2. THE PERSISTING CLOUDBAND OVER THE CENTRAL SOUTH PACIFIC IN NOVEMBER 1969

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The monthly maps of average cloudiness based on satellite cloud photographs taken in 1965 and 1966, presented by Sadler (1968), exhibit a zone of maximum cloudiness over the tropical and subtropical regions of the central South Pacific. This zone of maximum average cloudiness is the consequence of a persistent major cloudband in this region (Streten, 1970). Hubert (1961) studied one of these cloudbands when it lay over the subtropical region, and found that it was associated with an asymptote of confluence in the surface streamline analysis. He could not find a cyclonic shear of significant magnitude along the convergence line, and concluded "that the evolution of the system had passed through the frontal stage and even the shear line characteristic was dissipating". Sadler's maps also reveal a large area of minimum average cloudiness throughout the year over the equatorial and tropical regions of the eastern Pacific Ocean, for which Bjerknes (1969) suggested that the relatively cold surface temperature of the eastern Pacific Ocean was responsible.

The movement and behaviour of the central Pacific cloudband during the month of November 1969 has therefore been examined using the digital cloud mosaics (ESSA 9) for the period 2 to 30 November.

(a) General Characteristics of the Cloudband

One and occasionally two major cloudbands were observed over the tropical and subtropical regions of the central Pacific Ocean in the daily cloud mosaics. In general the northern part of the cloudband was aligned along a W-E or WNW-ESE direction and the southern part in a direction between N-S and NW-SE. On some occasions the cloudband lay wholly along a W-E direction, whilst on others it had a N-S or NW-SE orientation. Often during the month the southern part of the major cloudband curved westwards to form a cloud vortex between 25° and 40°S, or a relatively thin "finger cloud" spiralled out of the major cloudband and curved in a variety of cloud vortex patterns. Most of the time during the month the cloudband formed an entity of its own, but on occasions it was connected to a frontal band of the middle and high latitudes. The satellite cloud pictures indicate that the shape, position and width of the cloudband, as well as the intensity of convective activity within it, varied widely from day to day.

(b) Movement of the Major Cloudband

Isochrones representing the daily position of the southern and western boundaries of the W-E and N-S oriented parts of the major cloudbands respectively (neglecting the relatively thin "finger clouds"), are shown between 10° and 40°S in Fig 2.1, 2.2, and 2.3 for the periods 2 to 10, 11 to 20, and 21 to 30 November, 1969, respectively. Two major cloudbands were evident on each day between 2 to 6, and 19 to 30 November.

Examination of the isochrones reveals that the northern, W-E oriented, part of the cloudband moved irregularly, sometimes northwards and sometimes southwards, whilst the NW-SE oriented part of the cloudband also moved irregularly, either to the east or to the west.

The longitude of intersection between each isochrone and the latitude parallels 25, 30 and 40°S, when the band was N-S or NW-SE in orientation is shown as a time section in Fig 2.4, together with the intensity of convective activity within the cloudband between 25 and 30°S, according to the following code

A - intense convective activity

B - weak convective activity

C - the cloudband became disorganised or was dissipating.

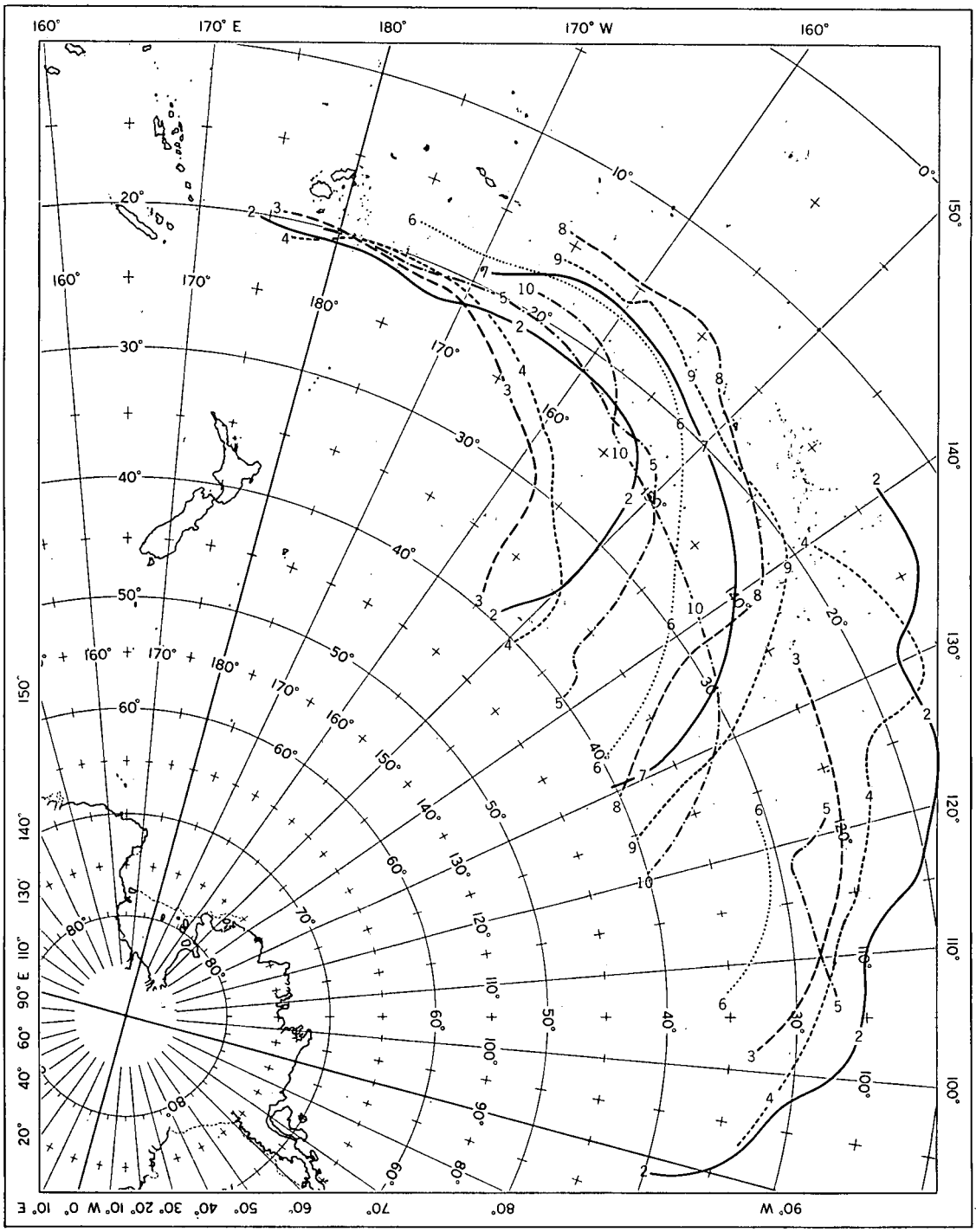

Fig 2.1 Isochrones of the daily position of the southern and western boundaries of the major cloud bands in the South Pacific Ocean for the period 2-10 November 1969.

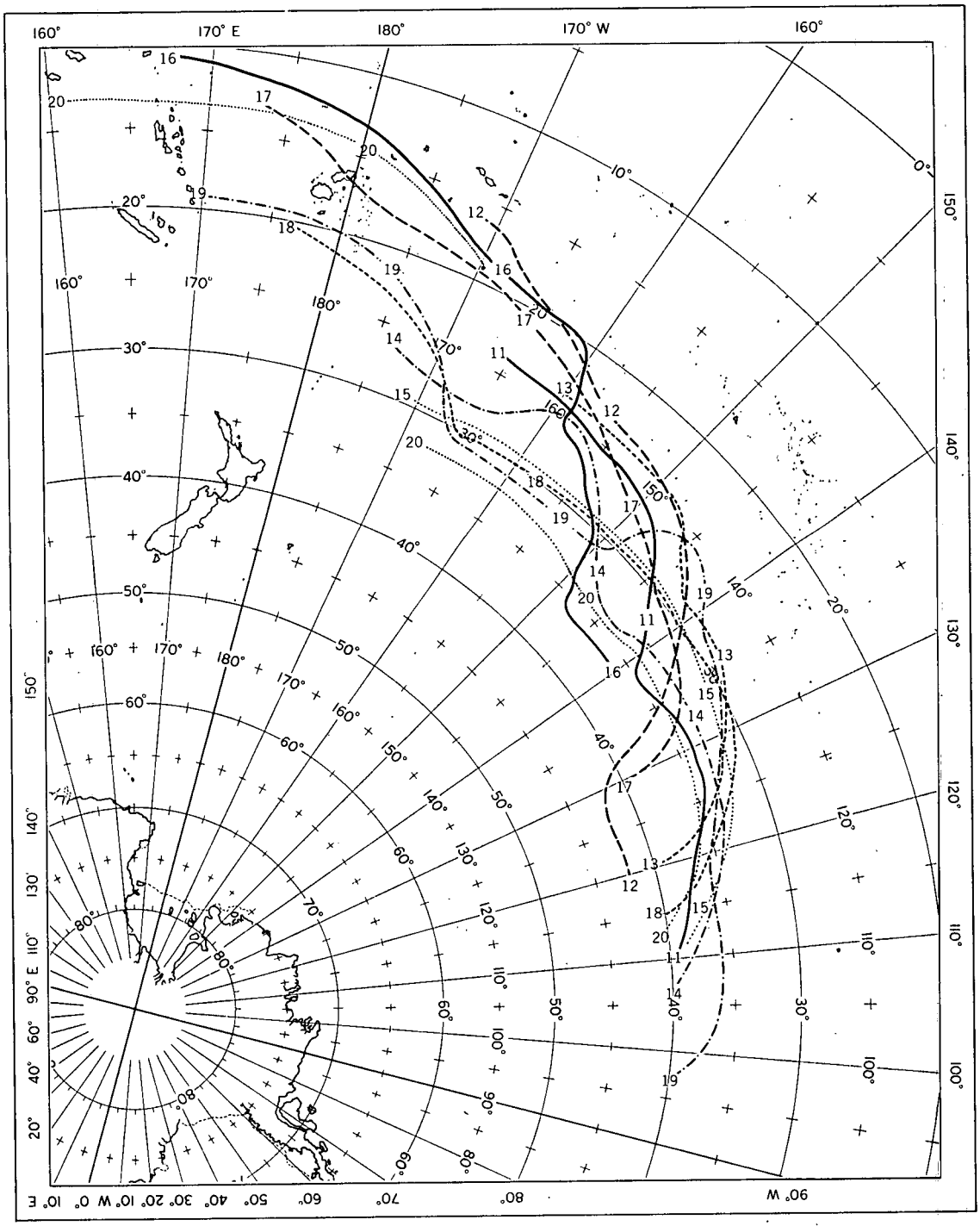

Fig 2.2 Isochrones of the daily position of the southern and western boundaries of the major cloud bands in the South Pacific Ocean for the period 11 - 20 November 1969.

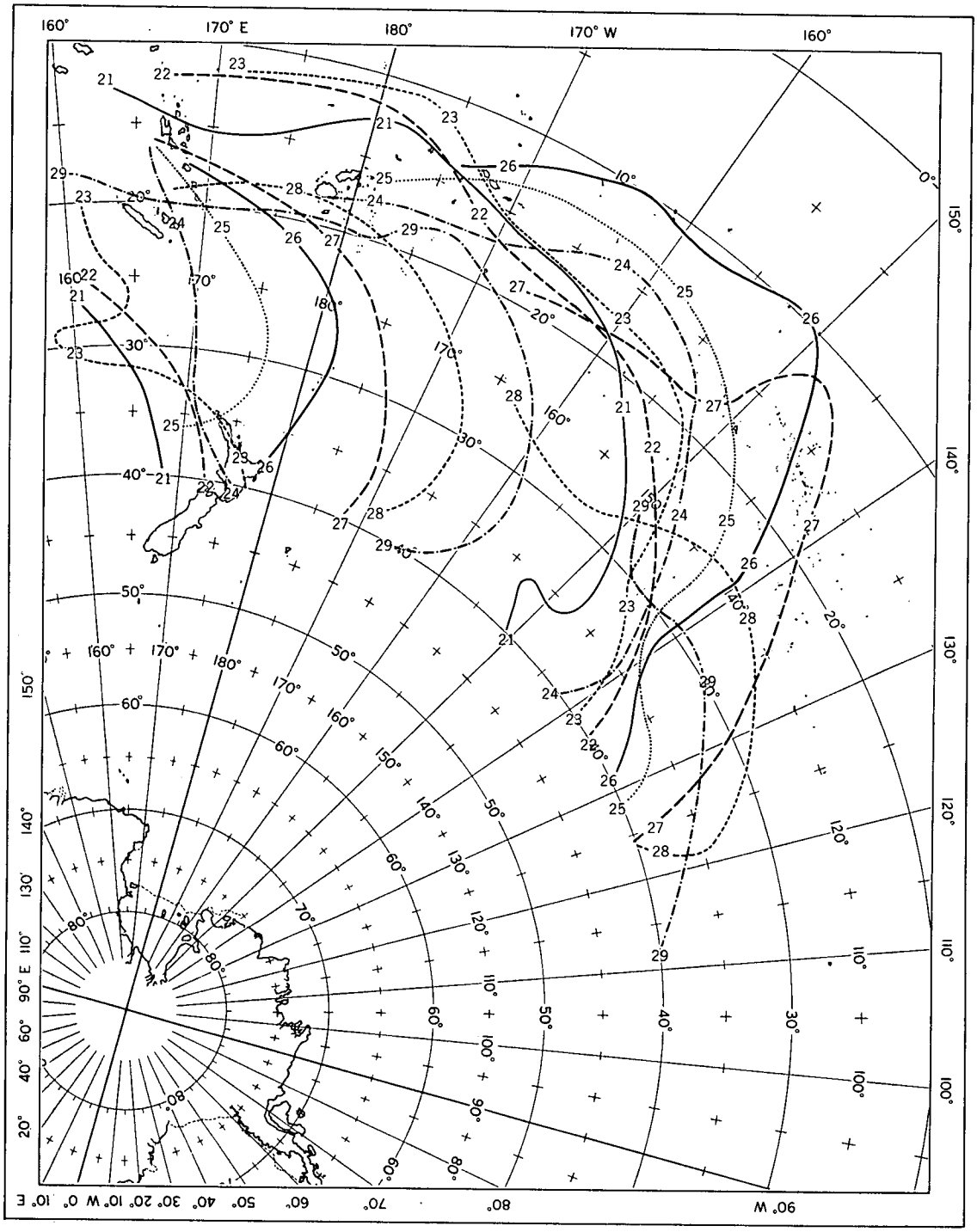

Fig 2.3 Isochrones of the daily position of the southern and western boundaries of the major cloud bands in the South Pacific Ocean for the period 21 - 30 November 1969.

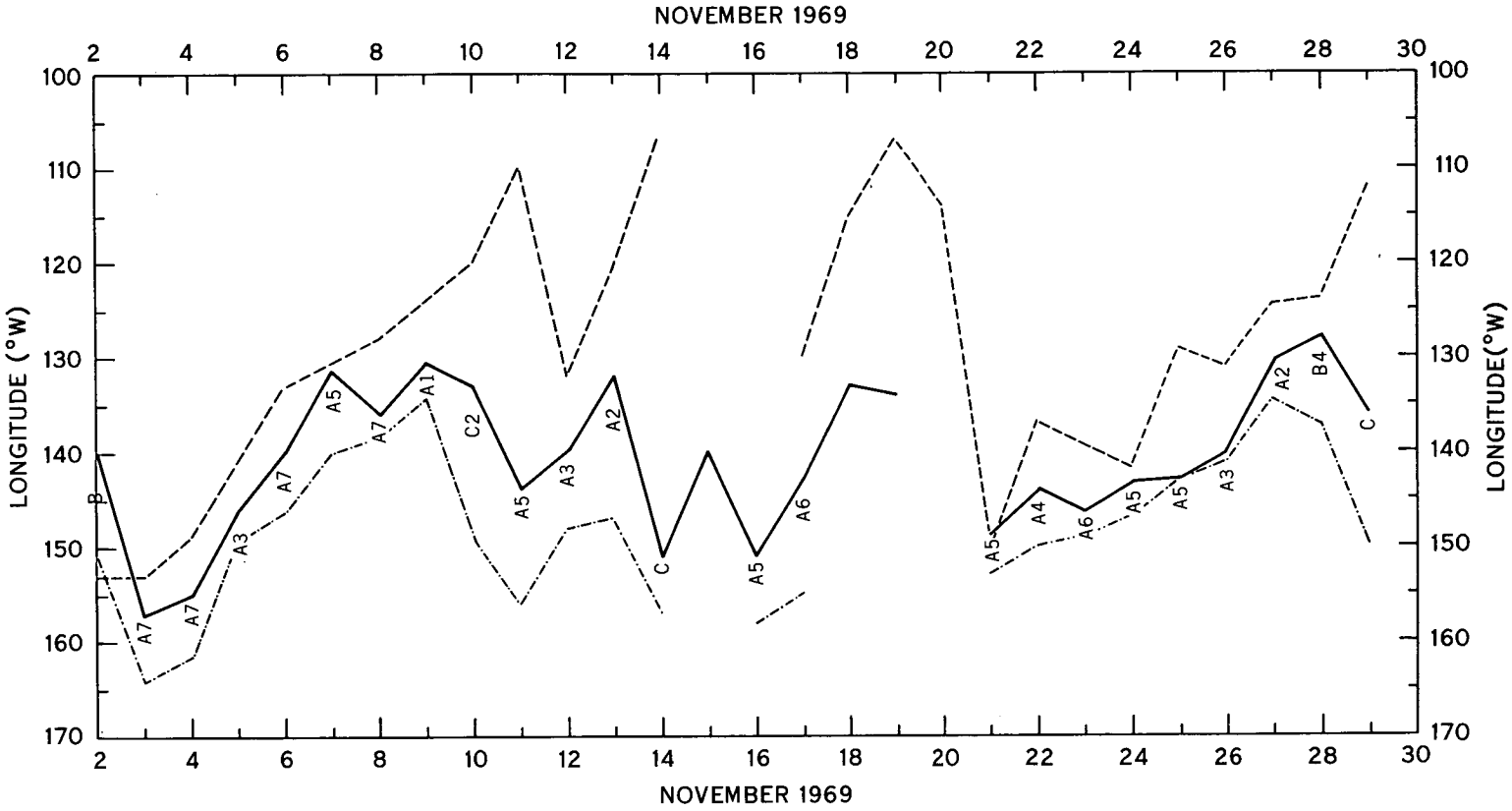

Fig 2.4 The longitude at which each isochrone of figures 2, 3 and 4 intersects the latitude parallels of 25°, 30° and 40°S during November 1969.

In addition the width (in degrees) between these latitudes has been entered. The intensity of convection is based on the brightness and "lumpiness" of the cloudband as observed in the digitised cloud mosaics.

The difference between two curves in Fig 2.4 gives a measure of the orientation of the cloudband between two selected latitudes. When the curves are very close together the cloudband is oriented approximately along a N-S direction, but when the curves are far apart the cloudband is very nearly W-E.

Fig 2.4 reveals the following

- the cloudband had well-defined NW-SE orientation from 2 to 14, 16 to 17, and from 21 to 28 November. In other periods the band was W-E oriented south of 25°S

- when the NW-SE oriented cloudband was intensely active convectively between 25° and 30°S, it moved eastwards. This occurred from 3 to 9, 11 to 13, 16 to 17 and 21 to 27 November. The eastward speed of translation varied between three and five degrees of longitude per day

- when the intensity of convection in the cloudband between 25° and 30°S became weak, or when the band showed signs of dissipation or became disorganised, that part of the band moved westwards. This occurred between 9 and 11, 13 and 14, and 27 and 29 November. On these days the southern part of the cloudband (near 40°S) continued to move eastwards. The difference of movement along the band had the effect of changing the orientation of the southernmost part to a more W-E direction.

(c) Evolution of a Central Pacific Cloudband in Relation to the Passage of a Cloud Front to the South

The evolution of the central Pacific cloudband when a cold front passed to the south in the period 8 to 12 November is illustrated in Fig 2.5.

On 8 November the central Pacific cloudband had an extensive WNW-ESE oriented part north of 20°S and a long part, nearly NW-SE oriented, extending to 40°S. A frontal cloudband lay to the south in latitudes 45° and 50°. Between 8 and 10 November the northern part of the central Pacific cloudband moved southwards whilst the frontal cloudband moved northwards. By 11 November, the two cloudbands were separated by about eight degrees of latitude between 150°W and 120°W.

On 9 November, an area covered by stratiform and well developed cumuliform clouds was situated between latitudes 20°S and 30°S, longitudes 155°W and 150°W. This cloudy region, shown by the hatched area in Fig 2.5, was the result of positive vorticity advection aloft, since there was at that time a marked short-wave trough at the 500 mb level along 155°W between 20°S and 30°S.

By 10 November, a small bulge appeared along the frontal band near 149°W, and on 11 November had developed into a cloud vortex. The vortex was formed partly by a "finger cloud" which spiralled out of the major central Pacific cloudband, and partly by the western end of the frontal cloudband which also curved around the southern and western parts of the cloud vortex. Up to that stage, both major cloudbands had conserved their separate identities, (as shown by the satellite cloud mosaic of Fig 2.6), but the southern part of the central Pacific cloudband was then dissipating.

By 12 November there was only a single major cloudband and the southern part had merged with the frontal cloud system. The northern part of the central Pacific cloudband had moved northwards whilst the part between 25 and 35°S had moved towards the east.

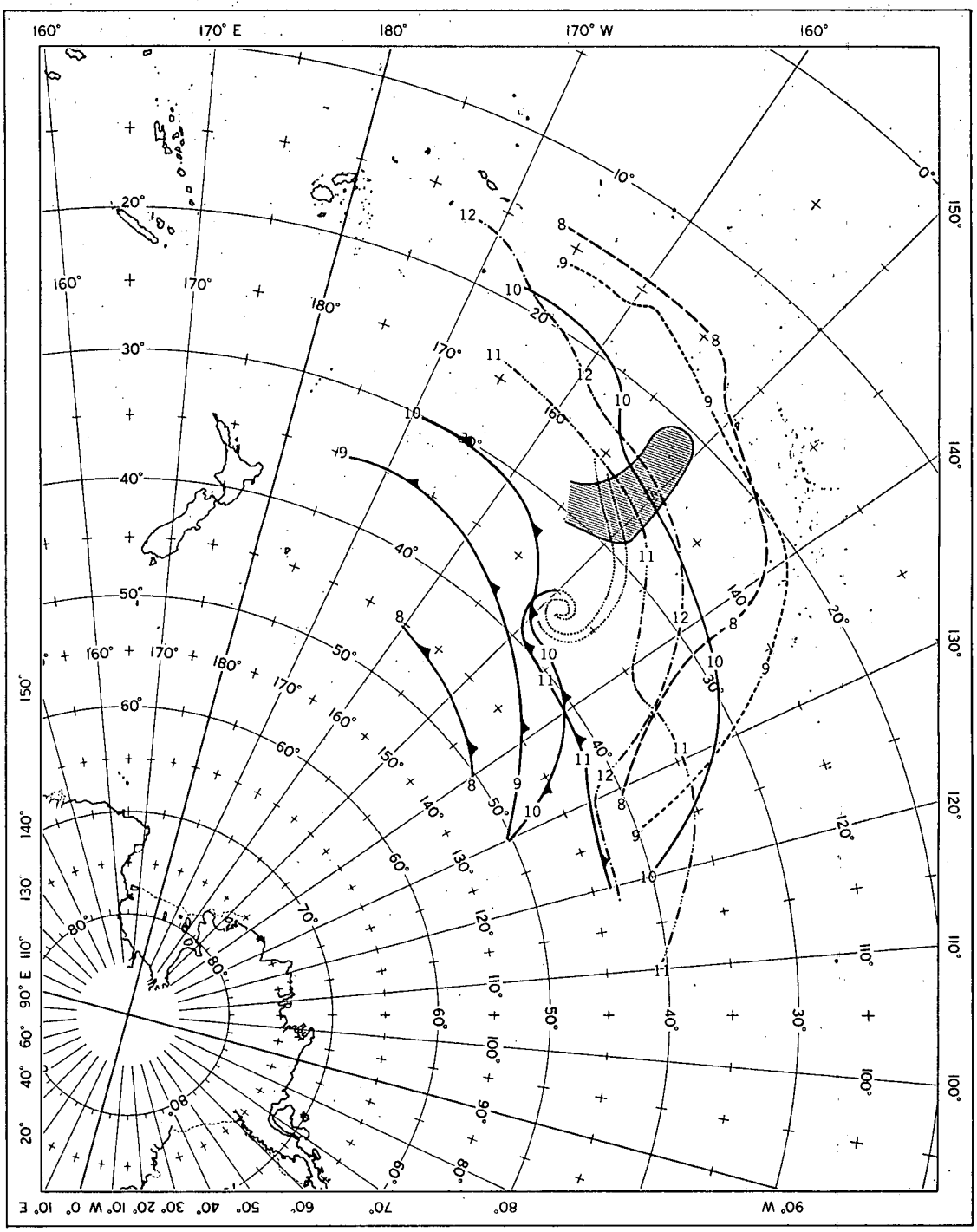

Fig 2.5 Showing the evolution of the South Pacific cloudband between 8 and 12 November 1969, when a cold front moved into the area from the south. The region between dotted curves represents the "finger" cloud vortex common to the cold front and the major central Pacific cloudband on 11 November.

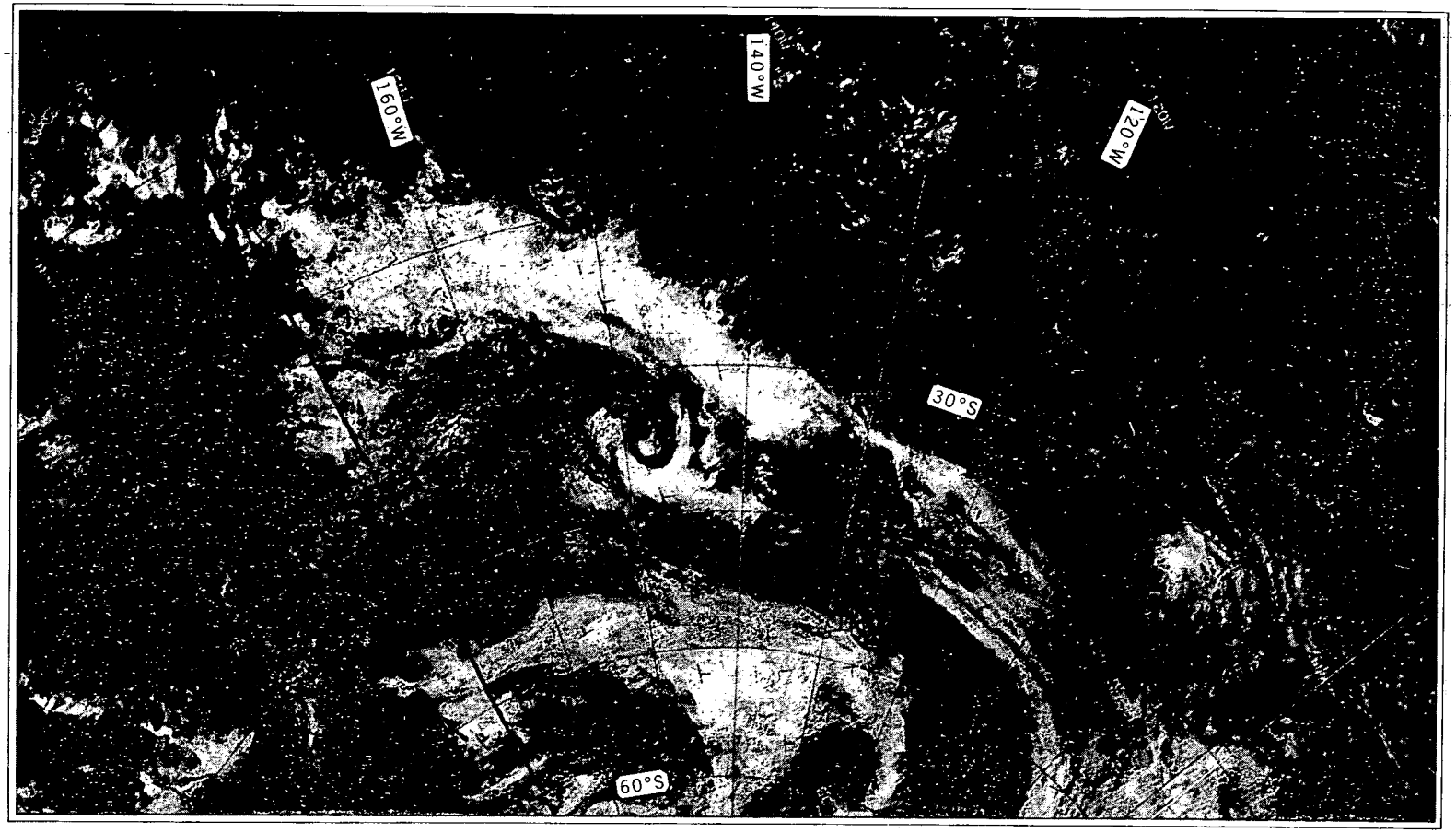

Fig 2.6 Satellite cloud mosaic for the South Pacific Ocean area. (The time corresponds closely to 00 GMT 11 November 1969).

It is thus worth noting that the part of the major cloudband of 12 November which lay over the tropical and subtropical regions of the central Pacific, even if it were connected to a frontal system of high latitudes, was not a remnant of a middle latitude cold front which had moved into lower latitudes.

(d) Eastern Limit of the Major Cloudband

The tropical and subtropical area of the central Pacific in which the major cloudbands evolved during the month of November 1969 (Fig 2.1, 2.2, 2.3) is shown again in Fig 2.7. As stated previously, N-S or NW-SE oriented cloudbands moved eastwards to some longitude where they started to dissipate, after which they moved westwards until they became convectively active again when they resumed an eastward movement. There was however an extreme eastern limit, shown by curve A (Fig 2.7), beyond which the cloudband did not penetrate.

This eastern limit

- is very close to the four okta isopleth (shown by the broken curve in Fig 2.7), of Sadler's two-year average November cloudiness map
- occurs along a line, the position of which delineates the warm waters of the central Pacific Ocean from the relatively cold waters of the eastern Pacific, as indicated by the sea-surface isotherms (Zillman, 1970). This is in agreement with Bjerknes (1969).

(e) Frequency distribution of the Isochrones

To determine the area most frequently affected by the major cloudbands in November 1969 the number of occasions that the isochrones of Fig 2.1 to 2.3 crossed each five-degree square was counted. The frequency distribution is indicated in Fig 2.7 by the closed curves labelled 5, 10 and 15 occasions and these are compared with the broken curves CD and C'D' which pass through the centre of the maximum cloudiness averaged over the months November 1965 and 1966 as given by Sadler. It would therefore appear that north of latitude 25°S, the most frequent position of the major cloudband in November 1969 was a little to the north of that in November 1965 and 1966. Between latitudes 25° and 30°S Sadler found two average cloudiness maxima, one near 153°W and the other near 140°W. In November 1969 the most frequent position of the major cloudband between 25 and 30°S lay near 147°W.

(f) Conclusion

This examination of the evolution of the major central Pacific cloudband during November 1969, has demonstrated that

- when the N-S or NW-SE oriented part of the cloudband was fairly active convectively, it moved eastwards at three to five degrees of longitude per day, but when the intensity of convection was weak or when the cloudband was dissipating, it became disorganised and moved westwards
- the orientation of the southernmost part of the cloudband became roughly W-E in direction when the intensity of convection within it became weak
- the cloudband lying over the tropical and subtropical regions of the central Pacific on 12 November was not a remnant of a middle latitude cold front which had moved into lower latitudes

- there was an extreme eastern limit beyond which the cloudbands did not penetrate. This eastern limit lay along a line delineating the warm waters of the central Pacific from the relatively cold waters of the eastern Pacific

- the most frequent position of the cloudband north of 25°S in November 1969 was apparently a little further north on the average than in November 1965 and 1966.

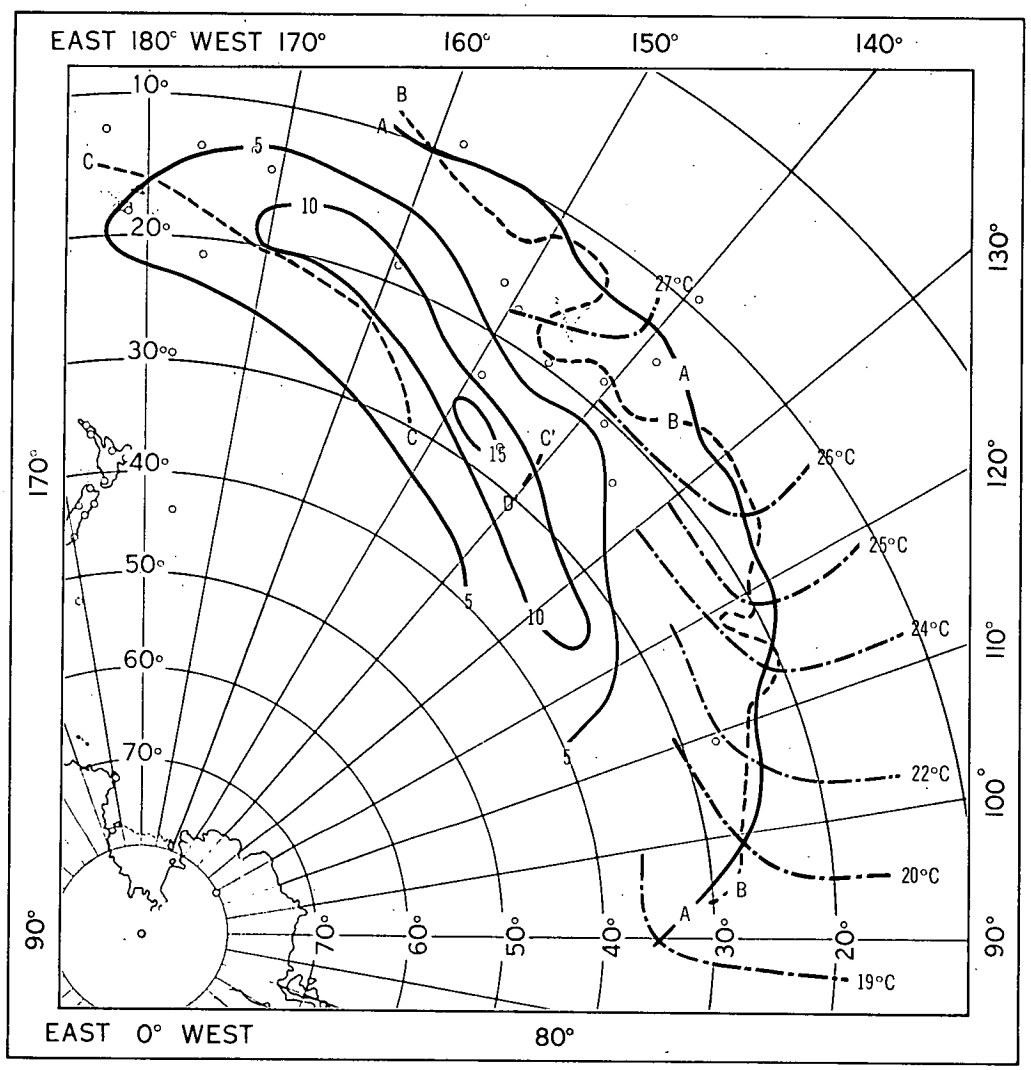

Fig 2.7 Showing:

(a) the eastern limit beyond which the cloudband did not penetrate in November 1969 (the curve A-A)

(b) (i) the 4-okta isopleth of average November cloudiness in 1965-1966 (the broken curve B-B)

(ii) the maximum average November cloudiness in 1965-1966 (the broken curves C-D, C'-D') (both taken from Sadler 1968)

(c) the distribution of sea surface temperatures in the area (from Zillman, 1970) (dot-dashed curves)

(d) the frequency (i.e. the number of occasions in November 1969) with which the isochrones of figures 2-4 fell within 5-degree areas.