University Physics II Honors Project

The Wind Turbine

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Section: H2

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PURPOSE

Electricity is commonly known to be an unarguably essential element of daily life. In a technologically advancing society continually increasing its energy consumption, the need for alternative energy resources is growing in demand. Various renewable sources of energy for electricity are becoming a focus for both environmentalists and politicians alike. With a desire to research a topic that could both expand knowledge in the areas of electricity and magnetism while complimenting an interest in the field of engineering, the experimenter was intrigued by the wind turbine method responding to this developing and concerning issue.

After thoroughly covering the subjects of electricity and magnetism in University Physics II and methodically gaining familiarity with relative experiments in lab, the researcher felt both experienced and educated to conduct an experiment involving the construction and testing of a homemade column wind turbine utilizing neodymium rare-earth magnets and a series of magnetic wire coils to create electricity. The primary focus of this experiment was assemble a wind turbine that, when subjected to wind, would rotate the large magnets rapidly over a series of wire coils, thus producing electrical current that could be utilized to light a LED bulb, demonstrating the physics of magnetic and electrical interaction.

PROCEDURE

The first step in conducting the experiment was to acquire a layout for the outline to construct a wind turbine. After reviewing the Industrial Ventilation for different wind turbine designs, the researcher chose the squirrel cage (vertical blades) layout due to its simplicity, realistic ability to be conveniently transported and capability to capture wind from any direction (ACGIH). Once the specific design was chosen, the experimenter researched online to attain a

better understanding of the basics to fabricating a column wind turbine. Stumbling upon the comparative design of a small scale version of the projected turbine in mind, the researcher discovered several of the supplies necessary and proportional dimensions for the different aspects of construction (Mussell). The following materials were determined to be required to sufficiently and safely conduct the experiment.

Materials:

0.1016 m. in diameter PVC pipe	two-part epoxy
0.0127 m. in thickness plywood	compass
0.0381 m. neodymium rare-earth magnets (9)	soldering gun
0.0381 m. washers (9)	extra wiring
Lazy Susan bearings (2)	electrical tape
26 Gage magnetic wire (3 spools)	wood screws and screw driver
terminal strips (3)	volt meter
terminal connectors (18)	various hardware machinery
LED lights	1.219 m. wooden dowel

Once the materials were gathered, construction of the wind turbine commenced. The first piece of focus to the puzzle was the spinning disc (0.3048 m. plywood circle) on which the eight blades were mounted atop and the magnets would be fixed to below. Eight curved incisions were made along the outside edges in order to slide the blades (each ¼ of the PVC circumference) into and secure with a wood screw. On the underside of the spinning disc, nine washers where secured in a circle in order to place the magnets on, allowing to be removed easily when experimentation is completed to be utilized for other reasons. Each magnet was placed upon a washer, carefully to keep the same polarity facing up.

The next piece of construction was the base which the coils and circuit wires would be placed. The top lid of the base served as a station for the wiring to be secured upon. Nine coils were fabricated from the 26 gage magnetic wire; all composed of 75 turns around a plastic core in the same direction with the beginning lead being left bare and the ending lead marked with a piece of tape to maintain uniformity. Every coil after being wound was tested with the volt meter to ensure electricity was flowing through them. The coils were screwed into the base, cautiously keeping the coils facing the same directions, and a distance that the magnets would travel very closely above them. Next, each beginning and ending lead where soldered to wiring and connected to a terminal strip in a series creating AC current as illustrated in Diagram 1. Beginning leads were connected at A followed by the coinciding ending lead connected at B. All of the coils were then connected by series through the terminal strips with the connections at coils 1A and 2A serving as the output.

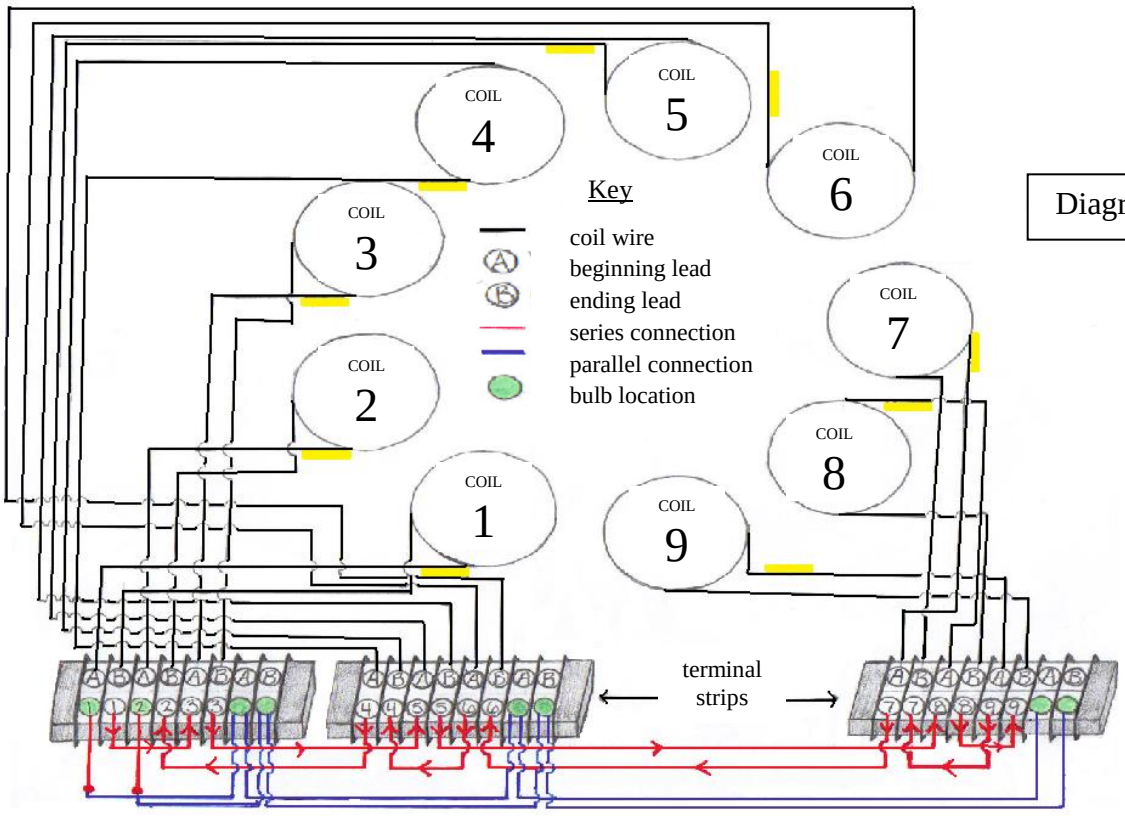

Diagram 1

Within the base, a Lazy Susan bearing was fastened in the center, which the spinning disc would soon be assembled to and spun on without the magnets interfering with its rotation. The wooden dowel was centered throughout the system to serve as a stabilizing support. Returning to the blades, a second spinning disc including the other bearing was connected above the blades to serve as a second means of balanced rotation.

The final step to the fabrication of the wind turbine was to connect the LED bulbs. The first two bulbs were fastened at the output coils 1A and 2A. Continuing in a parallel connection, the next two bulbs were fastened at the non-coil connection positions on the second terminal strip and the final two bulbs were similarly situated at the non-coil connection positions on the third strip (Diagram 1). These LED bulbs required a range of voltages to light:

Green – 2.1 volts Yellow – 3.2 volts

Red – 2.8 volts White – 5 volts

Once all the assembled pieces were connected together, the finalized work station was prepared for experimentation (Diagram 2 on following page).

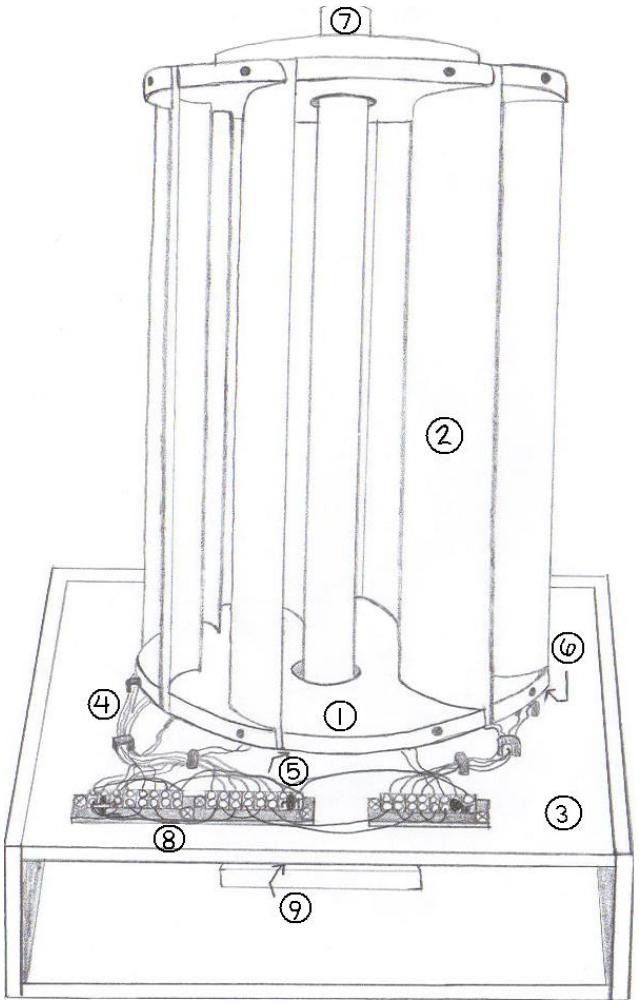

Diagram 2

Key

1 – spinning disc base

2 – blade

3 – base

4 – coil wiring

5 – coils fixed to base

6 – magnets underneath disc

7 – support dowel

8 – terminal strips

9 – Lazy Susan bearing

The first test involved placing the wind turbine, without LED bulbs connected, outside and once reaching maximum velocity, each coil was measured with a volt meter to determine volts being produced individually. Every coil was averaging a max yield of 1.5 volts. The final test involved the complete set-up, LED bulbs connected parallel, to observe if an adequate amount of current could be supplied to light all six. Once the turbine was rotating at a certain speed, all the bulbs did in fact light up and remain lit.

THEORY

The physics behind the simplistic design of a wind turbine involves two central dimensions: the interaction between the magnets and coils and the appropriate parallel and series connections of the wiring. The two-step process begins with the interaction between the rotating neodymium magnets and the magnetic wire coils. As current flows through the wires, a rotating non polar magnetic field is produced. In order to create electrical power, the wire coils must intercept the magnetic flux of the magnets, with the amount of current created depending on how much magnetic flux is cut. As a magnet approaches the coil, the electrons within the wiring are attracted towards the magnet producing a current. Then, as the magnet exits the coil, the current flows in the opposite direction, until the flowing magnet pulls it once again in the original directions. This back and forth continual repetition of motion creates an AC current, energizing the coils with electricity (Parsons).

The second stage of physics involves the organization of the series and parallel connections of the wind turbine. The nine coils are connected to the terminal strip in a series in order to allow maximum current to flow throughout the system. Each coil was marked so that all were placed in the same direction to prevent any current cancellation. At the output coil 1A and 2A, the first two LED lights were connected, though where in the series they were place did not matter as long as it was a point of connection. However, after the first two bulbs the following lights must be connected parallel, not within the series. This type of connection assures that each bulb receives the same amount of current as the bulb prior it (Stewart).

CONCLUSION

During the entire process, assembling and experimentation, various points of the project might have contributed as a source of error. The distance between the magnets and coils could have been closer for maximum results. Also, in regards to the magnets, the experimenter underestimated the strength of 0.0381 m. neodymium rare-earth magnets which happened to be strong enough that when the wind velocity was weaker, the magnets attraction to the coils would stop the blades from rotating. Systematic error could have stemmed from the accuracy of the volt meter. Finally, once the coils were set in place and the researcher connected each coil to the terminal strip, certain combinations did not produce the correct amount of voltage as they should. This more than likely is due to inaccurate phase angles amongst the coils.

The wind turbine obviously is not a perfect solution for the pursuit for renewable sources of electrical energy. The main reason for this returns to the initial point of the process, the rotating magnets energizing the coils. This interaction does create current flow, but only when a magnet is entering or exiting the coils. When the magnet passes directly above the coil, though a max output would be anticipated, a zero output is the accurate measurement due to half the current moving one direction while the other half moves the opposite, cancelling each other. Ignoring these few flaws to the design, the wind turbine was a success in its primary purpose; when subjected to a wind force, the turbine to produce an adequate amount of current to light not just one, but six LED bulbs ranging in voltage requirements and thus demonstrating the physics of magnetic and electrical interaction. For further experimentation, bridge rectifiers could be connected to the coils in order to convert the alternating current (AC) into direct current (DC) and serve for battery charging to provide more implications towards renewable alternative energy.

University Honors Physics II Project Proposal

A vastly developing issue worldwide is that as technology modifies, energy consumption increases drastically creating a requirement for development of alternative sources of energy. With a desire to research a topic that could both expand knowledge in the areas of electricity and magnetism while complimenting an interest in the field of engineering, the experimenter was intrigued by the wind turbine design. After obtaining knowledge throughout the duration of this course the researcher feels prepared to conduct an experiment involving the construction and testing of a homemade column wind turbine utilizing neodymium rare-earth magnets and a series of magnetic wire coils to create electricity. The primary focus of this experiment is to assemble a wind turbine that, when subjected to wind, will rotate the large magnets rapidly over a series of wire coils, thus producing electrical current that could be utilized to light a LED bulb, demonstrating the physics of magnetic and electrical interaction.

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