3. Development of the project

An iron structure was developed to support a mountain bicycle, a car alternator and six halogen light bulbs. It keeps the rear wheel of the bicycle suspended, so that the user can pedal without moving forward.

On the rear wheel, a medium-sized cogwheel fixed on the rear wheel is linked to the alternator by a chain (Fig. 3). The cogwheel of the alternator has a smaller diameter. This difference in cogwheels diameters is essential to achieve high rotation speeds of the alternator rotor.

The alternator used in this project had a damaged voltage regulator. So, a 12V battery was permanently connected to the rotor. This way, the rotor generates a constant magnetic field. When the rotor starts to turn, it induces a three-phase alternating current system in the coils of the stator. These currents are then rectified and the resulting direct current is used to power the halogen light bulbs.

The generated magnetic field opposes to the movement, offering a resistance that depends on the number of lamps used. The higher the current consumed by the lamps, the higher the effort by the user. To make the halogen lamps glow, the user has to make a considerable physical effort.

4. Conclusions

Generating environment-friendly electric power while keeping fit is possible with the device presented in this paper.

Figure 3. Car alternator linked to the rear wheel of the bicycle

A three-phase car alternator excited through a 12V battery and coupled to a mountain bicycle enables the lighting of six halogen lamps, if a cyclist pedals fast enough.

Such a machine gives rise to the thought of a self-powered gymnasium and is also very suitable for science fair events. It can be used to explain the production of electric energy and other Electromagnetism fundamentals. Considerable physical effort is required in order to make the lamps glow. This is pedagogical since it shows clearly that spending energy is much easier than generating it.

5. Acknowledgements

The authors are grateful to João Sepúlveda for the explanations and the revising of this paper.

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Alternating Current and Direct Current Generator

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Abstract. Spinning a wire loop within a uniform magnetic field in a convenient fashion induces a voltage between the loop terminals. This effect can be used to build an electric power generator, such as the one described in this paper. A coil attached to a shaft spins within the magnetic field of a "U" shaped magnet. Three conveniently designed conductive disks allow

the electrical load of the generator to be fed either with alternating current or direct current.

Keywords. Alternating Current, Direct Current, Generator, Magnetic Field, Induced Voltage.

1. Introduction

Although diverse forms of energy (mechanical, thermal, chemical etc.) can be converted into electrical energy, the expression *electric generator* is reserved, in the industry, only for the machines that convert mechanical energy into electrical energy. The generators that produce direct current (DC) are called *dynamos* and the ones that produce alternating current (AC) are called *alternators*.

The device described in this paper is a generator capable of supplying an electrical load with the desired type of current: alternating current or direct current.

2. AC generator principle of operation.

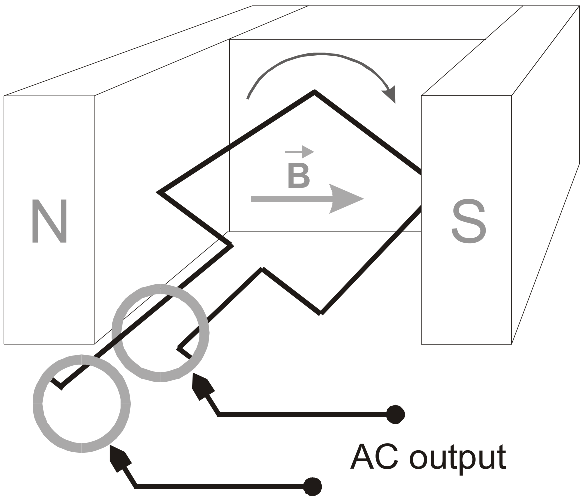

Figure 1. AC generator

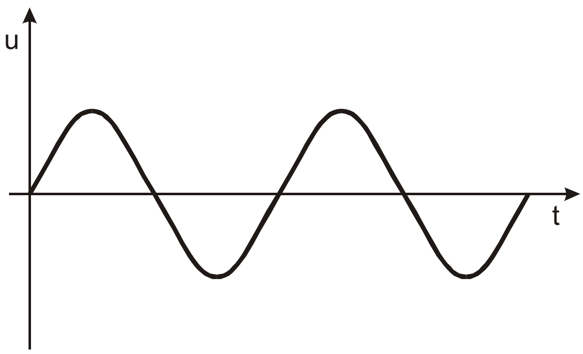

Figure 2. AC generator output

Figure 1 illustrates the principle of operation of an AC generator. A wire loop rotates within the magnetic field generated by a magnet, which induces an AC voltage between the loop terminals. The periodic change of the voltage polarity is due to the change of the position of the coil relatively to the magnetic poles. The amplitude of the voltage depends on the magnetic field strength and is also directly proportional to the rotating speed [1, 2, 3, 4]. If the magnetic field is uniform and the rotation speed is constant, the voltage induced between the loop terminals is sinusoidal with zero mean value (Fig. 2). Its frequency is equal to the number of revolutions per second executed by the loop.

Each terminal of the loop is connected to a metallic ring. The contacts with rings are made by means of fixed brushes. If the brushes are connected to an electrical load, an alternating current will be established in the circuit.

3. DC generator principle of operation

The described AC generator may be transformed into a DC generator, substituting the contact rings by a mechanical commutator. As illustrated on Fig.3, a simple commutator may be done with a metal ring divided into two isolated halves (segments), which are mounted in the axis. This type of commutator is denominated *collector*.

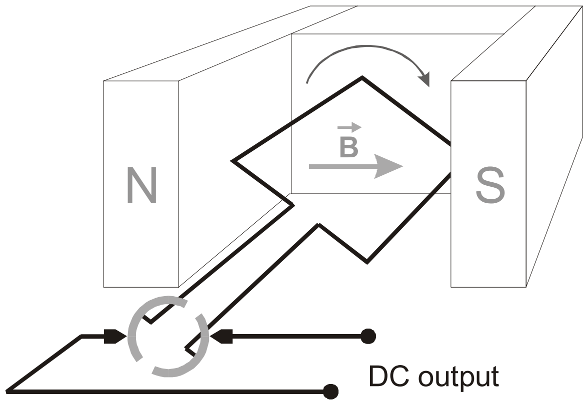

Figure 3. DC generator

Each terminal of the loop is connected to a segment of the collector. When the loop rotates, an AC voltage is induced in the coil, exactly as in the AC generator. But, before reaching the load, the induced voltage is transformed into a DC voltage by the collector (Fig. 4), which

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works as a mechanical rectifier. The contact segments of the collector move to a different brush each half turn of the loop, keeping a unidirectional current flowing through the electrical load of the circuit [1].

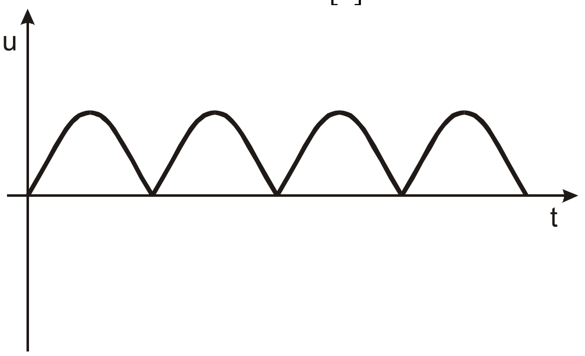

Figure 4. DC generator output

The rotation speed has to be well determined so that the final result is the expected one. As stated before, the rotation speed influences the induced voltage amplitude and frequency.

4. Built generator description

Instead of a simple loop, an iron core coil with 1241 turns of 0,16mm^2 varnished copper wire was used. The iron core and its windings are shown in Fig. 5.

Figure 5. Coil with iron core

The magnetic field used to induce a voltage between the coil terminals was provided by a "U" shaped strong permanent magnet, shown in Fig. 6.

The most challenging part to build was a contact rings and collector unit (Fig. 7). It was made of three printed circuit board disks, coaxially mounted on the rotating axis.

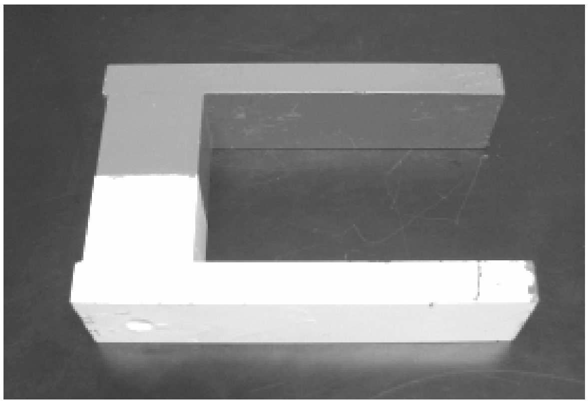

Figure 6. Permanent magnet used to induce a voltage in the coil

The two smaller disks were kept with their entire conductive layer and were intended to supply the generated AC voltage. The conductive layer of the larger disk was cut into two halves, in order to implement the collector, which mechanically rectifies the generated AC voltage.

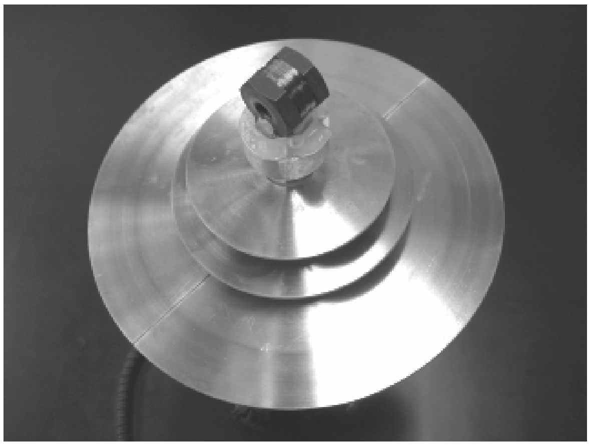

Figure 7. Three coaxial printed circuit board disks with coil on top

Fig. 8 and Fig. 9 illustrate how the rings and collector unit was built in a more comprehensive way.

In Fig. 8, a cross-section of this unit is shown, revealing how electrical connections were made: one terminal of the coil was connected to one of the smaller disks and to one of the halves of the larger disk (collector); the other terminal was connected to the other smaller disk and to the other half of the larger one.

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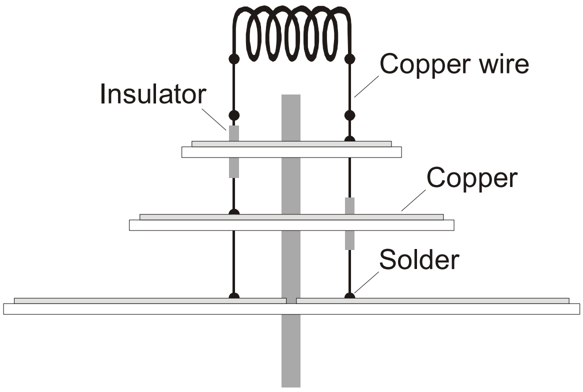

Figure 8. Connecting the coil to the three coaxial printed circuit board disks

Fig. 9 shows a panoramic view of the assembly and the generator outputs responsible for supplying alternating or direct current to an electrical load. In order to make the generator operate properly, the DC output brushes positions must be displaced by 180º from each other. The AC output brushes may be placed anywhere on the respective disks.

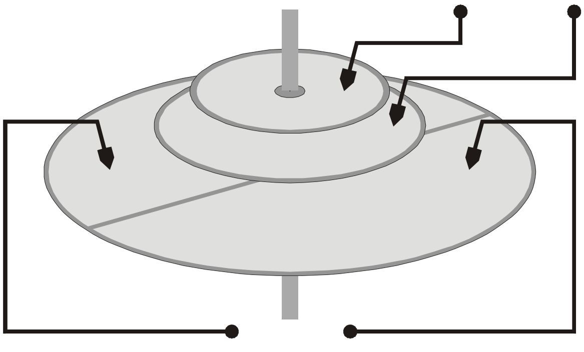

Figure 9. Outputs of the generator

5. Practical results

The energy efficiency of this generator was not possible to determine. Although electrical power could be easily measured, some sort of mechanical power meter was needed and it was not unavailable. There are always mechanical and electrical power losses in the process of transforming mechanical energy into electric energy. Mechanical losses may be reduced by lubricating friction points.

The generator was put to rotate at 3000RPM; the measured induced voltage was 1,2V peak-to-peak, with a 50Hz frequency.

6. Conclusions

Spinning a wire loop within a uniform magnetic field in a convenient fashion induces a voltage between the loop terminals. Rotation speed influences the induced voltage amplitude and frequency. If an electrical load is connected to the loop terminals, a current will be established in the circuit.

The current generated by a basic electrical generator is alternating current. If the generator is intended to supply direct current, it must have a device working as a mechanical rectifier: the collector.

A device capable of generating both AC voltage and DC voltage has been presented. A coil attached to a shaft spins within the magnetic field of a "U" shaped magnet. Three conveniently designed conductive disks allow the electrical load of the generator to be fed either with alternating current or direct current.

This device is very useful to illustrate the principles of electrical energy generation. It also shows the main similarities and differences between AC and DC generators: the working principle is the same for both machines, but the AC generator has contact rings and the DC generator has a collector.

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