MAGNETIC BAYS AT MACQUARIE ISLAND*

By K. D. COLE†

Robertson (1959) has examined a year's (1954) records of magnetic bays in H, D, Z obtained at the Australian National Antarctic Research Expedition's station at Macquarie I. (54·5° S., 159° E.). Robertson's Table 1 contains 450

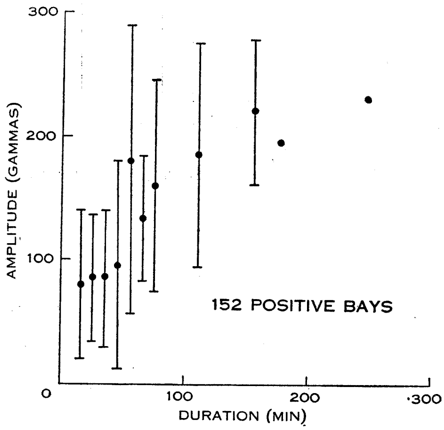

Fig. 1.—Amplitude of positive bays *v.* duration derived from 152 such bays at Macquarie I., 1954. Vertical bars through the points indicate standard deviation in amplitude.

bays in H. Of these 152 are positive bays, and 298 negative. These numbers do not include 38 periods (each of greater than 4 hr duration) of overlapping bay activity or in which bay activity is obliterated by a magnetic storm.

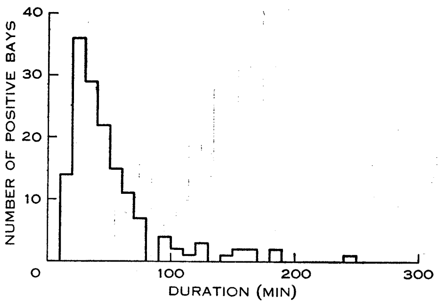

Fig. 2.—Number of positive bays *v.* duration, Macquarie I., 1954.

In a summary of this work Robertson (1960) states: "The amplitudes of all 1954 bays were plotted against their duration to find whether these two quantities were related. Apart from the fact that most positive bays have

* Manuscript received January 15, 1962.

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amplitudes less than 80 gammas and durations less than 50 min, no trends could be discerned." However, the writer has found trends in them. Figures 1, 2, 3, and 4 show plots of amplitudes and number of bays against duration for positive

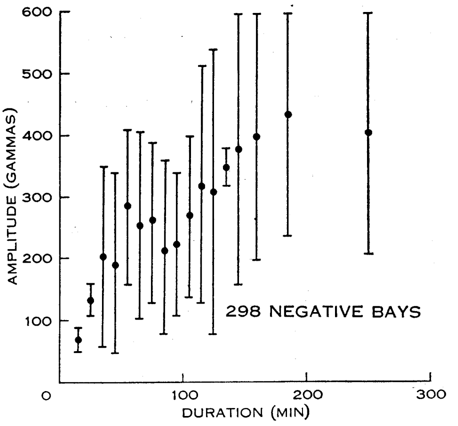

Fig. 3.—Amplitude of negative bays derived from 298 such bays at Macquarie I. in 1954. Vertical bars through the points indicate standard deviation in amplitude.

and negative bays separately. There is a clear trend for the durations of both kinds of bay to increase with amplitude. The numbers of bays are plotted against amplitudes in Figures 5 and 6.

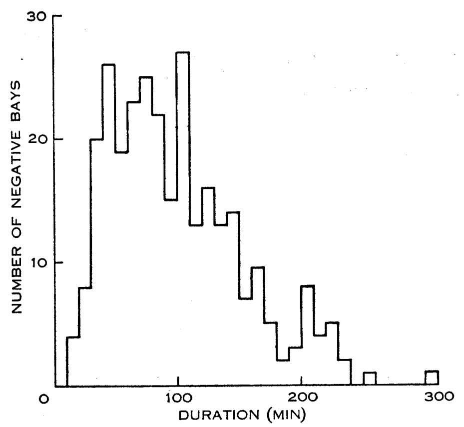

Fig. 4.—Number of negative bays *v.* duration, Macquarie I., 1954.

From Figures 2 and 4 it is seen that the modal duration of positive bays is about 40 min and of negative bays 100 min. Supposing the bays are caused by current systems fixed in space under which the Earth rotates, these durations correspond to dimensions of order 200 km for the modal size of the positive associated systems and 500 km for the negative.

Robertson's (1959) Table 2 contains a list of 80 negative D bays that were accompanied by either nil or slight activity in H and Z. Their average duration was 70 min. In terms of horizontal ionospheric current these bays are explained by (magnetic) north flowing current. The two tables contain all the H and D bays observed by Robertson in the 1954 records. It is evident from comparison of Robertson's Tables 1 and 2 that when a negative D bay occurs it either stands alone as the only disturbance of the day (28 out of 63 days) or it overlaps a positive H bay or is separated from bay activity in H by a relatively quiet period (25 out of 63 days) of average duration 160 min. This is difficult to reconcile with the current diagram of Fukushima and Oguti (1953 ; see Fig. 7) from which one would expect a gradual change from northward flowing current of the negative D bay regime to west current of the negative H bay regime.

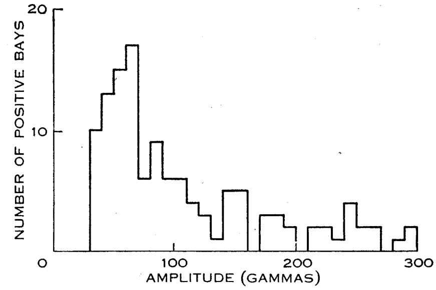

Fig. 5.—Number of positive bays *v.* amplitude, Macquarie I., 1954.

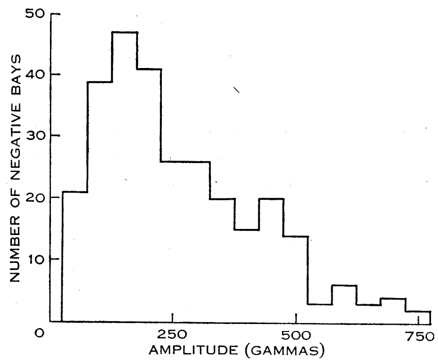

Fig. 6.—Number of negative bays *v.* amplitude, Macquarie I., 1954.

A significant feature of the bays in H emerges from Robertson's Table 1. He has listed the sign of H bays and also the sign of the accompanying activity in D (positive to east). 37% H bays were accompanied by D activity of both signs. On almost 63% occasions the sign of D activity was opposite to that of H. On less than 1% occasions was D neutral. If these results are to be explained conventionally by horizontal currents in the ionosphere then the 37% group would be due to current whose orientation fluctuated about (local magnetic) east–west; while the 63% group would be due to current whose orientation was preferentially in the north-east (or south-west) sector during bays. On the average the H-bay currents required to explain Robertson's Table 1 were inclined to the local magnetic east–west direction at an angle of about 20° and lay in the north-east (or south-west) quadrant. It is again difficult to reconcile these preferred directions with an average current system for disturbance derived by Fukushima and Oguti (1953) (see Fig. 7). Their figure does not suggest such preferential directions for current orientations for a station such as Macquarie I.

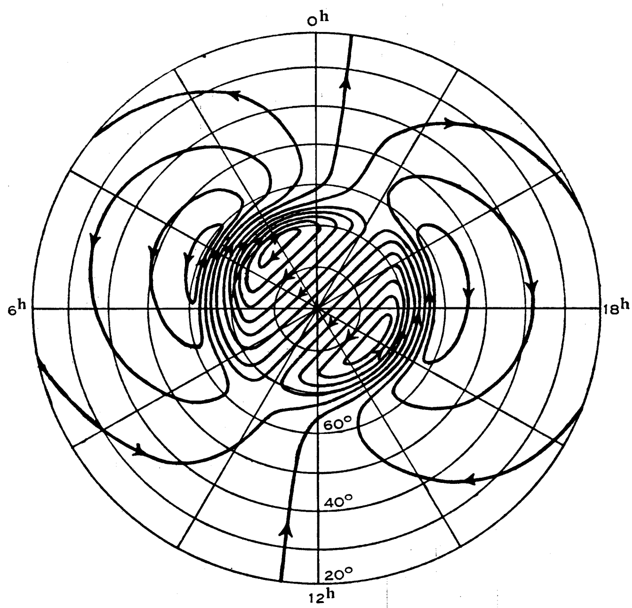

Fig. 7.—Taken from Fukushima and Oguti (1953). Current systems of the S_D-field for the equinoctial season. (Electric current of $1 \cdot 5 \times 10^5$ A flows between adjacent stream lines.)

It is interesting to note that this (63%) property of the sign of bays in D may have another explanation. Recent theory of solar wind generation of polar geomagnetic disturbance (Cole 1961) suggests that intense current may flow down a bundle of geomagnetic field lines from the exosphere and spread horizontally in the ionosphere. A southern hemisphere station displaced somewhat from underneath these field lines would observe D, H bays with this opposite sign interrelationship. On this model a northern hemisphere station, similarly situated with respect to its auroral zone as Macquarie I., should register bays of the same (rather than opposite) signs in D and H. Present knowledge suggests that College, Alaska, would be such a station. Eighteen 1951 magnetograms from College exhibited by Heppner (1954) do not show such an unambiguous characteristic. Independently of the theory the enquiry indicates that because of this differing nature of their H, D records College and Macquarie I. are at significantly different distances from their respective auroral zones. Either, then, the theory of Cole (1961) is inadequate to explain the sign relationship of components of bays or else the closeness of College to its auroral zone makes this sign relationship somewhat indeterminate. The likely existence of disturbance electric currents flowing along the geomagnetic field in the polar ionosphere presents a difficulty to the conventional interpretation of bays in terms of horizontal current, and to conclusions based thereon.

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