STATIC ELECTRICITY

When you get a 'shock', feel a 'jolt', or, a 'spark', you are experiencing the same type of electrical effect that makes lightning. Static electricity happens when there is an imbalance of electrons (which have negative charges).

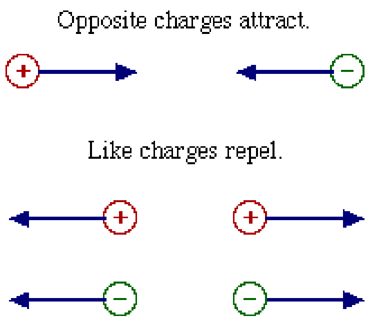
Producing Charges

Materials that attract or repel other materials are said to be charged, or carry an electric charge. Charges, which can be detected by an electroscope, are produced when materials are rubbed, touched or moved together and then separated. To refer to charges as stationary or ‘static’, would be inaccurate, because the charges are moving. ‘Unbalanced charges’ is a more accurate way of describing this electricity. The quantity of electric charge is measured in coulombs.

Van de Graff (VDG) Generators These generators build up an excess of static charge using friction. A rubber belt rubs a piece of metal and transfers the charge to a sphere. When you touch the sphere the charge builds up on you. (Remember! - like charges repel - that is why your hair strands separate as you touch the sphere as the charge builds up on your body.)

Laws of Electrical Charges

Most objects have the same number of positive (proton) and negative (electron) charges. This makes them neutral (no charge). When there is a difference in the electrical charge, certain actions are predictable, because of the Laws of Electrical Charges.



Benjamin Franklin was the first to describe the charges as ‘positive’ or ‘negative’. When amber is rubbed with fur - some of the electrons in the fur move to the amber - the amber becomes negatively charged and the fur is positively charged. Charge separation occurs, when a charged object is brought close to a neutral object. The charged electrons repel the electrons in the neutral object and the charged object is then attracted to the protons of the neutral object (balloon on a wall)

Conductors, Insulators, and In-Between

In insulators, electrons are bonded closely to the nuclei (allowing little movement), while in conductors, the electrons are free to move easily. Most metals are conductors and non-metals are insulators. A special type of conductor, called a resistor allows electrons to flow, but provides some resistance (so it is sort of in-between a conductor and insulator). **Semiconductors** are almost perfect conductors - they have almost no resistance to electron flow. Silicon semiconductors are used extensively to make computer microchips. The largest obstacle is to get the semiconductor to work at reasonable temperatures for practical applications. Superconductors are materials that offer little, if any, resistance to the flow of electrons.

Neutralizing Unbalanced Charges

Electrical Discharge is the movement of charges whenever an imbalance of charges occurs. The action results in neutralizing the objects. The over-charged electrons repel the electrons in the object and the positive protons attract the charged electrons causing a discharge or 'miniature lightning bolt'. There is now an electron balance. An ionizer can be used to neutralize charges on non-conductors.

Preventing Electrostatic Buildup

‘Static cling’ is a build-up of unbalanced charges on different materials. This build-up can be very costly because of the damage it can cause. Anti-static materials have to be used when handling charged objects, so that a discharge (which could cause harm or damage) does not occur. Anti-static sprays, coating or grounding strips.

CURRENT ELECTRICITY

Measuring Current
The steady flow of charged particles is called electrical current. The flow continues until the energy source is used up, or disconnected. The rate at which an electrical current flows is measured in amperes (A). This flow varies from a fraction of an ampere to many thousands of amperes, depending on the device. An instrument used to measure very weak electric current is called a galvanometer. Larger currents are measured with an ammeter.

Measuring Voltage
Electrical energy is the energy carried by charged particles. Voltage is a measure of how much electrical energy each charged particle carries. The higher the energy of each charged particle, the greater the potential energy. Also called 'potential difference', the energy delivered by a flow of charged particles is equal to the voltage times the number of particles. Voltage units are volts (V), and for safety purposes, the voltage of most everyday devices we commonly use is relatively low, while industries and transmission lines are relatively high. A simple way to measure voltage is with a voltmeter. [red to positive (+) and black to negative (-)] Some voltmeters can measure a wide range of voltages. These multi-meters should be used with caution, so that the sensitive needle is not damaged (by testing a low range with high voltage).

Integrated Circuits
Microcircuits (Integrated Circuits) - transistors are used with three layers of specially treated silicon, with the middle layer (receiving a small voltage, allowing it to control the voltage in the outer layers, allowing them to act as switches. Microcircuits are made up of transistors and resistors and are built on an extremely small scale. Integrated circuits put all of the components in one chip, reducing the size of the circuit.

Resistance
Resistance is a measure of how difficult it is for the electrons to flow through a conductor. Resistance also converts electric energy into other forms of energy. Generally, it can be said that conductors have low resistance and insulators have high resistance. The standard unit for resistance is ohm (Ώ). Resistance can be measured directly with an ohmmeter, but a multi-meter is used more often to measure resistance.

Calculating Resistance
Electrical resistance is calculated by finding the ratio of the voltage across the load (V) to the current through the load (I). This is called **Ohm's Law. $R = V / I$**

The more resistance a substance has, the greater the energy gain it receives from the electrons that pass through it. The energy gain is evident in heat and light energy (light bulb filament, wire in a toaster). Solutions can also be resistors. 'Lie detectors' are also special applications of resistance within the body (skin resistance, blood pressure and respiration). An increase in stress (usually associated with a lie) will improve conductivity and show a 'peak' in the recording device. If the temperature of a resistor changes, the resistance changes as well (resistance is usually low when the resistor is cool, and as the temperature increases, so does resistance).

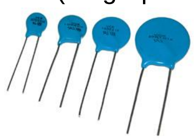
Resistors
Different resistors are used for different applications, especially in electronics. There are many styles, sizes and shapes. The major application for resistors is to control current or voltage to suit the specific needs of other electrical devices within the same circuit. The two most common resistors are the wire-wound and carbon-composition types. The colored strips on a resistor usually indicate the level of resistance and quality.

Variable Resistors
To change electron flow gradually, a variable resistor, or rheostat is used (a dimmer switch, volume control knob).

Rheostats (dimmer)

Thermistor (heat-sensitive)

Varistors (surge-protector)

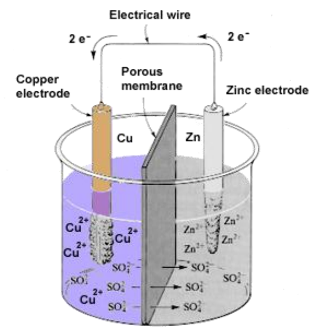


ELECTROCHEMICAL CELLS (BATTERIES)

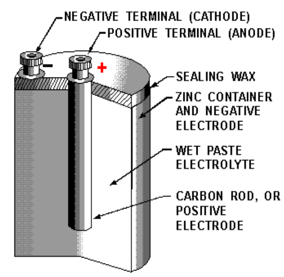
Two metal **electrodes** are surrounded by an **electrolyte**. These cells supply a steady current. The chemical reaction in a cell releases free electrons, which travel from the negative terminal of the cell, through the device, which uses the electricity, and back to the positive terminal of the cell. The chemical reactions within the cell determine the potential difference (voltage) that the cell can create. Several cells connected in series produces a higher voltage, and is commonly referred to as a battery, which is a sealed case with only two terminals.

A **primary cell** is one in which the reactions will not continue after the reactants are used up.

Wet cells use a liquid electrolyte. Wet cells are 'wet', because the electrolyte is a liquid (usually an acid). Each electrode (zinc and copper) reacts differently in the electrolyte. The acidic electrolyte eats away the zinc electrode, leaving behind electrons that give it a negative charge. The copper electrode is positive, but it is not eaten away. Electrons travel from the negative terminal (attached to the zinc electrode) through the device and on to the positive terminal (attached to the copper electrode).



Dry cells –the electricity-producing cells, referred to as 'batteries', are called dry cells, because the chemicals used in them are a paste. The dry cell is made up of two different metals, called electrodes in an electrolyte. An electrolyte is a paste or liquid that conducts electricity because it contains chemicals that form ions. An ion is an atom or group of atoms that has become electrically charged through the loss or gain of electrons from one atom to another. The electrolyte reacts with the electrodes, making one electrode positive and the other negative. These electrodes are connected to the terminals.



A **secondary cell** uses chemical reactions, which can be reversed. These are referred to as rechargeable batteries.

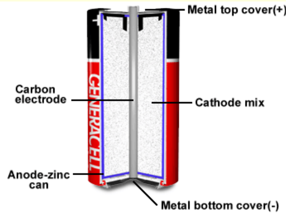
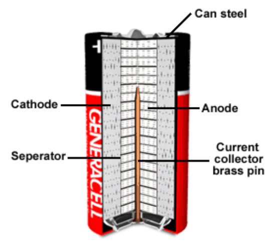
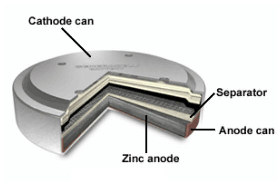
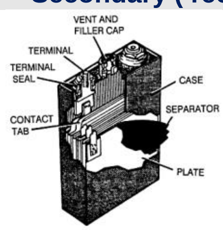
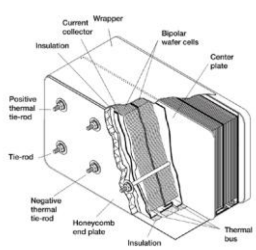
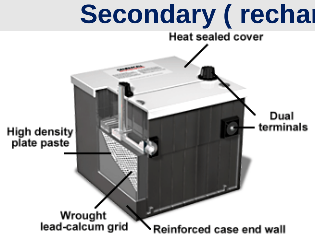
Rechargeable cells use an external electrical source to rejuvenate the cell. The reversed flow of electrons restores the reactants in the cell. The most common reactions that are efficient enough to be used for these types of cells are Nickel Oxide and Cadmium (Ni-Cad). The reactants are restored, but the electrodes will eventually wear out over time.

The tiny cells in a pacemaker can last from 5-12 years

Fuel Cells

Fuel cells combine hydrogen and oxygen without combustion. Electricity, heat and pure water are the only by-products of the fuel cell's reaction. They are 50-85% efficient.

Types of ‘dry’ cells (Batteries)

Primary Dry Cells			
Name	**Diagram**	**Uses**	**Pros and Cons**
zinc-carbon		Flashlights, portable stereos, CD players, walkmans	Not efficient at low temperatures
alkaline		Flashlights, portable stereos, CD players, walkmans	Last longer than zinc carbon, but more expensive
zinc-air		Calculators, hearing aids, watches	Highest energy per unit mass, but discharge rapidly
Secondary (rechargeable) Dry Cells			
nickel-cadmium		Electric shavers, laptops, power tools, portable TV’s	Rechargeable hundreds of times
nickel-metal hydride		Cameras, laptops, cell phones, hand tools, toys	Less toxic than NiCad – 40% more energy density than NiCad, rechargeable, no memory effect, lose charge when stored
Secondary (rechargeable) Wet Cell			
lead acid		Cars, motorbikes, snowmobiles, golf carts	Dependable, but heavy and has a corrosive liquid