LETTERS TO THE EDITOR

GEOPHYSICS

Determination of the Nature of the Earth's Distant Magnetic Field

ALTHOUGH surveys have been made with magnetometers on space-vehicles we still know very little about the geomagnetic field at great distances from the Earth. For example, it is not known to what extent the magnetosphere at a distance of 10 Earth radii rotates with the Earth; also it is not known whether the distant field is distributed symmetrically or asymmetrically about the Earth. There are good reasons for believing that the topological nature of the distant field is determined by the relative motion of the interplanetary medium; also the topology of the field in turn governs much of the physics of the Earth's immediate interplanetary environment and indeed may account for such phenomena as the aurora and the gegenschein[1]. It seems that if 'space geophysics' is to advance beyond its present state of theoretical speculation it is essential that we first learn the nature and character of the geomagnetic field at distances beyond 5 Earth radii.

With the present state of development in rockets and space-vehicles it is now possible to perform experiments on a global scale which can give direct evidence of the time and space varying properties of Earth's distant magnetic field. It is suggested[2] that an alkaline-earth element, either beryllium, magnesium, calcium, strontium, or barium, is released at a high altitude in a gaseous state. When singly ionized, these elements act as strong resonant scatterers of the solar radiation. The migrating ions will therefore trace or map out the distant geomagnetic field and their monochromatic radiation will provide evidence of the topology of the field.

It seems that the experiment can be started in either of two ways. The more obvious way is to release the resonant tracer in a gaseous state from a space-vehicle at a distance of 5–10 Earth radii. The probability per second of ionization by solar radiation varies from 10^{-5} for beryllium to 10^{-2} for barium, and this and other reasons indicate that barium is perhaps the best agent available for mapping out the geomagnetic field.

The alternative way of starting the experiment is to release the resonant tracer close to the Earth, at an altitude of at least 300 km., and at a latitude between the auroral zone and the magnetic pole. If the temperature of the resonant tracer material is sufficiently high, 10^5 ° K. in the case of beryllium and 10^6 ° K. for barium, a substantial fraction of the material will escape from the immediate vicinity of the Earth and will be trapped in the geomagnetic field. Such high temperatures suggest that the release should be accompanied by the bursting of a small atom bomb, as in the *Argosy* experiment[3]. This method has the advantage that the resonant tracer is released in an ionized state; unfortunately some fraction of the material is multiply-ionized and therefore ineffective as a resonant tracer.

The resonant scattering-rate of photons in the solar radiation is readily calculated, and after making allowance for the intensity within the absorption lines relative to the continuum it is found that the number of photons scattered per second per gram of ions is approximately the same for all the alkaline-earth elements and is of the order of 10^{22}. If we adopt the crude assumption that the ions are ultimately distributed about the Earth as a spherical shell of a mean radius equal to 10 Earth radii, the photon flux at the Earth's surface is of the order of 10^5 cm.$^{-2}$. sec.$^{-1}$ sterad.$^{-1}$ for 100 kgm. of ions. This is roughly equal to the radiation intensity from sodium in the night sky, and should be sufficient for observing the time variations of the distant field. Shortly after the release, while the ions are still concentrated in a relatively small space, the radiation intensity will be greater, and it should be possible to follow with relative ease the migration of the ions as they trace out the geometry of the field.

It is suggested that the release of an alkaline-earth element in the neighbourhood of the Earth will provide information of the greatest importance to space geophysics. The quantity needed of a given element is not excessively large, and perhaps as little as 10 kgm. would serve to establish some of the characteristics of the distant geomagnetic field.

A more detailed discussion is to be published elsewhere[2].

E. R. HARRISON
Atomic Energy Research Establishment,
Harwell, Berkshire.

[1] Harrison, E. R., *Geophys. J.* (to be published).
[2] Harrison, E. R., *Geophys. J.* (to be published).
[3] Christofilos, N. C., *et al.*, *J. Geophys. Res.*, **64**, 865 (1959).

PHYSICS

Nuclear Thermalization in Pulsed Moderators

A THEORETICAL investigation into the time-energy and space-energy behaviour of a pulse of fast, fission energy neutrons introduced into non-multiplying, moderating media has been concluded. In particular, interesting results have been obtained for the thermal region where the neutron energy is less than one electron volt and the neutron–nucleus scattering process is essentially quantum mechanical.

The energy-dependent Boltzmann equation has been solved after the manner of Kazarnovsky[1] for a general scattering operator *So* which includes chemical binding effects.

An exact expression has been obtained for the diffusion cooling coefficient, and the relative contributions of transport and energy effects to this parameter have been assessed. This throws further light on the work of Nelkin[2].

The spatial dependence of the thermal neutron energy spectrum and its departure from the Maxwellian has been investigated. A method for defining the region in a finite medium within which space and energy are accurately separable has been established.

An expression for an extrapolation distance independent of energy has been formulated. This is shown to depend on the geometrical buckling or fundamental eigenvalue of a finite system in a simple way.