A Nontoxic Barlow's Wheel

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Citation: The Physics Teacher 53, 42 (2015); doi: 10.1119/1.4904243
View online: http://dx.doi.org/10.1119/1.4904243
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Published by the American Association of Physics Teachers

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Barlow’s wheel has been a favorite demonstration since its invention by Peter Barlow (1776-1862) in 1822. In the form shown in Fig. 1, it represents the first electric motor. The interaction between the electric current passing from the axle of the wheel to the rim and the magnetic field produced by the U-magnet produces a torque that turns the wheel. The original device used mercury to provide electrical contact to the rim, and the dangers involved with the use of this heavy metal have caused the apparatus to disappear from the lecture hall.

The apparatus in Fig. 2 uses a rotating copper wheel in place of the mercury contact. To the best of our knowledge, this modification has not been published before. This design also uses a vertical magnet, making the details of construction more visible in the classroom. The two copper disks, 11.5 and 3.5 cm in diameter, are mounted on axles made from brass screws, the ends of which have been filed to conical points. The axles rotate in dimples, formed by a center punch, in the brass strips that support the wheels. Contact between the wheels is controlled by adjusting the knurled nut at the bottom of the upright brass strip holding the small wheel. This detail is shown in Fig. 3. The magnetic field is supplied by three ceramic magnets each measuring 1.9 x 2.5 x 0.5 cm. Two pole pieces of mild steel are secured to the magnets by a brass screw through a central hole in each magnet and the pole pieces. The ends of this screw are used to secure the magnet assembly to the base using right angle brackets.

A low-voltage power supply is used to operate the apparatus. The current should be limited to 15 A to prevent excessive arcing at the rims of the disks. Four D cells connected in parallel form a suitable battery and obviate the need for a current limiting resistor. The direction of rotation may be changed by reversing the battery connections or by rotating the magnet assembly 180°. Although it may not be visible at low currents in normal light, some arcing between the two rotating surfaces occurs. After some use the surface of the wheels will be pitted and must be cleaned with very fine sandpaper to restore the performance of the contacts.

The classic Barlow’s wheel will also function as a generator if the wheel is driven by an external agency. Faraday did this in 1831 and the resulting apparatus is called a “unipolar generator.” The design presented here is not suitable for demonstrating the generator, as the contact resistance between the two copper wheels is many times greater than that of the copper/mercury contact. The rims of the wheels are slightly irregular, causing an intermittent contact. The galvanometer cannot respond to this low-level intermittent signal in any intelligible way. However, low-impedance headphones or an audio amplifier may be connected to the terminals of the apparatus to produce a crackling sound when the wheel is
turned. The magnet can be moved aside to show that the magnetic field is necessary to produce the signal.

In Fig. 4 the apparatus is shown with the addition of an aluminum beam fitted with a small pulley near the upper end. A string wrapped around the axle of the large wheel is passed over this pulley and supports a weight. Two neodymium-iron-boron magnets measuring 18 mm diameter x 2.5 mm thick (not visible in the figure) have been placed on the inside of the steel pole pieces near the top to strengthen the magnetic field near the edge of the disk. The weight is released and the magnet is then brought to the vertical position, demonstrating the eddy current braking of the disk. This device is referred to as “Foucault’s disk.”

References