LETTERS TO THE EDITORS

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Blackett's Fundamental Theory of the Earth's Magnetic Field

Soon after the publication of Prof. P. M. S. Blackett's paper[1], Dr. E. C. Bullard suggested to us that it should be possible to test Blackett's theory against other theories by measurements of the magnetic field of the earth in the mines of the Witwatersrand. By courtesy of the management of the Blyvooruitzicht G.M. Co., we made a series of underground observations on Blyvooruitzicht mine.

Using an Askania horizontal magnetometer (Schmidt type), we measured ΔH at five points underground on three successive days, giving in all fifteen determinations of ΔH. A similar instrument was read at the surface at 5-min. intervals during the duration of the underground measurements, so that we were able to allow for diurnal variation. The observations were not as satisfactory as we had hoped, in that there was a larger closing difference than we had expected when the underground instrument was brought back to the surface base station after the observations underground. This difference amounted to 14, 22 and 32 gamma on the three separate days.

The observations were referred to the mean of the values found at four points on an east–west line of 300 yd. centred above the points at which the underground observations were made. The closing error was allowed for in two ways: (1) it was assumed that it was due to random errors of reading, and ΔH was calculated from the mean of the initial and final surface readings; (2) it was assumed that the closing difference was due to a drift linear in time.

The final results for the full fifteen sets of observations with their standard deviations are:

H (underground) $-$ H (surface) $= -26 \pm 4\,\gamma$, corrected according to (1), and
H (underground) $-$ H (surface) $= -24 \pm 4\,\gamma$, corrected according to (2).

For the three days separately, these results were:

-31 ± 9, -21 ± 4 and -25 ± 2, corrected according to (1); and
-30 ± 10, -19 ± 4 and -23 ± 1, corrected according to (2).

The mean depth of the observation points below the mean surface for a distance of five miles from the observation point was 4,800 ft.

In a private communication (to be published), S. K. Runcorn compares the variation of the field with depth for Blackett's theory and for all theories which attribute the magnetism to processes in the central core of the earth. He obtains the formula:

Blackett's theory: $H_d = H_0 \left\{1 - 2\left(\frac{5\rho_1}{\rho} + 1\right)\frac{d}{a}\right\}$;

Core theories: $H_d = H_0 \left(1 + 3\,\frac{d}{a}\right)$;

where H_0 is H at surface, H_d is H at depth d, a is radius of the earth, ρ_1 is mean density of rocks to depth d, and ρ is mean density of the earth. From these formulæ, for a depth of 4,800 ft., we calculate

$\Delta H = -26\,\gamma$ (Blackett's theory);
$\Delta H = +11\,\gamma$ (Core theory).

Before comparing the theoretical and observed effects, it is necessary to point out that the lower Witwatersrand system which underlies the underground observation point contains several shale bands which produce considerable anomalies at the surface (Krahmann[2]). Calculations based on Krahmann's values show that the shales produce a relative decrease at depth of not more than $9\,\gamma$. In addition, there were two dykes in the neighbourhood of the observation area which can be expected to give a relative decrease of not more than $5\,\gamma$. The effect of the local geological structure is thus to produce a decrease of at most $14\,\gamma$, and it might be as little as $6\,\gamma$. Allowing for the geological effects:

(1) H (underground) $-$ H (surface) $= -12 \pm 4$, or $-20 \pm 4\,\gamma$;
(2) H (underground) $-$ H (surface) $= -10 \pm 4$, or $-18 \pm 4\,\gamma$.

Even taking our lower limit, the results differ significantly from the core theory. They also differ significantly from the values calculated on the basis of Runcorn's formula. This difference may be accounted for by the fact that Runcorn's formula applies strictly to depth below the mean surface of the whole earth, whereas the mean surface level at Blyvooruitzicht is 5,200 ft. above mean sea-level. It is also possible that there is some geological factor of which we have not taken account. The uncertainty arising from local geological structure should be eliminated by an extended series of observations together with a detailed surface survey, which it is intended to carry out.

In addition to the management and staff of the Blyvooruitzicht G.M. Co., we are indebted to the director, Geological Survey Office, for the loan of instruments.

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[1] Blackett, P. M. S., *Nature*, **159**, 658 (1947).
[2] Krahmann, R., *Trans. Geol. Soc., S. Africa*, **39**, 1 (1936).

Universal Constants in Blackett's Formula

Recently, Blackett[1] has suggested that the formula

$$P = \beta \cdot \frac{G^{1/2}U}{c}$$

represents a fundamental relation between the angular momentum U and the magnetic moment P of a massive rotating body; where G is the gravitational constant, c the velocity of the light and β a dimensionless constant of the order of unity. If the formula were true, it would be a great aid towards finding a theory unifying the gravitational and the electromagnetic field. It is, therefore, interesting to investigate what conditions the formula would impose upon such a future theory. If we assume that the