very unevenly distributed, being heaviest in the north-central part. The greatest total snowfall for the month was 17 inches at Winsor's Ranch, on the headwaters of the Pecos River, and 25 inches at Chama. All other stations report little or no snowfall.

North Carolina—December was nearly normal in its chief features. During the greater part, from the 1st to 27th, the temperature was decidedly above the normal, the warmest days occurring on the 2d, 12th, 17th, and 22d, but the severe cold wave of the latter part of the month reduced the mean very considerably. The low temperatures recorded on the morning of the 29th were probably never before equaled in this State in December, though lower temperatures have occurred in January.

North Dakota.—The only unusual feature that characterized this month was its mildness. The temperature was unusually high, the winds light, and but little precipitation fell, and although there was a cold wave on the 26th, 27th, and 28th, it was not severely felt and soon passed away. On the 20th a very unusual occurrence was a thunderstorm in the southern portion of the State, something the people who have lived in that section a long time report not to have happened before. In the northern part of the State on the same day there was a rainstorm, something as unusual as the thunderstorm. The temperature at Bismarck averaged 8.4° higher for each day of the month than the normal or mean obtained from eighteen years' observations.

Ohio.—The month averaged slightly warmer than usual over the State. Up to the 25th temperatures ranged considerably above the normal; on that day the entrance of a severe cold wave, rapidly developing from the northwest, constantly lowered the temperature until the 29th, when it culminated below zero temperature over all sections of the State. The precipitation during the month was well distributed and was in excess of the average. The heaviest snowfall occurred on the 28th in advance of the cold wave from the northwest, covering the ground completely and affording ample protection from the severe cold that followed to the winter cereals in the ground. The percentage of weather forecasts received from Washington and distributed to 119 points over the State was 93 for temperature and 92 for weather. The cold-wave warnings of the latter part of the month were widely distributed and amply justified, and have no doubt proved of great value to all communities over the State where received.

Oklahoma.—The month was remarkably mild and pleasant until the afternoon of the 25th when a cold wave of considerable force began and continued until the close of the month. The maximum degree of cold was reached at 7 a. m. of the 28th, when the temperature was 1° below zero. The first snow of the season occurred on the 26th. The month closed leaving the ground practically without moisture, and wheat in bad shape. Farmers generally state that most of the roots are dried up and the germs without life.

South Carolina.—The month was remarkable chiefly for its extreme range of temperature, between 1° below zero and 85° above within the State. From available records it appears that the total snowfall during the month was the greatest ever recorded, especially in the north-central portion of the State, where in places it fell to a depth of 10 inches.

South Dakota.—The weather was unusually mild during the first two decades of the month. Comparatively little snow fell, and this, together with the generally mild and pleasant weather, was very favorable to live stock, which fed uninterruptedly on the ranges.

Tennessee.—While the mean temperature of the month was but little below the normal, several extremes occurred at intervals, the most noted of which was the cold wave of the 28–29th, causing abnormally low temperatures at most places on those dates. Owing to the fact that the ground was well covered with snow wheat suffered little or no damage. The warmest day during the month was the 8th and the coldest the 28th.

Virginia.—The temperature averaged very slightly below the normal in the northern portions of the State and slightly above in the interior, southern, and eastern. The coldest periods were the 5–7th, 18th–21st, and last six days of the month, with a very decided and sudden cold wave on the 28th and 29th, which gave the coldest temperature for the calendar year throughout the State, with temperatures of between zero and 11° below zero in the western portions of the State. The snow about the 26th proved of great value to winter crops, by affording protection during the severe cold wave of 28–29th, and from 1 to 4 inches of snow were still on the ground at the end of the month in the southwest and the valley.

Washington.—The month was noteworthy for its low mean temperature, which was about 4° below the normal, and for its deficiency in precipitation of about 1½ inch. The last nine days of the month were remarkably pleasant. A remarkably severe low-area storm prevailed over the coast from the 6th to the 11th, when the barometer touched the lowest point in recent years. There was considerable snow, particularly in the eastern part of the State. The coldest day was generally the 28th.

Wisconsin.—The month was remarkably mild. Up to the 24th there was very little frost in the ground and the farmers were plowing up to that date. A cold wave passed over the State about the 5th and another on the 14–16th, upon which dates the temperature fell below zero, while the warmest day occurred on the 20th. From the 24th to the end of the month the weather was cold and little or no snow lay on the ground.

NOTES BY THE EDITOR.

TEMPERATURE OF THE WATER, SEBAGO LAKE, NEAR PORTLAND, MAINE.

A record of the temperature of the water as it flows from Sebago Lake into the aqueduct that supplies the city of Portland, Me., has been kept by the gatekeeper, Mr. J. W. Hinkley. The following monthly averages corrected for the small thermometer errors have been kindly communicated by Mr. John M. Gould of that city:

1894.	°	1894.	°
January	34.5	August	74.8
February	34.5	September	65.5
March	35.1	October	56.2
April	37.3	November	46.7
May	46.0	December	37.9
June	59.3		
July	71.0	Annual	49.9

The ice went out of the lake April 18. The lake was frozen over December 30; it was therefore open 226 days.

BALLOON ASCENSION, DECEMBER 4, 1894.

On December 4, 1894, Dr. A. Berson, starting from Berlin, made a high ascension whose results, as given by Mr. O. Chanute in "Aeronautics," are of interest in connection with the area of high pressure then advancing westward over Europe.

The balloon started at 10.28 a. m., with a charge of 70,600 cubic feet of water gas. A strong east wind had been blowing during the preceding afternoon and night, but had diminished somewhat in the morning. The drag line, 650 feet long and weighing 180 pounds, was stretched on the ground in the direction of the wind in order that its weight might be taken up gradually as the balloon rose, thus insuring a very rapid rise at the start and consequent escape from interfering obstacles. The general trend of the voyage was toward the northwest. The ascent occupied three hours and the descent two hours and twenty minutes. The landing occurred at 3.45 p. m., a short distance west of Kiel. The following abstract of the observations is reported:

Time.	Altitude.	Temperature.	Remarks.
	Feet.	° *F.*	
10.40 a. m.	4,900	41	Up to this point the temperature had risen steadily.
10.43 a. m.	6,500	....	Fog and clouds below the balloon.
11.30 a. m.	16,400	0	Air very dry.
11.49 a. m.	19,700	—14	
12.00 m.	22,150	—20	
12.25 p. m.	26,250	—38	
....	26,900	....	
....	27,900	—43	
....	29,500	....	Balloon cuts through a thin veil or stratum of cirrus clouds consisting of perfectly formed flakes of snow and not simple ice crystals.
12.45 p. m.	30,000	....	The altitude as indicated on the aneroid barometer, which stood at 9.12 inches, was 31,500, but when properly corrected the actual height was 30,000. The mercurial barometer had already frozen at about noon, when the actual temperature was —20. This was the highest point reached; the balloon was covered with a thin envelope of snow; the sky was free of clouds and of a pure cold blue. The aeronaut was in good condition, having been sustained by inhalation from a special supply of oxygen. A farther ascent was not considered advisable in view of the small amount of ballast remaining.
1.26 p. m.	29,850	—52	Small gas valve opened and descent began.
3.40 p. m.	4,600	43	This was the highest temperature during the descent.
....	1,650	....	Swimming on the upper surface of the cloud-waves.
....	820	....	At the lower surface of the clouds the earth appears.
3.45 p. m.	....	34	On ground.

Among the results of the voyage the following may be stated:

1. The attainment of great altitude.
2. Observations of uncommonly low temperatures and many wide variations of temperature.
3. The increase of temperature up to 41° at 4,900 feet at 10.40 a. m., and up to 43° at 4,600 feet at 3.40 p. m., showing

that this so-called inversion, formerly supposed to characterize the lower atmosphere during the nighttime, actually occurs also during the daytime and up to very great heights.

Similar observations and results were obtained in the four balloon voyages made for the Weather Bureau by Mr. Hammon, under the general supervision of the present Editor, an account of which was published in the American Meteorological Journal, Vol. VII. These were the first that were made accurately enough to show that in the daytime, and especially in the winter and early spring, the temperature of the atmosphere increases as we go upward to an elevation somewhere between 2,000 and 5,000 feet. As the same inversion occurs probably always in connection with every area of high pressure, it must be looked upon as a general phenomenon whose explanation is to be found not in local conditions, but in some very general law of physics. In an article on the atmospheric radiation of heat (Am. Met. Journ., VIII, p. 537) the author has shown that the existence of a stratum of air at some moderate height, probably always below 2,000 meters, whose temperature is warmer than that of the layers either above or below it, is a normal phenomenon in clear weather, and is due to the combination of warming by compression and cooling by radiation as the air slowly descends toward the earth's surface. The curves connecting the temperature at any height with the temperature at the earth's surface are of an approximate hyperbolic form, as shown on page 550 of the journal referred to, and have the adiabatic temperature line as an asymptote. The diminution of temperature in ascending air is also a similar combination of the effects of cooling by radiation and by expansion; but if the ascent is rapid the effect of radiation is correspondingly unimportant and may generally be neglected or considered as compounded with the cooling by mixture that takes place in the case of rapid ascent. The ascent or descent of air will occur for either of the following causes, namely, excess of density due to coolness or to dryness or an excess of pressure due to motion. When the rate of diminution of temperature with altitude is about 1° F. for 187 feet, or 1.6° for 300 feet, dry air will have a density in each layer such that it will have no tendency to rise or sink and is said to be in neutral or indifferent convective equilibrium. A more rapid rate of cooling would constitute a state of unstable convective equilibrium such that when an upper layer settles down and displaces a lower mass it will be colder than the latter even after being warmed up by the compression that it experiences, so that ascending and descending air tend to perpetuate their movements. A less rapid rate of diminution of temperature would constitute a state of stable equilibrium with no tendency to topsy-turvy interchanges.

In the case of the balloon voyage of December 4 the layer of air below 4,600 feet had, at 3.45 p. m., a vertical temperature gradient of plus 1° F. in 500 feet; that is to say, not merely a less rapid diminution of temperature, but a positive increase of temperature upward. It was, therefore, in a very stable condition. The layer between 4,600 and 30,000 feet had a gradient of 1° F. diminution in 270 feet, which is also a very stable condition. In general, on that day the stability of the air increased with approach to the earth's surface, showing that the air which was descending slowly in an area of high pressure was cooled as it approached the earth's surface more rapidly than it was warmed by compression. Undoubtedly this is a general characteristic of the atmosphere in areas of high pressure.

THE STORM AT PONTA DELGADA, DECEMBER 8, 1894.

By the recent establishment of self-registering instruments at the meteorological observatory in charge of Fr. Francis Chaves at Ponta Delgada, in the Island of San Miguel (Azores), we are now, for the first time, able to follow the details of wind and pressure of Atlantic storms that pass near those islands.

Fr. Chaves states that—

By an examination of the barograph curves, by the direction of the wind (which changed from south-southeast through the south to south-southwest, then to southwest, and finally to west-southwest during the great barometric depression), and by the violence of the wind (26 meters per second or 93.6 kilometers per hour at 11 hours 55 minutes p. m., and for three hours with a mean hourly velocity of 80 kilometers, and one hour with a velocity of 85), I think one might conclude that a part of the dangerous zone of the cyclone passed over this place, but from further information that I have already obtained, especially that furnished by the captain of a steamer coming from Lisbon to this place, I find that the center of the storm moved in a straight line and with such great velocity (66 kilometers per hour) that it should be looked upon as a hurricane without the classic cyclonic rotation of the winds. I am more than ever convinced that the Azores offer a fine field for the study of meteorology.

The following table presents the record of hourly readings during the 7th and 8th of the current month:

Observations at Ponta Delgada, December 7 and 8, 1894.

Date.	Dry bulb.	Wet bulb.	Barometer.	Wind. Direction.	Wind. Velocity, per second.	Wind. Hourly movement.
	°C.	°C.	Mm.		Meters.	Km.
7th, midnight	16.4	5.7	766.4	....	....	......
1 a. m	16.0	5.8	766.0	....	....	......
2 a. m	15.2	5.8	765.3	....	....	......
3 a. m	15.3	5.8	765.0	....	....	......
4 a. m	16.0	5.7	764.0	....	....	......
5 a. m	16.0	5.8	764.1	....	....	......
6 a. m	16.1	6.2	763.8	....	....	......
7 a. m	16.3	6.4	763.2	....	....	......
8 a. m	16.5	6.5	763.0	....	....	......
9 a. m	16.7	6.5	762.9	s. 20° e.	....	......
10 a. m	17.0	6.6	762.2	s. 20° e.	11.0	*
11 a. m	17.2	6.6	761.0	s. 20° e.	11.0	40
noon	17.5	6.5	761.0	s. 20° e.	11.6	41
1 p. m	17.3	6.1	760.1	s. 20° e.	10.9	42
2 p. m	16.5	6.1	759.1	s. 15° e.	12.5	43
3 p. m	16.6	6.4	758.5	s. 15° e.	10.5	43
4 p. m	16.6	6.3	756.9	s. 22° e.	12.0	37
5 p. m	16.8	5.6	755.0	s. 25° e.	14.0	45
6 p. m	17.2	5.7	754.0	s. 25° e.	14.8	53
7 p. m	17.2	6.1	753.3	s. 22° e.	15.5	57
8 p. m	16.9	6.0	752.0	s. 22° e.	15.8	58
9 p. m	16.5	6.1	750.5	s. 22° e.	17.4	68
10 p. m	16.5	6.2	749.0	s. 22° e.	21.0	70
11 p. m	17.0	6.4	747.0	s. 20° e.	22.4	80
8th, midnight	17.5	6.7	745.4	s. 17° e.	†24.0	80
1 a. m	17.1	6.6	743.3	s. 11° e.	24.0	80
2 a. m	16.7	6.7	740.5	s.	25.0	85
3 a. m	16.9	6.7	‡736.3	s. 65° w.	16.0	70
4 a. m	16.5	6.5	737.9	s. 67° w.	14.5	55
5 a. m	16.8	6.0	740.5	s. 69° w.	18.0	55
6 a. m	16.2	5.7	743.5	n. 80° w.	15.0	45
7 a. m	16.3	5.5	747.0	n. 80° w.	16.0	50
8 a. m	16.0	4.7	749.9	s. 80° w.	10.8	47
9 a. m	16.0	4.6	751.6	s. 75° w.	9.5	33
10 a. m	16.0	4.6	753.1	....	8.0	30
11 a. m	16.1	4.3	753.9	....	....	......
noon	16.3	4.3	754.1	....	....	......
1 p. m	16.3	4.3	754.0	....	....	......
2 p. m	16.3	4.3	754.8	....	....	......
3 p. m	16.2	4.0	755.0	....	....	......
4 p. m	16.2	4.5	755.0	....	....	......
5 p. m	16.1	4.5	754.9	....	....	......
6 p. m	16.1	4.7	755.4	....	....	......
7 p. m	16.2	4.8	755.9	....	....	......
8 p. m	16.2	4.9	756.0	....	....	......
9 p. m	16.1	5.0	756.3	....	....	......
10 p. m	16.0	4.8	756.2	....	....	......
11 p. m	16.0	4.9	766.0	....	....	......
midnight	16.1	4.9	755.2	....	....	......

*Each movement is for the hour ending with the moment for which it is given.
†Maximum velocity 26.0, at 11.53.
‡The lowest pressure was 736.2, at about 3 h. 10 m., and the oscillations in pressure, from 12.15 a. m. until 3.10 a. m., averaged 1.5 and seem to show that high southwesterly winds produce some slight and very local low pressure.

The remarks of Fr. Chaves as to the rapid movement of this hurricane center harmonize entirely with the description given in another section of these notes of the various modifications to which storms are subject. As explained in paragraph 12 of that section a trough of low pressure may oftentimes be simply an indication that a cyclonic whirl and barometric depression is moving rapidly in the direction of the axis of the trough, but so rapidly that the lower atmosphere at any given point has not time enough to show evidences of a well-marked whirl with circular isobars and central depression. The storm that passed the Azores on the 7th seems to have subsequently moved more slowly before it broke up on the European coast.

OBSERVATIONS AT HONOLULU, HAWAIIAN ISLANDS.

As the weather on our Pacific coast depends so largely upon the conditions of the atmosphere to the westward, it is considered important to publish in full and as soon as practicable the data furnished by observers in Alaska, the Hawaiian Islands, and adjacent regions.

Meteorological observations at Honolulu, Republic of Hawaii, by Curtis J. Lyons, Meteorologist to the Government Survey.

Pressure is corrected for temperature and reduced to sea level, but the gravity correction, —0.06, is still to be applied.
The absolute humidity is expressed in grains of water, per cubic foot, and is the average of four observations daily.
The average direction and force of the wind and the average cloudiness for the whole day are given unless they have varied more than usual, in which case the extremes are given. The scale of wind force is 0 to 10.
The rainfall for twenty-four hours is given as measured at 6 a. m. on the respective dates.

December, 1894.	Pressure at sea level.			Temperature.					Humidity.			Wind.		Cloudiness.	Rain measured at 6 a. m.
	7 a. m.	2 p. m.	9 p. m.	6 a. m.	2 p. m.	9 p. m.	Maximum.	Minimum.	Relative. 9 a. m.	Relative. 9 p. m.	Absolute.	Direction.	Force.		
	Ins.	Ins.	Ins.	°	°	°	°	°	%	%					Ins.
1....	30.11	30.00	30.06	71	73	71	76	68	65	78	5.9	nne.	5-6	7	0.43
2....	30.11	29.98	30.04	69	73	70	74	68	67	79	5.8	ne.	5	10	0.44
3....	30.05	29.97	30.03	70	75	69	76	66	65	77	5.8	n.	3-5	5	0.17
4....	30.07	30.02	30.10	68	73	71	75	67	67	77	5.8	ne.	5	5	0.53
5....	30.17	30.10	30.17	70	74	71	75	65	67	65	5.5	ne.	4	5	0.05
6....	30.22	30.14	30.19	69	73	72	75	69	67	73	6.1	ne.	5	5	0.05
7....	30.20	30.13	30.18	71	72	71	74	69	64	67	5.9	nne.	5	7	0.10
8....	30.16	30.09	30.13	70	74	70	75	70	67	76	6.0	ne.	4	5	0.14
9....	30.16	30.07	30.13	70	75	72	77	68	61	74	6.0	ne.	4	4	0.04
10....	30.15	30.05	30.08	70	76	73	77	70	75	77	6.6	ene.	4	4	0.00
11....	30.09	29.98	30.05	67	78	69	79	67	74	90	6.9	se.	2	2	0.00
12....	29.97	29.88	29.95	67	77	69	79	65	79	95	7.0	se.	3	5-10	0.00
13....	29.99	29.95	30.04	68	75	75	76	67	90	73	6.9	e.	2-5	10	0.66
14....	30.12	30.03	30.10	73	75	72	76	72	74	....	6.9	ene.	5	5	0.30
15....	30.11	30.03	30.12	71	74	72	76	71	61	70	5.6	ene.	4	4	0.05
16....	30.15	30.06	30.13	70	74	72	75	68	59	69	5.6	ne.	5	7-3	0.10
17....	30.19	30.10	30.20	72	74	69	76	70	60	85	5.9	ne.	5	7	0.05
18....	30.21	30.11	30.21	71	74	71	75	66	61	61	5.3	ne.	5-6	5	0.15
19....	30.18	30.12	30.21	70	72	70	75	69	61	79	5.3	ne.	4	3	0.00
20....	30.20	30.12	30.19	68	74	70	75	66	65	71	5.7	ne.	4	4	0.06
21....	30.18	30.08	30.15	67	75	70	76	67	57	72	5.4	nne-ene	3	3	0.02
22....	30.15	30.07	30.17	65	75	70	77	65	61	73	5.6	ne.	3	2	0.03
23....	30.22	30.10	30.17	68	75	71	76	67	65	65	5.6	ne.	3	2	0.01
24....	30.21	30.07	30.15	69	74	70	75	69	53	64	5.1	ne.	3	2	0.00
25....	30.18	30.07	30.12	70	74	66	77	69	58	79	5.4	nne.	3	3	0.00
26....	30.11	30.03	30.08	66	74	66	77	63	53	77	5.2	nne.	2	1	0.00
27....	30.05	29.94	29.98	60	72	61	74	58	64	85	5.2	nw.	2	2	0.00
28....	30.02	29.96	30.02	62	71	70	74	59	84	73	5.5	ne.	2	4	0.06
29....	30.06	29.96	30.04	69	74	70	76	67	65	64	5.5	nne.	4	3	0.08
30....	30.04	29.96	30.06	67	75	65	76	65	61	80	5.5	ne.	2	3	0.00
31....	30.11	30.07	30.15	68	74	67	75	64	74	80	6.0	ne-se.	1	5	0.00
	30.19	30.04	30.11	68.6	74.1	69.8	75.8	66.9	65.9	72.5	5.82				3.52

Mean temperature: 6+2+9÷3 is 70.8; the normal is ......; extreme temperatures 58, and 79.

LOCAL ELECTRICITY IN A WINDSTORM IN WYOMING.

Mr. John Hunton, voluntary observer at Fort Laramie, Wyo. (N. 42° 12′, W. 104° 31′, altitude 4,519 feet), reports as follows:

On December 20, at 1.30 a. m., observed vertical red streaks above and below moon. Each about one and one-quarter diameters of moon in width and each about one diameter of moon from it. One streak extended below the horizon, the other extended upward about 20 diameters of moon in length. At 10.15 a. m., same date, electrical wind storm of great velocity commenced and continued until 7 p. m. Maximum velocity of wind obtained at about 1.30 p. m., when three houses were unroofed and substantial steel tower windmill was blown down, causing a loss of about $700.

The wind was phenomenal in that it would remove and break to pieces the most solid wood work of buildings and leave adjoining frail parts of the wood work undisturbed. Reliable information, obtained from over a section of country extending 12 miles south and 20 miles east, states that the electrical current was freely felt in many localities embraced in that area.

Mr. Silas Doty, a very reliable man living 8 miles south, reports that he discovered a fence post on fire 200 yards north of his house, and upon going to it to extinguish the fire found it burnt more than half through where one of the fence wires was fastened, and partly burned where another wire was in contact with it. Other fence posts were slightly marked by the electric sparks.

Mr. John F. Barnes, another reliable man, living 11 miles south of here, states that in going from his stable to his house he caught hold of a fence wire to assist him in walking against the strong wind and received a severe electric shock from which he was some time recovering. He had a strong healthy cow in a lot inclosed with wire fence. The wind drifted the cow into a corner against the fence and held her there, where Mr. Barnes found her dead late in the evening. He thinks that long contact with the heavily charged wires killed her, as there was no mark of violence or internal derangement to cause death.

Mr. E. B. Hudson, 20 miles east of here, reports that two of his employees when going from work to house, soon after the commencement of the windstorm, were severely shocked when crossing a wire fence. One of the men caught hold of a wire and received a shock which numbed and weakened his hand to such an extent that he was unable to take it from the wire but had to release it with his other hand. The injured hand and arm remained nearly helpless for several moments. Mr. Hudson, as well as the other two men referred to, is a reliable, truthful man.

The above account reminds one at first of the electricity attending the sand storms or the hot simoon, and which is usually attributed to the friction of the particles of hot, dry sand. But electric phenomena generally attend the snow that is formed in strong winds of dry, cold air, as has been frequently observed in North America, Kamchatka, Siberia, and Russia, and we may, therefore, attribute the electricity to the formation of snow, even though it be of small amount and mostly in the clouds above us.

LOCAL CONTRASTS OF WIND AND WEATHER.

On December 1 Capt. A. H. Myers, keeper of the life-saving station at Quoddy Head, reported:

This is a queer day; on the coast at this station it is blowing strong south and raining; just across the basin it is fresh northwest and thick snow; at my house there is snow enough for sleighing; at the station not a flake. I have been watching this all day and never saw such a great difference in so short a space.

Quoddy Head is the most easterly point of the United States and is well up in the Bay of Fundy. The basin referred to by Captain Myers is a bight or bend in the shore of Quoddy Bay, and the distance across in a straight line from the station is about one mile or less. His house is about one mile and a half, in a straight line, from the station. The Weather Bureau station at Eastport is about 8 miles north of Quoddy Head, and the observer reports at 8 a. m. southerly winds with snow, temperature 32°, but at 8 p. m. northwest winds cloudy, temperature 34°.

The weather map shows that in the interior of New England, New Brunswick, and Quebec, the temperature during the day was decidedly below freezing, but off the coast a little above freezing. A region of colder, dry, northerly winds was slowly pushing aside the region of warm southerly, and at the border between these snow was falling. The movement of this border region was evidently so slow that Eastport and Quoddy Head remained within it nearly all day.

A LOCAL SQUALL AT WEST BERKELEY, CAL., DECEMBER 11, 1894.

Mr. W. H. Hammon, local forecast official, and Mr. H. E. Smith, inspector, Weather Bureau, have made a special examination of the so-called "Cyclone or Tornado," which occurred on December 11 at a point about 5 miles northeast of the station at San Francisco. A comparatively small amount of damage was done, and there was evidence of several eddies in the neighborhood of the large building occupied by the soap works, but there was no clear evidence of a general whirl, such as is supposed to characterize the ideal tornado. There was a sudden shift of high wind from southwest to northwest, the record at the Weather Bureau station being as follows:

9.25 to 9.30 a. m. (90th meridian time), southwest, maximum velocity, 34 miles; 9.30 to 9.35, west, maximum velocity, 24 miles; 9.35 to 9.50, west; during the remainder of the day, between west and southwest. The barometer at 9.25 read 29.97 and rose about 0.02 during the squall, and then remained stationary. The temperature fell from 56° to 51° at the same time.

At the location of the squall in Berkeley a very black cloud was seen to approach with heavy rain, coming over the hills from north to northwest, but it is not likely that there was any funnel-shaped appendix to this cloud. The damage was confined to a narrow straight path about 100 feet wide and half a mile long. Mr. Hammon concludes "that the storm was merely a squall resulting from the changing of direction of the wind from southwest to northwest; at the point of meeting of the two masses of air moving in those directions the air must be forced forward in a resultant direction."

In the region between the opposing systems of wind and, in general, whenever a colder northwest pushes under a warmer southwest wind there is a narrow intermediate belt in which no wind is felt for a few moments. Within this region big cumuli are often formed, beneath which water-spouts and tornadoes sometimes develop. The strongest argument for considering the present squall as a tornado is drawn from the statement made by one observer that the atmosphere was perfectly at rest on either side of the path, but this testimony is not confirmed by others. The debris of buildings and lumber were not carried up into the air to any great extent. The squall of wind did its damage immediately after, and in connection with, a heavy downpour of rain, and the dark cloud accompanying the rain was seen approaching at a distance across the San Pablo Bay, but the evidence seems all in favor of the conclusion that the cloud and rain were not due to an ascending current, but rather to a cold descending mass of air that was producing rain by mixture with the warm surface air. Objects were, of course, often carried up a little ways above the earth by the rushing air, but not to any such height as is common in the case of the tornado proper. One observer remarks that the violent northwest wind rushing in from the sea brought along many seagulls that had been unable to stem the torrent of wind, and that he saw them whirled around in the cloud like fragments of wood.

At this time the center of low No. V was moving northeastward in British Columbia, and the inflow of colder northwest wind in its rear produced this local gust at West Berkeley. Whatever of the attributes of the tornado this storm may have had, it was certainly not developed to any great extent, and can hardly be called even an incipient tornado.

LOCAL STORMS ON THE WEST COAST OF MEXICO.

Mr. G. O. Rogers, Forest Grove, Oreg., communicates the following description of a circular storm observed by him off the Pacific coast of Mexico, about 15 miles from the land:

For at least two hours before and during the existence of the meteor and for some time subsequently there was a perfect calm. The ocean toward the land and to all other points of compass, as far as the vision could reach, was as smooth as a mirror, save the unruffled pulsating swells of the water. It was in the month of March, about 9 a. m., and the sky was perfectly clear, except about twenty-five degrees above the horizon. A little below the sun, eastward from the ship and toward the land, a peculiar cloud was observed, apparently lying perfectly horizontal. It seemed to be from three to four feet in diameter, as straight as a ship's mast, with uniform thickness throughout its length, extending from one to two miles across the sky from north to south. Almost immediately after this cloud had assumed shape there appeared attached to its under surface at irregular intervals pendant clouds, suspended at right angles, pointing to the water below. The horizontal cloud resembled a long roll of dark wool, while from its fibrous mass ravenous spindles were twisting their threads. Immediately the pendant directly in front and nearest our point of view began to elongate with marked rapidity, also to increase in diameter as well, extending itself to nearly one-half the distance to the water below and assuming the shape of an inverted Apollinaris bottle, with the bottom slightly enlarged at the point of contact with the parent cloud. Neither this pendant nor any of the others remained of the same length for any considerable time, but continued to advance and retreat with more or less activity. At this juncture, about six hundred yards from the ship and directly under the large pendant, was observed an active disturbance in the water, which rapidly grew into a whirling spray, increasing in volume, height, density, and activity until the spray became a smooth, revolving, hollow cone of water, quite like an inverted glass funnel, the point of which shot upward with lively motion, while at the same time the point of the pendant above came as rapidly downward until the two met in midair about two-thirds the distance from the horizontal cloud above to the ocean below. At this time the meteor was in its greatest activity. The points remained in contact for from five to eight minutes, when they parted, the yet whirling water slowly receded, resolving itself into spray, then agitation of the water and a final calm, the pendant cloud retiring in the same manner. During all this time the several miniature pendants kept up an active elongating and receding motion on a small scale, under neither of which was observed any disturbance in the water below. Soon all pendants retired and the horizontal cloud slowly disappeared. From the first notice of the phenomenon until it disappeared was about one hour. It is important to mention that the revolving motion of the spray and the water were with that of the sun or the hands of a clock. There could have been no disturbing currents of air from the upper surface of the horizontal cloud to the water below, for the cloud lay as still as a log and none of the pendants were swayed in the least from the perpendicular.

It is obvious that different currents of air, either as an initiative or as an incidental factor, must be abandoned in the development of our little meteor, and some other cause must be assigned to account for its existence.

PHOTOGRAPH OF A MOUNTAIN SHADOW.

The shadow cast by Mount Diablo, 40 miles east of Berkeley, Cal., is visible, at sunrise as a triangle thrown against the mists and distant mountains to the westward and, owing to its isolated situation, the shadow is sometimes seen with remarkable distinctness and is associated with many superstitious fancies. A photograph of this shadow was taken by J. J. B. Argenta of San Francisco. The right-hand side of the shadow is said to usually show a pale yellow tint on the inside and a pale green on the outside border; the left-hand side of the shadow shows only a reddish tint; the central portion of the shadow is a blue-black. These interesting colors still await a satisfactory explanation.

THE FLOOD IN THE COLUMBIA RIVER.

In May and June, 1894, a remarkable flood occurred in the Columbia River, some details of which are given in the REVIEWS for those months. The following additional items are taken from a recent report of the Chief of Engineers. The upper river gauge at the cascade's lock and canal had recorded 139.7 as the maximum high water of 1876, and the highest on record up to that time. In June, 1894, the maximum reading was 145.7, or 6 feet above the maximum of the year 1876, and it continued above for fifteen days. The occurrence of this unusual high water makes it necessary to increase the height of the embankments protecting the canal and provision will be made for a possible future flood reading of 152 feet on this gauge. During the last two years the daily steamer from Portland has ascended to the Cascade Canal when the river stage has been 36 feet or less above low water; on a falling river the daily trips have been resumed at about the same stage of water. When the river stage exceeds 42 feet the currents over the rapids, below the canal, become too strong for steamers to ascend. A table has been prepared showing the number of days each year for the last fifteen years that the stage has been between 20 and 42 feet above low water on the lower gauge. This table shows that the river was between these limits on an average of ninety days each year.

REPLIES TO CORRESPONDENTS.

Do winds on striking mountain ranges undergo reflection like elastic solids, or do they tend to produce a vacuum and follow the range like small currents of air blown obliquely against the surface of a table?

The wind follows the surface of the ground like the air in the experiment alluded to and does not rebound like a ball; similar phenomena may be observed in a broad stream of water. If in such a stream some obstacle be placed imitating a range of mountains, such as a gently slanting stone or plank, the liquid will be seen to glide up over the windward slope and descend on the leeward side, following the surface of the stone or plank as closely as practicable. On the windward side the liquid hugs the surface very closely, but on the leeward side it is very apt to leave the surface if the slope is too steep or the curvature too sudden. The motion of the liquid layers close to the stone or plank affects the movements of the layers above them, so that even at the surface of the water we see a mound or the crest of a wave just above the obstacle, while lower down stream this wave repeats itself a number of times, forming what is called a standing wave, growing smaller and smaller until it finally disappears. An analogous phenomenon occurs in the atmosphere on the leeward side of a mountain range, but as the winds are much more violent than the currents of water the air is thrown into a series of complete revolutions, forming rolls of clouds separated at regular distances from each other like the standing waves of water.

An analogous phenomenon is also produced when the wind blows past a vertical pole or chimney, or when water flows past the piers of a bridge. The fluid follows the obstacle on its windward side, but by the time it has been deflected round to the leeward side the inertia of its onward movement carries it forward, so that it does not follow the leeward side of the obstacle as closely as it did the windward side. There is consequently a space of dead air or water in the rear; beyond this, where the right-hand and left-hand currents come together, there are formed many whirls which may become visible as clouds, if the obstacle is a chimney from which smoke and steam are issuing, but are more frequently quite invisible to the eye. If the obstacle is a flagstaff then the currents on the right and left meet behind the staff but include the flag between them, which serves as a dividing surface, and what would have been a series of whirls in the free air now becomes a beautiful series of ripples running along with the wind over the surface of the flag.

As to the vacuum produced by the wind on the leeward side of a mountain range it is known that there is a tendency to produce a slight diminution of barometric pressure, but this is ordinarily too slight to be spoken of as a vacuum, and its amount depends upon the shape and size of the mountain, the velocity and direction of the wind, and especially the location of the observer. If one blows across the open end of a hollow reed he may make a whistling note, but every one knows how difficult it is to blow in the right direction so as to get the best result. When the wind blows against a vertical cliff of rock there is a small space on top of the cliff where there is almost no wind and a diminished barometric pressure, but this is a very local effect; it does not extend far away from the cliff, and it is possible that this is not the phenomenon referred to by our correspondent in his question quoted at the head of this article.

When a small jet strikes a plane surface almost perpendicularly, and spreads out in all directions, or when one blows strongly between two parallel sheets of paper, the layer of rapidly-moving air has within itself a barometric or elastic pressure that is lower than it was within the jet. This is due to the fact that the elastic pressure which it first had has been partly consumed in giving increased motion. If the flow of the atmosphere against a mountain slope were similar to the movement of a small jet against a plane table, then there would be a diminution of pressure in the former just as in the latter case. But such comparison is quite misleading when applied to the ordinary phenomena of the wind since in this case we have a comparatively small obstacle and a much larger volume of wind. The principal diminutions that occur are at the top of a mountain cliff, and on the leeward side of a mountain range.

What is the origin of cold waves; do they depend on the moon?

In reply to this query it should be stated that the origin of cold waves is considered to be not yet established with all the certainty that we may hope to attain eventually. The cold winds that blow upon us in the temperate zones are certainly experienced as far north as Manitoba and Saskatchewan, but north of that, although the air is very cold, yet the winds do not seem to be so severe, and there is no certainty as yet whether our winds are to be regarded as horizontal outflows of cold air from Siberia northward over the Arctic Sea and southward over British America, or whether they consist of descending air that has passed northeastward over the Rocky Mountains into British America, where it has cooled off and turned southward. In either case it has never yet been proved that the moon has anything to do with these cold waves. If there is a lunar tide in the atmosphere, as suggested by some, then there ought also to be a solar tide just as there is in the ocean, but neither of these has as yet been observed. It does not seem likely that the solar or lunar tidal action can be very important, and, in fact, the cold waves, as studied on the daily weather charts of the whole Northern Hemisphere, evidently have most to do with the great areas of low pressure on the Atlantic and Pacific oceans, and the great areas of high pressure over Asia and America.

What is the shape of the index of the minimum thermometer and in what manner does it permit the fluid to pass up the tube and yet allow itself to be pushed back?

The index of the minimum thermometers used by the Weather Bureau is a piece of dark-colored glass rod about three-fourths of an inch long and of very small diameter. When being made the end of the small fragment is applied momentarily to a gas or lamp flame; the glass softens and draws itself up so as to form a smooth rounded knob, similar to the head of a pin, but more rounded. In most cases the index is provided with a knob at each end, and then resembles a dumb-bell with a long handle between the balls. If a knob is formed at one end, as is sometimes the case, the index is placed in the tube so that the knob comes next to the end of the liquid column. The form of the index is seen distorted when examined through the stem of the thermometer, which magnifies the lateral dimensions.

The index of any particular thermometer always fits quite loosely in the narrow tube, so that there is plenty of space for the flow of the liquid around the knobs on the ends of the index. As the normal position of the minimum thermometer is horizontal no motion of the index takes place as long as the latter is wholly surrounded by fluid. When, however, the end of the liquid column by contraction reaches the knob at the end of the index a new kind of action takes place, and to explain this we must first consider the nature of the surface films. The surface of every liquid is, in fact, like a most delicate film of stretched skin. This invisible film, of exceeding thinness, exists not only where the liquid is separated from the air or other gaseous space, but also at any surface of contact between the liquid and another substance. The strength of the film varies with the nature of the two substances that are separated by it. Delicate films of this kind can exist separate from the mass of liquid and are familiarly known to every one in the exquisitely-colored soap bubbles.

In the minimum thermometer we have to consider (1) the stretched surface film, visible at the end of the liquid column, which clings to the sides of the thermometer bore and is drawn toward the bulb as the thermometer cools; (2) the invisible film that completely envelopes the index itself. When the visible surface film has been drawn down the tube so as to touch the invisible index film these two films do not unite, nor do they penetrate each other, but preserve their identity, and push against each other until the curvature of the surface film is altered by the pressure of the index film and receives a slight dimple, resembling the effect of a finger-tip pressed against a stretched sheet of rubber. This alteration in the surface film brings into action a small but sufficient force, that steadily presses the index film and its inclosed index backward as far as the surface film may go. When this backward movement ceases and the column of liquid ascends the tube, the surface film simply moves forward away from the index, around which the liquid is free to flow.

METEOROLOGY IN THE SCHOOLS.

It is very desirable that both the voluntary and the regular observers, and indeed all who are interested in the work of the Weather Bureau, should do their best to stimulate the proper study of meteorology in the public and private schools throughout the country. Even the ordinary district schools of the country, which find time for reading, writing, arithmetic, geography, history, and physiology, might well afford to teach something about the weather, the climate, and the weather map and its predictions. No one can be a good farmer without being a close observer of everything that affects his crops and his farm. Prof. Wm. M. Davis, of Harvard College, says:

> Meteorology fairly deserves a higher place in general teaching than it now receives. It is a subject of great popular interest and importance. We live in its midst; examples of its processes are always with us. In its more elementary presentation it involves excellent opportunities for observation and record, such as help to train a child in habits of accuracy and neatness. The understanding of nature thus gained goes far toward clearing away some of the longest-remaining superstitions of the darker ages. Both in information and training, meteorology may claim a high place in the science of education. A few intruments, a series of daily weather maps, such as are now readily obtainable from the stations of our Weather Bureau, and a well-prepared teacher, will go far toward overcoming the deficiencies of the text-book in use. If the teacher has the courage to discard the text-book as a guide, and use it only as a reference book, let him begin at once with the weather maps, and explain in simple language the meaning of the signs of clear, fair, and cloudy weather, rain or snow, wind and calm, warm and cold. Pressure follows in the second lesson, while humidity had best be omitted until a later chapter. A blank map, on which the record for some interesting example of varied weather can be entered, may be filled out on the wall before the class. Omit the isotherms and isobars at first. Ask the class to describe the distribution of the various weather elements over the country.

The general committee appointed by the "National Educational Association" to consider the subject of studies in secondary schools reported as follows:

> *Meteorology.*—Since the establishment of the National Weather Bureau meteorology has not only been greatly advanced as a systematic science, but has become a subject of wide popular interest. This, together with its importance as a factor of geography, moves the committee to recommend that meteorology be introduced as an elective study for half a year in the third or fourth year of the high-school course, when practicable. It should be opened by local observations of the passing weather changes, accompanied by a study of a series of daily weather maps, and the application of physical principles to explain the general phenomena of the atmosphere should follow. Local observations should be carried further in this course than they extended in years, especially regarding the sequence of phenomena in the atmosphere and the correlation of various weather elements. The study of weather maps, already familiar objects from the less systematic study of earlier years, should now reach to the clear understanding and description of the distribution of temperature and pressure, flow of the winds, and occurrence of clear, cloudy, rainy, or snowy areas.

Copies of the complete report on this subject can be had from the U. S. Bureau of Education, and should be in the hands of every teacher in the country. Both the regular and the voluntary observers of the Weather Bureau, who can give intelligent talks on the weather to the schools in their neighborhood, should seek opportunities for so doing.

THE ORIGIN OF STORMS.

The questions are often asked: "What is a storm? How does it originate and grow, and which of the many so-called theories is now recognized by meteorologists?" In reply to such questions the Editor would express his conviction that there is considerable truth in many of the explanations that have been propounded from time to time, and that it is not advisable or necessary to reject all of these as unnatural, although we may say that no special one explains all the great variety of storms that are shown upon the weather maps. It would be more correct to acknowledge that some one feature is more prominent in one class of storms, while other features may be common to other classes, and no single hypothesis applies to all storms alike. The following different explanations have been offered from time to time as to the origin and maintenance of storms:

1. The surface winds may be described as respectively polar and equatorial, and such systems exist simultaneously side by side. Within the main body of the equatorial system the air is warm, moist, and clear, but hazy, and within the polar system, cold, dry, and very clear, with blue sky. Between the polar system on the west and the equatorial on the east, a series of whirls is formed, constituting the larger whirlwinds or hurricanes; on the other hand between the polar system on the east and the equatorial on the west are formed the smaller thunderstorms and hailstorms and perhaps tornadoes and waterspouts. Considered as a description of the general geographical relations of the winds and storms this agrees fairly well with nature, but in so far as this statement implies the idea that the whirling movements are directly caused by the interference of the northerly and southerly currents as they go past each other this theory is quite unsatisfactory. The interference of parallel currents in opposite directions may cause small whirls like those in the water below a bridge pier or the dust whirls behind buildings and trees, but it can not alone of itself form the great whirls of cyclonic storms.

2. Where an extensive area of the earth's surface is abnormally warm the lighter layer of air in contact with it has a tendency to rise, and when once this ascent is under full headway and the surrounding denser air is flowing inward to take its place, the atmospheric motions follow an incurving ascending spiral whirl. This is apparently sometimes the origin and mechanism of the large dust whirls that originate on still, quiet afternoons. It is also the phenomenon seen in the atmosphere over an extensive fire. A certain class of thunderstorms apparently originates by the ascent of moist, light air, but it is carrying the analogy too far to consider hurricanes and similar extensive storms as originating in this manner, since in these storms the ascending movement and the vertical dimensions are small in comparison with the horizontal movement and dimensions.

3. When a region of southerly winds exists on the eastern side of a region of northerly winds the intermediate space will show a diminished atmospheric pressure, owing to the combined action of these winds and the rotation of the earth; the intermediate air will therefore tend to expand, possibly forming clouds and rain by the cooling due to expansion; the evolution of latent heat perpetuates the clouds and the updraught, so that the northerly and southerly winds may be deflected inward and a cyclonic circulation be set up, which will be maintained as long as the formation of cloud and rain continues.

4. The great inequalities of topography on a land surface and the great differences between the land and the water surfaces cause corresponding differences in the distribution of temperature and moisture throughout the superincumbent air and in the resistances to the motions of the atmosphere. Consequently the ideal general circulation for a smooth earth's surface is broken up into several large systems of circulation, and these frequently interfere with each other, producing what are called areas of low pressure (meiobars) and areas of high pressure (pleiobars), which vary decidedly in their extent and position from day to day and season to season. The meiobars of Bering Sea and of Iceland, the pleiobars of the tropical Atlantic and Pacific, and the meiobars of the equatorial region illustrate these great centers of atmospheric movements. When a corner or small portion of a meiobar becomes isolated or greatly displaced and the air from the neighboring pleiobars

flows in to fill it up a whirl is generally started and the barometer falls still lower, owing to the centrifugal force of the rotating air. If the whirl starts in the wrong direction it is soon checked by resistances and the rotation of the earth; if otherwise, the combination of local centrifugal force with the deflection due to the rotation of the earth on its axis maintains the whirl and suffices to explain the low barometer in the cyclonic system. The inflow and general movement of the air would soon cease by reason of inertia and resistances were it not that an effective force is produced by the latent heat evolved in the condensation of vapor and by the action of the solar heat on the tops of the clouds. Whatever tends to diminish the density of the central mass of air, thereby increasing its buoyancy and the inflow of the air from the outside, contributes to the rotary motion, to the diminished pressure, and to the continuance of the disturbance.

5. Owing to the mobility and slight viscosity of the air strong winds may exist in one region without affecting the movements in adjacent regions, but when the moving layer of air is a short distance above the earth's surface its effect upon the lower atmosphere, though indirect, may be important. If a cyclonic rotation exists only at some distance above the earth, the diminution of pressure in the upper strata will occur as in the preceding case. The lower strata must, therefore, expand and ascend. Rotatory motion may arise in the lower strata by the communication of rotation from the upper currents downward, or it may originate in the lower current itself. Here, again, the rotation and diminished pressures will continue so long as the formation of cloud and rain continues to disturb the distribution of heat.

6. The flow of air from a pleiobar into a meiobar may take place under such circumstances that the inflowing air is pushed up over a table-land or mountain range; this enforced ascent being accompanied by cloud and rain or snow, the resulting air flowing down on the leeward slope of the range is drier, and by descent becomes warmer than before—*i. e.*, a fœhn. But this dynamic heat is soon lost by radiation or partially consumed by the evaporation of water from the earth's surface, and gradually the descending air becomes cooler, damper, and denser than in the fœhn stage. It is now in condition to push southward under the influence of the centrifugal force of the earth's rotation, and eventually to underrun and lift up the warmer, damper, and lighter air which opposes its progress; in this way a new center of cloud and precipitation, a new thermal disturbance, and a new storm center are formed. This appears to be the ordinary occurrence on the eastern slope of the Rocky Mountains.

7. When a current of denser air (the density may be due either to dryness or temperature) flows over a steep declivity into the lowlands, and especially into the ocean, the denser air sinks, while the lighter air below is pushed up; in this way a series of severe gusts are formed, which usually are felt in a well-defined band some distance off the leeward side of the highlands. Such winds are called falling winds, and the resulting gusty storms are illustrated by the "Bora" of the Black Sea and Adriatic; the "Papagayo" or "Papagallo," and the "Tehuantepec" (peculiar to the gulfs of those names, and, indeed, to many portions of the west coast of Central America, and which are essentially northeast winds in the winter season); the "Tapayaguas," which are essentially southwest winds producing squalls during the summer season on the east side of the Central American Peninsula; and the tornadoes, or white squalls, off the west coast of Africa.

8. It is plausible that from one cause or other a series of waves may be set in motion, moving nearly horizontally through the atmosphere; especially will this happen at the dividing surface separating a lower layer of dense air from an upper layer of lighter air. When the trough of such a wave passes over a region of warm moist air the pressure upon this warm layer is appreciably diminished, and during the short time that this diminished pressure lasts there may take place an expansion, an ascent, and even a formation of cloud sufficient to initiate a general upward motion and determine the development of a storm.

9. When a layer of moist air is overlaid by a very clear sky the intense nocturnal radiation may cause the formation of a layer of fog, so that during the rest of the night the air beneath this surface is on the average warmer than some adjacent atmosphere at the same level. This disturbance in the distribution of heat is intensified, after sunrise, by the fact that all the sun's heat is stopped at the upper layer of the fog surface, and in dissipating the latter there arises a still further tendency in the mass to ascend and form a special storm center.

10. When the surface of the earth is covered by a rather extensive system of southwest winds, within which special or local ascending currents are formed wherever the wind strikes any obstacles, each of these ascending currents is likely to persist for a considerable time, and even until it reaches the level at which cumulus cloud is formed. Thus, the country becomes dotted over with cumuli, some of which will undoubtedly continue developing until they attain large dimensions, and possibly produce rain or hail; if the condensation within the cloud takes place under proper circumstances, about which, however, we know very little at present, lightning and thunder will be evolved and a characteristic thunderstorm produced.

11. The frequent electrical manifestations that occur in storms have led to the hypothesis that electricity is essential to their existence, and perhaps even to their origination. We have, therefore, to enumerate among the theories that which may be called the electrical theory of the origin of storms, but this is, at present, in an indefinite or chaotic condition, owing to our ignorance of the origin and functions of electricity in the atmosphere. We may only at present recognize the possibility that in rare cases electricity may be an important agent in producing storms.

12. If we consider the great variety of disturbances, large and small, we shall find that the well-developed cyclonic system is the exception rather than the rule, and if we consider the causes that contribute to the distortion of the circular isobars into ovals, elongated V's, and even parallel or trough-like systems, we shall find that not only the resistances due to the topography of the land come in play, but that frequently the troughs may be best explained as caused by a rapid motion of a cyclonic disturbance which affects the upper atmosphere but has not time to set the lower air into corresponding motion. The relation between the motions in the upper atmosphere and those of the lowest layers depends upon the extent of the upper disturbance and upon the time available to communicate downward to the earth's surface. When the movement of the storm center is comparatively slow the upper and lower systems of isobars are apparently parallel, and the axis of the ideal whirlpool is less inclined to the vertical, but when the movement of the upper disturbance is rapid the axis departs greatly from the vertical until finally all semblance of a horizontal system of wind rotation disappears and with it the central barometric depression, thus a waterspout or tornado which stands vertical at one portion of its route may be nearly horizontal at another, the pictures given by Baddeley, in his "Dust Storms of India," afford several illustrations of the great distortion that a whirl may experience and still remain a whirl without being a cyclone. Barometric troughs with whirls at the end moving rapidly in the direction of the trough are frequently shown on the weather map.