DOCUMENT RESUME

ED 034 333 40 EC 004 359

AUTHOR	Budoff, M.
TITLE	An Educational Test of the Learning Potential Hypothesis with Adolescent Mentally Retarded Special Class Children, Volume II. Final Report.
INSTITUTION	Cambridge Mental Health Center, Mass.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C. Bureau of Research.
PUB DATE	[69]
NOTE	216p.
AVAILABLE FROM	Cambridge Mental Health Center, 20 Sacramento Street, Cambridge, Massachusetts 02138.
EDRS PRICE	EDRS Price MF-$1.00 HC Not Available from EDRS.
DESCRIPTORS	*Curriculum Guides, Educable Mentally Handicapped, Electricity, *Exceptional Child Education, Instructional Materials, Junior High School Students, Lesson Plans, Manipulative Materials, *Mentally Handicapped, Nonverbal Learning, *Sciences, *Teaching Methods, Workbooks, Worksheets

ABSTRACT

A manipulative, nonverbal oriented unit on electricity which was used in an experiment with educable mentally handicapped students is presented. Lessons and worksheets to accompany them are represented with instructions and drawings. A teacher's curriculum guide for the unit includes concepts to teach, materials, lectures and activities, and answers to questions the students are asked to complete. Also presented are the lessons from the students' workbooks for the lecture-demonstration electricity unit. These materials were used in research reported in EC 004 358. [Not available in hard copy due to marginal legibility of original document.] (RJ)

BR-6-1184-VOL II
PA-40
OE-BR

ED034333

FINAL REPORT
Project No. 6-1184
Grant No. 32-31-0000-6019

Volume II

AN EDUCATIONAL TEST OF THE LEARNING POTENTIAL HYPOTHESIS WITH ADOLESCENT MENTALLY RETARDED SPECIAL CLASS CHILDREN

M. Budoff
Principal Investigator

J. Meskin
Educational Coordinator

Cambridge Mental Health Center
20 Sacramento Street
Cambridge, Massachusetts, 02138

The research reported herein was performed pursuant to a grant with the Office of Education, U.S. Department of Health, Education and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

Office of Education
Bureau of Research
Division of Handicapped Children and Youth

EC 004 35?E

APPENDIX G.

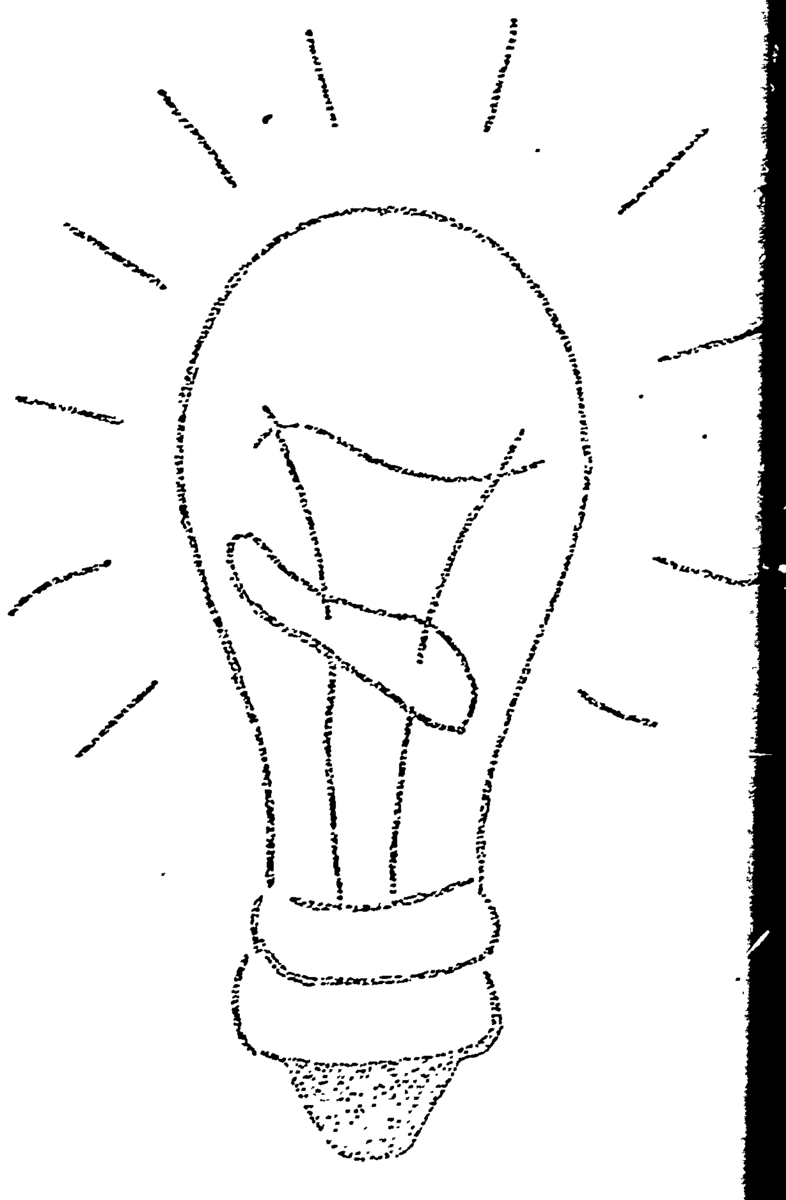
STUDENT'S WORKBOOK FOR THE MANIPULATIVE-

EXPLORATORY ELECTRICITY UNIT*

*Called "Experiments in Electricity" in the concluding (1968) study (Section VI).

Experiments in Electricity

Grade 8



NAME ______________________

BEGINNING CIRCUITS
Lesson 1

KEEPING RECORDS OF WHAT YOU DO IS IMPORTANT IN SCIENCE:

You have a battery and a bulb and a wire:

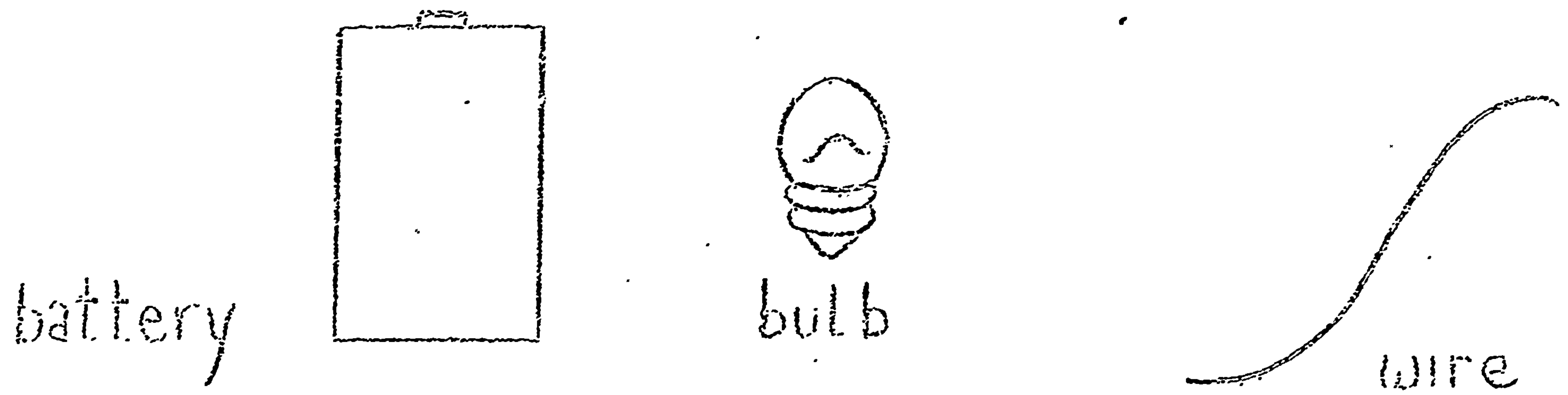
1. Can you make the bulb light?

2. See how many ways you can hold the wire and bulb on the battery and still have the bulb light.

3. When you have made the bulb light in as many ways as you can, try doing some of the positions over again.

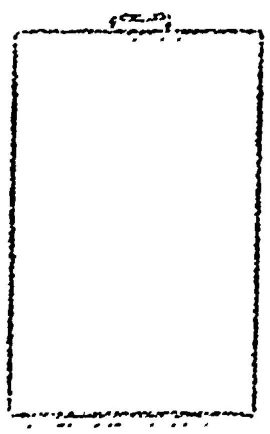
4. Look carefully at all of the positions that you try so you will be able to draw a picture of them. Some of them will light the bulb and some positions will not light the bulb.

MAKE YOUR DRAWINGS AS BIG AS THIS:



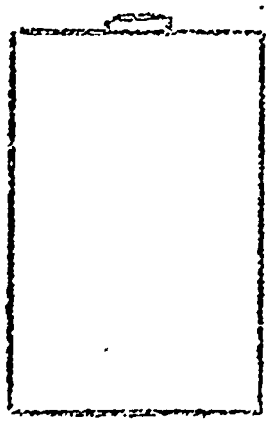
PRACTICE EXAMPLES:

Draw a picture of the bulb and wire on the battery with the bulb lights



YES

Draw a picture of the bulb and wire on the battery when the bulb does not light

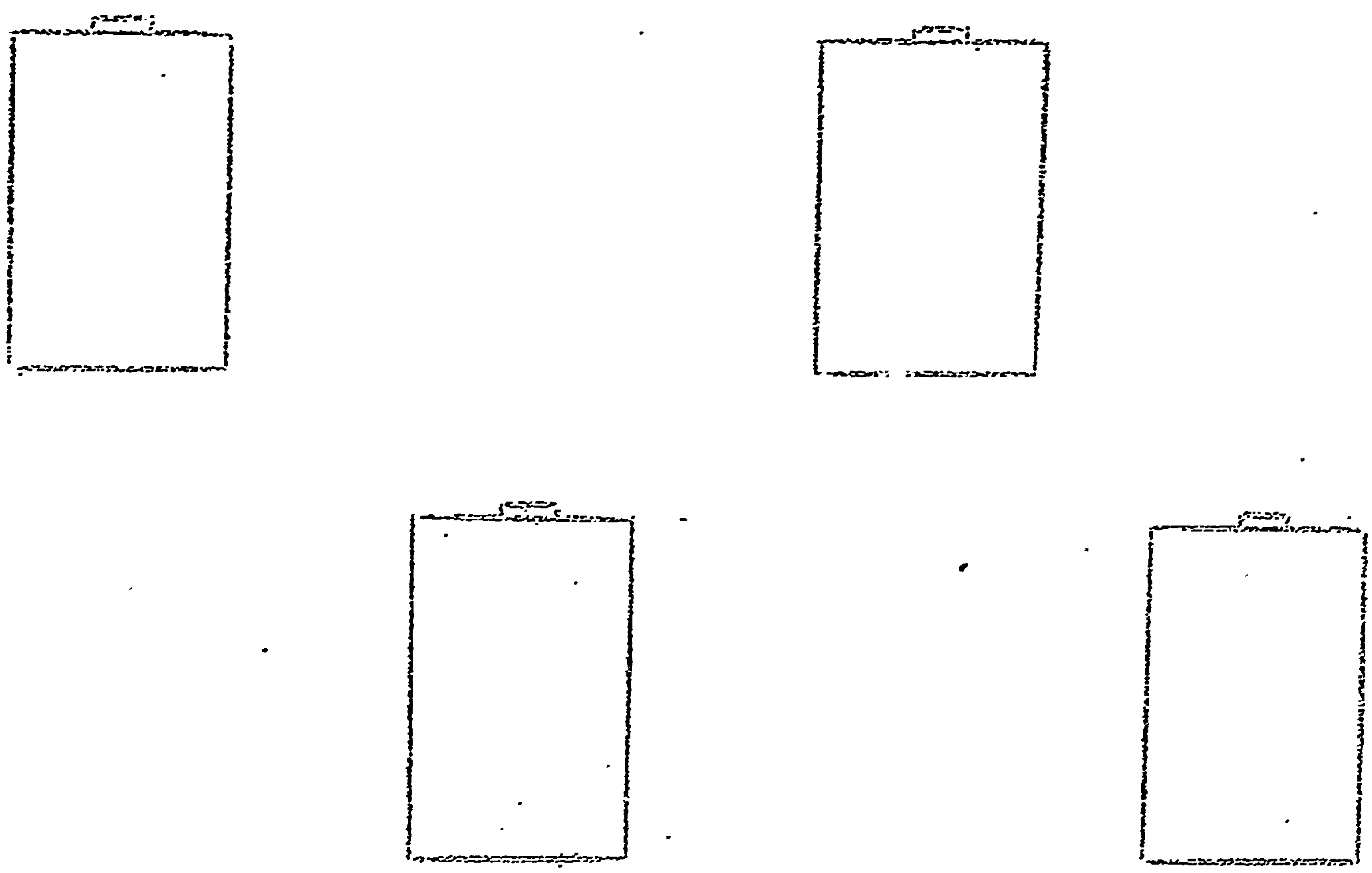


NO

NAME ______________________

WORK SHEET
Lesson 1 (a)

SHOW POSITIONS OF BULB AND WIRE WHICH WILL LET THE BULB LIGHT:

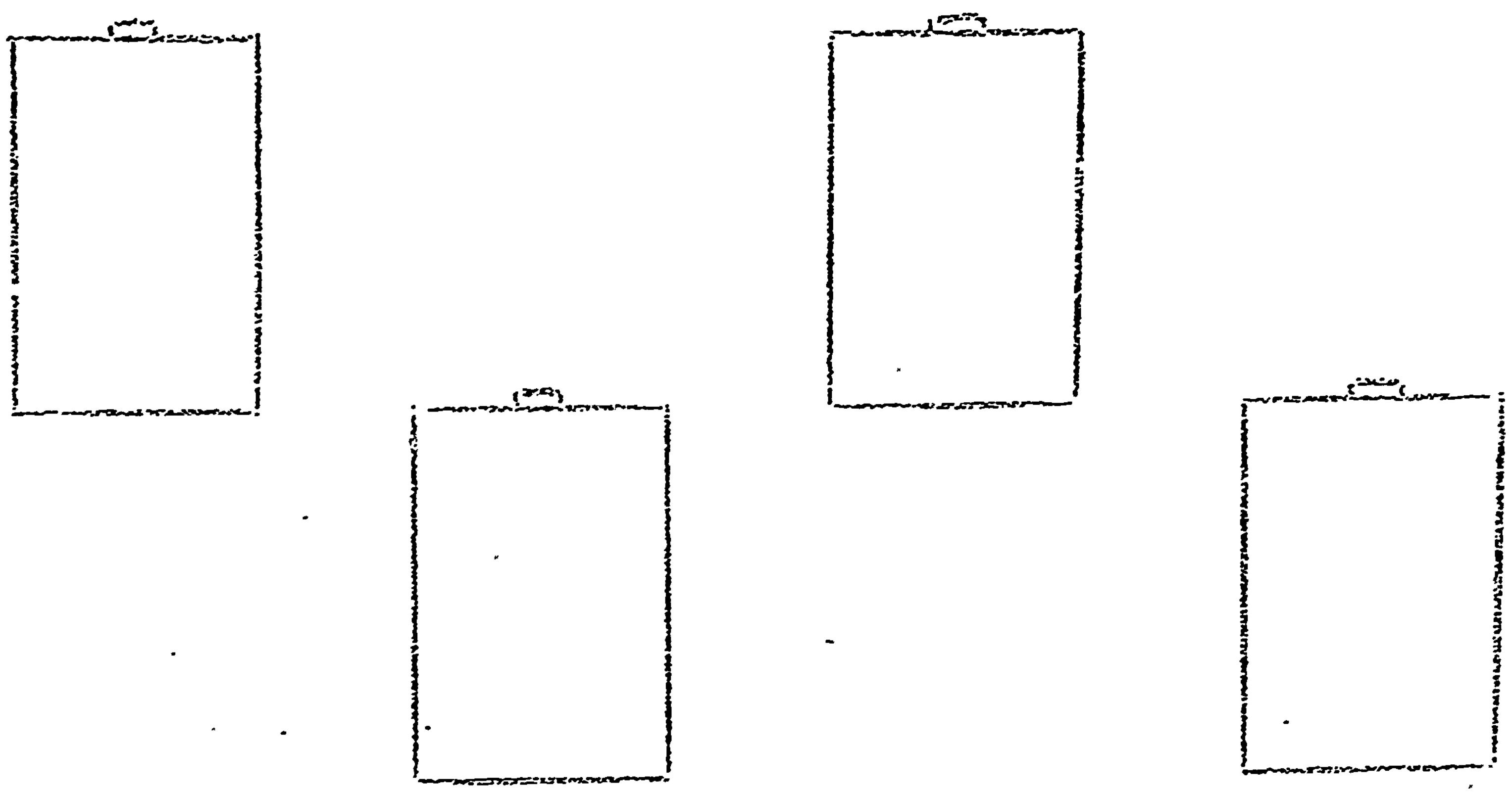


NOW, DRAW YOUR OWN DIAGRAMS, IF YOU NEED MORE

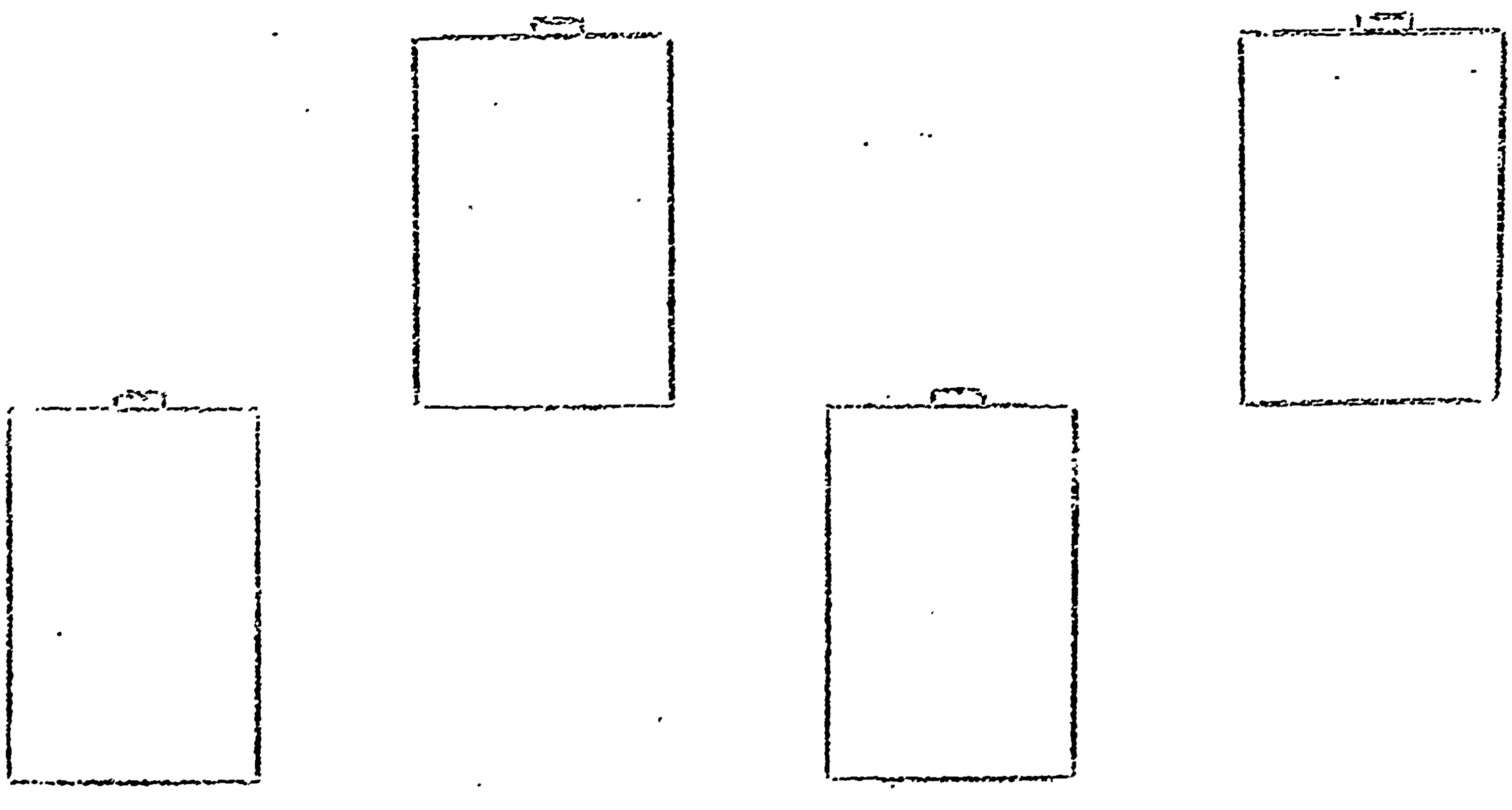
NAME

WORK SHEET
Lesson 1[illegible]

BULB WILL LIGHT:



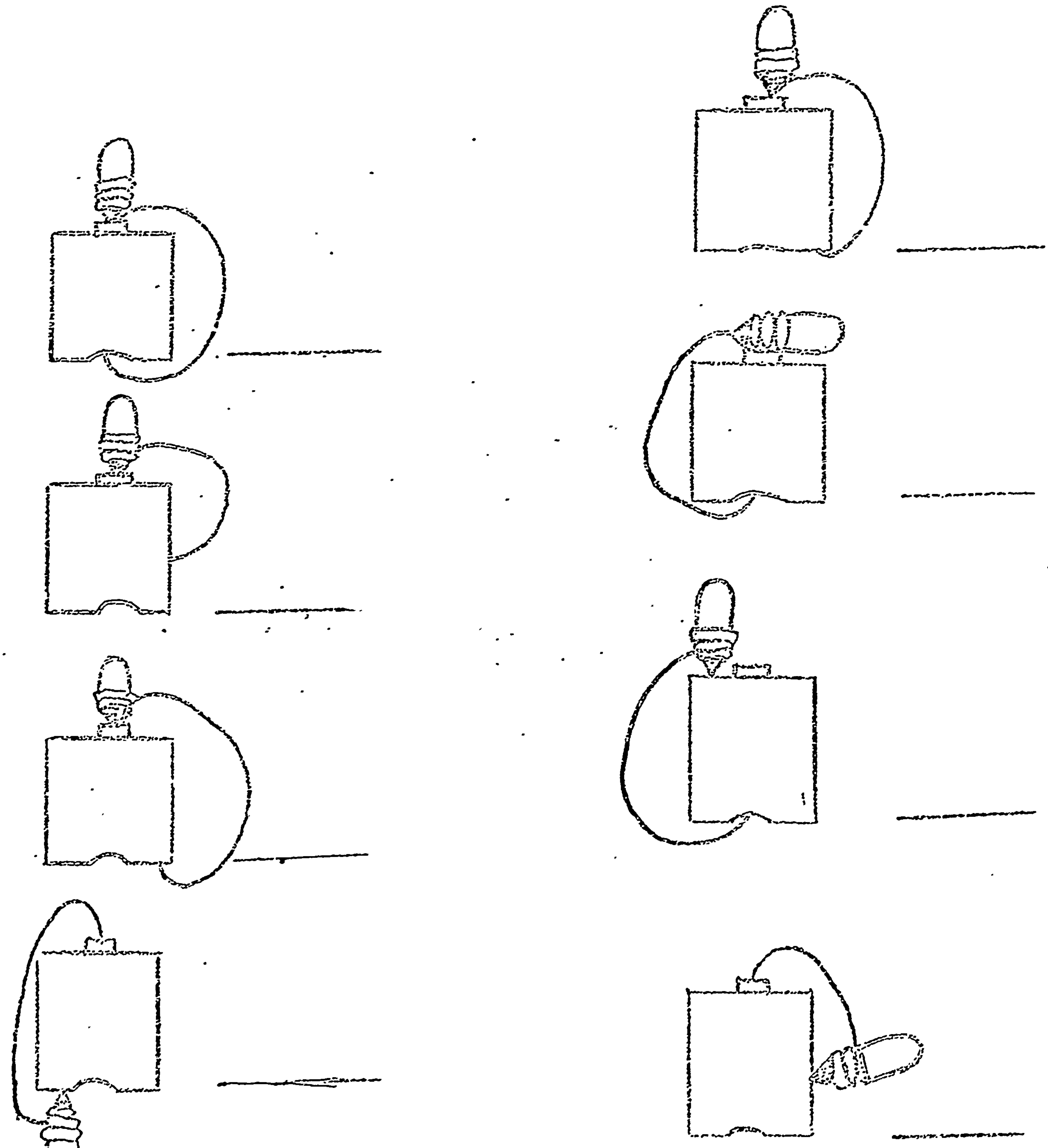
BULB WILL NOT LIGHT:



WORK SHEET 2A

TRY MAKING THESE CIRCUITS

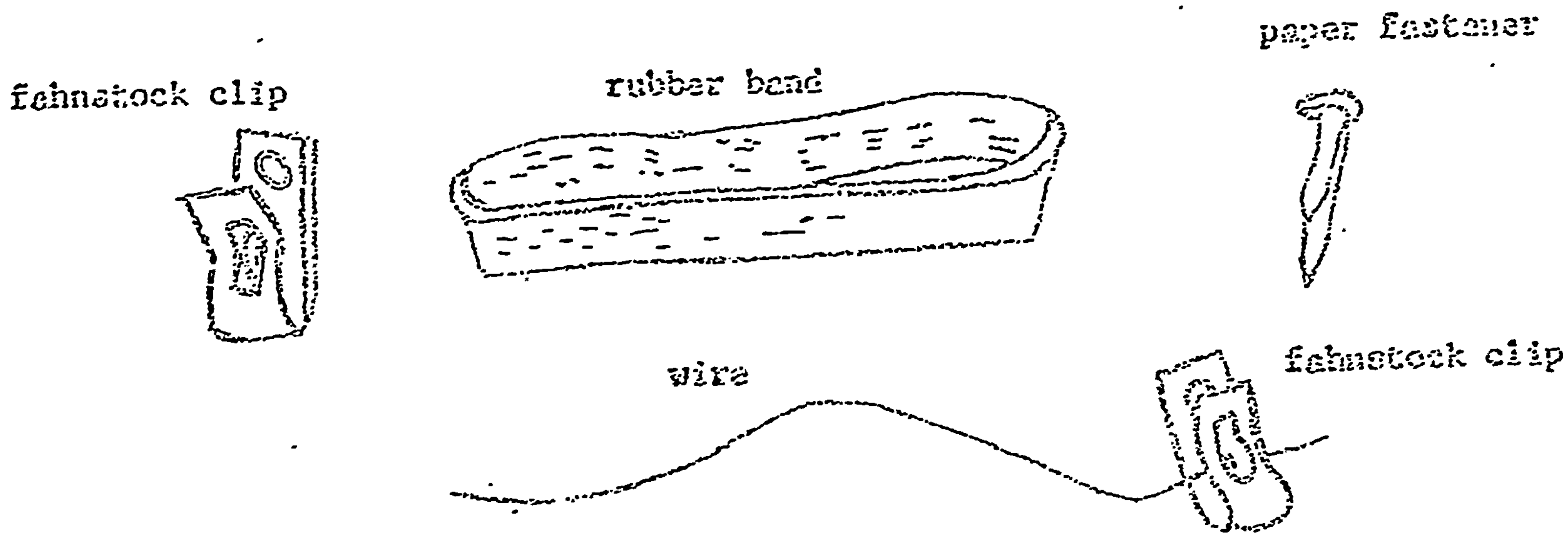
Write YES if the bulb lights.
Write NO if the bulb does not light.



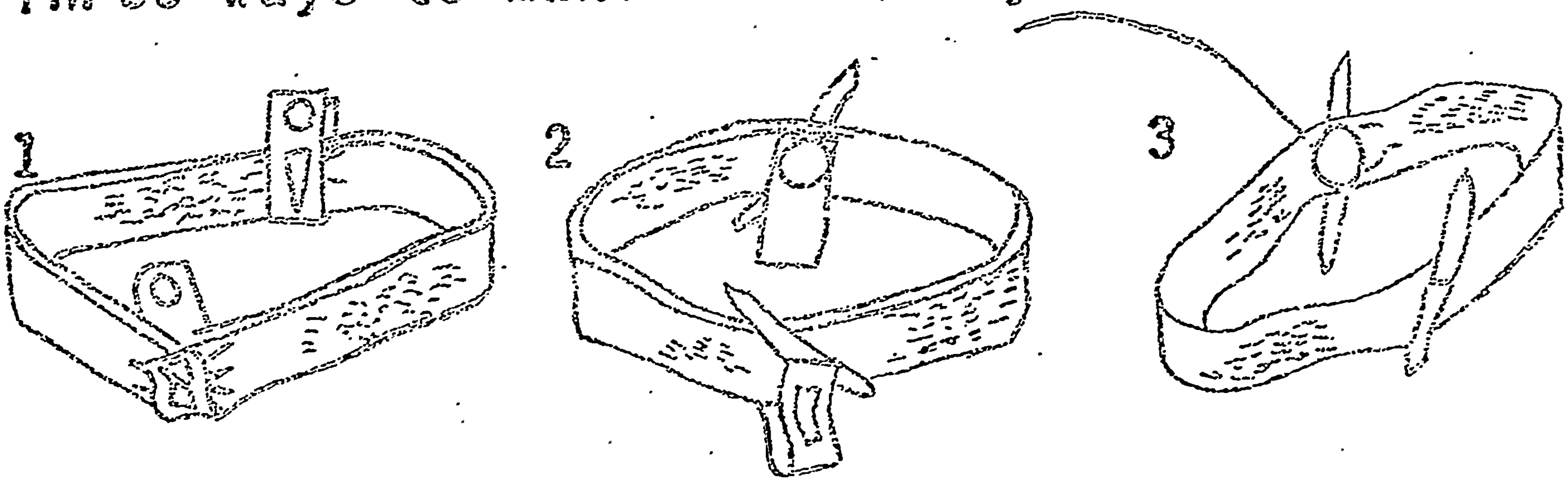
BATTERY HOLDERS

Sheet 4a

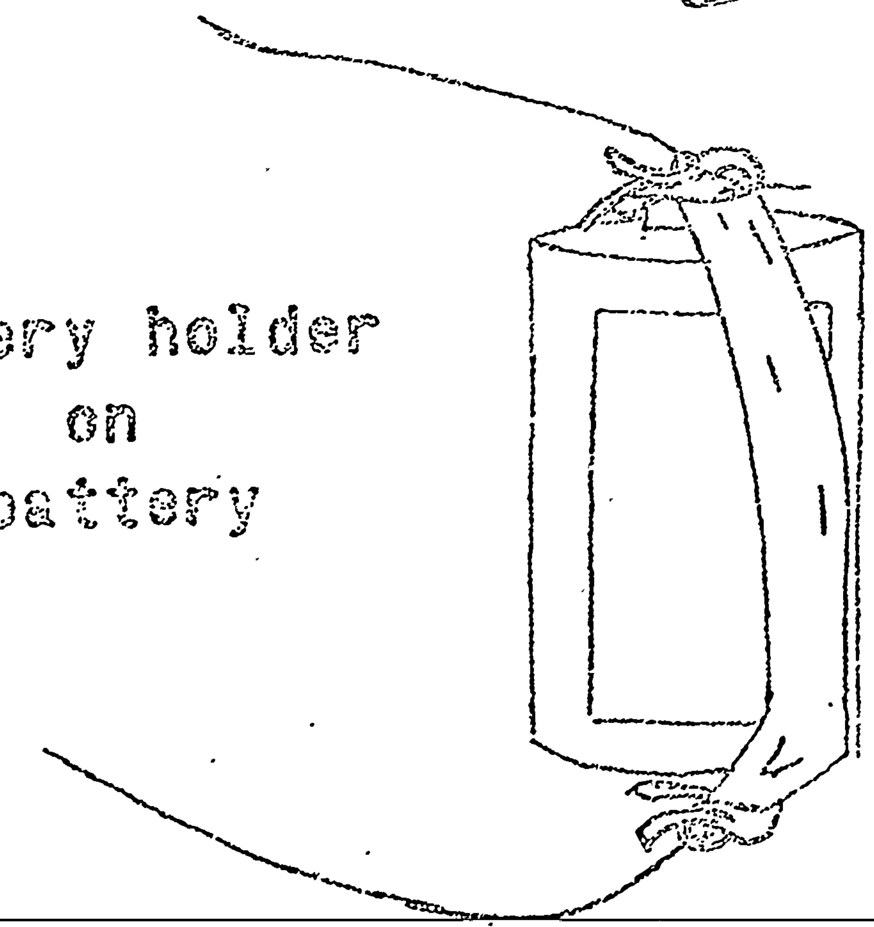
name



Three ways to make a battery holder



battery holder
on
battery



WORK SHEET 4b

____
name

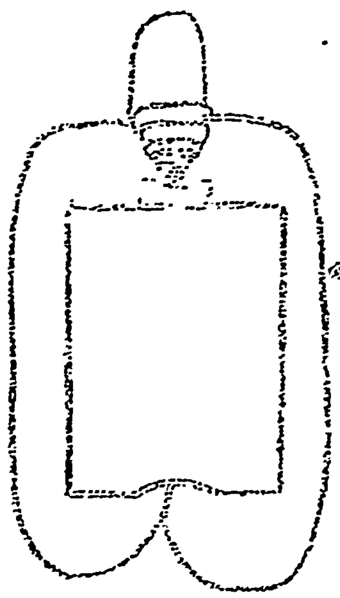
USING TWO WIRES

Try some of these circuits

Writt YES if the bulbblights

Write NO if the bulb does not light

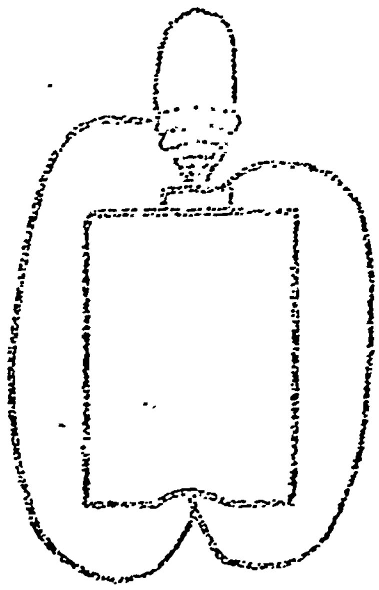
A



Move this wire on and off.
What happens?

____

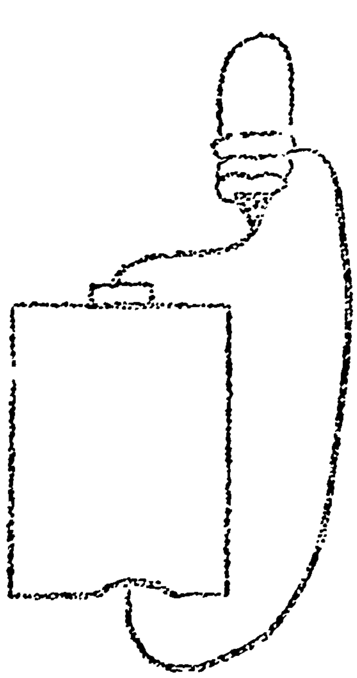
B



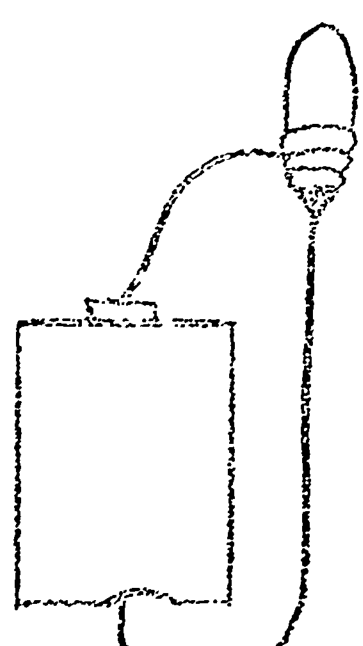
Move this wir on and off.
What happens?

____

C



D



NAME ______________________________

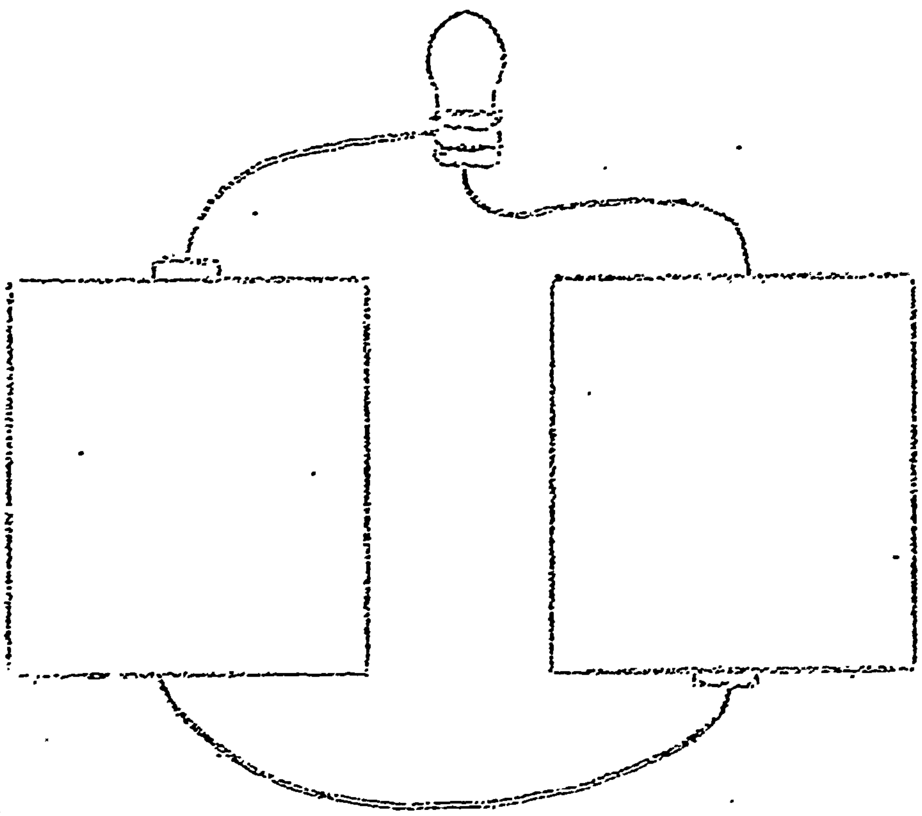
WORK SHEET 4
Battery Holders

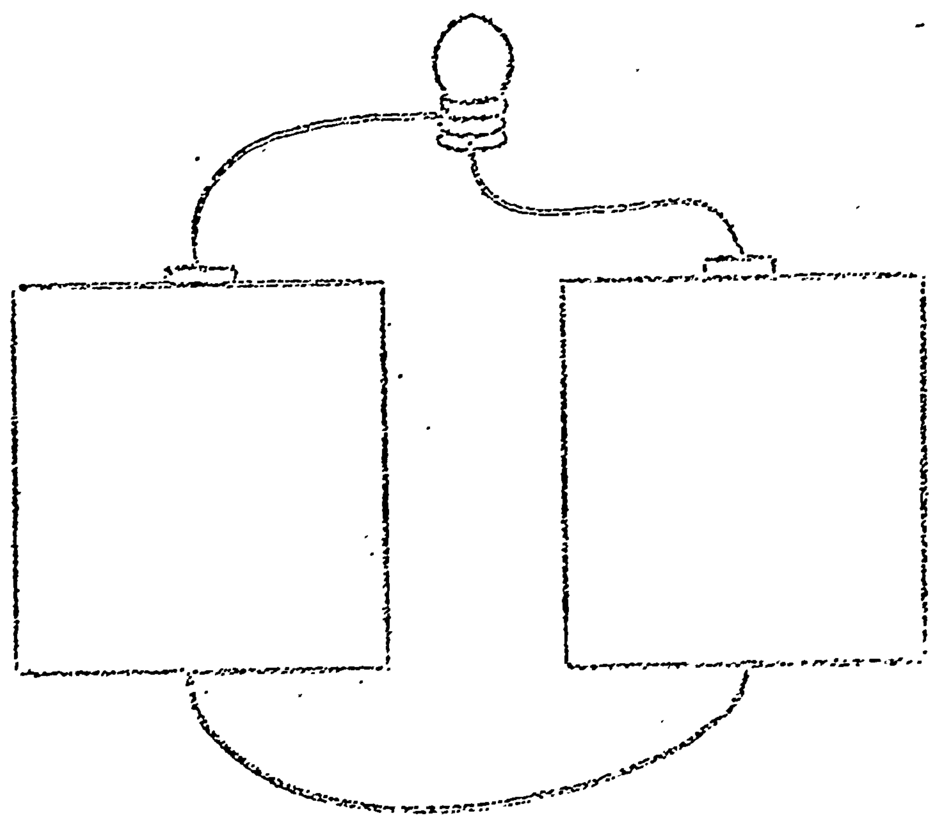
USING THREE WIRES

TRY THESE CIRCUITS:

WRITE <u>YES</u> IF THE BULB LIGHTS

WRITE <u>NO</u> IF THE BULB DOES NOT LIGHT

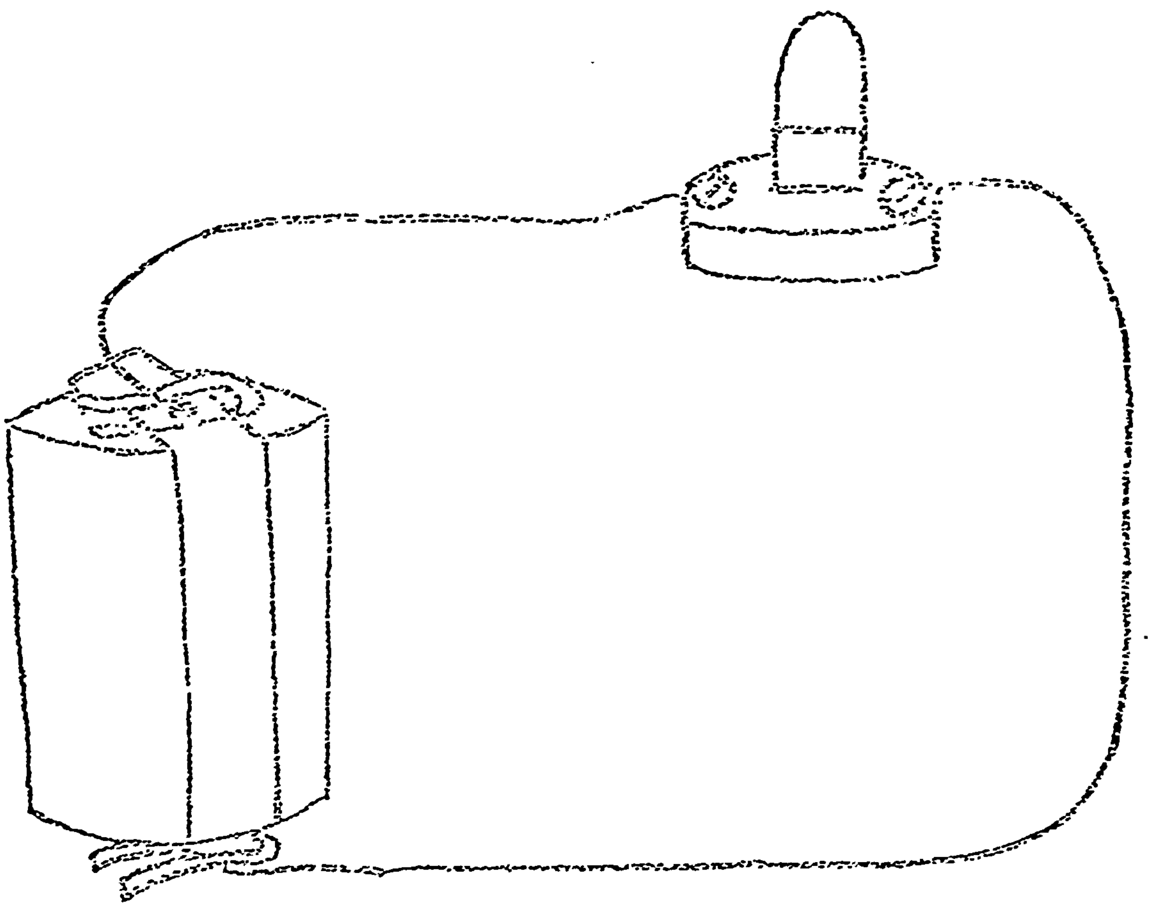




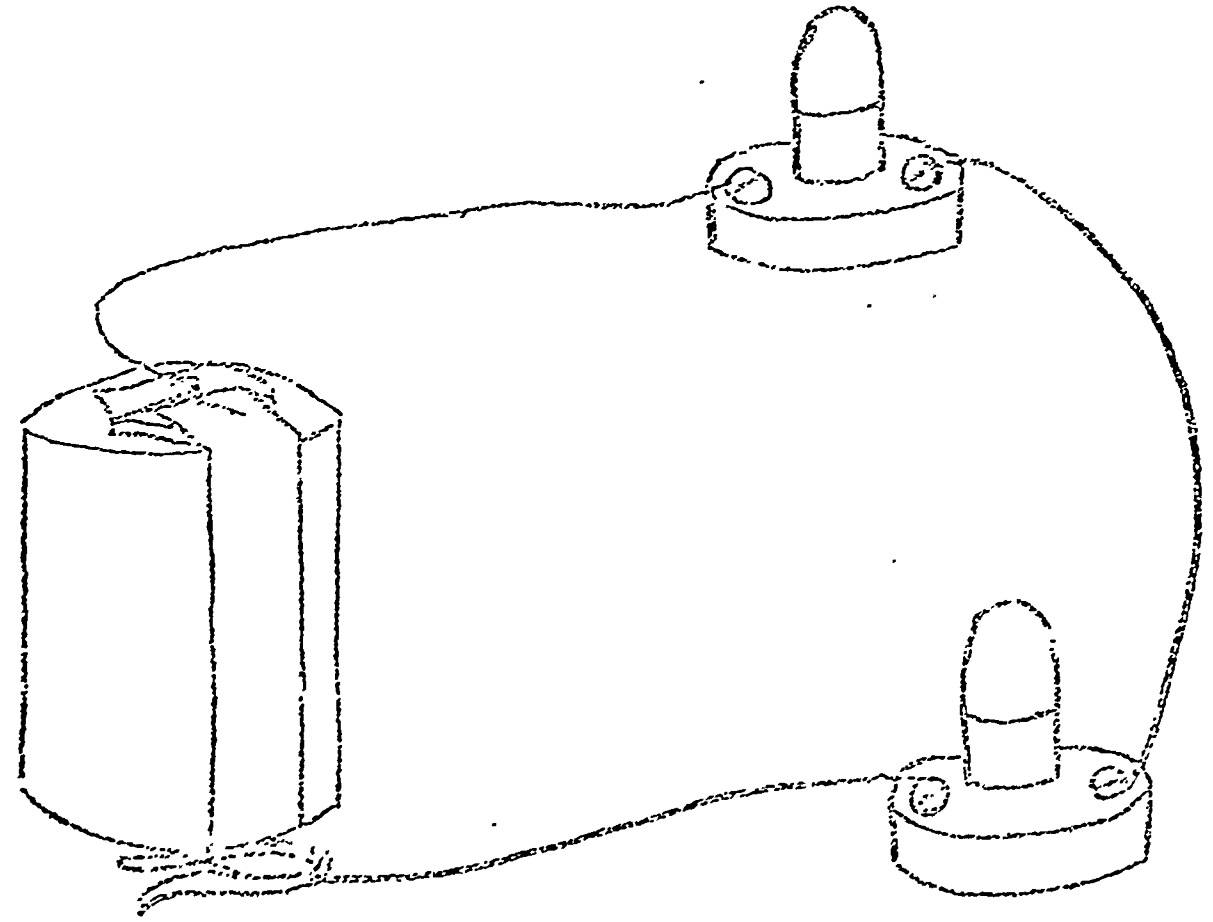
SHEET 8

name

A



B

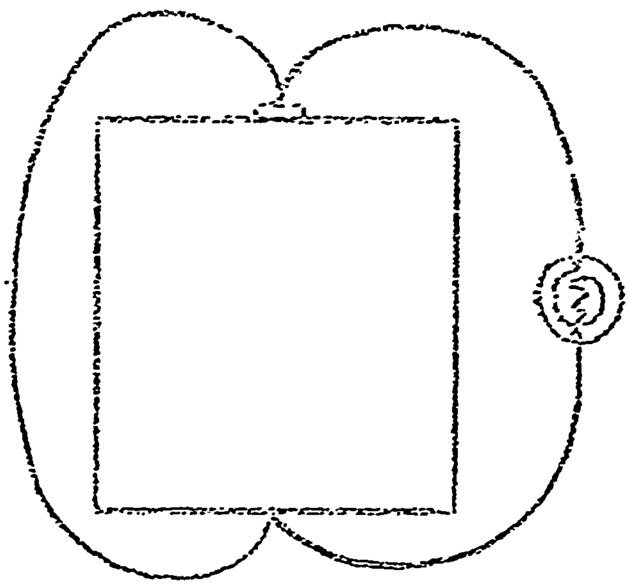


NAME ____________________

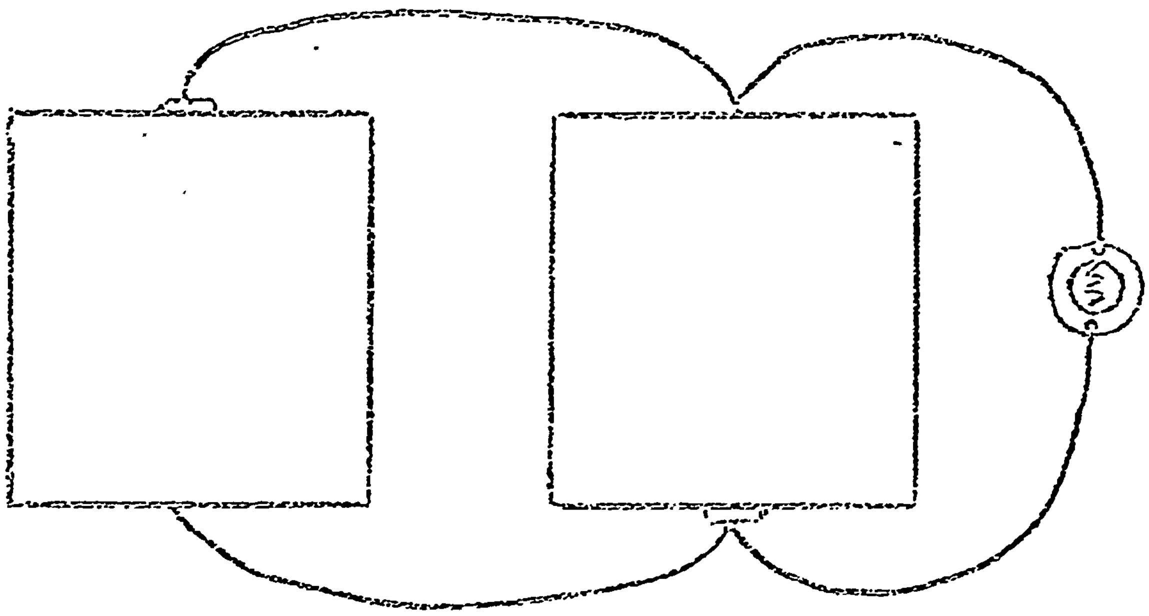
SHEET 5b

TRY MAKING THESE CIRCUITS

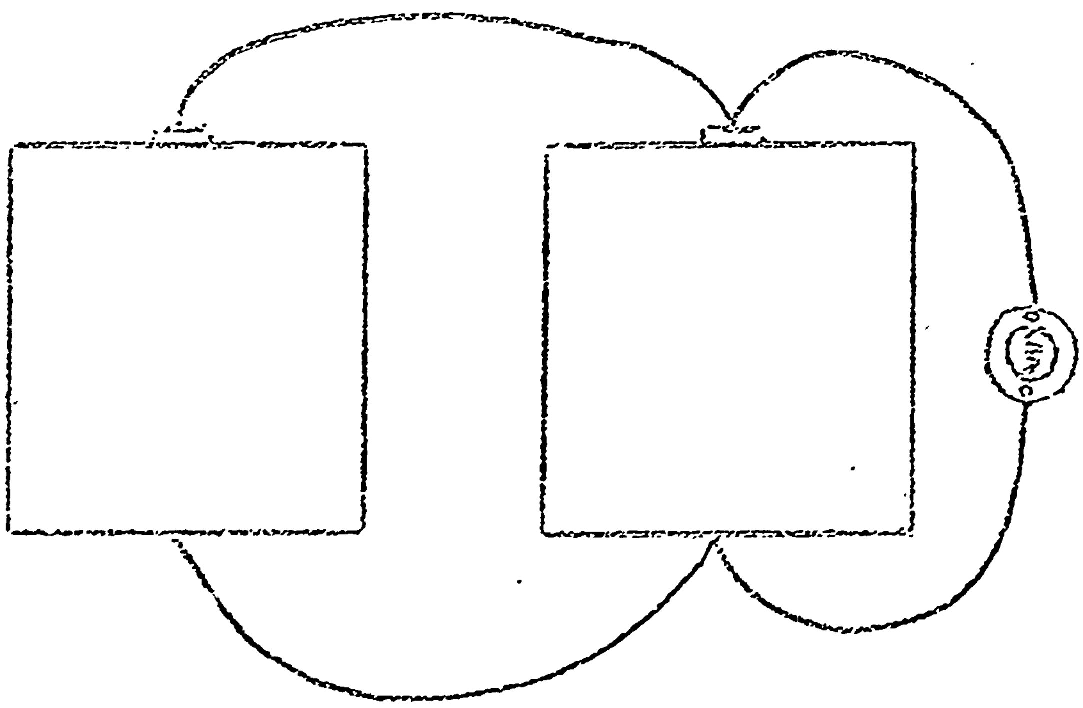
1



2



3

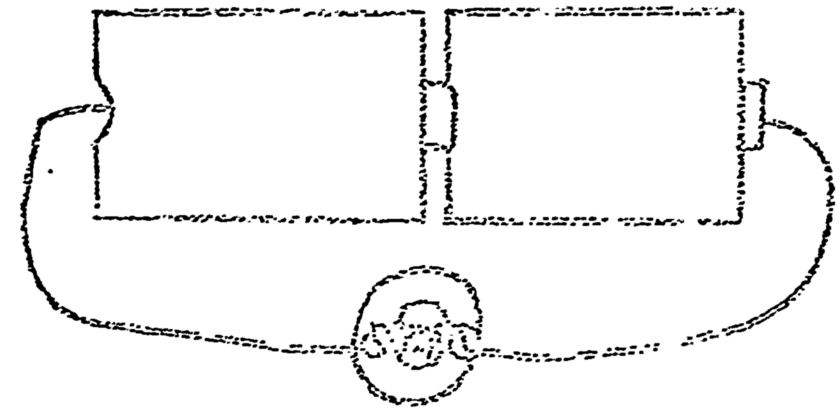


SHEET 5c

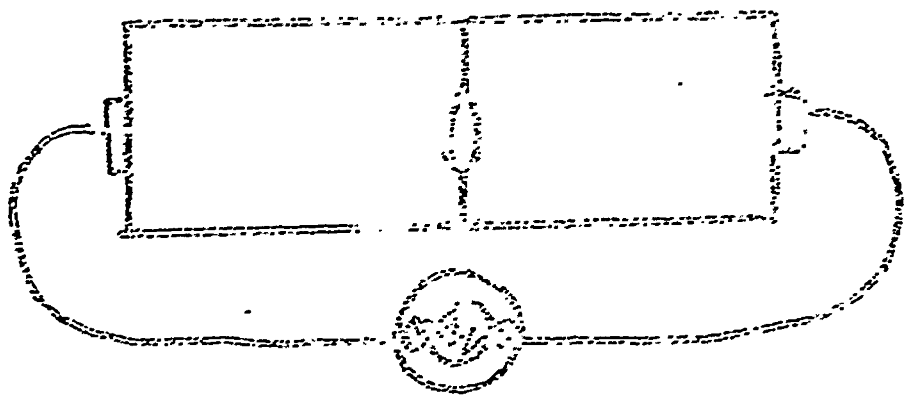
name ______________________

TRY MAKING THESE CIRCUITS

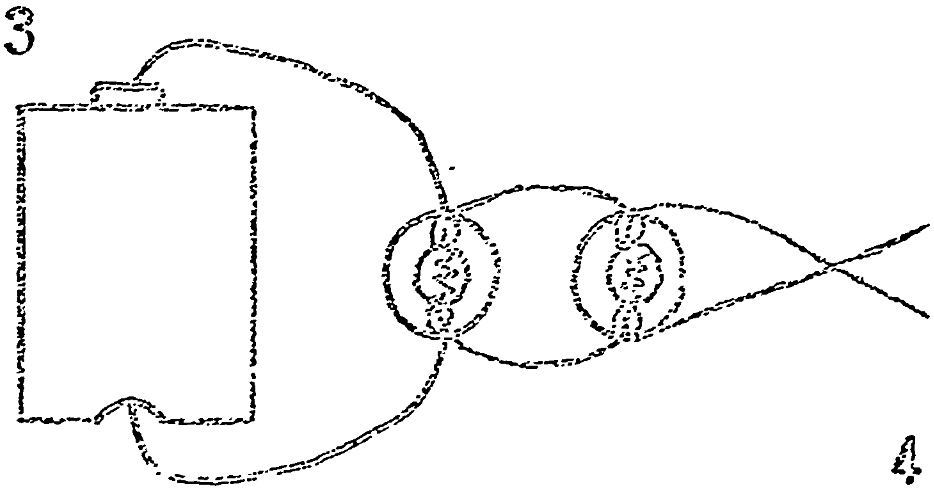
1



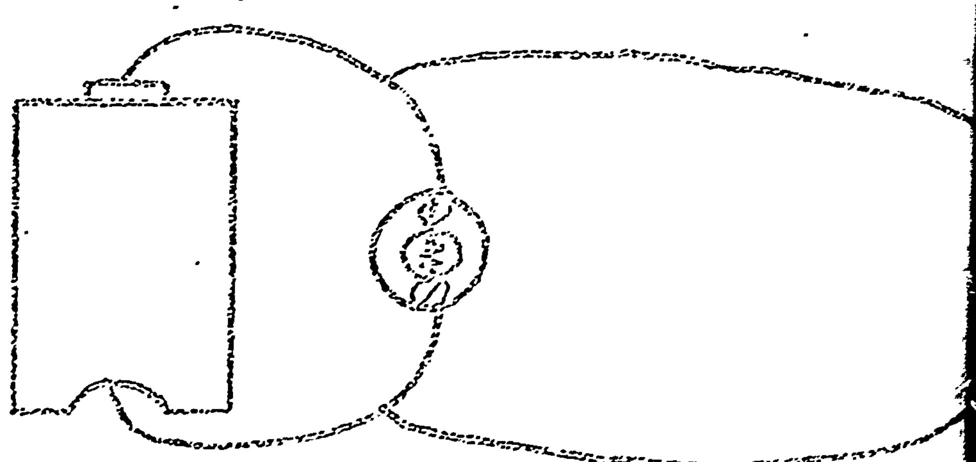
2



3



4

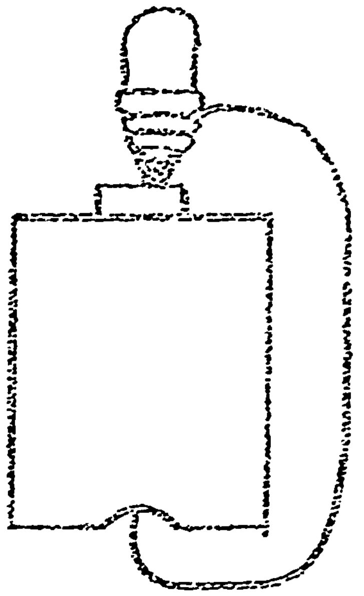


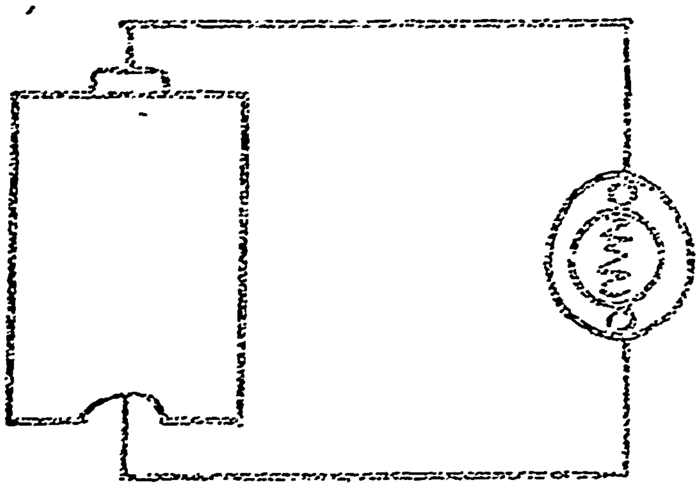
SHEET 5d

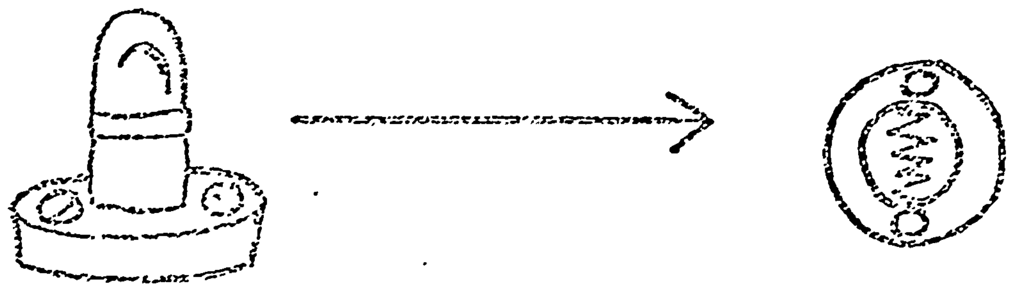
name

STANDARD BRIGHTNESS

one battery
one pink bulb





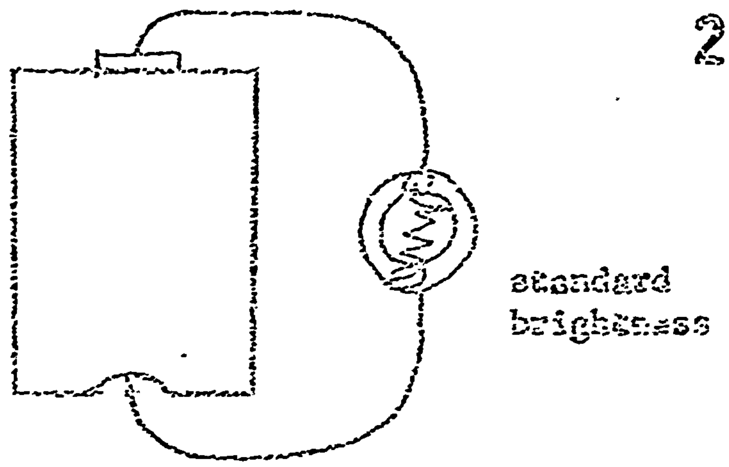


WORK SHEET 6a

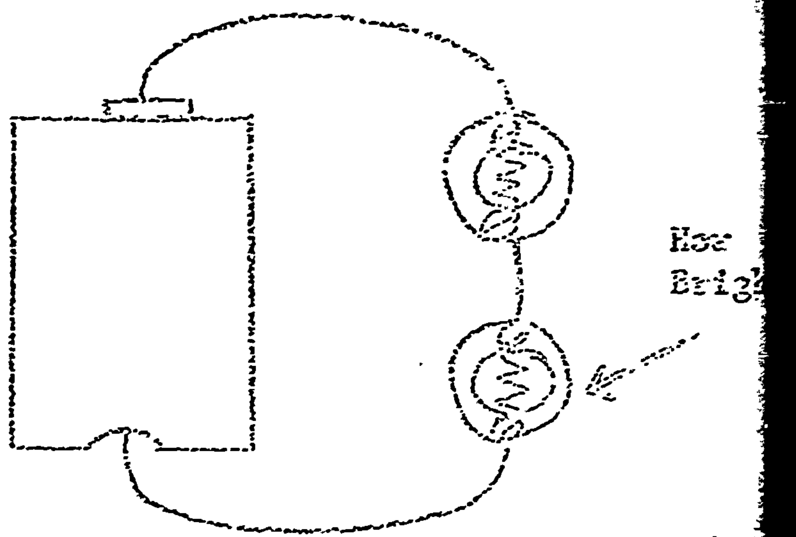
name

TRY MAKING THESE CIRCUITS

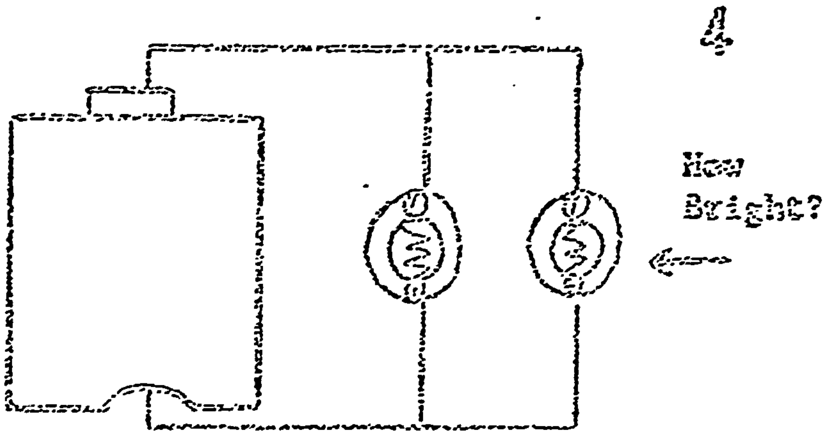
1



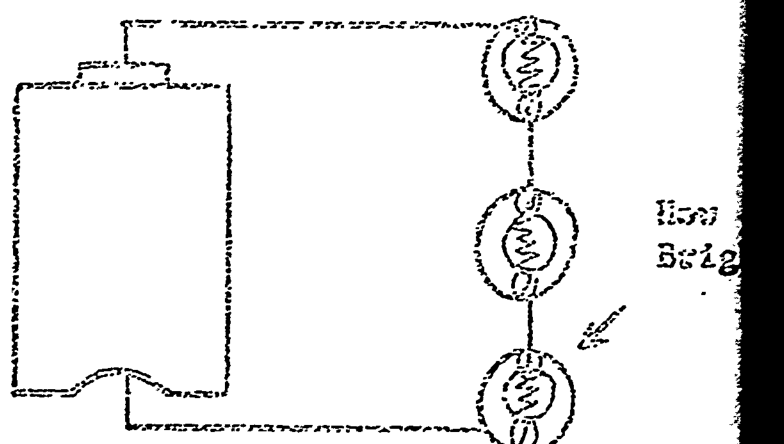
2



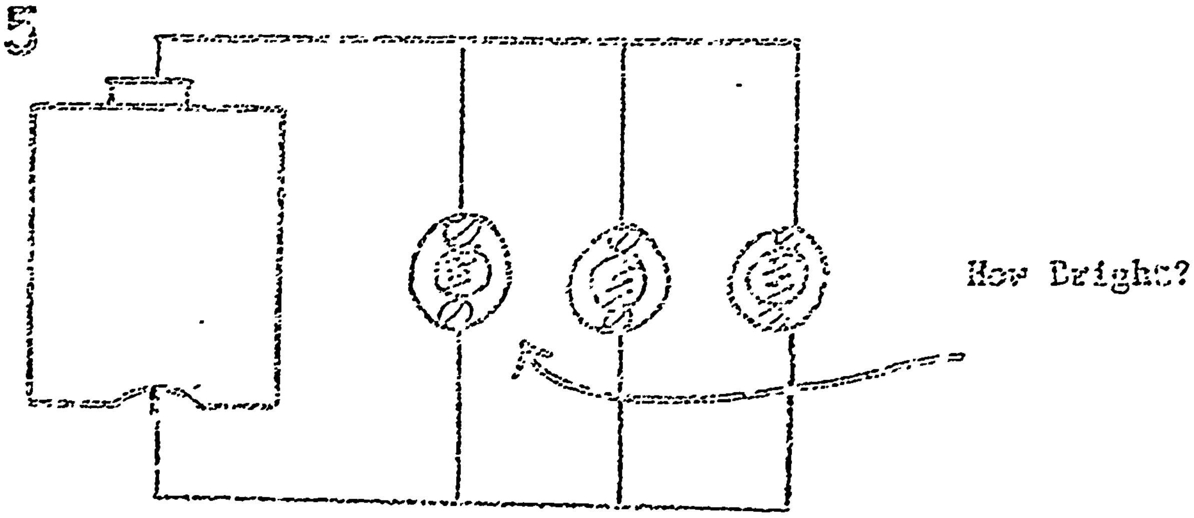
3



4



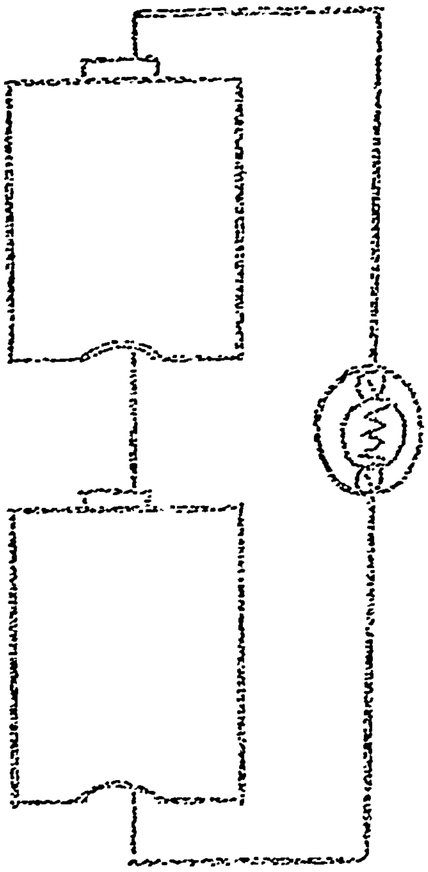
5



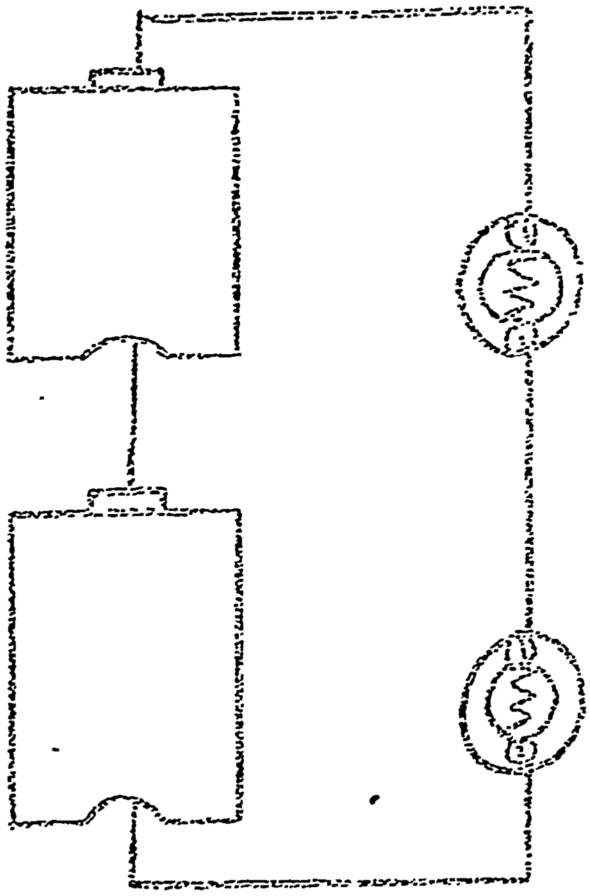
name

COMPARE these with circuits on sheet 5a.

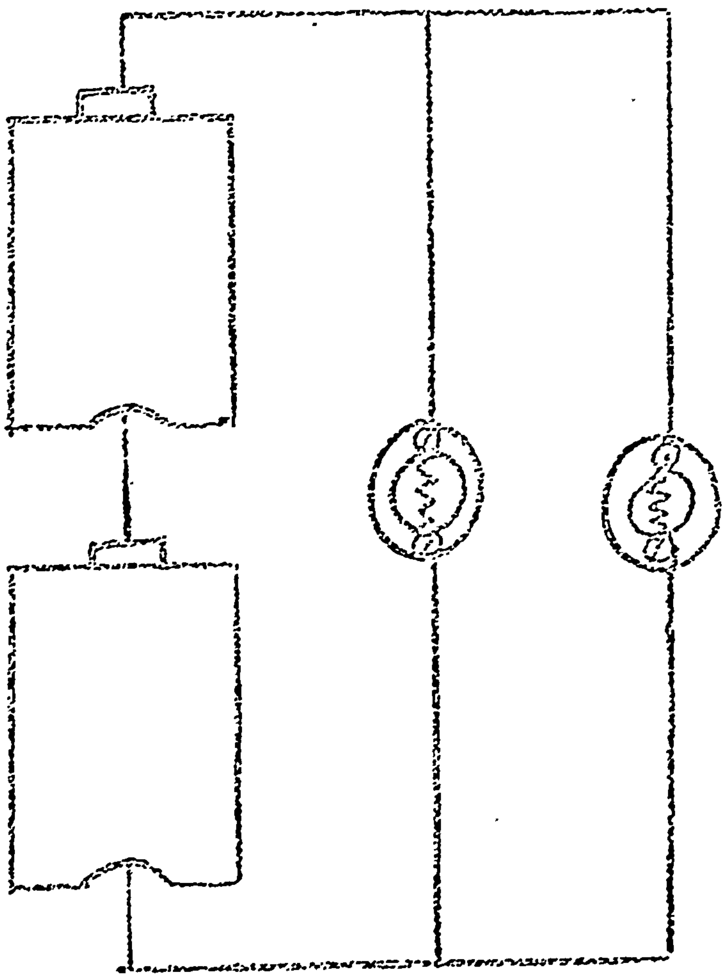
1



2



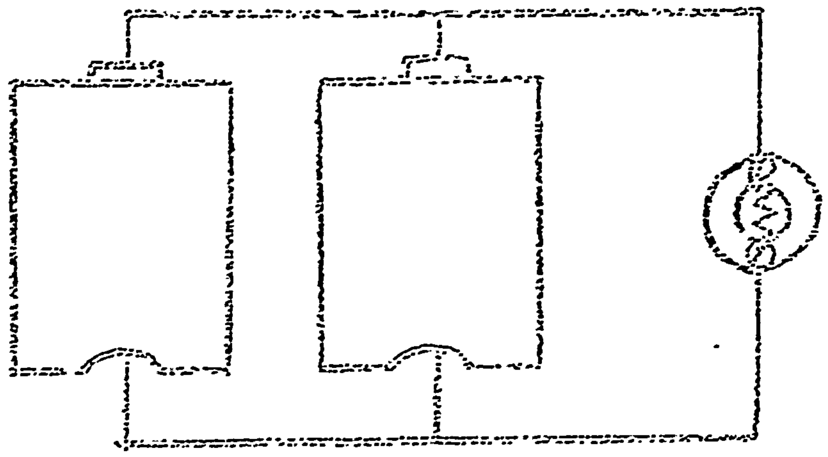
3



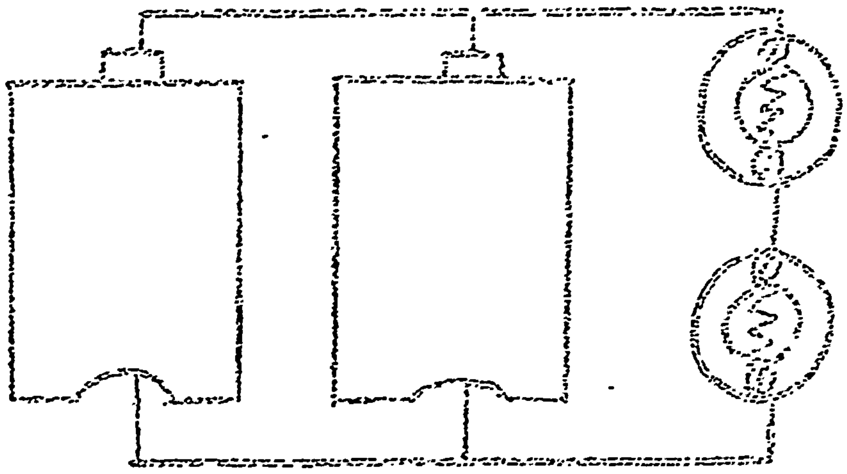
name ______________________

WORK SHEET 6b (continued)

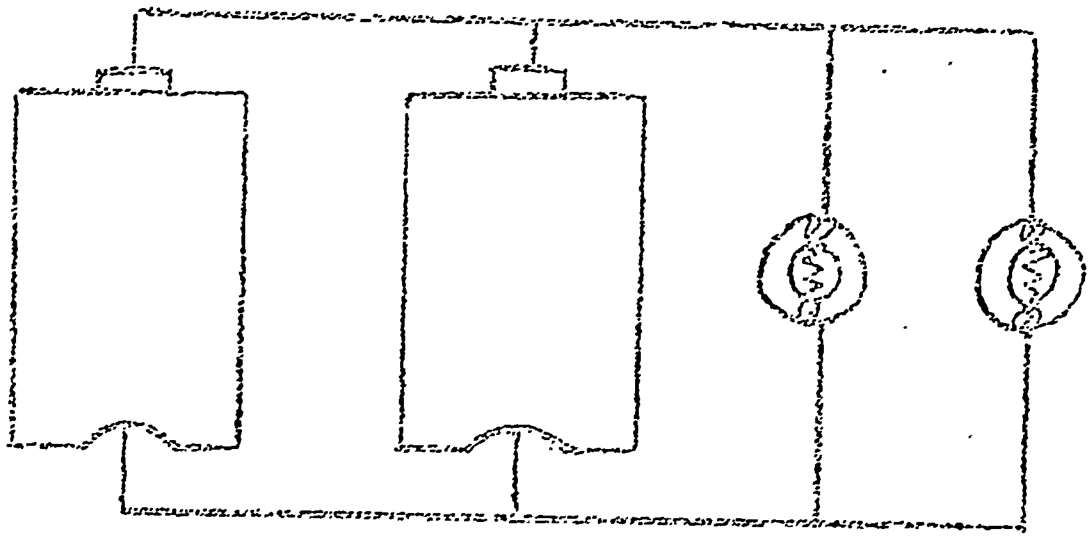
4



5

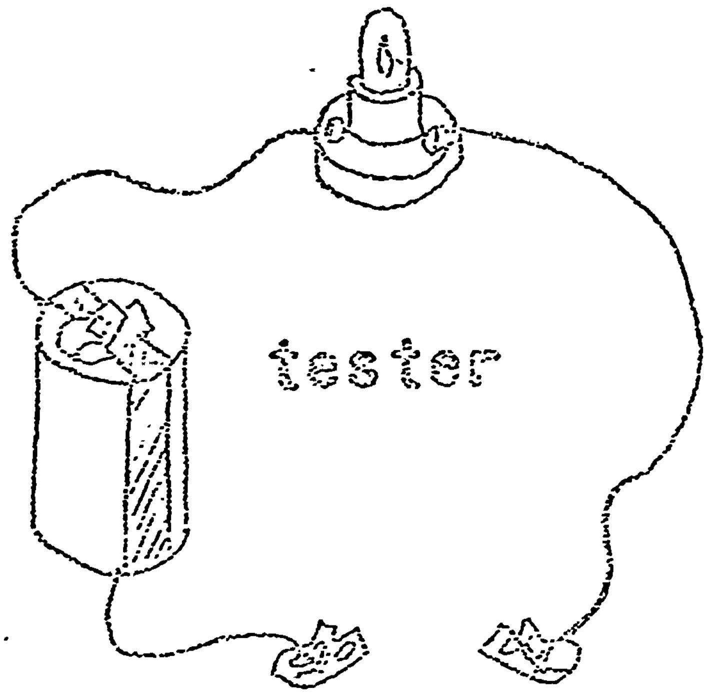


6



NAME

TESTING PATHWAYS
WORK SHEET 6e



In the "junk box" you will find all kinds of materials to put in the pathway of the tester shown in the picture. You may add anything you have which you wish to test.

See which things complete the path to the bulb so that it will light.

See which things do not complete the path so that the bulb will not light.

Are there any things which complete the path only under special conditions? What are they?

A. Make a list of all the materials which:

Will allow the bulb to light	Will not allow the bulb to light
1. ______	1. ______
2. ______	2. ______
3. ______	3. ______
4. ______	4. ______
5. ______	5. ______
6. ______	6. ______

QUESTIONS: 1. What types of materials are in the first list?

______

What types of materials are in the second list?

______

2. Do you get the same results from a pink bulb as a white bulb?

______

NEW SIGNS
(Reference)

MEMO

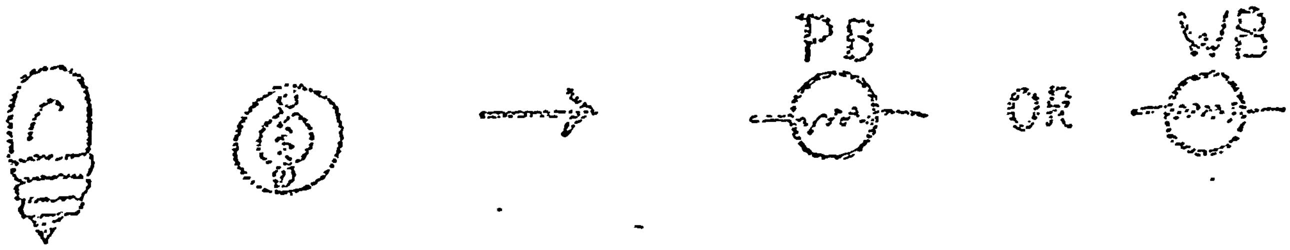
People who work with electricity use SIGNS instead of drawing pictures of bulbs, batteries and wires.

These are some of the SIGNS:

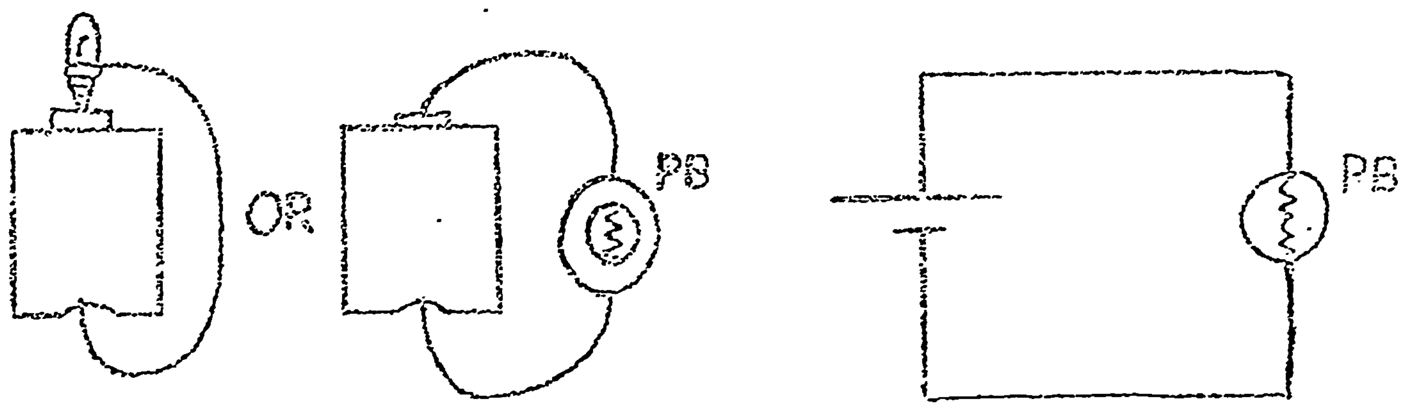
WE USED THIS PICTURE FOR: ELECTRICIANS USE THIS SIGN:

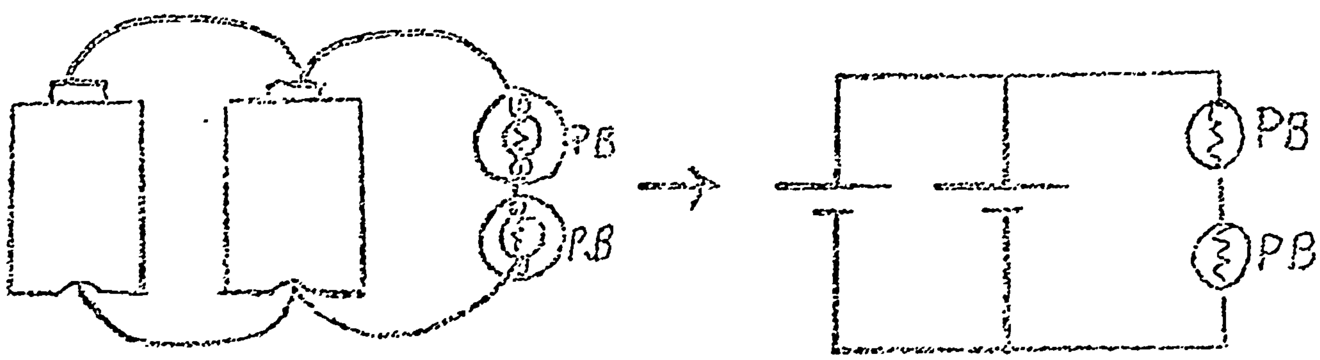
Battery

Bulbs

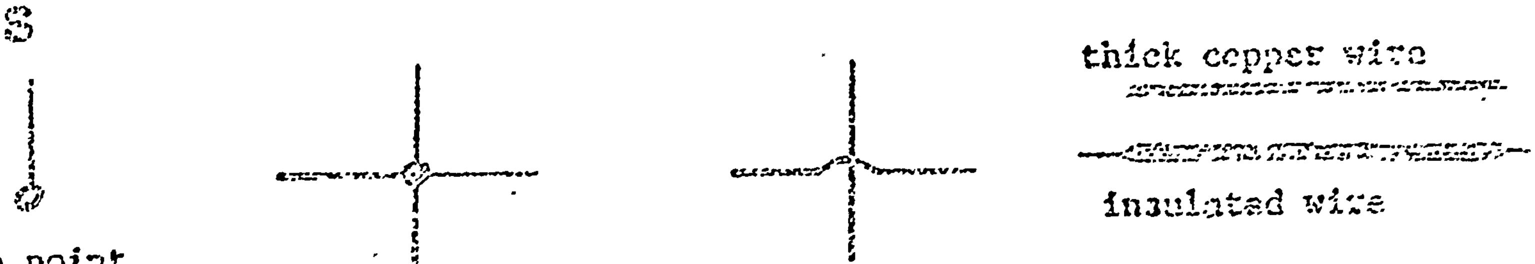


Circuit





Wires



tap point

wires joined or

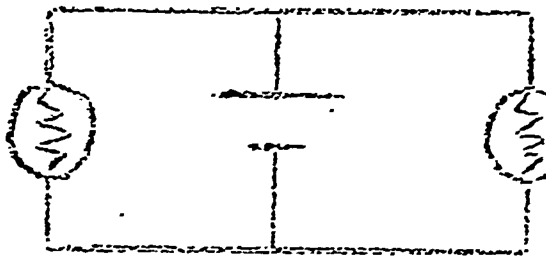
wires crossed but not

WORK SHEET 7a
NEW LANGUAGE

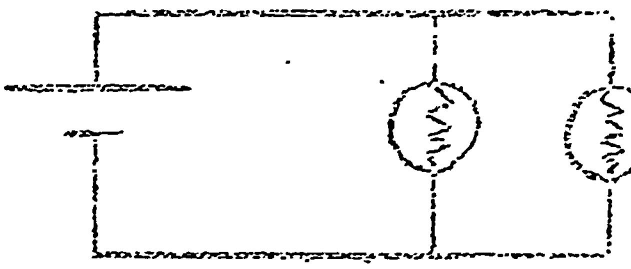
NAME ______________________

1. BUILD THESE CIRCUITS:

A



B

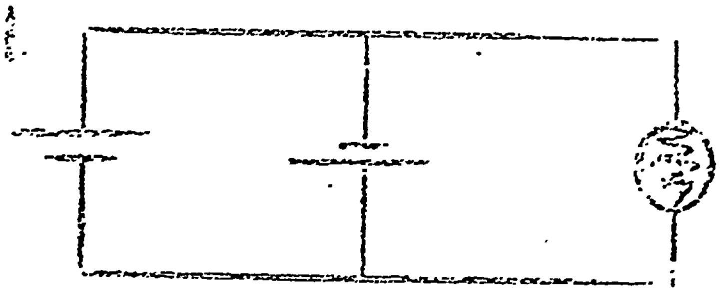


2. WHAT DO YOU THINK WILL HAPPEN IN THE FOLLOWING CIRCUITS?

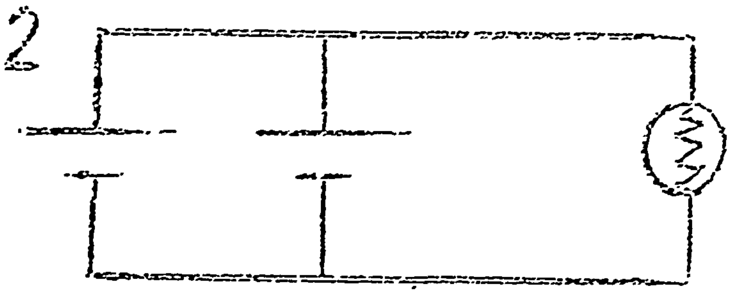
Write YES beside the bulb if you think it will light.

Write NO beside the bulb if you think it will not light.

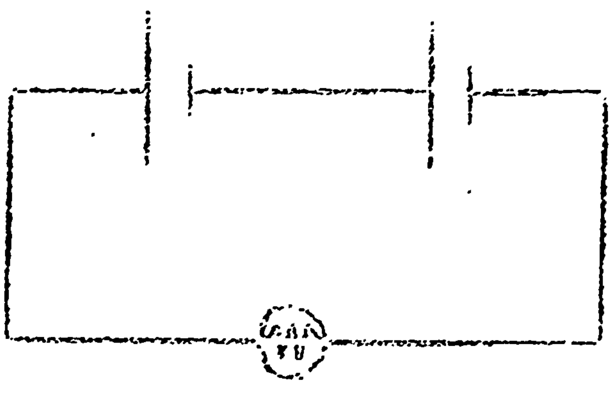
1



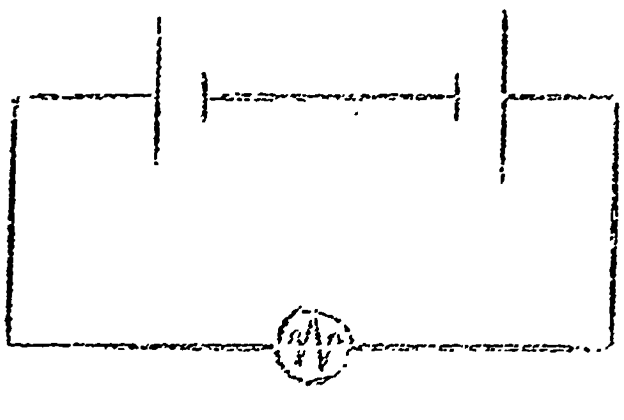
2



3



4

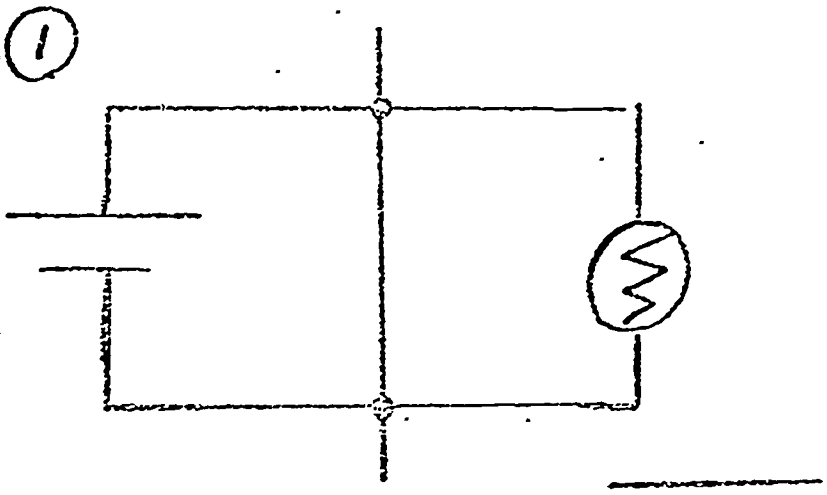


NAME

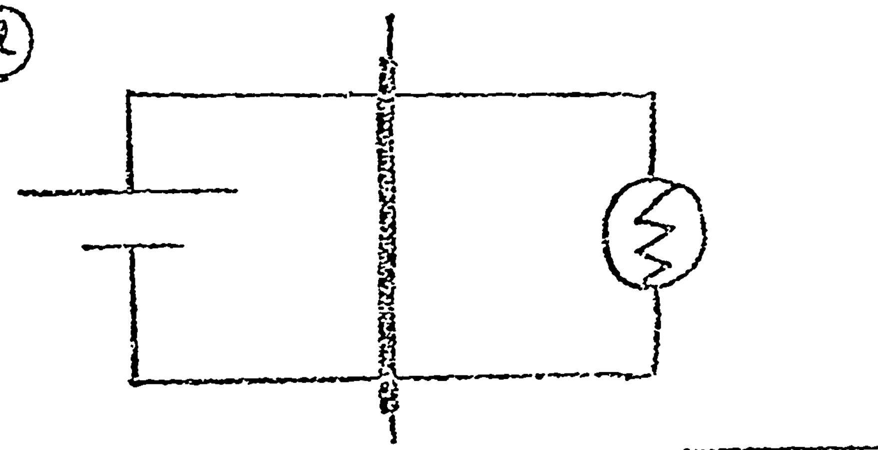
WORK SHEET 7b
NEW LANGUAGE

Write YES if the bulb will light.
Write NO if the bulb will not light.

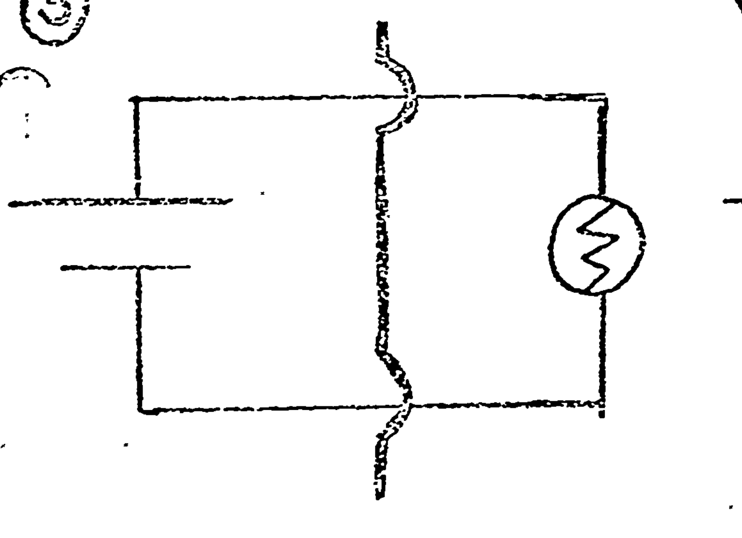
1



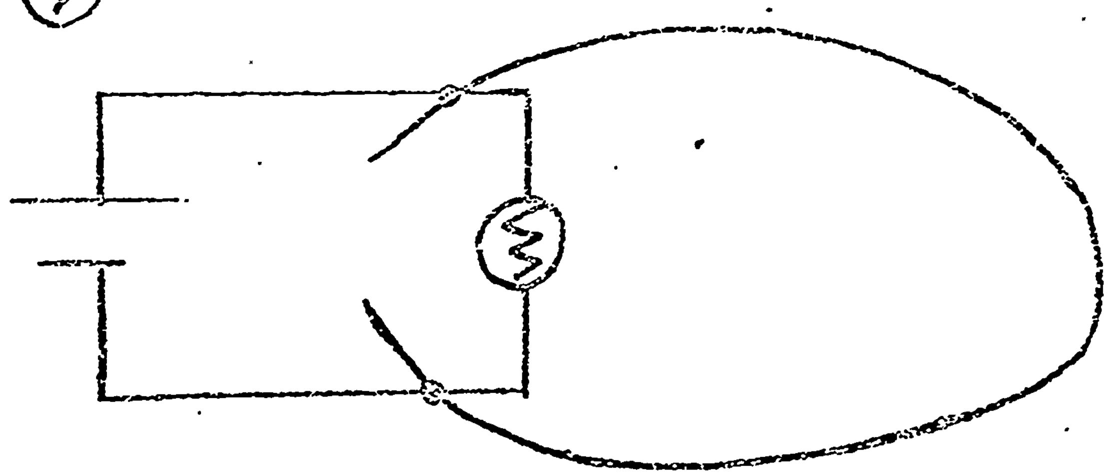
2



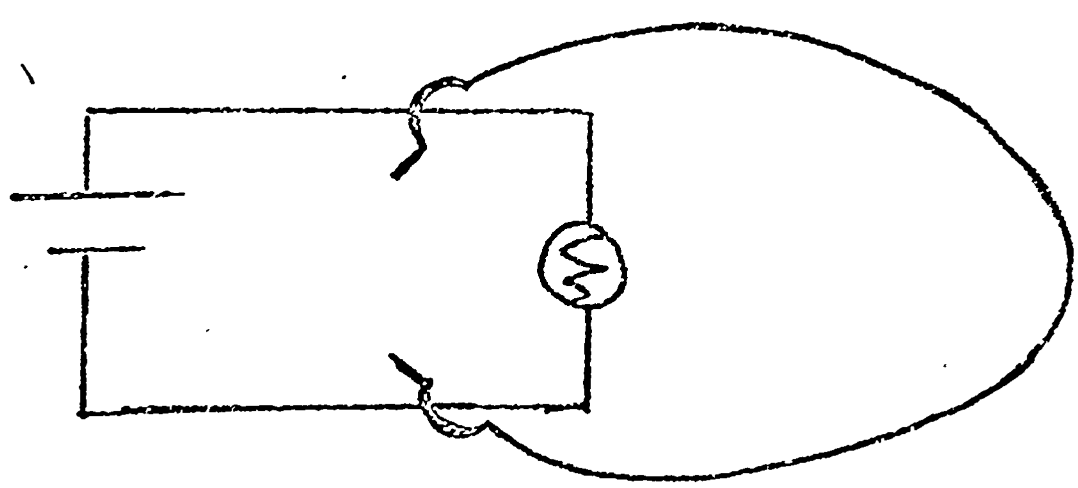
3



4



5



NAME

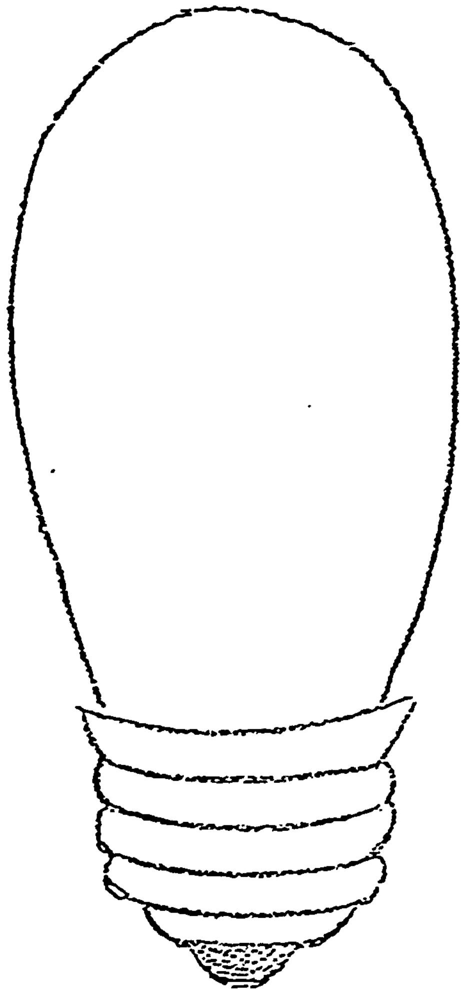
OCTOPUS BOY
Lesson 8

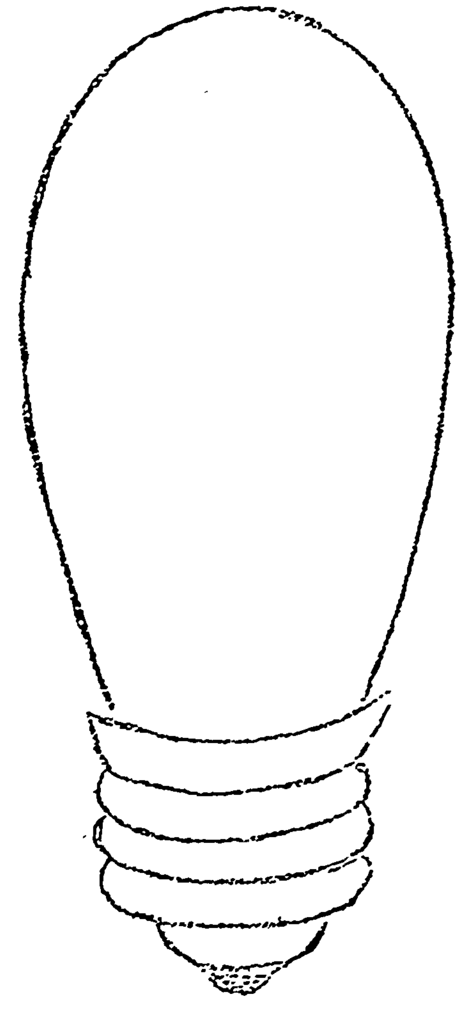
NAME

OCTOPUS BOY
Lesson 8

NAME

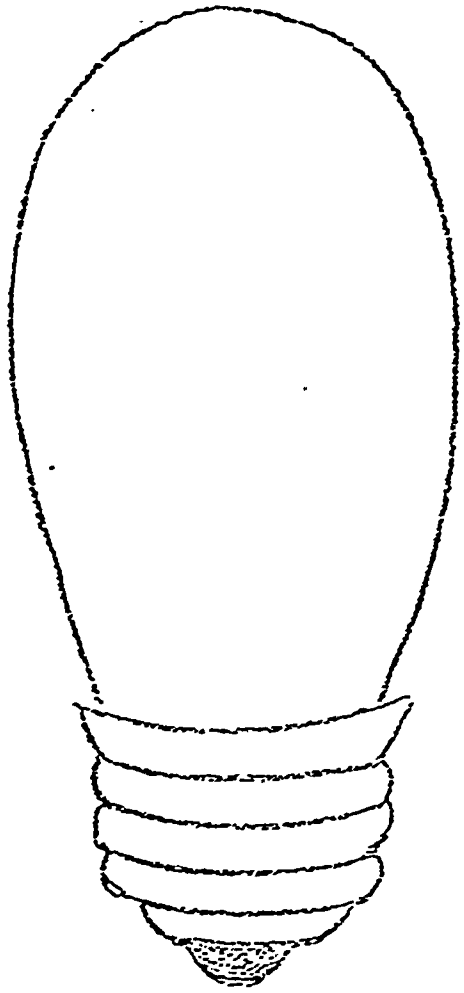
WORK SHEET 9A(2)
ANOTHER BULB

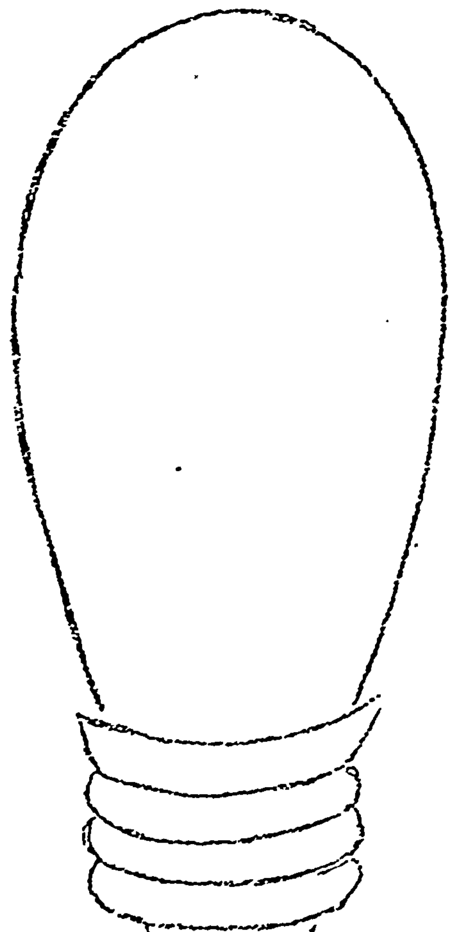




NAME

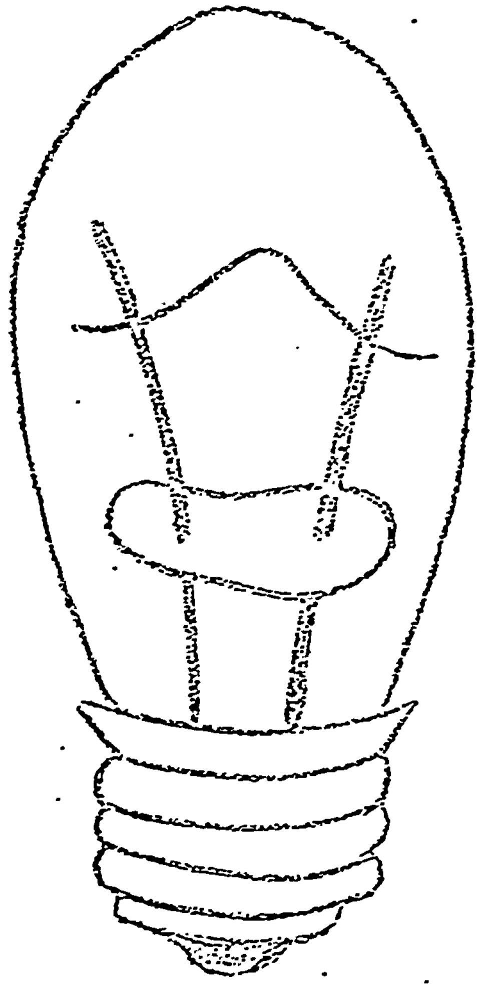
WORK SHEET 9A(2)
ANOTHER BULB



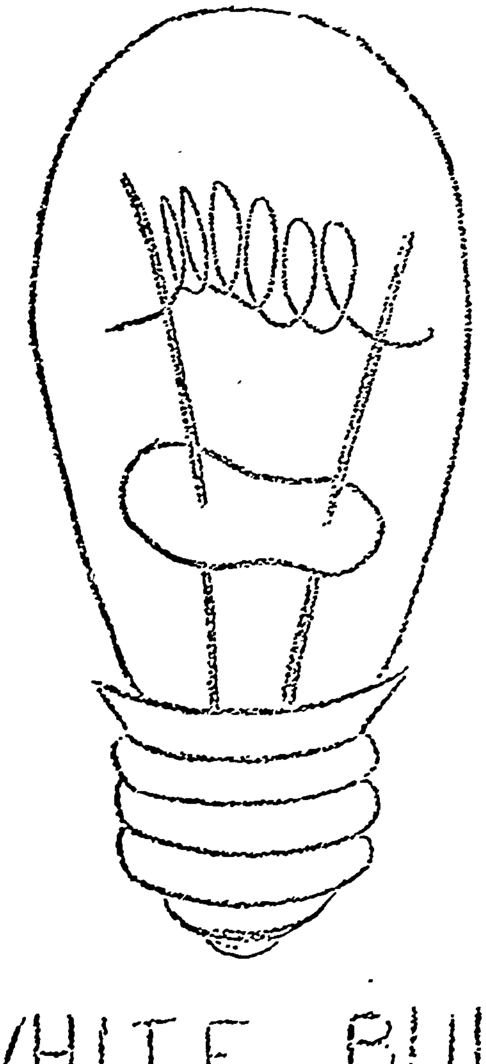


NAME ______________________

ANOTHER BULB
Lesson 9



PINK BULB



WHITE BULB

Name

Time sheet for testing the length of [illegible] to wear out a battery

Type of bulb
Number of batteries

DAY (DATE)	TIME STARTED	TIME STOPPED	[illegible]

Name ______________________

Work Sheet 3-
ANOTHER

Record of Results on :

1. Length of time to wear out a batter[illegible].

TYPE OF BULB	NUMBER OF BATTERIES	[illegible]
1 PB	1	
1 WB	1	
2 PBs	2	
2 WBs	2	
1 PB and 1 WB		

2. Number of batteries needed to [illegible] out different bulbs.

TYPE OF BULB	NUMBER OF BATTERIES
PB	
WB	
2PBs	
2WBs	
1Pb and 1WB	

Name ______________________

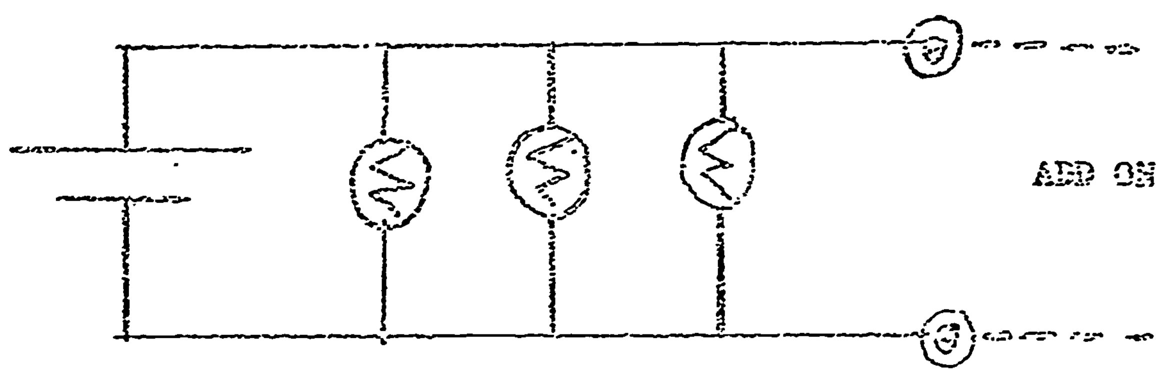
Work Sheet 9a
ANOTHER [illegible]

1. How many PBs will light in this circuit?

______

How many WBs will light in this circuit?

______

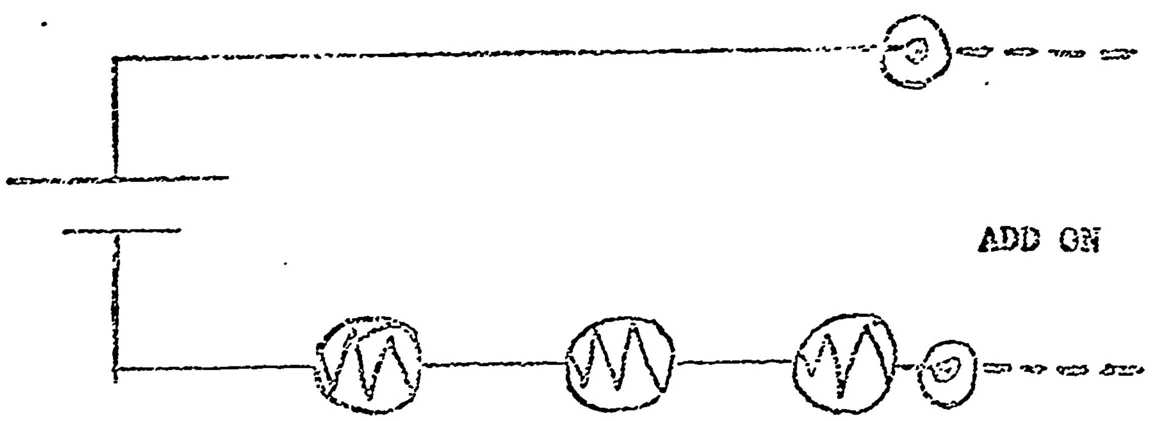


2. How many PBs will light in this circuit?

______

How many WBs will light in this circuit?

______



NOTE: DO NOT MIX PBs AND WBs IN THE SAME CIRCUITS!

NAME ________________

WHAT'S INSIDE A BATTERY

WORK SHEET I[illegible]

1. HOW FAR MUST THE CARBON ROD BE PUSHED BACK INTO THE BATTERY TO LIGHT

   1) A PB BULB ________________

   2) A WB BULB ________________

2. LIST MATERIALS IN A BATTERY THAT CAN BE PUT IN A PATH TO A PB BULB AND MAKE THE BULB LIGHT.

3. WHICH BULB WILL LIGHT WITH THE SMALLEST AMOUNT OF MATERIAL LEFT IN THE BATTERY?

   ____

4. DOES THE CARBON ROD TOUCH THE BOTTOM OF THE BATTERY CASE?

   ____

   WILL A BULB LIGHT IF IT DOES?

   ____

NAME ______________________

TESTING LIQUID PATHWAYS
WORK SHEET 12a

TYPE OF SOLUTION	TYPE OF BULB	NUMBER of BATTERIES	LIGHTS UP Yes or No	DEGREE OF BRIGHTNESS Standard, Dim, Bright?
SALT	PB			
	WB			
VINEGAR	PB			
	WB			
BAKING SODA	PB			
	WB			

DANGER - DO NOT MIX LIQUIDS

name ______________

TESTING LIQUID PATHWAYS

Work Sheet 12b

Type of Solution	Type of Bulb	Number of Batteries	Lights up? YES or NO	Degree of Brightness Bright, Standard, Dim
COMET CLEANSER	PB			
	WB			
CLEAR WATER	PB			
	WB			
COOKING OIL	PB			
	WB			
OTHER				

DANGER - DO NOT MIX LIQUIDS!

Name

WIRES LONG AND SHORT THICK AND THIN

YOU SHOULD HAVE:

Two (2) ft. piece of thin nichrome wire (#32)
Four (4) ft. piece of thick (#26) nichrome wire
Roll of thin (#26) copper wire
Roll of thick (#22) copper wire

A. Try using each of these new wires, instead of the copper wire you have been using, in some of the circuits you have made.

Do you notice anything new?

Try using different lengths of the wire.

Record what you see and how long the wire was in each case.

Can you dim a bulb with THIN nichrome wire until it goes out and then light it up again? ____________

B. Dim and put out a WE and a PB with each type of wire.
Record your results in the chart below:

WIRE	In a tester length to put out a WE	In a tester length to put out a PB	The length of wire that works the same as one ft. thin nichrome wire
Thin (#32) nichrome wire			
Thick (#26) nichrome wire			
Thin (#26) copper wire			
Thick (#22) copper wire			

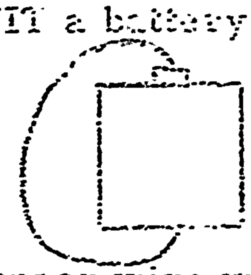
C. Make a circuit using one battery and two bulbs. Remove one of the bulbs from the circuit and put a piece of THIN nichrome wire in its place. FIND THE LENGTH of wire which will keep the remaining bulb as bright as it was when another bulb was in the circuit instead of the thin nichrome wire.

Name WORK SHEET 15

WIRES AND SHORT CIRCUITS

A. SHORT CIRCUIT a battery with copper wire.

Thus:



1. Replace copper wire with a six (6) inch piece of THIN nichrome wire (#32).

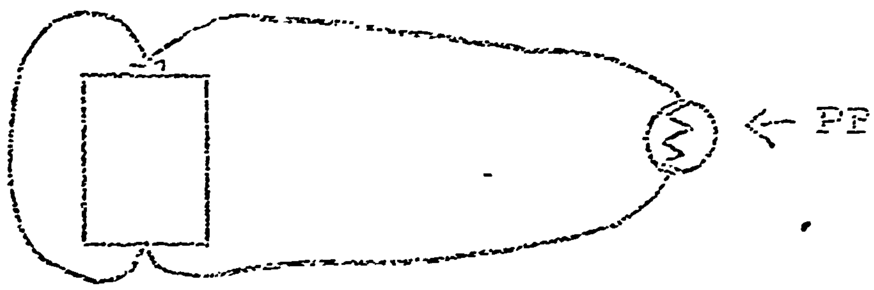
   What happens? ____________________

2. Replace copper wire with a six (6) inch piece of THICK nichrome wire (#26).

   What happens? ____________________

B. Build this circuit with copper wire.

Wire A



1. Replace copper wire A with two (2) feet of THIN nichrome wire (#32)

   What happens to the bulb? ____________________

   Keep shortening the length of this wire. Watch carefully.

   What happens to the bulb? ____________________

   What happens to the wire? ____________________

2. Now use thick nichrome wire (#26) in place of copper wire A.

   Can you find a length of wire that will allow the bulb to stay lighted?

   How long was the wire? ____________________

3. Now use very thin copper wire (#32) in place of copper wire A

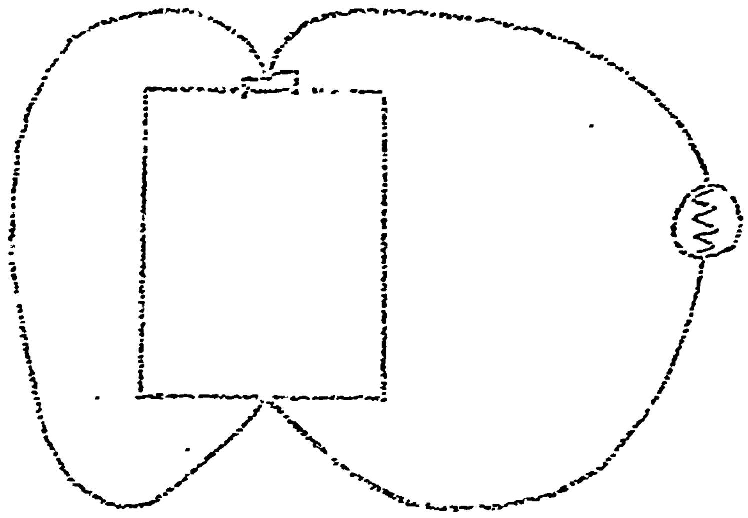
   Can you short circuit the bulb? ____________________

   How long was the thin copper wire you used? ____________________

WIRES AND SHORT CIRCUITS

C. Build this circuit with copper wire, using [illegible] instead of a PE bulb.

copper wire A



1. Replace copper wire A with two (2) feet of THIN nichrome wire ([illegible] 32).

   What happens to the bulb? ______________________

   Keep shortening the thin wire. Watch carefully.

   What happens to the bulb? ______________________

   What happens to the wire? ______________________

2. Now use thick nichrome wire ([illegible] 26) in place of copper wire A.

   Can you lengthen the wire until the bulb stays lit? ______________

   How long was the wire you used? ______________

3. Now use very thin copper wire ([illegible] 32) in place of wire A.

   How long a piece will make the short circuit? ______________

   How long a piece will allow the bulb to remain lighted? ______________

WORKSHEET 13

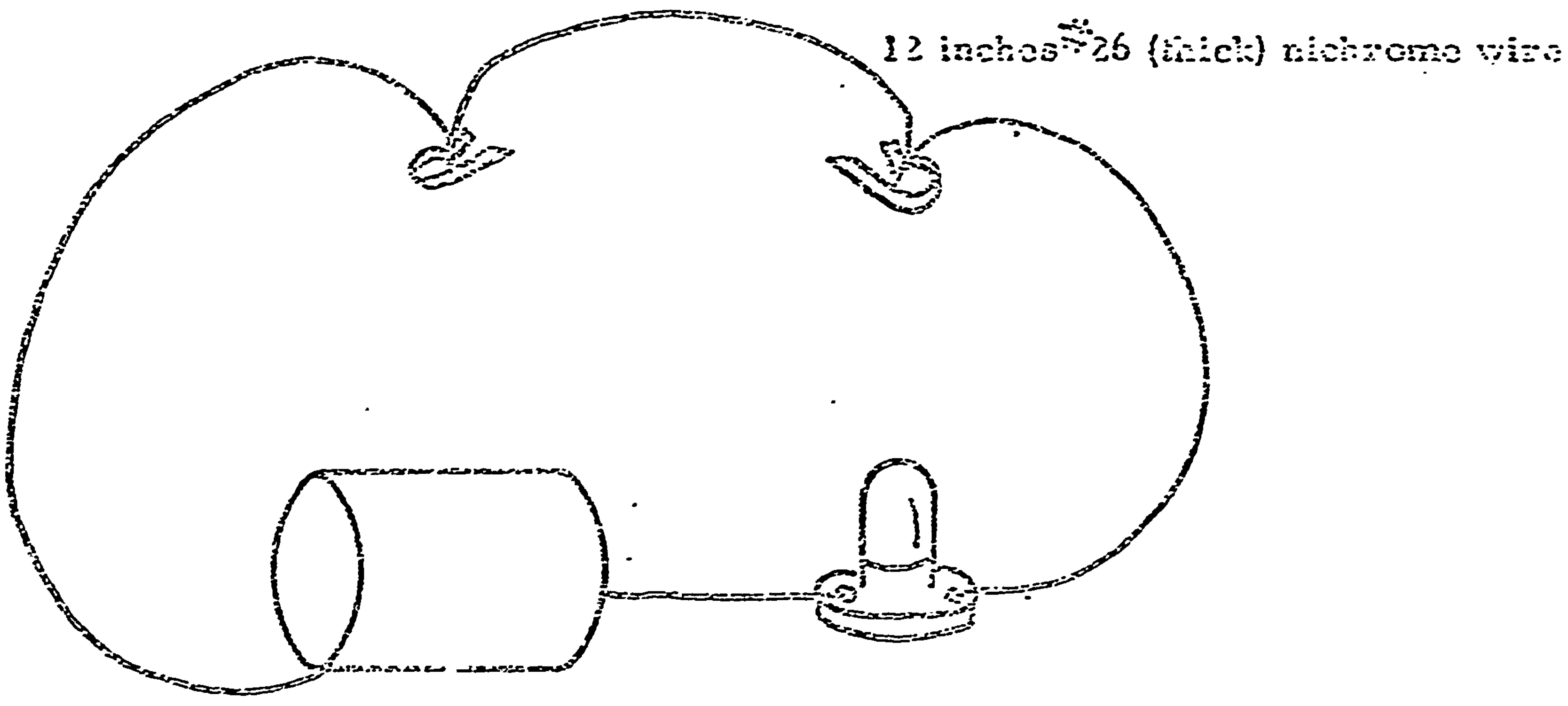
RESULTS of SHORT CIRCUITS WITH DIFFERENT WIRES

Copy the results of the work you did for sheets 13-b and 13-c onto the following chart:

Type of Wire	Length of wire that makes a PB go out in circuit C	Length of wire that makes a WB go out in circuit C
THIN nichrome		
THICK nichrome		
THIN copper		
THICK copper		

Will a WB bulb light in this circuit? ____________

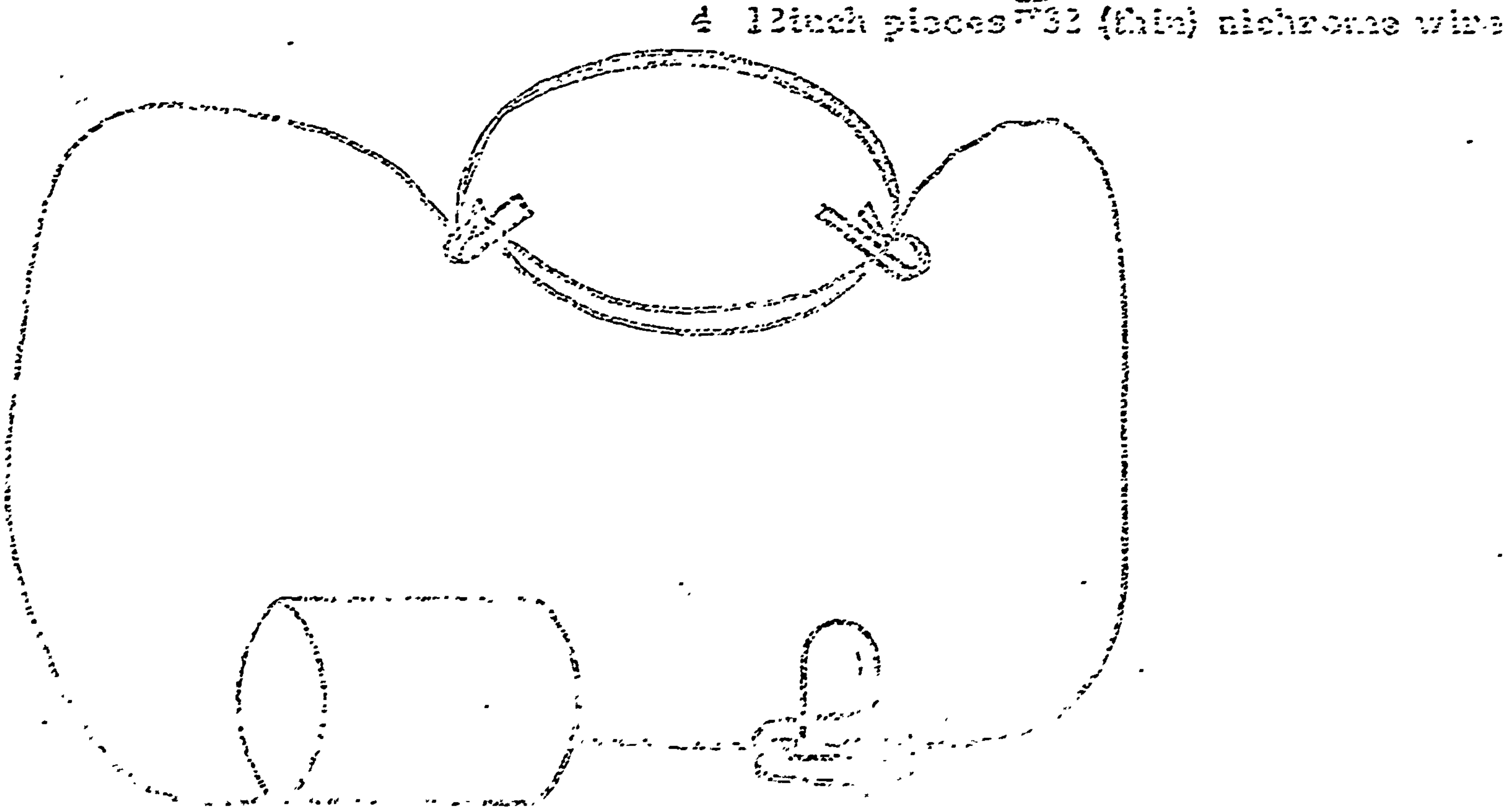
Will a PE bulb light in the circuit? ____________



CIRCUIT A

Will a WB bulb light in this circuit? ____________

Will a PE Bulb light in this circuit? ____________



CIRCUIT B

Name ____________________

EXTRA WORK

WIRES - LONG AND [redacted] THICK AND THIN

A. LIGHTING BULBS WITH VARIOUS WIRES

1. Using THIN NICHROME wire to do the following:

   a) Put a 12 inch piece of THIN nichrome wire in the pathway of your tester using a PB.
   What happens? ____________________

   b) What length of THIN nichrome wire will cause a PB to go out? __________

   c) What length of THIN nichrome wire will cause a WB to go out? __________

2. Using THICK NICHROME wire:

   a) What length of THICK nichrome wire will cause a PB to dim the same amount as it did with 12 inch piece of THIN nichrome wire?
   ____

   b) Do you get the same result with a WB? ____________________

3. Using VERY THIN COPPER wire:

   a) What length of THIN copper wire will cause a PB to dim the same amount as it did with a 12 inch piece of THIN nichrome wire?
   ____

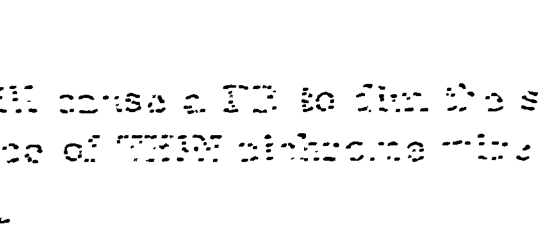
   b) Do you get the same results with a WB? ____________________

B/ SHORT CIRCUITS - BATTERY ALONE

1. Short circuit a BATTERY with a 6 inch piece of THIN nichrome wire.
   What happens? ____________________

2. Does the same thing happen with a 6 inch piece of THICK nichrome wire?
   ____

C/ SHORT CIRCUITS - WITH BULBS



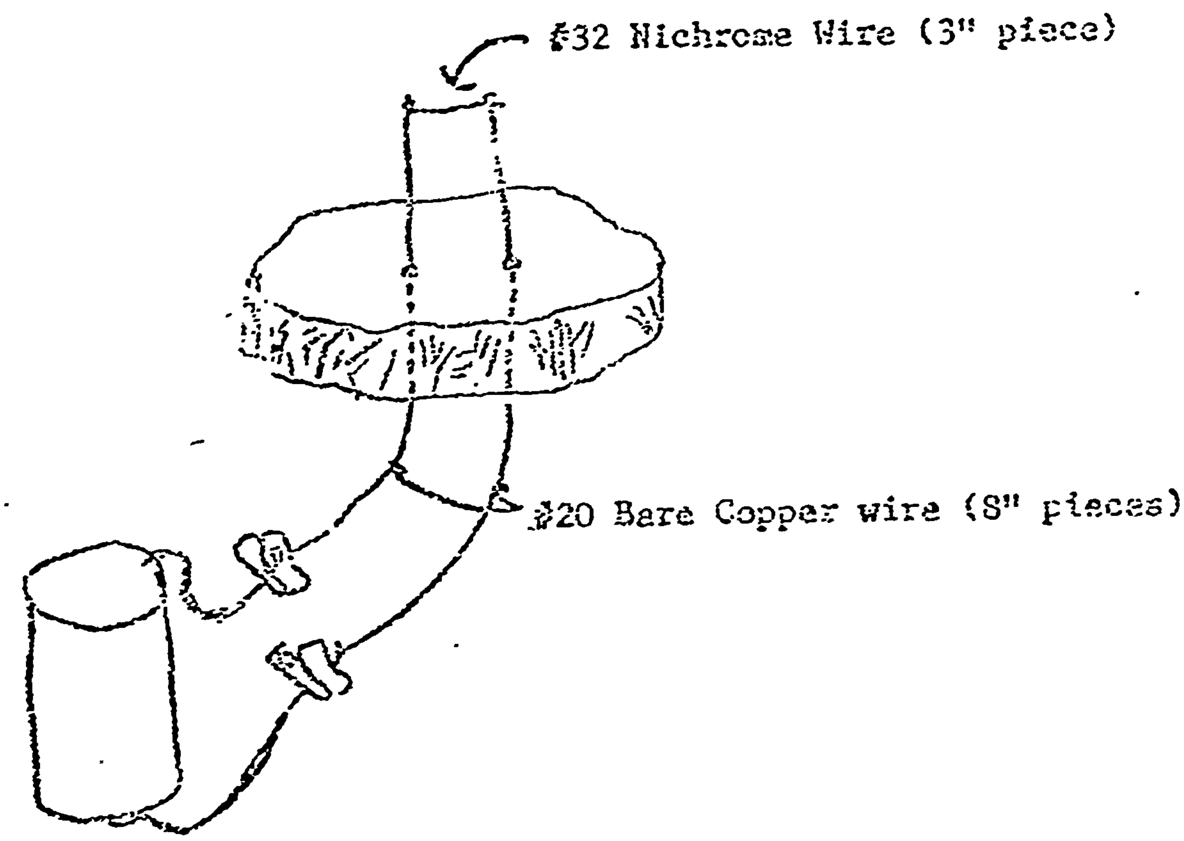
circuit

Make this circuit with copper wire and a PB bulb.

1. a) Can you short circuit this circuit with 2 feet of THIN nichrome wire?
   ____
   b) Keep shortening the length of wire. What happens? __________
2. a) Do the same experiments with THICK nichrome wire. What happens?
   ____
   b) Keep shortening the length of wire. What happens? __________
3. a) Do the same experiments with VERY THIN copper wire. What happens?
   ____
   b) Keep shortening the length of wire. What happens? __________

WORKSHEET 14a

MAKING A BULB



MATERIALS

1 two-inch ball modeling clay
2 eight-inch pieces #20 copper wire
1 three-inch piece #32 thin nichrome
Various lengths of other wires

WORKSHEET 14b

MAKING A BULB (CONT.)

QUESTIONS

Will the nichrome wire glow with one battery attached? ______________

What happens with two (2) batteries? ______________

What happens with three (3) batteries? ______________

Will thick copper wire glow? ______________

Will a longer piece of thin nichrome wire glow? ______________

Will any other type of wire glow? ______________

How much wire do you use? ______________

How many batteries does it take to make this other wire glow? ______________

WORK SHEET 15

THE COMPASS

1. Place a compass on a non-metal surface

   do not shake it

   take materials from the "junk box" such as paperclip, nail, battery, wood, keys another compass, etc.

   bring them close to the compass but do not touch it

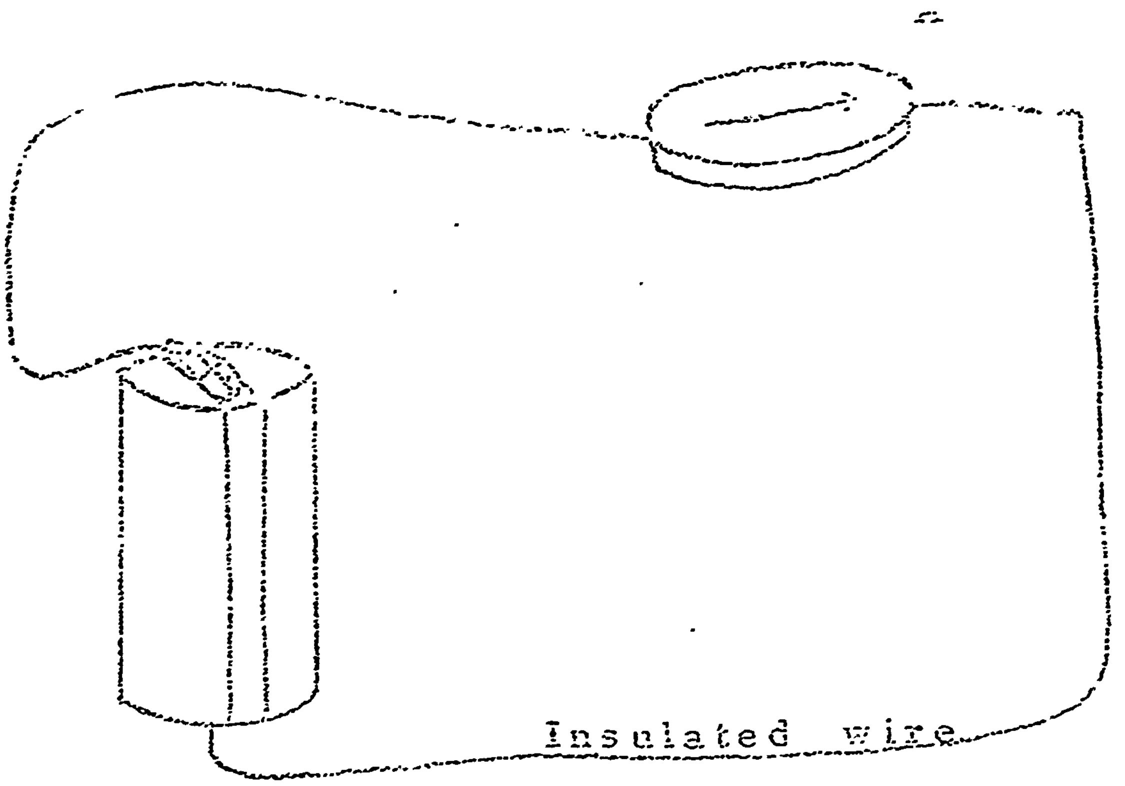
LIST MATERIALS AS FOLLOWS

COMPASS MOVES	COMPASS DOES NOT MOVE

NAME ______________________ WORK SHEET III

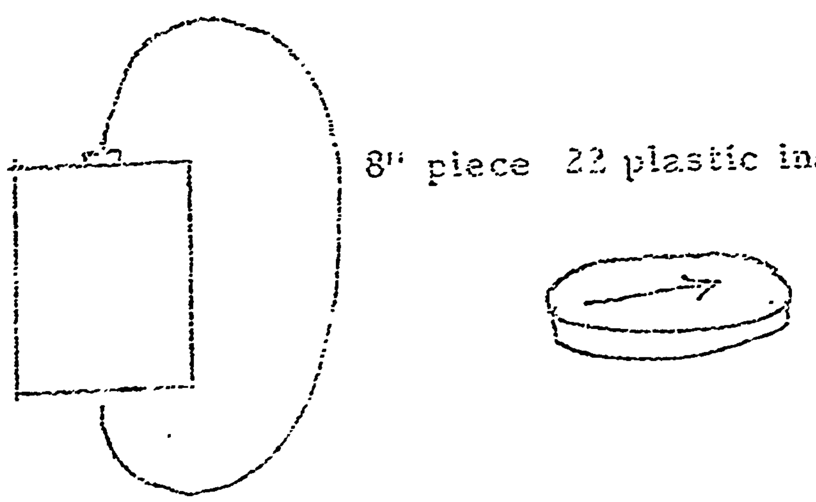
THE COMPASS

1. MAKE THIS SET-UP.



Move the wire at A over the case. Where must you touch the compass to make the needle move? ______________

2. SHORT CIRCUIT A BATTERY LIKE THIS:



Move wire over, under and around compass. Does the needle move is the wire is not moved? ______________

Quickly connect and disconnect wire from one side of battery. What happens? ______________

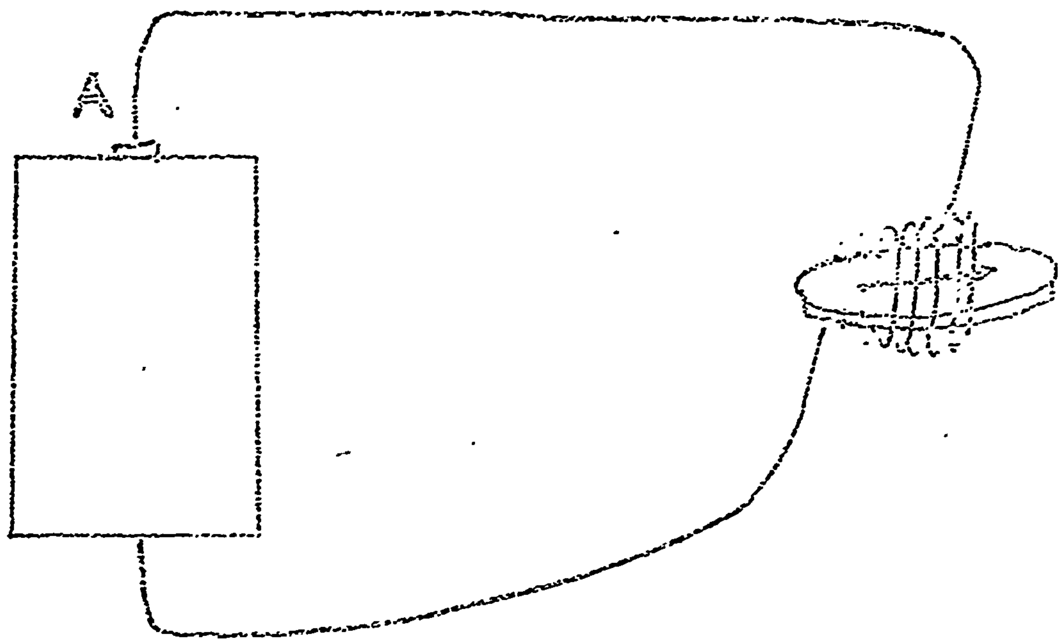
WARNING: KEEP COMPASS ON NON-METAL SURFACE

WORK SHEET 15c

THE COMPASS

Wrap a two (2) foot piece of 22 plastic-insulated copper wire FIVE TIMES around a battery. Remove the coil. Tape it to keep loops together.

Place the compass in the coil like this:



Quickly connect and disconnect the wire at A.

Notice how much the needle moves.

Wrap the coil around the compass in different ways to see if it makes any difference in how much the needle moves. ____________

See what happens if you reverse the position of the battery ____________

Make coils with ten turns and see what happens ____________

Make coils with fifty (50) turns and see what happens ____________

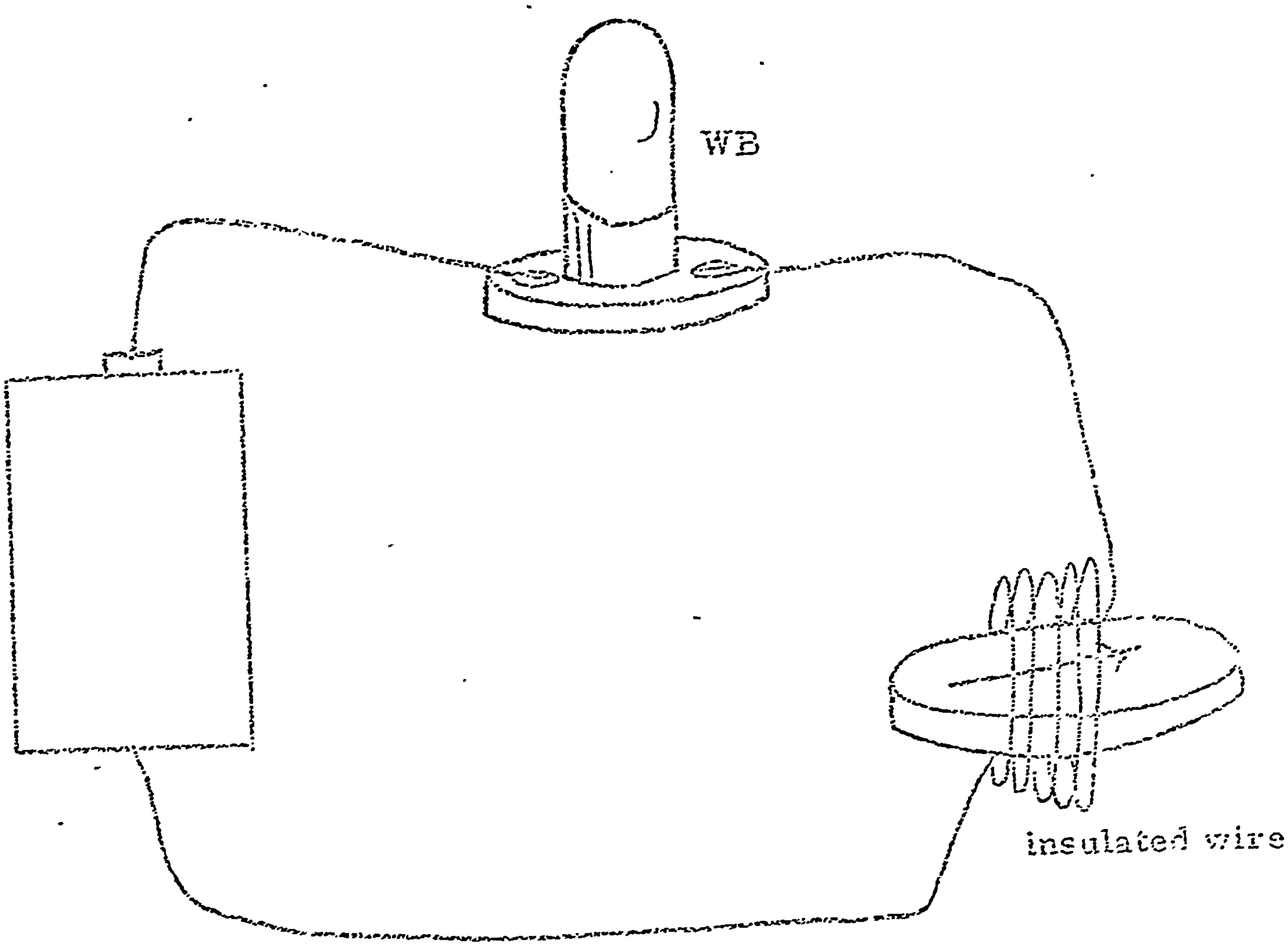
Compare the amount which the needle moves in these two compasses.

(10 turns and 50 turns/wire)

WORK SHEET 15d

THE COMPASS

Put a WB in the path to the battery



(Quickly "make" and "break" the circuit).

Does the needle move as much now? ______________________

Repeat using a PB. How much does the needle move? ______________________

Name

COMPLEX CIRCUITS A
TWO BATTERIES AND TWO BULBS

1. Connect two batteries and two bulbs so each bulb is STANDARD BRIGHTNESS

2. Connect two batteries and two bulbs so each bulb is BRIGHTER than STANDARD BRIGHTNESS.

3. Connect two batteries and two bulbs so each bulb is LESS than STANDARD BRIGHTNESS.

4. Unscrew bulbs in the circuits to see what happens.

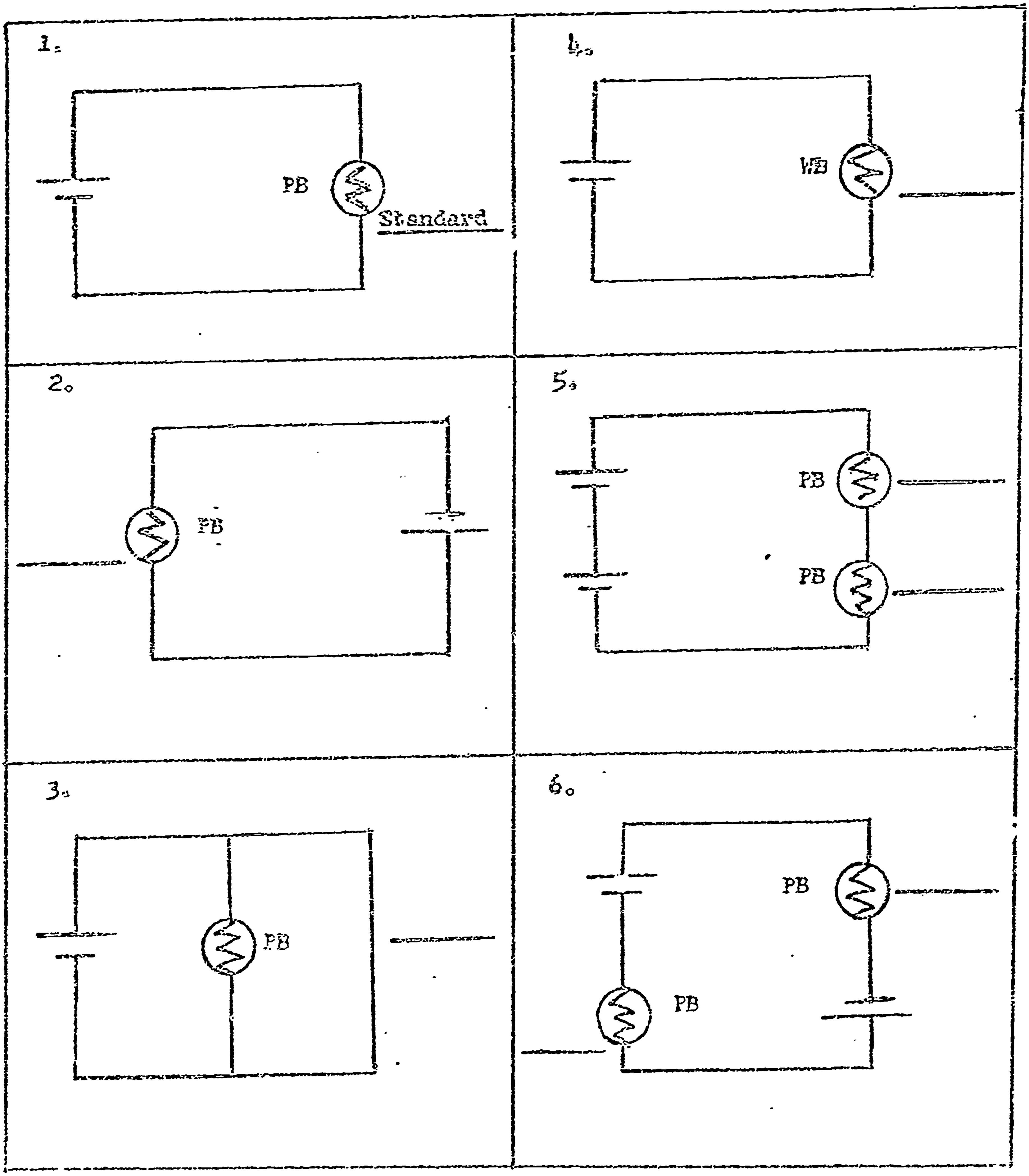
5. Touch a wire from one part of a circuit to other parts of the circuit to see what happens.

(Name)

EXTRA WORK

PREDICTION SHEET-A

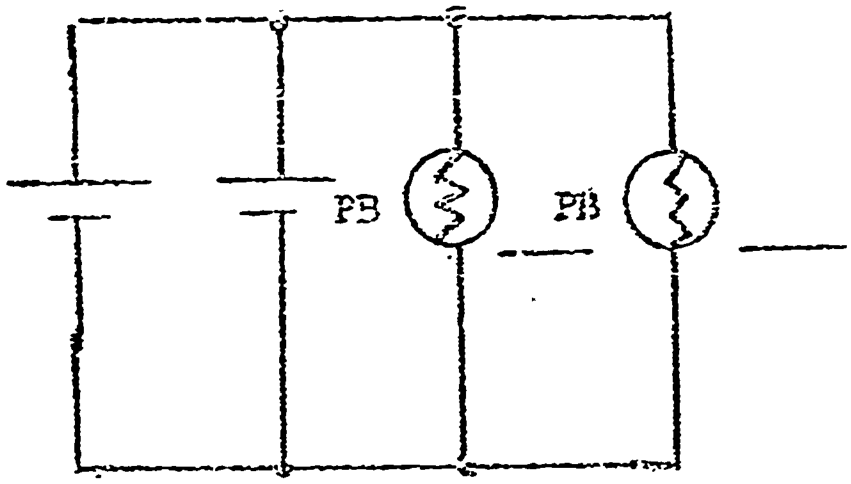
In the circuit diagrams below, write beside each bulb how bright you think the bulb will be: very bright, bright, standard, dim, or very dim.



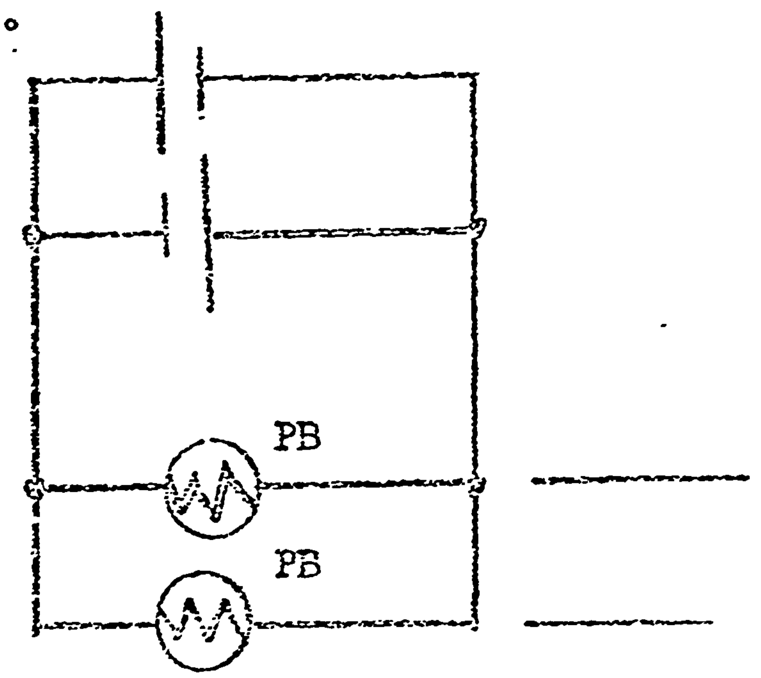
____
(Name)

PREDICTION SHEET-A
(continued)

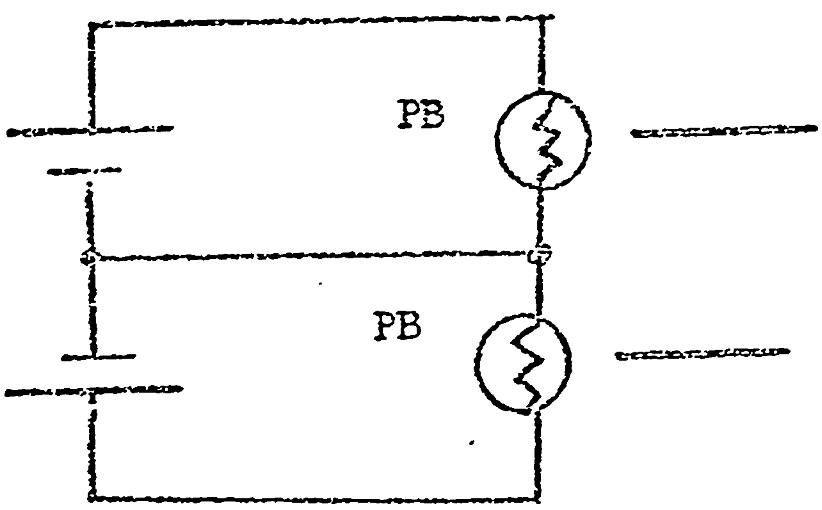
7.



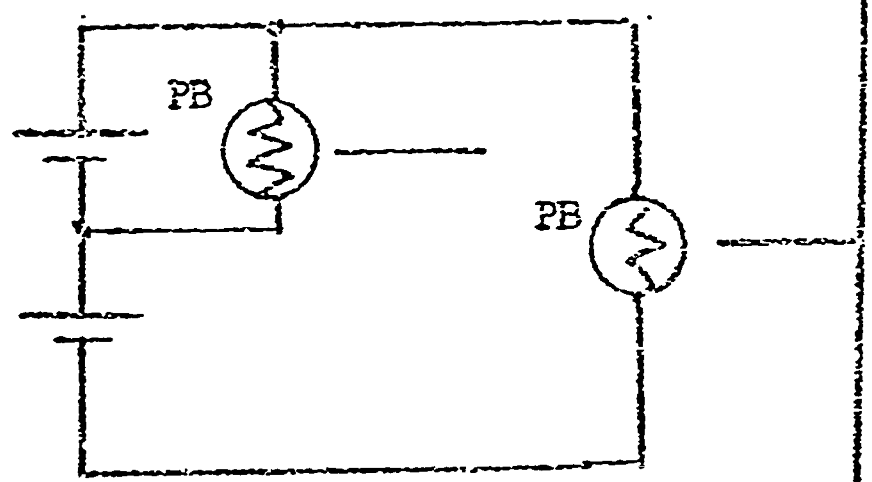
8.



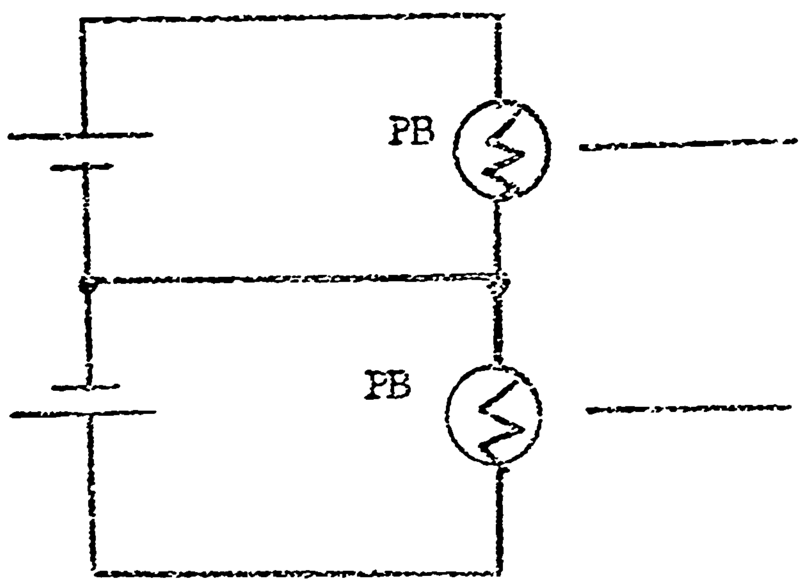
9.



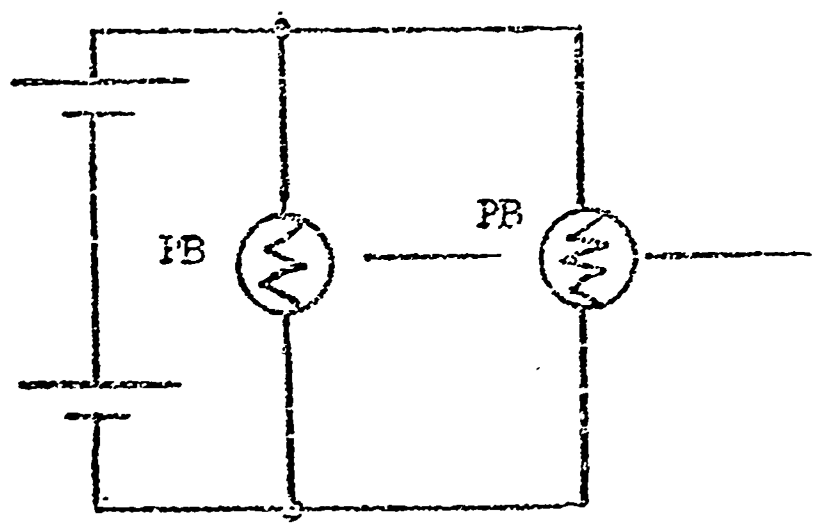
10.



11.



12.



EXTRA WORK

____
(NAME)

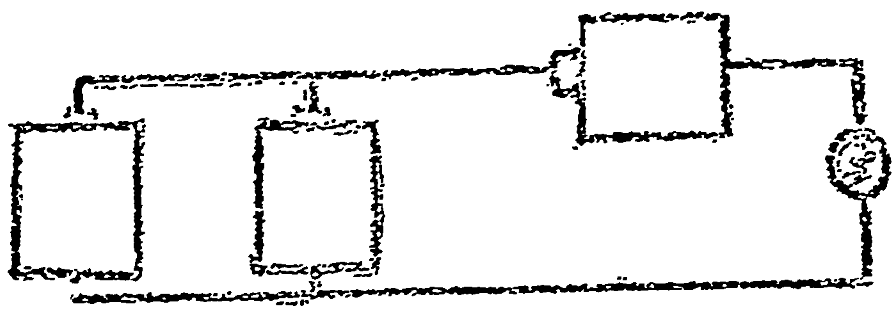
COMPLEX CIRCUITS — B

SEVERAL BATTERIES and One Bulb

1.) Connect several batteries to one bulb so it will light with <u>standard brightness</u>.

2.) Connect several batteries to one bulb so it will light <u>brighter</u> than standard brightness.

3.) Try making the following circuit:



What happens? ______________________

4.) Dim a bulb by adding a wire.

5.) Put batteries together in such a way that a bulb will <u>Not</u> light.

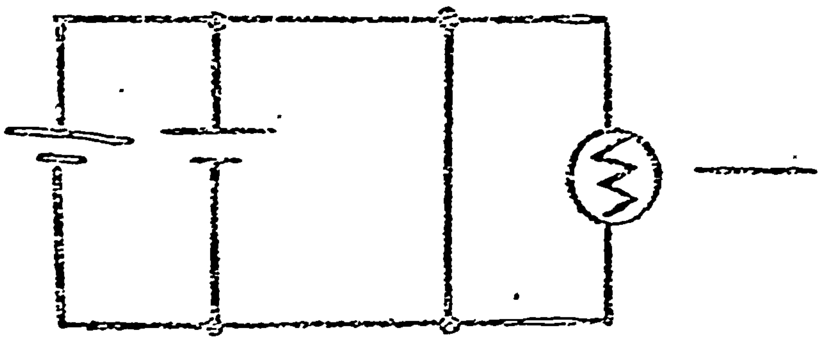
EXTRA WORK

____
(Name)

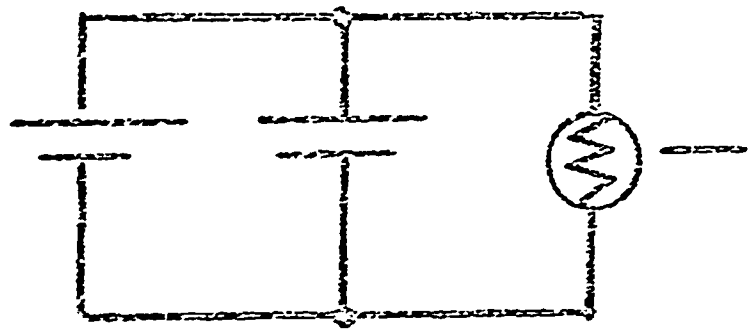
PREDICTION SHEET B

In the circuit diagrams below, write beside each bulb how bright you think it would be: very dim, dim, standard, bright, or very bright.

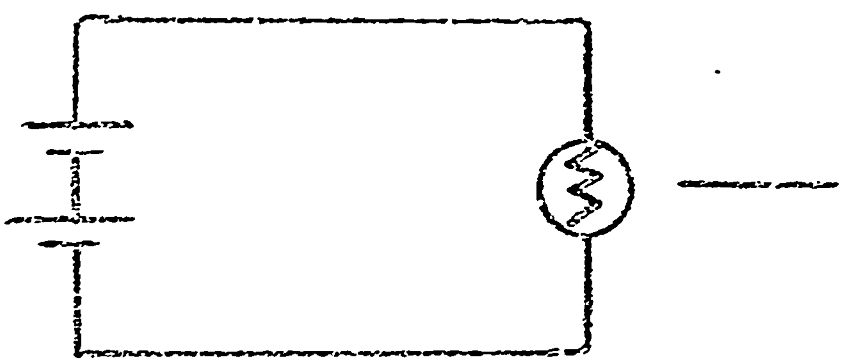
1.



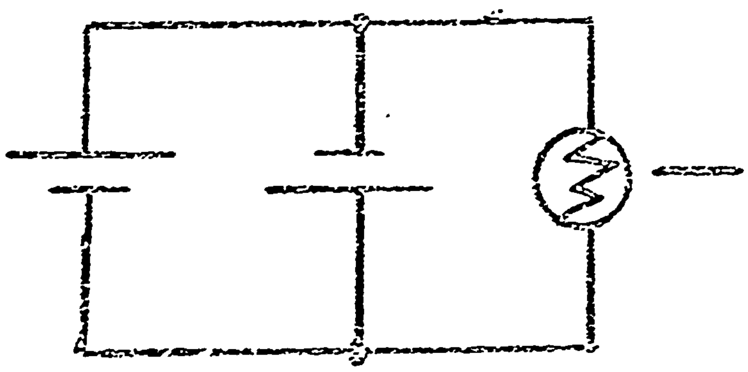
4.



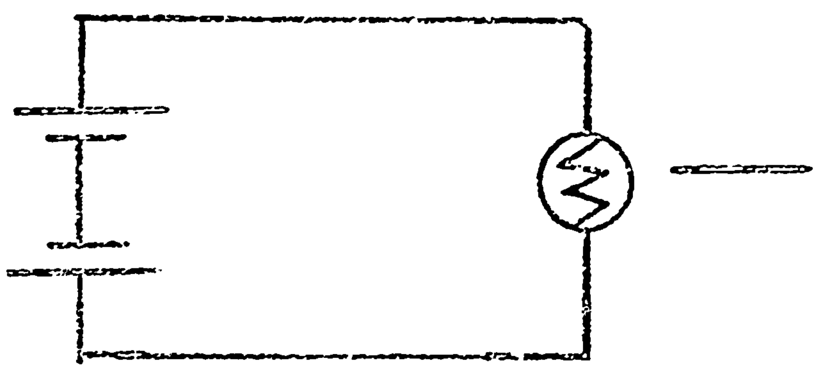
2.



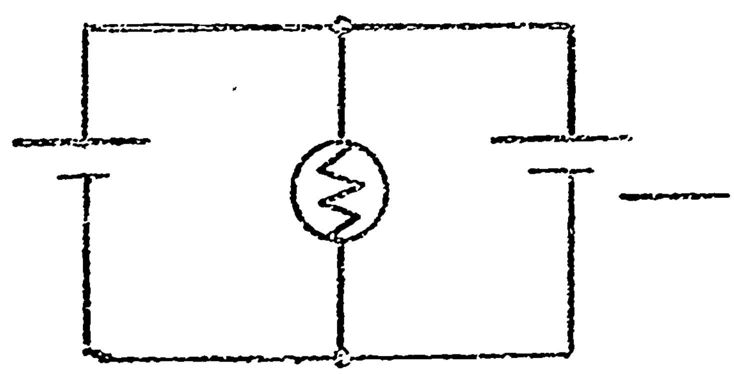
5.



3.



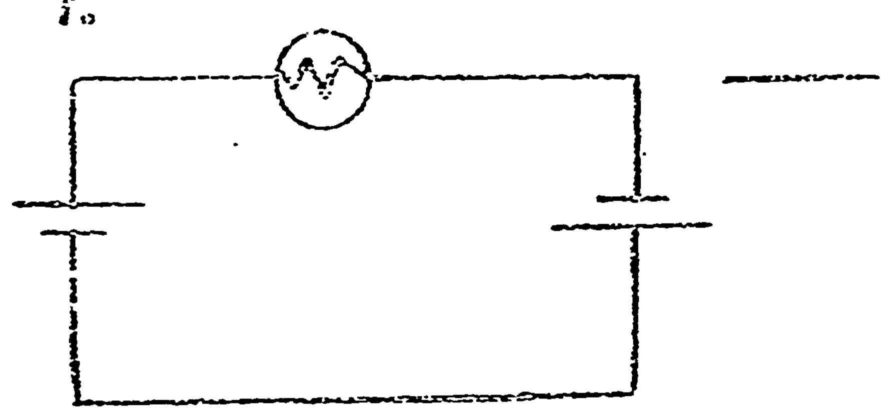
6.



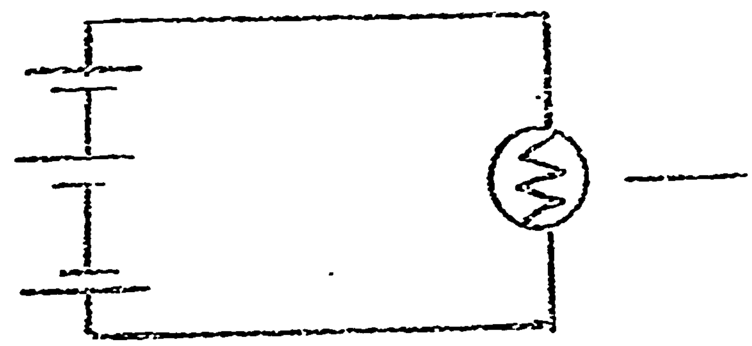
PREDICTION SHEET - B
(continued)

(Name)

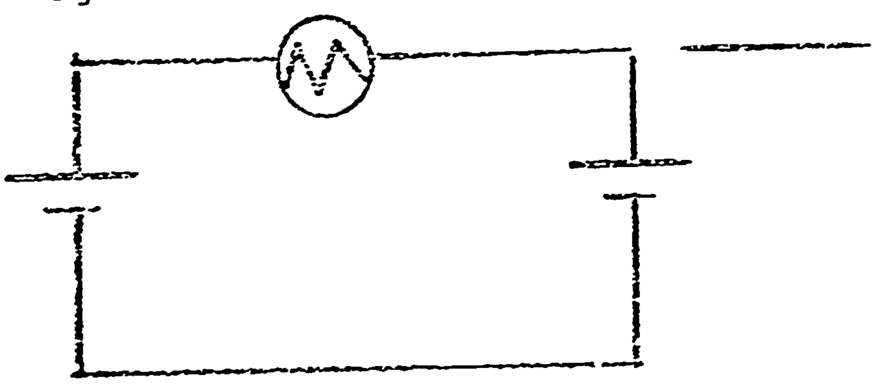
7.



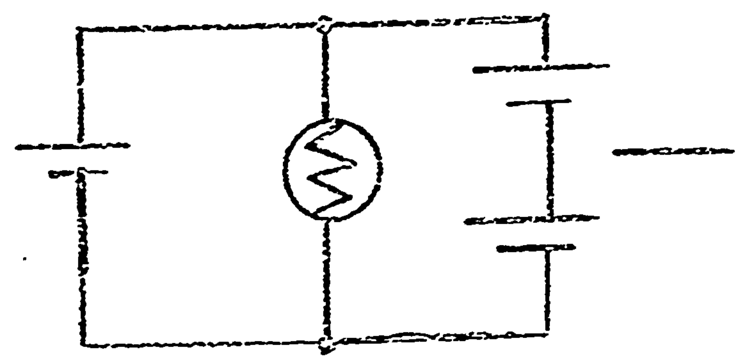
11.



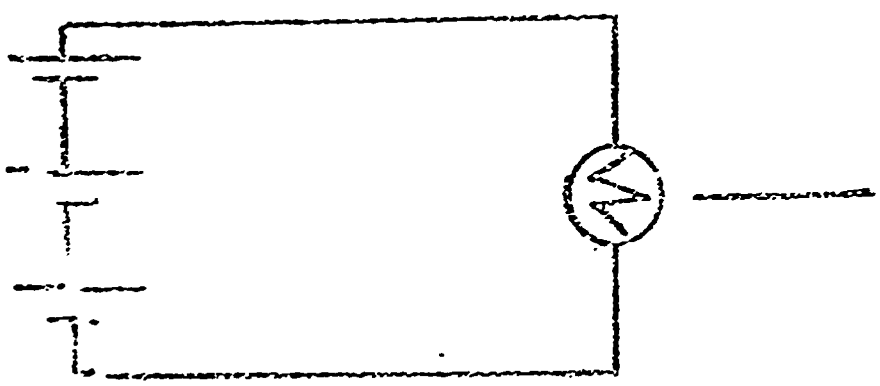
8.



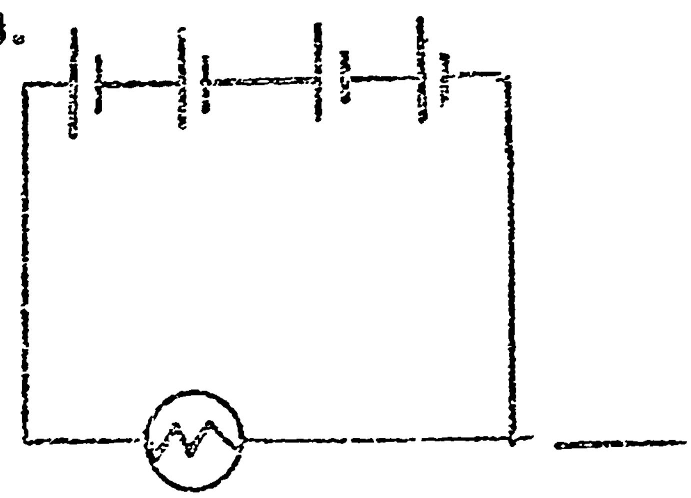
12.



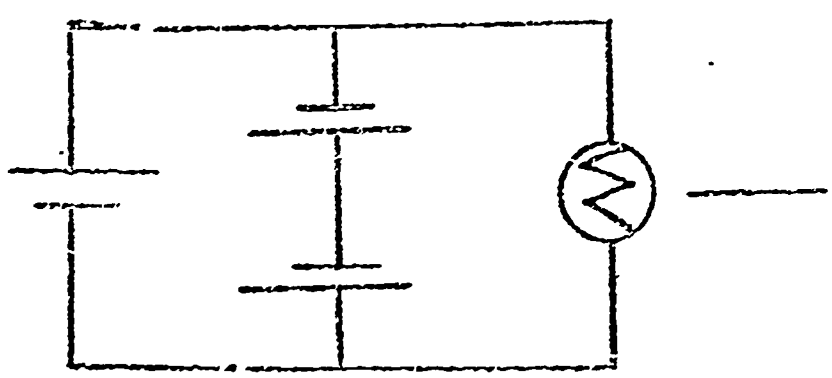
9.



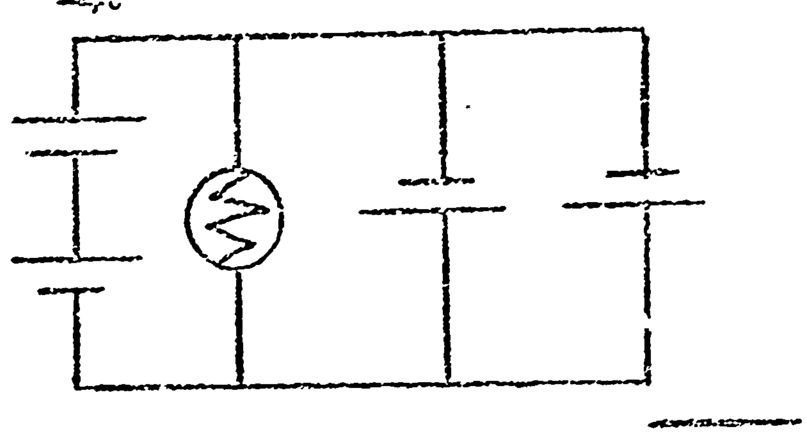
13.



10.



14.



EXTRA WORK

(Name)

COMPLEX CIRCUITS -C

ONE BATTERY and SEVERAL BULBS

1.) Connect several bulbs to one battery so that the bulbs light to standard brightness

2.) Connect several bulbs to one battery so that the bulbs light to less than standard brightness.

3. Connect several bulbs to one battery so that the bulbs light to greater than standard brightness.

Can this be done? ______

4. See how many bulbs in a row (series) one battery will light.

Is it the same for WB's and PB's ?

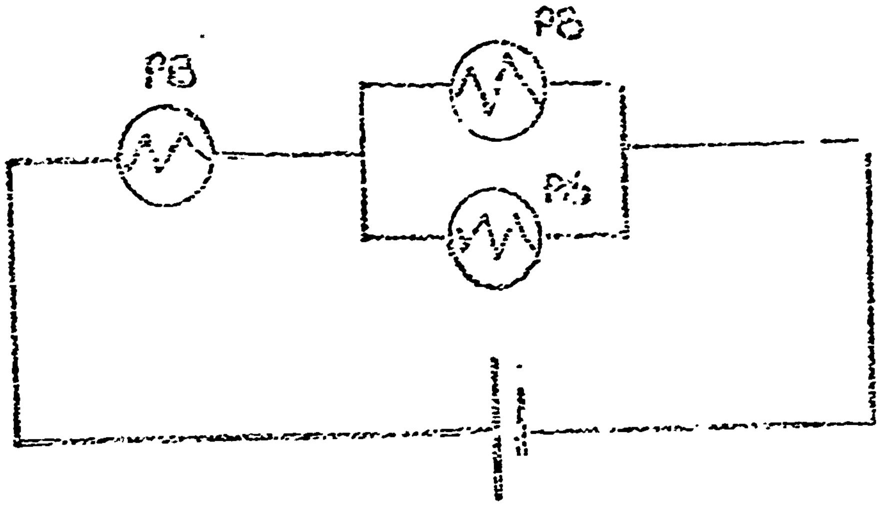
5. See how many bulbs in separate paths (parallel) a battery will light before the bulbs start getting dimmer.

Is it the same for WB's and PB's ?

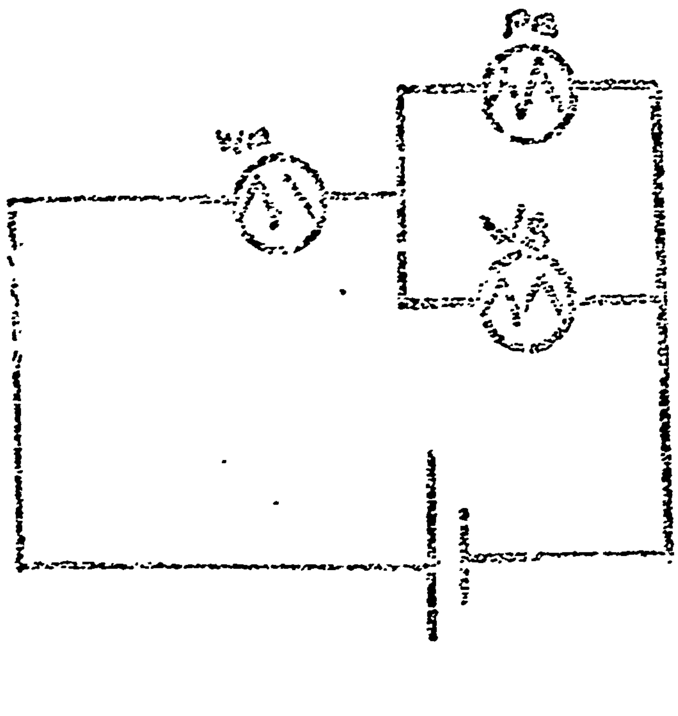
(Name)

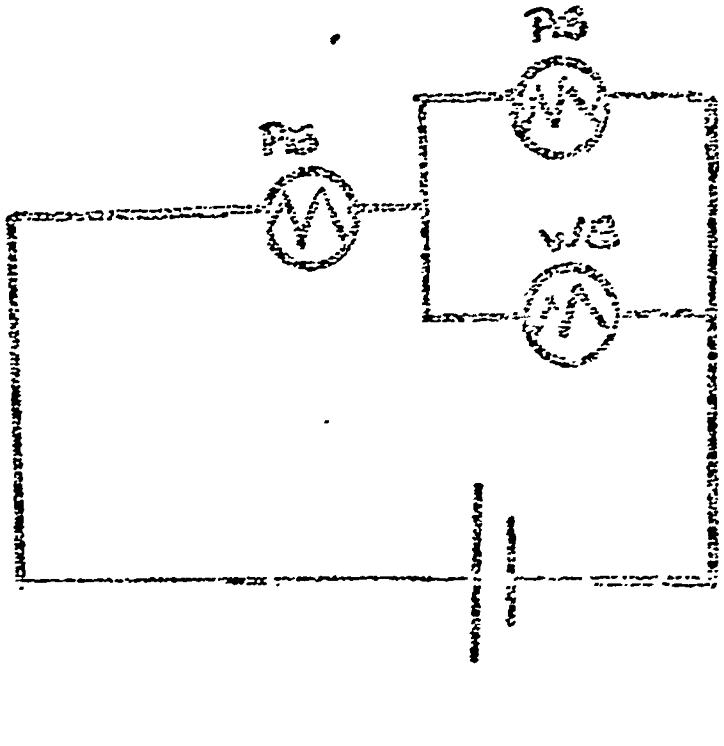
COMPLEX CIRCUITS - C
(Continued)

6. Try combinations of paths to one battery — some bulbs in a row, some on separate paths. How bright is each bulb?



7. Try combinations of WB's and PB's to one battery.
   1) On separate paths
   2) In a row
   3) In a combination of paths.





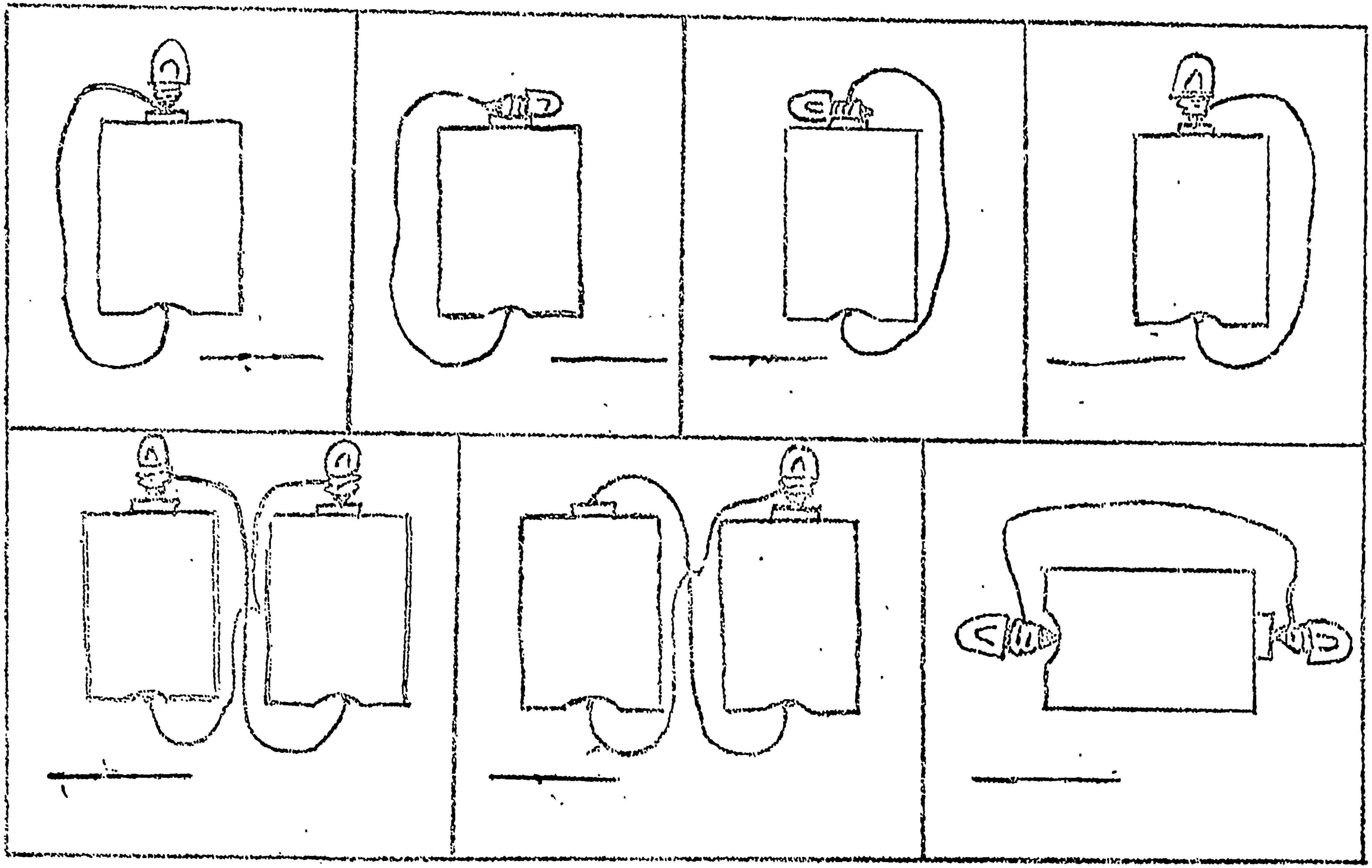
8. Use a piece of wire to put out a bulb.

9. Use a piece of wire to make a bulb brighter.

PREDICTION SHEET A

Please mark ___ if the bulb will light

Please mark ___ if the bulb will not light.

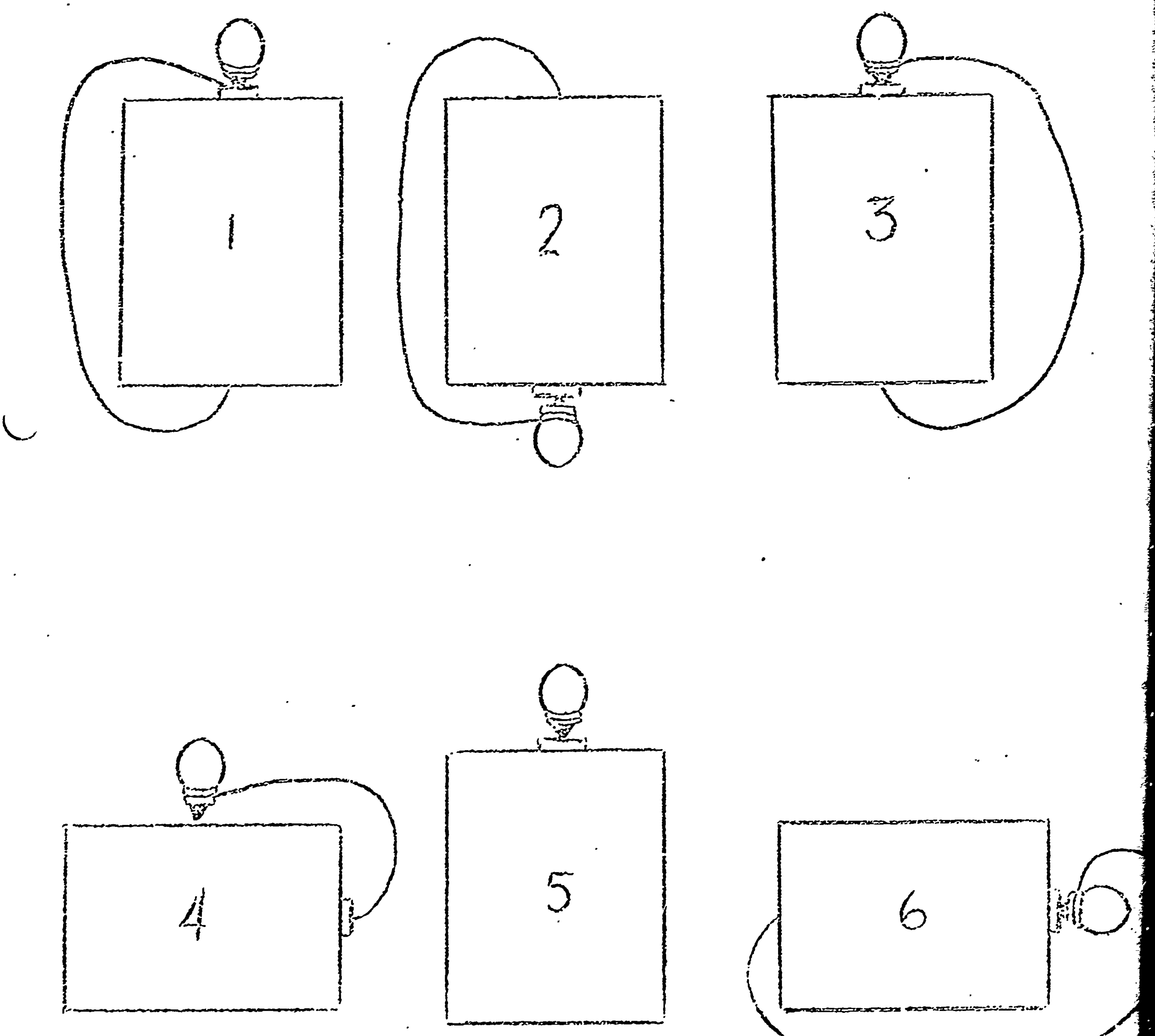


NAME ____________________

CIRCUITS I PREDICTION SHEET ONE (1)

Will the bulb light?

If you are not sure, try it and see!

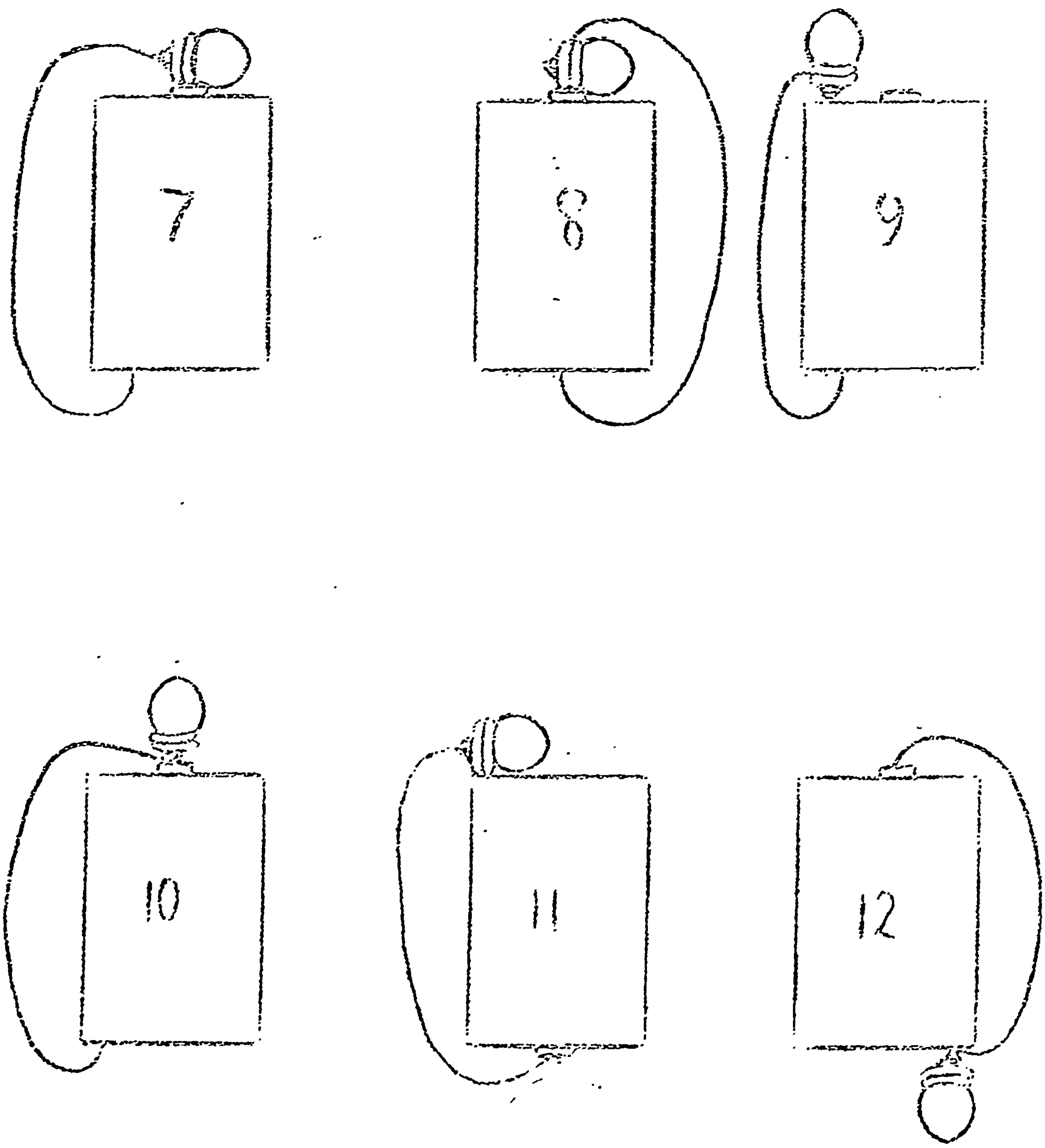


NAME ______________________

CIRCUITS I
PREDICTION SHEET ONE
(2)

WILL THE BULB LIGHT?

IF YOU ARE NOT SURE, TRY IT AND SEE

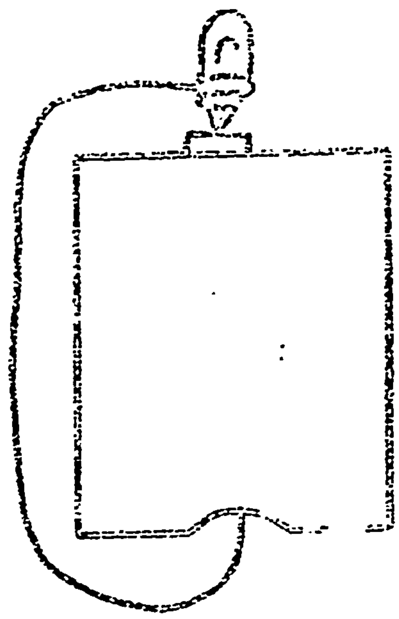


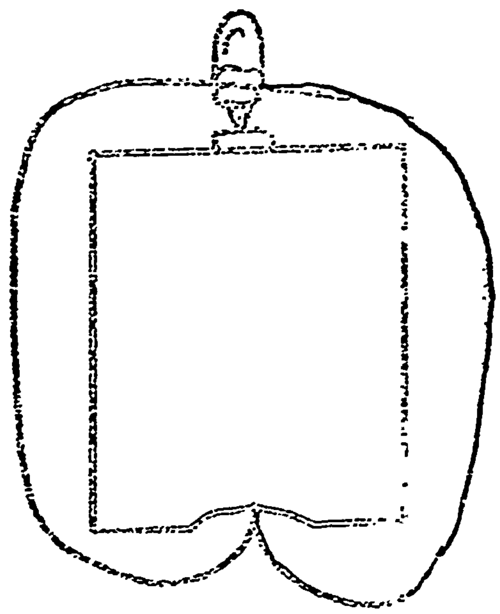
name

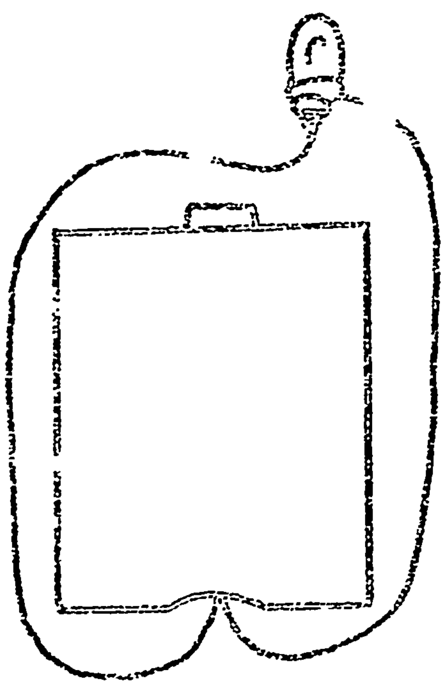
PREDICTION SHEET CI

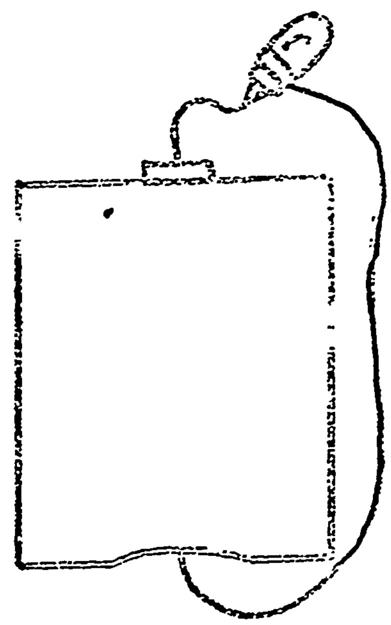
Write YES under the ones that will light.

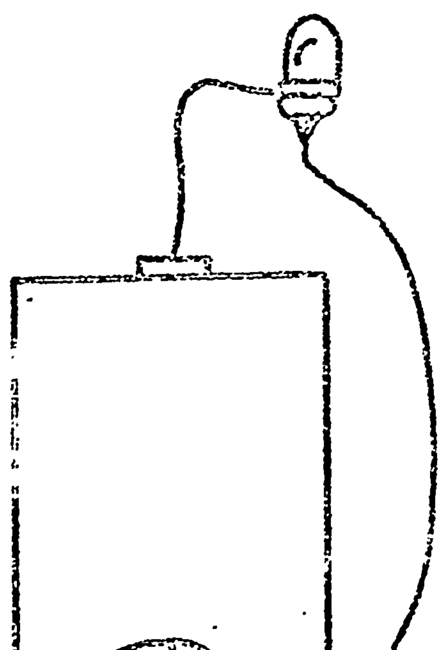
Write NO under the ones that will not work.



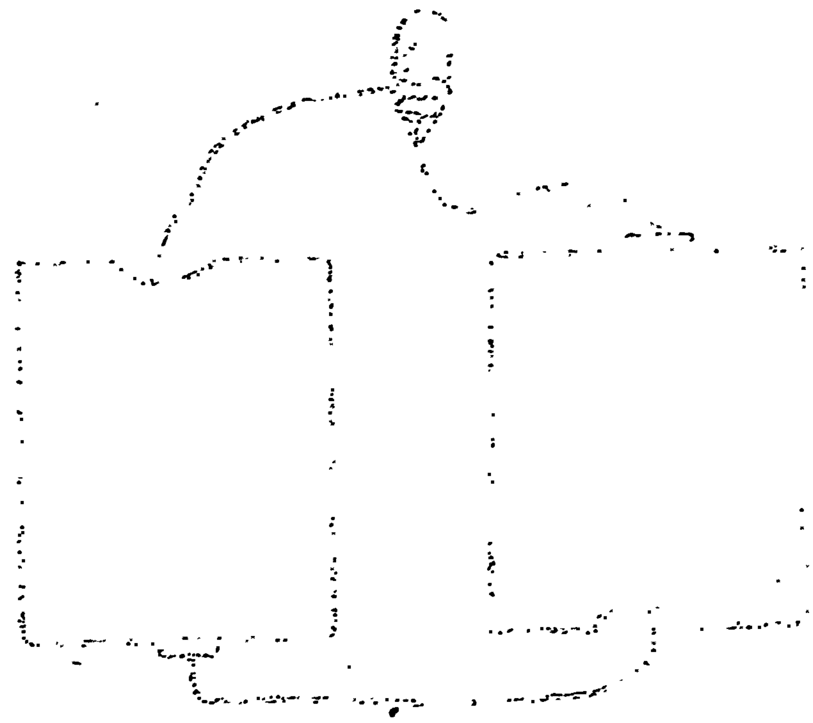


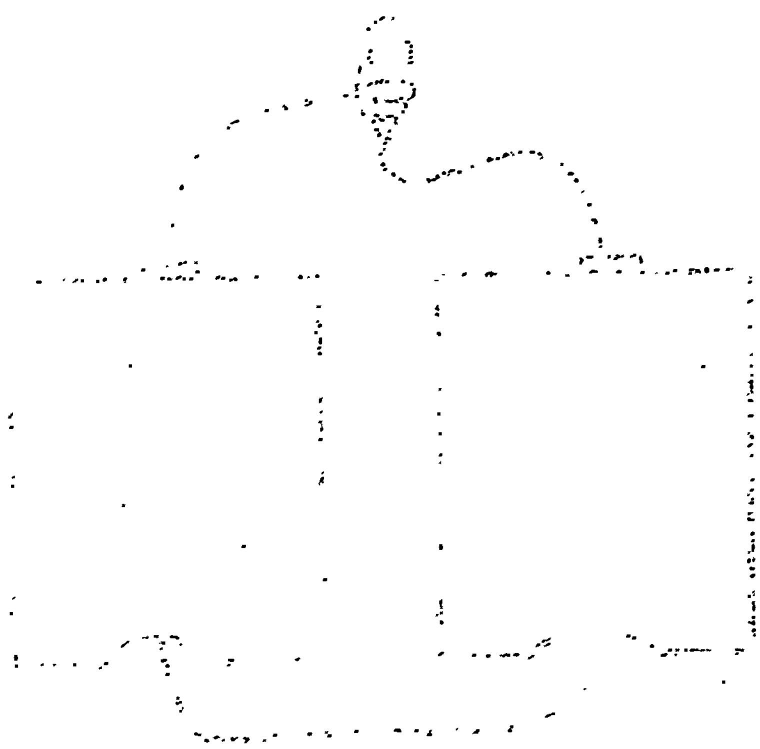


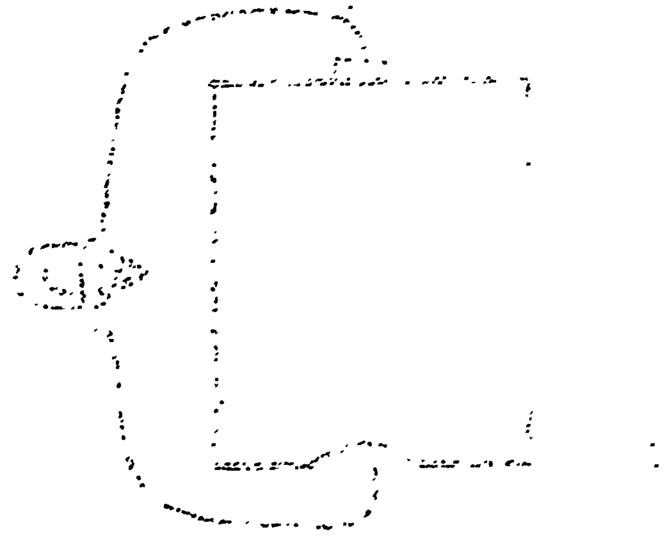




PREDICTION SHEET





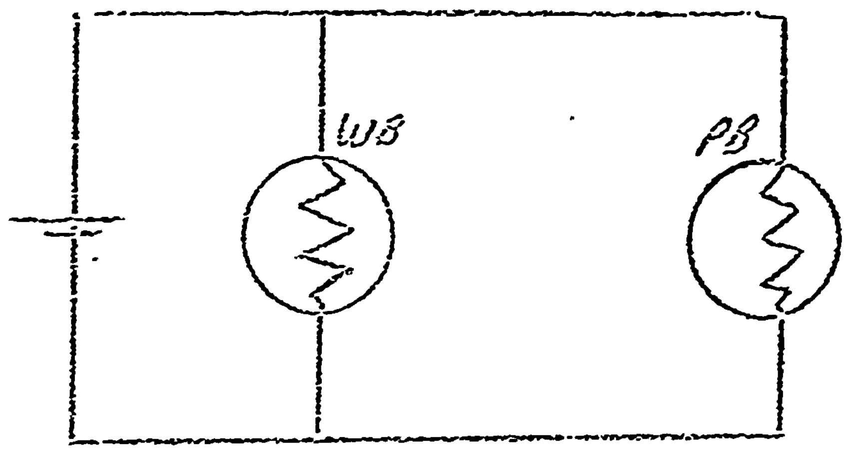


NAME ____________________

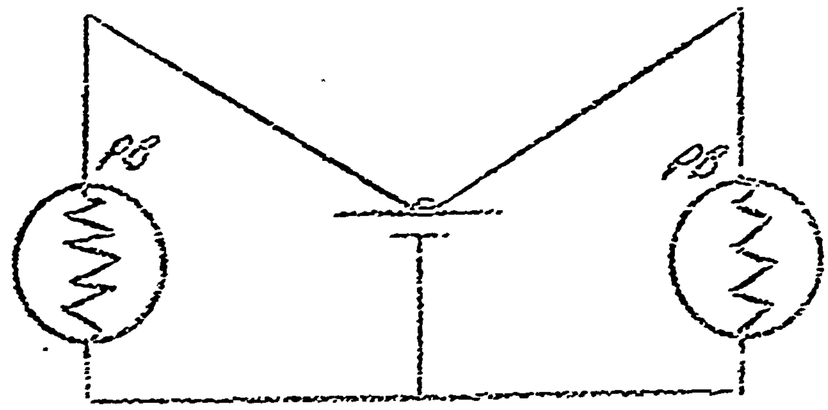
EXTRA WORK
Prediction Sheet C (1)

In the circuit diagrams below, write beside each bulb how bright you think it would be: DIM, VERY DIM, STANDARD, BRIGHT, VERY BRIGHT

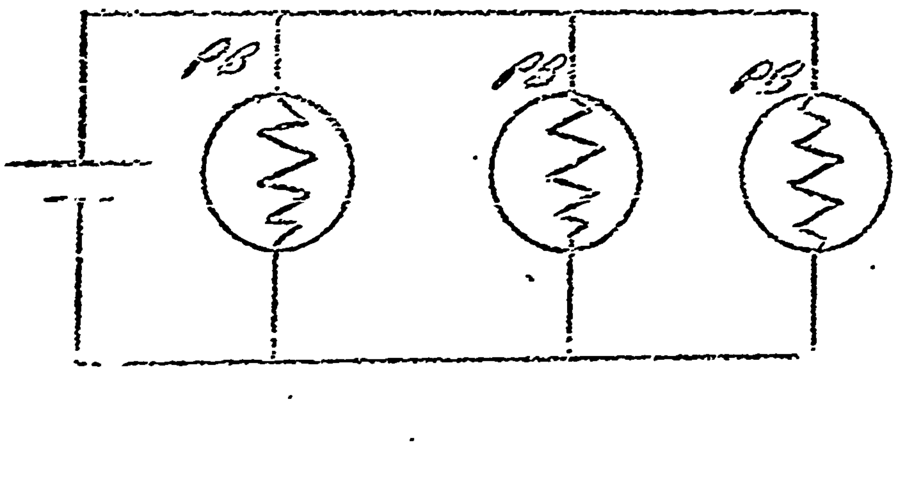
1



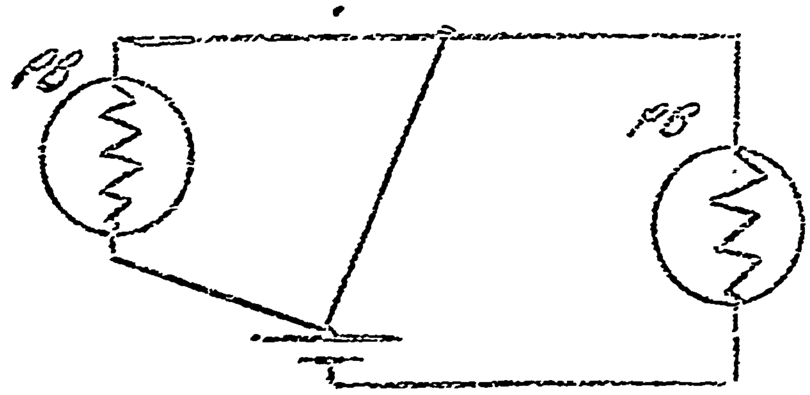
2



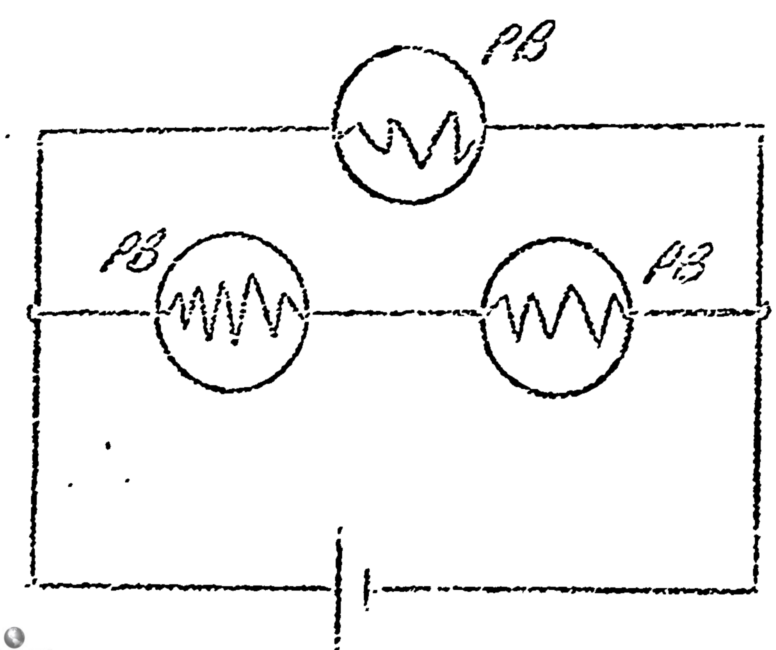
3



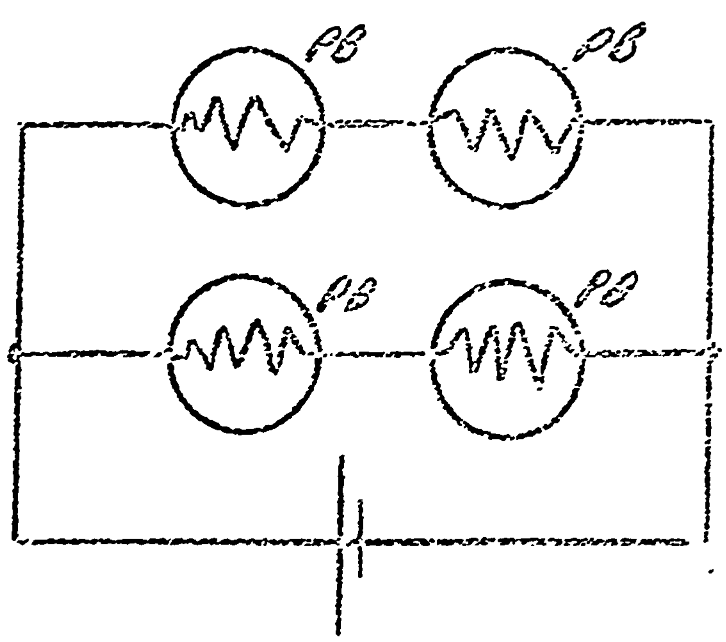
4



5



6

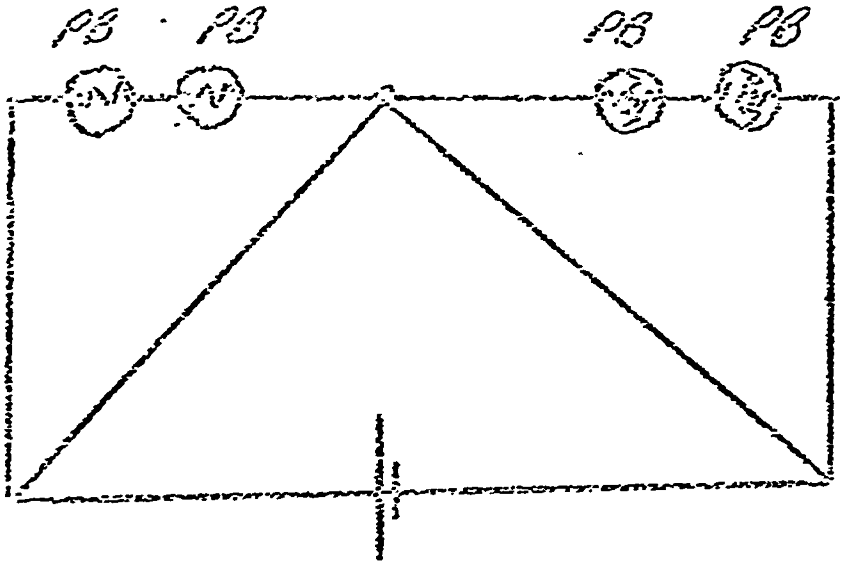


Name

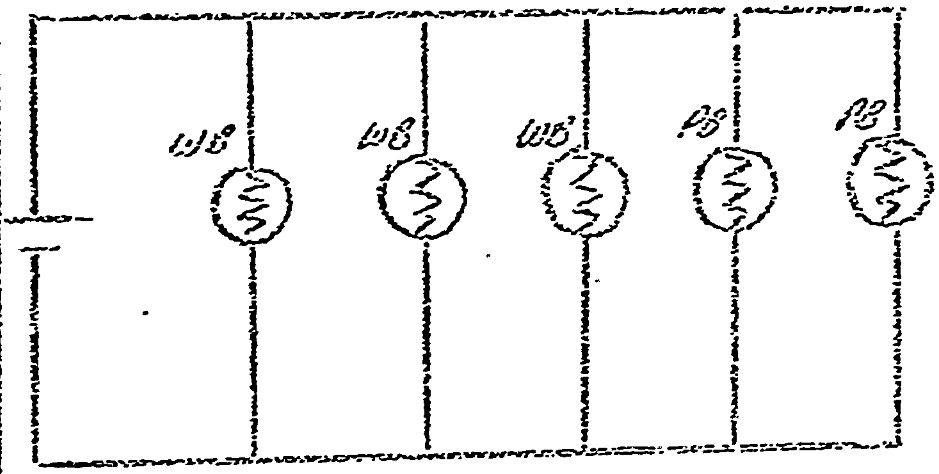
EXTRA WORK
Prediction Sheet C (2)

In the circuit diagrams below, write beside each bulb how bright you think is would be: VERY DIM, DIM, STANDARD, BRIGHT, VERY BRIGHT

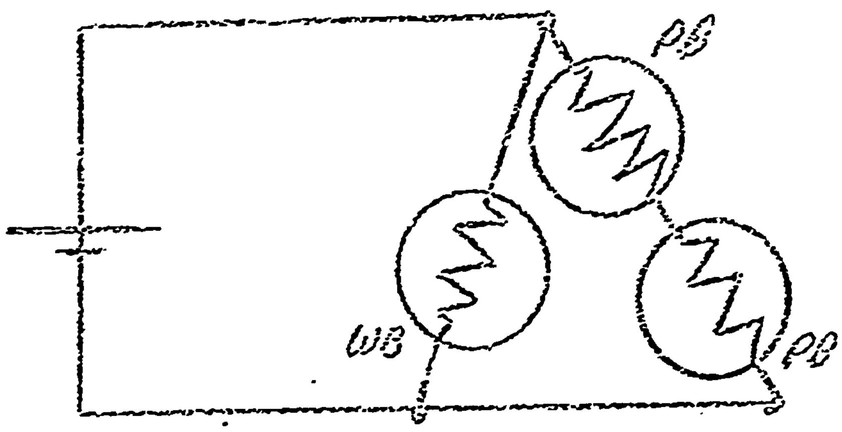
7.



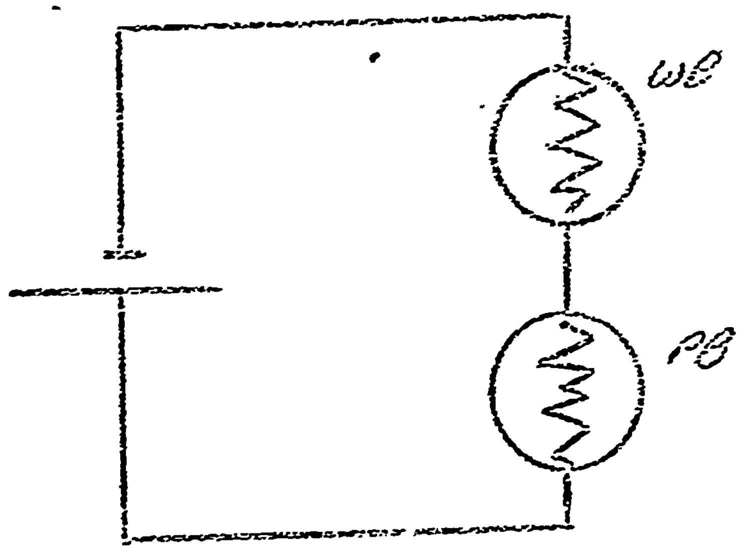
8



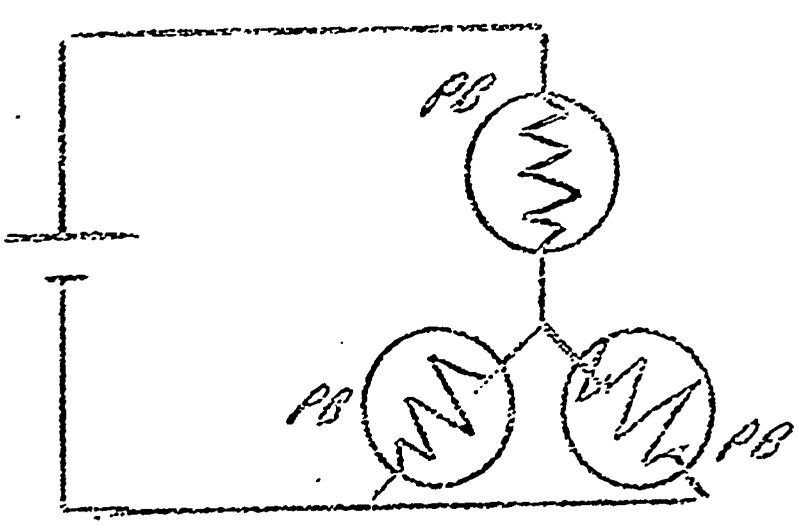
9



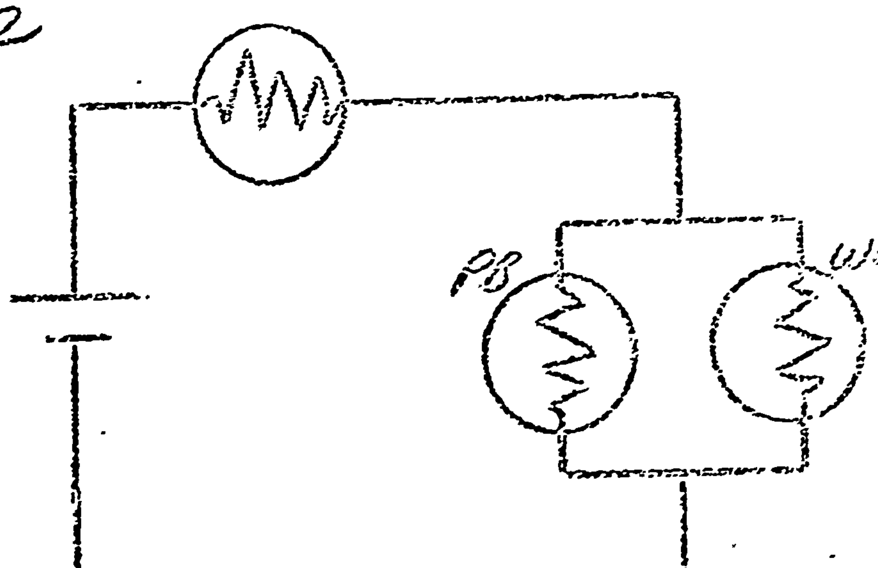
10



11



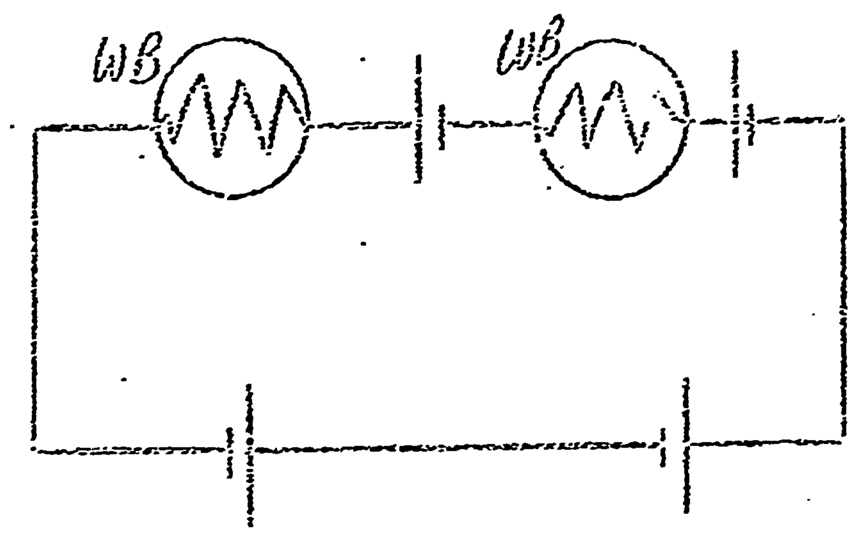
12

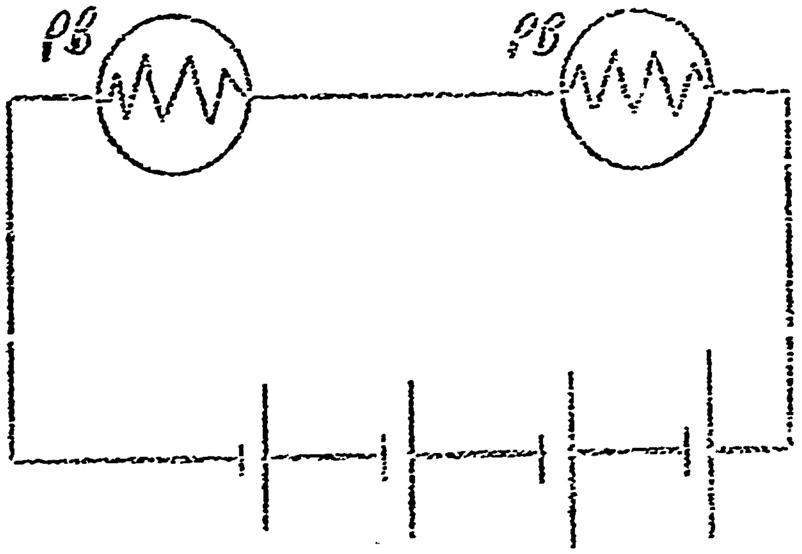


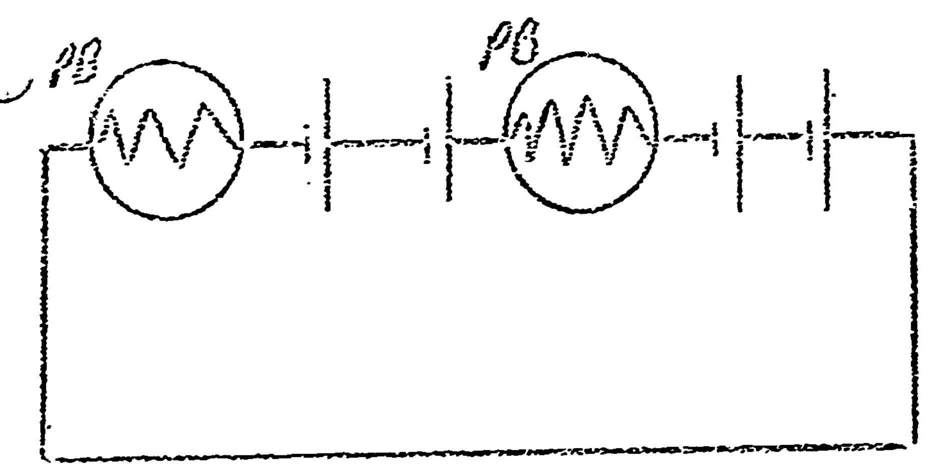
NAME

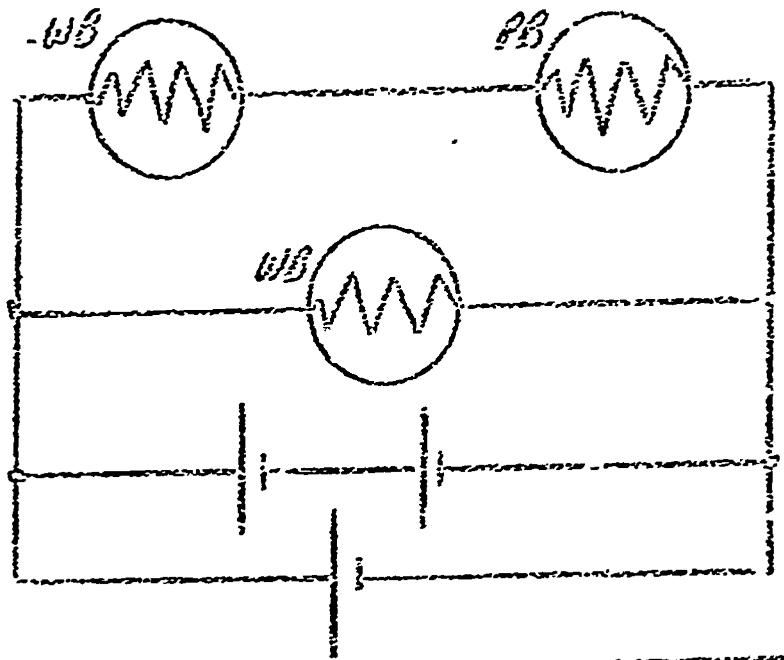
EXTRA WORK
Prediction Sheet D

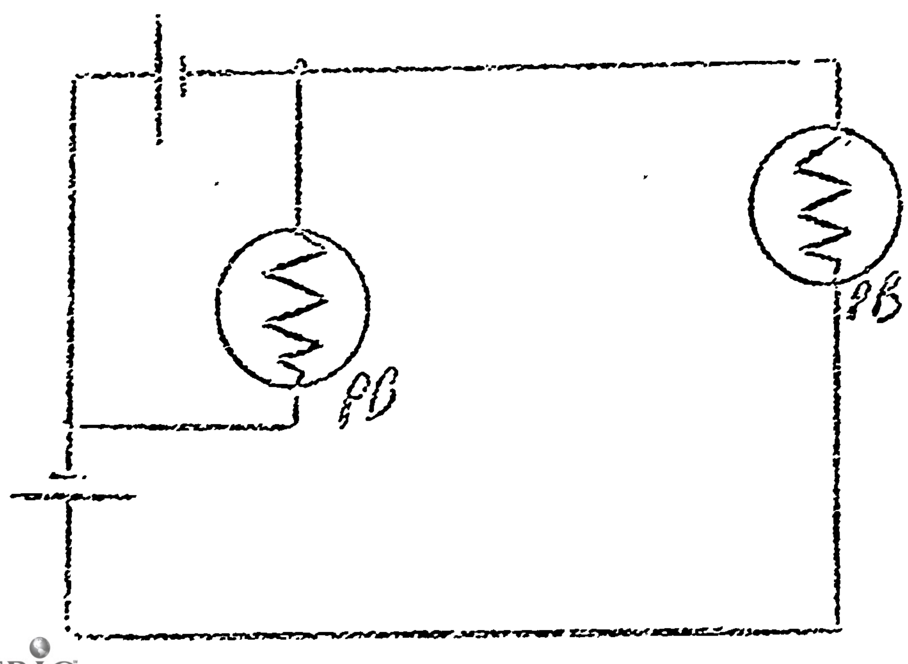
In the circuit diagrams below, write beside each bulb how bright you think it would be: VERY DIM, DIM, STANDARD, BRIGHT, VERY BRIGHT

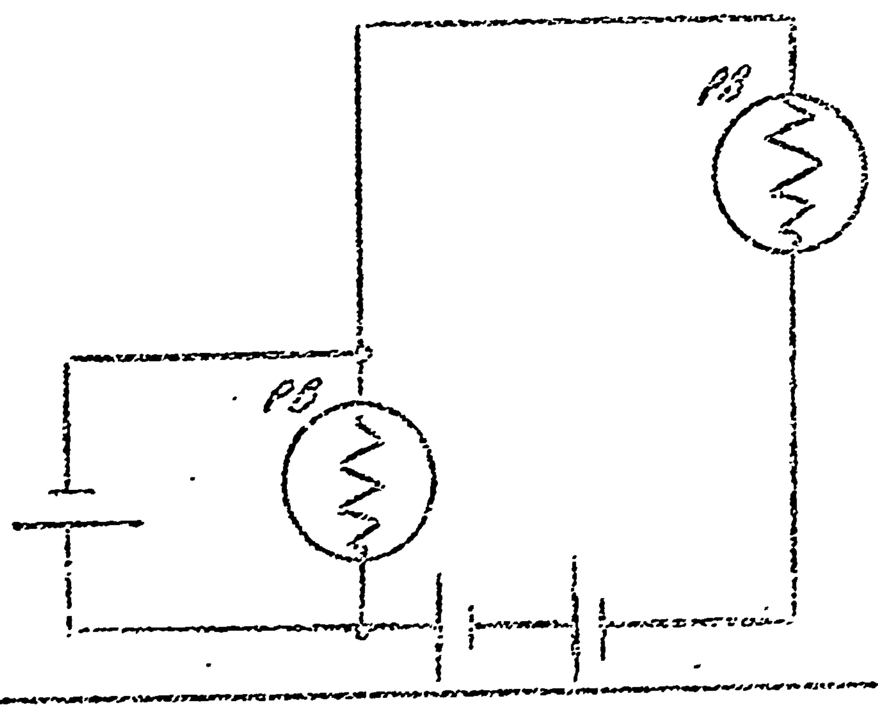










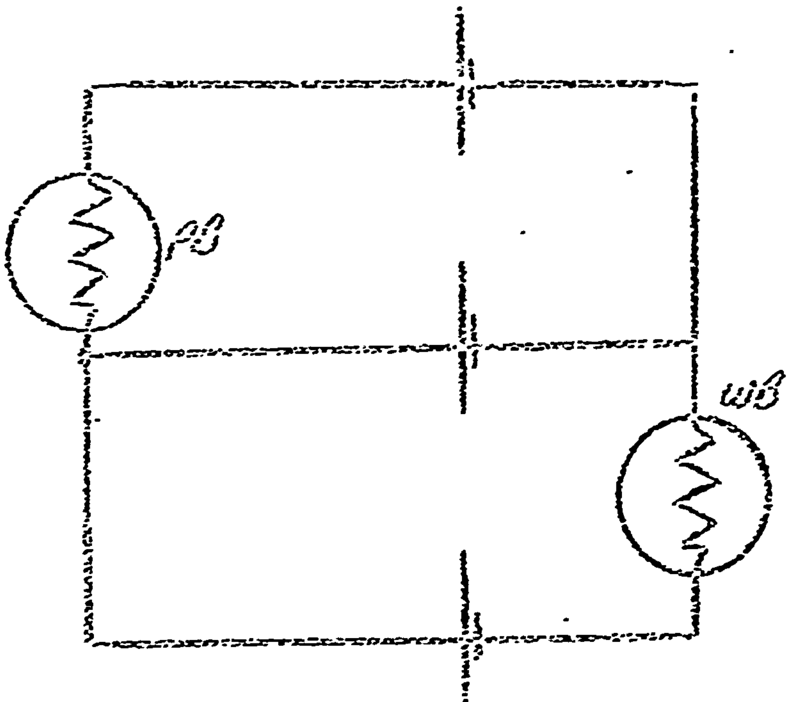


NAME ____________________

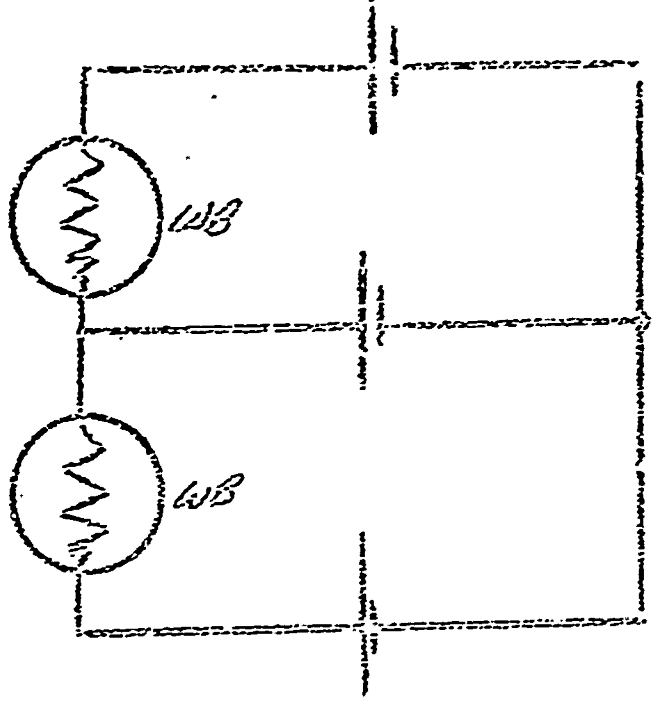
EXTRA WORK
Prediction Sheet D (2)

In the circuit diagrams below, write beside each bulb how bright you think it would be: VERY DIM, DIM, STANDARD, BRIGHT, VERY BRIGHT

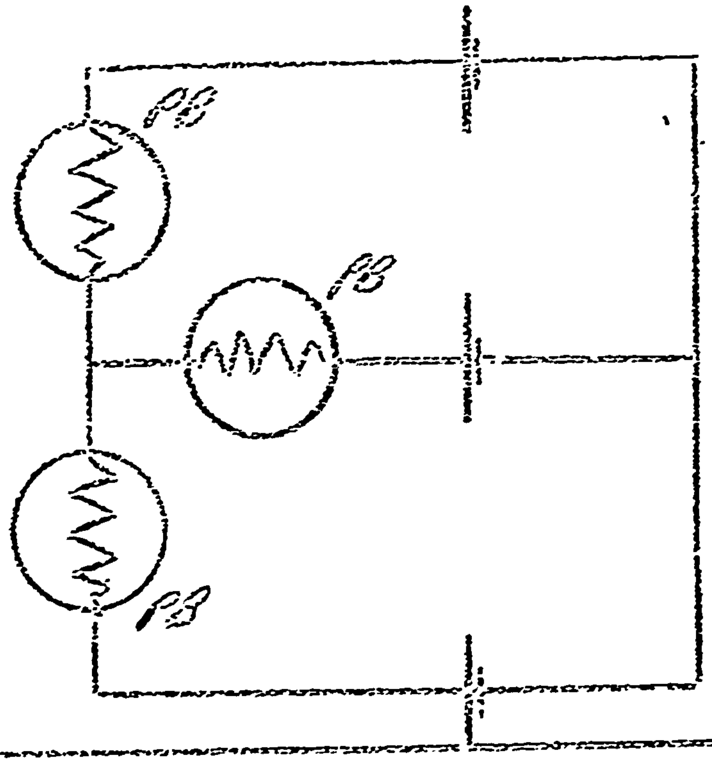
7



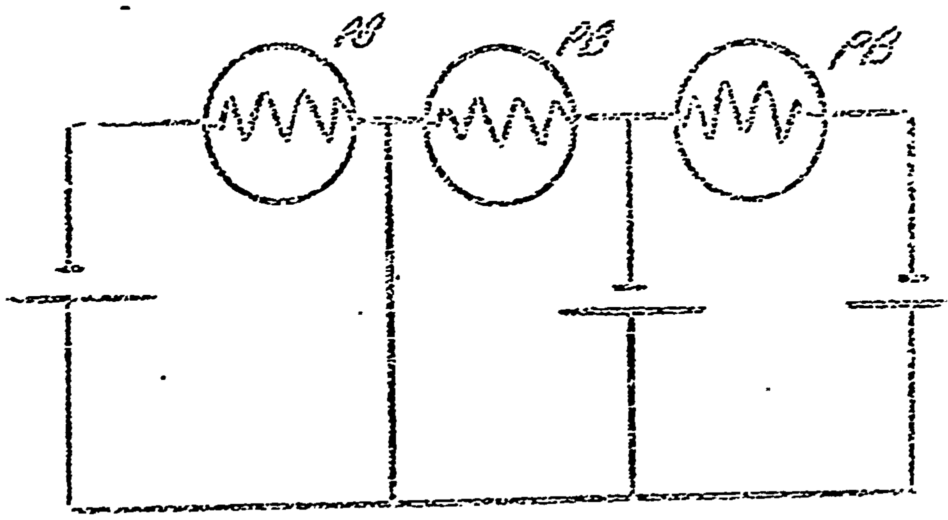
8



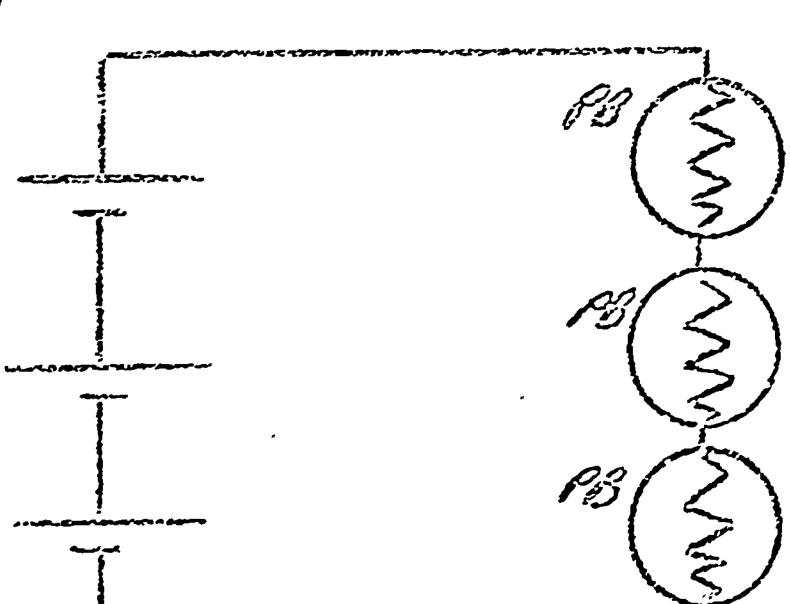
9



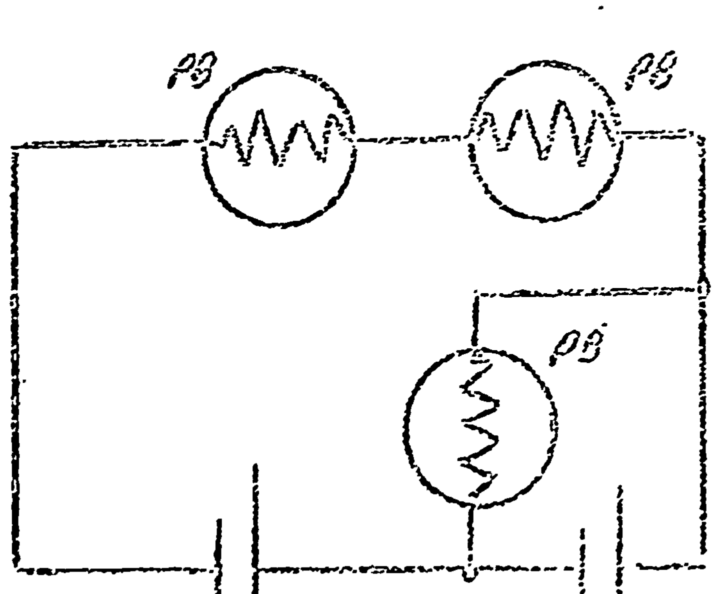
10



11



12

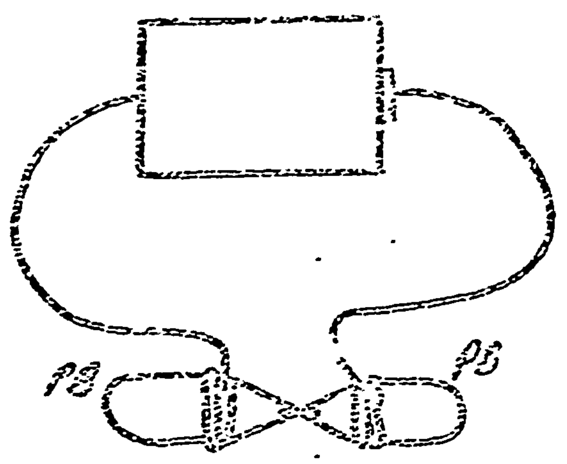


PREDICTION SHEET 3

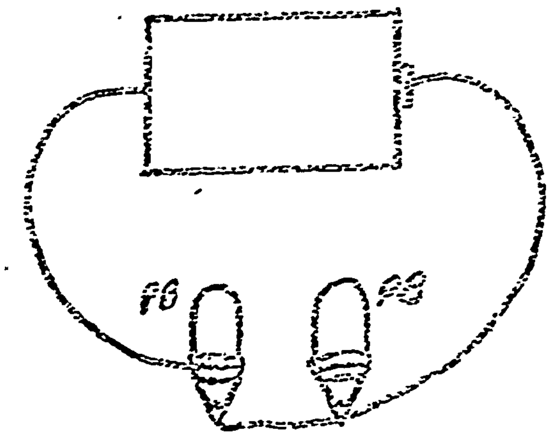
NAME ____________________

MARK AN ✓ FOR THOSE BULBS WHICH WILL LIGHT AND MARK AN X FOR THOSE BULBS WHICH WILL NOT LIGHT.

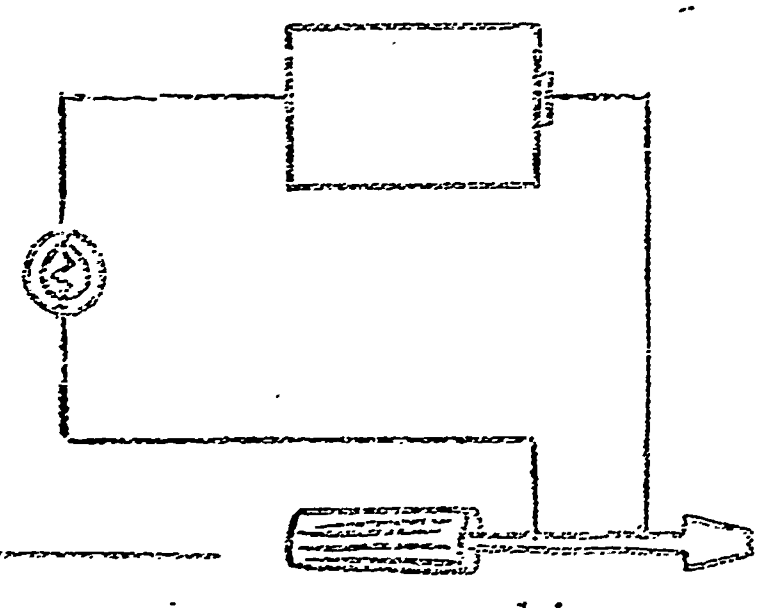
1.



2.

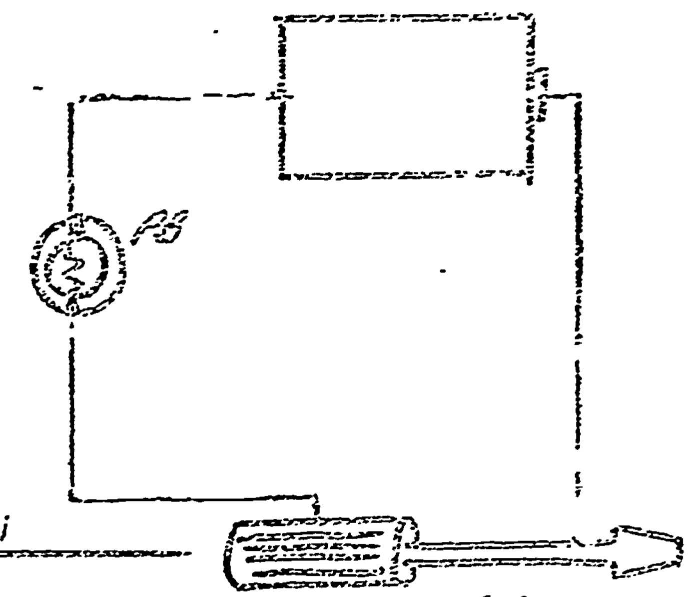


3.



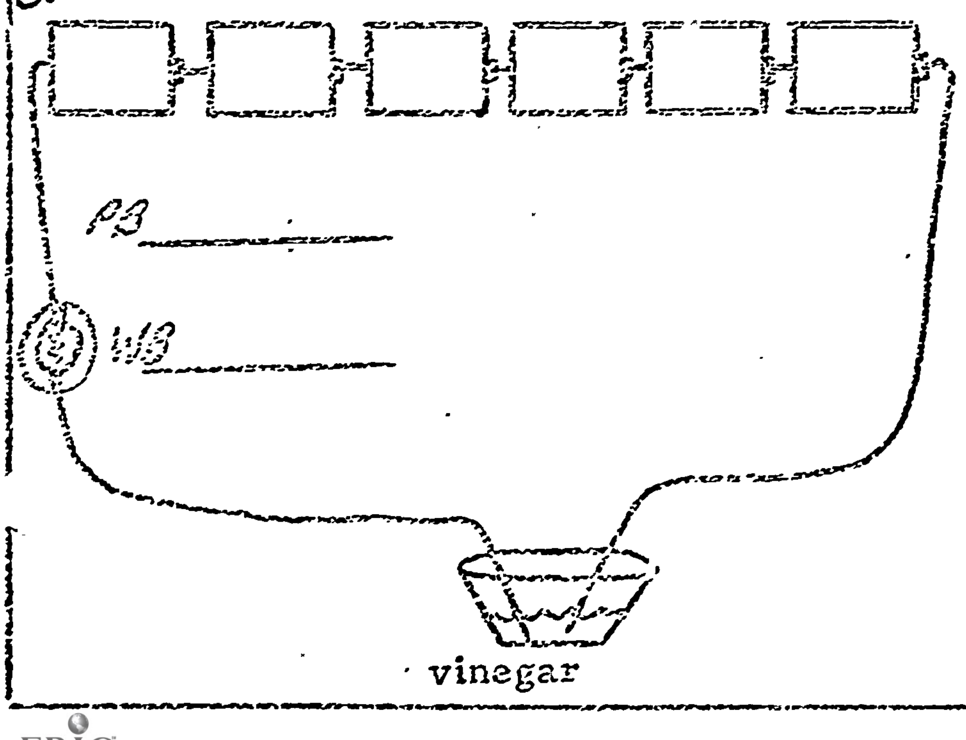
screw driver

4.



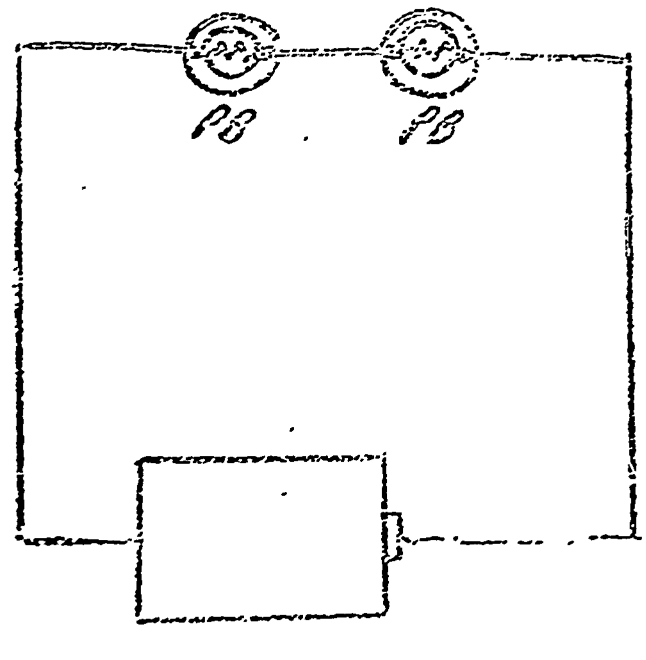
screw driver

5.



vinegar

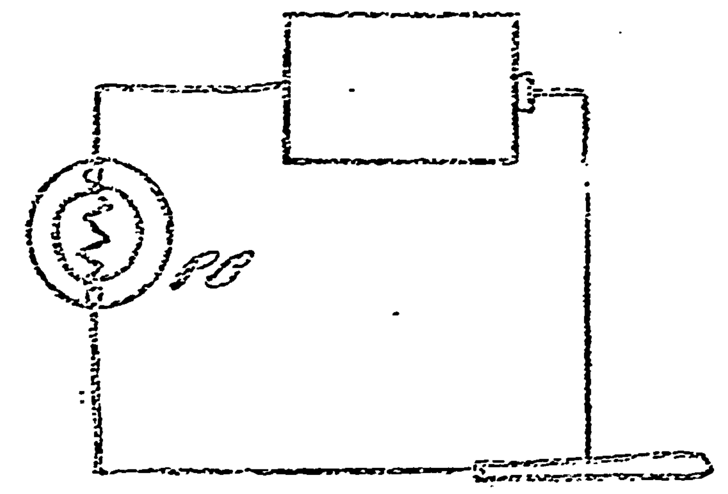
6.



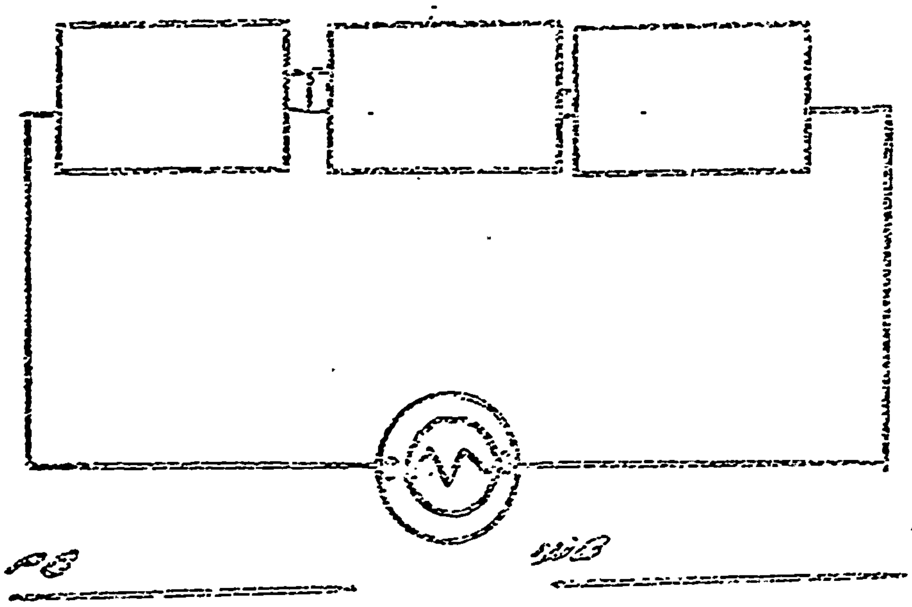
NAME ______________________

MARK AN (✓) FOR THOSE BULBS WHICH <u>WILL LIGHT</u> AND MARK AN (X) FOR THOSE BULBS WHICH <u>WILL NOT LIGHT</u>.

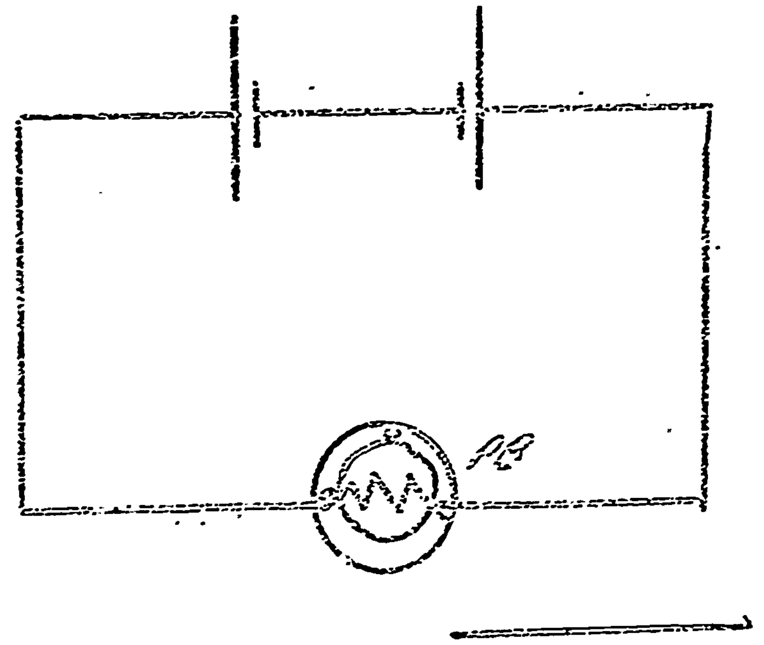
7



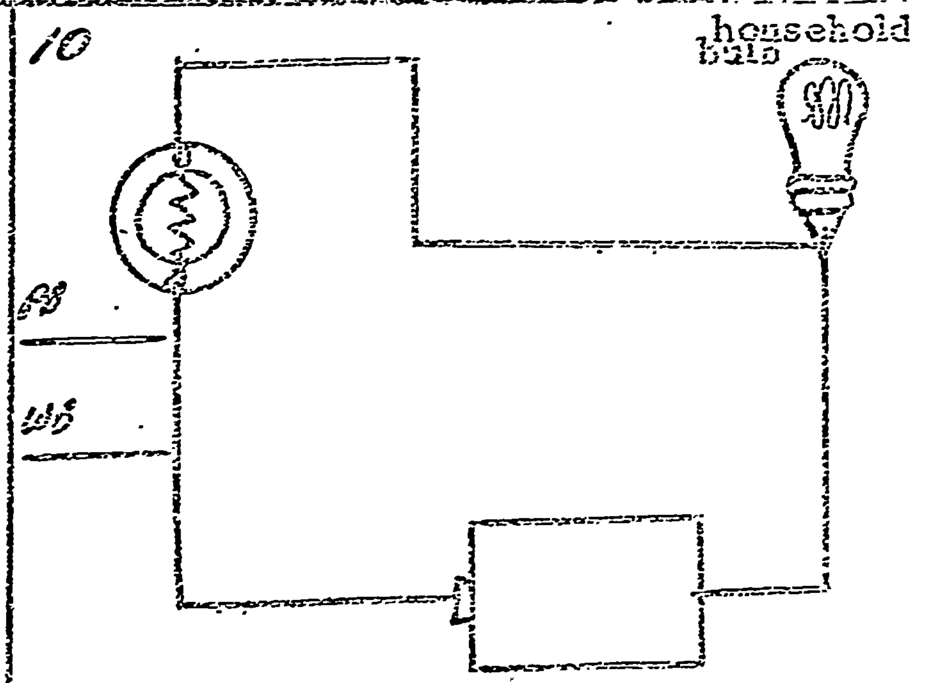
8



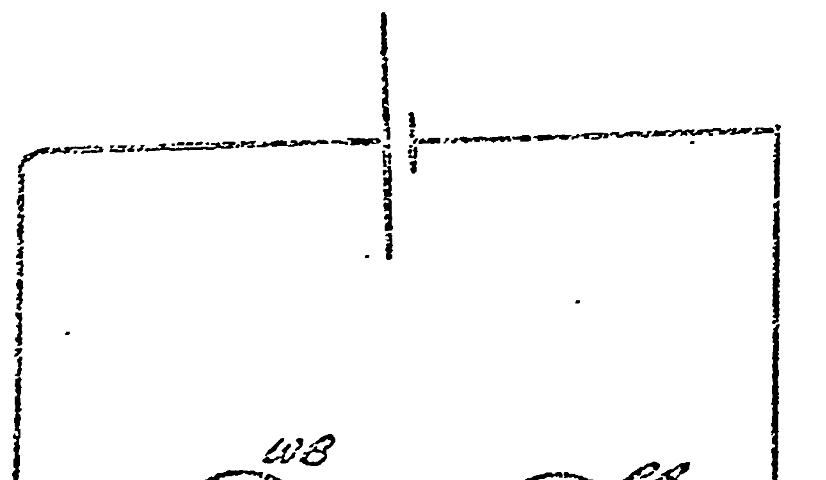
9



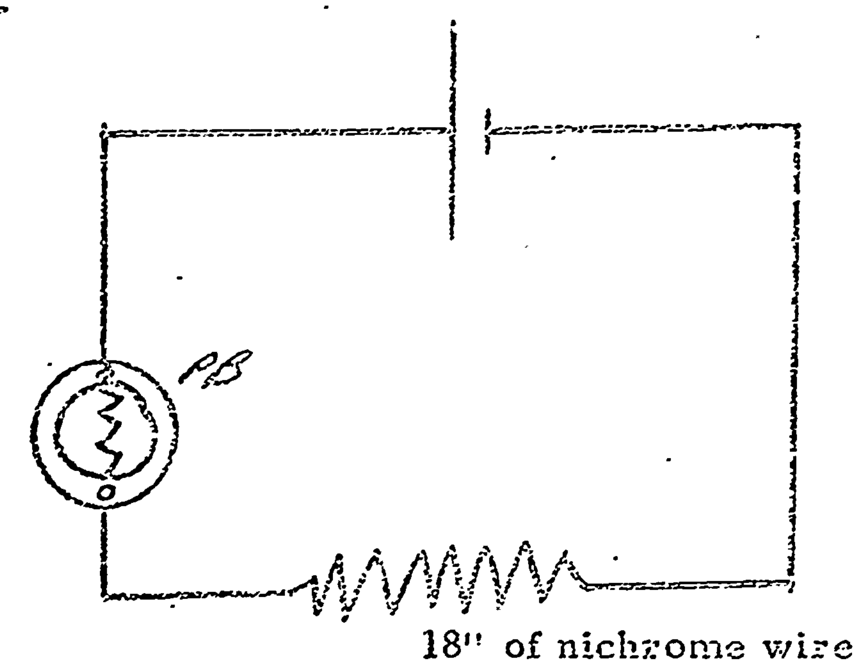
10



11



12

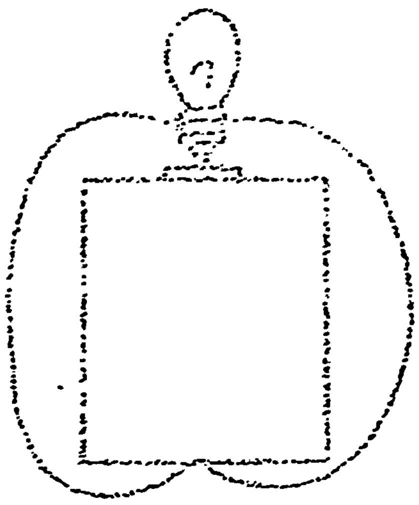


CIRCUITS I

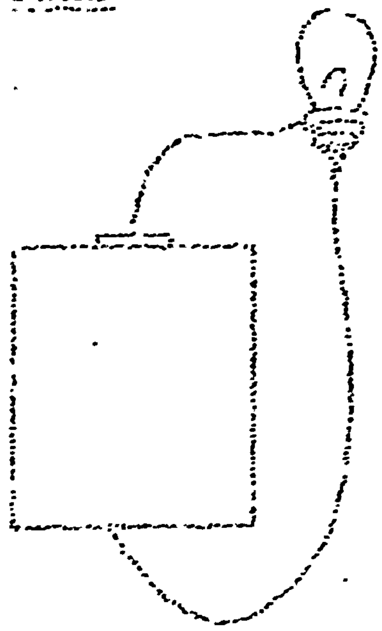
REVIEW SHEET I

MARK ✓ FOR BULBS THAT WILL LIGHT

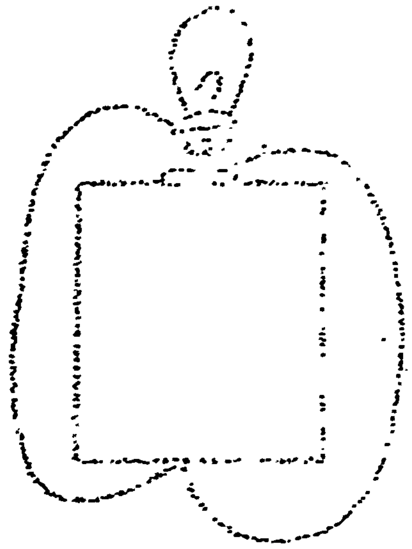
MARK X FOR BULBS THAT WILL NOT LIGHT



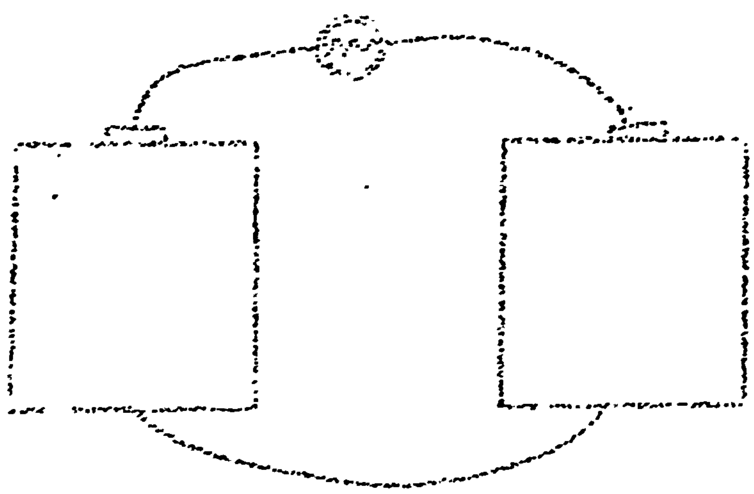
1. ________



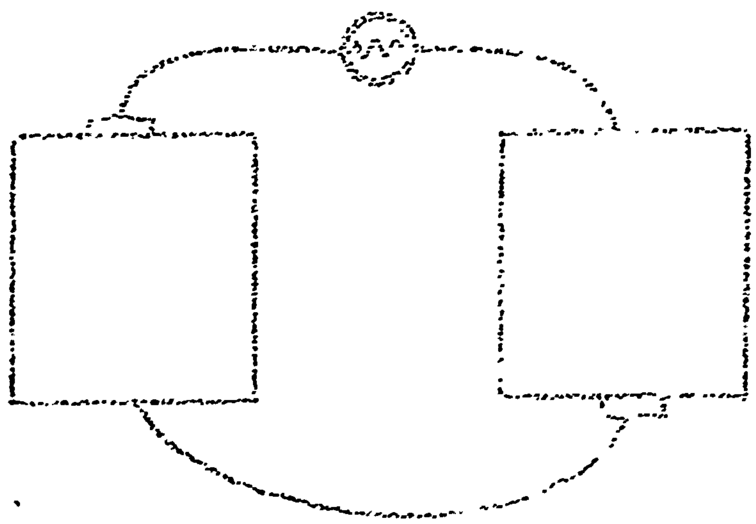
2. ________



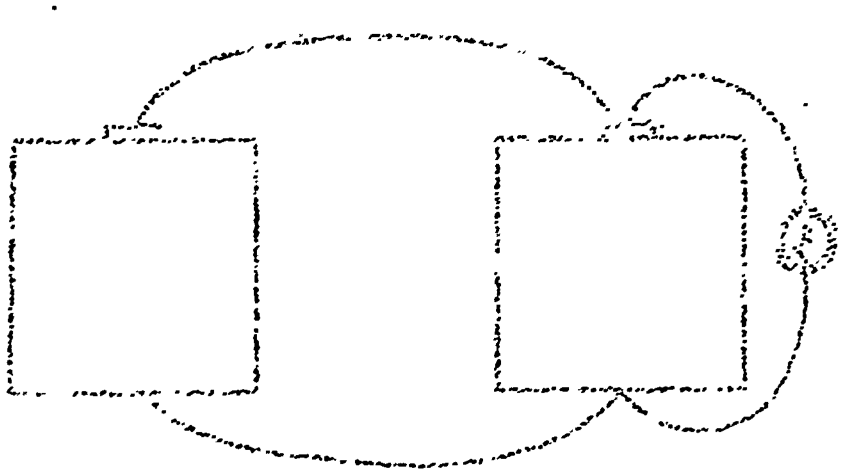
3. ________



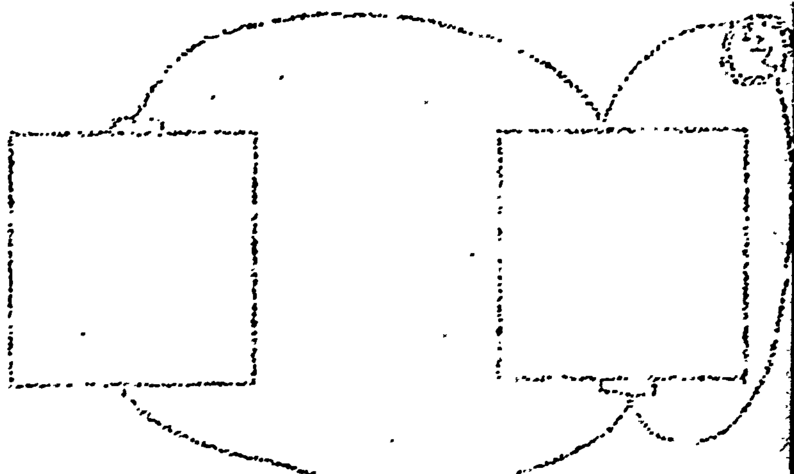
4. ________



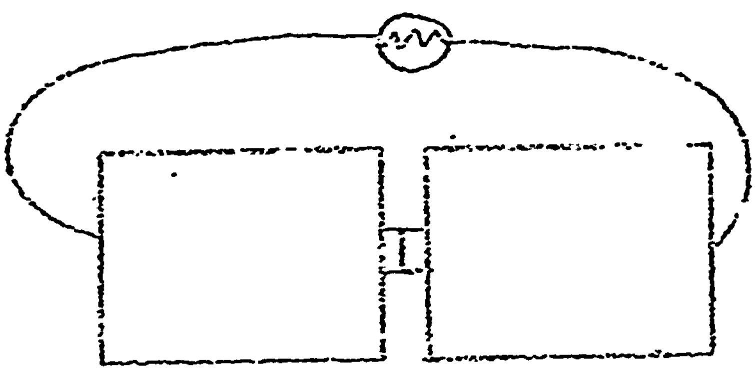
5. ________



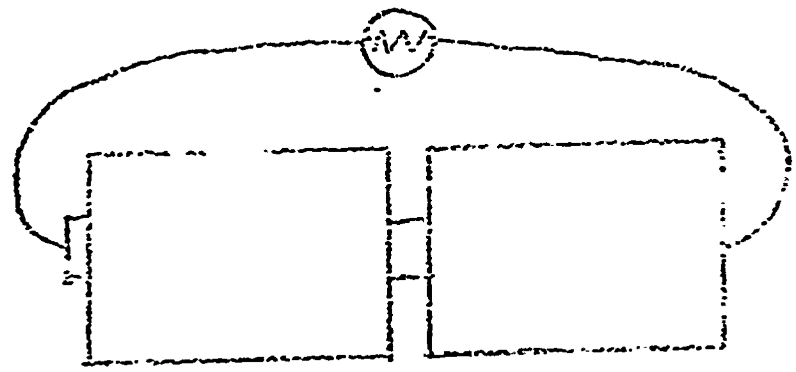
6. ________



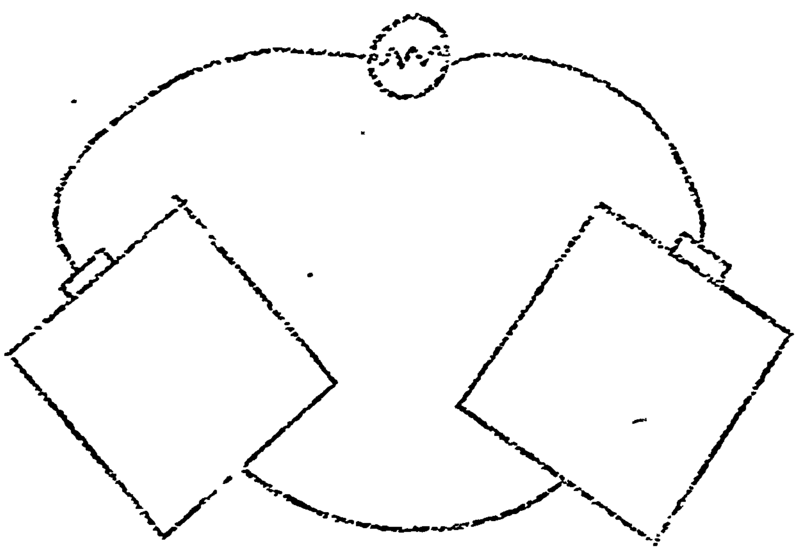
7. ________



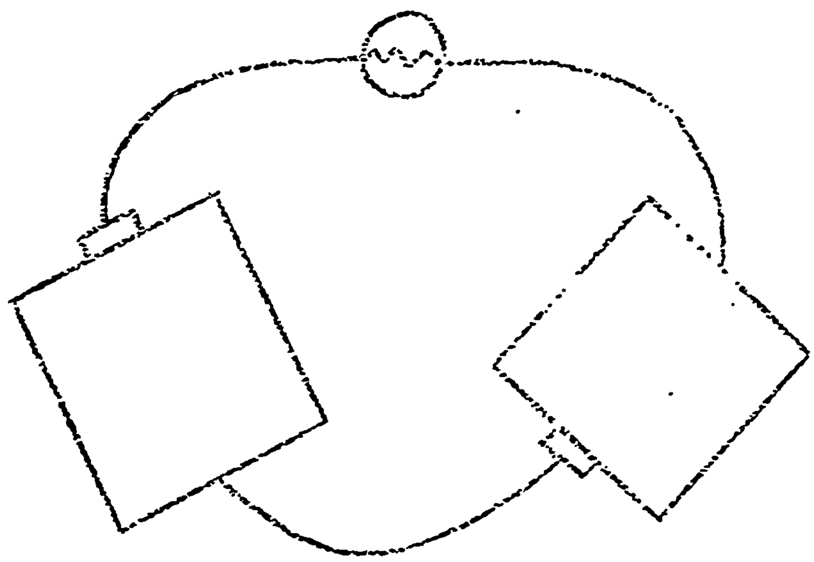
8. ______



9. ______



10. ______



11. ______

QUESTIONS:

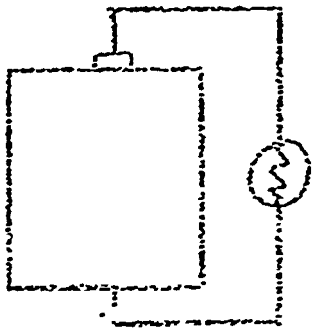
CIRCUIT 4 is the same as two other circuits. Which two? Number ____ and
Number ____

Circuit 5 is the same as two other circuits. Which two? Number ____ and
Number ____

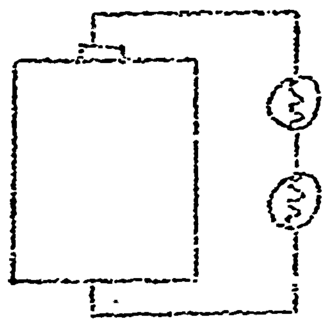
CIRCUITS I [redacted] REVIEW SHEET 2

Indicate HOW BRIGHT each bulb is. Use these symbols:

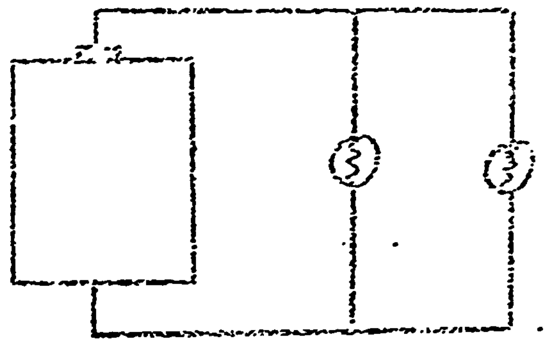
VERY BRIGHT
DIM
St. Br. (Standard Brightness)
X 2 - With brightness of two batteri
X 3 - With brightness of three batteries



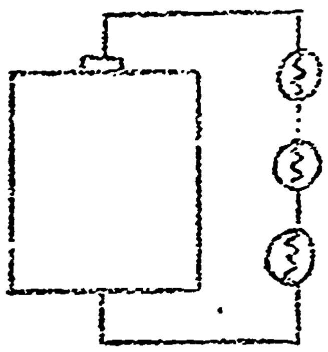
1.



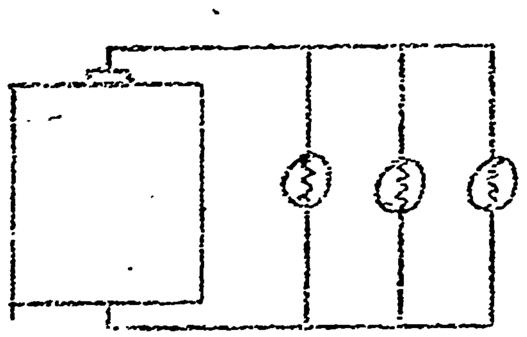
2.



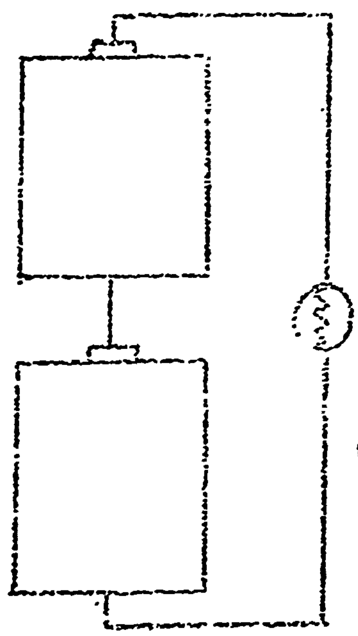
3.



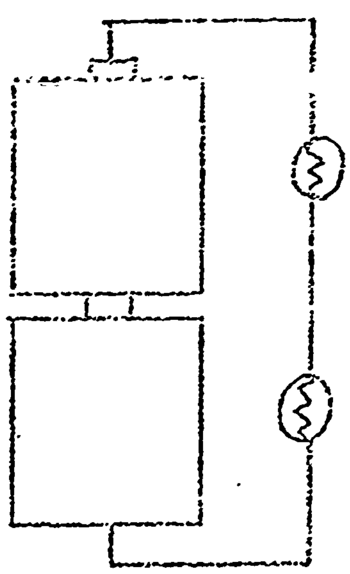
4.



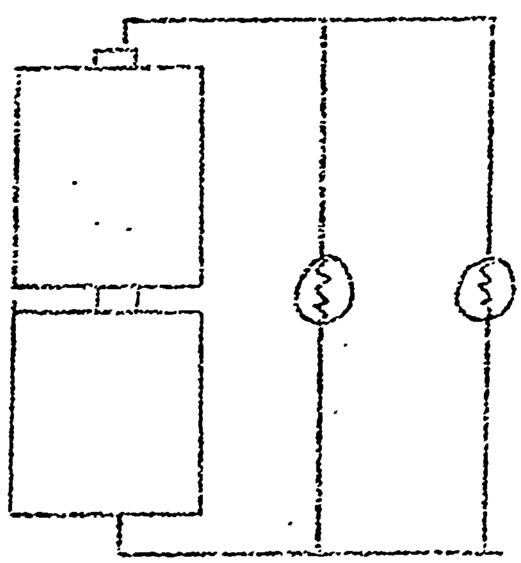
5.



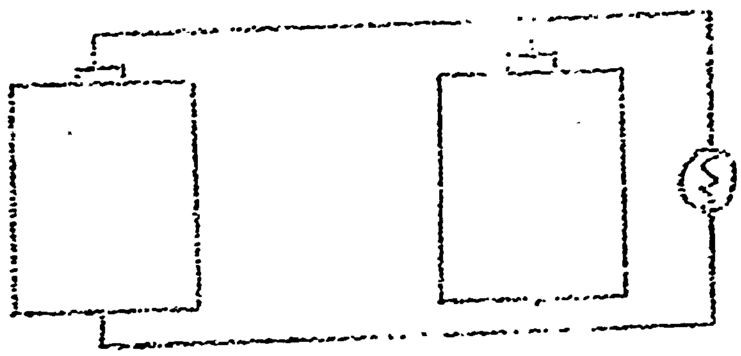
6.

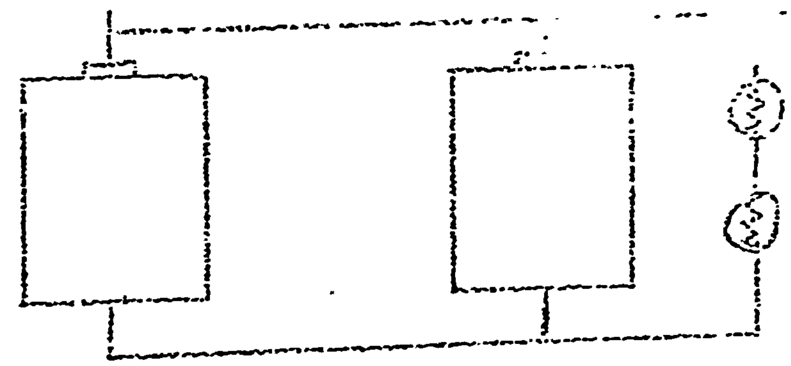


7.



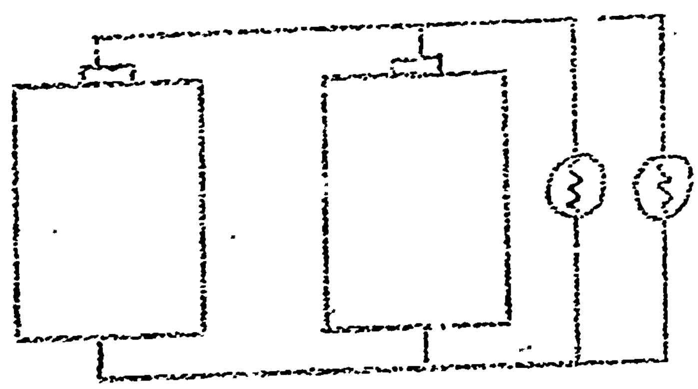
8.

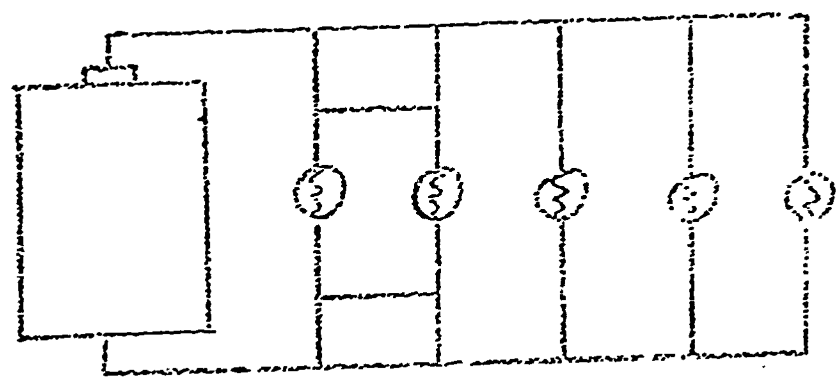




9.

10.

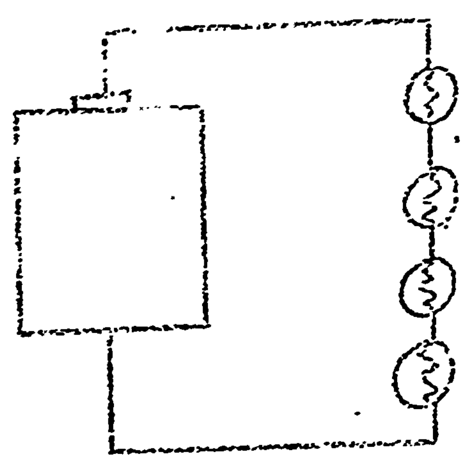




12.

11.

13.

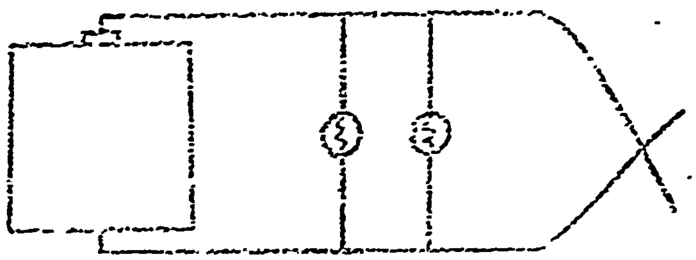


CIRCUITS I

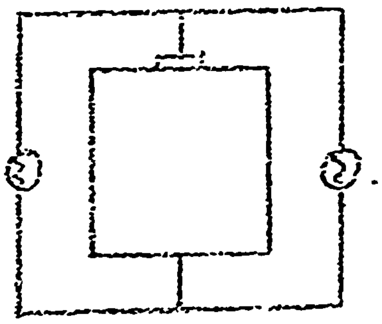
REVIEW SHEET 3

MARK ✓ FOR BULBS THAT WILL LIGHT

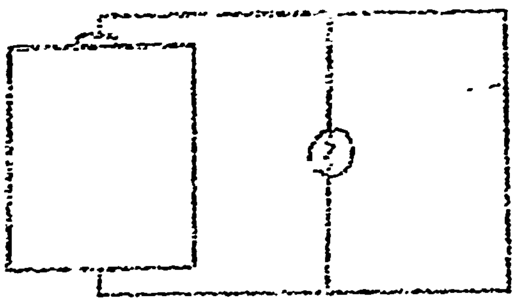
MARK X FOR BULBS THAT WILL NOT LIGHT



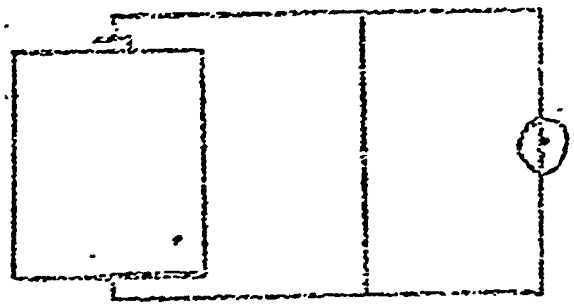
1. ________



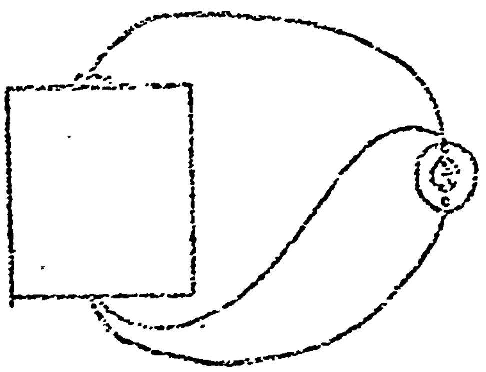
2. ________



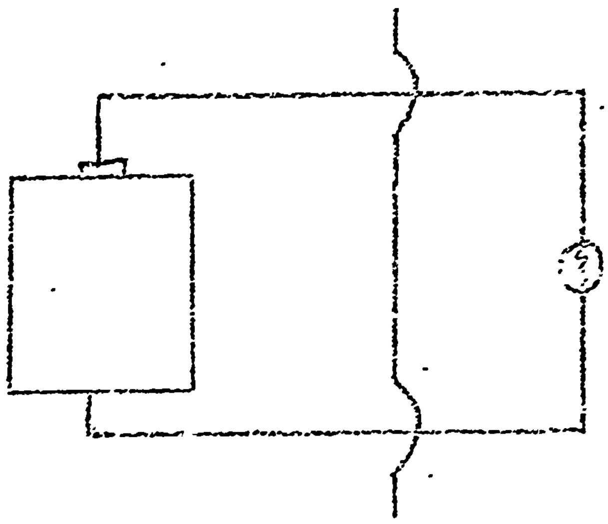
3. ________



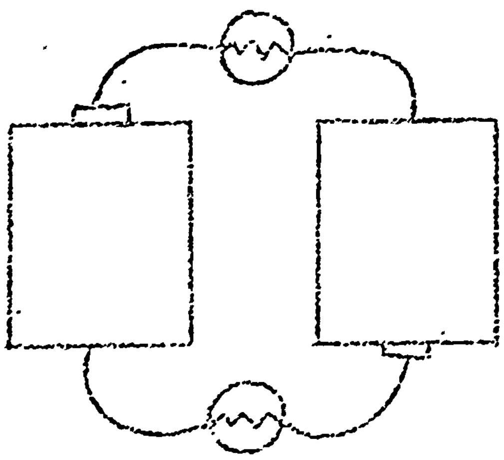
4. ________



5. ________



6. ________



7. ________

APPENDIX H.

TEACHER'S CURRICULUM GUIDE FOR THE LECTURE-

DEMONSTRATION ELECTRICITY UNIT

TABLE OF CONTENTS

INTRODUCTION TO ELECTRICITY

CONCEPTS TO TEACH:

There is a vast network of wires which supplies the electricity we use in our homes, school, and city.

Static electricity is a simple kind of electricity that is easily made, but unlike the electricity which travels the wires it can rarely be used to work for us.

The electricity which travels through wires and which can be made to do work like lighting bulbs or running machines, is called current electricity.

(Current electricity must have an electrical path to travel over. It must have a path over which it can travel from its source and back again, this path is called a circuit.)

MATERIALS:

Electric cords
Small throw rug
Piece of aluminium 24 cm square with wooden handle
Old rubber inner tube from an automobile tire
A piece of fur or flannel
A florescent light bulb
A hand-generated flashlight
Drawing of circuit to a powerhouse

ACTIVITIES:

I. Introduction to everyday use of electricity

A rather dramatic opening to the study of electricity might be to literally start the children in the dark. Shades could be drawn and lights turned out, before the children enter the room.

What is missing? Light .... electricity.
Do we take electricity for granted? What other things would we not have in our homes and school if we had no electricity? (Toasters, electric heat, fans, air-conditioners, hair dryers, refrigerators, washers, electric clocks, dryers, lamps, door bells, car lights, blenders, telephones, TV's, record players, etc.)

If you would prefer you could also start the introduction to electricity by setting up a discussion with such questions as:

1. What are some of the ways electricity is used in our classroom?
2. What are some of the things it does for us in our homes?

II. Electrical path - A Circuit

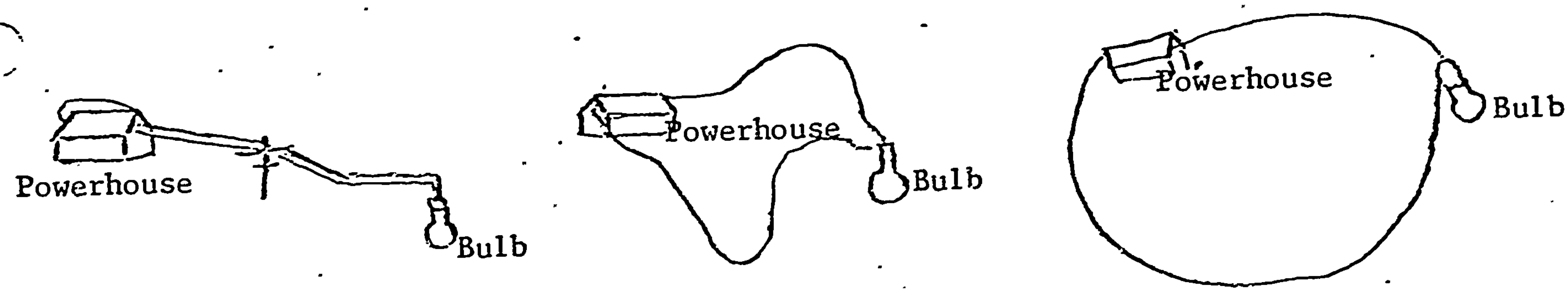
Have an electrical cord ready to be cut length wise.

There are cords on lamps, toasters, fans, and all of the other appliances that we use. Have the children watch closely as you remove part of the out covering of a cord and expose the metal wires within.

Lecture:

There are wires which lead into houses and schools and away from houses and schools. Wire between the houses and schools and the powerhouse provide a path over which electricity is able to travel. The powerhouse may be far away from the house or school, but each time electricity is used in the house or school the wires outside are used. There are wires in the walls which lead to the outside wires. When we plug in a cord for a lamp, fan or other appliance we are connecting the wires in the cord to the wires in the wall which lead to the wires outside. By plugging in a cord we are making a path which leads from the lamp, fan or appliance to the powerhouse far away. The path which the electricity follows is called a <u>CIRCUIT</u>.

The word circuit sounds a little like the word circle and that is kind of what a circuit actually is. Like a circle the circuit has no beginning or end. The circuit is not necessarily round, but could be if it were stretched out in that shape. Have the children look at these pictures to get the idea:



A CIRCUIT IS THE PATH OVER WHICH ELECTRICITY TRAVELS

III <u>Characteristics of electricity</u>

Attempt to find out what the children know about electricity by asking them to discuss what they think electricity is. You could use such probing questions as:

1 What do you think electricty is?
2.Where does it come from or how is it made?
3. Can you see it? If so,what does it look like?
4. Can you feel it?
5. Can you smell it?
6. Do you think there is electricity in a cord even if the lights are nt turned on?

After the children have expressed their ideas, tell them that they should keep these questions in mind and that as they study electricity they will learn some very exciting answers.

IV. A simple and familiar form of electricity - Static Electricity

To get the children in the mood for working with and exploring the subject of electricity an introduction to static electricity can be make with any number of the following experiments. You may first want to introduce static electricity as a kind of electricity which is easily made and does not come from powerhouses or travel by real circuits.

1. Either begin a discussion about what happens when a person shuffles across a rug, or get a little excitement going by having a child come to the front of the room and walk in place on a small throw rug until he is able to produce a "shock".

2. Have a piece of aluminium about 24 cm square, or an aluminium cake tin. Attach a wooden handle in the center of the aluminium by first punching a hole in the aluminium and then attaching the handle by a screw or a nail. Unfold an old rubber inner tube from an automobile and place in on a table. Stroke the surface of the rubber briskly with a piece of fur or flannel for half a minute. Place the aluminium on the rubber and press it down hard with your fingers. Remove your fingers and lift the metal by the handle. Bring your finger near the metal and you should get a spark. You can take many charges from the rubber without further rubbing. Just press the metal against the rubber, press with your fingers, and lift by the handle.[1]

3. Pull down the blinds and have the children stand around a small table in the front of the room. Rub a florescent light bulb briskly with a piece of flannel. The bulb should light faintly. Ask the children what they think has happened.[2]

4. Operate a hand-generated flashlight. Some of the children might be interested to learn that these were used often during war times because batteries would not last long under heavy use and dampness.

In the next lesson the children will learn some things about why and how electricity works.

Electricity is very interesting. A lot of experiments will be done in class which will be fun, fascinating and safe. Emphasize that wall sockets are not to be played with. Playing with wall sockets could result in very serious injury. If the children think of interesting experiments they should tell you and perhaps you could try them with batteries in class for all the children to see.

HOW ELECTRICITY TRAVELS

CONCEPTS TO TEACH:

All things are made of atoms. Atoms have a basic structure and all atoms have electrons which move in orbits rapidly around the center of the atoms.

Electrons may be forced to move from atom to atom, but the number of electrons per atom always remains the same.

Electricity is actually a chain of moving electrons, which needs a complete circuit in order to be used.

MATERIALS:

Large diagram of an atom.
Diagram of atoms within a wire
Thirteen balls of paper
Model of an atom

ACTIVITIES:

I. Review of last lesson:

Take a few minutes for a review of the main points of the last lesson:

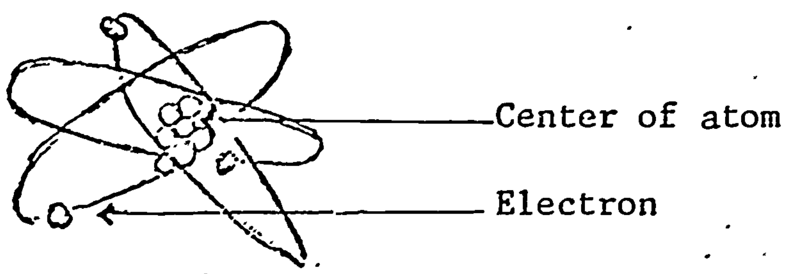
1. The vast network of wires which supplies electricity.
2. What a circuit is
3. The results of the experiments (only if there appears to be plenty of time.)

II. Structure of an Atom

In each of the experiments in the past lesson a little static electricity was made. To be able to understand how it is made and how it moves, a very simplified study of the atom must be done.

Lecture:

If it were possible for us to look through a magnifying glass which could make things look millions of times bigger than they actually are, we would see that all things, wood, people, metals, air, trees, all things are made out of billions of tiny,tiny,tiny, things called atoms.An atom if we could see it we think that it would look something like this:

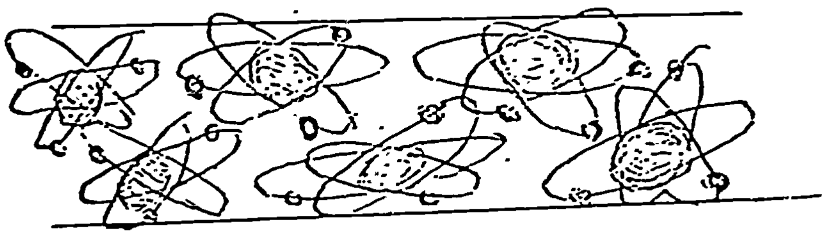


ATOM

The center of the atom stays in one place while the small parts called ELECTRONS zoom around it. Each electron has a separate path to spin on around the center of the atom. There is only one electron on each path and although the electrons are all moving around the center of the atom at very very fast speeds, they do not ram into the other electrons belonging to that atom. In some ways the center of the atom is like the sun and the electrons are like the earth and other planets which travel around the sun. Each atom has a certain number of electrons, it can never have any more or any less than the number of electrons it is supposed to have.

Electrons not only move around the center of the atom, but it is possible to force an electron to move from one atom to another atom.

Everything is made of atoms. Even a tiny speck of dust is made of billions of tiny atoms. The atoms are close together. Have the children pretend that the following is a picture of the inside of a very very thin wire and that they are able to see what the atoms look like inside the wire.



Activity:

Have a group of five or six children come to the front of the room and form a line one behind the other. Each child is to pretend that he is an atom. To each child give two balls of paper. The children are to pretend that these are their electrons. The instructions then are that each child is to have one and only one paper ball in each hand. They must accept any "electrons" handed to them and may pass behind them to the next "atom" one or both of their old electrons.

Give the first child in line a new "electron," an tell the rest of the children to watch as electrons travel from one atom to the next.

The child at the end will with face with the problem of what to do with his extra "electron" He may be encouraged to drop it or throw it.

Points to emphasize in a discussion are:

1. The atoms did not move, they stayed to make the line. Their electrons moved from one atom to the next.

2. Each atom always had the same number of electrons.

3. The electrons moving from atom to atom produced a force. That force is electricity.

4. Something could have been done with the extra electron at the end of the line. Instead of dropping it, (child) could have thrown it at a bell to make it ring, or at a switch to make it start a machine.

ELECTRICITY IS A STREAM OF MOVING ELECTRONS

V. Experiments

When a lot of electrons build up at the end of a chain of atoms and are all set to go someplace, we say that a charge has been set up. The children saw the charge in the aluminium and rubber experiment, and some felt the charge in the throw rug experiment. We can get the electrons to move in certain materials simply by rubbing them with another material.

1. Rub a plastic rod with a piece of flannel or have the children rub plastic combs with flannel, then hold them up to their hair and hear the crackling as the plastic attracts the hair.

All these experiments involve static electricity which is easy to make but hard to put to work. In the next few lessons the children will learn how electricity for buildings and cities is made. What gets the electrons moving to supply us with the electricity we need and use everyday? To help answer this question the class will first look at magnets and some of their properties.

MAGNETS

CONCEPTS TO TEACH:

Magnets have two poles - a north pole and a south pole.

The poles of one magnet are attracted to the opposite poles of another magnet. The north pole of one magnet is attracted to the south pole of another magnet.

Like poles push away like poles. A north pole of one magnet will push away the north pole of another magnet, and a south pole of one magnet will push away the south pole of another magnet.

The Earth is like a huge magnet. It has a south magnetic pole and a north magnetic pole.

A compass works because the needle of the compass is actually a magnet. The south pole of the needle magnet is attracted by the Earth's north magnetic pole, and the north pole of the needle magnet is attracted to the Earth's south magnetic pole.

MATERIALS:

A Lodestone or magnatite
A bar-magnet, a u-magnet, and a horse shoe magnet
Iron filings
String
Two yardsticks
A compass for each child.

LECTURE AND ACTIVITIES:

I. Different kinds of magnets

Have available several different sizes and shapes of magnets. Show the children how the magnets will stick to or pick up metal things.

Show the children a lodestone or a piece of magnatite. This is a natural magnet which will pick up pieces of iron filings. They should be surprised to see that nature and not only man can make magnets.

Pass out two magnets to each child. Tell the children to bring the magnets as close together as possible without touching each other. Ask if the magnets seemed to pull toward each other or push away. Explain that the push or pull that they felt is a force. This force they feel is called magnetic force.

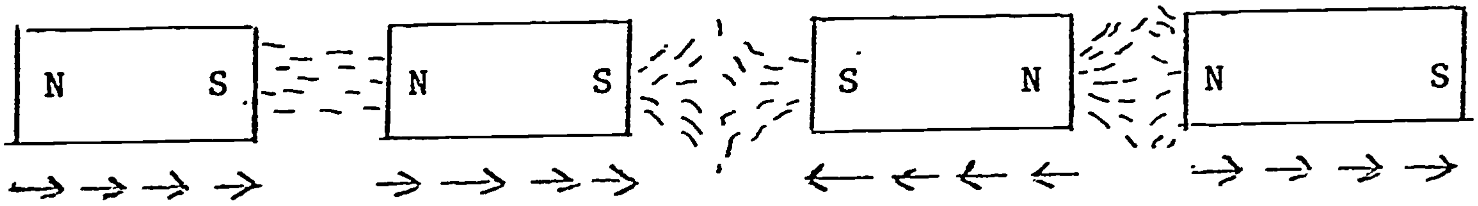
II. The poles of a magnet

Place a bar-magnet in a shallow box with iron filings. Let the children observe where the most filings are picked up. Do the same experiment with the horse shoe magnet and the U-magnet.

The force of the magnets is strongest near the ends. The ends of the magnets are called magnetic poles. There are always poles on a magnet no matter what shape the magnet may be.

The poles of a magnet are usually at the ends of the magnet. Every magnet has two poles. The poles are marked on some magnets. N stands for the north pole and S stands for the south poles

The force of magnetism is different at the two ends of a magnet. The children should remember that when they use the magnets together that the like ends push away from each other and the unlike ends pull toward each other. In other words, a north pole of one magnet will push away the north pole of another magnet. , and a south pole of one magnet will push away the south pole of another magnet. But a north pole of one magnet will attract the south pole of another magnet, and a south pole of one magnet will attract the north pole of another magnet.



Instruct the children to test their two magnets. As they bring their magnets together, tell them that if the magnets are attracted to each other they will feel a pull and will know that two opposite poles are involved. If the magnets push away from each other they will know that the same poles of the two magnets are facing each other.

III. Pull of magnetic poles

Experiment 1

Sprinkle some iron filings on two thin pieces of paper. Hold a horse-shoe magnet under the first sheet and let the children observe what happens to the iron filings. The iron filings should no longer be scattered about on the paper, but make a pattern when the magnet is placed under the paper.

Try the same experiment with the bar-magnet. Gently tap the edge of the cardboard. As you tap, make sure that the children see the pattern which is made.

1. The patterns of the filings should look like lines.
2. Most of the lines of the filings will be curved.
3. The curved lines should seem to run from one pole of the magnet to the other pole of the magnet.
4. The lines of force will be closest together at the poles of the magnet.

IV. The magnetic Earth

The children have heard of the North and South poles of the Earth. Point out the poles on a globe. The North and South poles are at opposite sides of the Earth and are called geographic poles (like geography). The Earth has two other poles which are very near to the geographic poles. These poles are called the Earth's magnetic poles. The region of the Earth's northern magnetic pole is the Artic. The region of the Earth's southern magnetic pole is the Antarctic.

V. The pull of the Earth's magnetic poles on bar-magnets

Experiment:

Mark the north poles of two bar-magnets with tape. Hang the magnets free from strings far apart from each other in the room. (The magnets can be hung with strings from yard sticks held on desks by books.) Wait until the magnets stop turning, then have the children notice in which direction the north and south poles of the magnets are pointing. Ask if anyone can guess why both magnets are pointing in the same direction.

When the magnets are hanging in the room they are free to move back and forth. The force of Earth's magnetic pull acted on each magnet. Like a huge magnet, the Earth's northern magnetic pole pulled at the south pole of the magnet, and the Earth's southern magnetic pole pulled at the northern pole of the magnets. So the dangling magnets ended up pointing in a north-south direction.

VI. Magnets as compasses

Point out to the children that the dangling magnets are acting like compasses by showing us which direction is north and which is south. The needle in a compass is really a magnet. It is a very small bar-magnet.

Pass out a compass for each child to look at as you explain how a compass functions.

The magnet in a compass can move freely just as the hanging magnets could. The force of the Earth's magnetic poles act upon the magnet needle in the compass. If the compass is still for awhile, the magnet needle stops moving. The needle points in a north-south direction when it comes to rest. It turns until it points in the direction of Earth's north and south magnetic poles.

Show the children how they can use a compass to find in which direction they are walking. Allow the children to walk around the room with the compasses, and ask them to determine in which directions they are walking.

HOW ELECTRICITY IS MADE

CONCEPTS TO TEACH:

Electricity is produced by setting electrons in motion.

Lightning is static electricity which has been produced by air currents setting electrons in motion.

Conductors are materials which will carry electricity.

Electricity that comes from the powerhouse is called current electricity.

The electricity which we use is either made by machines or chemicals.

MATERIALS:

Illustrations of machines producing electricity.
The blow up of the inside of a wire from Lesson 2 for display.

DISCUSSION:

I. A review of static electricity

Briefly review the idea of moving electrons from Lesson 2. Go over several of the experiments with static electricity. Emphasize that the "electric charges" were made by rubbing materials to make the electrons move through them.

The (static) electricity was removed from the rod and comb by bringing them near something that would accept and carry the extra electrons. Any materials which will carry electricity are called conductors.

The children, when they walk on a wool carpet and scuff their feet become charged with extra electrons. The electric charge which they build up in their bodies is given off when they touch metal or another individual. They receive a shock when the electricity moves from them to the conductor. (place word "conductor" on board.)

II. Lightning

The children would be interested to learn that lightning is made similarly. In a thunderstorm, great amounts of electricity are given off. The atoms in clouds moving rapidly in a storm rub against each other and a charge of electrons is set up. When the charge of electrons becomes great enough, lightning flashes through the sky. The moving electrons in lightning need to find some conductor to carry them.

The electrons may be attracted to any number of things, hopefully a lightning rod, or a tree. Lightning rods are metal rods which some people put on their houses so that the electricity will be attracted to the rod rather than to the house. (The children have probably been told never to stand under a tree or to carry an umbrella in a lightning storm.) Even though a tree will not conduct small charges of electricity, a flash of lightning is powerful enough to move through a tree. Lightning then is, a huge number of electrons that move fast - suddenly with a flash of light. The sound of their rapid movement is called thunder.

Some of the children may already know who Benjamin Franklin was, and be familar with the experiment he did with lightning and electricity. If you get no response you might give a brief discription of the kite and key experiment.

III. The electricity we use

A. Electricity from machines

The children should now know that we can get electricity from lightning, and we can get a little electricity from rubbing a plastic rod with wool, but the point should be made that a fantastic amount of electricity is used everyday all over the world. We don't sit around waiting for lightning storms and we don't have a zillion little men sitting around rubbing plastic rods. What do we do, how do we get all the electricity that is needed everyday to light our lights and run our machines?

Actually the way to make electricity as we have seen is to get those electrons moving from atom to atom. This can be done by two ways. The way that the electricity used in our homes and schools is made is by machines in powerplants. Machines with huge MAGNETS go over and over wires to start the electrons moving, they pull the electric current form made. The machines that make electricity are run by steam like trains used to be, or by the force of water falling from giant waterfalls like Niagra Falls turning the wheels of the machines.

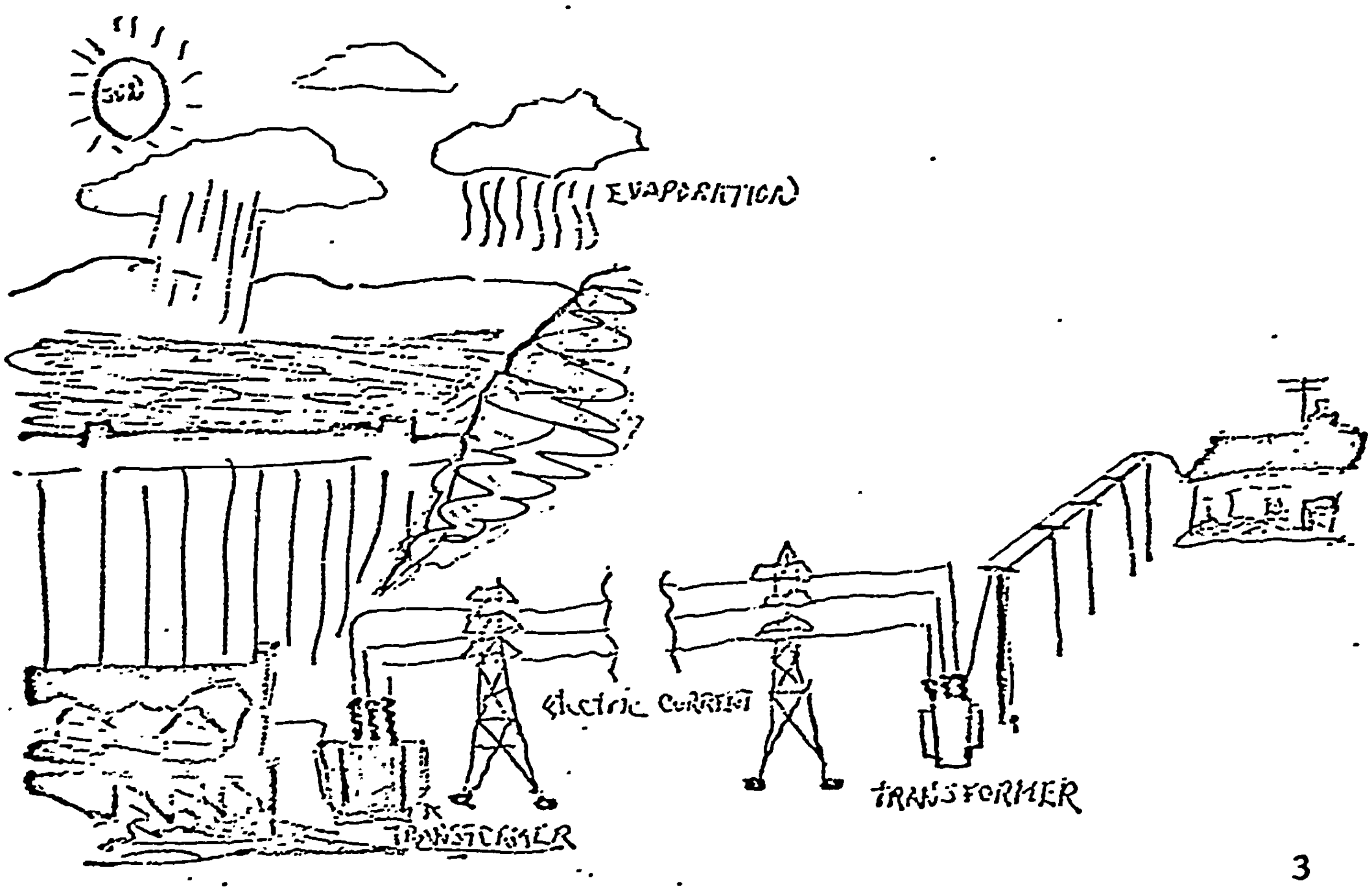
If the children appear interested or if you would like to go into a little more explanation you could use these drawings to illustrate the process. (Drawings of following page.)

B. Electricity from chemicals

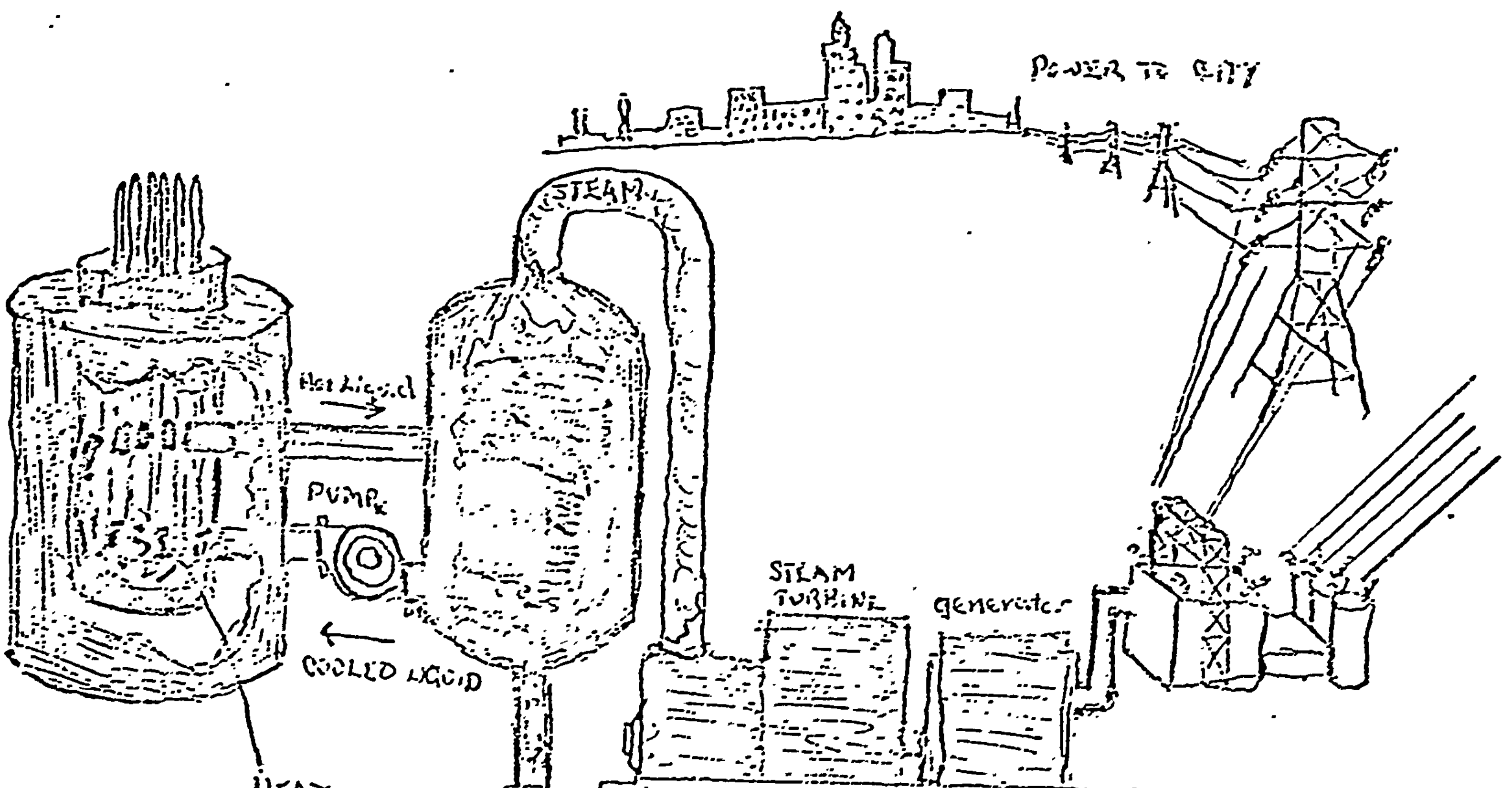
One of the ways electricity is made is by machines, and the other way is by the use of chemicals. Chemicals are liquids and powders which can be mixed together to make other materials.

Ask the children what they know about batteries. Have they ever worked with flashlight batteries or the small batteries in transistor radios. Have any of their batteries ever "gone bad" or leaked? What do they think that it means when a battery "goes dead"?

Next lesson you will take apart a battery so that the children can see what it is made of and learn why it makes electricity.



3



4

INSIDE A BATTERY

CONCEPTS TO TEACH:

A battery contains chemicals in a black material, a carbon rod, a metal cap, a zinc container, and a paper wrapper.

Electricity is produced in a battery by a chemical action which sets up a flow of electrons.

If electricity is to flow from the battery, a wire circuit must connect from the metal cap on the top of the battery to any place on the bottom of the battery.

A wire should not be left connected from the top of the battery to the bottom of the battery, because the wire will become very hot and the battery will soon wear out. Connecting a wire from the top of the battery to the bottom is called <u>shorting</u> a battery.

A battery holder consists of a rubberband and two Fahnestock clips, and is used to hold wires to a battery.

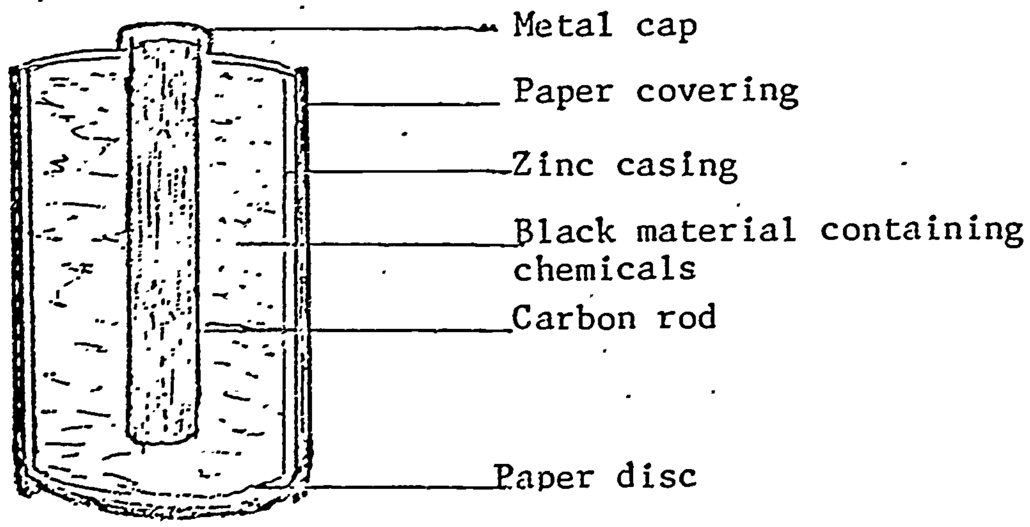
MATERIALS:

Several batteries
A large diagram of the inside of a battery
A small screw driver
Bulb

LECTURE AND DEMONSTRATION:

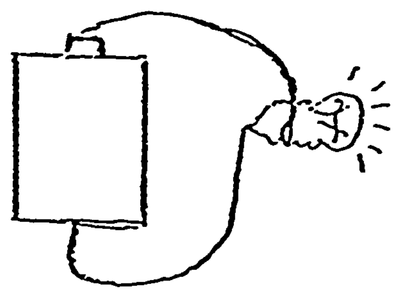
I. <u>The inside of a battery</u>

A battery is to be taken apart during this class period. This can be done by first prying the metal around the top of the battery with a screw driver until the metal stands straight up. The inside of the battery may then be pushed out of the outer metal covering or the outer covering may be pulled away. You may want to saw the battery in half so that the children can observe how the materials fit together. As you take the battery apart show the children the metal cap, the carbon rod, the black material containing chemicals, the zinc container, the outer paper covering, and the paper disc at the bottom.



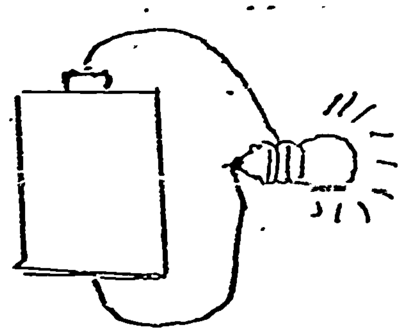
II. How a battery works

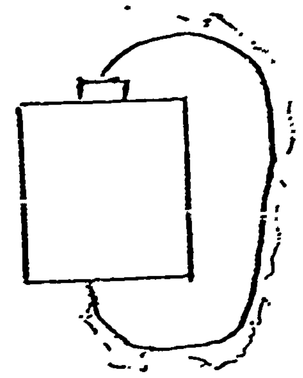
Using a large diagram you can explain how the black material which contains chemicals somehow makes the electrons in the battery move up the carbon rod in the center and out the top of the battery. As the electrons are forced to move towards the top of the battery, there are fewer and fewer electrons at the bottom of the battery. A complete circuit, and path for the electrons to travel to get back to the bottom of the battery from the top is needed. This is supplied by connecting a wire from the top of the battery at the metal cap, to the bottom of the battery. Show the children how to light a bulb this way by using two wires. The bulb will light showing that electricity is traveling through the wires.



III. Shorting a battery

Instead of using a bulb, use only a wire. The wire will heat up immediately, so call upon a child and wait until the child is in reach of the wire to make the connection. Ask the child to touch the wire. (You may wish to tell him that it will be warm.) Also have the child touch the wires of the set-up with the lighted bulb. Those wires will not be warm. The children should realize that electricity is traveling over both wires, but only the single wire gets hot.

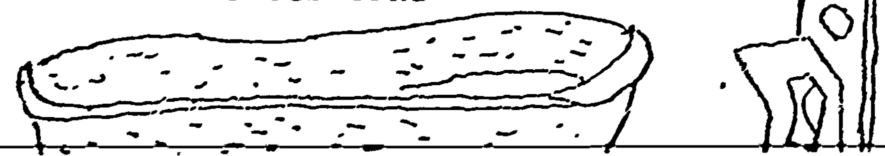




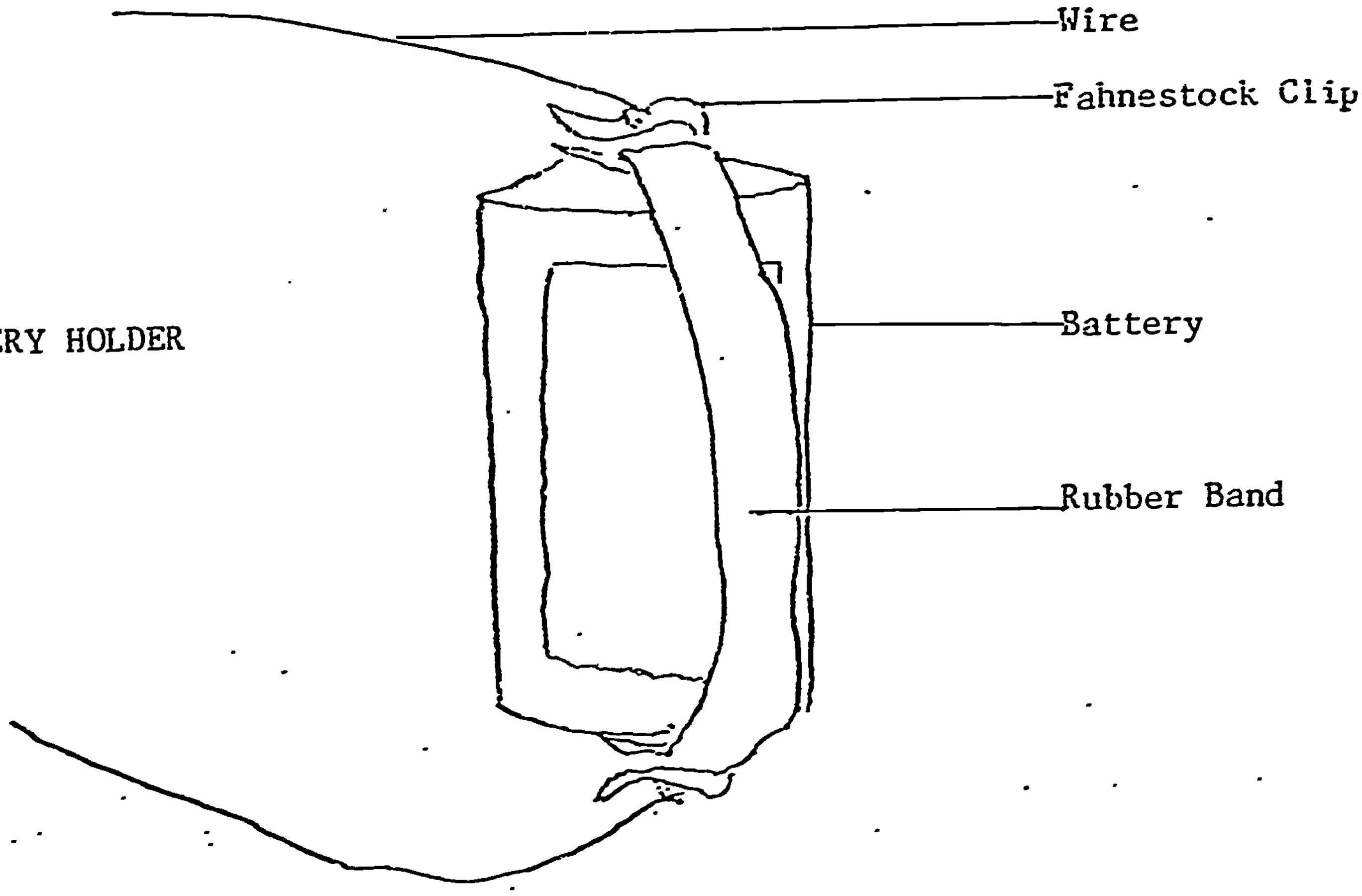
The danger of connecting only a wire to the top and bottom of a battery should be emphasized. The battery will wear out very quickly and the wire will be very hot.

IV. Battery holders

Show the children how to make a battery holder which will be used from now on to hold the wires to batteries. A battery holder consists of a rubber band and two Fahnestock clips. The Fahnestock clips are made of metal and hold the wires. One Fahnestock clip must be placed on the metal cap at the top of the battery and the other Fahnestock clip must be touching some part of the bottom of the battery.



BATTERY HOLDER



Pass a few Fahnestock clips around the room to give the children an opportunity to see how they work. Show them how the battery holder is fitted onto the battery.

LIGHTING A BULB

CONCEPTS TO TEACH:

A bulb in order to light in a circuit must be connected to the circuit through its silver tip and gold screws. The children should be able to light a bulb at least three different ways using a bulb, a battery and one or two wires.

A complete circuit is a continuous path through the battery and bulb or bulbs. To have a complete circuit the electricity must be able to pass through the silver tip and gold screws of the bulb and through the metal cap at the top of the battery and through the bottom of the battery.

A bulb holder is designed to hold a bulb and connect the bulb to an electric circuit. It makes sure that a wire is connected to the tip of the bulb and another wire is connected to the metal screws of the bulb.

MATERIALS:

Battery
Wires
Pink bulbs
Fahnestock Clip
Rubberband

ACTIVITY:

I. Lighting a bulb.

Wrap the end of a short piece of wire around the screwlike base of a small pink bulb so that it holds the bulb tightly. Bend the remainder of the wire in the shape of the letter C. Set the tip of the bulb on the metal cap of the battery and adjust the free end of the wire against the bottom of the battery. The bulb should light.

Turn the battery upside down and have the bulb touching the bottom of the battery and the end of the wire touching the metal cap. Again the bulb should light.

Explain to the children that there are two places on the bulb which must be touched by wire or battery. These places are the tip of the bulb and the "gold" colored screws on the bulb.

Ask the children to remember which parts of the battery must be touched by the wire or bulb. Repeat - Which 4 parts have to be touched? Tips of bulb, gold screws of bulb, metal cap of battery, bottom of battery.

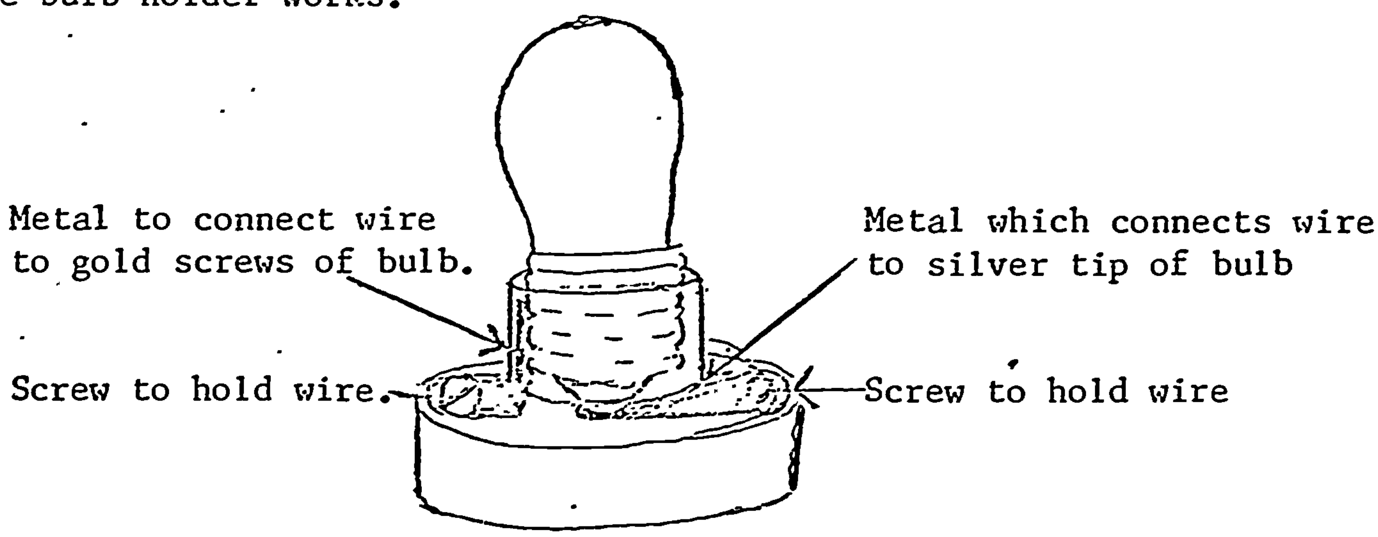
II. <u>Complete circuit concept.</u>

Make a drawing showing the path of the current through the bulb and through the battery. Again emphasize the concept of circuit. (The wires, the light, and the battery make an electric circuit. A circuit with no breaks is call a <u>complete circuit</u>. Electricity can not travel without a complete circuit. A complete circuit must pass through the silver tip of the bulbs, the gold screws of the bulbs, metal cap of the battery, and the bottom of the battery.

III. <u>Bulb holder.</u>

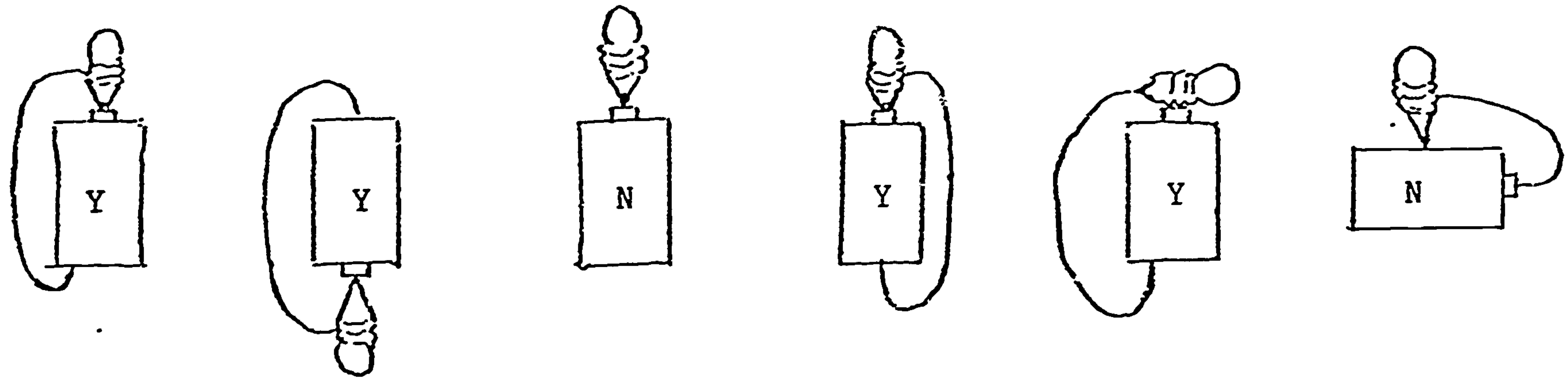
A bulb holder is designed to held a bulb and connect the bulb to a circuit. If connected in a circuit the bulb holder assures that the silver tip of the bulb and the gold screw of the bulb are in the circuit.

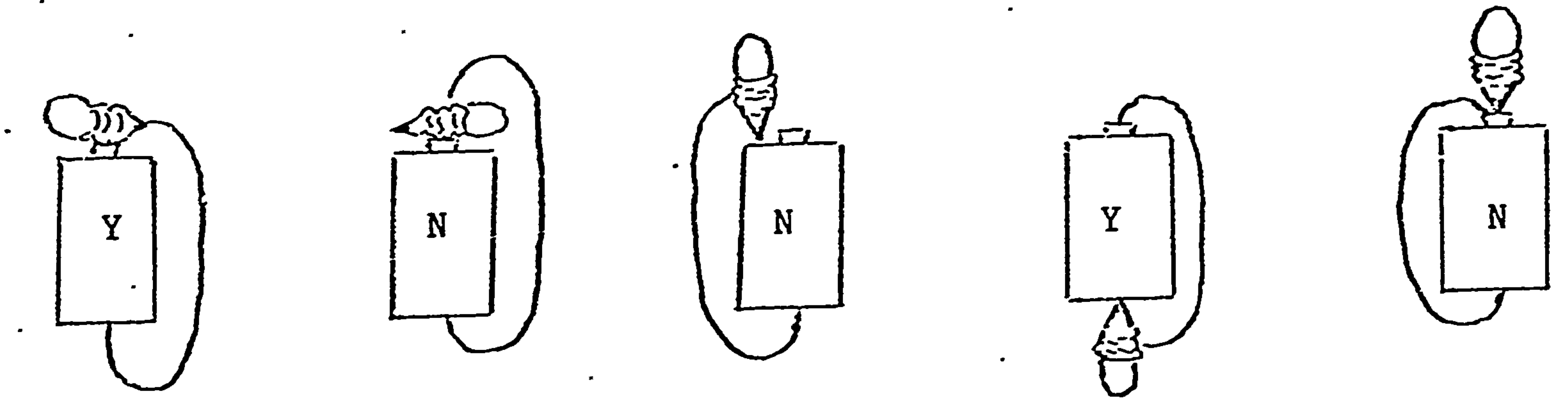
Show the children the small white bulb holders which will be used in class. Explain how the wires of a circuit will be attached to the bulb holder by the small screws. Use a diagram like the following to explain how the bulb holder works.



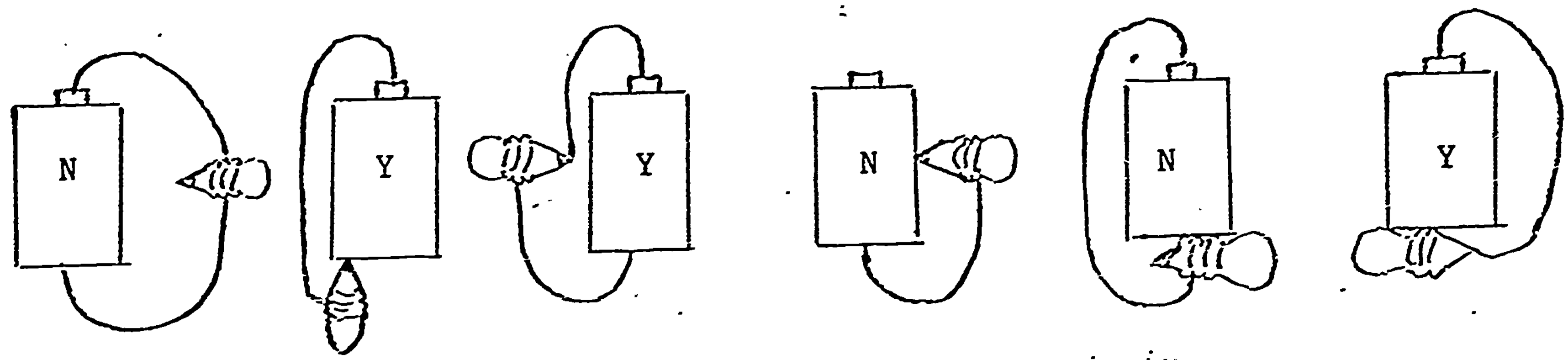
Show the children a set-up using a bulb holder and a battery holder. They should understand that sockets for large light bulbs work the same way that the little bulb holders do. Have a large porcelain bulb holder and large light bulb on hand for this demonstration.

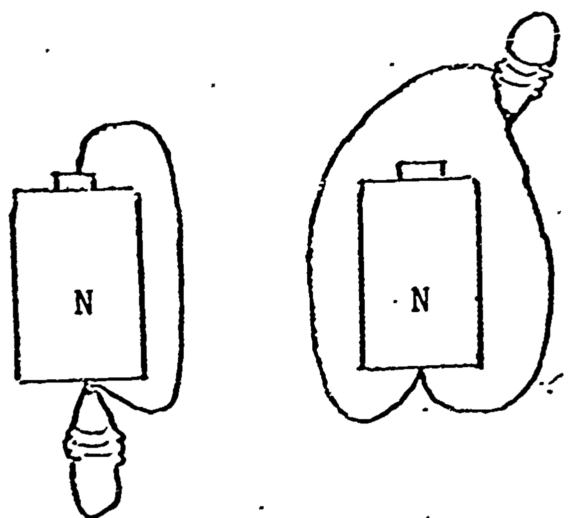
Draw a number of set-ups on the blackboard and ask the children if they think the bulbs will light. Test their answers by using the battery and bulb.





Ask someone what happens here - wire gets hot.





This could be turned into a type of game. One child at a time could come to the board and draw a set-up. He could whisper his answer, ask the other children to guess, and you could test his drawing with the battery and bulb.

Lesson 7

RESISTANCE, CONDUCTORS, AND INSULATORS

CONCEPTS TO TEACH:

A wire gets hot because there is resistance to the flow of electrons over it. Some kinds of wires have more resistance than other kinds of wires.

Metals which allow electrons to travel through them easily are called good conductors. Metals which make it more difficult for electrons to travel through them are called poor conductors.

Materials which stop the flow of electrons are called insulators. Insulators are used to protect against hot wires or shocks.

Silver and copper are good conductors, they allow electrons to travel over them easily. But silver is very expensive so copper is used for most of the wires in homes and schools. Nichrome, steel and tungsten are not good conductors. The electrons must really work to get through them, so these wires get hot easily. Tungsten is used in light bulbs, and nichrome and steel are used in heaters.

MATERIALS:

Batteries
Pliers
Small piece of paper
Bare copper wire
Bare steel wire
A short piece of insulated copper wire
"traffic chart"
Materials listed on third page
Testers with one, two, and three batteries

Ammeter
6" piece of silver wire
6" piece of steel wire
6" piece of copper wire
6" piece of nichrome wire
6" piece of tungsten wire

LECTURES AND ACTIVITIES:

I. Different wires in the same circuit

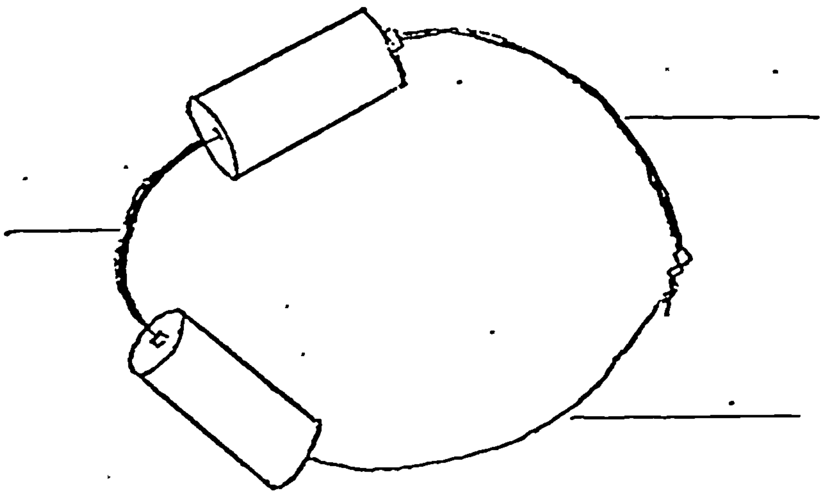
A light bulb and an electric heater both contain a wire made of a special metal. A bulb usually has a wire made of tungsten, and a heater usually has a wire made of the metal nichrome. When electric heaters were first made they had wires made of steel.

Experiment:

Have ready two batteries, pliers, a piece of bare steel wire, and bare copper wire both about three inches long and of equal thickness, and a small piece of paper.

Connect the batteries with the insulated wire as shown below. Twist the copper and steel wire together at one end. Connect the copper wire to the cap of one battery and the steel wire to the bottom of the other battery by holding it with the pliers.

Tell the children to watch carefully as you touch the paper first to the copper wire and then to the steel wire.



The same electricity flows through the copper wire and the steel wire. Yet steel wire heats up more than copper wire does. That is why steel wire was used in heaters.

II. <u>Flow of electrons over different kinds of wire</u>

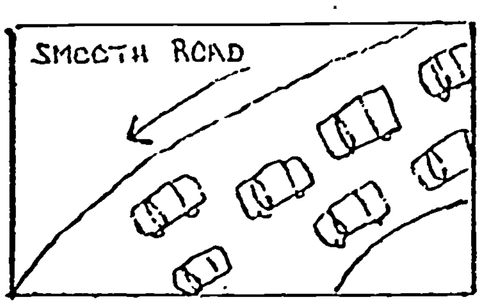
A. <u>Resistance</u>

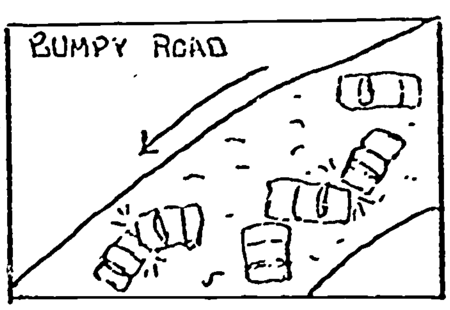
What is special about these metals that makes them produce heat when electrons are pushed through them?

Remember that a conductor is any material which will carry electricity or let electricity pass through it. Steel wire produces heat because although it is a conductor, (it lets electricity pass through it.) it is not as good a conductor as copper. The steel wire resists the flow of electrons more than copper does. To resist means to try to stop something.

B. <u>Good conductors and poor conductors</u>

Why does more resistance make more heat? We can compare the flow of electrons to the flow of automobile traffic. Traffic can flow smoothly on a well paved road. This road is a good conductor of automobiles, just as copper is a good conductor of electrons. The other road is like steel, a not-so-good conductor. On it the cars bump and jostle as they crawl along. In the steel wire the bumping and jostling of the electron traffic causes the atoms of steel to bang around and rub against each other. This rubbing of the atoms against each other produces heat, just as when you rub your hands together quickly for a time. The faster the atoms bump into each other the hotter the wire becomes.





C. Insulators

Perhaps this thought should occur to the children - if a material with fairly high resistance such as steel gives off some heat, then a material with very high resistance should give off much more heat. Cotton thread has a much higher resistance than steel wire, but when you try a piece of thread in the experiment instead of steel wire nothing happens, the thread doesn't get hot.

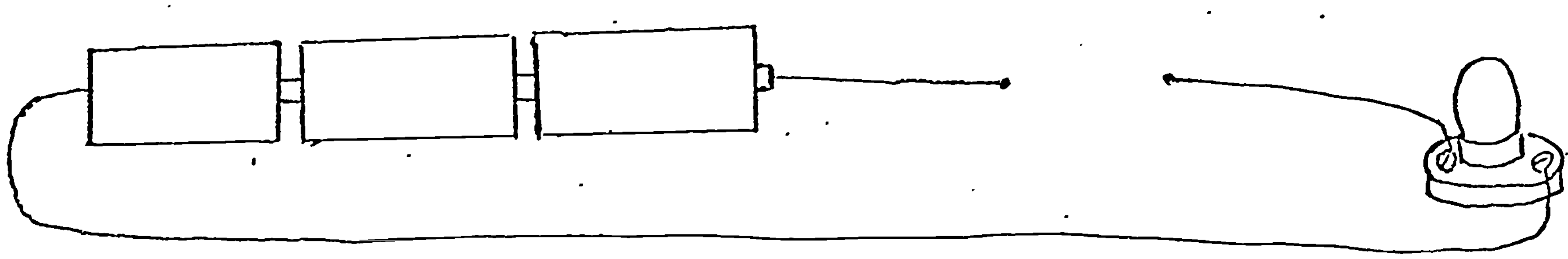
Just like a very very poor road with awful holes and ruts, the thread has so much resistance that no traffic can pass. Traffic of electrons is slowed down so much in the thread that there is little or no movement. Cars standing still don't have bumps or crashes with each other, so when the electrons can barely move let alone bump each other, there is not much rubbing and so heat is not made.

Materials which have high resistance to electron traffic and will not or will just barely carry electricity are called insulators. Materials which are insulators are often used to protect us from hot wires. When we looked at the electric cord the first lesson, we found that the wires were inside a covering. Plugs and light cords are often covered with plastic, cotton material, or rubber. If it were not for these insulators covering wires we would not be able to pick up electric cords when electricity was traveling through it nor would birds be able to sit on the telephone and electric lines outside.

III. Testing Materials: conductors and non-conductors

A. Experiment

Use a set-up like the following to test other materials which are either CONDUCTORS or INSULATORS.



You might ask two children to come to the front of the class and test the materials while you record the materials under one or two catagories, conductors or insulators. Materials which might be used:

key
something plastic (part of pen)
glass
scissors
wooden pencil
nail
handkerchief
lead part of pencil
penny
book
rubberband or eraser
aluminium foil
mirror
spoon
brick

After these materials have been done and if there is any extra time the children could be encouraged to test objects they may be curious about. They should be able to generalize that all the "conductors" they have tested are made of metal.

B. <u>There are no perfect insulators</u>

There are no perfect insulators. If there is a big enough electrical charge the force will go through any material. For the little wires we use, we could use paper or cloth as insulators; but if the electricity had a stronger flow the paper or cloth would not protect us. Materials can not be placed perfectly in one of the two groups we used, but there are definitely some materials which are better insulators than others.

IV. <u>Some metals are better conductors than other metals</u>

There are no perfect conductors either. In general metals are good conductors but some of them let the electricity pass through more easily than others. Silver is probably the best conductor, but the cost of silver makes it too expensive to use for all the wires we need. Most of our wires are made of copper. Copper is more expensive than some other metals like steel and iron. Why do you think that copper is used instead of these cheaper materials?

Experiment:

Perform an experiment using an ammeter to test six inch strips of copper, steel, nichrome and tungsten wires.

Metals:

	AMMETER	COMMENTS
SILVER		Best conductor but very expensive
COPPER		
NICHROME		
STEEL		
TUNGSTEN		Use in light bulb because of high resistance

The children will be able to see that the copper allows more electrons to pass through. This is because copper atoms do not hold onto their electrons as tightly as iron or steel atoms do.

WIRES LONG AND SHORT, AND THICK AND THIN

CONCEPTS TO TEACH:

The longer a wire the more total resistance it makes against the electricity traveling through it.

The thinner the wire the more resistance. Electricity must do more work to get through a thin wire than it does to get through a thicker wire.

MATERIALS:

1 two-foot piece of #32 (thin) Nichrome wire
1 four-foot piece of #26 (thick) Nichrome wire
2 rolls #22 (thick) copper wire
1 roll #36 (thin) copper wire
1 WB bulb and bulbholder
1 PB bulb and bulbholder
1 battery and battery holder

LECTURE AND ACTIVITIES:

I. Review of Lesson 7 - Conductors

In the last lesson the children were able to see that some metals are better conductors than other metals. The less resistance a metal gives to the travel of electrons over it the better a conductor it is. The outcome of the experiments with the ammeter and different wires were:

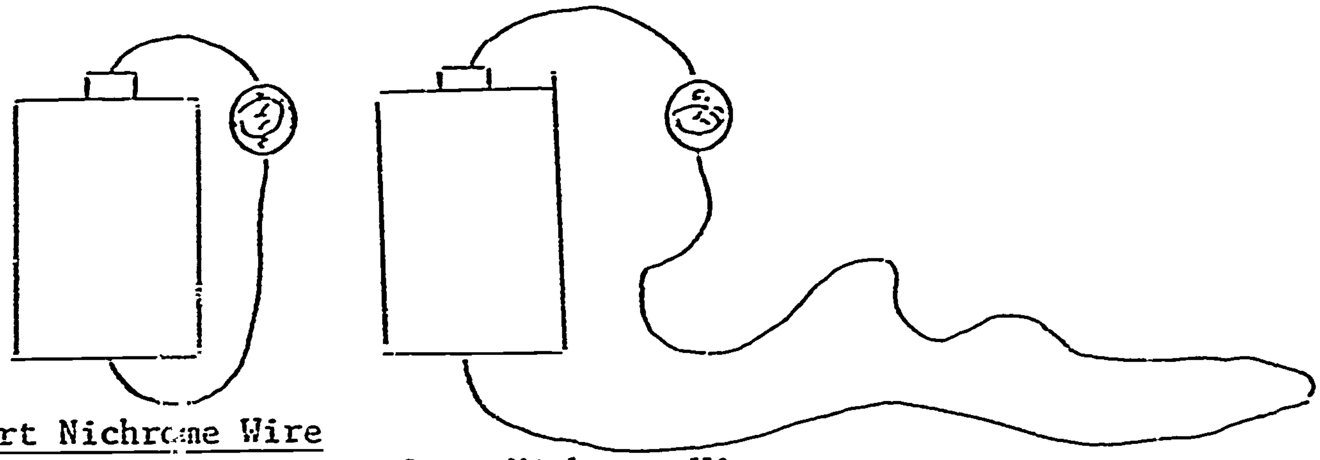
METAL	AMMETER READING	COMMENT
SILVER		Best Conductor - but very expensive.
COPPER		
NICHROME		
STEEL		

II. The longer the wire the more the resistance

Copper wire is a better conductor of electricity than nichrome wire. That is if we compared a six inch piece of copper wire with a six inch piece of nichrome wire the six inch piece of copper wire would be less resistant to the flow of electricity than the six inch piece of nichrome wire.

Ask the children if they think that the difference in the length of a wire will have any effect on the ammount of resistance it will give the flow of electricity passing over it. While they are thinking tell them to watch as you place the following on the board. (You might want to try set-ups 1 and 3 and lengthen the wires in set-ups 1 and 3 until the children can see the differences in the lights of the bulbs.)

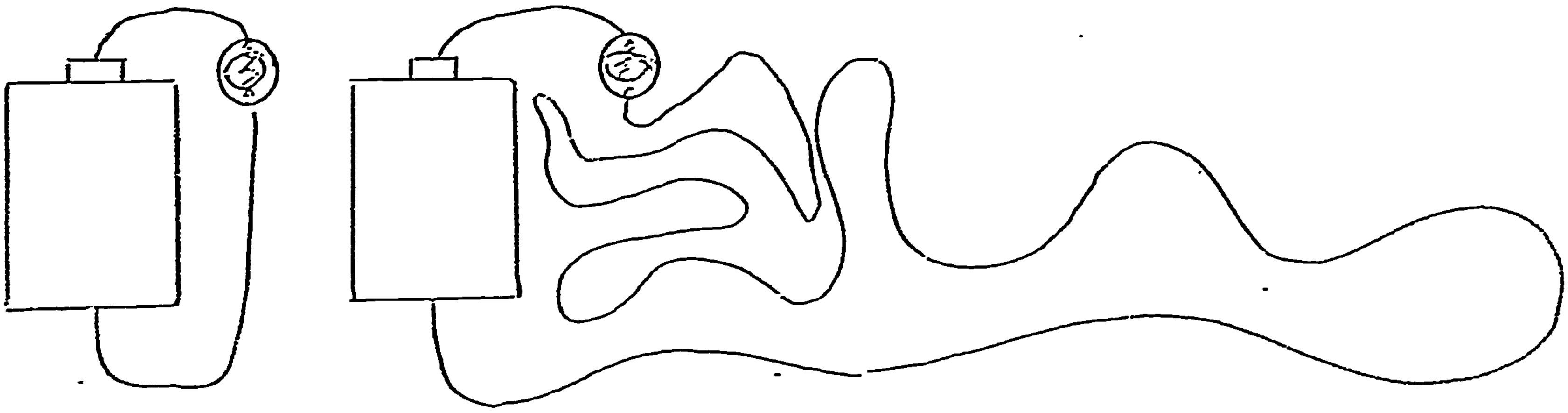
1.



Short Nichrome Wire

Long Nichrome Wire

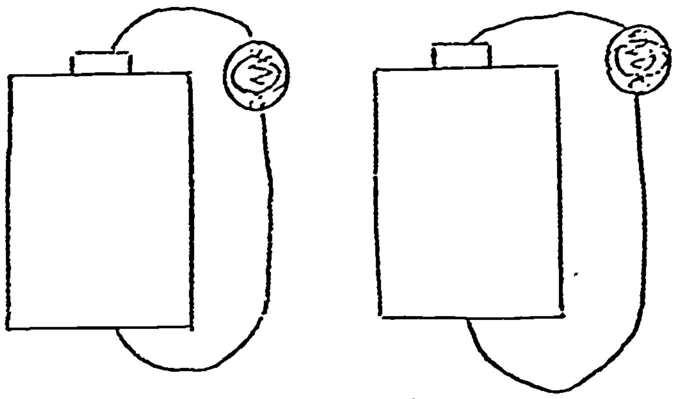
2.



Short Copper Wire

Long Copper Wire

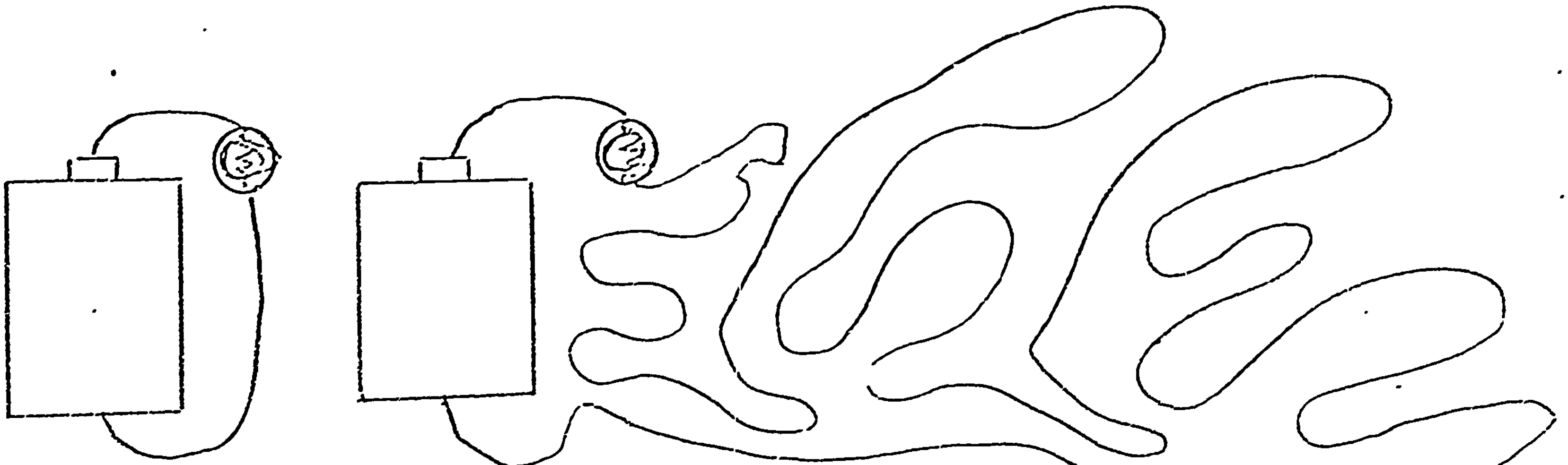
3.



Nichrome

Copper

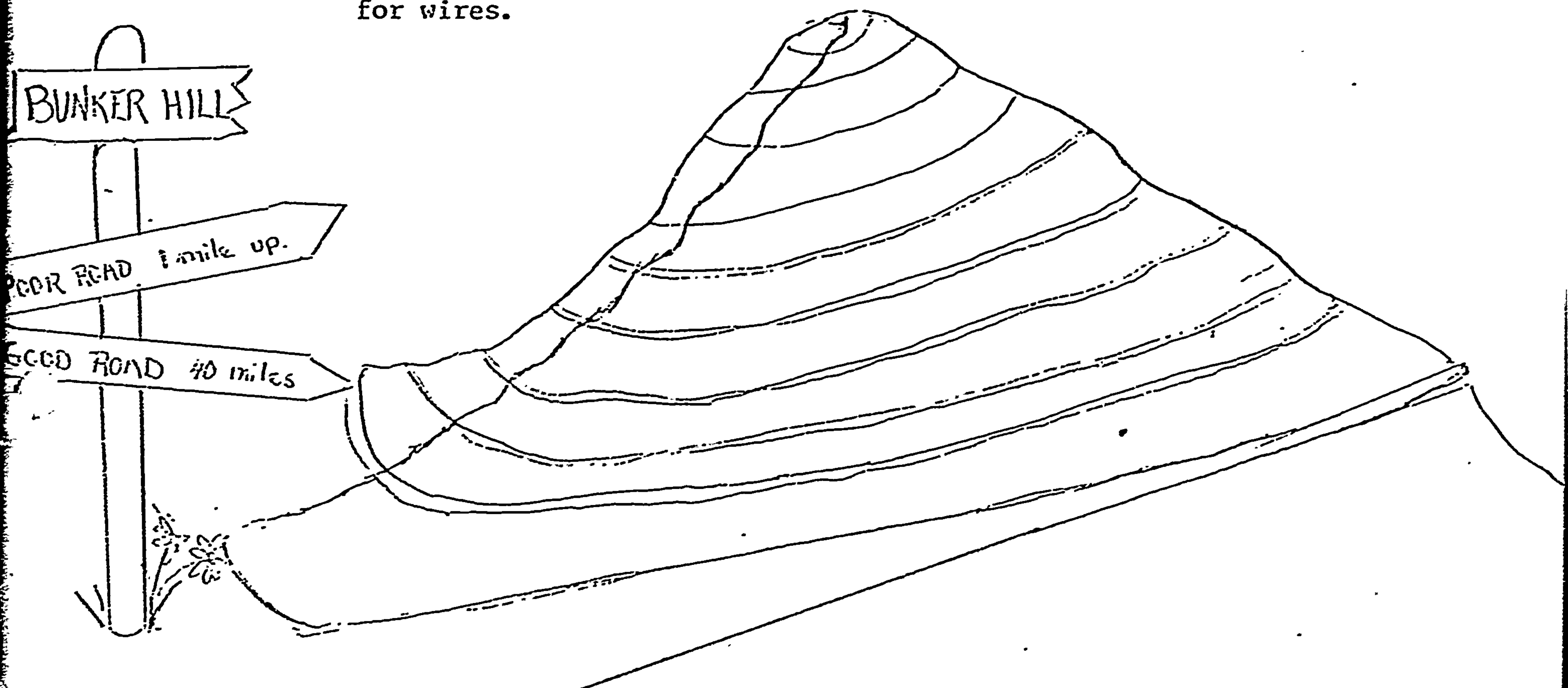
4.



Nichrome

Copper

The shorter the wire in a circuit the less work the electricity has to do to get from the top of the battery to the bottom of the battery. Again comparing different kinds of wire to different kinds of roads, if there are two roads of equal length, one of the roads is a very good road (a good conductor of traffic) and the other is a very poor road (a poorer conductor of traffic). So it is much easier and faster to take the good road. But if there is a very long good road and a very short poor road, even though the traffic may be much slower over the poor road the shorter distance may take less effort than the longer good road. The same is true for wires.



Poor Conductor = Good Conductor

Nichrome , Copper

III. Review

Different kinds of wires offer different amounts or resistance to the flow of electricity. Some wires are better conductors than others.

The longer a certain wire is the more resistance it offers. For instance a thick copper wire 10 inches long makes the electricity work harder than a thick copper wire only 2 inches or even 9 inches long.

Sometimes if a poor conductor is much much shorter than a good conductor the electricity will not have to work as hard going through the poor conductor as it does going through the good conductor.

IV. <u>The thinner the wire the more resistance it will have.</u>

The children have seen that the metal a wire is made of determines how good of a conductor the wire will be. They have also seen that the length of a wire affects the resistance it offers, the longer the wire the more resistance it has that must be overcome by the electricity. Ask the children if they think that the thickness of a wire will determine how well it will conduct electricity.

Use an ammeter to test foot lengths of:

#32 (thin) Nichrome wire
#26 (thick) Nichrome wire
#36 (thin) Copper wire
#22 (thick) Copper wire

Place the following grid on the board and have a child record the findings as you test the wires.

WIRES	AMMETER READING
#32 (thin) Nichrome Wire	
#26 (thick) Nichrome Wire	
#36 (thin) Copper Wire	
#22 (thick) Copper Wire	

Make sure that the children understand that <u>the thinner the wire the more resistance it offers to the flow of electricity.</u> More water can go through a big hose than through a small hose, and it is easier to go through a big tunnel than to squeeze through a little tunnel. A thick copper wire is a better conductor than a thin copper wire. A thick nichrome wire is a better conductor than a thin nichrome wire.

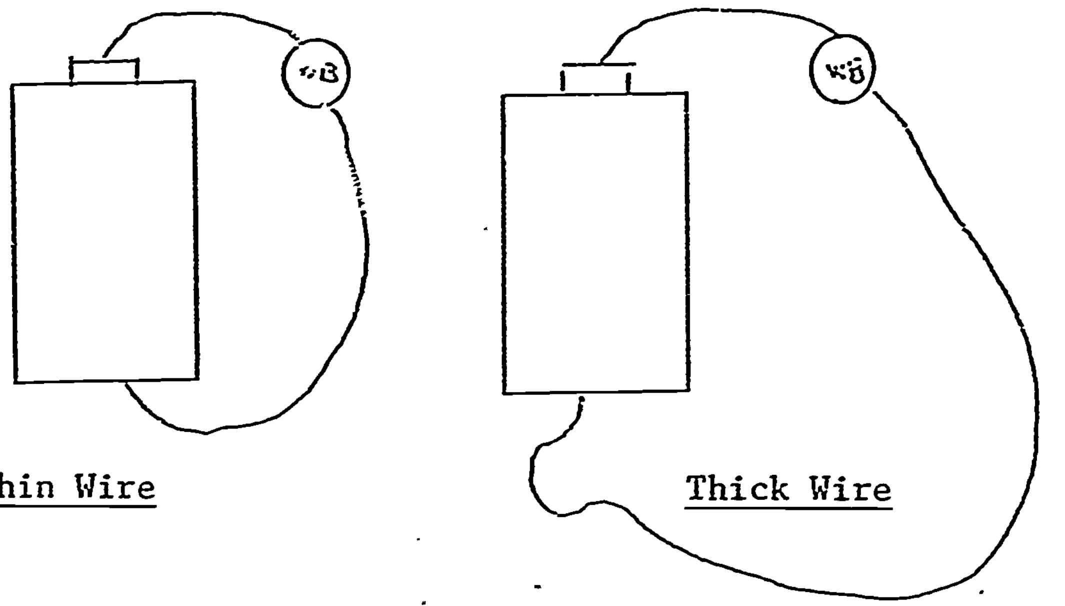
V. <u>To make a thin copper wire and a thick copper wire or a thin nichrome wire and a thick nichrome wire have equal resistance lengthen the thick wires.</u>

Only if you take a very long piece of thick nichrome wire and compare it with a very short piece of thin nichrome wire will both pieces of nichrome wire have about the same amount of resistance. The same would be true for copper wires.

A. Use a thin nichrome and a thick nichrome wire in the following set-ups. You may also use a thin copper wire and a thick copper wire, but because copper is a better conductor than nichrome you will have to lengthen the thick copper wire to a fantastic length (3 or 4 times around the room) in order to produce a noticeable difference in the bulb.

1. Lengthen the thick wire until the two bulbs light to about the same brightness.

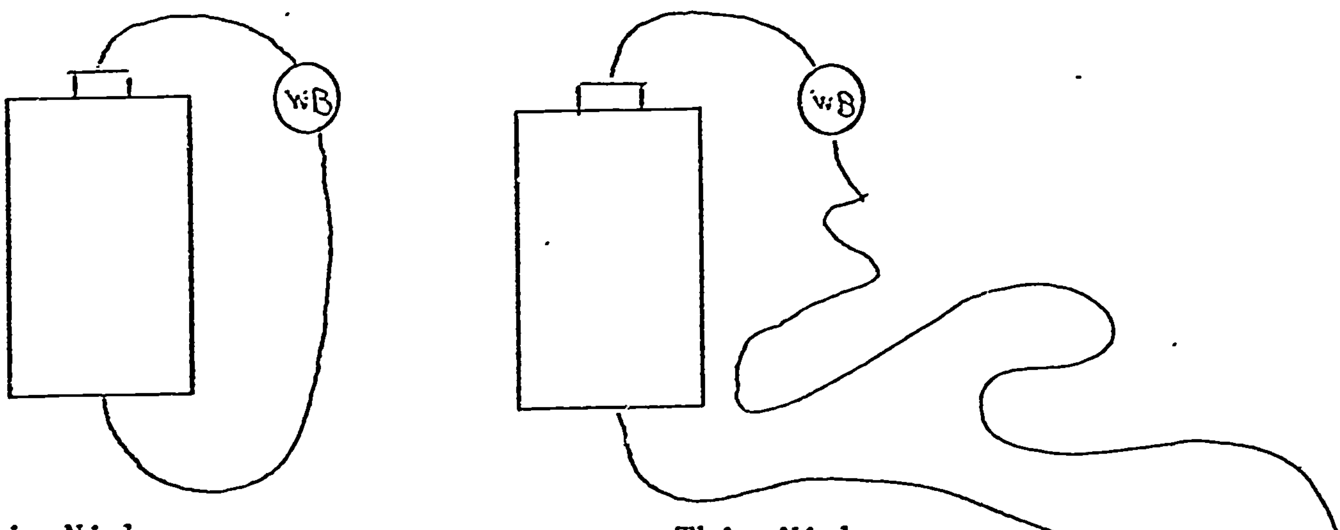
2. Measure both wires to see what length of thick nichrome has the same amount of resistance as a certain length of thin nichrome.



Thin Wire

Thick Wire

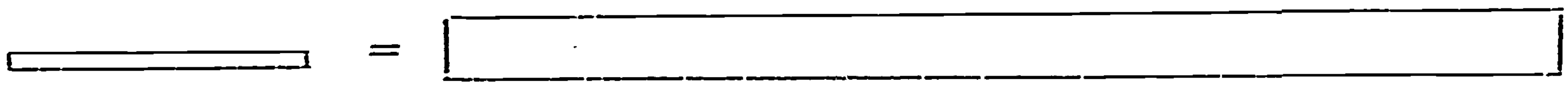
B. To increase the amount of work (resistance) that electricity must do to get over a wire - make the wire longer.



Thin Nichrome

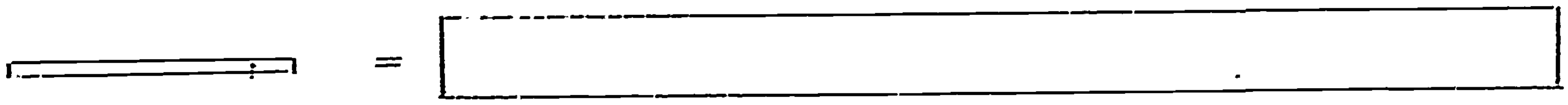
Thin Nichrome

As the wire in B is lengthened the bulb becomes dimmer. Eventually the wire will be so long that the electricity will find it is difficult to get to the bulb to light it.



Thin Copper Wire

Thick Copper Wire



Thin Nichrome Wire

Thick Nichrome Wire

V. <u>Review</u>

When considering how good a conductor a wire is you must consider:

1. What kind of metal it is made of. Some metals are better conductors than others.

2. How long is the wire - the longer the wire the more resistance and the more work the electricity must do to travel over it.

3. How thick is the wire - the thinner the wire the poorer a conductor it is, the harder it is for the electricity to travel through the wire.

LIGHT BULBS

CONCEPTS TO TEACH:

Thickness of wires affect their resistance to the flow of electricity - the thinner the wire the more resistance a wire offers, or the thicker the wire the better it will conduct electricity.

The reason that a bulb lights is because it contains a very thin wire which glows because it offers so much resistance.

Pink bulbs have thinner filaments than white bulbs and therefore offer more resistance to the flow of electricity.

Because the pink bulb has a thinner wire and offers more resistance in a circuit than a white bulb does, when both a white and a pink bulb are in the same circuit, only the pink bulb will light.

MATERIALS:

#32 (thick) copper wire
#36 (thin) copper wire
Ammeter
Batteries
Piece of clay
Several light bulbs of different voltage
Pink and white bulbs.

LECTURE AND ACTIVITIES:

I. Review - the thinner the wire the more the resistance

When different thicknesses of wire the same length were tested during the previous lesson the following results were obtained:

Kind and Thickness of Wire	Ammeter Reading
#22 (thick) copper	
#36 (thin) copper	
#26 (thick) Nichrome	
#32 (thin) Nichrome	

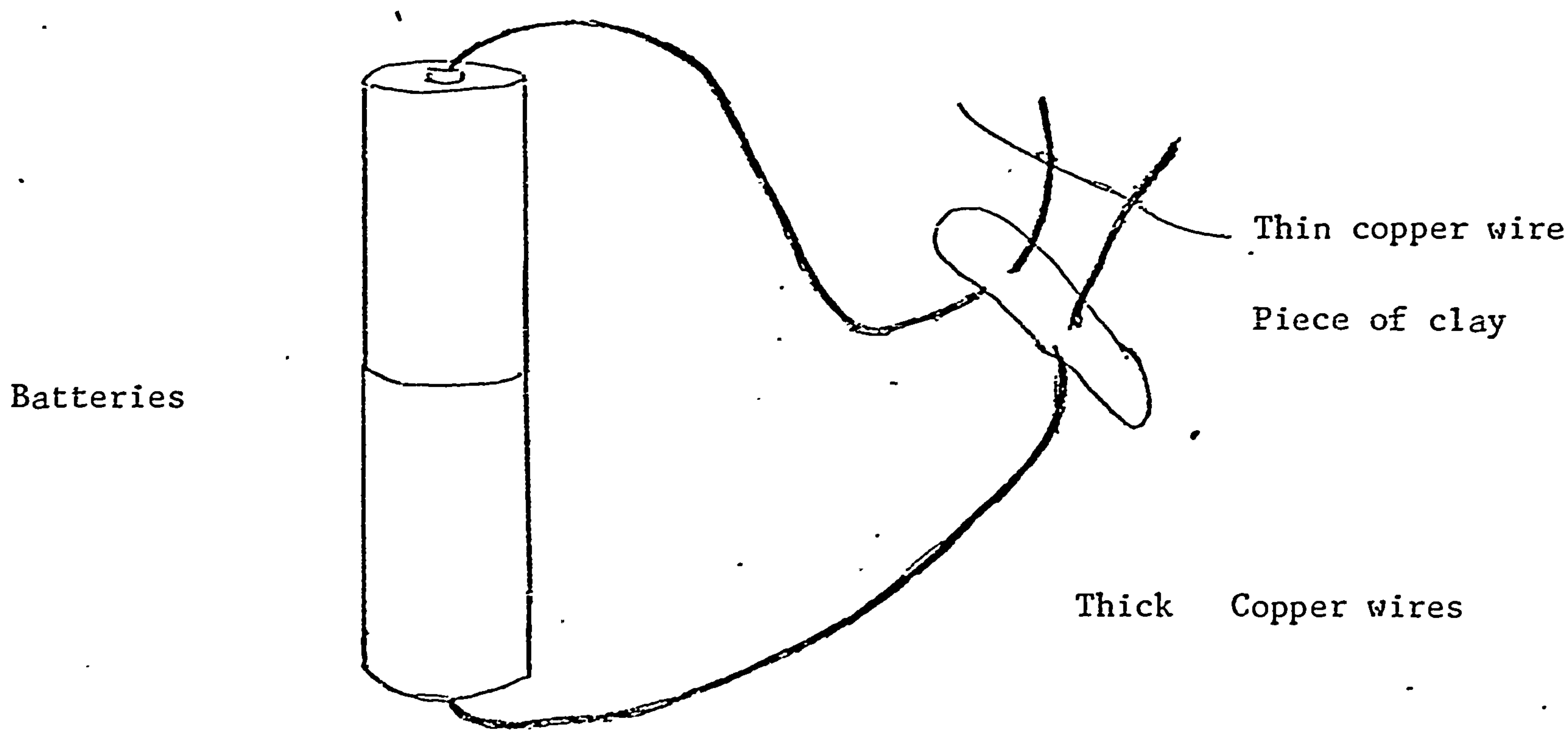
Thin copper wire gave more resistance than thick copper wire. Thin nichrome wire gave more resistance than thick nichrome wire. The thicker the wire the less work the electricity must do.

II. <u>How a bulb works</u>

Recall the experiment in lesson 7. A copper wire and a steel wire were placed in the same circuit. The steel wire gave more resistance than the copper wire so it became hot when the electricity worked its way through it. If a piece of wire with high resistance is placed in a circuit it will get hot.

Ask the children if they have any ideas how bulbs are made.

Make the following set-up. Pull the thin copper wire tight:



Remind the children that thin wire in a circuit gives more resistance to electricity and becomes hot. The thinner the wire the faster it gets hot.

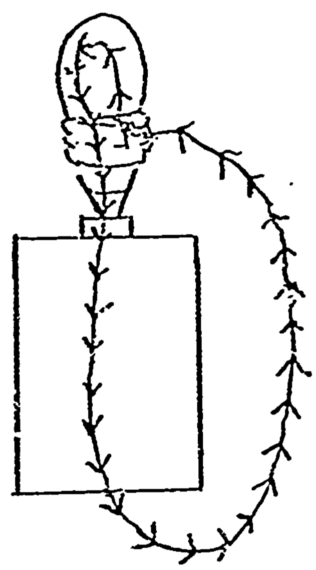
The very thin copper wire smoked and became "red" hot. The small batteries we use in class have only 1 1/2 volts a piece. If we use two of these batteries together we have an electric current of 3 volts because 1 1/2 plus 1 1/2 makes three volts.

A <u>volt</u> is the pressure that forces the electrons to move over the wire. A trickle of water on your nose can tickle you. A fine stream of water from a well-aimed water pistol can sting quite sharply because the water pistol adds pressure.. The small batteries have a pressure of 1 1/2 volts. The electricity coming from the sockets in your home and school comes at about 110 or 220 volts. The electricity from the sockets has about 100 times more force than the little batteries. That is why you should never ever play with the sockets in your home or school. The small batteries are safe, the sockets are not safe!

III. Inside a light bulb

Pass around several large bulbs so that the children can look at them and perhaps read the voltage.

Have a number of large light bulbs with the glass removed available to be passed around the room. Tell the children to look at the bulbs carefully and see if they can trace where the electricity travels inside the bulb. Show them a large diagram of the inside of a bulb. Explain how when the bulb is screwed into a socket it completes a circuit for the electricity. Trace the path the electricity for the children to see.



Ask the children what they think happens when they shake a bulb too hard or when the bulb "burns out". (The small wire is broken or burned in half, the circuit is then broken and no electricity is able to travel through the bulb.

IV. Pink bulbs and white bulbs

A. A white bulb has a thicker filament than a pink bulb.

Give each child a pink bulb, a white bulb, and a magnifying glass. Tell them that the pink beads or the white beads do not help the bulbs to light, but are merely there to hold the wires in place and are different colors so that we can easily tell the two bulbs apart.

Tell the children to look carefully at the bulbs with the magnifying glass. Ask them what difference they see in the bulbs besides the different colored beads. The small wire in the pink bulb is much smaller than the small wire in the white bulb.

Now, ask the children if they think that the difference in the size of the small wire will make any difference in the way the bulbs light.

B. The pink bulb is easier to light, but a white bulb is stronger.

Light each bulb using one battery. Explain that the pink bulb is easier to light. The smallest amount of electricity that is needed to light the pink bulb is not enough electricity to light the white bulb. It takes a little more electricity to get the white bulb to light than it takes to get the pink bulb to light. One battery is plenty of electricity to light either bulb, but perhaps half a battery would only light the pink bulb and not the white. This is not the only difference. Look at this: Add one battery after another to the pink bulb. Tell the children to count the batteries as the pink bulb becomes brighter and brighter. The children should enjoy seeing the bulb get brighter and be rather surprised to see it go out when about the fourth or fifth battery is added.

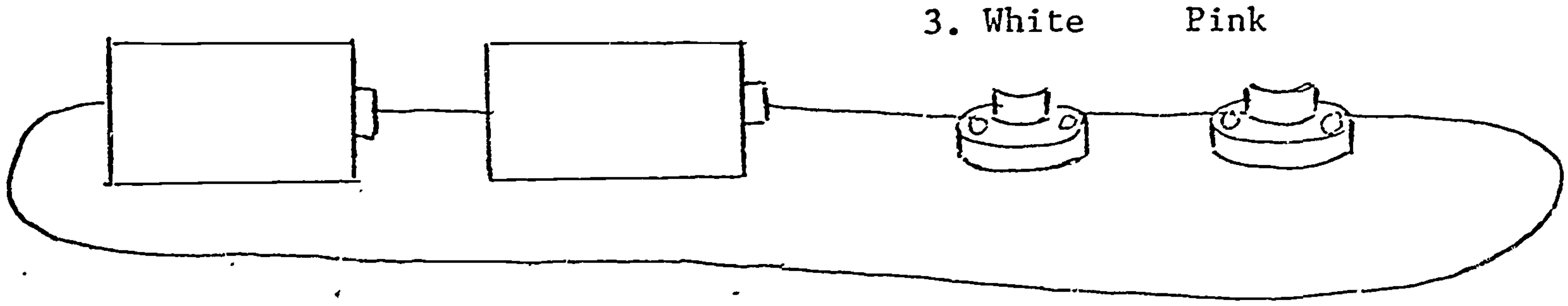
Do the same with the white bulb and again have the children count as you add batteries. The white bulb will go out when about the sixth or seventh battery is added.

Explain that as the batteries were added the bulbs burned brighter and brighter until the wires became so hot that they burned in half. The thin wire in the white bulb is thicker than the thin wire in the pink bulb, so that although the white bulb will not light as easily to begin with, it is stronger and will let a much stronger current of electricity pass over it.

C. Pink and white bulbs in the same circuits.

This is a very interesting experiment using pink bulbs and white bulbs. Set up a circuit which looks like the following.

1.	Pink	Pink
2.	White	White
3.	White	Pink



1. When two pink bulbs are placed in the same circuit both bulbs light.
2. When two white bulbs are placed in the same circuit, both bulbs light.
3. Now show also what happens when both a white bulb and a pink bulb are put in the same circuit.

The children should be very surprised to see that only the pink bulb lights and that it lights much brighter than either of the pink bulbs did when two pink bulbs were in the same circuit.

1. Discussion:

Ask the children if they think that any electricity is going through the white bulb?

1. How would one know that electricity is going through the white bulb? (There must be a complete circuit for the electricity to be able to travel to light the pink bulb, so some electricity is definitely going through the white bulb.)

2. If electricity is passing through the white bulb, why doesn't it make the white bulb light? This is the explanation:

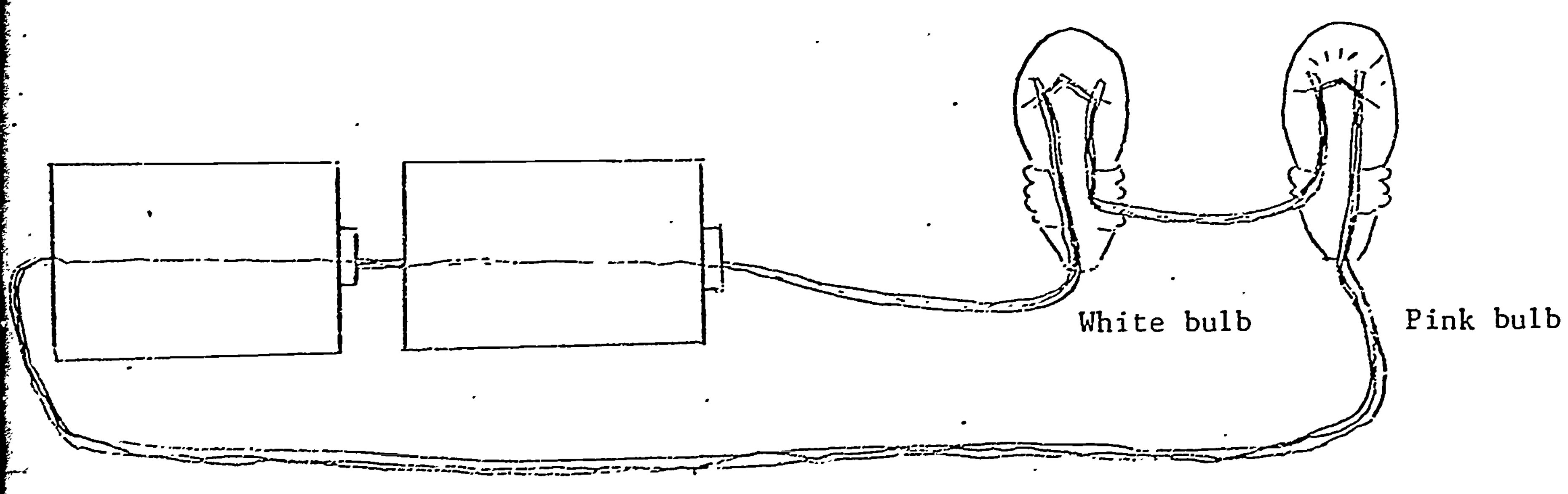
2. Explanation:

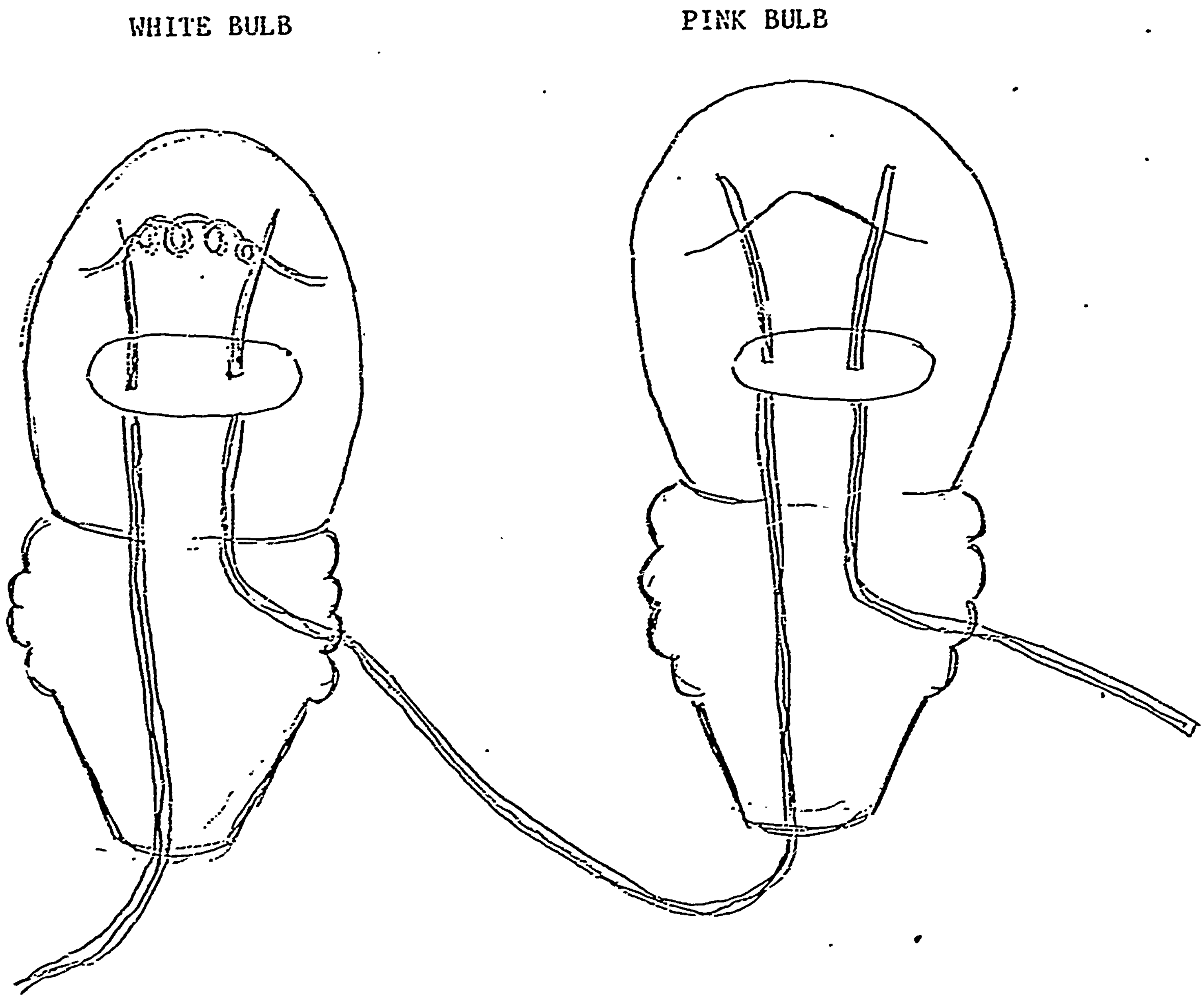
In order for the electricity to be able to travel over the circuit, it must be able to get through the smallest wire in the circuit. In this last circuit we made, the small wire in the pink bulb was the smallest wire in the circuit.

The operation is kind of like a person crawling through an underground cave. If a person is going to be able to go from one end of the cave to the other he must be small enough to fit through the narrowest tunnels of the cave. Only people small enough to fit through the narrow tunnels will be able to travel in the cave. When these people get to the very narrowest parts they will just barely be able to wiggle through. They will have to push and squeeze and when they push and squeeze they will rub against the sides of the tunnels, and just like when you rub your hands together very quickly, they will make a little heat.

This is what happens with the electricity. It pushes to get through the narrowest wires, but has a very easy time getting through the thicker wires.

You might use this diagram to further explain the phenomenon.





When there are only pink bulbs in a circuit identical wires of the pink bulbs are the narrowest parts of the circuit.

When there are only white bulbs in a circuit the identical wires of the white bulbs are the narrowest part of the circuit.

But when there are both white and pink bulbs in a circuit, the wires of the pink bulbs are narrower than the wires of the white bulbs so the pink bulb is the narrowest part of the circuit. The electricity works to get through the narrowest part of the circuit - the pink bulb, and once through it the white bulb requires almost no effort at all. The electricity pushing through the pink bulb, lights it, and slips easily through the white bulb.

Only when electricity has to push and work to get through a wire does electricity make heat, and it makes enough heat pushing through the small wire of a bulb to make the bulb light up.

SHORT CIRCUITS - AN EASIER PATH

CONCEPTS TO TEACH:

A short circuit is an easier path for electricity to take.

A fuse protects against fires by a thin wire which melts and breaks a circuit when the wires become too hot.

MATERIALS:

Batteries
Bulbs
Bulb holders
Copper wires
Fuses

LECTURE:

I. Short Circuits

A. Short Circuit - An Easier Path

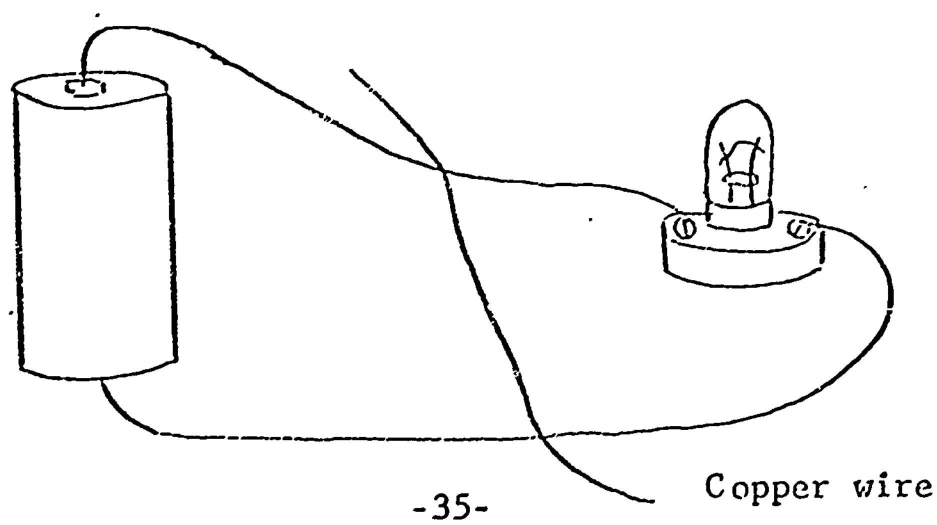
Probably alot of the children have heard the term "short circuit". A short circuit is not necessarily a smaller or littler circuit as they will soon see. A short circuit is really just an easier path for the electricity to take. I want you to remember that a short circuit means an easier path.

Electricity is like alot of people these days. It will do just as much work as it is forced to do, and it will take advantage of any way to get out of a job.

We know that we must have a completed circuit for electricity. We must be able to trace electricity from the place it started and back again.

B. Experiment

1. Tell the children to look carefully and see what happens when a copper wire is placed across the wires in the circuit to a lighted bulb.



Electricity actually flows in all wires but most of the electricity goes the easier path. Bulb doesn't light because not enough electricity goes through the bulb.

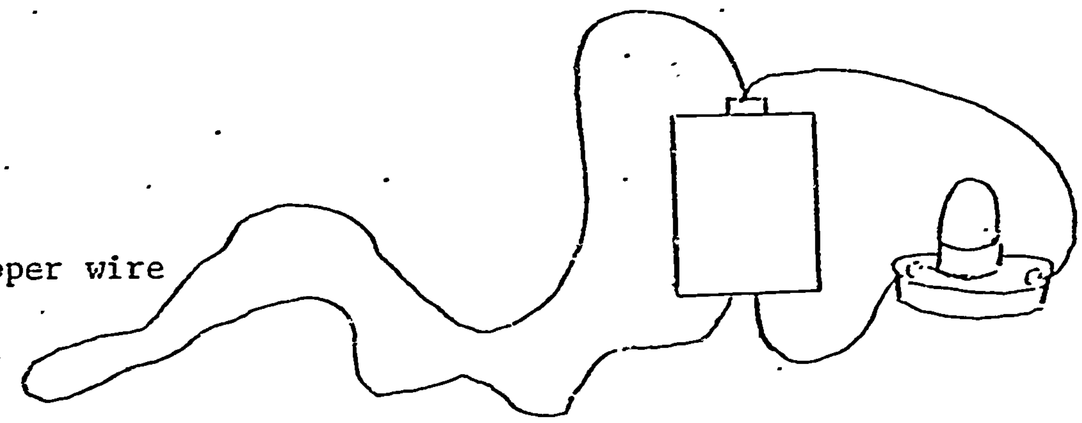
There is a bulb, a battery and wires leading from the battery to the lighted bulb. When the wire is placed across the circuit wires, the light goes out.

Ask the children if they think that there is any electricity traveling over any of the wires? If any of the children think that electricity is traveling over the wires, ask the child to come to the front of the room and trace the path it is taking. If there is no response from the class, ask one of the children to come forward and feel the wires.

Establish that there is a circuit which goes from the top of the battery to the bottom. Ask the children if there is any electricity going through the bulb, and why not ... The electricity had the choice of two paths leading from the top of the battery to the bottom (trace the paths) but the electricity took the path where it didn't have to light the bulb, it took the easier path with less work.

2. Take a long copper wire and attach it to the top and bottom of the battery like this:

Long copper wire



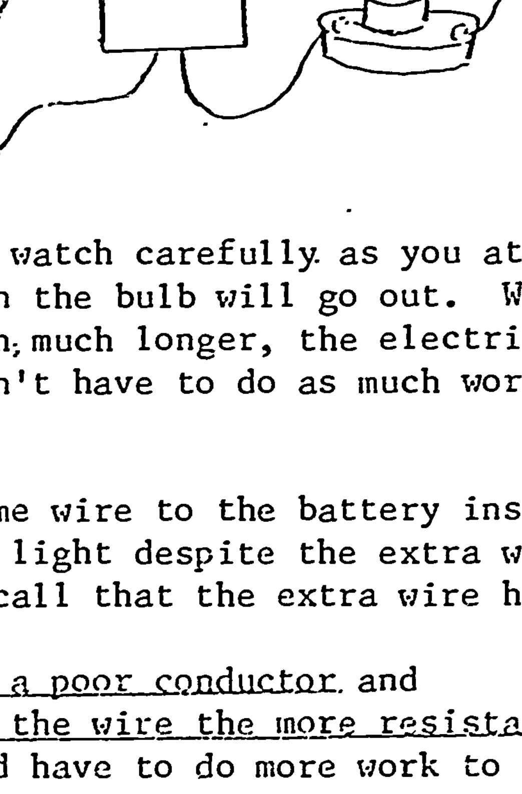
Tell the children to watch carefully as you attach the long wire to the set-up. Again the bulb will go out. Why? Even though this new path is much, much longer, the electricity chose this path because it doesn't have to do as much work, doesn't have to light the bulb.

3. Attach a thin nichrome wire to the battery instead of the copper wire. The bulb will light despite the extra wire (thin nichrome). Have the children recall that the extra wire has more resistance because:

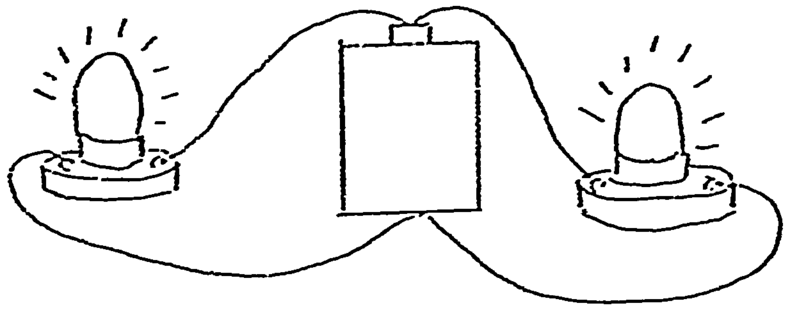
   1. nichrome is a poor conductor and
   2. the thinner the wire the more resistance it has.

The electricity would have to do more work to get through the thin nichrome wire than it does to light the bulb so it takes the easier path and goes over the copper wire and through the bulb.

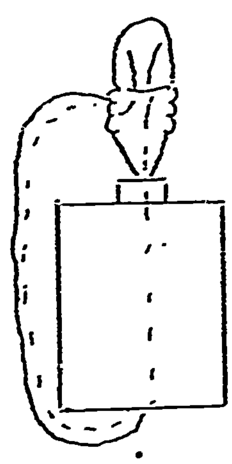
Thin nichrome →



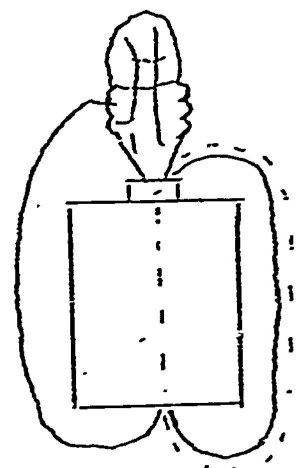
4. This time add another light with its own circuit to the same battery. The light will work because the electricity has an equal choice, it has the same amount of work to do on either circuit so there is no easier path - no short circuit.



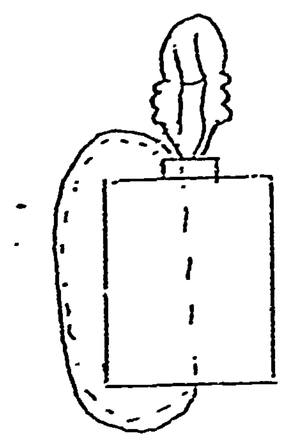
5. Draw the following six set ups on the board. Have the children trace the paths and show where electricity is flowing. Some will be complete circuits, some short circuits, some circuits through the bulb and some will have no complete circuit.



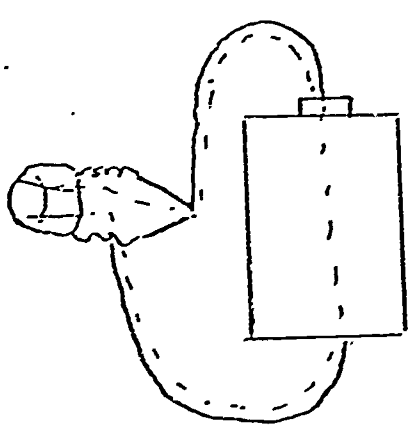
Complete circuit through the bulb.



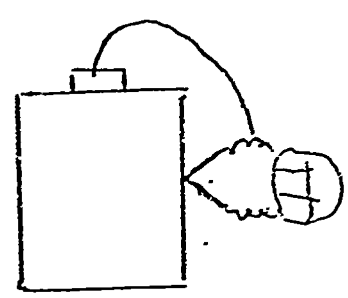
Short circuit made by the extra wire.



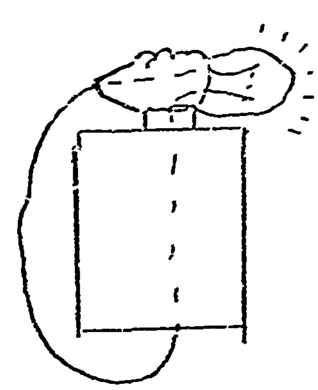
Circuit does not pass through the bulb.



Complete circuit through the bulb.



No circuit



Complete circuit through the bulb.

II. Danger of Short Circuits

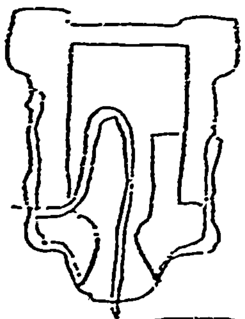
Lets make a short circuit using only a bare wire. We will attach one end of the wire to the top of the battery and the other end of the wire to the bottom of the battery. Ask one of the children to touch the wire. What has happened? (The wire is hot.) Ask if they think that a short circuit could be dangerous. Why or how? What do they think people do to protect their houses from the heat of short circuits which might develop because of poor wiring or worn out electric cords?

III. A Fuse - protects against short circuits.

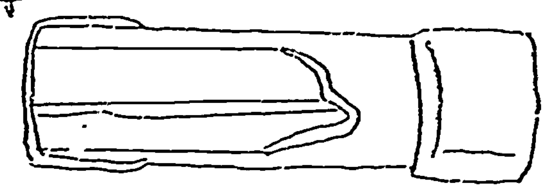
Ever hear of a fuse? Does anyone know what a fuse looks like? (Pass around a fuse for all to see.) Tell the children to look closely and they will see a thin wire stretched across its center.

There is a soft strip of metal in each fuse. If there is a short circuit, the soft metal becomes hot and melts before the wires can become hot enough to start a fire. When the metal in the fuse melts, the circuit is broken and electricity can no longer travel over the wires.

Ask the children if the lights have ever gone out in their homes, and their parents said, "must have blown a fuse", or "must have burned out a fuse". This is what they were talking about. These little fuses only cost about 25 cents, but they save a great deal of money by protecting against fires caused by poor wires.



Plug Fuse



Cartridge Fuse[5]

IV. Liquid Pathways

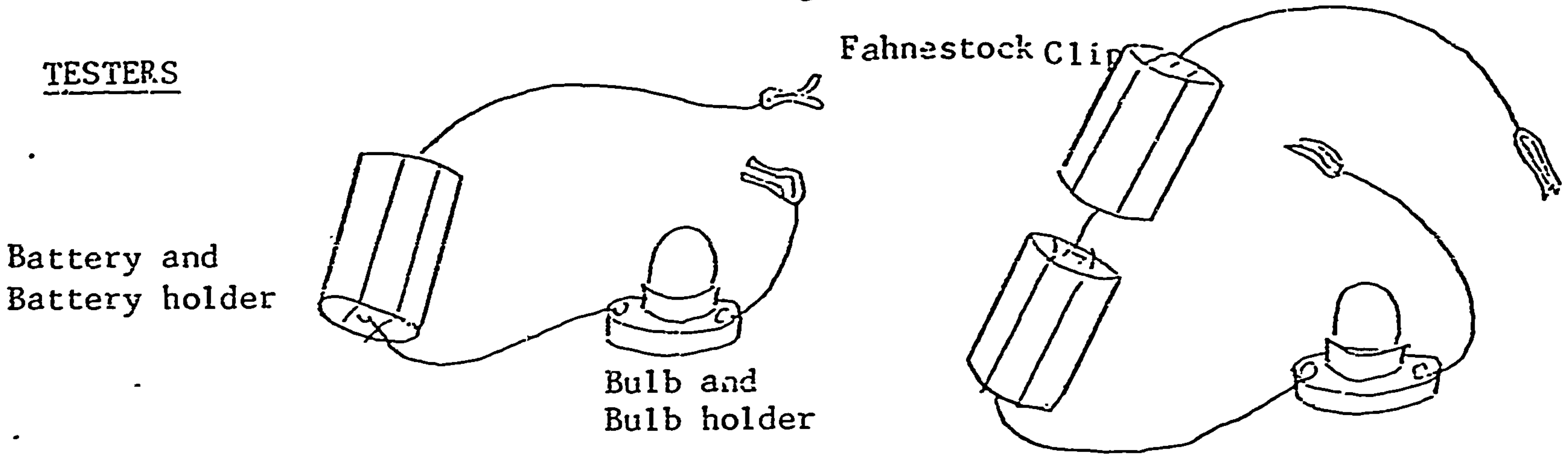
The children have studied good conductors, poor conductors, and insulators. They have seen that the good conductors are metals. But metals are not the only things that conduct electricity.

1. Experiment:

Have ready; clear containers of water, vinegar, and cooking oil. Use a tester like the one shown below. Test each of these liquids. (Actually you should have several testers available differing in number of batteries, to see if more power is required to light the bulbs with the liquids.)

Place the tester in the clear water and slowly add quantities of salt until the children can see the bulb light. Do the same for Comet cleanser and Bicarbonate of Soda, and cooking oil. A chart should be made to r ecord the findings.

TESTERS



SOLUTION	TYPE OF BULB	ONE BATTERY	TWO BATTERIES	BRIGHTNESS Bright, Standard, Dim
	PB			
WATER	WB			
	PB			
SALT WATER	WB			
	PB			
BAKING SODA	WB			
	PB			
COMET CLEANSER	WB			
	PB			
COOKING OIL	WB			

REVIEW

CONCEPTS TO TEACH:

This class period should be used to discuss the material presented in the past ten lessons, to answer any questions the children might have, and to clarify the important concepts of electricity.

DISCUSS:

The basic structure of atoms.
How current electricity is a chain of moving electrons which needs a complete circuit in order to be used.
Electricity is either made by machines or chemicals and that we depend upon a vast net work of wires to get the electricity to our homes or school.
Review the insides of a battery explaining the purpose of each part.
Review ways to light a bulb using one bulb and one battery. Have the flash cards available from lesson 5 and run quickly through them with the children.
Have one of the children explain the use and functioning of a bulb holder.
Discuss conductors and insulators. Have the children try to recall as many conductors or insulators as possible. Why or how do conductors and insulators do their jobs? (Theory of resistance)
Review that:

1. Certain metals are better conductors than other metals.
2. The longer a wire is the more work electricity must do to get over it.
3. The thinner a wire the harder work it is for electricity to get through it and the faster the wire will heat up.

Have the children explain how and why a light bulb lights. Review the diagram of the inside of a light bulb.
After reexamining the light bulb have the children explain the difference between a thick or thin wire in a circuit.
Review the difference between white and pink bulbs and have the children explain the phenomena of a white bulb not lighting when in the same circuit with a pink bulb.
Review the concept of a short circuit as "an easier path" for the electricity to take. Give them several examples of short circuits, and have them trace the circuits and explain why a wire is a short circuit.
Talk about the use of fuses to prevent damage and fires. Get the children to explain how a fuse works.

Terms:

Circuit - the path over which the electricity travels and it must be complete.
Electricity - the flow of electrons needing a complete circuit in order to be used.
Resistance -- is the slowing down or prevention of the movement of electrons through a material.

Conductors - materials, usually metals, which will allow electricity to travel through them easily.

Insulators - materials which will not allow electricity to travel through them easily and therefore can be put around wires to protect people and objects from hot wires or electrical shocks.

Liquid pathways - liquids which can be used as part of an electric circuit.

Pink bulb - one of the two small bulbs which we use in class. The pink bulb is marked by a pink bead and has a much thinner wire than does the white bulb.

White bulb - the other of the two bulbs used in class. The white bulb has a white bead and a much thicker wire than the pink bulb. The pink bulb is easier to light because its thinner wire offers more resistance to electricity and glows sooner, but the white bulbs thicker wire can take a stronger current of electricity so can glow brighter than the pink bulb before breaking.

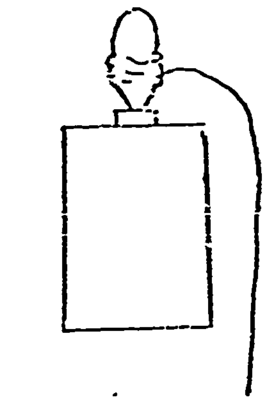
Short circuit - is an easier path which the electricity will take to get back to its source.

Fuse - a small round piece with a thin wire which is added to a circuit so that if the wires get too hot in the circuit the thinner metal wire in the fuse will melt and the circuit will be broken. This is used to protect against fires from over heated wires.

REVIEW of completing a circuit and lighting a bulb.

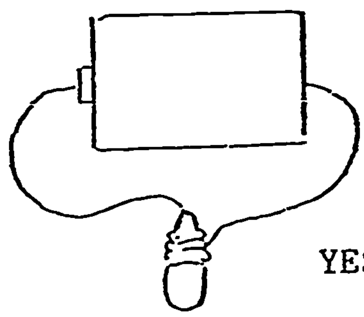
Will the following bulbs light in the set-ups? Check the path the electricity follows and the two parts of the battery and two places on the bulb which must be touched to be part of the circuit.

1.



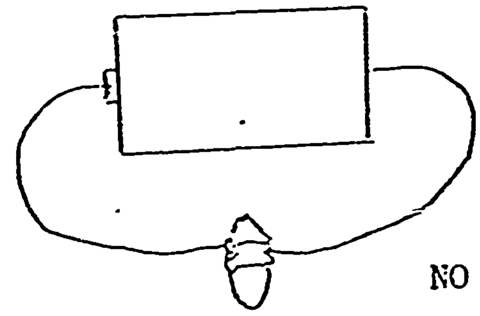
NO

2.



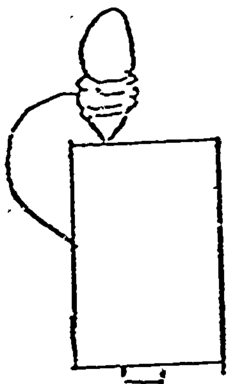
YES

3.



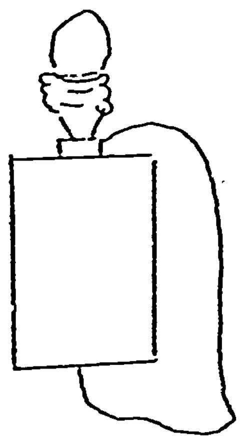
NO

4.



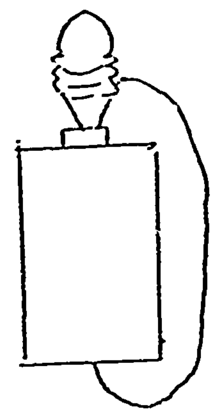
NO

5.



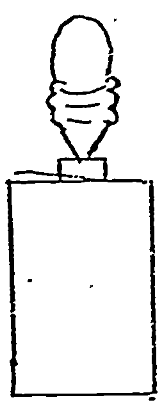
NO

6.



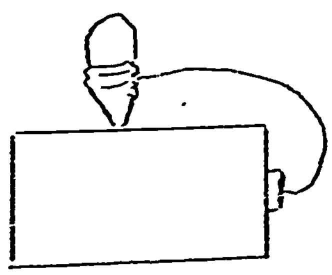
YES

7.



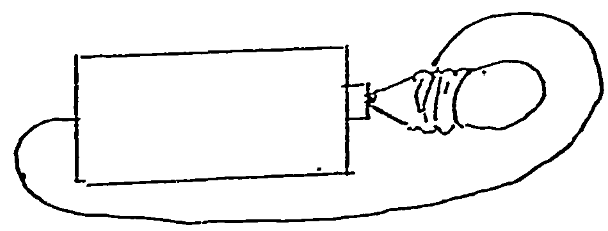
NO

8.



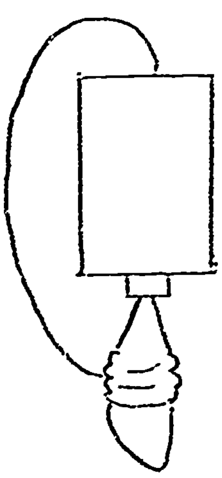
NO

9.



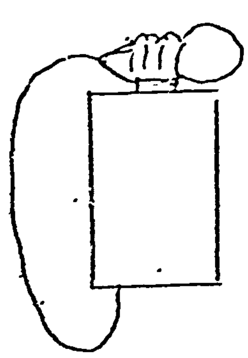
YES

10.



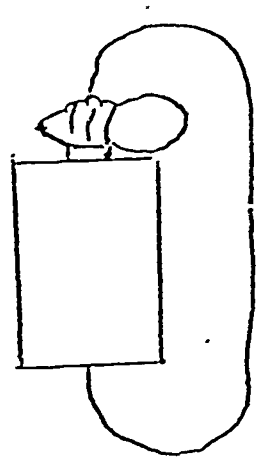
YES

11.



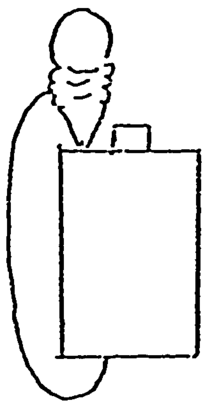
YES

12.



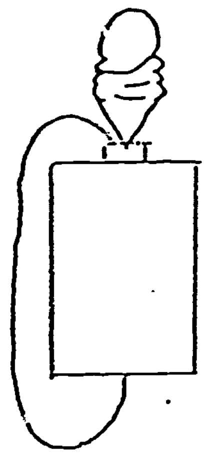
NO

13.



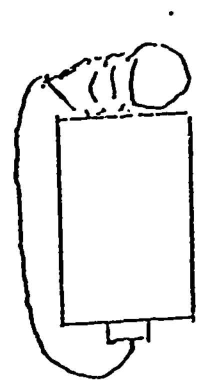
NO

14.



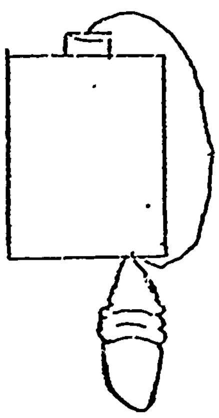
NO

15.



YES

16.



NO

BATTERIES IN SERIES

CONCEPTS TO TEACH:

The word series means to connect in a chain with one object following another.

The brightness of a bulb can be increased by adding more batteries in a series with the top of one battery following the bottom of another.

MATERIALS:

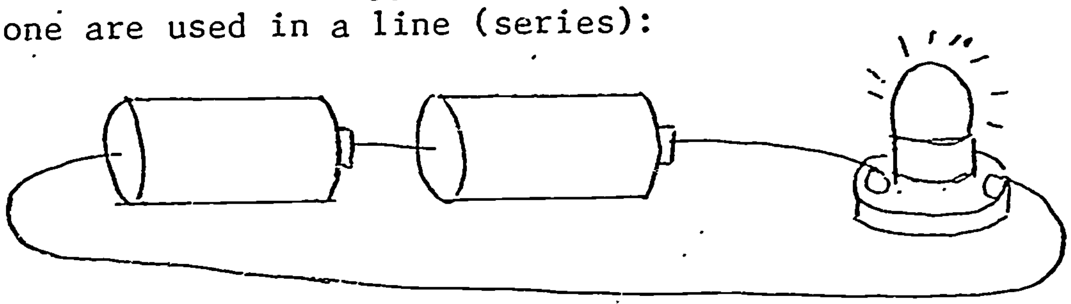
Bulbs
Bulb holders
Batteries
Battery holders
Wires

LECTURE AND EXPERIMENT:

I. Simple Series

Have four batteries in rubber band battery holders, and one bulb holder with wires attached.

Show the children what happens to a bulb when two batteries instead of only one are used in a line (series):

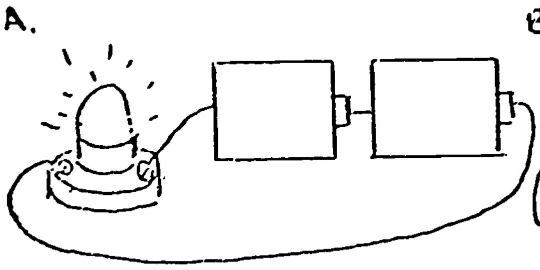


Ask the children what difference the added battery made. Add another battery and another battery. The bulb will become brighter as each battery is added. Explain that his way of connecting batteries in a circuit is called connecting in a series. Series means connected in a chain, one after another like a string of pearls. (The children may be familiar with the word series in World Series, which is a certain number of baseball games played one after another).

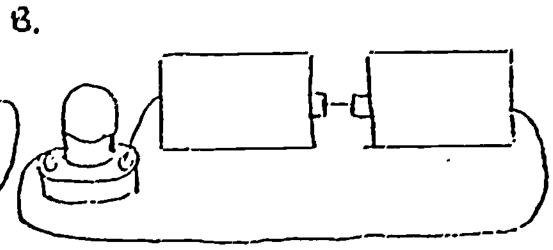
II. Special Series: What direction must the batteries face?

Tell the children to watch closely to see if it makes any difference in which directions the batteries are pointed when connected in a series. Then make the following three set-ups for them to compare.

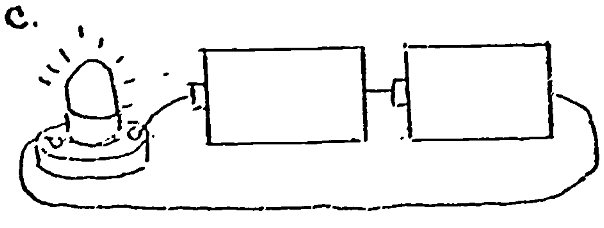
A.



B.



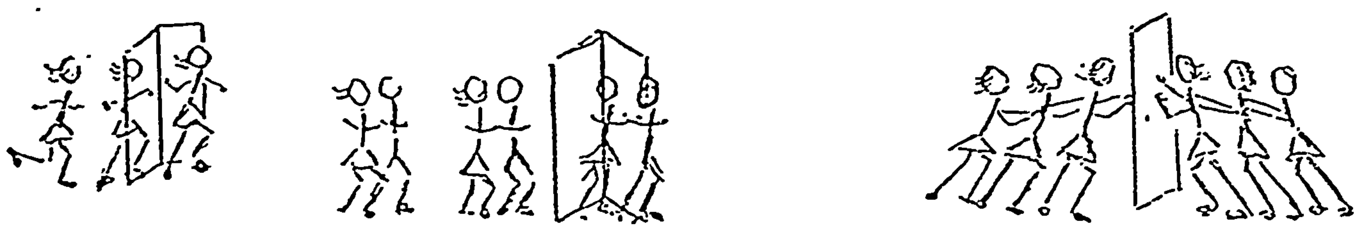
C.

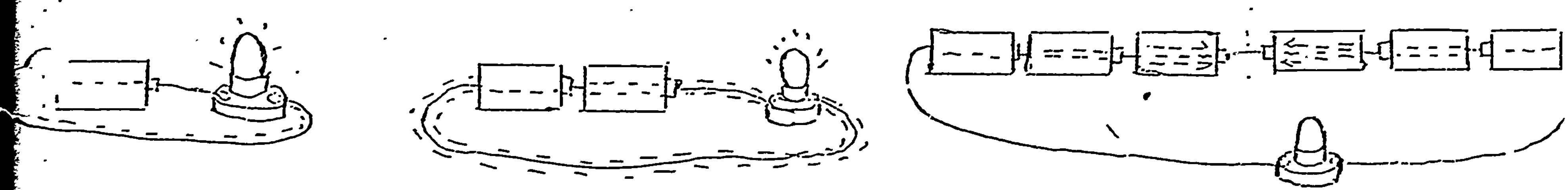


The bulb in set-up B will not light. Explain that the batteries must be pointing in the same direction. The top of one battery must follow the bottom of the other, like a chain of elephants each holding onto the tail of the one in front with his trunk.

Set-ups A and C worked because in both cases the batteries were pointing in the same directions. Set-up B did not work because the batteries were pointing in opposite directions.

The action involved here might be explained something like this: The forces from the batteries are like lines of people trying to get through a swinging door. If all the lines are going in one direction they can pull together and go through the door easily and in strength. But if an equal number of people are pushing on the swinging door from the opposite side of the door the door will not move either way and no one will be able to pass through it.



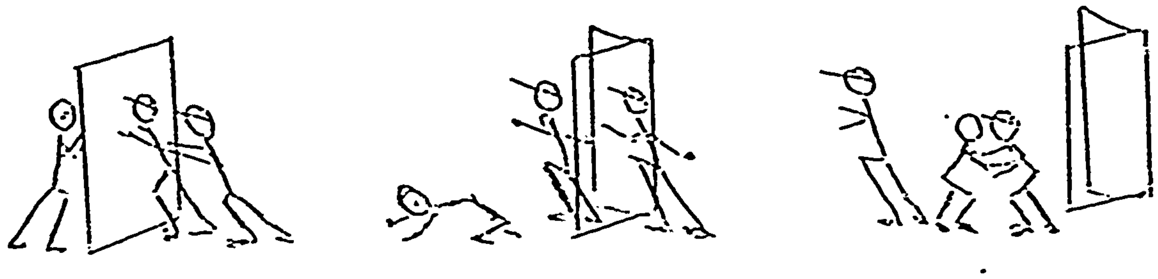


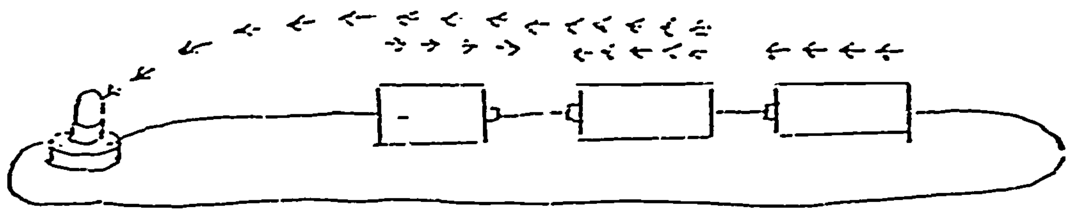
Use set-up A or C and add another battery. Make sure that again the children see that the bulb becomes brighter each time a battery is added. (It might be a good idea to have a "standard" - one bulb connected to one battery - available for comparison.)

III. <u>The batteries which are not opposed get to light a bulb</u>.

Ask the children to notice that as you added batteries you made sure that all of the batteries were pointing in the same direction. Remind them that when they saw set-up B with the two batteries facing each other, the bulb would not light. Ask the children what they think would happen if three batteries were used with two of the batteries facing in one direction and the third battery facing in the opposite direction. Make the set-up and show them what happens. (The bulb lights but only as if one battery were being used.) Explain this phenomenon as like

> Three boys of equal strength. Two boys are on one side of a swinging door and one is on the other side. Because there are two boys on one side they will be able to push past the one boy. But the one boy will grab one of the two boys as they run through the door, so only one of the two boys will be free to travel on.





Ask what would happen if there were

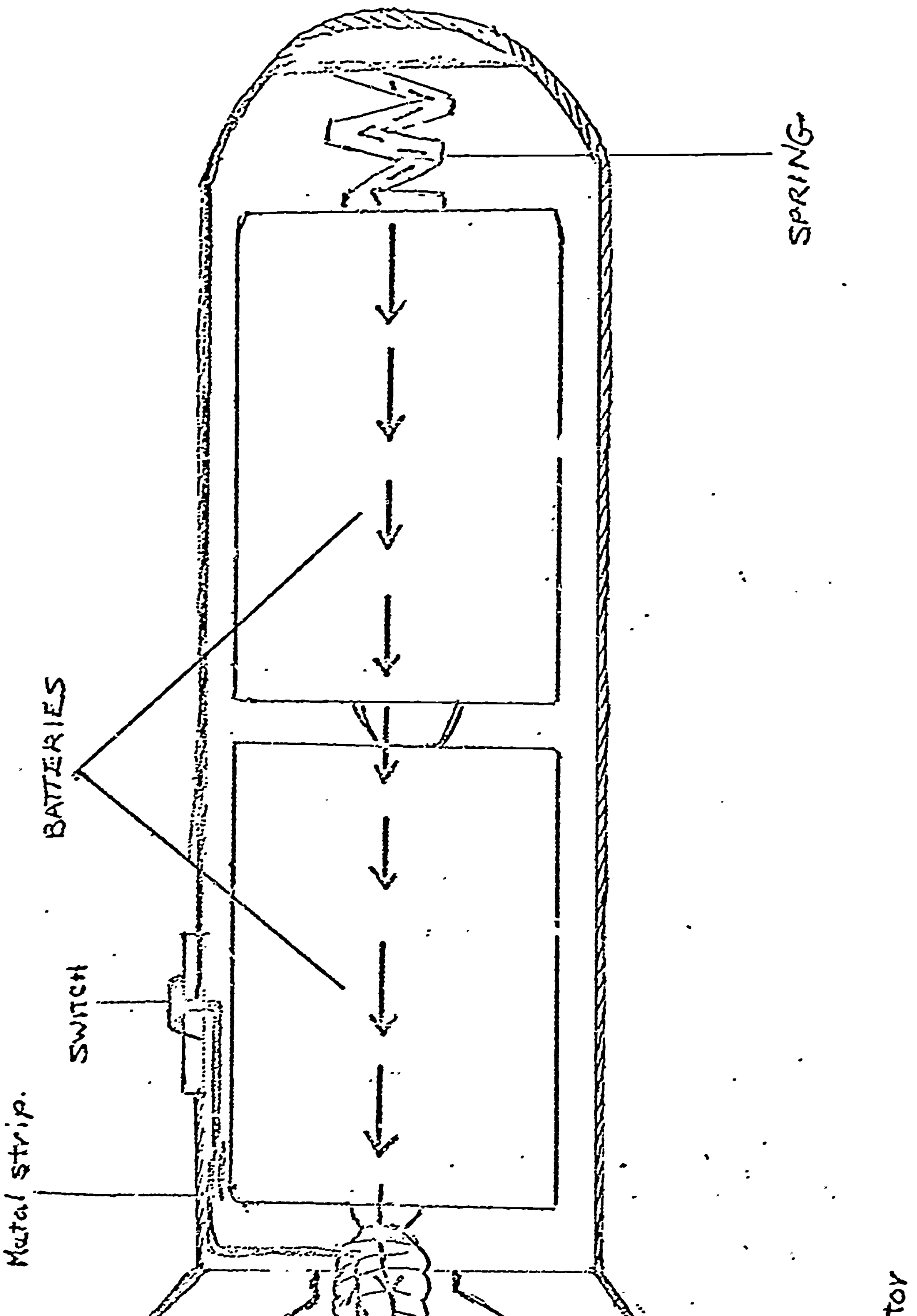
Two batteries on one side and two batteries on the other side.
Three batteries on one side and four batteries on the other side.
One battery on one side and four batteries on the other side.
Two batteries on one side and four batteries on the other side.
Two batteries on one side and three batteries on the other side.

Make each set-up to show whether or not the childrens guesses were correct.

The children may be interested to see that the series set-up for batteries is used in flash lights. Show them the diagram of the inside of a flashlight and let them trace the circuit.

III. A Switch - makes or breaks a circuit

Time should be taken to explain the operation of the switch. The switch is a piece of metal, which when moved in one direction completes the circuit from the batteries to the bulb. When the switch is pushed in the opposite direction the circuit is broken and the bulb goes off.


SPRING
BATTERIES
SWITCH
Metal strip.
Reflector

BATTERIES IN PARALLEL

CONCEPTS TO TEACH:

Parallel means lined up one after another like fence posts.

Hook batteries in parallel set-ups to provide a source of reserve or emergency electricity.

If batteries in parallel are allowed to point in opposite directions, often they form a separate circuit and can even short circuit a bulb.

MATERIALS:

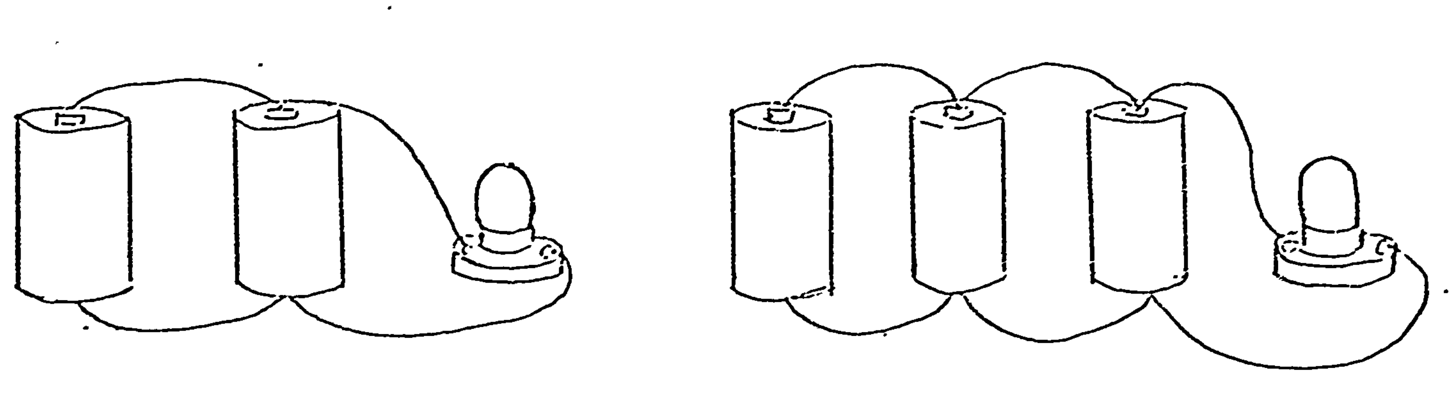
Bulbs
Bulb holders
Batteries
Battery holders
Wires

LECTURE:

I. Parallel batteries for emergency power

The children have seen what happens when batteries are connected top to bottom in a series; the bulbs get brighter, and when batteries are facing one another in a series set-up, either the bulb will not light or it will light very dimly depending how many batteries are pointed in each direction.

Tell the children to watch carefully to see what happens when batteries are set up next to each other like prison bars or fence posts. This type of set-up is called a PARALLEL set-up.



Connect a third battery. Still the bulb will light as though only one battery were being used. Try more batteries - no matter how many you hook up the bulb will light the same.

Sometimes it is important to be able to hook batteries up in parallel set-ups. See if the children can figure out why.

When batteries were hooked up in series, it was found that the more batteries the brighter the light. In a series set-up all of the batteries are helping to light the bulb. But in a parallel hook up the bulb lights the same brightness no matter how many batteries are used. What really happens in a parallel set-up is that only the battery nearest the bulb does the lighting. When that battery wears out, the next battery in line does the work of lighting the bulb.

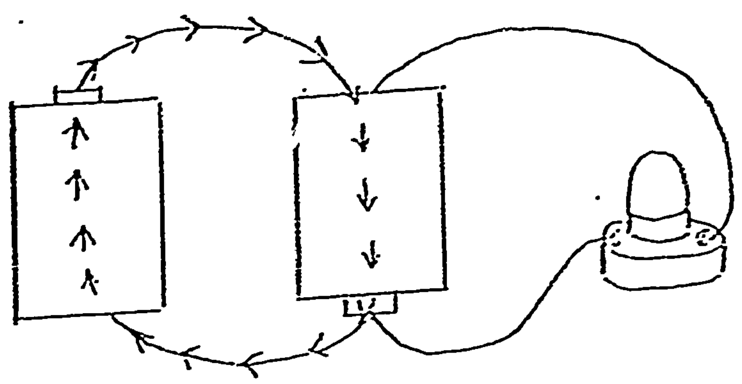
In a parallel set-up only one battery does the work and the rest are used for emergency. Kind of like eating one can of beans before opening another on a hike. The other batteries are held in reserve.

II. Must batteries in parallel point in the same way?

This will be very interesting. Parallel means to line up next to one another. Ask the children if they had noticed that you had always set the batteries on the table with the tops of the batteries pointing upward.

Have the children watch as you place two batteries next to one another, but point one upwards and one downwards like this:

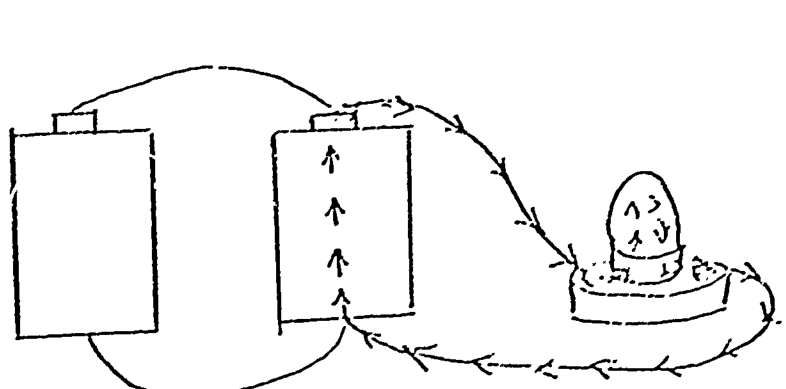
A.



The light does not light. Is there any electricity traveling over any of the wires? What is needed for the electricity to travel? A circuit! You can see that the electricity is not going through the bulb, because the bulb is not lighting. Ask if anybody knows what has happened. If a child wishes to, he may touch the circuits to feel which wires are warm. Tell them to think back to an old lesson and see if they can remember. The second battery has made an easier path. It has made a short circuit. A short circuit is an easier way, and electricity always will take the easier way. Tell the children to watch as you draw in some arrows to show them where the electricity is going. The electricity travels this circuit because there is almost no work to do going this path.

Here is a sketch of what happens when the batteries are set-up in parallel. Notice which way the batteries are pointing in both set-ups A. and B.

B.

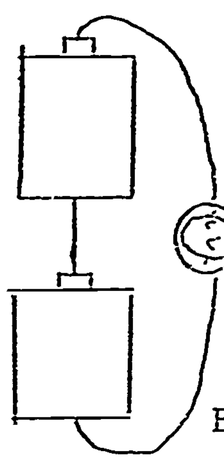


In set-up B the only circuit over which the electricity can travel goes through the bulb so the bulb lights. When the first battery wears out the second battery takes over and supplies the electricity.

Series and Parallel Batteries

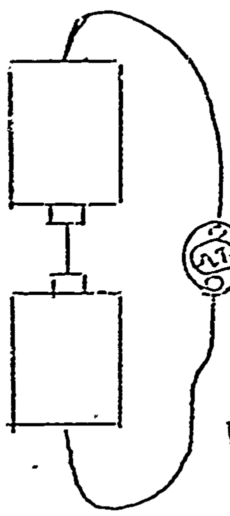
Compare the brightness of the bulbs to a standard set-up. (Be sure to have a standard set-up available - one battery and one bulb)

1.



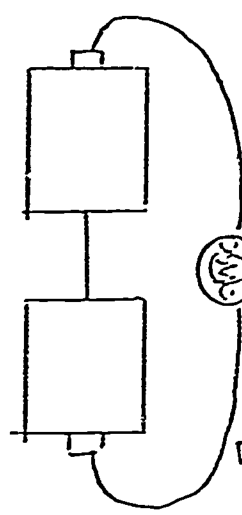
Bright

2.



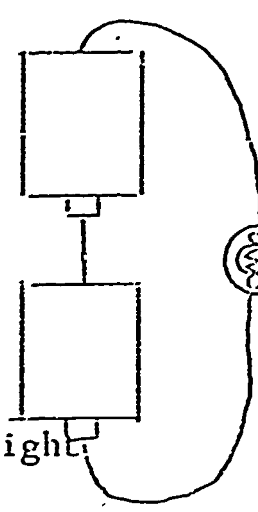
Won't Light

3.



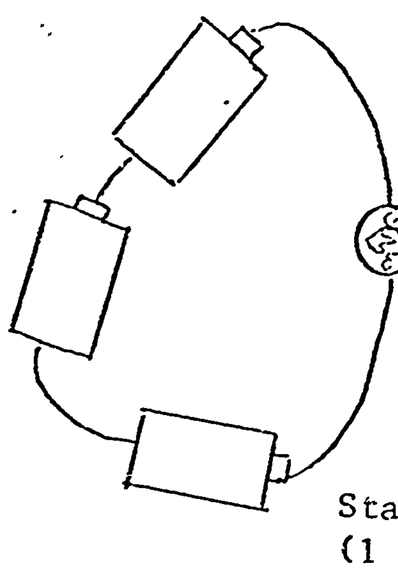
Won't Light

4.



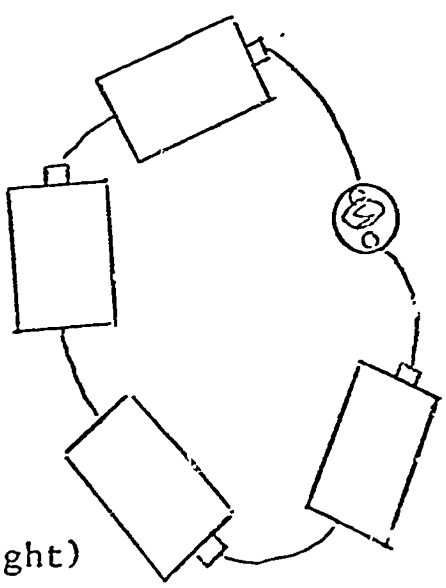
Bright

5.



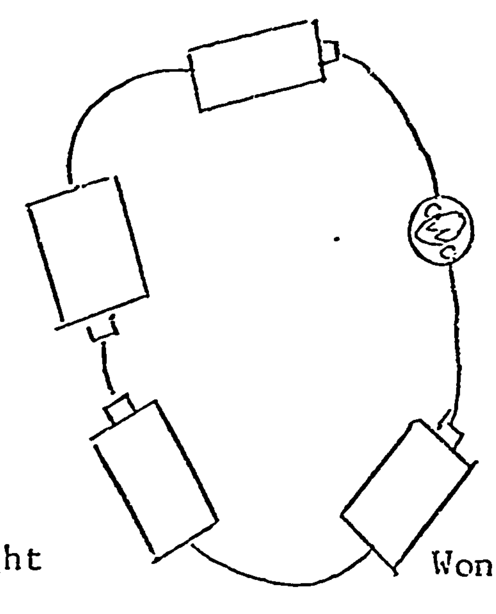
Standard
(1 battery bright)

6.



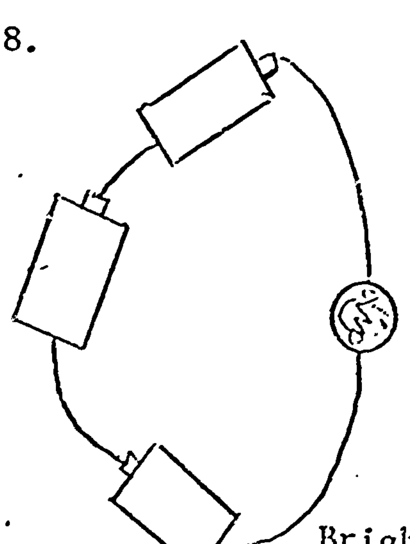
Won't Light

7.



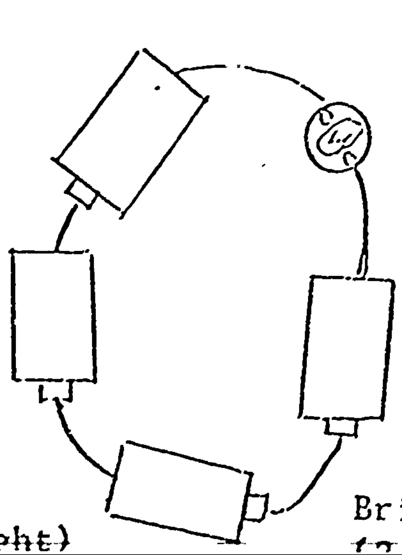
Won't Li

8.



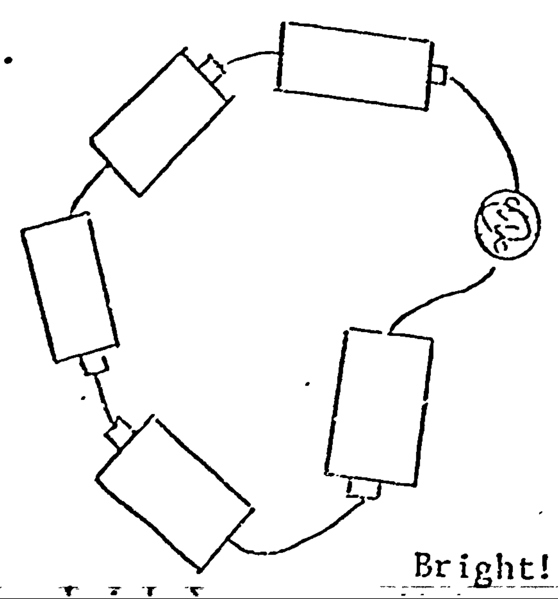
Bright!
(3 batteries bright)

9.



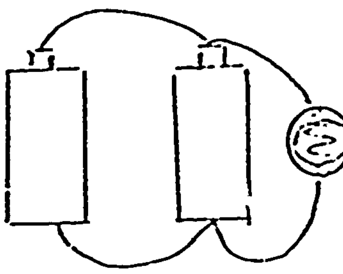
Bright

10.



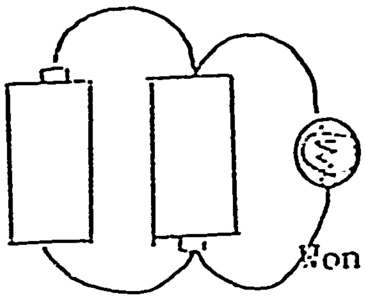
Bright!

11.



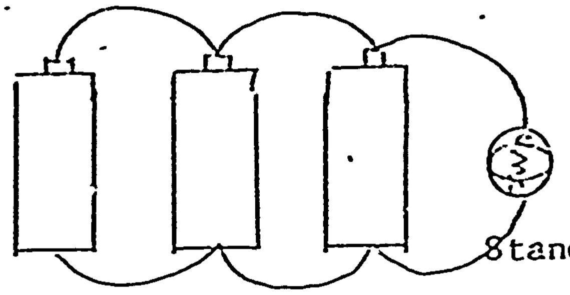
Standard

12.



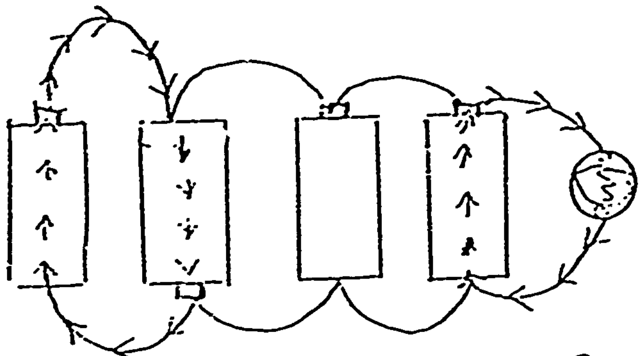
Won't Light

13.



Standard

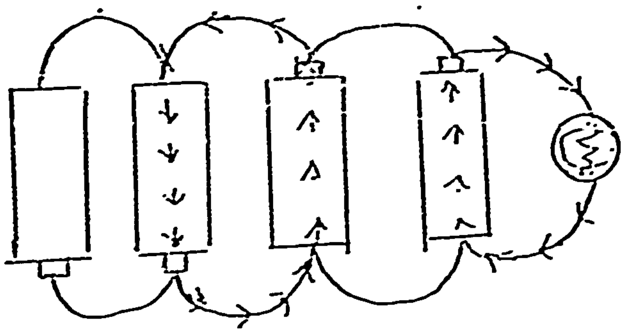
14.



(These 2 batteries will wear out)

Standard

15.



(These 2 batteries will wear out)

Standard

A NEW LANGUAGE

and

REVIEW OF BATTERIES IN SERIES AND PARALLEL CIRCUITS

CONCEPTS TO TEACH:

Signs can be used to stand for parts in a circuit.

MATERIALS:

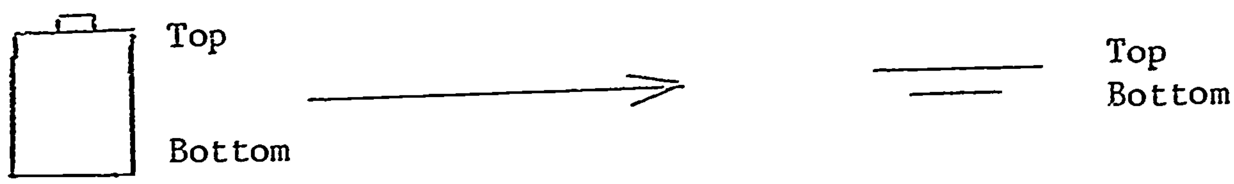
Flash cards with circuits on them from lesson 12.
Flash cards with circuits on them from lesson 13.

LECTURE:

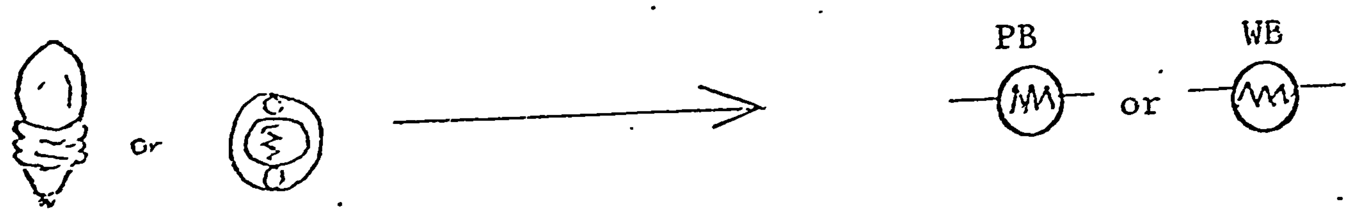
I. <u>Signs to Represent Equipment and Circuits</u>

It takes too much time to draw a battery and a bulb everytime we are working with a circuit. Scientists and electricians can't afford to waste time at the drawing board so they use signs to stand for batteries, a bulb and wires. This will be like a new language for you. It may be a little strange at first, but it will be easy after we have practiced for a little while. Then you will be able to read and write circuits that only electricians and such people can usually understand. This is the new language:

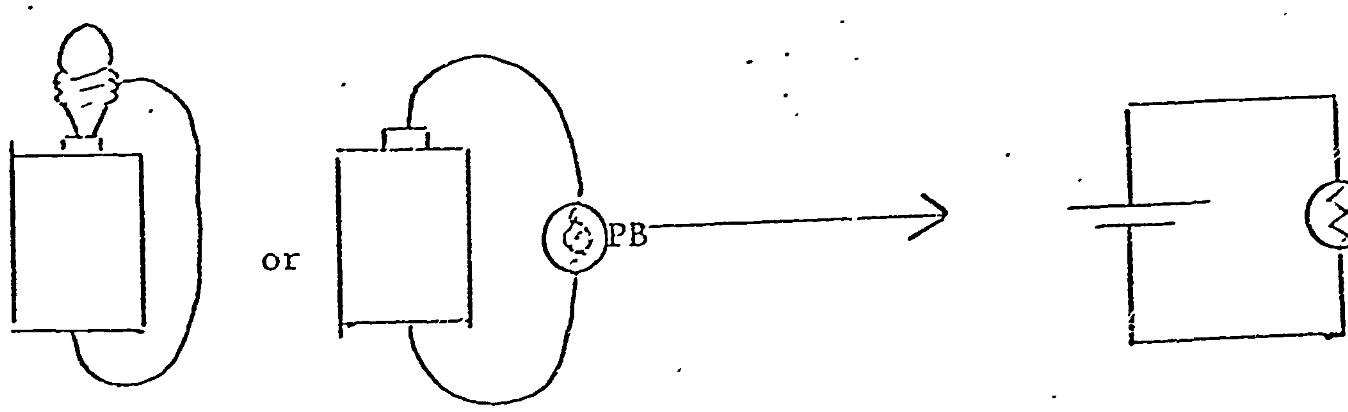
Battery



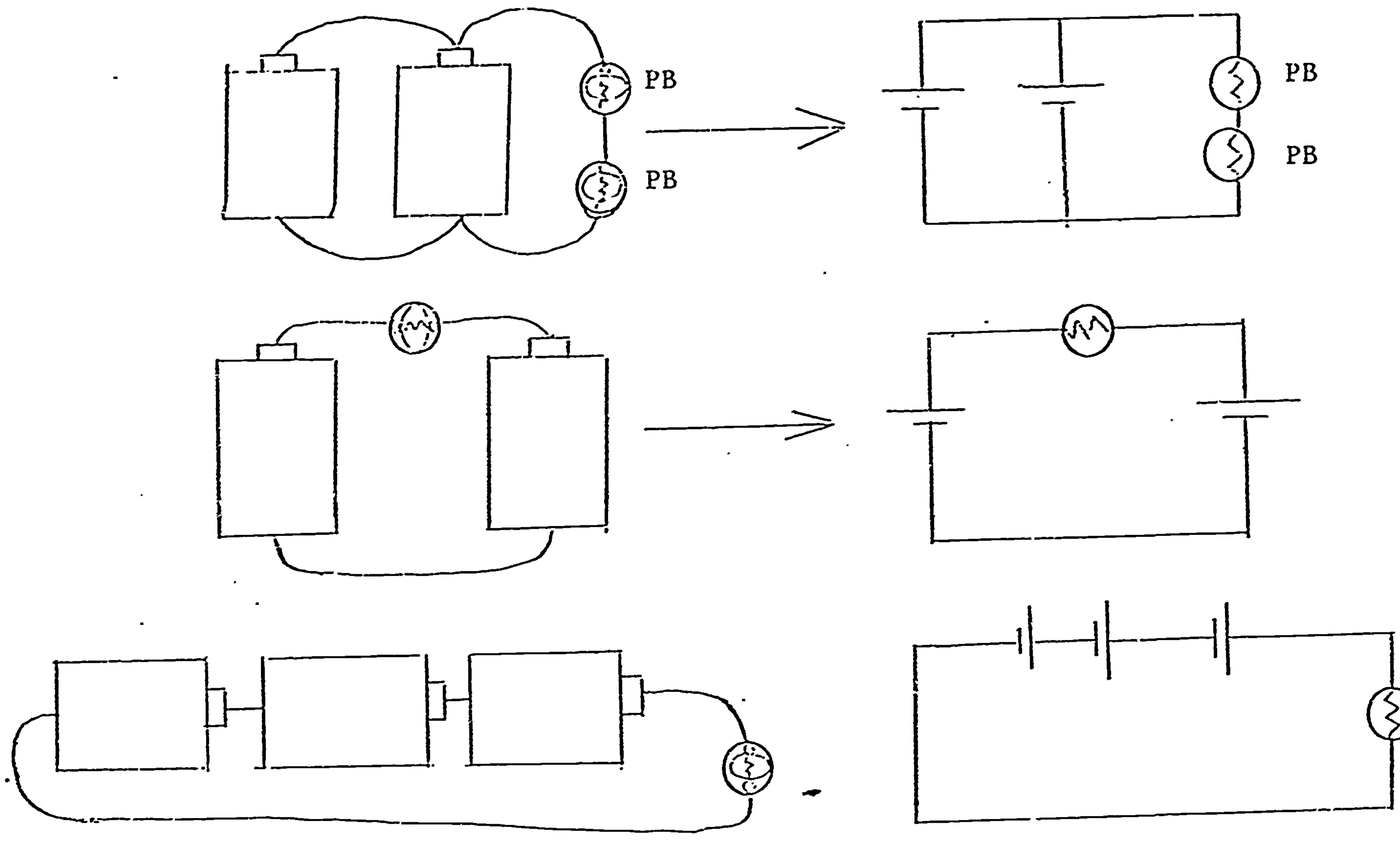
Bulbs



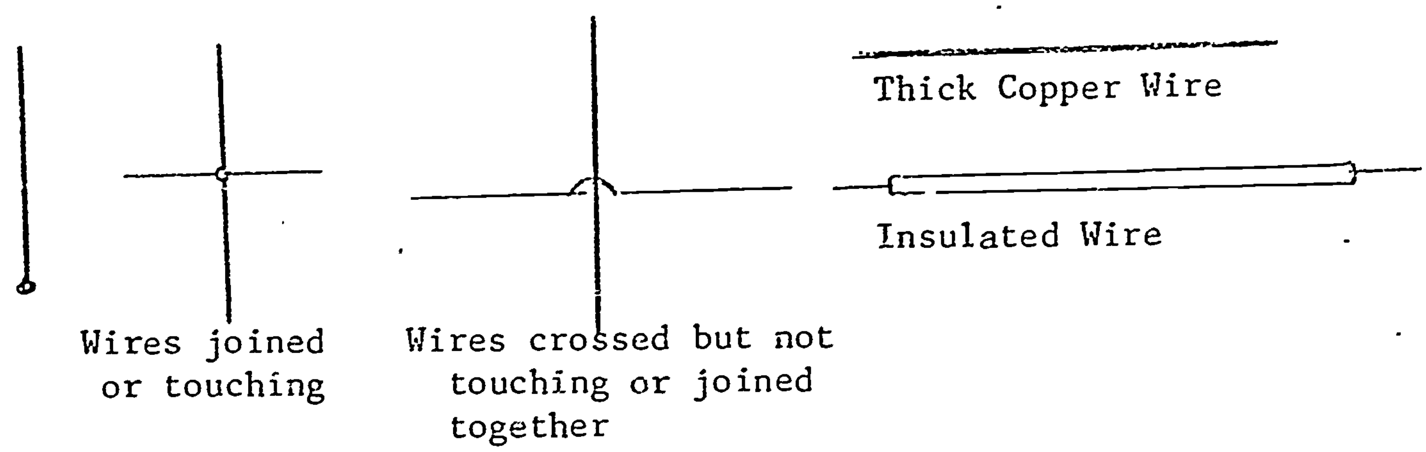
Circuit



Circuits



Wires



Have the children go over the new signs and then draw a few simple circuits on the board and have the children point out the directions of the batteries, the bulbs, etc.

II. Review of Parallel and Series

When the children seem fairly familiar with the signs, review the principles of series and parallel circuits.

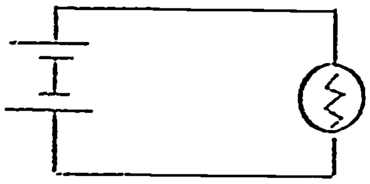
1. Series means connected one after another like a string of pearls. Each battery must be pointing in the same direction in order to get the full power of each battery. If some of the batteries are pointing in one direction and some in another, then the bulb will be lighted by the power from the

extra batteries on the one side. If there are an equal number of batteries pointing in both directions the bulb will not light.

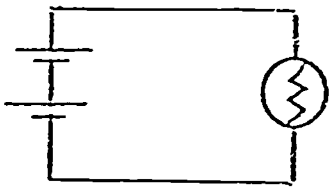
2. Parallel means that the batteries are lined up next to each other like fence posts. When all of the batteries are pointing upwards, only the first battery will light the bulb or bulbs, and when it wears out the next battery will take over the work. If some of the batteries are pointing up and some pointing down, then a short circuit might be set up so that the bulb may or may not light.

III. Using the New Signs

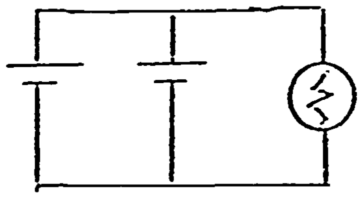
Review the flash cards from Lesson 11. When the children are able to move fairly smoothly through those cards, review the NEW LANGUAGE with them and have them solve the following set-ups:



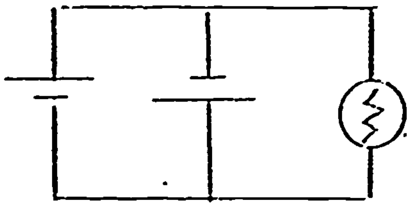
Won't Light



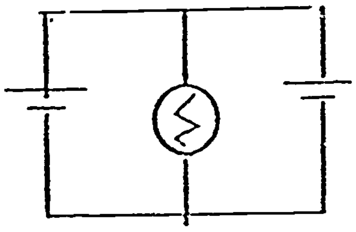
Bright



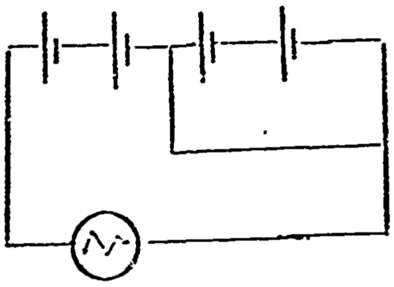
Standard



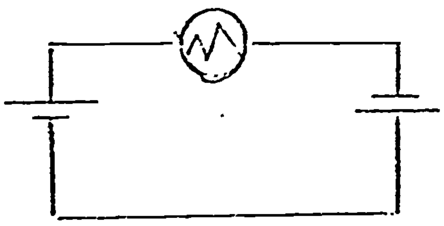
Won't Light



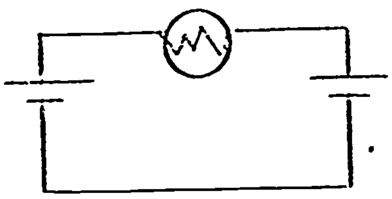
Standard



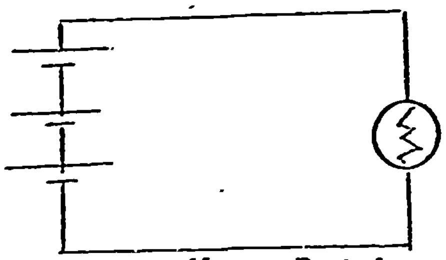
Bright



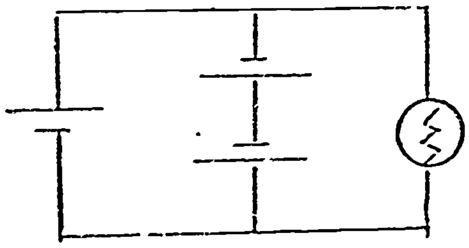
Bright



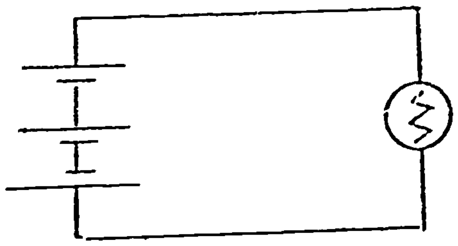
Won't Light



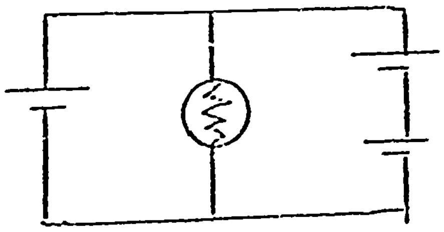
Very Bright



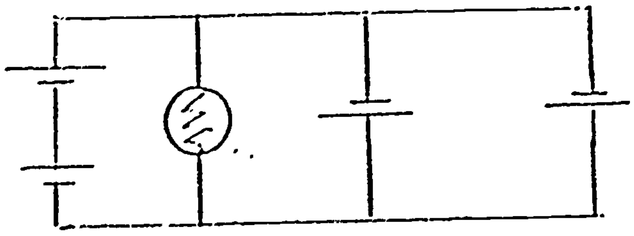
Very Bright



Standard



Bright



Dim

BULBS IN SERIES AND PARALLEL

CONCEPTS TO TEACH:

Bulbs connected in a series circuit share the electricity of that circuit so that the more bulbs that are added to the circuit the dimmer they will all become.

If one bulb in a series circuit is either unscrewed or burned out, the rest of the bulbs will go out. Each bulb in a series circuit is part of that circuit and when one bulb breaks the circuit the electricity is unable to get to the other bulbs to light them.

MATERIALS:

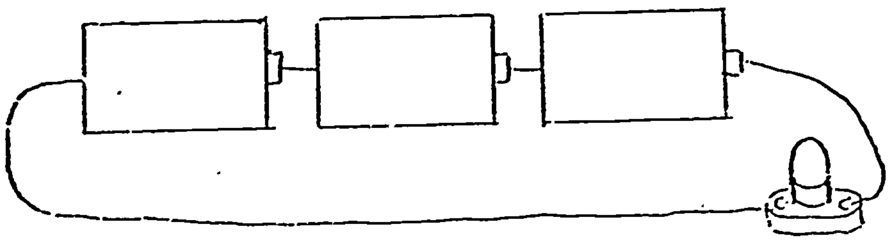
Batteries
Battery holders with wires
Bulbs
Bulb holders with wires
Wires

LECTURE AND ACTIVITIES:

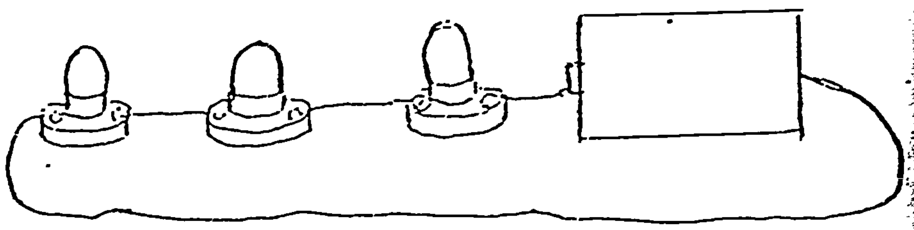
I. Bulbs in series share the electricity so the bulbs dim as more bulbs are added to the circuit.

Tell the children that when you talked about batteries being connected in a series it meant that one battery would follow another battery like picture A. Now they will see what happens when bulbs are connected one after another in a series like this. (picture B)

A.



B.



First start with one bulb and one battery, the good old STANDARD. Tell the children to look closely as you add another bulb, and another. As more bulbs are added the bulbs get dimmer and dimmer. (Like water rushing through a hose, the more holes that are made in the hose the lower the little fountains that are made by the holes.) Note how many have to be added until they go out.

II. <u>A bulb in series can act as a kind of switch</u>

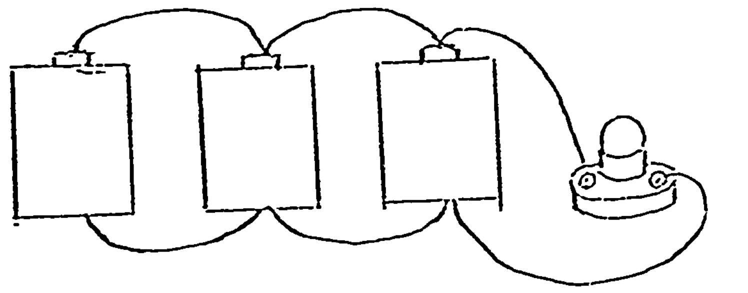
Ask the children what they think will happen if you unscrew one bulb? Why? Unscrew a bulb and the lights go out. Explain that the unscrewed bulb can be like a switch which opens the circuit and stops the electricity. When you want to turn the lights on you screw in the bulb, when you want to turn the lights out you unscrew it.

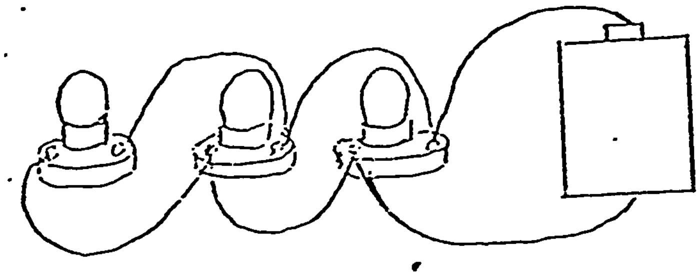
Removing the bulb is making a break in the circuit. The other bulbs need a complete circuit for the electricity to be able to go through them.

The series of lights they see in front of them are almost like Christmas tree lights except that they aren't colored. Ask what happens when their Christmas tree lights don't work. The first thing they probably do is to check each bulb to make sure it is not burned out. If a Christmas tree light burns out it means that the thin wire in it is broken and so the circuit is not complete. All of the bulbs share the same circuit and must have it complete in order to get the electricity necessary to make them light.

III. <u>Comparison of batteries in parallel and bulbs in parallel circuits.</u>

When we hooked batteries up into parallel set-ups each battery had its own path or circuit to the bulb. We can do the same sort of thing with bulbs. When bulbs are connected parallel there are more than one circuit to the battery or batteries. Compare parallel batteries and parallel bulbs:

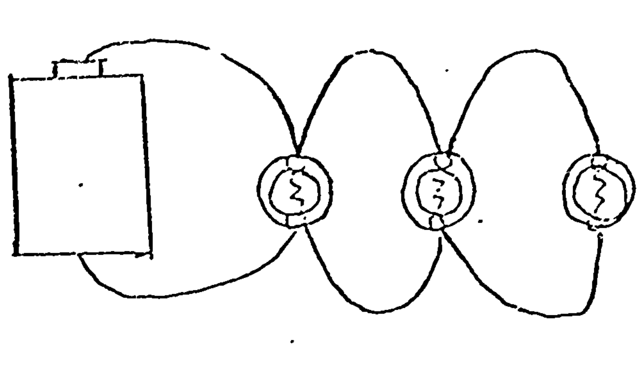




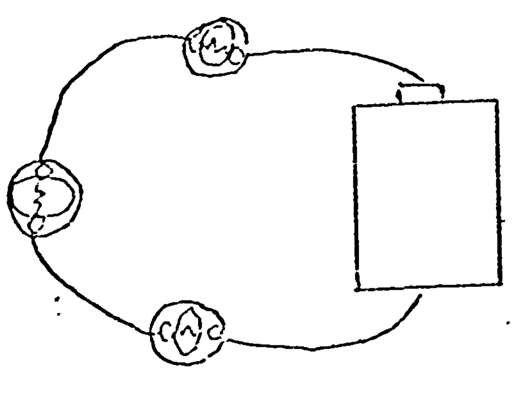
Have one of the children come up to the board and trace the three circuits in each of the above set-ups.

IV. <u>Bulbs in parallel dim only slightly when more bulbs are added, bulbs in series dims a lot each time another bulb is added.</u>

Start first with one bulb connected to one battery. Tell the children to watch the bulb as you add another bulb with its own circuit in parallel. Both bulbs will light to standard brightness. Add another bulb in parallel and another. All four bulbs will be pretty much the same. Now take one of the bulbs away and compare the three bulbs in parallel with three bulbs in a series circuit:



Parallel bulbs
3 separate circuits
Bulbs will all light to almost standard brightness



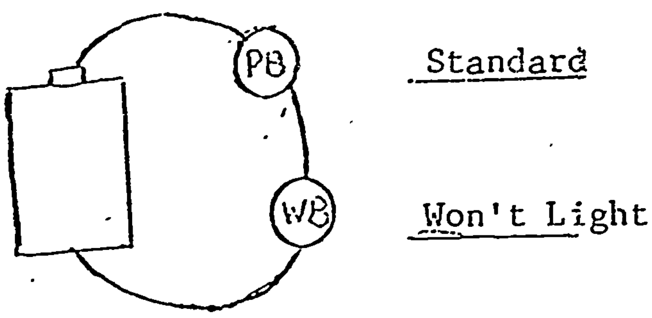
Series bulbs
Only one circuit
Bulbs will be very dim

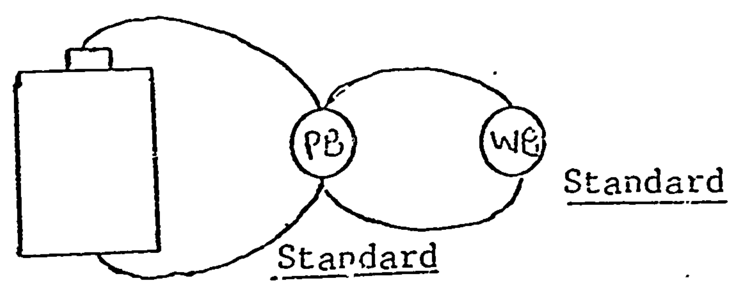
V. Any bulb in a parallel circuit can be unscrewed without affecting the other bulbs, but if a bulb is unscrewed in a series circuit the circuit will be broken and all the other bulbs will go out.

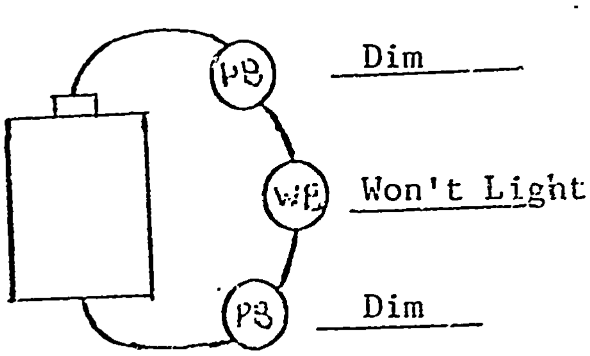
Remember what happens when we unscrew one bulb in the series set-up? all of the other bulbs will go out too. Look what happens when I unscrew one of the bulbs in the parallel circuit (do the middle one). We can take a bulb out of the parallel set-up and still the other bulbs will continue to light. The reason for this is that each bulb in a parallel set-up has its own circuit or path to the battery. The bulbs do not have to share a circuit as they do in a series set-up.

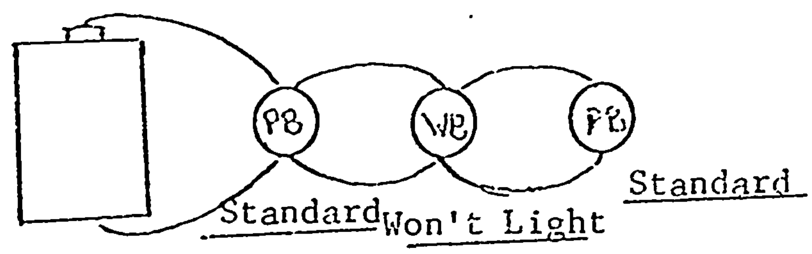
VI. <u>White and pink bulbs in series and parallel circuits</u>.

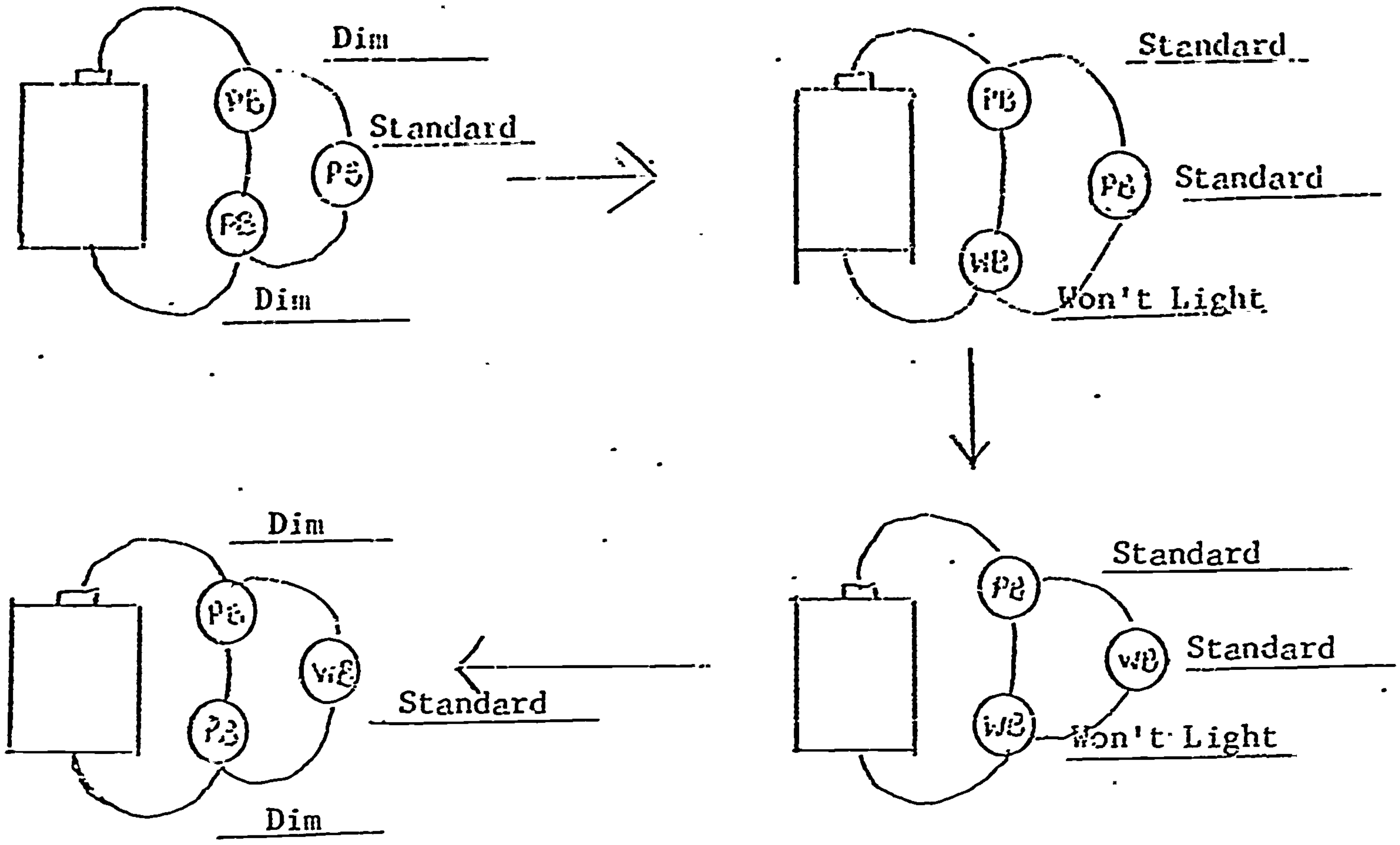
See if any of the children can remember what happened when a white bulb and a pink bulb were put in a series set-up. Make a set-up using a white bulb and a pink bulb in series. Then make a set-up using a white bulb and a pink bulb in parallel. Then add a pink bulb to each set-up. Then make a third set-up with a combination of series and parallel bulbs. These are the set-ups:











After you have built these circuits and shown the children what happens to the bulbs, show them diagrams of the set-ups and have them trace the circuits and explain the brightness of the bulbs.

Ask the children how they think the bulbs in the classroom are connected? Why?

PARALLEL AND SERIES BULBS AND BATTERIES

CONCEPTS TO TEACH:

This is a review and an application of the material learned in the past three lessons dealing with parallel and series bulbs, and parallel and series batteries.

MATERIALS:

Bulbs
Bulb holders
Batteries
Battery holders
Wires

DISCUSSION:

Review with the children what is parallel and what is series set-up in both batteries and bulbs. Go over the flash cards used in lessons 10, 11, 12, and 13. Get the children to discuss what happens to bulbs when batteries are connected in parallel or series, and what happens to the bulbs when the bulbs are connected in parallel or series. If questions arise use the time to go over any problems or confusion that the children might have. Have them think of ways where we use parallel batteries or series batteries, or parallel bulbs or series bulbs.

1. Parallel batteries -

2. Series batteries - Flash lights

3. Parallel bulbs - Ceiling lights in buildings, street light

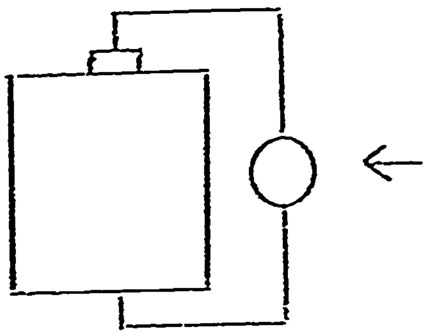
4. Series bulbs - Christmas tree lights

Start on the following diagrams. Have the children explain the brightness of the different bulbs, trace the flow of electricity, and identify the connections as parallel or series. You may wish to put the diagrams on the board, or have them prepared on large flash cards. Have batteries in battery holders and bulb holders with wires attached available for demonstration in case questions arise or answers need to be validated

Indicate HOW BRIGHT each bulb is.

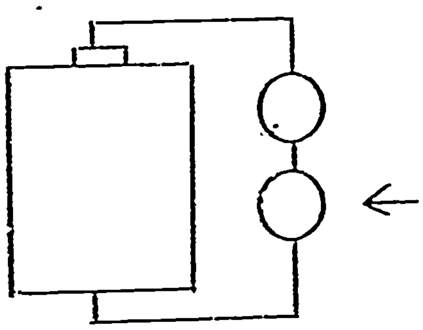
STANDARD
DIM
BRIGHT
  Brightness of two batteries
  Brightness of three batteries

1.



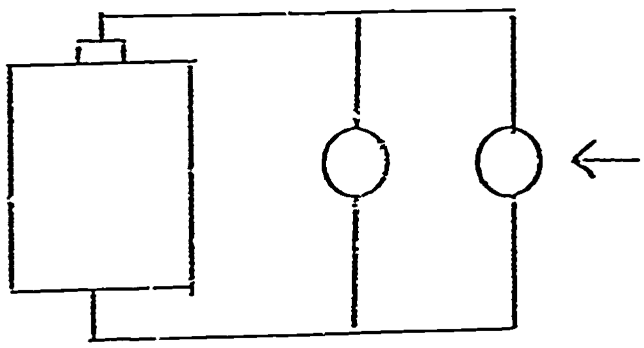
Standard

2.



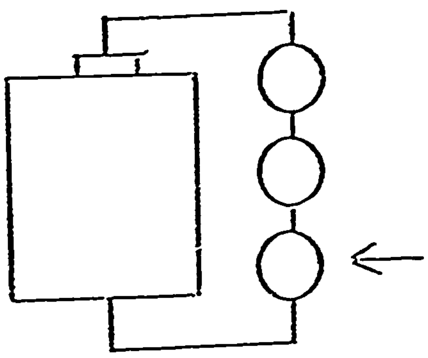
Dim

3.



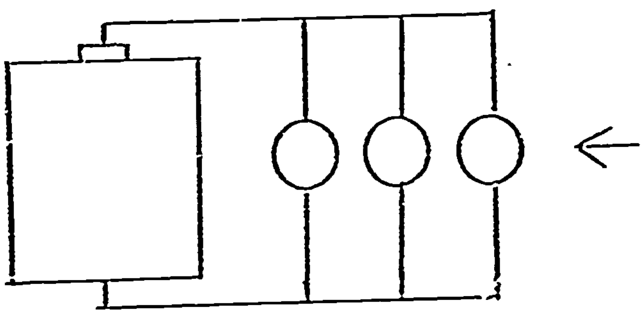
Standard

4.



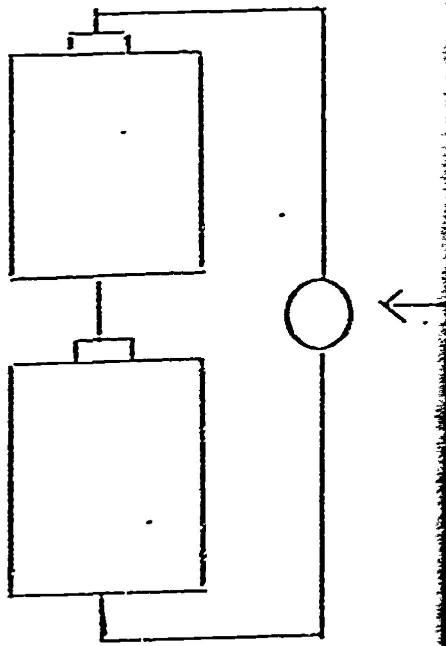
Very Dim

5.



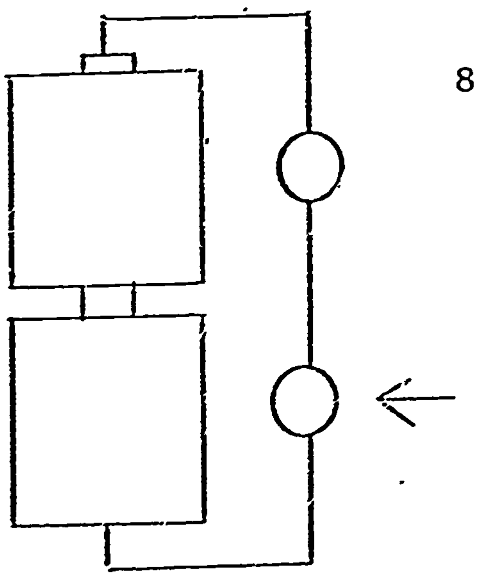
Standard

6.



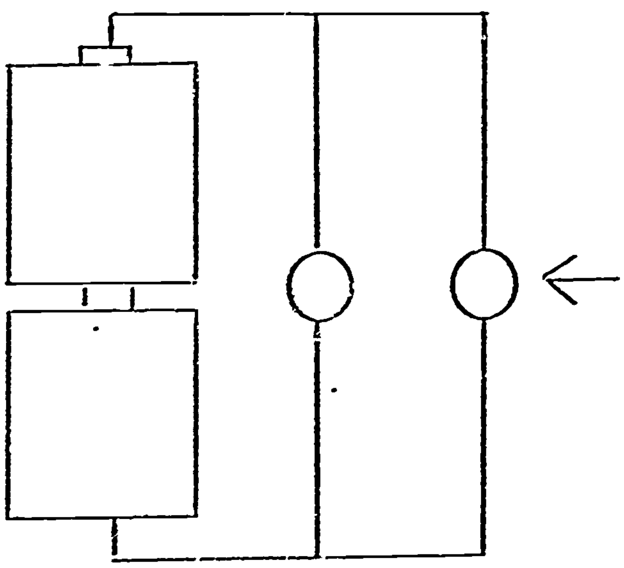
Bright

7.



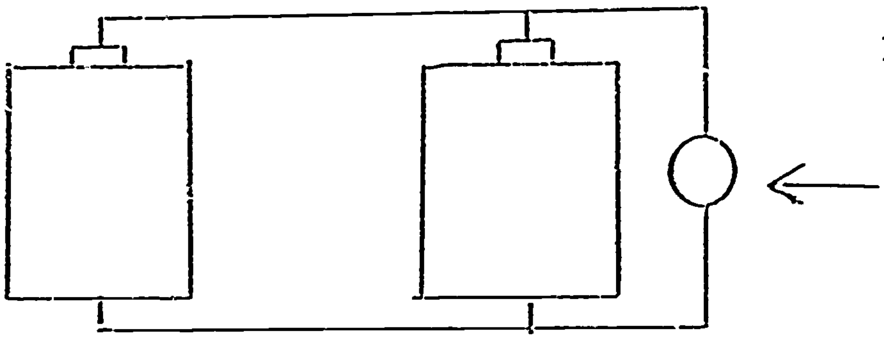
Standard

8.



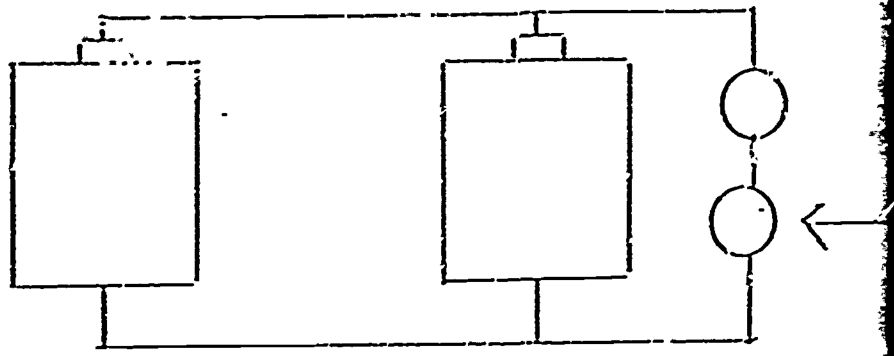
Bright

9.



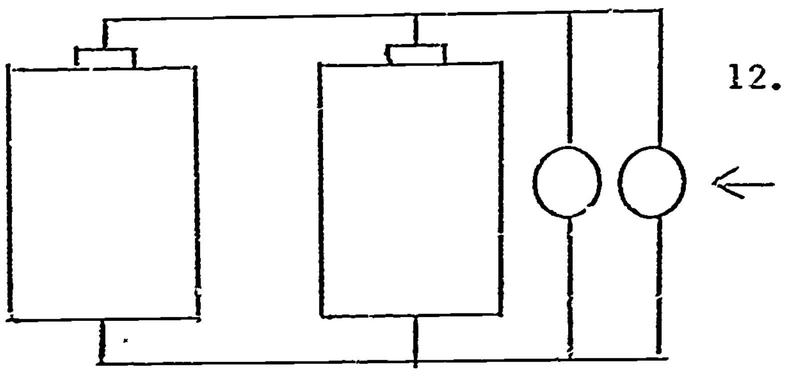
Standard

10.



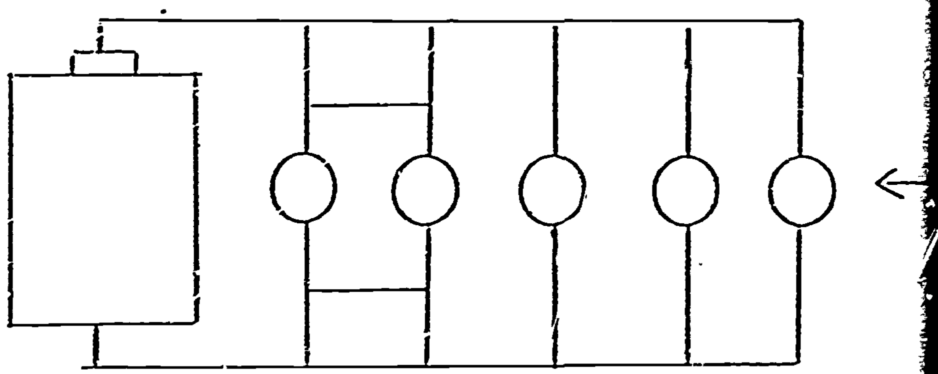
Dim

11.



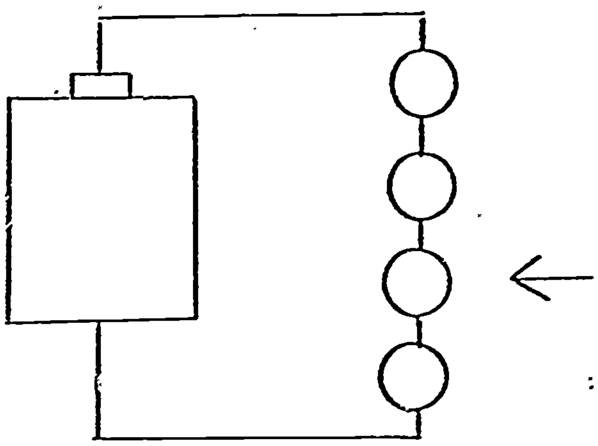
Standard

12.



A little dimmer than Standard

13.



Very Very Dim

COMPLEX CIRCUITS

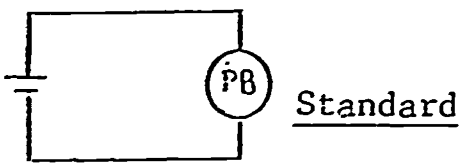
CONCEPTS TO TEACH:

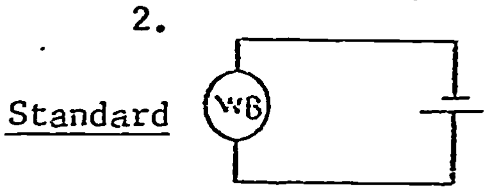
This lesson can be set up a number of ways. Basically it is a review and an application of the principles learned in the previous six lessons.

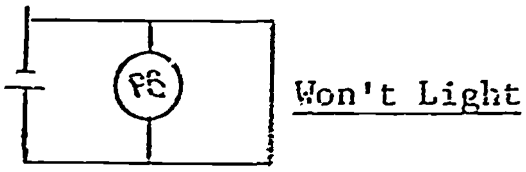
1. The set-ups may be placed on cardboard cards ahead of time and the bulbs screwed in after the children have guessed the outcome.

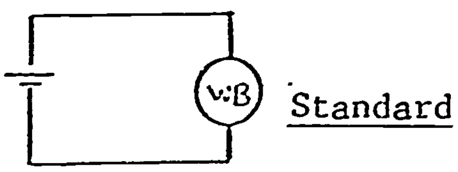
2. Two teams could be chosen to give answers and explanations to the set-ups drawn on cards.

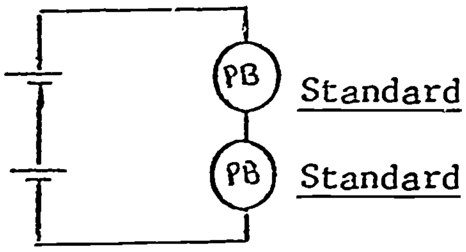
3. You might want to draw the set-ups one by one on the board and call upon different children to supply the answers, and then review with them the reason for the answer.

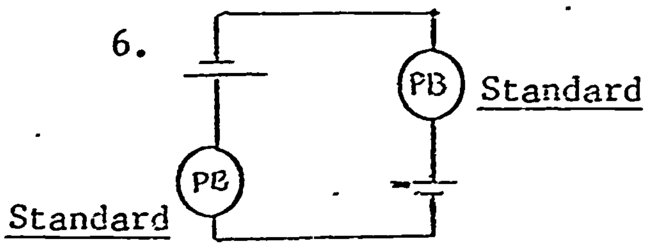
1.


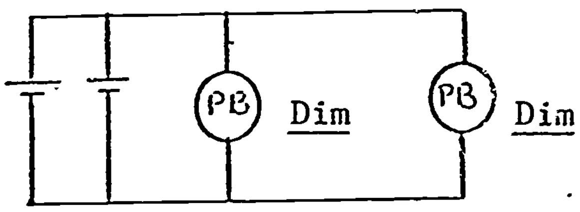
2.


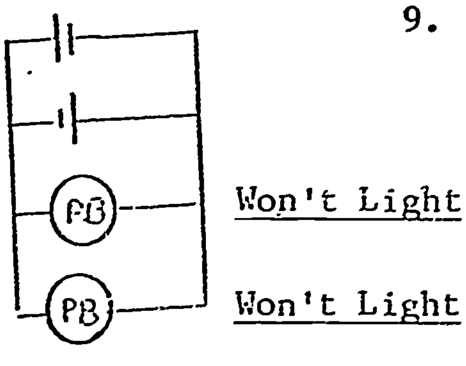
3.


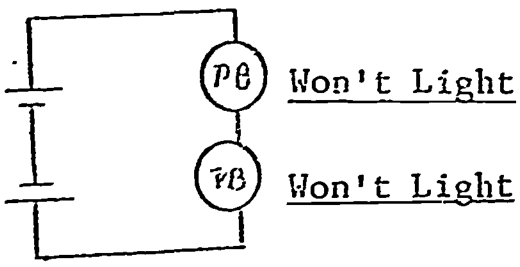
4.


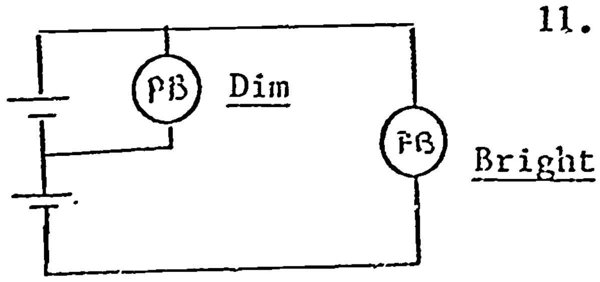
5.


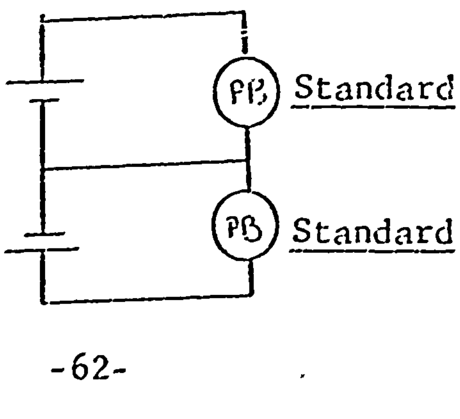
6.


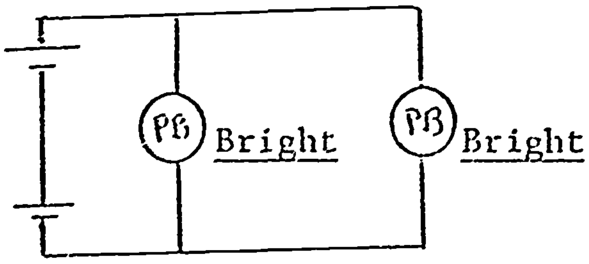
7.


8.


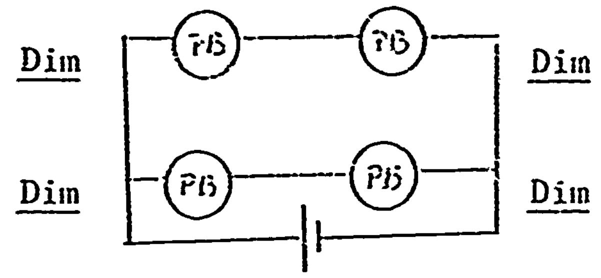
9.


10.


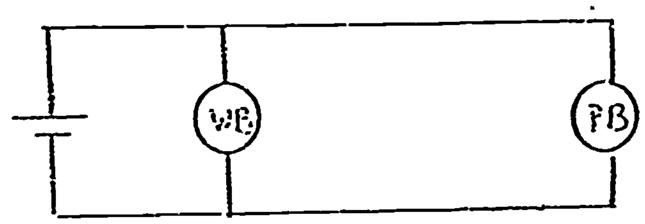
11.


12.


13.



14.



FINAL REVIEW

REVIEW:

1. A circuit is the path electricity travels. It must be complete, from the source of electricity through the places where the electricity must work, back to the source.

2. Electricity is the flow of electrons through a material.

3. Electricity is made in a battery by chemicals. If electricity is to travel from the battery, a wire circuit must connect from the metal cap on the top of the battery to any place on the bottom of the battery.

4. A bulb is made with a very thin wire which lights or glows because it has more resistance than the other wires in the circuit. The tip of a bulb and the gold screws of the bulb must be touched in the circuit, if the bulb is to light.

5. A wire gets hot because there is <u>resistance</u> to the flow of electrons over it. Some kinds of wire have more resistance than others.

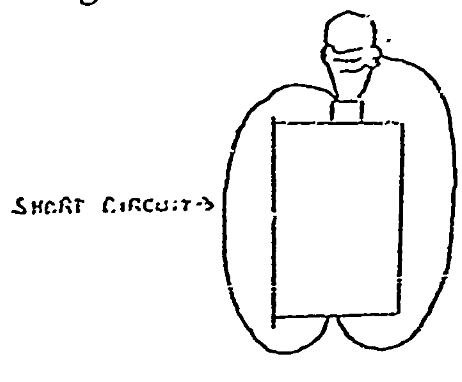
    A. Some wires in order of how well they conduct.
        1. Copper
        2. Nichrome
        3. Steel

6. Resistance is increased in a wire when,

    A. the wire is made longer, and
    B. when the wire is made thinner.

7. Some liquids can be used as part of a circuit, i.e., salt water, comet cleanser and water, baking soda and water.

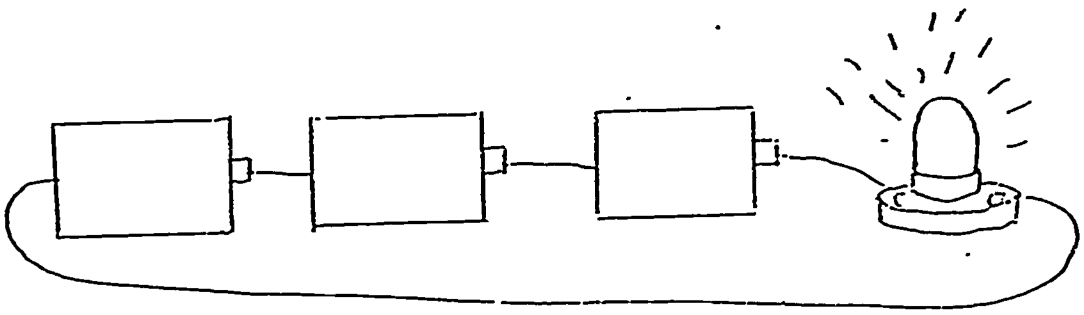
8. A <u>short circuit</u> is made when an easier path away from the source of power and back again is made for the electricity to travel over.



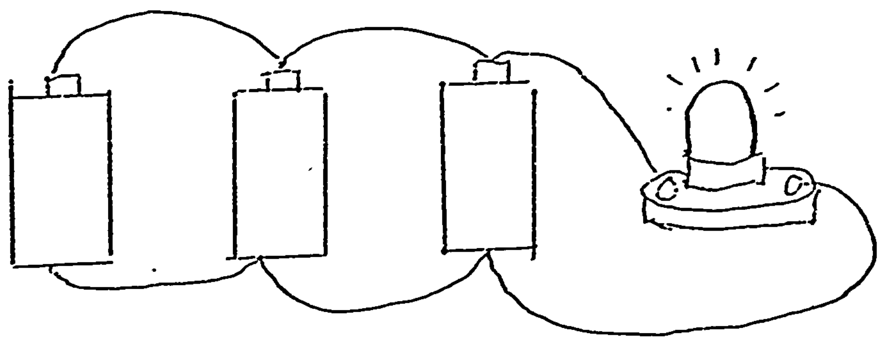
9. White bulbs will not light when in the same series circuit with pink bulbs because the pink bulbs have more resistance and narrows the flow of electricity that passes through the white bulbs, so that the electricity is not big enough to light the white bulb.

10. Batteries connected in series increase the power traveling a circuit when all batteries are facing in the same direction.

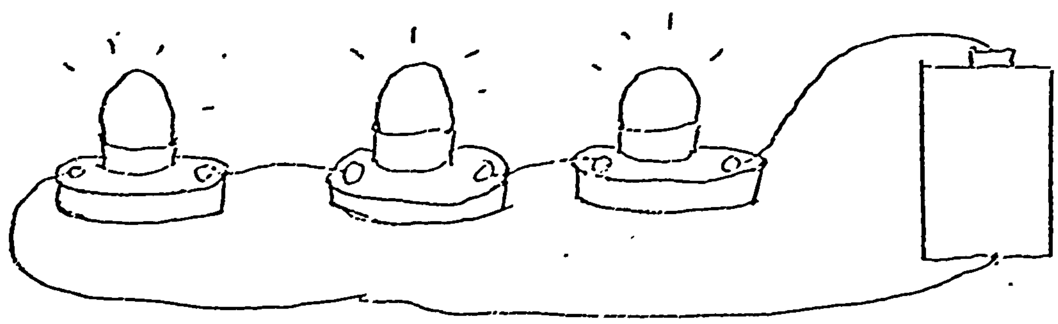
When some batteries in series are facing one direction and the others in the opposite direction, subtract the number in the one direction from the number of batteries in the opposite direction to find how much electricity is traveling the circuit.



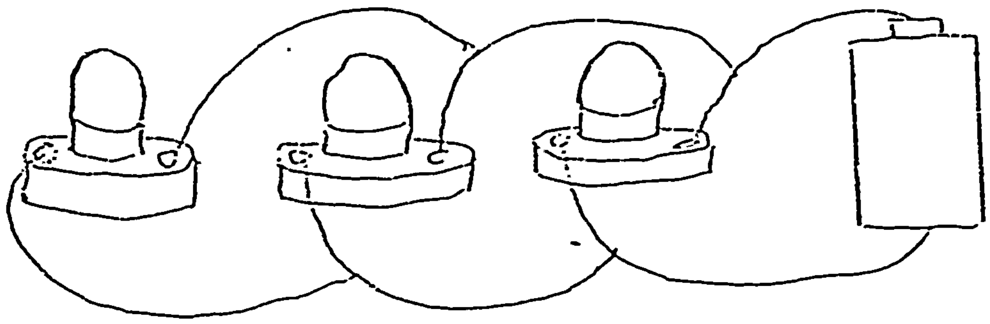
11. When batteries are connected in parallel and are pointing in the same direction only the battery closest to the bulb will produce the electricity and the others will take over as reserve power when the battery in front of it wears out.



12. Bulbs when connected in series share the electricity with each other so are dimmer than if each bulb had its own circuit. When one bulb in series is unscrewed the circuit to the battery is broken and all the other bulbs go out too.



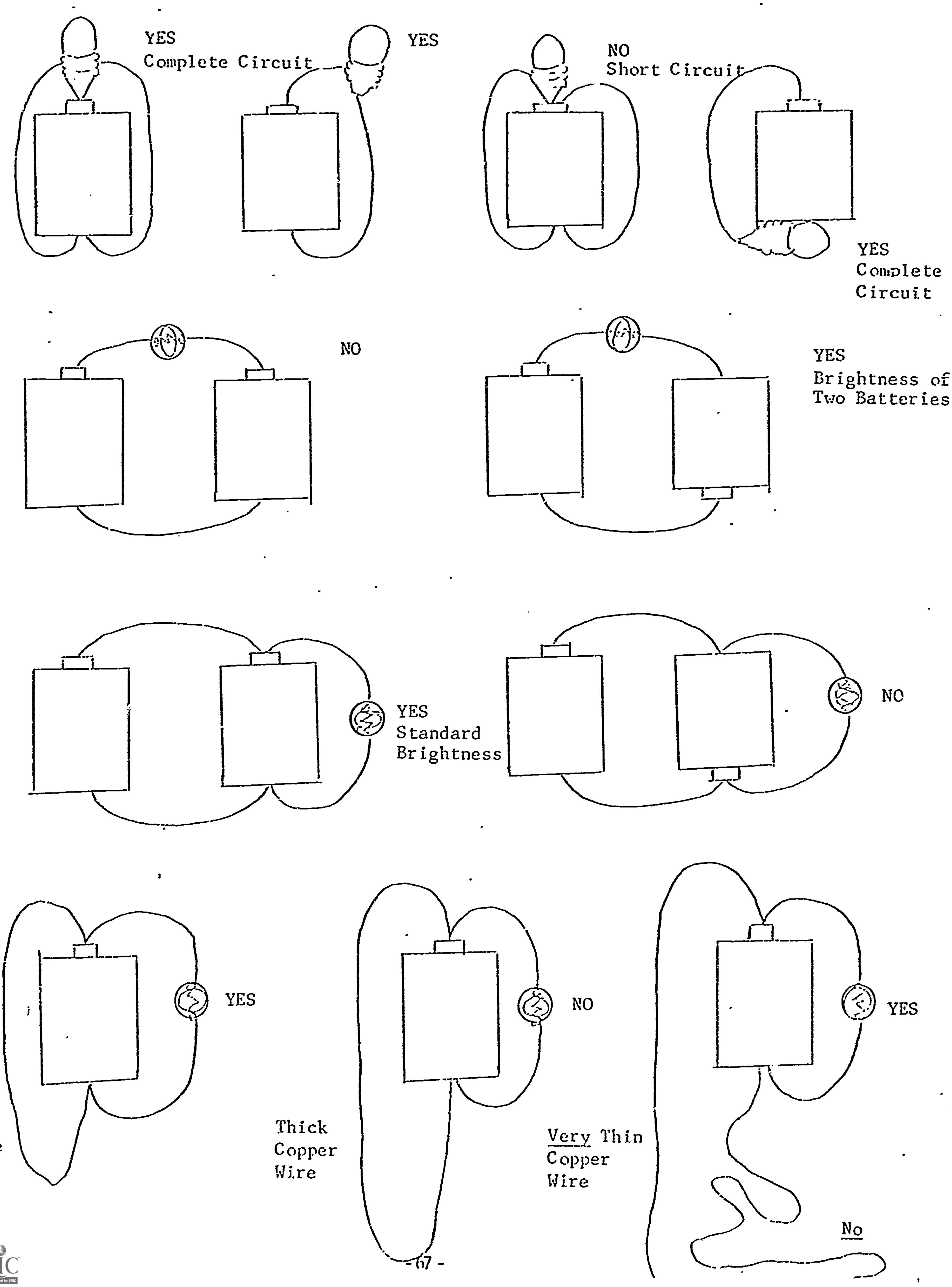
13. Bulbs connected in parallel have their own circuit to the battery and are not disturbed by taking out a bulb in another parallel circuit. Each bulb lights as though no other bulbs were connected to the battery.



14. When considering how bright a bulb will burn attention must be given to,

1. the type of bulb it is (pink bulb or white bulb).
2. The kind, length, and thickness of wires used (copper is a good conductor, nichrome is a poorer conductor).
3. The way the batteries are attached - parallel or series.
4. The way the bulbs are connected - parallel or series.
5. Any extra wires which may short circuit the electricity; or any breaks in the circuit which would prevent the electricity from having a complete circuit, which it needs to travel from the source of power and back again.

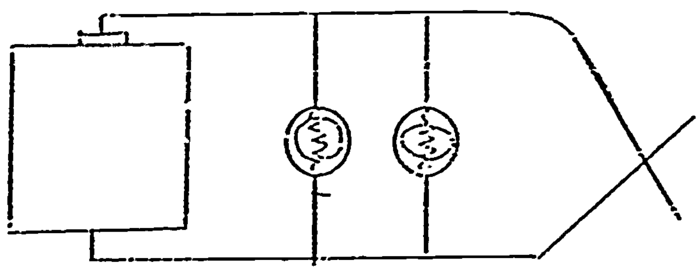
WILL THE BULBS IN THE FOLLOWING SET-UPS LIGHT?



HOW WILL THE BULBS LIGHT?

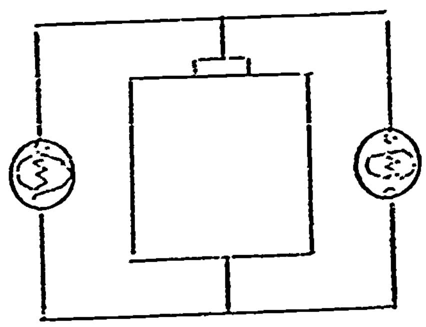
CHOICES: Bright
Standard
Won't Light

1.



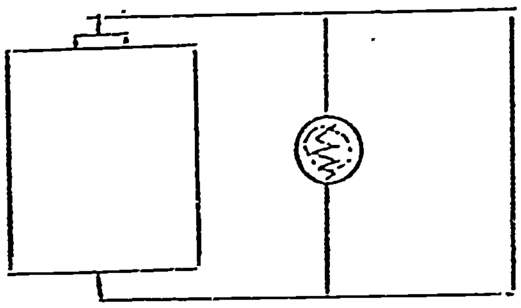
Short Circuit - Bulbs Won't Light

2.



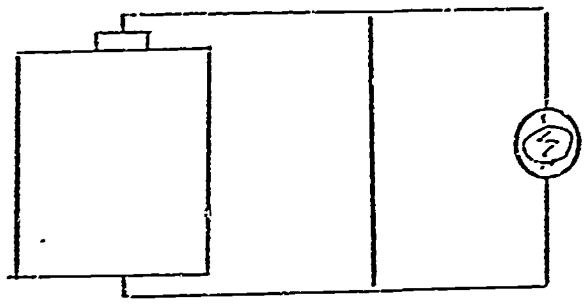
Standard Brightness

3.



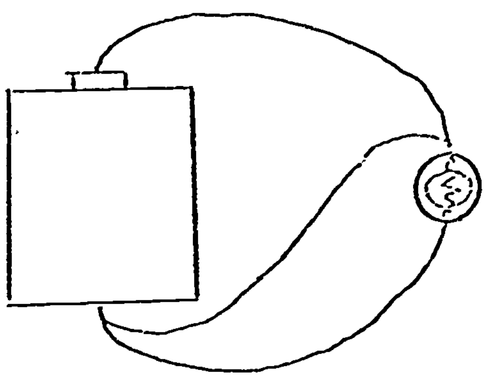
Won't Light - Short Circuit

4.



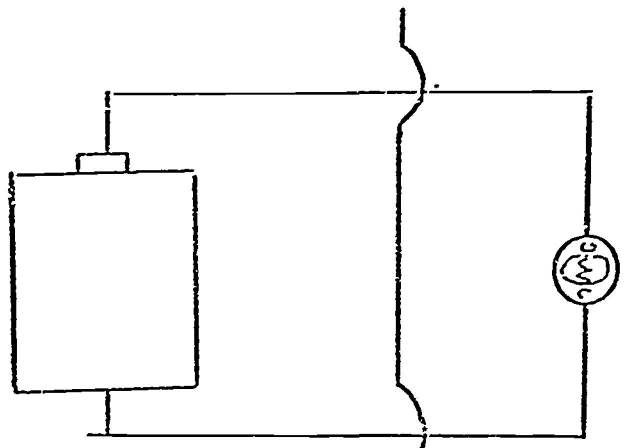
Won't Light - Short Circuit

5.



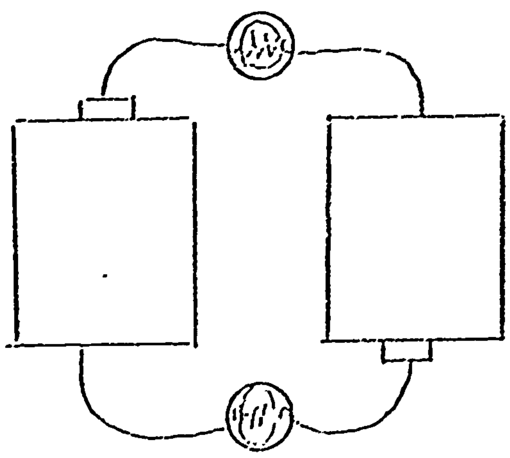
Won't Light - Short Circuit

6.



Standard - Insulated Wire

7.

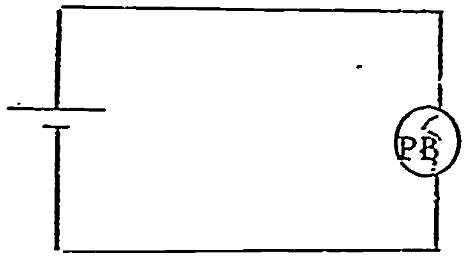


Bright - 2 Batteries

HOW BRIGHT WILL THESE BULBS BE

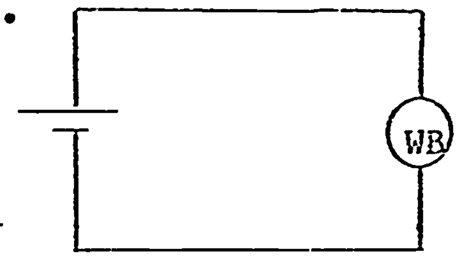
CHOICES: Standard
Bright
Dim
Won't Light

1.



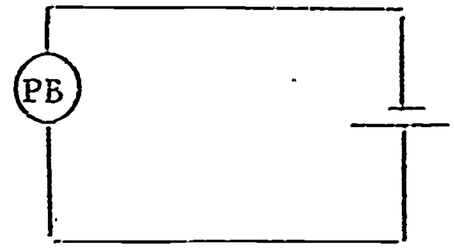
Standard

2.



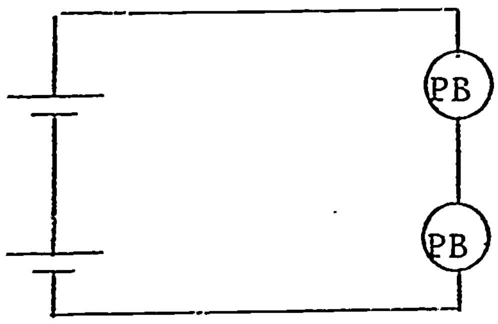
Standard

3.



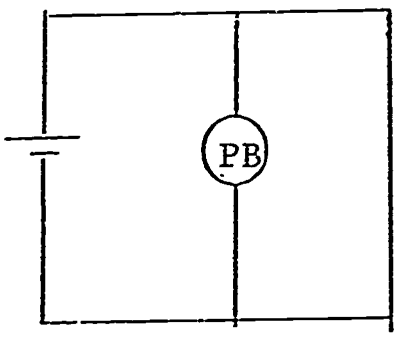
Standard

4.



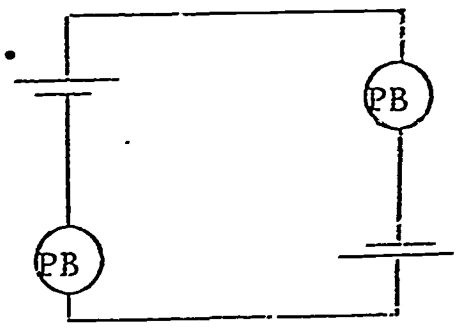
Standard
Standard

5.



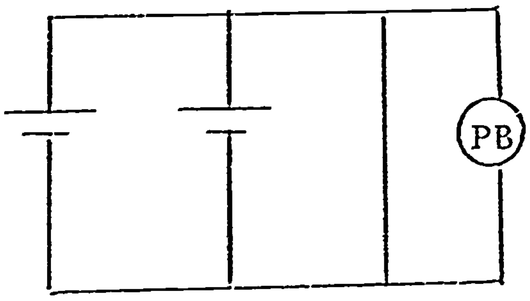
Won't Light

6.



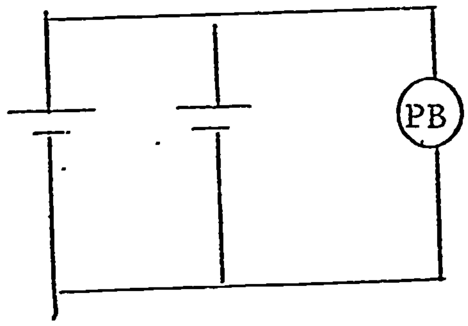
Standard Standard

7.



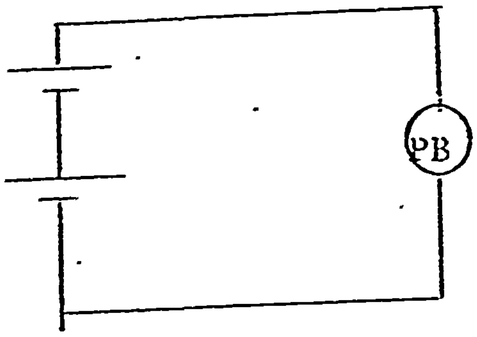
Won't Light

8.



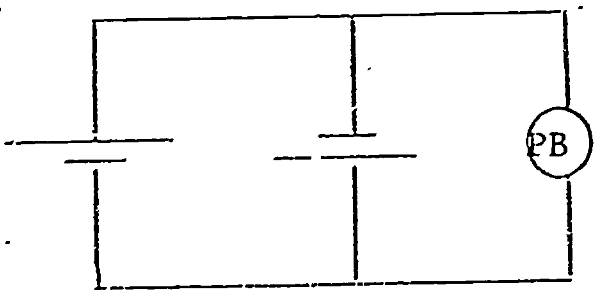
Standard

9.



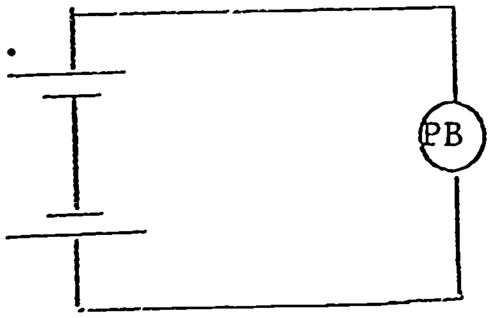
Bright
2 Batteries

10.



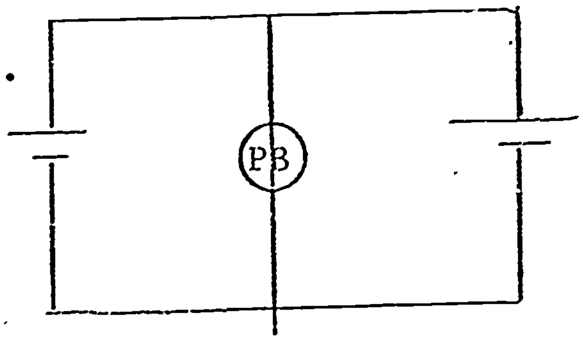
Won't Light

11.



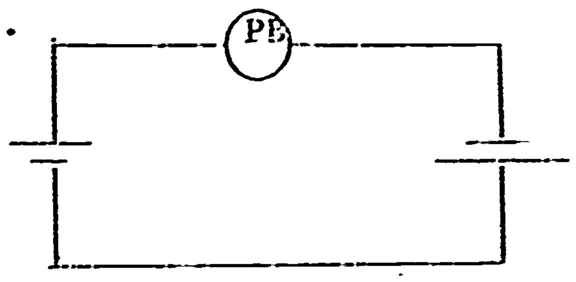
Won't Light

12.



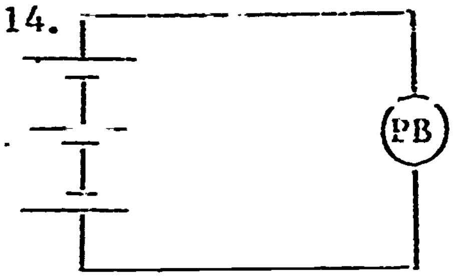
Standard

13.



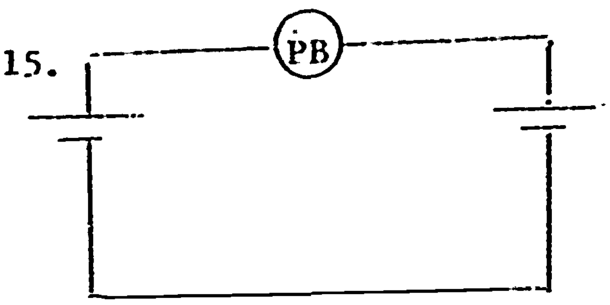
Bright - 2 batteries

14.



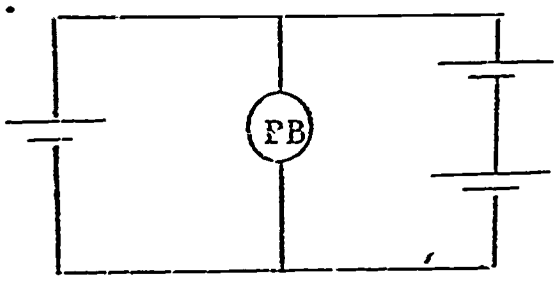
Standard

15.



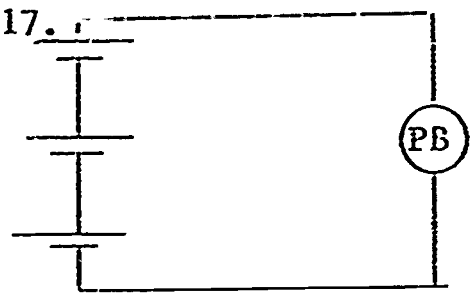
Won't Light

16.



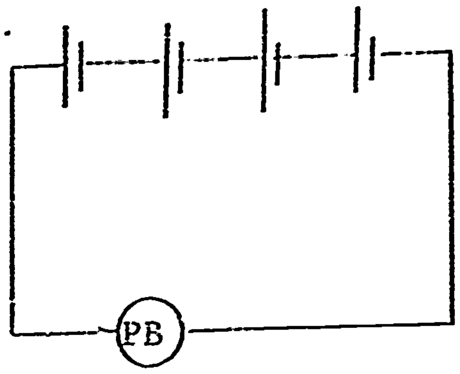
Standard

17.



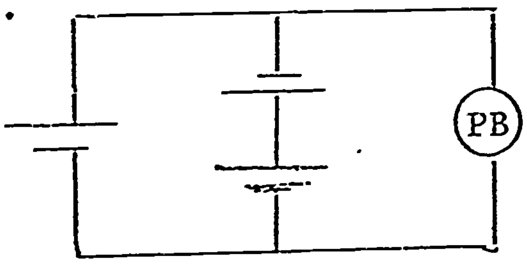
Very Bright
(3 batteries)

18.



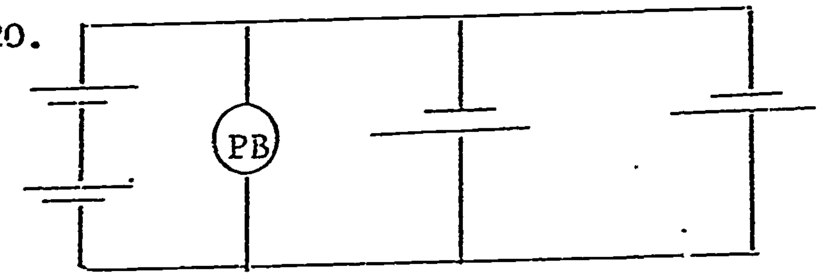
Very Bright
(4 batteries)

19.



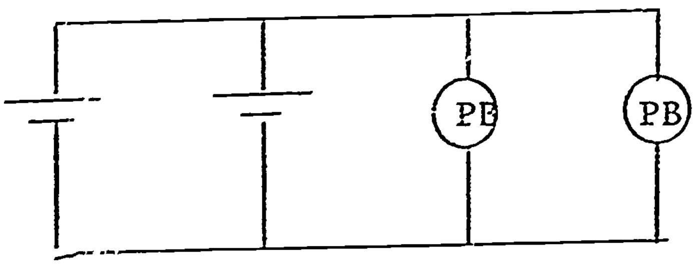
Standard

20.



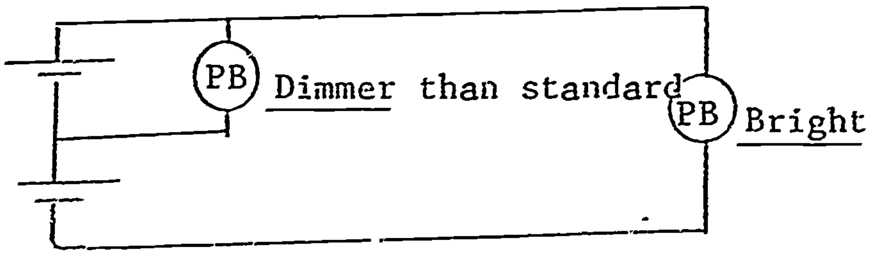
Dim

21.

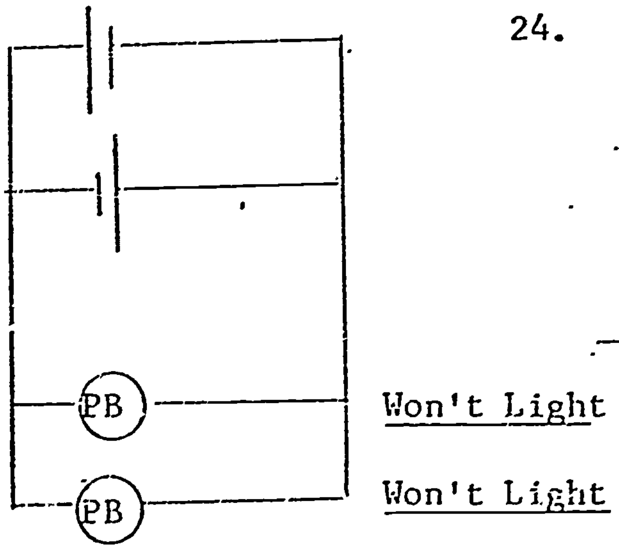


Standard Standard

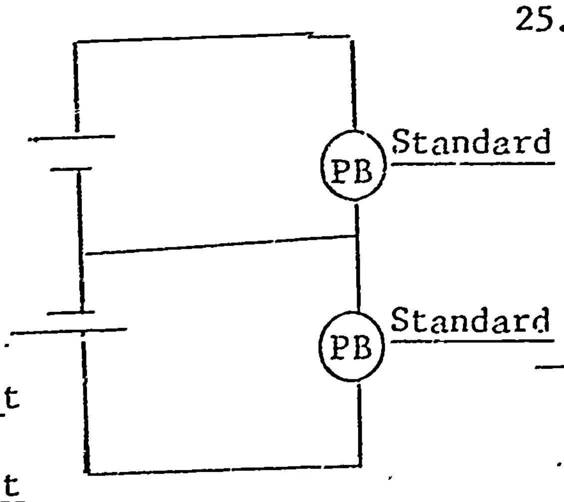
22.



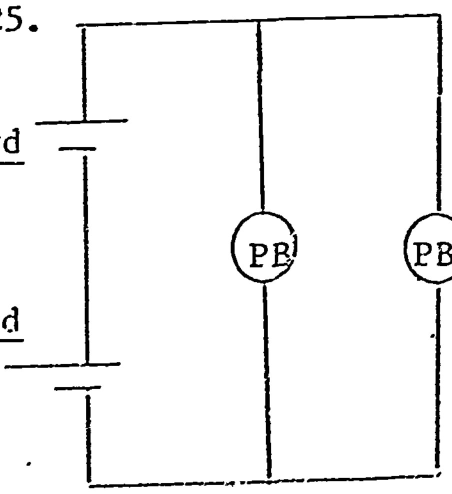
23.



24.



25.



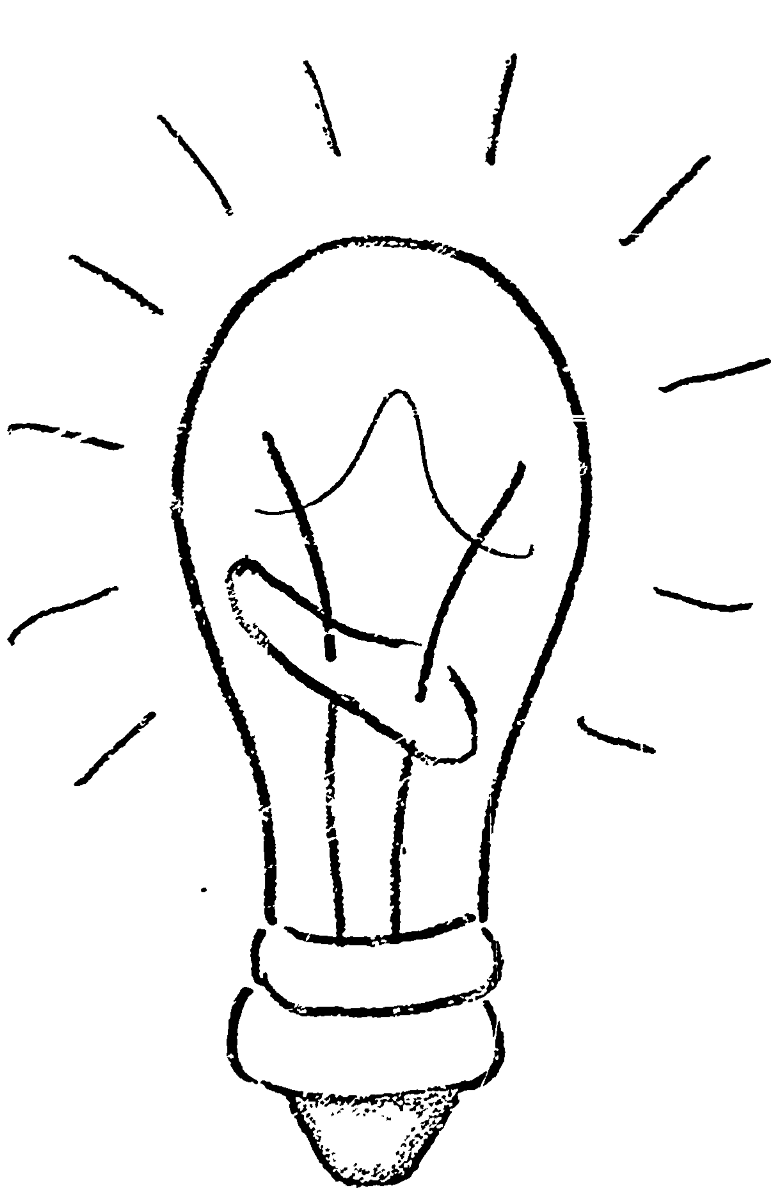
Bright Bright

APPENDIX I

STUDENT'S WORKBOOK FOR LECTURE-DEMONSTRATION ELECTRICITY UNIT*

*Called "Understanding Electricity" in the concluding (1968) study (Section VI).

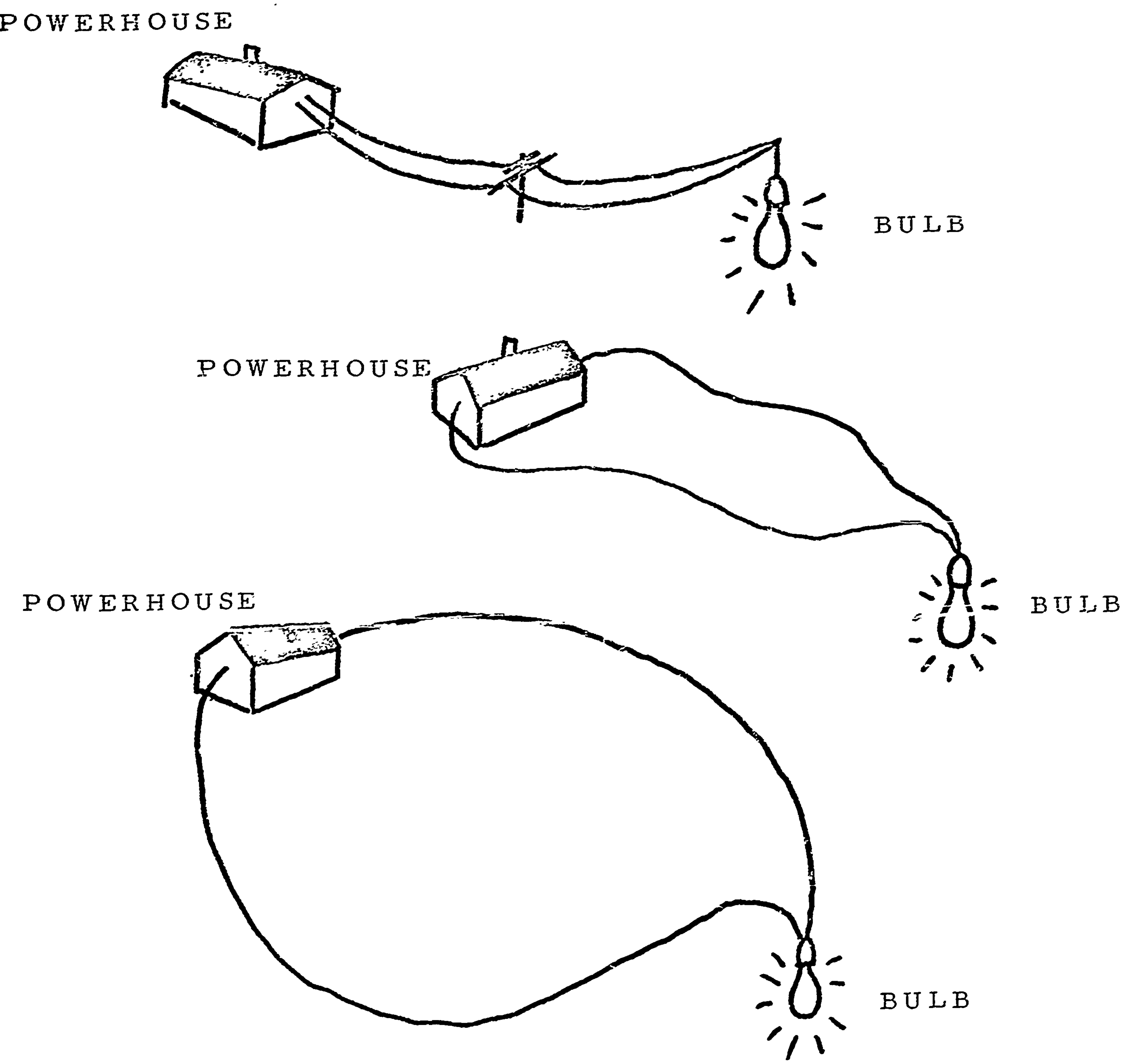
Understanding Electricity



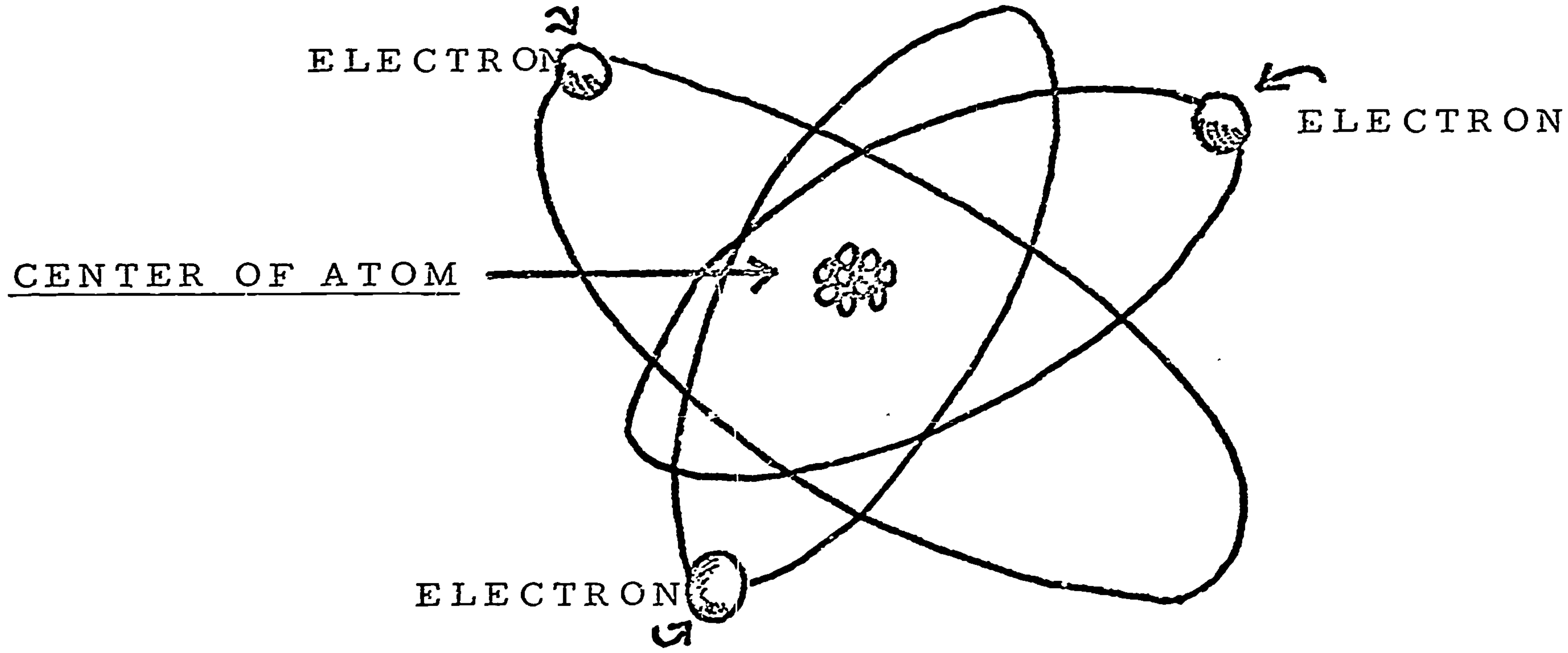
Grade 8

LESSON #1

A CIRCUIT IS THE PATH THAT ELECTRICITY TRAVELS OVER ——

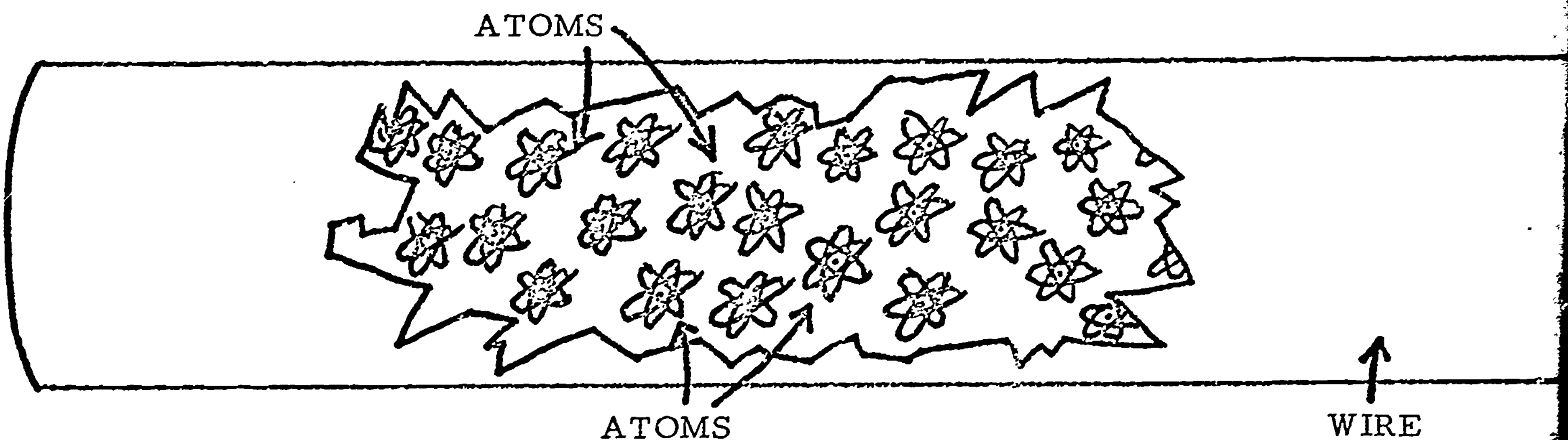


ELECTRICITY is a STREAM of MOVING ELECTRONS



ALL THINGS ARE MADE OF BILLIONS OF TINY ATOMS

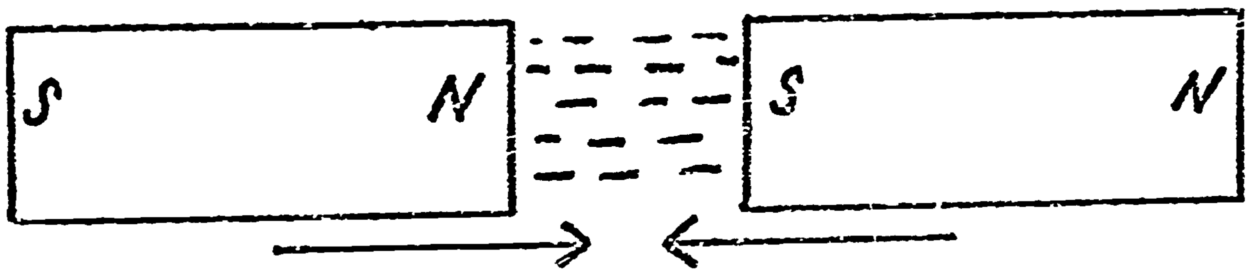
WE THINK ATOMS LOOK LIKE THIS



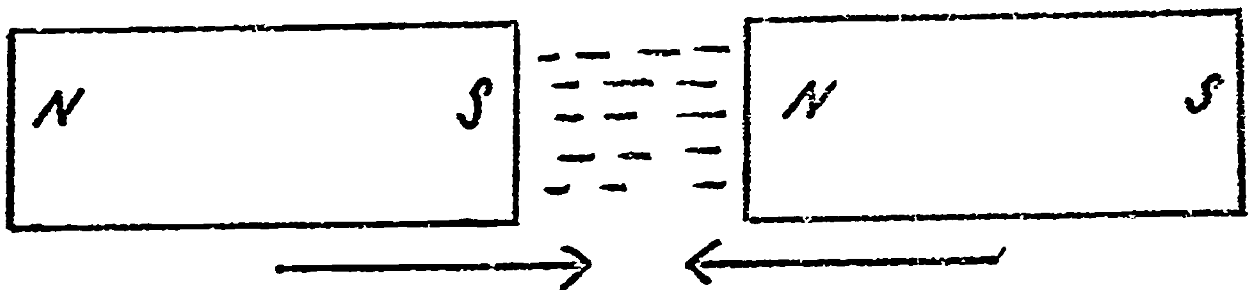
WHEN WE MAKE ELECTRONS MOVE, WE MAKE A CHARGE CALLED ELECTRICITY

-MAGNETS-

UNLIKE POLES OF MAGNETS PULL TOWARD EACH OTHER

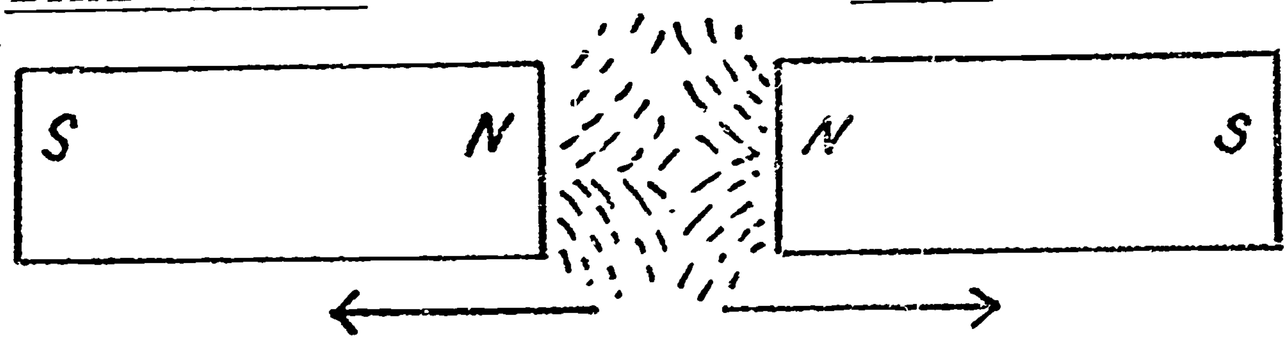


THE NORTH POLE OF ONE MAGNET WILL ATTRACT THE SOUTH POLE OF ANOTHER MAGNET.

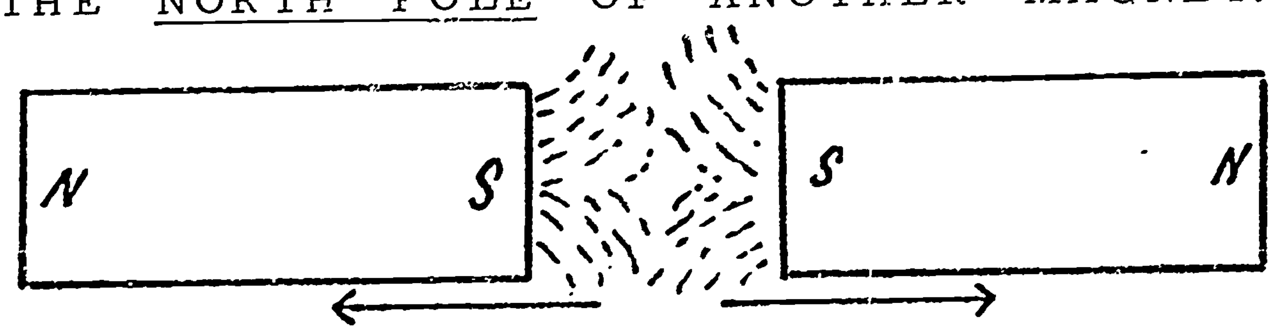


THE SOUTH POLE OF ONE MAGNET WILL ATTRACT THE NORTH POLE OF ANOTHER MAGNET.

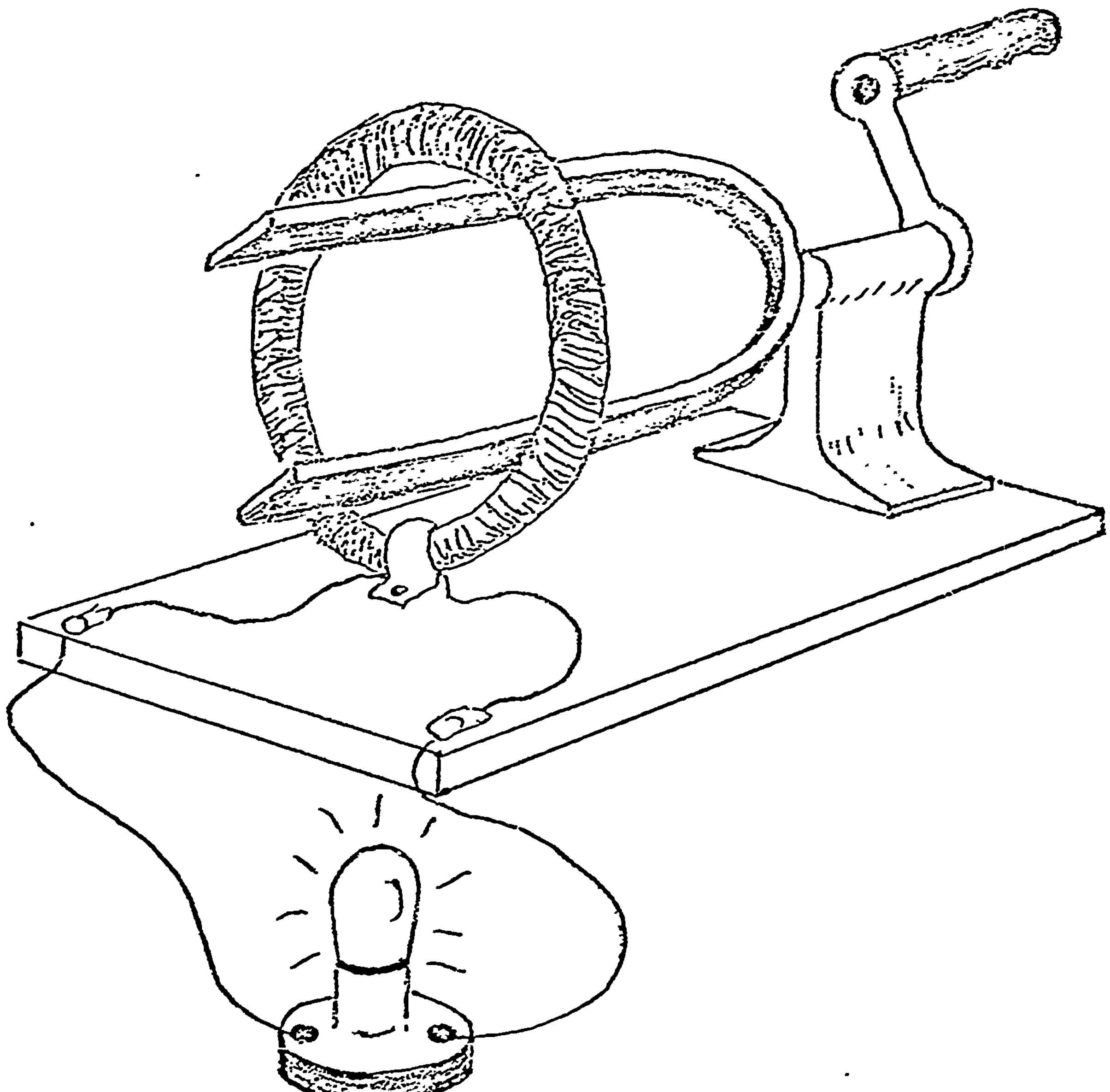
LIKE POLES OF MAGNETS PUSH EACH OTHER AWAY



THE NORTH POLE OF ONE MAGNET WILL PUSH AWAY THE NORTH POLE OF ANOTHER MAGNET.

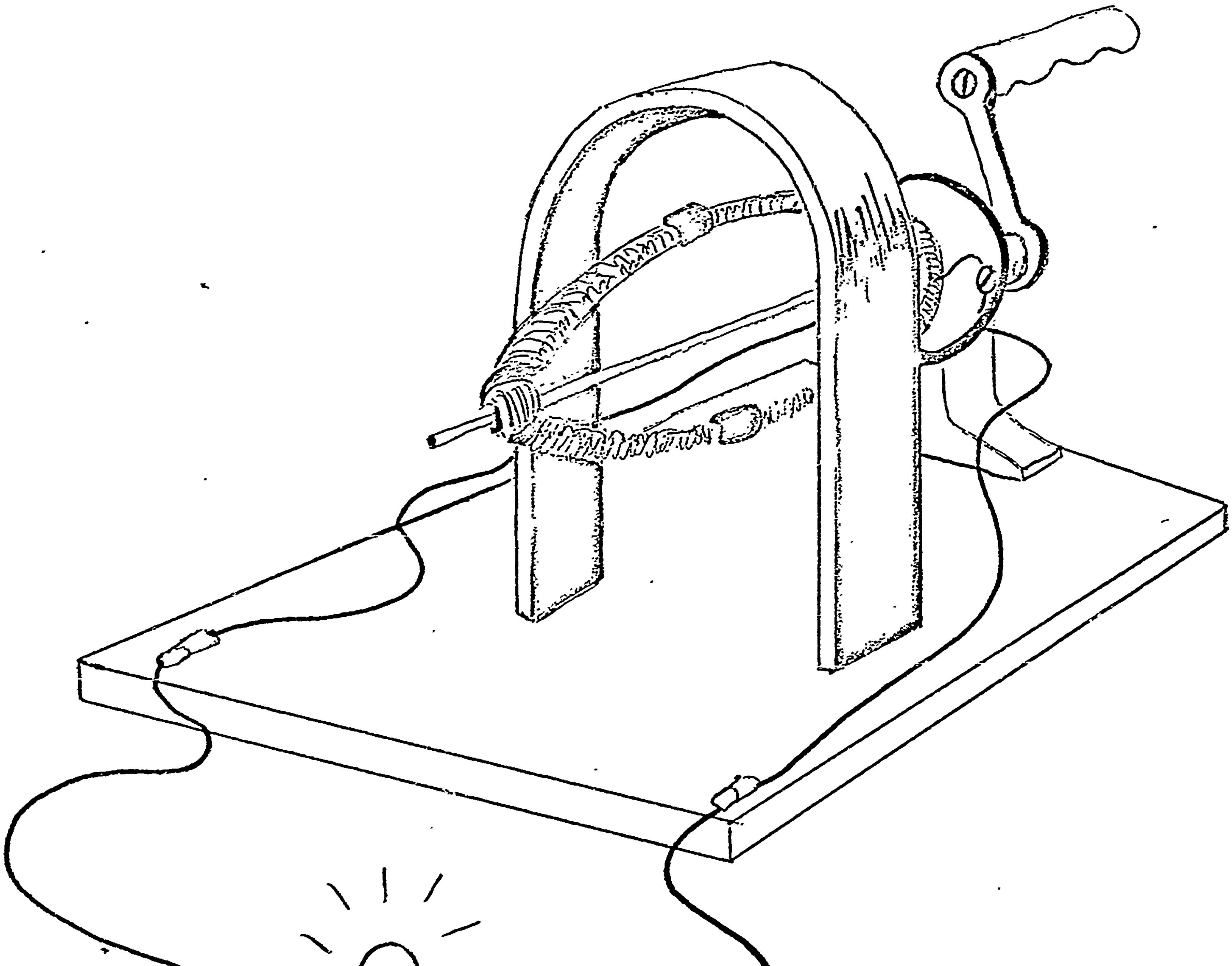


THE SOUTH POLE OF ONE MAGNET WILL PUSH AWAY THE SOUTH POLE OF ANOTHER MAGNET.

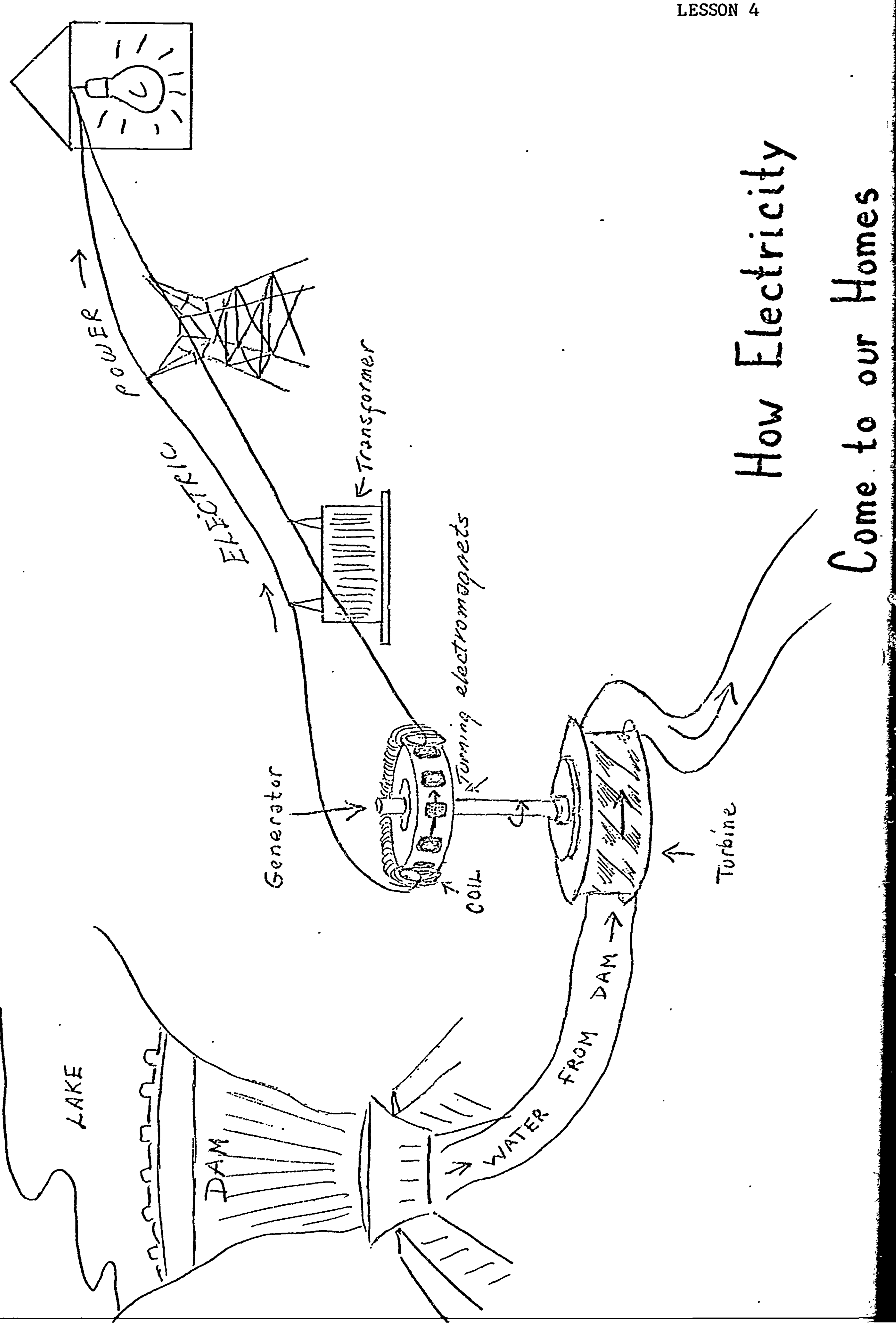


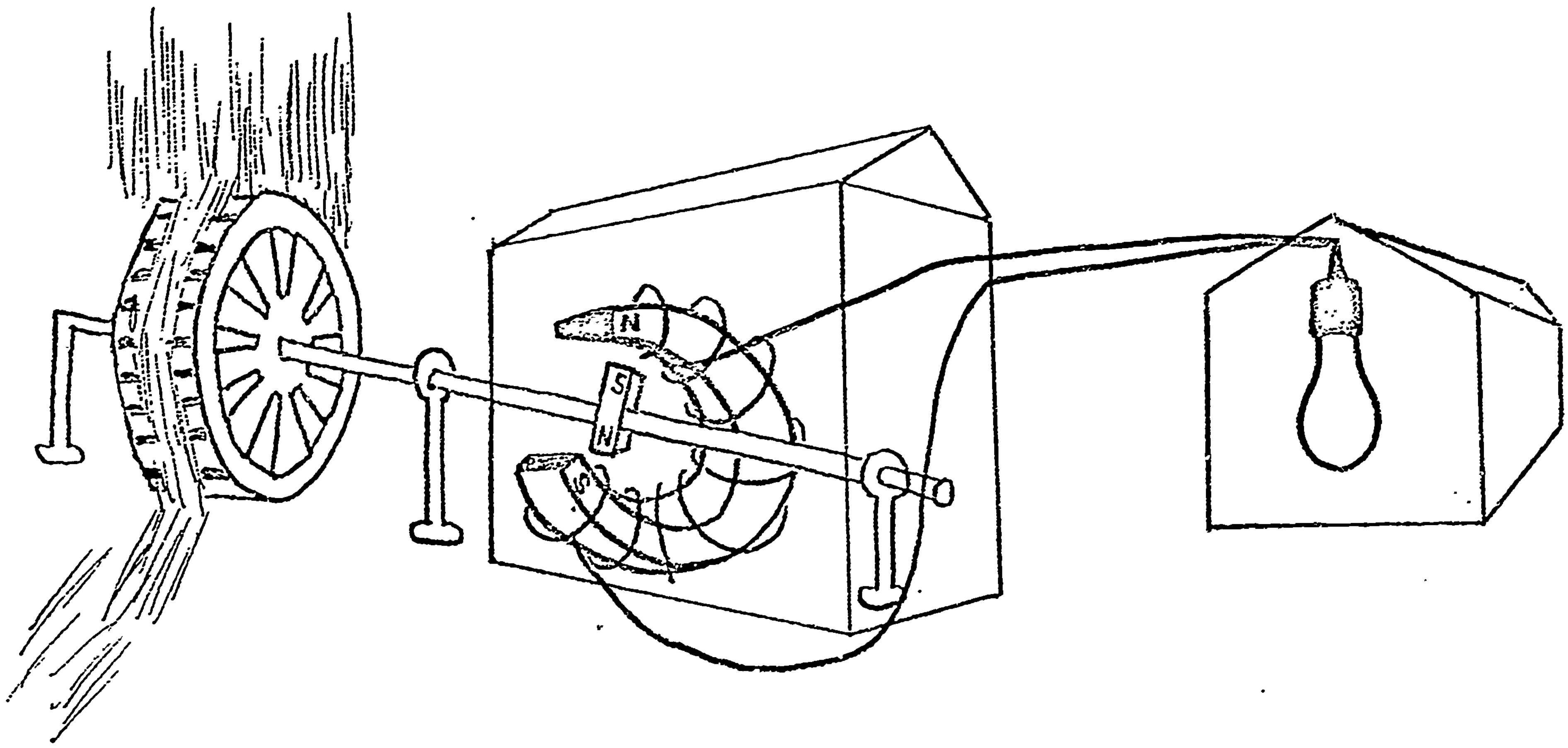
Generator

LESSON 4



Generator


How Electricity
Come to our Homes
LAKE
DAM
WATER FROM DAM
Turbine
Generator
COIL
Turning electromagnets
Transformer
ELECTRIC
POWER



Another Generator

SUMMARY

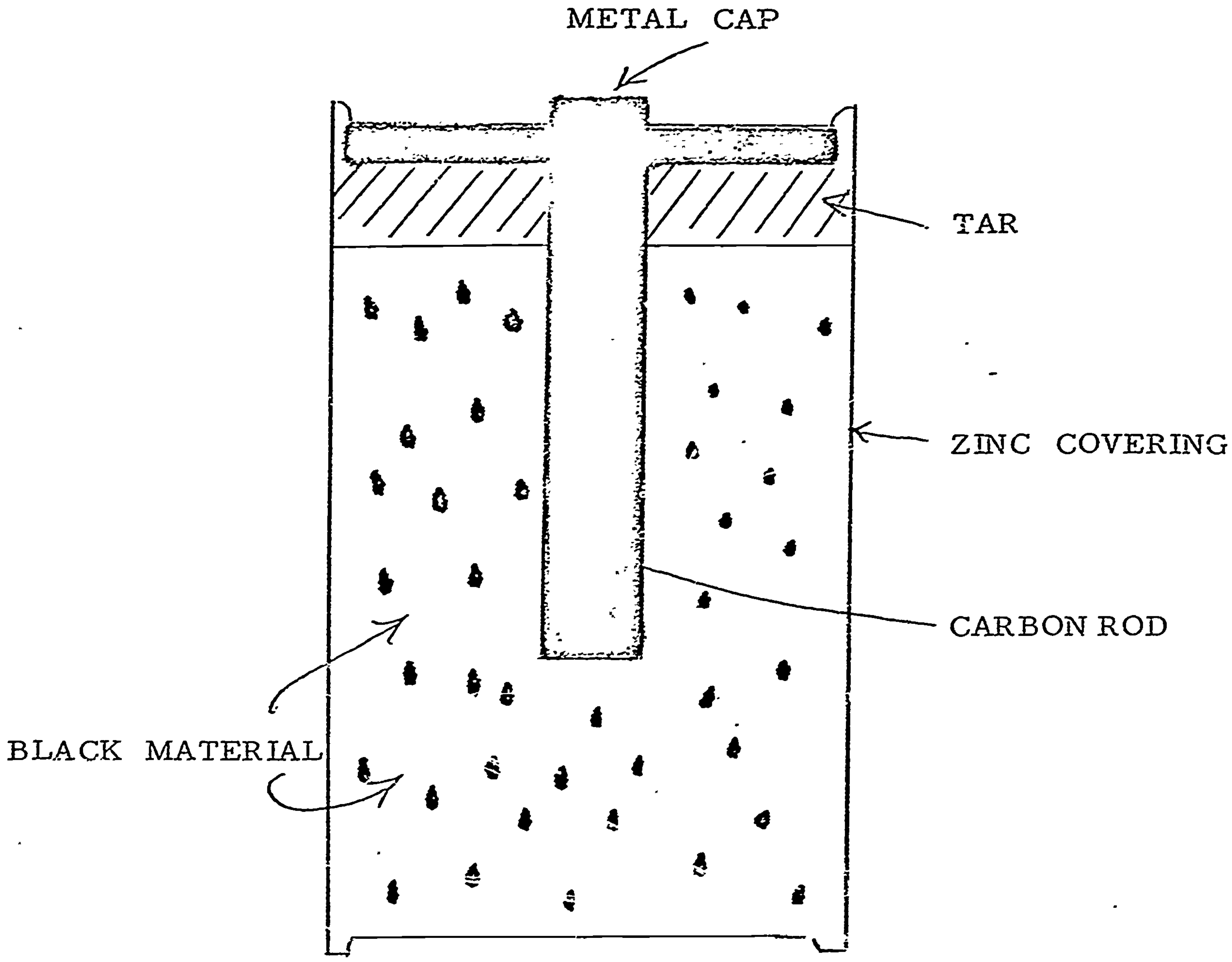
STATIC ELECTRICITY

CURRENT ELECTRICITY

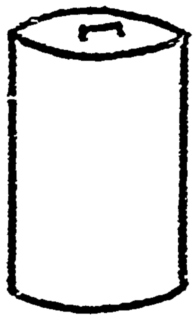
SUMMARY

CHEMICAL ELECTRICITY

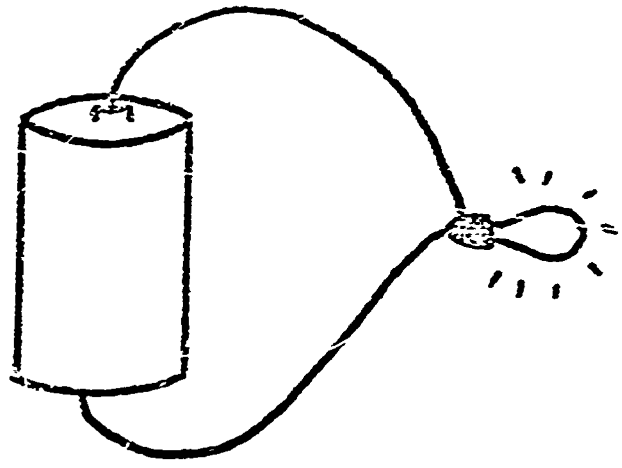
INSIDE A BATTERY



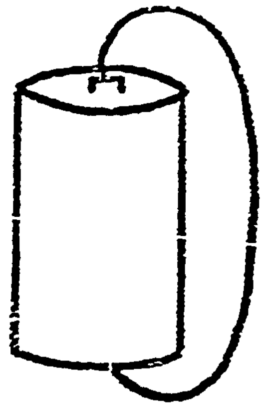
A BATTERY NEEDS A CIRCUIT TO WORK



NOT WORKING



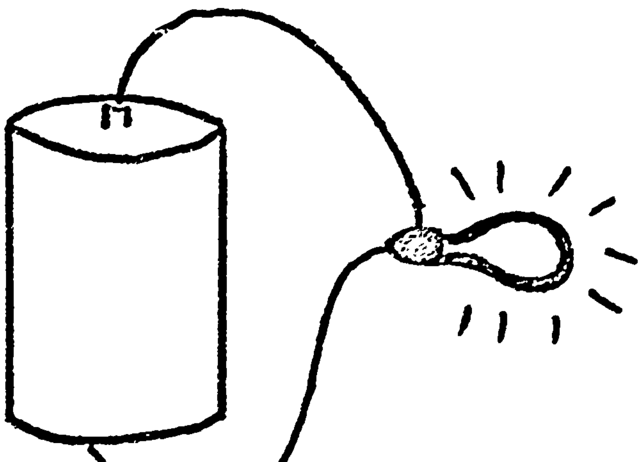
WORKING



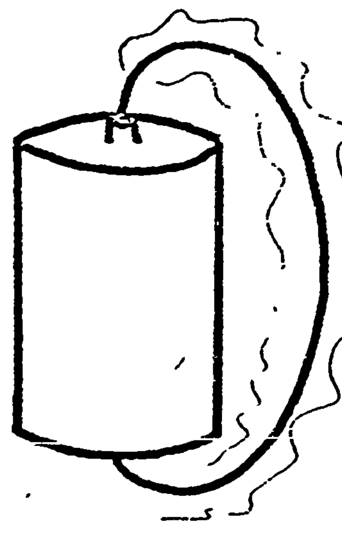
WORKING

A CIRCUIT MUST CONNECT TOP OF BATTERY AND BOTTON OF BATTERY

TWO CIRCUITS

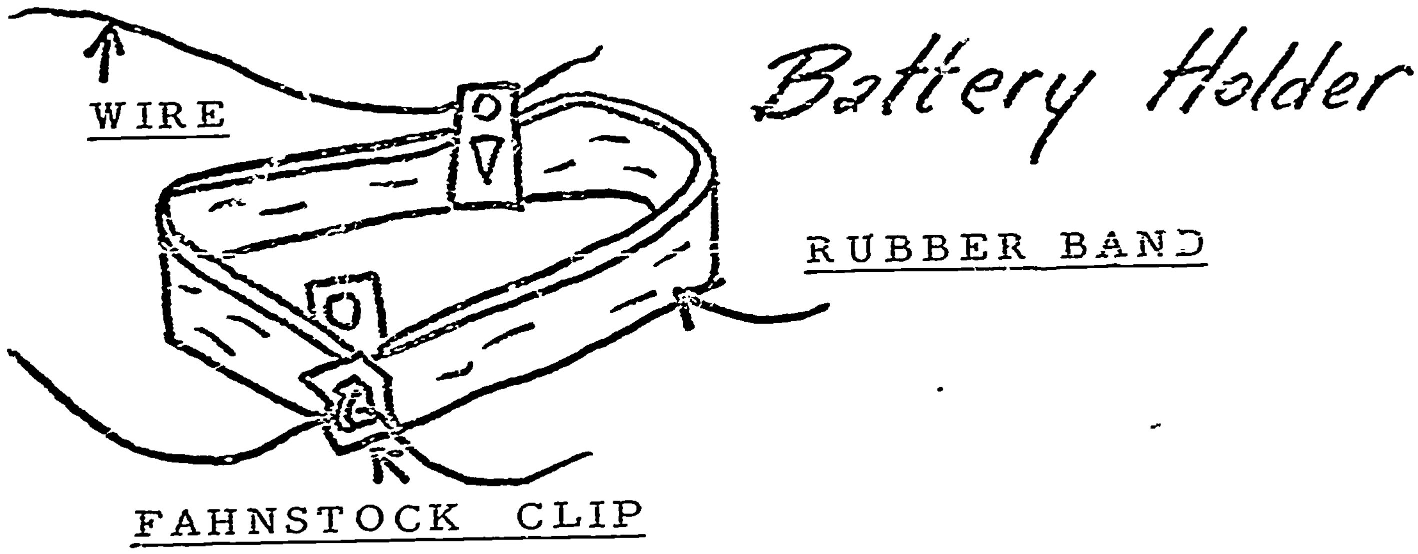


BULB LIGHTS

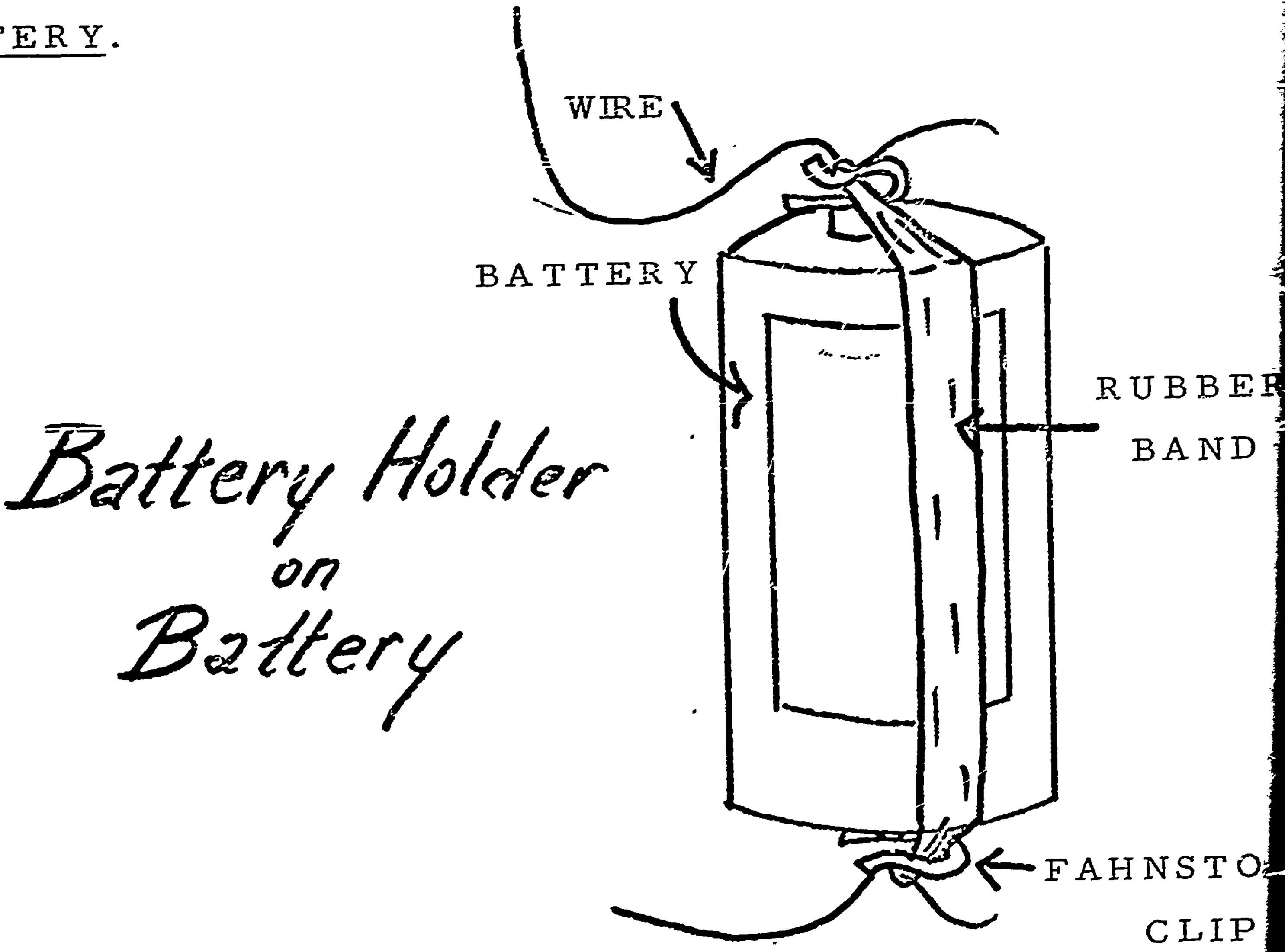


WIRE GETS HOT

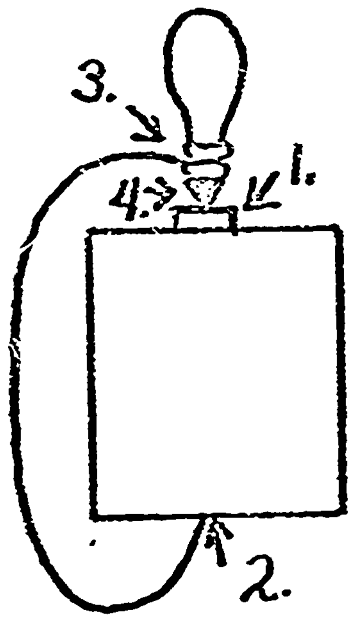
How a Battery Holder Works



A BATTERY HOLDER CONNECTS WIRES TO THE CAP OF THE BATTERY AND THE BOTTOM OF THE BATTERY.



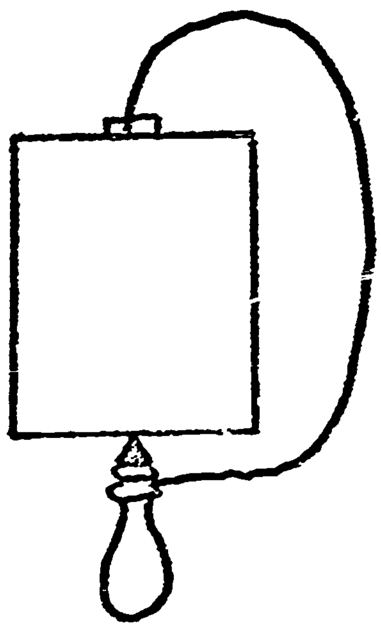
LIGHTING a Bulb

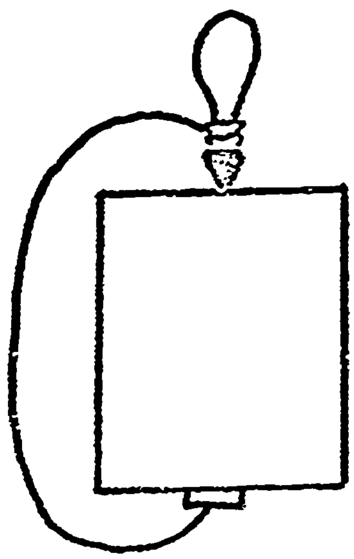


to light a bulb (make a complete circuit)

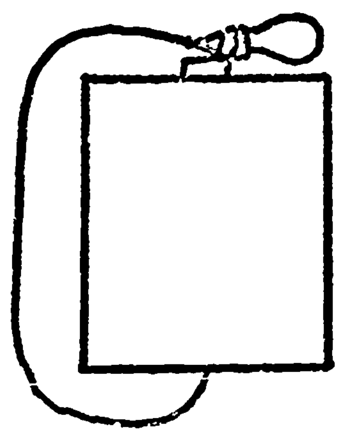
FOUR PLACES must be CONNECTED

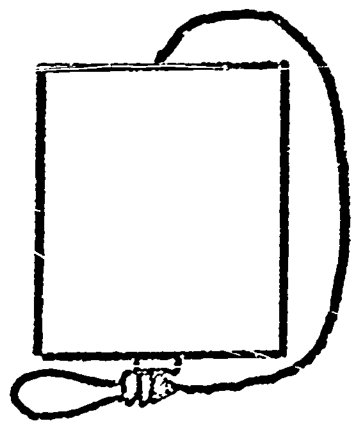
1. TOP of BATTERY
2. BOTTOM of BATTERY
3. BULB SCREW
4. SILVER TIP of BULB





IT DOES NOT MATTER IF THE BULB OR THE BATTERY IS UPSIDE DOWN, AS LONG AS ALL FOUR PLACES ARE CONNECTED.





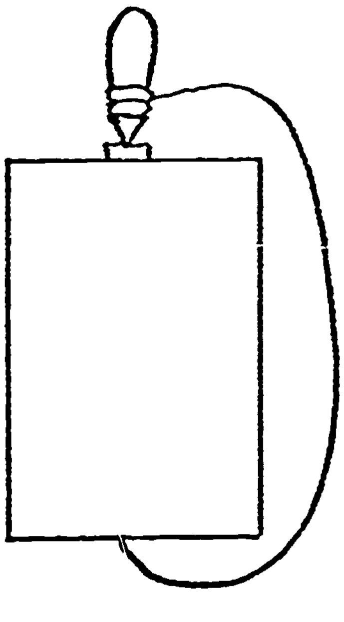
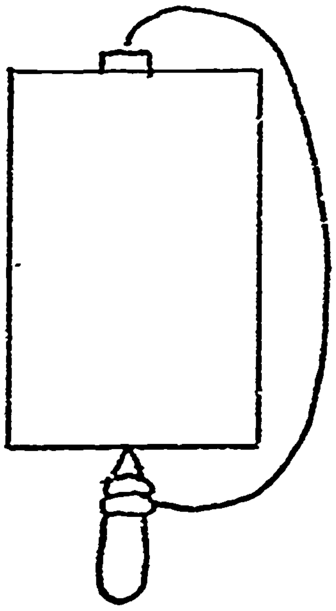
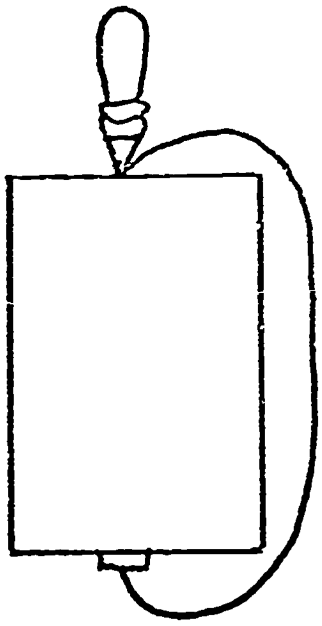
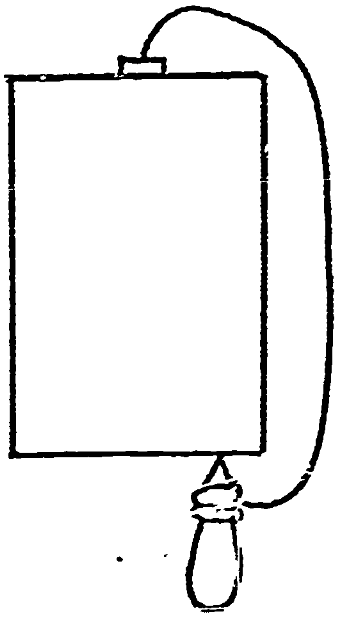
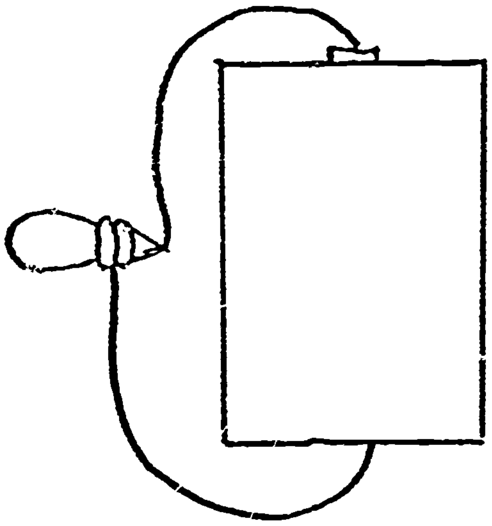
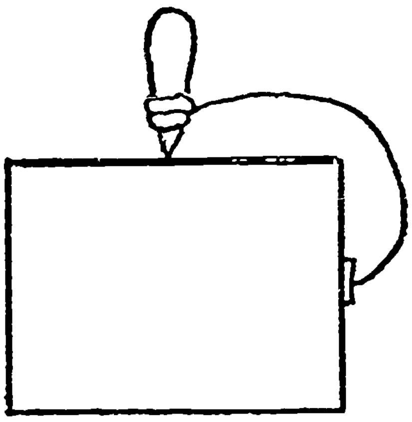
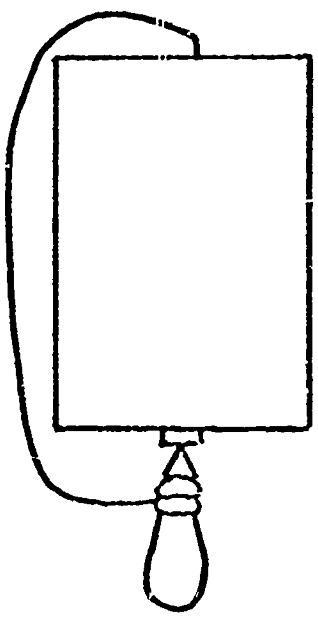
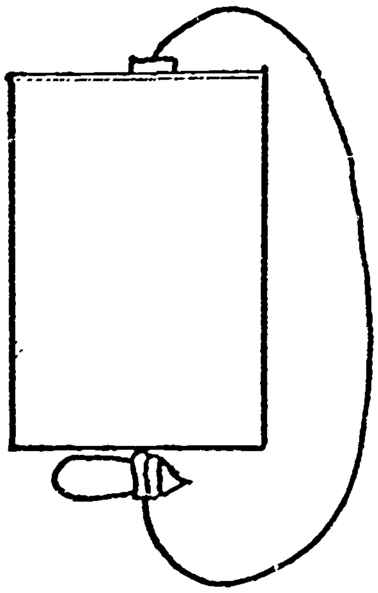
IT DOES NOT MATTER IF THE BULB IS ONE ITS SIDE, AS LONG AS ALL FOUR PLACES ARE CONNECTED.

SET-UPS

DO THE BULBS LIGHT OR NOT?

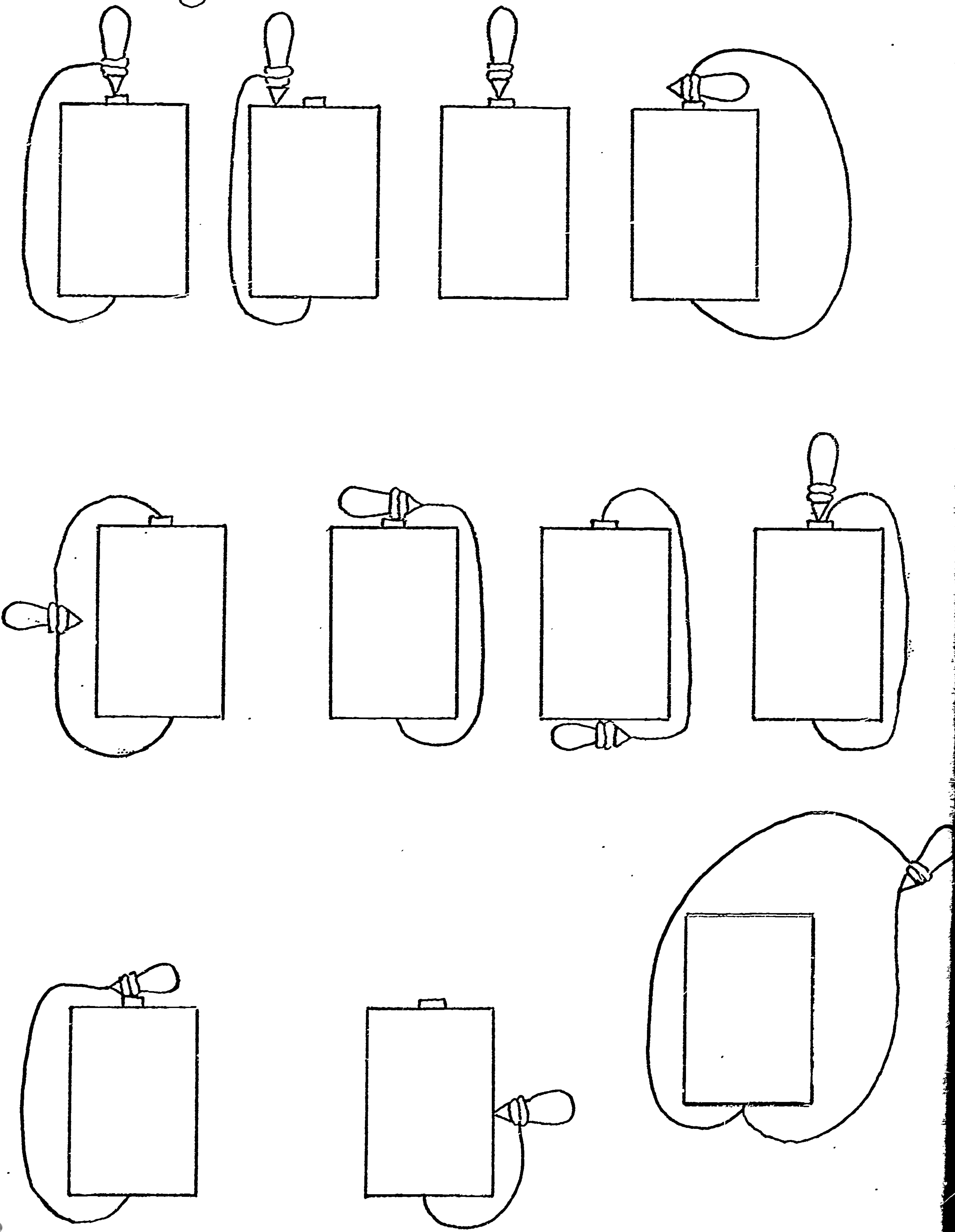
PUT (Y) IF THEY LIGHT

PUT (N) IF THEY DO NOT LIGHT

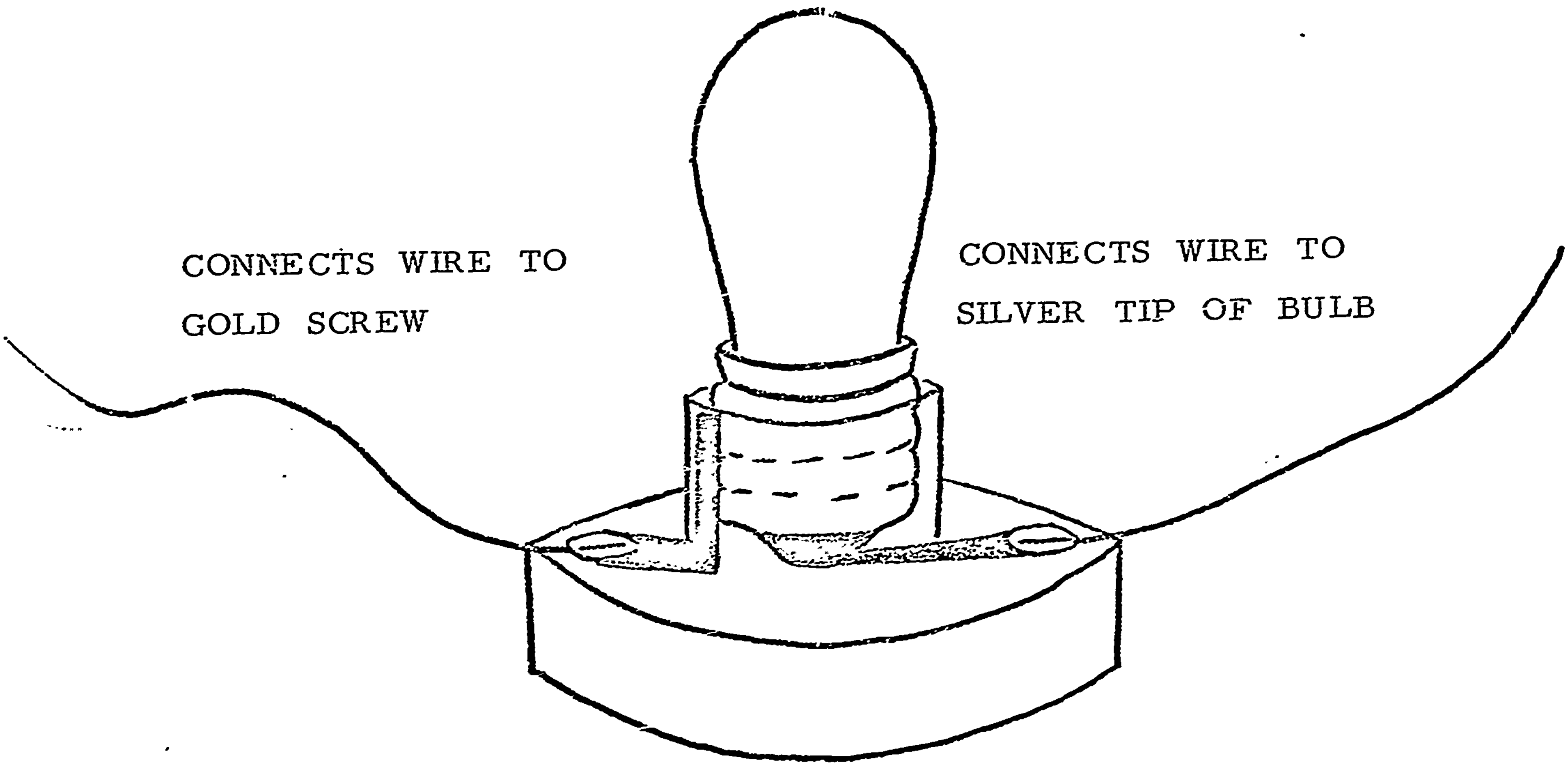









PUT Y IF THEY DO LIGHT

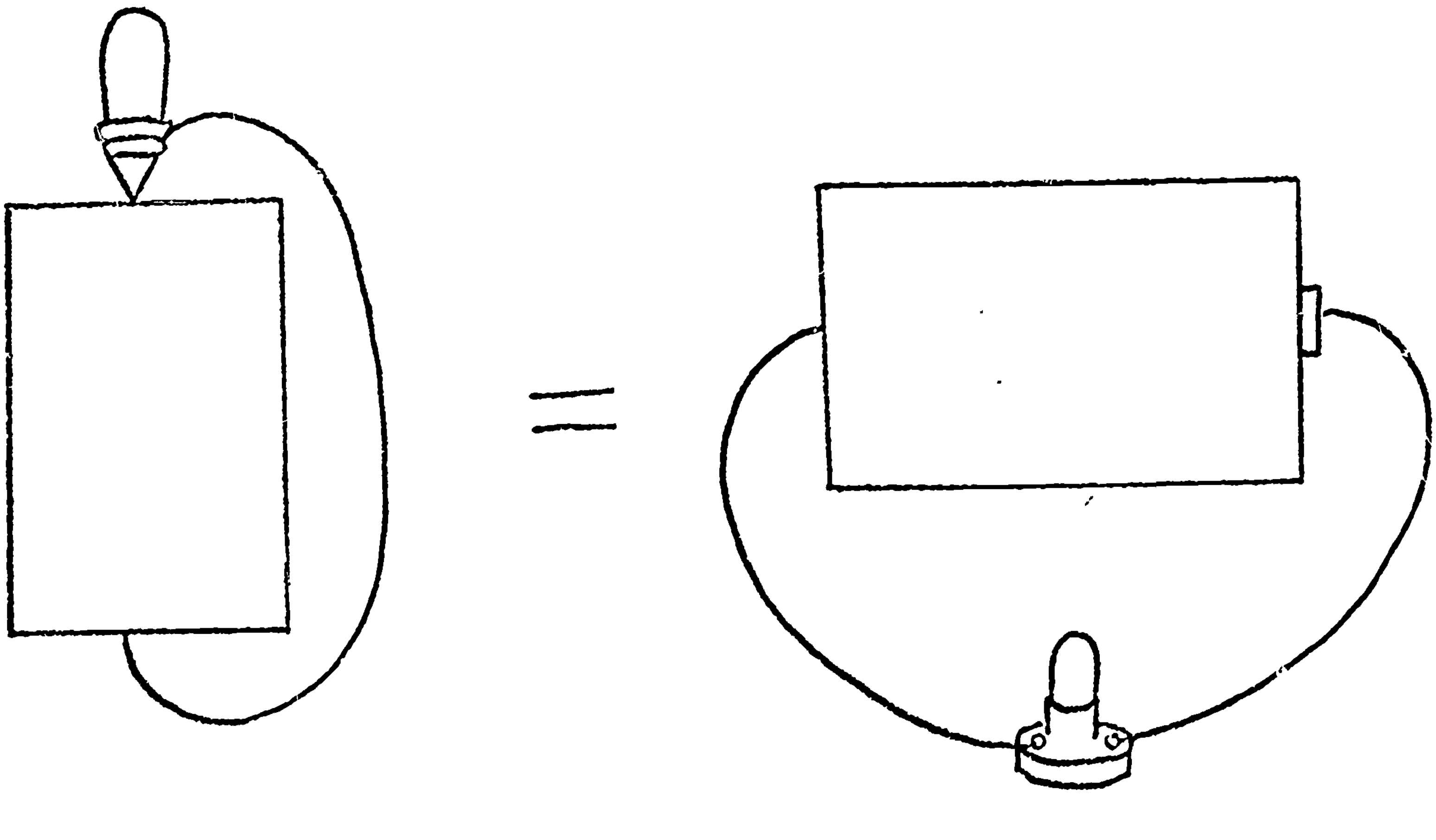
PUT N IF THEY DO NOT LIGHT



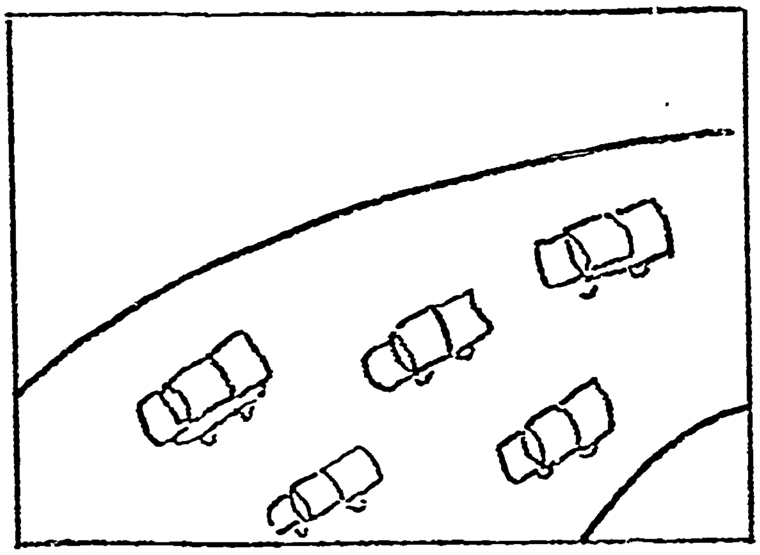
How a Bulb Holder Works



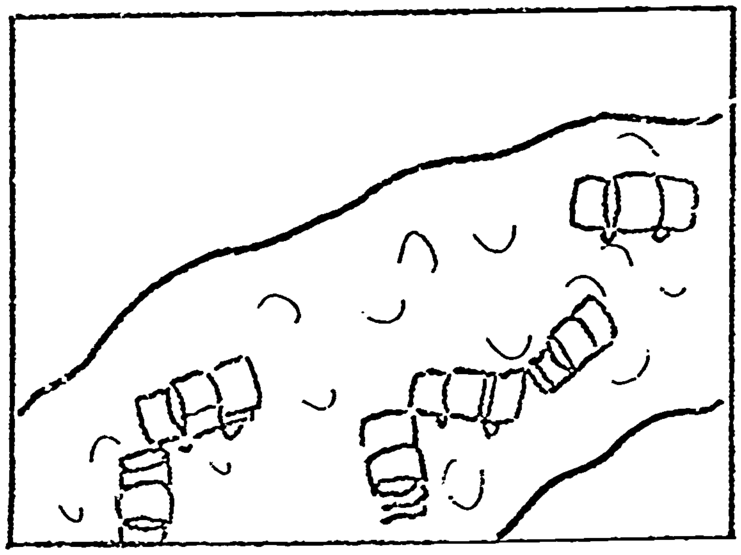
A BULB HOLDER CONNECTS WIRES TO THE SILVER TIP OF THE BULB AND TO THE GOLD SCREW



Conductors and Insulators



CONDUCTORS LET THE ELECTRICITY THROUGH EASILY - THEY DO NOT RESIST ELECTRICITY.



INSULATORS ARE LIKE POOR ROADS. THE ELECTRICITY STRUGGLES THROUGH - INSULATORS RESIST ELECTRICITY.

CONDUCTORS	INSULATORS - NON - CONDUCTORS

CONDUCTORS (CONTINUED)	INSULATORS (CONTINUED)

WHAT DO THE CONDUCTORS HAVE IN COMMON?

DO THE INSULATORS HAVE ANYTHING IN COMMON?

LESSON 7

SOME METALS ARE BETTER CONDUCTORS THAN OTHER METAL

	AMMETER READING	COMMENTS
SILVER		
COPPER		
NICHROME		
STEEL		
TUNGSTEN		

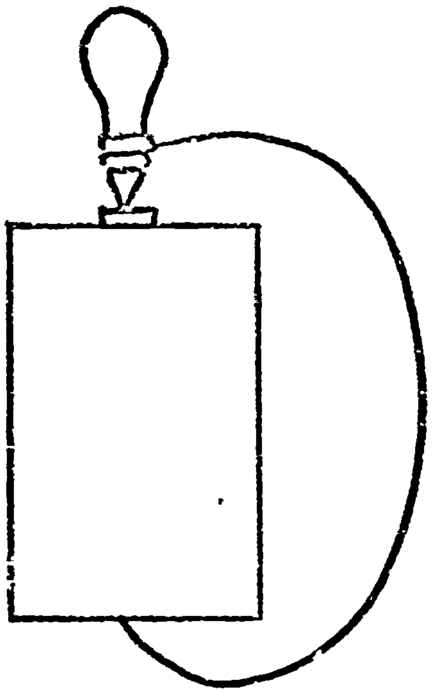
WHICH IS THE BEST CONDUCTOR?

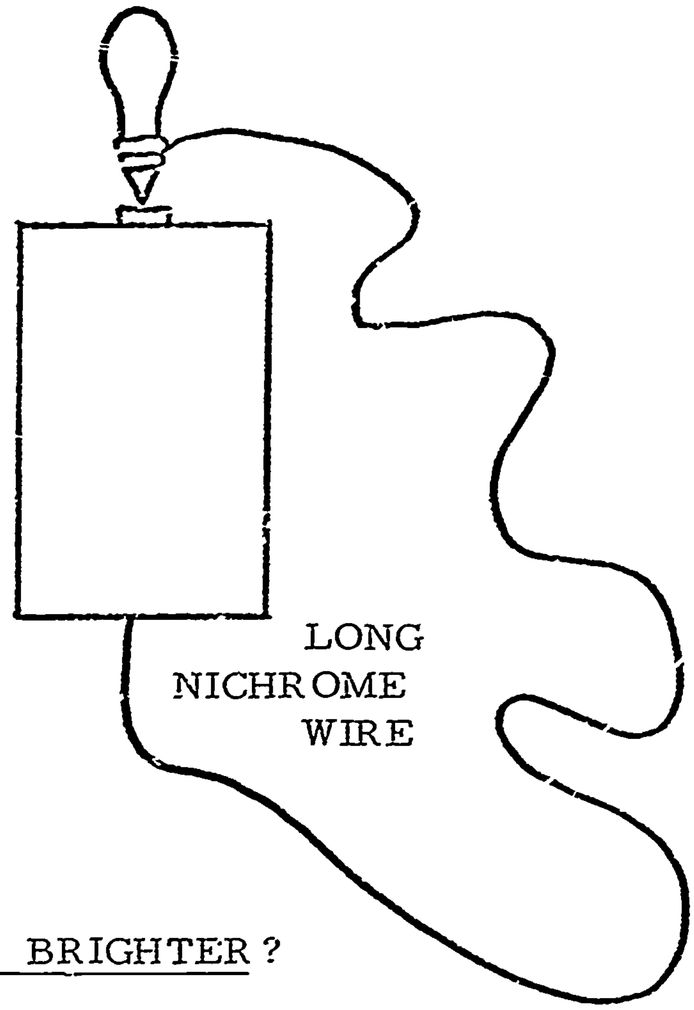
WHICH IS THE WORST CONDUCTOR?

WIRES...

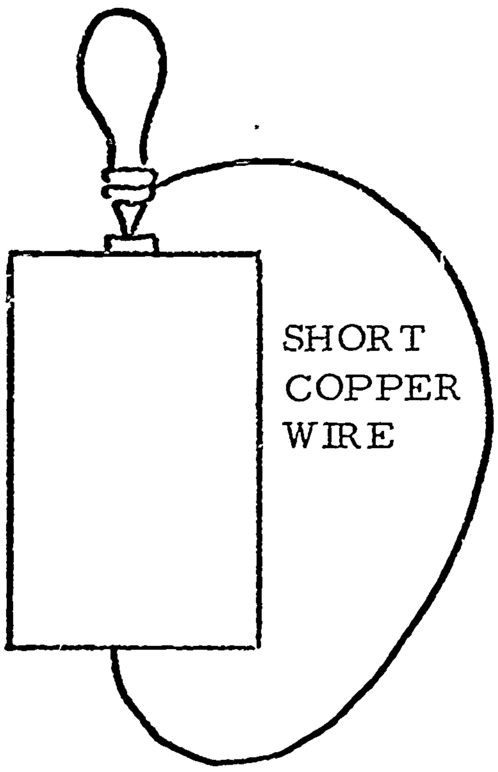
LESSON 8

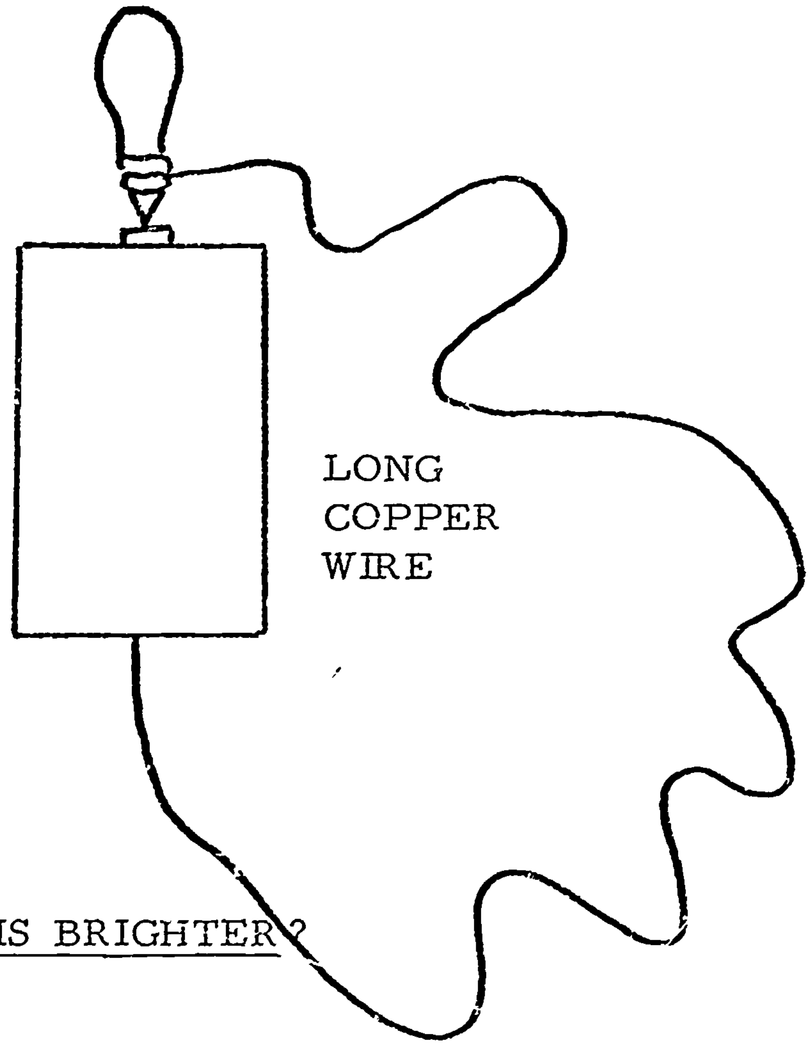
THE LONGER THE WIRE - THE MORE THE RESISTANCE





WHICH BULB IS DIMMER? WHICH BULB IS BRIGHTER?



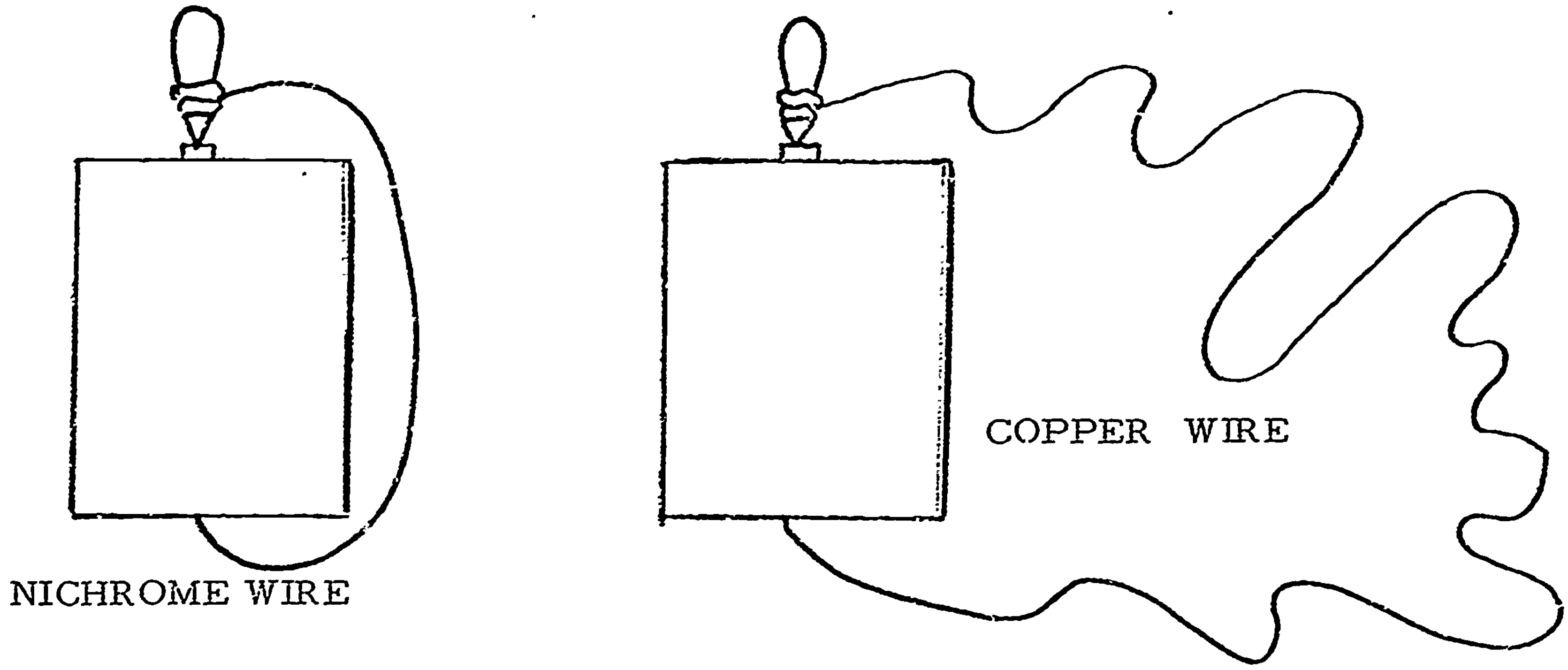


WHICH BULB IS DIMMER? WHICH BULB IS BRIGHTER?

SHORT NICHROME AND LONG COPPER

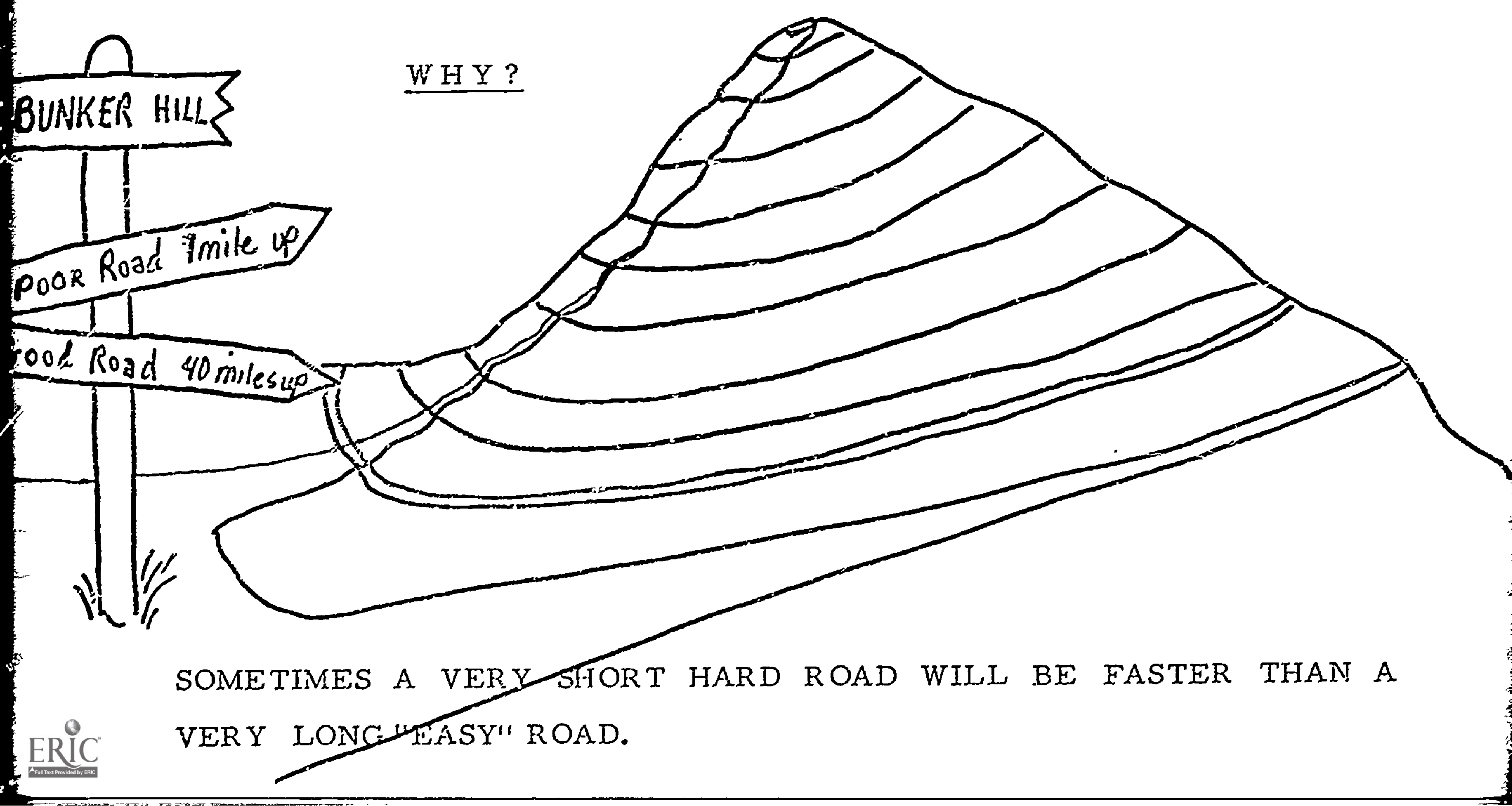
NICHROME RESISTS MORE THAN COPPER.

TO MAKE COPPER HAVE THE SAME RESISTANCE AS NICHROME -- MAKE IT LONGER.



POOR CONDUCTOR / NICHROME	=	GOOD CONDUCTOR / COPPER

WHY?



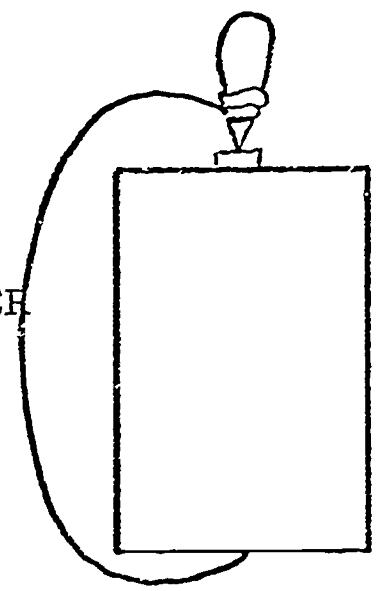
SOMETIMES A VERY SHORT HARD ROAD WILL BE FASTER THAN A VERY LONG "EASY" ROAD.

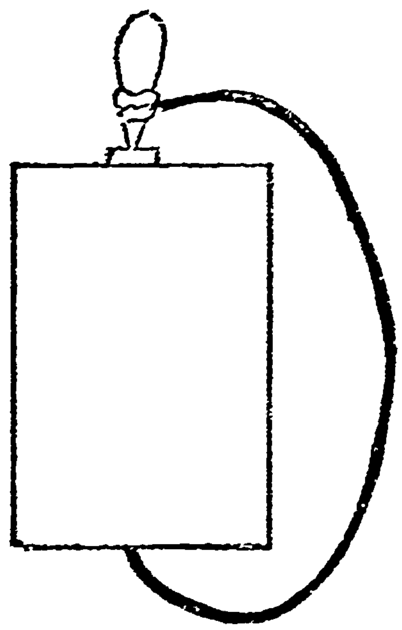
LESSON 8

THE THINNER THE WIRE, THE MORE RESISTANCE

WIRES	AMMETER READING
#32 (THIN) NICHROME	
#26 (THICK) NICHROME	
#36 (THIN) COPPER	
#22 (THICK) COPPER	

THIN
COPPER
WIRE

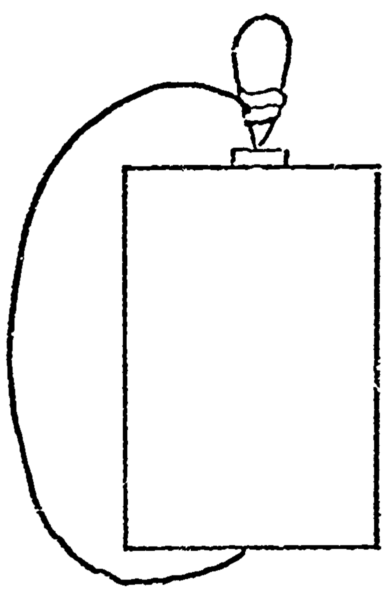




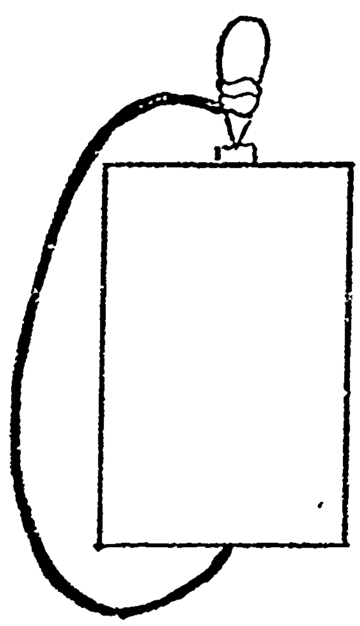
THICK
COPPER
WIRE

WHICH BULB IS BRIGHTER? DIMMER ?

THIN
NICHROME
WIRE

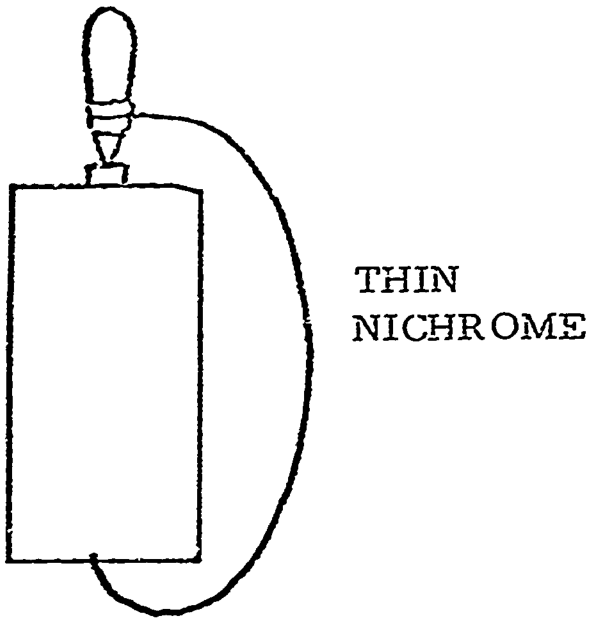


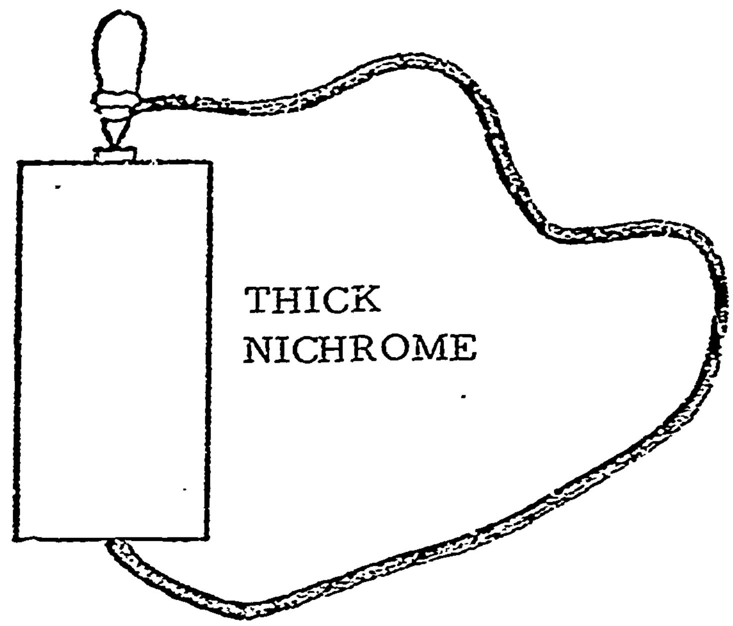
THICK
NICHROME
WIRE



WHICH BULB IS DIMMER ? BRIGHTER ?

TO MAKE THIN AND THICK WIRES OF THE SAME METAL HAVE THE <u>SAME RESISTANCE</u> - MAKE THE THICK WIRE LONGER.

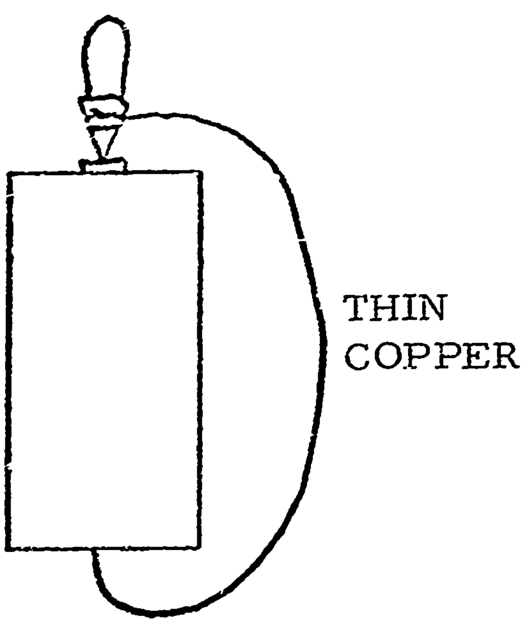


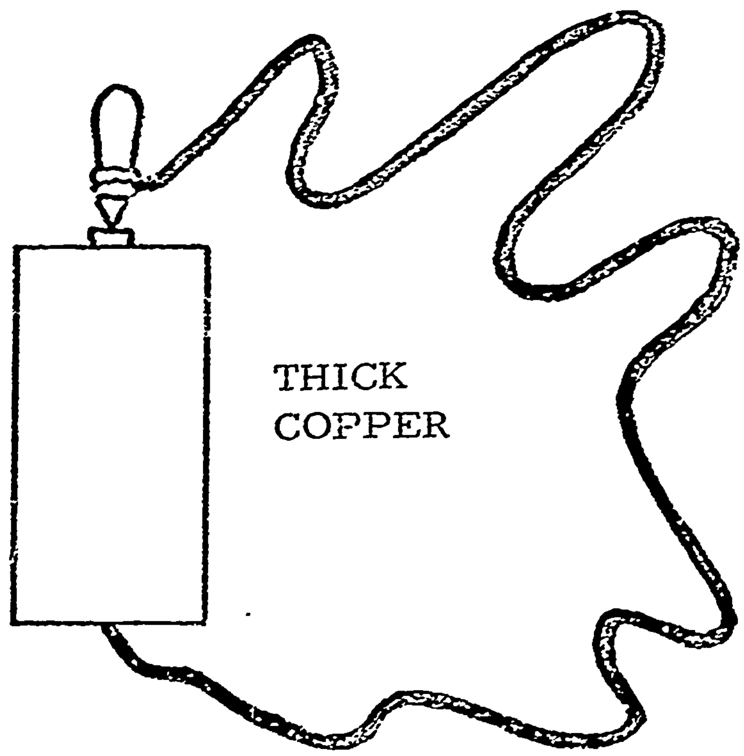


WHICH BULB IS BRIGHTER OR ARE THEY BOTH THE SAME?

______ Thin Nichrome Wire = ______ Thick Nichrome Wire

WE CAN MAKE A THIN AND THICK COPPER WIRE THE SAME RESISTANCE BUT WE WOULD HAVE TO MAKE THE COPPER WIRE <u>VERY</u> LONG.

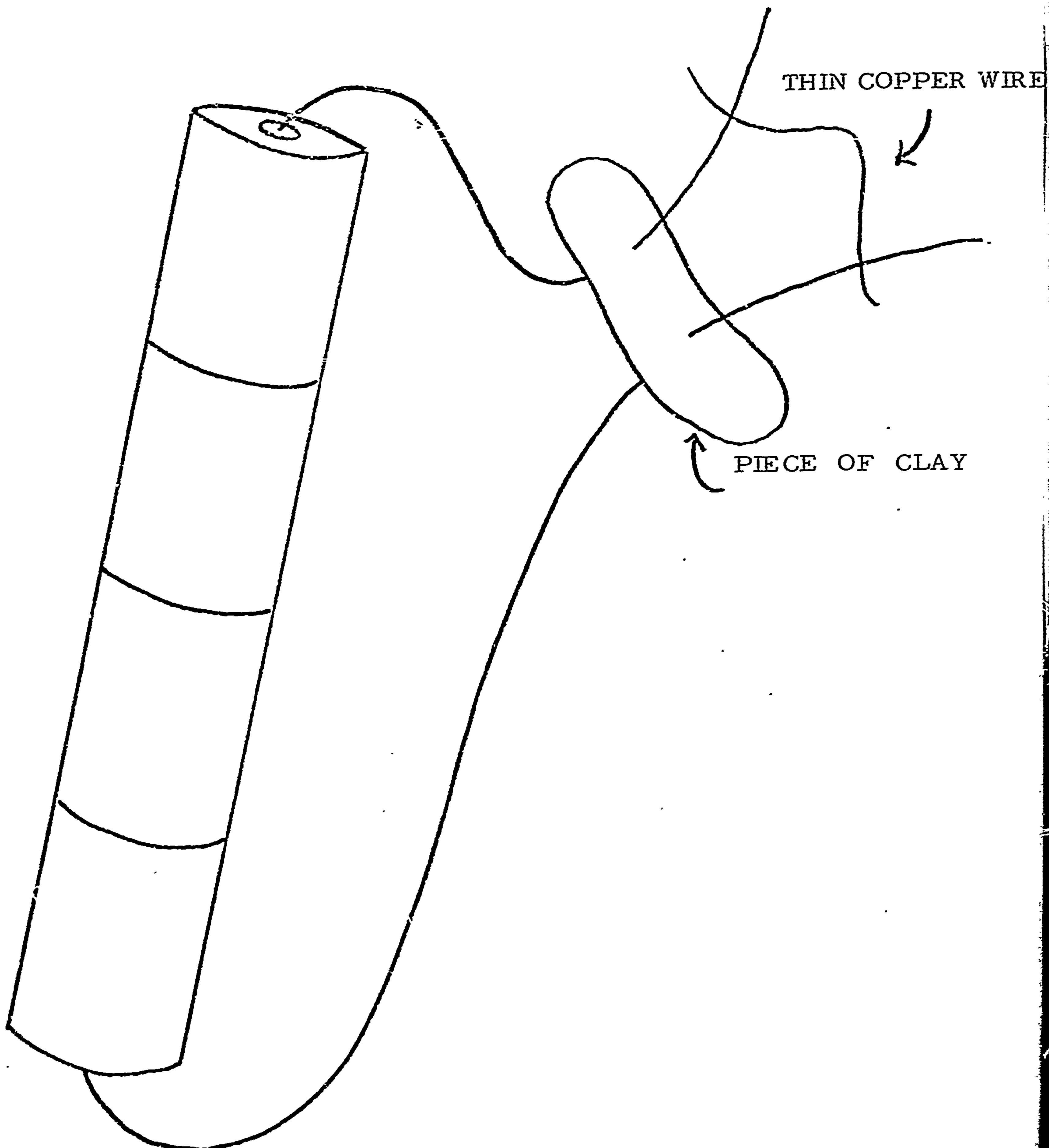




WHICH BULB IS BRIGHTER OR ARE THEY BOTH THE SAME?

______ Thin Copper Wire = ______ THICK Copper Wire

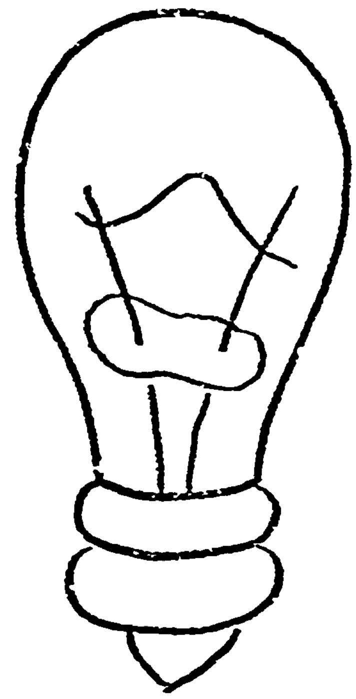
LIGHT BULBS



WHAT HAPPENED HERE?

WHY DID IT HAPPEN?

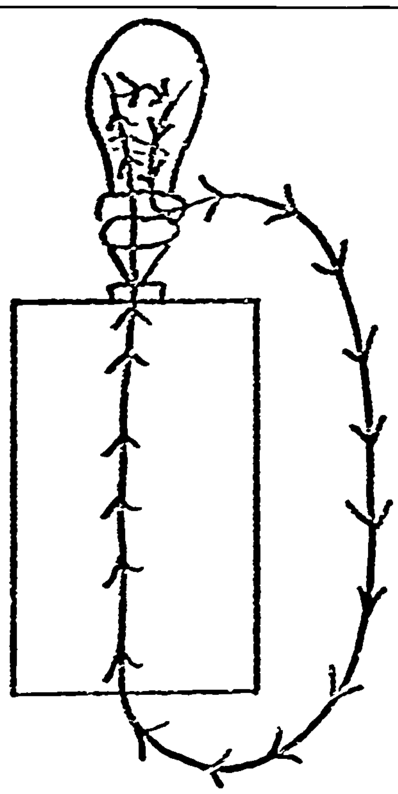
INSIDE OF A BULB



WHY DOES A BULB BURN OUT?

(BECAUSE THE THIN WIRE BURNS OUT)

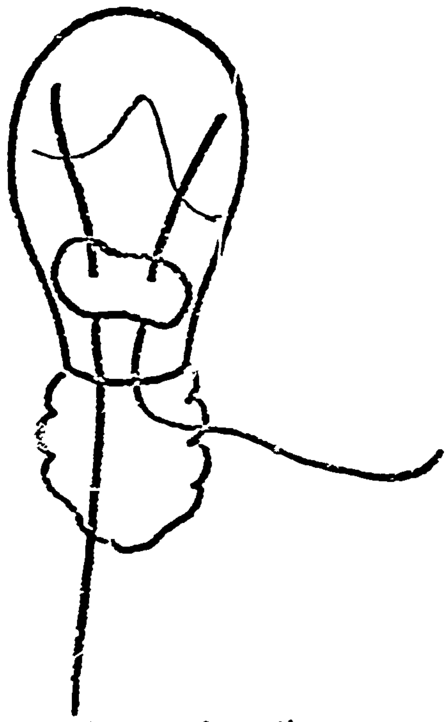
HOW THE ELECTRICITY TRAVELS



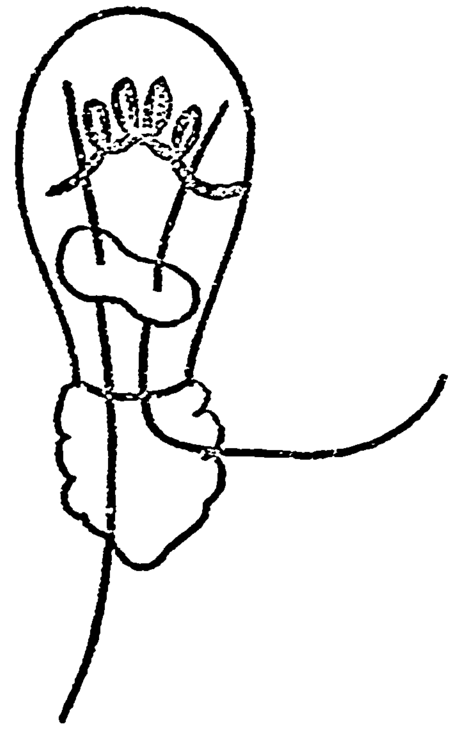
IT PASSES THROUGH THE SILVER TOP OF THE BATTERY THE GOLD SCREW OF THE BULB AND THE SILVER TIP OF THE BULB AND THE BOTTOM OF THE BATTERY. IT GOES FROM THE BATTERY TO THE THINWIRE OF THE BULB, WHERE IT MAKES THE BULB LIGHT, AND BACK TO THE BATTERY.

LESSON 9

2 Kinds of Bulbs



PINK BULB (45)



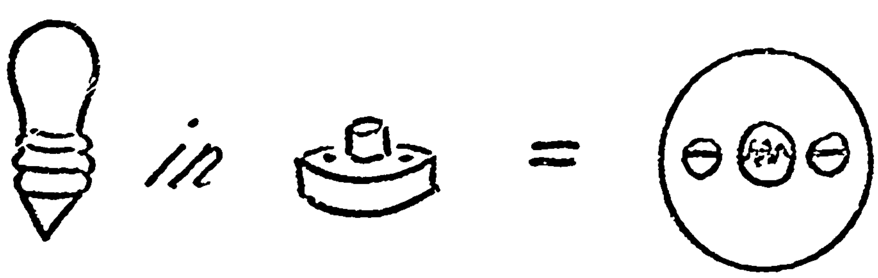
WHITE BULB (41)

WHAT IS DIFFERENT ABOUT THEM?

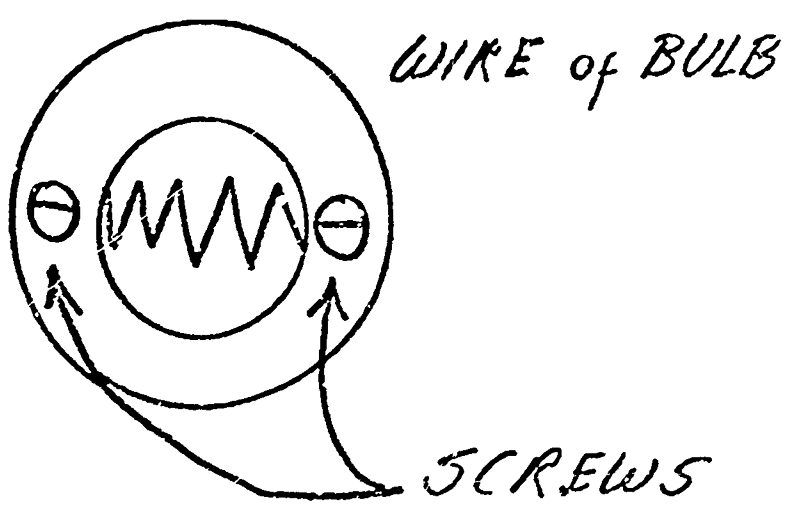
WHICH ONE WILL THE ELECTRICITY HAVE MORE TROUBLE GETTING THROUGH?

IT TAKES MORE ELECTRICITY TO GET THE PINK BULB TO LIGHT THAN TO GET THE WHITE BULB TO LIGHT.

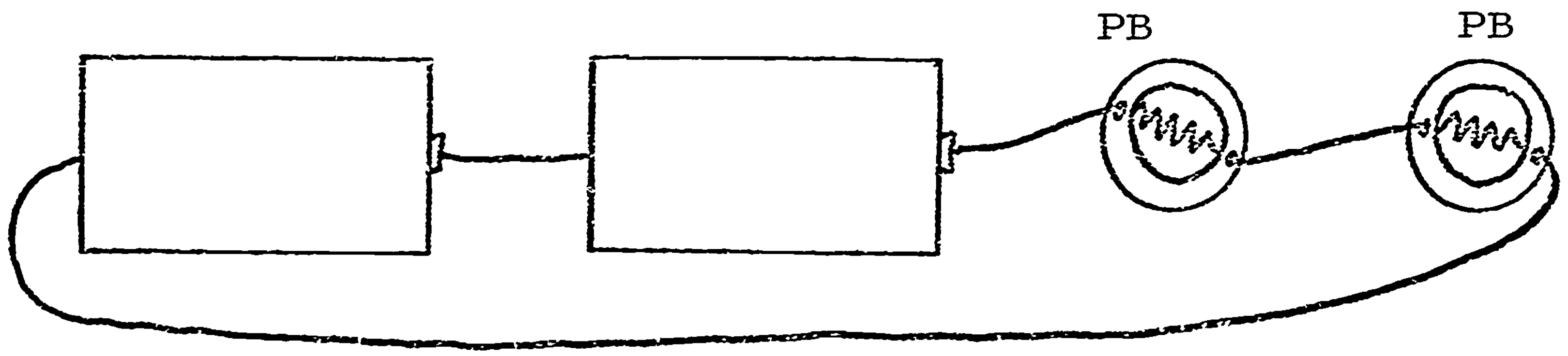
ANOTHER WAY TO DRAW A BULB IN A BULB HOLDER



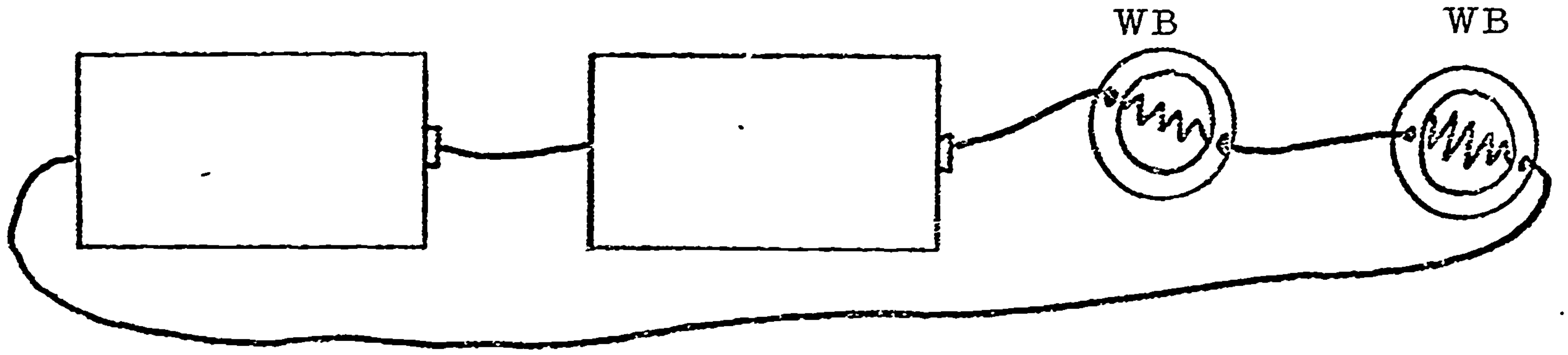
THIS IS A PICTURE OF A BULB IN A BULB HOLDER LOOKING FROM ABOVE.



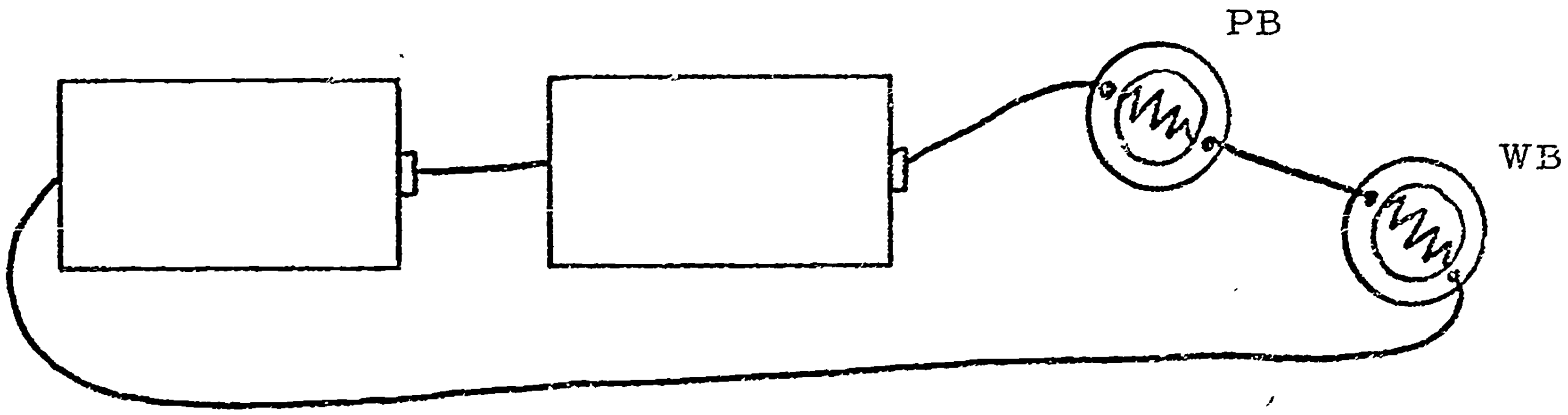
PINK AND WHITE BULBS IN THE SAME CIRCUITS



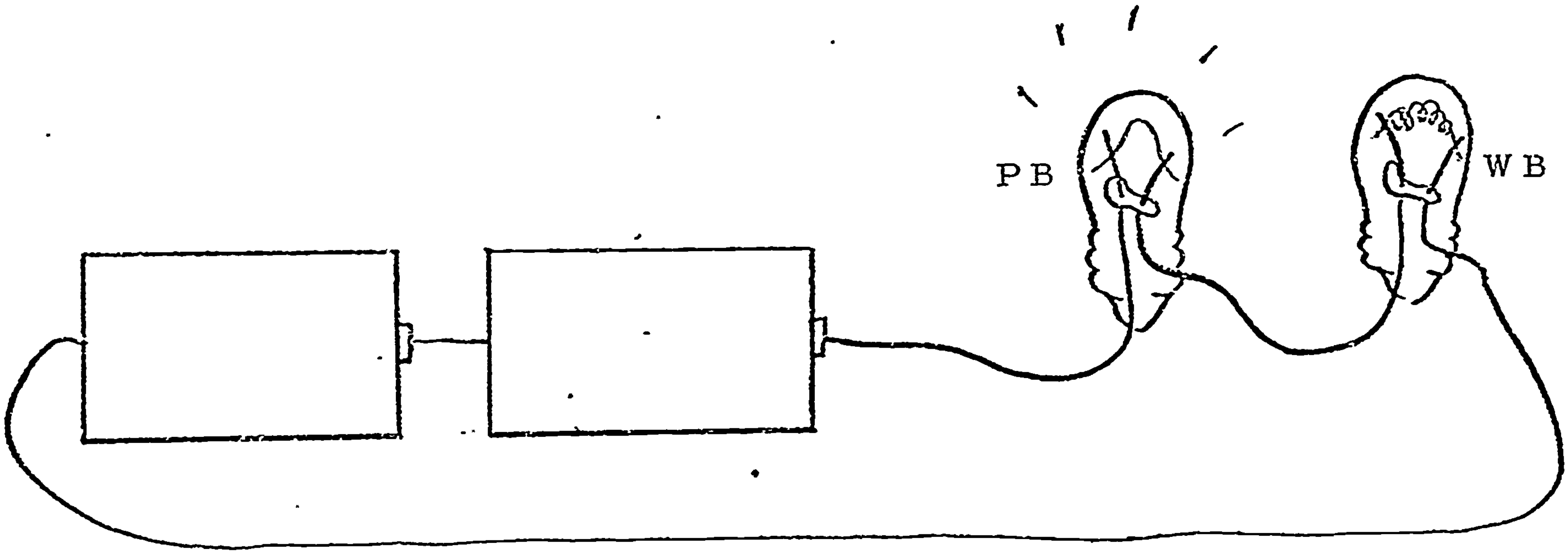
BOTH BULBS LIGHT - THE ELECTRICITY HAS TO PUSH TO GET THROUGH BOTH BULBS.



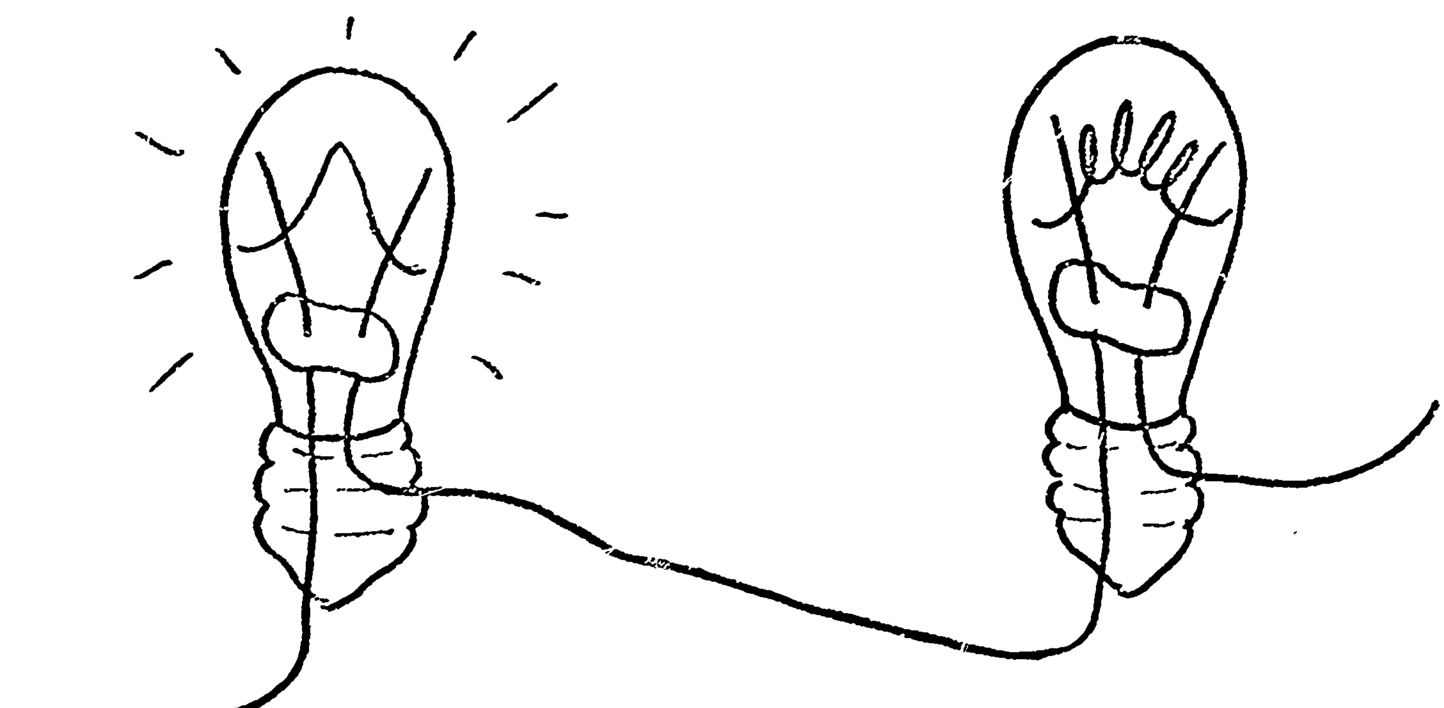
BOTH BULBS LIGHT - THE ELECTRICITY HAS TO PUSH TO GET THROUGH BOTH BULBS.



ONLY THE PB LIGHTS - THE ELECTRICITY HAS TO PUSH TO GET THROUGH THE PB BUT NOT THE WHITE BULB.

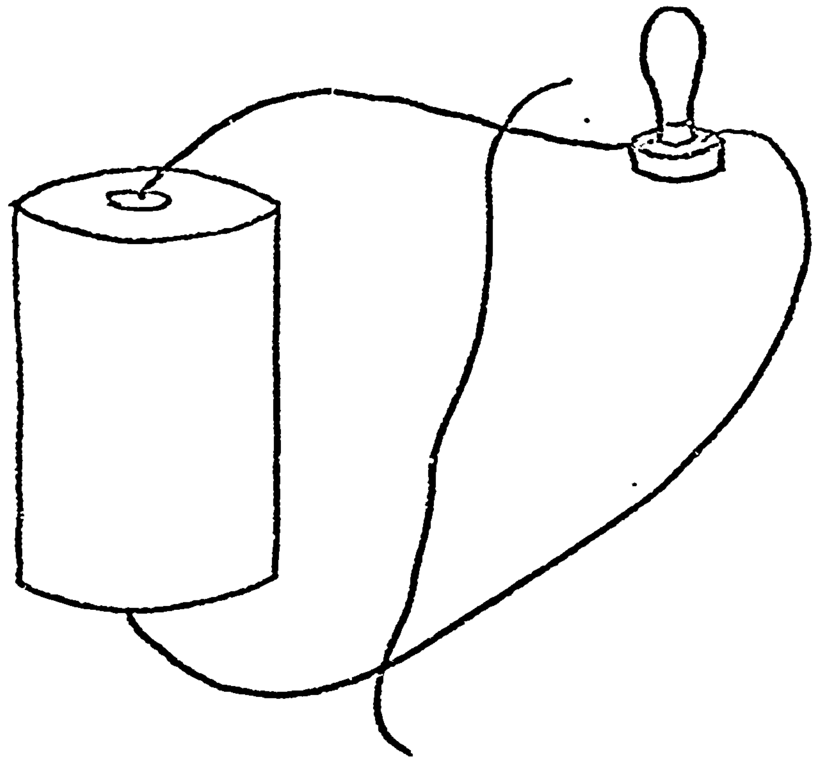


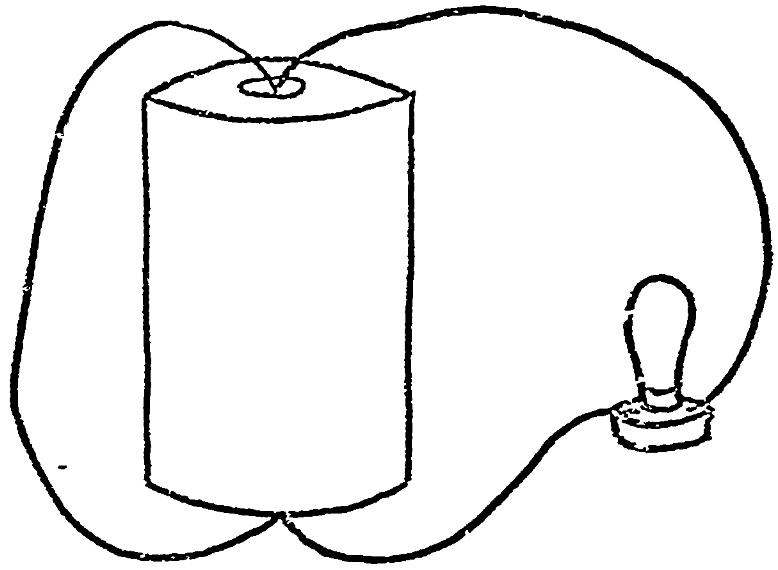
THE ELECTRICITY WILL ONLY LIGHT A BULB WHEN IT HAS TO PUSH AND WORK TO GET THROUGH IT. WHEN THE ELECTRICITY HAS TO PUSH TO GET THROUGH THE NARROW WIRE OF A PB, IT DOESN'T HAVE TO WORK TO GET THROUGH THE WIDER WB WIRE.



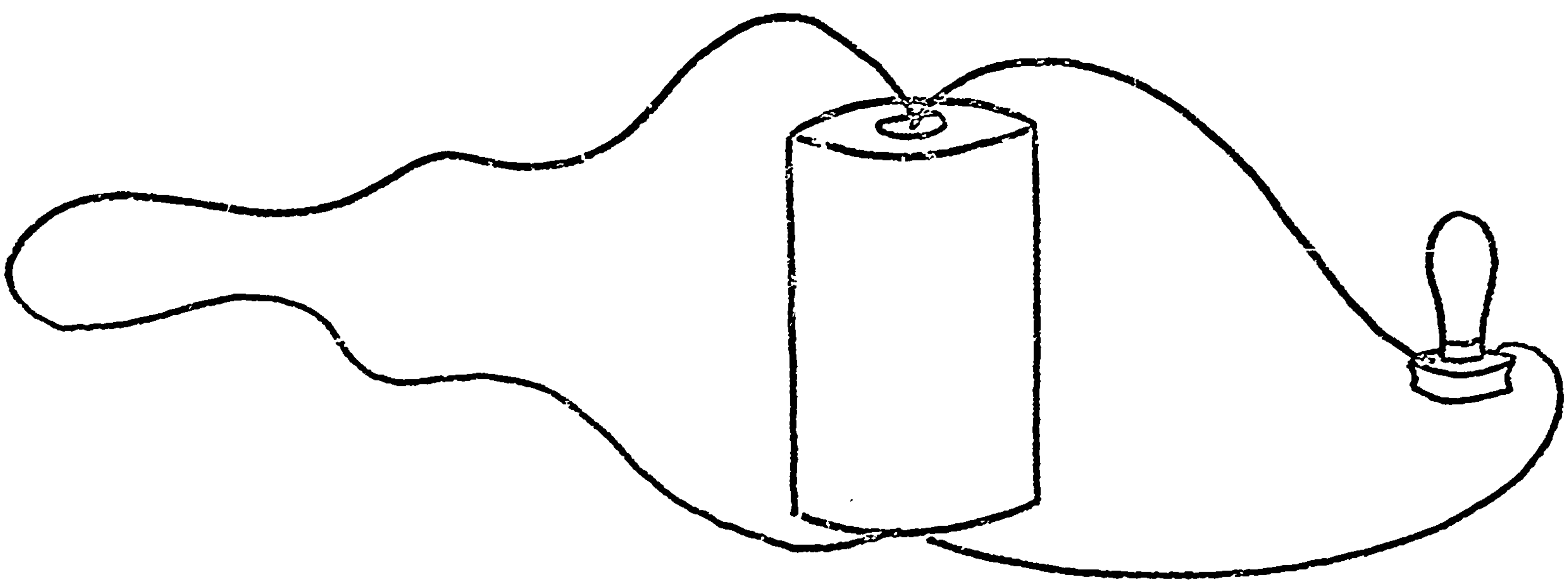
WHEN A PB AND A WB ARE TOGETHER IN THE SAME CIRCUIT, <u>ONLY THE PB LIGHTS</u>.

SHORT CIRCUITS

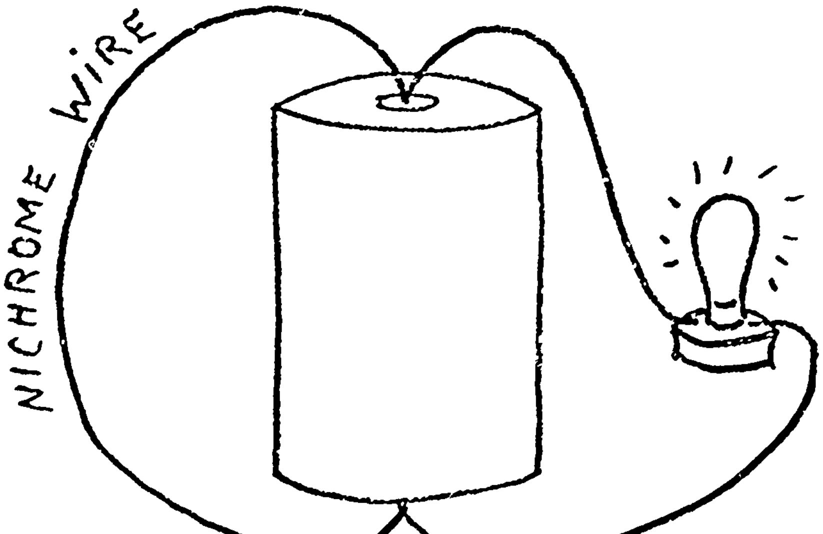




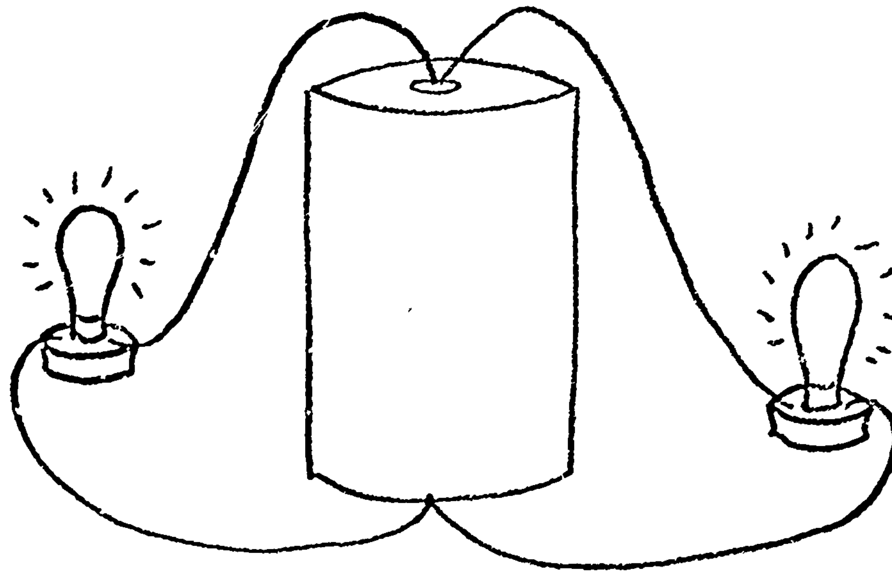
THE ELECTRICITY TAKES THE EASIER PATH IN BOTH THESE CIRCUITS. THE BULB DOES <u>NOT</u> LIGHT.



THOUGH THE WIRE IS LONGER, IT IS STILL AN EASIER PATH.

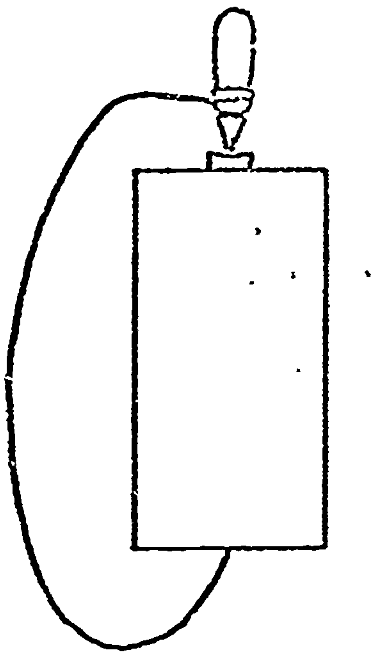


A piece of Nichrome wire does not make an easier path; does not short our battery.

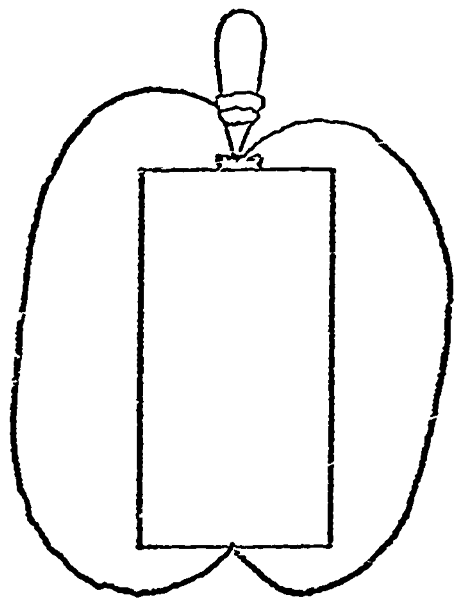


Both paths equally hard NO short circuit.

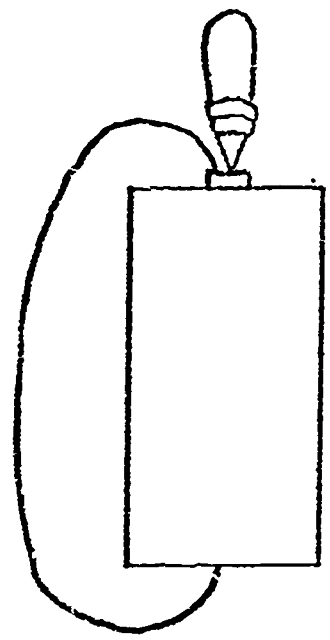
TRACE THE FLOW OF ELECTRICITY IN THESE SET-UPS



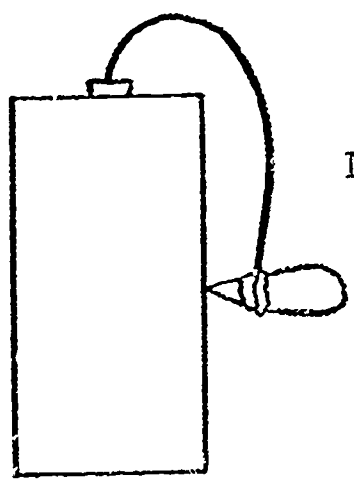
COMPLETE CIRCUIT
THROUGH THE BULB



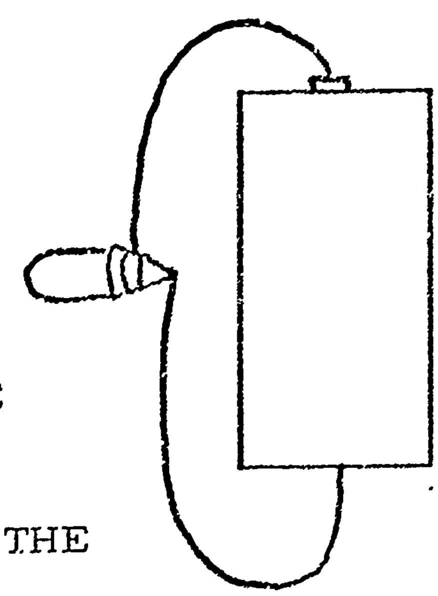
SHORT CIRCUIT MADE
BY THE EXTRA WIRE



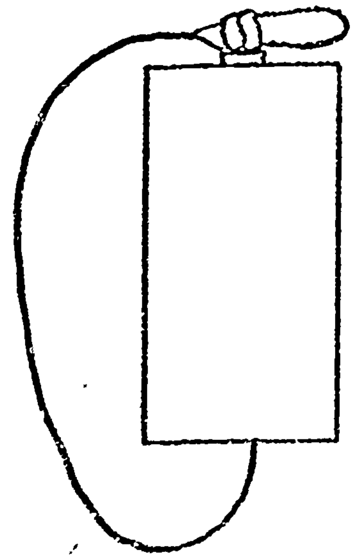
CIRCUIT DOES NOT
PASS THROUGH THE
BULB



NO CIRCUIT



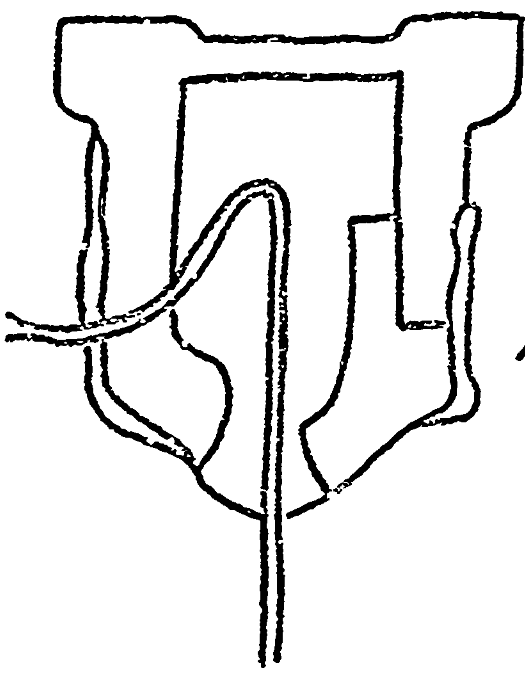
COMPLETE
CIRCUIT
THROUGH THE
BULB



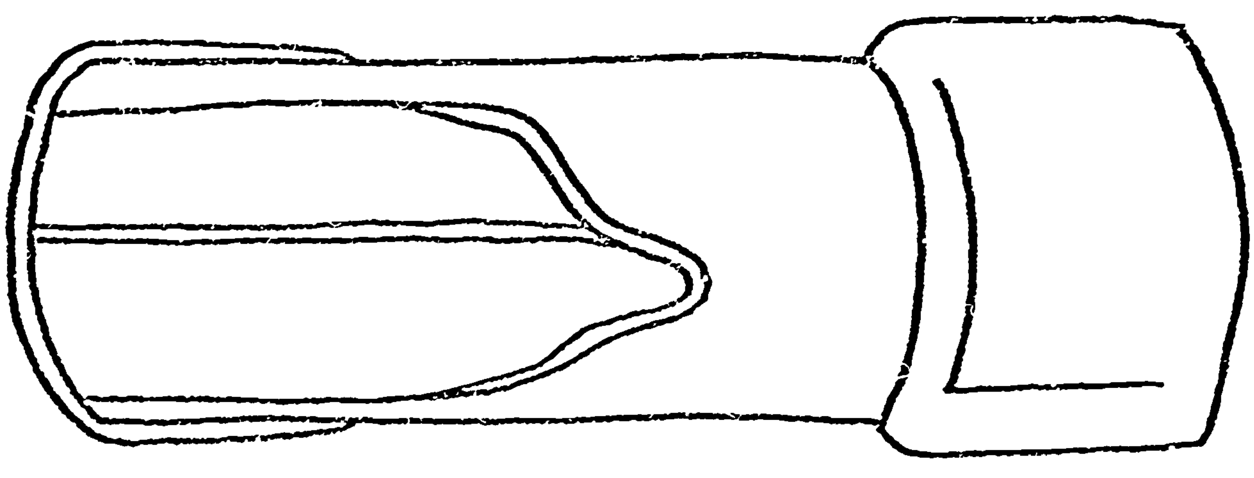
COMPLETE CIRCUIT
THROUGH THE BULB

FUSES

FUSE: A small round piece with a thin wire which is added to a circuit so that if the wires get too hot in the circuit, the thinner metal wire in the FUSE will melt and the circuit will be broken. This is used to protect against fires from overheated wires.

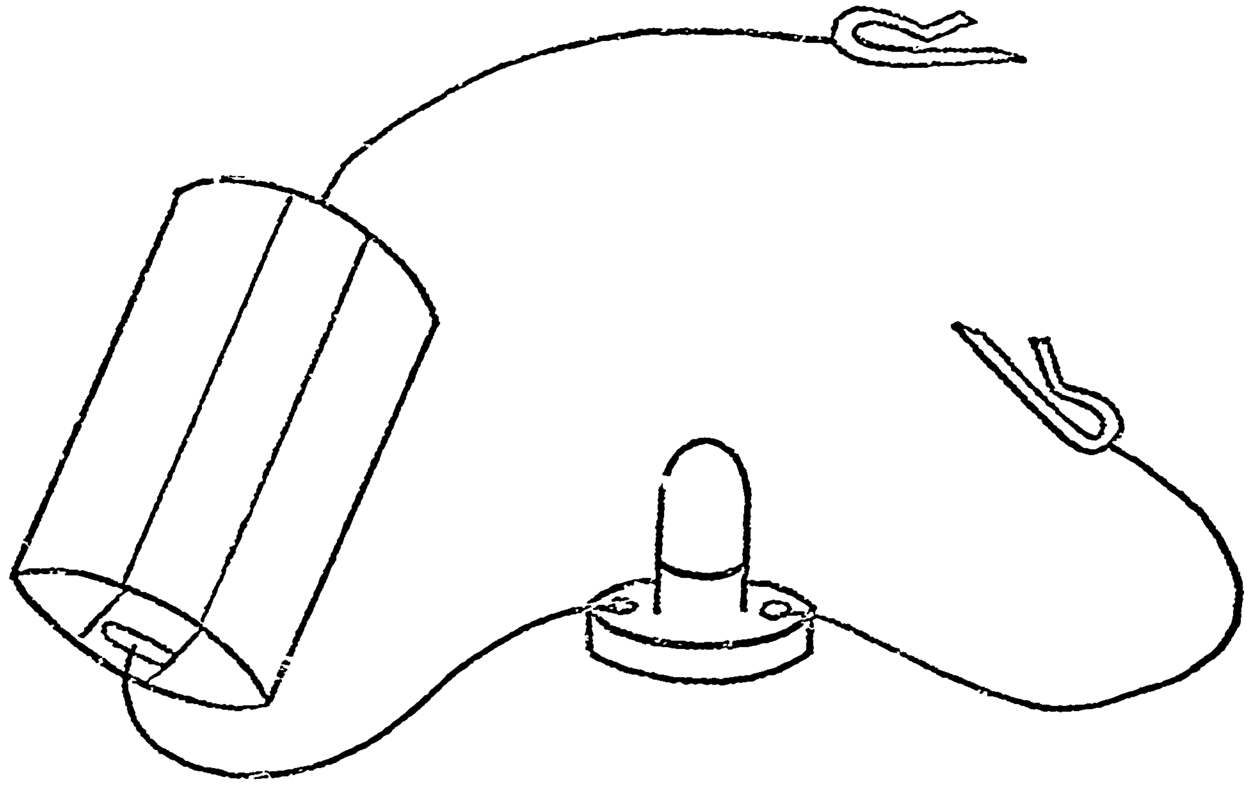


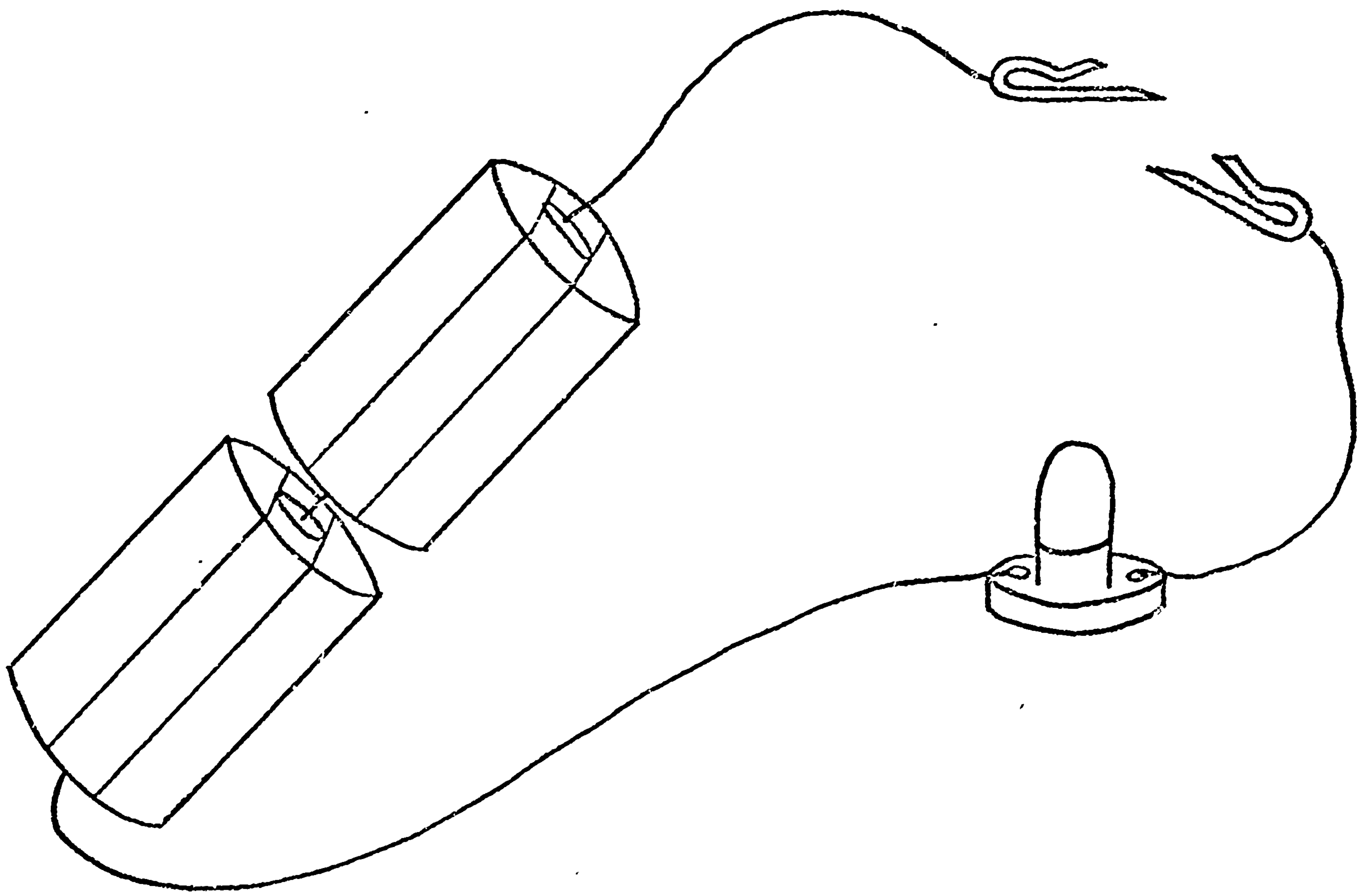
plug fuse



cartridge fuse

TESTERS





LESSON 10

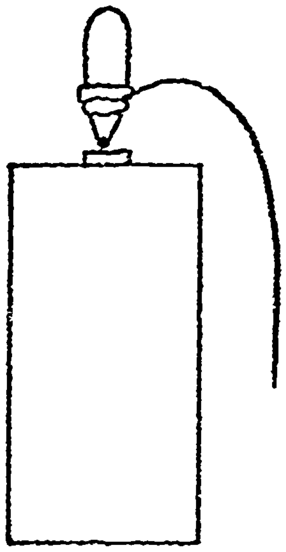
SOLUTION	TYPE OF BULB	ONE BATTERY	TWO BATTERIES	BRIGHTNESS Bright Standard Dim
WATER	PB			
	WB			
SALT WATER	PB			
	WB			
BAKING SODA	PB			
	WB			
COMET CLEANSER	PB			
	WB			
COOKING OIL	PB			
	WB			

REVIEW

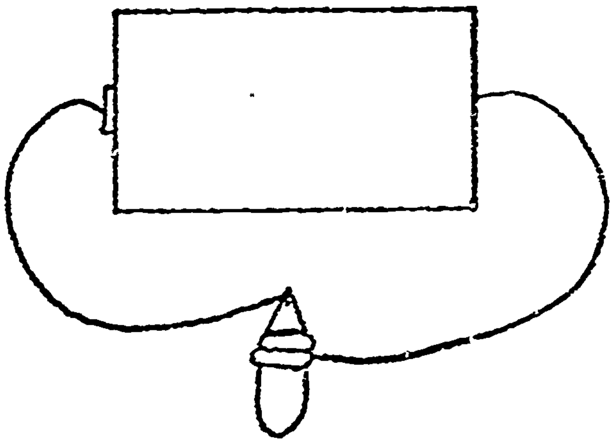
REVIEW

Will the following bulbs light in these set-ups?
Check the path the electricity follows and the two parts of the BATTERY and two places on the BULB which must be touched to be part of the circuit.

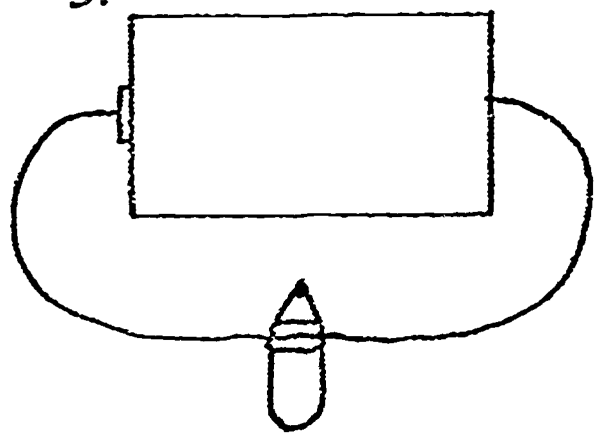
1.



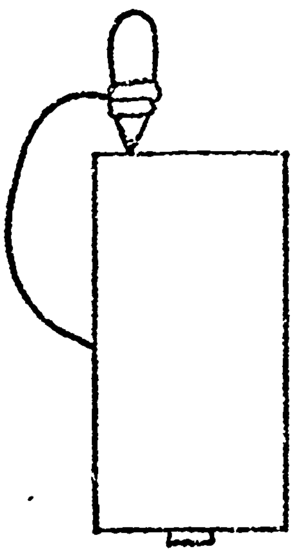
2.



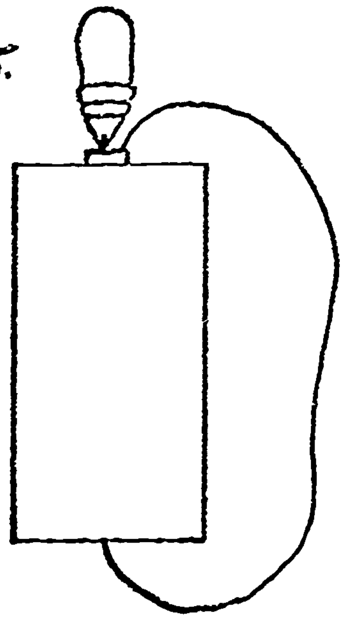
3.



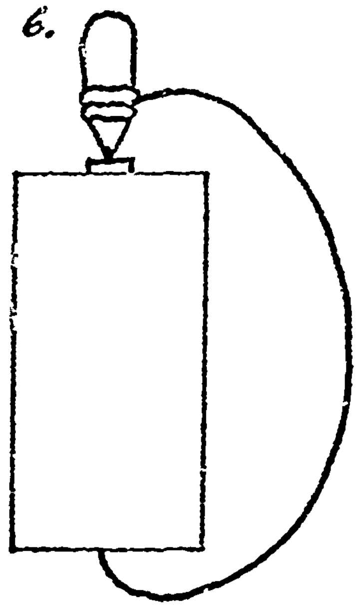
4



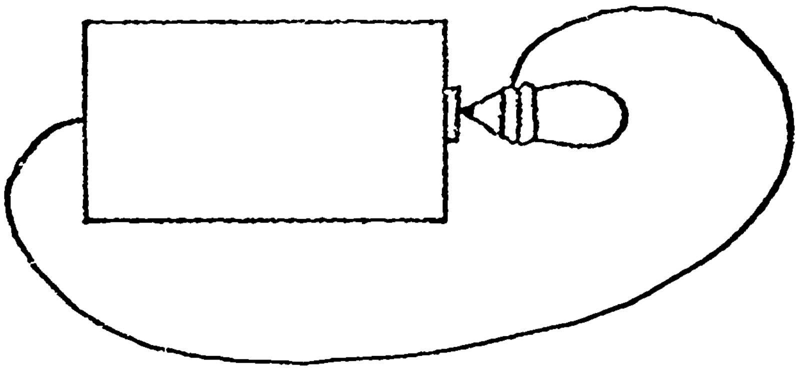
5.



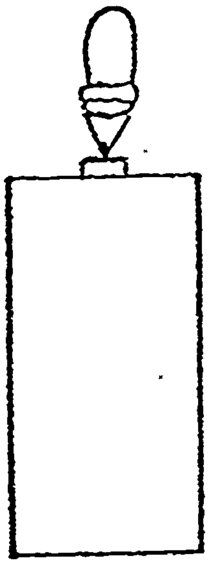
6.



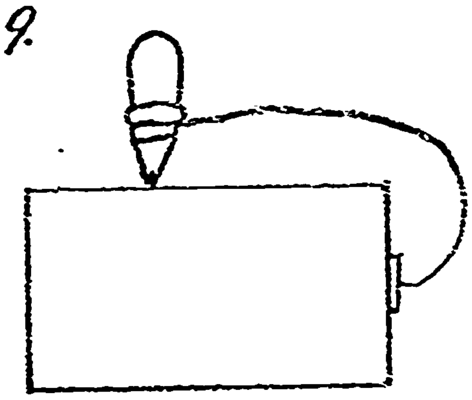
7.



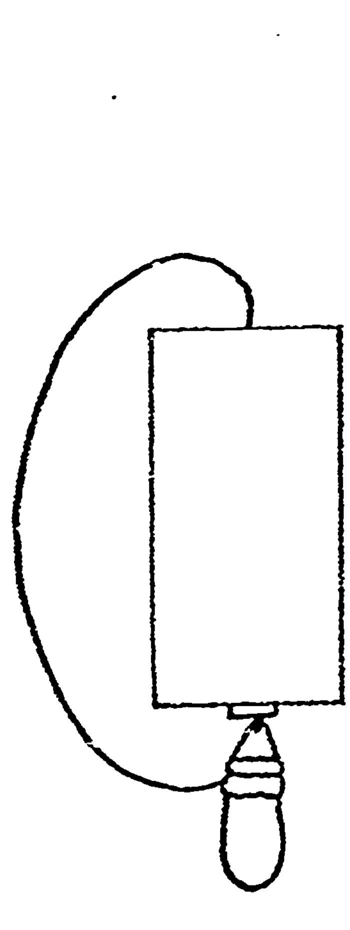
8.



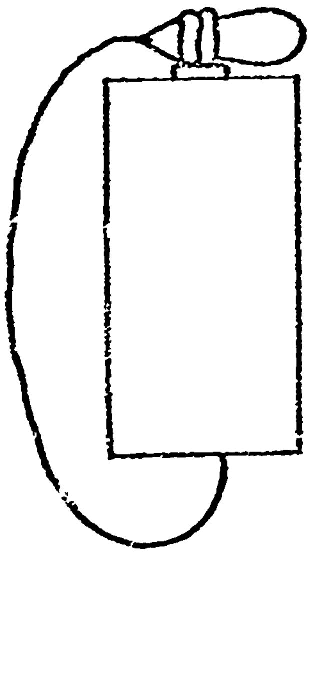
9.



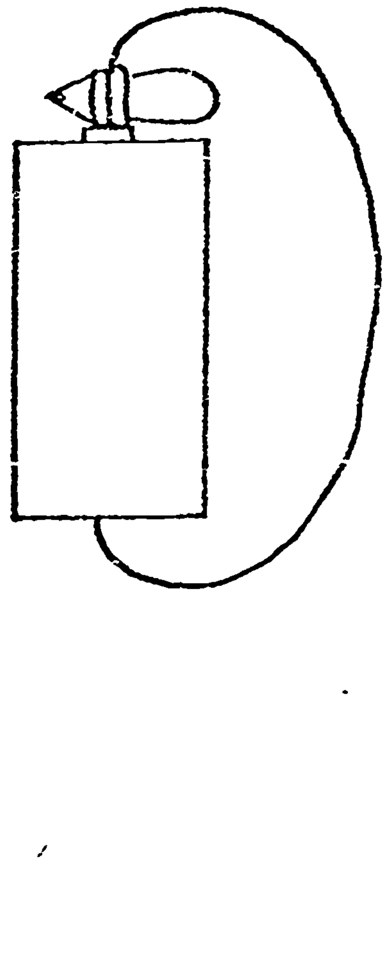
10.



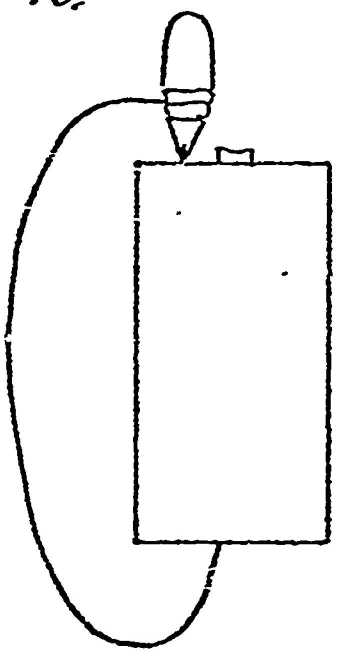
11.



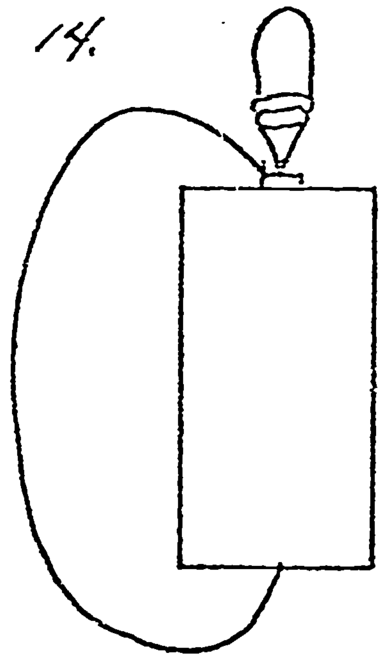
12.



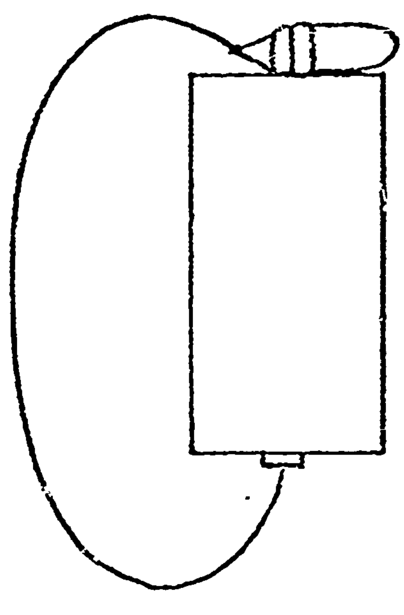
13.



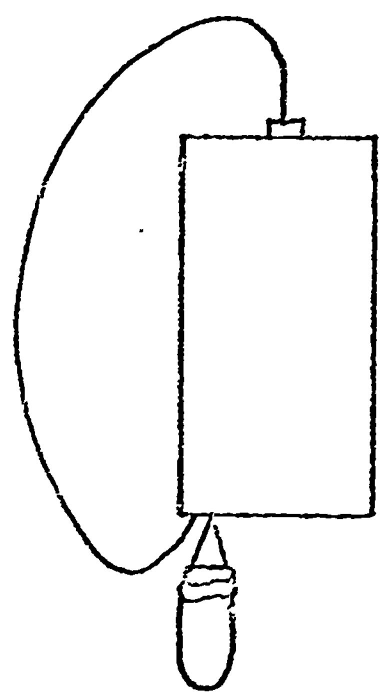
14.



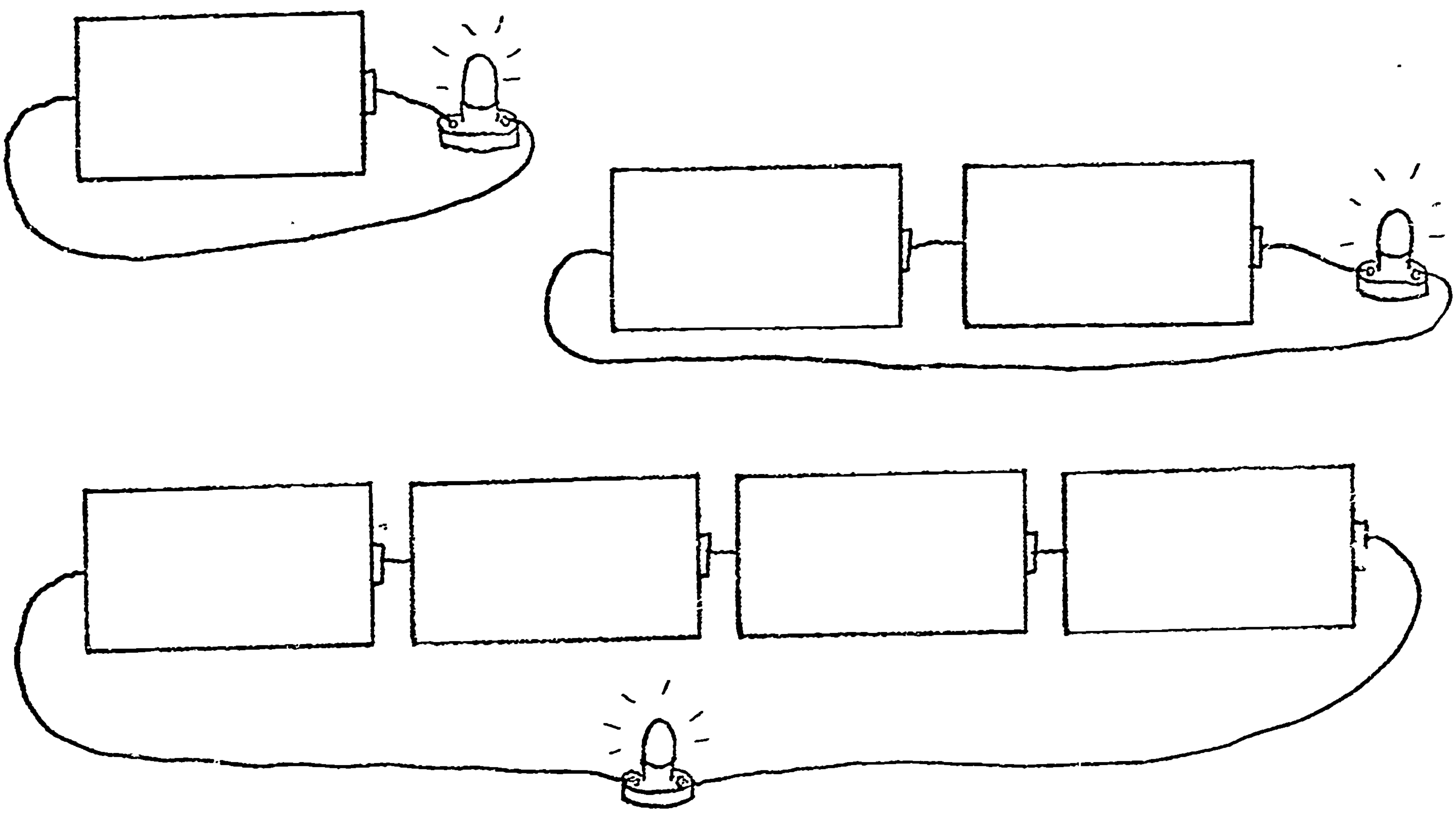
15.



16.

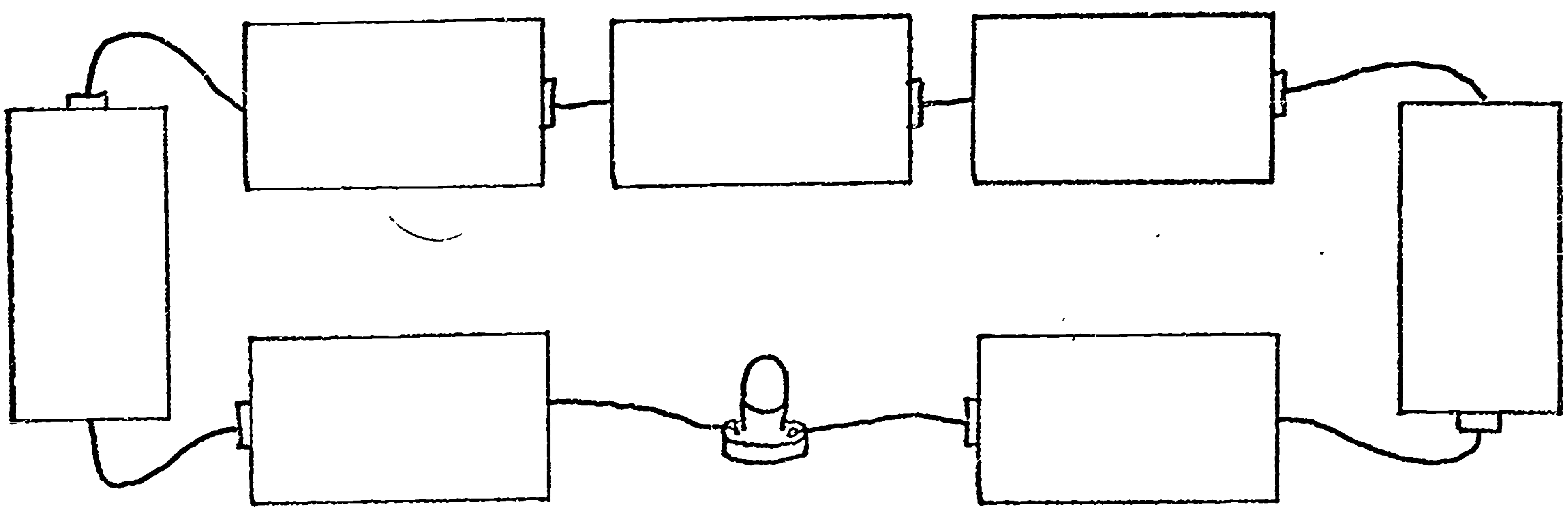


Batteries in Series



MORE BATTERIES ADD MORE POWER

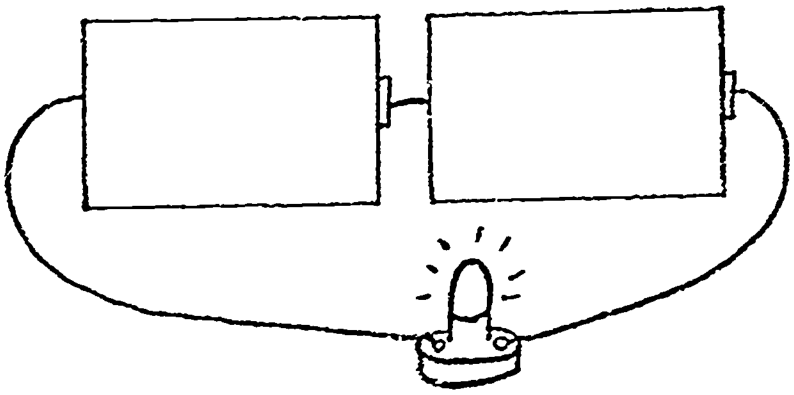
THE BULB GETS BRIGHTER AND BRIGHTER

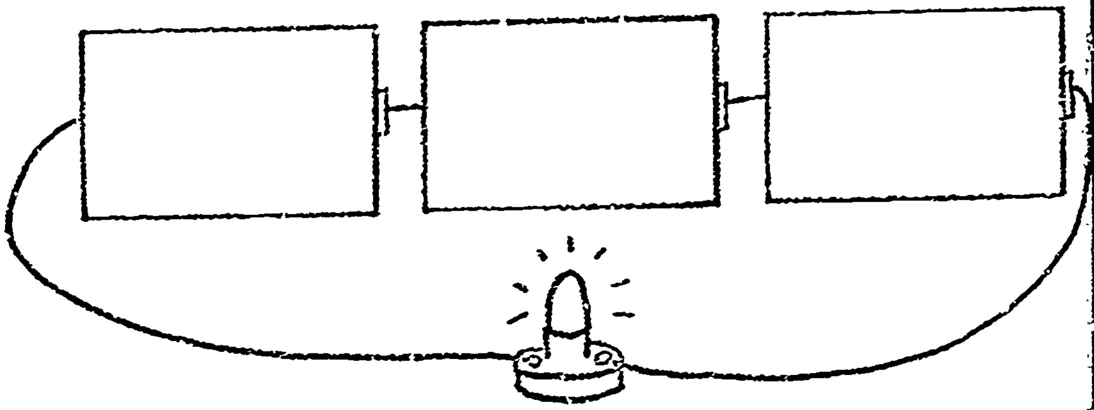


ENOUGH BATTERIES WILL BLOW A BULB OUT

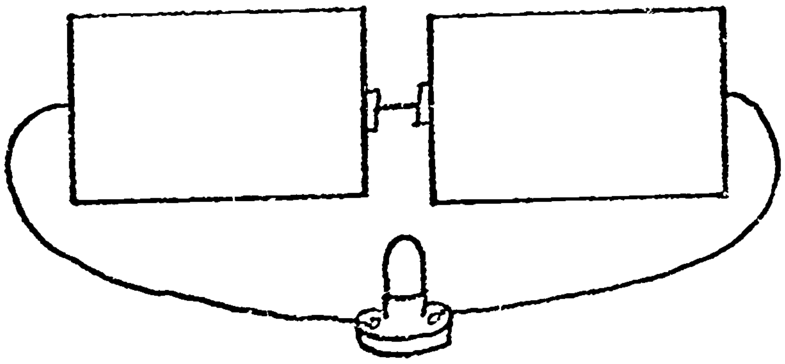
SERIES BATTERIES

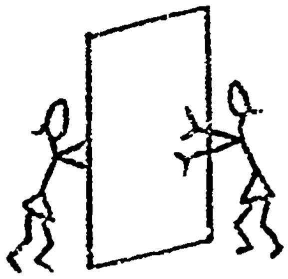
When batteries are facing the same direction, power will travel from one battery through the next (the bulb will light MORE BRIGHTLY with each battery)



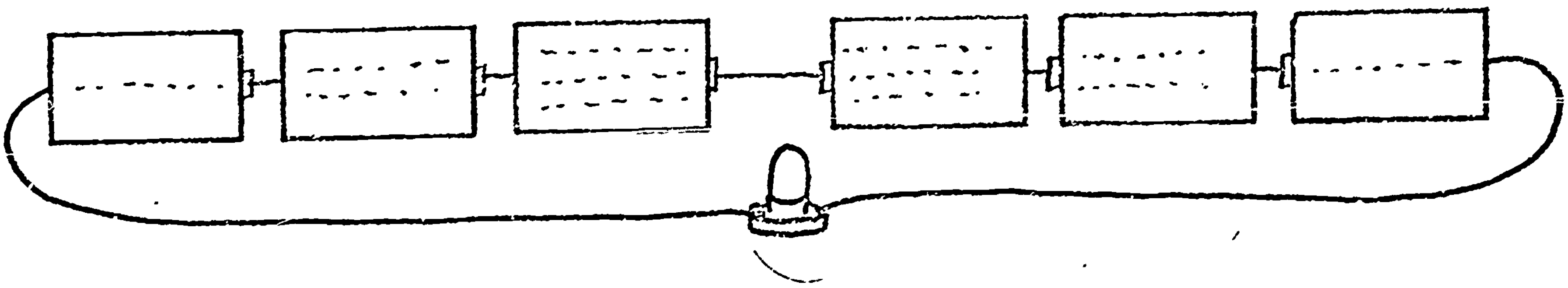


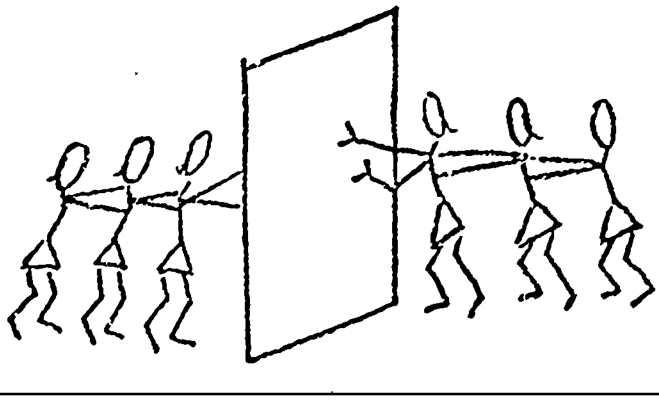
When batteries are facing one another, the power in one pushes against the power in the other and the bulb will NOT LIGHT ; it is like two people pushing against a swinging door - neither one can get through.



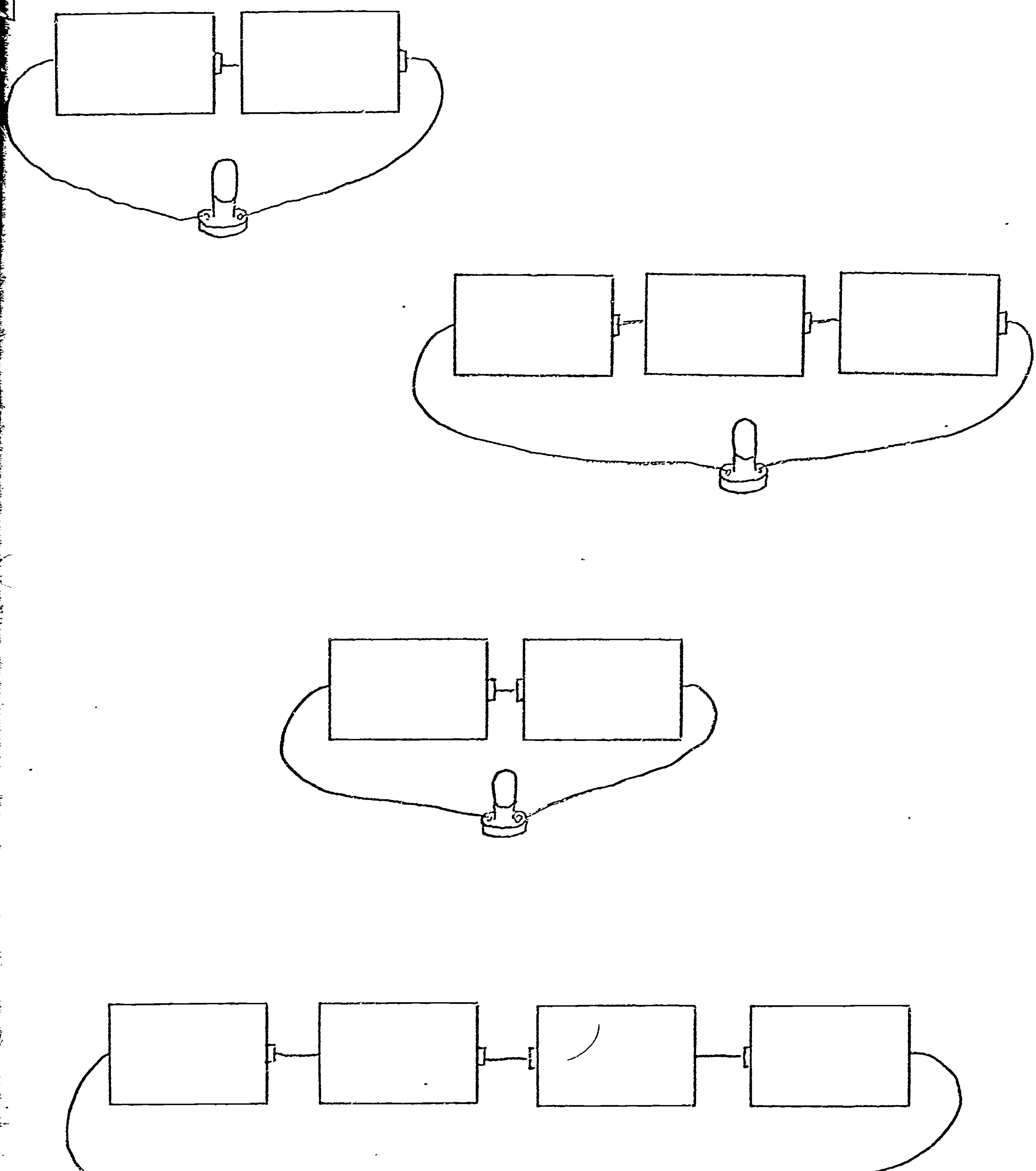


WHAT IS HAPPENING HERE?

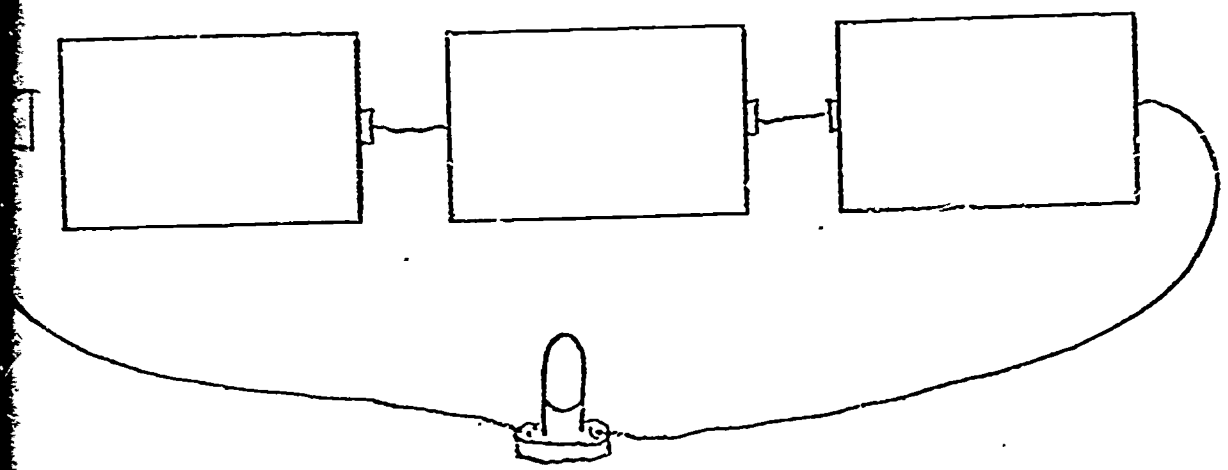


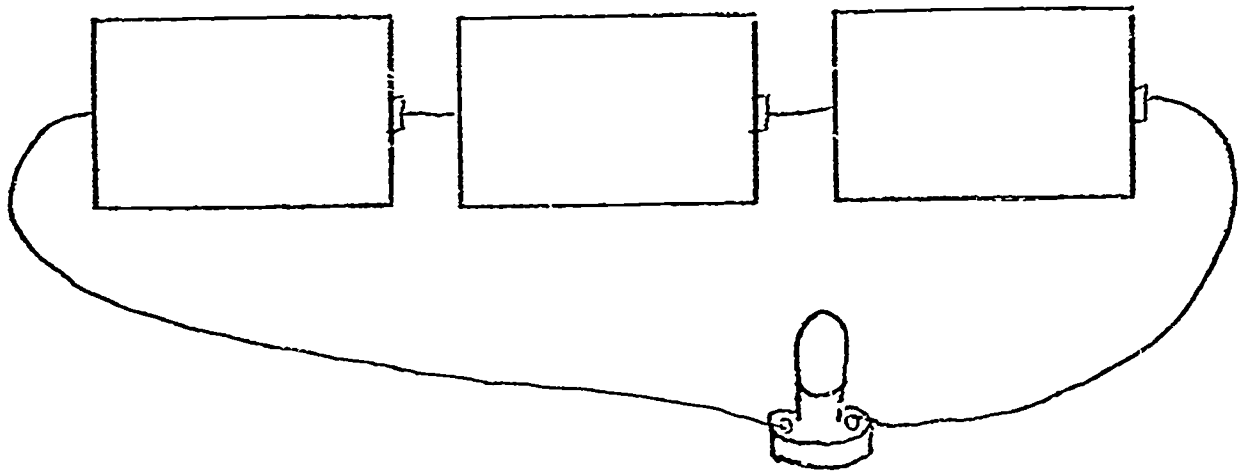


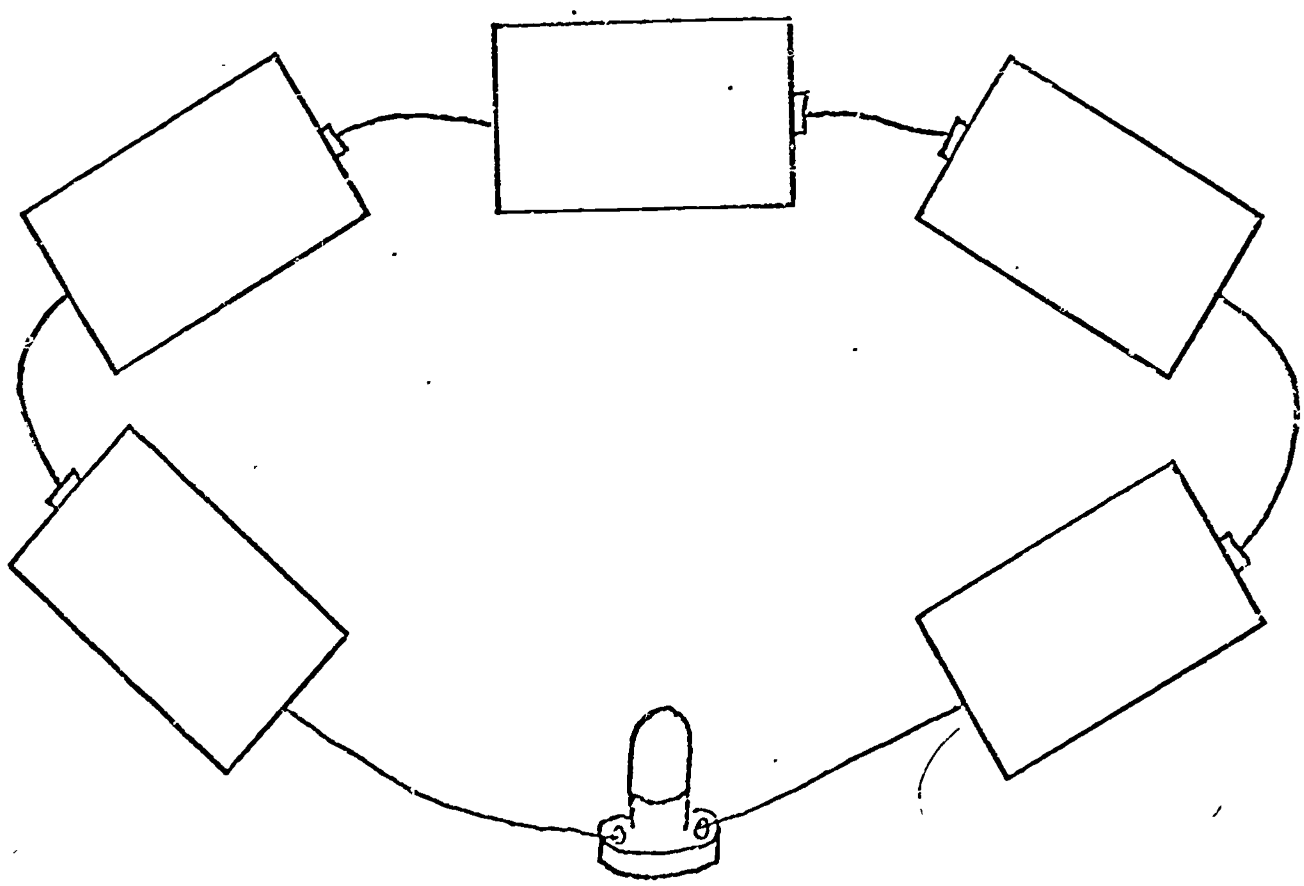
WHAT IS HAPPENING HERE?

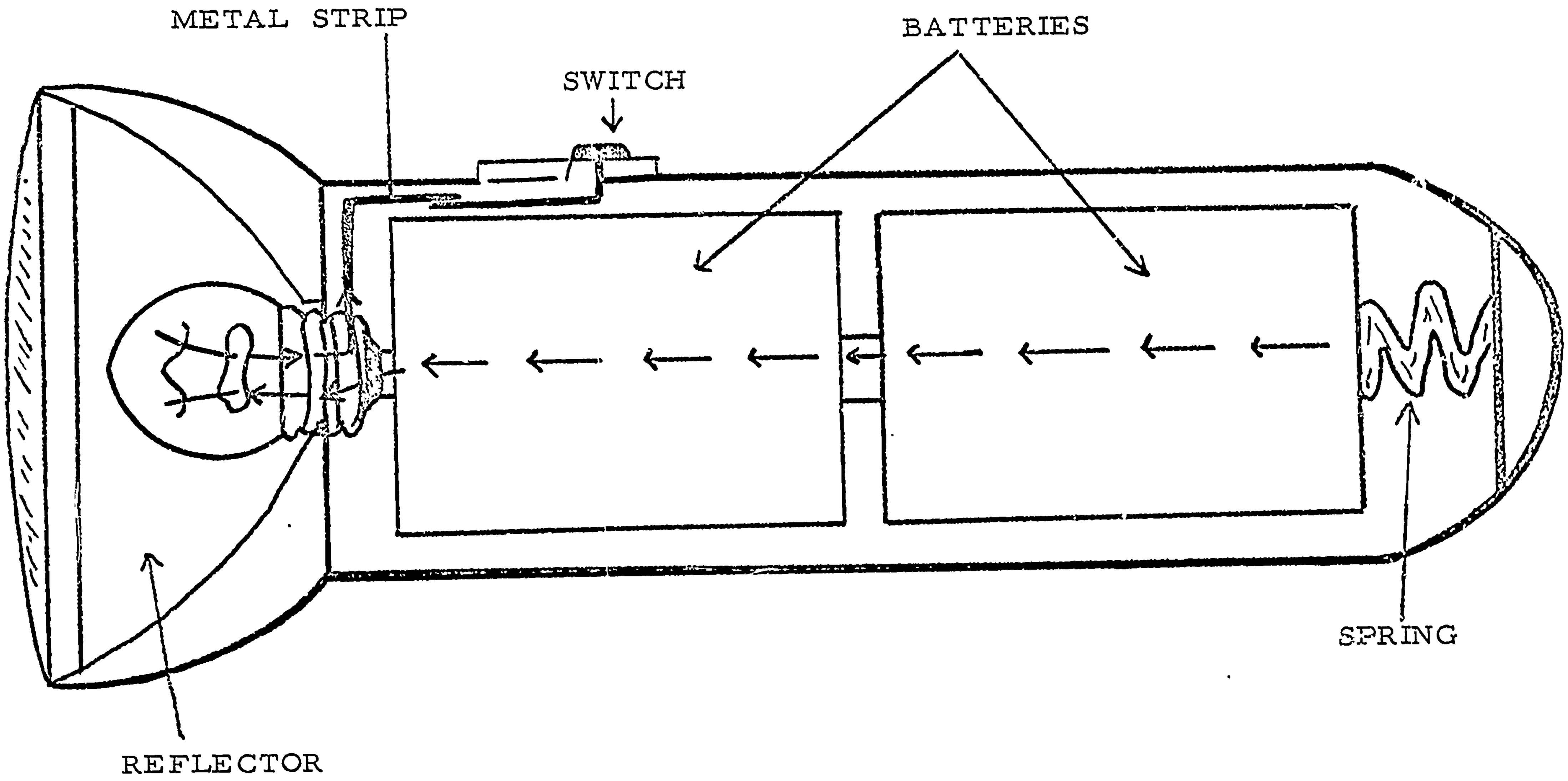


WHAT IS HAPPENING HERE?



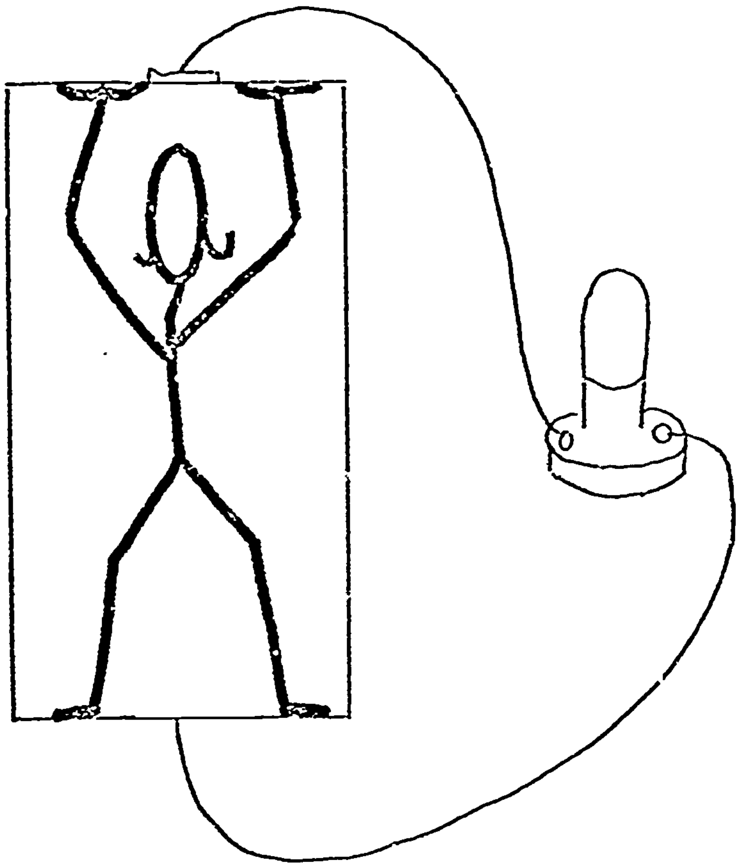




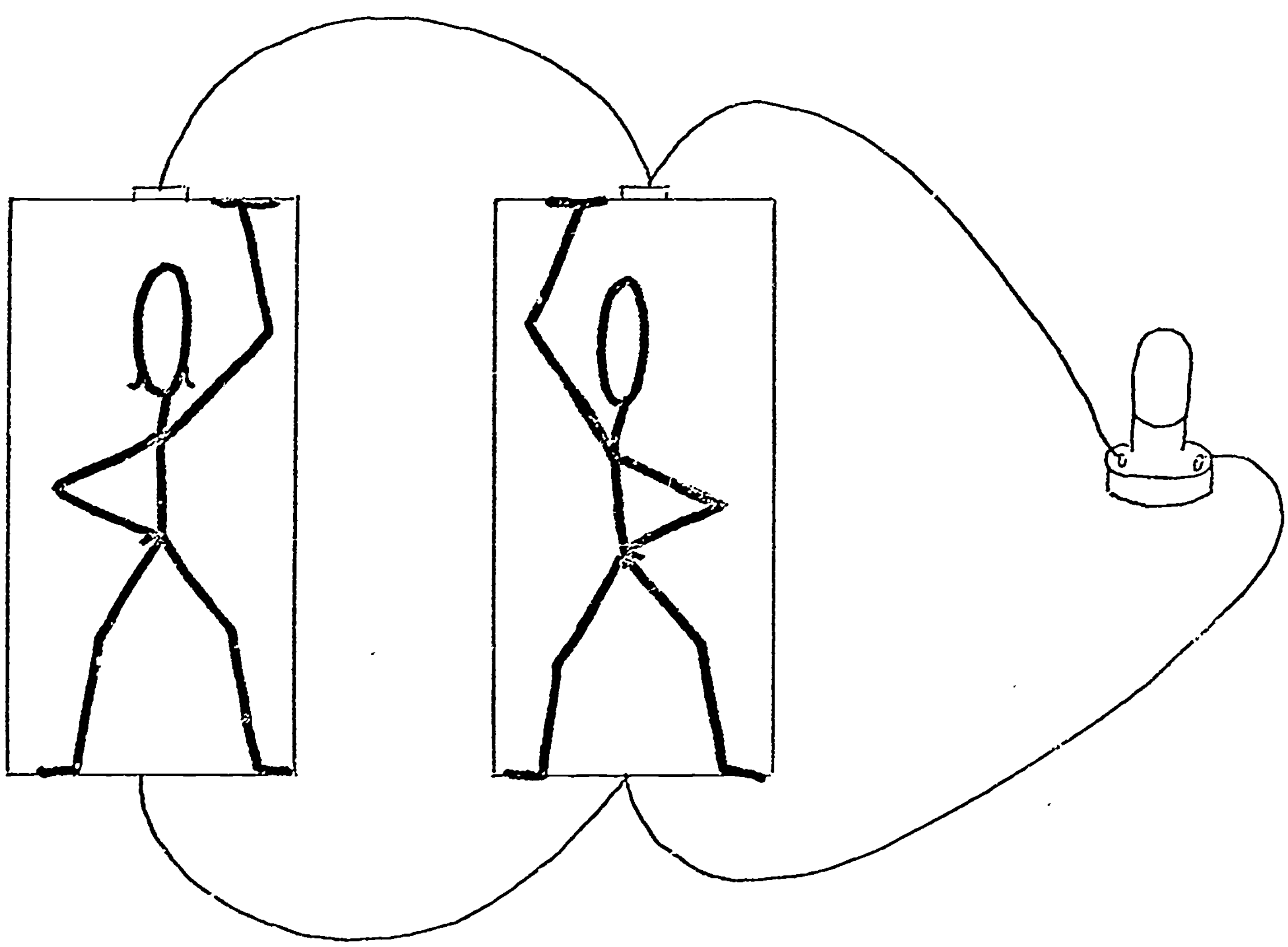

METAL STRIP
SWITCH
BATTERIES
SPRING
REFLECTOR

PARALLEL BATTERIES

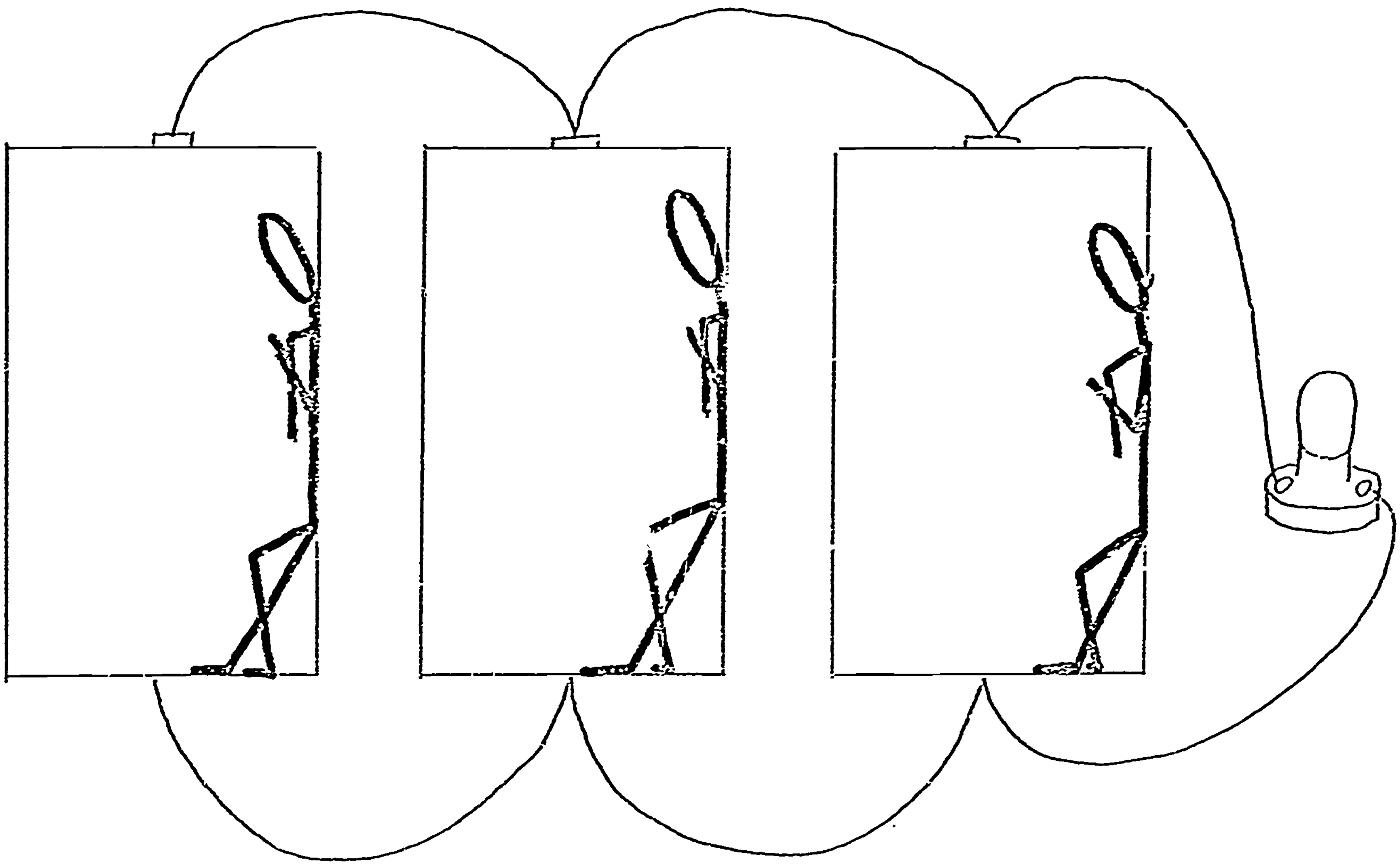
AS WE ADD MORE BATTERIES~ EACH BATTERY PUTS OUT LESS WORK



BATTERY USING FULL STRENGTH

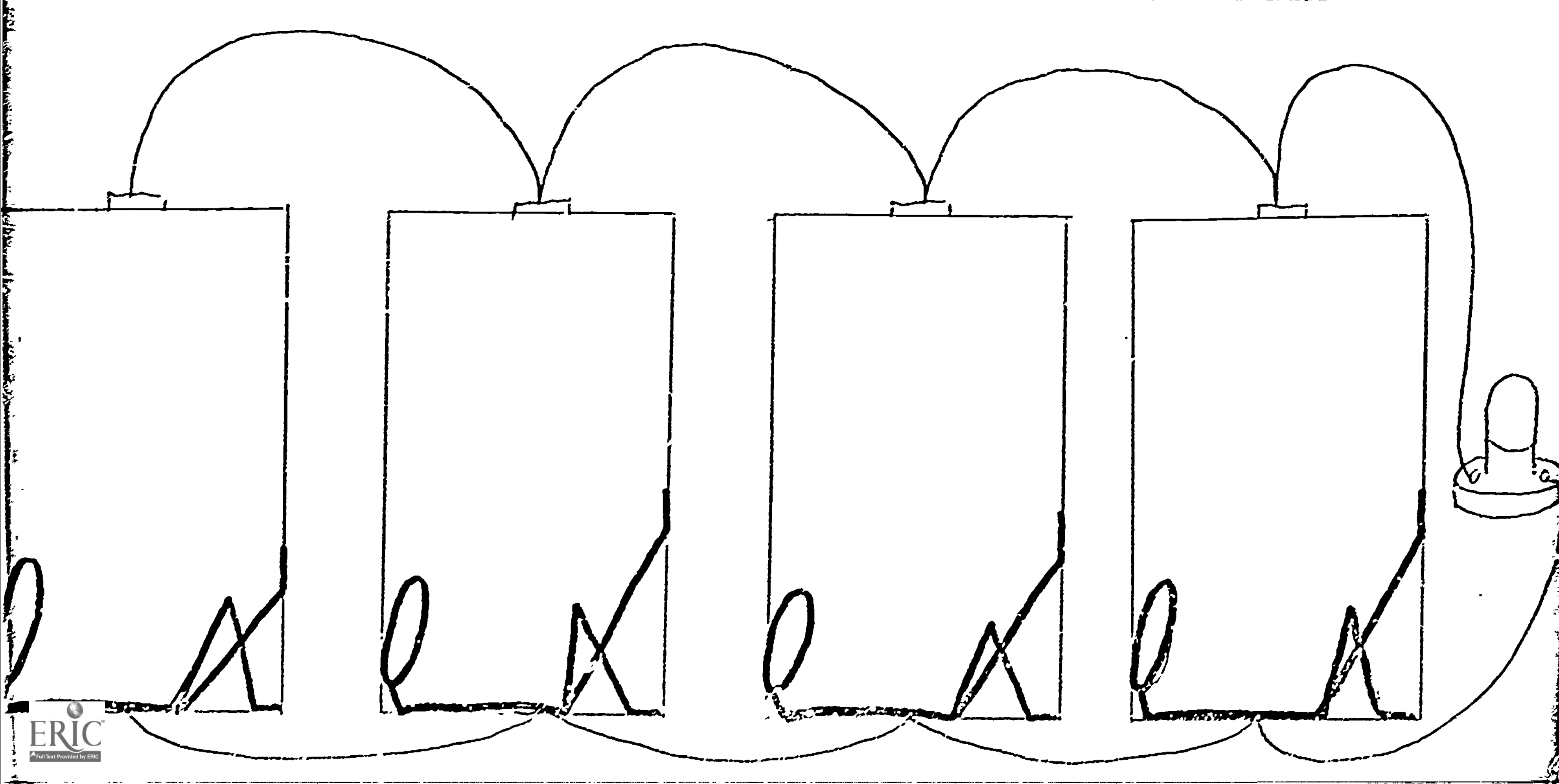


BATTERY USING ONLY 1/2 STRENGTH

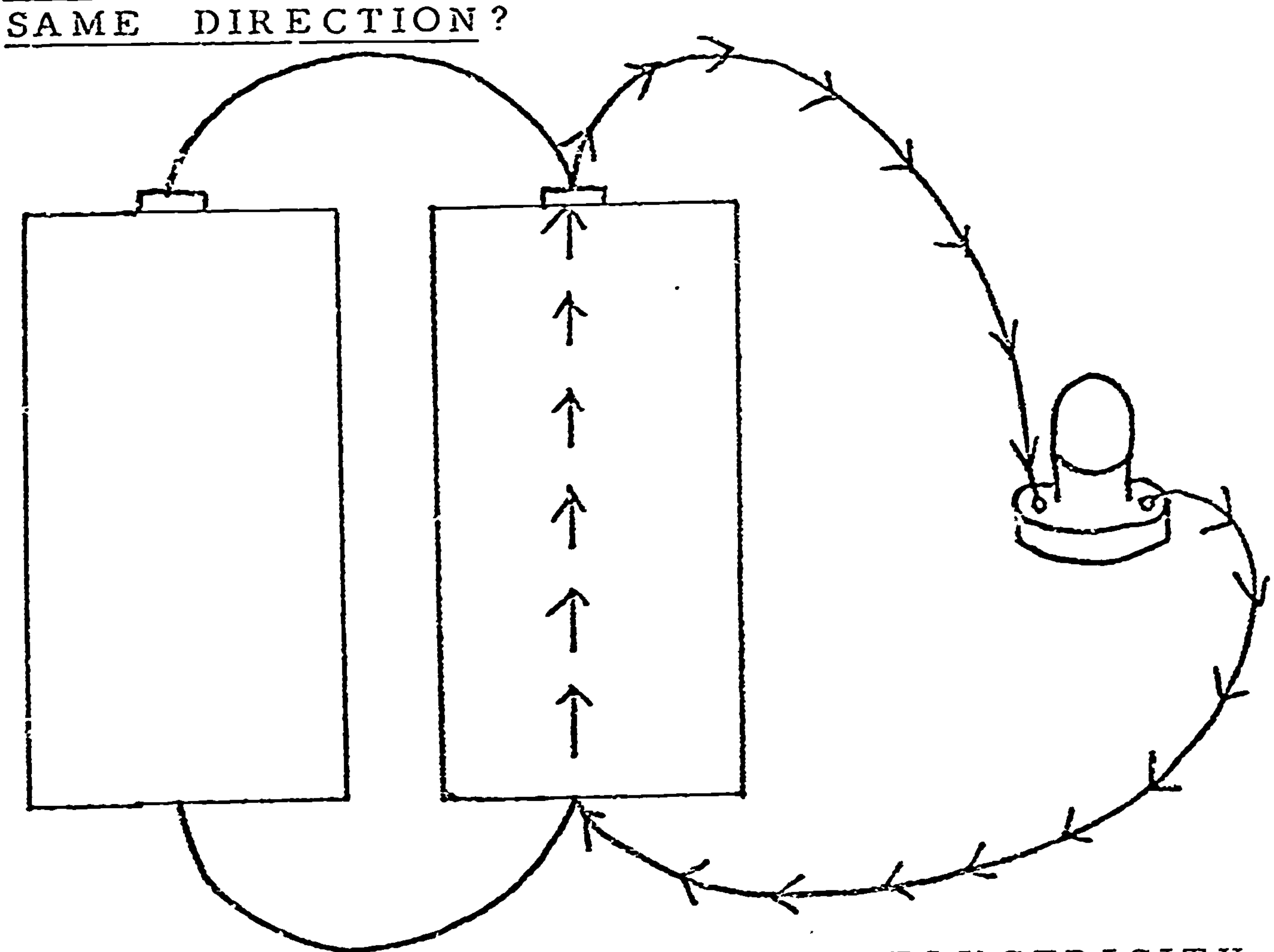


BATTERY ONLY USING ONE-THIRD STRENGTH

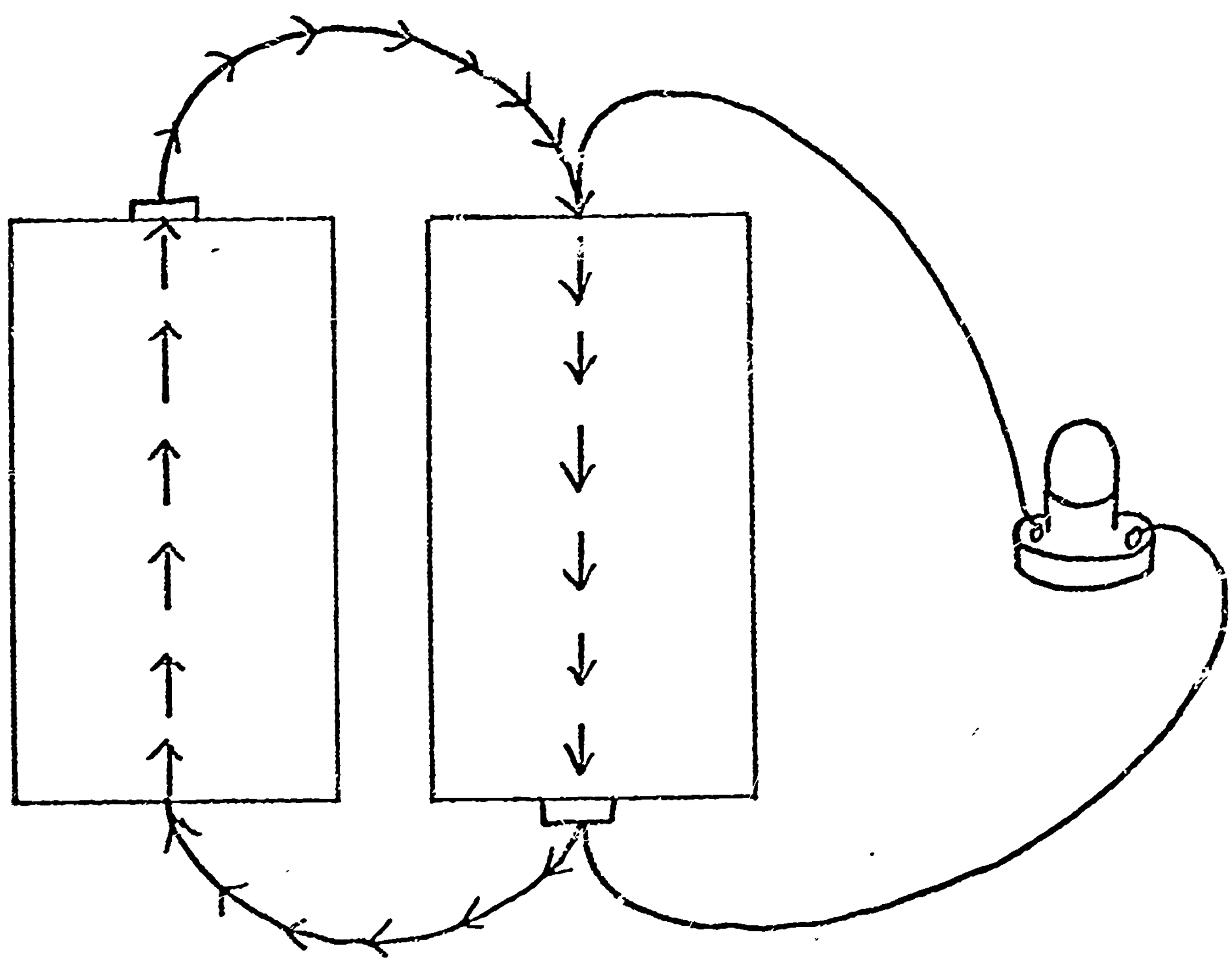
BATTERY USING ONLY ONE-FOURTH STRENGTH



DO PARALLEL BATTERIES HAVE TO POINT IN THE SAME DIRECTION?



FLOW OF ELECTRICITY WHEN THEY DO

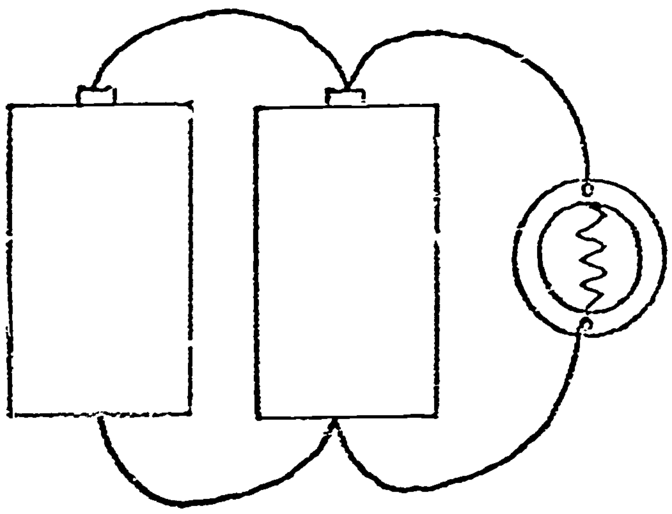


SHORT CIRCUIT OF BATTERIES WHEN THEY DO NOT

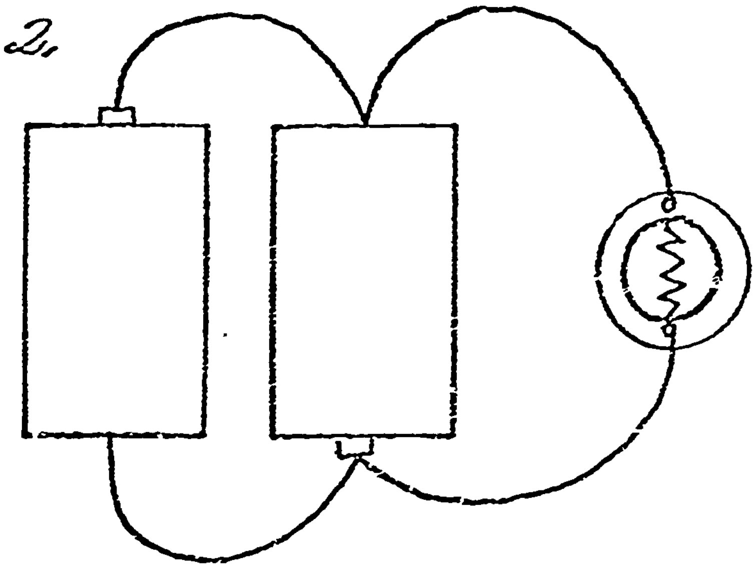
PARALLEL BATTERIES

Compare the brightness of the following set-ups to s andard brightness. What is happening in each one?

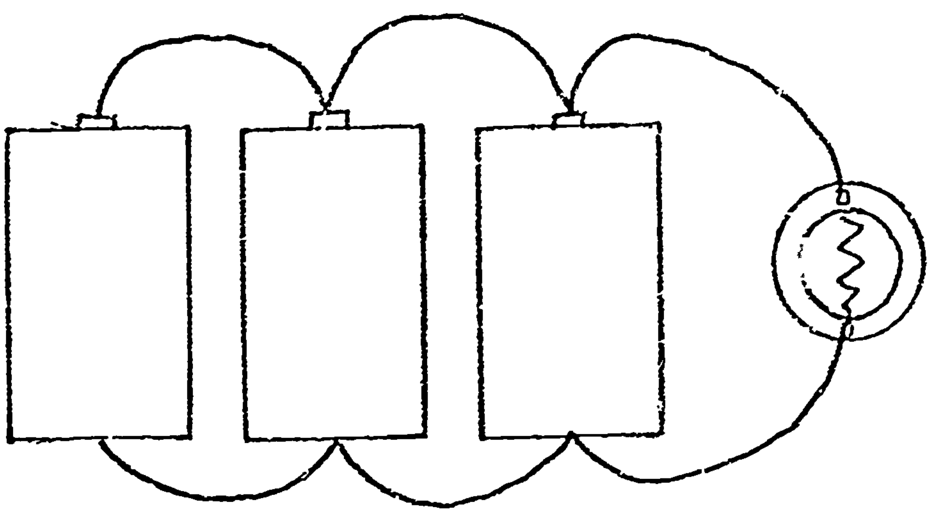
1.



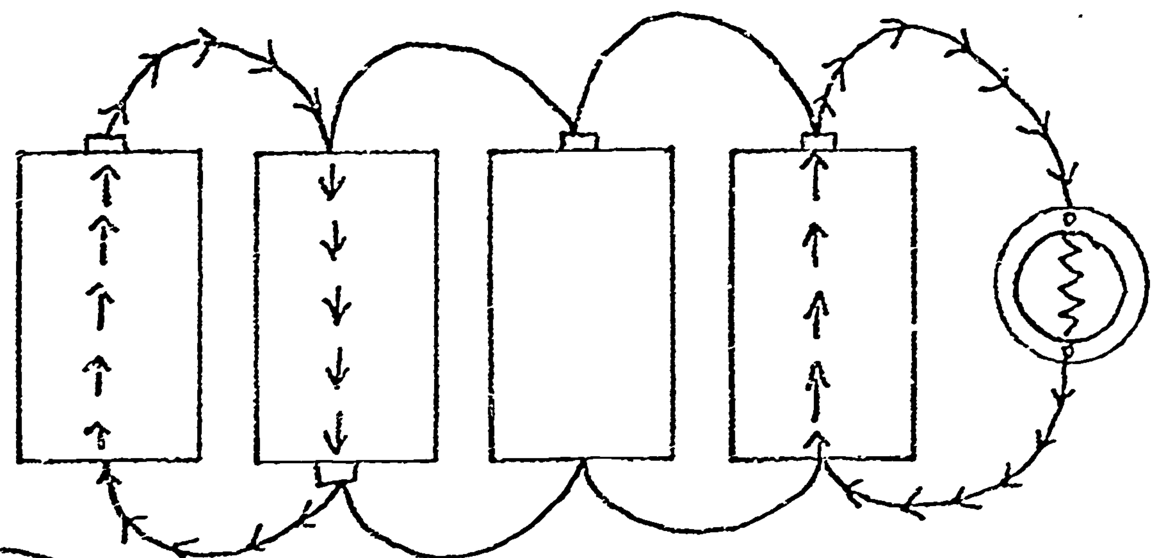
2.



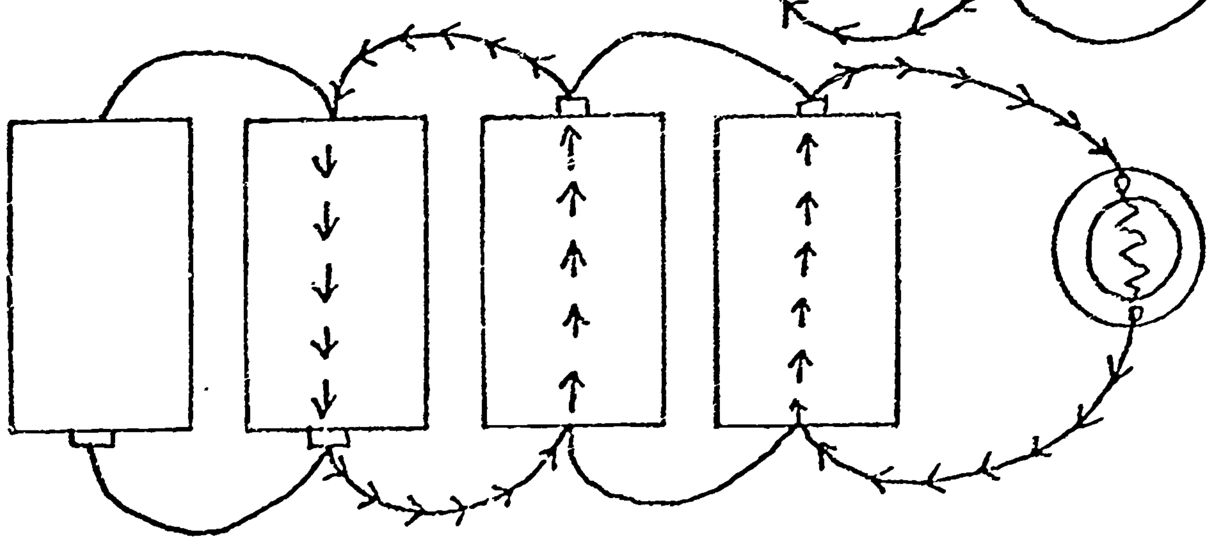
3.

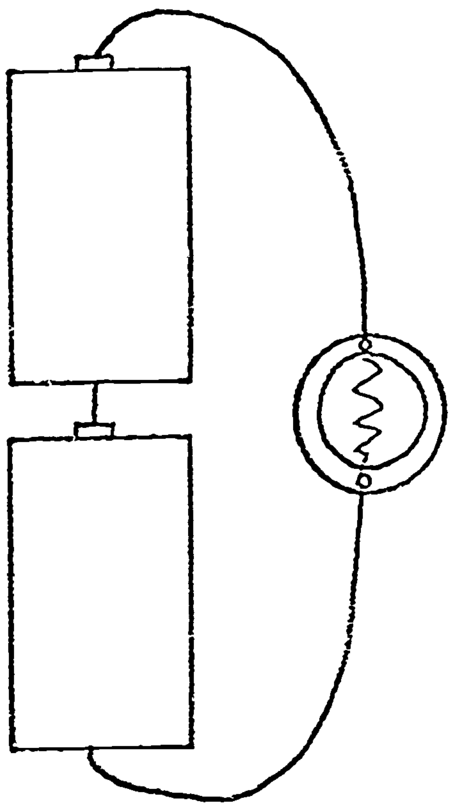


4.

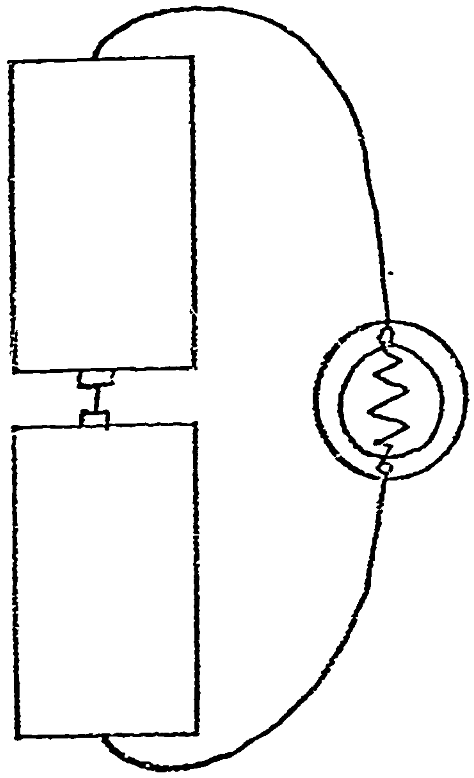


5.

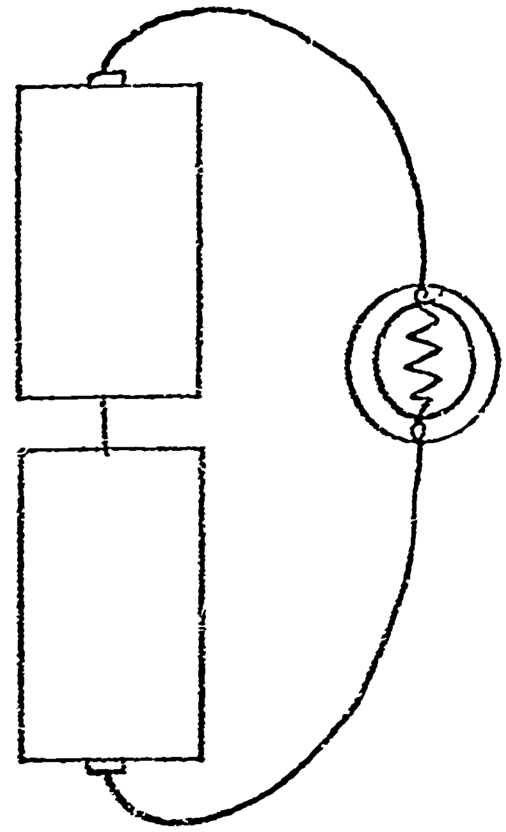


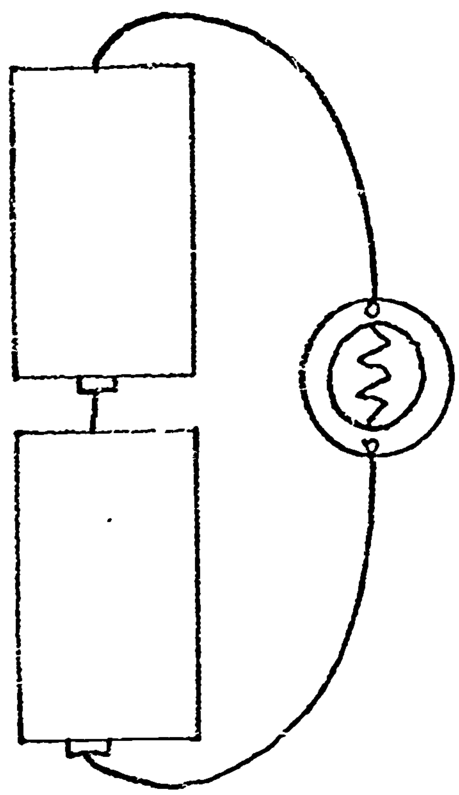


7.

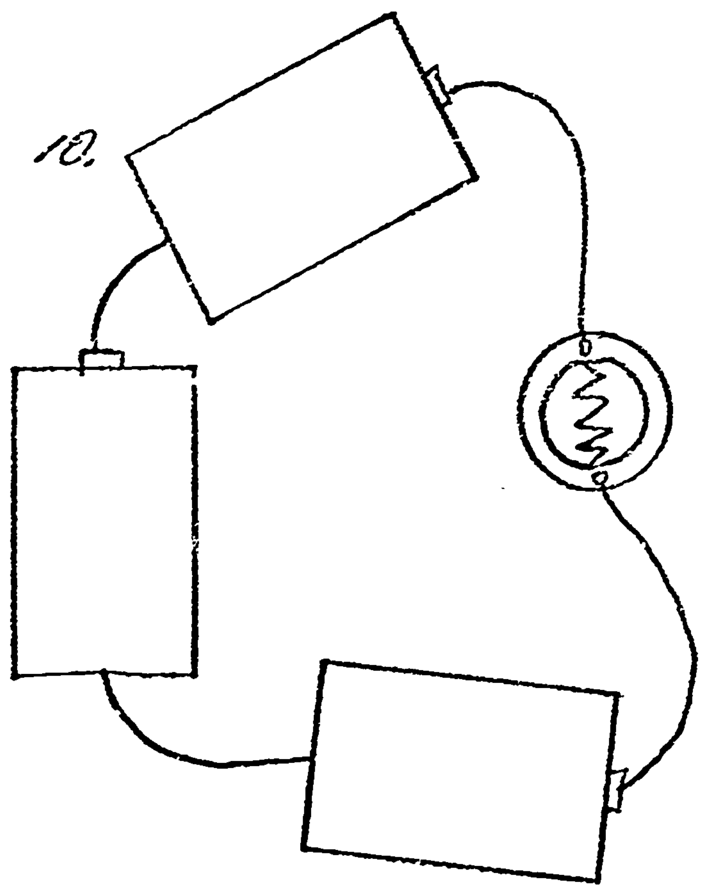


8.

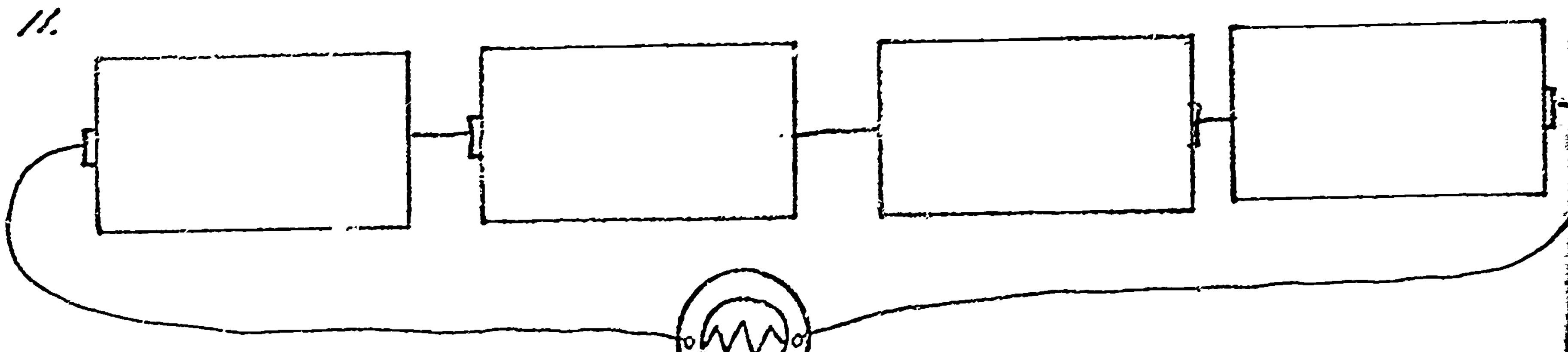




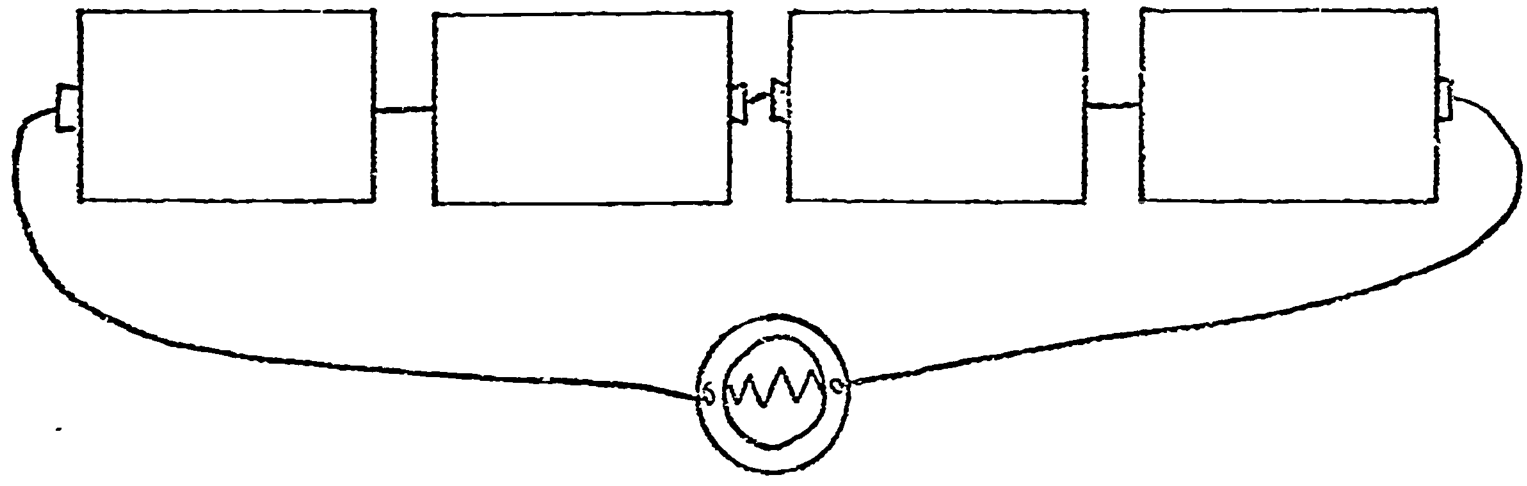
10.



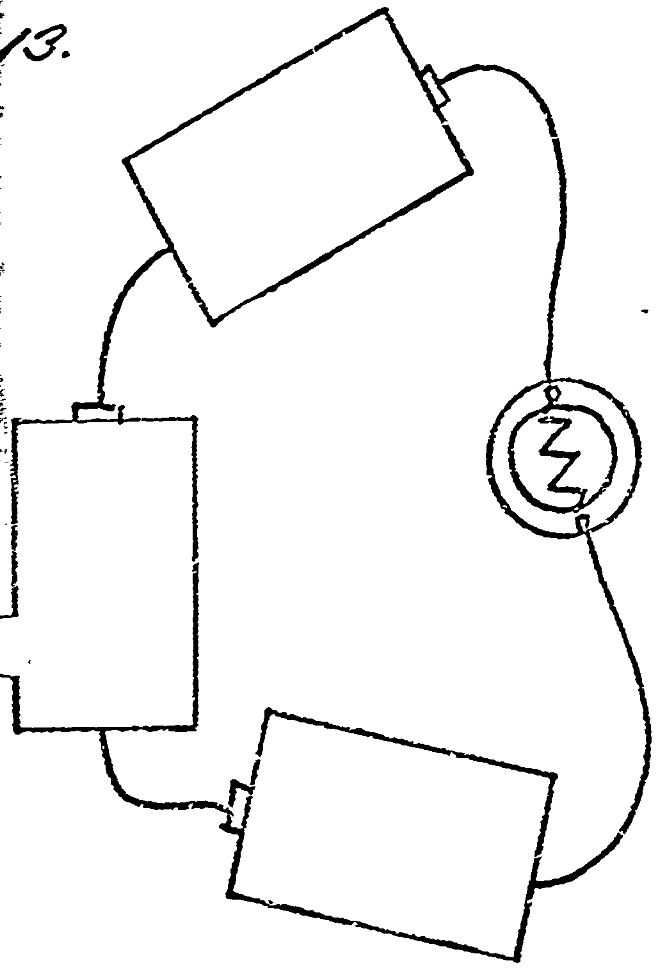
11.



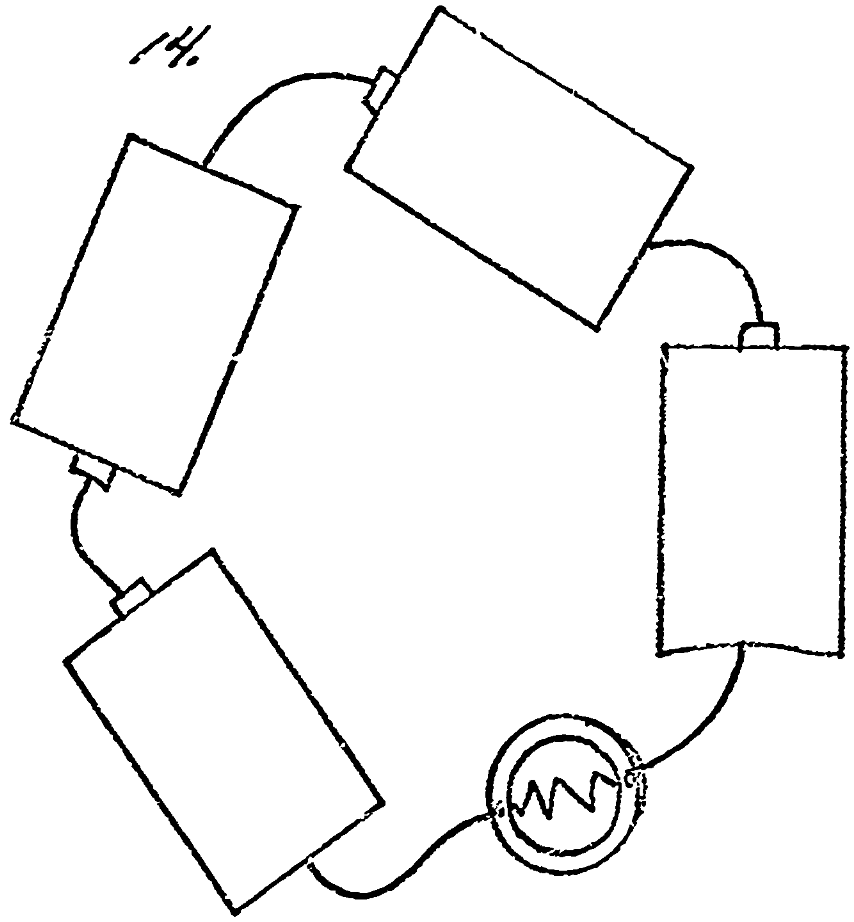
12.



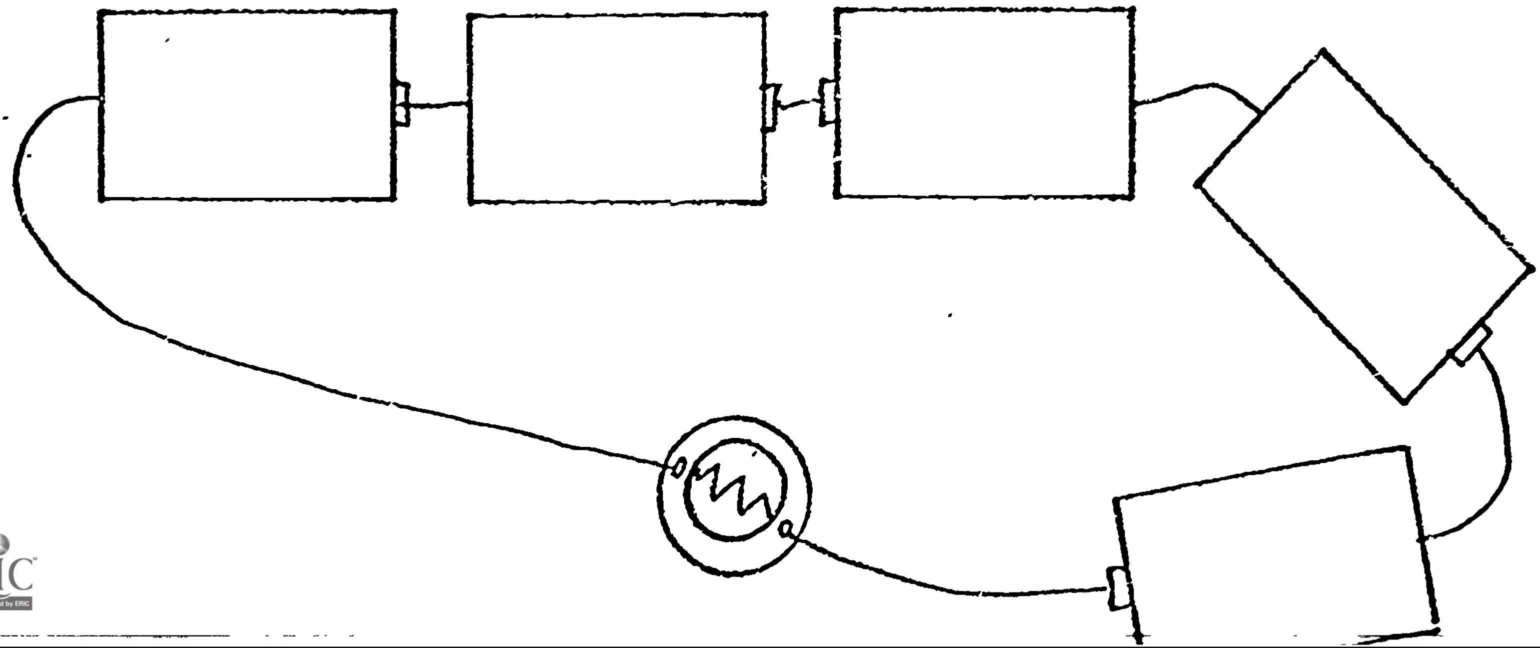
13.



14.

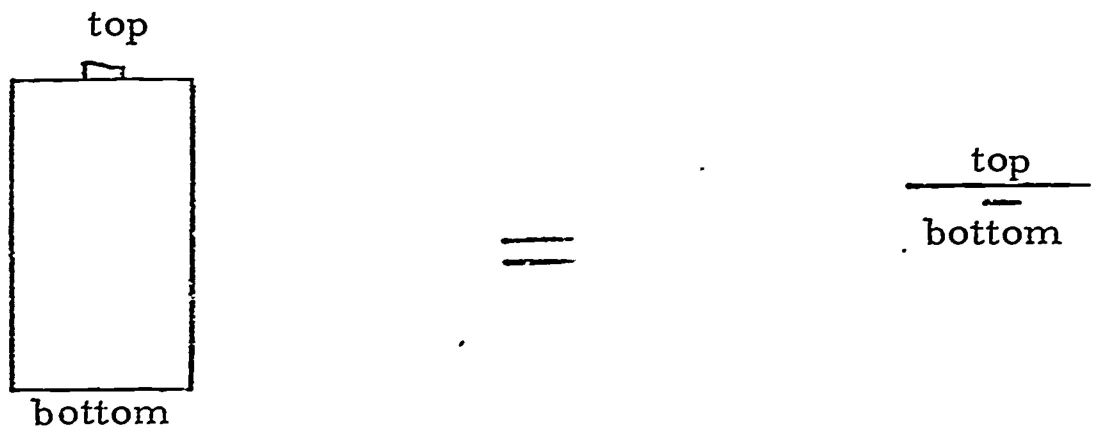


15.

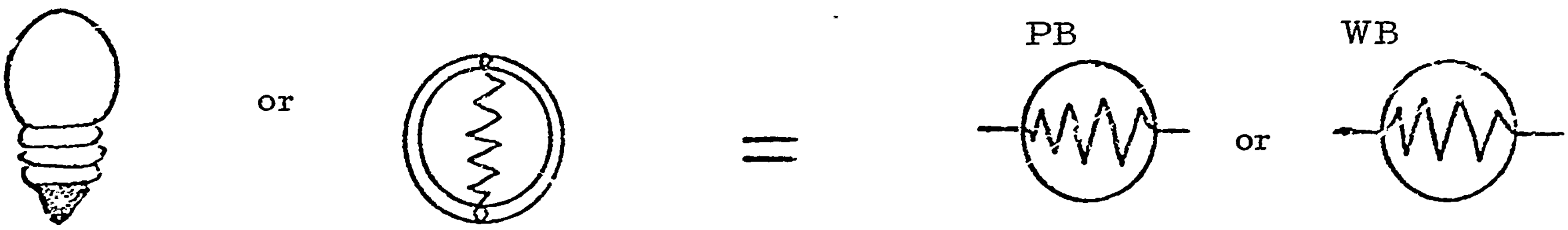


SIGNS FOR CIRCUITS

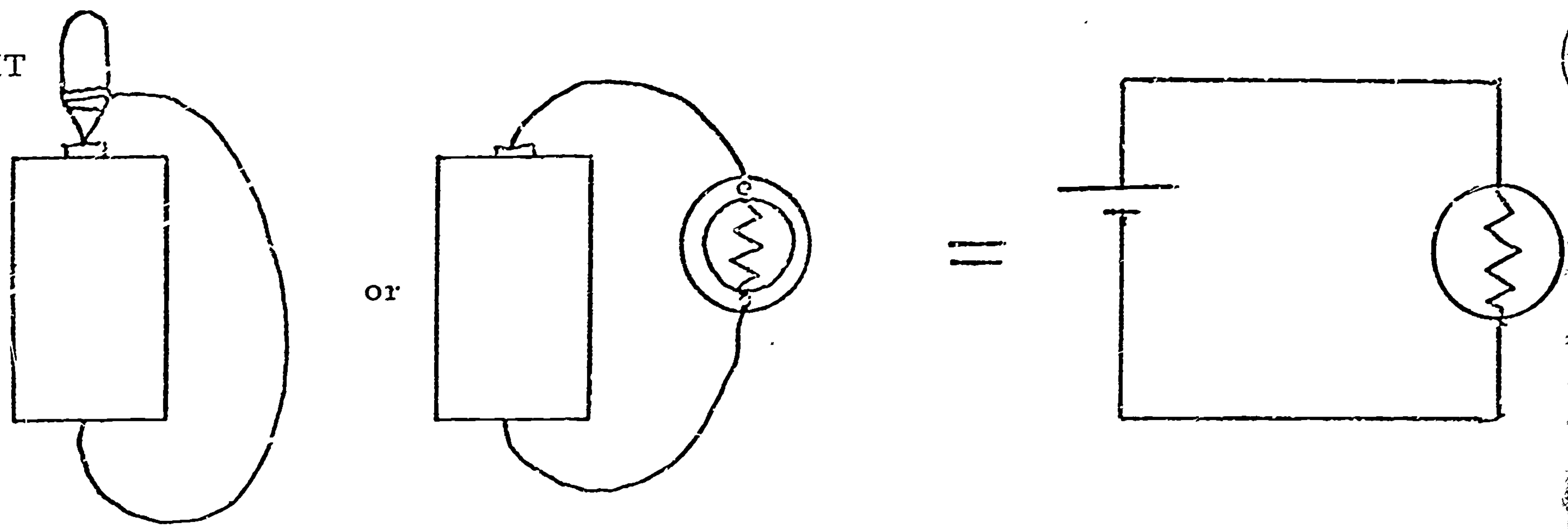
BATTERY



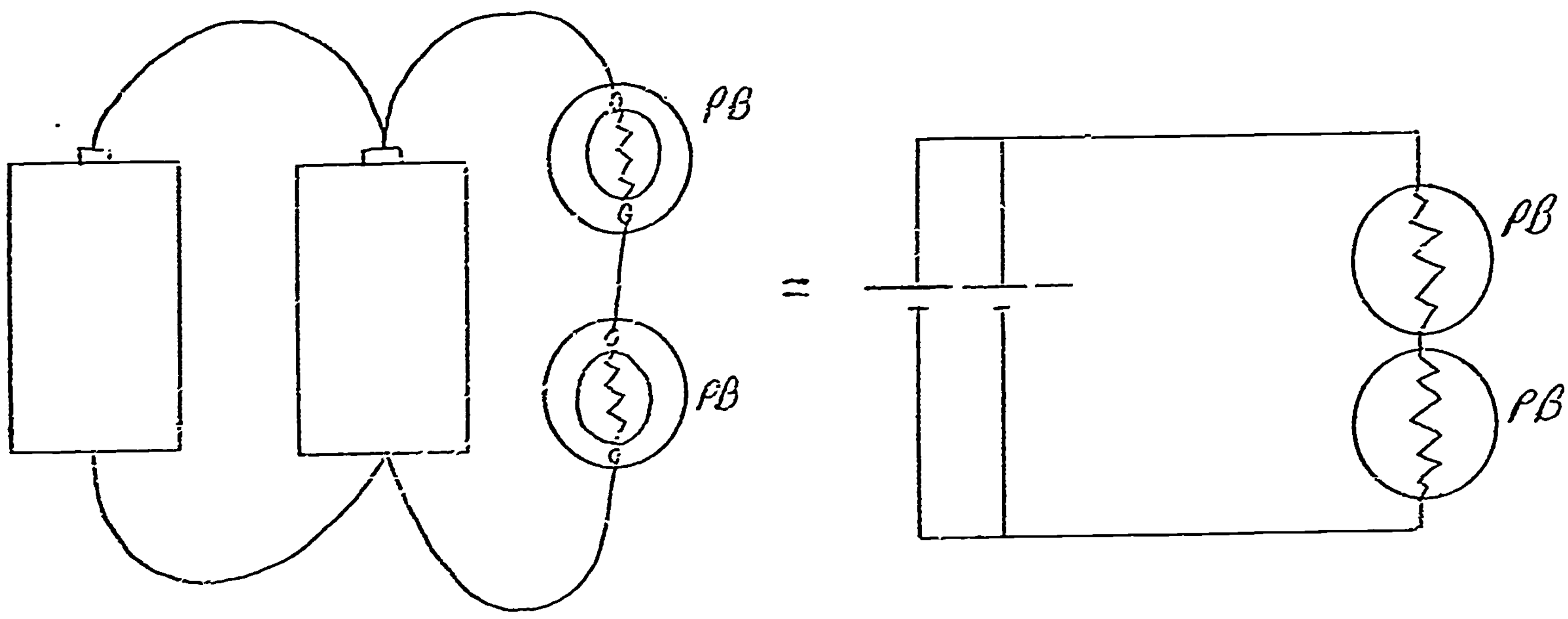
BULBS

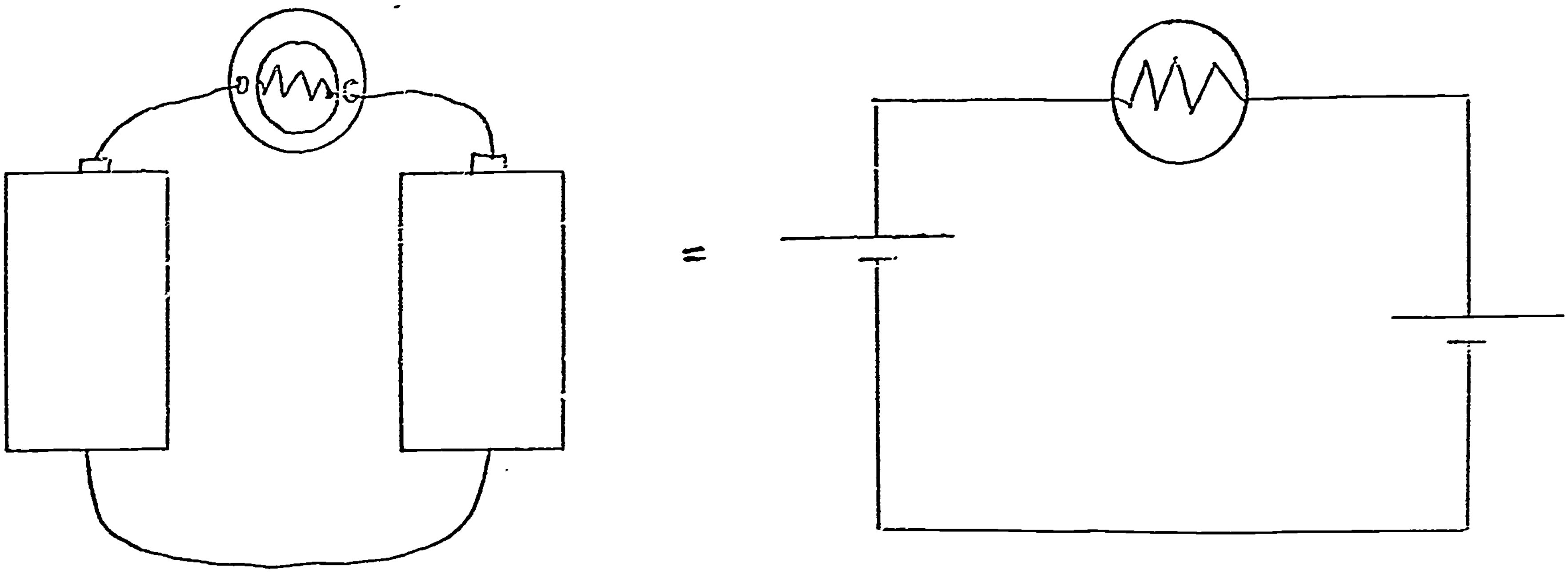


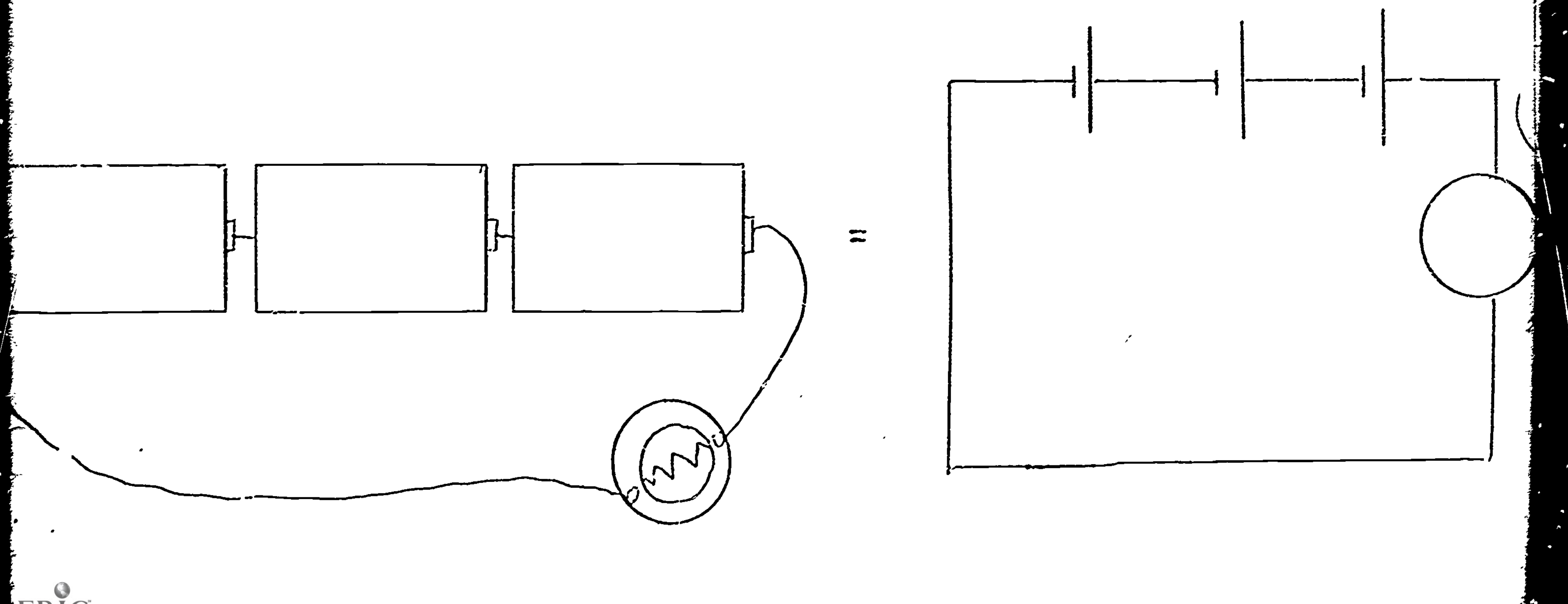
CIRCUIT



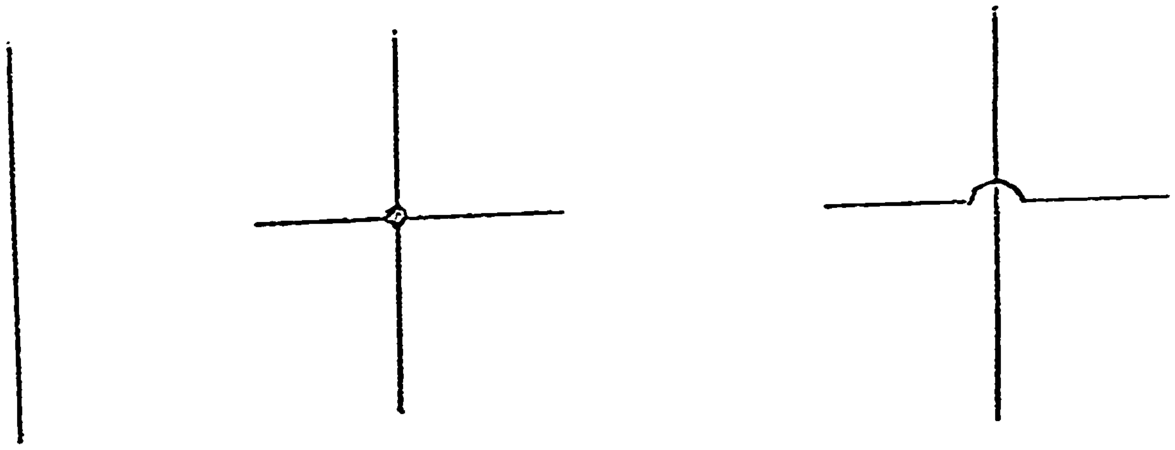
CIRCUITS

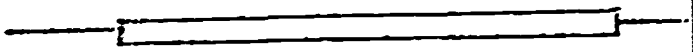




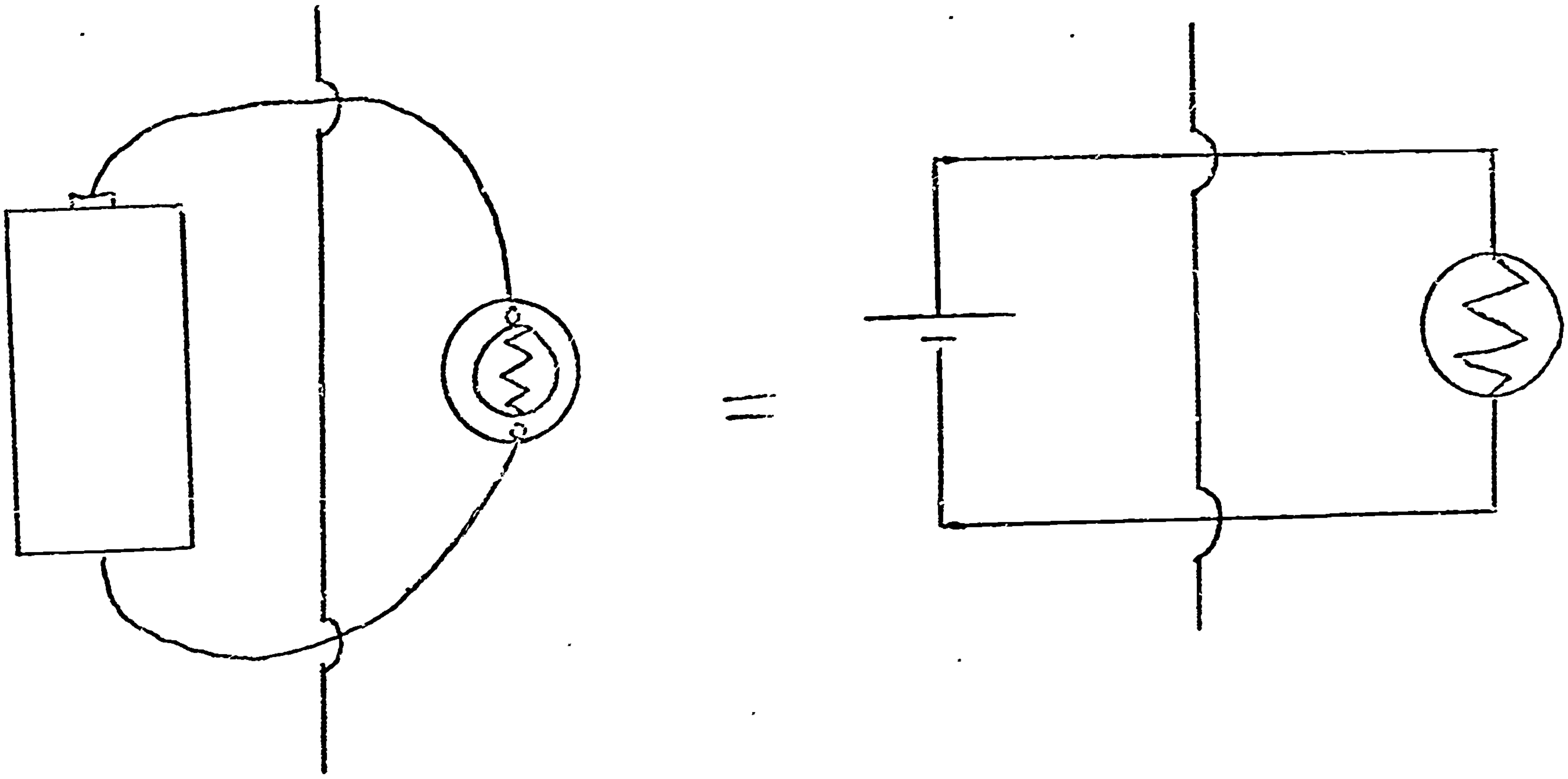


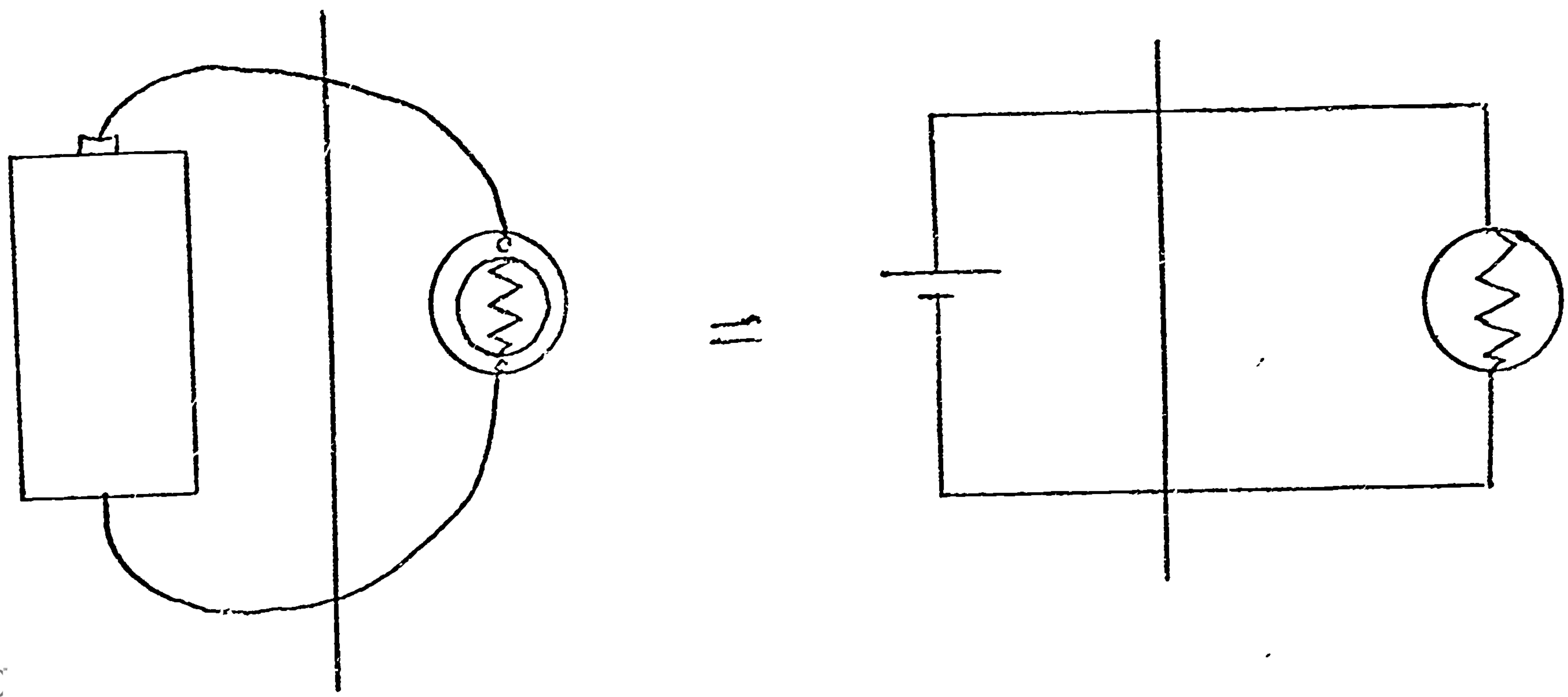
SIGNS FOR WIRES





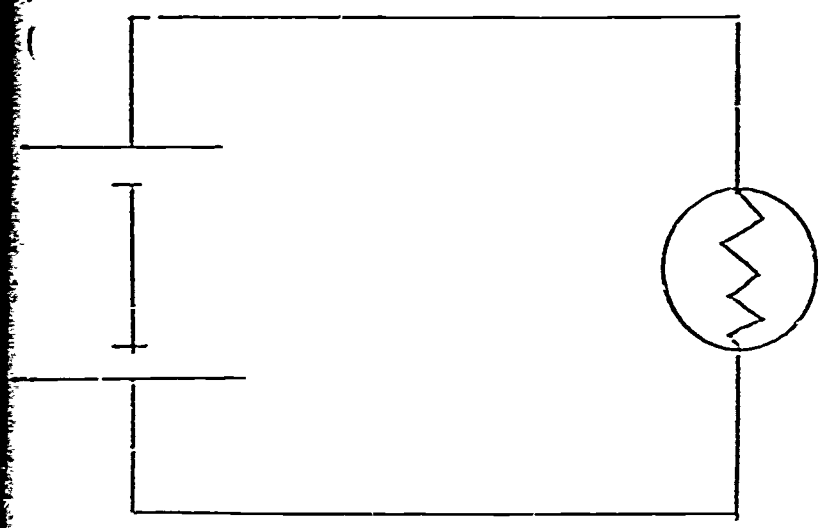
INSULATED WIRE



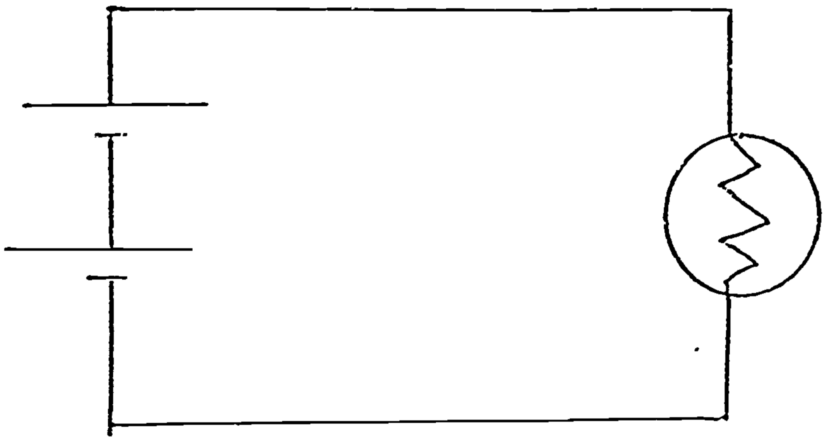


NEW SIGNS

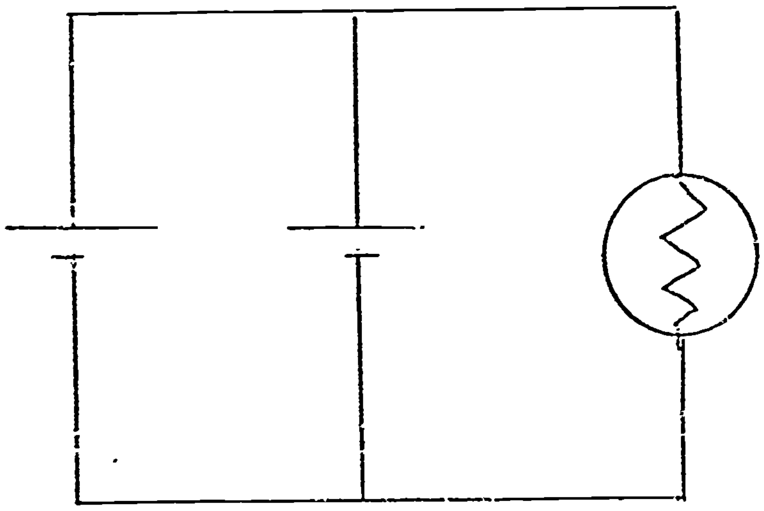
1.



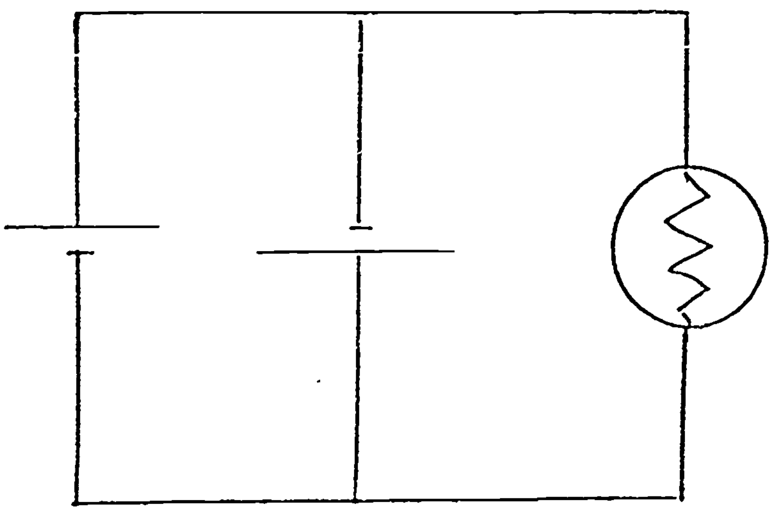
2.



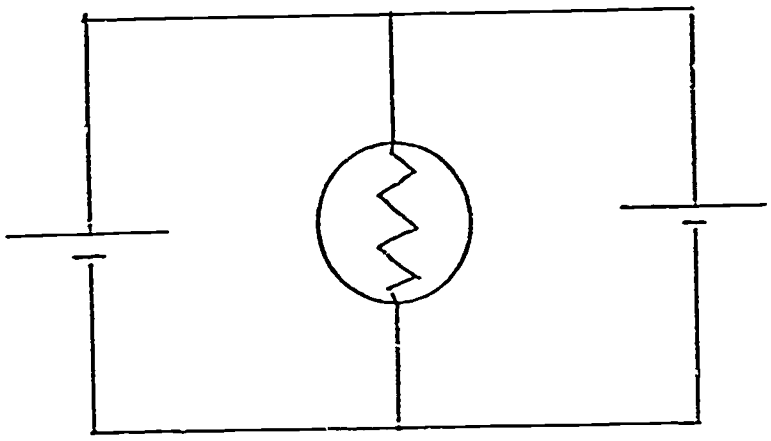
3.



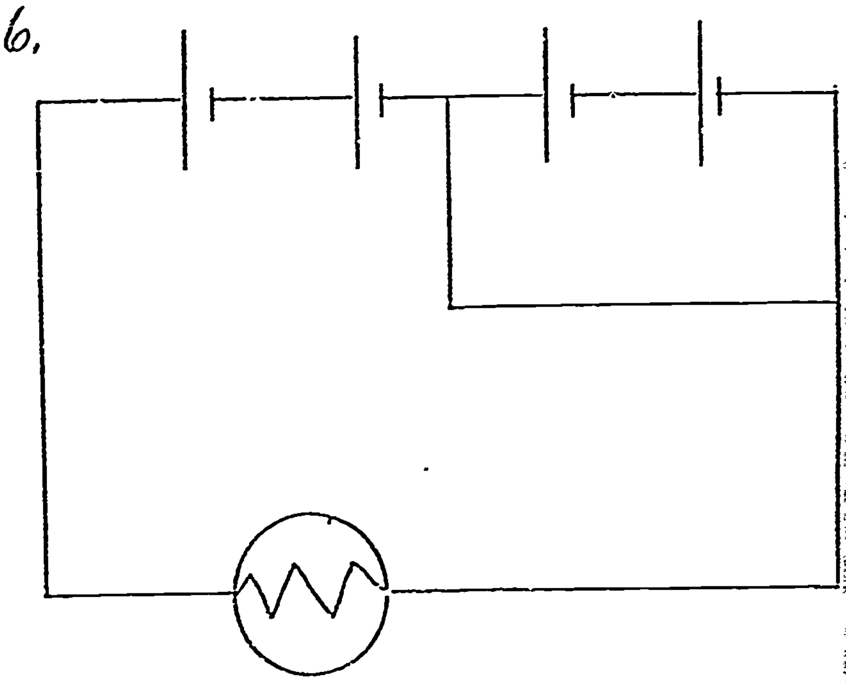
4.



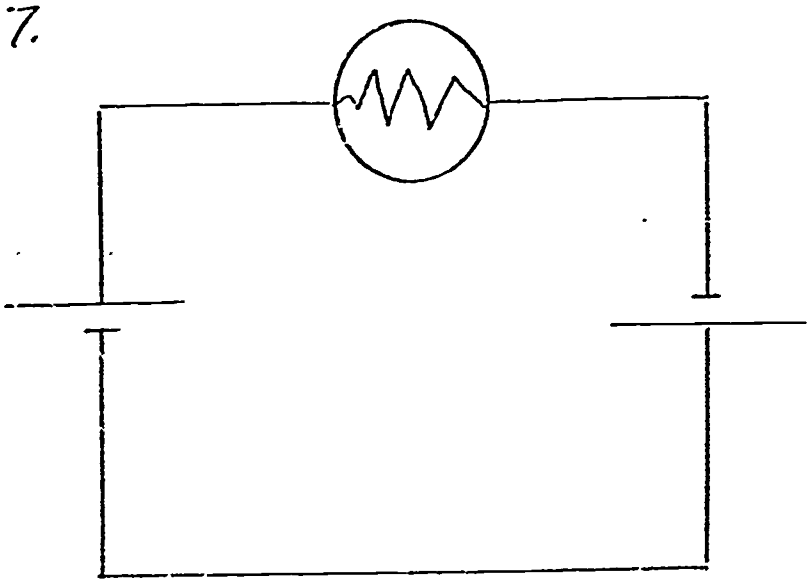
5.



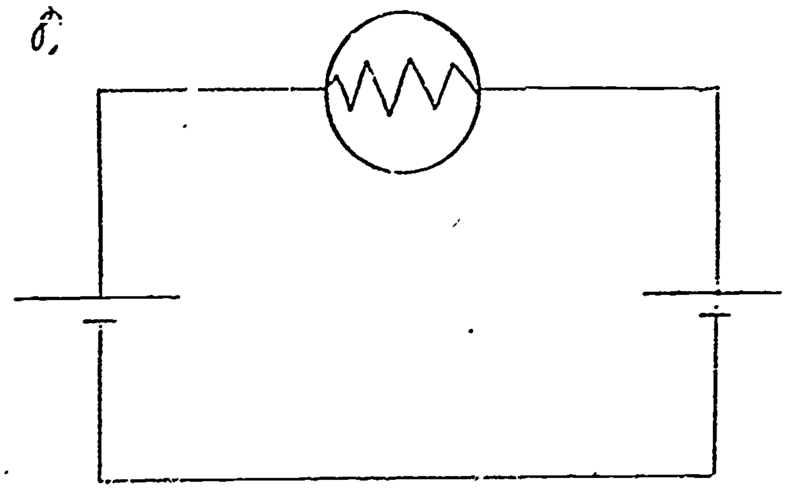
6.



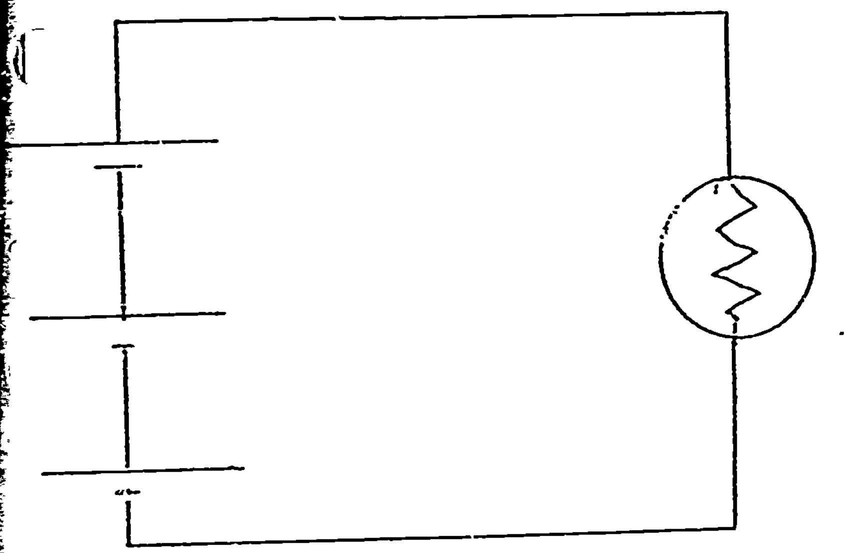
7.



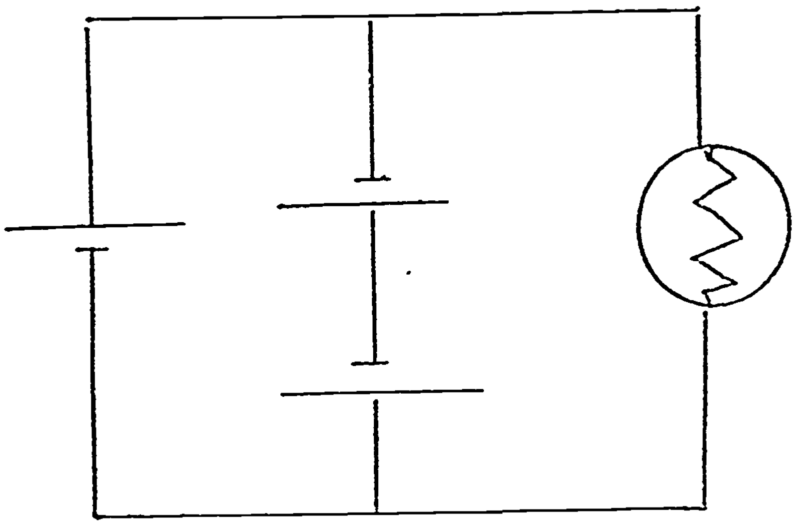
8.



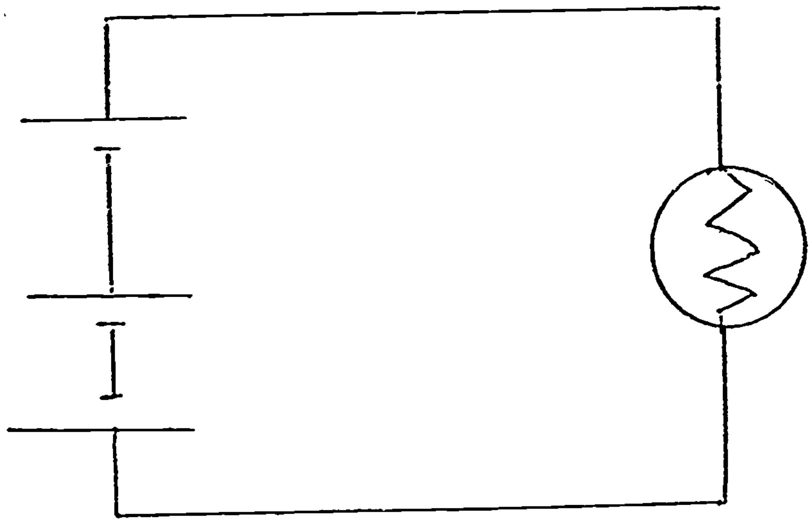
9.



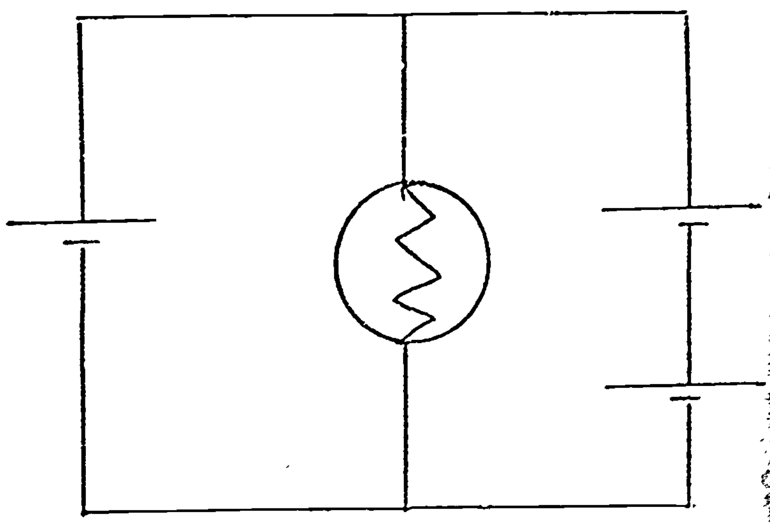
10.



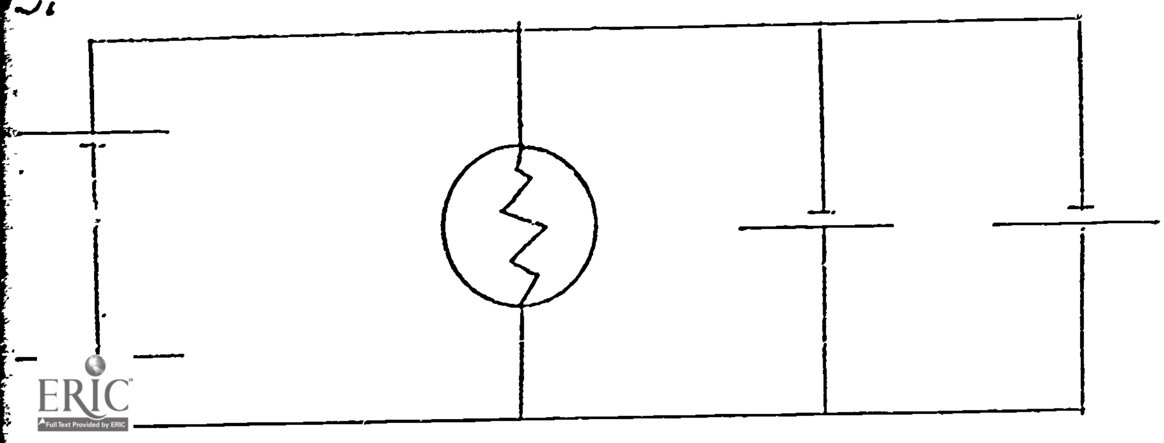
11.



12.

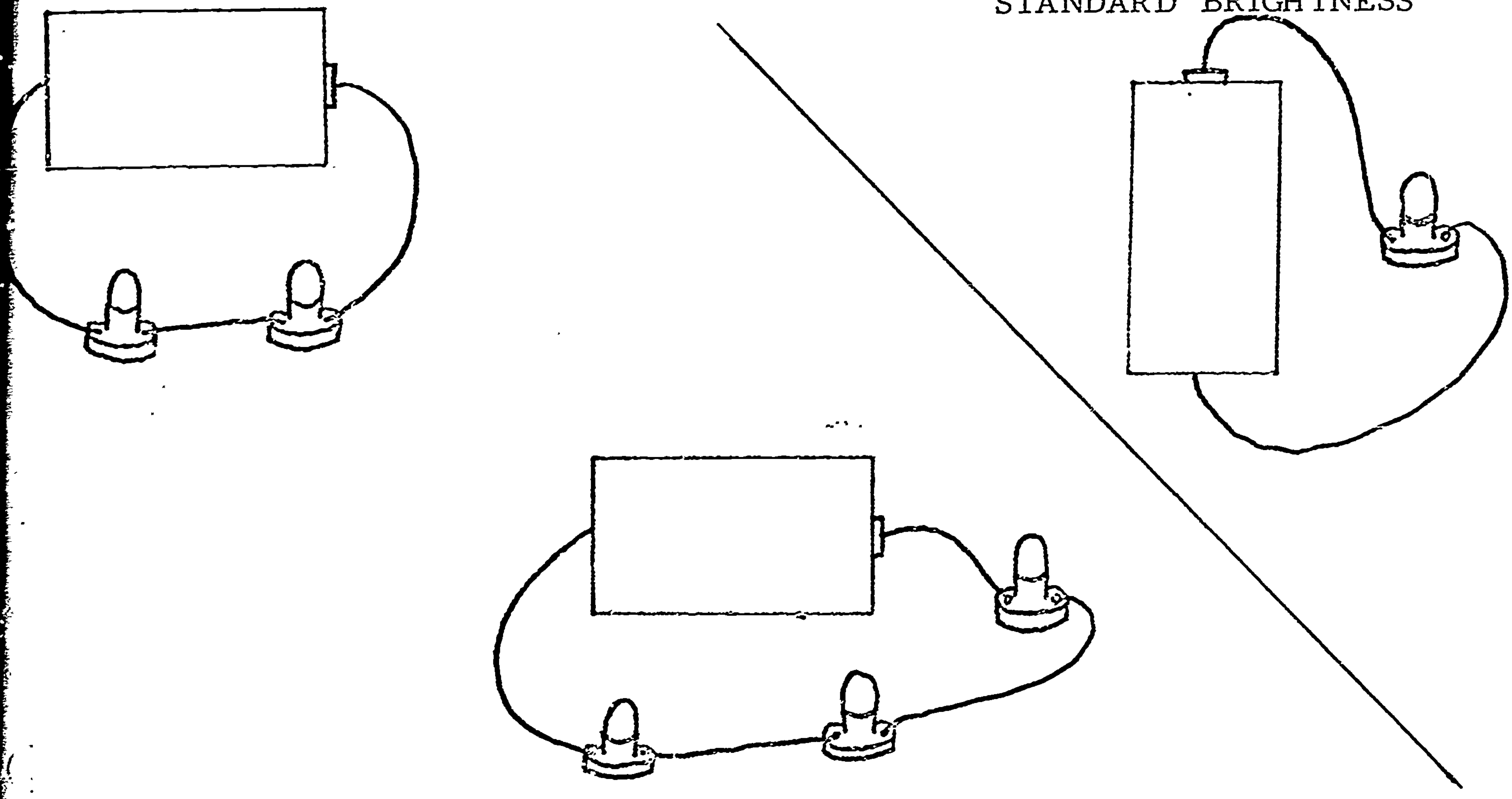


13.

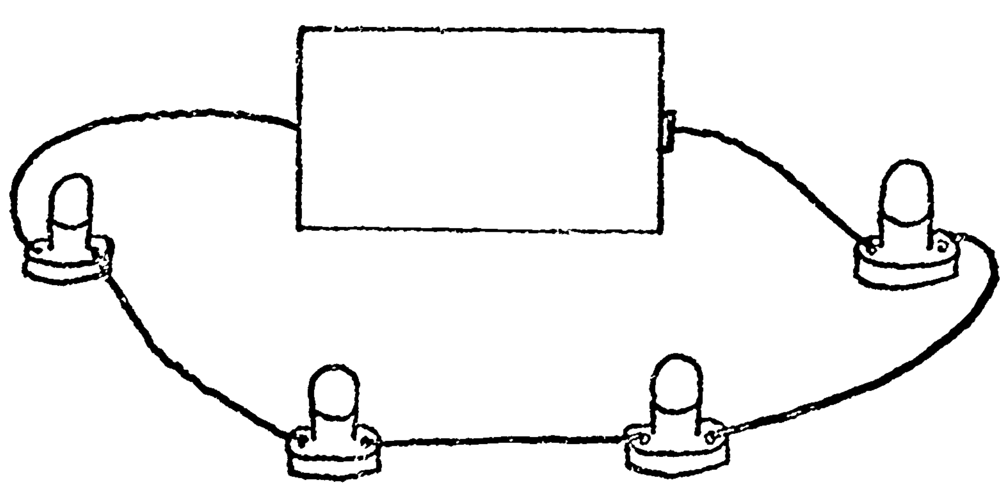


Series Bulbs

One BATTERY One BULB
STANDARD BRIGHTNESS

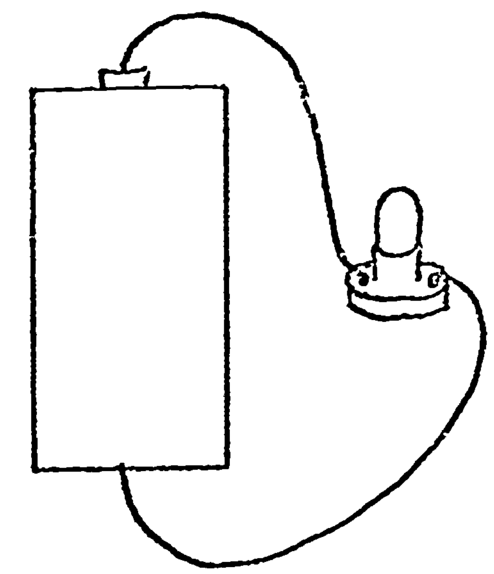


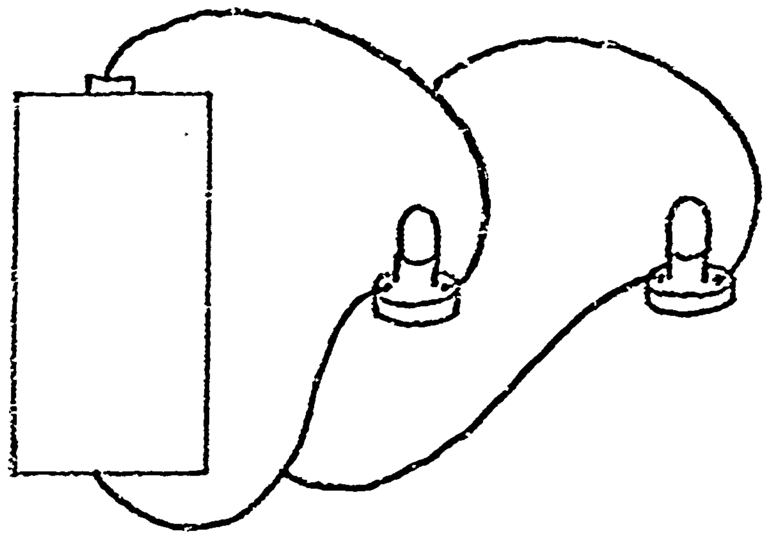
ALL THESE BULBS ARE DIM - THEY HAVE TO SHARE THE ELECTRIC POWER FROM THE ONE BATTERY



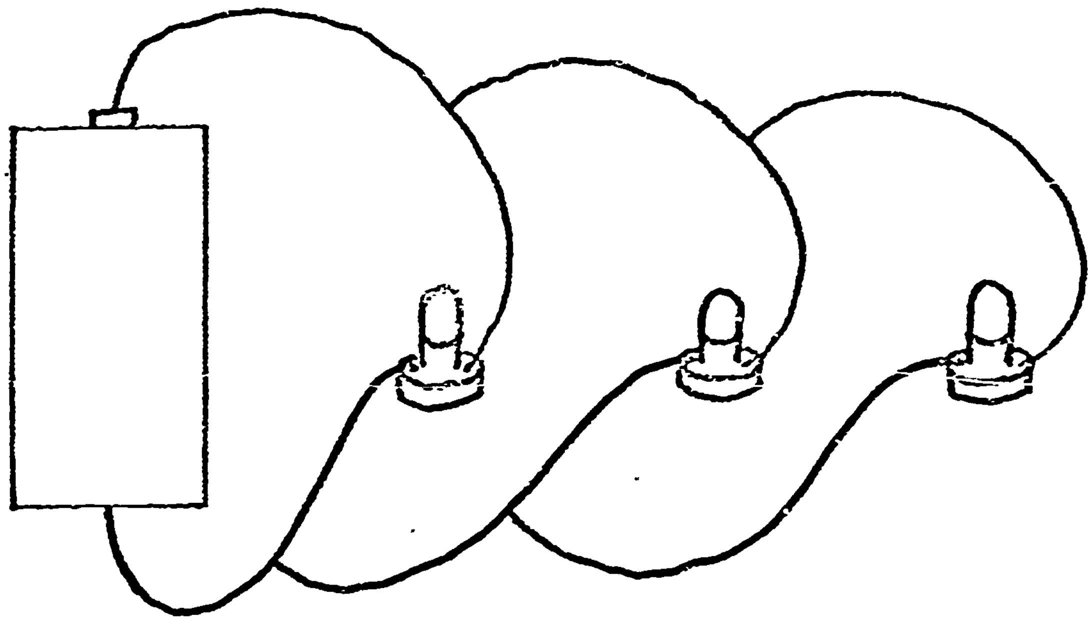
EACH OF THESE BULBS GETS SO LITTLE ELECTRIC POWER THAT YOU CAN'T SEE THEM LIGHT UP.

Parallel Bulbs

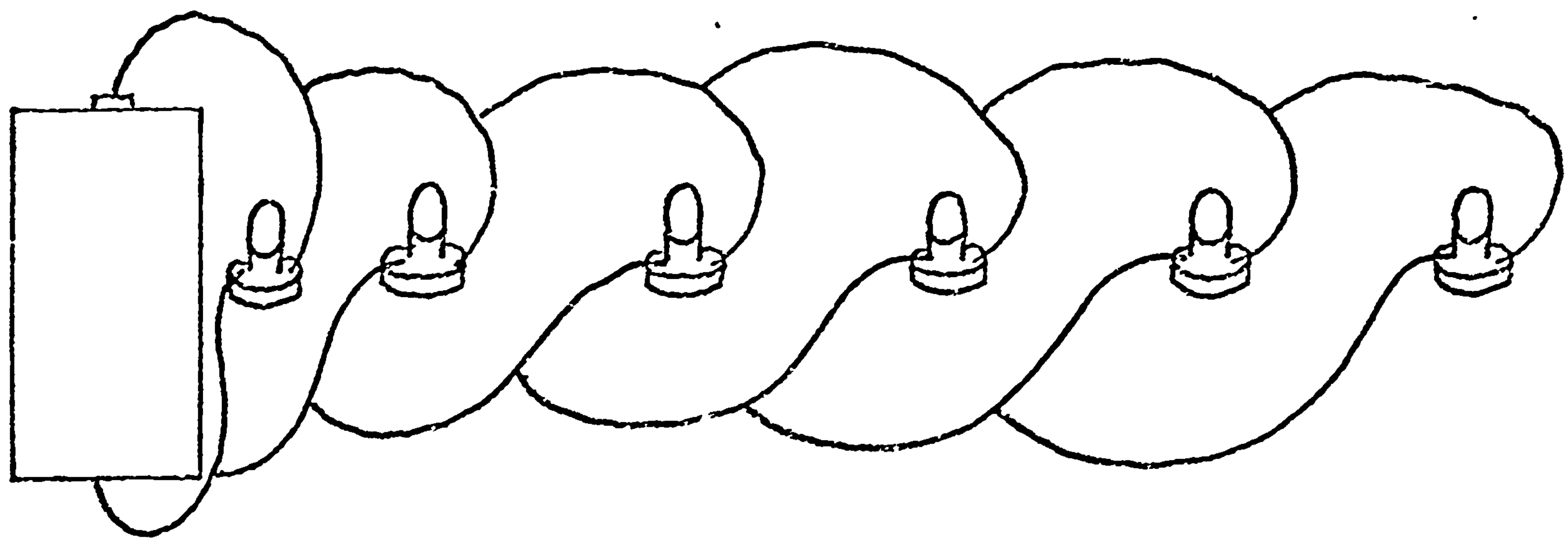




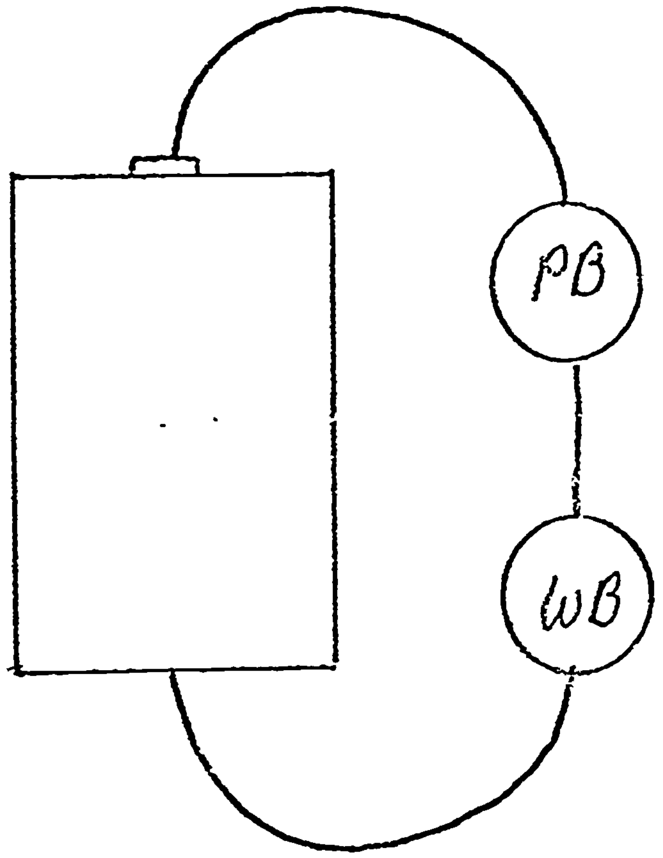
One BATTERY
One BULB
STANDARD BRIGHTNESS



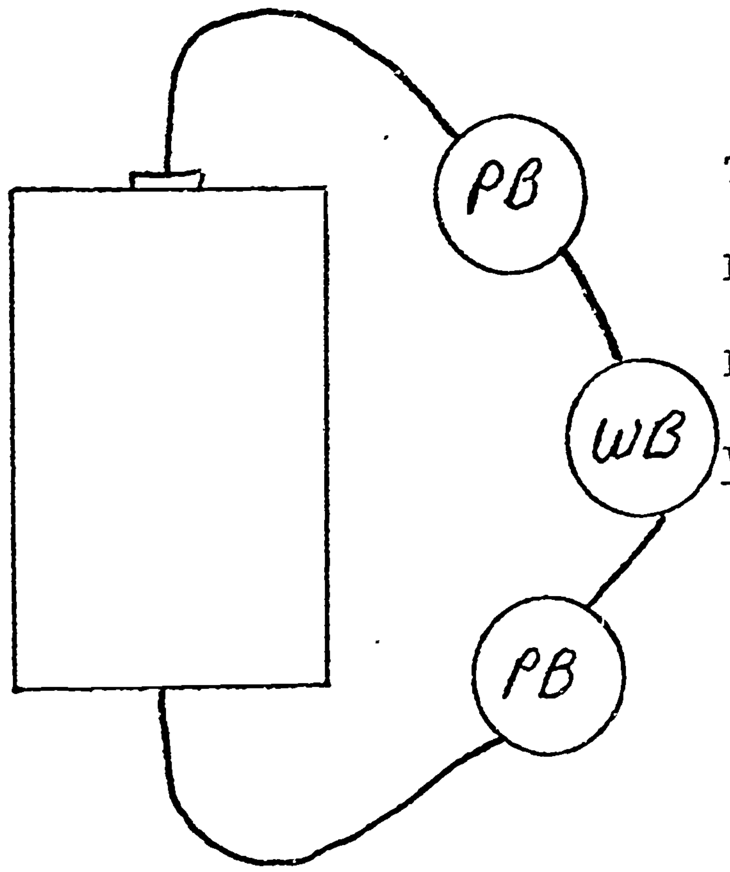
ALL OF THESE BULBS ARE STANDARD BRIGHTNESS -
THEY ALL HAVE THEIR OWN PATH TO THE BATTERY



PARALLEL AND SERIES PINK AND WHITE BULBS



THE PINK BULB LIGHTS TO STANDARD BRIGHTNESS THE WHITE BULB DOES NOT LIGHT. WHY?

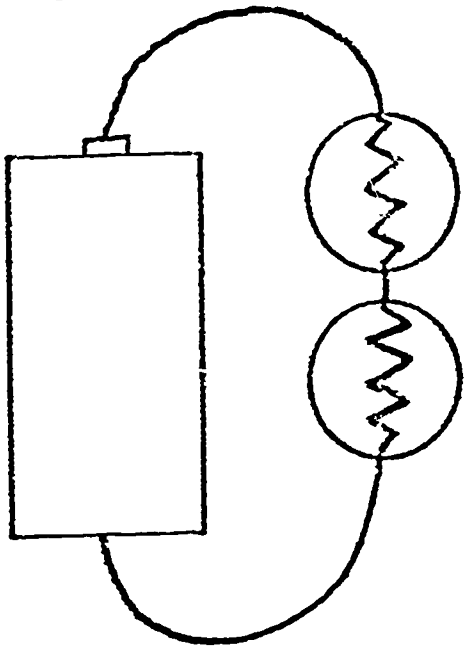


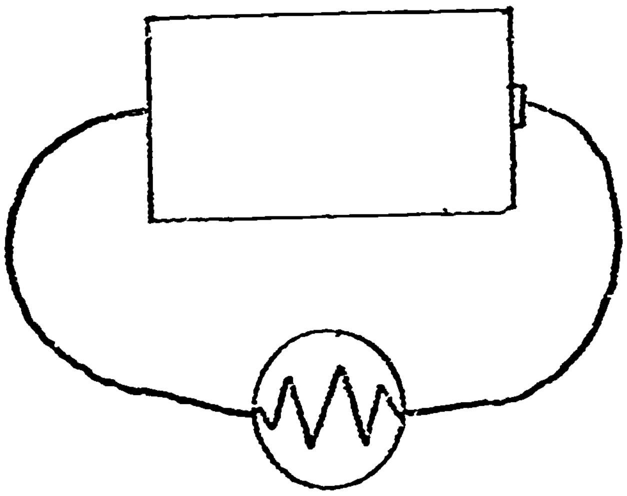
THE PINK BULBS LIGHT DIMLY; THE WHITE BULB DOES NOT LIGHT AT ALL. WHY?

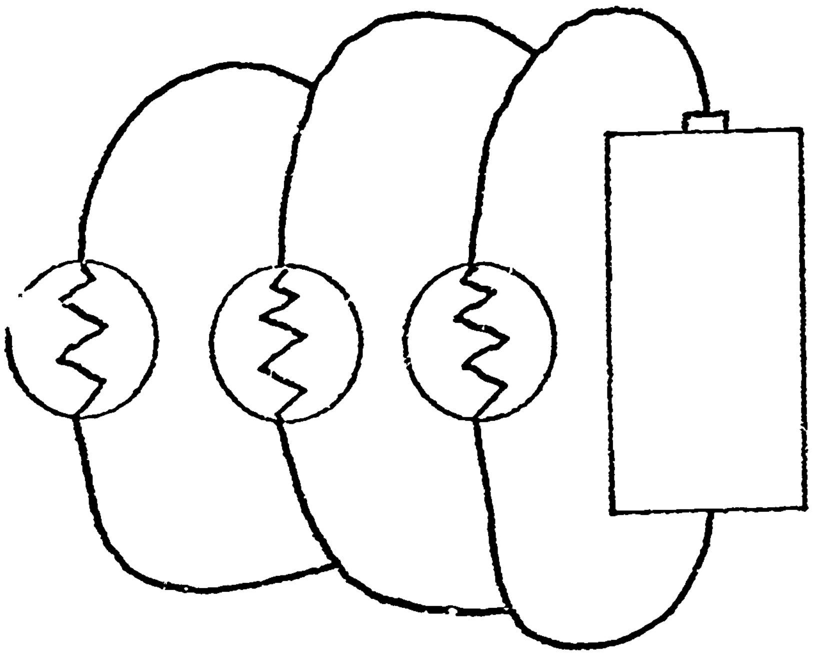
PREDICTION SHEET

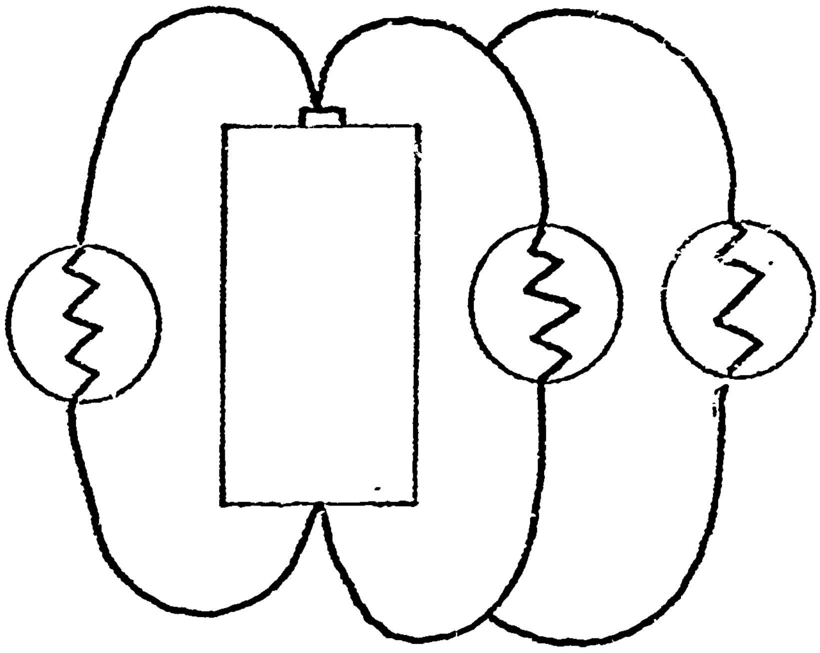
LESSON 15

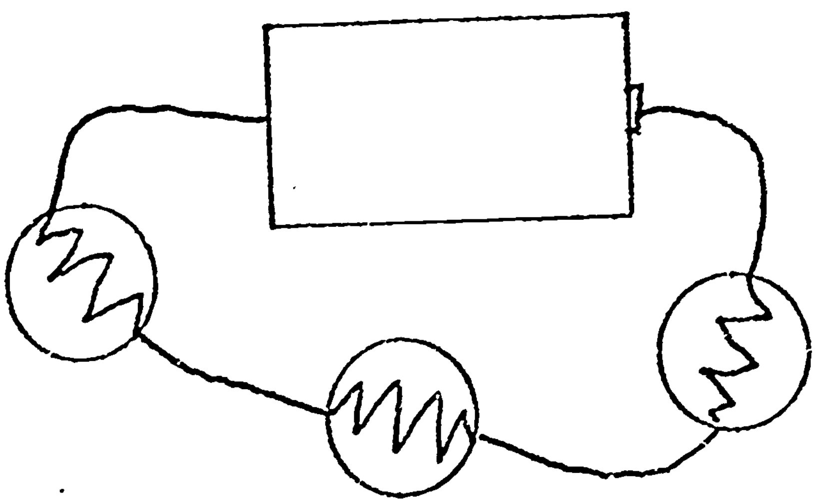
HOW BRIGHT WILL THE BULBS LIGHT IN THE FOLLOWING CIRCUITS?

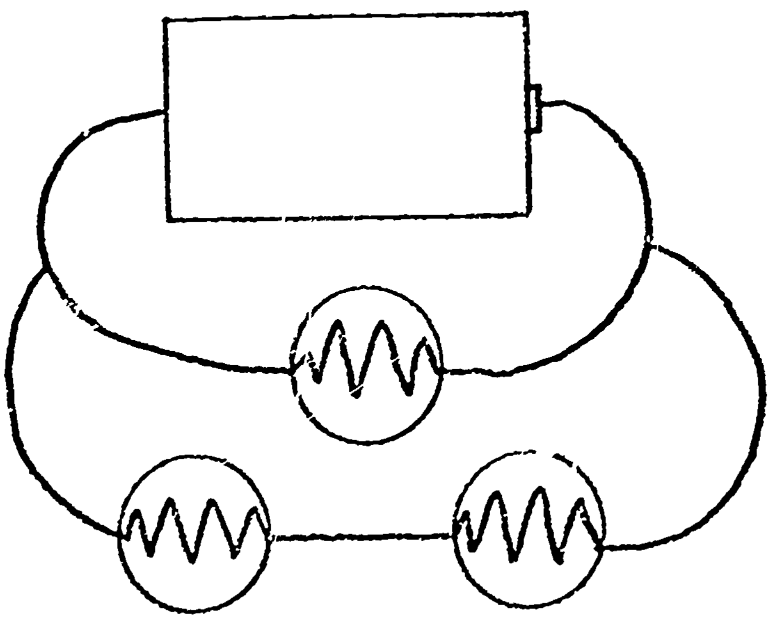






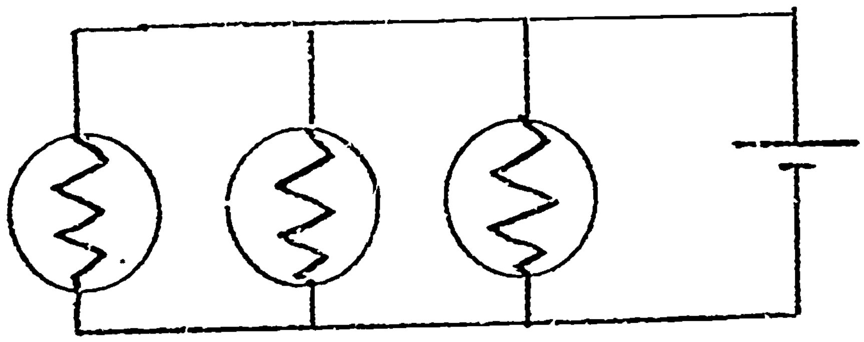


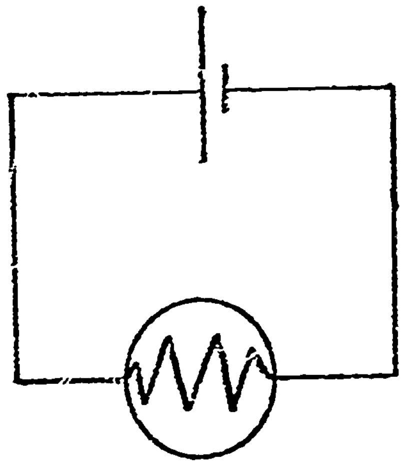


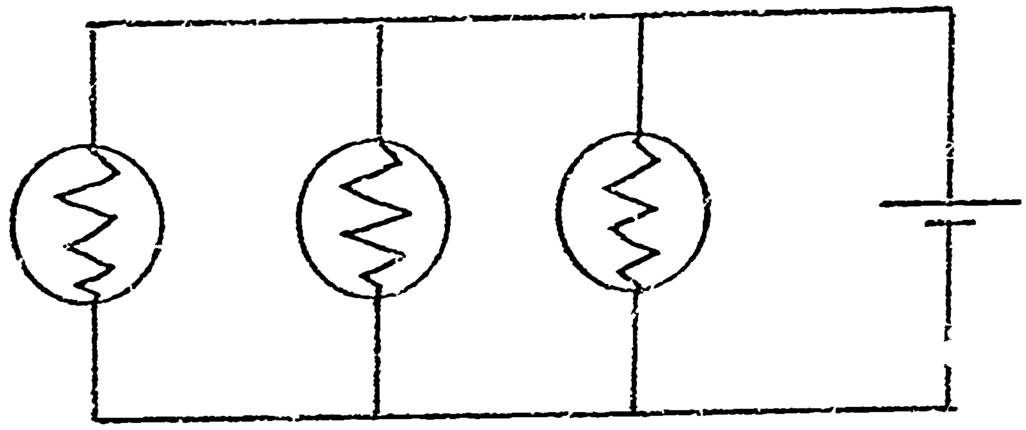


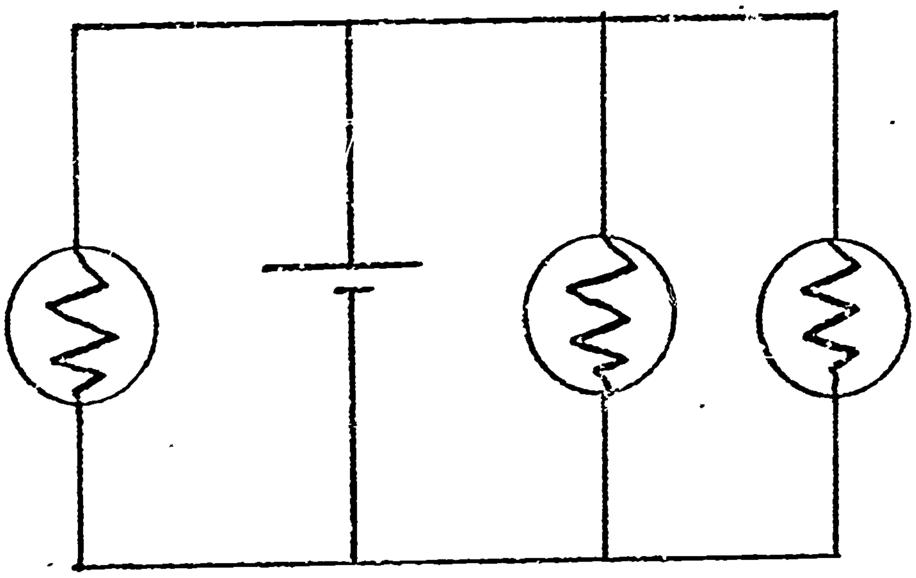
PREDICTION SHEET . LESSON 15

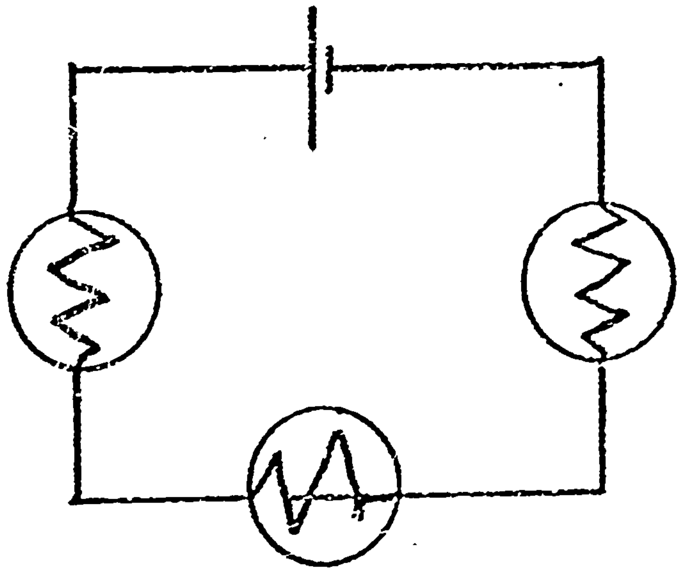
HOW BRIGHT WILL THE BULBS LIGHT IN THE FOLLOWING CIRCUITS?

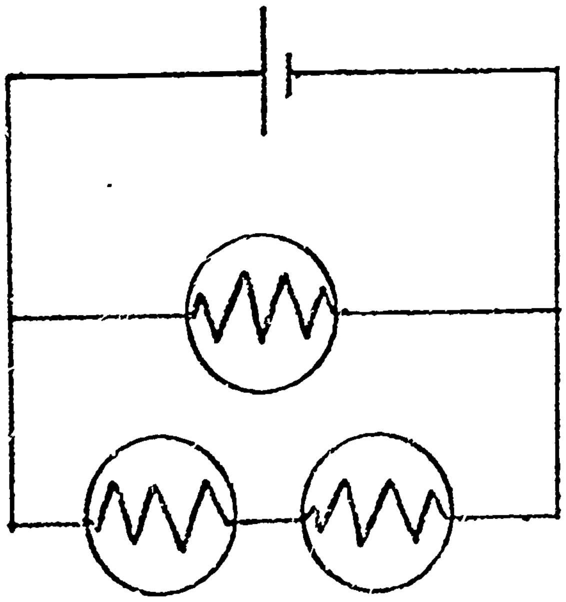


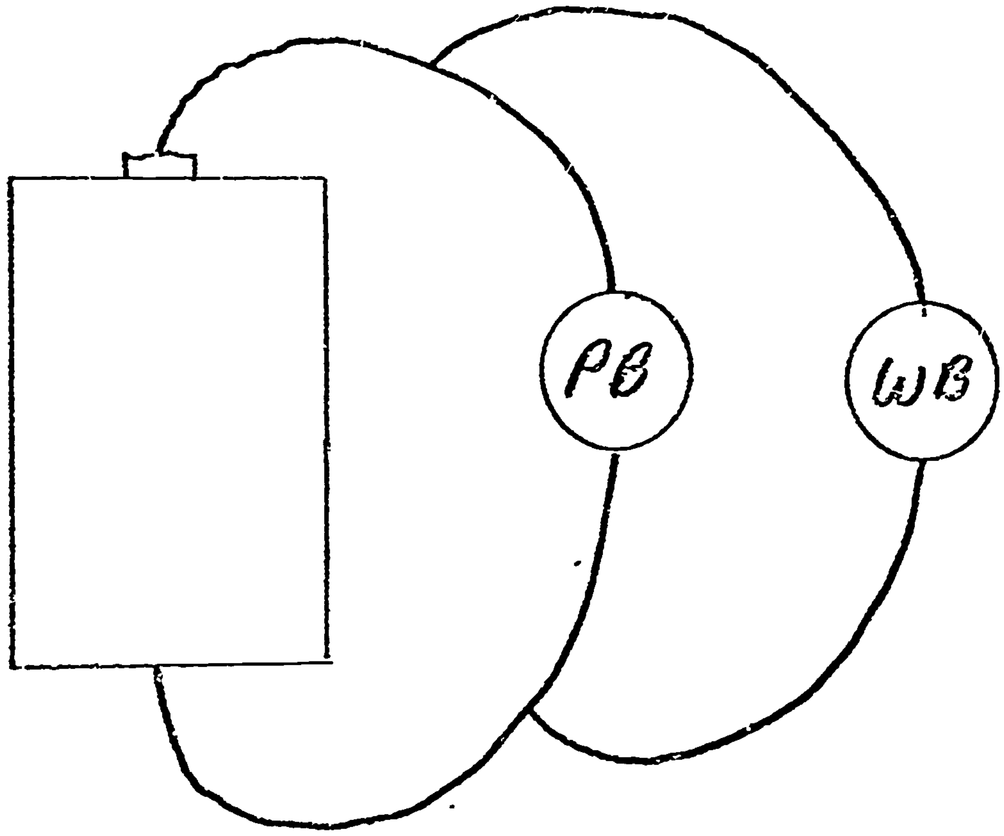








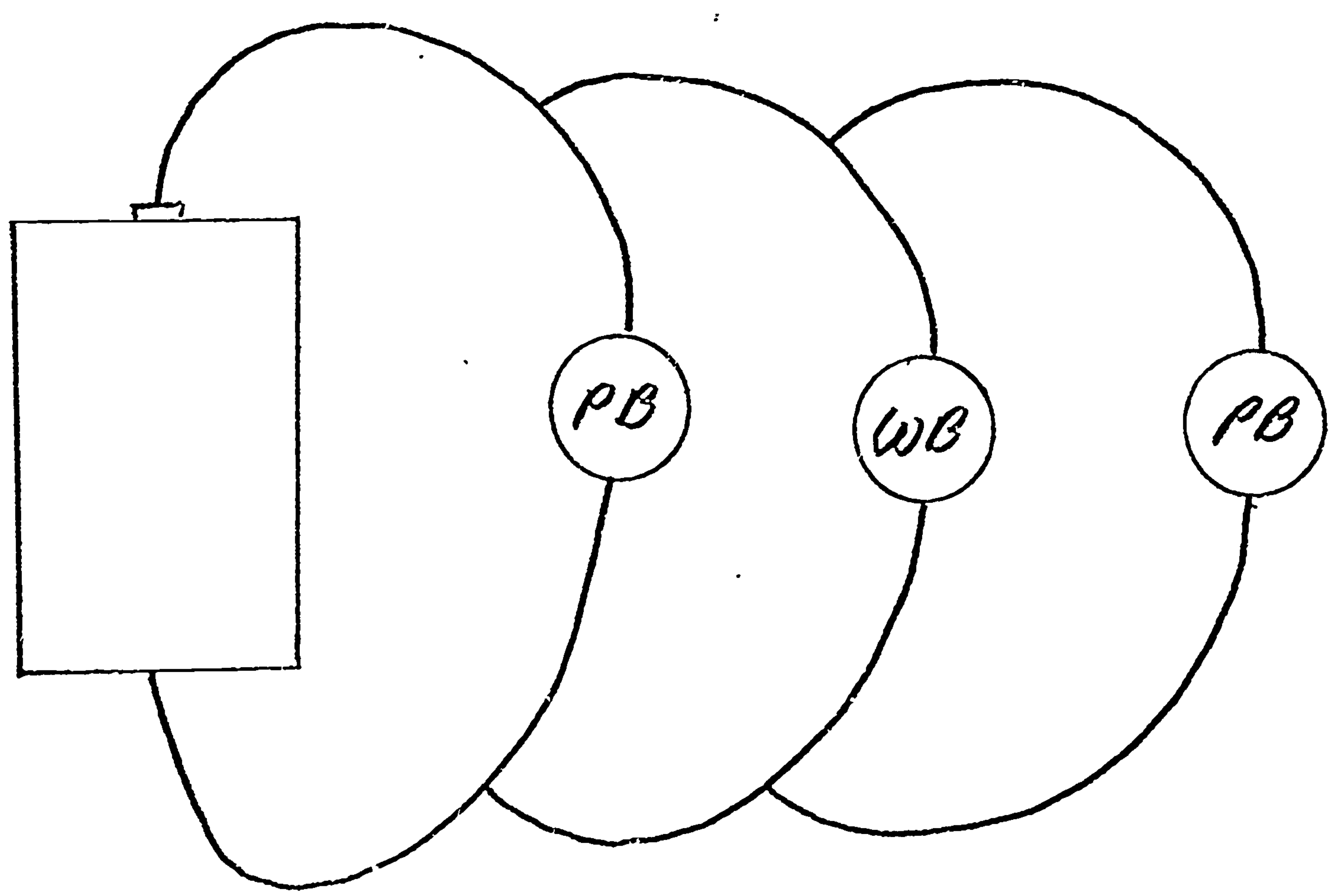




EACH OF THESE BULBS LIGHTS TO STANDARD BRIGHTNESS

WHY?

EACH OF THESE BULBS LIGHTS TO STANDARD BRIGHTNESS. WHY?



PARALLEL AND SERIES - REVIEW

SERIES BATTERIES

WHAT ARE THEY?

WHEN ARE THEY USED?

WHAT HAPPENS TO A BULB WHEN BATTERIES ARE IN SERIES?

HOW HARD DOES EACH BATTERY WORK?

PARALLEL BATTERIES

WHAT ARE THEY?

WHEN ARE THEY USED?

WHAT HAPPENS TO A BULB WHEN BATTERIES ARE IN SERIES?

HOW HARD DOES EACH BATTERY WORK?

PARALLEL AND SERIES - REVIEW

PARALLEL BULBS

WHAT ARE THEY?

WHEN ARE THEY USED?

WHAT HAPPENS TO A BULB WHEN MORE BULBS ARE ADDED IN PARALLEL?

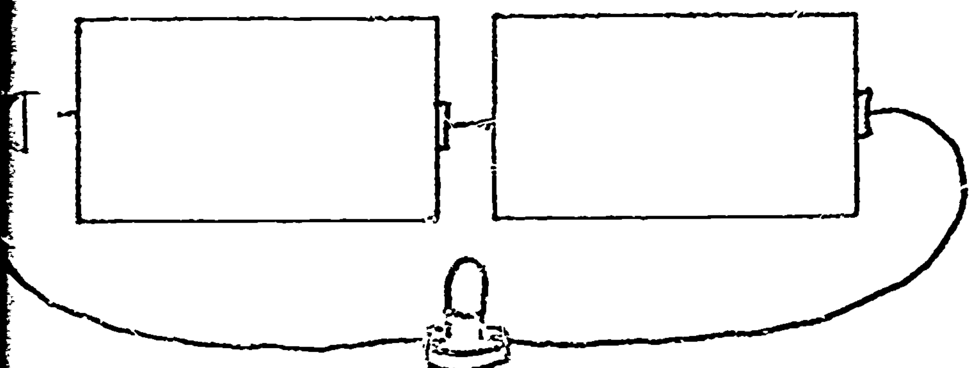
SERIES BULBS

WHAT ARE THEY?

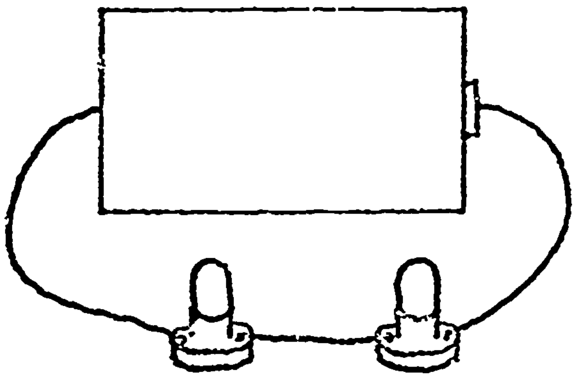
WHEN ARE THEY USED?

WHAT HAPPENS TO A BULB WHEN MORE BULBS ARE ADDED IN SERIES?

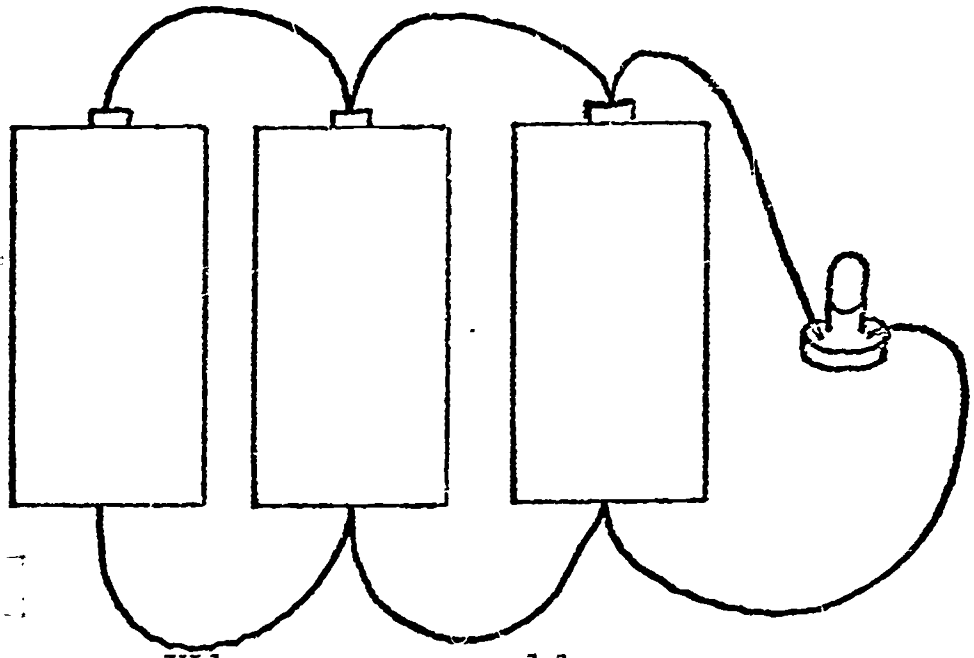
SERIES BATTERIES vs. SERIES BULBS



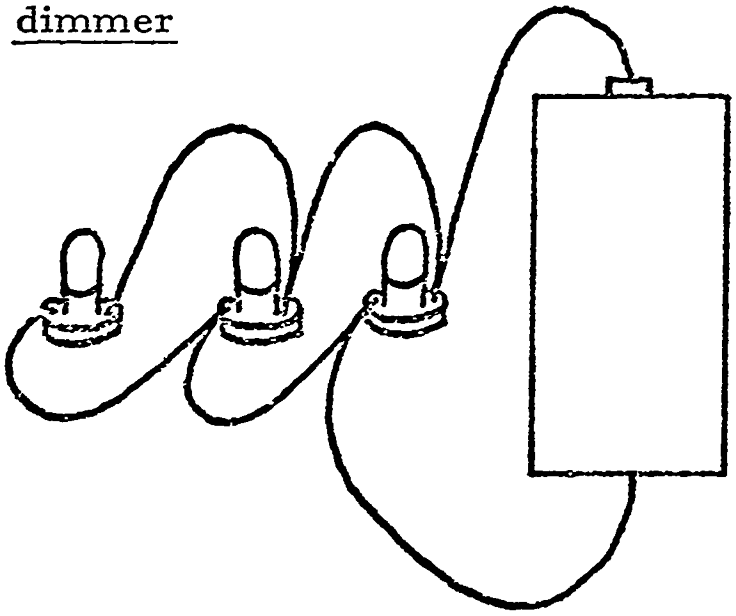
When you add more batteries in SERIES the light gets brighter and brighter



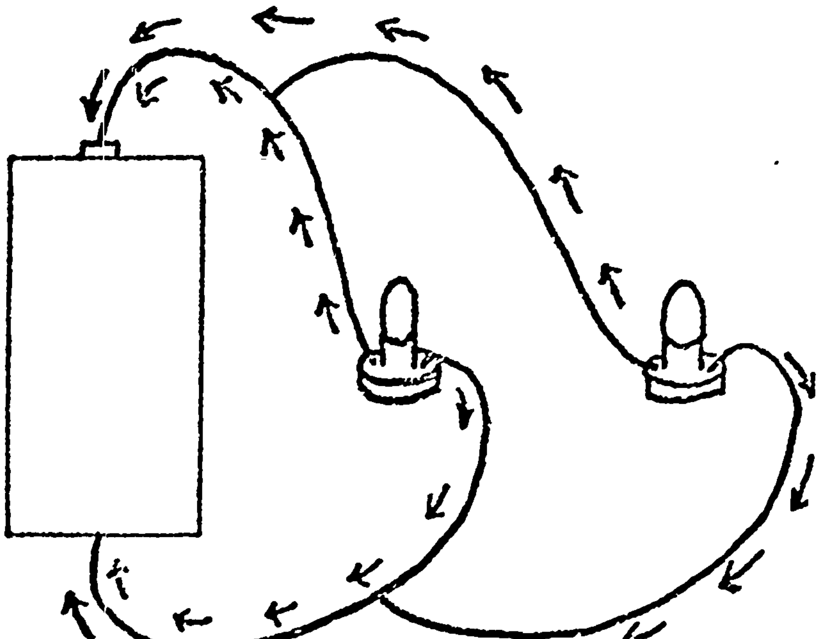
When you add more bulbs in SERIES the lights get dimmer and dimmer



When you add more batteries in PARALLEL the light stays the same



When you add more bulbs in PARALLEL the lights stay the same

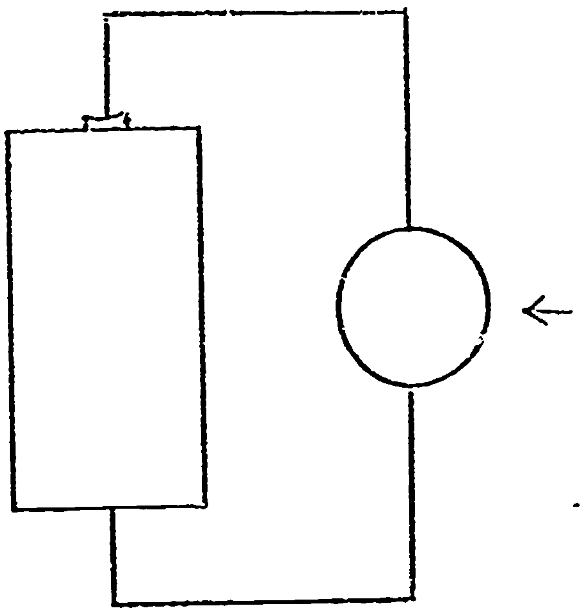


Each bulb is connected on its own path to the battery.

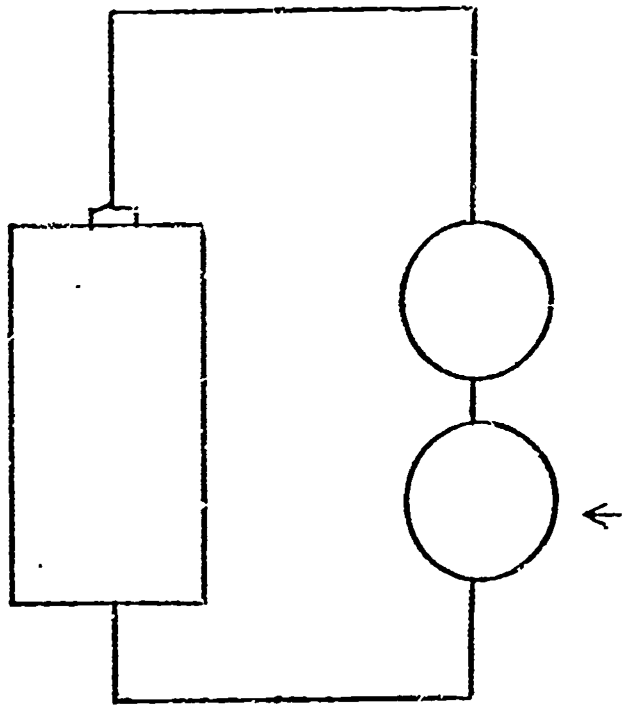
Each bulb is connected to its SOURCE

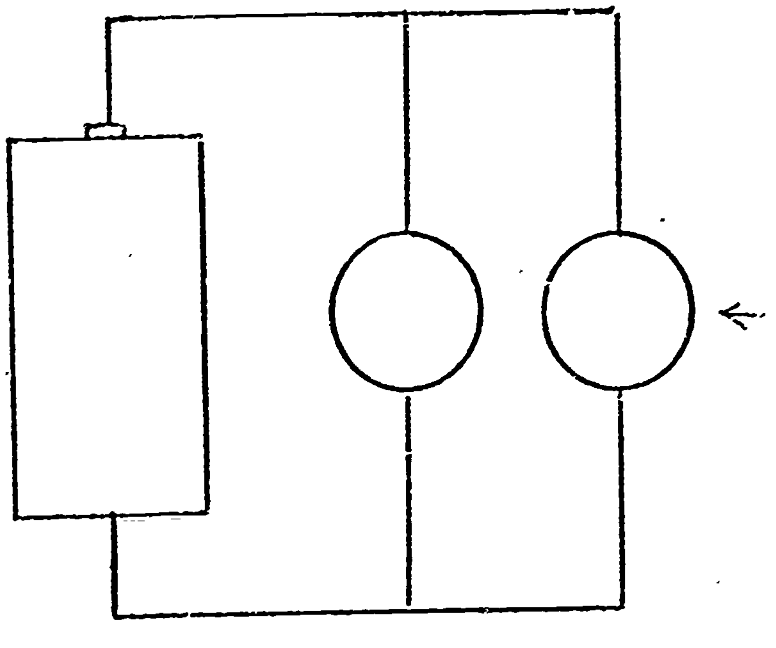
HOW BRIGHT IS EACH BULB?

STANDARD
DIM
BRIGHT
Brightness of two batteries
Brightness of three batteries

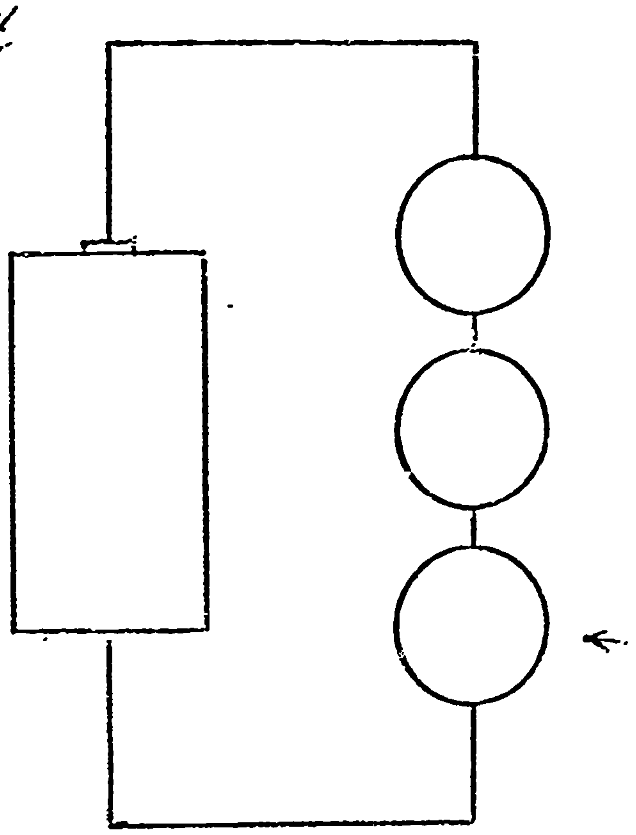


2.

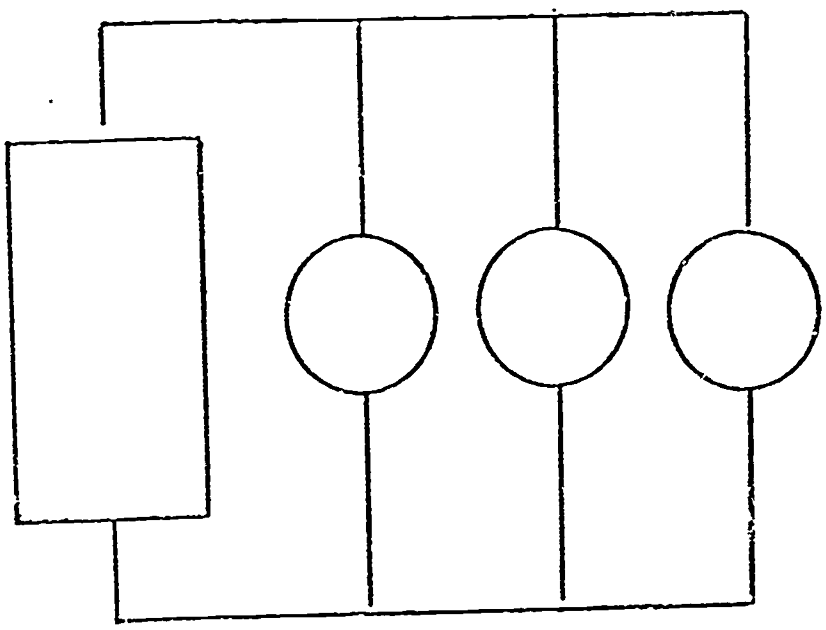




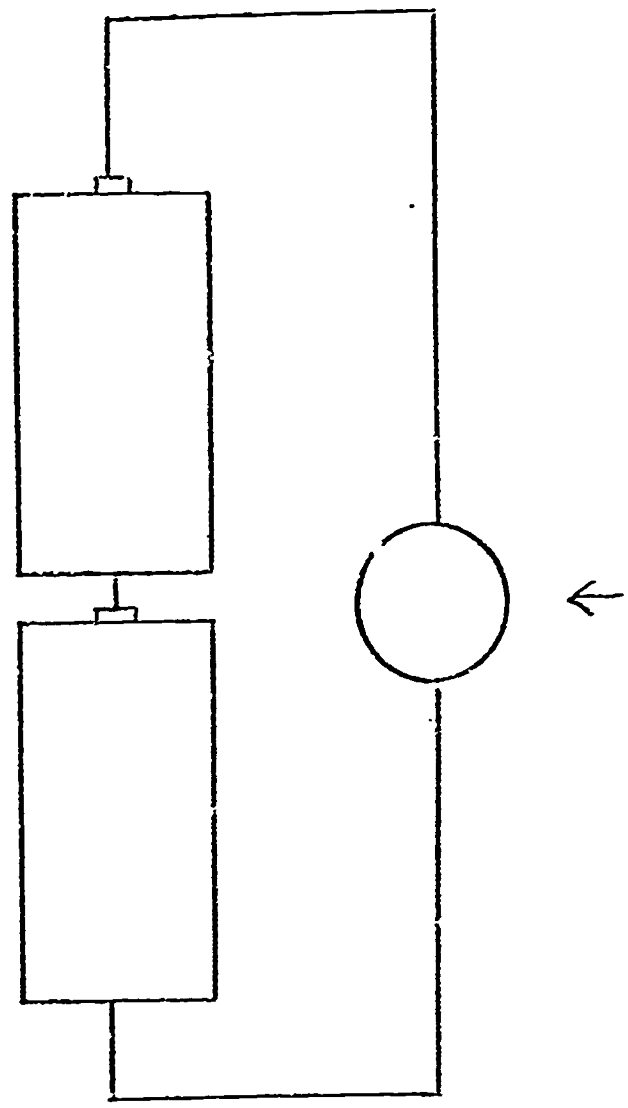
4.



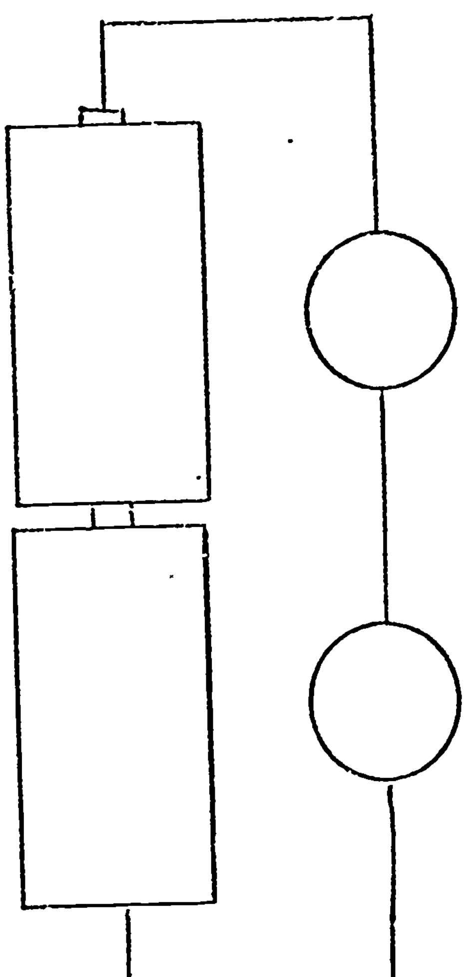
5.



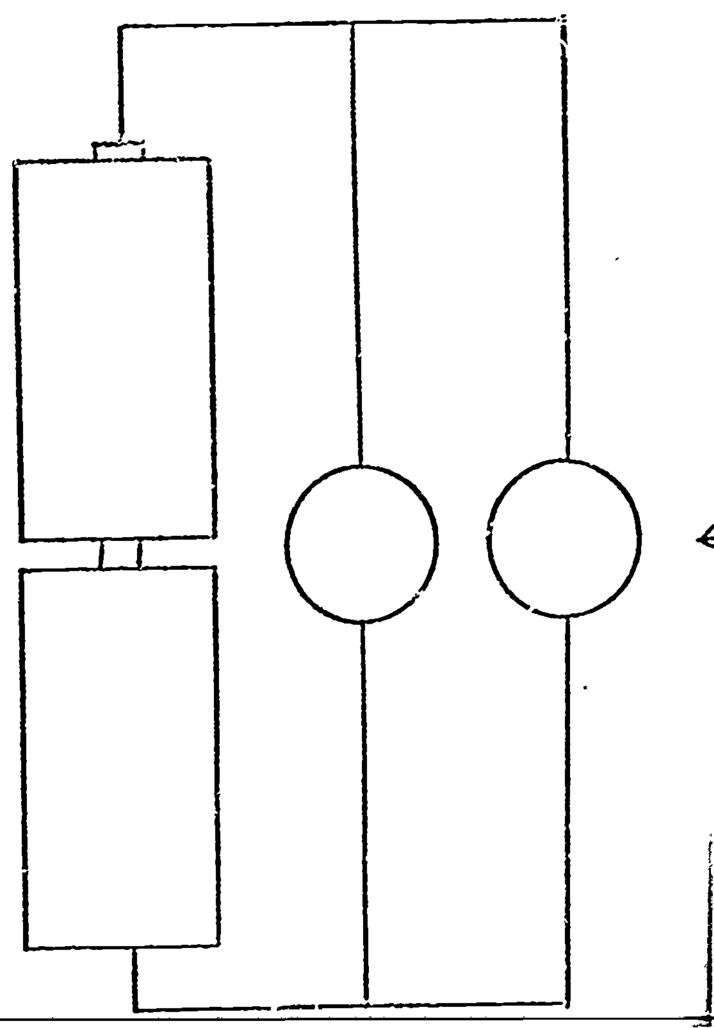
6.



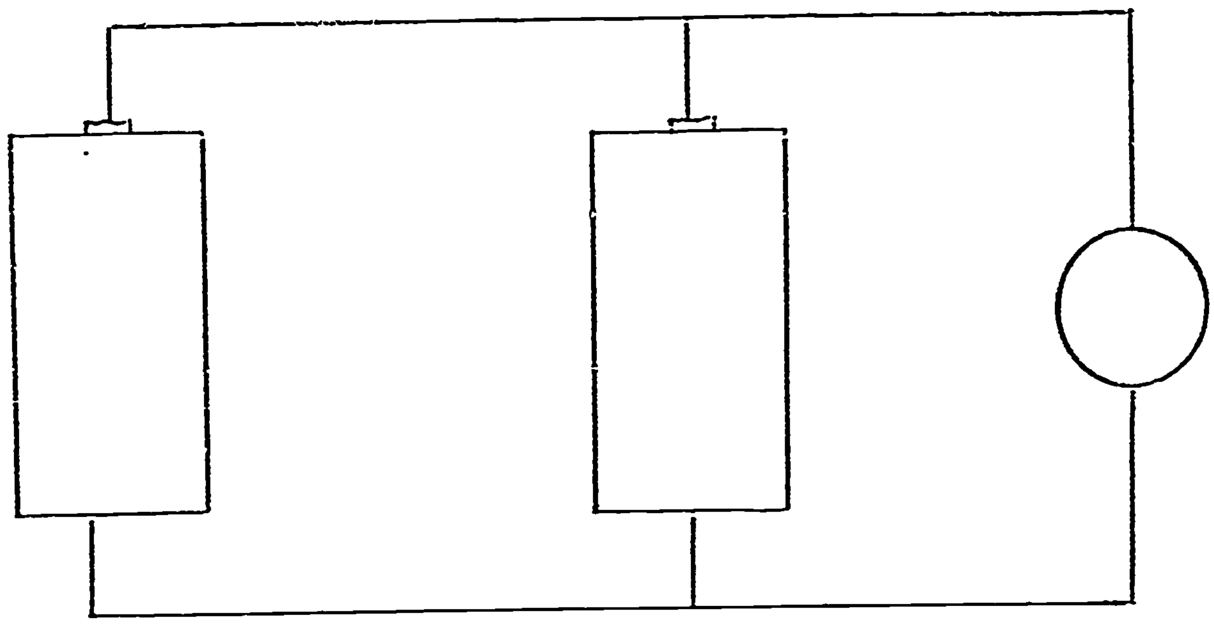
7.



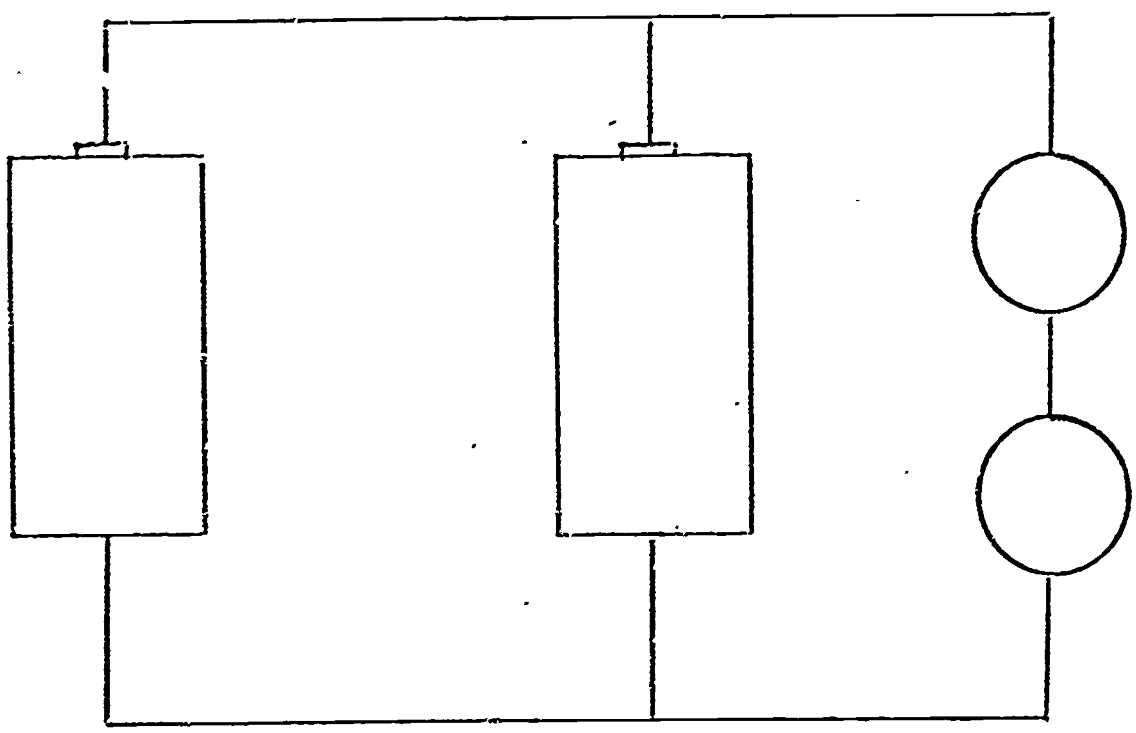
8.



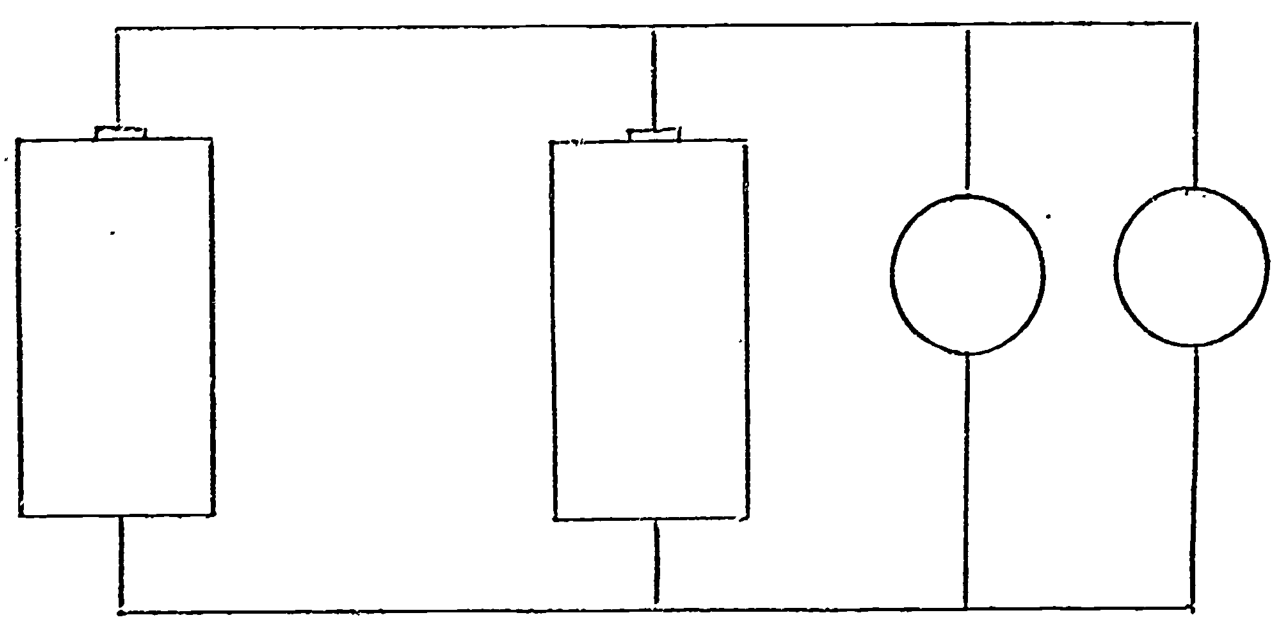
9.



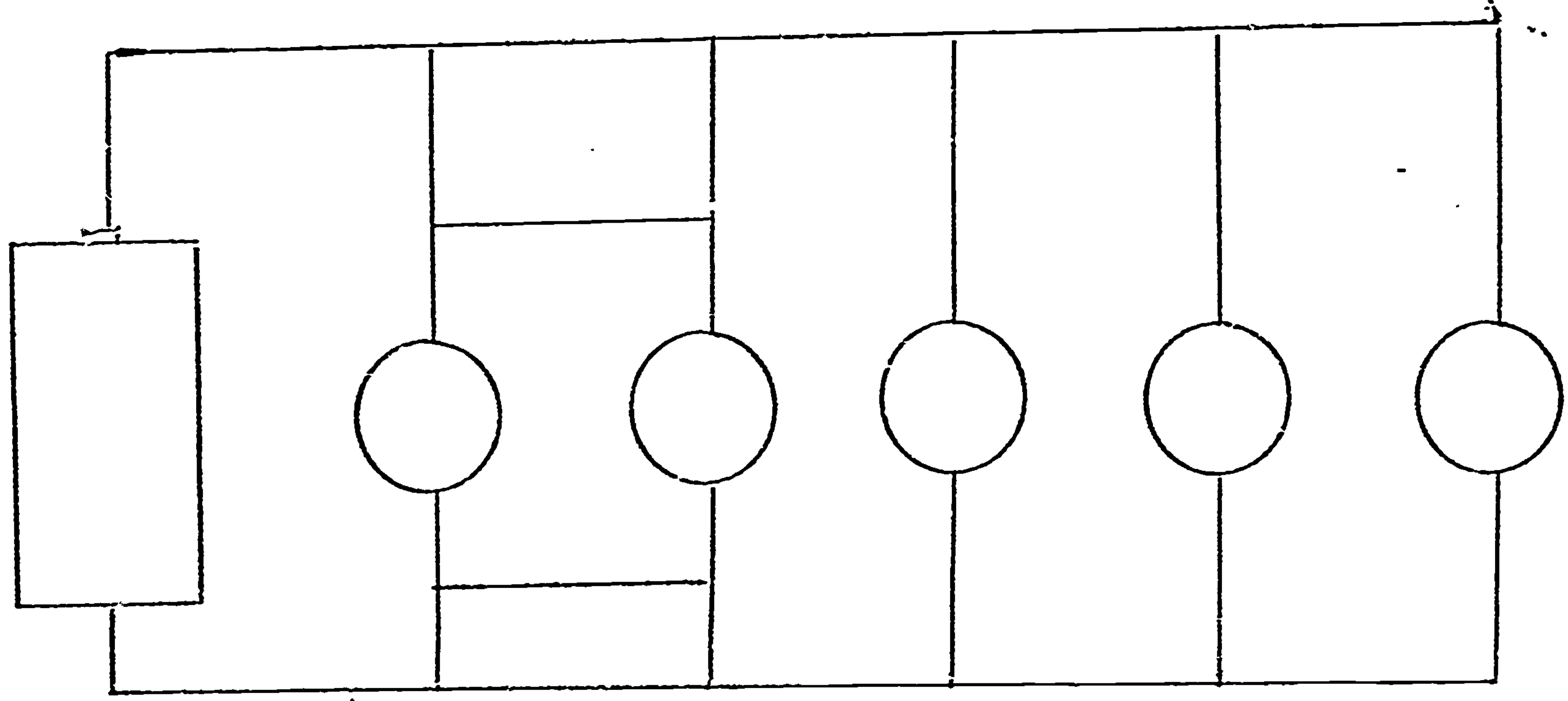
10.



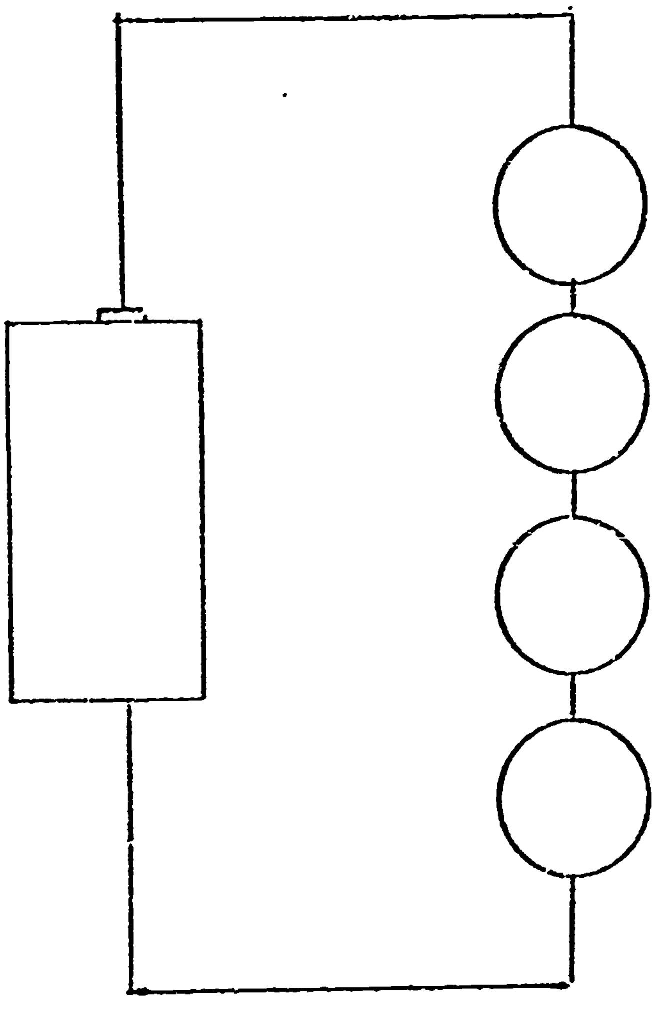
11.



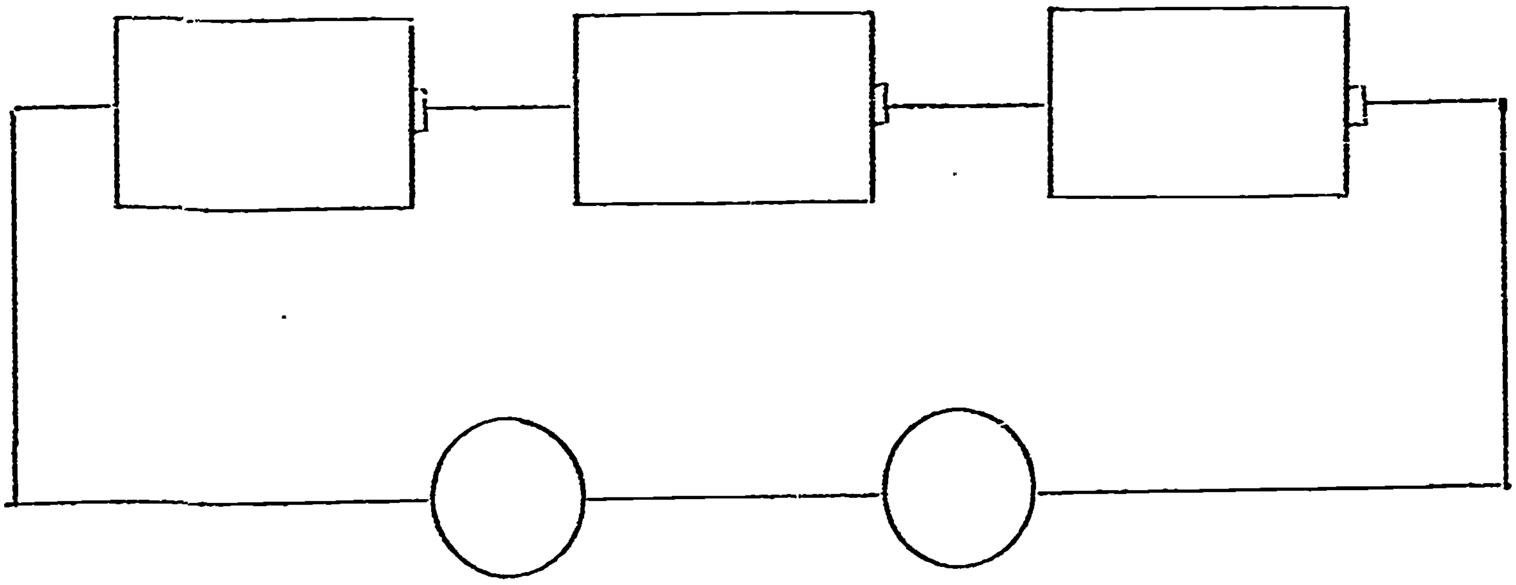
12.



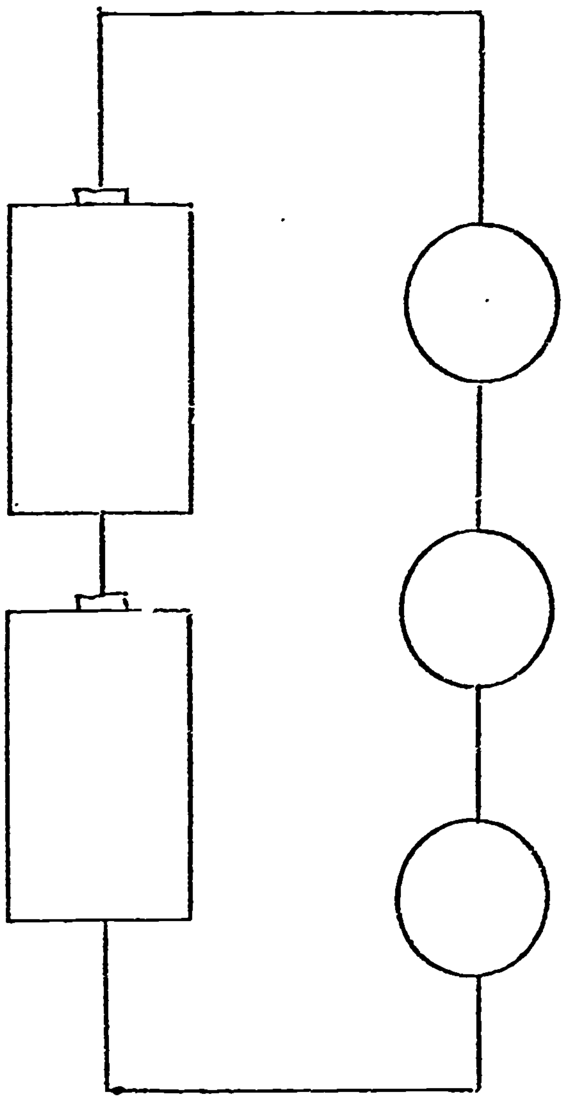
13.



14.



15.

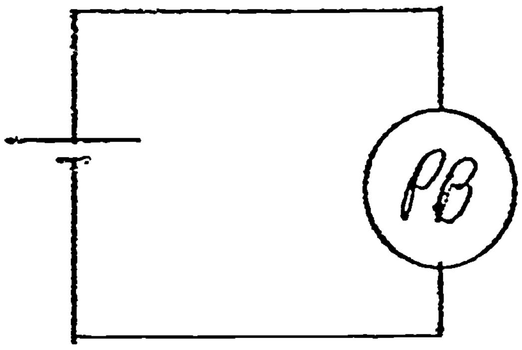


WILL THESE BULBS LIGHT?

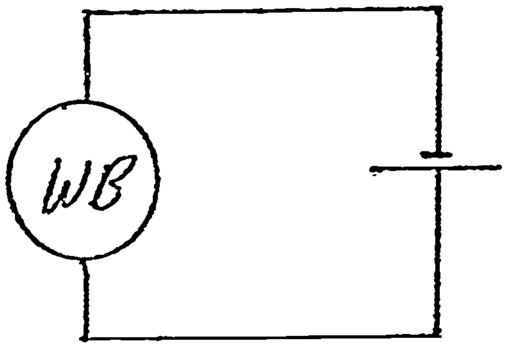
NO
STANDARD
BRIGHT
DIM

COMPLEX CIRCUITS

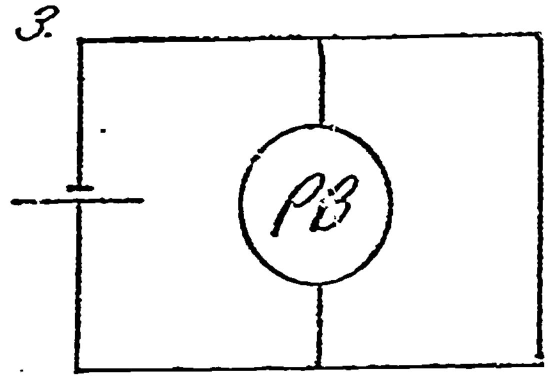
1.



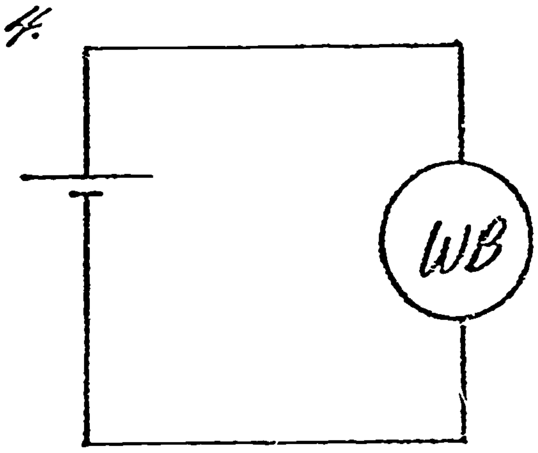
2.



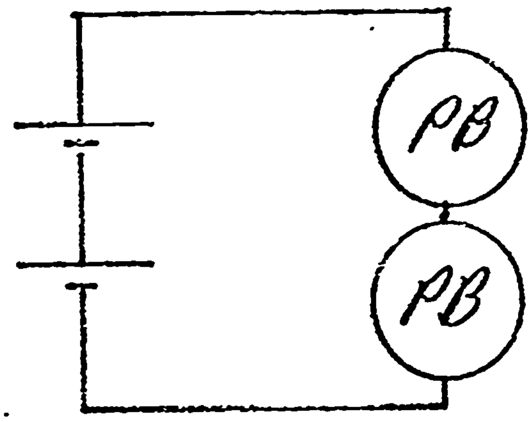
3.



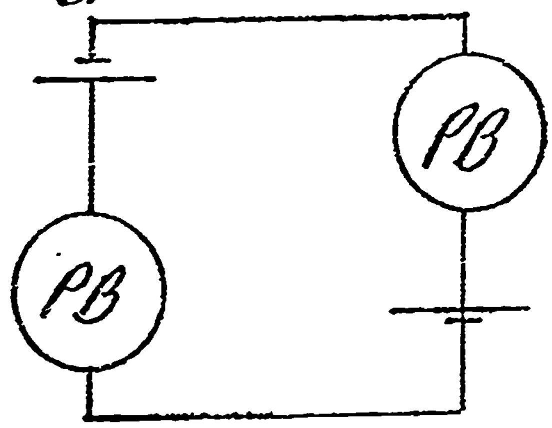
4.

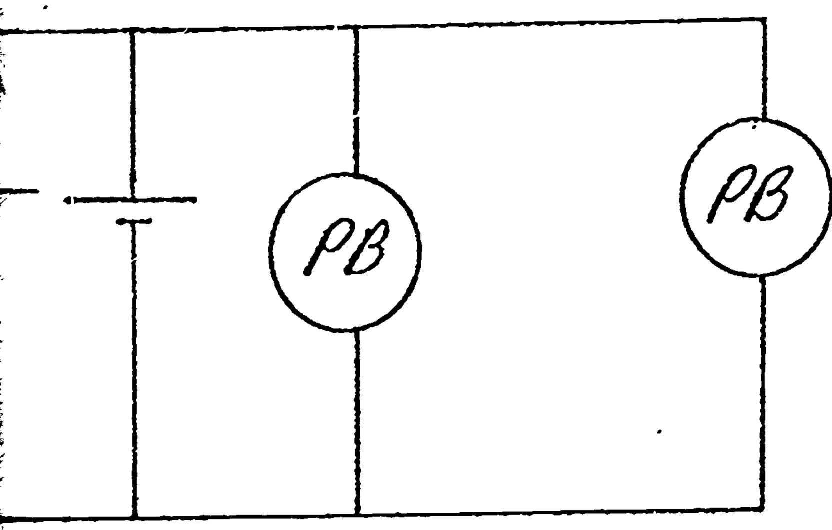


5.

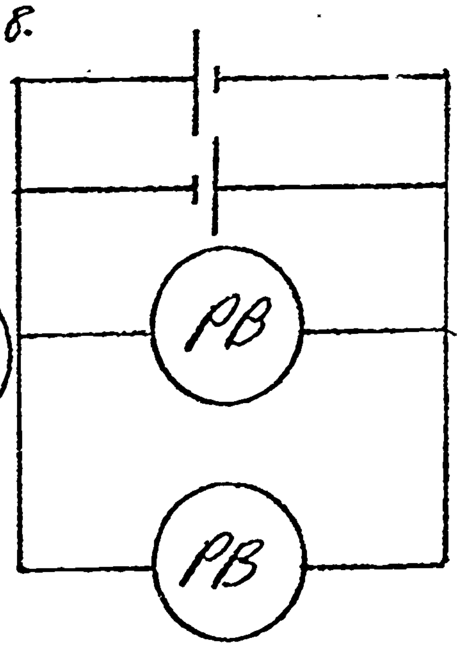


6.

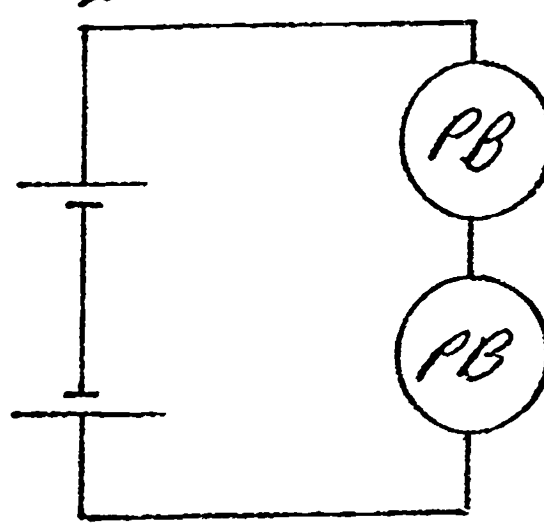


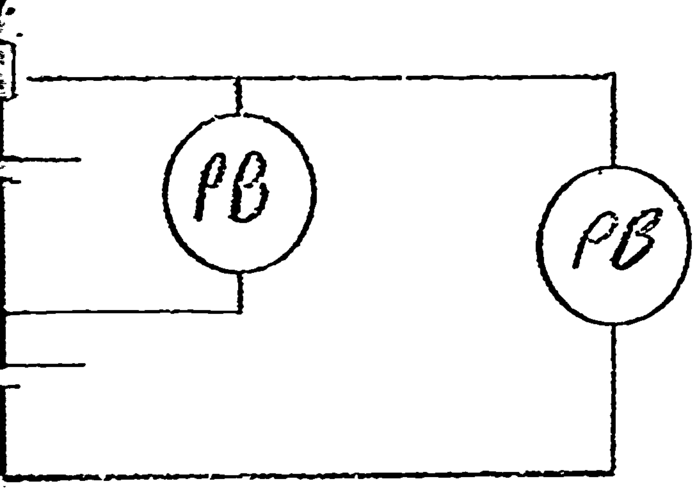


8.

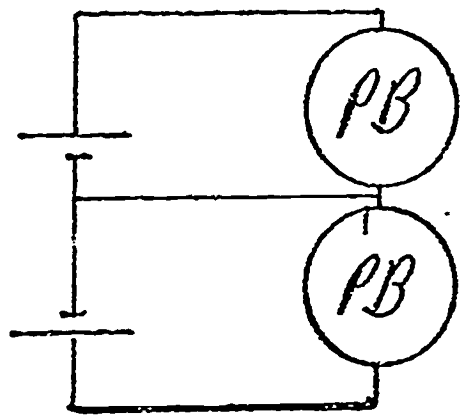


9.

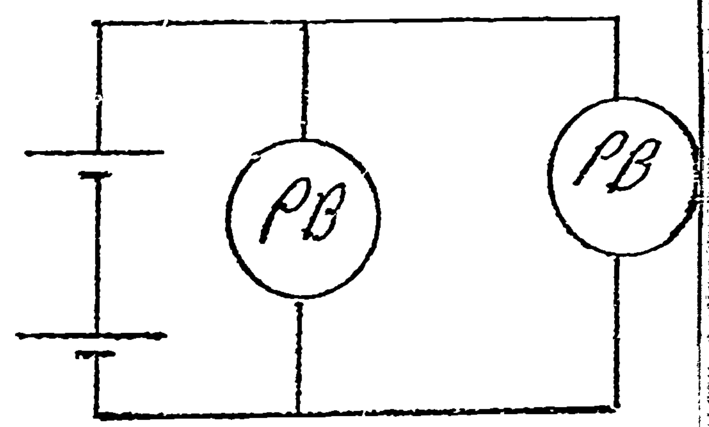




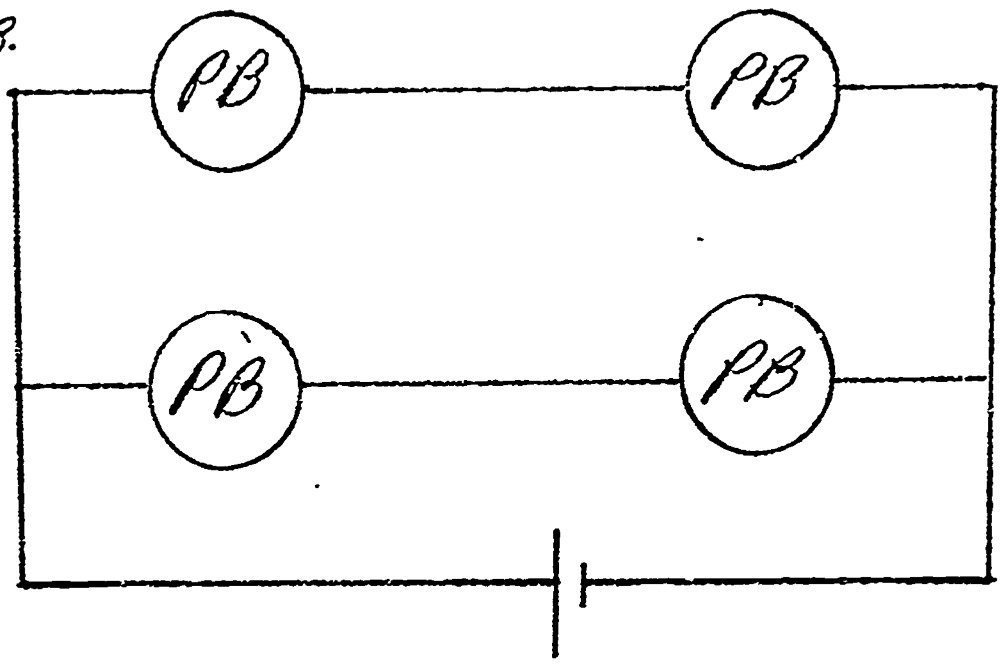
11.



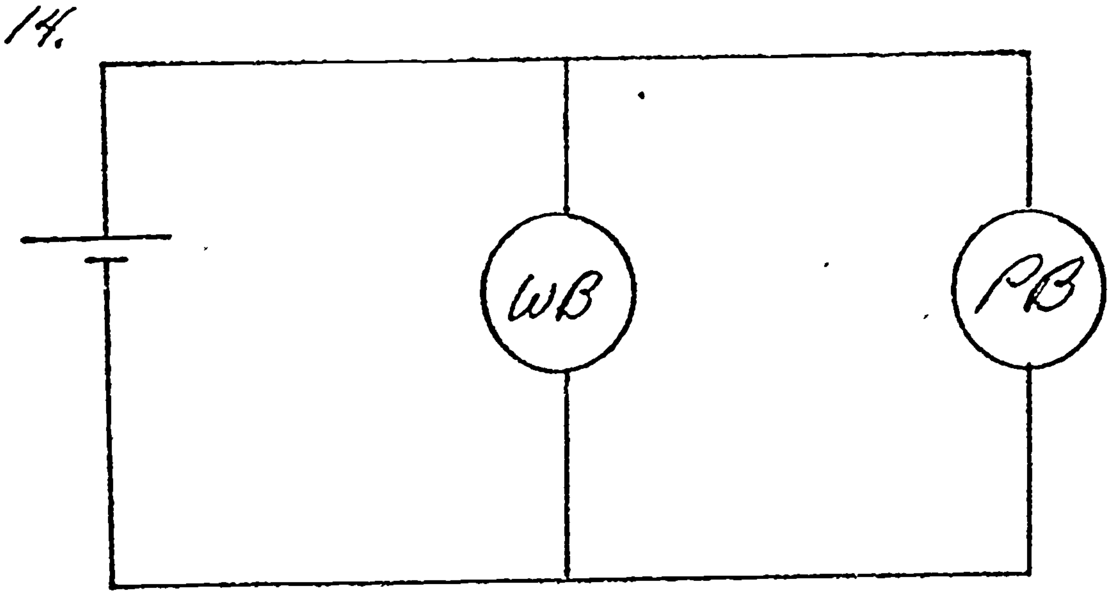
12.



13.

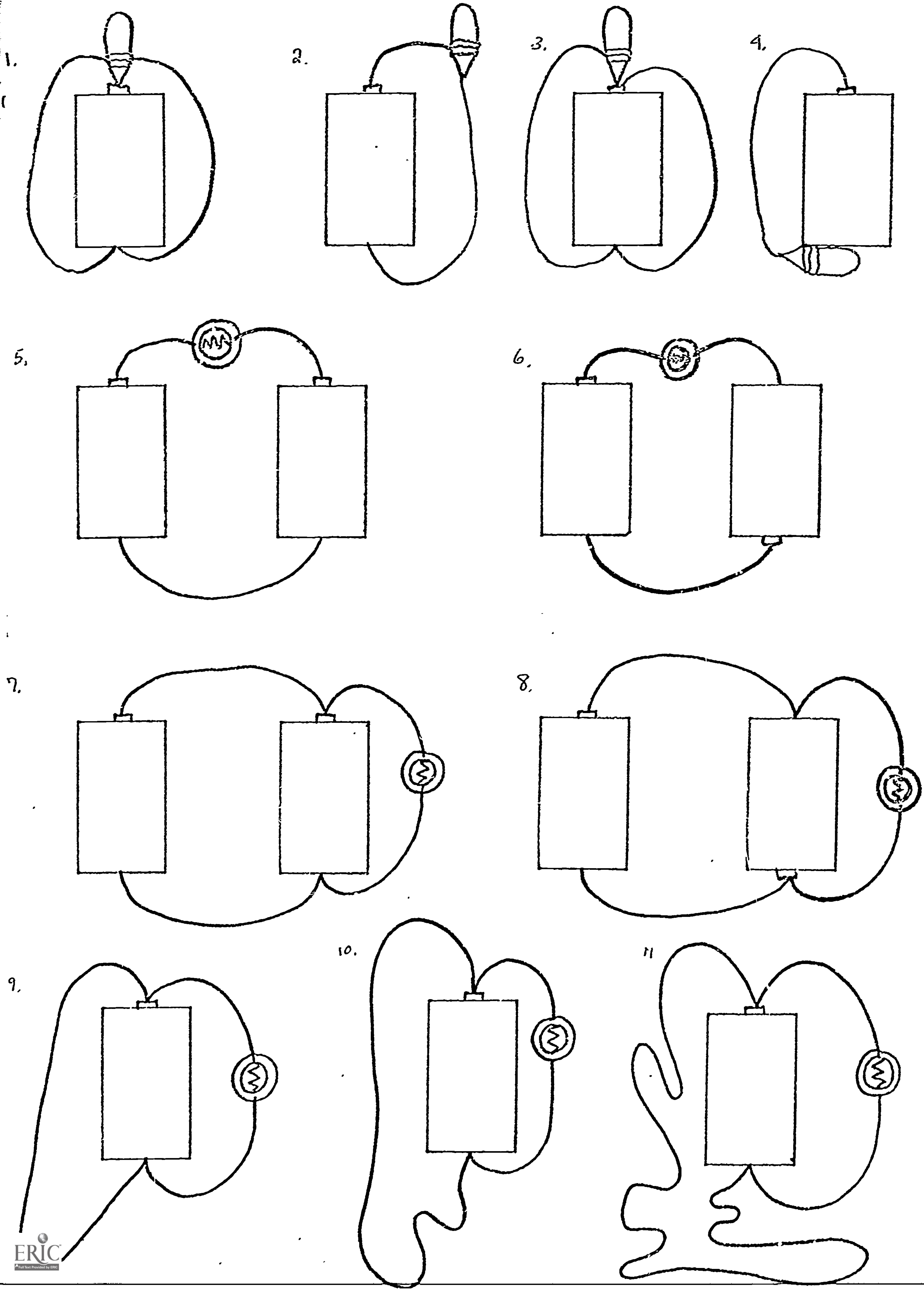


14.



FINAL REVIEW

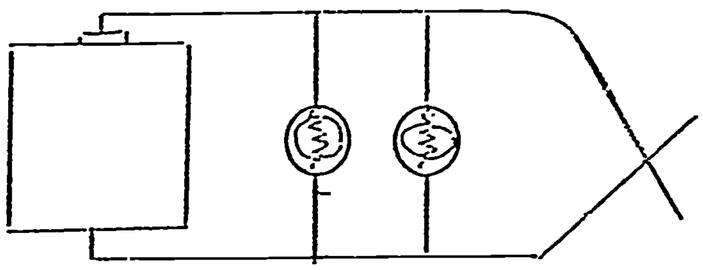
WILL THE FOLLOWING SET-UPS LIGHT?



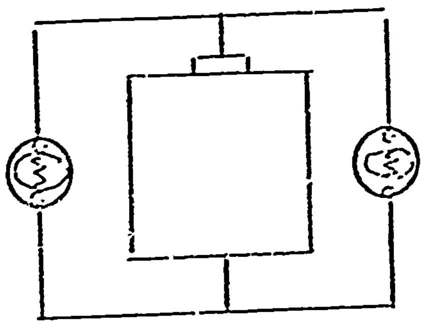
HOW WILL THE BULBS LIGHT?

CHOICES: Bright
Standard
Won't Light

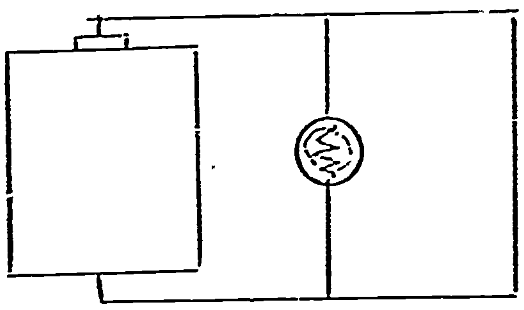
1.



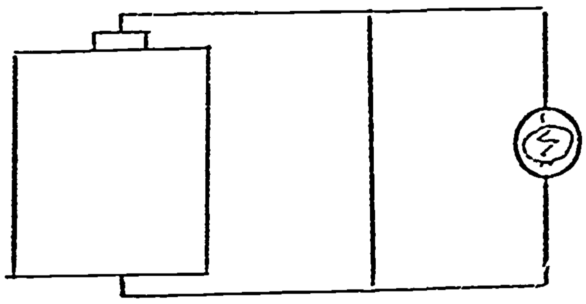
2.



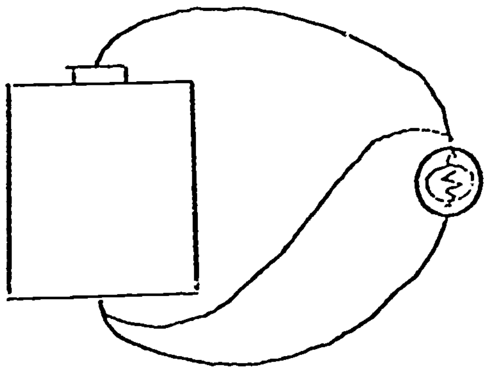
3.



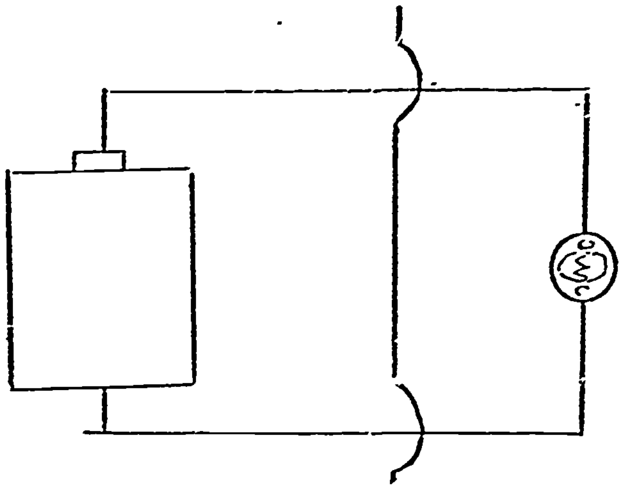
4.



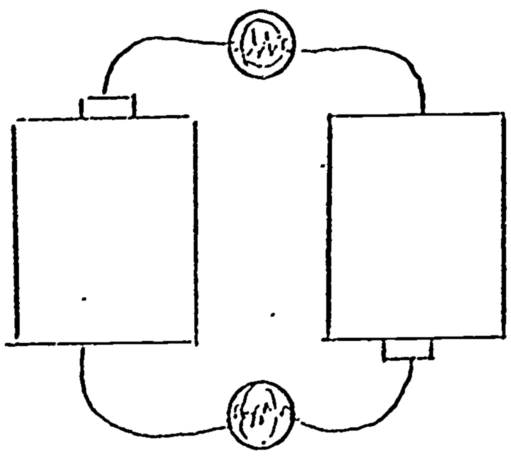
5.



6.



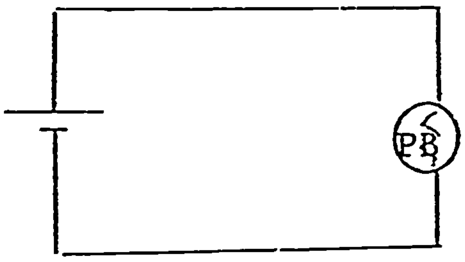
7.



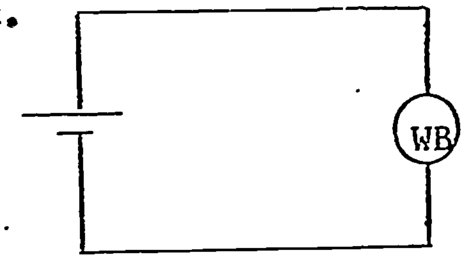
HOW BRIGHT WILL THESE BULBS BE

CHOICES: Standard
Bright
Dim
Won't Light

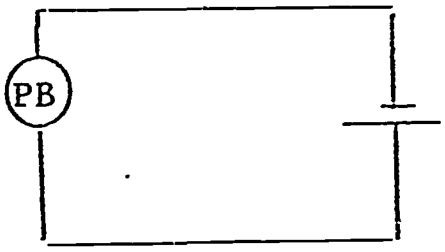
1.



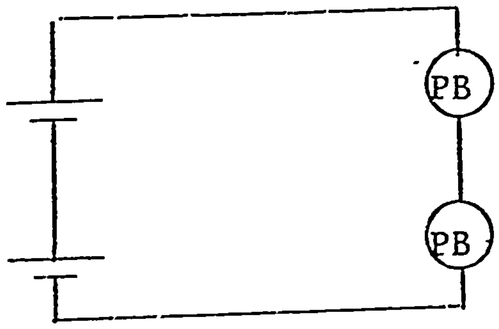
2.



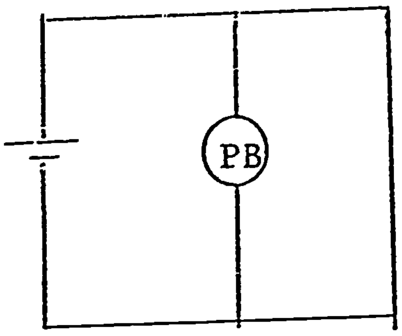
3.



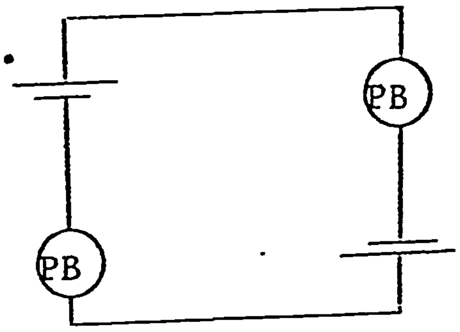
4.



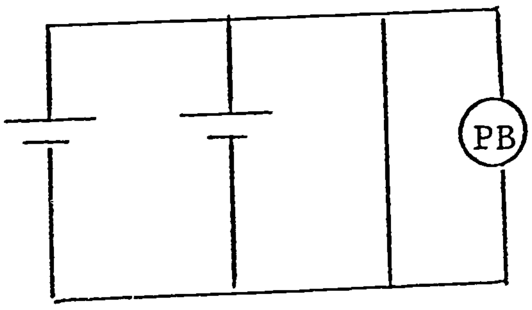
5.



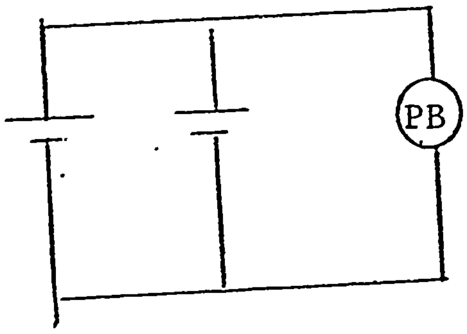
6.



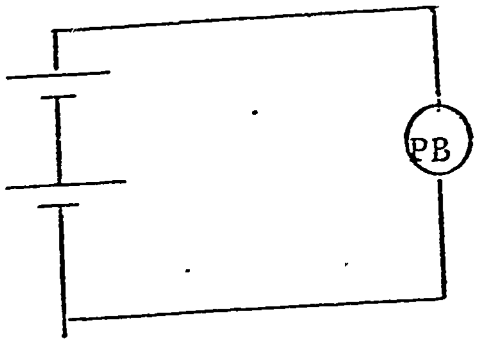
7.



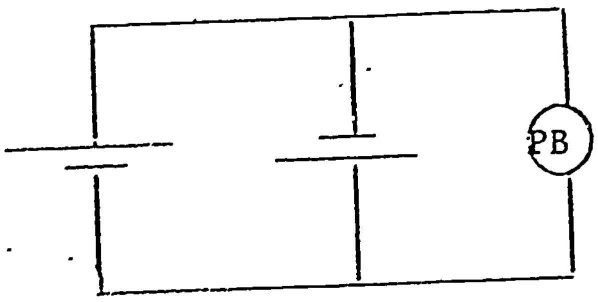
8.



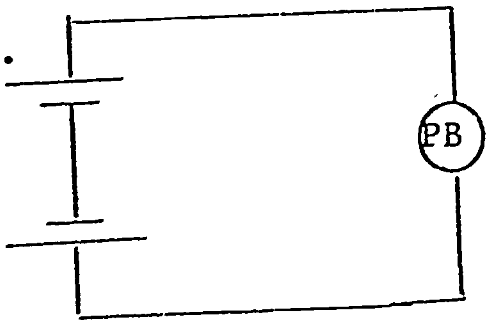
9.



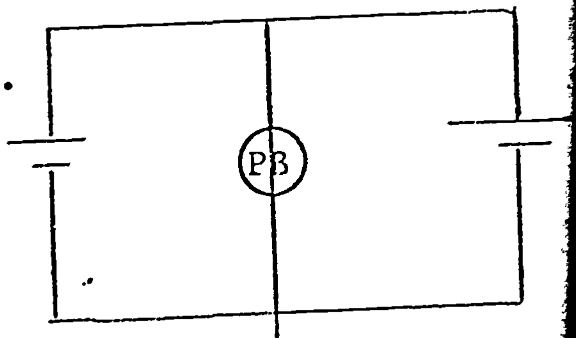
10.



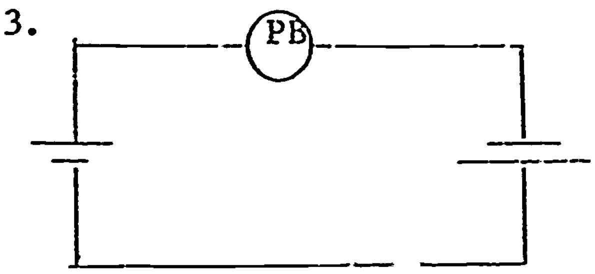
11.



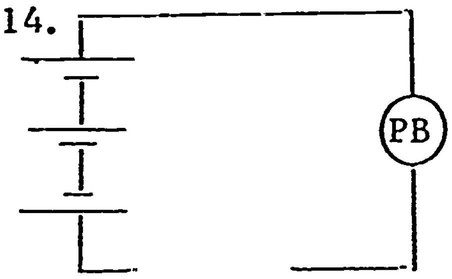
12.



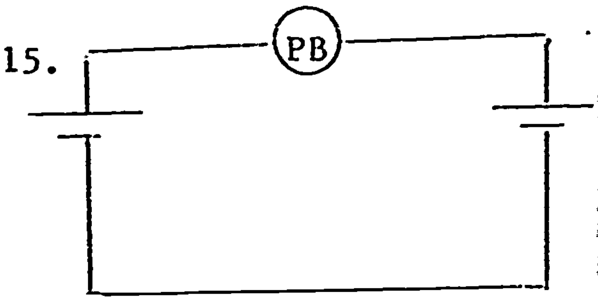
13.



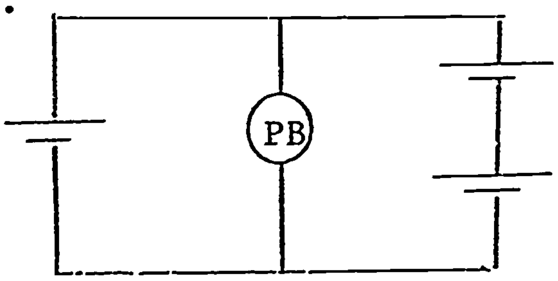
14.



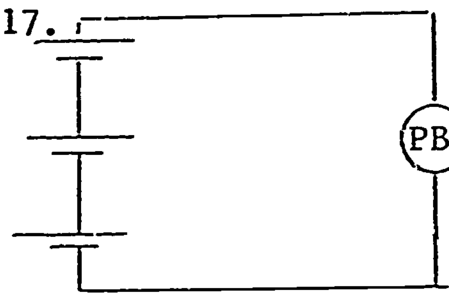
15.



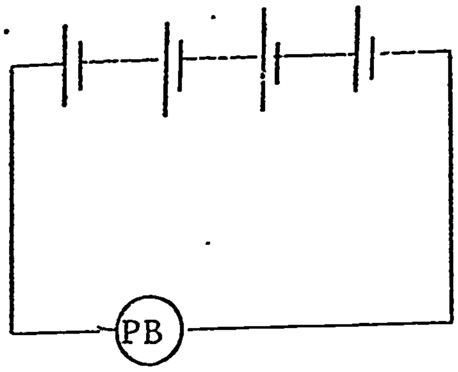
16.



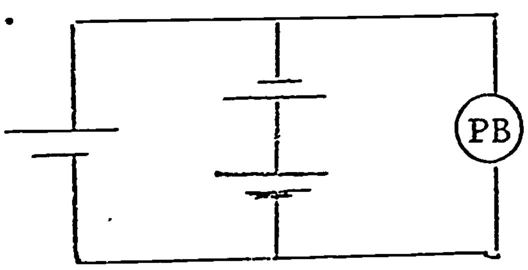
17.



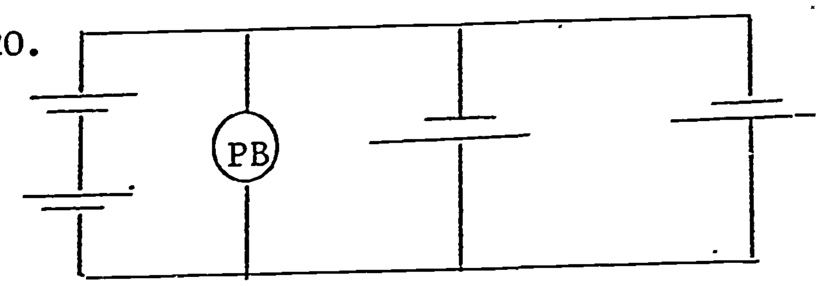
18.



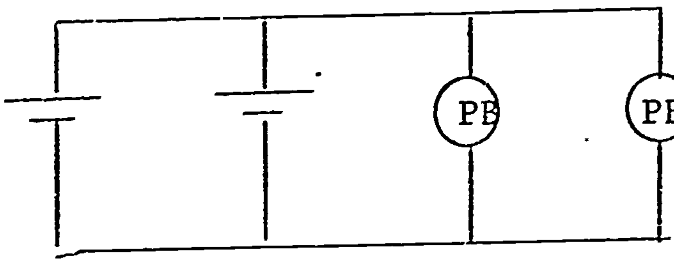
19.



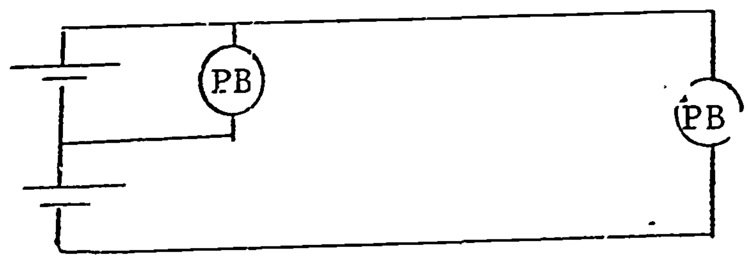
20.



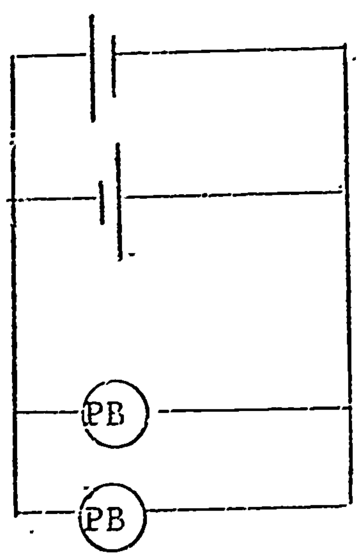
21.



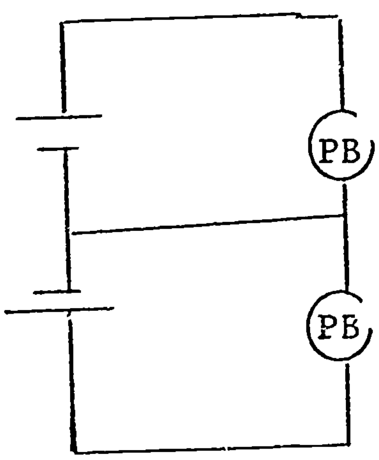
22.



23.



24.



25.