TABLE 1.—*Parts per million*

No.	Date	Amount	Precipitation	Nitrates	Nitrites	Free NH_3	Alb. NH_3	SO_4	Chlorides
		Inches							
1	June 18	1.8	Rain	0.01	Trace	0.32	0.04	------	2.5
2	June 19	.1	do	.01	------	.20	.09	------	6.1
3	June 26	.35	do	.01	------	.32	.14	------	8.65
4	Sept. 12	.7	do	.01	------	.40	.09	------	12.75
5	do	.5	do	------	0.09	.28	.17	------	8.65
6	Sept. 20	.4	do	.02	.20	.14	.19	------	8.75
7	Oct. 3	.7	do	.03	.10	.21	.23	------	5.1
8	Oct. 10	1.0	do	.07	.11	.05	.09	------	5.1
9	Oct. 25	.55	do	------	.55	.10	.11	------	8.65
10	Nov. 4	.2	do	.14	.03	.30	.10	------	3.75
11	Nov. 8	1.0	do	.01	.09	.12	.08	------	1.55
12	Nov 9	.15	do	------	------	------	------	------	5.1
13	Nov. 12	.7	do	.04	.14	.13	.09	------	1.55
14	Dec 13	.7	do	.11	.08	.15	.09	------	8.75
15	Dec. 11	4.0	Snow	.07	.10	.04	.08	------	3.55
16	Dec. 23	.5	Rain	------	.04	.43	.04	------	7.1
17	Dec. 25	.7	do	------	.04	------	------	------	4.1
18	Jan. 18	.2	do	.25	.25	.08	.04	------	1.1
19	Jan. 27	4.0	Snow	.03	.09	.20	.32	------	1.55
20	Feb. 8	4.0	do	.01	.09	.08	.16	------	2.8
21	Mar. 19	.7	Rain	.01	.07	.09	.11	------	1.6
22	Mar. 20	3.0	Snow	.07	.01	.11	.09	------	2.9
23	Mar. 24	4.0	do	.02	.01	.17	.03	------	1.6
24	Mar. 29	.65	Rain	.04	------	.10	.07	------	5.1
25	Mar. 30	1.75	do	.04	.01	.09	.10	------	5.1
26	Apr. 5	.7	do	.07	.01	.14	.13	------	7.3
27	Apr. 9	.25	do	.12	.03	.17	.09	------	7.7
28	Apr. 13	.35	do	.03	.07	.09	.04	------	4.5
29	Apr. 30	.55	do	.07	.07	.14	.15	------	5.1
30	May 2	1.25	do	.07	.15	.09	.11	------	5.1
31	May 5	.6	do	.09	.13	.05	.07	------	1.55
32	May 7	.75	do	.02	.09	.15	.14	------	5.1
33	May 12	1.4	do	.04	.03	.30	.04	------	2.05
34	May 15	.2	do	.07	.07	.04	.19	------	2.4
35	May 16	.45	do	.11	.07	.09	.07	------	2.4
36	May 18	.25	do	.10	.10	.13	.30	------	8.2
37	May 19	.7	do	.04	.06	.09	.17	------	7.55
38	May 20	.5	do	.11	.03	.04	.09	------	2.4
39	May 21	.25	do	.07	.09	.11	.08	------	2.3
40	May 26	.35	do	.11	.07	.04	.06	------	3.6
41	May 27	.40	do	.06	.09	.09	.10	------	5.5
42	May 30	.65	do	.06	.09	.03	.10	------	5.0
43	June 4	.7	do	.07	.03	.11	.07	------	2.8

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

[1 inch of rain over 1 acre=226875]

No.	Nitrates	Nitrites	Free NH_3	Alb. NH_3	Sulphur	Chlorides
1	0.004083	------	0.130680	0.016335	------	1.020937
2	.000226	------	.004537	.002041	------	.138390
3	.007940	------	.019009	.011116	------	.686861
4	.001588	------	.063524	.014293	------	2.024853
5	------	0.010209	.031762	.019284	------	.981230
6	.001815	.018150	.012705	.017242	------	.794062
7	.004764	.015880	.015881	.036526	------	.809941
8	.015881	.024956	.011343	.020418	------	1.157062
9	------	.068629	.012477	.013725	------	1.079155
10	.006352	.001361	.013613	.004537	------	.170156
11	.002268	.020418	.027425	.018150	------	.351656
12	------	------	------	------	------	.073558
13	.006352	.022233	.020645	.014293	------	.246158
14	.017469	.012705	.023821	.014293	------	1.389605
15	.005293	.006806	.003025	.006050	------	.268468
16	------	.004537	.048777	.004537	------	.805402
17	------	.006352	------	------	------	.651129
18	.011343	.011343	.003630	.001815	------	.049912
19	.002268	.006806	.015125	.024200	------	.117218
20	.000756	.006806	.006050	.012100	------	.211750
21	.001583	.011116	.014293	.017469	------	.254099
22	.003970	.000567	.006249	.005104	------	.164515
23	.001512	.000756	.012856	.002268	------	.121000
24	.005898	------	.014746	.010322	------	.752026
25	.015881	.003970	.035732	.039703	------	2.024863
26	.011116	.001588	.022233	.020645	------	1.159327
27	.006806	.001701	.009642	.005104	------	.436736
28	.002382	.004764	.007146	.003176	------	.357327
29	.008734	.007940	.017469	.018717	------	.636383
30	.019851	.042534	.025523	.031195	------	1.446329
31	.012251	.017696	.006806	.009528	------	.210993
32	.003403	.015314	.025523	.023821	------	.867800
33	.012705	.008507	.095287	.012705	------	.651131
34	.003176	.003176	.001815	.008621	------	.108900
35	.011230	.007146	.009188	.007146	------	.245023
36	.005671	.005671	.007373	.017015	------	.465095
37	.006352	.009528	.014293	.026998	------	1.199030
38	.012478	.003403	.004537	.010209	------	.108900
39	.003970	.005104	.006239	.004537	------	.130453
40	.008734	.003176	.003176	.004764	------	.285861
41	.009075	.008167	.008167	.009075	------	.499125
42	.008848	.013272	.004424	.014746	------	.737340
43	.011116	.004764	.017469	.011116	------	.444673

EXCESSIVE RAIN AND FLOOD IN THE LOS ANGELES, CALIF., AREA

By LAWRENCE H. DAINGERFIELD

[Weather Bureau Office, Los Angeles, Calif., Mar. 23, 1934]

A pressure distribution developed over the Pacific Ocean on December 29, 1933, closely resembling the "Westerly type" as defined by Thomas R. Reed in the MONTHLY WEATHER REVIEW of December 1932. During the following 4 days the pressure map was similar to Reed's "Westerly type" of December 22, 1931–January 2, 1932, which was attended by moderately heavy rain over the Los Angeles area on December 26, 28, and 29, 1931, and heavy-to-excessive precipitation over coastal areas to northward.

The disturbances of December 1931 and December 1933 possessed another common characteristic, namely, the appearance in each instance of a greatly modified depression some hundreds of miles inland, east or southeast of the parent storm, during the closing period of the major cyclone but with this difference. In the case of the 1931 disturbance, the subsequent modified depression appeared over Utah, western Wyoming, and western Colorado, while in the latter case the succeeding disturbance was over Arizona and New Mexico. Whether or not the succeeding disturbances were the "sheared-off tops" of the much vaster ocean cyclones, described by E. H. Bowie as applicable to, and accounting for, the reappearance LOWS of Alaskan Gulf depressions to the east or leeward of the near-coastal mountain ranges of Alaska and British Columbia, or possibly "secondaries" or even new developments, it is difficult to know with certainty.

In the case of the Los Angeles storm of December 1933, which was of the North Pacific type described by Dean Blake,[1] the breaking down, or far southward movement, of the protecting North Pacific HIGH is obvious, with one remnant near the Hawaiian Islands and another portion over Lower California, Sonora, and Sinaloa, Mexico, facilitating the southern extension of the Alaskan Gulf disturbance over the Pacific Ocean to somewhat below the latitude of Los Angeles. This movement was attended by a warm, moist front, believed to have had its origin over tropical or semitropical waters.

Under this pressure distribution, the rather localized, but moisture-bearing, warm front advanced northeastward or northward from its tropical or semitropical origin and crossed the coast line of Los Angeles, Orange, and the upper extremity of San Diego Counties.

The precipitation, generally, was only moderately heavy over the coastal area named, ranging from 2 to 4 inches, except from Santa Monica westward, where the abrupt, steep southerly slope of the Santa Monica Mountains, dropping sharply to the sea, exerted a profound influence, referred to later, on the rain-bearing wind.

Before the moist air reached the slopes of the San Gabriel and San Bernardino Mountains, however, it was underrun by a cold easterly wind which, obviously, largely increased the rainfall over the valley lands and lower foothill regions between the coast and mountains. In this connection Floyd D. Young, in charge of the Pacific Coast fruit-frost work of the Bureau, with head office in Pomona, Calif., says:

So far as the local area around Pomona is concerned, I believe the general conditions which prevailed here throughout the storm period were practically the same as those in Los Angeles. The outstanding feature of the storm here, or at least the feature which impressed me most forceably, was a strong, relatively cool, sus-

[1] MONTHLY WEATHER REVIEW, 61, 223, 1933.

tained surface wind, which continued from an easterly direction throughout the rainfall period. Most of the time this wind was from the east or northeast, but shifted to the southeast for short periods. This fact, as well as the fact that the rainfall was heaviest along the lower foothills, with, in many cases, considerably lighter rainfall in the higher mountains, leads me to believe that the orographic influences, except insofar as they may have affected the surface wind direction, were considerably less important in this storm than in most other rainstorms which have occurred here in the past. In other words, it appears to me that the strong and sustained southerly and southwesterly air currents, which prevailed from moderate to high elevations, as shown by pilot-balloon observations, began to rise over the relatively cold easterly currents at lower elevations considerably before the mountains were reached, and that the precipitation of the moisture was due not only to the rising of the southerly air currents, but also to a certain extent at least to the mixing with the relatively cold surface easterly wind.

The surface wind at Los Angeles also, like that at Pomona, had a strong easterly component during the precipitation period, December 30 to January 1, inclusive. The courses of the clouds, drifts of pilot balloons, and records at the higher level stations indicate, however, that the cool, underrunning easterly winds had no great depth during the progress of the storm. The southerly component was more pronounced at the higher levels, especially during the period of the heaviest precipitation, in keeping with the believed warm source of the moisture (tropical or subtropical).

Examination of the isohyetals for the storm shows centers of heaviest total rainfall at Hoegee's Camp, San Gabriel Mountains, elevation 2,650 feet, 19.91 inches; Opid's Camp, same mountains, elevation 4,254 feet, 17.93 inches; Squirrel Inn, San Bernardino Mountains, elevation 5,700 feet, 12.55 inches; Lytle Creek, in Lytle Creek Valley, between the mountain ranges named, elevation 2,250 feet, 13.44 inches; Malibu Headquarters, Topanga Canyon, Santa Monica Mountains, elevation 747 feet, 16.03 inches; Mount Wilson, loftiest reporting station in the San Gabriel Mountains, elevation 5,850 feet, 15.58 inches; and Big Bear Lake Dam, loftiest reporting station in the San Bernardino Mountains, elevation 6,800 feet, 10.30 inches. There undoubtedly is marked orographic influence on precipitation at all of these centers of excessive rainfall. Further examination of the isohyetals, however, shows that there were local areas of heavy rainfall in the valley and foothill regions adjacent to the San Gabriel Mountains, the Verdugo Hills, and Griffith Park in Los Angeles. Some of the wet-center, lower-elevation stations are: In the San Gabriel foot-hill area: Flintridge, above Glendale, 14.92 inches; Sunset Reservoir, above Pasadena, 14.95 inches; Azusa, 16.29 inches; Griffith Park Nursery, Los Angeles, 14.72 inches. Riverside, shadowed by the Box Springs Mountains on the east and southeast, received a total of only 1.74 inches, while Long Beach, San Pedro, Palos Verdes estates, on the immediate coast, received only 2.87, 2.20, and 2.25 inches, respectively. Table Mountain, elevation 7,500 feet, north of and in the shadow of the San Gabriel Mountains, recorded only 3.58 inches.

In the valley-foothill regions, both the topographic and underrunning cold air influences are apparent.

A suggestive fact incident to the history of the storm was that the initial precipitation at certain high-level stations located in the upper reaches of the San Antonio Canyon, San Gabriel Mountains, and in the vicinity of Lake Arrowhead, San Bernardino Mountains, was in the form of snow. This was followed, shortly, by heavy rain, when the precipitation was at its greatest intensity, harmonizing with the belief in the tropical or semitropical source of the moisture-bearing winds.

Despite the undoubted rain-producing factor involved in the underrunning cold easterly wind and the overrunning warm southerly currents, a highly significant feature of the storm, demonstrating pronounced and dominant orographic influences, was the fact that the precipitation was heaviest where the rain-bearing winds ascended directly rather steep valley floors and the steeper slopes of the foothills—the Verdugo Hills, the Santa Monica, San Gabriel, and San Bernardino Mountains. This is in harmony with studies on mountain influence in rain-production elsewhere. Cherrapunji, elevation 4,455 feet, on the southern slope of a front range of the Himalaya Mountains, near the head of the Bay of Bengal, presenting its steep incline to the summer monsoon winds, and Mount Waialeale, island of Kauai, Hawaii, elevation 5,075 feet, with its almost vertical slopes, facing the prevailing Trades, show striking examples of mountain influences in the interception and lifting of "head-on" rain-bearing winds with well-known results.

Occasionally we find instances of heavy rain being carried over the summits of mountain ridges from the wet windward side, for a mile or so to leeward, as illustrated by the phenomenal catch of 17.91 inches during the storm under discussion at Opid's Camp, near the head of the West Fork of the San Gabriel River, back of Mount Wilson.

Returning to the study of the excessive rainfall over the Los Angeles area, December 30–January 1, we find additional evidence of pronounced orographic influence by comparing the amount of precipitation over the region named with the catch over the San Diego area, immediately to the southeastward. The hill and mountain ranges in the Los Angeles area generally extend east and west, or at right angles to the rain-bearing winds of this storm, resulting in maximum efficiency in rain production from these southerly winds. On the other hand the mountains back of San Diego trend generally north-south and therefore are least efficient as rain makers when the moisture-bearing winds are from the south, as in this case. The fact that the Los Angeles area was subjected to excessive rainfall while the San Diego sector received only nominal amounts is highly suggestive of the prominence of the orographic influence.

The presence of vast beds of gravel and boulders in the stream washes of southern California valley lands is striking evidence of former floods. In fact the whole valley area is a picture of sand, silt, clay, gravel, and larger rock fragments, all telling the erosive story of the past. Surveys by the writer of the terrain flooded by the December storm show vast deposits in places in La Crescenta, Montrose, and, to a somewhat less extent, in parts of Glendale and elsewhere, with occasional marked erosion by the rushing water over the areas named.

An unfortunate preliminary to the flood was the brush and forest fire, originating on November 23, 1933, which burned over 4,850 acres extending from Haines to Halls Canyon and mountainward to the Mount Lukens (Sister Elsie Peak) Divide. This fire-devastated area lies immediately back of and above a large part of the later-flooded area in the La Crescenta-Montrose sector. That area of Glendale which was subjected to flood lies below a portion of the Verdugo Hills which was burned over as recently as December 1927.

It is estimated that the erosive scourings in the steep walls of the burned-over area reached depths as great as 12 feet in some localities as a direct consequence of the rain and resultant flood. It is further estimated that the flood waters, in certain areas, carried as high as 75 percent solid matter in the form of mud, sand, gravel, boulders, etc. It would seem, however, that there must have been wide exceptions to the rule regarding the heavy charge of solid matter, in view of the fact that splashes of muddy water have been observed as much as 15 feet above a flood crest surface, thus indicating a flow velocity of about 30 feet per second. Such a velocity is not in harmony with a stream carrying as much as 75 percent solid matter. Moreover, it is said that the flood water, in a certain instance, showed marks as much as 15 feet higher on the outer portions than on the inner or shorter sectors of the curved stream course, thus indicating extremely high velocities. At no place was the tremendous force of the flood better demonstrated than near the head of New York Avenue in La Crescenta, where a boulder estimated to weigh at least 40 tons was brought down the side of the mountain in the background and deposited on the street. At another point, a rock some 87 inches in length was deposited in the forks of a sycamore tree about 4 feet above the ground. Myriad boulders of enormous size were projected by the flood waters, in some instances, no doubt, miles from their previous locations, adding materially to the death and destruction from the storm, while in transit.

The following quotation on the run-off and erosion incident to this storm is taken from a recent report made by the United States Forest Service:

> From records gathered under the direction of C. J. Kraebel, senior silviculturalist of the California Forest Experiment Station, on experimental plots located in the San Dimas Canyon, during the storm of December 30–January 1, last, it was found that the run-off on burned watersheds was approximately 41 times that on unburned areas, and that the rate of erosion on denuded areas was 1,245 pounds per acre, compared to 68 pounds per acre where the watershed was protected by chaparral.
>
> These comparisons, based on accurate records, according to Forest Service officials, exceed previous estimates and tend to emphasize the value of plant growth on watersheds and explain the reason for the loss of life and property damage following the Pickens Canyon fire of last November.
>
> Other data compiled by C. J. Kraebel estimates the run-off from the partly burned Verdugo watershed as 50 times as great as in the Arroyo Seco and San Dimas Canyons, where the chaparral is intact.

In this connection, however, it is well to call attention to the fact that the west end of the Verdugo Hills, which was burned over by the fire of December 1927, failed to show phenomenal run-off, while the east end of the same range, with a good chaparral cover and unaffected by material fires during the last 25 years, had a very high run-off.

Greatest 10-minute intensities over and above the devastated La Crescenta-Montrose-Glendale areas appear to have been shortly before or after midnight of December 31–January 1; 30-minute intensities, same hours, but with some variations from late afternoon of December 31 to shortly after midnight of January 1; 1-hour intensities, somewhat wider variations from midafternoon of December 31 to after midnight, with a distinct tendency toward a secondary high hourly intensity between midnight and 2 a.m. of January 1, where greatest hourly intensities had occurred before midnight; 2-hour intensities, similar to the hourly intensities, with a tendency toward a slightly wider spread in time; 12-hour greatest intensities generally ended from somewhat before midnight of the 31st–1st, to near 2 a.m. January 1, 1934.

FLOOD PEAKS

Haines Canyon (1 mile above mouth): Flood increased rapidly at 11:30 p.m., December 31; a wall of water 8 to 10 feet high arrived at 11:50 p.m., accompanied by a loud roar, demolishing the observer's house; water fell back to the 11:30 p.m. stage by midnight.

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Blanchard Canyon mouth: Peak arrived at 11:55 p.m. of December 31, with 10-foot wall of water, lasting 4 to 5 minutes; observer was able to walk across the stream at 12:05 a.m. January 1. Somewhat farther downstream, the wall of water at 12:05 a.m. January 1, time of highest freshet was about 6 feet, lasting about 2 minutes. There were several freshets during the afternoon and evening of December 31; flood flow struck inhabited area of the Canyon about 11:40 p.m.

Cooke Canyon: Mud flow crest passed the mouth near Hillcrest Sanitarium at 11:50 p.m. December 31, and hit the C.C.C. Camp at Cooke Canyon and Verdugo Wash (about 1 mile down from mouth) at 12:10 a.m. January 1.

Wards Canyon: Flood flow arrive at 11:55 p.m. December 31, lasting 5 minutes; velocity said to be greater than a horse can run.

Shields, Eagle, and Goss Canyons: Crests arrived at mouths about 11:50 p.m. December 31; about 10 feet high in Shields Canyon, with flow lasting from 4 to 5 minutes, and hit Foothill Boulevard at 12:09 a.m. January 1 with wall of water 10 feet high; passed by 12:15 a.m.

Pickens Canyon: The flood flow, with wall of water about 10 feet high, reached mouth of Canyon at 11:50 p.m. December 31, lasting 5 to 6 minutes, and arrived at Foothill Boulevard at midnight.

Halls Canyon: The flood water passed the mouth of this canyon about the same time as Pickens Canyon—11:50 p.m. December 31, at mouth, and midnight at Foothill Boulevard.

Flood waters from Pickens, Ward, Blanchard, and Halls Canyons passed through Montrose.

The peak of the flood passed down the Verdugo Wash in Rossmoyne Addition, between Montrose and Glendale, between 1 a.m. and 1:30 a.m. January 1. At 6 p.m. December 31 the velocity of debris was 20 feet per second.

New 24-hour high-precipitation records were established at many points over the rain area; Los Angeles, as an example, with a record covering 56 years, was raised from 5.12 inches (on Feb. 23–24, 1913), to 7.36 inches (Dec. 31, 1933–Jan. 1, 1934), at the height of the storm. While the amount of rainfall for the whole storm was phenomenal, time and area considered, its short-period intensity for any particular station does not appear to have been outstanding, especially when compared with the remarkable 1-minute record of 1.02 inches, measured in two Fergusson gages, exposed side by side, at Opid's Camp (elevation 4,254 feet) back of Mount Wilson, near the headwaters of the west fork of the San Gabriel River, at 4:48 a.m. April 5, 1926.

On January 1, 1934, the final day of the storm, the surface winds, which had been dominantly from the east and southeast, veered through the south to southwest, as relatively high pressure was reestablished over the Pacific coastal areas of this latitude, bringing the precipitation to a close. The rain was prolonged somewhat north and northeast of the San Gabriel Mountains, over the Antelope Valley, Mojave Desert, even to the Death Valley area, during the afternoon and evening of January 1. The precipitation, over the desert areas on the date named, although heavy at times, was generally of short duration, frequently attended by thunderstorms, as observed by the author.

CONCLUSIONS

1. The Pacific HIGH largely broke down, with a modified fragment somewhat to the east of the Hawaiian

Islands and another over the States of northwestern Mexico.

2. The North Pacific-Alaskan Gulf LOW, in the absence of the shielding Pacific HIGH in central and southern California latitudes, spread far southward, bringing the coastal area under its influence.

3. The pressure distribution was of sufficient duration and proper kind to bring winds to the southern California coast from tropical or subtropical sources, considerably above the normal winter warmth of this latitude and high in moisture content.

4. While the underrunning easterly wind (at and near the surface of the valley lands) was comparatively cold and shallow, the resulting uplift of the overrunning Pacific "Tropical warm front" advancing from the south was sufficient to cause chill and to precipitate moisture.

5. *The mountains were a dominant and deciding factor in the heavy to excessive rainfall production.*—Had there been no intercepting east-west ranges in the path of the warm, moist front, advancing from the south the rainfall would not have been excessive. Impressive confirmation of this conclusion is the fact that winds paralleling the north-south mountains back of San Diego brought only moderate precipitation while heavy to excessive rainfall occurred adjacent to and over the east-west foothills and mountains of the Los Angeles area.

The property losses caused by this flood approximated $5,000,000, while there were 45 known deaths and a large number of injured people. Destruction of homes and automobiles and injury to the land and highways accounted for the major property losses.

METEOROLOGICAL CONDITIONS ATTENDING THE HEAVY RAINFALL IN THE LOS ANGELES, CALIF., AREA, DECEMBER 30, 1933, TO JANUARY 1, 1934, INCLUSIVE

By GEORGE M. FRENCH

[Weather Bureau Airport Station, Burbank, Calif., Apr. 18, 1934]

A pressure situation developed during the closing days of December 1933, in which a depression of considerable intensity was located on the 5 p.m. P.S.T. synoptic map, December 28, with the center located at about 48° N. latitude and 133° W. longitude.

The evening synoptic chart of December 28 shows an energetic and rather wide-spread flow northward of tropical Pacific air (hereinafter designated by initials TP), aided by the anticyclone near Lower California. While observations of upper-air winds are not available off the coast, this northward flow is inferred to be aloft in that region as well as on the surface. Upper-air winds show this flow over most of the western portion of the United States.

Temperatures were generally lower on the land surfaces from San Francisco Bay area northward than off the coast and in general surface winds over the land had a more easterly component than those at sea. This, together with the general steady rain along the coast from the San Francisco Bay district northward, indicated the presence of a warm front. In studying the data available it appears that the warm front was located along a line eastsoutheast from the center of the depression to some point near the Washington coast thence curving southeastward just off the coast to some point somewhat beyond the San Francisco Bay district.

Only a limited number of ship reports are received at this station (Los Angeles) in the preparation of our daily charts. For the purpose of this study additional ship reports were furnished by the San Francisco Weather Bureau office. Some temperature records were also furnished from the San Francisco office for Avalon, Catalina Island, and the San Diego office furnished some temperature, rainfall, and wind-direction records obtained from the Navy for San Nicholas Island. With this additional information a wind shift or cold front was located extending south-southeastward from the center of the depression to about latitude 30° N.

It is believed that little proof is needed in order to accept the statement that TP air lay to the eastward of this shift line. It is further believed that Transitional Polar Pacific air (hereinafter designated NPP) was in rear of this shift. The proof of the existence of NPP air in rear of the wind shift is not nearly so obvious, but despite meager information we have some indications that may be used as factors of proof.

First, it must be understood that any type of air, whether it is TP, PP (Polar Pacific), or PC (Polar Continental) cannot have a long history over the water without the air close to the surface taking on a temperature near that of the water. Therefore, PP air moving into southern latitudes over the water is likely to have a temperature near the surface close to that of TP air moving northward into the same latitude. In the case of the cold front referred to above, the temperature was actually higher in some cases on the west side than it was on the east side of the wind shift. This is believed to be due to the fact that the water is warmer some distance out from the coast than it is in the regions nearer the coast.

It is now evident that the lack of temperature discontinuity on the surface over the water is not proof of the nonexistence of a front and we will therefore have to look for other properties that may help identify the air mass. As indicated before a flow of TP air northward will result in the lower portion of the air being cooled and thus rendered more stable, but in the case of the PP air moving southward the reverse is true, namely, the air near the surface is being warmed and instability is increased. Therefore steep lapse rates should be encountered in the case of NPP air, giving rise to rain of the shower type while small lapse rates should be encountered in the TP air without rain unless other mechanical means are employed in raising the air mass to higher levels.

Again referring to the wind shift on the evening map of the 28th, the ship *Mojave* appeared to be located approximately on the shift line and the report showed showers. There were no other ships on or very near this shift, as I have it located, and therefore we have only the one report. Even the one report could be considered a rather strong factor, I believe, in identifying the air mass to be NPP as northward flowing TP air practically precludes showery weather. Further indications will be given later as we trace this front into the Los Angeles area.

The morning map of December 29 showed that the wind shift had moved much closer to the coast, having probably reached the coast and occluded north of San Francisco, indicated by the fact that steady rain had stopped at Eureka and the occurrence of a thunderstorm during the following 4 hours at Redding, showing the presence of more unstable air. The warm front showed signs of extending farther down the coast as the ceilings were