Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
1999 Volume VII: Electronics in the 20th Century: Nature, Technology, People, Companies, and the Marketplace

Modern Electronic Inventions: Changing the Way People Live

Curriculum Unit 99.07.03
by Roberta Mazzucco

This unit: Modern Electronic Inventions: Changing the Way People Live is written for use in a third grade classroom. However, second to fifth grade teachers can utilize it in whole or part.

Purpose

The purpose of this unit is to present an interdisciplinary curriculum which centers on electricity, but extends to social studies, art, math and language arts too. The seminar in which this was written for dealt not only with the scientific aspects but the resulting inventions, their inventors, and the effect all of these innovations had on the world. This unit seeks to take some of the basic principles of magnetism and electricity and join them with a study of how and why these things happened and why they were important.

My objective in writing this unit is to have my students deal with science while also seeing how it has practical implications for them. Most educators acknowledge that our students do not always get enough science education especially in the lower grades. Beyond that, many are woefully ignorant of the inventors who made these discoveries and their impact on the world. Most children do not realize the importance of the transistor or the electric light or electromagnetism. I believe that a unit like this can fulfil a lot of curriculum needs for my third graders.

Methods

Primarily this unit is attempting to be as hands on as possible. I hope to have the science in the form of experiments as the centerpiece of the unit. The unit will pick out a few of the milestones in the development of modern electronics and discuss it using a demonstrating experiment as the starting point. In this way the students will discover the same principles and hopefully see a progression in learning that occurred over hundreds of years. In this way students can see that inventions or new ideas are seldom the work of one person but are usually the fulfillment of the work of many people. The inventor who is credited with a find or breakthrough may even uncover something he/she does not recognize as a new idea. Sometimes, as in the case of the telephone, two people each working on their own make the same discovery.

Science Journal

When doing the science portion of the unit students will keep a science journal in which they will record the experiments they do. Students will be introduced to the scientific method in order to familiarize themselves with formulating a hypothesis and evaluating the results etc.

Research Project

In order to find out about the different scientists/inventors, students will complete a research project. This will give them a chance to learn about how to use materials in the library media center. Children will use a graphic organizer to help them find information. They will keep a bibliography and footnote their information.

Time-Line

To help make the historical changes brought on by the progress in electronics more intelligible to students the class will construct a time-line. This will help young students see the progression of developments, as well as, the time span over which these discoveries took place. Most of the students in this age group find visual aids very helpful in understanding difficult concepts. For most time is a difficult concept to understand. This will hopefully help them see how the chain of discoveries led to the technological advances we have today.

Classroom science center

One way to give students the opportunity to get time to experience or "play" with the science materials like magnets, batteries, etc. is to set up a science center in the classroom. Here you can leave equipment for students to redo experiments and demonstrations or extend their own learning when they have free time during class or as an activity that students can do when their class work is completed.

Organization

The unit will be presented in chronological order and hopefully expand students' ideas about electricity and magnetism as they historically occurred. At the beginning of each section the time-line suggestions will give examples of additions that should be added to the time-line as students progress. I will try to explain one or two examples of experiments that can be done with students and will refer to the bibliography for books that offer other suggestions about appropriate demonstrations.

Setting the Stage: Early Discoveries

It is always a good idea to begin by assessing what students know about as subject. In this case most third graders have had experiences with magnets. It cannot be stressed enough that students need plenty of opportunities to "play" with the magnets. Since my students already have experience with magnets it would be beneficial to do a class KWL chart. That is a listing of what they know, what they want to know, and what they learned about magnets during these preliminary explorations. This would help teachers to see what experiences students need to increase their level of knowledge. At this point it is perhaps not even necessary to give things specific names or use correct terminology, but to allow children to draw their own conclusions. Children need to begin keeping their journals of what they do and what they see. They should also be encouraged to draw diagrams and pictures of what they observe. In this way they are like Thales the philosopher/scientist who used observation as his basic tool.

Activities: There are many readily available resources that will give many suggestions for experiments. I would like to offer three.

1. What do magnets attract? This is a very basic experiment but can easily help to assess that students know the basics of how a magnet works. Students can complete a chart listing a group of items and whether they are attracted to the magnet or not. Students should be encouraged to add objects to the list. How powerful is a magnet? Students should be given the opportunity to work with a number of different magnets and to test how many paperclips the magnet can hold.
2. Students will hopefully discover that size does not predict the power of a magnet.
3. How can you make a magnet? Students can be given thicker blunt needles and shown that if they rub a magnet on the needle going in the same direction for around 50 strokes that the needle will become magnetized.

After some work on magnetism students need to think about another force Thales dealt with called static electricity.

Activities: In a simple experiment students can use a comb to rub on their hair or clothes to see if they can make the comb into a kind of magnet which will attract scraps of tiny paper or plastic wrap. Is the comb a magnet?

If there is nylon carpeting in the school or the teacher has a small rug scrap the children can then try rubbing their feet and then touching a metal doorknob where they will get a shock and possibly see a spark.

1. Blow up two balloons and tie a string to each. Rub them on a piece of wool (Someone may be wearing a wool sweater, which works just as well). Lift the two balloons up by the string and you will find that they float apart. Perhaps they are like the poles of a magnet. If you put a stiff piece of paper in between the balloons, they will be attracted to the paper and both will collapse toward it. Pull the paper away and the balloons will fly apart. Here the balloons are indeed acting like the

two ends of two bar magnets.

2. Can a balloon bend water? Take a balloon and rub it against apiece of wool. Hold it near a stream of water from a tap and you will see the water will bend toward the balloon. It the balloon gets wet the water will stop bending. This is a good place to do a comparison chart of the similarities and differences
between magnets and static electricity.

3. How can you make a magnet? Take a blunt needle and have students magnetize it as done in a previous experiment. Then attach the needle to a cork. Float the cork in a bowl of water and students will see that the needle will tend to float in one position. If compared to a conventional compass it will be obvious that the needle is pointing in a north, south position.

Background:

People have always been aware of electric energy whether it was from lightning, the sting used by certain fish to sting their prey, or the spark they felt when they rubbed certain materials together. Thales, who was a Greek philosopher (640 to 546 BC) is the first person to have left his recorded observations concerning static electricity and magnetism. He observed that when he rubbed a piece of the stone amber with a cloth it attracted bits of straw. The Greek word for amber is elektron from which the word "electricity" would later come.

Some three hundred years later the Chinese general Huang-ti was suppose to be the first to use lodestone as a compass. The Chinese had found that the stone was more precious than a group of jewels because it had three magical qualities. First it attracted iron. When the stone was first found in Europe it was near the Aegean Sea near the region of Magnesia. Our word "magnet" comes from this early name. Second when the stone was placed on a wooden raft in a bowl of water it always turned until it was pointing north- south. One side always pointed toward the North Star, which never changed positions so it became important for guiding sailors. Since it could help lead the way on a cloudy night it was called "lodestone" or stone that leads. The third peculiarity of this stone was that you could transfer its powers to an iron needle. Instructions for doing this were written down some fifteen hundred years ago by the Chinese.

The lodestone was not used for navigation until around the thirteenth century AD, which corresponds to the time when Marco Polo was exploring the Far East. Arab sailors saw the advantage of using a compass and they are the ones credited with bringing it to Europe. Sailors no longer would have to hug the coast when they sailed for the compass could easily allow them to get out into deeper waters. Christopher Columbus was undoubtedly using a compass when he crossed the Atlantic looking for a quick route to the Indies.

It is important for students to know that the finding of the lodestone was purely accidental but that it led to much progress in transportation. Astronomers had identified the North Star and it was very useful to navigators in planning their journeys. Still up until the development of the compass ships usually hugged the coastline and on cloudy or stormy nights navigation was impossible. The finding of the lodestone and the making of the compass changed everything. Ships could still navigate in cloudy weather because they no longer had to see the North Star the compass would point to it for them.

Continuing experimentation and some terminology - 17th Century

---

In this section dealing with the l7th and early 18th centuries the objective is now to begin formalizing the discussion a bit. Students should learn that Gilbert advocated the term electricity and a more scientific method, while also seeing that the idea of the earth as a magnet was also first postulated. In fact the earth is like a huge magnet.

According to Greek myths a young shepherd boy named Magnes discovered magnetism. While walking in the hills the nails in his sandals stuck to a rock. The name magnet was given to honor the young boy. Magnetite or lodestone. Again there are many books with demonstrations that you may want to try but I offer three.

Activities:

1. What does earth's magnetic field look like? To do this demonstration you need a bar magnet, some iron filings, a couple of sheets of stiff white paper, and a marker, a copy of an outline of the earth and its continents. The bar magnet should be able to fit within the earth's outline. You may need to reduce or expand the diagram. After you have the drawing complete put the bar magnet under it. Then begin to lightly dust the map with the iron filings. You should gradually see the filings arrange themselves to mimic the magnetic field of the earth.
2. Can we separate the Poles of a magnet? This experiment helps to point up a difference between static electricity and magnetism. Electricity can run in one direction and is gone. The magnetic attraction never leaves the field around its pole. It may bend or twist but it the field remains. No matter what we try we cannot separate the two poles. To try this demonstration you need a bar magnet, wire cutters, a large steel paper clip and a compass. You first need to unbend the clip and magnetize it by stroking it stroking it from the middle to the end about 50 times. Then turn the clip and repeat with the other end. You can test to make sure you have two poles by using the compass to verify this. Then you need to cut the clip in half. If you check the two pieces out with the compass you will see that each piece now has a north and south pole. You can keep cutting each piece again in half but you will continually get a new magnet. Cutting it in two does not separate the two poles. As you cut you will also notice that the magnet gets progressively weaker.

3. How do the magnetic fields of two magnets affect each other? In doing this demonstration you will need 2 bar magnets, iron filings, and a sheet of stiff paper. If you dip the north pole of one magnet and the south pole of the other magnet into the filings and then bring them a short

distance apart you will see that they seem to share the filings between them showing that the magnetic field is strong there. If you then take both north poles and dip them into the filings and bring them near you will see that the filings will retreat to the sides of the magnet showing how the like poles repel each other.

While scientists continued to study magnets no specific progress was made until William Gilbert (1544-1603) came along. Gilbert lived in Shakespearean England and was a doctor. At the time, many doctors were interested in magnetism. Since magnetism had certain effects on objects there was speculation that it might have healing potential for the human body.

Gilbert found that many objects besides amber could attract light objects. In order to gauge the ability of objects to attract, Gilbert invented the versorium. Versorium means, "turn around" in Latin. What the invention did was exactly that it turned toward or away from the object held near it. A long rod of any solid material even wood was suspended from a string. The rod would be rubbed vigorously and then the object would be held nearby. Gilbert made many other discoveries. He found that it was not heat that was given off by rubbing the rod that made amber attract light things but the friction. Gilbert is also credited with making up the word "electricity." If something placed near his versorium was not attracted it was a "nonelectric." If the object was attracted it was called "electric." Gilbert was the first to distinguish between magnetism and electricity. He also believed that the earth was a huge rotating magnet. This did not go over well with Gilbert's peers, many of whom believed that the earth was the center of the universe and stood immobile while the sun and planets rotated around it.

It is important to remember that up until this time most so called scientific experimentation consisted of mainly observation with little or no controlled experimentation. Gilbert brought this kind of discipline to the work he did. He set up experiments to prove his theories. It is important for students to understand the importance of the scientific method in solving scientific problems.

Students need to see that it was over two thousand years before any significant knowledge about electricity and magnetism was made. Gilbert's versorium is an interesting model to build with students and is quite simple. You will need a glass or plastic rod and then a length of thread. It should be tied around the rod so it can be suspended from a table so the rod can move freely. The rod then needs to be rubbed with a cloth until it gets warm. This is the most important part. After this is done the rod has to hang until it stops moving. Then bring a piece of paper near the rod and it will reach toward the rod. You can try other objects. If you tie a plastic ball point pen to a string and rub it with wool or some furry material then put it near the rod it will turn around and around. This proves again that like charges repel.

Stephen Gray (1695-1736) He was an Englishman who discovered that certain objects would carry an electric charge while others will not. He also figured out how to make an electrical charge (make electricity move). Objects that let an electrical charge pass are "conductors," while those that will not let a charge pass are insulators or nonconductors. Gray transmitted an electrical charge from a glass tube to an iron rod by using a wire. He was one of the first to use a wire as an electrical conductor.

What Gray did was clarify some ideas about static and current electricity. Up until now we have only static electricity because the charges positive or negative build up on an object or person and are not released till a conductor in many cases a piece of metal appears. Thus in walking across the rug we pick up a certain charge but we can't make the charge do anything unless it comes in contact with that conductor usually a doorknob and then we get that tiny shock and often see a spark of light. Now electricity is not held in an object but can be released. This ability to release the current would make electricity usable in the future.

Charles Du Fay a Frenchman (1698-1739) read some of the works of William Gilbert and Stephen Gray. He demonstrated that all objects could be electrified if they were heated and then rubbed with a cloth or fur. Even a conductor could be electrified if it were insulated. Du Fay is credited with identifying the two kinds of electricity, static and current. Static electricity is created by friction when certain objects are rubbed together. Current electricity is when electrons move through a conductor.

Still uncovering the basics of magnetism and electricity- 18th Century

---

During the eighteenth century electricity interested almost everyone but no one really thought that it could do anything useful. People attended lectures about electricity and there were constant attempts to produce larger and larger sparks and crackling noises for the assembled crowd.

Activities:

The activities that are offered are ones which will show the kind of spectacular affects that made people go to see the demonstrations and hear the lectures on these new affects.

1. What does electricity sound like? To do this you need a metal tray or the top of a cookie tin, and a lump of clay large enough to act as a handle, and a plastic garbage bag. Then stick the clay to the metal tray so you can pick it up without touching the metal. Then place the tray on the plastic and spin it on the plastic bag for two minutes. Don't touch the tray with your hands but lift it off the plastic with the clay handle. With your free hand pick up the metal fork and touch the edge of the tray with it. You should hear the sparks crackle.
2. Can we store up a charge and make a large flash? This demonstration results in the building of a Leydon jar which can store a number of charges and then be released for a grander affect.
3. If you have access to a static electricity generator you can do a lot of nice demonstrations about the power of static electricity. Students can join hands and actually make a charge go from one person to the other. The machine is harmless but the results are invaluable.

Around 1750, Pieter Van Musschenbroek (1692-1761) is credited with having made the first electrical storage jar. It was called the Leyden jar after the University of Leyden in Holland where he taught. The Leydon jar is a forerunner of what is now called a capacitor. It is used to store electricity and can generate a great burst of light when it is fully charged. It is similar to the device, which produces the flash in a flash camera. Televisions and radios and computers all depend on a capacitor to hold electricity for hours even days. The Leydon jar showed that you could store electricity, which would prove important later. It also showed that you could store a number of consecutive charges and fill the jar almost like filling a jar spoonful by spoonful until it was filled. It definitely held more electricity than a friction machine.17

Students will readily see the power of electricity and the importance of experiments like the Leydon Jar. It showed how storage of electrical charge could generate power.

Benjamin Franklin (1706-1790) was one of those people who were fascinated by this electricity idea. When a Professor Spencer of Edinburgh gave a lecture in Philadelphia on electricity Franklin was curious. He even ordered a static generator and a Leydon jar and did his own experimentation. Franklin repeated many of DuFay's experiments and reached the same conclusion (which he did not know of) that there were two kinds of electricity. Dufay called them vitreous and resinous. Franklin called them positive (+) and negative (-).18

Franklin also stated that electricity was not created by rubbing a cloth on a glass tube of the generator. The electricity was merely being transferred. He also stated that when an unelectrified object was rubbed it did one of two things: it either gained electricity and reached a positive state, or it lost some of the "electric fluid" and was left in a negative state. These principles are still used today.19

Luigi Galvani (1737-1798) was a professor of anatomy at the University of Bologna in Italy. While teaching class in 1780 Galvani was dissecting a frog in class when he put the frog down near an electrical machine which had been used in a previous experiment. A spark passed between the machine and when the frog's nerve center was touched with a scalpel the frog's leg twitched. Galvani could never really explain what happen but he kept experimenting. He always believed, incorrectly, that the electricity was somehow stored in the frog's leg.20

Making electricity usable - 19th Century

Activities:

> 1.How can you make a battery? You will need 12 copper coins and zinc washers close in size. You will also need 12 circles cut out the same size from blotting paper, vinegar, salt, 6 ½ feet of thin plastic coated wire and an iron nail. Pour the vinegar into a glass and put in a tablespoonful of slat. Soak each disc of blotting paper. Stack a coin then a washer then a disc, and finish with a washer. Take the wire and wrap it around the nail as many times as possible. Put one end of the copper wire on top of the copper coin and the other end toward the washer. Bring the nail near a small compass and the needle should spin. The salt and vinegar mixture results in a chemical reaction. Negatively charged particles flow through the coin through the washer around the wire and back to the battery. The current causes a magnetic field that affects the compass. 21

Students may also want to try making a lemon battery. You need a juicy lemon, a copper and zinc nail. Put both nails into the lemon. Touch both nails with your tongue and there should be a tingling feeling as the current flows from the battery.22

> 2. How can you make an electromagnet? You will need a large iron nail, a long piece of wire, a battery, and some small paper clips. Wrap the wire around the nail leaving about six to eight inches of wire at each end. Attach the ends to the battery. Try picking up the paper clips with the

end of the nail. Students can extend this demonstration by seeing if the power of the magnet is affected if more batteries are added. Also, if more or less wire is wrapped around the nail does the strength of the magnet change? Would you still be able to make an electromagnet if the wire were wrapped around a piece of wood? 23

Students can see that unlike a permanent magnet the poles can be reversed by merely changing the wires hooked up to the battery. This principle is what Oersted discovered and used to develop the electromagnet. Electricity could make a magnet.

3. Michael Faraday showed the opposite. A magnetic field could produce electricity. How can we make a Magnetic Dynamo? You will need a bar magnet, 5 feet of insulated copper wire, a compass, glass, and 4 twist fasteners like those found on grocery items or garbage bags. Wrap the wire around a drinking glass leaving about 18 inches of wire at each end. Slide the wire off the glass and tie it with the fasteners. Wrap both ends of the coil around the compass in the same direction. Then lift the coil up and pass the bar magnet through it. Moving this magnet back and forth the needle jumps. If you remove the magnet it stops the current flowing. This type of electrical current is called alternating current.24

Once students have made the battery it is a good time to have them experiment with batteries to understand simple circuits, both serial and parallel.

4. Can you make the bulb light up? For this activity you will need some wire, a bulb and battery. Allow students to work with a partner or on their own to try and light the bulb.
5. Once you light one bulb give them more. If they attach more what happens to the brightness of the bulbs. In this kind of circuit or series the bulbs will get progressively dimmer. In a parallel circuit, which we find in our homes, and schools, the bulbs are connected so that their number does not affect the brightness of the individual bulbs.
6. How does a flashlight work? Give students an old flashlight and let them look at the inside and try to trace the circuit that lights up the bulb. Let them see how the switch makes and breaks the connection. After students are familiar with the flashlight and how it works you can see if they can figure out what is wrong when you reverse one of the batteries, put a piece of paper between the two batteries or remove the coil at the ends of the case.25

Background:

Galvani's experiment intrigued Alessandro Volta (1745-1827) who was a professor of physics at Padua University. He believed that the electricity from the experiment came from the metals - the knife and the metal table the frog laid on. A big argument ensued between the two men and each had their followers who claimed the other side was crazy. Both in their way were right. Volta is best known for inventing what is called the voltaic pile, or electric cell. We know it best as a battery.26

Hans Christian Oersted (1777-1851) was the self-educated and through his own hard work he became a professor of physics at the University of Copenhagen. He thought that electricity and magnetism were somehow connected. While lecturing he discovered that the needle of a compass when brought close to his electronic equipment moved. He experimented and found that when the current was on the needle swung one way and when it was shut off the needle swung back. Oersted found that the current was not only deflected by the needle but the magnet. He discovered that a current of electricity creates a magnetic field and thereby connected electricity and magnetism for the first time.27 William Sturgeon (1783-1850) was the first to produce an electromagnet. An electromagnet is a magnet that works by having an electrical current pass around it. Wire is wrapped around a piece of iron and when the electric current goes through the wire it magnetizes the wire. When the current is turned off the magnetic force no longer exists. Sturgeon and his experiments had profound influence on the work of Michael Faraday.28 Michael Faraday (1791-1867) was an English physicist who combined what he learned about electricity and magnetism and developed some of his own ideas which became the foundation for our modern day methods of generating electricity on a large-scale basis. Faraday took Sturgeon's work on electromagnets and tried to see if magnetism could produce electricity. Through his experiments Faraday found that when he started or stopped the electronic current there was slight movement in the galvanometer. He reasoned that the electricity was induced when there was a change in the magnetic force. In other words if the lines of force were constant there was no current. Once the lines of force were created or stopped the electric current was induced. Faraday continued to experiment. He wanted to be able to generate a constant current. He built a device in which a moving magnet induced a current. The amount of current was determined by how fast or slow the magnet changes the field of force. Faraday's experiment proved to be the first electric generator or dynamo. It was the first device to change mechanical energy into steady electric current. Today's electric generators provide energy throughout the world. More electricity is produced by Faraday's discovery than by any other means. There are other ways to produce electricity but all of them put together cannot equal the amount of energy produced by Faraday's generator.29 As often happens at almost the same time as Faraday was working on his theory, Joseph Henry (1797-1878) was working on a theory of induction in America. He was shocked when he read about Faraday's research in a scientific journal. Henry did not give up but kept working. Henry is credited with discovery of the principles of self-induction. This would be a critical step in the later development of the modern generator and electric motor. Henry also discovered the principles of the transformer.30

Well known inventions and their inventors

This section deals with some inventors and inventions that changed our lives. I suggest using this section as a reference to have students begin working on their individual or group projects.

Georges Leclanche (1839-l882) developed the first dry cell battery. He really conceived of the idea of making electricity portable. His work led the way for development of hearing aids, cameras, electronic calculators and other inventions.

Students can research through many of the available resources listed to find experiments and demonstrations they may wish to do from recreating Morse's telegraph to making an alarm, quiz game or lighting a small house. (See lesson plans)

Samuel F.B. Morse is an interesting individual because he was primarily a portrait painter and one of the founders of the National Academy of Design. He became interested in electricity when he took a few courses at Columbia College. Morse renewed his interest in electricity while on a trip home from Europe. He worked out a plan for his idea of a telegraph and worked with an inventor named Page to design his device, which could send and receive code mechanically. Ever since Stephen Gray had shown that you could transmit electricity over wire and Oersted's discovery of electromagnetism there had been interest in researching a new kind of communication. Morse worked and Page worked on the idea for years. It was not until May 24,1844, that Morse finally finished constructing a line between Washington D.C. and Baltimore, Maryland. On that day the now famous message "What hath God wrought" was transmitted from Washington to Baltimore and then repeated by the operator in Baltimore back to Morse.31

Thomas Alva Edison (1847-1931) is one of America's foremost inventors. He is best known for his invention of the incandescent lamp. This lamp works by giving off light from a burning filament. While the principle of the burning filament was well known it was not considered practical because the filament usually burned out very quickly. Edison and his team took nearly a year to find a material that would burn for longer than a few minutes. Through this experimentation he also found that if the bulb had little air in it the filament burned longer. Edison also developed a better pump to help in trying to form a vacuum in the lamp. Among his dreams was a wish to electrify every home and factory in America. One mistake that Edison made was his reliance on direct current. He believed that alternating current was too dangerous.32

George Westinghouse (1846-1914) was one man who disagreed with Edison. Westinghouse had made a fortune from his invention of compressed air brakes for railroad cars. He then went into the electricity business. Westinghouse had bought a patent for a transformer from William Stanley. His transformer showed that you could transmit current by stepping up the volts from 500 to 3,000 from the generating station. Then you would step the voltage down at the other end back to 500. Stepping up the voltage was a more efficient way of transmitting current.33

The decision about AC or DC was fought by Edison and Westinghouse because there was a lot of money riding on which method was chosen. It wouldn't be just electrifying homes but selling generators and motors to factories. The question was finally settled by the work of another inventor Nikola Tesla. Nikola Tesla (1856-1943) was born in Croatia, which was once part of Yugoslavia. Tesla had only two years of engineering college but he was brilliant. He worked mostly with AC transmissions, AC motors and radio communications. Tesla worked for Edison but when he told Edison about his idea for an AC motor Edison tried to discourage him. After all Edison was in favor of DC transmission. However, Tesla believed in his idea and left Edison's lab. Westinghouse heard of Tesla's work and hired him. Tesla came up with the AC motor. Everyone but Edison agreed that it was superior to the DC motor. Even the company Edison had started, Edison Electric Company chose AC. This company is now General Electric.34

The transmission of information over the wires of a telegraph by Samuel Morse led to innovations of other kinds in the world of communication. If sounds could be transmitted why not the human voice. Alexander Graham Bell (1847-1922) was not the sole inventor of the telephone. Earlier scientist had written about this device that would be able to transmit the human voice. However many of their devices could not reproduce human speech accurately. On February 14, 1876 a man name Elisha Gray filed for a patent for a telephone. On that same day Alexander Graham Bell also filed for a patent for a telephone. Each man had worked independently of the other and filed for a patent without knowing about the other.35

Guglielmo Marconi (1874-1937) was an Italian inventor best known for his contributions for radio. After the discovery of electromagnetic waves, Marconi tried to utilize them for communication. After experimenting for several years he was able to send messages without wire over a distance of about a mile. By 1901 signals could be sent over longer distances. Marconi had developed the first radio.36

Electronics

It is usually said that the branch of science called electronics began with the invention of the vacuum tube. Tubes improved over the years but soon there were no improvements that could be made to them. The transistor age began in the mid nineteen fifties. One of the most advantageous things about a transistor is that it can take a tiny signal that cannot be heard and amplify it so that it fills a room with sound. A transistor can also work as a switch at very high speeds. Another difference between the vacuum tube and the transistor is that a tube works in a vacuum. A transistor works in solid material hence the term solid state is used to describe transistorized devices.37

Transistors also turn on instantly. Vacuum tubes need time to warm-up. Vacuum tubes are also more delicate. If dropped they probably will not function. Not so with a transistor. They are rugged a can operate for years. Transistors have continued to be shrunk and there seems to be no stopping them. Without the transistors inside the small chips now being produced there would have been no miniaturization of phones, calculators, computers television, or radios. Without the ability to shrink the computers necessary for a space capsule to function the American space program would surely have been indefinitely grounded. Vladimir Zworykin and John Baird worked during the 1920s on the concept of television. However it was not until the forties and fifties that television came into its own. In 1947 William Shockley, John Bardeen, and Walter H. Brattain invented the transistor. In 1955 William C. Pfann found a way to remove impurities from semiconductors.38

What has been presented is a very brief and simplified version of the history of electronics and magnetism. Not being a scientist I have tried to choose events that seemed to convey simple but important discoveries that I could make understandable to my students and that kept a certain historical pattern going. I'm sure that it would be obvious that to the trained person that I have simplified as much as possible due to my own limitations and those of my students. I believe that the combination of facts with hand-on experience will make the unit successful.

The unit would end with the presentation of final projects or models. Students would hopefully see the growth of knowledge that has taken place over hundreds of years.

Lesson Plan 1. Science Journals

Objective: Students will keep a science journal.

Materials: Notebook for each student

Pencils

Colored pencils and markers

Procedure:

1. Students will have been introduced to the scientific method, that is the format used in the citywide science fair: Problem, Question, Hypothesis, Materials, Procedure, Results, Limitations, and Conclusions. Students will use this format to record each experiment that is done in connection with this unit.
2. Students will work in pairs or small groups to complete an experiment. There may be an appropriate graphic organizer for them to keep notes depending on the task.
3. When experimentation and clean up is completed the class will share their findings and may complete a larger class graph or organizer.
4. Students will write down what they did and learned in science fair format in their notebooks.
5. Students will illustrate what they did or saw.
6. The teacher will review notebooks to make sure that each child understands what happened in the experiment.

Lesson Plan 2. Classroom Time-line

Objective: It is difficult for students to understand the concept of time. Visual displays are one way of making the timing of events. What is suggested is a classroom timeline that would be hung up in the classroom. It would give students a visual representation of the time involved in the development of electricity and how the different advances were preceded by years of work and discoveries. The advances we enjoy are seldom the result of one lone man working in complete isolation but is rather the work of synthesis and breakthrough which may involve just being at the right place at the right time or just plain luck.

I propose an activity proceed the adding of each addition to the timeline so students get the idea of the importance of the past. It is not necessary that younger student understand all the events just that they begin to see the continuum.

Materials: tagboard, markers. Clothesline rope to be hung around the room, clothespins

Procedure:

1. Begin by setting up a clothesline around the room. Identify this year and activities that have happened in the recent past, such as the beginning of school, major holidays, etc.
2. Add markers for the centuries and explain A.D. and B.C. The visual set up should help students see the way time has passed.

3. At the beginning of the unit write out a card for Thales and as the unit progresses add appropriate dates and events from the unit.

Lesson Plan 3. Final Project.

Objective: In this final project I would like to give students the greatest latitude in selecting a project that would interest them. I would like to have a kind of science demonstration that allows the students to either show something or someone from the history or electronics. Final projects could be recreating a model of a electromagnet, or an electronic device such as a burglar alarm, or produce a lighted dollhouse or perhaps do diorama of a Ben Franklin or Samuel Morse, or A.G. Bell.

Materials: books for students to look through to get ideas, graphic organizer for them to use in planning their project, a variety of colored paper, markers, crayons, scrap materials, boxes, wires, etc. for students to use in making their projects.

Procedure:

1. Students will have a choice as to what project they complete. They may do a model of some electronic device, diorama of some important event or purpose of some famous person in the history of electronics, or they may do demonstration of some principle of electronics. Students will have a chance to go to the Library Media center to preview books and resources to help them decide what they wish to do.
2. Students will complete graphic organizer to outline what they are going to do.
3. Students will meet with their teacher to discuss and complete or change their graphic organizer.
4. Students will be given an opportunity during class to complete their projects.
5. All students will write a short report telling about their projects, and what it shows.
6. Students will present their projects to the class, parents and other school personnel during special program.

Bibliography

Although all the books listed below were found in the juvenile section most of them were very technical and would not be usable by a primary student. I have asterisked the couple of volumes that could possibly be used independently by young students.

These books while questionable for students are ideal for adults.

Neil Ardley, The Science Book of Electricity, New York: Gulliver Books, 1991.

Simple experiments demonstrate basic principles of electricity.

Melvin Bergen, Atoms, Molecules, & Quarks, New York: G.P. Putnam's Sons, 1986.

An explanation of the composition, behavior, and used of atoms, molecules, and quarks, the building blocks of the universe.

Charlene W. Billings, Microchip: Small World, New York: Dodd, Mead & Company, 1984. Discusses the development of the microchip and how it contributed to the -development of modern technology we now enjoy. Charlene W. Billings, Superconductivity: From Discovery to Breakthrough, New York: Cobblehill Books/Dutton Publishers, 1991. Discusses the development of new and different types of materials intended to conduct energy more efficiently and how they may be used. Franklyn M. Branley, What Makes A Magnet?, New York: Harper-Collins Pub., 1996.Describes how magnets work and includes instructions for making a magnet and a compass. *Vicki Cobb, More Power to You, Boston: Little, Brown & Co., 1991. Explains electric power and other forms of power, answering such questions as "How does electric Power make a light turn on?" Includes experiments and tricks. Shaaron Cosner, Inventions that Changed Our Lives: the Light Bulb, New York: Walker & Company, 1984. Examines the electric light bulb, an invention at first ridiculed, distrusted, and feared, which ultimately led to new uses of electricity and transformed society. *Gary Gibson, Science for Fun: Understanding Electricity, Brookfield, CT: Copper Beach Books, 1995. Explains how electricity works through some simple experiments. Martin J. Gutnik, Electricity from Faraday to Solar Generators, New York: Franklin Watts, 1986. Traces the history of the study of electricity, from discoveries by the the early Greeks to more recent developments in communication, electronics, and solar generators. George deLucenay Leon, The Electricity Story: 2500 Years of Experiments, New York: Arco Publishing, 1983. Presents the history of electricity with related experiments. *Dee Lillegard and Wayne Stoker, I Can Be an Electrician, Chicago: Children's Press, 1986.Examines how electricians make, control, and work with electricity, and highlights the education and training necessary for the field. Sandra Markle, Power Up: Experiments, Puzzles, and Games Exploring Electricity, New York: Atheneum Books, 1989. Presents activities to investigate the nature of electricity. Steve Parker, Eyewitness Science: Electricity, New York: DK Publishing, 1992. Reviews the major developments in the history of electronics. Steve Parker, Young Scientist Concepts & Projects: Magnets, Milwaukee: Garth Stevens Publishing, 1998. Describes different kinds of magnets and how they are used and presents a variety of experiments and other activities involving magnetism. *Graham Peacock, Science Activities: Electricity, New York: Thomson Learning, 1994.Includes science activities for students to do from lighting a bulb to making electric motors, burglar alarms and quiz boards. E.G. Valens, Magnet, New York: The World Publishing Company, 1964.The story of magnets along with the basic principles of magnetism. Glen Vecchione, Magnet Science, New York: Sterling Publishing Co., 1995. Relates the discovery of magnetism, discusses the principles behind it, suggests experiments which offer a "hands-on" explanation of how it works.