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PRESSURE PATTERNS ACCOMPANYING CYCLONIC ACTIVITY IN THE AZORES-AREA

R. L. Pyle

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PRESSURE PATTERNS ACCOMPANYING CYCLONIC ACTIVITY IN THE AZORES-AREA

R. L. Pyle

This investigation has sought to make a limited test of the hypothesis which states that the appearance of a particular type of pressure system in a certain area may often be associated with the development of a corresponding pressure regime in surrounding areas. This effect has already been investigated, notably in the case of plateau anticyclones in western United States and associated cyclonic activity in the Aleutian area(1). Definite indications have been found in this case that such a correspondence is present.

This study was made with the idea of determining if there exists a similar tendency for winter-time cyclonic activity in the Azores region to be accompanied by any particular type of pressure pattern over the North Atlantic Ocean.

The available daily sea level Historical Weather Maps(2) of the Northern Hemisphere for winter months were studied and all cases where a low pressure center was present in the Azores region were selected. The period studied comprised the four winter months (November through February) for the years 1931 through 1938, and the months of December, 1930 and January, 1931 plus November, 1938 through January, 1939.

In selecting the cases, the Azores-Area was defined as the region bounded by the meridians 5°W and 30°W, and the parallels 30°N and 50°N. Cyclonic activity, or an Azores-Area Low, was considered to be present in this area when either or both of the following conditions were observed:

(1) The Azores-Area contained a Low with a closed isobar of 1010 millibars or less centered in the Azores-Area.

(2) The Azores-Area contained a frontal wave with central pressure below 1010 millibars and sufficiently developed to have at least a well-defined juncture of cold front and warm front.

For examples of the first condition only, see November 16, 17, and 18, 1933. For examples of the second condition only, see November 22 and 23, 1931. In cases where two different Lows with closed isobars of 1010 millibars or less were centered in the area, both positions were recorded. But when a Low satisfying the first condition was present and was accompanied

(1) Willett, H.C., and others, "Report of an Experiment in Five-Day Weather Forecasting", Massachusetts Institute of Technology, Cambridge, Massachusetts, 1940, p. 54.

(2) Daily Synoptic Series of Historical Weather Maps Northern Hemisphere Sea Level -- published by the U. S. Weather Bureau in cooperation with the United States Army and Navy.

by one or more frontal systems fulfilling the second condition, then only the closed Low was recorded.

For each case of the Azores-Area Low, the pressure pattern over the North Atlantic was examined and the central positions of surrounding pressure centers were recorded. The "surrounding pressure centers" included all Highs and Lows containing a closed isobar centered in the North Atlantic Area. The North Atlantic Area (see Figures 1-8) comprised the region bounded on the east by longitude 10°E, on the south by latitude 25°N, and on the west by a line commencing at 25°N - 65°W and running through the intersections of 30°N - 70°W, 35°N - 75°W, 40°N - 80°W, 45°N - 85°W, 50°N - 90°W, and thence along the meridian 90°W intersecting the eastern boundary at the North Pole.

In all it was found that Azores-Area Lows appeared on 238 days, or 24% of the above period. A preliminary study yields the following table:

Table 1

	Days (a)	Per cent of time (b)	Average Intensity (c)	Average Lows (d)	Average Highs (e)
November	75	31.3	1001.5 mb.	3.1	2.3
December	61	21.9	999.1	3.0	2.5
January	61	21.9	997.3	2.6	2.2
February	41	20.7	998.5	2.5	2.1

(a) Number of days in the respective month on which Azores-Area Lows were present.

(b) Ratio of (a) to total number of days in the respective month during the period studied.

(c) Average intensity of Azores-Area Lows as measured by the value of the lowest central isobar.

(d) Average number of "surrounding Lows" accompanying each Azores-Area Low.

(e) Average number of "surrounding Highs" accompanying each Azores-Area Low.

The percentage figures in the above table which should be noted are those which indicate that cyclonic activity in the Azores-Area is present about nine days during an average November. Also, note that such activity is present on less than seven days during December and January, and less than six in February. The somewhat larger figure for November is due in part to the exceptional year of 1937, when Azores-Area Lows were present on 23 days during the month. Even so, the corresponding figure in column (b) for the remaining seven Novembers would be 24.8%. The high frequency during November, then, appears to be real followed by a downward trend throughout the winter. The small number of maps available for February accounts for the relative scantiness of data for this month, with the

consequence that the resulting low percentage figures for February are more open to question.

A downward trend in the average intensities of Azores-Area Lows is also noticeable during the first three winter months, the February value being somewhat higher than that for January. The absolute minimum central pressure for each month during the period studied shows a similar trend (see Table 2).

Table 2

	November	December	January	February
Absolute Minimum Central Pressure	980 mb	965 mb	960 mb	965 mb

The last two columns of Table 1 show the average number of surrounding Highs and Lows which accompanied each Azores-Area Low. The tendency for the occurrence of more surrounding Lows than Highs is present in all four months. However, the difference between the number of surrounding Highsand Lows is small, except for November. It should be pointed out that the figures for Lows include only the Lows found in the area surrounding and outside of the Azores-Area and that the average for the whole North Atlantic Area is of course higher if the Azores-Area Lows are included. A study of the 22 consecutive days in November, 1937, when Azores-Area Lows were present, failed to reveal any trend or tendency for the number of surrounding Highs or Lows to be greater or less than average. It was noted, however, that during the latter part of the period the day-to-day variation in the number of surrounding Highs followed quite closely the variation in the number of Lows.

The recorded positions of surrounding Highs and Lows were combined into totals for each 10° square in the North Atlantic Area. These totals were plotted on maps which then show the distribution of surrounding Highs and surrounding Lows for each month (see Figures 1-8). Each figure on these maps represents the total number of Highs or Lows which appeared in the 10° square centered at the position of the figure.

In comparing Figures 1-4 it can be seen that certain features of the distribution of surrounding Lows are present in all months. It should be emphasized that because of wide variations from month to month in the number of Azores-Area Lows, comparisons of these maps should be made between areas of relative high and low concentration, rather than between absolute figures. In general the concentration is greater over a broad area extending from the Great Lakes eastward and northeastward. The concentration is not so heavy over the extreme northern and southern portions of the North Atlantic Area. In addition it may be noted that the concentration is heavier over the Davis Strait than over either of the flanking land areas to the east and west. A "trough" of light concentration is also apparent over eastern North America, extending from Hudson Bay southeastward to New England and the Atlantic seaboard. This is quite apparent on the maps for December and January, and close inspection reveals that it is also present to a lesser degree in November. The February chart shows a similar area of light concentration but the data are rather thinly spread.

The following trend may be noticed in the change of position of the area of greatest concentration in mid-Atlantic. In November, the greatest

concentration is in the 60°-65° latitude band. In December, however, it has moved south to 55°-65°N, in January to 50°-60°N, and by February it is down to 40°-50°N. In connection with this it is suggested that the reader compare the distribution of Azores-Area Lows utilizing available Historical Northern Hemisphere Maps. In November, when the surrounding Lows are concentrated farthest north, the Azores-Area Lows are seen to be fairly evenly spread over the area. In December and January, however, when the band of surrounding Lows moves southward approaching the Azores-Area, the Azores-Area Lows themselves are concentrated in the northern portion of the area. This suggests that in December and January the majority of the Azores-Area Lows are associated with old cyclonic systems moving eastward across the Atlantic and up into Europe. In February, even though the number of Azores-Area Lows is much fewer, a similar continuation of the band of surrounding Lows is indicated as extending across the northwestern corner of the Azores-Area, and a secondary continuation southeastward toward Morocco.

Referring to Figures 5-8, it is again apparent that certain features of the distribution of surrounding centers are maintained throughout the four months. The areas of great concentration of Highs in the central Atlantic could be expected from the normal position of the Bermuda High. Another area of higher concentration is present in southern Ontario. It is interesting to note that in December and January this latter area extends into the region between Hudson Bay and New England where the number of surrounding Lows in these months is small. In November, on the other hand, when the number of surrounding Lows is greater in this region, the surrounding Highs are relatively lightly concentrated. In February, moreover, a general tendency for higher concentration of surrounding Highs in this area accompanies the tendency for surrounding Lows to be relatively lightly concentrated. In considering these maps, it should be remembered that they depict the conditions accompanying cyclonic activity in the Azores-Area, and are not necessarily representative of a completely unbiased sample of synoptic situations.

In expressing the concentration of pressure centers as being so much per 10° square (where a 10° square is defined as the area bounded by two meridians differing by 10 degrees and two parallels differing by 10 degrees), no account is taken of the variation in the area of a 10° square over the globe. It can be shown that the area of a 10° square is a function of the cosine of the latitude. The North Atlantic Area is divided by parallels of latitude into 13 bands of 5° latitude width, and length varying from 75° to 100° of longitude. The area of each of these bands can be expressed as a per cent of the total North Atlantic Area. Similarly, the number of surrounding Highs in each band can be expressed as a per cent of the total number of Highs. The percentage figures for the relative areas of the 13 bands can be considered as the per cent of Highs which would be expected in each band from a completely random scatter of the Highs over the North Atlantic Area. Thus the percentages of Highs actually observed can be compared with the percentages expected from a random scatter, and the deviations noted. These deviations are plotted on the accompanying graph (Figure 9) along with a similar graph for surrounding Lows. The corresponding figures for the surrounding Lows were obtained in the same manner, except that all percentage figures were computed on the basis of the North Atlantic Area excluding the Azores-Area.

In the upper graph, the variations with latitude of the November, December, and January Highs are quite similar north of 55°N. If the line

for February Highs were displaced 5° southward, it too would correspond rather closely with the distribution indicated by the other three months. South of 55°N the disturbing influence of the Azores-Area is felt because of the low center which is automatically located in that area. Nevertheless, a maximum deviation from the expected percentage of Highs is noted in the 25°-30° band for both December and January. This maximum is 10° farther north in November whereas in February it has retreated to 20° north of its mid-winter position.

The lower graph for surrounding Lows shows wider deviations than was the case for surrounding Highs, and less similarity between months is noted. A maximum deviation from the percentage expected from random scatter is present between 60°N and 70°N in all months, flanked on each side by a low value. A secondary maximum exists between 40° and 55°N for December, January, and February. The large negative deviations in the lowest latitude bands are caused by the almost total absence of surrounding Lows from these bands, while the relative areas are greatest. As a result, the deviations in higher latitudes are thrown onto the positive side.

Although the general patterns of surrounding pressure centers accompanying Azores-Area Lows are fairly well shown on these maps it is questionable whether these results have brought out any significant relationships. The fundamental patterns of concentration of High and Low centers are just about as would be expected from considerations of winter normals. In any further study of Azores-Area Lows it is suggested, first, that a way be found to eliminate those cases in which the Azores-Area Low is an old cyclone of western Atlantic origin which travels eastward into Europe through the very northern part of the Azores-Area. Attention should be confined to the young cyclones which develop in the central or eastern Atlantic and move into southern Europe.

Secondly, it is suggested that consideration be given to large, predominant surrounding pressure systems, rather than individual closed cells. It is felt, as a result of this study, that the daily movements of surface pressure centers are so great and so erratic that any tendency for a general pressure setup is obliterated. It is also felt that the significance lies in the location of dominant areas of high and low pressure, such as extended troughs accompanying well-developed frontal systems and perhaps involving several individual closed centers connected by fronts. Not only the location of these dominant systems but their strengthening and weakening as cyclonic activity in the Azores-Area strengthens and weakens, should be a part of any future attack on the problem.

Thirdly, it is believed that a similar study of normal pressure patterns over the North Atlantic Area, as given by a completely random selection of winter cases, would be very helpful for purposes of comparison.

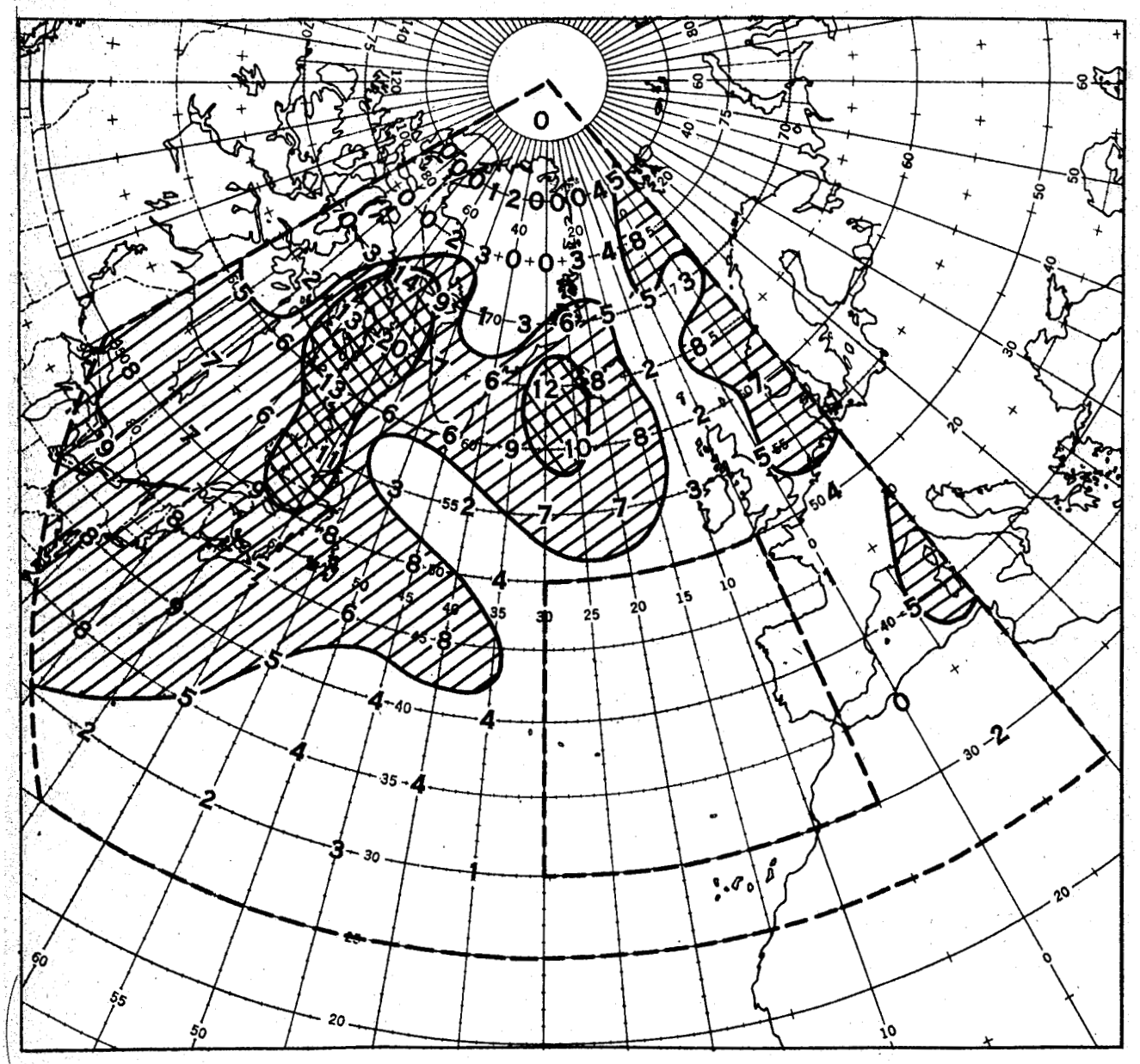

FIG. 1

NOVEMBER

Concentration of surrounding LOWS per 10° square

Concentration greater than 5 Lows per 10° square

Concentration greater than 10 Lows per 10° square

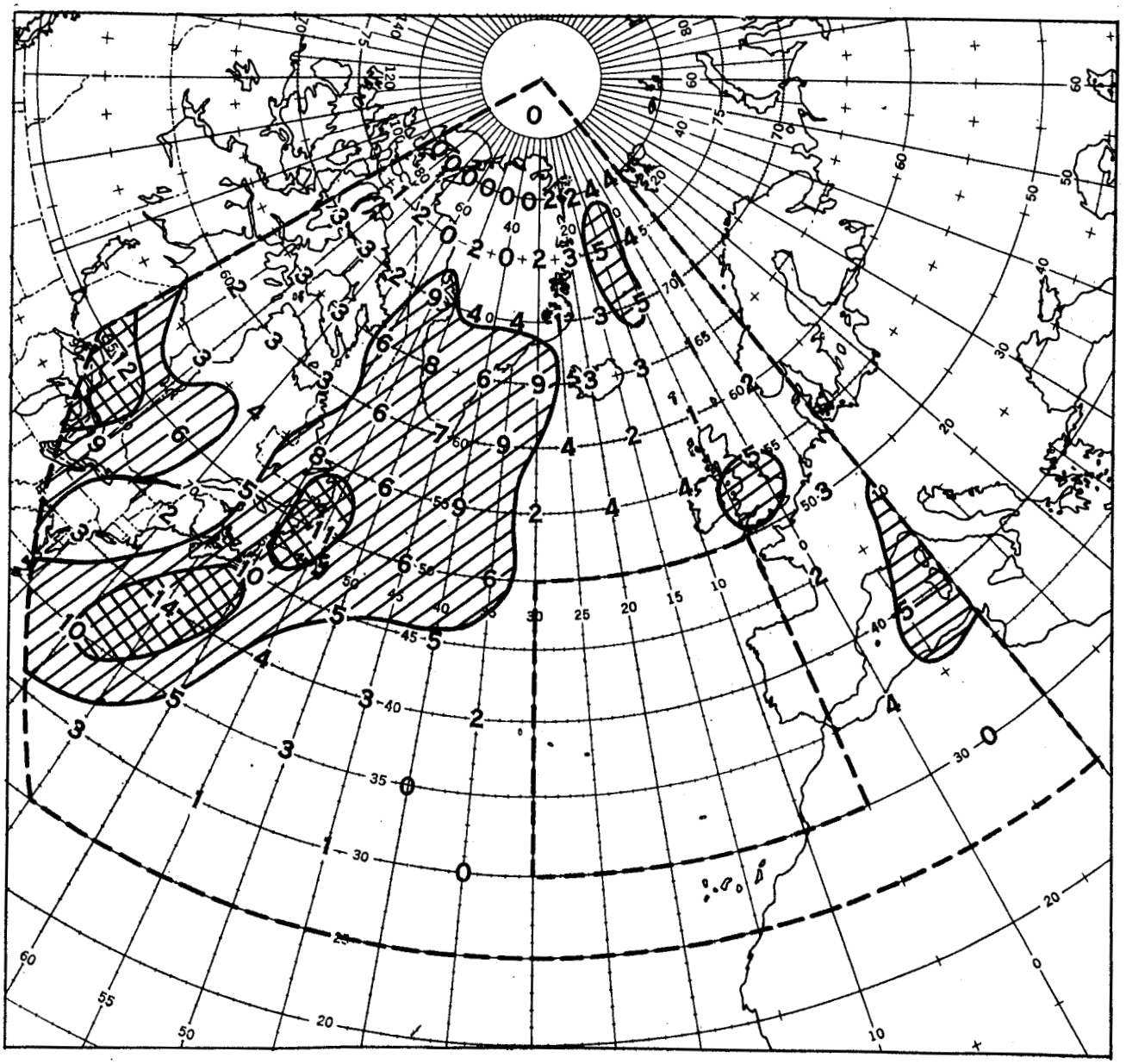

FIG. 2 DECEMBER

Concentration of surrounding LOWS per 10° square

Concentration greater than 5 Lows per 10° square

Concentration greater than 10 Lows per 10° square

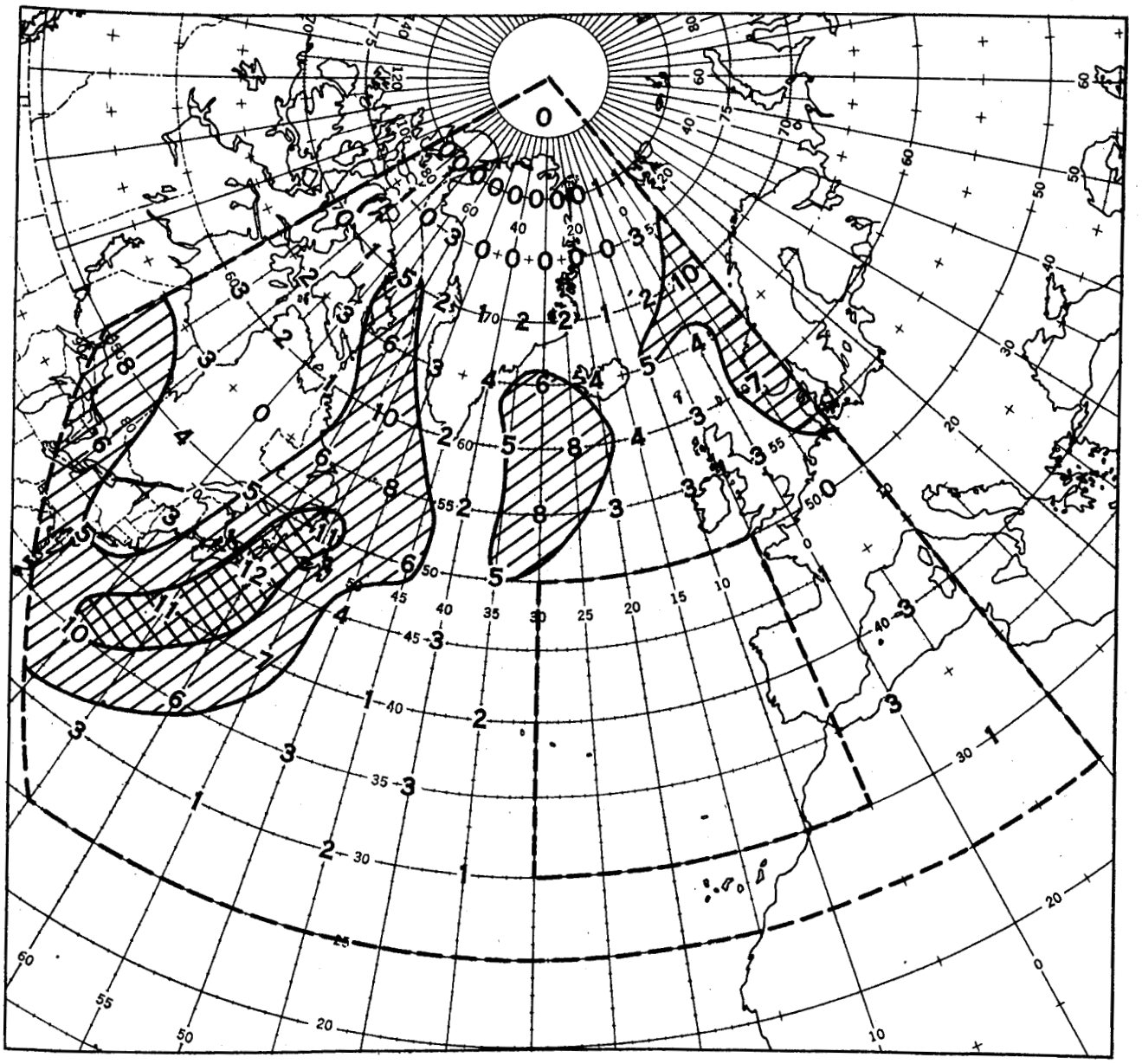

FIG. 3 JANUARY

Concentration of surrounding LOWS per 10° square

Concentration greater than 5 Lows per 10° square

Concentration greater than 10 Lows per 10° square

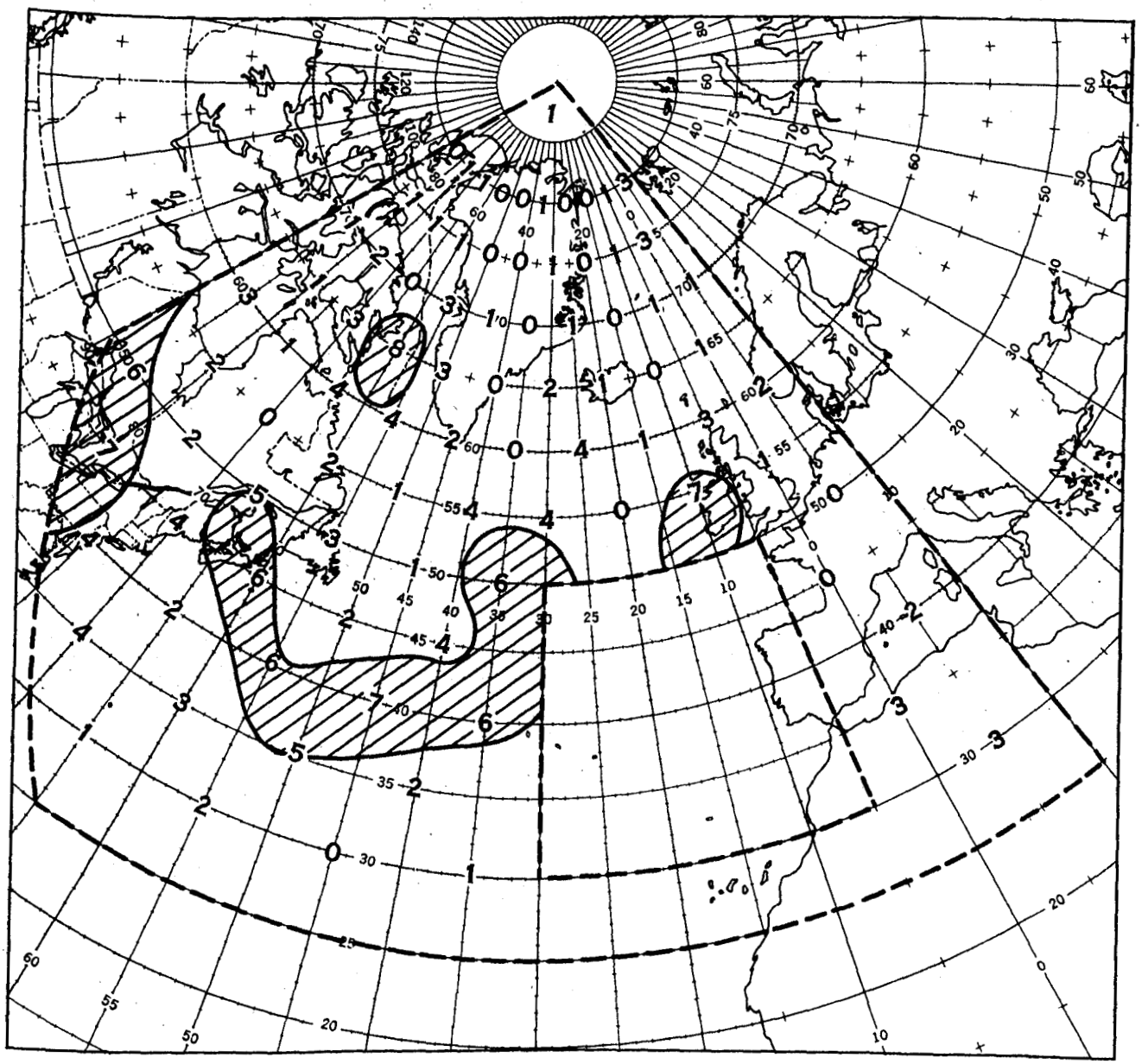

FIG. 4

FEBRUARY

Concentration of surrounding LOWS per 10° square

Concentration greater than 5 Lows per 10° square

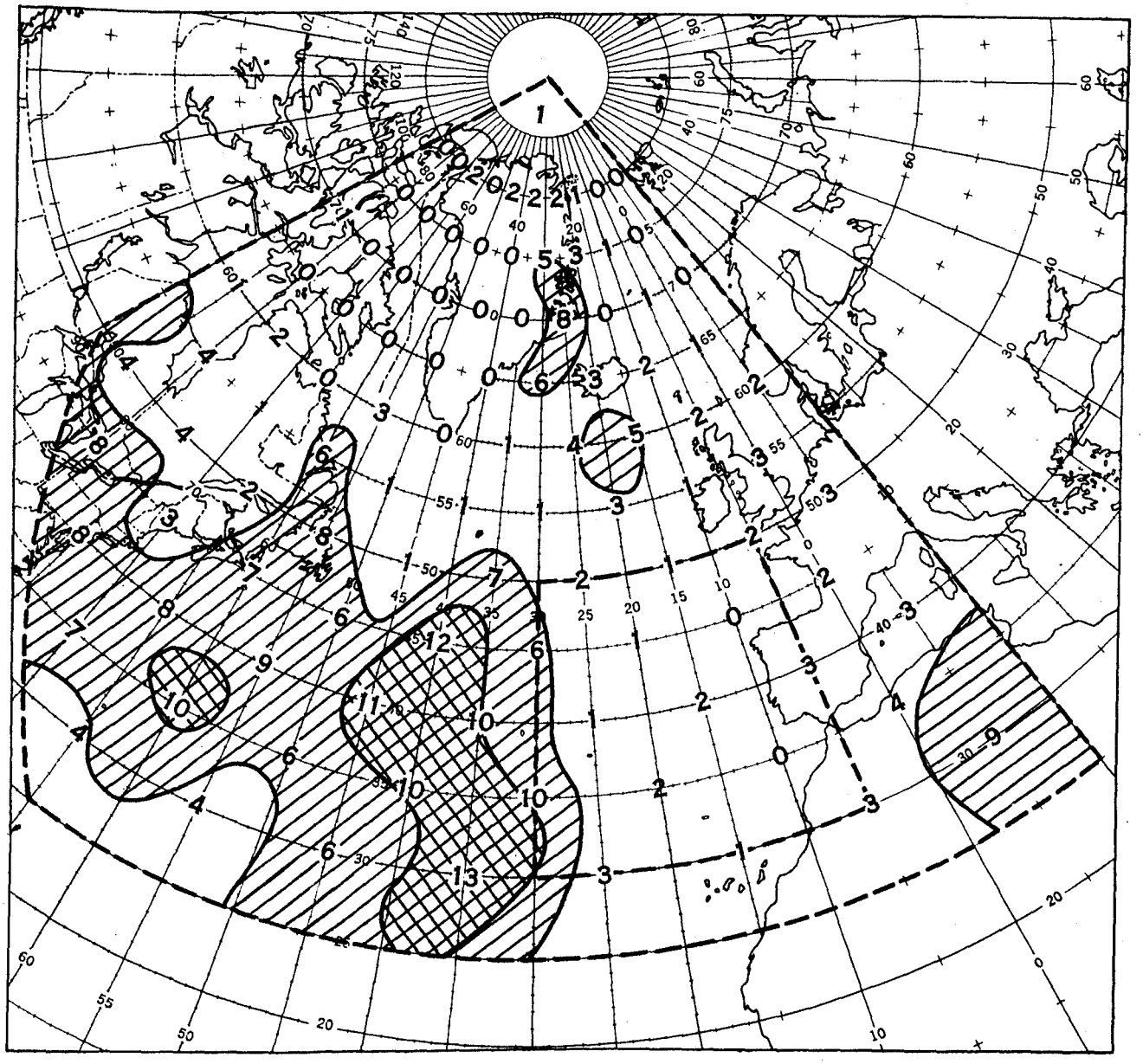

FIG. 5 NOVEMBER

Concentration of surrounding HIGHS per 10° square

Concentration greater than 5 Highs per 10° square

Concentration greater than 10 Highs per 10° square

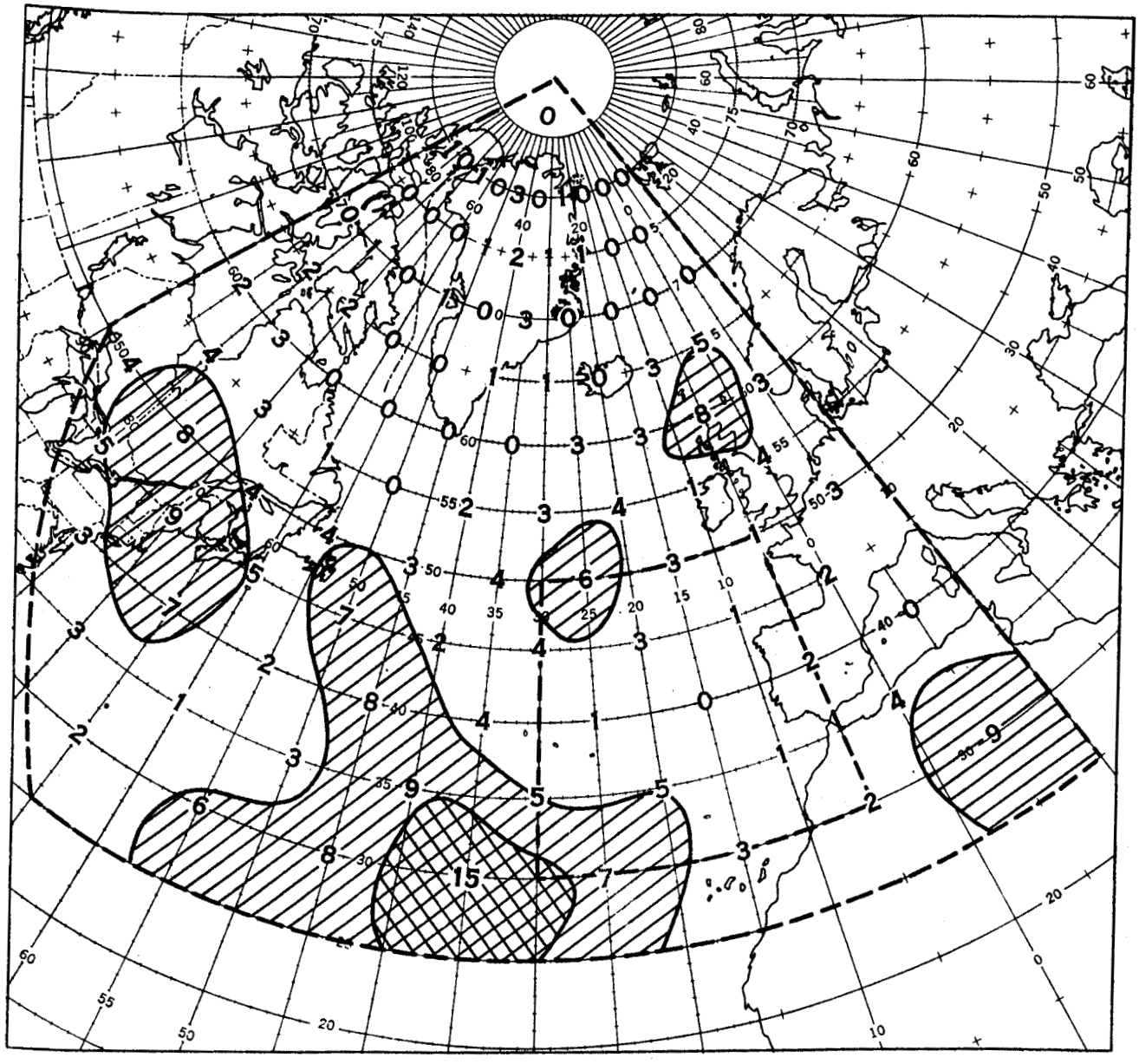

FIG. 6 DECEMBER

Concentration of surrounding HIGHS per 10° square

Concentration greater than 5 Highs per 10° square

Concentration greater than 10 Highs per 10° square

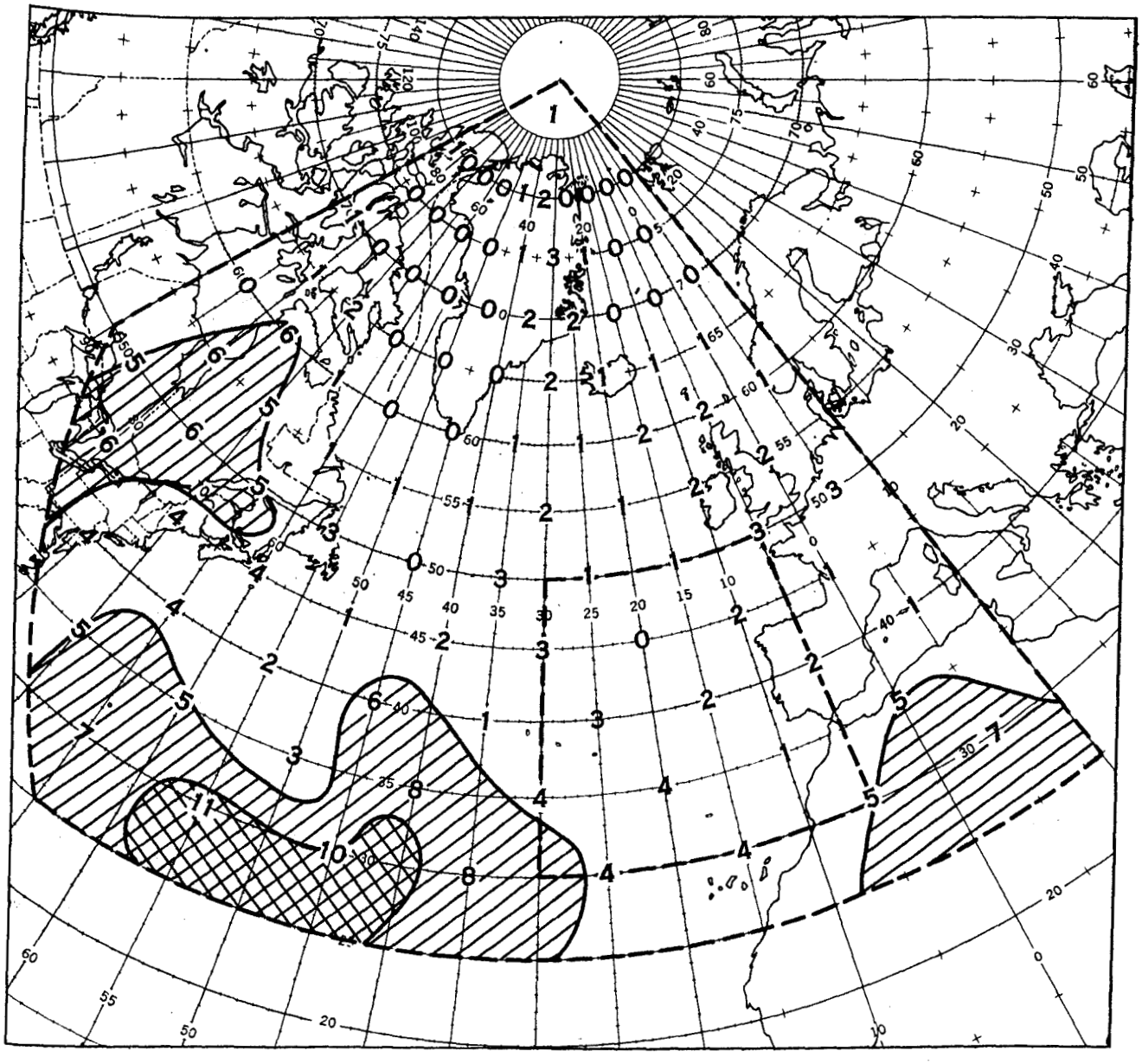

FIG. 7 JANUARY

Concentration of surrounding HIGHS per 10° square

Concentration greater than 5 Highs per 10° square

Concentration greater than 10 Highs per 10° square

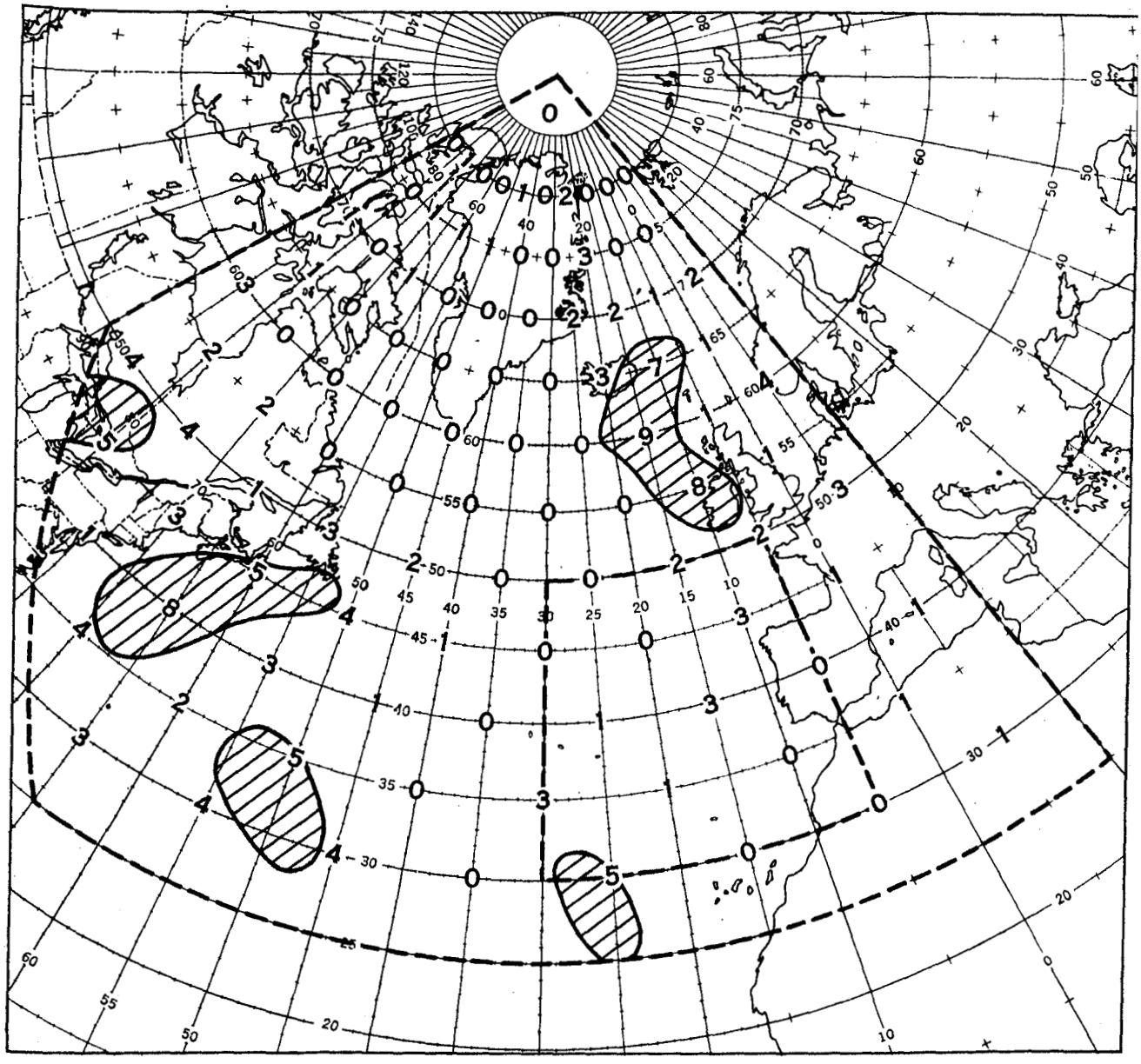

FIG. 8 FEBRUARY

Concentration of surrounding HIGHS per 10° square

Concentration greater than 5 Highs per 10° square

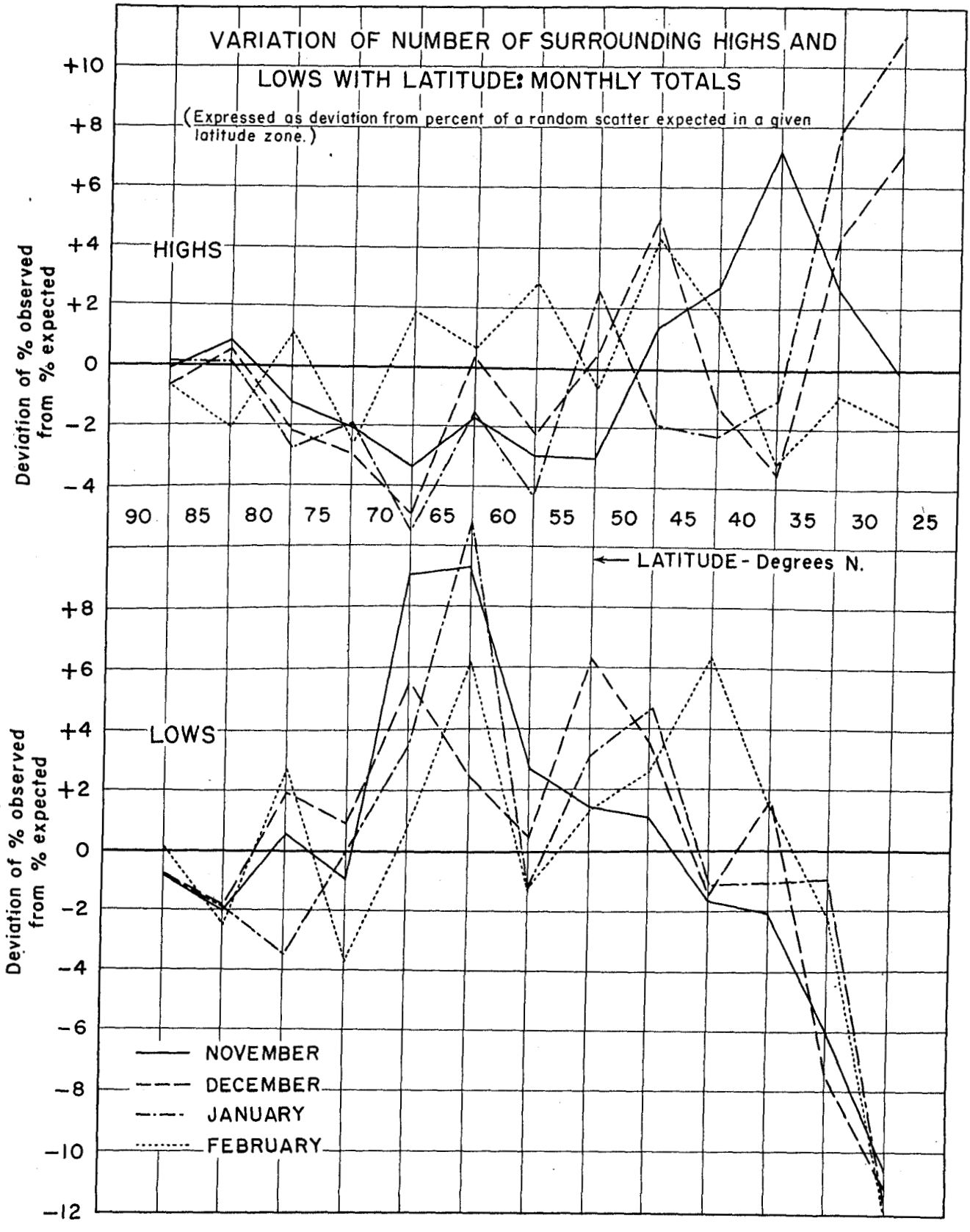
VARIATION OF NUMBER OF SURROUNDING HIGHS AND LOWS WITH LATITUDE: MONTHLY TOTALS
(Expressed as deviation from percent of a random scatter expected in a given latitude zone.)
HIGHS
LOWS
Deviation of % observed from % expected
+10
+8
+6
+4
+2
0
-2
-4
-6
-8
-10
-12
90 85 80 75 70 65 60 55 50 45 40 35 30 25
LATITUDE - Degrees N.
NOVEMBER
DECEMBER
JANUARY
FEBRUARY

FIG. 9