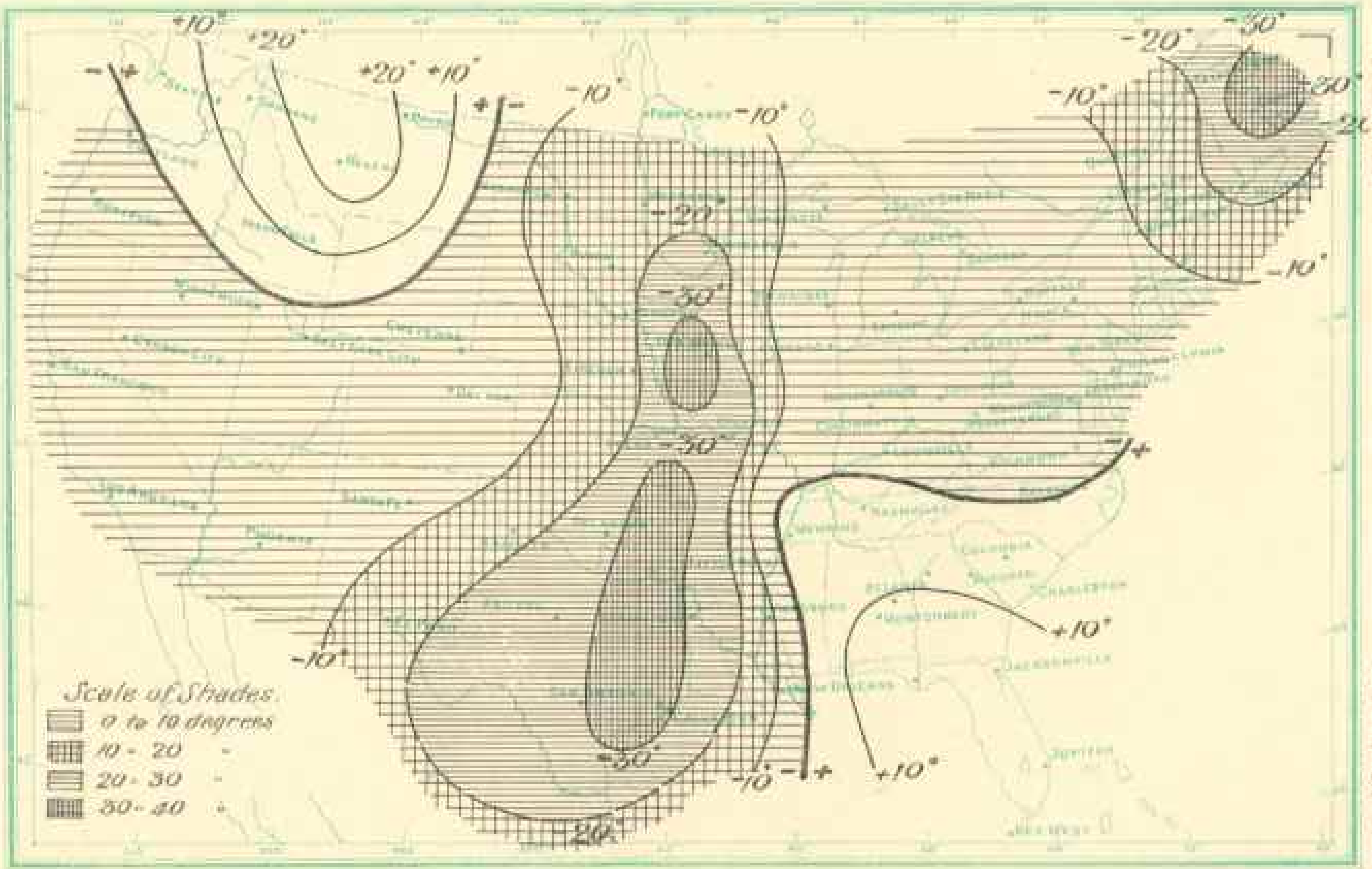
Cold Wave, January 8, 1886, 7 a. m.

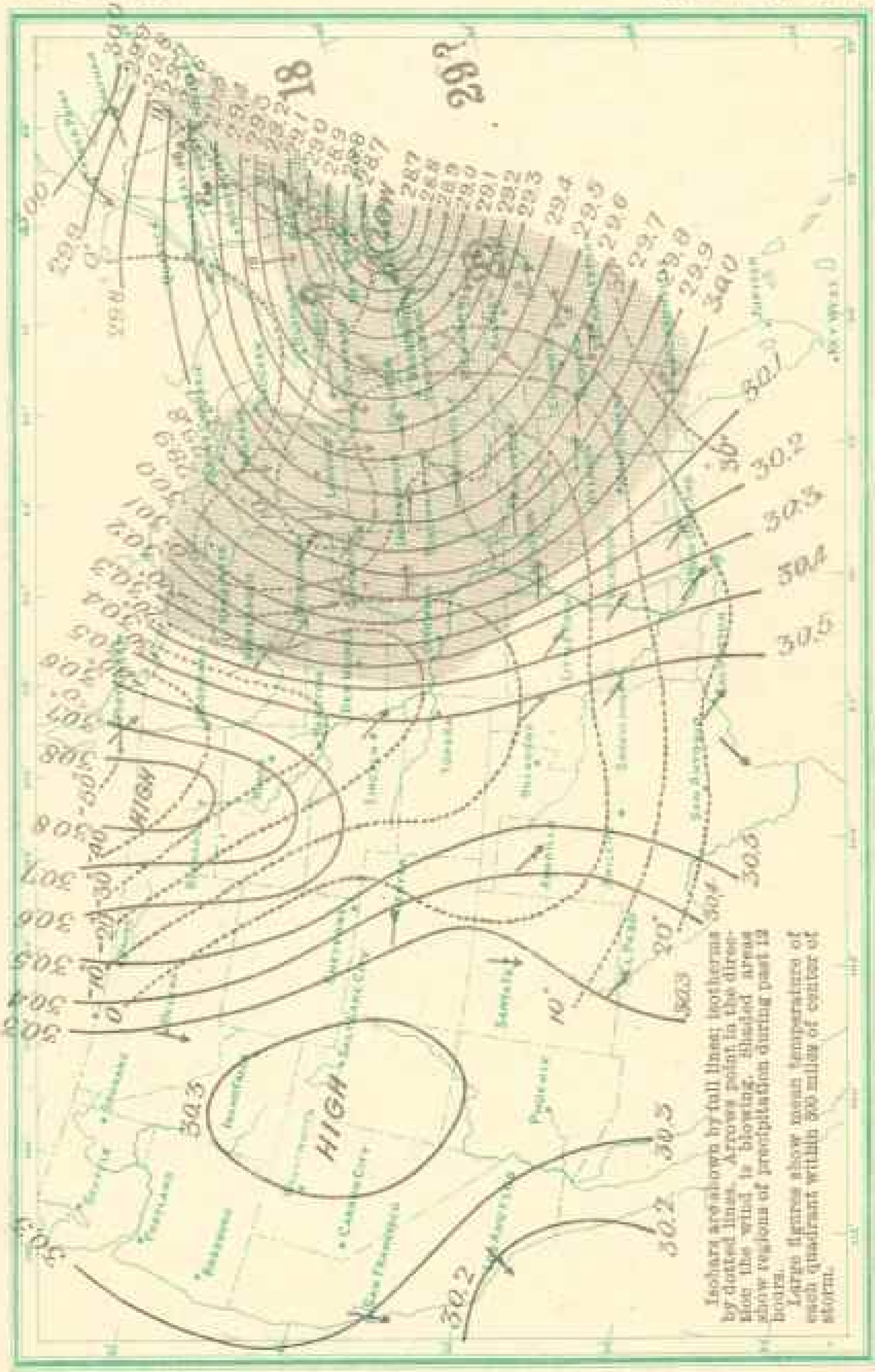


Isobars are shown by full lines; isotherms by dotted lines. Arrows point in the direction the wind is blowing. Shaded areas show regions of precipitation during past 12 hours.

Large figures show mean temperature of each quadrant within 500 miles of center of storm.

Chart IX. Cold Wave, January 8, 1886, 7 a. m. Temperature Change in Preceding 24 Hours.





Isobars are shown by full lines; isotherms by dotted lines. Arrows point in the direction the wind is blowing. Shaded areas show regions of precipitation during past 12 hours.

Large figures show mean temperature of each quadrant within 300 miles of center of storm.

Chart X. Cold Wave, January 9, 1886, 7 a.m.

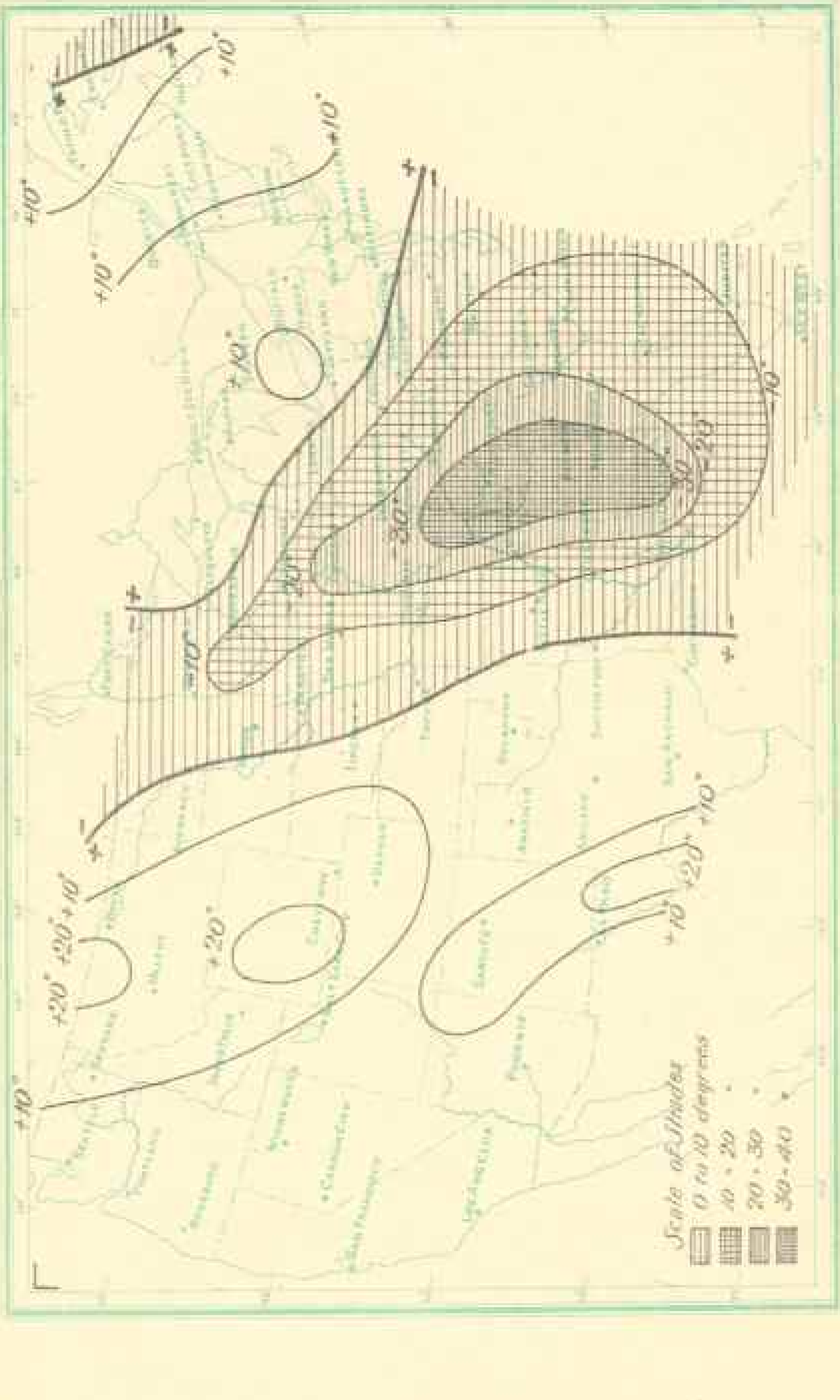


Chart XI. Cold Wave, January 9, 1886, 7 a. m. Temperature Change in Preceding 24 Hours.

Chart XII. Cold Wave, January 10, 1886, 7 a. m.

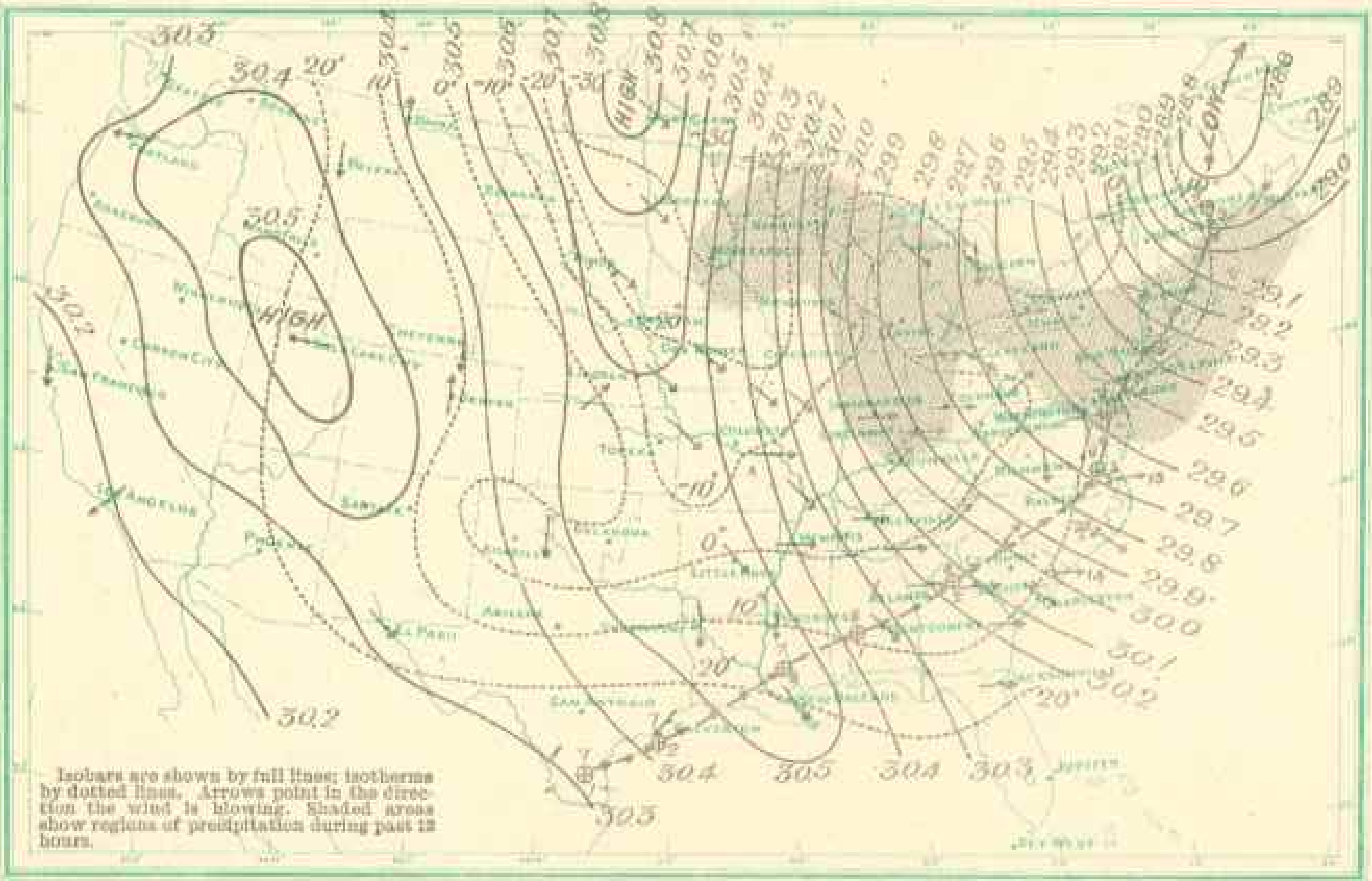
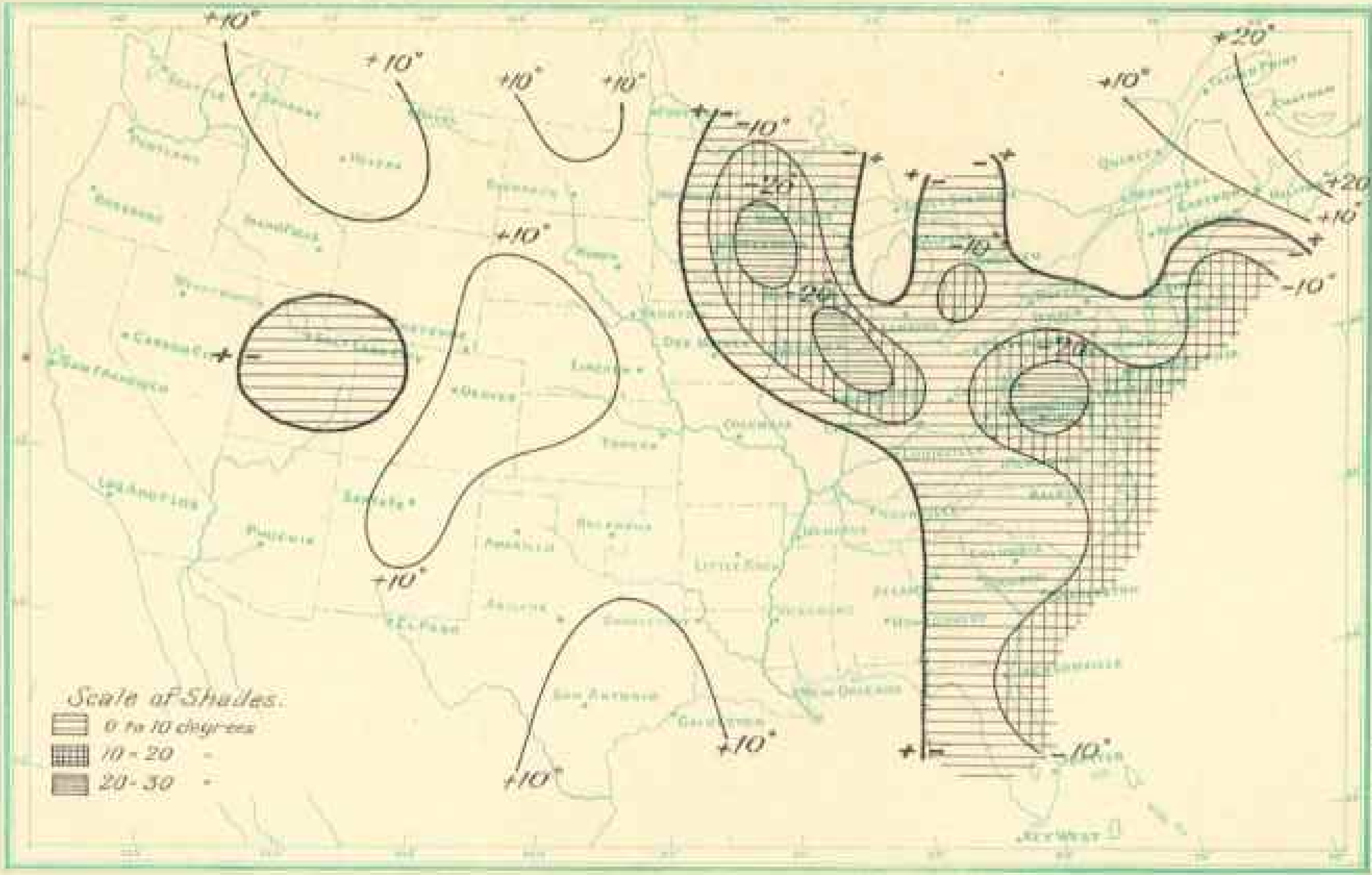


Chart XIII. Cold Wave, January 10, 1886, 7 a. m. Temperature Change in Preceding 24 Hours.



Now turn to Charts VIII and IX of the following morning and it will be seen from the latter that the cold wave has covered the entire Mississippi valley. The low shown on the preceding chart as being central in southern Texas has moved northeastward to Alabama, and on Chart VIII appears as a fully developed storm. The difference in pressure between the central isobar of the low and the central isobar of the high is now 1.4 inches. Precipitation has occurred, as shown by the dark shading.

Special attention is called to the large figures placed in the four quarters of the low-pressure area, about 300 miles from the center. They indicate the average temperatures of their respective quadrants, and strikingly illustrate how great may be the difference in temperature under cyclonic influence between regions separated by but short distances. It is certain that as the low or cyclonic whirl moves toward the northeast, along the track usually followed by storms in this locality, the cold of the northwest quadrant, by the action of the horizontally whirling disk of air, will be thrown southeastward toward Florida, lowering the temperature in the orange groves to below the freezing point.

Chart X shows that the center of the cyclone or low-pressure system has moved during the preceding 24 hours northeast to the coast of New Jersey, with greatly increased energy, the barometer at the center showing the abnormally low reading of 28.7 inches. Cold, northwest winds, as shown by the arrows, are now blowing systematically from the high-pressure area of the northwestern states southeast to Florida and the South Atlantic coast. The dotted isotherm of 30 degrees passes through the northern part of Florida, where, on the day before, the temperature was over 50 degrees. The cyclonic gyration of this storm extends 1,000 miles inland and probably to an equal distance out to sea. Heavy snow or rain has fallen throughout the area under its influence, seriously impeding railroad travel, and a gale of hurricane force has prevailed on the coast. But when, on the day preceding, the storm was central in Alabama all these conditions were foreseen and the necessary warnings issued.

Chart XI shows the temperature changes caused by the rapid movement of the storm center.

Charts XII and XIII show the conditions 24 hours later. The storm center has been three days in passing from southern Texas to the mouth of the St Lawrence. The temperature has fallen still lower on the Atlantic coast and in Florida as the result of uninterrupted northwest winds, and no material rise in temperature can occur until the high pressure of the northwest is replaced by a low pressure, and convectional currents are drawn toward the northwest instead of being forced southward from that region.

To summarize in regard to cold waves, it may be said that when the charts indicate the formation of a body of dense, cold air in the northwest, as shown by the barometer readings, the skilled forecaster is on the alert. He calls for special observations every four hours from the stations within and directly in advance of the cold area, and as soon as he becomes convinced that the cold wave will sweep across the country with its attendant damage to property, destruction to animal life, and discomfort to humanity, the well-arranged system of disseminating warnings is brought into action, and by telegraph, telephone, flags, bulletins, maps, and other agencies the people in every city, town, and hamlet, and even in farming settlements, are usually notified of the advancing cold twelve, twenty-four, or perhaps even thirty-six hours before it reaches them.

Charts XIV and XV show the cyclonic systems prevailing at 8 p.m. on the days of the Louisville and St Louis tornadoes. Several tornadoes occurred on each day; their tracks are shown by rows of crosses in the southeast quadrants of each cyclone.

Especially do I wish to emphasize the distinction between the cyclonic storm and the tornado. The press and nine out of ten people who should know better use these terms as synonymous. The cyclone shown on Chart XIV, which is fairly typical of all cyclones, is a horizontally revolving disk of air, covering the whole United States from the Atlantic ocean westward to and including the Mississippi valley, with the air currents from all points flowing spirally inward toward the center, while the tornado is a revolving mass of air of only 500 to 1,000 yards in diameter, and is simply an incident of the cyclone, nearly always occurring in its southeast quadrant. The cyclone may cause moderate or high winds through a vast expanse of territory, while the tornado, with a rotary motion almost unmeasurable, always leaves a trail of death and destruction in an area infinitesimal in comparison to the area covered by the cyclone.

The tornado is the most violent of all storms, and is more frequent in the central valleys of the United States than elsewhere. It has characteristics which distinguish it from the thunderstorm, viz., a pendent, funnel-shaped cloud and a violent, rotary motion in a direction contrary to the movements of the hands of a watch, together with a violent updraught in the center.

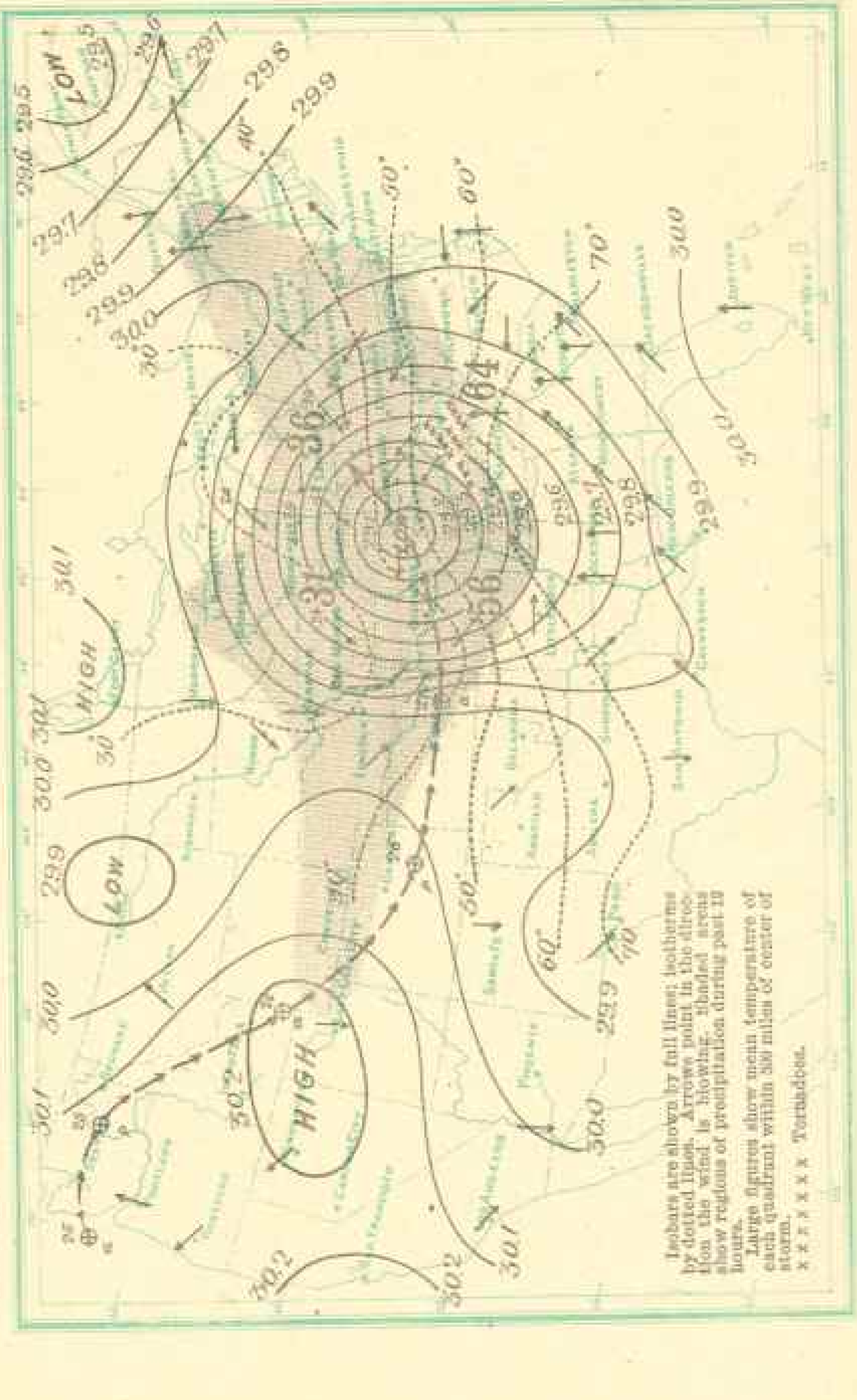
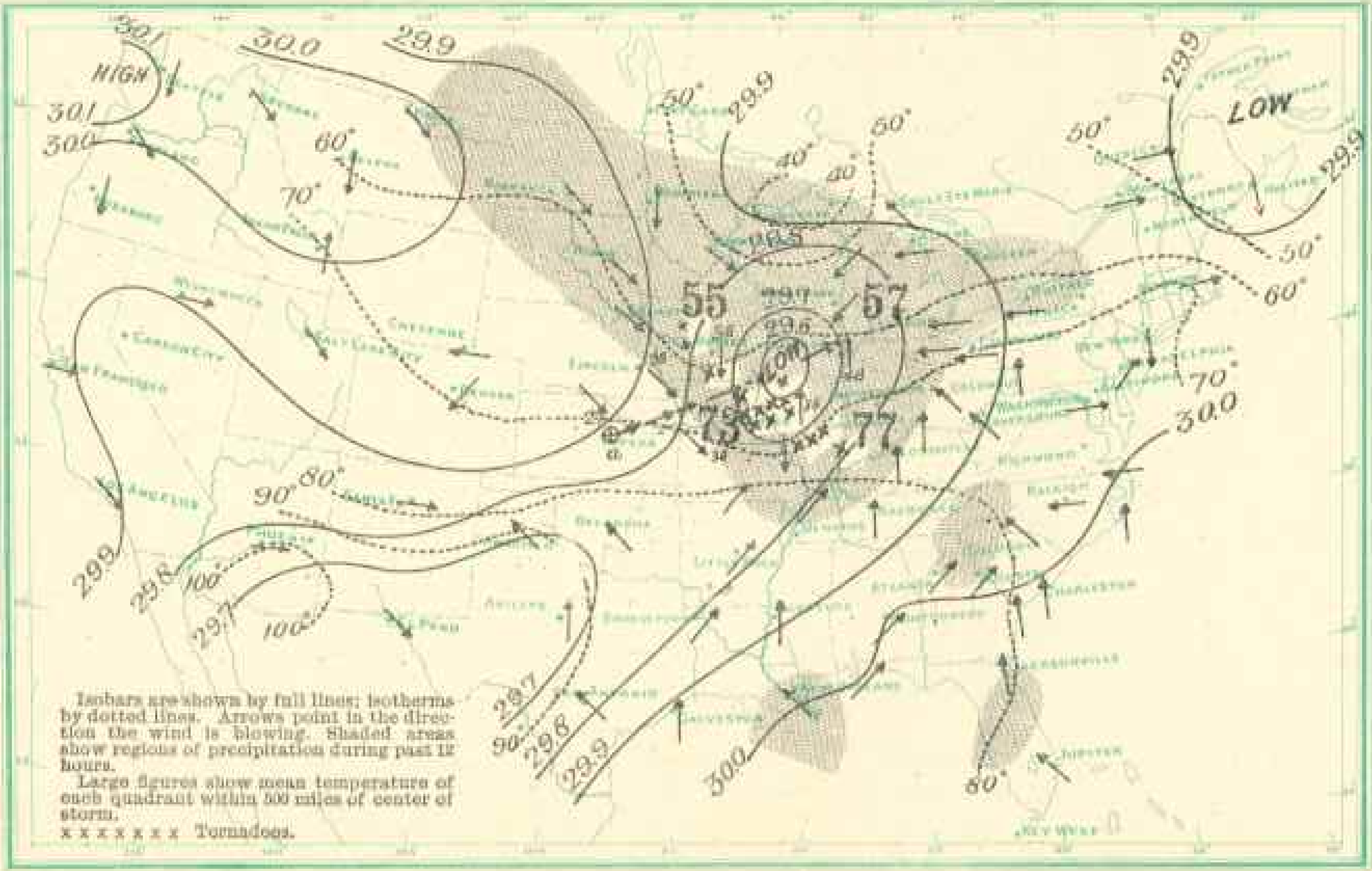


Chart XIV. Tornado at Louisville, Ky., March 27, 1890. Weather Map 8 p.m. of that date.

Chart XV. Tornado at St. Louis, Mo., May 27, 1896. Weather Map 8 p. m.



The three conditions essential to the formation of tornadoes are clearly as follows: (1) A cyclone or area of low pressure, the center of which is to the north or northwest, with a barometric pressure not necessarily much below the normal; (2) a temperature of about 70 degrees on the morning map; (3) a great humidity, and (4) that the time of year be March 15 to June 15. These conditions may and often do exist separately; one or two of them may be found coexisting; but so long as the third is absent, tornadic formation is not likely to occur.

I am satisfied that the number of these storms is not increasing; that the breaking of the virgin soil, the planting or cutting away of forests, the drainage of land surfaces by tiles, the stringing of thousands of miles of wire, or the laying of iron or steel rails have not materially altered the climatic conditions or contributed to the frequency or intensity of tornadoes. As well might one by the casting of a pebble attempt to dam the mighty waters of the majestic Mississippi as attempt the modification or restriction by the feeble efforts of man of those tremendous forces of nature which surround our earth and control our storms and climate. To be sure, as towns become more numerous and population becomes more dense, greater destruction will ensue from the same number of storms.

It is not possible with our present knowledge of the mechanism of storms to forewarn the exact cities and towns that will be visited by tornadoes without alarming some towns that will wholly escape injury; but we know that tornadoes are almost entirely confined to the southeastern quadrant of the cyclone, and that when the thermal, hygrometric, and other conditions are favorable, the spot 300 to 500 miles southeast from the cyclonic center is in the greatest danger.

Chart XV shows the conditions on the evening of the St Louis tornado, two hours after its occurrence. The abnormal heat, humidity, and other conditions of the rather small and weak cyclonic system shown by the morning chart were sufficient to justify the Weather Bureau in distributing at 10 a. m. danger warnings throughout the whole of Missouri and eastern Kansas. I am informed that the schools of St Louis were dismissed at once on the receipt of the warning forecast. What is urgently needed is a system by which weather signals may be sent simultaneously from telephone headquarters to all subscribers by a stroke of a telegraph key; then a whole city could be warned in a minute's time.

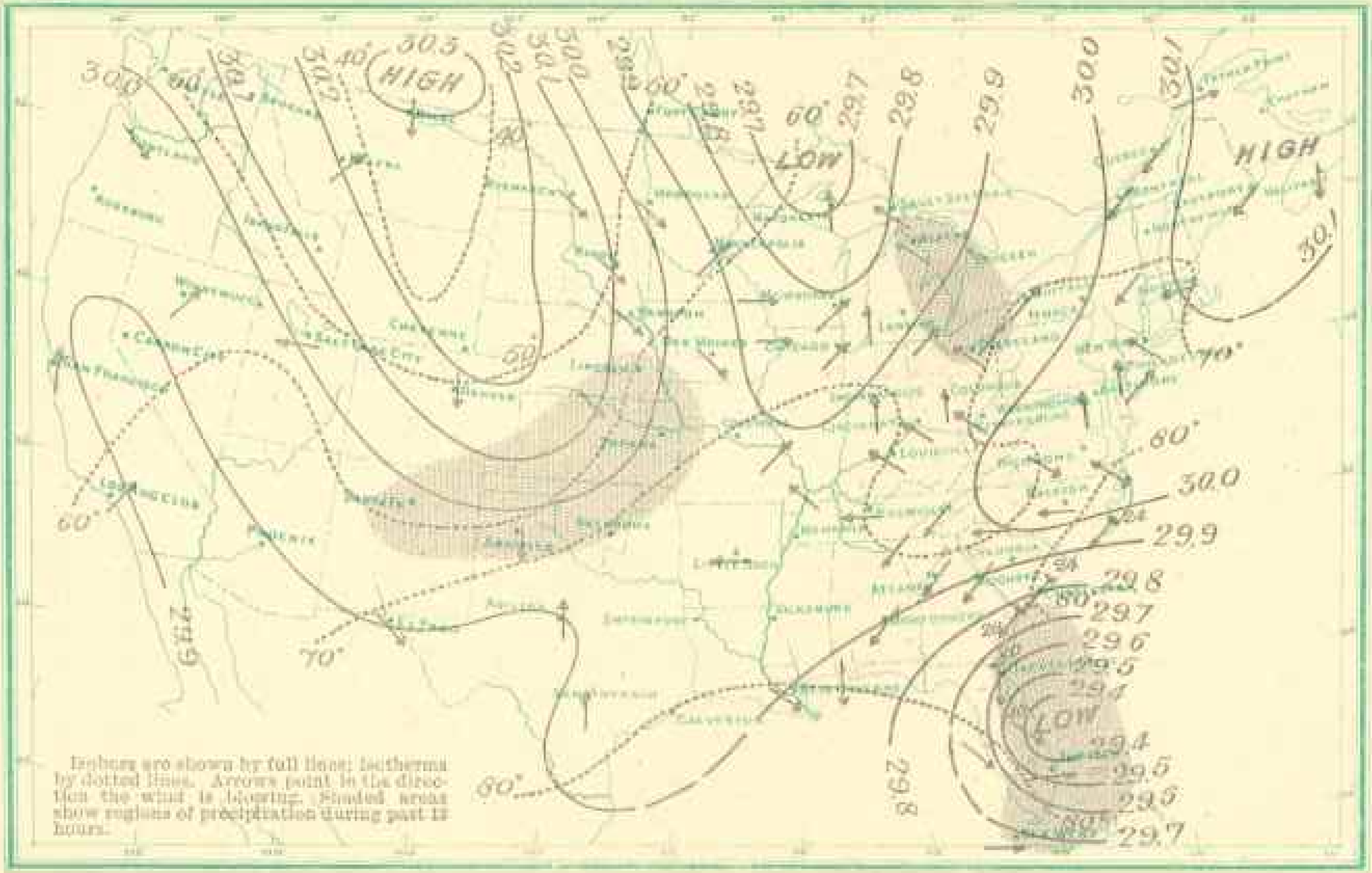
The writer visited St Louis the day after the storm, and was especially impressed with the fact that hundreds of buildings were burst outward at their upper stories, indicating that they were at the time of their destruction near the center of the rotating mass of air, where centrifugal force instantly had reduced the air pressure on the outside to such an extent that the expansion of the air in the upper stories of the houses whose windows and doors were closed had produced an explosion of the building. In one case all the four walls of the upper story of a house were thrown outward, leaving the lower story intact and the roof resting in proper position one story lower than in the original building. Again, great structures seemed to have been crushed over or taken up bodily and scattered in all directions.

The fact that this tornado traveled with destructive force through several miles of brick buildings and yet left the city with greater force than it possessed on entering it illustrates the futility of planting forests to the southwest of a city for the purpose of protection, as some have advocated. It is probable that the strongest trees would offer but little more resistance to this terrific force than would so many blades of grass.

Whenever the forecast contains the statement that conditions are favorable for severe local storms, it is well for the residents of a city receiving such forecast to observe carefully the formation of portentous clouds and be ready to seek places of safety in the cellars of frame buildings. We have no record of any person having been killed in the cellar of a frame building.

Chart XVI shows a West India hurricane just making its advent on the Florida coast. A number of stations in the West Indies report to Washington by cable whenever hurricanes pass over their region. Sometimes a hurricane composed of a rapidly revolving eddy of air of only two or three hundred miles in diameter passes between the observation stations on the islands of the West Indies without getting near enough to affect their instruments. Then, if it move rapidly northwest toward our Gulf coast, it may reach our seaboard unannounced. Fortunately such cases are rare, and in case the storm does reach any ports unexpectedly danger signals will be displayed in advance of its coming throughout the remainder of its course until it leaves our shores. At times hurricanes remain several days in the Gulf of Mexico, and the only indication we have of their proximity is a strong suction drawing the air briskly over some of our coast stations toward the center of the Gulf. Again, a

Chart XVI. West India Hurricane, August 27, 1893, 8 a. m.



Isobars are shown by full lines; isotherms by dotted lines. Arrows point in the direction the wind is blowing. Shaded areas show regions of precipitation during past 12 hours.

Chart XVII. Change in Air Pressure in Preceding 12 Hours, August 27, 1893, 8 a. m.

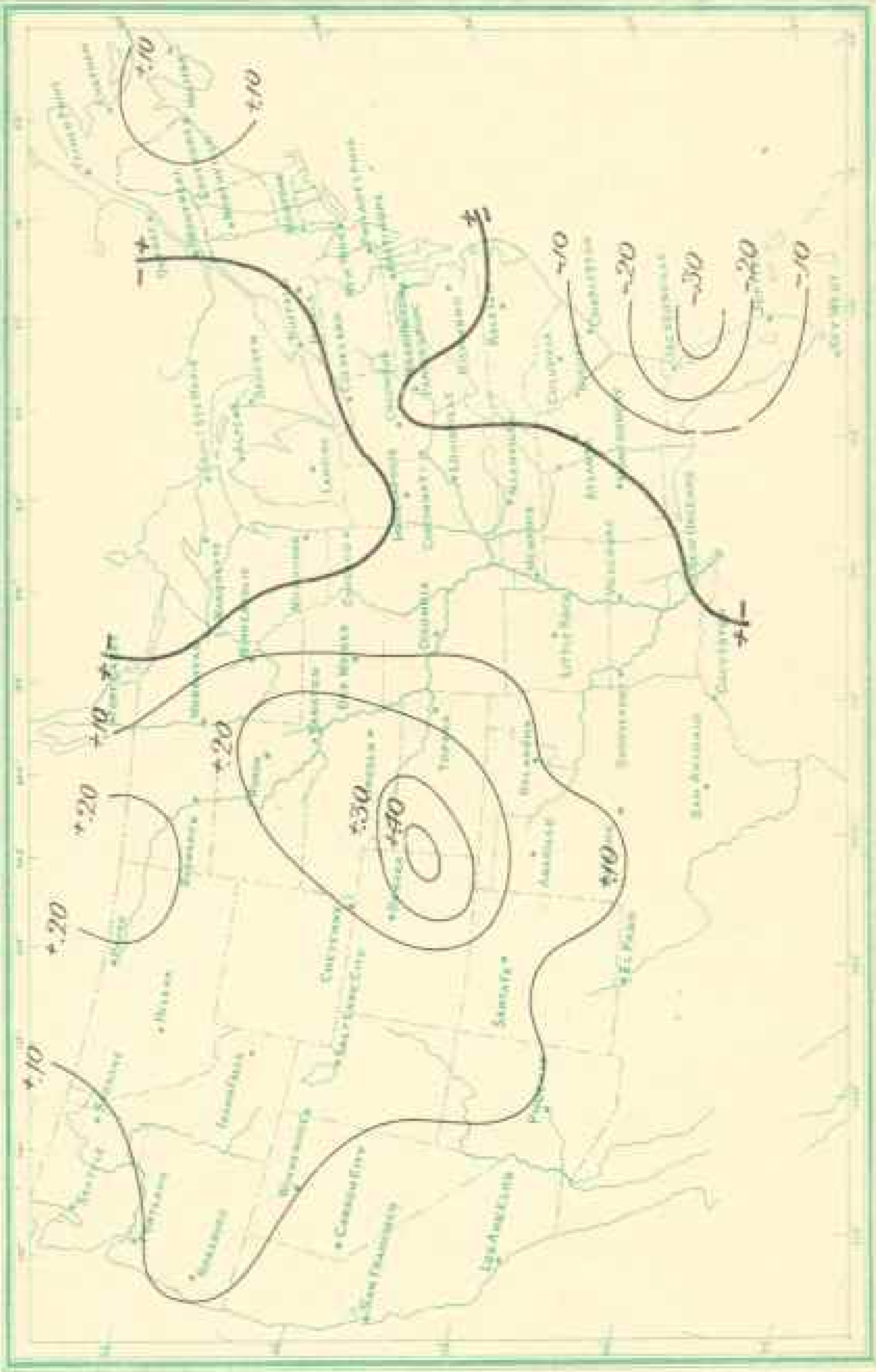
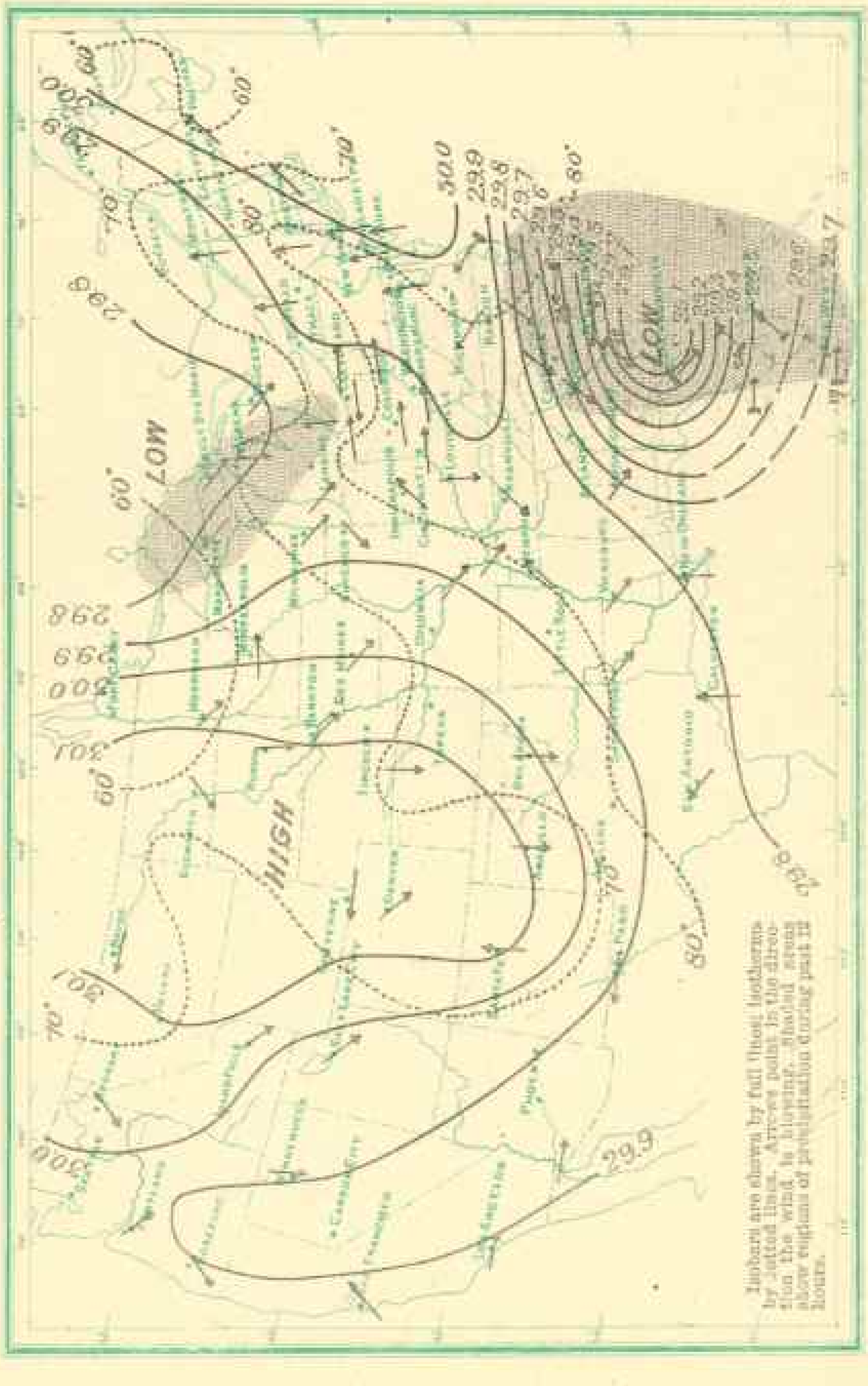


Chart XVIII. West India Hurricane, August 27, 1893, 8 p. m.



Isobars are shown by full lines; isotherms by dotted lines. Arrows point in the direction the wind is blowing. Shaded areas show regions of precipitation during past 12 hours.

Chart XIX. Change in Air Pressure in Preceding 12 Hours, August 27, 1893, 8 p. m.

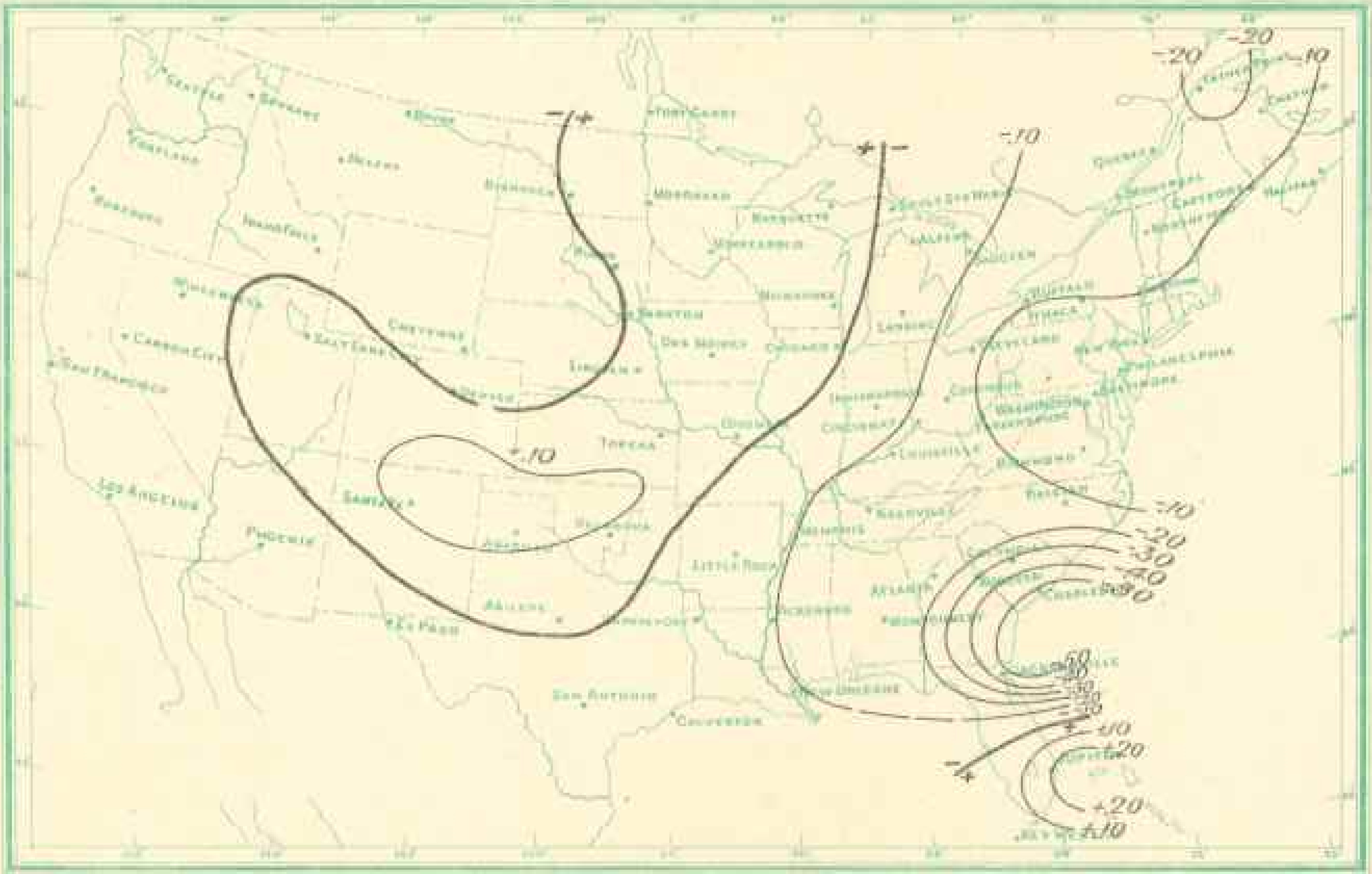
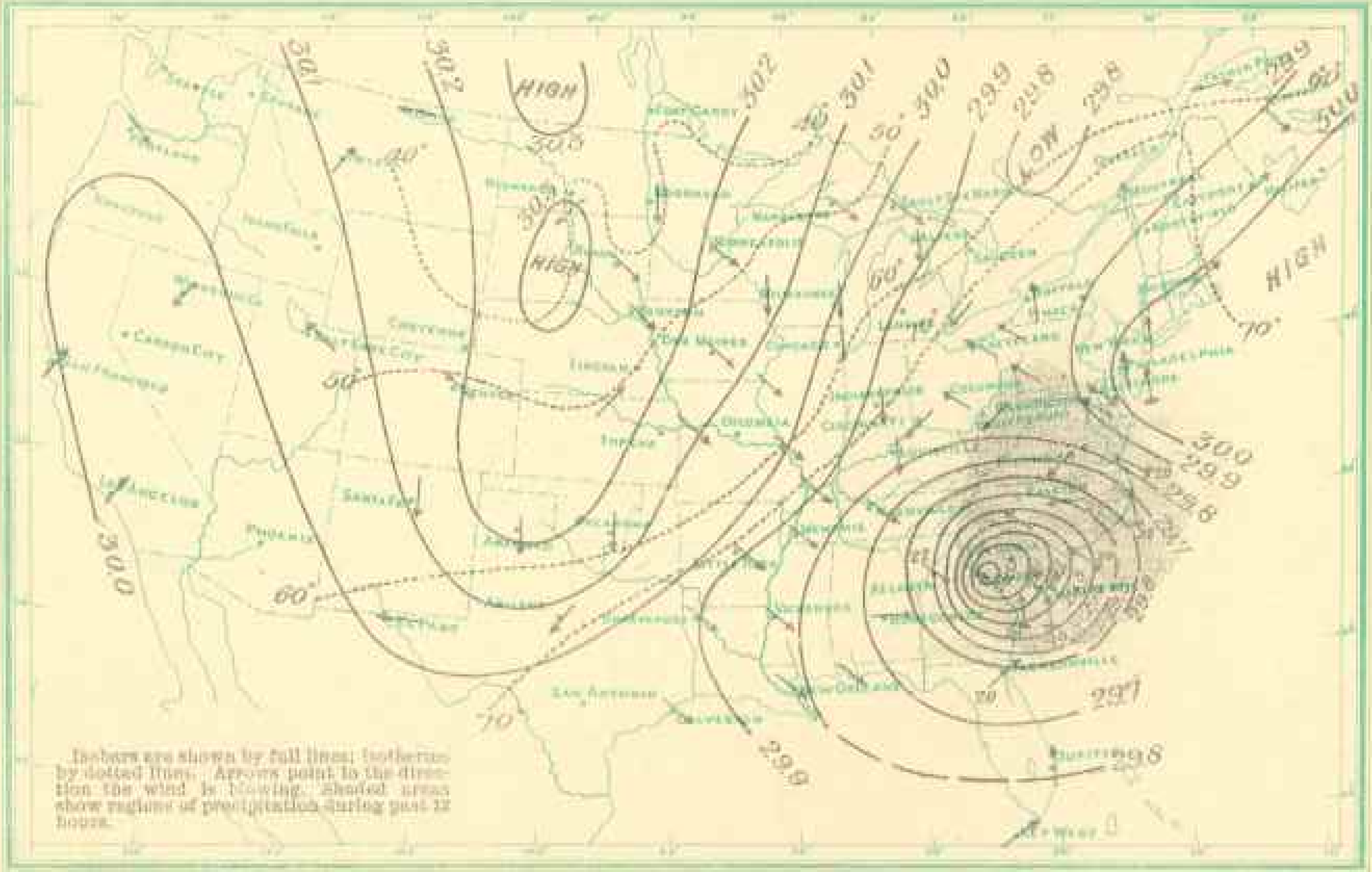


Chart XX. West India Hurricane, August 29, 1893, 8 a. m.



Isobars are shown by full lines; isotherms by dotted lines. Arrows point in the direction the wind is blowing. Shaded areas show regions of precipitation during past 12 hours.

Chart XXI. Change in Air Pressure in Preceding 12 Hours, August 28, 1893, 8 a. m.

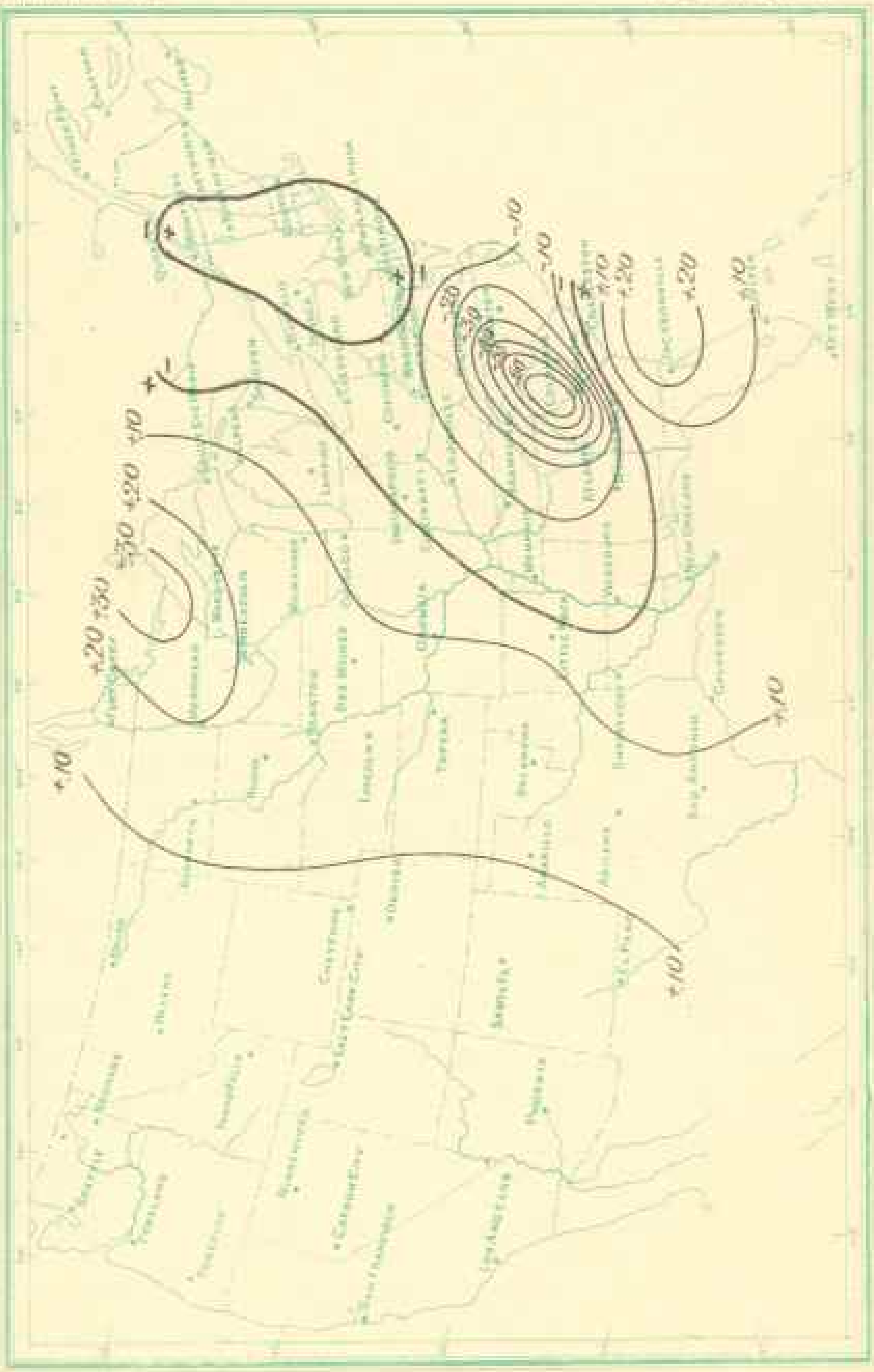
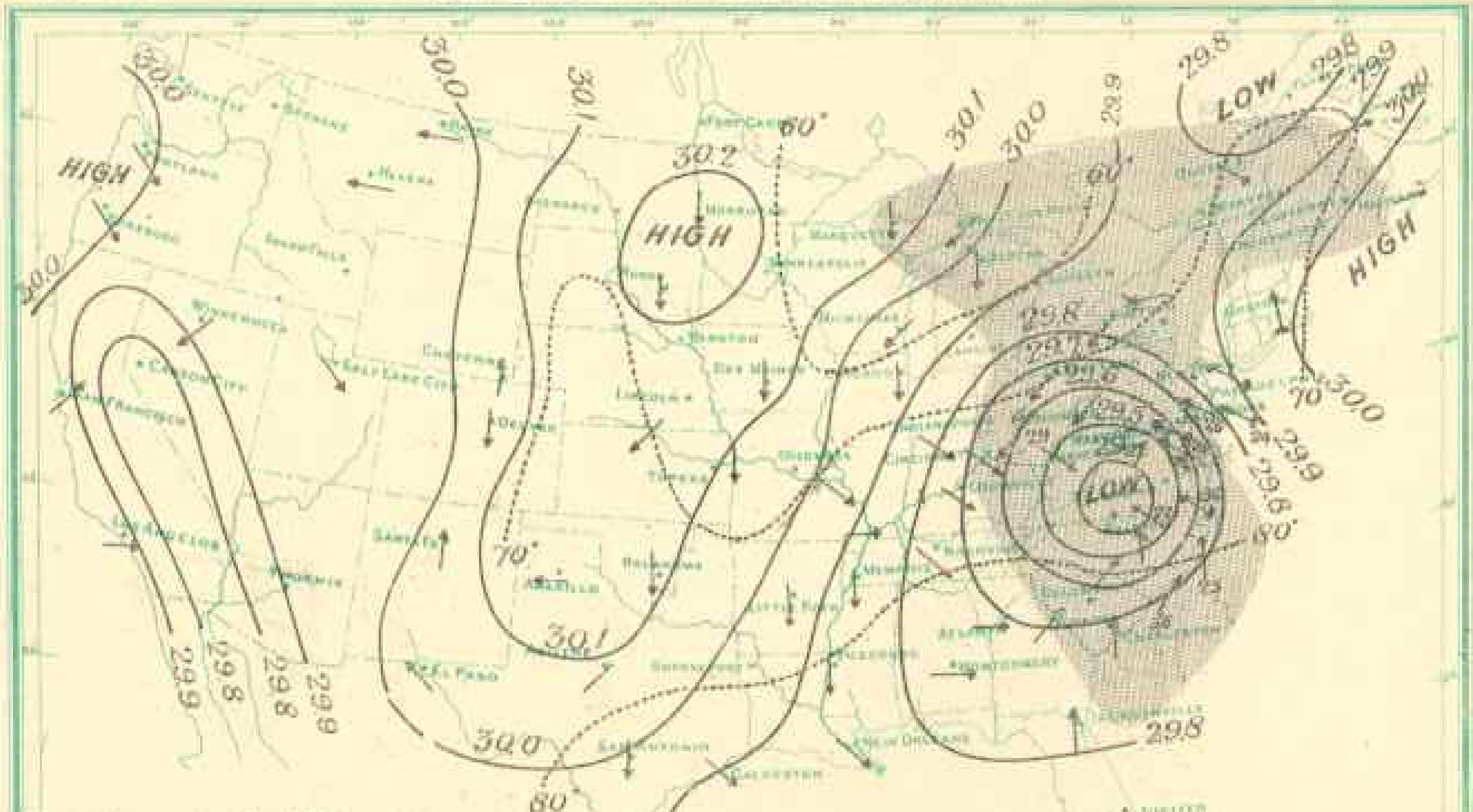


Chart XXII. West India Hurricane, August 29, 1893, 8 p. m.



Isobars are shown by full lines; isotherms by dotted lines. Arrows point in the direction the wind is blowing. Shaded areas show regions of precipitation during past 12 hours.

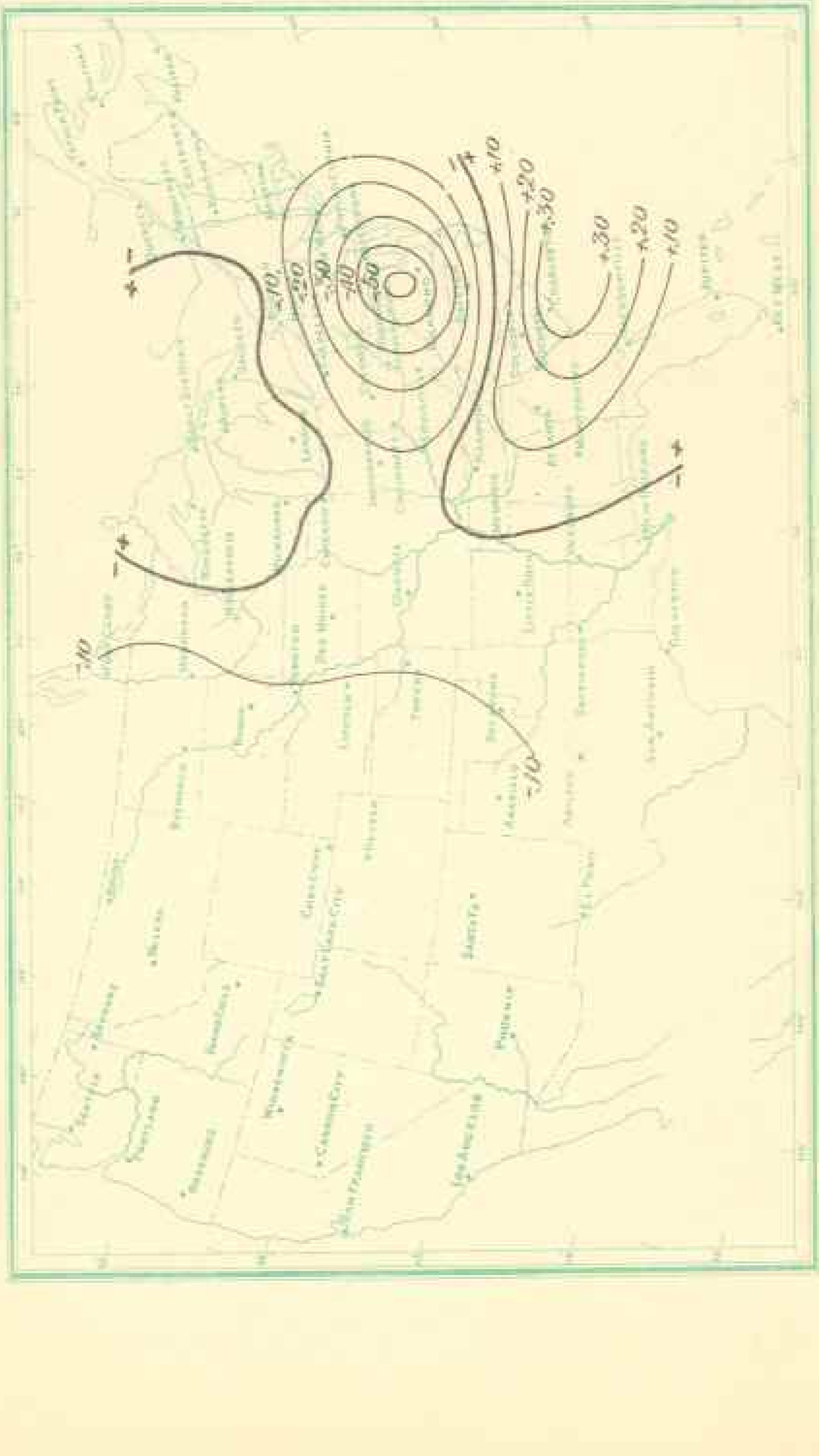
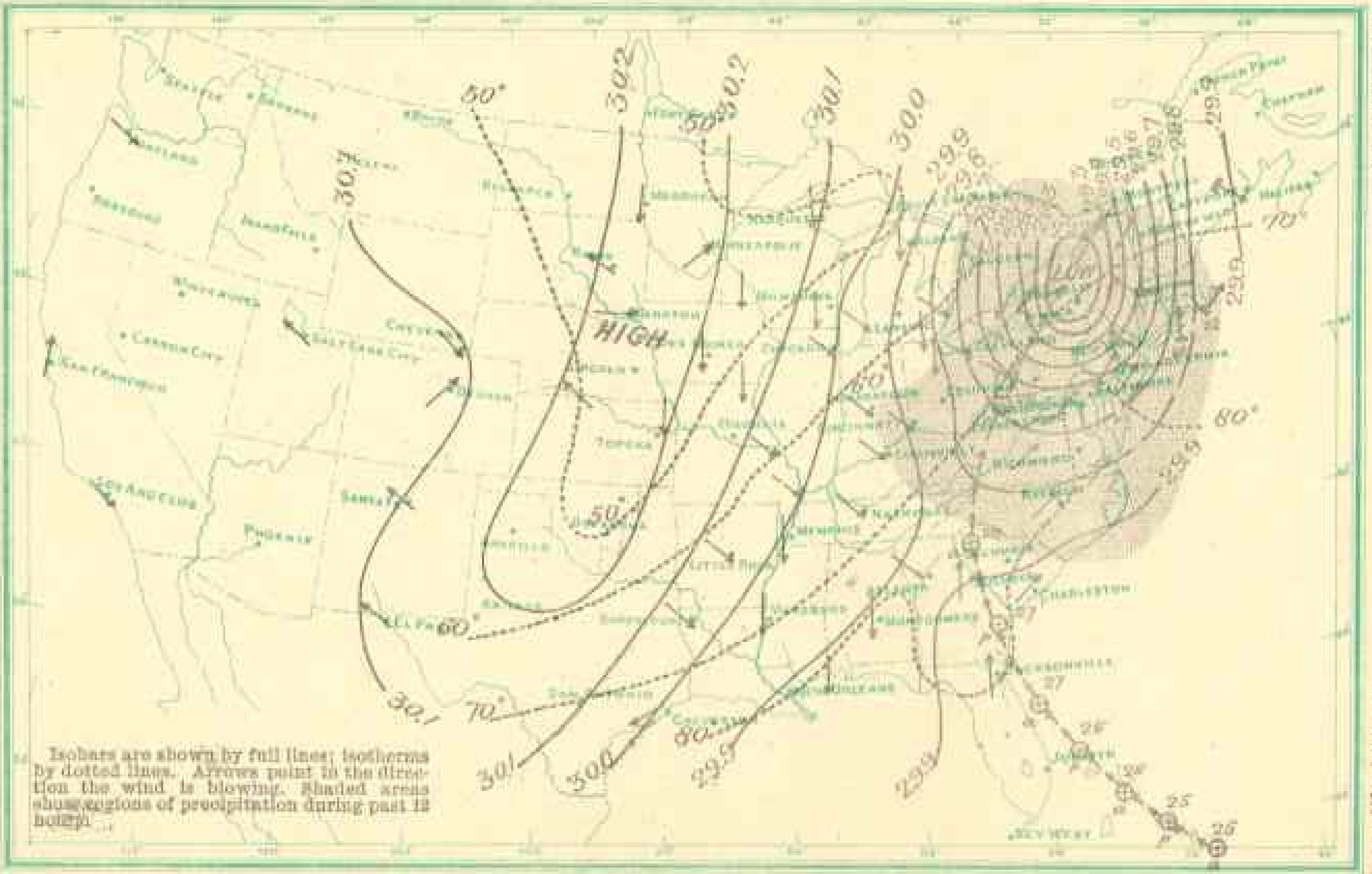


Chart XXIII. Change in Air Pressure in Preceding 12 Hours, August 28, 1893, 8 p. m.

Chart XXIV. West India Hurricane, August 29, 1893, 8 a. m.



Isobars are shown by full lines; isotherms by dotted lines. Arrows point in the direction the wind is blowing. Shaded areas show regions of precipitation during past 12 hours.

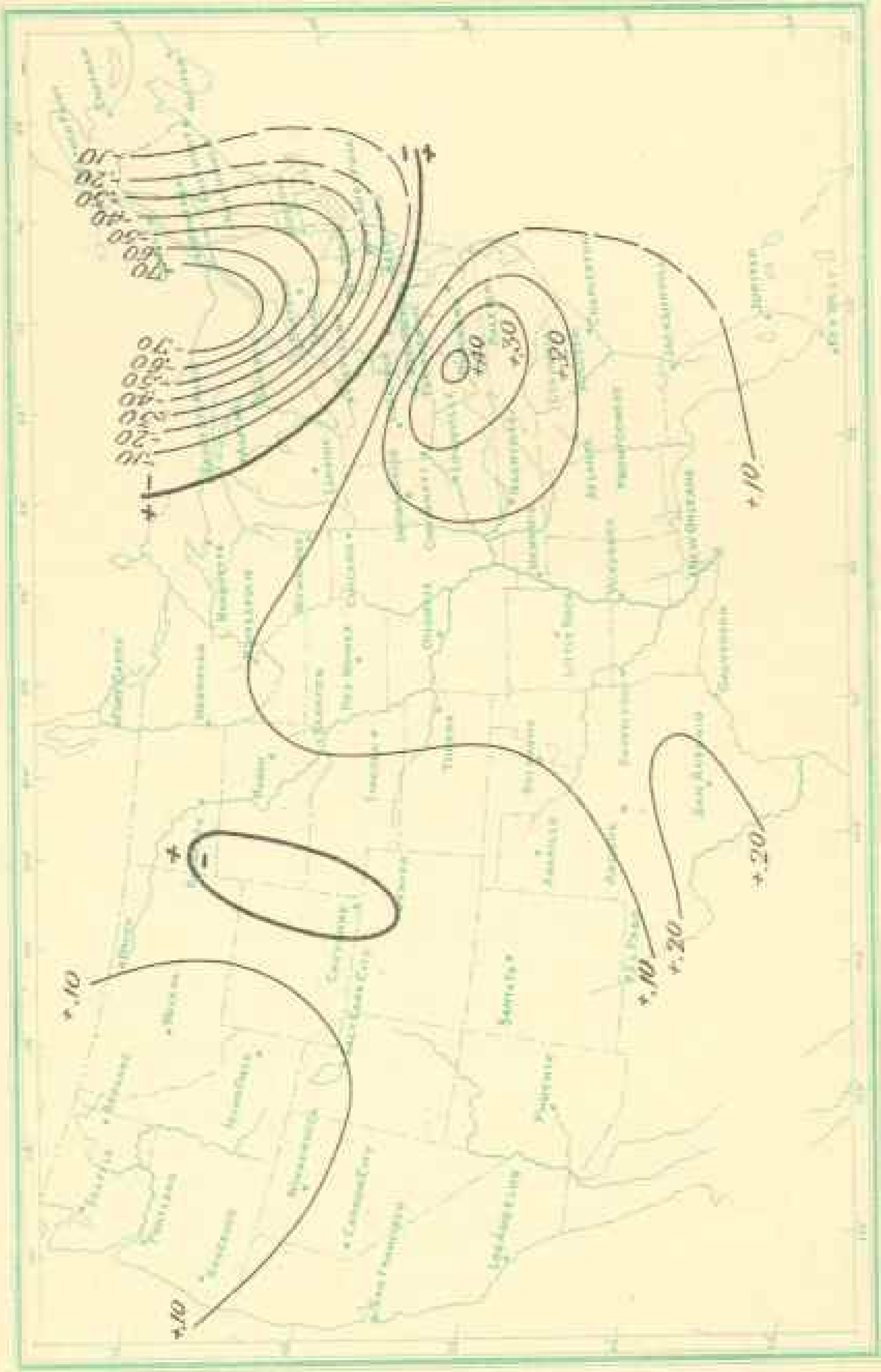


Chart XXV. Change in Air Pressure in Preceding 12 Hours, August 29, 1893, 8 a.m.

heavy ocean swell may be caused by the friction of the rapidly gyrating air on the surface of the water, and when the hurricane has a slow progressive movement this swell may be propagated outward from the center of the storm faster than the storm is moving and reach the coast several hours before either the barometer or the wind movement gives any indication of the coming storm.

The tracks of West India hurricanes are always in the form of a parabola. These storms come from the southeast, but on reaching the latitude of our Gulf coast recurve to the northeast along or off our coastline. An examination of the auxiliary chart on the adjoining page shows that the air pressure in the region of the storm has decreased .10 to .30 of an inch during the past 12 hours, and the little bars on the arrows shown on Chart XVI, from Norfolk southward, indicate that the forecast official at Washington has ordered up the storm signals in anticipation that the storm will move up the coast and increase in energy.

Chart XVIII, twelve hours later, shows that his warnings were timely, as the storm center has moved slowly northward to Jacksonville, with greatly increased energy, the barometer at the center reading 29.1 inches, which is about .9 of an inch under the normal air pressure. The auxiliary chart shows that the air pressure has decreased more rapidly during the past 12 hours than during the similar period next preceding. The most potent force in accelerating the motion of the eddy or hurricane was the vast amount of heat energy liberated by condensation in the whirling mass.

Danger signals have been carried northward to Norfolk, and ports north of the storm center have been warned that the dangerous winds will come from the northeast. I wish to make plain that the storm coming from the southwest causes northeast winds to flow in at its front. On the Georgia and Florida coasts the signals have indicated that the wind will blow from the northwest for a few hours, as the air whirls in behind the receding storm center. It will now be seen how it is possible for storms to progress against the wind.

In thunder-storms this rule does not hold, as there is a horizontal rolling of the atmosphere, caused by cold and heavy air from above breaking through into a light and superheated stratum next the earth. This rolling motion throws forward the cool air in the direction in which the cloud is moving.

Chart XX shows a slight aberration in the northeast course of the storm, which places the center inland, so that the whole eddy can be charted.

West India hurricanes are cyclonic in character, but on account of the fact that the diameter of the whirling eddy is much less and the velocity of rotation much greater than in the average cyclone, it is customary to designate them as hurricanes. In other words, the hurricane is a cyclone of small area but of powerful vortical action, and consequently of great destructive force. To get a rough idea of the difference between storms, we might classify them according to the diameter of the revolving mass of air under their influence as follows:

Cyclones, 1,000 to 2,000 miles; hurricanes, 200 to 500 miles, and tornadoes one-half mile to one mile. Then if a great quantity of heat energy is liberated by profuse condensation of aqueous vapor near the storm centers, we might imagine their vortical action and their destructive force to increase as their diameters of rotation decrease.

Charts XX to XXV show the progress, in twelve-hour intervals, of the hurricane northeastward to New England. It will probably leave the American continent at Nova Scotia and in three or four days cross the Atlantic and make its appearance on the northwest coast of Europe.

Twenty-five years ago mariners depended on their own weather lore to warn them of coming storms; then, although the number of boats plying the seas was much less than it is now, every severe storm that swept across them left death and destruction in its wake, and for days afterward the dead were cast up by the subsiding waters and the shores were lined with wreckage. Happily this is not now the case; the angry waters and the howling winds vent their fury the one upon the other, while the great mass of shipping, so long the prey of the winds and waves, rides safely at anchor in convenient harbors.

The United States has the most extensive weather service in the world, and its enormous practical utility is now universally recognized. Careful estimates based on reports from interested parties indicate that cold-wave signals effectively displayed in advance of one severe cold wave sweeping across our country result in a saving of over $3,500,000, while responsible marine representatives declare that each West India hurricane passing up the Atlantic seaboard would destroy not less than $2,000,000 worth of property and many lives if danger signals were not displayed well in advance of its coming.

RUBBER FORESTS OF NICARAGUA AND SIERRA LEONE

By General A. W. Greely,

Chief Signal Officer, United States Army

The increasing commercial demands for raw rubber and the steady diminution of caoutchouc produced by existing rubber forests give special interest to any information bearing on future supplies of caoutchouc pending the discovery of compounds that shall supplant it. In 1892 the Department of State published a Special Consular Report on rubber and rubber manufactures, which has lately been supplemented by additional information.

The india-rubber trees, of which there are several profitable varieties, will produce annually from 10 to 40 pounds of caoutchouc for many years, if they are tapped judiciously. It is, however, an almost universal complaint, from Africa, America, and Asia, that the greed and carelessness of the native collectors, who seek to obtain the greatest immediate quantity by the least laborious methods, are rapidly destroying the rubber-bearing plants. Trees are either felled or so deeply and roughly incised as to speedily die.

The fresh rubber juice, resembling cream in color and consistency, has an ammoniacal odor, which rapidly disappears, leaving the caoutchouc odorless and tasteless. Trees yield the milk copiously for several months each year, and the coagulated rubber averages about 30 per cent of the original juice, two pounds of caoutchouc to the gallon.

Brazil is the principal source of raw rubber, and that from Para is the best. In 1890 the receipts of caoutchouc at Para reached 16,570 tons, according to the report of Consul J. O. Kerbey, whose account of rubber-gathering may be of interest:

"The rubber-gatherer rolls out of his hammock as soon as it is light in the morning, and takes his gulp of rum and his calabash of coffee and starts out to visit his rubber trees. He wears a short pair of breeches and sometimes a shirt. He goes barefoot, for he must wade through the swamp mud and ooze of the tide up to his knees, and often up to his waist in water. He takes a basketful of earthenware gill cups, a hunk of adhesive clay, and a little, narrow-bladed hatchet.

"If he adopts the most approved method of tapping the trees, he reaches as high as he can with his hatchet, making an incision in the bark, but not reaching through to the wood. The milk immediately begins to issue in rapid drops or little streams. With a spat of the adhesive clay he immediately fastens one of his little gill clay cups just below the bleeding gash, and molds the clay so as to make all the rubber milk flow into the cup. Three such gashes, at equal distances around the tree and at equal height, is the rule. The next day he will make three more gashes in the same way, just a little below these three, and so continue, until by the end of the season he will have reached the level of the ground. Each of his 100 or 150 trees is treated in the same way, and he returns home, after having traveled from 3 to 5 miles, barefoot and almost naked, through thorny thicket and malarial, steaming swamp.

"When he reaches his hut, he again takes another gulp from the demijohn, snatches a breakfast of salt fish and mandioca meal, which are often moldy from the reeking damp of the swamp, and then he starts out again with his calabash buckets to gather the milk, which by this time has ceased to flow. His gill cups are full, or nearly so, and when he reaches home he has milk enough to make four kilos of rubber, on an average. The next task is the coagulation of the milk. For this purpose he has a jug-shaped furnace, made of earthenware, called a *boião*, open at bottom and top, and with a small aperture at the side to admit the air for the combustion. In this piece of furniture he builds a fire, or rather a smudge, with the nuts of the inija or urucury palm. The dense, black smoke which rolls from the open top of the *boião* is the reagent which coagulates the milk. For this purpose the rubber-gatherer has a circular-bladed paddle, like the paddle of a canoe, which he smears over with clay, so that the rubber will not adhere to it. This is suspended by means of a cord from the limb of a tree just above the smudge, the milk is poured over the blade of the paddle, which is then turned over and around about in the smoke, and in a few moments the film of rubber is coagulated. The same process is repeated of wetting with milk and smoking the growing lump until it reaches the weight of from 5 to 25 kilos or more. Then it is slipped off from the paddle as a mitten is pulled off from one's hand. This ball is the crude rubber."

RUBBER PROSPECTS IN NICARAGUA

A later report from Consul J. Crawfords contains the following information. Recently, many persons in western Nicaragua have declared their intention to plant and cultivate elastic rubber-yielding (some varieties of the *juno* are but slightly elastic) trees and vines in the eastern part of the state. Such estates are locally named *haciendas de hule*. These persons are inquiring concerning the localities having the most suitable lands and climate, the species and varieties of trees and vines that annually or biennially yield the largest quantity of good rubber, the proper distance apart for planting the trees and vines, the best modes of cultivation, and how many years must elapse before it is proper to commence the annual or biennial collection of rubber, etc.

Many of the valleys in central and northeastern Nicaragua contain all the natural conditions for a full yield of an excellent quality of elastic rubber. They are localities supporting numerous groves of large-sized trees yielding rubber until about fifteen years ago, when nearly all the trees had been killed by too severe scarifying by irresponsible collectors. Localities in Nicaragua south of latitude 15° north, and in low valleys where the soil is alluvial or vegetable humus and sand, capable of being rapidly drained, and in a climate that is uniformly warm and humid, suit the largest rubber-yielding varieties of trees and vines. Some varieties, giving an excellent quality of very elastic rubber, are indigenous to a higher, drier climate and soil.

There are several of the natural orders—*Urticaceae, Sapotaceae, Moraceae, Apocynaceae*, and *Euphorbiaceae*—indigenous in Nicaragua, which, when scarified deeply, exude a milk-like sap from which rubber of various degrees of elasticity is separated. The annual quantity and the quality in elasticity differ usually with the species and with different conditioned localities. Some prefer the low alluvial lands under a humid atmosphere, while other varieties flourish best in more elevated, sandy, and decomposed vegetable matter—lands rich in potash, as the volcanic valley districts south of Lake Nicaragua. The most desirable varieties for quantity per annum and quality of rubber are the *Siphonia elastica* and *Castilloa elastica*, habitants of well-drained, low, alluvial valleys, kept warm by a humid atmosphere. The second best rubber-producers are of the ficus family, a variety locally known as matapala, an epyphite having numerous bodies from aerial roots (like the banyan tree). It is also an inhabitant of low, fertile, well-drained lands. By cultivation this tree would probably equal the other low-valley varieties in quality and annual output of rubber. It has the advantage that if one of its trunks is deadened by excessive drainage of the sap, it has several other live trunks from which to obtain supplies of rubber. Another good variety is the *manihot balano*, locally known as the "arbolde vaca" (cow-milk tree), a large, hardy, indigenous kind found at altitudes of 1,000 to 2,000 feet above the ocean.

The annual yield of elastic material depends on the bulk of the bast or lactiferous tissues that exist or that can be developed. Some trees of 2 or 3 feet diameter and 35 to 50 feet tall will give annually 20 to 40 pounds of good rubber. The quality of rubber depends largely upon the form of the cells composing the bast, and in part in the process used to separate the elastic material from the emulsion-like sap. Quality and quantity are responsive to cultivation.

According to very recent reports from Nicaragua, the leaves yield a purer juice, and more copiously, than the bast. If this proves true, the supply of rubber can be largely increased without permanent injury to the tree.

The shoots should be transplanted to a nursery when one year old, and thence removed to their permanent place when 3 years of age, in rows—say, 64 Matapala, 81 Siphonia, and 100 Castilloa trees per acre.

Cultivation consists in ditching the land so as to drain it at will, keeping it moist without permitting water to stand. Keep all undergrowth cut down and the land "hilled up" around the trees. Fell other varieties of trees and vines until they shade but a very small part of the land. Commence during the sixth or seventh year to collect rubber by small area incisions through the bast, taking, if the trees have matured properly, 8 to 12 pounds of rubber from each tree biennially, but after the tree is 12 years of age a sufficient quantity of sap could be annually extracted to yield 10 to 15 pounds of good elastic rubber.

The two following modes of incision are preferable to other processes: (1) Cut with a curved, sharp instrument channels through the lactiferous tissues similar to those made in pine trees in turpentine orchards in the United States; (2) drive tubes cut from the internodes of bamboo (abundant in Nicaragua) through the bast, first making a slanting cut of a part of the circumference of the tube, and drive the sharpened end, 1½ to 2 inches long, into the tree; then, when the collecting season is passed, "plug up" the tubes of that season with wood that has been dipped in some liquid insecticide and saw off the tube and its wooden core even with the thin exterior bark of the tree.

The coagulation of the milk-like exudation and the separation from it of the elastic material can be effected by heating to 167 to 175 degrees F. and stirring in a hot decoction of some species of convolvulaceae, as morning glory, or stirring into the emulsion, when fresh and hot, the smoke from burning palm or other oleaginous nuts, which are abundant in rubber-yielding districts.

Secondary crops, planted between the rows of rubber-producing trees, could be the Liberia coffee tree, bananas, or such fibrous plants as hennequen, sisal, etc., of the agave family; also, the vanilla bean, one vine to each rubber tree, which would yield an annual crop equal in value to the rubber product. While the vanilla vine needs trees of this class for sustenance, yet it is probable that the vanilla would not materially reduce the flow of sap or the quantity of elastic material from the tree.

A comparative estimate of the annual value per acre in Nicaragua of coffee trees and rubber trees at nine years of age and thereafter, at present (1896) prices, gives $192 net profit from an acre in rubber trees.

RUBBER FORESTS OF SIERRA LEONE

The following information concerning the undeveloped rubber forests of Sierra Leone is drawn from the address of His Excellency Colonel Cardew to the legislative council of Sierra Leone on his journeys, aggregating 1,300 miles, in the hinterland and protectorate of Sierra Leone in 1894–'95.

There are large forests with abundance of rubber awaiting exploitation by intelligent and systematic methods and that will yield wealth to the first enterprising comer. An extensive rubber forest lies between Makali and Kruto, covering the greater part of the district between the Seli and Bagwee rivers. This area comprises portions of the Kuniki and Koranko districts, and the extent of the rubber forests is estimated at 600 square miles. The portion of the forests seen is composed of rubber trees about ten years old, called "Kewatia." These trees grow rapidly, and in ten years attain a girth of two or three feet, but under present methods they are felled by the rubber-gatherer. Two vines, the "nofe" and the "lilibue," yield rubber, the latter of the choicest quality. The "nofe" is invariably cut up and destroyed for its rubber, and the "lilibue" generally so.

The native processes of rubber-gathering are crude and wasteful in the extreme. If intelligent and economical methods were adopted, there would be far greater yields than formerly, and the west African rubber would command a higher price. Unless better methods of extracting rubber are introduced, it is safe to predict that under the increasing demand for rubber one of the most thriving industries of Sierra Leone will be ruined by the extinction of the plant. At present, for the purpose of extracting a few pounds of rubber, large trees are totally destroyed.

The forests in the Kuniki and Koranko districts are quite accessible, it being about seven days' march to Makali, where the woods are entered. Water carriage for light canoes is possible down the Rokel river from Benkia, two marches from Makali.

These forests, however, are small compared to those on the Anglo-Liberian frontier along the Morro and Mano rivers, which extend nearly a thousand miles. The exploitation of these forests has been impracticable for the last twenty years, owing to border raids, but under present conditions of peacefulness it is now possible to open up these forests, which abound in rubber and elephants, and the southern portions of which are within two days' journey of Sulina.

A protectorate will shortly be proclaimed over the British sphere of influence in the interior, and under the proposed arrangement of five districts, each to be under a competent commissioner, it is hoped there will be a rapid development of the interior, especially in the way of opening up communications and fostering trade.

RECENT EXPLORATIONS IN EQUATORIAL AFRICA*

Africa is fast losing its title of the Dark Continent, and if explorations continue at their recent rate for a few years longer it will be as well known as other parts of the globe. Three young men recently crossed it from east to west, following, in the main, the route taken by Stanley, and correcting a few of the slight mistakes made by that explorer, as the

* In studying the geography of the Dark Continent it should be borne in mind that owing to the interchangeability of the letters r, l, and d in many of the African dialects and to the fact that explorers of various nationalities have applied to the names of the different tribes and geographic features of the regions they have visited the orthographic forms peculiar to their own languages, the geographic nomenclature, even of such portions of the interior as are now mapped in more or less detail, is far from being definitely established. In some cases the variation in spelling is so great as almost to preclude identification, and not even in the case of names of European origin is there that uniformity of orthography which is so much to be desired. J. H.

result, probably, of his rapid marching. These travelers were M. Maurice Versepuy, who has since died of fever, the Baron de Romans, and M. Sporck, an artist, accompanied by an escort of 20 riflemen and 130 carriers engaged at Zanzibar. They secured a large collection of weapons from different tribes, of indigenous seeds, flowers, and timber, of skins of various mammalia; also a live leopard and a large number of photographs, and of water-color and other drawings. They traveled 4,000 kilometers on foot and 2,000 by boat, and their very complete itinerary of their travels contains much interesting geographical information.

The explorers left Zanzibar on July 6, 1895, sailing thence for Mombasa. Thence they crossed a barren, rocky country and reached Lake Jipé, where they hunted a while. They ascended the slope of the Kilimanjaro to the German post of Moshi, at an elevation of 1,200 meters. The Kilimanjaro is an imposing mass, nearly 6,000 meters high and covered with eternal snows. The confluence of the rivers Tsavo and Useri was located and the party crossed to the north of Kilimanjaro, a volcanic country entirely uninhabited, and passed by Lake Ngiri. Taking an entirely new route, they made for the English post of Kikuyu, across the plains of Kapotei, where they successfully hunted elephants, rhinoceros, zebras, and antelope. These plains were entirely devoid of vegetation and their rivers were dried up. Kikuyu was reached in November, at which time the Masai were in open rebellion. This brave and fearless tribe is known and feared from the Kenia to German East Africa. They are tall and well-built, are mostly naked, wear their hair long, and smear their faces and shoulders with grease and red clay. They wear war-feathers about the head and carry spears and shields, but while warlike and nomadic they raise some cattle. It was at this time that an English caravan, composed of 1,200 Wakikovus, was attacked by the Masai, who killed 700 of them. A Scotchman, named Dick, who was traveling with another caravan, left Kikuyu the day before the three French travelers, but hearing of the massacre he fell back and sent a letter to Kikuyu for assistance, which was refused. The Frenchmen joined forces with him and they were furiously attacked by the Masai in the Kedong valley. The attack was repelled, but Dick was killed.

Leaving the Kedong valley, the party passed to the east of the small lakes Naivasha, Nakuro, and Elmeteita, and on December 5 reached the English fort of Ravine. The next day they crossed the deep ravine of the Eldoma river, passed the Mau foothills to the country of the Wanandis, across the north of the Kavirondo country, to the Nzoia river, from the banks of which the Victoria Nyanza could be seen. The Usoga, a rich and thickly inhabited country, was next passed and the Nile was reached. The Ripon falls, about 800 meters wide and 10 meters high, were greatly admired. Crossing the Bay of Napoleon brought the travelers to Uganda, where the natives are sufficiently civilized to have built roads and bridges. Their capital is Mengo, which the travelers left on February 22, 1896. Passing by Lake Mitiana, which is more of a swamp than a lake, Lake Ruberoa was reached. It lies to the northeast of Lake Albert Edward, which is itself to the southwest of Mount Ruwenzori.

According to Stanley, there is a high peak, which he named Gordon Bennett, to the north of this lake, but the travelers were unable to discover it. Mount Ruwenzori is about 5,000 meters high, and at night numerous lights were seen on its slopes. On April 11 the explorers were at Kasagama, whence they started for Katoné, to the north of Lake Albert Edward, and on the frontier between British territory and the Kongo Free State. During this march they noticed that Lake Ruberou is not connected with Lake Albert Edward by a large bay, as Stanley says, but by a small stream. The two lakes are 40 kilometers apart and have a difference of 200 meters in elevation.

On April 17 Katoné was left behind, the thirtieth meridian was crossed, and the caravan camped right under the equator for the third time since leaving Mombasa. Continuing westward, they entered the Kongo Free State and crossed the foothills of the Ruwenzori, visited by Captain Lugard a few years ago, and entered the Semliki valley. The Semliki river is about 200 meters wide and has a very swift current. The next halt was made at the village of Mbéné, where Stokes was captured. From this place to Leopoldville the country is covered with an almost impenetrable forest, on the edge of which is the Arab village of Kissangué, an auxiliary post of the Kongo State. It is the duty of the chief of the village to warn the Kongolese authorities of the presence of strangers on their territory. After a ten days' march through the forest Kuamkubi was reached. In this part of the country traces of Arab civilization are everywhere apparent; these Arabs speak the Zanzibar dialect. Leaving this post, the Kongo basin was next entered. The march through the forest was exceedingly difficult, compass and ax being alike indispensable. Finally the Ibina, a branch of the Ituri river, was reached. Twenty days more along the banks of the Ibina brought the travelers to the Ituri itself, which they crossed in canoes, and then took a guide, who conducted them to the Kongolese military post of Kilongalonga. They were well received by the Belgian officers, the first Europeans they had met for several weeks, and after a short rest and the laying in of supplies they left for the next post. Recrossing the Ituri, they followed its left bank as far as Moussa, a small village opposite the mouth of the Ipulo. Here the Ituri is swift and narrow. Eight days more through the forest brought the travelers to Avakubi, where for the fourth time the Ituri had to be crossed. Avakubi is a post and market of some importance. Here the travelers saw a few specimens of the race of pygmies whose existence has by many writers been doubted. The stature of these pygmies is about 1 m. 20, they are absolutely naked, their noses are very flat, and their looks somewhat ferocious. Their weapons are spears and arrows, which are proportionate to their stature. They hunt a great deal and attack even the elephant. They build no huts, but live scattered about the forest, and their habitations are holes. Their suspicious nature renders them very difficult to meet, and it is only once in a while that a few of the least wild among them venture to go to the nearest post to exchange the products of their hunt for bananas or sweet potatoes.

From Avakubi the travelers proceeded in canoes as far as Stanley Falls.

Here they embarked on a small steamboat and descended the Kongo, which at Bumba has a width of 30 kilometers. On August 3 they sailed for Europe, and M. Versepuy died shortly after his return to France.

ERNEST DE SASSEVILLE.

PARIS, *January 22, 1897.*

GEOGRAPHIC LITERATURE

Laboratory Practice for Beginners in Botany. By William A. Setchell, Ph. D., Professor of Botany in the University of California. Pp. xiv + 199. New York: The Macmillan Company. 1897. 90 cents.

That school instruction in botany is emerging from the dilettanteism and dry terminologyism of "manuals" on the one hand, and the proud but narrow microscopism of the usual "laboratory guides" on the other, is evidenced by the appearance of Professor Setchell's Laboratory Practice for Beginners in Botany. It is a book in which technical names for the parts of plants and machinery for handling and examining specimens are given a subordinate place, while the gross structure of plants is examined with the question constantly in mind, "How does the plant make use of the organs, and in what way are the modifications in different plants adapted to their special requirements?" The book contains 16 chapters on the anatomy of seeds, seedlings, roots, stems, leaves, buds, flowers, inflorescence, and fruits, and interspersed chapters on protective structures, storage of food, climbing and insectivorous plants, vegetative reproduction, pollination, seed dispersion, and other similar subjects. The book cannot fail to go a long way toward placing the student—and, we may add, the teacher also—in the attitude of keenly observing the relation of structure to function, a kind of observation in which Charles Darwin and Sir John Lubbock have been our chief masters, and which will ultimately give the science of botany the acute scientific interest and real educational value in secondary schools to which it is so well adapted and so fully entitled.

F. V. C.

An Introduction to Geology. By W. B. Scott, Blair Professor of Geology and Paleontology in Princeton University. Pp. xxvii + 573, with numerous illustrations. New York: The Macmillan Company. 1897. $1.90.

Students and teachers are to be congratulated on the appearance of another elementary work on geology. As explained by the author, the treatise "had its origin in the attempt to write an introductory work, dealing principally with American geology, upon the lines of Sir Archibald Geikie's excellent little 'Class Book.' * * * The book is intended to serve as an introduction to the science of Geology, both for students who desire to pursue the subject exhaustively, and also for the much larger class of those who wish merely to obtain an outline of the methods and principal results of the science." The contents suggest that the treatise is an expansion of Professor Scott's lectures on geology in Princeton University.

The book has the attractive air due to the excellent editing, clear typography, and photo-mechanical illustrating adopted of late by The Macmillan Company. In matter it is eminently conventional, and in manner of presentation thoroughly conscientious. It must appeal strongly to the honest student of earth-making. In general, the author has abstracted and condensed in admirable fashion the substance of the geologic literature of the last quarter-century; thus there is nothing of the sensational, and except in vertebrate paleontology little of the novel, between title-page and index. Perhaps the chief weakness of the work—if weakness it can be called—grows out of the author's desire to avoid extremes. On mooted points both or all sides are stated judicially, and this even when one interpretation is old or speculative and the other new or more directly observational, so that many of the chapters smack of class-room rather than field. An example will suffice: In discussing the distribution of earthquakes it is noted that "The great earthquakes which shook the Mississippi valley in 1811-'12 are among the very few instances of violent and long-continued shocks in a region far from any volcano," and the obsolete Humboldtian notion of connection with West Indian volcanoes is quoted approvingly, while the notable shocks that have devastated both sides of the Indian peninsula far from volcanoes, though about the depositing grounds of great rivers, and even our own Charleston earthquake—which, through the studies of Dutton, threw more light on seismism than any other recorded in history—are ignored! It is chiefly on the dynamic side, or the side of agency, that the old and the new are thus confused. On the descriptive side the chapters are generally up to date, while in paleontology, especially in connection with vertebrate fossils, the work stands in the van of modern knowledge. On this ground alone it will be invaluable to both classes for whom it is designed, since it is the first general work to really vivify fossil skeletons and to compel readers to conceive them as of living things.

The main divisions are (1) Dynamical Geology, (2) Structural Geology, (3) Physiographical Geology, and (4) Historical Geology. The classification is one of the conventional features suggesting that the author's platform is built of planks carefully selected from platforms of a dozen predecessors. To escape consequent difficulties an excellent introduction, with a chapter on rock-forming minerals, is prefixed. A useful classification of animals and plants is appended, and the value of the book is multiplied by an excellent index. As is usual in recent works, the author has drawn freely on the common stock of current knowledge, and gives credit to a score of contemporary geologists. W J M.

GEOGRAPHIC SERIALS

In "The Journal of School Geography" we welcome a new periodical in the field of geographic literature. This journal, which is addressed particularly to teachers, is edited by Mr R. E. Dodge, Associate Professor of Natural Science in the Teachers College, New York, with, as associates, Prof. W. M. Davis, of Harvard; C. W. Hayes, of the U. S. Geological

Survey; H. B. Kummel, of the Lewis Institute, Chicago; F. M. McMurry, Dean of the School of Pedagogy, University of Buffalo, Buffalo, N. Y., and R. DeC. Ward, of Harvard. Ten numbers will be published a year, price $1.00, or 15 cents a number.

Two numbers have thus far been issued, the leading contents of which are as follows: In the January number, "Home Geography," by W. M. Davis; "Some Things About Africa," by Cyrus C. Adams; "Geographic Instruction in Germany," by W. S. Monroe; "Some Suggestions Regarding Geography in Grade Schools," by R. E. Dodge. The February number contains the following articles: "The Influence of the Appalachian Barrier upon Colonial History," by Ellen C. Semple. It appears to us that Miss Semple exaggerates the influence of this geographic feature in delaying the settlement of the interior of the country. "Meteorological Observations in Schools," by Robert DeC. Ward; "The Causal Notion in Geography," by F. M. McMurry; "Geographic Aids," by R. E. Dodge.

This is a much-needed publication, and we welcome it with the prediction that it will be successful.

Another periodical of somewhat similar character which has just been added to our list of exchanges is "The Inland Educator," edited by Francis M. Stalker and Charles M. Curry, and published at Terre Haute, Indiana, price $1.00 a year, monthly. The opening article of the February number, which lies before us, is entitled "The New Geography," written by Prof. Charles R. Dryer.

From time immemorial the teaching of geography in the schools has consisted in memorizing isolated facts regarding the earth, its products and inhabitants, with little attempt to show relations. It is only in recent years that educators have become dissatisfied with this condition of things, and it is only in recent years, moreover, that geography has advanced from what might be termed an art to the dignity of a science—*i. e.*, that it has become recognized that the class of facts grouped under the name of geography have causal relations among themselves. The unrest among educators regarding the teaching of geography, which at first was merely aimless dissatisfaction with existing methods, is gradually leading toward definite lines of improvement. Gradually teachers are learning that geography is a logical science, and must be taught as such, and the text-books are beginning to adapt themselves to this view. The introduction of physiography into text-books is but one step in this direction. Physiography explains the origin of relief and drainage forms, and when to this are added the relations between the earth's surface and its climate, on the one hand, and the distribution of life and of man's industries and products, on the other, in our text-books, the improvement will be a well-rounded one. Then geography in its broad sense can be taught as a science. These are some of the ideas which are brought out in Professor Dryer's admirable article. Other articles in "The Inland Educator" relate especially to other branches of education and require no special mention here.

"The Geographical Journal" for February seems to be especially devoted to African exploration. It opens with "A Journey in the Marotse and Mashikolumbwe Countries," by Capt. A. St H. Gibbons. Other articles are "A Journey up the Machili," by Percy C. Reid, "From the Machili to Lialui," by Capt. Alfred Bertrand; "Notes on a Journey Around Mount Masawa," by C. W. Hobley. Concerning Asia, there are "Explorations in Mysia," by J. A. R. Munro and H. M. Anthony; "Journey of Captain Wellby and Lieutenant Malcolm Across Tibet," and "Captain Deasy's Journey in Western Tibet." Mr J. Bartalhareis contributes an article entitled "The Supposed Discovery of South America Before 1448 and the Critical Methods of the Historians of Geographical Discovery."

"The Scottish Geographical Magazine" for February contains an account of "Recent Explorations in the Patagonian Andes South of 41° South Latitude," by Dr Hans Steffen, and "Notes upon the Geography of the Argentine Republic," by H. D. Hoskold, Director-General of the National Department of Mines and Geology, Buenos Aires.

H. G.

PROCEEDINGS OF THE NATIONAL GEOGRAPHIC SOCIETY, SESSION 1896-'97

Regular Meeting, February 19, 1897.—President Hubbard in the chair. Mr J. E. Spurr read a paper, with lantern-slide illustrations, on the Forty-Mile Creek Gold-Mining District, Alaska.

Special Meeting, February 20, 1897.—President Hubbard in the chair. Mr George Kennan lectured on Vagabond Life in Eastern Europe, with lantern-slide illustrations.

Special Meeting, February 26, 1897.—President Hubbard in the chair. Mr Frank Hamilton Cushing addressed the Society on the Ancient Sea-Dwellers and Key-Builders of Florida, illustrating his subject with lantern slides.

Special Meeting, March 1, 1897.—First lecture of the course of Monday afternoon illustrated lectures and annual address of the President of the National Geographic Society, under the auspices of the Joint Commission of the Scientific Societies of Washington. Surgeon-General George M. Sternberg, U. S. Army, Vice-President of the Joint Commission, in the chair. The subject of President Hubbard's address was the Effects of Geographic Environment in the Development of Civilization in Prehistoric Man.

Regular Meeting, March 5, 1897.—Secretary Hayden in the chair. Mr F. H. Newell delivered an address, illustrated by lantern slides, on the Distribution and Mining of Petroleum.

Special Meeting, March 8, 1897.—Second Monday afternoon illustrated lecture. President Hubbard in the chair. Rev. W. Hayes Ward, D. D., LL. D., of the New York *Independent*, lectured on Babylonia.

Special Meeting, March 12, 1897.—Vice-President Greely in the chair. Miss Annie S. Peck lectured on Mountaineering in the Tyrol and Switzerland, including an Ascent of the Matterhorn, with lantern-slide illustrations.

ELECTIONS.—New members have been elected as follows:

February 26.—Miss H. J. Baird-Huey, Judge George S. Batcheller, Mrs Diaz-Albertini, Alex. Everett Frye, George B. Hollister, Mark S. W. Jefferson, Albert M. Lewers, Robert H. Paxson, Mrs Altha Gibbs Powell, Miss Mattie Scott, Mrs George Westinghouse, Rev. R. P. Williams.

DEATHS.—The Society has recently lost by death the following-named members:

Mr J. M. Cunningham, of San Francisco; Mr Joseph Macfarland, of the U. S. Geological Survey; Hon. J. Randolph Tucker, of Lexington, Va.; General Alfred Pleasanton, U. S. A.; Mr Lewis Clephane, of Washington, D. C., and Mr L. P. Smith, of the U. S. Department of Agriculture.

GEOGRAPHIC NOTES

CENTRAL AMERICA

NICARAGUA. Concessions have been granted to United States citizens for a street railway to be operated by steam between the town of Bluefields and the Bluefields custom-house, situated at the mouth of the harbor, and also for a railway between Rama and San Ubaldo. The United States consul, however, makes the significant statement that "so little has ever been done in Nicaragua under any government concessions, big or little, that it seems a waste of time to enter into the details of any concession without positive proof that it is to be pushed."

A contract has been let for the construction of a canal to connect Pearl and Bluefields lagoons, which will afford an inside channel with a depth of 4.5 feet for a distance of 55 miles north of Bluefields.

EUROPE

RUSSIA. On September 13 the total length of railways in operation in Russia was 36,861 versts, or about 24,400 miles. Of these lines, 21,158 versts were operated by the government.

The development of the mineral and manufacturing industries of Russia is progressing with astonishing rapidity. The production of coal has trebled in the last 15 years and the progress in the textile industries is marvelous. The empire, however, is still largely dependent upon other countries for its machinery and upon foreigners for the more responsible positions in its factories and ironworks.

There has been an enormous increase in the shipping industry of the Caspian sea, owing to the development of the oil wells of Baku, one of which recently discharged 300,000 tons of oil, valued at $750,000, within a period of two months. Several of the Russian railways and most of the steamship companies on the Volga, as well as the manufacturing centers along that great waterway, are using oil for fuel.

ASIA

SIBERIA. By consent of the Russian authorities the peninsula discovered by Dr Nansen is to be named for King Oscar of Sweden.

Over 200,000 Russian peasants migrated to Siberia in 1896, but some 25,000 were forced to tramp back to their miserable homes, owing to the land set apart for colonization being insufficient to meet the demand.

SYRIA. A steamer is now making regular trips from Jericho to Tiberias—*i. e.*, from the Dead Sea to the Sea of Galilee—in five hours. Several Jewish families recently settled in Jericho and are preparing to irrigate extensive fruit farms.

JAPAN. The Russo-Japanese convention has been published in St Petersburg. It provides that Korea shall retain full liberty of action as regards both domestic and foreign policy. Russia and Japan will each keep a small force of troops in Korea until such time as the government can maintain order.

INDIA. It is estimated that the present famine in India would have reduced the population of that country by 10,000,000 if it had been allowed to run its course unchecked. Over 3,000,000 persons are employed on government relief works, and hundreds of thousands more are being succored out of the fund (now amounting to the equivalent of nearly $3,000,000) contributed in the British Islands.

AFRICA

TRANSVAAL. The total output of gold for November was 201,113 ounces, as compared with an output of 195,218 ounces in November, 1895.

MADAGASCAR. The French Colonial Minister has announced the intention of the government to maintain the equality of all religions in the island of Madagascar. He has forbidden, by telegraph, the proposed confiscation of Protestant churches.

ALGERIA. According to the recent census, the city of Algiers contains 96,000 inhabitants, 46,000 being French by birth or naturalization, 9,600 Jews, 25,000 Arabs or belonging to other native races, 9,800 Spaniards, 3,500 Italians, 1,100 Maltese, and 235 English.

CENTRAL AFRICA. Mr Poulett Weatherley, an Englishman, who recently visited Old Chitambo, where Livingstone's heart is buried, calls attention to the decay of the tree that marks the spot, and suggests the necessity of the immediate erection of a more enduring monument.

EGYPT. During the recent Sudan expedition the number of all ranks of the Egyptian army killed in action was 47; the wounded numbered 122; 235 of all ranks died of cholera, and 129 died of other diseases. The Egyptian troops are said to have displayed great powers of endurance and a remarkable capacity for hard and continuous work.

WEST AFRICA. Wherever British influence predominates, railroad building is in progress. A line is in operation from Dakar, the chief port of Senegal, to St Louis, 175 miles north. Another line runs from Kayes up the valley of the Senegal toward Timbuctu, which it will soon reach. A line from Conakry to the Niger is also in contemplation. Dr Karl Peters recently stated in London that the whole African question was one of communication.

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The Deserts and Forests of Arizona,

BY PROF. B. E. FERNOW, PH. D.,

CHIEF OF THE DIVISION OF FORESTRY, U. S. DEPARTMENT OF AGRICULTURE;

A Summer Voyage to the Arctic,

BY G. R. PUTNAM,

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