TABLE 1.—*Rain and snow at Mount Vernon, Iowa*

Number of sample	Date of precipitation	Amount	Rain or snow	Nitrates	Nitrites	Free ammonia	Albumenoid ammonia	Sulphates	Chlorine as chlorides
	1929								
1	June 11	0.3	Rain	0.04	0.0014	0.056	0.4		14.20
2	June 12	0.6	do	0.5	0.08	0.056	Traces.		17.75
3	June 13	0.6	do	0.12		0.026	0.112		17.75
4	June 30	0.8	do	0.4	0.003	0.8	0.16		17.75
5	July 19	0.3	do	0.02	0.0014	0.112	0.16		21.35
6	Sept. 16	0.25	do	0.8	Traces.		0.29		17.75
7	Sept. 19	0.25	do	0.6	0.002	0.2			24.85
8	Sept. 29	0.3	do	0.12		0.112	0.29	0.106	
9	Oct. 10	0.3	do	0.16	0.003		0.4		10.65
10	Oct. 12	1.0	do	0.1	0.0014	0.26	0.112		24.85
11	Oct. 20	.75	do	0.24	0.0014	0.600	0.58	1.81	46.15
12	Oct. 23	0.6	do	0.25		0.136	0.64		3.55
13	Oct. 29	0.4	do	0.12	0.0629	0.78	0.64	0.789	11.65
14	Oct. 31	0.4	do	0.4	0.0010	0.5	0.272	2.57	6.45
15	Nov. 10	0.75	do	0.8	0.002	0.006	0.012	1.64	31.95
16	Nov. 13	0.8	do	0.16	0.005	0.02	0.01		6.1
17	Nov. 19	0.2	do	0.0014		0.015	0.07		10.65
18	Nov. 27	0.12	do	0.0025		0.03	0.56		7.81
19	Dec. 1	6	Snow	0.5	0.001	0.26	0.16		16.33
20	Dec. 13	.2	Rain	0.2	0.075	0.2	1.4		2.13
21	Jan. 2	[1] 3	Snow	0.16	0.004	0.72	0.32	0.493	
22	Jan. 7	4	do	0.6	Traces.	0.78	0.16	0.647	24.8
23	Jan. 9	6	do	0.02	0.002	0.6	0.29		7.81
24	Jan. 13	3	do	0.6	Traces.	0.32	0.16		21.3
25	Jan. 14	6	do	0.4	Traces.	0.36	0.16	0.281	10.36
26	Jan. 17	2	do	0.5	Traces.	0.08	0.25	0.044	17.4
27	Jan. 21	2	do	0.3	Traces.	0.36	0.36		4.97
28	Feb. 16	2	do	0.4	Traces.	0.45	0.9	0.233	31.95
29	Feb. 24	0.5	Rain	0.4	0.0001	0.36	0.48	0.013	24.85
30	Feb. 25	0.6	do	0.12	Traces.	0.16	0.112	0.123	42.6
31	do	0.1	do		0.0007	0.36	0.32		3.55
32	Feb. 28	0.18	do	0.03	0.0025	0.36	0.36	0.219	2.6
33	Mar. 17	0.3	do	0.08	0.0015	0.72	0.8	0.815	24.85
34	Mar. 18	0.3	do	0.06	0.0002	0.16	0.36	0.104	10.6
35	Apr. 11	0.4	do	0.16	0.0004	0.36	0.72	0.247	17.45
36	Apr. 13	0.25	do	0.8	0.0001	0.112	0.16	0.195	10.65
37	Apr. 15	1	do	0.5	0.0003	0.32	0.36	0.096	21.3
38	Apr. 16	0.5	do	0.6	0.0001	0.16	0.32	0.123	28.4
39	Apr. 20	1.1	do	0.16	0.0001	0.112	0.64		23.7
40	Apr. 27	0.2	do	0.1	0.002	0.136	0.36		10.65
41	Apr. 29	0.16	do	0.6	0.0025	0.32	0.4		7.1
42	May 1	0.4	do	0.12	0.0025	0.01	0.002		2.75
43	May 2	0.6	do	0.05	0.0014	0.01	0.001		
44	May 4	0.85	do	0.07	0.0025				31.95
45	May 7	0.1	do	0.1	Traces.	0.01	0.01	0.0042	17.75
46	May 11	0.5	do	0.9	0.0025				10.6
47	May 16	0.25	do	0.14	0.02				3.55
48	May 23	1.2	do	0.0016	0.0007				31.95

[1] Inches.

TABLE 2.—*Data from Table 1 converted to pounds per acre*

[1 inch rain over 1 acre=226,875.0 pounds. 12 inches snow=1 inch rain]

Number	Nitrates	Nitrites	Free ammonia	Albuminoid ammonia	Sulphates	Chlorides
1	2.72	0.91	3.8	0.27		0.9664
2	6.80	10.8	7.6	Traces.		2.4162
3	16.33		35.3	0.05		2.4162
4	7.26	5.4	14.5	2.89		3.0202
5	1.36	0.91	7.6	10.8		1.4531
6	4.53			1.64		1.0067
7	3.4	1.13	11.3			1.4094
8	8.16		7.6	5.9	0.0721	
9	10.89	2.0		0.2		0.7248
10	22.68	3.17	58.9	2.54		5.6378
11	40.83	2.26	102.0	9.86	0.3079	7.8527
12	34.03		18.5	8.71		0.4832
13	10.89	16.33	70.7	5.8	0.0559	1.0672
14	3.63	0.9	45.3	2.46	0.4373	0.5853
15	13.61	0.34	1.0	0.81	0.2976	5.4364
16	29.04	0.83	3.5	0.18		1.1071
17	0.00006		0.6	0.3		0.4832
18	0.00006		0.8	0.13		0.2126
19	56.71	1.13	9.4	1.81		1.8524
20	9.07	34.03	1.36	4.70		0.0952
21	4.07	2.26	40.83	1.81	0.0279	
22	4.53		68.98	1.2	0.0489	
23	22.68	2.26	68.6	3.28		0.8359
24	34.03		18.15	0.9		1.2081
25	45.37		40.83	1.81	0.0208	1.1752
26	18.70		3.02	0.94	0.0019	0.7731
27	1.13		13.61	1.34		1.8418
28	1.51		204.18	3.40	0.0105	14.4972
29	1.51	1.23	40.83	5.44	0.0014	1.1275
30	4.53		3.02	7.52	0.0167	5.7988
31		9.52	49.0	0.72		0.8050
32	0.122	10.2	15.01	1.46	0.0089	0.7637
33	10.89	10.2	49.0	0.54	0.0579	1.5637
34	8.16	1.36	10.89	5.44	0.0070	0.7214
35	14.51	3.63	32.67	6.53	0.0224	0.5832
36	4.53	0.567	6.35	0.9	0.0110	0.9664
37	11.34	6.8	95.28	8.16	0.0217	4.8324
38	6.80	1.13	18.15	3.63	0.0139	3.2216
39	39.91	2.52	27.95	15.94		5.7574
40	4.51	9.07	6.17	1.63		4.8032
41	2.17	9.07	11.61	0.14		0.1006
42	7.54	22.68	0.9	0.045		0.2495
43	2.71	19.45	1.35	0.013		
44	2.57	48.20				2.5063
45	2.26		0.22	0.02	0.3667	0.4027
46	12.60	45.37				1.0701
47	3.97	278.43				1.5658
48	17.01	3.53				0.781

NOTES, ABSTRACTS, AND REVIEWS

Some Problems of Modern Meteorology[1] *by D. Brunt—I. The present position of theories of the origin of cyclonic depressions.*—The main features of the cyclonic depression of middle latitudes are its center of low pressure and its associated system of winds which blow counterclockwise around this center. Now the pressure at any level measures to a high degree of approximation the mass of air above unit area of horizontal surface at that level. Hence the existence of a center of low pressure denotes that air has been removed from the region, and it is clear that the removal must finally be in a horizontal direction. Theories of the origin of depressions differ fundamentally only in the mechanism which they propose for this removal of air.

It might be thought that a center of low pressure could be formed by air diverging outward from a center, moving everywhere in a horizontal direction. It is known, however, that any body moving over the surface of the earth tends to swing round to the right (in the Northern Hemisphere). Hence the divergence of air from a point would generate a clockwise rotation of the air, and would produce a system of winds opposite to those in the cyclone. The suggestion of accounting for a depression by divergence from the central area is therefore ruled out.

[1] Under this title it is proposed to publish a series of brief articles by various authors discussing some of the unsolved problems of meteorology. They will aim not at advocating new theories, but at stating the difficulties involved in existing theories. (Reprinted from Quarterly Jour. Roy. Met. Soc., July, 1930, pp. 345-350.

The only alternative is convergence towards the central region, which by a similar line of argument is seen to produce a counterclockwise system of winds. The excess of air which would otherwise accumulate in the central region must be removed by vertical motion initially. But since the removal of the superfluous air to a higher level does not in itself produce a decrease of surface pressure, we must further postulate some mechanism capable of removing the superfluous air horizontally. There appears to be only one possible mechanism, an upper current moving with a different velocity and possibly in a different direction, from the currents of lower levels. We are thus led from the general nature of cyclonic depressions to postulate two conditions as necessary for their formation—firstly, an ascending current of air in the lower troposphere, strictly limited in horizontal extent, and secondly, an upper current differing in speed or direction or both, from the currents in the lower troposphere. If the upper current has the same direction as the currents of the lower troposphere, it will be constantly moving forward in advance of the depression, and any clouds formed within it will appear to move outward from the center in the line of advance. These clouds would herald the approach of the depression. If on the other hand the upper current is in a different direction from the currents of the lower troposphere, any clouds formed in the upper current will fail to indicate the line of advance of the depression. Much has been written of the use of cirrus clouds as prognostics of the line of advance of a depression, but the net result appears to be that cirrus movement may be anywhere within the two front quadrants of the depression (see Pick and Bowering, Q. J. R. Meteor. Soc., January, 1929, p. 71). Thus the observed movements of cirrus indicate that the upper current is usually oriented at any angle up to 90° with the direction of the lower currents. The fact that the cirrus movement is seldom, if ever, opposite in direction to the motion of the lower levels agrees with the idea that the prevailing air movement in middle latitudes is in general from west to east.

We are, therefore, in a position to assume the existence of a strong upper current at the cirrus level as a feature of all depressions, and as such a current is a necessary feature of the formation of depressions on any theory, the only difference that remains between different theories consists in the mechanism which they propose to account for the vertical removal of air in the lower layers of the troposphere.

The two main theories available to account for the vertical removal of air are the "local heating" theory and the "polar-front" theory. The first of these assumes that the air over a restricted region is heated to a higher temperature than its surroundings, or is heated from below by contact with heated ground or warmer sea until it becomes unstable. The heated air may then be capable of rising to considerable heights. The effect of high temperature may be increased by high humidity, since damp air is lighter than warm air at the same pressure and temperature. If the lapse rate is less than the dry adiabatic but greater than the saturated adiabatic, and any surface air which is saturated and at a higher temperature than its environment begins to ascend, it will become increasingly warmer than its environment with increasing height. The motive power is the lowering of density of a portion of the air below that of its environment, and it is probable that the effect of water vapor on the rate of decrease with height of the temperature of the ascending air is an important factor in the convection. The phenomenon of ascent is not as simple as we have supposed above. The ascending air can not remain intact during its ascent. Turbulence will be set up at its boundary, causing some mixing with the environment, but the effect of mixing is to share the defect of density between the total mass which mixes, and the whole mixture will be lighter than its environment, and therefore capable of ascent. The mixing here described is a necessary feature of the formation of a cyclonic depression by convection. The system of winds is regarded as an effect of the horizontal convergence of air to take the place of air removed by convection, and the extension of the system of winds to considerable heights demands the removal of air from all levels up to these heights, and except in the lowest layers the necessary removal is brought about by the effect of mixing of the ascending air with some of its immediate surroundings, a process to which Sir Napier Shaw gave the name of "eviction."

Water vapor is regarded as an essential factor in the theory as stated above to the extent that the ascending air is assumed to be saturated either initially or at an early stage in its ascent. In completely dry air the same phenomena would demand enormous local differences of temperature. The mean lapse rate in the troposphere is about 0.6° C. per 100 meters, the dry adiabatic being 1° C. per 100 meters. Thus ascending dry air would approach the temperature of its environment at the rate of 0.4° C. per 100 meters, or 4° C. per kilometers and ascent up to 5 kilometers would only be possible for air which initially had a temperature 20° C. higher than the normal surface temperature of its environment.

If, however, we may assume the initial lapse rate to lie between the dry and saturated adiabatics, then a relatively small increase of temperature in the lowest layer will enable damp surface air to rise to considerable heights; or instability in a relatively shallow layer near the surface will act as a trigger to set in motion convection capable of extending to the top of the troposphere. And it must be noted that marked instability when produced by surface heating is limited to a relatively shallow surface layer. It is for this reason that emphasis is laid on the function of water vapor in the process, and on the effects of mixing of the ascending air with its environment during the ascent.

The "local-heating" theory which we have just outlined thus reduces itself to finding a physical cause capable of producing instability in the surface layer, over a sufficient area. The most obvious cause to consider is the direct effect of solar radiation in heating the surface of the earth. But the direct effect of solar radiation on the surface of the sea is very slight, and produces only a small diurnal variation of temperature, with a total range of about 1° F. Moreover, most of the cyclonic depressions of middle latitudes originate over the ocean. We can not, therefore, assume that direct solar radiation is capable of producing over the ocean the intense local heating of the air sufficient to give rise to depressions.

There is, however, a plausible alternative to this. Air originating in high latitudes, and moving to low latitudes, will be heated from below as it passes over progressively warmer land or ocean, until a stage is reached at which marked instability occurs in the lowest layers. The surface air will be at or near saturation, and when convection starts it can proceed to very great heights. We might therefore expect that depressions should form in cold polar currents. This is borne out by observation, since it is not infrequently noted that depressions are formed in cold polar currents. These are the only depressions formed over the ocean whose origin can be definitely ascribed to instability.

The first clear discussions of the convection or local-heating theory outlined above will be found in Espy's Philosophy of Storms. Espy was also the first to emphasize the importance of water vapor in the atmosphere. The same ideas underlie what are known as "revolving-fluid" theories, as discussed recently by Shaw,[2] Brunt,[3] and others.

The main alternative to the local-heating theory is the polar-front theory, developed during the last 15 years or so by the Norwegians. This theory in a more or less definite form can be traced in earlier writers, but it was left to V. and J. Bjerknes and their colleagues to give it a definite form. Dove[4] developed in some detail the idea that a cyclone could be regarded as a region of opposition between warm and cold currents, and later writers supported this view. Bigelow[5] pointed out that on the whole cyclones could not be regarded as having warm centers or cold centers, but that the phenomena could be more accurately described by saying that the centers of cyclones usually occurred along the

[2] Shaw: Revolving fluid in the atmosphere. *London, Proc. R. Soc.*, A, 94, 1917, p. 33; also *London, Meteorological Office, Geophysical Memoirs*, No. 12.

[3] Brunt: Revolving fluid on a rotating earth. *London, Proc. R. Soc.*, A, 90, 1921, p. 397; *ibid.*, 105, 1924, p. 70.

[4] *Vide* Sprung: Lehrbuch der Meteorologie, Hamburg, 1885.

[5] *Washington, Monthly Weather Review*, 1902, p. 251.

lines separating warm and cold currents. Again Shaw and Lempfert[6] showed that the rain which fell in a cyclone could be explained by the forced convection due to the convergence of air, or by the ascent of warm air over cold air. V. Bjerknes[7] combined Shaw and Lempfert's picture of the cyclone with the ideas of Helmholtz.[8] The latter had shown that two currents of air of different temperatures and different velocities could flow side by side separated by a surface of discontinuity, the arrangement being stable. Bjerknes suggested that the cyclone should be visualized as a wave in the surface of separation, between a cold easterly or "polar" current, and a warm westerly or "equatorial" current. The surface of separation, or more frequently its intersection with sea level, is known as the "polar front." The wave increases in amplitude, and a cyclone sometimes forms at the northern crest of the wave The theory is very strongly reminiscent of Emden's[9] theory of the origin of sunspots.

In discussing this theory it is necessary to draw a clear distinction between the theoretical discussions of V. Bjerknes and the methods of analysis of synoptic charts developed by his son, J. Bjerknes.[10] The latter pictures the development of a depression as starting with a straight line separating the cold easterly current from the warm westerly current. The first step is a bulge of the warm air into the cold air, and as the bulge increases, a well-marked center of low pressure develops at the tip of the bulge. The warm tongue is compressed by the cold air and eventually all the warm air is pushed up from the ground. From this stage onward the depression decreases in intensity, and its motion of translation dies away.

We are not here concerned to describe the association of weather with the different parts of the system described by J. Bjerknes. The reader will find full descriptions of these in the original papers. The practical use of these ideas has been elaborated by the author in a masterly way. Moreover, there is no question that in a large number of cyclones of middle latitudes the development of the cyclone is associated with developments of the polar front in the precise manner described by J. Bjerknes.

The difficulty lies not so much in confirming the association of cold fronts with cyclones as in obtaining a clear idea of the physical principles underlying the association. In the first place the polar-front surface is only inclined at a small angle of 1° or less to the horizontal, and in any gravitational wave formed in this surface the motions should be predominantly vertical. V. Bjerknes suggests that the effect of the earth's rotation will be to increase the extent of the horizontal components of motion, so that they become enormously greater instead of much less than the vertical motions, but this process is not obvious. There is the further difficulty that the manner in which the warm air is caused to ascend over the cold air is by no means clear. Helmholtz suggested in one of his early papers that the warm and cold air would not in practice be separated by a sharp surface of discontinuity, but by a layer formed by the mixing of cold and warm air, and he further suggested that the initial ascent takes place in the layer of mixing.

The outstanding physical difference between the polar-front theory and the local-heating theory is to be found in the cause of the ascent of air. In the one case the ascent is apparently largely due to dynamical causes, while in the other it is due to thermal causes. But this distinction must not be taken too literally, since atmospheric phenomena are seldom to be interpreted as purely dynamical or purely thermal. Again Helmholtz showed that the cold and warm currents are in equilibrium when separated by a sharp surface of discontinuity, and it is not clear why the warm air begins to ascend up the slope of the wedge of cold air. Oscillations in the surface of separation should rapidly die out. It is, of course, possible that even in depressions formed at a polar front the initial stages are produced by thermal causes. But when the motion of cold and warm currents is geostrophic, there is no tendency for the warm air to climb over the cold air, as has been emphasized by Brunt and Douglas.[11] Helmholtz also showed that the waves formed in the surface of discontinuity should have wave lengths of the order of 1 kilometer rather than of the 1,000 kilometers which would be more appropriate in the case of cyclones.

To summarize our present view, we may say briefly that while it is undeniable that depressions frequently form at surfaces of discontinuity, and that the weather within them can be explained by the interaction of warm and cold currents at the polar front, yet it is not clear what causes the growth of the depression initially. Nor must it be overlooked that frequently fronts occur at which no depression subsequently forms. It is not even clear that the condition laid down earlier in the present article, that there must be an upper current differing from the current in the lower troposphere, is itself sufficient to determine whether a depression shall form or not. But this particular question has never been investigated in full detail.

Exner [12] and others of the Austrian school of meteorologists have regarded cyclones as formed, not at a continuous polar front, but at the edge of a discontinuous outburst of cold air. The cold air bursting southward as a tongue projected into the warm current cuts off the supply of air from the region to its left, causing a diminution of pressure at that point. At the same time the warm air is dammed up behind the cold tongue (i. e., to its right), causing an anticyclone there. The theoretical discussion of these subjects leaves it uncertain whether the processes suggested would produce the changes of pressure which are actually observed in the atmosphere. Exner's views on this subject are to be found mainly in his textbook, *Dynamische Meteorologie*, but a very complete bibliography of Austrian papers on this and allied subjects up to the end of 1922 has been given by Ficker.[13]

Whatever view we may adopt concerning the genesis of cyclones, we find that the fundamental cause is always to be ascribed to the direct or indirect effect of horizontal differences of temperature over the earth's surface. Since the horizontal differences of temperature are greatest in winter, cyclones should be more frequent and more intense in winter than in summer. The strength of the currents in the atmosphere are proportional to the horizontal temperature gradients.

[6] The Life History of Surface Air Currents, London, 1906.

[7] V. Bjerknes: The dynamics of the circular vortex, etc. *Geofysiske Publikationer*, 2, No. 4. The structure of the atmosphere when rain is falling. *Q. J. R. Meteor. Soc.*, 46, 1920, p. 119.

[8] *Wien, SitzBer. Akad. Wiss.*, 1888, p. 647; 1889, p. 761. These papers are reproduced in Wissenschaftliche Abhandlungen of Helmholtz and are given in Abbe's Collected Translations, Series II.

[9] Emden: Gaskugeln, 1st edition Berlin, 1907, Chapter XVIII.

[10] J. Bjerknes: On the structure of moving cyclones. *Geofysiske Publikationer*, 1, No. 2.
J. Bjerknes and H. Solberg: Meteorological conditions for the formation of rain; *ibid.*, 2, No. 3.
J. Bjerknes and H. Solberg: Life cycle of cyclones and the polar-front theory of atmospheric circulations, *ibid.*, 3, No. 1.
J. Bjerknes: Diagnostic and prognostic applications of mountain observations, *ibid.*, 3, No. 6.
Bergeron and Swoboda: Wellen und Wirbel an einer quasistationären Grenzfläche über Europa, *Veröff Geophys. Inst. Univ., Leipzig*, 3, No. 2. This paper gives a very complete summary of the views of the Norwegian school.
A. Refsdal: Der feuchtlabile Niederschlag, *Geofysiske Publikationer*, 5, No.12.

[11] Brunt and Douglas: *Mem. R. Meteor. Soc.*, 3, No. 22.

[12] Exner: Dynamische Meteorologie, 2d edition, Chapter XII.

[13] Ficker: *Met. Zs.*, March, 1923.

The ideas described above all ascribe to conditions in the lower atmosphere the predominating rôle. Exner [14] on the other hand has suggested that the major changes of pressure are brought about by advection, or horizontal movement of air masses of different temperatures. C. K. M. Douglas [15] has also suggested in recent papers that the advection of low pressure at high levels may play an important rôle in the formation of cyclones, but the physical processes involved in this have not yet been thoroughly discussed.

Kobayasi [16] has shown that if a column of revolving fluid draws in air of different temperatures from different sides it may produce lines of discontinuity of temperature at the surface.

Any theory which shall provide a full explanation of the processes in a cyclone must explain the lowering of the stratosphere above it, and the relative cold in the troposphere, and relative warmth in the stratosphere in a cyclonic region. The statistical data bearing on this aspect of the subject have been given by the late Mr. W. H. Dines.[17]

Exceptionally severe snowstorm of October 18–19, 1930, near Buffalo, N. Y. By J. H. Spencer, Weather Bureau, Buffalo, N. Y.—The very heavy and wet snowfall of Saturday and Sunday, October 18 and 19, was south from Buffalo to Erie and beyond, where one of the worst storms of record occurred, amounts ranging from 6 inches to 3 or 4 feet falling over a great area, but worse perhaps in the Hamburg-Angola section. The temperature was near the freezing point. The Lake Shore and other highways of that section became impassible, and hundreds of motorists were stranded in their cars or near-by farmhouses and taverns some for 24 hours or more.

Apple orchards were heavy with fruit, and the added weight of the snow broke down many trees. Many shade trees were also ruined. Telephone and power lines were down in many sections, and rail, bus, and steamship lines were hampered or interrupted. The roofs of some buildings collapsed because of the weight of the snow. A day or two before the storm summerlike conditions prevailed and late fall flowers were in bloom, even roses.

The great fall of snow near the south shore of Lake Erie was caused by abnormally cold weather and moisture-laden west winds off the lake, occurring at a time when a pronounced southwest storm area covered the entire lake region and districts to the northward. This disturbance remained nearly stationary over the Great Lakes for more than three days, causing one snow period after another.

Buffalo, except the south portion, escaped the storm because west winds that blow over central and northern sections of the city do not come off the lake. Snowfall on Sunday, October 19, in the vicinity of Church and Franklin Streets, was nearly 2 inches; in the Delaware Park section it was less than one-half inch; and in South Buffalo 6 inches or more. Little snow fell at the Buffalo airport. From Buffalo north to Niagara Falls, northeast to Lockport, and east to Williamsville and beyond there was also little or no snow. At the time the snowfall at Angola was deepest, and highways impassible, there was no snow whatever 3 miles away on the shore of the lake, where the grass was green and flowers blooming, but with a misty rain. Dunkirk and Hamburg were among the cities without electric lights and power until the lines were restored after the storm.

Among the losses reported by the press in western New York were the following: A building at the Angola airport caved in; also the roof of the Angola Hotel, resulting in damage of about $3,000. At Orchard Park the roof of the Acme Veneering Co. collapsed, causing damage around $5,000. Thousands of dollars in damage to fruit trees resulted in the vicinity of Orchard Park and other sections. Several roofs caved in at Dunkirk, among them the Famous Store, which reported a loss of $15,000. The roof of Floral Hall at the county fair grounds, Dunkirk, also caved in. Damage to shade trees and shrubbery, South Park, Buffalo, was estimated at $50,000.

The following are the amounts of snowfall reported to this office: Angola, 42 inches; Arcade, 7; Belfast, 2; Belmont, none; Bliss, 8; Boston, 30; Cherry Creek, 1; Dansville, 2; Dayton, 15; Dunkirk, 36; East Aurora, 37; Eden, 48; Ellicottville, 3; Franklinville, 3; Geneseo, 1; Gowanda, 5; Hamburg, 33; Hamlet, 5; Holland, 24; Lancaster, 15; Mount Morris, 3; New Albion, 6; Orchard Park, 42; Randolph, 4; Sinclairville, 5; Silver Creek, 36; Springville, 6; Strykerville, 36; Warsaw, 10; and West Valley, 4.

A new rainfall map of the State of Washington [18] *by Dr. O. W. Freeman, State Normal, Cheney, Wash.* [*author's abstract*].—Previous rainfall maps of Washington have been so generalized, especially in eastern Washington, that they failed to show as close a relationship to the relief and to the vegetation of the region as was desirable.

Isohyets drawn on the present map used all the records available in the State for mean annual rainfall. Stations having records for only a few years were compared with Spokane and Walla Walla in eastern Washington and Seattle in western Washington as standards since these places have long continuous records, and such corrections as were needed were made and the adjusted results used in drawing the isohyets. In places where no records were available personal observations by the author of the vegetation and relief were used in the location of critical isohyets.

In western Washington 20, 30, 40, 60, 80, 100, and 120 inch isohyets were drawn. In eastern Washington 8, 10, 12, 15, and 25 inch isohyets were added. This was found necessary because the usual jump from 10 to 20 inch annual rainfall, which is an increase of 100 per cent is too much to show the proper relationship between farm crops or natural vegetation and the rainfall.

The rainfall of Washington is principally affected by the Pacific Ocean, the direction of the prevailing winds, the relief of the land, and the course of the cyclones. There are three zones of heavy rainfall crossing the State north and south. These correspond to the Coast Range, Cascades, and Highlands of eastern Washington. To leeward of the Coast Range the rainfall declines in the Puget Sound lowland, especially in the rain shadow of the Olympics where it is under 20 inches.

In eastern Washington the 15-inch isohyet corresponds to the limit of growth toward the dry lands of the yellow pine (pinus ponderosa). The 12-inch isohyet marks the limit of the bunch grass and the preponderance of the sagebrush begins. Above the 12-inch isohyet wheat raising is generally successful. Between 10 and 12 inches the best farmers can still succeed in most years, although crop damage from drought is common. From 8 to 10 inches is quite definitely border-line farming and failures probably outnumber successes. Below 8 inches annually wheat raising is rarely tried any more and never

[14] Exner: Dynamische Meteorologie, Chapters XI and XII.
[15] C. K. M. Douglas: Q. J. R. Meteor. Soc., 54, 1928, pp. 19–25; 55, 1929, pp. 123–151.
[16] Kobayasi: Q. J. R. Meteor. Soc., 49, 1923, p. 177.
[17] W. H. Dines: The characteristics of the free atmosphere; *London, Meteorological Office, Geophysical Memoirs*, No. 13.

[18] Presented at Eugene, Oreg., meeting American Meteorological Society, June, 1930.

Heavy snowfall (42 inches) at Angola, N. Y., on October 17–18, 1930 was permanently successful. Under these conditions irrigation must be used if crops are raised. Fortunately the heavy snows of winter in the mountains in most years supply an abundance of irrigation water to fruitful valleys that lie in the rain shadow of the highlands.

M. A. Giblett, 1894–1930.—The untimely death of M. A. Giblett in the crash of the *R-101* on October 5 brought to a close a life that was not only full of accomplishment but also one that gave promise of a much enlarged sphere of usefulness in the years that are to come.

Giblett, in company of J. Bjerknes, paid a short visit to the central office of the Weather Bureau in the late summer of 1924. Together they made an analysis of the working charts of the forecast division of the bureau and contributed a paper bearing the title An Analysis of a Retrograde Depression in the Eastern United States, published in this REVIEW 52: 521–27. While at the Weather Bureau he endeared himself to the members of the staff by his intense enthusiasm in his chosen work and his charming personality. The sympathy of his friends on this side of the Atlantic goes out to the family and associates of the deceased.—*A. J. H.*

Sunspots and pressure distribution.[19]—The issue by the meteorological office of the daily charts of the weather in the Northern Hemisphere has enabled me to ascertain the barometric changes which take place from day to day in high latitudes. As a rule, the cyclones and anticyclones are large as compared with the polar uncharted area, and it proved possible to extend the isobars of the surrounding areas over the Arctic Sea. However, east Siberia could not, in the absence of the Japanese daily charts, which reach England about six months late, be dealt with.

From the partially completed charts the mean pressures were calculated for each day along latitudes 30°, 40°, 50°, 60°, 70°, and 80° north. When plotted they showed irregular periodic variations, some of which had a swing of something more than 25 days. As this is about the apparent period of rotation of the sun and pointed to our chief luminary as the cause of the variability of pressure from day to day, I decided to consider the sunspot question carefully.

By the courtesy of the Astronomer Royal, I have been supplied with bromide prints for each day for January, February, March, and April, and been allowed to see some of the later negatives of the solar disk. Also, by the courtesy of the director of the meteorological office, I have obtained the pressure charts—issued to the public since March—for January and February.

The sunspots have been plotted upon a diagram, the abscissæ of which are days and the ordinates degrees on the sun's surface measured from the apparent center of the disk. They clearly show the movements of each spot or group of spots, as they approach or recede from the center of the disk, owing to the sun's rotation.

An examination of this diagram demonstrates the fact that the pressure is low over the Arctic regions when there are sunspots near the sun's center, and that there are high pressures over the Arctic regions when there are no spots near the centre of the disk. Such low pressures due to sunspots occur in the long Arctic winter quite as markedly as they do during the summer. When the sun's disk was clear in the center on April 24, the mean pressure north of 60° was 1,025 millibars. On March 8 the mean pressure was 1,001 millibars and there were spots near the sun's center.

[19] Reprinted from *Nature*, London, Sept. 13, 1930.

I hope to be in a position to publish full details concerning the matter soon after the receipt of the Japanese weather charts of the North Pacific area for June.—*R. M. Deeley.*

The bora.—In a note on a recent geographical study of the vicinity of Fiume, at the north end of the Adriatic Sea (*Geogr. Rev.*, April, 1930, pp. 331–332), the following note on the bora appears:

> The bora blows when a "low" over the Adriatic or Mediterranean causes a draft of cold air to sweep "like a cascade" down the Dinaric mountain sides. Its vehemence is at a maximum in the gaps, where the air is compressed and condensed. The unexpected and capricious gusts (*refoli*) are particularly dangerous to navigation, but even on land they can easily upset a loaded railway car. Consequently the railways leaving Fiume are protected at the most exposed points by palisades and thick high walls.—*C. F. B.*

City temperatures.—The yearbook of the Baden weather service for 1929 has just been published.[20] This annual contains the usual summary of observations in Baden, both surface and aerological. Two scientific papers are also presented, one of them being on the temperature distribution in Karlsruhe on hot summer days.[21] In this paper Dr. Albert Peppler describes, in the form of temperature profiles and a detailed map, the local distribution of temperature in and about Karlsruhe. The observations are obtained by the temperature survey method by automobile. The instrument used was an Assmann aspiration thermometer.

Most striking is the exceptional contrast in evening temperatures between the interior of Karlsruhe and the wooded surroundings. The hottest parts of Karlsruhe had temperatures exceeding 30° C., while the woods nearby had temperatures from 25° down to below 23°. Owing to the marked contrast there was a slow flow of cool air from the country towards the city, this flow being marked on the streets entering the city. The heated air of the city flowing out over the surrounding countryside produced such a sharp inversion of temperature that the locomotive and other smoke was closely held to a low ceiling.—*C. F. B.*

Rain map of Australia for 1929.—Every year the Commonwealth meteorologist publishes a rain map of Australia on a scale of 130 miles to the inch. This map for 1929 shows many interesting contrasts. The least rainfall was 0.65 inch in the northeastern corner of south Australia. This was lowest on record for the station. The greatest rainfall was 120 inches at Innisfail, at latitude 17½ on the coast of Queensland. There was a rainfall of 110 inches near Port Macquarie about latitude 32 on the coast of South Wales. This was the greatest on record at that place. Tasmania had even more, the maximum exceeding 150 inches on the western mountains. Spots in the southeastern lowland, however, had less than 20 inches.

Printed in the space around the map is a table and discussion of the rainfall of the year by districts, also small-scale maps of Australia showing the distribution of areas having more or less than average rainfall. On the back of the map are 12 smaller scaled maps showing the rainfall by months. In January, February, and March monthly rainfalls of 30 to over 40 inches occurred on parts of the coast of Queensland.—*C. F. B.*

Climatological summary for Chile, August, 1930, by J. Bustos Navarrete, Observatorio del Salto, Santiago, Chile.—During the first half of the month atmospheric

[20] Meteorologisches Jahrbuch für 1929, Veröffentlichungen der Badischen Landeswetterwarte, Nr. 16, Karlsruhe, 1930.

[21] Albert Peppler, Die Temperaturverhältnisse von Karlsruhe an heissen Sommertagen, pp. 59–60, 2 figs.

conditions were relatively stable with moderate increase in temperature, but during the last decade there was a change to decidedly unsettled weather and general rains.

The most important depressions, all crossing the extreme southern region, were mapped on the 21st to 23d, 25th to 26th, and 28th to 30th.

Anticyclones, advancing from southern Chile toward Argentina, were mapped in the following periods: 1st to 5th, 11th to 13th, and 14th to 21st. In the period 6th to 9th an antarctic HIGH crossed the continent in a northerly direction.—*Translated by W. W. R.*

Climatological summary for Chile, September, 1930, by J. Bustos Navarrete, Observatorio del Salto, Santiago, Chile.—Like September this month was characterized by settled atmospheric conditions. Cyclonic storms of importance appeared in the extreme south during the periods 21st to 22d and 29th to 30th. During the remainder of the month anticyclonic areas dominated conditions and the weather was fine. The important HIGHS, all of which moved from southern Chile toward Argentina, were charted in the periods 2d to 12th, 13th to 17th, and 22d to 26th.—*Translated by W. W. R.*

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C FITZHUGH TALMAN, in charge of Library

RECENT ADDITIONS

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SOLAR OBSERVATIONS

SOLAR AND SKY RADIATION MEASUREMENTS DURING OCTOBER, 1930

By HERBERT H. KIMBALL

For reference to descriptions of instruments and exposures, and an account of the method of obtaining and reducing the measurements, the reader is referred to this volume of the REVIEW, page 26.

Table 1 shows that solar radiation intensities averaged close to the normal intensity for October at Washington, D. C., and Lincoln, Nebr., and slightly below normal at Madison, Wis.

Table 2 shows an excess in the total solar radiation received on a horizontal surface directly from the sun and diffusely from the sky at Washington, New York, Fresno, and La Jolla, and a slight deficiency at Chicago, Madison, and Lincoln. The excess was marked at Washington.

Skylight polarization measurements obtained at Washington on six days during the month give a mean of 52 per cent and a maximum of 55 per cent on the 4th. At Madison, measurements obtained on four days give a mean of 54 per cent and a maximum of 61 per cent on the 10th. The values for both stations are considerably below the corresponding October averages for the respective stations.

TABLE 1.—*Solar radiation intensities during October, 1930*

[Gram-calories per minute per square centimeter of normal surface]

Washington, D. C.

Date	Sun's zenith distance										
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass A. M.					Air mass P. M.				Local mean solar time
	e.	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Oct. 1	6.27	0.77	0.87	1.07	1.16						5.36
Oct. 2	5.79	0.70	0.80	1.08	1.24	1.48	1.23	1.03	0.92	0.80	4.95
Oct. 3	6.27				1.09						6.27
Oct. 4	6.76				1.08		1.18	1.05	0.90	0.75	4.95
Oct. 6	6.02	0.85	0.96	1.08	1.24	1.56					5.79
Oct. 7	6.76	0.67	0.78	0.81	1.03	1.27					5.79
Oct. 11	10.21	0.50	0.63	0.77	0.90						9.83
Oct. 17	11.81			0.71							10.21
Oct. 18	5.36	0.78	0.93	1.08							3.45
Oct. 20	2.16	0.76	0.96	1.08	1.33		1.22				1.96
Oct. 22	3.45	0.66	0.78	0.91	1.08	1.34					3.45
Oct. 23	4.95			0.91							3.30
Oct. 24	6.50	0.67		1.06	1.21						4.37
Oct. 28	7.57			1.03							6.76
Oct. 30	5.16	0.62	0.71	0.91	1.05						4.75
Oct. 31	4.17	0.49	0.64								3.81
Means		0.68	0.81	0.96	1.13	1.41	1.21	(1.04)	(0.91)	(0.78)	
Departures		−0.07	−0.02	+0.01	+0.01	±0.00	+0.09	+0.11	+0.11	+0.07	