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AUTHOR	O'Brien, Ralph D.
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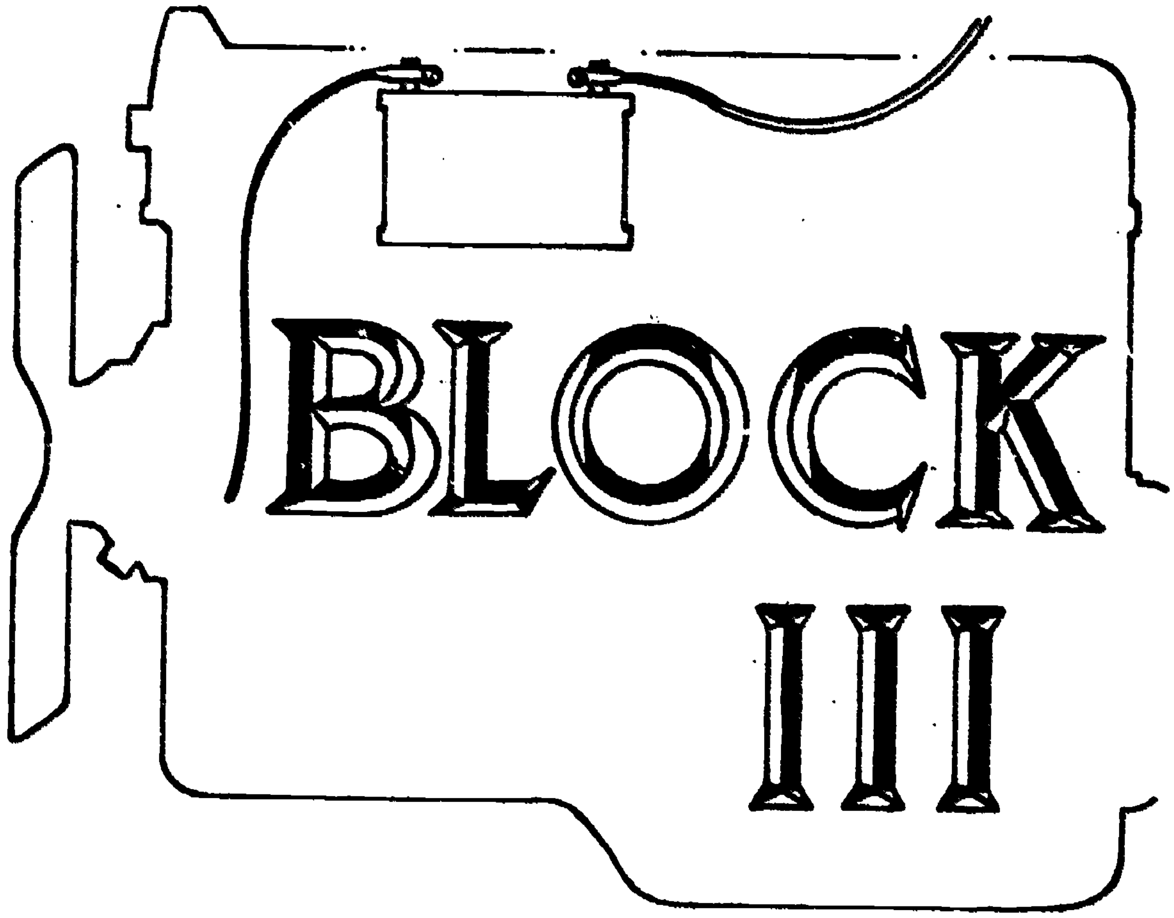
ABSTRACT

The third of six instructional blocks in automotive mechanics, the lessons and supportive information in the document provide a guide for teachers in planning an instructional program in automotive electricity at the secondary and post secondary level. The material, as organized, is a suggested sequence of instruction within each block. Each lesson is stated in terms of a specific teaching objective, teaching aids, references, and an outline of information. Upon successful completion of the 40 lessons in the block of work, students will be able to: (1) define the basic principles necessary to develop a working knowledge of electricity and magnetism and their uses; (2) describe basically the principles, types of circuits, symbols, and devices that are somewhat unique to vehicle systems; (3) develop skills such as measuring; (4) define the principle of specific gravity and describe the construction and functioning of the storage battery; and (5) analyze the performance and condition of the storage battery and apply techniques of proper maintenance. Included with the course outline are transparency masters and a reference guide listing related books, texts, and other publications. (MW)



Automotive Electricity

General Teaching Objectives

Upon successful completion of the forty lessons in this block of work, students will be able to:

1. Define the basic principles necessary to develop a working knowledge of electricity and magnetism and their uses.

2. Describe basically the principles, types of circuits, symbols and devices that are somewhat unique to vehicle systems.

3. Develop skills, such as measuring, splicing, connecting and soldering, for working with basic circuits, devices and instruments.

4. Define the principle of specific gravity and describe the construction and functioning of the storage battery.

5. Analyze the performance and condition of the storage battery and apply techniques of proper maintenance.

CONTENTS - BLOCK III

AUTOMOTIVE ELECTRICITY

INFORMATION

Block: Automotive Electricity

Lesson: The Electron Theory

Block III
Job
Lesson

Teaching Objective: Upon completion of this lesson, students will be able to logically describe the principles underlying the electron theory as related to matter, electrons and energy.

Teaching Aids: Transparencies:
- Proton, Neutron, Electron, p. III-3
- Like and Unlike Charges, p. III-4

References: Basic Electrical and Electronic Principles, Suffern, Chapter 1
Fundamentals of Applied Electricity, Jones, Chapter 1

Outline of Information:

1. The nature of matter

   a. All substances (matter) are made up of active orbital systems.

   Note: It is suggested that an analogy be drawn between our planetary solar system, with the sun as the nucleus, and the micro-miniature atomic solar system making up matter.

   -- A nucleus and its orbiting electrons constitute the structure of an atom.
   -- The atomic identity (structure) differs from element to element.
   -- A substance of two or more elements is a compound.

   b. The nucleus and the electrons that make up an atom are charges of electrical energy.
   -- The nucleus is made up of two types of nucleons.
      (1) Neutrons - bear no charge (electrically neutral)
      (2) Protons - bear a positive charge
      (3) Protons and neutrons adhere firmly except when destroyed (split) by nuclear reaction.
   -- Two types of electrons
      (1) Planetary electrons - holds a steady orbit and cannot be readily disturbed
      (2) Free electrons - will escape from orbit easily
      (3) Free electrons must be motivated to travel (activated) by means of work or energy. They will flow through a conductor when pushed by battery or generator pressure or by heat, light or mechanical pressure.

The Electron Theory (Continued)

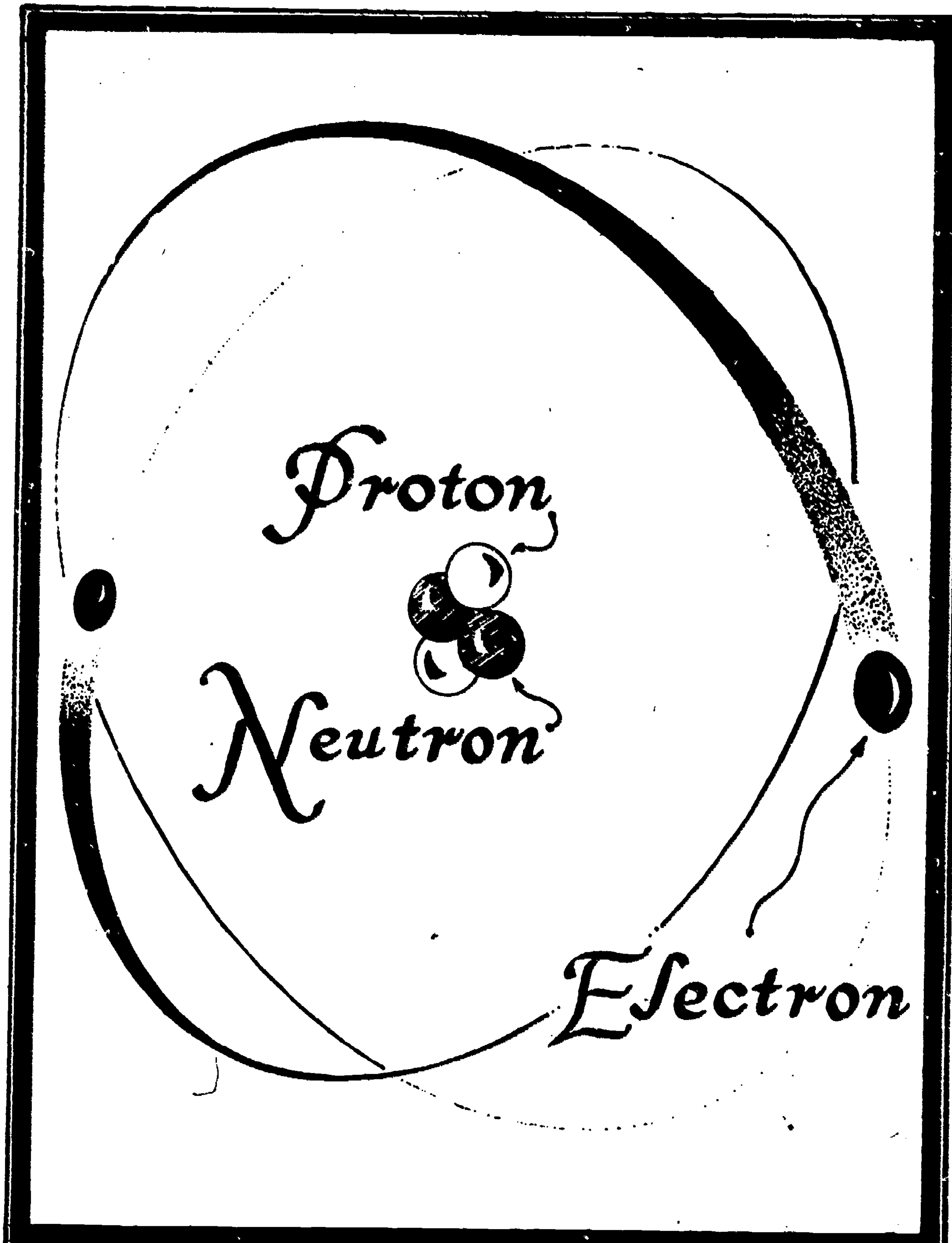
c. A balanced atom has exactly the same numbers of protons and electrons and therefore is electrically neutral.
   -- When negatively-charged free electrons leave the orbit, the atom becomes a postively-charged body.
      (1) The unbalanced atom (positively-charged) seeks and attracts free electrons.
      (2) Postive-charged bodies will attract any negative-charged body.

Note: The rule is, that like charges repel, unlike charges attract.

      (3) Descriptively, it is the electrons that move from atom to atom.

Note: At this point, a descriptive theory of electricity can be established: Electricity is the flow of electrons through a conductor. The direction of flow is from a negative point towards a positive point.

      (4) Technically, the terms electronics and electricity mean the same. In application, the term electronics is utilized to describe activities dealing with vacuum tubes, semiconductors, compacted circuitry, transistors and specialized apparatus control.


Proton
Neutron
Electron

INFORMATION

Block: Automotive Electricity

Lesson: Electricity As Energy

Block III
Job
Lesson

Teaching Objective: Upon completion of this lesson, students will be able to define the phenomenon of electricity and its basic characteristics within the limitations of simplified scientific technique.

Teaching Aids: Transparencies:
- Electricity. . . The Movement of Electrons Through a Conductor, p.III-7
- Facts About Electricity, pp. III - 8, 9

Reference: Basic Electricity, Turner, Chapter 1

Outline of Information:

1. Defining electricity

   a. Physicists and mathematicians can offer advanced, complex explanations.
      -- As a simple explanation, electricity can be defined as:
         One of the major phenomenal, basic energy forces of the universe that can be harnessed, controlled and converted to and from other basic energy sources.

   b. Electricity occupies two conditional states.
      -- In motion (working)
      -- At rest (stored)

2. Static Electricity (so termed because it is motionless energy)

   a. Some materials such as glass, certain kinds of plastic, hard rubber, etc., become electrified with a charge of static electricity when rubbed with a silk cloth or fur.
      -- Electrification leaks off of these materials after a period of time.
      -- Static electricity is also termed frictional electricity.

   b. Electrostatic Field
      -- Extends in all directions around a charged body
      -- Field contains lines of force, collectively called flux
      -- Two kinds of electrification
         (1) Positive
         (2) Negative

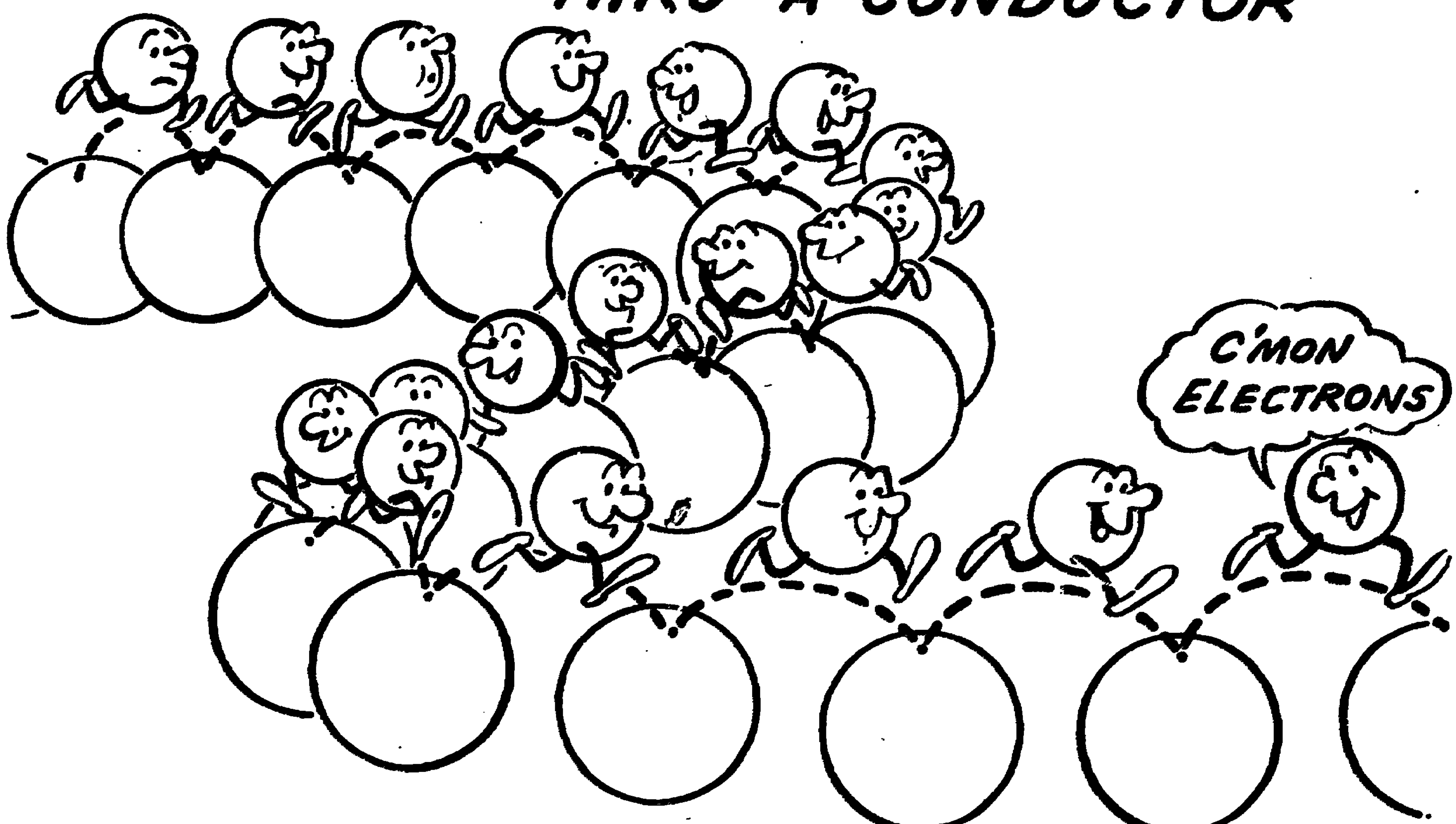
3. Current Flow (energy in motion)

   a. Electron drift is the movement of electrons from atom to atom.

   b. Metals have more free electrons to contribute to the electron flow (drift) than most other materials.

ELECTRICITY....

THE MOVEMENT OF ELECTRONS THRU A CONDUCTOR



FACTS ABOUT ELECTRICITY

1. All matter is made up of molecules.

2. A molecule is composed of two or more atoms.

3. All atoms have an equal number of protons and electrons.

4. An electron is a known negative charge of electricity.

5. A proton is a known positive charge of electricity.

6. A neutron has no electrical charge.

7. The difference in the number of pairs of protons and electrons is responsible for all different materials.

8. An electron is constantly moving in an orbit around a proton.

9. Materials which have many free electrons are known as conductors.

10. Materials which have very few free electrons are known as insulators.

11. The exchange of electrons from one atom to another is at the rate of 186,000 miles per second.

Courtesy - Automotive Electric Association

FACTS ABOUT ELECTRICITY (CONTINUED)

12. Current flow is the result of movement of electrons.

13. The unit of measurement for electrical pressure is a volt.

14. The unit of measurement for electrical current flow is an ampere.

15. The unit of measurement for an electrical resistance is an ohm.

16. Ohm's Law is stated as:

$$\text{Amperes} = \frac{\text{Volts}}{\text{Ohms}} \quad \text{or} \quad \text{Ohms} = \frac{\text{Volts}}{\text{Amperes}} \quad \text{or}$$

$$\text{Volts} = \text{Amperes} \times \text{ohms.}$$

17. A watt is the product on one volt X one ampere.

18. The same amount of current flows through all units of a series circuit.

19. The flow of current divides through units in a parallel circuit.

20. An electrical horsepower is 746 watts.

INFORMATION

Block: Automotive Electricity

Lesson: Conductors, Insulators, Semiconductors

Block III
Job
Lesson

Teaching Objective: Upon completion of this lesson students will be able to define conductors, insulators and semiconductors and give examples of each.

Teaching Aids: Transparency:
- Good Conductors, Semiconductors, Poor Conductors, p. III - 11

References: Basic Electricity, Turner, Chapter 1
Fundamentals of Applied Electricity, Jones, Chapter V.

Outline of Information:

1. Conductors (material that supports current flow)

   a. The best conductors are metallic elements.
      -- Contain more free electrons than non-metallic materials
      -- Most common conductors (wire for current flow) are made from copper and/or aluminum.

   b. Ionic conduction (simultaneous flow of positive to negative and negative to positive) can take place in gases and electrolytic liquids (acids, alkali and salt solutions).

2. Insulators (material that opposes current flow)

   a. Many materials are classified as insulators.
      -- Glass, rubber, most plastics, ceramics, dry cellulose-base materials
      -- Wire that is manufactured for conductor use is very often coated or covered with insulating material.
      -- Pure water (free of metallic salts and other conductive impurities) is technically a good insulator.
      -- Air provides a natural insulation (prevents current flow).

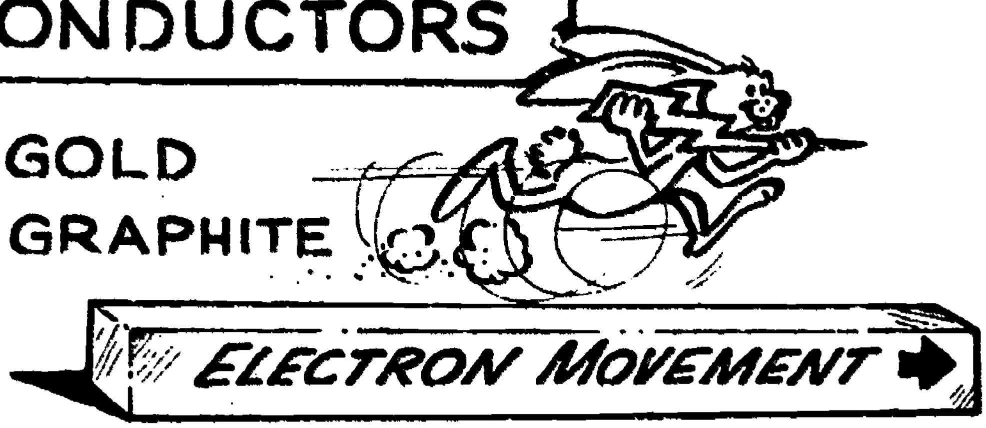
3. Semiconductors (materials sharing some properties of both insulators and conductors)

   a. Certain materials when used in conjuntion have special application of assisting directional current flow, while preventing its reversal.
      -- Copper oxide, copper sulphide, silicon, germanium are examples of semiconductors.

   b. An example of the application of a semiconductor is the selenium rectifier in battery chargers and other appliances.

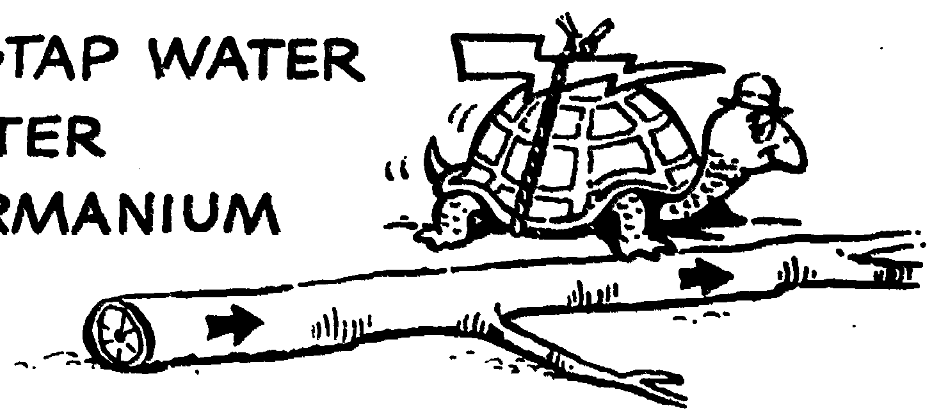
GOOD CONDUCTORS

- SILVER
- GOLD
- COPPER
- GRAPHITE



SEMICONDUCTORS

- DRY WOOD
- TAP WATER
- IMPURE WATER
- IMPURE GERMANIUM



POOR CONDUCTORS

- GLASS
- MICA
- HARD RUBBER
- AMBER
- BAKELITE
- GERMANIUM

INFORMATION

Block: Automotive Electricity

Lesson: Sources of Electricity

Block III
Job
Lesson

Teaching Objective: Upon completion of this lesson, students will be able to cite six basic sources of applicable electrical energy and define each related physical principle.

Teaching Aids: Transparency:
- Sources of Electrical Energy, p. III-13

Reference: Basic Electricity, Turner, Chapter 1

Outline of Information:

Electricity is produced in useful quantities through the following physical actions:

1. Mechanical - Using magnetism in reciprical and rotating machines to generate electricity. Sources of mechanical power are wind, water, internal combustion, steam, hand power.

2. Chemical - Batteries to produce and store power are energized chemically.

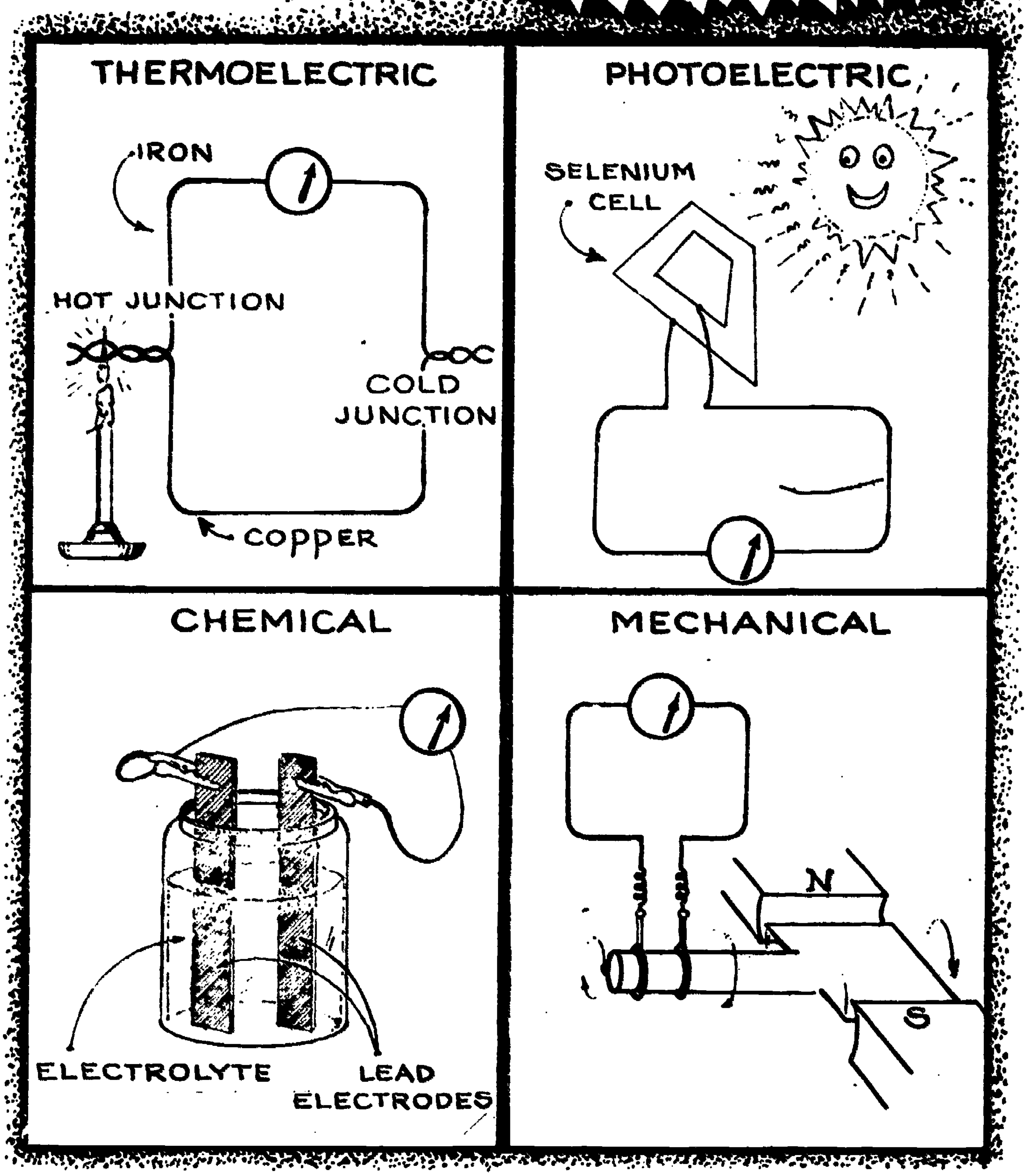
3. Light - Photoelectrical cells, using semiconductors, convert sunlight or artifical light into electrical energy.

4. Heat - Thermoelectricity utilizes heat energy imposed upon dissimilar metals to produce a potential difference which creates electrical energy. The junction of the dissimilar metals is called a thermocouple.

5. Pressure - Certain crystals, such as quartz, emit electrical energy when squeezed or strained.

6. Friction - Static electricity is produced by friction between two materials.

Sources of Electrical ENERGY



INFORMATION

Block: Automotive Electricity

Lesson: Magnetism

Block III
Job ____
Lesson ____

Teaching Objective: Upon completion of this lesson, students will be able to define and discuss the basic principles and laws of magnetism.

Teaching Aids: Transparencies:
- Magnetic Fields, p. III - 16
- Magnetic Fields, P. III - 17
- Facts About Magnetism, pp. III - 18
- Magnetic Field About a Current-Carrying Conductor, p. III - 22

References: Fundamentals of Applied Electricity, Jones, Chapter IV
Basic Electricity, Turner, Chapter 5

Outline of Information:

1. Major portion of world's power supply is converted into electricity and back again to be used as mechanical energy.

   a. This conversion and consumption utilizes many electrical devices.
      -- Generators, meters, motors, transformers, controls

   b. Most electrical devices operate on principles of magnetism.

2. Principles of magnetism

   a. Magnetism is not fully understood.
      -- Related to, but not the same as electrical energy
      -- Caused by electron spin
      -- Magnetism is a medium (an intermediate step) through which energy passes in its conversion.
         (1) Mechanical to electrical (as in the generator)
         (2) Electrical to mechanical (as in the motor)

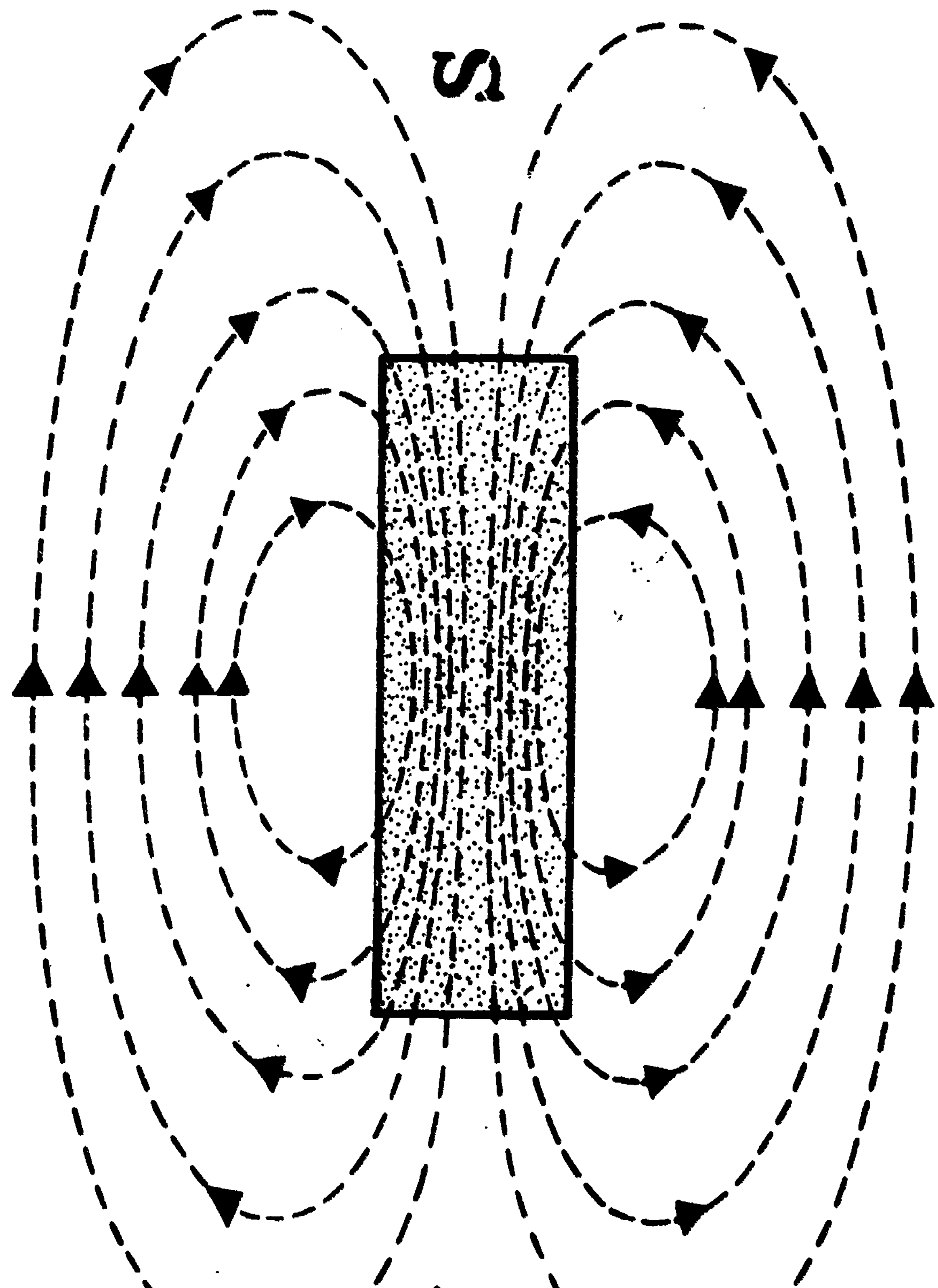
   b. All matter conducts magnetism.
      -- There is no known insulator against its force.

   c. Only a few materials can be magnetized.
      -- Lodestone (iron ore called magnetite) is a natural magnet.
      -- Iron, nickel and cobalt can be strongly magnetized.
      -- Copper, aluminum, carbon, lead cannot be magnetized.
      -- Certain materials, some nonmagnetic, when alloyed with magnetic metals, provide for greater magnetic strength and permanency.

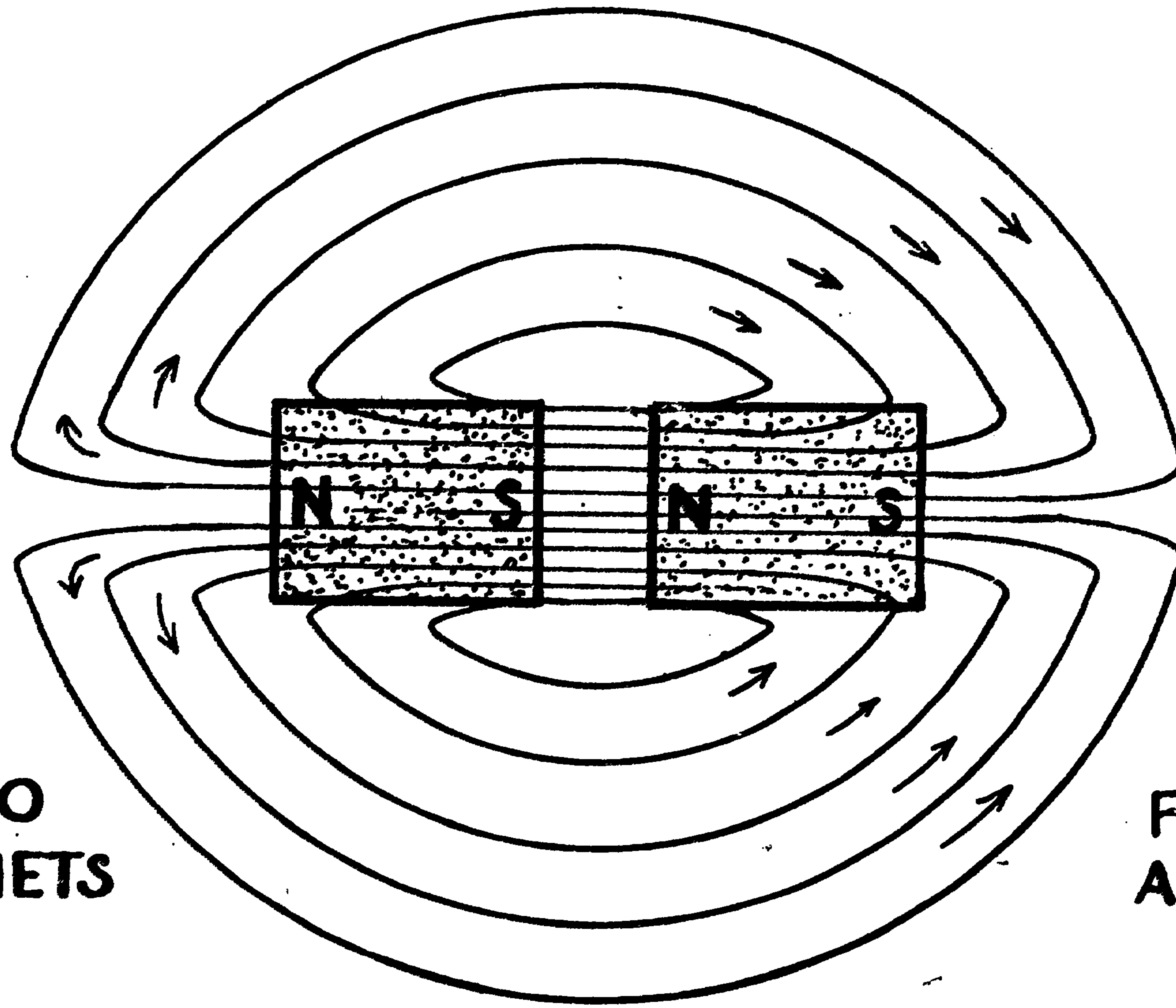
d. Magnetic poles
   - -- The centers of the areas have greatest concentration of magnetic strength.
   - -- Usually located at the ends of a magnet where the magnetism enters and exits
     - (1) South pole - magnetism <u>enters</u>
     - (2) North pole - magnetism <u>exits</u>
   - -- <u>Like</u> poles repel, unlike poles <u>attract</u>.

e. Electromagnetism
   - -- Every current-carrying conductor produces a surrounding magnetic field extending the total length of the conductor.
   - -- With insulated wire as the conductor, and when coiled, the magnetic field is greatly concentrated.
   - -- When an iron core is inserted into the coiled wire, the field strength (flux) is increased hundreds of times.

MAGNETIC FIELDS



MAGNETIC FIELDS



TWO MAGNETS

FIELDS AIDING

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FACTS ABOUT MAGNETISM

1. The earth is a hugh magnet.
2. The north geographic pole is a south magnetic pole.
3. A magnet creates a field of force.
4. Only the magnetic materials, iron, nickel, cobalt, or their alloys can be strongly magnetized.
5. Like magnetic poles tend to repel each other.
6. Unlike magnetic poles tend to attract each other.
7. Lines of force are complete loops from the north pole to the south pole of a magnet.
8. Lines of force never cross each other.
9. There is no insulator for lines of force.
10. Any magnetic material that has once been magnetized will retain some magnetism.
11. Iron is 2500 times a better conductor of lines of force than air.

FACTS ABOUT MAGNETISM (CONTINUED)

12. Residual magnetism is the amount of magnetism retained in a substance after the magnetizing force is removed.

13. The space through which magnetic lines of force pass is called a magnetic field.

14. The conducting path for lines of force is called a magnetic circuit.

15. A current-carrying conductor creates a magnetic field around the conductor for the full length of the conductor.

16. Current-carrying conductors tend to move from a strong field into a weak field.

17. The magnetic strenght of a coil is measured in ampere turns which is the product of amperes X turns.

18. Voltage is generated when a conductor is passed through lines of force.

19. Voltage is generated when lines of force are passed through a conductor.

20. The attractive force of an electro-magnet is not changed with polarity.

OPERATION

Block: Automotive Electricity

Operation: Proving Magnetic Field with Filings and Compasses

Block III
Job
Operation

Teaching Objective: To teach students to determine the existance of a magnetic field by using iron filings and a compass

Tools: Compass

Materials: Iron filings, bar magnet, sheet of lucite

References: Basic Electricity, Howard Sams, Unit 4

Steps:

1. Place sheet of lucite over magnet
2. Sprinkle iron filings on the lucite sheet
3. Observe the iron filings arranging themselves in a definite pattern with more filings attracted to the magnet poles than other places
4. Substitute compass for the filings and note the direction the compass needle is pointing

OPERATION

Block: Automotive Electricity

Operation: Proving the Magnetic Field about a Current-Carrying Conductor Using a Compass

Block III
Job ____
Operation ____

Teaching Objective: To teach students to prove the existance of a magnetic field around a current-carrying conductor using a compass

Tools: Compass, side cutters

Materials: #14 wire, 2.5-ohm resistor, DC power supply, 6" x 6" piece of cardboard

Teaching Aids: Transparency:
- Facts About Magnetism, pp. III -18, 19

Reference: Basic Electricity, Rainey, Chapter II

Steps:

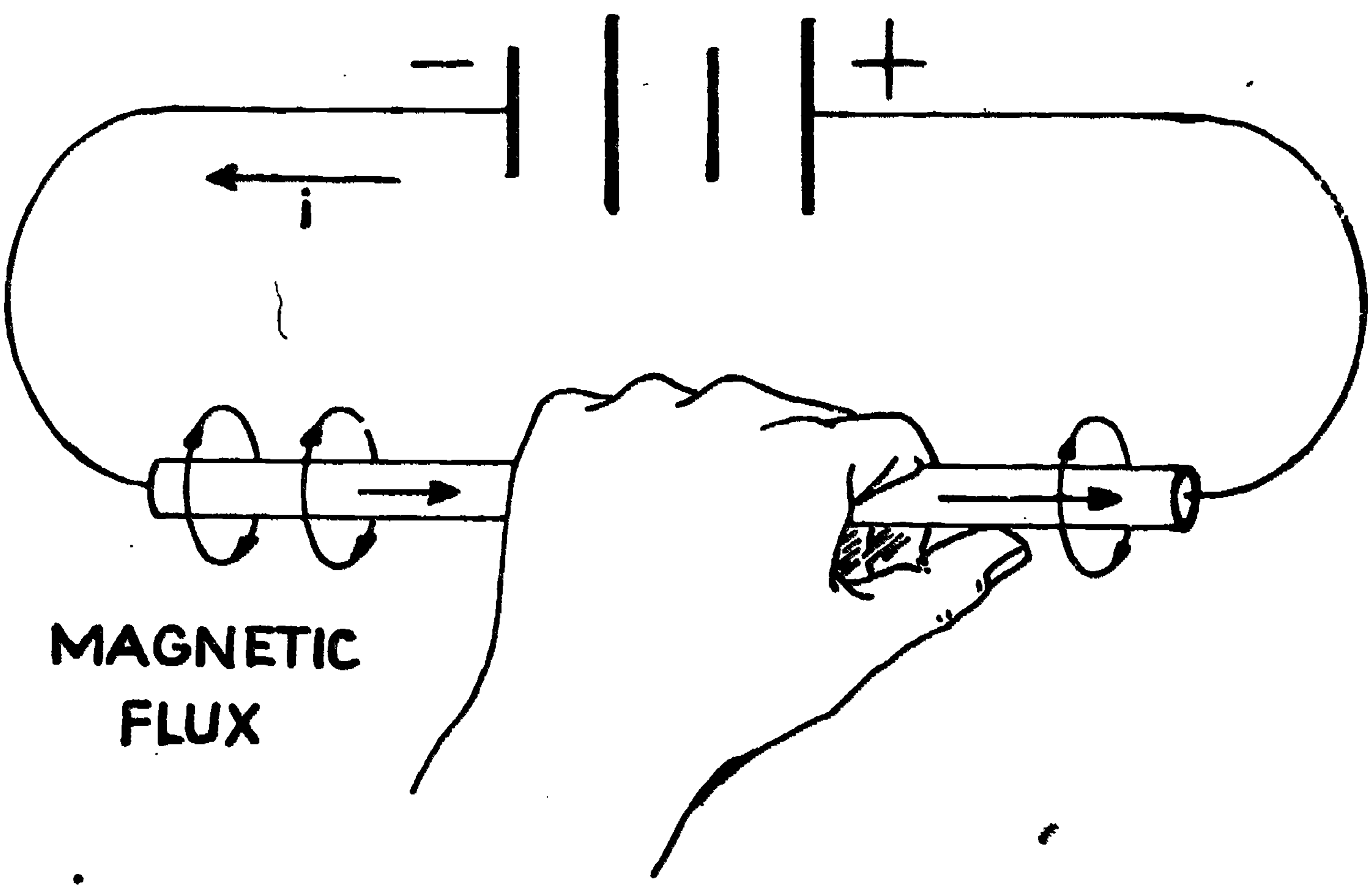
1. Insert #14 wire through a small hole in cardboard

2. Connect a resistor in series with the power supply. Place the #14 wire so that it will be perpendicular to the cardboard

3. Energize the circuit and pass compass around the wire

4. The compass needle will be deflected, indicating a magnetic field.

MAGNETIC FIELD ABOUT A CURRENT CARRYING CONDUCTOR



LEFT-HAND RULE FOR FINDING THE DIRECTION OF THE FLUX LINES

OPERATION

Block: Automotive Electricity

Operation: Constructing an Electromagnet

Block III
Job
Operation

Teaching Objective: To teach students to construct an electromagnet

Tools: Wire cutters, needle-nose pliers, knife, 6 or 12 volt power supply

Materials: #20 gauge magnet wire, 3/8" diameter iron rod 3 inches long, 1-piece of laminated iron (1" square by 3" long), SPST switch

Teaching Aid: Transparency:
- Facts About Magnetism, pp. III-18, 19

Steps:

1. Wind several turns of magnet wire on the core
2. Place the iron rod inside the coil
3. Connect the toggle switch in the circuit with the solenoid
4. Attach to power source and turn switch "on." Try to remove rod
5. Turn power "off," and remove rod
6. Turn on power and bring rod to or near core
7. Allow rod to enter the core of the coil. Note results
8. Turn power off
9. Place solenoid in a vertical position with the bottom edge about 2 1/4" above the table top
10. Place iron rod inside and turn on the power. Note what happens
11. Lift solenoid further away from table top as in Steps 8 through 10, and turn off the power

Note: This indicates how a solenoid may be used for mechanical energy.

INFORMATION

Block: Automotive Electricity | Block III
Job
Lesson: Voltage | Lesson

Teaching Objective: Upon completion of this lesson, students will be able to define the principle of voltage and to calculate its measure in a working circuit.

Teaching Aids: Transparencies:
- Pressure, p. III - 25
- Ohm's Law, p. III -31
- Facts About Measuring Instruments, p. III -45, 46
- Facts About Electricity, pp. III - 8, 9

References: Basic Electricity, Turner, Chapter 2
Fundamentals of Applied Electricity, Jones, Chapter II

Outline of Information:

1. Voltage is electromotive force (EMF).

   a. Caused by natural attraction and repulsion which electrons and protons exert on each other
      -- Pressure (force) of the actual electron flow
      -- Equate with water pressure in a garden hose or pipeline
      -- Compare faucet with switch
      -- Voltage occurs with static electricity but cannot be measured.

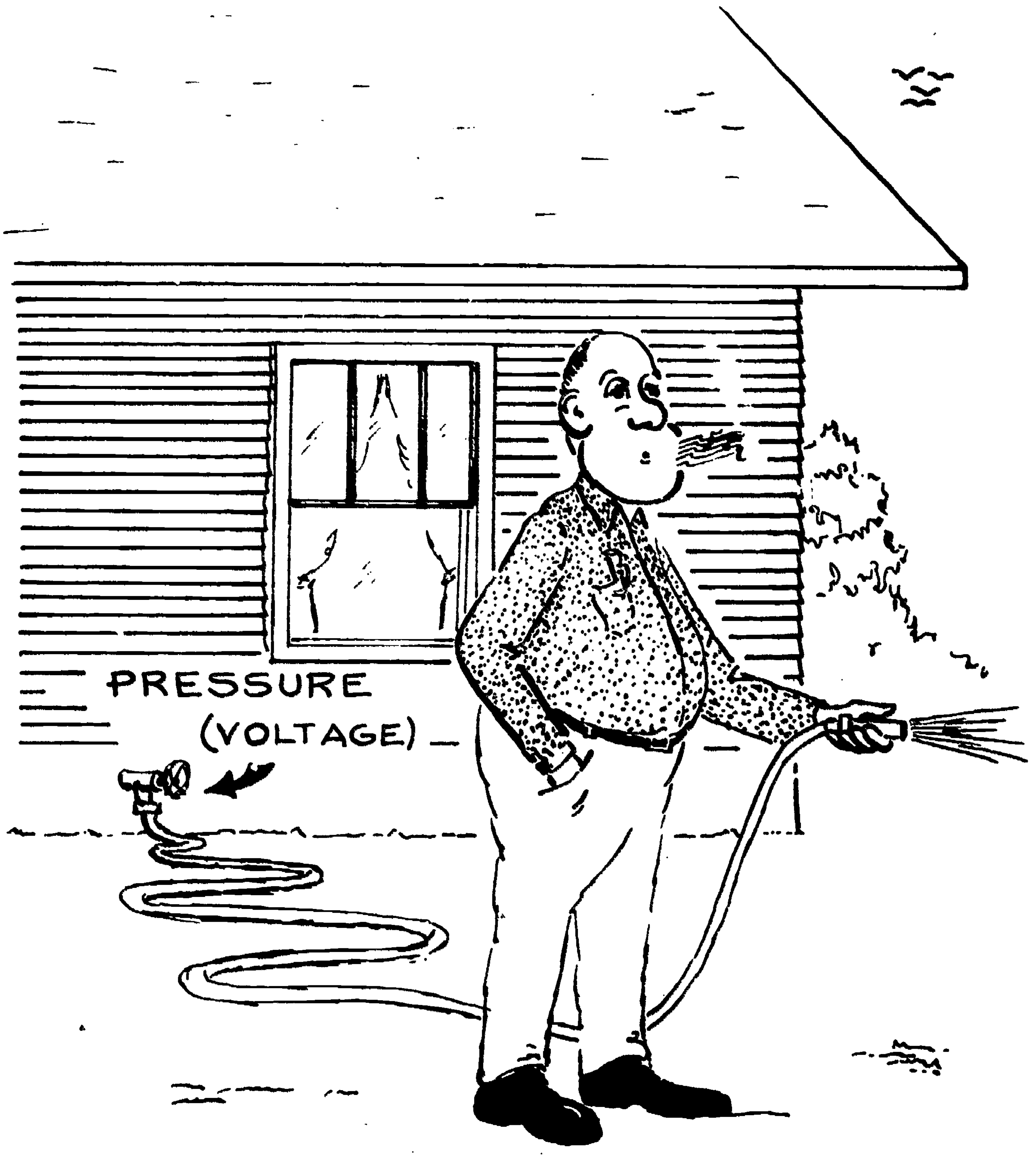
   b. In a working electrical circuit, voltage is produced via basic physical actions.

      Refer: Lesson "Sources of Electricity" p. III - 12

      -- The source of EMF serves to "pump up" the circuit pressure.
      -- The pressure "drops" as circuit energy is expended doing work.

   c. Measuring voltage
      -- The Volt is the unit of measure.
      -- The measuring instrument is the voltmeter.
      -- One Volt is the amount of electrical pressure required to push one ampere through a conductor having one ohm of resistance.
      -- Ohm's law is applied for calculations.
      -- Mathematical abbreviation for Volts is (E).

PRESSURE



INFORMATION

Block: Automotive Electricity

Lesson: Amperage

Block III
Job
Lesson

Teaching Objective: Upon completion of this lesson, students will be able to define amperage as a measure of current in an electrical circuit and to apply Ohm's Law accordingly.

Teaching Aids: Transparencies:
- Current, p. III - 27
- Facts About Electricity, pp. III - 8, 9
- Ohm's Law, p. III - 31
- Facts About Measuring Instruments, pp. III - 45, 46

References: Basic Electricity, Turner, Chapter 1
Fundamentals of Applied Electricity, Jones, Chapter II

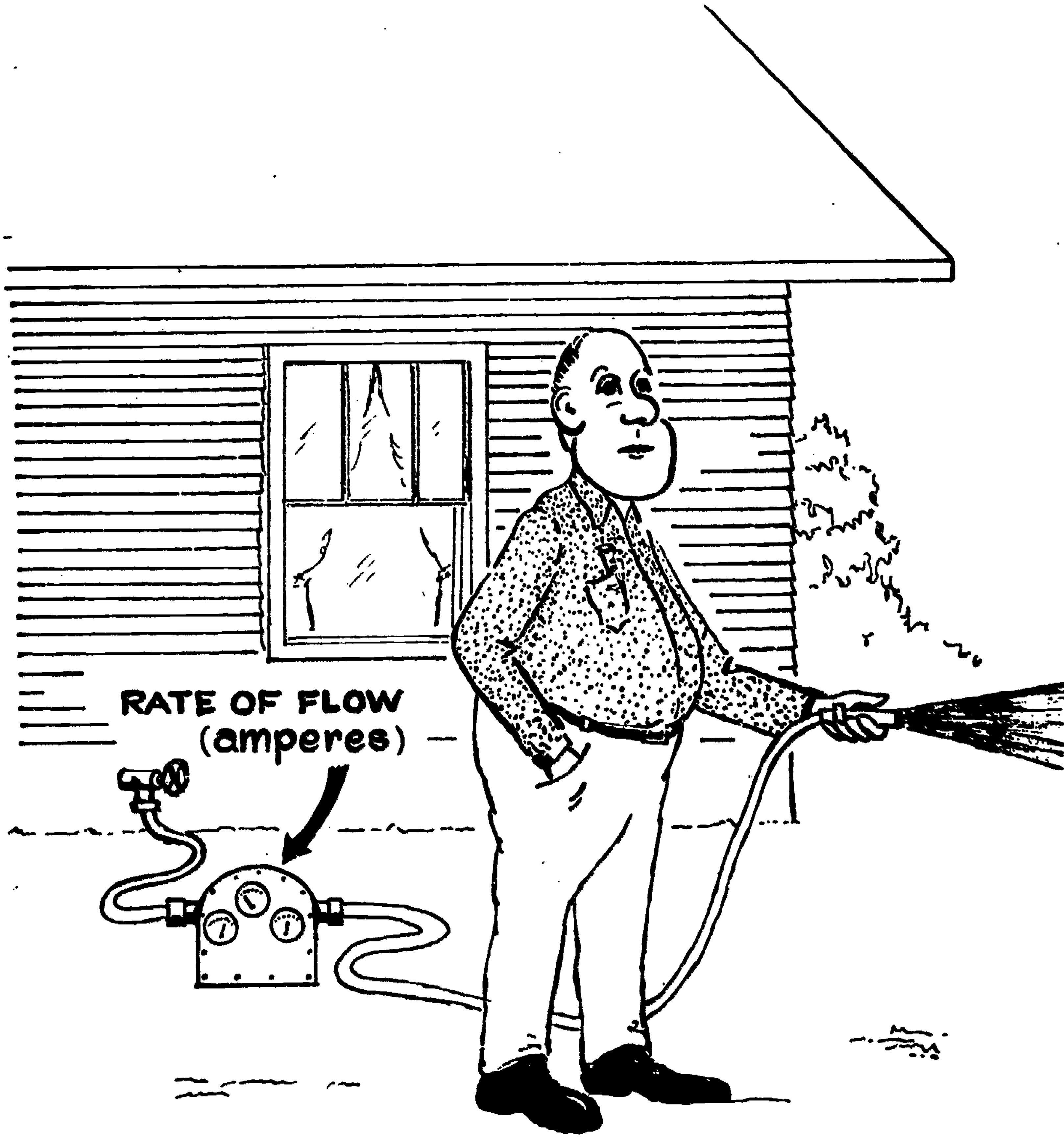
Outline of Information:

1. Amperage is the current strength of electricity.

   a. The unit of measure is the ampere.
      -- Milliamperes - thousandths of an ampere
      -- Microamperes - millionths of an ampere

   b. Measuring amperes
      -- One amp = 6300 quadrillion electrons flow past a given point in one second
      -- Current is measured with an ammeter.
      -- Ohm's law is applied for calculations.
      -- Mathematical abbreviation for amperes is (I).

Current



INFORMATION

Block: Automotive Electricity

Lesson: Resistance

Block III
Job
Lesson

Teaching Objective: Upon completion of this lesson, students will be able to define resistance and its effects in a working electrical circuit and to calculate measures of resistance using Ohm's Law.

Teaching Aids: Transparencies:
- Current, p. III - 27
- Facts About Electricity, pp. III - 8, 9
- Meter Connections, p. III - 40
- Ammeter Connections, p. III - 43

References: Basic Electricity, Turner, Chapter 2
Fundamentals of Applied Electricity, Jones, Chapter II

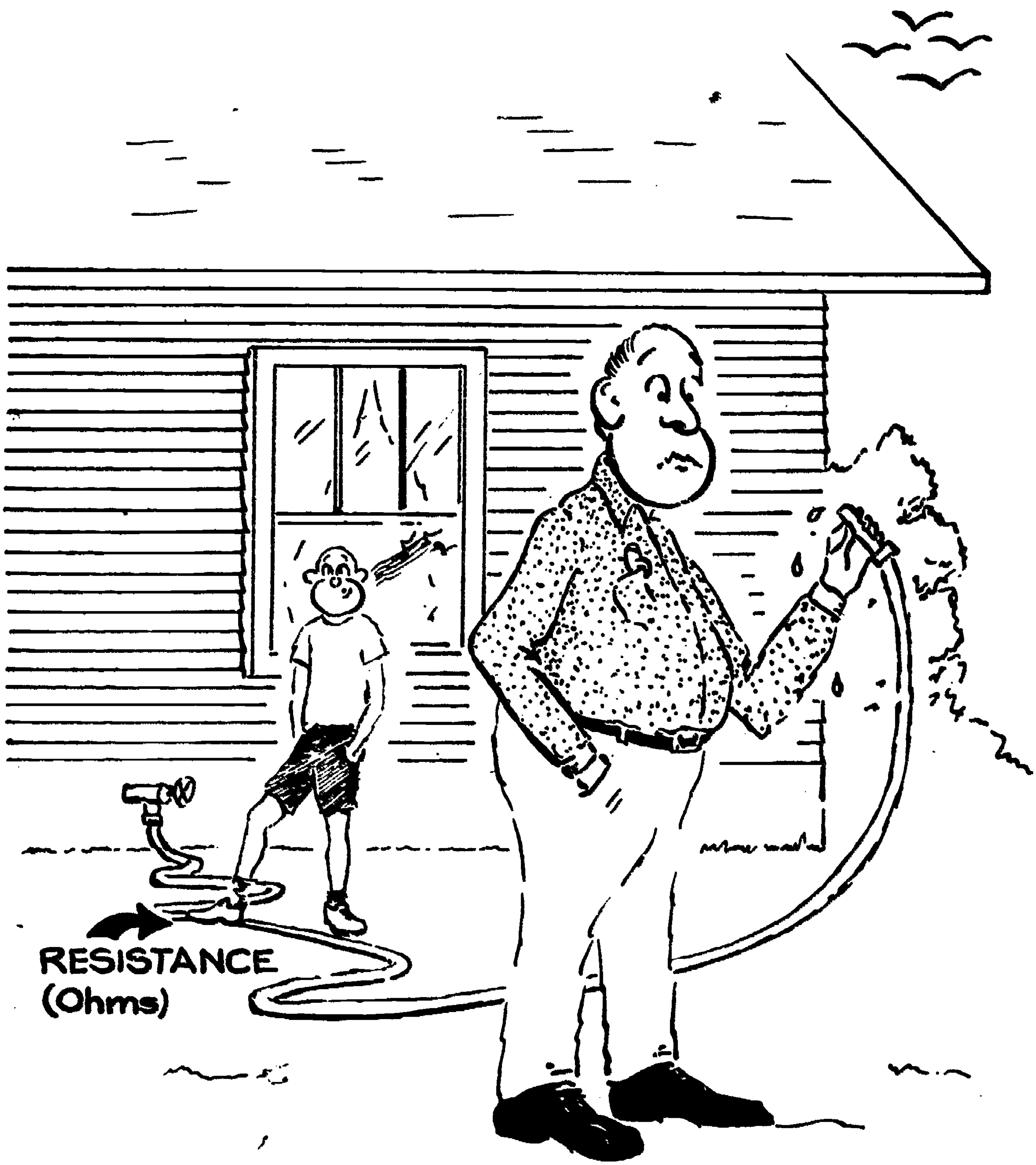
Outline of Information:

1. Resistance is the opposition to electron flow through a conductor.

   a. Characteristics and effects of resistance
      -- No conductor is free of resistance.
      -- Good conductors have low resistance.
      -- Poor conductors have high resistance.
      -- Insulators have resistance proportionate to prevent electron flow.
      -- Resistance is often referred to as electrical friction.
      -- Resistance in a conductor varies with:
         (1) Length of conductor
         (2) Size (cross-sectional) of conductor
         (3) Temperature of conductor
      -- Resistance is utilized (calculated) to control current flow.
      -- Resistance is utilized in heat production.

   b. Measuring resistance
      -- The unit of measure for resistance is the ohm.
      -- One ohm = the resistance of a conductor through which one volt will force a current of one ampere.
      -- Ohm's Law is applied for calculations.
      -- Mathematical abbreviation for Ohm is (R).

RESISTANCE



INFORMATION

Block: Automotive Electricity

Lesson: Wattage

Block III
Job
Lesson

Teaching Objective: Upon completion of this lesson, students will be able to define wattage as a measure of rate of power consumption in a working electrical circuit and to perform simplified calculations.

Teaching Aids: Transparencies:
- Facts About Electricity, pp. III - 8, 9
- Ohm's Law, p. III - 31

References: Basic Electricity, Turner, Chapter 2
Fundamentals of Applied Electricity, Jones, Chapter II

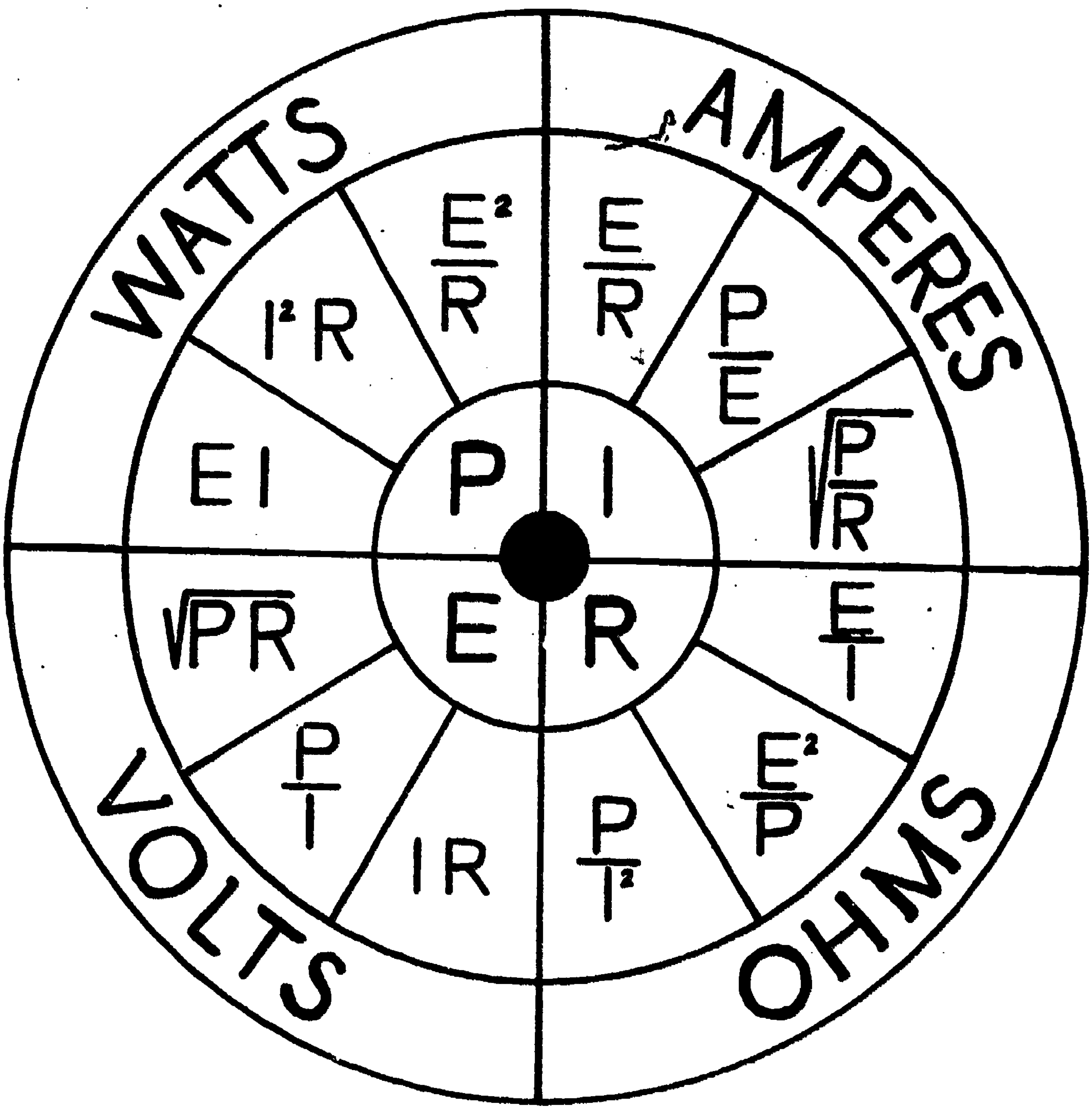
Outline of Information:

1. Wattage is the measure of rate of power generation and/or consumption.

   a. The unit of power is the watt.
   -- Also expressed in fractions and multiples:
   milliwatts - thousandths of a watt
   microwatts - millionths of a watt
   kilowatts - thousands of watts
   magawatts - millions of watts

   b. Measuring wattage
   -- The most common unit of measure is the kilowatt-hour.
   -- One kilowatt-hour is the energy consumed at the rate of one-kilowatt during one hour of time.
   -- One electrical horsepower (HP) = 746 watts.
   -- Ohm's law is applied for calculations.
   -- Mathematical abbreviation for Watts is (P).

OHM'S LAW



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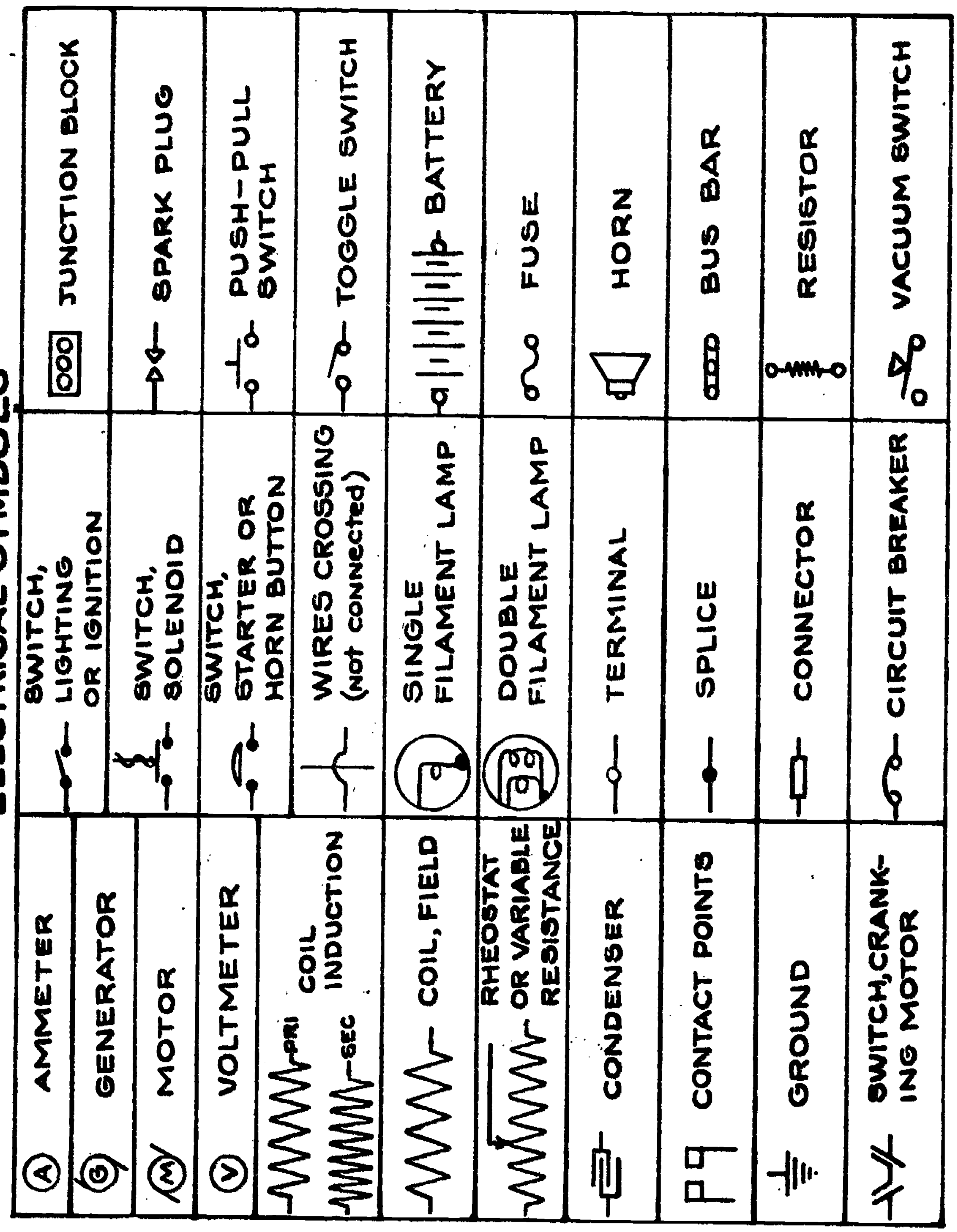
ELECTRICAL SYMBOLS



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OPERATION

Block: Automotive Electricity

Operation: Constructing Basic Circuits (Simple), (Series)

Block III
Job ____
Operation ____

Teaching Objective: To teach students to construct basic circuits.

Tools: Screwdriver, wire cutters, needlenose pliers, power supply (battery charger), generator, etc., knife, test light

Materials: Automotive light units with bulbs, switches, 18 gauge wire

Teaching Aids: Transparency:
- Simple Circuit, Series Circuit, p. III - 35
- Electrical Symbols, p. III - 32

References: Basic Electricity, Turner, Chapter II
Basic Electricity, Howard Sams, Unit 2

Steps:

Simple Circuit

1. Connect wires to each terminal on light unit
2. Connect a knife switch or other suitable switch in series
3. Connect circuit to power source
4. Close switch

Series Circuit

1. Connect wires to light units
2. Connect a knife switch or other suitable switch in series
3. Place bulbs in units
4. Connect circuit to the power source (Proper voltage)
5. Close switch
6. With both bulbs glowing, note their brilliance. Why are they dim?

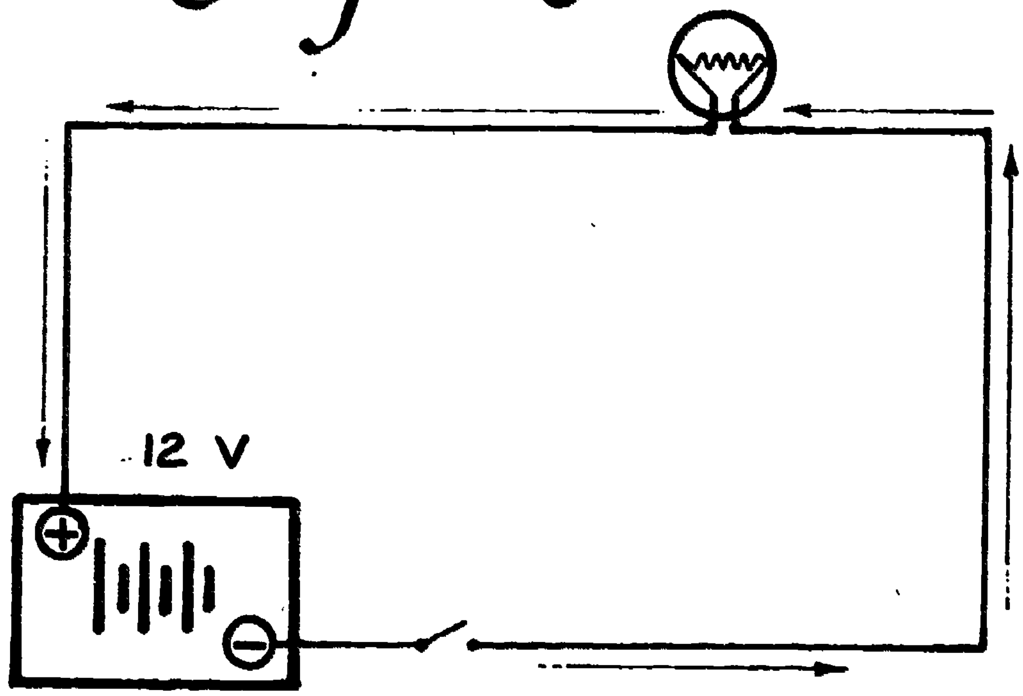
7. Remove one of the bulbs. Note what happens to the other bulb

8. Place a jumper wire across the bulb that was disconnected

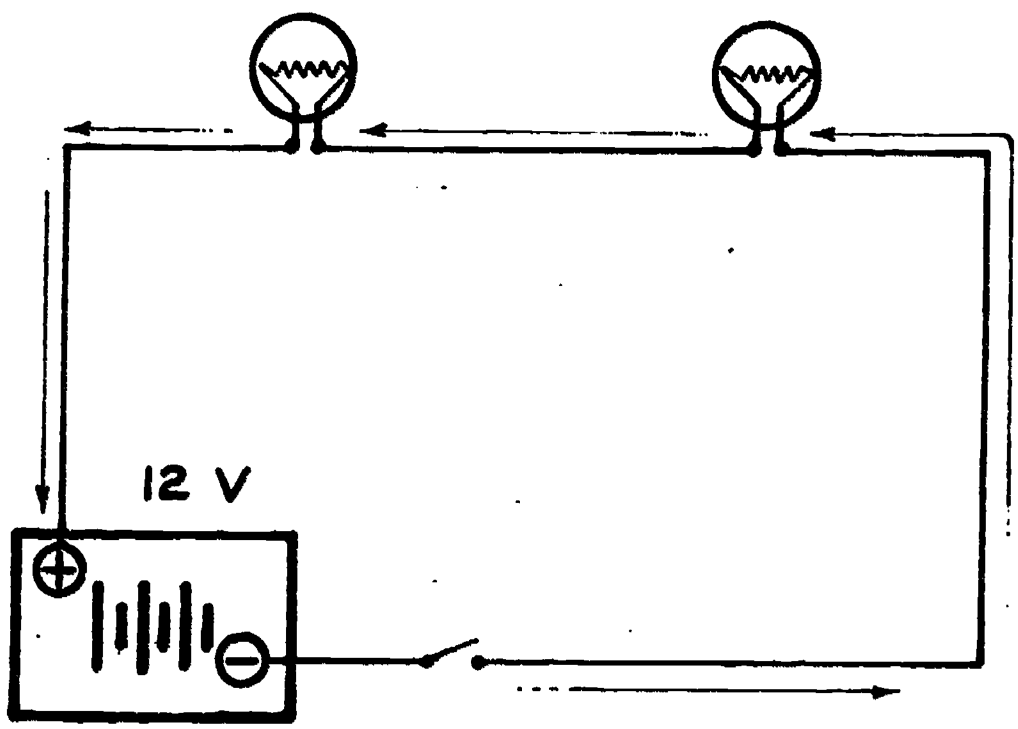
9. Determine the disadvantage of this type of a circuit

   Note: Bells, buzzers, motors or other suitable devices may be satisfactorily substituted for the light units.

Simple Circuit



Series Circuit



OPERATION

Block: Automotive Electricity

Operation: Constructing Basic Circuits (Series-Parallel)

Block III
Job
Operation

Teaching Objective: To teach students to construct a series-parallel circuit

Tools: Needlenose pliers, knife, screwdrivers, wire cutters, test light

Materials: Automotive light units, 18 gauge wire, switches

Teaching Aids: Transparency:
- Parallel Circuit, Series Parallel Circuit, p. III - 38

References: *Basic Electricity*, Turner, Chapter 2
Basic Electricity, Howard Sams, Unit 2
Fundamentals of Applied Electricity, Jones, Chapter II

Steps:

1. Connect two light units in parallel with each other

2. Connect a knife switch or other suitable switch in series

3. Connect one light unit in series with the power source and the other four lamp holders

4. Connect circuit to power source

5. Close switch. Note results

   Note: Consultation between student and instructor is needed before proceeding.

6. Place a wire jumper around the light unit in series. Record results

7. Remove bulb in series. Note results. Next remove a bulb in parallel and note results

OPERATION

Block: Automotive Electricity

Operation: Constructing a Parallel Circuit

Block III
Job ____
Operation ____

Teaching Objective: To teach students to construct a parallel circuit

Tools: Screwdrivers, wire cutters, needlenose pliers, knife, power supply, test light

Materials: Automotive light units with bulbs, 18 gauge wire, switches

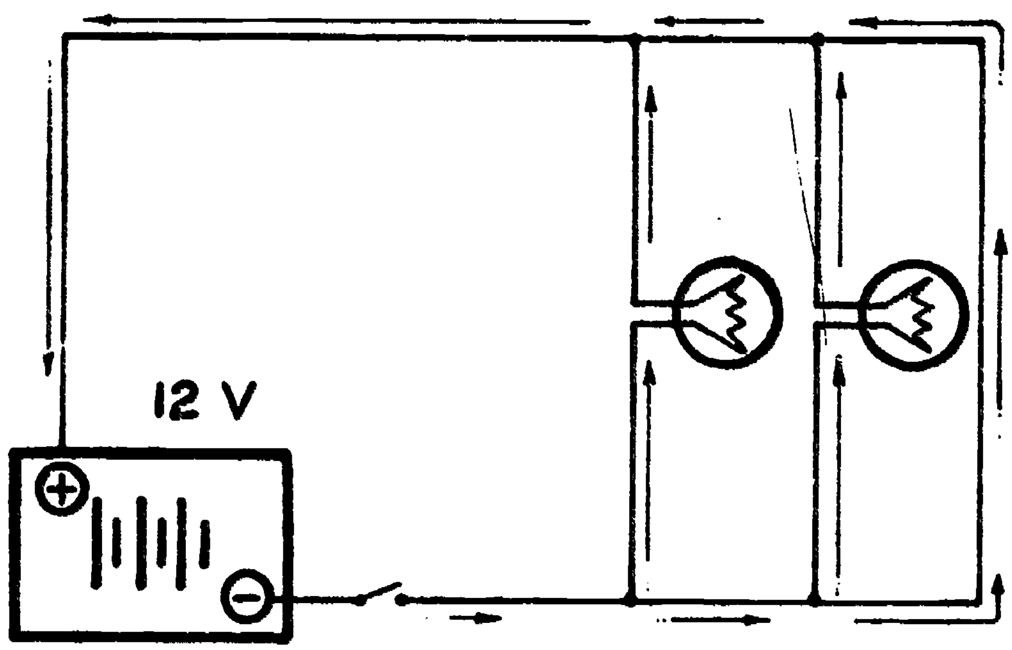
Teaching Aids: Transparency:
- Parallel Circuit, Series-Parallel Circuit, p. III - 38

References: Basic Electricity, Turner, Chapter 2
Basic Electricity, Howard Sams, Unit 2

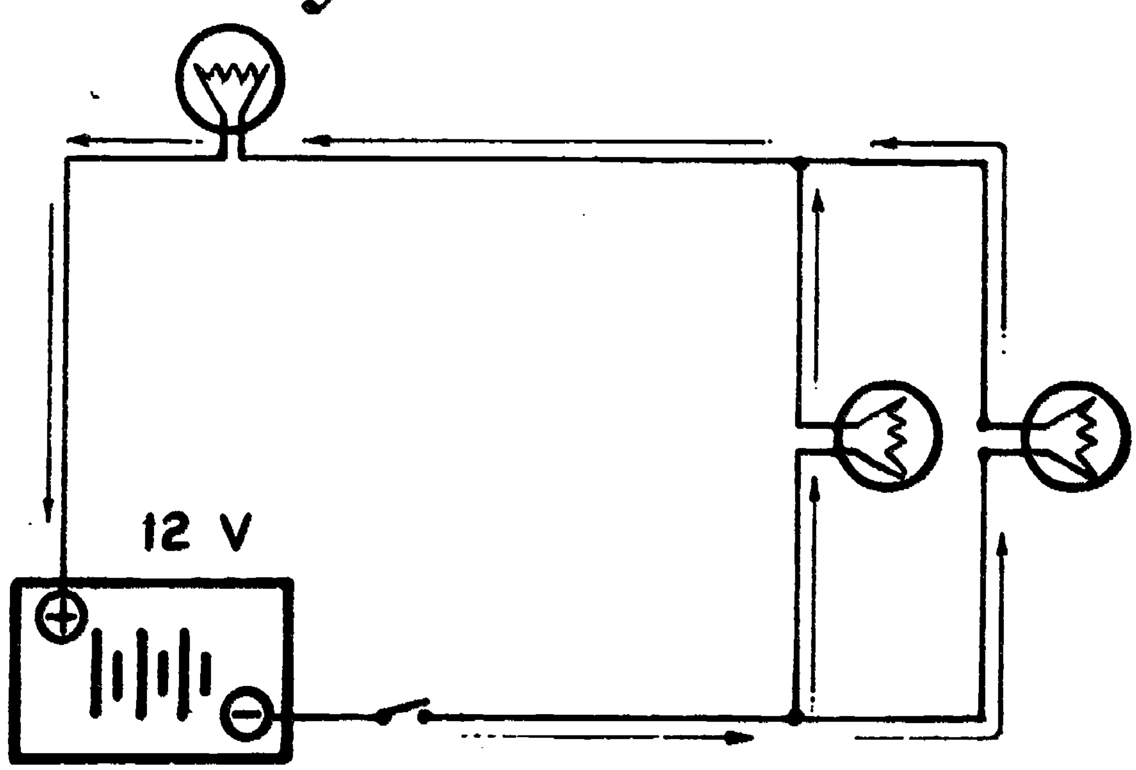
Steps:

1. Connect the light units in parallel
2. Connect a knife switch or other suitable switch in series
3. Connect power supply to circuit
4. Close switch. Note the brilliance of glow of each light. Recall the difference between these and the ones in the series circuit
5. Remove one bulb and record what happens to the remaining bulbs. Do not put a jumper wire across the units. Why not?
6. Note the path of current flow to the other unit

Parallel Circuit



Series Parallel Circuit



OPERATION

Block: Automotive Electricity

Operation: Measuring Voltage with Voltmeter

Block III
Job
Operation

Teaching Objective: To teach students to measure voltage with a voltmeter

Tools: Voltmeter, test light

Materials: Power supply (battery, battery charger), leads and clips (if meter is not so equipped)

Teaching Aids: Transparencies:
- Meter Connections, p. III - 40
- Voltmeter Connections, p. III - 41

References: Basic Electricity, Howard Sams, Unit 7
Fundamentals of Applied Electricity, Jones, Chapter II

Steps:

1. Set meter dial on highest voltage scale range

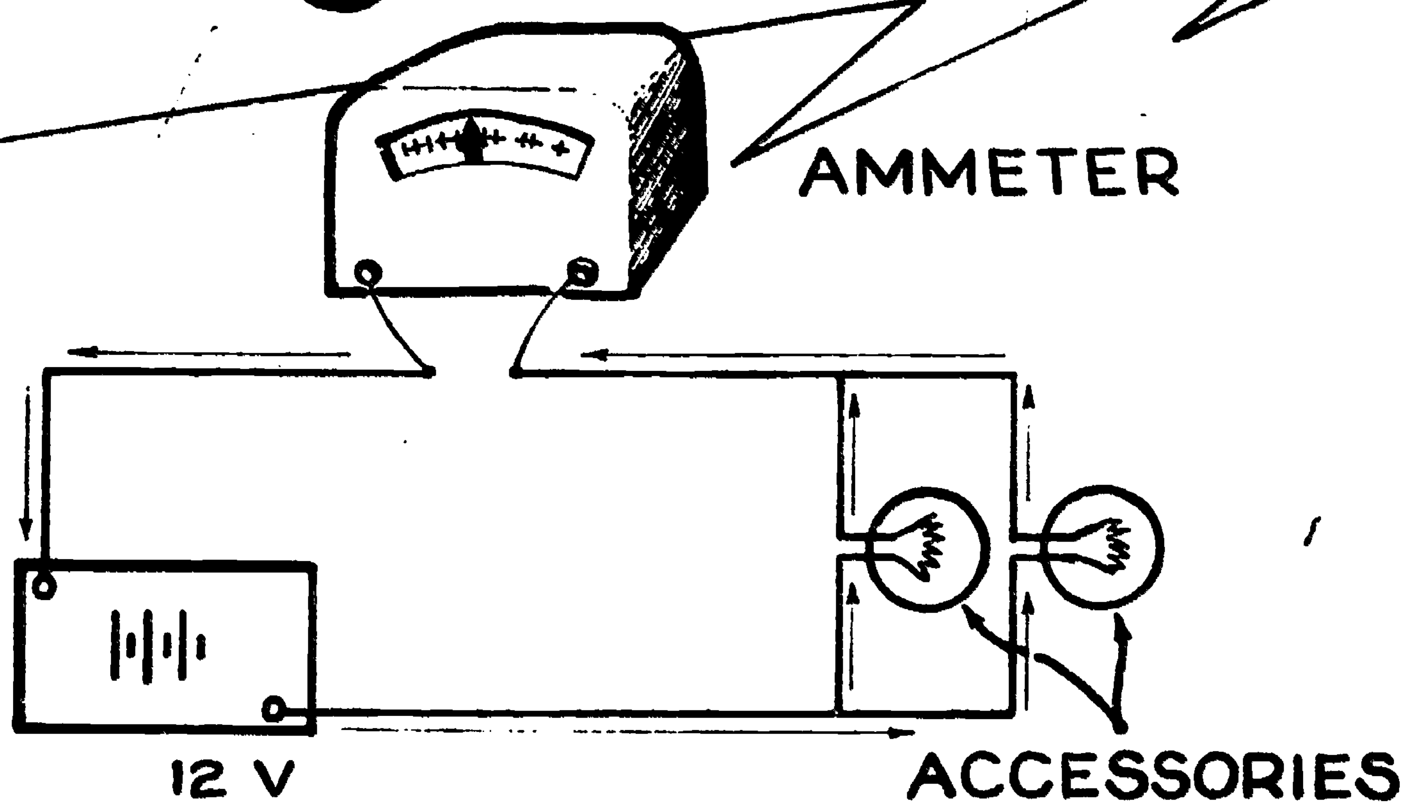
2. Place meter leads in correct jacks on meter

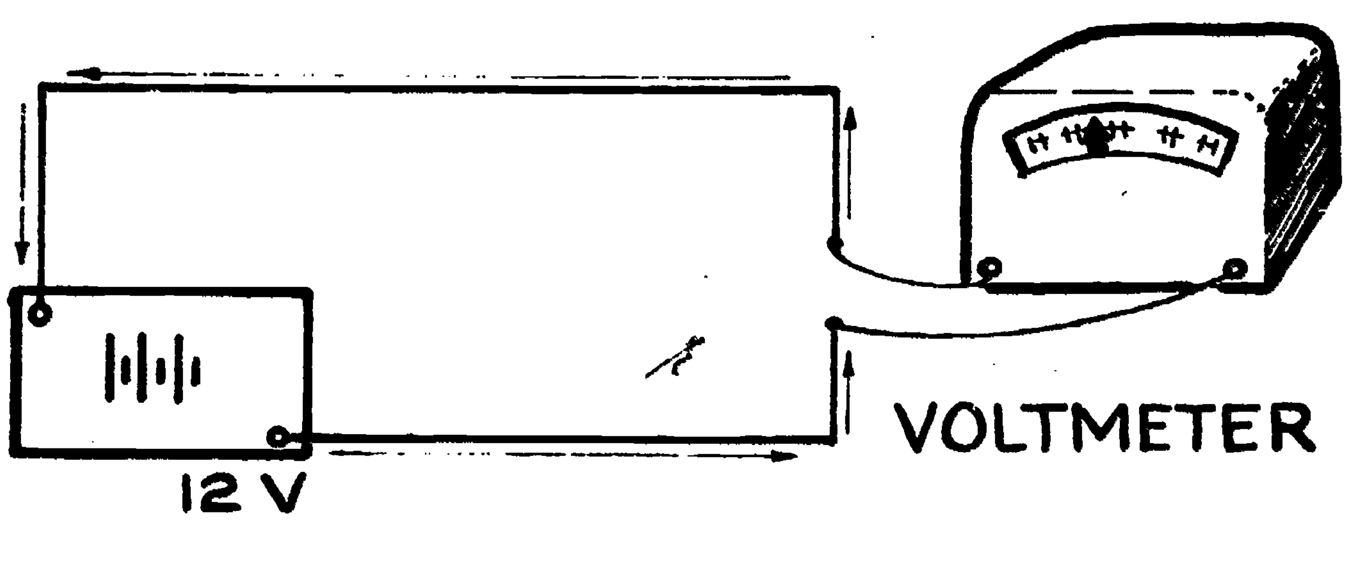
3. Snap meter leads on the two outside circuit terminals

4. Check meter reading. If pointer is not near the middle of the scale on the meter and the voltage is hard to determine, set the meter on next voltage scale.

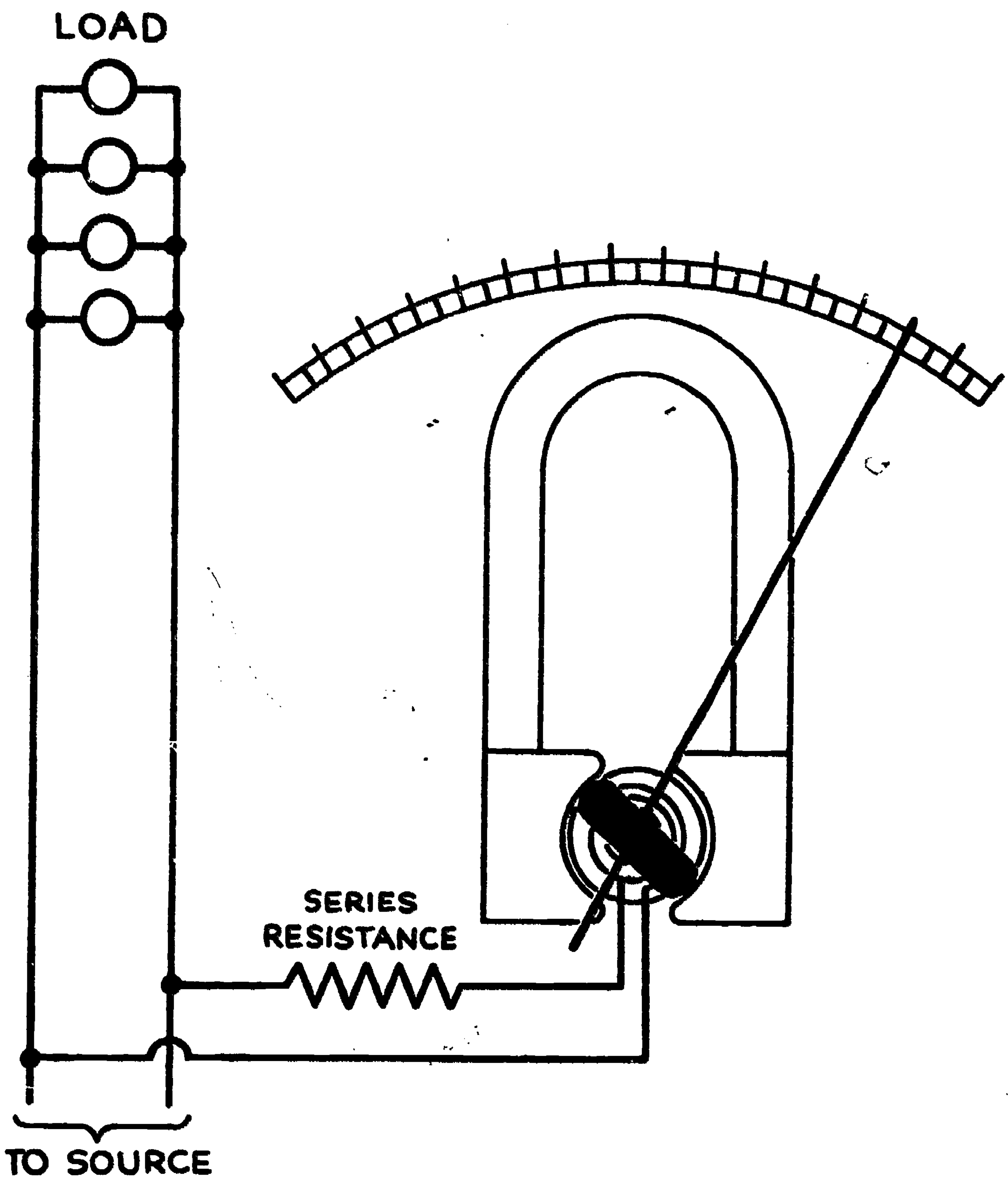
   Note: When you are not sure of the voltage to be measured, always set meter on the highest range and work downward. The meter is damaged when a high voltage is tested on a low scale.

Meter Connections





VOLTMETER CONNECTIONS



OPERATION

Block: Automotive Electricity

Operation: Measuring Amperes with Ammeter

Block III
Job
Operation

Teaching Objective: To teach students to measure amperes with an ammeter

Tools: Ammeter, knife, test light

Materials: Small automotive accessory or light units, leads and clips (if meter is not so equipped)

Teaching Aids: Transparencies:
- Meter Connections, p. III - 40
- Ammeter Connections, p. III - 43
- How to Use an Ammeter, p. III - 44

References: Basic Electricity, Turner, Chapter 2
Fundamentals of Applied Electricity, Jones, Chapter II
Basic Electricity, Howard Sams, Unit 7

Steps:

Caution: The ammeter is always connected in series with the line that delivers current to the circuit. The meter will be damaged when it is connected in any other way.

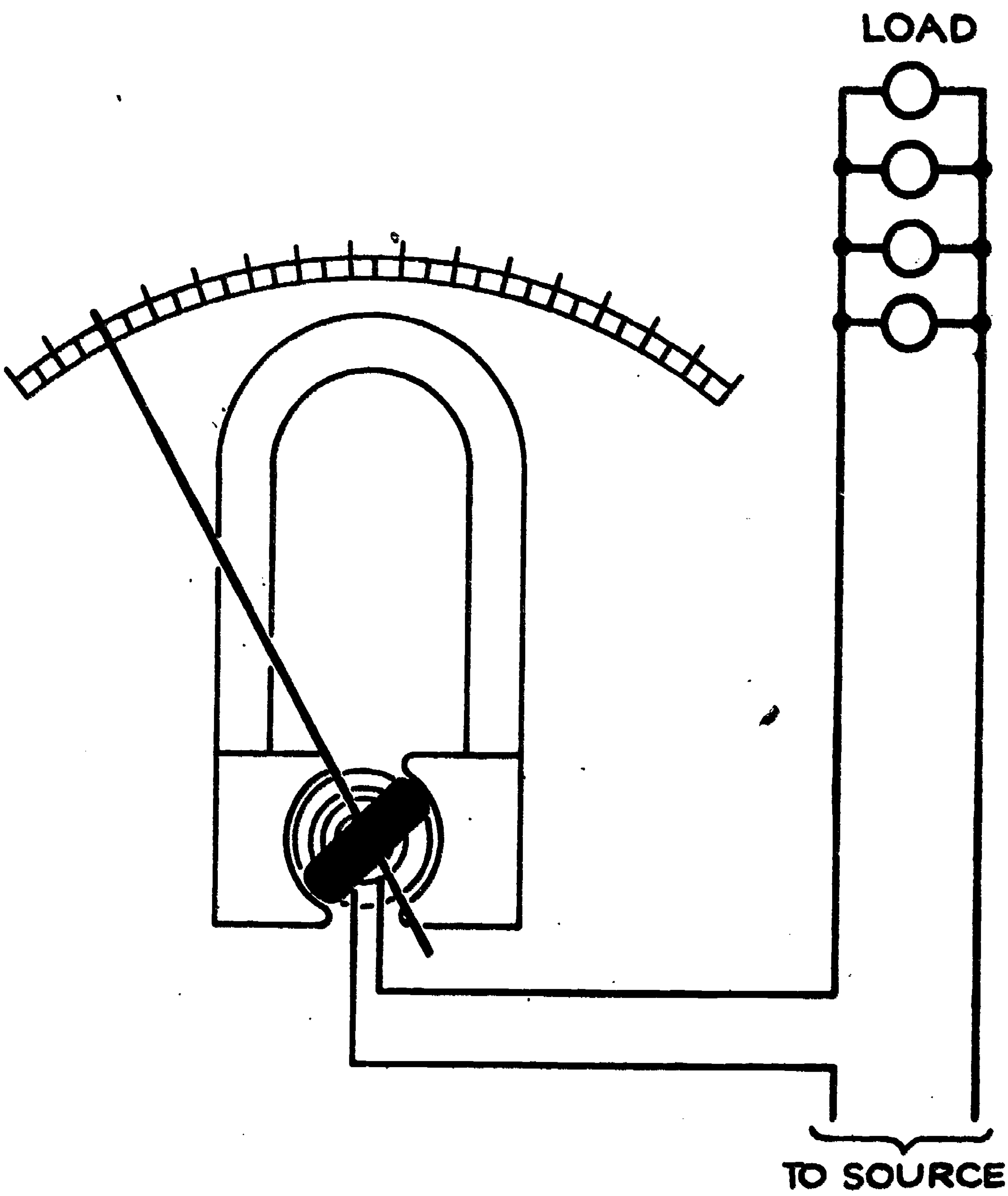
1. Connect ammeter into the line by breaking or opening the line

2. Set ammeter on the highest amp scale

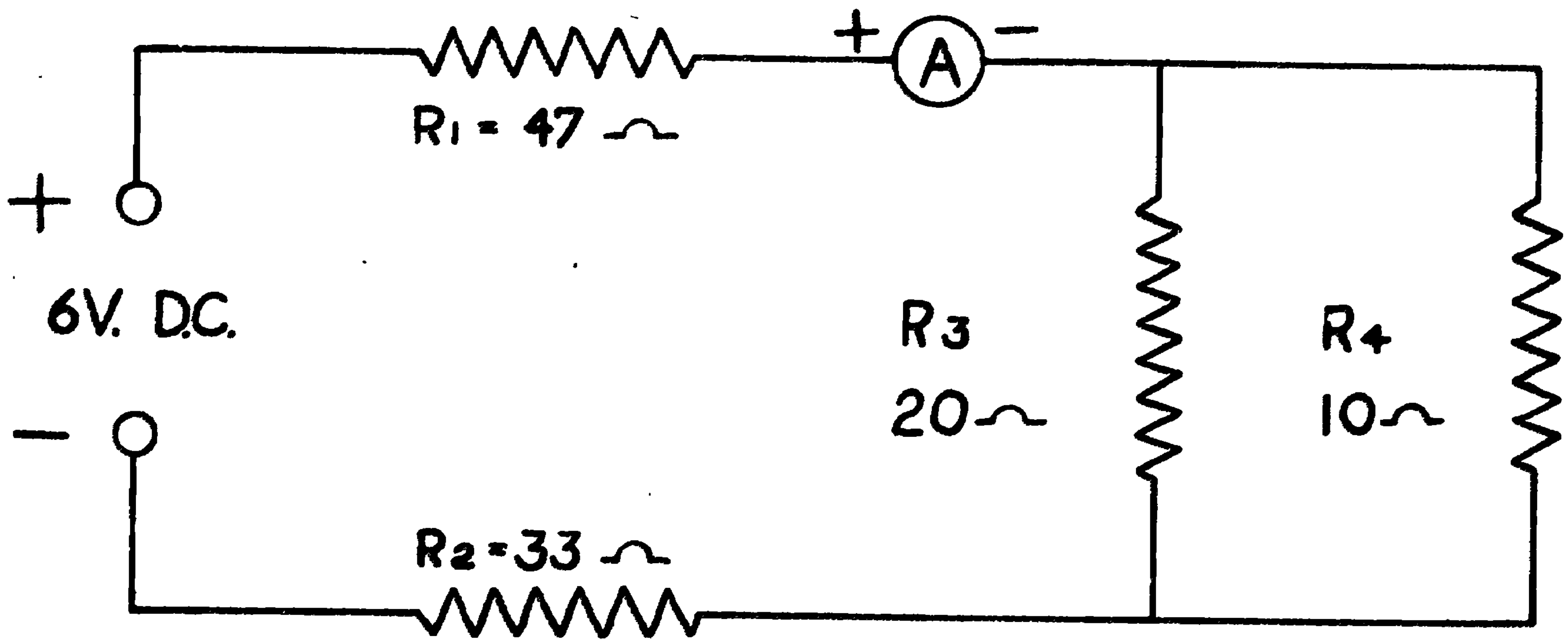
3. Plug in line and take meter reading

4. Adjust scale setting so meter will read about mid-scale

AMMETER CONNECTIONS



HOW TO USE AN AMMETER



FACTS ABOUT MEASURING INSTRUMENTS

1. An accurate instrument is required for accurate work.

2. The construction of an instrument movement is the same for either a voltmeter or an ammeter.

3. A voltmeter has a very high resistance in series with the instrument movement.

4. An ammeter has a very low resistance shunted across the instrument movement.

5. A voltmeter is connected across a circuit.

6. A voltmeter measures the pressure between two points of a circuit.

7. An ammeter is connected in series with a circuit.

8. An ammeter may be damaged if connected across a circuit.

9. A volt is a unit to measure the electrical pressure in a circuit.

10. An ampere is a unit to measure the rate of flow of electrical current.

Courtesy - Automotive Electric Association

FACTS ABOUT MEASURING INSTRUMENTS (CONTINUED)

11. An ammeter shunt is considered a part of the ammeter.

12. The moving parts of an instrument must be balanced.

13. Weston type movements are used in most testing instruments.

14. Instruments should be calibrated every three months.

15. A good voltmeter has a resistance of 100 ohms or more per volt of scale.

16. Automotive voltmeters should read accurately within one-tenth of a volt.

17. An ammeter should be accurate within one-half an ampere.

18. Most instruments are "damped" to prevent an overswing of the pointer.

19. Car instruments are indicators to show either charge or discharge current and may not be accurate.

20. Car instruments are of a rugged construction know as the moving iron type.

INFORMATION

Block: Automotive Electricity	Block III
	Job
Lesson: Wire and Wiring	Lesson

Teaching Objective: Upon completion of this lesson, students will be able to classify types and uses of wire and wiring devices used for automotive purposes.

Teaching Aids: Transparencies:
- Automotive Wiring, p. III - 49
- Terminals, p. III - 64

Reference: Auto Service and Repair, Stockel, Chapter 6

Outline of Information:

1. Two basic types of automotive wire

   a. Primary Wire
   -- Conducts battery voltage
   -- Stranded copper
   -- Proper insulation to handle voltages of 6, 12 and up to 24 (some commercial vehicles)
   -- Used in all circuits except the ignition high-tension circuit

   Note: Special wiring such as the types used in windings, motors, transformers, radios, antennas, speakers, etc., is not covered in this block.

   b. Secondary Wire
   -- High tension ignition circuit
   (1) Stranded copper
   (2) Carbon-impregnated thread (resistance wire)
   -- Heavy insulation to reduce corona

   Note: Corona is the term applied to the loss and transfer of electrons into surrounding air. Cross-firing, or the absorption of electrons from one spark plug wire to others, can occur when secondary wires are cracked, frayed or insufficiently insulated.

   Caution: Never use primary wire in a secondary circuit.

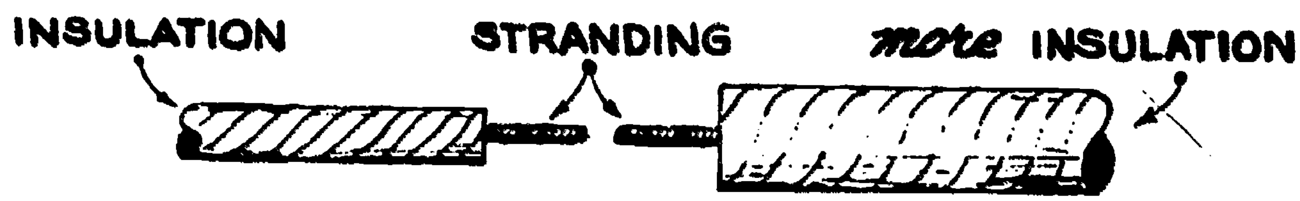
Wire and Wiring (continued)

2. Cables and Terminals

   a. Types of cables
      -- Battery cables
         (1) Heavy gauge copper, insulated - carries initial service voltage to system junctions and fuse blocks, switches, etc.
         (2) Receives charging current from generator/alternator via voltage regulation system
      -- Ground cables and straps
         (1) Usually braided copper, flat and flexible - used for engine to frame (ground), battery to ground applications

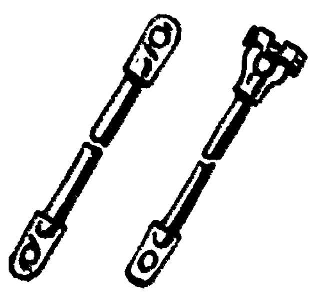
   b. Terminals
      -- Barrel terminals for battery cable ends
         (1) Solder type
         (2) Solderless type
      -- Secondary wiring terminals for spark plug wires, coil and distributor applications.

Automotive Wiring

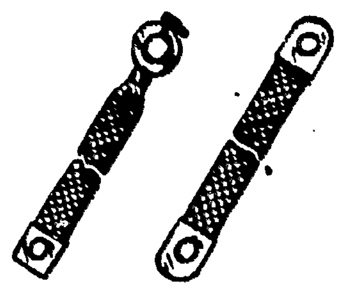


PRIMARY WIRE

SECONDARY WIRE

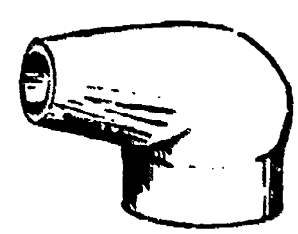


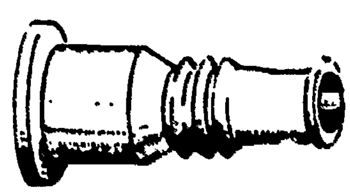
BATTERY CABLES



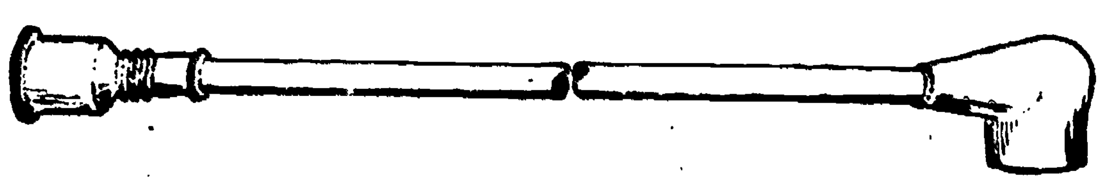
GROUND CABLES

RIGHT ANGLE DISTRIBUTOR END BOOT





FLEXIBLE PLUG END BOOT



BOOTS BONDED TO WIRE

INFORMATION

Block: Automotive Electricity	Block	III
	Job	
Lesson: Wire Size and Wire Measuring	Lesson	

Teaching Objective: Upon completion of this lesson, students will be able to describe the standardized system of wire as classified by gauge and how it is measured.

Teaching Aids: Transparency:
- American Wire Gauge Chart, p. III - 51

Reference: Auto Service and Repair, Stockel, Chapter 6

Outline of Information:

1. Wire size

   Note: Wire diameters (cross-section) are standardized. Refer to wire manufacture's charts for selecting proper sizes according to application and load specifications.

   a. Gauging solid wire
      -- Measure diameter with micrometer
      -- Locate size and determine gauge on wire gauge chart

   b. Gauging stranded wire
      -- Count strands
      -- Measure diameter of one strand
      -- Square diameter and multiply answer by number of strands to determine cross-sectional area in circular mils
      -- Locate size in mils and determine gauge on wire gauge chart

AMERICAN WIRE GAUGE CHART

AMERICAN WIRE GAUGE	WIRE DIAMETER IN INCHES	CROSS SECTIONAL AREA IN CIRCULAR MILS
0	.32486	105500
1	.2893	83690
2	.25763	66370
3	.22942	52640
4	.20431	41740
5	.18194	33102
6	.16202	26250
8	.12849	16510
10	.10189	10380
12	.080808	6530
14	.064084	4107
16	.05082	2583
18	.040303	1624
20	.031961	1022
22	.025347	642.4
24	.0201	404.0
26	.01594	254.1
28	.012641	159.8
30	.010025	100.5

OPERATION

Block: Automotive Electricity

Operation: Gauging Wire with Wire Gauge

Block III
Job
Operation

Teaching Objective: To teach students to gauge wire with a wire gauge

Tools: Wire gauge (American Standard)

Materials: Assortment of wires with different diameters

Reference: Fundamentals of Applied Electricity, Jones, Chapter V

Steps:

1. Place wire in one of the slots in the gauge

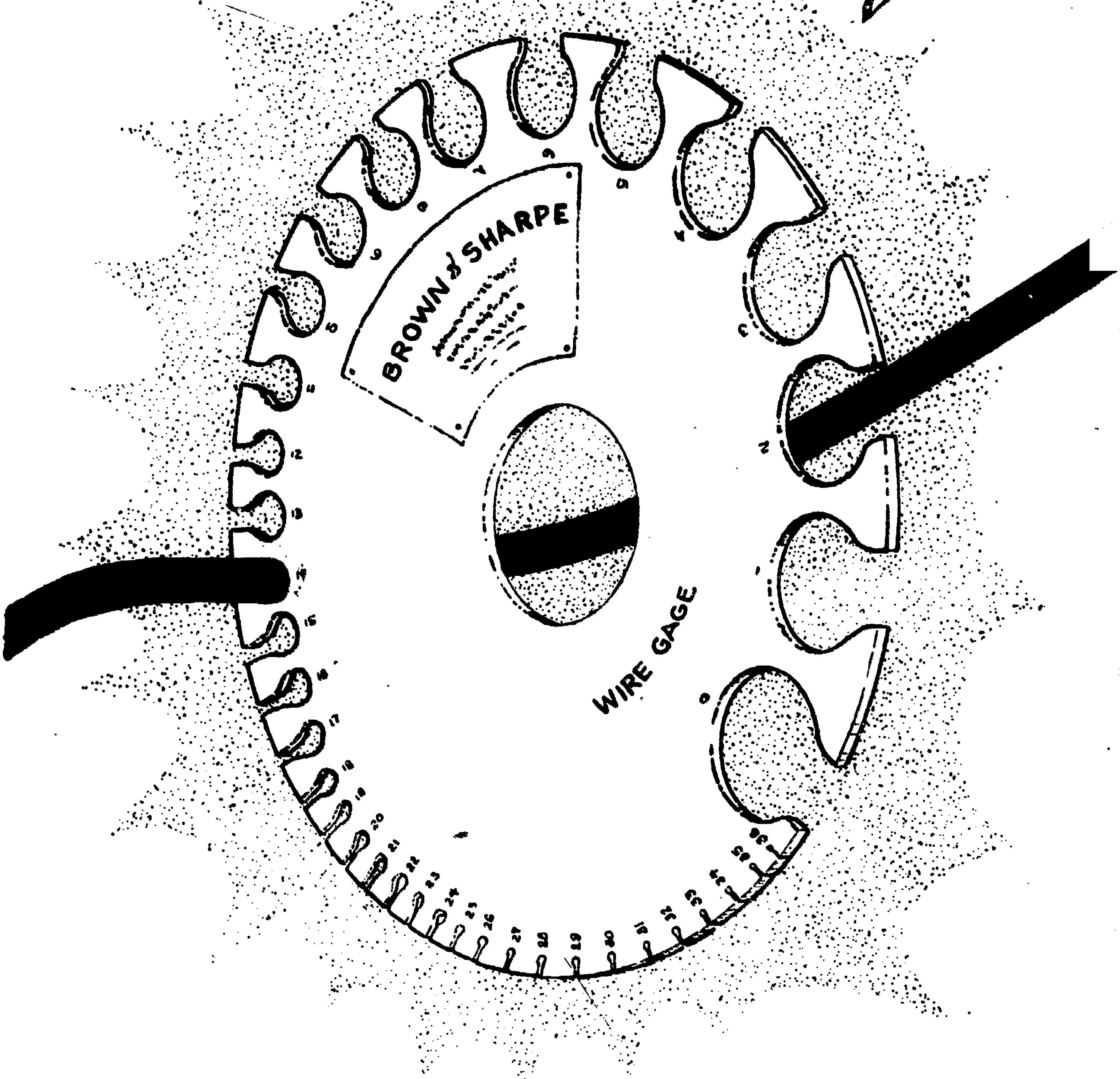
2. Check corresponding fitting on wire

3. If gauge is too tight on wire or the wire is too loose, remove the wire and place it in another slot and check.

4. The wire should completely fill the hole in the wire gauge. A micrometer "touch pressure" fit should be determined. Diameter in thousandths of an inch are found on reverse side of gauge.

5. Check several more wires using the same procedure

American Wire Gauge



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INFORMATION

Block: Automotive Electricity

Lesson: Soldering (soft soldering)

Block III
Job
Lesson

Teaching Objective: Upon completion of this lesson, students will be able to describe the essentials of the soft soldering processes, including types of solder and fluxes, and proper use of necessary tools.

Teaching Aids: Transparencies:
- Types of Solder, p. III - 56
- Attaching Solder - Type Battery Terminal, p. III - 65
- Splicing, p. III - 62
- Tools for Soldering, p. III - 57

Reference: Modern Metalworking, Walker, Unit 29

Outline of Information:

1. Types of Solder

   a. Most soft solders are a tin/lead alloy. The proportions of tin and lead determines the melting point temperature.

   b. Solder type is identified by designating the percentage amount of tin first, then the amount of lead.

   Example: Tin/Lead
   50/50

   c. Commonly-used types and melting points are as follows:
   -- 50/50 melts at 415° F.
   -- 60/40 melts at 370° F.
   -- 40/60 melts at 450° F.
   -- 63/37 melts at 361° F.

   Note: Because of its low melting point, 60/40 is generally preferred for electrical work.

   d. The solder shape to be used should be selected according to the nature of the work. Most wiring jobs, as well as other electrical work, can be suitably accomplished with wire shaped solder.

   e. Soft solder is available in wire, bar, cake, powder, pig and slab styles.

Soldering (soft soldering) (continued)

2. Proper Flux

   a. Corrosive
      -- Acid core
      -- Paste (acid content)
      -- Liquid (dilute acid)

   b. Noncorrosive
      -- Resin core

3. Proper Tools

   a. Common copper
      -- External heat source required
      -- Totally portable
      -- Many sizes and shapes available

   b. Electric copper
      -- Maintains constant temperature
      -- Not portable (functionally)
      -- Many shapes, sizes and wattage capacities available

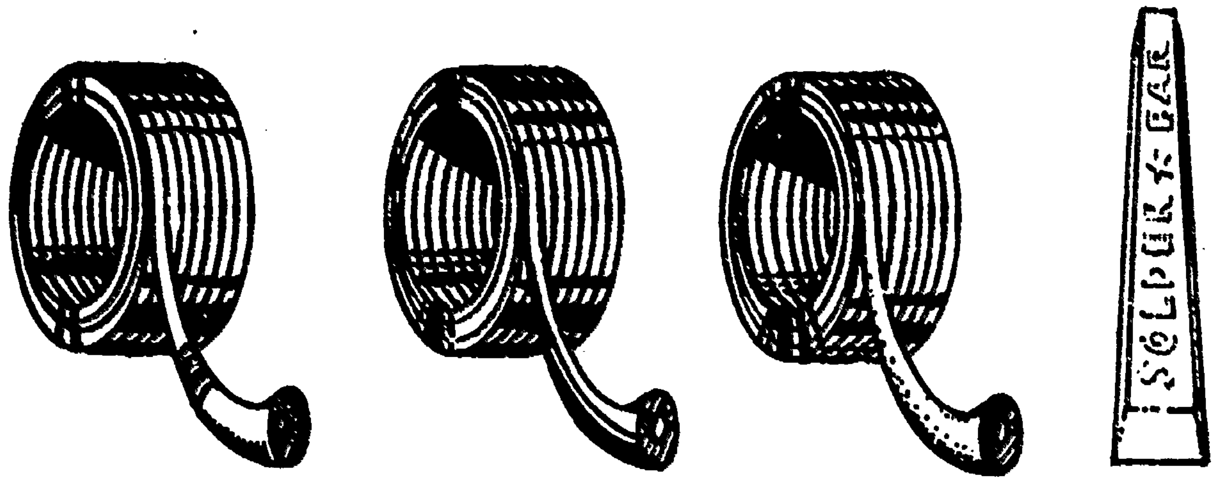
   c. Electric gun
      -- Reaches operating temperature instantaneously
      -- Best for electrical work

   d. Gas torch
      -- Portable
      -- Direct use of heat
      -- No tinning process necessary

<u>Note</u>: Special solders and fluxes are available for soldering aluminum.

Types of Solder

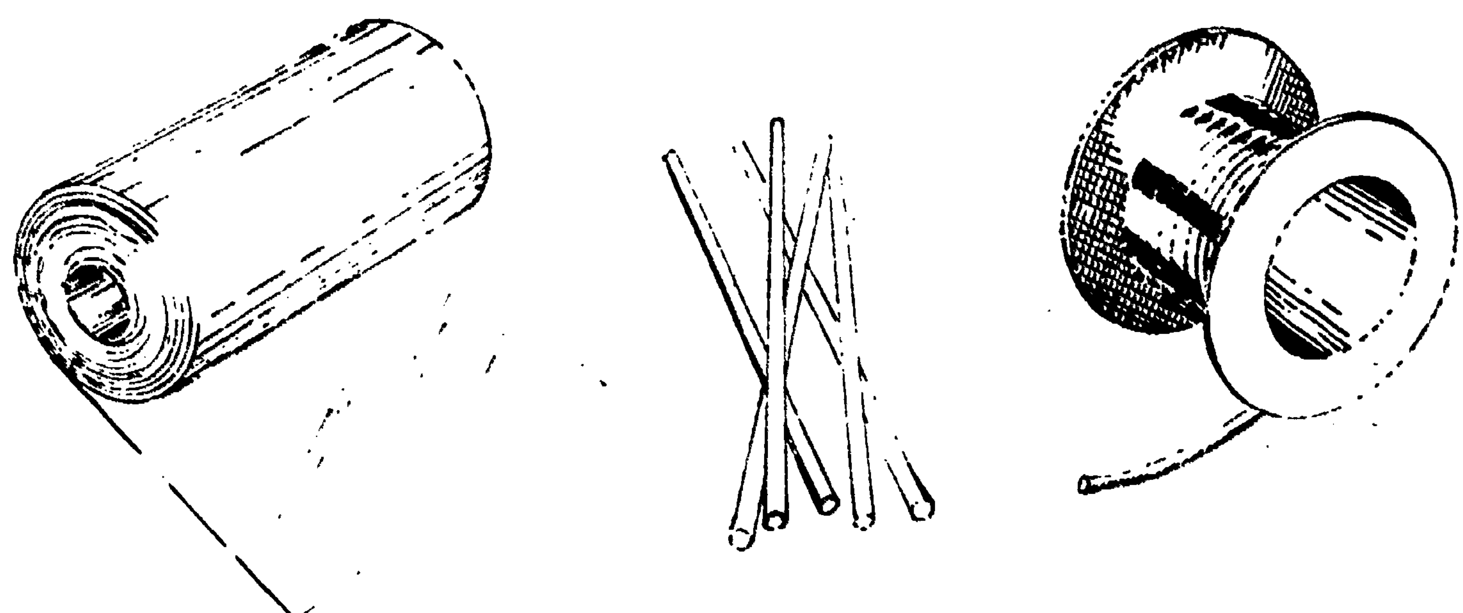
BAR-TYPE



SOLID WIRE ACID CORE RESIN CORE

TIN-LEAD ALLOY TYPES

FLOW TEMP 400°-450°

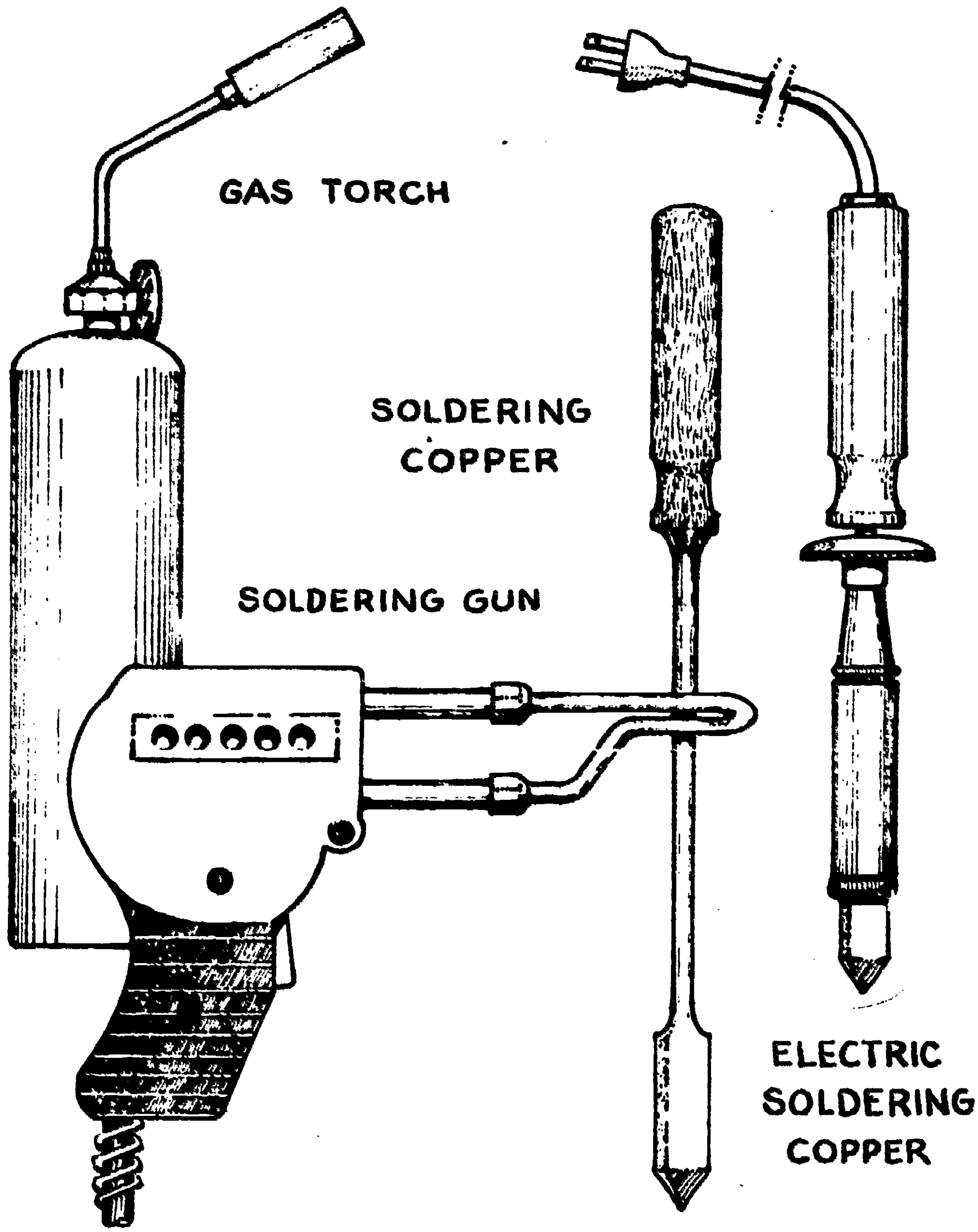


THIN SHEET ROD-TYPE WIRE TYPE

HARD SOLDER (Silver Alloy)

FLOW TEMP 1300°-1500°

TOOLS FOR SOLDERING



OPERATION

Block: Automotive Electricity	Block III
	Job
Operation: Tinning Soldering Copper	Operation

Teaching Objective: To teach students to tin a soldering copper

Tools: Soldering iron, flat file (fine-cut)

Materials: Solder (40/60 alloy), rosin flux, sal ammoniac block, wipe cloths

Teaching Aids: Samples of properly tinned soldering coppers
Transparency:
- Tinning a Soldering Copper, p. III - 59

Steps:

1. Clean the surfaces of the tip of the soldering copper, using a file only if the copper is badly oxidized or pitted

   Note: Remove a minimum of copper from the tip with a file

2. Heat the copper

3. Rub the copper on the sal ammoniac block

4. Add flux to the tip to isolate the cleaned metal from oxidation

5. Apply solder to the cleaned tip of the soldering copper (about 1/4 of the area of the taper back from the tip) or rub the tip on a sal ammoniac block on which droplets of solder have been deposited

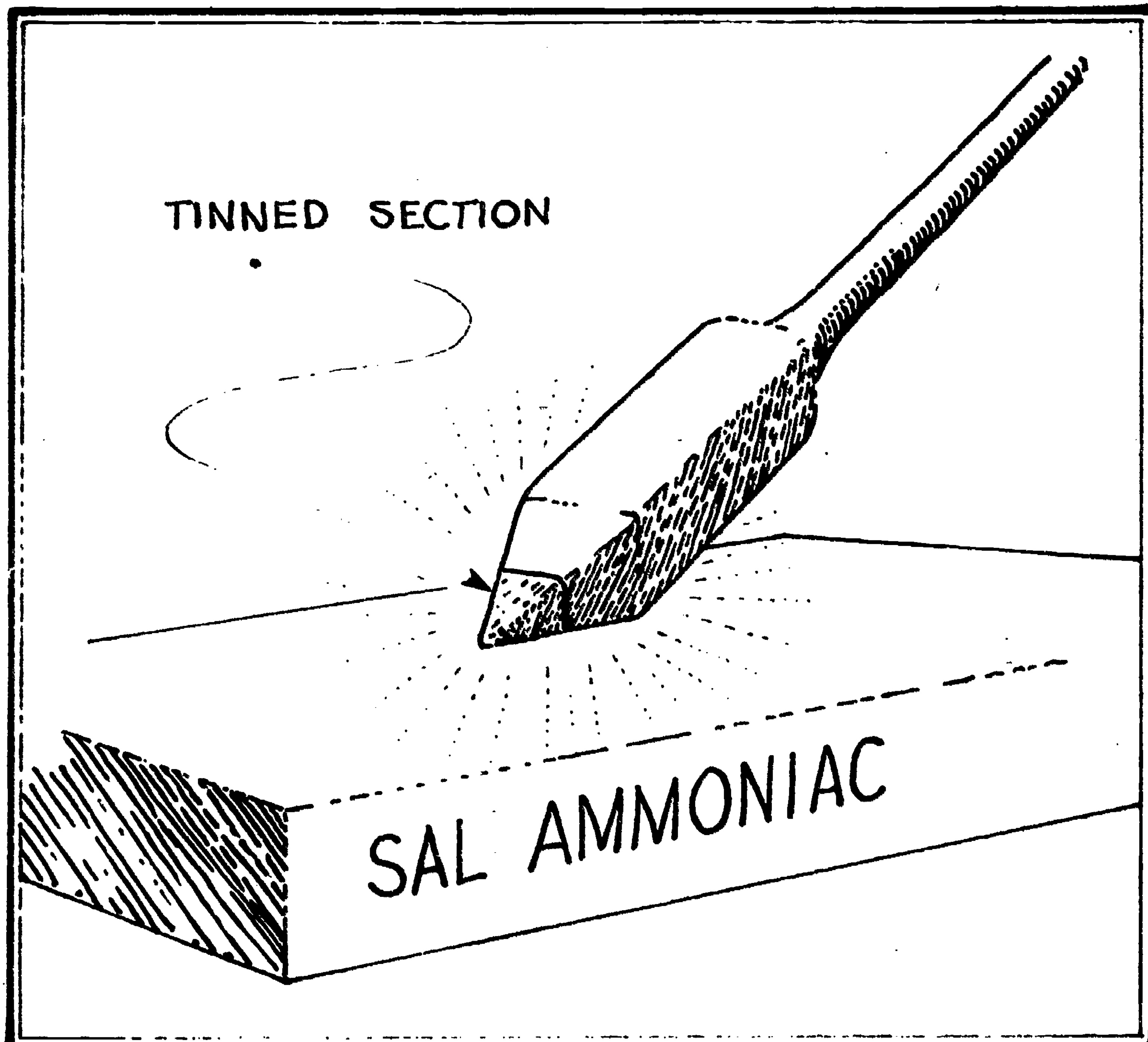
6. Repeat this process until desired portion of the tip is coated smoothly with solder

   Note: Do not waste solder

7. Test the copper

   Caution: Overheating may destroy the tinning.

TINNING A COPPER



OPERATION

Block: Automotive Electricity

Operation: Soldering Wire Connections

Block III
Job ____
Operation ____

Teaching Objective: To teach students to solder wire connections

Tools: Soldering copper or gun, flat file (fine-cut), side cutters

Materials: Scrap pieces of #12 wire, solder, flux, wipe cloths

References: Modern Metalworking, Walker, Unit 29

Steps:

1. Tin soldering copper or gun tip
2. Apply a coating of resin flux to the wire joint
3. Place the soldering tip to the bottom of the joint. Hold it against the joint until it becomes hot enough to melt the solder
4. Apply solder to both the tip and the joint simultaneously, allowing solder to flow freely into and around the connection

   Note: Do not apply too much solder

OPERATION

Block: Automotive Electricity

Operation: Splicing Wire (Western Union)

Block III
Job ____
Operation ____

Teaching Objective: To teach students to make a secure, safe electrical wiring splice

Tools: Knife, sidecutters or diagonals, soldering gun or iron

Materials: Wire (solid or stranded, #16 or #18), solder, paste or flux, electrical tape, wipe cloths

Teaching Aids: Transparency:
- Splicing, p. III - 62

Reference: Basic Electricity, Turner, Chapter 14

Steps:

1. Remove insulation from wire ends. For most automotive wiring 1" to 2" of wire exposure is sufficient.

   Note: If the insulation is heavy, it should be cut on a taper. Thin insulation may be stripped away with cutting pliers or a wire stripper. Care should be exercised not to nick or cut into wire, as it may break upon bending.

2. Scrape remaining particles of insulation from the exposed wire ends

3. Overlap exposed ends of the wire and twist one around the other evenly and securely

4. Apply a small amount of flux to the twisted splice. (The use of acid-free flux is advisable.)

5. Solder the splice

6. Remove excess solder (if necessary) with soldering iron

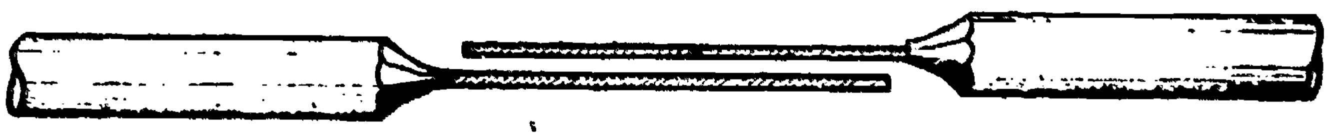
7. Wipe excess flux or moisture from splice

8. Tape the spliced joint evenly and securely

   Note: It is not advisable to splice wiring in the ignition secondary circuit.

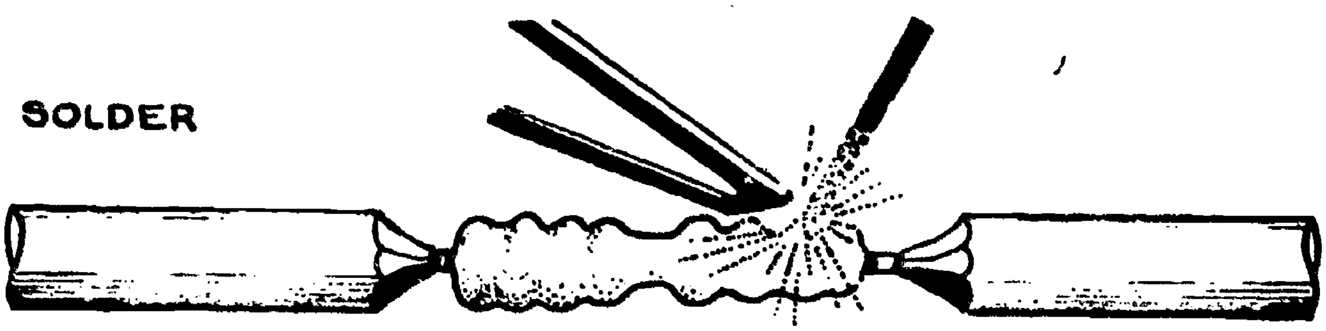
Splicing

STRIP

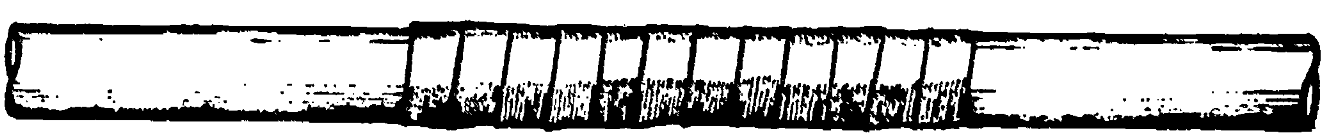


TWIST

SOLDER



TAPE



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OPERATION

Block: Automotive Electricity

Operation: Attaching Terminals

Block III
Job
Operation

Teaching Objective: To teach students to correctly attach terminals for automotive wiring

Tools: Knife, side cutters, crimping tool, torch

Materials: Sample terminals, practice wire and cable portions, solder, flux, L. P. gas supply or other torch fuel, wipe cloths, electrical tape

Teaching Aids: Transparencies:
- Attaching Solder-Type Battery Terminals, p. III - 65
- Terminals, p. III - 64

References: Auto Service and Repair, Stockel, Chapter 6

Steps:

Barb-Type (Secondary Wiring)

1. Strip insulation allowing for enough wire to be bent back against outside of insulation for assured terminal contact

2. Attach terminal by folding terminal barrel tangs securely around insulation, making certain that the barbs penetrate the conductor

   Note: When attaching terminals to resistor-type wire always use a staple to secure the connection

Crimp-Type (Primary Wiring)

1. Strip insulation back to expose enough conductor equal to the barrel depth of the terminal

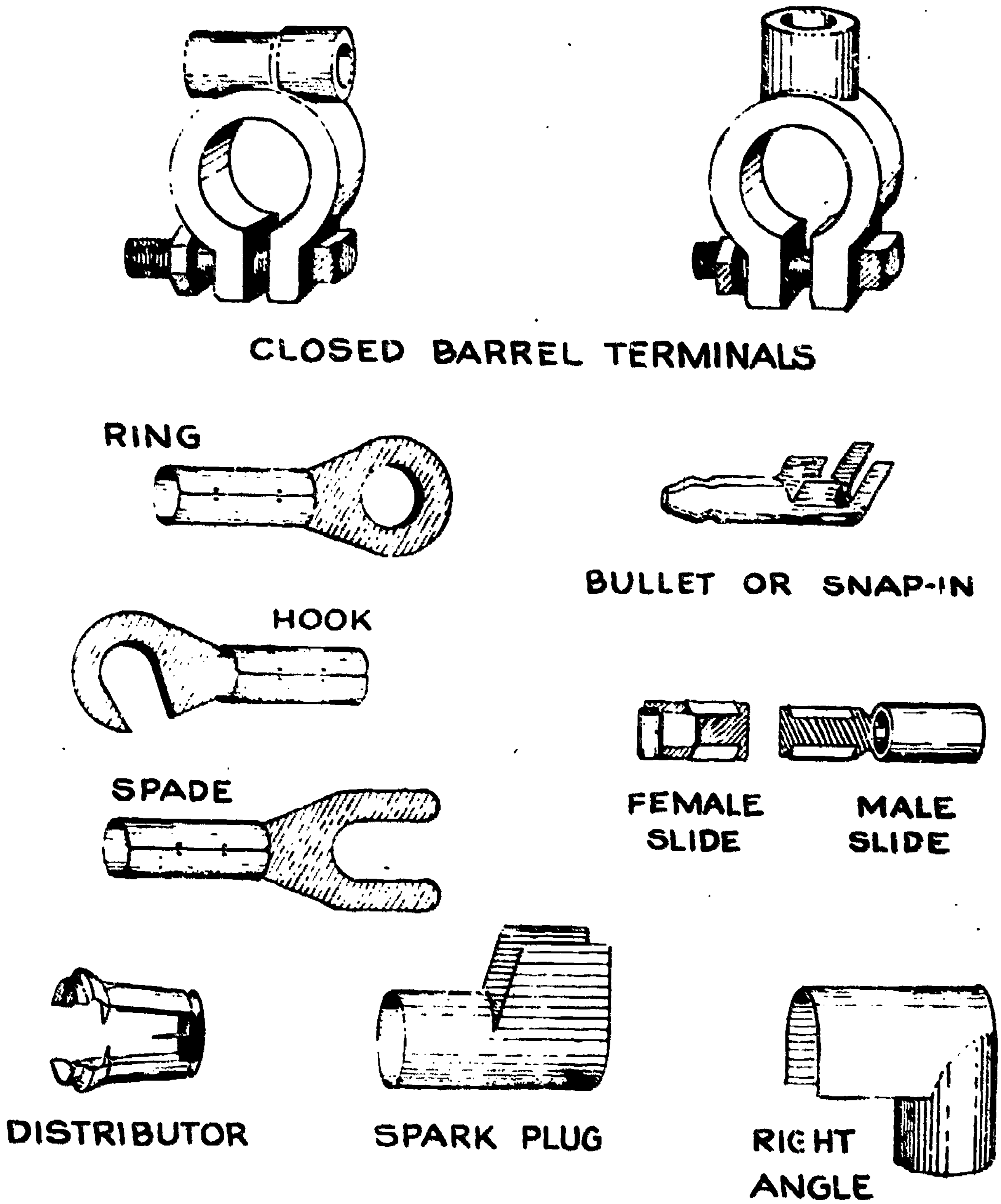
2. Insert the wire into barrel and hold in place while crimping the connection, using the proper edge of the crimping tool

   Note: Do not use pliers or cutters in lieu of a crimping tool

Solder-Type (Usually Primary Wiring)

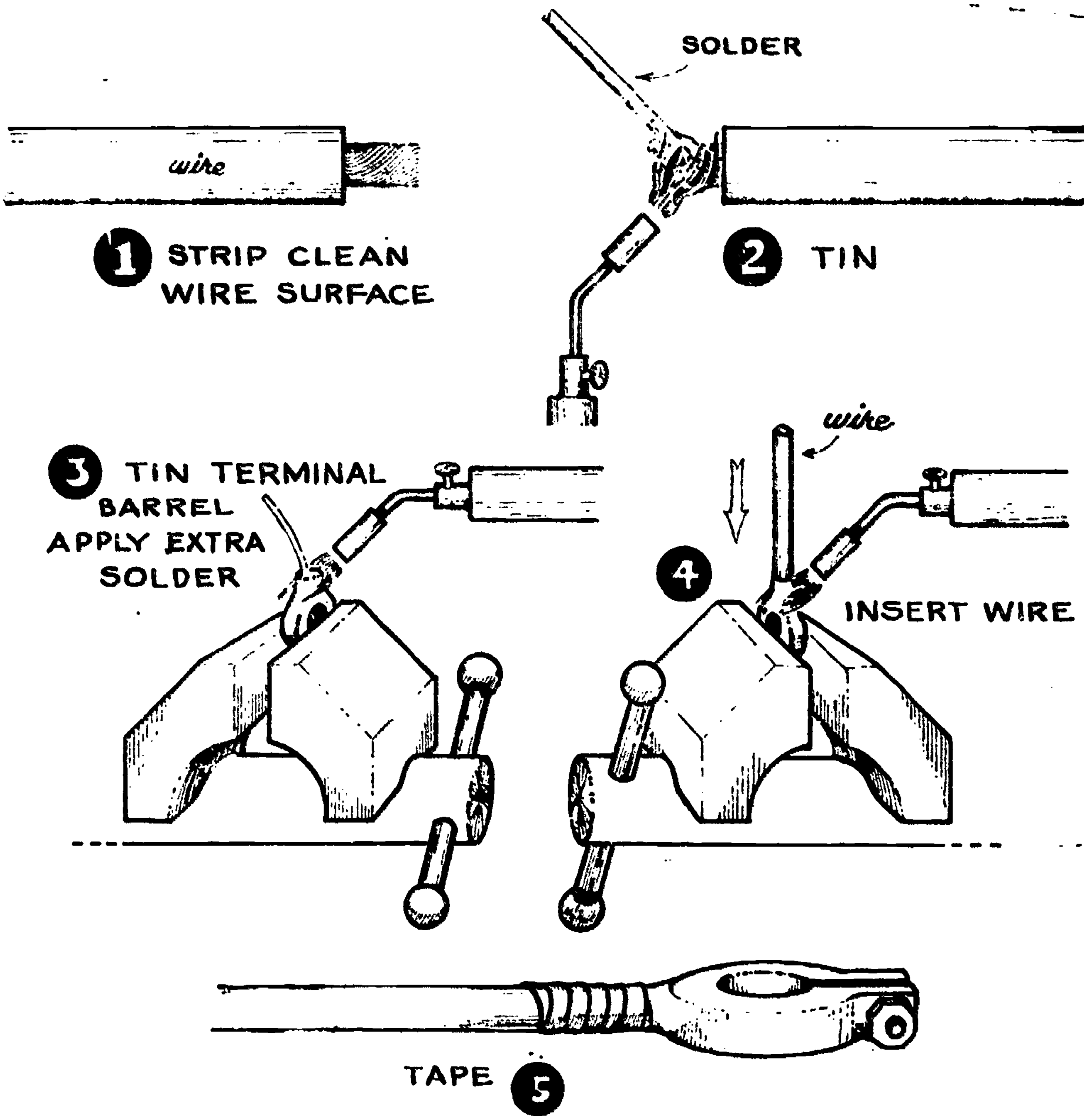
Note: Follow steps illustrated on page III -65 for this operation

TERMINALS

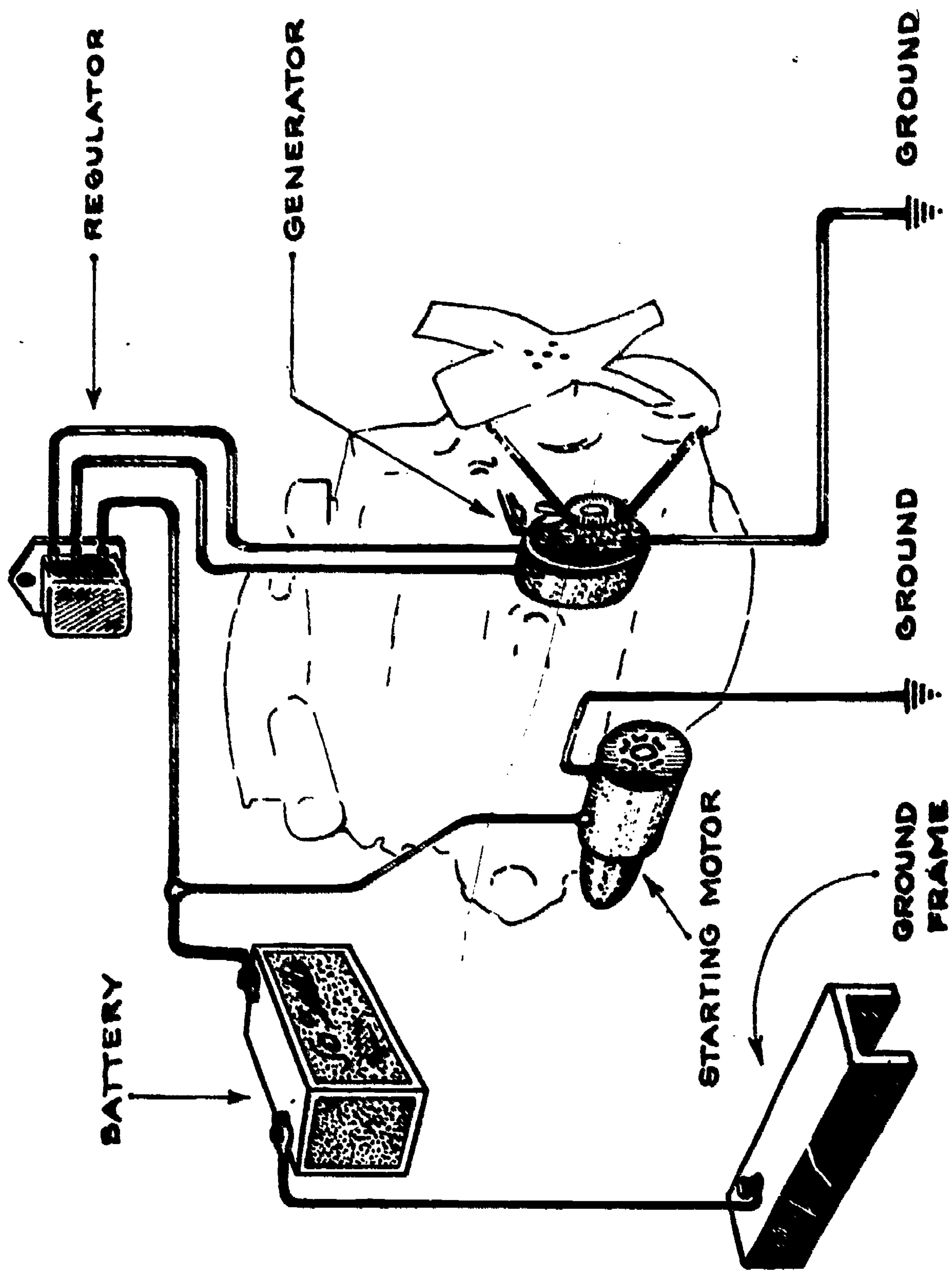

CLOSED BARREL TERMINALS
RING
BULLET OR SNAP-IN
HOOK
SPADE
FEMALE SLIDE
MALE SLIDE
DISTRIBUTOR
SPARK PLUG
RIGHT ANGLE

Attaching Solder-Type

BATTERY TERMINAL



BASIC ELECTRICAL POWER SYSTEM



INFORMATION

Block: Automotive Electricity

Lesson: Storage Battery Chemistry

Block III
Job
Lesson

Teaching Objective: Upon completion of this lesson, students will be able to describe the chemical make-up and functional principles of the automotive storage battery.

Teaching Aids: The Store of the Modern Storage Battery, ESB Film
Delco-Remy Chart No. 7
Transparencies:
- How the Battery Works, p. III - 69
- How the Battery Works, p. III - 70
- Facts About Batteries, pp. III - 78

References: Storage Batteries, Delco Remy Chart Manual
Facts About Batteries, Electric Storage Battery Company
Auto Service and Repair, Stockel, Chapter 22

Outline of Information:

1. Electrolyte

   a. Use of acid electrolyte provides the chemical reaction necessary for conversion to electrical energy.

   b. Electrolyte in a fully charged battery has a specific gravity of approximately 1.270 at 80° F.

   c. Solution is approximately 36% sulfuric acid (H_2SO_4) and 64% water (H_2O).

   d. Names and Symbols
      -- PbO_2 - Lead Peroxide or Dioxide
      -- Pb - Lead
      -- O - Oxygen
      -- H - Hydrogen
      -- SO_4 - Sulfate
      -- H_2O - Water
      -- $PbSO_4$ - Lead Sulfate
      -- H_2SO_4 - Sulfuric Acid

Lesson: Storage Battery Chemistry (continued)

2. Chemical action occurs during discharge and charge phases.

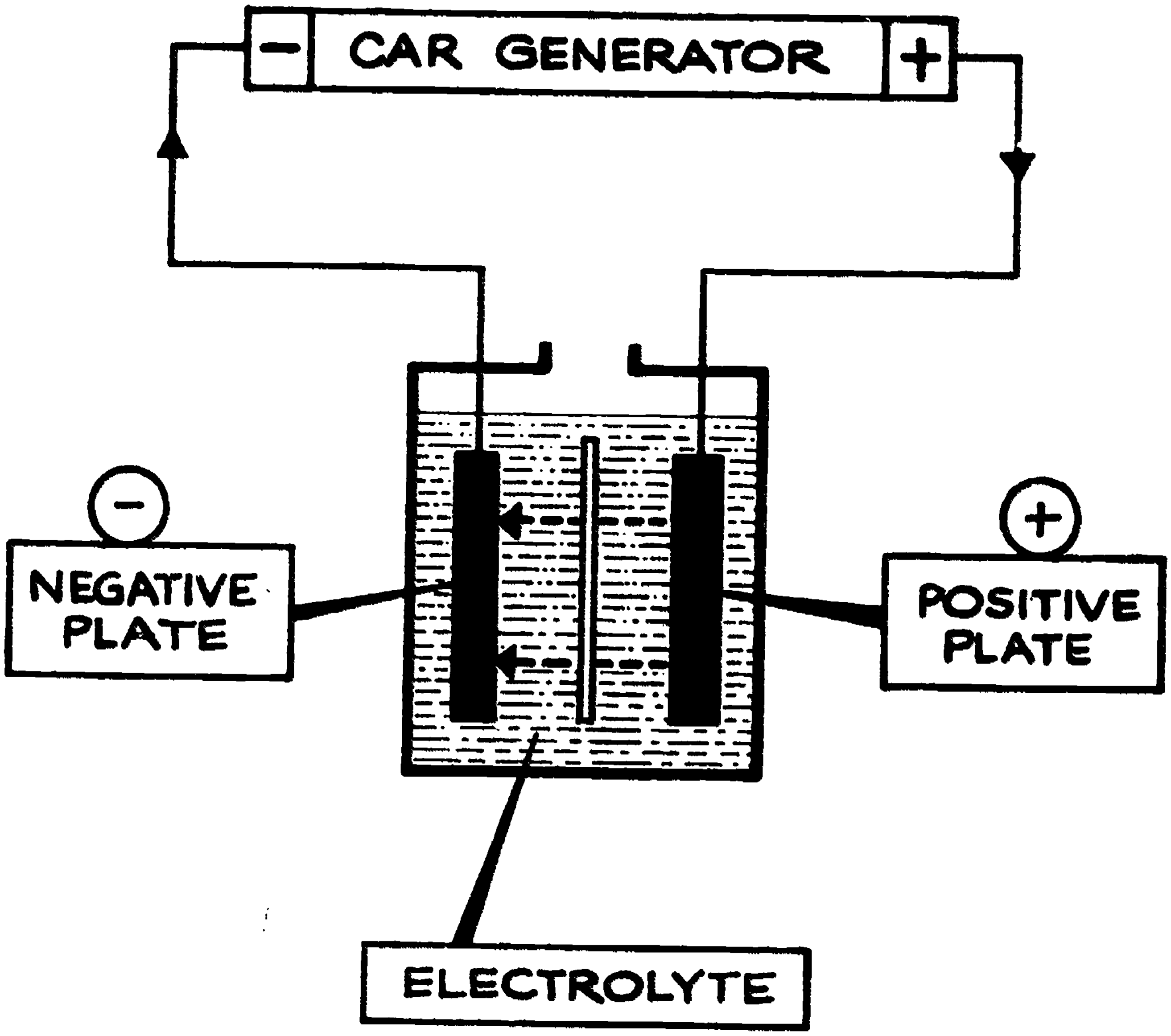
   a. Discharge phase
      -- Removing electricity from the cells
      -- Electrolyte acts on both positive and negative plates.
      -- Forms lead sulphate
      -- Electrolyte becomes weaker as discharge proceeds.
      -- Removing electrical energy can be approximated by measuring specific gravity of electrolyte.

   b. Charge phase
      -- Electric current passes through battery in opposite direction of discharge.
      -- Sulphate is decomposed and expelled from plates.
      -- Sulphate absorbed by electrolyte restoring strength

Note: When taking charge, battery gives off oxygen and hydrogen gases which can ignite and explode if exposed to flame or sparks. Use Caution

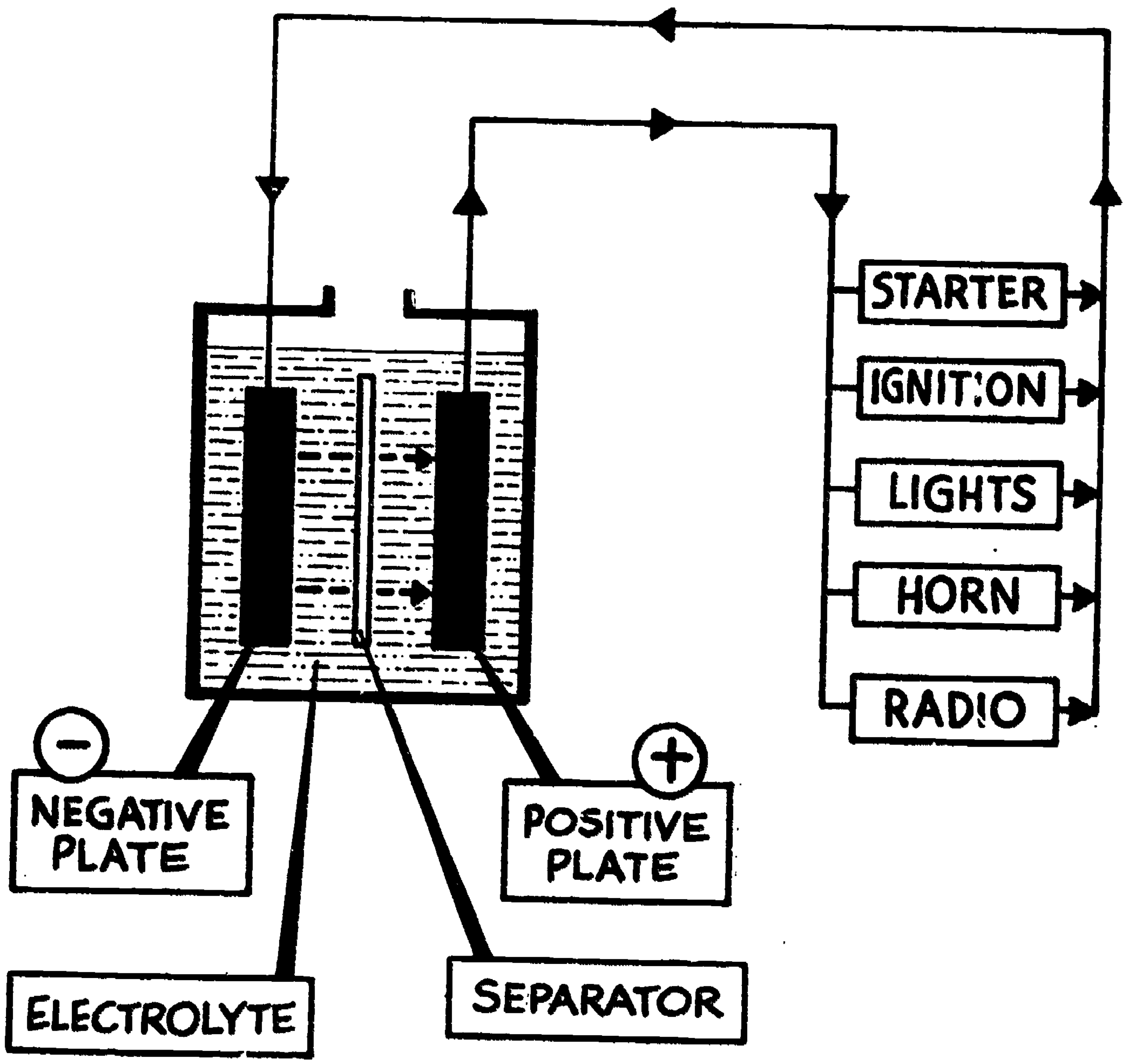
HOW THE BATTERY WORKS

DURING THE CHARGE



HOW THE BATTERY WORKS

DURING DISCHARGE



INFORMATION

Block: Automotive Electricity

Lesson: Storage Battery Construction

Block III
Job
Lesson

Teaching Objective: Upon completion of this lesson, students will be able to describe the construction of a typical automotive storage battery by listing main components and relating their functions.

Teaching Aids: Transparencies:
- Battery, p. III - 75
- Facts About Batteries, pp. III - 78, 79

References: Automotive Mechanics, Crouse, Chapter 13
Storage Batteries, Training Chart Manual, Delco Remy
Automotive Electrical Systems, Technical Training Manual, Automotive Electric Association
Facts About Storage Batteries, 6th edition ESB Brands, Inc.

Outline of Information:

1. Construction and components

   a. Grids
      -- Lead-antimony alloy casting designed to hold active materials

   b. Plates
      -- After grids have become charged with active materials (they now have chemical work potential), they are now referred to as plates.

   c. Separators
      -- Insulation between positive and negative plates

      Note: Each compartmentalized group of plates and separators is called an element which when installed becomes a cell. Twelve volt batteries contain six cells.

   d. Case
      -- Made of hard rubber and/or plastic compounds to contain cells

   e. Cell covers
      -- Cover top of each cell and provide for sealing top of battery case

      Note: A sealing compound is poured around top perimeter of cell covers and case to prevent leakage.

      -- Allow opening for venting and adding water to each cell

Storage Battery Construction (continued)

f. Cell connectors
   -- Welded from cell to cell to establish series circuit

g. Terminal posts
   -- Welded to plate strap

h. Vent caps
   -- Allow for inspection of water level and venting of gases

INFORMATION

Block: Automotive Electricity

Lesson: Battery Plates

Block III
Job
Lesson

Teaching Objective: Upon completion of this lesson, students will be able to technically describe the function of storage battery plates.

Teaching Aids: Cutaway battery or assembly model
Training Charts, Delco Remy
Transparencies:
- Battery, p. III - 75
- Facts About Batteries, pp. III - 78, 79

References: Automotive Mechanics, Crouse, Chapter 13
Storage Batteries, Training Chart Manual, Delco Remy
Automotive Electrical Systems, Technical Training Manual, Automotive Electric Association
Facts About Storage Batteries, 6th edition ESB Brands, Inc.

Outline of Information:

1. Plate structure of battery consists of positive and negative groups of plates. The two groups are interlaced and insulated from each other by separators.

   a. Positive plate (PbO_2)
      -- Grid-like structure containing lead peroxide as the active metal
      -- Plate, when charged, has a dark brown color.
      -- Lead peroxide is in crystalline form (provides for high degree of porosity allowing electrolyte to penetrate plate).

   b. Negative plate (Pb)
      -- Grid-like structure filled with sponge lead
      -- Most battery cells have one additional negative plate to compensate for extra chemical activity that occurs on positive plates.

INFORMATION

Block: Automotive Electricity	Block III
	Job
Lesson: Separators	Lesson

Teaching Objective: Upon completion of this lesson, students will be able to technically describe the function of storage battery separators.

Teaching Aids: Cutaway battery or assembly model
Training Charts, Delco Remy
Transparencies:
- Battery, p. III - 75
- Facts About Batteries, pp. III - 78, 79

References: Automotive Mechanics, Crouse, Chapter 13
Storage Batteries, Training Chart Manual, Delco Remy
Automotive Electrical Systems, Technical Training Manual, Automotive Electric Association
Facts About Storage Batteries, 6th edition ESB Brands, Inc.

Outline of Information:

1. Function of separators

   a. Prevent contact, providing insulation between positive and negative plate groups

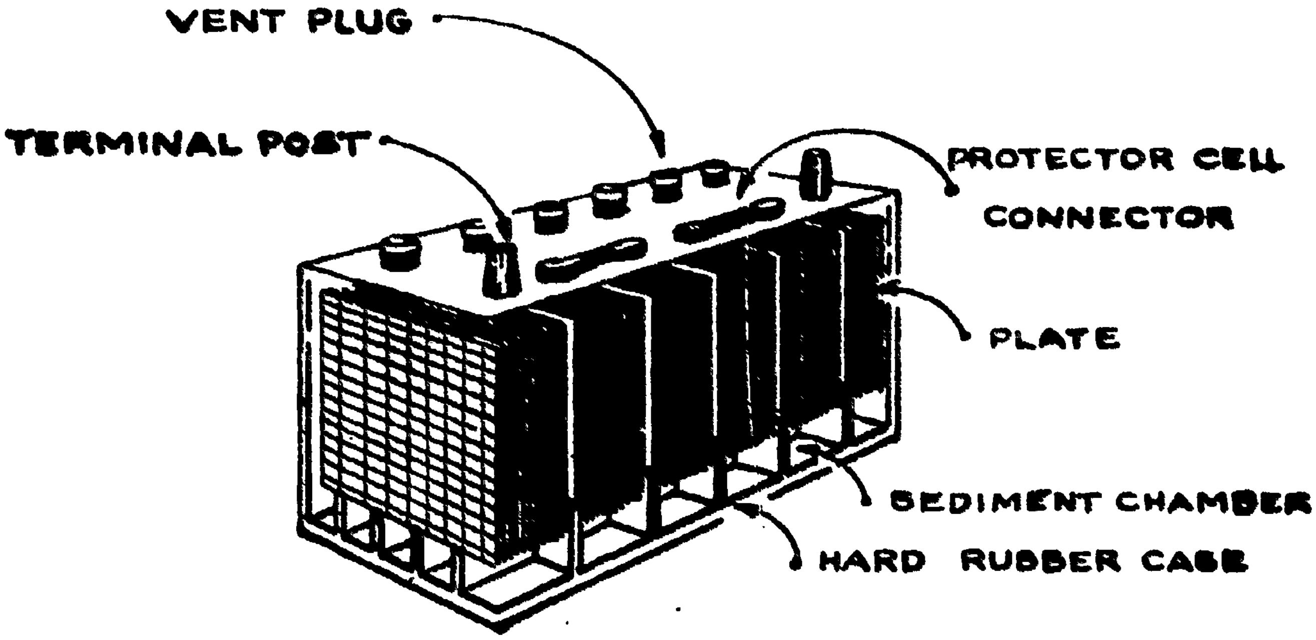
2. Construction

   a. Made of either wood, glass mesh, or rubber, plastic

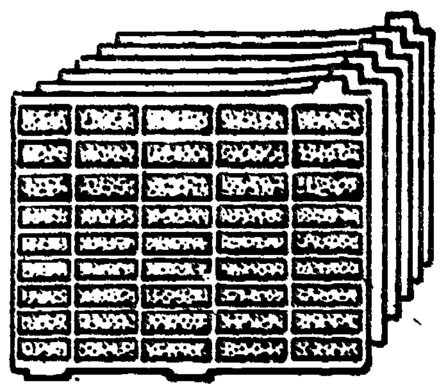
   b. Highly porous
      -- Porosity allows for free circulation of electrolytes.

   c. Ribbed on side adjacent to positive plate
      -- Channels provide more flow, greater circulation of electrolyte for maximum chemical reaction.

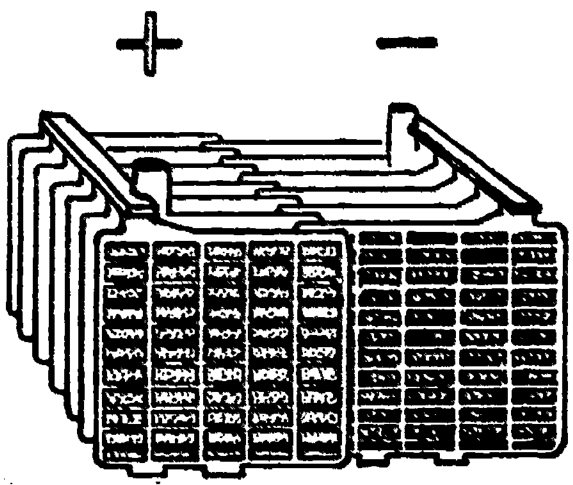
BATTERY



STORAGE BATTERY



FRAMES



POSITIVE PLATES NEGATIVE PLATES

INFORMATION

Block: Automotive Electricity

Lesson: Storage Safety and Handling Precautions

Block III
Job ____
Lesson ____

Teaching Objective: Upon completion of this lesson, students will define the factors regarding storage battery technology and handling that present hazards and will list appropriate precautions.

Teaching Aids: Transparencies:
- Facts About Batteries, pp. III - 78, 79
- Caution, p. III - 80

References: Automotive Mechanics, Crouse, Chapter 13
Storage Batteries, Training Chart Manual, Delco Remy

Outline of Information:

1. Safety precautions

   a. Hydrogen and oxygen gases are present in battery cells at all times.

   b. An excessive mixture of hydrogen and oxygen gases are formed beneath the cell covers when battery is being charged.

   c. A spark or flame can ignite the mixture and cause an internal battery explosion.

   d. Spray or splatter of sulpheric acid could result in injury to eyes and skin and damage to clothing and finished surfaces of automobile.

   e. Care should be taken to avoid sparks and flame near the battery.

   f. Gases can be purged from the cells by blowing a gentle stream of air through a small tube into the open areas of the cells.

   g. Remember that removing or connecting battery cables while the battery is on charge or discharge can cause dangerous sparks

2. Precautions when installing batteries

   a. Be sure the battery carrier is level and that the battery rests level when installed

Storage Safety and Handling Precautions (Continued)

b. Tighten the hold down evenly until snug
   -- Do not draw down tight enough to distort or crack battery case

c. Check polarity to be sure battery is not reversed with respect to the generating system

d. Be sure the cables are in good condition and the terminal clamps are clean and tight
   -- Grease battery terminals lightly after attaching cable clamps
   -- Make sure the ground cable is clean and tight at engine block or frame

e. Connect "grounded" terminal of battery last to avoid short circuit which may damage the battery

FACTS ABOUT BATTERIES

1. A battery creates electricity by chemical action.
2. The chemical voltage and the resistance of a battery combine to make counter electromotive force.
3. Iron in water causes both plates of a battery to become discharged.
4. Copper in the battery solution causes the negative plates to discharge.
5. It is easy to charge a run-down battery.
6. High temperatures cause permanent damage to the negative plates.
7. Acid adjustments should be made only when a battery has been fully charged.
8. Batteries must not stand in a discharged condition.
9. Large sulphate crystals are formed when a battery is allowed to stand in a discharged condition.
10. Sulphuric acid of 1.280 sp.gr. will freeze at 90^{0} F. below zero.

Courtesy - Automotive Electric Association

FACTS ABOUT BATTERIES (CONTINUED)

11. The positive plates manufacture water when current is used.

12. The normal charging rate for a battery is one ampere for each positive plate in one cell.

13. Only water approved for battery use should be added to the electrolyte.

14. The plates in a battery must always be covered with electrolyte.

15. No battery should be condemned until an attempt has been made to charge it.

16. New batteries have a higher counter voltage than old batteries.

17. The gas given off by a battery on charge is explosive.

18. A battery is not damaged by high rate discharge.

19. Continuous overcharge ruins the positive plates in a battery.

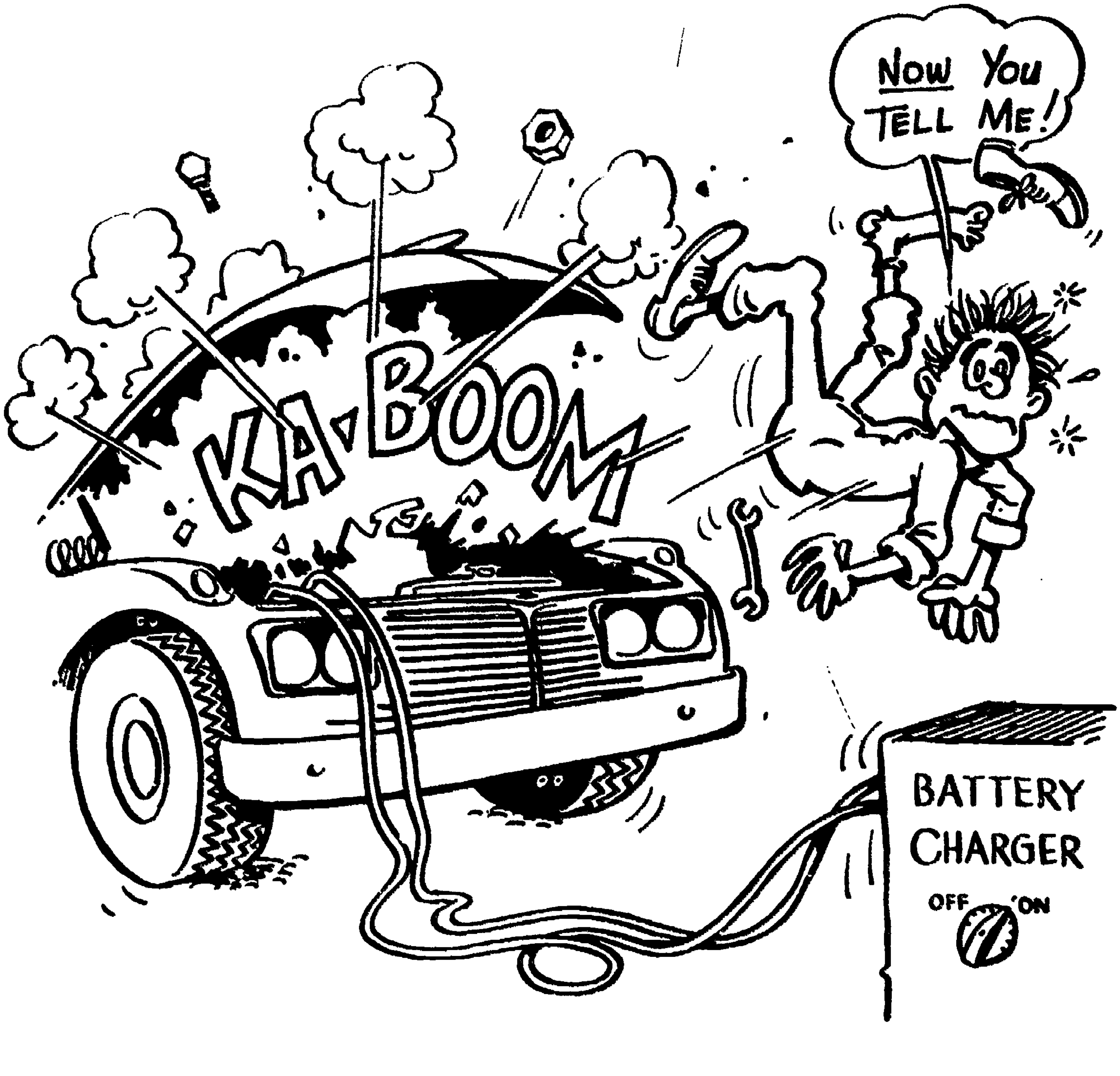
20. A battery is only 40% efficient at 0° F. Temperature.

Courtesy - Automotive Electric Association

CAUTION !!

AN EXPLOSIVE MIXTURE OF HYDROGEN AND OXYGEN GASES IS FORMED BENEATH THE CELL COVER WHEN A BATTERY IS BEING CHARGED.

WATCH OUT FOR SPARKS OR FLAMES!



T. VANTREESE, INST. MATL. LAB., U.K.

INFORMATION

<u>Block</u>: Automotive Electricity

<u>Lesson</u>: Specific Gravity and Hydrometer Readings

Block III
Job ____
Lesson ____

<u>Teaching Objective</u>: Upon completion of this lesson, students will be able to basically define the principle of specific gravity and relate the use of a hydrometer in performing measurements.

<u>Teaching Aids</u>: Transparencies:
- The Principle of Specific Gravity, p. III - 82
- Hydrometer, p. III - 85

<u>References</u>: <u>Auto Service and Repair</u>, Stockel, Chapter 22
<u>Battery Service Manual</u>, Association of American Battery Manufacturers, Inc.
<u>Storage Batteries</u>, Training Chart Manual, Delco Remy

<u>Outline of Information</u>:

1. Specific gravity refers to the ratio of the density of a substance to the density of the substance being compared.

2. The density is determined by weighing the substances.

   <u>Example</u>: Storage battery electrolyte weighs 1.28 times as much as pure water. Thus, the 1.280 full charge reading.

3. The hydrometer, used to measure approximate specific gravity, does not weigh a substance but floats in liquids at depths varing with liquid density.

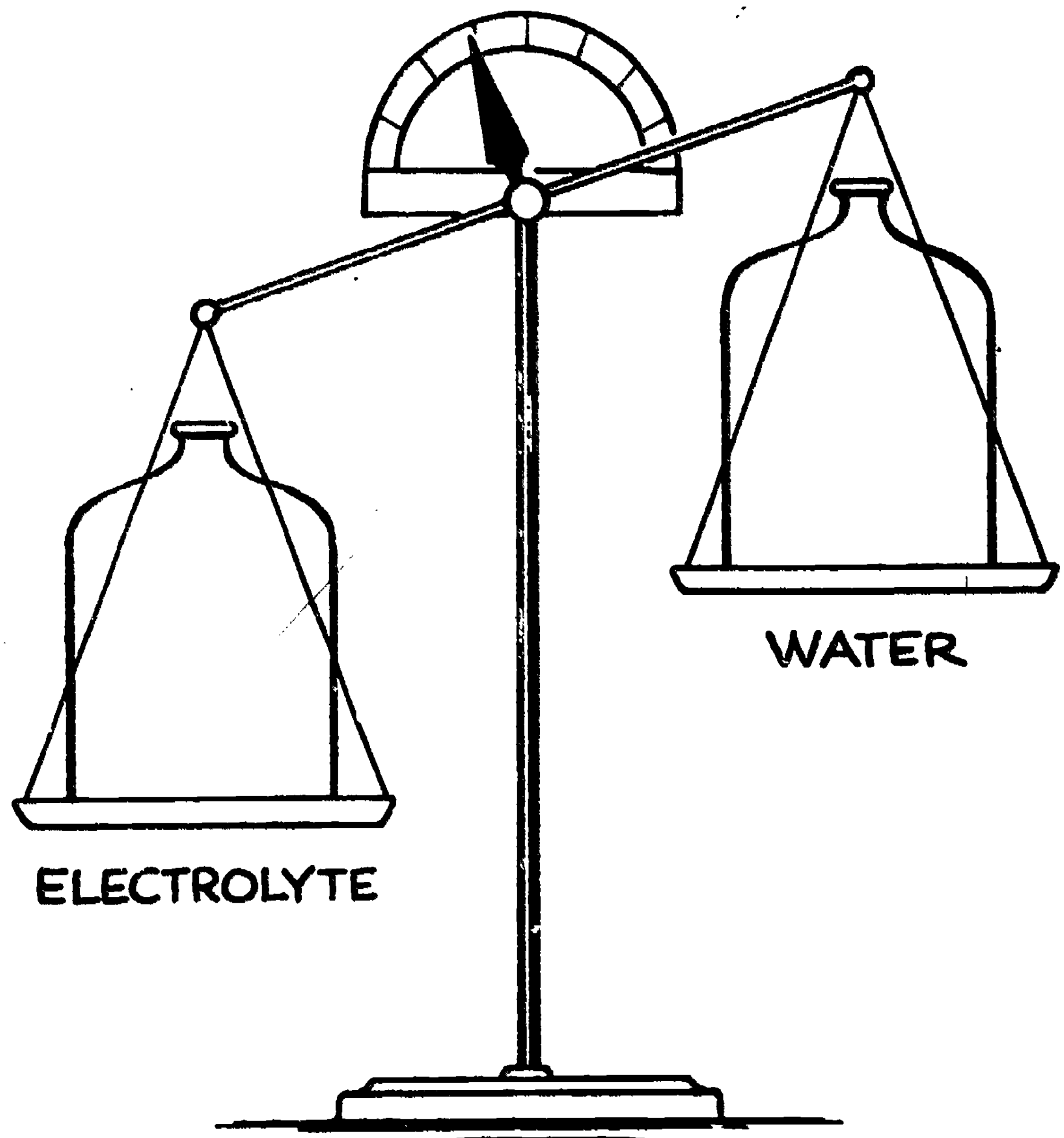
   <u>Note</u>: High floating indicates high specific gravity. Low floating indicates low specific gravity.

4. Hydrometer readings less than 1.230 on a fully charged battery on any cell indicates the battery is defective and must be replaced.

5. Hydrometer readings above 1.310 on fully charged battery on any cell indicates that the cells have been improperly filled or improperly serviced. Poor service and short battery life will result

6. Hydrometer readings 1.230 to 1.310 on all cells and the difference between the lowest and the highest cell is .050 or more, the battery is defective. Otherwise, the battery is good

The Principle of SPECIFIC GRAVITY



OPERATION

Block: Fundamentals of Electricity

Operation: Checking the Specific Gravity of the Storage Battery

Block III
Job
Operation

Teaching Objective: To teach students the proper procedures of testing the storage battery.

Tools: Battery hydrometer, battery pliers, combination wrenches (1/2" x 9/16"), wipe cloths

Materials: Distilled water, baking soda and water solution

Teaching Aids: Transparencies:
- The Principle of Specific Gravity, p. III - 82
- Hydrometer, p. III - 85
- Battery State of Charge As Related to Specific Gravity, p. III-87
- Hydrometer Readings, p. III - 86

References: *Let's Talk Energizers*, and Batteries, Delco Remy
Battery Service Manual, Association of American Battery Manufacturers, Inc.

Steps:

1. Remove vent plugs from battery cell covers

2. Use hydrometer to remove just enough electrolite from cell to allow float to float freely without touching the top or bottom of the tube of the tester

   Caution: Do not draw in too much electrolyte and make sure float is not sticking to side of glass tube

3. Take reading at eye level on float at point where it comes out of electrolyte

   Note: If the electrolyte level in the battery is too low to permit drawing out enough electrolyte to take a reading, water must be added to the battery and the battery charged.

4. Check temperature of electrolite with thermometer on tester. If temperature is not at 80 degrees, add 4 points (.004) to specific gravity reading of float for each 10 degrees. Subtract 4 points (004) from the specific gravity reading of the float for each 10 degrees below 80 degrees

5. Squeeze bulb to return electrolyte to cell

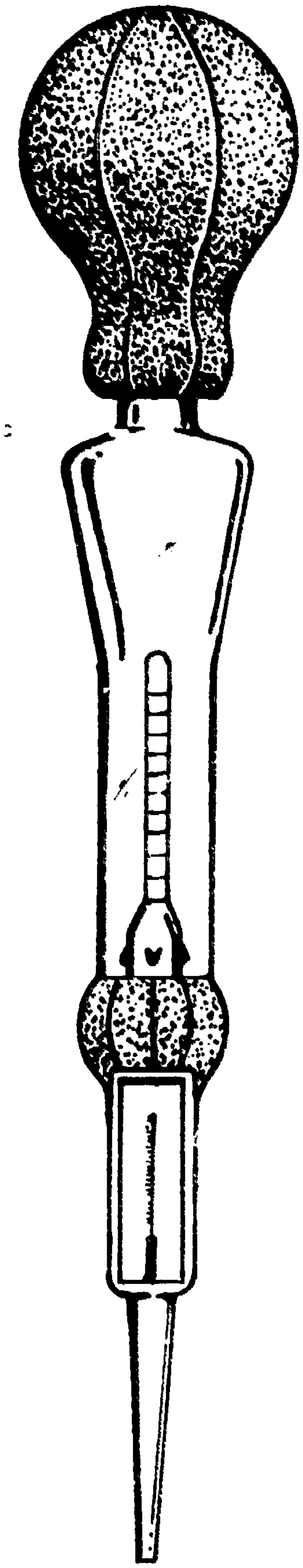
6. Repeat test on all remaining cells and record results

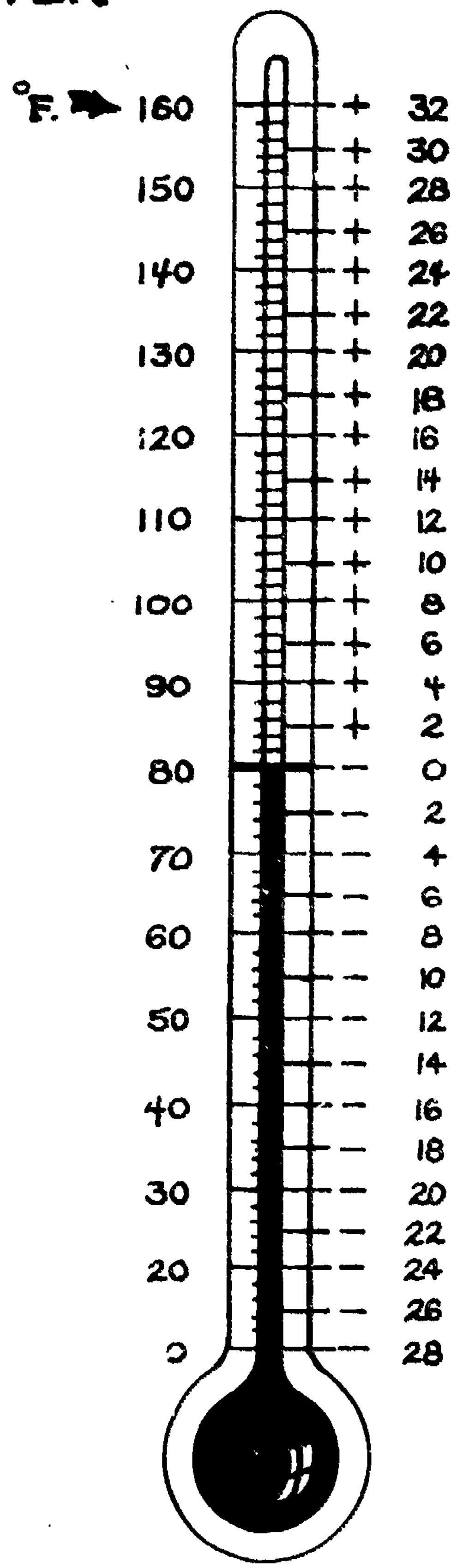
   Note: The amount of variation in specific gravity between cells, unless otherwise specified, should be even within 50 points (.050). If variations exceed this amount, an unsatisfactory condition is indicated.

7. Determine state of charge of battery by comparing final float readings to percentage of charge table

   Caution: Make certain that electrolyte does not come into contact with skin or clothing

HYDROMETER





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HYDROMETER READINGS

Battery Number	Cell One Voltage	Cell Two Voltage	Cell Three Voltage	Cell Four Voltage	Cell Five Voltage	Cell Six Voltage
1	____	____	____	____	____	____
2	____	____	____	____	____	____
3	____	____	____	____	____	____
4	____	____	____	____	____	____

BATTERY STATE OF CHARGE AS RELATED TO SPECIFIC GRAVITY

APPROXIMATE STATE OF CHARGE	APPROXIMATE RANGE OF SPECIFIC GRAVITY
FULLY CHARGED	1.250 — 1.280
3/4 CHARGED	1.210 — 1.235
1/2 CHARGED	1.160 — 1.180
1/4 CHARGED	1.115 — 1.130
DISCHARGED	1.070 — 1.085

NOTE: SPECIFIC GRAVITY READINGS IN VERY WARM AND HOT CLIMATES WILL BE LOWER THAN THE RANGES SUGGESTED ON THE ABOVE CHART

INFORMATION

Block: Automotive Electricity

Lesson: Battery Failures

Block III
Job
Lesson

Teaching Objective: Upon completion of this lesson, students will be able to list the common causes of battery failure suggested for study.

Teaching Aids: Transparencies:
- Basic Electrical Power System, p. III - 66
- How the Battery Works, pp. III - 69, 70

References: Automotive Mechanics, Crouse, Chapter 13
Storage Batteries, Training Chart Manual, Delco Remy
Automotive Electrical Systems, Technical Training Manual, Automotive Electric Association
Facts About Storage Batteries, 6th edition ESB Brands, Inc.

Outline of Information:

1. Accessories inadvertently left on, while vehicle is not in use, causes a discharge condition.

2. Slow speed driving on trips of short duration, causing an under-charged condition.

3. Improper voltage regulator setting for the type of driving involved

4. A vehicle electrical load exceeding the generator capacity

5. Improper charging system diagnosis

6. Failure to keep the battery top clean and caps tight

7. Improper addition of water to the cells

8. Failure to charge the battery properly

9. Battery of insufficient capacity to meet demands of vehicle

INFORMATION

Block: Automotive Electricity

Lesson: Visual Inspection Procedures

Block ___III___
Job ______
Lesson ______

Teaching Objective: Upon completion of this lesson, students will be able to describe visual inspection methods for analyzing battery conditions.

Teaching Aids: Used battery
Assembly Model
Transparency:
- Facts About Batteries, p. III - 78

References: Automotive Mechanics, Crouse, Chapter 13
Battery Service Manual, Association of American Battery Manufacturers, Inc.

Outline of Information:

1. Check the outside of the battery for broken or cracked case and cell covers. If evidence of serious damage, battery should be replaced.

2. Note the electrolyte level. Levels that are low or too high cause serious battery problems.

   a. Electrolyte level too low
      -- Overconcentration of acid
         - Destroy separators
         - Plates may become permanently sulphated
      -- Plates must be completely covered for maximum action.

   b. Electrolyte level too high
      -- Danger of overspilling
      -- Escaping gases can cause bubbling and squirting discharge of electrolyte from cap vents.

3. Check for corroded areas on top of the battery

4. Check for corroded or loose cable connections, corroded carrier, and hold down bracket

INFORMATION

Block: Automotive Electricity		Block	III
		Job	
Lesson: Light Load Testing		Lesson	

Teaching Objective: Upon completion of this lesson, students will be able to describe the light load test for storage batteries and relate the readings resulting from a test to battery condition.

Teaching Aids: Transparency:
- Light Load Readings, p. III - 92

References: Storage Batteries, Training Chart Manual, Delco Remy
Auto Service and Repair, Stockel, Chapter 22

Outline of Information:

1. The light load test should be used on all batteries with separate cell covers.

2. An expanded scale voltmeter that has .01 volts per scale divisions is used to take the cell readings.

3. This test should be performed before batteries are charged, as defective cells may read as being sound giving a false diagnosis.

   a. If every cell shows a reading of 1.95 volts or more and the variance between the highest reading and lowest reading is less than .05 the battery is good and is adequately charged.

   b. If cell readings show to be both above and below 1.95 volts, and the variance between the highest reading is less than .05 the battery is good, but must be charged.

   c. If any cell reading is 1.95 volts or more, and there is a variance of .05 volt or more between the highest reading and the lowest reading, the battery is defective.

OPERATION

Block: Automotive Electricity | Block III
Job
Operation: Testing Storage Batteries Using the Light Load Test | Operation

---

Teaching Objective: To teach the students to test storage batteries using the light load test.

Tools: Ammeter (150 amperes load), ammeter (10 amperes load), voltmeter (.01 volt per scale divisions)

Materials: Wipe cloths

Teaching Aids: Batteries with individual cell covers
Transparency:
- Light Load Reading, p. III - 92

References: Automotive Mechanics, Crouse, Chapter 23
Auto Service and Repair, Stockel, Chapter 22
Storage Batteries, Training Chart Manual, Delco Remy

Steps:

1. Check the electrolyte level in each cell and if needed, adjust it to the proper level by adding water

2. If the battery is in the vehicle, place a load on the battery by holding the starter switch "on" for three seconds or until the engine starts. If the engine starts, turn off the ignition immediately

3. If the battery is out of the vehicle, place a 150 ampere load on it for three seconds

4. Turn on headlights (low beam) or if battery is out of the vehicle, place a 10 ampere load on battery

5. After one minute with lights still "on" or with 10 ampere load, read the voltage of each battery cell with voltmeter

   Note: It is necessary to remember only the highest and lowest cell voltage.

LIGHT LOAD READINGS

Battery Number	Cell One Voltage	Cell Two Voltage	Cell Three Voltage	Cell Four Voltage	Cell Five Voltage	Cell Six Voltage
1	______	______	______	______	______	______
2	______	______	______	______	______	______
3	______	______	______	______	______	______
4	______	______	______	______	______	______

OPERATION

Block: Automotive Electricity

Operation: Removing a Storage Battery

Block III
Job
Operation

Teaching Objective: To teach students to properly remove a storage battery

Tools: Cable clamp puller, wrench to fit clamp nuts, battery carrier strap, screwdriver, hydrometer

Materials: Wipe cloths, fender covers

Teaching Aids: Battery in service
Engine on stand with battery hook-up
Transparency:
- Caution, p. III - 80

References: *Automotive Mechanics*, Crouse, Chapter 23
Battery Service Manual, Association of American Battery Manufacturers, Inc.

Steps:

1. Protect vehicle finish with proper covering

2. Disconnect the battery ground cable first. Use wrench to loosen clamp nut. Spread clamp by prying between clamp jaws with screwdriver. Use special clamp puller if necessary to remove clamp.

3. Disconnect insulated battery cable

4. Remove hold-down brackets

5. Use battery carrier to lift old battery from vehicle

6. Inspect cables. Check to see if corrosion exists between cable and terminal clamp. This would indicate a poor connection.

7. Inspect carrier and clean or replace as necessary

8. Check specific gravity of battery to determine state of charge

INFORMATION

Block: Automotive Electricity		Block	III
		Job	
Lesson: Storage Battery Cleaning Procedures		Lesson	

Teaching Objective: Upon completion of this lesson, students will be able to describe the proper methods of maintaining and cleaning storage batteries.

Teaching Aids: Storage batteries
Transparency:
- Caution, p. III - 80

References: Storage Batteries, Training Chart Manual, Delco Remy
Automotive Mechanics, Crouse, Chapter 13

Outline of Information:

1. Preservation - cleaning

   a. The way to combat battery failure is through proper preservation and cleaning.
      -- Even if only a small amount of corrosion is present,on or about the battery terminals, or if the surface of the battery appears moist, corrective steps are necessary.
      -- Preventive maintenance is required.

   b. The battery should be removed from the vehicle and taken to a spot where it may be cleaned.

   c. The surface of the battery, including its terminal posts, may be cleaned by using a solution of baking soda and water.
      -- By brushing the solution over the surface of the battery, corrosion and the effects of acid can be neutralized.

   Caution: Never allow a soda-water solution to enter cells of the battery. This will destroy the electrolyte. In washing the top of the battery, plug or cover the vent holes in the cell caps

   d. After a thorough cleaning with soda and water, completely flush the external surface of the battery with fresh water

   e. Wipe the battery completely dry

   f. Clean the cable plugs and the terminal post

   Note: Use a wire brush or a cable and post cleaner

   g. Apply petroleum jelly or corrosion inhibitor to terminals

INFORMATION

Block: Automotive Electricity	Block III
Lesson: Storage Battery Charging	Job
	Lesson

Teaching Objective: Upon completion of this lesson, students will be able to describe the commonly accepted methods of charging storage batteries and the pertinent, related technical information.

Teaching Aids: Transparencies:
- How the Battery Works, p. III - 69, 70
- Caution, p. III - 80

References: Battery Service Manual, Association of American Battery Manufacturers, Inc.
Storage Batteries, Training Chart Manual, Delco Remy

Outline of Information:

1. Preparing the battery for charging

   a. Battery must be cleaned (refer to lesson, p. III-94)

   b. Electrolyte level must be correct (approximately 1/4" above separators)
      -- Too much electrolyte could overflow during charge
      -- Too little electrolyte could result in battery overheating
      -- Remove or add as necessary

2. Charging methods

   a. Fast charging
      -- Initial settings on charger range from 40-70 amperes for 12 volt batteries and 80-120 amperes for 6 volt batteries; depending on battery capacity and condition.
      -- Temperature during charge should not exceed 125° F.
      -- Charging time varies up to 3 hours depending on battery size and type.

   Note: To avoid damage to batteries during charge, charger manufacturer's operating instructions should be carefully followed.

      -- Constant-potential chargers begin at a high rate and automatically taper off as the battery voltage increases.

Storage Battery Charging (Continued)

b. Slow charging
   -- Ampere setting will vary with battery size and capacity.
   -- Settings can be determined as follows:
      (1) Rate = 1 amphere per positive plate per single cell.
      or
      (2) Rate = 7% of the battery's amphere rating.
   -- Most batteries will take a full charge in 10-15 hours, however badly sulfated battery will require longer.

c. Dry-charged batteries
   -- Activated when properly prepared electrolyte is added
   -- Follow manufacturer's directions carefully

d. Trickle charging
   -- Ampere settings of less than 1 to keep batteries freshly charged

OPERATION

Block: Automotive Electricity

Operation: Replacing a Storage Battery

Block III
Job
Operation

Teaching Objective: To teach students to properly replace a storage battery

Tools: Wrench to fit clamp nuts, battery carrier strap, wire brush or battery terminal or post cleaner

Materials: Petroleum jelly or corrosion inhibitor, wipe cloths, fender covers

Teaching Aids: Batteries in service
Engine on stand with battery hook-up

References: Automotive Mechanics, pp. 360-361

Steps:

1. Protect vehicle finish with proper covering
2. Install battery, making sure terminals are in right locations
3. Temporarily touch cable clamps to terminals to test for spark. If there is a spark, some electrical device is on, or a circuit is shorted or grounded.
4. Remove grounded cable clamp from terminal to avoid accidental grounds, during the next step
5. Install insulated cable clamp on battery terminal and tighten clamp nut
6. Attach ground cable clamp and tighten clamp nut
7. Apply petroleum jelly or corrosion inhibitor to both clamps and terminals
8. Crank motor to assure that engine will start

References - Block III

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