EFFECTS OF AN ELECTRIC CURRENT

In this section you will learn about the effects associated with the flow of an electric current.

At the end of this section the student will be able to:
• List the four effects of an electric current.
• Describe the heating effect of an electric current and list practical examples of its application.
• Describe the magnetic effect of an electric current and list practical examples of its application.
• Describe the chemical effect of an electric current and list practical examples of its application.
• Describe the physiological effect of an electric current and list the precautions taken to avoid it.
• Connect an electrical circuit to demonstrate the heating, magnetic and chemical effects of an electric current.

EFFECTS OF AN ELECTRIC CURRENT

An electric current causes a number of effects some of which can be useful, others merely unwanted by-products.
The four basic effects associated with the flow of an electric current are:

- ___________________________________effect
-
- ___________________________________effect
-
- ____________________________________effect
-

o _____________________________________effect

The following provides a brief description of each of the four effects.

HEATING EFFECT

When current flows in a conductor work is done in ____________________________________

The work done appears in the form of____________________________________

This effect is used in -

Heat is produced by a conductor because of its _______________________ All conductors have a certain amount of resistance, so heat is always produced when current flows.
The higher the resistance, the greater the amount of heat produced (for a given value of current). Because of this, the resistance of conductors supplying power to electrical

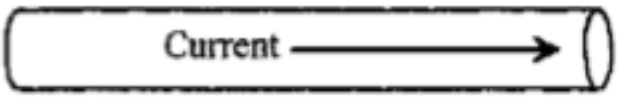
equipment should be ______________________________

If however heat is wanted, as in an electric radiator, the conductor used in the heating element needs to have a certain amount of resistance. The material used is therefore designed to have resistance, and to withstand the heat it produces without burning out.

Materials for this purpose include ___________________________ (a combination of nickel and chrome), which is used in electric radiator elements. The material used to make the filament in an incandescent lamp is another example.

MAGNET EFFECT

Current flowing in a conductor creates a magnetic field which surrounds the conductor.

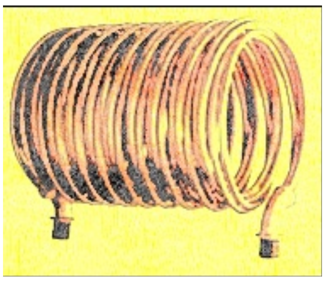


The direction in which the magnetic field acts depends on the direction of current flow.

When viewed end on, the direction in which the magnetic field acts may be represented as shown in figures below.

The strength of the magnetic field surrounding a straight conductor depends on the magnitude of the current flowing in the conductor. The larger the current, the stronger the magnetic field.

To concentrate the magnetic effect, a straight conductor may be wound into a coil.



Applications for the magnetic effect include -

The magnetic effect caused by an electric current is perhaps the most useful of all.

CHEMICAL EFFECT

It has been shown that current can flow in conductors made of copper or other metals. However, an electric current can also flow in certain types of liquids called electrolytes. Salt water is an electrolyte as it contains salt (sodium chloride) dissolved in water. Acids and alkalies are also used to form electrolytes.
An electrolyte contains ______________________, which are atoms with a positive or a negative charge.
A positively charged ion has less electrons (negative charge) than protons (positive charge) and a negatively charged ion has more electrons than protons, as shown below.
For example, in salt water the sodium atoms become positive ions as they each lose one electron which is taken by the chlorine atoms, making the chlorine atoms (which are now ions) negative. However, the liquid isn't charged because the number of positive ions equals the number of negative ions.
Because the ions are charged, they can be attracted by a If two metal electrodes connected to a voltage source are placed in an electrolyte, the positive ions will flow towards the negative electrode (cathode) and the negative ions will flow towards the positive electrode (anode), as shown below. As a result, an electric current flows in the liquid.

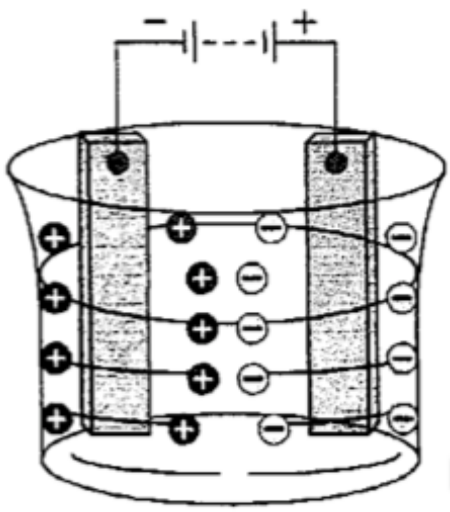


Figure 6

In other words, the electrolyte behaves as a conductor. The more ions there are in the liquid, the better the liquid can conduct an electric current. If more salt is added to the liquid, more ions are created and the resistance of the liquid is less.
This is why salt water is a better conductor than fresh water.
It's important to understand that an electric current does not itself have a chemical effect, but that it causes a chemical effect when passed through an electrolyte.
Applications of the chemical effect of current flow include -

1. _________________________________ In this, the current causes ions of a particular metal (such as chrome, gold or silver) to

flow towards an object immersed in the electrolyte. The object (such as a car bumper-bar) and another electrode are put into a solution with the required ions in it, and a voltage is connected to the electrodes, as in figure 6. The ions are attracted to the electrodes, leaving a metallic coating on whatever is being plated.

2.____________________________________ In which an electric current going through a bath containing a chemical solution
produces chemicals and metals. Aluminium is made by passing a very large current through a solution of alumina and cryolite. Chlorine is made by passing a current through salt water.

3 ______________________________________ Charging a battery is another example of the chemical effect, in which the charge
current reverses the chemical action caused when the battery is discharged. In effect, electrical energy is stored in the battery during charging, and released by chemical action during discharge. This applies to re-chargeable batteries like the lead-acid type used in cars, and to nickel cadmium cells.

PHYSIOLOGICAL EFFECT

This effect is the result of passing an electric current through a living organism, such as a human or an animal. It has a few medical uses, mainly to stimulate a heart by applying a short burst of current that will shock the heart out of ventricular fibrillation (explained shortly).
Otherwise this effect is limited to stun-guns, cattle prods, electric fences and to those countries that still use the electric chair. The purpose of these items is either to produce a short, sharp electric shock, or for an electric chair, to cause death. So it's important you understand this effect as your life may depend on it!
Life is kept going by two important body functions -
.2 breathing (via the lungs)
• blood circulation (via heart-beat).
If either of these stop for more than a few minutes, the brain is starved of oxygen, and there will be so much damage that death soon follows.
If an electric current passes through the body, the current can interfere with the tiny electrical impulses that travel through the body's nervous system to control the heart and lung muscles.

Table 1

Current	Effect
up to 2mA	barely perceptible
2mA to 8mA	sensation becomes obvious and more painful
8mA to 12mA	muscle spasms and greater pain
12mA to 20mA	unable to let go the conductor, can't control muscles
20mA to 50mA	if passing through the chest, breathing might stop
50mA to 100mA	if near the heart, there'll be ventricular fibrillation
100mA to 200mA	heart stops beating
above 200mA	severe burns as well

The amount of interference depends on -
• the value of the current
• the time the current flows
• where current flows in the body.
Current which flows through the brain, or the chest region where the heart and lungs are, is more dangerous than a current passing through two fingers or from one foot to the other.
If breathing stops after an electric shock, the heart can go into what is called ventricular fibrillation. This is when the electrical impulses from the brain controlling the heart are confused enough to be out of step, making the heart quiver and stop pumping blood.
An electric current can also cause terrible burns and make muscles tighten severely. Death and injury can not only result directly from electric shock, but indirectly. Electric shocks have caused people to fall off ladders and power poles, flung them into dangerous chemicals, and made them drop something heavy on themselves, such as the live appliance they were carrying at the time.
The value of the current causing the shock can determine whether it's lethal.
Ta b l e 1 shows the effects of various values of current. Remember that a milliamp (mA) is one-thousandth of an ampere, so the current values are quite small. A current as low as 3 to 4mA can cause pain and a current over 20mA can stop the lungs from functioning. These values of current will hardly even light a lamp, but could kill you.

Skin has a relatively high resistance, but blood is a good conductor. If your skin is wet, it reduces its resistance, and current can flow through your skin to the low resistance path of the arteries.
The value of current that flows during an electric shock depends on two things:
• the value of the voltage causing the shock
• the resistance your body offers to the current.

Voltage

There is no such thing as a 'safe' voltage. However, voltages less than 32V are unlikely to deliver a lethal shock. The type of voltage also has different effects. Because an alternating (AC) voltage regularly changes its polarity, it doesn't have the same effect on the muscles as a direct (DC) voltage. A shock with a DC voltage causes the muscles to contract, making it almost impossible to let go the live conductor. An AC voltage could allow you to let go, although this would depend on the value of the current.

NOTE:

If you have to touch an electrical appliance, do so with the hack of your hand instead of the front. If the appliance is 'live', the shock will throw your hand away rather than make it contract and grip even tighter.

Resistance

Is mainly that of the skin. Wet, sweaty hands have less resistance than dry skin. Standing on a wet floor allows current to flow through you to the ground by way of the feet. Standing barefoot is obviously very dangerous - always wear

rubber-soled shoes when working with electricity.
Wet clothes are another hazard when working with electricity, as wet cloth can conduct an electric current. The resistance of the cloth depends on the type of liquid soaked up by the material. Remember that tap water with all its usual impurities will conduct electricity. As we've said before, electricity and water is a dangerous combination!
Here are some basic rules for avoiding an electric shock -

- Think of any appliance, conductor, terminal or equipment as live, until you have proved otherwise.
- Don't work on an electrical appliance or circuit with wet hands.
- A wet floor is a good conductor of electricity - be extra careful.
- Don't wear metal jewellery (rings, watch) when working with electricity.
- Remember that 'familiarity breeds contempt'. Always have respect for electricity - it has no respect for you!

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