EMF TOPIC 6

In this section you will learn about different sources that produce an electromotive force **(emf)**

At the end of this section the student will be able to:

- List the three main methods of converting energy to electrical energy, that is, meehattieal, chemical and radiant.
- Name at least two examples of an emf source that uses mechanical, chemical or radiant energy as its source.
- Describe the principle of operation of a de generator, piezoelectric device, primary cell, secondary cell, solar cell and a thermoeouple.
- Describe the difference between primary and secondary cells. Draw the equivalent circuit of an emf source.

1. PRODUCTION OF AN EMF

Electricity is a form of energy. A basic law, called the Conservation of Energy, says that energy cannot be created or destroyed.

However, energy can be ___________________ from one form to another.

This means that electrical energy has to come from other sources of energy, by a conversion process. The most commonly used energy sources for this are:

- _________________________ energy

- _________________________ energy

- _________________________ energy

Figures 1, 2 and 3 illustrate the commonly used energy conversion processes.

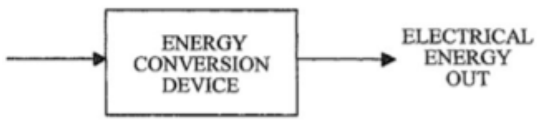


Figure 1

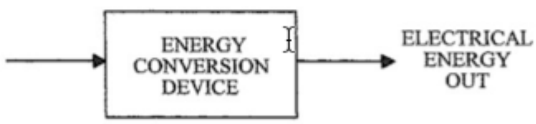


Figure 2

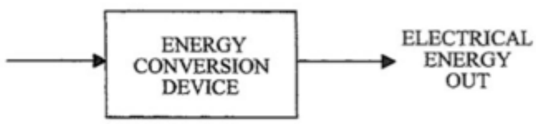


Figure 3

As you saw in Sections 1 and 2 of this module, a voltage is 'electrical pressure' and current is a flow of electrons. The current does the work (fights a lamp, makes a motor turn), as a voltage by itself is simply a pressure source. So, electrical energy is a combination of voltage and current.
Electrical energy is used (or more correctly, transformed) only when current flows.

This means that the energy source to produce the electrical energy is only being used when current flows. For instance, a battery that's not connected to anything isn't supplying electrical energy, even though there's a voltage developed across its terminals.
A brief look now at the various ways of producing electricity. All these methods convert one form of energy into electrical energy.

2. MECHANICAL ENERGY TO ELECTRICAL ENERGY

Mechanical energy is movement. The three main ways to convert mechanical movement into electrical energy are:

- _______________________ between two materials

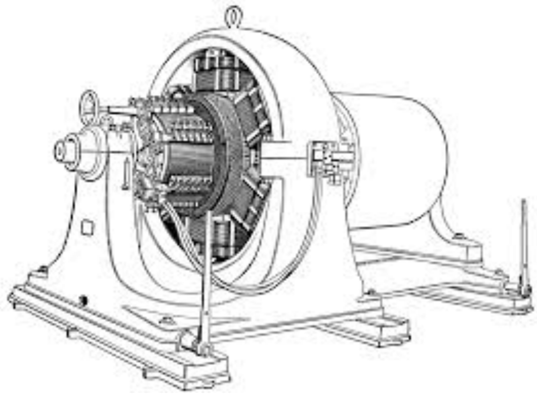
- _______________________ a conductor in a magnetic field

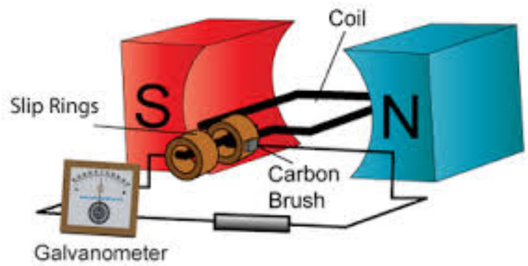
- _______________________ stress applied to a piezzo electric crystal

Friction

Most of us have felt the effect of 'static' electricity. When you walk on a nylon carpet or slide over a fabric covered car seat you can be 'charged up' to a high voltage. This is because electrons have either been tran~erred to you or taken from you.
Static electricity is produced when clouds move in the atmosphere, became of friction between the cloud and the surrounding air. Once the voltage is high enough, an electric current can flow through the air between two charged clouds. We see the current as lightning, caused by the voltage ionising the air. Rubbing certain types of materials together can also produce static electricity.
The available energy from static electricity is rarely useful, although very high voltages can be produced.

The Generator





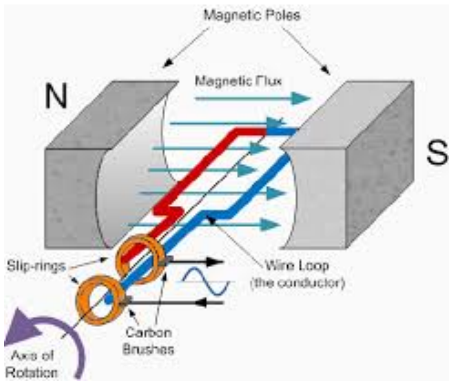
The generator must be driven by a prime mover, for example -

- ________________ turbine ___________________ turbine

- ________________ turbine ___________________ turbine

A voltage can be produced by moving a conductor through a magnetic field. By winding the conductor into a coil, a higher voltage is produced as there are more conductors in the field. This diagram in figure 5 shows the principle.

figure 5



The voltage produced by the electromagnetic effect depends on the -

- the number of ___________________ that move in the electric field

- ____________________ of the magnetic field

- _____________________ of movement

ote, it doesn't matter whether the magnetic field or the conductor moves - a voltage is produced if either moves.
Movement between the conductor and the magnetic field is produced by mechanical energy and its energy source can come from a diesel or petrol engine, flowing water, high pressure steam that turns a turbine, even human power.

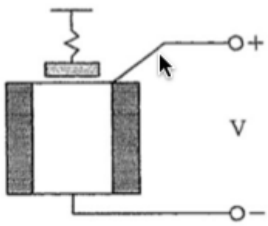
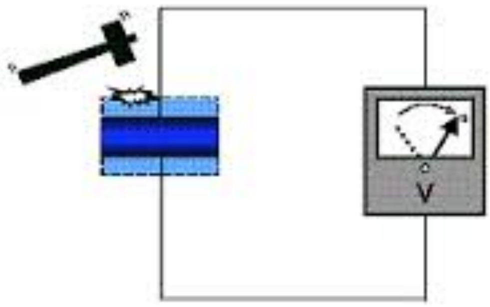
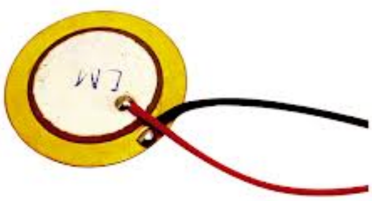


Figure 6



Piezo-electric crystal

Some types of quartz crystals such as quartz and rochelle salt produce a voltage between opposite sides of the crystal ff there's pressure on them. The voltage produced depends on the amount of pressure.



Materials that have this characteristic are called

____

materials.

these materials are used in -

- load cells

- electronic cigarette lighters and gas lighters

- record player pick-ups

- some kinds of microphones (and some small speakers as output)

The amount of energy produced is very small, so this method is used only when very small currents are needed.
When used in electronic gas lighters, a piezo-electric crystal produces a spark. The spark is the result of a very high voltage developed by the crystal when someone operates the trigger
of the lighter.
The pick-up cartridge in many record players has a piezo-eleetric element. These are usually called 'ceramic' cartridges as the piezo element is made from ceramic materials rather than with a quartz crystal. The pick-up stylus is connected to the ceramic element, which produces a voltage caused by the movement of the stylus.
Electronic watches also have a quartz crystal which produces the timing signals for the electronics in the watch.

3. CHEMICAL ENERGY TO ELECTRICAL ENERGY

When two different metals are put into a liquid called an electrolyte (an acid or an alkali), a voltage is developed between the two metals. The emf produced is due to the chemical activity between the electrodes and the electrolyte.

The basic electric cell, shown below in figure 7 has three components -

- a positive electrode
- a negative electrode
- an electrolyte.

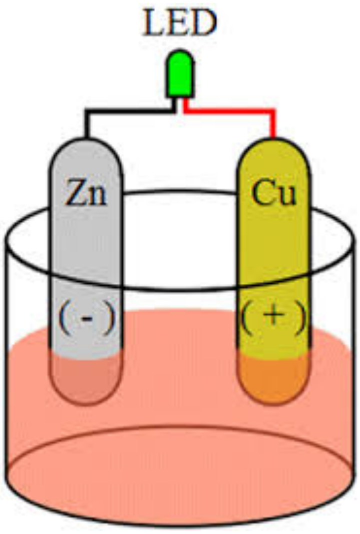


Fig. 7

The magnitude of the emf produced depends upon the metals used for the electrodes.

There are two broad categories of cell -

- ____________________ cell, cell - cannot be recharged
- ____________________ cell, ell - can be recharged.

An example of a primary cell is the ________________ cell which develops a voltage of approximately _______ volts.

Examples of secondary cells are -

- _______________________ cell which develops a voltage of approximately ___ volts

• ________________________ cell which develops a voltage of approximately ___ volts

A ______________________ is a number of cells connected together inside the one package.

A carbon-zinc cell produces 1.5V and a lead-acid cell produces 2V. Therefore, a 6V lead-acid battery has three cells and a 12V battery has six. These are connected externally by swaps. A 9V carbon-zinc battery has six cells, stacked on top of each other.

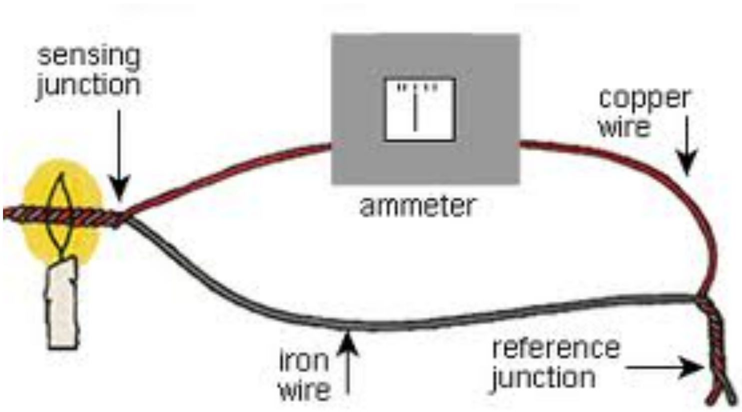
4. RADIANT ENERGY TO ELECTRICAL ENERGY

Radiant energy is available in either of two forms -

• ____________________ energy

• ____________________ energy

Heat can be used to directly produce a voltage using a device called a __________



A thermocouple is simply two different metals joined at a point called the junction. If heat is applied to the junction as in figure 8, a voltage is developed by the thermocouple. The other end - the cold end - is not heated and usually has the same temperature as the surrounding air (ambient temperature).

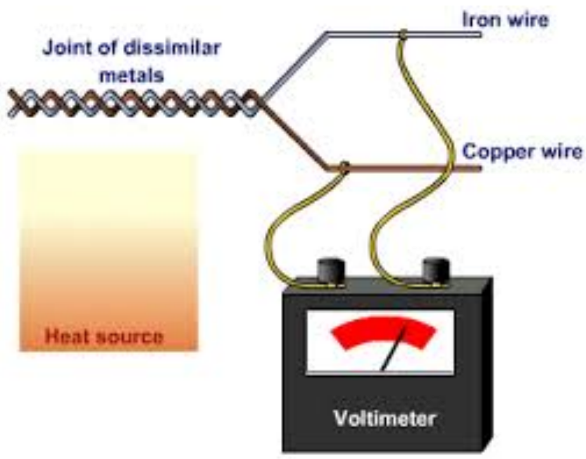


Figure 8

The voltage produced depends on the -

• type of materials used in the thermocouple

and the

• difference in the temperature between the ends of the thermocouple.

The metals used in the thermocouple wires depend on the temperature the junction will be exposed to. For example-

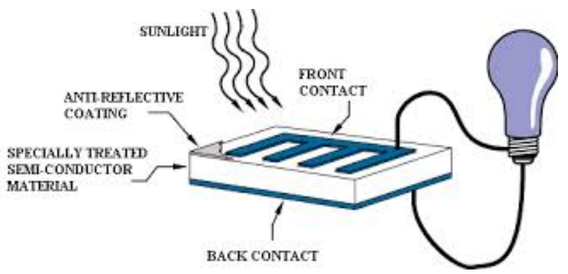
• iron and constantan thenuocouple is used for temperatures up to about 600°C
• chromel-alumel type for temperatures up to about 1300°C.

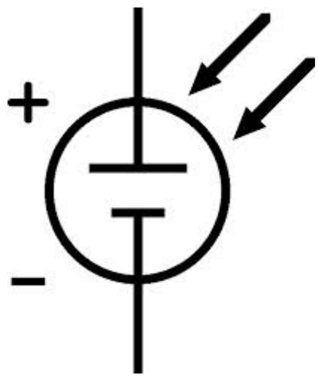
The terms 'chromel', 'altanel' and 'constantan' are manufacturers' names for the metals the thermocouple wires are made of. These metals are special alloys and are made by combining
a number of different metals.
The voltage output of a thermocouple is only a few thousandths of a volt (mitlivolts). An iron-constantan thermocouple with a temperature difference of 5000(3 between both ends of the thermocouple produces a voltage of around 30 mlllivolts (0.03 volts).
Thennocouples are used in industry. The wires are usually individually wrapped in some type of heat-resisting insulation then encased in a protective outer sheath. The junction is made by welding the wires together at a single point.
Obviously thermocouples are not able to produce useful amounts of electricity as the voltage they develop is too low. However, because the voltage produced by a thermocouple is proportional to temperature, it can be used in the measurement of temperature.
Radiant energy also appears in the form of light energy, which can be used in the production of am emf.

A device that produces a voltage when exposed to light is called ____________________

The best known photo-voltaic device is the ___________ cell, which is made from specially treated silicon.

The Australian Standard drawing symbol for the photo-voltaic cell is shown below.





A single solar cell produces about 0.4V. The size of the cell determines how much current it can supply. Most solar cell panels have a number of cells and are generally used to charge a battery.
Satellites are powered by banks of solar cells, and there a number of experimental solar power stations. Solar cells are also used in the country to power telephones, houses and weather stations. As the main problem is to concentrate the energy from the sun onto the cells, mirrors which track the sun's movement are often used with the cells. A solar cell doesn't need any maintenance and produces electricity whenever light is present.

5. VOLTAGE SOURCE EQUIVALENT CIRCUIT

Any device that produces an ¢mf can be represented by what is known as its equivalent circuit.
The equivalent circuit consists of-

• cell - representing the emf developed

• a series connected resistor- representing the internal resistance of the device.

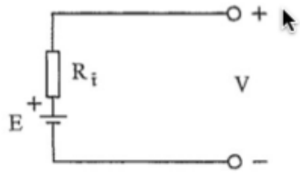


Figure 10

The quantifies associated with the equivalent circuit are -
E = emf developed in volts
Ri= internal resistance in ohms
V = terminal voltage in volts

The terminal voltage of an emf source ________________ ith increased load, due to the internal resistance of the device.

(refer to the lab in class and the section in the Kirchoff's Voltage Law ppt about batteries)

notes:

end