CORNELL NOTES

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TOPIC/OBJECTIVE: Building a Circuit

CONTENT/CLASS:

NAME:

CLASS/PERIOD:

DATE: 9/20/17

ESSENTIAL QUESTION: How do Electrical Circuits Work?

QUESTIONS:	NOTES:
	I.

SUMMARY:

QUESTIONS:

NOTES:

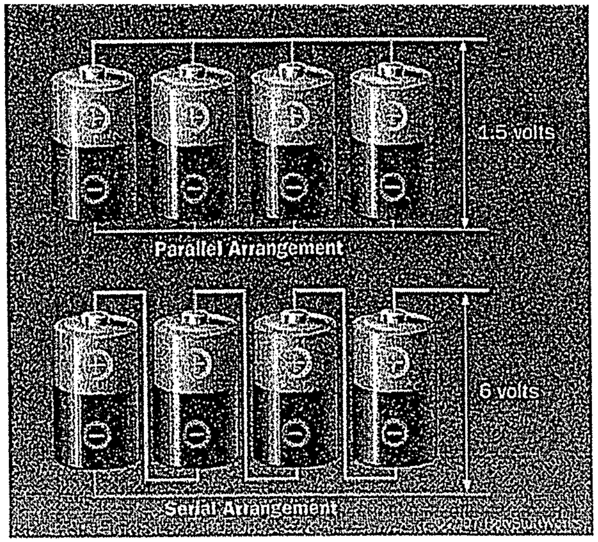
SUMMARY:

I. Take a look at any battery, and you'll notice that it has two **terminals**. One terminal is marked (+), or positive, while the other is marked (-), or negative. In normal flashlight batteries, like AA, C or D cell, the terminals are located on the ends. On a 9-volt or car battery, however, the terminals are situated next to each other on the top of the unit. If you connect a wire between the two terminals, the electrons will flow from the negative end to the positive end as fast as they can. This will quickly wear out the battery and can also be dangerous, particularly on larger batteries. To properly harness the electric charge produced by a battery, you must connect it to a **load**. The load might be something like a light bulb, a motor or an electronic circuit like a radio.

II. The internal workings of a battery are typically housed within a metal or plastic case. Inside this case are a **cathode**, which connects to the positive terminal, and an **anode**, which connects to the negative terminal. These components, more generally known as **electrodes**, occupy most of the space in a battery and are the place where the chemical reactions occur. A **separator**creates a barrier between the cathode and anode, preventing the electrodes from touching while allowing electrical charge to flow freely between them. The medium that allows the electric charge to flow between the cathode and anode is known as the **electrolyte**. Finally, the **collector** conducts the charge to the outside of the battery and through the load.

III. A lot happens inside a battery when you pop it into your flashlight, remote control or other wire-free device. While the processes by which they produce electricity differ slightly from battery to battery, the basic idea remains the same.

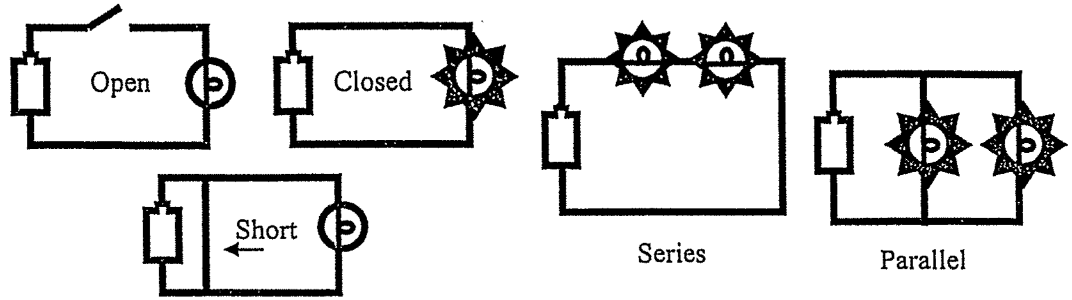
When a load completes the circuit between the two terminals, the battery produces electricity through a series of electromagnetic reactions between the anode, cathode and electrolyte. The anode experiences an **oxidation reaction** in which two or more **ions** (electrically charged atoms or molecules) from the electrolyte combine with the anode, producing a compound and releasing one or more electrons. At the same time, the cathode goes through a **reduction reaction** in which the cathode substance, ions and free electrons also combine to form compounds. While this action may sound complicated, it's actually very simple: The reaction in the anode creates electrons, and the reaction in the cathode absorbs them. The net product is electricity. The battery will continue to produce electricity until one or both of the electrodes run out of the substance necessary for the reactions to occur.



Battery arrangement determines voltage and current. Check out serial battery arrangements, parallel arrangements and what maximum current is about.
HOWSTUFFWORKS.COM

Circuits – an electron maze

Understanding open, closed, short, series, and parallel circuits



Controlling the flow of electrons provides us with heat, light, power, entertainments, and communications over vast distances. Bulbs, batteries, and wires can help students build a basic understanding of electrical circuits.

IV.

In many devices that use batteries -- such as portable radios and flashlights -- you don't use just one cell at a time. You normally group them together in a **serial arrangement** to increase the **voltage** or in a **parallel arrangement** to increase **current**. The diagram shows these two arrangements.

The upper diagram shows a **parallel arrangement**. The four batteries in parallel will together produce the voltage of one cell, but the current they supply will be four times that of a single cell. **Current** is the rate at which electric charge passes through a circuit, and is measured in amperes. Batteries are rated in amp-hours, or, in the case of smaller household batteries, milliamp-hours (mAH). A typical household cell rated at 500 milliamp-hours should be able to supply 500 milliamps of current to the load for one hour. You can slice and dice the milliamp-hour

V.

Imagine a world where everything that used electricity had to be plugged in. Flashlights, hearing aids, cell phones and other portable devices would be tethered to electrical outlets, rendering them awkward and cumbersome. Cars couldn't be started with the simple turn of a key; a strenuous cranking would be required to get the pistons moving. Wires would be strung everywhere, creating a safety hazard and an unsightly mess. Thankfully, batteries provide us with a mobile source of power that makes many modern conveniences possible.

While there are many different types of batteries, the basic concept by which they function remains the same. When a device is connected to a battery, a reaction occurs that produces electrical energy. This is known as an **electrochemical reaction**. Italian physicist Count Alessandro Volta first discovered this process in 1799 when he created a simple battery from metal plates and brine-soaked cardboard or paper. Since then, scientists have greatly improved upon Volta's original design to create batteries made from a variety of materials that come in a multitude of sizes.

VI. Rechargeable Batteries

batteries has grown substantially in recent years. Rechargeable batteries have been around since 1859, when French physicist Gaston Plante invented the lead acid cell. With a lead anode, a lead dioxide cathode and a sulfuric acid electrolyte, the Plante battery was a precursor to the modern-day car battery.

Non-rechargeable batteries, or **primary cells**, and rechargeable batteries, or **secondary cells**, produce current exactly the same way: through an electrochemical reaction involving an anode, cathode and electrolyte. In a rechargeable battery, however, the reaction is reversible. When electrical energy from an outside source is applied to a secondary cell, the negative-to-positive electron flow that occurs during discharge is reversed, and the cell's charge is restored. The most common rechargeable batteries on the market today are **lithium-ion** (LiOn), though **nickel-metal hydride** (NiMH) and **nickel-cadmium** (NiCd) batteries were also once very prevalent.

The Science Behind the Activity

VII. Batteries contain chemicals that interact to provide a "push" and a "pull" for external electrons that are connected in a continuous path of from one contact (**negative -**) of a battery to the other contact (**positive +**) of the same battery. This continuous path is called a **circuit.** Students need to know batteries, solar cells, generators, fuel cells, and other **power sources** create forces to **move electrons**; they **do not create electrons!**

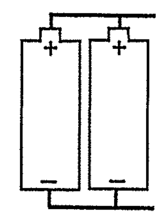
VIII. Essentially, all things contain electrons. Metal objects have electrons that can easily be made to move in one direction. Electrons can move within the metal object and to other connecting metal objects. **Conductors** are materials, like metal wires, that can provide a path for electrons to easily move or, more accurately, to bump along. Wires are often covered with an **insulator** or non-conducting material that does not allow electrons to move about easily. Folded Foil Wires have no insulating covering, so there is an increased risk of short circuits.

IX. In a circuit the power source is connected to some type of **load** or object being powered. A load can be a light, motor, electromagnet, etc. An **open circuit** has a gap or opening somewhere in the path of conductive material from the power source to the load and back to the power source. A circuit that has no gaps is called a **closed or complete circuit**. A **switch** is a device with a movable piece of a conductor that can be moved to close a gap.

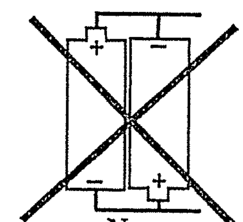
X. Electrons act as if they are lazy and want to take the shortest path, electrically, to and from the battery or other power source, instead of going to "work" in the light bulb, motor or other resistive load. A path that is a short cut (a low resistive path) back to the power source is called a **short circuit.** A short circuit can cause a rapid and massive flow of electrons that can heat wires until they are **burning hot**. This is why homes and cars have **fuses**, devices with a metal wire that will melt at a lower temperature than other wires. If heated up by a short circuit, this special wire will melt so as to create a gap in the circuit. The gap stops the flow of electrons so the other wires will not heat up enough to start a fire. **Circuit breakers** perform the same function as a fuse, to create a gap in the circuit during a short circuit, but they can be reset instead of needing to be replaced like a fuse.

Taking it Further

- What will happen when 2 batteries are used in a circuit? The batteries, like the bulbs, can be placed in parallel or in series. If the batteries are placed side by side (parallel) they **must be placed facing the same direction when connected**, positive to positive (+ to +) and negative to negative (- to -). Wiring the batteries with their ends together, with one battery inverted to the other (- to +), would create a short circuit that can make the batteries and the wires **burning hot!**



Yes

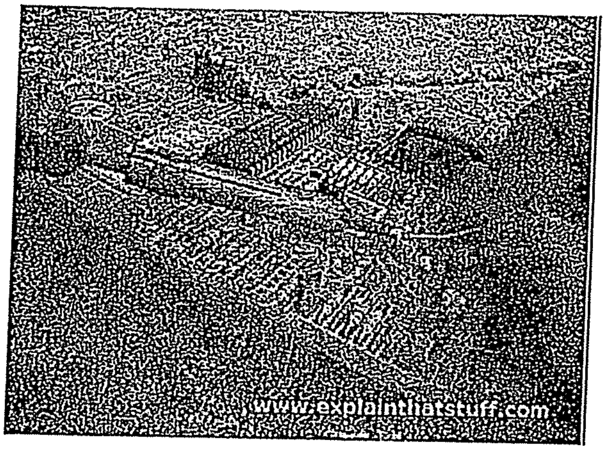


No

Electronics

XI.

by Chris Woodford



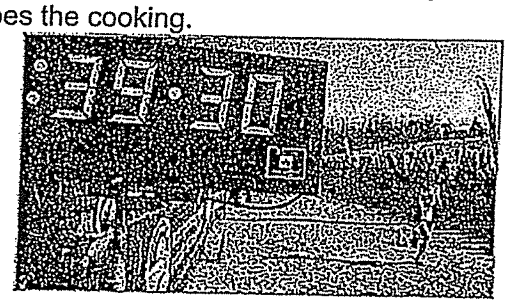
They monitor your heartbeat. They carry the sound of your voice into other people's homes. They even bring airplanes into land. We're talking about electrons! It's amazing to think just how many things they actually do. Electrons are tiny particles within atoms that carry electrical energy. One of the greatest things people learned to do in the 20th century was to use electrons to control machines and process information. The **electronics** revolution accelerated the computer revolution and both these things have transformed many areas of our lives. But how exactly do small particles, far too small to see, achieve things that are so big and dramatic? Let's take a closer look and find out!

XII. What's the difference between electricity and electronics?

Electricity is a kind of energy—a very versatile kind of energy that we can make and use in all sorts of ways. When electricity flows around a circuit it can drive an electric motor or a heating element, or power appliances like electric cars, kettles, toasters, and lamps. Generally, electrical appliances need a great deal of energy to make them work so they use quite large (and often quite dangerous) electric currents.

Electronics is a much more subtle kind of electricity in which tiny electric currents are carefully directed around much more complex circuits to process signals (such as those that carry radio and television programs) or store and process information. Think of something like a microwave oven and it's easy to see the difference between ordinary electricity and electronics. In a microwave, electricity provides the power that generates high-energy waves that cook your food; electronics controls the electrical circuit that does the cooking.

XIII. Analog and digital electronics



There are two very different ways of storing information—known as analog and digital. It sounds like quite an abstract idea, but it's really very simple. Suppose you take an old-fashioned photograph of someone with a film camera. The camera captures light streaming in through the shutter at the front as a pattern of light and dark areas on chemically treated plastic. The scene you're photographing is converted into a kind of instant, chemical painting—an "analogy" of what you're looking at. That's why we say this is an **analog** way of storing information. But if you take a photograph of exactly the same scene on your phone with a digital camera, the camera stores a very different record. Instead of saving a recognizable pattern of light and dark, it converts the light and dark areas into numbers and stores those instead. Storing a numerical, coded version of something is known as **digital.**

Electronic equipment generally works on information in either analog or digital format. In an old-fashioned transistor radio, broadcast signals enter the radio's circuitry via the antenna sticking out of the case. These are analog signals: they are radio waves, traveling through the air from a distant radio transmitter, that vibrate up and down in a pattern that corresponds exactly to the words and music they carry. So loud rock music means bigger signals than quiet classical music. The radio keeps the signals in analog form as it receives them, boosts them, and turns them back into sounds you can hear. But in a modern digital radio, things happen in a different way. First, the signals travel in digital format—as coded numbers. When they arrive at your radio, the numbers are converted back into sound signals. It's a very different way of processing information and it has both advantages and disadvantages. Generally, most modern forms of electronic equipment (including computers, cell phones, digital cameras, digital radios, hearing aids, and televisions) use digital electronics.

XVI. Electronics around us

Electronics is now so pervasive that it's almost easier to think of things that don't use it than of things that do. Try to think of something you do that doesn't involve electronics and you may struggle. Your car engine probably has electronic circuits in it—and what about the GPS satellite navigation device that tells you where to go? Even the airbag in your steering wheel is triggered by an electronic circuit that detects when you need some extra protection.

Electronic equipment saves our lives in other ways, too. Hospitals are packed with all kinds of electronic gadgets, from heart-rate monitors and ultrasound scanners to complex brain scanners and X-ray machines. Hearing aids were among the first gadgets to benefit from the development of tiny transistors in the mid-20th century, and ever-smaller integrated circuits have allowed hearing aids to become smaller and more powerful in the decades ever since. Who'd have thought have electrons—just about the smallest things you could ever imagine—would change people's lives in so many important ways?