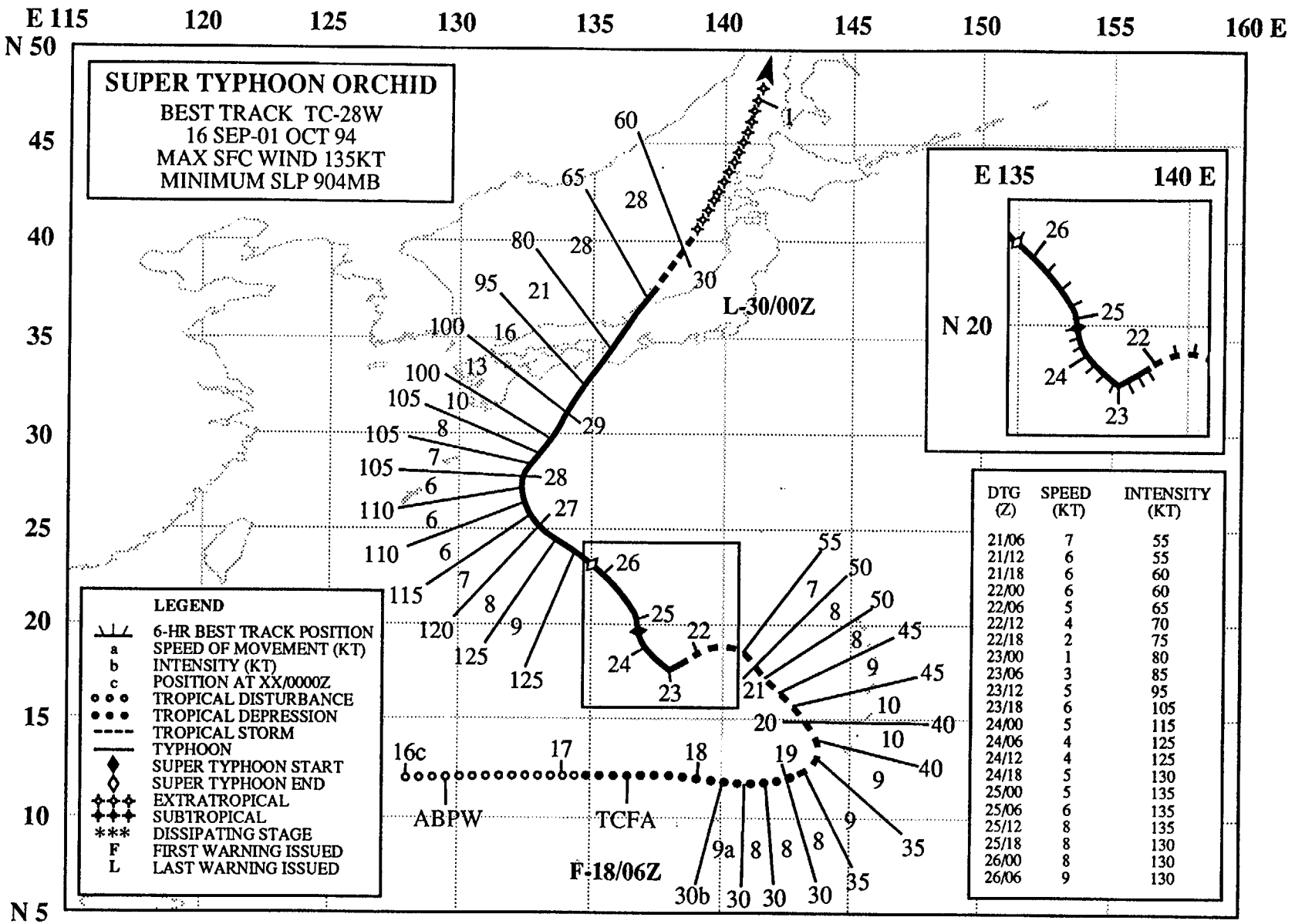


| DTG (Z) | SPEED (KT) | INTENSITY (KT) |
|---|---|---|
| 21/06 | 7 | 55 |
| 21/12 | 6 | 55 |
| 21/18 | 6 | 60 |
| 22/00 | 6 | 60 |
| 22/06 | 5 | 65 |
| 22/12 | 4 | 70 |
| 22/18 | 2 | 75 |
| 23/00 | 1 | 80 |
| 23/06 | 3 | 85 |
| 23/12 | 5 | 95 |
| 23/18 | 6 | 105 |
| 24/00 | 5 | 115 |
| 24/06 | 4 | 125 |
| 24/12 | 4 | 125 |
| 24/18 | 5 | 130 |
| 25/00 | 5 | 135 |
| 25/06 | 6 | 135 |
| 25/12 | 8 | 135 |
| 25/18 | 8 | 130 |
| 26/00 | 8 | 130 |
| 26/06 | 9 | 130 |

# TYPHOON ORCHID (28W)

## I. HIGHLIGHTS

The fifth super typhoon of 1994, Orchid was one of eight tropical cyclones to form during the very active month of September. Orchid underwent unusual motion (e.g., eastward motion at low latitude) that can be attributed to the influence of the large-scale monsoon circulation. Unlike most very intense tropical cyclones, Orchid did not appear to go through a period of rapid intensification. Orchid affected the island of Guam and later, after recurvature, it crossed the Japanese island of Honshu.

## II. TRACK AND INTENSITY

The tropical disturbance that became Orchid was first detected about 100 nm (185 km) east of the Philippine island of Samar, and was mentioned on the 160600Z September Significant Tropical Weather Advisory. The disturbance moved slowly eastward under the influence of deep-layer westerly flow associated with an active monsoon. At 171130Z September, when the disturbance was located about 250 nm (460 km) north-northwest of Yap, a Tropical Cyclone Formation Alert was issued based upon improved organization of deep convection. The first warning was issued on Tropical Depression 28W at 180600Z as the organization of the satellite-observed deep convection continued to improve. The system continued eastward along about 12°N, towards the island of Guam. At 190000Z, Tropical Depression 28W began a turn toward the north. It was upgraded to Tropical Storm Orchid at 191200Z as the system (moving northward) passed 60 nm (110 km) to the west of Guam. During the next 48 hours (191200Z to 211200Z), Orchid moved northwestward at about 6 kt (11 km/hr) and slowly intensified. On the morning of 22 September, the system turned toward the southwest, then 24 hours later it turned back toward the northwest forming a V-shaped notch in its track. Typhoon intensity was first attained at 211800Z based upon its cloud structure as observed by satellite (Figure 3-28-1). During the next three days, Orchid's intensity increased at a normal rate of one "T" number per day, and by 250000Z it reached peak intensity of 135 kt (69 m/sec). After reaching peak intensity, the system accelerated toward the northwest, and slowly weakened (Figure 3-28-2). On 27 September, Orchid slowed its speed of forward motion as it approached its recurvature point. After 271800Z, Orchid turned toward the north-northeast and began to accelerate. At approximately 291000Z, Orchid made landfall on the Pii peninsula of the Japanese main island of Honshu. The eye passed just to the west of the coastal city of Tanabe (WMO 47778), where a minimum pressure of 960.9 mb and a peak gust of 92 kt (47 m/sec) were recorded. A central pressure of 961 mb supports an intensity of 85 kt (44 m/sec) sustained one-minute average wind with gusts to 105 kt (54 m/sec) using the Atkinson and Holliday (1977) wind-pressure relationship. Orchid crossed the mountainous island of Honshu at a forward speed of nearly 25 kt (46 km/hr) and entered the Sea of Japan as a minimal typhoon. On the afternoon of 30 September, Orchid passed over western Hokkaido with sustained winds of 55-60 kt (28-31 m/sec). On the evening of 01 October, the system dissipated over Sakhalin Island, at a latitude poleward of 50°N.

## III. DISCUSSION

### a. Monsoonal influences on Orchid's motion

From 160000Z (when Orchid was first detected) until 190600Z (when Orchid reached minimal tropical storm intensity), the system moved eastward more than 800 nm (1480 km). This unusual motion was the result of relatively deep westerly monsoon flow along the band of deep convection associated with a reverse-oriented monsoon trough that was connected to the major rain band on the south side of

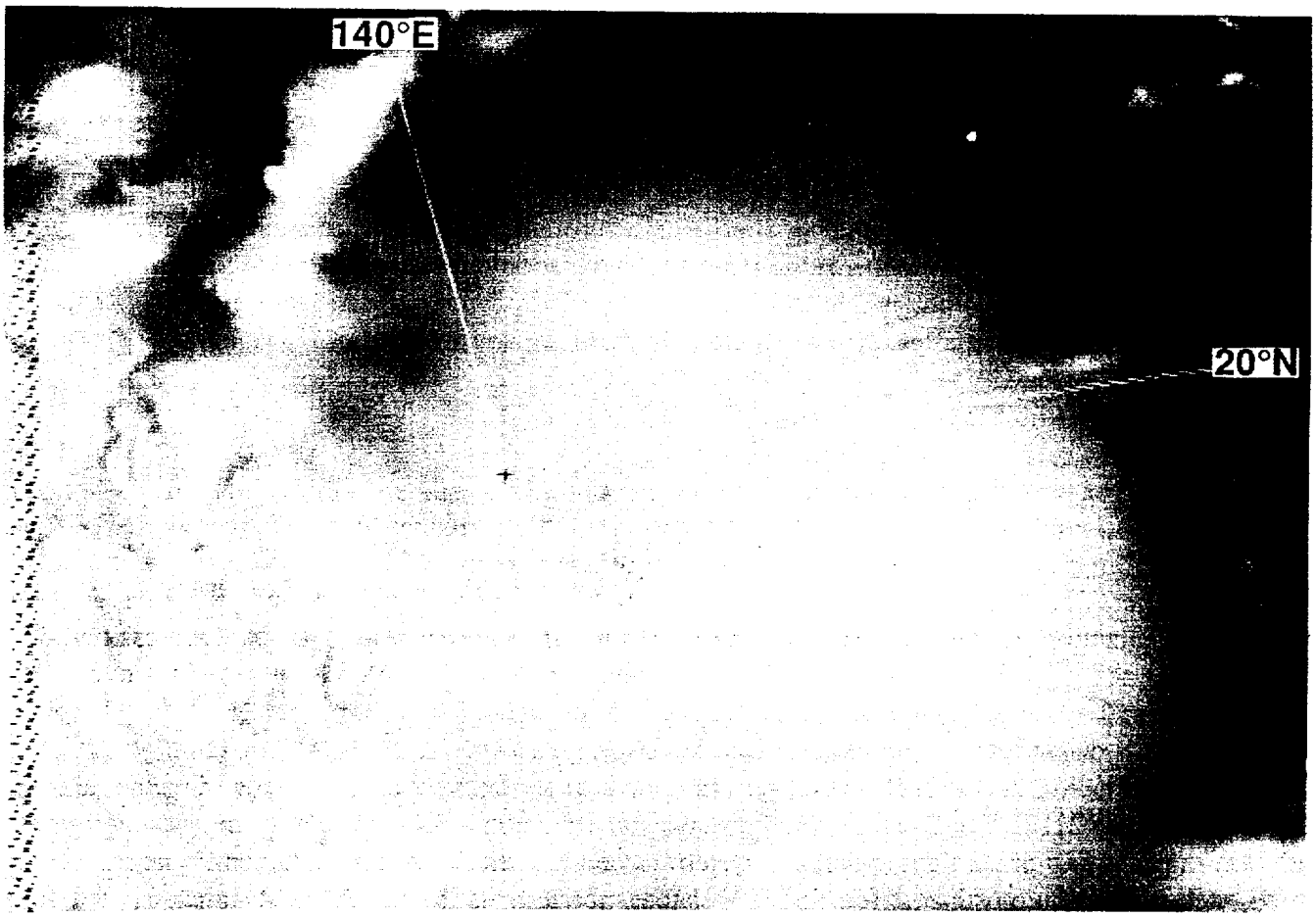


**Figure 3-28-1** Orchid at 60 kt (31 m/sec) intensity at a location about 400 nm (750 km) northwest of Guam (212331Z September visible GMS imagery).

Melissa (26W). When Orchid reached about 142°E, it turned sharply to the north, passing 60 nm (110 km) west of Guam. After passing Guam, Orchid turned to the northwest. On 22 September, it turned abruptly to the southwest for 18 hours, then stalled and headed to the northwest, tracing a "V" shape.

The character and evolution of the mid-tropospheric subtropical ridge and the midlatitude disturbances passing poleward of this ridge have long been cited as the causative agents of the behavior of storms in most post analyses (e.g., Matsumoto 1984; Sandgathe 1987; and past ATCRs issued by the JTWC). Other factors deemed to be of importance to TC motion in the WNP include: binary interaction (Brand 1970, Dong and Neumann 1983, and Lander and Holland 1993), and the effects of the large-scale monsoon circulation (Harr and Elsberry 1991, Lander 1994a, and Carr and Elsberry 1994). The effects of the monsoon circulation on tropical cyclone motion have recently been receiving more attention.

A plausible explanation for the erratic "V" motion of Orchid is a monsoonal effect described by Carr and Elsberry (1995). They studied the properties of the motion of a tropical cyclone that resulted from the interaction between the tropical cyclone and a larger-sized "monsoon gyre" located to its north or west. The tropical cyclone undergoes about 180° of a counter-clockwise orbit around the gyre, and the two systems approach. Eventually the tropical cyclone merges with the gyre. Upon merger, the track abruptly changes to a steady northwestward drift (Figure 3-28-3). This theoretical motion and the actual

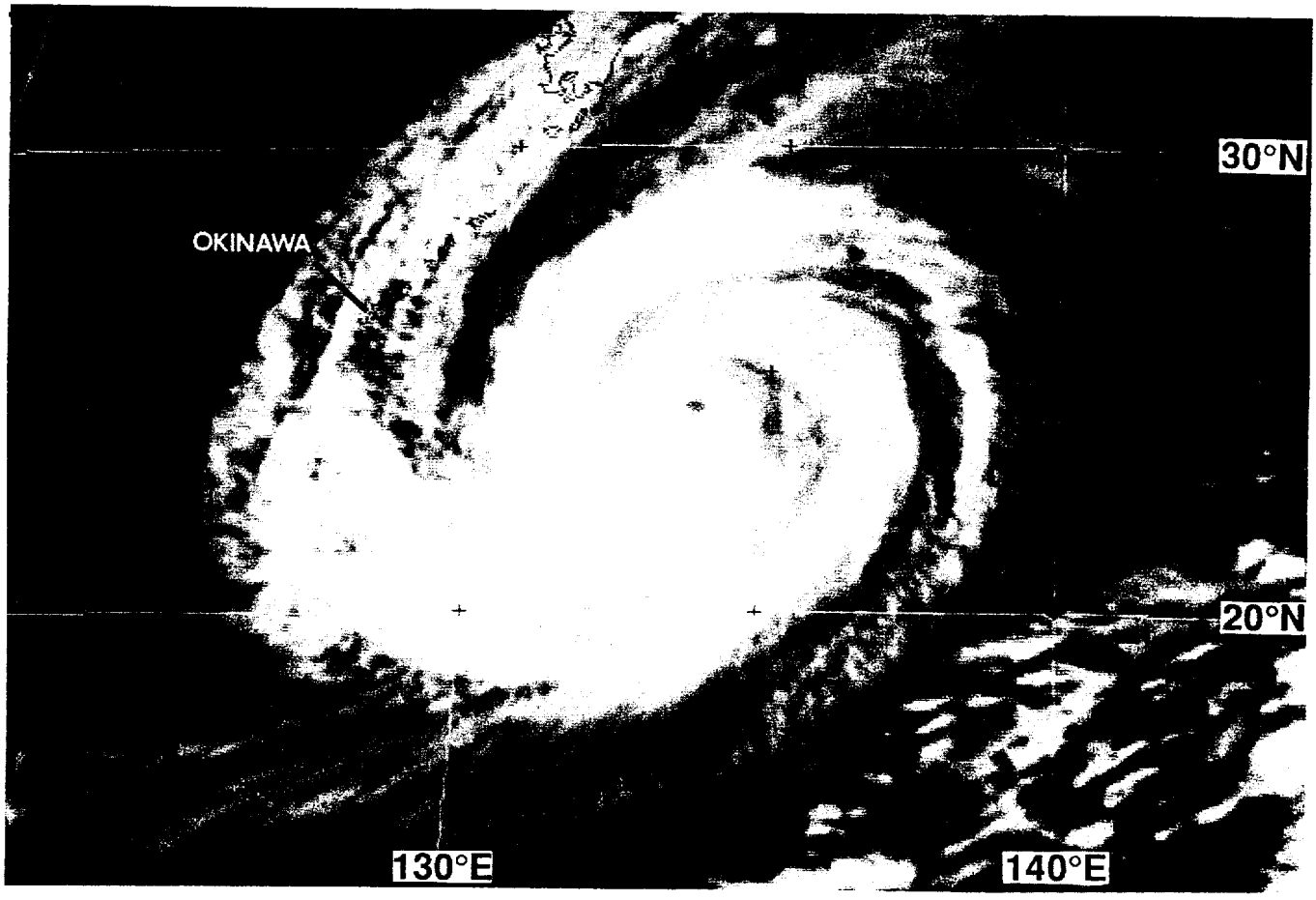


**Figure 3-28-2** Orchid's intensity is 115 kt (59 m/sec) as it nears its point of recurvature (261538Z September infrared GMS imagery).

motion of Orchid are similar. Although Orchid was embedded in a reverse-oriented monsoon trough, there was, at the time of its "V" motion, a separate low-pressure area to its west (Figure 3-28-4a) with which Orchid could conceivably have orbited and merged (Figure 3-28-4b).

b. Changes in eye size during intensification

Orchid was the third super typhoon — the two others were Fred (17W) and Doug (19W) — that exhibited changes in the size of the eye that were contrary to those normally expected during the intensifying and weakening phases of a typhoon's life cycle. Orchid's eye expanded during the intensification period and it shrank during the weakening phase (see Figure 3-28-1). The changes in the size of Orchid's eye were not as dramatic as those that occurred with Doug (17W) or Fred (19W), but in each case, the changes were contrary to those expected.

IV. IMPACT

Orchid spent most of its life at sea. During its brush past Guam as a tropical storm, Orchid caused some local flooding. A peak gust of 46 kt (24 m/sec) was recorded at the JTWC. Orchid's passage over central Japan helped to alleviate a two-month drought which in some areas had left reservoirs dry. No reports of casualties or damage were received, however Orchid forced the cancellation of 400 international and domestic flights across Japan, and stopped the operation of over 100 ferry routes.

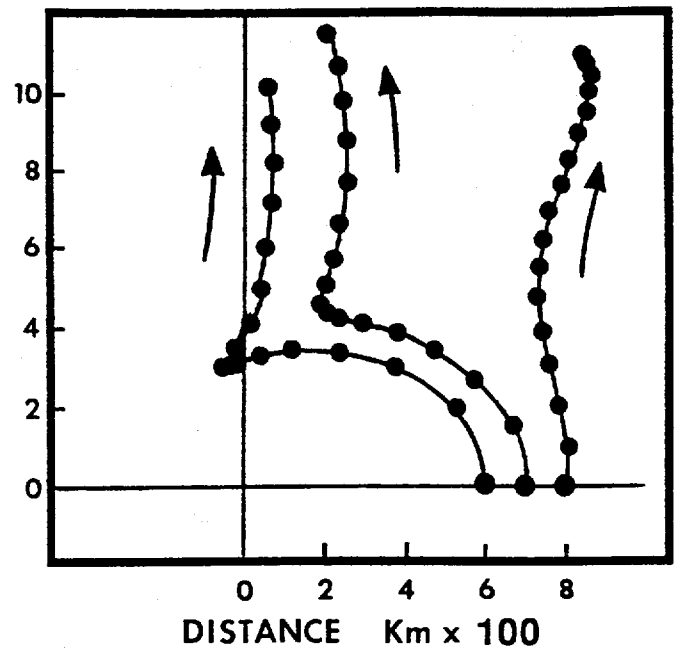


**Figure 3-28-3** Typical track changes associated with the interaction of a tropical cyclone with a monsoon gyre. Dots show positions at six-hour intervals for 96 hours of the simulated tracks of three tropical cyclones placed at 600, 700, and 800 km respectively east of the center of a monsoon gyre. (Figure adapted from Carr and Elsberry, 1995.)

**Table 3-28-1** Changes in the size of Orchid's eye diameter during the period when a well-defined eye was visible.

| DATE/TIME (Z) | BEST-TRACK INTENSITY (kt) | EYE DIAMETER (nm) |
|---|---|---|
| 23/00 | 80 | 26 |
| 23/06 | 85 | 17 |
| 23/12 | 95 | 18 |
| 23/18 | 105 | 17 |
| 24/00 | 115 | 16 |
| 24/06 | 125 | 14 |
| 24/12 | 125 | 18 |
| 24/18 | 130 | 14 |
| 25/00 | 135 | 21 |
| 25/06 | 135 | 18 |
| 25/12 | 135 | 11 |
| 25/18 | 130 | 19 |
| 26/00 | 130 | 23 |
| 26/06 | 130 | 30 |
| 26/12 | 125 | 26 |
| 26/18 | 125 | 22 |
| 27/00 | 120 | 22 |
| 27/06 | 115 | 13 |
| 27/12 | 110 | 11 |
| 27/18 | 110 | 14 |
| 28/00 | 105 | 12 |
| 28/06 | 105 | 17 |
| 28/12 | 105 | 14 |
| 28/18 | 100 | 14 |
| 29/00 | 100 | 9 |

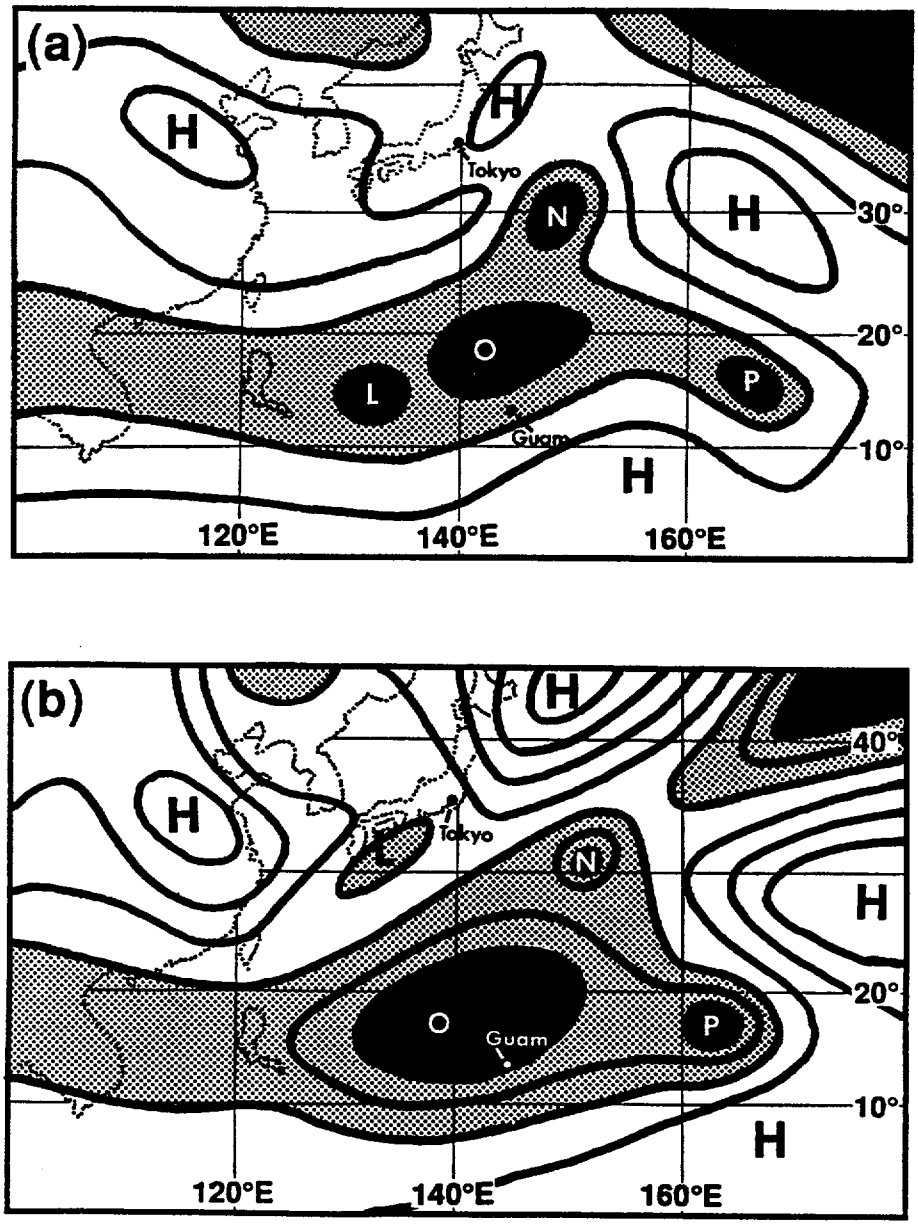


**Figure 3-28-4** (a) Sea-level pressure (SLP) analysis at 210000Z October showing the location of Orchid in the monsoon trough. A low-pressure area to the west of orchid, labeled, L, may possibly have interacted with Orchid to cause Orchid's unusual southwestward motion which began at about this time. Key: Shaded regions are lower than 1010 mb, black regions are lower than 1008 mb. O = Orchid, N = Nat (27W), P = Pat (29), L = low-pressure area, and H = high pressure area. Contours are at 2 mb intervals. (b) SLP analysis at 231200Z October showing that Orchid has merged with the low-pressure area previously to its west. At this time, Orchid turned towards the northwest. Key: same as in (a) except that the black regions are lower than 1006 mb.