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ABSTRACT

This self-study course is designed to familiarize Marine Corps enlisted personnel with the principles of electricity, safety, and tools. The course contains three study units. Each study unit begins with a general objective, which is a statement of what the student should learn from the unit. The study units are divided into numbered work units, each presenting one or more specific objectives. Text is furnished, illustrated as needed, for each work unit. At the end of the work units are study questions, with answers listed at the end of the study unit. A review lesson completes the course. The three units of the course cover the following subjects: fundamentals of electricity, safety and first aid, and electrician's tools. (KC)

UNITED STATES MARINE CORPS
MARINE CORPS INSTITUTE
ARLINGTON, VA. 22222-0001

11.41
20 Feb 86

1. ORIGIN

MCI course 11.41, MARINE ELECTRICIAN, has been prepared by the Marine Corps Institute.

2. APPLICABILITY

This course is for instructional purposes only.

K. M. Kennedy

K. M. KENNEDY
Lieutenant Colonel, U.S. Marine Corps
Deputy Director

ACKNOWLEDGMENT

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INFORMATION

FOR

MCI STUDENTS

Welcome to the Marine Corps Institute training program. Your interest in self-improvement and increased professional competence is commendable.

Information is provided below to assist you in completing the course. Please read this guidance before proceeding with your studies.

1. MATERIALS

Check your course materials. You should have all the materials listed in the "Course Introduction." In addition you should have an envelope to mail your review lesson back to MCI for grading unless your review lesson answer sheet is of the self-mailing type. If your answer sheet is the pre-printed type, check to see that your name, rank, and social security number are correct. Check closely, your MCI records are kept on a computer and any discrepancy in the above information may cause your subsequent activity to go unrecorded. You may correct the information directly on the answer sheet. If you did not receive all your materials, notify your training NCO. If you are not attached to a Marine Corps unit, request them through the Hotline (autovon 288-4175 or commercial 202-433-4175).

2. LESSON SUBMISSION

The self-graded exercises contained in your course are not to be returned to MCI. Only the completed review lesson answer sheet should be mailed to MCI. The answer sheet is to be completed and mailed only after you have finished all of the study units in the course booklet. The review lesson has been designed to prepare you for the final examination.

It is important that you provide the required information at the bottom of your review lesson answer sheet if it does not have your name and address printed on it. In courses in which the work is submitted on blank paper or printed forms, identify each sheet in the following manner:

DOE, John J. Sgt 332-11-9999
08.4g, Forward Observation
Review Lesson
Military or office address
(RUC number, if available)

Submit your review lesson on the answer sheet and/or forms provided. Complete all blocks and follow the directions on the answer sheet for mailing. Otherwise, your answer sheet may be delayed or lost. If you have to interrupt your studies for any reason and find that you cannot complete your course in one year, you may request a single six month extension by contacting your training NCO, at least one month prior to your course completion deadline date. If you are not attached to a Marine Corps unit you may make this request by letter. Your commanding officer is notified monthly of your status through the monthly Unit Activity Report. In the event of difficulty, contact your training NCO or MCI immediately.

3. MAIL-TIME DELAY

Presented below are the mail-time delays that you may experience between the mailing of your review lesson and its return to you.

	TURNAROUND MAIL TIME	MCI PROCESSING TIME	TOTAL NUMBER DAYS
EAST COAST	16	5	21
WEST COAST	16	5	21
FPO NEW YORK	18	5	23
FPO SAN FRANCISCO	22	5	27

You may also experience a short delay in receiving your final examination due to administrative screening required at MCI.

4. GRADING SYSTEM

LESSONS			EXAMS	
GRADE	PERCENT	MEANING	GRADE	PERCENT
A	94-100	EXCELLENT	A	94-100
B	86-93	ABOVE AVERAGE	B	86-93
C	78-85	AVERAGE	C	78-85
D	70-77	BELOW AVERAGE	D	65-77
NL	BELOW 70	FAILING	F	BELOW 65

You will receive a percentage grade for your review lesson and for the final examination. A review lesson which receives a score below 70 is given a grade of NL (no lesson). It must be resubmitted and PASSED before you will receive an examination The grade attained on the final exam is your course grade, unless you fail your first exam. Those who fail their first exam will be sent an alternate exam in which the highest grade possible is 65%. Failure of the alternate will result in failure of the course.

5. FINAL EXAMINATION

ACTIVE DUTY PERSONNEL: When you pass your REVIEW LESSON, your examination will be mailed automatically to your commanding officer. The administration of MCI final examinations must be supervised by a commissioned or warrant officer or a staff NCO.

OTHER PERSONNEL: Your examination may be administered and supervised by your supervisor.

6. COMPLETION CERTIFICATE

The completion certificate will be mailed to your commanding officer and your official records will be updated automatically. For non Marines, your completion certificate is mailed to your supervisor.

7. RESERVE RETIREMENT CREDITS

Reserve retirement credits are awarded to inactive duty personnel only. Credits awarded for each course are listed in the "Course Introduction." Credits are only awarded upon successful completion of the course. Reserve retirement credits are not awarded for MCI study performed during drill periods if credits are also awarded for drill attendance.

8. AMERICAN COUNCIL ON EDUCATION (ACE) ACCREDITATION

Many of MCI's MOS courses have been evaluated by ACE and determined to have equivalency credit in either the Vocational Certificate (VC) category or the Baccalaureate/Associate Degree (BA) level.

If you are enrolled in a college or vocational program or plan to enroll and have completed one or more MCI courses, you may be able to receive college or vocational credit for them. All that you need to do is to petition your school to see if they will award you credit for the courses that apply to your program area. You will need your completion certificate, and the Evaluation of Educational Experiences in the Armed Services.

9. DISENROLLMENT

Only your commanding officer can request your disenrollment from an MCI course. However, an automatic disenrollment occurs if the course is not completed (including the final exam) by the time you reach the CCD (course completion deadline) or the ACCD (adjusted course completion deadline) date. This action will adversely affect the unit's completion rate.

10. ASSISTANCE

Consult your training NCO if you have questions concerning course content. Should he/she be unable to assist you, MCI is ready to help you whenever you need it. Please use the Student Course Content Assistance Request Form (ISD-1) attached to the end of your course booklet or call one of the AUTOVON telephone numbers listed below for the appropriate course writer section.

Personnel/Administration/Corrections/Logistics Embarkation/Maintenance Management	288-3259
Communications/Electronics/Aviation/NBC/Intelligence	288-3604
Infantry	288-3611
Engineer/Motor Transport/Utilities	288-2275
Supply/Food Services/Fiscal	288-2285
Tanks/Artillery/Infantry Weapons Repair Assault Amphibian Vehicles	288-2290

For administrative problems use the UAR or call the MCI HOTLINE: 288-4175

For commercial phone lines, use area code 202 and prefix 433 instead of 288.

MARINE ELECTRICIAN: FUNDAMENTALS

Course Introduction

MARINE ELECTRICIAN: FUNDAMENTALS is designed to familiarize the student with the principles of electricity, safety, and tools necessary to perform his mission.

ADMINISTRATIVE INFORMATION

ORDER OF STUDIES

Study Unit Number	Study Hours	Subject Matter
1	5	Fundamentals of Electricity
2	4	Safety and First Aid
3	3	Electrician's Tools
	2	REVIEW LESSON
	2	FINAL EXAMINATION
	16	

RESERV. RETIREMENT CREDITS: 5

EXAMINATION: Supervised final examination without text or notes with a time limit of 2 hours

MATERIALS: MCI 11.41, Marine Electrician: Fundamentals, review lesson and answer sheet.

RETURN OF MATERIALS: Students who successfully complete this course are permitted to k..p the course materials.

Students disenrolled for inactivity or at the request of their commanding officer will return all course materials.

SOURCE MATERIALS

NAVEDTRA 10546-E1	Electrician's Mate 3 & 2, 1983
NAVEDTRA 10547-D1	Electrician's Mate 3 & 2, 1983
ELECTRICITY AND ELECTRONICS	1980, 5th edition
FUNDAMENTALS OF ELECTRICITY	1974, 6th edition

HOW TO TAKE THIS COURSE

This course contains 3 study units. Each study unit begins with a general objective that is a statement of what you should learn from the study unit. The study units are divided into numbered work units, each presenting one or more specific objectives. Read the objective(s) and then the work unit text. At the end of the work unit are study questions that you should be able to answer without referring to the text of the work unit. After answering the questions, check your answers against the correct ones listed at the end of the study unit. If you miss any of the questions, you should restudy the text of the work unit until you understand the correct responses. When you have mastered one study unit, move on to the next. After you have completed all study units, complete the review lesson and take it to your training officer or NCO for mailing to MCI. MCI will mail the final examination to your training officer or NCO when you pass the review lesson.

TABLE OF CONTENTS

MARINE CORPS INSTITUTE STUDY GUIDE

Congratulations for enrolling in the Marine Corps Institute's correspondence training program! By enrolling in this program, you have shown a desire to improve the skills you need to enhance your on-the-job performance.

Since 1920, MCI has been helping tens of thousands of hard-charging young Marines, like yourself, achieve educational goals by teaching necessary new skills or reinforcing existing skills. MCI will do every thing possible to help you reach your individual goals, whatever they may be.

Before you begin your course of instruction, you may be asking yourself, "How much will I benefit from a correspondence training program?" The answer to this depends upon you, *"YOUR PROFESSIONAL TRAITS"* (what you bring to the learning situation).

Because you have enrolled in an MCI course, your professional traits are evident and we know that:

YOU ARE PROPERLY MOTIVATED. You made a positive decision to get training on your own. Self-motivation is perhaps the most important force in learning-or achieving—anything. Wanting to learn something badly enough so that you will do what's necessary to learn—*THAT IS MOTIVATION.*

YOU SEEK TO IMPROVE YOURSELF. You enrolled to learn new skills and develop special abilities.

YOU HAVE THE INITIATIVE TO ACT. By acting on your own, you have shown that you are a self-starter, willing to reach out for opportunities.

YOU ACCEPT CHALLENGES. You have self-confidence and believe in your ability to gain training in your areas of interest.

YOU ARE ABLE TO SET PRACTICAL GOALS. You are willing to commit time, effort, and resources toward accomplishing what you set out to do. These professional traits will help you achieve success in your MCI program.

To begin your course of study:

* Look at the course introduction page. Read the COURSE INTRODUCTION to get the "nitty gritty" of what the course is about. Then read the MATERIALS section near the bottom of the page to find out which text(s) and study aids you should have received with the course. If any of the listed materials are missing, see *Information for MCI Students* to find out how to obtain them. If you have everything that is listed, you are ready to begin your MCI course.

* Read through the *TABLE OF CONTENTS* of your text(s). Note the various subjects covered in the course and the order in which they are taught. Leaf through the text(s) and look at the illustrations. Read a few work unit exercise questions to get an idea of the types of questions that are asked. If MCI provides other study aids, such as a slide rule or a plotting board, familiarize yourself with them. Now, you are ready to begin work on your MCI course.

* Turn to the first page of study unit 1. On this page you will find the study unit goal. This is a statement of what you should be able to do when you complete the final exam. Each study unit is divided into work units. Each work unit contains one terminal learning objective and several enabling objectives. The terminal learning objective is what you should be able to accomplish when you complete the work unit exercises. The enabling objectives are the steps you need to learn to help you accomplish the terminal learning objective. Read each objective for the work unit and then read the work unit text carefully. Make notes on the ideas you feel are important.

* Without referring to the text, answer the questions in each exercise.

* Check your answers against the correct ones listed at the end of the study unit.

* If you miss any of the questions, restudy the work unit until you understand the correct response.

* Go on to the next work unit, repeating the above steps, until you have completed all the work units in the study unit.

* Follow the same procedure for each study unit of the course. If you have problems with the text or work unit questions that you cannot solve on your own, ask your training NCO for the name of someone who can help you. If they cannot aid you, request assistance from MCI on the Student Course Content Assistance Request included with this course, or refer to your INFORMATION FOR MCI STUDENTS (MCI-R24i-NRL) for the telephone number of the appropriate Course Developing Division at MCI.

* When you have finished all the study units, complete the course review lesson. Try to answer each question without the aid of reference materials. However, if you do not know an answer, look it up. When you have finished the review lesson, take it to your training officer or NCO for mailing to MCI. MCI will grade it and send you a feedback sheet (MCI-R69) with your final examination listing course references for any questions that you missed on the review lesson.

"RECON" Reviews:

To prepare for your final examination you *must* review what you learned in the course. Therefore, why not make reviewing as interesting as possible. The following suggestions will make reviewing not only interesting but also a challenge.

1. Challenge yourself. Reconstruct the learning event *in your mind*. Try to recall and recapture an entire learning sequence, without notes or other references. Can you do it? You just have to "look back" to see if you've left anything out, and *that* will be an interesting read-through (review) for you.

Undoubtedly, you'll find that you were not able to recall everything. But with a little effort you'll be able to recall a great deal of the information.

Also, knowing that you are going to conduct a "reconstruct-review" will change the way you approach your learning session. You will try to learn so that you will be able to "reconstruct the event."

2. Use unused minutes. While waiting at sick bay, riding in a truck or bus, living through field duty, or just waiting to muster—use these minutes to review. Read your notes or a portion of a study unit, recalculate problems, do self-checks a second time; you can do many of these things during "unused" minutes. Just thinking about a sequence of instruction will refresh your memory to help "secure" your learning.

3. Apply what you've learned. Always, it is best to do the thing you've learned. Even if you cannot immediately put the lesson to work, sometimes you can "simulate" the learning situation. For example, make up and solve your own problems. Make up problems that take you through most of the elements of a study unit.

4. Use the "shakedown cruise" technique. Ask a fellow Marine to lend a hand and have him ask you questions about the course. Give him a particular study unit and let him fire away. It can be interesting and challenging.

The point is, reviews are necessary for good learning, but they don't have to be long and tedious. Several short reviews can be very beneficial.

Semper Fi

STUDY UNIT 1

STUDY UNIT OBJECTIVE: WITHOUT THE AID OF REFERENCES, YOU WILL IDENTIFY THE PRINCIPLES OF ELECTRICITY AND ELECTRICAL CHARACTERISTICS, SUCH AS VOLTAGE, CURRENT, RESISTANCE, MAGNETISM, AND ELECTROMAGNETISM, PLUS THE RELATIONSHIP OF THESE CHARACTERISTICS IN ELECTRICAL CIRCUITS. IN ADDITION, YOU WILL IDENTIFY THE PRINCIPLES OF DIRECT AND ALTERNATING CURRENT CIRCUITS, BASIC POWER SOURCES, AND TRANSFORMER THEORY.

Work Unit 1-1. ELECTRICAL PRINCIPLES

DIFFERENTIATE BETWEEN COMPOUND AND MIXTURES.

SPECIFY ELECTRON FLOW.

DEFINE VOLTAGE.

INDICATE THE FORCE EFFECTS OF CURRENT.

SPECIFY THE UNIT OF MEASUREMENT FOR RESISTANCE.

DIFFERENTIATE BETWEEN TYPES OF MAGNETS.

STATE SPECIFIED CHARACTERISTICS OF MAGNETS.

DEFINE "LINES OF FORCE."

FROM A LIST OF STATEMENTS CONCERNING ELECTROMAGNETISM, IDENTIFY THE THREE TRUE STATEMENTS AND EXPLAIN WHY THE OTHERS ARE NOT TRUE.

DEFINE DIRECT CURRENT.

DEFINE ALTERNATING CURRENT.

All activity which takes place in any type of electrical circuit depends on the behavior of tiny electrical charges called ELECTRONS. To understand the behavior of electrons, you must first understand the nature of matter. Hence, your first step in the study of electricity involves learning how electrons fit into the world of physical things that surrounds us.

Have you ever thought about the fact that everything around you, even the air you breathe, occupies space and has weight? Anything that meets this description is called MATTER.

It is impossible to name a physical substance or object that is not matter. Coal, water, wood, gas--all are examples of matter.

Just what makes up matter? Well, it is made up of very small units called MOLECULES. Molecules are made up of ATOMS. The atoms, in turn, are made up of minute particles called PROTONS, NEUTONS, and ELECTRONS.

Not only does matter consist of the minute particles mentioned in the preceding paragraph, but it can also be stated that all matter is composed of ELEMENTS. Elements are the so-called building blocks of nature. They cannot be divided or reduced to a simpler form by chemical means. Examples of elements are pure iron, gold, silver, copper, hydrogen, and oxygen. There are some 100-plus natural elements known to man. All the things in our world are made up of these elements or combinations of them. There are about 12 other elements that have been synthetically prepared (manmade) in laboratories.

Elements may be combined in two ways, either by compounds or mixtures. A COMPOUND is a combination of elements that can be separated only by chemical means. Examples of some compounds are pure water (which is made up of the elements hydrogen and oxygen) and salt (which is made up of the elements sodium and chlorine). A MIXTURE, on the other hand, is a combination of elements or compounds that can be separated by physical means. Some examples of mixtures are brass (a mixture of copper and zinc) and air (a mixture of nitrogen, oxygen, carbon dioxide, and several other gaseous substances).

You will find that a drop of water can be divided until the parts are no longer visible, yet each part still keeps the characteristics of the original drop. The smallest part of a substance that has all the characteristics of the substance is called a MOLECULE. A single drop of water is made up of millions of molecules, as are all other substances.

A molecule of water is expressed chemically as H_2O, meaning that each molecule is made up of two distinct elements. H_2O stands for the combination of two parts of the element hydrogen (H_2) and one part of the element oxygen (O). The water molecule has a very simple structure, consisting of only two common elements. Molecules of other substances may be more complex, sometimes consisting of several elements. Just what are molecules made up of. Perhaps, more specifically, we should ask what the elements that make up molecules are made of?

The elements that combine to form molecules are made up of atoms. For a long time it was thought that the atom was the smallest part of matter. However, in recent years the electron theory has been advanced; it helps to explain many electrical and chemical phenomena. According to the electron theory, atoms are made up of minute parts called protons, neutrons, and electrons. Furthermore, all the atoms that make up an element are the same structure. The reason for the different types of elements--why iron differs from oxygen, for example--is that the protons, neutrons, and electrons differ in number and are arranged in a different way within the atoms of each element.

Each proton and each electron has an electrical charge--protons have a positive charge, and electrons have a negative charge. The neutrons have no charge. The ELECTRON THEORY is that all atoms are made up of a central nucleus with orbiting electrons. The protons and neutrons are held in the closely packed nucleus in the center of the atom. The electrons spin around the nucleus in much the same way as the planets move around the sun.

You may recall from your high school science course that our solar system has nine planets that revolve around the sun. In the same way, one atom may have nine electrons spinning around its nucleus; other atoms may have more or fewer electrons.

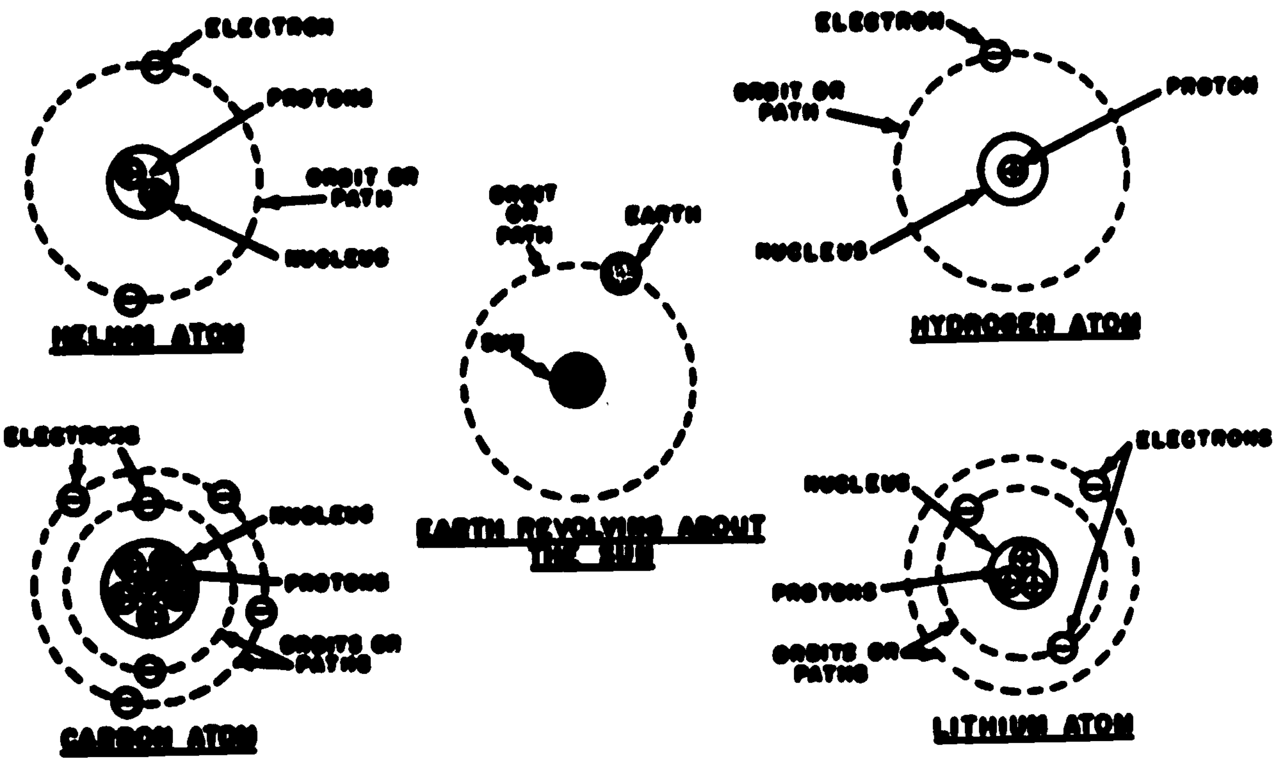


Fig 1-1. Structure of common atoms.

Figure 1-1 shows you the atomic structure of four common atoms. Note that their makeup is similar and can be compared with our planet earth and its relationship with the sun. The hydrogen atom, as shown in the figure, is the simplest of all atoms. It has one electron revolving around one proton, which acts as a nucleus. Because the negative charge of the electron is equal to the positive charge of the proton, the atom is electrically balanced or neutral. For simplification, only the charge parts (protons and electrons) of the atom are shown in the illustration. However, as was previously discussed, the nucleus of all atoms contains neutrons as well as protons. A proton is said to weigh many times (approximately 1,800 times) more than an electron.

Take a closer look at the helium atom in figure 1-1. Note that the nucleus contains two protons. The positive charge of these two protons is balanced by the negative charges of the two revolving electrons, and the electrical charge of the entire atom is neutral. Atoms of other elements are more complex than the hydrogen and helium atoms. For example, look at the lithium atom shown in figure 1-1. Notice that there are three electrons revolving around the nucleus in two different paths or orbits. An even more complex atom, the carbon atom, is also shown in the same figure. It has six electrons revolving around the nucleus in two different paths.

The four common atoms shown in figure 1-1 illustrate that the only difference in atoms of the various elements is in the number and arrangement of the protons, electrons, and neutrons. In some elements, the electrons in the outer paths are called free electrons because they can be dislodged from their regular paths and be made to move from one atom to another. It is the movement or displacement of these free electrons that gives us electrical energy.

The discussion of protons and electrons is important. Electrons moving or flowing through a conductor (wire) are called an ELECTRIC CURRENT. Electric current always flows from a point of negative potential (excess of electrons) to a point of positive potential (deficiency of electrons).

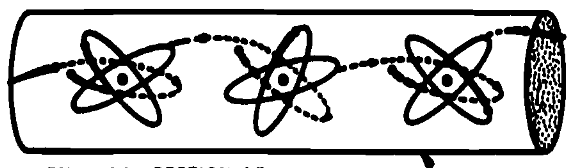


Fig 1-2. Electron movement in a conductor.

Current flowing through a conductor may be compared to water flowing through a pipe. If you have a pipe full of water and pump in more water at one end, water is forced out of the other end. If a copper wire containing billions of free electrons in the outer paths of the copper atoms has electrons forced into one end of the wire, electrons are forced out of the other end. The excess of electrons at one end forces an electron away from a nearby atom and causes it to crowd an electron away from the next atom, and so on. This electron flow principle is illustrated in figure 1-2. Imagine an almost instantaneous shift of billions upon billions of free electrons throughout the entire length of the conductor, and it will not be difficult to picture the electric current. Scientific research tells us that current (electron flow) flows through a conductor at the speed of light (186,000 miles per second).

There are three fundamental things which must be present before you can have an operating electrical circuit: VOLTAGE, CURRENT, and RESISTANCE. If you understand the relationships among these three things, then you have a good foundation toward understanding and increasing your knowledge of electricity.

Just as you need a pump of some sort to keep water flowing through a pipe, an electrical pressure is also needed to make current flow through a conductor. The "pump" that produces this pressure may be a battery or an electric generator which can produce a potential difference in the conductor. Water pressure is measured in pounds per square inch; electrical pressure is measured in volts. One volt is the electrical pressure required to force 1 ampere of current through a resistance of 1 ohm. Electrical pressure, electromotive force (EMF), and potential difference are used interchangeably; they all mean the same thing--voltage. The basic unit of measurement for voltage is the VOLT.

The VOLTAGE of an ordinary dry cell, such as a flashlight battery, is 1.5 volts. The voltage for most domestic electrical service is about 120 volts. When voltage is applied to a circuit, a certain amount of current will flow through the circuit. When the voltage is increased, the current flow increases in direct proportion to the increase in voltage.

You have already learned that current flow is the movement of electrons through a conductor. Electric current and some of its effects were discovered long before the electron. The fact that current flows through a circuit in a given direction was also known. It was this fact that initiated the concept of polarity.

To provide a standard for indicating the direction of current flow, one terminal of the early chemical cell used as a source of electrical energy was marked plus (+); the other terminal was marked minus (-). It was then assured that when a circuit was connected to the cell terminals, a current would flow through the circuit from the plus (positive) terminal to the minus (negative) terminal (plus [positive] to minus [negative]). But because of the discovery of the electron, this theory (conventional current flow) was found to be incorrect. It is now known that when a circuit is connected to the post of a battery, current flows through the circuit from the negative post to the positive post (electron flow theory).

You will find in your studies that CURRENT has four effects--heat, magnetism, chemical action and physical shock. Current always produces HEAT when it flows through a conductor. The amount of heat depends on the material of the conductor and on the amount of current flowing. For example, electric irons and toasters must have heating elements that produce enough heat to be practical. The light from a light bulb is caused by current flowing through a small wire inside the bulb, called a filament. The conductors that carry the current to the filament must be large enough so that they do not get hot.

MAGNETISM is produced when current flows in a conductor. This has a very important effect, for it is the basis for millions of electrical machines, such as generators, motors, and electromagnets. Without this effect, there is no known way to generate electricity cheaply and convert it into mechanical energy to do work.

Current produces CHEMICAL ACTION when it flows through various liquids. Examples of this effect are the charging of a storage battery and the electro-plating process. PHYSICAL SHOCK is the unpleasant and sometimes dangerous sensation caused by coming into contact with a source of electric energy. We often speak of voltage as the cause of shock; however, the fact is that current flowing through the human body produces the physical shock. The pain and the muscular contraction are due to the effect of current on the nerve centers and on the nerves themselves.

Current is measured in terms of the number of coulombs that pass by a point in one second. When a conductor is connected across a source of voltage and 6.28×10^{18} electrons (one coulomb) pass through the wire in a period of one second, then the result is one unit of current flow. This unit of current flow is called on AMPERE.

The definition of resistance is the opposition to the movement of free electrons through a conductor. The amount of opposition in a conductor depends on what the wire is made of, its length, its cross-sectional area, and its temperature.

Resistance to current flow is present in all matter, but one material may have much more resistance than another. Air, rubber, glass, and porcelain have so much resistance that they are called insulators and are used to keep electricity in the circuit. The rubber covering on the wires of an electric lamp prevents the wires from touching each other and causing a short circuit. The rubber also protects a person who is using the lamp from an electric shock. Air acts as an insulator when a light switch is opened. Air fills the gap between the open contacts of the switch and no current flows because of the high resistance. However, even air may act as a conductor if the voltage is high enough; an example of this would be the discharge which appears as a lightning stroke.

Metals are good conductors of electricity, but some are better than others. Copper and silver are both good conductors of electricity because of their low resistance. Aluminum is not as good but is used for long overhead spans because of its light weight. Steel is a poor conductor, but it is used in combination with aluminum for added strength. Alloys of nickel and chromium are used in heater elements to provide a specific resistance which passes enough current to heat the elements to a red glow. The alloy makes it possible to operate the elements at high temperatures without melting them. Since copper is a good conductor and also relatively inexpensive, it is widely used in electrical circuits. However, copper is seldom used in its pure form. It is usually mixed with other metals to form a copper alloy.

The resistance of a copper wire is determined by three things--the cross-sectional area of the wire, its temperature, and its length. Since a wire with a large diameter has a greater cross-sectional area than a smaller wire, it has less resistance. A long wire has more resistance than a short wire. A cold wire has less resistance than a hot wire. The OHM is the standard unit of measurement for resistance. The symbol for an ohm is the Greek symbol omega (Ω).

A magnet is an object which has the ability to attract iron or steel, and, if permitted to turn freely, will turn to a definite direction. Magnets attract other materials, such as nickel and cobalt, but not with as much force as they do iron and steel. Materials which can be attracted by magnets are called magnetic substances. There are two kinds of magnets--natural and artificial.

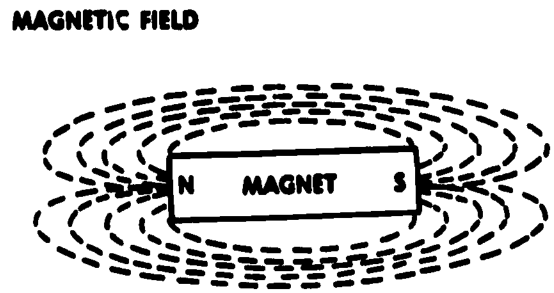
NATURAL MAGNETS are a black mineral ore called lodestone or magnetite, which is found in large amounts in Asia Minor, and contain magnetic properties. Lodestone is called a natural magnet because it exists in nature in a magnetized state. Lodestone was used in the Middle Ages to magnetize compass needles. Today, however, lodestone has very little value as a magnet, chiefly because of its unstable structure and low magnetic strength.

ARTIFICIAL MAGNETS are made of iron or steel and can be either permanent or temporary. They are magnetized, by induction from an external source, by stroking with some other artificial magnet, or by being placed in the field of an electromagnet. (More on electromagnets will be covered later.) Temporary magnets are those which will hold their magnetism only as long as the magnetizing force is maintained. Permanent magnets will hold their magnetism after the force is removed. Hard steel will hold its magnetism for a long time, and for this reason permanent magnets are made of hard steel and other substances which have the same characteristics. They are made in various shapes. Soft iron can be magnetized easily but will lose its magnetism quite fast. The property of a substance which causes it to stay magnetized is called retentivity, and the magnetism which remains is called residual magnetism. Steel has high retentivity, whereas that of soft iron is low.

Magnetic lines of force surround the earth in much the same way that lines of force surround a bar magnet. Also, the earth has two magnetic poles, one near the geographic North Pole and the other near the geographic South Pole. These facts are responsible for man's most important navigational instrument--the magnetic compass. The compass needle is an artificial magnet mounted in such a way that it aligns itself with the earth's magnetic lines of force, with one end always pointing toward magnetic north.

When a bar magnet is dipped into iron filings, a large number of filings will cling to the magnet near its ends, but just a few will cling to the magnet near its center. This fact shows that the magnetism is concentrated at the two ends. These ends are called the poles of the magnet. The strengths of the two poles of the magnet are the same. A magnet, free to turn, will always turn to a north-south direction, aligning itself with the earth's magnetic field. The pole of the magnet which turns to the north is called the North-seeking pole, or the North pole (N); and the pole at the opposite end is called the South-seeking pole, or South pole (S).

Placing a sheet of glass or some other nonmagnetic substance over a magnet and sprinkling iron filings on it will give you a means of observing the lines of force in the magnetic field. If you tap the glass, the filings will align tnemselves up into chains of lines that will look like the magnetic field itself.



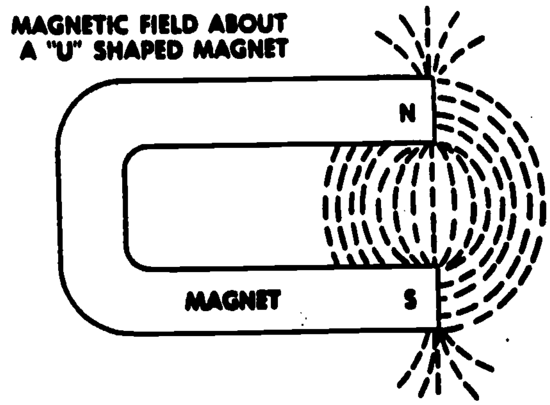


Fig 1-3. Lines of force.

Figure 1-3 shows the theoretical lines of force about a bar magnet and a U-shaped magnet. Lines of force travel from the North Pole to the South Pole, have only one direction at a given point, and form closed loops. The path of each loop is from the North Pole to the South Pole in space, and thence through the magnet back to the North Pole. When two magnets are brought together, the fields of force interact, causing repulsion or attraction, depending upon the polarity of the poles. Like poles repel each other, and unlike poles attract each other.

Over a century ago, Dersted, a Danish physicist, discovered that a current-carrying conductor is surrounded by a magnetic field. He also discovered that the magnetic field's strength became less as the distance from the center of the conductor increased and that lines of force form about the conductor as current is applied to it.

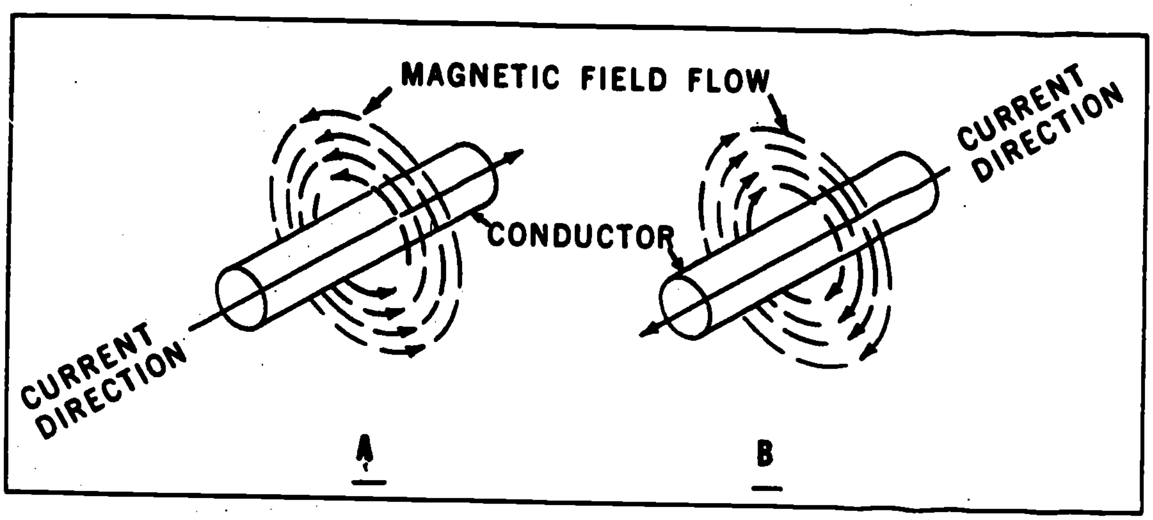


Fig 1-4. Direction of electron flow.

The LINES OF FORCE about a current-carrying conductor move in either a clockwise or a counterclockwise direction, depending upon the direction of electron flow. For example, in figure 1-4, A, the electrons are moving to the right through the conductor. In this case, the direction of the field about the conductor is counterclockwise. In figure 1-4, B, the electrons are moving to the left through the conductor and the direction of the field is clockwise. To determine the direction of the lines of force about any conductor, use the left-hand thumb rule: If you grasp a conductor with you left hand in such a manner that your thumb points in the direction of electron flow, your fingers will show the direction of the lines of force. If you were to bend a straight conductor into a one-turn loop, as shown in figure 1-5, the lines of force will concentrate within the loop. This concentration is due to the fact that all lines of force enter the loop from one side and leave it at the other. If you wind several turns of wire close together into the form of a coil, the magnetic fields about each turn will all have the same direction.

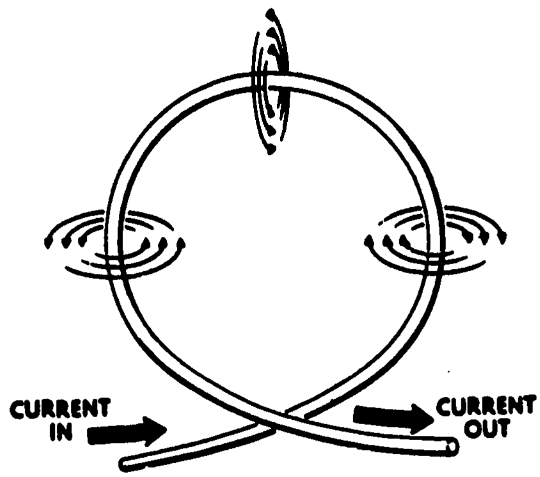


Fig 1-5. Magnetic field about a loop.

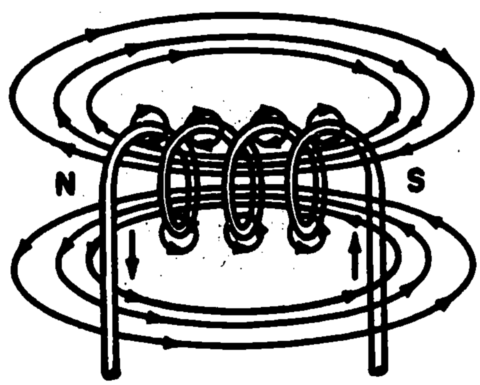


Fig 1-6. Magnetic field produced by a coil.

When current flows through this wire, the coil (solenoid) is surrounded by a magnetic field like that which is shown in figure 1-6. One end of this coil is called the north magnetic pole. To find out the polarity of a coil, use the left-hand thumb rule (fig 1-7) as follows: grasp the coil with your left hand so that your fingers point in the direction of electron flow, and note the direction your thumb is pointing. This direction is the North Pole. Inserting a soft iron core into a coil will greatly increase the magnetic force of the coil. This increase in magnetic force is not caused by an increase in the number of magnetic lines, but from a concentration of the lines of force in the iron core.

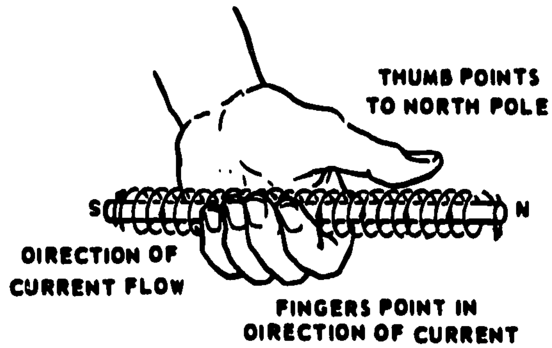


Fig 1-7. Determining the polarity of a coil.

Because magnetic lines of force from closed loops, the path that the plus loops follow is called a magnetic circuit. Electrical circuits and magnetic circuits nave some thing in common. The force which produces a flow of electrons in an electrical circuit is the electromotive force (EMF). In the magnetic circuit, the force which produces the flux is called the magnetomotive force (MMF). Just as resistance opposes the flow of current in an electrical circuit, reluctance opposes the magnetic flux in a magnetic circuit. Also, just as conductance indicates the ease with which electrical current flows, permeability indicates the ease with which magnetic lines of force flow in a magnetic circuit.

Electricity that flows or is in use is called dynamic electricity. You have learned that current flow is the movement of electrons through a wire. So, any time electrons flow through a wire, dynamic electricity is at work. If the electrons move in one direction through the wire, we have direct current (DC). If they (electrons) move back and forth through the wire in a given time frame, we have ALTERNATING CURRENT (AC).

Thus far in this discussion, it has been said that electric current is a flow of electrons caused by a voltage applied to a circuit. Also it has been stated that current flows from a negative to a positive potential, or that there is a steady flow in one direction. This type of current is known as DIRECT CURRENT (DC). There are many uses for which only direct current is good, such as battery charging, electro-plating, and certain electronic circuits.

Some electrical circuits make use of a particular type of direct current called PULSATING DIRECT CURRENT. A pulsating direct current is obtained by using specially designed switches which alternately turn direct current off and on, causing the current to flow in pules. The automobile ignition coil circuit is a good example of pulsating direct current. Each time the ignition points close, a short pulse of direct current flows through the ignition coil. The current pulses always flow in the same direction.

A current which flows first in one direction and then reverses and flows in the opposite direction is an ALTERNATING CURRENT (AC). One direction is called positive (+) and the other is called negative (-).

Alternating current cannot be obtained from batteries. It originates from mechanical devices called generators and alternators.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. What are the building blocks of nature?

___

2. Of what is matter composed?

___

3. What can current flow through a conductor be compared with?

___

4. Explain the difference between compounds and mixtures.

5. What is the smallest part of a substance that has all the characteristics of that substance?

6. What are the elements called that form molecules?

7. Electric current is composed of what?

8. What is voltage?

9. What effects does current have?

10. What is produced when current passes through a conductor?

11. On what does the resistance of a conductor depend?

12. What is the standard unit of measurement for resistance?

13. Explain the difference between the two types of magnets.

14. Define what is meant by the lines of force around a magnet.

15. Why does lodestone have little value as a magnet today?

16. What happens when two magnets are brought together?

Identification: For questions 17 through 21, identify the correct statements from the incorrect ones by placing C for CORRECT and I for INCORRECT in the spaces provided.

17. When a soft iron core is inserted into a solenoid, the lines of force will increase.

18. In a magnetic circuit, the force which produces the flux is called the electromotive force.

19. When you place your left hand around a coil with your fingers pointing in the direction of electron flow, your thumb will point to the North Pole.

______

20. When current is flowing through a single-drop conductor, the magnetic lines of force are concentrated to the outside of the loop.

______

21. The magnetic field's strength decreases directly as the distance from the center of the conductor increases.

______

22. Define "direct current."

____

____

23. Define "alternating current."

____

____

Work Unit 1-2. DIRECT CURRENT (DC) CIRCUITS

SPECIFY THE RELATIONSHIP OF RESISTANCE, CURRENT, AND VOLTAGE.

USE OHM'S LAW TO SOLVE GIVEN DC SERIES CIRCUIT PROBLEMS.

FROM GIVEN INFORMATION, SOLVE DC PARALLEL AND SERIES-PARALLEL CIRCUIT PROBLEMS.

GIVEN A LIST OF POWER TERMS AND A LIST OF DEFINITIONS, MATCH EACH TERM WITH ITS DEFINITION.

GIVEN SEVERAL VARIABLES, DETERMINE THE AMOUNT OF POWER CONSUMED.

In order for current to flow, there must be both a source of voltage and a complete circuit. The source of voltage may be a battery, a generator, or some other device. The complete circuit is a complete path from the negative terminal through the load and back to the positive terminal of the source. The complete path should let the electrons flow freely to the load, do their work in the load, and then move freely back to the source without straying off to other loads or doing any unneccessary work.

In this work unit you will learn the relationship of VOLTAGE, CURRENT, and RESISTANCE and the application of Ohm's law in solving DC circuit problems.

There is a definite relationship between the voltage, current, and resistance of any circuit or part of a circuit. If the voltage is increased, the current increases in proportion, and if the resistance is increased, the current decreases in proportion. You will learn the basic law on which this relationship is based and use the law to compute quantities of voltage, current, and resistance in a basic electrical circuit.

A German scientist, Ohm, developed a law for the quantities of a circuit as follows: one volt is the pressure required to force one ampere of current through a resistance of 1 Ohm. Ohm's law, simply stated, is as follows: "For any circuit or part of a circuit, the current in amperes is equal to the EMF in volts divided by the resistance in Ohm." This means that, if the voltage and resistance are known, the current may be found by dividing the voltage by the resistance. This equation is written as follows:

$$\text{Current} = \frac{\text{Voltage}}{\text{Resistance}}$$

Also, the values of voltage and resistance can be found if the other two values are known. These relationships are shown by the following equations:

$$\text{Resistance} = \frac{\text{Voltage}}{\text{Current}}$$

Voltage = current x resistance

By the use of the symbols "I" for current, "E" for voltage, and "R" for resistance, Ohm's law can be shown in the following three ways:

$$E = I \times R$$

$$I = \frac{E}{R}$$

$$R = \frac{E}{I}$$

If you look at figure 1-8, A, you will see the Ohm's law circle, which may better help you to remember the previous equations. To use this circle, just place your thumb over the unknown value and it will show you what you must do to obtain the unknown value. As you progress through this course of study you will need them.

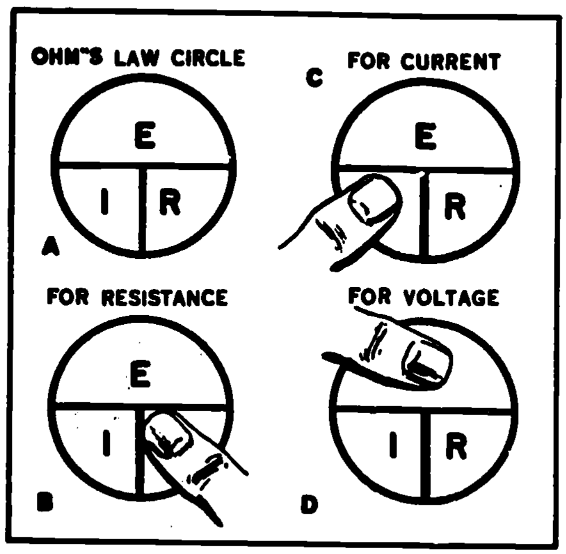


Fig 1-8. Ohm's law circle.

An example of the application of the Ohm's law formula follows:

A circuit has an applied voltage (E) of 120 volts and a resistance (R) of 20 ohms. To find the current flow (I), simply apply Ohm's law (refer to fig 1-8, C) in the following manner:

$$\frac{\text{E of 120 volts}}{\text{R of 20 Ohms}} = \text{I of 6 amperes}$$

If a circuit has an applied voltage (E) of 120 volts and a current flow (I) of 2 amperes, the resistance (R) is determined by the following application of Ohm's law (refer to fig 1-8, B):

$$\frac{\text{E of 120 volts}}{\text{I of 2 amperes}} = \text{R of 60 ohms}$$

To find the applied voltage (E) of a circuit if the current (I) and resistance (R) are known, find the product of the current (I) and resistance (R) as follows (refer to fig 1-8, D):

I of 2 amperes x R of 60 ohms = E of 120 volt

In any practical circuit, certain components are necessary. For a basic series circuit, the components required are a source of power, conductors, a fuse or other protective device, a switch, and a unit of resistance.

A SERIES CIRCUIT is defined as "a circuit which has only one path for current flow." In other words, in a series circuit the units are connected one after the other so that the circuit current must flow through each unit. Figure 1-9 shows the arrangement of a series circuit.

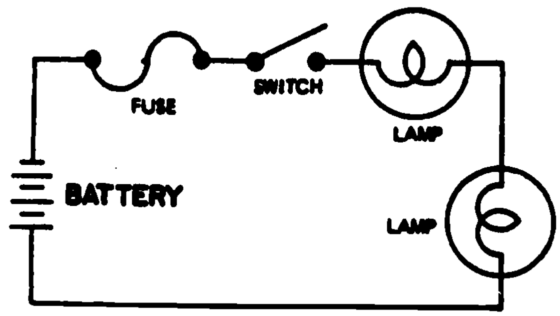


Fig 1-9. Series circuit.

Each electrical circuit has certain operating characteristics. The three characteristics of a series circuit are as follows:

- The total resistance is the sum of each of the resistors.
- The same current flows in each part of the circuit.
- The applied voltage will divide among the resistors according to their resistance.

To apply the characteristics of a series circuit, consider the circuit in figure 1-10. It has a 120-volt source of power (in this case a generator), a fuse, a switch, and two 30-ohm resistors in series. Since the total resistance of a series circuit is equal to the sum of the resistors, then the total for this circuit is 30 ohms plus 30 ohms, or a total of 60 ohms. Knowing the total voltage (120 volts) and the total resistance, you can now find the total current flow by the use of Ohm's law. Using the equation E/R = I, the problem is solved as follows:

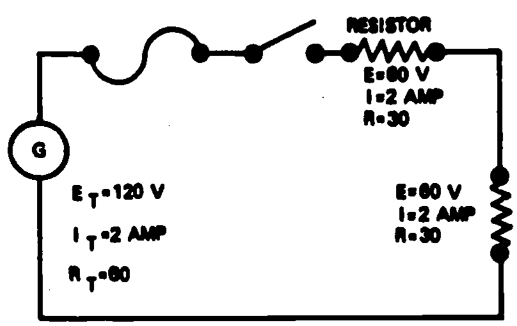


Fig 1-10. Series circuit with equal resistors.

$\frac{E}{R} = I$ Add the known values

$\frac{120 \text{volts}}{60 \text{ ohm}} = I$

$\frac{120 \text{ volts}}{60 \text{ ohms}} = 2$ amperes

You find that 2 amperes of current will flow in the circuit when the switch is closed. Since the same current flows in each part of a series circuit, a current of 2 amperes will flow through each of the two resistors. To see how the voltage divides among the resistors, use Ohm's law again. At each resistor of 30 ohms, you now have a current flow of 2 amperes. To solve for the voltage used at each resistor (voltage drop), use the equation I x R = E as follows:

I x R = E

2 amperes x 30 ohms = E

2 amperes x 30 ohms = 60 volts

Note that this is the same for each resistor. The reason for this is that the resistance is the same in both. Figure 1-11 shows how voltage divides among unequal resistors in a series circuit. Notice that the unit with the most resistance uses most of the voltage.

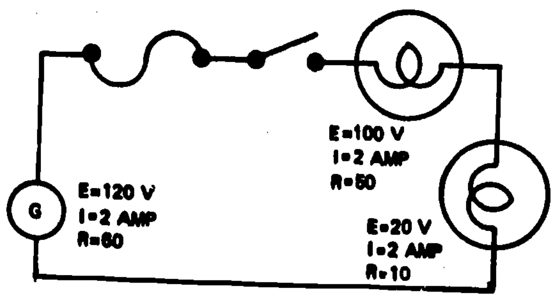


Fig 1-11. Series circuit with unequal resistors.

Almost all power and interior lighting circuits are hooked up in PARALLEL; therefore, a good understanding of parallel circuits is a must. Parallel circuits, sometimes called shunt circuits, are circuits in which components (units) are arranged in such a way that the current divides between them. Thus, there are as many paths for the current to flow in as there are conductors. Unlike a series circuit, a parallel circuit has two or more paths through which the current will flow.

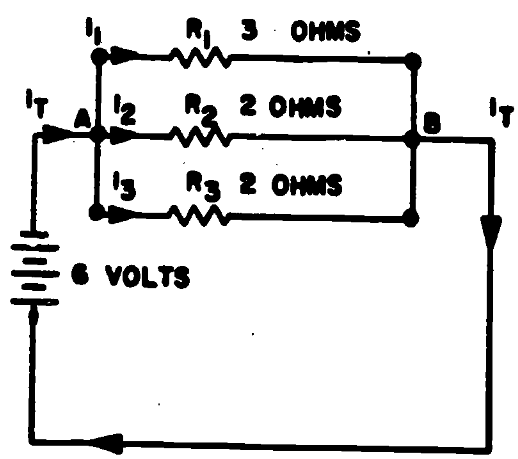


Fig 1-12. Parallel circuit.

If you examine figure 1-12, you can see that the same voltage that is applied to resistor R1 is also applied to resistors R-2 and R-3. This is true because the corresponding points of each resistor are connected to the same points, A and B, and the same difference of potential must exist between these points for all three resistors. This illustrates the first law of a parallel circuit: <u>In a parallel circuit the same voltage is applied across each element</u>.

If an additional path is provided through which current can flow in a circuit, the total current (I_t) in the circuit must be the original plus that of the additional path. In figure 1-12, if only R_1 is connected to the be 6-volt source, it can be determined by Ohm's law (I = E/R) that the current is 2 amperes (6 amps divided by 3 amps). When R_2 is added, the same voltage is applied to it that was applied to R_1. The current through R_2 must equal 3 amperes (6 amps divided by 2 amps). The total current flowing from the source is now 5 amperes (2 amps + 3 amps). When R_3 is added, the total current is then 8 amperes (2 amps + 3 amps + 3 amps). From these results, this rule of a paralleled circuit may be stated: The total current in a parallel circuit is equal to the sum of the current flow in each of the branches.

When the total current in the circuit and the applied voltage are known, the total (combined) resistance (R_t) may be calculated by the use of Ohm's law (R = E divided by I). The total resistance is 0.75 ohms (6 ohms divided by 8 ohms). From this result, another rule for parallel circuits may be stated: The total (combined) resistances of a parallel circuit is equal to the applied voltage divided by the total current. Compare the total resistance with the individual resistance of R_1, R_2, or R_3. Total resistance in this case equals 0.75 ohms and is less than that of either R_1, R_2, or R_3. REMEMBER, in a parallel circuit the total (combined) resistance of the circuit is ALWAYS less than the resistance of the smallest element.

It would be very helpful for you to establish the following laws of a parallel circuit firmly in your mind:

- In a parallel circuit the same voltage is applied across each element.
- The total current (I_t) in a parallel circuit is equal to the sum of the currents in the individual branches.
- The total (combined) resistance (R_t) of a parallel circuit is equal to the applied voltage divided by the total current (I_t) and is always less than the smallest individual resistance (R).

When the total current is unknown and several resistors of equal value are connected in parallel, the combined or total resistance can be found by dividing the resistance of one piece of equipment by the number of pieces connected in parallel. Example: If two 10-ohm resistors are in parallel, the total resistance offered by the combination is 5 ohms (10 ohms divided by 2 ohms). If three 12-ohm resistors are in parallel, the total resistance is 4 ohms (12 ohms divided by 3 ohms). If five 10-ohm resistors are in parallel, the total resistance is 2 ohms (10 ohms divided by 5 ohms). To state this as a rule: The total resistance of equal resistances connected in parallel is equal to one resistance divided by the number of connected resistances.

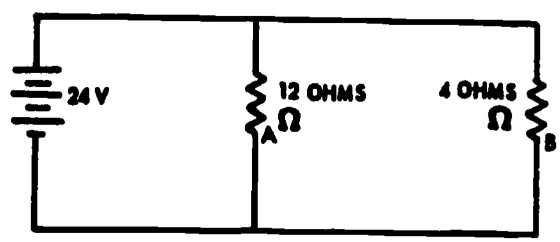


Fig 1-13. Two unequal resistors connected in parallel.

All equipment used in electrical circuits does not have the same resistance. Therefore, when different pieces of equipment are connected in a parallel circuit, they do not draw the same current. Two unequal resistors connected in parallel are shown in figure 1-13. In this case, the current through the parallel connected resistor A is

$$I_A = \frac{E}{R_A}$$

$$I_A = \frac{24}{12}$$

$$I_A = 2 \text{ amperes}$$

The current through resistor B is

$$I_B = E/R_B$$

$$I_B = \frac{24}{4}$$

$$I_B = 6 \text{ amperes}$$

The total current (I_t) is equal to the sum of the current in the branches (I_T = 6A + 2A = 8 Amperes). Ohm's law will give the total resistance offered by the current as $R_T = E/I_T$ = 24/B = 3 ohms.

The rule for equal resistors in parallel could not be used for this circuit since the resistors A and B are not equal in resistive value. For such cases, another rule has been developed for the calculation of total resistance: The total resistance of two resistors in parallel is equal to their product divided by their sum. This rule as applied to the circuit in figure 1-13 is as follows:

$$R_T = \frac{\text{Product}}{\text{Sum}} = \frac{12 \times 4}{12 + 4} = \frac{3B}{16} = 3 \text{ ohms}$$

As you can see, this is the same answer found previously when applied voltage was divided by total current.

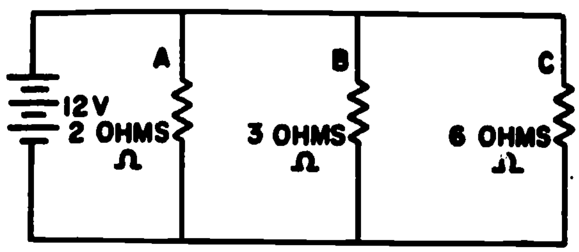


Fig 1-14. Three unequal resistors connected in parallel.

The PRODUCT-OVER-SUM METHOD may be applied to any two resistors in parallel whether they are equal or not. It is the most commonly used method of determining the resistance of a parallel circuit. This method may be extended to include three or more unequal resistors in parallel. First, you determine the resistance of two resistors in parallel; then combine the results of this calculation with one of the remaining resistances by additional application of the same rule (product-over-sum). In each case, the result of the previous calculation is combined with one of the remaining resistive values until the total or joint resistive value has been determined. For example, consider the circuit shown in figure 1-14. In this circuit, three unequal resistors are connected in parallel. To apply the product-over-sum rule to this circuit, you would proceed as follows:

$$R_{eg} = \frac{B \times C}{B + C} = \frac{3 \times 6}{3 + 6} = \frac{18}{9} = 2 \text{ ohms}$$

Combine the above results (2 ohms) with the remaining resistance A as follows

$$R_T = \frac{R_{eg} \times A}{R_{eg} + A} = \frac{2 \times 2}{2 + 2} = \frac{4}{4} = 1 \text{ ohm}$$

As you can see, this result of 1 ohm is the total, joint, and/or combined resistance (R_{eq}) of three unequal resistors (A, B, and C in fig 1-14).

There is another method of finding the total resistance of several resistors in parallel. This method is known as the reciprocal method. As you have seen the product-over-sum method can be used only with two resistors at one time. If as many a five or six resistors (or more) are in parallel, the arithmetic solution would be a lengthy procedure. The reciprocal method may used to find the joint resistance of any number of resistors in one operation. This is stated as follows: the joint resistance (total resistance of a parallel circuit) is equal to the reciprocal or the reciprocals of the individual resistances. This method can be stated as a formula and applied to figure 1-14 as follows:

$$R_T = \frac{1}{\frac{1}{R_A} + \frac{1}{R_B} + \frac{1}{R_C}}$$

$$R_T = \frac{1}{\frac{1}{2} + \frac{1}{3} + \frac{1}{6}}$$

$$R_T = \frac{1}{.5 + .33 + .17}$$

$$R_T = \frac{1}{1} = 1 \text{ ohm}$$

If the joint resistance of only two resistors in parallel is required, the product-over-sum method is probably the easier to use. If the total resistance of three or more resistors is required, the product-over-sum may be used but the reciprocal method is better. When in doubt, the work can be proved by assuming an applied voltage and using Ohm's law to determine the total current and resistance.

Series-parallel circuits consist of groups of parallel resistors in series with other resistors. Any leg of a parallel group may consist of two or more resistors in series. Series-parallel circuits may be analyzed by the same rules applied to simple series and simple parallel circuits. To do this, the series-parallel circuit is reduced to an equivalent, simplified circuit. Each group of parallel resistors is first replaced by its equivalent single resistance, and the entire circuit is then treated as a series circuit.

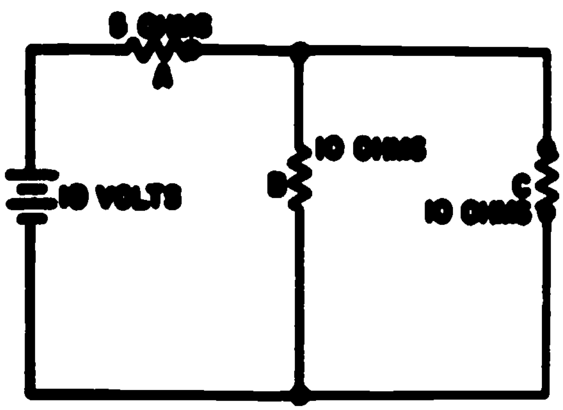


Fig 1-15. Simple series-parallel circuit.

When this is applied to the circuit in figure 1-15, the first step is to change the two parallel resistors B and C to an equivalent single resistance. Since B and C are equal, divide 10 by 2. This gives you 5 ohms as the joint resistance of the parallel branch. The circuit is now a simple series circuit of two 5-ohm resistors. The total resistance is found by adding the resistance A to the equivalent of B and C. This gives 5 plus 5, or 10 ohms, as the resistance of the entire circuit. Knowing this, you can calculate the total current by applying Ohm's law as follows:

$$I_T = \frac{E_T}{R_T} = \frac{10}{10} = 1 \text{ ampere}$$

This 1 ampere flows through resistor A, giving a voltage drop of 5 volts. Since the two parallel resistances have the same value, the 1 ampere of current divides equally between the two. The IR drop across B equals 1/2 x 10, or 5 volts, and across C it equals 1/2 X 10, or 5 volts also. This demonstrates the rule that each element of a parallel circuit is supplied with the same voltage. By following one complete path around the circuit, you can see that the sum of the voltage drops is equal to the applied voltage. Starting from the positive side of the battery, there is a 5-volt drop in resistor A, another 5-volt drop in resistor B, and thus back to the battery. You must take care to follow only one path at a time in tracing through a circuit.

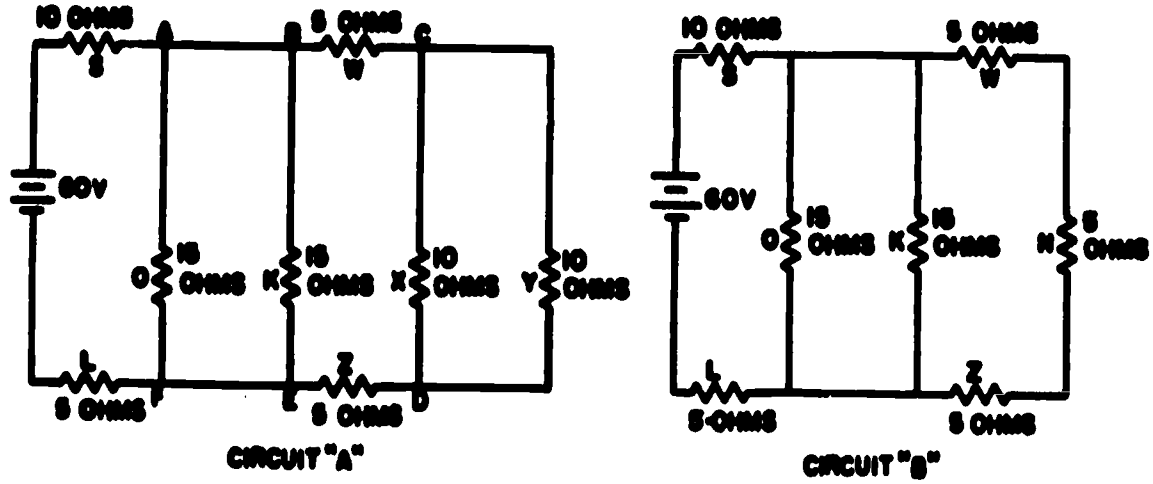


Fig 1-16. Solving series-parallel circuits by simplification.

The example just presented was of a very simple nature. In figure 1-16, you have a series-parallel circuit of a less simple nature, and the solution will involve more steps, as you shall see. The steps in the solution of circuit A in figure 1-16 are as follows:

o Combine resistor X and Y of circuit A; they can be represented by resistance N of Circuit B which is the equivalent circuit of circuit A in figure 1-16. Resistors X and Y are equal and in parallel; therefore, their joint resistance is as follows:

$N = \frac{10}{2} = 5$ ohms

o Combine resistors W, N, and Z (circuit B of fig 1-16) into a single resistor M of circuit C in figure 1-17. W, N, and Z are in series; therefore, the resistance of M equals 15 ohms (5 + 5 + 5 = 15).

o Combine resistors O, K, and M (of circuit C in fig 1-17) into a single resistance P of circuit D of figure 1-17. Since resistors O, K, and M are equal and in parallel, they can be treated as follows: Total resistance of equal resistances connected in parallel is equal to one resistance divided by the number of connected resistances, therefore:

$P = \frac{15}{3} = 5$ ohms.

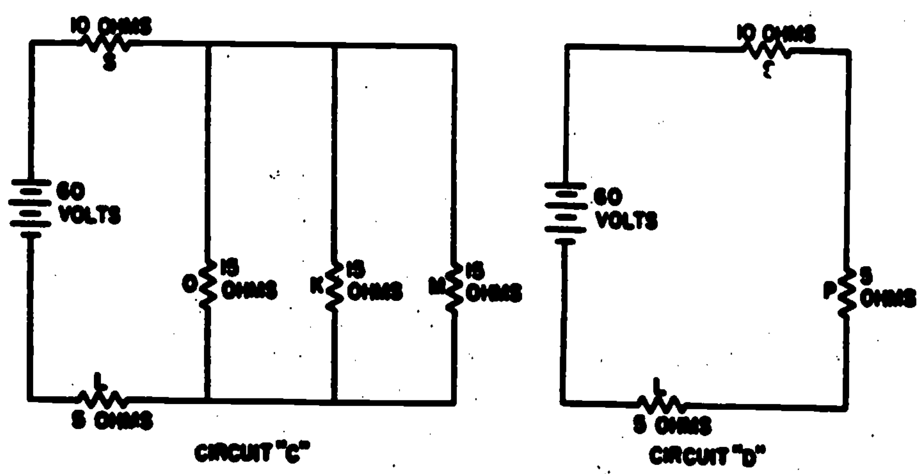


Fig 1-17. Solving series-parallel circuits by simplified equivalent circuits.

- Combine resistors S, P, and L (circuit D, fig 1-17), which are in series. The combined or total resistance (R_T) of the whole circuit equals 20 ohms (10 + 5 + 5).

- Find the total current (I_T) of the circuit as follows:

  $$I_T = \frac{E}{R_T} = \frac{60}{20} = 3 \text{ amps}$$

- Find the voltage drop across equivalent resistance P (equivalent of O, K, M, circuit C) as follows:

  $E_p = E_T - (E_S - E_L) = 60-(30 - 15) = 15$ volts (circuit D, fig 1-17).

- Find the current in resistor O as follows:

  $$I_O = \frac{E}{R_O} = \frac{15}{15} = 1 \text{ amp}$$

- At point A of circuit A, figure 1-16, there are two paths for the current flow. In a parallel circuit the total current equals the sum of the currents in the branches. Therefore, the current flowing from point A to point B equals $I_T - I_O$, or 3 amps - 1 amps = 2 amps.

- The voltage drop across parallel resistors is equal, so the voltage drop across K is 15 volts; the current = $\frac{E}{R}$, or $\frac{15 \text{ volts}}{15 \text{ ohms}}$ = 1 amp.

- Since a current of 2 amperes flows from point A to point B and 1 amp of current flows through resistor K, the current through W must be 1 amp (2 amps - 1 amps).

- At C the current divides again. Since the resistive value of X and Y is the same, the current divides equally, with 1/2 amp going through each resistor.

- Voltage across X and Y will be the same (1/2 X 10 = 5 volts).

- At C to D of circuit A (fig 1-16) the two currents of 1/2 ampere join, and 1 ampere flows through Z. The voltage drop across Z is 5-volts (1 x 5).

- At point E the current through Z and K join, and 2 amps (1 + 1) flow through E to F.

- At point F the current flowing through resistor O joins the current flowing from point E to F, and 3 amps (1 + 2) flow through L. You may recall that this 3 amps is equal to the total current.

As was stated previously, there is a very definite relationship between current, voltage, and resistance of any circuit. You should know how to compute for each of them with the aid of Ohm's law (refer to fig 1-8 A, B, C, D).

You will find it of value to learn the meanings of the following terms commonly used with electricity: FORCE, WORK, ENERGY, and POWER.

- FORCE is that which produces, or tends to produce, a change in the motion of a body. In electronics, electrical force causes electrons to move from one point to another. The unit of force is called the dyne.

- WORK is the production of motion against a resisting force. In electricity and electronics, electromotive force causes electrons to move against the opposing force offered by the resistance in a circuit. When an ampere of current flows through a resistance of 1 ohm for 1 second, a joule of work is done.

- ENERGY is the capacity or ability to do work. Energy that is due to motion of matter is called kinetic energy; energy that is due to the position of matter is called potential energy. As an example, the electrons on a negatively charged body, have potential energy with respect to a less negatively charged body, because these electrons would flow if the two bodies were connected by a conductor. The electrons moving in the conductor connecting the two bodies have kinetic energy because such electrons are in motion. Energy may be dissipated in such forms as heat, light, and motion. It may be transformed from one form to the other, as is done in producing electron flow by mechanical or chemical means. Since energy is the capacity to do work, energy and work have the same unit (joule).

o <u>POWER</u> is the rate of doing work and is abbreviated by the symbol P. Forcing electrons through a resistor requires work, and energy is expended in the resistor in the form of heat. If this heat is not too great, it can be radiated and will not damage the resistor. If it is too much, it cannot be radiated as quickly as it is generated; consequently, the resistor becomes too hot and burns out. As a precaution against too much heat, a resistor will have a power rating, meaning that no more than a specified amount of current (given number of electrons per second) can be allowed to flow through the resistor without damaging it. Electrical power is the rate that electrons are forced through resistance by electromotive force.

Let's take a closer look at power in a DC circuit.

The unit of electrical power is the <u>WATT</u>. One watt of power is present in a 1-ohm resistor in which a current of one amp is flowing; in other words, a resistor consuming 1 joule of energy per second. A large unit of power is the kilowatt, which equals 1,000 watts. The power used by some resistors can be as small as one tenth of a watt, and you may encounter some as high as 500 watts. One horsepower, the unit of measuring mechanical power, is the equivalent of 746 watts.

Since power is the rate of doing work or consuming energy, the length of time it is used is the true measure of energy used. It is common practice to purchase electrical energy by watt-hour (watts x hours). The watt is so small that the unit kilowatt-hour, equal to 1000 watt-hours, is used. As an example, let's take an ordinary 100-watt light bulb, as found in your home. A 100-watt bulb requires 100 watts of power for proper operation and consumes 100 watt-hours of energy in 1 hour. In terms of kilowatt-hours, the lamp uses 0.1 kilowatt-hour in 1 hour. In 10 hours of operation, the bulb would use 1 kilowatt-hour of energy. In 24 hours, the bulb would consume 2.4 kilowatt-hours.

In order to determine the power in a DC circuit, the formula $P = E \times I$ may be used. For example, a circuit with an applied voltage of 120 volts and a current flow of 10 amps will use 120 x 10, or 1,200 watts. The circuit in figure 1-18 shows a circuit with two lamps in series. Each lamp has a resistance of 60 ohms, and the circuit has an applied voltage of 120 volts. Note that each lamp is consuming 60 watts of power. In other words, they are 60-watt lamps.

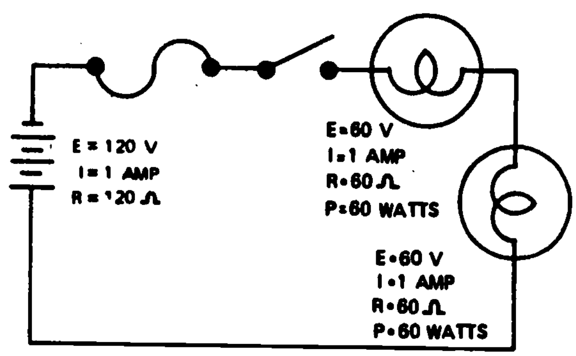


Fig 1-18. Two 60-watt lamps in series.

You can also find the power in a DC circuit if you know the resistance (R) by using these two formulas:

$$P = \frac{E2}{R} \text{ or } P = I^2R$$

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. Specify the relationship of the current to the voltage and resistance in a DC circuit as given in Ohm's law.

____

____

2. Show the Ohm's law equation for, and the solution to, the following problems:

a. Voltage = 90v, current = 30 amps, Resistance = ?

Equation ______________________________

Solution ______________________________

b. Voltage = ?, current = 2 amps, and resistance R_1, = 7 ohms, R_2 = 5 ohms

Equation ______________________________

Solution ______________________________

c. Voltage = 24V; current = ?; resistance R_1 = 10 ohms, R_2 = 8 ohms

R_3 = 6 ohms

Equation ______________________________

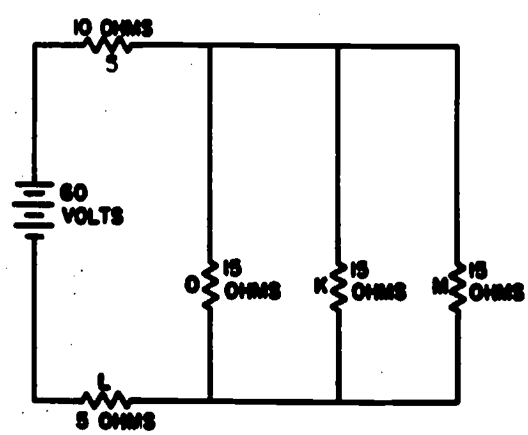
Solution ______________________________

3. What is the relationship of resistance, current, and voltage in a DC series circuit?

____

____

4. What should be the first step to solve the following circuit?



____

____

5. What is the rule pertaining to the total current in a parallel circuit?

____

____

6. When solving a series-parallel circuit, what should you do first to the circuit?

____

____

Matching: Match each power term in column 1 with its appropriate definition in column 2. Place your answers in the spaces provided.

Column 1 Term	Column 2 Definition
7. ______ Force	a. The ability to do work. The unit of measurement is the joule.
8. ______ Work	b. The production of motion against a resisting force. The unit of measurement is the joule.
9. ______ Energy	c. The rate of doing work. The unit of measurement is the watt.
10. ______ Power	d. That which produces a change in the motion of a body. The measurement is the dyne.

11. How is power computed in a DC circuit with only resistance and current known?

____

12. In a parallel circuit having four equal lamps, with an applied voltage of 120 volts, and a total current flow of 4 amps, what is the amount of power consumed at each lamp?

____

Work Unit 1-3. ALTERNATING CURRENT (AC) CIRCUITS

MATCH TERMS RELATED TO ALTERNATING CURRENT WITH PHASES WHICH DEFINE THEM OR INDICATE THEIR FUNCTIONS.

STATE HOW ELECTRONS TRAVEL.

SPECIFY THE USE OF HERTZ.

WHEN TRUE POWER IS LESS THAN OR EQUAL TO APPARENT POWER, STATE THE CONDITIONS THAT EXISTS AND GIVE THE FORMULA FOR FINDING THE POWER FACTOR.

GIVE THE FORMULA FOR FINDING THE POWER FACTOR.

As was stated in previous work units, in order to understand how electrical equipment is connected and how it works, you must first understand how current flow, voltage, and resistance are related in the circuit. You have learned this relationship in DC circuits, now you will learn this relationship as it applies to AC circuits.

Electrical current flow, as you already know, consists of electrons moving in a circuit. Since the electron is negatively charged, it is repelled at the negative end of the circuit and attracted to the positive point. Therefore, it travels from negative to positive. In the direct current circuit, it moves in one direction only. In the alternating current (AC) circuit, its polarity is changing at regular intervals. This causes the current to flow in one direction and then in the opposite direction. Those alternations in current flow are illustrated in figure 1-19. The solid arrows indicate the direction of current flow during the positive alternation, and the dotted arrows show the current flow during the negative alternation. since the current flow is continuously changing direction, it is called ALTERNATING CURRENT.

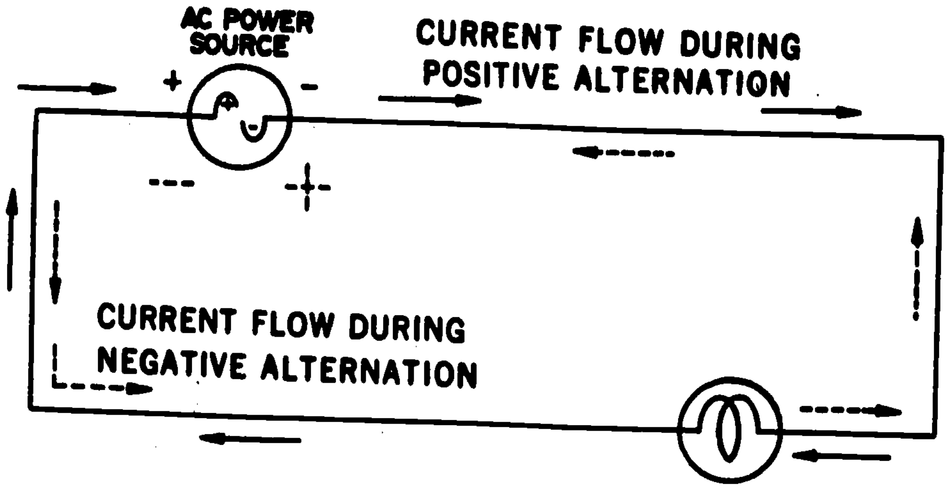


Fig 1-19. Electron flow in an AC circuit.

When an AC generator (power source) completes a positive and a negative alternation, it has completed one electrical cycle. It is represented by the symbol (Hz) . The number of times each cycle occurs in 1 second is called FREQUENCY. This is now expressed is HERTZ per second or simply by Hertz. We now say that the frequency of a power system as 60 hertz.

Note: The term "hertz" has been adopted in the last few years in recognition of Heinrick Rudolph Hertz, a German physicist. He discovered in his experiments that electricity can be transmitted in electromagnetic waves at the speed of light.

The frequency of a system was formerly expressed in cycles per second. The wave forms of alternating current are shown in figure 1-20. This is usually referred to as a SINE WAVE. The term "sine wave" comes from the operation of a generator. It is so named because the alternator output voltage at any one point on the wave is the product of the sine of the rotor angle and the peak voltage.

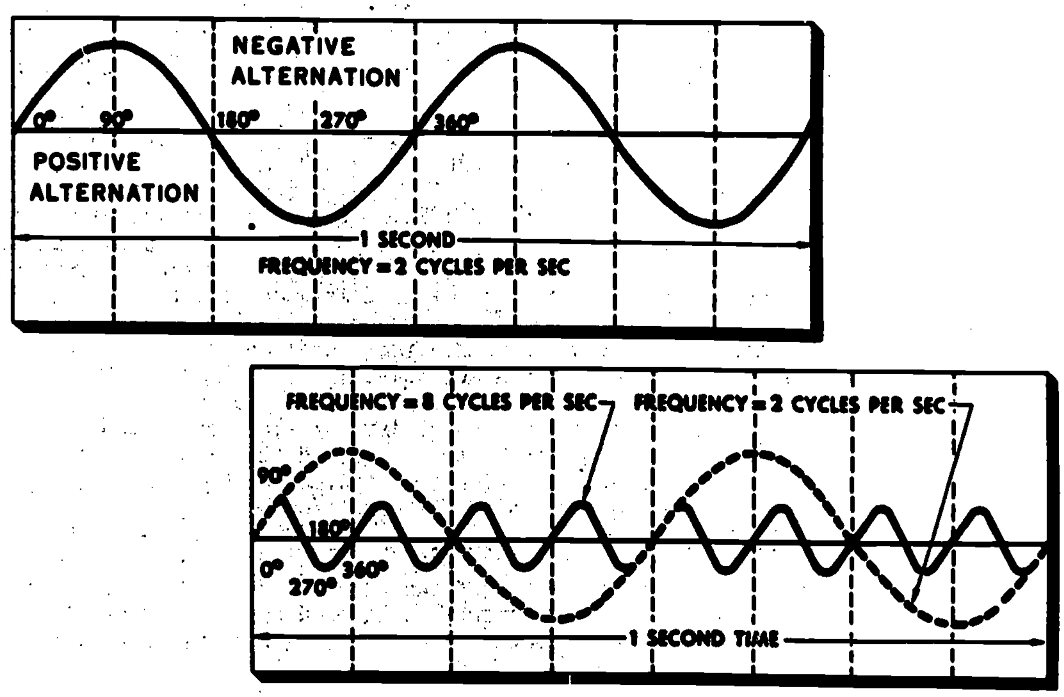


Fig 1-20. Alternating circuit (AC) frequency.

The frequency of the AC generator voltage output depends upon the speed of rotation of the rotor and the number of pairs of poles. With a given number of poles, the faster the speed of rotation of the rotor, the higher the frequency wi'l be, and conversely, the lower the speed of rotation, the lower the frequency. When a rotor has turned through an angle so that two adjacent rotor poles has turned through an angle so that two adjacent rotor poles (paired north and south poles) have passed one winding, the voltage induced in that winding will have varied through one complete cycle. Therefore, for a given frequency, the more pairs of poles there are, the lower the required speed of rotation.

A two-pole generator must rotate at twice the speed of a four-pole generator for the same frequency of generated voltage. The frequency of the generator in hertz can be determined by the following formula:

$$f = \frac{P}{2} \times \frac{N}{60} = \frac{PN}{120}$$

P is the number of poles, and N is the speed in RPM. For example, a 2-pole, 3,600-RPM generator has a frequency of 2/120 x 3,600 = 60 hertz; a 4-pole, 1,800 rpm generator has the same frequency; a 6-pole, 500-rpm generator has a frequency of 6/120 x 500 = 25 hertz; and a 12-pole, 4000-rpm generator has a frequency of 12/120 x 4,000 = 400 hertz.

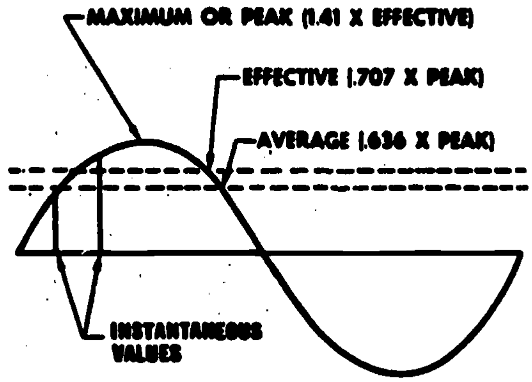


Fig 1-21. AC values.

Four values must be considered when you discuss alternating current and voltage. You will learn them in the following order: The maximum or peak value, the instantaneous values, the average value, and the effective value. These valves are illustrated in the sine-wave form in figure 1-21. Also, we'll take a brief look at the way they affect the power in an AC circuit.

The MAXIMUM or PEAK VALUE is indicated as the highest voltage or the highest current reached on either the positive or the negative alternation. It occurs when a coil is cutting the maximum number of flux lines. No greater amount of current or voltage can be induced by this magnetic field in this coil. Because of this characteristic, generator voltage output is most often called PEAK. From this point on in our discussions, this term will be used in lieu of the term "maximum."

The INSTANTANEOUS VALUES are between zero and the peak value in either the positive or negative alternation. An instantaneous value is the value of the alternating current or voltage at one point in time. It may be the same as the peak value if the selected point is at the time the voltage or current stops increasing and starts decreasing, or it could be zero if the selected point is the time during which the polarity of the voltage is changing. For this reason, in alternating current the peak value of voltage or current cannot be used in solving for power consumption as it can be in direct current.

The AVERAGE VALUE in alternating current is the average of all the instantaneous valves during one alternation. Except for being a mathematical viewpoint, it is of no great significance since it is a numerical average of all the sine values for all the angles. Average value has been computed to be equal to 0.636 times the peak value. It is always this ratio.

With AC, any value given for current or for voltage is assumed to be EFFECTIVE value unless otherwise specified. In your work you will be dealing only with effective values of voltage or current. You should not confuse this value, as people often do, with the "average value" because the "effective value" is the actual rating of the power available to do work. Since it is the actual rating to do work, perhaps a discussion of what is meant by the term is in order.

As you know, in any DC circuit the voltage across the circuit and the current through the circuit have certain magnitudes. You also learned earlier that these are determined by the actual values of the voltage and the resistance in the circuit. It should be clear, then, why the term "effective value" had no particular significance in the discussion of DC circuits. After all, if 10 volts or 1000 volts is applied to a DC circuit it is obviously 10 or 1,000 volts. (If this statement is puzzling, it is suggested that you go back and read those pages pertaining to DC circuits.) However, in AC circuits, since the instantaneous values of current or voltage vary, there must be some basis on which to judge them. The basis used is direct current; therefore, when the voltage or current in an AC circuit is in phase, the effective value of alternating current is the same as direct current in the same circuit that would cause the same amount of electrical energy to be dissipated or produce on equal heating effect.

While on the subject of values, it might be well to discuss what is known as APPARENT POWER. The apparent power in an AC circuit is equal to the product of the effective values of voltage and current. This product is not equal to the true power, except when the voltage and current are in phase.

It might be well to know that apparent power is expressed in KILOVOLT-AMPERE (KVA). Thus, an expression of a quantity of kilovolt-amperes is a measurement of the apparent power of an AC electrical system. The quantity kilovolt-amperes is found by dividing the number of volt amperes by 1,000. Apparent power, or volt-amperes, is of considerable importance because it is the volt-amperes, and not volts, which determine the operating limits of an AC generator.

When an alternating current flows through a coil of wire, it sets up an expanding and collapsing magnetic field about the coil. The expanding and collapsing magnetic field induces a voltage within the conductor which is opposite in direction to the applied voltage.

This induced voltage opposes the applied voltage, thus serving to lessen the effect of the applied voltage. This results in the self-induced voltage tending to keep a current moving when the applied voltage is decreasing and to oppose a current when the applied voltage is increasing. This property of a coil which opposes any change in the value of the current flowing through it is called INDUCTANCE.

The inductance of a coil is measured in henrys, and the symbol for inductance is "L." In any coil, the inductance depends on several factors. The main ones are the number of turns of wire in the coil, the cross-sectional area of the coil, and the material in the center of the coil, or the core. A core of magnetic material greatly increases the inductance of the coil.

Remember, however, that even a straight wire has inductance, small though it may be when compared to that of a coil. All AC motors, relays, transformers, and the like contribute inductance (or inductive reactance) to a circuit.

In an AC circuit containing inductance, there is opposition to the flow of current in addition to the resistance normally present. The extent of this opposition depends on two things, the frequency of the applied voltage and the amount of inductance that is present in the circuit. This opposition is known as INDUCTIVE REACTANCE. Inductive reactance is identified by the symbol X_L and is measured in ohms. The formula used for finding inductive reactance is

$X_L = 2\ pi\ (f \times L)$

2pi = 6.28

f = frequency in hertz

L = inductance in henrys

Because of the nature of a counter EMF, there is no actual loss of electrical energy. Therefore, even though inductive reactance is in opposition to alternating current flow, its result is not loss, but it does require a greater applied voltage to overcome this additional opposition. Because of the opposition by inductive reactance, current lags the voltage in an AC circuit. You will quickly see, if you multiply the instantaneous values of the voltage and current together when this out-of-phase condition exists, that the power output is greatly diminished. Also, if the circuit is purely inductive, the current will lag the voltage by 90°. Figure 1-22, B, shows this current lag in a purely inductive circuit.

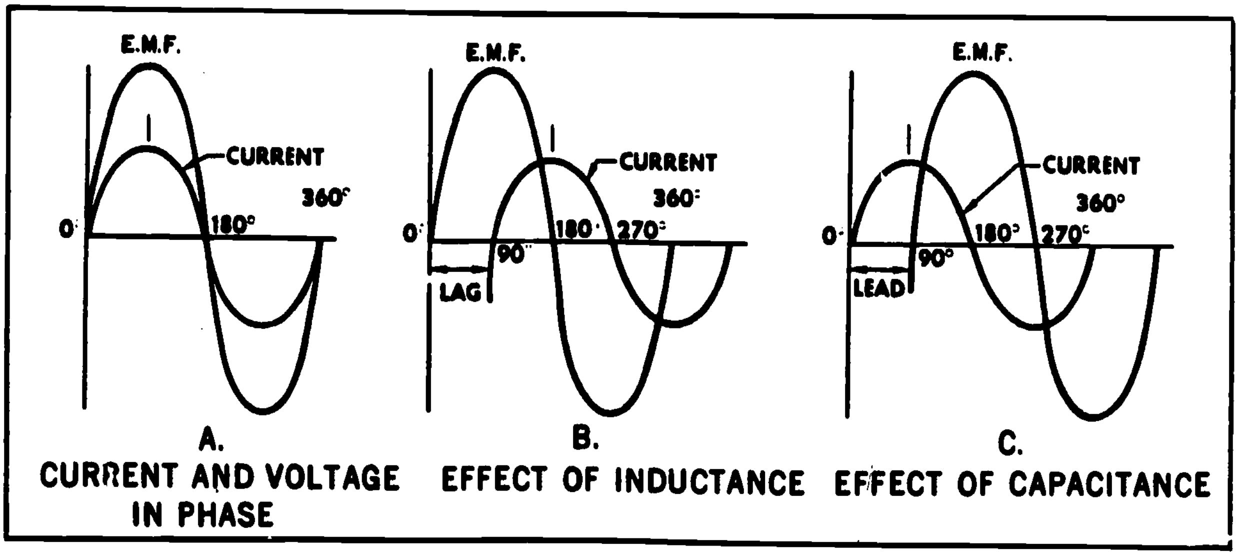


Fig 1-22. Sine wave of alternating current and voltage.

While inductance is the property of a coil in an "X" circuit, capacitance is the property of a capacitor. The unit of capacitance is called the FARAD. A capacitor is a device having the ability to store, or hold, a charge of electricity. When this device is placed in an AC circuit, it stores electricity on one alternation (1/4 cycle), and when the current is at the point of reversing polarity, the capacitor discharges in the original current direction on the second half alternation.

In a circuit where there is only capacitance, the current leads the impressed voltage. This is in direct contrast to a circuit containing pure inductance, where the current lags the voltage.

Capacitance, like inductance, offers opposition to the flow of alternating current. This opposition is called CAPACITANCE REACTANCE and is measured in ohms, just as inductance is measured, but is it designated by the symbol "X_C:"

$$X_C = \frac{1}{2 \text{ pi} \times F \times C}$$

2 pi = 6.28

f = frequency in hertz

C = capacitance in farads

Go back for a moment, to the formula for inductive reactance and further compare it with this formula for capacitance reactance.

By comparing the two formulas, you can see that while X_L is directly proportional to the frequency, inductance X_C is inversely (the exact reverse) proportional to the frequency and capacitance. Another way of saying the same thing is that X_L increases as the frequency and inductance increases, and X_C decreases as the frequency and capacitance increases. This simply means that since inductive and capacitive reactances act in opposite directions, one can be used to cancel out the effects of the other. How is this accomplished? You know that if a power circuit contains a large value of inductance, it will cause the current to lag the voltage, and by the same token, you know that too much capacitance will cause the current to lead the voltage (see fig 1-22, C). Therefore, by adding just enough capacitance to the circuit to counteract the effects of the inductance, you can bring the current and voltage back into phase (see fig 1-22, A). This is usually done in AC circuits and causes the apparent power and true power to be equal.

IMPEDANCE is the term used to identify the total opposition to current flow in an AC circuit. Although they cannot be added together, it is the combined effect of the reactance and the resistance of a circuit that gives us impedance. This is shown in the impedance triangle in figure 1-23. The length of the reactance line shows the total reactance (the difference between X_L and X_C), the length of the resistance line shows total resistance, and then the resulting length of the impedance line shows total opposition to current flow. Because impedance opposes current flow, it has the same unit of measurement as resistance--the ohm. The symbol for impedance is "Z," and the formula used is Z = the square root of resistance^2 + reactance^2.

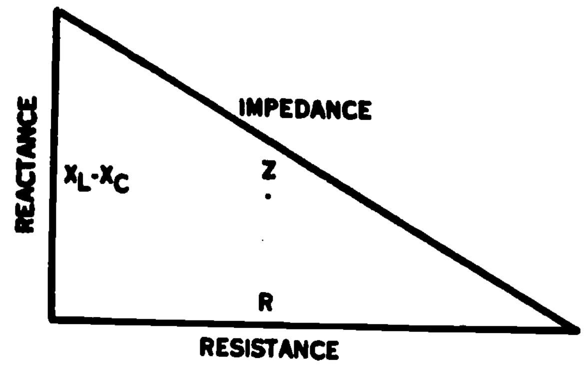


Fig 1-23. The impedance triangle.

You have learned that the unit of electrical power is the watt and that electrical power is the rate at which electrical energy in a circuit is spend. Another way of expressing the same thing is that power is the rate of doing work. In DC electricity, power is equal to the voltage multiplied by the current in the circuit. For obtaining the power in a circuit, the formula reads P = E x I, or watts equal volts times amps. Consequently, if 1 amp flows in a DC circuit with a force behind it of 220 volts, the power is 220 watts. This product of the volts and the amps is what is known as the true power in the circuit, but in the previous work unit, DC circuit were discussed, and in this work unit AC is being discussed. Actually, they are similar. However, in an AC circuit a voltmeter indicates the effective voltage and an ammeter indicates the effective current. Apparent power is the product of these two readings. It is only when the AC circuit consists of pure resistance that the apparent power is equal to the true power. The ratio between the apparent power and true power is known as the power factor. It is usually expressed in percent and the formula is written:

$$\text{Power factor} = \frac{\text{true power}}{\text{apparent power}}$$

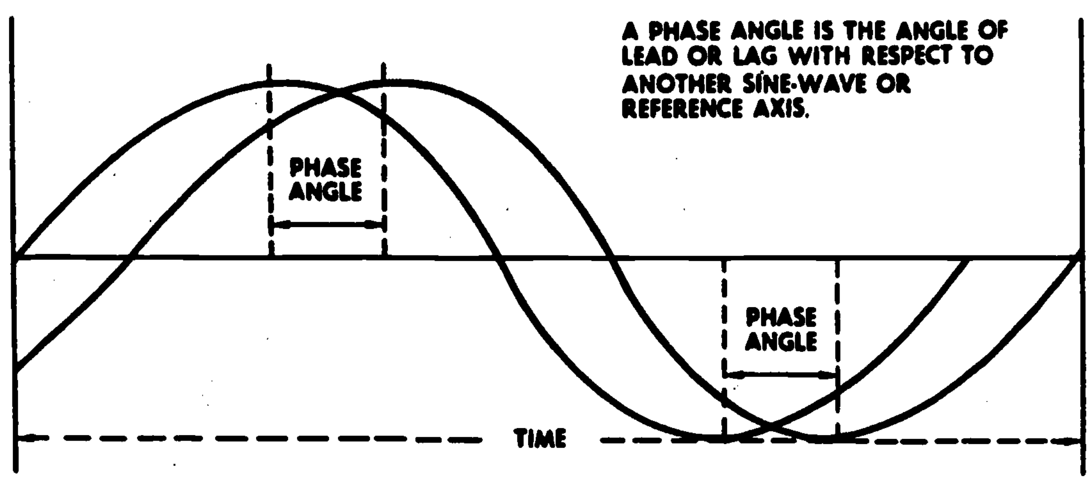


Fig 1-24. Phase angle.

The reason for the equation being written in this way is that the difference between true power and apparent power is caused by the phase separation of the voltage and current in an AC logical circuit to have a very definite relationship between the phase angle, the true power, and the apparent power. To find the phase angle, which is illustrated by figure 1-24, you must divide the true power by the apparent power--the apparent power (volt-amperes) being the power delivered (watts) to the circuit, and the true power (or effective power) being the power actually used by the circuit.

Let's take a look at the power relations in an AC circuit. Note, in figure 1-25, the triangle that displays the relationship between reactive power, true power in watts, and apparent power in volts times amperes. If the circuit was a pure resistance circuit and contained no reactance, the reactive power leg of the triangle would diminish to zero. Apparent power and true power would then lie along the same line and would be equal.

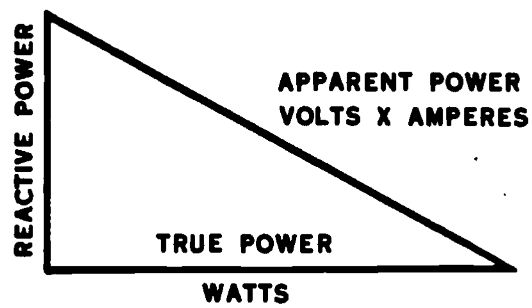


Fig 1-25. Power relationship.

In an AC circuit, the true power is less than the apparent power when the current and voltage are out of phase. This out-of-phase condition is caused by the amount of capacitance or inductance (reactive power) in the circuit. The true power in an AC circuit must be found by a wattmeter reading and not by multiplication as it is in DC circuits. It is the ratio of the true power (base line) to the apparent power (hypotenuse) that is called the power factor, usually expressed in percent. Look at this relationship in equation form:

$$\text{Power factor} = \frac{100 \times \text{watts (the true power)}}{\text{volts} \times \text{amps (the apparent power)}}$$

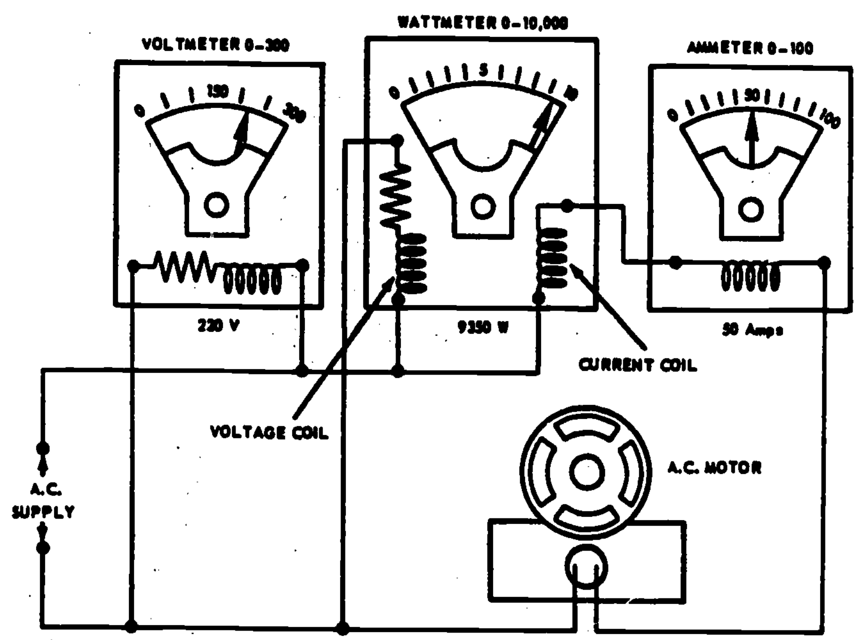


Fig 1-26. Power factor measurement.

Because you cannot compute the true power in an AC circuit, figure 1-26 should clarify the measurement of the power factor in a typical circuit. As you can see, the 220-volt AC motor is apparently taking 50 amps from the line. The wattmeter in the line, however, shows that only 9,350 watts are taken by the motor. Obviously, there is a disparity here and you've got to go a little further. You have to find the apparent power and the power factor to analyze the situation. In a case like this, use the equation. You know that the apparent power is equal to the volts times the amperes, so

Apparent power = 220 x 50 amps or 11,000 volt-amps

therefore,

$$\text{Power factor} = \frac{9,350 \times 100}{11,000}$$

$$\text{Pf} = \frac{935,000}{11,000}$$

Pf = 85, or 85 percent

As was pointed out earlier, volt-amperes in alternating current is important because it determines the operating limits of an AC generator, and since it is important, perhaps more should be said in regard to these limits.

The output limits of an AC generator are determined chiefly by the temperature rise, which is produced in the windings. This increase in temperature is caused by core and copper losses. Core losses depend on the frequency and the flux density and are fixed by the operating voltage and frequen·· these you can do nothing about. Copper losses, on the other hand, are determined by the a.... nt of current, and this you can control. Full load (maximum output capability) is reached when the generating equipment is carrying the full rated current at the rated voltage and frequency. Any increase in load that exceeds the rated output will likely cause overheating and probable damage to the generator.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. How do electrons travel in an AC circuit?

____

2. Why is the term "hertz" used instead of frequency?

____

Matching: Match each term in column 1 to its description or function in column 2 by placing the correct letter in the spaces provided. There is one item in column 2 that is not used.

Column 1		Column 2
Terms		**Definition/function**
3. ________ Cycle	a.	Equal to the product of the effective values of voltage and current
4. ________ Apparent power	b.	Symbol for inductive reactance
5. ________ Inductance	c.	Determined by the frequency and amount of inductance
6. ________ X_L	d.	Total opposition to the flow of alternating current
7. ________ Farad reactance	e.	Unit of capacitance
8. ________ Capacitance in Circuit	f.	Found by adding the individual reactances
9. ________ Impedance	g.	Number of times each cycle occurs in a second
10. ________ Inductive reactance	h.	Causes the current to lead to voltage
11. ________ Frequency	i.	A complete positive and negative alternation
12. ________ $\frac{8}{2} \times \frac{N}{60}$	j.	Formula for determining frequency
	k.	The property of a coil in an AC circuit which opposes any change in the value of the current flowing through it
	l.	Highest voltage or current reached during an alternation

13. When, in an AC circuit, is the apparent power equal to the true power?

____

14. When is the true power less than apparent power?

____

15. What is the formula used to find the power factor?

____

Work Unit 1-4. Basic Electrical Power Sources

SPECIFY THE FUNCTIONS OF ELEMENTARY GENERATORS AND ALTERNATORS.

GIVEN SEVERAL STATEMENTS PERTAINING TO GENERATORS AND ALTERNATORS, IDENTIFY EACH STATEMENT AS BEING EITHER CORRECT OR INCORRECT.

LIST THE TYPES OF ALTERNATORS.

SPECIFY THE OPERATIONAL CHARACTERISTICS OF SINGLE-AND THREE-PHASE OUTPUT.

DISTINGUISH BETWEEN PRIMARY AND SECONDARY CELLS.

SPECIFY HOW STORAGE BATTERIES ARE CONSTRUCTED.

You have learned the sources of voltage. To produce voltage, some form of energy must be used to bring about the actions of electrons. The six basic sources of energy which can be used are friction, pressure, heat, light, magnetism, and chemical action. Although all of these sources of energy provide some practical sources of power, this discussion will be limited to two of the six. The two that supply the majority of our power are magnetism and chemical action. The first to be covered is a power supply that makes use of magnetic energy.

A generator is a machine which converts mechanical energy into electrical energy. The machinery which supplies mechanical energy to the generator is usually called the prime mover. There are many types of prime movers--water power, diesel, and gasoline engines, for example. The electrical power (electromotive force) output from a generator may be either direct current or alternating current, depending upon the construction. However, in principle, the rotating coils and the magnetic field through which they turn are the same for both types of generators. The primary difference between AC and DC generators is the method by which the current is taken from the machine.

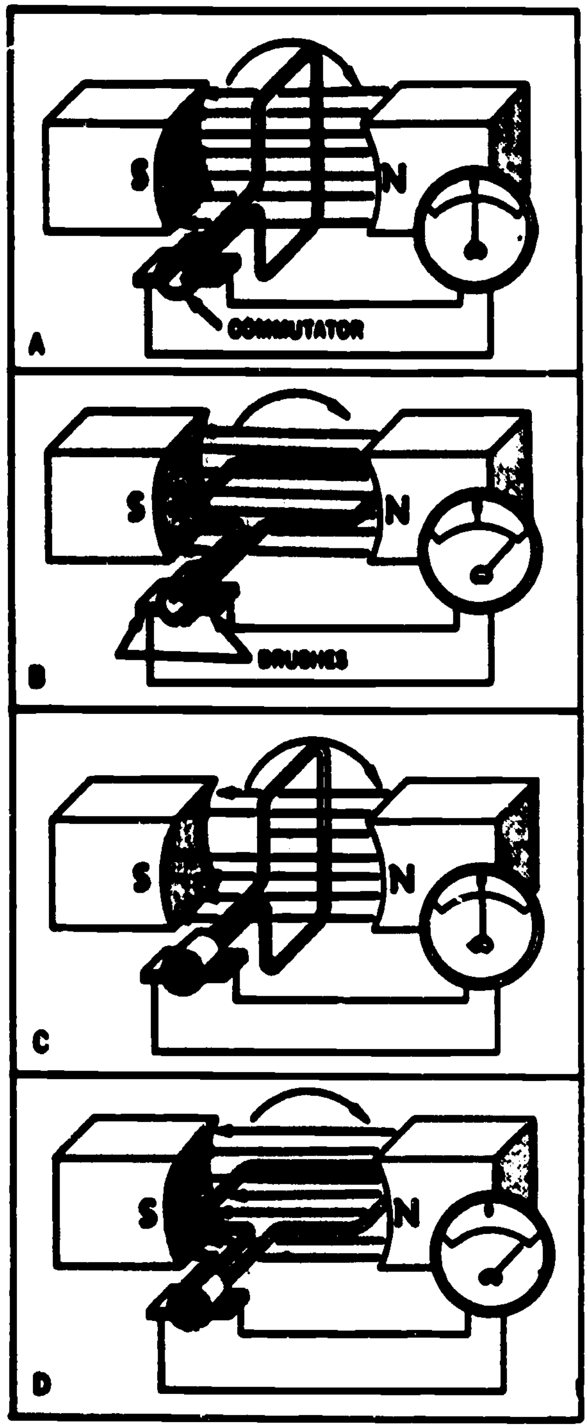


Fig 1-27. Simplified direct-current generator.

An elementary DC generator can produce voltage with a rotating loop of wire in a magnetic field: One set of coils is in motion, and the other set of coils acts as an electromagnet to set up a magnetic field. A simplified diagram of a DC generator is illustrated in figure 1-27. A loop of wire is the conductor which rotates in the magnetic field. The ends of the loop terminate in two copper half-rings which are insulated from each other. Fixed brushes make contact with the copper rings to conduct electricity to the external circuit. The loop is rotated in a clockwise direction. In position "A", the conductors of the loop are moving parallel with the field, and since the conductor is not cutting the lines of force, there is no voltage produced.

At position "B," the loop is moving at a right angle to the field, and voltage is at a maximum. At position "C," the loop is again moving parallel with the field, and voltage is zero. At position "D," the loop is cutting across the field and voltage is again at a maximum. Notice that the sides of the loop have now reversed themselves, but voltage to the external circuit, in this case a galvanometer, is still in the same direction. As the brushes are stationary, they deliver direct current, because either conductor in contact with a particular brush will have the same direction of motion across the field. Check the black brush in figure 1-27 at positions "B" and "D," and you will see that the sides of the loop change but the brushes remain stationary. With two brushes riding on the commutator to carry the current on an external circuit, you will have an ELEMENTARY DC GENERATOR producing direct current.

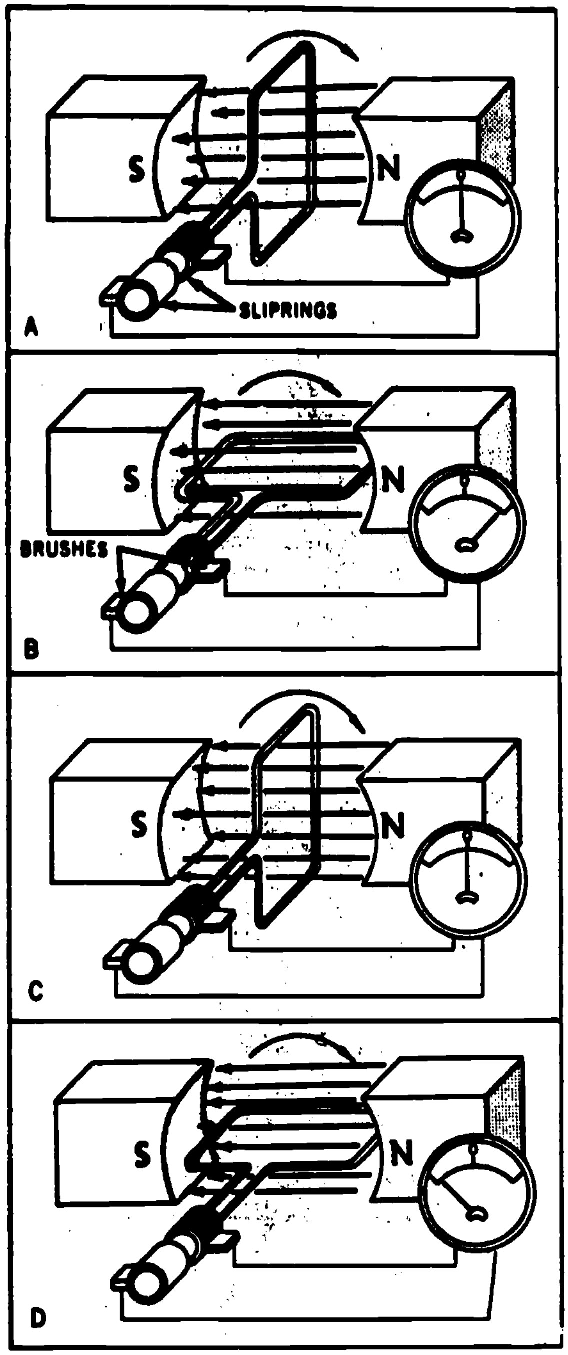


Fig 1-28. Simplified alternating-current generator.

A simplified diagram of an ELEMENTARY AC GENERATOR is shown in figure 1-28. The difference between the DC generator and the AC generator is in the method used to deliver the current to the brushes. In the AC generator, sliprings are used instead of a commutator. This means that the same side of the loop delivers current to the same brush regardless of rotation; otherwise, the operation is the same. Figure 1-28 shows the loop turning in a clockwise direction.

At position "A," the conductors are moving parallel to the field, so no voltage is produced. At position "B," the conductors are cutting across the field, and the galvanometer indicates the direction of current by the needle's pointing to the right. At position "C," the meter shows zero, as the conductors are again moving parallel with the field. At position "D," the conductors are again cutting the field, and the meter shows maximum voltage but in the opposite direction. What happened? At position "B," the black side of the loop is moving up through the field. Now the black slipring is negative. Current is directed from the white slipring to the meter and back. The direction of current in the loop reversed itself, and the same is true in the external circuit to the meter.

The two ends of the loop are connected to sliprings. Two brushes ride on the sliprings. Rotating the loop causes a current to be generated. The current, in turn, is transferred by the brushes to an external circuit. You now have an ELEMENTARY AC GENERATOR.

An AC and DC generator, then, are identical in generating voltage by the use of the rotating loop. If the current is taken from the loop by sliprings, it is an alternating current, and the generator is called an AC Generator. If the current is collected from a commutator, it is direct current. You will find that AC generators are normally referred to as ALTERNATORS.

Almost all of the alternators used in electrical power production by the Marine Corps are of the synchronous type with rotating fields and stationary armatures. With this type construction, the fields are wound on rotor poles, and the armature coils are assembled inside the alternator frame to form a stator assembly.

Generally speaking, alternators are of two types--SINGLE-PHASE and THREE-PHASE. They all look alike but are constructed differently. They operate on the principle of either moving conductors across a magnetic field or moving a magnetic field across the conductors. In either case, the results are the same. However, most of the AC alternators used in electrical power production are designed so that the magnetic field is moved across the conductors. With this construction, the AC output is taken directly from the stationary stator coils. Thus, no brushes or sliprings are used in the alternator high voltage output, but they are used to feed relatively low DC to the rotor coils to produce the magnetic fields.

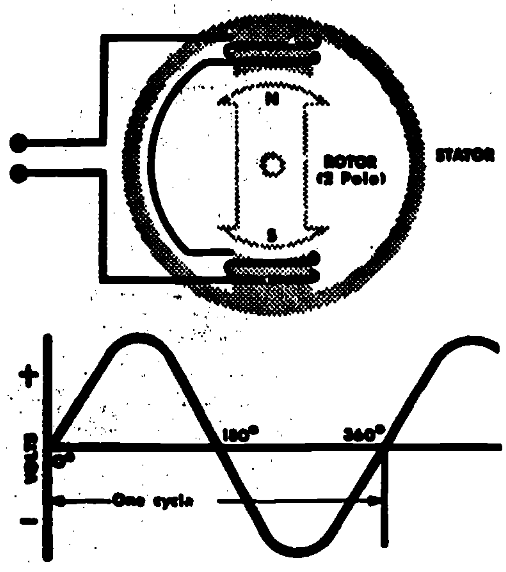


Fig 1-29. Single-phase alternator.

A single-phase alternator is the simplest type. Notice the schematic wiring diagram of the single phase alternator in figure 1-28. As shown by the sine wave in the diagram, the rotor revolves through one full revolution and produces one cycle of alternating current. The first half-revolution of the rotor produces a voltage in one direction and completes the first half of the cycle; the second half-revolution produces a voltage in the opposite direction and completes the last half of the cycle. This alternator will produce only one cycle of AC voltage during one revolution of the rotor. Since there are no overlapping cycles produced by the alternator, the voltage output is only single-phase.

The output of the three-phase alternator is used to operate almost all electrical equipment in the Marine Corps. For this reason, the three-phase alternator is most commonly used in electrical power production. While the output of this alternator is being used to operate three-phase equipment, it can be used at the same time to operate single-phase equipment from each of the phases or from a combination of any two of the phases.

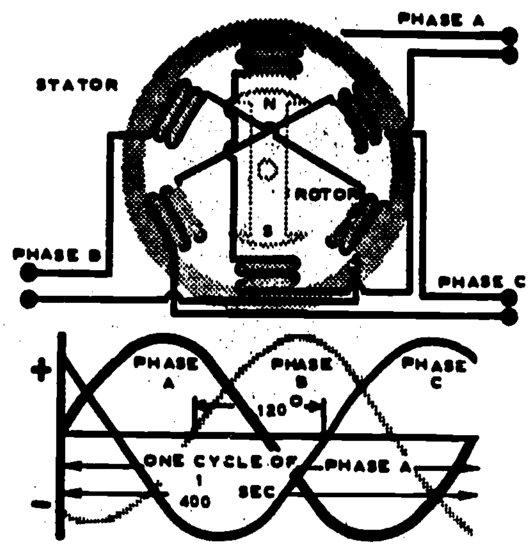


Fig 1-30. Three-phase alternator.

Figure 1-30, a wiring diagram of the three-phase alternator, shows the stator fields connected in pairs to produce a three-phase output. As the rotor turns through one revolution, each phase produces one cycle. By overlapping the cycles, as shown by the sine wave, the three-phase alternator produces a three-phase voltage output.

In actual construction, the rotor pole windings of an AC alternator are electromagnets whose magnetic strength is controlled by the amount of DC voltage applied to the brushes and sliprings. An increase in DC voltage applied to the brushes and sliprings causes an increase in current through the rotor pole windings. This increase in current produces a stronger magnetic field and, thus, provides a greater AC output. On the other hand, when less DC voltage is applied to the rotor pole windings, the alternator will have a lower AC output.

To furnish electric current for exciting the rotor pole windrings of an alternator, a source of direct current must be provided. This current is produced by an exciter. The exciter is a single, direct current generator with a rotating armature and stationary field coils. The basic components of the exciter are the same as those for a generator.

As the rotor of a three-phase alternator revolves, each phase delivers voltage in a given sequence, according to the method in which the alternator is connected. These phase voltages occur 120 electrical degrees apart. That is, when a cycle is started in a given direction by phase one, either phase two or phase three must start a cycle in the same direction, 120 electrical degrees later. Also, a third cycle must be started in the same direction 120 electrical degrees after the start of the second cycle. The order in which these cycles are generated is called PHASE ROTATION.

You will find that there are two methods of connecting three-phase alternators. These are the "DELTA" and "WYE" methods.

With the DELTA CONNECTION, the three alternator phases are connected together as you see in figure 1-31. In this illustration, each coil of the delta represents one phase of the alternator. The voltage between any two lines is the same as the voltage of the coil between the lines (phase voltage). For example, if volts were generated in each phase of the alternator, the voltage between any pair of the three lines would also be volts.

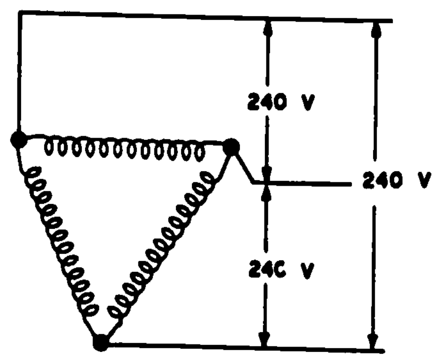


Fig 1-31. Delta connection.

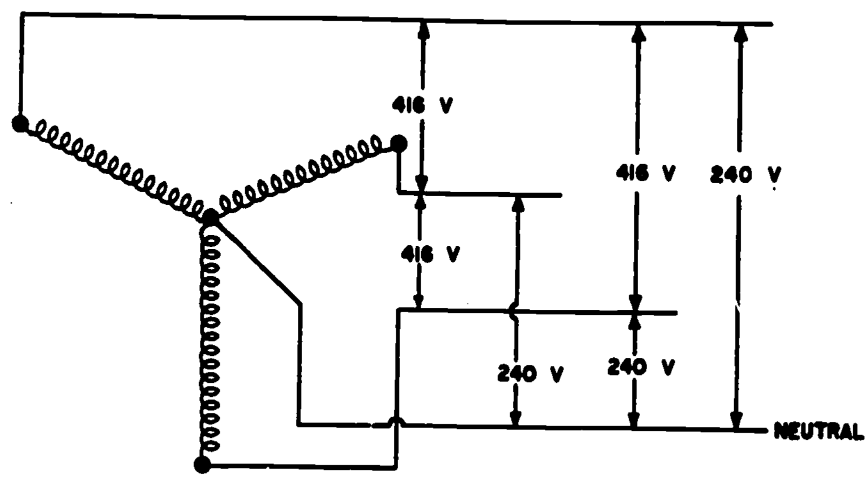


Fig 1-32. Wye connection.

With the WYE connected alternator, the phases are connected as shown in figure 1-32. In this type of connection, the voltage between any phase line and neutral is equal to alternator phase voltage--2,400 volts in this illustration. The voltage between any two of these phase lines, however, is approximately volts.

A BATTERY is a device used to produce a voltage by chemical means. When such a source of voltage is connected to a closed circuit, chemical energy is changed to electrical energy. Other than generators, chemical action is the most common source of electrical energy. In this day and age most of us use batteries in some way. You start your cars and play your portable radios with the energy from a battery. You use batteries for emergency light and power, for alarm circuits, and for the operation of relays and other devices.

A true battery is made up of units called CELLS. Often times, the terms "cell" and "battery" are used interchangeably. All cells are divided into two general types--PRIMARY and SECONDARY. Once the primary cell is used up, it is useless. On the other hand, the secondary cell may be recharged. In the following paragraphs you will learn more about the primary cell and the storage battery. The storage battery consists of two or more secondary cells.

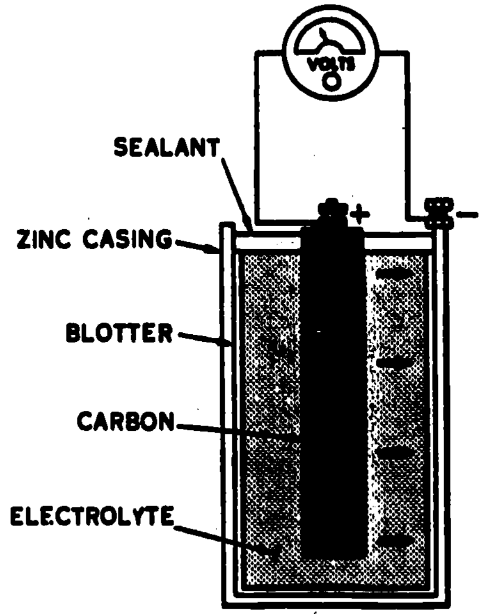


Fig 1-33. Primary (dry) cell.

First, let's look at the primary cell. There are many different sizes and shapes of primary cells in use today, and to try to cover them all would take a book in itself. The most common primary cell is the DRY CELL, the type used in an ordinary flashlight. A cross-sectional view of a dry cell is shown in figure 1-33. The two terminals are connected to plates in the cell and are called ELECTRODES. The zinc can serve as the negative electrodes as well as the container for the cell, and the carbon rod serves as the positive electrode. The electrolyte consists of a chemical dissolved in water and mixed with a thick paste. the paste prevents the electrolyte from spilling. The top of the cell is sealed to prevent evaporation of moisture and to keep the contents of the can from spilling. Connections to the cell are made by means of the terminal posts, which are connected to the zinc and carbon electrodes.

When the cell is connected to a circuit, a chemical reaction takes place between the electrolyte and the negative electrodes. This reaction results in a current flow from the negative terminal through to external circuit back to the positive terminal.

A single primary cell of the type shown in figure 1-33 develops a voltage of 1.5 volts. Keep in mind that the size of the cell has nothing to do with the voltage that it can develop. the voltage depends on two factors only--the type of electrolyte and the electrode material. The amount of current that a cell can furnish, forever, is dependent upon the area of the plates exposed to the electrolyte, or, the amount of current is directly dependent on the cell size. This is why flashlight batteries are quite small; whereas, batteries designed for heavier current flow are much larger.

As stated earlier, the voltage developed by a primary cell is 1.5 volts. This is the open circuit or no-load voltage. When a cell is supplying current to a circuit, the voltage is somewhat lower. The voltage under a load is called TERMINAL VOLTAGE.

The most common STORAGE BATTERY is the LEAD-ACID type, so called because the plates are made of lead and the electrolyte is acid. Probably the type of storage battery with which you are most familiar is the type used in cars and trucks (see fig 1-34).

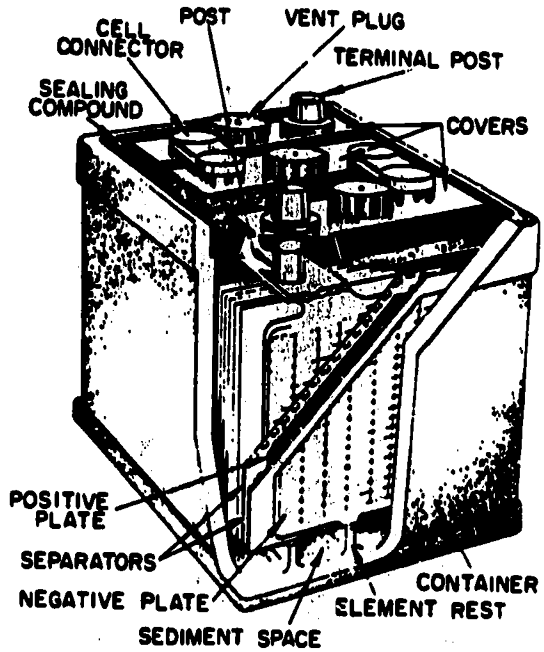


Fig 1-34. Lead-acid battery.

In a previous paragraph, a storage battery was defined as being made up of two or more cells. The exact number of cells, of course, depends on the desired voltage. Most cars, for example, use a 12-volt lead-acid battery. The battery consists of six cells (2 volts each) connected in series.

The battery is contained in a case which is divided into compartments, one compartment for each cell. Groups of positive and negative plates are assembled to form an element, and each element makes up one cell. The elements are immersed in a sulfuric acid and water solution called ELECTROLYTE. Thin sheets of wood, porous rubber, or glass fiber (called separators) are placed between the plates to prevent them from touching and causing a short circuit.

The battery plates are made in the form of a grid, which is filled with a soft lead paste, the active material in the plates. Several plates are put together to form a positive group and a negative group. The plates of each group are connected together and then connected to the external terminal or connecting post.

When a lead-acid type battery is charged and in operating condition, the active material on the positive plates is LEAD PEROXIDE, and on the negative plates, it is SPONGY LEAD. When the battery is discharging, the plates undergo a chemical change. The acid from the electrolyte units with the active plates material, and lead sulfate is formed on both the positive and negative plates. During discharge, the acid content of the electrolyte is decreased. If the battery is allowed to continue discharging, the sulfate deposit on the plates increases until no further chemical action can take place. In this condition, the battery is said to be completely discharged. Under normal operating conditions, the battery is NOT allowed to become completely discharged. A battery in which the plates have been allowed to accumulate a heavy deposit of lead sulfate is practically useless because it is almost impossible to recharge a battery in this condition.

The voltage of a storage battery is determined by the number of cells that it has connected in series. Although the open-circuit voltage of a lead-acid cell is approximately 2.2 volts, the cell is normally rated at only 2 volts. The cell is normally rated at only 2 volts because it drops to that value under load. A battery rated at 12 volts consists of 6 lead-acid cells connected in series, while a battery rated at 24 volts has 12 cells.

Another type of storage battery used in the Marine Corps is the NICKEL-CADMIUM. Its name comes form the composition of the plates--nickel in the positive plate and cadmium in the negative plate. Each cell of the battery is housed in a rubber case protected by a steel can. A special hydrometer is used to check the level of distilled water which is added to the cells to replace water lost by evaporation. Unlike the lead-acid battery, the nickel-cadmium battery contains an electrolyte solution of potassium hydroxide and distilled water. The electrolyte has no charge because it acts as a carrier of irons. For this reason, standard hydrometer readings are of no value in determining the state of charge in a nickel-calmium battery.

Nickel-cadmium storage batteries have several major advantages over other types of storage batteries. These batteries will recharge by the constant potential method with high initial current load and will maintain a relatively steady voltage when being discharged at a high current flow. It is possible for these batteries to stand idle in any state for a long period of time without damage. They can withstand extremely cold temperatures and are not subject to failure by vibration or severe jolting.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. What is the function of a generator?

____

2. How does a generator perform its function?

____

____

3. Identification: Identify the following statements concerning generators and alternators as being either correct or incorrect. Place a "C" in the space provide for the correct statements and "INC" by those that are incorrect.

_____ a. Any DC generator must have a commutator.

_____ b. There is a difference between the rotating coils and the magnetic field of an AC and DC generators.

_____ c. If current is taken from a rotating loop by sliprings, then it is alternating current.

_____ d. The difference between AC and DC generators is the method of collecting the current.

_____ e. When the generator rotating loop is parallel with the field, it will be producing maximum voltage.

_____ f. A generator takes the energy of the prime mover and charges the energy to electrical power.

4. What are the two types of alternators?

a. ______________________________

b. ______________________________

5. What are the two ways that an alternator might operate?

a. ______________________________

b. ______________________________

6. By what methods might a three-phase alternator be connected?

a. ______________________________

b. ______________________________

7. Explain briefly the operations of a single-phase alternator.

____

____

____

8. What is used to supply the DC voltage in a three-phase alternator for the magnetic field?

____

9. How many degrees are the plases set apart for three-phase operations of an alternator?

____

10. What is the difference between a primary and a secondary cell?

____

11. When fully charged, what materials make up the negative and positive plates of a lead-acid battery?

____

12. What solution is used for the electrolyte in a lead-acid battery?

____

13. What solution is used for the electrolyte in a nickel cadmium battery?

____

Work Unit 1-5. TRANSFORMER THEORY AND APPLICATION

GIVEN PERTINENT INFORMATION, DETERMINE THE OUTPUT FROM THE SECONDARY WINDING OF A TRANSFORMER.

SPECIFY THE TRANSFORMER ACTION WHICH INDUCES VOLTAGE.

NAME THE MAIN PARTS OF A TRANSFORMER.

In the discussion of electromagnetism and production of electromotive force, you found out that the induction of a voltage requires a relative motion between a magnetic field and a conductor and that the motion is produced mechanically in generators and alternators. You can also produce this relative motion electrically by building up and collapsing a magnetic field.

A TRANSFORMER is a device with no moving parts. It transfers energy from one circuit to another by electromagnetic induction. The energy is always transferred without a change in frequency. The change is usually in voltage and current.

Transformers are built in various shapes and sizes and serve various purposes. A step-up transformer receives electrical energy at one voltage and delivers it at a higher voltage. A step-down transformer receives energy at one voltage and delivers it at a lower voltage. Transformers require little care and maintenance because of their simple, rugged, and durable construction. The high efficiency of transformers is responsible for the extensive use of alternating current.

Various types of small transformers are used in a switch-gear. In many installations, transformers are used on switchboards to step down the voltage for indicating lights, instruments, and electrical protective devices. Other common uses include low-voltage supplies for lighting circuits, etc.

Instrument transformers include both voltage and current transformers. They are commonly used with AC instruments to measure high voltage or large currents and to isolate the high-power circuits.

Electronic circuits and devices use many types of transformers to provide necessary voltages for proper operation of components. The physical construction of these transformers differs widely and is not pertinent here.

Let's take a look at transformer action.

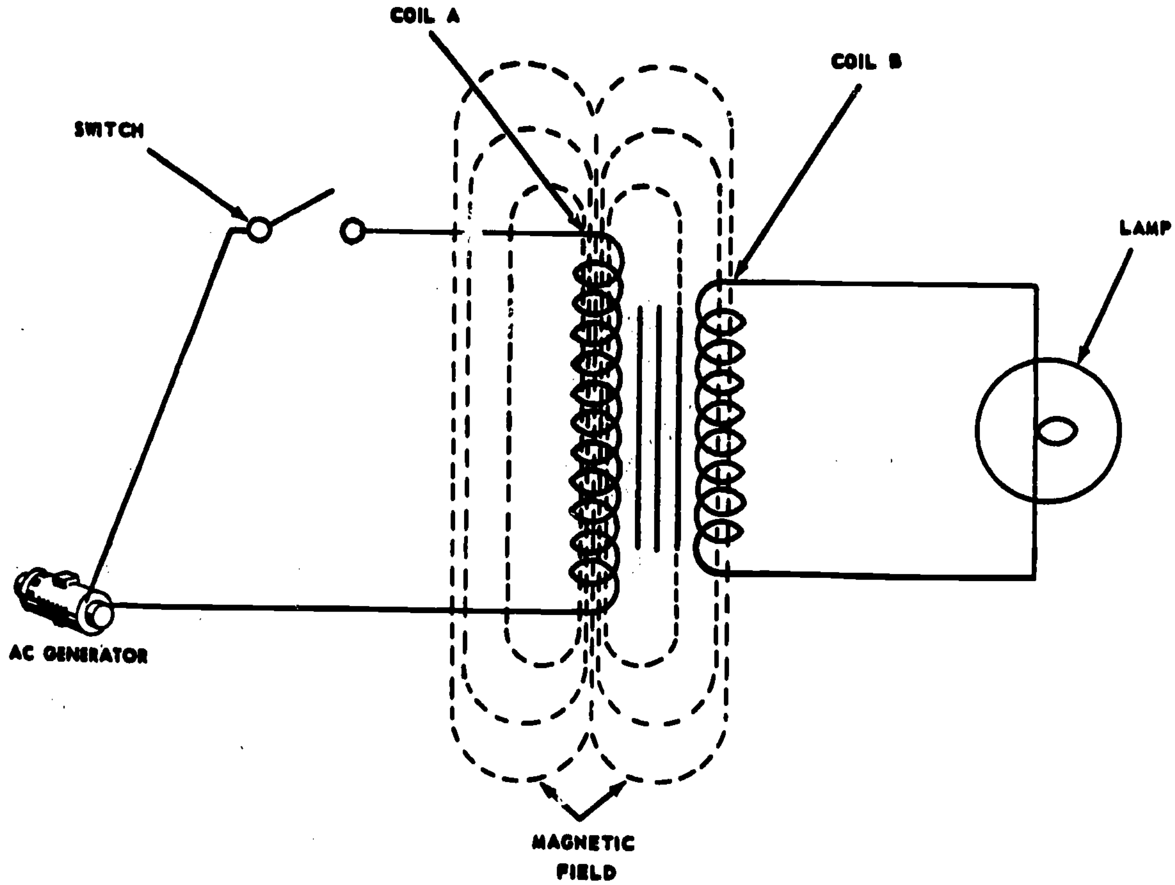


Fig 1-35. Transformer action.

Now, if you apply an alternating current to an electromagnet, a magnetic field will build up and collapse during each half cycle. In other words, the magnetic field which the current builds up during one-half of the cycle will collapse and build up in the opposite direction during the next half of the cycle. For example, a 60-cycle current will build up and collapse a magnetic field 120 times per second. If a second winding is placed around the iron core, the same magnetic field will build up and collapse across the turn of the second winding and induce a voltage in this second circuit (see fig 1-35). This action is called transformer action and is the principle upon which transformers operate. In actual construction, the iron core of a transformer has two windings: the INPUT, or primary winding and the OUTPUT or secondary winding. If both windings have the same number of turns, the voltage and current induced in the secondary winding are the same as that applied to the primary winding. If the secondary has more turns than the primary, a greater voltage and a smaller amount of current is induced in the secondary than that applied to the primary. If the secondary has fewer turns than the primary, a lesser voltage and a greater amount of current is induced.

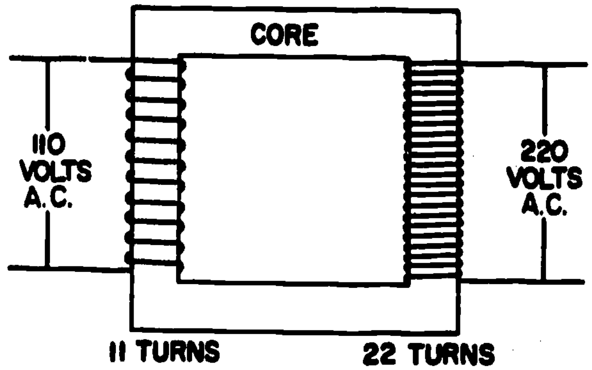


Fig 1-36. Transformer ratio.

The RATIO between the number of turns in the primary to the number of turns in the secondary determines the voltage ratio of the transformer. Figure 1-36 is a schematic diagram which illustrates the relationship between the turns ratio and the voltage. If the left-hand coil is connected to a 110-volt AC source, it would be the primary winding. The turns ratio would be stated as 1 to 2, the primary number being given first, since there are twice as many voltage turns (22) in the secondary as the primary. The voltage induced in the secondary (220) is twice the voltage applied to the primary. A transformer with a greater secondary voltage is called STEP-UP TRANSFORMER. If, in figure 1-36, you applied 220 volts to the 22-turn winding, the output of the secondary (11 turns) would be 110 volts. This would be called a STEP-DOWN TRANSFORMER because the secondary voltage would be less than the primary. The ratio of the transformer when connected in this way is stated at 2 to 1.

Transformers are often wound with the secondary split into two coils so that two voltages are available. A 240-volt secondary that has a lead brought out from a center tap will give 120 volts between the center-tap and either end of the coil; whereas, the full winding produces 240 volts. Taps are also used for voltage regulation in power distribution transformers. A series of taps are brought out, and by changing the tap connection, the voltage is changed. Distribution transformers are usually tapped for a 10-percent change in steps of 2.5 percent. Transformer windings are insulated for the voltage rating stamped on the name plate. They may be used on lower voltages, but should not be used on higher voltages because the insulation would break down.

A transformer will always have a small current in the primary winding when it is connected to a power source. This is the current necessary to set up the magnetic field in the core, the charging or magnetizing current. The power rating of a transformer is given on the name plate. This is the safe loading rating of the transformer and should not be exceeded. You should remember that the transformer is changing electrical power from one voltage value to another. The greatest advantage in transformer use is to transmit power over considerable distance at a high voltage and then to step it down to the desired usable value at the point of use.

The following points will help to explain to you the theory of the transformer operation:

- A transformer is an AC device which as a primary winding, a secondary winding, and an iron core.
- The primary and secondary are insulated from each other but are linked by the action of the magnetic field, which produces mutual induction.
- The number of turns in the windings determines the turns ratio of the transformer and the ratio between the primary and secondary voltages.
- A step-up transformer produces a secondary voltage which is higher than the primary voltage. Secondary current is less than the primary current.
- A step-down transformer produces a secondary voltage lower than the primary. Here the secondary current is greater than the primary current.
- The secondary winding may be center-tapped to produce more than one voltage.

- The transformer is one of the most efficient electrical devices in use; it loses very little power.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. If the ratio of a transformer is 6 to 1 and the applied voltage to the primary is 120 VAC, what is the voltage output from the secondary?

   ____

2. What type of transformer has a 1 to 6 ratio?

   ____

3. What isolates instruments from high voltages or large currents?

   ____

4. What will the transformer with a 2 to 1 turn ratio do to the voltage?

   ____

5. What causes voltage to be induced in the magnetic field?

   ____

6. Name the main parts of a transformer.

   ____

7. What can you do to the secondary winding of a transformer to produce more than one voltage?

   ____

SUMMARY REVIEW

In this study unit, you have learned the principles of AC and DC electricity, electrical characteristics, and the relationship of voltage, current, resistance, magnetism, and electromagnetism. In addition, you have learned to principles of basic power sources and transformer theory.

Answers to Study Unit #1 Exercises

Work Unit 1-1

1. Elements
2. Matter is composed of elements. It may also be said that matter is made up of very small units called molecules, which are made up of atoms, which in turn are made up of particles called protons, neutrons, and electrons.
3. To water flowing through a pipe
4. Compounds can be separated only by chemical means, and a mixture can be separated by physical means.
5. A molecule
6. Atoms
7. Electrons moving or flowing through a conductor
8. Voltage is electrical pressure.
9. Heat, magnetism, chemical action, and physical shock
10. Magnetism and heat
11. On what is it made of, its cross-sectional area, its length, and its temperature
12. The ohm
13. A natural magnet is a black mineral called lodestone or magnetite which exhibits magnetic properties. An artificial magnet is made of iron or steel magnetized by induction from some exterior source.
14. The lines connecting the direction of the field around a magnet from pole to pole are called lines of force.
15. It has an unstable structure and a low magnetic strength.

16. The fields of force interact, causing repulsion or attraction, depending upon the polarity of the poles.
17. C
18. INC
19. C
20. Electromotive force
21. increase
22. Electrons moving in one direction through a conductor
23. Electrons moving back and forth through a conductor at specific intervals

Work Unit 1-2.

1. The relationship applies to any circuit or part of a circuit; the current in amperes is equal to the EMF in volts divided by resistance in ohms.
2. a. $R = \frac{E}{I}$; $R = \frac{90}{30}$; R = 3 ohms
   b. E = I x R; E = 2 x (7 + 5);
      E = 2 x 12; E = 24 volts
   c. $I = \frac{E}{R}$; $I = \frac{24}{10 + 8 + 6}$; $I = \frac{24}{24}$;
      I = 1 AMP
3. In a series circuit, the relationship is a follows: The total resistance is the sum of the individual resistors; the same current flows in each part of the circuit; the applied voltage will divide among the resistors according to their resistance.
4. The first step should be to the reduce the two parallel resistors B and C to an equivalent single resistance.
5. In a parallel circuit, the total current equals the sum of the current in the branches.
6. A series-parallel circuit should be reduced to an equivalent, simplified circuit. Each group of parallel resistors is first replaced by its equivalent single resistance; the entire circuit is then treated as a series circuit.
7. d
8. b
9. a
10. c
11. The power is computed with the formula $P = I^2R$.
12. 120 watts

Work Unit 1-3.

1. From negative to positive
2. The term "hertz" has been adopted in recognition of Heinrich Rudolph Hertz, a German physicist.
3. f
4. a
5. k
6. b
7. e
8. h
9. d
10. c
11. g
12. j
13. l
14. When the circuit consists of pure resistance
15. When the current and voltage are out of phase due to reactance in the circuit
16. Power factor (PF) = $\frac{\text{100 x watts (three power)}}{\text{volts x amperes (apparent power)}}$

Work Unit 1-4.

1. The function of a generator is to convert mechanical energy into electrical energy
2. The generator converts mechanical energy into electrical energy by rotating field through the use of electromagnetic induction.

3. a. c
   b. inc
   c. c
   d. c
   e. inc
   f. c
4. a. Single-phase
   b. Three-phase
5. a. By moving conductors across a magnetic field
   b. by moving a magnetic field across the conductors.
6. a. Delta
   b. Wye
7. The first half-revolution of the rotor produces a voltage in one direction and completes the first half of the cycle; the second half-revolution produces a voltage in the opposite direction and completes the least half of the cycle.
8. An exciter supplies the DC voltage.
9. 120°
10. A secondary cell can be recharged; a primary cell cannot be.
11. Negative plate - spongy lead
    Positive plate - lead peroxide
12. Sulfuric acid and water
13. Potassium hydroxide and distilled water

Work Unit 1-5.

1. 20 VAC
2. A step-up transformer
3. Instrument transformers
4. Step it down
5. Build up and collapse of the current
6. Primary winding, secondary winding, and iron core
7. Center-tap it

STUDY UNIT 2

SAFETY AND FIRST AID

STUDY UNIT OBJECTIVE: WITHOUT THE AID OF REFERENCES, YOU WILL IDENTIFY THE SAFETY AND FIRST AID PROCEDURES THAT ARE OR MAY BE NECESSARY IN OR AROUND THE WORK AREA, PLUS THE JOB SITE, SO THAT YOU WILL BETTER UNDERSTAND THE DANGERS THAT YOU WILL FACE IN YOUR WORK ENVIRONMENT.

As an electrician, you are a skilled worker. The mark of a skilled worker can be seen by the excellence of the product he produces and also by the safe manner and methods he uses in producing it. A master of his trade seldom gets hurt. He knows his tools and equipment and keeps them in good working condition. He understands the dangers of his working environment and never takes chances that will put him/her in danger of being hurt. He studies the rules of safety and has the wisdom to apply them. DO NOT for one minute think that your NCOIC or OIC will think more of you if, to save a little time, you ignore the rules of safety. They will know you for what you are--foolish or immature. That statement in plain, simple language is "TO BREAK SAFETY RULES IS TO BE A FOOL."

Develop in your mind a respect for SAFETY RULES. They were developed for your protection and for the protection of the equipment you operate. Always operate your equipment according to the step-by-step procedures given in the operational instructions. If there are no operational instructions published by the unit, follow the manufacturer's operating and maintenance instructions.

Base and Unit safety personnel know beyond the shadow of a doubt that unsafe working habits will eventually create an ACCIDENT. If an accident occurs and someone is hurt, you should be prepared to perform first aid. First aid refers to the treatment given the sick or injured before regular medical or surgical treatment can be administered by trained medical personnel. In this study unit you will be provided with information that, if followed, will prevent accidents and help those that are injured in accidents.

Work Unit 2-1. SAFETY

STATE WHO CAUSES MOST OF THE ACCIDENTS IN A WORK AREA.

LIST THE THREE BASIC CAUSES OF ACCIDENTS.

FROM A LIST OF STATEMENTS RELATIVE TO WORK AREA SAFETY PRACTICES, IDENTIFY THOSE THAT ARE TRUE.

FROM A LIST OF PRACTICES RELATIVE TO THE GENERAL USE OF HAND-TOOLS, IDENTIFY THOSE THAT ARE NOT SAFETY PRACTICES.

FROM SITUATIONS INDICATING SAFE AND UNSAFE OPERATION OF ELECTRICAL POWER TOOLS, DISTINGUISH BETWEEN THE SAFE AND UNSAFE PRACTICES.

GIVEN WORK SITUATIONS, DISTINGUISH BETWEEN THOSE THAT CONTRIBUTE TO UNSAFE USE OF POWER EQUIPMENT AND THOSE THAT CONTRIBUTE TO SAFE USE.

DIFFERENTIATE BETWEEN SAFE AND UNSAFE LIFTING SITUATIONS AND SEQUENCE LIFTING STEPS IN THE CORRECT ORDER.

GIVEN VARIOUS TYPES OF LADDERS AND THE USES OF EACH, MATCH THE TYPE OF LADDER WITH THE APPROPRIATE TYPE OF USE.

FROM SELECTED SITUATIONS, CHOOSE BETWEEN THOSE THAT DEMONSTRATE PROPER LADDER RAISING TECHNIQUES AND PLACEMENT AND THOSE THAT ARE IMPROPER.

GIVEN SITUATIONS CONCERNING THE USE OF LADDERS, MATCH EACH SITUATION WITH THE APPROPRIATE LADDER SAFETY PRECAUTION.

FROM A LIST OF PRACTICES RELATIVE TO ELECTRICAL WORK, IDENTIFY THOSE THAT ARE SAFE.

FROM A LIST OF PRESUMED SAFETY PRECAUTIONS RELATED TO HANDLING CHEMICALS OR CHEMICAL SOLUTIONS, DISTINGUISH BETWEEN THOSE THAT ARE ACTUALLY SAFE AND THOSE THAT ARE ACTUALLY UNSAFE.

GIVEN A LIST CONTAINING THE TYPES OF FLAMMABLE MATERIAL AND A LIST WITH THE CLASSES OF FIRE, MATCH THE FLAMMABLE MATERIAL WITH THE CLASS OF FIRE.

STATE THE EXTINGUISHER AGENT TO USE ON VARIOUS TYPES OF FIRES.

ACCIDENTS are usually the result of a failure to think. You must think safety and use safe procedures. You must be aware of the hazards involved in your work. When you fail to think safety and practice safety, you are not only a danger to yourself but to everyone working with you. One moment of carelessness may result in a serious injury or death. Therefore, it is part of your job as an electrician to practice safety at all times. The goal of this study unit is to present information that will cause you to think of the hazards and their causes in your work area and to think of the action to take for protection against these hazards and their causes.

ACCIDENTS DO NOT JUST HAPPEN, THEY ARE CAUSED. Most of the accidents are caused by the worker. He causes the accidents by being careless or getting in too much of a hurry to take the necessary precautions. In fact, 88 percent of all accidents are caused by unsafe acts of people. Likewise, a worker failing to recognize unsafe conditions in his/her work area is a likely candidate for an accident. Usually, this type of accident is the result of physical hazards and includes unsafe equipment. Accidents of this type amount to 10 percent of all accidents. Accidents caused by unsafe acts and by physical hazards can be prevented. Even natural elements can be controlled to some extent, and it is only in the realm of nature involving such phenomena as lightning, st-rms, earthquakes, or floods that accidents are extremely difficult to prevent. However, only 2 percent of all accidents are caused by natural phenomena (see fig 2-1).

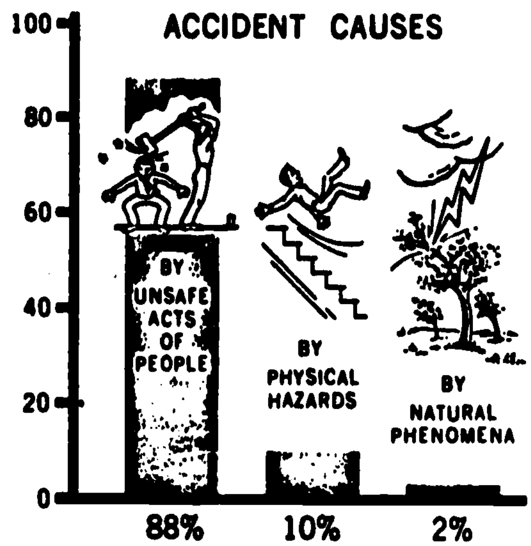


Fig 2-1. Accident causes.

Your work area may contain many potential hazards if you fail to follow the safety rules set up for your protection. The safety rules will make you conscious of some of the things you should do and some you should not do.

Failure to keep your work area clean and in order can result in both major and minor accidents. Broken bones, cuts, gouges, bruises, burns, and many other injuries can result from poor housekeeping. To prevent these injuries you simply practice good housekeeping. Here are some important items to consider as safety practices for your work area (and also your living area):

o Keep all floors and walkways clean, dry, and free from spilled oil, fuel, and or other contaminants. If fuel, oil, or grease is spilled, clean it up immediately.

o Make sure your shop or other areas are adequately ventilated at all times. Vapors from fuels, oils, gases, and some types of acids are injurious to your health.

- Keep all working areas well lighted, if at all possible. You cannot work efficiently and safely without sufficient light. Check the lighting system frequently and report or replace burned out lamps and fuses.

- DO NOT leave tools scattered about on floors, workstands, or other places. Always use the cabinets and boxes provided for tool storage.

- DO NOT clutter your work area with unnecessary equipment. If you do not intend to use an item, store it in a safe place.

- Keep all ropes, chains, cables, hoses, and electrical cords properly stored when not in use.

- Provide suitable waste containers and make sure that waste is promptly put into the proper container. Mark each container for the material for which it is to be used. Use extra care in disposing of scrap metal, tubing, wire, glass, etc. Make sure that all parts of the materials are well inside the waste container. The sharp edges of these materials can cut and tear your skin as well as your clothes.

- Inspect all electrical cables and equipment for frayed wiring insulation, exposed contacts, and inspect the condition of switch handles and other controls.

- Inspect your shop frequently for protruding nails, bolt ends, and other sharp points that can cause injury. Also make sure that broken windows and door glasses are replaced promptly and that the broken glass is properly disposed of.

- Insure that water fountains, lunch areas, and clothing lockers are clean and sanitary. Illness caused by contaminated water and food can become more serious than most accidents.

Poor maintenance and the improper use of common handtools result in many accidents which could be avoided if proper safety procedures were always followed. As you cover specific tools later in study unit 3, you will learn safety precautions about individual tools. The following are safety procedures pertaining to handtools in general:

- Keep tools sharp.

- Keep tools in their proper places.

- Replace handles that become splintered or loose.

- Dress mushroom heads on cold chisels, punches, drift pins, etc.

- Protect the edges of cutting tools with a sheath or by storing them separately from other tools.

- Select a box-end wrench or a socket in preference to a open-end or an adjustable wrench as the former are less likely to slip. To help prevent slippage, always pull the wrench toward you.

- Wear goggles or face shields when there is a possibility of flying chips, sparks, etc.

- Hold small items that you are working on in a vise.

- NEVER use a tool for anything other than what it is intended to be used for: i.e., don't use a hammer handle for a pry bar, a wrench for a hammer, a knife for a screwdriver.

- Use screwdrivers for what they are designed--to drive and remove screws. Keep the blades ground and shaped properly at all times. Select the proper type and size of screwdriver for the job. Never hold an object in one hand while working on it with a screwdriver. Place it in a vise.

- Use files and rasps with handles that are designed for them. Without the proper handle, a file or rasp is dangerous because it is easy for the tang to injure the palm of your hand.

- Keep chisels and punches clean and sharp because it is easy for a dull or dirty tool to slip and injure you.

Each year, scores of workers have been injured on the job because of neglect or because of not knowing that a dangerous situation existed. An electrician using a grounded drill was severely injured when he fell off a ladder after grabbing a moist water pipe as he was drilling a hole in a wall. As he touched the pipe, he received a severe electrical shock that passed from his right hand, through his body near his heart, and to his left hand which contacted the pipe. Although the voltage was only 110, the jolt frightened him. He fell sideways on a sawhorse, and the body of the drill hit him on the shoulder. This electrician was off duty for 3 weeks. A 110-volt charge of electricity is dangerous, especially when you are working on damp or wet pavements and grounds. It can kill you, so be aware of electrical hazards and precautions as you use electrically powered tools.

As an electrician, you will use a variety of tools powered by electricity because they make your work easier and because they are faster and more efficient. However, because of their source of power, they can be hazardous unless you know how to guard against the hazards. The main hazards are from fire and shock caused from improper or no grounding and from cord abuse.

Electric powered handtools are a source of ignition for a fire if used near flammable materials or in explosive atmospheres unless they are of the explosion-proof type. You must be aware of this hazard as you work in areas which have dust and fumes.

When you use power tools, check them to make sure they have three-wire cords. The extension cord must also have three wires and be plugged into a grounded receptacle. Figure 2-2 shows how a drill motor equipped with a three-wire cord can protect the operator by providing a low resistance path to ground for the current from a defective tool. It also shows what can happen to you when using equipment that is improperly grounded.

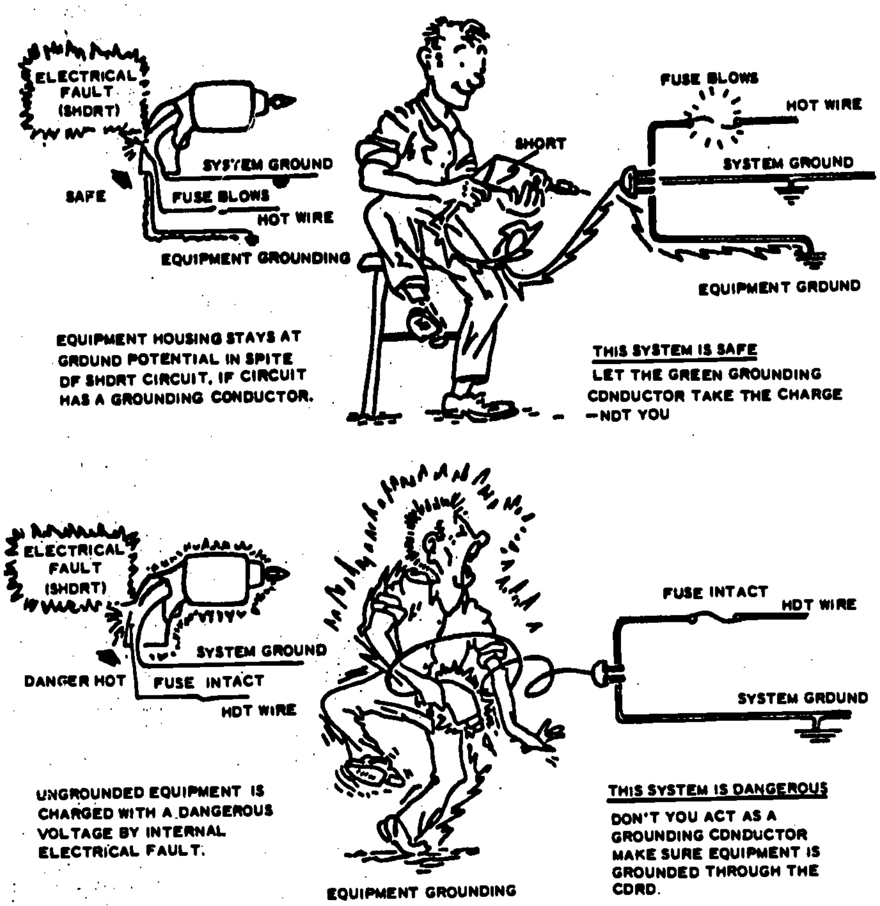


Fig 2-2. How equipment grounding works.

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It is important to protect the cord on your power tools. This is also true of the extension cord. The conductors in the cord, the insulation on the cord, and the plugs must be protected if you are to have safe operation. Scrapes, kinks, or stretching, as well as grease and oil, will damage power tool cords or extension cords. Use heavy-duty plugs which clamp to the cord. DO NOT jerk the cord when unplugging it from a receptacle. Jerking the cord can break the cord wires or cause the connections in the plug to become loose which may cause a short circuit.

The following is a list of precautions to take when you use electric power tools:

- Inspect the equipment, especially the external wiring, before you use it.
- Use safety glasses or face shields where chips or dust could fly or tools could break.
- DO NOT wear loose gloves or loose clothing while using rotating equipment.
- Exchange accessories with the power off and the cord unplugged. Remove guard if necessary.
- The guard must be in place before starting the tool.
- DO NOT wear rings, metal-rimmed glasses, watches, or other metallic objects when working with electrical tools.
- If you use equipment in damp locations, stand on a rubber mat and wear rubber gloves.
- Be certain the tool is properly grounded.
- Check the operating instructions prior to operating electrical tools. On large equipment these instructions are usually located on a data plate which is attached to the equipment. On smaller, portable equipment go to the manufacturer's manual to find instructions.
- Operate all tools in accordance with manufacturer's instructions.

You can be severely injured by coming in contact with moving machine parts. Although the Marine Corps has prescribed standards for safety in the use of machines, you must use common sense as you work with and around power equipment. Since machines are developed or changed frequently, you must be able to apply general safety rules to specific machines or specific uses of power machines. Some of the general rules that apply to equipment safety follow:

- DO NOT wear jewelry, loose clothing, long sleeves, or gloves while operating machinery.
- Use brushes to remove chips and metal particles. DO NOT use your hands.
- Where the possibility of flying particles exists, wear goggles or a face shield.
- DO NOT remove or block a machine guard while the machine is in operation.
- DO NOT leave machinery operating unattended.
- DO NOT clean, lubricate, adjust, or maintain machinery while it is in motion.

When you must lift a heavy or large object from the floor, remember this advice: USE YOUR LEGS--NOT YOUR BACK. If you are not mindful of this advice, you can hurt your back very seriously. A hurt back often takes a long time to heal and can keep you from taking part in many athletic activities. Figure 2-3 shows the way you should lift. Study the figure and pay close attention to the feet, legs, and back. Lifting and setting down are the first and last movements performed in handling materials. It is during these movements that most strains occur. It is important that an electrician consider the following basic lifting techniques so as to reduce the possibility of injury:

- Consider the size, weight, and shape of the object to be carried. DO NOT try to lift more than you can handle comfortably. If necessary, get help.

o Set your feet solidly with one foot slightly ahead of the other for increased stability. Place your feet far enough apart to give you good balance.

o Get as close to the load as possible. Bend your legs about 90° at the knees. Crouch or squat.

o Keep your back as straight as possible. It need not be vertical, but it should not be arched. Bend at the hips and knees, not at the waist.

o Grip the object firmly. Maintain your grip while lifting and carrying.

o Straighten your legs to lift the object and, at the same time, bring your back to a vertical position.

o <u>NEVER</u> carry a load that you cannot see over or around. Make sure that the path of travel is clear.

o Set down the object using procedures opposite to those you used to pick it up.

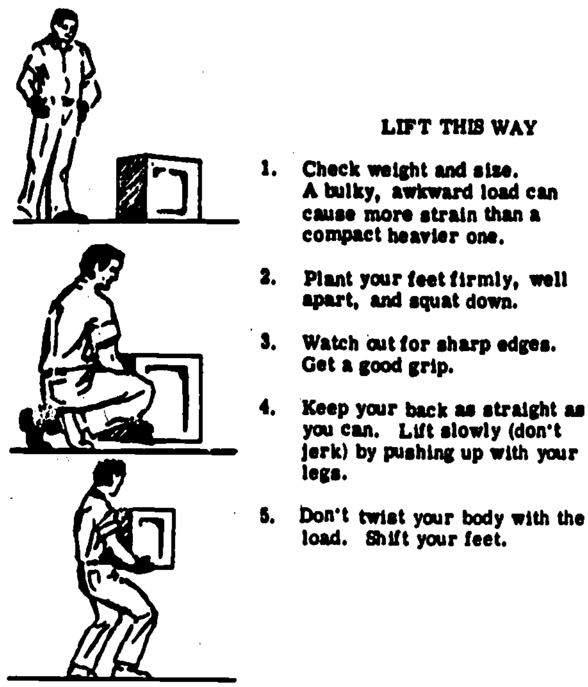


Fig 2-3. Lifting procedures.

Much of the work you do will have to be done from a ladder. Serious accidents have been caused by electricians who use ladders improperly. It is important for you to know the right type of ladder for the job. The most common types of ladders that you will be using are the <u>single ladder</u>, <u>extension ladder</u>, and <u>stepladder</u>.

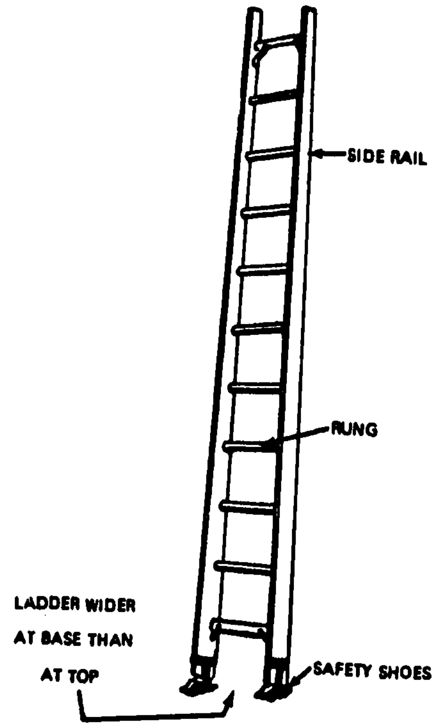


Fig 2-4. The single ladder.

The SINGLE LADDER used by the electrician consists of two side rails from 8 to 26 feet in length, with rungs spaced 1 foot apart. A good single ladder will support up to 500 pounds. The size of a ladder is determined by its overall length. Figure 2-4 shows a typical single wooden ladder.

The EXTENSION LADDER (see fig 2-5) consists of two or more sections. These sections overlap and are extended by pulling on an attached rope. They are available in lengths up to 60 feet. Extension ladders are required by the electrician to do work of short duration, such as changing lamps, checking circuits, or getting onto a roof.

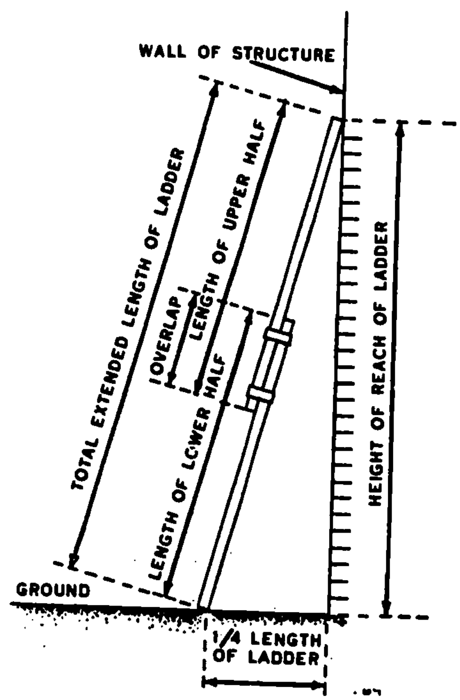


Fig 2-5. Extension ladder.

A STEPLADDER is self-supporting (see fig 2-6). This ladder can be used effectively as a portable work platform because it has wide rungs to make it easier to stand on for long periods of time. The most common size you will use is the 6-foot stepladder, but they are available in sizes up to 16 feet.

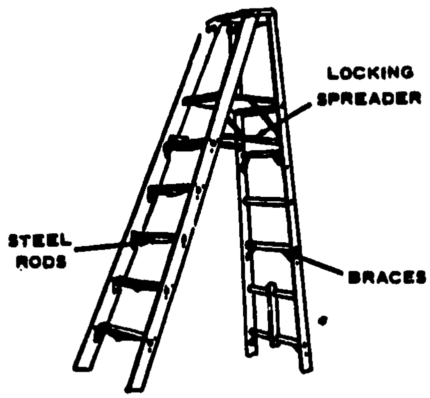
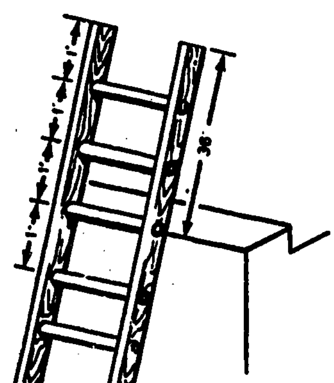


Fig 2-6. Stepladder.

When you work with a ladder, be aware of the proper procedures to follow in the erection of it.

Raise a straight ladder by placing the base of the ladder (wide end) against the foundation of the structure. Lift the top and walk under the ladder toward the bottom end, grasping and raising the ladder rung by rung as you proceed. When the ladder is perpendicular, pull the bottom out from the building to a distance of one-fourth its length, as shown in figure 2-5. If you must get on top of the building, the ladder should extend at least 36 inches above the eave (see fig 2-7).



NOTE: LADDER SHOULD EXTEND AT LEAST 36" ABOVE BUILDING OR PLATFORM

Fig 2-7. Correct ladder height.

When the extension ladder is in the collapsed position, it looks the same as the straight ladder. After the extension ladder is placed against the structure, extend the sections by the means provided until the ladder reaches the necessary height.

To put up a stepladder, spread the back legs away from the front legs until the locking device locks. This locking device keeps the legs from collapsing when weight is placed on the ladder.

When using any type of ladder follow these safety precautions:

- ALWAYS inspect a ladder before using it.

- Before climbing a ladder, be sure that both rails rest on solid footing.

- Equip the ladder's side rails with safety shoes (see fig 2-8). This is especially necessary when you use the ladder on surfaces that would permit the ladder to slip.

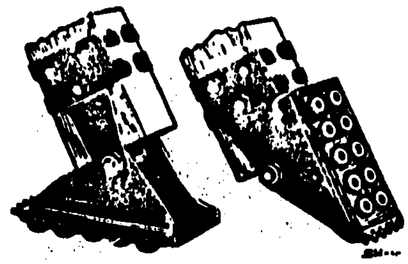


Fig 2-8. Ladder safety shoes.

- Under NO circumstances use stepladders as substitutes for workbenches.

- When you go up or come down a ladder, face the ladder and hold on to each side rail.

- When the security of a ladder is endangered by other activities, rope off the area around it, fasten it securely, and assign someone to steady the bottom.

- When you use a ladder in front of a door, lock the door or block off the door and route personnel to another exit.

- NEVER leave a ladder unattended for any length of time while it is erected--take it down and lay it on the ground.

- When working from an extension ladder, stand no higher than the third rung from the top and DO NOT attempt to reach beyond a normal arm's length.

- If you need help to do the work, have your helper get another ladder - DO NOT allow anyone on the ladder with you.

- NEVER climb a ladder while using both hands to hold material; at least one hand must be used while climbing or descending a ladder.

- NEVER place either the top or bottom of a ladder against unstable material.

- Before climbing a stepladder, be sure it is fully open and locked and that all four legs are on solid footing.

- DO NOT leave tools on the rungs of a stepladder unless it is equipped with a special holder.

- DO NOT stand on either of the top two steps of a stepladder.

- NEVER use metal ladders where there is a possibility of coming in contact with electric current.

- Get help when erecting long, heavy ladders.

As an electrician, one of the major hazards which you will encounter in your job is that posed by electricity. You shun an area when you see a sign reading: DANGER HIGH VOLTAGE. Why? Because you have heard that it takes high voltage to kill and that low voltage does not kill. This is not true. Many people have been killed when they came into contact with a 120-volt house circuit. Others have been killed by lower voltage. Still other people have experienced shock from much higher voltages and suffered no injury. Since you never know what your body resistance is, avoid contact with any live circuit. When your body is wet, you offer less resistance to shock than when you are dry. NEVER work with electricity when your body is wet.

Current flow through the human body is actually the cause of electric shock. Voltage causes the current to flow through the body; therefore, you are more likely to get a fatal shock from a high voltage circuit. Some authorities state that a current flow of 100 milliamperes (1/10 ampere) through the human body is usually fatal. Electric shock interferes with your breathing process and paralyzes your muscles. When the shock is great enough, you lose consciousness in just a few seconds.

With your work in the electrical field, you must be FULLY aware of the hazards involved when working with electrical equipment. In fact, the more you know about electricity, the safer you can do your work. The rules given here are for your own safety and for the protection of the people who work with you. You should study them carefully until you are familiar with them. You must practice them until they become second nature to you. Among pilots the term called "forgiven error" refers to a mistake which did not result in disaster. This term can well be applied to your work in the electrical field. When you find that you made one of these forgiven errors, you should review the events which led you to make this mistake. You will thus find the source of your mistake and be able to avoid a similar situation in the future.

TREAT ALL ELECTRICAL CIRCUITS AS BEING LIVE. This rule must be observed in all cases, except when you open the switch, make a voltage test, and know that the line is dead. In the case of long lines which are opened and grounded at some distant point, an inspection or test must always be made to find out what conditions exist. REMEMBER that someone may accidentally close the wrong breaker, connecting your circuit to high voltage. Furthermore, to keep anyone from accidentally closing the breaker to a circuit which is undergoing repair, the breaker should be locked on the OFF position and tagged to indicate that the system is being repaired. General rules which must be observed in electrical work are as follows:

- DO NOT wear identification tags when working around electrical machinery.

- DO NOT wear jewelry or clothing with exposed metallic fasteners when around batteries or electrical equipment.

- Always use safety tools and devices wherever they are provided. This includes the following:

  - Fuse pullers for removing and replacing fuses.
  - Rubber floor mats around electrical panels.
  - Rubber aprons when working on acid type batteries.
  - Work gloves when working around high temperature equipment.
  - Rubber gloves when working on live electrical circuits.

- ALWAYS follow safe operating procedures. A person must NEVER work alone on energized electrical circuits.

- DO NOT struggle with a tool box or an item which is too heavy to be handled conveniently.

- DO NOT clutter your work area with unnecessary equipment. If you do not intend to use an item, store it in a safe place.

- ALWAYS use the right tool for the job.

- When possible, use handtools so that the working force is always directed away from your body. This will minimize the chances of injury in case the tool should slip.

- NEVER put your hand on an electrical conductor unless you are working on a circuit and know that the circuit is dead. Always be sure that the switches to the circuits on which you are working are locked out and tagged.

- NEVER try to remove a person or a tool from a live circuit with your hands or a piece of material which may be a conductor. Insulating material, such as a shirt or piece of dry rope, can be used as a loop to pull a person from a live circuit.

- If battery acid should splash on you, immediately flood the affected part by washing with water. In cases involving the eyes or face, flush thoroughly and immediately seek medical aid.

As a general rule, NO work should be performed on energized electrical circuits or equipment. As an exception, work MAY be performed on energized circuits to prevent possible injury to others, or where critical missions will be jeopardized by interruption of service. If it becomes necessary for you to work on energized circuits, work ONLY with other fully qualified electricians. Make sure you have the necessary protective equipment--rubber gloves, rubber blankets, rubber mats, etc. The type of work and the conditions under which you work determine the exact type of protective equipment to use. One thing you must remember: safety equipment can be defective, so inspect it before you use it. A small crack or hole may make it unsafe for use. Do your job thoroughly; your life depends upon your thoroughness.

De-energized circuits do not present as great a hazard as do energized circuits. Nevertheless, you must be careful and observe safety rules. Make sure the circuit is de-energized by opening the switch. In some cases, you may be able to lock the switch in the OPEN position. Where the switch cannot be locked, remove the fuses and attach a warning sign to the switch. Keep in mind that a circuit may become accidentally shorted to another circuit. For this reason, test the circuit with a voltmeter to make sure it is not shorted and still "hot." You cannot afford to become careless, even when working on a "dead" circuit. NEVER lean against water pipes or other grounded devices when you work on any electric circuit.

The types of chemicals that you will most likely be concerned with are those used for storage batteries. These chemicals are used as electrolyte for the batteries. The two you may come in contact with are sulfuric acid, used in lead-acid batteries, and potassium hydroxide, used in the nickel-cadmium batteries.

The first precaution to observe in working with acids is the process of mixing them. The proper mixing procedure is always to ADD THE ACID TO THE WATER. Pouring small amounts of acid into a larger volume of water allows adequate cooling of the mixture. If this mixing procedure is reversed by pouring water into the acid, a violent reaction may occur and acid may be splashed over a wide area.

SULPHURIC ACID is dangerous to any part of your body, especially to your eyes. In the event of any contamination, the affected area must be flushed immediately with a solution of bicarbonate of soda and water. If the eyes become contaminated, immediately flushing with large volumes of water is important, and expert medical aid should be obtained at once. Sulphuric acid will also damage clothing, shoes, or just about anything with which it comes in contact. One more hazard of this unpleasant material is its possible explosion hazard. When a battery containing sulphuric acid is being charged, a quantity of hydrogen gas is given off. This hydrogen gas is highly explosive. For this reason, battery rooms or other battery charging areas must always be considered as NO SMOKING AREAS.

POTASSIUM HYDROXIDE is not an acid, but its use requires the observance of certain safety precautions. Potassium hydroxide (KOH) is very dangerous to the skin and eyes. It destroys tissues and causes severe burns. Breathing the vapors may result in injury to the respiratory system. Some safety precautions to observe in handling any battery electrolyte are listed as follows:

- ALWAYS wear full protective clothing, including gas tight goggles.
- Use safety showers and eyewash fountains immediately upon contamination.
- Neutralize and flush all contaminated areas and equipment.
- Keep all battery areas well ventilated and DO NOT breathe vapors from batteries.
- Treat lead-acid type batteries area as NO SMOKING AREAS.

Although firefighting is the prime responsibility of the fire department, it is your job to prevent fires and to help put them out if they do start.

Good housekeeping is essential in the prevention of fires. If you let trash, waste, dust, and other residue build up, they become a source of fire. Oily rags, for example, can ignite by spontaneous combustion. You can prevent fires of this type by storing oily rags in a metal container with a lid (see fig 2-9).

Fig 2-9. Fire prevention at work.

Another serious fire hazard is the accumulation of fuel vapors, gases, paint vapors, and other items of this nature. To eliminate this type of hazard, keep your shop clean and well ventilated. Prevent fires whenever you can, but also know something about the four classes of fires and something about how to fight them.

You can put out fires in each of the four classes by the use of a particular action or extinguishing agent. Some fire extinguishers do not work well on all classes of fires. Water, for example, may cause an oil fire to spread rather than put out the fire.

CLASS A FIRES are fires occurring in wood, clothing, paper, rags, and other items of this type. This type of fire can usually be put out with water. Water provides the cooling and quenching effect necessary to extinguish class A fires. You may also use the soda-acid type extinguisher on this class of fire. Another type of extinguisher you can use on class A fires is the foam type. You may also use foam on class B fires.

CLASS B FIRES are those occurring in flammable liquids such as gasoline, fuel oil, lube oil, grease, paint, etc. The agents required to put out this type of fire are those which will blanket the surface of the fire. This action creates a smothering effect. The types of fire extinguishers for use on class B fires are foam, carbon dioxide (CO_2), and dry chemical. The dry chemical units contain a dry powder, usually sodium bicarbonate, and an activiting agent of CO_2 or nitrogen gas. The dry chemical extinguisher is also used on class C and class D fires.

CLASS C FIRES are fires that occur in electrical equipment and facilities. The extinguishing agent for this type of fire must be a nonconductor of electricity and must provide a smothering effect. The dry chemical extinguisher is used for this purpose.

CLASS D FIRES occur in combustible metals such as magnesium, potassium, powdered aluminum, zinc, sodium, titanium, ziconium, and lithium. The extinguishing agent for this type of fire must be a dry-powdered compound which creates a smothering effect.

In the case of any fire, there are some actions required of the individual who discovers the fire. His/her first action should be to sound the alarm and alert all personnel. Second, the base fire department must be notified and given exact directions to the location of the fire. These two actions must be taken quickly, and after they have been taken, the personnel in the area should apply the most effective means available to put out or contain the fire. When assigned to a new shop, you should locate the nearest fire extinguisher in the area. Also find out what types of extinguishers are available and how to operate them. This information is usually printed on the extinguisher itself.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. Who causes most of the accidents in a work area?

   ____

2. List the three basic causes of accidents.

   a. ______________________

   b. ______________________

   c. ______________________

3. Identification: Place "S" beside each of the following statements which reflects good work area safety practices and a "U" beside the unsafe ones.

   a. Prodding a fellow worker in the ribs is OK if not done too often.

      ____

   b. Frayed 110-volt wires can be used if bare wires are not exposed.

      ____

   c. Since you will use a portable drill in 4 hours, leave it on the workbench.

      ____

   d. Close all shop windows in the winter to save on the heating bill.

      ____

   e. When a fuse keeps burning out in a certain circuit, place a penny behind it.

      ____

   f. Leave your tools in the places where you will use them.

      ____

   g. A clean shop is an inefficient shop.

      ____

   h. Assume that broken windows are replaced promptly.

      ____

4. Indentification: Indicate by placing an "U" beside the following statements which are NOT good safety practices. Place an "S" beside the statements which indicates good safety practices.

   a. Use a screwdriver as a wedge. __________

   b. Use a box-end wrench in preference to an open-end wrench. __________

   c. Store all cutting tools with the other tools, without sheaths. __________

   d. Wear goggles when drilling a hole above your head. __________

   e. Hammer a rusted pipe union with a pipe wrench. __________

   f. Keep tools sharp. __________

   g. Sharpen screwdrivers to a knife edge to cut wood. __________

5. Identification: Identify each of the following situations as "S" for safe or "U" for unsafe procedures to follow when using electric-powered tocls.

   a. Using a 2-wire extension cord ______

   b. Jerking the plug from a receptacle ______

   c. Ventilating areas subject to petroleum vapors ______

   d. Operating electric motors in dust-filled rooms ______

   e. Tools operated on 110-volts need not be grounded ______

   f. Read operating instructions before operating an electric tool ______

   g. Inspect equipment before you use it ______

   h. Never operate an electric tool in damp locations without protection ______

6. Identification: Place an "S" after each of the following statements which indicates good safety procedures and place a "U" after each statement which indicates unsafe practices.

   a. Inspect shop machines prior to using them ______

   b. Machines operated with motors of less than 2 horsepower require no ground ______

   c. Brush off metal cuttings from machines with gloves ______

   d. Do not leave machines operating unattended even for 5 minutes ______

7. Identification: In using a ladder mark the following situations with an "S" for safe and a "U" for unsafe practices.

   a. Lifting a ladder 12 feet long with a helper ______

   b. Lifting an object 4 feet in diameter that weights 65 pounds by yourself ______

   c. Lifting your toolbox by bending at the waist ______

Matching: Match each usage in cloumn 1 (items 8-11) with the most appropriate type of ladder in column 2. Place your answer in the spaces provided.

Column 1 Usage	Column 2 Ladder
8. ______ Used to get onto a flat roof that is 30 feet high.	a. Single ladder
9. ______ Used in the middle of a room. To remove a panel from a 9-foot ceiling to get to a circuit.	b. Stepladder
10. ______ Used to get onto a roof 10 feet high.	c. Extension ladder
11. ______ Used for a job requiring you to work for several hours. Your reach must extend 2 feet more than it can when you are standing at ground level.	

12. Identification: Indicate by placing "Yes" before each of the following statements which indicate the proper ladder raising techniques and "No" before each which indicates improper techniques.

a. ______ The top of a 20-foot ladder extends 4 feet above the roof. The base of the ladder is 4 feet from the foundation.

b. ______ The top of a 10-foot ladder extends 36 inches above the eave.

c. ______ Extend an extension ladder on the ground before raising it.

d. ______ Spread a stepladder until the legs lock in position.

e. ______ Place the bottom of a straight ladder against a foundation to raise it.

13. What part of a straight ladder do you grasp with your hands when you erect it?

____

____

Matching: Match the flammable material in column 1 (items 14-17) with its class of fire in column 2. Place your answer in the spaces provided.

Column 1

Flammable Material

14. ______ Magnesium

15. ______ Electrical equipment

16. ______ Paper and rags

17. ______ Gasoline and grease

Column 2

Class of fire

a. Class A
b. Class B
c. Class C
d. Class D

Work Unit 2-2. FIRST AID

STATE THE RESPONSIBILITIES OF INDIVIDUALS ADMINISTERING FIRST AID.

LIST THE FOUR LIFESAVING STEPS OF FIRST AID.

SPECIFY THE PROCEDURES NECESSARY TO PERFORM THE FOUR LIFESAVING STEPS.

STATE THE FIRST AID TREATMENT REQUIRED IN CASE OF ELECTRIC SHOCK.

STATE THE METHODS USED TO TRANSPORT INJURED PERSONNEL.

As you may already know, first aid refers to the treatment given to the sick and injured before trained individuals can administer regular medical or surgical treatment. Personnel in the Navy Medical Service have the finest medical equipment available, and they are trained in the most modern methods of saving lives and easing pain. But they can not be everywhere at once, so in an emergency you may have to depend upon your own knowledge of first aid.

Someday you may save someone's life--possibly your own--if you know how to give first aid. As a MARINE you have two reasons for learning first aid. Proper first aid may not only save the lives of many fellow Marines, it may mean a vital mission can be accomplished which might save many lives of fellow Marine's. Learn how to give first aid; you can not afford not to.

You can easily learn the fundamentals of first aid. Highly technical, involved study is not necessary to become a proficient first-aider. You can improve your first aid skills just by learning the contents of this work unit. But you can--and should--do more.

The proficient first aider deals with the whole situation, that is, the person as well as the injury. When giving first aid, a person who lacks the knowledge and skill of proper techniques could cause more injury to an injured person. A person who causes such injuries could be held liable in a court of law. Anyone attempting to assist another must use extreme care and skill in performing first aid.

In practicing first aid, it is just as important to know what NOT to do as it is to know what to do. Keep calm, use first aid measures, and seek medical help as soon as possible. NEVER attempt treatment that is beyond your skill, and never move an injured person unless it is absolutely necessary.

Your job as a first-aider is to take the right emergency measures and to have the patient in better condition for treatment when trained medical personnel get to him or her.

To treat an injured person, you should carry out what is known as the FOUR LIFESAVER STEPS. These steps are: assure breathing, stop the bleeding, protect and treat the wound, and prevent or treat shock. You should memorize these four lifesaver steps and learn the simple methods of carrying them out. Now is the time to learn how to do this. Prompt and correct first aid not only may save a life but will also speed healing.

The first action to take is to clear the airway and stop any severe bleeding immediately. Clearing the airway will allow the victim to breathe and will permit mouth-to-mouth respiration if it is necessary. Arterial bleeding must be stopped or the victim will bleed to death in a very short time.

To protect the wound is the next important step. This action may also be a good way to stop the bleeding as pointed out in a later objective on treating wounds. The final step, which actually begins when you control bleeding, is to prevent or treat for shock. This should always be done regardless of symptoms. These steps will be covered in more detail.

ALWAYS make sure a victim is breathing properly. ASSURE BREATHING. To do this, place your ear close to the victim's mouth and nose, look toward the victim's chest for rise and fall, listen for air from exhalation, and feel for flow of air on your check. You should take at least 5 seconds for this check to make sure the person is not just slightly breathing.

If a victim has stopped breathing completely, give artificial respiration at once. Death occurs quickly once breathing has stopped, so quick rescue and treatment of a person whose chest movement is stopped by debris, beams, etc., are essential. Irreparable brain damage results from the lack of oxygen for more than four minutes.

The most important thing to keep in mind in giving artificial respiration is to start immediately!!! DO NOT waste time moving the victim to an ideal spot; DO NOT wait for mechanical equipment. START AT ONCE.

You may have learned the old prone pressure method or the more recent back pressure-arm lift or back pressure-hip lift methods. It has now been proved that the mouth-to-mouth (or mask-to-mouth) method is far better than any other. In this method, the victim is placed on his back and receives your exhaled air. It saves more lives, and it is simpler to perform. It works because you normally take only one quarter of the oxygen out of the air that you breath in.

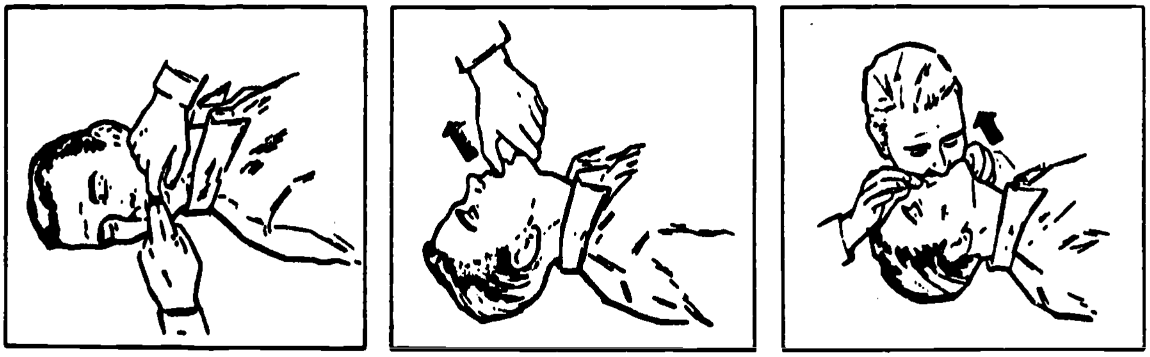
DO NOT waste time on old methods or by worrying about getting infected. The chance of infection is small. You have a life to save.

One of the first steps of artificial respiration is to be sure that the airway is open. If there is an obstruction, air cannot get in the lungs no matter what method you may use. The airway of an unconscious victim is usually blocked to some degree.

There are three main causes for obstruction of the airway. The first is foreign matter, such as false teeth or liquids, in the mouth or throat. The second is relaxation of the jaw. The tongue is attached to the jaw so that it can fall backward and block the throat (called swallowing the tongue). The third is the position of the neck. When the neck is bent forward so that the chin is down close to the chest, there is a tendency for the throat to become "kinked" and block the passage of air.

Keep the airway open by placing the victim's head in the position of an individual looking upward while holding his/her lower jaw forward in a sword-swallowing position. When someone stops breathing, establish an open airway at once.

Refer to figure 2-10 as you study the following steps for mouth-to-mouth artificial respiration.



A B C

Fig 2-10. Mouth-to-mouth artificial respiration.

- Turn the victim on his/her back.

- Clean the mouth, nose, and throat. If the mouth, nose, and throat appear clean, start artificial respiration immediately. If foreign matter such as vomitus or mucous is visible in the mouth, nose, and throat, wipe it away quickly with a cloth or by passing the index and middle fingers through the throat in a sweeping motion (see fig 2-10, A).

- Place the victim's head in the "sword-swallowing position." Place his/her head as far back as possible so that the front of his/her neck is stretched.

- Hold his/her lower jaw up. Approach the victim's head preferably from his/her left side. Insert your left thumb between the victim's teeth at the midline. Pull his/her lower jaw forcefully outward so that the lower teeth are further forward than the upper teeth. Hold his/her jaw in this position as long as the victim is unconscious. You can wrap a piece of cloth around your thumb to prevent injury to yourself by the victim's teeth (see fig 2-10, B).

- Close the nose. Close the victim's nose by compressing it between the thumb and the forefinger of your right hand.

- Blow air into the victim's lungs. Take a deep breath and cover the victim's open mouth with your open mouth to make an airtight contact. Blow until the chest rises. Blow forcefully into adults and gently into children (see fig 2-10, C).

- When his/her chest rises, stop blowing and quickly remove your mouth from the victim's. Take another deep breath while listening for his/her exhalation. If the victim's exhalation is noisy, elevate the jaw further.

- When exhalation is finished, blow in the next deep breath. The first three or four breaths must be deep (except for infants and small children) and given at a rapid rate in order to provide rapid reoxygenation. After the first 3 or 4 breaths, adjust your breathing to a rate of 12 to 20 times per minute with only moderate increase in normal volume. In this way, rescue breathing can be continued for long periods without fatigue.

Caution: Excessive deep and rapid breathing may cause you to become faint, to tingle, and even to lose consciousness.

Continue rhythmically without interruption until the victim starts breathing or is pronounced dead by qualified medical personnel. A smooth rhythm is desirable, but split-second timing is not essential.

After performing rescue breathing for a period of time, you may see that the victim's stomach is bulging. This is due to air being blown into the victim's stomach instead of the lungs. Although inflation of the stomach is not dangerous, it makes inflation of the lungs more difficult.

If you see that the stomach is bulging, turn the victim's head to one side and be prepared to clear the mouth before you apply brief but firm pressure to the stomach. This action gets the air out of the stomach but may cause regurgitation. If this happens, clear the mouth and throat before you resume inflation of the lungs.

The following are steps necessary to perform mouth-to-mouth respiration for small children and victim's with tight jaws. Usually, you cannot use the mouth-to-mouth procedure described above on children under the age of 3 because the large size of your thumb interferes with adequate mouth-to-mouth contact. In addition, you may find this method difficult in a victim whose mouth cannot be opened. In these cases, use the following steps:

- (Same) Turn the victim on his back.

- (Same) Clean the mouth, nose, and throat.

- (Same) Place the head in the "sword-swallowing position."

- Hold the lower jaw up--alternate technique.

- Approach the victim's head from his/her left side. With both of your hands, one on each side of the victim's head, grasp the angle of his/her lower jaw below the ear lobes. Lift his/her lower jaw forcefully upward so that the lower teeth are further forward than the upper teeth. To open the victim's lips, pull his/her lip down with your thumb while forcefully holding the lower jaw up and forward. Hold the jaw in this position as long as the victim is unconscious.

- Close the victim's nose and blow air into the lungs--alternate technique.

- Take a deep breath and cover the victim's mouth with your mouth, causing an airtight contact. Block the victim's nose to prevent air leakage by pressing your right cheek against the nasal openings. (Your hands are occupied elsewhere.) With a baby, the rescuer's mouth can cover both the mouth and nose with an airtight contact. Blow rapidly until the chest rises. Blow forcefully into adults and gently into children.

- Let air out of the victim's lungs. After the chest rises, quickly separate lip contact with the victim and allow the victim to exhale by himself/herself. If the chest does not rise, improve the support of the victim's air passageway and blow more forcefully. Repeat the inflations 12 to 20 times per minute.

If a victim wounded in the face, neck, or chest is having difficulty in getting enough air, your best move is to get him/her to where he/she can receive medical attention quickly. It may be best to transport the victim lying on his/her abdomen ratner than on his/her back. Consider all injuries in determining which position to carry him/her in. <u>USE GOOD JUDGMENT.</u>

Adequate respiration is not enough if the heart is not circulating the blood. The indications of loss of heart action are absence of pulses in the large vessels of the neck, thighs, and other places used as pressure points; gradually enlarging pupils; loss of consciousness; bluish discoloration; and occasionally, convulsions. The best place to check for a pulse is in the neck. This is called the carotid pulse and can be felt with the tips of the index and middle fingers slightly behind the larynx between the wind pipe and the muscles at the side of the neck. If you are confident that the heart has stopped (cardiac arrest), you should begin closed chest massage at the same time with mouth-to-mouth respiration. This is commonly referred to as cardiopulmonary resuscitation (CPR).

To perform CPR, the following procedures are used:

<u>Note</u>: If at all possible it is highly recommended that you enroll in a CPR class to become proficient in the procedures used in CPR. These classes are provided by the Red Cross and the Naval Medical Service.

- Place the victim on a firm surface.

- Place the heel of one hand over the lower half of the victim's breastbone (but not ver the tip end); then place the other hand on top of the first.

- Rock forward, keeping your arms straight and using the weight of the upper part of our body to exert enough pressure to depress the breastbone 1-1/2 to 2 inchas (see fig -11). Keep your hands in place while you release the pressure (see fig 2-12).

- Repeat this cycle uniformly and smoothly about once per second.

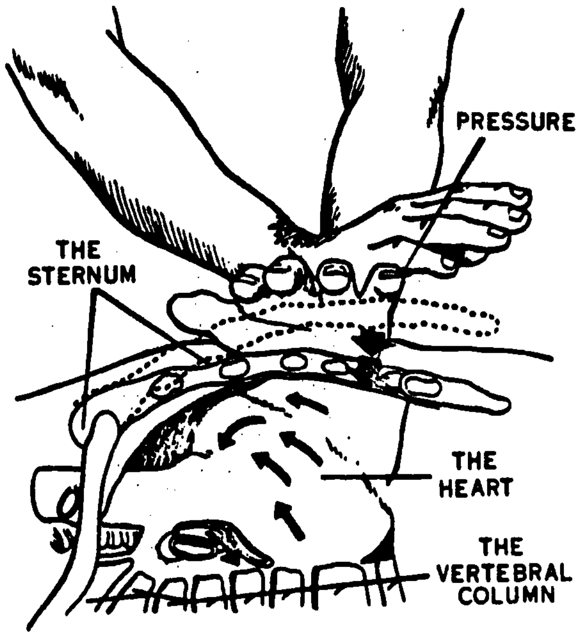


Fig 2-11. Pressure forces blood out of the chest.

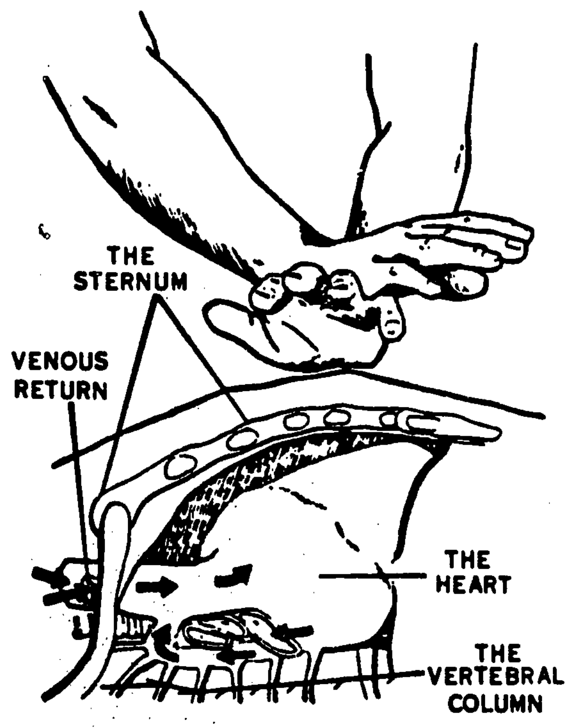


Fig 2-12. Release pressure to refill the heart.

Use only the heel of one hand on larger children, and only two fingertips on a baby or very small child.

If you are alone, give 2 inflations, mouth-to-mouth, after each 15 compressions of the chest. If you have help, compress the chest five times to each inflation.

In the second lifesaving step, "STOP THE BLEEDING," when blood leaves the heart, it is pumped into large blood vessels called arteries. As pressure from the heart drives the blood, it moves through smaller and smaller arteries, finally reaching the smallest blood vessels, the capillaries. By the time the blood begins its trip back to the heart, it has lost the push given by the heart. After leaving the capillary the blood enters larger and larger vessels, called veins, which lead back to the heart.

Types of bleeding are classified by the type of blood vessel which has been cut. These types are called arterial, venous, and capillary bleeding. In arterial bleeding, the most dangerous type, there is a large amount of bright red blood, and it is usually possible to detect a spurting or pumping action. When a vein is cut, a large amount of darker red blood flows, but without the pulsating flow which characterizes arterial bleeding. In capillary bleeding, the blood oozes or flows very slowly from the wound.

Uncontrolled bleeding may cause or increase shock, and it may finally result in death. To stop bleeding, first apply pressure to the wound with a dressing, or, if necessary, with some substitute such as a parachute or undershirt. Be sure to use clean articles if possible. Place the open dressing against the wound and apply firm pressure. Continue pressure as long as needed. Wrap the tails of the dressing around the wounded part and tie the ends to hold the dressing firmly against the wound. If the pressure of the bandage is insufficient to control bleeding, continue hand pressure.

If the wound is on an arm or leg and if bleeding continues, place the victim on his/her back with wounded arm or leg raised. In this position the blood does not flow into the wounded limb as fast, thus bleeding from the wound is slowed. The bleeding is slowed, not stopped, by raising the arm or leg, so you still have to use the dressing and pressure.

DO NOT raise the limb if you suspect that the limb is broken. Moving a broken arm or leg is dangerous since it can result in further injury to the victim and may increase shock.

You can often reduce or stop bleeding by applying hand or finger pressure at various points on a victim's body. These points are shown in figure 2-14.

The PRESSURE POINTS in the groin and neck are particularly important. If the wound is too high to apply a tourniquet on the leg, use the pressure points in the groin. Use a neck pressure point when the casualty has a profusely bleeding scalp wound; however, use the neck pressure point only as a last resort--when other methods of stopping bleeding have failed. DO NOT APPLY PRESSURE TO BOTH NECK POINTS AT THE SAME TIME. To do so would severely reduce the blood supply to the brain, causing unconsciousness and then death.

When pressure and elevation fail to stop bleeding from a limb within a few minutes, or when blood is gushing from a wound, apply a tourniquet quickly. A tourniquet is a wide band of cloth or other material applied around the wounded limb to stop the flow of blood. DO NOT use a wire or rope. If someone else is available, have that person use an appropriate pressure point while you apply a tourniquet. REMEMBER, NEVER APPLY A TOURNIQUET UNLESS BLOOD IS GUSHING FROM THE WOUND OR UNLESS THE PREVIOUS METHODS OF STOPPING BLEEDING HAVE FAILED. THE REASON FOR THIS IS THAT UNINJURED TISSUE BELOW THE TOURNIQUET MAY DIE FROM LACK OF BLOOD AND OXYGEN.

Tighten a tourniquet ONLY enough to stop arterial bleeding (gushing of blood from the wound). Veins continue to bleed until the limb is drained of blood already present in it; thus, in such an instance, bleeding is not reduced by further tightening of the tourniquet.

Always place the tourniquet between the wound and the heart, in most cases just above the wound. However, if there is bleeding right below the knee or elbow, you should place the tourniquet just above those joints. When possible, protect the skin by putting a tourniquet over the smooth sleeve or pant leg.

The victim should be seen by a medical officer as soon as possible once the tourniquet is applied. The tourniquet should not be loosened by anyone other than medical personnel prepared both to stop the bleeding by other means and to replace the blood. Repeated loosening of the tourniquet by inexperienced personnel is extremely dangerous because the life of the victim is endangered through further loss of blood.

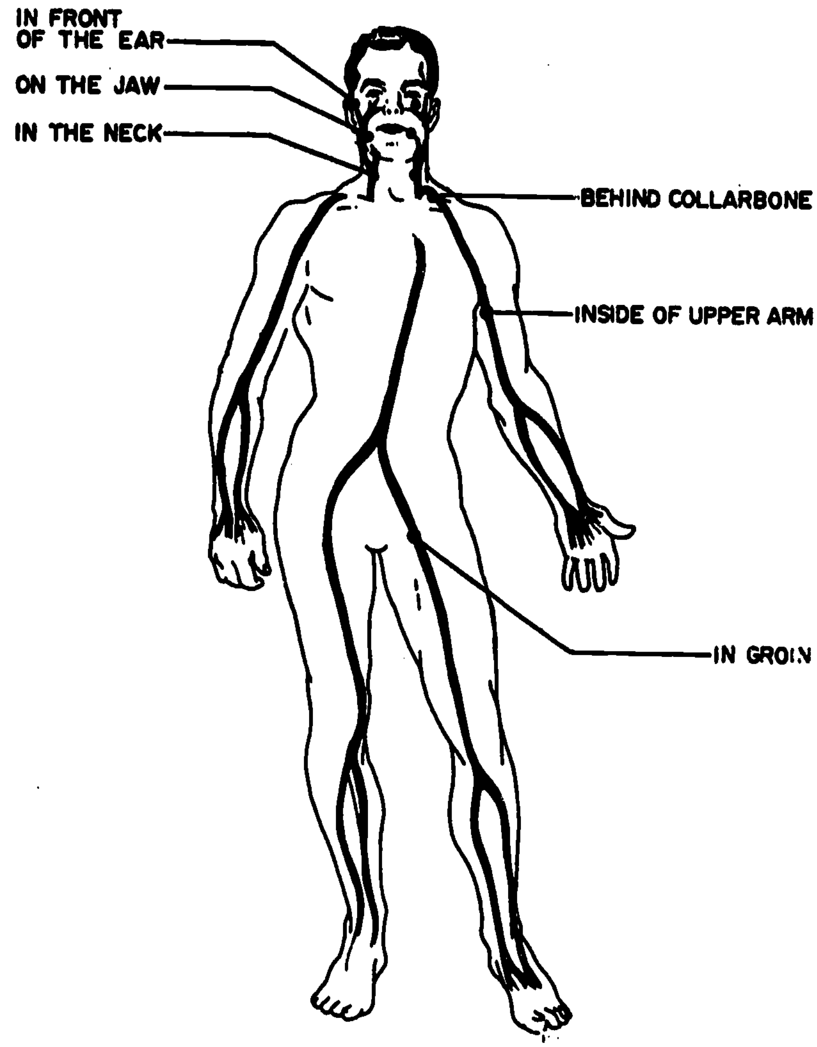


Fig 2-14. Pressure points for bleeding control.

If conditions permit you to stay with the wounded person, inspect the tourniquet frequently to see if it has slipped or if there is any sign of more bleeding. Replace the tourniquet if necessary, to its proper position. If further bleeding occurs, further tightening of the tourniquet may be required.

In extremely cold weather, arms and legs to which tourniquets have been applied are subject to cold injury; therefore, be careful to protect such extremities from cold.

PROTECT AND TREAT THE WOUND, the third lifesaving step, are important measures that must be kept in mind while giving first aid to any casualty.

The best way to protect a wound is to cover it with a sterile gauze or dressing. A dressing held in place by a bandage helps to stop the bleeding, as you learned earlier. It also helps protect the wound from germs and other foreign matter and helps prevent more injury.

You should keep your hands off the wound when applying the dressing; do not touch the side of the dressing that goes next to the wound. Do not pull clothing over the wounded area; tear or cut clothing away from the wound instead.

A wound that is not bleeding severely and is not deeper than skin tissues should be cleaned before it is dressed and bandaged. To clean the wound, wash your own hands with soap and water. Wash in and around the wound to remove bacteria and foreign matter. Rinse the wound with clean water and blot the wound with a dry sterile gauze pad or clean cloth. Then apply a dry sterile dressing, or at least a clean dressing, and bandage it in place. DO NOT attempt to cleanse a deep wound because doing so may cause bleeding to resume.

Chest wounds are particularly dangerous if air is being sucked in and blown out of the chest cavity through the wound. When such a condition exists, the wound itself is not as bad as the air which goes through it, because air squeezes the lung, thus collapsing it. Proper breathing becomes impossible.

Make the chest wound airtight as soon as possible. The victim's life depends on it. To make the wound airtight, have the victim exhale (breathe out) as much as possible. As soon as all of the air is exhaled, apply a dressing which is large enough to stop the flow of air through the wound; the dressing should do more than cover it. Pack the dressing firmly over the wound. Cover the dressing with a large piece of material, such from a waterproof garment, to help make the wound airtight. Bind this covering securely with a belt or strips of torn clothing.

Encourage the victim to lie on his/her injured side to that the lung of his/her uninjured side can receive more air. If the victim wishes, let him/her sit up. This may ease breathing. As in all cases of severe injury, treat for shock.

To treat a belly wound, cover it with a sterile dressing from a first aid pack or kit. Then fasten the dressing securely, and treat for shock.

DO NOT try to replace organs, such as intestines, protruding for the belly. To do so might cause infections and severe shock. However, if you must move an exposed intestine in order to cover the wound, do so. Be sure to keep the intestines wet with water.

DO NOT give the victim food or water through the mouth because the food would pass out through the intestines and might spread germs in the belly. If evacuation is delayed, you may moisten the victim's lips with a wet handkerchief or a cloth. REMEMBER, always treat for shock.

Bleeding for a neck wound is usually severe because of the many blood vessels in that area. Stop the bleeding by exerting pressure with a sterile dressing. Then bind the dressing to protect the wound.

If a large artery, a vein, or both are cut, apply hand pressure above and below the cut. Continue the pressure until a medical officer directs that the pressure be released. In such lifesaving situations, you need not worry about getting your hand in the wound. A folded cloth or a pad of clean material under your fingers may be a great help since the blood makes the neck slippery to hold.

A victim with a penetrating neck wound needs special treatment to prevent him/her from choking on blood. Have the victim lean forward with his/her head held forward and down, or lie face down. These positions allow the blood to drain out of the mouth instead of the down into windpipe. REMEMBER to treat for shock, but do not use a face-up shock position.

Part of the treatment for jaw wounds is similar to that for neck wounds because many times there is severe bleeding and, consequently, danger of choking on blood. Have the victim sit up with his/her head held forward and down, or have them lie face down. If the jaw is broken, do not bandage the mouth tightly shut. Place the absorbent part of the dressing over the wound and tie the tails over the top of the head to lend support to the jaw. An additional dressing may be tied under the chin for added support, but remember to allow enough freedom for free drainage from the mouth.

When treating a jaw wound, as in the case of a neck wound, do not use a face-up shock position.

A head wound may consist of any one of the following conditions or a combination of these conditions: a cut or bruise of the scalp, fracture of the skull, and injury to the brain, or injury to the blood vessels of the scalp, skull, or brain. Many times, serious skull fractures and brain injuries occur together.

A scalp wound is easily detected because of the profuse bleeding. To treat such a wound, perform the four lifesaving steps. Once the dressing is applied, do not remove it.

It is more difficult to discover whether there is internal injury to the head. Suspect a brain injury if an individual:

- Is or has recently been unconscious.
- Has blood or other fluid escaping from the nose or ears.
- Has a slow pulse.
- Has a headache.
- Is vomiting.
- Has had a convulsion.
- Has different sized eye pupils.
- Has difficulty in rousing.

If you must watch over a victim with a head injury for a long period of time, restrict the fluid intake for the first 24 hours. Keep down high temperature with sponge baths or water or alcohol. Use aspirin if the victim is conscious. If he/she becomes irrational, you may need to tie him/her down. Such victims need close attention 24 hours a day.

DO NOT place the victim's head in a position lower than the rest of his/her body. Keep the victim flat on his back unless he is unconscious or unless the wound is on the back of his head.

If the victim is unconscious, examine the mouth for false teeth or other objects which might cause choking. Remove such objects when found. Place him face down with the head turned to one side.

Take victims with head wounds to the medical facility at once for treatment, if at all possible. If the patient is unconscious, move him/her on a litter face down and lying on his/her abdomen, or on one side to aid in breathing.

The fourth and final lifesaving step is PREVENT AND TREAT SHOCK. Shock is a condition of great weakness of the body. It can, and quite often does, result in death. Shock can be caused by any kind of injury. Loss of blood, crushed bones, bone fractures, burns, bullet wounds, and other injuries may cause shock. The more severe the injury, the more likely the occurrence of shock.

Although treatment of shock is listed as the fourth of the lifesaving steps, you actually start treating for shock at the same time you stop the bleeding. Always treat an injury victim for shock, regardless of what symptoms occur. You start by keeping calm; a calm behavior reassures the victim. If it is possible, keep the victim from seeing the wound. By reassuring the victim and by keeping him/her from seeing the wound, you lessen the chances of his/her falling into a state of severe shock.

A person in shock may tremble and look nervous and have a fast and weak pulse. The person may also be excessively thirsty and may become quite pale and wet with sweat. He/she may gasp for air and become unconscious.

Shock may not show up for some time after an injury. Treat a victim for shock whether or not the symptoms for shock are present. Your efforts will have a greater chance of being effective if you treat the victim for shock before he/she has a chance to suffer from it.

To prevent or treat shock, make the victim comfortable. Remove any bulky items the victim has been carrying. Loosen the victim's belt and clothes. Handle the victim very gently. DO NOT move him/her more than is absolutely necessary. If he/she is lying in an abnormal position, make sure no bones are broken before you straighten him/her out. Treat the victim with head wounds as described previously.

Use a blanket, coat, poncho, etc., to keep the victim from becoming chilled or cold. Be sure to put something under him to protect him from the cold ground.

If the victim is unconscious, place him/her face down with his/her head turned to one side. This helps to prevent choking should he/she vomit.

Once you have the victim in shock position, do not move him/her, because to do so might make the blood pressure drop.

If oxygen is available, give it to the victim.

To repeat: TREAT FOR SHOCK WHETHER OR NOT THE WOUNDED PERSON SHOWS ANY SIGNS OF SHOCK.

Again, briefly, the treatment for shock is as follows:

- Reassure the victim and make him/her comfortable by removing bulky items and by loosening clothing.
- Move him/her as little as possible, and handle gently.
- Make certain there are no broken bones before straightening the person out.
- Keep the victim warm.
- If the victim is unconscious, place him/her face down with the head turned to one side.
- Give oxygen if it is available.

As an electrican you may one day have to give first aid for electric shock to a fellow Marine. Contact with a live or hot wire is normally the cause of electric shock. Before first aid can be given, the power must be turned off or the victim removed from the wire. In such a case, turn off the switch if it is nearby but do not waste time. If the switch can not be found, remove the victim from the wire by using a dry wooden pole, dry clothing, dry rope, or some other material which will not conduct electricity. Your best bet is to use a wooden pole if it is available. If using dry clothing, make it into a rope and use it to drag the victim off the wire. DO NOT touch the wire or the victim with your bare hands, or you may end up in the same condition.

Whatever the cause of electric shock, you must start first aid treatment as soon as possible. Most shock victims will need artificial respiration because electric shock paralyzes the breathing center in the brain and breathing stops. Mouth-to-mouth artificial respiration and treatment for shock will need to be performed as described previously. Frequently electric shock will cause the heart to stop. In this case, it will be necessary to perform closed-chest massage in addition to artificial respiration. This procedure was also covered earlier. Continue first aid until the victim recovers or medical help arrives. REMEMBER, FAST ACTION MUST BE TAKEN IN CASE OF AN ELECTRIC SHOCK. SECONDS COUNT AS THEY CAN MEAN THE DIFFERENCE BETWEEN LIFE AND DEATH.

Many times, seriously injured persons have to be moved at once. Knowing how to move them is one of the most important aspects of first aid. Careless or rough handling not only can increase the seriousness of an injury, but also can cause the victim's death. Unless there is a good reason for immediately moving an injured person, DO NOT transport him until a litter or ambulance is available.

Since there may be times when you will have to move the victim yourself, you should know the different ways of carrying casualties. Always give necessary first aid before attempting to move the wounded person. If the casualty has a broken bone, splint it before you move him.

A litter is any device, such as a stretcher, used for carrying a sick or injured person in a flat position. Using a litter not only makes it easier for you to carry the casualty, but also makes the trip safer and more comfortable for the victim. If the distance is long or if the victim has a fracture of the leg, hip, back, neck or skull, do not move him except on a litter. You can improvise a litter from many different things.

- Pole and blanket litter (fig 2-15) - Use a blanket, shelter half, tarpaulin, or other material for the bed of a pole and blanket litter. You can make the poles from such objects as strong branches, tent poles, rifles, or skis.

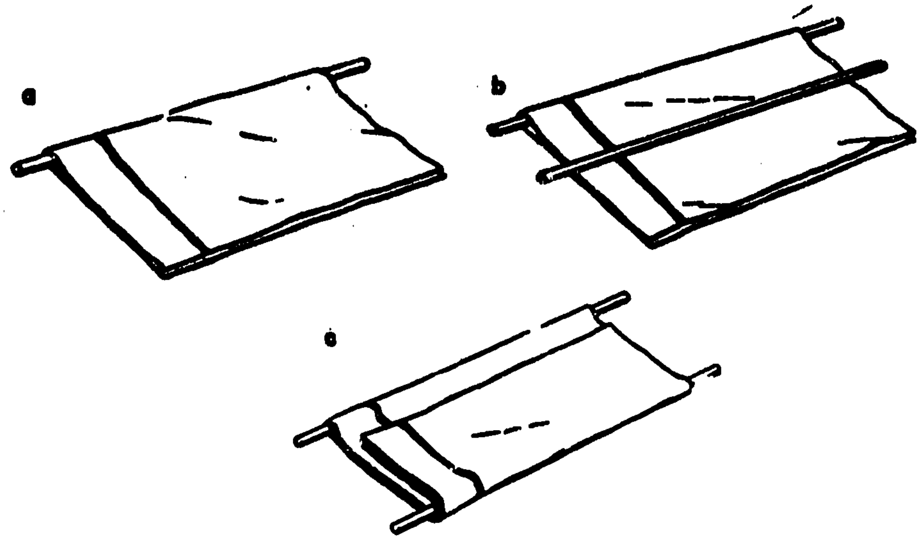


Fig 2-15. Pole and blanket litter.

o Pole and jacket litter (fig 2-16) - Find two or three blouses, shirts, or field jackets to make a pole and jacket litter. Button them up and turn them inside out so that the lining is outside and the sleeves are inside. Pass a pole through each sleeve, and you have a litter.

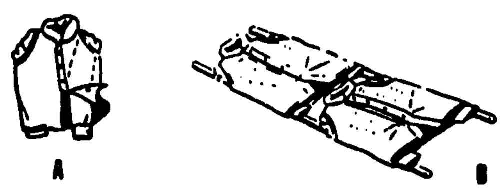


Fig 2-16. Pole and jacket litter.

o Door or board litter - To make a door litter, use any plain-surfaced object of suitable size, such as cots, window shutters, doors, benches, ladders, boards, or poles tied together. Pad the litter if possible.

o Pole and sack litter (fig 2-17) - Rip open the bottom or cut the corners of sacks, bags, bedticks, or mattress covers to make a pole and sack litter. Pass two poles through them.

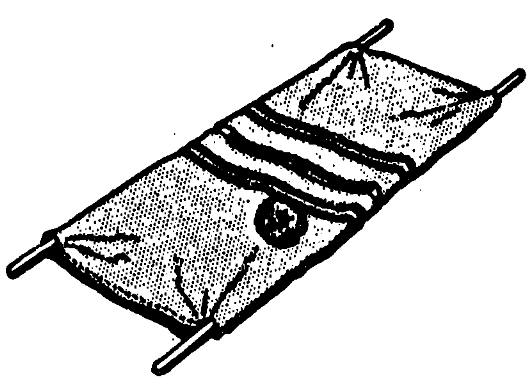


Fig 2-17. Pole and sack litter.

o <u>Blanket or parachute roll litter</u> (fig 2-18) - If you can not get any poles to make a litter, roll a parachute, blanket, shelter half, or tarpaulin on both sides toward the center. Use the rolls as grips when carrying the victim.

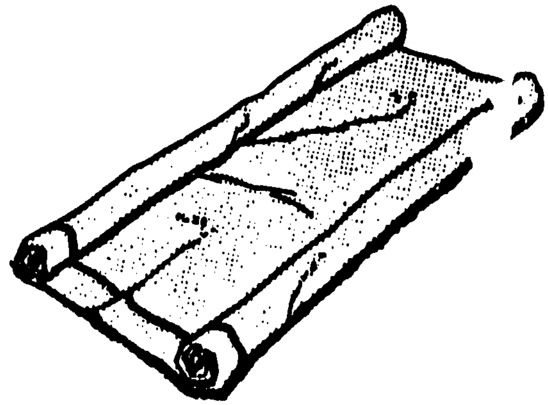


Fig 2-18. Blanket and parachute roll litter.

Several ways to move a casualty without a litter are described in the following paragraphs. These carries require only one person. Use the carry which is easiest for you and which is best for the situation. <u>DO NOT</u> try to carry a person who has a broken back or neck.

o <u>Fireman's carry</u> (fig 2-19) - A fireman's carry is the easiest method for one person to carry another. Follow these steps:

- Turn the victim face down on the ground and support the head on his arm.
- Straddle the victim's body, placing your hands under the armpits.
- Walk backward a few steps, dragging the victim so that his legs trail in front with his knees locked straight. Then lift by walking forward, pushing against the straight legs.
- Support the victim by putting your arm around his waist, and then step to the victim's front.
- Grasp the victim's right hand with your left hand. Bend at the waist, pulling the victim's right arm around the back of your neck so that the victim's body comes across your back.
- Now grasp the victim's legs at the knees with your right hand. Holding the knees with your right hand and the right arm of the victim with your left hand, straighten up, lifting the victim off the ground as you do so.
- Grasp the victim's right hand with your right hand, leaving your left hand free.

This is the position of the fireman's carry. You can carry a victim some distance in this manner without too much difficulty.

After getting a victim off the ground by using the first three steps of the fireman's carry, you can use any of the following alternate one-man carries:

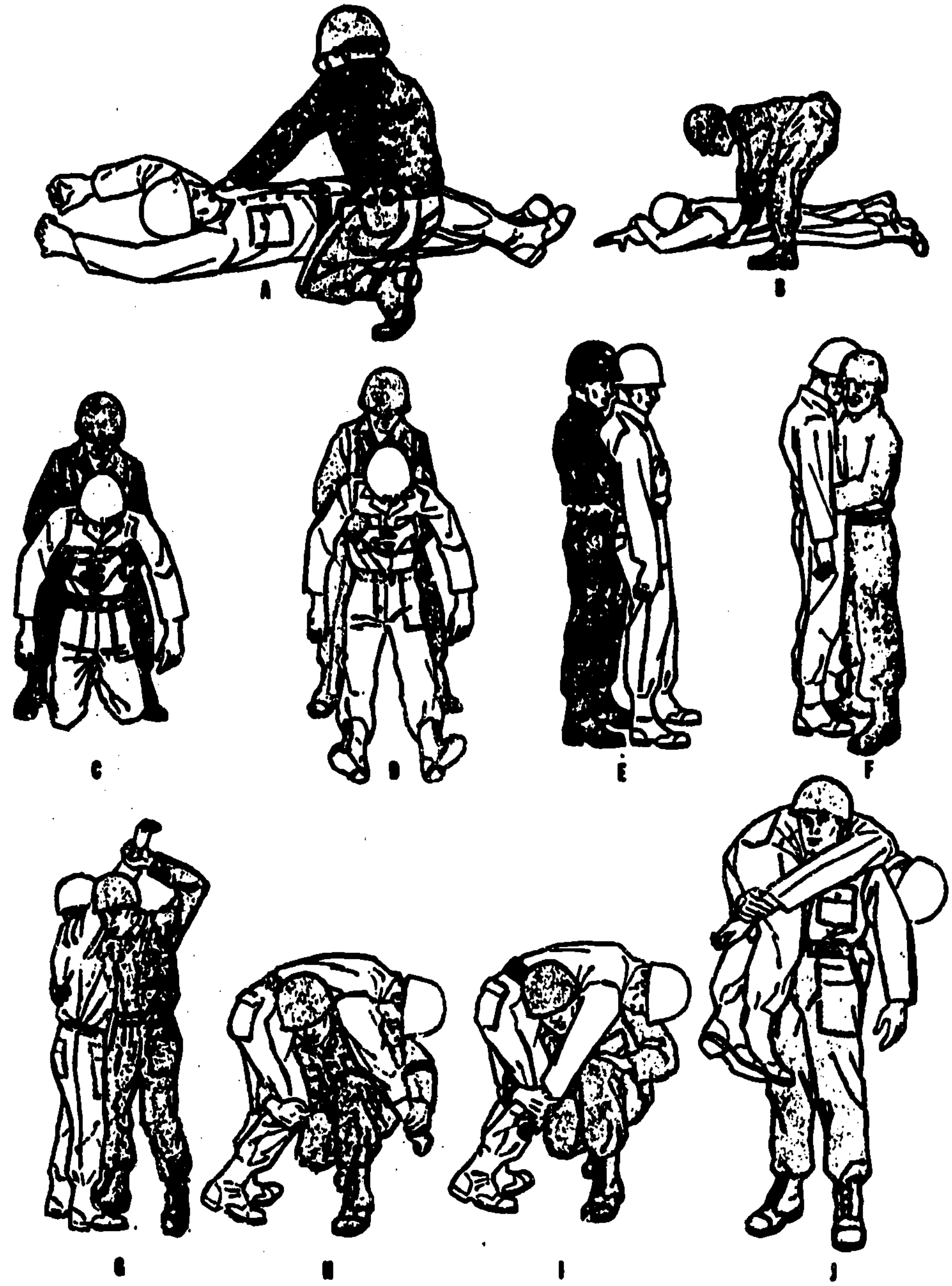


Fig 2-19. Fireman's carry.

o Supporting carry (fig 2-20) - Grasp the wrist of the victim's uninjured arm and draw the arm around your neck. The victim now can walk, using you as a crutch. This carry i useful when the victim is only slightly hurt, as when the victim has a foot or ankle injuries

Fig 2-20. Supporting carry.

Fig 2-21. Arms carry.

o Arms carry (fig 2-21) - The arms carry is good for short distances. The victim is lifted and carried using one arm under the legs at the knees and one arm behind the back at the armpits. You should carry the victim high to lessen fatigue. DO NOT use this type of carry when the victim has a broken leg.

Fig 2-22. Saddleback carry.

o Saddleback carry (fig 2-22) - After getting the victim up, keep a hold on the arm and step in front of him/her. Have the victim encircle your neck with his arms. Now stoop, clasp your hands beneath the thighs, and raise the victim upon your back.

o Pack-strap carry - After raising the victim, step in front of the victim. Grasp the victim's wrists with your hands and hoist him so that the armpits are over your shoulders. The pack-strap carry is good for carrying an unconscious victim. DO NOT use it if the victim has any broken bones.

o Back lift and carry - To use the back lift and carry method, the victim must be conscious and able to stand on one leg. After raising him to a standing position, place yourself back-to-back with him. Have him stretch out his arms sideways. Bend backward, put your hands under the victim's arms, and grasp his upper arms. Bend forward, pulling him onto your back.

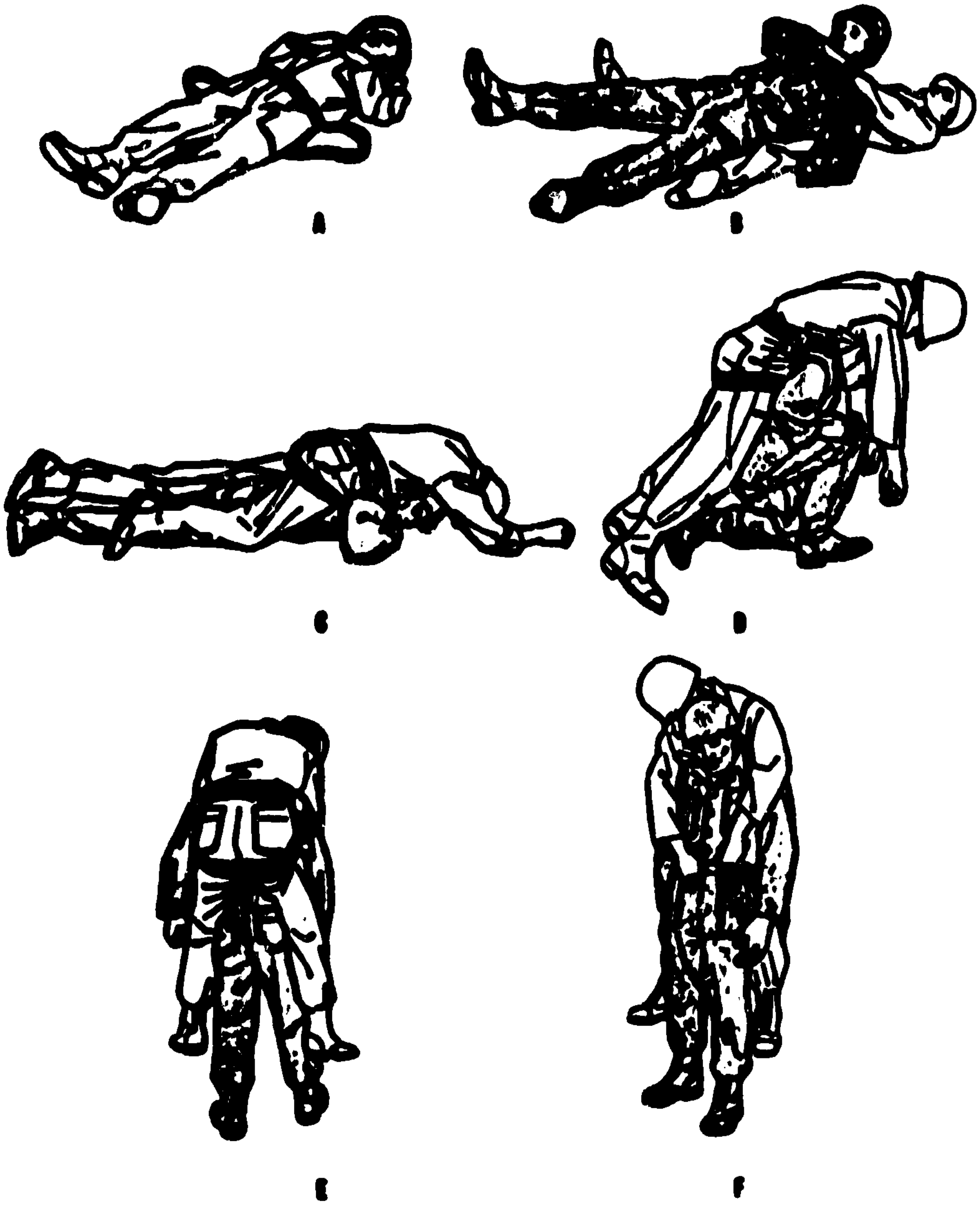


Fig 2-23. Pistol-belt carry.

- <u>Pistol-belt carry</u> (fig 2-23) - Link together two pistol belts into a continuous belt, then follow these steps:

  - With the victim on his back, spread the belt and place it under the thighs and hips so that a loop extends from each side.

  - Lie down on your back between his outstretched legs. Thrust your arms through the belt loops. Reach across your body and grasp his left hand with your right hand, and his left leg with your left hand.

- Then rolling to the right, turn face downward, pulling the wounded person onto your back. Adjust slings before proceding. (If the victim has an injury on the right side, reverse these procedures. Grasp his right hand with your left hand and his right leg with your right hand.)

- Then rise to a kneeling position. The continuous belt will hold the victim in place.

- Place one hand on your knee for support, then stand up. The victim is now supported on your shoulders.

- Your hands are free to help you climb steep banks and to get over other obstacles. Both you and the victim can also fire your rifles if the need arises.

If you are not able to use a litter or one of the carries listed, you may be able to use one of the following drags to move the victim:

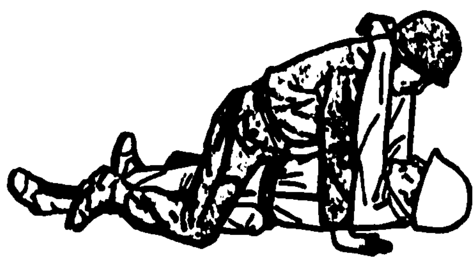


Fig 2-24. Neck drag.

o <u>Neck drag</u> (fig 2-24) - Tie the victim's hands together and loop them around your neck. This enables you to crawl along, dragging the victim, who may be unconscious. The advantage of this method is that you and the victim you are dragging can remain low on the ground protected from enemy fire. <u>NEVER</u> attempt to drag an individual who has sustained a broken back.

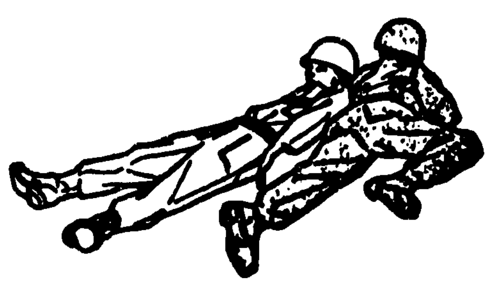


Fig 2-25. Pistol-belt drag.

o <u>Pistol-Belt drag</u> (fig 2-25) - Take two pistol belts and join them in one continuous sling. After placing the victim on his back, pass a loop of the sling over his head and work it into position across his chest and under the armpits. Then cross the sling straps at the victim's shoulders, forming another loop. Lie slightly forward on your stomach next to the victim. Slip the second loop of the sling over your arm and shoulder. Place your arm which is nearest the victim's head underneath his head to protect it during movement.

Then advance by crawling, dragging the wounded person with you. This carry permits both you and the victim to stay on the ground, protected from enemy fire. It can be used only for short distances.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. Under what condition should a person giving first aid move an injured person?

____

____

2. What could be the result if a person giving first aid causes additional injury?

____

3. What is as important as knowing what to do when giving first aid?

____

4. List the four lifesaving steps.

   a. ____

   b. ____

   c. ____

   d. ____

5. What is the best method of artificial respiration?

____

6. Why is it important to clear the airway of a victim before performing artificial respiration?

____

____

7. After the first 3 or 4 breaths, what breathing rate should be established when performing mouth-to-mouth respiration?

____

8. How is the airway maintained open when the victim is a small child or has tight jaws?

____

____

9. How far should the breastbone be depressed when performing CPR?

____

10. If you see a fellow Marine receive an electrical shock while working on an electric circuit and his heart has stopped, what action should be taken?

____

11. Where should a victim's pulse be checked if you suspect that the heart has stopped?

____

12. What is the first method that should be used to control bleeding?

____

13. What are the two most important pressure points?

a. ______________________________

b. ______________________________

14. What is the purpose of raising the arm or leg that is wounded when trying to stop the bleeding?

____

15. As a last resort, what is applied to stop bleeding?

____

16. Why is a tourniquet dangerous?

____

17. How should a wound be protected?

____

____

18. When treating a chest wound, how do you make the wound airtight?

____

____

19. What specific procedure is used for treating a penetrating neck wound to prevent the victim for choking on blood?

____

____

20. What causes shock?

____

____

21. When should treatment of shock begin?

____

____

22. What is the first step in prevention and treatment of shock?

____

____

23. What must be accomplished before first aid treatment for electric shock can be started?

____

____

24. What first-aid treatment will be required for most victims of electric shock?

____

____

25. List three methods used to move an injured person.

a. ____

b. ____

c. ____

26. What is the easiest method for one person to carry another?

____

SUMMARY REVIEW

Accidents are usually the result of a failure to THINK. You must think safety and use safe procedures. You must be aware of the hazards involved in your work areas. When you fail to think safety and practice safety, you or your co-workers are not only a danger to yourself but to everyone working with you. In this study unit you have learned some of the hazards and causes in your work area and the action to take for protection against these hazards and their causes.

In addition you have learned the steps necessary to perform first aid for the personnel who fail to practice safety in the work area. Proper first aid may not only save your life but the life of a fellow Marine. Insure that you practice the four lifesaving steps that you learned in this study unit. YOU CAN NOT AFFORD NOT TO.

Answers to Study Unit #2 Exercises

Work Unit 2-1.

1. The worker
2. a. Unsafe acts by people
   b. Physical hazards
   c. Natural phenomena
3. a. U
   b. U
   c. U
   d. U
   e. U
   f. U
   g. U
   h. S
4. a. U
   b. S
   c. U
   d. S
   e. U
   f. S
   g. U
5. a. U
   b. U
   c. S
   d. U
   e. U
   f. S
   g. S
   h. S

6. a. S
   b. U
   c. U
   d. S
7. a. S
   b. U
   c. U
8. c
9. b
10. a
11. b
12. a. Yes
    b. Yes
    c. No
    d. Yes
    e. Yes
13. Grasp the ladder by the rungs as you walk toward the bottom.
14. d
15. c
16. a
17. b

Work Unit 2-2.

1. Only when it is absolutely necessary
2. That person could be held liable in a court of law
3. Knowing what NOT to do
4. a. Assure breathing
   b. Stop the bleeding
   c. Protect and treat the wound
   d. Prevent or treat shock
5. Mouth-to-mouth
6. If the airway is not clear, air will not enter the lungs.
7. 12 to 20 times per minute
8. Hold the lower jaw upwards with both hands
9. 1 to 1-1/2 inches
10. Begin closed-chest massage concurrently with mouth-to-mouth respiration (CPR).
11. At the neck (carotid pulse)
12. Apply pressure to the wound
13. a. Groin
    b. Neck
14. To slow blood flow to the wound
15. Tourniquet
16. Uninjured tissue below the tourniguet may die from lack of blood and oxygen.
17. It should be covered with sterile gauze or dressing
18. Have the victim exhale, apply a dressing large enough to cover the wound, and cover the dressing with a material that will make it airtight.
19. Have the victim lean forward with his head held forward and down, or have him lie face down.
20. Any kind of injury may cause shock
21. Immediately or simultaneously with one of the other lifesaving steps
22. Keep calm and make the victim comfortable.
23. Rescue the victim. Remove the victim from the electrical contact or remove the electrical contact from the victim, whichever is the best method of rescuing the victim.
24. Artificial respiration (CPR)
25. a. Litter
    b. Carry
    c. Drag
26. Fireman's carry

STUDY UNIT 3

ELECTRICIAN'S TOOLS

STUDY UNIT OBJECTIVE: WITHOUT THE AID OF REFERENCES, YOU WILL LEARN HOW TO IDENTIFY AND USE TOOLS. YOU WILL ALSO IDENTIFY THE SAFETY PRECAUTIONS TO OBSERVE WHEN USING THEM.

To perform your tasks as a Marine Corps Electrician, you must know what handtools, special tools, or power tools are needed and how to effectively employ them.

Regardless of the type of work to be accomplished, you must select and use the correct handtools. Without the right tools and the knowledge of how to use them, the electrician wastes time and cuts down his efficiency. This efficiency in using handtools is also determined, to a great extent, by the condition in which you maintain your tools. A good electrician will take care of his tools and will select the proper tool for the job. Therefore, we will begin by discussing the most common handtools such as screwdrivers, pliers, wrenches, hammers, and vices.

Work Unit 3-1. COMMON ELECTRICIAN HANDTOOLS

IDENTIFY THE FUNCTIONS AND USES OF SELECTED COMMON HANDTOOLS.

IDENTIFY THE FUNCTIONS AND USES OF SELECTED CUTTING AND BORING TOOLS.

The <u>SCREWDRIVER</u> is one of the most common handtools; but because it is so common, everyone thinks he knows how to use it properly. For this very reason, it usually winds up being the most <u>abused</u> tool. Some of the abuse is a result of not knowing the type or proper use of the tool.

There are several different types of screwdrivers. However, there are two main types of screwdriver blades:

- Phillips (crosspoint or cross slot)
- The standard (common) blade

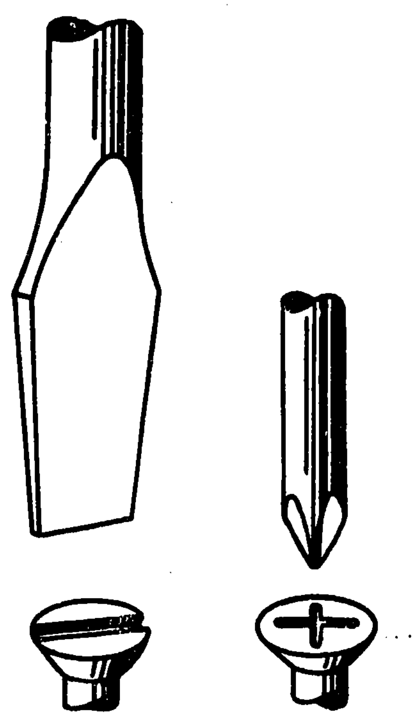


Fig 3-1. Screwdriver blades.

Each type is designed to fit a particular type of screw, as shown in figure 3-1. Within each type there are several sizes and shapes. The size is measured from the BASE of the handle to the TIP of the blade, which is called the SHANK. The common sizes are 3, 4, 5, 6, 8, 10, and 12 inches. The shape can be an OFFSET, STRAIGHT, or FLARED TIP (refer to fig 3-2). The offset shape can be a standard or crosspoint.

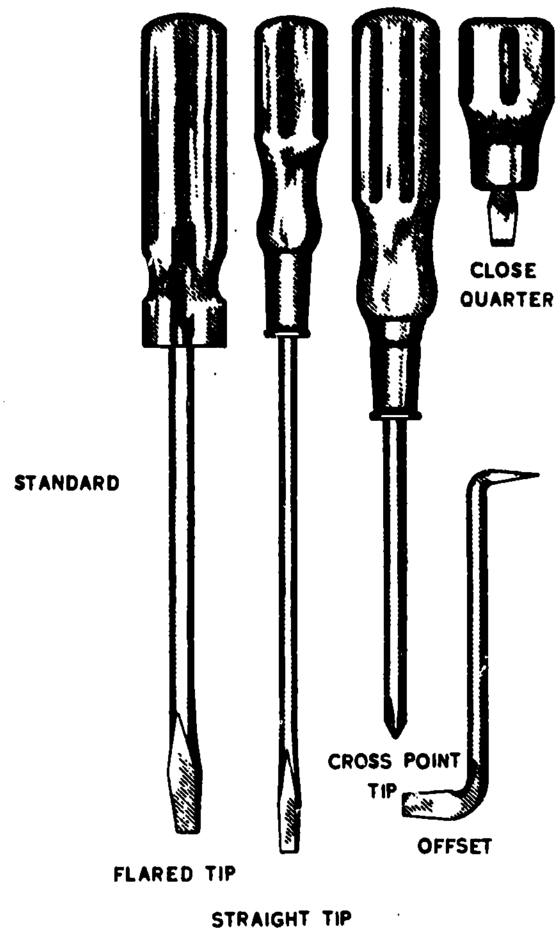


Fig 3-2. Screwdrivers.

The standard screwdriver is used where the screw or bolt is slotted in the standard manner. The crosspoint is used only on screw or bolt-heads which are cross slotted. The offset is used when it is impossible to get at a screw head with a standard or crosspoint screwdriver because of a small clearance.

Use screwdrivers ONLY for the job they are designed to do--drive and remove screws. NEVER use the screwdriver as a prybar or chisel. If you do, you are likely to break the blade. When you turn a screw, hold the screwdriver firmly against the screwhead; and do not hold the blade at an angle in the screwhead. NEVER use pliers or a wrench on a screwdriver blade. Apply force on the handle with your hand. Figure 3-3 illustrates the right and wrong uses of screwdrivers. These illustrations apply to all types of screwdrivers.

When selecting a screwdriver for a job, select the type and size that will fit the screw. The blade tip must have sharp corners and fit the screw closely. If you use a standard screwdriver that is too small, you will probably ruin the slot in the head of the screw. You may also bend or break the blade of the screwdriver. See figure 3-4 for right and wrong fitted standard screwdrivers. The same will hold true for crosspoints--use a screwdriver that fits the screw.

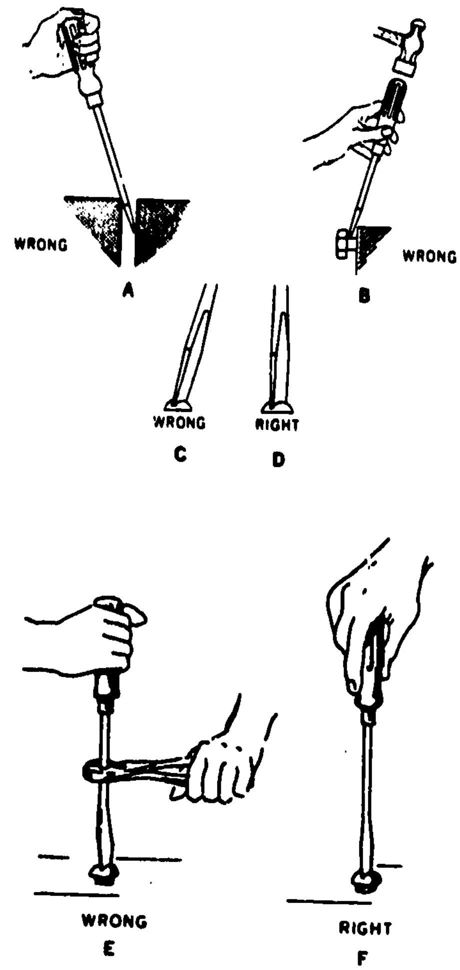


Fig 3-3. Use of screwdrivers.

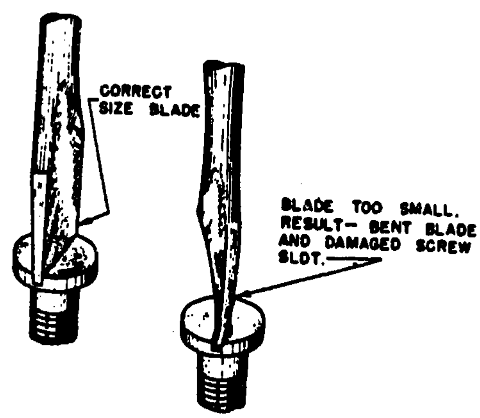


Fig 3-4. Blade fit (thickness).

When a screwdriver blade tip becomes rounded, nicked, or broken, you can usually restore it to the original shape with a grinder or file. The tip should be ground or filed so that the sides are parallel to keep them from slipping out of the screw slot. It is also good practice to slightly hollow-grind the sides of the blade, as shown in figure 3-5. This puts the tip of the blade at the bottom of the screw slot, making it easier to drive and remove screws without damaging the screw head.

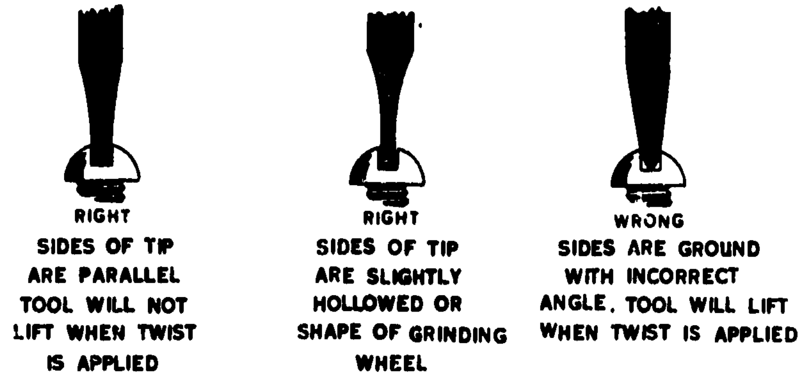


Fig 3-5. Blade tip shape.

To remove the nicks or sharpen a screwdriver, file or grind the tip until the nicks are removed and the tip is squared. Then shape the faces and sides by grinding lightly on the side of the emery wheel or by filing. To keep it from overheating and destroying the temper of the blade, dip the tip in water between short periods of grinding. DO NOT remove any more material than is necessary.

The crosspoint screwdriver must be treated in a different manner. In restoring the crosspoint screwdriver to its original condition, apply a three-cornered file to remove any burns that exist on the damaged tips. Due to the delicacy of its fine blades, the Phillips screwdriver has to be discarded whenever the blades are damaged beyond the filing point.

Each pair of PLIERS is designed for a specific function. There are cutting, gripping or holding types, consisting mainly of a pair of jaws, a pivot point, and a pair of handles. The types most often used by the electrician are the diagonal, sidecutters, longnose, combination, and water pump pliers, all of which are illustrated in figure 3-6.

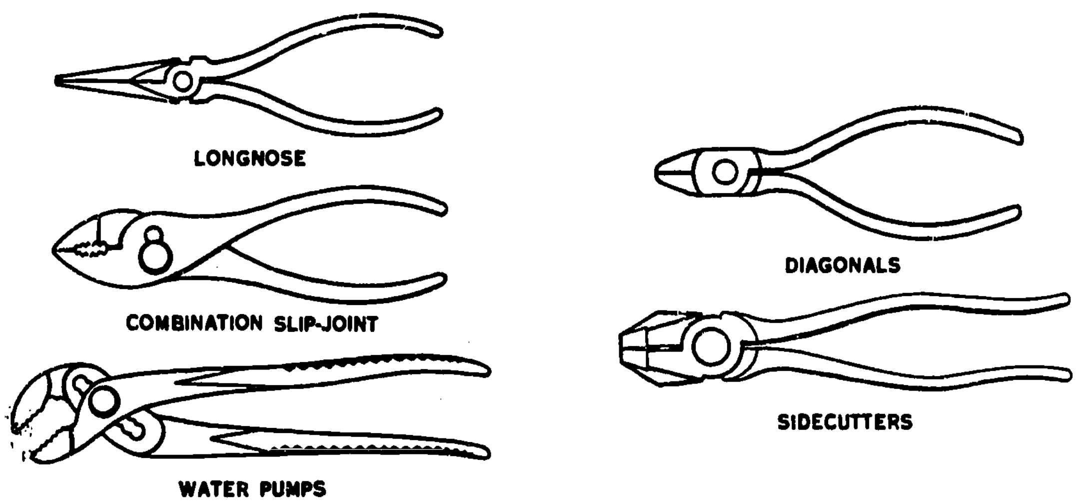


Fig 3-6. Pliers.

The sidecutting pliers and diagonals are of the cutting type. The diagonals are for close cutting, while the sidecutters are used for much heavier cutting of layer wire and small cables. In addition to cutting wire, the sidecutters are used for holding wire while bending or twisting and are often used to strip the insulation from wires. The combination slip joint and water pump pliers are also used in electrical work. They are used to grip flat or round stock and to bend small pieces of metal to desired shaped. The water pump pliers are made with extra long handles for increased gripping power. Both types of pliers are adjustable to several positions for handling various size objects. Longnose pliers also serve many useful purposes. They may be used to bend an eye or loop in solid wire so that it can be placed under a bolthead or screwhead. In places where you cannot fit your fingers to place or tighten wires, the proper application of the longnose pliers will be very helpful. These pliers are actually extensions of your fingers in many instances.

DO NOT use pliers as an all-purpose tool. They are not to be used as a wrench for tightening nuts or boltheads, for example. Pliers round the corners on nuts or boltheads so that a wrench cannot get a firm grip. DO NOT use pliers as a prybar or as a hammer, as you may bend or bread the handles. DO NOT attempt to cut extremely hard objects, since such action will nick or dull the cutting edges of the jaws.

Good judgment must be used in selecting pliers for a job. You must make sure the pliers are large enough for the job. Pliers are made in a wide range of sizes to avoid overstraining and breaking the tool. Not only must you select the proper size tool, you must also select the right tool for the task. For example, you would not use diagonal pliers to hold a piece of round stock. Select the right size and type of pliers for the job and cut out the lost time used for extra care of the tool.

The care of pliers usually involves cleaning, pivot point maintenance, and sharpening the cutting edges. Pliers require an occasional oiling at the pivot points or joints. After pliers are used for a period of time, the pivot point often becomes loose and must be tightened. Some pliers have a nut that can be tightened; others have a solid pin that must be tightened by laying the pliers on an anvil and striking the pivot lightly with a hammer. Cutting pliers at times may become pitted at the cutting edge. The proper use of a fine file over a pitted spot on the cutting edge is sufficient to restore its original condition. You can also use the fine file to sharpen the cutting edge of the diagonals or sidecutters if necessary. The knurled jaws or gripping teeth of the holding pliers require cleaning for better gripping. Use a wire brush to clean out steel wastes, paint, or grease that has piled up on the teeth or knurled jaws.

WRENCHES - Some wrenches are used for tightening and loosening bolts and nuts; others may be used for turning round materials such as conduit and pipes. The more common wrenches used in your work are shown in figure 3-7.

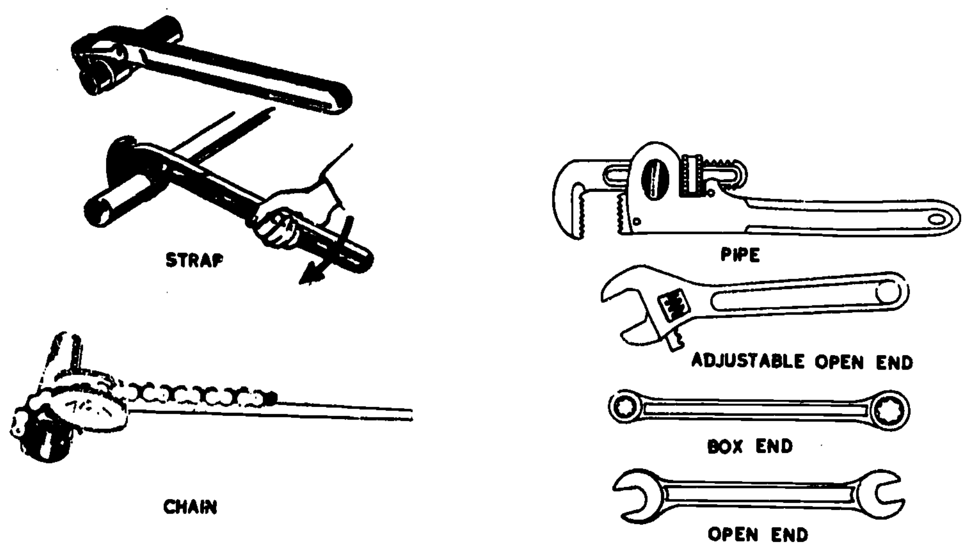


Fig 3-7. Wrenches.

The pipe wrench has a knurled drive wheel to adjust the space between the jaws. The movable jaw is spring loaded so that it will bind or lock when it pulls on a pipe. If you reverse the direction of pull, the jaw releases its hold. You use a pipe wrench to assemble threaded conduit and coupling. The adjustable open-end wrench has a spiral drive wheel to adjust the jaws. You must adjust the wrench so the jaws fit snugly on a nut before you apply pressure to turn it. If the jaws fit loosely, the wrench may slip and damage the nut, and damage your hand as well. As a rule, adjustable wrenches are suitable for heavy duty work. Open-end wrenches fit standard size nuts. They are lightweight, strong, and convenient for doing work in limited space. Because the jaws are usually set at 15° or 90° angles, it is easy to work in close places by turning the wrench over after each movement. The length of the wrench will vary according to the size of the opening. Some open-end wrenches are angular in construction. Box-end wrenches may be used only on hexagon nuts and boltheads. This wrench cannot be used to turn a square nut or bolthead. The strap wrench is used on brass, copper, and chromium-plated pipes and fittings, because it will not scratch or mar the finished surfaces. It has a thick canvas strap instead of a chain or jaws to grip the pipe or fittings. The chain wrench is also used on pipes and fittings. It is placed on the pipe by wrapping the chain around the pipe and attaching it to the wrench by a slot arrangement. The advantage of a chain wrench is that it will grip and apply an even pressure all the way around the pipe or fittings, whereas a large conventional pipe wrench grips the pipe only at two points. The chain wrench is much safer to use than the conventional pipe wrench, because it will not slip off the pipe.

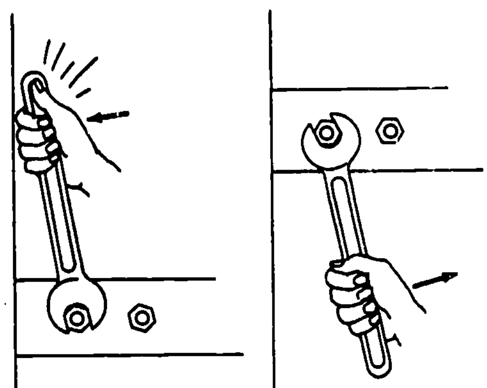


Fig 3-8. Use of open end wrench.

When using a wrench of any kind, always try to pull on it; it is usually dangerous to push on it. Figure 3-8 shows the right and wrong way to use an open-end wrench. When using and adjustable wrench, if the pulling force is applied to the adjustable jaw, the wrench is likely to slip or break. Figure 3-9 shows the right and wrong procedures for using adjustable jaw wrenches. NEVER use a pipe to increase leverage, for the handle is not designed for this and will bend or break.

All of the wrenches have special advantages. For example, the open-end wrench is used where space is limited or where a straight wrench cannot be used. The box-end wrench is safer to use and is less likely to slip off the nut. However, the box-end cannot be used on the standard square nuts. Adjustable wrenches are used only when other wrenches do not fit. The pipe wrench is used to assemble conduit and couplings. In this case, though, the strap and chain wrenches are much safer to use than the conventional pipe wrench, because they will not slip off the pipe. A good electrician chooses the one best suited for the job and also selects the correct size of wrench, as illustrated in figure 3-10.

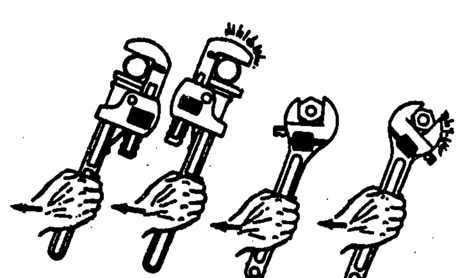


Fig 3-9. Use of adjustable jaw wrenches.

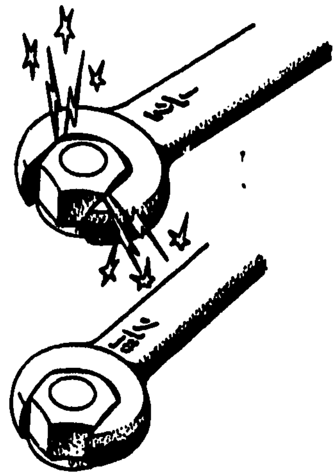


Fig 3-10. Select correct wrench size.

All wrenches must be kept clean and free of rust. Wash any grease and dirt from wrenches with drycleaning solvent. Any rust spots should be removed with crocus cloth or steel wool. Periodically wipe down your wrenches with a clean cloth dipped in a light grade of lubricating oil. Lubricate the worm adjustment on pipe wrenches and adjustable jaw wrenches with a few drops of oil. NEVER use a wrench that has battered, chipped, or spring jaws. The wrenches that have bad defects should be taken out of service.

HAMMERS are made in varying sizes, shapes, and types. Each type is designed for a specific type of work. Some types are used for driving nails; other types are used for metal forming or to drive a chisel or punch. Yet another type is designed for use where a steel hammer might mar or damage the work. You will find that you use the CLAW and BALL-PEEN hammers more than any other types. Figure 3-11 shows some hammers and mallets with which you should be acquainted.

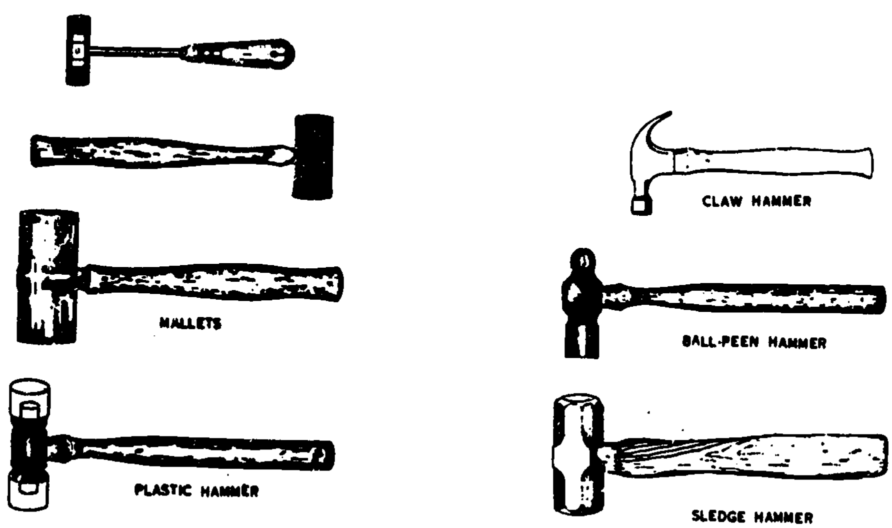


Fig 3-11. Mallets and hammers.

The CLAW HAMMER is used to drive or pull nails in wood construction. When driving nails, hold the claw hammer near the end of the handle with the face of the striking surface parallel to the work, as illustrated in figure 3-12. DO NOT hold the hammer near the neck or head. A grip just tight enough to control the tool is best. Deliver blows upon the object by raising the arm and hammer in a smooth arc away from the object and then bring the hammer down with a quick, sharp motion. The ball-peen hammer is used mainly in mechanical and shopwork. Use it with driving and cutting tools, such as punches and chisels. The manner in which you use a ball-peen hammer is the same as for the claw hammer. The mallet is a hammer used mainly at a work bench for tapping on more delicate equipment. Mallets are handy for disassembling motors and other electrical equipment. Mallets come with plastic, hard rubber, or pressed leather heads, and are generally lightweight. Another hammer you sometimes have need for is the sledge hammer. It has a double-faced head and is used for very heavy work, such as driving stakes and ground rods. It can also be use for breaking concrete.

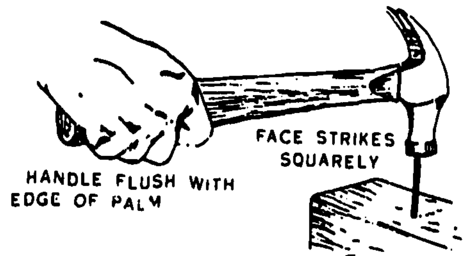


Fig 3-12. Nail driving (claw hammer).

Since each type of hammer is designed for a specific type of work, you should select the right hammer for the task at hand. For example, you would not use a ball-peen hammer or mallet to drive a nail; nor would you use a sledge hammer. You would use a claw hammer. Likewise, you would not use a claw hammer to drive a large grounding rod; you would use a sledge hammer. You would use a mallet to assist in the disassembly of a motor. Whichever hammer you select, make sure it is in good condition.

Always inspect it prior to using it. NEVER use any hammer if the head is loose on the handle. Hammer handles that are cracked or split must be replaced. Do not attempt to repair a handle by wrapping tape around it.

There are several types of vises at the electrician's disposal. Figure 3-13 shows four of the more common types:

Machinist's Vise

Utility Vise

Chain Vise

Pipe vise

The MACHINIST'S and UTILITY vises are sure bench mounted and very similar in design. The machinist's vise has flat jaws and a swivel base and is suitable for most ordinary shop work. The utility vise, on the other hand, has removable soft jaws inserts and is equipped with pipe jaws. For this reason, the utility vise is more versatile, since it will grip pipe or round rods. When working with a polished metal, use the soft jaw inserts. The conventional pipe vise is a quick release type that can be mounted either on a shop bench or on portable legs and carried to the job site. As you can see in figure 3-13, the chain type vise grips the pipe by a chain arrangement. The pipe and chain vises are used when cutting and threading conduit.

Vises require very little maintenance other than keeping them clear and the movable parts well oiled. Do not use the jaws of a vise as an anvil. There is a danger of breaking the jaws or battering the inserts. Never use a pipe to increase the handle leverage, because excessive pressure on the handle may break the handle or jaws.

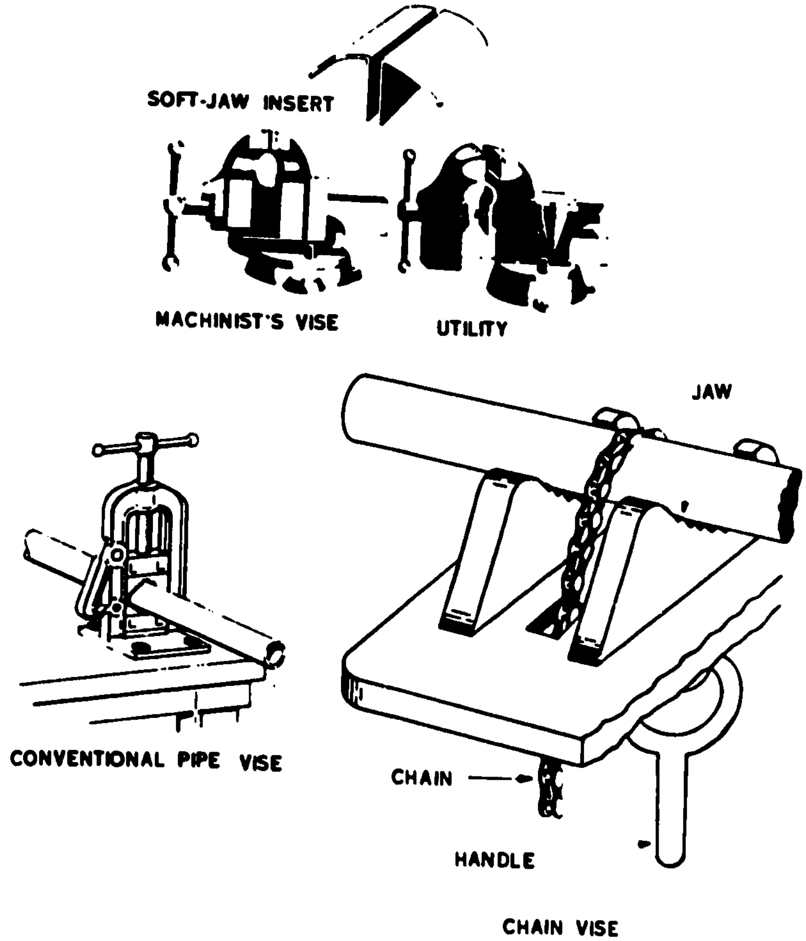


Fig 3-13. Vises.

In many cases, you must cut or drill openings in walls, floors, and ceilings for installation of electrical devices. You will have at you disposal cutting and boring tools to do this job.

There are several types of cutting tools used by the electrician. Among these tools are the carpenter's saw (cross-cut or rip), hacksaws, conduit cutters, knockout punch, pocketknife, and chisels.

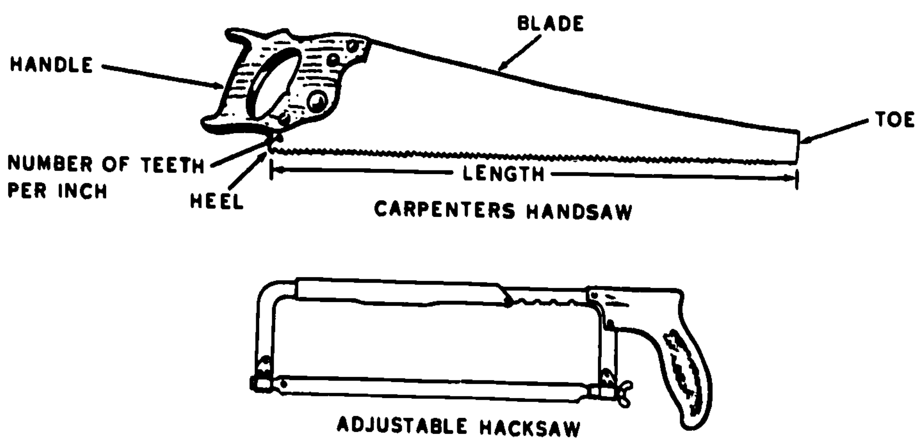


Fig 3-14. Saws.

CARPENTER'S SAW - The carpenter's handsaw, illustrated in figure 3-14, is available in two types: the ripsaw and the crosscut saw. The length of the cutting edge determines the size of the saw. These saws range in size from 18 to 26 inches. The ripsaw has coarse teeth and is used for sawing wood with the grain. On the other hand, the crosscut saw has fine teeth and is used for sawing wood across the grain. Although the carpenter's saw is designed for sawing wood, it may also be used for sawing plastic. The teeth are fixed so that they cut on the downward (away from your body) stroke only. Be sure there are no nails or other edge-destroying objects in the way. If you are sawing out a strip of waste, do not break out the strip by twisting the saw blade. This action dulls the saw and can spring the blade. Once a blade is sprung, it is impossible to cut a straight line. Hang up the saw when it is not in use to avoid contact with other tools, and keep the saw coated with light oil to prevent rust.

HACKSAWS - The hacksaw, one type of which is shown in figure 3-14, is used for cutting metal. Most hacksaws have adjustable frames which use blades from 8 to 16 inches in length. Several varieties of hacksaw blades are available. They differ in the hardness of the blade and the number of teeth per inch. A hard blade is best for sawing brass, tool steel, or case iron, but a flexible blade is better for cutting hollow shapes and metals of light cross section, such as tubing, tin, or copper conduit. The teeth range from 14 to 32 teeth per inch. In general, use a coarse-toothed blade for sawing soft metal and a fine-toothed blade for sawing hard metals. Two or more teeth should be in contact with the work to prevent stripping of the teeth.

After you have selected the correct blade, insert it in the frame with the point of the teeth pointed away from the saw handle. Sawing is done by moving the saw forward with a light steady stroke. At the end of the stroke, relieve the pressure and draw the blade straight back. After the first few strokes, make each stroke as long as possible without striking the saw frame against the work. Always keep the saw in line with the cut being made and do not bear down on the backstroke (doing so may crimp and break the blade). If the blade breaks, it can cut your hand. Do not push down on a hacksaw to try to make it cut faster. The weight of the saw should be sufficient to cause the blade to bite into the metal. Keep the hacksaw clean and stored where the blade is protected from becoming dull or broken. Dull blades cannot be sharpened; they must be replaced.

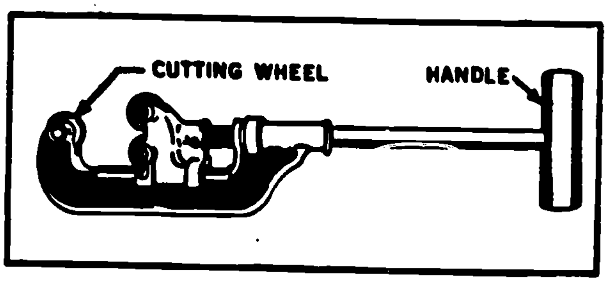


Fig 3-15. Rigid conduit cutter.

RIGID CONDUIT CUTTERS - Rigid conduit cutters, like the one shown in figure 3-15, are available in several sizes. The size is usually indicated on the frame of the cutter. A cutter with a range from 1/2 inch to 2 inches will cut a pipe up to 2 inches in diameter. Do not attempt to cut thin-wall conduit with this type because to do so will result in flattening the ends of the conduit and reducing the inside diameter. As for care, keep the wheel pins and the threads on the shaft of the handle well oiled. When the cutter wheel becomes dull, you should replace it with a new wheel. Keep the tool clean at all times.

KNOCKOUT PUNCH - The purpose of the knockout punch, shown in figure 3-16, is for enlarging holes in metal. The tool will handle metal thickness up to 1/8 inch. You will use the tool to punch holes in steel cabinets, panels, and boxes, for the installation of conduit. The diameter of the holes cut by the various punches will allow various sized conduit to fit the opening. For example, a punch that will cut a hole 1-11/32 inches in diameter is used for a 1-inch conduit. The following is a list of punches and the size of conduit to be used:

Punch	Conduit
7/8	1/2
1 11/32	3/4
1 11/16	1 1/4
1 15/16	1 1/2
2 3/8	2
2 7/8	2 1/2
3 1/2	3

As you can see from the previous list, the size of the conduit to be connected will determine the size of punch required.

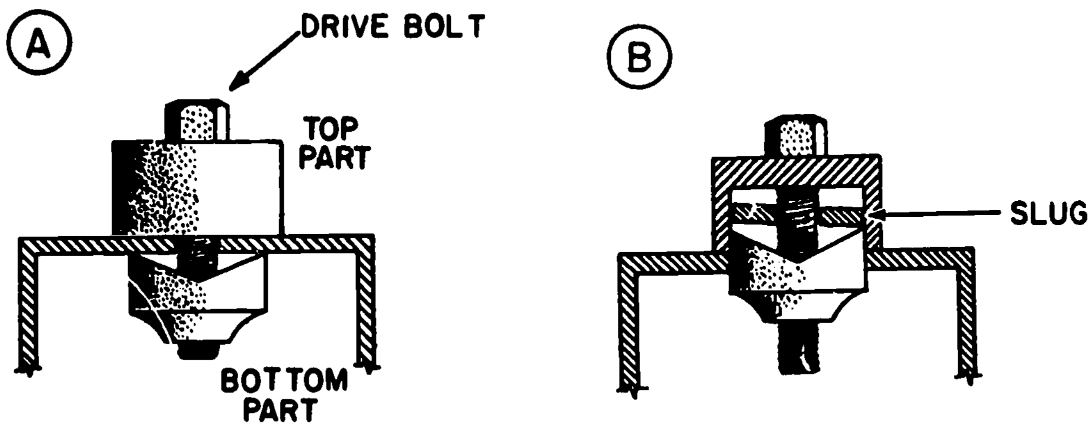


Fig 3-16. Knockout punch.

To use the tool properly, you must first have a hole in the material to be punched. The hole must be large enough to accommodate the drive bolt of the knockout. The hole should be drilled with an electric drill and twist bit. The drive bolt for a 7/8-inch punch, for example, will normally require a 3/8-inch hole. Larger knockouts will require a 3/4-inch hole. Once the hole for the drivebolt is drilled, you must insert the drivebolt through the top part (die) of the knockout and then through the hole in the box. The bottom part (punch) of the knockout is then threaded onto the drivebolt until both parts, the die and punch, are tight against the box, as shown in figure 3-16, A. Now, use a wrench and turn the drivebolt to punch the hole as shown in figure 3-16, B. Turn the bolt until you feel or hear two distinct snaps of metal. This lets you know that the hole has been punched and the slug is free from the box. DO NOT tighten the drivebolt once the slug is free, as you may damage the cutting edge of the punch. Now, remove the tool from your work and remove the slug from the die part of the tool. You may need a punch and hammer to tap the slug from the die.

The punch can be sharpened when it becomes dull. However, this action is an emergency measure. Your concern with the care of the knockout punch, then, is limited to keeping the tool clean and well filed.

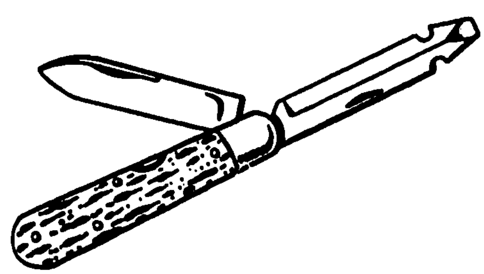


Fig 3-17. Electrician's pocketknife.

POCKETKNIFE - The electrician's pocketknife (fig 3-17) serves many purposes. It consists of a regular cutting blade and a screwdriver-type blade. The cutting blade may be used to skin insulation from wires and to scrape the thin coat of varnish insulation from a copper conductor when making splices or connections. The screwdriver-type blade may be used to turn screws. When the knife is not in use, fold and place it in your toolbox. Knives should not be used as prybars, and the blades should be kept sharp and free of nicks.

COLD CHISELS - Cold chisels are used to cut or chip metal. The flat chisel, like the one shown in figure 3-18, is used by the electrician to shear nuts or boltheads that are frozen to such extent that a wrench cannot remove them. This flat chisel is also used to cut sheet metal. Keep the cutting edge sharp and ground to the original angle. The hardness or softness of the metal to be cut determines the cutting angle required. A cutting edge angle of 60° to 70° is fine for most light metals. An angle of 90° is recommended for hard and tough metal. The chisel must be kept sharp and the edge slightly rounded as shown in figure 3-18.

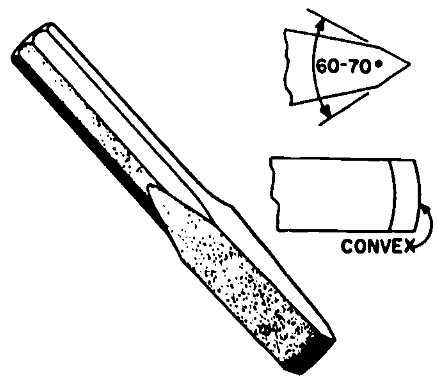


Fig 3-18. Cold chisels.

To use the chisel, place the cutting edge on the mark where the cut is desired and at whatever angle will cause it to follow the desired finished surface. Strike the chisel head squarely with a hammer. Start with a few light blows to get the cutting started, then let the hammer fall with more force. After each blow, lift the chisel, check the cut, and set the chisel back in the cut for the next cut. Take care that the hammer does not slip off the end of the chisel and injure your hand. When the cutting edge of a chisel becomes dull, sharpen it with a bench grinder.

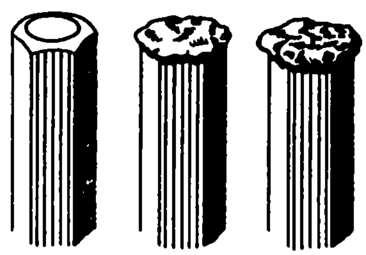


Fig 3-19. Properly dressed and mushroomed chisel heads.

To grind a chisel, set the rest on the grinder to secure the desired level angle. Move the chisel head from side to side a little during the grinding operation to slightly curve the cutting edge. Turn the chisel over and grind the hammered end to its original shape. It is very dangerous to use a chisel with a mushroomed head, because steel pieces may fly off the chisel and cause injury to you or your co-worker. An example of a mushroomed chisel head and also a properly dressed head are shown in figure 3-19. When the chisel is not in use, it should be stored in a wooden box. Scour off any rust with light lubricating oil.

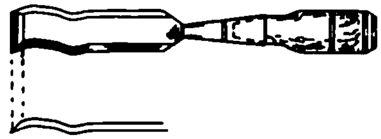


Fig 3-20. Wood chisel.

WOOD CHISELS - The wood chisel is used to cut holes and grooves in lumber and other soft building materials. The chisel is a flat piece of steel with one end ground to an acute level to form a cutting edge, as shown in figure 3-20. Some of the chisels are driven by hand pressure, others are driven with a mallet. NEVER use a hammer or metal tool to drive the chisel. Drive wood chisels outward, away from the body, with a rubber or rawhide mallet. Do not use a wood chisel as a pry or wedge. The steel is hard and brittle, and may snap. NEVER place chisels on a workbench or on a shelf so that they can roll off and drop to the floor, because they can be kicked or dropped on a worker's foot, causing severe injury. Keep chisels on a rack so that the sharp edges will be protected.

Wood chisels must be kept sharp to prevent injury to the user. Use an emery wheel to sharpen a wood chisel and then hone it on an oilstone. Secure the oilstone to a bench. Do not hold it in your hand, because the sharp edge slipping off the face of the stone can cause a severe hand or wrist injury. Handles for wood chisels are made of wood or plastic.

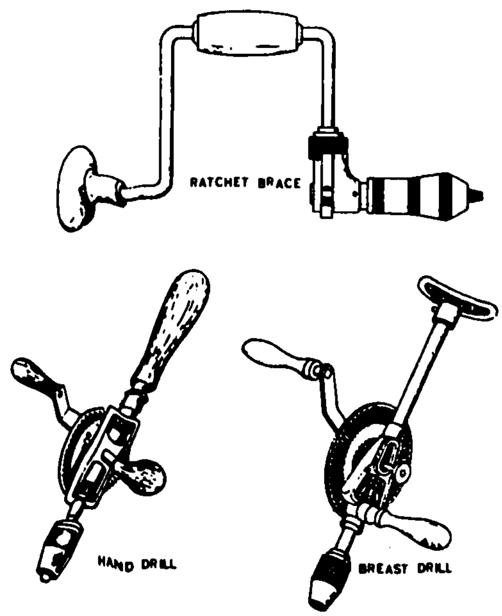


Fig 3-21. Drills.

During the installation of electrical units, the electrician will need to bore holes in various materials. This is a simple task that involves the use of common hand drills, twist bits, anger bits, and star bits.

The most common hand drills you will use are the RATCHET BRACE and the HAND and BREAST DRILLS. Check the types of drills in figure 3-21. The ratchet brace consists of a knob, crank, and chuck for holding the bit. The chuck usually has a ratchet that allows the handle to turn in either direction to turn the chuck. This permits the boring of holes in places where a full revolution of the crank cannot be made. The chuck is built to hold only auger bits that have a square tang and is used for drilling holes in wood. Both the hand drill and the breast drill use a wheel with a handle to drive the bit. The chuck on these two drills holds a straight shank bit, called a twist bit.

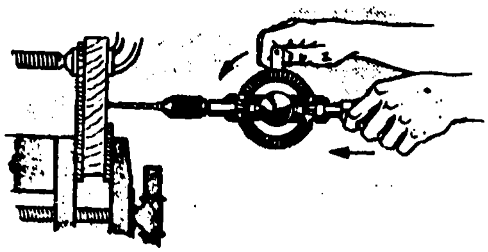


Fig 3-22. Drilling with a hand drill.

To drill with the brace, place the bit on the work and turn the handle clockwise, using a light, but firm, pressure on the head of the brace. Heavy pressure can cause the bit to break from overheating, or cause the hole to be drilled oversize. The bit should be perpendicular to the work at all times. When using the hand or breast drill, the procedures are generally the same as when using a brace. Hold the hand drill with one hand on the handle and operate it by turning the crank with the other as illustrated in figure 3-22. The pressure is applied with the hand. To apply pressure to the breast drill, the operator pushes against the end of the tool with his/her body. Keep the drills clean and the moving parts well oiled.

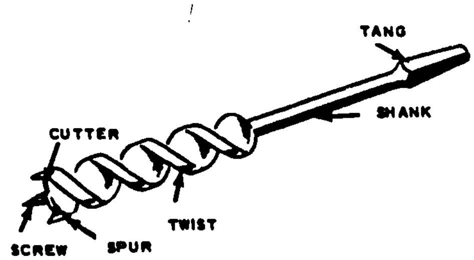


Fig 3-23. Auger bit parts.

AUGER BITS are screw-shaped tools with six parts and are used only for drilling holes in wood. Figure 3-23 illustrates the six parts of the bit. When you turn the brace, the spurs score a circle and the two cutting edges shave the wood from within the scored circle. The screw centers the bit and draws it into the woods. The twist carries the cuttings away from the cutters and deposits them in a mound around the hole.

Both the electric and the manually operated hand drill, and the breast drill require twist bits. Most twist bits have a round shank that fits the jaws of the drills. Some twist bits are made with a tang to be used in a brace. Both types are shown in figure 3-24. The size is marked on the shank or tang and is usually given in fractions of an inch. These bits are used to drill holes in wood or metal. You must apply pressure to get the hole started. Always slack off on the pressure as the drill is about to break through. This action often prevents skinned knuckles and helps to prevent the drill from breaking.

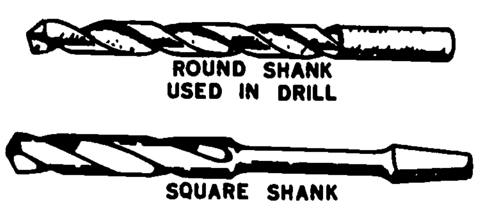


Fig 3-24. Twist bits.

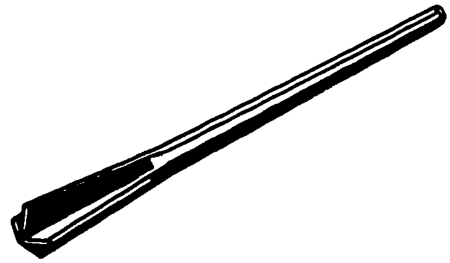


Fig 3-25. Start drill.

A <u>STAR BIT</u> (fig 3-25) is used to drill holes in concrete or brick walls, or floors for mounting electrical controls, or for passage of conduit or cable. Driven by the impact of a ball-peen hammer, the star bit is twisted left and right in the hole as each blow is struck. In hard stone, it is advisable to keep clearing out the drilled material. The size of the bit used determines the size of hole being drilled. The smaller sized tools are usually driven by one person. The larger tools require two people. The most common sizes used by the electrician are the 1/4- and 1/2-inch star bits. The star bits, as with other types of bits, require cleaning after each task and being kept rust free and well oiled.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

Matching: Match each of the descriptive statements in column 1 (items 1-14) to the correct tool in column 2 by placing the appropriate letter in the spaces provided . Some letters may be used more than once.

Column 1

<u>Description</u>

1. ______ Has removable soft jaws inserts and pipe jaws
2. ______ Used for forming wire loops
3. ______ Used for driving and removing screws
4. ______ Uses a chain to grip its work
5. ______ When turned backwards, releases its grip.
6. ______ Used for driving or pulling nails
7. ______ Used for turning nuts and bolts if the right size box or open end wrench is not available
8. ______ Comes in standard sizes to fit nuts and bolts
9. ______ Used to assemble conduit and couplings
10. ______ Used to cut large wire and small cables

Column 2

<u>Tool</u>

a. Screwdrivers
b. Longnose pliers
c. Pipe wrench
d. Adjustable jaw wrench
e. Claw hammer
f. Box- or open-end wrench
g. Sledge Hammer
h. Utility Vise
i. Chain vise
j. Sidecutting pliers
k. Conventional pipe vise
l. Water pump pliers

11. ______ Can be mounted on legs and carried to the job sites

12. ______ Equipped with adjustable jaws and extra long handles for gripping round stock

13. ______ Used for driving stakes and ground rods

14. ______ Should not be used for a chisel or punch

Matching: Match each of the descriptive statements in column 1 (items 15-38) to the proper cutting tools in column 2 by placing the correct letter in spaces the provided. Some letters may be used more than once.

Column 1

Description

15. ______ Used to cut conduit, tubing, or flat metal.

16. ______ Used to cut rigid conduit only.

17. ______ Used to cut wood across the grain.

18. ______ Used to cut grooves in wood.

19. ______ Used to enlarge holes in metal.

20. ______ Used to cut and chip metal.

21. ______ May be used to skin insulation from wires.

22. ______ Driven by hand pressure or with a mallet.

23. ______ Do not break out waste by twisting the tool.

24. ______ Using the tool on thin-wall conduit flattens the end.

25. ______ A wrench is used to turn the bolt until a hole is made.

26. ______ A dull blade for this tool cannot be sharpened.

27. ______ Requires a hole be drilled or punched before it can be used.

28. ______ On this tool, a cutting blade angle of 60° to 70° is fine for most light metals.

29. ______ These tools range in size from 8 to 16 inches.

30. ______ When using this tool, two or more teeth should always be in contact with the work.

Column 2

Tool

a. Carpenter's Saw
b. Hacksaws
c. Rigid conduit cutter
d. Knockout punch
e. Pocket knife
f. Cold chisel
g. Wood chisel

31. ______ The cutting wheels must be replaced when dull.

32. ______ A hammer and punch may be used to remove the slug from the die of this tool.

33. ______ A cutting blade angle of 90° is recommended for cutting hard and tough metal.

34. ______ Never use a metal hammer to drive this tool.

35. ______ Should shrapened on an emery wheel and then bored on an oil stone.

36. ______ Has a blade that can be used as a screwdriver.

37. ______ Cuts a 1 11/32-inch hole for 1-inch conduit.

38. ______ A coarse-tooth blade is used to cut soft metal.

Matching: Match each of the descriptive statements in column 1 (items 39-44) to the proper boring tool in column 2 by placing the correct letter in the space provided.

Column 1 Description	Column 2 Tool
39. ______ Used to drill holes in concrete or brick walls.	a. Ratchet brace b. Hand drill c. Breast drill
40. ______ Used for drilling holes in wood only.	d. Auger bit e. Twist bit f. Star bit
41. ______ Usually has a round shank.	
42. ______ Uses bits with a square tang.	
43. ______ Uses a twist bit and requires only hard pressure.	
44. ______ Uses a twist bit and allows pressure to be applied with the body.	

Work Unit 3-2. SPECIAL TOOLS

NAME THE TOOLS NEEDED TO PERFORM GIVEN TASKS AND STATE HOW THEY ARE USED.

In addition to the common handtools just covered. There are several special tools used by electricians to do special tasks. You must know how to select and use these tools to make your job easier. They include fish tapes, rules and tapes, wire gages, fuse pullers, wire strippers, and reaming tools.

FISH TAPES are made of tempered steel. Most of them are flat and are rolled up in a metal or plastic frame for ease of handling and storage. See figure 3-26 for an illustration of a flat-type fish tape. Tapes come in various widths and in coils of 25, 50, 75, 100, and 200 feet. A fish tape is used to pull wire through conduit or other raceways. The fish tape is stiff enough not to bend in normal use but can be pushed or pulled easily through conduit bends. For large conductors, the tape is used to pull a winch line or rope through the conduit first. You then use the winch line or rope to pull the conductors through the length of conduit.

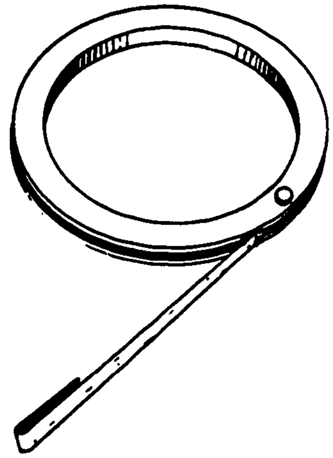
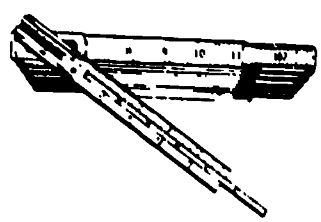
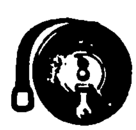


Fig 3-26. Fish tape.

RULES AND TAPES are measuring tools used by an electrician. The 6-foot folding rule and the cloth tape (fig 3-27) are the most common types. The folding rule is used for measurements of 6 feet or less when doing layout work or roughing in boxes. It is very handy because its hinged sections can be folded and placed in your pocket or tool punch. To use the rule, hold it in one hand and with the other hand unfold only the sections needed to take the desired measurement. The rule shown in figure 3-27 also has a slide in the end of one section that can be used for taking inside measurements. The cloth tape is used to make long measurements, for instance 10 feet or more, and is made of cloth or linen. The tape is used by placing the metal ring at the end of the tape over a nail at the start of the measurement and walking in the direction to be measured, pulling the tape out of its case. After the measurement is taken, the tape is rewound with the pop-out handle ont he side of the case.



FOLDING RULE



CLOTH TAPE

Fig 3-27. Measuring tools.

Usually the graduations on the rule or tape are in fractions of an inch. A small number printed on the rule near the end tells you the fractions of an inch used on the rule. Thus, the number 8 would indicate that the markings are 1/8-inch apart; the number 16 means 1/16 inch, and 32 and 64 indicate that 1/32- or 1/64-inch graduations are used.

The folding rule must be unfolded very carefully to prevent breaking off sections near their joints. Keep the rule clean to prevent the joints from becoming stiff. If the joints do become hard to operate, lubricate them with a small drop of light oil or graphite to make the sections easier to fold or unfold. Remove any excess oil with a cloth. Keep the rule folded when not in use. Cloth tapes must be kept clean and dry. Dirt may damage the winding mechanism. If the tape gets wet, unroll it and allow it to dry.

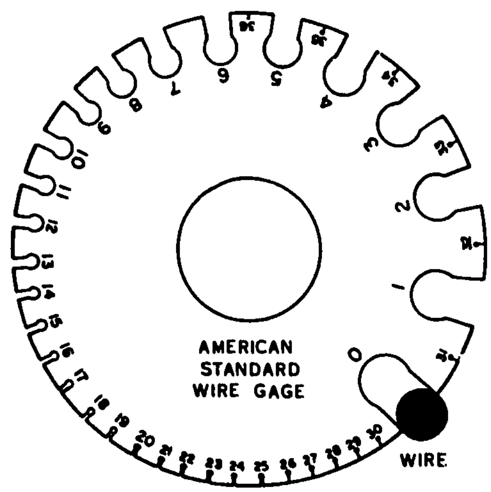


Fig 3-28. Wire gage.

A WIRE GAGE is a tool used to measure the diameter of wires. When you read in the code that replacement wires must be of a certain size, you can check them with a wire gage. The gage, shown in figure 3-28, is simply a round, flat metal disc with holes and slots around its circumference. To use it, slide the slots over the wire until you find the slot that fits the wire. The size is etched on the disc next to the slot. The gage shown in figure 3-28 is called the American standard wire gage (AWG) and is the standard gage for electrical wire used in the United States.

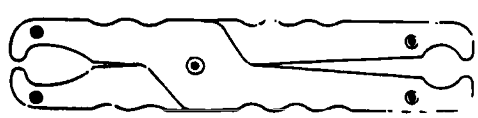


Fig 3-29. Fuse puller.

The FUSE PULLER, shown in figure 3-29, is constructed for pulling and replacing both large and small cartridge fuses. It is made of laminated fiber with good insulating qualities. Fuse pullers come in sizes from 5 to 20 inches long. Large pullers contain more laminations and have a larger slot in the jaws to use on bigger fuses. You must always use a fuse puller to pull and replace cartridge fuses to eliminate the danger of electric shock. The puller may be used also to adjust loose fuse clips.

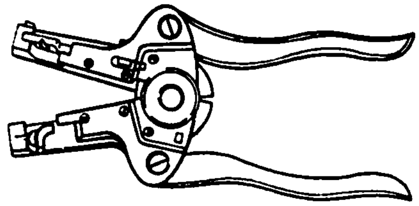


Fig 3-30. Wire stripper.

The WIRE STRIPPER, shown in figure 3-30, is used to strip the insulation from small size wires before making splices or attaching the conductor to a terminal screw. The stripper can e used for stripping insulation from various sizes of wire up to No. 11 AWG. When using the stripper, take care to insure that the wire size is not bigger than the stripper slots, since this would cause damage to the wire. If the wire is stranded, several of the strands will be cut. If the wire is single strand, it will be picked and weakened to the point where it will break when twisted even slightly. The wire stripper should be kept clean, and light oil may used on the moving parts.

Fig 3-31. Reamer.

After conduit has been cut to length, the cut end must have the sharp edges on the nside removed to prevent damage to the wire insulation. This procedure is called "reaming." he tool that is used is the REAMER. Rigid conduit is normally reamed with a tool similar o the drawing in figure 3-31. Notice the square long tang on the shank. It is normally used ith the ratchet brace described previously, or you may use a tool that is especially designed or reaming. The reaming is complete when the sharp edges and metal burns have been removed. o not store the reamer in a position that may cause the cutting edges to become dull. If the eamer is equipped with a ratchet, it should be kept clean and well oiled.

XERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. What special tool is used for pulling conductors (wires) through conduit and how is it used if the conductors are very large?

____

____

____

2. Which measurement tool is used by the electrician for layout or roughing in boxes?

____

3. How can the folding rule be used for taking inside measurements?

____

4. What is the purpose of the wire gage?

____

____

5. Why should a fuse puller be used in place of something else when replacing fuses?

____

____

6. What tool is used to remove the sharp edges from the inside of conduit after it has been cut to length?

____

7. When using the wire stripper, what precautions should be observed and why?

____

____

____

Work Unit 3-3. SOLDERING EQUIPMENT AND SOLDERING

NAME DIFFERENT TYPES OF SOLDERING EQUIPMENT.

STATE CHARACTERISTICS OF DIFFERENT TYPES OF SOLDERING EQUIPMENT.

CITE THE FUNCTION OF THE HEAT SINK.

STATE MATERIALS USED IN SOLDERING.

SPECIFY THE PROPER PROCEDURES FOR USING SOLDERING EQUIPMENT.

According to the National Electrical Code, a splice must be joined with devices suitable for use or by soldering. Most of the time you will be able to use the devices made available, such as wire nuts, twist locks, etc. However, there will be times when you will need to solder splices or connections to complete your work.

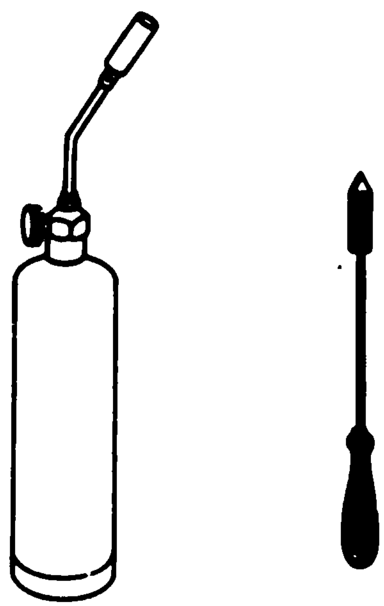


Fig 3-32. Torch and soldering copper.

SOLDERING DEVICES are divided into two types: nonelectric and electric. The nonelectric type is used when there is no power source close to the worksite. Two nonelectric types are the torch and the soldering copper (commonly called a soldering iron), shown in figure 3-32. The torch is normally fueled by a propane bottle that can be changed when it is empty. It can be used for direct soldering of large splices, or it can be used to heat the iron to the desired temperature when soldering smaller splices. The electric gun and electric irons shown in figure 3-33 can be used for soldering when there is a power source close to the worksite. All electric soldering irons and guns are rated in watts. Those with high wattage ratings produce more heat. Since large splicers require more heat for soldering, a high wattage gun or iron will be needed. Higher wattage devices may be used for smaller splices, but care must be taken to avoid melting of the insulation. In some cases a heat sink may be needed to prevent damage to circuit components. The heat sink absorbs heat that might otherwise be absorbed by the component and cause it to burn up. An example of a heat sink that may be used while soldering is a pair of locking pliers or a spring clamp attached to the work being soldered. The electrical irons and guns have cords of varying lengths and nearly all operate on 120 volts AC.

Soldering is the process of joining metals by adding another metal to bond them together. Electrical work requires solder made with lead and tin in near-equal amounts. Common types of solder used are 60/40 and 50/50. The first number represents the amount of lead and the second number the amount of tin in the solder. To make a wood bond, the metal to be joined must be clean, and you must have enough heat to melt the solder. Heat is supplied by one of the devices discussed previously to the joint to be soldered. To clean the joint, a cleaning agent or flux (made of rosin) that removes oxides from the surfaces to be joined is used. Flux may be applied in the form of a paste, or it may be included as the core of the solder. If the flux is in the solder, it is called rosin-core solder. Flux used for soldering shut metal is made with an acid base. Acid-base flux should NEVER be used for electrical work because it will cause corrosion.

Soldering jobs in electrical work are of three main types: (1) soldering two or more wires together, (2) soldering wires to lugs or terminals, and (3) soldering wires to metal surfaces. No matter which type job you are doing, there are certain steps you must take to have a good soldered splice or connection.

First, the soldering iron or gun must be tinned. To tin the end of the iron or gun, you must first heat it and clean it with flux; then put a thin coat of solder on it. If you have an iron that is burned and pitted, it may need to be filed and brushed before it is tinned. Next, the splice or connection should be twisted or held firmly together. Then prepare the joint for soldering by applying flux. When the metal is heated the flux will boil, cleaning the joint in the process. If rosin-care solder is used, cleaning will take place as you apply the solder.

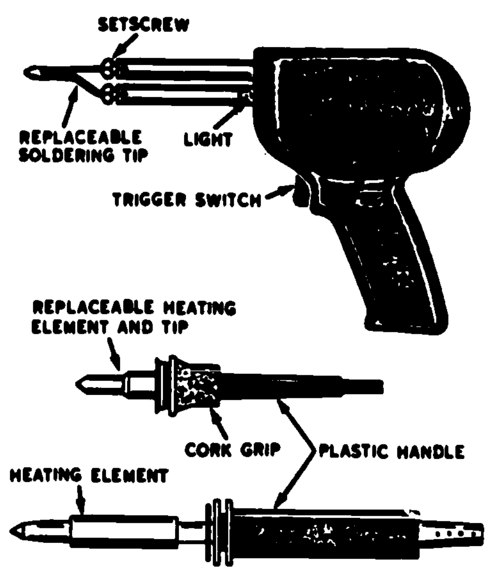


Fig 3-33. Electric soldering gun and iron.

Now, hold the gun or iron under the joint, if possible, and heat it until the joint, not the iron on gun, melts the solder. Apply heat until the solder runs freely around the wires or metal being joined. A good soldering job is one in which a thin coat of solder has flowed on all surfaces to be joined. When the solder cools, after you have removed the heat, it should be a dull silver color. If it is a dull white, you have what is known as a "cold solder" and you must reheat it. Cold solder joints are caused by not using enough heat. Once the joint has been made as just described, it is a waste of time and material to add solder just to make it look better.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. Name the two types of soldering devices.

   ____

2. What type fuel is used for the torch?

   ____

3. What is another name for the soldering iron?

   ____

4. How are electric soldering devices rated?

   ____

5. What is the purpose of a heat sink?

   ____

6. What materials are contained in the solder used for electrical work?

   ____

7. What do the numbers 60/40 mean as applied to solder?

   ____

   ____

8. What type of flux is used for cleaning joints in electric soldering?

   ____

9. What is the first step in preparing a soldering gun or iron for soldering?

   ____

10. After the splice or joint is twisted or held firmly together, what is the next step required to assume a good soldering job?

    ____

    ____

11. If possible, heat should be applied from which direction?

    ____

12. How do you prevent "cold solder" joints?

    ____

    ____

STATE THE CHARACTERISTICS OF PORTABLE POWER TOOLS.

CITE PROCEDURES FOR POWER TOOL USES.

Portable power tools are used to make jobs easier. You can drill holes in wood with a brace and bit, but you can drill the holes much faster and easier with an electric hand drill. For these reasons, you should use the power tools that are available to you whenever possible. In this work unit, we will cover two of the most common portable power tools used in the electric shop, the electric hand drill and saber saw.

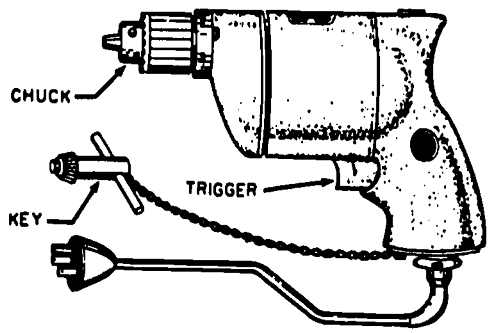
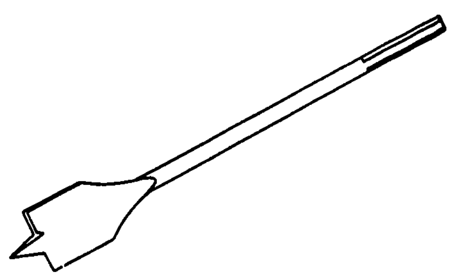


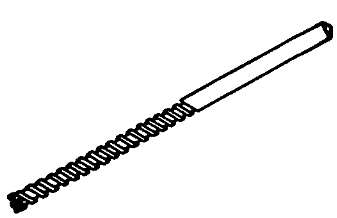
Fig 3-34. Portable electric drill.

The most used portable tool that you will find in the electrical shop is the electric hand drill. With it you can drill holes in almost anything to be found in and around the facilities. The drills are available in various sizes, the size being determined by the largest size drill shank that the chuck will take. For example, a 1/4-inch drill will take all twist bit shanks up to and including 1/4-inch sizes; 3/8-inch sizes, 3/8-inch bit; 1/2-inch size, 1/2-inch bit, and etc. The drills are equipped either with a pistol grip or closed handle (spade grip). The bits are secured in a key-type gear chuck that automatically centers the drill shank. An example of a typical electric hand drill is shown in figure 3-34.

When drilling holes with the electric drill, you must be sure that the bit you are using is suitable for the material to be drilled. In another part of this study unit, you learned that the twist bit could be used to drill work on metal. Other bits that can be used with the electric hand drill are the spade bit and the masonry bit, shown in figure 3-35.



Spade Bit



Masonry Bit

Fig 3-35. Spade and masonry bits.

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The SPADE BIT, sometimes called a speed bit, is used exclusively for drilling wood and is available in sizes up to an inch and a half with a 1/4-inch shank. Note that the spade bit does not have a screw tip like the auger bit, so pressure must be applied for starting and drilling. The point is primarily for centering the bit when you start to drill. As the hole is bored, you must reduce the pressure on the drill just prior to going through the wood. If you don't, the bit will splinter the wood and leave a ragged hole.

The MASONRY BIT is used with the electric hand drill for drilling holes in concrete, cinder block, or brick. Often you need to anchor a box or conduit to this type of material. To do this, it is necessary to drill a hole to accommodate a lead anchor or toggle bolt. These bits come in various sizes with different size shanks.

An important thing to remember when using a masonry bit or a twist bit with the electric hand drill is DO NOT overload the drill motor. The best way to do this is to avoid using oversize bits. As an example, if you are drilling metal with a 1/2-inch electric hand drill, do not use a bit that is larger than 1/2 inch.

When drilling metal with a twist bit, center punch the spot to be drilled and drill the hole. Experience will teach you just how hard to push the bit to cut a proper sized chip and not overload the motor. Watch closely when it seems that the bit is on the point of breaking through; then slack off on the pressure so that the bit comes through easily. This will keep it from wedging in the uncut material and sticking, which is apt to break your grip and injure your hand or cause injury to someone else. Occasionally, when drilling wood, a nail is hit while drilling a hole. Here again, the drill will try to twist out of your hand. For these reasons, be sure that you are standing well braced when using the drill. The ventilation holes on the drills should be kept free of dust or lint to prevent overheating of the motor. Continued stalling and overheating will damage the motor to a point where it will become useless. So, do not overload the motor and keep the chuck clear and well oiled.

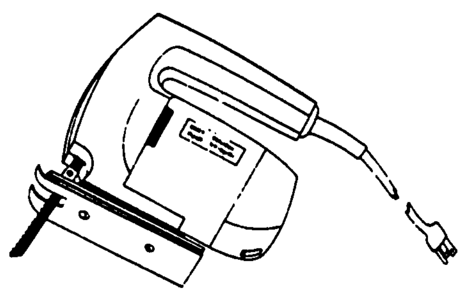


Fig 3-36. Saber saw.

Another common portable power tool used in th electric shop is the saber saw, shown in figure 3-36. Several types of blades are made for the saw to cut different types of material. They can be changed by loosening the set screw that holds the blade in place. The saber saw is used by the electrician to cut openings in finished walls so that outlet boxes or panel boards can be flush mounted. It can also be used to cut notches in studs to make runs of cable and to cut conduit if a metal cutting blade is used.

To use the saw for cutting openings in finished walls, a pilot hole must first be made in the area that is to be cut out. The blade of the saw is then put into the hole with the base plate held firmly against the wall. You may then start to cut the opening required.

When using the saber saw, always apply steady, even pressure and hold the base plate firmly against the work. Forcing the saw will cause stalling and overheating. The saber saw, like the electric drill, has ventilation holes that should be kept clean and free of dust or dirt to prevent overheating.

There is one last thing to remember when cutting or drilling in finished walls on around any electrical circuits that are already installed. That is, check to make sure you do not drill or cut into anything that may be concealed in the wall, including electrical circuits that may be energized.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. What determines the size of an electric hand drill?

   ____

2. What are the three types of bits ordinarily used with the electric drill?

   a. ______________________________

   b. ______________________________

   c. ______________________________

3. Bits are secured in an electric drill by a(n) ____________________.

4. To avoid splintering the hole with the spade bit, apply less pressure ____________________.

5. What type of bit is used with the electric hand drill for drilling into concrete, cinder block, or brick? ____________________

6. What is the best way to keep from overheating the electric hand drill?

   ____

7. When drilling metal with a twist bit and electric drill, what must be done to avoid wedging the bit prior to breaking through?

   ____

8. Saber saws are used to cut what type material? ____________________

9. When cutting an opening in a finished wall with a saber saw, what must be done first? ____________________

10. Forcing the saber saw through material will cause what ?

   ____

SUMMARY REVIEW

In this study unit you have learned to select and use common handtools, special tools and portable power tools. You learned the proper safety precaution associated with these tools so that you can effectively employ them while performing your duties.

Answers to Study Unit #3 Exercises

Work Unit 3-1.

1.	h	12.	k or i	23.	a	34.	g
2.	b	13.	g	24.	c	35.	g
3.	a	14.	a	25.	d	36.	e
4.	m	15.	b	26.	b	37.	d
5.	c	16.	c	27.	d	38.	b
6	e	17.	a	28.	f	39.	f
7.	d	18.	g	29.	b	40.	d
8.	f	19.	d	30.	b	41.	e
9.	c	20.	f	31.	c	42.	a
10.	j	21.	e	32.	d	43.	b
11.	k	22.	g	33.	f	44.	c

Work Unit 3-2.

1. Fish tape. It is used to pull winch line or rope through first, then the winch line or rope is used to pull the conductor.
2. Folding rule
3. By extending the metal slide at one end of the folding rule
4. To measure the diameter of a wire to check the size
5. To eliminate the danger of electric shock
6. Reamer
7. Make sure the size wire being stripped is not larger than the slot. If you don't, the wire may be nicked or cut.

Work Unit 3-3.

1. nonelectric and electric
2. Propane
3. Soldering copper
4. In watts
5. To absorb heat and protect components
6. Lead and tin
7. The solder contains 60 percent lead and 40 percent tin.
8. Rosin flux
9. It must be tinned.
10. Clean with a rosin flux
11. From under the splice or joint
12. Make sure enough heat is used.

Work Unit 3-4.

1. The size drill shank its chuck will take
2. a. Twist bits
   b. Spade bit
   c. Masonry bit
3. Key type gear chuck
4. Just prior to going through the wood.
5. Masonary bit
6. Avoid using oversize bits
7. Reduce pressure on drill
8. Wood
9. Drill pilot hole
10. Stalling and overheating

MARINE ELECTRICIAN: FUNDAMENTALS

REVIEW LESSON

INSTRUCTIONS: This review lesson is designed to aid you in preparing for your final exam. You should try to complete this lesson without the aid of reference materials, but if you do not know an answer, look it up and remember what it is. The enclosed answer sheet must be filled out according to the instructions on its reverse side and mailed to MCI using the envelope provided. The questions you miss will be listed with references on a feedback sheet (MCI-R69) which will be mailed to your commanding officer with your final exam. You should study the reference material for the questions you missed before taking the final exam.

A. Multiple Choice: Select the ONE answer that BEST completes the statement or answers the question. After the corresponding number on the answer sheet, blacken the appropriate circle.

Value: 1 point each

1. Identify the smallest three particles that make up matter.

   a. Elements, molecules, and electrons
   b. Molecules, neutrons, and electrons
   c. Electrons, neutrons, and protons
   d. Atoms, molecules, and elements

2. Identify the building blocks of nature.

   a. Molecules
   b. Elements
   c. Atoms
   d. Electrons

3. By what means may a compound be separated?

   a. By chemical means
   b. By physical means
   c. By magnetism
   d. By heat

4. Electron flow is defined as the movement of

   a. atoms through a conductor.
   b. molecules through a conductor.
   c. protons and electrons through a conductor.
   d. electrons through a conductor.

5. Voltage is defined as

   a. electrical pressure.
   b. water pressure.
   c. electromagnetic pressure.
   d. physical pressure.

6. The four effects of current are chemical action, physical action, heat, and

   a. ohm.
   b. watt.
   c. magnetism.
   d. temperature.

7. Identify the unit of measurement for resistance.

   a. Henry
   b. Dyne
   c. Watt
   d. Ohm

8. Identify the type magnet that is made of iron or steel magnetized by induction from some exterior source.

   a. Natural
   b. Artificial
   c. Lobestone
   d. Parallax

9. What type of magnet has unstable structure and a low magnetic strength?

   a. Natural
   b. Artificial
   c. Lobestone
   d. Parallax

10. The lines connecting the direction of the field around a magnet from pole to pole are called

a. lines of force.
b. electrons.
c. lines of magnetism.
d. negative charges.

11. From the statements below concerning electromagnetism, identify the true statement.

a. In a magnetic circuit, the force which produces the flux is called electromotive force.
b. When you place your left hand around a coil with your fingers pointing in the direction of electron flow, your thumb will point to the North Pole.
c. When current is flowing through a single-loop conductor, the magnetic lines of force are concentrated to the outside of the loop.
d. When a soft iron core is inserted into a solenoid, the lines of force will decrease.

12. Identify the type current that is defined as electrons moving in one direction through a conductor.

a. Negative current
b. Positive current
c. Alternating current
d. Direct current

13. Identify the type current that is defined as electrons moving back and forth through a conductor at specific intervals.

a. Direct current
b. Electron current
c. Alternating current
d. Hertz current

14. Which of the following statements shows the correct relationship of the current to the voltage and resistance in a d.c. circuit as given in Ohm's law?

a. The current in amperes is equal to the EMF in volts multiplied by resistance in ohms.
b. The current in amperes is equal to the resistance in ohms divided by the EMF in volts.
c. The current in amperes is equal to the EMF in volts divided by the resistance in ohms.
d. The current in amperes is equal to the resistance in ohms divided by the EMF in volts.

15. If a d.c. series circuit has an applied voltage of 24 volts and a resistance of 4 ohms, what is the current flow in the circuit?

a. 4 amps
b. 5 amps
c. 6 amps
d. 7 amps

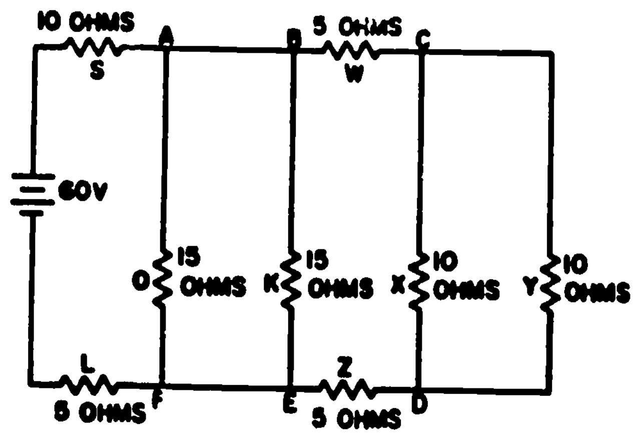
16. If a d.c. series circuit has two resistors, R_1 = 7 ohms and R_2 = 5 ohms and the current flow is 2 amps, determine the total voltage applied to the circuit.

a. 20 volts
b. 24 volts
c. 40 volts
d. 44 volts

17. If a d.c. series circuit has an applied voltage of 110 volts and a current flow of 5 amps, determine the total resistance of the circuit.

a. 24 ohms
b. 23 ohms
c. 22 ohms
d. 21 ohms

Referring to the following circuit schematic, solve for the unknown values in questions 18 thorugh 20.



18. What is the total current of the circuit?

    a. 3 amps
    b. 7 amps
    c. 10 amps
    d. 12 amps

19. Using the answer from question 18, what is the current in resistor "O"?

    a. 1 ampere
    b. 2 amperes
    c. 3 amperes
    d. 4 amperes

20. What is the voltage drop across resistors X and Y?

    a. 3 volts
    b. 5 volts
    c. 6 volts
    d. 7 volts

In questions 21 through 24 identify the correct term for the statement being made in the question.

21. The ability to do work and the unit of measurement is the joule.

    a. Force
    b. Work
    c. Energy
    d. Power

22. The production of motion against a resisting force and the unit of measurement is the joule.

    a. Force
    b. Work
    c. Energy
    d. Power

23. The rate of doing work and the unit of measurement is the watt.

    a. Force
    b. Work
    c. Energy
    d. Power

24. That which produces a change in the motion of a body and the measurement is the dyne.

    a. Force
    b. Work
    c. Energy
    d. Power

25. Find the power required in a d.c. circuit with an applied voltage of 90 volts and a current flow of 6 amperes.

    a. 15 watts
    b. 540 watts
    c. 3240 watts
    d. 4500 watts

26. Identify the direction that electrons flow in an electrical circuit.

a. Positive to negative
b. High pressure to low pressure
c. Negative to positive
d. Low pressure to high pressure

B. Matching: Column 1 (items 27 through 30) lists the description or function of electrical terms. Column 2 (a through e) lists the terms. Match the description or function in column 1 with its term in column 2 and blacken the appropriate circle. One item in column 2 will not be used.

Column 1

Description/Function

27. Equal to the product of the effective values of voltage and current

28. Determined by the frequency and amount of inductance

29. Causes the current to lead the voltage

30. The property of a coil in an AC circuit which opposes any change in the value of the current flowing through it

Column 2

Term

a. Inductive reactance
b. Capacitance in circuit
c. Apparent power
d. Inductance
e. Impedance

C. Multiple Choice: Select the ONE answer that BEST completes the statement or answers the question. After the corresponding number on the answer sheet, blacken the appropriate circle.

Value: 1 point each

31. At what point in an a.c. circuit is the apparent power equal to the true power?

a. When the current and voltage are out of phase due to the reactance in the circuit
b. When the circuit consists of pure resistance
c. When the circuit consists of pure capacitance
d. Both b and c

32. The number of times that each cycle occurs in one second is referred to as

a. reactance.
b. capacitance.
c. revolutions per second.
d. hertz.

33. The following formula 100 times watts (true power) divided by volts times amperes (apparent power) will give you the

a. total power.
b. capacitance of the circuit.
c. power factor.
d. frequency of the circuit.

34. Identify the machine that converts mechanical energy into electrical energy.

a. Compressor
b. Generator
c. Capacitor
d. Resistor

35. The primary difference between an AC and DC generator is the

a. method in which they are used.
b. rotating coil and the magnetic field.
c. miscibility, freezing point, and boiling point.
d. method by which the current is taken from the unit.

36. Identify two types of alternators.

a. Single and poly phase
b. Single and dual phase
c. Single and three phase
d. Dual and three phase

37. What are the two ways that an alternator might operate?

  a. By inductance and capacitance
  b. By the use of sliprings and commutators
  c. By the principle of either moving conductors across a magnetic field or moving a magnetic field across the conductor
  d. By the principle of either moving electrons or moving protons

38. By what method(s) might a three-phase alternator be connected?

  a. Delta
  b. Delta and wye
  c. Wye
  d. Wye and series

39. What is used to supply the DC voltage in a three-phase alternator for the magnetic field?

  a. An accumulator supplies the AC voltage
  b. An exciter supplies the DC voltage
  c. An exciter supplies the AC voltage
  d. An accumulator supplies the DC voltage

40. How many degrees are the poles set apart for the three-phase operations of an alternator?

  a. 90^{o}
  b. 120^{o}
  c. 180^{o}
  d. 360^{o}

41. What is the difference between a primary and a secondary cell?

  a. A primary cell can be recharged and the secondary cell cannot.
  b. The secondary has six cells and the primary has three.
  c. A secondary cell can be recharge and the primary cannot.
  d. There is no difference between the two cells.

42. When fully charged what materials make up the negative and positive plates of a lead-acid battery?

  a. Spongy lead and lead peroxide
  b. Spongy lead and distilled water
  c. Sulfuric acid and lead peroxide
  d. Potassium hydroxide and lead peroxide

43. What solution is used for the electrolyte in a lead-acid battery?

  a. Sulfuric acid and water
  b. Sulfuric acid and potassium
  c. Potassium hydroxide and distilled water
  d. Peroxide and distilled water

44. What solution is used for the electrolyte in a nickel cadmium battery?

  a. Sulfuric acid and water
  b. Sulfuric acid and potassium
  c. Potassium hydroxide and distilled water
  d. Peroxide and distilled water

45. If the ratio of a transformer is 6 to 1 and the applied voltage to the primary is 120 VAC, what is the voltage output from the secondary?

  a. 15 volts
  b. 20 volts
  c. 24 volts
  d. 48 volts

46. What isolates instruments from high voltages or large currents?

  a. Capacitors
  b. Transformers
  c. Resistors
  d. Fuses

47. What will the transformer with a 1-to-2 turn ratio do to the voltage?

  a. Step it up
  b. Center tap it
  c. Step it down
  d. Nothing

48. What causes voltage to be induced in the magnetic field?

   a. A build up and collapse of current
   b. A build up and collapse of voltage
   c. A movement of protons through a conductor
   d. Combination rotary and reciprocating movement

49. Identify what causes most of the accidents in a work area.

   a. The worker
   b. Unsafe equipment
   c. Natural phenomena
   d. Unsafe work space

50. Physical hazards and natural phenomena are two of the three causes of accidents. Identify the third.

   a. Unsafe equipment
   b. Unsafe work space
   c. Unsafe acts by people
   d. Unsafe safety regulations

51. Which of the following is a good work area safety practice?

   a. Prodding a fellow worker in the ribs is OK if not done too often.
   b. Assure that broken windows are replaced promptly.
   c. When a fuse keeps burning out in a certain circuit place a penny behind it.
   d. Leave your tools in the place where you will use them.

52. From the following practices relative to the general use of handtools, identify which is not a safety practice.

   a. Wear goggles when drilling a hole above your head.
   b. Use a box-end wrench in preference to an open-end wrench where possible.
   c. Keep tools sharp.
   d. Store all cutting tools with the other tools without sheaths.

53. From the following select the one which is an unsafe practice in the operation of electrical power tools.

   a. Ventilate areas subject to petroleum vapors.
   b. Tools operated on 110 volts need not be grounded.
   c. Read operating instructions before operating an electric tool.
   d. Never operate an electric power tool a in damp location without protection.

54. From the given work situations, select the one which contributes to the safe use of power equipment.

   a. Machines operated with motors of less than 2 horsepower require no ground.
   b. Brush off metal cuttings from machines with gloves.
   c. Do not leave machine operating unattended even for 5 minutes.
   d. To facilitate lubrication, grease a machine during operation.

D. Matching: Indicate the sequence for lifting a heavy load in proper order by matching the numbers in column 2 with the steps in column 1 and blacken the appropriate circle.

Value: 1 point each

Column 1 Steps	Column 2 Numbers
55. Keep your back straight and squat down.	a. 1
56. Check weight and size.	b. 2
57. Plant your feet well apart.	c. 3
58. Lift slowly by pushing up with your legs.	d. 4
	e. 5

E. Multiple Choice: Select the ONE answer that BEST completes the statement or answers the question. After the corresponding number on the answer sheet, blacken the appropriate circle.

59. What type of ladder would you use to get on top of a roof that is 30 feet high?

a. Single ladder
b. Stepladder
c. Extension ladder
d. Chain ladder

60. Of the following which does not indicate the proper ladder raising technique?

a. Extend an extension ladder on the ground before raising it.
b. Spread a stepladder until the legs lock in position.
c. The top of a 20 foot ladder extends 4 feet above the roof. The base of the ladder is 4 feet from the foundation.
d. The top of a 10 foot ladder extends 36 inches above the eave.

F. Matching: Match each situation in column 1 with its appropriate safety precaution in column 2. After the corresponding number on the answer sheet, blacken the appropriate circle.

Value: 1 point each

Column 1

Situation

61. Climbing a ladder

62. Working from an extension ladder

63. Before climbing a stepladder

64. Be sure ladder rails are equipped with these before climbing

65. Using a stepladder

Column 2

Safety precautions

a. Be sure the locking device is locked
b. Face the ladder and use both side rails.
c. Stand no higher than the third rung from the top.
d. Do not stand on the top two steps.
e. Safety shoes

G. Multiple Choise: Select the ONE answer that BEST completes the statement or answers the question. After the corresponding number on the answer sheet, blacken the appropriate circle.

Value: 1 point each

66. From the following which is NOT a safe practice relative to electrical work?

a. Do not wear jewelry when working on electrical systems.
b. A man must never work alone on an energized circuit.
c. Regard all electrical circuits as being alive.
d. It is not necessary to take further precautions when you know the circuit breaker for the circuit you are working on is off.

67. When handling chemicals and chemical solutions, which of the following is unsafe?

a. Use full protective clothing when handling electrolyte.
b. The proper mixing procedure for mixing acids is always to add the acid to the water.
c. Ventilation is unnecessary for potassium hydroxide.
d. Treat lead acid type battery areas as no smoking areas.

68. What type of fire extinguisher is used on electrical fires?

a. Water
b. Foam
c. Dry chemical
d. CO^2

69. Under what condition(s) should you move an injured person?

a. When the injured person is lying in direct sunlight
b. To make the injured person more comfortable
c. Prior to medical help arriving
d. Never unless it is absolutely necessary

70. What could be the result if while administering first aid you caused additional injury to the victim because you did NOT know what was to be done?

a. Nothing
b. The victim would get mad at you.
c. You could be held liable in a court of law.
d. You would be sent to medical school.

71. In practicing first aid, what is as important as knowing what to do?

a. Knowing what NOT to do
b. Knowing where sick bay is
c. Knowing two reasons for giving first aid
d. Knowing who to report the accident to

72. Identify the four lifesaving steps of first aid.

a. Assure breathing, stop the bleeding, report the accident, and prevent or treat shock
b. Assure breathing, stop the bleeding, protect and treat the wound, and prevent or treat shock
c. Stop the bleeding, protect and treat the wound, prevent or treat shock, and call for medical assistance
d. Stop the bleeding, give the victim salt water, ask the victim if it hurts, and call for medical assistance

73. Identify the procedures you should use to determine if an accident victim is breathing.

a. Place your ear over the victim's mouth and nose, look for a rise and fall of the chest, listen for breathing, and feel for air flow on your cheek.
b. Ask the next person if the victim is breathing; check with the doctor and then ask the victim.
c. Place your hand on the victim's chest, place your hand over the victim's mouth and nose, and use a mirror over the mouth of the victim.
d. You do nothing until medical help arrives.

74. Select the best method of artificial respiration.

a. Back pressure-arm lift
b. Back pressure-hip lift
c. Mouth-to-mouth
d. Back pressure-leg lift

75. Why is it important to clear the airway of a victim before performing artificial respiration?

a. Because if the airway is not cleared, the victim is not able to tell you what is wrong.
b. If the airway is not clear, air will not enter the lungs.
c. It will restrict the intake of fluids.
d. It might cause infection.

76. Identify the tool used for driving and removing screws.

a. Claw hammer
b Screwdriver
c. Water pump pliers
d. Pipe wrench

77. Identify the tool used to cut large wire and small cable.

a. Longnose pliers
b. Water pump pliers
c. Screwdriver
d. Sidecutting pliers

78. Which tool is used to assemble conduit and couplings?

a. Pipe wrench
b. Sledge hammer
c. Box- or open-end wrench
d. Screwdriver

79. Identify the tool that is used for turning nuts and bolts if the right size box or open-end wrench is not available.

   a. Pipe wrench
   b. Adjustable jaw wrench
   c. Box- or open-end wrench
   d. Water pump pliers

H. Matching: Match the descriptive statements in column 1 to the proper cutting tool in column 2 by placing the correct letter in the provided blank. Some letters may be used more than once.

Value: 1 point each

Column 1	Column 2
Description	Cutting tool
80. Used to cut conduit, tubing, or flat metal	a. Carpenter's saw
81. Used to cut rigid conduit only	b. Hacksaws
82. Used to cut wood across the grain	c. Rigid conduit cutter
83. Used to enlarge holes in metal	d. Knockout punch
84. May be used to skin insulation from electrical wires	e. Pocketknife
85. Using the tool on thin-wall conduit flattens the ends	
86. A wrench is used to turn the bolt until a hole is made in the object.	
87. Requires a hole to be drilled or punched before it can be used	

I. Multiple Choise: Select the ONE answer that BEST completes the statement or answers the question. After the corresponding number on the answer sheet, blacken the appropriate circle.

Value: 1 point each

88. Identify the tool used to drill holes in concrete or brick walls.

   a. Star bit
   b. Eccentric bit
   c. Twist bit
   d. Auger bit

89. What tool uses a twist bit and allows pressure to be applied with the body?

   a. Ratchet brace
   b. Breast drill
   c. Auger brace
   d. Shaft drill

90. What is the tool that uses a bit with a square tang?

   a. Ratchet brace
   b. Breast drill
   c. Auger brace
   d. Shaft drill

91. What special tool is used for pulling conductors (wires) through conduit?

   a. Reamer
   b. Shaft tape
   c. Fish tape
   d. Folding tape

92. Which measurement tool is used by the electrician for layout or roughing in boxes?

a. Reamer tape
b. Shaft rule
c. Fish rule
d. Folding rule

93. Which tool should be used to replace fuses to eliminate the danger of electrical shock?

a. Shaft puller
b. Fuse puller
c. Folding puller
d. A reamer

94. What is the purpose of the wire gage?

a. To make sure the size of the wire is not larger than the slot
b. To pre-punch slotted metal
c. To measure the diameter of a wire to check the size
d. To pull winch line or rope through a raceway

95. What are two types of soldering devices?

a. Nonelectric and electric
b. Nonelectric and guns
c. Electric and heat
d. Heat sink and guns

96. What fuel is used for the soldering torch?

a. Propane
b. Natural gas
c. Leaded gas
d. Resin

97. What two materials are contained in the solder used for electrical work?

a. Lead and resin
b. Flux and tin
c. Lead and tin
d. Lead and acid

98. What do the numbers 60/40 mean as applied to solder?

a. That the solder contains 40 percent lead and 60 percent lead
b. That the solder contains 40 percent tin and 60 percent resin
c. That the solder contains 60 percent lead and 40 percent tin
d. That the solder contains 60 percent tin and 40 percent lead

99. What is the first step in preparing a soldering iron or gun for soldering?

a. Clean it with a resin flux.
b. It must be tinned.
c. Make sure that enough heat is used.
d. To make certain it entraps the liquid for future use.

100. If possible, heat should be applied to the wire joint from which direction?

a. From under the splice or joint
b. From any direction you want
c. From the top of the splice or joint
d. It is applied from the right side always

101. The size of an electric drill is determined by the

a. type of bit that it uses.
b. method in which it is used.
c. size of the hand of the electrician.
d. size of the drill shank its chuck will take.

102. What are the two most common electric power tools found in the electric shop?

a. Drill press and electric drill
b. Drill press and saber saw
c. Electric drill and saber saw
d. Saber saws and skill saw

Total Points: 102

* * *

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