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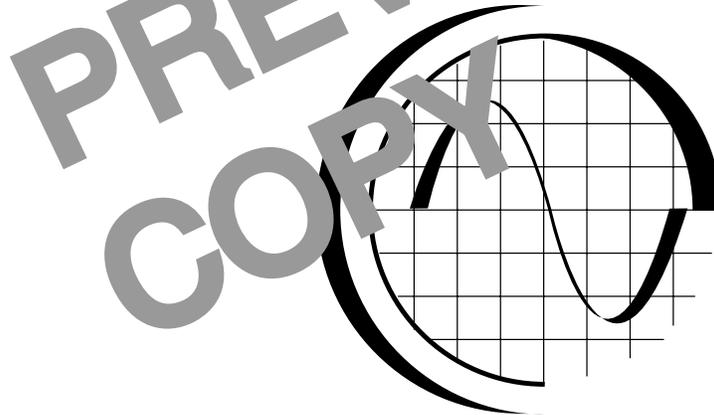
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BASIC ELECTRICITY AND ELECTRONICS

Lesson One

***Introduction to
Electricity***



TPC Training Systems

20101

Lesson**Introduction to Electricity****TOPICS**

History of Electricity
 Language of Electricity
 Structure of Matter
 Structure of Atoms

Electron Shells
 Transferring Charges
 Electrical Forces
 Electrical Terms

OBJECTIVES

After studying this lesson, you should be able to...

- Describe the structure of an atom.
- Tell the difference between a compound and an element.

- Explain how electrical forces cause objects to attract or repel other objects.
- Describe electron flow.
- State the definition of a cell.

KEY TECHNICAL TERMS

Electromagnetism 1.03 the relationship between an electric current and a magnetic field

Compound 1.17 matter consisting of two or more different kinds of atoms, chemically joined

Element 1.20 matter consisting of only one kind of atom

Inert element 1.35 an element that does not combine chemically with other elements

Circuit 1.53 path for electric current

Potential difference 1.55 the potential energy of an electron in one place compared to another place

Cell 1.58 combination of materials that produces a potential difference between two points

Battery 1.59 two or more cells connected together

Electricity, once a scientific curiosity, is a necessity in the modern world of sophisticated equipment and machinery. Without electricity, industry as we know it would not exist. Production equipment, communications systems, and utilities operate on electricity.

The language of electricity may confuse the layman, but electrical and electronics specialists must know the specific meaning of each word and term. This lesson defines electrical terms used in the plant by electrical craftsmen. It also describes matter, molecules, atoms, and their relationship to electricity

Electrical force is also explained in this lesson. It describes how objects attract and repel each other depending on their electrical charge. You may want to experiment with forces after studying this lesson.

History of Electricity

1.01 Electricity is one of our most useful sources of energy today. It is hard to imagine how a modern industrial society could exist without electricity. But until the mid-1800s, no one knew much about electricity or how to use it. Until then, electricity was nothing more than a scientific curiosity.

1.02 When scientists first began studying electricity, they discovered that electricity and magnetism are related. For example, they discovered that when an electric current flows in a wire, it creates a magnetic field. The magnetic field is exactly like the field produced by an ordinary magnet. It produces the same effects on a compass and on iron filings. They also discovered that you can make an electric current flow in a wire if you move the wire rapidly through a magnetic field.

1.03 These experiments led to an understanding of *electromagnetism*—the relationship between an electric current and a magnetic field. Electromagnetism is the foundation of all our modern electrical machinery and equipment.

1.04 Understanding the relationship between electricity and magnetism has made it possible to invent machines that generate large amounts of electricity at low cost. Electricity from these generators drives countless kinds of industrial machinery and provides mass transportation in our cities. It also provides the power for light, heat, communications, and data processing.

Language of Electricity

1.05 Electrical and electronics technicians use special words and phrases, just as carpenters and

mechanics do. The workers in each trade have their own special ways of communicating to other workers in the trade. When you use electrical terms, make sure you understand what each term means.

1.06 For example, you may hear someone say, “The power output is low.” You may think you know what the statement means. But the word “power” has a very special meaning. Low power is not necessarily the same as too little electricity.

1.07 Almost every electrical machine or appliance has a tag or nameplate stating the operating voltage and current of the unit. These terms also have special meanings. You must understand those meanings in order to make use of the information they provide.

1.08 Electrical *voltage* is often compared to pressure in a water system. The two ideas are not exactly the same. But they are enough alike to make the comparison useful. You may find electricity easier to understand at first if you think of voltage as a sort of “electrical pressure” that pushes electric current through a wire or through a piece of equipment.

1.09 Another name for voltage is *electromotive force*, abbreviated *emf*. This term is used by many people, but it is very misleading. Electromotive force is not the same as the force of gravity or the force that a tool exerts on a workpiece. It refers to the same electrical pressure as voltage, and it is measured in *volts*.

1.10 Electricity in motion is called *current electricity*. You can think of electric current as being similar to a current of water in a pipe or in a stream. But there are some important differences you must learn about

in order to avoid confusion. Electric current is measured in *amperes*, often abbreviated *amps*.

1.11 Electricity that does not move is called *static electricity*. You probably have had first-hand experience with static electricity. If you walk across a carpet when the surrounding air is fairly dry, static electricity may build up on your body. If you then touch a door knob, a water faucet, or some other metal object, the static electricity flows into the metal.

1.12 If you have built up enough static electricity on your body, the electricity may suddenly jump from your hand to the metal. It jumps just before you touch the metal. Then you can feel the electricity flowing for an instant. You call that feeling a “shock.” The shock may startle you and may cause a little pain, but it is harmless.

1.13 If you connect a wire across the terminals of a dry cell or a storage battery, electric current flows through the wire. The flowing electricity raises the temperature of the wire. The wire may become hot enough to glow or even melt.

1.14 This effect demonstrates another important idea concerning electricity. Electricity has *energy*. When it flows, its energy decreases, and the energy of something else increases. A wire increases its thermal energy when it gets hot. A motor increases its rotational energy when the armature and shaft start spinning.

Structure of Matter

1.15 To understand electricity, you must understand the structure of matter. Electricity is related to

some of the most basic building blocks of matter—atoms, electrons, and protons. All matter is made of these electrical building blocks, and therefore all matter is said to be “electrical.”

1.16 *Matter* is defined as anything that has mass and occupies space. All matter is made of tiny, invisible particles called *molecules*. A molecule is the smallest particle of a substance that has the properties of the substance. Each molecule can be divided into simpler parts by chemical means. The simplest parts of a molecule are called *atoms*.

1.17 Matter consisting of two or more different kinds of atoms is called a *compound*. Water, table salt, and alcohol are examples of compounds. The smallest particle of a compound is a molecule. Each molecule of a compound consists of the same number and kind of atoms, joined chemically into a single unit.

1.18 If you separate the atoms of a molecule into smaller groups or into individual atoms, you no longer have the same compound. The simpler molecules or atoms make up a different material having different properties.

1.19 For example, a molecule of water is made of two atoms of hydrogen and one atom of oxygen, as shown in Fig. 1-1. This molecule is the smallest bit of water that still has the properties of water. If you break the atoms apart, you no longer have water. Instead you have two gases—hydrogen and oxygen—with properties entirely different from those of water. They have different densities, boiling temperatures, and chemical properties.

1.20 When all of the atoms in a given piece of matter are of the same kind, the matter is called an *element*. More than 100 different elements are known today. Ninety-two of them are stable and occur in nature. Examples include *nitrogen* and *oxygen* in the air, *carbon* in living things, and *silicon* in sand.

1.21 About a dozen elements are unstable. Each atom of such an element exists for only a fraction of a second during a nuclear reaction. No one has ever seen material made of one of these elements.

Structure of Atoms

1.22 Most of the mass of an atom is concentrated in a tiny spot at the center, called the *nucleus*. The

Fig. 1-1. Water molecule

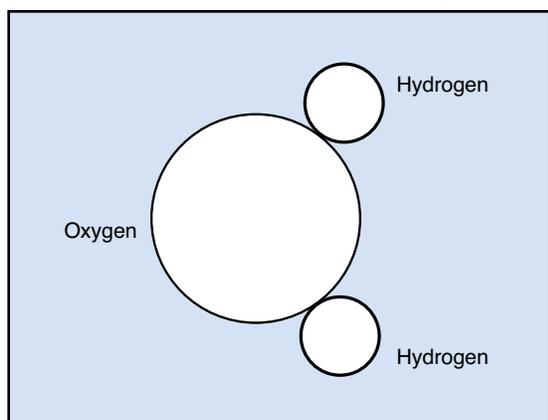
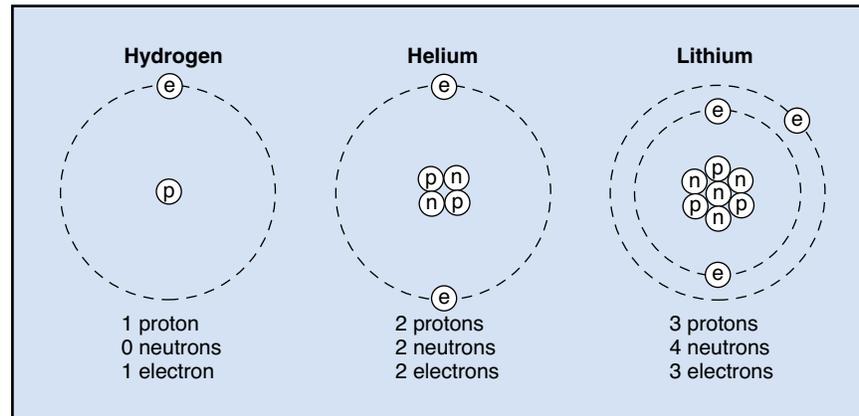


Fig. 1-2. Atomic structures



nucleus is not a single particle, however. It is a collection of two kinds of particles, called *protons* and *neutrons*. The proton has a positive electrical charge. The neutron has no electrical charge. It is neutral.

1.23 The positive charge of each proton equals the negative charge of each electron. The two opposite charges cause a force of attraction between the proton and the electron. The proton pulls inward on the electron, and the electron pulls outward on the proton.

1.24 If the proton and electron had the same mass or nearly the same mass, they would rotate around a central point located somewhere between them. But the proton has about 1840 times as much mass as the electron. Therefore, the proton hardly moves. The electron moves around it, somewhat like a planet in orbit around the sun.

1.25 The protons, neutrons, and electrons in every element are identical. But the numbers of protons, neutrons, and electrons differ, as shown in Fig. 1-2. These differences make one element different from another.

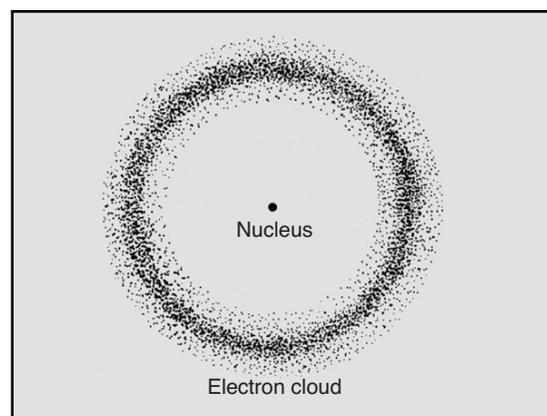
1.26 When the number of protons in the nucleus equals the number of orbiting electrons, the atom is electrically *neutral*. That is, the atom as a whole has no electrical charge. But in some atoms, the outermost electrons are attracted to the nucleus only weakly. The force of attraction is weak because of the inner electrons. The inner electrons repel the outer electrons. This force combines with the attraction of the protons, creating a weaker force on the outer electrons.

1.27 In such an atom, one or more of the outermost electrons can escape from the atom. Each electron that escapes removes one unit of negative charge from the atom, leaving the remainder of the atom with a net positive charge.

Electron Shells

1.28 If it were possible to see the electrons around the nucleus of an atom, you would see a sort of cloud in the shape of a hollow sphere. The drawing in Fig. 1-3 is a rough idea of how an atom of oxygen might look. If you could look very closely at the electron cloud in a real atom, you might see a few layers within the cloud. The 16 electrons of an oxygen atom exist within this cloud, but not as compact objects moving on simple paths. You would not see individual electrons moving like planets in orbit around a sun.

Fig. 1-3. Electron cloud



1.29 To understand the behavior of an atom, it helps to think of the electrons as being arranged around the nucleus in *shells* of different size. You can picture each shell as a thin, hollow sphere. Several shells can surround the nucleus of the atom, the larger ones surrounding the smaller ones, as shown in Fig. 1-4.

1.30 Each shell can contain only a certain maximum number of electrons. The innermost shell, the one closest to the nucleus, can contain a maximum of only two electrons. That is, it can contain either one or two electrons. In the hydrogen atom, this shell contains only one electron. In all other atoms, it contains a full set of two electrons.

1.31 The second shell is larger than the first. It can contain up to eight electrons. The third shell is still larger and can contain up to 18 electrons. The fourth shell can contain 32.

1.32 If you study the electron shells more closely, the picture is a little more complicated. All shells except the innermost one are divided into *subshells*. The second shell is divided into two subshells, the third into three subshells, and the fourth into four subshells. In each case, the innermost subshell can contain up to two electrons, the second can contain up to six electrons, the third can contain up to ten, and the fourth can contain up to 14. Figure 1-5 shows the subshells for the first three electron shells.

1.33 Table 1-1 shows the electron distribution of the first 55 atoms. You can see that the first ten atoms

make up a simple pattern as the electrons fill the first two shells. The inner shell fills up first with two electrons, and then the second shell fills up with eight. When the second shell fills, the first two electrons go into the inner subshell and the next six go into the outer subshell.

1.34 As the third shell begins filling, the pattern becomes more complicated. The first subshell fills first with two electrons. Then the second subshell fills with six. But before the third subshell begins to fill, the first subshell of the fourth shell fills. Notice that another odd series begins with element 37.

1.35 The chemical and electrical behavior of atoms depends on how completely the various shells and subshells are filled. The atoms that are most active chemically are those that have one electron *more* or one electron *less* than a completely filled shell. Atoms that have the outer shell exactly filled are chemically inactive. They are all gases that do not combine chemically with other elements. These gases are called *inert elements*. You can identify these inert elements in Table 1-1.

1.36 Elements that belong to the class called *metals* are good electrical conductors. In these elements, the electrons in the outer shells and subshells can easily move from one atom to another. In moving from atom to atom, they carry charge through the material.

1.37 You can see which atoms in Table 1-1 are classified as metals. They are marked with an asterisk (*) in front of the element name. Many of these ele-

Fig. 1-4. Electron shells

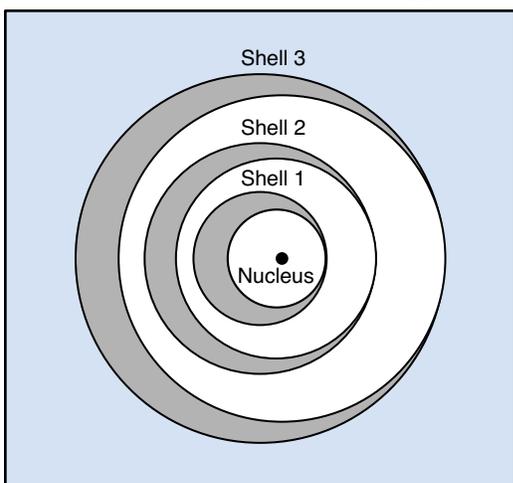


Fig. 1-5. Electron subshells

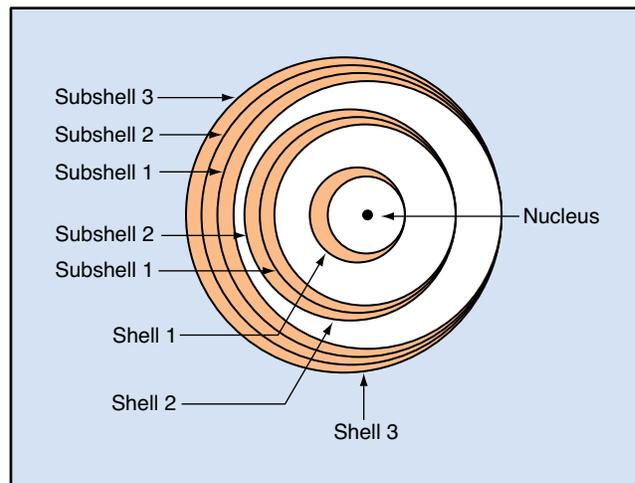


Table 1-1. Electron distribution in atoms

Element	Number of protons	Number of electrons												
		Shell 1	Shell 2	Shell 3	Shell 4	Shell 5	Shell 6							
		[]	[1 2]	[1 2 3]	[1 2 3 4]	[1 2 3 4]	[1 2 3 4]							
Hydrogen	1	1						← Very active element						
Helium	2	2						← Inert element						
* Lithium	3	2	1					← Very active element						
* Beryllium	4	2	2											
Boron	5	2	2	1										
Carbon	6	2	2	2										
Nitrogen	7	2	2	3										
Oxygen	8	2	2	4										
Fluorine	9	2	2	5				← Very active element						
Neon	10	2	2	6				← Inert element						
* Sodium	11	2	2	6	1			← Very active element						
* Magnesium	12	2	2	6	2									
* Aluminum	13	2	2	6	2	1								
Silicon	14	2	2	6	2	2								
Phosphorus	15	2	2	6	2	3								
Sulfur	16	2	2	6	2	4								
Chlorine	17	2	2	6	2	5		← Very active element						
Argon	18	2	2	6	2	6		← Inert element						
* Potassium	19	2	2	6	2	6	1	← Very active element						
* Calcium	20	2	2	6	2	6	2							
* Scandium	21	2	2	6	2	6	1							
* Titanium	22	2	2	6	2	6	2							
* Vanadium	23	2	2	6	2	6	3							
* Chromium	24	2	2	6	2	6	5							
* Manganese	25	2	2	6	2	6	5							
* Iron	26	2	2	6	2	6	6							
* Cobalt	27	2	2	6	2	6	6							
* Nickel	28	2	2	6	2	6	6							
* Copper	29	2	2	6	2	6	6	1						
* Zinc	30	2	2	6	2	6	10	2						
* Gallium	31	2	2	6	2	6	10	2	1					
Germanium	32	2	2	6	2	6	10	2	2					
Arsenic	33	2	2	6	2	6	10	2	3					
Selenium	34	2	2	6	2	6	10	2	4					
Bromine	35	2	2	6	2	6	10	2	5	← Very active element				
Krypton	36	2	2	6	2	6	10	2	6	← Inert element				
* Rubidium	37	2	2	6	2	6	10	2	6	1	← Active element			
* Strontium	38	2	2	6	2	6	10	2	6	2				
* Yttrium	39	2	2	6	2	6	10	2	6	1				
* Zirconium	40	2	2	6	2	6	10	2	6	2				
* Niobium	41	2	2	6	2	6	10	2	6	4	1			
* Molybdenum	42	2	2	6	2	6	10	2	6	5	1			
* Technetium	43	2	2	6	2	6	10	2	6	6	1			
* Ruthenium	44	2	2	6	2	6	10	2	6	7	1			
* Rhodium	45	2	2	6	2	6	10	2	6	8	1			
* Palladium	46	2	2	6	2	6	10	2	6	10				
* Silver	47	2	2	6	2	6	10	2	6	10	1			
* Cadmium	48	2	2	6	2	6	10	2	6	10	2			
* Indium	49	2	2	6	2	6	10	2	6	10	2	1	Active element	
* Tin	50	2	2	6	2	6	10	2	6	10	2	2	Inert element	
Antimony	51	2	2	6	2	6	10	2	6	10	2	3		
Tellurium	52	2	2	6	2	6	10	2	6	10	2	4		
Iodine	53	2	2	6	2	6	10	2	6	10	2	5	← Active element	
Xenon	54	2	2	6	2	6	10	2	6	10	2	6	← Inert element	
* Cesium	55	2	2	6	2	6	10	2	6	10	2	6	1	← Active element

* Indicates the elements that are metals

ments have gaps in their electron shells and subshells. The first group with gaps consists of atoms 19 through 28.

1.38 As you can see from studying Table 1-1, some elements without gaps are among the best conductors—for example, aluminum (number 13) and copper (number 29). And some elements with gaps are not good conductors—for example, iodine (number 53), which is missing subshell 4 of shell 4. But in general, most elements that have gaps in their electron shells and subshells are good conductors of electricity.

The Programmed Exercises on the following page will tell you how well you understand the material you have just read. Before starting the exercises, remove the Reveal Key from the back of your book. Read the instructions printed on the Reveal Key. Follow these instructions as you work through the Programmed Exercises.

PREVIEW
COPY

1-1. The relationship between an electric current and a magnetic field is called _____.	1-1. ELECTROMAGNETISM Ref: 1.03
1-2. Electricity in motion is called _____.	1-2. CURRENT ELECTRICITY Ref: 1.10
1-3. Electricity that does not move is called _____.	1-3. STATIC ELECTRICITY Ref: 1.11
1-4. Matter is defined as anything that has _____ and occupies _____.	1-4. MASS; SPACE Ref: 1.16
1-5. Matter consisting of two or more different kinds of atoms is called a(n) _____.	1-5. COMPOUND Ref: 1.17
1-6. When all the atoms in a given piece of matter are of the same kind, the matter is called a(n) _____.	1-6. ELEMENT Ref: 1.20
1-7. Which particle in the nucleus has a positive charge? Which has no charge?	1-7. PROTON; NEUTRON Ref: 1.22
1-8. Gases that do not combine chemically with other elements are called _____.	1-8. INERT ELEMENTS Ref: 1.35

Transferring Charges

1.39 Under certain conditions, one or two of the outermost electrons of an atom can be stripped away from an atom and transferred somewhere else. This process leaves the atom with a net positive charge. Something else in the universe then has a net negative charge.

1.40 For example, if you rub a piece of plastic with fur or wool, electrons are stripped away from some of the atoms in the wool and transferred to the plastic. The plastic then becomes *negatively charged*, because it has an excess of electrons. The fur or wool becomes *positively charged*, because it has a deficiency of electrons. Figure 1-6 shows this redistribution of charge.

1.41 Likewise if you rub a glass rod with silk, electrons are stripped away from some of the atoms in the glass. The glass rod then becomes positively charged, because it has lost electrons. The silk becomes negatively charged, because it has gained electrons. Figure 1-7 shows how the charges are redistributed on the glass and silk.

1.42 You should note that electrons are not created in either of these examples. The total number of electrons in the universe always remains unchanged. Some electrons are moved from one place to another, but the excess in one place equals the deficiency in the other. The balance remains perfect.

1.43 The balance for the universe as a whole always remains perfect. For every extra electron in

one place, there is an electron missing somewhere else. Thus, for every positively charged object, there is a net negative charge of exactly the same amount in the remainder of the universe. For every negatively charged object, there is a net positive charge of exactly the same amount in the remainder of the universe.

Electrical Forces

1.44 Objects having electrical charges can exert forces on each other. These forces are the strongest forces known in nature. No other forces—magnetic, gravitational, or nuclear forces—are as strong as electrical forces for objects of the same size or separated by the same distance. Electrical forces *attract* two objects that have opposite charges (one positive and one negative). They *repel* two objects that have identical charges (both positive or both negative).

1.45 Figure 1-8 shows a common way to demonstrate the forces of attraction and repulsion. The plastic ball shown at the far left has no charge. It is then given a negative charge by rubbing it with fur. A plastic rod, also charged negatively, is then brought near the ball. The ball swings away from the rod, because the two objects have the same charge. The same thing would happen if the ball and the rod both had a positive charge.

1.46 Next, a positively charged glass rod is brought near the negatively charged ball. The ball swings toward the glass rod because of the attraction between

Fig. 1-6. Charge redistribution on a plastic rod

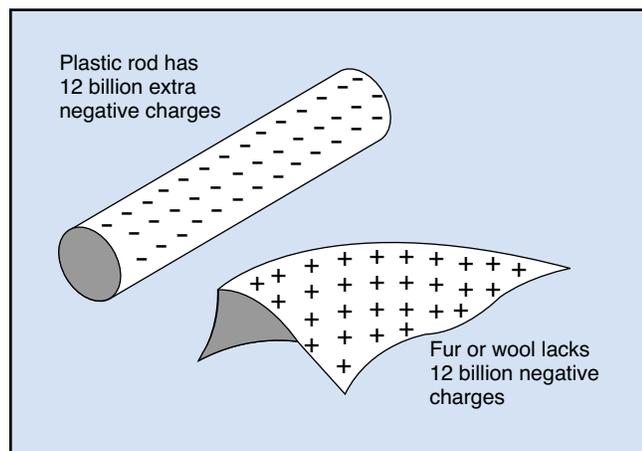


Fig. 1-7. Charge redistribution on a glass rod

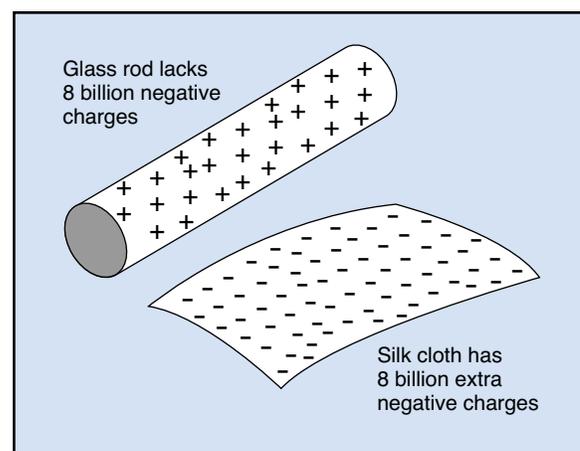
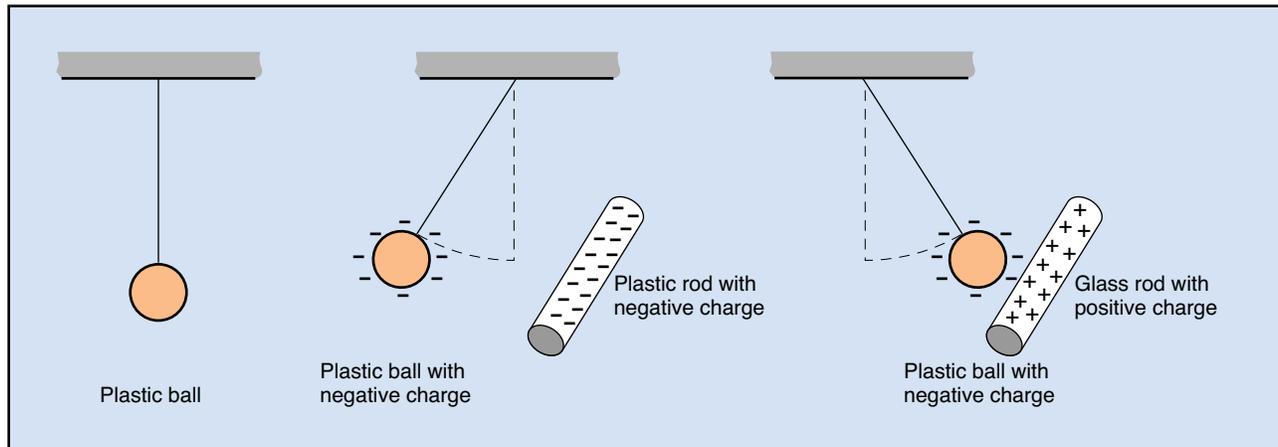


Fig. 1-8. Forces between charged objects



the opposite charges. A negative rod would attract a positive ball for the same reason.

1.47 The forces of attraction and repulsion between electrical charges give shape and substance to the world. Atoms that share electrons in chemical bonds are held together by the forces of attraction between unlike charges.

1.48 When you press your hand against something solid, there is an electrical force repelling your hand from the object. This force exists because electrons in the atoms of your hand repel the electrons of the object. If the electrical force of repulsion did not exist, your hand would pass right through the solid object, because every atom is mostly empty space.

Electrical Terms

1.49 As you study electricity in your training program, and as you work with electricity in the plant, you will hear, read, and use various electrical terms. These terms have very exact meanings. You must know what each one means if you are to understand other people and make them understand you. The following paragraphs explain the meaning of the most basic electrical terms. Other terms will be explained in other lessons and courses as you need them.

1.50 **Electric current.** When electrons flow from one place to another, they make a *current*. The electrons always flow from a negative point to a positive (or less negative) point, because electrons have a negative charge.

1.51 Unfortunately, the direction of current flow can be confusing. Some people think of a positive current that is in the opposite direction from the electron flow—that is, from positive to negative instead of from negative to positive. You must be careful to distinguish between the two kinds of flow. Both kinds are commonly used, both in words and in diagrams.

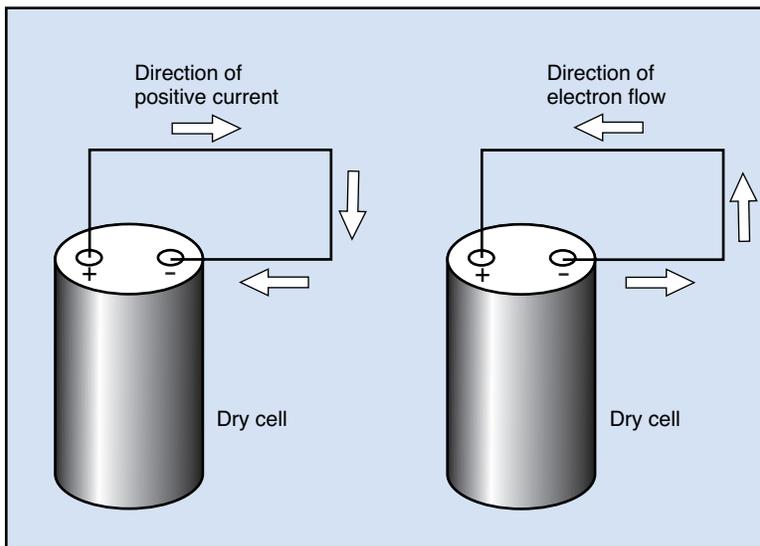
1.52 The so-called “positive current” is from positive to negative. The “electron flow” is from negative to positive. These training manuals will always use the word “current” to mean *electron flow*—from negative to positive. Figure 1-9, on the following page, shows the difference between positive current and electron flow.

1.53 **Circuit.** Electrons flow along some kind of path in going from one point to another. This path is called a *circuit*. If the path has no gaps to stop the flow of electrons, the circuit is said to be *complete* or closed.

1.54 If the path has a gap that the electrons cannot cross—for example, a break in a wire where the ends are separated by air—the circuit is said to be *open*. If another pathway provides an easier way—a shortcut—for the electrons to go from one point to another, that part of the circuit is said to be *shorted*. Figure 1-10, on the following page, shows circuits that are complete, open, and shorted.

1.55 **Potential difference.** This term is the correct name for what is often called “voltage” or “electro-

Fig. 1-9. Two directions of electric current



motive force.” *Potential difference* is a measure of how much potential energy an electron has in one place compared to another place.

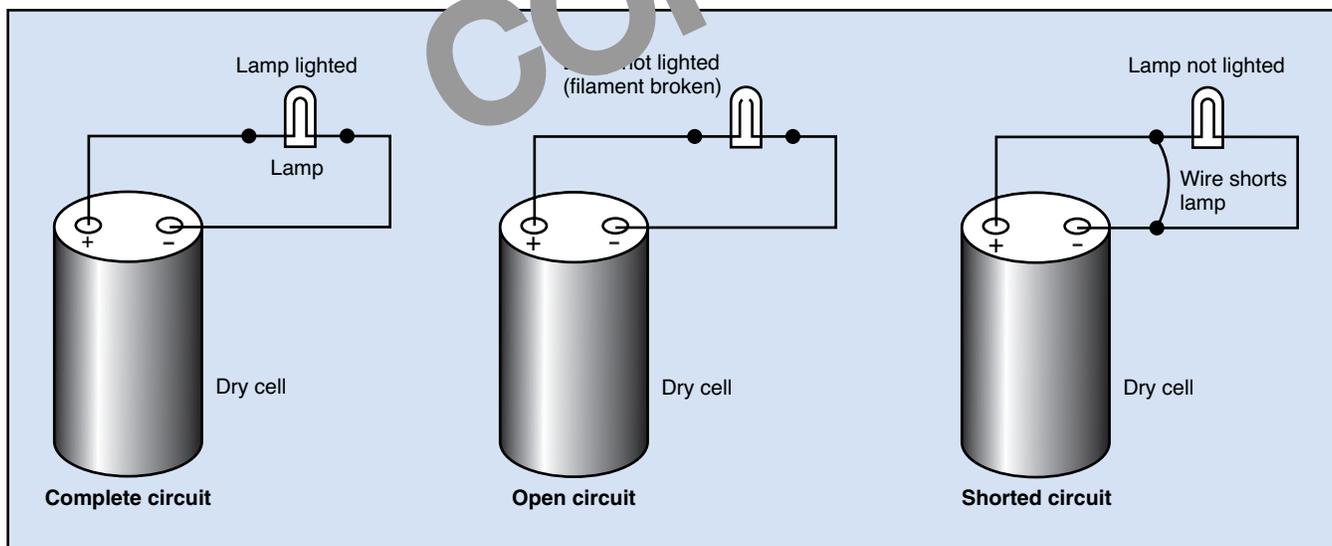
1.56 The greater the potential energy, the more work an electron can do in going from one place to the other. The potential energy of each electron also determines how much current will flow from one point to another in a given circuit.

1.57 **Resistance.** Every electrical pathway from one place to another has the property of resisting

the flow of electrons. Some pathways resist the flow only slightly. For example, a thick copper wire offers very little resistance. Other pathways—for example, an air gap—offer great resistance. The greater the resistance, the less the current for a given potential difference.

1.58 **Cell.** Electricity can be produced by chemical means. The arrangement of materials that produces a potential difference between two points by chemical means is called a *cell*. Familiar cells include the dry cells used in flashlights, calculators, and radios.

Fig. 1-10. Electric circuits



1.59 **Battery.** When you connect two or more cells together, the combination is called a *battery*. If your calculator takes two dry cells, the combination is called a *two-cell battery*.

1.60 The storage battery in a car or truck is usually a six-cell battery that produces a potential difference of 12 V between the terminals. Each cell in such a battery produces a potential difference of 2 V between its internal terminals. The terminals of the cells are connected in such a way that their potential differences add together between the external terminals.

1.61 As you study the remaining lessons in this course and the other courses in your series, make sure you learn the proper terms to use in discussing electricity, and the exact meaning of each term. Always use the correct terms, even if other people do not. If you use the wrong terms, you are likely to be misunderstood. In addition, other people will think you know less about electricity than you actually do.

PREVIEW
COPY

16 Programmed Exercises

<p>1-9. An object becomes positively charged by _____ electrons. It becomes negatively charged by _____ electrons.</p>	<p>1-9. LOSING; GAINING Ref: 1.41</p>
<p>1-10. No forces are stronger than _____ forces between objects of the same size or separated by the same distance.</p>	<p>1-10. ELECTRICAL Ref: 1.44</p>
<p>1-11. Electrical forces _____ two objects that have the same charge.</p>	<p>1-11. REPEL Ref: 1.44</p>
<p>1-12. Electrons always flow from a(n) _____ point to a(n) _____ point.</p>	<p>1-12. NEGATIVE; POSITIVE Ref: 1.50</p>
<p>1-13. The path that electrons follow is called a(n) _____.</p>	<p>1-13. CIRCUIT Ref: 1.53</p>
<p>1-14. What is the correct name for “voltage” or “electromotive force”?</p>	<p>1-14. POTENTIAL DIFFERENCE Ref: 1.55</p>
<p>1-15. The combination of materials that produces a potential difference between two points by chemical means is called a(n) _____.</p>	<p>1-15. CELL Ref: 1.58</p>
<p>1-16. Two or more cells connected together are called a(n) _____.</p>	<p>1-16. BATTERY Ref: 1.59</p>

Answer the following questions by marking an "X" in the box next to the best answer.

- 1-1. The foundation of all our modern electrical machinery and equipment is
- a. electricity
 - b. electromagnetism
 - c. physics
 - d. science
- 1-2. What is the name for electricity in motion?
- a. Current electricity
 - b. Electromagnetism
 - c. Flowing electricity
 - d. Static electricity
- 1-3. Anything that has mass and occupies space is called (a/an)
- a. electron
 - b. fluid
 - c. matter
 - d. solid
- 1-4. Each molecule of a compound consists of the same number and kind of
- a. atoms
 - b. elements
 - c. neutrons
 - d. protons
- 1-5. Most of the mass of an atom is concentrated in the
- a. core
 - b. electron
 - c. nucleus
 - d. proton
- 1-6. When the number of protons in the nucleus equals the number of orbiting electrons, the atom is electrically
- a. charged
 - b. complete
 - c. inert
 - d. neutral
- 1-7. The strongest forces for objects of the same size and separated by the same distance are
- a. electrical
 - b. gravitational
 - c. magnetic
 - d. nuclear
- 1-8. Two objects having the same charge will _____ each other
- a. attract
 - b. repel
 - c. either attract or repel
 - d. not affect
- 1-9. Electrons flowing from one place to another make a(n)
- a. channel
 - b. circuit
 - c. current
 - d. track
- 1-10. Two or more cells connected together make a combination called a(n)
- a. battery
 - b. coulomb
 - c. engine
 - d. motor

SUMMARY

The industrial world is largely an electrical world. Most equipment and machinery operates on electricity. It is matter—molecules made up of atoms—that makes electricity possible. Atoms are made up of electrons, protons, and neutrons.

The center of the atom is called the nucleus. It contains protons and neutrons. Electrons revolve around the nucleus. The relationship between the protons and the electrons creates force. This force attracts or repels objects depending on whether the objects have opposite charges or the same charge. Objects with opposite charges attract each other. Objects with the same charge repel each other.

Electricity in motion is called current electricity. Electricity that does not move is called static electricity. When electrons flow, they create a current. The path they flow along is called a circuit. The measure of how much potential energy an electron has in one place compared to another place is called potential difference.

Electricity can also be created by chemical means. A cell is an arrangement of materials that produces a potential difference between two points. Cells are used in combination to make batteries.

Answers to Self-Check Quiz

- | | | | | | |
|------|----|--------------------------------|-------|----|-----------------------|
| 1-1. | b. | Electromagnetism. Ref: 1.03 | 1-6. | d. | Neutral. Ref: 1.26 |
| 1-2. | a. | Current electricity. Ref: 1.10 | 1-7. | a. | Electrical. Ref: 1.44 |
| 1-3. | c. | Matter. Ref: 1.16 | 1-8. | b. | Repel. Ref: 1.44 |
| 1-4. | a. | Atoms. Ref: 1.17 | 1-9. | c. | Current. Ref: 1.50 |
| 1-5. | c. | Nucleus. Ref: 1.22 | 1-10. | a. | Battery. Ref: 1.59 |