SOME RELATIONSHIPS BETWEEN FIVE-DAY MEAN SURFACE MAPS AND THEIR COMPONENT DAILY MAPS

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Extended forecasts prepared by the Five-Day Forecast Section of the United States Weather Bureau are based in large part on five-day mean surface and three-kilometer charts. The physical and statistical basis for such forecasting procedure has been discussed in several reports.(1) More recently the forecast procedure has been adapted to forecasting the day by day sequence of weather over North America and adjacent oceans.

This adaptation has led to the routine preparation of a series of daily prognostic charts covering the entire forecast period. The purpose of these maps is to interpret the mean forecast in terms of a time sequence and thus indicate the time of occurrence of the weather changes expected during the period covered by the forecast. Six daily maps are constructed, the last five of which comprise the five-day mean.

The first map of the series is a twenty-four hour forecast and is made chiefly by using methods commonly practiced, although mean trends and circulation indices are also considered in this twenty-four hour prognosis. This twenty-four hour forecast is considered by the mean forecaster in preparing his mean forecast.

The next five maps interpret the forecast mean charts at sea level and 10,000 feet on a daily basis in a consistent and logical development from the first day forecast. The temperature and precipitation anomalies as forecast by the mean forecaster are also used to indicate the air masses expected and the intensity and paths of storms.

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

Willett, H. C., and others, "Report of the Five-Day Forecasting Procedure, Verification and Research as Conducted between July 1940 and August 1941," Massachusetts Institute of Technology, Cambridge, Massachusetts, 1941.

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Certain concepts in addition to those just mentioned are used in the preparation of the daily maps. First, the correlation between an observed mean surface map and each of the ten twice daily maps compo ing the mean show that the middle maps bear the greatest resemblance the mean map. Second, different circulation index values, to some e tent, determine the intensity and movements of cyclones and anticyc

The first of these concepts is considered by placing all principal centers on the middle daily map of the period in the position indica by the centers on the forecast mean chart, thus arranging the pressu pattern to fit roughly the mean picture. The second is used to indi the speed of centers and type of weather development expected in va areas, particularly when the indices are considered sectionally. Fo example, a low easterly index indicates the relatively rapid eastwa motion of systems at low latitudes.

The purpose of this report is to inquire more quantitatively into th basis for these concepts, and in this manner improve our technique f forecasting the day by day sequence of weather.

The relationships investigated were:

1. Comparison between pressure on mean maps with the pressure in each center on the daily maps.

2. Movement and number of daily centers in the five day period.

3. Position and intensity of centers on the middle daily map compared to centers on the mean charts.

4. Paths of daily centers compared to mean paths.

These relationships are considered with regard to the classification zonal index values indicated below.

The data were obtained by plotting the daily positions and intensiti of pressure centers on corresponding five-day mean sea level charts. Pressure differences were obtained directly from the charts from the values at the position of the daily centers and the mean at the same location. Movements of centers were measured in degrees of longitud per day (at 45°N).

Ten cases involving fall and winter maps were studied. Maps with zo indices less than 2 m/s were classified as low; 2 to 5 m/s medium, greater than 5 m/s high. These maps are shown in figures 1 to 10. Fronts are shown for the middle day of the five day mean.

Table 1 shows the comparison of pressures of the daily centers to the mean pressures at the same location for different index ranges. The pressure of the daily lows averaged 8 to 11 millibars less than the mean pressure; pressure in daily highs averaged 4 to 6 millibars higher than the mean. The departure from the mean appears to increase with increasing index.

Table I

Comparison of Pressures of Daily Centers to Mean Pressure

Index	I_Z < 2 mps	I_Z = 2-5 mps	I_Z > 5 mps
Daily Lows (mbs mean)	8	10	11
Daily Highs (mbs mean)	4	5	6

Zonal speed of highs and lows in degrees of longitude (at 45°N) per day is given in Table II. Lows moved 9 to 14 degrees per day, the distance increasing with higher index. Highs moved slower, varying from 7 to 11 degrees per day.

In Table III is given the meridional speed of highs and lows in degrees of latitude. These values represent both north and south movements and are combined without regard to sign. Lows showed slightly more meridional movement than highs. There appears to be little or no variation in meridional speed with change in index for either highs or lows.

Table II

Zonal Speed of Centers (Degrees per Day at 45°N)

Zonal Index	I_Z < 2 mps	I_Z = 2-5 mps	I_Z > 5 mps
Lows	9	11	14
Highs	7	8	11

Table III

Meridional Speed of Centers (Degrees per Day)

Zonal Index	$I_Z < 2$ mps	$I_Z = 2$-5 mps	$I_Z > 5$ mps
Lows	3	4	4
Highs	3	2	3

A knowledge of the number of daily systems of highs or lows that w comprise a mean center is of considerable importance to the foreca Tables IV and V show this number for different ranges of indices. low indices only one or two daily low systems comprised the mean l while sometimes as many as four occurred with high indices. The p centage of the mean lows in each index group comprised of one, two more daily low pressure systems is also given.

Similar results are given for high pressure centers. Here in all the mean highs are made up of only one or two daily high systems. percentage of mean highs made up of one daily high system, however decreases with increasing index.

Table IV

Number of Daily Lows in Mean Lows

	$I_Z < 2$ mps		$I_Z = 2$-5 mps				$I_Z > 5$ mps			
No. of Daily Lows	1	2	1	2	3	4	1	2	3	4
Percentage of mean lows associated with one or more lows	62	38	47	41	6	6	45	15	15	23

Table V

Number of Daily Highs in Mean Highs

	$I_Z < 2$ mps		$I_Z = 2$-5 mps		$I_Z > 5$ mps	
No. of Daily Highs	1	2	1	2	1	2
Percentage of mean highs with one or more daily centers	84	16	81	19	58	42

The correspondence of the middle daily map to the mean is treated in Table VI, where is listed the percentage of all centers on the middle daily map that occurred within five degrees of the mean centers. About fifty per cent of the daily cyclones on the maps of low and medium index lay within five degrees of the mean low centers but this percentage value falls to only twenty-two per cent with high index.

The high percentage of daily highs occurring on the middle map that lay within five degrees of the mean high are explained in part by the inclusion of sub-tropical oceanic highs and polar highs. When these are excluded, much lower values are obtained but the decrease in percentage value with rising index is still observed.

Table VI

Percentage of Centers on Middle Daily Map Within 5° of Mean Center

	$I_z < 2$ mps	$I_z = 2$-5 mps	$I_z > 5$ mps
Lows	53	52	22
Highs	94	94	86
Highs (not including Oceanic or polar)	80	71	33

Finally, an inspection of the paths of highs and lows with respect to the mean charts indicates that very few daily centers depart from the paths indicated by mean troughs and ridges, and, in general, follow the mean centers. Figures 1 to 10 bring out these features.

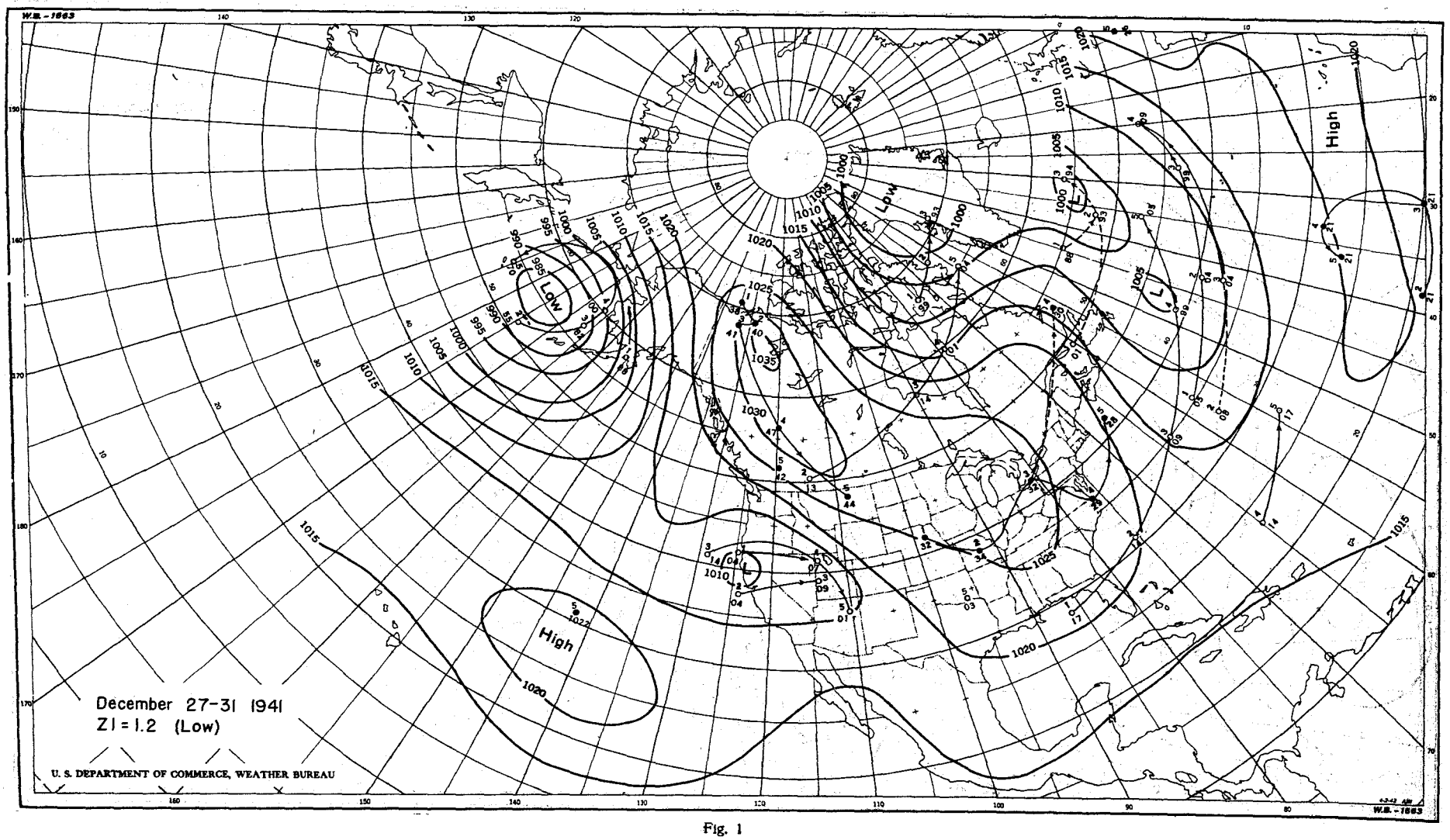
December 27-31 1941
ZI = 1.2 (Low)
U. S. DEPARTMENT OF COMMERCE, WEATHER BUREAU
Low
High
W.B. - 1863

Fig. 1

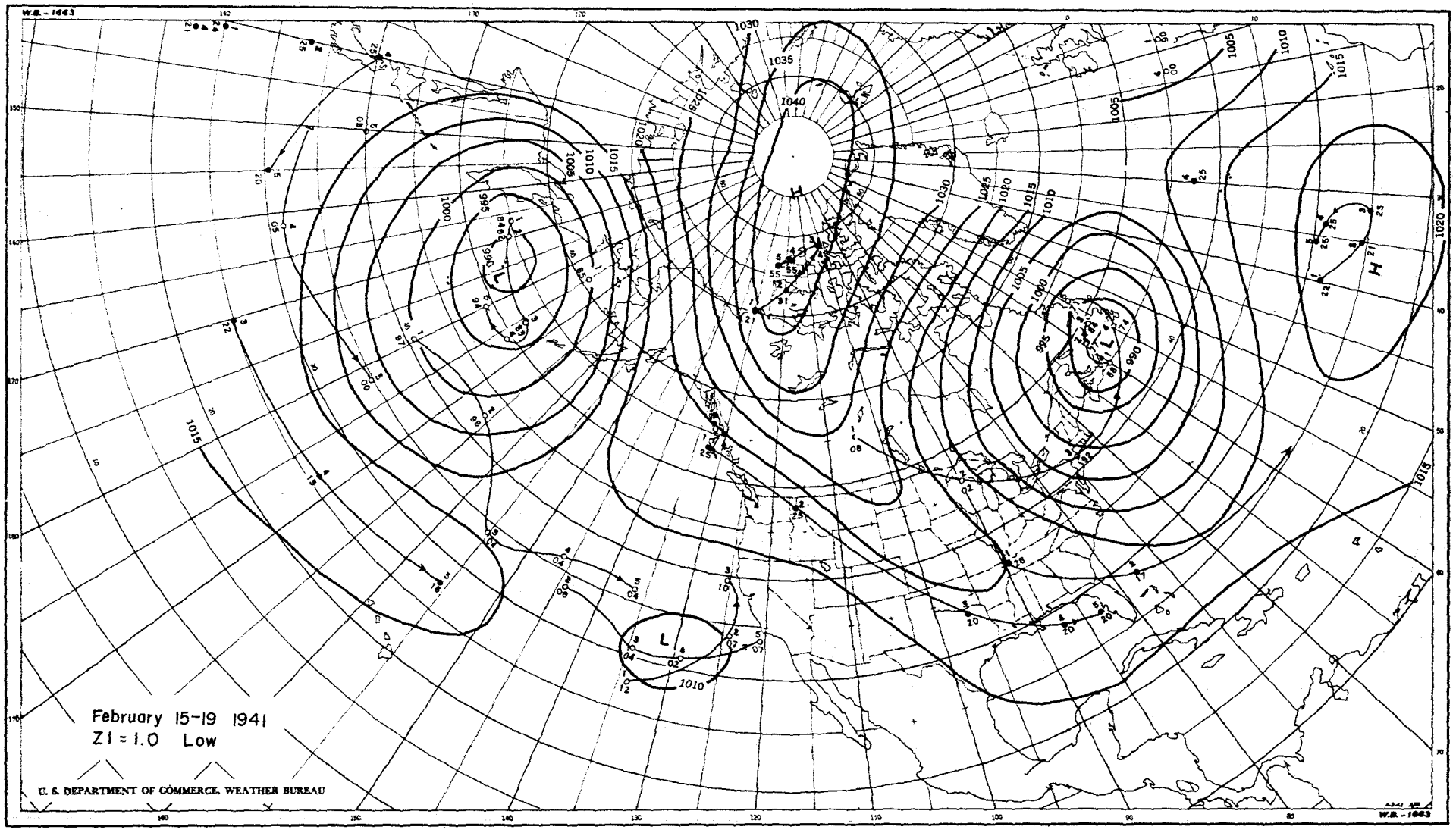
February 15-19 1941
Z1 = 1.0 Low
U. S. DEPARTMENT OF COMMERCE, WEATHER BUREAU

Fig. 2

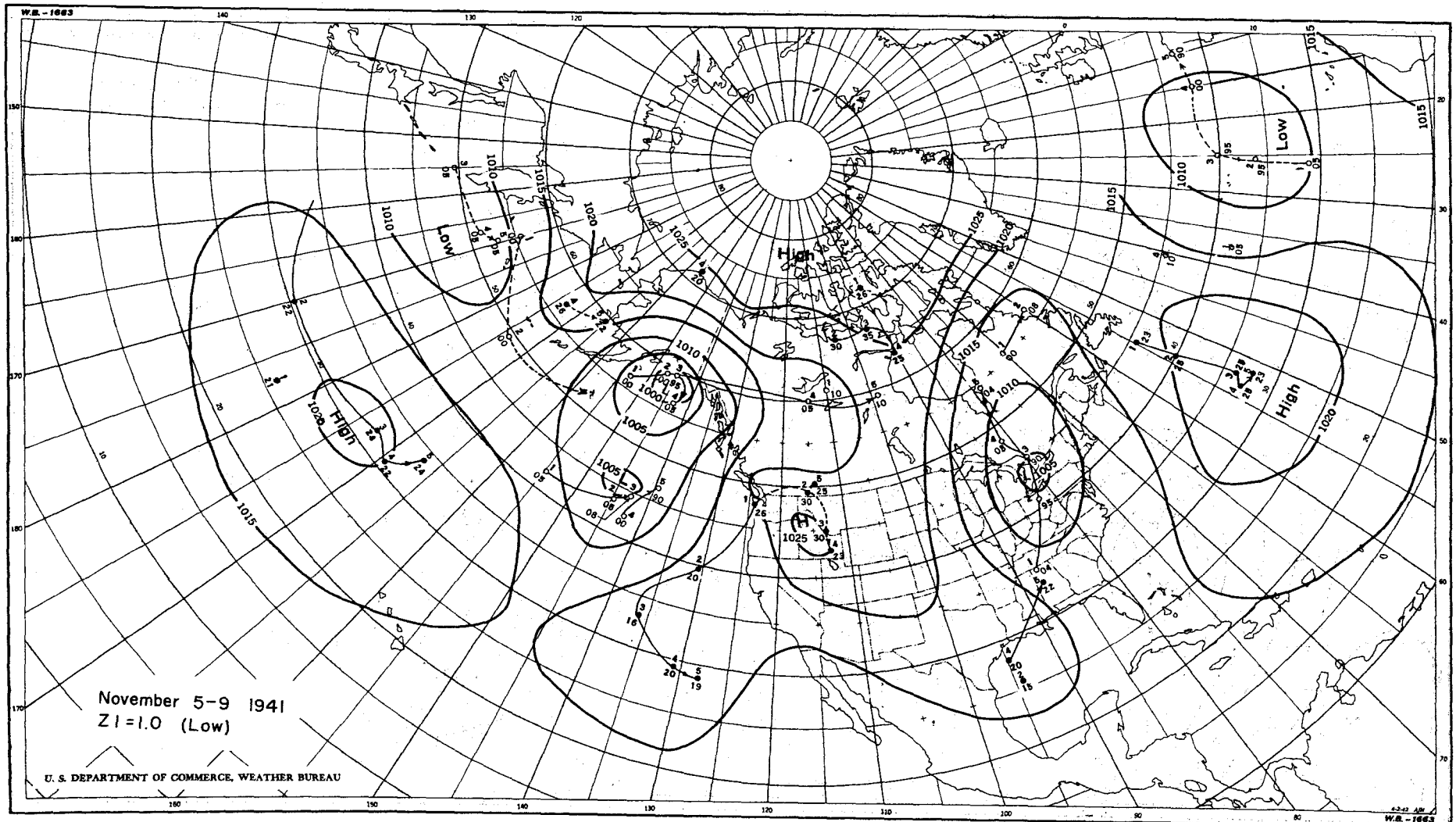
November 5-9 1941
ZI=1.0 (Low)
U. S. DEPARTMENT OF COMMERCE, WEATHER BUREAU
High
Low
High
Low
High
W.B.-1663

Fig. 3

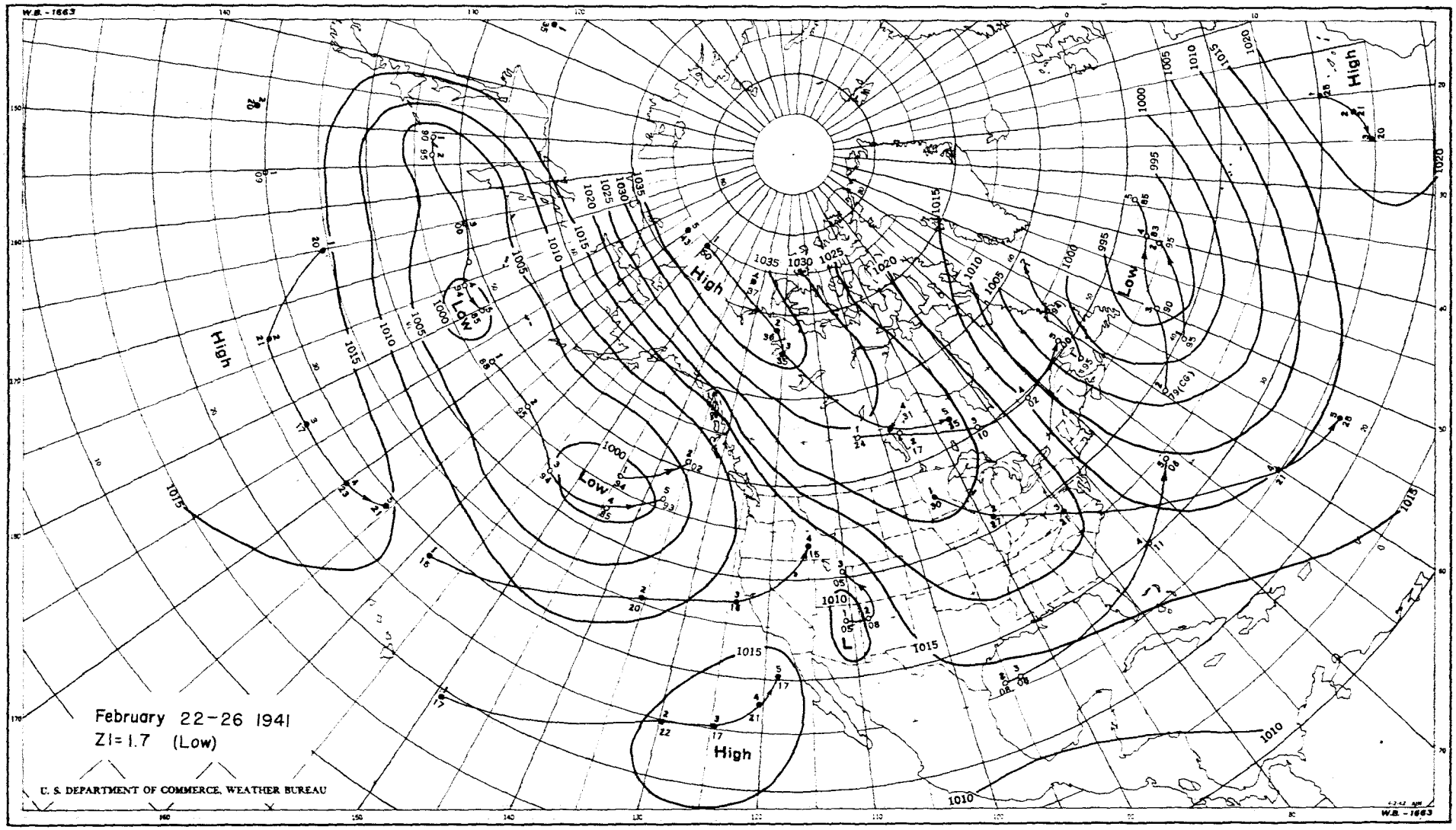
February 22-26 1941
ZI=1.7 (Low)
U. S. DEPARTMENT OF COMMERCE, WEATHER BUREAU
High
Low
W.B. - 1663

Fig. 4

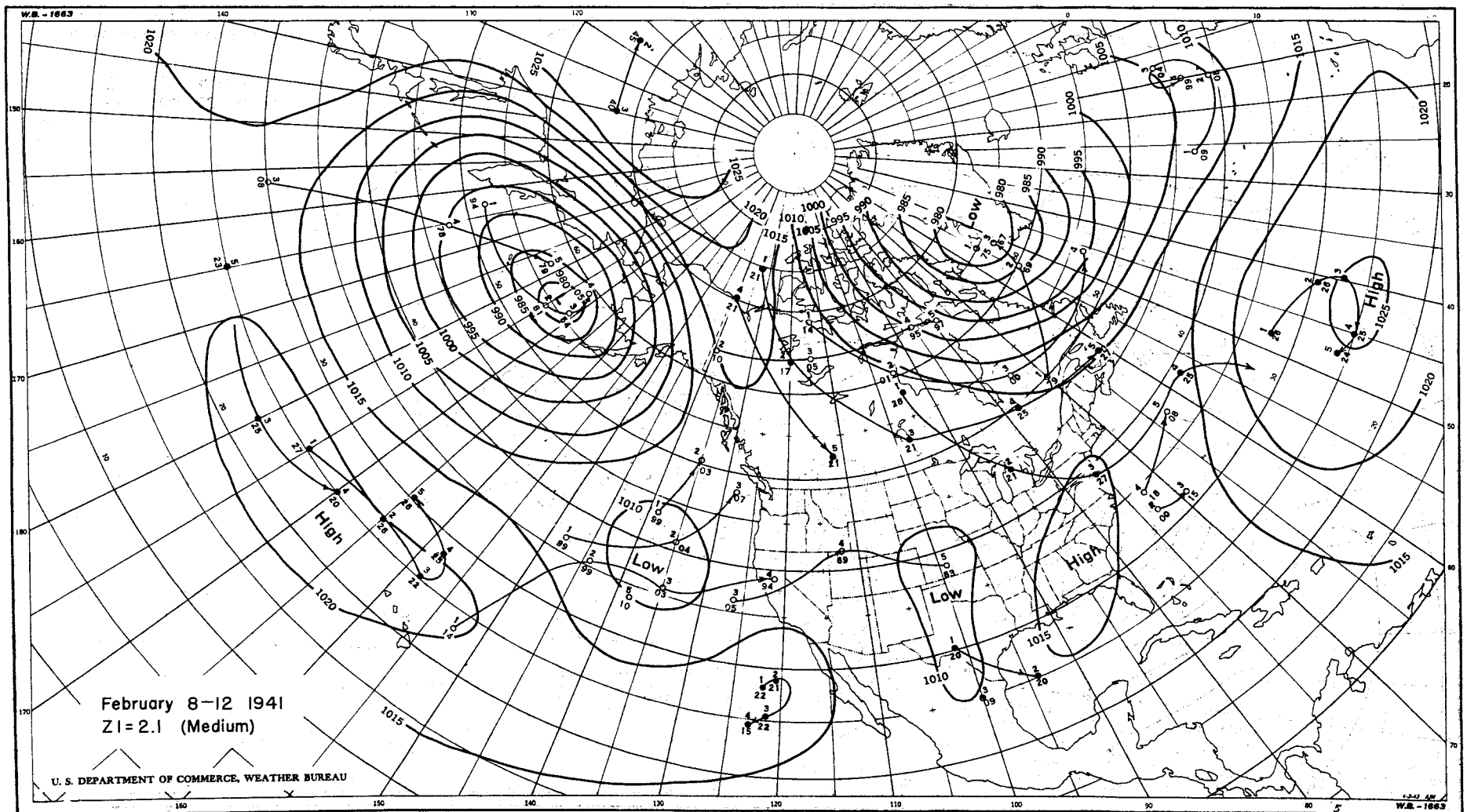
W.B. - 1663
February 8–12 1941
ZI = 2.1 (Medium)
U. S. DEPARTMENT OF COMMERCE, WEATHER BUREAU
High
Low
High
Low
Low
High

Fig. 5

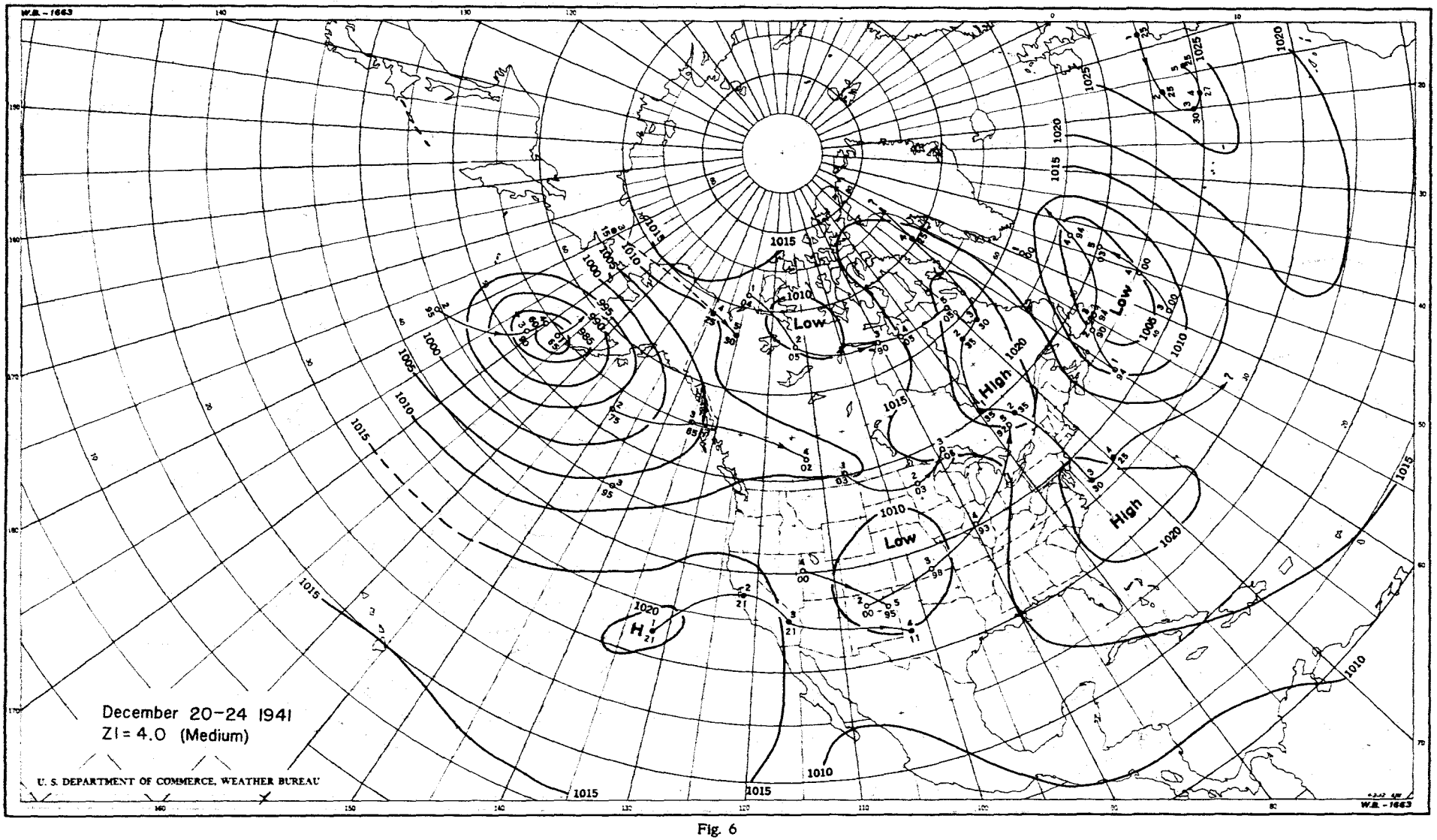
W.B. - 1663
December 20-24 1941
ZI = 4.0 (Medium)
U. S. DEPARTMENT OF COMMERCE, WEATHER BUREAU
Low
High
Low
High
Low
H
1015
1010
1005
1000
995
990
985
1020
1025

Fig. 6

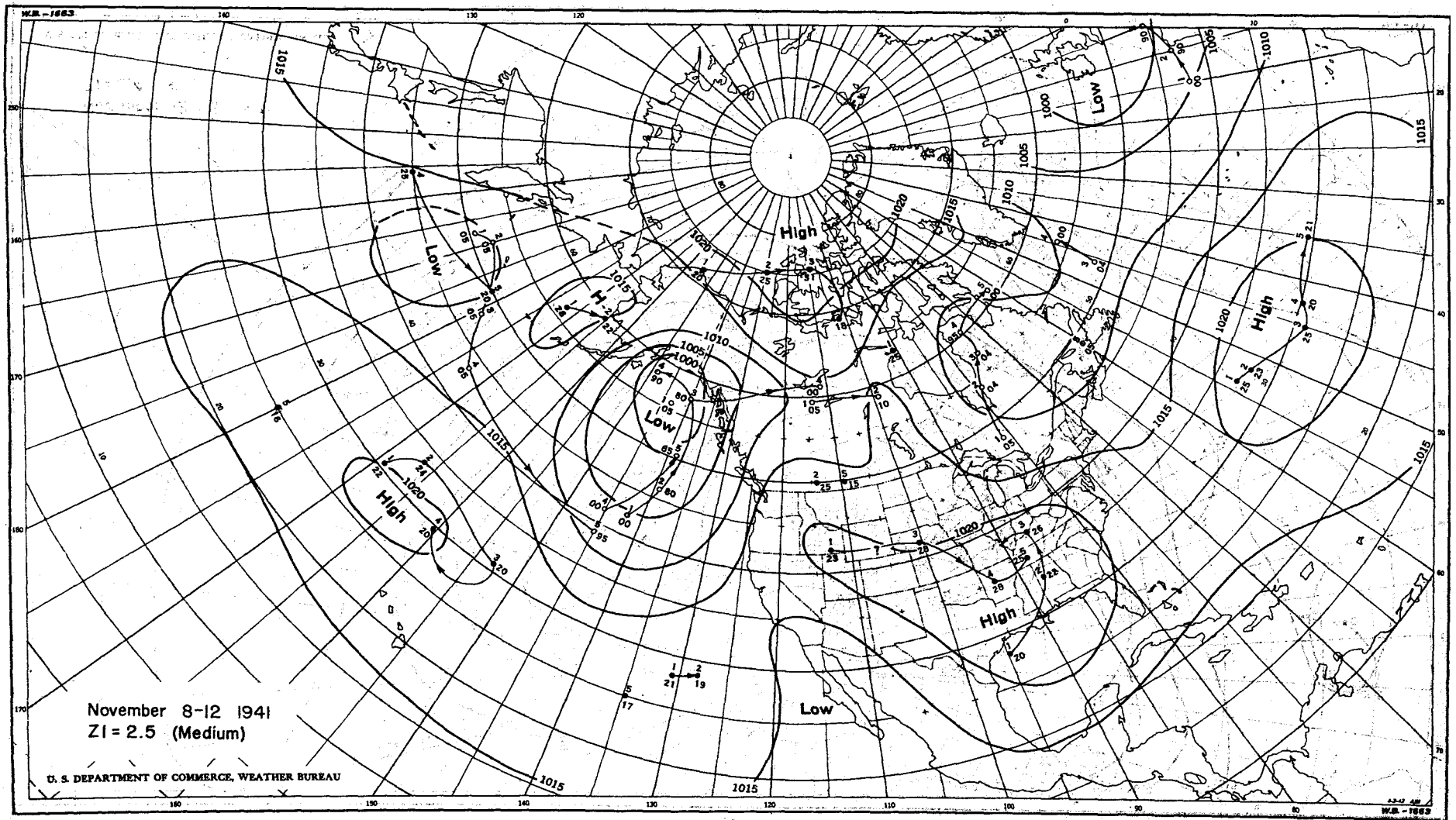
November 8-12 1941
ZI = 2.5 (Medium)
U. S. DEPARTMENT OF COMMERCE, WEATHER BUREAU
High
Low
H-2
W.B.-1663

Fig. 7

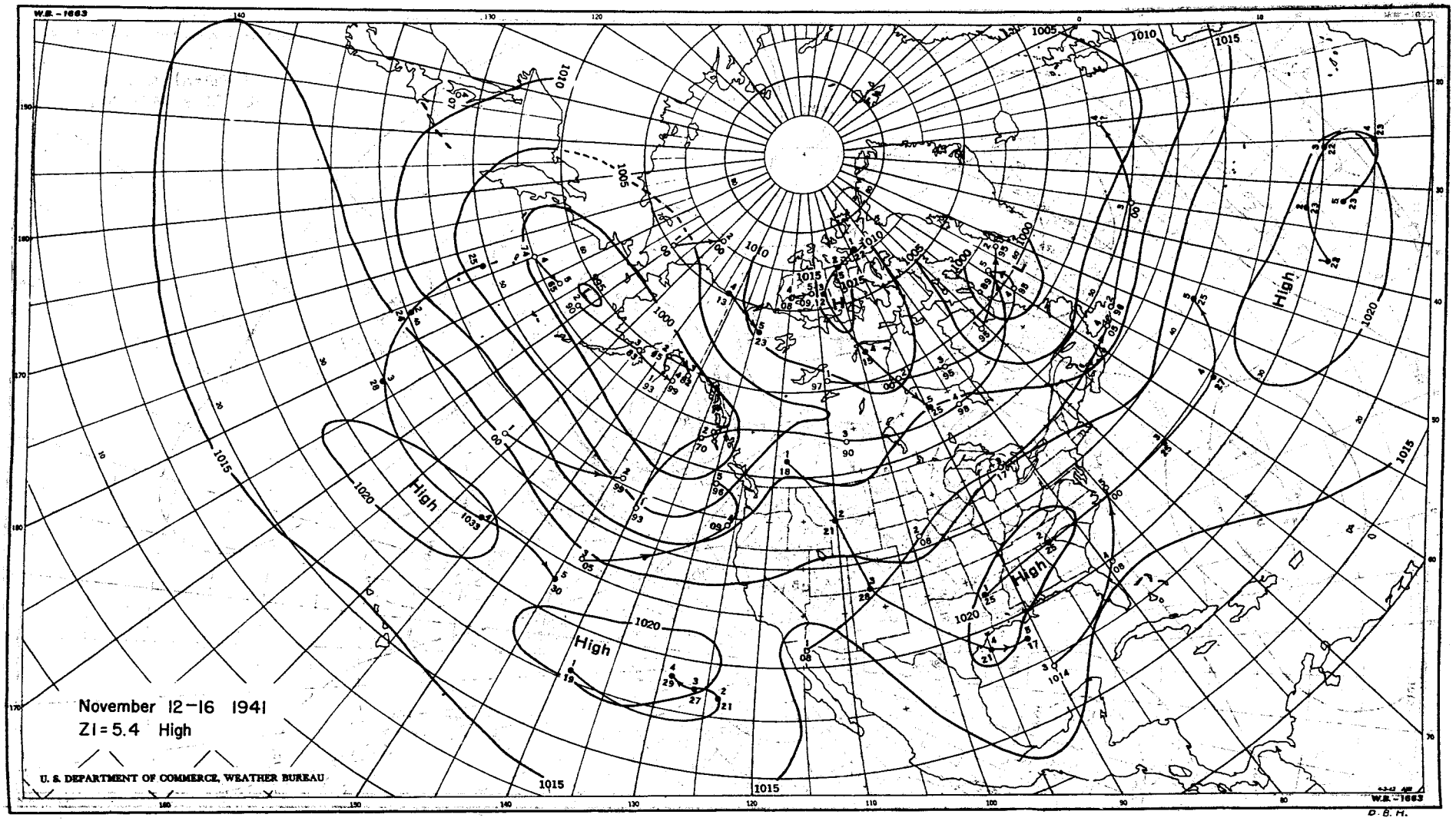
W.B. - 1663
November 12-16 1941
Z1 = 5.4 High
U. S. DEPARTMENT OF COMMERCE, WEATHER BUREAU
High
High
High
High
1015
1020
1010
1005
1000
1033
1014
W.B. - 1663
D. B. H.

Fig. 8

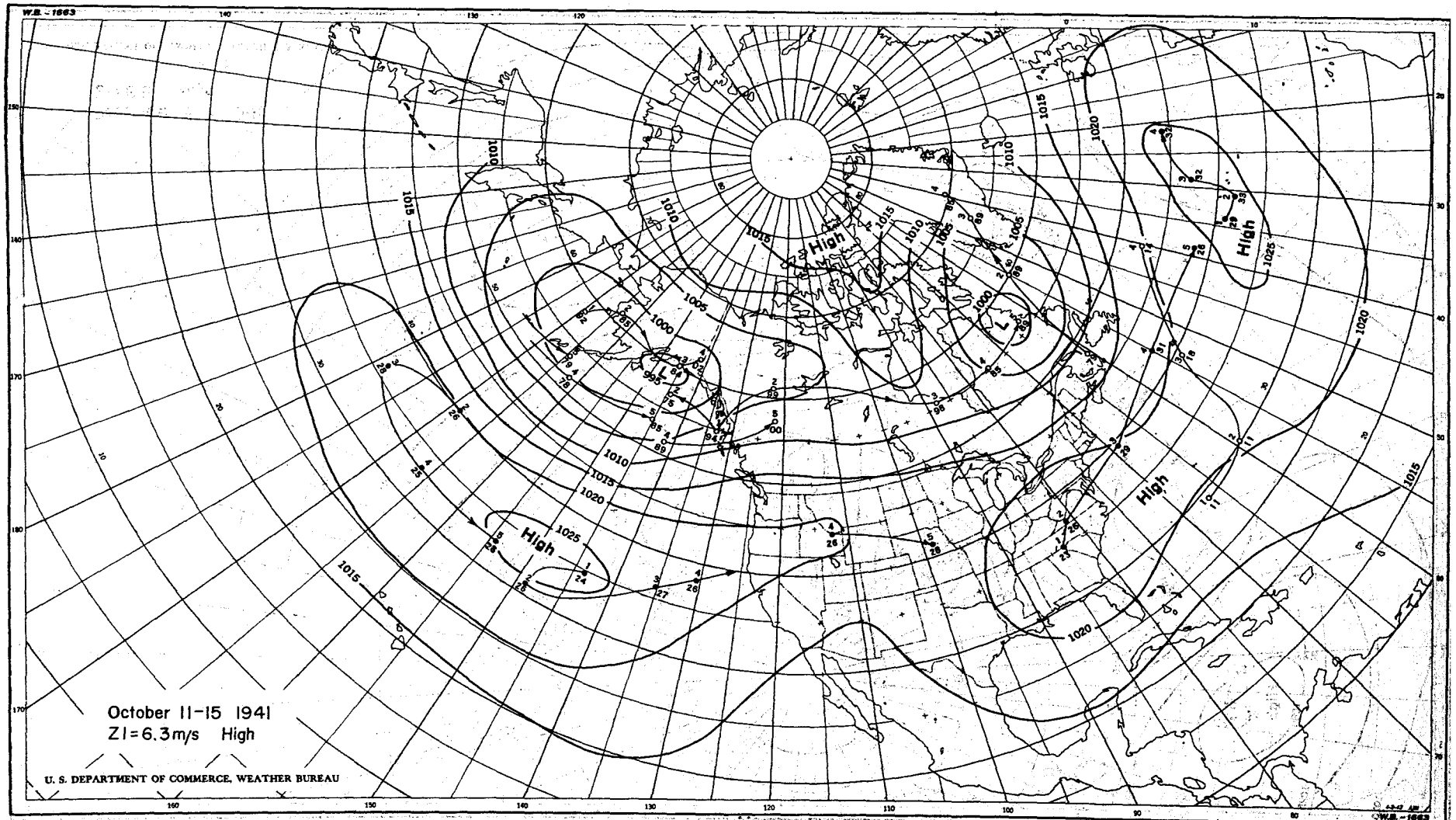
October 11-15 1941
ZI=6.3m/s High
U. S. DEPARTMENT OF COMMERCE, WEATHER BUREAU
High
High
High
L
L

Fig. 9

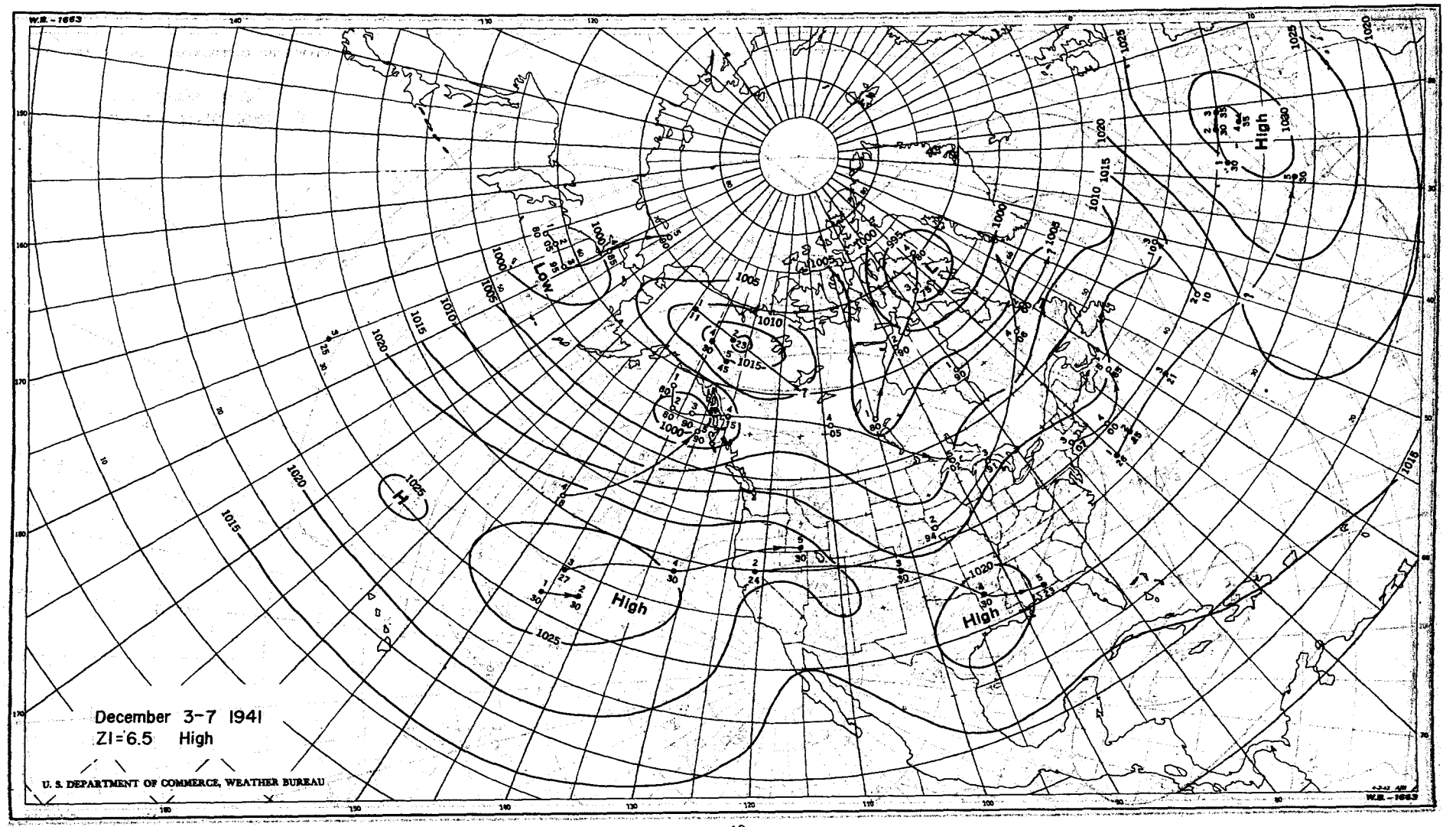
W.B. - 1663
December 3-7 1941
ZI=6.5 High
U. S. DEPARTMENT OF COMMERCE, WEATHER BUREAU
High
High
High
Low
H
L

Fig. 10