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ABSTRACT

This document is an instructional module package prepared in objective form for use by an instructor familiar with the basic concepts of electricity as applied to water and wastewater treatment. Included are objectives, instructor guides, student handouts, and transparency masters. This module considers definition of terms, voltage, current measurement, and power, and includes a brief discussion of motors. (Author/RH)

BASIC ELECTRICITY

Training Module 3.325.1.77

Prepared for the

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by

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September, 1977

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SUMMARY

Module No.	Module Title: Basic Electricity
	Topics:
Approx. Time: 14 hours	1. Introduction 2. Electrical Terms and Measures 3. Wiring Materials and Practices 4. Fuses and Breakers 5. Motors 6. Safety 7. Application

Overall Objectives:

Upon completion of this module the learner should have a basic understanding of electricity, should be able to measure voltage and current, should be able to read an electric meter, should be able to calculate voltage, current, or resistence using "ohn's law", and should respect electricity and exercise safety when dealing with electrical appliances (motors, etc.)

Instructional Aids:

Handouts
Transparancies
Meters
Model

Instructional Approach:

Lecture
Demonstration
Discussion
Hands-on

References:

1. Understanding and Using Electricity, McKenzie and Zachariah

2. Electricity Fundamentals, Baker and Crow, Howard W. Sams & Co. Inc., Kansas City

Class Assignments:

Module No:	Topic: SUMMARY
-	

Instructor Notes:	Instructor Outline:

1. The module includes traditional lecture, in class problem solution and hands-on activity.
2. It is suggested that the students each have a copy of the text. (Understanding and Using Electricity). It may be obtained from:

   Interstate Printers & Publishers, Inc.
   Danville, Illinois 61832
   Tele. 217-446-0500
   Cost $1.95 per copy

3. Table 1 and Figure 11 detail the materials and show an appropriate model for the hands-on activity.
4. The following additional equipment should be available for hands-on activity.

   A. Voltage - resistance meter

   B. Current meter (ammeter)

   C. Ground fault interruptor

   D. Fuses (blown and good ones)

   E. Wire samples of various sizes

   F. Three-prong receptacle check instrument

5. The evaluation should include both the written evaluation and performance to the instructor's satisfaction of the hands-on activity.
6. This is a module to give the student a basic understanding of electricity. Special emphasis should be directed to "safety". The student will not be an electrician upon completion of the basic electricity module.

Module No:	Module Title: Basic Electricity
	Submodule Title: Introduction
Approx. Time: 3 hours	Topic:

Objectives:

1. Define electricity
2. Define a conductor and give two examples of good conductors.
3. Define an insulator and give two examples of good insulators.
4. Define the difference between direct and alternating current as a function of electron flow.
5. Diagram single phase and three phase voltage curves (AC).
6. Define the purpose of a transformer.

Instructional Aids:

1. Transparancies
2. Text (Reference #1 is the text for the workshop).

Instructional Approach:

1. Lecture
2. Discussion

References:

1. Understanding and Using Electricity, McKenzie & Zachariah, Interstate Printers and Publishers, Inc., Danville, Illinois 61832 (text).

Class Assignments:

Module No:	Topic: Introduction

Instructor Notes:	Instructor Outline:

Figure 1 - Diagram of typical atoms

I. Definition of Electricity

In this module electricity shall be defined as the movement of electrons through a conductor.

A. Atoms

1. Made up of protons, neutrons, and electrons. Protons and neutrons in the nucleus, electrons travel in orbits around the nucleus.

2. Charges: Protons positive - Electrons negative.

When number of protons equal the number of electrons the atom has no charge.

Atoms can give upon and take on electrons. The movement of the electrons from one atom to another results in an electric current.

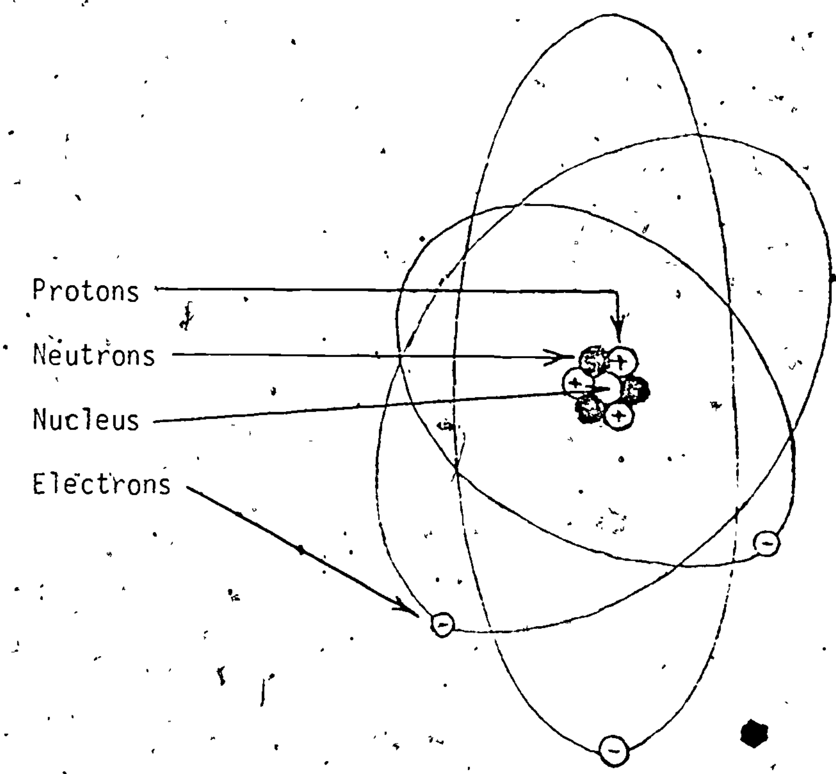
B. Conductors

Materials that are made up of atoms which readily allow their electrons to move from atom to atom. Examples: Copper, aluminum, silver, tap water, damp soil, human body.

C. Insulators

Materials made up of atoms with their electrons more tightly bound are called insulators i.e. the atoms do not allow the relatively free movement of electrons from atom to atom. Examples: Glass, rubber, plastics, bakelite, oil, pure water, dry sandy soil.

FIGURE 1



Module No:	Topic: Introduction

Instructor Notes:	Instructor Outline:

II. Sources of Electricity

A. Friction - electric charge proved by rubbing certain materials together, frequently called static electricity. Because the charge builds up without the flow of current. It is of little practical value and can be a nuisance, even a hazard.

B. Heat - electricity can be generated by connecting two dissimilar metals and heating the junction, electrons will pass from one metal to the other.

C. Light - some materials can produce electricity when subjected to light; termed photovoltaic.

D. Chemical Action - combinations of certain metals placed in special solutions, called electrolytes can result storage batteries produce electricity from chemical action. The three most common types of storage batteries are:

1. Lead-acid
2. Edison
3. Nickel-cadmium

E. Magnetic Action - this is the most common method of producting electricity in large quantities. Michael Faraday in 1831 discovered that if a coil of copper wire is rotated in a magnetic field cutting across the lines of magnetic force, an electric charge is created or induced in the wires. (A magnetic drawn through a coil will also generate electricity).

Alternating current (AC) is a current flowing first in one direction and then in the opposite direction. This can be shown from consideration of a generator as a single loop being rotated in a

Module No:	Topic: Introduction

Instructor Notes:	Instructor Outline:
Figure 2 - One cycle of AC current.	magnetic field. The full cycle of an alternating current is shown going from zero to a maximum, back to zero, to a maximum in the reverse direction, back to zero.
Figure 3 - Single phase and three phase current	Electricity generated in the U. S. is sixty of the above described cycles per second. (Term for cycles per second is hertz). Single phase current is the basic two wire 60 hertz current. Three phase current is three single phase combined with peak voltages equally spaced. Note that the distance between peaks (actually the time between peaks) is reduced to one-third of the single phase distance (time) between peaks.
	F. Transformers - electricity (current) is generated by rotating a loop in a magnetic firld. It is also true that by wrapping a material such as soft iron with a coil of wire and passing a current through the wire magnetizes the soft iron. It is this principle which enables the transformer to exist. The transformer is then a device for stepping up or stepping down the voltage.
Figure 4 - Transformer schematic	The formula indicates the relationships of the transformer.

$$\frac{\text{Primary voltage}}{\text{Primary turns}} = \frac{\text{Secondary voltage}}{\text{Secondary turns}}$$

Given: 120 volts 100 turns on primary
Wanted: 24 volts

The number of turns on the secondary winding must then be 20, therefore

$$\frac{120}{100} = \frac{24}{20}$$

FIGURE 2

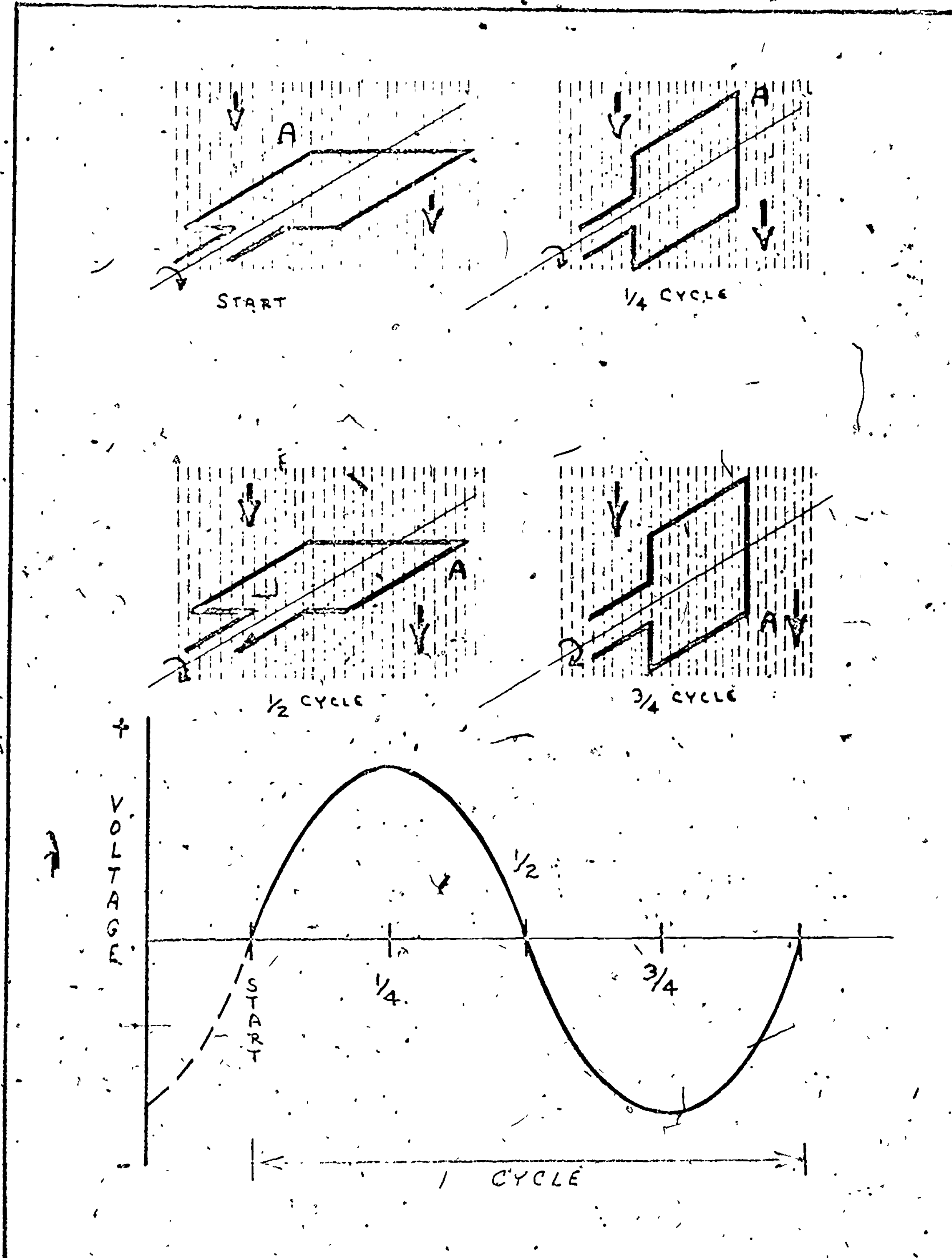
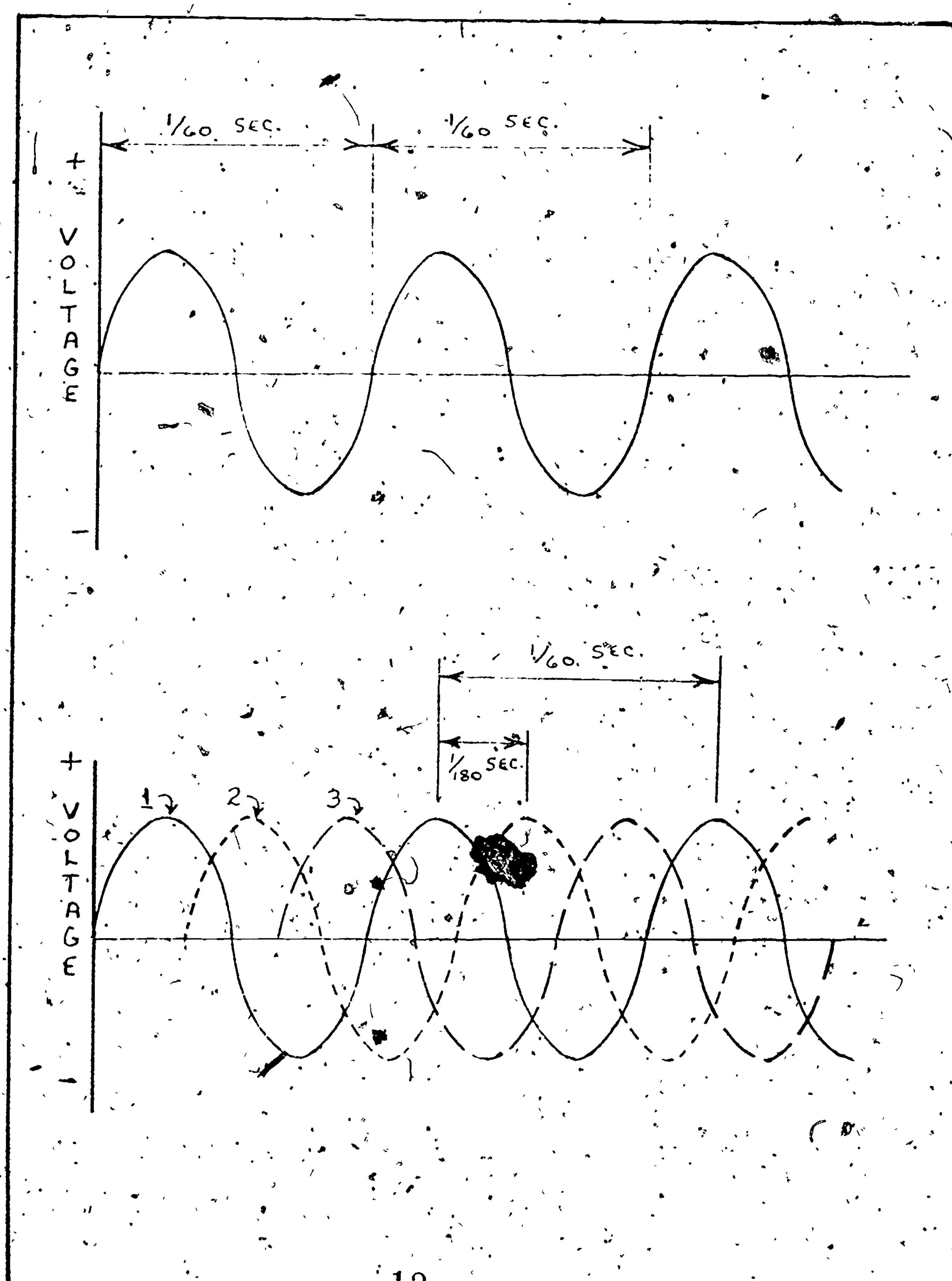
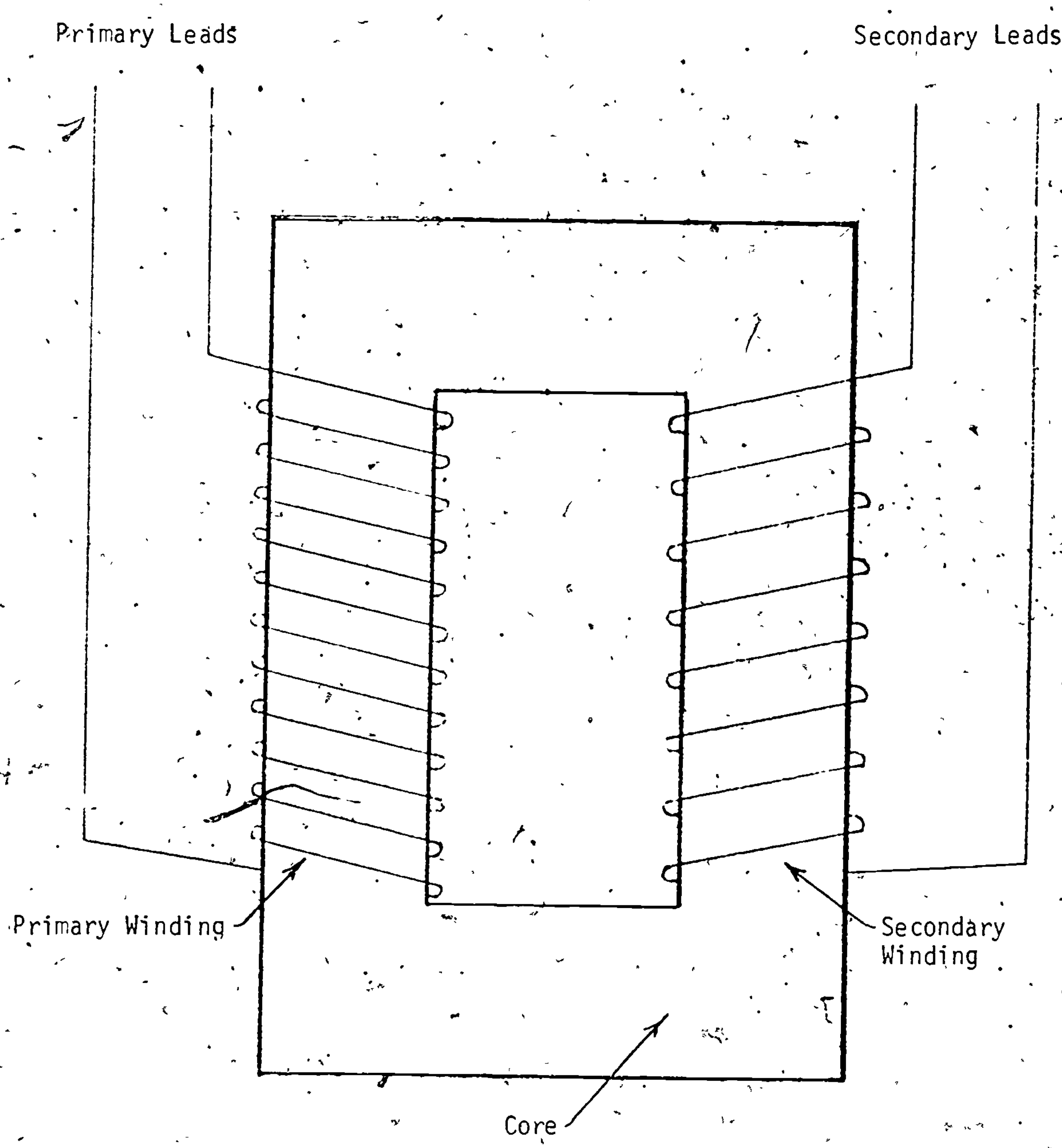

A
START
A
1/4 CYCLE
A
1/2 CYCLE
A
3/4 CYCLE
+
VOLTAGE
1/2
START
1/4
3/4
1 CYCLE

FIGURE 3





Transformer

Module No:	Topic: Introduction

Instructor Notes:	Instructor Outline:
	This would be a "step down" transformer i.e. the voltage is stepped down from 120 volts to 24 volts. A "step up" transformer is used to increase the voltage from the primary to the secondary windings. It is important to understand that stepping up the voltage does not result in an increased power. (Power will be discussed in next section). Transformers neither increase nor decrease the power transferred except for a slight decrease due to losses within the transformer itself. An example problem will be included in the next section. G. Direct Current (DC) - for purposes within this module direct current is defined as that current which results when electrons flow in only one direction. (Electrical system in newer automobiles is 12 bolts DC).

Module No:	Module Title: Basic Electricity
	Submodule Title: Electrical Terms and Measures
Approx. Time: 3 hours	Topic:

Objectives:

1. Define a closed circuit.
2. Define an open circuit.
3. Define a short circuit.
4. Define by matching: A. Current, B. Amperes, C. Ohms, D. Voltage, E. Watts, F. Kilowatt Hours.
5. Given any two of three variables (voltage, current, or resistance) solve a problem using "Ohm's Law".
6. Given a picture of a pointer register kilowatt hour meter, give the reading.

Instructional Aids:

1. Transparencies
2. Handouts

Instructional Approach:

1. Lecture
2. Discussion

References:

1. Understanding the Using Electricity, McKenzie & Zachariah.

Class Assignments:

Module No:	Topic: Electrical Terms and Measures

Instructor Notes:	Instructor Outline:

I. Circuits - Electrical current is the flow of electrons in a conductor. The electrons are not "used up", they flow around a path or a circuit. The pathway begins at the source of power (generator or battery) goes to the "load" (motor or light), passes through the load, and back to the source. It is important to realize that for an electrical current to flow, the pathway must be continuous, unbroken, or a complete circuit.

Figure 5 - Closed circuit, open circuit

A. Closed Circuit - a circuit that provides a complete pathway for electric current to flow.

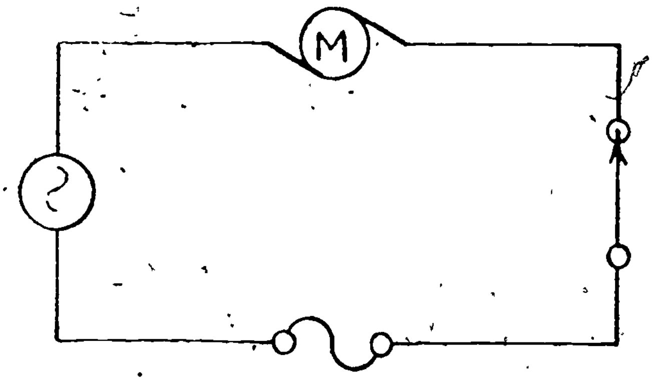
B. Open Circuit - a circuit that is not closed i.e. it has been broken, or disconnected or opened by a switch, fuse, circuit breaker or other opening in the line.

C. Short Circuit - improper or accidental contact between two or more wires.

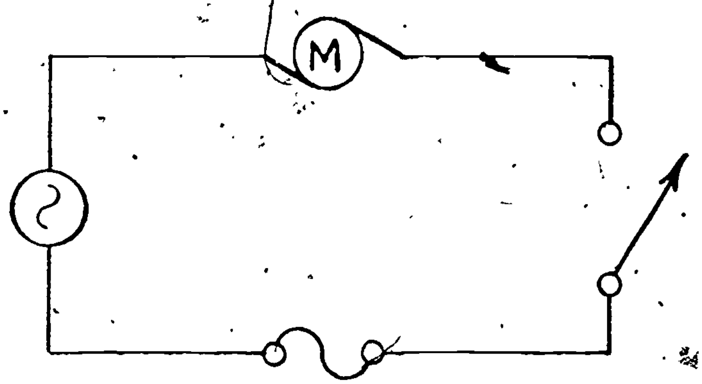
II. Electrical Measures

A. Current - the unit for the rate of current flow is <u>amperes</u>. Current is the name for the flow of electrons through a conductor. The main point is that the <u>rate</u> of current flow is measured in amperes.

B. Resistance - resistance is that which cuts down the rate of current flow in a circuit. The unit of measure is <u>ohms</u>. Conductors of electrons have levels of resistance to current flow. A copper wire has less resistance to electron flow than an equal size and length of aluminum wire.



Closed Circuit.



Open Circuit

Module No:	Topic: Electrical Terms and Measures

Instructor Notes:	Instructor Outline:
	C. Voltage - a generator produces the driving force for electron flow through a conductor. This driving force or electrical pressure is called voltage. The unit of measure of this pressure is the volt.
	III. Ohm's Law
	A. Relationship between the electrical pressure, voltage; the rate of current flow, amperes; and the resistance to current flow, ohms, which exists is known as Ohm's Law.
Given: I = 10 amps R = 12 ohms Find: V = ? (120 volts	The voltage (V) equals the product of current (I) and resistance (R) V = I x R
Given: V = 240 volts R = 100 ohms Find: I = ? (1.2 amps)	The equation can be solved for any of the three terms if the remaining two terms are known.
Given: V = 120 volts I = 3 amps Find: R = ? (40 ohms)	V = I x R or I = V/R or R = V/I
	IV. Power - electrical power is measured in watts. The definition of a (one) watt is the power available from one amp of current with a voltage of one volt. The watt is then a combination of the electrical pressure (voltage) and the rate of flow of the electricity. The equation used for solving for power (Watts - W) is the product of the voltage and current. W = I x V
Given: 1500 watt space heater 120 volt circuit I = ? (12.5 amps)	This equation holds for direct-current circuits and alternating current circuits connected to heating devices. The equation can be solved for any variable provided two

Module No:	Topic: Electrical Terms and Measures

Instructor Notes:	Instructor Outline:
	the equation requires an additional term when the power is being calcualted from a motor in an alternating current circuit. The equation becomes:
	W = V x I x p.f.
	Where p.f. is called the power factor the power factor term results from the fact that in alternating current circuits connected to motors, the voltage waves and current waves do not peak at the same time. The product of voltage and current must be corrected for this difference. Manufacturers bulletins on a given motor will usually include the value of the power factor. Power factors will generally be in the range of from 0.5 to 0.87. The power factor will not be greater than 1.0.
	Two additional terms should become a part of the vocabulary:
Kw = 1000 x W	A. Kilowatt - the kilowatt is equal to one thousand watts.
1 Hp. = 746 watts	B. Horsepower - the measure of electrical power is the watt. The measure of mechanical power is horsepower.
	V. Energy - the previous units of voltage, current, and power now lead to a most important issue confronting the operator - that being energy. The unit of electrical energy consumption at the treatment facility, or in the home or office, is the kilowatt-hour (1000 x Watts - Hours).
	The watt-hour is the measure of one watt of power used for one hour resulting in energy consumption of one watt-hour. The kilowatt hour is used more commonly.

Module No:	Topic: Electrical Terms and Measures

Instructor Notes:	Instructor Outline:

The operator should be able to read the meter which records the amount of energy used at the facility. He should also be able to understand what individual units are using this energy. He must be able to understand the difference between a 5 horsepower electrical motor and a trouble cord with a 60 watt light bulb. He must become energy conscious, relating lights left on needlessly (or motors) to energy consumed - dollars spent wastefully.

A. Meter Reading

Text Figure 2-7 A

1. Cyclometer register kilowatt-hour meter. This meter is quite easy to read as it displays the kilowatt-hour reading in digits like an automobile's odometer. Consideration should be given to recording the meter reading daily. If the facility is manned around the clock, flow meters are typically read and recorded at midnight. Read this meter also and record energy consumed for the twenty-four hour period. Graphical display should also assist in increasing "energy awareness". One- or two-shift operations need only select a specific time for daily readings. Energy used is simply the current day's reading minus the previous day's reading.

Given: 32169 Tues.
Given: 31086 Mon.
1,083 Kw-Hrs.

Text Figure 2-7b

2. Pointer register kilowatt-hour meter These meters have four or five dials. The point of caution is that the dials do not all read the same direction. Some rotate clockwise, the others counter-clockwise. First check if the dial is numbered clockwise or counter-clockwise. Then read each dial by recording which number has just been passed, reading and recording from left to right. Energy consumed is then figured as

Text Figure 2-8 shows two readings

Module-No:	Topic: Electrical Terms and Measures

Instructor Notes:	Instructor Outline:
	previously described by subtracting previous day's reading from present day's reading.
The meter at the building being used for the workshop should be read the first and second day of the workshop if accessible <u>safely</u> and conveniently.	Final Caution. Some meters have a "multiplier". If a multiplier is used, the value of the multiplier is posted on the meter face. This requires that the difference between two day's readings be multiplied by the value of the multiplier to determine energy used.

Module No:	Module Title: Basic Electricity
	Submodule Title: Wiring Materials and Practices
Approx. Time: 1 hour	Topic:

Objectives:

1. List two basic differences between metal conduit and ordinary water pipe.
2. Define by matching the "color code".
3. Given two wire sizes (e.g. 8 and 12) name the larger.
4. List a symptom of undersized wire.
5. Sketch the following two circuits:

   A. 3 light bulbs wired in series
   B. 3 light bulbs wired in parallel

Instructional Aids:

1. Transparancies
2. Handouts
3. Model (possibly)

Instructional Approach:

1. Lecture
2. Discussion

References:

1. Understanding and Using Electricity, McKenzie & Zachariah.

Class Assignments:

Module No:	Topic: Wiring Materials and Practices

Instructor Notes:	Instructor Outline:
It is not the intent of this module to "make" electricians of those completing the workshop. It is the intent to make the operator "aware" of wiring practices.	I. Electric Wire A. Insulation - insulation serves two purposes: 1. Prevents electrical leakage 2. Shields the conductor from physicsl damage B. Application - Table 3-1 of the text (Page 12) is excerpted from the National Electrical Code and presents some common electrical cable and wire types, their designation and their application.
(If possible samples of as many types and sizes of wires should be available for the student to see.)	C. Imprint - wire intended for permanent installation and some extension cord wires are imprinted as example is "NM 10-3" meaning nonmetallic sheated, number 10 wire size, three conductor cable. An imprint "GROUND" or "GRND" indicates a grounding conductor. Grounding is covered in the "Safety" section. D. Size - electric wire size is measured by the area of the cross section and normally designated by an American Wire Gauge (AWG) number. Figure 3-4 of the text shows actual wire size. Note that the larger the AWG number, the smaller the wire diameter. Size of electric wiring is very important. Electric wire can be compared to water pipe. In a water system, large flows require large pipes. Wire is comparable in that high current (high rate of flow) requires large wire. If the wire is too small, the wire will heat up, the heat resulting from the resistance to the high flow rate.

Module No:	Topic: Wiring Materials and Practices

Instructor Notes:	Instructor Outline:

There are other comparisons that can be made between electric circuits and water systems.

Text Figure 2-4

Pump - generator

Rate of flow (gallons/hr) - flow of electrons (amps)

Pressure - voltage

Valve - switch

Turbing (load) - motor (load)

II. Conduit Wiring - this is the most common technique used in treatment facilities (as opposed to nonmetallic wiring done in private residences).

A. Advantages include:

1. Pulling wire through with reasonable ease.

2. Can be cast into concrete, suspended, or surface mounted.

3. Is a conductor for "ground".

B. Material

1. Steel, aluminum, or plastic

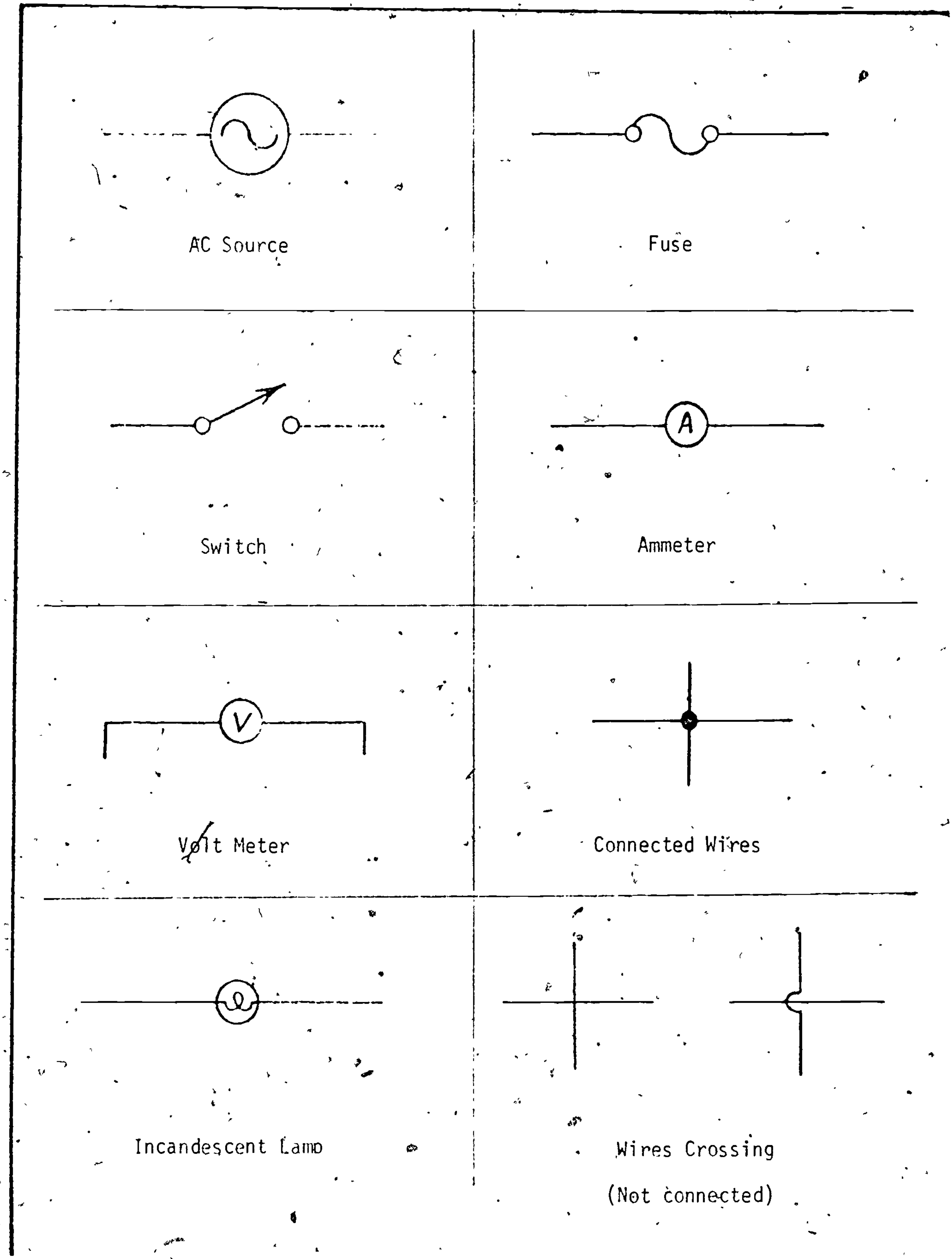
2. Differs from water pipe in that:

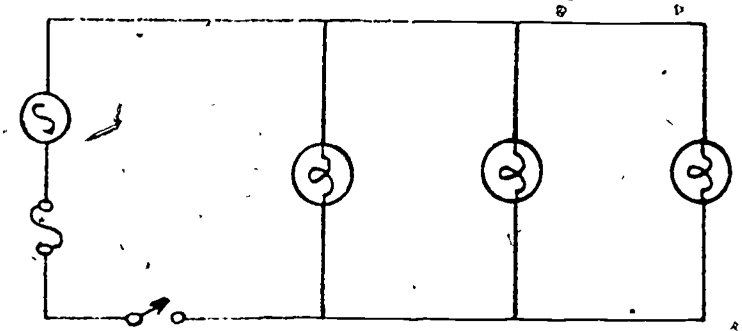
a. Bends easily
b. Smooth inside surface
c. Corrosion resistant (water pipe should never be used as conduit)

Module No:	Topic: Wiring Materials and Practices

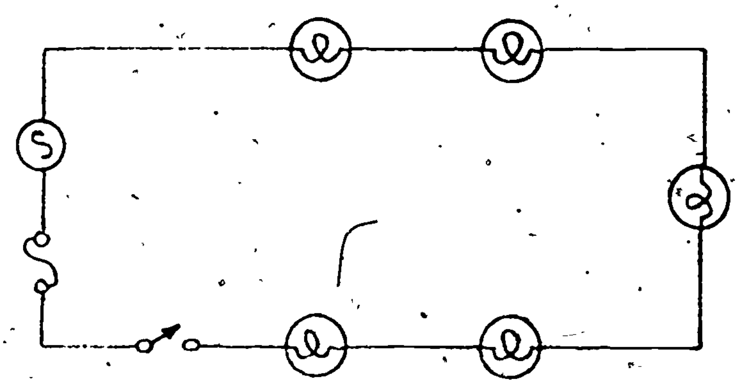
Instructor Notes:	Instructor Outline:
Text Figure 3-6b shows some of the components (a display model would be appropriate to show the components).	C. Components 1. Boxes 2. Clamps 3. Bushings 4. Connectors
	III. Color Coding 1. White or natural gray is the color for the grounded also called neutral conductor. 2. The "grounding" conductor, that which connects to the surface of an appliance or unit to supply a continuous low resistance path to ground, is green or green with yellow stripes. 3. The ungrounded or "hot" conductor in a two-wire plus ground is normally black. 4. Three wire plus ground is usually one black, one white, and one red. 5. Switches or duplex receptacles are also coded: a. Hot side has brass screws b. Neutral side has silver or chrome screws c. Grounding terminal is green

Module No:	Topic: Wiring Materials and Practices
Instructor Notes:	**Instructor Outline:**
Figure 6 - Electrical symbols for: 1. AC source 2. Fuse 3. Switch 4. Ammeter 5. Voltmeter 6. Connected wires 7. Wires crossing - not connected 8. Incandescent lamp	IV. Symbols - most electrical wiring diagrams have a legend to assure the readability of the wiring diagram. A few generally accepted symbols are shown in Figure 6. These should aid in the discussion of simple circuits.
Figure 7 - Series and parallel circuits	V. Simple Circuits - a circuit was previously defined as a complete pathway for electric current to flow. Two types will be briefly covered: A. Series Circuit - some Christmas tree lights are wired in series. This should give a clue as to why lighting fixtures in a home or office are <u>not</u> wired in series. There are three circumstances which could result in an "open" circuit: 1. Blown fuse 2. Open switch 3. Burned out light bulb (in which case the remaining good lamps wouldn't light). If the source is 120 volts, and there are three 60 watt bulbs in the light fixtures, what is the smallest fuse which should be used? $I = \frac{V}{R} = \frac{120}{180} = .67$ amp B. Parallel Circuit - notice that in the parallel circuit each lamp provides an independent path for current to flow and removing a light bulb does not cause the other two to go out i.e. a closed circuit still exists.


AC Source
Fuse
Switch
Ammeter
Volt Meter
Connected Wires
Incandescent Lamp
Wires Crossing
(Not connected)



Parallel Circuit



Series Circuit

Module No:

Module Title:
Basic Electricity

Submodule Title:
Fuses and Breakers

Approx. Time:
1 hour

Topic:

Objectives:

1. List what causes a fuse to "blow" and what actually happens to the fuse as it "blows".
2. List three common types of fuses.
3. List why an overcurrent device should never be placed in any permanently grounded conductor.

Instructional Aids:

1. Resistance meter (VOM)

Instructional Approach:

1. Lecture
2. Discussion
3. Hands-on

References:

1. Understanding and Using Electricity, McKenzie & Zachariah.

Class Assignments:

Module No:	Topic: Fuses and Breakers

Instructor Notes:	Instructor Outline:

I. Overload Protection - yet another comparison of an electrical system and a water system. Just as a water system typically has safety (pop-off) valves, so too it is a must that electrical systems have protection against overloads. There are two basic types of overload protection that will be covered.

A. Circuit Protection - every size of electrical wire has a "safe" current carrying capacity. Circumstances around and above the wire in a given circuit may have some influence on the safe capacity such as exposure to direct sunlight, well or poorly ventilated room etc. The protection device to protect the wiring of a given circuit should "open" at such time as the power demand would cause the conductor to heat, damaging the conductor's insulation. The device might allow short duration overloads, but even short duration overloads can be detrimental to the wiring.

Never should circuit protection devices be negated (penny behind fuse or tying a circuit breaker are examples of that which should never be done).

B. Equipment Protection - motors and some additional electrical devices must have overload protection just ahead of the unit.

Consider a motor which draws 3 amperes of current at full load. The circuit which serves this motor has an overload protection device rated at 15 amperes. Note that if the 15 ampere device (fuse) is the only overload protection, the motor could draw as much as 5 times its full load current before the 15 ampere device would "open" the circuit. The motor could suffer some damage - a person coming into contact with the motor is in

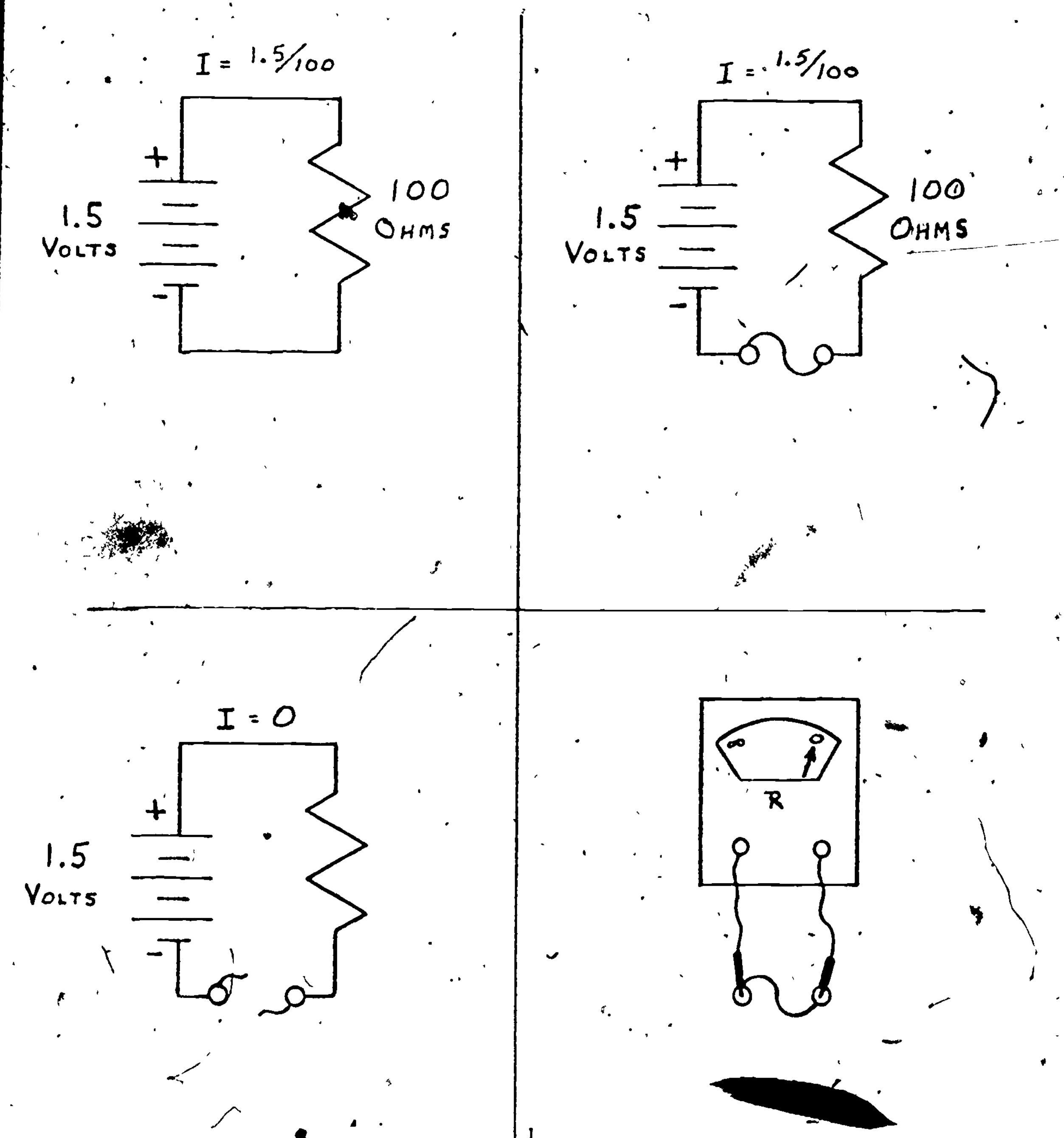
Module No:	Topic: Fuses and Breakers

Instructor Notes:	Instructor Outline:
	danger. If, however, only this one motor is served by the circuit, the 15 ampere overload protection device could be replaced with an appropriate 3 ampere overload device. In other words, if only one motor or appliance or electrical unit of whatever purpose is served by a circuit, the equipment protecting device and the circuit protecting device may in fact be just one overload protection device. In this case the circuit overload level must be higher than the unit overload level i.e. the wire's safe current carrying limit must be greater than the current limit of the motor or appliance.
	II. Overload Protection Devices - the overload protection devices are generally considered to be fuses or circuit breakers.
	A. Fuses - an electric fuse contains a strip of soft metal or wire which is designed to carry only up to a given amount of current. If for whatever reason, more current begins to flow in the circuit than the fuse is designed to carry, the metal strip melts, or burns out. This results in an open circuit, the current flow stops. Fuses are generally of two types: Plug or screw base and cartridge.
	There are then three main types of screw base fuses: Instant blow, time delay and non-tamperable.
Text Figures 4-3, 4-4, and 4-5 display the three types of fuses.	1. Instant blow is the common type fuse and is designed to burn out as soon as its rated current capacity is exceeded.

Module No:	Topic: Fuses and Breakers

Instructor Notes:	Instructor Outline:
	2. Time delay fuses are available for circuit protection in which momentary overloads can exist, starting a motor for example. This type fuse will carry an overload for a few seconds without burning out but will burn out if the overload persists beyond the delay time.
	3. There is another type of fuse, the "non-tamperable" fuse. (Fusestat for example). The two component parts are the adaptor and the fuse. The adaptor has a spring barb on the outside that prevents it from being removed once installed. The adapters have amperage ratings and only accept fuses of one amperage rating. In other words if a 15 ampere adapter is installed, only 15 ampere fuses will fit into the adaptor; a 20 ampere fuse will not fit a 15 ampere adaptor. Thus the name non-tamperable.
Text Figure 4-2 displays two cartridge fuses	Cartridge fuses are generally of two types: The smooth ferrule and bayonet. The screw base fuses and some cartridge fuses can be recognized as blown from a visual inspection, the metal strip is broken and a blackening of the glass may occur. How does one determine if a cartridge is blown? A volt-ohm (VOM) meter, a meter which can measure voltage and resistance, is an excellent "tool" for this determination. Consider the first circuit diagram on Figure 8. Notice that a complete <u>closed</u> circuit exists with a battery providing 1.5 volts of electrical pressure and a "load" of 100 ohm resistance. Current will
Figure 8 Circuit one showing a battery and resistor (load)	

FIGURE 8



I = 1.5/100
+
1.5
Volts
-
100
Ohms
I = 1.5/100
+
1.5
Volts
-
100
Ohms
I = 0
+
1.5
Volts
-
∞
0
R

Module No:	Topic: Fuses and Breakers

Instructor Notes:	Instructor Outline:
$I = V/R = \frac{1.5}{100}$	flow in this circuit. Now let's add a "fuse" to this circuit, the fuse that may or may not be blown.
Circuit two, adds fuse	If the fuse is blown and open circuit now exists, if the fuse is not blown a closed circuit still exists.
An ohm meter, a good fuse, and a blown fuse should be available for demonstration	Now let's rename a portion of this circuit and ohm meter (resistance meter). It comes complete with a voltage source, a battery; and a load, a built in resistor. First let's look at the circuit possibilities. There will either be a closed circuit (the fuse is not burned out i.e. the soft metal strip is intact) or there will be an open circuit (the fuse is burned out i.e. the soft metal strip is broken.) All that remains is to determine how the ohm meter will indicate the two possible situations. The following steps should be taken.
	1. Remove fuse from the fuse-box 2. Move away from the fuse box 3. "Zero" the resistance meter 4. Check the fuse a. Cartridge fuse - hold a "lead" to each end of the fuse. b. Screw in fuse - hold one lead to the center (silver or chrome) contact of the fuse and one lead to the brass thread (side of fuse)

Module No:	Topic: Fuses and Breakers

Instructor Notes:	Instructor Outline:
	5. Results of determination a. Resistance meter reads zero - fuse is good (on most meters the dial will move from the left to the right). b. Resistance meter shows no deflection -- fuse is not good. (The dial does not move when the leads are properly held to the fuse.)
Text Figure 4-6 displays a circuit breaker cross-section	B. Circuit Breakers - a circuit breaker is a combination of a fuse and a switch. In place of the soft metal strip that burns out necessitating the replacement of the complete fuse the circuit breaker has a bimetal (two different metals) strip. During an overload situation heating occurs. The heat causes the metals to expand at different rates causing bending. The bendig trips the breaker, "throws" the switch, and the result is an open circuit. After the bimetal strip cools (and straightens) the breaker may be reset, closing the circuit. If the breaker continues to be "thrown", the cause of the overload must be determined (generally an electricians duty) anytime a circuit breaker opens, it is an indication of trouble. It is important to realize that a circuit breaker is in part a mechanical device. All circuit breakers should be opened and reclosed on a regular "preventative maintenance type" schedule (once per month is suggested) to help insure free action and contacts.
	C. "Heaters" - most operators have been using the term or at least heard the term "heater" in conjunction with motors. A heater used in this context is an overload protection device. It is an "equipment protection device" as opposed to a "circuit protection

Module No:	Topic: Fuses and Breakers

Instructor Notes:	Instructor Outline:
	device". Motors have starting current demands sometimes as high as four times the normal running current. Circuit protection is not infrequently fused at a higher level than what would be a damaging current for the motor. The principle of the heater is quite similar to a circuit breaker. For example, a 15 ampere heater is designed and constructed so that an extended current above 15 amperes will result in heating of the overload protection device (the heater) which then "opens" the circuit, thus preventing damage to the motor.
	D. Location of Overload Protection Devices.- Overload protection devices should <u>never</u> be placed in any permanently grounded conductor. If this were done, pulling the fuse or breaker opens the circuit, but the hot lead would still be connected, ready to supply power. If a short circuit developed at the load point, there would be no fuse in the hot (power) line to open the circuit.

Module No:	Module Title: Basic Electricity
	Submodule Title: Motors
Approx. Time: 1 hour	Topic:

Objectives:

1. List the two typical types of motor bearings.
2. Define "service factor" as used on a motor nameplate.
3. Define temperature rise as used on a motor nameplate.
4. Given a motor nameplate list: A. Phase, B. Voltage - current, C. Duty Rating, D. Service Factor, E. Temperature Rise, F. Horsepower.
5. List the main advantage DC motors have over AC motors.

Instructional Aids:

Instructional Approach:

1. Lecture
2. Discussion

References:

1. Understanding and Using Electricity

Class Assignments:

Module No:	Topic: Motors

Instructor Notes:	Instructor Outline:
It is not the intent of this section to go into much depth of understanding. There are many types of motors and courses of instruction are generally available at Community Colleges. This brief section will emphasize primarily the information on the motor nameplate.	Text Table 8-1 (Page 48) lists some of the types of electric motors, some of their characteristics, and typical uses. There may well be both AC and DC motors in the treatment facilities (both water and wastewater). DC motor have one major advantage over most AC motors, that being the ease with which the DC motor speed can be changed.
	The operator should read manufacturer's information on motors in the treatment facility. The information should be a part of, or an attachment to, or readily accessible to the operator. There is an extremely appropriate few statements in the text appropriate to motors and in other units of a given facility. "Knowing what questions to ask is frequently more important than knowing what the answers are. The danger lies in the questions that he never thinks to ask until it is too late".
	I. Nameplates - motors are of various types - the operator should, again, read the information available at his facility on the given motors in use. Although motors are of various types the nameplate on each motor contains most of the important information about that motor. A basic understanding and knowledge of that information greatly enhances the operator's ability to "ask the appropriate question".
Figure 8-11 shows typical nameplates	A. Model number - an obviously important bit of information should repair parts be necessary and to alert the manufacturer to exactly what motor is being discussed in a given situation.
	B. Horsepower - self explanatory
	C. R.P.M. - revolutions per minute
	D. pH - phase, single (1) or three (3)

Module No:	Topic: Motors

Instructor Notes:	Instructor Outline:

E. Duty - duty rating concerns the durability designed into the motor. Motors are designed for continuous and limited duty.

1. Continuous - will deliver rated horsepower for an indefinite period of time without overheating.

2. Limited - will deliver rated horsepower for a <u>specified</u> period of time only.

F. Rise - the normal temperature is taken to be 40 degrees C. (104° F.). This is called the "ambient temperature". A number following "rise" on the nameplate refers to the maximum temperature rise above the level of ambient temperature that will occur while the motor is operating at full load. Damage to the insulation of the motor could be expected if the ambient temperature of the area in which the motor is mounted is greater than 40°.

G. Ser. Fact - service factor indicates the amount of overload the motor can operate. A service factor of 1.0 means that the motor will not tolerate any continuous overload.

H. V. - voltage in volts

I. A. - full load current in amperes. it is not uncommon for motors to be able to be connected to different voltage levels. Wiring diagrams are generally on the nameplate or in the junction box to which the wires are connected for the electricians benefit. Periodic current readings (possibly displayed on graph paper) of motors are appropriate

Module No:	Topic: Motors

Instructor Notes:	Instructor Outline:

"preventive maintenance" procedures. Troublesome down times can at times be minimized if a "history" of motor performance has been routinely compiled.

J. Code - code letters have been established which relate to the amount of current that will flow into the motor windings when the rotation of the shaft is blocked. Practically, this refers to the starting current. Consider a motor which is shut off, not running. The switch is turned on, electron flow begins instantly, but for a split second the motor is not yet running, and it may take some seconds to reach its operating R.P.M. During that period of time the current flow may well be several times the normal full load current. These "code" letters have assigned ranges of values. The code assigns ranges in alphabetic order where code letter A on a nameplate would indicate a starting current on the order of 3 times normal full load current. Code letters farther into the alphabet may indicate a starting current as high as 6 times normal full load current.

II. Motor Bearings - There are typically two types of motor bearings.

A. Sleeve bearings - motors of less than one horsepower usually have sleeve bearings. They are oil lubricated. Manufacturer's instructions should be followed for lubrication directions.

B. Ball bearings - motors mounted with the shaft vertical should have ball bearings. They are typically lubricated with grease but here again manufacturer's instructions should be strictly adhered to for lubricating directions.

Module No:	Module Title: Basic Electricity
	Submodule Title: Safety
Approx. Time: 2 hours	Topic:

Objectives:

1. Define: A. Reaction current, B. Let-go current, C. Fibrillating current.
2. List two reasons that fuses or circuit breakers are installed.
3. List the purpose of the grounding (green) conductor on an appliance or tool.
4. Define "double insulation".
5. Define a "ground fault interruptor", and detail how it works.

Instructional Aids:

1. Resistance meter (VOM)
2. Grounded receptacle check instrument
3. Three prong adapter
4. Ground fault interruptor

Instructional Approach:

1. Lecture
2. Discussion
3. Hands on

References:

1. Understanding and Using Electricity

Class Assignments:

The Cedar Rapids Gazette: 1977

Man, 27, Electrocuted

By Tom Alex
Gazette Police Reporter

A 27-year-old man was electrocuted Monday afternoon, apparently when the drop cord to the electric drill he was using came in contact with water, Linn sheriff's deputies said.

Deputies said (He) was trying to fix a gate about 75 feet from his house. "The drop cord was in water and the grass was wet," authorities said. "The cord had a bad connection."

Module No:	Topic: Safety

Instructor Notes:	Instructor Outline:

I. Electric currents and people

There is no more important topic in this module of instruction than the discussion of safety. Electrical safety means more than being careful to not be shocked. It is wrong to think that the common 120 volt circuit is not dangerous. Most have no doubts of the danger of faulty 220 or 440 volt circuits. It is a fact that it requires less than the amount of current needed to light a 7.5 watt Christmas tree light bulb to kill a human being. It is significant to note that more people die from 120 volt shocks than from high voltage lines. Of importance is that persons only must realize the potential hazards and exercise generally simple, common sense type precautions.

Anytime a person gets more than a simple static electricity shock when he comes into contact with an appliance or piece of equipment, exercise caution. The unit should be disconnected, the problem determined and corrected.

There are three levels of concern relative to effects of electrical current on the human body.

A. Reaction Current

This is the smallest current that might cause an unexpected involuntary reaction resulting from a shock that could produce an accident, for example dropping an electric soldering iron or falling from a ladder.

B. Let-go Currents

This is the level of current above which a person cannot let go of a conductor (frozen to the conductor). When the let-go current is exceeded the person has lost voluntary muscle control. The safe

Module No:	Topic: Safety

Instructor Notes:	Instructor Outline:
	let-go current for women is generally about two-thirds that for men. Generally for men, the let-go current is about 9 milliamperes (.009 amps).
	Recall Ohms law (V = IR). Let voltage equal 110 volts and the current equal 0.009 amperes and solve for R, the resistance. (R = V/I).
Given: V = 110 volts R = 5,000 ohms I = ? (.022 amps)	This means that a 110 volt circuit with a load (resistance) of 12,222 ohms has a current flow of 0.009 amps. Now rearrange the equation and notice what happens to the current as the resistance decreases; it increases. Take the resistance meter and have a student, after zeroing the meter, firmly grasp a lead in each hand. The student should have dry hands. The resistance shown on the meter may well be over 100,000 ohms. Now have the student moisten the fingers on each hand that he is gripping the leads. The resistance will now be less than 10,000 ohms, possibly as low as 1,000 ohms. The point is not that if you have dry hands you can safely handle electricity - the point is that with even 110 volt circuits, a harmful, possible fatal shock can occur to the careless operator.
	C. Fibrillating Current
	Fibrillating currents are currents high enough that will cause an effect on the heart known as "ventricular fibrillation". In lay terms that means the heart has stopped. If the heart goes into fibrillation, it will rarely recover without assistance. It is important to remember that immediate and continuous artificial respiration is essential for a person who has received a shock resulting in ventricular fibrillation.

Module No:	Topic: Safety

Instructor Notes:	Instructor Outline:

Of equal importance is to realize that the person who has received a shock of this magnitude is likely to be "frozen" to the circuit. If you touch the person, you in all probability will become a part of the circuit. It is then a necessity to remove the person from the circuit. If the circuit breaker or fuse is immediately and safely accessible, remove (open) it. If the location of the circuit breaker or fuse is not immediately or safely accessible or unknown the person must be removed from the circuit. This can be accomplished with a non-conductor such as a rope, shirt, wooden broom handle, or something similar. (Not a chain, or pipe, or any "conductor").

II. Safety Protection Methods and Devices

A. Fuses and circuit breakers

Fuses and circuit breakers have been discussed as devices to protect circuits and equipment or electrical devices. They are also safety devices in that if an overload situation arises the circuit will be opened by the protection device. This does not mean however that just because a circuit has a fuse and an overload protection device on the electrical unit that an unsafe or hazardous condition might not exist.

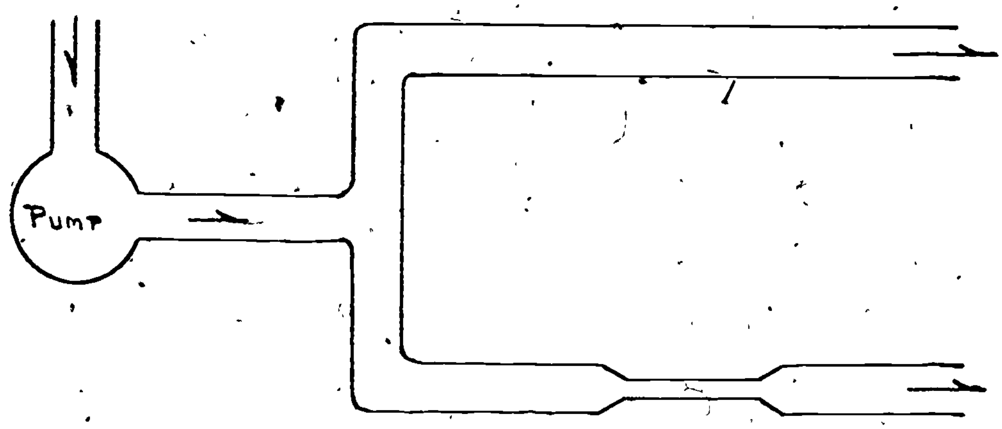
B. Grounding Conductor

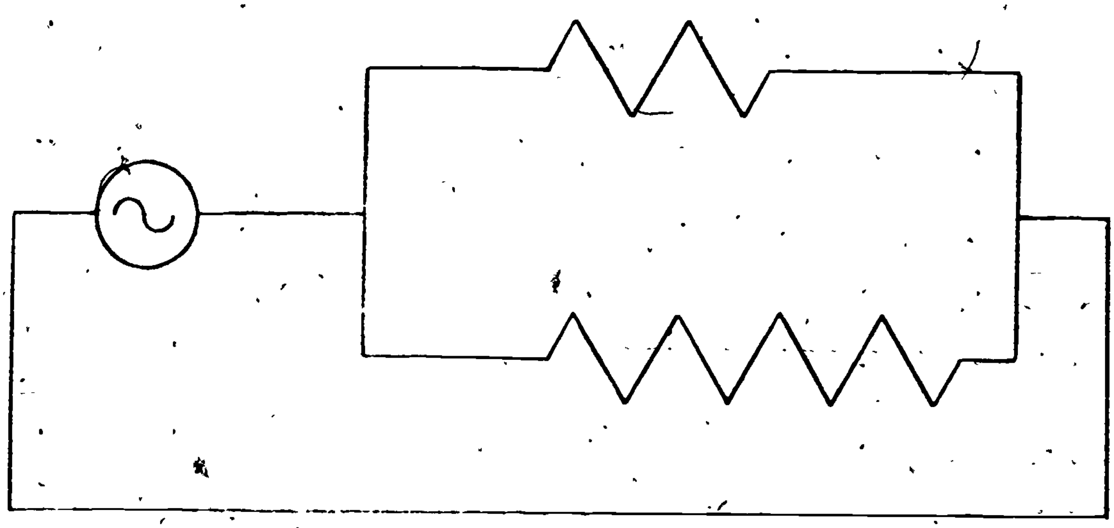
A grounding conductor is a green wire connected from the metal surface of a stationary or portable device and continued as a separate conductor until it reaches the ground terminal at the service panel. At that point it is

Module No:	Topic: Safety

Instructor Notes:	Instructor Outline:
	connected to the grounded (white) side of the service conductors. The purpose of the grounding (green) conductor is to supply an uninterrupted low resistance path for any current that might reach the metal surface of the stationary or portable device.
Figure 9	Recall the similarity between electric systems and water systems, and then recall the parallel circuit diagram. There will be a greater flow of water in the pipe without the restriction (resistance). A grounding circuit provides a parallel circuit also in the case of a short circuit - parallel to the ground with the human body to the ground. The ground wire then provides a line of little if any resistance (compared to the human body - recall resistance determinations of the human body) for current to flow. If the current is sufficiently high, it would hopefully "blow" the circuit protection device resulting in an "open" circuit and a stoppage of current flow.
	The third prong of a three prong plug-in is the ground line. This prong should never be removed as that would "open" the ground conductor line.
A grounded receptacle check instrument should be available and demonstrated. The possibilities that could result from the check, as shown on the device, should be explained.	A relatively inexpensive device (less than $10, 1977 price) is available for checking wall plugs which include the "third" or ground conductor receptacle. The purchase of such a device should be given consideration as it is a very safe instrument to use and could result in the location of potential hazards.

FIGURE 9





Module No:	Topic: Safety

Instructor Notes:	Instructor Outline:

C. Double Insulation

Newer hand held tools such as electric drills are now quite commonly "double insulated". The three prong plug-in (the third wire being the grounding conductor) hand tools still exist and the importance of the third wire should now be realized. The operator must realize that if an adapter is used to plug a three prong plug into a two prong receptacle and the "green" wire is left hanging in the open air, that parallel wire to ground does not exist. The path for current in a short circuit situation is then through the person holding the tool to ground. This is certainly a part of the reason that manufacturers of hand held tools are making more double insulated tools.

A three prong adapter should be available.

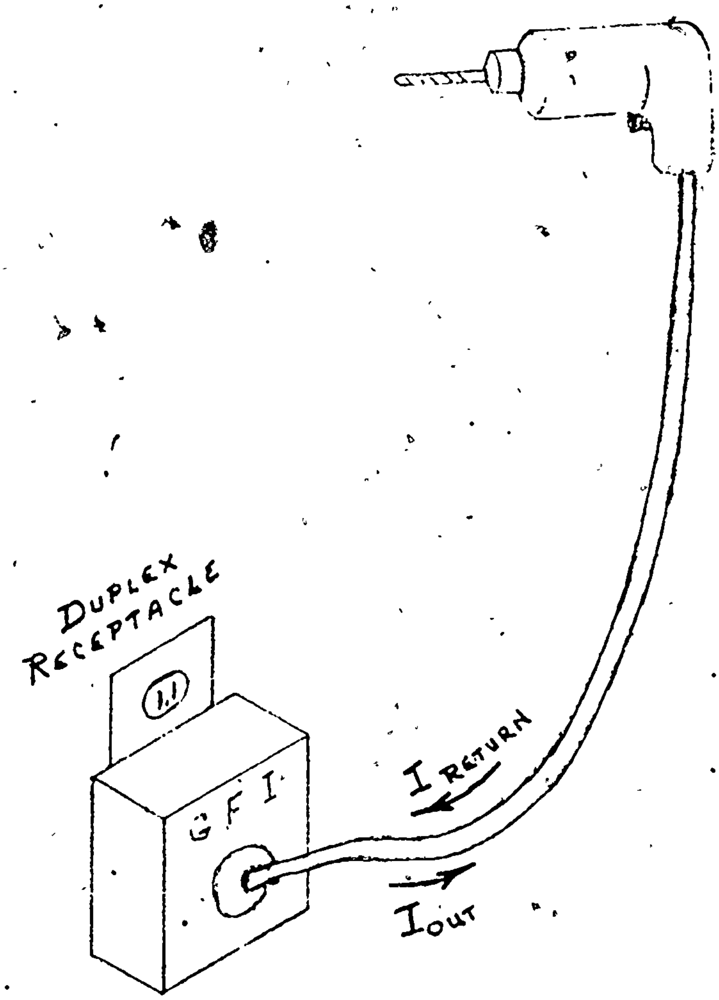
Double insulation is exactly as the name implies. Rather than a low resistance ground conductor (third wire) for safety, there is a plastic (insulated) shell so that the operator cannot make contact with a live conductor. The insulating shell isolates the live circuitry inside. The inner circuits are made up of insulated conductors. Any metal exterior elements are isolated by insulating material or shafts so that fault currents from the inside cannot reach them.

D. Ground Fault Interruptors (GFI)

A GFI should be available for the student to see.

This is an electronic device placed in a circuit to detect any difference in the amount of current flowing to and from an electrical device. Recall the "closed" circuit diagram and the fact that current flows completely around the closed circuit. Using Figure 11 trace the path that the current takes around the circuit. The GFI compares the current level as if flows

Figure 10 - Schematic of a wall receptacle, GFI, and an electric drill.


DUPLEX
RECEPTACLE
GFI
I RETURN
I OUT

Module No:	Topic: Safety

Instructor Notes:	Instructor Outline:

to the drill and then from the drill. It detects very small differences in the two values of the current flow. If there is a reduction in the return flow current, the GFI automatically "opens" the circuit. The GFI opens the circuit if the difference in current level is 5 milli-amperes.

This type device warrants strong consideration in a treatment facility.

E. Other "Safety" Suggestions

1. If a knife switch is to be pulled in an emergency situation, do not stand directly in front of the switch. And are resulting from a short-circuit may be so violent as to burn through the metal switch cover, spewing hot metal in the proximity of the switch.
2. Never cut off the third prong of a grounded plug.
3. Never touch a wire before determining if it is "live".
4. Never allow work to be done on a circuit without disconnecting the master switch.
5. Check all wires and plugs for fraying (bare wires) on a routine basis.
6. Have an emergency telephone list posted near all phones.
7. Be conscious of potential electrical hazards.

Module No:	Module Title: Basic Electricity
	Submodule Title: Application
Approx. Time: 3 hours	Topic:

Objectives:

1. Measure voltage using a voltmeter in a simple circuit.
2. Measure current using an ammeter in a simple circuit.
3. Measure resistance using a "VOM":

   a. Fuse (good and "blown" ones)
   b. Lengths of wire
   c. Heating element

Instructional Aids:

1. Handout
2. Model
3. Ground fault interruptor
4. Voltage meter
5. Ammeter (amp clamp)

Instructional Approach:

1. Demonstration
2. Lecture
3. Hands-on

References:

Class Assignments:

Module No:	Topic: Application

Instructor Notes:	Instructor Outline:
Figure 11 - Electrical model. Table 1 is a bill of materials for the model shown schematically on Figure 11. In addition a volt-ohm meter and "amp-clamp" should be available for student use. A ground fault interrupter should be used.	The remainder of the workshop is to be hands-on training. Exercises which can be included are: A. "Building" a series circuit B. "Building" a parallel circuit C. Measuring voltage D. Calculating current E. Measuring current F. Calculating watts checking against the light bulbs being lighted in the circuit. G. Removing one bulb in a series circuit and one bulb in a parallel circuit. H. "Blowing" a "slo-blo" fuse. I. "Blowing" an "instant-blo" fuse. J. "Blowing" a circuit breaker K. Testing fuses for failure.

FIGURE 11

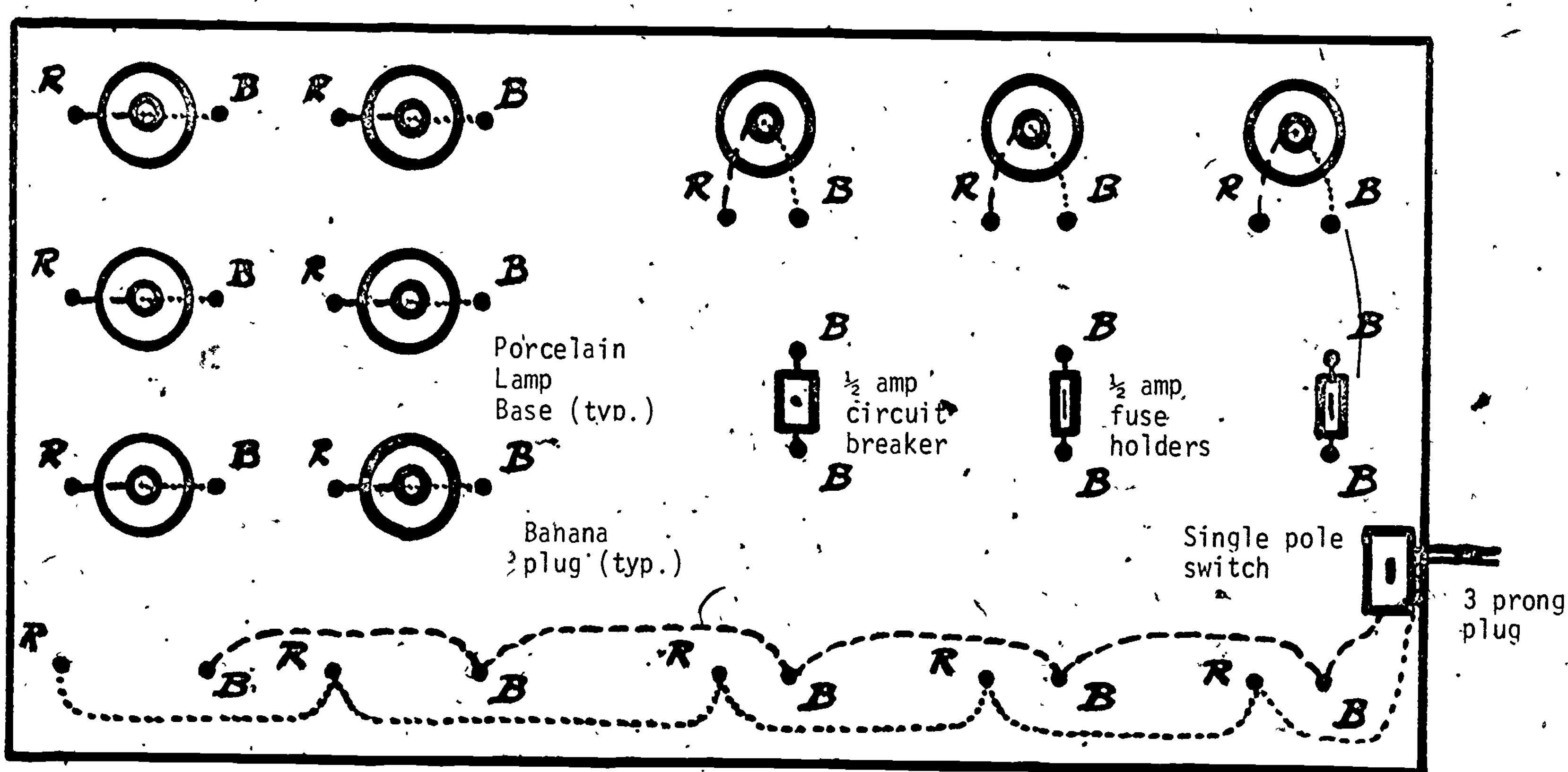

Porcelain Lamp Base (typ.)
½ amp circuit breaker
½ amp fuse holders
Banana plug (typ.)
Single pole switch
3 prong plug

FIGURE 11

A. Series Circuit

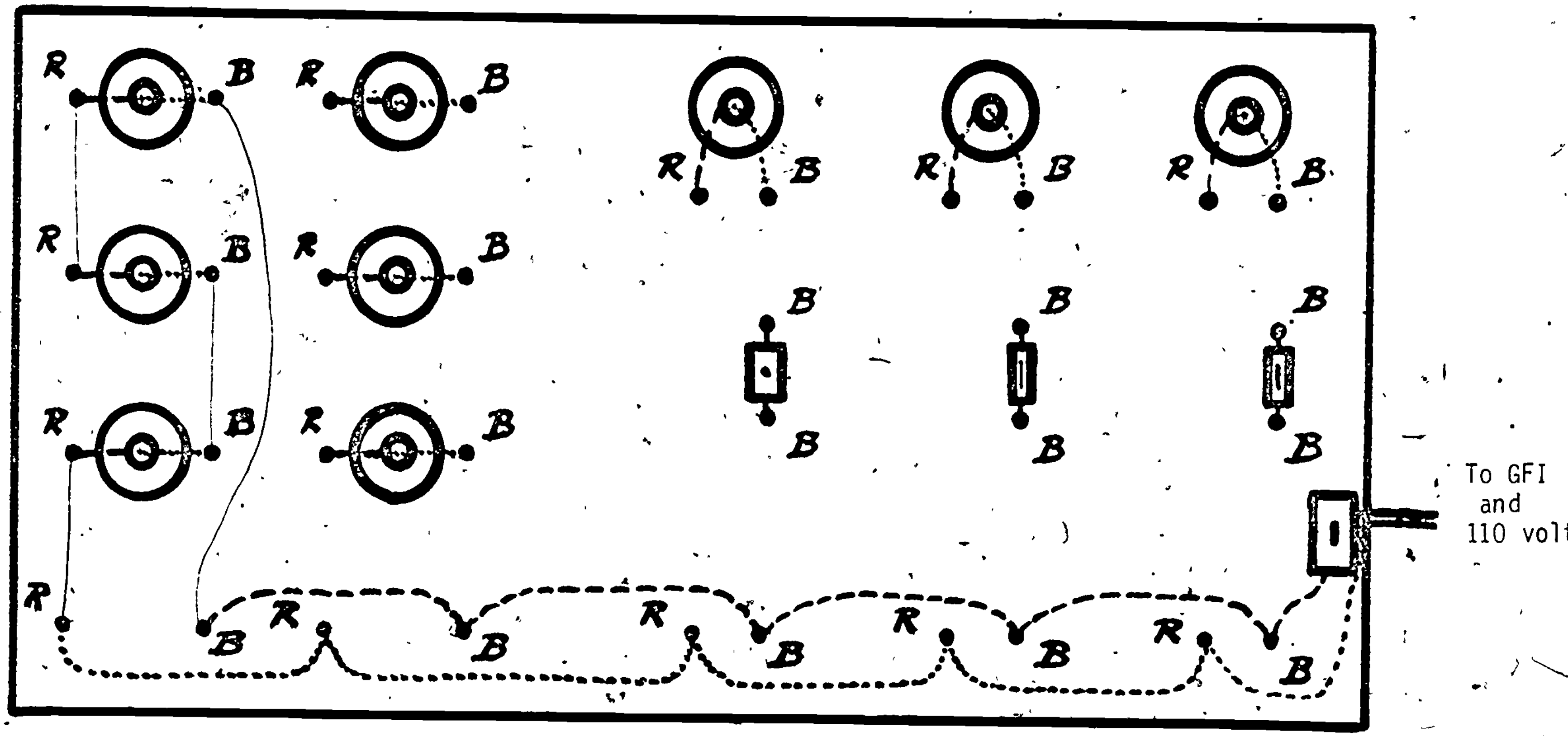


FIGURE 11

B. Parallel Circuit

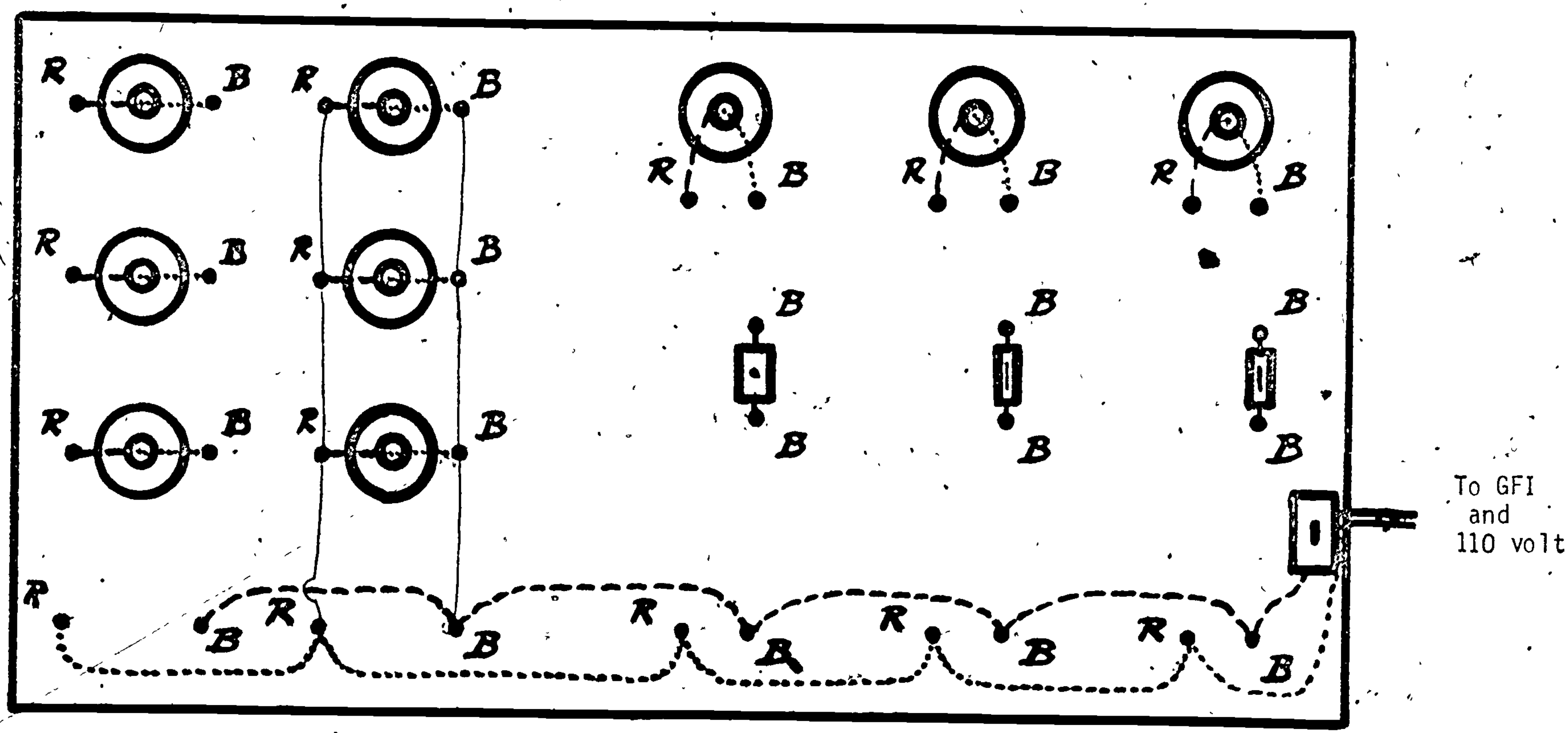


FIGURE 11

H. - I - J. "Blowing" Fuses & a Circuit Breaker

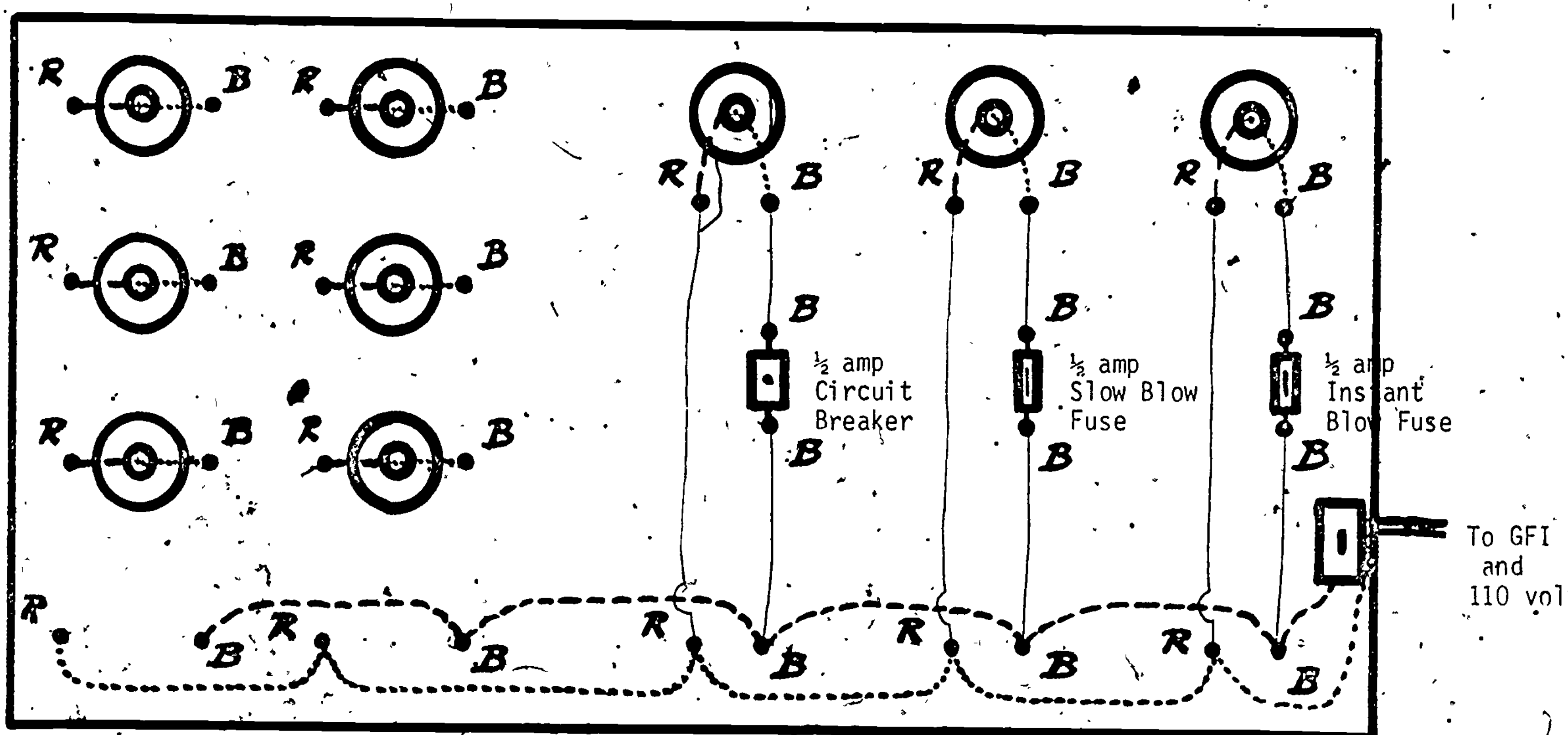


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TABLE I

3 - 24" Test leads (red)

12 - 12" test leads (red)

12 - 12" Test leads (black)

17 - Red banana plugs

17 - Black banana plugs

9 - Porcelain lamp bases

2 - ½ ampere fuse holders

1 - ½ ampere circuit breaker

1 - Single pole switch, box, and cover plate

1 - Ground fault interrupter (GFI)

1 - 2' x 4' x ¼" Peg board (front)

12' - 1" x 2" lumber (edges)

1 - 2' x 4' x ½" plywood (back)

14 gauge insulated wire

Solder

1 - 3-prong plug

60 watt, 100 watt, 150 watt light bulbs

The following ten figures are appended from which transparencies may be made.

FIGURE 1

Protons

Neutrons

Nucleus

Electrons

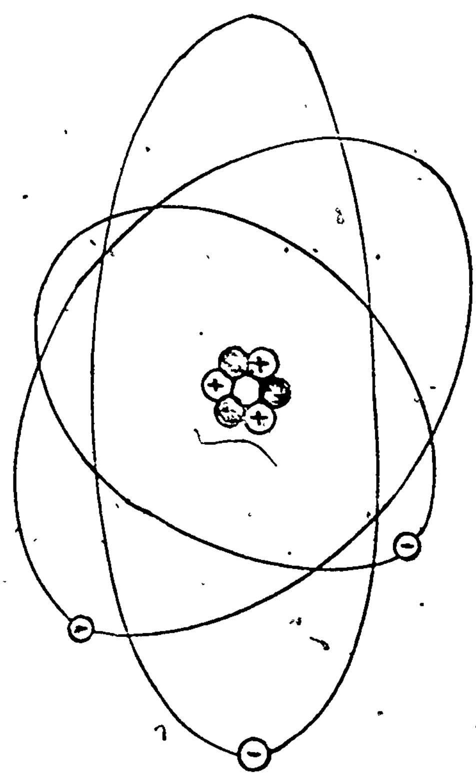


FIGURE 2

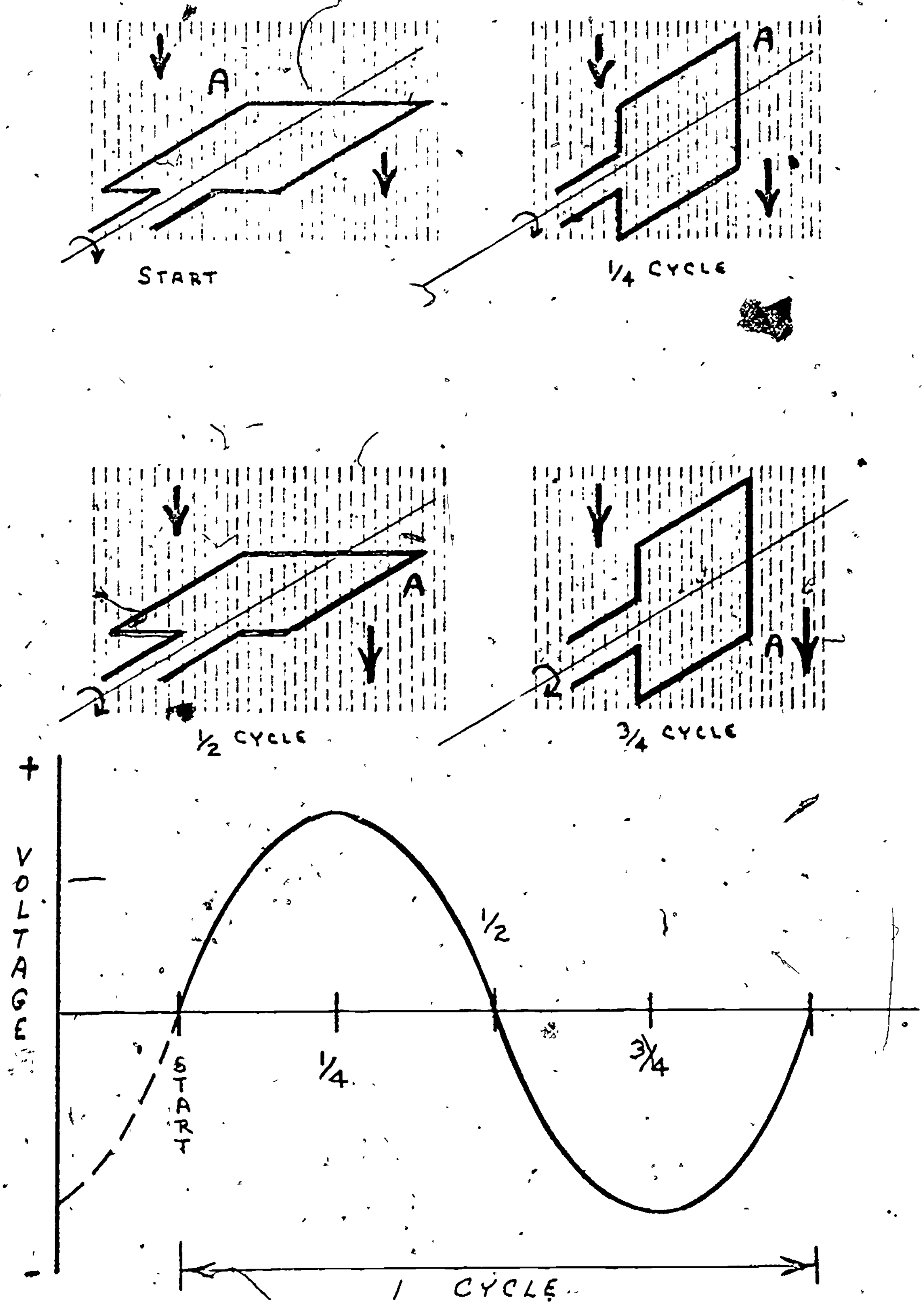

A
START
A
1/4 CYCLE
A
1/2 CYCLE
A
3/4 CYCLE
+
VOLTAGE
-
1/2
START
1/4
3/4
1 CYCLE

FIGURE 3

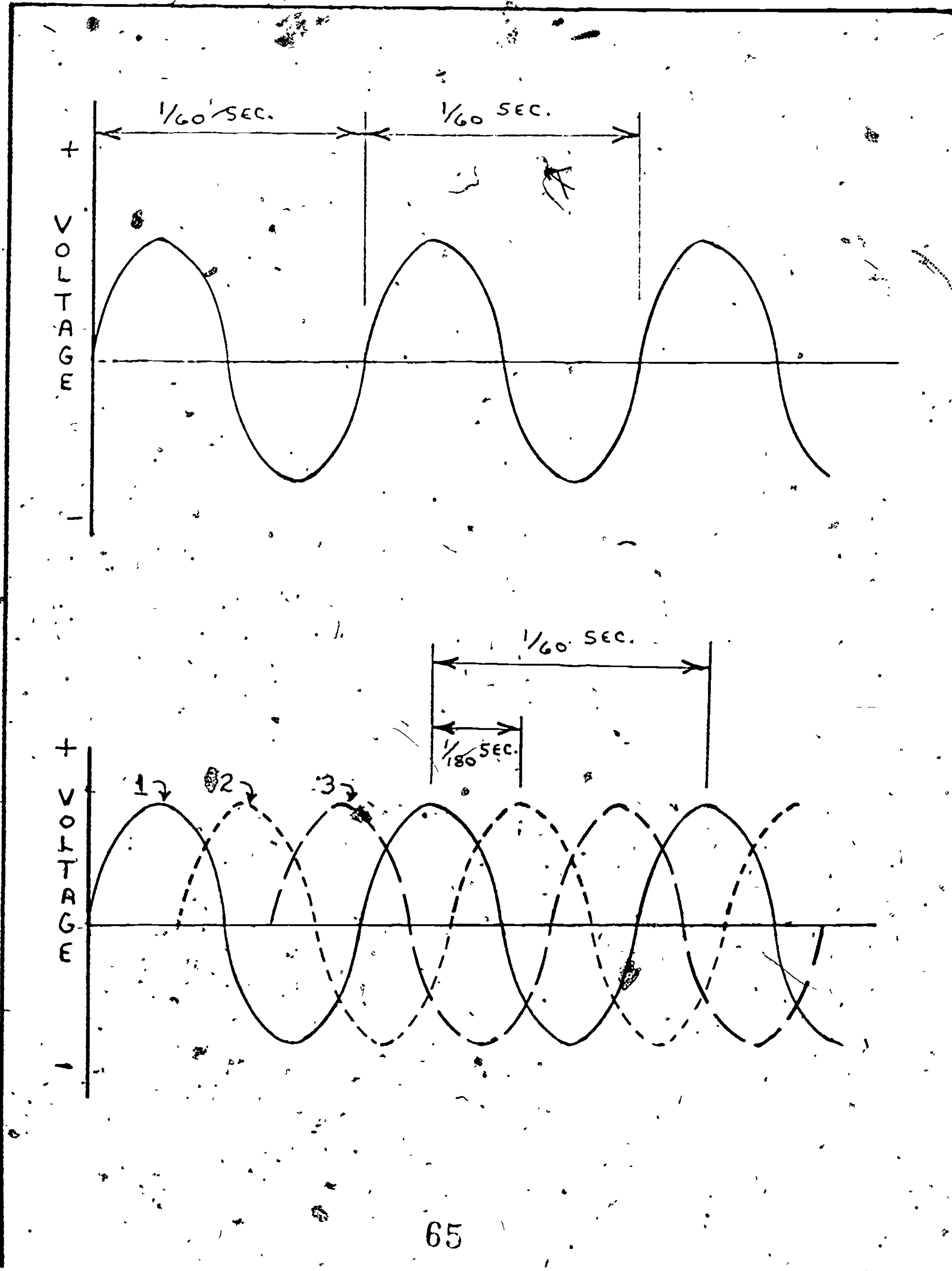
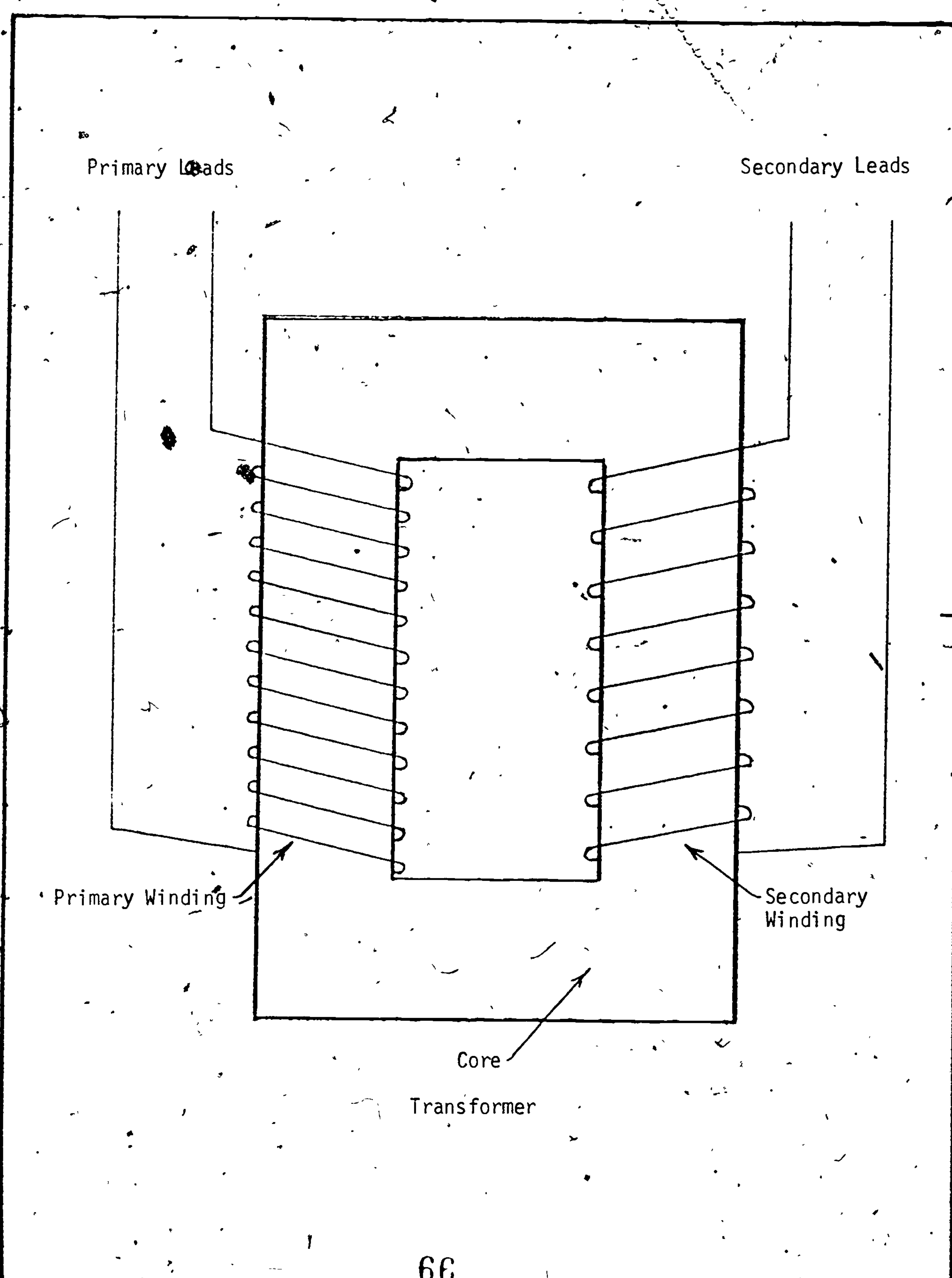
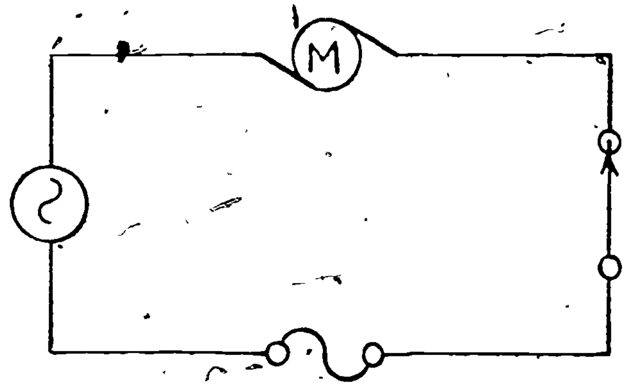


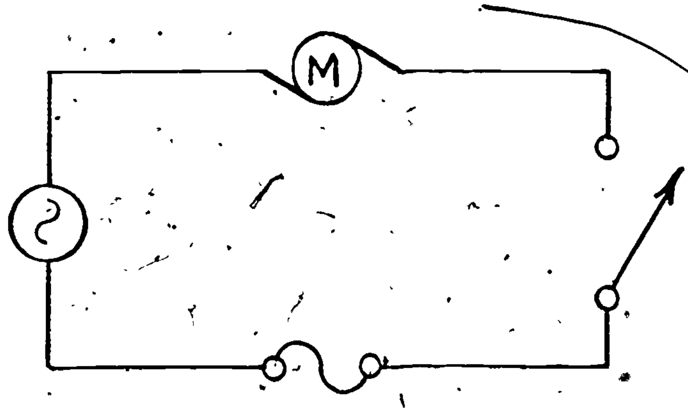
FIGURE 4



Transformer



Closed Circuit



Open Circuit

FIGURE 6

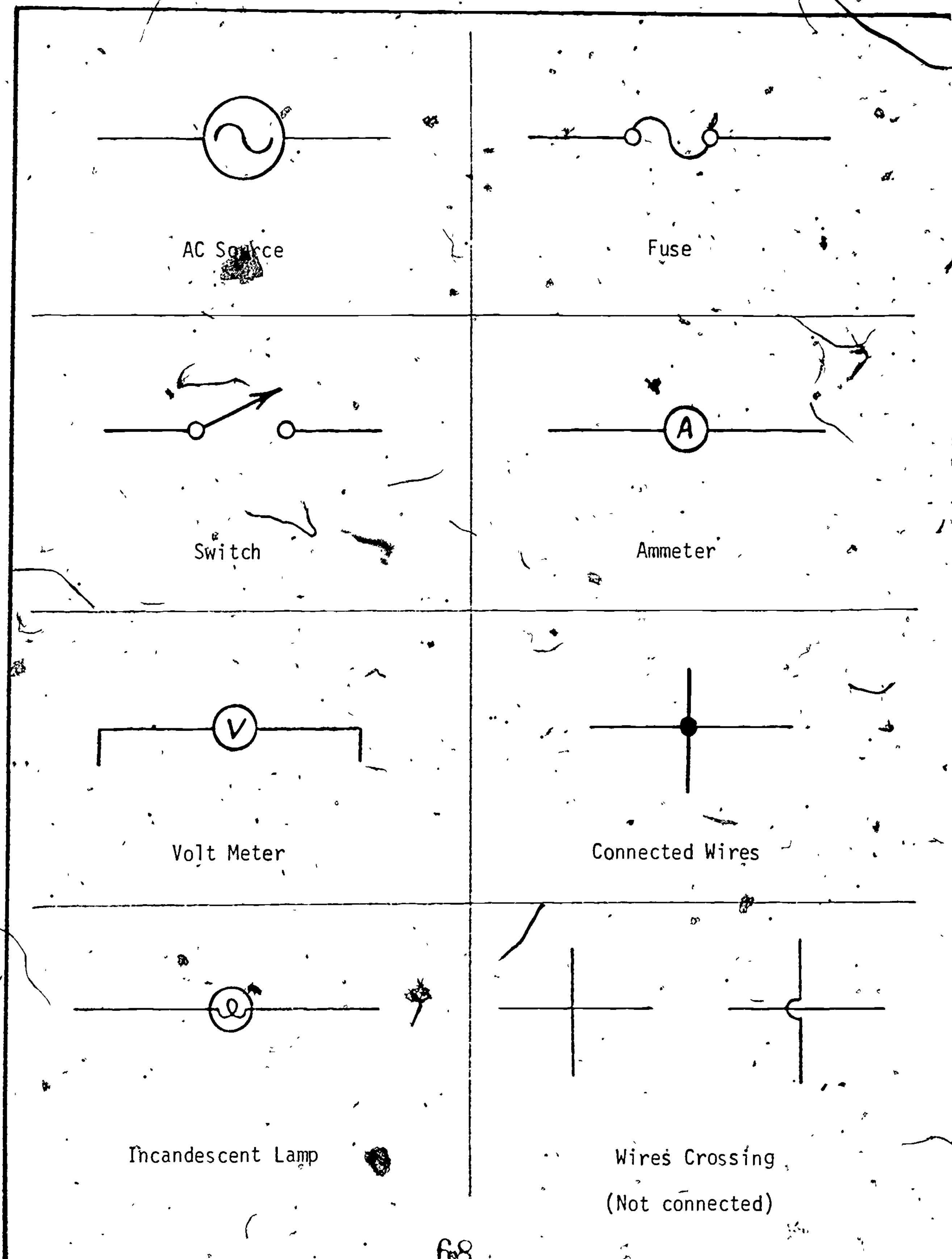
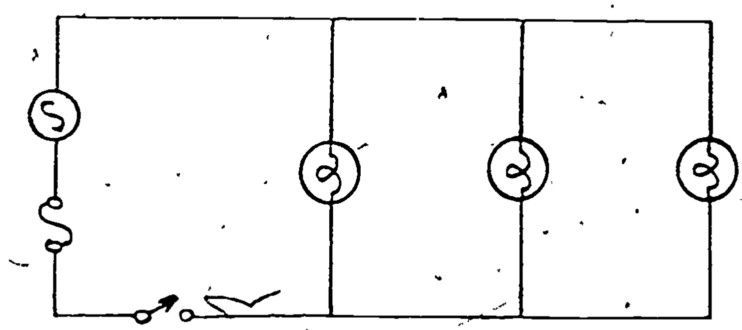
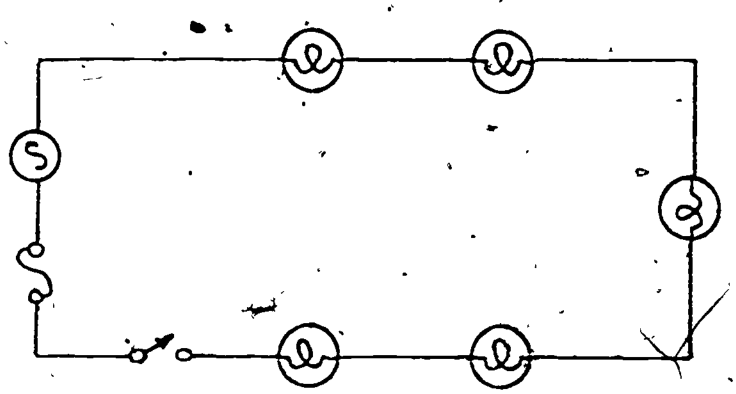

AC Source
Fuse
Switch
Ammeter
A
V
Volt Meter
Connected Wires
Incandescent Lamp
Wires Crossing
(Not connected)

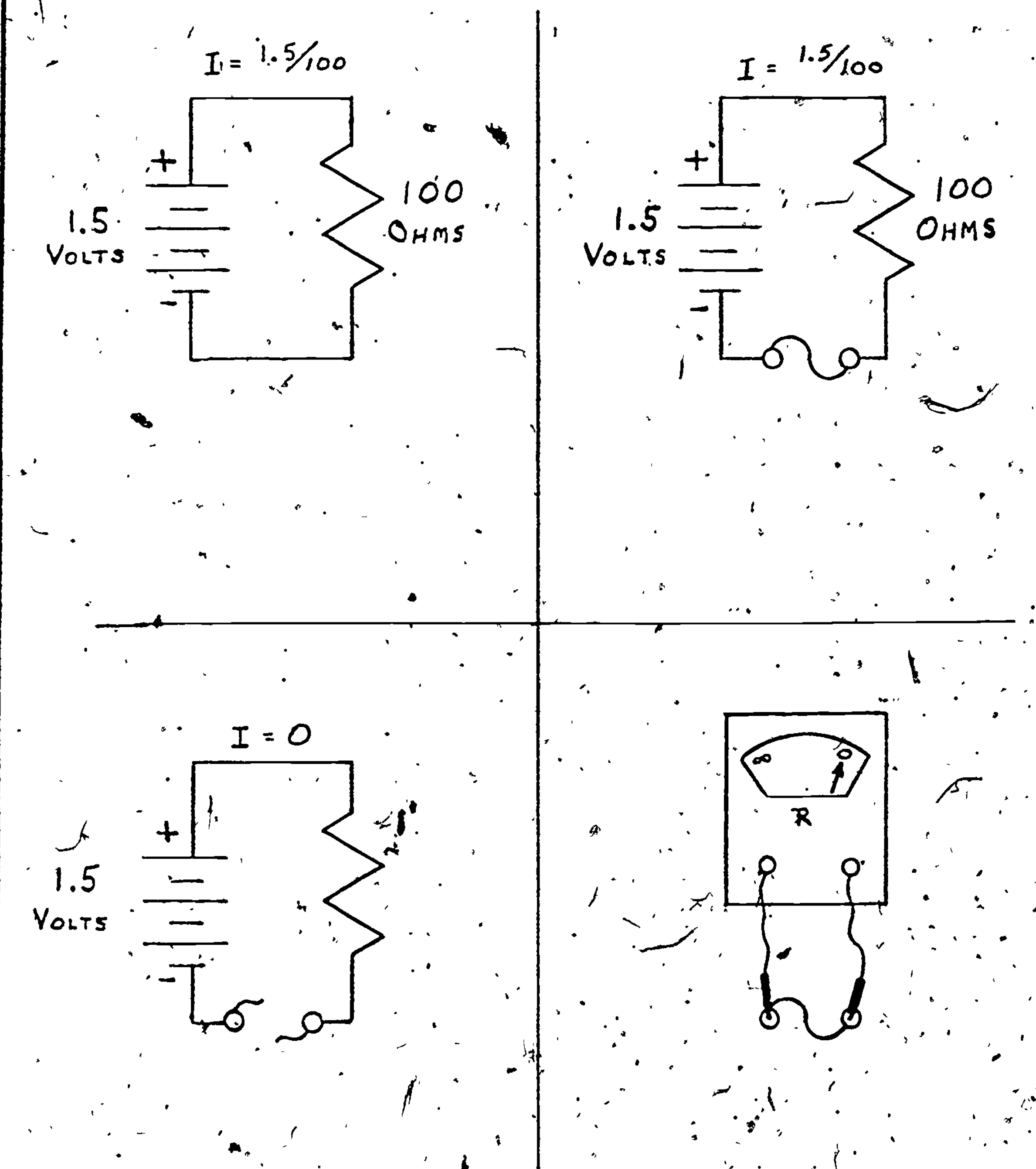
FIGURE 7

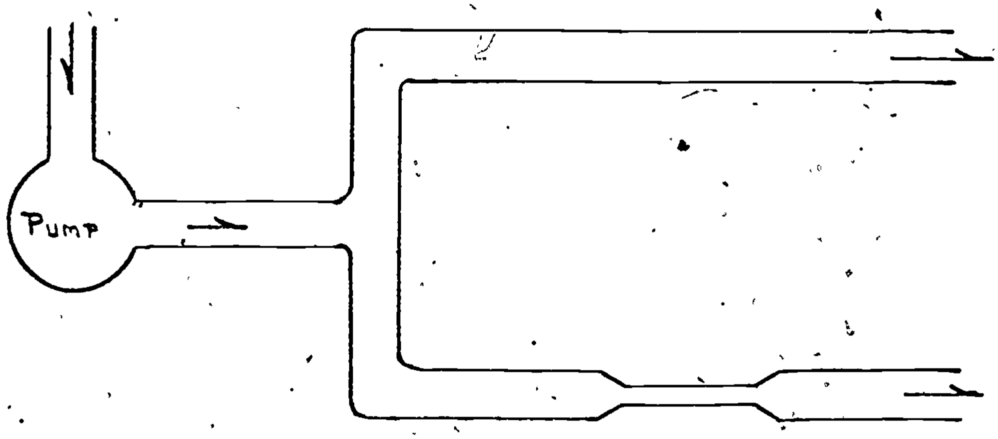


Parallel Circuit



Series Circuit


I = 1.5/100
+
1.5
VOLTS
-
100
OHMS
I = 1.5/100
+
1.5
VOLTS
-
100
OHMS
I = O
+
1.5
VOLTS
-
∞
O
R


Pump

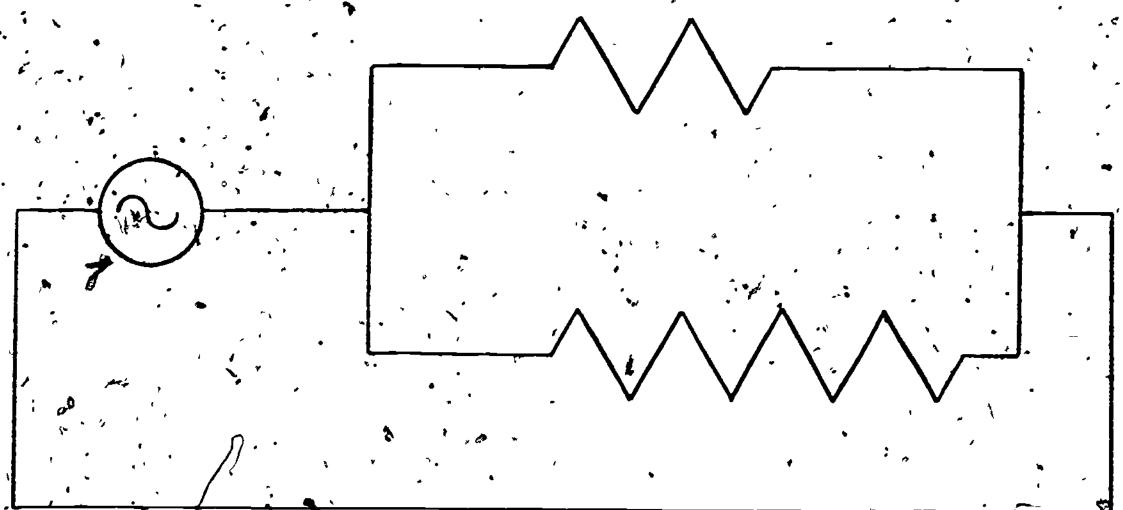
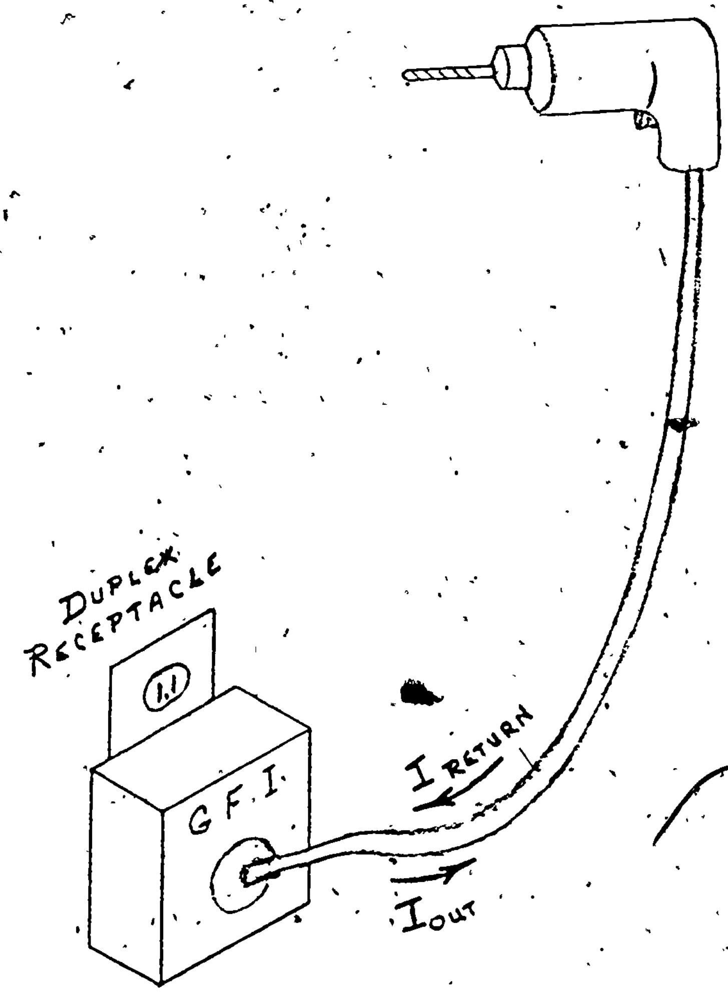


FIGURE 10



Module No:	Module Title: Basic Electricity
Approx. Time:	Submodule Title:
	EVALUATION

Objectives:

The learner will demonstrate that he has achieved the objectives of the module by correctly answering 70% of the questions.

1. Electricity of the form discussed in this module may be defined as ____________ ____________________________.

2. Materials made up of atoms which readily allow their electrons to be transferred from atom to atom are called ____________________________.

3. Materials made up of atoms which do not readily allow their electrons to be transferred from atom to atom are called ____________________________.

4. List two examples of good insulators.

   A. ____________________

   B. ____________________

5. List two examples of good conductors.

   A. ____________________

   B. ____________________

6. ____________ current is current in which the electrons flow constantly in one direction.

7. ____________ current is current in which the electrons flow first in one direction and then in the reversed direction in a circuit.

8. Diagram one cycle of single phase current, 60 hertz. Show time to complete the one cycle, and label axes.

9. Diagram three phase current, 60 hertz. Show the time to complete one cycle and time between voltage peaks. Label axes.

10. A ______________ is a device which allows voltage to be increased (or decreased).

11. A ______________ circuit results from improper or accidental contact between two or more wires.

12. A circuit that is continuously providing a complete path for the flow of current. ______________ circuit.

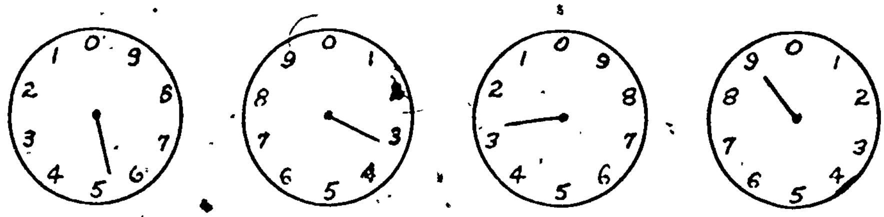
13. A circuit that has been disconnected by a switch, fuse, circuit breaker, or other break in the line. ______________ circuit.

14. Match the following:

_____A. Current	A.	The measure of electrical power.
_____B. Amperes	B.	The movement of electrons through a conductor.
_____C. Ohms	C.	The measure of the resistance of a conductor to flow of an electric current.
_____D. Voltage	D.	The measure of actual electrical energy usage.
_____E. Watts	E.	The measure of rate of flow of electrons through a conductor.
_____F. Kilowatt hours	F.	Electrical pressure

15. Ohm's law states that voltage equals the product of current times resistance (V = IR). The circuit breaker in your laboratory has been tripping when you turn on your muffler furnace. The muffler furnace is plugged into a 220 volt receptacle. The circuit breaker is rated at 20 amperes. What is the level of resistance that is safely applied to this circuit. ______________

16. Record the reading of the meter. ____________



17. List two basic differences between metal conduit and ordinary water pipe.

A. ______________________________

B. ______________________________

18. Match the following:

_____A. White wire — A. Grounding conductor (neutral)

_____B. Green wire — B. "Hot" or undergrounded conductor

_____C. Black wire — C. Grounding conductor of a branch circuit-

19. True or False. A No. 10 solid conductor will carry less current than a No. 14 stranded wire conductor. ____________

20. List a symptom of wire that is too small for the current flow in it.

____

21. Sketch 3 light bulbs wired in series.

22. Sketch 3 light bulbs wired in parallel.

23. What causes a fuse to "blow"? ________________

24. What physically happens to a fuse that "blows"? ________________

25. List three common types of fuses.

A. ________________

B. ________________

C. ________________

26. Why should an overcurrent device never be placed in a permanently grounded conductor?

27. List two typical types of motor bearings.

A. ________________

B. ________________

28. A motor has a service factor of 1.15. What does that mean?

____

____

____

29. True or False. The number following "rise" on the nameplate of a motor refers to the maximum temperature rise above the level of ambient temperature that will occur while the motor is operating at full load.

____

30. From the nameplate shown, list the required information.

Model 2A 641	H.P. 1	V. 115	V. 230
RPM 1725	PH. 1	A. 15	A 7.5
Hz 60	Fr. 656		
Duty cont.	Rise		
Type KF	Ser. fact. 1.0		

A. Phase ______________________

B. Voltage ______________________

C. Current ______________________

D. Duty rating ______________________

E. Service factor ______________________

F. Temperature rise ______________________

G. Horsepower ______________________

31. List the major advantage of a DC motor compared to most AC motors.

____

32. Match the following:

____A. Reaction current	A. A level of current above which a person cannot let go of a conductor.
____B. Let-go current	B. The smallest current that might cause an unexpected involuntary reaction and produce an accident as a result of being shocked.
____C. Fibrillating current	C. The level of current which causes heart action and blood circulation to stop.

33. List two reasons for installing fuses or circuit breakers.

A. ____

B. ____

34. Match the following:

____A. Grounding conductor	A. An electrical device placed in a circuit to detect any differences in the amount of current flowing to an appliance and returning.
____B. Double insulation	B. A plastic shell which isolates the wiring inside an appliance; the wiring itself is also insulated.

____C.	Ground fault interruptor	C.	The green wire connected from the metal surface of an applicant and continued as a separate conductor until it reaches the ground terminal at the service panel.

Evaluation Answers

1. The movement of electrons through a conductor.

2. Conductors

3. Insulators

4. Glass, rubber, plastic, bakelite, oil, pure water, dry sandy soil.

5. Copper, aluminum, silver, tap water, damp soil, human body.

6. Direct

7. Alternating

8. Check against Figure 3

9. Check against Figure 3

10. Transformer

11. Short

12. Closed

13. Open

14. A. B.

  B. E.

  C. C.

  D. F.

  E. A.

  F. D.

15. 11 ohms

16. 5[illegible]9

17. C[illegible]uit bends easily

  Inside of conduit is smooth

  Conduit has corrosion resisting finish

18. A. A.
    B. C.
    C. B.
19. False
20. Heat
21. Check against text Figure 2-2.
22. Check against text Figure 2-3.
23. Current flow in excess of the fuses rated capacity.
24. Metal strip within fuse melts, resulting in an open circuit.
25. A. Screw or plug
    B. Cartridge
    C. Bayonet
26. If fuse is removed the "hot" lead is still connected to the motor, for example, ready to supply power.
27. A. Sleeve
    B. Ball
28. The motor can tolerate a 15 per cent overload.
29. True
30. A. Single (1)
    B. 115 or 230
    C. 15 or 7.5
    D. Continuous (cont.)
    E. 1.0 (ser. fact.)
    F. None shown
    G. 1 (H.P.)

31. The speed of rotation of DC motors can easily be changed.

32. A. B.

    B. A.

    C. C.

33. A. Protection of the wiring (circuit)

    B. Protection of equipment or appliances

34. A. C.

    B. B.

    C. A.