ON THE QUESTION OF SYNCHRONISM OF CLIMATIC CHANGES IN THE NORTH ATLANTIC-ARCTIC AND NORTH PACIFIC ARCTIC

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An analysis of the climatic changes from the 1921-50 period to the following 1951-60 and 1961-70 decades showed moderate synchronism in the annual and December-May changes of the circulation of the two regions as revealed by the intensity and position of the No. Pacific (Aleutian) and No. Atlantic (Icelandic) Lows. A filling-in and southwestward retreat of the Aleutian Low in the 1950's and 1960's in relation to the 1921-50 period was paralleled by a filling-in of the Icelandic Low in the same periods. This was

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accompanied by a lowering of the annual temperatures in the 1950's and a further lowering in the 1960's in Alaska and Iceland and also a lowering of the December-May temperatures in both regions in the 1950's and a further lowering in the 1960's in Iceland though not in Alaska, possibly due to a change in the site of the stations in the 1960's.

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FINAL REPORT

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Summary Report

An investigation was made of the degree of synchronism of climatic changes in the No. Atlantic-Arctic and No. Pacific-Arctic from a consideration of the changes in the circulation (pressure distribution), temperature, and ice conditions in Bering Strait and off Iceland to help us obtain some ideas of the causes of the climatic changes. An increased amount of heat, for example, reaching the surface of the earth due to a possible increase in the sun's heat output or to a decrease in the atmospheric turbidity for different causes would in time call for a global warming or a synchronous rise in temperature in all regions while an internal adjustment of the atmospheric circulation involving also the oceans would lead to a warming in some regions and cooling in others or a non-synchronous change.

An analysis of the changes in the circulation from the 1921-50 period to the following 1951-60 and 1961-70 decades showed moderate synchronism in the annual and December-May changes of the circulation of the two regions as revealed by the intensity and position of the No. Pacific (Aleutian) and No. Atlantic (Icelandic) Lows. Thus, the filling-in and southwestward retreat of the Aleutian Low in the 1950's and 1960's in relation to the 1921-50 period was paralleled by a filling-in of the Icelandic Low in the same periods together with a related southward intrusion of the Arctic High towards Iceland. This was accompanied by a lowering of the annual temperatures

in the 1950's and a further lowering in the 1960's in Alaska and Iceland and also a lowering of the December-May temperatures in both regions in the 1950's and a further lowering in the 1960's in Iceland through not in Nome and Bethel, possibly due to a change in the site of the stations in the 1960's. The sharp increase in the ice off Iceland in the 1960's presumably had its origin in the increased transport of the ice from the pack in the North that manifested itself first north of Iceland in the 1950's.

On the Question of Synchronism of Climatic Changes in the No. Pacific and No. Atlantic Arctic

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A. Introduction

An important consideration in studies of possible causes of climatic changes is the degree of synchronism of the changes of different regions; whether or not they develop more or less simultaneously and in the same direction or not in various regions depending on the cause of the climatic change. An increased amount of heat, for example, reaching the surface of the earth due to a possible increase in the sun's heat output or to a decrease in the atmospheric turbidity with a decrease in volcanism would in time call for a global warming or a synchronous rise in temperature in all regions while internal adjustments of the atmospheric circulation involving also the oceans would lead to a warming in some regions and a cooling in others or a non-synchronous change.

Evidence that changes in the ice conditions in the North Atlantic-Arctic can differ markedly in a given year from those in the North Pacific-Arctic was recently presented by Rodewald (1968) by comparing phenomenally heavy ice conditions off northern Alaska in 1965 with the light ice conditions in the

Greenland Sea (off Iceland) the same year. We may assume however, that over a period measured in decades, rather than in years, the response to a cause of climatic change would show itself as a trend. To learn whether changes in ice conditions of the order of a decade or more in the North Atlantic-Arctic are relatively synchronous with those in the North Pacific-Arctic, a study was made of the ice conditions off Iceland and in Bering Strait along with the circulation (pressure distribution) and air temperatures of the three different periods 1921-50, 1951-60, 1961-70 and compared for the two regions.

B. Ice off Iceland and in Bering Strait

1. Ice off Iceland. The severity of the ice off Iceland is usually expressed by an index that measures the duration and extent of the ice along the coast. The average value of this index for the 30-year period (1921-50) was 3.1 units followed by 1.1 units in the 1951-60 decade and by a sharp rise in the last decade (1961-69) that came to 50.4 units (Eythorsson and Sigtryggsson, 1971).

2. Bering Strait Ice. St. Michael Break-Up and Freeze-Up Dates. In the absence of historical data on the ice limit in the Bering Sea, we turn to the long record of opening and closing dates to navigation of St. Michael's in Norton Sound, opening on Bering Strait (Weightman, 1941). While the dates of opening and closing in individual years at a given location are not likely to reflect ice conditions over a wide area, we may assume that over a longer period, one or more decades, it

may. The average duration of the ice season at St. Michael for the 1921-50 period is 206 days followed by 202 days in the 1950's, while the dates for the 1960's are still being processed by the National Climatic Center in Asheville (see also Weightman, 1941).

C. No. Atlantic (Icelandic) Low

1. Annual. Fig. 1 giving the average annual pressure distribution in the No. Atlantic-Arctic shows isobar 1008 mb north of Iceland to run westward to the coast towards Greenland indicating little ice movement towards Iceland. A movement of ice towards Iceland in the 1950's is indicated (Fig. 2) from the direction of isobar 1012 mb which runs southwestward and a still greater movement in the 1960's (Fig. 3) as indicated from this isobar which runs south/southwestward towards the coast.

Along with the indicated increased southward movement of the ice from the pack in the North in the 1950's and a still greater movement in the 1960's, we note a lowering in temperatures at Stykkisholm and Teigarhorn, respectively, in Iceland in the 1950's and an additional lowering in the 1960's as the cold air from the north penetrates farther southward. This is revealed also from a filling-in of the Icelandic Low in the 1950's as shown by a shrinkage of the area enclosed by the 1008 mb isobar and a further filling-in of the Low in the 1960's shown by a further reduction of the enclosed area (Figs.1-3) as well as the disappearance of the area enclosed by the 1006 mb isobar in that decade.

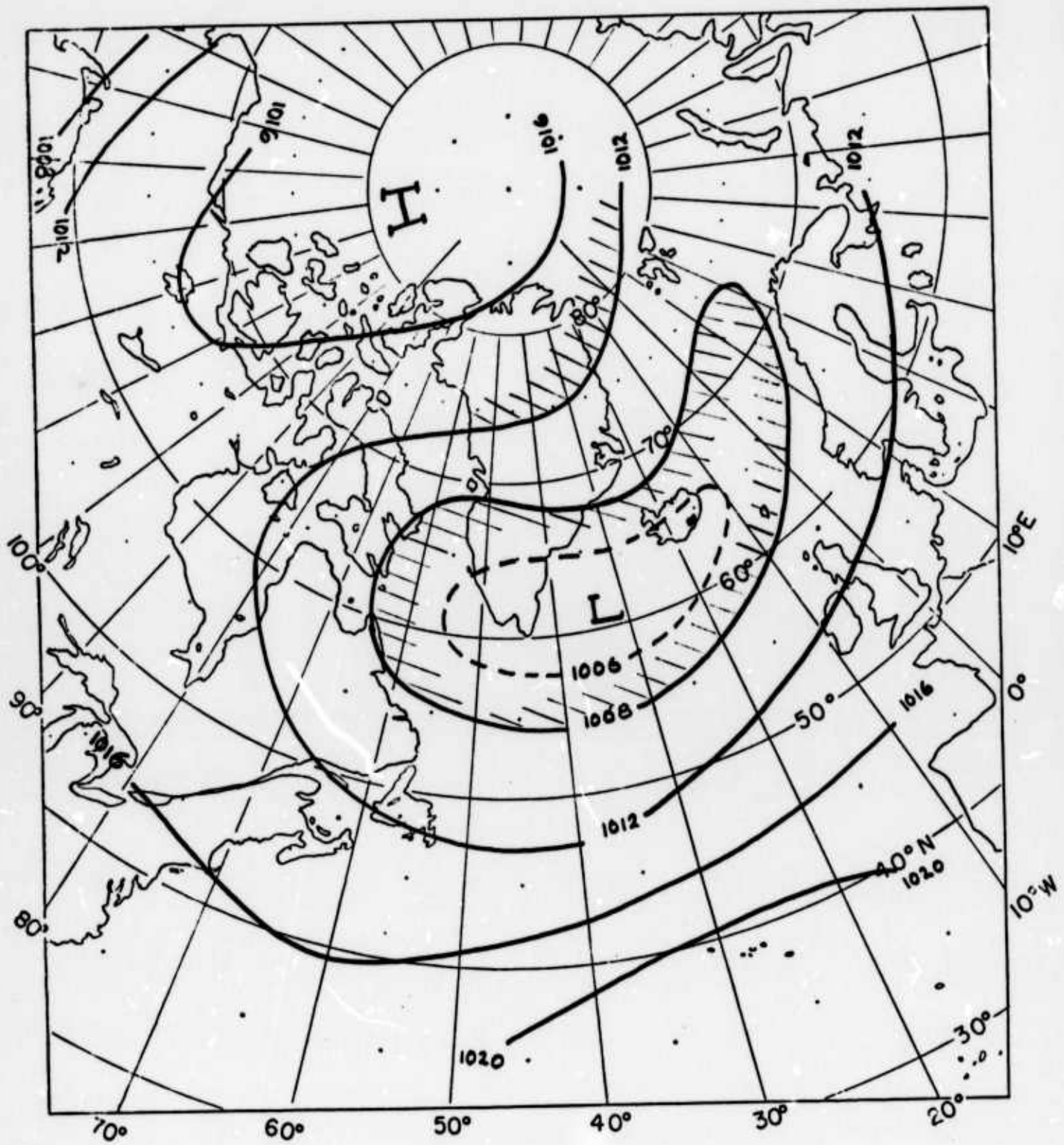

Fig. 1 1921-1950 Annual Pressure (mb).

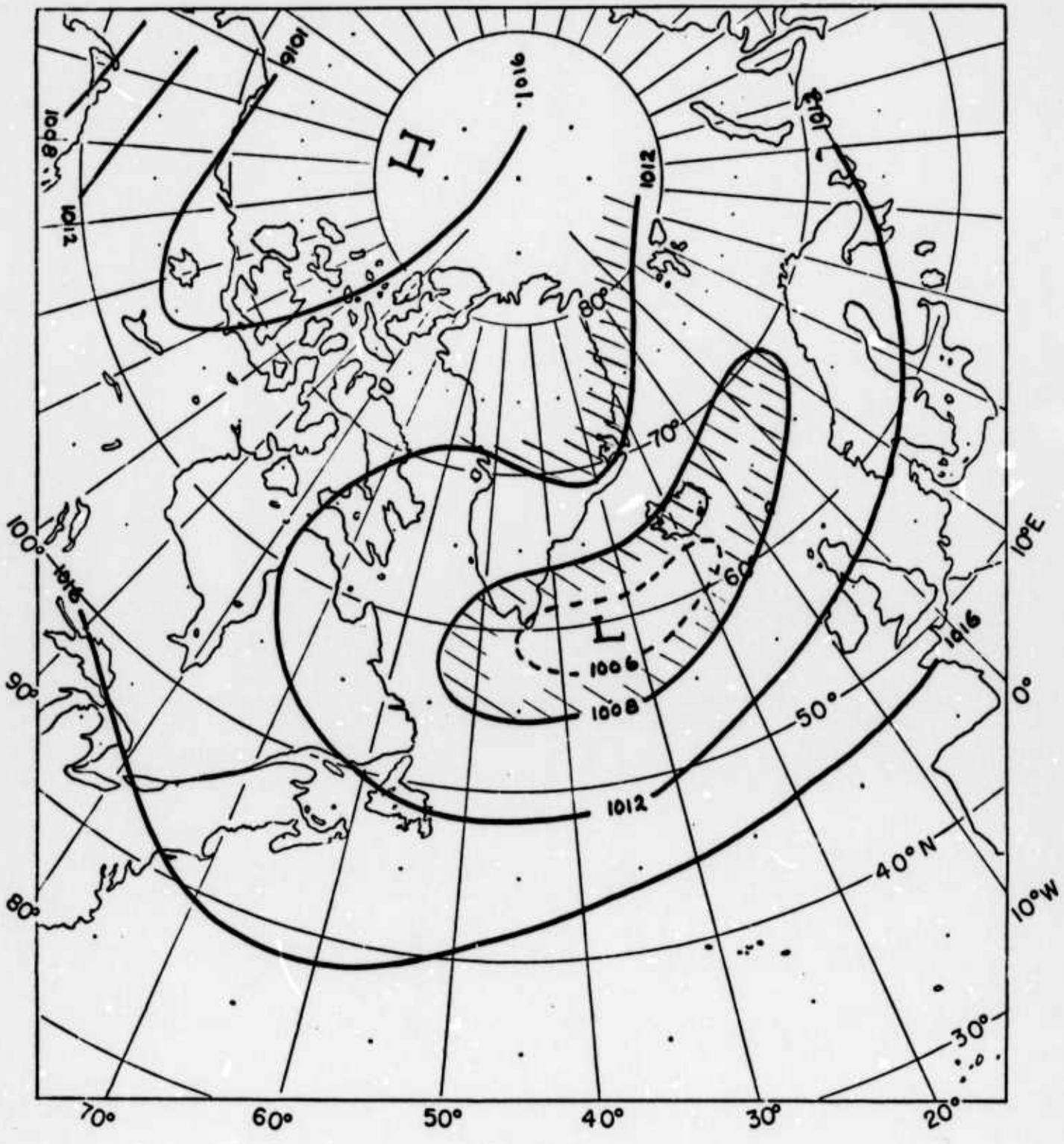

Fig. 2 1951-1960 Annual Pressure (mb).

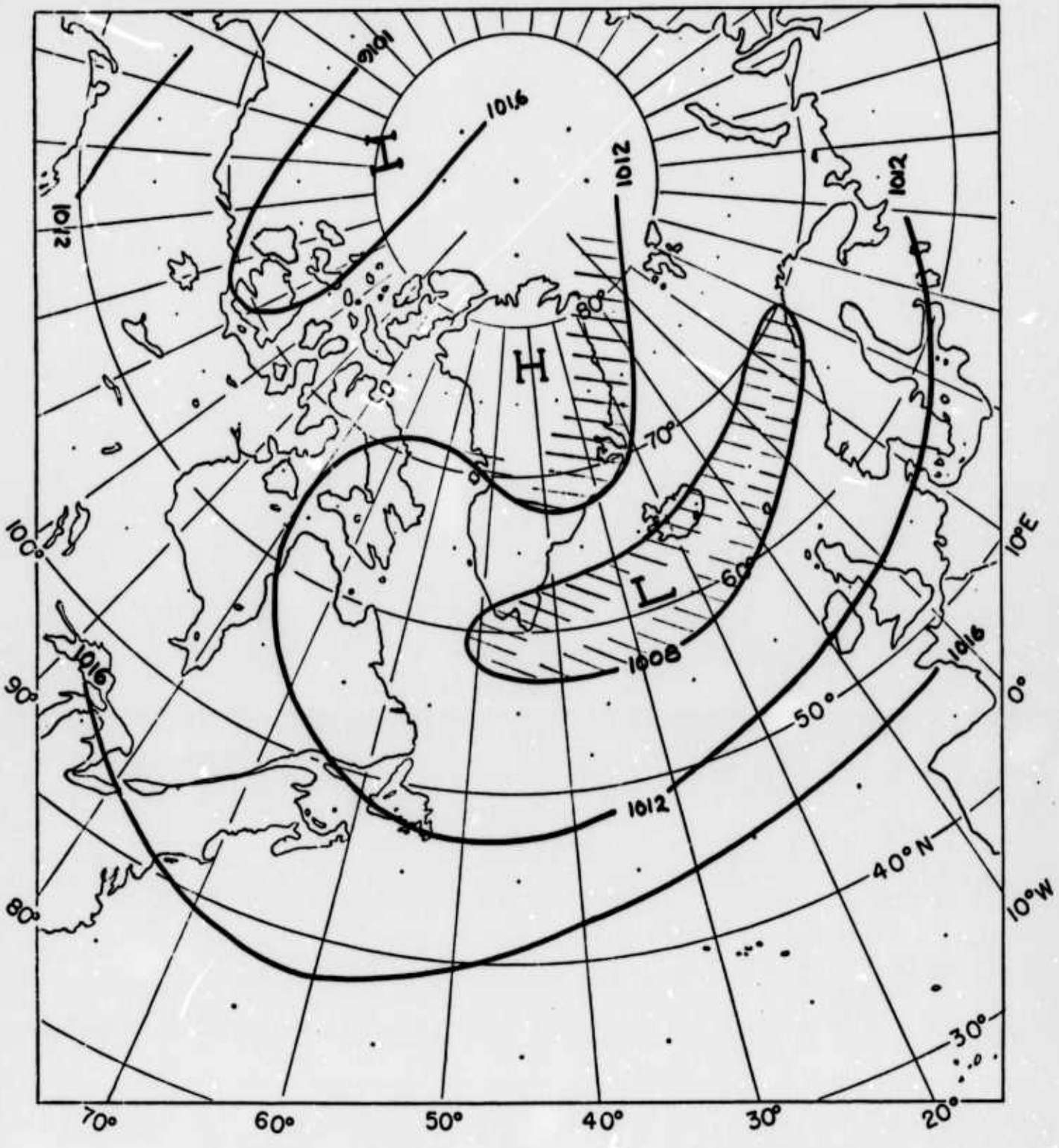

Fig. 3 1961-1970 Annual Pressure (mb).

2. Dec.-May. A similar filling-in of the Icelandic Low may be seen in the 1950's and another filling-in in the 1960's during the December-May season as shown by the shrinking of the area enclosed by the 1004 mb isobar in the 1950/1-1959/60 period (Fig. 5) as compared with the 1920/1-1949/50 period (Fig. 4) and its disappearance in the 1960/1-1969/70 (Fig. 6.). This is associated with a southward extension of the Arctic High (1016 mb isobar) in the 1950's (Fig. 5) from its position in the preceding 30-year period (Fig. 4) and a further southward extension of the High in the 1960's (Fig. 6), together indicating a progressively greater outflow of cold air and a southward movement of the ice from the pack in the North towards Iceland that finally reaches the coast in the 1960's.

D. No. Pacific-Arctic (Aleutian Low)

1. Annual. Fig. 7 shows the Aleutian Low in 1921-50 to be well developed with isobar 1008 mb extending northeastward into southwestern Alaska in contrast to the same isobar extending only into the Alaskan Peninsula in 1951-60 (Fig. 8) and even less northeastward stopping short of the Peninsula in the 1961-70 decade (Fig. 9), reflecting a progressive southwestward withdrawal of the Low in the 1951-60 and 1960-70 decades. The southwestward withdrawal of the Aleutian Low in 1951-60 and again in 1961-70 suggests a lesser inflow of relatively warm air into the region in the last two decades that would account for the lowering of the annual temperature at Nome and Bethel in 1951-60 as compared with the 1921-50 period and a further lowering in 1961-70 (see Table 1).

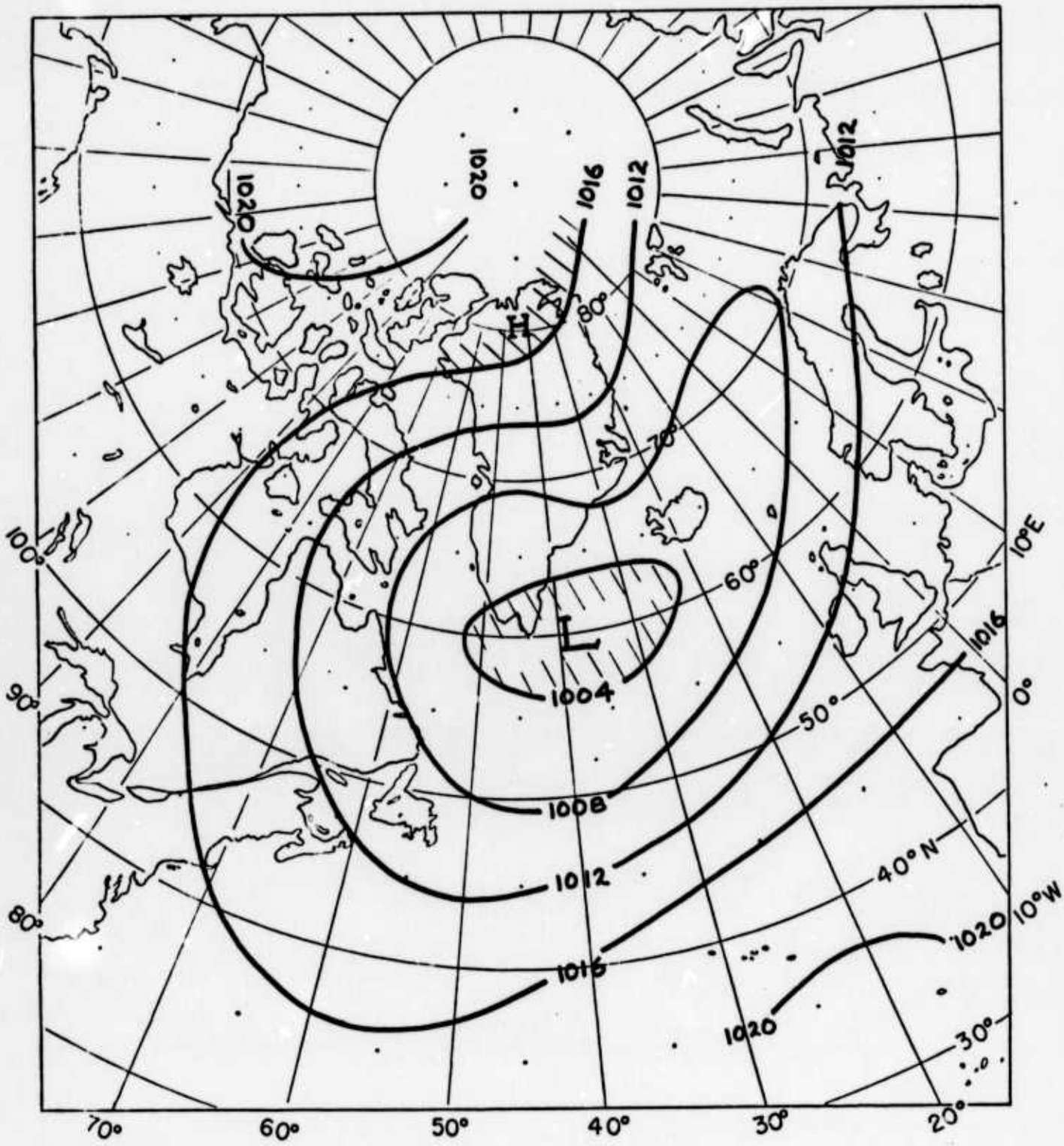

Fig. 4. December-May 1921-1950 Pressure (mb).

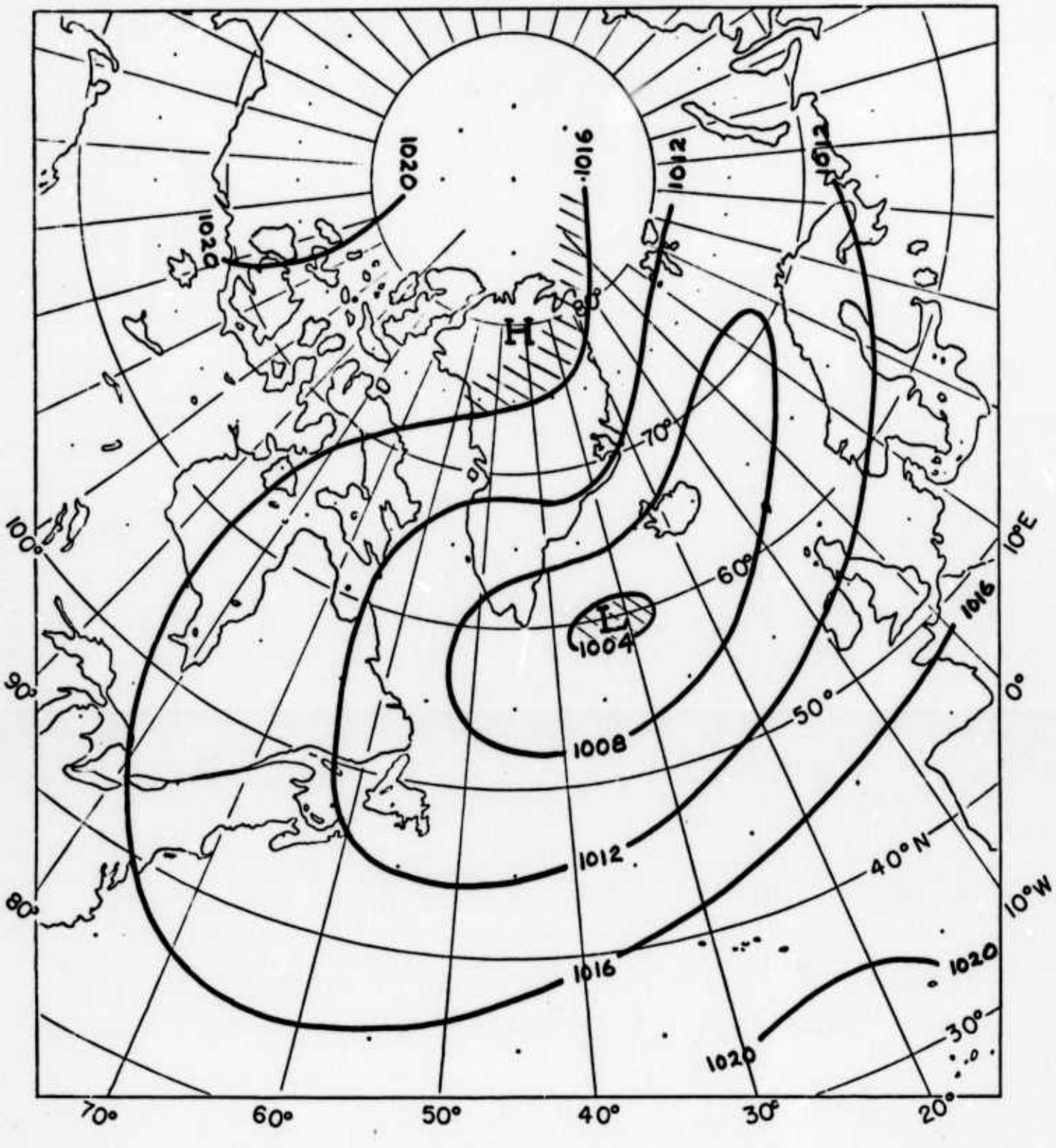

Fig. 5. December-May 1951-1960 Pressure (mb).

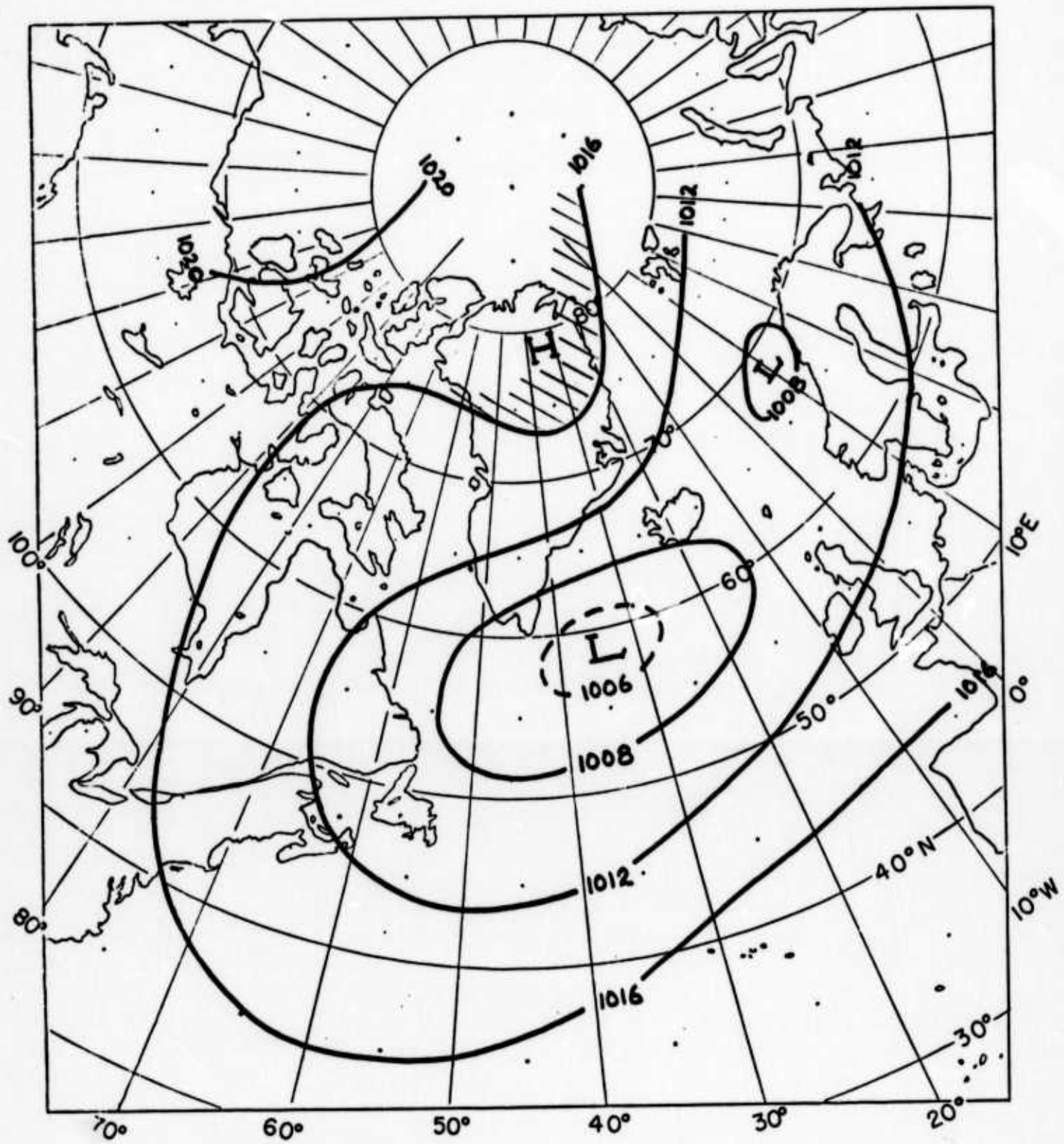

Fig. 6. December-May 1961-1970 Pressure (mb).

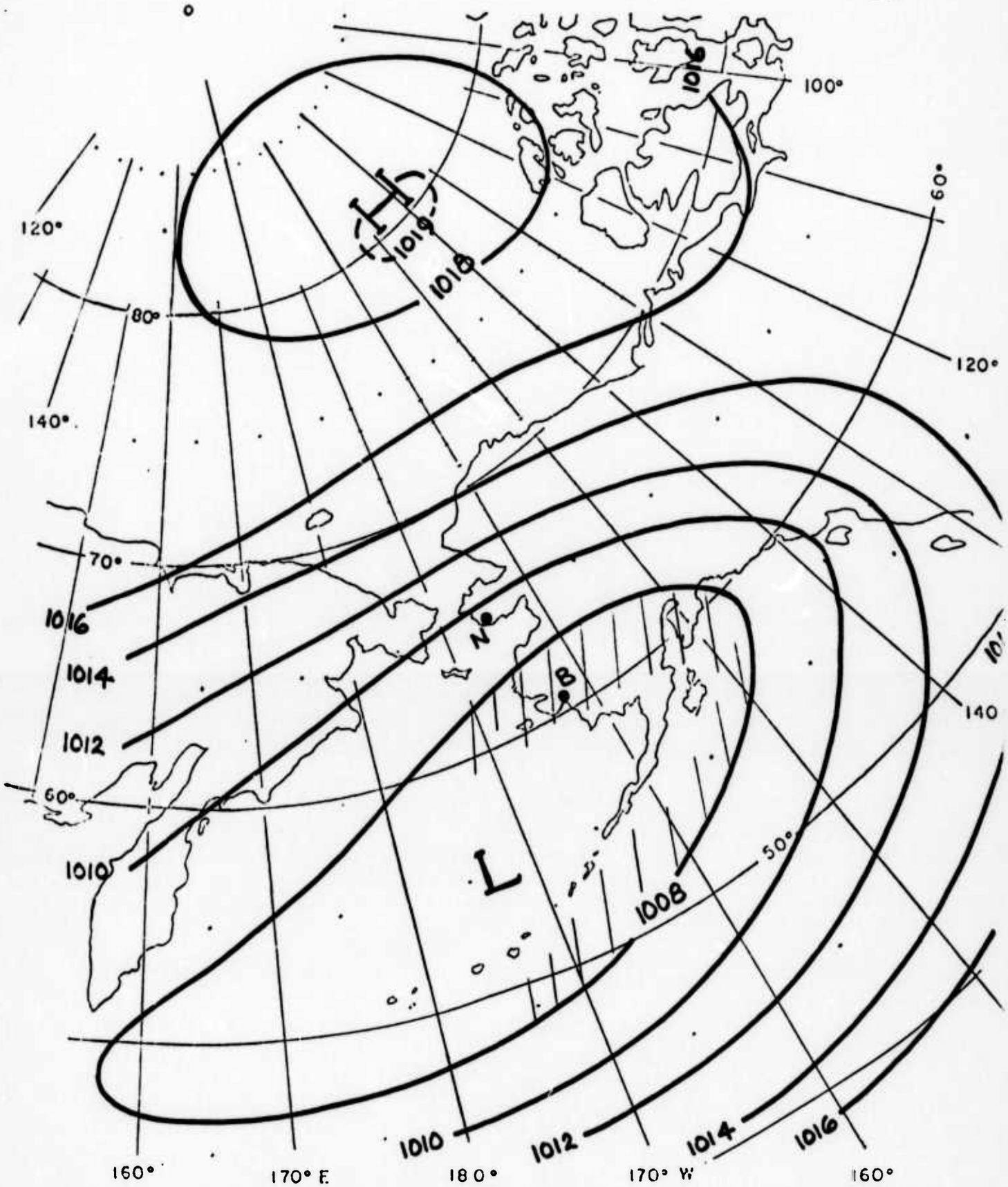

Fig. 7. 1921-1950 Annual Pressure (mb).

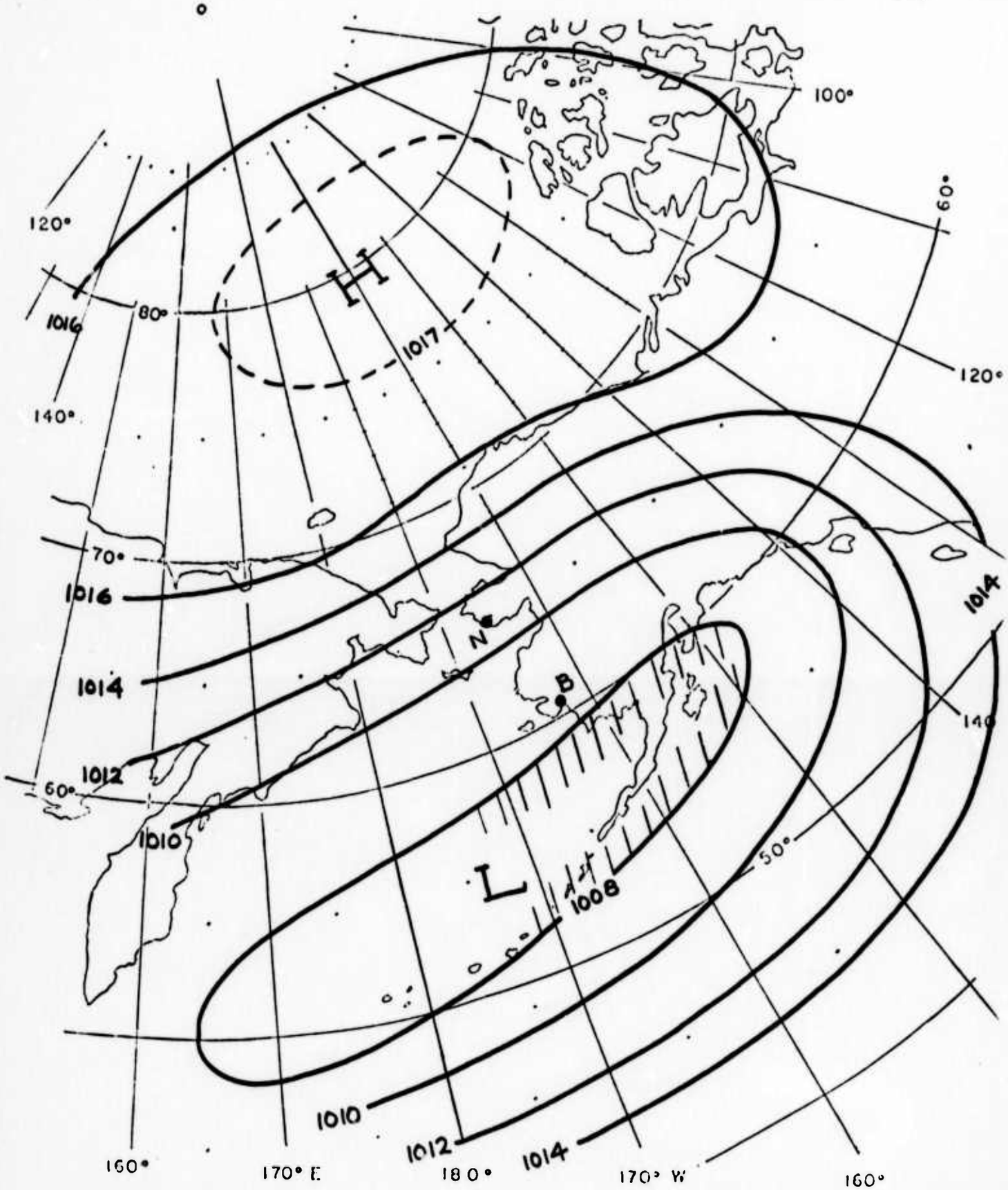

Fig. 8. 1951-1960 Annual Pressure (mb).

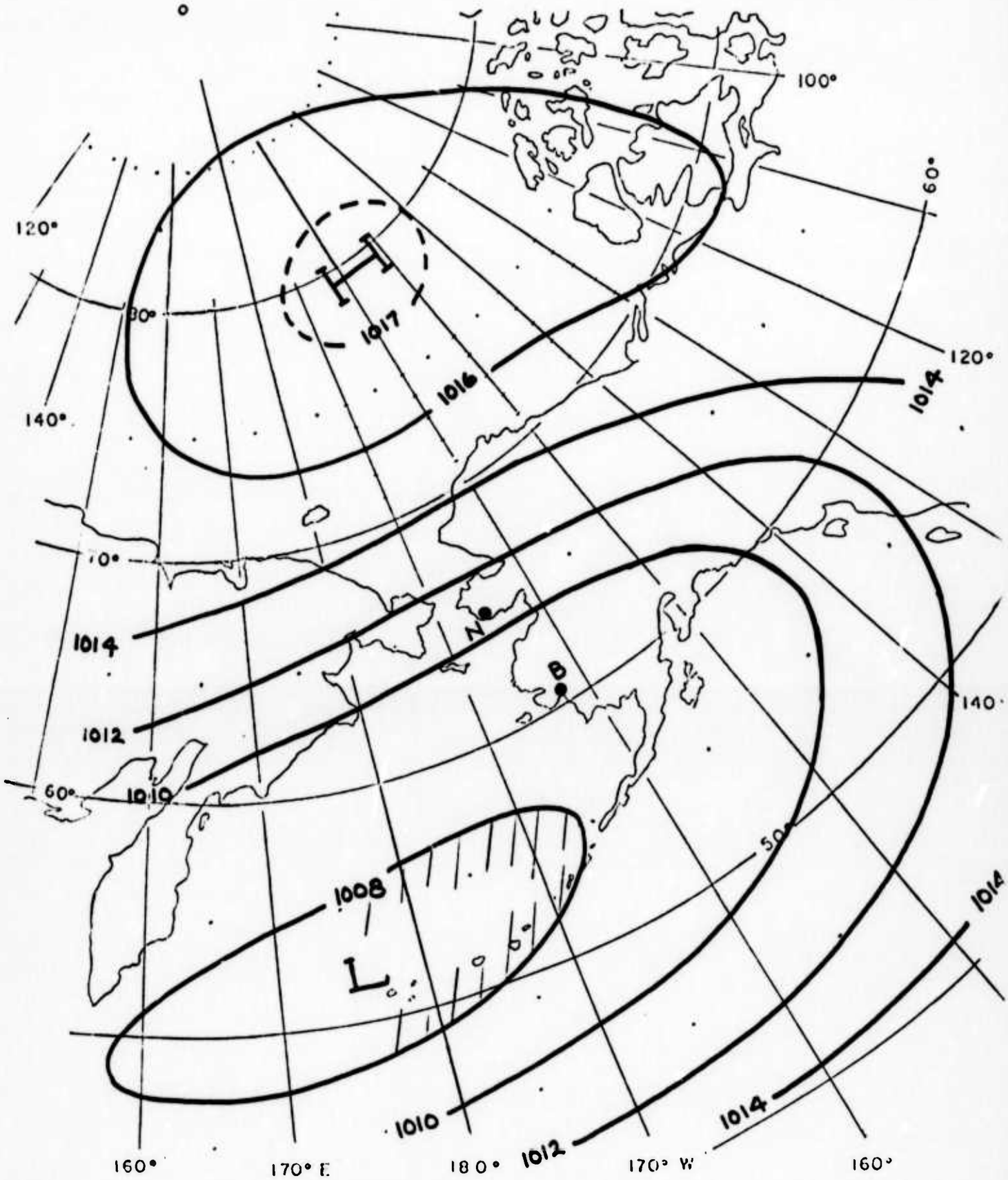

Fig. 9. 1961-1970 Annual Pressure (mb).

2. December-May. A similar trend appears in the December-May season when St. Michael is on the average beset by ice as reckoned in whole months. Figs. 10-12 show isobar 1008 mb reaching northeastward into southwestern Alaska in 1921-50, and again stopping short of the Peninsula in 1961-70, showing a progressive withdrawal of the Low southwestward . A filling-in of the Aleutian Low in the 1951-60 and 1961-70 periods is revealed from the absence of the 1004 mb isoabar shown in the 1921-50 period (Fig. 10). This is accompanied by lowering temperatures in both the 1950's and the 1960's (see below).

E. Temperature

Table 1 giving the mean annual as well as December-May temperatures at Stykkisholm and Teigarhorn (Iceland) shows a decrease in the 1951-60 decade from its 1921-50 averages and a further decrease in the 1961-70 decade, in accordance with an increased inflow of cold air from the north in the 1950's and again in the 1960's as compared with the 1921-50 period.

Table1 similarly giving the mean annual as well as the December-May temperatures at the Alaskan stations Nome and Bethel opening on Bering Strait shows a decrease during the 1951-60 decade from the average of the preceding 1921-50 period and a further decrease in the annual though not in December-May, in the 1961-70 decade (see below), in keeping with the southwestward withdrawal of the Aleutian Low and a presumed lesser inflow of relatively warm air from the ocean modified by its passage over land.

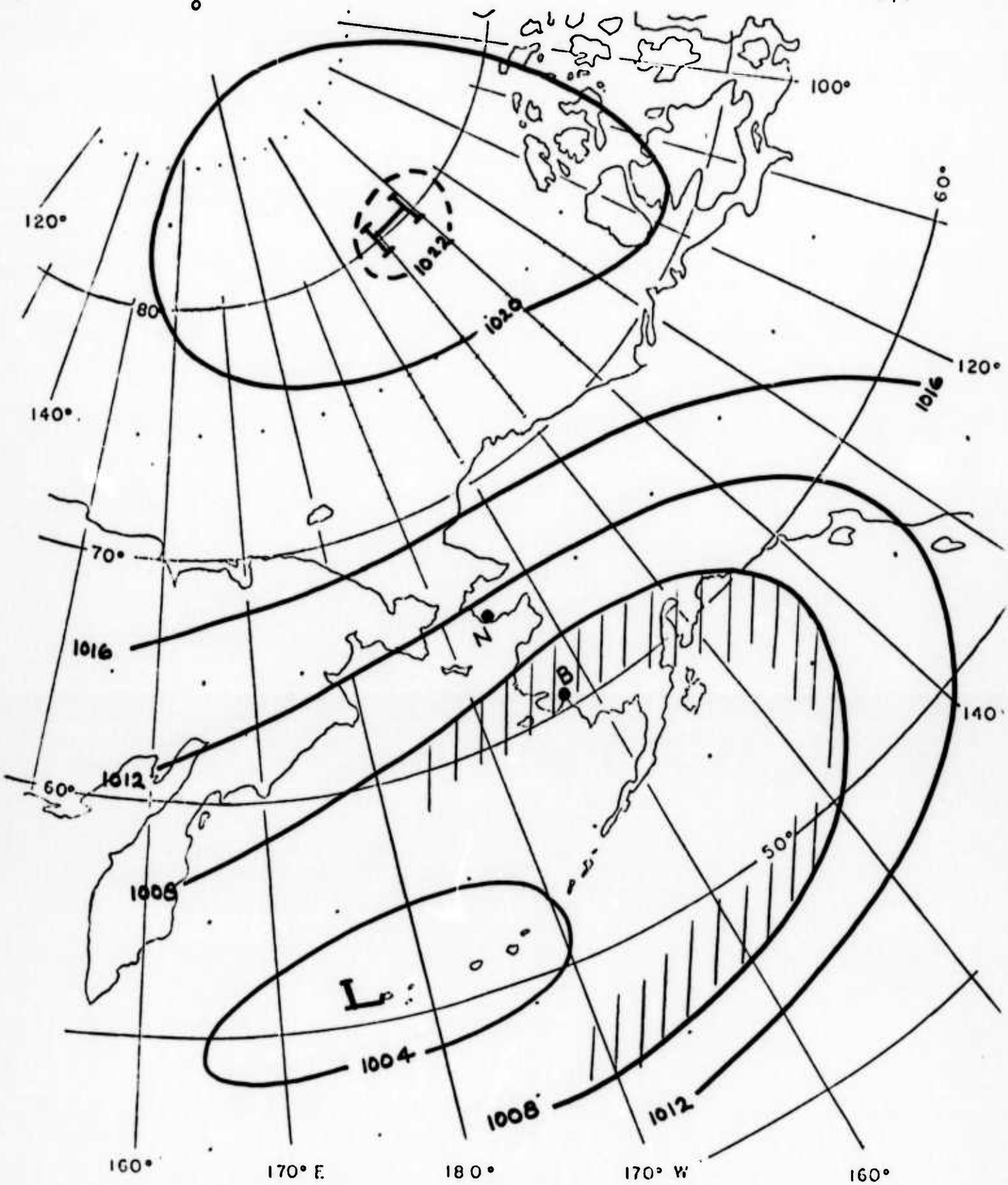

Fig. 10. December-May 1920/1-1949/50 Pressure (mb).

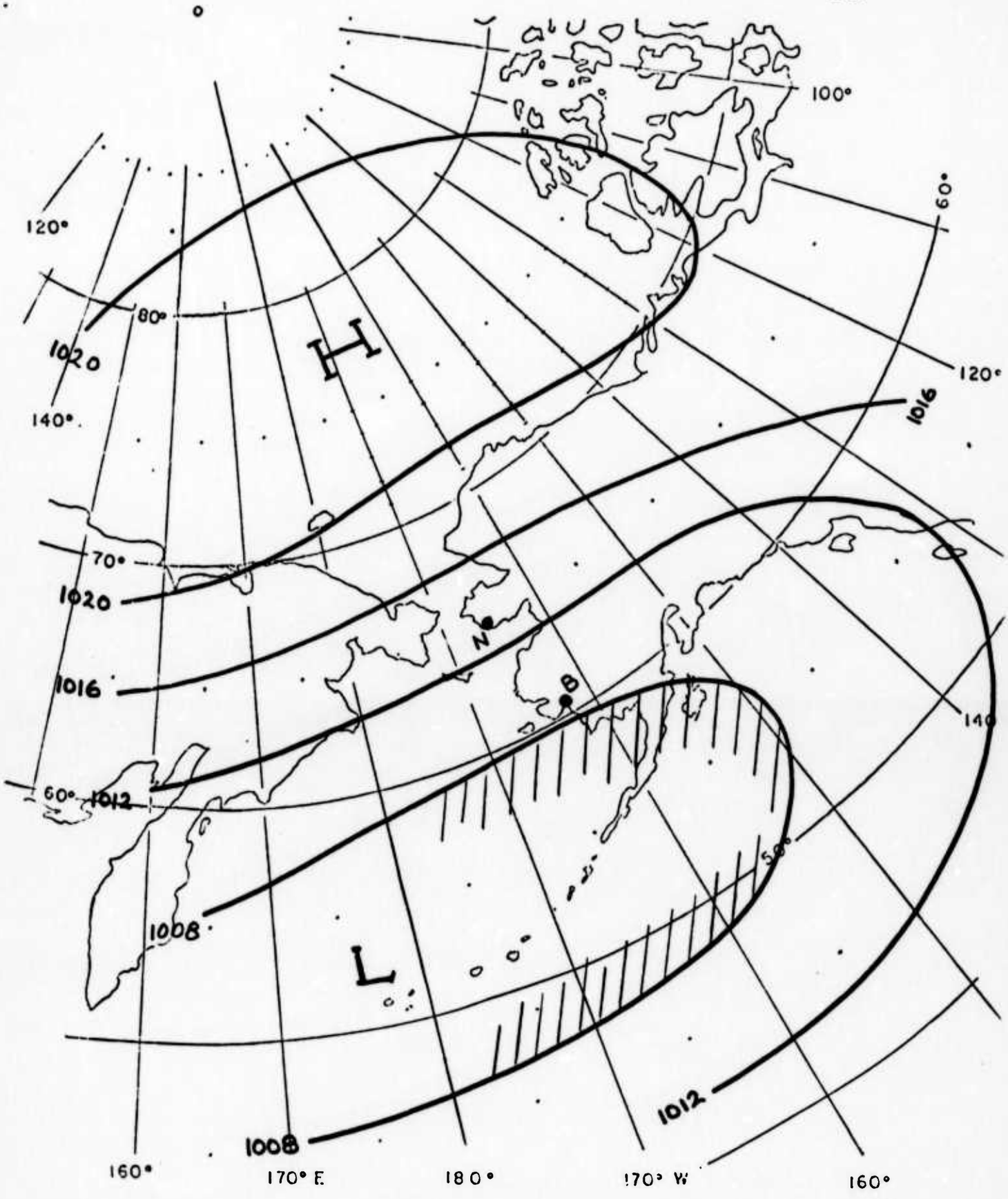

Fig. 11. December-May 1950/1-1959/60 Pressure (mb).

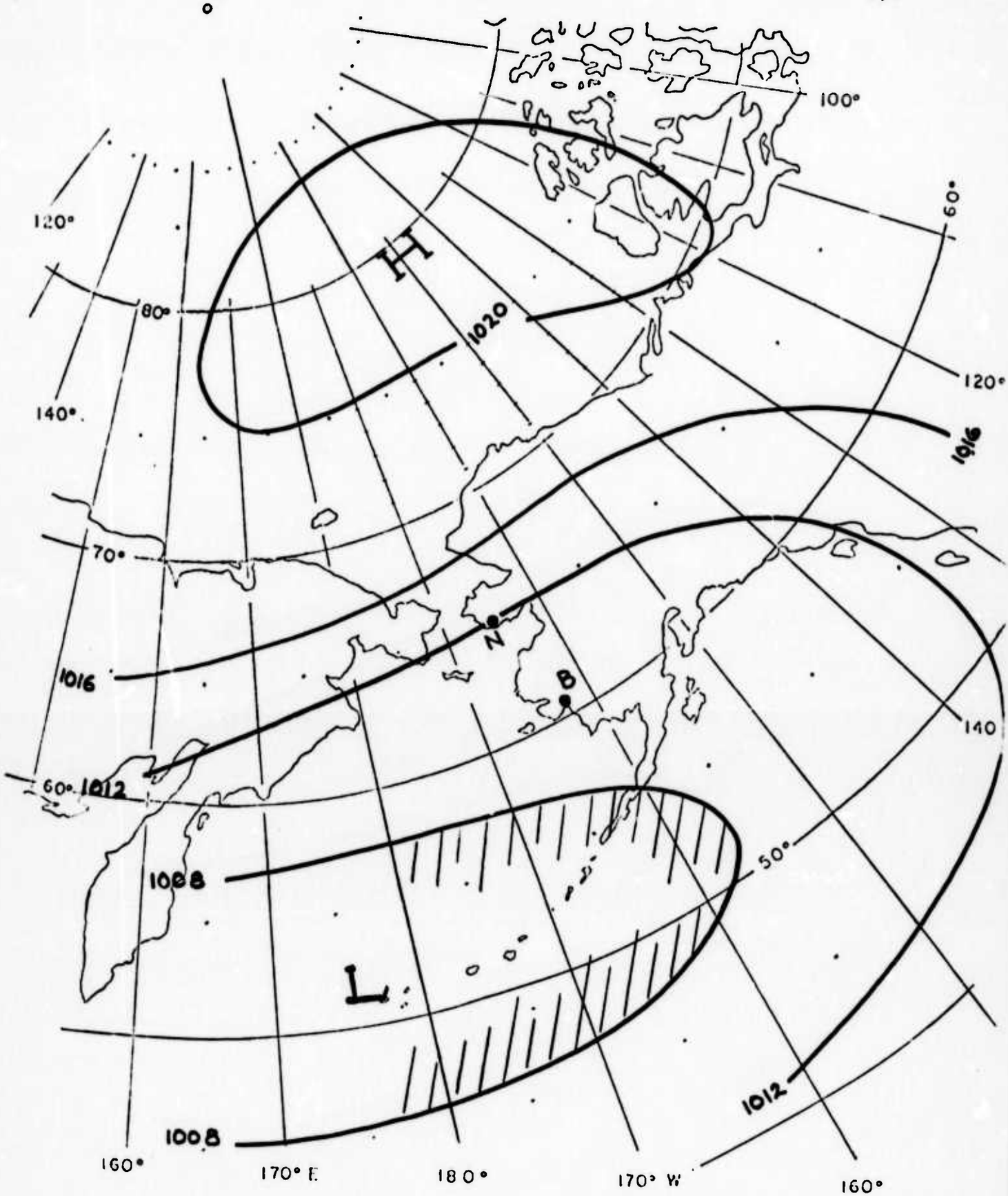

Fig. 12. December-May 1960/1-1969/70 Pressure (mb).

We are at a loss to explain the lack of a further decrease in the December-May temperatures at Bethel and Nome in the 1960's unless it arose from a change in the site at Bethel and to an elevation of the thermometer to 125 feet from 10 feet, which would raise its temperature in winter due to the inversion, and also a move of the Nome station from its previous site.

Table 1. Mean annual and December-May temperature deviations at Nome and Bethel in Alaska and at Stykkisholm and Teigarhorn in Iceland in the 1951-60 and 1961-70 decades from their respective 1921-50 averages.

	Nome		Bethel		Stykkisholm		Teigarhorn	
	Ann.	Dec-May	Ann.	Dec-May	Ann.	Dec-May	Ann.	Dec-May
	°C	°C	°C	°C	°C	°C	°C	°C
1951-60	-0.2	-0.9	-0.5	-1.3	-0.1	-0.3	-0.2	-0.6
1961-70	-0.6	-0.6	-1.2	-0.8	-0.7	-0.7	-0.8	-0.8
1921-50 (average)	-3.2	-10.2	-1.4	-8.3	4.1	1.4	4.6	2.3

F. Remarks

Our attempt to show synchronism in the changes in the No. Atlantic-Arctic and the No. Pacific Arctic by comparing the circulation (pressure distribution), air temperatures, and the ice conditions off Iceland with those in Bering Strait can be said to have been moderately successful.

A moderate degree of synchronism between the two regions is shown by the southwestward retreat and filling-in of the Aleutian Low in the 1951-60 decade as compared with the 1921-50 period preceding it, and again a further retreat and a filling-in

of the Low in the decade 1961-70 on the one hand, and a progressive shrinking and a filling-in of the No. Atlantic Low and a southward extension of the Arctic High over northern Greenland affecting Iceland in the 1950's and 1960's on the other. Similarly, the lowering of the annual and December-May temperatures in the 1950's in both regions and the further lowering of the annual and December-May temperatures in the 1960's in Iceland and possibly also in Alaska signifies again a certain synchronism in the climatic changes of the two regions.

The record of opening and closing dates to navigation at St. Michael opening up on Bering Strait in the 1960's, as this is being written, is not yet available to allow a comparison with the ice conditions off Iceland.

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