THE WEATHER AND CIRCULATION OF JUNE 1952[1]

A Month With A Record Heat Wave

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THE HEAT WAVE

One of the most extensive and prolonged heat waves of recent years dominated the weather of June 1952 in the eastern two-thirds of the United States. This was the hottest June on record in over a dozen cities located in a broad belt stretching from the foothills of the Colorado Rockies to the Carolina coast. The greatest monthly mean temperature anomaly (+10° F) was reported in Kansas City, Mo. (Chart I–B). The monthly mean temperature of 85° F. recorded in Nashville, Tenn. (Chart I–A) not only exceeded the previous June record by 3° but also was higher (by almost 2°) than the temperature for any other month in history. In that city the daily maximum was over 100° F. on each of the last eight days of June and over 90° F. on the last 28 days. The heat wave was particularly severe in the last week of the month, when temperatures of 100° F. or higher were general as far north as Boston and Detroit, and many all-time record high temperatures were equalled or exceeded. On June 27 the nation's capital had its hottest night in 80 years of record when the temperature dropped no lower than 82° F. from a maximum of 101° F. the preceding afternoon.

The magnitude and extent of this month's hot weather is well illustrated in figure 1-A, where the surface temperature anomaly is analyzed in terms of five classes. Except for the northern border and west Gulf Coast, the entire country from the Continental Divide to the Atlantic Coast had temperatures averaging much above normal, a class which normally occurs only ⅛ of the time. Contrast this with the situation existing in June of 1951 (fig. 1-B), when much-below-normal temperatures were observed in a large portion of the central United States and near normal in much of the East.

The striking temperature difference between the past two Junes extended to all levels of the observed atmosphere. This is illustrated by mean soundings for the two months at Omaha, Nebr., figure 2. Temperatures during June 1952 averaged warmer than those during June 1951 at all levels of the troposphere, but the reverse temperature distribution existed in the stratosphere. The normal June sounding for Omaha [1] has not been reproduced because it lies approximately half way between the two ascent curves given in figure 2. It is noteworthy that the temperature difference between June 1952 and June 1951 was greatest at the surface, fairly constant in the upper troposphere (600 to 200 mb.), at a minimum near the tropopause, (200 to 150 mb.), and then large, but of opposite sign, in the stratosphere (from 150 mb. upward).

The contrast between the temperatures of the past two Junes was reflected in the monthly mean circulations at the 700-mb. level. During June 1951 (fig. 3) 700-mb.

[1] See Charts I–XV following page 109 for analyzed climatological data for the month.

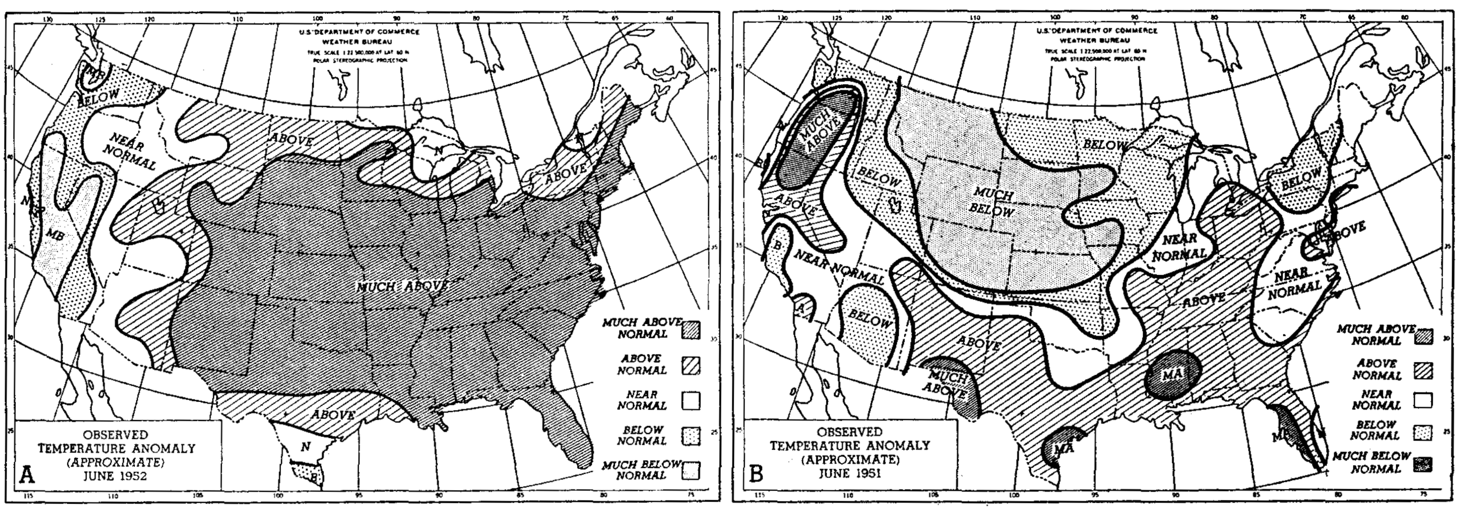

FIGURE 1.—Monthly mean surface temperature anomalies for June 1952 (A) and June 1951 (B). The classes above, below, and near normal occur on the average one-fourth of the time, while much above and much below each normally occur one-eighth of the time. Areas of above and much above are hatched; below and much below are stippled.

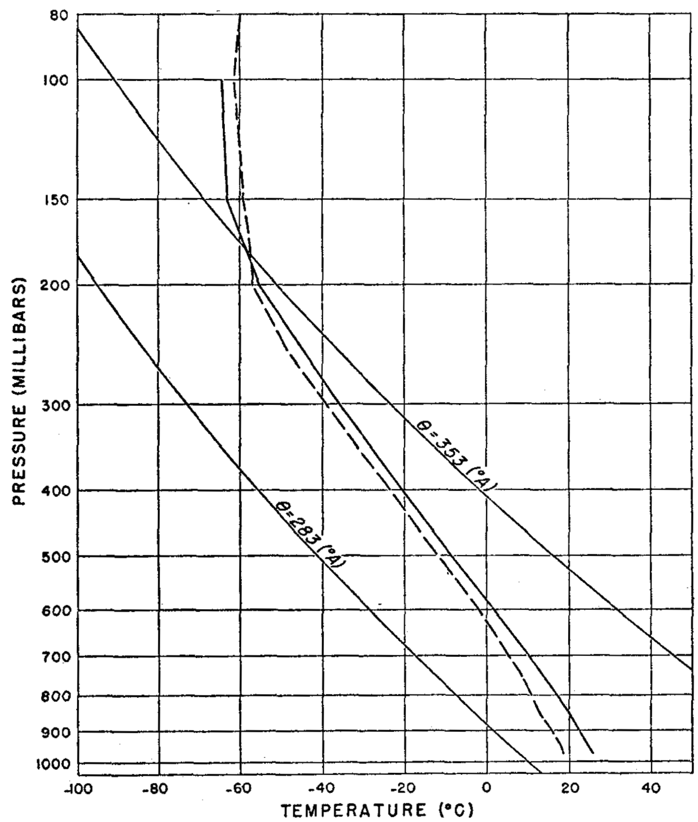

FIGURE 2.—Monthly mean soundings at Omaha, Nebr. for June 1952 (solid line) and June 1951 (dashed line). Two potential temperature lines (θ=283 and θ=353) are given for reference.

heights were below normal in much of the United States, and the central part of the country was dominated by cyclonically-curved flow around a deep mean trough stretching from North Dakota to southern California. Repeated surges of cold polar continental air were carried into this trough by abnormally strong northwesterly flow emanating in a pronounced ridge in the eastern Pacific and Alaska. Further details concerning the weather and circulation of June 1951 can be found in an earlier article of this series [2].

Examine now the mean 700-mb. circulation for June 1952, figure 4. Almost the entire United States east of the Rocky Mountains was under the influence of anticyclonic curvature, anticyclonic shear, and above-normal heights north of a well-developed High centered on the east Gulf Coast. These conditions were favorable for abundance of clear skies (Chart VI), sunshine (Chart VII), and heating by solar radiation (Chart VIII). Furthermore, stronger-than-normal flow between the High on the Gulf Coast and a deep mean trough located along the west coast of the United States transported an unusually large amount of air from the hot desert regions of the Southwest into the central United States. From there the warm air spread eastward to the Atlantic Coast in a stream of abnormally strong westerlies along the northern border of the country, downstream from a pronounced zone of confluence. These westerlies were effective in preventing any appreciable penetration into the United States of cool polar air from Canada and the Arctic. Although cool polar Pacific air masses did enter the country at frequent intervals, they were confined mostly to the Far West, and were rapidly warmed after crossing the mountains.

The question naturally arises: Was the circulation pattern of June 1952 typical of heat wave situations in summer in the central United States? In order to shed some light on this problem a composite map was prepared by averaging the 700-mb. height anomaly observed during the 10 hottest 5-day mean periods (non-consecutive) at Kansas City during the summer months (June, July, and

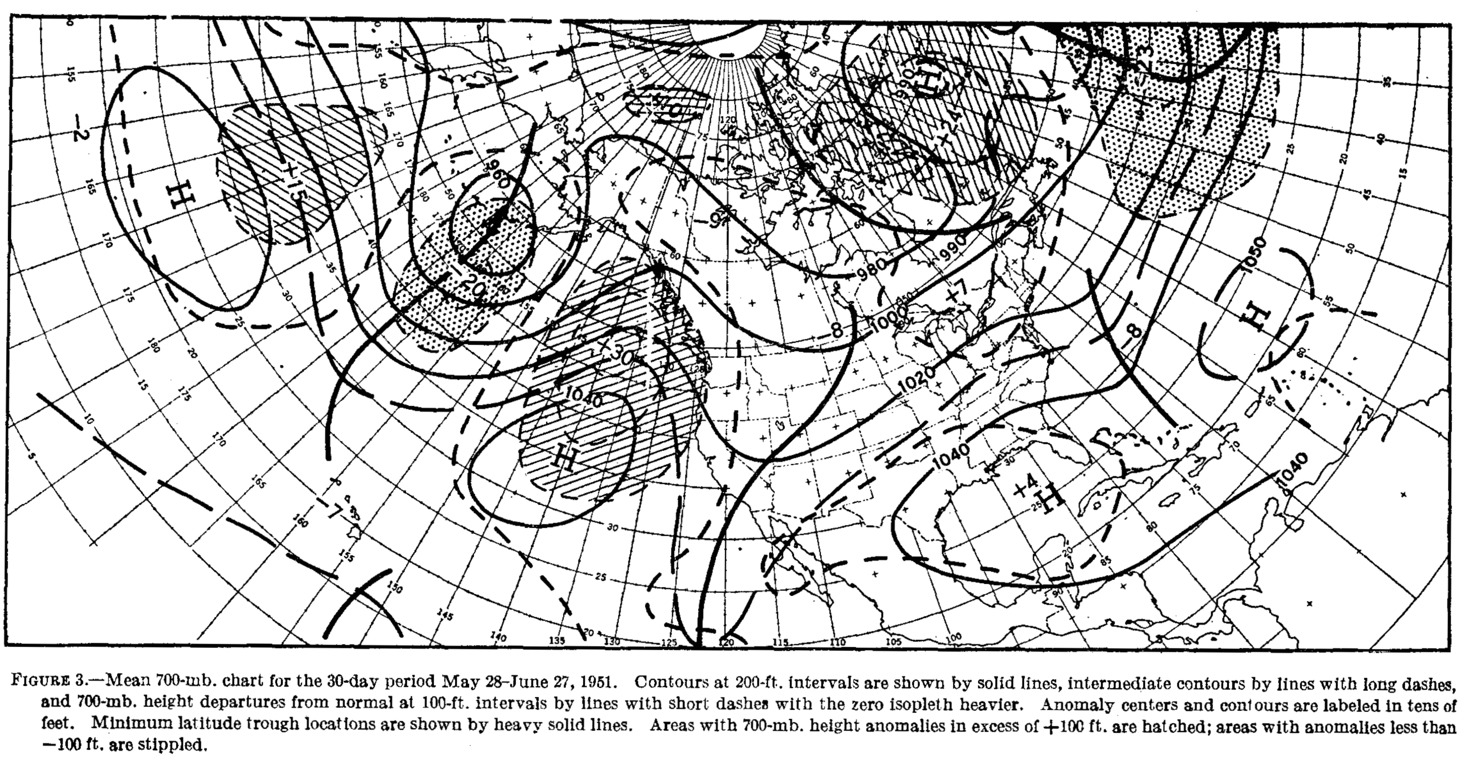

FIGURE 3.—Mean 700-mb. chart for the 30-day period May 28–June 27, 1951. Contours at 200-ft. intervals are shown by solid lines, intermediate contours by lines with long dashes, and 700-mb. height departures from normal at 100-ft. intervals by lines with short dashes with the zero isopleth heavier. Anomaly centers and contours are labeled in tens of feet. Minimum latitude trough locations are shown by heavy solid lines. Areas with 700-mb. height anomalies in excess of +100 ft. are hatched; areas with anomalies less than −100 ft. are stippled.

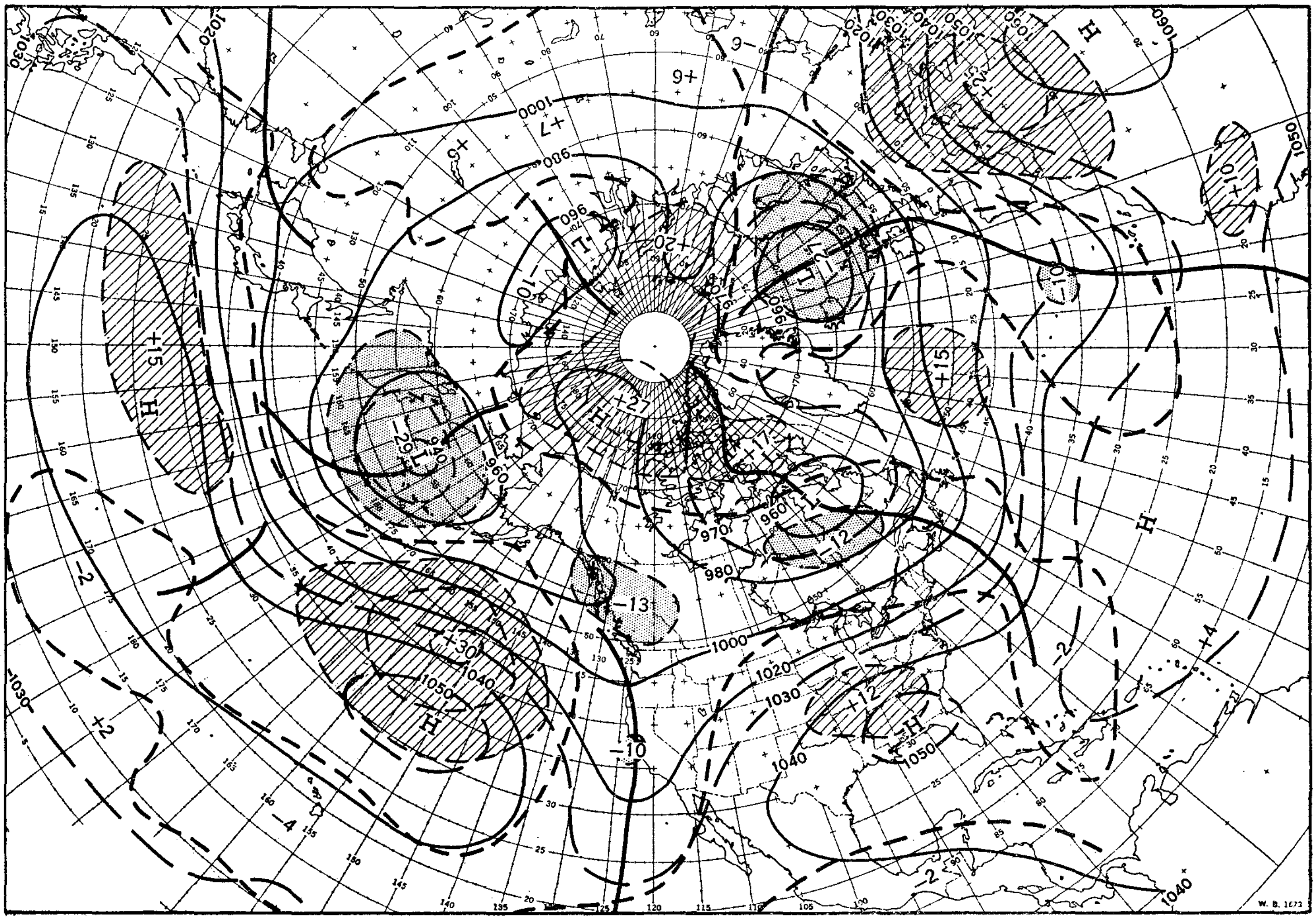

FIGURE 4.—Mean 700-mb. chart for the 30-day period June 1–29, 1952. Contours at 200-ft. intervals are shown by solid lines, intermediate contours by lines with long dashes, and 700-mb. height departures from normal at 100-ft. intervals by lines with short dashes with the zero isopleth heavier. Anomaly centers and contours are labeled in tens of feet. Minimum latitude trough locations are shown by heavy solid lines. Areas with 700-mb. height anomalies in excess of +100 ft. are hatched; areas with anomalies less than −100 ft. are stippled.

August) from 1947 through 1951.[2] These anomalies were then converted to actual 700-mb. heights by adding them to the normal 700-mb. height for June. The resulting composite map, figure 5, can now be compared directly with the chart for June 1952, figure 4. Common characteristics of both maps are a stronger-than-normal ridge in the Mississippi Valley, a deeper-than-normal trough along the West Coast, a relatively weak trough off the East Coast, a zone of confluence in southern Canada, and below-normal 700-mb. heights in most of Canada. These conditions are ideal for generating and maintaining strong currents of warm air from the southwest United States and preventing any appreciable influx of cooler air from Canada or the oceans. Similar features appear on composite maps published by Martin [3] for extremely warm summer cases in Boston, Mass., Evansville, Ind., and Denver, Colo. *Thus it appears that the circulation pattern of June 1952 was typical of that observed during summer heat waves in most of the central and eastern United States.* The resemblance between figures 4 and 5 also extends to most of the Pacific and Atlantic and even to central Europe. It is believed that this is indicative of large-scale interaction between component parts of the general circulation and is not merely fortuitous.

Figure 5 is based on only ten cases. In order to demonstrate that the interrelation between temperature and circulation described above is generally applicable, figure 6 has been prepared by using data for all summer 5-day mean periods during the 4 years from 1946 through 1949. For these 105 periods simple linear correlation coefficients were computed between the surface temperature anomaly at Kansas City (°F.) and the concurrent 700-mb. height anomaly (ft.) at standard intersections of latitude and longitude. The geographical distribution of the resulting correlation coefficients is given in figure 6. A similar correlation field, for winter temperatures at Eureka, Calif., has been published in an earlier article of this series [4]. Figure 6 shows that above-normal temperatures in Kansas City in summer are generally accompanied by above-normal 700-mb. heights in the eastern two-thirds of the United States and the eastern Pacific, where the cor-

[2] It would be preferable to use data for the month of June only and for 30-day rather than 5-day mean periods. However, the existing file of 700-mb. maps is inadequate for selecting enough cases with good hemispheric analyses on this basis. Furthermore, the interrelation between weather and circulation is generally similar for 5-day and 30-day mean periods.

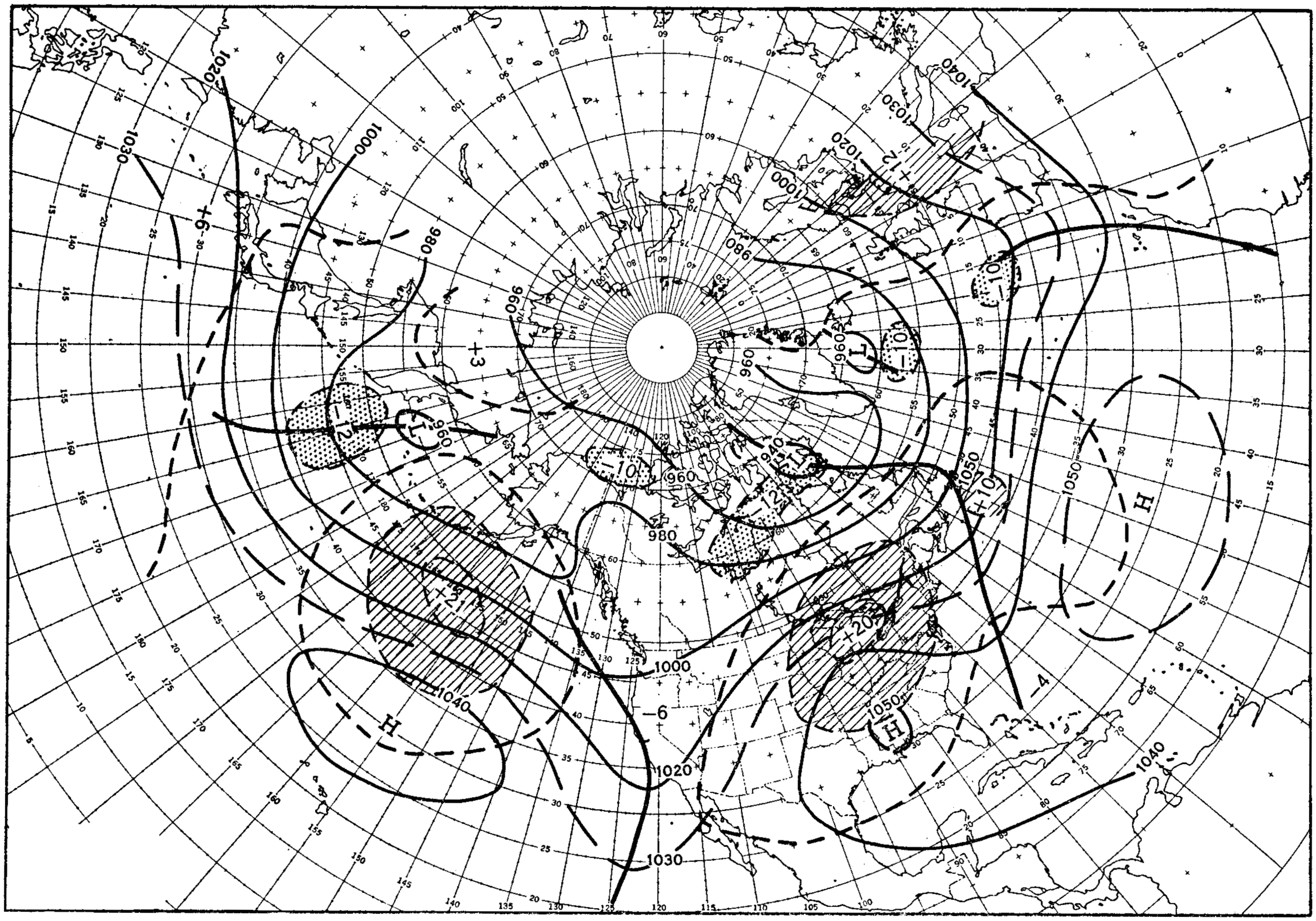

FIGURE 5.—Mean 700-mb. chart for the ten 5-day mean periods with largest positive surface temperature anomaly observed at Kansas City during the past 5 summers (1947-1951.) Contours at 200-ft. intervals are shown by solid lines, intermediate contours by lines with long dashes, and 700-mb. height departures from normal at 100-ft. intervals by lines with short dashes with the zero isopleth heavier. Anomaly centers and contours are labeled in tens of feet. Minimum latitude trough locations are shown by heavy solid lines. Areas with 700-mb. height anomalies in excess of +100 ft. are hatched; areas with anomalies less than −100 ft. are stippled.

relations are positive, but below-normal heights in Canada (except the southeast part) and the West Coast region, where the correlations are negative; and conversely for cool weather. The center of maximum correlation, in the Ohio Valley, and the secondary center, in the eastern Pacific, are located close to centers of positive 700-mb. height anomaly in figures 4 and 5, while the center of negative correlation, in central Canada, is occupied by below-normal 700-mb. heights in figures 4 and 5. *In fact, here is a striking parallelism between the lines of equal correlation in figure 6 and the lines of equal 700-mb. height anomaly in figures 4 and 5.* Thus the fundamental interrelations between temperature and circulation illustrated for extremely warm cases can be extended essentially intact to a much larger number of cases.

OTHER ASPECTS OF THE WEATHER AND CIRCULATION

While residents of the eastern and central United States were sweltering, the Far West experienced an unusually cool month. Monthly mean temperatures of as much as 6° F. below normal were reported in the interior valleys of California (Chart I–B). The minimum temperature of 44° F. in Sacramento on June 12 was the lowest ever recorded so late in the season and within 1° of the lowest temperature on record for June. On the same date several inches of snow fell in northeastern Oregon, and below-freezing minima were reported at several interior stations as far south as Reno, Nev., where the existing low temperature record for June was broken.[3] Cool weather in this region was associated with excessive cloudiness (Chart VI) and below-normal heights in the vicinity of a deep mean trough at 700 mb. (fig. 4). Recurrent outbreaks of cool maritime polar air overspread the Far West, generated by stronger-than-normal northwesterly flow in the eastern Pacific, between the West Coast trough and an intense ridge located along the 150° W. meridian. The fact that this ridge was about 15° farther west than its counterpart during June 1951 is believed to be a major factor responsible for the difference in weather and circulation of the two months. Last year, the Pacific ridge was sufficiently far east to interrupt the flow of polar maritime air into the Far West, but the flow

[3] For further details see adjoining article by Hughes and Ross.

of polar continental air into the central United States was enhanced. As a result above- and much-above-normal temperatures prevailed in the West Coast States with below- and much-below-normal temperatures in north central sections (fig. 1–B); just the reverse of this June's temperature distribution for these areas (fig. 1–A).

The anomalies of temperature generally paralleled those of precipitation (Chart III and fig. 7). It is well known that there is a negative correlation between these two elements in summer. Thus in the region of abnormal warmth, east of the Continental Divide, rainfall was mostly subnormal during June 1952. In parts of Arkansas, Oklahoma, and Texas no measurable amounts at all were recorded (Chart II). Conversely, in the Far West, where cool conditions prevailed, heavy precipitation was the rule. Statewide amounts averaged more than twice as great as normal in California and Oregon. Likewise, during June 1951 light precipitation accompanied above-normal temperatures in the Far West, but heavy rains fell in the cool central and eastern sectors. During both years the cool wet weather was associated with cyclonic vorticity and below-normal heights at 700 mb., while the warm dry weather was accompanied by anticyclonic curvature with above-normal heights at 700 mb.

Further details of the general circulation in June 1952 are revealed by the field of mean 700-mb. geostrophic wind speed shown in figure 8. The strongest average wind speed in the entire Northern Hemisphere (16 m. p. s.) was found in the central Pacific, in southwesterly flow about half way between trough and ridge positions. Weaker centers of maximum wind speed were located in southwesterly flow just east of mean troughs in southwestern United States, western Atlantic and western Europe. Another strong center of maximum wind speed was located in west-northwesterly flow just south of James Bay, downstream from a confluence zone near Lake Winnipeg. The axes of maximum speed (jets) were clearly marked in the oceans but indistinct over western North America, where three weak branches were in evidence.

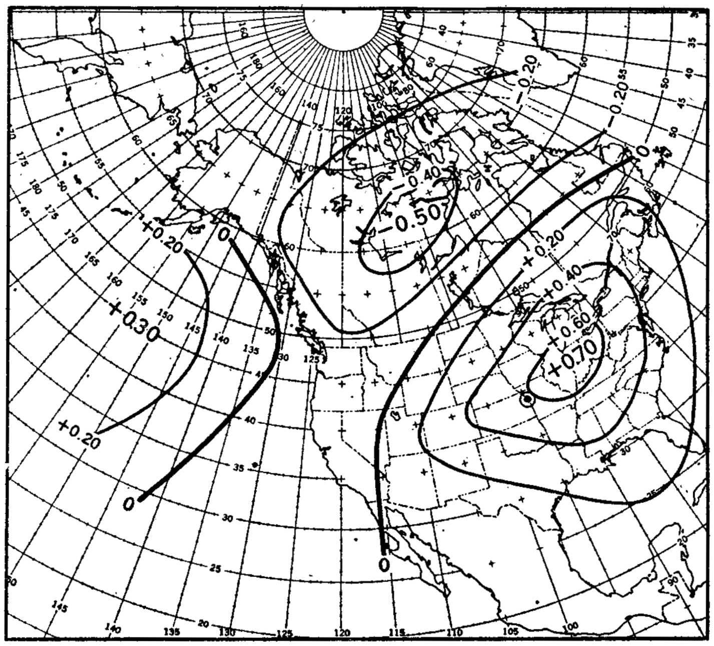

FIGURE 6.—Geographical distribution of simple linear correlation coefficient between 5-day mean surface temperature anomaly in summer at Kansas City (location shown by heavy black circle inside open circle) and simultaneous 5-day mean 700-mb. height anomaly at standard intersections of latitude and longitude. The lines of equal correlation coefficient are drawn at intervals of 0.20 with the zero isopleth heavier. Centers of maximum and minimum correlation are labeled with highest observed value.

Figure 8 is useful in interpreting the tracks of centers of anticyclones and cyclones, Charts IX and X. The geographical distribution of the frequency of these tracks is illustrated in figure 9, where the principal tracks have been drawn through the axes of maximum frequency in a quasi-objective fashion. In most of the Western Hemisphere some relation existed between the location of the 700-mb. jet streams and the principal tracks of both anticyclones and cyclones, as previously noted [5]. The former track was generally found in the region of anticyclonic wind shear to the right of the jet (looking downstream), while the latter was located in cyclonic shear to the north. However, the distance between the tracks and the jets varied considerably in different parts of the world. It should also be noted that the regions of greatest cyclone

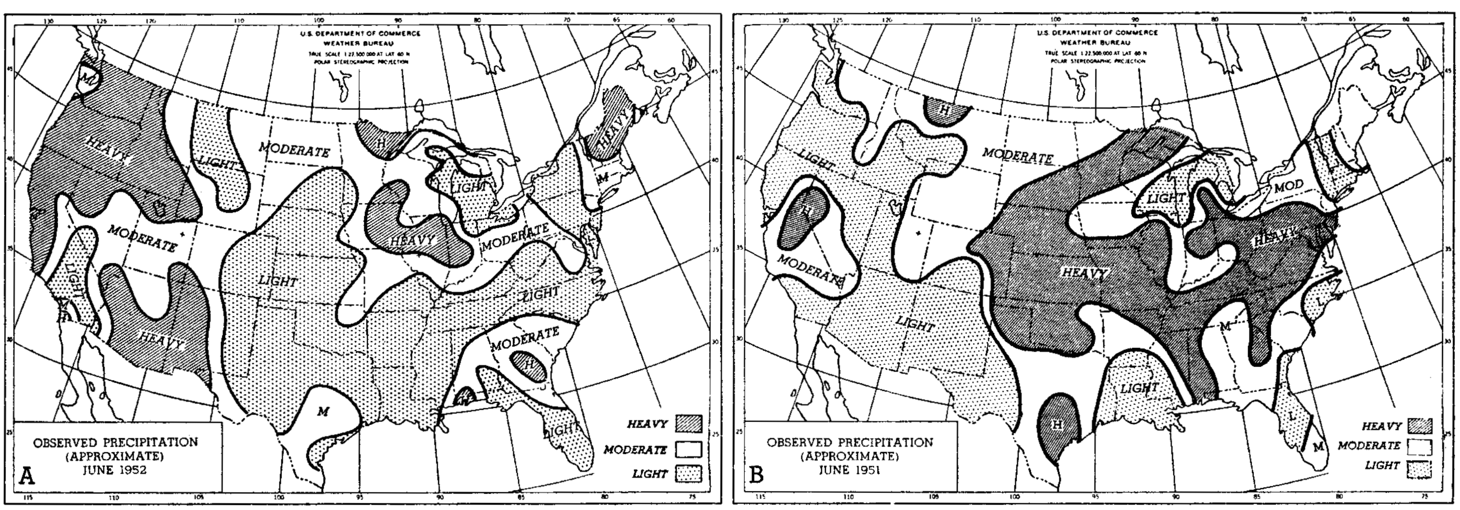

FIGURE 7.—Observed precipitation for June 1952 (A) and June 1951 (B). The classes light, moderate, and heavy occur on the average one-third of the time and therefore have equal probability of occurrence. Areas of heavy precipitation are hatched; areas of light precipitation are stippled.

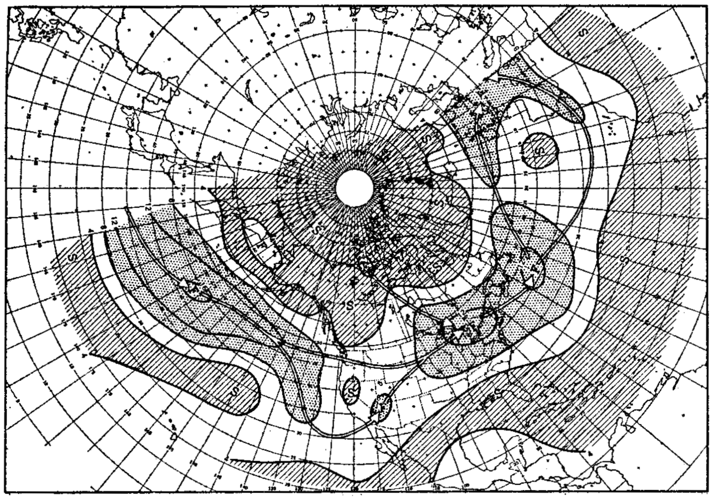

FIGURE 8.—Mean geostopohic (total horizontal) wind speed at 700 mb. for the 30-day period June 1-30, 1952. Solid lines are isotachs at intervals of 4m/sec. The open double-arrowed lines delineate the axes of maximum wind speed (jets). Centers of maximum and minimum wind speed are labeled "F" and "S" respectively. Areas with speeds in excess of 8m/sec. are stippled; areas with speeds less than 4m/sec. are hatched.

frequency, near James Bay and Newfoundland, were located just north of centers of maximum wind speed, while anticyclones were frequent just south of these centers. This illustrates the well known tendency for the westerlies aloft to be strongest just south of deep Lows and just north of Highs at sea level.

The prevailing tracks of anticyclones and cyclones were related to the anomalies of temperature and precipitation. Offshoots of the quasi-permanent eastern Pacific High brought cool air into the Far West at frequent intervals throughout the month. These migratory anticyclones either dissipated in the southern Rocky Mountains or moved rapidly eastward along the northern border of the United States, where they were reinforced by Highs of polar continental origin. Very few of these systems penetrated south of 40°N. in the United States. As a consequence they had little cooling effect upon the eastern two-thirds of the Nation, except for the extreme northern border where temperatures averaged near normal for the month. Unusually well-marked cyclonic activity along the West Coast contributed to cool wet weather in that region, but cyclones were virtually absent in the South and East, where warm dry conditions predominated. The principal cyclone track was clearly delineated north of the jet stream from Lake Winnipeg eastward to Newfoundland. Prefontal and frontal showers to the south of this track, as well as some overrunning at warm fronts, were largely responsible for heavy precipitation occurring in parts of the Upper Mississippi Valley and New England. During the last week of the month damaging tornadoes, hail storms, and flash floods were reported in Minnesota, Wisconsin, Iowa, and South Dakota.

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2. L. H. Clem, "The Weather and Circulation of June 1951," *Monthly Weather Review*, vol. 79, No. 6, June 1951, pp. 125–128.
3. D. E. Martin and H. F. Hawkins, Jr., "The Relationship of Temperature and Precipitation over the United States to the Circulation Aloft," *Weatherwise*, vol. 3, No. 3, June 1950, pp. 65–67.
4. D. E. Martin, "The Weather and Circulation of March 1952," *Monthly Weather Review*, vol. 80, No. 3, March 1952, pp. 47–49.
5. E. J. Aubert, "The Weather and Circulation of December 1950," *Monthly Weather Review*, vol. 78, No. 12, December 1950, pp. 217–219.

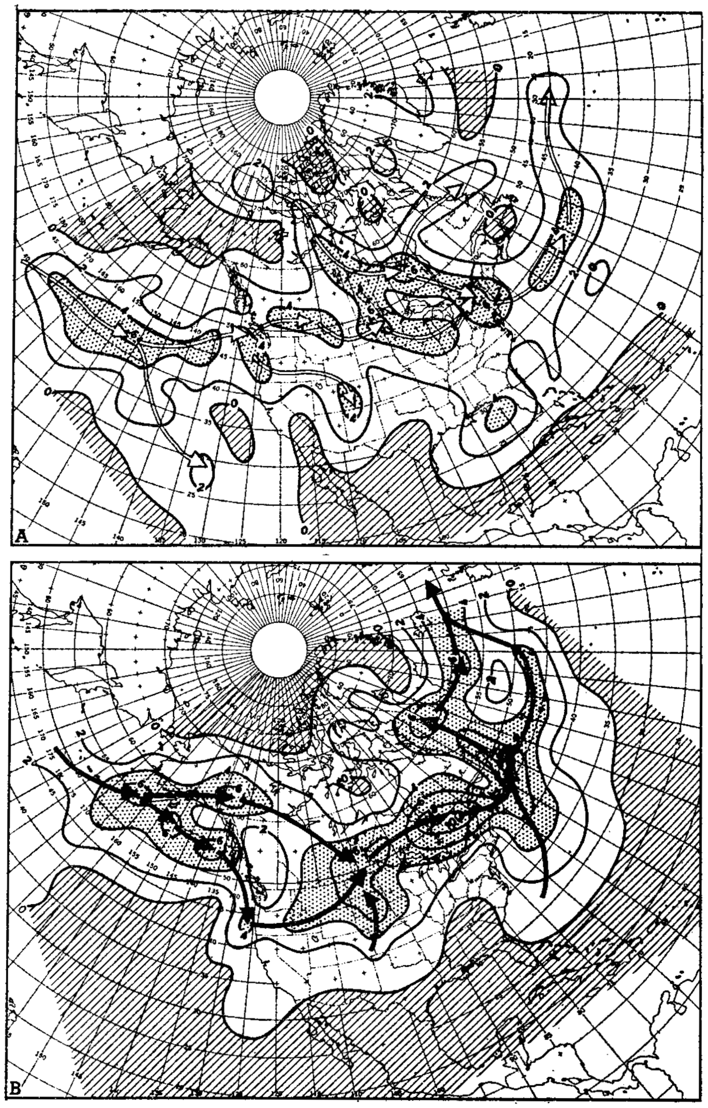
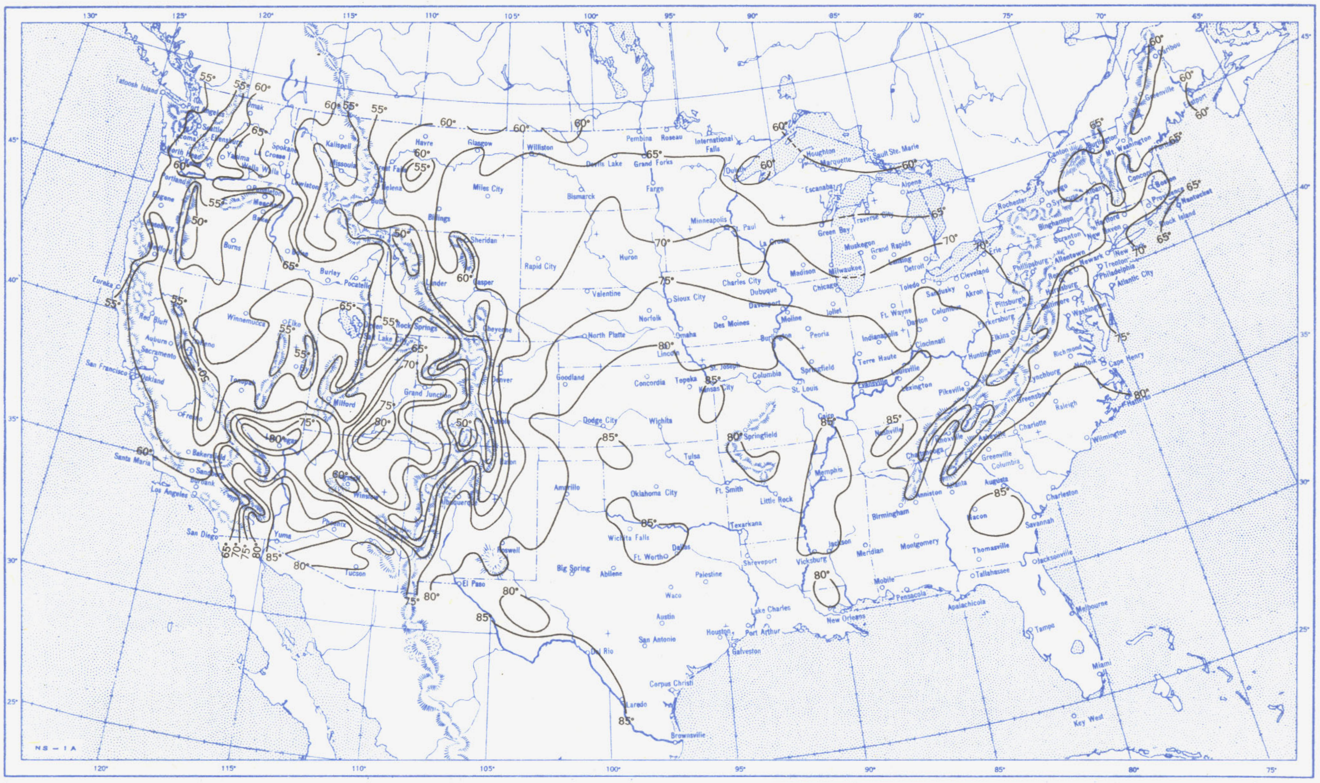
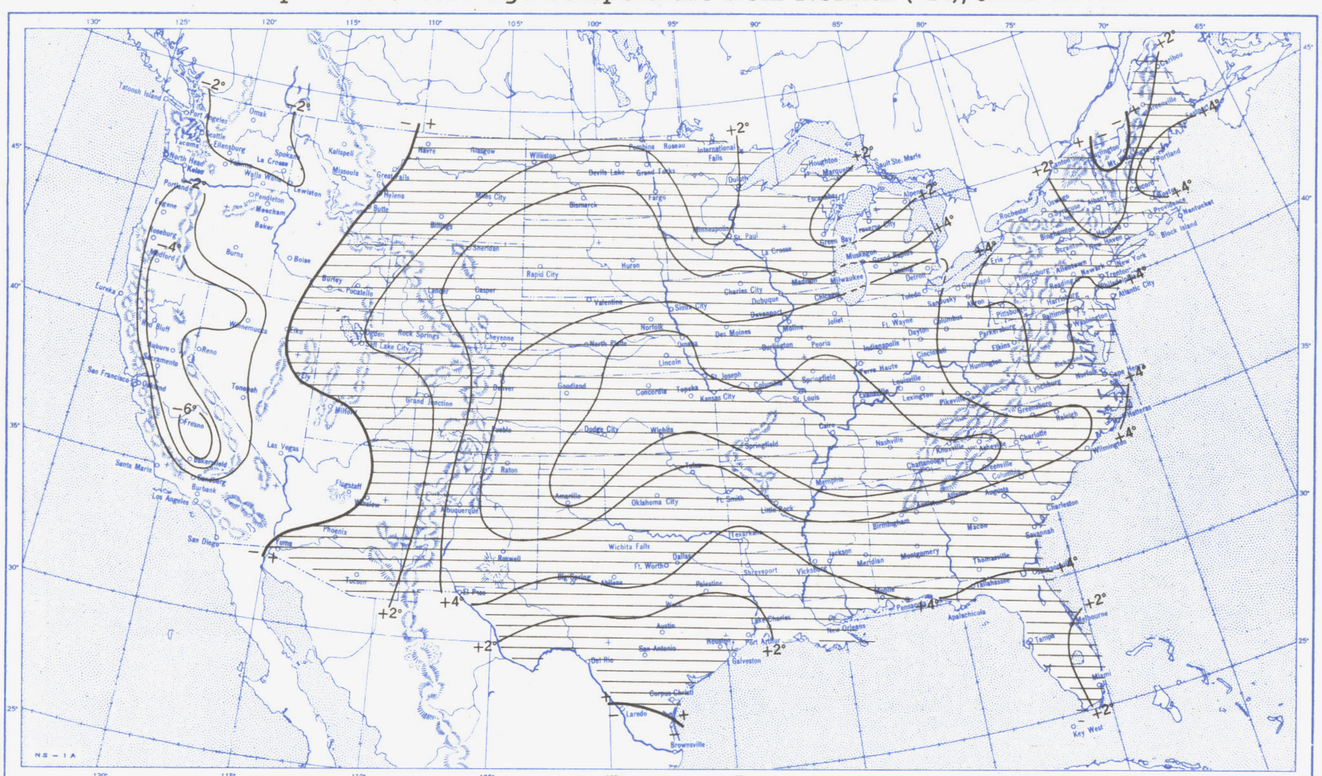


FIGURE 9.—Geographical frequency of tracks of sea level anticyclones (A) and cyclones (B) observed on daily maps during June 1952 within approximately equal-area boxes of size 5 mid-latitude degrees of longitude by 5° of latitude. The isopleths are drawn at intervals of 2. Principal anticyclone and cyclone tracks are indicated by open and solid arrows, respectively, and are broken in areas of maximum frequency. Areas of zero frequency are hatched; areas with more than 4 anticyclone or cyclone passages are stippled. All data obtained from Charts IX and X.

Chart I. A. Average Temperature (°F.) at Surface, June 1952.



B. Departure of Average Temperature from Normal (°F.), June 1952.

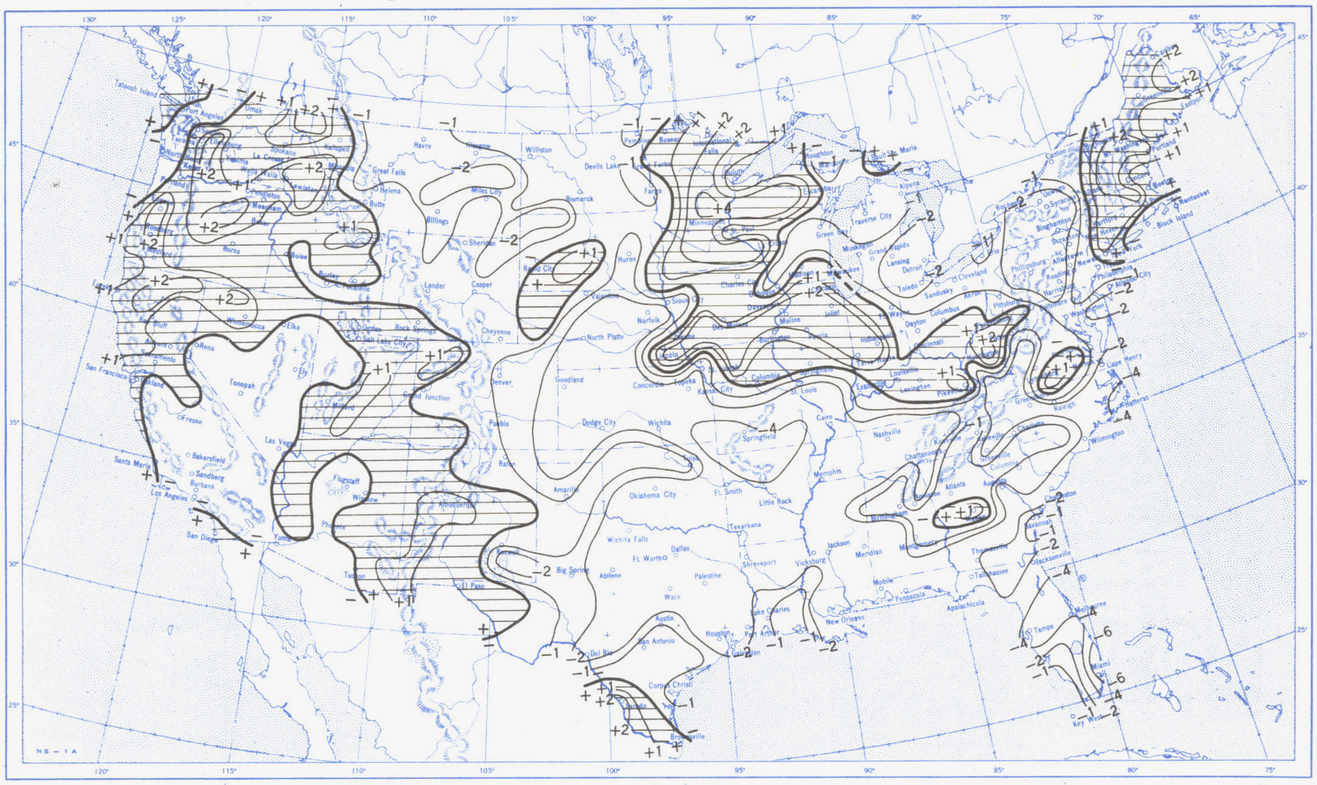


A. Based on reports from 800 Weather Bureau and cooperative stations. The monthly average is half the sum of the monthly average maximum and monthly average minimum, which are the average of the daily maxima and daily minima, respectively.
B. Normal average monthly temperatures are computed for Weather Bureau stations having at least 10 years of record.

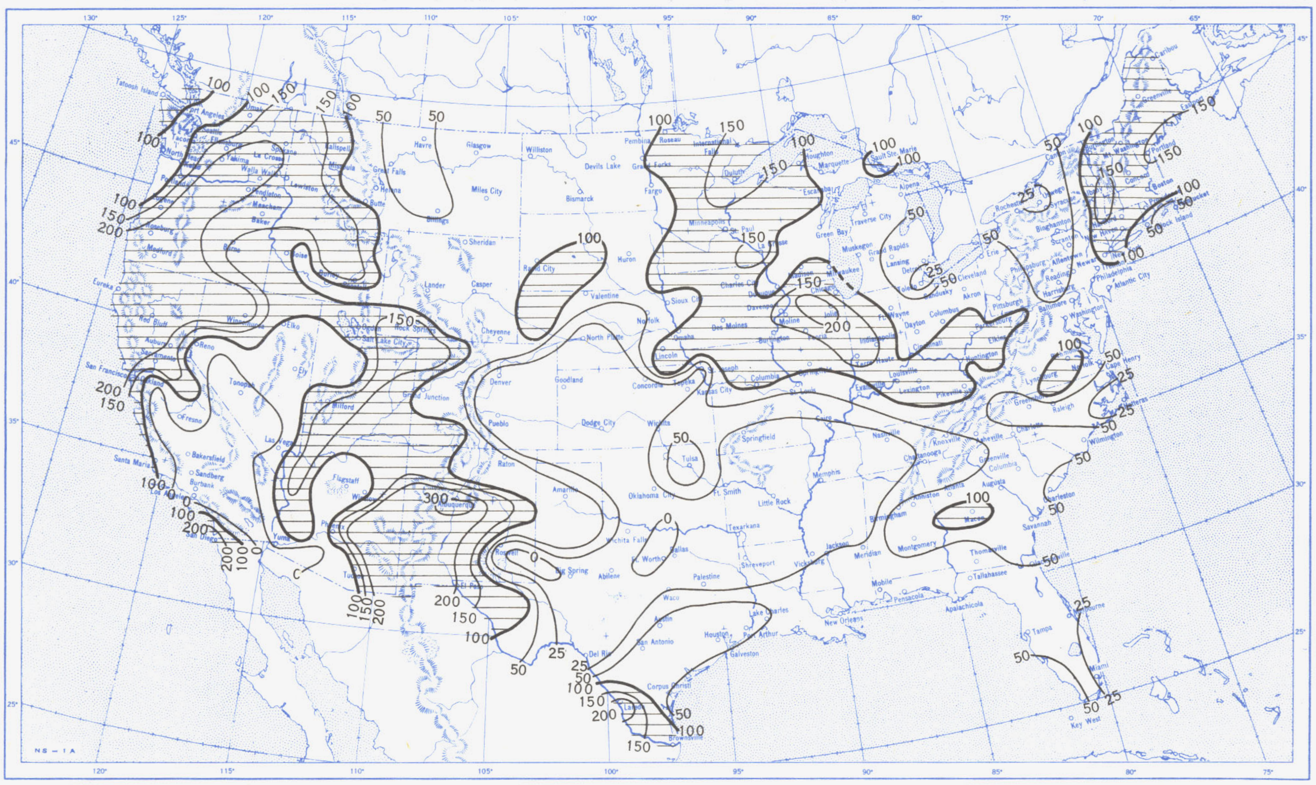
Chart II. Total Precipitation (Inches), June 1952.

Based on daily precipitation records at 800 Weather Bureau and cooperative stations.

Chart III. A. Departure of Precipitation from Normal (Inches), June 1952.

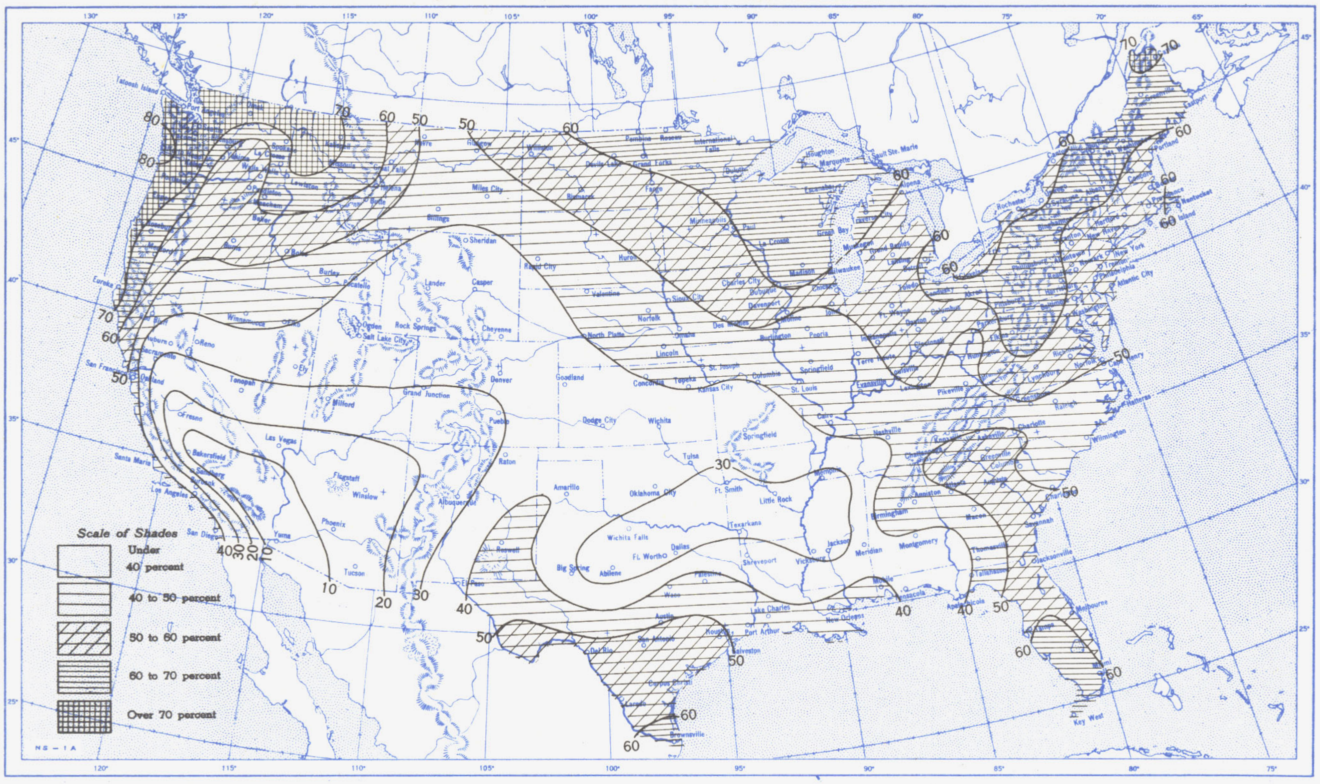


B. Percentage of Normal Precipitation, June 1952.

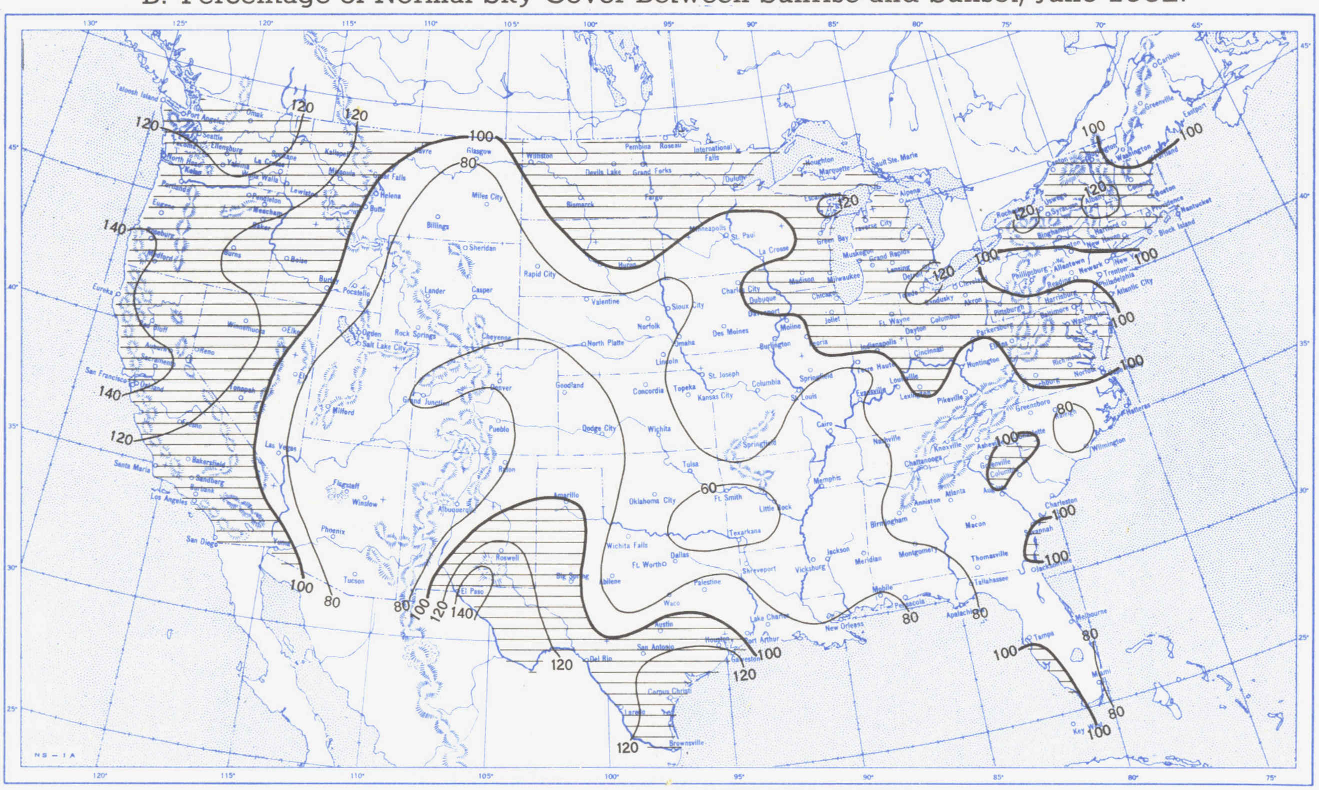


Normal monthly precipitation amounts are computed for stations having at least 10 years of record.

Chart VI. A. Percentage of Sky Cover Between Sunrise and Sunset, June 1952.

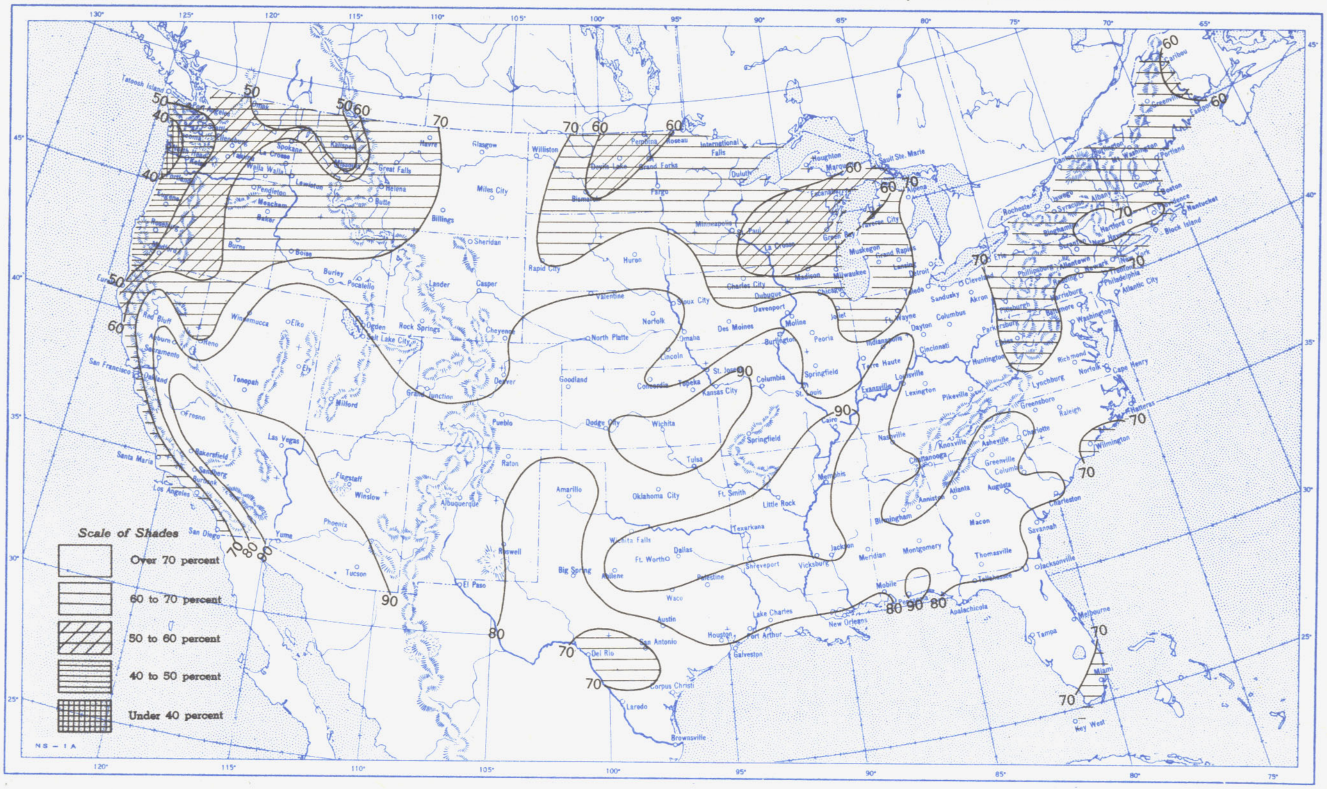


B. Percentage of Normal Sky Cover Between Sunrise and Sunset, June 1952.

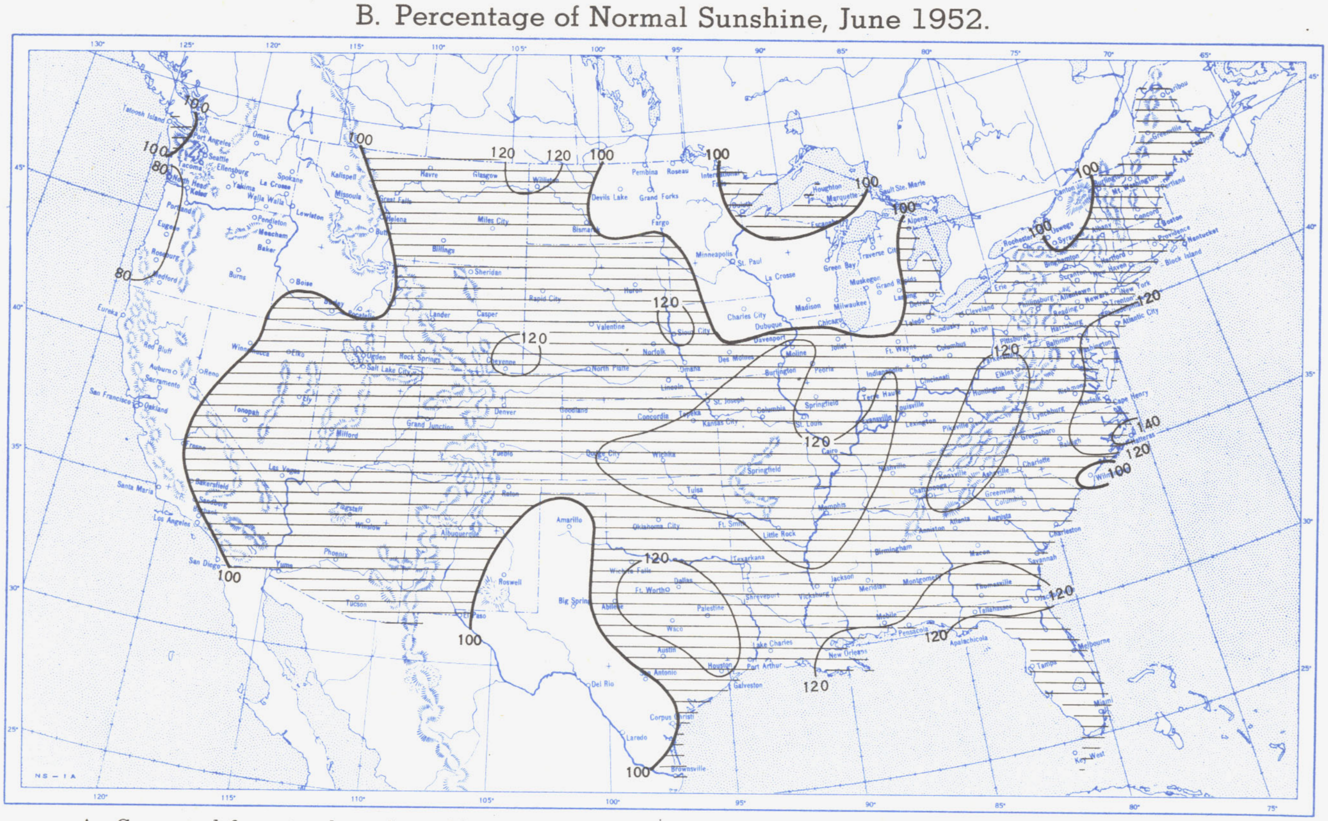


A. In addition to cloudiness, sky cover includes obscuration of the sky by fog, smoke, snow, etc. Chart based on visual observations made hourly at Weather Bureau stations and averaged over the month. B. Computations of normal amount of sky cover are made for stations having at least 10 years of record.

Chart VII. A. Percentage of Possible Sunshine, June 1952.



B. Percentage of Normal Sunshine, June 1952.



A. Computed from total number of hours of observed sunshine in relation to total number of possible hours of sunshine during month. B. Normals are computed for stations having at least 10 years of record.

Chart VIII. Average Daily Values of Solar Radiation, Direct + Diffuse, June 1952. Inset: Percentage of Normal Average Daily Solar Radiation, June 1952.

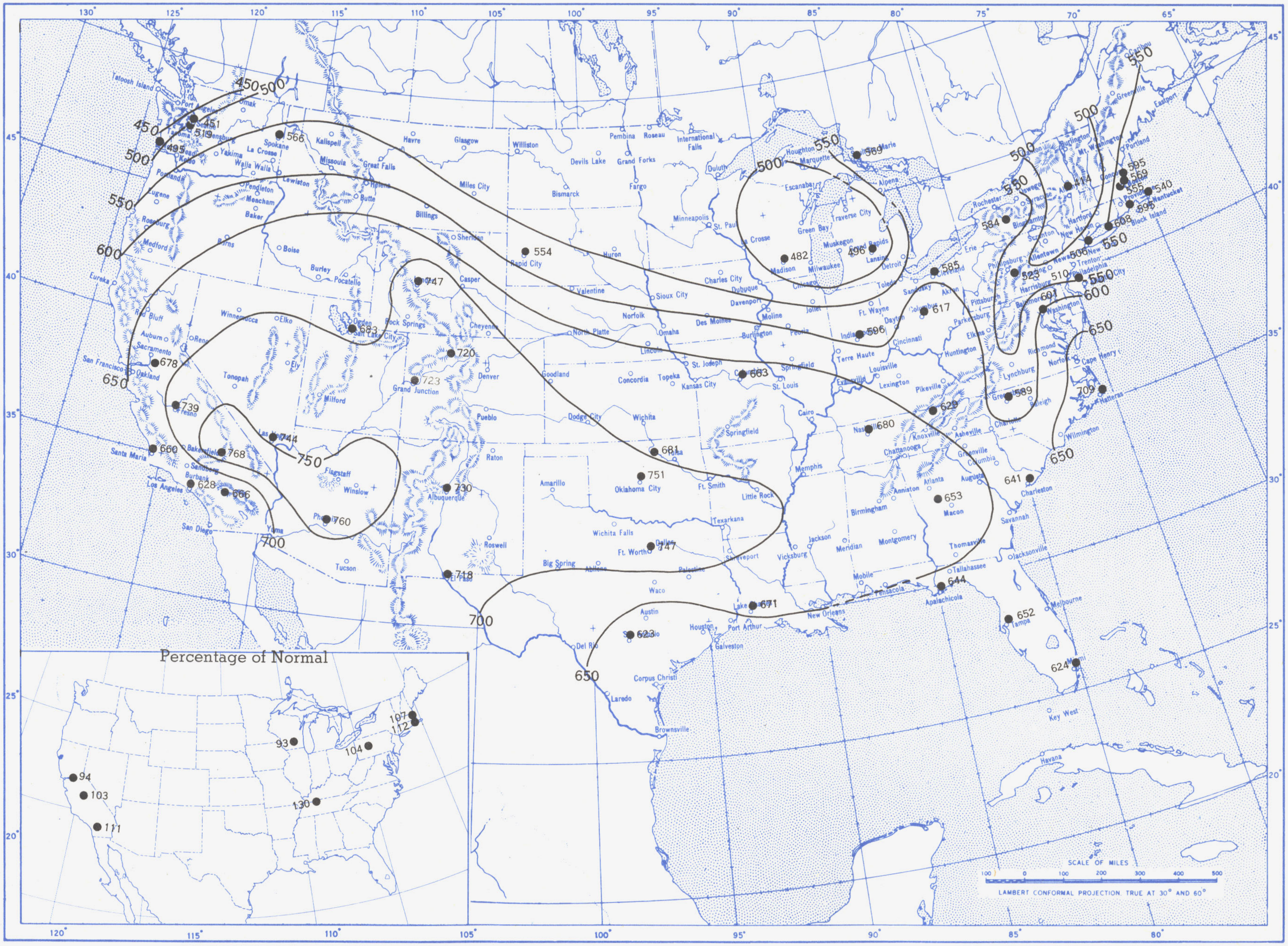
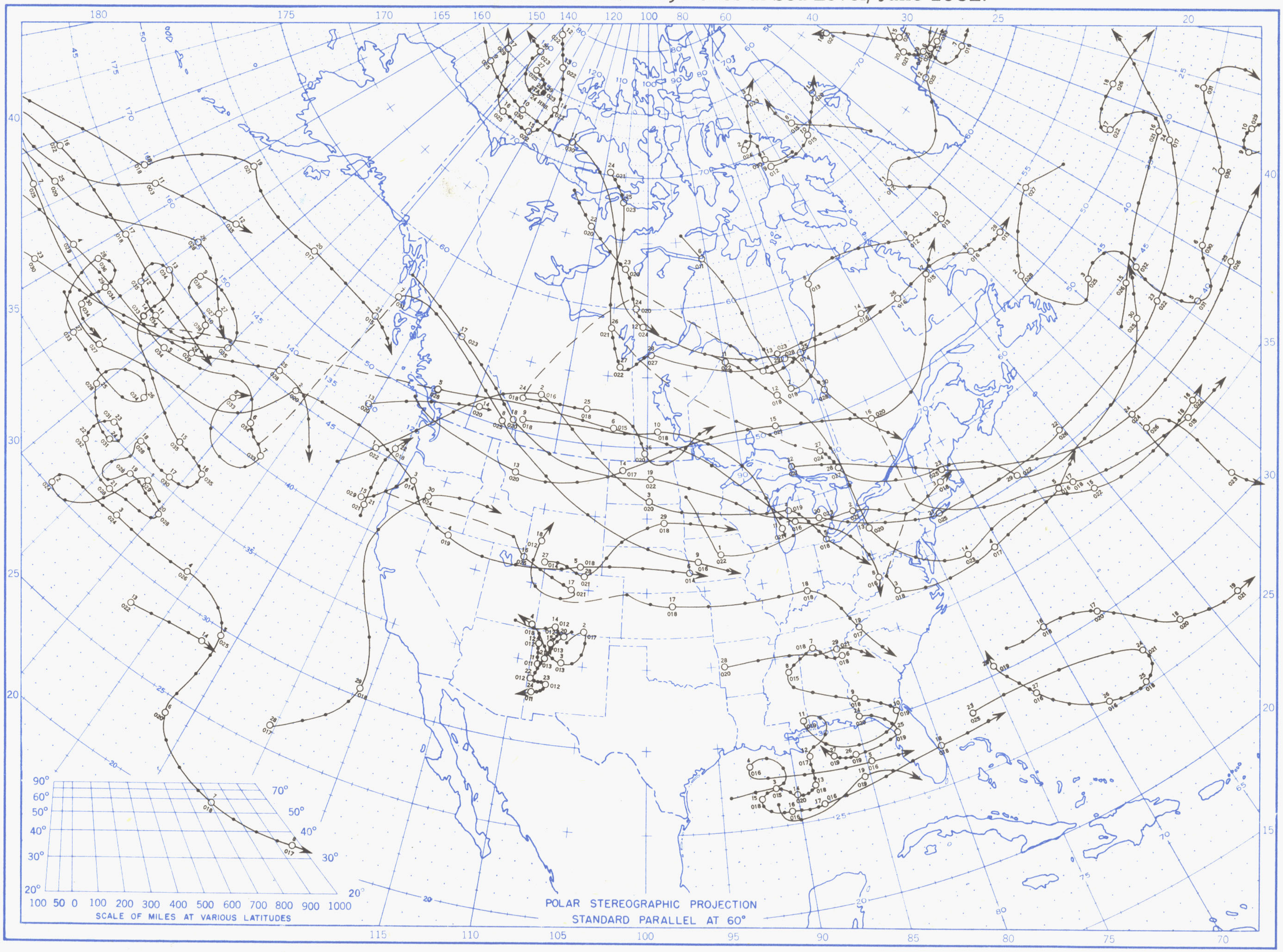


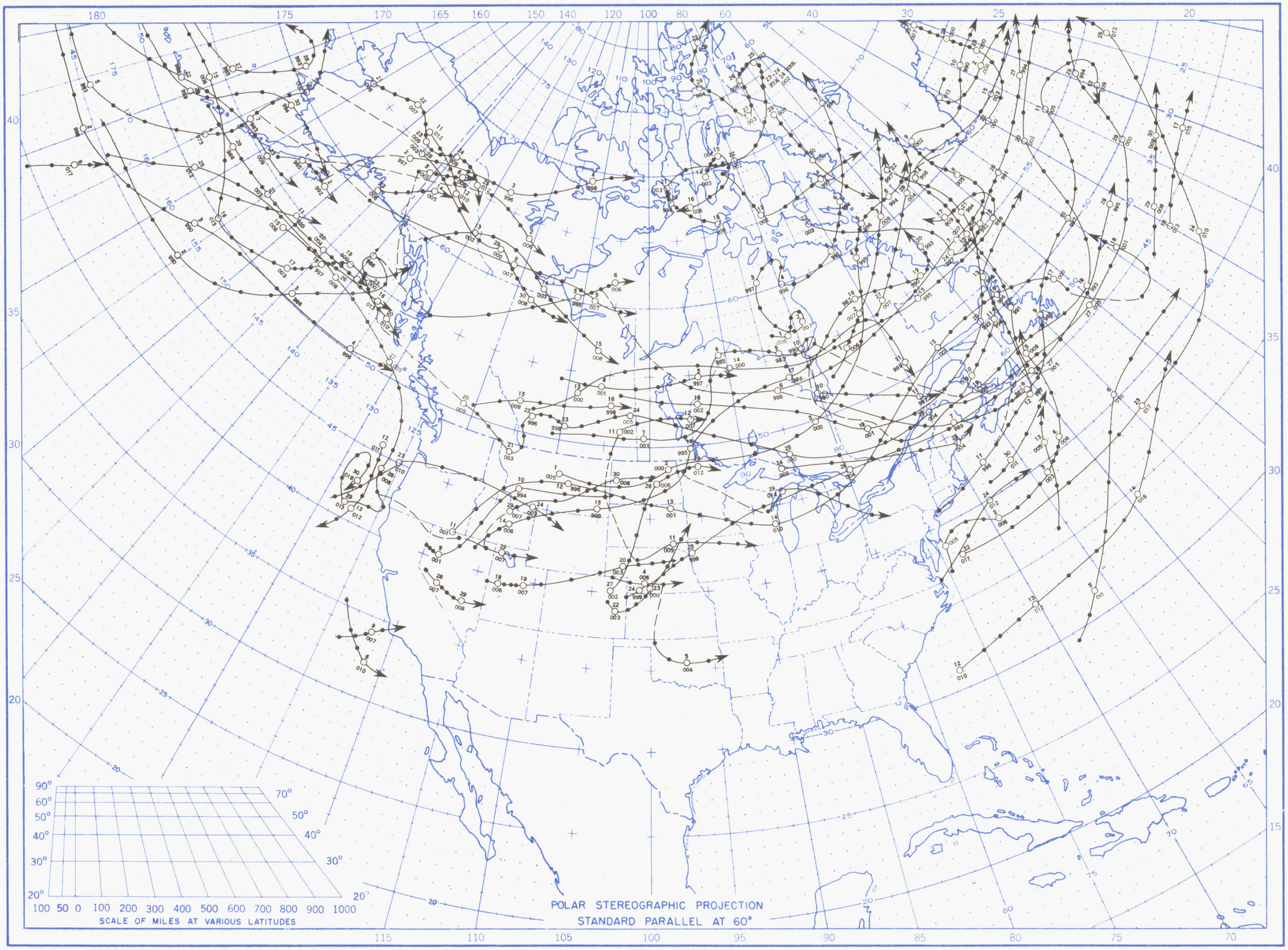
Chart shows mean daily solar radiation, direct + diffuse, received on a horizontal surface in langleys (1 langley = 1 gm. cal. cm.$^{-2}$). Basic data for isolines are shown on chart. Further estimates are obtained from supplementary data for which limits of accuracy are wider than for those data shown. Normals are computed for stations having at least 9 years of record.

Chart IX. Tracks of Centers of Anticyclones at Sea Level, June 1952.



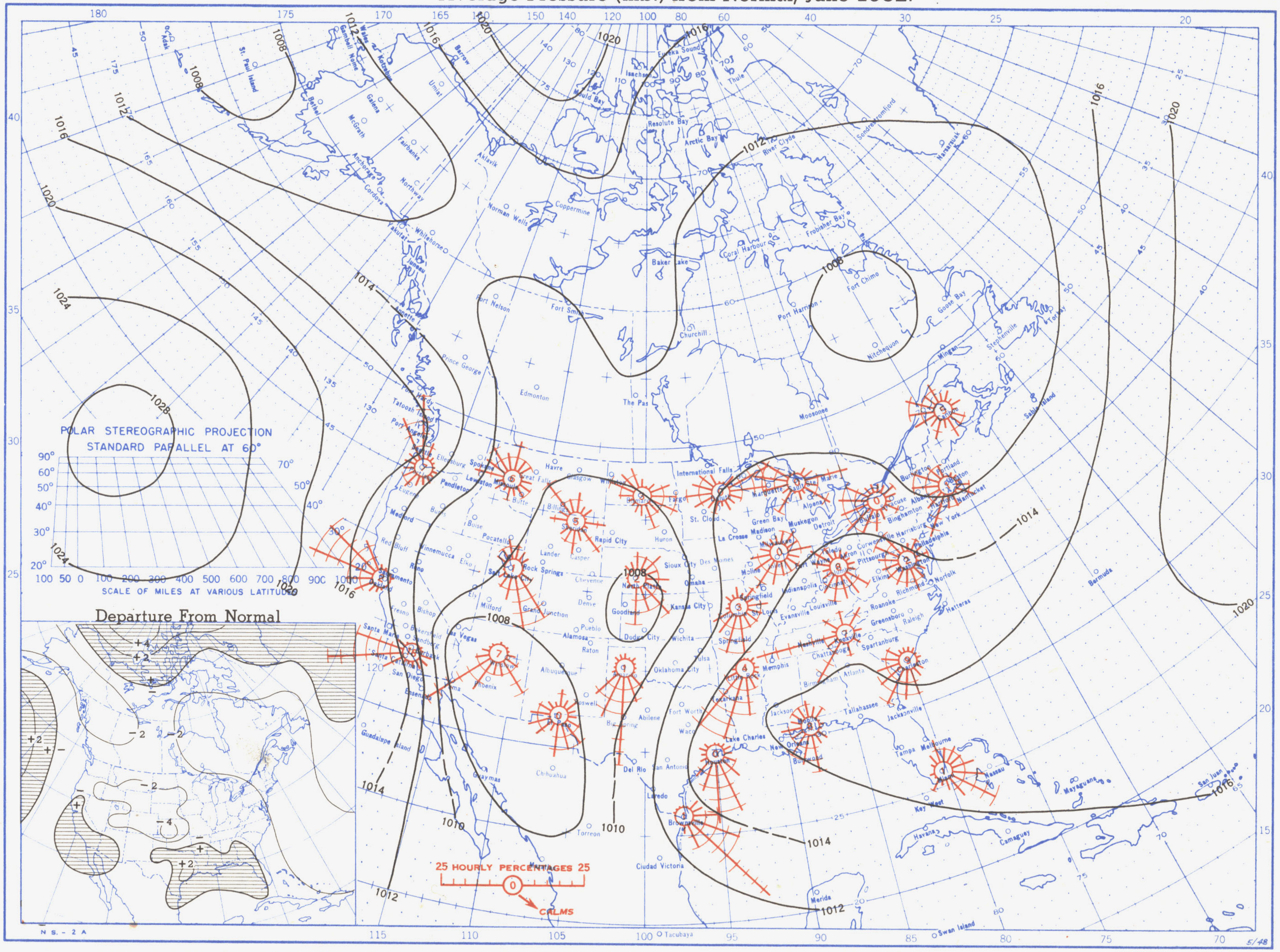
Circle indicates position of center at 7:30 a. m. E. S. T. Figure above circle indicates date, figure below, pressure to nearest millibar. Dots indicate intervening 6-hourly positions. Squares indicate position of stationary center for period shown. Dashed line in track indicates reformation at new position. Only those centers which could be identified for 24 hours or more are included.

Chart X. Tracks of Centers of Cyclones at Sea Level, June 1952.



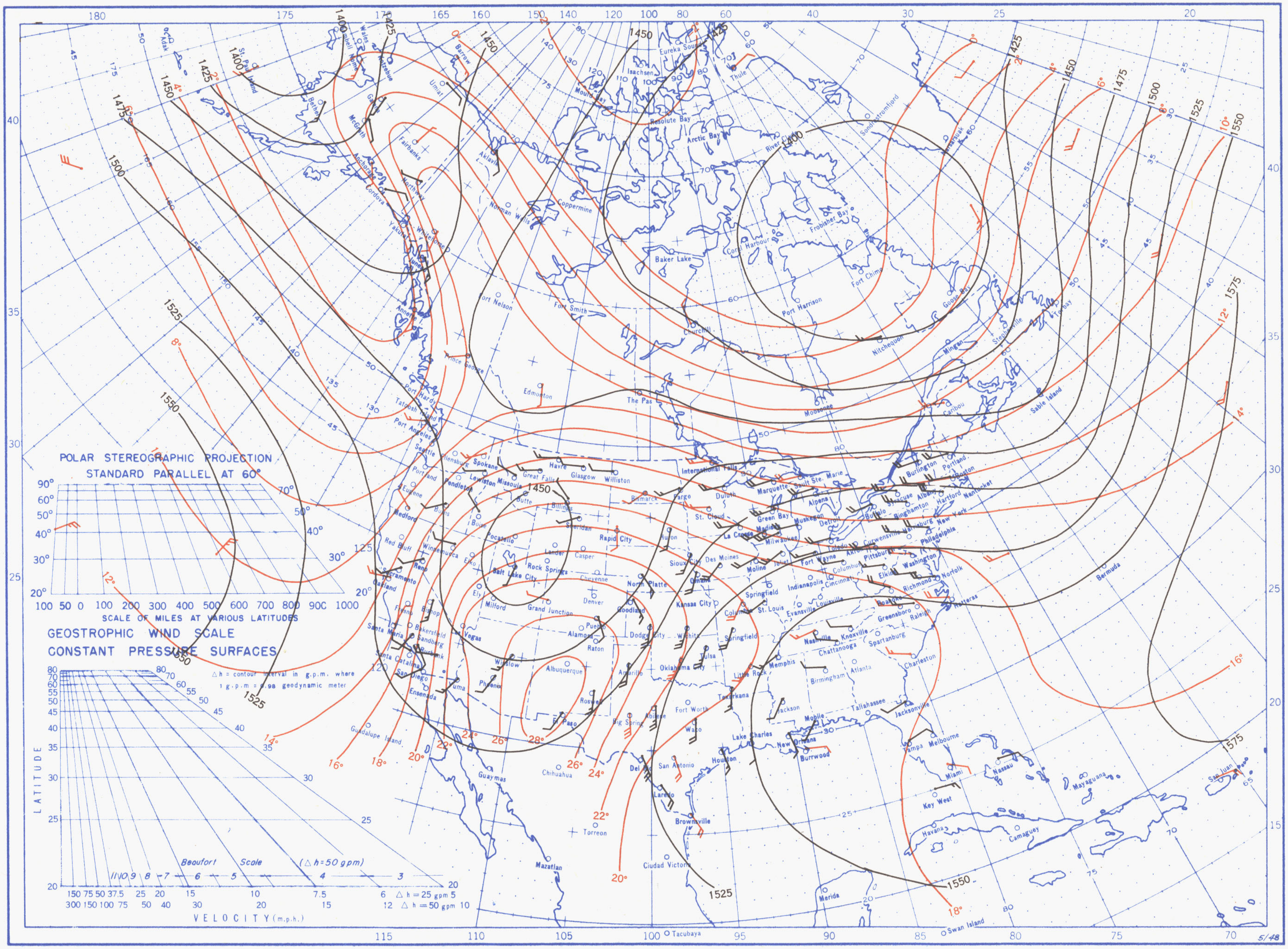
Circle indicates position of center at 7:30 a. m. E. S. T. See Chart IX for explanation of symbols.

Chart XI. Average Sea Level Pressure (mb.) and Surface Windroses, June 1952. Inset: Departure of Average Pressure (mb.) from Normal, June 1952.



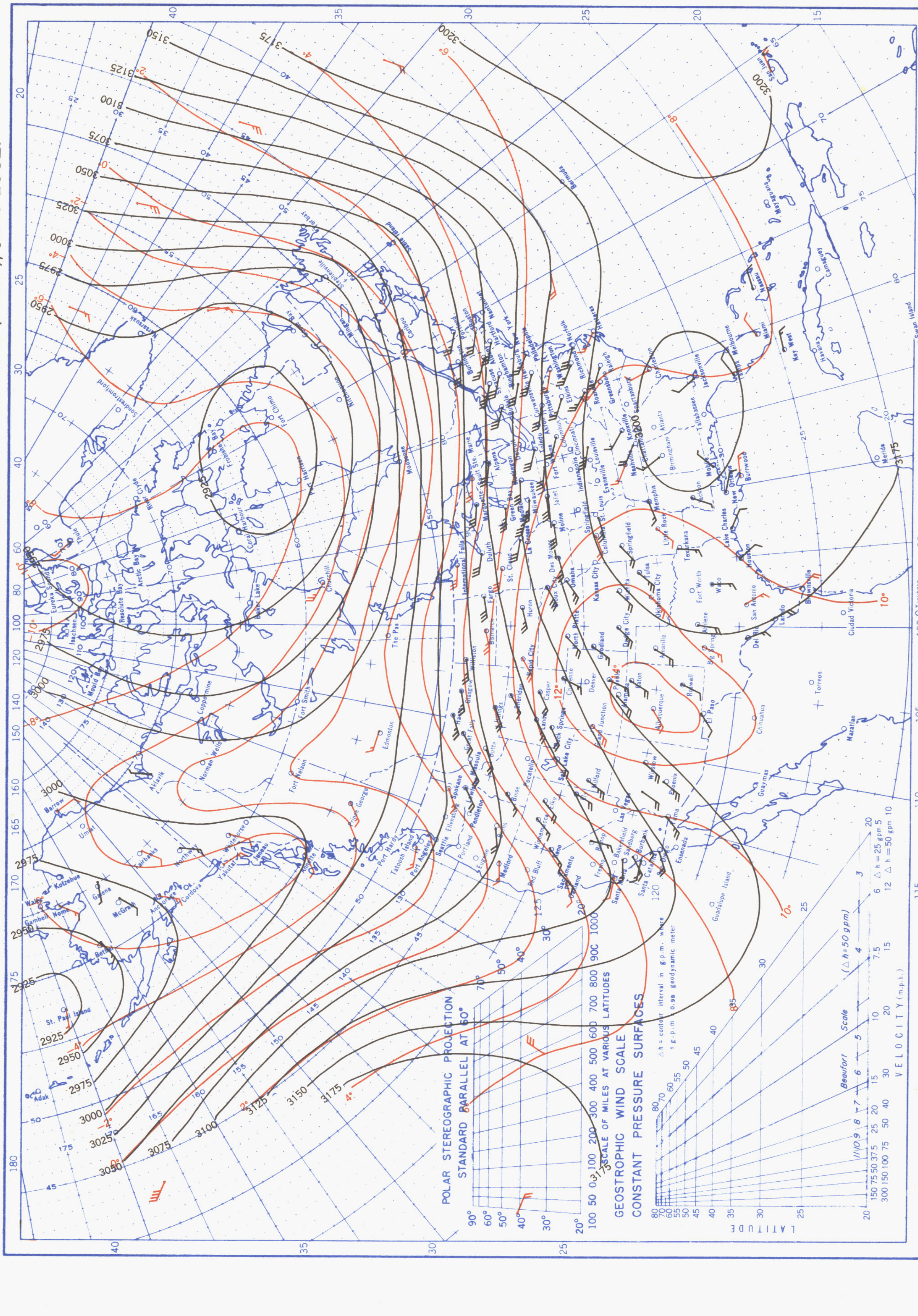
Average sea level pressures are obtained from the averages of the 7:30 a. m. and 7:30 p. m. E. S. T. readings. Windroses show percentage of time wind blew from 16 compass points or was calm during the month. Pressure normals are computed for stations having at least 10 years of record and for 10° intersections in a diamond grid based on readings from the Historical Weather Maps (1899-1939) for the 20 years of most complete data coverage prior to 1940.

Chart XII. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 850-mb. Pressure Surface, Average Temperature in °C. at 850 mb., and Resultant Winds at 1500 Meters (m.s.l.), June 1952.



Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins at 0300 G. M. T.

Chart XIII. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 700-mb. Pressure Surface, Average Temperature in °C. at 700 mb., and Resultant Winds at 3000 Meters (m.s.l.), June 1952.



Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins at 0300 G. M. T.

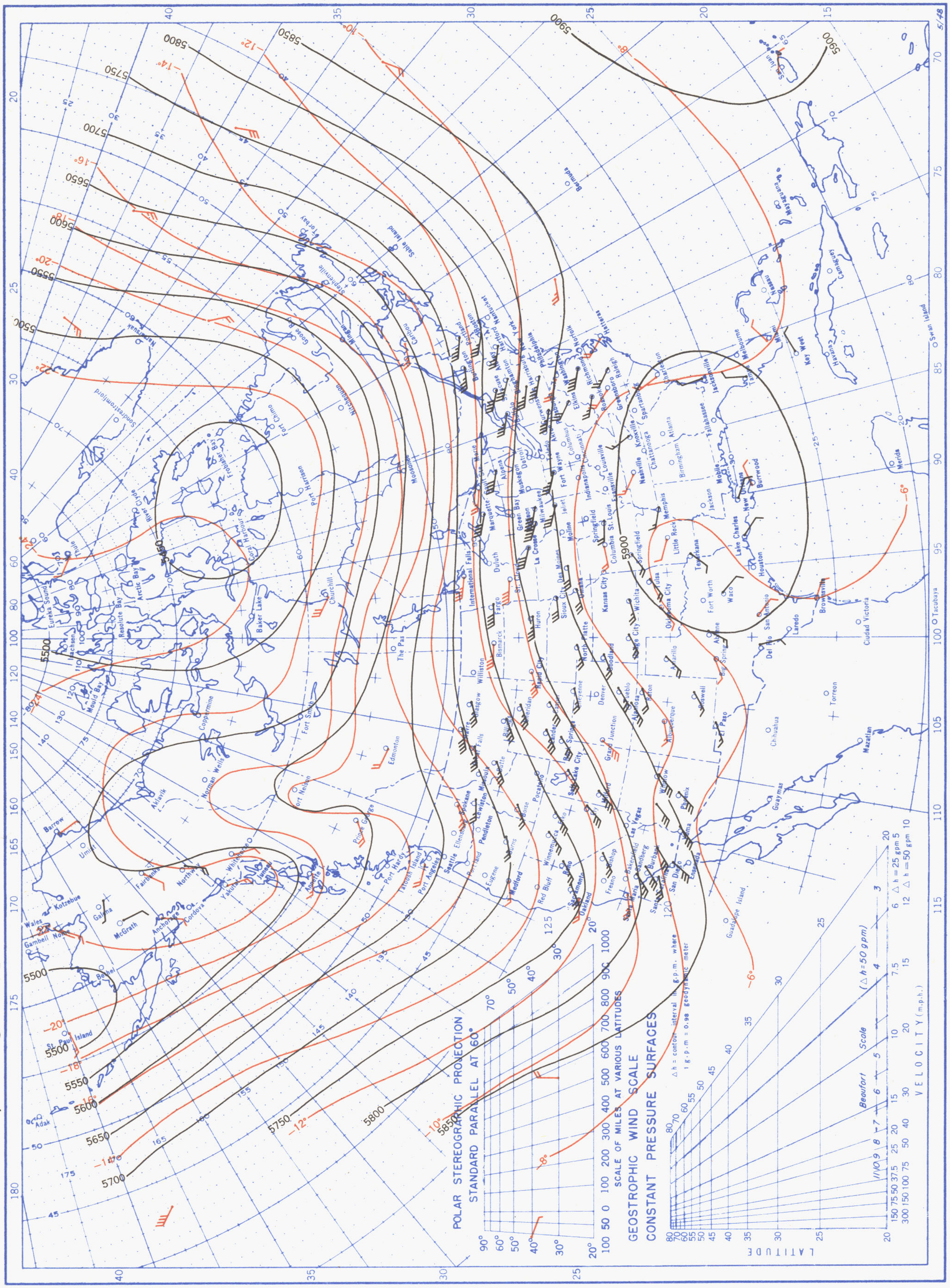
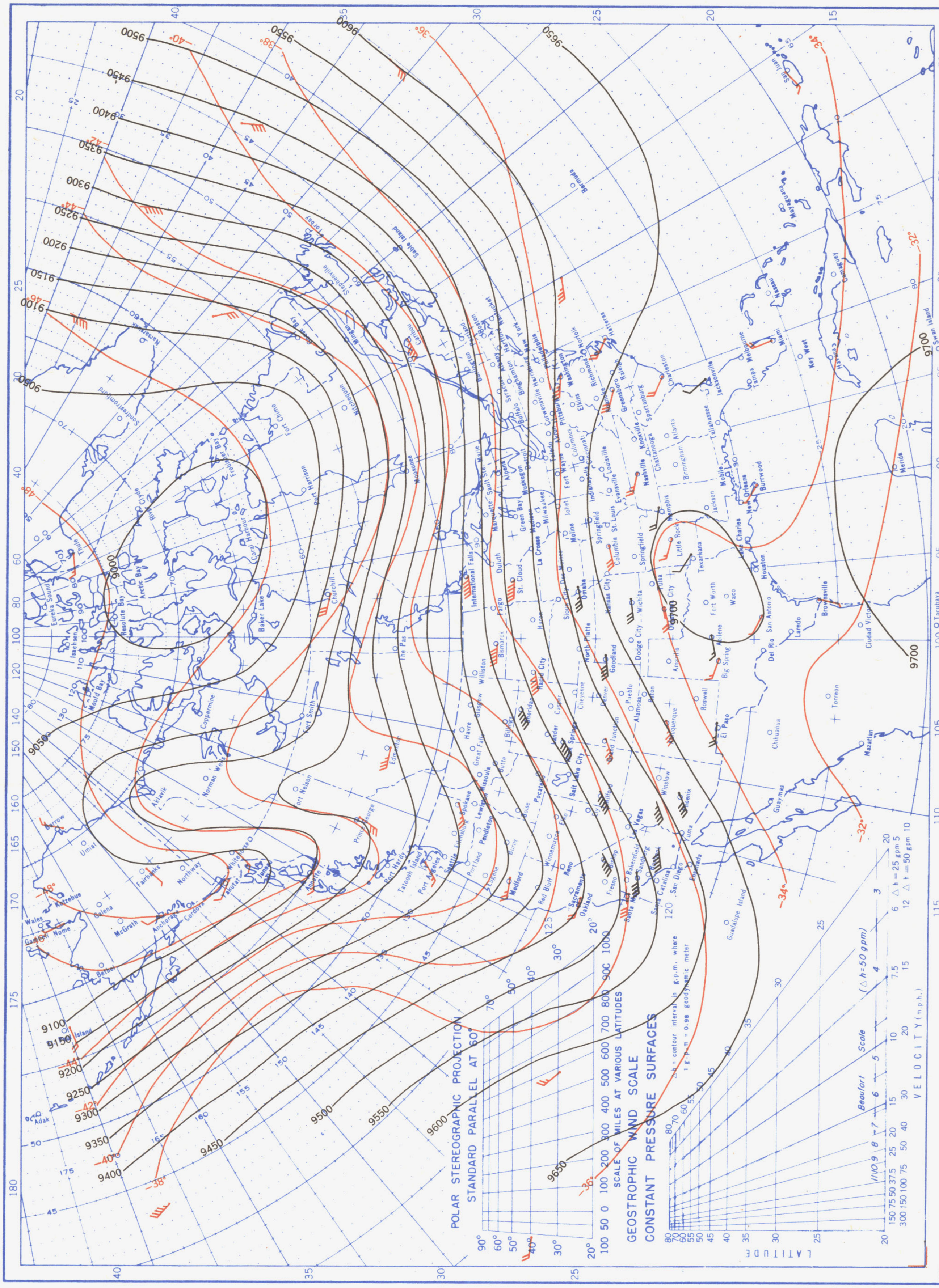


Chart XIV. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 500-mb. Pressure Surface, Average Temperature in °C. at 500 mb., and Resultant Winds at 5000 Meters (m.s.l.), June 1952.

Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins taken at 0300 G. M. T.

Chart XV. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 300-mb. Pressure Surface, Average Temperature in °C. at 300 mb., and Resultant Winds at 10,000 Meters (m.s.l.), June 1952.



Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins taken at 0300 G. M. T.