# LETTERS TO THE EDITORS

## PHYSICS

### Impossible Magnetic-Field Self-Patterning

THE 'self-sustaining' Corbino disk recently proposed[1] is suspect. It was suggested that an axial magnetic field could Hall-deflect from an impressed radial current the azimuthal current just necessary for its existence. Inside, or axis side (outside, respectively), of an elemental current ring, its field contribution has indeed the sense of the field responsible for the ring, for inward (outward) motion of the dominant carriers. Outside (inside) the ring, however, its contribution is counter-sense to the field at the ring. This crucial embarrassment makes it difficult to imagine any finite, that is, physical, possibility for field self-patterning.

Certainly Midgley's solution, $B_z = Ar^{-k}$, $J_\theta = (k/\mu\eta_0)\, Ar^{-k-1}$, with neither changing sign, is trivial in the finite. In a disk with non-vanishing inner radius (finite radial current density) and finite outer radius, the fields at radii just within the inner and outer boundaries, lying inside and outside, respectively, all but an arbitrarily small circulating current, must differ in sign or both vanish. Thus $A$, the constant of integration, is zero. In an alternative view, the azimuthal current density, $J_\theta$, must go the 'wrong' way just within the outer (inner) boundary, for inward (outward) motion of dominant carriers, unless $J_\theta$ vanishes identically.

Perhaps the one-dimensional formulation is insufficient. Specifically, the tacit neglect of the term $\partial B_r/\partial z$ in the $\theta$-component of curl $\mathbf{B}$ is puzzling and possibly unjustified. One might have thought that, in the presence of azimuthal current, the radial component of the field would change considerably, and monotonically, along an axially directed path through a thin, but finite, current slab ; and that at a true current sheet Maxwell's equation would not be applicable.

It should be stressed that only the theory of magnetic-field self-patterning in a finite, unencumbered Corbino disk has been considered here. No disparagement of the magnetic power amplifier or bi-stable trigger circuit suggested by Midgley is intended. Suitable biasing at the outer boundary, for example, might replace 'infinity'.

Self-patterning, or self-determining, fields (the terms 'self-sustaining' and 'self-maintaining' have unfortunate energetic connotations) are sustained (*a*) by exogenous current or (*b*) by current from motional induction within the system considered. In the light of impossibility theorems[2,3] for certain simple classes of steady-state, magnetofluid-dynamic dynamos (type *b*), one might hypothesize that type-*a* self-patterning fields in cases of material homogeneity, high symmetry, and topological simplicity are unlikely to exist. For its own sake as a fundamental problem, and also for its possible relation to the important fluid dynamo problem under type *b*, the question of the possibility of type-*a* self-patterning fields deserves closer attention.

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[1] Midgley, D., *Nature*, **186**, 377 (1960).
[2] Cowling, T. G., *Mon. Not. Roy. Astro. Soc.*, **94**, 39 (1933–34).
[3] Backus, G. E., and Chandrasekhar, S., *Proc. U.S. Nat. Acad. Sci.*, **42**, 105 (1956).

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IT is true that Cowling's impossibility theorem would apply to a finite and unencumbered disk. To achieve a non-zero solution, it is essential that a finite disk be encumbered to the extent of an input coil, or a magnetic feedback path as proposed in Fig. 2 of my communication. If such configurations of the magnetic field with more than one interlinkage of the electric circuit were admissible in the astronomical context, the difficulties of dynamo maintenance would be reduced.

The essentially one-dimensional solution is valid for a disk of finite thickness and permeability $\mu$, bounded either by a medium of infinite permeability or by an axial stack of similar disks, such that $\partial/\partial z \equiv 0$. A finite disk not so bounded demands a more elaborate solution, in which $B_r$ varies with $z$.

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### Short-Period Time Variations of Extensive Cosmic Ray Showers

AN exploratory experiment has been conducted to determine whether or not short-period fluctuations in the arrival of extensive showers are sufficiently systematic to warrant detailed study.

Two Geiger–Müller tubes 4 cm. in diameter and 40 cm. in length were connected in a coincidence circuit, and the output was recorded on an oscillograph with a paper speed of 5 mm./sec. The two tubes were placed parallel and were horizontally separated by 1 metre. The equipment was placed on the roof of a building free from obstructions. Two such equipments were operated independently. Approximately one count per minute was obtained.

A total of 60 records, 5 hr. in length, were studied. There were 30 such records for each equipment. The two equipments were separated by 12 and 330 m.. so that the results obtained are regarded as independent samples.

The time-interval between successive counts, $\tau_i$, was listed as a function of the serial number of the count, $i$. This provides about 300 data pieces per record. The auto-correlation function was computed for each record, and was afterwards used to obtain the spectral curve. If the time-interval between successive counts is independent of any preceding or succeeding such time-interval, the auto-correlation function should be identically zero for lags of one or