New Means of Control of Compensating the Earth's Magnetic Field in Investigations on a Vertical Astatic Magnetometer

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A new method is given for checking the required intensity of a current in the windings of a vertical astatic magnetometer for compensating the vertical components of the earth's magnetic field and other external parasitic fields.

THE method offered here is based on the utilization of the magnetic temperature hysteresis[1-5], i.e.,on the irreversible variation of the intensity of magnetization in a weak, steady magnetic field upon heating and cooling of a ferromagnetic specimen.

Figures 1 and 2 display, respectively, the curves for the magnetic temperature hysteresis of specimens of Fe-Si alloy and polycrystalline nickel in a field of 0.06 oersted, according to Shur and Baranova [4], taken with the use of an A type cycle, i.e. heating followed by cooling.

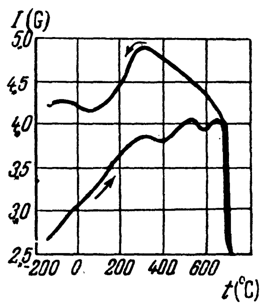

Fig 1. Magnetic temperature hysteresis of a sample of of iron-silicon alloy (3.7% Si) He = 0.06 oersted

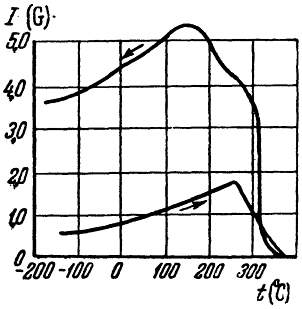

Fig. 2. Magnetic temperature hysteresis of a sample of polycrystalline nickel. H_e= 0.06 oersted

It is observed from these Figures that, as one approaches the Curie point, the magnetization of the samples grows suddenly up to a maximum (Hopkinson's effect [6]), and then falls down to zero. On cooling, a sudden increase in magnetization appears again, with a maximum which lies far above the Hopkinson's maximum.

If these phenomena are observed in absence of current in the magnetizing coil of the magnetometer, it is obvious that the sample lies in a weak steady field due to the vertical component of earth's magnetism or in a constant parasitic magnetic field. On selecting the appropriate current in the compensating winding of the magnetometer one can achieve a situation such that a crossing of the Curie point on cooling will not be followed by an increase in the magnetization of the sample. At the same time this will serve as a proof of the full compensation of the influence of the vertical component of the earth's magnetic field and of any external parasitic fields.

[1] Ia. S. Shur and V. I. Drozhzhina, J. Exper. Theoret. Phys. USSR **17**, 607 (1947)

[2] V. I. Drozhzhina and Ia. S. Shur, Izv. Akad. Nauk. SSSR Ser. Fiz. **11**, 539 (1947)

[3] Ia. S. Shur, N. A. Baranova and V. A. Zaikova, Doklady Akad. Nauk. SSSR **81**, 557 (1951)

[4] Ia. S. Shur and N. A. Baranova, J. Exper. Theoret. Phys. USSR **20**, 183 (1950)

[5] S. V. Vonsovskii and Ia. S. Shur, *Ferromagnetism*- Moscow 1948, p. 426

[6] Hopkinson, Phil. Trans. **153**, 443 (1889)

Thus, if one investigates with the magnometer a process related to temperature change, then, in order to select the right current in the compensating winding, there is no need to build a complicated additional device such as a ballistic coil in series with a galvanometer [7], i.e. an induction inclinator[8], or an arrangement of switches and potentiometers in the magnetic circuit in order to obtain in it an alternating current with a smoothly damped amplitude. If one studies a process at room temperature, in order to choose the current in the compensating windings, one substitutes a nickel sample (Curie point 360 °C) for the original one, by placing it inside of the bifilar winding of the furnace; this is much simpler to do than to manufacture an induction inclinator or to arrange a set of potentiometers which would smoothly decrease the amplitude of the alternating current.

Thus, on working with a vertical magnetometer, for compensating the external fields one has first to compensate the effect of the magnetic fields of the magnetometer coils on the astatic suspension; this is achieved by moving the movable coil of the magnetometer [1] and by using a shunt in the magnetic circuit [9]. Then, with the magnetizing circuit open, the sample is placed in the fixed coil and is heated up to a temperature above the Curie point.

[7] *Spezialny Fizicheskii Praktikum*, Moscow State Univ. **2**, 115 (1945)

[8] *O. D. Khvol'son Kurs Fiziki (Course in Physics)* **4**, 2 (Rikker Edition) (1915) p. 164

[9] J. Richard and R. M. Bozorth, J. Opt. Soc. Amer. **10**, 593 (1925)

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The light spot reflected from the mirror of the static suspension is to be positioned on the division of the scale which corresponds to a zero magnetization of the specimen. After that, current is fed into the compensating coil and the furnace is disconnected.

On the cooling of the sample the crossing of the Curie point is usually followed by a deviation of the spot in a direction which depends on the intensity of the current in the compensating winding. By repeating similar operations one can select a "compensating current" of a magnitude such that the crossing of the Curie point on cooling of the sample will not be followed by a deviation of the spot from the zero position.

There is no need to cool the sample down to the room temperature on each operation. For Ni, for instance, it is sufficient to cool down to 320 °C to detect a deviation of the spot from the zero position of magnetization. Therefore, the time lost in each operation is not more than 3-5 minutes and the total time for compensating the vertical field components is about 20-25 minutes, i.e., almost the same as that in using an induction inclinator.

The accuracy of compensation by the proposed method is increased considerably because the very high sensitivity of the static suspension is utilized. Fields of the order of 10^{-4} oersted are "caught" by this method; with a magnetizing field of 0.015 oersted this represents a relative error of only 0.6%.

If the dimensions of the magnetometer coil permit the making of a very sensitive induction inclinator, the proposed method can be used to control the correctness of the compensation of the vertical components of earth's magnetic field and external parasitic fields.