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FORECASTING A BOMB

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Rapidly deepening cyclones, or bombs, generate high winds that are destructive both on land and at sea. They typically form quite rapidly from rather flat waves. Over the ocean, they are difficult to forecast and can be difficult to even accurately depict on surface analyses (see Sanders, 1990). Numerical models typically underestimate the surface development. Other techniques must be employed to forecast the occurrence of a bomb. Jannuzzi (1985), Sanders (1985), and Lang (1986) discuss some characteristics of rapidly developing oceanic cyclones that can be used to forecast a bomb. The case of February 3-4, 1991 will illustrate how careful diagnosis of these factors can be used to predict such an event.

Long-range numerical surface progs, while inaccurate on timing and location of a bomb, do sometimes forecast a deep low to occur in some long-range projections; giving indication that conditions are ripe for development. However, such was not the case in this episode. An examination of successive NMC's Medium Range Forecast Model 84 hour to 132 hour forecasts verifying at 12Z February 4 (charts not shown) showed low centers of 995-1000 mb, but no deep system. Shorter range forecasts by the RGL and ERL models also failed to indicate that a deep system would develop.

The surface analysis for 18Z February 3 (Fig. 5) showed only a flat wave near 35N/141W. Figures 1, 2, and 3 show the 24-hour surface progs from the ERL, RGL, and AVN models verifying at 12Z February 4. The models forecasted only slight development the first 12 hours and no additional deepening the next 12 hours. The forecasters on duty, courageously and correctly chose to disregard these model scenarios, and predicted a much deeper low. What gave the forecasters the confidence to do so?

The forecasters, aware of conditions common to bomb development, performed careful analysis to assess the potential for rapid deepening. Below is a brief listing of most of the bomb criteria as discussed by Jannuzzi (1985), and the forecasters assessment of them in this situation:

1. Surface Analysis. While few ships were available to provide detailed analysis at 18Z February 3 (Fig. 5), a 977 mb ship report near 35N/145W, behind a frontal wave analyzed by NMC, indicated that the 24-hour model forecasts would not be deep enough unless some mechanism existed to weaken the wave.

2. Warm Advection. No paper copy of the 850 mb prog was available, but the 00Z February 4 850 mb analysis (Fig. 6) shows significant warm advection in the area where the development occurred during the next 12 hours.

3. Available Moisture. The water vapor satellite imagery at 20Z February 3 (Fig. 9) and other infrared images (not shown) indicated ample moisture in the warm sector.

4. Strong Jetstream. The jet analysis (Fig. 7) showed a strong zonal jet along 29N, undercutting a 110 kt jet streak at 41N/139W. While only 110 kt maximums were depicted, these jets were likely stronger in these areas of few AIREPS. Jet progs for 06Z February 4 (not shown) and 12Z February 4 (Fig. 8) depicted a potential for strong upper-level divergence at 45N/130W between the left exit region of the cyclonic jet to the south and the right entrance region of the anticyclonic jet to the north.

5. Satellite Cloud Signatures. The water vapor image (Fig. 9) showed a dark, dry slot forming behind the system. This is indicative of a strong jet and deepening. The infrared image (Fig. 10) showed strong baroclinic support with cold air cumulus feeding in from the northwest quadrant behind the warm, moist signature ahead of the cold front. The "head-cloud" signature is indicative of an intense or deepening low-pressure center.

Figure 4 shows the verifying surface analysis for 12Z February 4. A time series from buoy 46036 (Table 1), which was near the low center, shows the rapid development. Successive 3-hour pressure falls of 13 and 16 millibars occurred between 06Z and 12Z.

Sometimes the "big-ones" can get away, but this bomb was forecasted by the staff. The forecasters explained their reasoning for discounting numerical guidance in the afternoon state forecast discussion, forecasted gale wind conditions in the coastal waters, and issued a high wind watch for the Oregon coast. The watch was later upgraded to a warning on the night shift. The forecaster's recognition of a pattern ripe for rapid development and careful analysis of meteorological parameters resulted in an excellent forecast of wind conditions.

Table 1

BUOY 46036 SA 04/0600 951/47/47/1016G19/ APP 7046
BUOY 46036 SA 04/0900 824/47/47/0727G33/ APP 7127
BUOY 46036 SA 04/1200 658/49/47/1923G29/ APP 7166
BUOY 46036 SA 04/1500 760/46/47/2929G37/ APP 2102

Acknowledgements

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References

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Lange, O., R. Fett, R. Landis, G. Wells, G. Rasch, E. Auciello, M. Horita, and J. Jannuzzi, 1985: Summary of a Workshop/Seminar on Oceanic Storms, 9-13 September 1985, Seattle, Washington. *Bulletin of the American Meteorological Society,* 67, 1272-1277

Sanders, F., 1990: Surface Analysis over the Oceans-Searching for Sea Truth. *Weather and Forecasting,* 5, 596-612

Sanders, F. and E. Auciello, 1985: Explosive Cyclogenesis Checklist, developed for use at Boston WSFO.

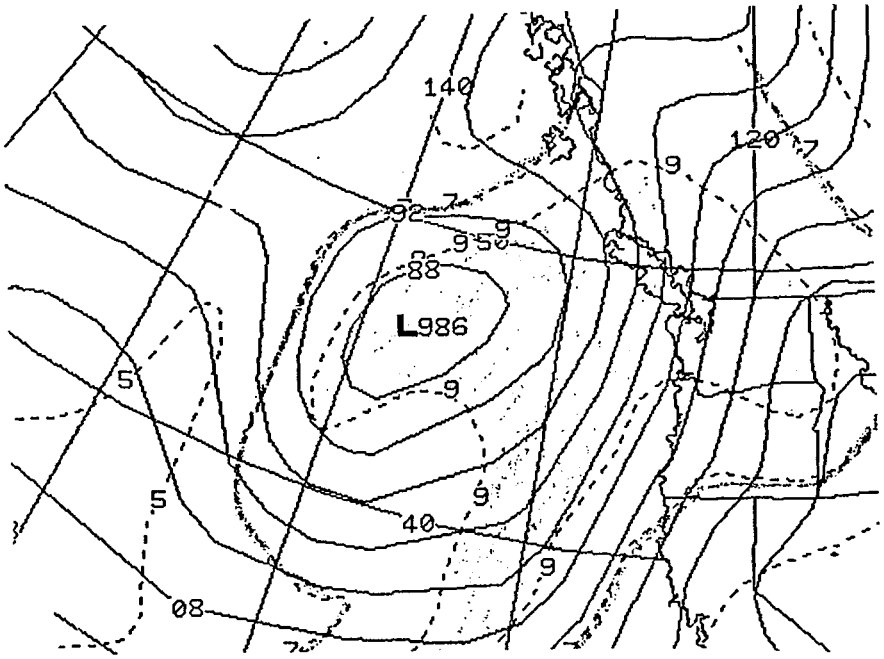

FIG. 1 ERL 24-hour prog valid 2/4/91 12Z

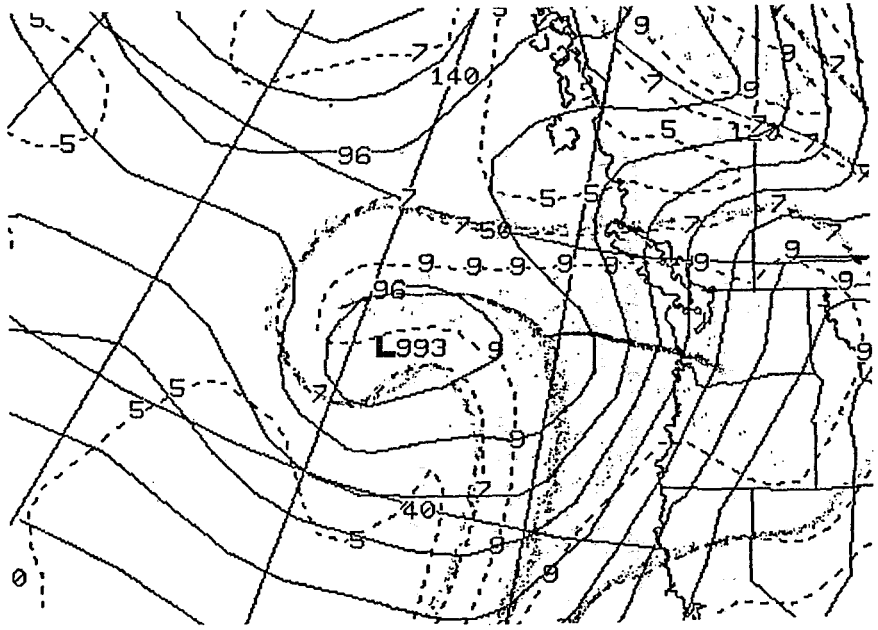

FIG. 2 RGL 24-hour prog valid 2/4/91 12Z

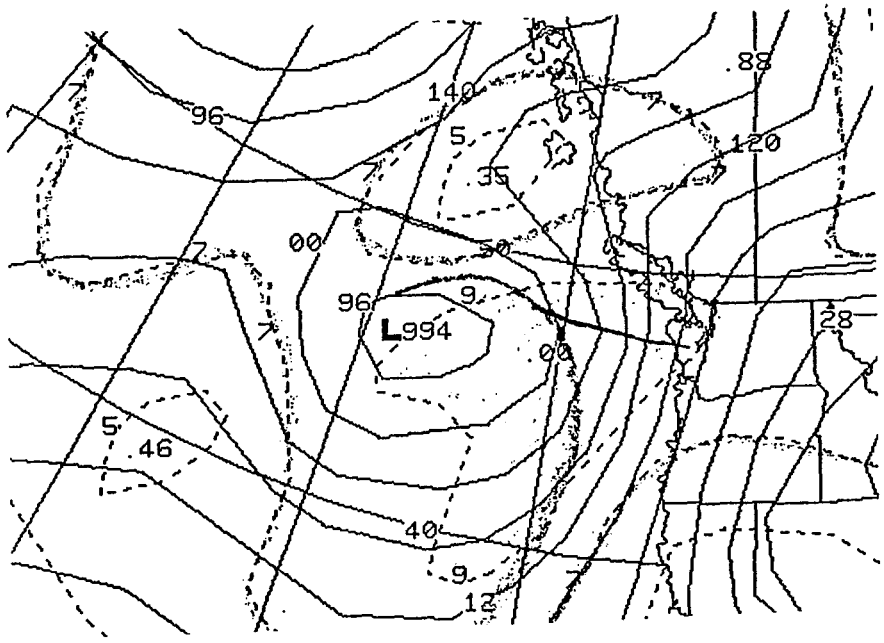

FIG. 3 ANV 24-hour prog valid 2/4/91 12Z

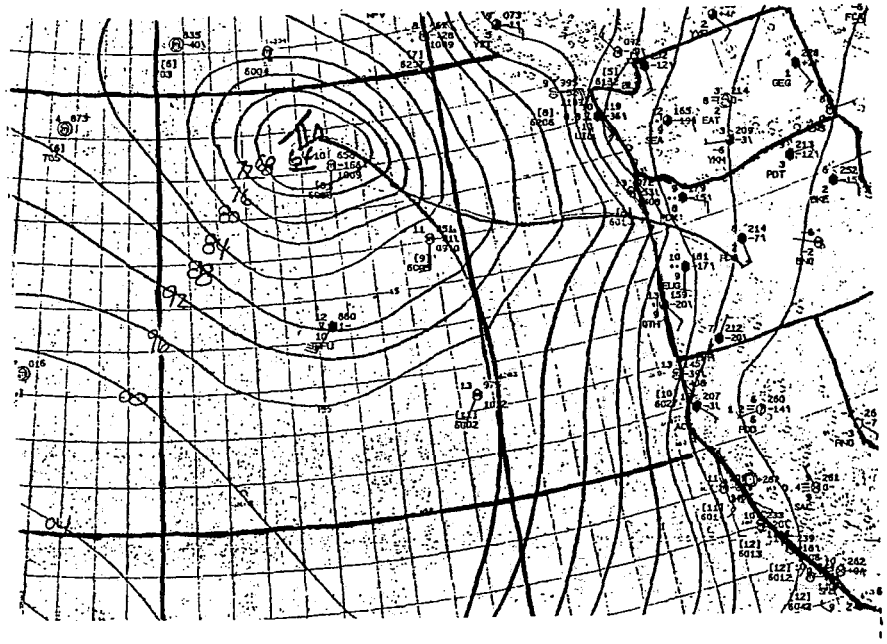

FIG. 4 Surface Pressure - 2/4/91 12Z

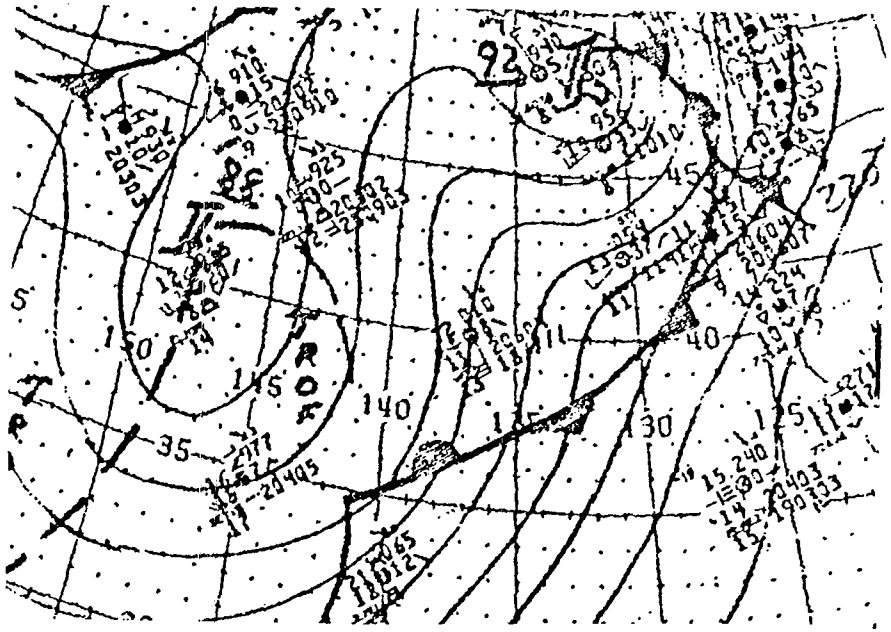

FIG. 5 Surface Pressure - 2/3/91 18Z

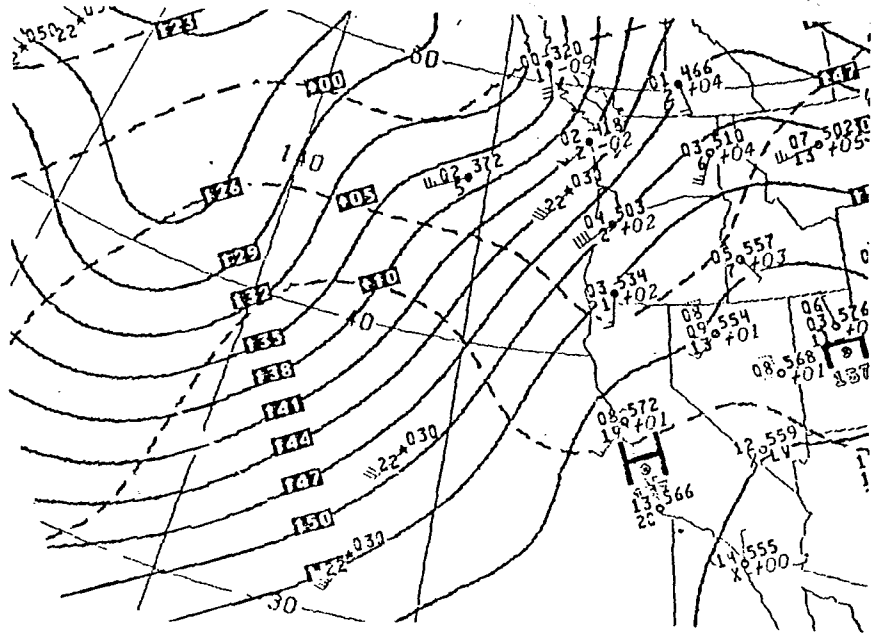

FIG. 6 850mb Analysis 2/4/91 00Z
Heights (solid) and Temperature (dashed)

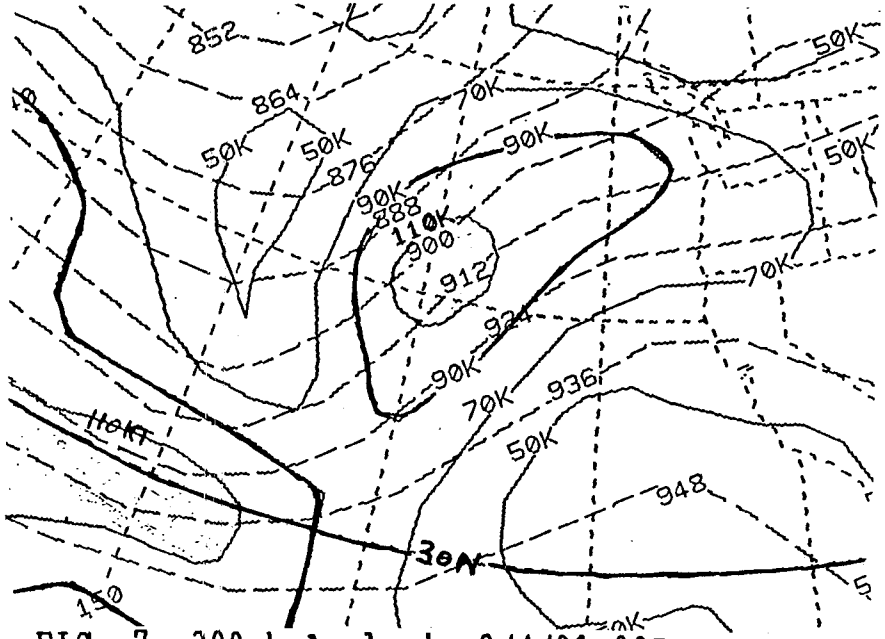

FIG. 7 300mb Analysis 2/4/91 00Z
Isotachs (solid) and Heights (dashed)

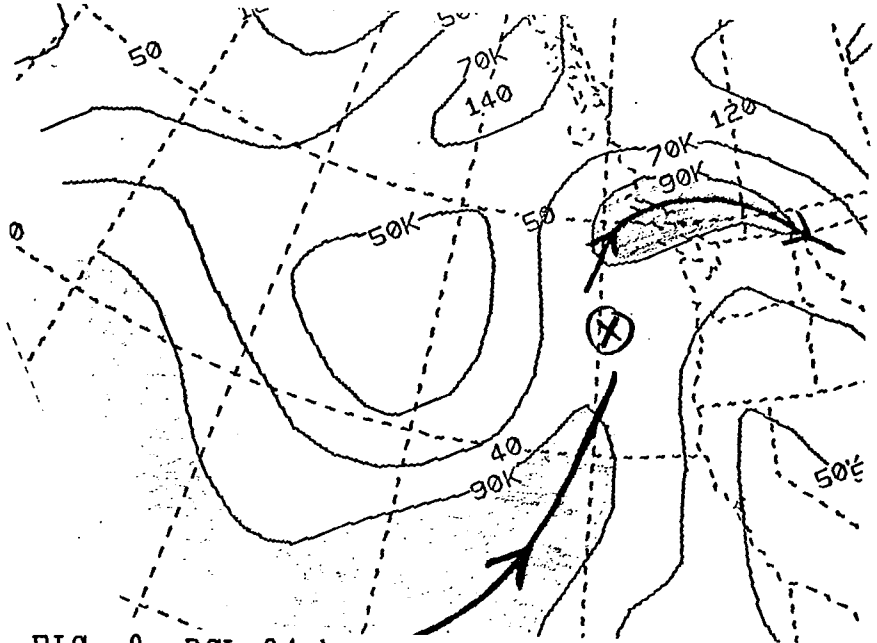

FIG. 8 RGL 24-hour prog valid 2/4/91 12Z
Isotachs (shaded > 90 knots)

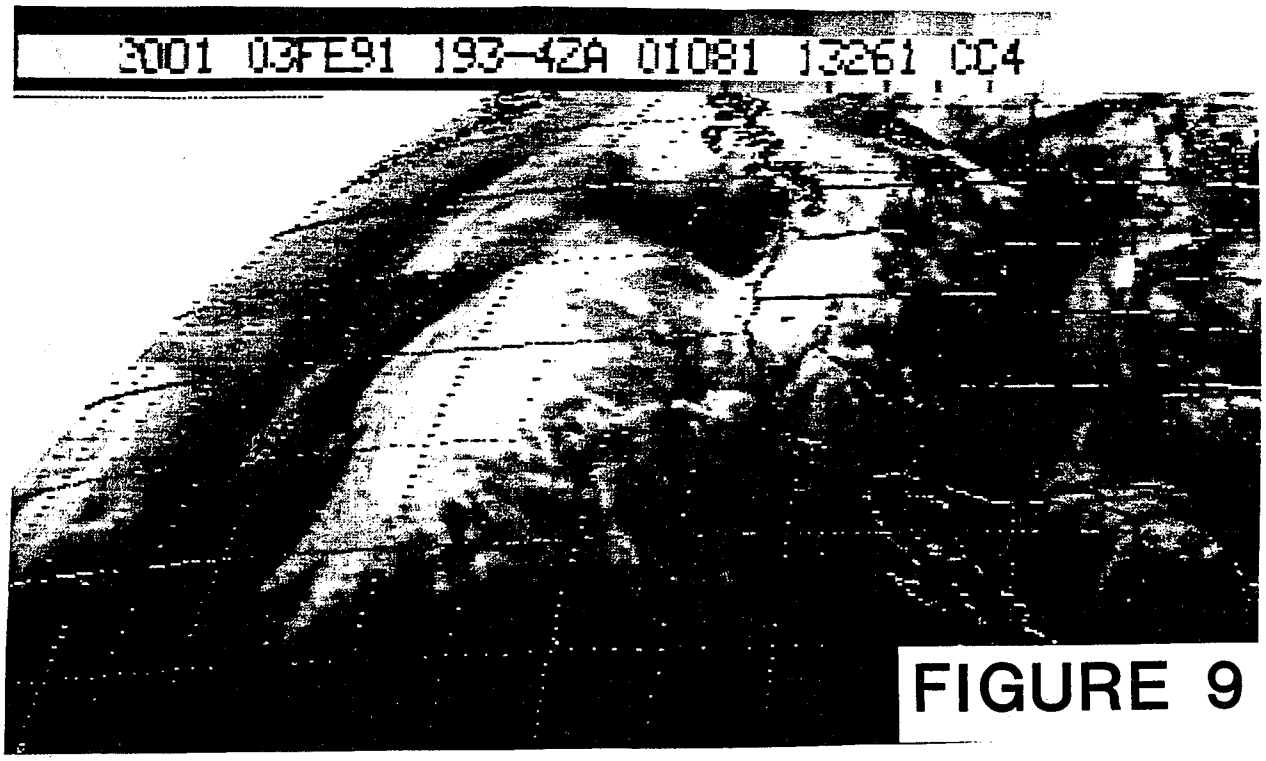

FIGURE 9

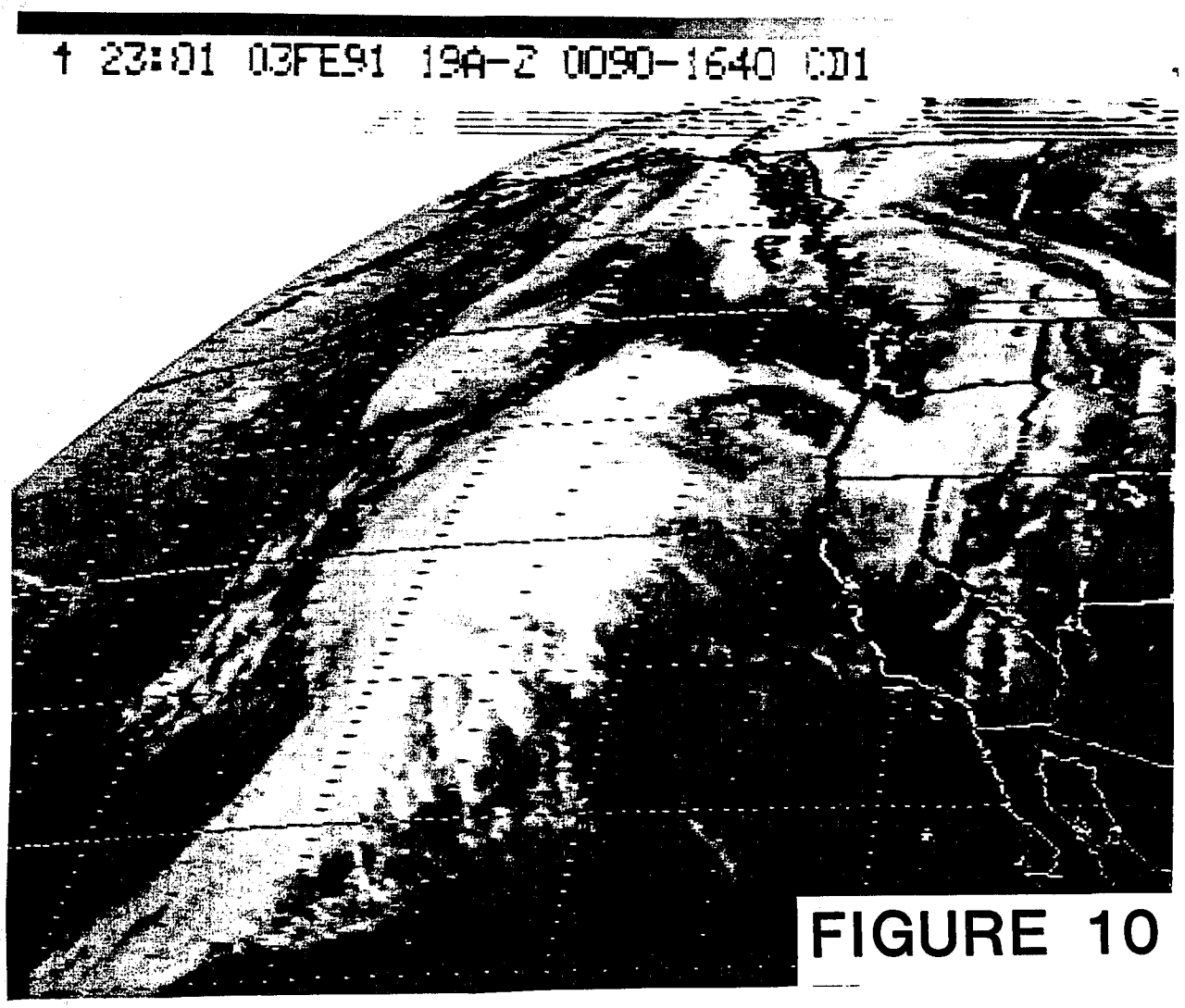

FIGURE 10