ELIMINATION OF ANHYSTERETIC EFFECTS DURING ALTERNATING FIELD DEMAGNETISATION IN PALAEOMAGNETIC INVESTIGATIONS

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IT is a common practise in plæomagnetic investigations to test a rock sample for its magnetic stability and to eliminate or sufficiently reduce the secondary magnetic components, if any. For this purpose two laboratory techniques are available, *viz.*, alternating field demagnetisation and thermal demagnetisation.

The principle of these demagnetisation techniques is based on the experimentally verified result that the primary magnetisation in a rock is more stable against demagnetisation than the secondary magnetisation. In the alternating field demagnetisation technique when a rock sample is subjected to an alternating magnetic field of a certain peak value the magnetic domains having coercive forces equal to or less than that of the applied field are alternately magnetised and demagnetised and when the applied alternating field is reduced to zero gradually these magnetic domains are carried through progressively smaller and smaller hysteresis cycles and are finally demagnetised. Since the secondary magnetisations, as mentioned earlier, are less stable than the primary magnetisation, the secondary components of the natural remanent magnetisation in a rock sample can be effectively removed by demagnetising the sample.

As a rule this demagnetising process should be carried out in a space free of any direct magnetic field, say that of the earth, since the superposition of any steady magnetic field over the alternating magnetic field results in the development of 'anhysteretic magnetisation'.[1,2] In general the compensation of the earth's magnetic field in the a.f. demagnetisation equipment is done by employing three pairs of Helmholtz coils set in a mutually perpendicular arrangement. These coils carry suitable direct currents and produce magnetic field which exactly balances the earth's magnetic field at the centre of the coil system. Such a coil system is also employed in highly sensitive astatic magnetometers used to measure the natural remanent magnetisation in the weakly magnetised rocks. This steady magnetic field, *i.e.*. the earth's magnetic field, should be very critically balanced in the case of the a.f.

demagnetisation for even small fields of the order of 50×10^{-5} Oersted may produce anhysteretic components which mask the direction as also the moment of the magnetic vector in the sample. This effect can be more serious when weakly magnetised samples are demagnetised, particularly at higher fields.

To measure the magnetic field and to determine the currents to be sent through the Helmholtz coils to compensate the earth's magnetic field, an earth inductor connected to a ballistic galvanometer is generally employed. The accuracy that can be attained following this technique is, however, not sufficient. In the absence of more sensitive instruments like flux gate magnetometer probes we have adopted the following procedure based on the phenomenon of the acquisition of anhysteretic magnetisation, to find the currents required to compensate the field thus facilitating the estimation of magnetic vector in the sample during successive stages of demagnetisation with greater accuracy. The alternating field demagnetiser constructed by us has been described elsewhere.[3]

First the currents 'i_x', 'i_y' and 'i_z' in the Helmholtz coils 'X', 'Y' and 'Z' required to compensate effect of the earth's magnetic field along the respective directions were found using the earth inductor and the ballistic galvanometer (Fig. 1).

A magnetically stable rock sample (Deccan Trap basalt) was then cut in the form of a cylinder of dimension $2 \cdot 5 \times 1 \cdot 25$ cm. (height and radius) and was placed in the a.f. demagnetizer with its axis (designated x-axis) parallel to the alternating magnetic field. The sample was demagnetised in this position at 380 Oersteds using the previously determined currents 'i_x', 'i_y' and 'i_z' in the respective Helmholtz coils. After demagnetisation the magnetic moments of the sample 'M_x', 'M_y' and 'M_z' along the three perpendicular directions were measured with a highly sensitive astatic magnetometer. Then the sample was placed in a reversed position, *i.e.*, antiparallel to the earlier position, and was again demagnetised at the same field using the same currents in the Helmholtz coils. The three components of

the magnetic moment of the sample were again measured. This procedure was repeated with different currents in the X-coil, say i_{x_1}, i_{x_2}, i_{x_3}, ...etc., on either side of 'i_x' without changing currents in the 'Y' and 'Z' Helmholtz coils.
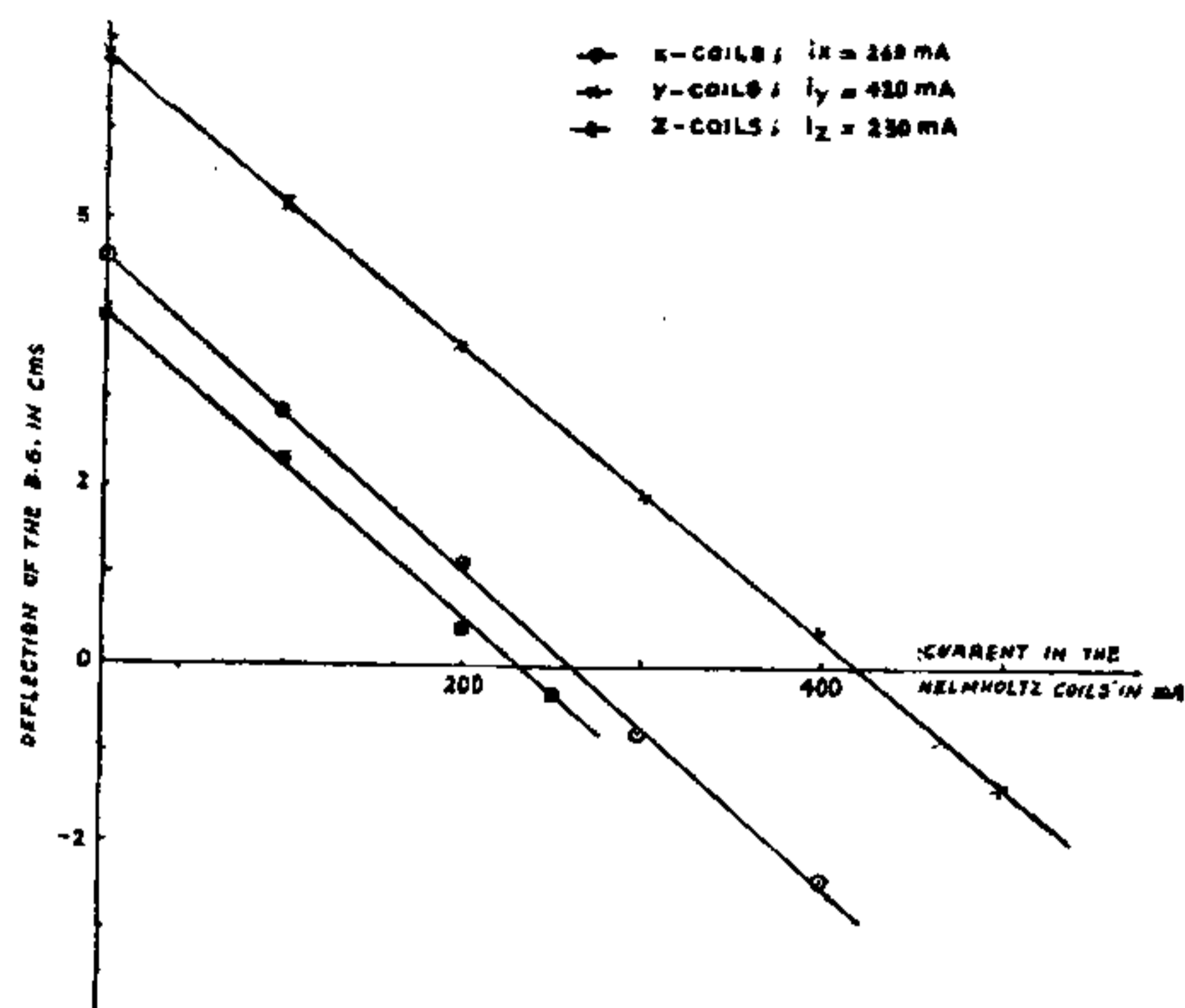

FIG. 1. Compensation currents for the earth's field obtained for the three coil systems using earth inductor and ballistic galvanometer.
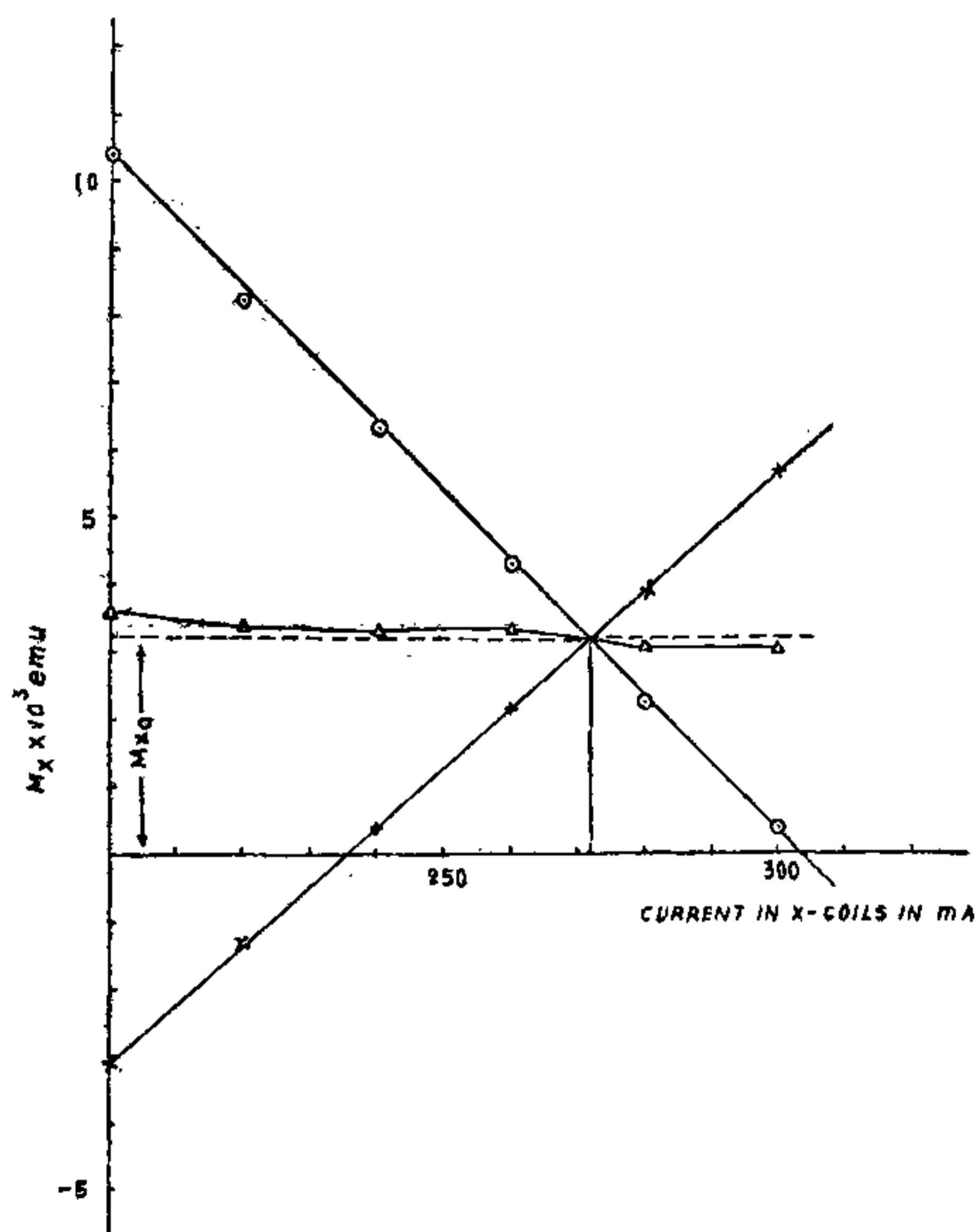

FIG. 2. Eliminations of anhysteretic magnetisation along X-component M_x = $3 \cdot 2 \times 10^{-3}$ emu. i_{x_0} = 272 mA, compare with i_x = 260 mA (Fig. 1).

Whenever the current in one of the Helmholtz coils, the 'X' coil in this case, is different

from the value of the current required to compensate the earth's field along that axis, x-axis here, an unbalanced magnetic field developed in that direction producing an anhysteretic magnetisation in the demagnetised sample. Calling the true x-component of the magnetic moment of the sample as 'M_{x_0}' the measured value can, therefore, be written as '$M_{x_0} \pm dM_{x_0}$' where 'dM_{x_0}' is the anhysteretic component in that direction. For the reverse position of the sample the measured moment will similarly be '$M_{x_0} \mp dM_{x_0}$' since the anhysteretic magnetisation will now be acquired in the reversed direction.

In Fig. 2 are plotted the measured x-components of the magnetic moment of the sample obtained after demagnetisation in the 'normal' and 'reversed' positions for various currents in the x-coils. The points fall roughly on a pair of straight lines which meet at a point with co-ordinates 'M_{x_0}' and 'i_{x_0}', the true value of the demagnetised x-component and the current required to compensate the field along the x-direction respectively. Further, the mid-points of the two measurements of the 'normal' and 'reverse' positions of the sample, also plotted in Fig. 2, fall reasonably on a straight line parallel to the current axis. This straight line cuts the ordinate at:

$$\tfrac{1}{2} \{ \; (M_{x_0} \pm dM_{x_0}) + (M_{x_0} \mp dM_{x_0}) \; \} = M_{x_0}$$

Thus, incidentally, one can take the average value of 'M_{x_0}' of this straight line as the true demagnetised value of the magnetic vector in the x-direction.

A similar procedure was adopted for the other two coils and the correct values of 'i_{y_0}' and 'i_{z_0}' were estimated. These results are, however, not being given here.

By the above procedure it is found that the compensation of the earth's magnetic field can be done more accurately than with the use of earth inductor alone. Subsequent studies have justified this conclusion, as evidenced by the fairly high quality of the demagnetisation results.

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2. Cox, A. and Doell, R. R., *Bull. G.S.A.*, 1960, **71 (6)**.
3. Bhimasankaram, V. L. S., Prasad, V. and Pal, P. C., *U.G.C. Seminar on 'Mafics and Ultramafics of India*,' Osmania University, August 1966.