LOUISVILLE FORECAST DISTRICT.*

[Kentucky and Tennessee.]

The first week and the last day of the month were quite cold, but the temperature was above normal during practically all the remainder of the month. The period 13–18th was exceptionally warm, during which time maximum temperatures registering between 60° and 70° were general. In eastern Tennessee the precipitation was somewhat above normal, but over the balance of Tennessee and Kentucky there was not much more than half the normal amount, altho well distributed in frequent showers. There was a good number of fair days and also of days with light rain.

Exceptionally few general disturbances past over the district. Of these only one or two were of any importance and even they were unattended by any severe stress of weather.

Cold-wave warnings were issued on the 6th and the 30th for the cold weather following those dates.—*F. J. Walz, District Forecaster.*

CHICAGO FORECAST DISTRICT.

[Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas, and Montana.]

The month opened and closed with cold waves that covered the greater portion of the district. Ample warnings were given in each instance. During the 3d and 4th a barometric depression was attended by rain or snow from the lower Missouri Valley over the Ohio Valley and Lake region and was followed by a sharp fall in temperature.

A depression from the southwest crost the district during the 5th and 6th, attended by high winds in north and rain or snow in south portions, and followed by a cold wave that carried the line of zero temperature over southern Iowa on the morning of the 7th. Warnings for the territory covered by the cold wave were issued on the 6th and the usual warnings for high winds were sent to upper Lake stations.

From the 8th to 30th a succession of low areas over the northern portion of the district produced prevailing fair and warm weather, with frequent but not marked changes in temperature. During the afternoon and night of the 30th the temperature fell rapidly and continued low during the 31st. On Sunday, the 27th, announcement was made that a change to colder was indicated and that a winter type of weather would be experienced during the latter half of the week.

Navigation on the Great Lakes closed for the season after the 12th, and advisory warnings for high winds were issued only to open ports on Lake Michigan after that date.—*E. B. Garriott, Professor of Meteorology.*

DENVER FORECAST DISTRICT.*

[Wyoming, Colorado, Utah, New Mexico, and Arizona.]

Except in the southern portions of New Mexico and Arizona the month was colder than normal, especially in western Colorado and southern Utah. At Modena and Flagstaff lower temperatures were recorded than in any preceding December, but in the greater part of the district the low mean temperature was due to continued cool weather rather than to any very severe extremes.

The precipitation was remarkably heavy in Arizona and southwestern Colorado, exceeding all previous records for December at several stations. In northern Utah and northwestern Wyoming, as well as in New Mexico, there was a considerable deficiency. The more important storms of the month were of the southwestern type and were characteristically sluggish and erratic in movement.—*P. McDonough, Local Forecaster.*

SAN FRANCISCO FORECAST DISTRICT.†

[California and Nevada.]

As a whole the month was a cold, foggy period, with a marked deficiency in precipitation. Less than 50 per cent of the normal rainfall occurred. There were no prolonged rain periods and, with the exception of five days at the beginning of the month, rain was not recorded as lasting over forty-eight hours. In some respects the month resembled December, 1901. As a rule the low areas moved quickly across the northern portion of the Pacific slope.

There was an unusual amount of tule fog in the Great Valley, with temperatures ranging from 32° to 38°. The high humidity, low temperature, and absence of sunshine resulted in generally disagreeable weather. In the southern portion of the State frosts were heavy and frequent. Numerous warnings were sent to orange growers, both north and south, and at many places temperatures of 26° and 28° occurred. Thruout the long frost period no mistakes were made in forecasting.

The month began with a depression on the southern coast, which moved slowly southeastward. Unsettled weather continued until the 5th. A storm on the northern coast on the 8th moved southward and was followed by quickly clearing weather. Subsequent disturbances on the northern coast moved rapidly eastward.

There were no noteworthy failures in forecasting, except on December 16 a forecast of decidedly colder weather for Nevada was not made.—*Alexander G. McAdie, Professor of Meteorology.*

PORTLAND, OREG., FORECAST DISTRICT.†

[Oregon, Washington, and Idaho.]

December in this district was cold, with less than the usual amount of precipitation. The most severe disturbance of the month made its appearance over western Washington on Christmas morning, and shortly afterwards caused a maximum wind velocity of 90 miles from the southwest at Tatoosh Island, and 72 miles from the south at North Head, Wash. Another severe storm swept the district on the 12th, causing a wind velocity of 84 miles from the southwest at Tatoosh Island, Wash., and 74 miles from the south at North Head, Wash. Besides these two storms there were three others of moderate intensity, and warnings were issued for all of them in time to be of benefit.

A moderate cold spell prevailed from the 14th to the 22d, at which time the lowest temperatures of the month occurred. The principal periods with precipitation were from the 7th to the 15th, and from the 20th to the 28th.—*E. A. Beals, District Forecaster.*

RIVERS AND FLOODS.

The MONTHLY WEATHER REVIEW for November, 1908, stated that at the close of the month a flood was in progress in the Neosho and Arkansas rivers, and also in the rivers of Oklahoma. These floods were caused by heavy rains that began about November 22, and continued with an interval of two days until November 30. The floods did not extend north of Iola, Kans., on the Neosho River. They began at that place on the evening of the 29th, lasting but a day, with a crest stage of 9.5 feet, 0.5 foot below flood stage, and it was about the middle of December before the flood waters past into the Mississippi. The following reports on this flood have been received:

ARKANSAS RIVER AND TRIBUTARIES TO FORT SMITH, ARK.

By L. J. GUTHRIE, in charge of the local office of the Weather Bureau, Fort Smith, Ark.

Beginning November 22, and continuing four days, frequent, heavy rains occurred thruout Oklahoma and southern Kansas. These rains, tho local, were sufficient to thoroly saturate the soil and to cause a slight rise in all the streams of the district. Little or no rain fell on the 26th and 27th, but during the seventy-two hours ending 8 a. m. of the 30th, from 1.5 to 5 inches fell over the entire district. Owing to the saturated condition of the soil the effect of these general and heavy rains was immediate, especially upon the Neosho River. Rises of from

* Morning forecasts made at district center, night forecasts made at Washington, D. C.

† Morning and night forecasts made at district center.

4 to 10 feet in the Neosho from Le Roy, Kans., to Fort Gibson, Okla., and in the Arkansas from Tulsa, Okla, to Webbers Falls, Okla., occurred in the twenty-four hours ending 8 a. m. of the 29th. By the following morning the Neosho had risen 2 to 8 feet at all points, passing above the flood stages at Oswego, Kans., and Fort Gibson; and the Arkansas had risen 1.6 feet at Tulsa, 9 feet at Webbers Falls, and 10.5 feet at Fort Smith, Ark. The flood crest reached Oswego and Fort Gibson on December 1, Tulsa on November 30, Webbers Falls on December 1, and Fort Smith on December 2. The flood receded very slowly in the lower Neosho, and in the Arkansas below Fort Gibson, both continuing above flood stage from November 30 to December 6, inclusive.

A general flood warning for the Arkansas and Canadian and for the Neosho from Iola to Fort Gibson was issued at 10 a. m. of the 29th. The dissemination along the Neosho was practically complete, and the warning of inestimable value. The special river observers at Fort Gibson and Oswego, and the postmaster at Echo, were especially diligent in this work. Much property and doubtless a number of lives were saved thru their efforts to spread the warning. Interests on the Arkansas, also, were well protected, especially from Webbers Falls to Fort Smith and Van Buren, Ark. Tho the flood stage was not reached at Tulsa considerable damage ensued in that locality, and there, too, the warning was of great value.

The warning for the Canadian was not justified. It was based solely on reports from Calvin, no report of the rainfall at Oklahoma City being available when the warning was issued.

The highest stages reached were as follows: Emporia, Kans., 6.8 feet, on November 30; Neosho Rapids, Kans., 7.0 feet, on November 30; Le Roy, Kans., 20.6 feet, on November 30; Iola, Kans., 9.5 feet, on November 30; Oswego, Kans., 21.7 feet, on December 1; Fort Gibson, Okla., 31.0 feet, on December 1; Calvin, Okla., 8.4 feet, on November 29; Tulsa, Okla., 15.4 feet, on November 30; Webbers Falls, Okla., 26.5 feet, on December 1; Fort Smith, Ark., 29.0 feet, on December 2.

As in the October flood, a large percentage of the damage was caused by the smaller tributaries, among which may be mentioned the North Canadian, Cottonwood, and Little rivers, and Black Bear Creek. The flood, tho much higher stages were reached on the larger streams, was not as destructive as that of October, except as regards erosion. Fewer of the smaller streams were affected, and the matured crops that were reached by the recent flood had already been damaged or ruined. Then, too, much of the October damage to other property had not been repaired. Erosion was greater than during any of the previous floods of the year.

The money value of the property destroyed and damaged, including railroads and excluding crops, was $375,000.

The money value of crops destroyed and of damage to them was $95,000.

The damage to farm lands by erosion was $870,000.

Money value of losses occasioned by enforced suspension of business thru the flood, including wages of employees, was $85,000.

The value of property saved by the flood-warnings of the Weather Bureau was $300,000.

ARKANSAS RIVER FROM BELOW FORT SMITH, ARK., TO MOUTH.

By H. F. ALCIATORE, in charge of the local office of the Weather Bureau, Little Rock, Ark.

At Dardanelle, Ark., the river began to rise after the morning observation of November 28, and by 8 a. m. of December 1 had risen 13.2 feet to a stage of 23.0 feet, or 2 feet above flood stage. The wave crested December 3 with a stage of 25.3 feet. The river was above flood stage from December 1 to 7, inclusive.

At Little Rock the rise began November 30, and by 11 a. m., December 2, the water had risen 13.1 feet to flood stage, 23.0 feet. The wave crested at 5 p. m., December 4, with a stage of 24.8 feet. The water was above flood stage from December 2 to 7, inclusive.

At Pine Bluff, owing to the loss of the gage in the flood of October, 1908, no official stages are available for November and December, but the river observer reports that the December flood crested during the evening of December 5, with a stage estimated at 26.5 feet, and that the river had fallen about 0.3 foot by Sunday morning December 6, flood stage was at 25 feet.

Flood warnings were first issued on November 29, and daily thereafter until December 4, inclusive.

So far, as is known, no loss of life resulted from the December flood. At Van Buren, Ark., a short distance below Fort Smith, caving banks damaged the mains of the gas company; about 500 families were without gas for several days, and schools and city offices were closed for want of fuel.

The greatest damage was done at Pine Bluff, and was caused by the caving of the river bank, not by overflows, the under strata having been undermined by the swift current. The area affected was about twelve city blocks in length and averaged about one-half block in width. It is reported that about ninety-five buildings, six of which were brick, were destroyed or damaged. The $50,000 annex to the county court house was abandoned, as the rear wall of the building hangs over the river bank. The total damage to land and buildings is estimated at $100,000.

Ample and timely warnings of the approach of the flood wave were issued by the Weather Bureau, but, in the case of Pine Bluff, the river was so low at the time the warnings were issued that the U. S. Engineer fleet, near Rob Roy, Ark., which could have rendered valuable assistance in protecting the bank from erosion, could not pass the bar.

The flood was caused by heavy rains in the upper drainage basin, and was characterized by a sudden rise, swift current, and quick subsidence.

It will be seen from these reports that the floods were forecast with excellent judgment and accuracy, and the warnings were instrumental in saving lives and a great amount of property. No losses occured that could have been avoided.

The loss and damage amounted to something over $1,500,000. This is exclusive of the losses in central Oklahoma which would probably have brought the total up to at least $2,000,000. This flood was the fourth severe one of the year in Oklahoma, the previous ones having occurred in May, June, and October. Bottom lands all over the State were under water three or four times; crops were replanted two or three times, but the major portion was a failure.

There were moderate floods in the lower Roanoke and the rivers of the Santee System on the 23d and 24th, caused by rains about that time. Warnings were issued in ample time, and no losses have been reported. Many cattle were saved along the rivers of the Santee System.

Warnings were issued on the 22d and 23d for moderate tides in the Oconee and Ocmulgee rivers, of Georgia, and again on the 31st for the Ocmulgee River.

No other floods occurred except in Arizona. These were caused by heavy rains and snows about the middle of the month; an effort will be made to secure some detailed information regarding them.

The Ohio and upper Mississippi rivers were quite low, altho in the former conditions were somewhat improved. Navigation on the Mississippi, between Cairo and St. Louis, was practically suspended on the 22d.

ICE.

The Missouri River was closed by ice as far down as Bismarck, N. Dak., on the 1st; on the 4th as far as Sioux City, Iowa, and at Omaha, Nebr., on the 2d, opening again at the lat-

ter place on the 25th. Floating ice was observed as far south as Boonville, Mo., on the 7th. The James River at Huron, S. Dak., closed on the 3d, while the Red River of the North, at Moorhead, Minn., was closed during the entire month.

The Mississippi River closed at Fort Ripley, Minn., on the 6th; at St. Paul, Minn., on the 2d; at Red Wing, Minn., on the 1st; at La Crosse, Wis., on the 7th, and at Prairie du Chien, Wis., on the 2d. At Dubuque, Iowa, the ice gorged above the bridge on the 14th, but remained open below. At Leclaire, Iowa, the river closed on the 7th.

The rivers of Maine were closed after the 4th or 5th, while the Connecticut closed at Wells River, Vt., on the 3d, and at Whiteriver Junction, Vt., on the 9th.

The highest and lowest water, mean stage, and monthly range at 207 river stations are given in Table IV. Hydrographs for typical points on seven principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.—*H. C. Frankenfield, Professor of Meteorology.*

SPECIAL ARTICLES, NOTES, AND EXTRACTS.

STUDIES ON THE VORTICES OF THE ATMOSPHERE OF THE EARTH.

By Prof. FRANK H. BIGELOW. Dated Washington, D. C., March 16, 1908.

V.—THE IMPERFECT TRUNCATED DUMB-BELL-SHAPED VORTEX AND THE COMPOSITION OF VORTICES ILLUSTRATED BY THE OCEAN-CYCLONE OF OCTOBER 11, 1905.

THE METEOROLOGICAL DATA.

A close examination of the isobars in the DeWitte typhoon[1] shows that there is a tendency to depart from the spacing which is required to produce the geometrical proportions called for by the formulas of the dumb-bell-shaped vortex. This feature is perceived first on the outer and on the inner isobars rather than in the middle ones of the group, and the general result is to change from a geometrical ratio for the radii to such a spacing as gives an equal distance between the successive radii of the series. This is equivalent to saying that the hyperbolic law, $v\varpi$=constant, which has been employed in the dumb-bell-shaped vortex, tends to become the parabolic law, $\frac{v}{\varpi}$ = constant. (Compare the Cloud Report, pages 509, 620.) In the hyperbolic type of motion the gyration of the inner tubes is much greater than that of the outer tubes; in the parabolic type of motion the inner tangential velocities are not so great relatively as in the hyperbolic type. It is the purpose of this, and the following paper on the land-cyclone, to study the facts regarding this transition, and the thermodynamic causes which produce them. In the ocean-cyclone with strong development we find evidences of both of these types of motion in combination, and in the land-cyclone the parabolic type seems to be in the lead thruout the area of the local circulation. The subject is much complicated by the fact that the cyclone is generated by independent streams of warm and cold air which underrun the powerful eastward drift. This feature is influential in modifying the types of motion from pure forms to others that are quite incapable of being reduced to mathematical analysis of any simple kind.

The synoptic weather chart of the ocean-cyclone of October 11, 1905,[2] constructed by Mr. James Page (see fig. 17), contains much of the data required for study. Table 65 contains the geographical positions of 110 ships which rendered reports for October 11, 1905, at Greenwich mean noon, the wind direction and velocity, the barometric pressure and the temperature, all reduced to metric measures from extracts of the original records prepared by myself for this paper.

In order to eliminate the local conditions and secure the data for a symmetrical vortex about a central axis, we proceeded as follows: The linear diameters of the isobars were scaled on fig. 17, first in the northwest-southeast direction and then in the southwest-northeast direction, and the mean radii computed. Table 66 gives the computations from step to step.

[1] See Monthly Weather Review, October, 1908, 36, p. 328, and Chart IX.
[2] See Monthly Weather Review, January, 1906, 34, p. 5, fig. 3.

The columns contain in succession: (1) the barometric pressure in inches; (2), (3), the diameters of the isobars in two directions about 90° apart; (4) the sum of (2) and (3); (5) the

TABLE 65.—*Temperatures observed in the ocean-cyclone of October 11, 1905, at Greenwich mean noon.*

No.	Latitude N.	Longitude W.	Wind. Direction.	Wind. Meters per second.	B	T
					Mm.	°C.
1..	.....	.....	e.	8	762	10.0
2..	.....	.....	.....	.....	.....	.....
3..	45.5	55.3	nne.	22	747	5.6
4..	50.6	27.3	sse.	13	766	14.6
5..	19.9	56.9	w.	6	758	28.0
6..	47.1	46.8	ne.	18	744	9.4
7..	41.6	42.6	se. & e. tosw.	40	719	20.6
8.	35.6	51.5	n.	22	744	20.0
9..	41.9	64.8	nne.	10	767	9.5
10..	39.6	49.6	nnw.	18	753	13.9
11..	42.8	61.0	ne.	13	768	10.0
12..	41.5	65.5	nne.	6	758	14.4
13..	49.8	26.1	sse.	10	766	15.5
14..	50.0	26.8	s.	10	767	13.9
15..	39.0	55.7	n.	18	756	12.8
16..	44.9	49.6	ne.	25	761	9.5
17..	50.7	25.6	se.	10	767	15.0
18..	50.8	43.4	ne.	15	748	13.3
19..	47.0	46.1	n.	22	746	10.0
20..	41.0	42.6	wsw.	34	720	17.3
21..	40.8	28.9	se.	13	761	21.1
22..	51.6	31.5	sse.	13	755	18.9
23..	48.4	49.1	nne.	18	747	7.3
25..	28.5	68.2	e. & n.	6	770	24.4
26..	45.1	48.9	ene.	29	743	8.4
27..	42.7	58.0	n.	13	761	10.0
28..	31.9	58.8	n.	4	758	24.0
29..	42.7	61.7	ne.	13	764	10.0
30..	45.8	49.9	nne.	25	744	9.0
31..	49.1	37.4	s.	5	752	18.4
32..	28.0	79.5	ene.	13	762	29.7
33..	.....	.....	.....	.....	.....	.....
34..	20.2	61.7	nw.	6	764	24.6
35..	43.9	54.8	nne.	22	757	7.8
36..	.....	.....	.....	.....	.....	.....
37 .	42.9	58.6	ne.	15	755	7.0
38..	50.4	30.3	sse.	10	764	15.6
39..	42.3	44.0	n.	40	719	18.0
40 .	.....	.....	.....	.....	.....	.....
41..	21.7	67.0	nne.	8	763	27.7
42..	26.0	66.9	ene.	8	760	26.0
43..	49.5	27.4	sse.	10	765	14.5
44..	36.6	59.0	n.	23	763	19.5
45..	Horta, Azores.		se.	9	763	21.5
46..	50.4	29.5	sse.	10	765	14.4
47..	40 0	19.0	se.	10	762	13.9
48..	41.7	45.4	nnw.	40	716	16.7
49..	47.5	26.7	se.	4	764	16.2
50..	45.5	34.3	sse.	22	751	21.1
51..	41.0	66.3	nne.	8	766	13.0
52..	35.8	40.3	s. 60 w.	22	749	24.4
53..	49.1	34.1	sse.	18	759	16.2
54..	40.1	68.1	ne.	8	767	12.5
55..	49.8	12.0	ene.	10	773	15.0
56..	45.3	43.2	ene.	29	732	16.0
57..	49.5	32.0	se. by s.	18	753	16.2
58..	49.5	42.2	ne.	6	750	12.8
59..	Halifax	.....	nw.	3	765	6.7
60..	40.3	30.0	s.	18	736	20.6
58a	36.1	42.1	wsw.	22	782	25.5
61.	40.3	47.3	wnw.	22	740	11.1
62.	30.0	67.4	ene.	4	760	24.4
63.	43.9	56.2	n.	22	762	8.9
64.	42.4	52.5	nnw.	29	755	11.1
65.	49.8	30.0	s.	15	760	14.4
66.	42.3	59.0	nne.	22	757	10.0
67.	40.5	33.5	s.	18	761	22.2
68.	45.2	47.0	ne.	25	727	8.9
69.	43.7	41.9	sse.	2	719	14.0
70.	22.4	34.5	sw.	13	764	25.0
71.	49.8	36.4	s. & e.	18	778	15.0
72.	44.6	49.8	n.	37	743	8.9
73.	50.2	28.3	s.	10	766	15.8
74.	36.2	66.8	wnw.	10	758	20.0
75.	40.6	73.1	ese.	13	761	17.5
76.	48.0	38.1	se.	25	747	17.3
77.	.....	.....	.....	.....	.....	.....
78.	40.2	23.9	ene.	4	761	20.6
79.	49.2	44.5	ne.	15	740	10.0
80.	25.7	68.2	e. & s.	6	761	27.2
81.	42.6	60.0	ne.	15	762	10.0
82.	17.3	72.4	e.	6	758	— 1.0
83.	25.1	38.9	sse.	13	767	— 2.2
84.	43.3	53.7	n.	25	755	11.1
85.	54.0	22.5	se.	10	770	14.2
86	48.4	40.9	ne.	16	741	15.0
87.	42.5	48.5	n.	29	738	8.3
88.	Santa Cruz, Az.		se.	2	760	20.7
89.	.....	.....	.....	.....	.....	.....
90.	48.2	51.3	n.	18	751	6.7
91.	.....	.....	.....	.....	.....	.....
92.	44.3	53.9	nne.	18	753	—10.6
93.	51.2	19.0	sse.	10	766	15.6
94.	41.8	60.4	ne.	15	761	9.4
95.	16.0	47.3	se. & s.	10	760	26.6
96.	27.1	73.7	Var.	8	762	26.0
97.	30.8	52.4	nnw.	15	752	23.3
98.	40.2	48.0	n.	29	738	12.8
99.	51.6	44.3	nne.	13	745	10.6
100.	.....	.....	.....	.....	.....	.....
101.	38.5	22.0	ne.	10	763	18.9
102.	44.7	46.7	ne.	40	703	13.3
103.	35.3	45.8	w.	18	734	20.0
104.	24.2	68.4	ene.	8	763	— 3.3
105.	43.8	56.2	n.	18	756	6.7
106.	46.5	47.0	nne.	22	744	9.4
107.	49.5	31.0	s.	15	757	13.9
108.	49.9	41.5	n.	2	751	—11.1
109.	38.8	69.6	e.	8	763	18.9
110.	49.5	32.8	s.	13	755	16.2