TABLE 3.—*Height of the boundary of the "eye" of the Manila cyclone, Oct. 19–20, 1882*

Before passage of center		After passage of center	
Distance from center	Height of boundary	Distance from center	Height of boundary
km.	*m.*	*km.*	*m.*
312	9,100	40	5,830
243	9,000	75	8,050
171	8,530	110	8,150
101	7,590	180	9,060
66	6,410	251	10,100
48	3,460	321	10,500
30	1,740		

We do not claim that the boundary of the calm zone as represented by figure 2 is in all respects a true boundary in the sense that no air can cross this surface. It might well be that only the inner steep part is a boundary in this hydrodynamical sense of the word, while the more horizontal part is rather a transitional zone where the air changes its qualities more rapidly.

Formula (4) may also be derived by means of the relation between the inclination of a surface of discontinuity and the velocity and density distribution on both sides. This deduction shows that formula (4) is also in agreement with reasonable assumptions about the wind distribution in a tropical hurricane.

SOUNDING-BALLOON OBSERVATIONS AT OMAHA, NEBR., DURING THE INTERNATIONAL MONTH, JANUARY 1934

By J. C. BALLARD

[Weather Bureau, Washington, D. C., January 1935]

The Weather Bureau conducted a series of sounding-balloon observations at Omaha, Nebr., during the international month, January 1934. The observations were made in cooperation with the International Commission for the Exploration of the Upper Atmosphere, and the program followed was similar to that for other series of this nature except for the addition of some special observations. The latter included a total of 5 observations on the 21st and 22d, 2 on the 24th, and 5 on the 30th.

It was intended to make the special observations during the passage of a low-pressure area over the station, to obtain a cross-sectional picture of the meteorological conditions. No satisfactory condition occurred during the month, however, so the instruments for special use were released as indicated below. Those of the first set (on the 21st and 22d) were released in the southern part of a LOW, those of the 24th were made during the advance of a cold wave, and those of the 30th were made to determine whether a slower rate of ascent would result in greater altitudes being reached by the balloons before bursting. The reason for expecting better altitude performance from a nearly floating balloon lies in the fact that at low temperatures more time is required for the rubber of the balloons to stretch to the fullest extent than at higher temperatures. The best altitude performance from a slowly rising balloon probably would be obtained in the daytime, but the temperature record would then be of little value.

For a description of the instrument used, the method of attachment, etc., and a record of previous sounding-balloon series in this country, the reader is referred to the following issues of the MONTHLY WEATHER REVIEW, in which either references or descriptions will be found: January 1932; February 1934; April 1934.

Most of the observations were made during daylight hours, so that the balloons could be followed by theodolite; and even though they were made as late in the day as practicable, the temperature records probably were affected by insolation. However, the amount of this effect could not be determined because of lack of a sufficient number of night flights (1).

Detailed data obtained from the observations will be published by the International Commission for the Exploration of the Upper Air.

A summary of the individual observations will be found in table 1. Altogether 46 instruments were released and all but two were found. Two of the records were destroyed by the finders. Of the remaining 42 records, 38 were good; and at least 1 good record was obtained on all but 3 days during the month.

The highest altitude reached was 29.3 km on the 10th, and a height of 20 km was exceeded seven times. The average height reached in those flights in which the record was good up to the maximum altitude was 17.5 km.

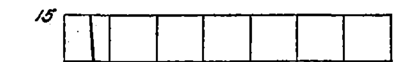

FIGURE 1.—Mean temperature curve for January 1934 at Omaha, Nebr. Solid line based on late afternoon sounding-balloon observations and dashed line on early morning airplane observations.

The greatest height of the tropopause observed during the month was 14.2 km, on the 10th; and the lowest, 7.9 km, on the 12th. The average height was 11.1 km.

Figure 1 shows the average temperature curve for the month, obtained by the difference method from the regular flights made near 4 p. m. (the special observations were not considered) and the mean temperatures for the month obtained from the airplane observations made near 4 a. m. It will be noted that the morning temperatures observed by airplane averaged higher above 800 meters (m. s. l.) and lower above 3,000 meters (m. s. l.) than the afternoon temperatures observed by sounding balloon, in spite of the fact that due to diurnal variation the temperature below 1,500 meters (m. s. l.) averages lower in the morning than in the afternoon (2).

As a further check on the agreement between the temperatures observed by the two methods, the Polar Year observations were used (1). On 2 days per month during the Polar Year, sounding-balloon observations were made near 6 a. m. On each day on which one of these sounding-balloon observations was available, together with an airplane observation made near 4 a. m., the temperature differences between the two types of observations, at the standard levels, were found and the averages obtained. The results for Dallas, Tex. and Omaha, Nebr., are shown in figure 2, together with the results obtained during January 1934, at Omaha.

It will be seen that the surface differences in each case are in accordance with what would be expected from a knowledge of the diurnal variation. The differences in the free-air, however, cannot be explained in this way. The differences at Omaha during the Polar Year and during the month of January agree fairly well. The differences at Dallas agree well in the lower levels with those at Omaha, but at the higher levels the temperatures obtained by airplane at Dallas average higher than those obtained by sounding balloon, while the reverse is true at Omaha.

Recently some test flights were made in which two airplane instruments were carried simultaneously on the airplane. One instrument was the standard type aerometeorograph now in use by the Weather Bureau and the other was a new type of instrument designed to provide the temperature and humidity elements with better ventilation. The average differences for five flights between the temperatures recorded by these two instruments at the standard levels are shown in figure 2 (d).

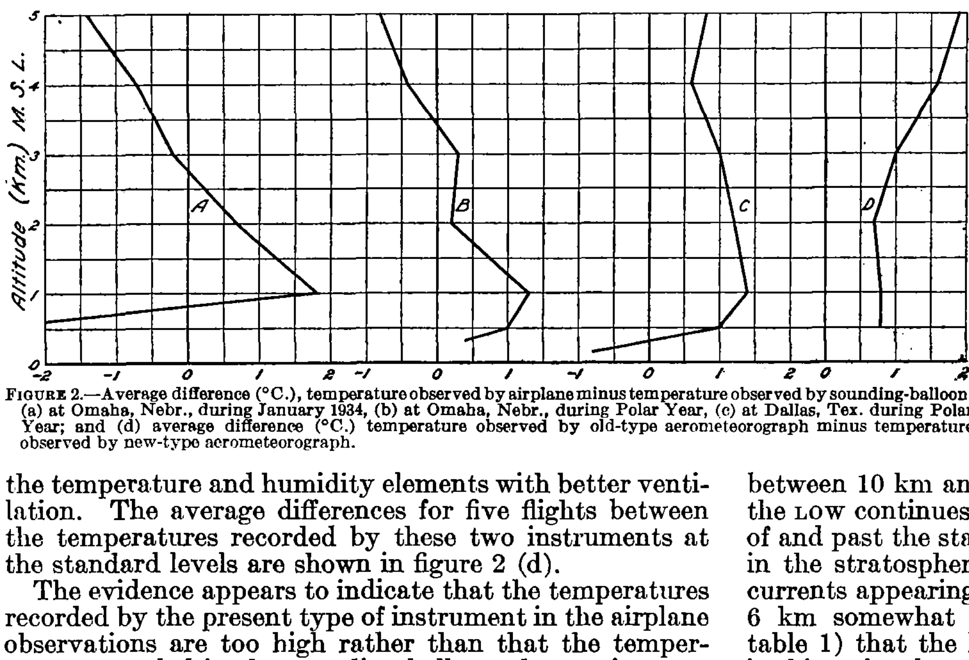

FIGURE 2.—Average difference (°C.), temperature observed by airplane minus temperature observed by sounding-balloon, (a) at Omaha, Nebr., during January 1934, (b) at Omaha, Nebr., during Polar Year, (c) at Dallas, Tex. during Polar Year; and (d) average difference (°C.) temperature observed by old-type aerometeorograph minus temperature observed by new-type aerometeorograph.

The evidence appears to indicate that the temperatures recorded by the present type of instrument in the airplane observations are too high rather than that the temperatures recorded in the sounding-balloon observations are too low.

Figure 3 shows free-air isotherms for the month based on the sounding-balloon observations. For convenience of reference the observed variation of the height of the tropopause and the wind directions obtained from theodolite observations of the sounding-balloons have been added to this figure.

It will be noted that the greatest variations in the height of the tropopause occur during the first 12 days of the month. During this part of the month the sky was overcast at the time of observation on all but two of the days (the 1st and 8th), and the surface temperatures varied but little except on two occasions (the 1st and 7th).

Figure 4, prepared by drawing lines through points of equal departure from the average for the month, shows the extent of the warm and cold air masses more clearly than the chart of isotherms. The frequent inverse relationship between the relative temperatures in the lower and upper atmospheres, i. e., relatively warm in the stratosphere at the same time it is relatively cold in the lower atmosphere and vice versa, is brought out very well in this figure. The pressure changes at the surface, being the results of the temperature change aloft, can obviously be predicted quite accurately from the extent of the warm and cold air masses; but to show this relationship, the surface pressures observed at the times of each of the soundings have been plotted at the bottom of the figure.

The cold wave occurring on the 7th is interesting since the cold area can apparently be traced from the surface upward into the stratosphere. The coldest period in the stratosphere, however, occurred 3 days later than at the surface. A similar situation appears on the 12th. Here the fall was only slight at the surface, increased to several degrees between 2 and 8 km, and occurred 2 days later (on the 14th) in the stratosphere.

On the 7th the center of the cold wave passsed to the north, only the southern edge passing over Omaha. From the data from only one station, it is impossible to say for certain whether there is any direct relationship between the cold air in the stratosphere on the 10th and that at the surface on the 7th, or whether the two are separate and distinct phenomena. That there is or is not any causal relationship between such phenomena can be determined only by frequent high-altitude soundings from a network of stations.

Figures 5 and 6 have been constructed similarly to figure 4, and show the temperature conditions during the special observations taken on the 21st and 22d, and on the 24th.

Figure 5 shows about the average temperature distribution and average height of the tropopause as a LOW approaches from the northwest. As the southerly winds continue, the temperature departure between the surface and 1 km increases until about sunrise, the departure between 1 km and 10 km becomes negative and that between 10 km and 15 km increases. After this time, as the LOW continues to move in an easterly direction, north of and past the station, the temperature continues to rise in the stratosphere and to fall in the lower levels, cold currents appearing at 6 to 8 km around noon, and at 3 to 6 km somewhat later. It is interesting to note (see table 1) that the landing places of the balloons released in this series changed in a regular manner from a direction of 54° (NE. of the station) for the balloon released at 4 p. m. on the 21st, to 123° (SE. of the station) for the one released at 4 p. m. on the 22d.

Needless to say, the series would have been much more valuable if the LOW had moved in a southeasterly direction and passed directly over the station.

Figure 6 shows the front of a cold current passing over the station on the 24th just after the lower layers had been relatively warm. The height of the tropopause decreased somewhat as the cold air came in, and a cold current appeared in the stratosphere at about the same time the front of the cold air mass appeared at the surface.

Of the five instruments released on the 30th with a slow ascensional rate, one was not found, one failed to record, one clock stopped at a height of 6.7 km and another at 16.6 km, and the fifth, with a good record throughout, reached a maximum height of 19 km or 1.5 km higher than the average. Therefore, nothing was learned as to the relationship between the slow ascensional rates and the maximum heights reached.

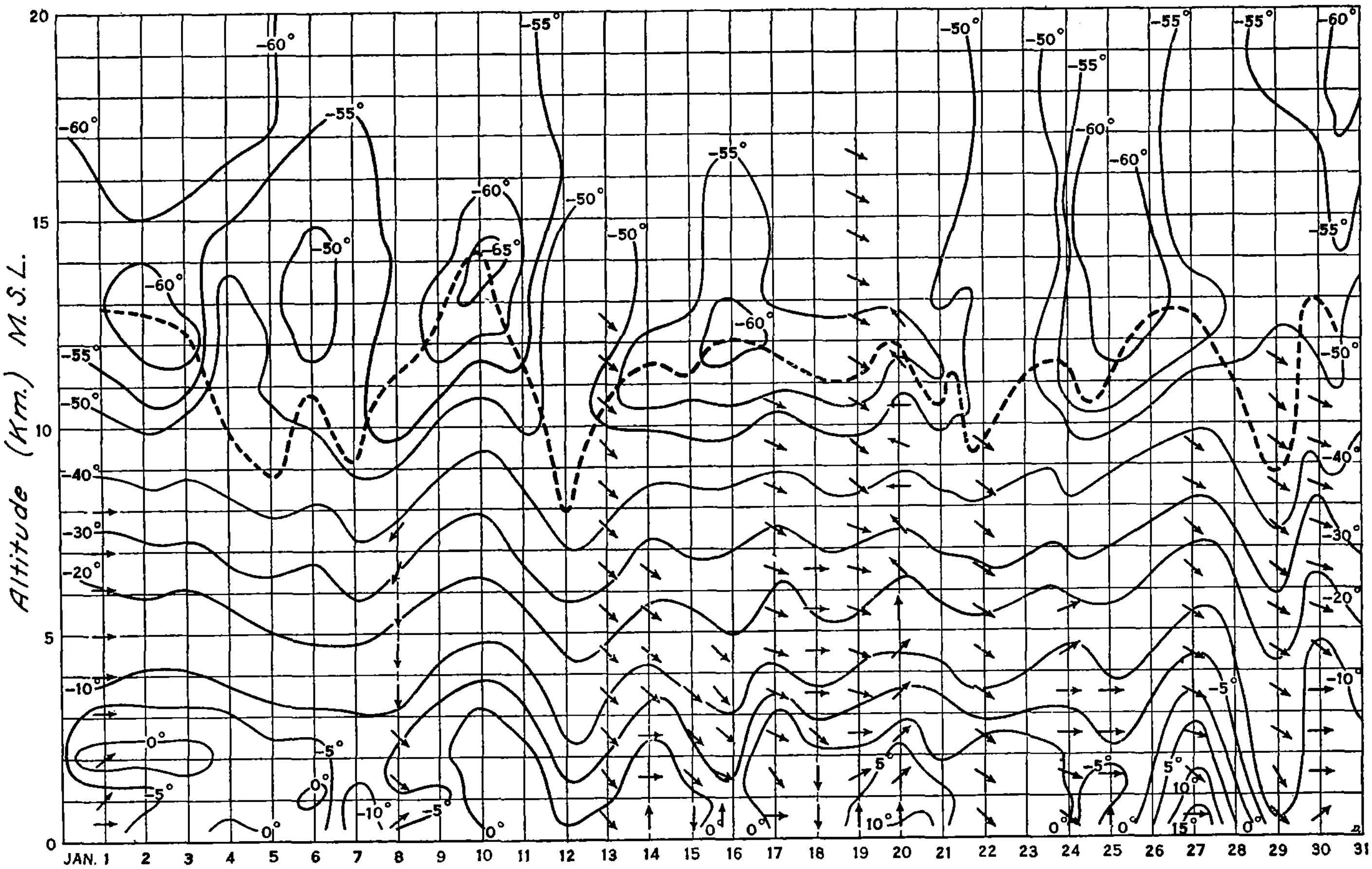

FIGURE 3.—Free-air isotherms (solid lines), height of the tropopause (heavy dashed line), and wind directions (arrows) for January 1934 at Omaha, Nebr.

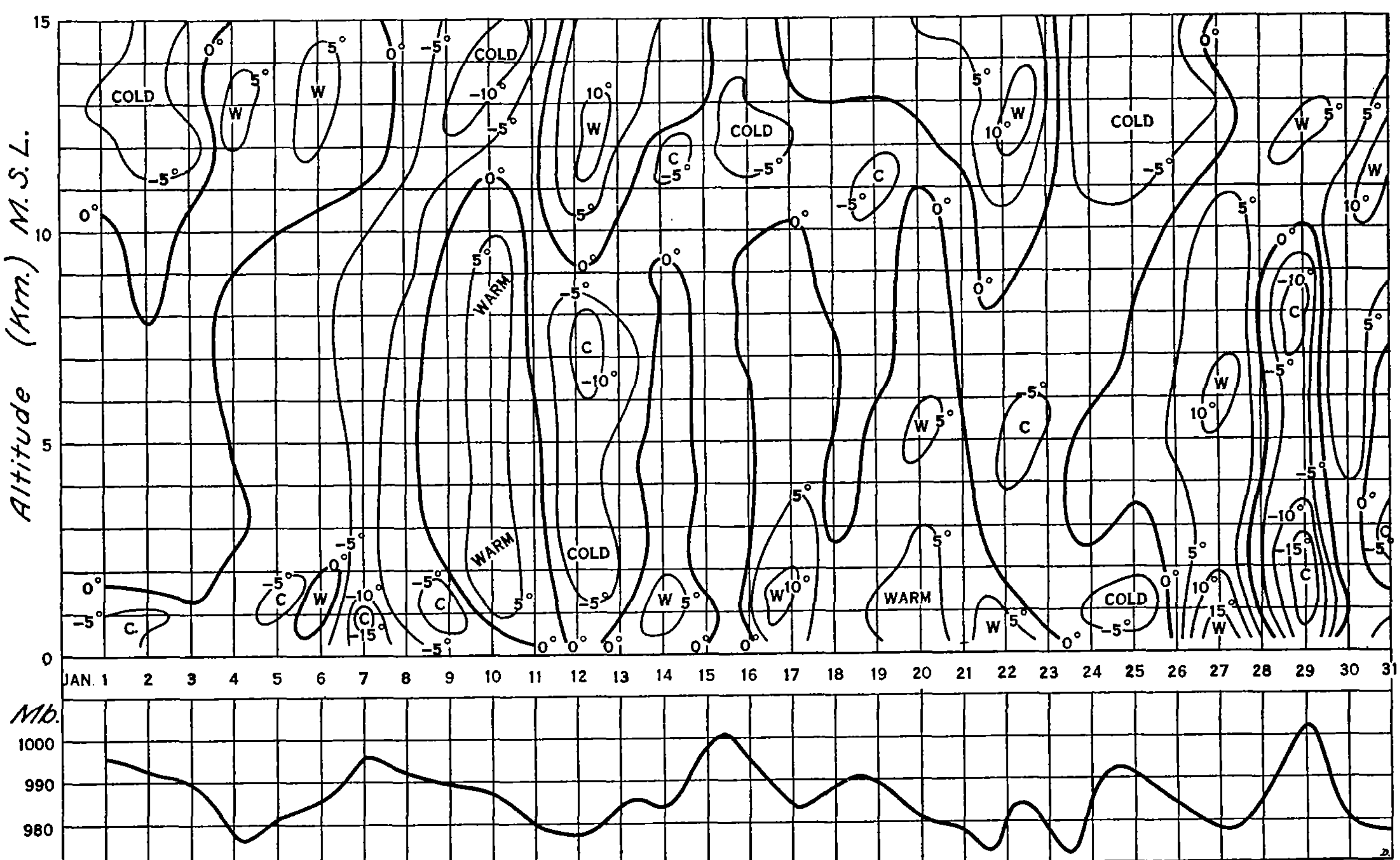

FIGURE 4.—The lines at the top connect points of equal departure (°C.) from the average temperature for the month, and the curve at the bottom shows the surface pressure plotted against day of the month.

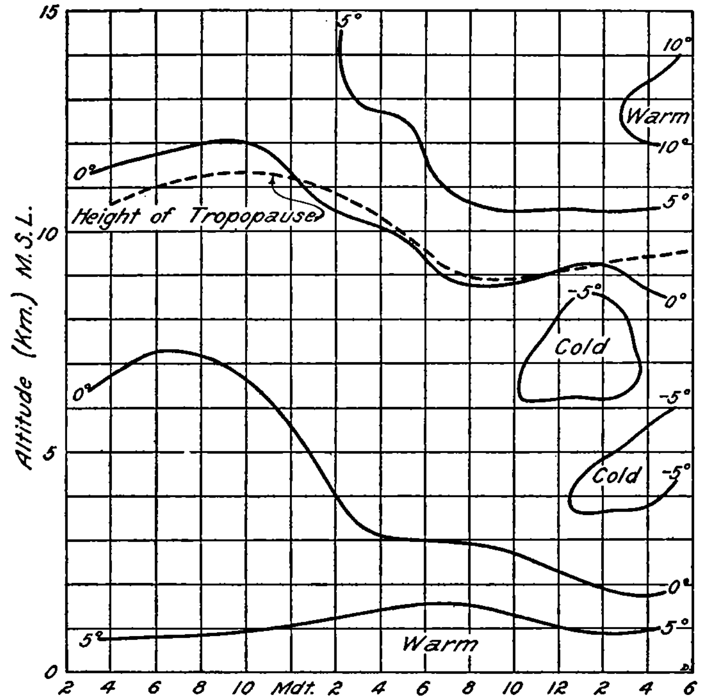

FIGURE 5.—Lines of equal departure (°C.) on the 21st and 22d from the average temperature for the month.

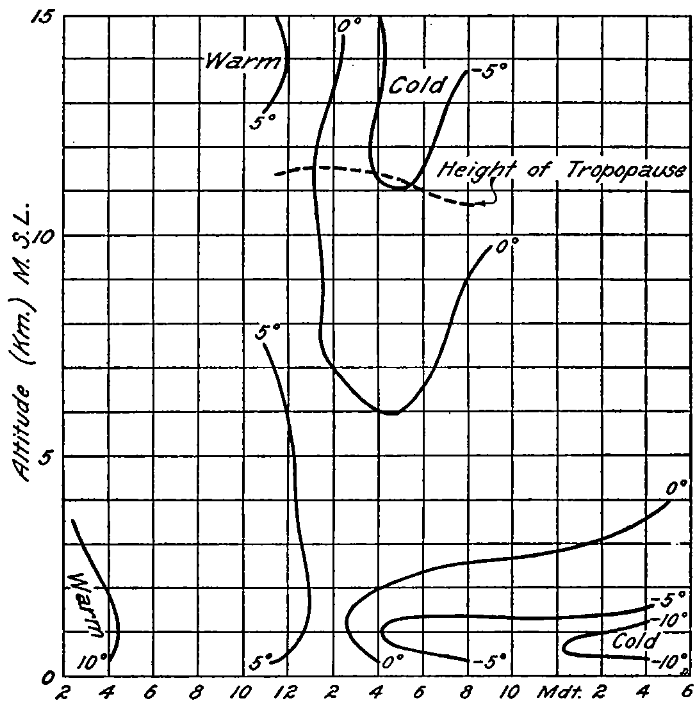

FIGURE 6.—Lines of equal departure (°C.) on the 24th and 25th from the average temperature for the month,

It is desired to acknowledge the cooperation of the entire station personnel at Omaha during the making of these observations, which is a difficult and disagreeable task during cold and windy weather; and the assistance of Mr. C. J. Doering of this office in the computations of the records.

REFERENCES

(1) Monthly Weather Review, February 1934.
(2) Monthly Weather Review, March 1933.

TABLE 1.—*Summary of sounding-balloon observations made at Omaha, Nebr., during January 1934*

Date	Time of release 90th mer.	Tropopause		Maximum height	Minimum temperature recorded	Balloon followed with—		Meteorograph found	
		Height	Temperature			2 theodolites	1 theodolite	Distance from station	Direction from station
		Meters (m. s. l.)	*°C.*	*Meters (m. s. l.)*	*°C.*	*Min.*	*Min.*	*Km*	
1	4:51 p.	12,900	−60.0	21,700	−62.4	0	38	185	E.
2	4:32 p.	12,700	−62.9	20,100	−62.9	0	0	144	ENE.
3	4:26 p.	12,300	−64.4	18,700	−64.4	0	0	99	NE.
4	4:29 p.	9,900	−47.3	17,300	−61.2	0	0	88	NE.
5	4:19 p.	8,900	−47.2	14,800	−54.8	0	0	87	E.
6	4:21 p.	10,700	−52.4	21,800	−56.0	0	0	169	NE.
7	4:25 p.	9,200	−52.8	17,500	−54.7	0	0	71	ENE.
8	4:30 p.	11,300	−59.4	18,000	−59.2	0	43	142	S.
9	4:05 p.	12,700	−67.7	16,100	−67.7	0	0	166	SSW.
10	4:16 p.	14,200	−67.8	29,300	−67.8	0	0	50	E.
11	4:15 p.	11,300	−55.6	12,800	−56.7	0	0	84	NE.
12	4:22 p.	7,900	−47.8	14,900	−51.1	0	0	43	E.
13	4:05 p.	10,600	−51.6	13,200	−51.6	0	57	129	SE.
14	4:09 p.	11,400	−59.3	12,500	−59.7	0	27	197	ESE.
15	4:13 p.	11,300	−56.1	17,200	−56.3	15	15	178	E.
16	8:15 a.	12,000	−62.5	21,400	−63.4	0	23	217	SE.
16	4:09 p.	--------	--------	--------	--------	38	43	(1)	(1)
17	7:45 a.	11,900	−62.1	18,800	−62.1	0	0	123	ESE.
17	3:56 p.	11,800	−59.8	15,100	−59.8	46	51	157	ESE.
18	7:55 a.	--------	--------	--------	--------	0	0	(2)	(2)
18	4:23 p.	11,100	−58.3	15,900	−58.5	33	34	158	E.
19	3:57 p.	11,200	−58.6	17,700	−58.6	0	75	98	ESE.
20	4:01 p.	11,900	−58.5	14,300	−58.5	0	74	47	NNE.
21	4:10 p.	10,600	−55.3	14,400	−55.3	0	0	150	NE.
21	10:20 p.	11,300	−53.5	18,300	−54.0	0	0	158	ENE.
22	3:17 a.	10,500	−51.6	14,600	−51.6	0	0	182	ENE.
22	6:32 a.	9,300	−45.8	16,300	−50.8	0	0	133	E.
22	9:33 a.	--------	--------	(3)	(3)	0	0	175	ESE.
22	1:01 p.	9,200	−48.2	21,400	−51.4	0	25	140	ESE.
22	4:11 p.	9,400	−45.0	18,500	−50.6	0	31	225	ESE.
23	4:10 p.	--------	--------	(4)	--------	10	21	179	E.
24	12:26 p.	11,500	−53.7	18,000	−54.0	0	28	206	ENE.
24	4:23 p.	11,400	−60.3	16,200	−61.5	0	0	295	ENE.
24	7:24 p.	10,800	−56.6	13,700	−57.2	0	0	250	ENE.
25	4:13 p.	(5)	−53.2	(5)	−53.2	0	14	203	E.
26	4:20 p.	--------	--------	(6)	(6)	5	10	184	ESE.
27	3:57 p.	12,700	−59.1	19,700	−59.4	40	42	259	ESE.
28	4:51 p.	--------	--------	(7)	(7)	0	6	384	SE.
29	4:09 p.	8,800	−50.7	15,100	−53.3	33	45	238	SE.
30	4:11 p.	12,700	−54.9	21,000	−59.4	0	43	161	ESE.
30	6:57 p.	--------	--------	--------	--------	0	0	(1)	(1)
30	7:14 p.	--------	--------	(8)	(8)	0	0	233	ESE.
30	7:35 p.	--------	--------	(6)	(6)	0	0	10	ENE.
30	7:50 p.	12,100	−56.6	19,000	−62.8	0	0	250	E.
30	8:12 p.	11,500	−57.0	(9)	−61.0	0	0	270	ESE.
31	4:09 p.	(10)	(10)	(11)	--------	0	0	461	ESE.

[1] Instrument not found.
[2] Instrument and record destroyed by finder.
[3] Record obliterated.
[4] Pressure record missing.
[5] Pressure record bad above 7,700 m.
[6] Instrument failed to record.
[7] Record obliterated by finder.
[8] Clock stopped at 6,700 m.
[9] Clock stopped at 16,600 m.
[10] Tropopause not definitely indicated.
[11] Clock stopped at 17,600 m.