

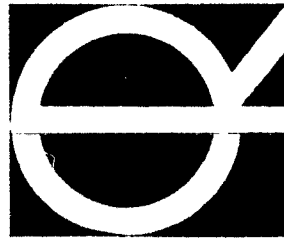
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Research Report

**ATLAS OF MONTHLY MEAN STRATOSPHERE CHARTS, 1955-1959
PART II, JULY-DECEMBER**

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ATLAS OF MONTHLY MEAN STRATOSPHERE CHARTS, 1955-1959. PART II, JULY-DECEMBER

ABSTRACT

This volume is the second of two depicting average conditions in the stratosphere over the northern hemisphere during the period July 1955 to July 1959. Monthly mean charts of contours and isotherms are presented for the 100-mb, 50-mb, and 25-mb levels for each of the 48 months. In addition, four-year composite means are presented for each of the twelve months of the year at each level. The maps clearly show how the monthly mean pattern for a winter month can vary considerably from year to year, whereas the patterns for the summer months vary but little from year to year.

INTRODUCTION

There are several ways to describe the circulation patterns of the stratosphere as they are observed, and during recent years many subjective and objective descriptions have been prepared, each with a slightly different purpose. One of the first comprehensive graphic descriptions was done by Kochanski (1953) who presented data in the form of midseasonal cross sections. Wege (1957, 1958) presented a series of monthly mean northern hemisphere charts at 100 mb and 50 mb, based on data from 1949 to 1953. Wege showed, among other features, substantial longitudinal variations in the circulation patterns, even when five years of data were averaged. A report by Wege and others (1958) presented seasonal mean charts at levels from 30 mb to 15 mb along with seasonal cross sections at several longitudes. More recently, a group directed by S. Teweles under the U.S. Weather Bureau (1960, 1961) has been publishing a series of daily charts at 100 and 50 mb during the IGY. In addition, daily charts for the 100, 50, and 25 (or 30) mb level have been published by Scherhag (1960) for the past several years, based on teletype data.

Graphic descriptions of the stratosphere have both uses and limitations and none is suitable for all purposes, nor answers all questions. The Atlas contained herein sets no precedent along these lines. The justification for the creation of this Atlas is that it presents better answers to some questions and uses more recent data than many of the other studies. Thus the purpose is twofold - to present recent data in a summarized form and to answer certain questions on the reliability of normal charts based on a few years of data.

The method of summarizing the data was simply to construct monthly mean charts for four years at the 100-mb, 50-mb, and 25-mb levels. A four-year period was chosen because data summaries were available from 1955 through 1959, and indicated something of the difference in

behavior of the circulation from one year to the next. Also, it was found to be convenient to use graphical averaging in obtaining overall means for each month, and it is easier to graphically average four rather than three or five. The data might have been summarized in the form of daily charts as the USWB group is doing for the IGY, but this is an exhausting task in terms of plotting, analyzing, drafting, and reproduction. On the other hand, seasonal charts or charts of midseasonal months hide much of the variation of one year from another. As a compromise, the data are summarized in the form of monthly mean charts. The one-month period is not unique, and if the wind and temperature spectra were investigated (Chiu, 1960) a meteorologically more significant time period might be found (the author prefers 15-day periods for the stratosphere, especially during fall, winter, and spring), but the one-month period is compatible with previous studies by Wege and with monthly mean charts at 500 mb published by the long-range forecast group of the USWB.

DATA SOURCES

Ideally, for a study of this sort there should be a comprehensive network of stations with sufficient compatible radiosonde observations to permit reliable computations of mean temperature, mean pressure-height, and mean vector wind. With limited time, funds and manpower, however, many compromises had to be made with regard to data, and it is hoped that such compromises did not seriously affect the accuracy of the charts.

To avoid needless duplication, summaries of previously computed monthly mean data were assembled and tabulated:

1. Climatological Data, National Summary, USWB, Asheville, N.C., July 1955 - June 1959.
2. Monthly Climatic Data for the World, USWB, Asheville, N.C., September 1956 - June 1959 (no data above 150-mb level prior to September 1956; none above 100-mb level after September 1956).
3. Mean Monthly Upper Tropospheric Circulation Over the Tropical Pacific During 1954 - 1959, Joint Task Force Seven, Meteorological Center, University of Hawaii, Vols. 1, 2 and 4.
4. Aerological Data of Japan, Japan Meteorological Agency, Tokyo, Japan, July 1955 - September 1959.

Data were extracted from the original charts used to prepare "Monthly mean 50-mb and 100-mb Charts Preceding the IGY" by Hans A. Panofsky, Pennsylvania State University, University Park, Penn., Final Report, Part III, AF19 (604)-2180.

A special summary, "Mean Upper Air Data and Statistics for Northern Hemisphere, 50- and 25-mb Levels, July 1958 to December 1959," was prepared for this project by the Data Processing Division, Climatic Center, AWS, Asheville, N.C.

Even with all these summaries, it was still necessary to compute additional monthly mean data to fill in regions of sparse data, and for this purpose the following data sources were used:

1. Daily series, Synoptic Weather Maps, Part II, Northern Hemisphere Data Tabulations, USWB, July 1955 - June 1959.
2. Summary of Constant Pressure Data, WBAN Form 33, National Weather Records Center, Asheville, N.C.
3. IGY Microcards, Form 3 (Radiosonde and Rawinsonde Observations) and Form 4 (Upper Wind Observations), WMO/OMM Geneva, Switzerland.

An extensive series of monthly mean data was received from Massachusetts Institute of Technology covering the period July to December 1957. The data was a by-product of a general circulation project underway at M.I.T. under the direction of Victor P. Starr.

DATA PROCESSING AND PLOTTING

Analysts working with radiosonde data at levels of 100 mb or higher over the northern hemisphere are plagued with problems of errors in the data. The random day-to-day errors become greatly smoothed by time averaging of the data and the RMSE (root-mean-square error) of the mean of 25 observations would be but 20 percent of the RMSE of a single observation (assuming a normal distribution of errors). Since the RMSE's or noise level of United States radiosonde data at 50 mb appear to be about 53 meters in pressure height, 1° to 2° C in temperature and 8 to 10 knots in wind (Muench, Hering), and foreign data do not appear to be too much worse, then the mean value of a month of data should be reasonably accurate so that horizontal smoothing, using a vast number of stations, is not necessary.

A second source of error in the data, that due to incompatibility between different sondes and different times of ascent, is not affected by averaging and remains to annoy the analyst. The groups at Pennsylvania State University and the USWB worked up elaborate schemes to correct for incompatibility. Unfortunately, some of the summarized data sources are not clear as to the type of instrument used, any corrections used, or even the time or rate of ascent. The simplest approach to this problem was found to be the use of only nighttime pressure-height and temperature data.

and winds from either observation. Apparently, most of the incompatibility among different instruments is due to solar radiation heating of improperly ventilated temperature elements, and this source of error is lacking at night. There still remained problems because some stations took only daytime soundings; other stations, because of their location, sent up soundings in daytime at both observation periods during the spring and summer season; and there was some incompatibility among different types of sondes even at night. These problems were approached in the analysis stage by subjectively modifying or ignoring certain data and relying heavily on mean vector winds and data from U. S. radiosonde instruments abroad.

In the process of computing additional mean data to fill in regions of sparse data, the number of observations necessary to compute a reasonable mean was noted, since it was a bit difficult to work with some of the raw data. The usual procedure is to average all of the observations. The day-to-day temperature changes in the stratosphere, however, are nearly always small compared to changes over periods of weeks or months, so that daily observations are not really very independent. This means that only a few observations are necessary to obtain a representative value, and more observations would be useful only to reduce the inherent random error.

As an example of how few observations are necessary to produce reasonable mean heights and temperature, a month with great variation in temperature and height was selected. In January 1958, the data for 00Z at 100 mb at Thule, Greenland were tabulated, and mean heights and temperatures were computed with different numbers of observations equally spaced throughout the month. The averages, and temperature data are shown in Fig. 1. The averages, using different numbers of observations, are shown in Table 1, and the error, or difference from the mean of 31 observations, is shown in Fig. 2 as a function of the number of observations. (The approximate RMSE's of a single observation are indicated on the margins.) It should be noted that the observation for 25 January was missing and data for that date were estimated by linear interpolation between data from the 24th and 26th.

Obviously from this example, which represents a case of extremely great variability, a relatively small number of evenly spaced observations, as few as eight or ten, will produce very satisfactory means. This is not too surprising, considering that the USWB computes means of daily temperatures based on only two points, the maximum and minimum temperature. With stratosphere data, however, it is desirable to reduce both sampling bias and effects of errors in individual observations, so it seems necessary to use at least eight days per month, while more than fifteen is super-

fluous. In practice it was found convenient to use ten observations, since division of the summation is so simple.

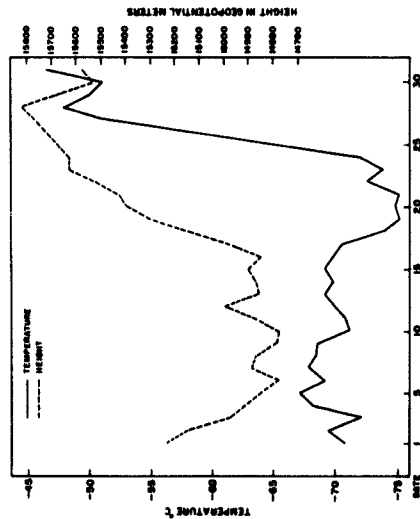


FIG. 1. Daily 100 mb 00Z temperature and height at Thule, Greenland, January 1958.

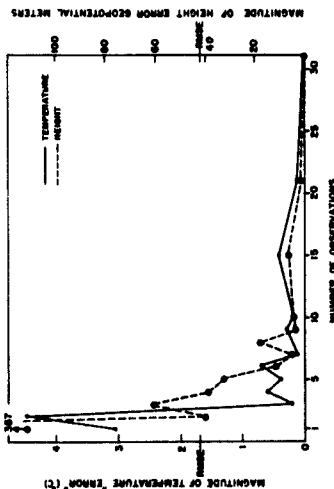


FIG. 2. Magnitude of "error" of means computed from evenly spaced observations.

Looking at the curves of height and temperature in Fig. 1, one may easily see how strongly biased means might arise if even five or ten days of observations, bunched in either the first or second half of the month, were missing. And considering that monthly means of data from high latitude stations are often made from fifteen or fewer observations, sampling bias could easily be a problem especially in mean data that are already summarized. In many cases five evenly spaced observations will produce a better mean than ten or fifteen nonuniformly spaced observations. In practice, efforts were made to use temporal or vertical extrapolation to fill in missing observations and insure against sampling bias when means were computed by this group.

Published means were checked and corrections made when necessary if there were indications that sampling bias might be present. For this reason differences will be found between some of the maps in this study and those published by Pennsylvania State University, particularly those on high latitudes during winter months. In general, the data were processed so as to reduce errors due to instrumentation and to sampling, and it is hoped that the results were better than might be obtained from blindly analyzing unprocessed data.

TABLE 1. Mean heights and temperatures by using different numbers of observations.

Number	Mean Height, Meters	Mean Temperature, °C
1	14,849	-69.9
2	15,246	-71.1
3	15,144	-66.9
4	15,245	-66.1
5	15,173	-67.1
6	15,218	-67.4
7	15,211	-66.8
8	15,188	-66.9
9	15,202	-67.0
10	15,211	-66.9
15	15,200	-67.1
21	15,204	-66.6
31	15,206	-66.7

ANALYSIS

The analysis procedure was rather straightforward, though admittedly subjective. The flow patterns as indicated by mean winds were quite simple with only a few troughs and ridges, and there was little difficulty in drawing smooth contours consistent with the accuracy of the data. For the most part, the winds were assumed to be geostrophic at least south to 10° north latitude. There were some indications of small systematic ageostrophic components in the entrances and exits of strong wind maximums, but the magnitude of these components was probably less than five knots. The contour analyses were continued right down to the equator where the winds were, of course, not geostrophic; but streamlines were entered in low latitudes to indicate at least the direction of the flow.

As mentioned previously, four-year means computed graphically for each month and each level are included. Since a large part of the variance in the wind at low latitudes is contained in a period of oscillation of 24 to 27 months (Reed et al.; Verrard and Ebdon) and there is little amplitude in a twelve-month period, there seemed no point in analyzing the four-year means below 15° north latitude.

RESULTS

The charts for 100 mb, 50 mb, and 25 mb for July through December are presented, assembled in order of month, level and year. The four-year means are also included. The contour spacing is for every 100 meters of height from July through September and for every 200 meters of height from October through December. The contours are labelled in tens of meters on charts from July through September (four digits) and in hundreds of meters from October through December (three digits). The temperature spacing is for every 10°C at 100 mb and for every 5°C at 50 mb and 25 mb. Intermediate contours and isotherms have been added to better define temperature and contour patterns. Customary H and L symbols have been added. At times, several H's are present along a ridge line even though there is little evidence of separate centers, in order to emphasize the direction of the gradient. Temperature maxima and minima have been designated by W for warm and C for cold.

The maps quantitatively demonstrate features that were previously known qualitatively. The average circulation patterns of some months appear to be quite similar from one year to the next, notably July through October and to some extent November. Thus the four-year mean for these months should be representative and useful. The patterns of December vary considerably from year to year, particularly in high latitudes, and as an extreme, at 25 mb there is a difference in pressure-height gradients of more than 750 meters between the mean pressure-height gradients for December of 1957 and December of 1958. This probably indicates that the four-year mean for this month is not a very good estimate of the long-term mean (say the twenty-year mean) and also that a long-term mean would not be very useful as an estimate of the average circulation pattern for the month of December much less as an estimate of the daily circulation pattern.

At 50 mb and 25 mb, the biennial equatorial wind oscillation, investigated by Reed and by Veryard and Ebdon, clearly shows east winds one year switching to westerlies the following year and returning to easterlies the third year. There was good evidence that at 100 mb both easterlies and westerlies were often present in the means at the same time but at different longitudes around the equator. There is still much to be explained of equatorial circulation patterns, particularly in the stratosphere.

The four-year means compared quite closely to those obtained by Wege from 1949 to 1953 data. In general, the heights for this four-year period were slightly lower than those found in Wege's study, both in high and low latitudes, and it is not known whether this is real or because this author used only nighttime heights and temperature data.

The contour patterns on Wege's maps do appear slightly less zonal south of 25° latitude than on these charts. Otherwise the patterns appear similar, and heights, temperatures and winds derived from one set would no doubt be similar to values derived from the other.

Perhaps after another couple of years, a similar study will be made using data from July 1959 through June 1963 and the results of the new study, this study and Wege's study combined to produce a fairly reliable set of monthly normal charts for the stratosphere. It would also be nice to have maps of standard deviations of wind, temperature, and height about individual monthly means. This Atlas gives information on how the individual monthly mean circulations differed from the four-year mean and indicates to some extent the usefulness of the four-year mean in specifying the circulation for any one month. Information of the extent to which any monthly mean chart can be used to specify the circulation for any individual day would be desirable, and standard deviations would certainly be useful for this purpose.

TABULATION OF MEAN WIND, MEAN HEIGHT AND MEAN TEMPERATURE

Although the form of presentation in the Atlas is considered appropriate from a meteorological point of view, it may not be desirable for general engineering use. Therefore, immediately following the charts, some of the information is presented in tabulated form. These tables contain values of the mean wind, mean height, and mean temperature taken from the graphically averaged four-year mean charts for each of the mid-seasonal months.

The geostrophic wind approximation was used to obtain mean vector winds from the analyzed geopotential fields. Mean winds and interpolated values of height and temperature are given for 10° latitude intervals for latitudes 20°N through 80°N and at 30° longitude intervals around the hemisphere. In addition, mean values of height and temperature are presented for the North Pole.

In the tables the mean vector wind directions (DD) are rounded to the nearest 10°, and the velocities (VV) are rounded to the nearest 5 knots when the extracted value was less than 30 knots, and to the nearest 10 knots when the extracted value was over 30 knots. If the extracted velocity was less than 3 knots, a 00 code is entered in the table under VV. In the case of a calm, both DD and VV are coded as 00. Perhaps it should be emphasized at this point that the direction is the direction from which the wind is blowing. The mean heights are tabulated in 10's of geopotential meters* and the mean temperatures to the nearest degree (Centigrade).

*By meteorological convention, units of geopotential meters are merely geometric meters multiplied by local values of the acceleration of gravity (g) and then divided by 9.8 so that geopotential meters are actually units of specific energy and not of geometric height. However, the geopotential meter has been defined so that specific energy in these units is numerically very close to geometric height in meters. For example, at the equator the geometric height would be two-tenths of a percent higher than the geopotential height, while at the North Pole it would be three-tenths of a percent lower.

Contents of the Tables

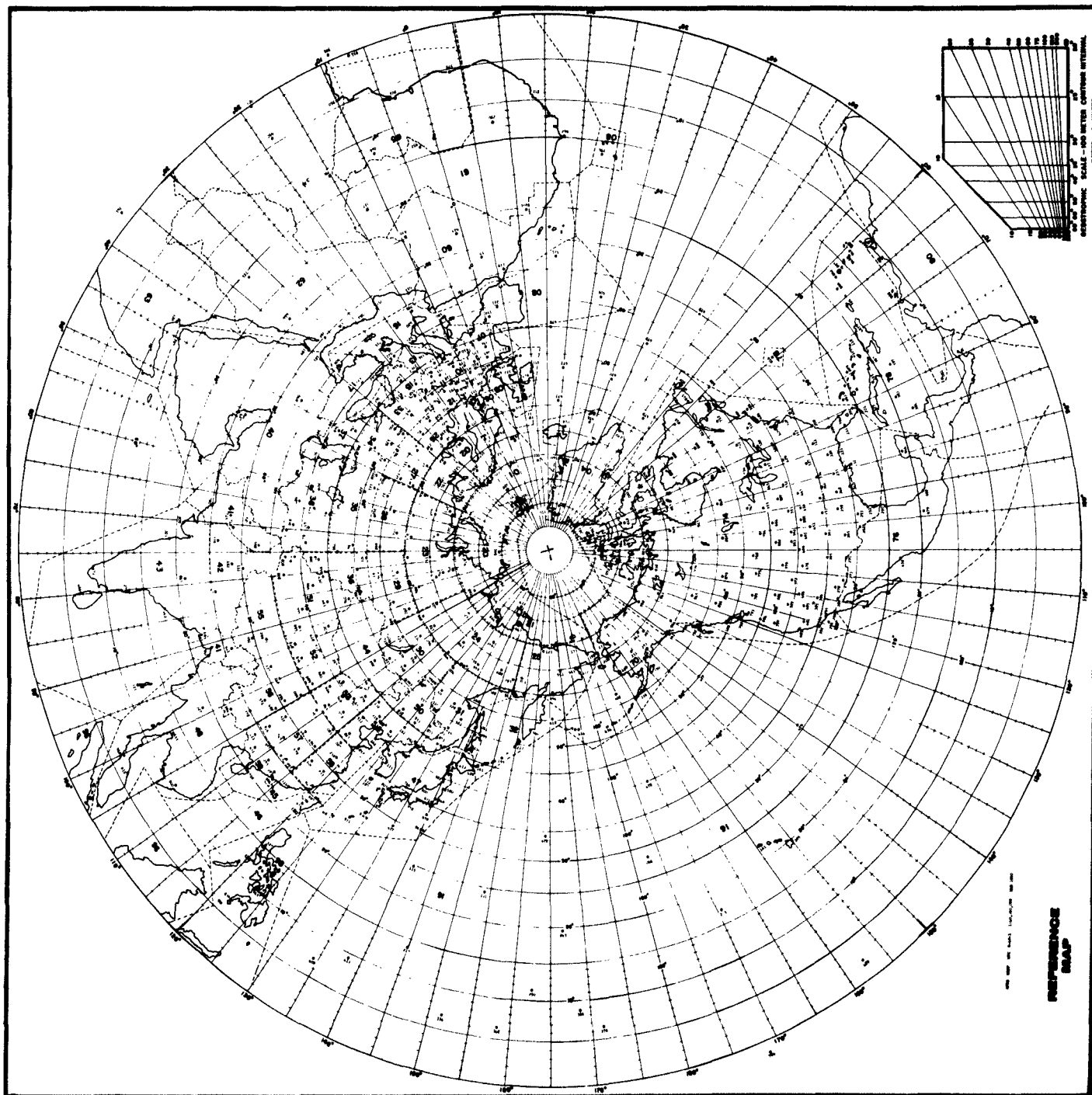
Tables 1A, 2A, 3A, and 4A show values of the mean vector wind at 100 mb, 50 mb, and 25 mb for the months of January, April, July, and October, respectively.

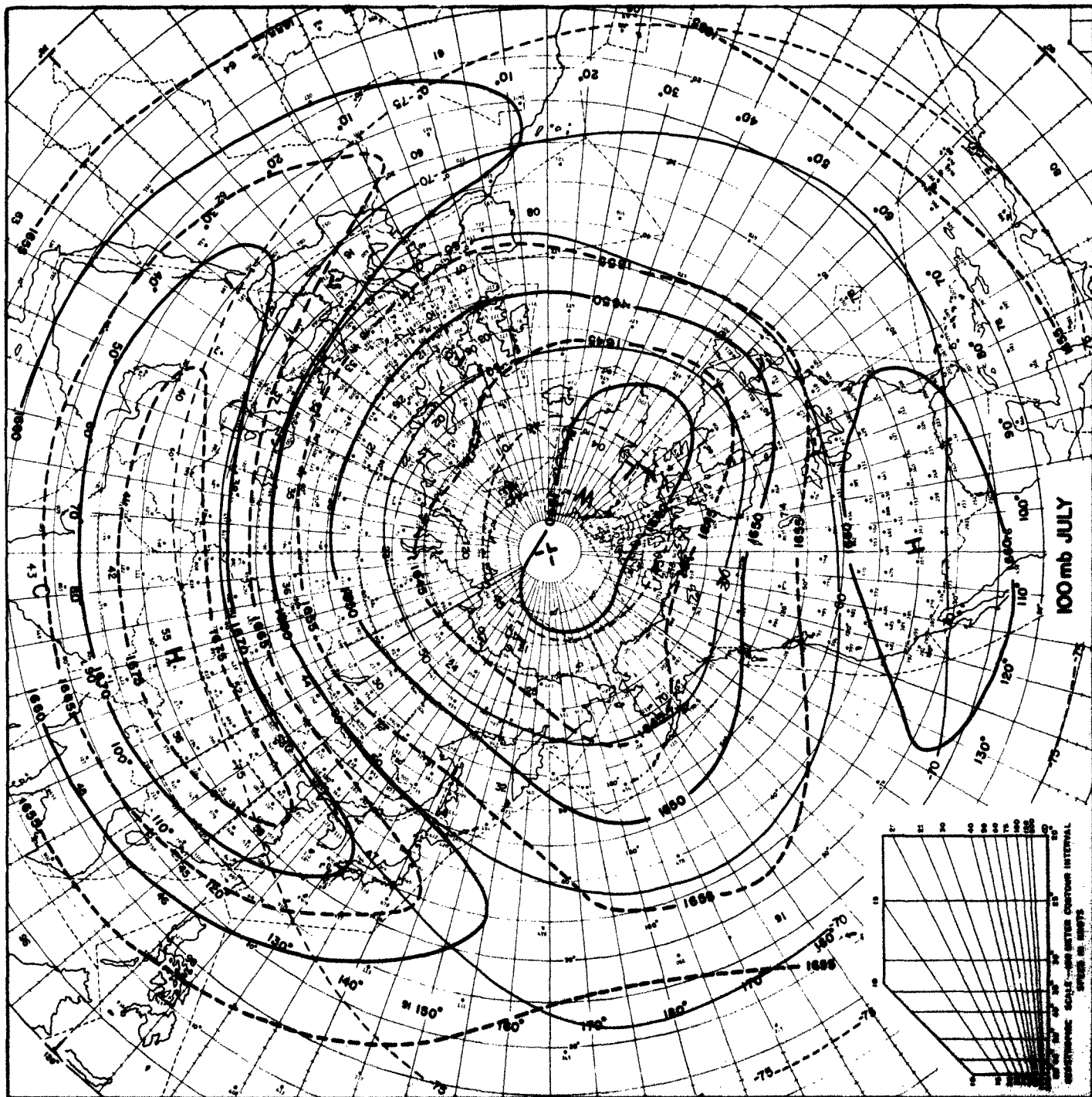
Tables 1B, 2B, 3B, and 4B show values of the mean height at 100 mb, 50 mb, and 25 mb for the months of January, April, July, and October, respectively.

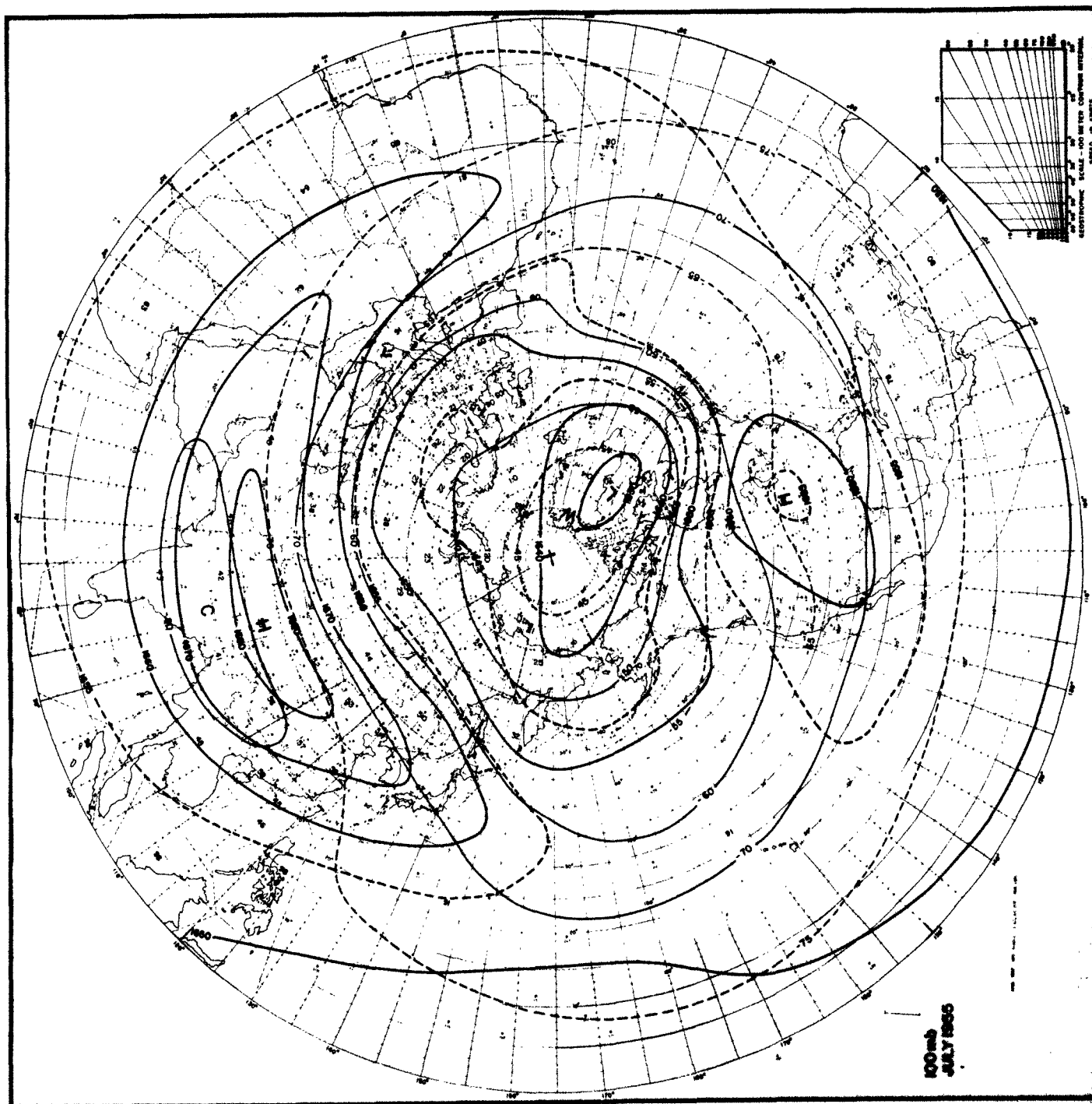
Tables 1C, 2C, 3C, and 4C show values of the mean temperature at 100 mb, 50 mb, and 25 mb for the months of January, April, July, and October, respectively.

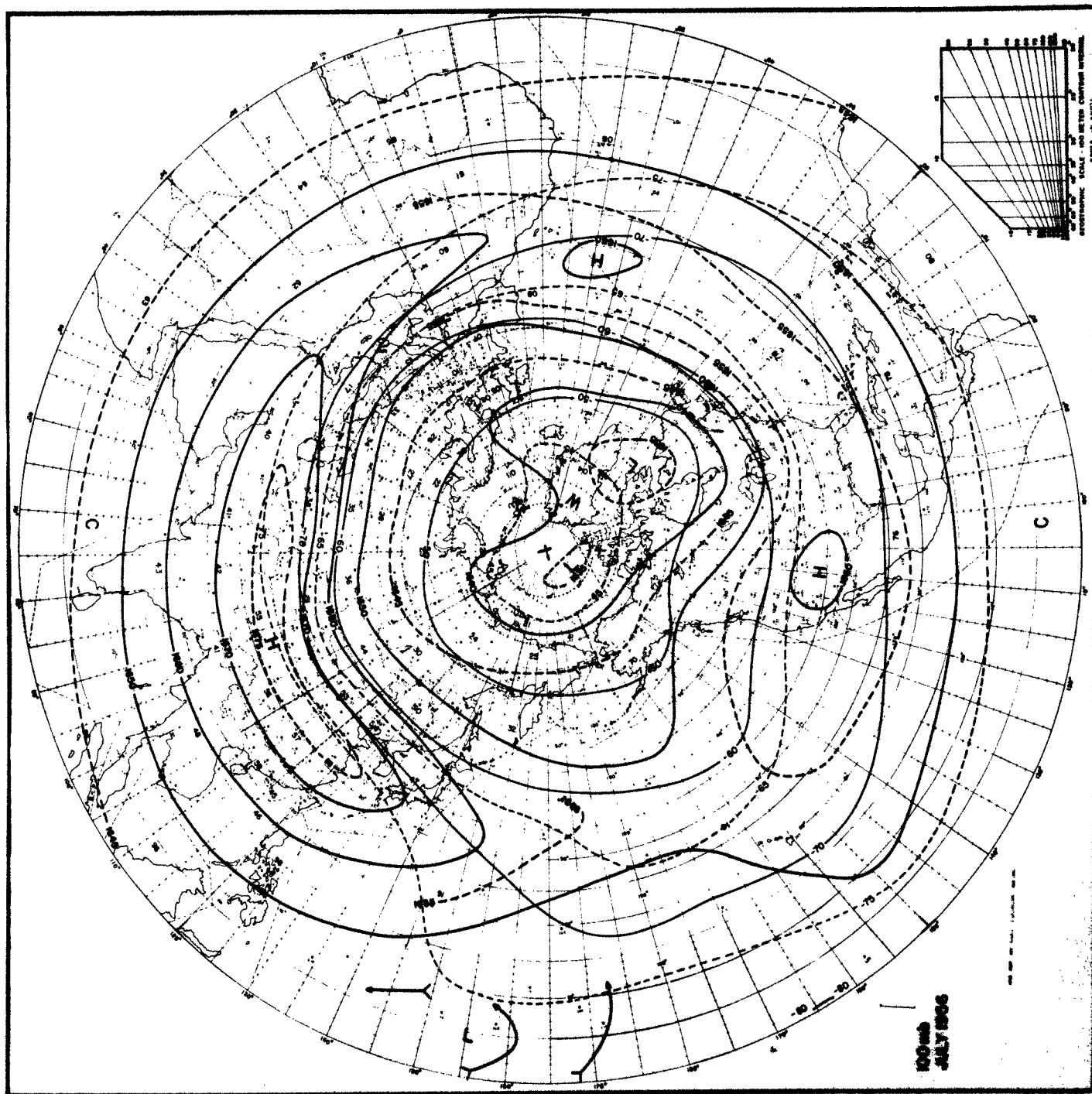
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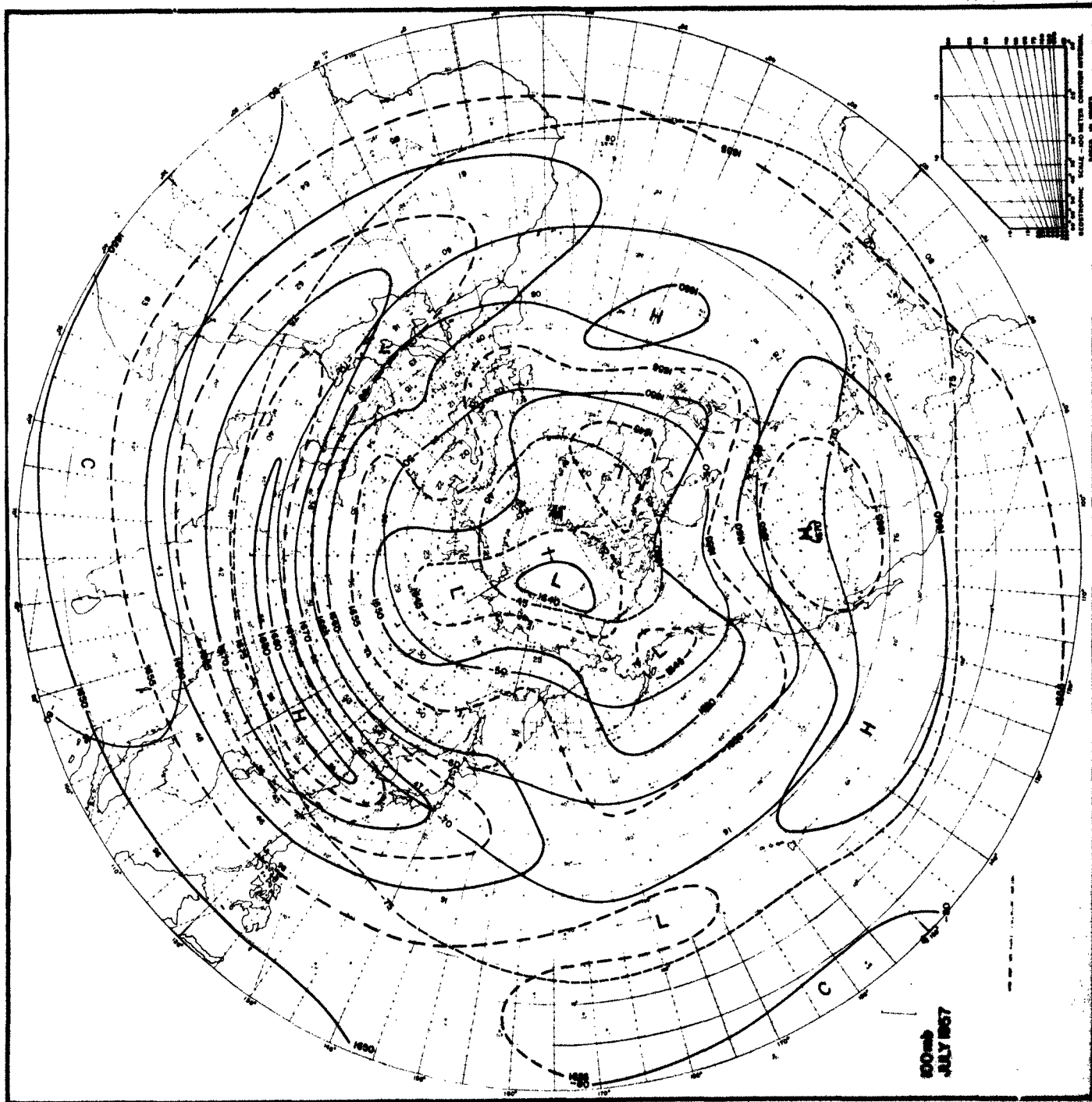
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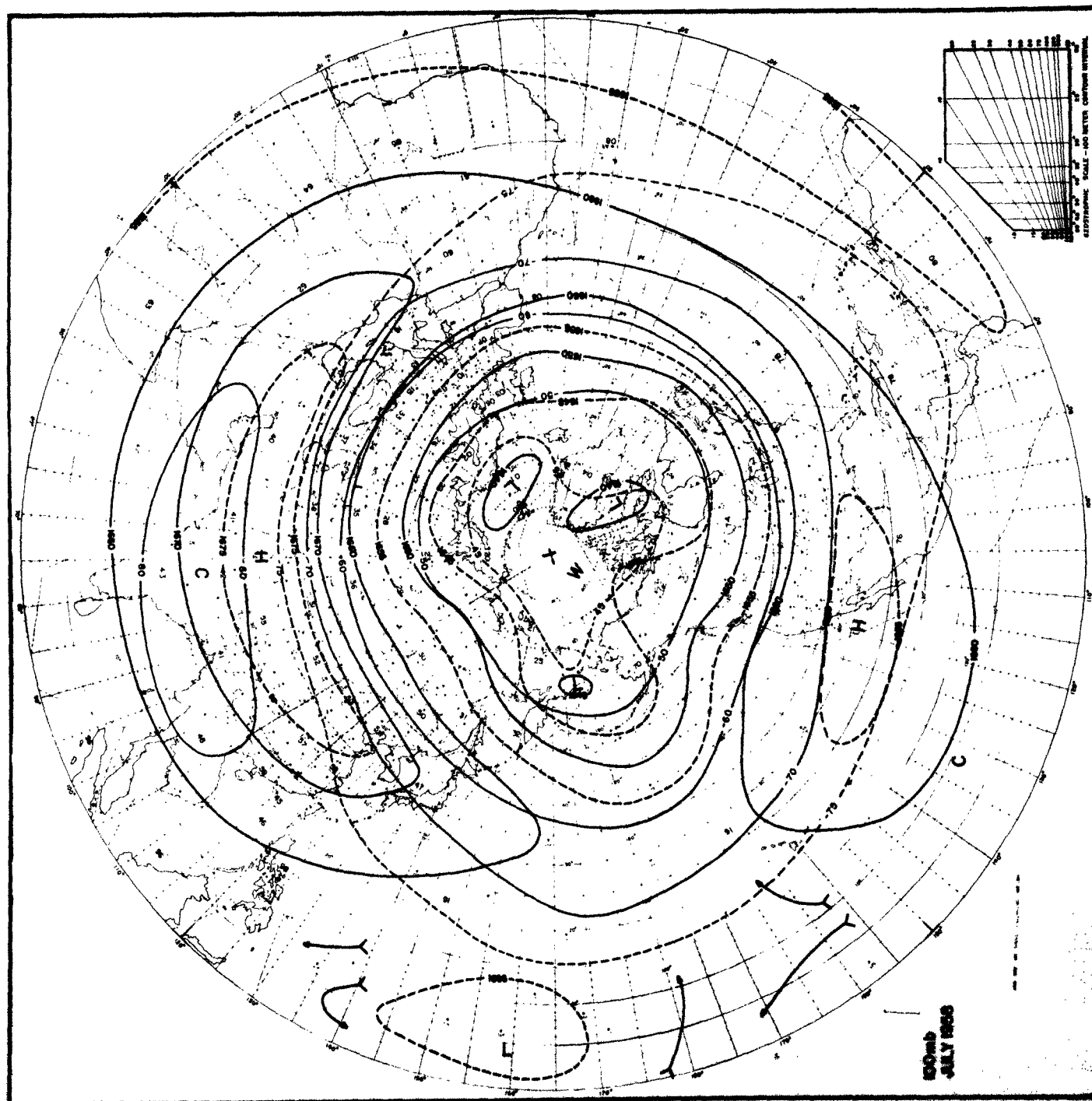


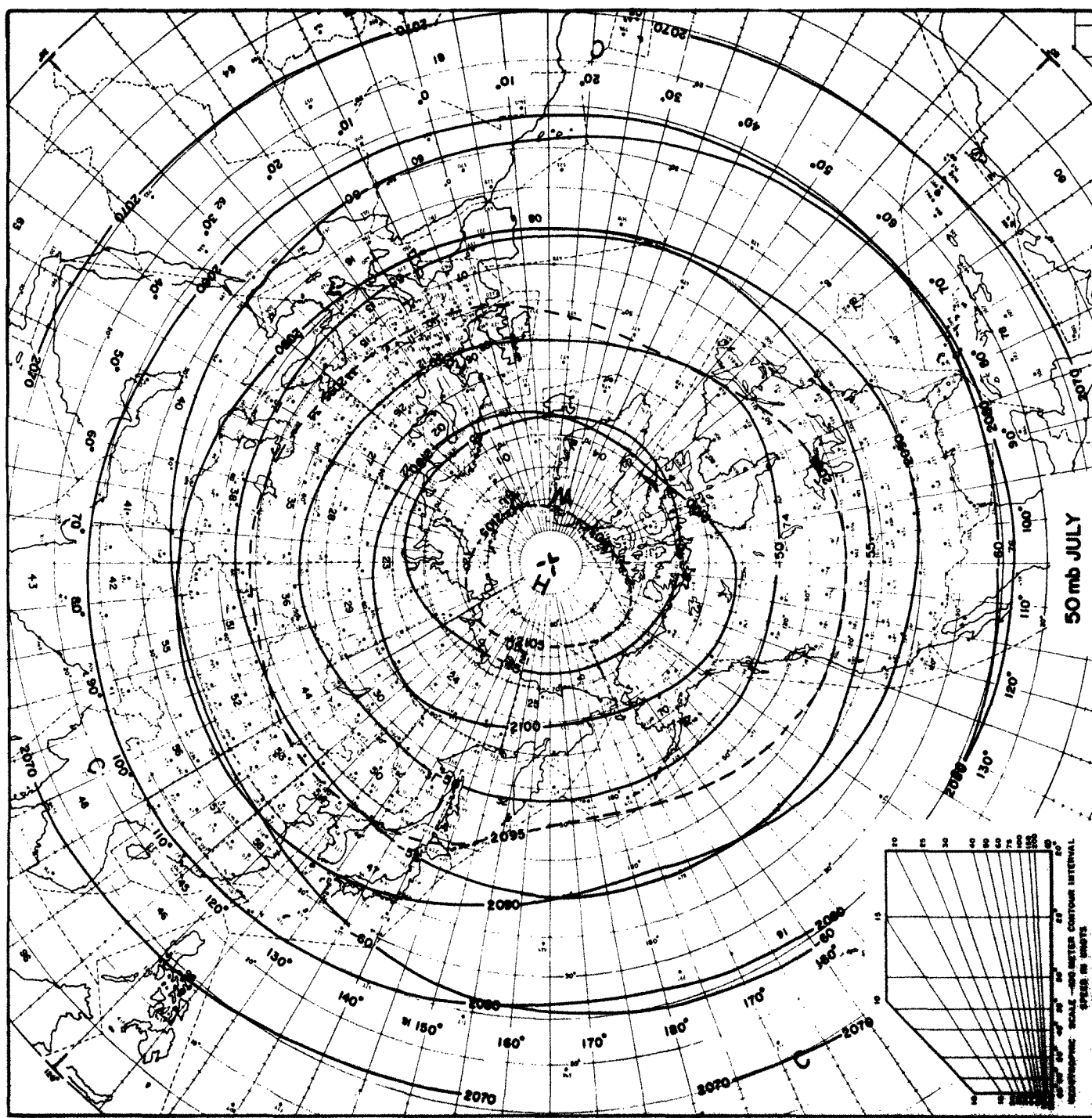




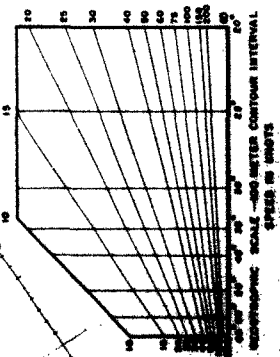


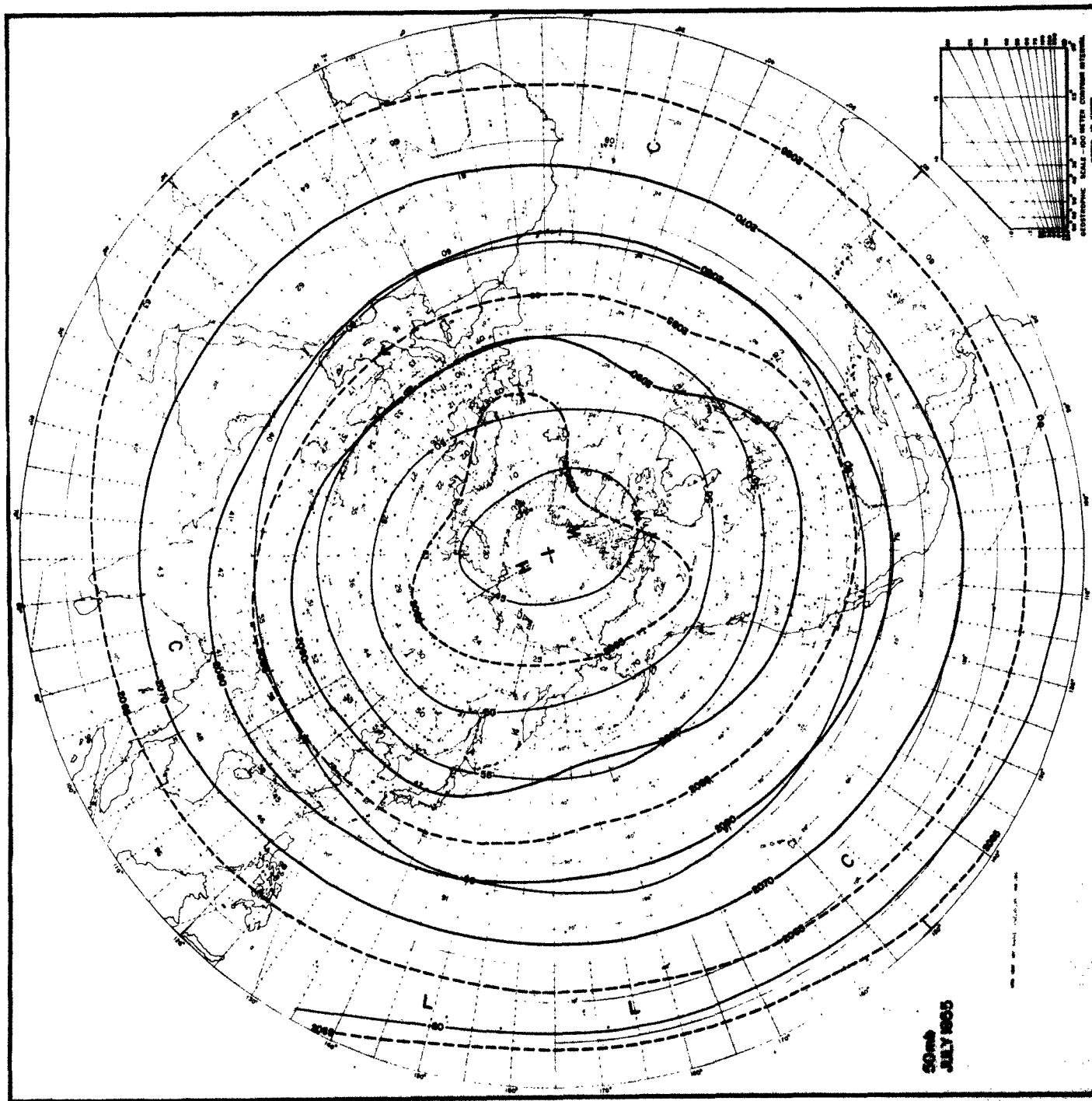


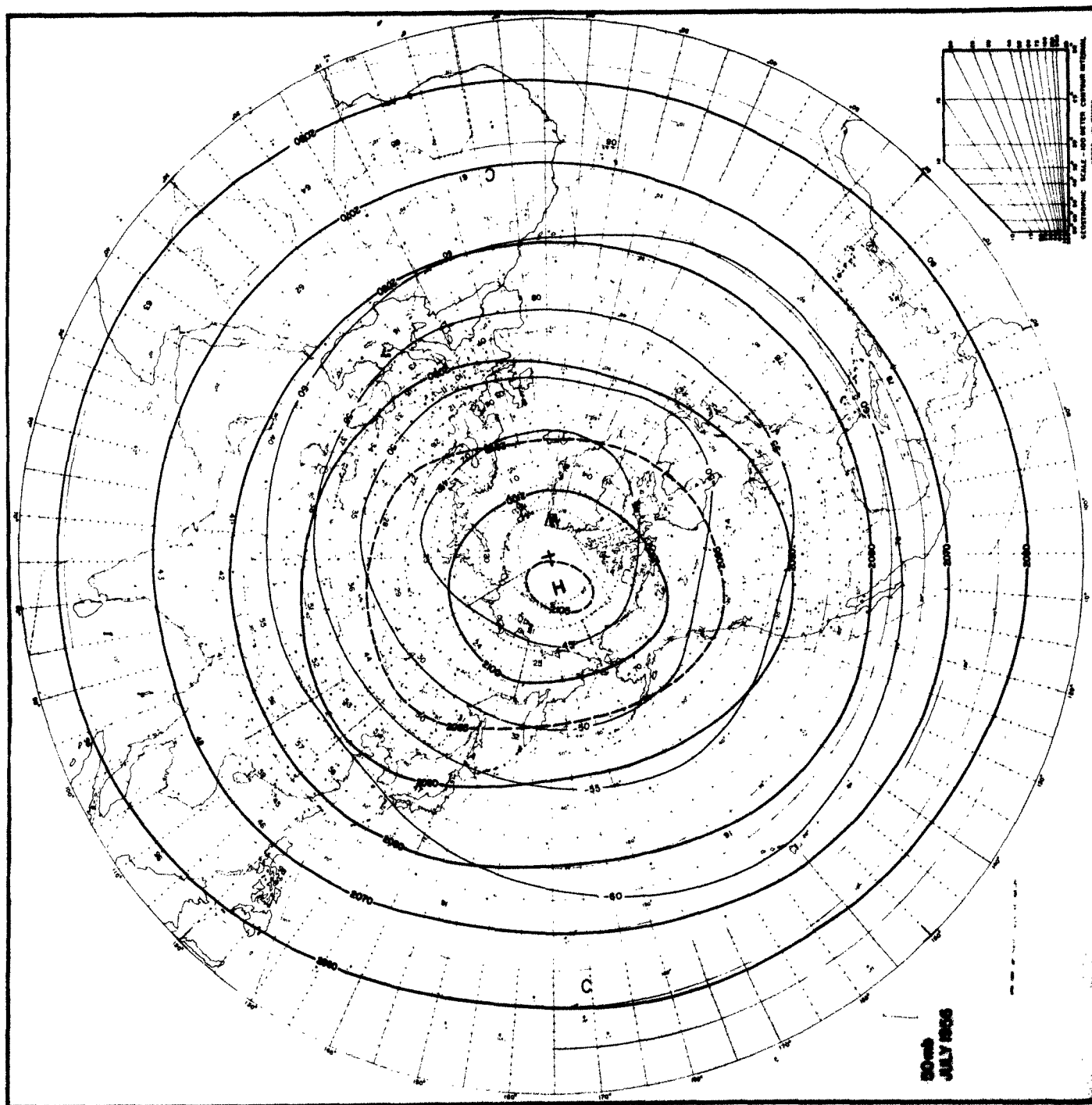


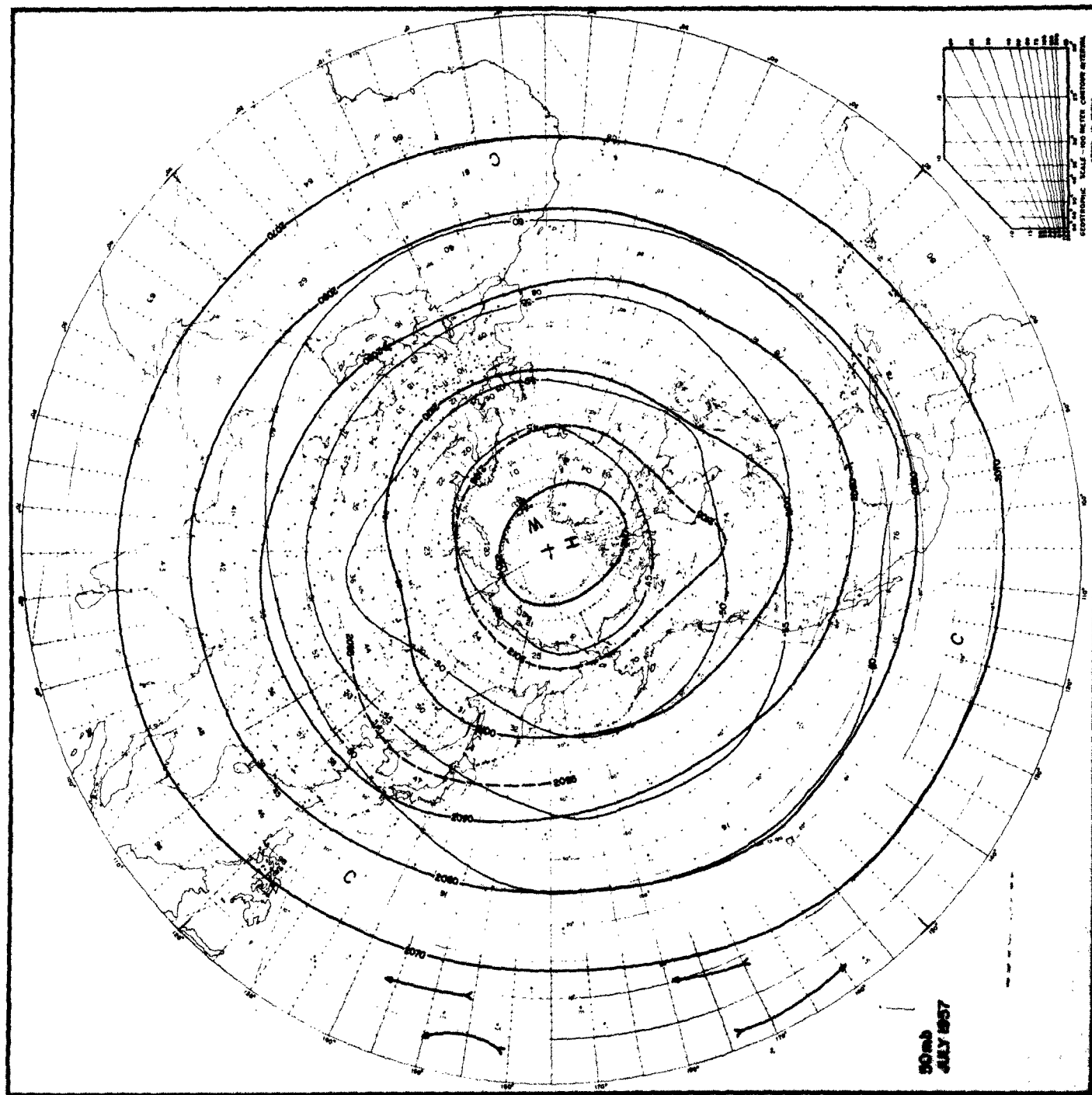


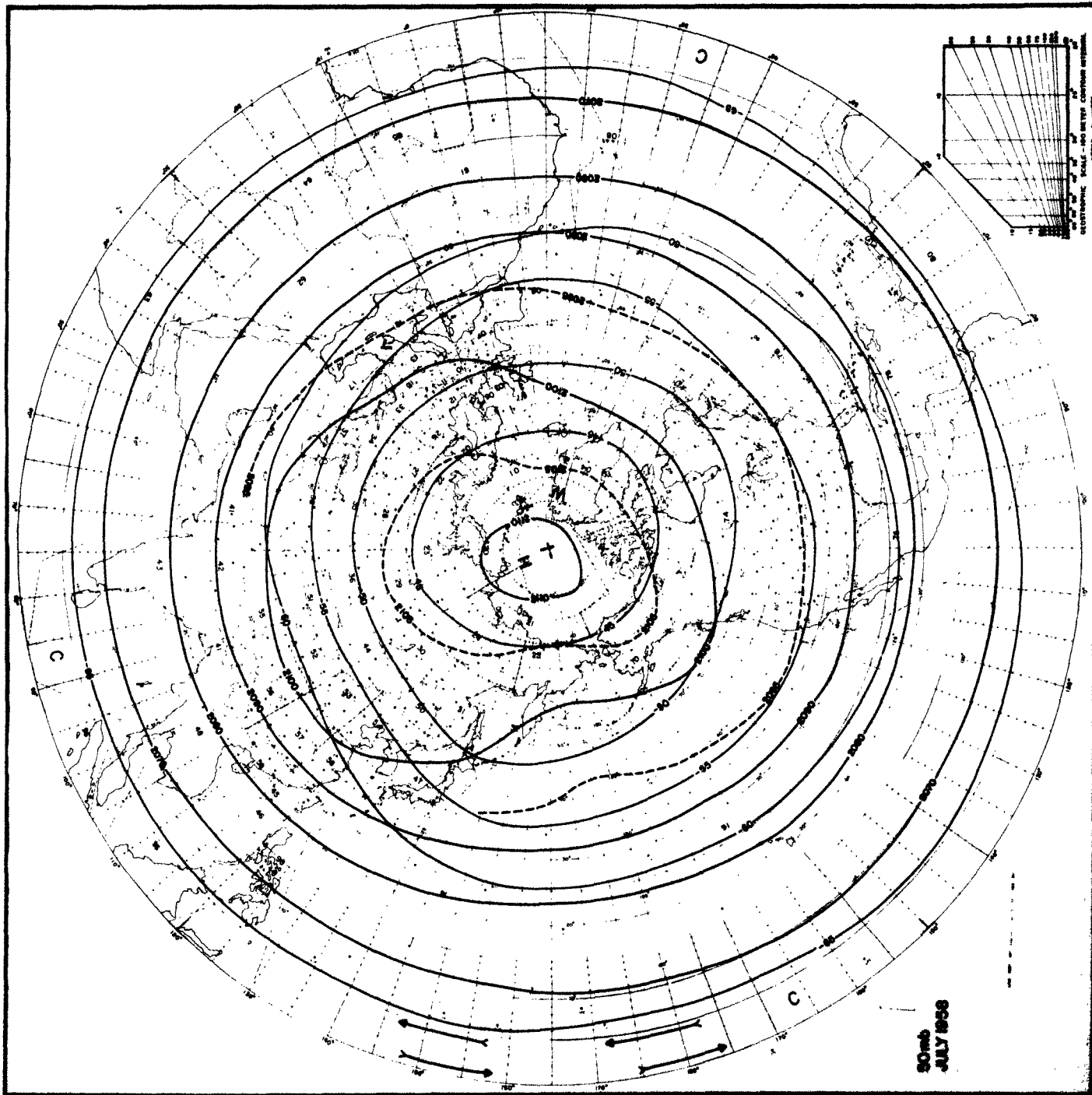
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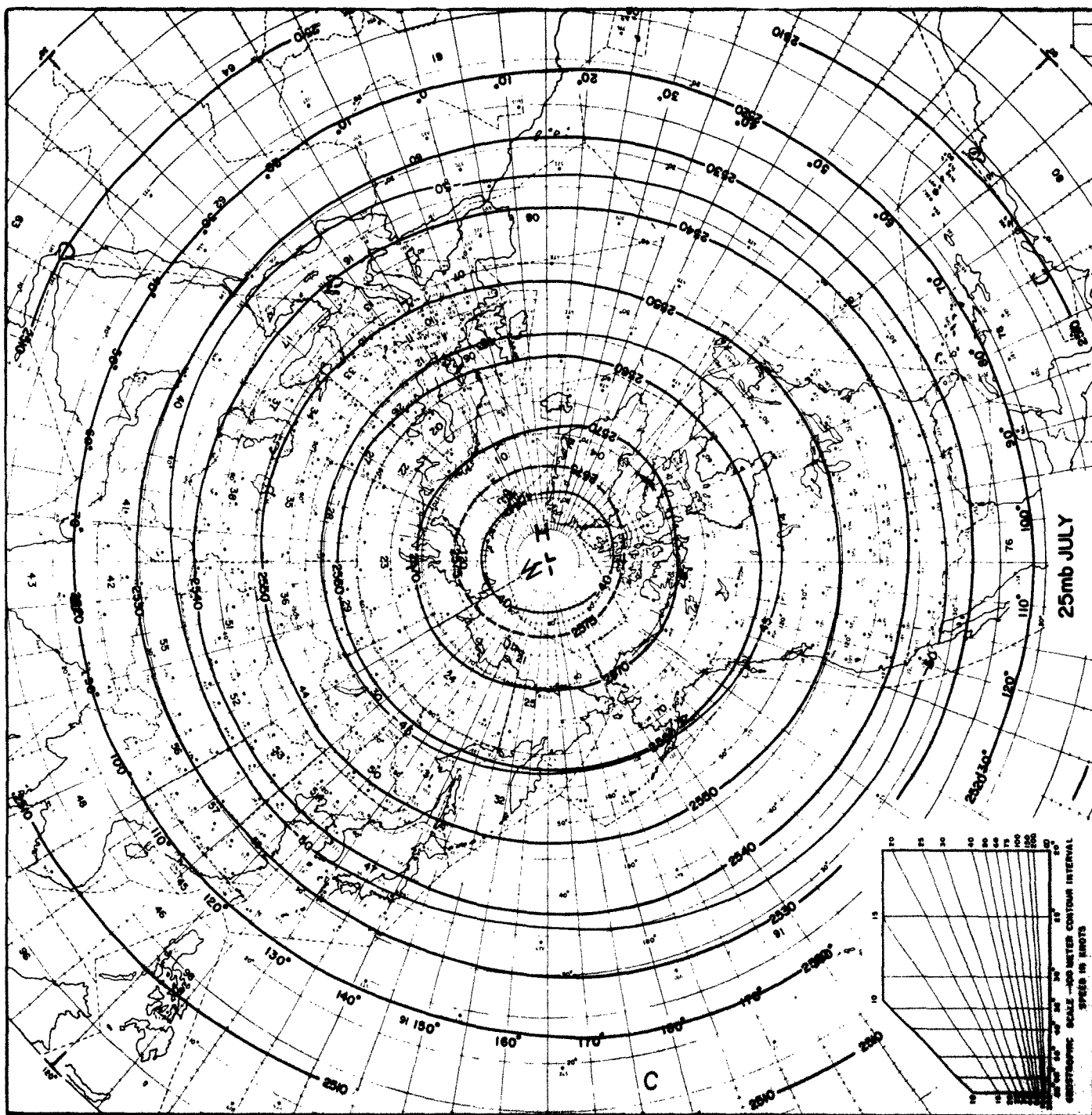


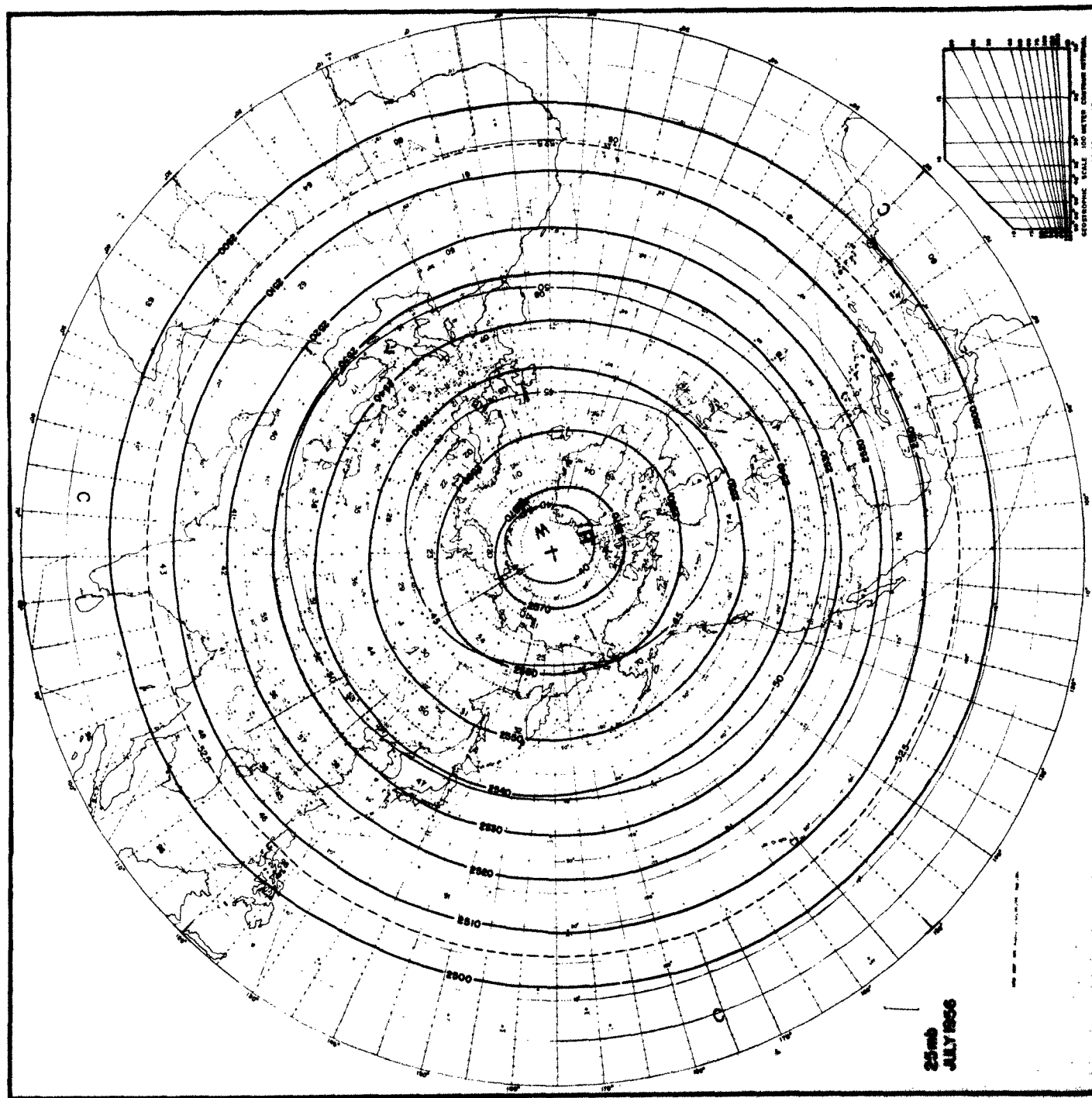


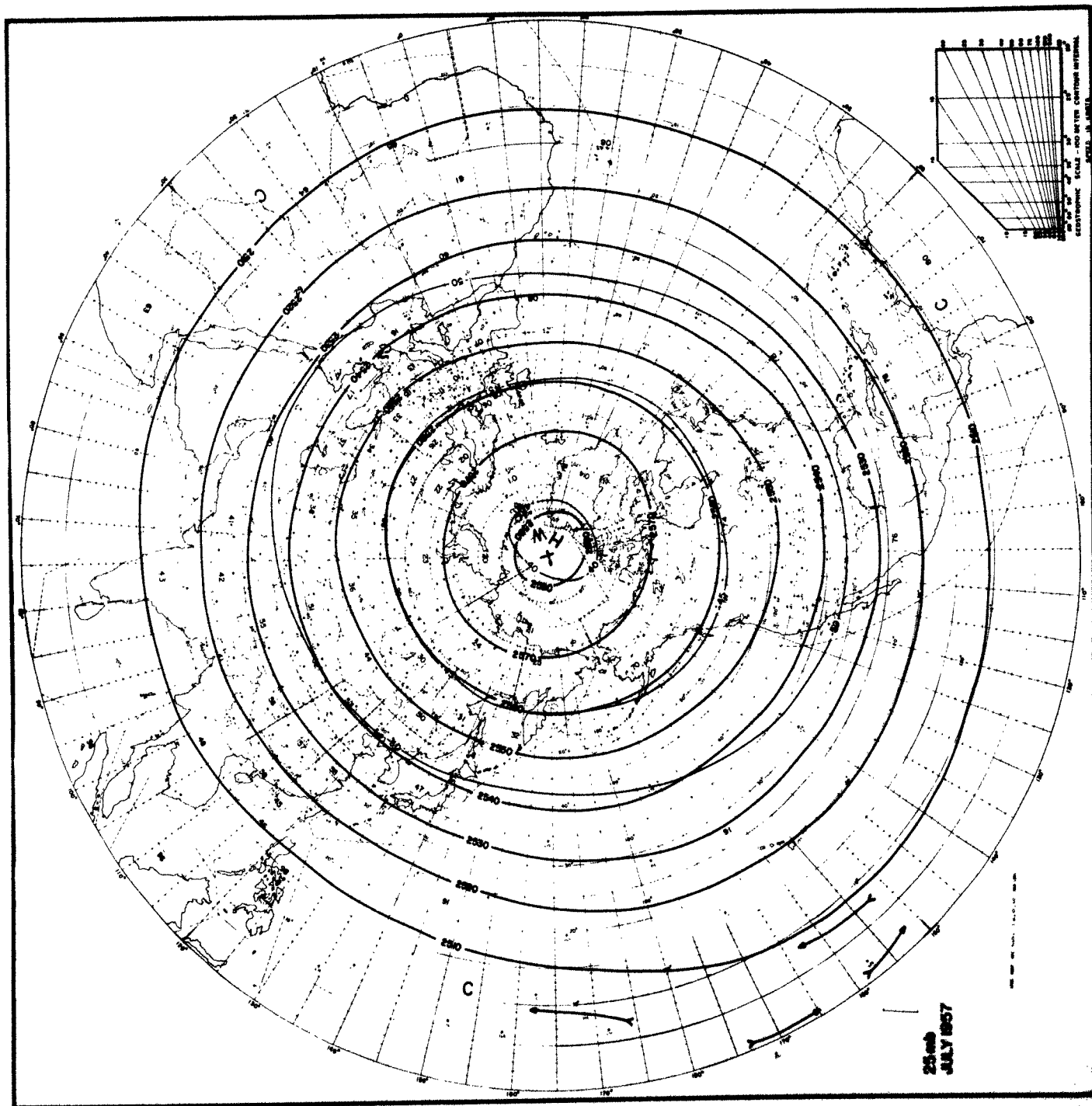


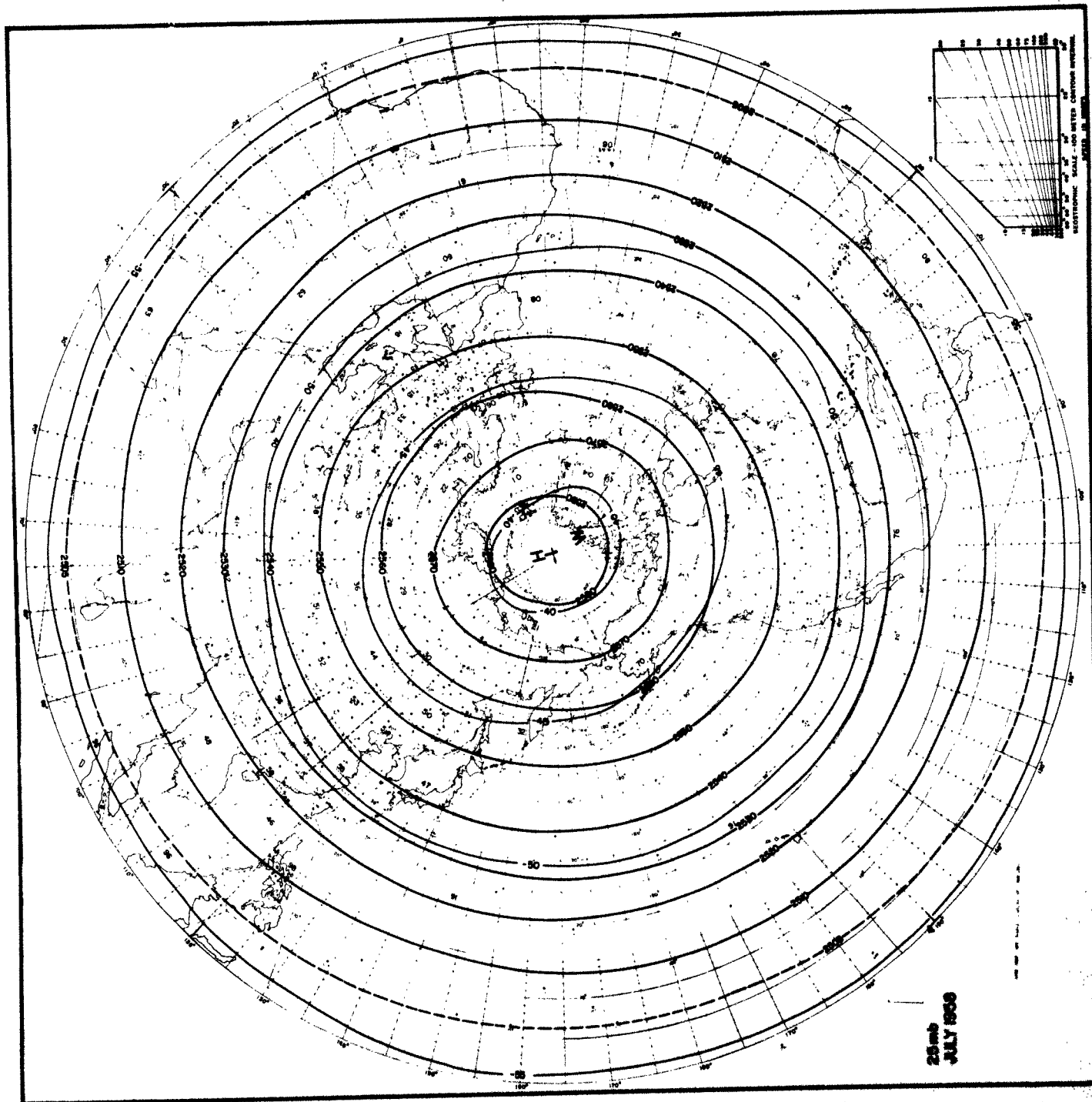


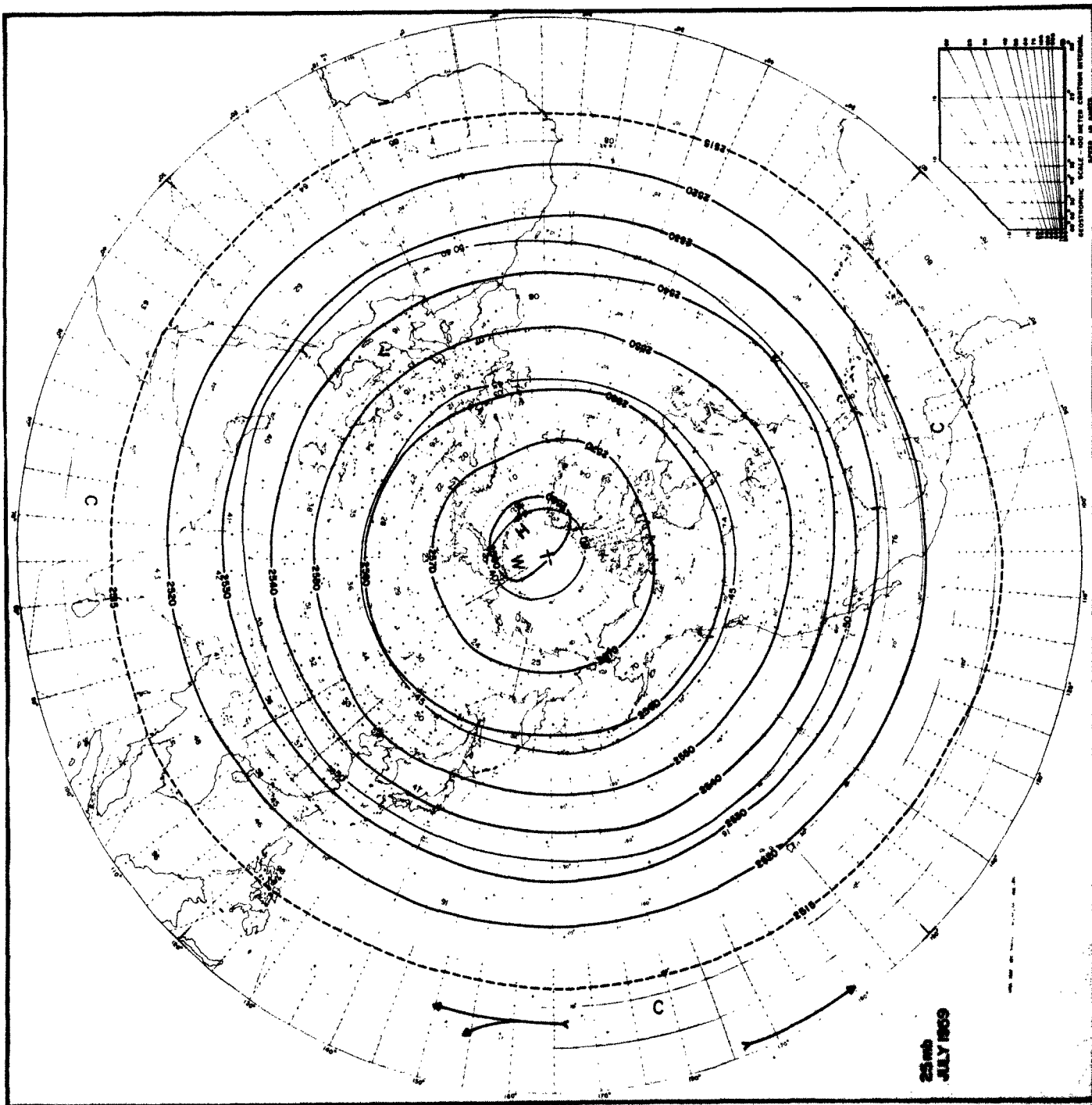


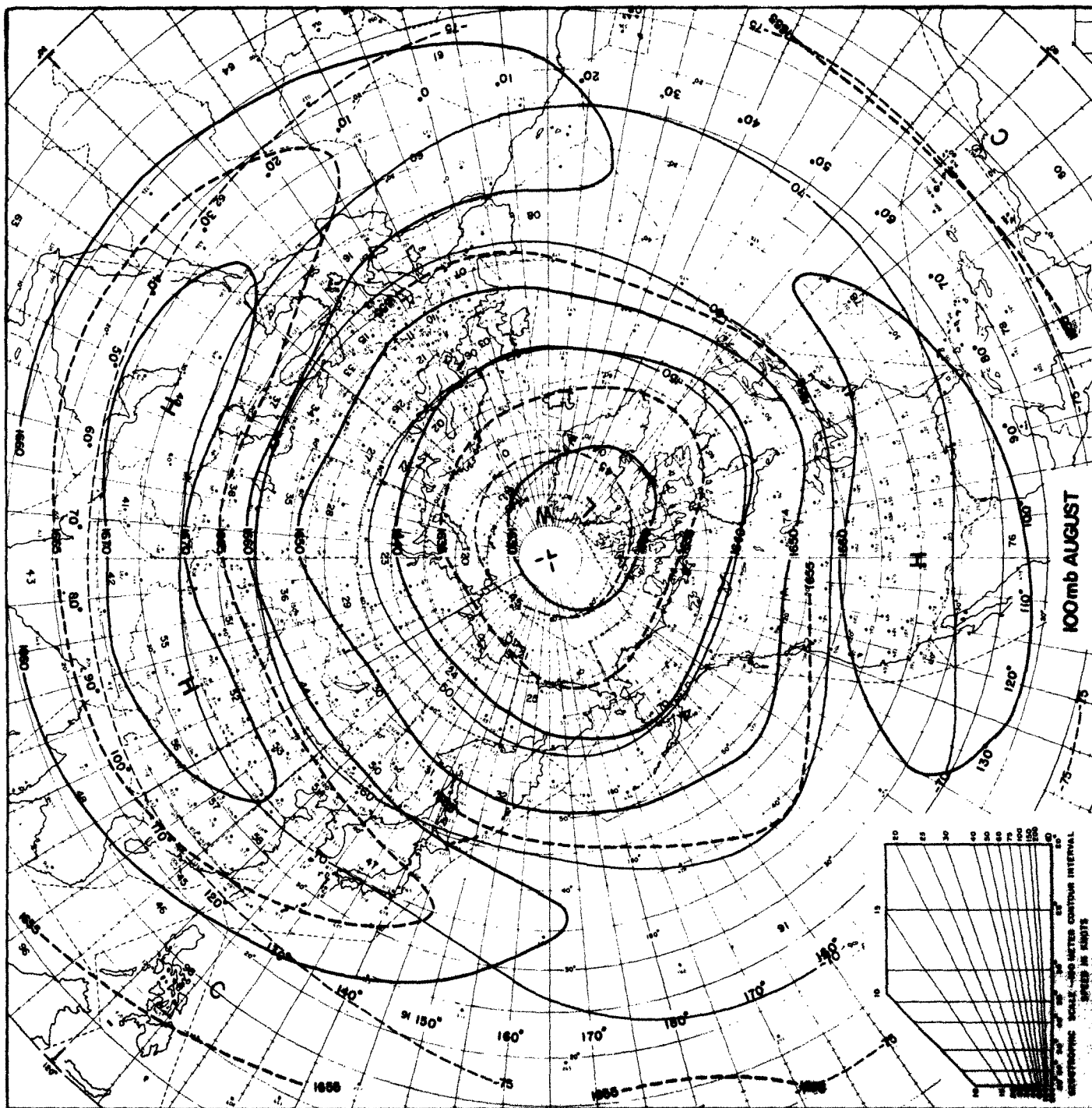


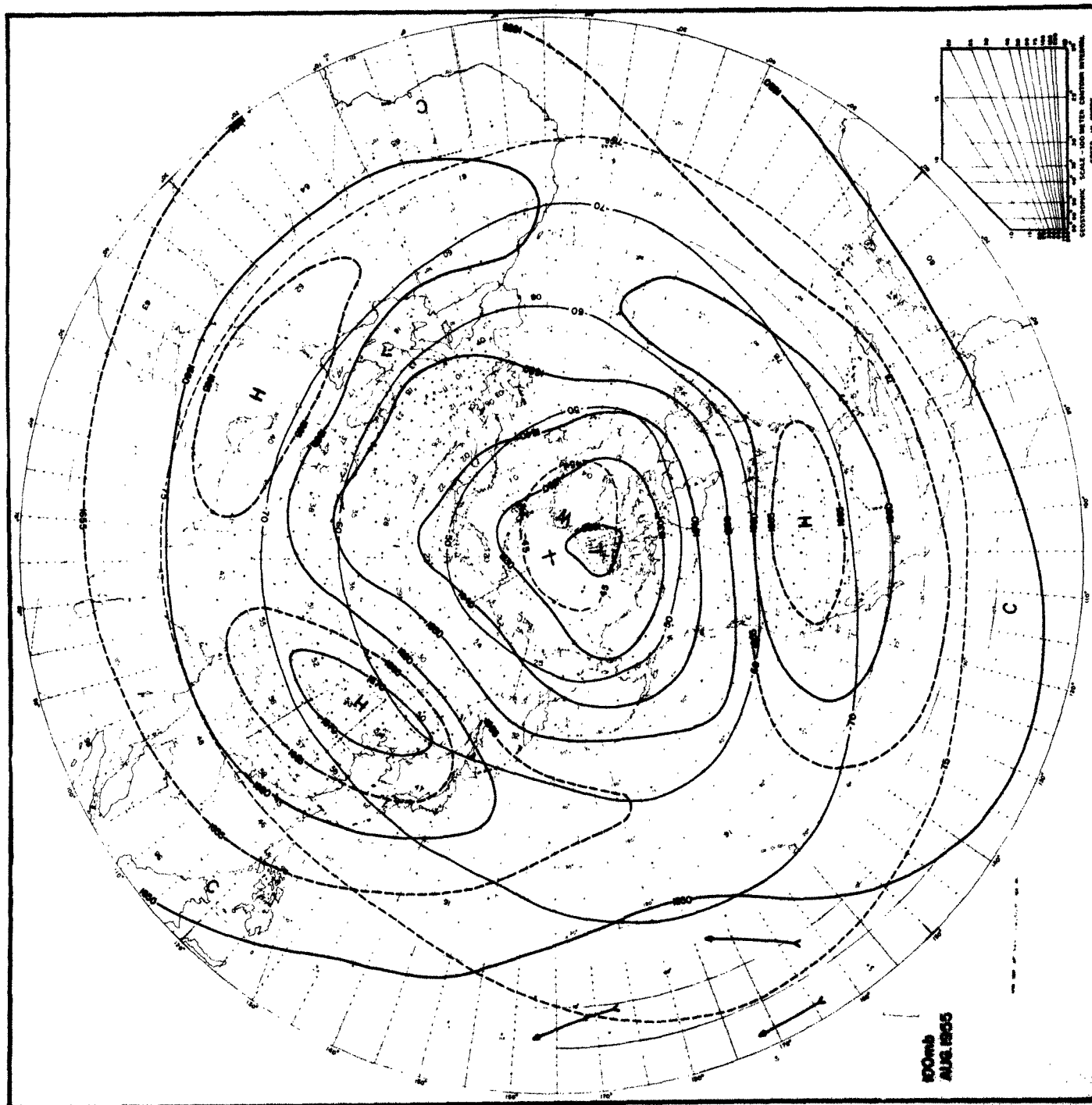


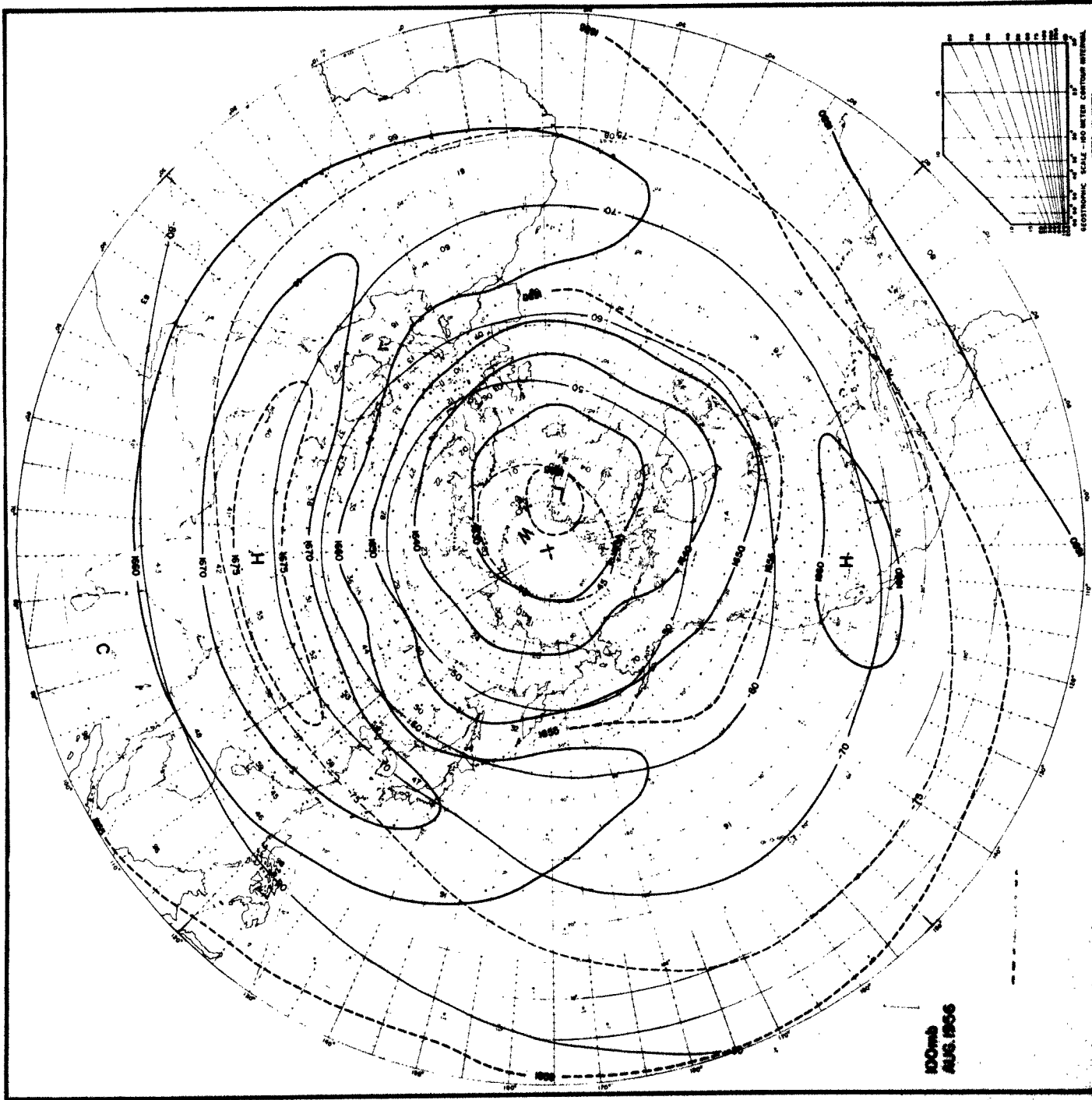




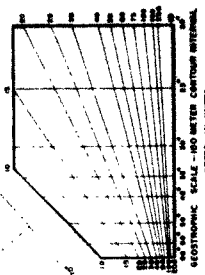


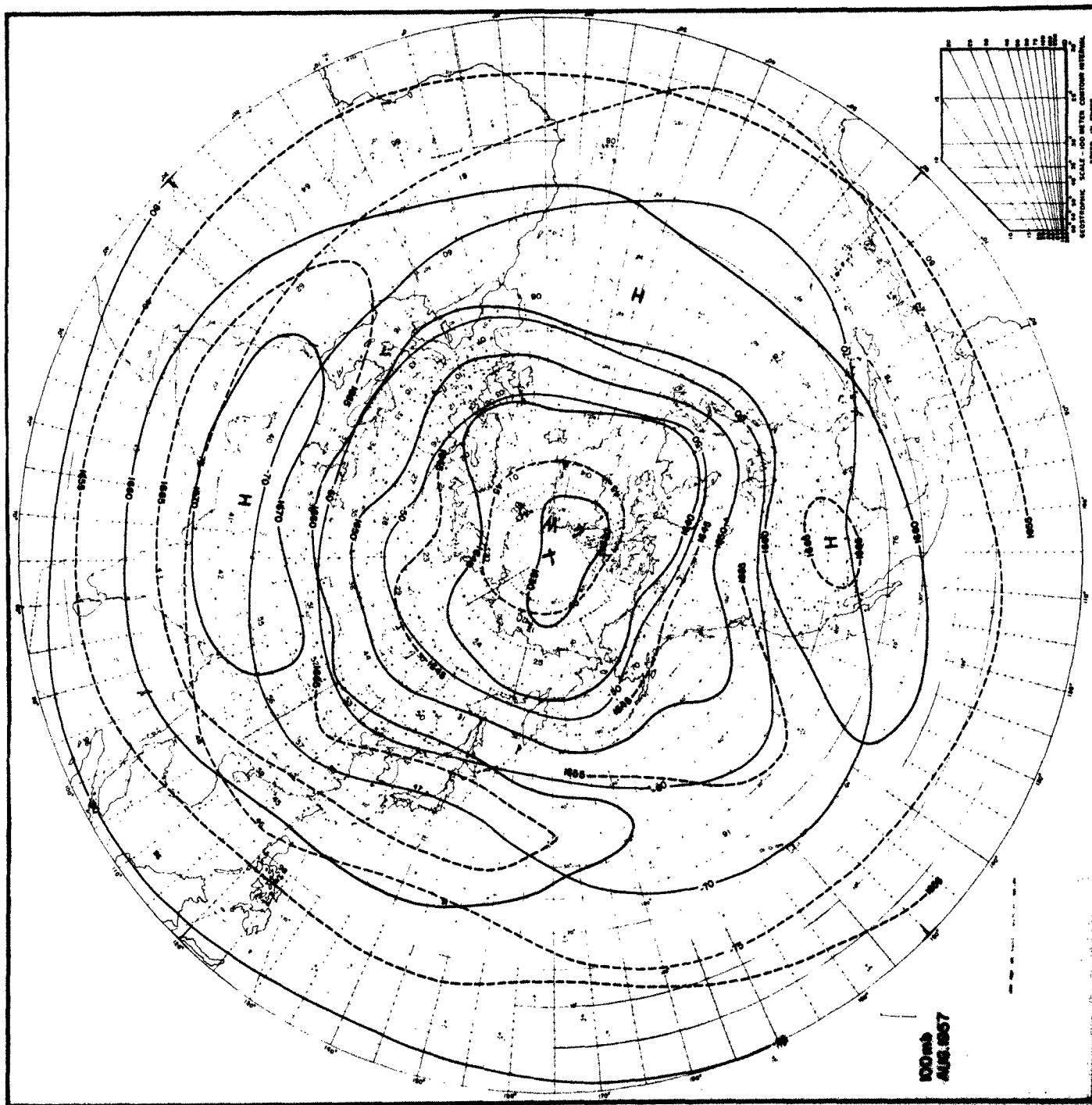


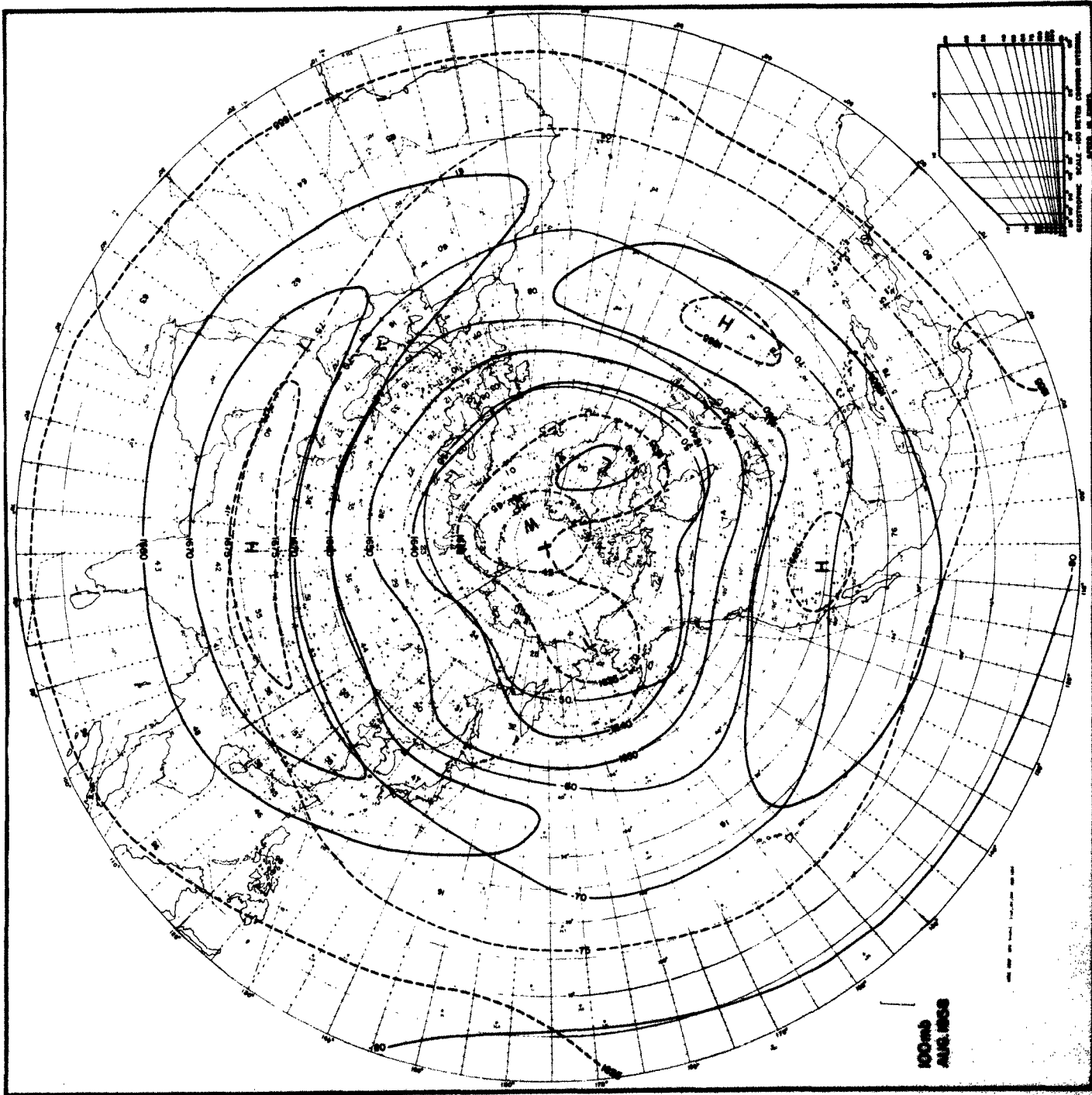


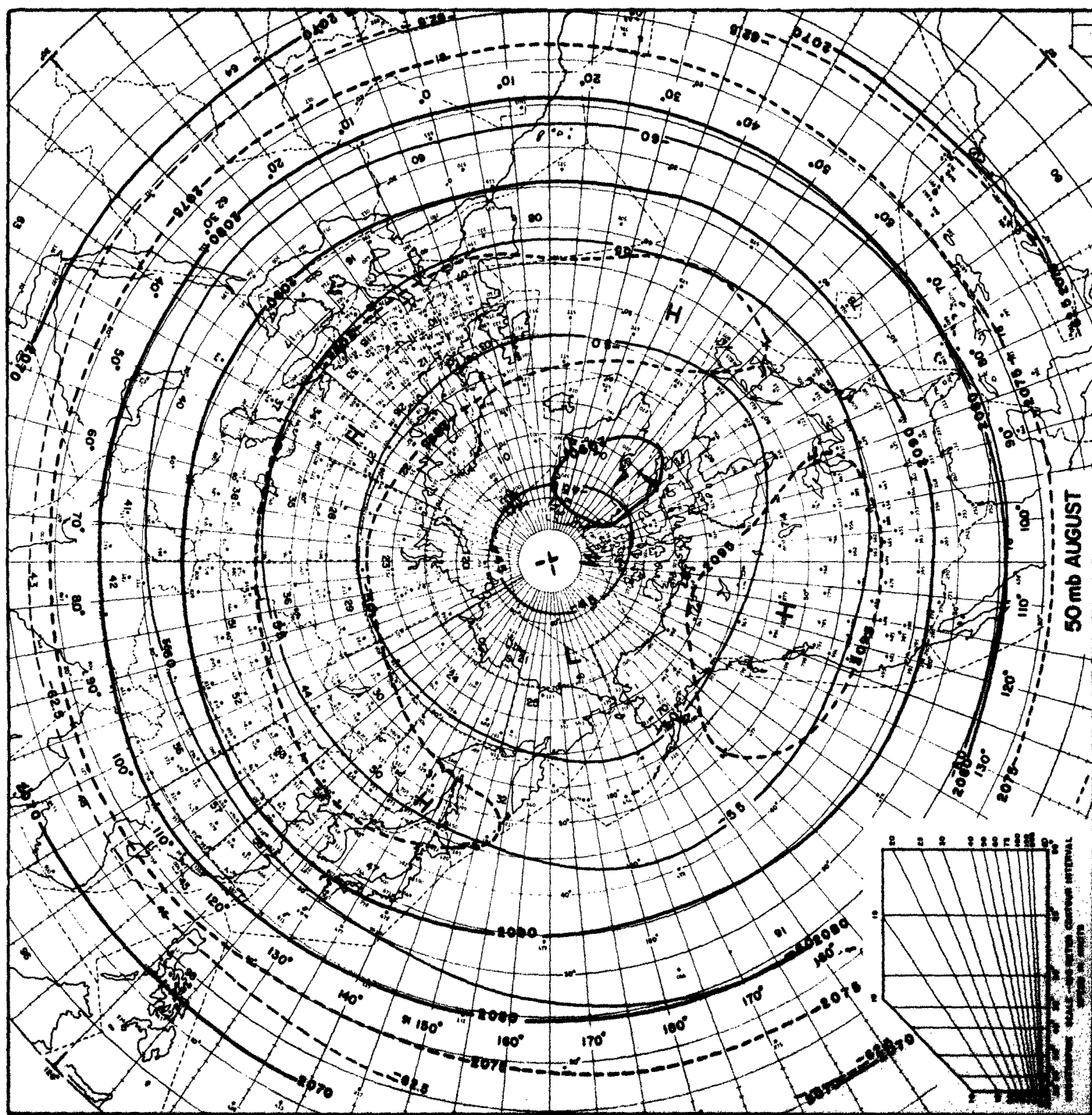


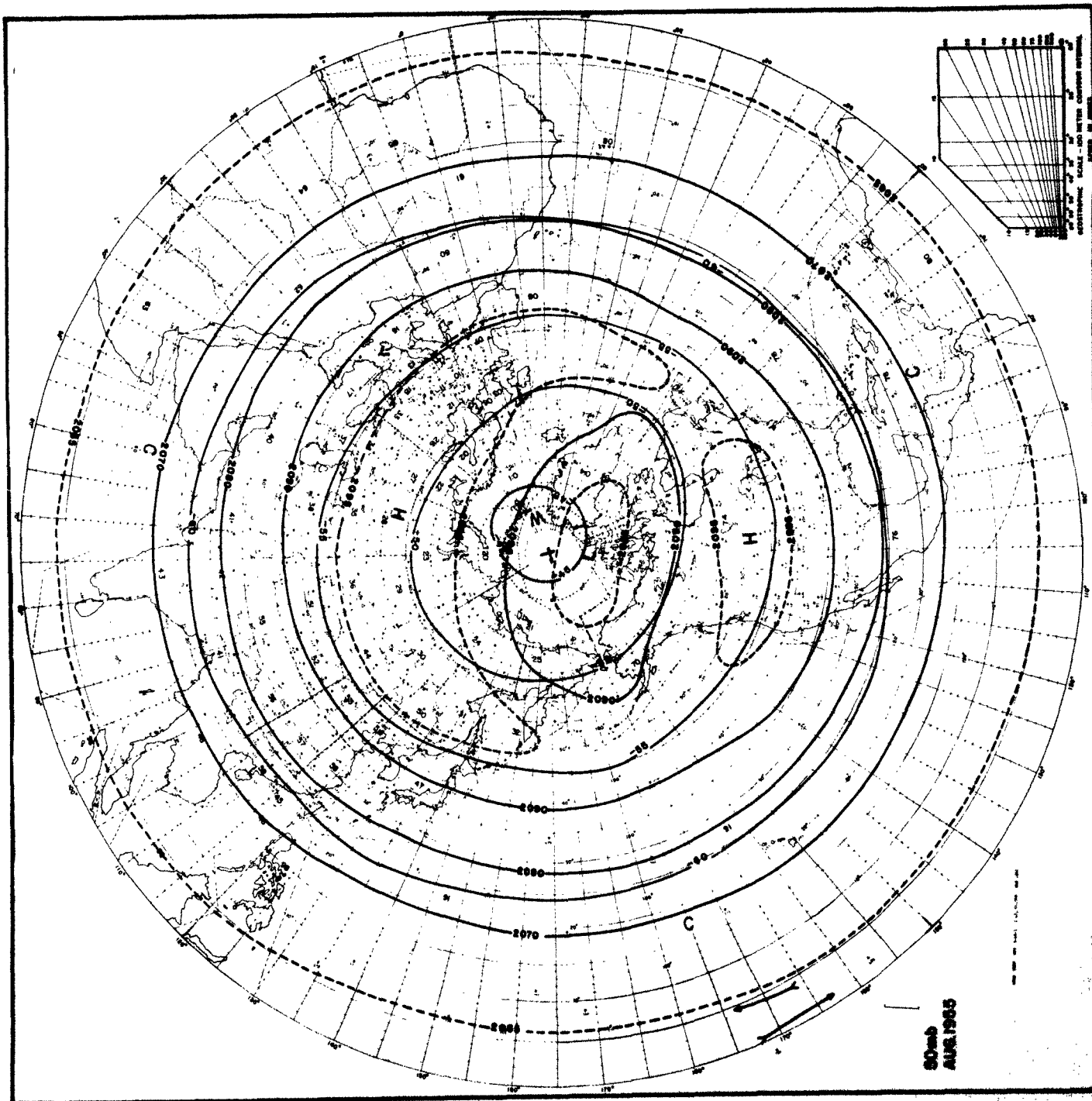
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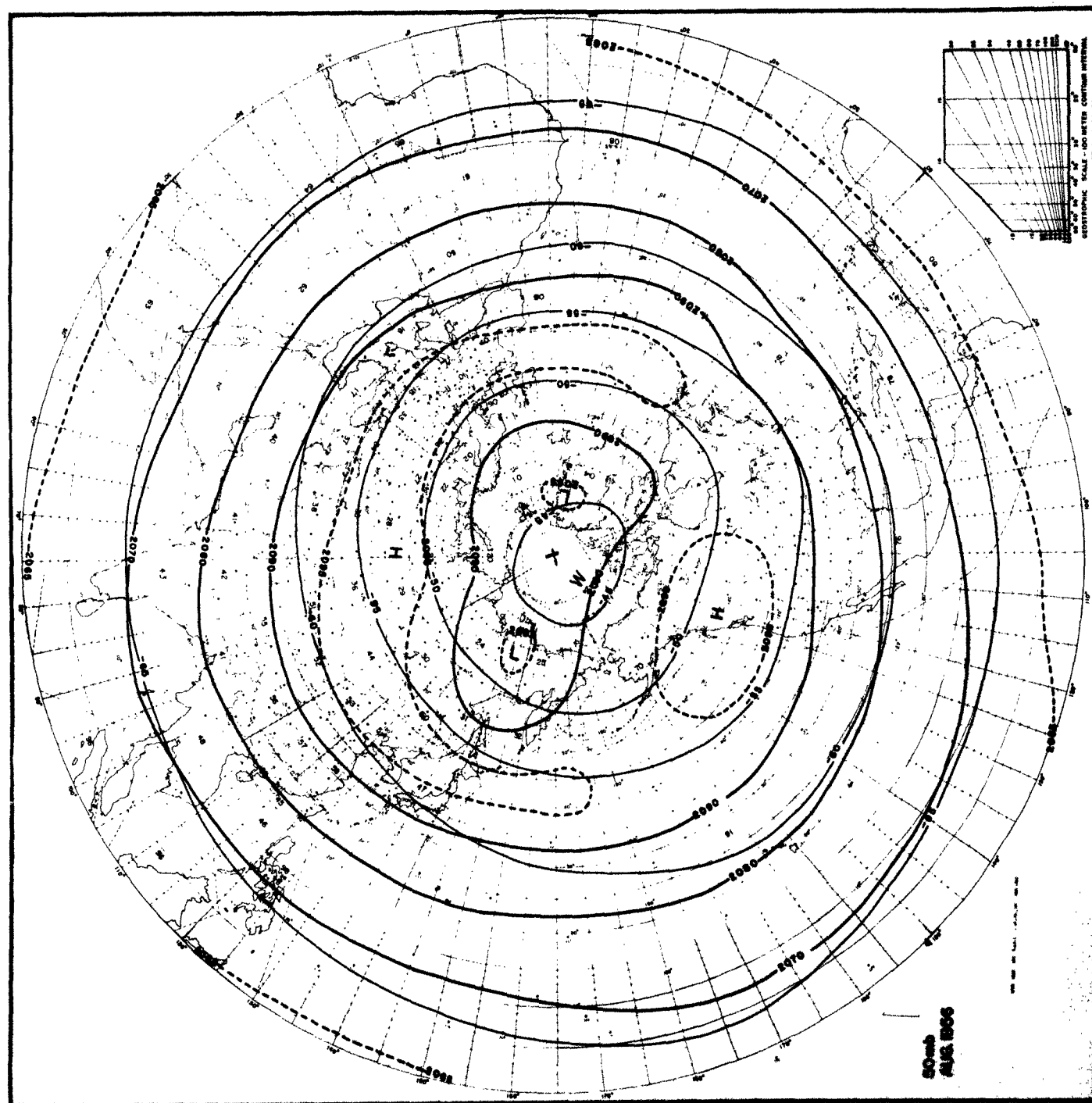


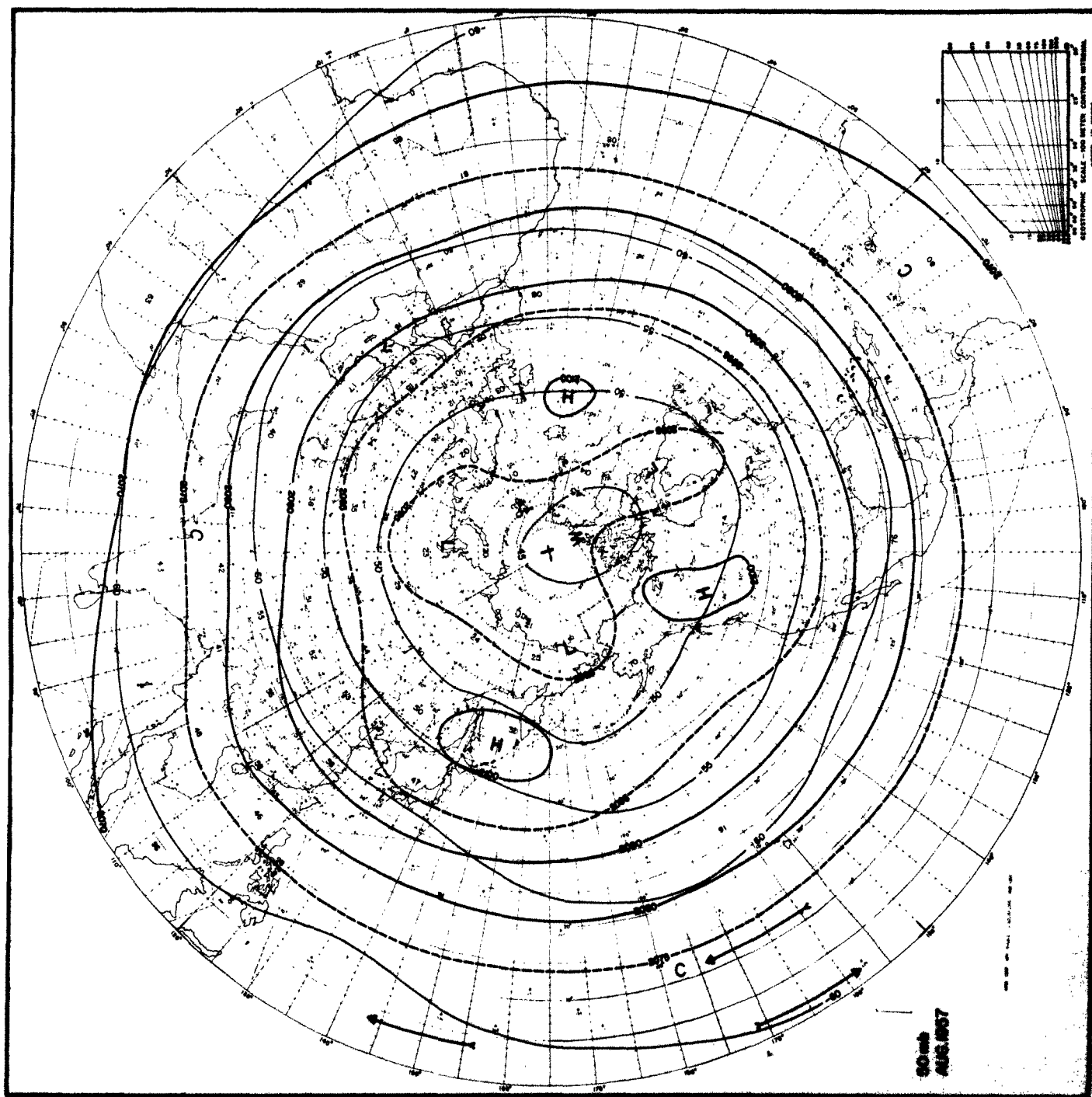


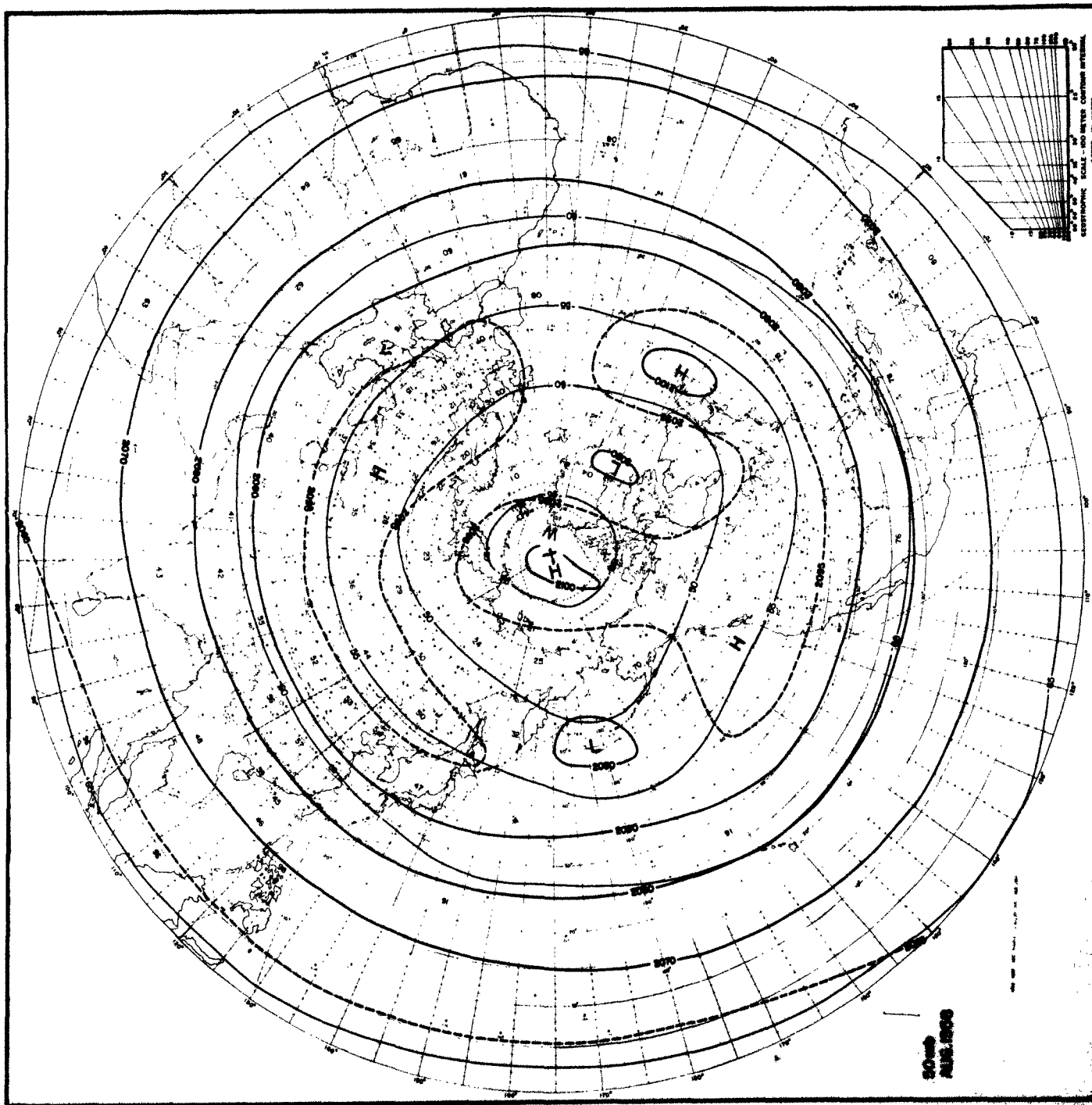


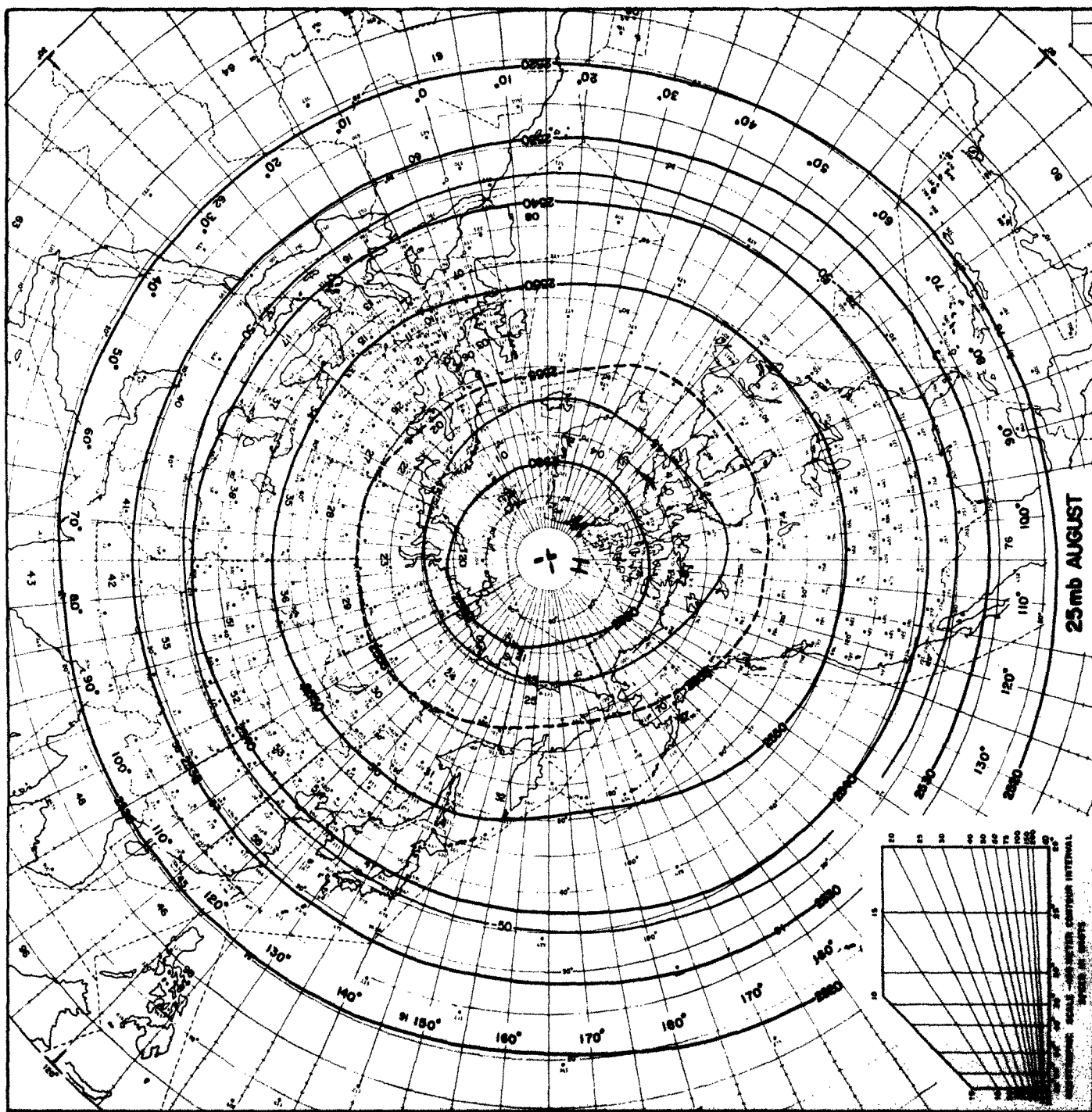


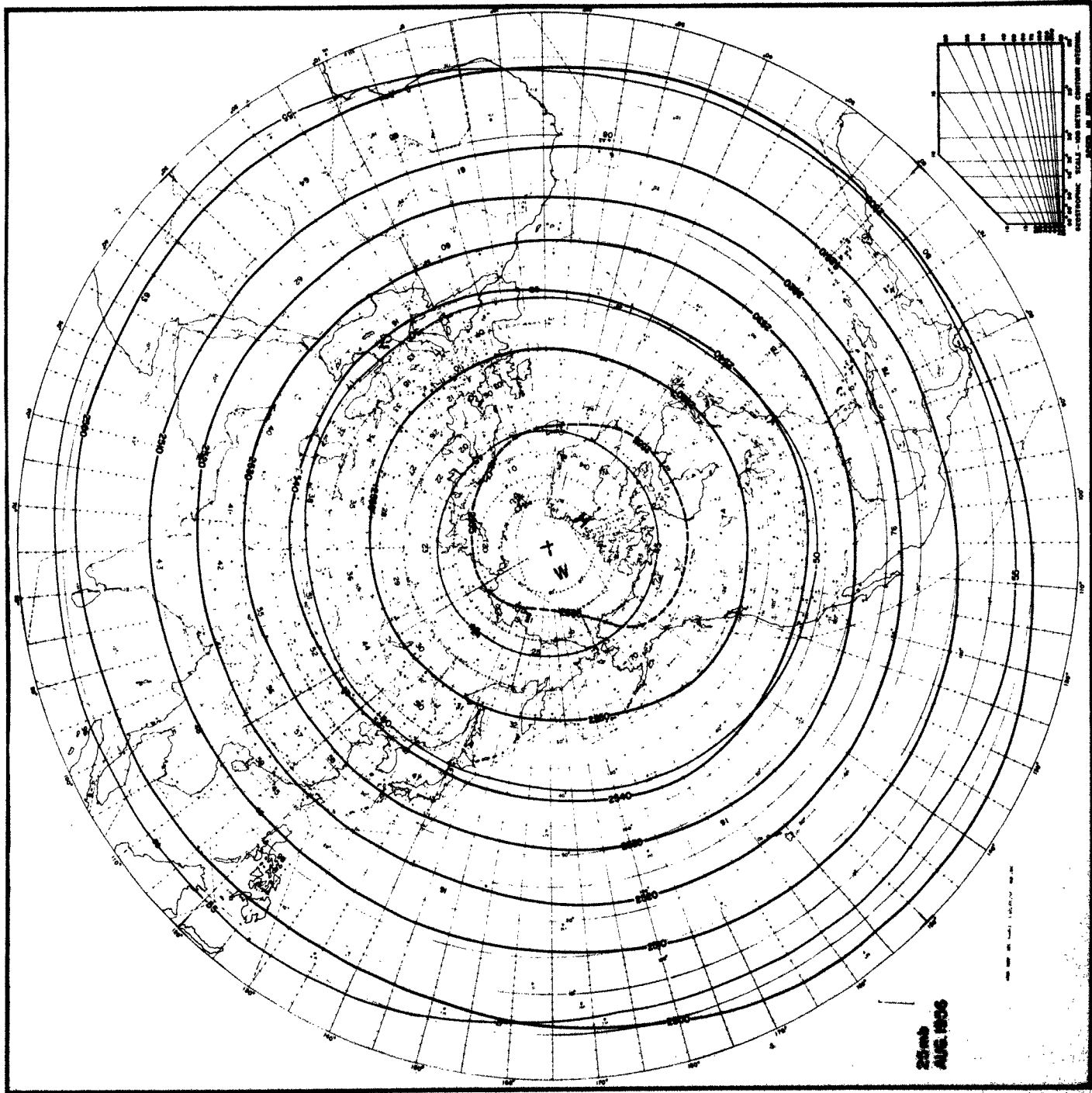


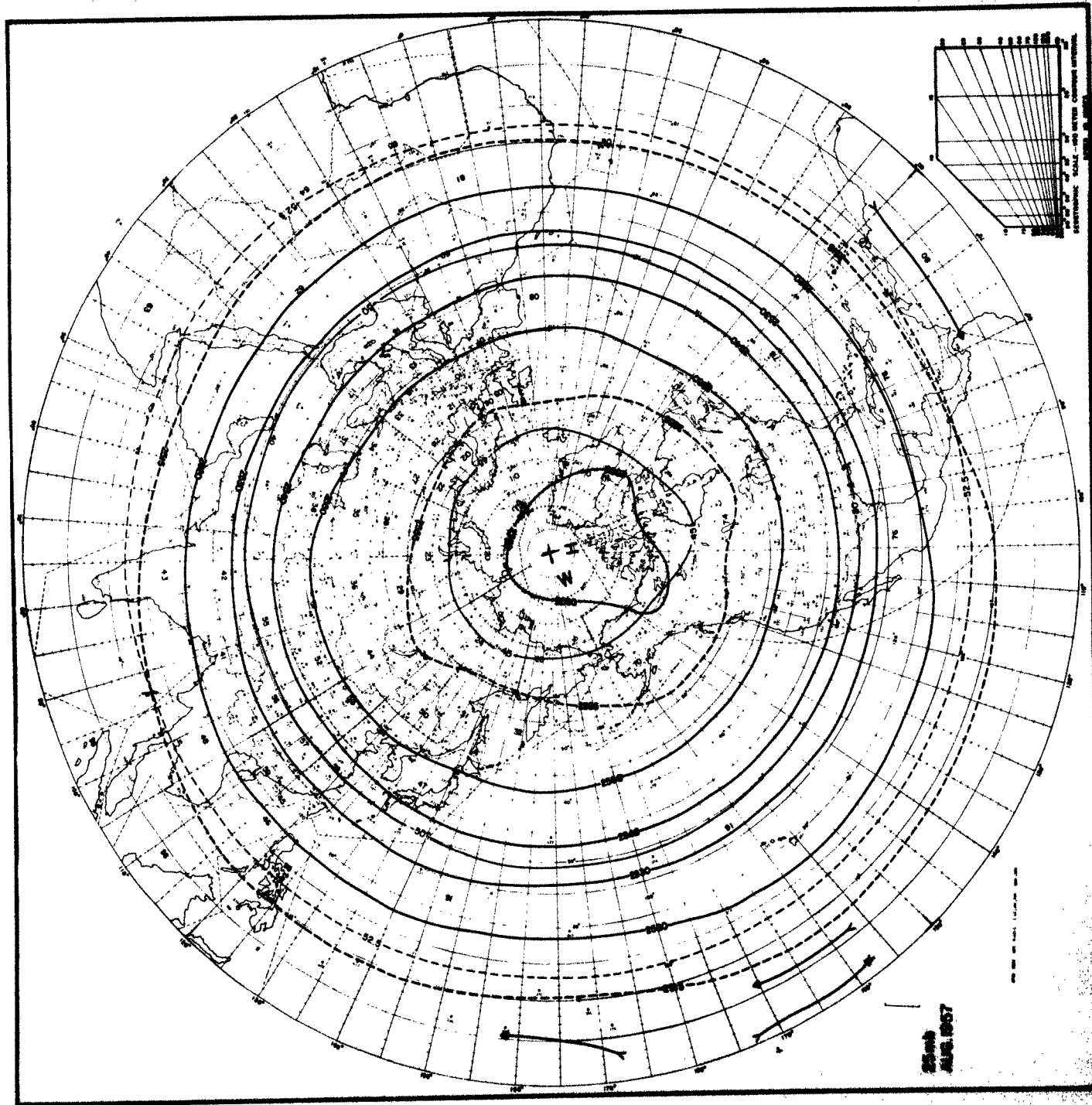


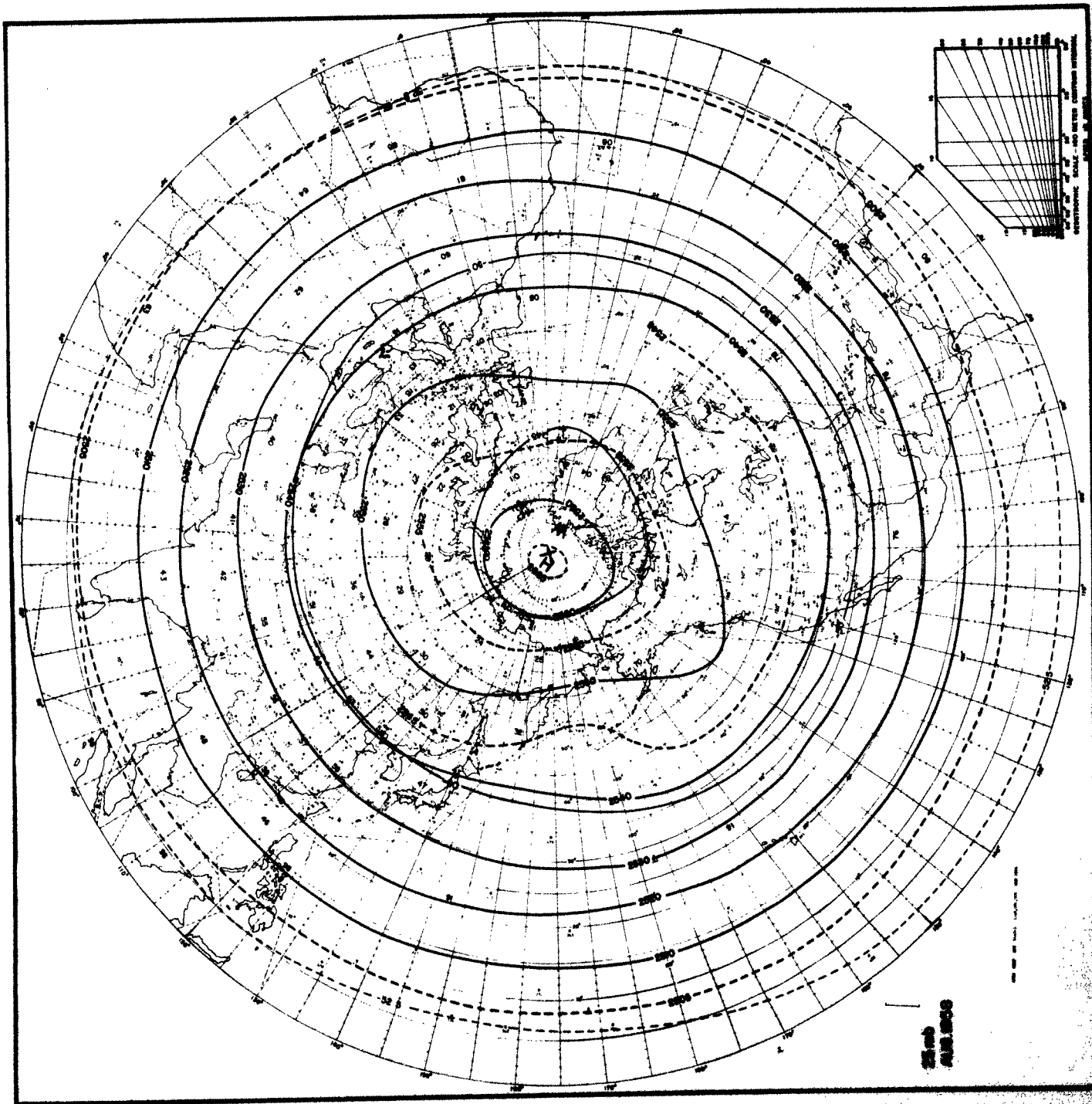


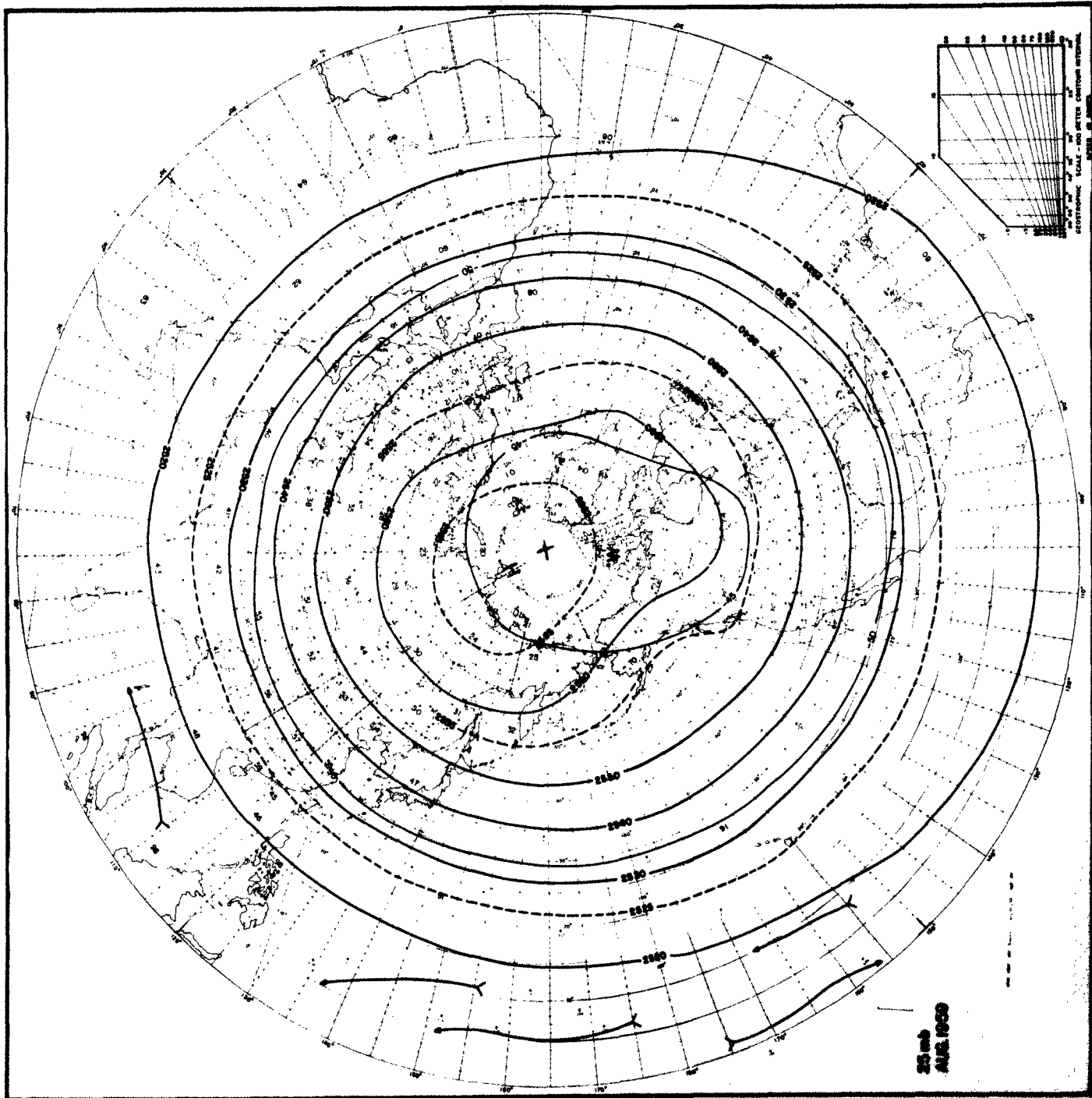


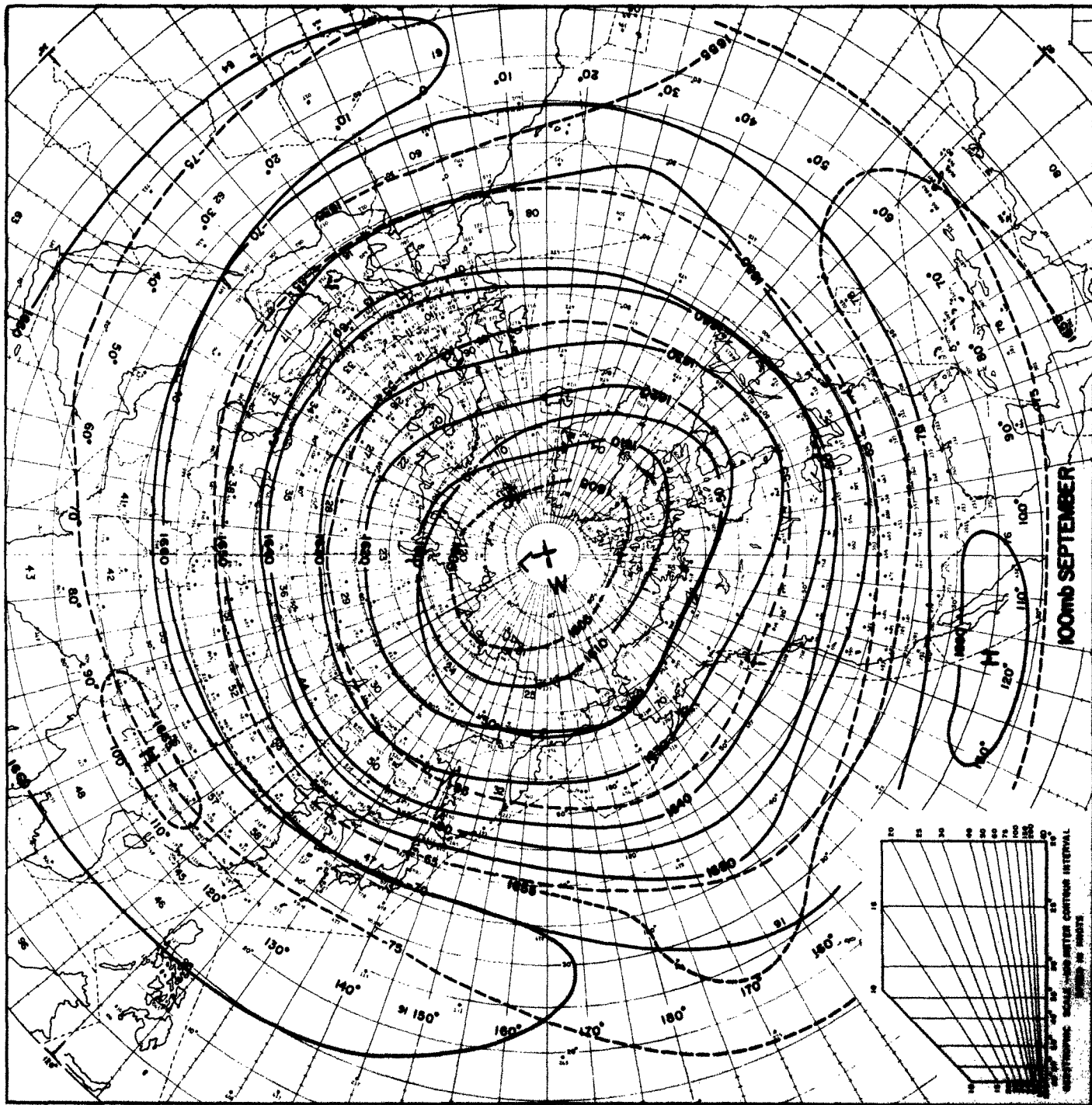


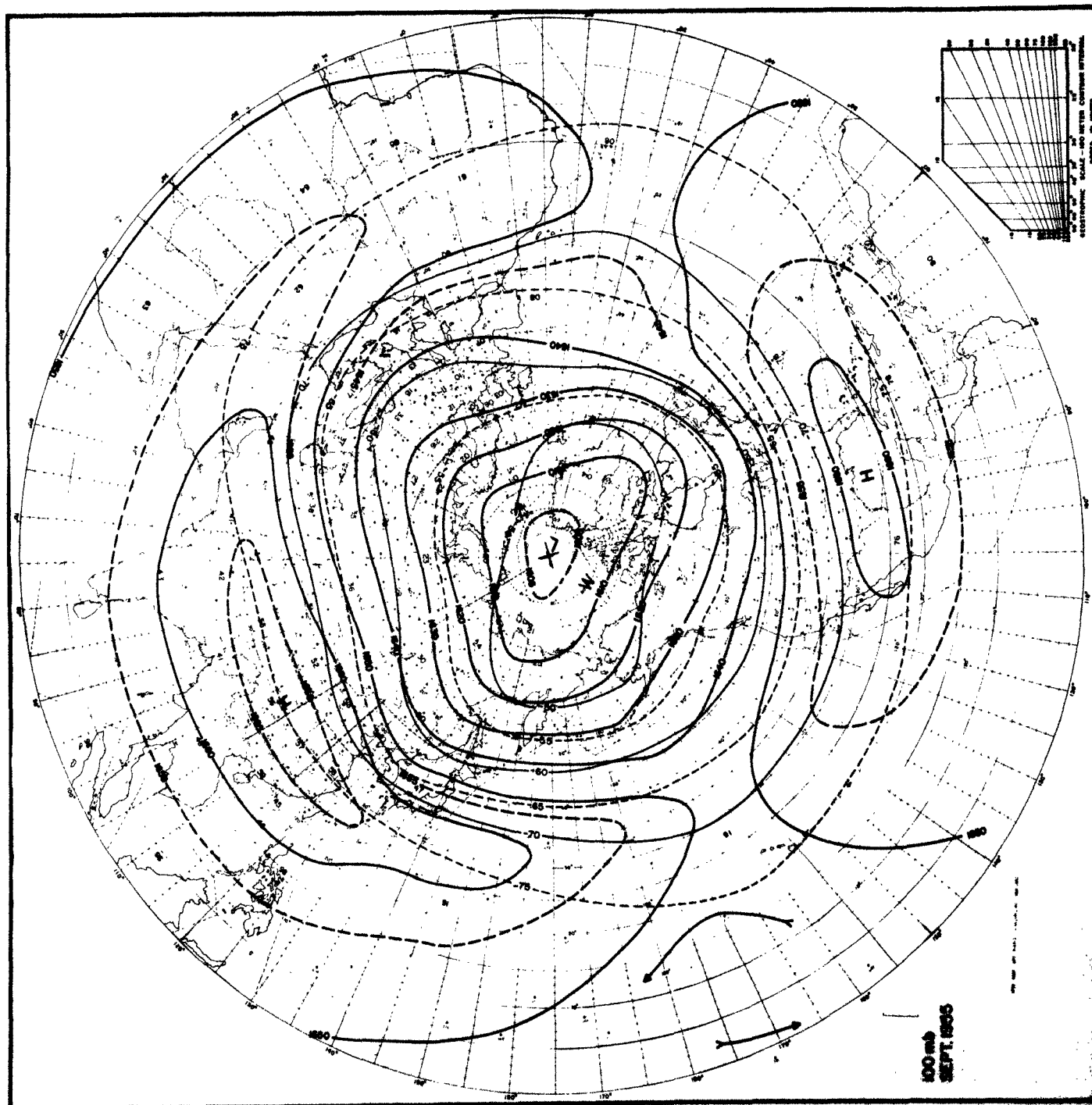


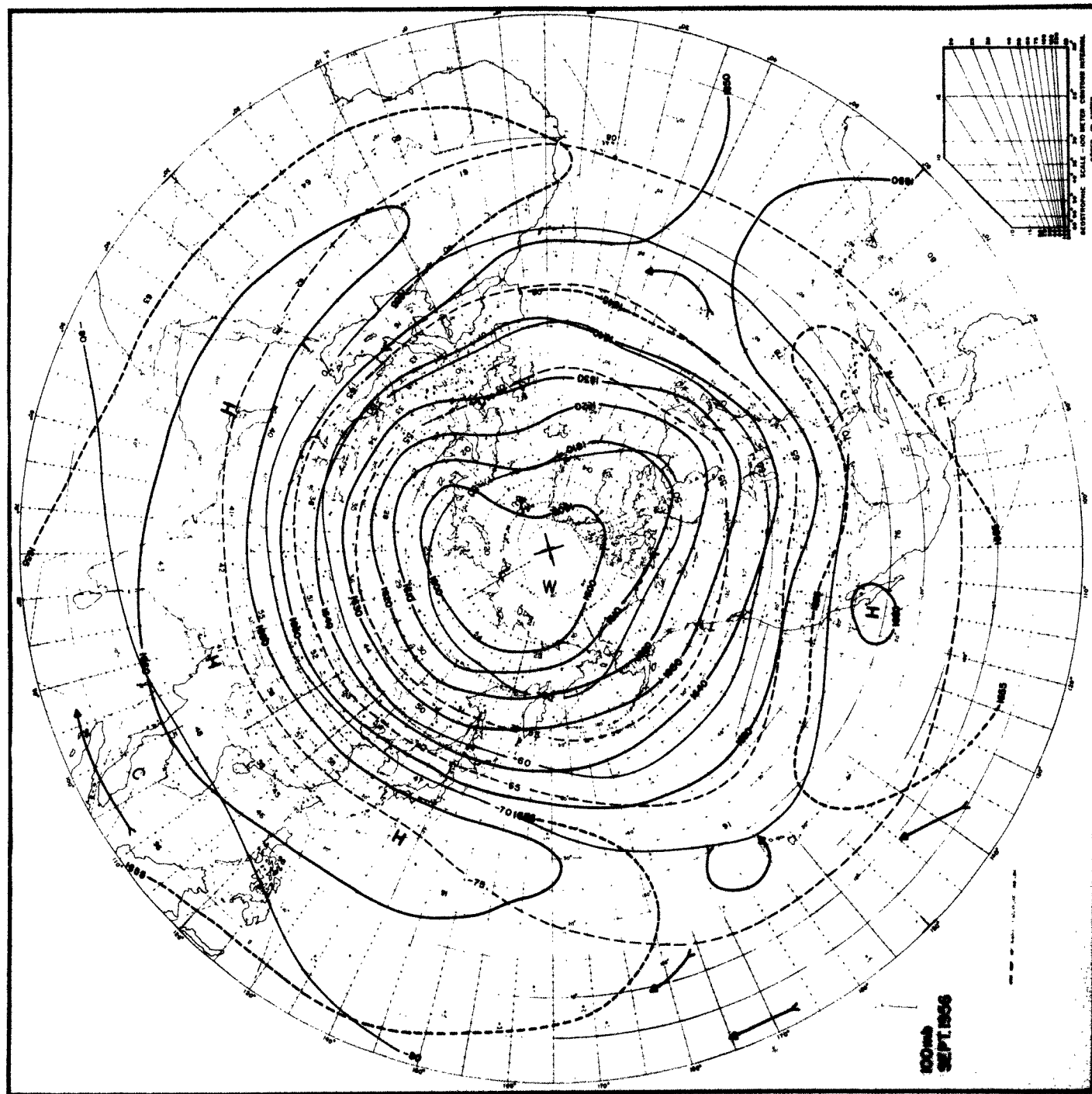


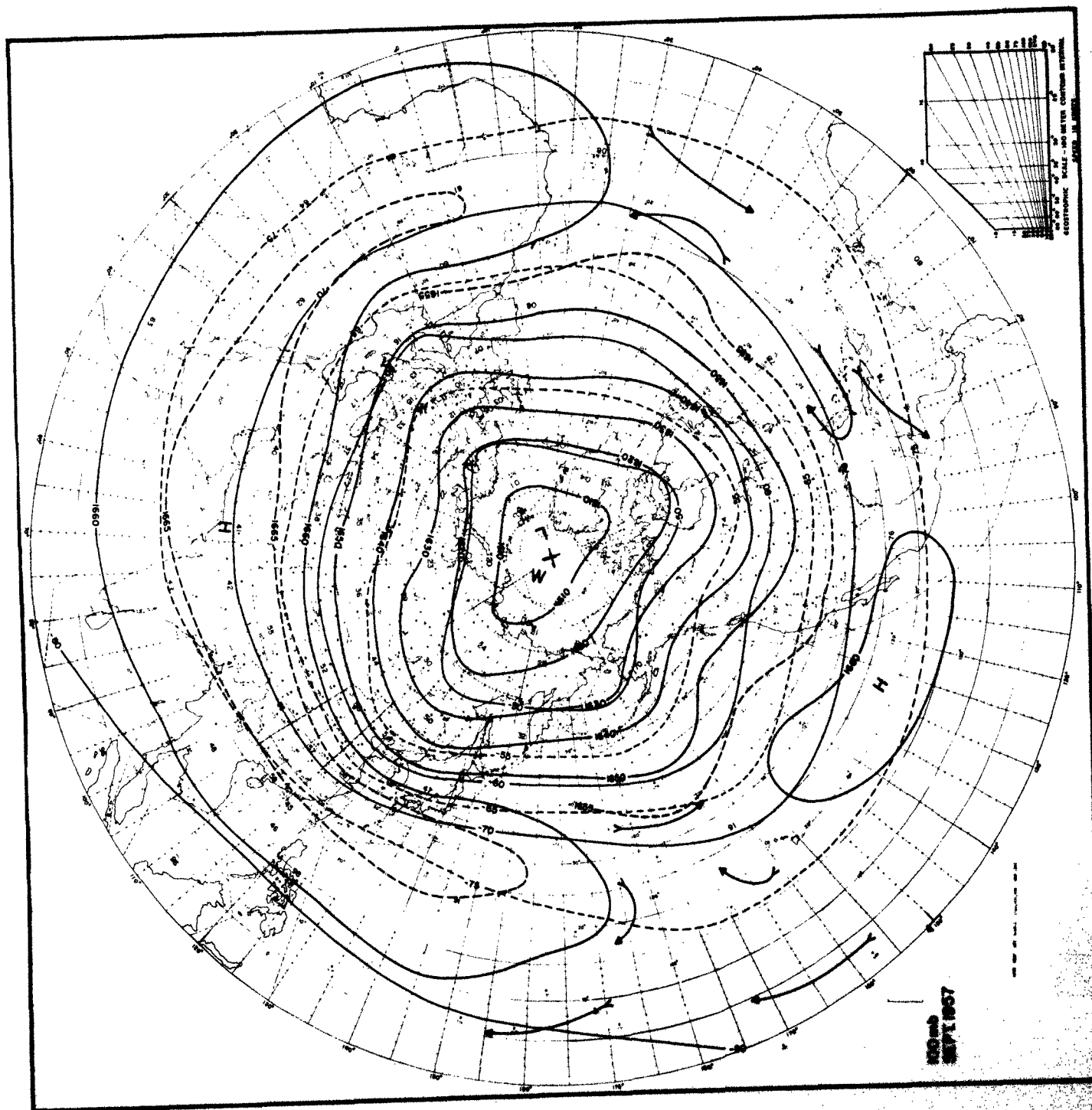


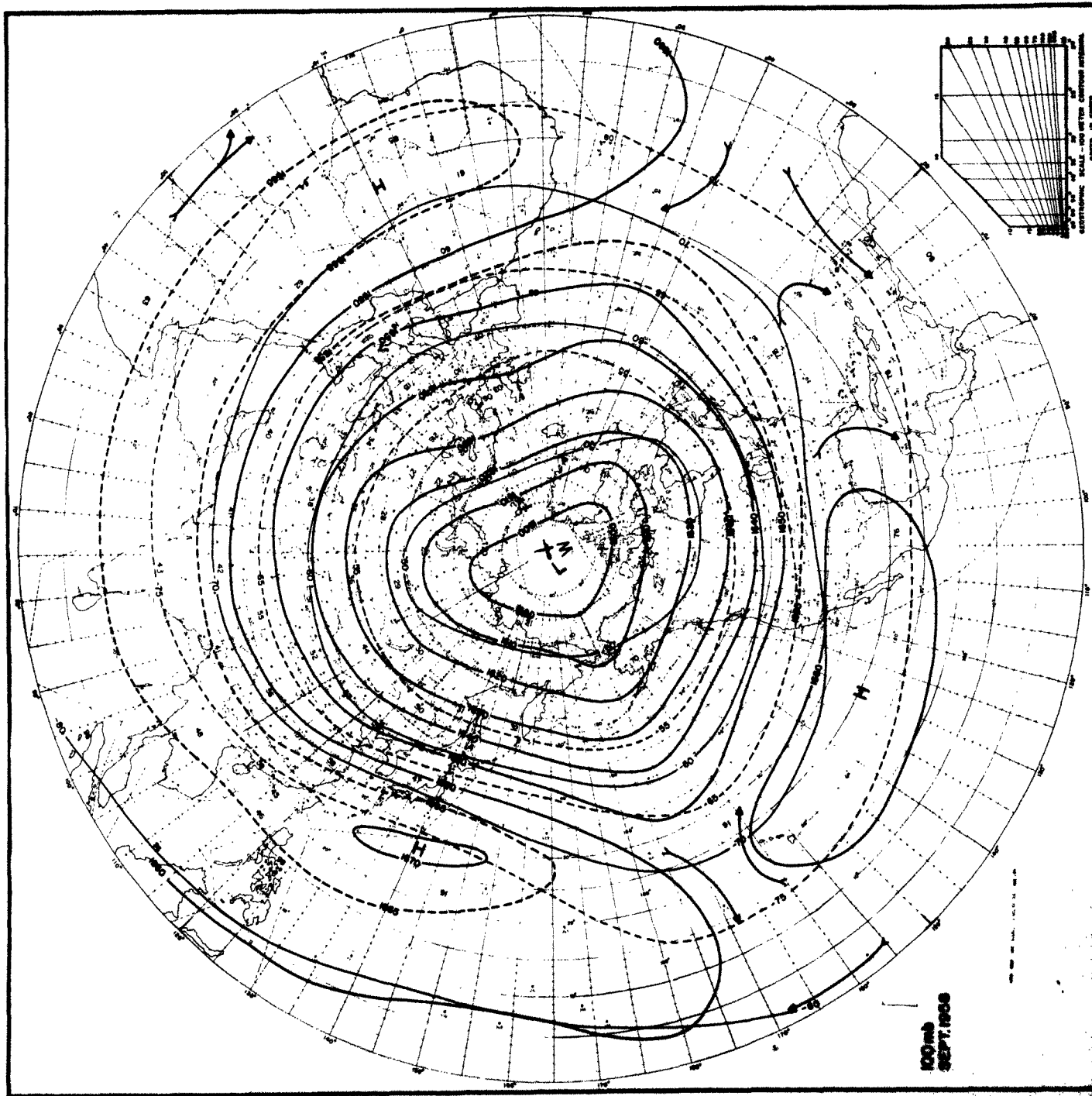


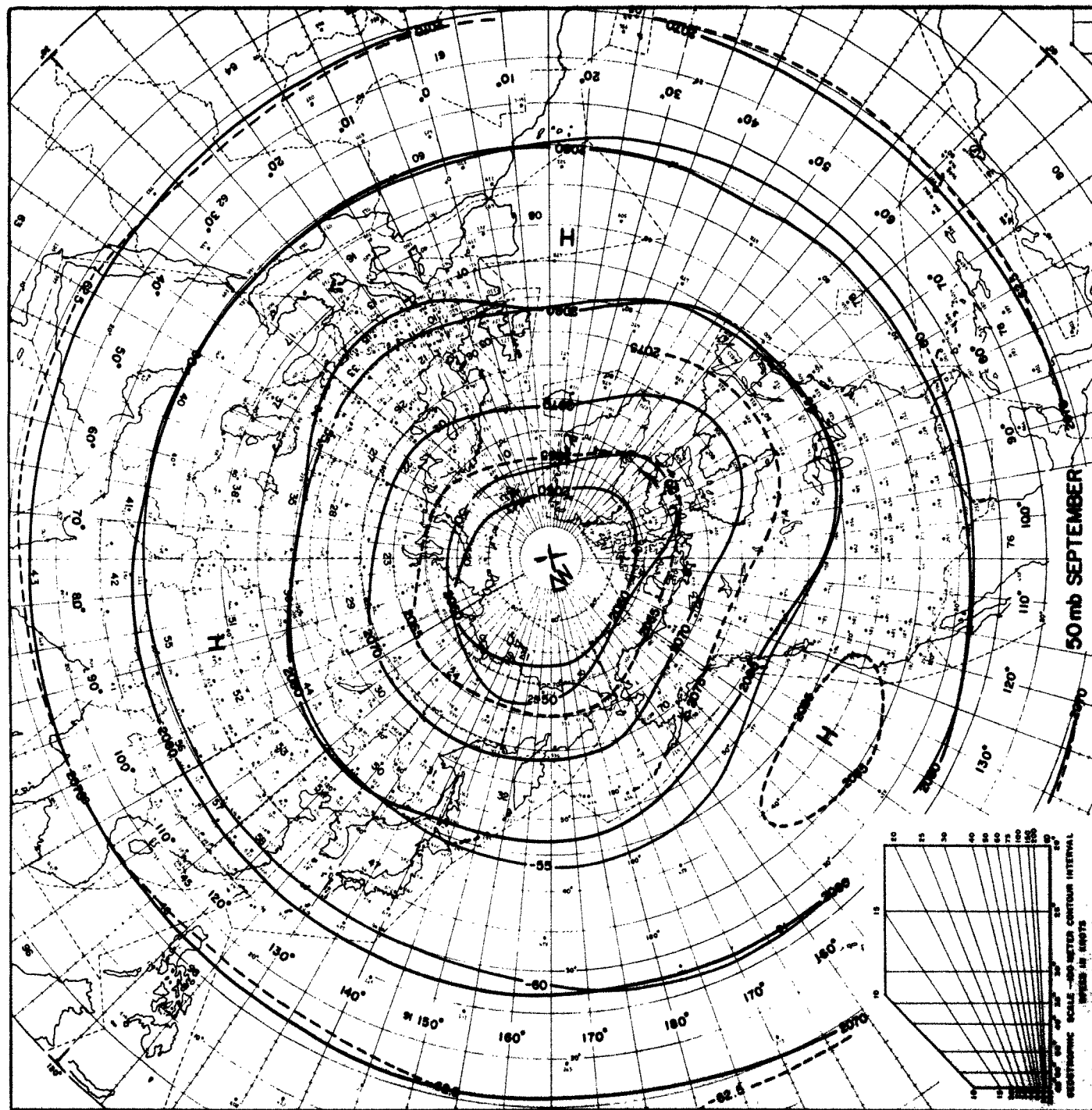




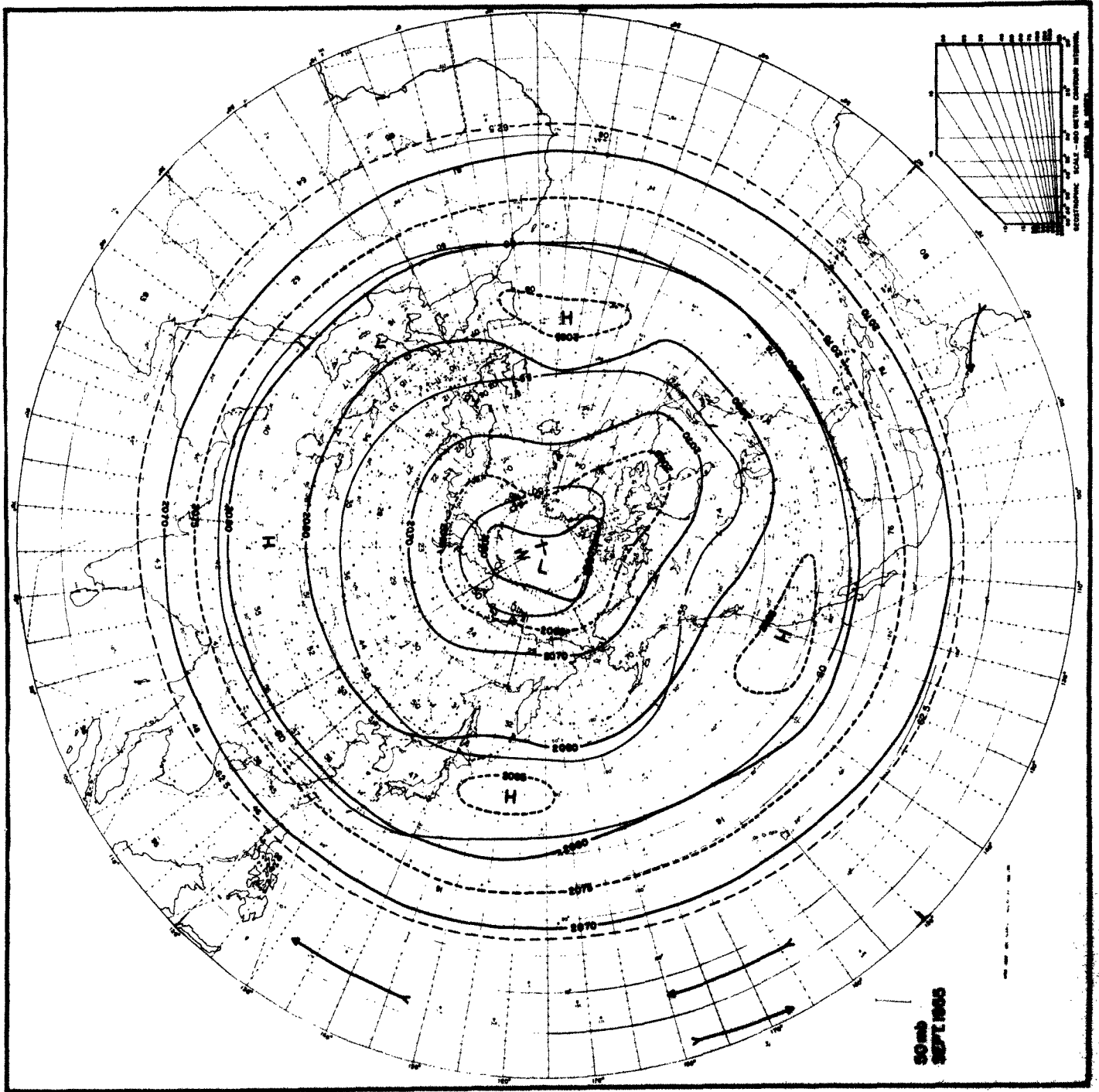


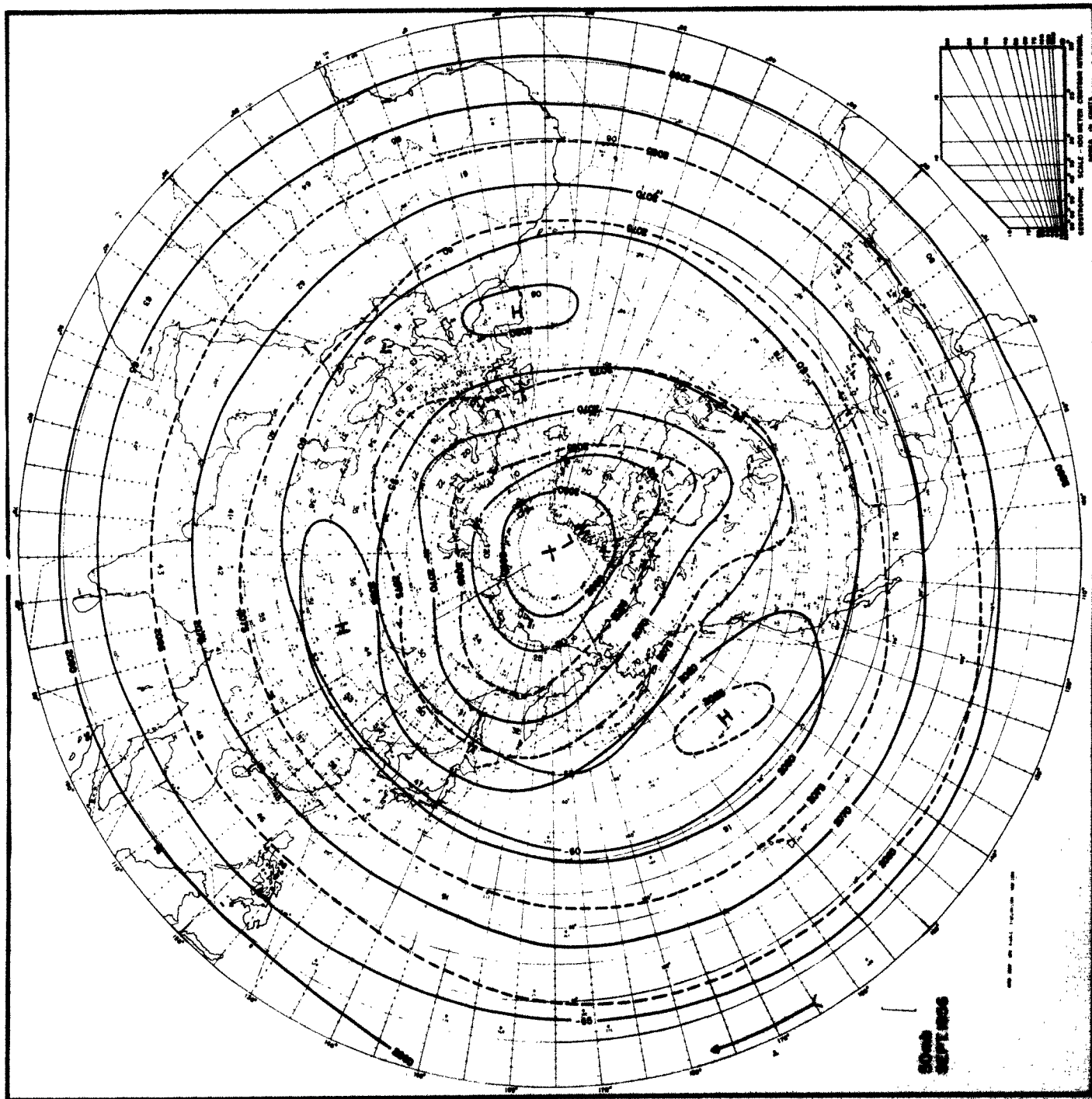


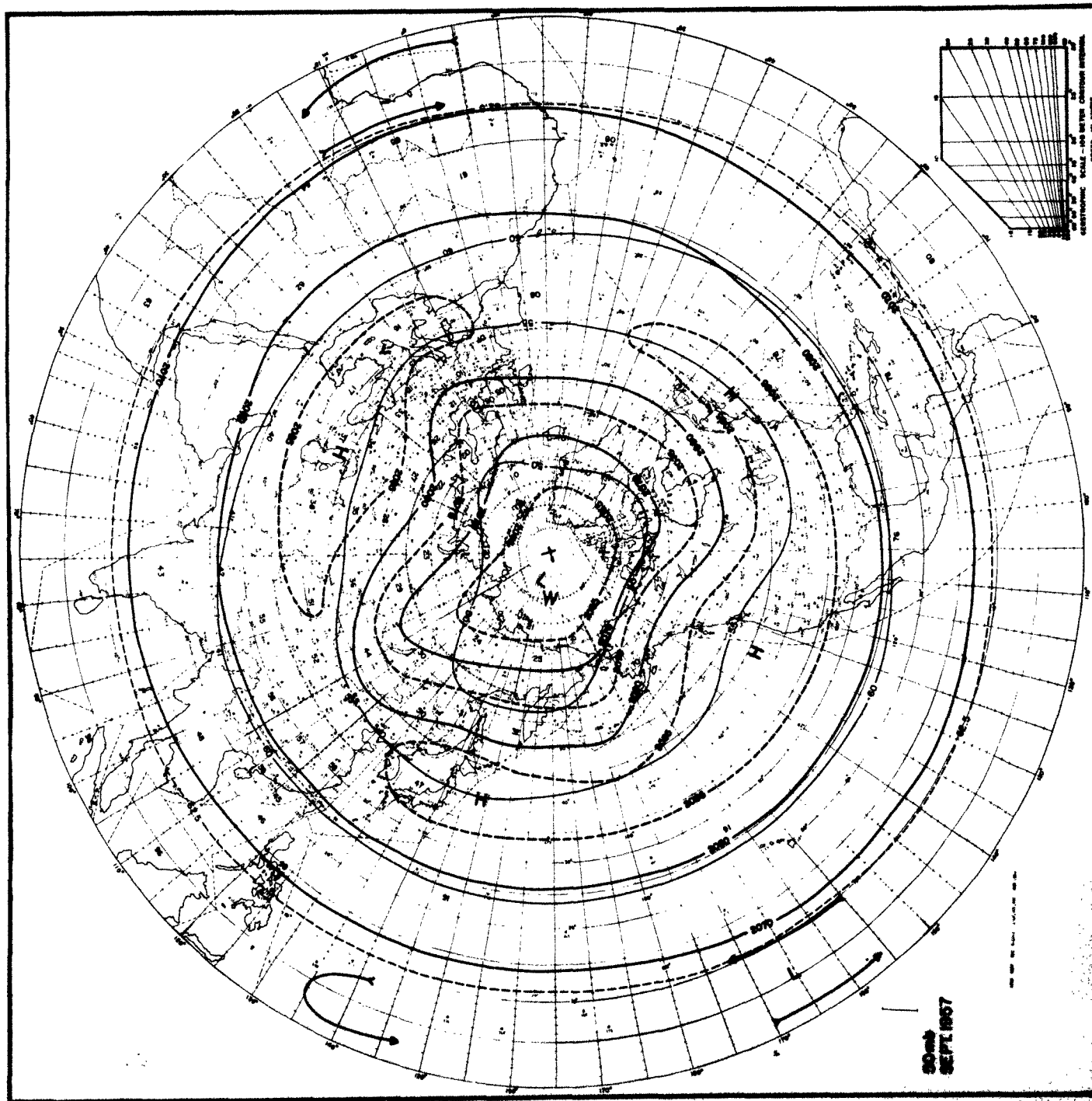


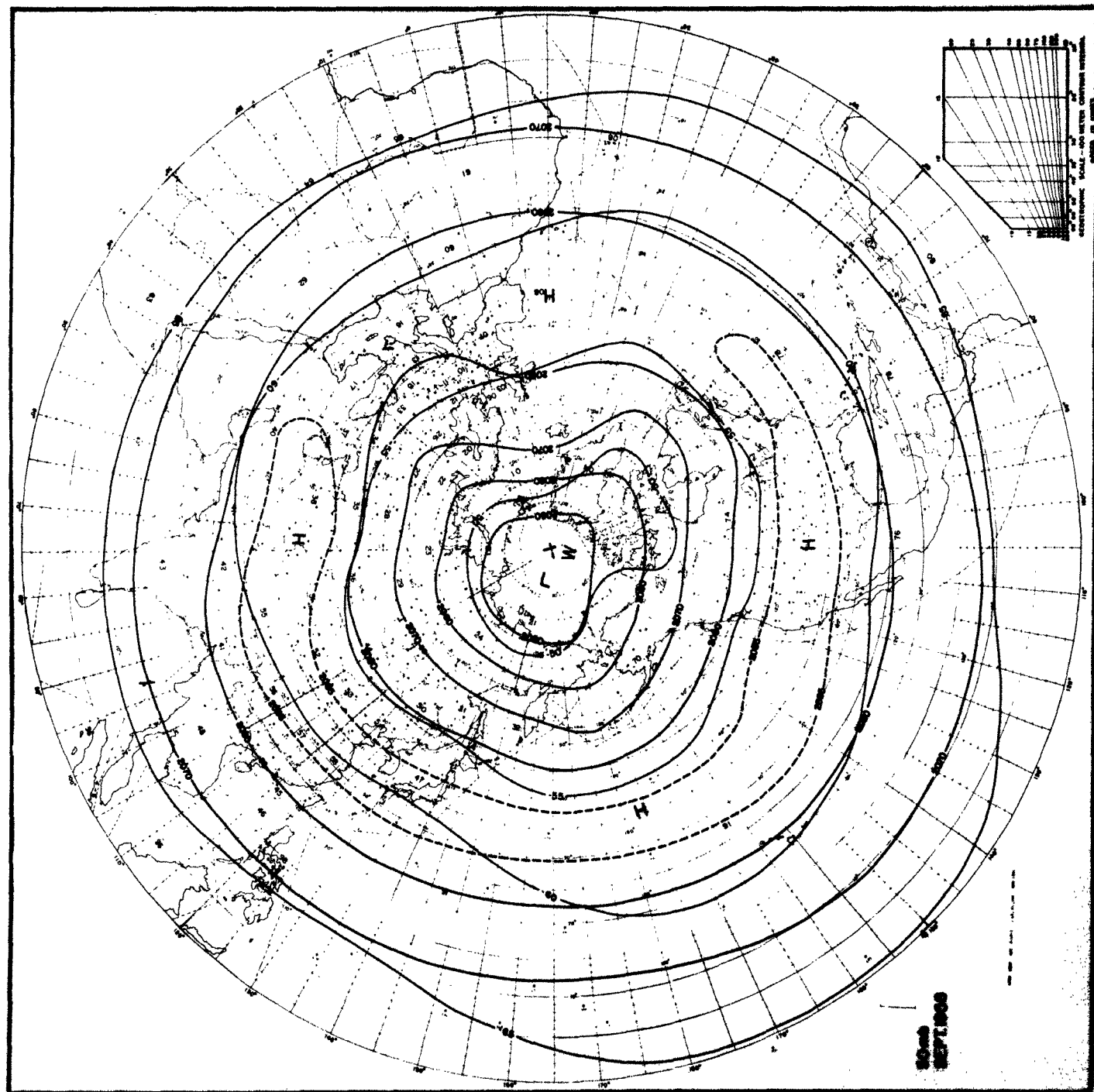


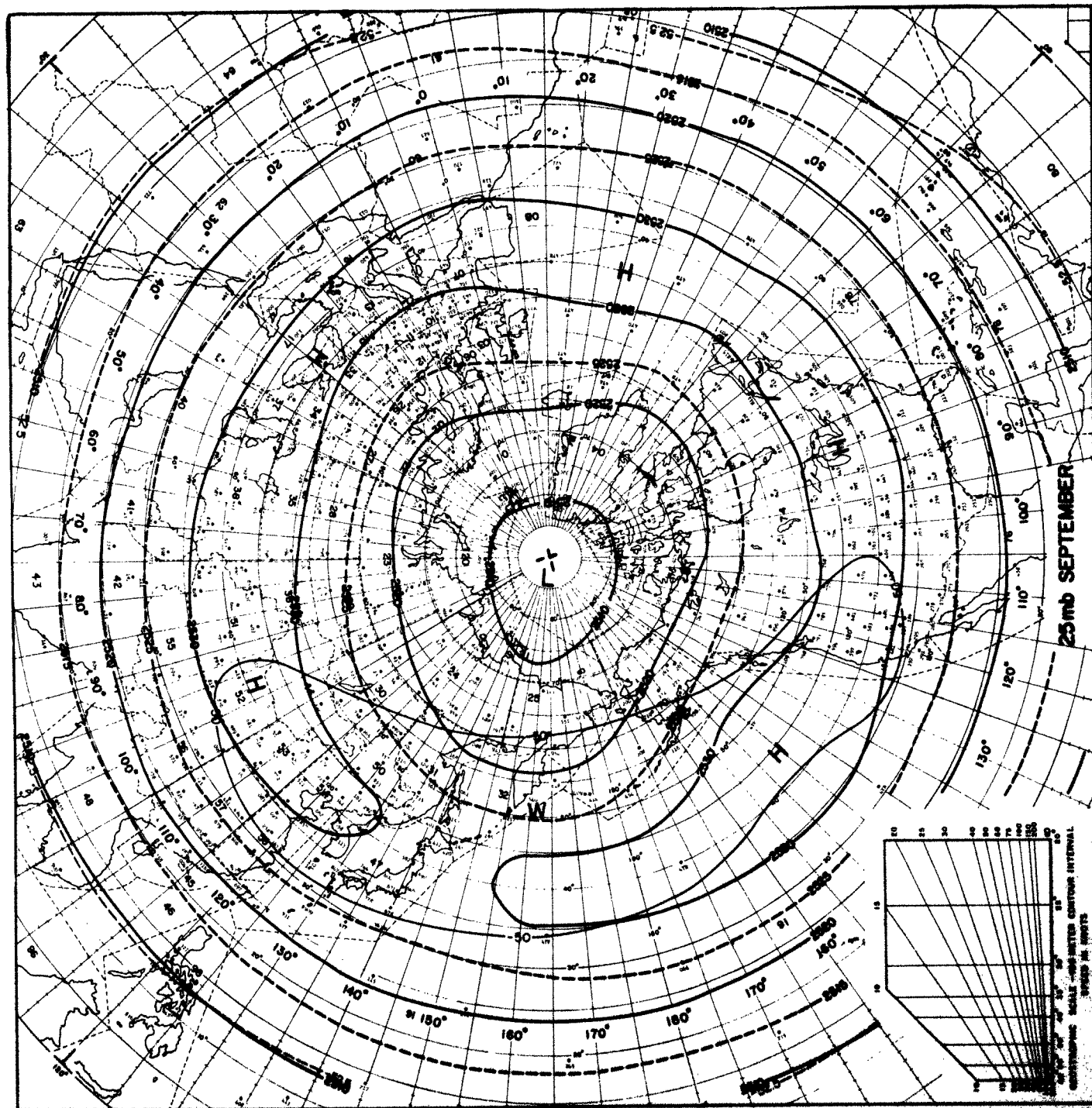
50 mb SEPTEMBER

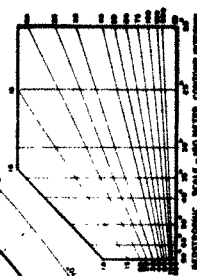
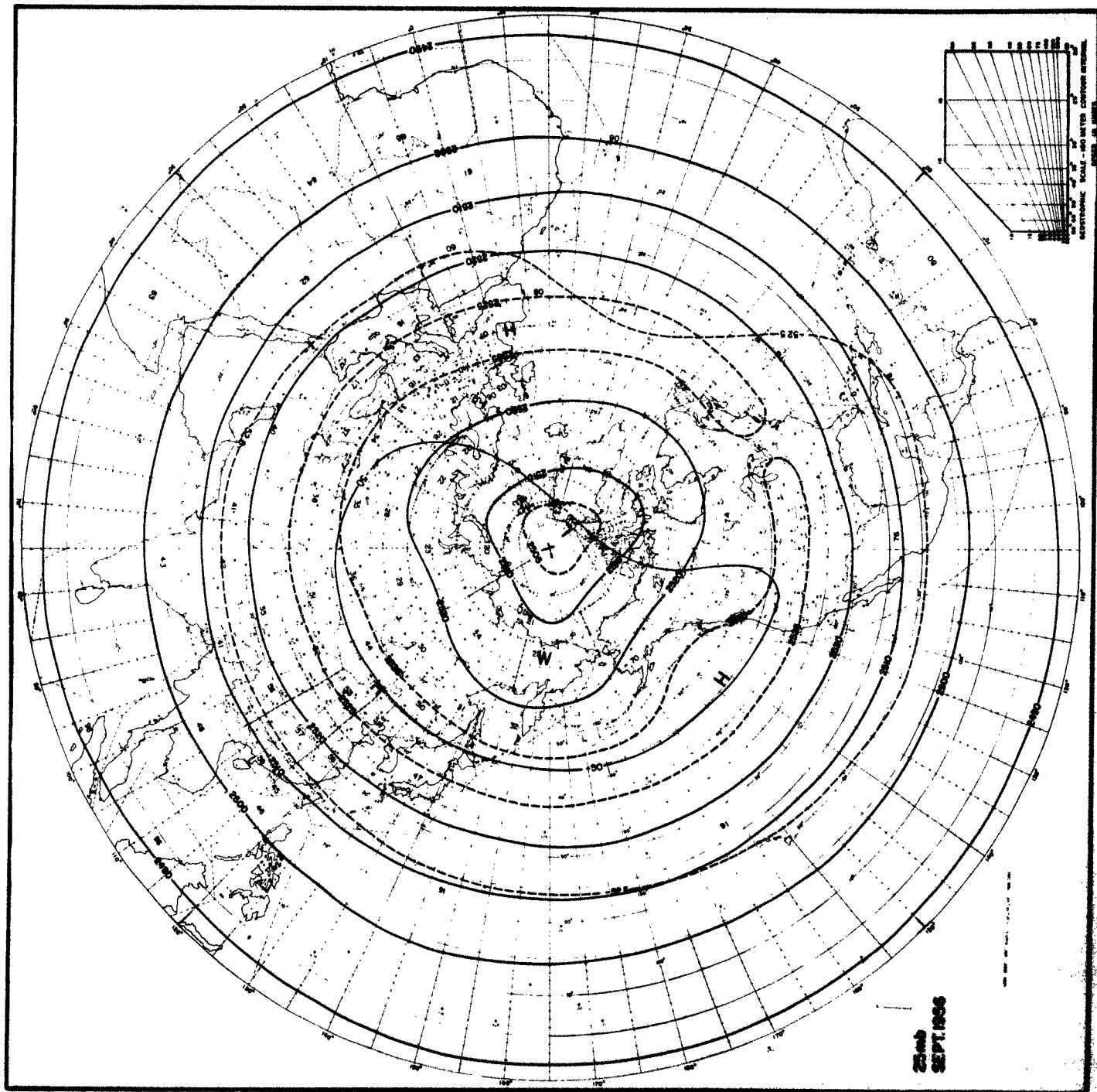


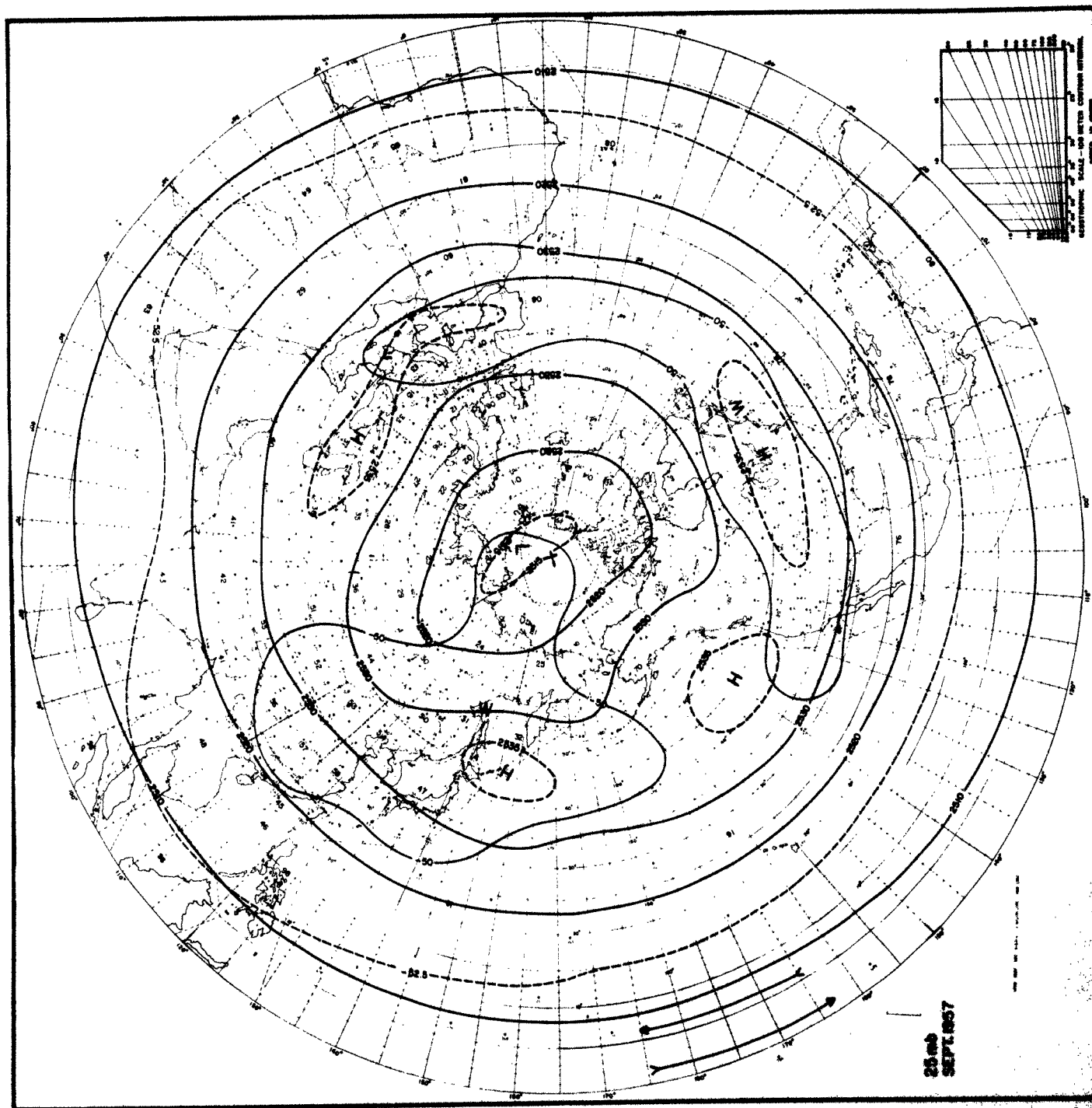


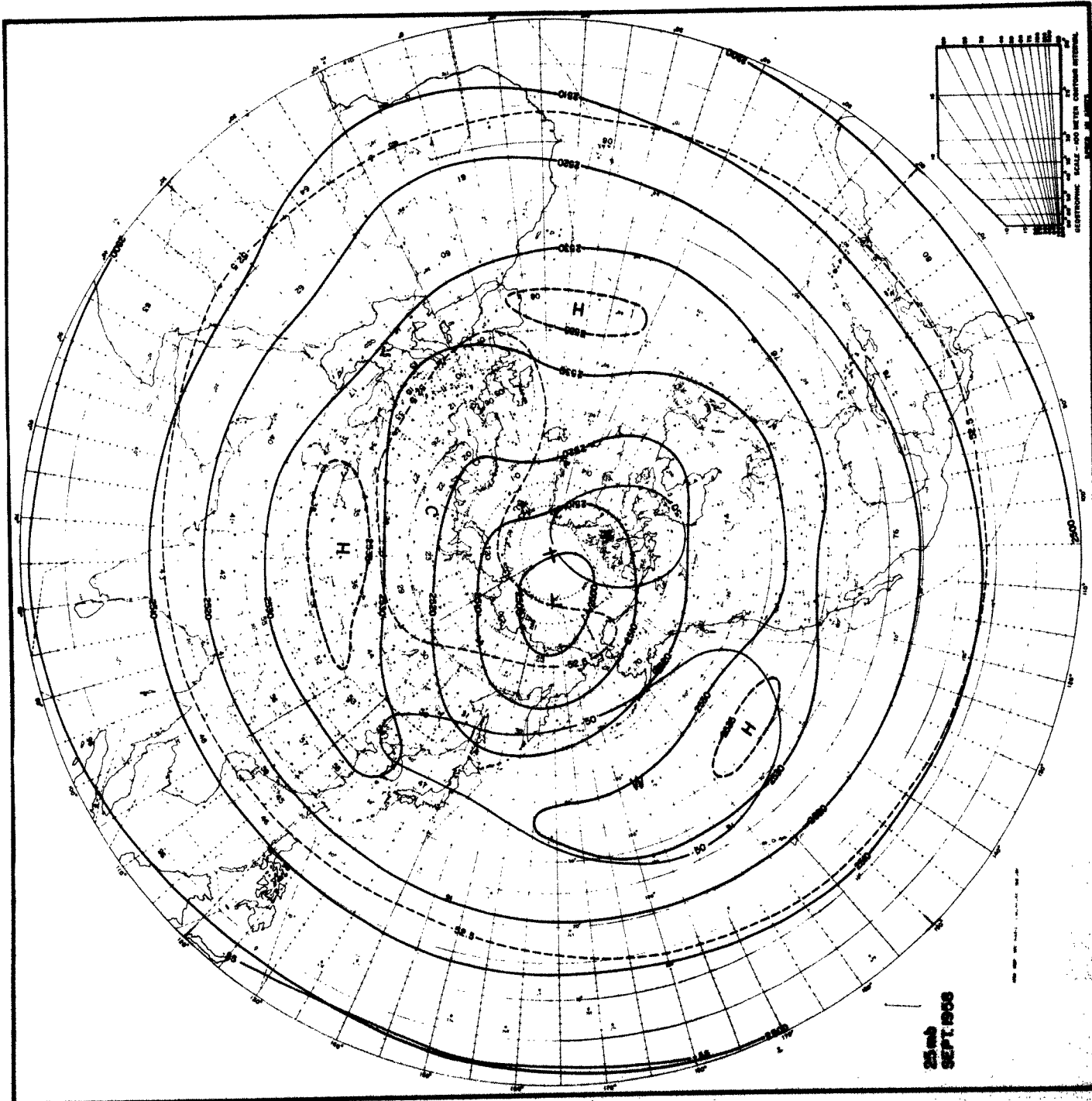




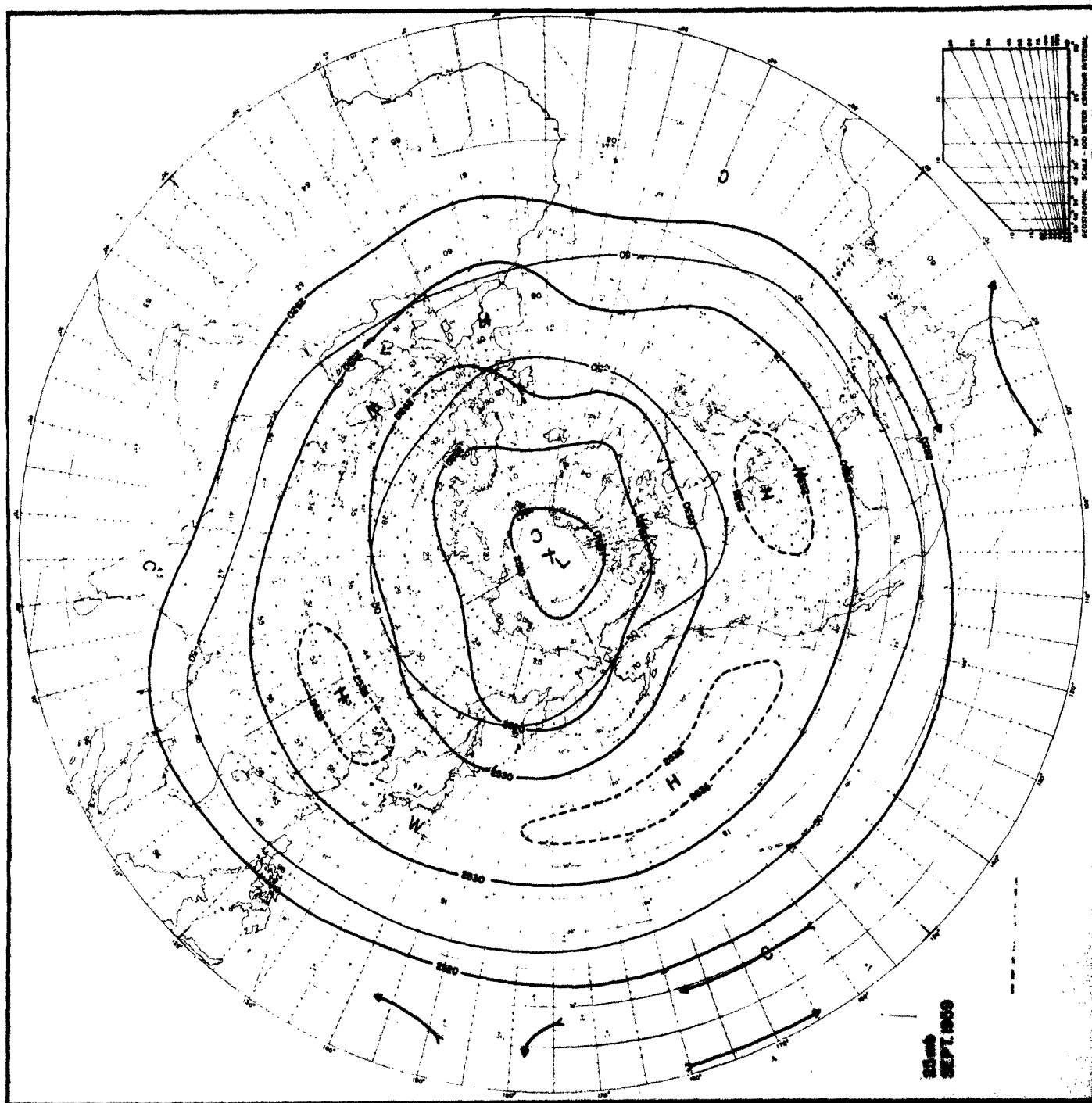


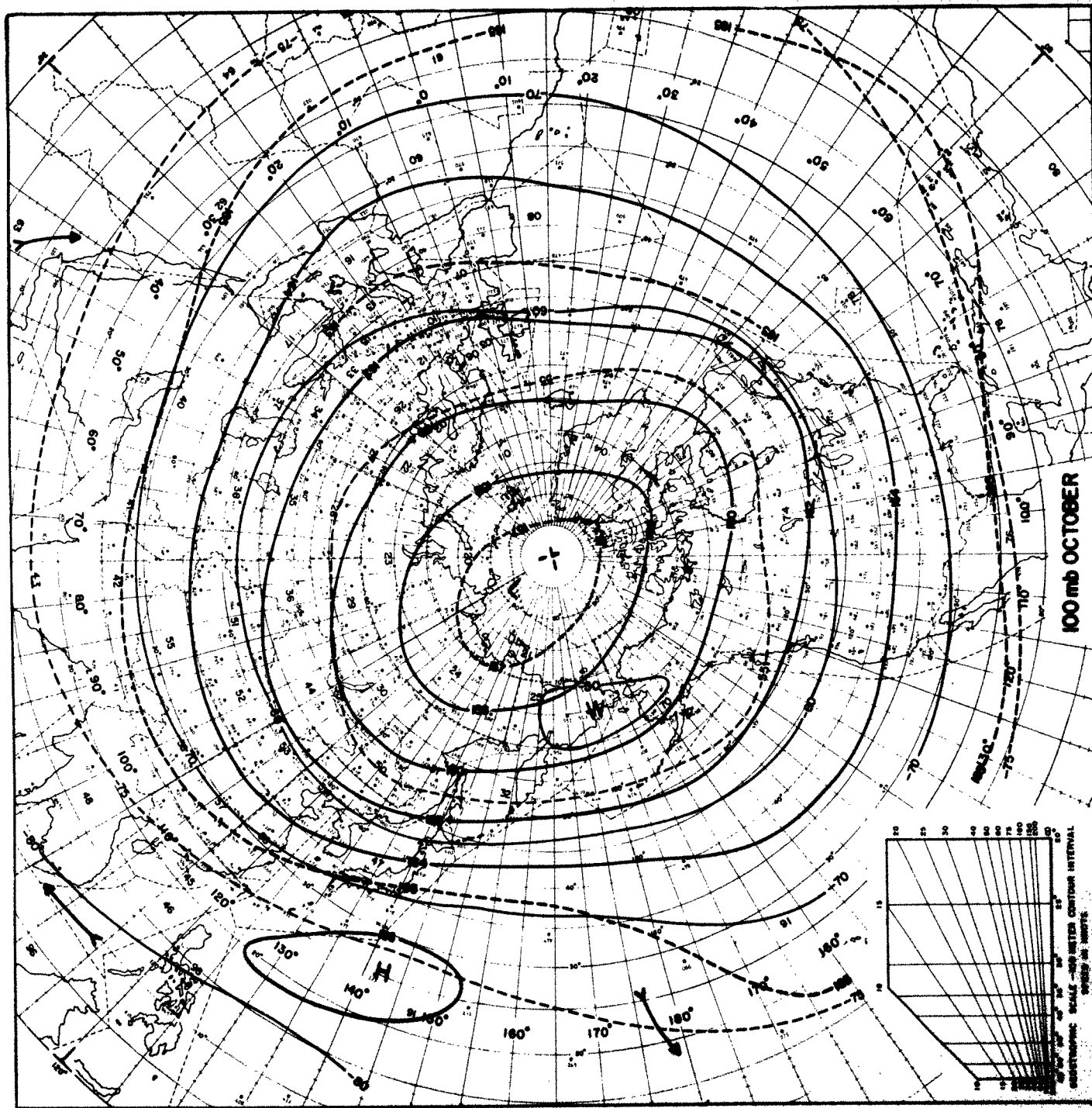


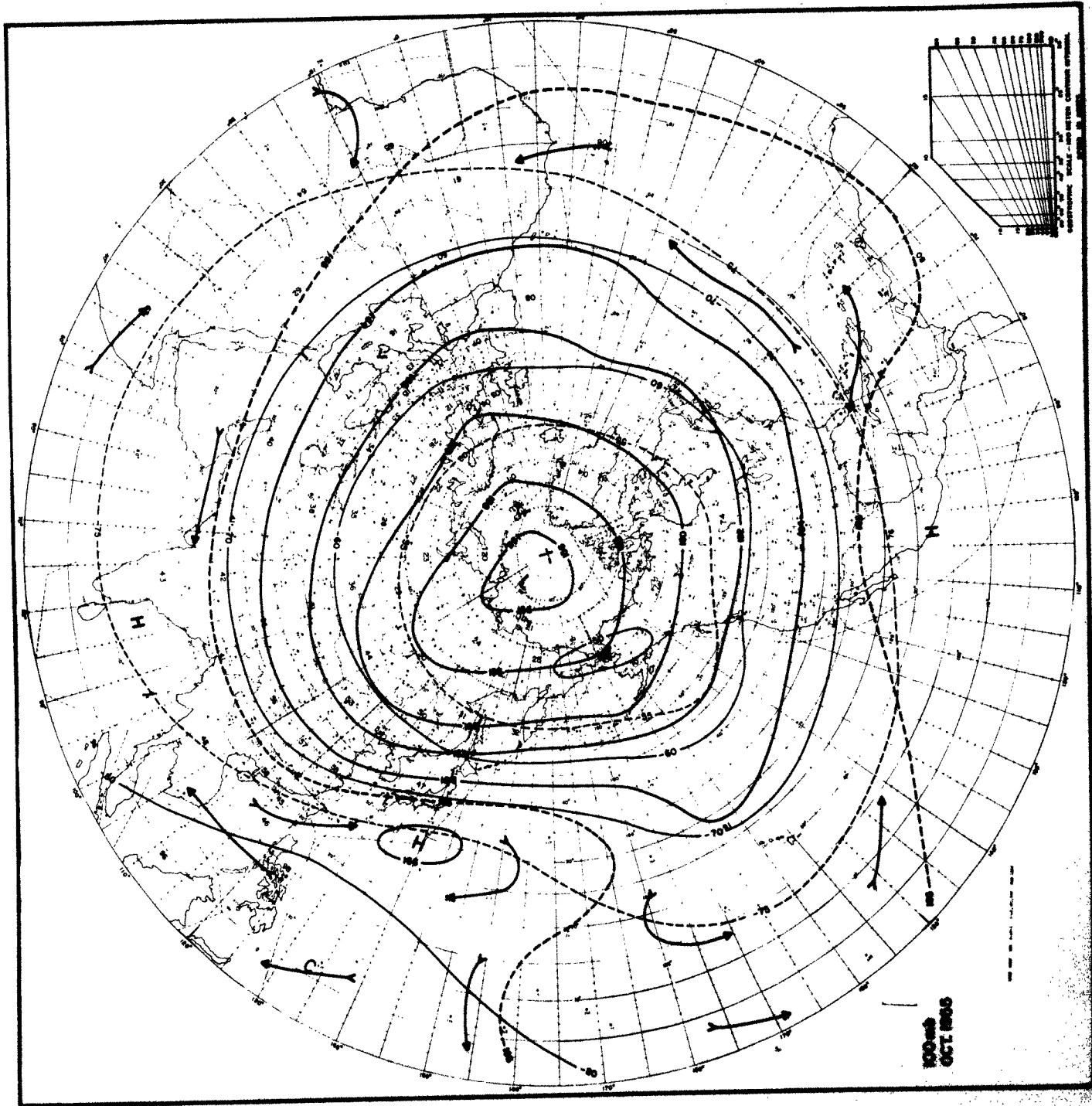


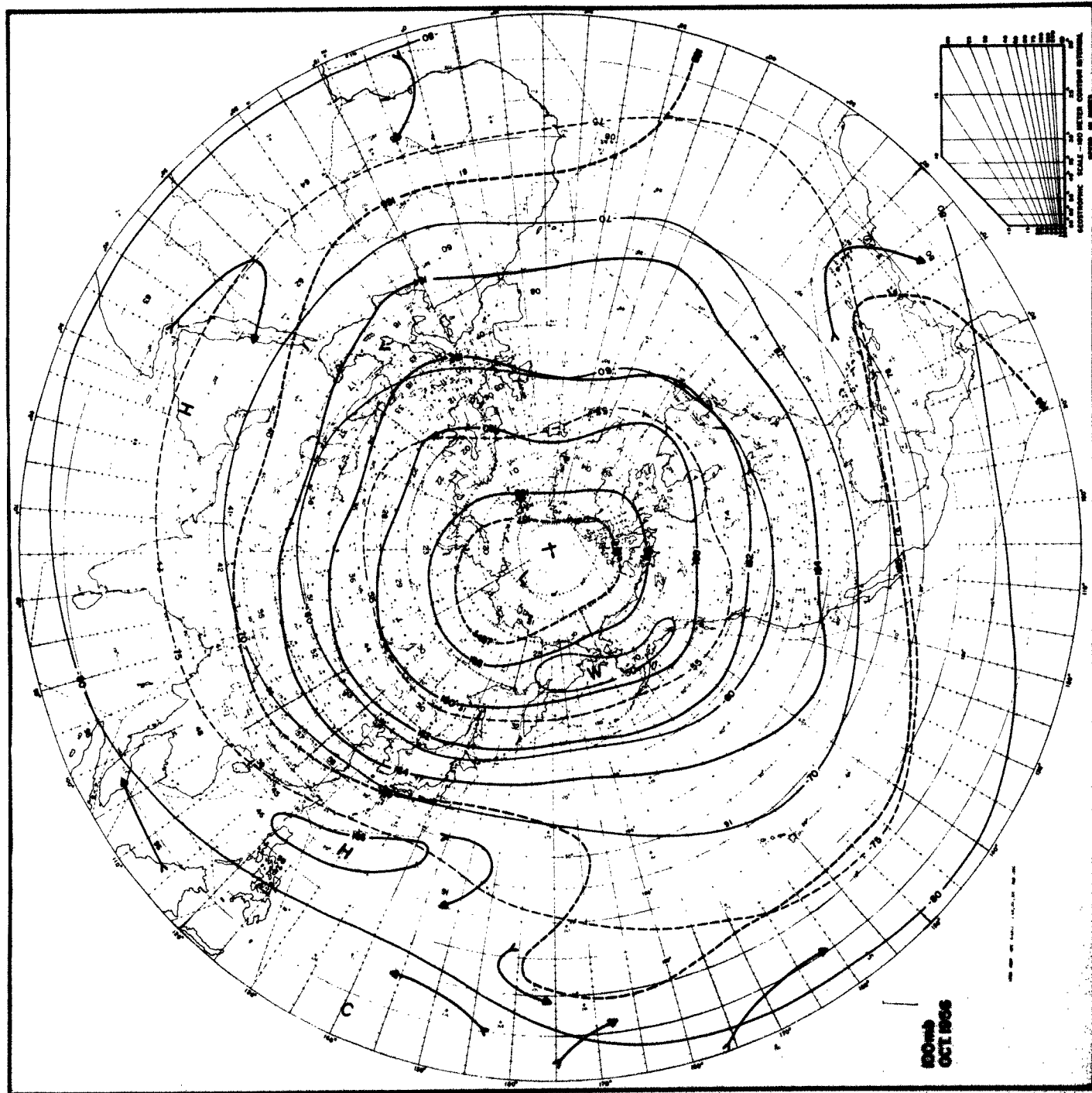


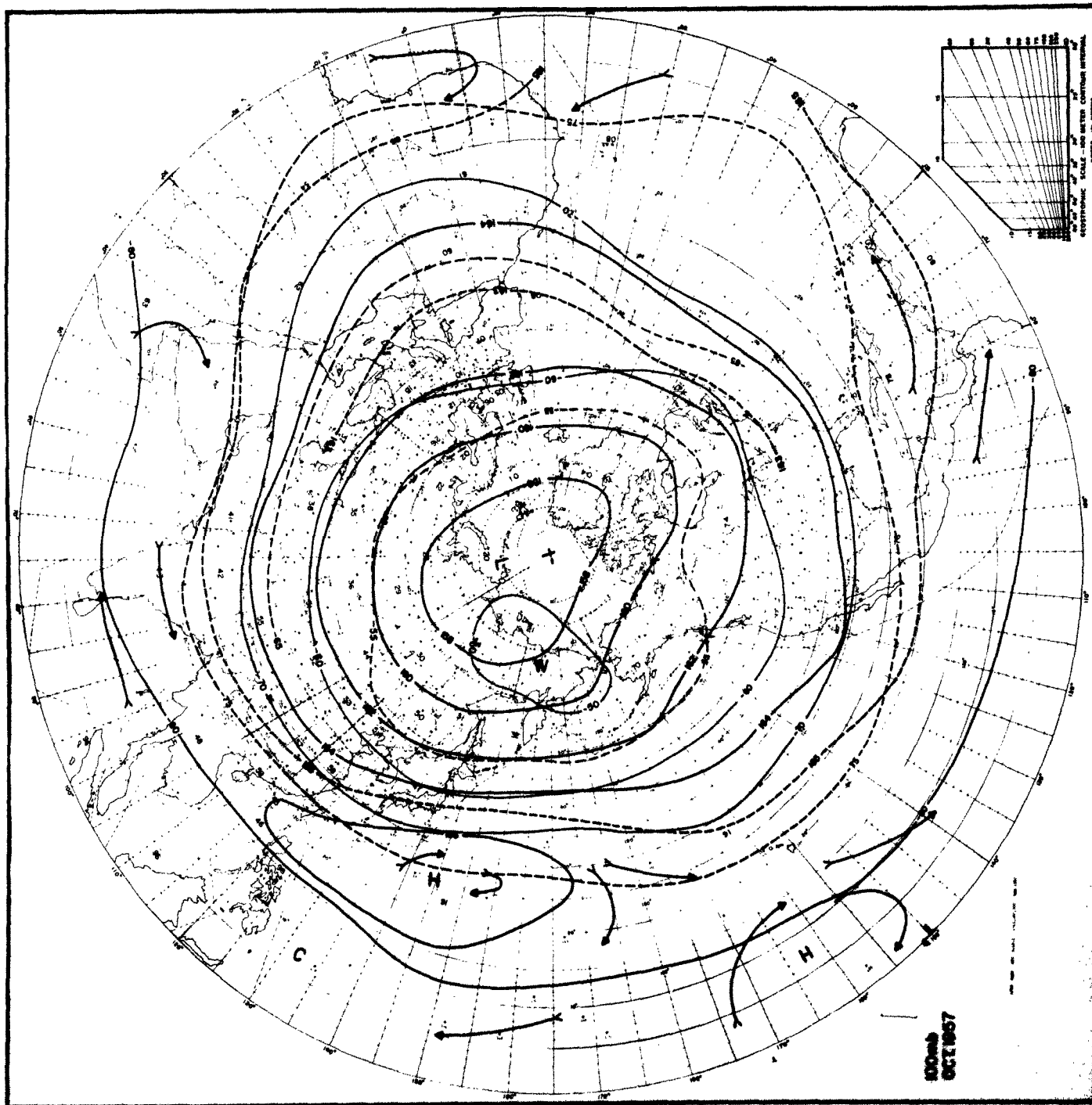
21 mb
SEPT 1988

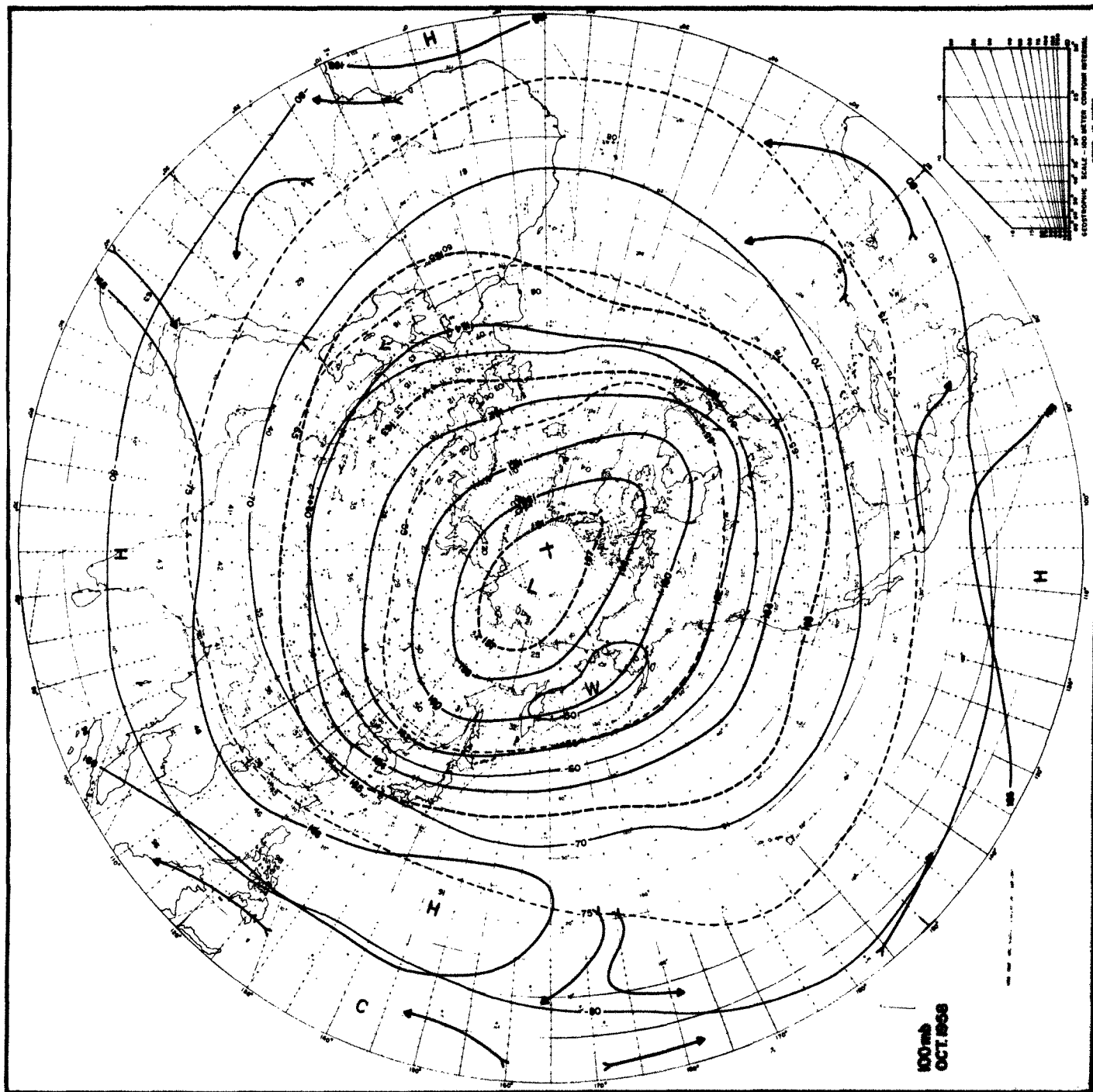


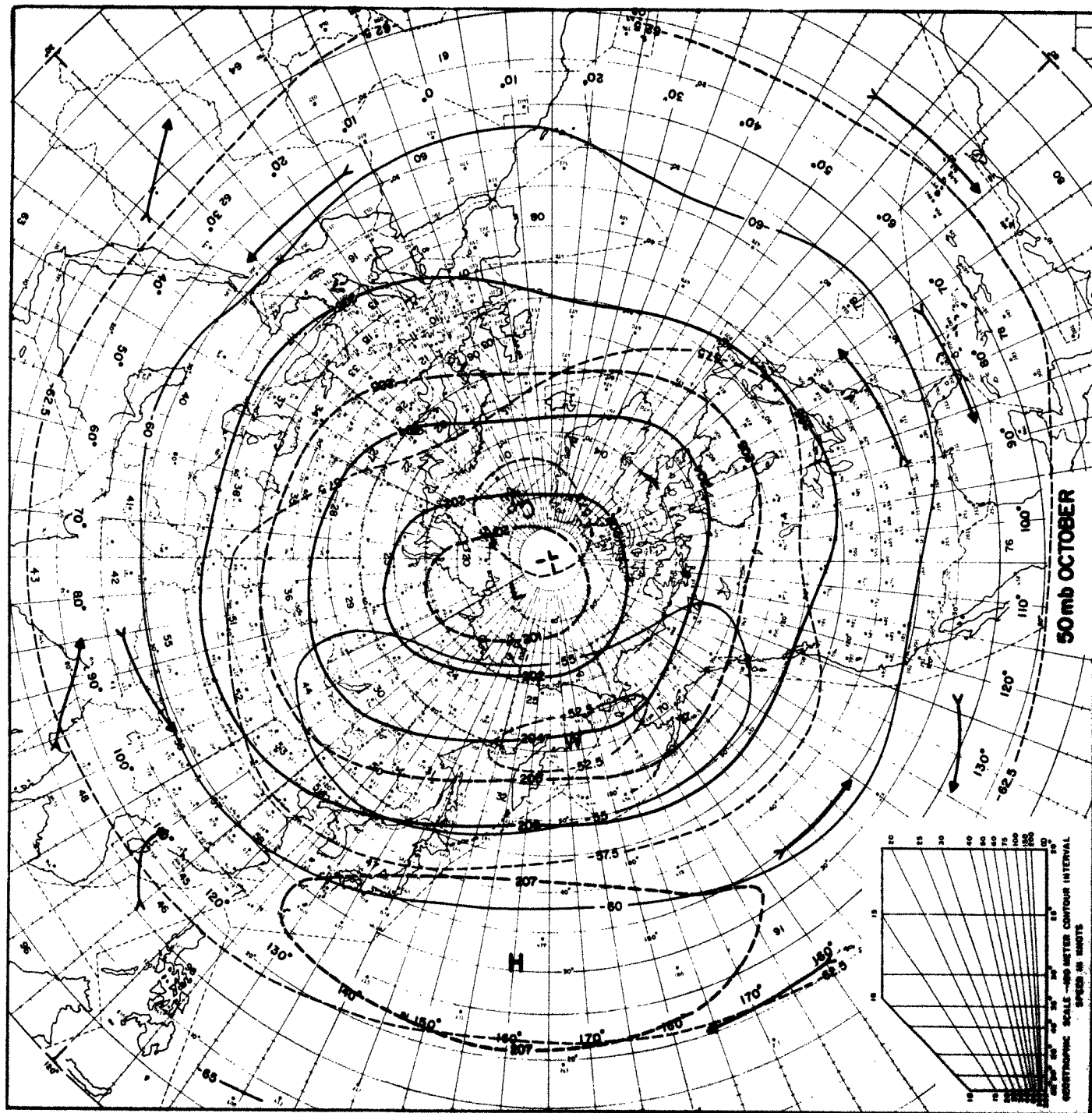


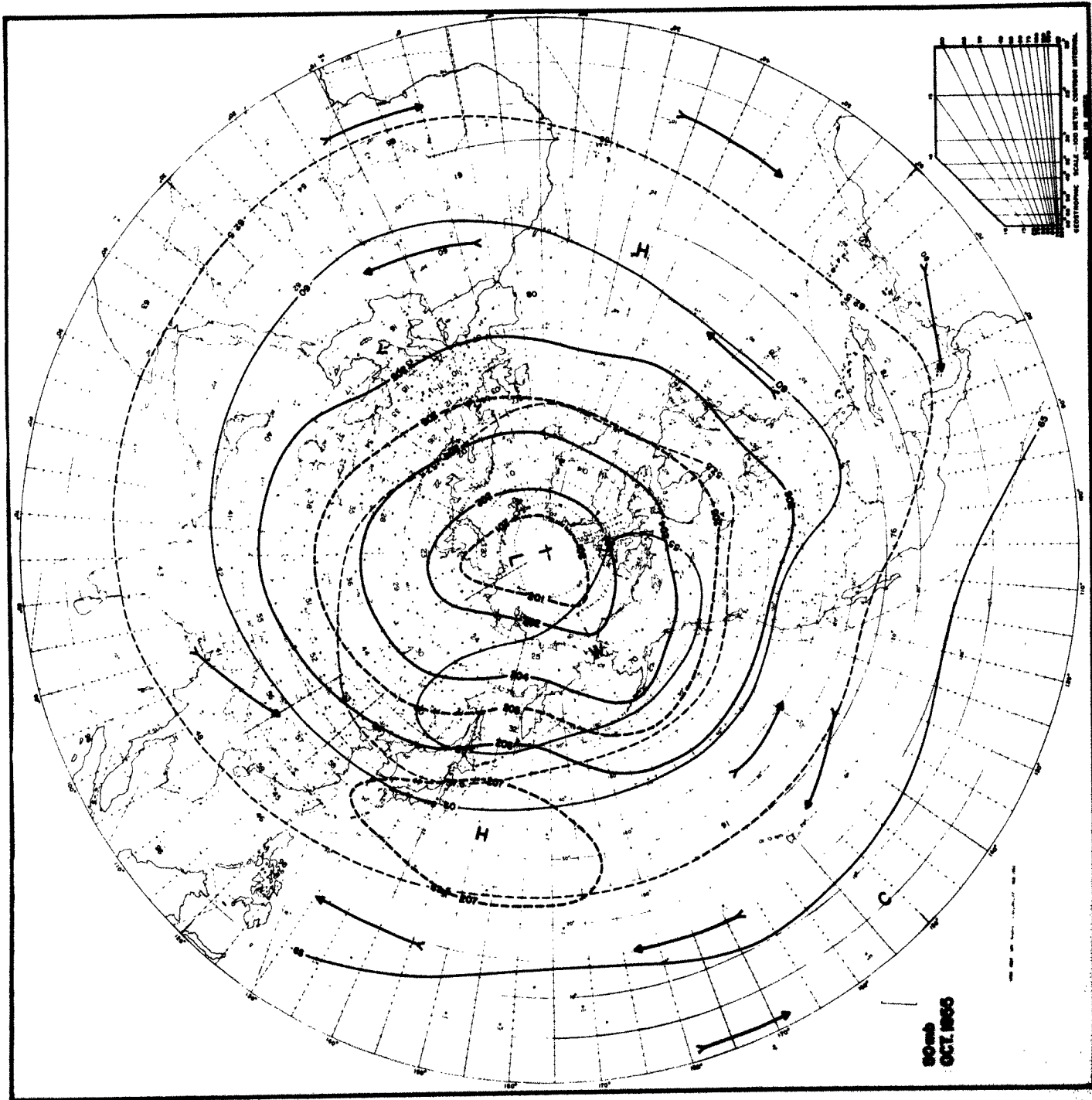


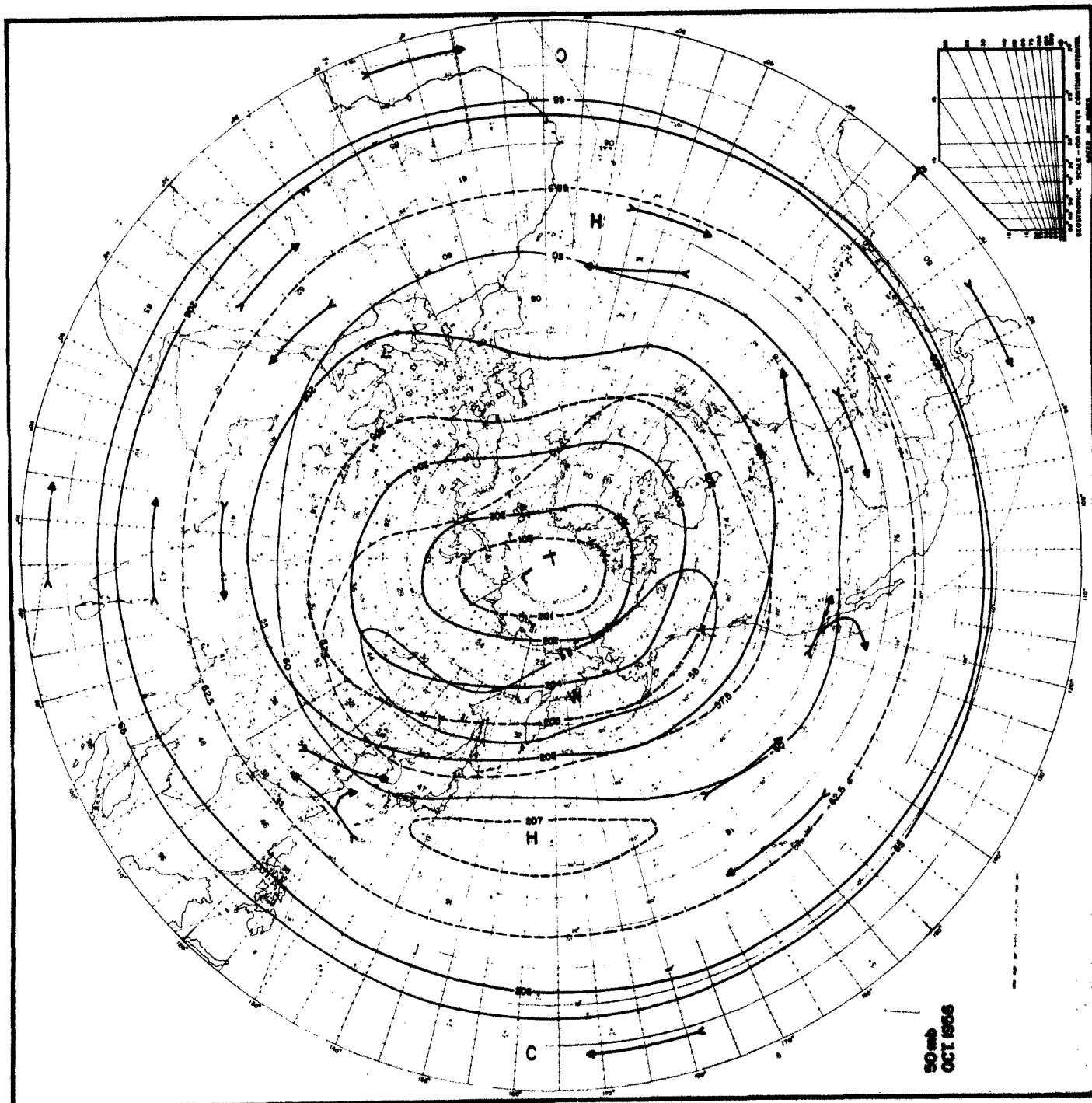


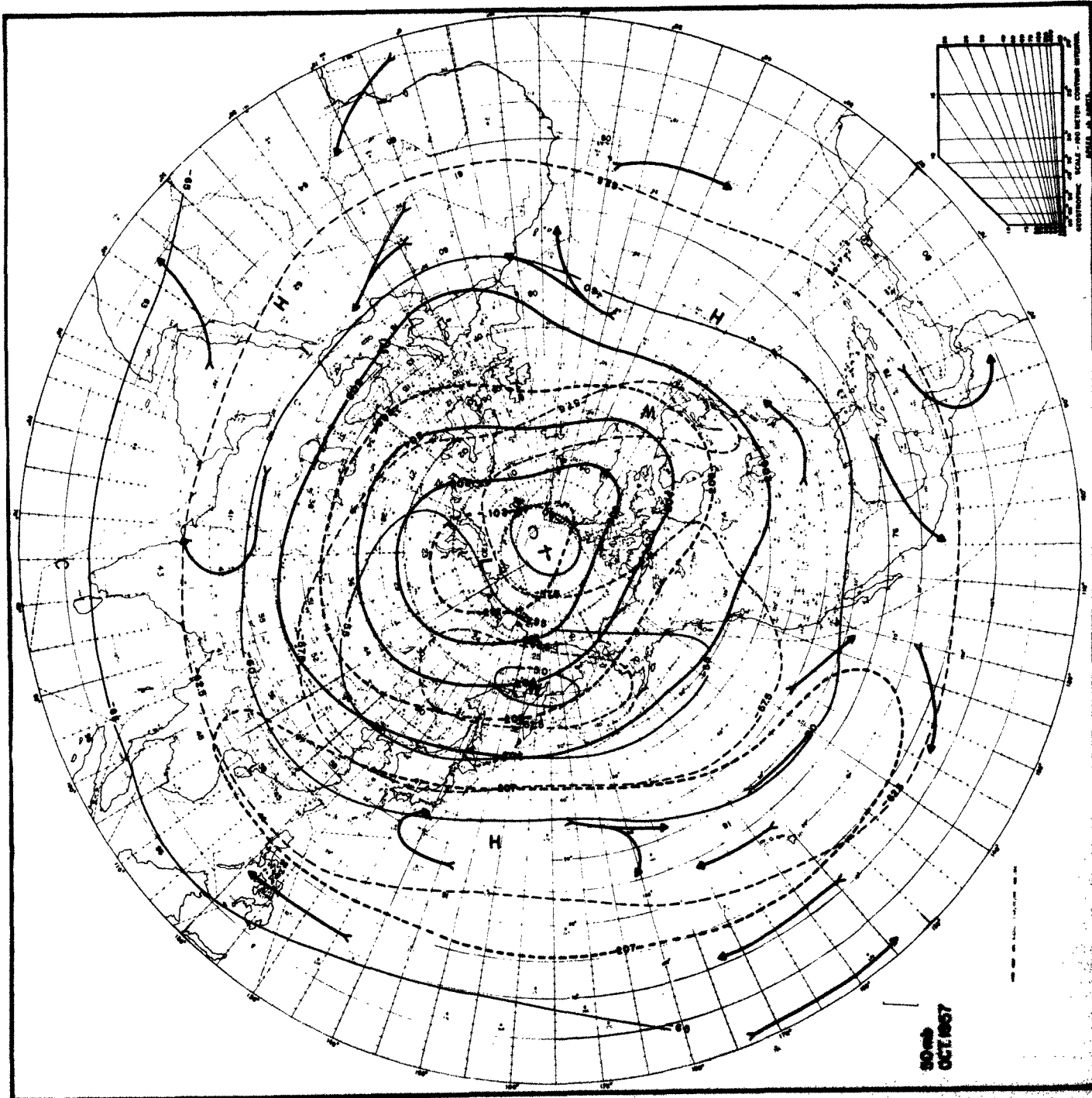




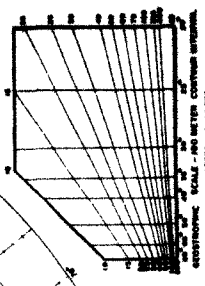


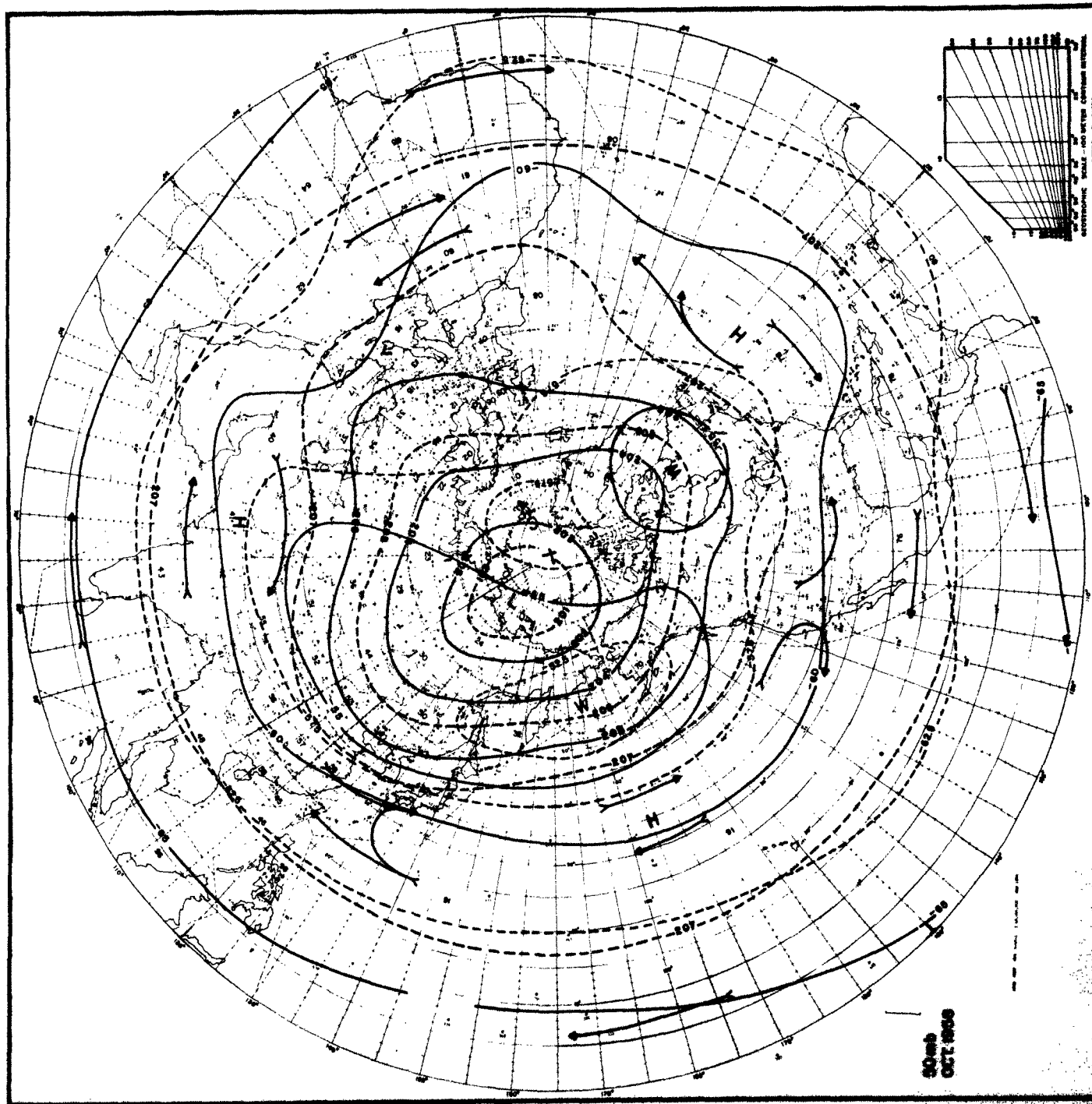


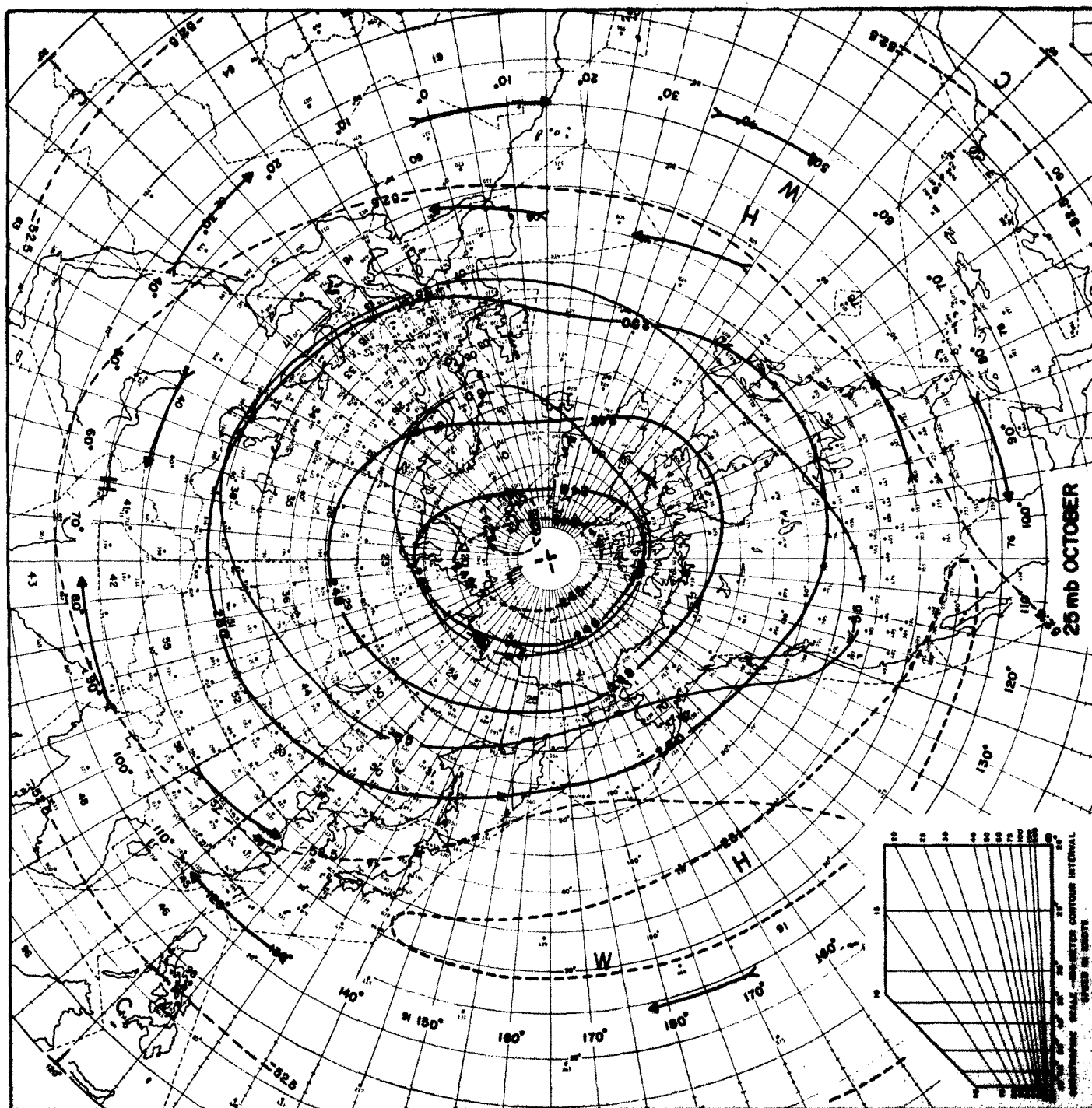


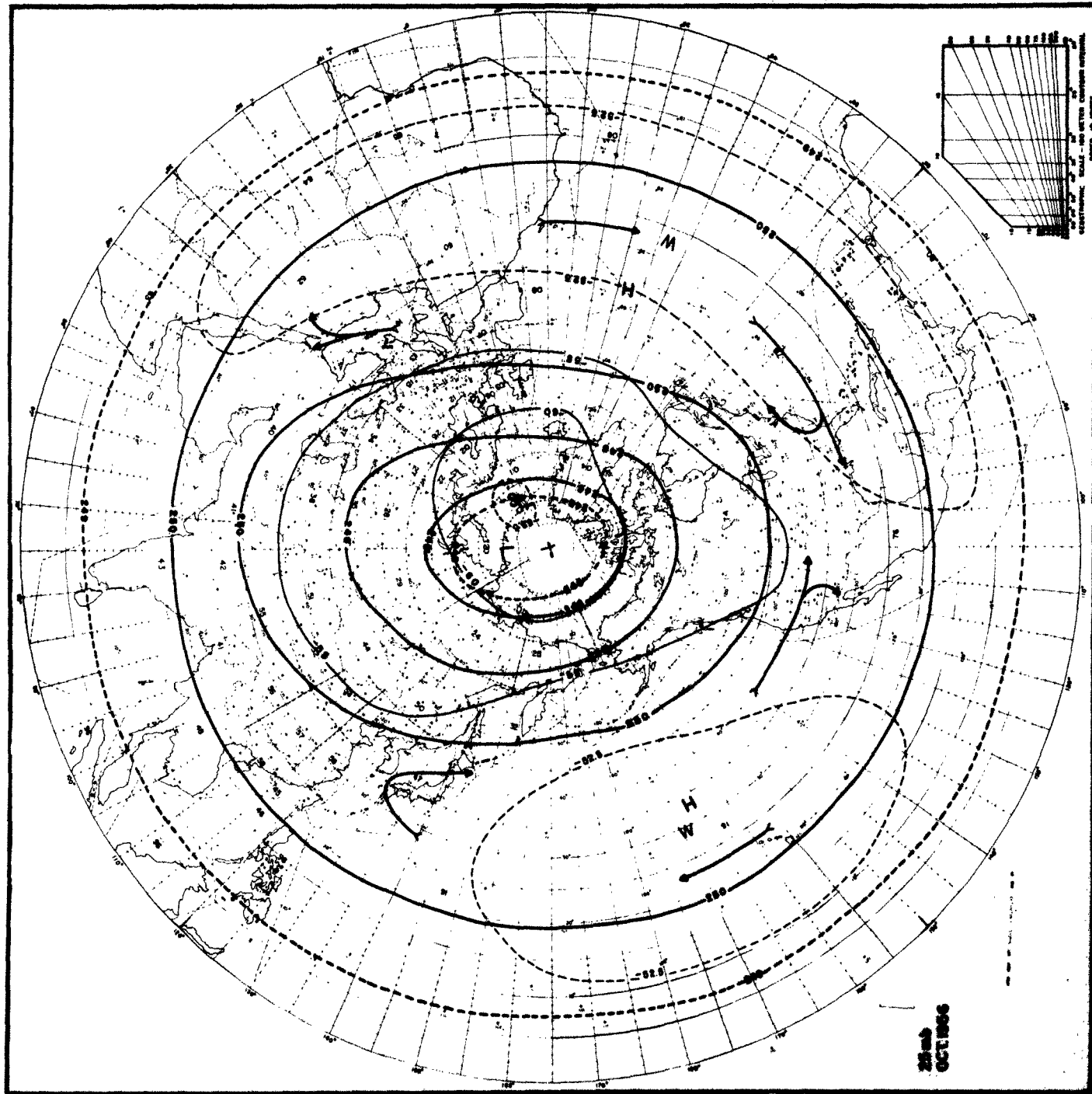


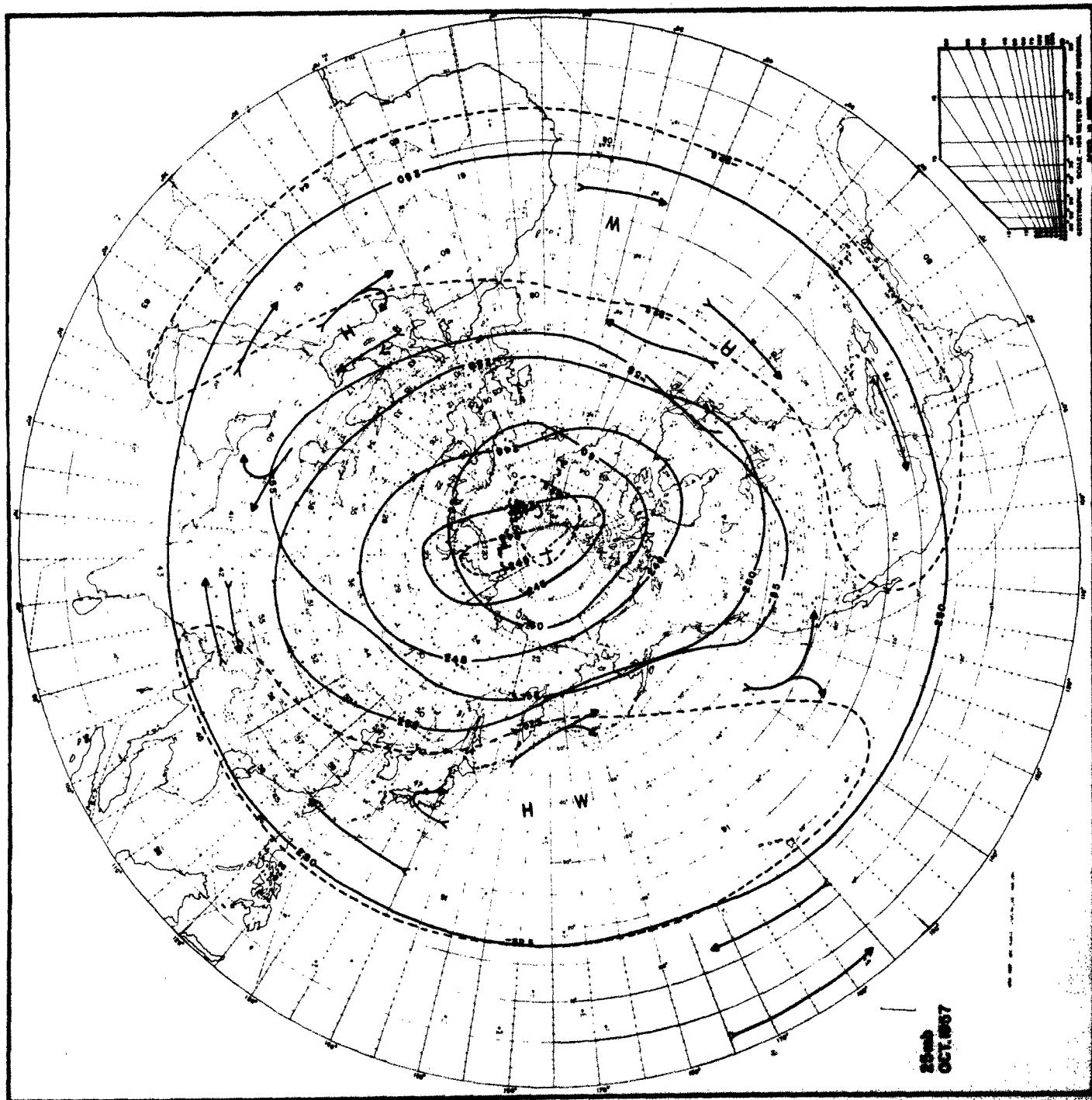
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OCT 1967

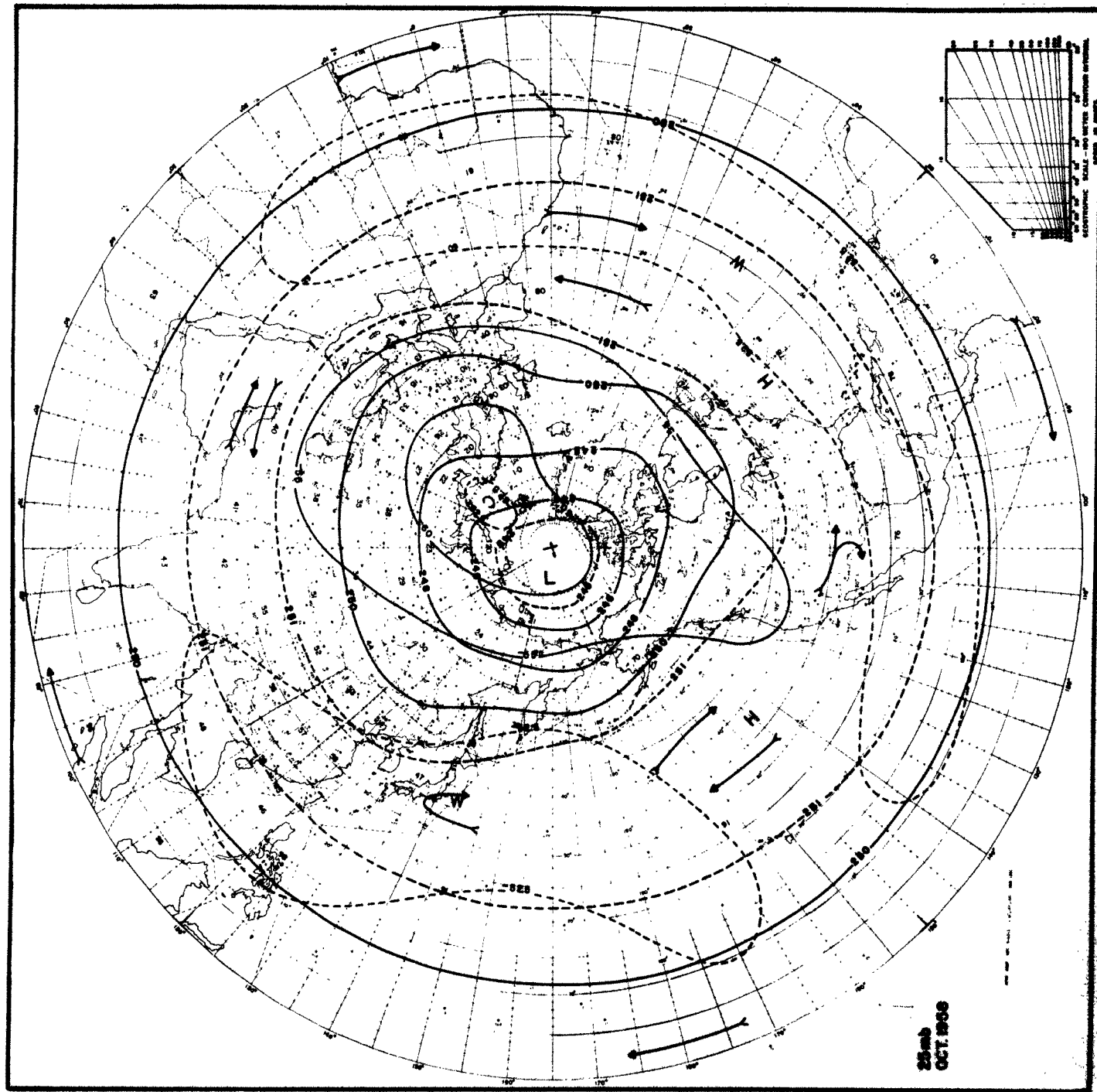




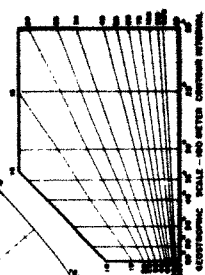
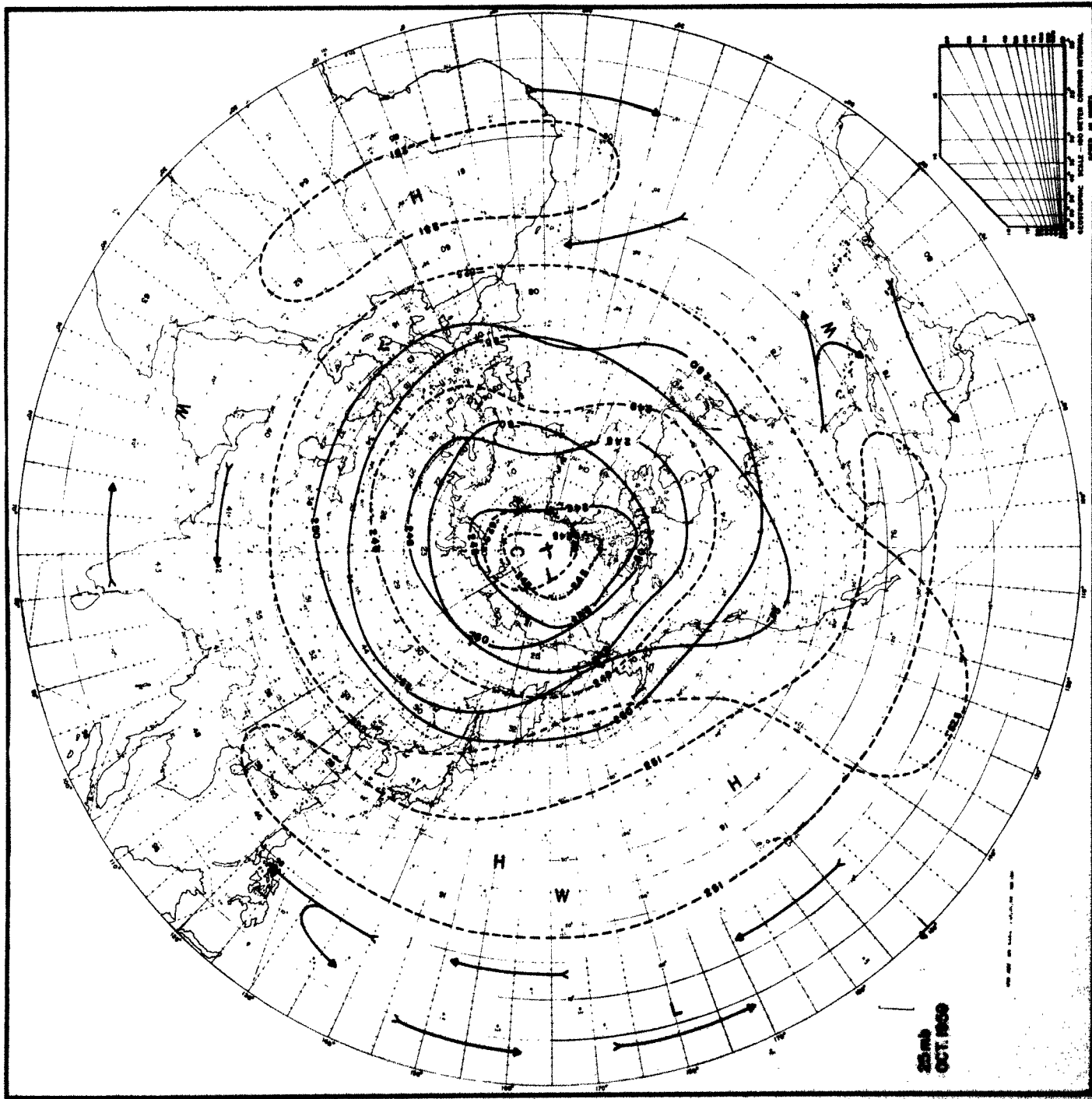




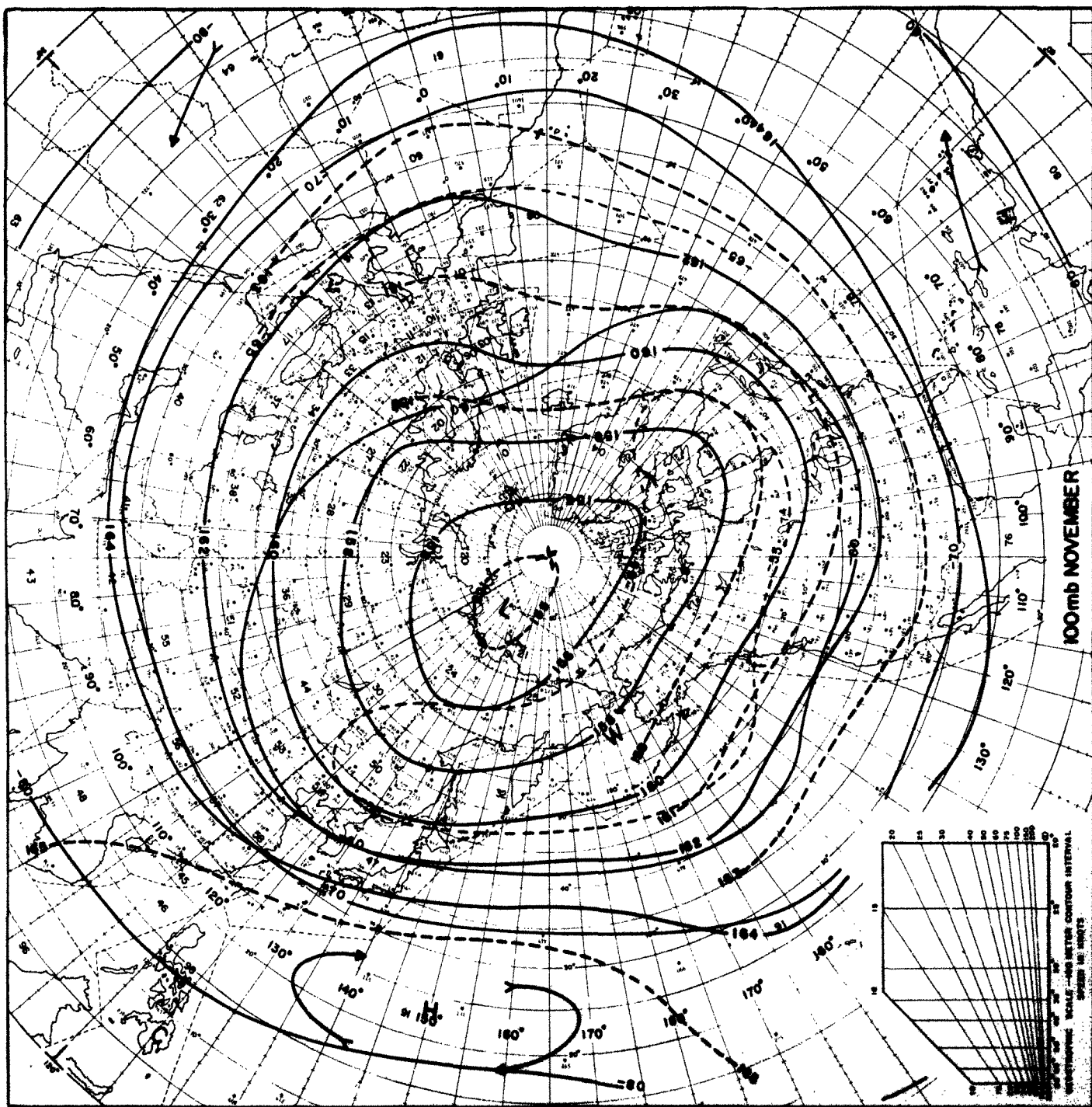


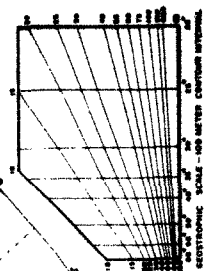


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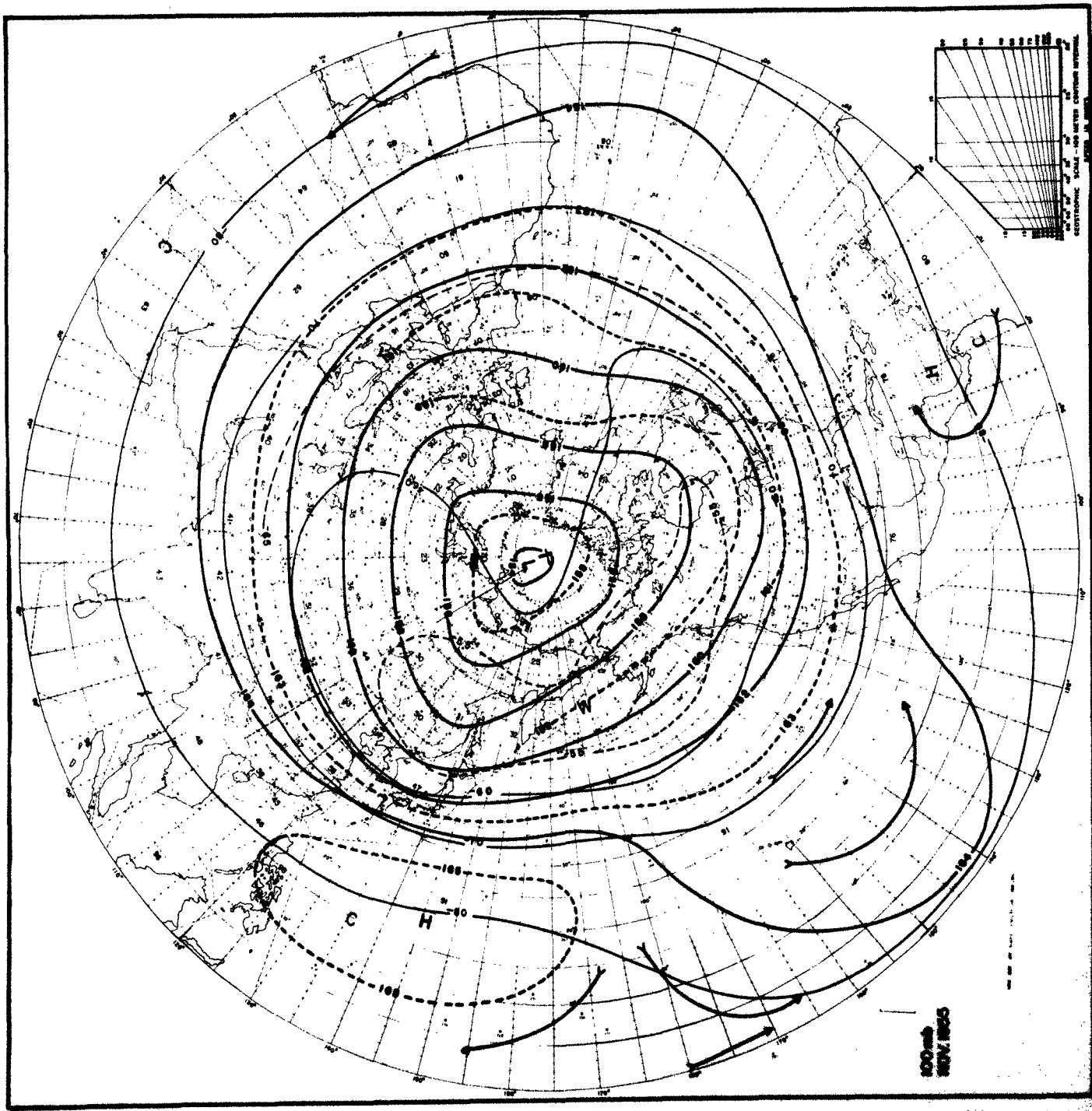


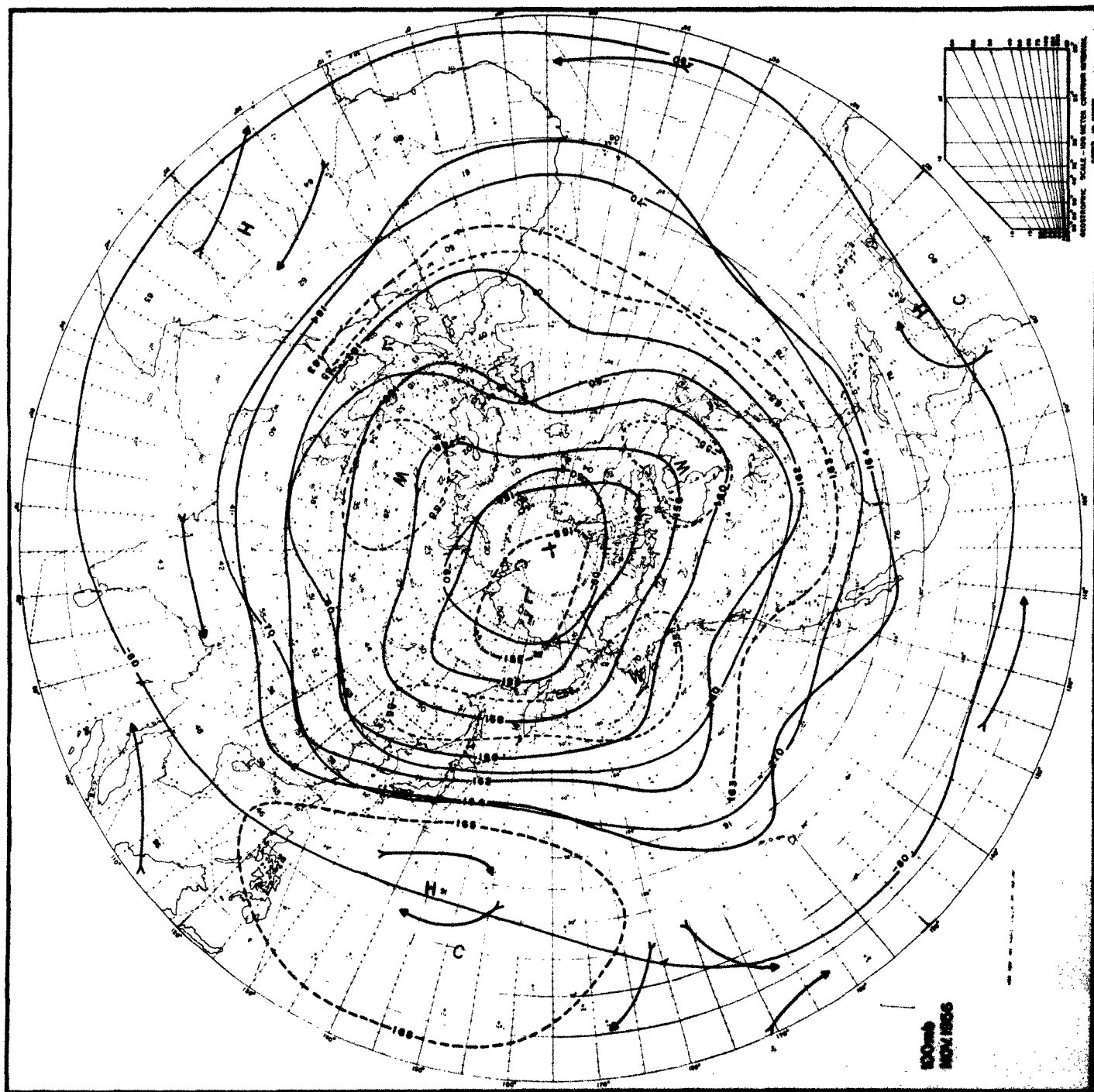
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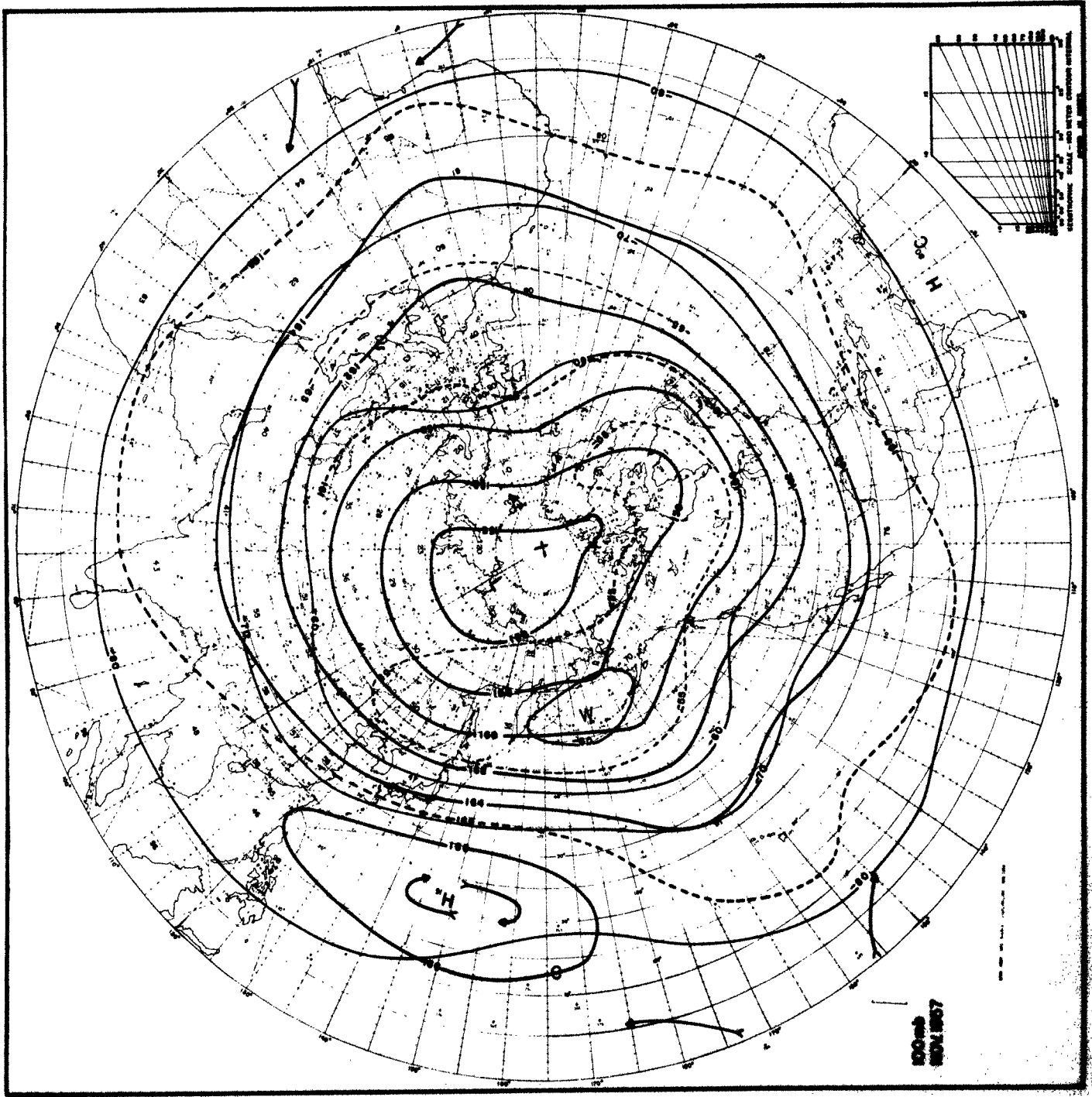


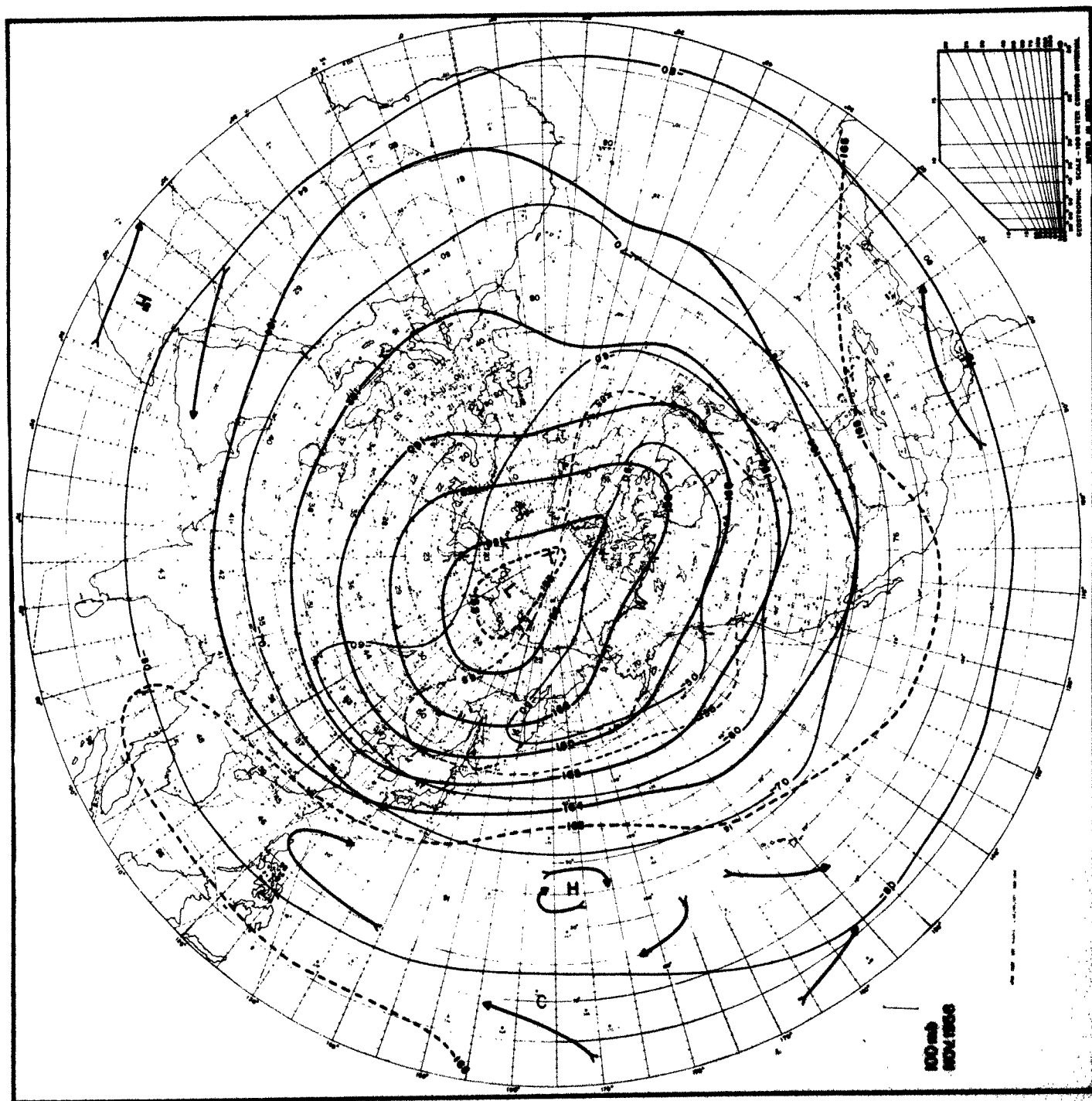


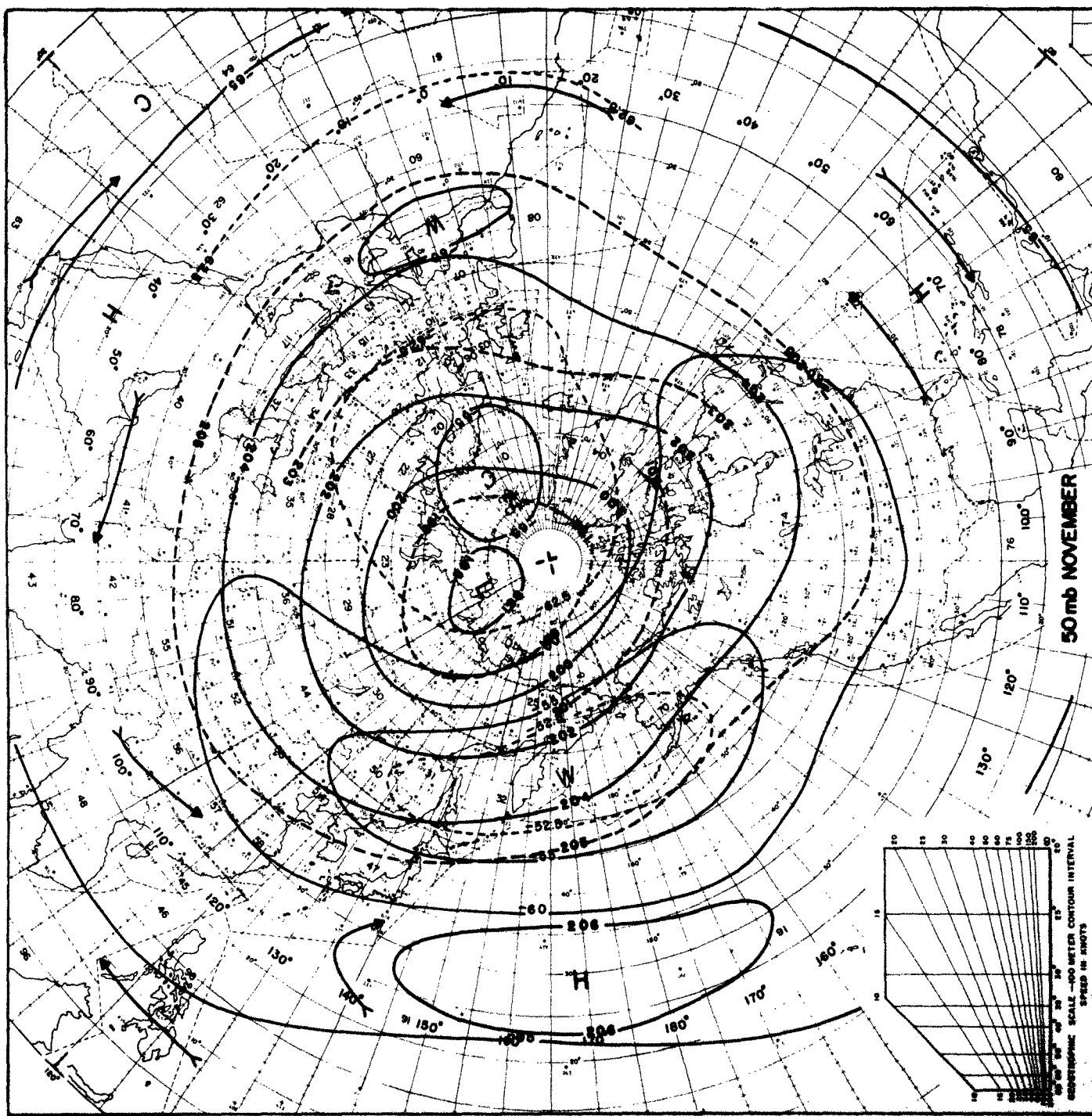
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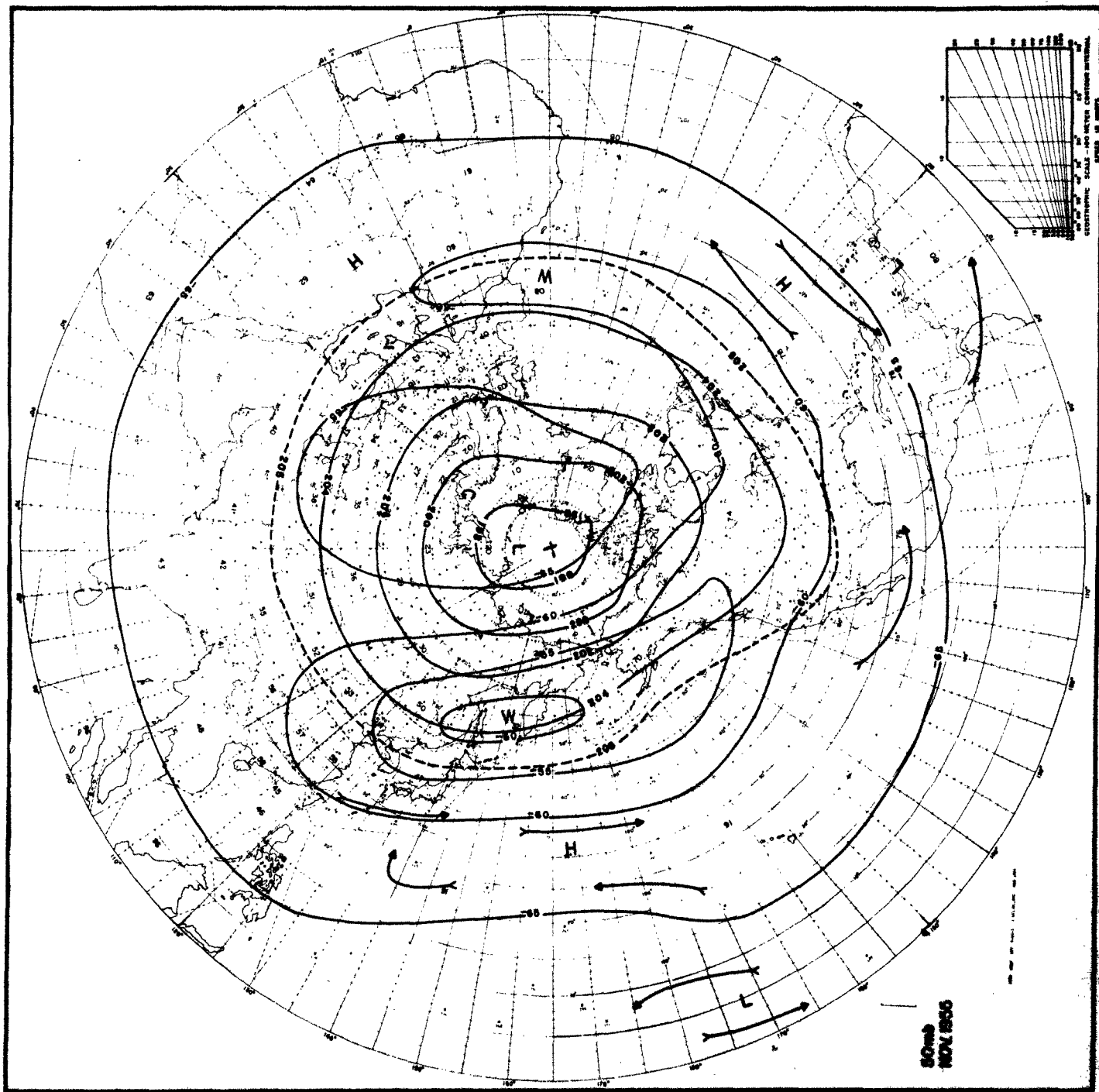


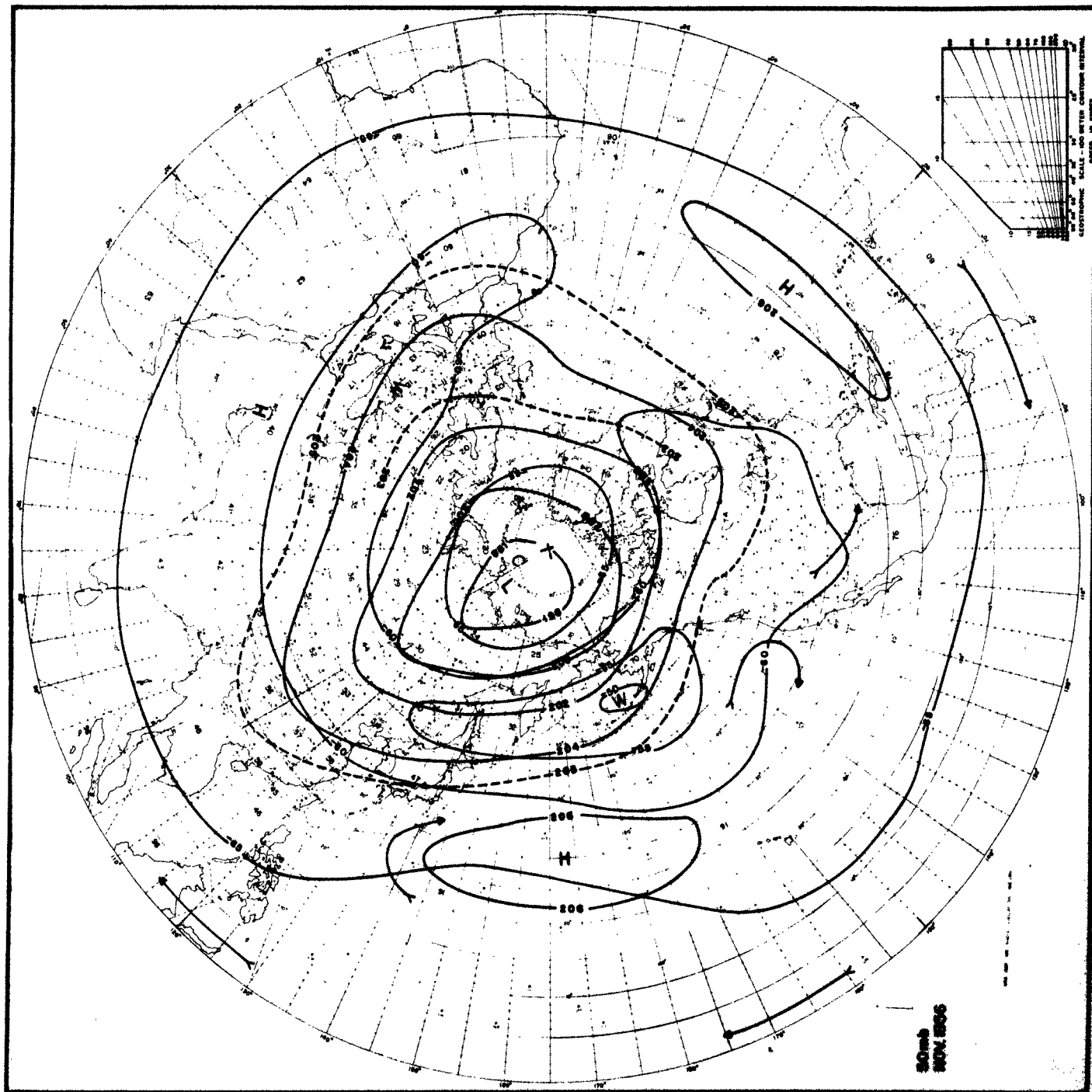


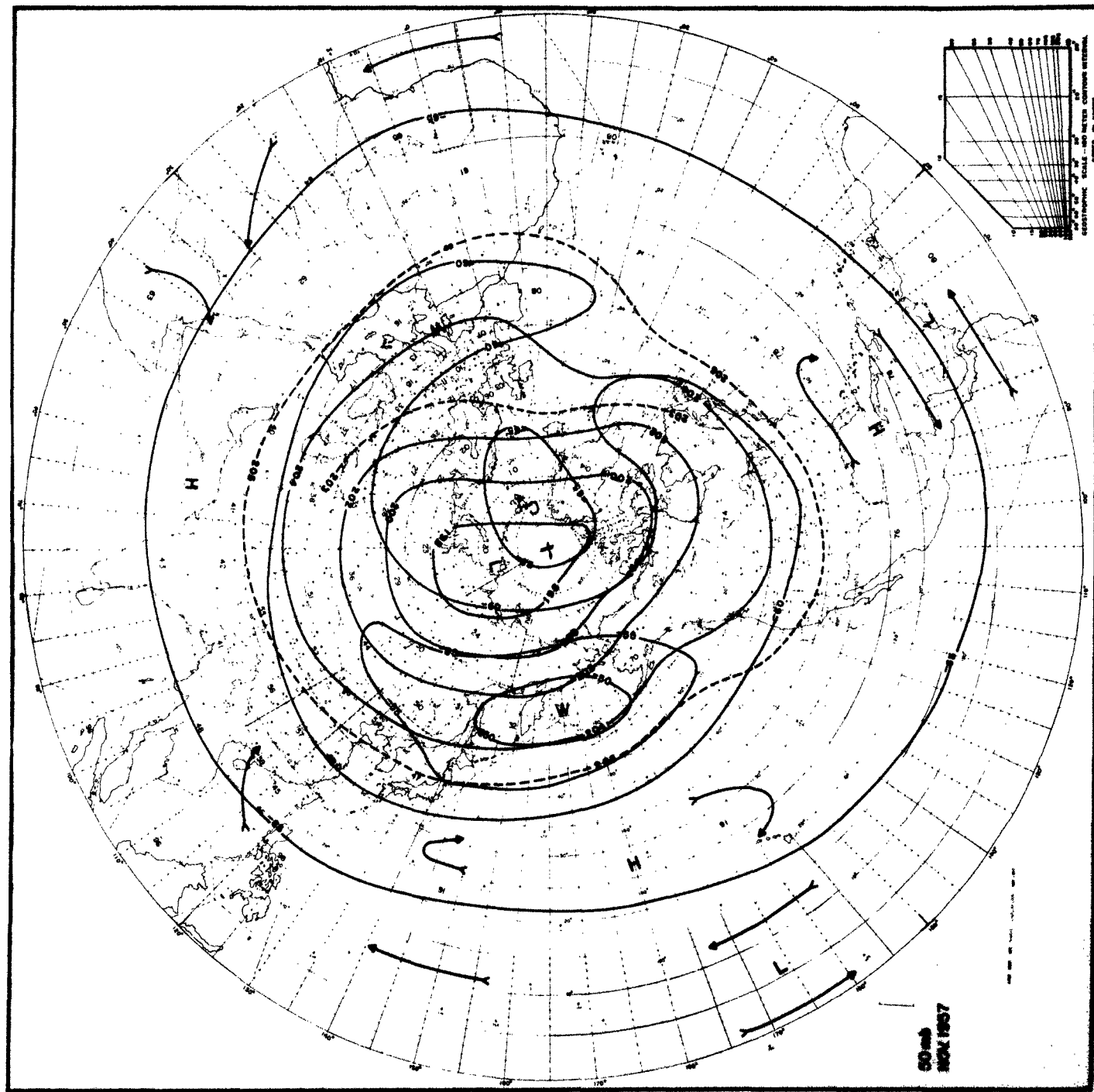


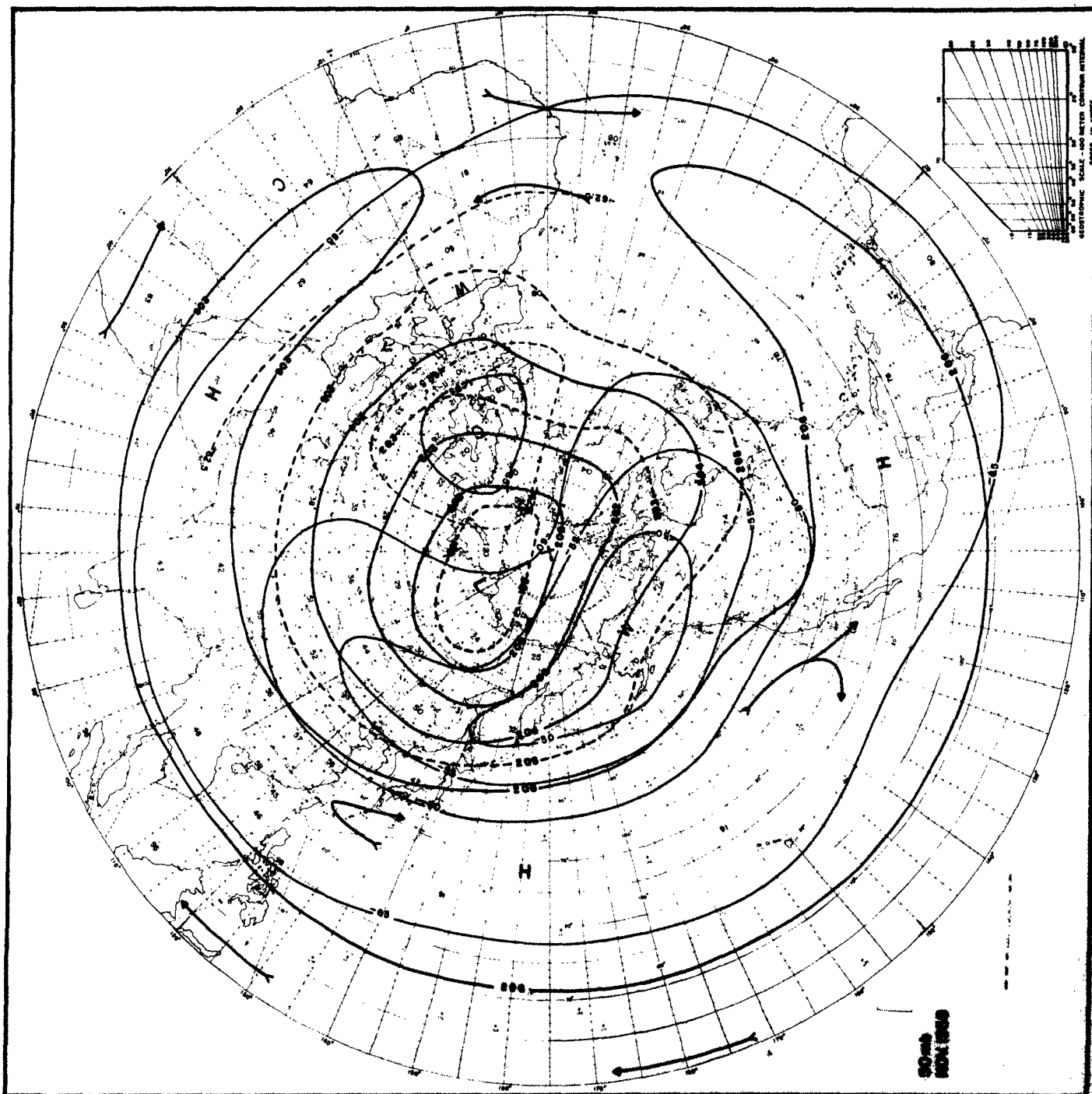


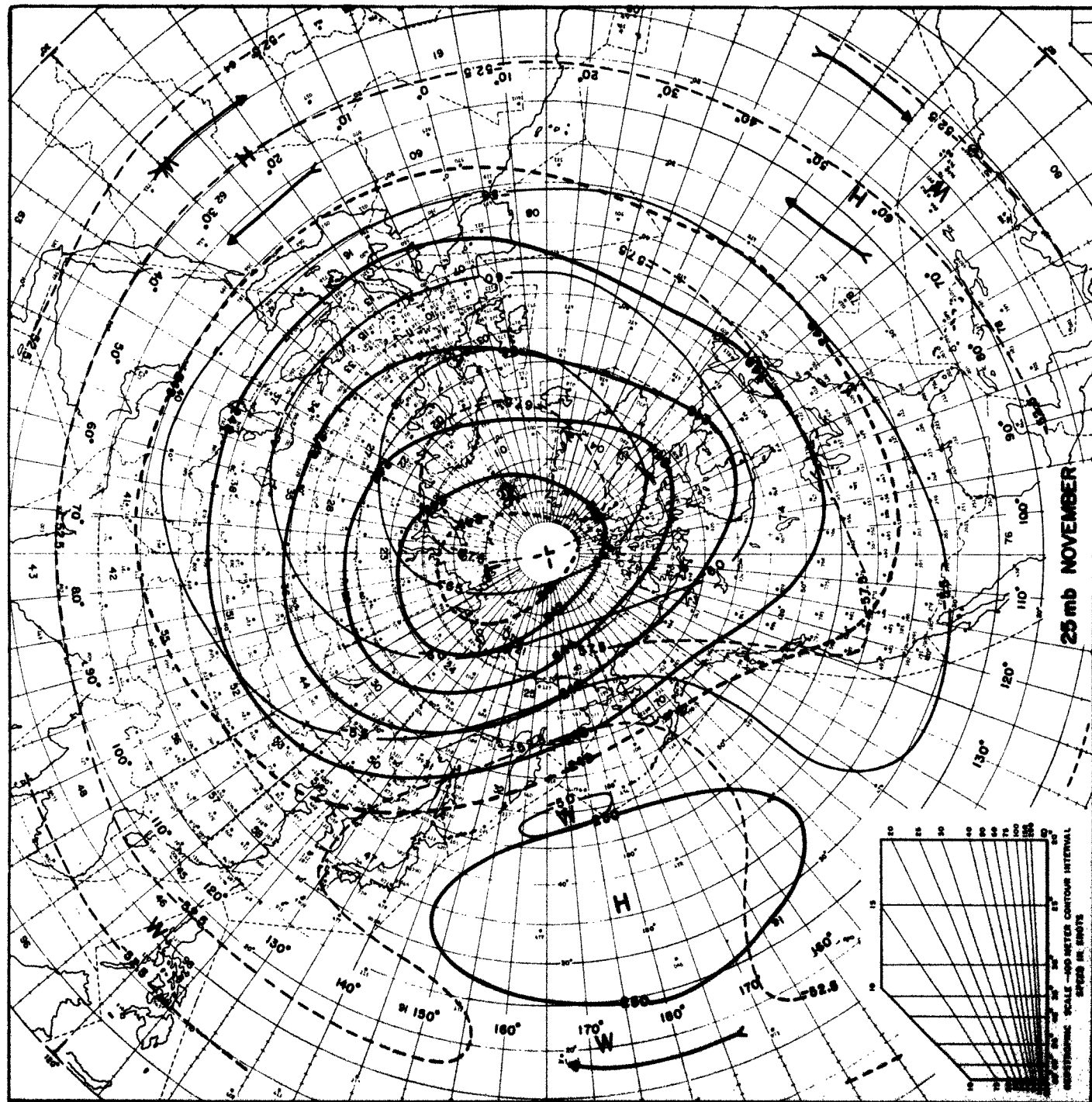
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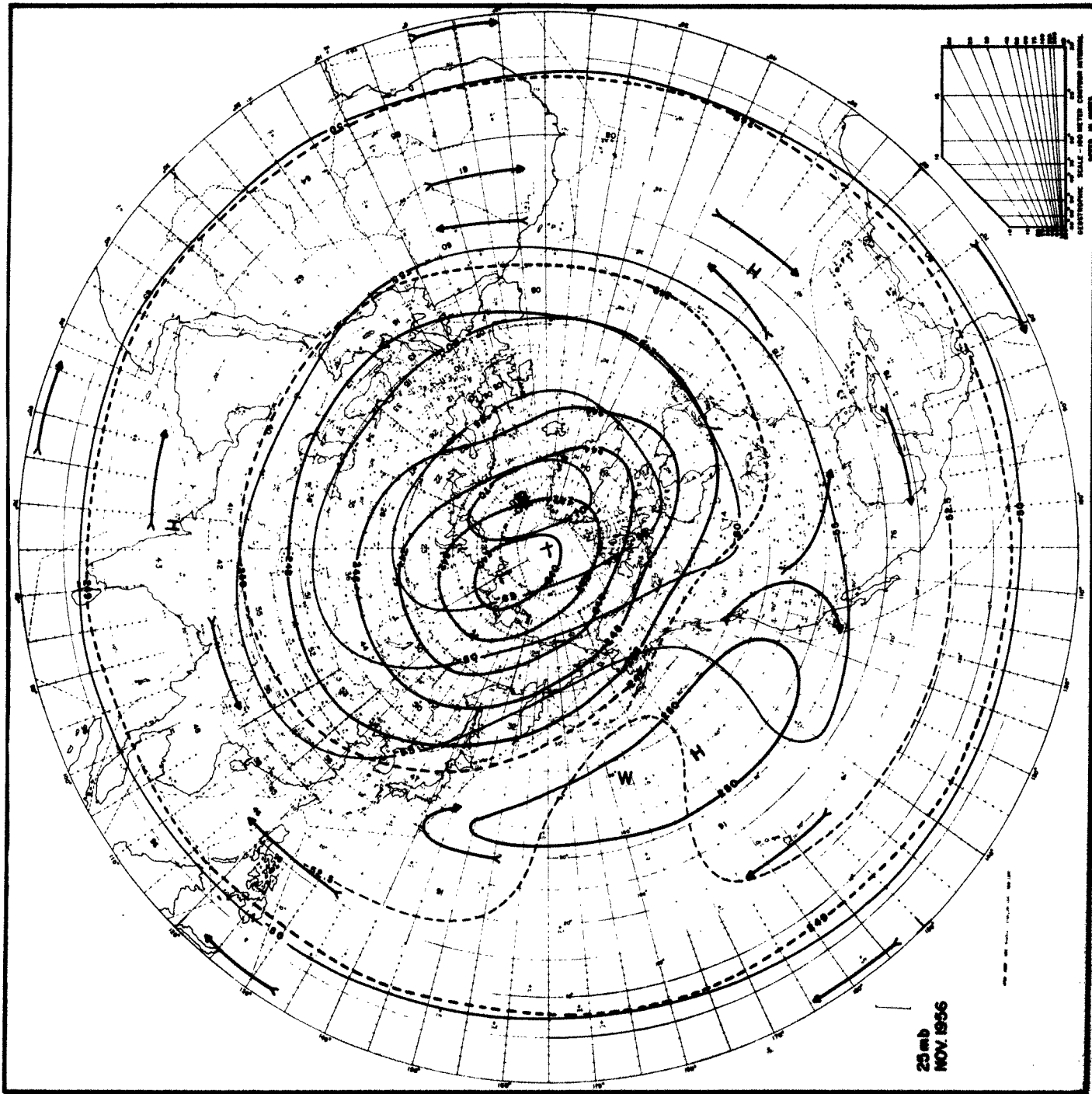
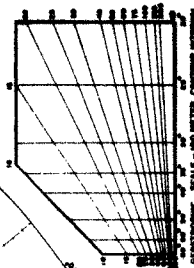


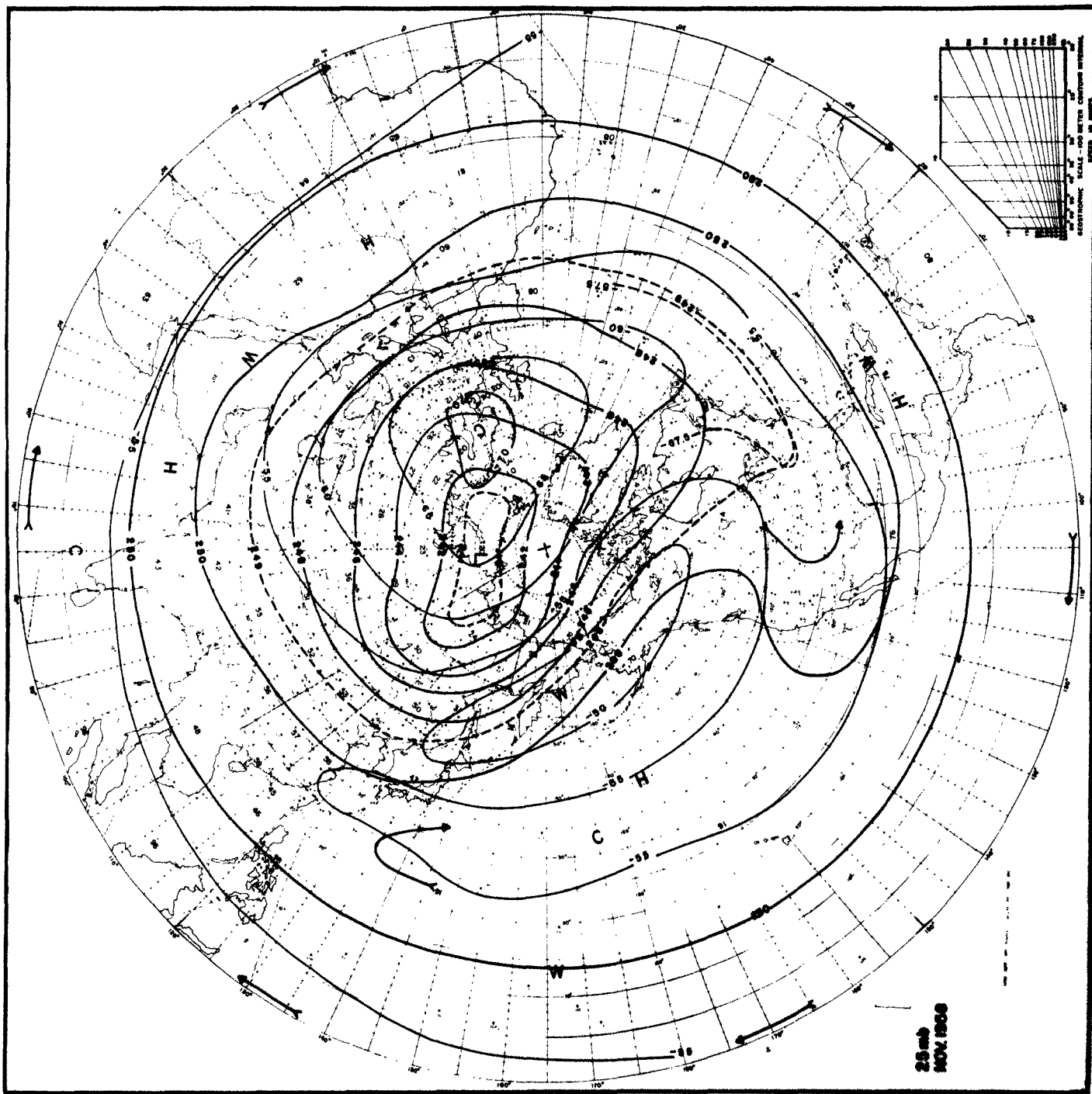


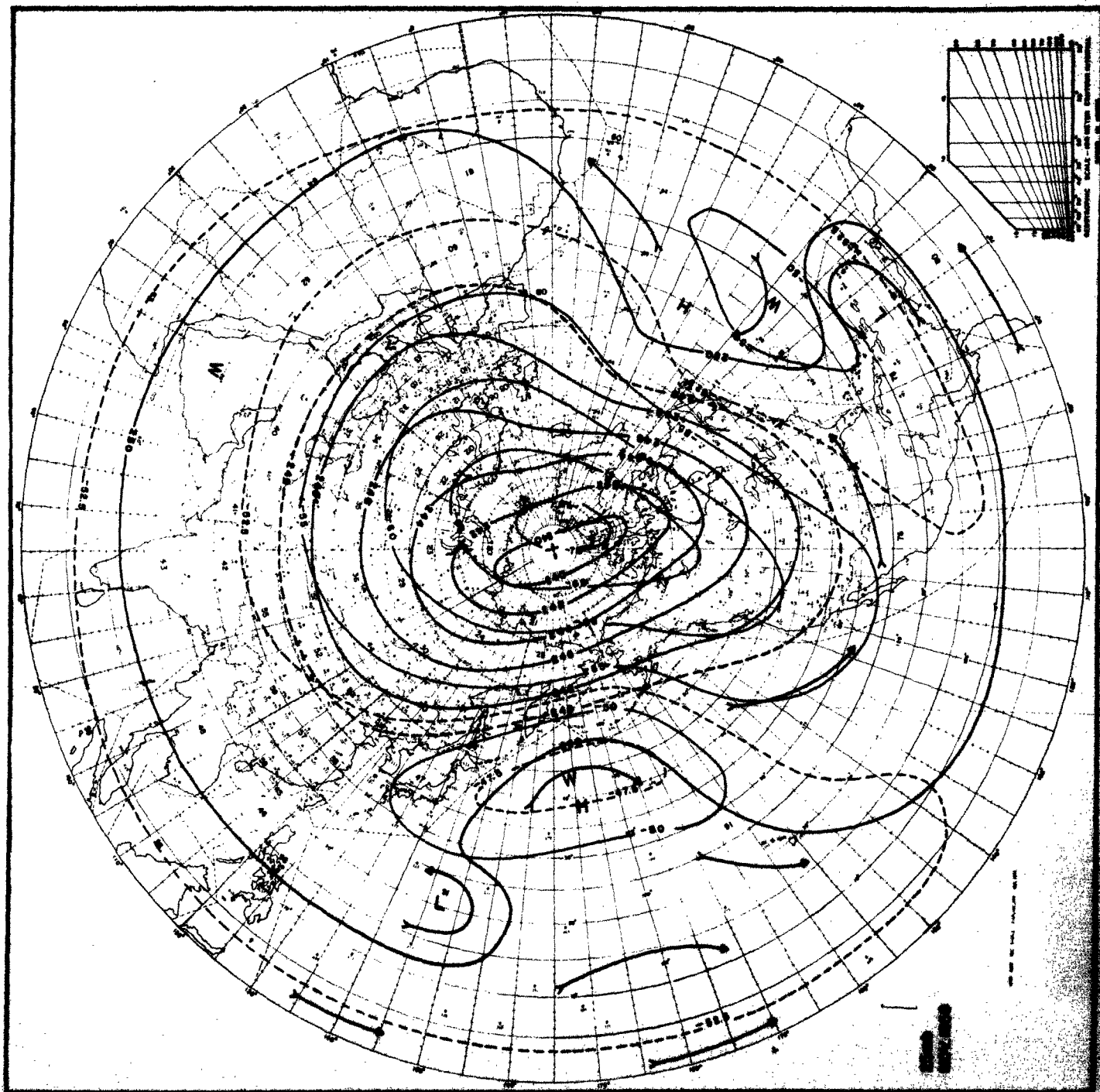




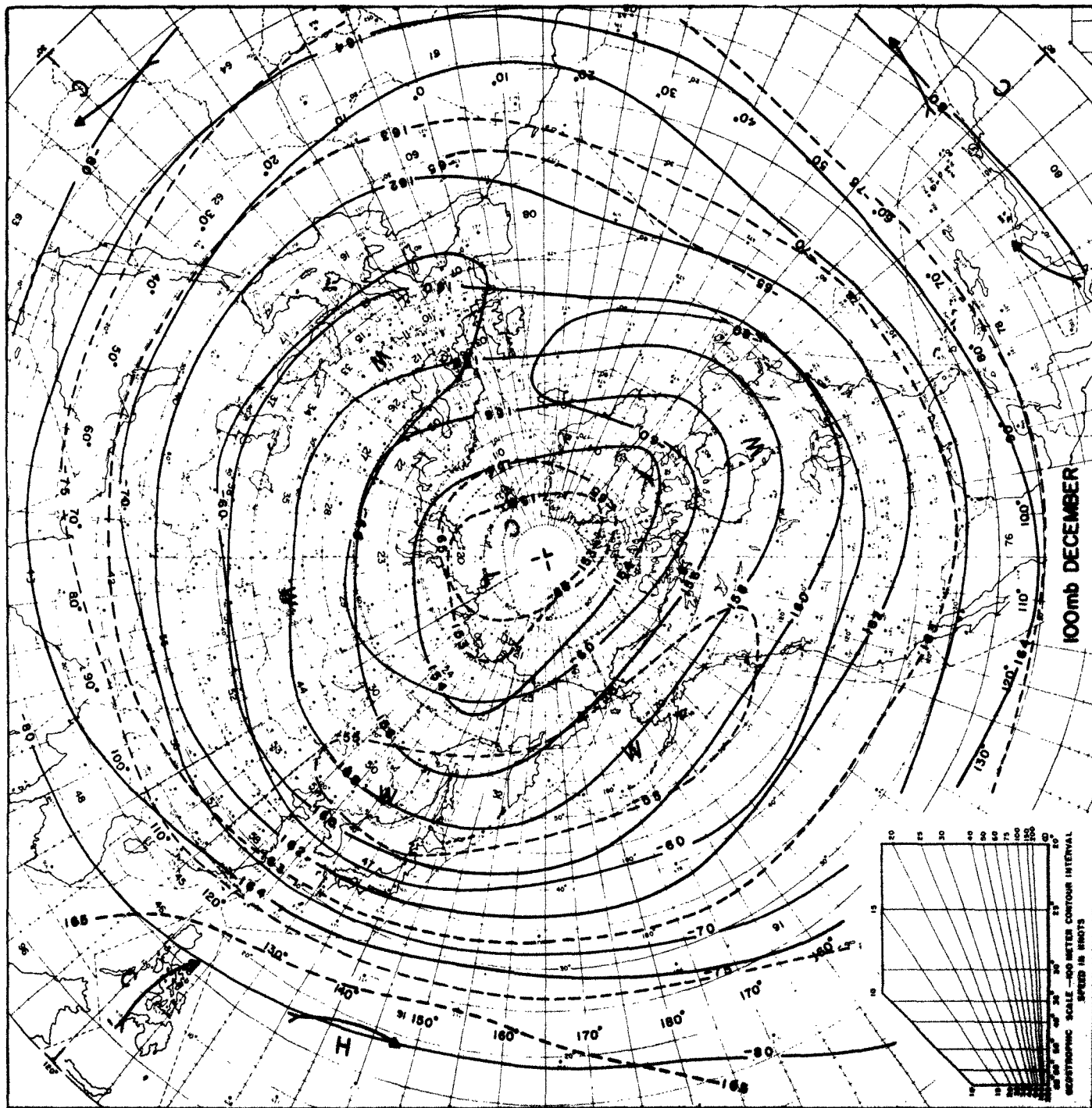
23mb
NOV 1966

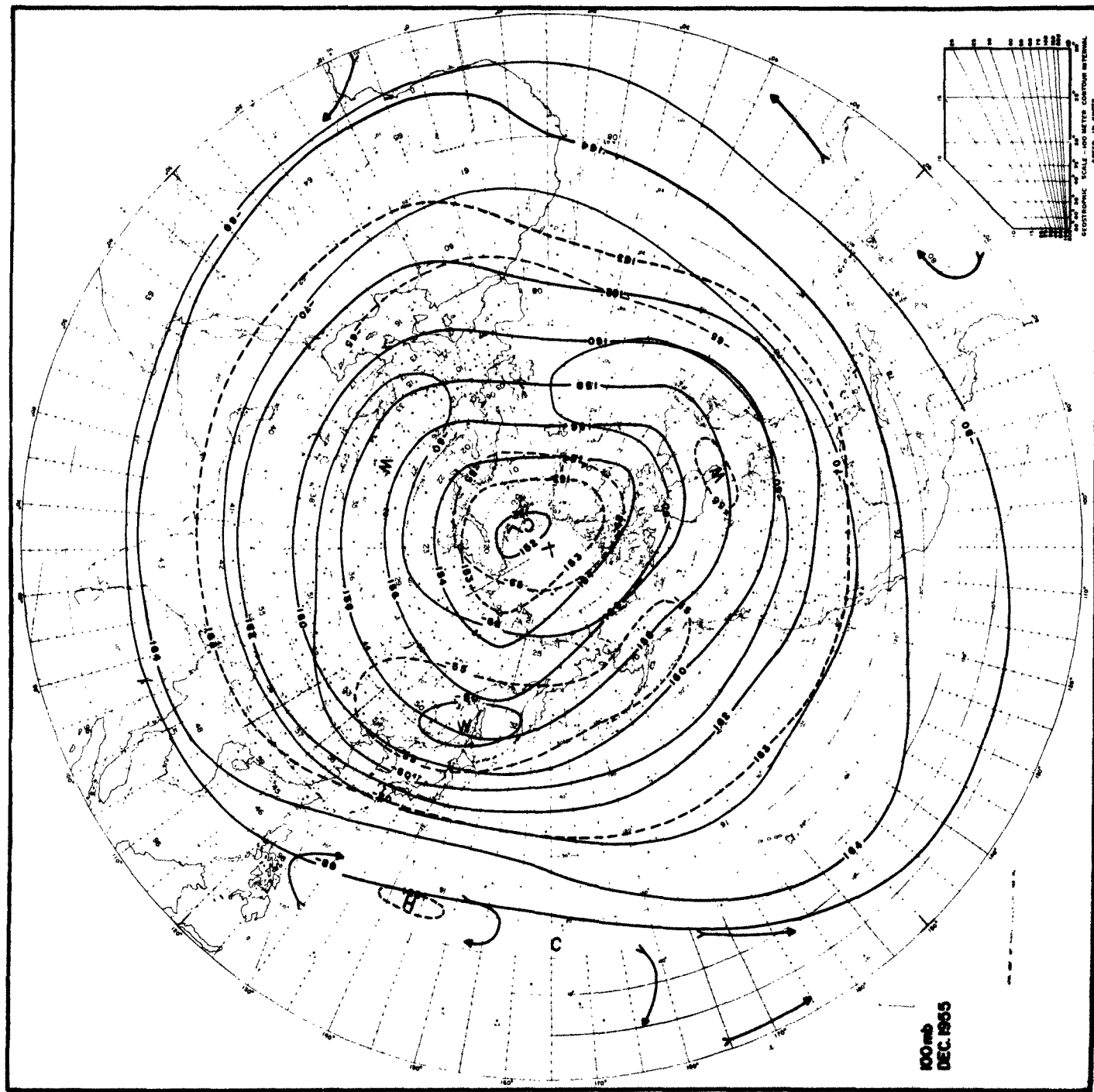


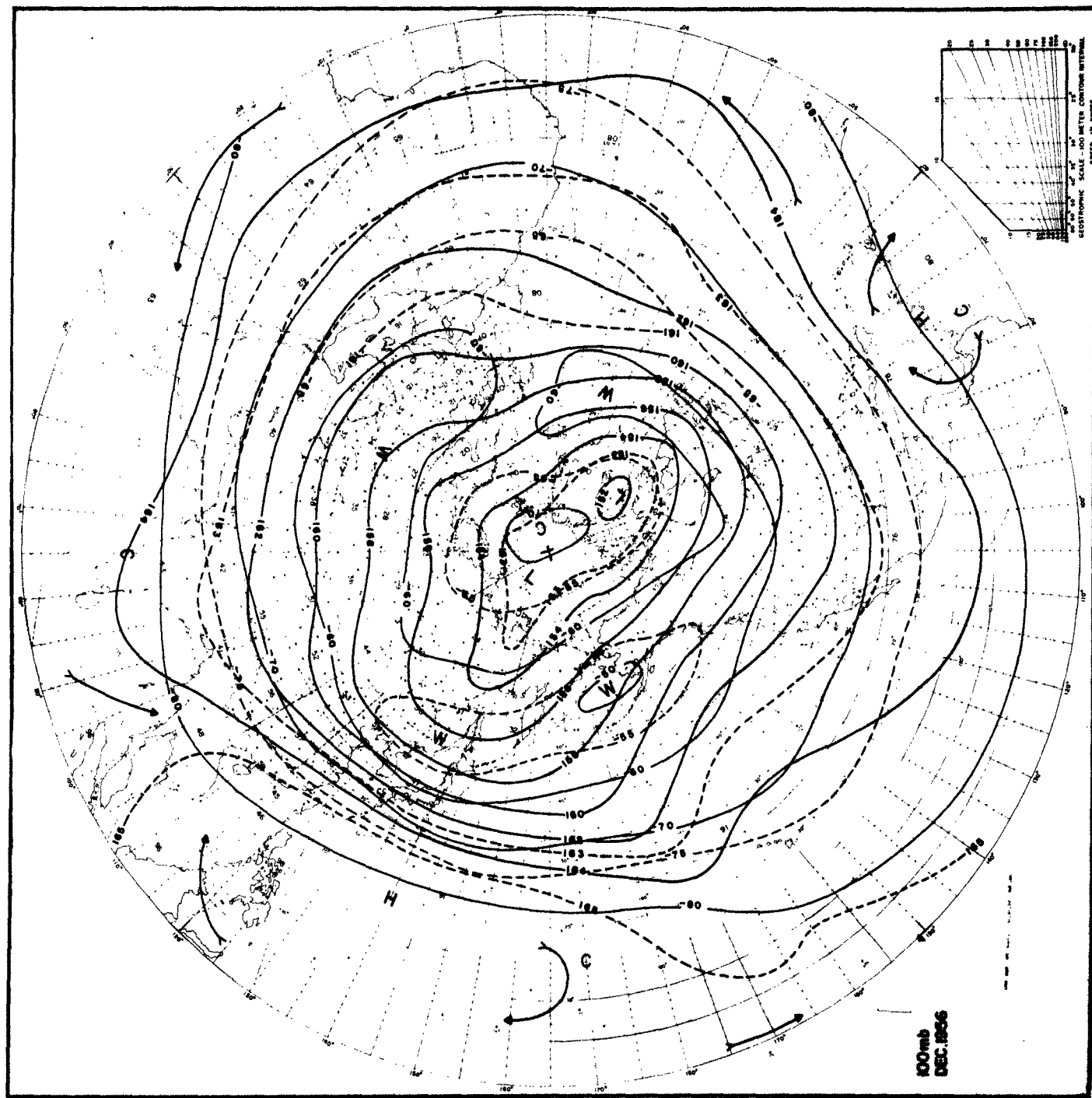


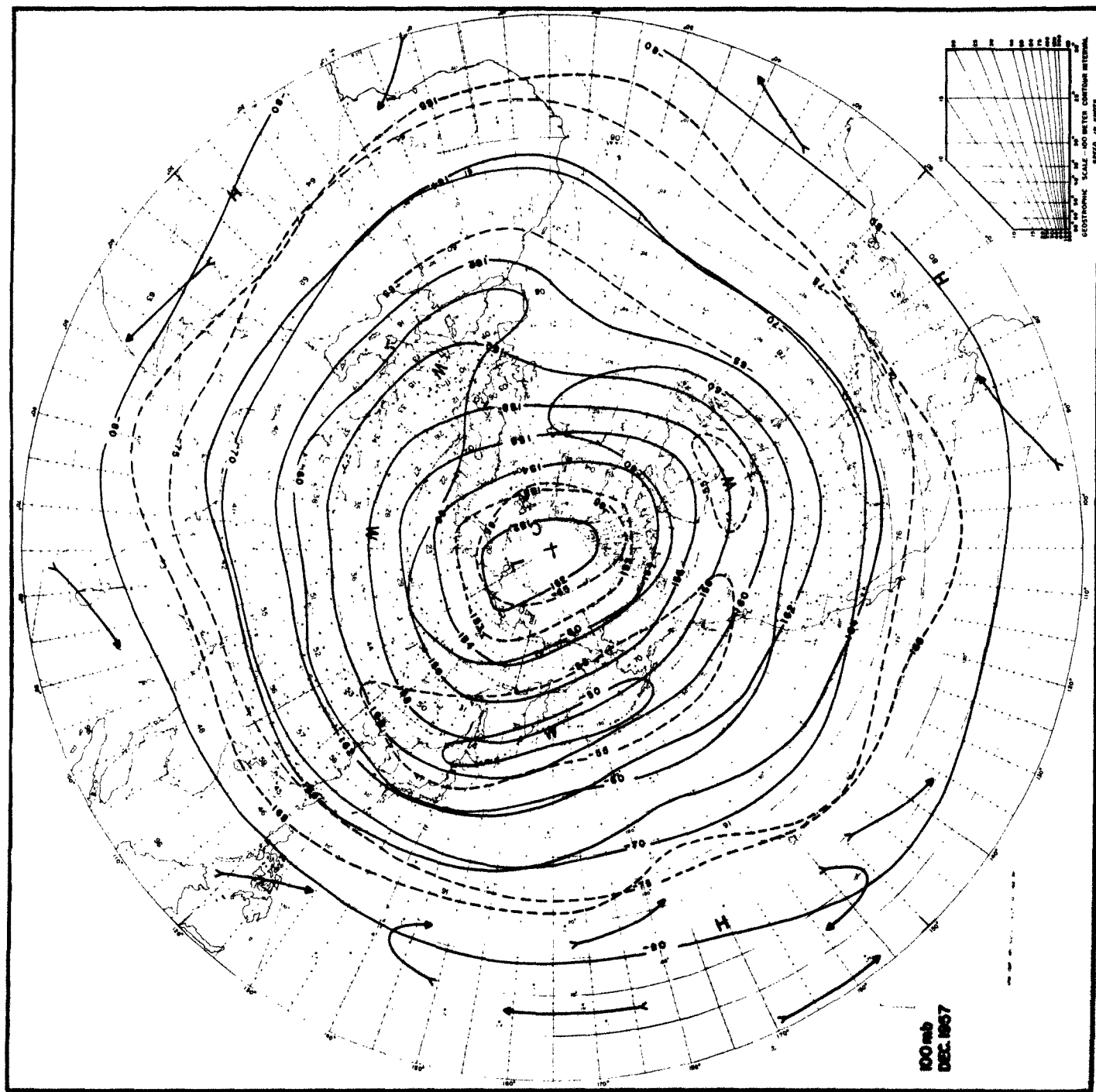


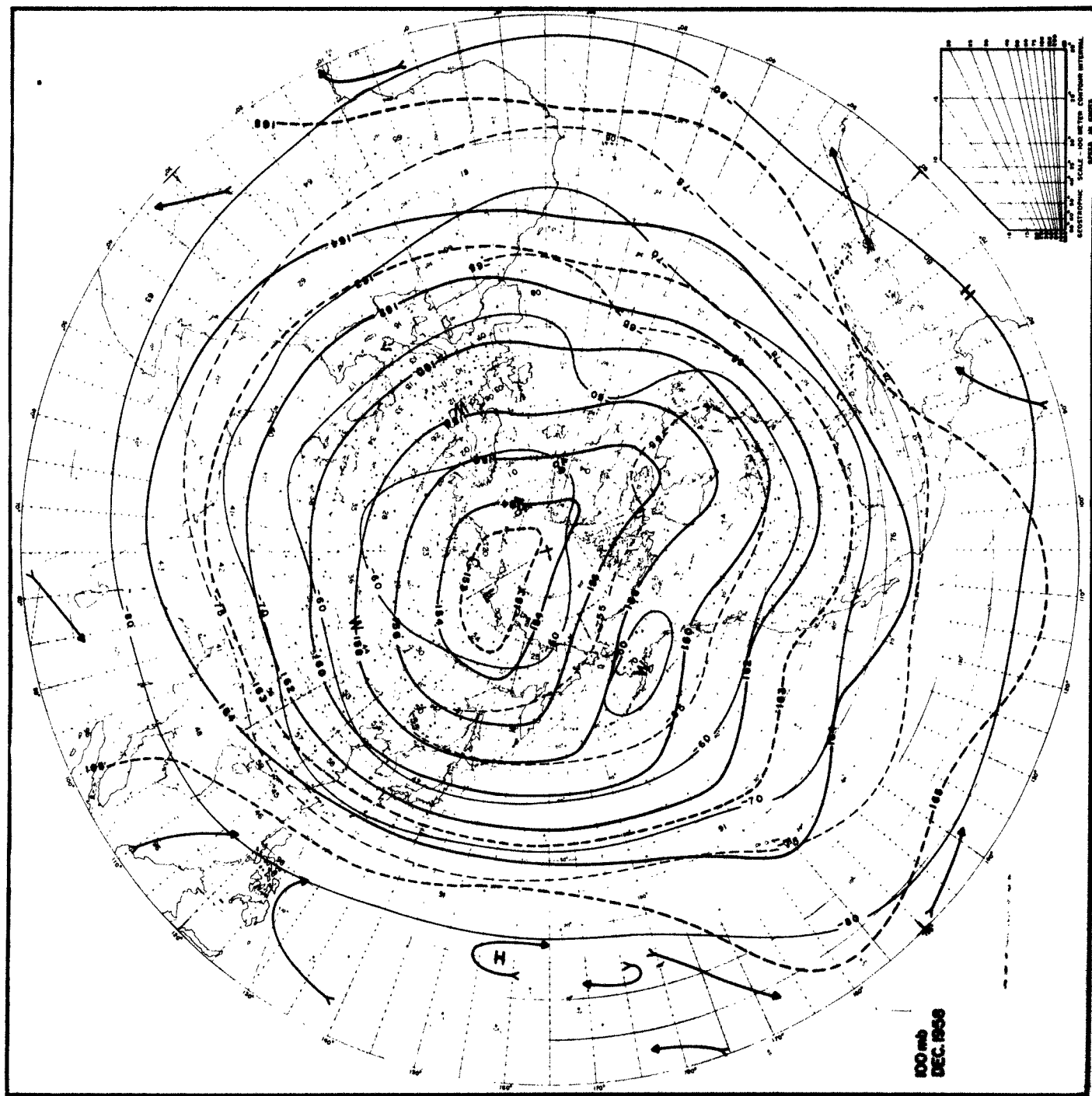
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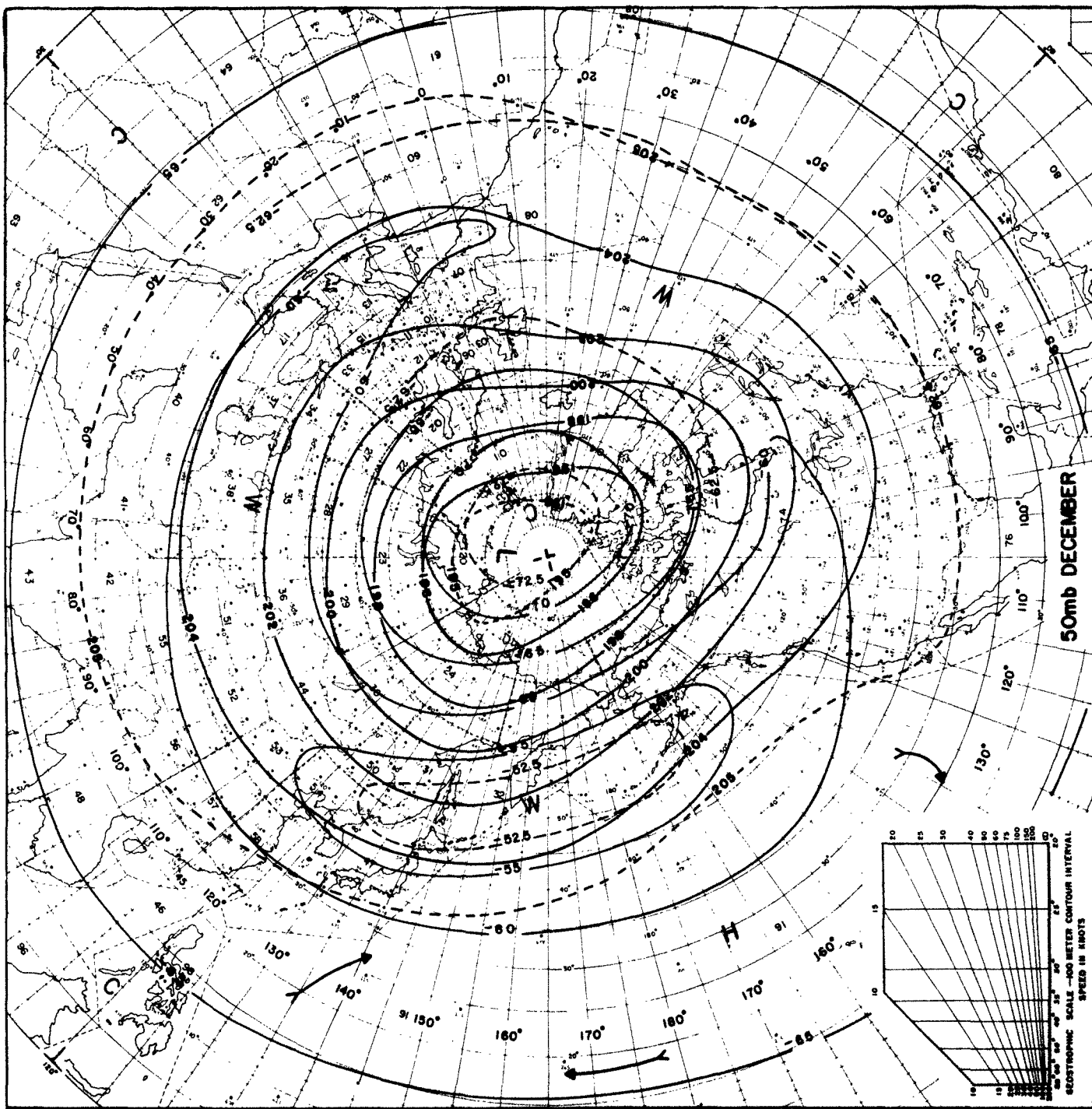


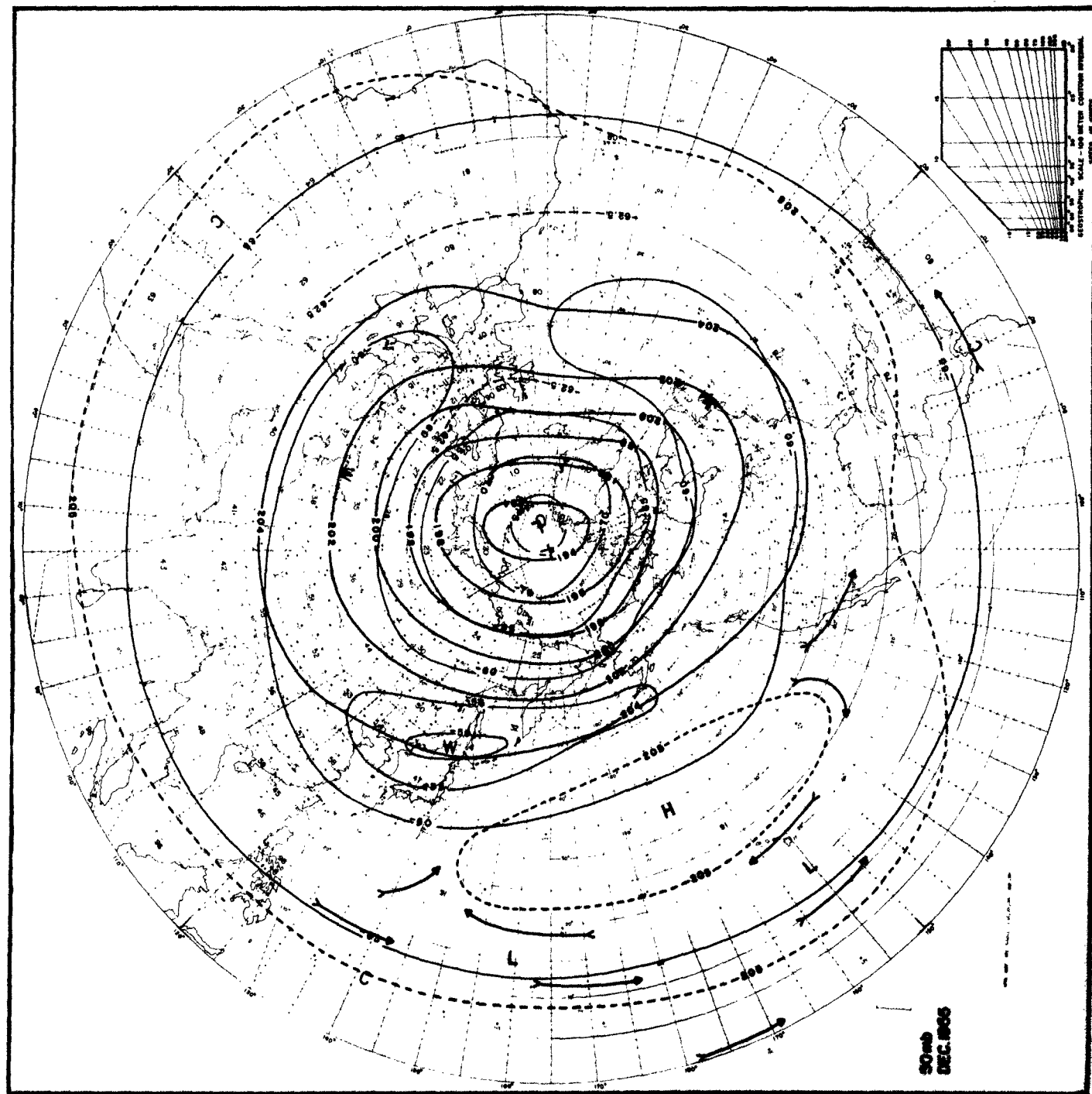


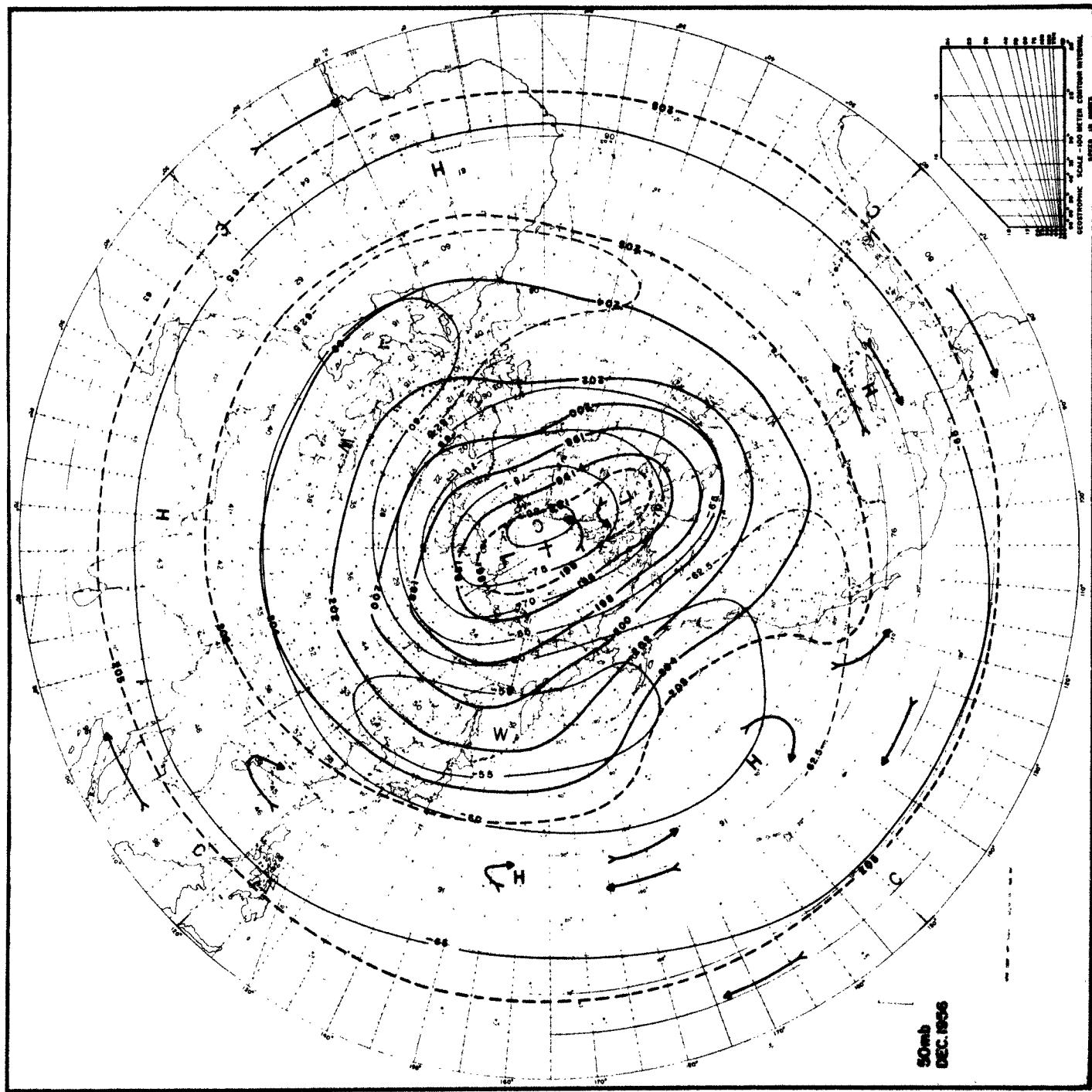


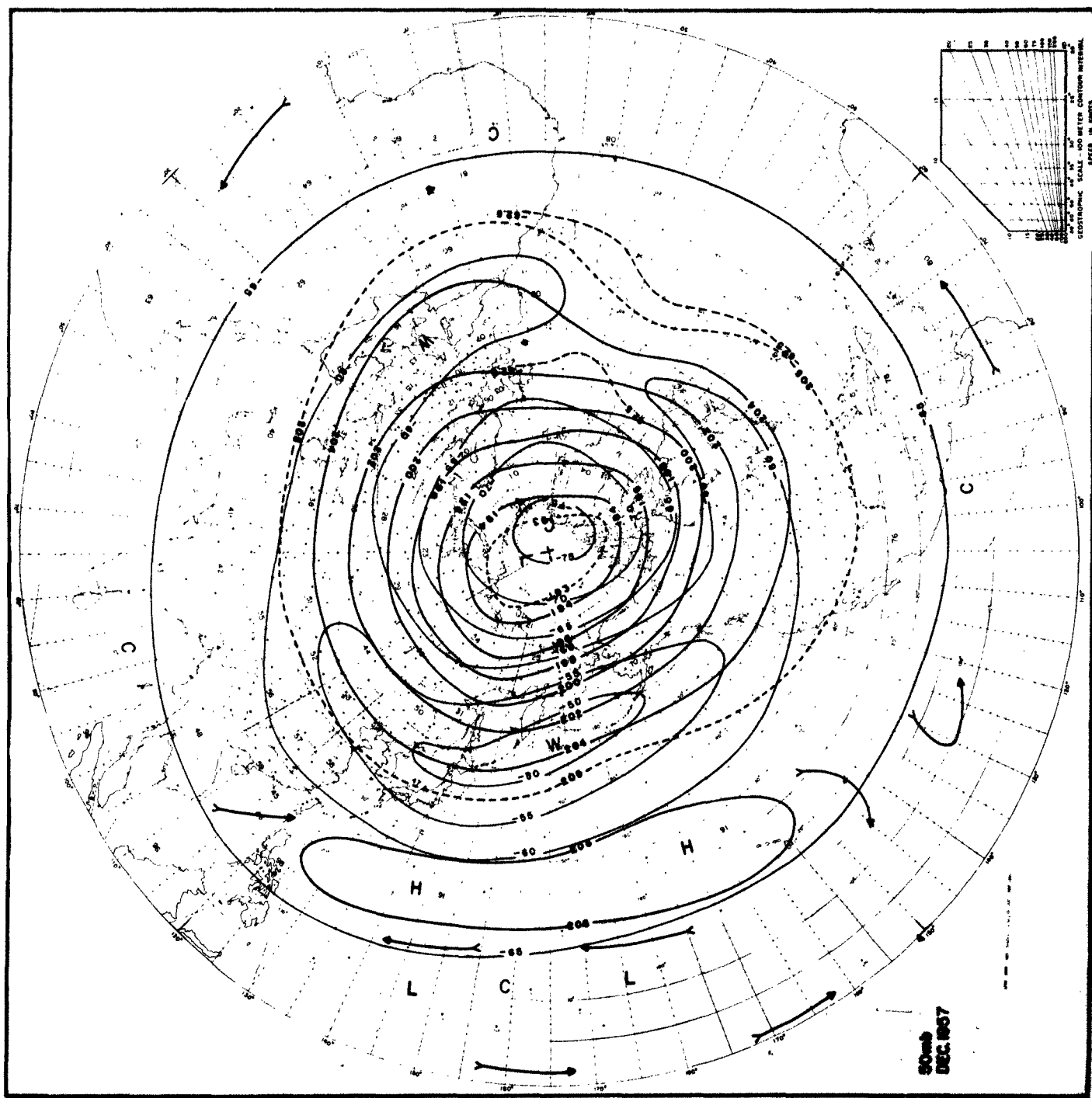


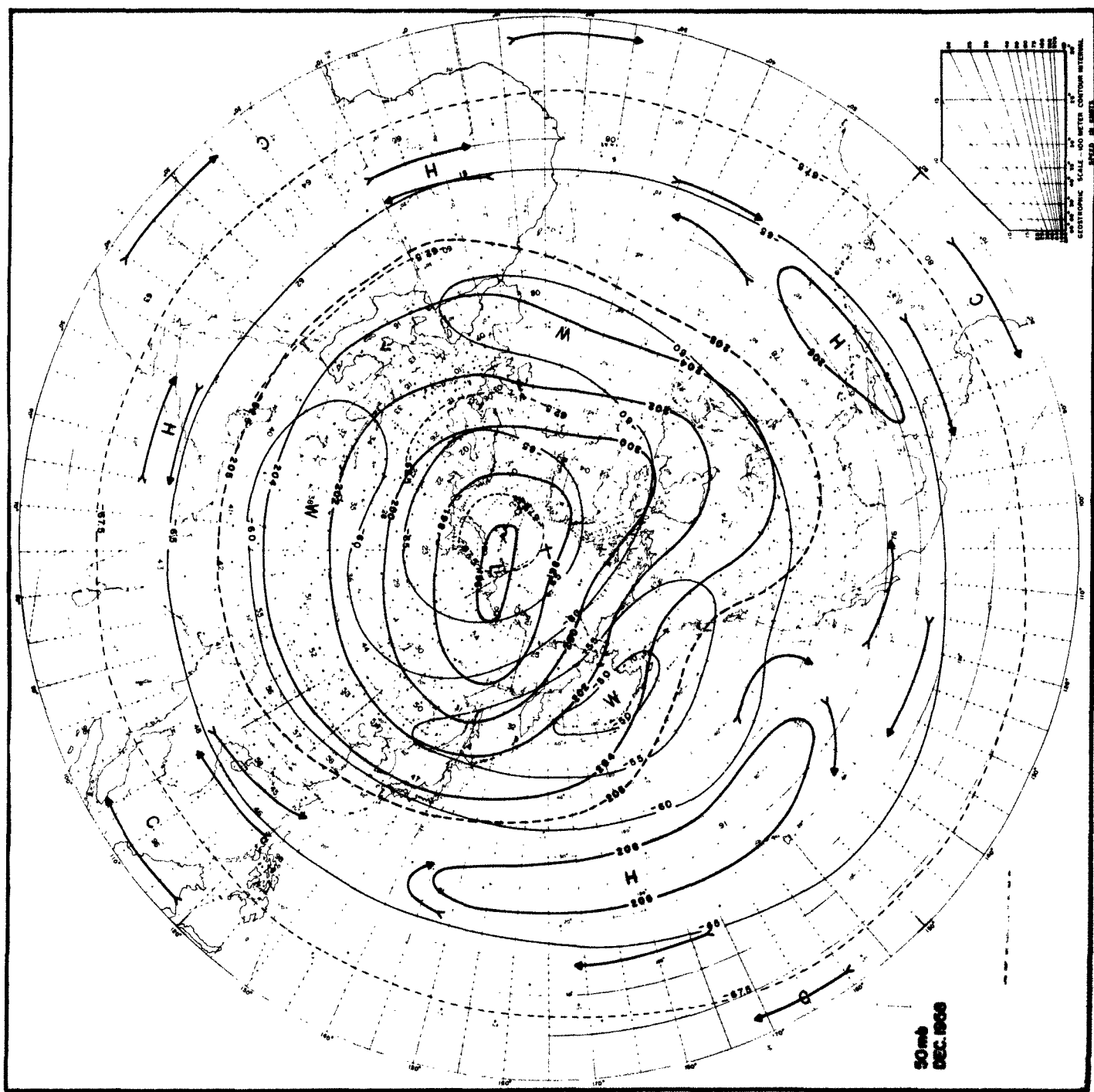
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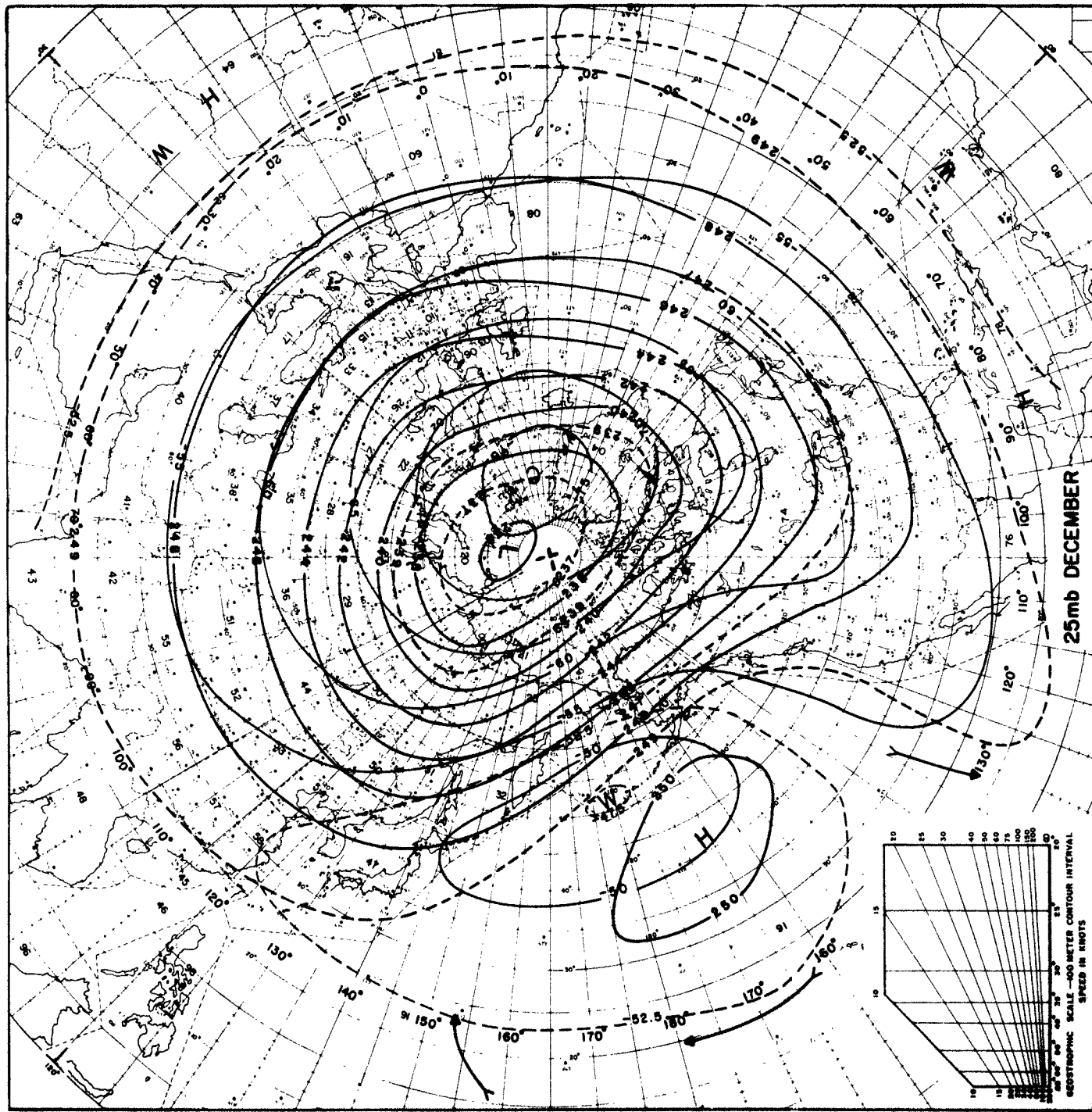


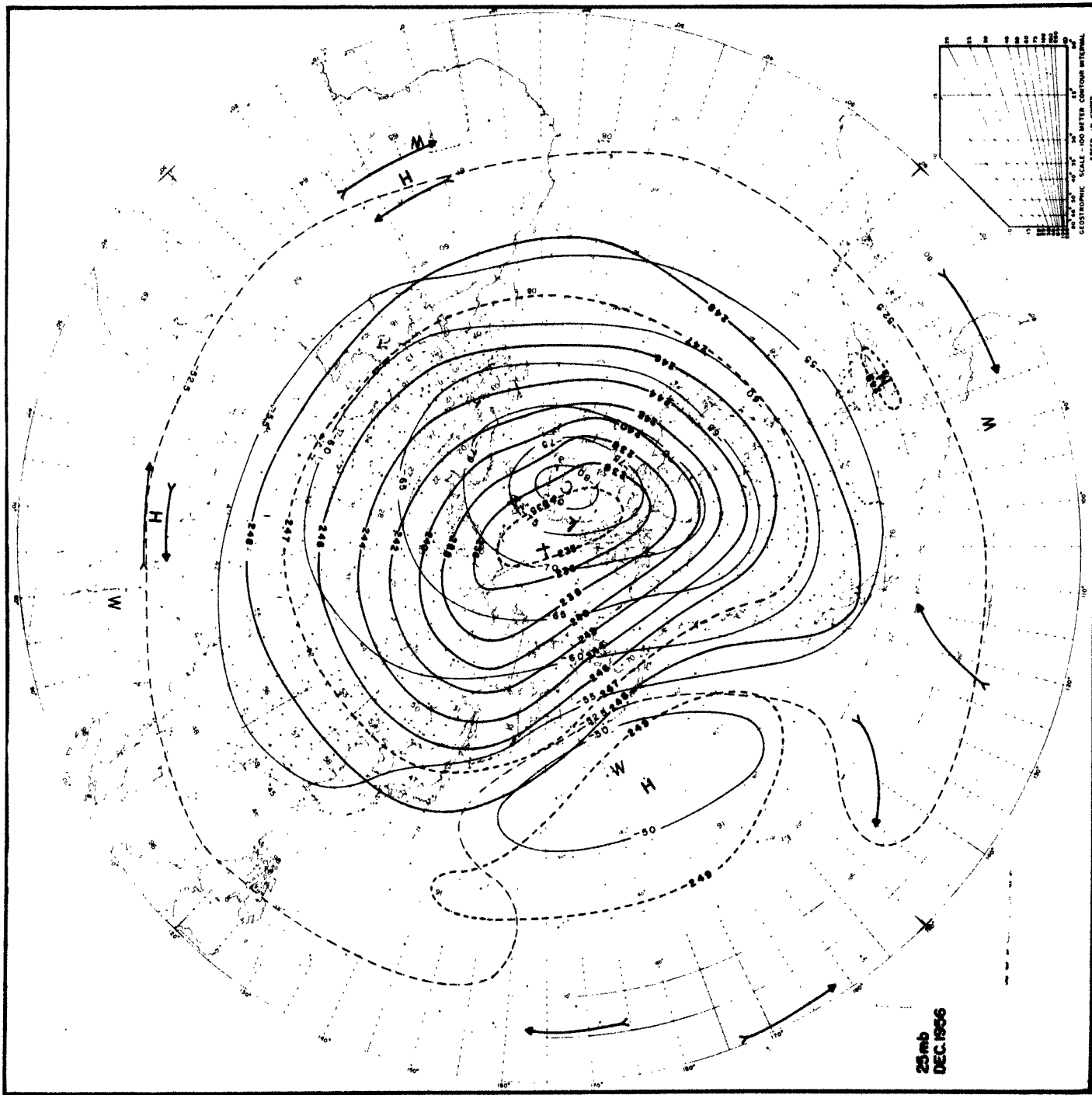


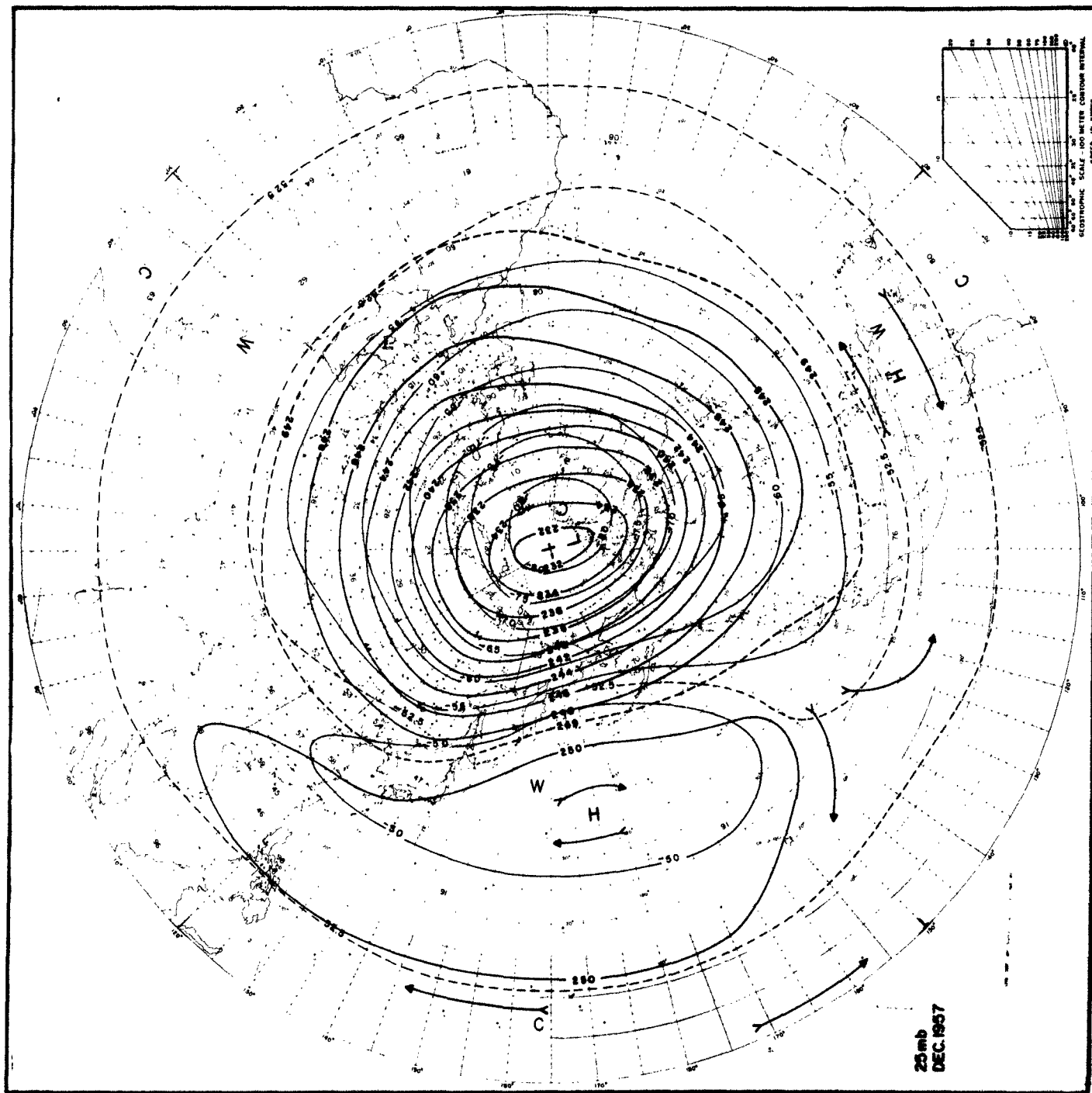


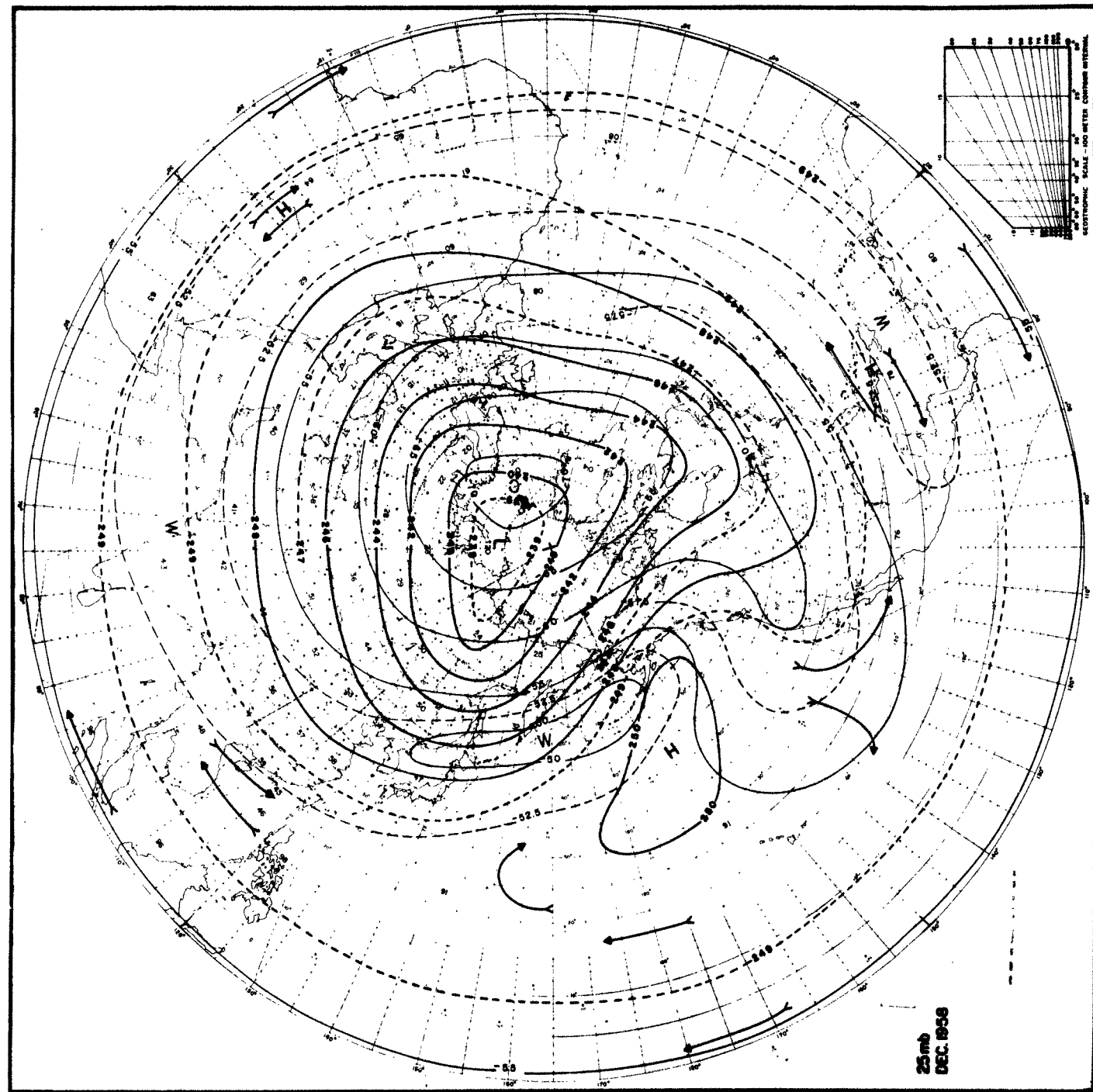












25 mb
DEC. 1958

25mb
DEC 1959

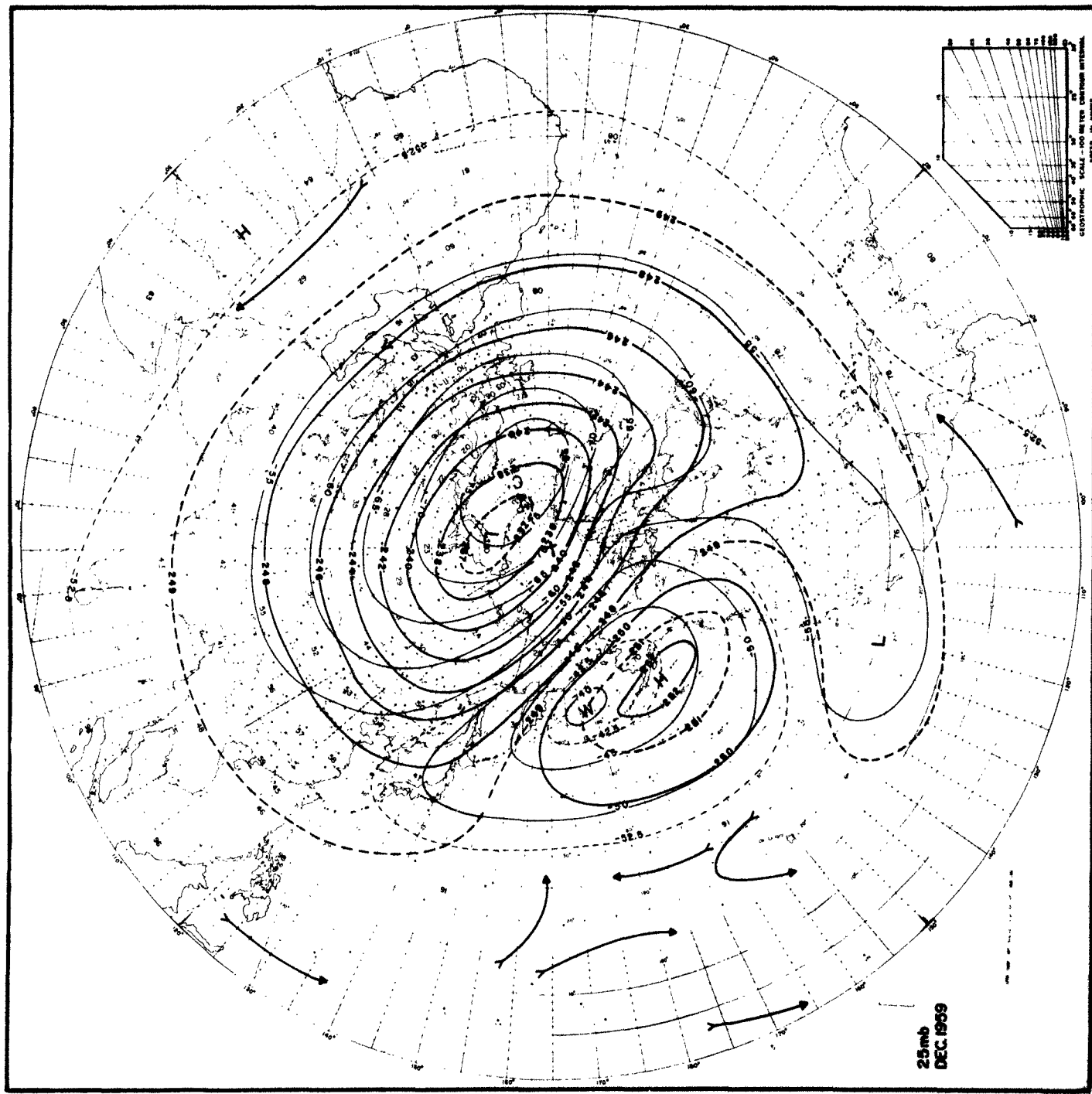
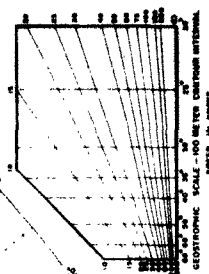


Table 2B. Mean height (10's of meters) in April

Latitude Degrees North	Longitude, Degrees									
	WEST					EAST				
	0	30	60	90	120	150	180	150	120	90
	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z
20	1648	1642	1646	1651	1645	1644	1651	1656	1658	1654
30	1632	1632	1634	1638	1633	1634	1641	1645	1642	1637
40	1616	1620	1619	1618	1618	1618	1617	1618	1612	1622
50	1607	1609	1605	1603	1607	1605	1599	1592	1590	1609
60	1601	1603	1597	1595	1598	1597	1591	1582	1577	1587
70	1591	1594	1591	1589	1592	1586	1578	1572	1576	1582
80	1583	1586	1585	1585	1586	1585	1583	1578	1574	1577
NORTH POLE							1581			
							50 mb			
20	2059	2058	2058	2059	2058	2059	2058	2059	2061	2061
30	2056	2056	2058	2059	2057	2058	2059	2057	2056	2058
40	2051	2053	2053	2054	2054	2053	2053	2052	2045	2051
50	2046	2049	2049	2049	2050	2049	2047	2040	2036	2042
60	2043	2047	2047	2047	2048	2044	2044	2037	2029	2033
70	2038	2043	2044	2044	2045	2044	2042	2035	2028	2031
80	2037	2040	2042	2042	2042	2040	2035	2032	2029	2030
NORTH POLE							2037			
							25 mb			
20	2496	2496	2496	2496	2496	2496	2496	2496	2496	2496
30	2496	2497	2497	2497	2497	2497	2497	2497	2496	2496
40	2491	2495	2496	2495	2496	2497	2497	2495	2491	2493
50	2486	2494	2494	2493	2494	2495	2497	2489	2486	2489
60	2484	2491	2493	2493	2494	2496	2496	2489	2482	2483
70	2482	2492	2495	2496	2497	2497	2495	2489	2481	2480
80	2487	2492	2496	2497	2497	2496	2493	2489	2481	2483
NORTH POLE							2492			

Table 4B. Mean height (10's of meters) in October

Latitude Degrees North	Longitude, Degrees									
	WEST					EAST				
	0	30	60	90	120	150	180	150	120	90
	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z
20	1648	1647	1647	1651	1651	1650	1653	1653	1657	1654
30	1642	1643	1643	1646	1645	1643	1651	1658	1648	1646
40	1633	1637	1635	1635	1636	1634	1642	1642	1625	1628
50	1623	1624	1616	1618	1621	1619	1619	1613	1601	1608
60	1608	1609	1598	1601	1604	1601	1597	1590	1582	1590
70	1592	1592	1584	1585	1588	1585	1579	1573	1570	1576
80	1577	1576	1573	1573	1573	1571	1568	1566	1563	1567
NORTH POLE							1566			
							50 mb			
20	2068	2067	2067	2067	2067	2067	2069	2069	2068	2068
30	2066	2068	2067	2069	2069	2069	2073	2074	2067	2065
40	2062	2065	2065	2065	2067	2067	2069	2070	2060	2056
50	2057	2060	2056	2055	2057	2057	2057	2056	2045	2042
60	2050	2060	2043	2044	2048	2044	2043	2042	2030	2032
70	2036	2036	2030	2032	2032	2032	2024	2022	2013	2017
80	2018	2019	2017	2017	2015	2011	2009	2007	2004	2009
NORTH POLE							2008			
							25 mb			
20	2506	2505	2505	2506	2506	2506	2505	2505	2505	2504
30	2509	2509	2509	2509	2511	2511	2511	2510	2509	2507
40	2507	2508	2506	2506	2508	2509	2509	2508	2503	2499
50	2499	2502	2497	2496	2500	2504	2504	2501	2493	2487
60	2488	2490	2482	2482	2487	2492	2490	2487	2481	2474
70	2477	2469	2469	2469	2471	2474	2472	2470	2454	2460
80	2458	2458	2455	2452	2453	2454	2453	2451	2449	2448
NORTH POLE							2448			

Table 1B. Mean height (10's of meters) in January

Latitude Degrees North	Longitude, Degrees									
	WEST					EAST				
	0	30	60	90	120	150	180	150	120	90
	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z
20	1643	1641	1644	1644	1645	1645	1649	1644	1643	1643
30	1635	1632	1632	1636	1636	1636	1625	1624	1625	1620
40	1609	1614	1606	1606	1613	1618	1609	1584	1597	1605
50	1592	1592	1592	1597	1597	1603	1590	1568	1580	1582
60	1543	1560	1540	1548	1577	1587	1577	1540	1550	1553
70	1533	1528	1519	1528	1551	1563	1554	1532	1514	1526
80	1511	1511	1512	1516	1524	1529	1526	1518	1509	1506
NORTH POLE							1508			
							50 mb			
20	2052	2054	2055	2055	2053	2055	2054	2056	2052	2053
30	2048	2052	2050	2051	2057	2056	2052	2044	2047	2044
40	2041	2044	2040	2047	2059	2054	2043	2026	2035	2036
50	2024	2024	2008	2017	2039	2052	2048	2024	1997	2003
60	1990	1983	1966	1979	2019	2040	2032	1994	1962	1971
70	1945	1939	1936	1950	1980	2000	1985	1965	1937	1934
80	1919	1918	1923	1931	1943	1952	1950	1938	1930	1921
NORTH POLE							1923			
							25 mb			
20	2489	2490	2491	2490	2489	2492	2492	2490	2487	2491
30	2489	2491	2488	2484	2488	2497	2496	2495	2485	2485
40	2482	2484	2476	2473	2485	2501	2500	2495	2475	2468
50	2454	2454	2437	2443	2473	2480	2487	2486	2472	2468
60	2412	2400	2383	2405	2448	2487	2492	2497	2398	2386
70	2357	2345	2339	2365	2408	2442	2444	2410	2365	2345
80	2323	2320	2328	2338	2360	2377	2377	2363	2342	2332
NORTH POLE							2332			

Table 3B. Mean height (10's of meters) in July

Latitude Degrees North	Longitude, Degrees									
	WEST					EAST				
	0	30	60	90	120	150	180	150	120	90
	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z
20	1859	1857	1856	1858	1858	1857	1853	1856	1852	1857
30	1863	1858	1858	1862	1862	1857	1856	1860	1873	1877
40	1857	1856	1861	1859	1853	1861	1871	1872	1871	1863
50	1850	1850	1847	1854	1855	1850	1848	1855	1858	1857
60	1846	1842	1840	1847	1849	1846	1845	1848	1848	1848
70	1843	1839	1838	1842	1844	1843	1842	1844	1845	1845
80	1842	1839	1837	1837	1839	1839	1839	1840	1842	1843
NORTH POLE							1839			
							50 mb			
20	2074	2074	2075	2077	2077	2077	2074	2074	2077	2075
30	2063	2064	2066	2065	2065	2064	2063	2064	2067	2065
40	2060	2060	2061	2063	2063	2063	2063	2062	2064	2063
50	2056	2054	2054	2056	2056	2056	2056	2056	2056	2056
60	2056	2057	2057	2057	2057	2057	2057	2057	2057	2057
70	2102	2101	2102	2102	2103	2103	2102	2103	2103	2102
80	2104	2104	2104	2105	2106	2107	2107	2107	2107	2106
NORTH POLE							2108			
							25 mb			
20	2518	2518	2518	2518	2518	2518	2518	2517	2517	2518
30	2531	2533	2533	2533	2533	2532	2531	2529	2529	2530
40	2542	2543	2544	2545	2544	2543	2543	2542	2543	2543
50	2553	2553	2553	2554	2554	2553	2553	2553	2553	2552
60	2563	2563	2563	2563	2563	2563	2563	2563	2563	2562
70	2576	2572	2572	2571	2571	2571	2571	2570	2571	2571
80	2577	2577	2577	2576	2576	2576	2576	2576	2576	2577
NORTH POLE							2576			

Table 1C. Mean temperature (°C) in January

Latitude Degrees North	Longitude, Degrees										
	WEST					EAST					
0	30	60	90	120	150	180	150	120	90	60	30
					<u>100 mb</u>						
20	-73	-72	-74	-72	-74	-78	-80	-77	-75	-74	-73
30	-67	-67	-68	-67	-68	-69	-71	-68	-67	-67	-67
40	-60	-62	-60	-60	-59	-60	-58	-56	-58	-59	-59
50	-58	-61	-58	-58	-55	-53	-52	-55	-59	-59	-58
60	-63	-63	-63	-60	-56	-53	-51	-54	-64	-64	-63
70	-66	-66	-66	-63	-59	-57	-61	-66	-68	-68	-67
80	-68	-68	-67	-66	-64	-63	-64	-66	-70	-72	-71
NORTH POLE						-68					
					<u>50 mb</u>						
20	-64	-64	-64	-63	-64	-65	-65	-63	-65	-65	-64
30	-63	-62	-62	-61	-61	-62	-61	-60	-61	-62	-62
40	-59	-59	-60	-59	-58	-56	-54	-54	-58	-58	-58
50	-60	-60	-61	-59	-57	-54	-50	-48	-58	-61	-59
60	-65	-67	-63	-58	-53	-50	-55	-64	-67	-61	-65
70	-72	-73	-72	-68	-63	-58	-62	-68	-72	-72	-71
80	-76	-76	-74	-72	-68	-67	-68	-71	-73	-75	-76
NORTH POLE						-74					
					<u>25 mb</u>						
20	-53	-53	-53	-54	-56	-53	-55	-53	-53	-53	-53
30	-54	-54	-54	-55	-57	-53	-53	-52	-54	-54	-54
40	-55	-55	-57	-58	-58	-53	-51	-55	-57	-57	-57
50	-58	-59	-63	-62	-59	-53	-49	-55	-58	-59	-61
60	-66	-67	-68	-67	-63	-54	-50	-65	-64	-65	-67
70	-71	-72	-72	-71	-66	-61	-56	-59	-65	-67	-71
80	-74	-74	-74	-72	-70	-67	-67	-69	-72	-74	-74
NORTH POLE						-73					

Table 4C. Mean temperature (°C) in October

Latitude Degrees North	Longitude, Degrees									
	0	30	60	90	120	150	180	210	240	270
20	-72	-72	-74	-76	-75	-73	-75	-77	-77	-74
26	-67	-68	-69	-71	-70	-68	-71	-73	-71	-69
40	-44	-44	-43	-44	-43	-42	-44	-44	-41	-42
56	-61	-61	-58	-58	-57	-55	-57	-55	-54	-57
60	-67	-66	-64	-64	-64	-61	-60	-61	-53	-54
70	-64	-64	-63	-63	-62	-61	-61	-61	-62	-53
80	-63	-63	-63	-63	-62	-62	-62	-62	-53	-53
NORTH POLE										
						50 mb				
20	-61	-62	-62	-62	-62	-62	-63	-63	-62	-62
36	-60	-60	-60	-61	-61	-61	-61	-61	-60	-60
46	-59	-59	-59	-59	-59	-58	-59	-58	-57	-58
50	-58	-58	-57	-57	-57	-55	-55	-54	-56	-58
60	-58	-57	-57	-56	-55	-53	-52	-54	-55	-57
70	-57	-57	-57	-56	-56	-54	-54	-55	-56	-57
80	-56	-56	-57	-57	-57	-56	-56	-56	-57	-58
NORTH POLE										
20	-61	-61	-61	-61	-62	-62	-62	-62	-62	-62
36	-62	-62	-62	-62	-62	-62	-62	-62	-62	-62
46	-63	-63	-63	-64	-64	-64	-64	-64	-64	-64
50	-64	-64	-64	-64	-64	-64	-64	-64	-64	-64
60	-64	-64	-64	-64	-64	-64	-64	-64	-64	-64
70	-64	-64	-64	-64	-64	-64	-64	-64	-64	-64
80	-64	-64	-64	-64	-64	-64	-64	-64	-64	-64
NORTH POLE										

Table 2C. Mean temperature (°C) in April

Latitude Degrees North	Longitude, Degrees									
	0	30	60	90	120	150	180	210	240	270
20	-74	-71	-73	-74	-73	-73	-75	-77	-77	-75
30	-66	-66	-67	-69	-67	-68	-70	-71	-69	-68
40	-59	-60	-59	-59	-59	-60	-60	-61	-58	-59
50	-57	-56	-54	-54	-56	-55	-54	-53	-56	-57
60	-54	-52	-50	-50	-52	-52	-50	-49	-52	-54
70	-51	-50	-49	-49	-49	-49	-48	-48	-49	-51
80	-49	-49	-48	-48	-47	-47	-47	-47	-46	-49
NORTH POLE							-48			
20	-64	-63	-63	-63	-62	-64	-65	-66	-66	-65
30	-61	-61	-61	-61	-61	-62	-62	-62	-62	-62
40	-58	-58	-57	-57	-58	-58	-57	-56	-58	-59
50	-56	-56	-55	-54	-55	-55	-54	-53	-55	-57
60	-54	-53	-53	-53	-52	-50	-49	-51	-54	-54
70	-53	-53	-52	-51	-51	-50	-48	-47	-50	-53
80	-52	-51	-50	-49	-49	-48	-48	-49	-51	-52
NORTH POLE							-50			
20	-52	-52	-53	-52	-52	-52	-52	-52	-52	-52
30	-53	-53	-53	-53	-53	-53	-52	-52	-53	-53
40	-53	-54	-53	-53	-54	-53	-52	-52	-53	-54
50	-54	-54	-53	-53	-53	-53	-51	-51	-53	-54
60	-53	-53	-53	-53	-52	-52	-49	-50	-52	-53
70	-53	-53	-52	-52	-52	-51	-50	-48	-51	-52
80	-52	-52	-52	-51	-50	-50	-49	-50	-51	-52
NORTH POLE							-51			

Table 3C. Mean temperature (°C) in July

Latitude Degrees North		Longitude, Degrees									
		WEST					EAST				
0	30	60	90	120	150	180	150	120	90	60	30
100 mb											
20	-76	-73	-72	-73	-73	-71	-73	-77	-78	-78	-77
30	-71	-68	-66	-69	-69	-65	-64	-70	-75	-76	-75
40	-62	-62	-63	-63	-58	-58	-63	-69	-70	-69	-65
50	-55	-55	-57	-57	-54	-54	-57	-59	-58	-58	-57
60	-50	-48	-48	-49	-49	-49	-52	-53	-53	-52	-51
70	-46	-45	-44	-45	-46	-46	-47	-48	-48	-47	-44
80	-43	-42	-42	-42	-43	-43	-44	-44	-45	-45	-44
NORTH POLE											
20	-62	-62	-61	-61	-61	-61	-62	-63	-63	-62	-62
30	-59	-59	-58	-58	-58	-58	-59	-61	-61	-61	-60
40	-56	-55	-55	-55	-55	-55	-55	-57	-57	-56	-56
50	-52	-52	-51	-52	-51	-52	-52	-52	-51	-51	-52
60	-48	-48	-47	-48	-48	-48	-48	-48	-47	-47	-48
70	-44	-44	-44	-45	-45	-45	-46	-46	-45	-44	-44
80	-42	-41	-42	-43	-43	-43	-43	-43	-43	-43	-43
NORTH POLE											
25 mb											
20	-51	-51	-51	-51	-51	-52	-52	-52	-52	-51	-51
30	-50	-50	-50	-50	-50	-51	-51	-51	-51	-50	-50
40	-48	-48	-48	-48	-48	-49	-49	-49	-48	-48	-48
50	-46	-46	-46	-46	-46	-47	-47	-47	-46	-46	-46
60	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44
70	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42
80	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40
NORTH POLE											
20	-51	-51	-51	-51	-51	-52	-52	-52	-52	-51	-51
30	-50	-50	-50	-50	-50	-51	-51	-51	-51	-50	-50
40	-48	-48	-48	-48	-48	-49	-49	-49	-48	-48	-48
50	-46	-46	-46	-46	-46	-47	-47	-47	-46	-46	-46
60	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44
70	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42
80	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40
NORTH POLE											
20	-51	-51	-51	-51	-51	-52	-52	-52	-52	-51	-51
30	-50	-50	-50	-50	-50	-51	-51	-51	-51	-50	-50
40	-48	-48	-48	-48	-48	-49	-49	-49	-48	-48	-48
50	-46	-46	-46	-46	-46	-47	-47	-47	-46	-46	-46
60	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44
70	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42
80	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40
NORTH POLE											
20	-51	-51	-51	-51	-51	-52	-52	-52	-52	-51	-51
30	-50	-50	-50	-50	-50	-51	-51	-51	-51	-50	-50
40	-48	-48	-48	-48	-48	-49	-49	-49	-48	-48	-48
50	-46	-46	-46	-46	-46	-47	-47	-47	-46	-46	-46
60	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44
70	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42
80	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40
NORTH POLE											
20	-51	-51	-51	-51	-51	-52	-52	-52	-52	-51	-51
30	-50	-50	-50	-50	-50	-51	-51	-51	-51	-50	-50
40	-48	-48	-48	-48	-48	-49	-49	-49	-48	-48	-48
50	-46	-46	-46	-46	-46	-47	-47	-47	-46	-46	-46
60	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44
70	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42
80	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40
NORTH POLE											
20	-51	-51	-51	-51	-51	-52	-52	-52	-52	-51	-51
30	-50	-50	-50	-50	-50	-51	-51	-51	-51	-50	-50
40	-48	-48	-48	-48	-48	-49	-49	-49	-48	-48	-48
50	-46	-46	-46	-46	-46	-47	-47	-47	-46	-46	-46
60	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44
70	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42
80	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40
NORTH POLE											
20	-51	-51	-51	-51	-51	-52	-52	-52	-52	-51	-51
30	-50	-50	-50	-50	-50	-51	-51	-51	-51	-50	-50
40	-48	-48	-48	-48	-48	-49	-49	-49	-48	-48	-48
50	-46	-46	-46	-46	-46	-47	-47	-47	-46	-46	-46
60	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44
70	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42
80	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40
NORTH POLE											
20	-51	-51	-51	-51	-51	-52	-52	-52	-52	-51	-51
30	-50	-50	-50	-50	-50	-51	-51	-51	-51	-50	-50
40	-48	-48	-48	-48	-48	-49	-49	-49	-48	-48	-48
50	-46	-46	-46	-46	-46	-47	-47	-47	-46	-46	-46
60	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44
70	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42
80	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40
NORTH POLE											
20	-51	-51	-51	-51	-51	-52	-52	-52	-52	-51	-51
30	-50	-50	-50	-50	-50	-51	-51	-51	-51	-50	-50
40	-48	-48	-48	-48	-48	-49	-49	-49	-48	-48	-48
50	-46	-46	-46	-46	-46	-47	-47	-47	-46	-46	-46
60	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44
70	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42
80	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40
NORTH POLE											
20	-51	-51	-51	-51	-51	-52	-52	-52	-52	-51	-51
30	-50	-50	-50	-50	-50	-51	-51	-51	-51	-50	-50
40	-48	-48	-48	-48	-48	-49	-49	-49	-48	-48	-48
50	-46	-46	-46	-46	-46	-47	-47	-47	-46	-46	-46
60	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44
70	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42
80	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40
NORTH POLE											
20	-51	-51	-51	-51	-51	-52	-52	-52	-52	-51	-51
30	-50	-50	-50	-50	-50	-51	-51	-51	-51	-50	-50
40	-48	-48	-48	-48	-48	-49	-49	-49	-48	-48	-48
50	-46	-46	-46	-46	-46	-47	-47	-47	-46	-46	-46
60	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44
70	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42
80	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40
NORTH POLE											
20	-51	-51	-51	-51	-51	-52	-52	-52	-52	-51	-51
30	-50	-50	-50	-50	-50	-51	-51	-51	-51	-50	-50
40	-48	-48	-48	-48	-48	-49	-49	-49	-48	-48	-48
50	-46	-46	-46	-46	-46	-47	-47	-47	-46	-46	-46
60	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44
70	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42
80	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40
NORTH POLE											
20	-51	-51	-51	-51	-51	-52	-52	-52	-52	-51	-51
30	-50	-50	-50	-50	-50	-51	-51	-51	-51	-50	-50
40	-48	-48	-48	-48	-48	-49	-49	-49	-48	-48	-48
50	-46	-46	-46	-46	-46	-47	-47	-47	-46	-46	-46
60	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44
70	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42
80	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40
NORTH POLE											
20	-51	-51	-51	-51	-51	-52	-52	-52	-52	-51	-51
30	-50	-50	-50	-50	-50	-51	-51	-51	-51	-50	-50
40	-48	-48	-48	-48	-48	-49	-49	-49	-48	-48	-48
50	-46	-46	-46	-46	-46	-47	-47	-47	-46	-46	-46
60	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44
70	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42
80	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40
NORTH POLE											
20	-51	-51	-51	-51	-51	-52	-52	-52	-52	-51	-51
30	-50	-50	-50	-50	-50	-51	-51	-51	-51	-50	-50
40	-48	-48	-48	-48	-48	-49	-49	-49	-48	-48	-48
50	-46	-46	-46	-46	-46	-47	-47	-47	-46	-46	-46
60	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44
70	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42
80	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40
NORTH POLE											
20	-51	-51	-51	-51	-51	-52	-52	-52	-52	-51	-51
30	-50	-50	-50	-50	-50	-51	-51	-51	-51	-50	-50
40	-48	-48	-48	-48	-48	-49	-49	-49	-48	-48	-48
50	-46	-46	-46	-46	-46	-47	-47	-47	-46	-46	-46
60	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44
70	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42
80	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40
NORTH POLE											
20	-51	-51	-51	-51	-51	-52	-52	-52	-52	-51	-51
30	-50	-50	-50	-50	-50	-51	-51	-51	-51	-50	-50
40	-48	-48	-48	-48	-48	-49	-49	-49	-48	-48	-48
50	-46	-46	-46	-46	-46	-47	-47	-47	-46	-46	-46
60	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44	-44
70	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42
80	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40
NORTH POLE											
20	-51	-51	-51	-51	-51	-52	-52	-52	-52	-51	-51
30	-50	-50	-50	-50	-50	-51	-51	-51	-51	-50	-50</