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A ROTATING PROBE FOR MEASUREMENTS OF FIELD STRENGTH GRADIENT OF LABORATORY ELECTROMAGNETS

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The construction of a probe for measurements of magnetic field strength grandient of laboratory electromagnets is described. The probe consists of two very small coaxial coils whose distance is constant. The windings of the coils are in series opposing connection. The coils are mounted on a spindle which is driven by a synchro-motor. When they are placed in a non-uniform magnetic field an e.m.f. is induced which is a measure of the magnetic field grandient at that particular place.

Measurements of some magnetic quantities frequently necessitate the knowledge of the magnetic field gradinet. There are several methods of determination of the latter, *e. g.* the method of a magnetic balance with a standard sample. This method is rather inconvenient, in particular if the knowledge of the togopraphy of the field is required for various pole-shoe distances and supplying currents. On the other hand a very convenient tool for measuring the gradient is a rotating probe of sufficiently small diameter. By shifting it in the investigated magnetic field region one can measure not only the field strength but also the gradient in arbitrary direction.

For measurement of the field strength a single small coil is sufficient whereas in gradient measurements of reasonable precision such single coil does not suffice. It is, in principle, possible to determine the field strength in two consecutive regions of the field by shifting the coil in a given direction and then calculate the mean gradient by dividing the field strength difference by the distance between these two regions. The error of such procedure is, however, quite considerable, especially for small field gradients.

More accurate measurements can be performed by means of a probe with two coils placed in magntic field in a way to induce on e.m.f. proportional to the difference of the field strength in regions in which they are rotating. The construction of such a probe is described in the present paper and illustrated in Figs 1 and 2.

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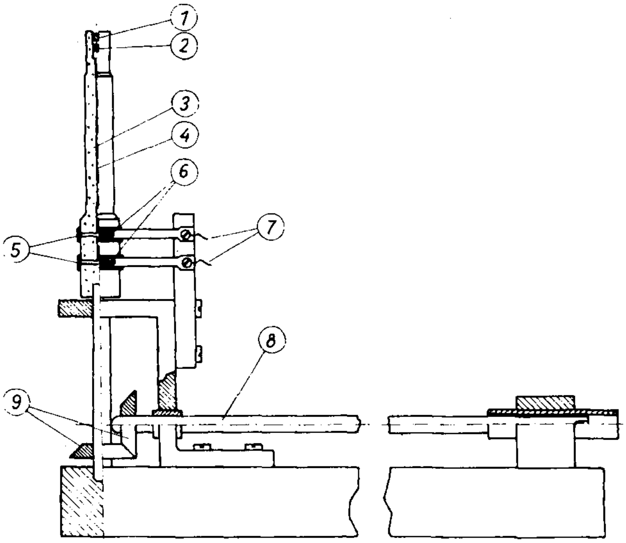

Fig. 1. Cross-section of the probe

Small identical coils *1* and *2* are fastened in a holder mounted on the spindle *3*. The turn planes are vertical. The distance between the middle parts of the coils is 2.5 mm, their thickness 1.5 mm and the diameter of the wire 0.03 mm. The terminals of each coil are led through the channel *4* and go out through the apertures *5*. They are soldered to the half-rings *6* so that each coil plays the role of a separate d. c. generator. Each of the two sets of half-rings has its own brushes leading the induced voltage to the leads *7*. The voltages can be connected in series either in aiding or opposing connection. The spindle *3* is mounted on the axle driven through the transmission *9* by the transmission shaft *8* of the synchronous motor. The whole arrangement is mouted on the vertical column of a compound

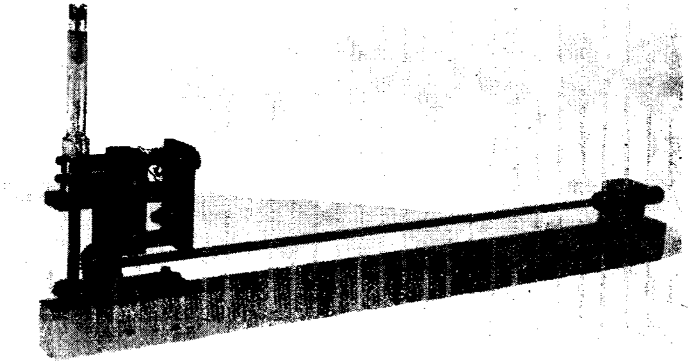

Fig. 2. Photograph of the probe

slide by means of which the probe may be shifted in any of three perpendicular directions. The position of the probe can be read on a scale attached to the support.

Since in the case discussed, the turn planes are vertical and rotate about a vertical axis, the induced emf in each coil is due to the flux of the horizontal component of the field. The vertical component does not play any appreciable role here. When the probe is rotated each of the coild contributes an emf proportional to the mean magnetic field strength at the place where it rotates. If the field is uniform then the electromotive forces cancel in case of opposing connection.

If, however, the field is not uniform, then the resulting emf will be proportional to the difference between the mean field strengths in the regions where the coils rotate. Since the distance between the coils is known, it is possible to determine the mean drop of the horizontal component of the field strength in the direction of interest. To determine the drop of field strength in any other direction the probe has to be suitably situated.

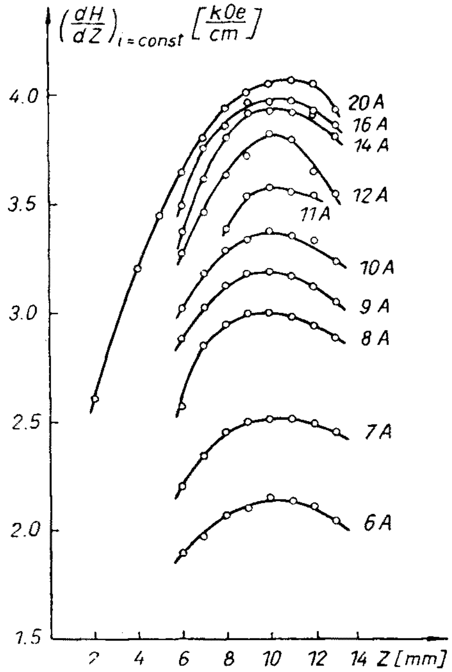

Fig. 3. Curves of the dependence of the magnetic field gradient for an electromagnet with conical pole-shoes on the position of the middle part of the probe on the vertical symmetry axis (Z). Zhe gradient was measured by means of the rotating probe

The probe described permits a rapid topography to be performed, in particular it permits a rapid determination of a region in which the gradient is the greatest and constant. It also enables us to check whether this region has this property when changing the supplying current.

Fig. 3 shows an example of the results of the topography of the field of an electromagnet with core diameter of 100 mm, conical pole-shoes and pole face diameter of 20 mm. The abscissae are distances from a given point accepted as the origin of the Z-axis while the ordinate gives the value of the mean gradient for various positions of the probe and various supply currents.

The distance between the pole-shoes was constant. It is seen that for different currents the maximum of the gradient is almost in the same region. The gradient is also constant in this region for a displacement of about 1.5 mm. After finding the region in which we are interested it is possible to determine the gradient with a better precision *e. g.* by means of magnetic balance with standard sample. It should be pointed out that such determinations of the magnetic field are particularly important in magnetization and magnetic susceptibility measurements by means of magnetic balance.

It is important that the system of brushes and half-rings should be possibly far from the strongest field region which means, that the spindle *3* should be sufficiently high. The obvious reason is to avoid any significant emf induced in this part of the device.

The induced e.m.f., which is a measure of the gradient, can be measured by means of a calibrated millivoltmeter or even a galvanometer since the e.m f. does not alternatie. The calibration is carried out easily by placing the coils in a uniform field of known strength and measuring the e.m.f. induced in one coil.

The accuracy of the determination of the gradient is better than 3%.