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TRANSIENTS OF MAGNETOGRAPHS
AND INSTANTANEOUS VALUES FROM
RECORDINGS

It is usual to divide magnetic disturbances into two classes (1) where the values of magnetic elements (H —the Horizontal Force, V —the Vertical Force and D —the Declination) undergo a sudden change in the course of a few minutes and (2) where the corresponding values change only gradually. In describing the former type of disturbances the value of the 'first impulse' at the time of commencement is given for each element (H , V , D). The horizontal and vertical Magnetic impulses are given in terms of γ (10^{-5} Gauss) and that for declination is given in terms of degrees. The 'impulse' is derived by measuring the sudden displacement in terms of the scale value. The scale value is determined by superposing a known magnetic variation near the magnetographs, allowing the magnets to become steady and measuring the resultant displacements. The magnification is a *static* determination.

For the last few years (1949 onwards) at the Alibag Magnetic Observatory, the Watson Magnetographs have on some selected occasions been put on quick-run with an extended time-scale (about 180 mm instead of 15 mm hr⁻¹).

While tabulating the equivalent magnetic variations a doubt arose whether the displacements as instantaneously recorded represented genuine variations in the magnetic field. To put it in another way, were any magnetic transients being recorded purely as a result of the constants of the magnetographs? Would one be justified in using the static scale values when the magnetographs were moving rapidly? Obviously one should expect some complications due to the vibratory nature of the recording instruments.

Changing the magnetic field by electric currents was not satisfactory as then the transients due to the electric circuits would complicate the problem. It was decided

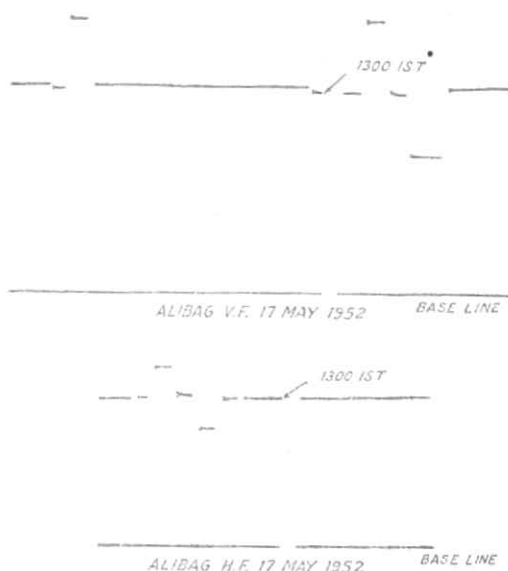


Fig. 1

to change the magnetic field by orienting permanent magnets from a horizontal position to a vertical one and *vice versa*. By this process, the particular component of the magnetic field either decreases or increases unidirectionally from one value to another.

The recorders were put on quick-run while the above experiments were conducted so that the transients if any could be clearly seen. The change from the vertical to the horizontal or *vice versa* of the magnets were done as quickly as possible. The illumination is by kerosene lamp and the trace is not as contrasty as one might like it to be. The photographic papers used were Criterion Hard or Ortho-document Bromide.

The traces for the V and H instruments have been reproduced in Fig. 1.

When the field is changed, from the records no evidence of lag in the recording instruments is noticed. The initial displacement is much greater than that expected from the scale value. The trace is a damped oscillatory harmonic one till it settles down to the ultimate value.

The equation for the deflection θ can be written as

$$\ddot{\theta} + 2k\dot{\theta} + (n^2 + k^2)\theta = A(n^2 + k^2)F$$

where A is the static magnification,
 F the changed magnetic field,
 k the damping factor and
 $2\pi/n$ is the period of vibration of the magnetograph.

In the particular instruments at Alibag the periods are 4.9 sec for H and 10.2 sec for V . The damping factors are 0.286 for H and 0.015 for V .

The complete solution for the above differential equation can be written down easily (Lamb 1926).

$$\theta = \frac{\sin nt}{n} \varepsilon^{-kt} \int (n^2 + k^2) AF \varepsilon^{kt} \cos ntdt - \frac{\cos nt}{n} \varepsilon^{-kt} \int (n^2 + k^2) AF \varepsilon^{kt} \sin ntdt$$

In large magnetic disturbances, the records at many stations consist of rapidly changing traces and sometimes of only disjointed specks at the extremities which will need to be connected up by lines to get the final photographic trace. It would be clear that in view of what has been brought out above that the extreme values given by the traces would not represent the actual magnetic variations. The application of static magnification values would need modification when rapidly changing records are dealt with. Hence in the initial stages of the sudden commencement, the values are over-estimated. As the records are not all on the same type of instrument at different observatories, a strict comparison of the actual values would need the constants of the magnetometers.

The next question that poses itself is whether the disturbance curves are affected by the above discussion. A complete answer is only obtained by finding the true curve from the photographic trace after applying the equation above which is being done in a few cases.

The general character of disturbance curves as calculated by Moos (1910), Chapman (1936) and Chapman and Bartels (1940) would be essentially maintained. The characters are tabulated at intervals of time which are large compared with the free periods of the magnetographs. Most of magnetographs are from the usual slow-run instruments where it is difficult to tabulate at intervals which become comparable with the free periods of the instruments. The periods of the superimposed magnetic field dealt with till now are also large compared with those of the instruments. Hence except in the region when rapid fluctuations in the magnetic elements are occurring, it may just be possible to ignore the first two terms of the differential equation. The static magnification equation is the result.

But once one tries to enter into the finer structure for example the sudden changes in the elements or when one wants to correlate individual peaks or troughs of the record with other records where free periods of the recording instrument are extremely small compared with those of the magnetographs (e.g. ionospheric variations), the discussion in this note would become immediately significant and essential.

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