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The radial magnetic field homopolar motor

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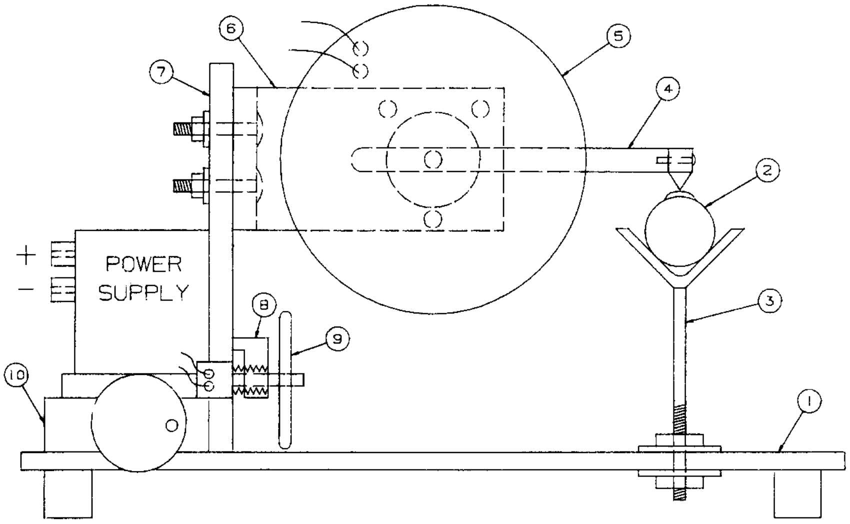

ITEM	DESCRIPTION
1	BASE PLATE
2	MODEL
3	BRACKET FOR THE MODEL
4	PROFILING ARM AND POINTER
5	Y-AXIS POTENTIOMETER
6	BRACKET FOR Y-AXIS POT
7	ADJUSTABLE BRACKET
8	BRACKET FOR X-AXIS POT
9	10 TURN X-AXIS POT
10	LINEAR MOTION STAGE

Fig. 2. Side view of the profilometer.

sensitive single-turn, straight wire potentiometer,[1] which is used to detect the surface roughness, allows measurement of the ice layer as thin as 0.005 in. The x axis of the profile, i.e., the length of the ice layer along the cylinder, is generated by a 10-turn, wire-wound precision potentiometer.[2] This potentiometer is connected to the profiling arm assembly and produces an output signal as the rubber wheel connected to it rolls on the base plate. The output of both potentiometers when connected to an x-y recorder produces a profile of the ice layer along the cylinder at a particular angular location.

Angular profiles of the ice layer around the cylinder are obtained by first moving the profiling arm to the location of interest along the cylinder. The cylinder is then rotated manually about its axis while resting in the supporting cradles. The ice thickness and its surface profile is obtained as the ice surface is passed under the pointer at the end of the arm. The x axis of the profile, i.e., the angular position, is generated by a single-turn, wire-wound precision potentiometer[3] to which a rubber wheel is connected. The wheel is placed directly on the cylinder so that it turns proportionately as the cylinder is rotated. Once again, the output of these two potentiometers when connected to an x-y recorder produces a profile of the ice layer around the cylinder at a particular axial location.

The scale of the plots is properly adjusted by choosing an appropriate diameter for the potentiometer wheels. The plot size and its scale are also set by the scale/gain control knobs on the recorder.

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[a] Assistant Professor of Engineering.

[1] A Texas Instrument (TI) potentiometer (serial #16677).

[2] A 10-K Ω Clarostat potentiometer model 73JA with ± 0.25% linearity.

[3] A 500-Ω Helipot potentiometer model 5311 with ± 0.5% linearity.

The radial magnetic field homopolar motor

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I. INTRODUCTION

There are two types of homopolar electric generators and motors: the axial field and the radial field types. The axial field type has been discussed in previous articles that have appeared in this Journal.[1-4] However, none of these mention the radial field variation, which is described in Sec. II of this article. Figure 1 illustrates the axial field motor wherein a static magnetic field is oriented along the axis of a rotatably mounted metal disk. A device similar to that shown in Fig. 1 was constructed by Peter Barlow in 1823 and is considered to have been the first electric motor.

II. APPARATUS

The structural details of the radial field homopolar motor are shown in Fig. 2. The rotor consists of a 1-cm-diam stainless steel tube. It is mounted in nonmagnetic bearings and is in electrical contact with the mercury contactors as shown. The stator consists of a 0.5-cm-diam alnico V contrapolarized magnetic rod. It is supported by nonmagnetic bearings and is free to rotate independently of the rotor. In the presence of the stator's radial magnetic field, the rotor will experience a torque when an electrical current flows through the tube. By sliding the stator to one side, the mag-

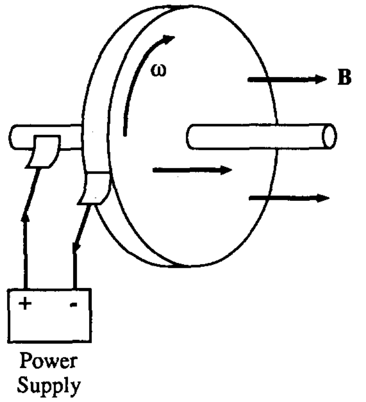

Fig. 1. The axial field homopolar motor.

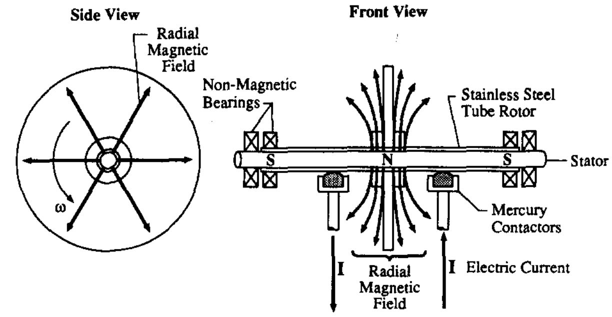

Fig. 2. The radial field homopolar motor.

netic polarity may be reversed and the direction of the rotation is likewise reversed. In our apparatus the magnetic field strength was about 1 kG and the current required to produce a torque sufficient to overcome rotor friction was about 25 A. A disk with a spiral pattern is attached to the rotor in order to facilitate observation of its rotation in classroom demonstrations.

III. COMMENTS

This apparatus may be used either as a lecture demonstration or as a laboratory experiment. In order to use it as a laboratory exercise, one should determine the angular velocity as a function of time. One good way of measuring the angular velocity is to use a photodetector. Pasco Scientific is one source of such a detector specifically designed to measure angular velocities.

It should be noted that even though the stator is free to rotate in this apparatus it does not rotate. At this point, it is an interesting exercise for the student to explain why the reaction torque apparently does not produce an equal and opposite rotation in the stator. Details on how to construct a contrapolarizing magnetizer may be obtained from M. N. Kaplan.

[1] D. R. Corson, Am. J. Phys. **24**, 126 (1956).

[2] M. J. Crooks, D. B. Litvin, and P. W. Matthews, Am. J. Phys. **46**, 729 (1978).

[3] P. J. Scanlon and R. N. Henriksen, Am. J. Phys. **47**, 917 (1979).

[4] R. D. Eagleton, Am. J. Phys. **55**, 621 (1987).

An inexpensive Ampere's law experiment

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There are very few simple and inexpensive experiments that enable students to verify directly the equations of electromagnetism or determine the fundamental constants of electromagnetism. This note describes a simple apparatus that students can use to deduce Ampere's law for a long straight wire B_f is proportional to I/r where B_f is the magnetic field resulting from a current I at a distance r from the wire. There are iron filings and compass experiments that will give students a qualitative picture of the magnetic lines of force around a current-carrying wire. We will assume that these results are already well known by the students and they are now ready to deduce experimentally the above equation. Clearly, it is necessary to measure B_f for various values of I and r. Then graphs of B_f vs I and B_f vs $1/r$ at constant r and I, respectively, will establish the relation B_f is proportional to I/r. The proportionality constant obtained from the slope of the B_f vs I/r will then define the Ampere since the permeability constant is fixed. The usual

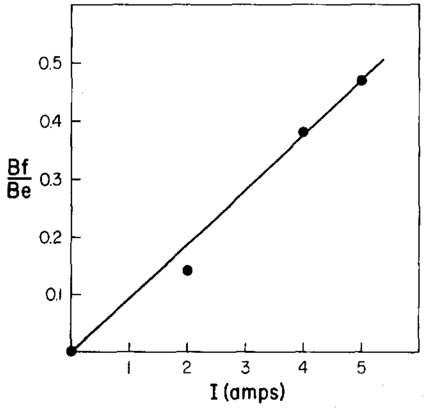

Fig. 1. The ratio B_f/B_e versus current I.

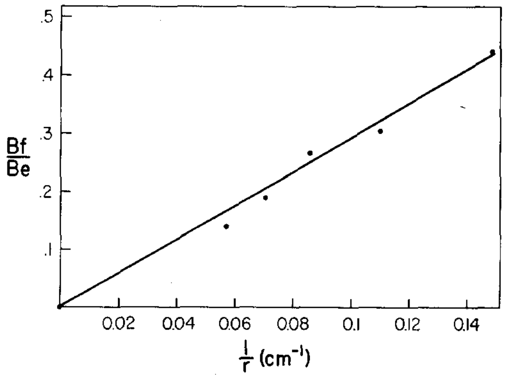

Fig. 2. The ratio B_f/B_e versus inverse distance from wire, $1/r$.