Build a Circuit

Apple

SUNBURST
COMMUNICATIONS

PLEASE OPEN THIS PACKAGE!

WE WANT YOU TO PREVIEW OUR PROGRAM.

OPENING IT PLACES YOU UNDER NO OBLIGATION.

PERMISSIONS

All Sunburst material is copyrighted. However, Sunburst does give the purchaser the following permissions:

1. You have permission to reproduce any student worksheets in this guide for your classroom use. You should not, however, copy the whole guide.

2. If there is no backup disk, you have permission to make <u>one</u> backup disk.

3. If you purchased this program for one computer, you may install it onto one hard drive accessible by a single computer.

4. If you wish to use this software on multiple computers, you must purchase the right to do so from Sunburst. Call and ask for lab pack/site licensing prices.

5. You have permission to use lab packs/site licenses within one site. You do not, however, have permission to divide the package and use the software in more than one site.

6. Network versions are available for many products. Please call for information. A standard network version permits use on up to 50 stations. For use on more than 50 computers, call our Customer Service department for information on purchasing the right to do so.

Customer Service: (800) 321-7511

APPLE Computer, Inc. license agreement and disclaimer

The following disclaimer is required by Apple Computer, Inc. and applies to all Apple software included in this product.

Designers:	Education Development Center
Programmer:	Yagnesh Shah
Project Manager:	Eleanor Arita
Teacher's Guide:	Carol Koetke

BUILD A CIRCUIT

TABLE OF CONTENTS

INTRODUCTION

Electricity plays an important part in the lives of today's children. Daily events — flicking on the lights, snapping on the television, turning on a hair dryer — are the result of electricity at work.

In **Build a Circuit,** students apply their knowledge of electricity by building circuits on the computer screen. Students can experiment with batteries, motors, switches, light bulbs and two different types of wires to design and build circuits. Some will be simple, other quite complex.

When students are ready, the program's test option allows them to check a circuit. If motors turn and bulbs glow the circuit is complete. Students may also measure the amperes of bulbs and motors and the voltage of batteries. A print option enables students to print their circuits, and a disk option allows students to save their work on a disk or load other circuits that were previously saved.

Opportunities for playing with **Build a Circuit** will encourage students to explore characteristics of circuits, experiment, and use a variety of thinking skills that are part of the scientific process. This simulation program can also serve as a bridge between concrete, hands-on play with real materials and abstract, paper and pencil drawings of circuits. In many cases, educators may elect to have students play with **Build a Circuit** before using actual materials so students can strengthen their understanding of circuits.

The **Build a Circuit** guide contains a complete program description, as well as background material on electricity and a glossary of terms. Classroom lessons and activity sheets are also included in the guide to help teachers orchestrate students' exploration of circuits.

PROGRAM OVERVIEW
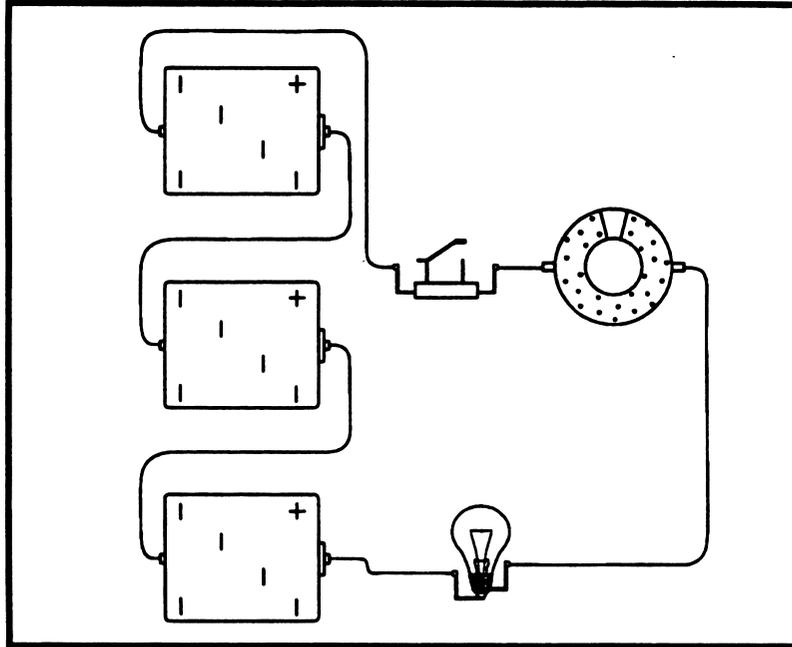
Description: **Build a Circuit**, a simulation, allows students to electrically wire circuits on screen by connecting battery, bulb, motor, switch, and wire. Two activities, an experimental mode and a challenge mode, promote students' understanding of how electricity works.

Skills needed: • Basic understanding of electricity and circuits.

• Vocabulary of scientific words relating to electricity and circuits.

Grade level: 4-8

Objectives: • To enhance understanding of electricity and circuits through an on-screen investigation of electric currents.

• To develop science process skills: observing, analyzing, predicting, forming hypotheses, testing, reformulating hypotheses based upon the results of testing, and communicating science.

• To strengthen problem-solving skills: organizing, estimating and predicting, seeing a problem as a whole and in parts, and building on what is known.

PROGRAM DESCRIPTION

When **Build a Circuit** is loaded into the computer, the Sunburst logo and title screen appear, followed by the program's Main Menu.

```
 ╔══════════════════════════════════════════╗
 ║   ░░░░                    ┌─┲─┱─┐         ║
 ║  ▒▒▒▒▒   Build a Circuit  ┘  ┗━┛          ║
 ║   ╙         ════════════{+ •}{+ •}        ║
 ║                                           ║
 ║   ┌──────────────────────────────────┐   ║
 ║   │ ▎Build your own circuits▏         │   ║
 ║   │                                   │   ║
 ║   │    Build a circuit challenges     │   ║
 ║   │                                   │   ║
 ║   │          Instructions             │   ║
 ║   │                                   │   ║
 ║   │             Exit                  │   ║
 ║   └──────────────────────────────────┘   ║
 ║       Use arrow keys to select.           ║
 ║       Press <return> to accept.           ║
 ╚══════════════════════════════════════════╝
```
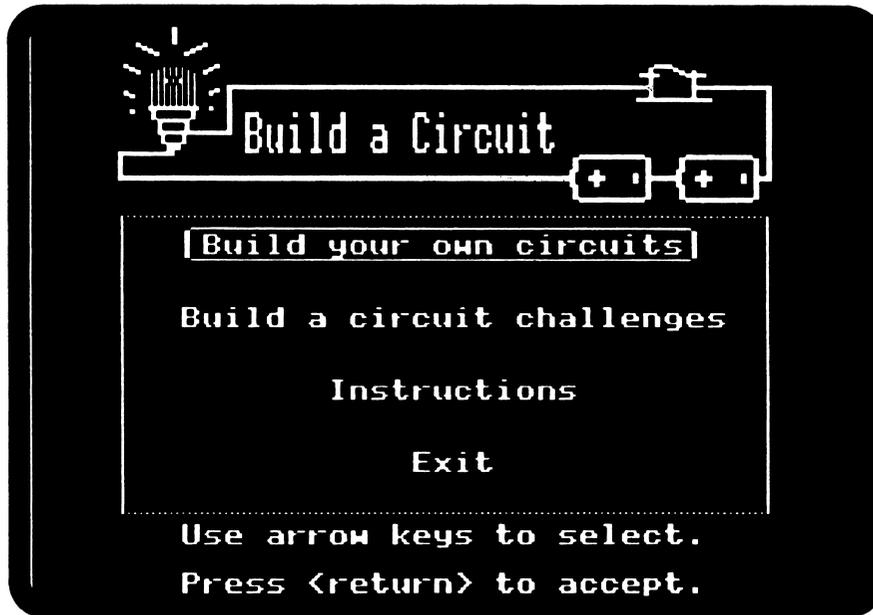
At this point you may choose to use a mouse, instead of the keyboard, by pressing the command key (⌘) and the M key at the same time. The instructions that follow are written for users of the keyboard. Additional instructions for using **Build a Circuit** with a mouse are given on page 31.

Use the arrow keys to move the selection box to your choice. Then press RETURN.

Teacher Options, which allow you to set program parameters (see page 25), are accessed from the Main Menu by pressing CTRL-T (Control key and T key at the same time).

You can return to the Main Menu at any time during the program by pressing CTRL-E (Control key and the E key at the same time).

3

BUILD YOUR OWN CIRCUITS

Build your own circuits promotes investigation of electric circuits by providing a screen workspace in which you construct your own circuit designs. You can test the circuits and modify them if you wish.

When you select this option from the Main Menu the following screen appears:
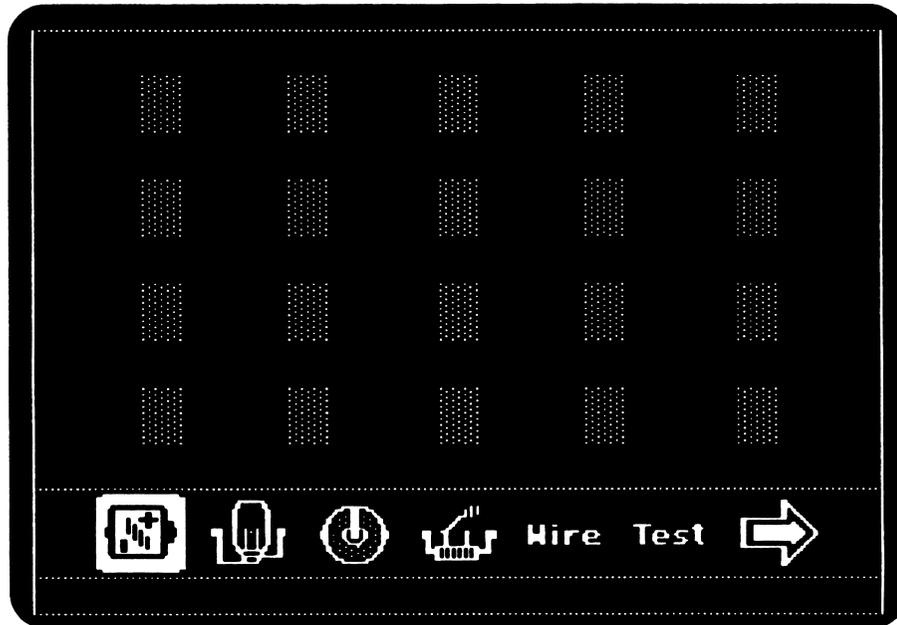
The workspace, the upper part of the screen, is the area where you place the objects and wiring to build the circuit. The line of symbols and words at the lower part of the screen offers you choices of objects, procedures for carrying out the construction, and commands for managing the program. The first screen's choices include:

Battery	Bulb	Motor	Switch	Wire	Test	Forward Arrow
						(next screen)

If you select the forward arrow the choices continue, and include:

Back Arrow	Clear	Print	Disk	Help	Exit
(previous screen)					

Objects

You may choose to build a circuit with any of the following objects:
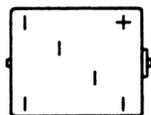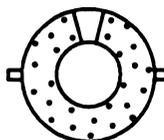
Battery   **Bulb**   **Motor**   **Switch**

To select an object, use the arrow keys to highlight the first object you wish to put into the workspace. When you press RETURN the object you selected appears in the lower part of the workspace.

To move an object, use the arrow keys to move the object around the workspace until it is in the desired location.

When the object is in the desired location, press RETURN to place the object in that position. You can then select another object or go on to another operation or option.

As long as an object in the workspace is not connected with wires it can be replaced with a different object. Select and position the new object over the object you wish to replace and press RETURN; the old object disappears, leaving the new one.

To delete an object, select any object and place it in the space occupied by the object you wish to delete. Press the DELETE key and both objects disappear from the workspace.

Wire

You can wire objects as you go along, or you can first place all the objects and then do the wiring. To wire the objects, highlight *Wire* and press RETURN. You will see the Wiring Menu at the bottom of the screen beneath the workspace.
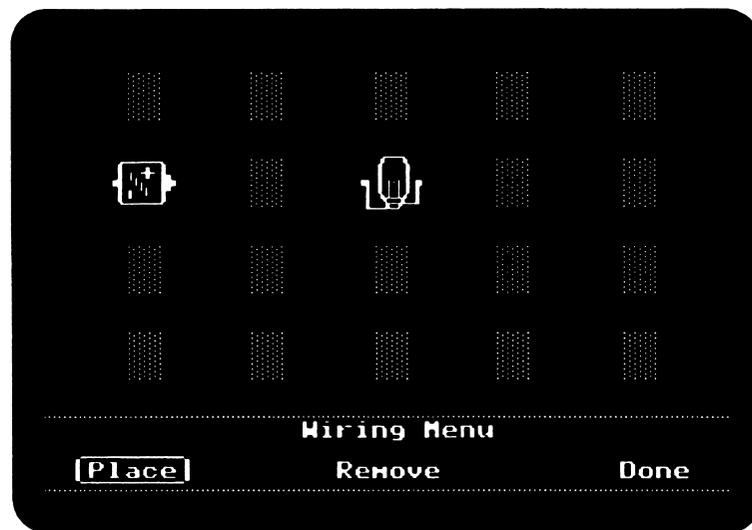
To select a wire, use the arrow keys to choose *Place* and press RETURN. If both *Copper* or *Nichrome* wire have been selected in the Teacher Options, you will then be asked to choose the type of wire you want to use in your circuit.

To <u>attach</u> wires to an object, use the arrow keys to place the wire at a lead position of one of the objects you are wiring. Press RETURN to complete the attachment.

Lead Position——————Lead Position

```
Use arrow keys to run the wire, "Esc"
to cancel. Press Return to connect.
```
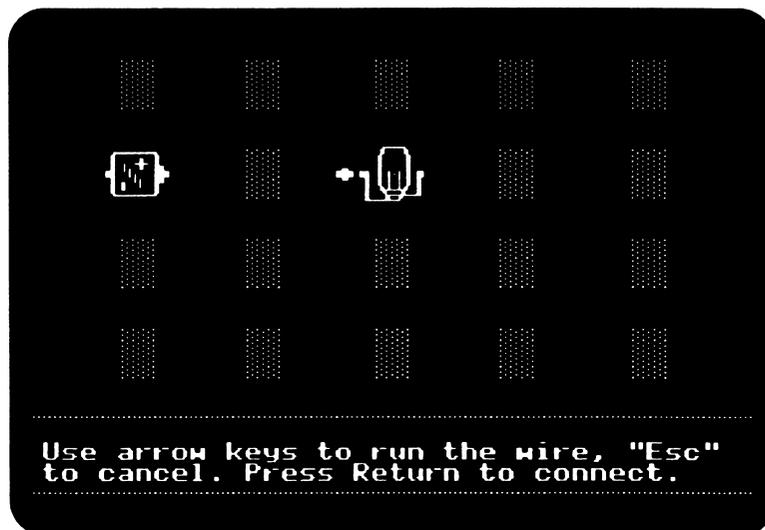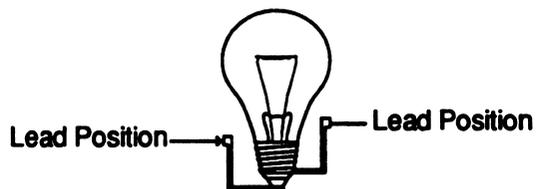
To <u>connect</u> wire to another lead position, use the arrow keys to unroll the wire to a lead position of another object. Press RETURN to complete the connection.

```
                    Wiring Menu
[Place]          Remove          Done
```

7
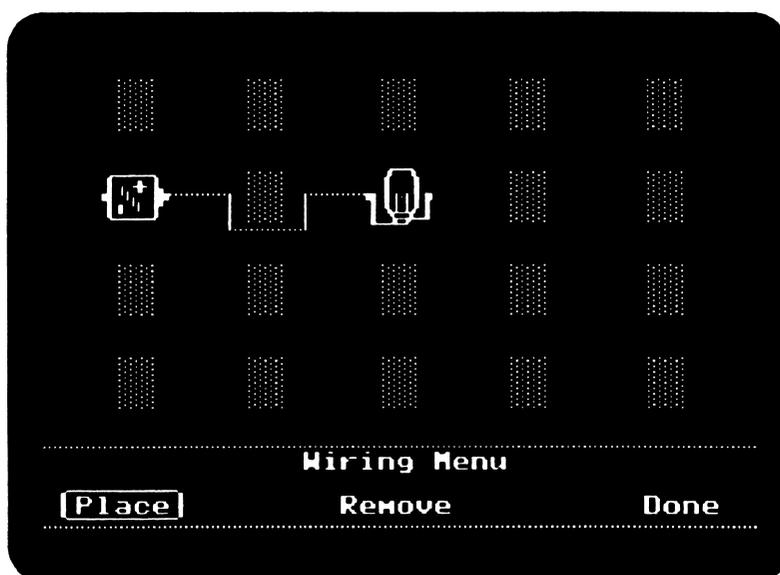
To correct a wiring mistake that occurs as you unroll the wire, press ESC to erase the wire. As long as you have not pressed RETURN to connect that wire, this procedure allows you to re-run that wire or to work in a different location.

To remove a wire from your circuit after the connection has been made, select *Remove* from the *Wire* sub-menu. Use the arrow keys to move the wire cursor to a lead position of the wire you wish to remove and press RETURN.
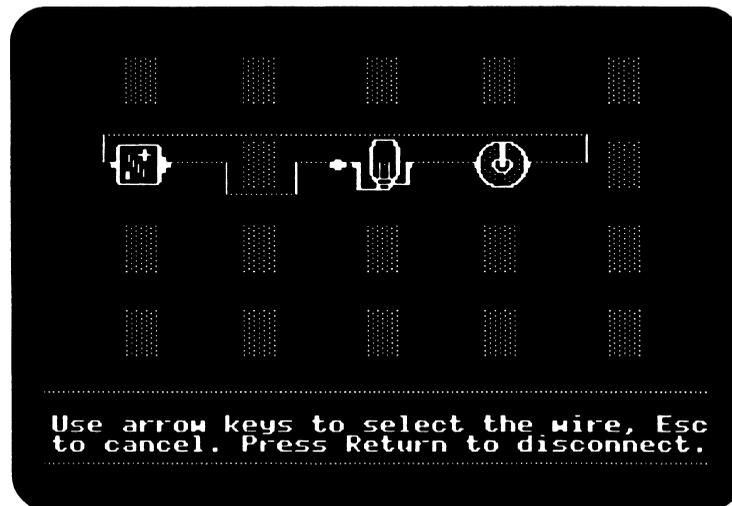
To <u>complete</u> a circuit continue making wiring connections until all the objects have been wired and the circuit is complete. Select *Done* from the *Wire* sub-menu and press RE-TURN. If there are two wires connected at the same point, the program will ask which wire you wish to remove, top or bottom. After making a choice, press RETURN. The wire will disappear. You will then return to the *Build your own circuits* menu, where you may test your circuit or choose another option.
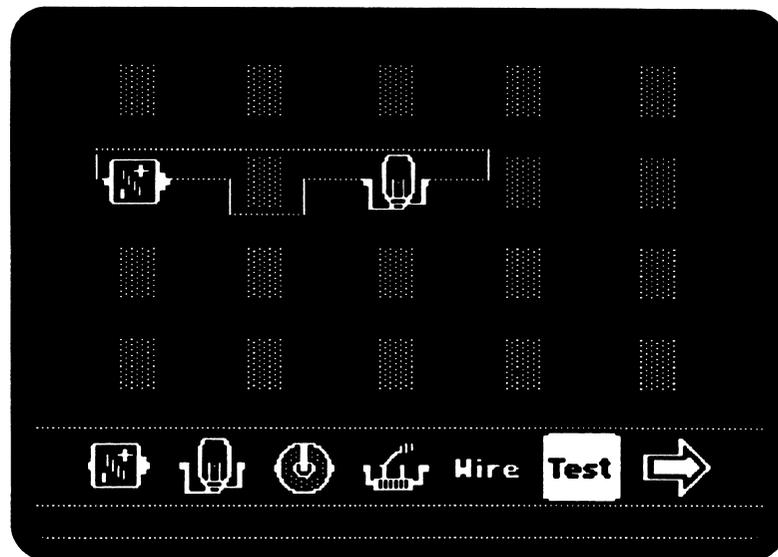
Test

To test the wiring of your circuit highlight *Test* and press RETURN. If the circuit is wired properly bulbs light up and motors rotate. A hand cursor will appear in the workspace.

9
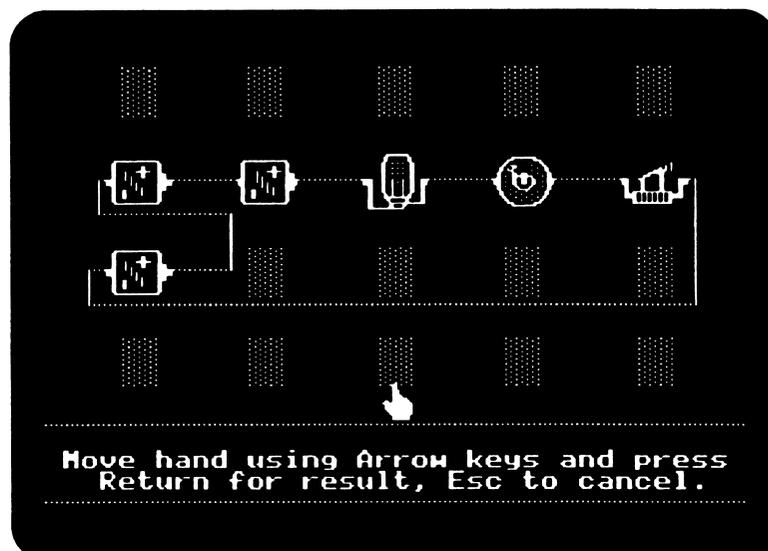
Use the arrow keys to move the hand cursor to the object of your choice and press RETURN.

When the hand cursor is at a battery, you can measure the voltage:


```
                       1.5 VOLTS
        Move hand using Arrow keys and press
            Return for result, Esc to cancel.
```
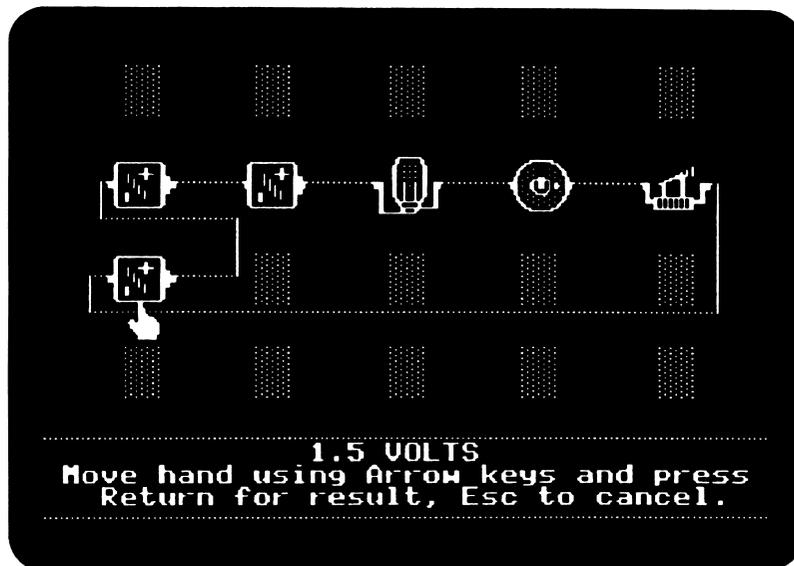
When the hand cursor is at a bulb or motor, you can measure the amperes:


```
                  Current = .209A
        Move hand using Arrow keys and press
            Return for result, Esc to cancel.
```

10
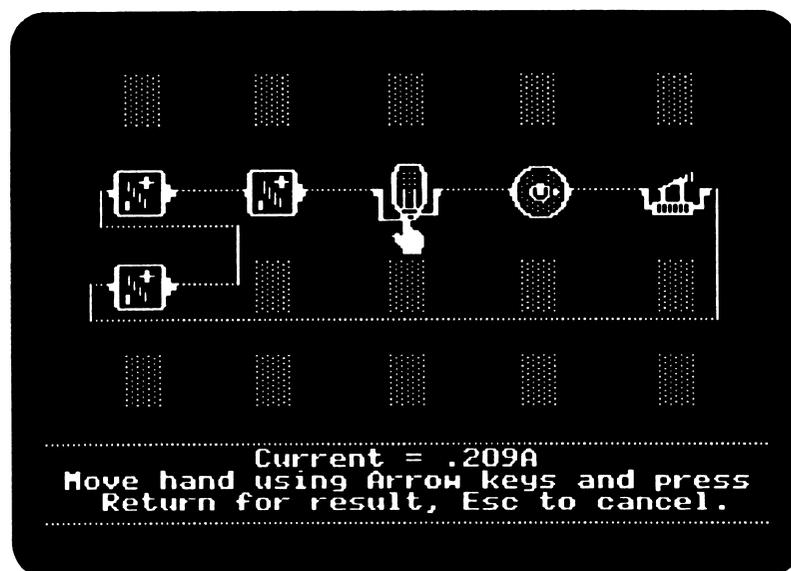
When the hand cursor is at a switch, you can open or close the switch:

Move hand using Arrow keys and press
Return for result, Esc to cancel.
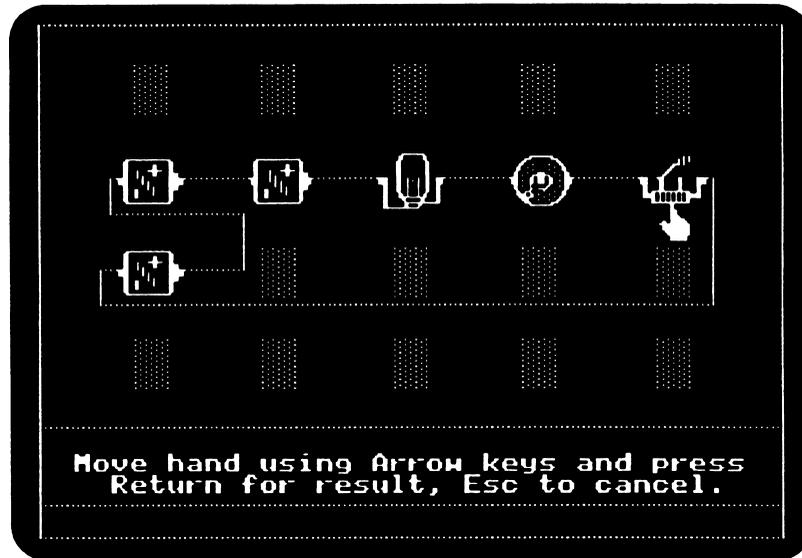
Since **Build a Circuit** allows a maximum of five loops in any circuit, it will not test circuits with more than five loops. Also, the result of the circuit (including the ampere reading) will be unpredictable if there is a short in the circuit.

When you have finished testing the objects and setting the switches, press ESC to exit the *Test* option.

Menu Arrows

The large arrows at the bottom of the screen take you forward to the next screen of menu options or back to the previous screen.

Clear

When you select *Clear* the program inquires if you are sure you want to clear the screen. *Yes* clears the screen and then returns you to the *Build your own circuits* menu where you may construct a new circuit. If you answer *No* the *Clear* sequence terminates.

Print

The *Print* option allows you to print the circuits you build. The program asks you to ascertain that your printer and card have been selected and are online, ready to receive the program's information. The program also allows you to *Title* the circuit you wish to print. There is a *Cancel* option if you change your mind and decide not to print the circuit.

Disk

The *Disk* option allows you to load a circuit that has been previously saved on a data disk. Or, you can save a circuit for future use on a data disk that must be selected in the Teacher Options (see page 25 for information in *Disk Utilities, Indicate data disk*). To access this option choose *Disk* from the menu and press RETURN. You will have three choices:

12
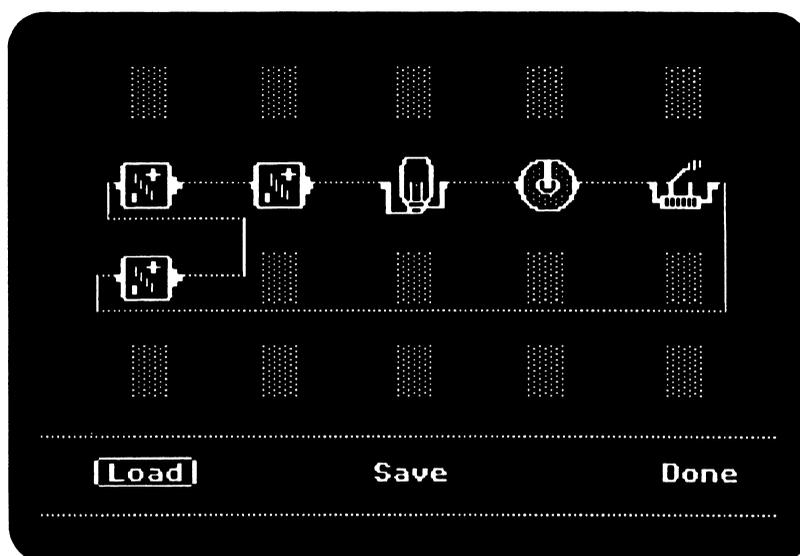
To load a disk insert the data disk that contains the circuit you want to retrieve, and select *Load.* You will see a list of circuits that are on the disk. Use the arrow keys to choose the title of the circuit you want and press RETURN. The circuit will appear on the screen. With the program disk in the disk drive, you may work with that circuit, making changes, testing, and choosing operations from the menu. If you do not want to load any of the listed titles choose ESC and the *Load* sequence will be cancelled.

To save a circuit that is onscreen, select *Save.* Insert a prepared data disk and press RETURN. To prepare a data disk, use the Teacher Options (access by pressing CONTOL-T at the Main Menu) and select *Disk Utilities.* Then choose *Make a data disk.* If you have previously made a data disk and wish to add more circuits to this disk, select *Disk Utilities,* then *Indicate data disk* from the Teacher Options. Type in the name of the circuit and press RETURN to save the circuit on the data disk.

To return to the program, select *Done* from the disk options after you have finished loading or saving a circuit.

Help
The *Help* option allows you to review the onscreen instructions to get information about the objects, wire, testing, and special keys. You can access this option at any time from the *Build your own circuits* menu. (For a detailed description of the *Help* information see *Instructions* on page 21.)

```
             BUILD YOUR OWN CIRCUITS lets you
          experiment with wiring batteries,
          bulbs, motors, and switches to
          make circuits. Place objects in
          the workspace and use the WIRE
          option to make connections among
          the various objects. When you are
          finished, use the TEST option to
          test the circuit. The bulbs will
          light and the motors will turn if
          the circuits are wired properly.

          [Objects]  Wire   Test   Keys   Done

       Use  arrow  keys,  press  return  to  select.
```

When you have finished with the *Help* option, select *Done* to return to the screen you were previously using.

Exit

When you are finished with the *Building your own circuits* section of the program and want to return to the Main Menu, select *Exit*. The program will ask if you are sure you want to return to the Main Menu. If so, select *Yes*; select *No* to continue at the previous screen.
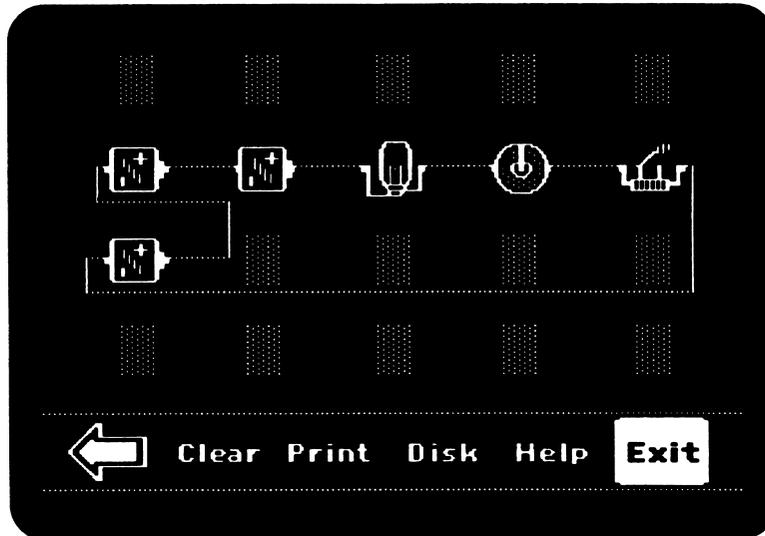
BUILD A CIRCUIT CHALLENGES

This section of the program provides challenges for you to solve in your exploration of circuits. For example, the program may give you specifications for a circuit which you are to construct. Another challenge may supply several components and ask you to build a particular kind of circuit using those components to meet specific requirements.
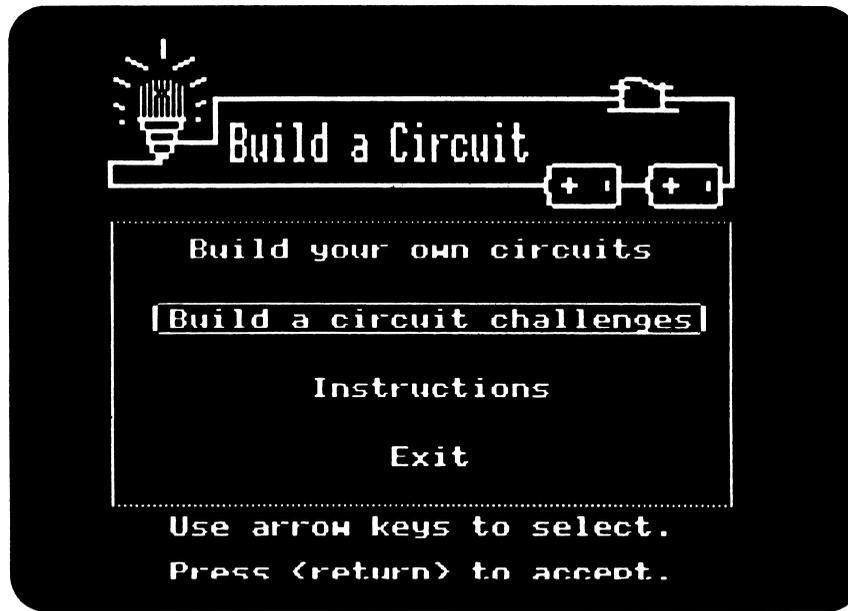
When you select *Build a circuit challenges* from the Main Menu you will see the *Challenges* menu, showing the levels of difficulty.

Select the level of challenge you want and press RETURN. The next screen lists five challenges by number.
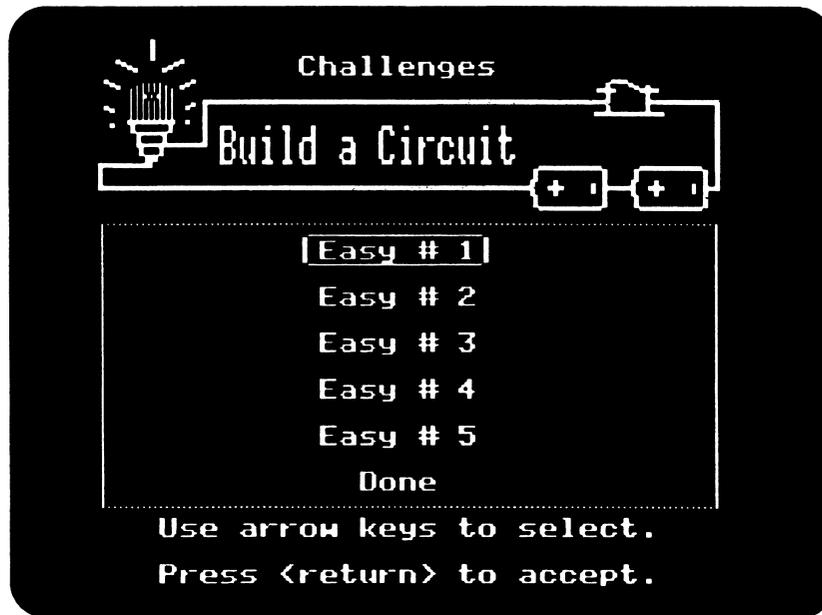
Select one of the numbers. After you have made your choice the workspace appears. In some cases the workspace holds two or more objects, and in other challenges the workspace is empty. The lower part of the screen shows the object symbols and three commands, *Wire*, *Test* and *Try*.
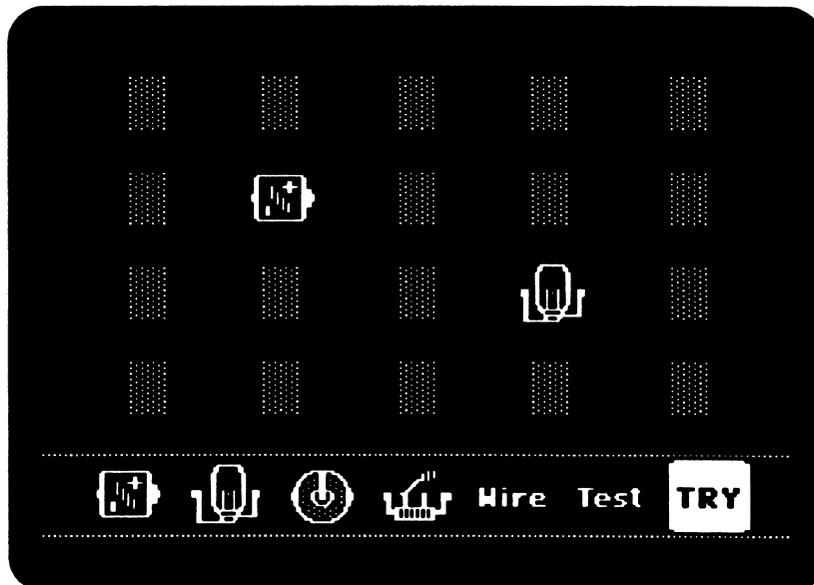
To read the challenge, select *Try.* A typical challenge screen looks like this:


```
.....................................................................


       ::::          ::::          ::::          ::::          ::::
       ::::          ::::          ::::          ::::          ::::


                    {.!.+}         ::::          ::::          ::::
       ::::                        ::::          ::::          ::::


       ::::          ::::                       ↓Ɫ↓          ::::
       ::::          ::::          ::::                        ::::


       ::::          ::::          ::::          ::::          ::::
       ::::          ::::          ::::          ::::          ::::

.....................................................................
       Connect wires so that the bulb
       lights.
.....................................................................
    [Return]                                          [ESC]
```

At the bottom of the screen you have a choice of RETURN or ESC. If you choose to accept the challenge press RETURN. If you do not wish to take this challenge press ESC, and you will be given the opportunity to return to the *Challenges* menu.

When solving a challenge, use the objects at the bottom of the workspace.   When you think you have solved the challenge, select *Test.* If the circuit is wired properly, bulbs light up and motors rotate. A confirmation message will also appear on the screen. If the circuit is not wired properly, a "That's not the solution" message will appear.

Very good.

[Same]   New

That's not the solution.

[Same]   New
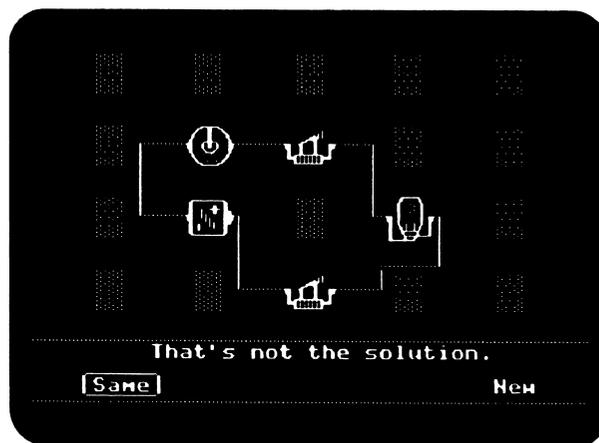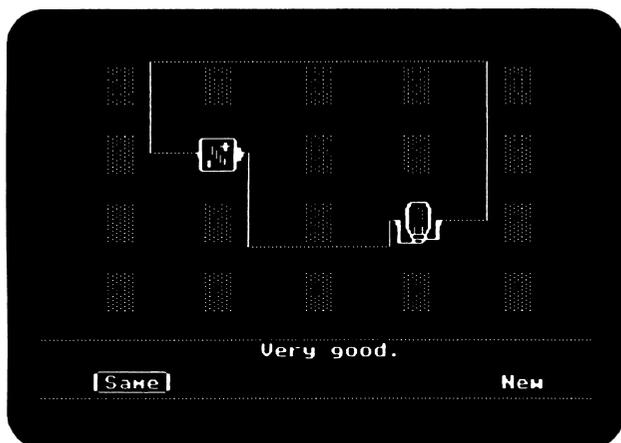
After testing a circuit, the program asks you to select *Same* or *New*. If your solution did not satisfy the specifics of the challenge you have a chance to try again by selecting *Same*. If you select *New*, the program returns to the *Challenges* menu and you may again choose a difficulty level and a new challenge.

When you have finished select *Done* from the *Challenges* menu to return to the program's Main Menu.

Summary of Challenges

Below is a summary of the three levels of challenges: Easy, Medium, and Hard. Each level contains five different challenges.

EASY

Choice	You are given	The challenge
#1	One battery One bulb	Connect wires so that the bulb will light.
#2	One battery One motor	Connect wires so that the motor rotates.
#3	One battery Two bulbs	Connect wires so that both bulbs light. Use only one battery.
#4	One battery One bulb One switch	Add wires so that the light comes on when you close the switch.
#5	A wired circuit containing: One battery One switch One motor	Fix the wiring so that closing the switch makes the motor rotate.

MEDIUM

Choice	You are given	The challenge
#1	One battery Two switches One bulb	Wire the circuit so that the light comes on when both switches are closed.
#2	One battery One switch Two bulbs	Wire the circuit so that closing the switch turns both lights on and opening it turns them off.
#3	Two circuits, each consisting of: One battery One motor	Connect one motor to a battery so that it turns clockwise. Connect the other motor to a battery so that it turns counter-clockwise.

19

#4	No components	Light as many bulbs as you can with one battery.
#5	No components	Wire a circuit that will light a bulb and turn a motor.

HARD

Choice	You are given	The challenge
#1	No components	Wire two circuits, each with two bulbs and one battery so that the bulbs in one of the circuits are brighter than the bulbs in the other.
#2	One battery Two switches One bulb One motor	Connect these objects so that one switch rotates the motor and the other lights the bulb.
#3	One battery One switch Two bulbs	Connect these objects so that one bulb is always on and the other bulb is controlled by the switch.
#4	One battery One bulb Two switches	Connect these objects so that one switch will turn the light on but both switches turn it off.
#5	One battery One switch Two bulbs	Connect these objects so that one bulb is lighted when the switch is closed and two are lighted when it opens.

INSTRUCTIONS

Instructions for using **Build a Circuit** are available from the Main Menu. Use the arrow keys to move the selection box to *Instructions* and press RETURN. These instructions are also available from the *Help* option in *Build your own circuits.*
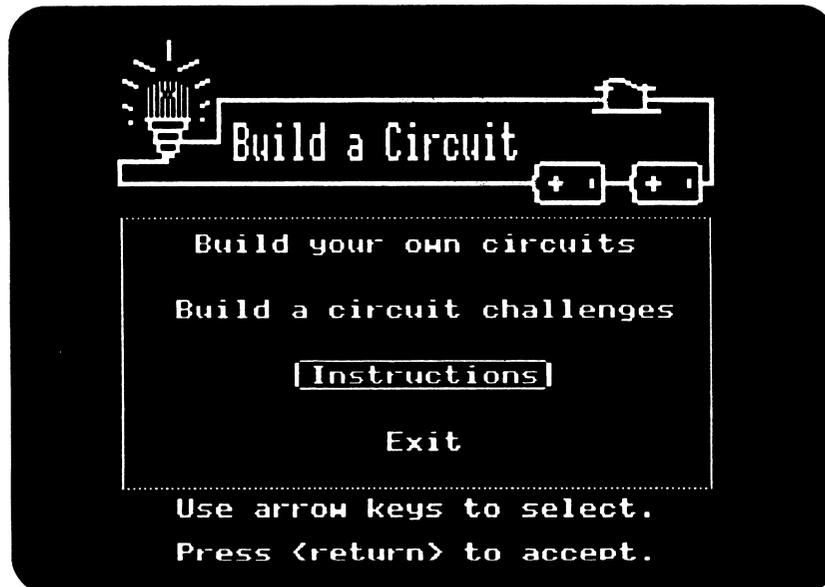
The *Instructions* menu gives you several choices of things to review: *Objects, Wire, Test* and *Keys.*
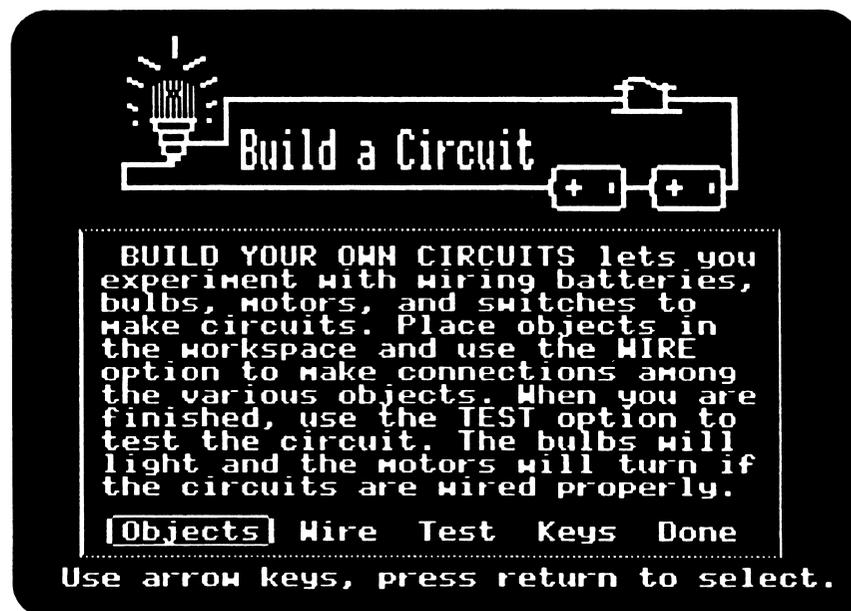
Objects instructs you in the management of the objects you use in building circuits.

```
                  I
            `:-`
            Build a Circuit        + I  + I

    ┌─────────────────────────────────────┐
    │ OBJECTS:                             │
    │                                      │
    │  Select an object (battery, bulb,    │
    │ motor, or switch) by using arrow     │
    │ keys to highlight the object and     │
    │ press RETURN to pick the object.     │
    │ The object will appear at the        │
    │ bottom of the workspace. Use the     │
    │ arrow keys to move the object        │
    │ around the workspace and press       │
    │ RETURN to place the object. An       │
    │ existing object can be replaced      │
    │ if it has no wire connections.       │
    └─────────────────────────────────────┘
    ⊞ Page down              ⊞ Page up
```
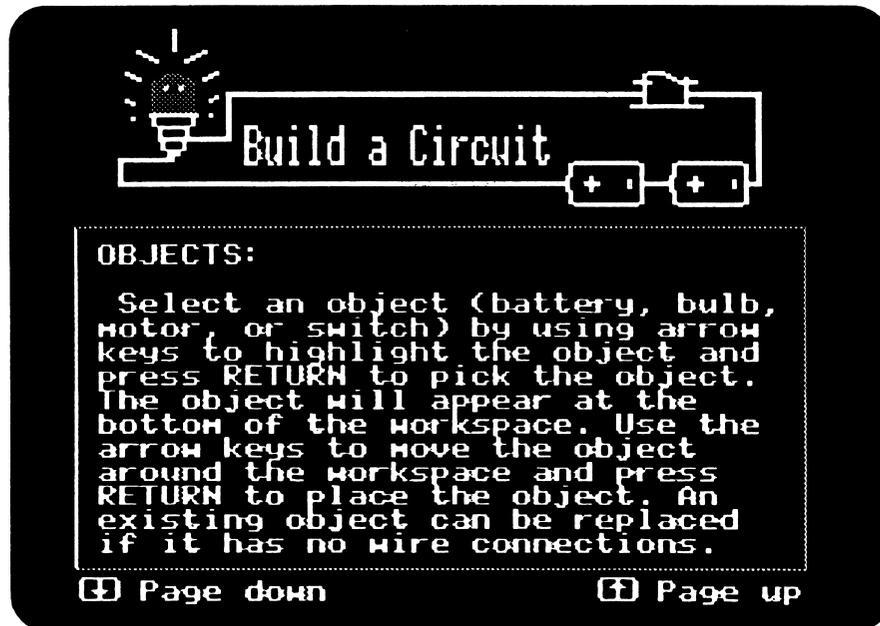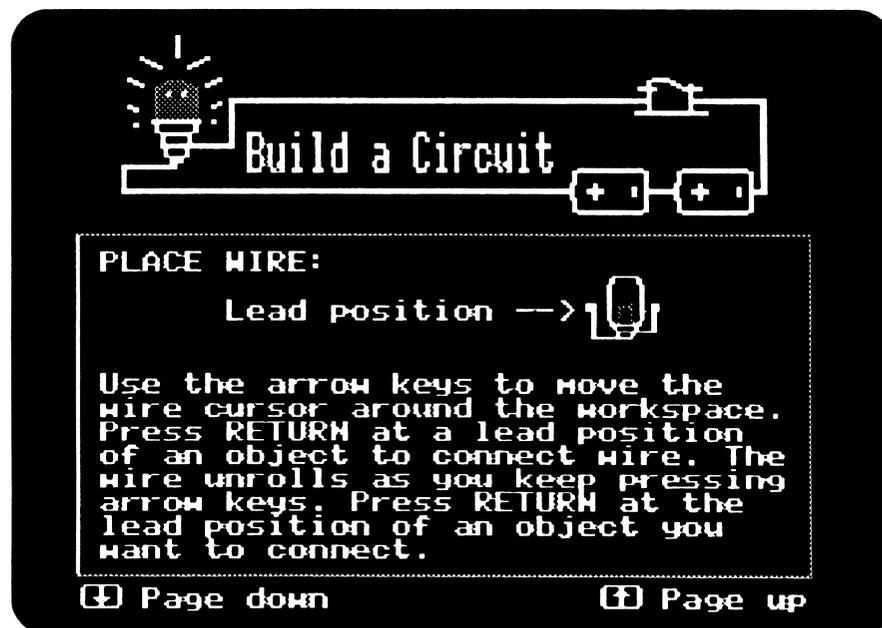
Wire explains how to place a wire or remove a wire from a circuit.

```
                  I
            `:-`
            Build a Circuit      + I  + I

    ┌─────────────────────────────────────┐
    │ PLACE WIRE:                          │
    │                                      │
    │      Lead position --> ▯             │
    │                                      │
    │ Use the arrow keys to move the       │
    │ wire cursor around the workspace.    │
    │ Press RETURN at a lead position      │
    │ of an object to connect wire. The    │
    │ wire unrolls as you keep pressing    │
    │ arrow keys. Press RETURN at the      │
    │ lead position of an object you       │
    │ want to connect.                     │
    └─────────────────────────────────────┘
    ⊞ Page down              ⊞ Page up
```

Test gives you information about the test function and how to use it.

Keys identifies the "hidden keys" and their uses.
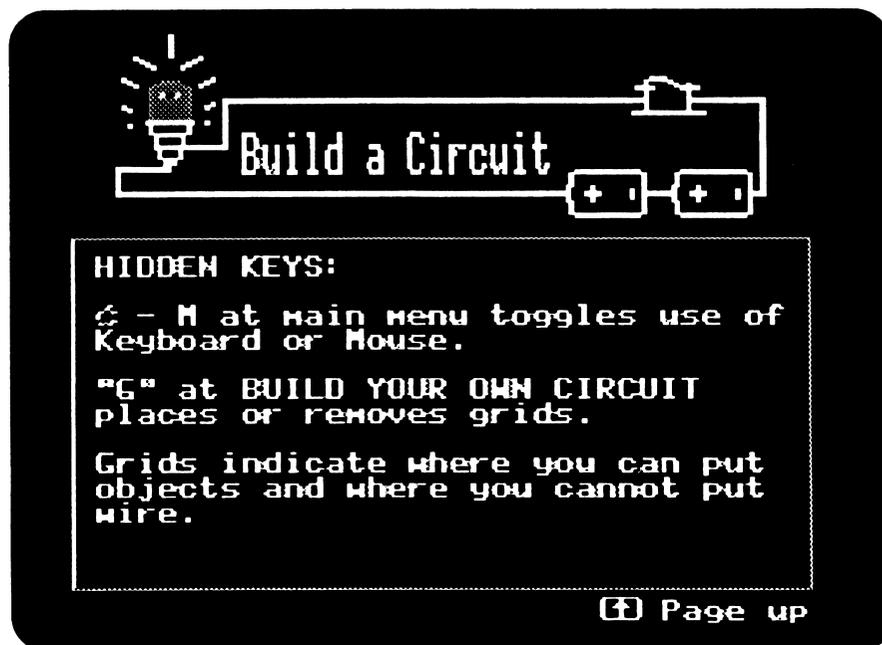
Done tells the program when you are finished with the instructions and want to return to the Main Menu.

EXIT

When you are finished with the program, choose *Exit* from the Main Menu.
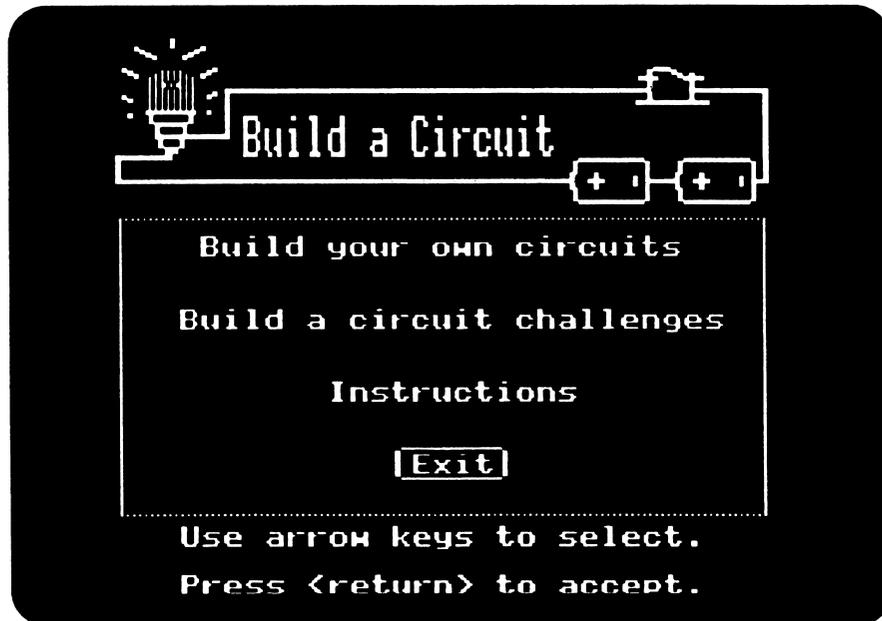
The next screen asks if you want to use a different program.
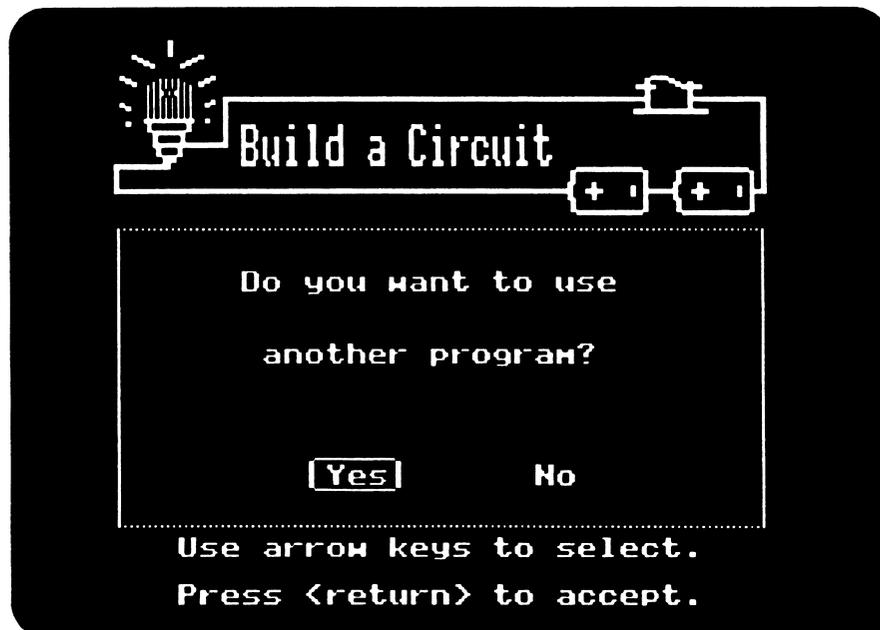
A *Yes* answer allows you to boot a different disk and you leave the program. If you answer *No*, the screen prompts you to turn off your computer and monitor, ending the current session with **Build a Circuit.**

TEACHER OPTIONS

```
        Teacher Options
      ┌──────────────────────
      │ Build a Circuit
      └──────────
      ┌──────────────────────────┐
      │        │Wire│            │
      │                          │
      │   Printer and Interface  │
      │                          │
      │     Disk utilities       │
      │                          │
      │         Done             │
      └──────────────────────────┘
           Ctrl-e to cancel.
        Use arrow keys to select.
        Press <return> to accept.
```
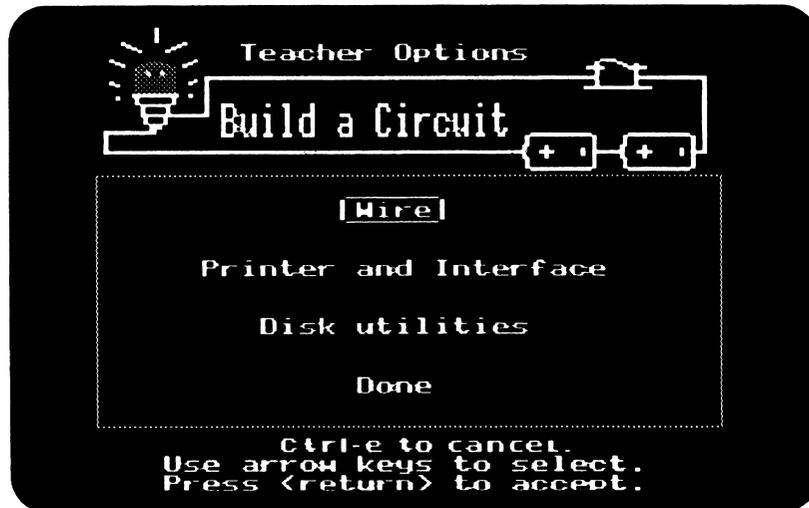
The Teacher Options are available from the Main Menu by pressing CTRL-T (the control key and the T key at the same time).

Wire
You may select copper wire only or copper and nichrome wire.

Printer and Interface
This option allows you to select the printer and interface card for your computer. After doing so, you may test the set-up by selecting *Test card and printer.*

Disk utilities
This option gives you the following choices.

```
        Teacher Options
      ┌──────────────────────
      │ Build a Circuit
      └──────────
      ┌──────────────────────────┐
      │    │Catalog a disk│      │
      │    Make a data disk      │
      │   Indicate data disk     │
      │    Copy data disk        │
      │     Delete files         │
      │         Done             │
      └──────────────────────────┘
           Ctrl-e to cancel.
        Use arrow keys to select.
        Press <return> to accept.
```
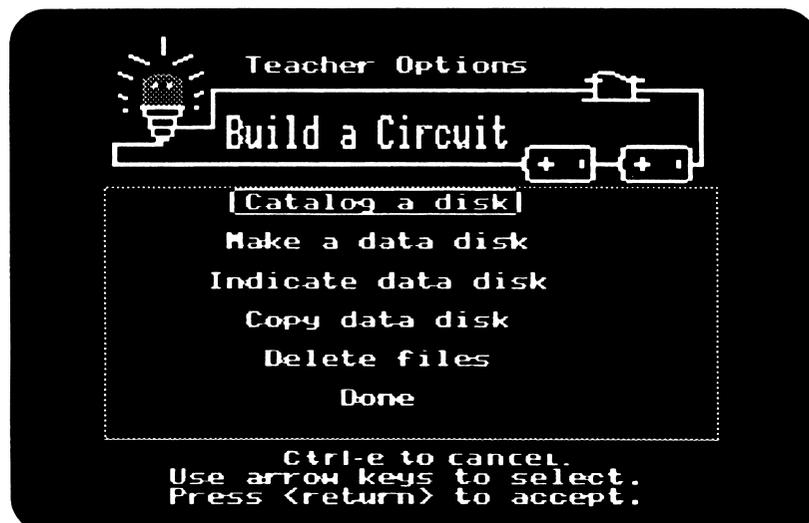
Catalog a disk displays a complete list of saved circuits. If the data disk you are using was formatted in PRODOS by another program, you may save more than 51 circuits by putting them in folders. See note about folders on the next page for details.

Make a data disk formats a blank disk that can be to be used to save a circuit. Any information on the disk will be erased. Upon selecting this option, the list of devices (disk drives) currently attached to your system will appear. Use the arrow keys to highlight the disk drive you will use and press RETURN. Insert the new disk in the drive. Since the program recognizes disks that have been made by Apple Computer PRODOS operating system, it will warn you if you are about to destroy a disk containing data.

Indicate data disk allows you to specify the disk you want to use for loading or saving circuits. Upon selecting this option, the list of the devices (disk drives) currently attached to your system will be displayed. Use the arrow keys to highlight the location of the disk you want to use as a data disk and press RETURN. The screen will display a complete list of circuits created by **Build a Circuit**. Press the SPACEBAR key to set this disk as the data disk you will use.

To copy one disk to another select Copy data disk from the menu, then indicate the location of your source disk. (The source disk drive is the drive containing the disk from which you want to copy.) Next, indicate the location of the destination disk. The destination disk will be the drive containing a new disk or a disk you want to reuse. Any old information on this disk will be erased and replaced with the information from the source disk. The destination drive must be the same type of disk drive as the drive containing the source disk. (You may not, for example, copy a 3.5 inch to a 5.25 inch disk or vice versa) When you place the disks in the drives, check the screen to be sure that locations of the source and destination disk drives are correct. Since this procedure destroys all information on the destination disk, **Build a Circuit**, will examine the disk in the destination drive. If the disk contains any recognizable data (it will only recognize a disk that was made using the Apple Computer PRODOS operating system), you will be warned that you are about to destroy a disk containing data.

Note: You should not use the copy disk option to copy disks other than the ones created by **Build a Circuit**, nor should you copy disks created by **Build a Circuit** using another program. As a safety precaution, you should always write-protect your source disk during any copying process to prevent an accidental loss of data. If you are using a one-drive system, once the copying process has begun, make sure that you always insert the correct disk. If you inadvertently insert the wrong disk, the information on that disk may be destroyed.

<u>Delete files</u> erases a circuit from a data disk. Upon selecting this option, the list of the devices (disk drives) currently attached to your system will be displayed. Use the arrow keys to highlight the location of the disk from which you want to delete a circuit and press RETURN. The screen will display 51 circuit files on that disk. Use the arrow keys to high-light the circuit you want to delete and press the SPACEBAR key to delete it.

Done
This option returns you to the Main Menu.

Note

Folders are the subdirectories in a disk where the user can save more than 51 files. **Build a Circuit** cannot make folders, however, it is able to recognize and use a disk that has been made by an Apple Computer PRODOS operating system.

If you used a PRODOS formatted disk as a data disk, the *Catalog a disk* option in *Disk Utilities* will display the circuits and folders. A folder can be easily identified by the icon of the folder preceding its name. To catalog a folder use the arrow keys to highlight it and press RETURN. All circuits and folders saved in that folder will be displayed along with a prefix (disk name) of the disk included between "/" for example, "/prefix/". To go back to the original list, highlight this /prefix/ and press RETURN. **Build a Circuit** will display the first 51 files or folders in a folder. To catalog a folder that is not displayed in the list of the 51 you must know the folder's name. Press the TAB key. The screen cursor will appear next to "Enter Name". Enter the name of the folder you wish to catalog and press RETURN.

Users can also use any PRODOS formatted disk or folder on a disk as a data disk by using the *Indicate data disk* option of *Disk Utilities*. To set a disk or folder as a data disk for **Build a Circuit** select *Indicate data disk*. The list of devices (drives) currently attached to your system will come on the screen. Select the drive which has a PRODOS formatted disk and press RETURN. The circuits and folders in that disk will be displayed. Press the SPACEBAR to set this disk as your data disk. To set a folder as a data disk use the arrow keys to highlight a folder and press RETURN. Press the SPACEBAR to set this folder as your data disk. To set a folder that is not displayed in the list of the first 51 circuits and folders in a folder, you must know the folder's name. Press the TAB key. A screen cursor will appear next to "Enter Name". Enter the name of the folder you wish to set and press RETURN; then press SPACEBAR to set this folder as your data disk.

Users can delete a circuit that is saved in a PRODOS formatted data disk or in a folder of the PRODOS formatted disk. Select *Delete files* and a list of devices (drives) currently attached to your system will be displayed. Select a drive which has a PRODOS formatted disk and press RETURN. Circuits and folders in that disk will be displayed. Use the arrow keys to highlight the circuit you want to delete and press the SPACEBAR to delete it. To delete a circuit saved in a folder use the arrow keys to highlight the folder and press RETURN. When the circuits and folders in that folder are displayed on the screen, use the arrow keys to highlight the circuit you want to delete and press the SPACEBAR to delete it.

To delete a circuit that is not displayed in the list of the first 51 circuits and folders in a folder, you must know the circuit's name. Press the TAB key. When the cursor appears next to "Enter Name", enter the name of the circuit you wish to delete and press SPACEBAR to delete it.

NOTES ABOUT *BUILD A CIRCUIT*

Below is some additional information that is useful in working with **Build a Circuit**. Some of this information concerns the circuit components or objects, while some involves specific operations and limits of the program.

Circuit Components

Batteries: The batteries used in this program are 1.5 volt batteries. Batteries have a positive (right) and negative (left) end.

Bulbs: The bulbs light with 18 levels of brightness depending upon the components and their arrangement. The ampere range is 0.03 to 1.50 and up.
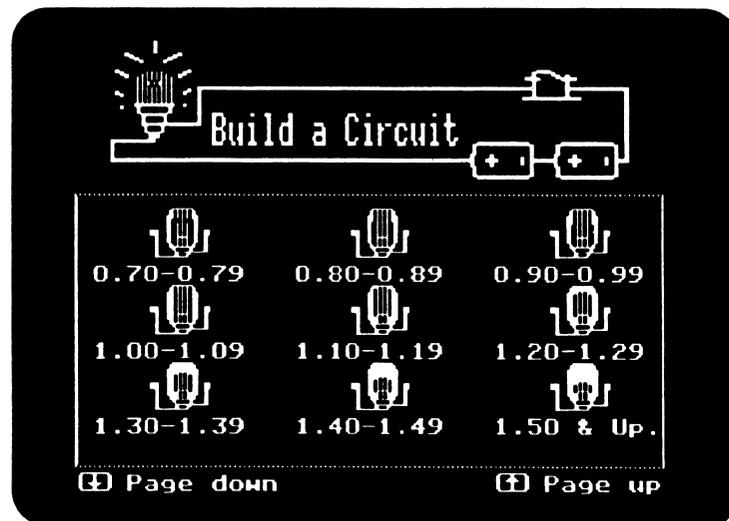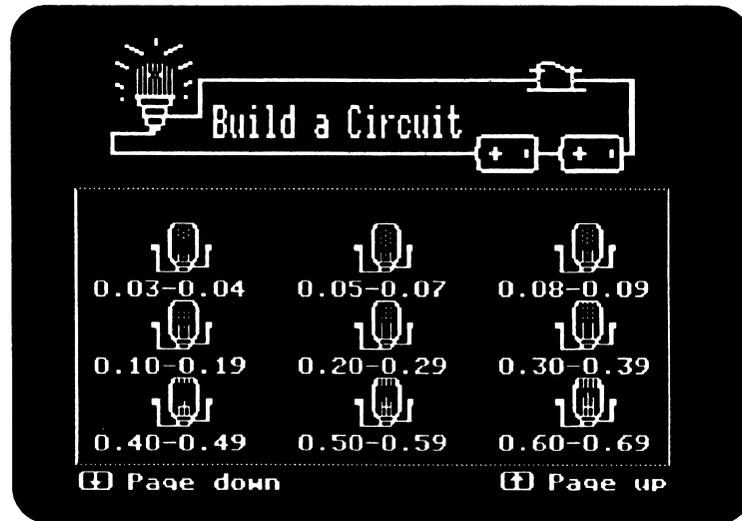
Motors: Like batteries, motors have a positive end (right) and a negative end (left).
Current will flow with the following effects:
- positive of battery to positive of motor: motor turns clockwise
- positive of battery to negative of motor: motor turns counterclockwise

Motors also rotate with 7 different speeds, depending upon circuit components and their arangement as detailed below.

Ampere range	Speed
0.00 - 0.19	No rotation
0.20 - 0.99	Speed 1
1.00 - 1.99	Speed 2
2.00 - 2.99	Speed 3
3.00 - 3.99	Speed 4
4.00 - 4.99	Speed 5
5.00 - 5.99	Speed 6
6.00 - 6.99	Speed 7

Resistance: The resistance of the components is a factor when working with the bulbs, motors, switches and wires in **Build a Circuit.** The following table shows the resistance of the electrical objects used in this program:

Object	Resistance
Bulb	19.0 ohms
Motor	2.5 ohms
Switch	0.0 ohms
Copper wire	0.001 ohms (for any length)
Nichrome wire	0.1 ohms (for any length)

For a more detailed discussion of terms and circuitry, see pages 32-37.

Key strokes

Up to 60 arrow key strokes are allowed for placing a wire between two objects.

Hidden keys

There are two hidden key commands in **Build a Circuit.**

⌘ - M switches from keyboard to mouse or back to keyboard. At the Main Menu, hold down the open Apple key while pressing the M key.

The G key hides the workspace grid, or shows it. When the workspace is on screen, press G to change from one to the other. The grid is useful as an aid in placing objects in the workspace and helps define the pathways in which wires can be run. There may be times when you want this grid to be invisible, such as when a circuit has been completed and you wish a clean visual effect.

Limit for Circuits

Build a Circuit allows a maximum of five loops in any one circuit.

USING THE MOUSE WITH *BUILD A CIRCUIT*

Build a Circuit is initially set for use with the Apple II keyboard. However, you have the option of selecting using the Apple II mouse with the program. Mouse or keyboard selection is only available when the program is at the Main Menu.

Before beginning the **Build a Circuit** program, the mouse must be attached to the Apple computer. Once the Main Menu appears, press the open apple key (⌂) + M to select the mouse option. The following screen will appear.
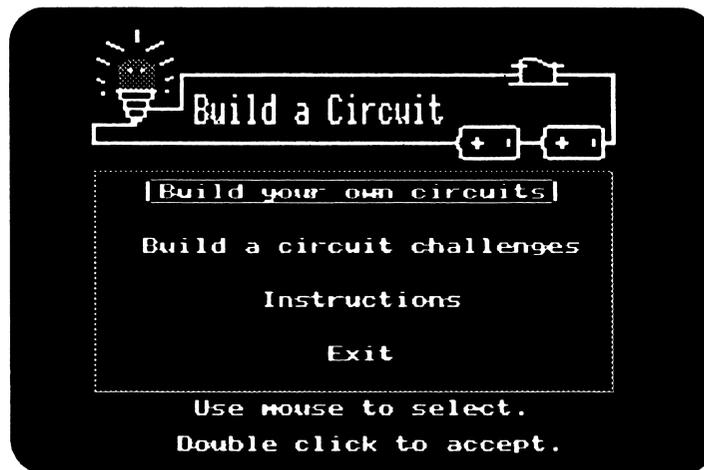
To reselect the keyboard option, press the open apple key (⌂) and the M key.

Use the mouse to click on your choice in the Main Menu: the object will be highlighted. Click again to enter the selection.

Objects in the Workspace
Click on the object you wish to place in the workspace. Click again to place the object on the workspace screen. Move the objects to a desired position on the screen by clicking on the arrows at the bottom of the screen. Once in position, click *Place* to enter.

Wiring
To attach the wires to a connection point, click on the arrows at the bottom of the screen to bring the cursor to the lead point of the object you are wiring. Click once on *Connect* to begin the wire and use the arrows to unroll the wire to the next connection point. Click *Connect* again to complete the connection. Use the same format when disconnecting a wire.

Testing
To test the wiring of your circuit, click twice on *Test*. A hand will appear on the screen that will enable you to measure the voltage of a battery, the amperes of a bulb or motor, or turn the switch on/off. Use the arrows at the bottom of the screen to move the hand to the object you choose and click RETURN. Click *Cancel* to exit.

31

PRINCIPLES OF ELECTRIC CIRCUITS

As students explore, make discoveries, and draw conclusions about circuits, you may wish to reinforce their learning by describing some of the principles of electric circuits in more formal ways. The following material outlines some of these principles.

Background Information
If a flashlight bulb is connected by wires to each end of a battery, the tiny wire inside the bulb gets hot and glows. A chemical reaction inside the battery has caused an electric **current** to flow through the wires and light the bulb.

Electric current is the term that describes the movement of electrons along a pathway, or **circuit**. An energy force must be present to push the electrons along the pathway. One of the most familiar sources of this energy force is a battery. A chemical reaction inside a battery creates a positive (+) charge at its top terminal and a negative (-) charge at the bottom of the battery. When these two terminals are connected by a wire the charges push electrons through the wire, creating current.

The electric current flowing through the wire can light bulbs and run motors when these objects are attached to the wire in such a way that they provide a continuous pathway for the current. When battery, wires, and other objects are connected so that electric current flows in an uninterrupted pathway, the arrangement is called a **complete (or closed) circuit**.

One analogy for the flow of electric current is that of a water pump and pipe. When a water pump is started it pushes the water near it through the pipe, and *all* of the water in the pipe moves as well. If the water is to flow through the pipe continuously — as in an aquarium's circulation system, for example — you must connect the pipes and pump so that the water returns to the pump continuously. The pump and pipes form a complete (or closed) circuit.

If the pipe in a closed water circuit is cut, the pump will continue to pump water out of the cut pipe until all the water is gone. If an electric circuit is cut, however, the flow of current stops. No current escapes from the cut wire because the electrons making up the current are held firmly inside the wire. Although the battery is still capable of pushing the current, current flow ceases.

To better understand complete circuits, it is helpful to look at the structure of a bulb. Two wires inside a bulb hold up a thinner wire called a **filament**. The wire supporting one end of the filament is connected to the base of the bulb; the wire supporting the other end of the filament is connected to the metal cup of the bulb. The connection points for these two wires form the **lead positions** for connecting other wires that go to the two ends of the battery, making up the complete circuit.

Filament
Supporting Wire

Glass Bead
Side Terminal
Base Terminal
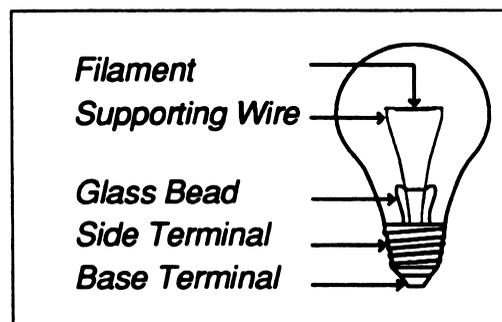
The filament in a bulb is a **resistor**. Because the wire is very small it resists the large current, and this resistance causes the filament wire to become hot — hot enough to glow.

Resistance is an important factor affecting circuits. In the case of the thin wire of a filament, the thinner the wire, the more resistance is offered. Another factor affecting resistance is the material used in any part of the circuit. Some materials, such as metals, have structures in which electrons can move easily. These materials are called **conductors**. They transmit the current along the circuit, and current flows readily through them. Good examples of conductors include metals (such as copper wire, paper clips, aluminum foil), a watch, or a ring.

Some other materials have structures that do not allow electrons to move easily, and current does not flow through them. These materials are known as **insulators**, or **non-conductors**. They prevent the current from moving along the circuit. Examples of insulators include rubber (such as rubber bands), wood, paper, and plastic.

Even among materials that are conductors there are variations in ability to allow electron movement. Copper wire is an example of a material that is a very good conductor—that is, it allows electrons to move through it easily. It is said to have little resistance to current. Nichrome wire, however, because of its structure, is an example of a conductor that does not allow electrons to move through it so easily; it has more resistance to current flow than copper wire. Bulbs, motors, and switches are also resistive elements.

A **switch** is a device that may be added to a circuit to control the presence or absence of current flow. The switch must be closed in order for the circuit to be complete. In the complete circuit, current flows, and a bulb, for example, will light. The switch must be opened to "break", or open, the circuit. If the circuit is not complete, no current flows, and the bulb will not light.

Current flow also has **direction**. When wires are switched from one end of a battery to the opposite end, the flow of current is reversed. Thus a motor may turn clockwise or counter-clockwise, depending on how it is wired to the battery.

There are two kinds of circuits, based on their wiring: a series circuit and a parallel circuit. A **series** circuit is a complete circuit, with no branching pathways, in which the components are wired one after another in the same pathway. If the series is broken none of the components will function. For example, if there are three bulbs, a battery, and a switch in the circuit, and the switch is opened, none of the bulbs will light.

A common example of a series circuit is that of a string of holiday lights in which one bulb becomes loose, causing a break in the series; because the circuit is not complete none of the bulbs will light.

Resistance is increased with the addition of components, and, in the case of bulbs, the bulbs will become dimmer as more bulbs are added to the circuit. More than one battery can be wired in a series circuit, and as each battery is added, the voltage increases. The bulbs that are wired in series with additional batteries will shine more brightly than bulbs wired with only one battery.
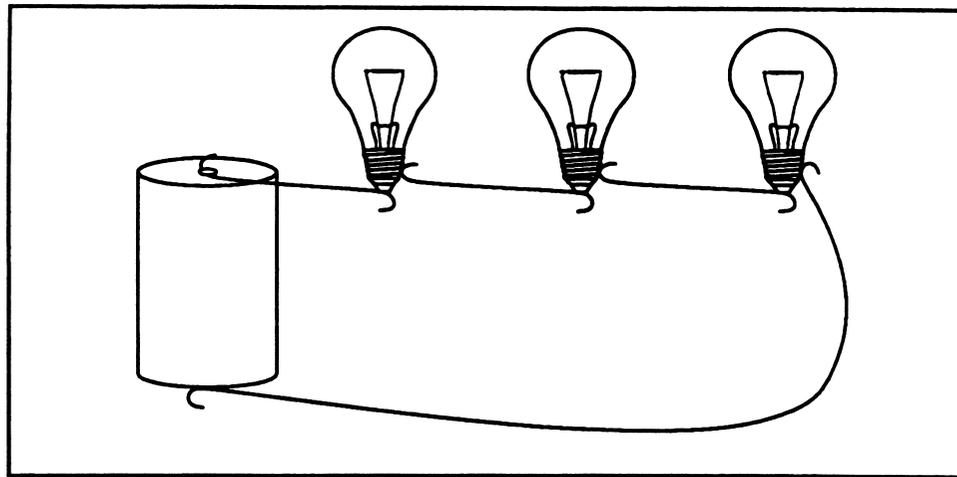
An example of a series circuit

A second kind of circuit is called a **parallel** circuit. In this circuit each component is wired to the battery in a separate circuit of its own. If one of the member circuits is broken, only the components wired in that circuit will cease to function; components in the other member circuits will continue to work. In the case of a string of lights wired in parallel, only the loose bulb will fail to light; the other lights will continue to glow. In a parallel circuit each bulb gets the full current it needs to glow brightly, independent of other bulbs.
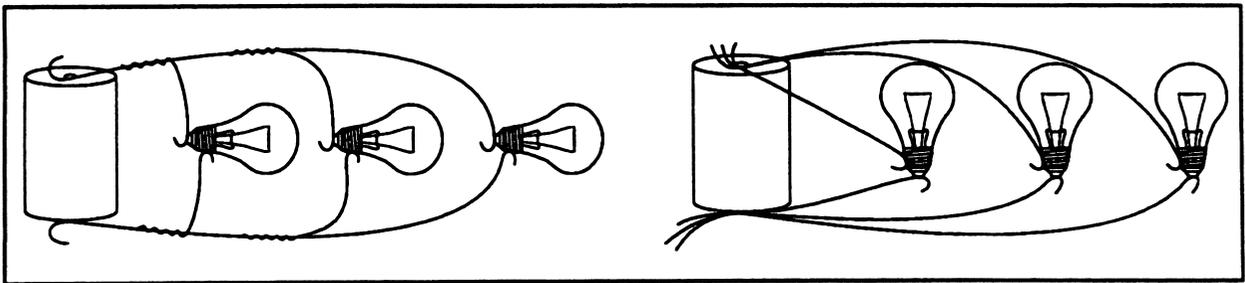
Examples of parallel circuits

Terms of Measurement

There are standard terms of measurement to describe electric circuits:

> A battery is described as having a certain number of **volts**.
> Current itself is measured in **amperes**.
> A unit of resistance is called an **ohm.**

For a particular circuit—for example, a battery, wire, and one bulb—the more volts (push), the more amperes (current). There is also some resistance provided by the wire and the bulb's filament. If the bulb is removed and just a piece of wire is left with the battery, there is less resistance in the circuit and more current.

Ohm's Law describes the relationship between voltage, current, and resistance. This law, named after Georg S. Ohm, the German physicist who discovered it, states that:

> Voltage = Current x Resistance.

Another way to look at this law is that resistance is defined as the ratio of the voltage applied across a piece of material to the current flowing through the material, or

> Resistance = Voltage/Current

Ohm's Law can be used to calculate the voltage drop across resistive elements. In **Build a Circuit** a battery's voltage is 1.5 volts. **Build a Circuit** also uses specific measurements of resistance for the components provided in the program. (These measurements are listed in the tables on page 29.) For example, in the circuit below, the voltage of the battery is 1.5 and the resistance of the bulb is 19 ohms. According to Ohm's Law, the current is 1.5/19, or 0.078 amperes.

A Safety Note

It is important to remember that electricity can be dangerous in certain situations. Up to ten 1.5 volt batteries in series can be used without danger of a serious shock, but more than ten such batteries can be dangerous under certain circumstances and should not be used. *House current, such as from wall outlets, is always dangerous.* Regular house current supplies 120 volts, equal to eighty batteries. It is prudent to plan for a thorough discussion of safety factors concerning electricity at a specific class time, when broad safety issues can be addressed.

GLOSSARY

ampere	a measurement of electric current. Named after Andre Ampere, a French physicist and mathematician.
circuit	a pathway through which electric current flows.
closed circuit	a complete pathway through which electric current flows, a complete circuit.
conductor	material that lets electric current pass through it easily.
current	the movement of electrons along a conductor.
filament	the thin wire inside a light bulb that glows when current flows through it.
hypothesis	a theory or supposition tentatively accepted as a basis for further investigation and experimentation.
insulator	material such as rubber, wood, or paper that does not conduct electricity.
nichrome	an alloy of nickel and chromium. A wire made of this alloy has a high resistance to electric current.
nonconductor	a material that does not readily transmit electric current.
ohm	unit for measuring electrical resistance. Named after the German physicist Georg Ohm (1789 - 1854).
Ohm's law	law of electricity stating that the current in most solid conductors increases in direct proportion to the voltage on it. Also stated as Voltage = Current x Resistance.
open circuit	a circuit that has an incomplete pathway for the electric current to flow along; an incomplete circuit.
parallel	a circuit in which each component is wired to the power source in a separate circuit of its own. If one of the members of the circuit is broken, only the components wired in that circuit will cease to function.
prediction	a guess about outcome based on past experience and observation.
resistance	opposition to the flow of electric current.

resistor   a device, such as a coil or length or wire, used in a circuit primarily to provide resistance to electric current.

series   a term describing a circuit whose components are connected in an end to end arrangement. All the electric current flows through each component of the circuit.

switch   a device that opens or closes an electric circuit.

terminal   a point of connection in an electric circuit or device such as a battery.

volt   a measurement of the force with which a battery or other energy source pushes electrons along a wire. Named after Alessandro Volta (1745-1827), an Italian professor of physics, who invented the forerunner of the battery.

watt   a measurement of electric power, determined by how much current is flowing and the force with which it is being pushed by the power source. As commonly understood, "watts" refers to the power required by a light bulb.

OVERVIEW OF CLASSROOM ACTIVITIES

The following five activities present several ideas for using **Build a Circuit** with students. The lessons are independent of each other, so you may select the lessons that you believe best meet the needs of your students and curriculum. Students should be familiar with the operation of **Build a Circuit** before starting any activity.

Cooperative Learning Strategies

Many activities with **Build a Circuit** can involve students' working together in small groups or in pairs. If your students are new at cooperative learning experiences, you may need to guide them in developing the attitudes and strategies that will help them benefit the most from their group work.

Encourage students to be supportive of each other as they explore the program. You may wish to assign roles to the groups' members, being specific about the responsibilites of each role — keyboard operator, note taker, artist, reporter, etc. Rotate the roles frequently among members of the group, so that each student has the chance to work on different tasks and to develop a variety of skills. Rotation also helps insure sharing of responsibility.

Be sure that all members of each group participate and that no one or two individuals dominate a group. Stress the importance of each member's contribution in terms of tasks and ideas, and emphasize that good ideas can be built from contributions of all members.

When students are working in pairs or small groups, your role as a teacher can be as a coach. It is important that you circulate among the groups, asking questions, providing direction, observing the investigation and interaction that is taking place. As you work with the groups:

- ask questions; open-ended queries can stimulate ideas that go beyond solving the immediate problem and address the science process itself.

- overcome the temptation to solve students' problems for them; work with them to encourage their own solutions.

- notice where students need help; look carefully at the students' level of knowledge, so that you can plan your classroom discussions to help them explore weak areas and investigate concepts that need reinforcement.

Extension Activities

The study of circuits provides the opportunity for countless activities that reinforce and extend the students' learning about electricity. Here are some suggestions.

Give the students the opportunity to explore electricity further by building actual circuits using real batteries, bulbs, motors, switches, and wire. Students can explore the materials in investigative ways, trying out ideas, observing the results, and gathering information about circuits through their experimentation. For example, students can design and test circuits using **Build a Circuit**, then duplicate the circuits using real materials and compare the results of the two methods. Students may explore further by using real materials for such projects as lighting a model room, building a fan with a small motor and oaktag blades, or constructing a model flashlight.

Research your school's library for books and articles on electricity. Assemble a collection in a special area of your classroom. If you have enough space, you may be able to set up a special interest area where students can use **Build a Circuit** and actual materials to design circuits, pursue ideas, and conduct experiments.

Students can bring in battery-operated appliances or toys that are no longer needed. These items can offer a good opportunity to identify and explore actual circuits. Before including any of the items in class, be sure to inspect them carefully to make sure they are safe. Do not include any appliances or toys that use household current for their power supply. Use only items with a low total battery voltage; remember that *more than ten 1.5 volt batteries used together can be dangerous* in certain situations.

Observation and Evaluation

As you observe students' work with **Build a Circuit**, there are several assessments you may wish to make. For example:

* After students have worked for some time with **Build a Circuit** and have become familiar with the program, do they show a grasp of the principles of electric circuits?

* Do the students use the science process as they work? Are they:
  asking questions, defining problems?
  observing?
  predicting?
  verifying and testing?
  drawing conclusions?
  communicating science by writing, drawing, explaining, and demonstrating?

* How well do the students work as cooperative group members?
  Are the students sharing ideas freely?
  Are they sharing the work?
  Are any group members left out of the process?
  Do they encourage each other?
  Is the group able to arrive at a consensus of ideas from all the members?

SERIES CIRCUITS

Overview: Students apply their knowledge of series circuits by drawing circuits and then testing them at the computer.

Objectives:
- To strengthen students' understanding of series circuits
- To develop students' skills in observation, prediction, and testing
- To communicate science by drawing and writing

Materials:
- Copies of Student Activity Sheets #1, 2, 3 and 4 for each group
- **Build a Circuit** program disks
- Computers

Activity:

1. Review the meaning of a complete circuit (see page 32 for a brief explanation) with students. As a discussion initiator, you may want students to first draw circuits on the blackboard and then use these circuits to discuss the definition of a complete circuit.

2. After students demonstrate an understanding of complete circuits, expand the discussion to include series circuits. (A series circuit is a complete circuit, with no branching pathways, in which the components are wired one after another in the same pathway. If the series is broken, none of the components will function.)

3. Tell students that they are going to work in groups to draw series circuits, make predictions about them, and then test their circuits at the computers. Distribute copies of Student Activity Sheets #1, 2, 3 and 4 to each group of students.

4. When they have finished their first series circuit, have each group test their design with the software. They should select *Build your own circuits* from the Main Menu, construct the circuit on the screen, and then use the *Test* option to check the circuit. They should finish their analysis by completing the worksheet.

5. Have students continue with the challenges posed in the other three activity sheets.

Assessment:

1. Bring the class together to discuss the challenges. What difficulties did they encounter? Did the process of drawing a circuit first then testing it at the computer help them understand the concept? Did they become better circuit designers with each new challenge?

2. Collect the activity sheets from each team to use as another measure of students' understanding of series circuits.

SERIES CIRCUIT #1

Names_____

1. Draw a complete circuit using 1 battery, 1 bulb, and wire:

    Will the bulb glow?

2. Use **Build a Circuit** to construct the circuit you have drawn. Then use the *Test* option to check the following:

    Does the bulb glow?   _____

    Amperes at bulb: _____

    Volts at battery: _____

    Were your predictions true?_____ If not, why not?

    Other observations:

SERIES CIRCUIT #2

Names _____

1. Draw a series circuit using 1 battery, 2 bulbs, and wire:

Will the bulbs glow?

Use **Build a Circuit** to construct the circuit you have drawn. Then use the *Test* option to check the following:

Do the bulbs glow?	_____
Amperes at bulbs:	_____(1) _____(2)
Volts at battery:	_____

Were your predictions true?_____ If not, why not?

Other observations:

SERIES CIRCUIT #3

Names _____

1. Draw a series circuit using 1 battery, 3 bulbs, and wire:

   Will the bulbs glow?

2. Use **Build a Circuit** to construct the circuit you have drawn. Then use the *Test* option to check the following:

   Do the bulbs glow? _____

   Amperes at bulbs: _____ (1) _____ (2) _____ (3)

   Volts at battery: _____

   Were your predictions true? _____ If not, why not?

   Other observations:

SERIES CIRCUIT #4

Names _____

1. How many bulbs can you light using a series circuit with 1 battery? Draw your circuit below:

    Add a second battery in series to your circuit. Draw your circuit below:

    Will the bulbs glow? Predictions:

2. Use **Build a Circuit** to construct the circuit you have drawn. Then use the *Test* option to check the
    following:

	1- Battery Circuit	2- Battery Circuit
Do the bulbs glow?	_____	_____
Amperes at bulbs:	(1) _____	_____
	(2) _____	_____
	(3) _____	_____
Total amperes:	_____	_____
Volts at batteries:	(1) _____	_____
	(2) _____	_____
Total volts:	_____	_____

    Were your predictions true? _____ If not, why not?

    Write other observations on the back of this paper.

BUILDING, PREDICTING, AND TESTING CIRCUITS

Overview: Students view a circuit that is displayed on an overhead projector and record their predictions about the circuit. Then, using **Build a Circuit** they construct and test the circuit and observe the results.

Objectives:
- To develop students' understanding of complete circuits
- To develop skills in analyzing, predicting, and testing circuits
- To help students see analogous relationships between drawings, diagrams, and computer screen representations of circuits

Materials:
- Overhead projector
- Overhead transparencies #1, 2, 3, 4 and 5 of circuit diagrams.
- Copies of Student Activity Sheets #5, 6, 7, 8 and 9 (circuit report forms) for each group.
- Computers
- **Build a Circuit** program disk.

Note: This activity is designed for cooperative learning groups of three to four students each. These directions, therefore, are given in terms of working groups. However, the activity is also effective with individual students working alone, and you may adapt it accordingly.

Activity:

1. Explain to students the procedure for this activity: that you will display a diagram of a circuit; that they will make predictions about the circuit; record their predictions on the circuit report forms; use **Build a Circuit** to construct and test the circuit; and record the test results on the circuit report forms. Also review with students how measurements for motors and bulbs are related.

2. After students are in their groups and each group has their circuit report forms, display a circuit diagram on the overhead projector for the groups to analyze. Encourage discussion, debating, and the exchange of ideas among group members.

3. At this juncture you may want to provide computer time to the groups to test the circuit, or you may want to continue at the overhead projector with other circuit diagrams.

4. When students use the software, tell them to select *Build your own circuits* from the Main menu. Ask the students to build the circuit that is displayed on the overhead projector (also in the upper right hand corner of their circuit report forms). Then they should test the circuit using the *Test* option. Have them record the test results on their circuit report forms.

Assessment:

1. After the circuits have been constructed, tested, and results have been recorded, bring the class together to discuss the difficulties they had in drawing, predicting, constructing, and testing the circuits. Encourage them to share their problems and solutions.

2. Collect the circuit report forms from each group. Use these forms to help you assess students' progress in understanding circuits. In your assessment, look for students' analysis of the diagrams, construction of the circuits, and understanding of the testing process.
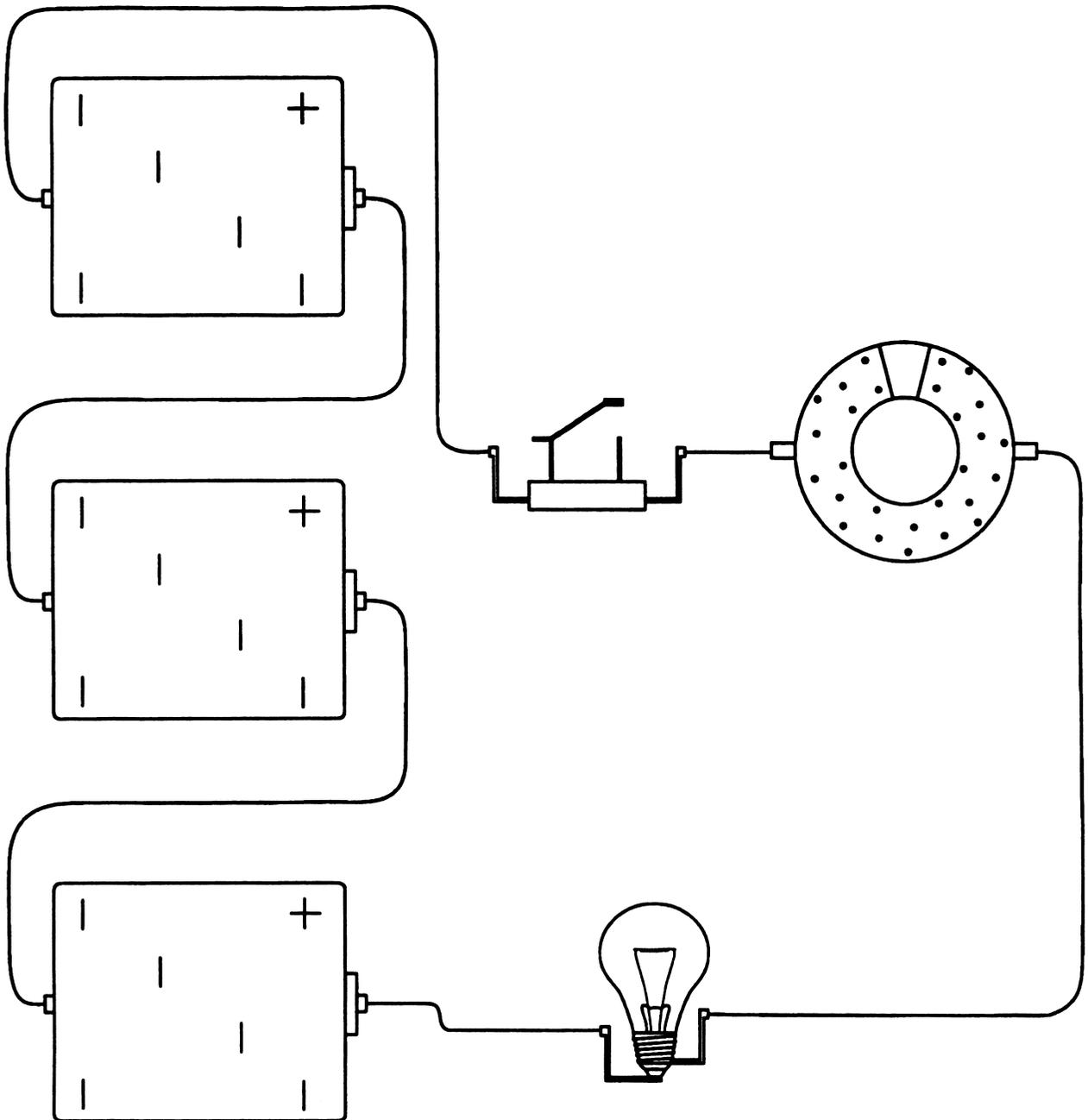
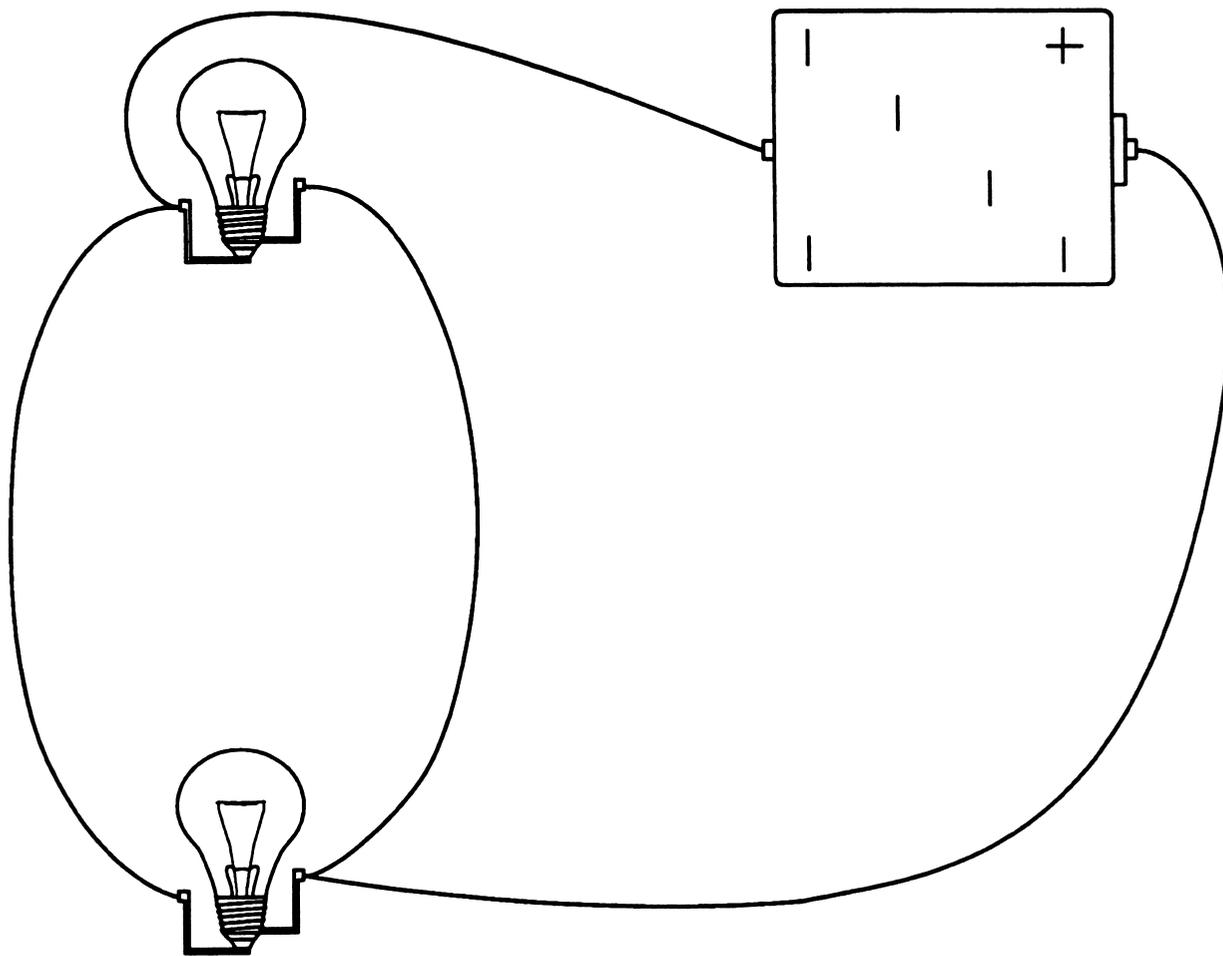# CIRCUIT DIAGRAM #1

CIRCUIT DIAGRAM #2

SUNBURST © 1992
COMMUNICATIONS
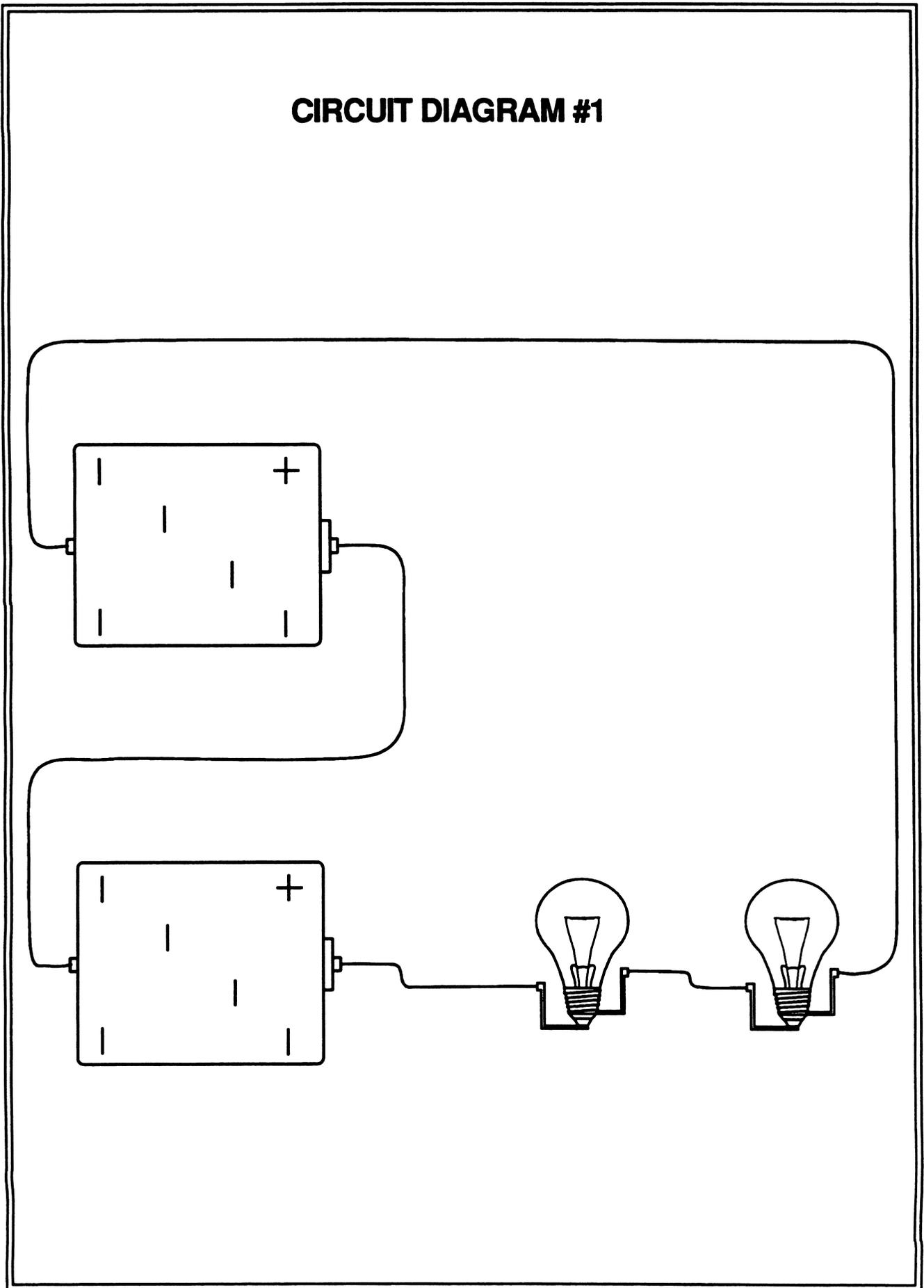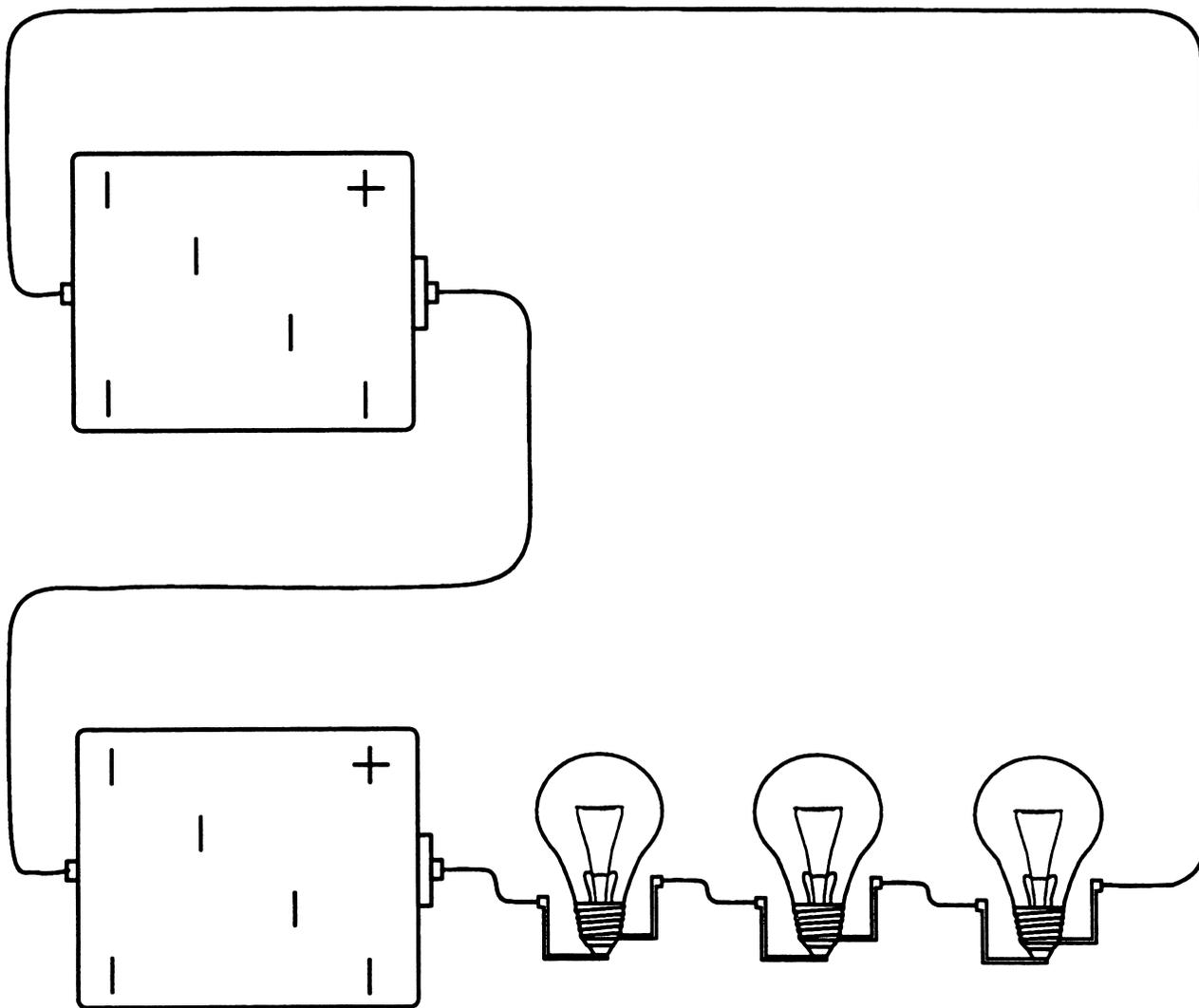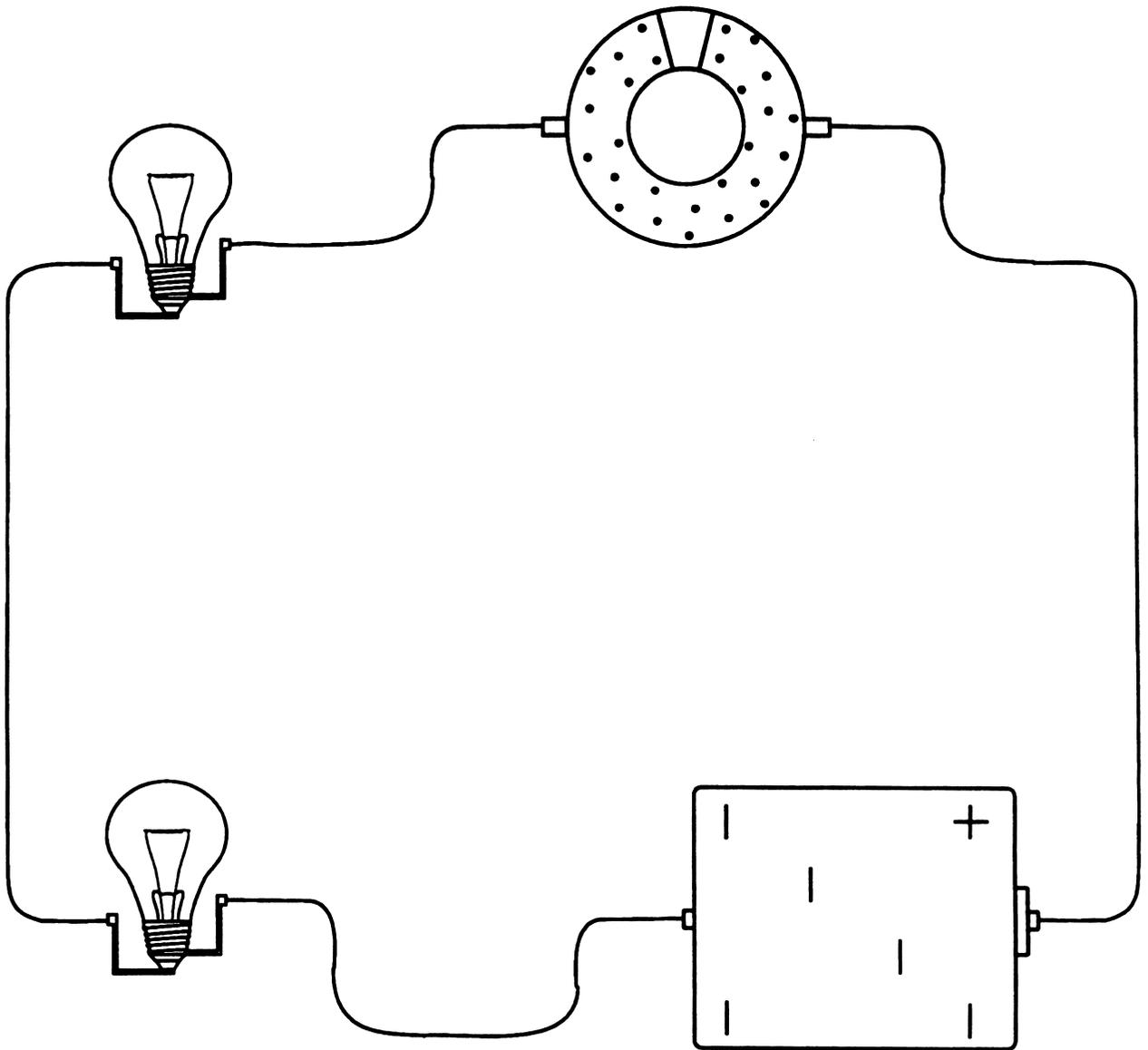
CIRCUIT DIAGRAM #3

CIRCUIT DIAGRAM #4

CIRCUIT DIAGRAM #5

CIRCUIT REPORT FORM

Names:_____

_____

_____

Circuit #1

Predictions:

Will the bulbs light?_____

Is the circuit a complete circuit?_____

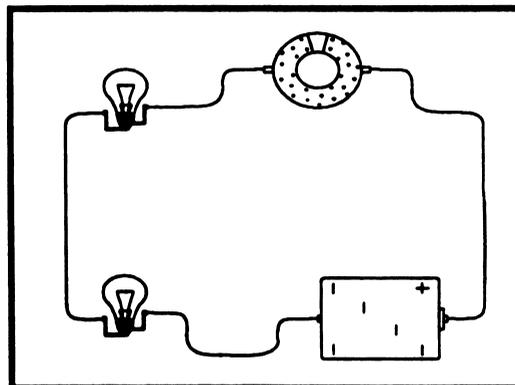What will be the measurement of the amperes for bulbs?_____ Why?_____

_____

Write your other predictions_____

_____

At the Computer:
Build the circuit in this diagram. Write the results on the back of this paper. How do they compare with your predictions?

CIRCUIT REPORT FORM

Names:_____

_____

_____
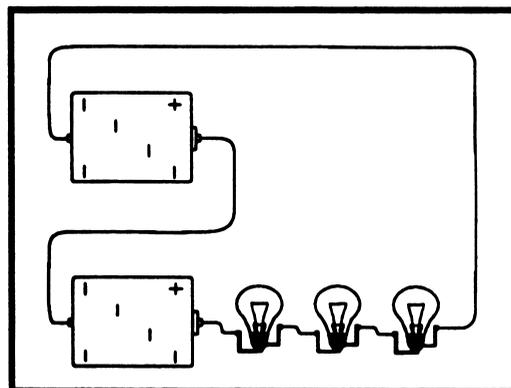
Circuit #2

Predictions:

Will the bulbs light?_____

Is the circuit a complete circuit?_____

What will be the measurement of the amperes for bulbs?_____ Why?_____

_____

Write your other predictions_____

_____

At the Computer:
Build the circuit in this diagram. Write the results on the back of this paper. How do they compare with your predictions?

CIRCUIT REPORT FORM

Names:_____

_____

_____

Circuit #3

Predictions:

Will the bulbs light?_____

Will the motor turn?_____ Clockwise or counter-clockwise?_____

Is the circuit a complete circuit?_____

What will be the measurement of the amperes for bulbs?_____

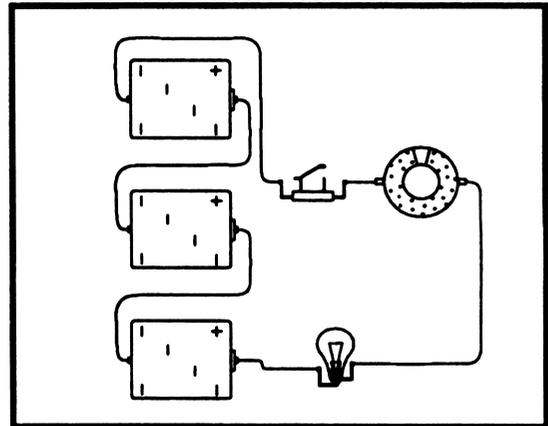Why?_____

What will the measurement be for the motor?_____

Why?_____

Write your other predictions_____

_____

At the Computer:
Build the circuit in this diagram. Write the results on the back of this paper. How do they compare with your predictions?

CIRCUIT REPORT FORM

Names:_____

_____

_____

Circuit #4

Predictions:

Will the bulb light? _____

Will the motor turn? _____   Clockwise or counter-clockwise? _____

Is the circuit a complete circuit? _____

What will happen if the switch is open? _____

Closed?_____

What will be the amperes for the bulb?_____ Why? _____

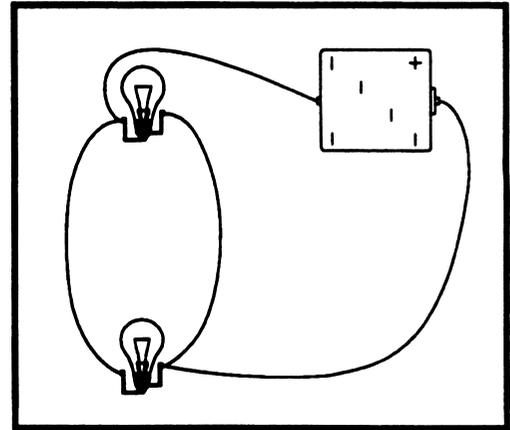What will be the measurement for the motor?_____ Why? _____

Write your other predictions _____

_____

At the Computer:
Build the circuit in this diagram. Write the results on the back of this paper. How do they compare with your predictions?

CIRCUIT REPORT FORM

Names:_____

_____

_____

Circuit #5

Predictions:

Will the bulbs light?_____

Is the circuit a complete circuit?_____

What will be the measurement of the amperes for bulbs?_____ Why?_____

_____

Write your other predictions_____

_____

At the Computer:
Build the circuit in this diagram. Write the results on the back of this paper. How do they compare with your predictions?

DESIGN A CHALLENGE

Overview: Students design a circuit, write a description of the circuit, and ask other students to build a circuit that fits the description.

Objectives:
- To strengthen students' understanding of circuits
- To develop students' skills in observation, prediction, and testing
- To provide practice in communicating science by drawing, diagramming, and writing

Materials:
- Computers
- **Build a Circuit** program disk for each computer
- Copies of Student Activity Sheet #10 for each group

Activity:

1. Distribute copies of Activity Sheet #10 to each group of students. Explain that they are going to design a circuit as a challenge for another group of students.

2. Students should follow the directions on the activity sheet. They will need to make predictions and test the circuit first, before giving a description of the circuit to their peers. Emphasize that it is acceptable to modify a design circuit, but they should be sure that the drawing and predictions apply to the modified design.

3. Discuss the importance of writing a complete and precise description of their circuit design, as this is the only information their peers will use to duplicate the circuit design.

4. When they have finished writing a description of their circuit, have students exchange page 2 of the activity sheets with another group of students. Students should use the lower portion of their peers' activity sheet to draw the circuit described on the top of the page. Encourage students to use the software as they develop their solutions to the circuit challenges.

5. When the groups are finished, tell them to compare their designs.
   - Are the circuits alike? Why or why not?
   - Does the new circuit behave in accordance with the description? Why or why not?
   - Can the description result in more than one correct circuit design?
   - Could the circuits be designed more simply?

Assessment:

1. Observe students in their groups, especially when they compare their designs with the new design based on their description. In their conversations, do students demonstrate an understanding of circuits? Can they identify problems and solutions?

2. Review students' activity sheets. You may want students to repeat the challenge, in which case you may compare the progress from one challenge to another.

DESIGN A CHALLENGE

Names_____

1. Draw an original circuit design in the space below.

2. Write five predictions about your circuit. Then use the software to test your predictions. Check if they were true or false.

	Predictions	True	False
1.			
2.			
3.			
4.			
5.			

3. Based on the results of your testing, write a description of your circuit on the next page. The description must be complete and precise so another group can draw it. Your predictions should be part of your description.

3. Circuit description:

4. Now your classmates should draw the circuit described above.

CIRCUIT CHALLENGES

Overview: Students apply their knowledge of circuits in ten different challenges.

Objectives:
- To reinforce students' understanding of complete circuits
- To develop students' skills in analyzing circuits and predicting their behavior
- To help students develop the ability to conceptualize circuits in diagram form

Materials:
- Student Activity Sheet #11 for each student
- **Build a Circuit** program disks
- Computers

Activity:

1. Distribute copies of Student Activity Sheet #11 to each student. Explain that each circuit must be modified according to the instructions. Encourage students to use the software to help them complete the challenges.

2. When all students have completed the activity sheet, discuss the solutions to each problem as a class. In case of discrepancies or multiple solutions, you may want students to build the circuits at a computer positioned in front of the classroom.
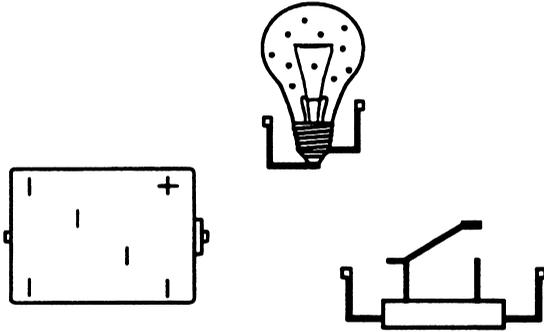
Assessment:

Review the activity sheets. Are students able to conceptualize circuits in diagram form? Are there recurring difficulties in analyzing the circuits?
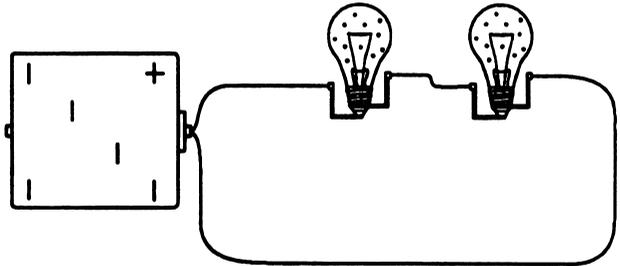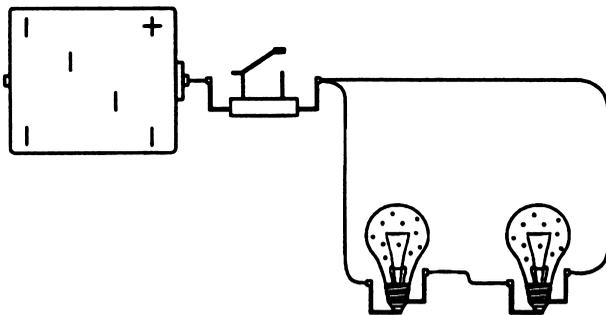
CIRCUIT CHALLENGES

Names _____

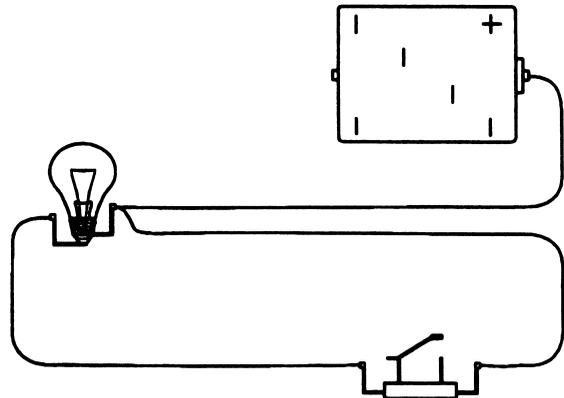**1.** Wire these objects to make a complete circuit

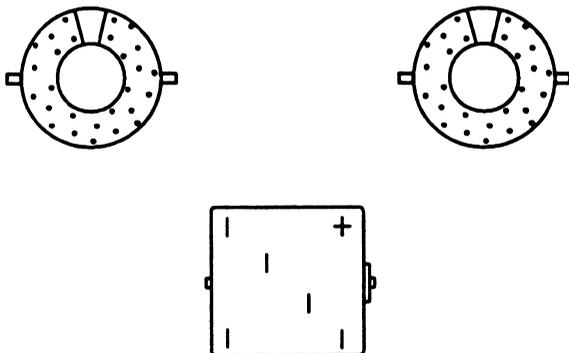**2.** Change one segment of wire to make this circuit complete.

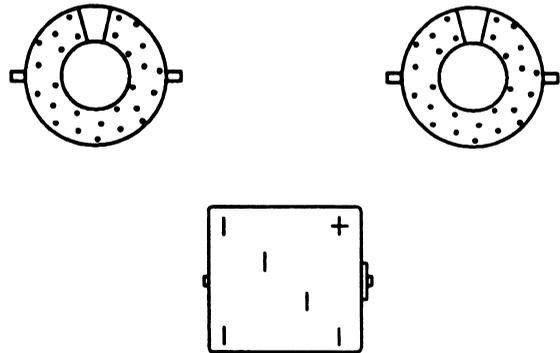**3.** Change one wire to make this circuit complete.

4. Rewire this circuit so that the bulb will glow when the switch is closed.

5. Wire this circuit so that one motor turns clockwise and the other motor turns counter-clockwise
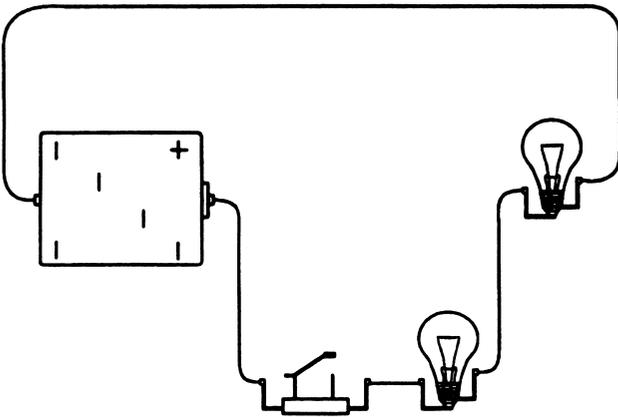
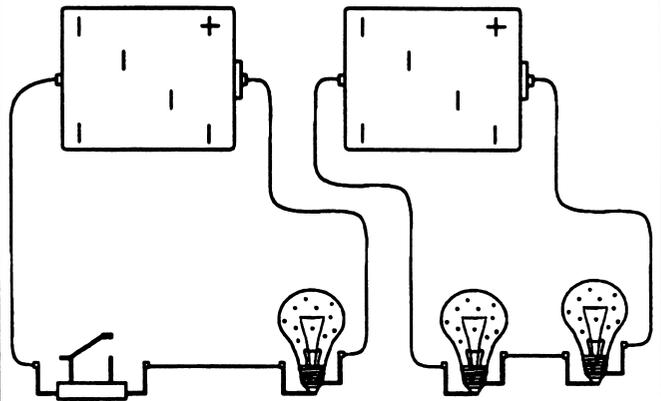**6.** Wire those same objects so that both motors turn clockwise.
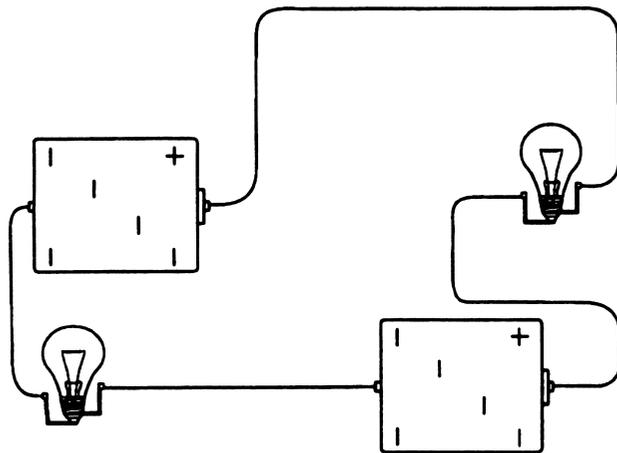
CIRCUIT CHALLENGES

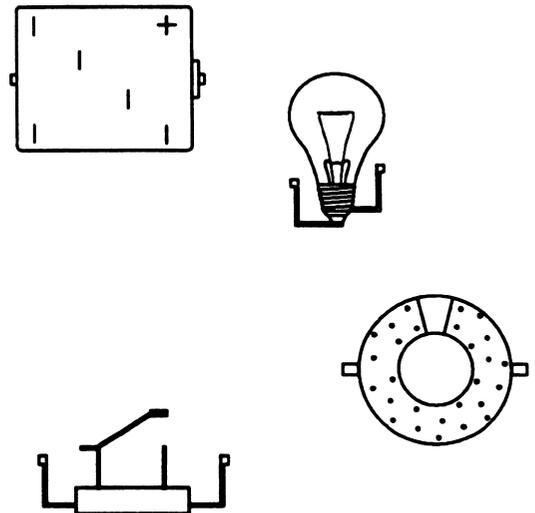7. Fix this circuit so the bulbs will light.

8. Rewire these two circuits to combine them into one series circuit.

9. Correct the error, or errors, in wiring so that the bulbs will glow.

10. Wire these four objects so that the motor always turns, while the bulb can be switched on or off.

SUNBURST
COMMUNICATIONS © 1992

BUILDING A CIRCUIT WITH ACTUAL COMPONENTS

Overview: Students construct circuits using real batteries, bulbs, and wire, and then experiment to find as many ways as possible to light the bulbs.

Objectives:
- To strengthen students' understanding of circuits
- To develop students' skills in observation and analysis
- To strengthen students' ability to record their observations

Materials:
- A materials box for each group of students containing:
    - 2 batteries (1.5 volt)
    - 2 battery holders
    - 2 six-inch pieces of copper wire
    - 2 bulbs
    - 2 bulb holders

- Copies of Student Activity Sheet #12 for each group.

Activity:

1. Explain to the students that they will be constructing circuits using real batteries, bulbs, and wire. Afterwards, they will experiment with their circuit to find as many ways as possible to light the bulbs. Emphasize that the purposes of this activity are investigation and exploration and that they will learn as much from circuits that do not light any bulbs as from those that do.

2. If students have not previously used circuit materials, show them the proper contact points where wire can be attached to the batteries and the bulbs. Demonstrate putting the batteries and bulbs into the holders. Avoid indicating any arrangement that will form a circuit.

> **Note:** Students may need reassurance that the class materials for this activity are safe to handle. Explain that up to ten 1.5 volt batteries in series can be used without danger of a serious shock, but that more than ten such batteries can be dangerous in certain situations and should not be used. Let students know that a wire can become hot even at the level of these activity materials and if that happens, they should simply disconnect the wire.
>
> It is important for students to know that electricity can be dangerous in certain situations. *House current, such as from wall outlets, is always dangerous.* Regular house current carries 120 volts—equal to eighty batteries.

3. Distribute the materials boxes and Student Activity Sheet #12 to the groups so that they may begin their investigations. Circulate among the groups during this activity, responding where guidance is needed. As you notice a group experiencing problems with wiring, resist the temptation to solve their problem with a ready answer; instead,

guide the students with questions that will lead to investigation and discovery on their own.

4. Remind students to draw one of their circuits and write their observations on the activity sheet. Encourage students to include in their written observations whether a particular arrangement did or did not light the bulbs, and why.

5. When the groups have explored the materials in depth bring the class together to discuss the discoveries they made.

Assessment:

At the end of the class period, collect the activity sheets from all groups and use them in your assessment of the students' understanding of circuits and circuit materials.

BULB CIRCUITS

Name _____

Draw your circuit in this space.

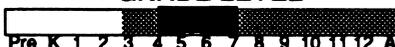Write your observations below.

Build a Circuit

Science

Overview

Build a Circuit allows students to electrically wire circuits on screen by connecting batteries, bulbs, motors, switches, and wires.

READING LEVEL
3

GRADE LEVEL
Pre K 1 2 3 4 5 6 7 8 9 10 11 12 A

TIME REQUIRED
10 - 20 minutes
per session

Curriculum

PREREQUISITE SKILLS
- Basic understanding of electricity and circuits

OBJECTIVES
- To enhance understanding of electricity and circuits through an on-screen investigation of electric currents.
- To develop science process skills: observing, analyzing, predicting, forming hypotheses, testing, reformulating hypotheses based upon the results of testing, and communicating science.
- To strengthen problem-solving skills.

PROBLEM SOLVING SKILLS
- Using a model
- Looking for a pattern or sequence
- Organizing
- Analyzing
- Predicting
- Hypothesizing

Courseware

NOTEWORTHY FEATURES
- Contains two levels: an expereimental mode and a challenge mode.
- Students may print their circuit diagrams
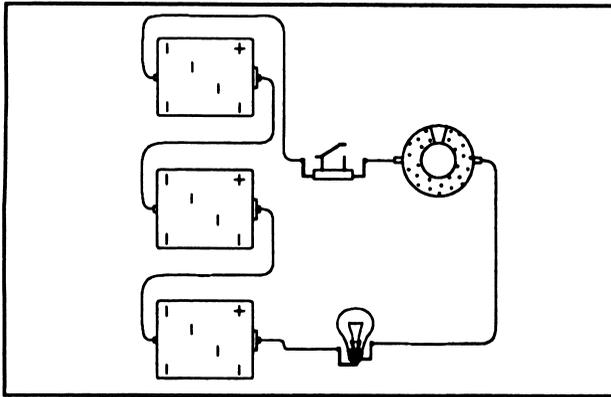
TEACHER OPTIONS
- Choice of type of wire
- Selection of printer type and interface card
- Choice of disk utilities

Hardware

- Apple II

Build a Circuit

DESCRIPTION
Build a Circuit promotes investigation of electrical circuits in two activities.

Build your own circuits - Students design their own circuits on screen using batteries, bulbs, motors, switches, and wire. When they are finished, they may test their circuit. If it is wired correctly, bulbs will light up and motors rotate. They will also be able to measure the voltage of the battery and the amperes of the bulb or motor, as well as open and close the switch.

Build a circuit challenges - Students are challenged to construct 15 different circuits according to a set of specifications. This activity has three levels of difficulty.

GETTING STARTED
Before using the software, review basic principles of electric circuits. A 4-page overview is provided in the teacher's guide.

AT THE COMPUTER
Step 1: Demonstrate the features of the program to the class by reviewing the Instructions.

Step 2: Pair students to work at the computer together. Allow sufficient time for them to experiment with the software so they are comfortable with its features.

Step 3: Continue at the computer with one of the lessons provided in the teacher's guide.

SUGGESTED EVALUATION
Listen to students as they discuss the difficulties they had in drawing, predicting, constructing, and testing circuits. Also use the various activity sheets in the teacher's guide to assess students' understanding of electrical circuits.

SPECIAL KEYS
- CTRL-T from the Main menu accesses Teacher Options
- CTRL-E exits the program at any time.
- ⌂ - M toggles the use of the mouse and keyboard

Build a circuit challenges
Medium Level #3

Apple II+, IIe, IIc: Working With The Computer

Turning on the system

1.   Turn on the monitor.

2.   Insert the diskette into the disk drive with the label facing up.

3.   Close the door to the disk drive.

4.   Turn on the computer. (The on-off switch is on the back left side of the computer.)

5.   You will see a red light on the disk drive turn on. If the disk drive light does not turn off after about 10 seconds, turn the Apple off and make sure your disk is placed correctly in the disk drive.

6.   The SUNBURST logo will appear on the screen, followed by the opening screen of the program.

7.   Follow directions given in the program.

8.   If you wish to stop during the program, hold down the CTRL (CONTROL) Key and press E.

Turning off the system

1.   Remove the disk from the disk drive and return it to its place of storage.

2.   Turn off the computer.

3.   Turn off the monitor.

Apple IIGS: Control Panel Settings

To allow your Apple IIGS to work properly with SUNBURST software, certain Control Panel settings should be selected. The Apple IIGS retains these settings even after the power is turned off.

To Use the Control Panel:

- Turn on the Apple IIGS and monitor.
- Enter the Control Panel Main Menu by holding down the CONTROL and OPTION keys, and then press RESET (the rectangular key located above the number keys). If your Apple IIGS is in an Apple //e case, use the closed-apple (⬤) key instead of OPTION.
- Press the 1 key to enter the Control Panel.
- Use ↑ and ↓ to highlight the feature you want to change and press RETURN. Again use ↑ and ↓ to highlight a specific option and change it by using the → and ← keys.
- After you have finished making changes, select Quit to use the Apple IIGS

To Change the Display:

- Highlight **Display** and press RETURN.
- Set **Type** to **Color**.
- Set **Columns** to **40**.
- Set **Text** to **White**.
- Set **Background** to **Black**.
- Set **Border** to **Black**.
- Press RETURN to save the changes and to go back to the Control Panel.

To Change the System Speed:

- Highlight **System Speed** and press RETURN.
- Set **System Speed** to **Normal**.
- Press RETURN to go back to the Control Panel.

To Change the Slots:

- Highlight **Slots** and press RETURN.
- Set **Slot 1** to **Printer Port**. If you are using a printer card, set the slot number your printer card is in to **Your Card**.
- Set **Slot 6** to **Disk Port**, if you use a 5.25 - inch drive connected to the disk drive port.
- Set **Slot 6** to **Your Card**, if you use a 5.25 - inch drive connected to a controller card in card in Slot 6.
- Set **Startup Slot** to **Scan**.
- Press RETURN to go back to the Control Panel.

"WHAT HAPPENS IF...?"—SUNBURST COURSEWARE AND WARRANTY

What happens if a program will not load or run?

Call us on our toll-free number and we will send you a new disk.

What if I find an error in the program?

We have thoroughly tested the programs that SUNBURST carries, so we hope this does not happen. But if you do find an error, please note what you did before the error occurred. Also, if a message appears on the screen, please write the message down. Then fill out the evaluation form or call us with the information. We will correct the error and send you a new disk.

What happens if the courseware is accidentally destroyed?

SUNBURST has a lifetime guarantee on its courseware. Send us the product that was damaged and we will send you a new one.

How do I stop a program in the middle to go on to something new?

These programs can be ended at any time by holding the Control (CTRL) Key and pressing the E Key. To change disks, select the QUIT option on the menu and insert a new disk.

Can I copy the disk?

The material on the disk is copyrighted. You should not copy the courseware.

Can I take the disk out of the computer after the program has been loaded and put it into another computer?

No.

Software Replacement Request

SUNBURST

You may receive a replacement of your software, free of charge, if it
- is lost or damaged during normal school use.
- is defective.
- has an updated version. (For a list of updated titles, check the order form in the latest Sunburst catalog).

Fill out this form and send to:

Sunburst Communications, Inc.
Customer Service
101 Castleton Street
Pleasantville, NY 10570

Send new software for:

Program Name_____ Product # *(see disk title)*_____

Computer Type_____ ☐ 5.25" disk   ☐ 3.5" disk   ☐ CD

Quantity* _____ Original invoice number_____
      *Specify disk if multi-disk program.   (if available)

Reason for replacing (check one and supply information):

☐ defective   Comments:_____
☐ damaged   _____
☐ lost   _____
☐ wrong software title   _____
☐ update offered for this program

(NOTE: Some updates require more computer memory than the previous version. Check catalog description.)

☐ Original software enclosed with this form   ☐ Will send original software after replacement

Send replacement(s) to:

Name   _____

Position   _____

Name of School _____

Address   _____

                _____ Zip_____

Phone   _____

Software Replacement Request

AGREEMENT

SUNBURST

FOR INSTALLATION
ON   5   COMPUTERS
AT A SINGLE SITE

This purchase entitles you to install this program on **FIVE** computers.   For additional installations (at the same site) at lower cost, please call SUNBURST Customer Service, toll-free 800-321-7511. You will receive full credit toward the purchase of a Site License.

COST SAVINGS: Your cost per computer **drops rapidly** with additional installations as this example for a $79 product shows:

Number of Computers	Site License Price	Your Cost Per Computer to Install
One	xxx	$79.00 per computer
Five	$158.00	$31.60 per computer
Twenty-Five	$399.95	$15.99 per computer
Unlimited	$599.95	$ 5.99 per computer (for 100 machines)

These example prices are for a $79 product. If your product has a different catalog list price, please call toll-free 800-321-7511 for your Site License Savings.

PROGRAM EVALUATION FORM

SUNBURST

Dear Educator:

After you look at this Sunburst program, we would like to know what you think of it. Your comments help us produce high-quality materials and meet your teaching needs. Please return this evaluation form by folding it in thirds and taping it closed.

TITLE OF PROGRAM _____

☐ I am purchasing this program.

☐ I plan to purchase this program.

☐ I do not plan to purchase this program.

What did you like or dislike about the format (activity cards, binder, etc.)?

_____

_____

_____

What did you think of the content? _____

_____

How did your students react? _____

_____

How did you use this program?

☐ in classroom   ☐ for independent work

☐ with small groups   ☐ in media center

What grade levels? _____

General Comments _____

_____

Name   _____
Title   _____
School   _____
Address   _____
Zip/Postal Code _____

In the United States and Canada, call 800/321-7511.

STUDENT EVALUATION FORM

1. What is the name of the program that you used? _____
_____
_____

2. Would you like to use this program again? Explain why. _____
_____
_____

3. Did you understand the instructions?_____
_____
_____

4. Were the pictures in the program interesting?_____
_____
_____

5. What did you learn from the program that you didn't know before?_____
_____
_____

6. What *didn't* you like about the program? _____
_____
_____

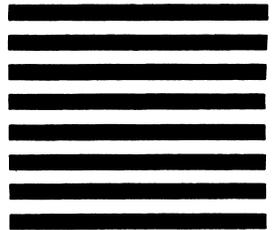Fold into thirds, tape closed (do not staple) and mail.

SUNBURST

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL
FIRST CLASS MAIL   PERMIT NO. 30   PLEASANTVILLE NY

POSTAGE WILL BE PAID BY ADDRESSEE

SUNBURST COMMUNICATIONS
101 CASTLETON STREET
P.O. BOX 100
PLEASANTVILLE NY 10570-9963

Sunburst Lifetime Warranty Registration

Congratulations on your purchase of quality **SUNBURST** courseware! In order to register ownership and protect your warranty, please complete and return this card. The **SUNBURST** warranty—unlike any other—**guarantees replacement** of any program component, except hardware and student books, that becomes lost or damaged during normal use. This warranty applies as long as the product is offered for sale.

User Name

Title

School/Institution

Address

City   State/Province   Zip/Postal

Grade Span of School

Product Title   Date Purchased

Product Number   Computer Type

I learned about **SUNBURST** products through:

I buy software for the following computers:

Macintosh _____

Windows _____

DOS _____

Apple _____

MAY WE SEND A CATALOG TO A COLLEAGUE?

Name

School/Institution

Address

City   State/Province   Zip/Postal

(800) 321-7511
(914) 747-3310 (collect)

BUSINESS REPLY MAIL

FIRST CLASS MAIL   PERMIT NO 30 PLEASANTVILLE NY

POSTAGE WILL BE PAID BY ADDRESSEE

SUNBURST COMMUNICATIONS
101 CASTLETON STREET
PO BOX 100
PLEASANTVILLE NY 10570-9961