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CASE STUDIES OF FOUR SEVERE GULF OF ALASKA STORMS

J. E. Overland, PMEL Coordinator
V. J. Cardone

Pacific Marine Environmental Laboratory
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CONTENTS

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V. J. Cardone
Ocean Weather Inc.
White Plains, N.Y. 10601

ABSTRACT

This memorandum presents the meteorological development and life history of four severe storms from 1974-1976 which resulted in high winds in the inner Gulf of Alaska. Storm tracks and a narrative of each storm are provided along with sequences of sea-level pressure analyses, streamline-isotach analyses and wind variation at four offshore locations between Yakutat and Kodiak, Alaska. The four storms represent a variety of storm histories and a range of coastal wind response.

1. INTRODUCTION

The purpose of this study is to describe surface wind fields in severe storms for the northern Gulf of Alaska. Among other applications, such as STREX (Storm Transfer and Response Experiment), the wind fields will be used to assess the resolution errors inherent in the use of the synoptic climatology for this region developed by Overland and Hiester (1980).

The storms presented here were selected from cases treated in prior studies. Storms selected were all characterized by strong surface winds with an onshore component along the stretch of coast from Kodiak to Yakutat.

The method of wind field analysis employed is described in detail in Cardone et al. (1979). Briefly, a detailed postanalysis is performed using mainly hand analysis techniques to derive the surface wind distribution directly from the basic meteorological observations. Real-time data sources are augmented by archived observations from transient ships obtained from manuscript logs. Coastal and island station data are also used in the postanalysis. Surface winds are calculated from sea-level pressure gradients using a marine planetary boundary layer (PBL) model. PBL winds are retained only in uninteresting parts of the wind field, however, and are used only to guide the construction of streamlines and isotachs (kinematic analysis) in the areas of high winds near storms.

The accuracy of the wind fields produced by these techniques has been documented by Cardone et al. (1979). On the scales resolved (minimum length scale of 100-200 km), the wind speeds have an error of about 2.5

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m sec^{-1} rms about a negligible bias with wind direction errors of about 20°. The minimum resolvable length scale is determined by the basic data density in the northeast Pacific. Hence, the deforming influences of the shoreline topography along the Gulf of Alaska (GOA) on the nearshore field are not depicted in the wind fields presented here. In a storm environment such local influences are to be considered mesoscale and to influence the winds for a distance of perhaps 10-20 km offshore. However, the synoptic-scale wind field is also affected by the topography, since the orientation and intensity of isobaric gradients around intense extratropical cyclones are affected by the large-scale effects of the Alaskan Peninsula on storm speed and track. These synoptic-scale influences are included in the wind fields presented.

For each case study, the following material is presented:

1. Copies of microfilmed Northern Hemisphere 6-hourly surface maps at 12-hourly intervals throughout the storm (3-to 5-day period);

2. A storm track;

3. Several streamline/isotach charts covering the area between 130°W and 170°, and from 45°N to the Alaskan coast. The base maps show all winds reported from buoys, transient ships, and selected coastal and island stations;

4. Time histories of surface wind speed and direction at four offshore locations between Kodiak and Yakutat as follows:

Location 1	57°N	153°W
Location 2	59°N	149°W
Location 3	60°N	145°W
Location 4	59°N	141°W;

5. A narrative description of the storm.

2. STORM 1: OCTOBER 27-31, 1974

The storm track for this storm in the Gulf of Alaska is shown in Figure 1, while the complete history of the storm is shown in the series of surface analyses in Figures 2a-2i. Wind fields were constructed over the Gulf of Alaska beginning at 0600 GMT October 27, 1974, when, as seen in Figure 2a, the storm preceding the one of interest was producing winds of 30-35 kn along the Alaskan coast. Time histories of surface wind speed and direction at the offshore locations are shown in Figure 3. The preceding storm was of moderate intensity, reaching a central pressure of about 970 mb before stalling and filling in the GOA on October 27 and 28.

The intense storm of October 27-31 began as a wave (~1010 mb) on the polar front near 35°N, 180°W early on October 27. The low moved

northeastward at nearly 40 kn during October 27 and 28 and deepened to 986 mb, reaching 46°N, 160°W by 1800 GMT October 28. As seen in the detailed track obtained by postanalysis in Figure 1, the low slowed considerably after 0000 GMT October 29 and gradually curved northward. The minimum central pressure of about 950 mb was attained at 1800 GMT October 29, when the center was located 360 mi south of the Kenai Peninsula. The storm then drifted northward, filled slowly for about 12 hr, then filled more rapidly later on October 30 and 31. The storm ultimately drifted northwestward toward the Kenai Peninsula and filled.

The kinematic analyses are presented in Figures 4a-4d. The analyses are restricted to the region bounded by 130°W, 170°W, 45°N and the Alaskan coast. Ships' wind reports are plotted in standard fashion, except that two digits are shown next to the wind barb. The first digit resolves the tens' place of the wind direction reported while the second digit resolves the units' place of the wind reported in knots (e.g. 

is a wind report of 300° at 14 kn). Isotachs are drawn at 5-kn intervals. Coastal and island reports, where plotted, are shown as open boxes; while ship and buoy reports are shown as open circles.

The analysis for 0000 GMT October 29, 1974, (Fig. 4a) shows the decaying wind pattern about the filling storm in the GOA and the increasing winds about the intensifying cyclone. At this time maximum winds of 40-45 kn occurred in a north-south band located about 300 mi east and south of the intensifying storm center with light winds to the north and northwest. Light winds (< 20 kn) were affecting the GOA nearshore area from Kodiak to Yakutat. By 1200 GMT October 29, 1974, winds were increasing rapidly offshore Kodiak and, soon thereafter, at the other locations (as shown in Fig. 3). The isotach maximum rotated to the northeast of the low center and, for the first time in the history of the wind field for this storm, strong winds developed in the northwestern quadrant. The winds there developed much closer to the center than in the northeastern quadrant.

By 0000 GMT October 30, 1974, the low center reached maximum intensity (central pressure near 950 mb) and winds in excess of 50 kn covered the eastern, northern and western quadrants with speeds between 55 and 60 kn northeast of the center as far as the GOA coast between Yakutat and Middleton Island. By 1200 GMT, winds began to decrease, but a ring of wind speeds in excess of 40 kn surrounded the center (Fig. 4d) with smaller areas of winds between 45 and 50 kn just northeast and southwest of the low center.

The most striking aspect of the time histories interpolated from the wind fields at the four coastal locations (Fig. 3) is the rapid increase in wind speed from less than 15 kn to greater than 50 kn in about 12 hr. All locations experience maximum winds at about the same time, with wind directions consistent with cyclonically curved flow about the approaching center. Only near Kodiak do the wind directions have an offshore component.

3. STORM 2: DECEMBER 29, 1974 TO JANUARY 1, 1975

This storm was not quite as intense as storm 1 but was unusual in that the strong winds were associated with wind directions between south and west between the Kenai Peninsula and Yakutat. Near Kodiak, winds of only moderate strength occurred and these were associated with offshore directions.

The time histories (Fig. 5) begin at 0000 GMT December 29, when a 979-mb low with a broad center containing relatively light winds was located in the GOA. The storm of interest here developed apparently in the broad westerly polar air stream. Figure 5a shows the trough near 50°N, 170°E in which the new low developed. This system moved eastward to near 50°N 165°W at 0000 GMT and began to acquire frontal wave characteristics. The detailed track (Fig. 1) shows the system turning east-northeastward and intensifying rapidly, passing near Middleton Island on October 31 with a central pressure of about 954 mb.

As seen most readily in Figure 5e, the storm had a fairly complicated isobaric pattern, with a deep trough extending southeastward from the center of lowest pressure. The strongest south and southeast winds, therefore, occurred well east of the center. Also, because of the nearshore track of the broad center, strong easterly winds did not occur along the GOA coastline. Rather, the strongest winds occurred after the center had crossed the GOA and moved into extreme southern Alaska. The indicated behavior is shown in the 12-hourly streamline/isotach analyses, Figures 7a-7d, covering the period 1200 GMT December 30, 1974, to 0000 GMT January 1, 1975.

The time histories of surface wind, Figure 6, indicate that 45- to 50-kn winds occurred offshore Prince William Sound-Yakutat. Those winds had an onshore component through much of the event, while weaker offshore winds affected the shelf near Kodiak.

The time scale of this storm was significantly longer, as winds increased over a 36-hr period, than that of storm 1.

4. STORM 3: DECEMBER 16-21, 1975

This event was selected to show the rapid succession of storms possible in the GOA. The period December 16, 1975, to December 21, 1975, included, at some sites, five separate events in which wind speeds exceeded 30 kn along at least some portion of the coast. East of Kodiak, the strong winds were mainly onshore.

The sequence of 12-hourly surface maps for the period is given in Figures 8a-8i. The broad scale sea-level pressure pattern shifted during this period. In the beginning of the period, a large extratropical cyclone centered in the Bering Sea dominated the north central North Pacific. During the period, a series of disturbances moved northeastward from the southern periphery of that low into the GOA, so that by the end of the period, the center of cyclonic action had shifted from the Bering Sea to the GOA.

Fig. 8a shows the first such disturbance just entering the GOA at 1200 GMT December 16, 1975. This system caused 40- to 45-kn onshore winds along the entire region between Kodiak and Yakutat. The second disturbance in the series reached the Alaskan coast shortly after 1200 GMT December 17 (Fig. 8c) but caused only a minor increase in wind speeds between Kenai Peninsula and Yakutat.

The strongest storm of the sequence apparently originated as an open wave on the polar front in the western Pacific. The wave (996 mb) is seen in Figure 8a near 38°N, 171°E. The wave moved eastward without intensification for about another 24 hr, then turned northeastward and began to intensify sharply. By 1800 GMT December 18, 1980, the first position shown in Figure 1, central pressure had fallen below 960 mb. The system continued to curve northward, decelerate and deepen over the next 24 hr. The center passed just east of Kodiak around 1800 GMT December 19, with a central pressure near 950 mb, before drifting over the Kenai Peninsula and filling rapidly on the 20th.

Figures 10a through 10f show the wind field about the intense storm at several times. As the storm entered the GOA (Fig. 10a), the wind field was not unlike that depicted for storm 1, with strong winds mainly east and south of the center. Also, a band of strong surface winds developed well northeast of the center ahead of the occlusion (Figs. 10b, 10c), with lighter winds separating that area from the isotach maxima south of the center.

As observed in storm 1, the northwest quadrant of the circulation was the weakest, as stronger winds developed there only late in the history and covered a small area close to the center of circulation.

As the low center moved from east of Kodiak into Kenai (Figs. 10d and 10e), the isotach maximum located initially south of the center appears to have rotated to the southeast quadrant, producing the sharp east-west gradient in wind speed across the GOA evident on the 0000 GMT December 20 wind field.

The time histories shown in Figure 9 for this event are quite similar to those of storm 1, with a rapid increase in wind speed over a 12-hr period between 1800 GMT December 18 and 0600 GMT December 19. The secondary maximum in wind speed at the eastern locations 12- to 18-hr later is a response to the movement onshore of the strong southeastern quadrant of the circulation noted above in Figure 10e.

Southwesterly winds in the wake of the intense storm backed to easterly late on December 20 in advance of yet another strong impulse. This fourth impulse also formed as an open wave on the polar front around 0000 GMT December 19. At that time (Fig. 8f) a vigorous low, which had formed in the polar air stream, was located near 45°N 180°W. Over the following 24-36 hr, the frontal wave moved northward and deepened, ultimately merging with and absorbing the circulation of the low in the polar air stream. By 1200 GMT 21 December, the combined system had deepened to 956 mb and was located about 200 miles northwest of weather ship "P". This low, however, did not move further northward into the GOA, but began to fill and drift eastward. Figure 10f shows

the wind field over the GOA at 0600 GMT December 21, when this storm was most intense. Easterly winds covered the entire GOA, with the strongest winds offshore Kodiak. Maximum winds probably did not exceed 50 kn throughout this storm.

The most striking feature of time histories for this last event of the sequence is the uniformity of wind direction across the shelf between Kodiak and Yakutat. This type of storm provides strong winds with an onshore component at Kodiak.

5. STORM 4: JANUARY 27-31, 1976

A long period of moderate (20-30 kn) onshore flow along the entire upper GOA coast preceded this storm. The wind field history began at 0000 GMT January 27, 1976, as a relatively weak system moved northward through the GOA. The passage of the broad center of this low caused the shifting wind pattern evident in the time histories at all four offshore locations between 0000 GMT January 27 and 0000 GMT January 28 (see Figs. 11a-11i).

Between 0000 GMT January 28 and 0000 GMT January 30, the GOA was under the influence of a broad southerly flow. As an extratropical cyclone moved into the Bering Sea early on January 29, a minor increase in the flow is evident in the time histories at all sites between 0000 and 0600 GMT January 29.

The important storm in this sequence for the GOA is traceable to a flat wave on the polar front which had moved due eastward across the North Pacific along 35°N on January 28. By 0000 GMT January 29, this wave had begun to turn northeastward and deepen. The 6-hourly positions thereafter are indicated in Figure 1. This storm moved northeastward more rapidly than any of the other storms studied and decelerated only slightly as it approached the Alaskan coast. Indeed, the center moved quickly northward across western Alaska and reached Norton Sound by 0000 GMT January 31. The lowest central pressure attained in this storm was about 958 mb, when the center was 200 mi south of the Trinity Islands.

The streamline/isotach analyses presented in Figure 13a-13d show the wind field between 1200 GMT January 29 and 1800 GMT January 30. This storm is similar in many respects to storms 1 and 3 in that the southern and eastern quadrants of the wind field are much stronger than other quadrants as the low enters the GOA. It differs in that strong winds develop quickly in the northeast sector of the storm as the gradient is enhanced between the storm center and the Alaska coast. The enhancement apparently causes winds to increase between Kenai and Yakutat in advance of this type of low more rapidly than would be expected from simple advection of the wind field (Fig. 12).

It is interesting to note that in storm 4 the strong winds never develop to any discernible extent in the northwestern quadrant, despite the existence of strong surface pressure gradients there close to the center. This effect was also observed in storms 1 and 3, except that as those storms decelerated, stronger winds eventually developed northwest

of the center. This suggests that the acceleration of air entering the northwestern quadrant is retarded greatly by the highly cyclonic curvature which characterizes trajectories of air parcels there.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

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Overland, J. E., and T. R. Hiester (1980): Development of a synoptic climatology for the northeast Gulf of Alaska. J. Applied Met., 19, 1-14.

FIGURES

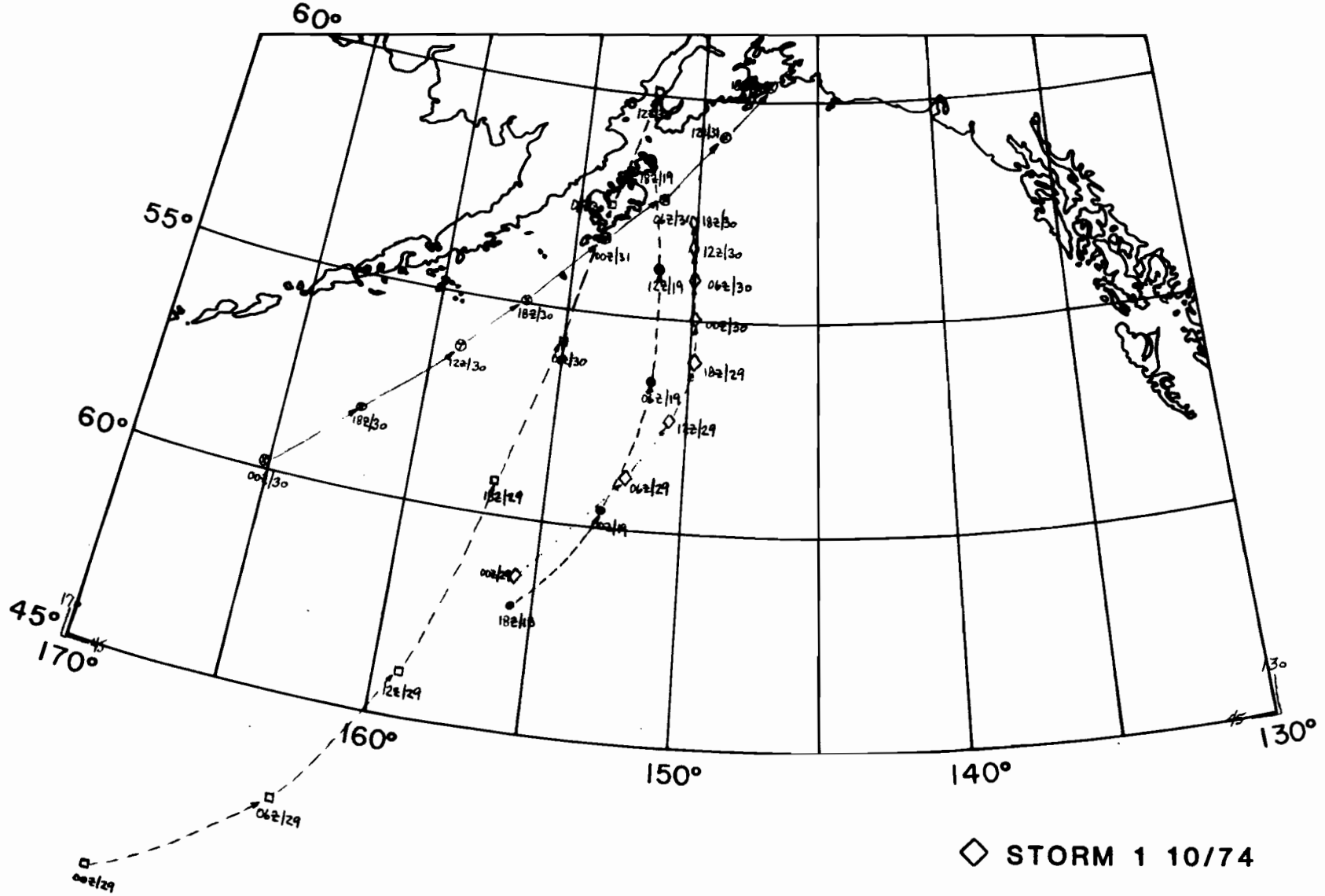
60°
55°
60°
45°
170°
160°
150°
140°
130°
◇ STORM 1 10/74
⊗ STORM 2 12/74
● STORM 3 12/75
□ STORM 4 1/76

FIGURE 1

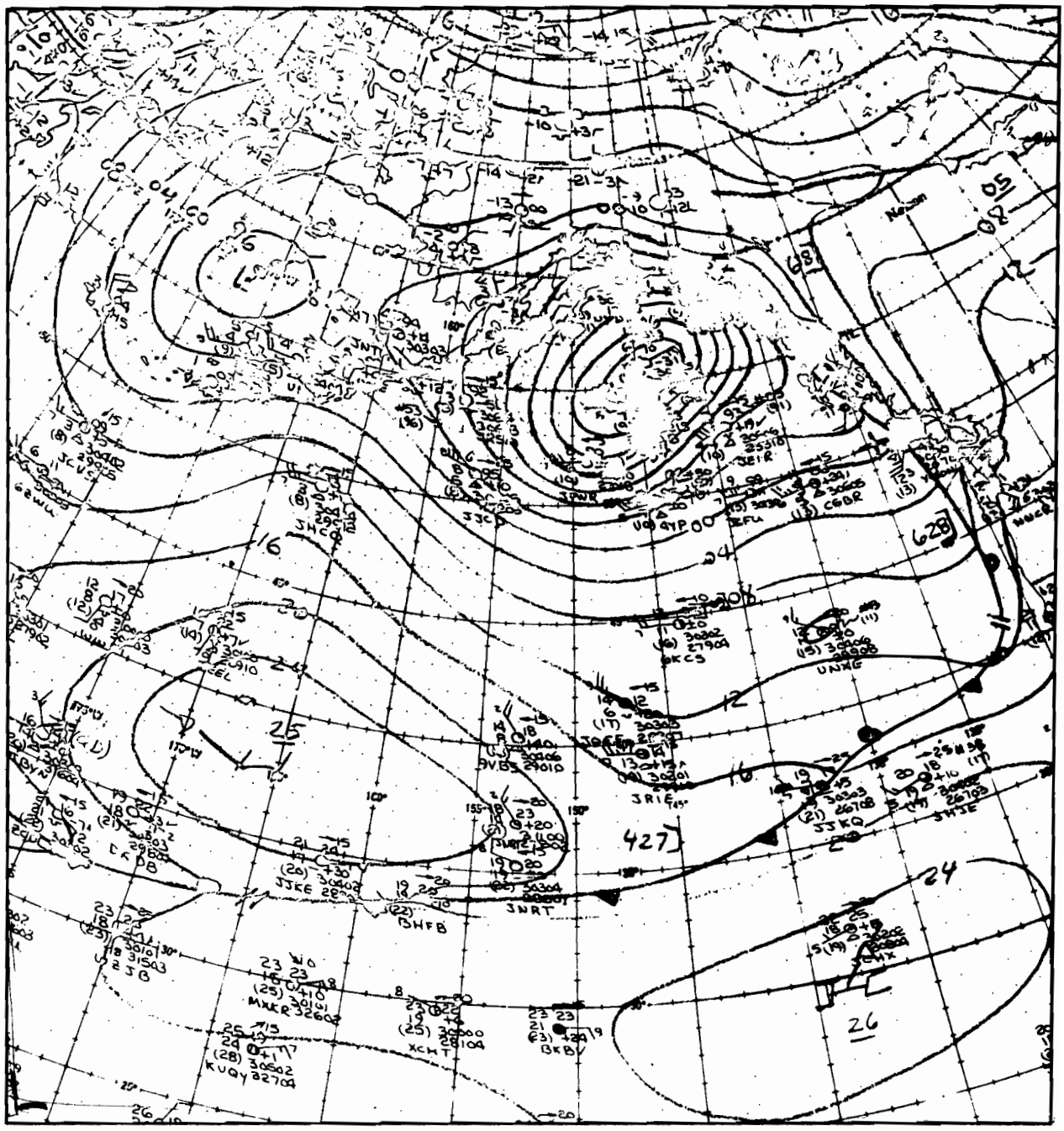

Fig.2a

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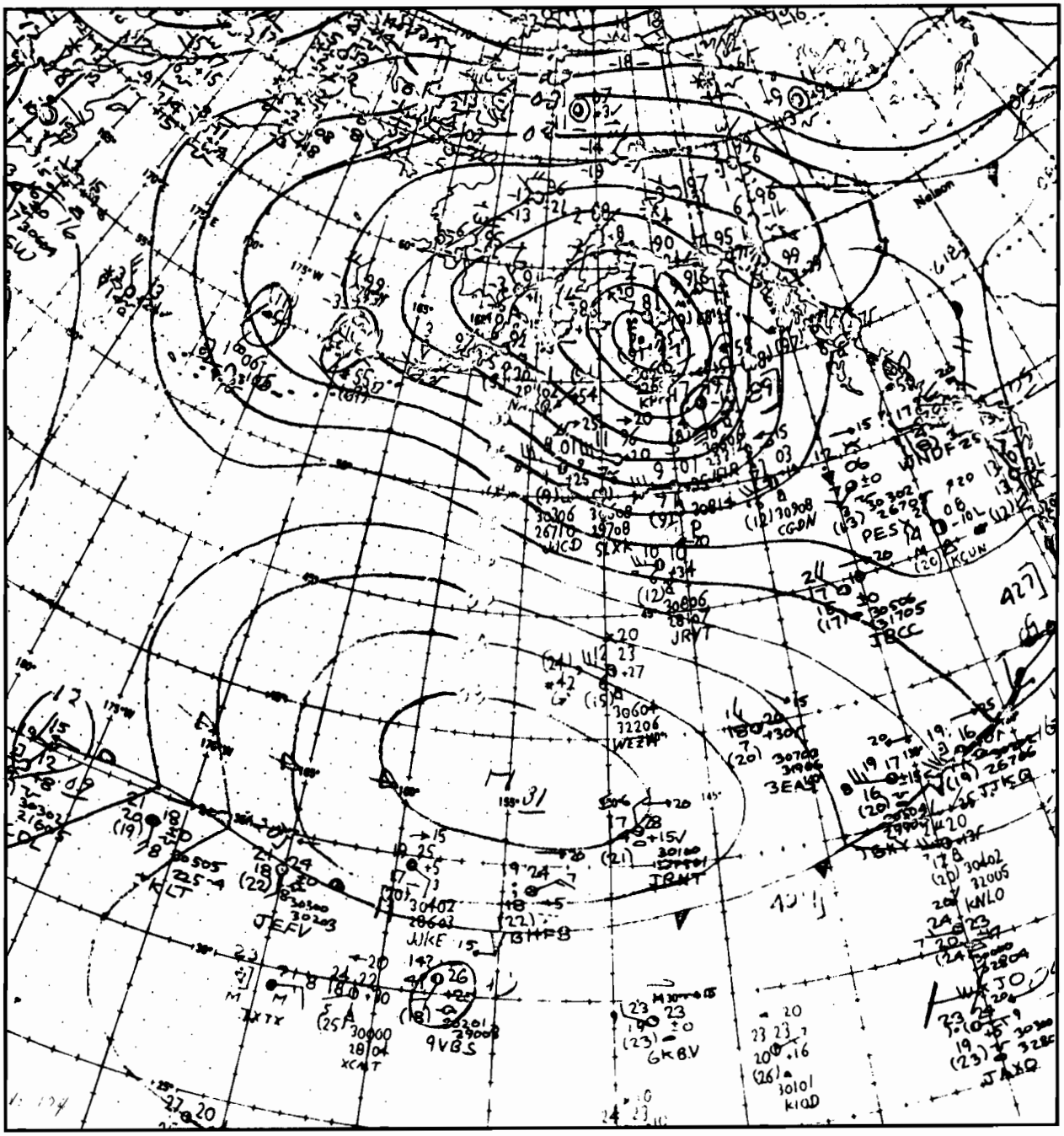

Fig.2b

18GMT 10/27/74

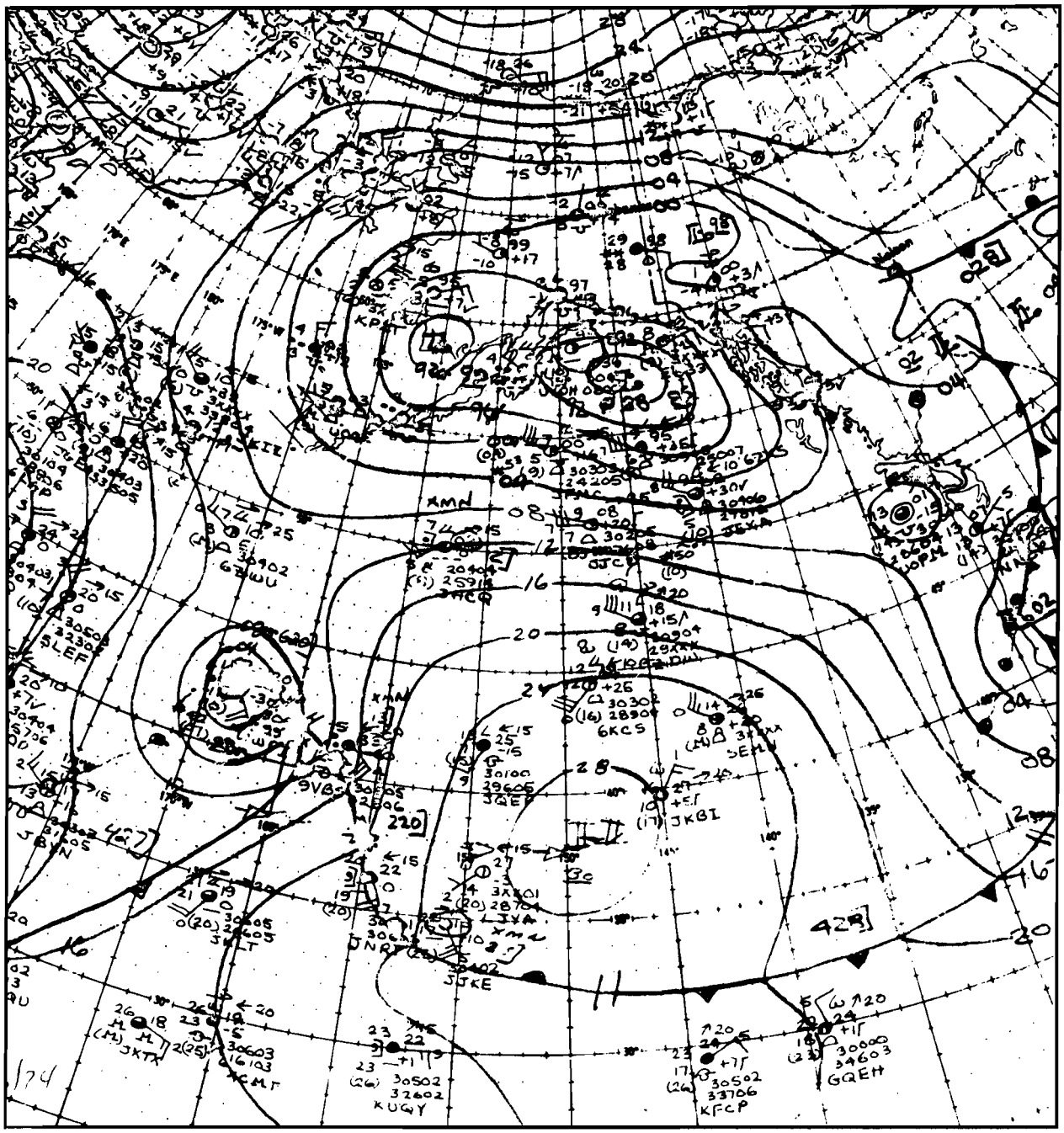

Fig.2c

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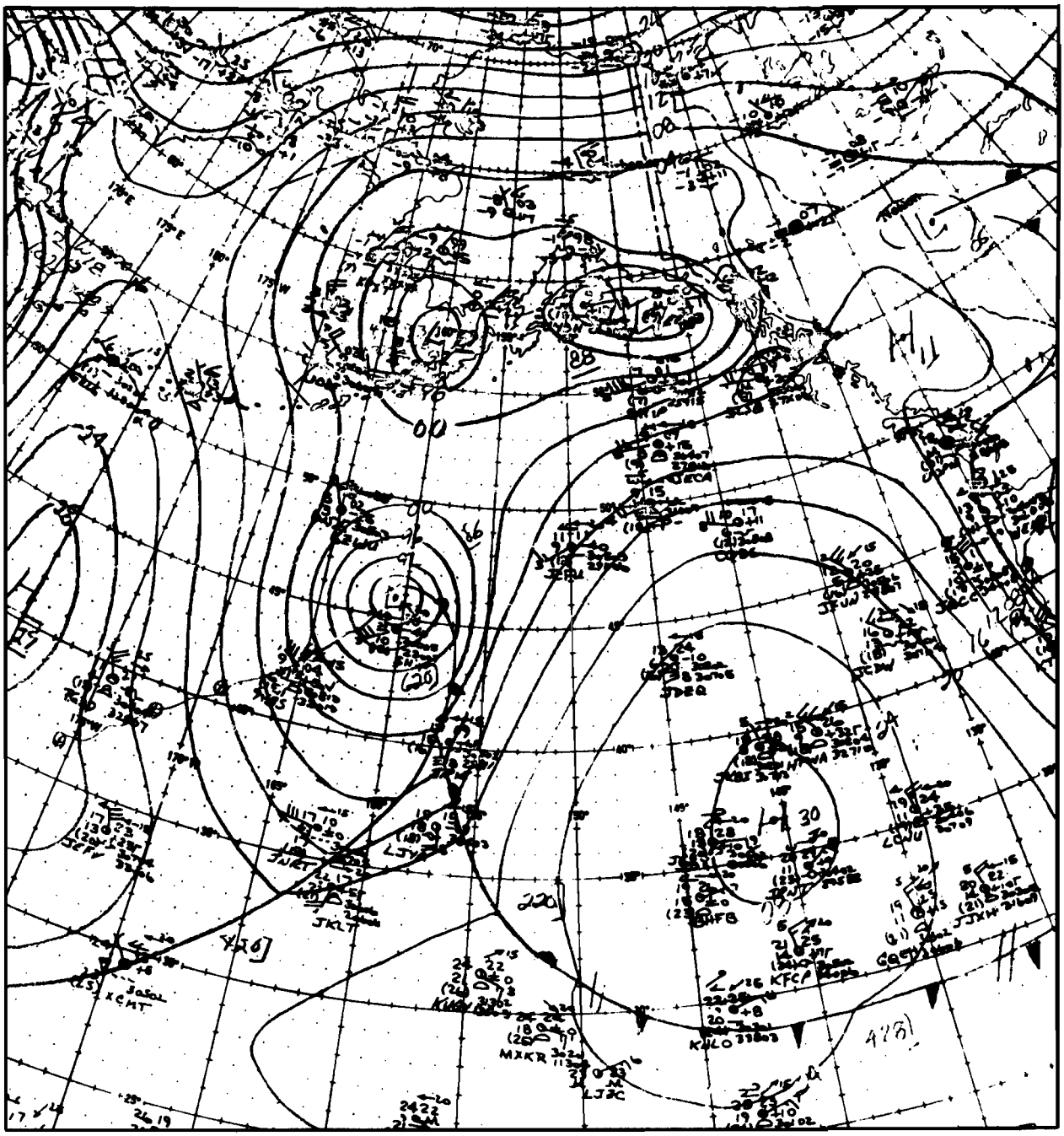

Fig.2d

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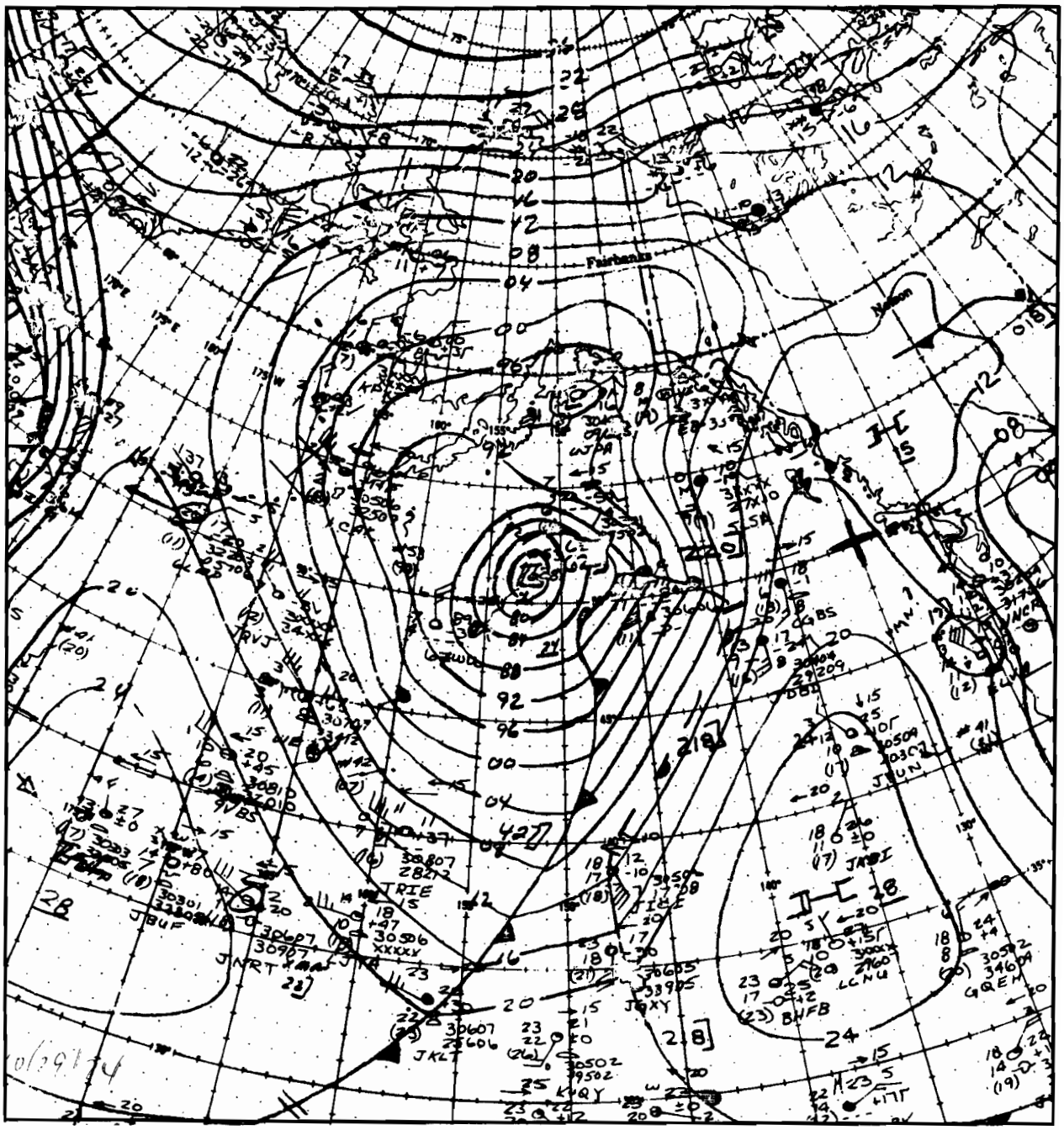

Fig.2e

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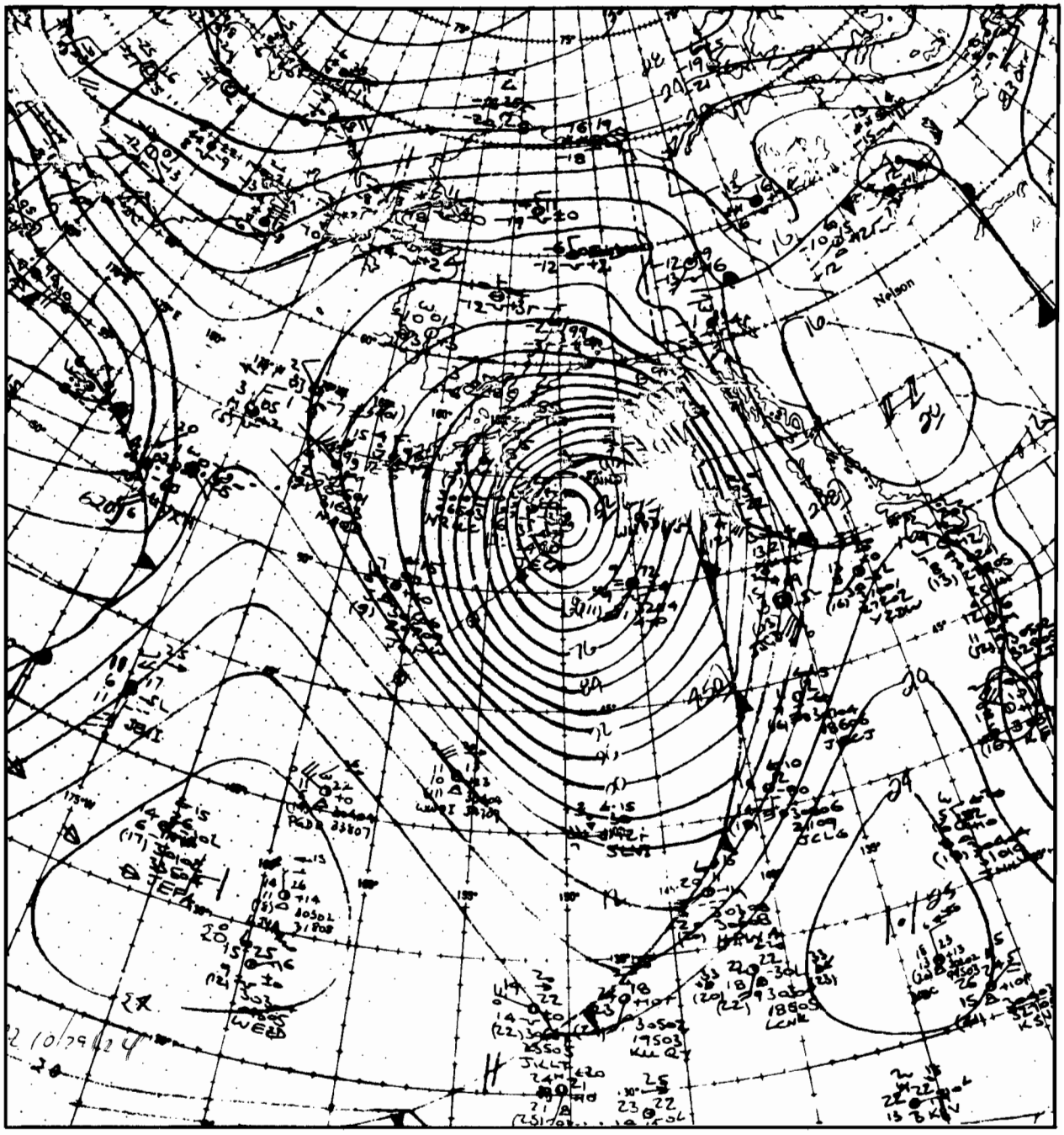

Fig.2f

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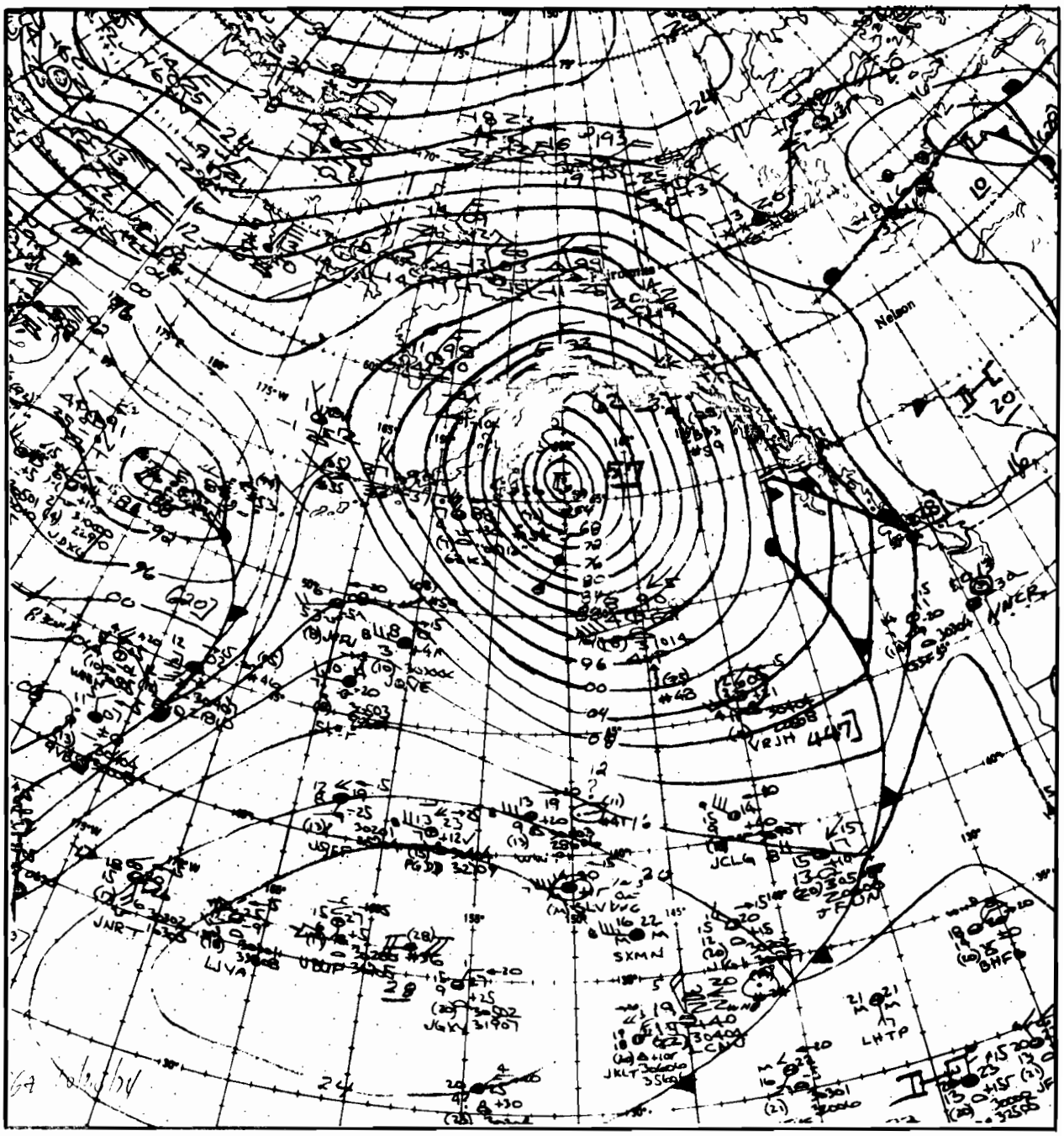

Fig.2g

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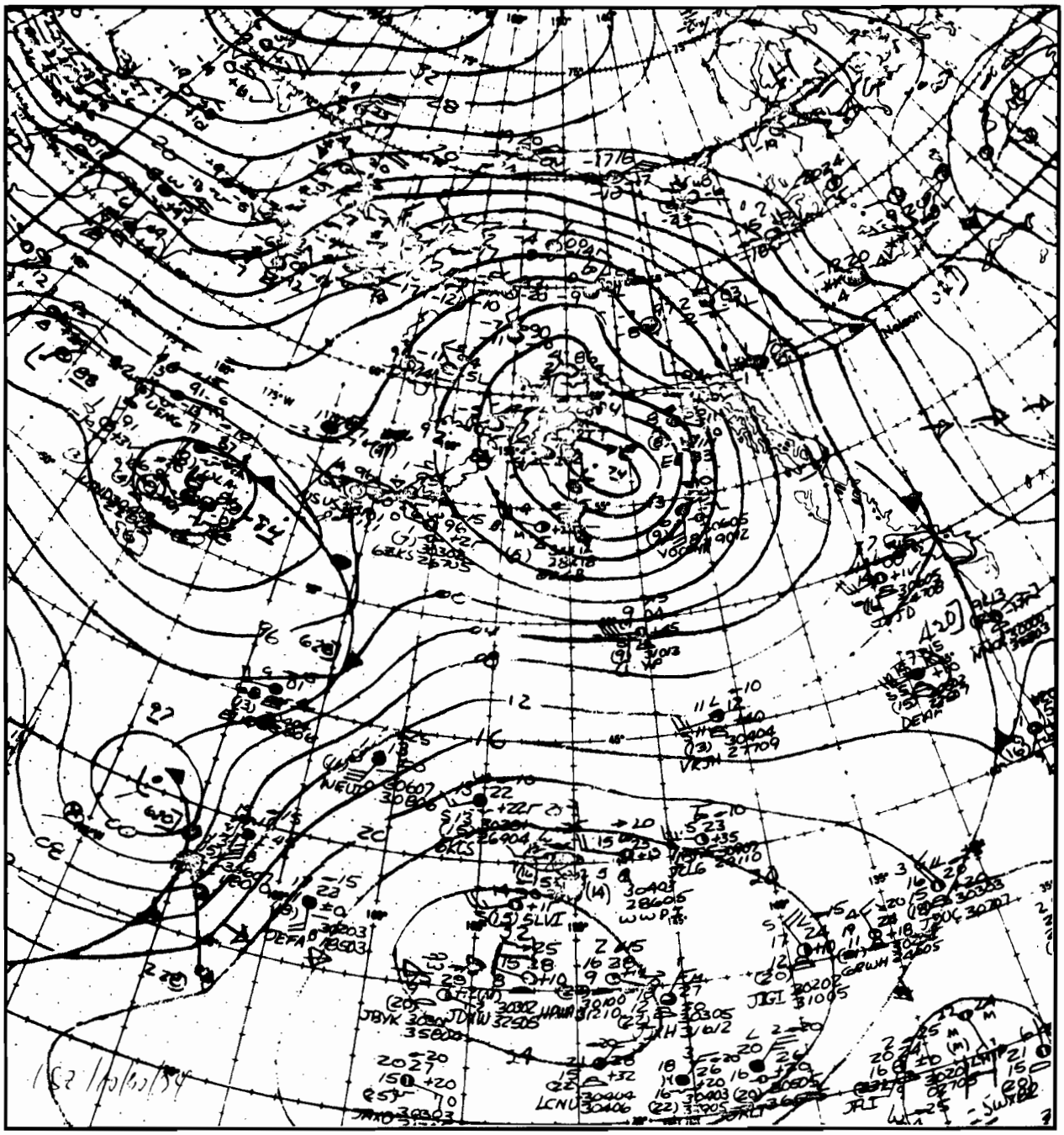

Fig.2h

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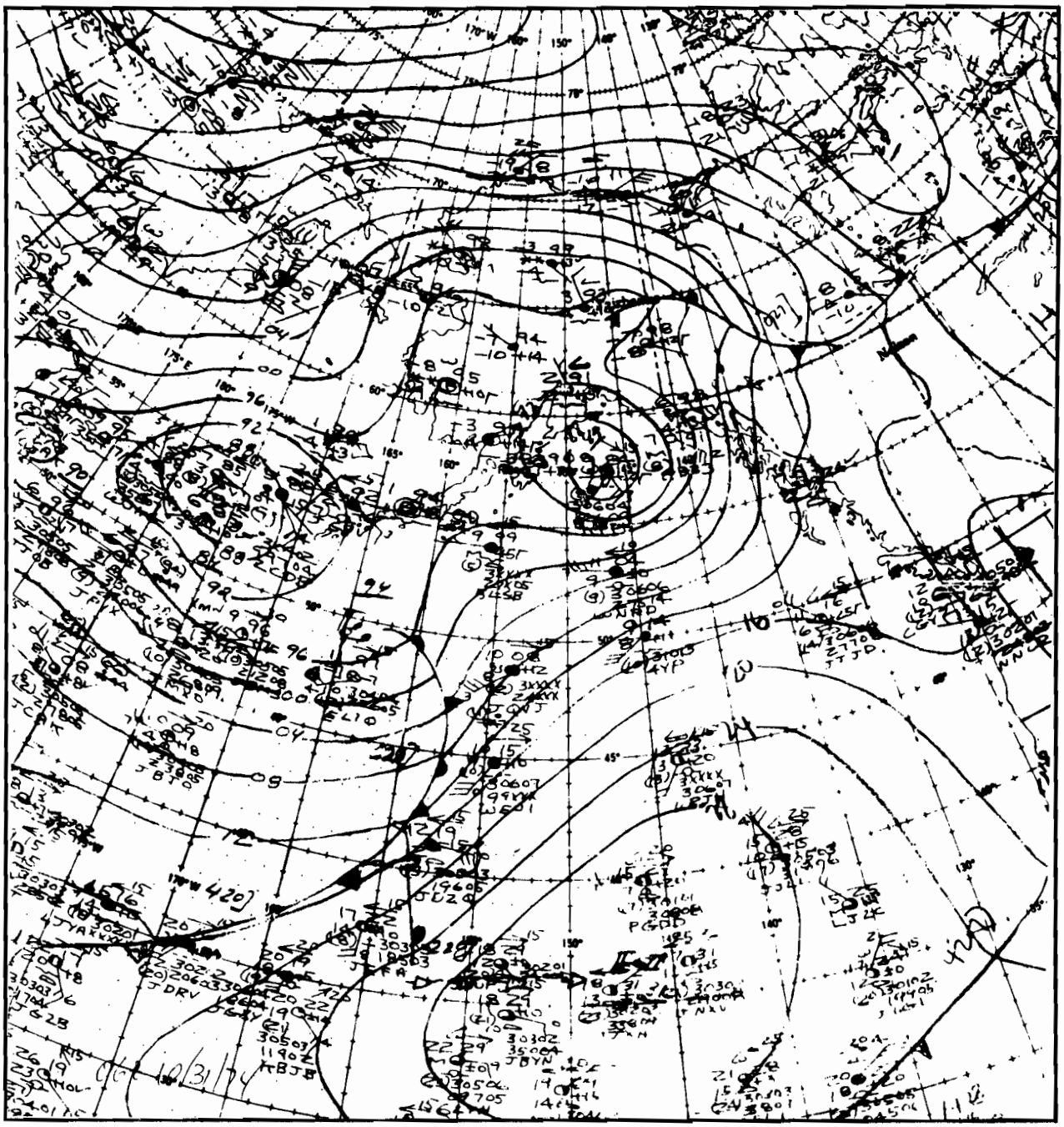

Fig.2i

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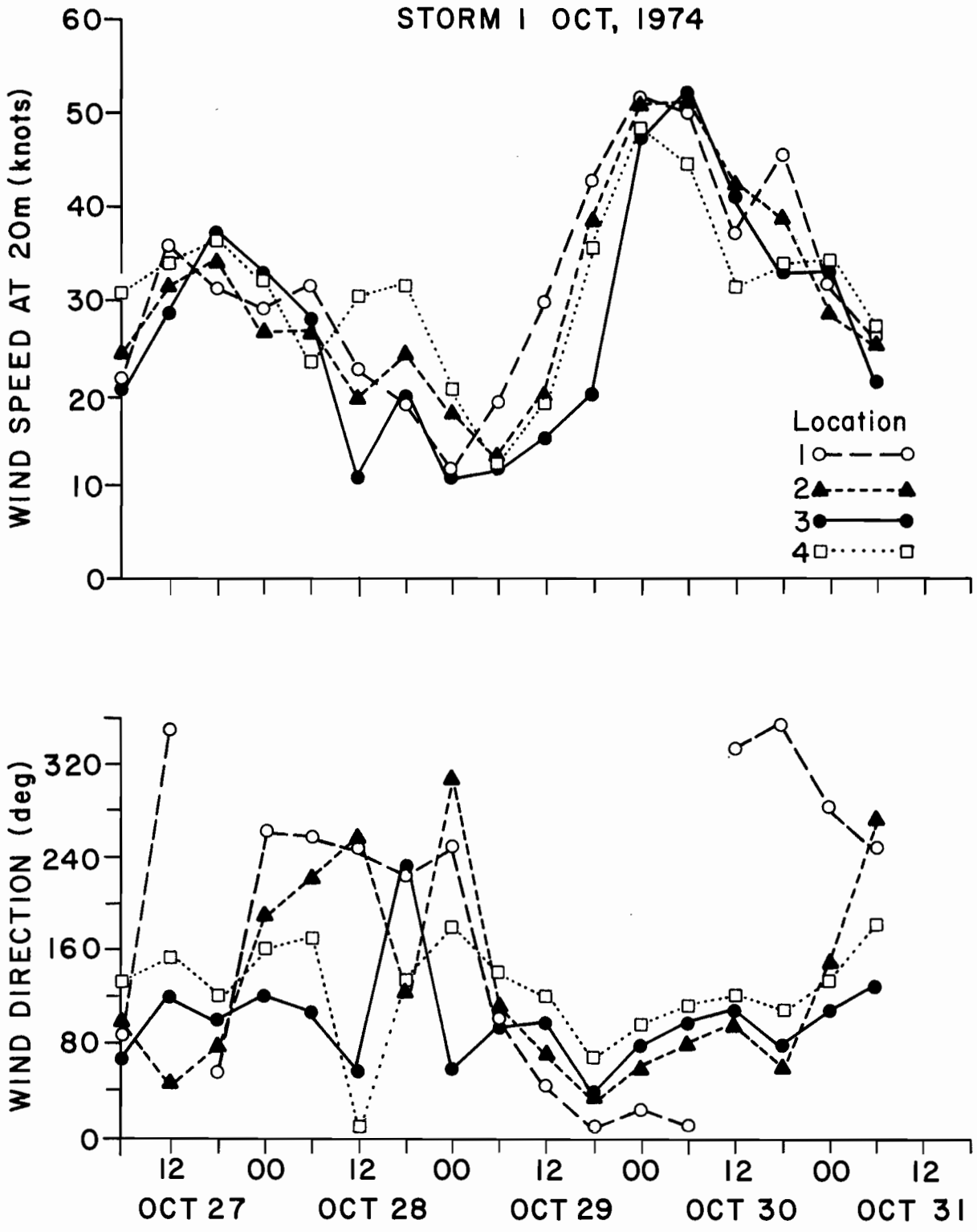
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40
30
20
10
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Location
1
2
3
4
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320
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00
12
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12
00
12
00
12
OCT 27
OCT 28
OCT 29
OCT 30
OCT 31

Figure 3

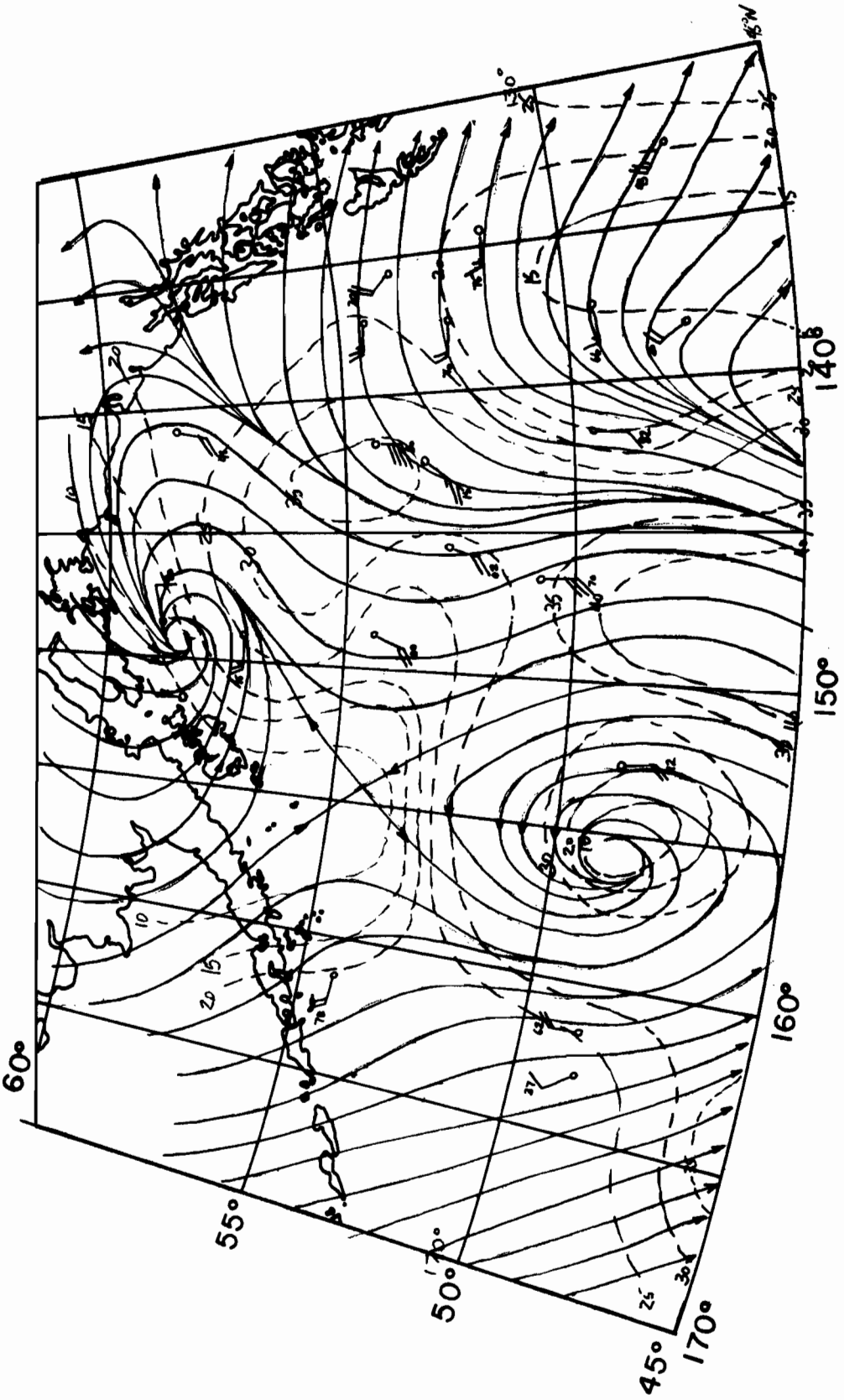

FIGURE 4a
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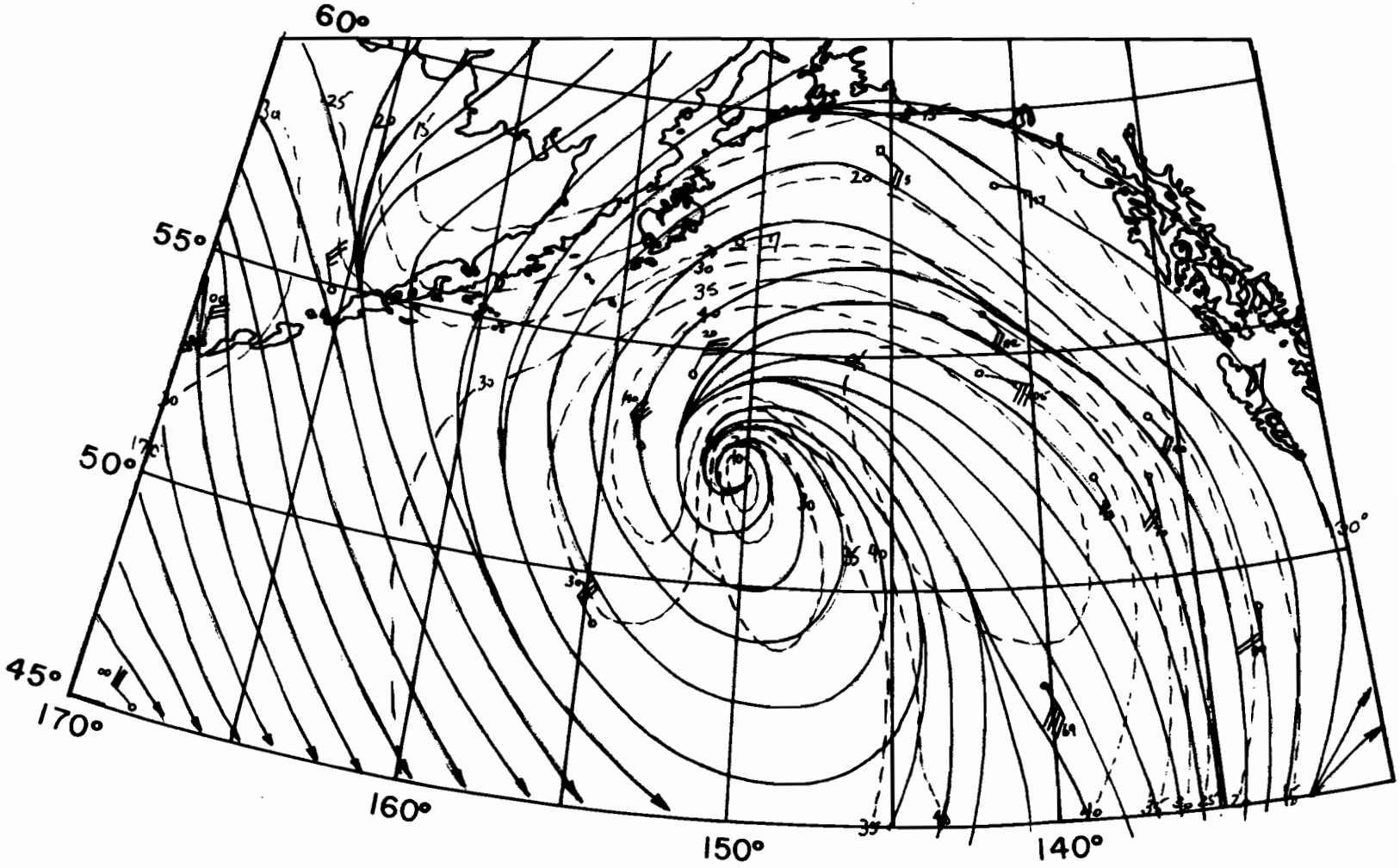

FIGURE 4b
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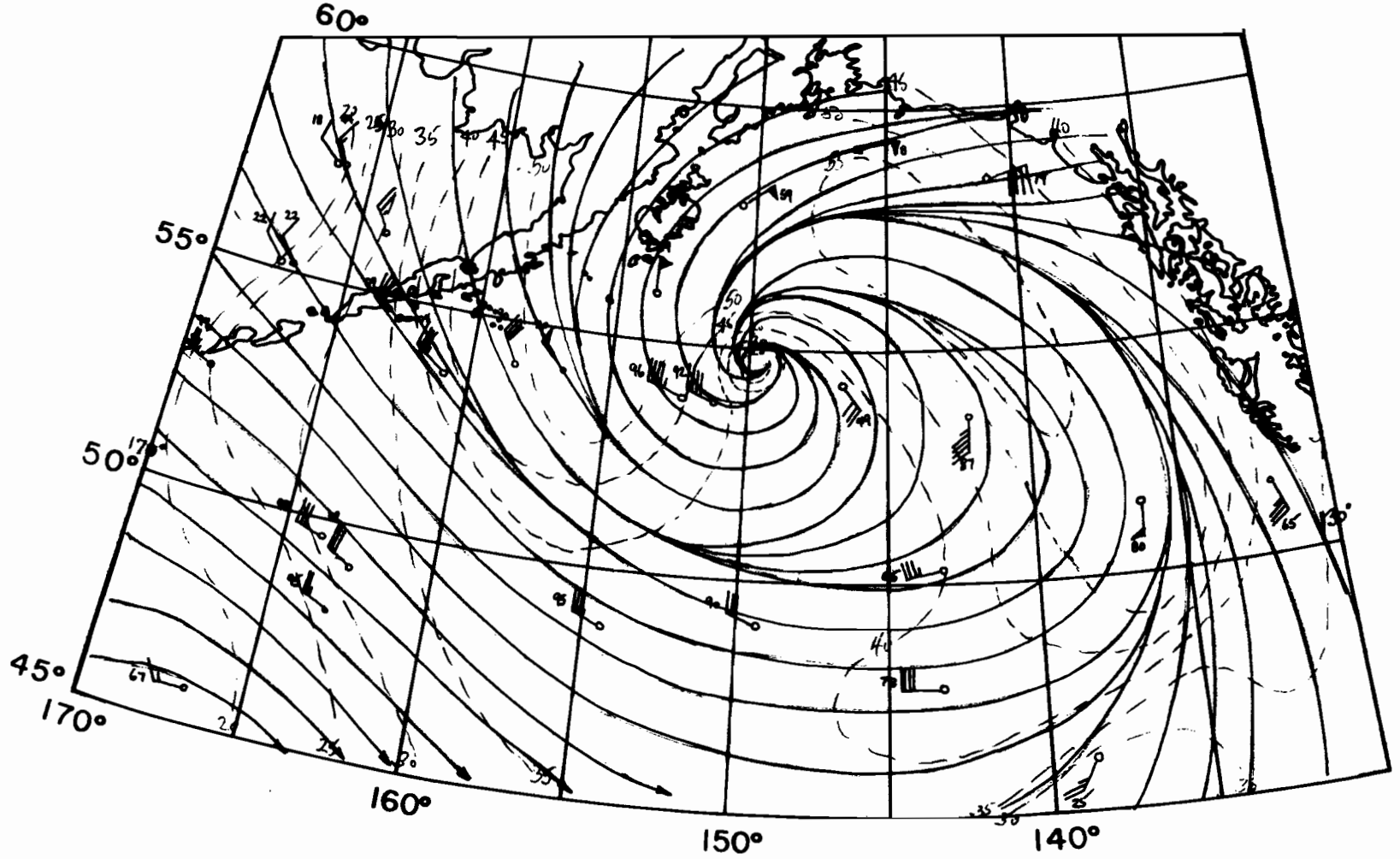

FIGURE 4c
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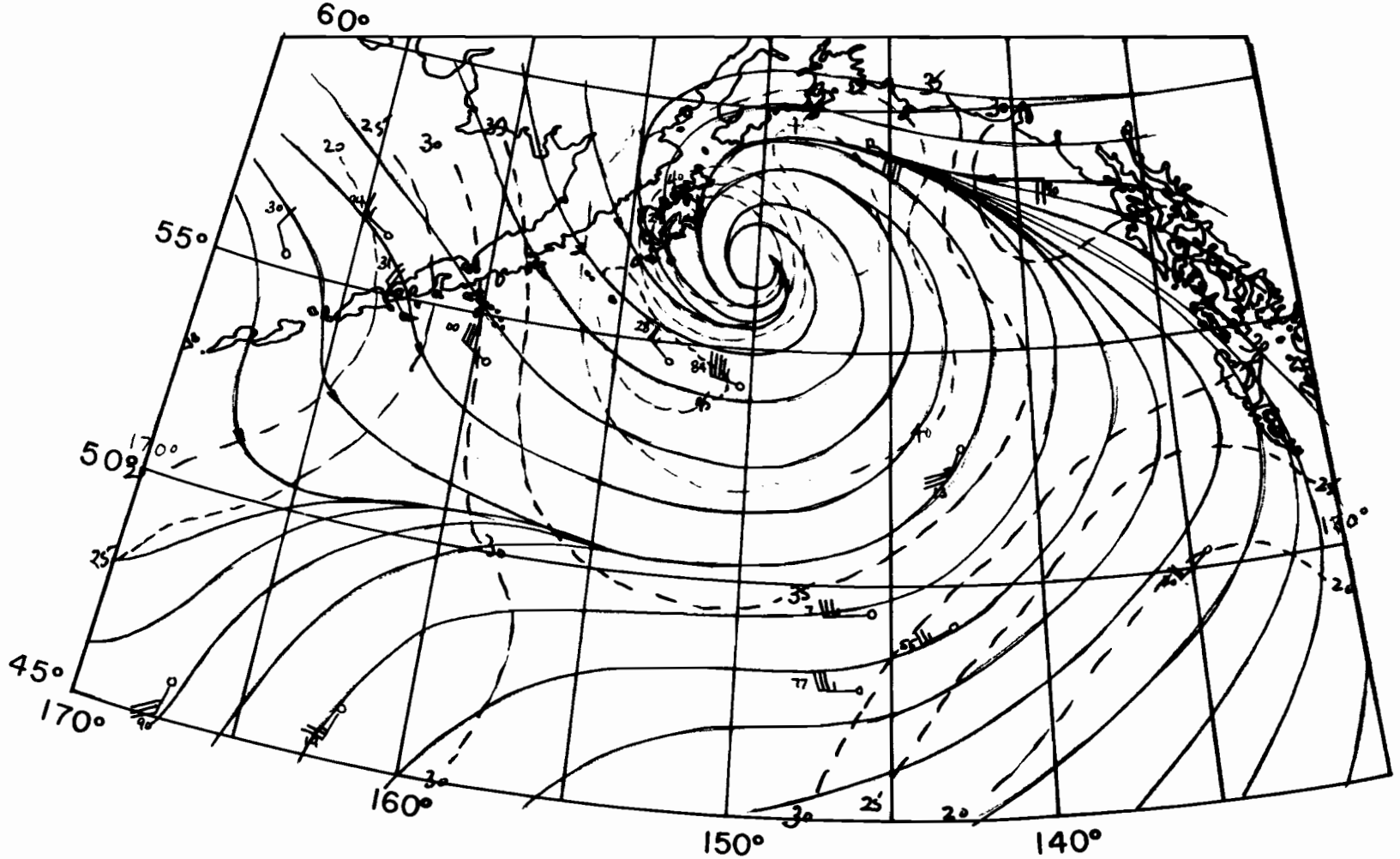

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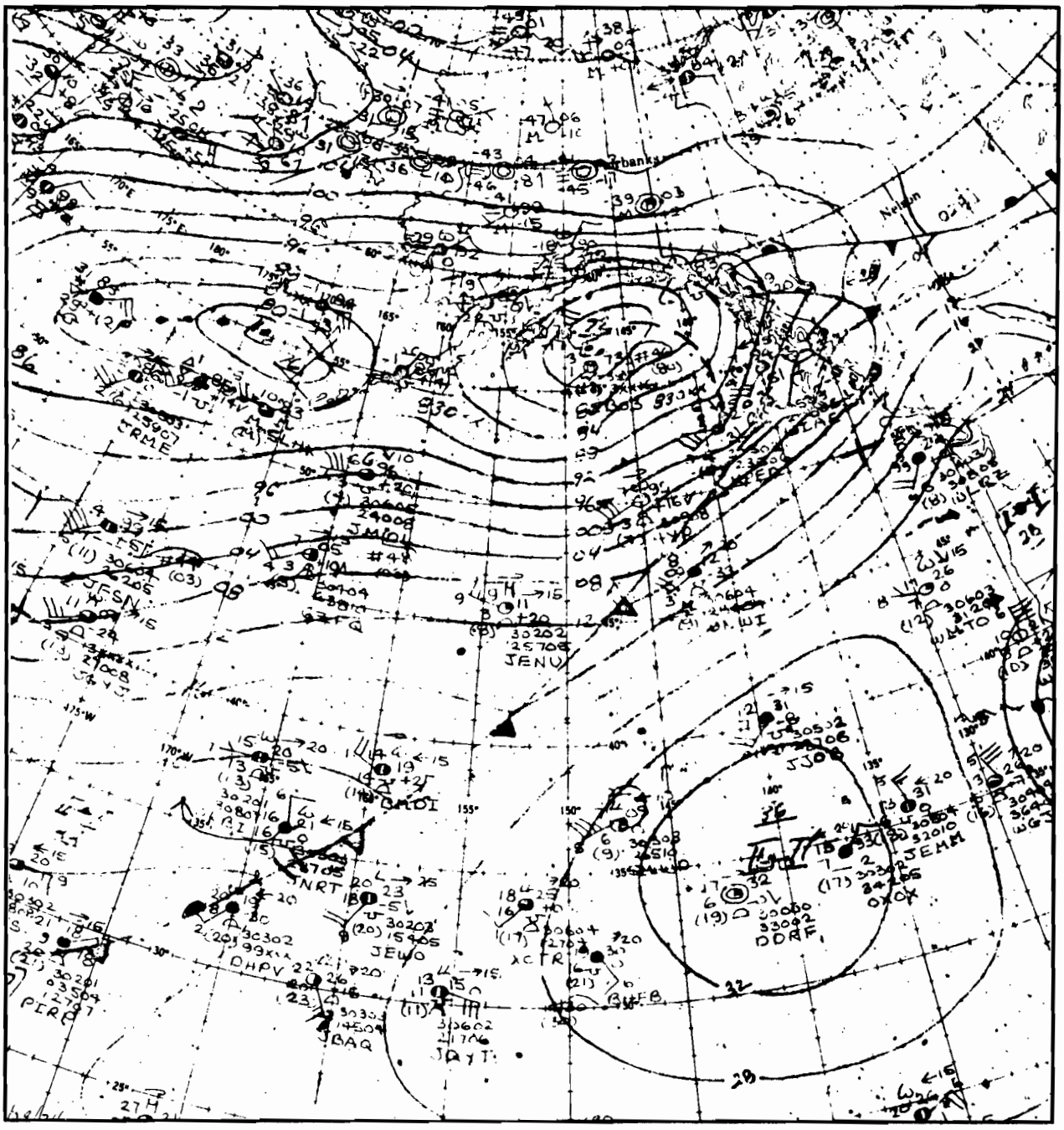

Fig.5a

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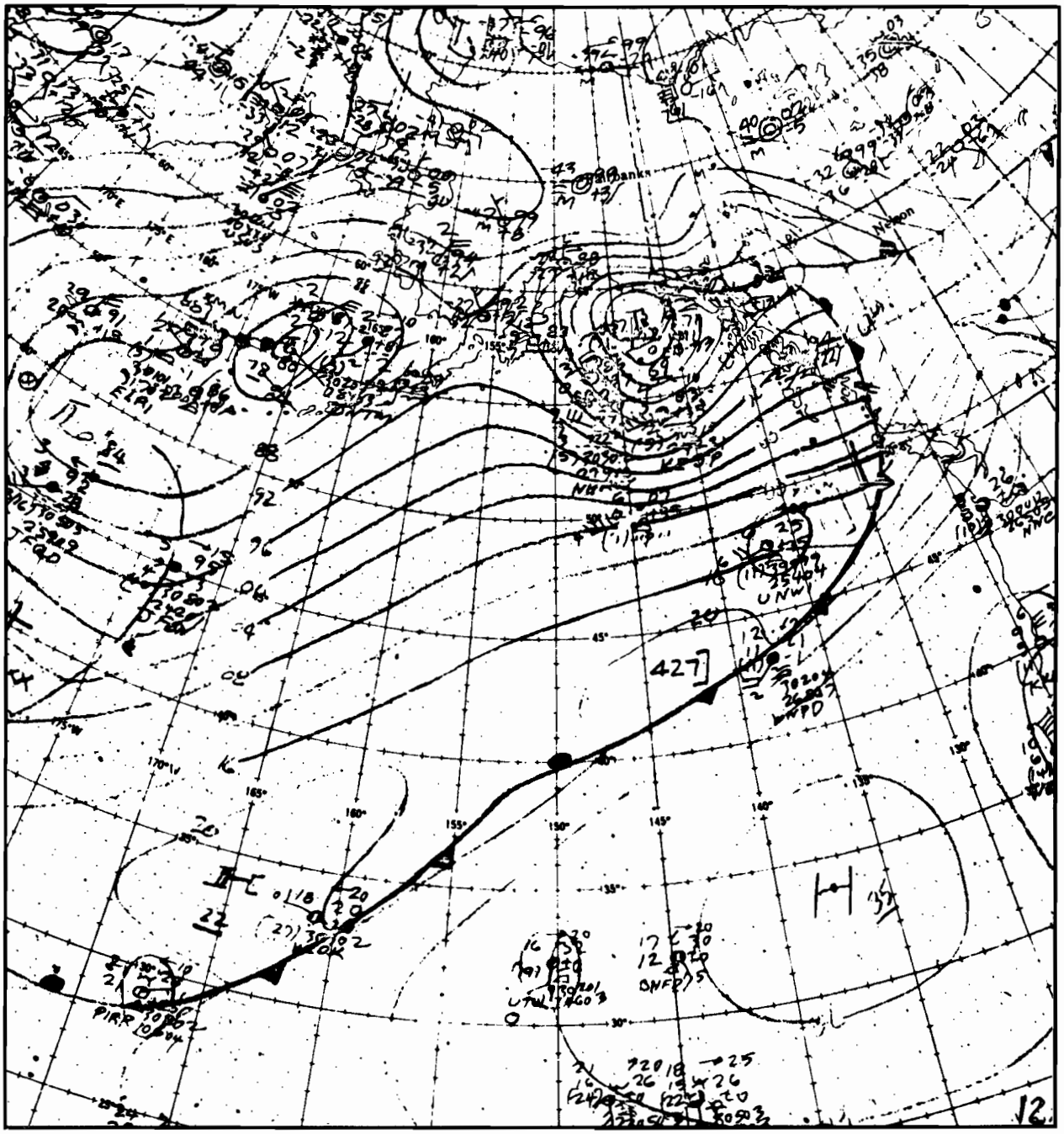

Fig.5b

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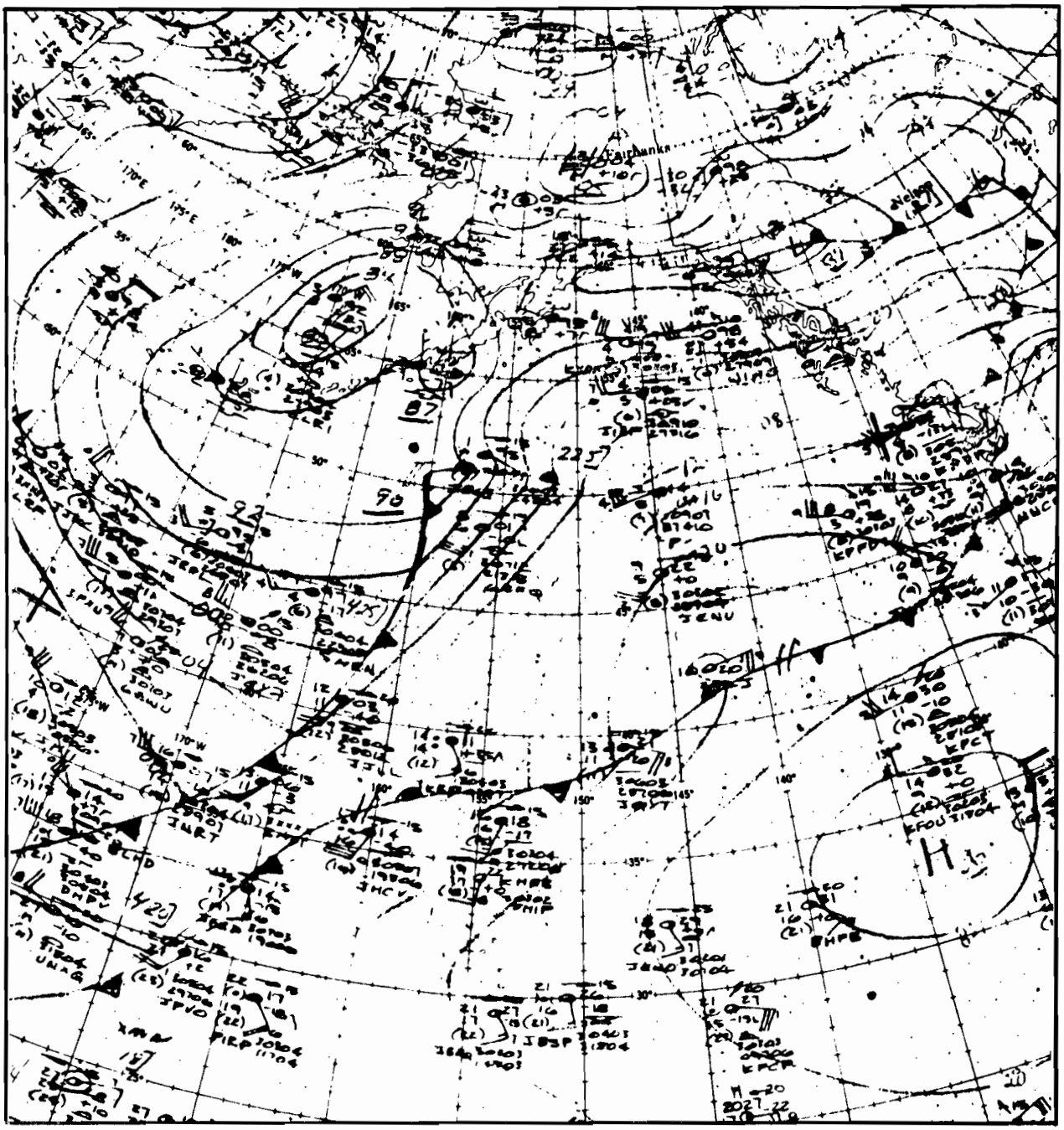

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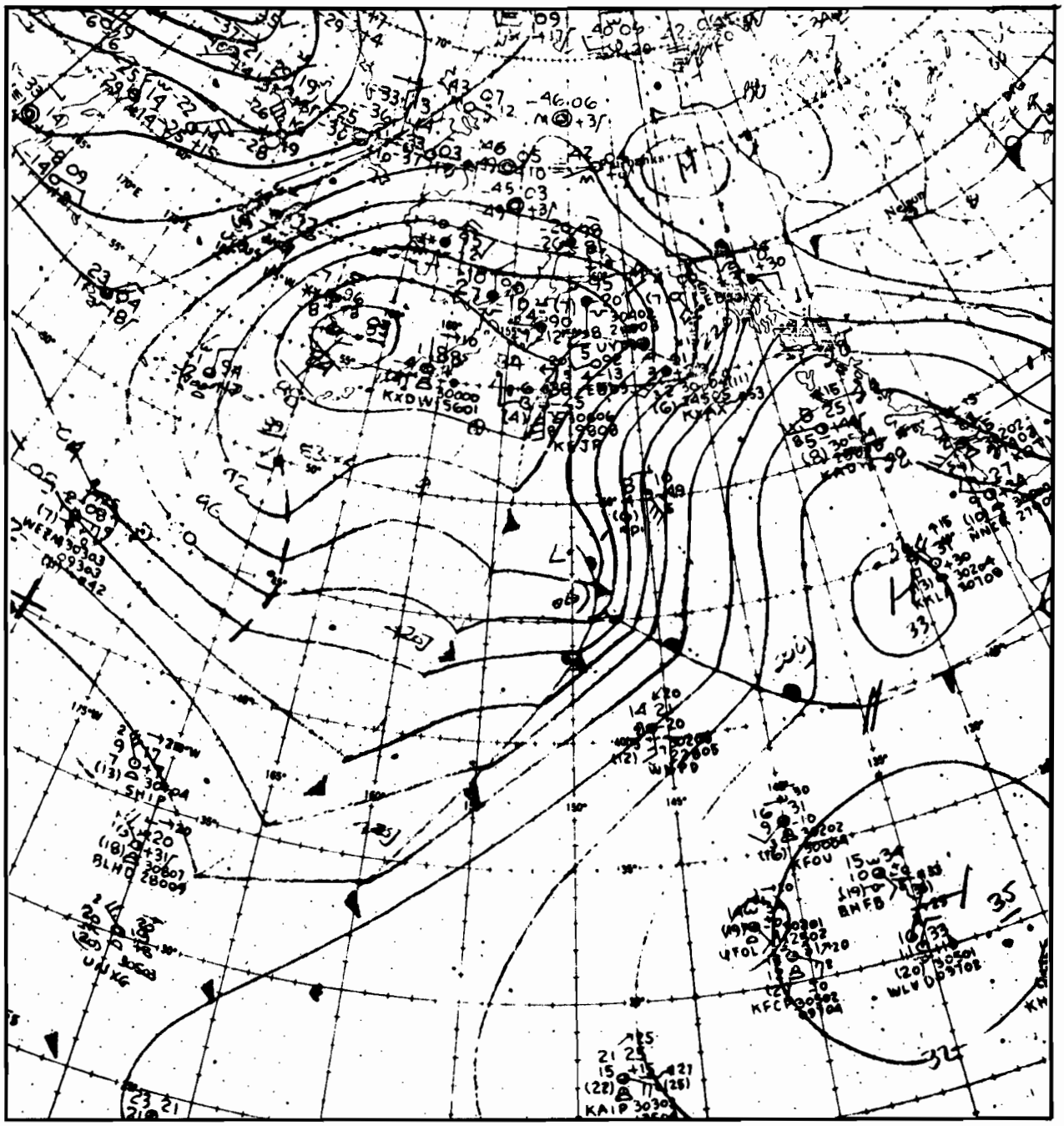

Fig.5d

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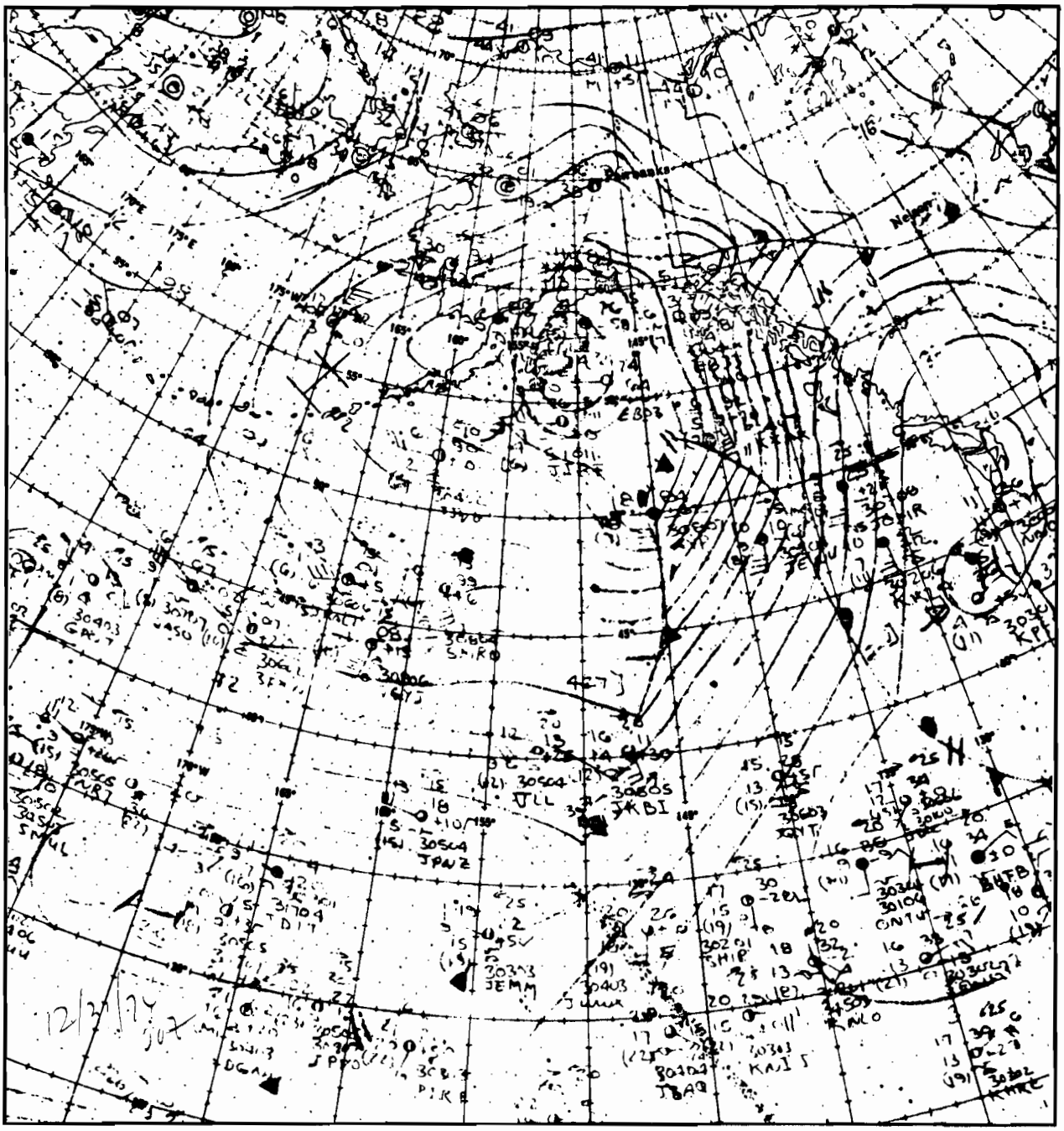

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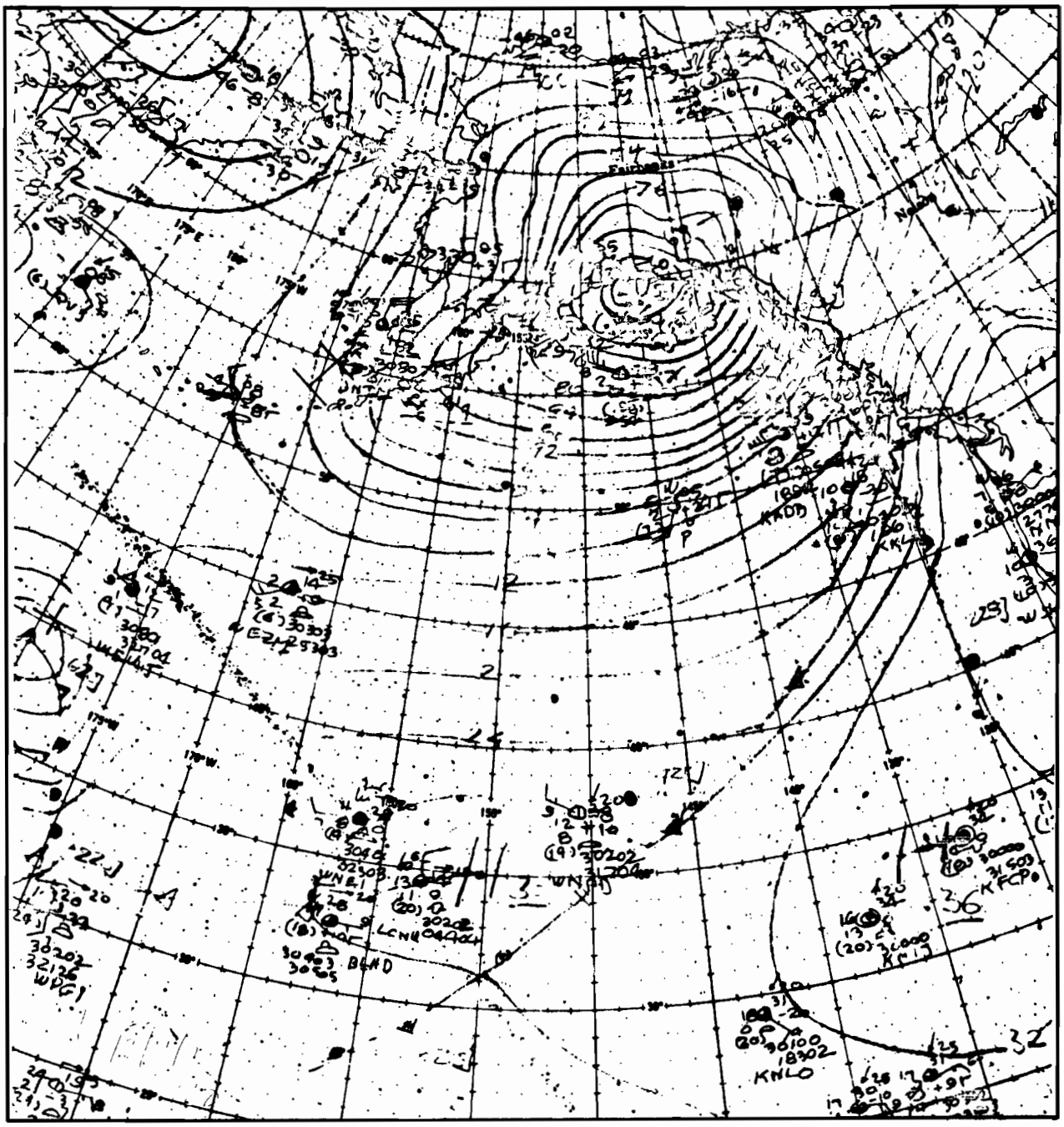

Fig.5f

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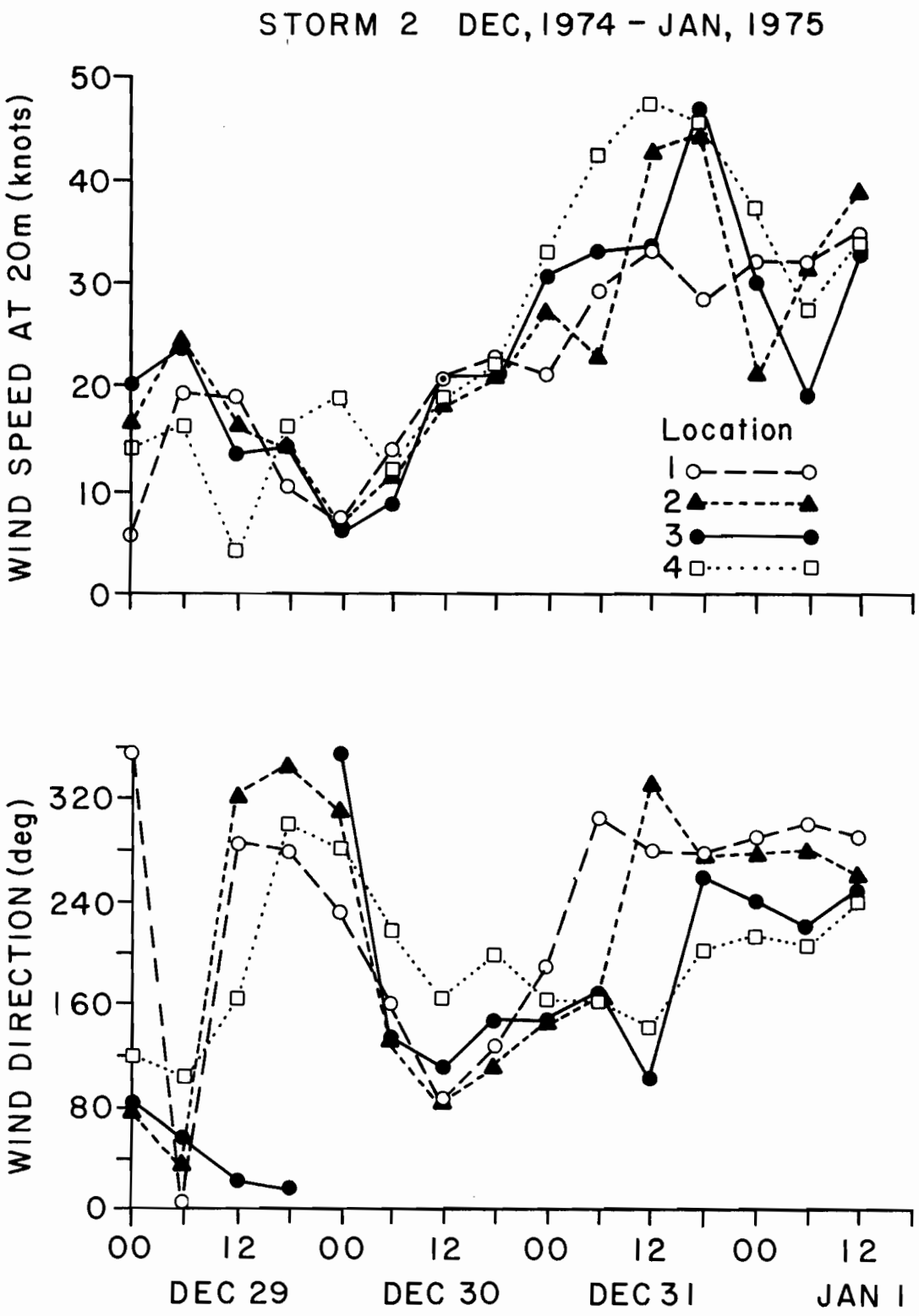
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WIND SPEED AT 20m (knots)
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Location
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3
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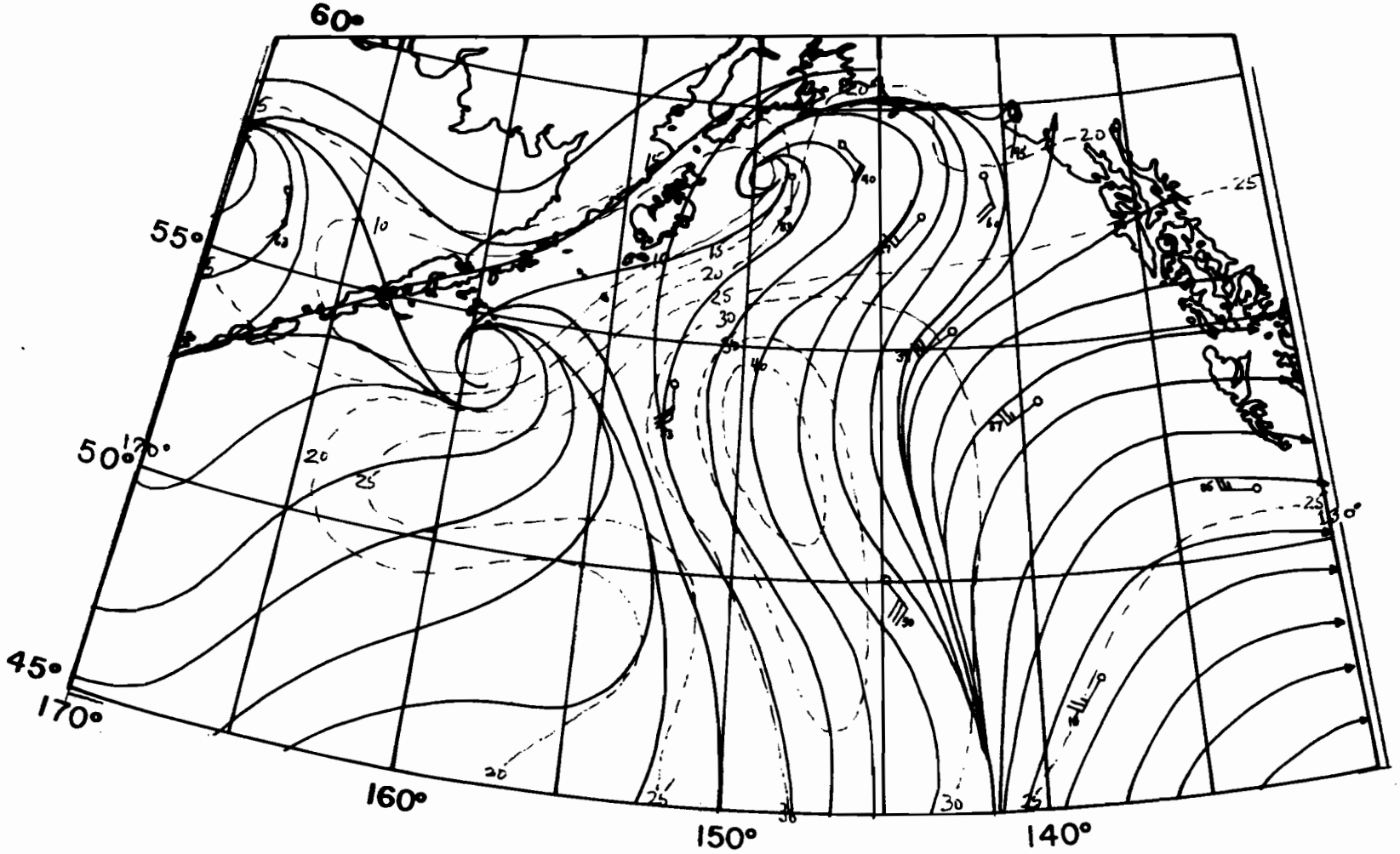
DEC 29
DEC 30
DEC 31
JAN 1

Figure 6



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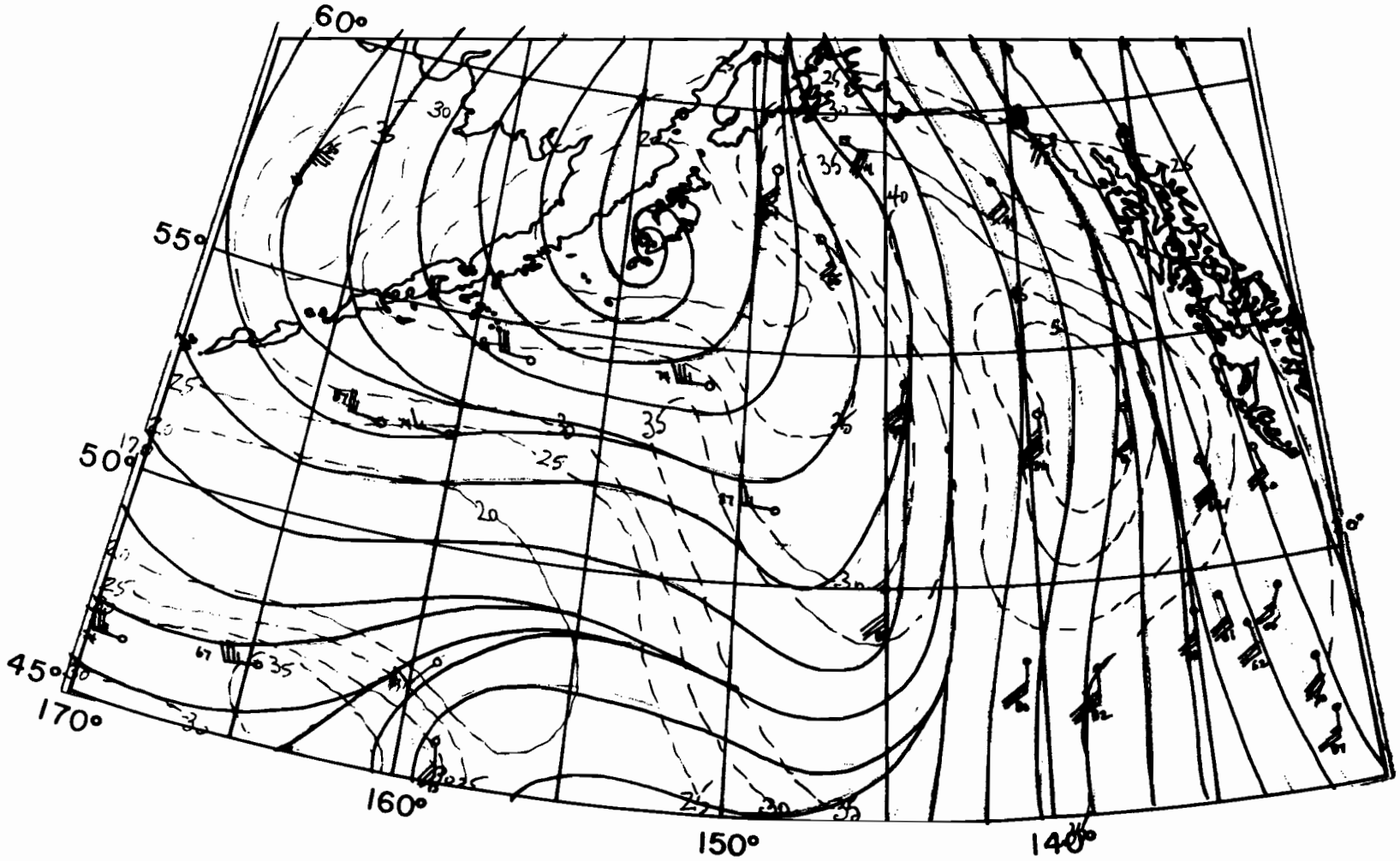

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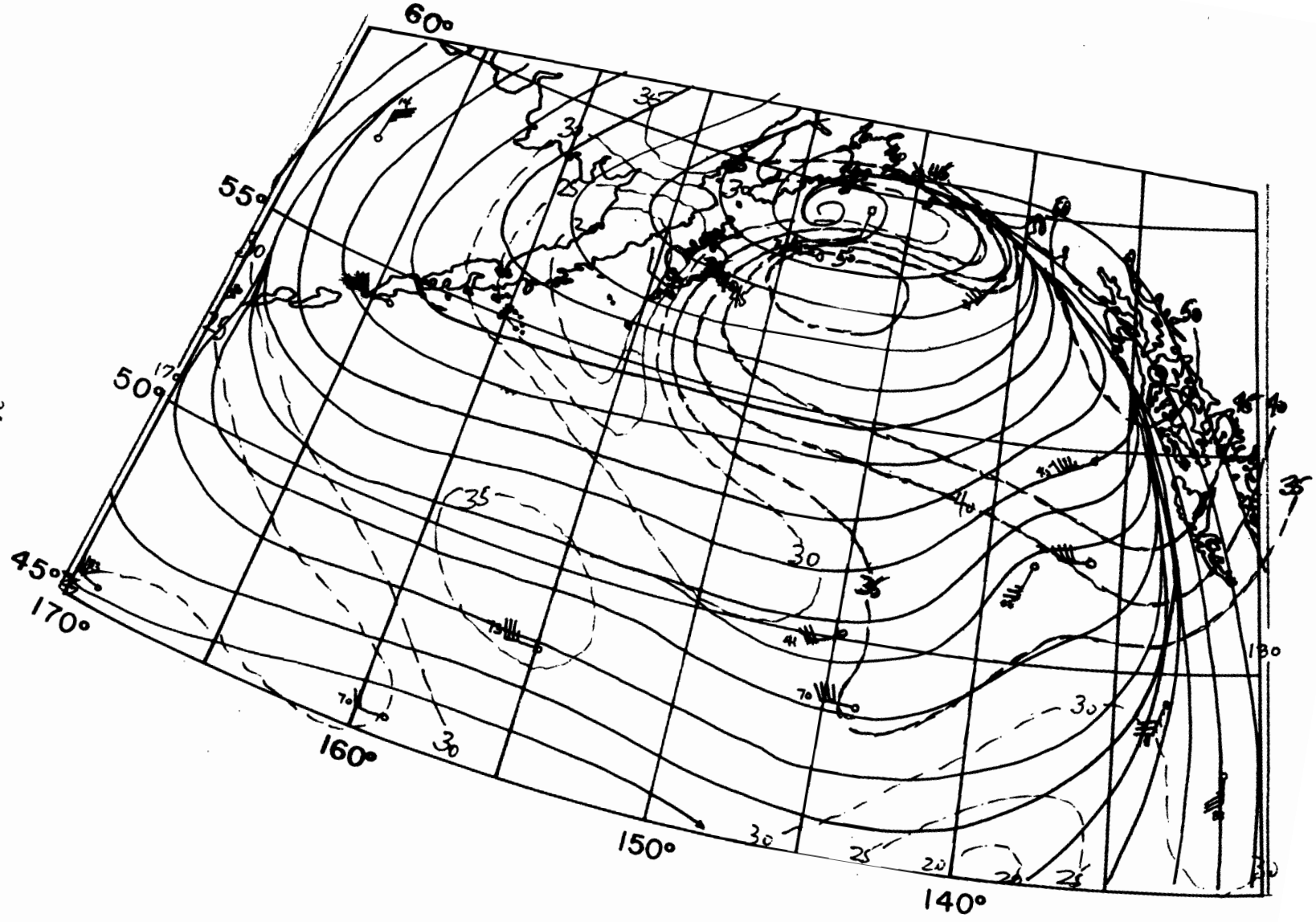

FIGURE 7c
1200 GMT
12/31/74

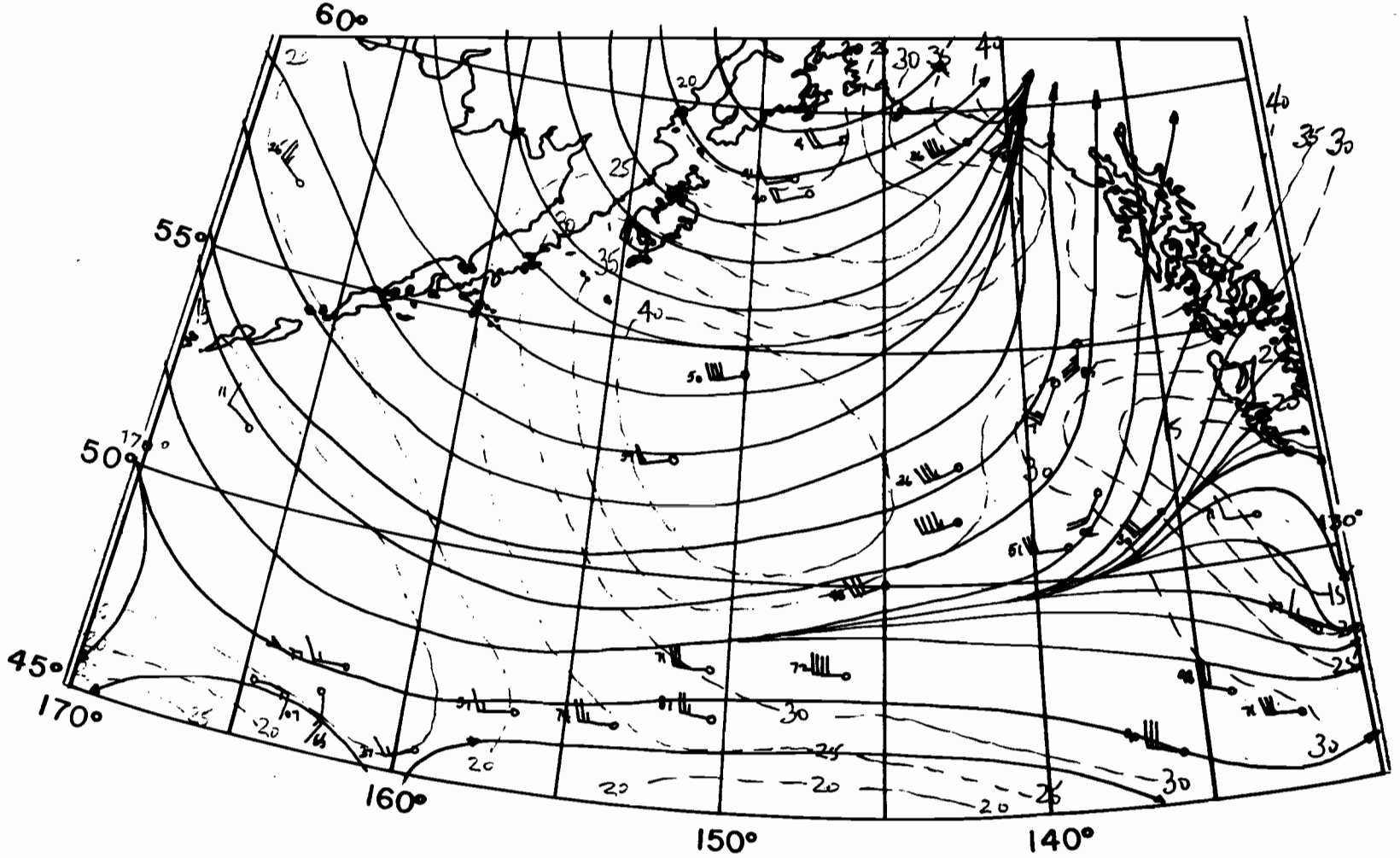

FIGURE 7d
0000 GMT
1/1/75

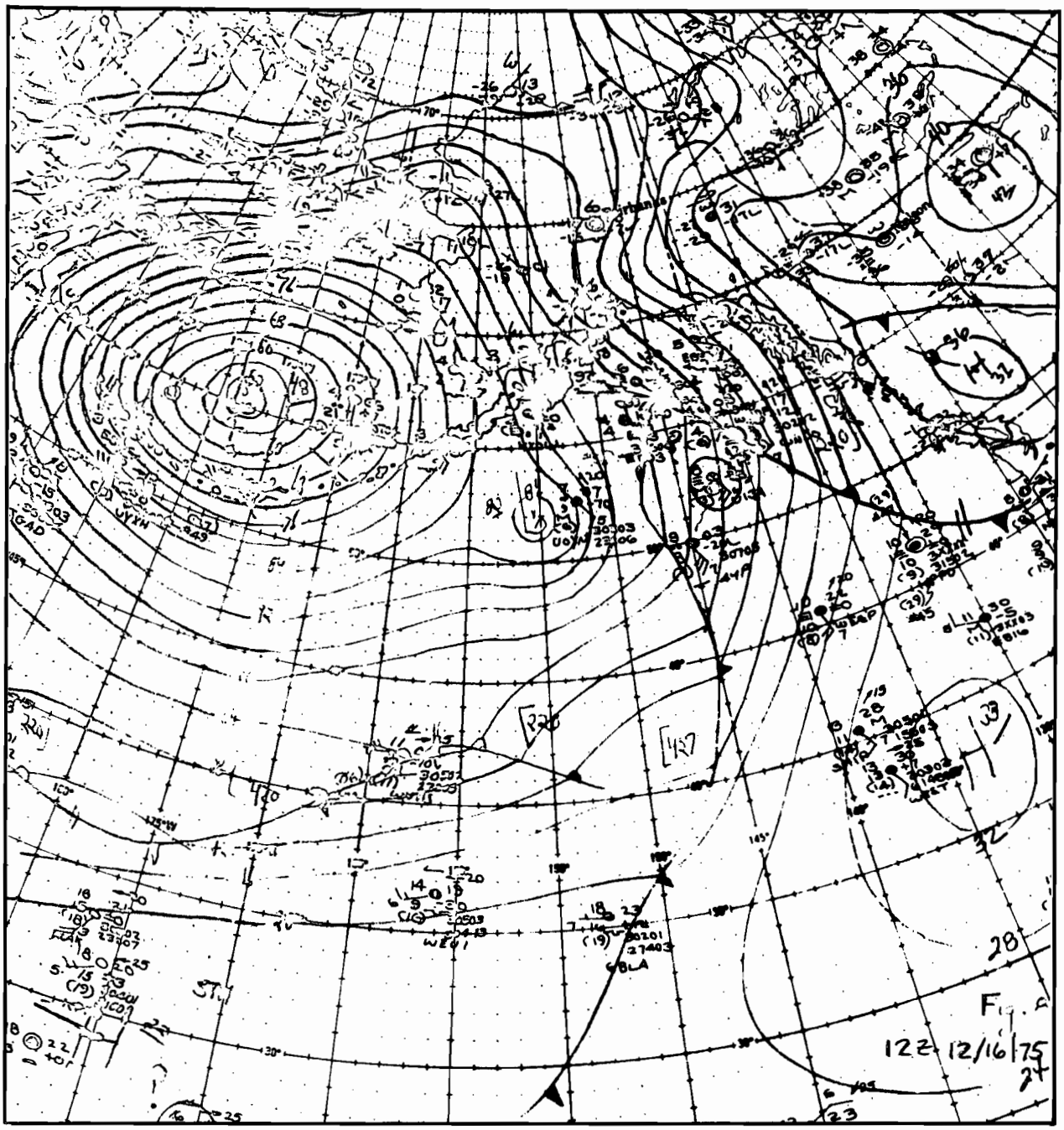

Fig.8a

12GMT 12/16/75

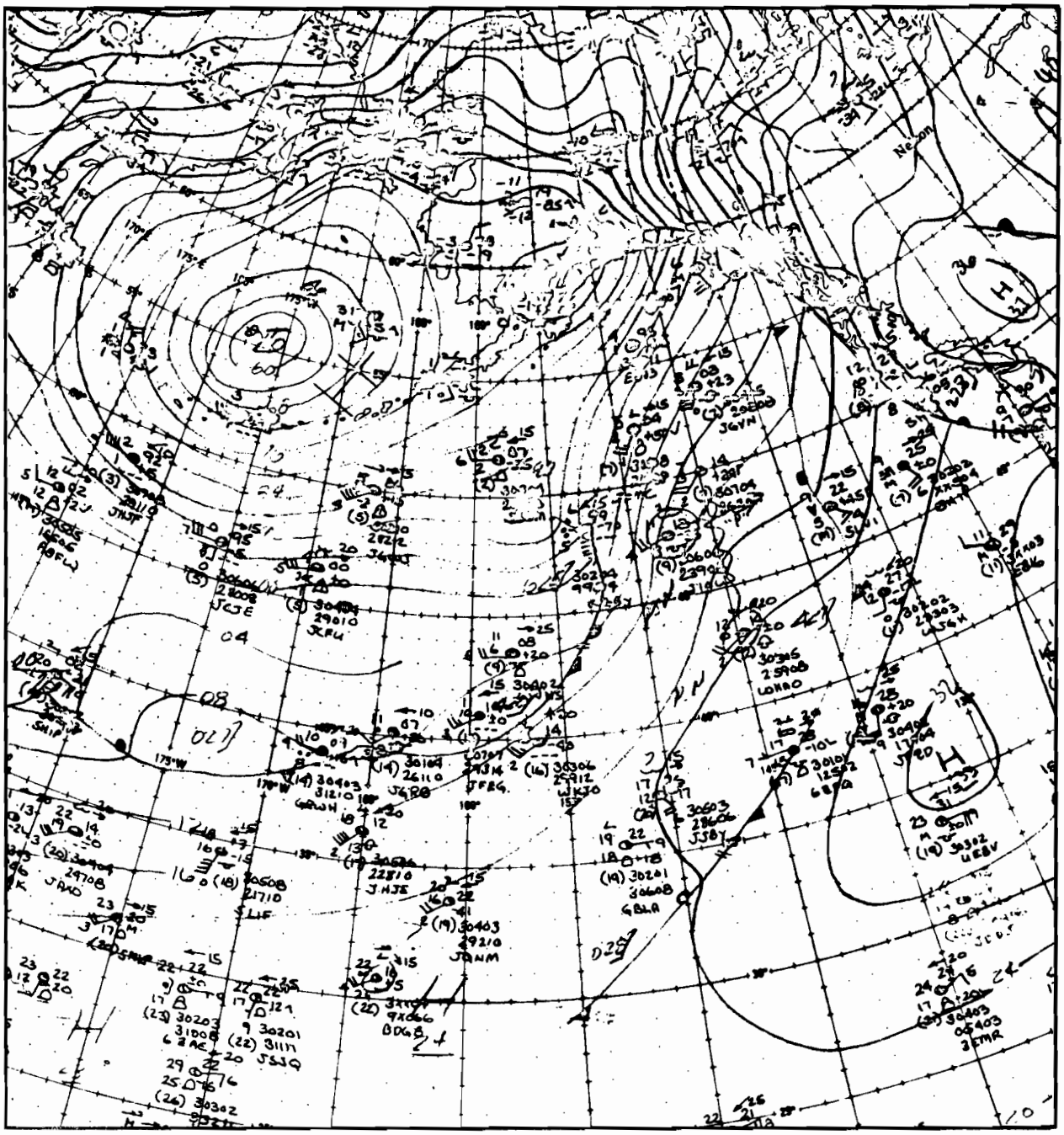

Fig.8b

00GMT 12/17/75

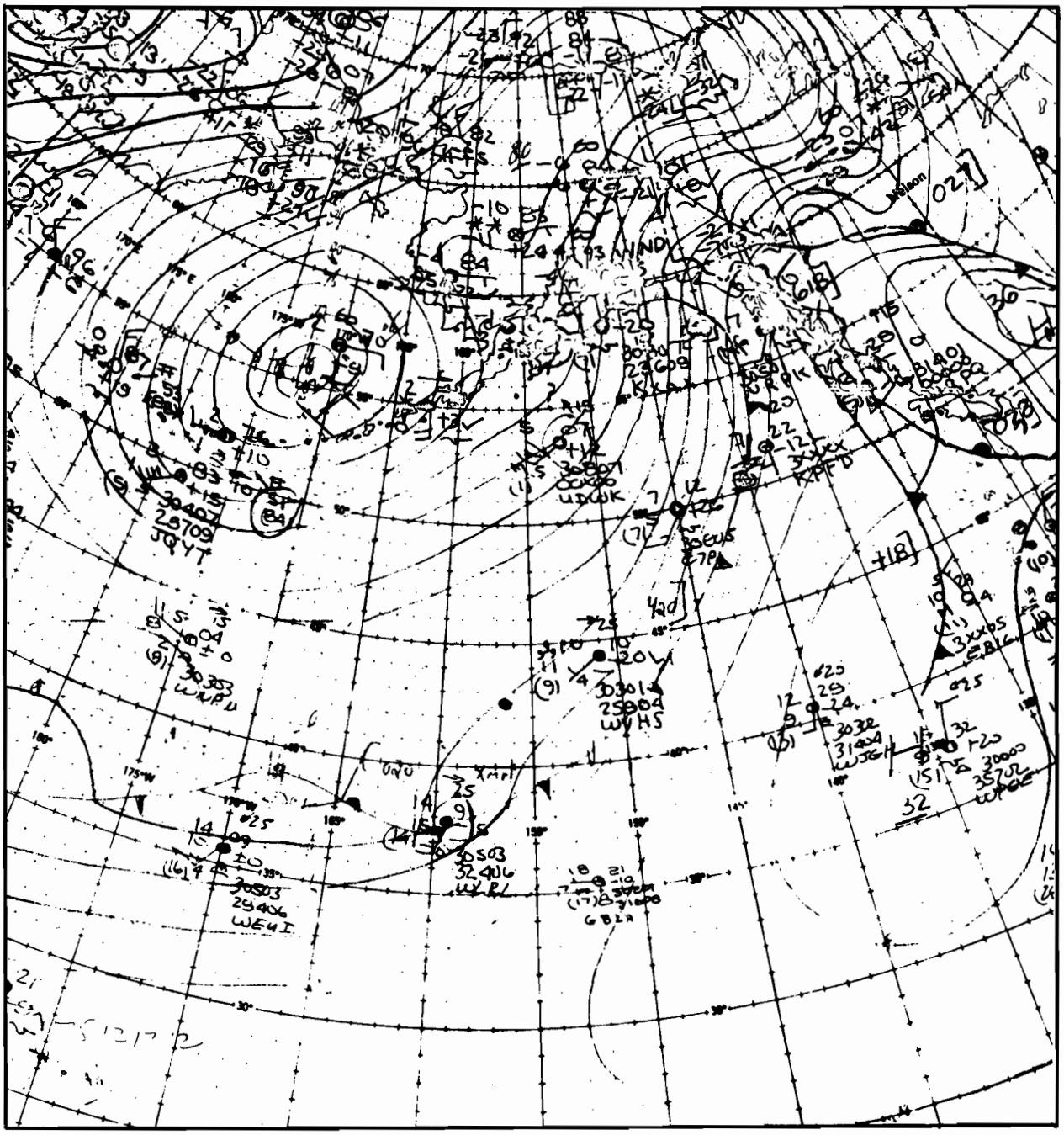

Fig.8c

12GMT 12/17/75

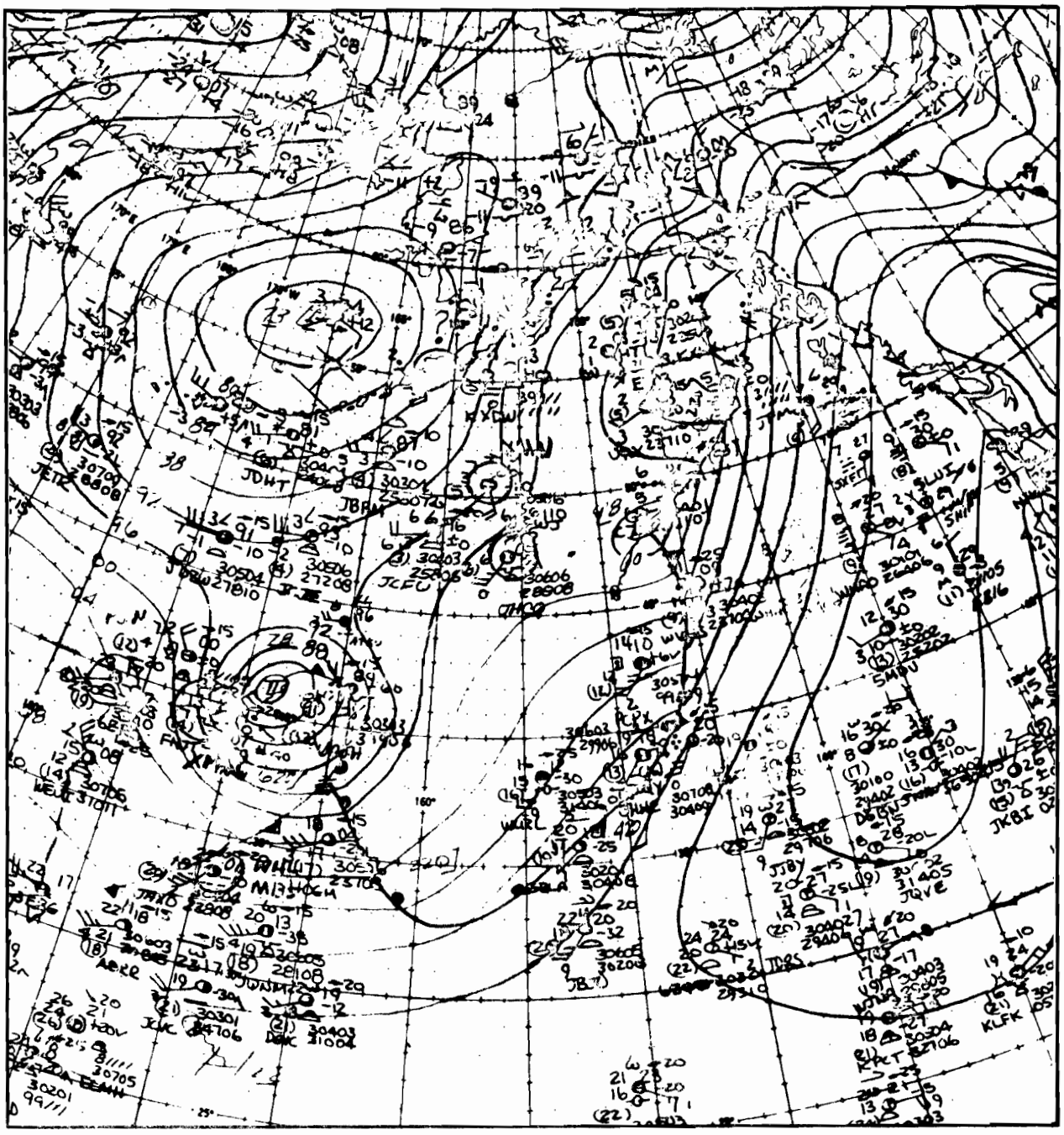

Fig.8d

00GMT 12/18/75

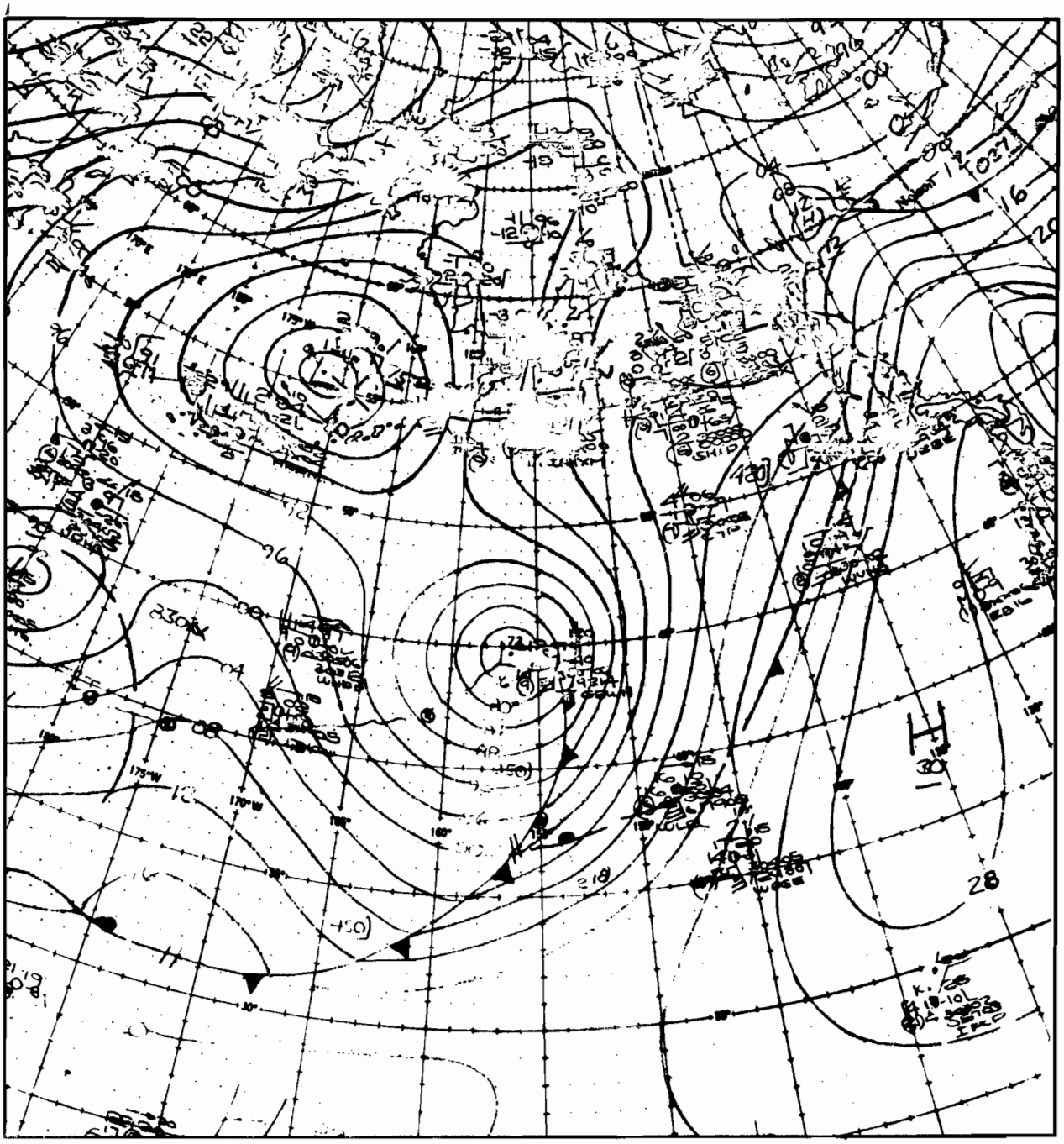

Fig.8e

12GMT 12/18/75

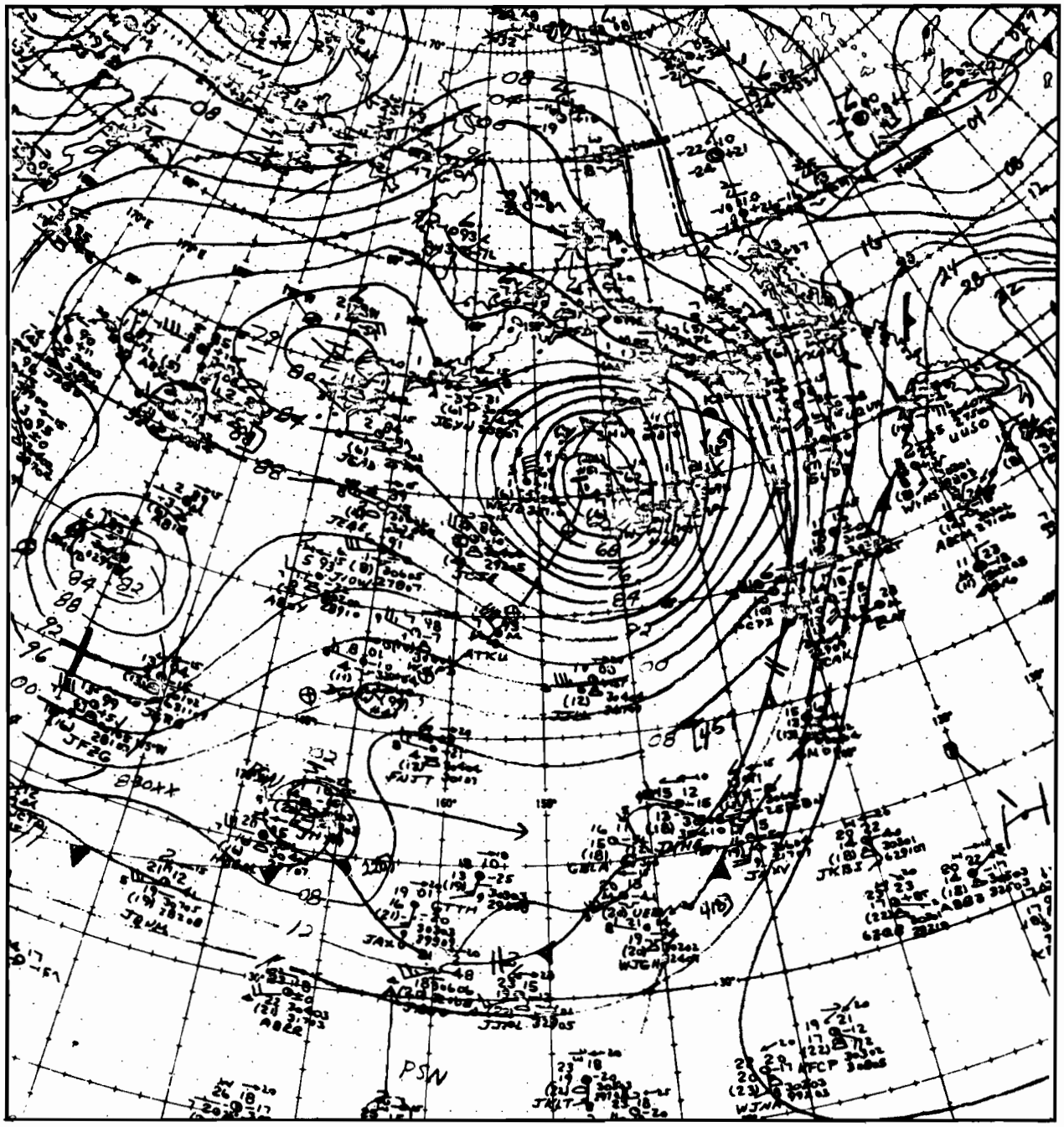

Fig.8f

00GMT 12/19/75

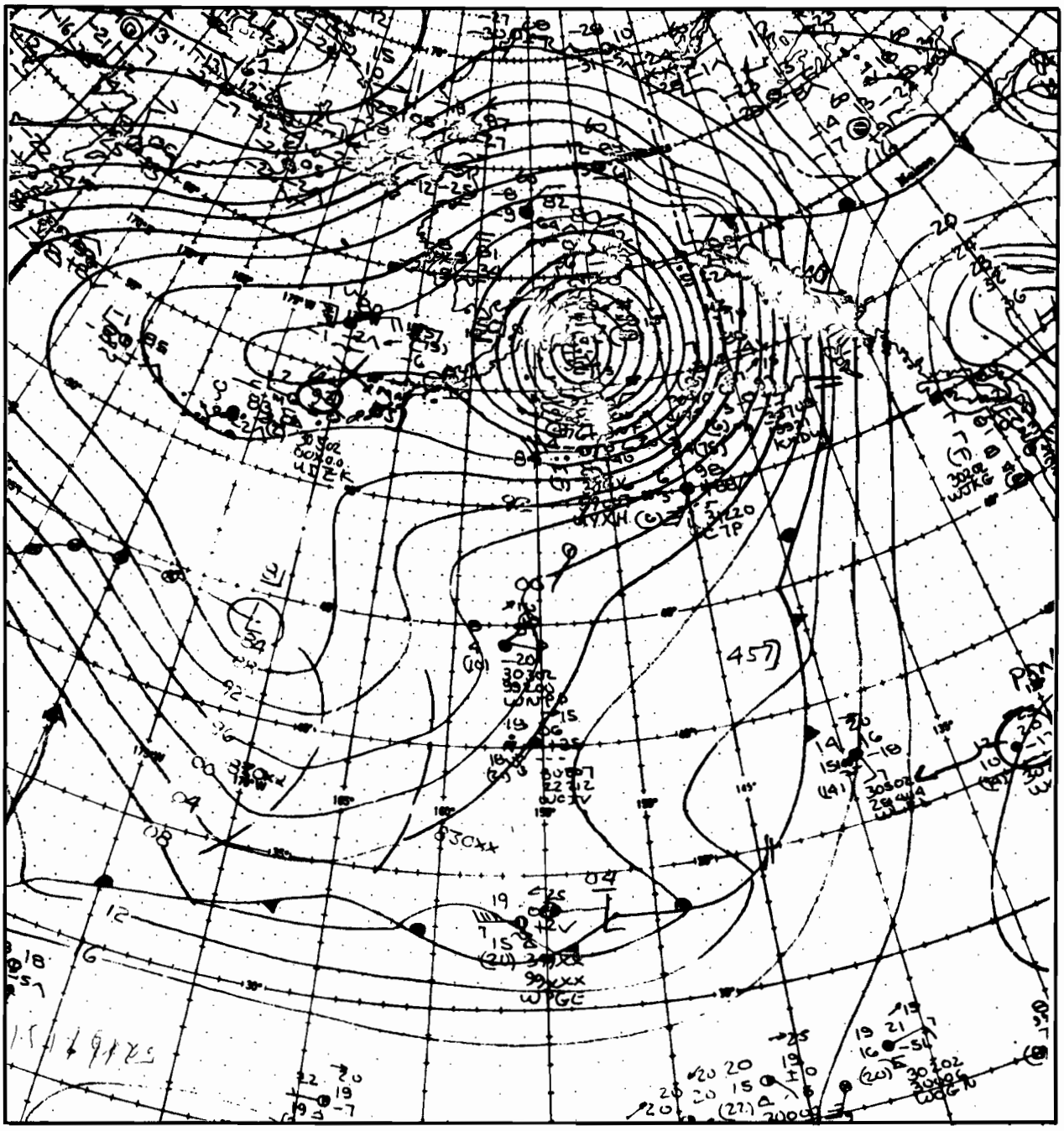

Fig.8g

12GMT12/19/75

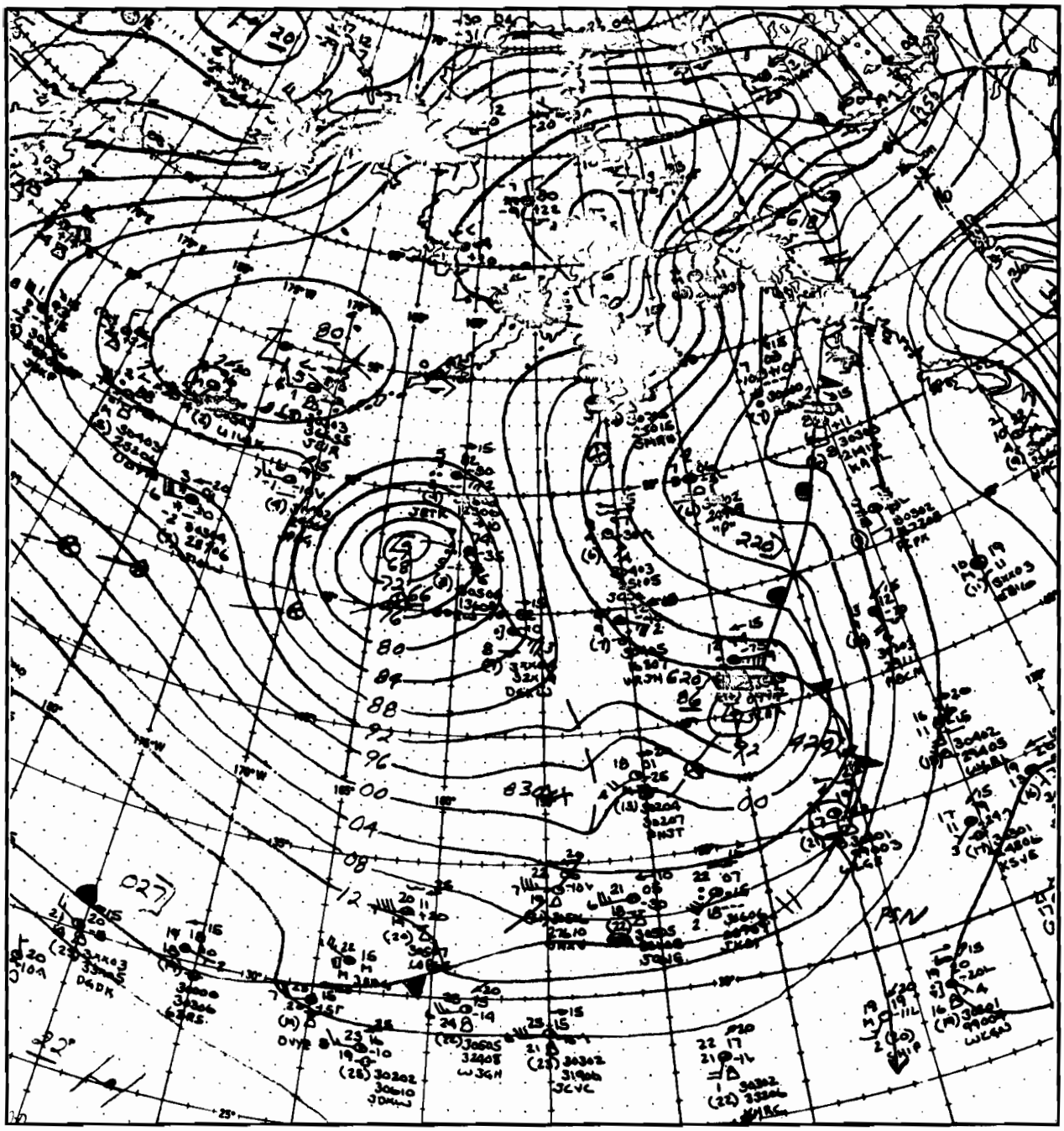

Fig.8h

00GMT 12/20/75

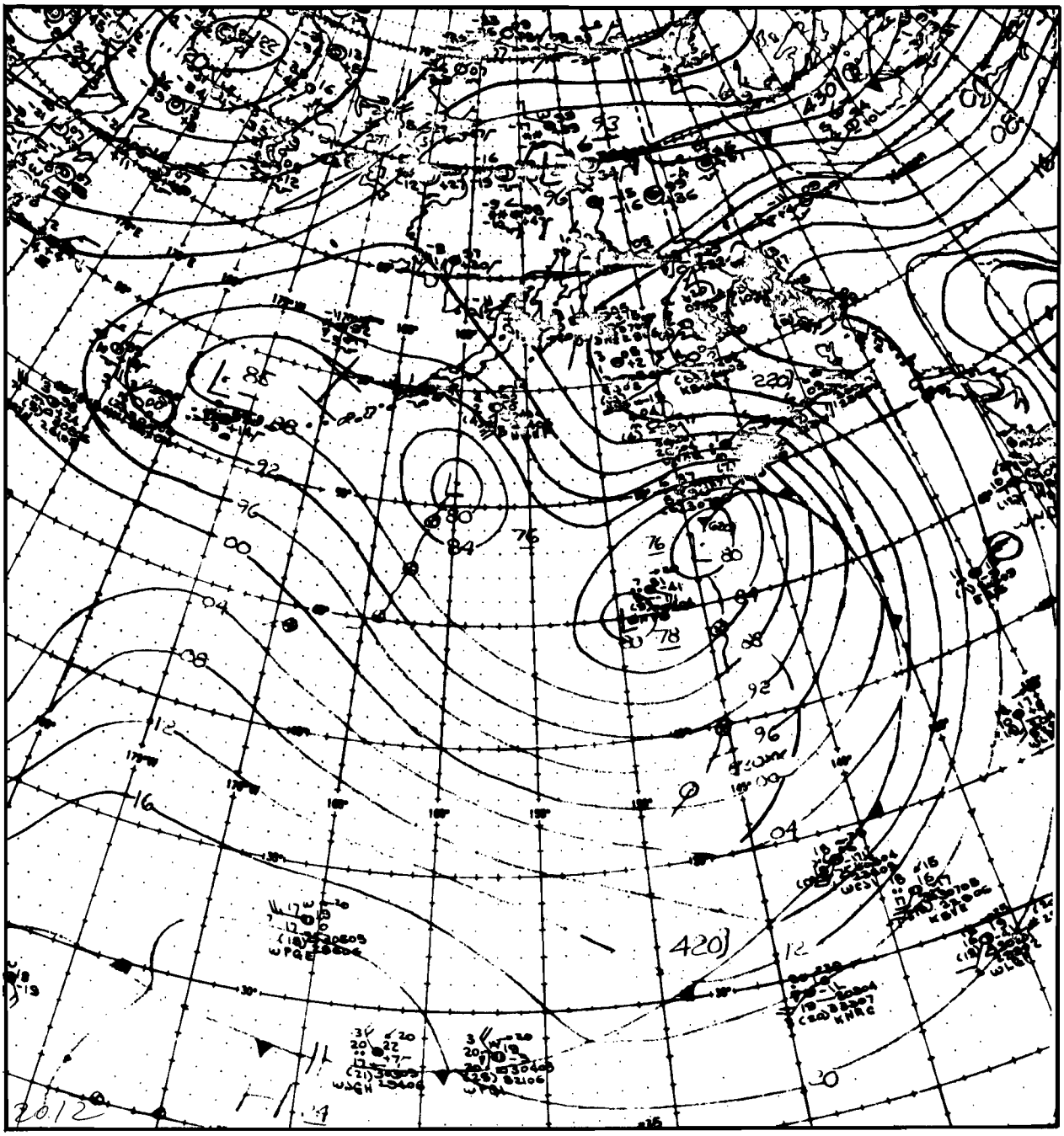

Fig.8i

12GMT 12/20/75

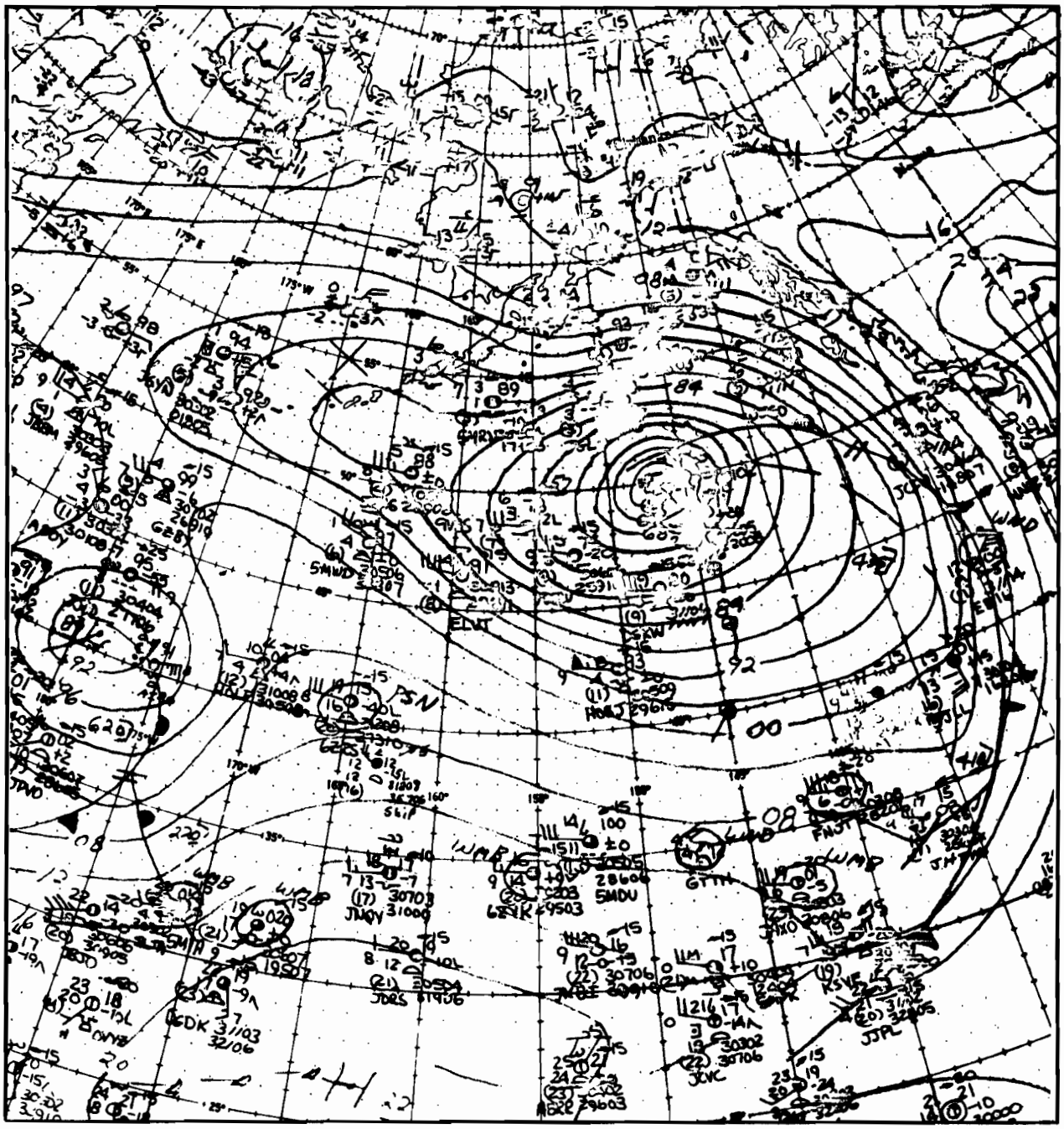

Fig.8j

00GMT 12/21/75

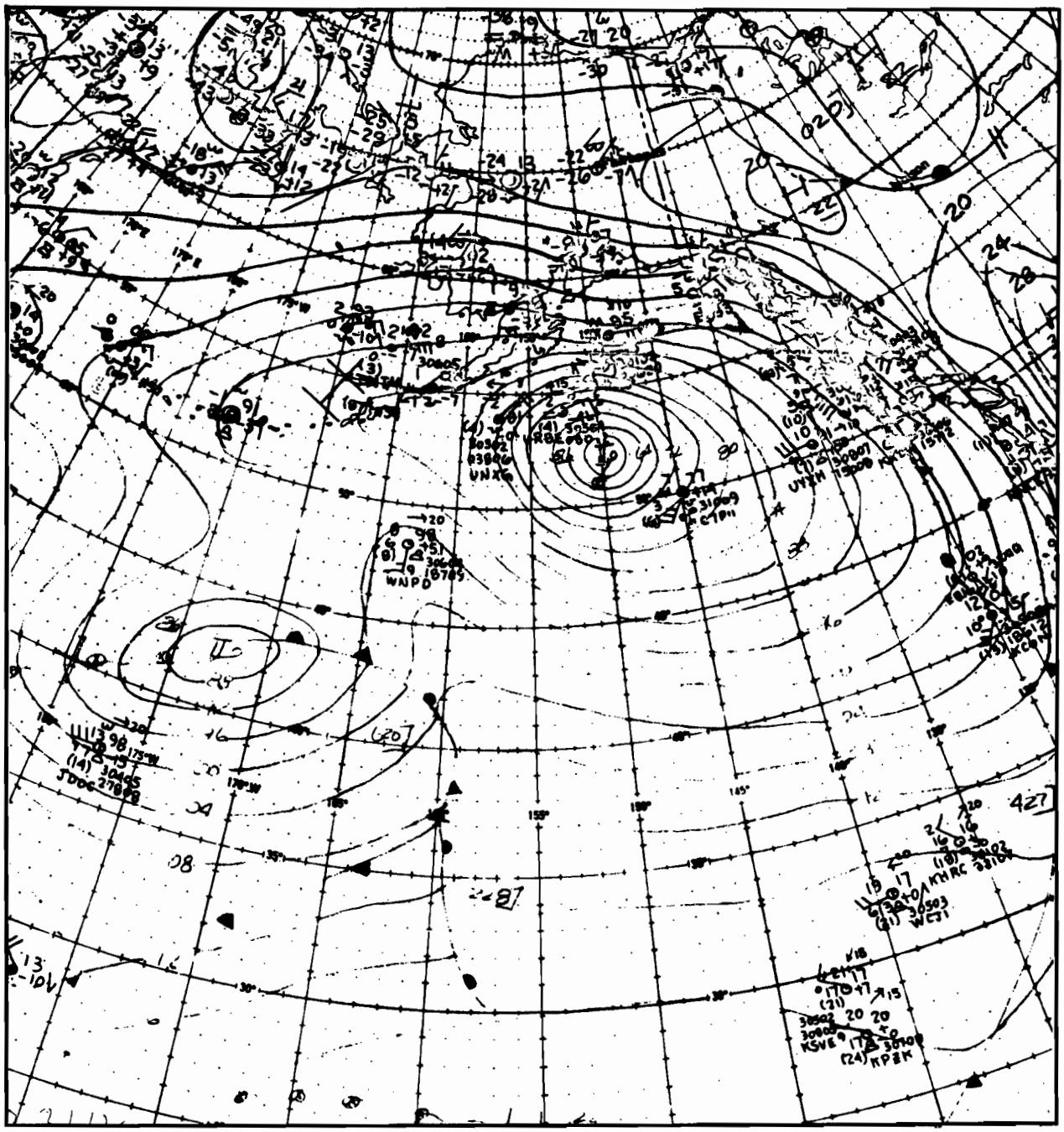

Fig.8k

12GMT 12/21/75

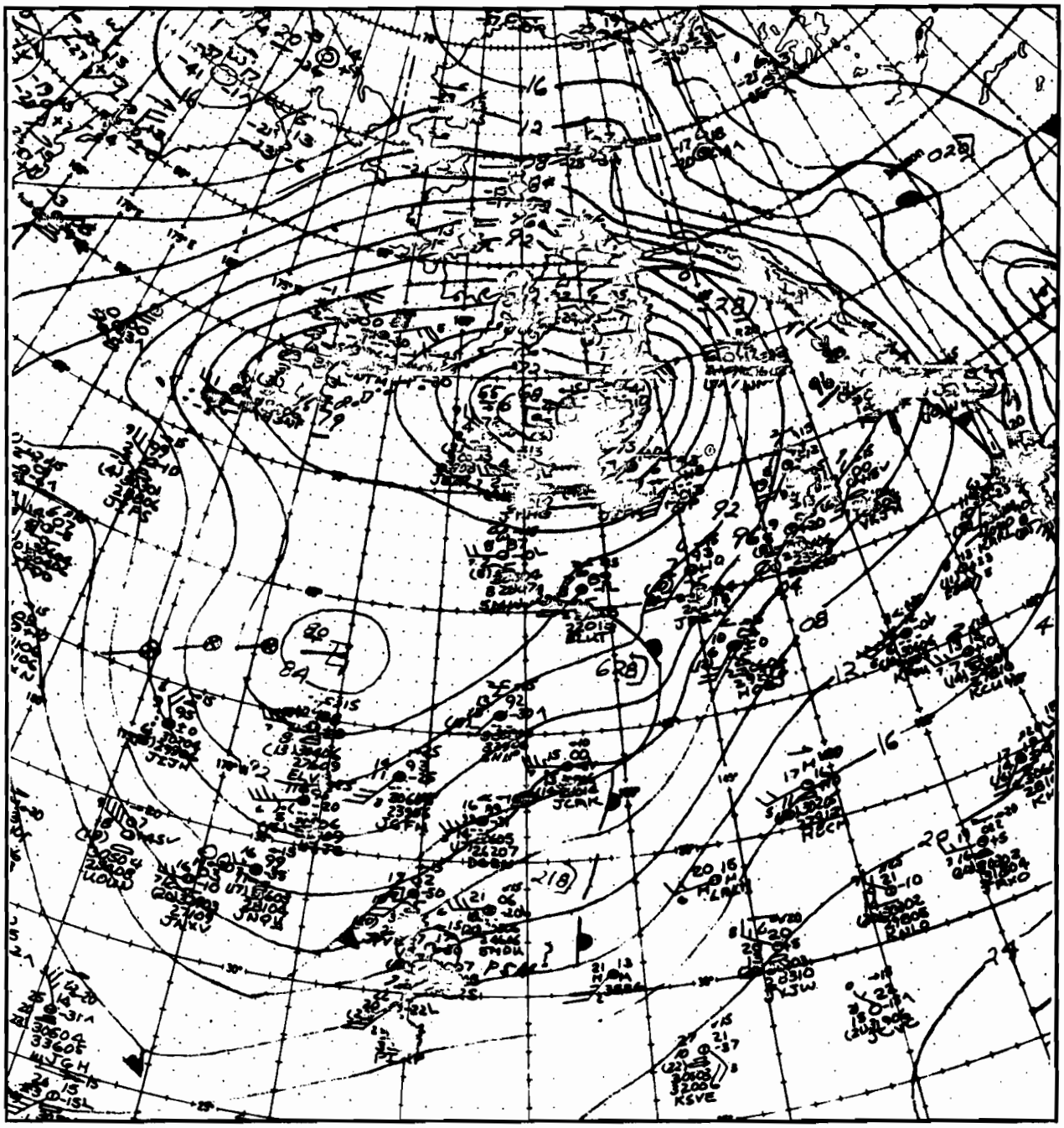

Fig.8l

00GMT 12/22/75

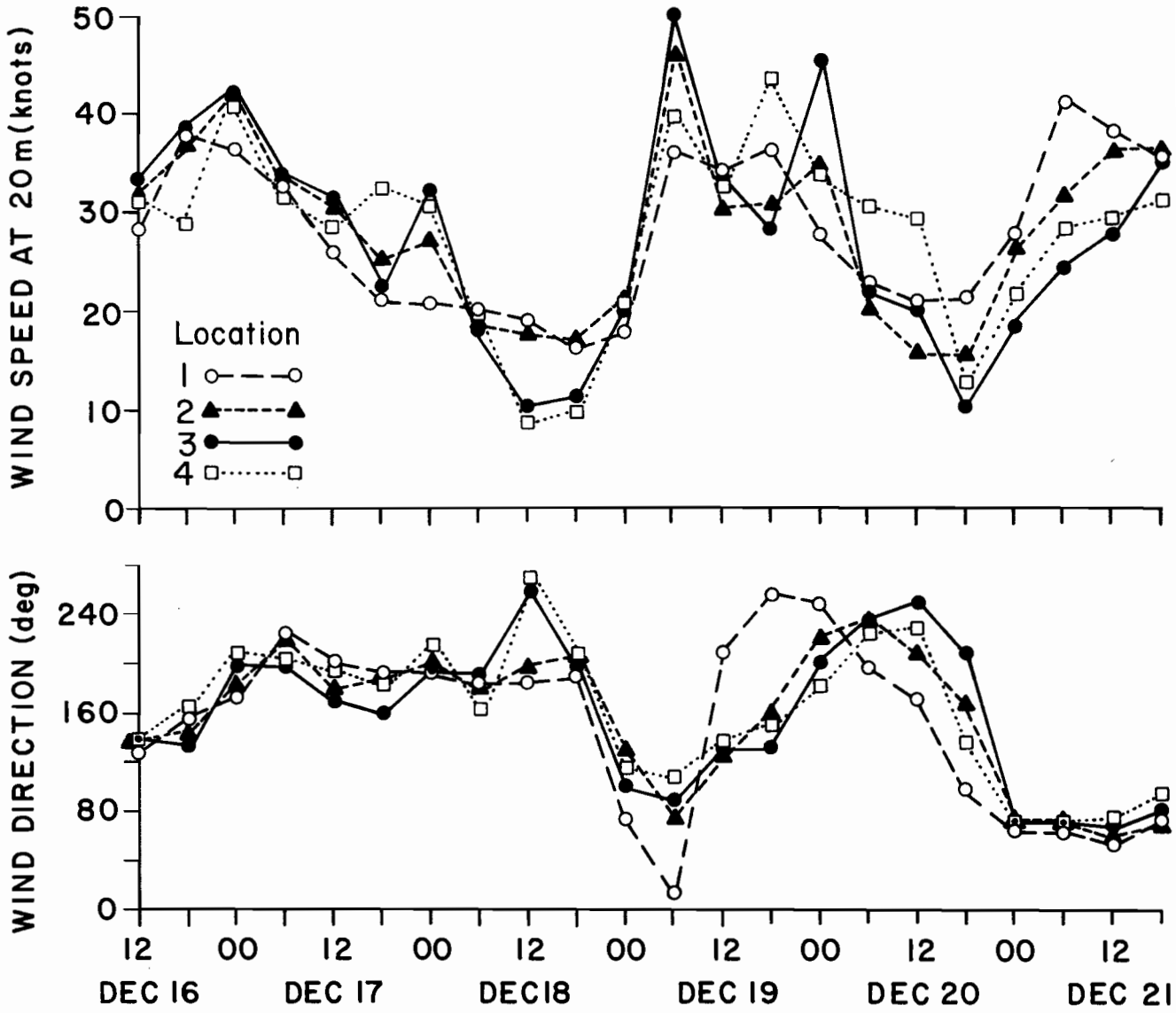
STORM 3 DEC, 1975
WIND SPEED AT 20m(knots)
50
40
30
20
10
0
Location
1
2
3
4
WIND DIRECTION (deg)
240
160
80
0
12
00
12
00
12
00
12
00
12
00
12
DEC 16
DEC 17
DEC18
DEC 19
DEC 20
DEC 21

Figure 9

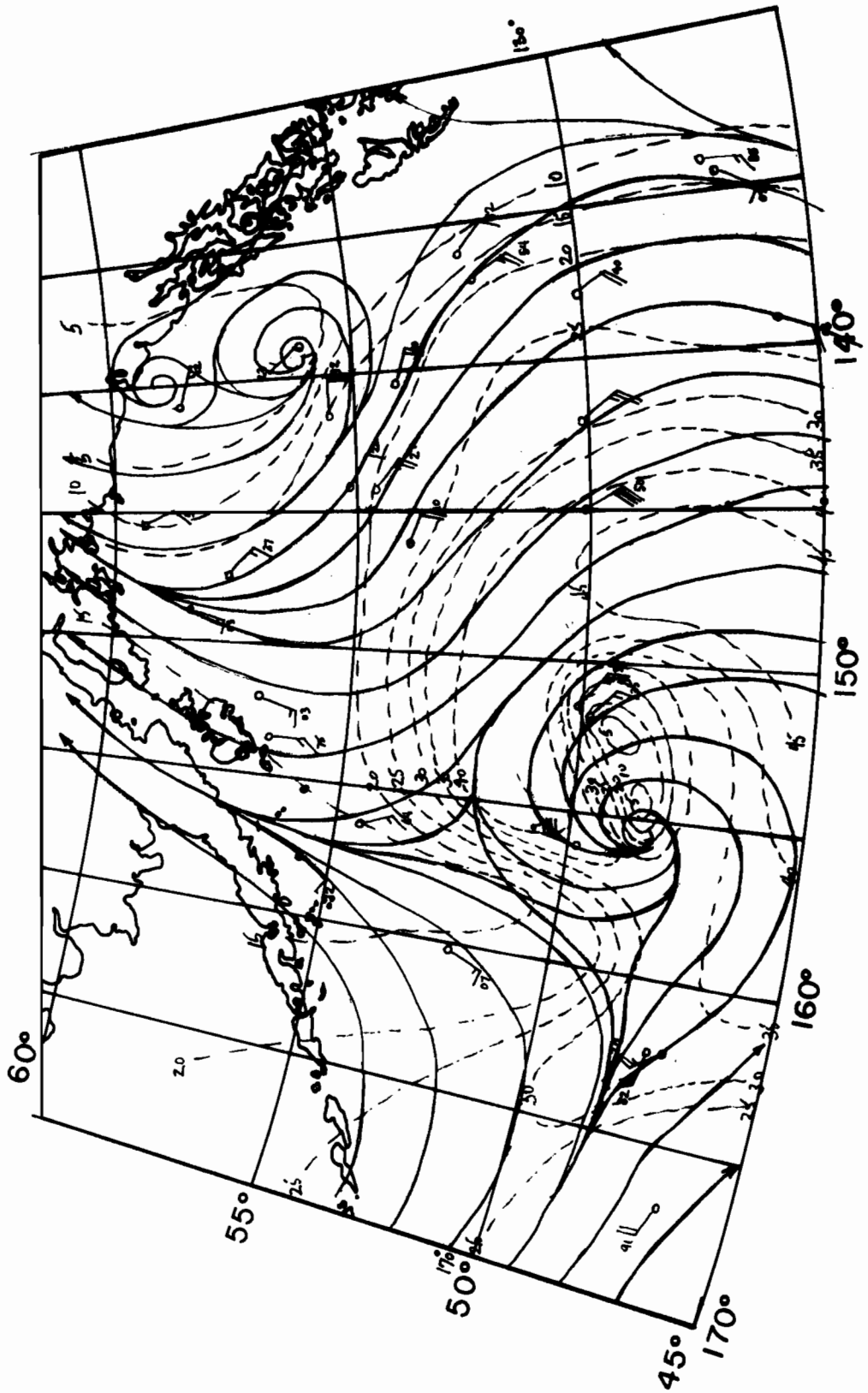

FIGURE 10a
1800 GMT
12/18/75

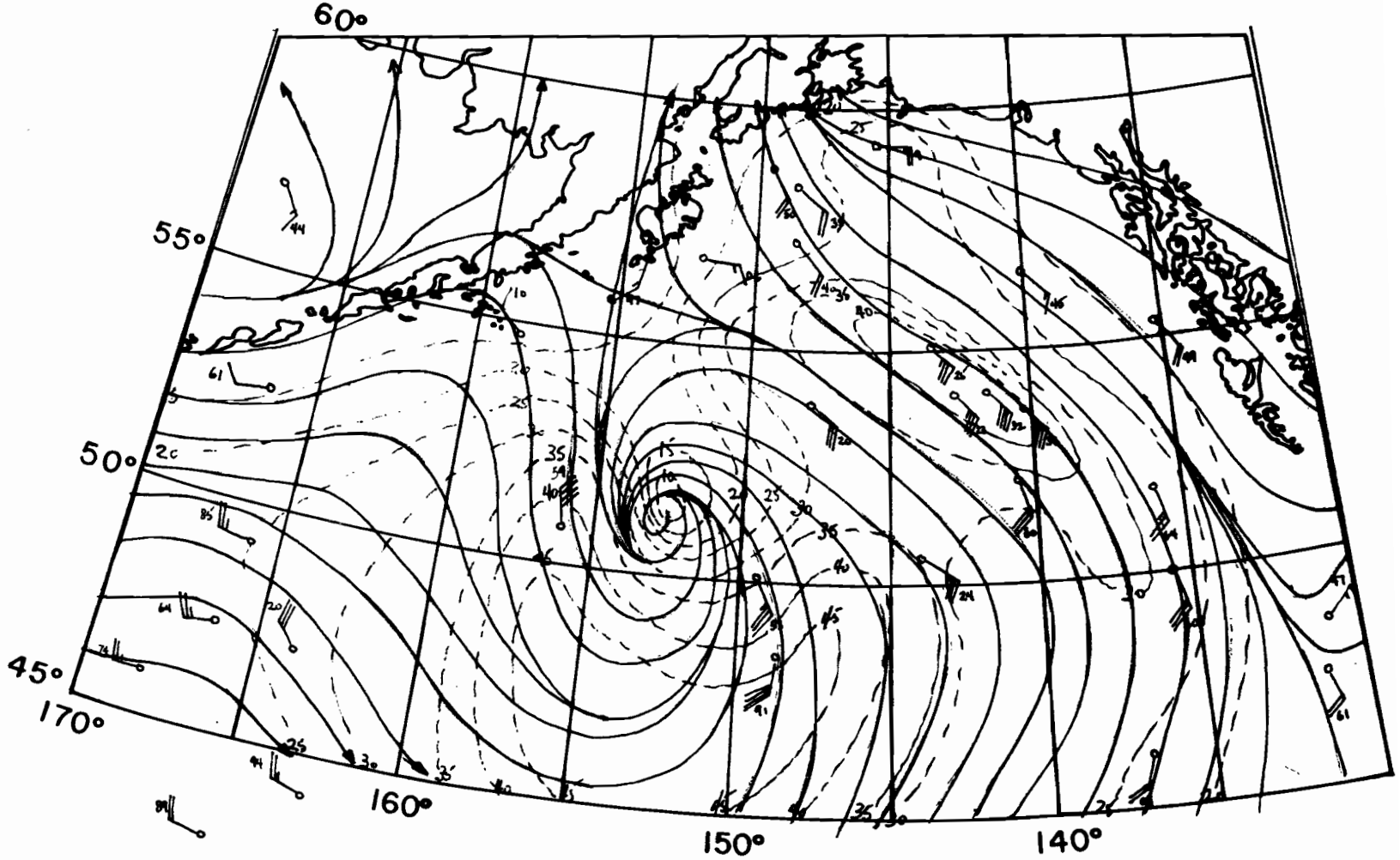

FIGURE 10b
0000 GMT
12/19/75

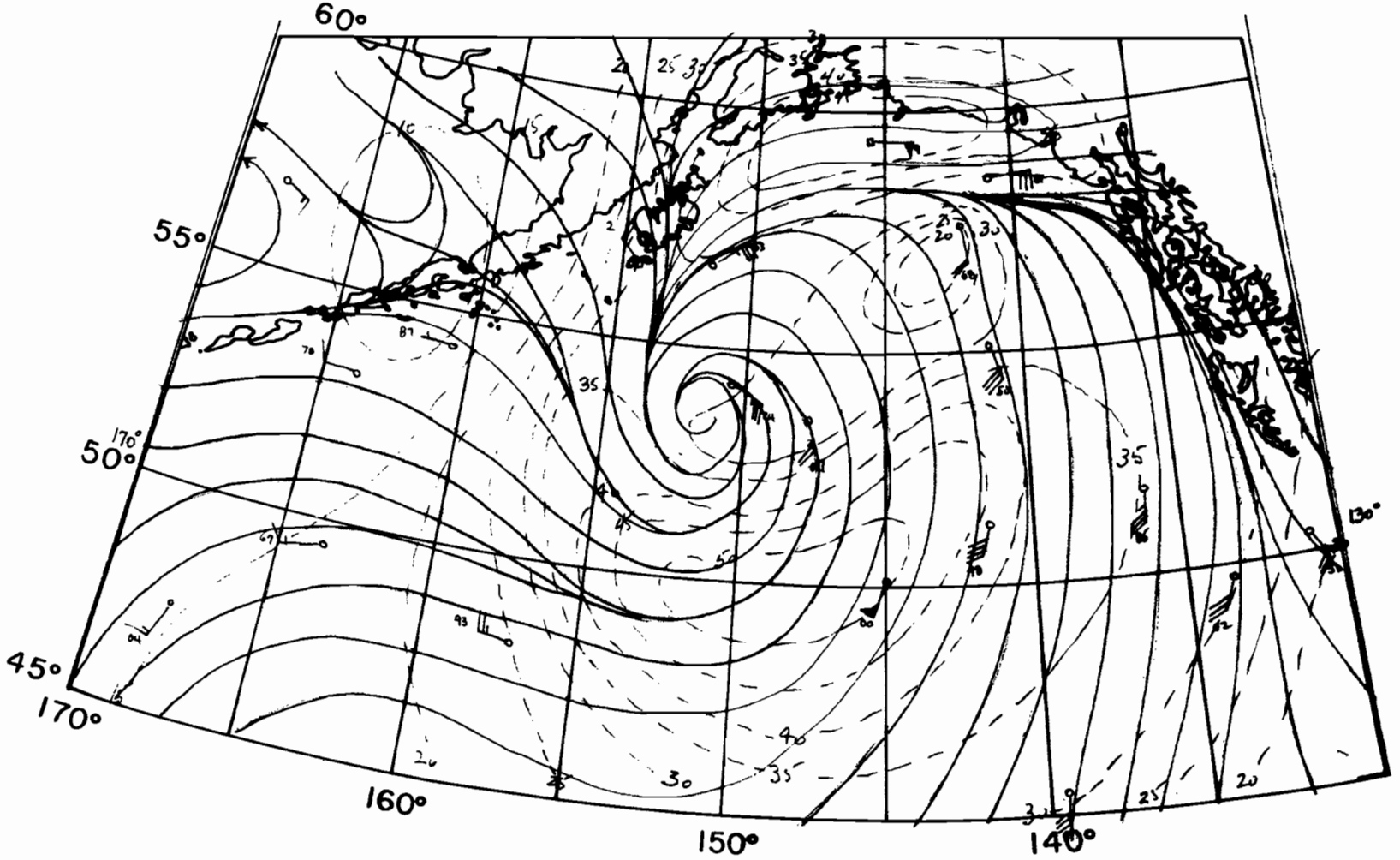

FIGURE 10c
0600 GMT
12/19/75

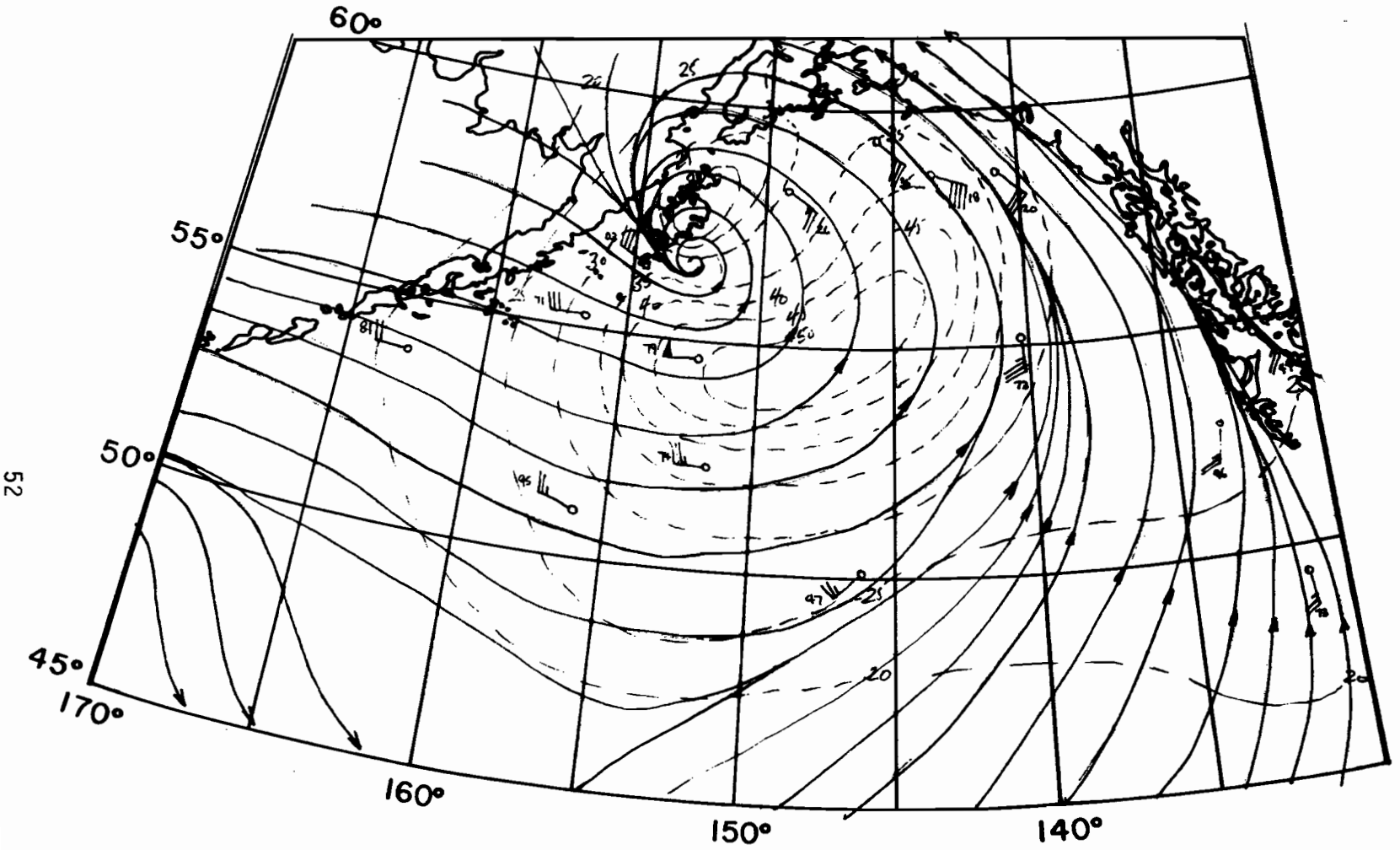

FIGURE 10d
1200 GMT
12/19/75

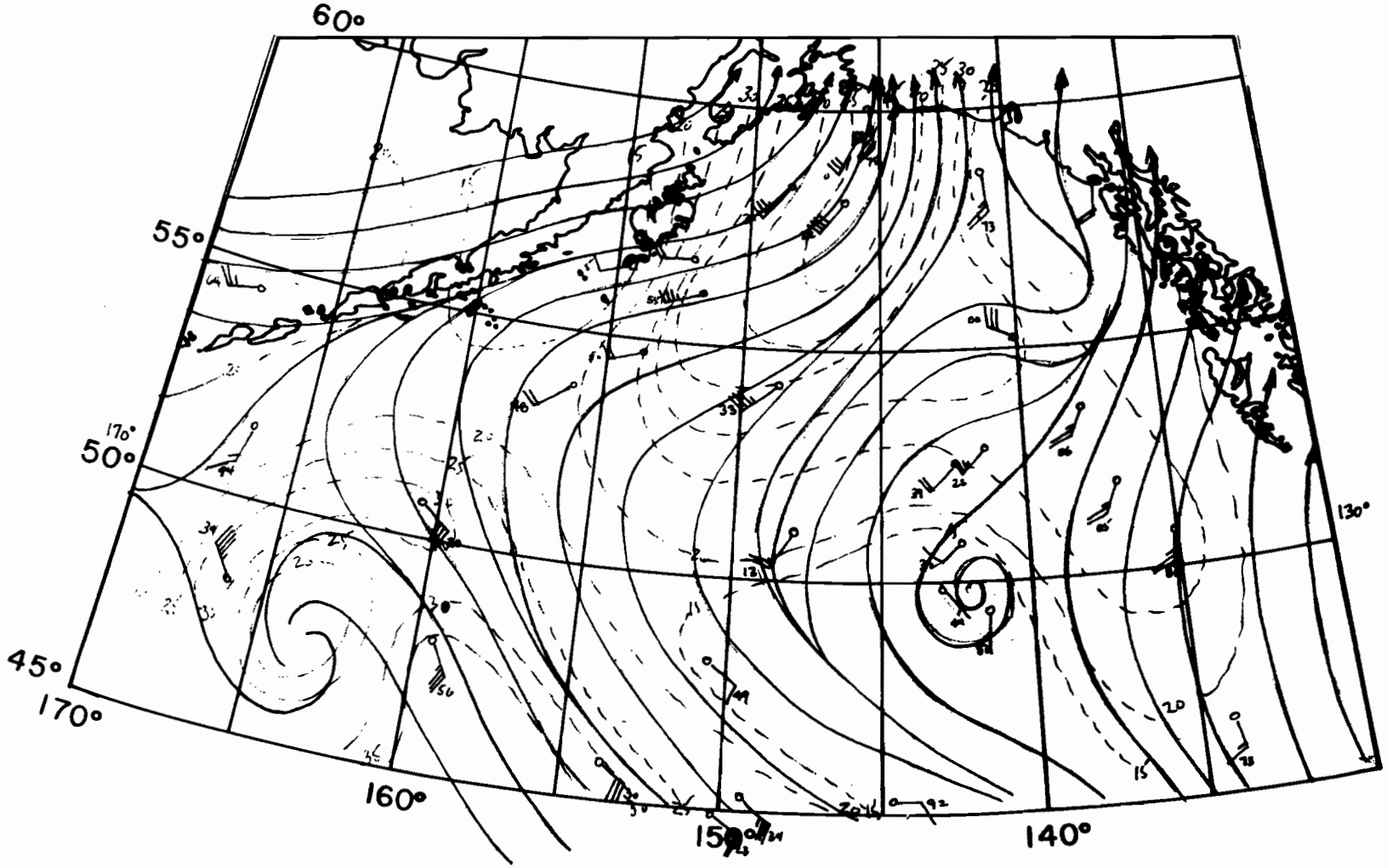

FIGURE 10e
0000 GMT
12/20/75

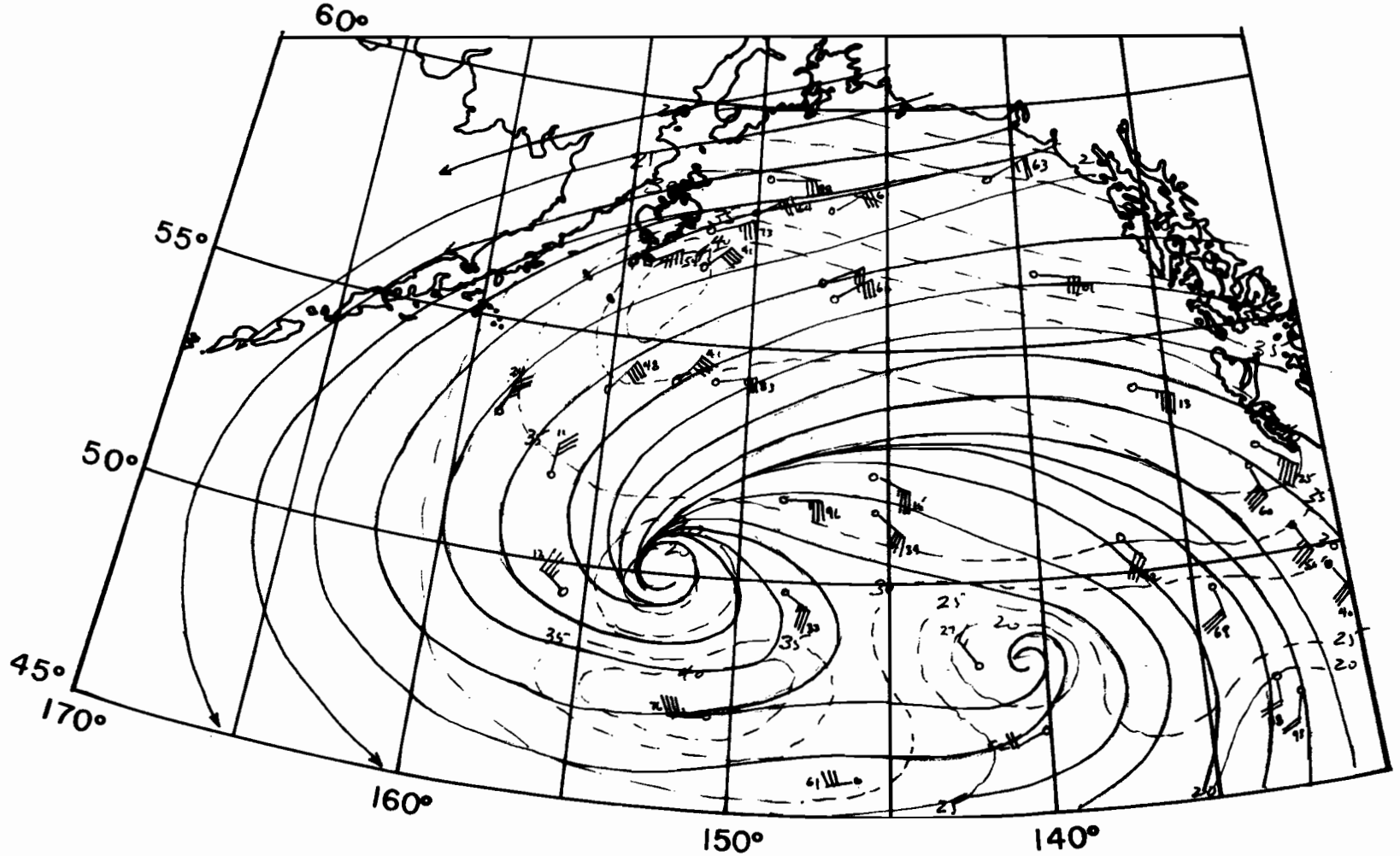

FIGURE 10f
0600 GMT
12/21/75

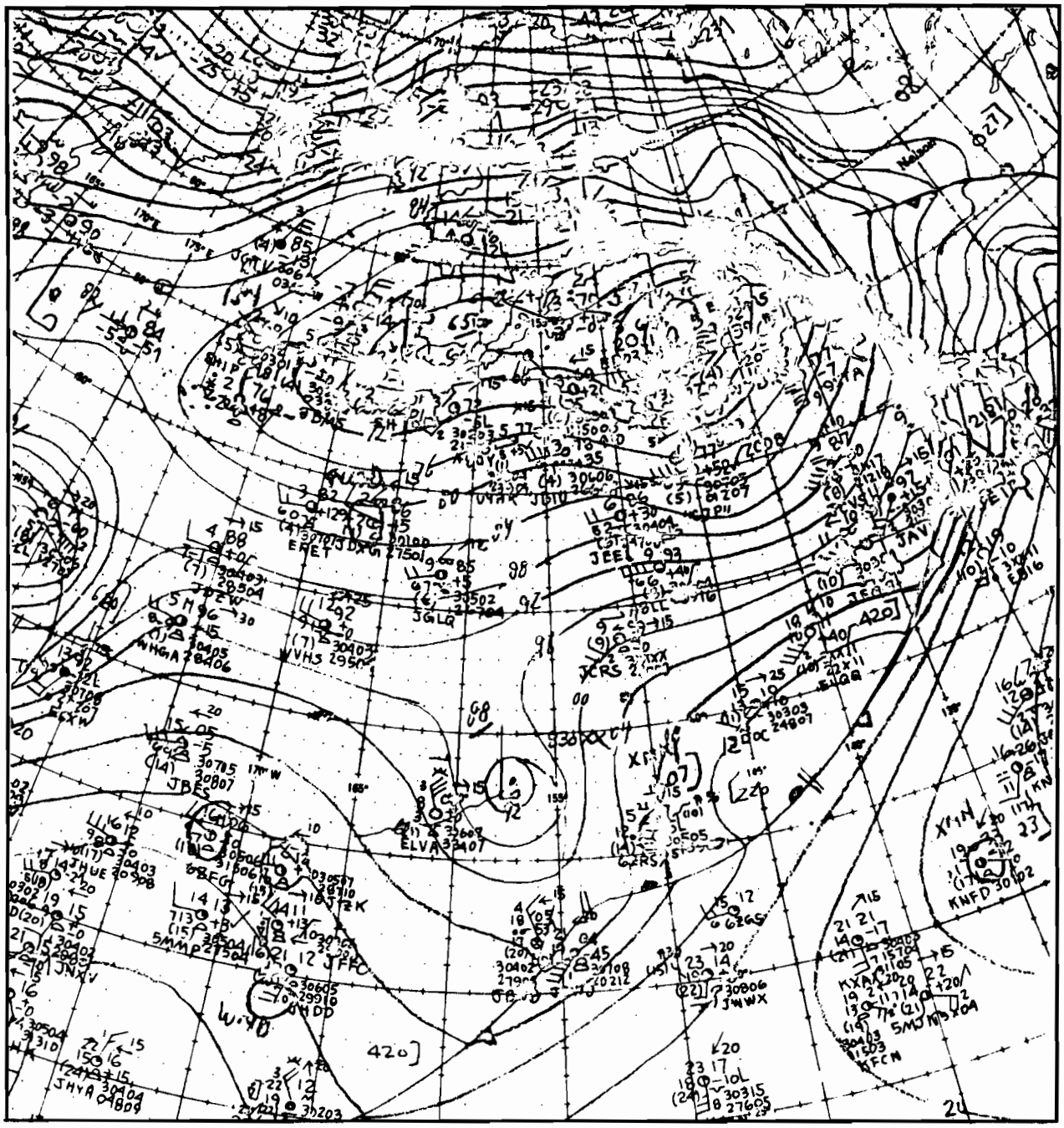

Fig. 11a

00GMT 1/27/76

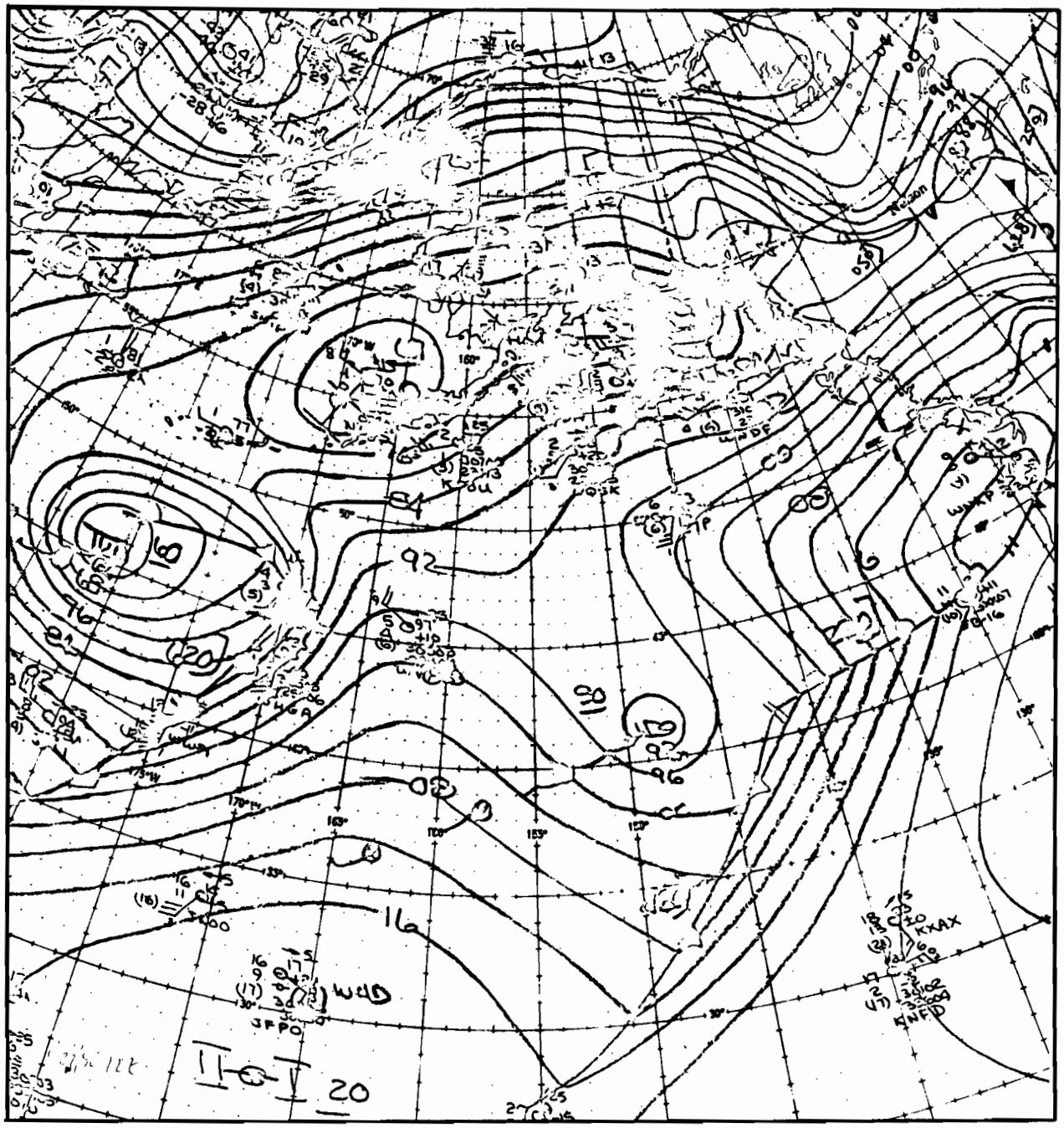

Fig.11b

12GMT 1/27/76

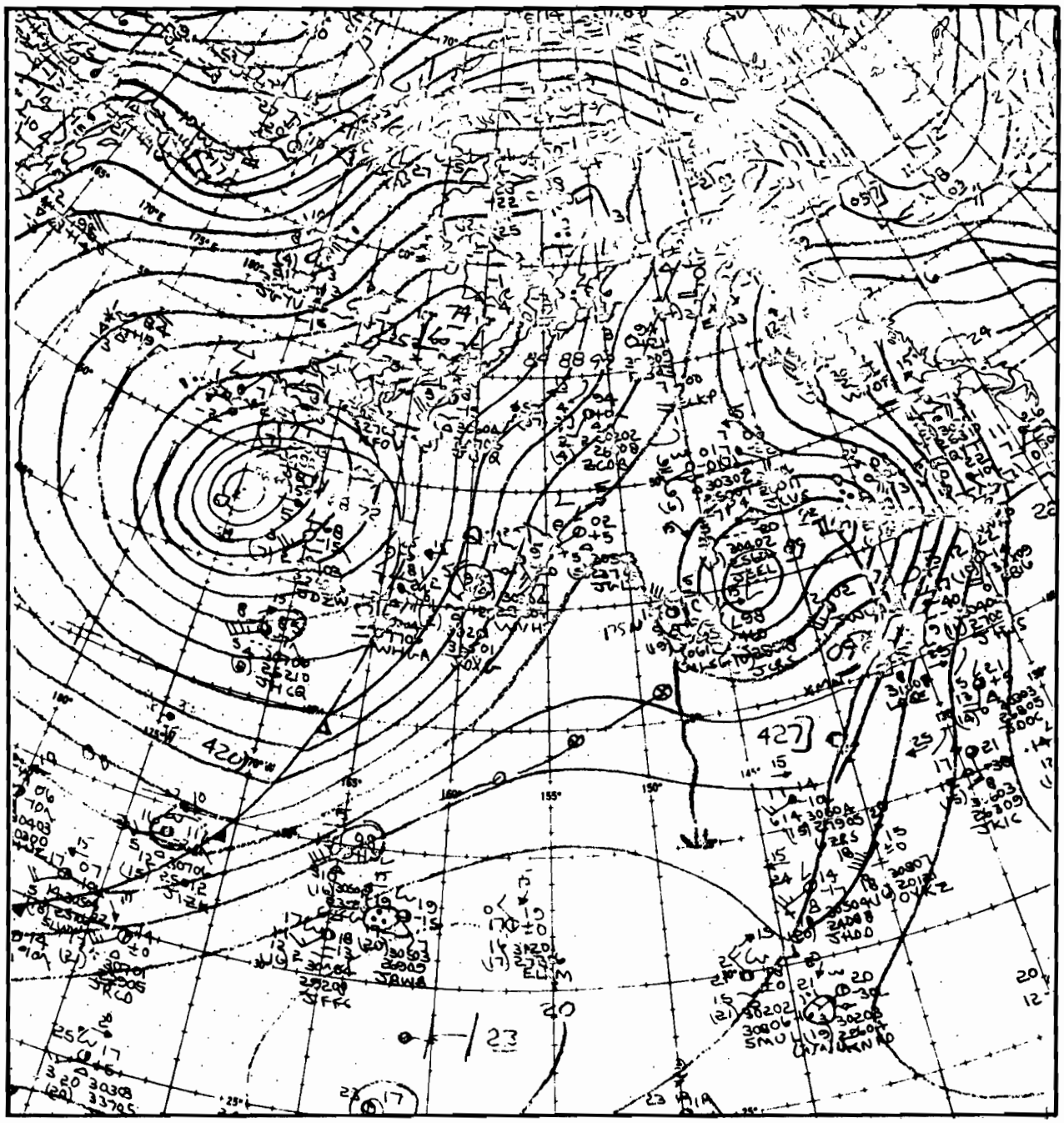

Fig. 11c

00GMT 1/28/76

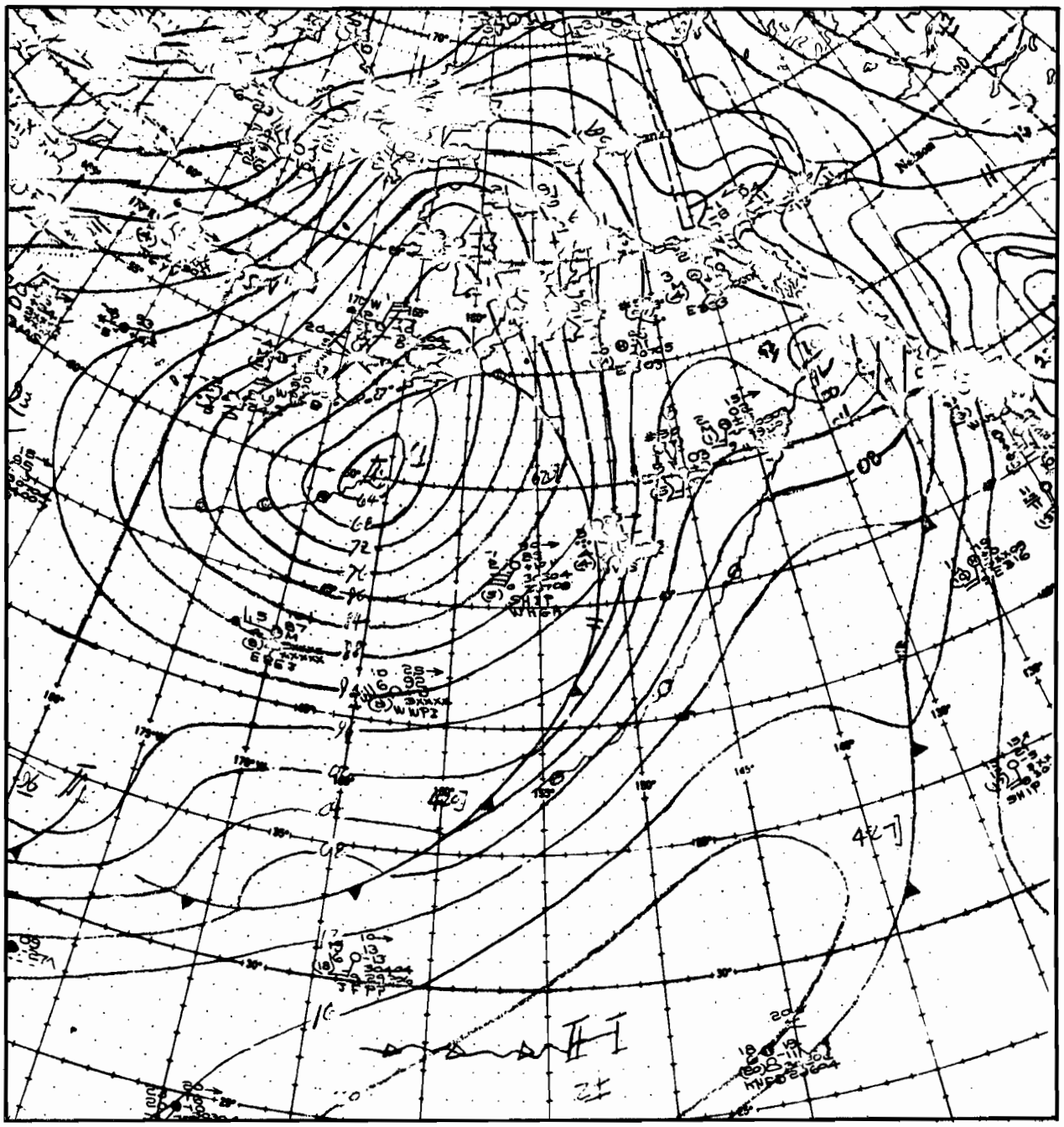

Fig.11d

12GMT 1/28/76

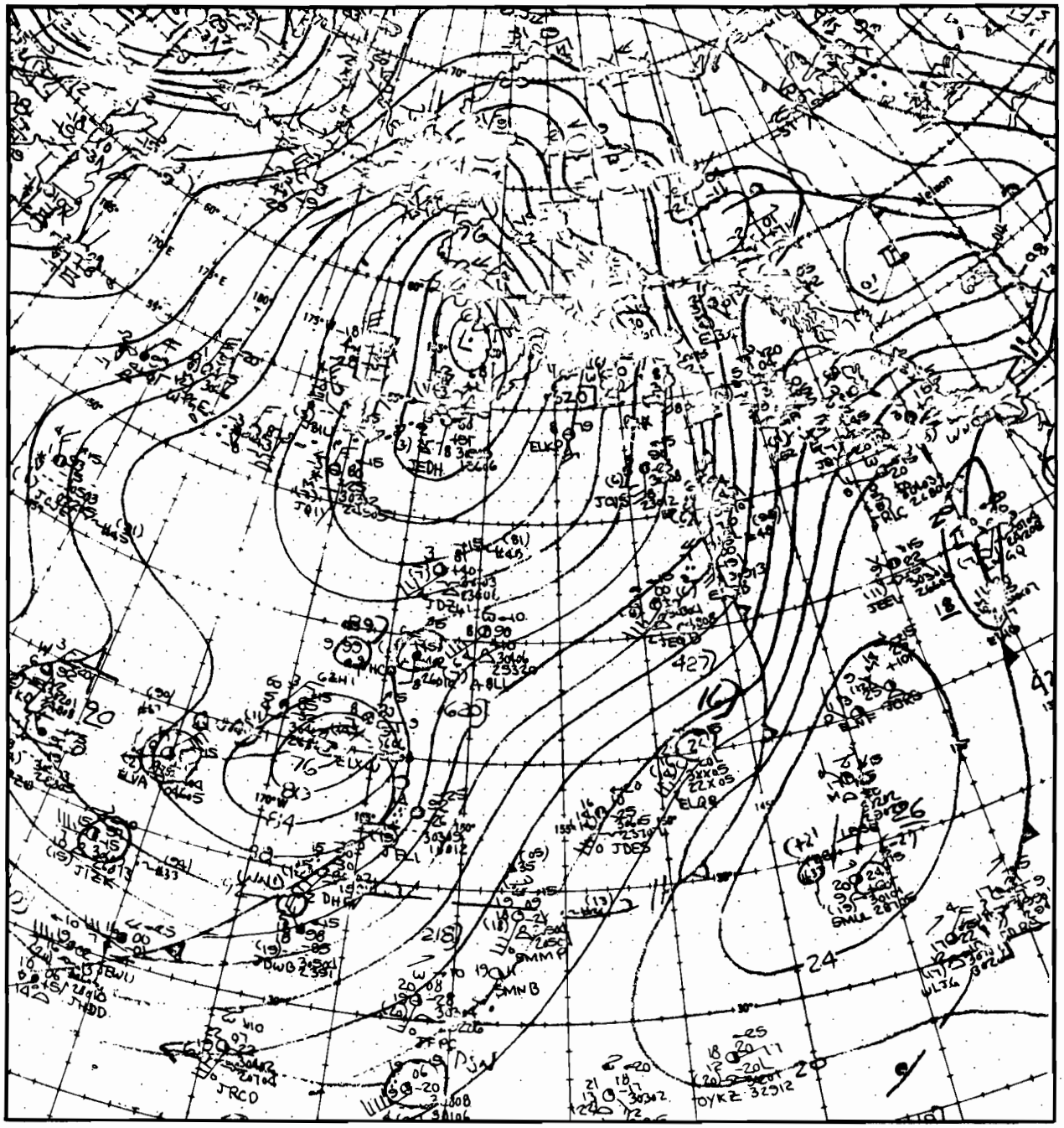

Fig.11e

00GMT 1/29/76

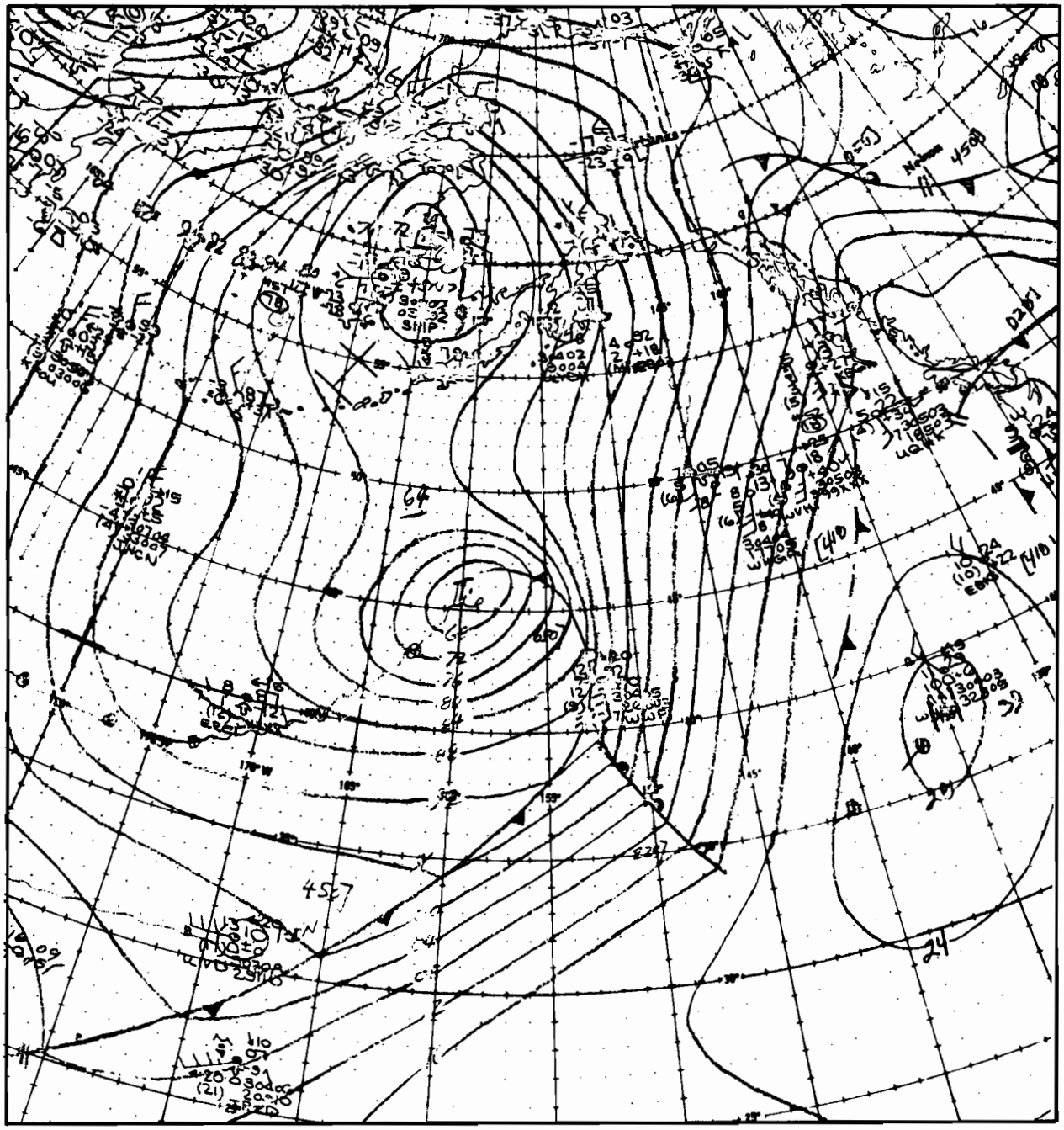

Fig.11f

12GMT 1/29/76

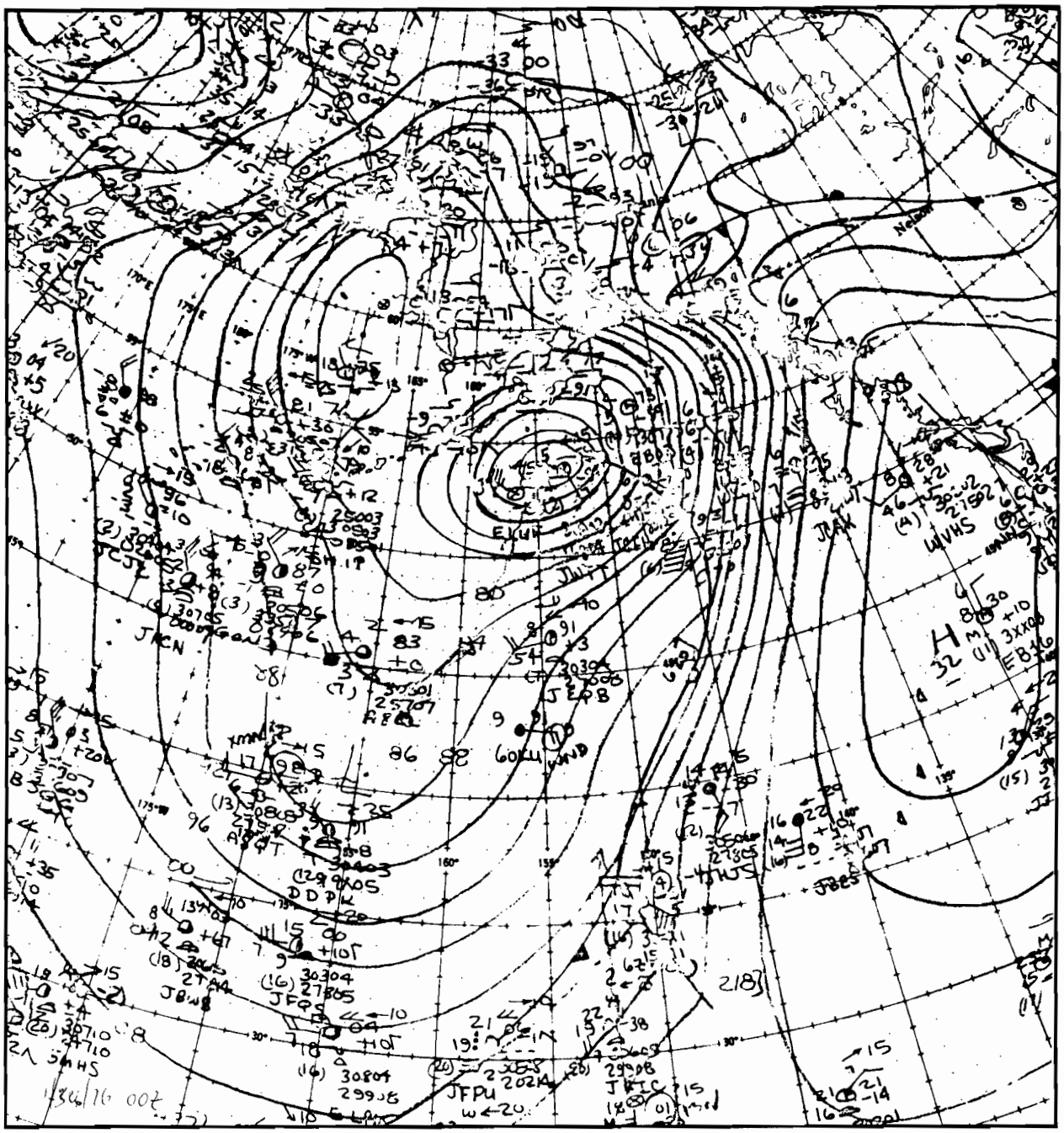

Fig. 11g

00GMT 1/30/76

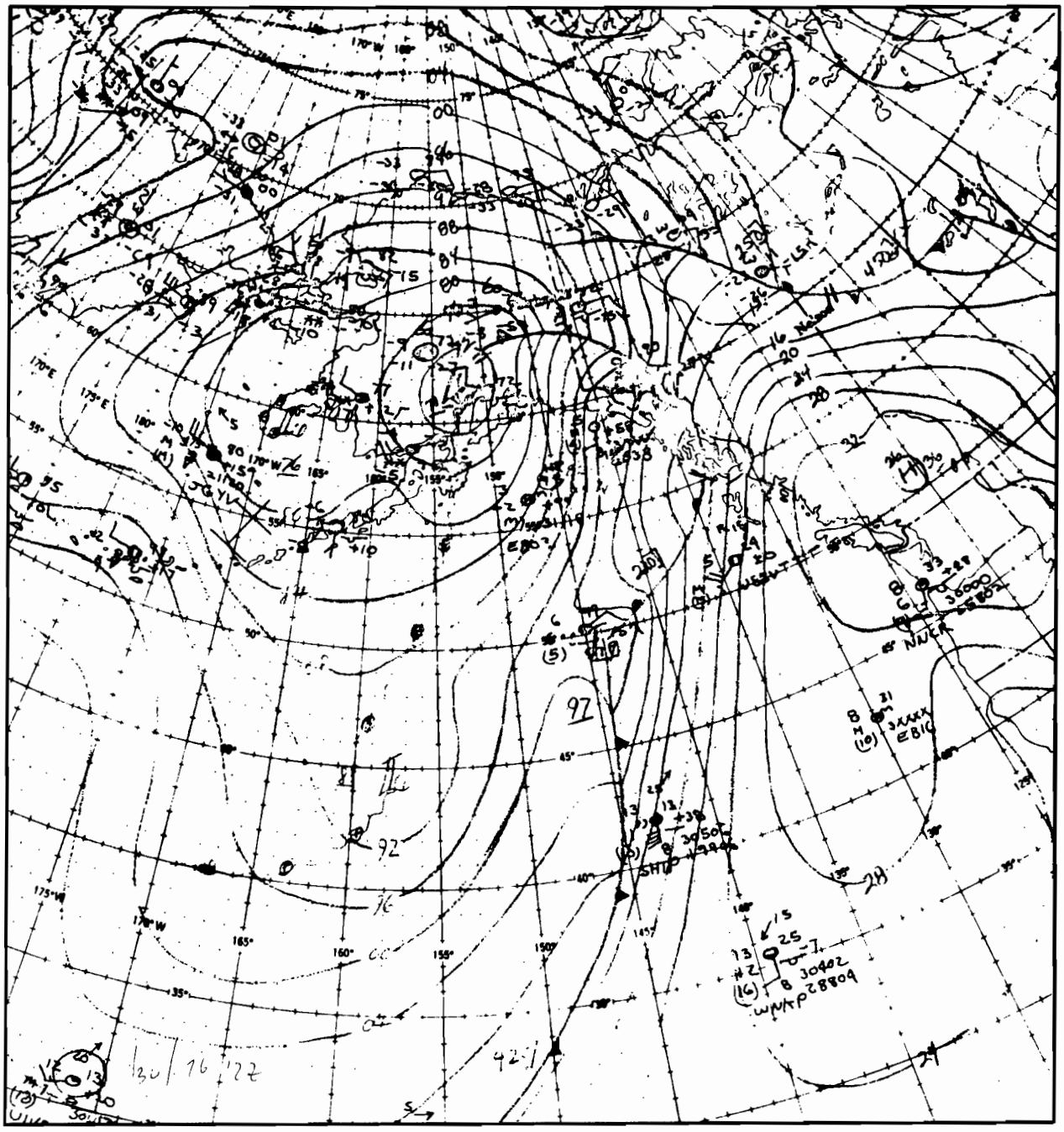

Fig.11h

12GMT 1/30/76

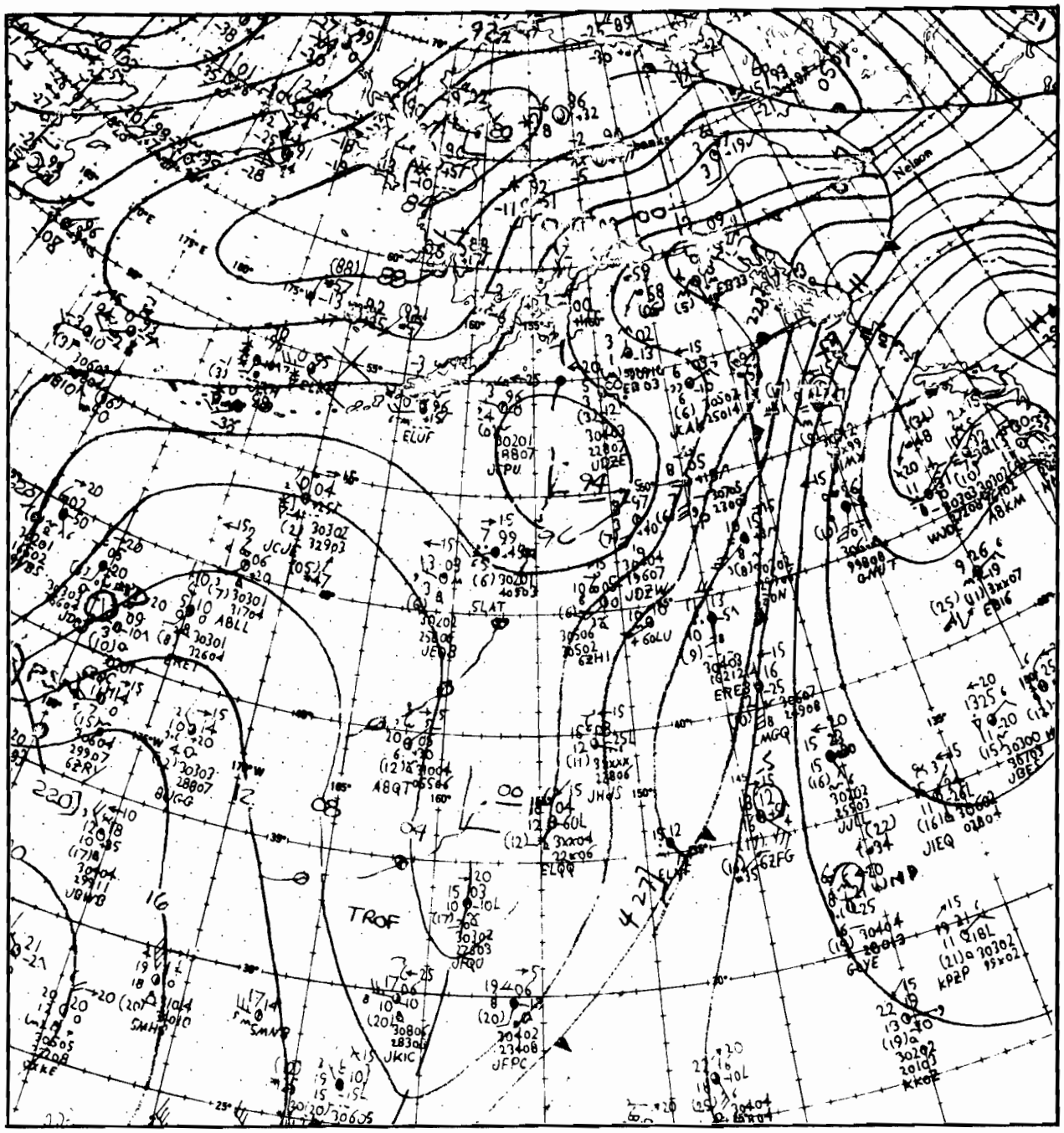

Fig. 11i

00GMT 1/31/76

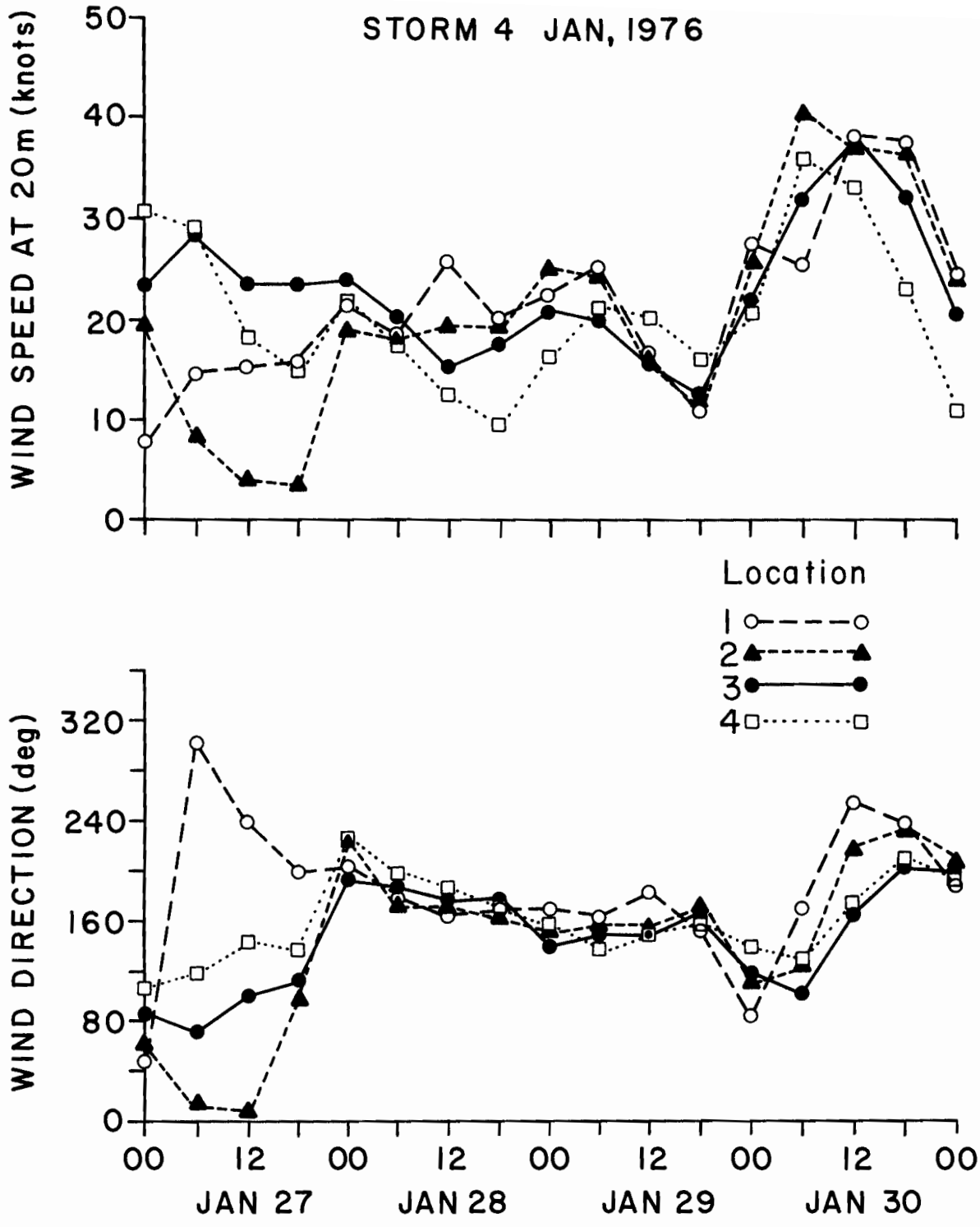
STORM 4 JAN, 1976
WIND SPEED AT 20m (knots)
50
40
30
20
10
0
Location
1
2
3
4
WIND DIRECTION (deg)
320
240
160
80
0
00
12
00
12
00
12
00
12
00
JAN 27
JAN 28
JAN 29
JAN 30

Figure 12

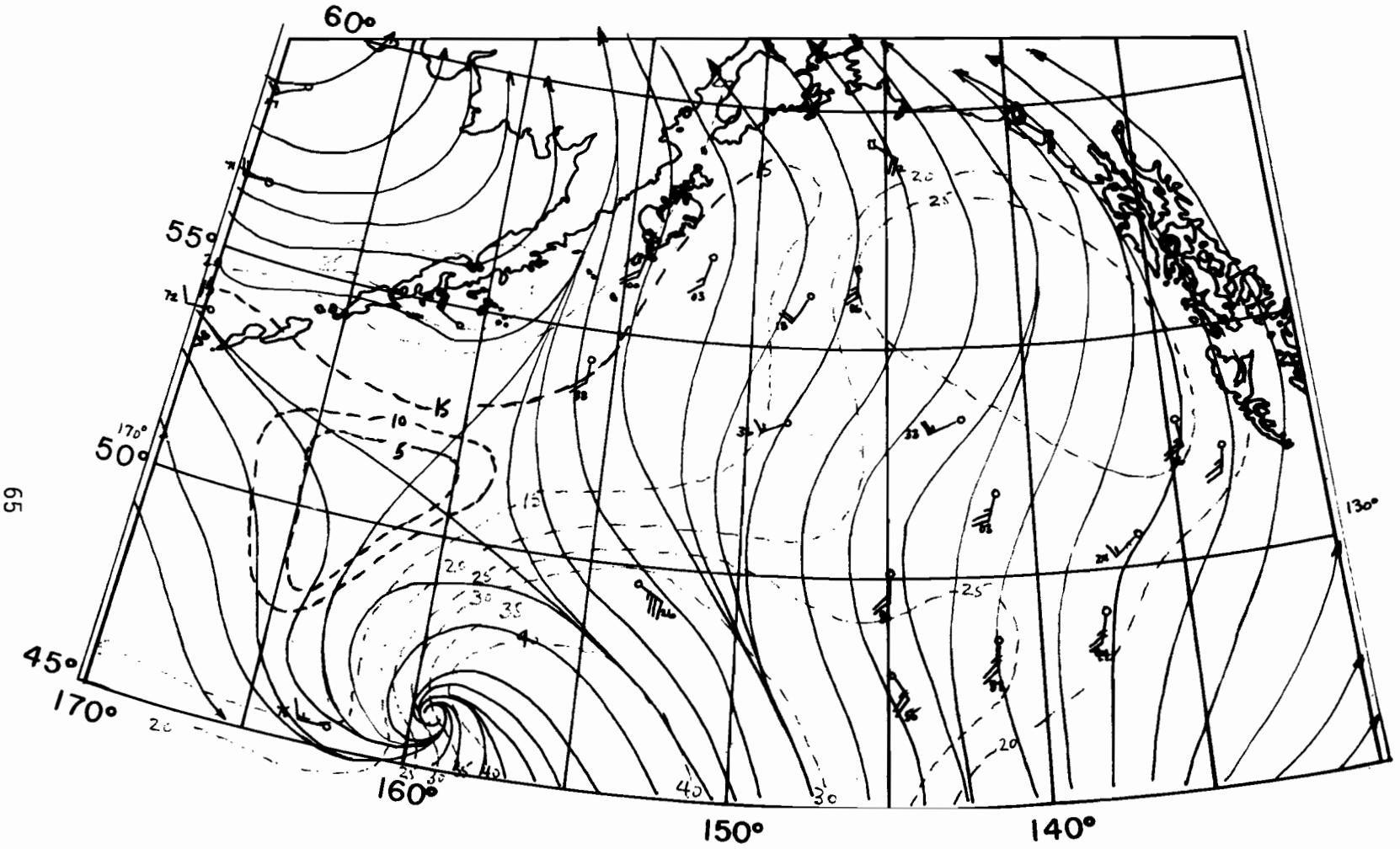

FIGURE 13a
1200 GMT
1/29/76

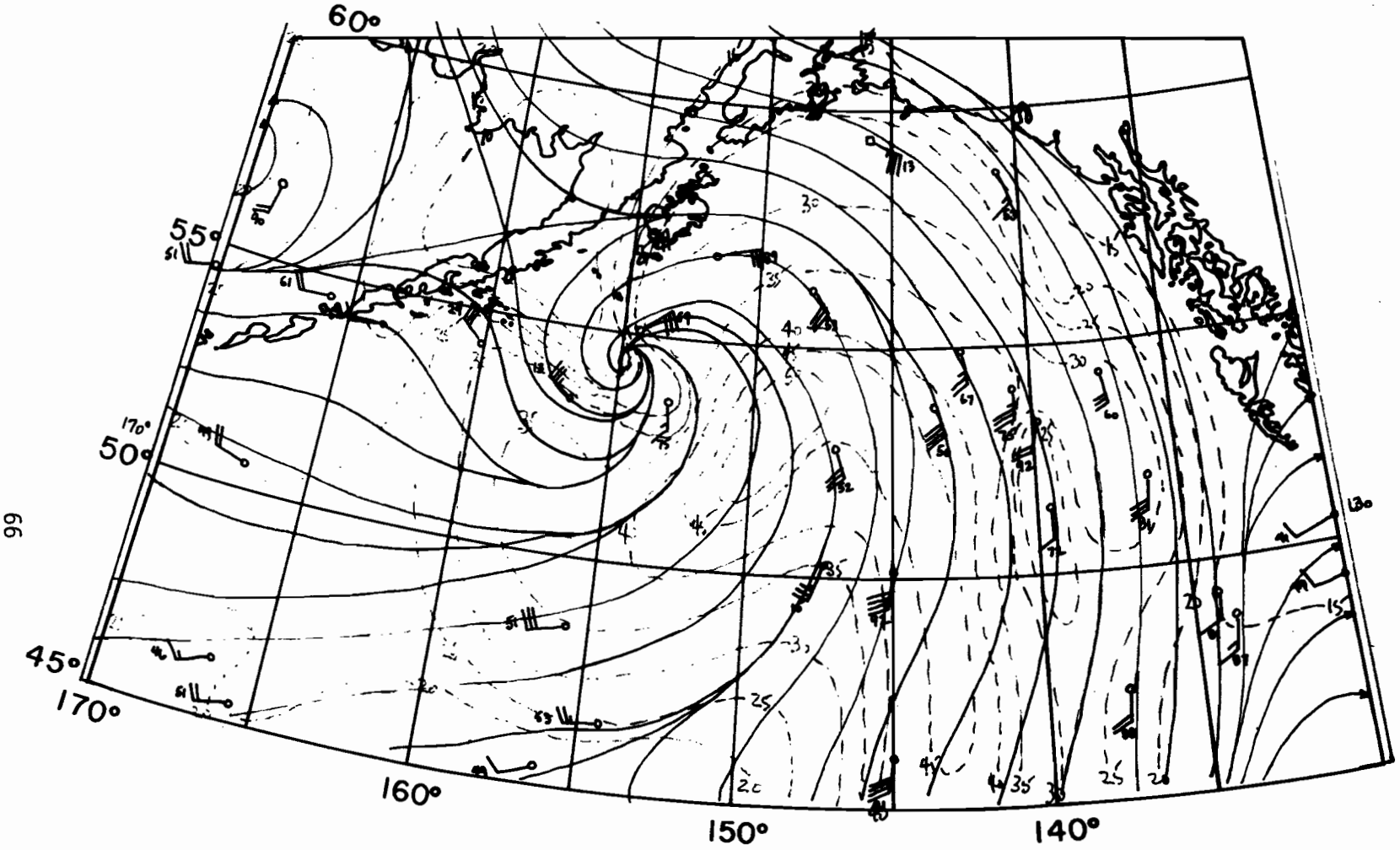

FIGURE 13b
0000 GMT
1/30/76

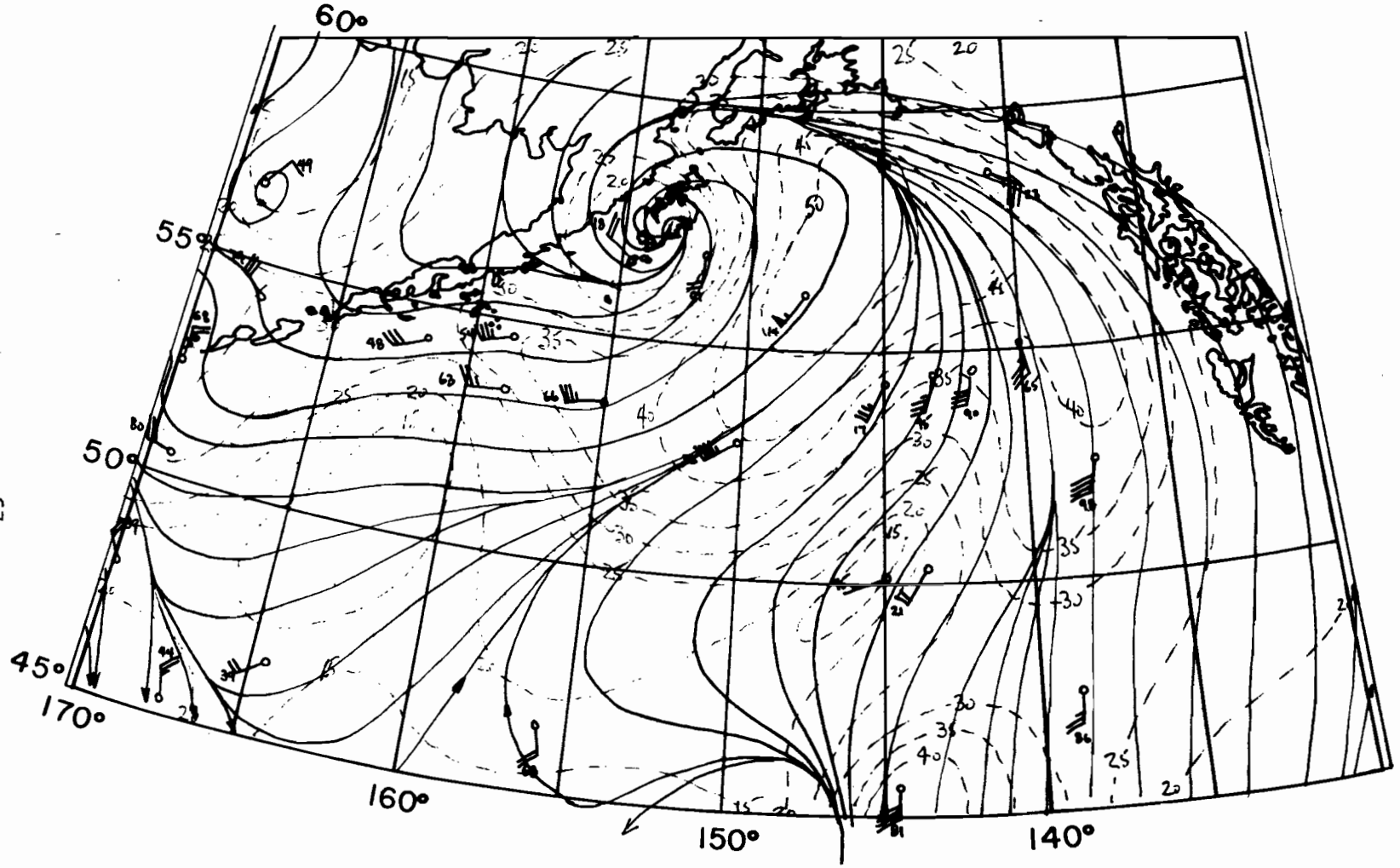

FIGURE 13c
0600 GMT
1/30/76

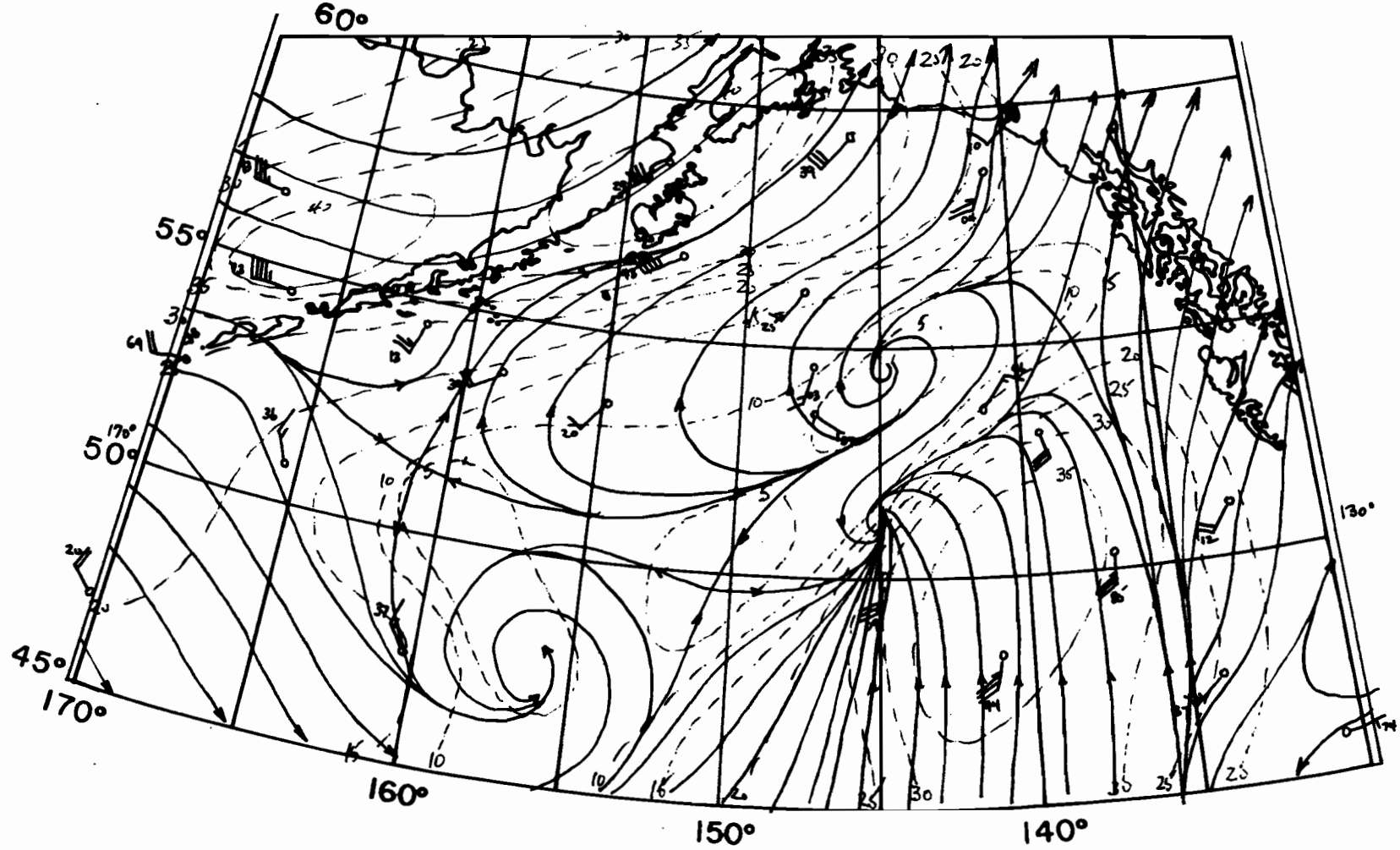

FIGURE 13d
1800 GMT
1/30/76