Effect of Near Lightning Discharges on a Magnetometer

DURING two thunderstorms at the beginning of the present monsoon, the recorded curves of the Copenhagen declination magnetograph recently installed at Alibag showed some characteristic features which on examination appear to be due to the effect of the magnetic field of the lightning discharge currents on the magnetometer. The magnetograms are reproduced in Fig. 1. The variations occurred between 2 hr. and 4 hr. and between 18 hr. and 22 hr. I.S.T. The storm was most intense in the second of the two intervals at about 20 hr. The magnetometer needle experienced a number of sudden kicks, and the subsequent oscillations gradually died down in 2–3 minutes. The maximum first deflection was about 1·5 mm.

It is easy to make a rough estimate of the deflection of the magnetometer needle that may be expected due to the magnetic field of a near lightning discharge. For impulsive discharges the total duration of which is small compared with the periods of the magnetometer, the instrument will behave as a ballistic galvanometer, the relation between the discharge current, its duration, the constants of the suspended needle and the field in which it is suspended being given by the usual formula:

$$\int idt = q = \frac{HT}{\pi G} \sin \frac{\theta}{2} \left(1 + \frac{\lambda}{2}\right),$$

if the magnetic field due to the current is perpendicular to H. In the present instance, T was 3·95 sec. and H was $\frac{0 \cdot 376}{4 \cdot 9}$ gauss. The effective magnetic field was smaller in the ratio 1 : 4·9 because, in order to increase the sensitiveness of the magnetometer, the north pole of the needle had been made to face south by applying torsion to the suspending quartz fibre

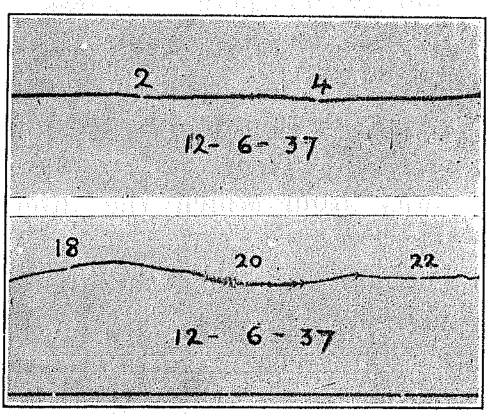

Fig. 1.

RECORDS OF A D. LA COUR DECLINATION MAGNETOGRAPH OBTAINED ON MAY 12, 1937, AT ALIBAG, NEAR BOMBAY, SHOWING THE EFFECT OF NEAR LIGHTNING DISCHARGES. THE TIMES ARE IN HOURS (INDIAN STANDARD TIME).

in the manner recommended by Dr. D. La Cour. Now G, the field at the needle (supposed short) due to unit current in the discharge circuit is given by

$$G = \frac{l \sin \theta}{r^2},$$

where l is the length of the discharge current, r its distance and θ the angle between r and the discharge path. The direction of the field is perpendicular to the plane containing l and the centre of the needle. Assuming $\sin \theta = 1$, $l = 2$ km. and $r = 2$ km., then $G = 5 \times 10^{-6}$. A probable value for q is 20 coulombs (see C. T. R. Wilson's article on Atmospheric Electricity in the "Dictionary of Applied Physics"). From these data the deflection of the needle can be easily calculated. It comes out to be 1/4820 radian when the lightning discharge is most favourably oriented. The corresponding deflection on the chart when the distance of the photographic paper from the mirror of the magnetometer is 165 cm. is 2 × 165/4820 cm. or 0·7 mm. The observed and expected deflections are of similar magnitudes.

Attempts are being made to design a simple magnetometer with a Helmholtz compensating coil for the purpose of measuring the discharges of individual lightning flashes.

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