THE APPLICATION OF A NEW SHAPE OF A MAGNET POLE CAPS FOR THE FARADAY MAGNETOMETER

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An electromagnet is designed for magnetic susceptibility measurement by the Faraday method with pole caps of the same form as those in magnets used in micromanometers with diamagnetic levitation. In this paper the results of tests of this magnet are presented.

INTRODUCTION

In Faraday magnetometers magnets are used with specially designed pole faces which provide the regions for which $B\,\partial B/\partial z$ = const, that is, the force F on the sample has a plateau [1] .

For diamagnetic levitation magnets with large values of the gradient $\partial B/\partial z$ in the pole gap [2] are used. The shapes of the pole caps used for this purpose are described in various papers in which the application of diamagnetic levitation in the construction of absolute micromanometers is considered (f.e. [3]).

In this paper the design of one electromagnet with pole caps previously used for a type of levitation micromanometer [3] is described. The magnet is used for magnetic susceptibility measurements. The paper presents the results of tests with this magnet.

DESCRIPTION OF THE MAGNET

For the construction of the magnet low carbon commercial iron is used. The magnetic permeability for this material changes from $\mu_r = 300$ at $H = 25$ A/m to $\mu_r = 100$ at $H = 550$ A/m.

The design of magnetic pole caps and magnetic circuit of the magnet is performed using the known procedure (e.g. [4]).

The electromagnet is shown in one projection in fig. 1. In the figure the basic dimensions of the magnet are given. The lower pole is immobile while the upper pole may be screwed in the nider part of the magnetic circuit. This enables the pole gap width (L) and configuration of the field to be changed. The coils on the magnetic poles have two sections each with 1500 windings of copper wire 1,5 mm in diameter. The coils are water cooled.

The shape and dimensions of the pole caps are shown in fig. 2. The information on the magnetic field strength which may be attained with this magnet is given in fig. 3. It presents the dependence of the magnetic induction B(T) on the magnetizing current I(A) for the pole gap L = 14 mm. The measurement was performed with the Hall - teslameter with the probe at the distance z=1 mm from the lower pole face. All the measurements described further in the text were performed at I = 9 A.

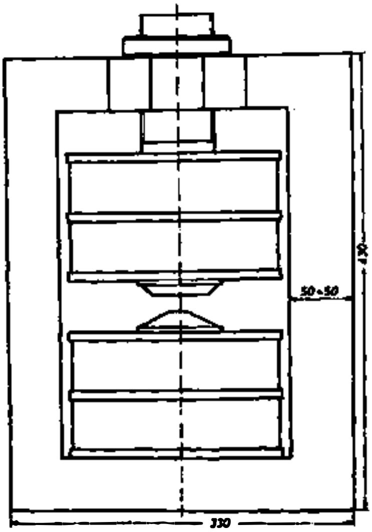

FIG. 1

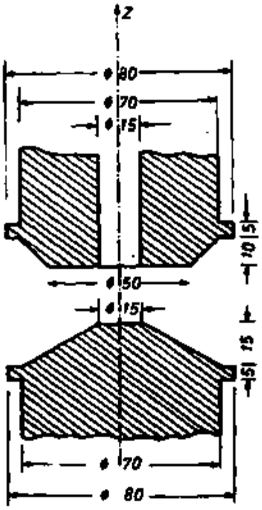

FIG. 2

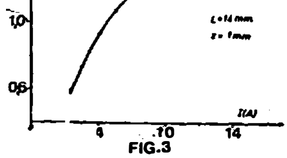

FIG. 3

DEVICE FOR SUSCEPIBILITY MEASUREMENT

The device is shown in fig.4. The electromagnet (1) is mounted on a hydraulic support (2) which enables the regulation of the magnetic position. The magnet is connected with a stabilized power supply (3). The measurements of the force are performed by measuring the extension of a helical silica spring (4) also designed in our laboratory. The position of the sample suspended on a spring and the strain of the spring are measured optically by the use of a cathetometer (5). It was found that one division of the ocular scale (0,01 mm) corresponds to the force $1,95.10^{-7}$ N.

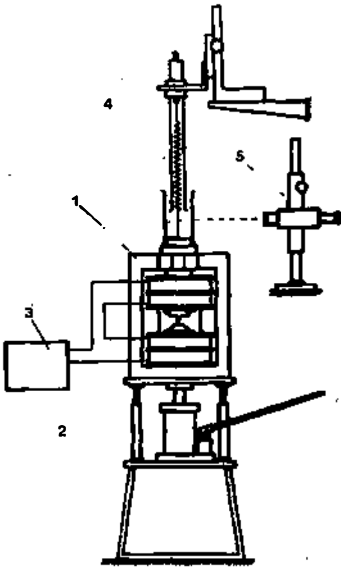

FIG.4

TESTES OF THE DEVICE

The tests were accomplished withe a powder sample of $ZnSO_4.7H_2O$. The sample holder is made of glass 6 mm in height and 5,4 mm in diameter. The mass of the sample holder was 0,095 g and the mass of the sample was 0,122 g.

The measurements of the force on the sample F(N) was performed at different distances z(mm) from the lower pole face. The results of these measurements for different values of magnet pole gap L(mm) are presennted in

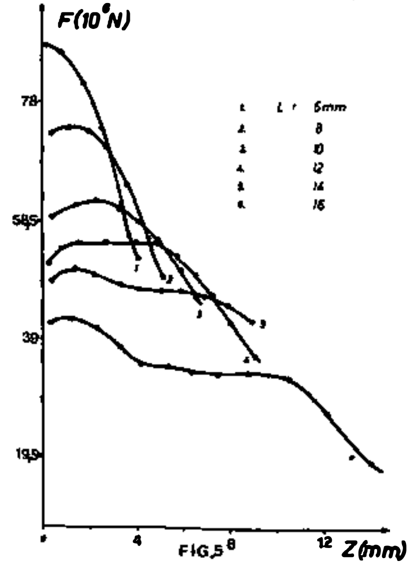

FIG.5

fig. 5. From this figure it follows that when L_1=12 mm (curve N^{o}4) and L_2=16 mm (curve N^{o}6)there exist the plateaus $F \propto B\partial B/\partial z$= const. The lengths of these plateaus are z_1=3,5 mm and z_2=4 mm. Using a value of - 0,497.10^{-6} emu/g [5] for the mass susceptibility of $ZnSO_4.7H_2O$ we obtained at the pole gaps L_1 and L_2 the values of $B\partial B/\partial z$ to be 0,902 T^2/cm and 0,547 T^2/cm respectively. For the magnetic field intesity of 0,9 T and the gap L_1 the value of $B\partial B/\partial z$ is at the same field, 11,8 times greater than that of commercial magnet (ALPHA M 6000, Systron-Donner) with Faraday pole caps of 6 inches in diameter and the pole gap of 1,5 inches. The adventage of the shape of the applied pole caps is apparent.

As and additional chek of device, a number of different compounds whose susceptibility is known from previous work have been measured using NH_4Br as a reference (-0,480.10^{-6} emu/g [5]). Table I shows results. The results obtained are in good agreement with reported values.

Table I. Mass susceptibilities ($\varkappa$) of powdered specimens at 22^{o}C.

Substance	-(10^6 emu/g)		$\Delta\varkappa/\varkappa_r$ (%)
	this work $\varkappa_e$	literature [5] $\varkappa_r$	
NH_4Cl	0,708	0,686	- 3,2
NH_4F	0,606	0,621	+ 2,4
NH_4NO_3	0,432	0,420	- 2,9

FINAL REMARKS

The fact that for two values of pole gap there exist two different plateaus of F, enables the realization of double measurements and the elimination of the error caused by the sample holder.This error is apalyzed in details in [6] and it is described also in [7] .

Finally, it should be remarked that because of axial symmetry of the magnetic field, the lateral effects which limit the maximum force on the sample [8] are eliminated. Because of the axial symetry, the shape of pole caps used may be suitable for measurements on samples of large anisotropy.

REFERENCES

1. Bates, L.F., Modern Magnetism,Cambridge Univ.Press,London,1963.
2. BraunbeckW., Z.Phys.112,753, (1939); 112,764 (1939)
3. Boutry G.A.,Evrard R. and Perrin R.,Compt.Rend.257,70 (1963).
4. Montgomery D.B.,in High Magnetic Fields,ed.H.Kolm,B.Lax, F.Biter and R.Mills,J.Wiley,New York,1962,pp.180-193.
5. Handbook of Chemistry and Physics,ed.R.C.Weast, Chemical Rubber Co., Cleveland, 1975.
6. Napijalo M.Lj. and Žegarac S., J.Engon.Phys. (Belgrade) 15, 5 (1976)
7. Zell W., Roden B. and Wohlleben D.,J.Magn.Magn.Mat.,9, 26 (1978)
8. Stewart A.M., J.Phys. E, 3, 251 (1970).