Geopotential Topographies and Currents off West Australia, 1965-69

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GEOPOTENTIAL TOPOGRAPHIES AND CURRENTS OFF WEST AUSTRALIA 1965–69

By B. V. HAMON*

Abstract

Dynamic height anomalies for the sea surface and the 300-decibar surface, relative to 1300 db, are presented and discussed for nine cruises. The seasonal variation in dynamic height at 32°S., 112°E. is shown, based on all available data. The main conclusions are (i) the circulation is variable, but less intense than off the east coast of Australia, (ii) seasonal effects are small compared to the non-seasonal variability, (iii) there is no sign of a regular north-flowing "west Australian current" in the dynamic topographies of individual cruises.

I. INTRODUCTION

Currents and water transports in the south-eastern Indian Ocean have already been discussed by Wyrtki (1962) and Hamon (1965). This paper presents results from nine more recent cruises.

II. DYNAMIC HEIGHT ANOMALIES

Anomalies of dynamic height were computed first for observed depths, using standard methods. Anomalies of dynamic height for standard depths were then computed by linear interpolation. Since at most stations sampling was carried out to a nominal maximum depth of 1500 m, 1300 db has been chosen as a reference level. (For comparison with earlier work, the difference in dynamic height anomaly between 1300 and 1750 db is approximately 27 dynamic centimetres.) Where the maximum sampling depth was between 900 and 1300 m, dynamic height anomalies were extrapolated to the reference level, using data from adjacent stations.

III. RESULTS

Results are presented for each cruise separately, in the form of contours of dynamic height anomaly of the surface and the 300 db level, relative to 1300 db.

(*a*) *Cruise Dm* 2/65 (July 17–29, 1965)

The 0/1300 and 300/1300 dynamic topographies are shown in Figures 1(*a*) and 1(*b*). The main features are a trough between 30° and 34°S., about 200 km off shore, and a ridge between 24° and 30°S., about 300 km off shore. The trough appears in both the 0/1300 and 300/1300 db plots, but the ridge is barely discernible at 300 db.

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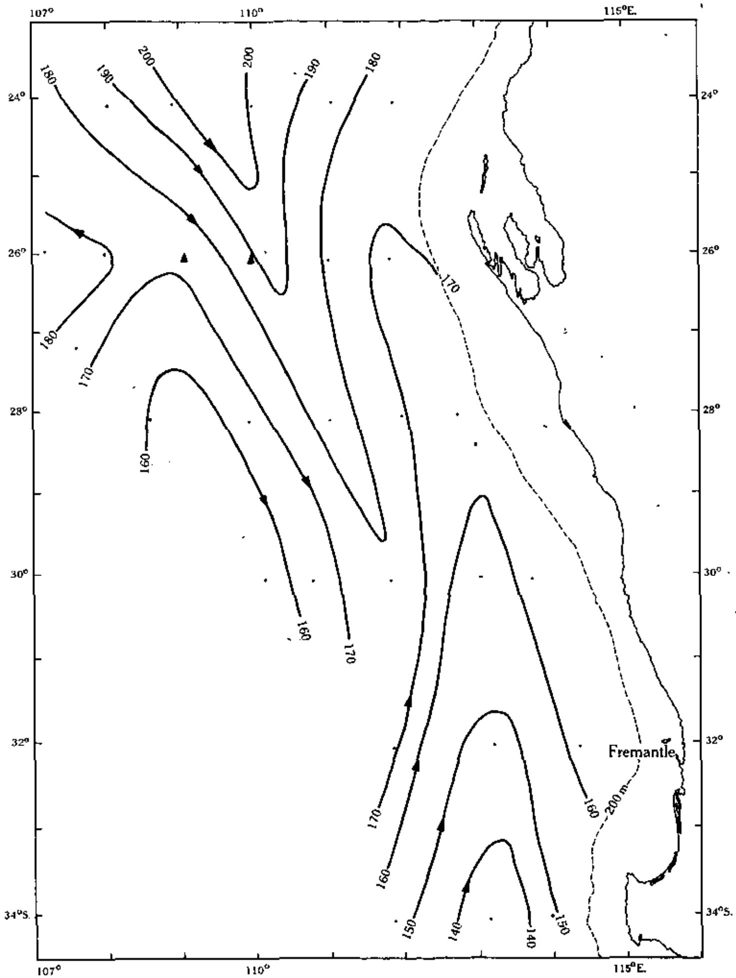

Fig. 1(*a*).—Dynamic topographies of the sea surface, relative to 1300 db. Cruise Dm 2/65 (July 17–29, 1965).

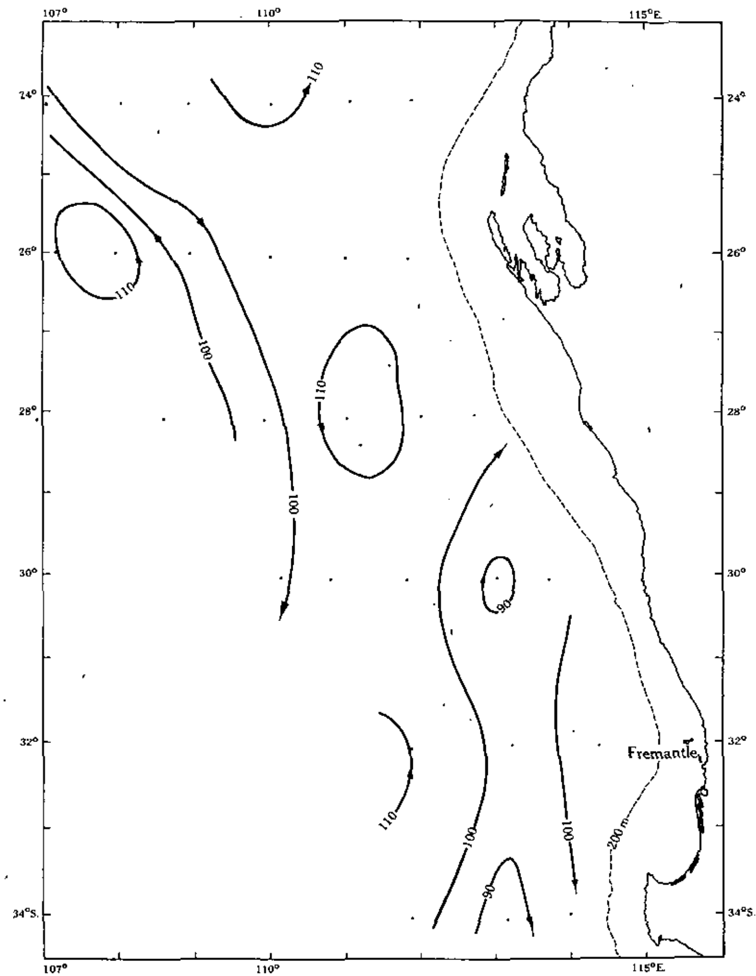

Fig. 1(*b*).—Dynamic topographies of the 300-db surface, relative to 1300 db. Cruise Dm 2/65 (July 17–29, 1965).

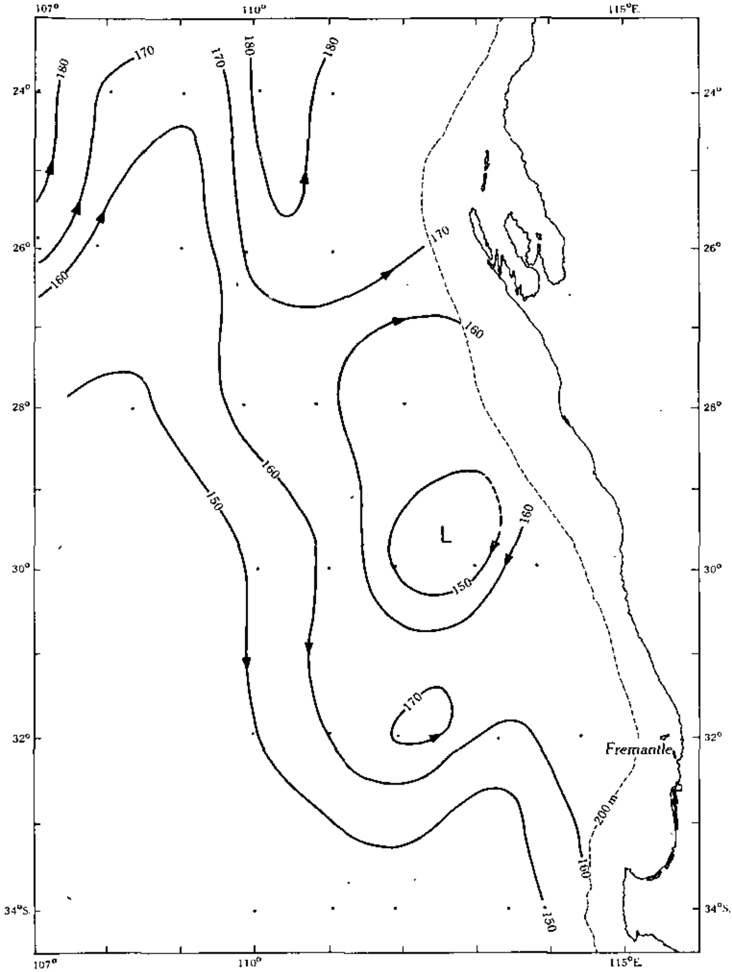

Fig. 2(*a*).–Dynamic topographies of the sea surface, relative to 1300 db. Cruise Dm 3/65 (October 25 – November 5, 1965).

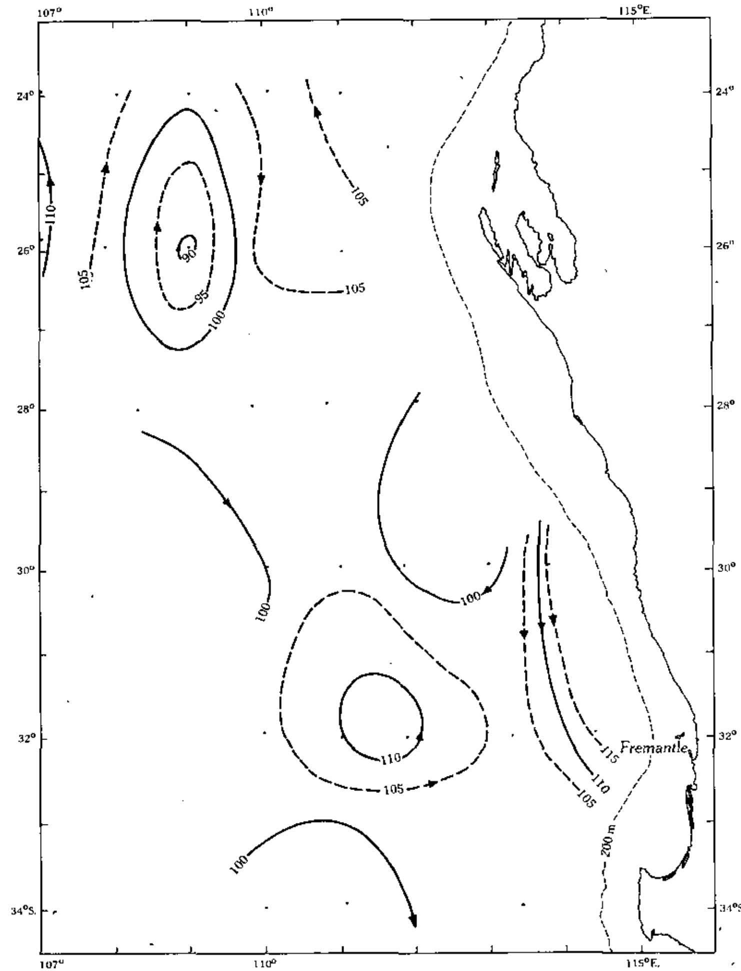

Fig. 2(*b*).–Dynamic topographies of the 300-db surface, relative to 1300 db. Cruise Dm 3/65 (October 25 – November 5, 1965).

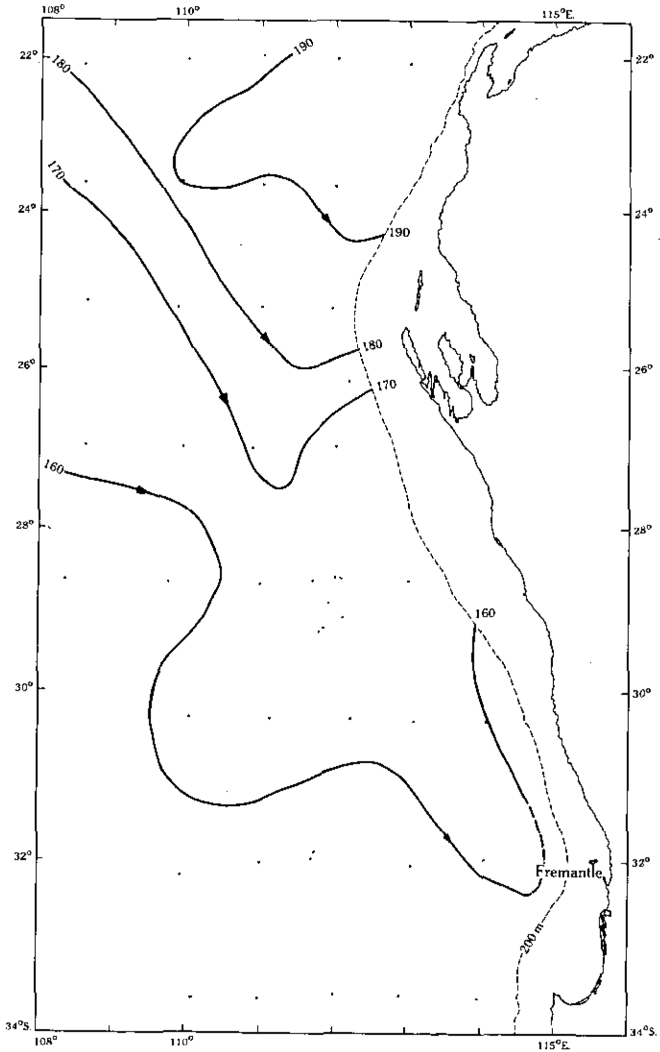

Fig. 3(*a*).—Dynamic topographies of the sea surface, relative to 1300 db. Cruise Dm 1/66 (March 3–21, 1966).

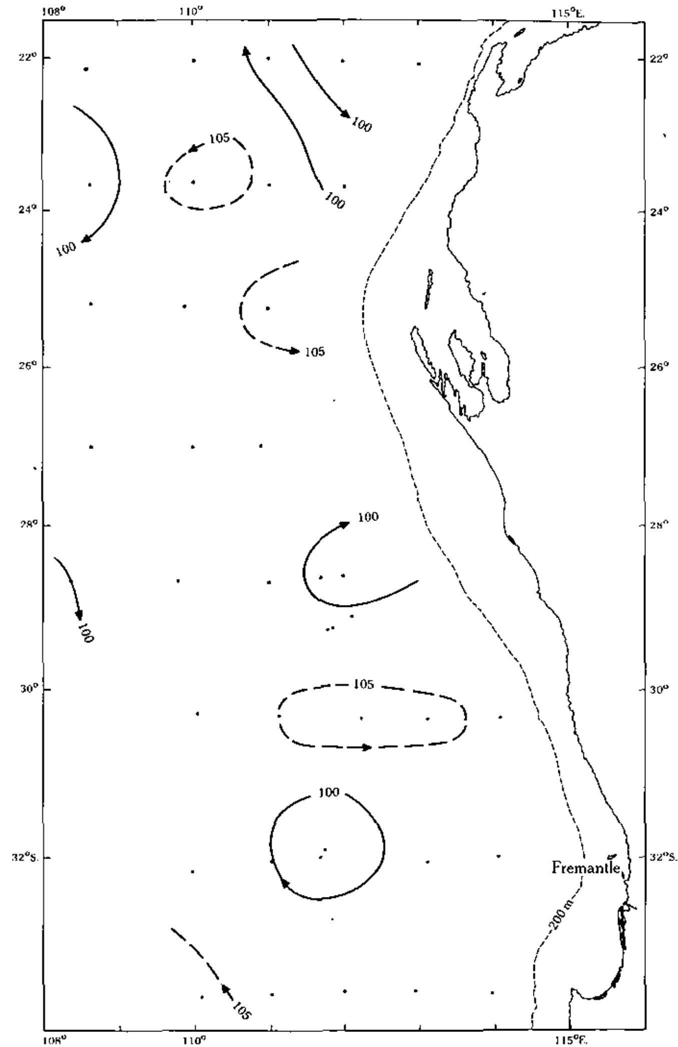

Fig. 3(*b*).—Dynamic topographies of the 300-db surface, relative to 1300 db. Cruise Dm 1/66 (March 3–21, 1966).

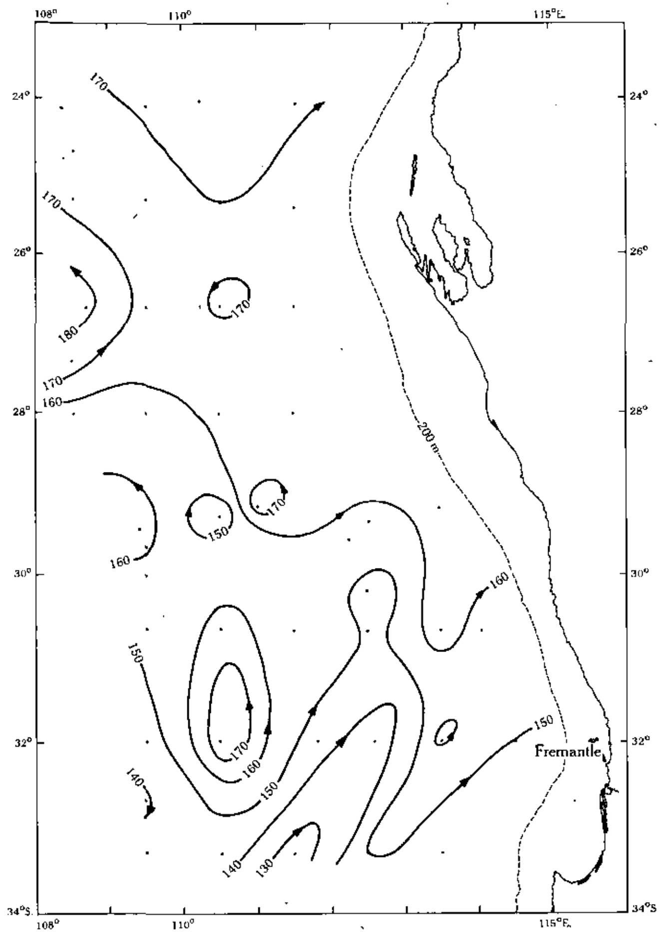

Fig. 4(*a*).—Dynamic topographies of the sea surface, relative to 1300 db. Cruise Dm 5/67 (October 30 – November 17, 1967).

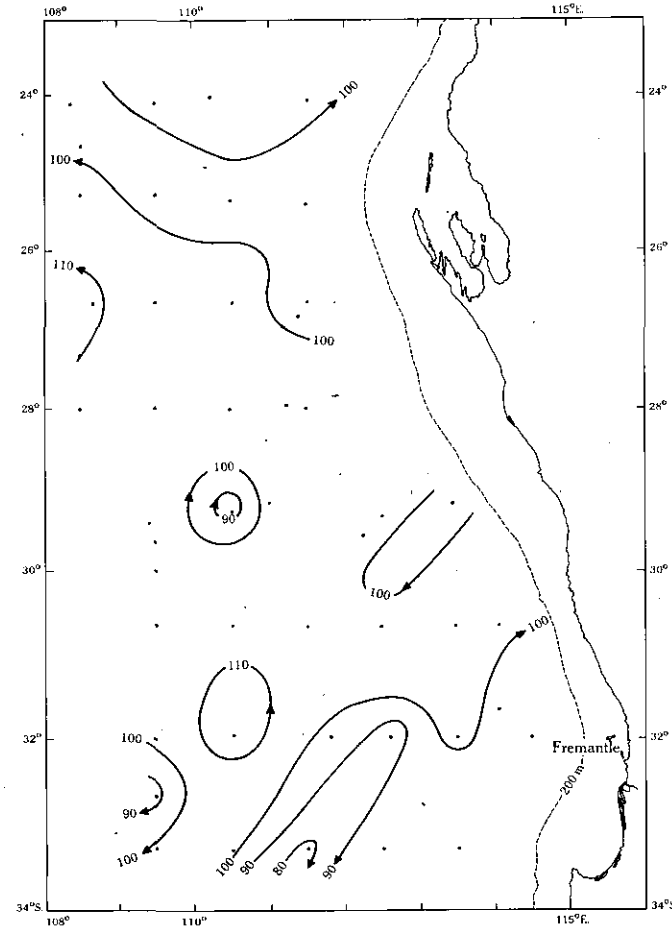

Fig. 4(*b*).—Dynamic topographies of the 300-db surface, relative to 1300 db. Cruise Dm 5/67 (October 30 – November 17, 1967).

(*b*) *Cruise Dm* 3/65 (October 25 – November 5, 1965)

There is appreciable difference between the shapes of contours of the 0 and 300 db levels (Figs. 2(*a*) and 2(*b*)), but the difficulty in contouring when lines of stations are so far apart should be kept in mind.

(*c*) *Cruise Dm* 1/66 (March 3–21, 1966)

Figures 3(*a*) and 3(*b*) show very little relief in the topography at either 0 or 300 db. The main feature of the 0/1300 db topography is the gradual increase in height towards north. This is due to surface layers becoming warmer nearer the equator and is a well-established feature in temperate latitudes.

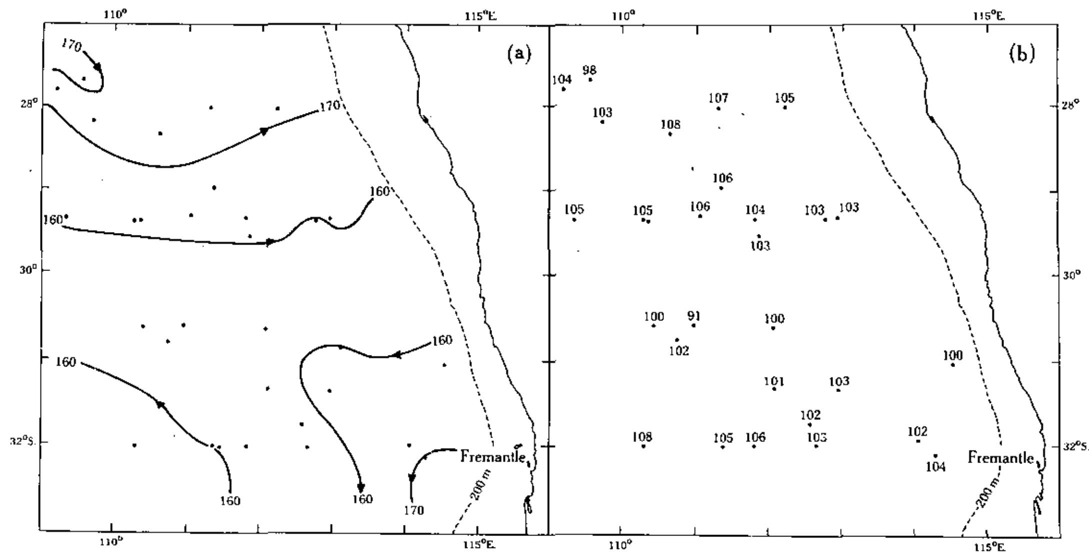

Fig. 5.–Dynamic topographies of (*a*) the sea surface and (*b*) the 300-db surface, relative to 1300 db. Cruise Dm 1/68 (February 19 – March 10, 1968).

(*d*) *Cruise Dm* 5/67 (October 30 – November 17, 1967)

Figure 4(*a*) shows a trough extending NNE. 300–400 km off Fremantle and a cyclonic eddy further west. The trough is still clearly defined at 300 db (Fig. 4(*b*)) but the eddy has become weak at this depth.

(*e*) *Cruise Dm* 1/68 (February 19 – March 10, 1968)

There is little relief on either surface (Fig. 5); in fact, the relief at 300 db (Fig. 5(*b*)) was so small (range 98–108 dyn. cm) that meaningful contours could not be drawn. In Figure 5(*a*) there is a weak zonal trough at 30–31°S., with a weaker meridional trough joining it from the south.

(*f*) *Cruise Dm* 6/68 (October 10 – November 21, 1968)

This cruise covered a relatively small area which was visited four times in six weeks. It was not possible to contour the dynamic heights when all data from the cruise were plotted together. Figure 6(*a–f*) shows the dynamic topographies for each

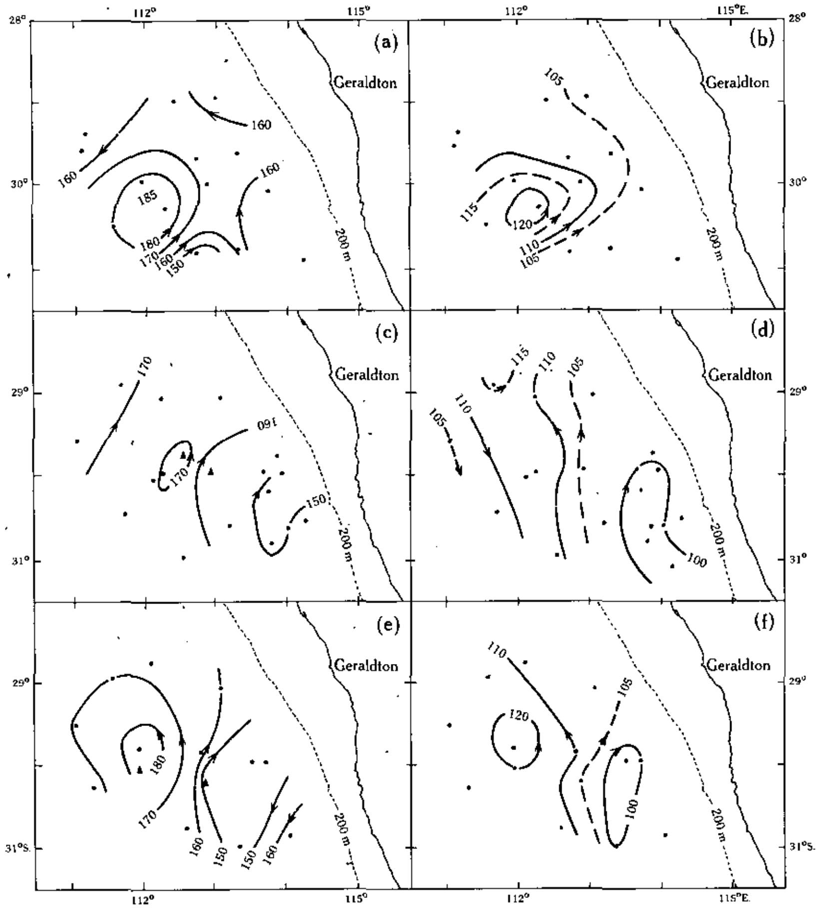

Fig. 6.—Dynamic topographies of the sea surface (*a*), (*c*), (*e*), and of the 300-db surface (*b*), (*d*), (*f*), relative to 1300 db. Cruise Dm 6/68: (*a*) and (*b*), October 10–19; (*c*) and (*d*), October 22 – November 1; (*e*) and (*f*), November 4–12 and 15–21, 1968.

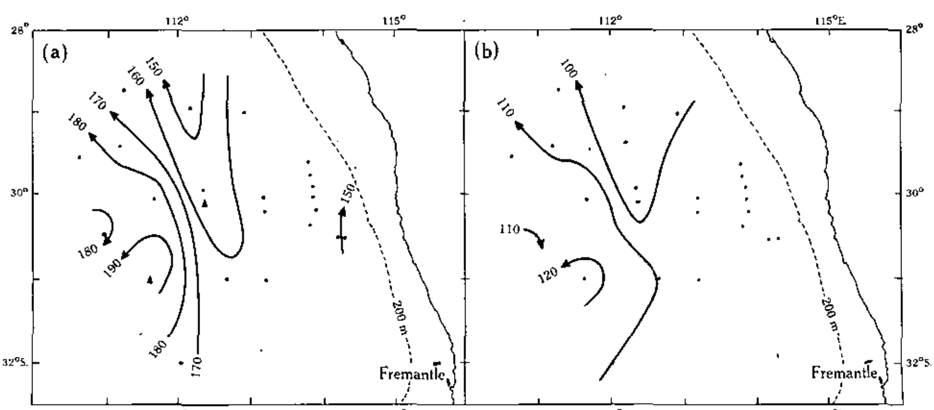

Fig. 7.—Dynamic topographies of (*a*) the sea surface and (*b*) the 300-db surface, relative to 1300 db. Cruise Dm 4/69 (September 9–21, 1969).

of the three main parts of the cruise. Changes in 0/1300 db dynamic height at a given position were as high as 18 dyn. cm in three weeks. An anticyclonic eddy, initially well marked at 0 and 300 db, appears to have moved towards north-west and weakened.

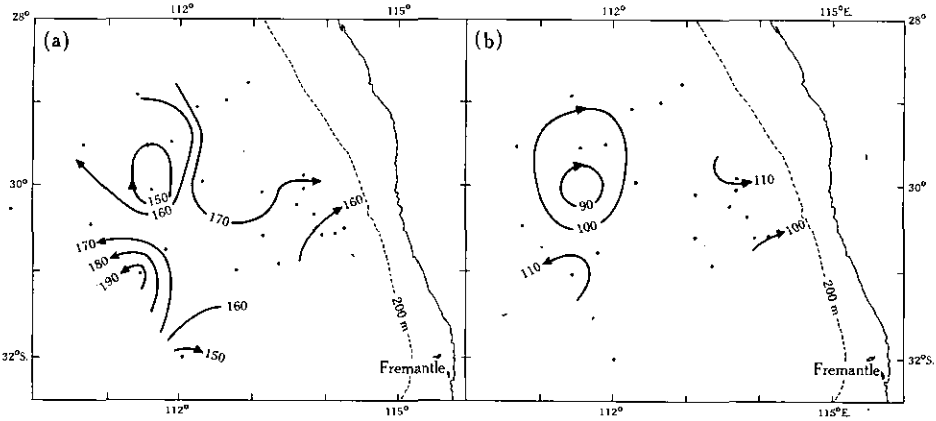

Fig. 8.–Dynamic topographies of (*a*) the sea surface and (*b*) the 300-db surface, relative to 1300 db. Cruise Dm 5/69 (October 2–14, 1969).

(g) *Cruises Dm* 4–6/69 (September 9–21, October 2–14, October 23 – November 3, 1969)

These cruises covered the same area three times within about eight weeks. The dynamic topographies are shown in Figures 7–9. There are appreciable changes from

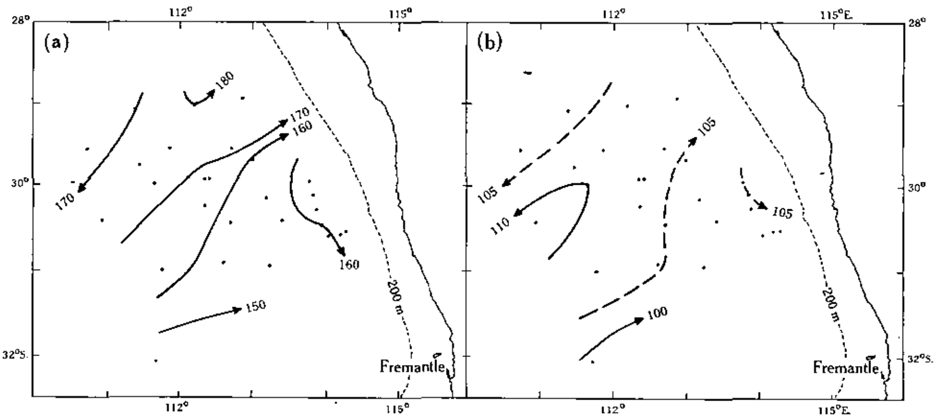

Fig. 9.–Dynamic topographies of (*a*) the sea surface and (*b*) the 300-db surface, relative to 1300 db. Cruise Dm 6/69 (October 23 – November 3, 1969).

one cruise to the next. Near 29°S., 112°10′E. the 0/1300 dynamic height anomaly changed 27 dyn. cm between Dm 4/69 and Dm 5/69. Figure 7(*a*) and (*b*) shows currents to NNW., approximately parallel to the coast and 400 km off shore. This feature is missing in Figure 8(*a*) and (*b*).

(*h*) *Dynamic Heights at Reference Station* (32°S., 112°E.)

Figure 10 shows the annual variation of dynamic height anomalies at 32°S., 112°E. using all available data. Figure 10(*a*) is 0/300 db; this is essentially a measure of the average specific volume of the upper 300 m. The expected seasonal

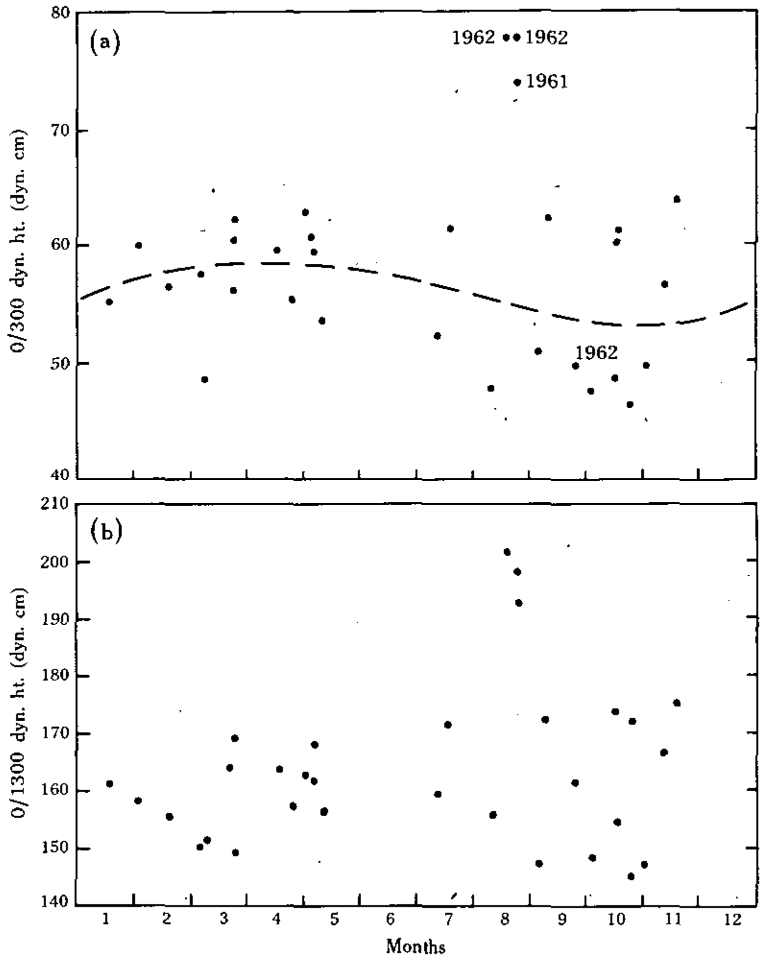

Fig. 10.—Annual variation of dynamic height anomalies of (*a*) the surface relative to 300 db and (*b*) the surface relative to 1300 db, at 32°S., 112°E.

variation, due to heating and cooling, is barely discernible (dashed line). Figure 10(*b*) shows 0/1300 db; no seasonal variation can be seen in this. Both figures show a tendency towards greater variability in the months August–November. The most extreme values were in August 1961 and 1962. The overall range for 0/1300 db is 55 dyn. cm.

(*i*) *Variation of Current with Depth*

Five pairs of stations that showed appreciable surface gradients, and therefore surface geostrophic currents, were chosen and the relative currents as functions of depth were calculated. The results are shown in Figure 11. The stations are indicated by filled triangles on Figures 1, 6, and 7. Figure 11 shows that currents decrease monotonically with increasing depth, with one small exception (stations 128 and 129, Dm 2/65). The surface currents decrease to half at depths between 220 and 500 m. The general shape of the vertical current profiles is similar to that found off eastern Australia. None of the profiles in Figure 11 shows a reversal of relative current between the surface and the reference level.

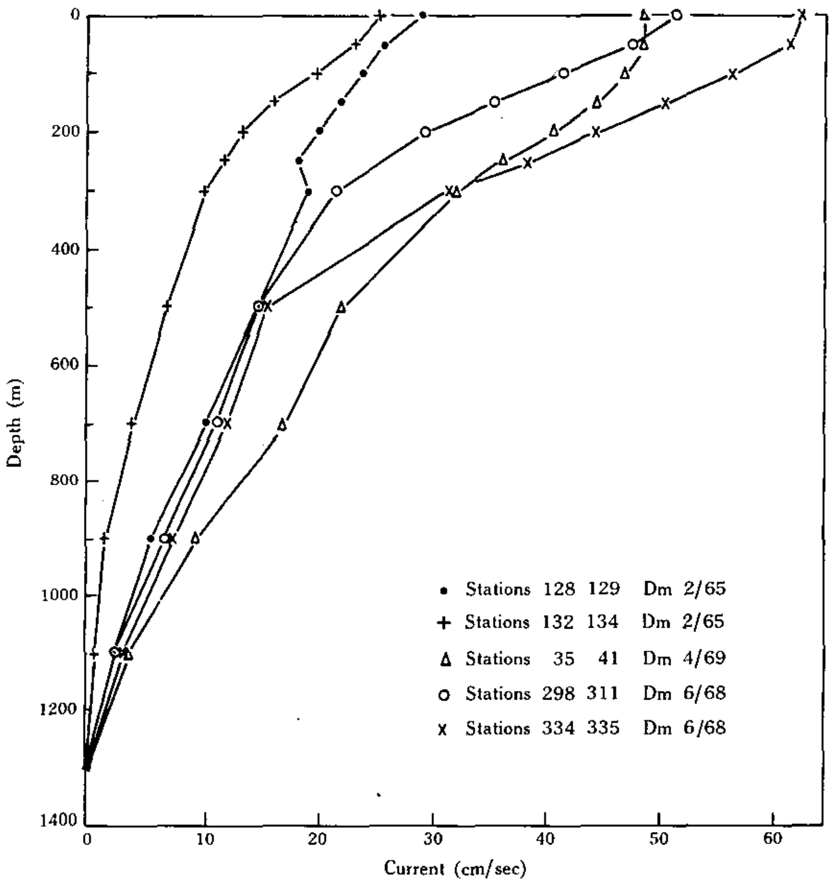

Fig. 11.–Geostrophic currents relative to 1300 db as functions of depth.

(*j*) *G.E.K. Surface Currents*

A G.E.K. (von Arx 1950) was used on Dm 5/69 and Dm 6/69. Owing to malfunction of equipment the record was not complete on either cruise.

The G.E.K. surface currents generally show persistence with distance up to 50 km, although direction changes of 90° or more are possible in shorter distances. The current speeds ranged up to about 2 kt (100 cm/sec). On both cruises, but more particularly Dm 6/69, the G.E.K. currents were mainly towards north and west. Agreement with surface dynamic topographies was only fair.

IV. Conclusions

Since the cruises were designed for other purposes it is not surprising that the results do not throw much additional light on the dynamics of water movements in the area.

Taken in conjunction with earlier results, it appears that:

(1) Circulation off the west Australian coast is variable. The variability appears to be similar in character to that off the east coast but maximum currents are less.

(2) Seasonal effects can scarcely be detected in currents or dynamic heights; they are buried in the "noise" due to random variability.

(3) Rochford (1969) has shown a southward flow in autumn–winter and a northward flow in summer, at least in coastal waters. In the dynamic topographies of individual cruises there is no sign of a regular seasonal pattern of flow, or of the north-flowing "west Australian current" indicated in some current charts.

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