BEGINNER'S MANUAL

Experiment # 1.

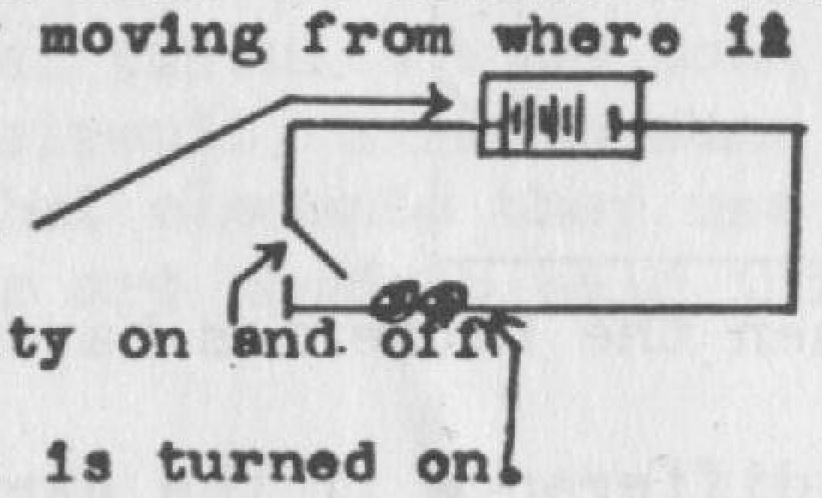
Simple Circuits.

1) The simplest electric setup you can make is called a circuit which means it forms a circle with electricity moving from where it is to where it isnt.

   Here is what a circuit has in it:
   A battery which holds electricity.

   A switch which turns the electricity on and off

   A bulb that lights when the switch is turned on.



2) Turn to page 60 of your GENIAC MANUAL. Here is a circuit just like the one above but it shows how the special switches work.
   The black dots are bolt heads sticking through the panel.
   The circles are the rings of little holes.
   The little box is a brass jumper on the disc(pp 54-55 MANUAL).
   This swings around and lets the electricity move between a bolt in one circle and a bolt in another.

Why do we need these discs? Why not just use knife-blade switches?
First, we need many switches for some experiments and to use the big switches would be very difficult and very expensive. Secondly, we sometimes have to turn on and off several circuits at once. This is done very easily with our discs. In fact that is why they were designed.

Some questions to think about:

- How many bulbs can one battery light?
- What other things can you put in the circuits in place of bulbs?
- What makes a battery work? When yours is worn out, take it apart.
- Why does the bulb light when the current flows through it?
  Take one apart, but be careful not to cut yourself on the glass.
  Draw a picture of what you see. How does the electricity move through the bulb?

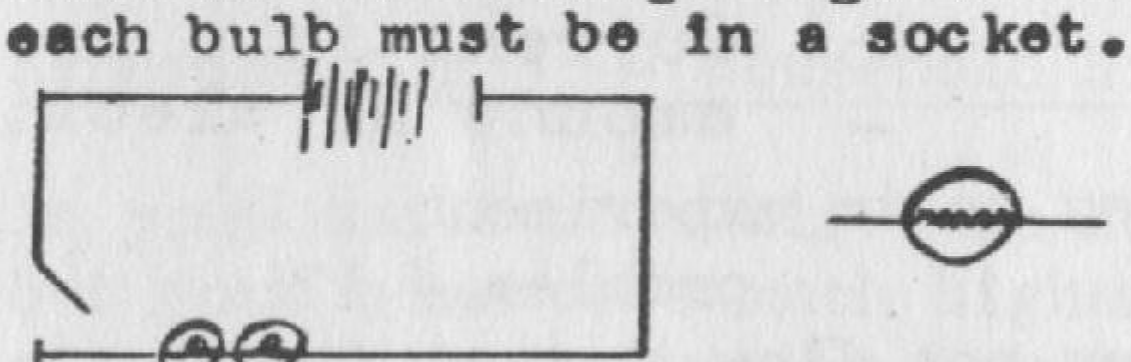
You will find the answers to these questions in later experiments.

Experiment # 2.

Series Circuits.

You remember in experiment # 1 we made a simple circuit so that wherever we closed the switch, electricity went from the battery through the bulb and then back again to the battery.
In this experiment we put different things in the circuit to see how much we can make one battery do.

1) Wire up the circuit with two bulbs.
   This is the wiring diagram. Of course each bulb must be in a socket.



Do both bulbs light up? If not, why not?
We have drawn the bulbs in a diffârent way. Why?

2) Wire up the circuit with three bulbs in series.
   Does it still work? If not, why not?

Symbols:

+ Where the electricity is

— Where the electricity isn't

Small coil of wire

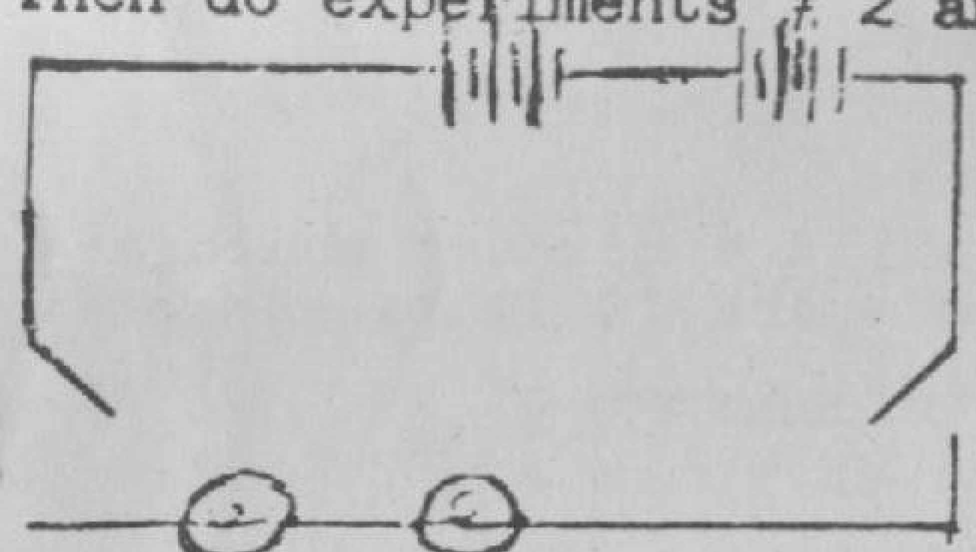
Direction electricity moves in

Bulb

Battery

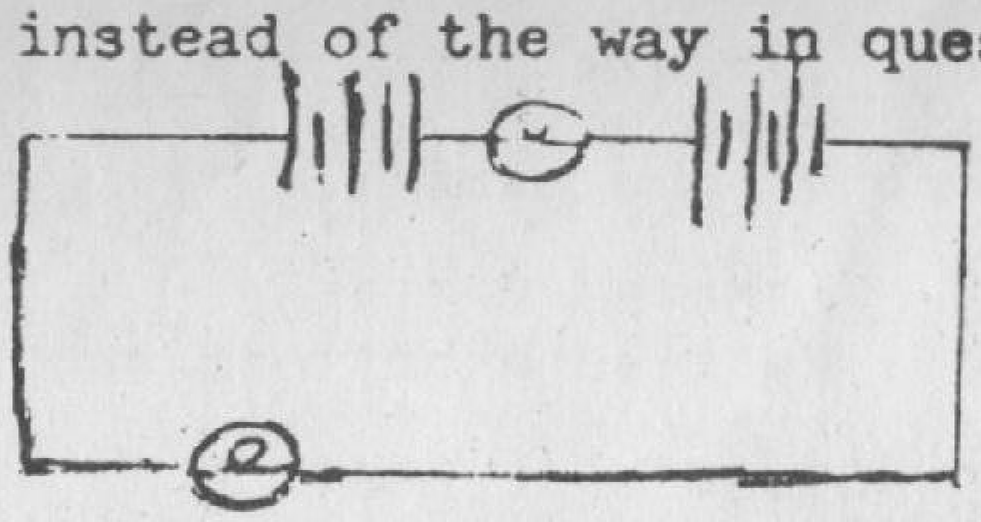
Switch

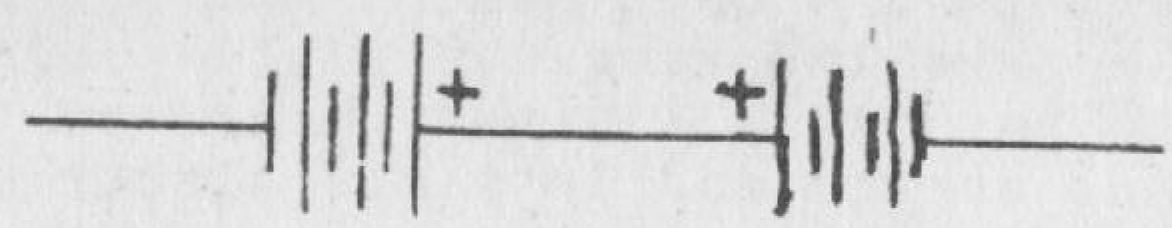
3) Now put two batteries in series so that they are cap to bottom. This puts the + of one next to the — part of another.
Then do experiments # 2 and # 3 again.



What happens when the batteries have the two + poles facing each other?

4) Does it make a difference if the circuit is wired this way instead of the way in question # 3? If it does, why?



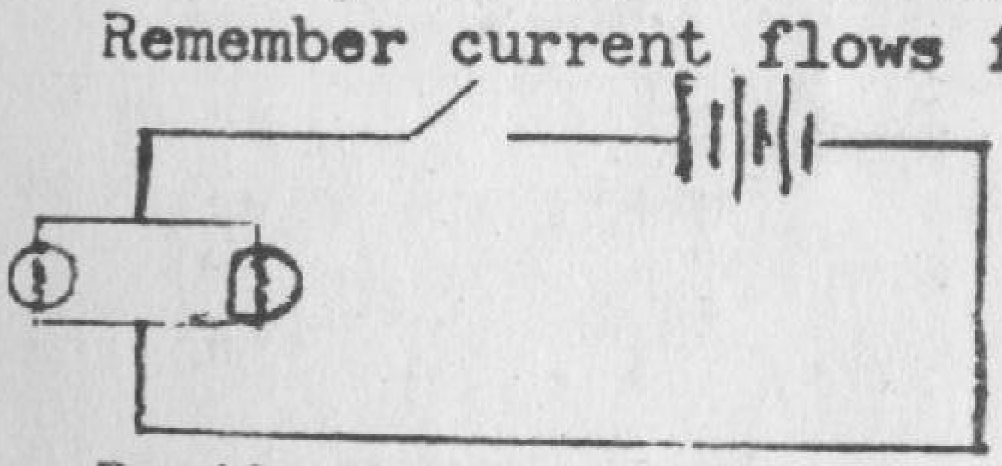


You can now answer some of the questions in experiment # 2. Were you right?

Why are these circuits called series circuits?
Do all bulbs light up equally well?
What makes one bulb shine more brightly than another?
Is it because of the bulb? the place of the bulb in the circuit? or the battery?
Can you make an experiment to answer these questions?
Could you use this circuit to signal over great distances?
What changes would you have to make?

Experiment # 3 -- Parallel Circuits.

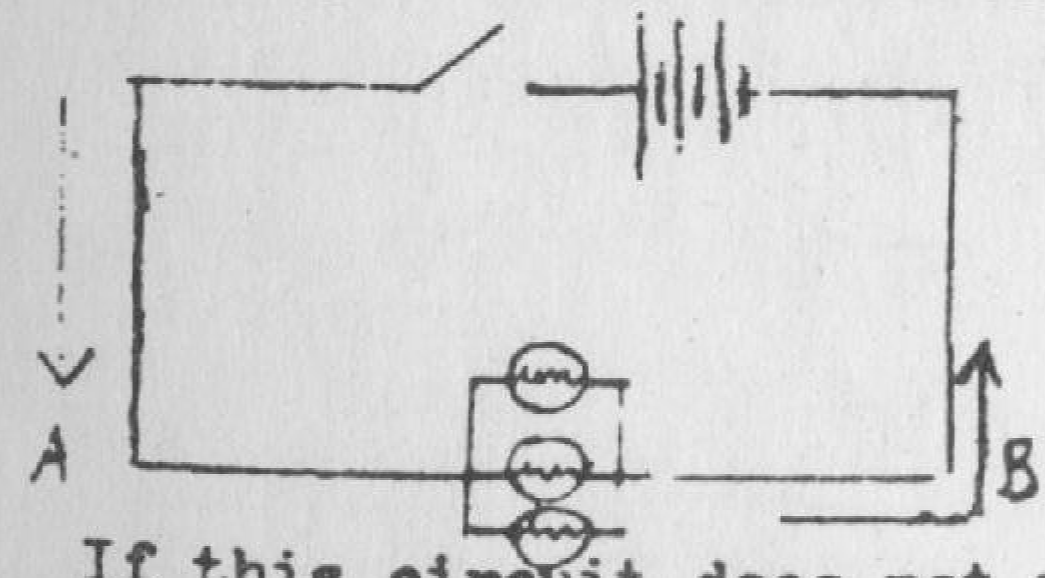
1) In the diagram below show which way the current flows from the battery and how it comes back again.
Remember current flows from + to — .



Symbols:
|| Parallel
R Resistance
I Current is amount of elect.

Do the bulbs light more brightly than they do in experiment # 2 problem # 1?

2) In a parallel circuit all the current does not flow through the same things. In the diagram below we see that it moves from the battery into three different paths.



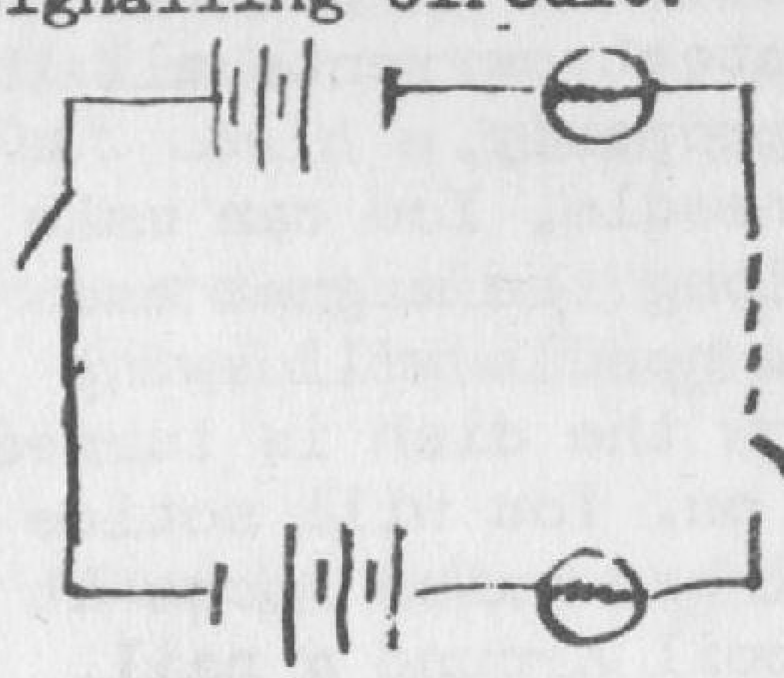
If this circuit does not work, try it with an extra battery.

3) Is there the same amount of current at A and B? At A and C? At A and D? At A and E?
With parallel and series circuits you can design all the circuits used in GENIAC. In fact no more is needed for much more advanced computers.
In subsequent sections of this Beginner's Manual we show you how to use special symbols to describe the circuits and a special algebra to help simplify your first diagrams.

4) Make up your own series parallel circuits with both series and parallel elements in the same circuit. Examine some of the circuits in your GENIAC MANUAL to see what elements they use and how the parallel circuits in particular are used to hold information.

Experiment # 4 -- Signalling Circuits.

Signalling Circuit:



Symbols:
Dot, a quick flash or sound made by closing S.C. and quickly opening it.

Dash, made by holding down the switch longer, then pulling it up.

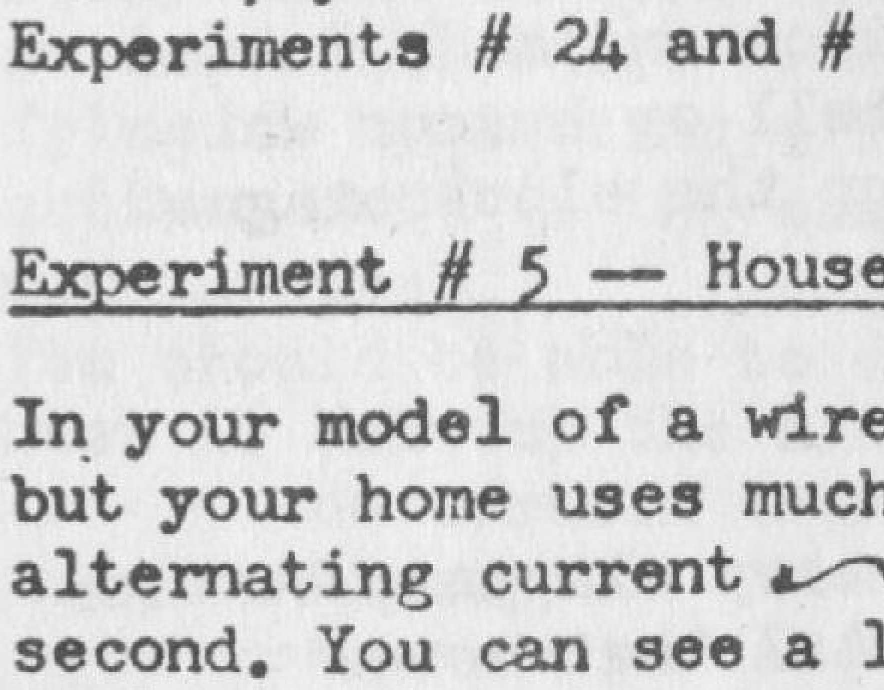
The little dashes ---- mean that you can make the wire as long as you like.

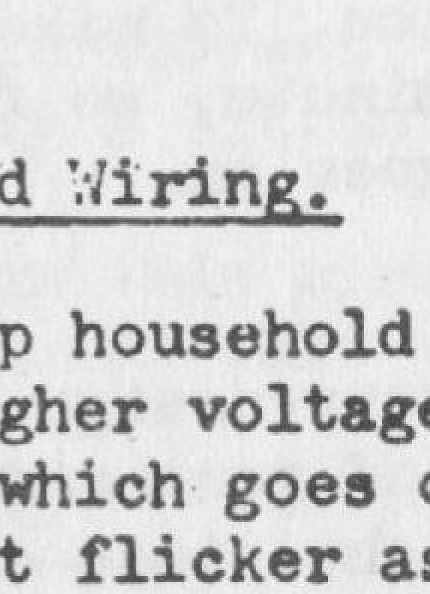
Will the circuit light the bulbs if both switches are open at any one time?

The code most frequently used for signalling in the United States is the MORSE CODE which has a different collection of dots and dashes for each letter. A signal is made either with flash-lights or by having a buzzer sound when you make the current flow.
Remember to keep the batteries + to —.
How long can the wires be with only two batteries?
If you have an Encyclopaedia, look up the MORSE CODE or SAMUEL MORSE, the inventor. How did people send messages over great distances before they had electricity?
Make up your own secret codes to use with friends in GENIAC MANUAL Experiments # 24 and # 25.

Experiment # 5 -- Household Wiring.

In your model of a wired up household you will use 1½ volt batteries but your home uses much higher voltages and a different kind of current-alternating current ∿ which goes on and off 60 times (cycles) per second. You can see a light flicker as the current rises and falls.
Saale Models of your home lights can be made with the bulbs, sockets and switches in your kit. Up to 10 can be lighted if the circuits are in. Here is one circuit that was built to light a scale model log cabin.





∿ Alternating current
Ⓞ Motor
~~~ Heater
V=E ← Volts Electromotive Force
Fuse ∿

These dotted lines indicate the wires run inside the house.
~~~

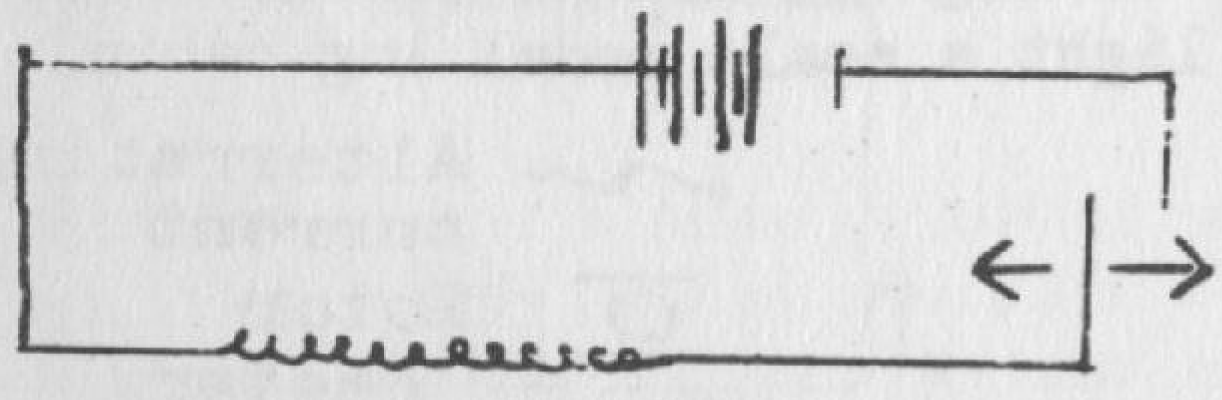
One switch is used. If you want to turn off the lights one by one, loosen them in their sockets. The voltage or maximum push is the same for each bulb. If each bulb has the same current flowing through it, what fraction of the total current flows through each bulb?
Design a circuit that duplicates the wiring in your house.
What is a fuse used for? Go back and take a look at the fuse-box in your house. Before you touch it, make sure your mother or father show you how. You can be hurt badly by handling fuses incorrectly. Take a look at a spare fuse and describe it. Compare it with a burnt-out fuse.

Experiment # 6 -- Magnetic Fields and Compasses: Electromagnets.

One surprising effect of an electric current is that wherever it moves it can be detected at a distance. Sometimes this distance is short-- as when we tap a telephone, but sometimes we can detect currents all the way around the world, if they have been broadcast properly.
For this experiment you will need a small compass needle. You can make a compass from a bar magnet. Just rub the needle along the magnet and place it in a cork floating in a dish of water. The needle will swing around and fix itself in one direction no matter how the dish is turned.
Now make a small coil of wire and turn the current on. You will notice that the compass needle moves slightly. If the coil has extra loops it will affect the compass needle more. Make a tight coil around a nail. This will create a stronger magnetic field. The nail will then become a magnet test.
How powerful can you make the magnet?
How far away can you detect the electric current flowing?
Can you detect a current flowing in your telephone-line cord?
A loop wrapped around the cord will increase the strength of the signal, amplifying it.

Experiment # 7 -- Bell and Buzzer.

Before we saw how a wire coiled about a piece of iron was made into a magnet when the current was turned on. To make a bell or buzzer which moves back and forth many times a minute, we fix up the electromagnet so that it goes off as soon as it goes on.
Can you do this?
Try to work the diagram out here.
Then make a model of this to test your design.
For a bell you will need some kind of gong and a heavy clapper, but for the buzzer you will want a short light piece of metal that moves quickly back and forth.
Here is a diagram that works:



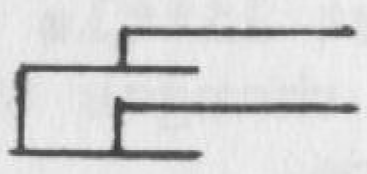
How fast and how often can you make the clapper move?
Can you combine a code key and a buzzer?

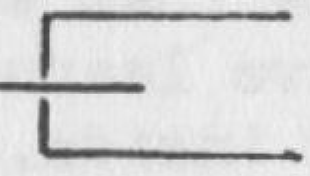
Experiment # 8 -- Relay Memory.

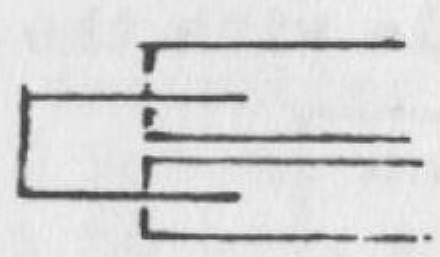
We now come to a circuit which has a memory!
Stop a minute and think of how your own memory works. Do you remember everything? Or only special things? Do you find that after you have put in extra work remembering something that it stays remembered and is difficult to forget?
Well, this is what a relay does. A relay is just an electromagnet, which is turned on by the current when the current is strong enough. The relay either operates another circuit, or releases when another current flows into the coils on the other side pulling the contact back.
Draw a diagram, then make a relay.
Can you make hook relays in series? in parallels?
How is the remembering in a relay like remembering in the brain?
Which is more certain? Which is more rapid? More complicated?
What other kinds of mechanical memory are there?
What could a human remember that no machine can remember?

Some relay circuits you will find:

Single Pole Single Throw (SPST) 

Double Pole Single Throw (DPST) 

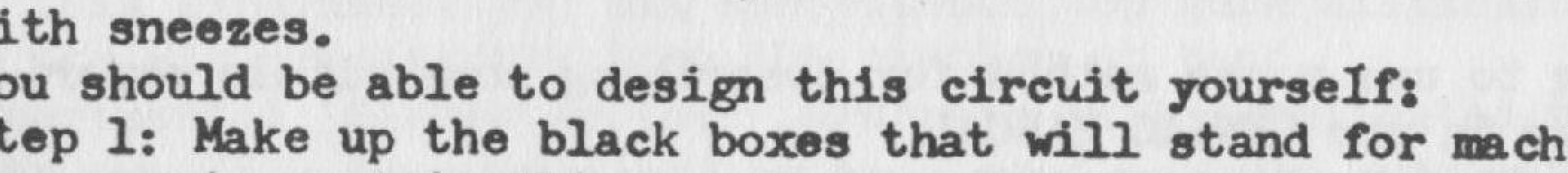
Single Pole Double Throw (SPDT) 

Double Pole Double Throw (DPDT) 

Experiment # 9 -- Burglar Alarm.

To design a burglar alarm for your home, decide which windows or doors you expect to be opened. Now rig up a circuit that trips a relay when the window is opened. (See MANUAL EXPERIMENT # 5.)
This means that a little current flows through the magnet of the relay which in turn causes a much larger current to flow. This is an important idea. We are really making the current larger or amplifying it by letting a little current "tickle" a larger current into action. Just in the same way a little bit of dust makes us shake with sneezes.
You should be able to design this circuit yourself:
Step 1: Make up the black boxes that will stand for machines that do certain things.

Burglar Alarm Relay gives Signal



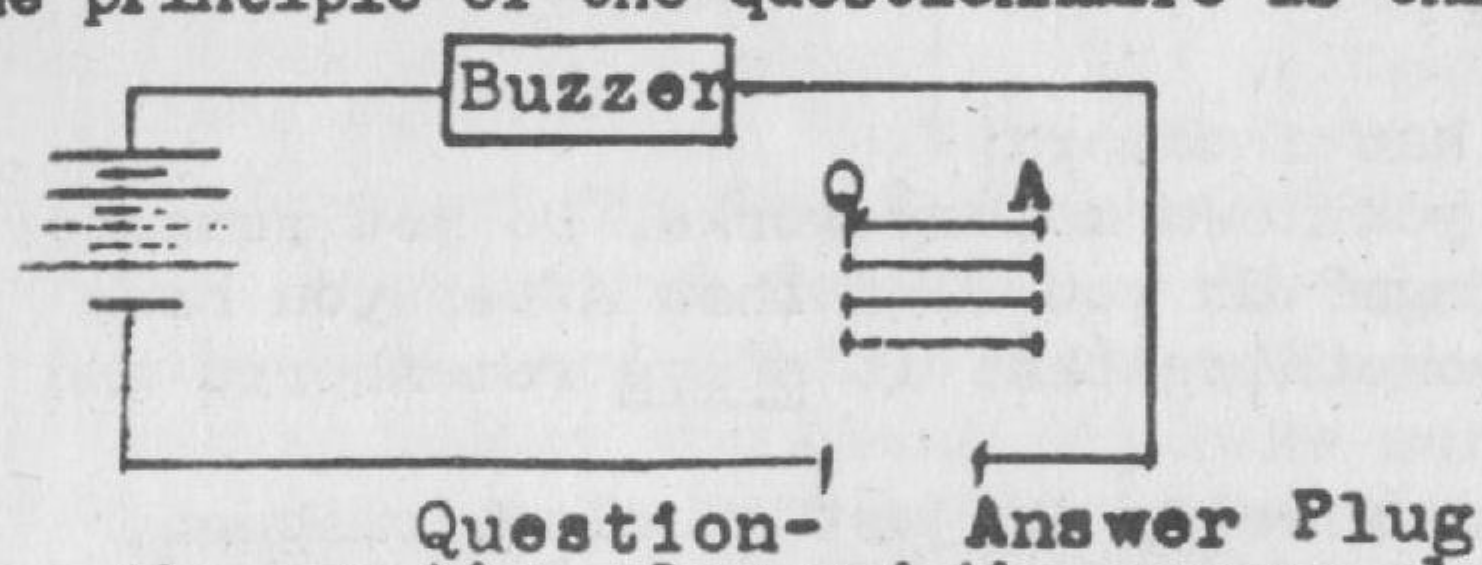
Just a circuit that sends a current when the window opens

Can be a bell or buzzer

Whenever you have a circuit you think will work, make a model and test it. Keep trying until you get just what you want.
The actual wiring for the burglar alarm can be seen in MANUAL EXPERIMENT # 5.

Experiment # 10 -- Question-answering Game.

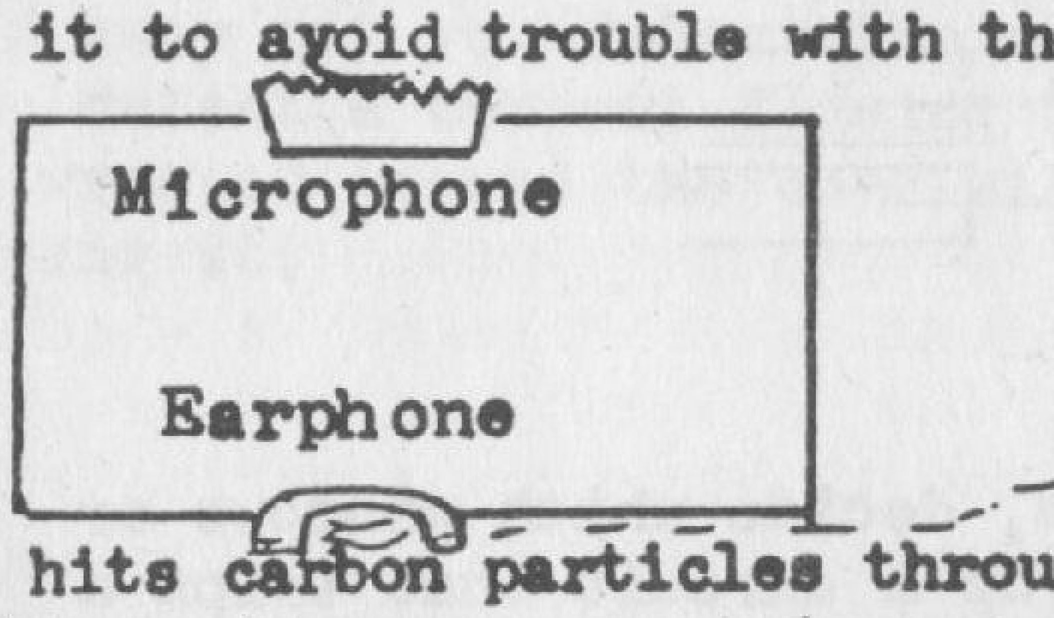
The principle of the questionnaire is this:



When the question plug and the answer plug are connected to the right answer, they are joined by a length of wire.
This is clue enough. If you are still puzzled, take a look at any Electric Game to see how it works.

Experiment # 11 -- Telephone.

The telephone is just a wire carrying a voice. You can make a telephone without electricity, but they carry further with it.
To make an electric telephone you create an electric current that is strong when your voice is strong, weak when your voice is weak, and changes just as rapidly as your speech does.
One way is to talk against little pieces of carbon through which a current is passing. This changes the resistance as your voice hits it— loud voice less resistance.
Try to devise a telephone that works with a different mechanism. Take advantage of what you have learned so far. Examine your own phone. Unscrew the cup and look inside. Replace it and put it back as you found it to avoid trouble with the telephone company.



Voice hits carbon particles through which current is passing. Current resistance drops, current increases.
At the other end this increased current causes the plate in the earphone to vibrate more rapidly, reproducing the original sound.

Experiment # 12.

We are now going to use a new method for describing some simple experiments that appear in the GENIAC MANUAL.
This method is called Boolean Algebra and is used by computer engineers to simplify their circuit networks. Boolean Algebra operates like ordinary algebra, but is different from it. Ordinary algebra is concerned with numbers, Boolean Algebra is interested in states or conditions.
For example:
Experiment # 12 (# 1 in your MANUAL).
Problem: Describe in symbols the various states in which a simple on-off switch can exist.
Condition ON, switch is closed, current flowing,
Condition O
Condition OFF, switch is open, current not flowing,
Condition I
We could call Condition O - a or x or p and
Condition I - a'(for non-a) or x'(for non-x) or p'(for non-p).

In describing states of different combinations of equipment we can use any set of letters or numbers that are useful to us.

Experimental: If a switch closed is 0 and open is I, describe the switch arrangement symbolically in MANUAL EXPERIMENT # 2.

Experiment # 13.

In experiment # 12 you were asked to describe the MANUAL EXPERIMENT called "Hall Lights" in symbols.

One solution is:

0 plus 0 means both switches are closed.

I plus I means both switches are open.

Plus means they are in series. A dot between two numbers means they happen at once, or are in parallel.

Thus for 0 • 0 you read " A closed circuit in parallel with a closed circuit is a closed circuit". --------0 • 0=0

Read " An open circuit in series with an open circuit is an open circuit". ---------I • I=I

Write out the meanings of the following equations:

I+0=0+I=I

0 • I=I • 0=0

0+0=0

I • I=I

Experiment # 14.

Before we go further in the problem of describing more complicated circuits we can see that system of 0 I for on and off is all that is necessary in building computer circuits to add, subtract, multiply or divide with digital computers. We are primarily interested in whether the circuit is on or off. Much like the game of Twenty Questions Yes or No is sufficient direction when combined in the proper series of questions to allow you to identify any object. If we signify Yes by 0 and Nó by I, we can find the answer to a variety of questions. Look for example at experiment # 11 in your MANUAL, the machine for Douglas MacDonald's Will. We can sort out the different cases into recombinations in a variety of Yes-No answers. The machine's wiring diagram (see Wiring Diagram Manual) just carries out the arrangement of the schematic's easily moved parts.

In this experiment you can see without too much difficulty how to set up the wiring directly from the problem at hand.

Experimental: Choose another paragraph with complicated material in it, your own life insurance policy is a good example, and set the contents in a schematic diagram after the paradigm on page 16. Then set up a pattern of switches to handle the information and lights to give you an asnwer. You will have to correlate the wiring in #11 (MANUAL) with the schematic to understand how your own machine should be built up. Once you have sketched out the wiring, you can simplify it.

Experiment # 15.

We can write a set of yes-no answers as follows: (from Experiment # 8)

A (shut-open) 0 I Zero and I correspond to the state of being shut or open. No further significance should be attached to these numbers.

B (on-off) 0 I

C (zero-full) 0 I

Then 000 or 0 for switch A and zero for switch B and zero for switch C will light bulb 2.

00I	light 1	This becomes a convenient way of summarizing a
0I0	light 3	complicated description. That it also is the binary
0II	light 3	for certain numbers is only incidentally important here.
II0,III	light 4	
I0I,I00	light 3	

We can describe all the states that exist with only 3 positions and two numbers 0 and I.

Once your machine is set up you can introduce a variety of other mechanical problems involving three problems by substituting new labels for the old ones. All of these can incorporate three variables in two positions. Furthermore, you can connect the output of the circuits to do useful work, besides just lighting bulbs, e.g. a rain alarm that rings when a conducting plastic strip is moistened. A becomes "if you are in the house (in-out)" and is connected to the front hall light switch or door latch. B dial is window (open-shut), C "plastic trigger" (available from Science Kits) has extra moisture above dew level on it.