SOVIET PHYSICS USPEKHI VOLUME 12, NUMBER 5 MARCH-APRIL 1970

538.65

Methodological Notes

FREE SUSPENSION OF A CONDUCTING DISC IN AN ALTERNATING MAGNETIC FIELD

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Usp. Fiz. Nauk 99, 141–142 (September, 1969)

To demonstrate the interaction of alternating currents, frequent use is made of the experiment by E. Thomson[1] (a solid aluminum or copper ring is repelled from the core of a solenoid when the latter is connected to an ac line).

The interaction of alternating currents can be demonstrated most effectively using the apparatus described below for free suspension of a conducting nonferromagnetic disc, which in principle is analogous to the apparatus of B. Berdford[2], but differs from it in having much smaller dimensions and in the construction of the magnetic circuit.

The construction of the apparatus is shown schematically in Fig. 1. The magnetic circuit of the electromagnetic system of cores C_1, C_2, and C_3, made up of laminations of electric steel EZ10 0.35 mm thick. On cores C_1 and C_2 are placed coils A and B, the windings of which are fed with alternating current in anti-phase. The magnetic force lines emerging from the cores C_1 and C_3 are closed in the core C_2. When a conducting disc D is placed over the magnetic core, the eddy currents induced in it by the magnetic field produce their own field, which weakens the external field inside the disc and intensifies the field under the disc. The increase of the volume energy density of the field under the disc gives rise to a lifting force that balances the weight of the disc and holds it up in the space over the magnetic circuit. The disc is prevented from moving in a horizontal direction by the magnetic field in the air between the cores C_2 and C_3. When the disc is horizontally displaced, the vertical component of the field is increased from that side to which the disc is displaced. As a result, an opposing force is produced restoring the disc to its initial position.

The core C_3 is a disc of thickness 14 mm with outside diameter 330 mm. Glued to it on the top are the two cores C_1 and C_2, in the form of cylinders of height 60 mm and of wall thickness 10 mm each. The outside diameters of the cylinders C_1 and C_2 are 40 and 230 mm, respectively. The electric-steel laminations and the individual parts of the core are glued together with epoxy resin. Windings A and B are made of copper wire of rectangular cross section, 2 × 1.5 mm, with glass insulation, and contain 670 and 520 turns, respectively. Both windings are connected in parallel to the 220 V ac line.

The suspended discs can be made of non-ferromagnetic conducting materials, such as aluminum, duraluminum, or copper, with thickness from 1 to 4 mm. (Discs of brass or stainless steel are worse, since they have a larger resistivity.)

When a copper disc of 260 mm diameter, 2.5 mm thickness, and weight 1.160 g is suspended at a height of 22 mm from the core, the required electromagnetic power is ~920 W. The maximum value of the induction is then 2300 G at the end surface of the core C_1 and 1170 G at the end of the surface of C_2. An aluminum disc of the same diameter, weighing 250 g, can be suspended at the same height at a power consumption of ~860 W.

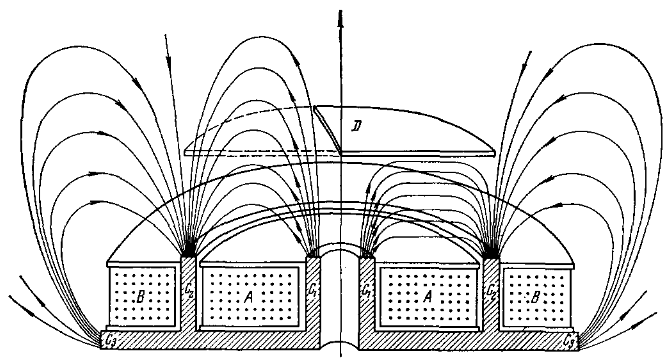

FIG. 1

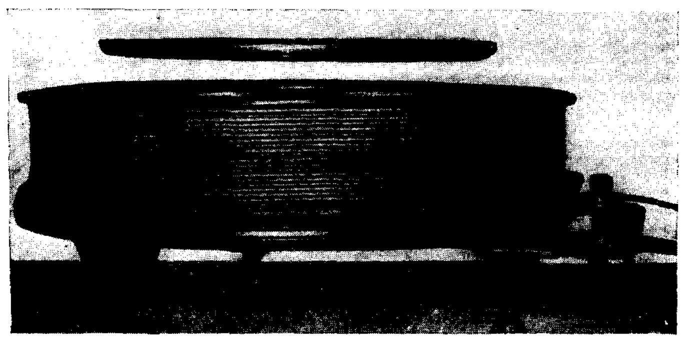

FIG. 2

The largest suspension height, 30 mm, was obtained with a duraluminum disc 4 mm thick, 260 mm in diameter, and weighing 553 g. The corresponding power consumption was 840 W. The exterior view of the apparatus in the working position is shown in Fig. 2. The photograph shows suspension of an aluminum disc with rounded edges weighing 116 g (the rounding of the disc edges is not essential). The suspended discs do not rotate and are quite stable against lateral displacements. When they are displaced 60 mm away from the symmetry axis, they return to the initial position. The eddy currents cause the discs to become heated to a temperature of ~85°C.

[1] Lektsionnye domonstratsii po fizike (Lecture

Demonstrations in Physics), V. I. Iveronova, ed., Nauka, 1965.
[2]B. D. Berdford, L. H. B. Peer, and L. Tonks, General Electric Rev. 42 (6), 246 (1939).

Translated by J. G. Adashko