AURORAL POLES*

By F. R. Bond†

The centred dipole geomagnetic poles and the eccentric dipole geomagnetic poles are established mathematical entities (Chapman and Bartels 1940). Here the related concept of the "auroral" poles is outlined. The relationship of the auroral pole to the maximum iso-aurore of the auroral zone as well as to the instantaneous auroral belt is indicated.

Northrop and Teller (1960) showed that for motion of a particle in the Earth's magnetic field the longitudinal invariant is adiabatically conserved. Vestine and Sibley (1960), using 1955 magnetic data, reported the loci of longitudinal drift (I curves) on surfaces where the magnetic field strength F takes on the constant value F_{m} at the mirror points of particles with a given energy. They used the relation

$$I = \int_S^N (1-F/F_{\mathrm{m}})^{\frac{1}{2}}\,\mathrm{d}l,$$

where $\mathrm{d}l$ is the incremental length along the field line and the integral is evaluated from a south point S to a north point N. Bond and Jacka (1962) projected these I curves along the generating field lines to the average lower border height of auroral arcs at 105 km.

The Bond and Jacka curves were labelled as colatitudes, using the colatitude in the centred dipole approximation which corresponds to that value of I found in the real field. Figure 1 shows some examples of auroral arcs recorded over Norway (Störmer 1955) with the Bond and Jacka colatitudes superimposed. It can be seen that the quiet auroral arcs closely follow the colatitudes.

A revised set of colatitude curves θ, which are conceptually similar to the former set, has been computed for 1960 magnetic data using the relationship $L\sin^2\theta = 1$, where L is the parameter that specifies the greatest distance of a field line from the centre of the Earth (McIlwain 1961). McIlwain's computer programme for L was modified slightly to give, at both ends of each selected field line, the colatitudes corresponding to an auroral lower border height of 105 km.

Since the primary magnetic data used to determine the field lines are the "absolute value" magnetic field parameters, the colatitudes θ can be regarded as the isolines of auroral arcs that would exist in an undeformed magnetic field.

The overhead auroral frequencies of the southern hemisphere (Bond and Jacka 1962) are replotted against the new colatitudes θ in Figure 2. The fact that a smooth

* Manuscript received September 18, 1967.

† Antarctic Division, Department of External Affairs, Melbourne, Vic. 3004.

curve can be drawn in relation to the plotted points, under the conditions stated in Bond and Jacka, indicates that the colatitude curves may be taken to represent the iso-aurores. The maximum iso-aurore corresponds to $\theta = 22 \cdot 5^\circ$ S.

A comparison between the iso-aurore $22 \cdot 5^\circ$ N. and the maximum iso-aurore found by Fel'dstein (1960) is given in Figure 3. Agreement is good over northern Russia, where Fel'dstein had the larger proportion of his data.

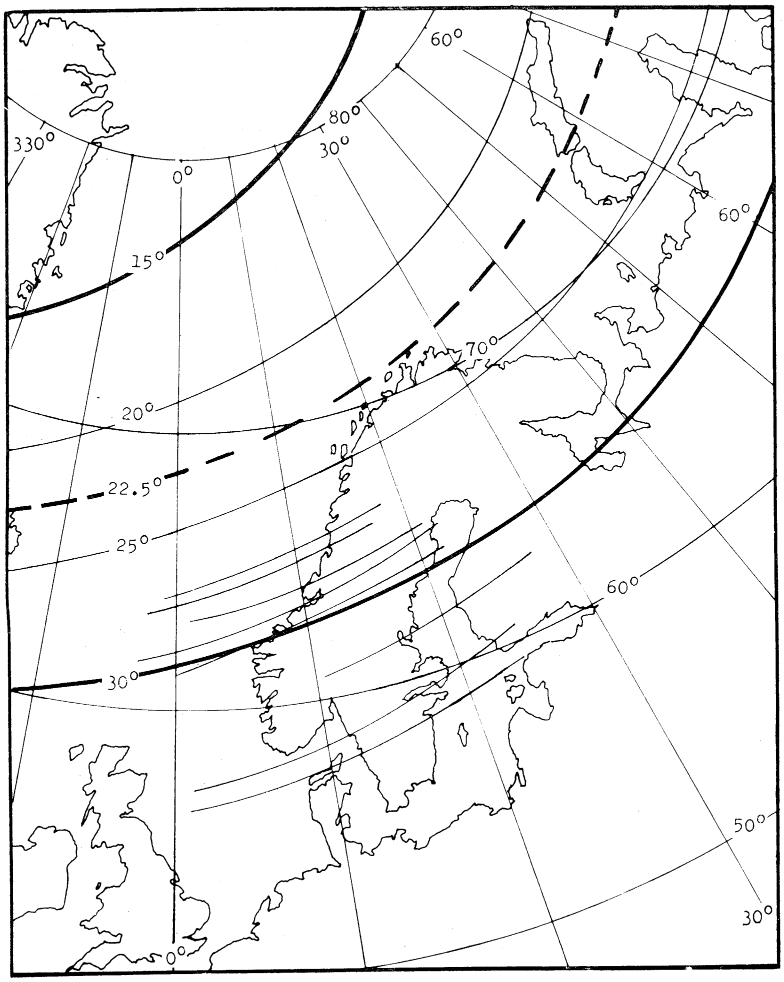

Fig. 1.—Auroral arcs, obtained in the years 1947–49 by Störmer (1955), replotted with the Bond and Jacka (1962) iso-auroral colatitudes superimposed.

As progressively smaller colatitudes are considered, the oval iso-aurores centre around a point, which can be regarded as the "auroral" pole.

The computer programme readily determines the $\theta = 5^\circ$ N. and 5° S. colatitudes, and from these iso-aurores the auroral poles were established geometrically.

For Jensen and Cain's (1962) magnetic data for epoch 1960, the geographical coordinates of the auroral poles are: north auroral pole, latitude 80·0° N., longitude 79·6° W.; south auroral pole, latitude 74·5° S., longitude 126·0° E.

The existence of the solar wind results in a deformation of the Earth's magnetic field, or magnetosphere, compressing the field on the sunward side and extending the field into a magnetic tail in the antisolar direction (Ness 1965).

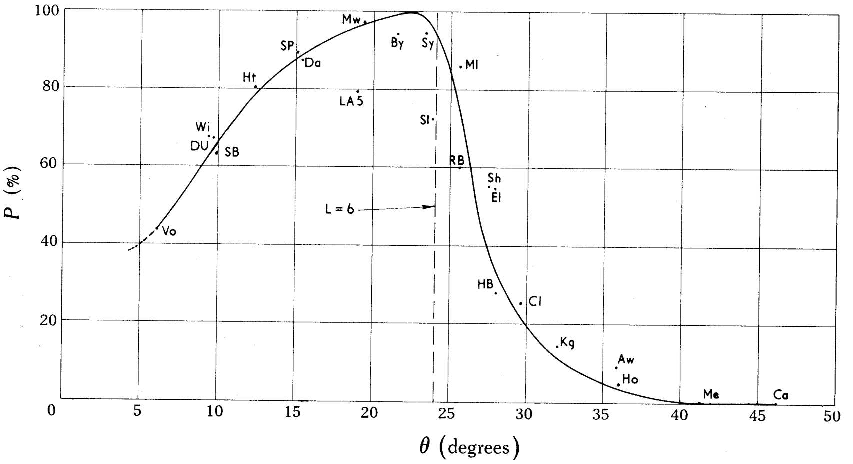

Fig. 2.—Frequencies of overhead aurora P plotted against colatitude θ. The letters indicate southern hemisphere stations (Bond and Jacka 1962).

Akasofu (1966) and Fel'dstein (1967), working with northern hemisphere data, have demonstrated that the instantaneous auroral oval or belt has its centre displaced, from the point we have called the auroral pole, in the antisolar direction. Continuing researches by the author, using the maps of auroral lower borders observed from 23 southern hemisphere stations during the International Geophysical Year, have indicated that the same situation exists in the southern hemisphere.

It may be noted that the auroral pole proposed here can be taken to represent the centroid of the instantaneous centres of the auroral oval with a constant level of deformation of the magnetosphere.

A more detailed account of this work is being prepared for publication in the near future.

Dr. F. Jacka, now Director of the Mawson Institute for Antarctic Research, University of Adelaide, suggested the plot of auroral frequency against θ while with the Antarctic Division.

Note added in Proof

Father P. N. Mayaud has been kind enough to point out that, in his equatorial ring system of geomagnetic coordinates, the geographical coordinates of the geomagnetic poles are: latitude 79·7° N., longitude 80·6° W., latitude 74·7° S., longitude 128·1° E. These locations are comparable with the auroral poles presented here.

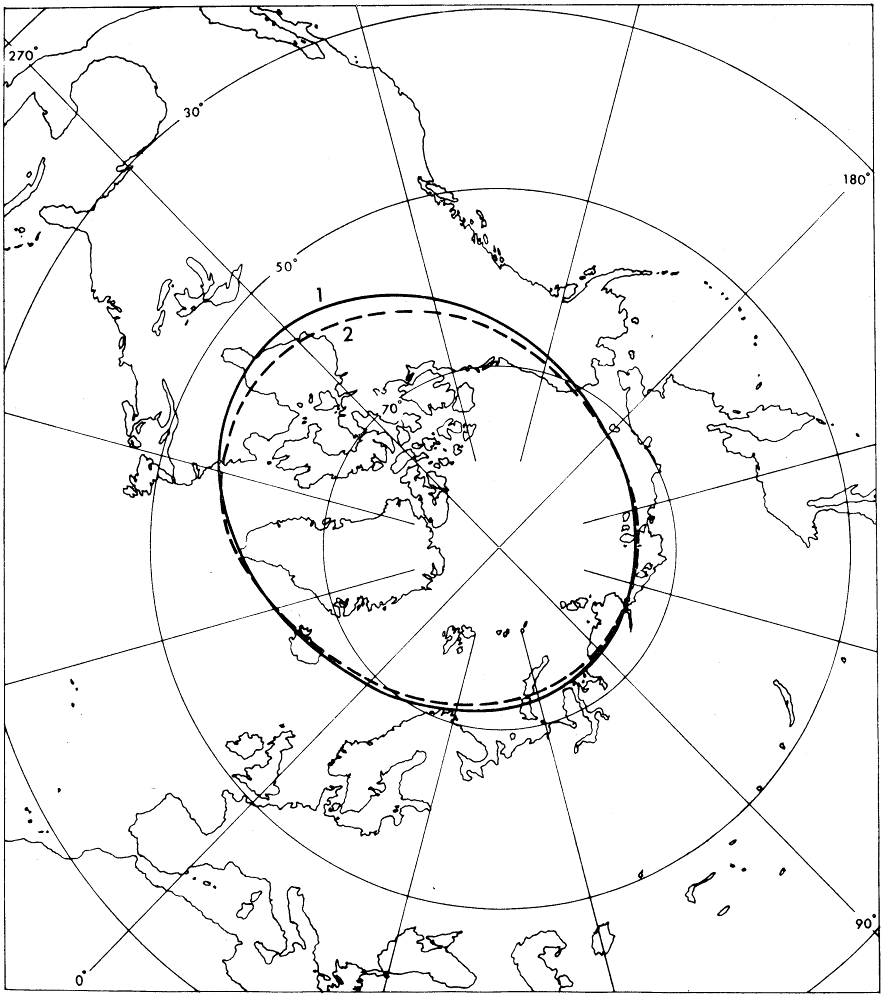

Fig. 3.—The iso-aurore, $\theta = 22 \cdot 5°$ N., conjugate to the southern hemisphere iso-aurore of maximum overhead frequency (1), together with the maximum iso-aurore of maximum frequency determined by Fel'dstein (1960) from observations (2).

References

Akasofu, S. I. (1966).—*Planet. Space Sci.* **14**, 587.

Bond, F. R., and Jacka, F. (1962).—*Aust. J. Phys.* **15**, 261.

Chapman, S., and Bartels, J. (1940).—"Geomagnetism." Vol. 2. (Oxford Univ. Press.)

Fel'dstein, Ya. I. (1960).—*Investigations of the Aurorae,* No. 4, p. 61. (In Russian.) (Academy of Sciences, U.S.S.R.)

Fel'dstein, Ya. I. (1967).—*Auroras and Airglow,* No. 13, p. 98. (In Russian.) (Nauka Publishing House: Moscow.)

Jensen, D. C., and Cain, J. C. (1962).—*J. geophys. Res.* **67**, 3568.

McIlwain, C. E. (1961).—*J. geophys. Res.* **66**, 3681.

Ness, N. F. (1965).—*J. geophys. Res.* **70**, 2989.

Northrop, T. G., and Teller, E. (1960).—*Phys. Rev.* **117**, 215.

Störmer, C. (1955).—"The Polar Aurora." (Oxford Univ. Press.)

Vestine, E. H., and Sibley, W. L. (1960).—*J. geophys. Res.* **65**, 1967.