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ABSTRACT

This booklet, one of a series developed by the Frederick County Board of Education, Frederick, Maryland, provides an instruction module for an individualized or flexible approach to secondary science teaching. Subjects and activities in this series of booklets are designed to supplement a basic curriculum or to form a total curriculum, and relate to practical process oriented science instruction rather than theory or module building. Included in each booklet is a student section with an introduction, performance objectives, and science activities which can be performed individually or as a class, and a teacher section containing notes on the science activities, resource lists, and references. This booklet is the second part of a three part series on electricity and concentrates upon the control and measurement of electricity. The estimated time for completing the activities in this module is 2-3 weeks. (SL)

Electricity: Part 2

AIDS TO INDIVIDUALIZE THE TEACHING OF SCIENCE

MINI-COURSE UNITS

BOARD OF EDUCATION OF FREDERICK COUNTY

1974

ELECTRICITY: PART II

THE CONTROL AND MEASUREMENT OF ELECTRICITY

Prepared by:
Marvin Blickenstaff

Estimated Time for Completion
2-3 weeks

Frederick County Board of Education

Frederick, Maryland

Frederick County Board of Education

Mini Courses for

Physical Science, Biology, Science Survey,

Chemistry and Physics

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1974

FOREWORD

The writing of these instructional units represents Phase II of our science curriculum mini-course development. In Phase I, modules were written that involved the junior high disciplines, life, earth and physical science. Phase II involves senior high physical science, biology, chemistry, physics and science survey.

The rationale used in the selection of topics was to identify instructional areas somewhat difficult to teach and where limited resources exist. Efforts were made by the writers of the mini-courses to relate their subject to the practical, real world rather than deal primarily in theory and model building.

It is anticipated that a teacher could use these modules as a supplement to a basic curriculum that has already been outlined, or they could almost be used to make up a total curriculum for the entire year in a couple of disciplines. It is expected that the approach used by teachers will vary from school to school. Some may wish to use them to individualize instruction, while others may prefer to use an even-front approach.

Primarily, I hope these courses will help facilitate more process (hands on) oriented science instruction. Science teachers have at their disposal many "props" in the form of equipment and materials to help them make their instructional program real and interesting. You would be remiss not to take advantage of these aids.

It probably should be noted that one of our courses formerly called senior high physical science, has been changed to science survey. The intent being to broaden the content base and use a multi-discipline approach that involves the life, earth and physical sciences. It is recommended that relevant topics be identified within this broad domain that will result in a meaningful, high interest course for the non-academic student.

ALFRED THACKSTON, JR.
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ELECTRICITY: PART II

THE CONTROL AND MEASUREMENT OF ELECTRICITY

You probably already know that every material thing is basically electrical. All material objects are made of atoms. All atoms contain electrons. Electrons can be stored or set into motion. In either case, stored or moving, we have electricity when we can control and measure electrons.

In this mini-course you will be learning how we control and measure the flow of electrons. We will be investigating such things as switches and circuits, and the instruments which measure the electricity as it passes through these switches and circuits.

A. Properties of an Electric Circuit

OBJECTIVES

The student will be able to:

1. assemble a simple circuit given a power source, switch, conductor, and a means of determining electric current flow.

2. define and demonstrate an open and a closed circuit.

3. determine whether or not a current is flowing in a circuit, given the proper materials.

ACTIVITY

Do Lab Problem Sheet 7-7, Magnetism & Electricity, Cambridge Company, pp. 216-218. Get Problem Sheet 7-7 from your teacher. When doing this lab, and nearly all other labs involving electricity, do not keep circuits closed for more than a few seconds - just long enough for you to make the specific observation related to your investigation.

B. Two Types of Circuits — Series and Parallel

OBJECTIVES

The student will be able to:

4. given the proper materials, assemble a series and a parallel circuit.

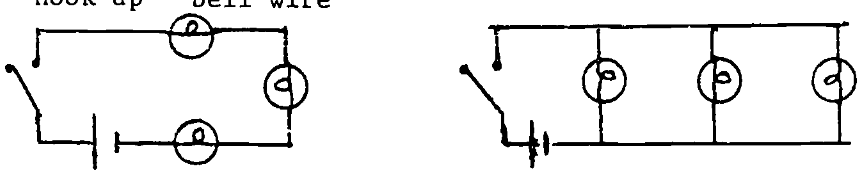
5. state a difference in the physical appearance of a series circuit and of a parallel circuit.

ACTIVITIES

Lab: <u>Two Types of Circuits - Series and Parallel</u>

Materials

2 dry cells (with terminals or holders)
2 knife switches
6 flashlight bulbs and sockets ( means bulb)
hook up - bell wire



Series Parallel

Procedures:

1. Read Chapter 4, Book 1, The Series Circuit, <u>Pathways In Science</u>, pp. 18-20 (stop at paragraph #4)

2. Read Chapter 5, Book 1, Parallel Circuits, <u>Pathways In Science</u>, pp. 24-27 (stop at paragraph #6)

3. Set up a series circuit as shown in the diagram, page 26. <u>Do not close switch</u>.

4. Set up a parallel circuit as shown in the above diagram. <u>Do not close switch</u>.

5. When you have completed steps 1-4 above, ask your teacher to approve your set-up.

6. <u>While your teacher watches</u>, close both switches at the same time for several seconds. What do you see different in the bulbs when the circuits are closed?

Note: If possible, keep your set-ups just as they are for later use. If you are not able to do this, be sure you remember how you make your set-up because you will be using it again.

Interpretations:

1. How do you think parallel circuits got their name?

2. Why do we call series circuits by that name?

3. List any advantages of the series circuit over the parallel circuit.

4. List any advantages of the parallel circuit over the series circuit .

5. Although you have not used a meter to measure the amount of electricity flowing in these two circuits, can you make any conclusions about the electricity flowing through the two different circuits?

6. If one bulb "goes out" on a string of Christmas lights, what kind of circuit do you have if the rest also go out?

7. If one bulb "goes out" while the rest stay on in a string of Christmas lights, what kind of circuit do you have?

8. What kind of circuits do you think you would have in your home? Why?

Conclusion:

Draw a series circuit and a parallel circuit and explain any differences you discovered when closing both of these circuits.

C. Protecting Circuits

OBJECTIVES:

The student will be able to:

6. define a short circuit.

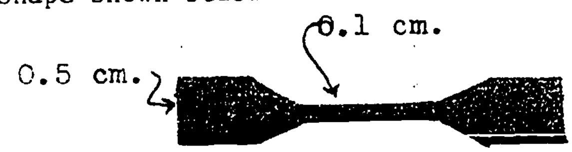
7. describe the function of any of the conventional circuit breakers - fuses etc.

ACTIVITIES:

a. Read pp. 21-22 of <u>Pathways In Science, Physic 1</u>.

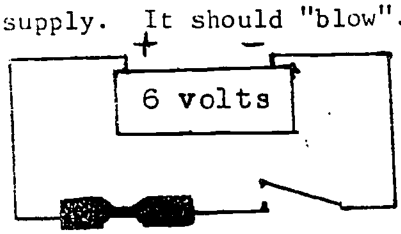
b. Watch your teacher demonstrate the use of a fuse or circuit breaker in a circuit which is "overloaded" or carries more current than it should, ie. has a short circuit.

c. Quickie Lab for students
   1.) Cut a piece of aluminum foil about 0.5 cm. by 5 cm. long.
   2.) Put a piece of scotch tape to the dull side of this foil.
   3.) Now trim the foil—tape combination into the size and shape shown below.



foil backed by tape (5.0 cm. long)

   4.) Now hook this "home-made" fuse to a 6 volt power supply. It should "blow".



d. Watch film: Elements of Electrical Circuits, 11 min.

D. Circuit Symbols

OBJECTIVES:

The student will be able to:

8. identify 15 selected circuit symbols commonly used in electronic circuit diagrams.

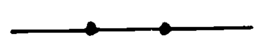
9. draw very simple circuits using the selected symbols and specifications as to their location in the circuit.

ACTIVITIES:

a. Read and study the circuit symbols listed on page 32 of Pathways In Science, Physic 1. Add to this list of symbols the following:

ohmmeter

motor



switch (closed)

(Note: The switch in the book is an open switch.)

b. Drill: Your partner (or team) will practice until everyone is ready to take a quiz on these symbols - (About 10 minutes).

c. Quiz - 15 selected symbols - Check and repeat after 5 more minutes of study. Study again for homework if you did not get at least 10 of the 15 correct.

d. Drill on drawing simple circuits - Watch your teacher draw simple circuits on the chalk board as examples for you. Now you draw the following circuits:

   1.) A series circuit containing a cell, a bulb, and a switch.

   2.) A parallel circuit containing a battery, a switch which operates a bulb, and a coil.

Your teacher may want you to do more of this circuit diagramming.

E. Units and Instruments (meters) for Measuring Electricity

OBJECTIVES:

The student will be able to:

10. demonstrate the proper use of an ammeter.

11. demonstrate the proper use of a voltmeter.

12. demonstrate the proper use of an ohmmeter.

ACTIVITIES:

Lab - Units and Instruments (meters) for Measuring Electricity

Materials:

If you saved the set-up for the Lab in section B, Types of Circuits, use them for this lab.

2 dry cells (with terminals or holders)
2 knife switches
6 flashlight bulbs and sockets
hook-up wire
1 each of ammeter, voltmeter, ohmmeter or multimeter.

Procedures:

a. Read pp. 19-20 in Pathways - Physic I. Attach an ammeter as shown in figure 19-2 and record the reading for each of the four positions. What do you notice about these readings?

b. Read pp. 25-26 in Pathways - Physic I. Attach a voltmeter as shown in figure 25-1 and record the reading for each of the five positions. What do you notice about these readings?

c. Read pp. 30-31 in Pathways - Physic I.
   1. Attach an ammeter and voltmeter as shown in figures 31-1 on page 31.

   2. Read and record the current flow (amps) and current pressure (volts) when the number of bulbs is changed.

   3. Zero-in your ohmmeter as directed by your teacher. Measure and record the resistance of your switch, your bulb, and your dry cell while not connected.

4. Connect the cell, switch, and bulb in a series circuit. Measure the resistance of each while current is flowing in the circuit.

Interpretations:

1. Tell how to connect an ammeter in a series circuit.
2. What are the units of current flow?
3. Tell how to connect an ammeter in a parallel circuit.
4. Tell how to connect a voltmeter in a series circuit.
5. What are the units of electrical pressure?
6. Tell how to connect an ohmmeter in a series circuit.
7. What are the units of electrical resistance?
8. Of the three instruments(ammeter, voltmeter, ohmmeter), through which does all the electricity of the circuit flow?
9. Through which instrument does very little of the electricity of the circuit flow?
10. Which instrument provides its own electricity while it is in use?

Conclusion:

What are three factors of an electric current which can be measured? What is the name of each meter which can measure these factors?

F. Finding Resistance Without an Ohmmeter - Optional

OBJECTIVES:

The student will be able to:

13. demonstrate the effect on amperage and voltage when resistance is changed in a circuit.

14. state the mathematical relationship between amps, volts, and ohms ($R = \frac{E}{I}$).

15. calculate the resistance of an object using an ammeter, a voltmeter, and Ohm's Law.

ACTIVITY:

Lab - Finding Resistance Without an Ohmmeter

Materials:

1 dry cell or power supply ($\leq$ 12 volts DC)
hook - up wire
ammeter
voltmeter
unknown resistance (coil or wire, bulb, or some other convenient object)

Procedures:

a. Read paragraph 6 on page 46 of Pathways In Science - Physics I.

b. Set up a series circuit with the provided materials, leaving out the unknown resistance.

c. Using your ammeter and voltmeter, find the amperage and voltage in the circuit. Record your results.

d. Using Ohm's Law ($R = \frac{E}{I}$) calculate the resistance of the wire and switch in your circuit. Record your results showing your calculations.

e. Now insert your unknown resistance into your circuit and again find the amperage and voltage. Record results.

f. Calculate the total resistance in your circuit containing the unknown resistance. Record your results and calculations.

g. Calculate the resistance of the unknown by subtracting the resistance you found in step d. Record your results and calculations. Why is this the resistance of the unknown?

h. Using an ohmmeter, find the resistance of the unknown resistance. How did your calculated resistance in step g compare with this answer?

Interpretations:

1. An ohmmeter contains a power supply which sends a current through a resistance you are trying to measure. Why do you think ohmmeters are not found as often as ammeters and voltmeters?

2. Why is it important to have your dials and "plug in leads" correct when you use electric meters?

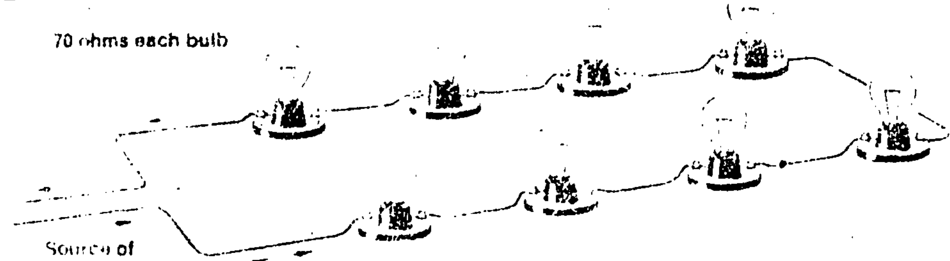
3. What is meant by "zeroing" an ohmmeter?

OPTIONAL

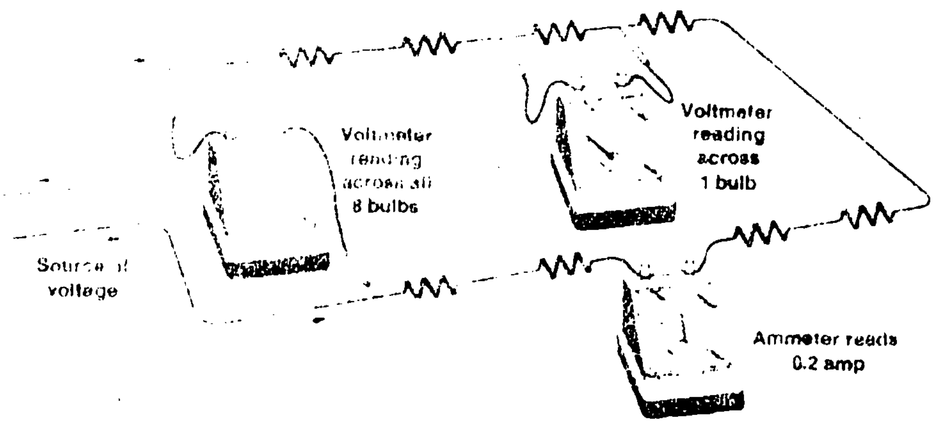
4. Why do you think a multimeter costs so much money?

Conclusions:

How can you find the resistance of an object without an ohmmeter? Explain. Look at the diagram below and tell how each of the meters shown is being used. How are the lamps in the top diagram illustrated in the bottom diagram? Tell where you would put an ohmmeter to find the resistance of any one of the lamps. What is the total resistance in the circuit? Explain how you found your answer. Is the current in this circuit AC or DC?



(a) circuit of 8 bulbs in series



(b) wiring diagram series circuit

G. Sending Electricity to Our Homes

OBJECTIVES:

The student will be able to:

16. assemble a primary and a secondary coil using a common (the same) core of soft iron.

17. demonstrate the induction of a current in the secondary coil of a transformer by applying a current in the primary coil.

18. define step - up and step - down transformer.

19. diagram the transfer of electricity from power plant to your home showing the major places where transformers are used.

ACTIVITIES:

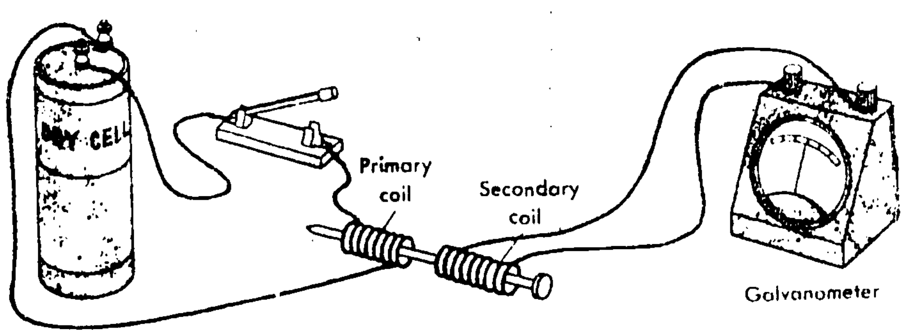
a. View film 300F95100 Powerline - Transportation of Energy, available from, Board of Education, 11 min.

b. Read pp. 111-118, Pathways in Science - Physics I.

c. Lab - Sending Electricity to Our Homes.

Materials:

dry cell or (power pack, 12 volts)
switch (knife)
soft iron core (large nail or 20 penny nail)
wire, insulated
galvanometer



Procedures:

1. Assemble the materials as shown in the diagram on page 10.

2. Now open and close the switch several times. What happens to the reading of the galvanometer each time you open and close the switch? Tell why this happens.

3. Until now you were using direct current (DC) in this lab. Now connect your primary coil to a source of alternating current (AC) of no more than 12 volts. Connect a voltmeter to the secondary. Close the switch and read the voltage in the secondary coil. Record your results.

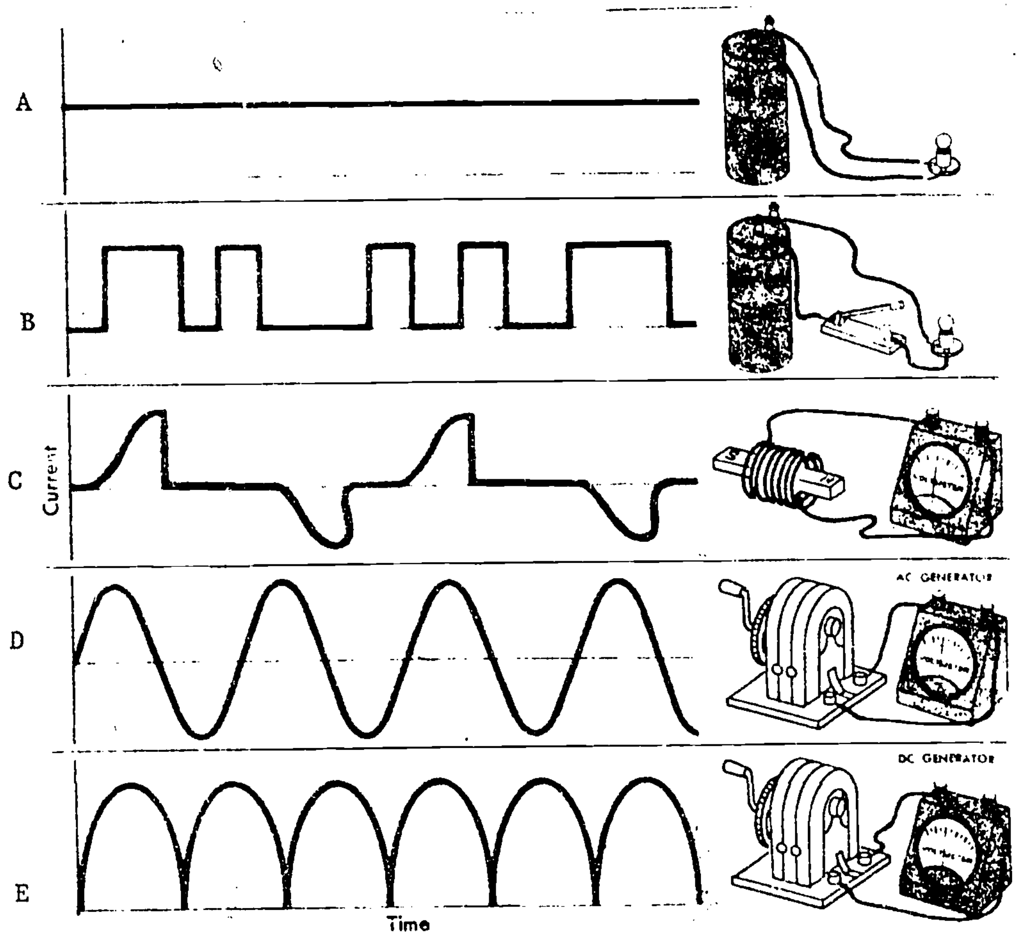
4. Optional. If your school has a model generator, examine the primary and secondary coils. How do they differ?

5. Look at the primary and secondary coils of a ring transformer. Count the number of turns of wire in each. If you can't count the actual number of turns, estimate a ratio by comparing the size of the two coils. Measure the voltage in the primary and in the secondary. How are these voltages different? Is this a step - up or a step - down transformer? How do you know?

Interpretations:

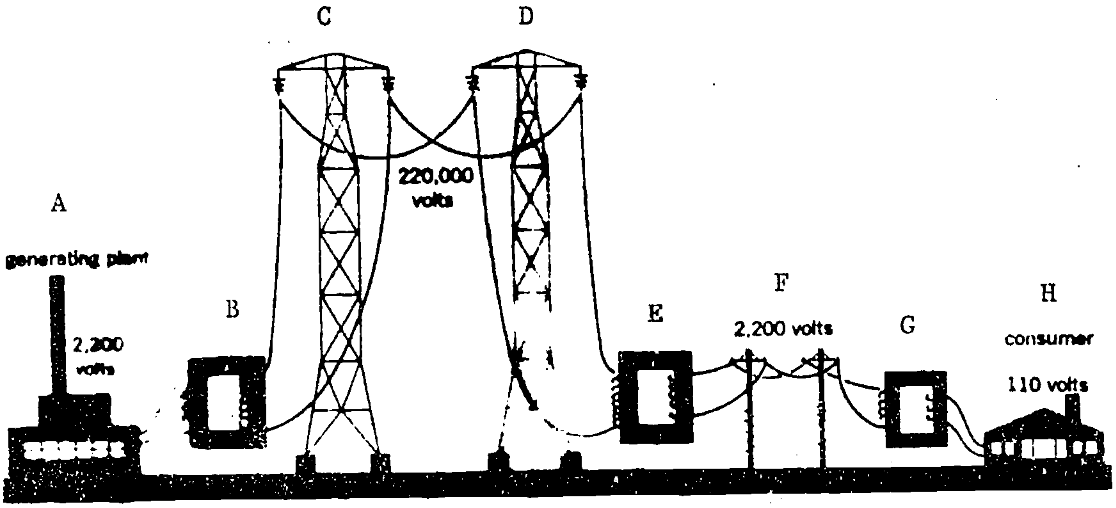
1. How can electricity in a primary coil cause electricity to flow in a secondary coil?

2. Electricity must have a place or origin and a complete path back to that place of origin (called a circuit) in order for electrons to flow. Look at the diagrams on top of page 12 and tell why the current (amperage) is different in each case A, B, C, D, and E.



3. None of the above diagrams represents a transformer but each has something in common with a transformer. What is it?

4. The electricity that is generated at a power plant may have its voltage increased or amplified 100 or perhaps even 1000 times. This is done to prevent loss of current in the long journey from the power plant to your home. Look at the diagram p.13 and tell where transformers are being used. Indicate whether they are step - up or step - down. Use letters for your answers.



In this ideal diagram there are 4 turns in the primary of the generating plant transformer. How many turns should there be in the secondary? There are 3 turns in the secondary of the house transformer. How many turns should there be in the primary? Discuss the turns ratio in the middle transformer.

5. Choose any one of the transformers in the diagram above and find the ratio of the number of turns in the primary to the number or turns in the secondary.

Conclusion:

Explain how a step - up and a step - down transformer works. List several places in or around your home where transformers can be found.

H. Measuring Electrical Energy Used by an Electrical Appliarce

OBJECTIVES:

The student will be able to:

20. define electricity in terms of energy.

21. calculate the energy requirements of an electrical appliance while it is in use.

ACTIVITIES:

When an electrical appliance is in use, it consumes a certain amount of electricity. The amount of electricity used is expressed in watts. To find the amount of electricity used, you multiply the current used by the voltage applied. The mathematical expression for this calculation is W (Watts) = I x E.

a. Lab - Finding the Electrical Energy Used by an Electrical Appliance

Materials:

various household appliances
ammeter (30 amp range)
voltmeter (130 volt range)

Procedures:

a. Plug in one electrical appliance into a standard house circuit.

b. Measure and record the amperage in the circuit using your ammeter.

c. Measure and record the voltage in the circuit using your voltmeter.

d. Calculate the number of watts used by this appliance as described in the introduction. Record your results.

e. Carefully inspect the appliance and find its wattage which is stamped or molded somewhere on it. How did your calculated value compare with the manufacturer's rating of this appliance?

f. Repeat steps a-e for as many different appliances as your teacher tells you.

Interpretations:

1. From your experimental data and from the data from other members of your class, do you think that manufacturers correctly state the wattage of their products?

2. If you needed to know which of two (or perhaps even a whole series of) appliances used the most electricity, how would you tell?

3. Look at the wattage of several different appliances. What factor or factors seem to affect the wattage of the different appliances?

4. Does a 100 watt light bulb use more or less electricity than a radio which has a wattage of 100?

5. A toaster usually is rated at about 1,000 watts, could you toast bread with a 100 watt bulb? Explain your answer.

6. How many watts would an appliance use if it were rated at 8 amperes in a 120 volt circuit? Hint: W= I x E

Conclusion:

Since the electricity that passes through any appliance must have a circuit which ultimately leads back to the power source (power plant), how or why can we say that any electricity has been used? How does one know the number of appliances which can safely be put in one circuit of your home? How are homes protected when we accidentally use too many appliances on one circuit?

OPTIONAL:

Find the electrical code for Frederick County and report to class your findings.

I. Power Consumption - Figuring Your Electric Bill

OBJECTIVES:

The student will be able to:

22. define electrical power in terms of watts and hours.

23. define the term <u>kilowatt - hour</u>.

24. read a wall - hour meter.

25. calculate an electric bill for one month.

ACTIVITIES:

a. Investigation - Power Consumption - Figuring Your Electric Bill. You have just learned to figure the energy requirements for an electrical appliance. To find the power used by electrical appliances you multiply their energy rating (in watts) by the time (in hours) they were in use. The mathematical formula would be watt - hours (w·h) = watts W x hours (h). Since most of us use thousands of watts in a short period of time, power companies charge for electricity in kilo - watt - hours (k·w·h). The prefix <u>kilo</u> means 1,000; therefore a kilowatt - hour is 1,000 watt - hours. Below is a table showing a schedule used by Potomac Edison Company for determining electric bills. You will be using this schedule for this investigation.

First	150	kilowatt hours	used for $6.90
Next	250	kilowatt hours	2.16 cents per kilowatt hour
Next	1250	kilowatt hours	1.50 cents per kilowatt hour
All over	1650	kilowatt hours	1.40 cents per kilowatt hour

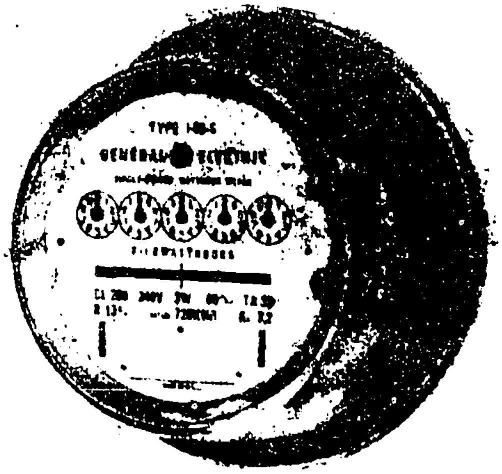
Materials:

watt - hour meter in school for practice reading
watt - hour meter in your home
electric bill

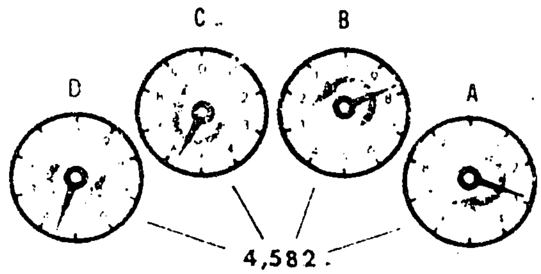
Procedures:

a. Read paragraph 6 on page 27 in <u>Pathways In Science - Physics 1</u>.

b. Look at the sketch p.17 and determine how to read a watt-hour meter. Now read the watt - hour meter in your school. Have your teacher verify that you can do this accurately.



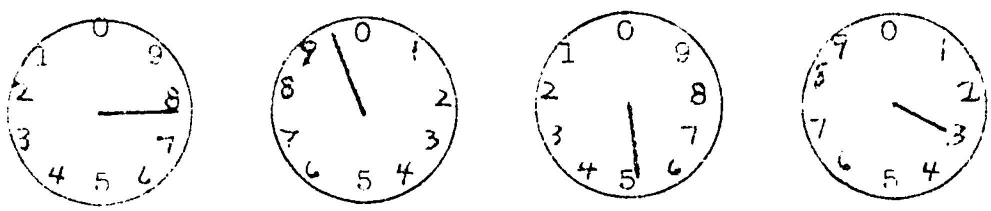
General Electric Co.



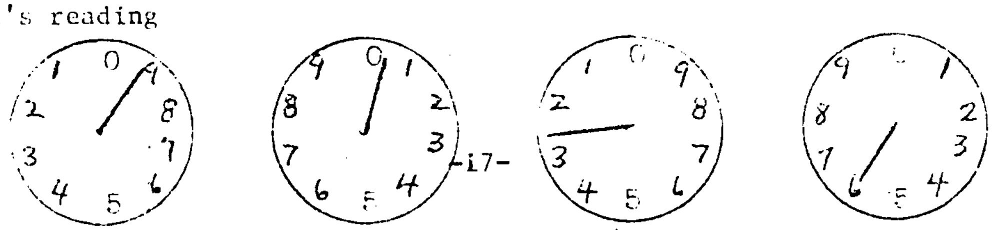
Electric-Meter Dials *read, from right to left,* in units of ones, tens, hundreds, and thousands. Some meters have a fifth dial that registers in units of 10,000, like the meter in the photograph, *top.* Dial A's pointer must make a complete revolution for dial B's to move ahead one unit, and so on down the line.

c. Read the following watt - hour meters and record your results.

Last month's reading



This month's reading



d. Find the amount of kilowatt - hours that were used during the month.

e. Using the schedule (rate charged by the electric company) in the introduction to this investigation, find the electric bill which would be charged for the difference between the two readings in step c above.

f. Read the watt - hour meter of your home at one month intervals and then calculate what your bill should be. Compare this figure with the bill sent by the electric company. (Note: In Frederick County, electric bill are sent out at two month intervals.)

Interpretations:

1. If your calculation of an electric bill does not agree with the one sent by the electric company, what could account for the difference?

2. If you find an unexplained difference between a bill from the company and what you calculate the bill should be, what should you do?

Conclusion:

a. How do we pay for the electric power we use, ie., explain how to figure an electric bill.

b. Optional Activity - Have a guest speaker come to your class from the electric company to lecture and answer questions from your class.

c. Optional Activity - List all the electrical appliances in your home. Look up the power rating of each appliance in the table p.19 (a better way is to look on the appliance if the information is given.) Keep a record of the number of hours each appliance is in use and then calculate the number of kilowatt - hours that were used in your home for that day. If you want to have precise results, you will need to know the number of feet of wiring and the kind of metal in the wire. Since wire has resistance, some electric power is used by the wiring of your house. Does this method of finding power consumption agree with monthly meter readings?

ELECTRICAL RATINGS OF SOME HOUSEHOLD DEVICES

Device	Watts	Device	Watts
Lamp bulbs	7½ watts upward	Portable heater	600 to 1,500
Radio	75 to 100	Hot plate per burner	500 to 1,000
Refrigerator	200 to 275	Mangle	1,200 to 1,500
Electric iron	600 to 1,000	Electric range per	
Coffeemaker	500 to 900	burner	500 to 1,200
Toaster	500 to 1,000	Electric range all	
Electric fan	25 to 300	burners	up to 12,000
Sewing machine	50 to 75	Water heater, tank	
Heating pad	10 to 60	type	1,500 to 3,000
Electric blanket	100 to 300	¼ horsepower motor	325
Sunlamp	275 to 600	½ horsepower motor	600
Clock	1 to 3	1 horsepower motor	1,000
Vacuum cleaner	150 to 500	Television	200 to 300
Kitchen mixer	150 to 250	Freezer	200 to 300

d. Optional Activity - Find out by research whether heating homes is more economical using electricity or by other means. Your research should involve more than just asking different companies because they will be biased. Report to your class.

e. Optional Activity - Filmstrip - Electrical Terms And Use, Potomac Edison

J. Review

OBJECTIVES:

To review the 25 objectives of this mini - course.

ACTIVITIES:

a. cryptogram - see your teacher

b. crossword puzzle - see your teacher

An important point to make with all your students for the first few days and then periodically throughout this mini-course is: Respect electricity. Although your students probably will not be dealing with harmful amounts of electricity, they can harm their equipment. Stress this idea about being careful when using electricity - promote safety for the student and safety for the equipment the student is using.

Each section is intended to be one period in length. All reference sheets and problem sheets should be mimeographed for the students.

A. Properties of Electric Circuits

Materials for lab, Problem Sheet 7-7

dry cell	lamp socket (to fit bulb)
flashlight bulb	cell holder (optional)
enameled wire	knife switch
sand paper	small screw driver

During your discussion of this Lab, you can summarize the main ideas very nicely with Milliken transparency #6, Complete Circuit. (Note: If you do not use reference sheet 7-3 from this same text, you may need to review the nature of current electricity. Procedure 1 of this lab tells the student to review this information.)

B. Two Types of Circuits - Series and Parallel

As you can see, no attempt to measure electricity has as yet been made. If you do not have enough bulbs to carry out the lab as it is written, you should do this lab as a demonstation.
The Milliken transparency #7, Electricity Book may be used here, but it is advisable to omit discussing the ammeter shown in the circuit. The Milliken transparency #12, Electricity Book Electrical Circuits At Home will aid in your discussion of parallel circuits.

C. Protecting Circuits

a. If you could have some actual fuses as shown in Pathways p. 21 to pass around as the students read, they will understand this passage.

b. Your demonstration will depend on the materials available. A simple set-up would be to use a standard fuse in a socket which is placed in series with several other appliances (resistances). If you use a 15 amp fuse, it will blow when you connect enough resistances (appliances such as an iron, toaster, fan, etc.) in a parallel circuit. You will need to explain that, as the current increases, heat is generated, and the fuse "blows" - actually melts.

This opens the circuit and prevents further heating. Ask students why they should not put a penny "behind" a blown fuse.

c. Tell students to keep fingers clear of their "home-made" fuse when they close the circuit.

You may now summarize section C. Protecting Circuits by using Milliken transparency # 8, Electricity book.

d. Film: 290F092 Elements of Electrical Circuits, 11 min. Board of Education.

D. Circuit Symbols

a. You may want to add or delete from this list as you choose.

b. Circulate around the room while the students are memorizing the selected symbols.

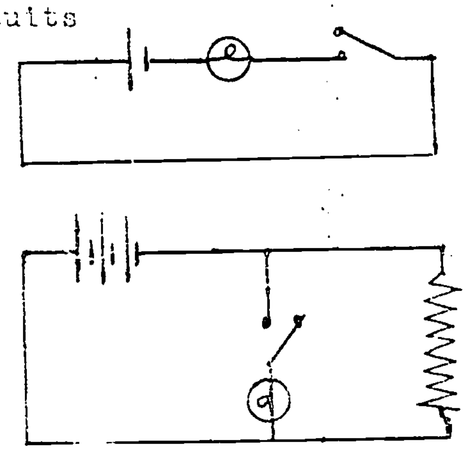
c. Self checking Quiz - Simply call out in any order you choose, the symbols and have students answer on their own papers. If majority of class gets 10 or more correct on the first try, then go on to activity d. If your students are self paced you will need to provide a self test quiz for them to administer to themselves at this point.

d. Use your own judgement here - you may want to omit this activity, or if your class shows interest and/or need, go into greater depth .

Sample circuits

1)

2)



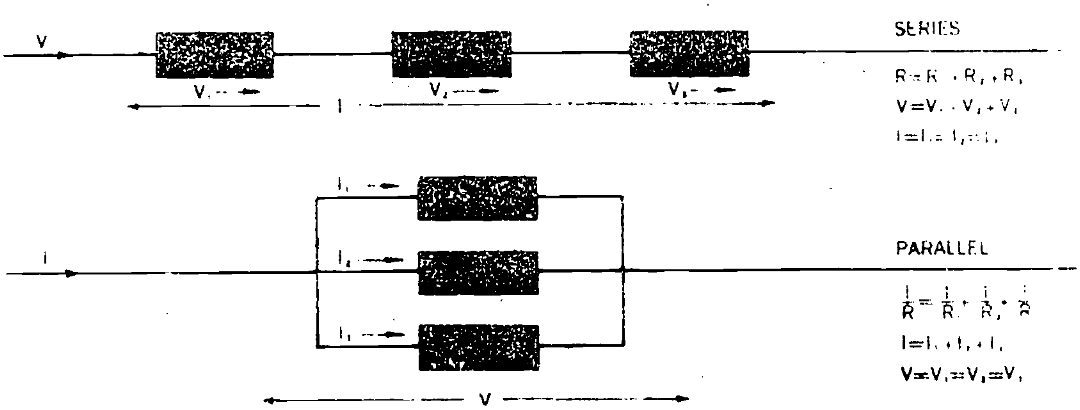
E. Units and Instruments (meters) for Measuring Electricty

a. Remind students to close circuits for as long as it takes to make a reading. If your school has multimeters, you probably will need to give instructions as to how they operate (ie., settings, ranges, scales, and plug in positions). It might be a good idea to have each team signal when they have a particular circuit set-up finished. Then you (the teacher) can avert any incorrect placement of meters in the circuit which would damage the meter.

Transparency #16, Series and Parallel Circuits from the Milliken book, Magnetism & Electricity can be used to summarize this Lab. The ditto #16 could be used as a quiz.

F. Finding Resistance Without an Ohmmeter (Optional)

Even if you do this lab with your capable students, make it clear to them that measuring electricity is not as simple as these labs seem to indicate. Explain that parallel circuits require different variations of Ohm's Law; and, that when you work with alternating current, the mathematics become quite complicated. For those who insist on more information show them the diagram below. If they insist on more details, give them one or more of the resources listed in this manual. If they want still more information get them a physics text or an electronics text.



In a series circuit, the voltage across each resistor is different, but the current is the same in each resistor. In a parallel circuit, the current splits up so that it is different in each branch. The total current in a parallel circuit is the sum of the individual currents. The voltage in a parallel circuit, however, is the same across each resistor and across the whole circuit.

G. Sending Electricity to Our Homes

a. The film, Powerline-Transportation of Energy, 300F95130 is 11 minutes long and is listed under social studies but it has scientific implications.

b. No comment.

c. You may omit procedures 4 and 5 if you don't have the equipment. However, you should make an attempt to explain the concepts of transformers using the chalk board, lecture, or by duplicating material from one of the may resources listed in this manual.

H. Measuring Electrical Energy Used by an Electrical Appliance

a. Since students will be working with house current in this lab, it is essential that they be supervised closely in the use of their instruments. You could use the transparency and ditto sheet #20 from the Milliken Book, Magnetism and Electricity, to summarize the importance of not using more wattage in a particular circuit than it is designed to carry.

b. This special project should be done by one person or by a team of persons who will give one report to the class.

I. Power Consumption - Figuring Your Electric Bill

a. If your students have difficulty with math, you may want to modify this activity and give them only one rate for all the kilowatt-hours used. If your school does not have watt-hour meters for demonstration purposes, you could assign a student or students to build one large enough for your whole class to see.

b. Finding someone from the electricity company to come talk with your class will be your biggest problem - good luck!

c. This activity would become quite involved and only highly motivated students should attempt this.

d. This activity will require research into the topic of heat loss and gain. Only highly motivated and students well prepared in math should attempt this activity.

J. Review

a. Cryptogram - for "below average" students.

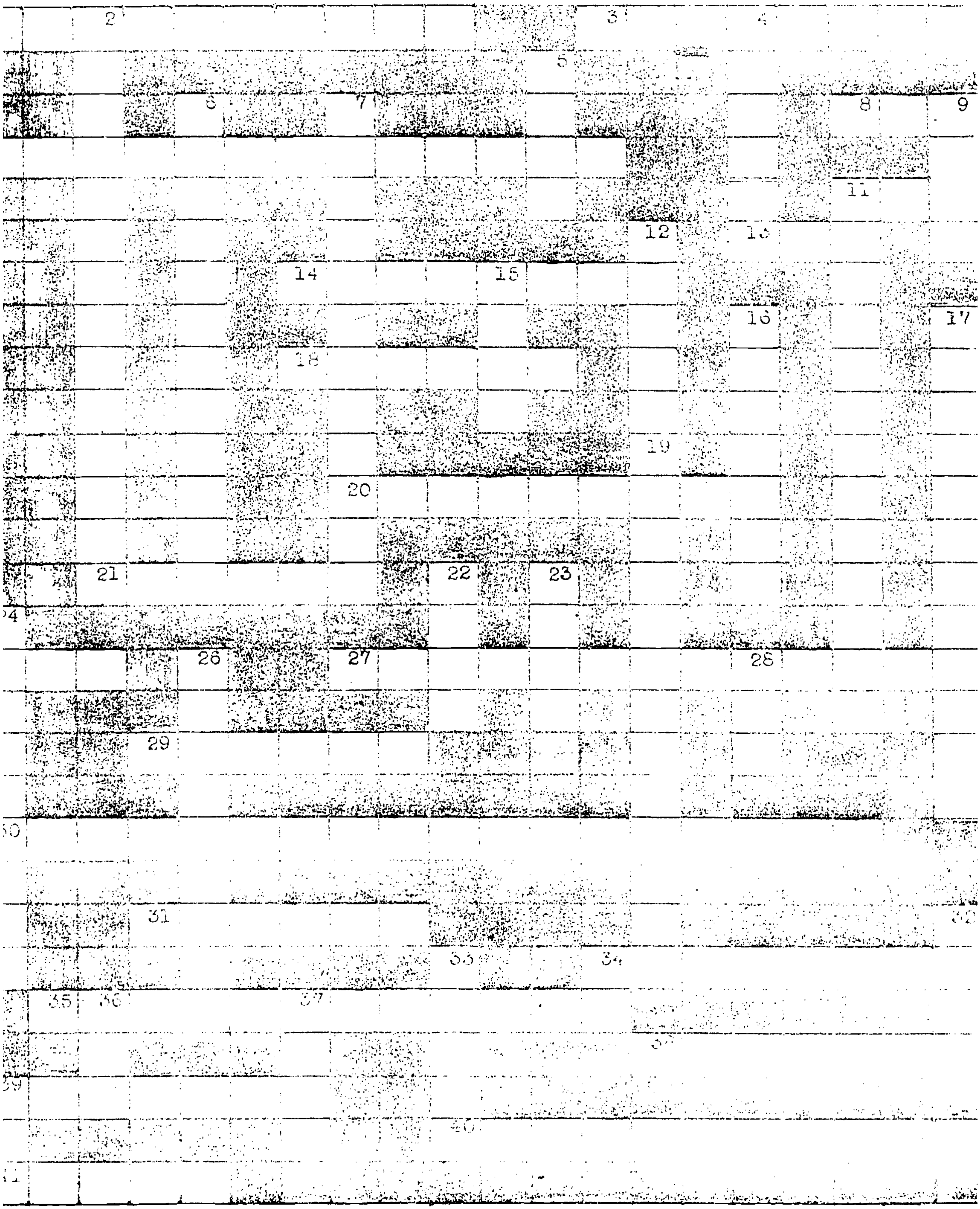
b. Crossword Puzzle - for "average" and "above average" students.

E	L	E	C	T	R	I	C	I	T	Y	J	G	E	H	T	F	X	V	C	P
C	L	R	B	R	R	T	C	G	H	C	K	F	L	J	T	G	G	W	O	R
N	L	O	P	A	S	I	I	E	R	I	W	D	E	T	A	L	U	S	N	I
A	E	C	O	N	T	U	R	H	G	R	L	D	T	K	W	H	G	Z	D	M
I	C	N	W	S	D	C	C	I	F	C	M	C	R	L	D	F	N	B	U	A
L	Y	O	E	F	T	R	U	B	L	U	B	C	I	R	C	U	I	T	C	R
P	R	R	R	O	R	I	I	J	D	I	N	B	C	M	C	S	R	C	T	Y
P	D	I	C	R	E	C	T	K	S	T	P	Z	B	N	B	E	I	D	O	C
A	M	P	O	M	C	N	B	L	T	S	Q	Y	I	O	Z	J	W	F	R	O
D	C	U	M	E	T	E	R	M	E	Y	S	P	L	I	T	R	I	N	G	I
F	L	P	P	R	C	P	E	N	K	M	V	P	L	T	Y	K	V	G	W	L
G	I	E	A	G	U	D	A	V	C	B	R	X	Q	R	E	T	E	M	M	A
H	O	T	N	A	R	O	K	O	O	O	H	M	M	E	T	E	R	H	V	X
L	C	S	Y	L	R	H	E	P	S	L	I	P	R	I	N	G	T	J	T	Y
I	L	R	S	V	E	M	R	Q	C	S	T	W	R	H	C	T	I	W	S	Z
O	O	E	E	A	M	V	F	R	B	W	O	M	A	N	Y	D	S	K	E	B
C	S	S	C	N	T	E	R	M	I	N	A	L	E	S	X	L	R	L	I	E
Y	E	I	N	O	P	W	D	R	I	N	D	U	C	T	I	O	N	M	R	N
R	D	S	A	M	O	P	E	W	A	L	S	M	H	O	E	M	Q	N	E	I
A	C	T	I	E	W	A	C	T	I	U	C	R	I	C	T	K	O	H	S	L
D	I	A	L	T	E	R	N	A	T	I	N	G	C	U	R	R	E	N	T	F
N	K	N	P	E	R	A	B	S	Z	N	W	O	D	P	E	T	S	P	S	E
O	C	C	P	R	L	L	A	S	C	I	E	N	C	E	I	S	F	U	N	W
C	H	E	A	Q	I	L	Z	T	Y	S	T	V	T	V	W	N	P	Q	R	O
E	I	J	N	P	N	E	Y	V	X	Y	L	P	P	U	S	R	E	W	O	P
S	T	K	L	M	E	L	X	W	R	U	O	H	T	T	A	W	D	L	I	K

What "secret message" can you find in the cryptogram?

meter	wire	circuit symbols
circuit	bulb	coil
series	ammeter	resistance
parallel	voltmeter	transformer
electricity	ohmeter	step-up
switch	amp	step-down
conductor	volt	iron core
open circuit	ohm	insulated wire
closed circuit	Ohm's Law	galvanometer
short circuit	fuse	power line
sockets	circuit breaker	primary coil
terminals	power supply	secondary coil
direct current	dry cell	dynamo
split ring	alternating current	slip ring
induction	electric bill	appliance
kilowatt-hour	power company	watt
		wiring

CROSSWORD PUZZLE



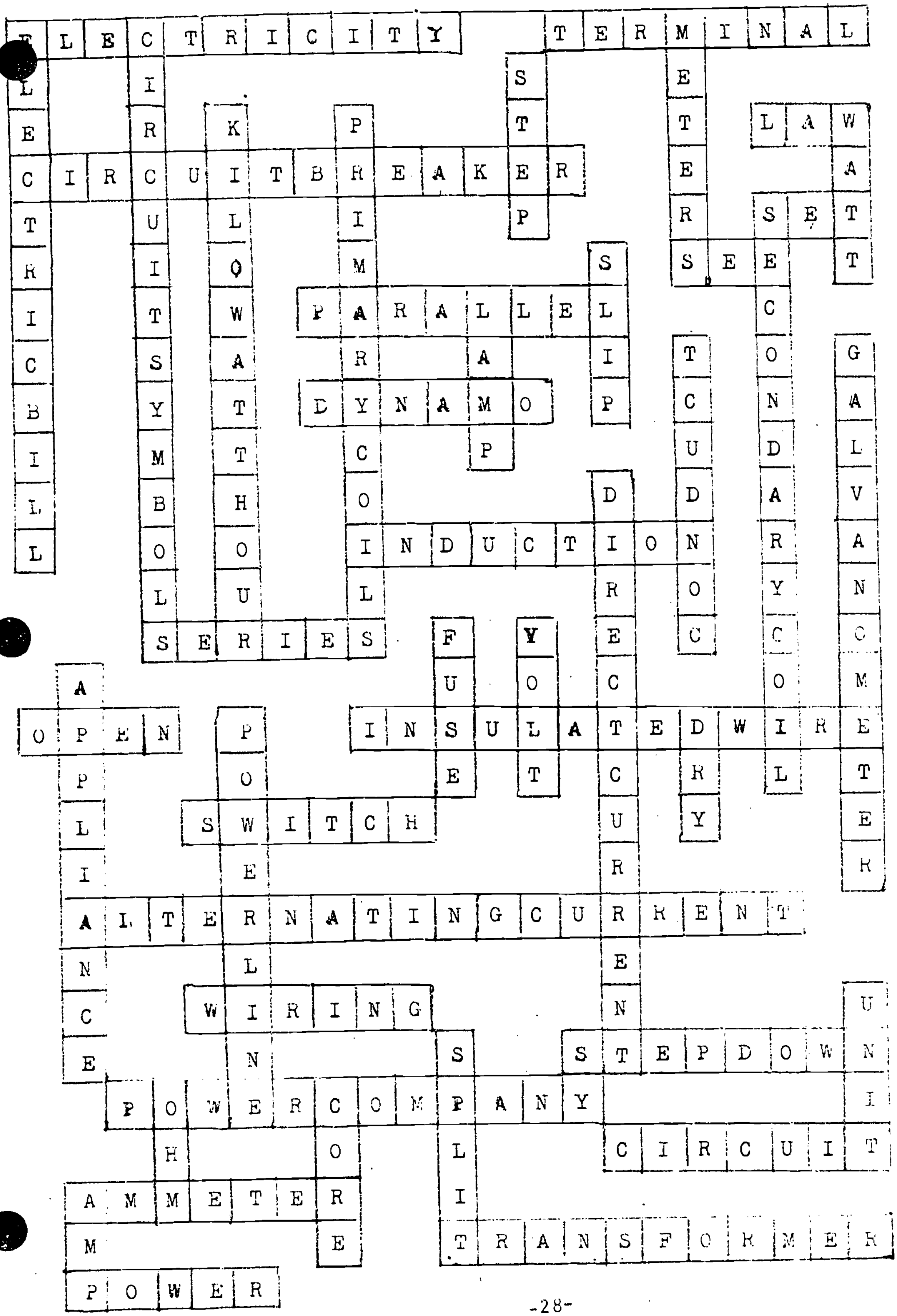
ACROSS

1 energy in the form of flowing electrons
3 end; that part of an electrical device to which wires are attached
8 Ohm's ______; the ratio of volts to amps $R = \frac{E}{I}$
10 a device which automatically opens an electrical circuit when too much current flows
11 to put in place; to open a closed circuit breaker
13 have or use the sense of light
14 _________ circuit; a circuit with more than one path for flow of electrons
18 another word for generator
20 to cause; as the current in the primary causes ________ of another current in the secondary
21 a type of circuit which has only one path for the electron flow
25 __________ circuit; electricity cannot flow through this circuit
27 a conductor in long slender strands which has a covering that allows it to carry electricity with safety (two words)
29 a device which either opens or closes a circuit
30 electricity which changes direction of flow at a regular rate; abbreviated AC
31 the conducting material which carries electricity to all parts of your home
34 _______-_______ transformer, a device which reduces the voltage
35 a service organization which sells electrical power
38 a path that electrons follow
39 an instrument which measures the flow of electrons in a circuit
40 a device to change the current or voltage during electrical power transmission
41 the rate of using energy

DOWN

1 charge made for the electric service in your home
2 characters used to make diagrams representing the path of electricity
4 devices used to measure, for example, voltmeters and ammeters
5 ___________-up transformer
6 a unit of power involving electricity
7 turns of wire which supply electricity to a transformer
9 a unit of electrical energy
11 turns of wire through which electricity flows from a transformer
12 rub against; or ________ ring, part of an A.C. generator
15 a device which gives off light
16 to carry; the word is spelled backwards in the puzzle
17 a very sensitive ammeter
19 the flow of electrons in one direction within a circuit
22 a device which melts and opens a circuit which is overloaded
23 a unit of electrical pressure
24 a device which uses electricity to do a use service
26 wire which carries electricity from a power plant to places where the electricity is used
28 _________ cell; a device which makes electricity from chemical energy
32 one of anything; a way of expressing different kinds of measurement
33 to divide or ________ ring, part of a D.C. generator
34 abbreviation for a word which means a mark or sign that stands for another object, or for an idea, quality, etc.
36 a unit of electrical resistance
37 the center of something; the long tubular material around which wire is coiled

CROSSWORD PUZZLE SOLUTION



Objectives

The student will be able to:

1. assemble a simple circuit given a power source, switch, conductor, and a means of determining electric current flow.

2. define and demonstrate an open and a closed circuit.

3. determine whether or not a current is flowing in a circuit, given the proper materials.

4. given the proper materials, assemble a series and a parallel circuit.

5. state a difference in the physical appearance of a series and a parallel circuit.

6. define a short circuit.

7. describe the function of any of the conventional circuit breakers - fuses, etc.

8. identify 15 selected circuit symbols commonly used in electronic circuit diagrams.

9. draw very simple circuits using the selected symbols and specifications as to their location in the circuit.

10. demonstrate the proper use of an ammeter.

11. demonstrate the proper use of a voltmeter.

12. demonstrate the proper use of an ohmmeter.

13. demonstrate the effect on amperage and voltage when resistance is changed in a circuit.

14. state the mathematical relationship between amps, volts, and ohms $(R = \frac{E}{I})$

15. calculate the resistance of an object using an ammeter, a voltmeter, and Ohm's Law.

16. assemble a primary and a secondary coil using a common (the same) core of soft iron.

17. demonstrate the induction of a current in the secondary coil of a transformer by applying a current in the primary coil.

18. define step-up and step-down transformer.

19. diagram the transfer of electricity from power plant to your home showing the major places where transformers are used.

20. define electricity in terms of energy.

21. calculate the energy requirements of an electrical appliance while it is in use.

22. define electrical power in terms of watts and hours.

23. define the term <u>kilowatt-hour</u>.

24. read a watthour-meter.

25. calculate an electric bill for one month.

RESOURCES

Resources marked * are primarily for student use or for teacher duplication.

Matter, Life, and Energy, Lyons & Carnohan, 1972, Ch. 15-18, pp. 256-323

Physical Science Challenges To Science, McGraw Hill, 1973, Ch. 19-23, pp. 272-353

Focus on Physical Science, Charles E. Merrill Pub. Co., 1974 Ch. 18-19, pp. 374-409

Physical Science, Lippincott, 1972, Ch. 9-10, pp. 277-351

Energy Matter and Change, Scott Foresman, 1973, Ch. 6-8, pp. 116-225

Physical Science Investigations, Houghton Mifflin, 1973, Ch. 8, pp. 244-300

Science You Use, Prentice Hall, 1964, Topic 3, pp. 77-112

Spaceship Earth, Physical Science, Houghton Mifflin, 1974, Ch. 6-8, pp. 113-184

* Physical Science, soft back, Cambridge, 1971, pp. 69-80

Physical Science, Ginn, 1971, Ch. 12-13, pp. 278-326

Modern Physical Science, soft back, Holt, Rinehart & Winston, 1974, Exercises and Investigations, Ch. 31-37, pp. 155-176

Modern Physical Science, soft back, Holt, Rinehart & Winston, 1974, Lab Investigations, Exp. 36-38, pp. 100-108

Modern Physical Science, soft back, Holt, Rinehart & Winston, 1974, Ch. 31-37, pp. 562-673

Physical Science Review Test, softback, 1970, Amsco School Publications, Ch. 17, pp. 318-343

Modern Science Forces, Changes, and the Universe, Holt, Rinehart & Winston, 1972, Ch. 10, pp. 268-304

* Pathways in Science, Globe, 1968, Textbook 1 - Physics, Units I, II, III, pp. 1-122

* Pathways in Science, Globe, 1968, Lab Book - Physics 1, Labs 3, 6, 8, 10

Energy, It's Forms and Changes, Harcourt, Brace, 1972, Ch. 11-13, pp. 91-113

Basic Physical Science, Singer, 1964, pp. 418-430

* Physical Science, Cambridge Book Co., 1971, pp. 206-224

World Book Encyclopedia, 1972, Volume 6

* Electricity, Transparency Book, Milliken, 1969

* Magnetism and Electricity, Transparency Book, Milliken, 1969

Exploring Physical Science, Allyn & Bacon, 1970, Ch. 10-13, pp. 273-432

Film : Elements of Electrical Circuits, Board of Ed., F092

Film : Powerline : Transportation of Energy, Board of Ed., F951

Evaluation Form for Teachers

Name of mini-course ______________________________

Evaluation Questions	Yes	No	Comments
1. Did this unit accomplish its objectives with your students?			
2. Did you add any of your own activities? If so, please include with the return of this form.			
3. Did you add any films that other teachers would find useful? Please mention source.			
4. Were the student instructions clear?			
5. Was there enough information in the teacher's section?			
6. Do you plan to use this unit again?			

7. Which level of student used this unit? ______________________________

8. How did you use this unit - class, small group, individual? __________

____

PLEASE RETURN TO SCIENCE SUPERVISOR'S OFFICE AS SOON AS YOU COMPLETE THE COURSE.

SCIENCE MINI-COURSES

PHYSICAL SCIENCE	Prepared by
ELECTRICITY: Part 1 (Types of Generation of Electricity)	Marvin Blickenstaff
ELECTRICITY: Part 2 (The Control and Measurement of Electricity	Marvin Blickenstaff
ELECTRICITY: Part 3 (Applications for Electricity)	Marvin Blickenstaff
CAN YOU HEAR MY VIBES? (A Mini-course on Sound)	Charles Buffington
LENSES AND THEIR USES	Beverly Stonestreet
WHAT IS IT? Identification of an Unknown Chemical Substance	Jane Tritt
BIOLOGY	
A VERY COMPLEX MOLECULE: D.N.A. The Substance that Carries Heredity	Paul Cook
Controlling the CODE OF LIFE	Paul Cook
Paleo Biology – BONES: Clues to Mankind's Past	Janet Owens
A Field Study in HUMAN ECOLOGY	Janet Owens
Basic Principles of GENETICS	Sharon Sheffield
HUMAN GENETICS – Mendel's Laws Applied to You	Sharon Sheffield
SCIENCE SURVEY	
WEATHER Instruments	John Fradiska
TOPOGRAPHIC Maps	John Geist and John Fradiska
CHEMISTRY	
WATER	Ross Foltz
PHYSICS	
PHYSICAL OPTICS	Walt Brilhart