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presentation will by given in the class of the leader of the team. In these occasions experiments, drawings, entertaining games, written descriptions, and photos will be used to help systematize what was learnt and to help register the events that took place. These will be exhibited in «Hands-on Science» Conference 2006. Those responsible for the project may add more activities to it upon the interests of the children.

**Keywords.** Science fairs, Hands-on experiments.

# Electric Power Generating Bicycle

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**Abstract.** It is manifest the growing interest in both personal health and environmental issues. The device described on this paper contemplates both aspects: generating environment-friendly electric power while keeping fit. A car alternator excited through a 12V battery is coupled to a mountain bicycle, and this arrangement 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. Considerable physical effort is required in order to make the lamps glow, which is pedagogical since it shows clearly that spending energy is much easier than generating it.

**Keywords.** Electrical Power Generation, Alternators, Alternating Current, Direct Current.

## 1. Introduction

The device described in this paper integrates a car alternator and a mountain bicycle (Fig. 1), allowing the generation of environment-friendly electric power while keeping fit by pedalling. This contemplates both personal health and environmental issues.

A car alternator excited through a battery is coupled to a mountain bicycle. This arrangement enables the lighting of six halogen lamps, if a cyclist pedals fast enough. The device is very suitable for science fair events, where it can be used to explain the production of electric energy and other Electromagnetism fundamentals.

## 2. Principle of operation of the alternator

Rotating a coil within a magnetic field (Fig. 2) induces a voltage at the coil terminals [1, 2, 3], which allows powering a load connected to these terminals. If the coil rotates at constant speed within a uniform magnetic field, an AC voltage with zero mean value is induced at its 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 the rotation speed. This is the principle of operation of an alternator.

**Figure 1. Electric Power Generating Bicycle**

Instead of rotating a coil within a magnetic field, as suggested in Fig. 2, it is possible to generate an AC voltage rotating a magnetic field around a fixed coil [4].

The magnetic field of an alternator may be produced by a permanent magnet or by an electromagnet.

An electric current flowing in a conductor generates a magnetic field in its surroundings [1, 2, 3]. This effect is used by electromagnets to generate magnetic fields.

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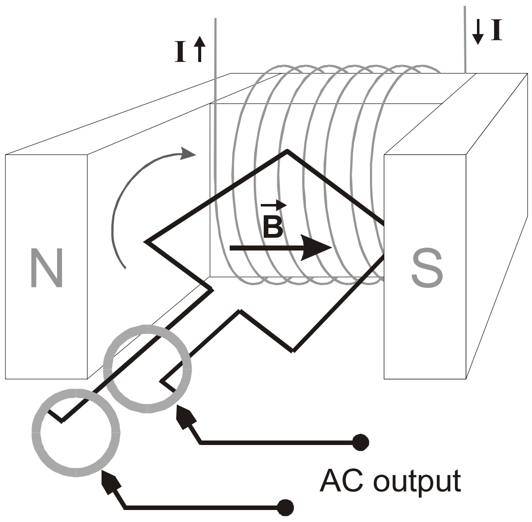


**Figure 2. Principle of operation of a single-phase alternator**

Typically, an electromagnet has a coil with iron core and the strength of the generated magnetic field depends on:

- the number of turns of the coil;
- the amplitude of the current that flows in the coil;
- the type of iron core used.

The current flowing in an alternator electromagnet, which is called the *excitation current,* may come from an external energy source – a battery, for instance – or from the electric circuit of the alternator itself.

The principles described so far explain the operation of a single-phase alternator. The alternator used in this project is three-phase: it has three identical coils symmetrically mounted on the rotor, (with an electrical 120º angle between each two coils). As long as the rotor keeps turning, three alternating currents of the same frequency and amplitude are generated. These currents are displaced by an angle of 120º.

Usually, a three-phase alternator would require six wires to conduct the currents induced in the three coils. It is possible to reduce the number of wires to three by connecting the coils between each other. They may be connected in electrical delta or in electrical star. A delta connection only requires three wires out of the coils. A star connection requires three or four wires.

In car alternators, the coils where the voltages are induced are usually mounted in the stationary part of the equipment (the stator). The coils that produce the magnetic field are placed in the mobile part (the rotor) of the equipment [5].

## 2.1. Rectification of the alternating currents

The alternating currents generated by a car alternator cannot charge the car battery and are not appropriate to supply the electric and electronic parts of the vehicle, either. The solution used to overcome these limitations is to rectify the currents. This rectification is made with a semiconductor rectifying diode bridge.

The output of the rectifying bridge is a pulsating direct current. The ripple in the current can be reduced by the battery, as well as by a capacitor connected at the same time to the bridge output.

## 2.2. Self-excitation of the alternator

Initially, a current from the battery is required in order to create a magnetic field in the armature of the rotor. When the voltage in the stator is high enough, it becomes possible the self-excitation of the alternator. This means that the rotor is supplied by the stator. Eventually, a voltage that is higher than the initial one will be induced in the stator, allowing the charge of the battery and the powering of all electric and electronic parts of the car. This voltage is controlled by the voltage regulator.

## 2.3. Voltage regulator

The function of the voltage regulator is to keep the output voltage of the alternator constant, regardless of the rotation speed of the rotor and the electrical load of the alternator [5].

An automatic regulation of the voltage is not simple because the motor of the vehicle, which powers the alternator rotor, constantly changes its rotation speed. Besides, many of the electric and electronic devices of the vehicle only stay connected for short periods of time or are operated manually. Therefore, the load that the alternator has to feed is not constant.

When the motor achieves high rotation speeds or when there are only a few loads to be fed, it has to be ensured that the output voltage of the alternator is limited to a predefined value. The voltage regulator accomplishes this task by interrupting the excitation current, which makes the magnetic field of the rotor decrease. When the voltage falls under a predefined value, the excitation current is re-established.

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## 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