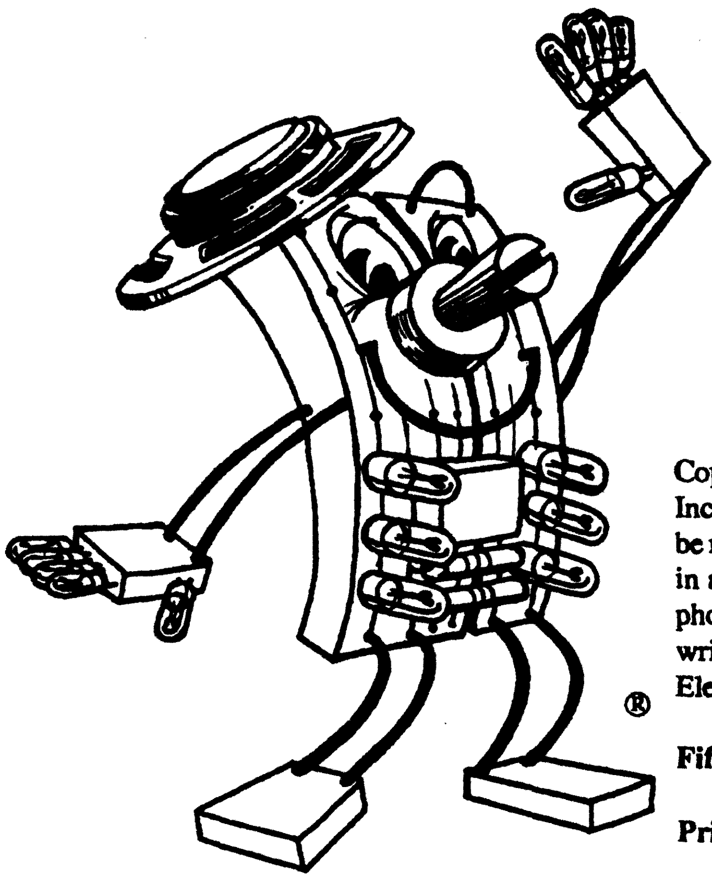
EKI

Electronic Kits International Inc.

SCIENCE ELECTRONIC LAB

LAB
#1 - 15



Written and Developed for EKI, Inc. by Jorge L Taliercio, Electrical Engineer.

Technical Drawings by Carlos Quintana

Illustrations by Tom Howell

Editors: Gary Gibson
Douglas Gibson

Fifth Edition.

Printed In The United States Of America

Mr. CIRCUIT ®

SCIENCE ELECTRONIC LAB

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30 - In - 1 SCIENCE ELECTRONICS LAB

Introduction

The EKI 30-In-One Science Electronic Lab was designed to provide science teachers and electronic students with a meaningful and exciting introductory course in electronics. No previous electronic knowledge is required. The EKI Science Electronics Lab stimulates students minds by using easy to understand experiments to increase their knowledge about electronics and explain how much electronics is a part of our world . Science project ideas will come as they build the thirty experiments while working with integrated circuits, light emitting diodes (LED's), photocells, semiconductors, etc.
The Lab was prepared for individuals of 10 years old and up.

Objective

The main objective of this Lab is to help students:
- recognize the basic components used in electronics
- learn the names and schematic symbols of electronic components
- learn to follow and understand electronic schematic diagrams
- learn the basic function of electronic components
- learn how to construct electronic devices by following schematic diagrams

The student will achieve the above objectives by using the proven technique of **learning by doing.**

How To Use It

This Lab Manual was designed with a progressive order of complexity. Therefore, we recommend that the beginner start with lesson #1 and follow the lessons and experiments in the order given in the manual. But this is not a requirement. After the student has learned the basic concepts taught in the lessons, they can choose any lesson or project and construct it by following the directions.

Now you are ready for the fun and excitement in the world of electronic technology.

PARTS INVENTORY SHEET

EKI SCIENCE ELECTRONIC LAB

EKI

RESISTORS 17

10 ohm (Brown, Black, Black, Gold)

47 ohm (Yellow, Violet, Black, Gold)

47 ohm (Yellow, Violet, Black, Gold)

100 ohm (Brown, Black, Brown, Gold)

100 ohm (Brown, Black, Brown, Gold)

220 ohm (Red, Red, Brown, Gold)

220 ohm (Red, Red, Brown, Gold)

1K (Brown, Black, Red, Gold)

1K (Brown, Black, Red, Gold)

2.2K (Red, Red, Red, Gold)

3.3K (Orange, Orange, Red, Gold)

6.8K (Blue, Gray, Red, Gold)

16K (Brown, Blue, Orange, Gold)

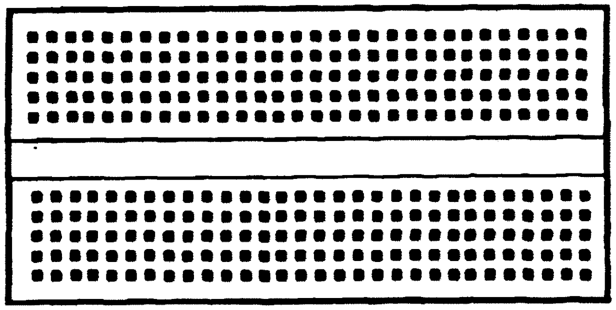
33K (Orange, Orange, Orange, Gold)

33K (Orange, Orange, Orange, Gold)

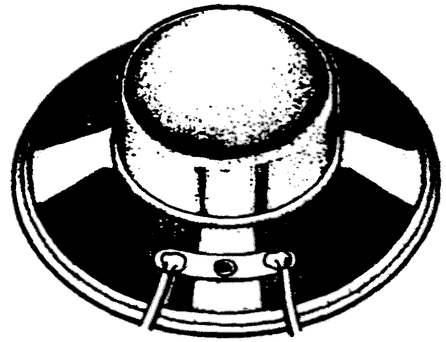
120K (Brown, Red, Yellow, Gold)

470K (Yellow, Violet, Yellow, Gold)

Solderless Circuit Board

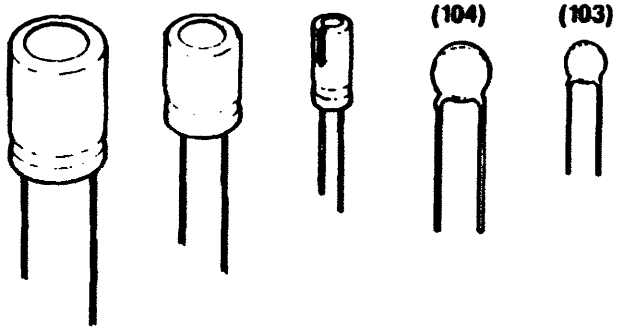


Speaker

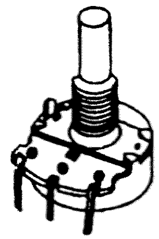


CAPACITORS

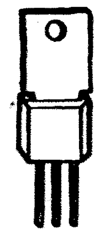
1000 µF 100µF 10µF .1µF (104) .01µF (103)



Potentiometer



SCR



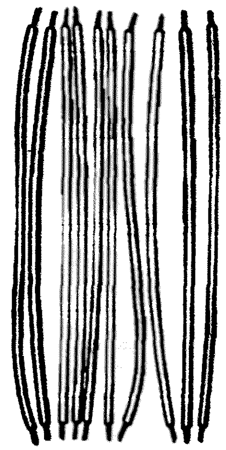
Diode IN4003

LED

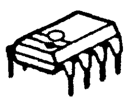
Photocell

Battery Snap

Wires

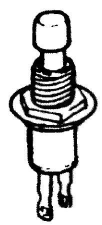


IC555

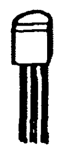


LED

Pushbutton



Transistor 2N3906



Transistor 2N3904

LESSON 1
Basic Electronic Theory

MATTER
Everything you see around you is made of "matter". The desk, pen, paper, water, etc., even yourself!. **Matter is something that has mass and takes up space.** It can be found in three states: SOLID, LIQUID, and GAS. At this point you might ask, what is matter made of?

Answer: ELEMENTS
Matter is made up of elements, which are substances found naturally in the universe, such as carbon, oxygen, silver, gold, etc. There are approximately 104 different known elements in the universe. These elements when chemically mixed together in specific combinations make-up...EVERYTHING. Now, the next question, what are the elements made of?

Answer: ATOMS

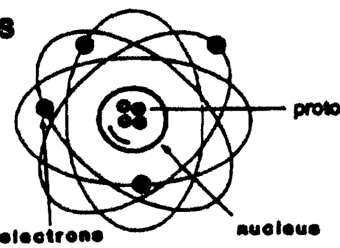


Fig. 1

Each element is made up of "atoms", as the one shown in fig. 1. Atoms have a central core, called a NUCLEUS, filled with positively (+) charged particles known as PROTONS. Surrounding the nucleus, in several orbits, are negatively (-) charged particles called ELECTRONS. All atoms are arranged in this way, regardless of whether they constitute an element of hydrogen or gold. The only important difference is the number of protons and electrons each atom has. For example, hydrogen has one electron, while gold has thirty-nine.

PENCIL EXERCISE # 1.
Draw an atom and label its parts.

THE ELECTRONS AND THE ELECTRIC CURRENT
Now you can say, "Okay, I understand that everything is made up of atoms, and that atoms are made up of protons inside a nucleus with electrons running around it, but ...what does this have to do with electronics?" By definition, electronics is a part of physics that studies the movement of electrons. Electric current, is the movement of millions of electrons through a conductor (wire).

When you connect a lamp to a battery as shown in fig. 2, the lamp lights up, because electric current circulates through it. What actually happens is: in the negative side of the battery you have millions and millions of electrons in excess and in the positive side of the battery you have a lack of electrons. Therefore, electrons flow from the negative terminal of the battery to the positive terminal, passing through the lamp. This flow of electrons, called "electric current", causes the lamp to light up.

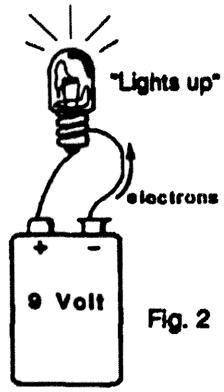


Fig. 2

PENCIL EXERCISE #2

1) In the negative side of the battery, there are millions and millions of ____________.
2) In the positive side of the battery, you have atoms with a ________ of electrons.
3) When you connect a lamp or any other conductive material across the terminals of a battery, electrons will flow from the __________ terminal to the _________ terminal of the battery. This flow is called ___________ current.

Now that you know that electronics is the part of the physics that studies the movement of electrons, and that an electric current is the movement of millions and millions of electrons, from a negative source to a positive source, you are ready to go to Lesson 2, called: The Resistor Color Code.

LESSON 2
Resistor Color Code

RESISTORS, RESISTANCE & OHMS (Ω).

Resistors are one of the most popular and fundamental electronic components. You will always find them in electronic circuits. Resistance is the opposition to the current flow. We often need resistance to control current flow . Each resistor contains a certain amount of resistance. Resistance is measured in ohms(Ω). For example, a resistor of 10,000 ohms would provide much more opposition to a current flow than a resistor of 1000 ohms. So the higher the number of ohms, the higher the resistance, the fewer electrons flow through the resistor.

PENCIL EXERCISE 1.

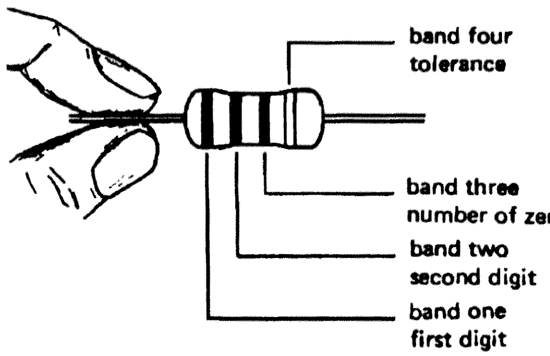
1. Resistance is the _________________to current flow.
2. Each resistor contains a certain amount of_________.
3. Resistance is measured in_________.
4. A resistor of 20,000 ohms will provide_______opposition to the current flow than a resistor of 5,000 ohms.

THE RESISTOR COLOR CODE

The resistor color code is a method of indicating the resistance value in ohms. It is not a secret code designed by sinister cryptographers to confuse and frustrate us. On the contrary, it was made simple and easy to read, so that everyone can learn it in just a few minutes, including you !

WHY THE COLOR CODE

With the color code we use colored bands in order to overcome two basic problems:
ONE: It would be very difficult to print numbers on a small resistor.
TWO: Even if we could print numbers on them, placement of the resistor in the project might make it impossible to see the numbers.
The color coded bands that go entirely around the resistor seem to solve these two problems. When reading the color code, the resistor should be held with the gold (or silver) band on the right, as shown in the next picture.



THIS IS THE RESISTOR COLOR CODE

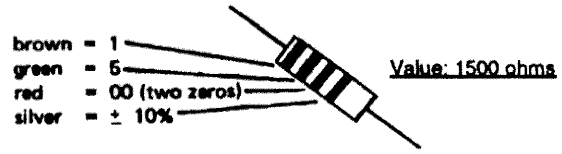
black	0
brown	1
red	2
orange	3
yellow	4
green	5
blue	6
violet	7
gray	8
white	9

Each color stands for a particular number. For example, red equals two. When reading the color code remember:
-The FIRST BAND always represents A NUMBER.
-The SECOND BAND always represents A NUMBER.
-The THIRD BAND always represents the NUMBER OF ZEROS to be added to the two preceding numbers. (If the third band is black, no zeros are added).
-The FOURTH BAND represents the TOLERANCE value. This band is usually GOLD, 5%; or SILVER 10%.

Tolerance means the precision or exactness of the value of the resistor. For example, resistors with a gold band have an actual value plus or minus 5% of what the color code indicates, due to differences in manufacturing.

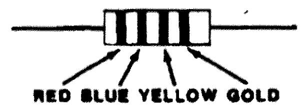
EXAMPLE.

What is the value in ohms, and the tolerance of the following resistor ?

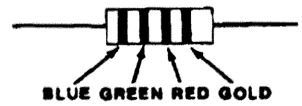


PENCIL EXERCISE 2.

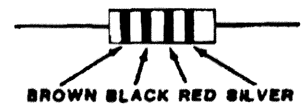
Give the value in ohms and the tolerance, of the following resistors:



Value:__________ +/-____%



Value:__________ +/-____%



Value:__________ +/-____%

ABBREVIATING NUMBERS

Usually the values of resistors are abbreviated by using the letter K to represent 1000 ohms and the letter M to represent 1,000,000 ohms. For example, a 1K resistor is a resistor of 1000 ohms. A 3.3K resistor is a resistor of 3300 ohms. A 2M resistor is a 2,000,000 ohm resistor.

LESSON 3
Using The Solderless Circuit Board

The Solderless Circuit Board is a device that allows you to assemble electronic circuits without the use of solder. It makes for quick and easy construction and is thus ideal for experimentation. A Solderless Circuit Board comes supplied in this Lab Kit A0. Lay the board in front of you, as shown in fig. 1.

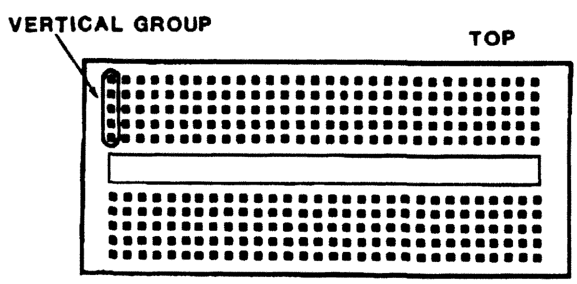


FIG. 1

Notice that there are many tiny holes in each board. Each hole will accept a component lead or wire. ALL FIVE HOLES IN EACH VERTICAL GROUP ARE CONNECTED TOGETHER. Each vertical group is "shorted" together.

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Two or more wires or leads plugged into anyone of the five holes will be connected together. There are 60 groups of five holes.

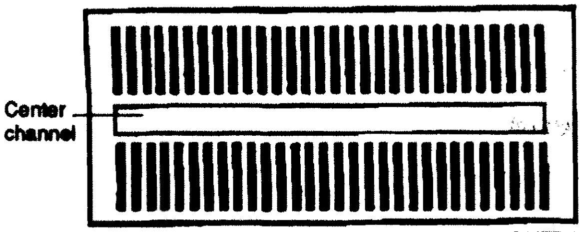

Fig. 2

Under side view of Soldeiress Circuit Board showing metal strips which connect each group of five holes

A center channel divides the board in half. Integrated Circuits can be straddled across this channel as shown in fig. 3. Also note that numbers and letters were printed on the board to help identify each hole during the construction process.

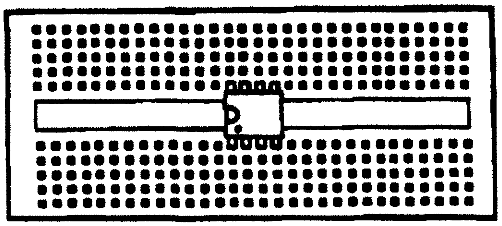

Fig. 3

In order to learn how to use the Solderless Circuit Board do the following experiment. Let us say that we want to build a simple circuit to light up an LED, like the one shown in fig. 4.

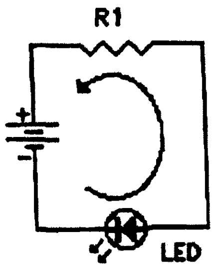

Fig. 4

In this circuit an electric current flows from the negative terminal of the battery to the positive terminal, passing through the LED and the resistor. As current flows through the LED, it illuminates.
One way to build this circuit is by soldering the leads of the components to one another, as shown in figure 5.

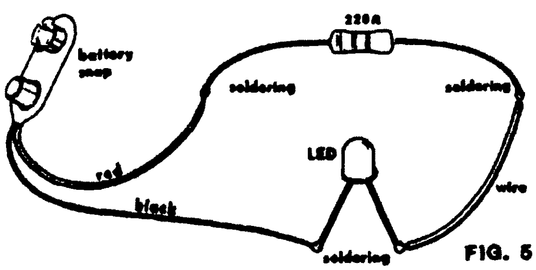

FIG. 5

Or, the same circuit can be constructed, easily and neatly, by using a solderless circuit board, as shown in fig. 6.

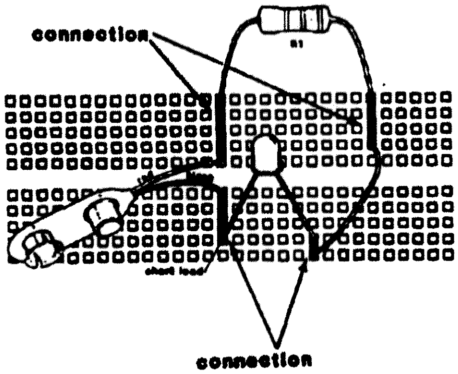

Fig. 6

In this case, the leads of the components are connected to one another by the metal strips of the solderless circuit board, as shown in fig. 6. REMEMBER, WIRES THAT MUST BE CONNECTED TOGETHER MUST BE INSERTED INTO HOLES OF THE SAME VERTICAL COLUMN.
Now, using the solderless circuit board and the parts, build the circuit of fig. 6.
Take special care while installing the LED to put the short lead in the right direction. Once you have the circuit assembled, connect a battery to the battery snap and the LED should light up. Now, make a little change in the circuit. Pull out the red wire of the battery snap from its original position and insert it in the hole shown in figure 7.

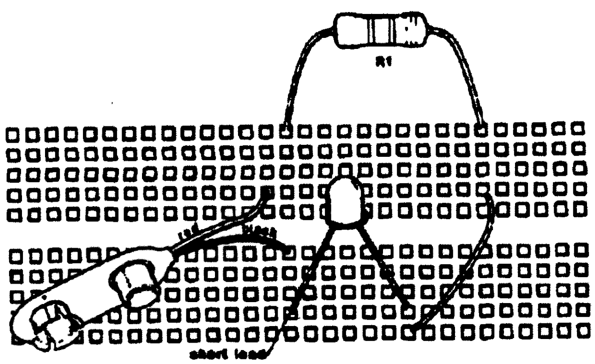

Fig. 7

What happened to the LED when you made that change?______________________________

Explain why. ____________________________________

____

____

The LED went out because in the circuit shown in fig. 7 there is no connection between the red wire of the battery snap and resistor R1.
Therefore, again, always remember, "WIRES THAT NEED TO BE CONNECTED TOGETHER MUST BE INSERTED INTO THE SAME VERTICAL COLUMN OF HOLES".
NOTE: Never connect the LED directly to the battery. It will destroy the LED
Now you are ready to work on more Lab Kits.

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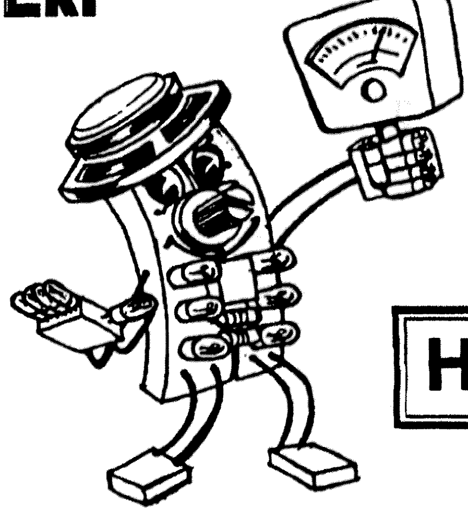


Mr. CIRCUIT®

Solderless Electronic Kit

HOW A RESISTOR WORKS

LAB KIT A1

*** * * START HERE * * ***

(A) PURPOSE OF THIS EXPERIMENT:

In this experiment you will build a simple device that will allow you to observe the effect of a resistor controlling a current flow. You will observe how the value of the resistor in the circuit affects the brightness of the LED.

(B) THEORY OF THIS CIRCUIT

In this experiment we introduce two components, the resistor and the LED.

A **resistor** limits the amount of current flowing through a circuit by presenting **opposition or resistance to the current flow.** Just like a funnel, where much water can be poured into it, and only a set, small, amount of water comes out, a resistor limit the amount of electrons that can flow out of it.

Appearance	Schematic Symbol	Draw Schematic Symbol
		

An **LED** (light-emitting diode) is a special kind of diode that emits **light when current flows through it.** It has two terminals called cathode (C) and anode (A). The cathode is indicated by a flat side on the case of the LED or by a shorter lead.

Appearance	Schematic Symbol	Draw Schematic Symbol
		

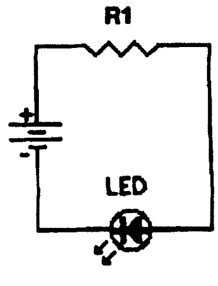
This project is made up of three components: the battery, the LED, and the resistor, which are connected in series, one following the other (*see schematic diagram*).

In this circuit the current flows from the negative terminal of the battery to the positive terminal of the battery, passing through the LED and the resistor.
As current passes through the LED, it lights-up. The more current, the more light.

The element that controls the amount of current flowing through the circuit is the resistor. The smaller the resistance value, the smaller the opposition to the current flow and therefore, the higher the current. The higher the current, the brighter the LED.
On the other hand, the higher the resistance value, the greater the opposition to the current flow and the lower the current. The lower the current, the dimmer the LED.

Now you should understand why, as you insert in the circuit progressively higher values of resistance, the brightness of the LED decreases. The higher the resistance, the lower the amount of current that flows through the circuit, and therefore, the lower the brightness of the LED

SCHEMATIC DIAGRAM & PARTS LIST



	Part #
- Battery Snap	SL35001
- LED (Light Emitting Diode)	SL06001
- R1:	
- 100 ohms (Brown, Black, Brown, Gold)	SL01041
- 220 ohms (Red, Red, Brown, Gold)	SL01049
-1K ohm (Brown, Black, Red, Gold)	SL01065
- 6.8K ohm (Blue, Gray, Red, Gold)	SL01085

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Mr. Circuit Solderless Electronic Kit

(C) Step-By-Step Assembly Instructions

HOW A RESISTOR WORKS / LAB KIT A1

GET THE SOLDERLESS CIRCUIT BOARD AND BUILD THE PROJECT ALWAYS COMPARING YOUR WORK WITH THE ASSEMBLY DIAGRAM.

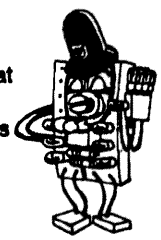
( ) **STEP 1.**
Find the Battery Snap. Insert the red wire into hole 15f and the black wire into hole 17e.

( ) **STEP 2.**
Find R1, the 100 ohm resistor (Brown, Black, Brown, Gold). Insert one lead into hole 15j and the other into hole 25j.

( ) **STEP 3.**
Find the red LED (light emitting diode). Insert its short lead into hole 17b and its long lead into hole 18b.

( ) **STEP 4.**
Get one wire. Insert one side into hole 25g and the other side into hole 18a.

( ) **STEP 5.**
STOP! Before you test your project verify it against the Assembly Diagram to be sure that all the components are installed in the right place. Also be sure there are no short circuits on the board (wires or leads touching each other). To operate the project follow the directions in the Section D " Operating Instructions."



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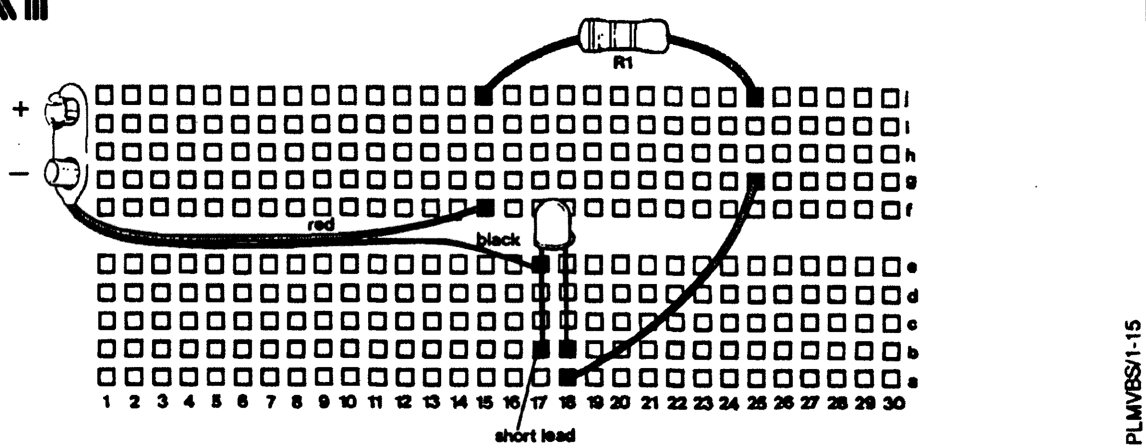
ASSEMBLY DIAGRAM



(D) OPERATING INSTRUCTIONS

1- Now that you have this project assembled connect a fresh 9 volt battery to the battery snap. As you do this the LED will turn ON. Notice the brightness of the LED.

2- Replace resistor R1 (100 ohm) with resistors of larger value and observe how this affects the brightness of the LED. Therefore, remove the 100 ohm resistor from the board. The LED will turn OFF.
Install, one at a time, the following resistors in the place of R1 (leads to holes 15j and 25j), and observe in each case the brightness of the LED.
- 220 ohm (Red, Red, Brown, Gold).
- 1K ohm (Brown, Black, Red, Gold)
- 6.8K ohm (Blue, Gray, Red, Gold).

(E) RESULTS & OBSERVATIONS

By performing this experiment you should have found that the brightness of the LED depends upon the value of the resistor in the circuit. The higher the resistance value, the lesser the brightness of the LED.

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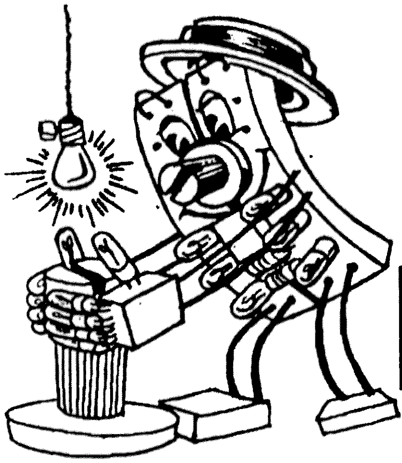

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Solderless Electronic Kit

HOW A POTENTIOMETER WORKS

LAB KIT A2

*** * * START HERE * * ***

(A) PURPOSE OF THIS EXPERIMENT.

The purpose of this experiment is to observe how a potentiometer works as a variable resistor.

(B) THEORY OF THIS CIRCUIT

In this experiment we introduce the potentiometer which is a variable resistor. So with the potentiometer you can vary the amount of electrons that flow through a circuit by twisting the control shaft.

Appearance — Schematic Symbol — Draw Schematic Symbol

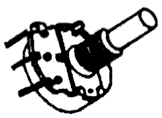


Fig. 1A shows the schematic symbol of a potentiometer. It has three leads labeled A, B and C. C is the cursor that moves between A and B.

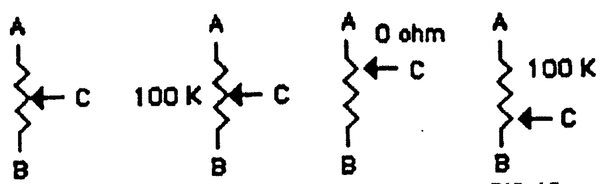
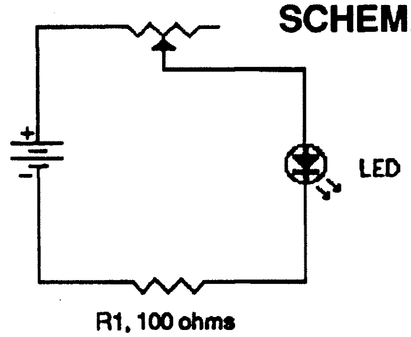


FIG 1A FIG 1B FIG 1C FIG 1D

If the value of the potentiometer is, for example, 100K ohm, between A and B there will be a resistance of 100K ohm (Fig. 1B). The resistance between A and C depends upon the position of the cursor. If the cursor is touching the end A, the resistance will be zero (Fig. 1C). If the cursor is touching the end B, the resistance between A and C will be 100K ohm (Fig. 1D). If the cursor is in any position between A and B, the value of the resistance between A and C will be somewhere between 0 and 100K ohm.

Now, observe the schematic diagram of this project. The current flows from the negative terminal of the battery to the positive terminal of the battery, passing through resistor R1, the LED, and the potentiometer. As you adjust the potentiometer from one end to the other, the resistance changes, producing a change in the amount of current flowing through the circuit. This change in the amount of the current is observed by the change in the brightness of the LED.
NOTE: The 100 ohm resistor (R1), is placed in the circuit to limit the current, so the LED does not burn out when the potentiometer is at its minimum value of resistance (zero ohms).

SCHEMATIC DIAGRAM & PARTS LIST



	Part #
- Battery Snap	SL35001
- LED (Light Emitting Diode)	SL06001
- R1: 100 ohms (Brown, Black, Black, Gold)	SL01041
- R2: 100K ohm Potentiometer	SL33008

PLMV8F/2-15

Mr. Circuit Solderless Electronic Kit

(C) Step-By-Step Assembly Instructions

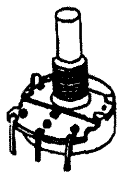
HOW A POTENTIOMETER WORKS / LAB KIT A2

GET THE SOLDERLESS CIRCUIT BOARD AND BUILD THE PROJECT ALWAYS COMPARING YOUR WORK WITH THE ASSEMBLY DIAGRAM.

( ) **STEP 1.**
Find the Battery Snap. Insert the red wire into hole 13f and the black wire into hole 13e.

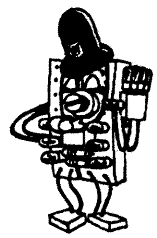
( ) **STEP 2.**
Find R1, the 100 ohms resistor (Brown, Black, Brown, Gold). Insert one lead into hole 13a and the other into hole 24a.

( ) **STEP 3.**
Find the potentiometer. Insert the wire connected to the left lead to hole 13h and the wire connected to the center lead to hole 24i.

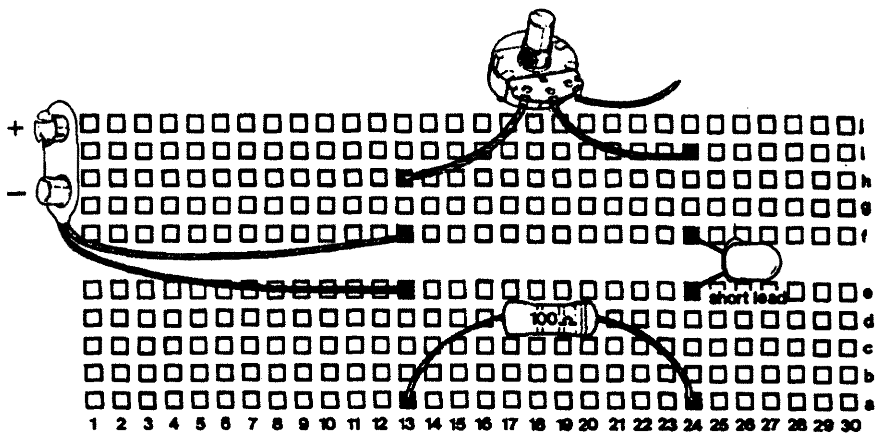


( ) **STEP 4.**
Find the LED (light emitting diode). Insert its long lead into hole 24f and its short lead into hole 24e.

( ) **STEP 5**
STOP! Before you test your project verify it against the Assembly Diagram to be sure that all the components are installed in the right place. Also be sure there are no short circuits on the board (wires or leads touching each other). To operate the project follow the directions in the section called " Operating Instructions."



ASSEMBLY DIAGRAM



(D) OPERATING INSTRUCTIONS

1- Now that you have this project assembled, connect a fresh 9 volt battery to the battery snap.

2- Twist the shaft of the potentiometer from one end to the other observing the brightness of the LED.
You will notice that by twisting the shaft of the potentiometer from one end to the other you can control the brightness of the LED.

(E) RESULTS & OBSERVATIONS

By performing this experiment you should have found that the brightness of the LED depends upon the position of the shaft of the potentiometer. Also you should have learned that by twisting the shaft of the potentiometer you change its internal resistance. Potentiometers are used for volume control and other knobs on TV's, radios, etc.

PLMVBS/1-15

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HOW A PHOTOCELL WORKS

LAB KIT A3

* * * START HERE * * *

(A) PURPOSE OF THIS EXPERIMENT.

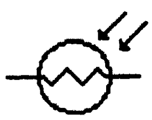
The purpose of this experiment is to observe how a photocell works as a light sensitive resistor.

(B) THEORY OF THIS CIRCUIT

In this experiment we introduce the photocell, which is a special kind of resistor that varies its internal resistance according to the intensity of the light that hits its surface. So the more light you shine on a photocell, the lower the resistance it will have, and the more electrons it will allow to pass through it.

Appearance

Schematic Symbol



Draw Schematic Symbol

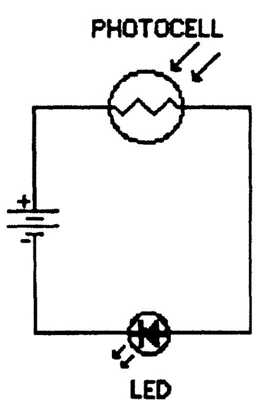
The circuit of this experiment is made up of three components: the battery, the LED, and the photocell, which are connected in series, one following the other.
In this circuit, the current flows from the negative terminal of the battery to the positive terminal of the battery, passing through the LED and the photocell (see the schematic).

As current passes through the LED it illuminates. The more the current, the greater the brightness.
The element that controls the amount of current flowing through the circuit is the photocell.
The photocell is a light sensitive resistor that changes its resistance according to the light that hits its surface.

The more light hitting its surface, the lower its internal resistance. The less light hitting its surface, the greater its resistance.
Therefore, the greater the light hitting the surface of the photocell, the smaller its resistance and therefore, the greater the current in the circuit and the brighter the LED.
On the other hand, the less light hitting the photocell, the higher its resistance and, therefore, the smaller the current in the circuit and the dimmer the LED.

Now you understand why, as you shadow the surface of the photocell, the brightness of the LED decreases, and as you illuminate the surface of the photocell the brightness of the LED increases.

SCHEMATIC DIAGRAM & PARTS LIST



	Part #
- Battery Snap	SL35001
- LED (Light Emitting Diode)	SL06001
- Photocell	SL45028

 PLMVBF/2-15

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(C) Step-By-Step Assembly Instructions

HOW A PHOTOCELL WORKS / LAB KIT A3

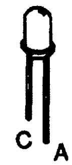
GET THE SOLDERLESS CIRCUIT BOARD AND BUILD THE PROJECT ALWAYS COMPARING YOUR WORK WITH THE ASSEMBLY DIAGRAM.

( ) **STEP 1.**
Find the Battery Snap. Insert the red wire into hole 18f and the black wire into hole 18e.

( ) **STEP 2.**
Find the photocell. Connect its leads to holes 18g and 19g.

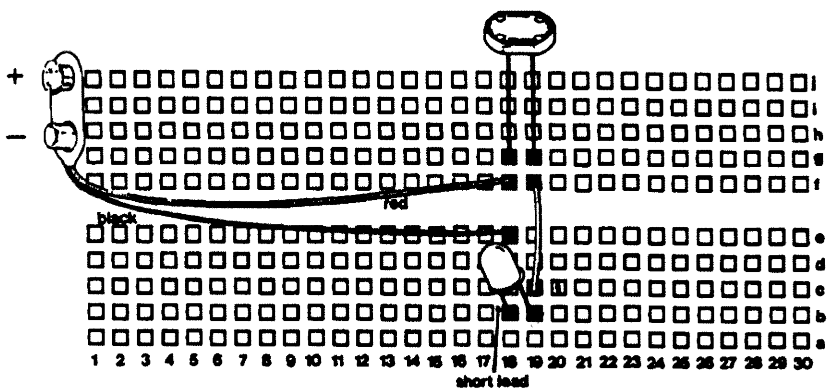
( ) **STEP 3.**
Find one wire. Connect one side of the wire to hole 19f and the other side to hole 19c.

( ) **STEP 4.**
Find the LED (light emitting diode). Insert its long lead into hole 19b and its short lead into hole 18b.



( ) **STEP 5.**
STOP! Before you test your project verify it against the Assembly Diagram to be sure that all the *components are installed in the right* place. Also be sure there are no short circuits on the board (wires or leads touching each other). To operate the project follow the directions in the section called "Operating Instructions."

ASSEMBLY DIAGRAM



(D) OPERATING INSTRUCTIONS

1- Now that you have this project assembled, connect a fresh 9 volt battery to the battery snap.

2- Using your hand, partially cover the surface of the photocell to vary the intensity of the light striking the photocell. Observe how this affects the brightness of the LED. When your hand is covering the photocell, the LED is dimmer. When the photocell is not covered the LED is brighter.

(E) RESULTS & OBSERVATIONS

By performing this experiment you should have found that the brightness of the LED depends upon the intensity of light striking the photocell. Because, as you have observed, the value of the internal resistance of the photocell depends upon the intensity of light striking its surface.

PLMVBS/1-15

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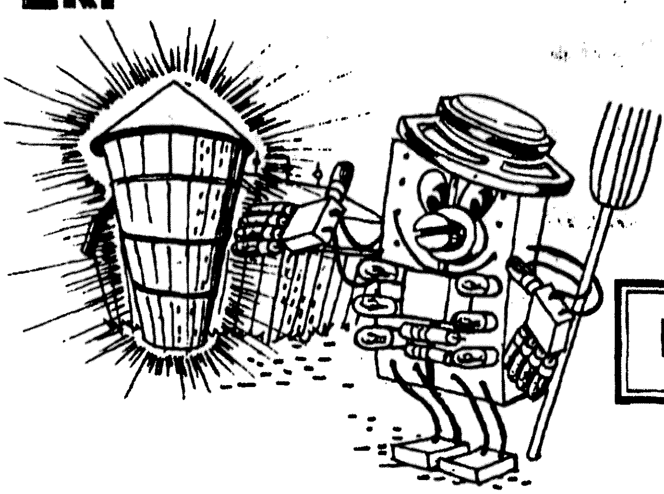

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HOW A CAPACITOR WORKS

LAB KIT A4

* * * START HERE * * *

(A) PURPOSE OF THIS EXPERIMENT.

The purpose of this experiment is to observe the effect of a capacitor storing electrical energy.

(B) THEORY OF THIS CIRCUIT

A capacitor acts as a temporary battery by storing electricity. In this experiment we use an electrolytic capacitor that can store a relatively large amount of electricity. Electrolytic capacitors have polarity, which means that they have a positive and negative terminal and therefore care must be taken when connecting them to a circuit. They must be installed in the right direction.

Appearance | Schematic Symbol | Draw Schematic Symbol

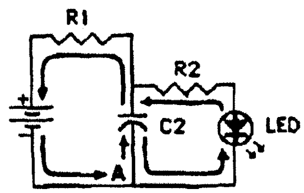


FIG 1

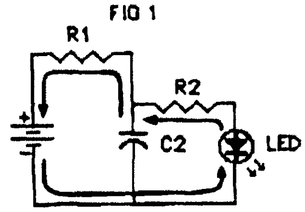


FIG 2

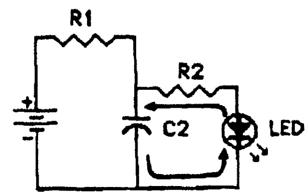
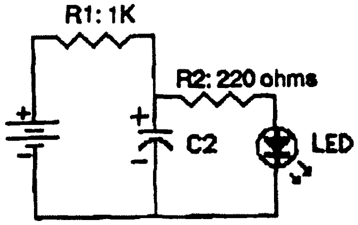


FIG 3

Figure 1 shows the circuit of this experiment and the flow of current when the battery is first connected. The current goes from the negative terminal of the battery to point A, where it divides. A part of it goes through the LED and R2, causing the LED to turn on, and the other part goes through capacitor C2, which starts to charge. Once C2 is charged, current stops flowing to it. Then, the current path in the circuit is the one shown in Figure 2. The current passing through the LED causes it to illuminate.

When the battery is disconnected, the electrical energy stored in the capacitor flows as shown in Figure 3. It keeps the LED illuminated until the capacitor completely discharges.
Now you can understand why, when the battery is disconnected, the LED remains illuminated for a while.

SCHEMATIC DIAGRAM & PARTS LIST



	Part #
- Battery Snap	SL35001
- LED (Light Emitting Diode)	SL06001
- R1: 1K ohm resistor	SL01065
- R2: 220 ohm resistor	SL01049
- C21000 µF capacitor	SL05009

 PLMVBF/2-15

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(C) Step-By-Step Assembly Instructions

HOW A CAPACITOR WORKS / LAB KIT A4

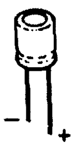
GET THE SOLDERLESS CIRCUIT BOARD AND BUILD THE PROJECT ALWAYS COMPARING YOUR WORK WITH THE ASSEMBLY DIAGRAM.

( ) STEP 1.
Find the Battery Snap. Insert the red wire into hole 9g and the black wire into hole 9d.

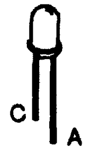
( ) STEP 2.
Find the 220 ohm resistor (Red, Red, Brown, Gold). Insert one lead into hole 9h and the other into hole 16h.

( ) STEP 3.
Find the 1K ohm resistor (Brown, Black, Red, Gold). Insert one lead into hole 16g and the other into hole 27g.

( ) STEP 4.
Find the 100 µF capacitor. Insert its positive lead (long lead) into hole 16f and its negative lead into hole 16e.



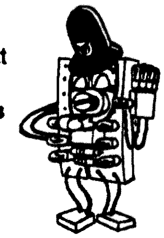
( ) STEP 5.
Find the LED (light emitting diode). Insert its long lead into hole 27f and its short lead into hole 27e.



( ) STEP 6.
Get two wires. Install the first wire from hole 27a to hole 16b. The second wire from hole 16a to hole 9b.

( ) STEP 7.

STOP! Before you test your project verify it against the Assembly Diagram to be sure that all the components are installed in the right place. Also be sure there are no short circuits on the board (wires or leads touching each other). To operate the project follow the directions in the section called " Operating Instructions."



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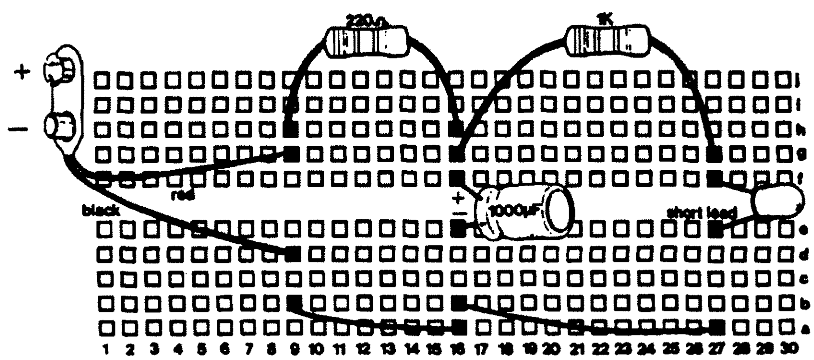
ASSEMBLY DIAGRAM



(D) OPERATING INSTRUCTIONS

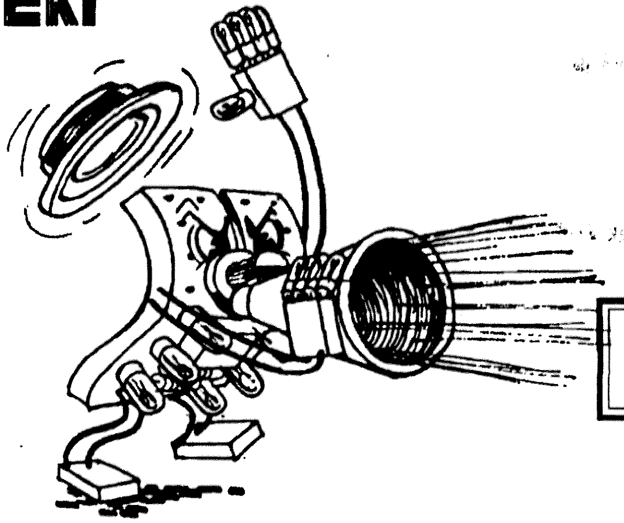
1- Now that you have this project built, connect a fresh 9 volt battery to the battery snap. The LED will turn ON.

2- Disconnect the battery from the battery snap and observe how the LED remains ON for a few seconds after the battery was disconnected. This occurs because the electricity stored in the capacitor maintains the flow of electrons to the LED for a few seconds after the battery is disconnected.

(E) RESULTS & OBSERVATIONS

By performing this experiment you found that after disconnecting the battery from the circuit, the LED continues to be illuminated for a while. The light decreases until it completely turns off.
After the battery was disconnected from the circuit, the LED received the electricity from the capacitor.

PLMVBS/1-15



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HOW A SPEAKER WORKS

LAB KIT A5

*** START HERE ***

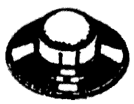
(A) PURPOSE OF THIS EXPERIMENT.

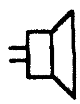
The purpose of this experiment is to observe how a speaker transforms electrical energy (current flowing through it) into sound waves.

(B) THEORY OF THIS CIRCUIT

In this experiment we introduce the speaker. Speakers are devices that produce sound waves from the electric current that flows through them.

Appearance — Schematic Symbol — Draw Schematic Symbol





A speaker is an electromechanical device that produces movement of its cone when current is flowing through it. If the current flows in one direction through the speaker, the cone moves in a certain direction. If the current flows in the opposite direction, the cone moves in the opposite direction. See Figure 1a and 1b.

As the cone of the speaker moves, it generates sound waves. The sound waves generated by the speaker are proportional to the variations of the current that flows through it.

Figure 1a, shows the current flowing in one direction through the speaker, causing the cone of the speaker to move inwards. Figure 1b, shows the current flowing through the speaker in the opposite direction, causing the cone to move outwards.

When an alternating current, generated by a microphone, oscillator or phone cartridge, is amplified and then sent to the speaker, it will cause the cone to follow the variations of that current producing sound waves (words or music).

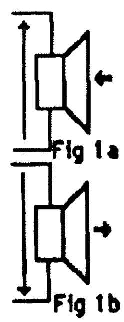
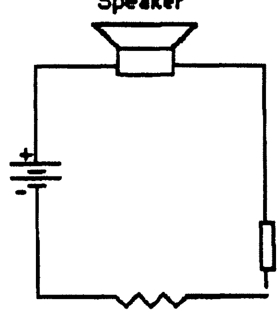


Fig 1a

Fig 1b

SCHEMATIC DIAGRAM & PARTS LIST



	Part #
- Battery Snap	SL35001
- R1: 10 ohm resistor	SL01017
- Speaker (8 ohm)	SL27001

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(C) Step-By-Step Assembly Instructions

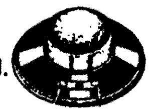
HOW A SPEAKER WORKS / LAB KIT A5

GET THE SOLDERLESS CIRCUIT BOARD AND BUILD THE PROJECT ALWAYS COMPARING YOUR WORK WITH THE ASSEMBLY DIAGRAM.

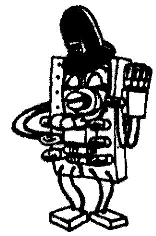
( ) **STEP 1.**
Find the Battery Snap. Insert the red wire into hole 14f and the black wire into hole 14e.

( ) **STEP 2.**
Find the 10 ohm resistor (Brown, Black, Black, Gold). Insert one lead into hole 14d and the other into hole 24d.

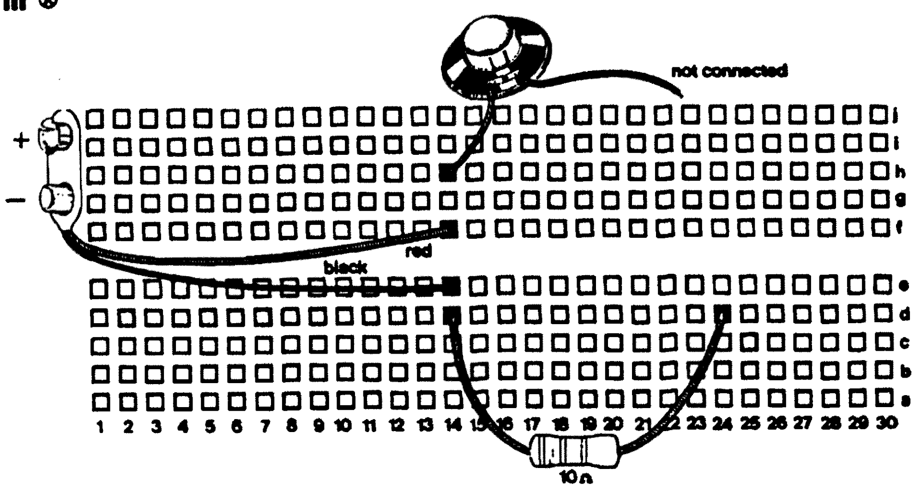
( ) **STEP 3.**
Find the speaker. Connect one of its wires into hole 14h and leave the other wire disconnected.



( ) **STEP 4.**
STOP! Before you test your project verify it against the Assembly Diagram to be sure that all the components are installed in the right place. Also be sure there are no short circuits on the board (wires or leads touching each other). To operate the project follow the directions in the section called " Operating Instructions."



ASSEMBLY DIAGRAM



(D) OPERATING INSTRUCTIONS

1- Now that you have this project assembled connect a fresh 9 volt battery to the battery snap.

2- Touch the unconnected speaker wire to the lead of the resistor connected to hole 24d. As you do this, hear the sound and observe the direction of the movement of the speaker cone. Repeat this step if necessary.

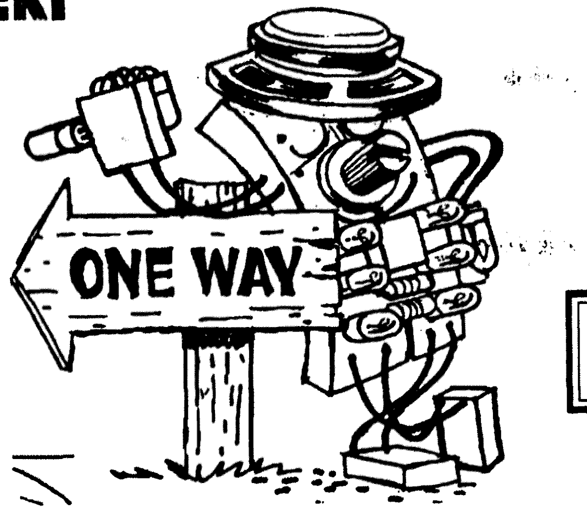
3- Reverse the polarity of the battery wires connected to the board (connect the red wire in the place of the black wire and the black wire in the place of the red wire).

Again, hear the sound and observe the movement of the speaker cone. It should move in the opposite direction from before.

(E) RESULTS & OBSERVATIONS.

By performing this experiment you have learned the following:
A) Every time you touch the speaker wire to the resistor the cone moves and produces a sound.
B) At Step 2 of the Operating Instructions the cone moves from the normal position away from the magnet.
C) At Step 3 of the Operating Instructions the cone moves from the normal position toward the magnet. These alternating movements of the speaker cone, when faster pulses of electricity are sent to the speaker, produce sound waves.

PLMVBS/1-15



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HOW A DIODE WORKS

LAB KIT A6

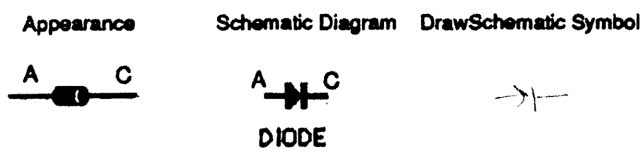
*** START HERE ***

(A) PURPOSE OF THIS EXPERIMENT.

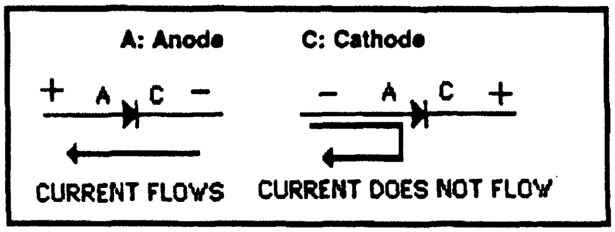
The purpose of this experiment is to observe how a diode allows current to flow through it in one direction only.

(B) THEORY OF THIS CIRCUIT

A diode is a device that allows current to flow through it in one direction only. You can compare the diode to a "one way street" for electrons.
Diodes have two leads, one is the anode and the other is the cathode. The cathode is indicated by a band around the body of the diode.

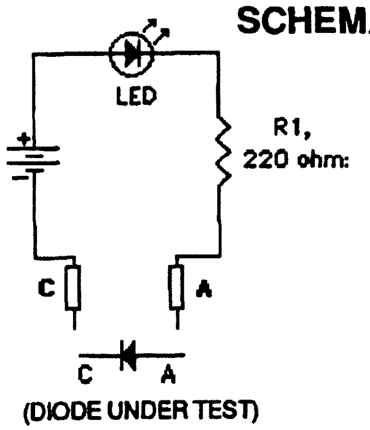


A diode is a one-way gate. It allows current to flow through it only when its anode is positive and its cathode is negative, as shown in the next picture.



When the diode is connected in the circuit of this experiment with its anode on point A (positive point) and its cathode on point C (negative point), it allows current to flow through it, and therefore, the LED turns on.
On the other hand, when the diode is connected in the circuit of this experiment with its cathode on point A and its anode on point C, current will not flow through the diode and the LED will remain off.
Now you can understand why in this circuit, the LED turns on when the diode is connected in one direction and remains off when it is connected in the other.

SCHEMATIC DIAGRAM & PARTS LIST



	Part #
- Battery Snap	SL35001
- R1: 220 ohm resistor	SL01049
- LED	SL06001
- Diode	SL30001

PLMVBF/2-16

Mr. Circuit Solderless Electronic Kit

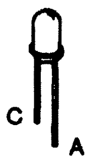
(C) Step-By-Step Assembly Instructions

HOW A DIODE WORKS / LAB KIT A6

GET THE SOLDERLESS CIRCUIT BOARD AND BUILD THE PROJECT ALWAYS COMPARING YOUR WORK TO THE ASSEMBLY DIAGRAM.

( ) **STEP 1.**
Find the Battery Snap. Insert the red wire into hole 17f and the black wire into hole 15e.

( ) **STEP 2.**
Find the LED (light emitting diode). Insert its long lead into hole 17g and its short lead into hole 18g.



( ) **STEP 3.**
Find the 220 ohm resistor Red, Red, Brown, Gold). Insert one lead into hole 18f and the other into hole 20c.

( ) **STEP 4.**
Find the diode. Notice that it has a band on one side of its body. Insert the lead on the side of the band into hole 15b and the other lead into hole 20b.

( ) **STEP 5.**
STOP! Before you test your project verify it against the Assembly Diagram to be sure that all the components are installed in the right place. Also be sure there are no short circuits on the board (wires or leads touching each other). To operate the project follow the directions in the section called " Operating Instructions."

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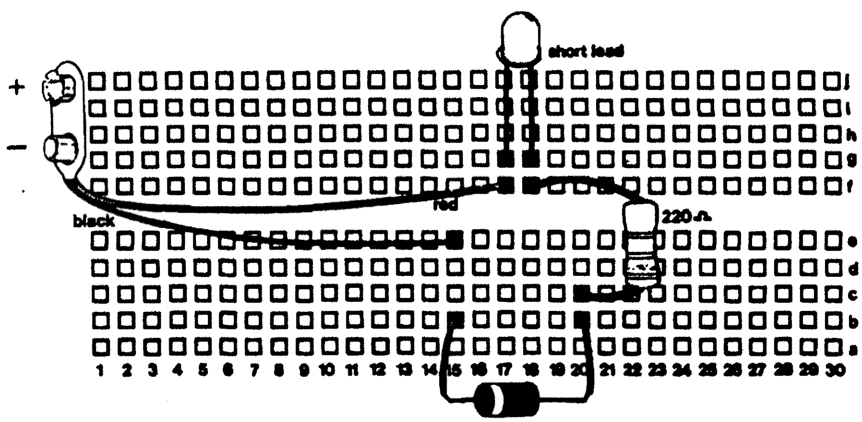
ASSEMBLY DIAGRAM

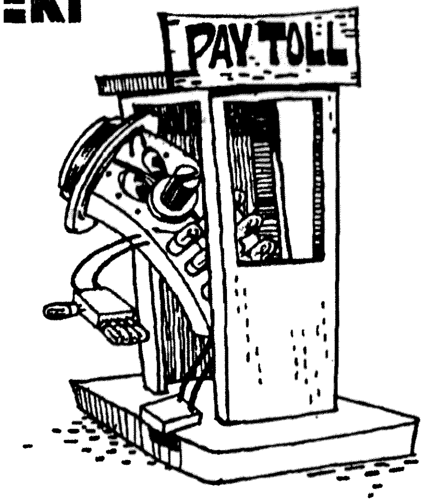


(D) OPERATING INSTRUCTIONS

1- Now that you have this project assembled, connect a fresh 9 volt battery to the battery snap. As you do this the LED will turn ON.
2- Remove the diode from the circuit, the LED will turn OFF.
3- Connect the diode in opposite direction as it was before. This means, the lead on the side of the band to hole 20b and the other lead to hole 15b. The LED will remain OFF even with the diode connected in the circuit.
4- Remove the diode and install it again in its original position, as shown in the Assembly Diagram. The LED will turn ON.

(E) RESULTS & OBSERVATIONS

By performing this experiment you have found that the diode works as a " one way gate " in that that it allows current to flow through it in one direction only. Also, if Steps 1 through 4 of this procedure can be completed successfully, you can conclude that the diode being tested is OK.



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HOW AN SCR WORKS

LAB KIT A7

*** * * START HERE * * ***

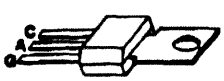
(A) PURPOSE OF THIS EXPERIMENT.

The purpose of this experiment is to observe how an SCR works and to build a useful SCR checker.

(B) THEORY OF THIS CIRCUIT

The SCR is a device that allows current to flow through it only after a momentary positive voltage is applied to its gate.
SCR's have three leads which are called: anode, cathode and gate.

Appearance | Schematic Symbol | Draw Schematic Symbol

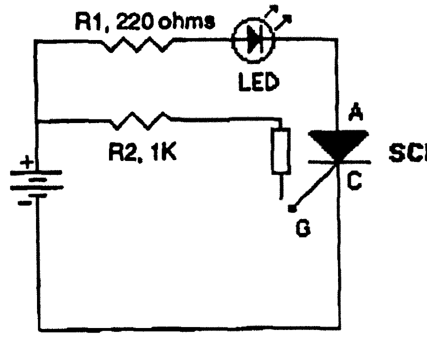


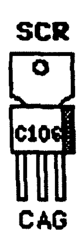
An SCR is a "diode with a difference". Like a diode, it has a cathode and anode, and allows current to flow through it in one direction only. Yet unlike an ordinary diode, it has a gate electrode as well. The gate is used to "trigger" the SCR into conduction.

Only when the gate receives a positive voltage will the SCR conducts. Even if the positive voltage is then remove from the gate, the SCR will continue to conduct. The only way to turn off the SCR is to remove the positive voltage from its anode by, for example, disconnecting the battery.

In this experiment by touching the gate of the SCR with a wire, you apply a positive voltage to it, and, therefore, the SCR starts to conduct causing current to flow from the negative terminal of the battery to the positive terminal, passing through the SCR, LED, and the resistor.
When the battery is disconnected, current stops flowing and the SCR turns off. When the battery is reconnected, the SCR will be off until a positive voltage is again applied to its gate.

SCHEMATIC DIAGRAM & PARTS LIST





	Part #
- Battery Snap	SL35001
- R1: 220 ohm resistor	SL01049
- R2: 1K ohm	SL01065
- LED	SL06001
- SCR	SL13001

Mr. Circuit Solderless Electronic Kit

(C) Step-By-Step Assembly Instructions

HOW AN SCR WORKS / LAB KIT A7

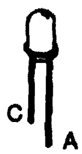
GET THE SOLDERLESS CIRCUIT BOARD AND BUILD THE PROJECT ALWAYS COMPARING YOUR WORK TO THE ASSEMBLY DIAGRAM.

( ) **STEP 1.**
Find the Battery Snap. Insert the red wire into hole 11f and the black wire into hole 11e.

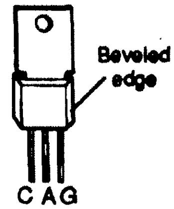
( ) **STEP 2.**
Find the 220 ohm resistor (Red, Red, Brown, Gold). Insert one lead into hole 11j and the other into hole 22j.

( ) **STEP 3.**
Find the 1K ohm resistor (Brown, Black, Red, Gold). Insert one lead into hole 11g and the other into hole 20g.

( ) **STEP 4.**
Find the LED (light emitting diode). Insert its long lead into hole 22h and its short lead into hole 23h.

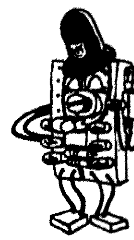


( ) **STEP 5.**
Find the SCR (silicon controlled rectifier). Insert its three leads into holes 25e, 26e and 27e, with the lead on the side of the beveled edge going to hole 27e.



( ) **STEP 6.**
Get three wires. Install the first wire from hole 11d to hole 25a, the second wire from hole 23f to hole 26d. Connect only one side of the third wire to hole 20f.

( ) **STEP 7.**
STOP! Before you test your project verify it against the Assembly Diagram to be sure that all the components are installed in the right place. Also be sure there are no short circuits on the board (wires or leads touching each other). To operate the project follow the directions in the section called " Operating Instructions."



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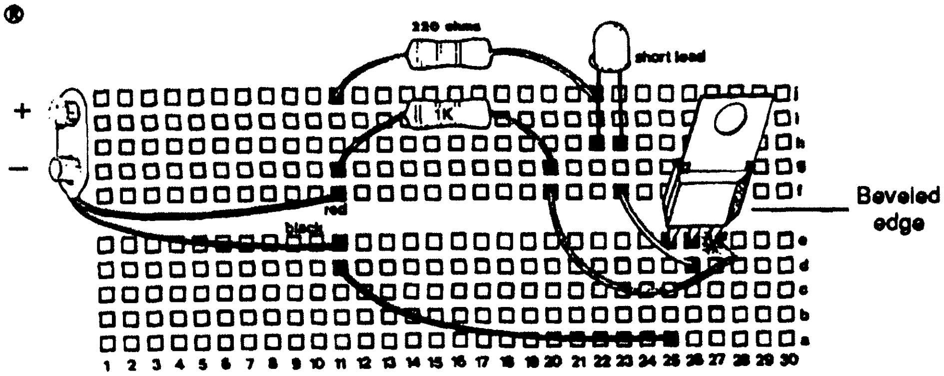
ASSEMBLY DIAGRAM



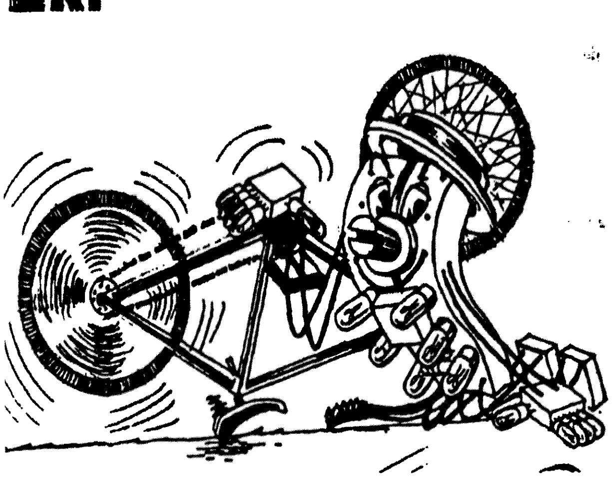
(D) OPERATING INSTRUCTIONS

1- Now that you have this project assembled, connect a fresh 9 volt battery to the battery snap.
2- Briefly touch, the unconnected end of the wire connected to the 1K ohm resistor, to the lead of the SCR connected to hole 27e (gate of the SCR), as shown in the assembly diagram. As you do this, the LED will turn ON and remain ON, indicating that current is flowing through the circuit.
3- Disconnect the battery briefly and connect it again. The LED will turn OFF when the battery is disconnected and remain OFF after it is reconnected. The only way to turn the LED ON again is by touching the wire to the gate of the SCR (hole 27e).

(E) RESULTS & OBSERVATIONS

By performing this experiment you have found that the SCR conducts current (LED ON) when a positive voltage is applied to its gate. Also, you found that the SCR continues conducting even if the positive voltage has been removed from its gate. You also learned that the only way to turn the SCR OFF is by removing the positive voltage from it by disconnecting the battery. Also, if steps 1 to 3 of this procedure can be completed successfully, you can conclude that the SCR is OK.

PLMVBS/1-15



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Solderless Electronic Kit

HOW AN NPN TRANSISTOR WORKS

LAB KIT A8

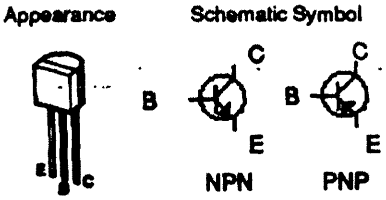
* * * START HERE * * *

(A) PURPOSE OF THIS EXPERIMENT.

To observe how a NPN Transistor works as a current amplifier and to build a useful NPN Transistor Checker.

(B) THEORY OF THIS CIRCUIT

The transistor is a component used to amplify electricity. It has three terminals: Emitter, Base and Collector.
According to how transistors are manufactured they become NPN or PNP type. Observe the difference in the schematic symbol between these two types.



When the collector of an NPN transistor is positive, the emitter negative, and the base slightly positive, the transistor is correctly biased (polarized) and there are two currents flowing through it: the Collector Current (Ic) (flowing in the Emitter and out the Collector), which is a large current, and the Base Current (Ib) (flowing in the Emitter and out the Base), which is a small current, as shown in Figure 1.
The interesting thing about transistors, is that the Base Current (Ib) which is a small current, controls the Collector Current (Ic), which is a large current. The larger the Base Current, the greater the Collector Current.

This important process, of having a small current controlling a large current, is called AMPLIFICATION.
Figure 2 shows the circuit of this experiment. It uses a NPN transistor. Its collector receives a positive voltage from the battery through resistor R2 and LED2. The emitter is connected directly to the negative terminal of the battery and the base receives a positive voltage from the positive terminal of the battery through resistor R1, the pushbutton, and LED1.
The brightness of LED1 is proportional to the Base Current, and the brightness of LED 2 is proportional to the Collector Current.
Performing the experiment, you will find that LED2 (collector LED) is brighter than LED1 (base LED). This means that the Colector Current is larger than the Base Current.
In this experiment you will also find out that if there is no Base Current (pushbutton open) there is no Collector Current. If there is a Base Current (pushbutton pressed), there is a Collector Current. This means that the Base Current, which is a small current, is controlling the Collector Current, which is a large current.

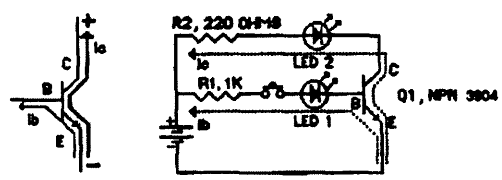
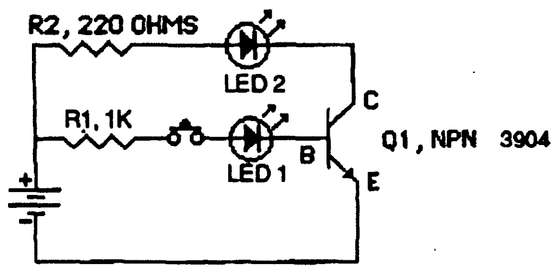


Fig 1 Fig 2

SCHEMATIC DIAGRAM & PARTS LIST



	Part #
- Battery Snap	SL35001
- R1: 220 ohm resistor	SL01049
- R2: 1K ohm	SL01065
- LED1 / LED2	SL06001
- Q1: 2N3904 (NPN)	SL18001
- Pushbutton	SL25004

Mr. Circuit Solderless Electronic Kit

(C) Step-By-Step Assembly Instructions

® HOW AN NPN TRANSISTOR WORKS / LAB KIT A8

GET THE SOLDERLESS CIRCUIT BOARD AND BUILD THE PROJECT ALWAYS COMPARING YOUR WORK TO THE ASSEMBLY DIAGRAM.

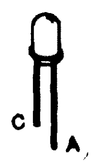
( ) **STEP 1.**
Find the Battery Snap. Insert the red wire into hole 1f and the black wire into hole 1e.

( ) **STEP 2.**
Find the 220 ohm resistor (Red, Red, Brown, Gold). Insert one lead into hole 1j and the other into hole 5j.

( ) **STEP 3.**
Find the 1K ohm resistor (Brown, Black, Red, Gold). Insert one lead into hole 1g and the other into hole 8g.

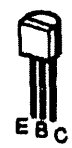
( ) **STEP 4.**
Find the LED (light emitting diode). Insert its long lead into hole 5i and its short lead into hole 7i.

( ) **STEP 5.**
Find another LED. Insert the long lead into hole 14g and the short lead into hole 16g.

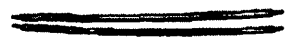


( ) **STEP 6.**
Find the pushbutton. Insert one lead into hole 8f and the other into hole 9f.

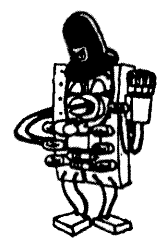
( ) **STEP 7.**
Find the 3904 transistor. Insert the three leads into holes 15i, 16i and 17i. Be sure that the flat side of the transistor is pointing in the direction shown in the assembly diagram.



( ) **STEP 8.**
Get three wires. Install the first wire from hole 7j to hole 17j, the second wire from hole 9h to hole 14h. The third wire from 1a to 15f.

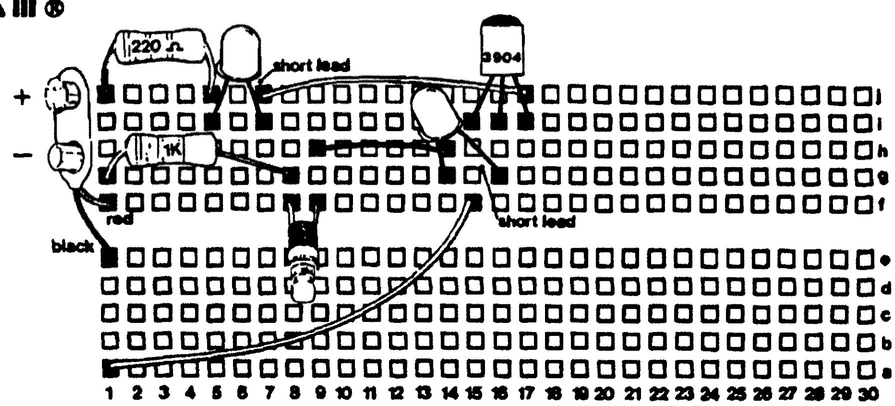


( ) **STEP 9.**
STOP! Before you test your project verify it against the Assembly Diagram to be sure that all the components are installed in the right place. Also be sure there are no short circuits on the board (wires or leads touching each other). To operate the project follow the directions in the section called "Operating Instructions."



EKI®

ASSEMBLY DIAGRAM



(D) OPERATING INSTRUCTIONS / RESULTS & OBSERVATIONS

1- Now that you have your project assembled, connect a fresh 9 volt battery to the battery snap.
2- Press the pushbutton. If both LEDs light-up (one brighter than the other) when the pushbutton is pressed you can assume that the transistor being tested is OK.

If the transistor is defective three things might occur:
- None of the LEDs light-up when the pushbutton is pressed.
- Only one LED lights-up when the pushbutton is pressed.
- One or both LEDs light -up when the pushbutton is not pressed.

 PLMVBS/1-15

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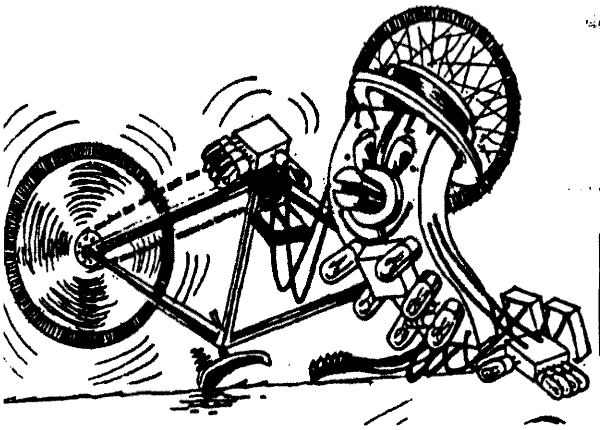

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Solderless Electronic Kit

HOW A PNP TRANSISTOR WORKS

LAB KIT A9

* * * START HERE * * *

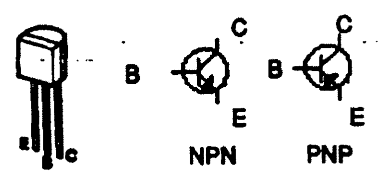
(A) PURPOSE OF THIS EXPERIMENT.

To observe how a PNP Transistor works as a current amplifier and to build a useful PNP Transistor Checker.

(B) THEORY OF THIS CIRCUIT

The transistor is a component used to amplify electricity. It has three terminals: Emitter, Base and Collector.
According to how transistors are manufactured they become NPN or PNP type. Observe the difference in the schematic symbol between these two types.

Appearance   Schematic Symbol   Draw Schematic Symbol



When the collector of an PNP transistor is negative, the emitter positve, and the base slightly negative, the transistor is correctly biased (polarized) and there are two currents flowing through it: the Collector Current (Ic)(flowing in the Collector and out the Emitter), which is a large current, and the Base Current (Ib)(flowing in the Base and out the Emitter), which is a small current, as shown in Figure 1.
The interesting thing about transistors, is that the Base Current (Ib) which is a small current, controls the Collector Current (Ic), which is a large current. The larger the Base Current, the greater the Collector Current.

This important process, of having a small current controlling a large current, is called AMPLIFICATION.
Figure 2 shows this experiment. It uses a PNP transistor. Its collector receives a negative voltage from the battery through resistor R2 and LED2. The emitter is connected directly to the positve terminal of the battery and the base receives a negative voltage from the negative terminal of the battery through resistor R1, the pushbutton, and LED1.
The brightness of LED1 is proportional to the Base Current, and the brightness of LED 2 is proportional to the Collector Current.
Performing the experiment, you will find that LED2 (collector LED) is brighter than LED1 (base LED). This means that the Colector Current is larger than the Base Current.
In this experiment you will also find out that if there is no Base Current (pushbutton open) there is no Collector Current. If there is a Base Current (pushbutton pressed), there is a Collector Current. This means that the Base Current, which is a small current, is controlling the Collector Current, which is a large current.

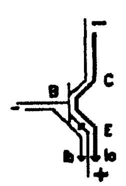


Fig 1

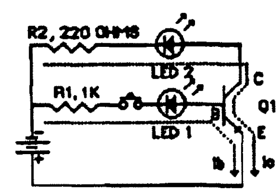
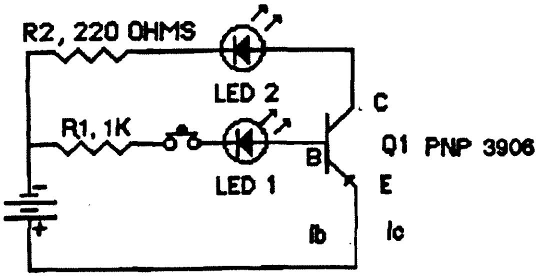


Fig 2

SCHEMATIC DIAGRAM & PARTS LIST



	Part #
- Battery Snap	SL35001
- R1: 220 ohm resistor	SL01049
- R2: 1K ohm	SL01065
- LED1 / LED2	SL06001
- Q1: 2N3906 (PNP)	SL18002
- *Pushbutton*	SL25004

PLMVBF/2-15

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(C) Step-By-Step Assembly Instructions

HOW A PNP TRANSISTOR WORKS / LAB KIT A9

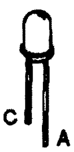
GET THE SOLDERLESS CIRCUIT BOARD AND BUILD THE PROJECT ALWAYS COMPARING YOUR WORK TO THE ASSEMBLY DIAGRAM.

( ) **STEP 1.**
Find the Battery Snap. Insert the red wire into hole 1f and the black wire into hole 1e.

( ) **STEP 2.**
Find the 220 ohm resistor (Red, Red, Brown, Gold). Insert one lead into hole 1j and the other into hole 5j.

( ) **STEP 3.**
Find the 1K ohm resistor (Brown, Black, Red, Gold). Insert one lead into hole 1g and the other into hole 6g.

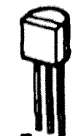
( ) **STEP 4.**
Find the LED (light emitting diode). Insert its long lead into hole 7i and its short lead into hole 5i.



( ) **STEP 5.**
Find another LED. Insert the long lead into hole 17f and the short lead into hole 15g.

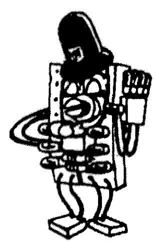
( ) **STEP 6.**
Find the pushbutton. Insert one lead into hole 6f and the other into hole 8f.

( ) **STEP 7.**
Find the 3906 transistor. Insert the three leads into holes 16h, 17h and 18h. Be sure that the flat side of the transistor is pointing in the direction shown in the assembly diagram.



( ) **STEP 8.**
Get three wires. Install the first wire from hole 7j to hole 16j, the second wire from hole 8h to hole 15h. The third wire from 1a to 18f.

( ) **STEP 9.**
STOP! Before you test your project verify it against the Assembly Diagram to be sure that all the components are installed in the right place. Also be sure there are no short circuits on the board (wires or leads touching each other). To operate the project follow the directions in the section called " Operating Instructions."



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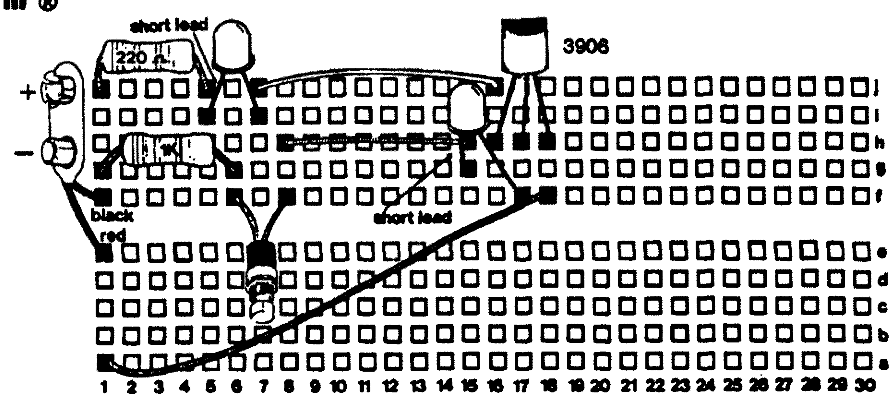
ASSEMBLY DIAGRAM



(D) OPERATING INSTRUCTIONS / RESULTS & OBSERVATIONS

1- Now that you have your project assembled, connect a fresh 9 volt battery to the battery snap.
2- Press the pushbutton. If both LEDs light-up (one brighter than the other) when the pushbutton is pressed you can assume that the transistor being tested is OK.

If the transistor is defective three things might occur:
- None of the LEDs light-up when the pushbutton is pressed.
- Only one LED lights-up when the pushbutton is pressed.
- One or both LEDs light-up when the pushbutton is not pressed.

PLMVBS/1-15

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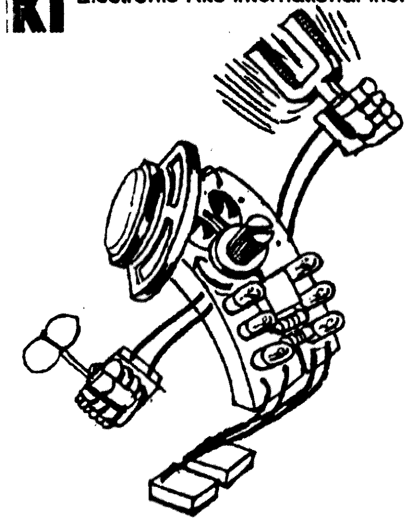

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Solderless Electronic Kit

TRANSISTOR OSCILLATOR

LAB KIT A10

*** * * START HERE * * ***

A) PURPOSE OF THIS EXPERIMENT.

'he purpose of this experiment is to build a simple two transistor oscillator and to learn about ransistorized oscillator circuits.

B) THEORY OF THIS CIRCUIT

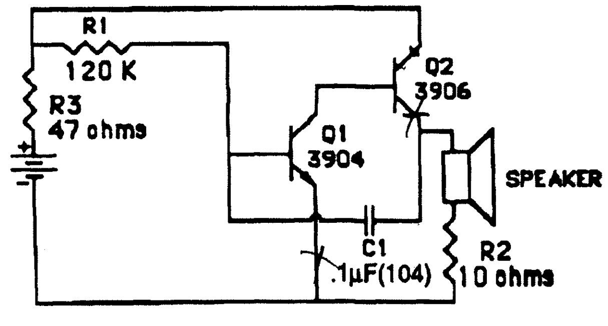
transistor oscillator is an electronic device that generates constantly increasing and decreasing current.

'he frequency of this varying current is how many times per econd the current increases and decreases. The unit of leasurement for frequency is Hertz (Hz), which repre- ents one complete cycle or pulse per second.
'he circuit you will build oscillates at a frequency of approxi- lately 500Hz (500 cycles or pulses per second). This 'equency is called an audio frequency, because when a peaker vibrates at this frequency, it generates a tone that an be heard by the human ears. Audio frequencies range om approximately 10Hz to 16,000 Hz.
he oscillator that you will build is a two transistor oscilla- or. It uses one PNP (3906) and one NPN (3904) transis- or.

As the battery is connected, electrons flow from the negative terminal of the battery through R2 and the speaker to charge capacitor C1. This small current flowing through the speaker while C1 is charging, causes the cone to move slightly. As capacitor C1 is charging, Q1 will begin to conduct, which allows Q2 to begin to conduct. When Q2 conducts, the electrons travel from the negative of the battery through R2, the speaker and Q2 back to the positive of the battery. This larger current causes the speaker to move more. When Q2 conducts, it will dis- charge C1, which causes Q1 to stop conducting, which in turn causes Q2 to stop conducting and the speaker returns to its normal position. Then C1 begins to charge again and the cycle is repeated.

The frequency of oscillation of this circuit and thus the speaker, is determined by the values of resistor R1 and capacitor C1. The larger the values of R1 and C1, the lower the frequency of oscillation.

SCHEMATIC DIAGRAM & PARTS LIST



	Part #
- Battery Snap	SL35001
- R1: 120K ohm	SL01115
- R2: 10 ohm	SL01017
- R3: 47 ohm	SL01033
- Q1: 2N3904 (NPN)	SL18001
- Q2: 2N3906 (PNP)	SL18002
- C1: .1 µF Cap. (104)	SL02016
- Speaker	SL27001

PLMVBF/2-15

Mr. Circuit Solderless Electronic Kit

(C) Step-By-Step Assembly Instructions

TRANSISTOR OSCILLATOR / LAB KIT A10

GET THE SOLDERLESS CIRCUIT BOARD AND BUILD THE PROJECT ALWAYS COMPARING YOUR WORK TO THE ASSEMBLY DIAGRAM.

( ) **STEP 1.**
Find the Battery Snap. Insert the red wire into hole 2f and the black wire into hole 1e.

( ) **STEP 2.**
Find the 120K ohm resistor (Brown, Red, Yellow, Gold). Insert one lead into hole 1i and the other into hole 10i.

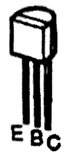
( ) **STEP 3.**
Find the 47 ohm resistor (Yellow, Violet, Black, Gold). Insert one lead into hole 2g and the other into hole 6f.

( ) **STEP 4.**
Find the 10 ohm resistor (Brown, Black, Black, Gold). Insert one lead into hole 13b and the other into hole 18b.

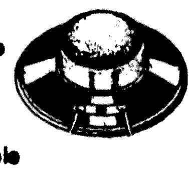
( ) **STEP 5.**
Find the 3904 transistor. Insert its three leads into holes 9g, 10g and 11g. Be sure that the flat side is pointing in the direction shown in the assembly diagram.

( ) **STEP 6.**
Find the 1μF ceramic capacitor (104). Insert one lead into hole 10f and the other into hole 15f.

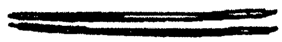
( ) **STEP 7.**
Find the 3906 transistor. Insert the three leads into holes 13g, 14g and 15g. Be sure that the flat side of the transistor is pointing in the direction shown in the assembly diagram.



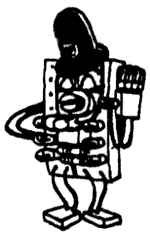
( ) **STEP 8**
Find the speaker. Insert one lead into hole 15h and the other to hole 18d.



( ) **STEP 9.**
Get five wires. Install the first wire from hole 1j to hole 13j, the second wire from hole 9h to hole 14h. The third wire from 1h to 6h. The forth from 1c to 11f and the fifth wire from 1a to 13a.



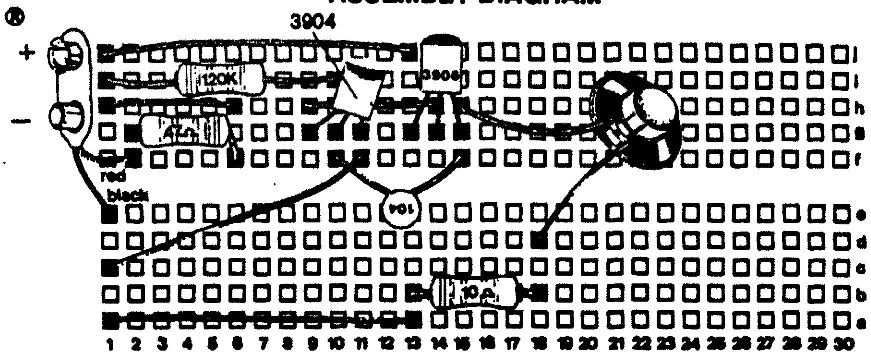
( ) **STEP 10.**
STOP! Before you test your project verify it against the Assembly Diagram to be sure that all the components are installed in the right place. Also be sure there are no short circuits on the board (wires or leads touching each other). To operate the project follow the directions in the section called " Operating Instructions."



EKI®

TRANSISTOR OSCILLATOR

ASSEMBLY DIAGRAM



(D) OPERATING INSTRUCTIONS

1- Now that you have your Transistor Oscillator assembled, connect a fresh 9 volt battery to the battery snap. As you do this an audio tone should be heard from the speaker.

(E) RESULTS & OBSERVATIONS

By performing this experiment you have found that the Two Transistor Audio Oscillator generates a constant audio tone.

PLMVBS/1-15

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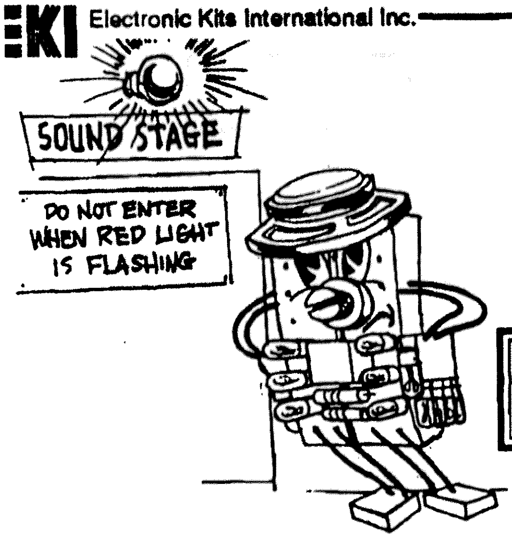


Mr. CIRCUIT®

Solderless Electronic Kit

BLINKING LIGHT

LAB KIT A11

*** * * START HERE * * ***

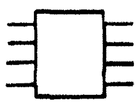
(A) PURPOSE OF THIS EXPERIMENT.

The purpose of this experiment is to build a useful LED Blinking Light and to learn about the IC Timer 555.

(B) THEORY OF THIS CIRCUIT

In this experiment we introduce an integrated circuit (IC).
Integrated circuits (ICs) have several components (transistors, diodes, resistors, etc) condensed into a very small package. Each type of IC performs a different function according to the different components it has inside.

Physical Appearance Schematic Symbol Draw Schem. Symbol

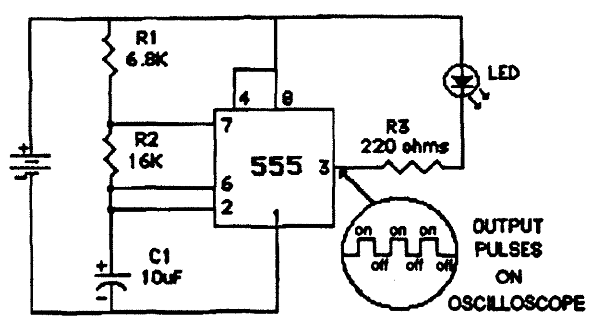


In this experiment the 555 IC Timer is used as a clock.
A clock, as the term is used in electronics, does not mean a device to tell the time. It refers to a circuit that provides a continuous series of pulses, the frequency of which can range from less than one per second to over a million per second.
The Schematic Diagram of this experiment, shows the 555 Timer connected as a clock. This circuit, as you will notice, has no input signal, and in that sense, it operates as an oscillator; a device that generates its own signal.

The pulses produced by the clock are present on pin #3. This means that pin 3 will be alternately positive (High) and negative (Low).
The frequency of the pulses produced by the IC timer depends on the values of resistors R1 and R2, and capacitor C1. The larger the values of the resistors and the capacitor, the lower the frequencies of the pulses. On the other hand, the lower the values of R1, R2 and C1, the higher the frequency of the pulses.
If an LED (light emitting diode) is connected to the output of the IC Timer (pin #3), as in the circuit of the Blinking Light, when pin 3 is Low, a current will flow from pin 3 to the positive of the battery, passing through resistor R3 and the LED, and, therefore, the LED will turn on. When pin 3 is High, no current flow through the LED and, therefore, it will be off. In this manner, as pin 3 alternates from High to Low, the LED constantly turns on and off.

If you replace the 10 µF capacitor with a 100 µF capacitor, the frequency of the pulses decreases and, therefore, the LED turns on and off less frequently.
Now you can understand why the LED of your Blinking Light blinks.

SCHEMATIC DIAGRAM & PARTS LIST



	Part #
- Battery Snap	SL35001
- R1:6.8K ohm	SL01085
- R2: 16K ohm	SL01094
- R3: 220 ohm	SL01049
- C1: 10 µF Cap.	SL05003
- 555 IC Timer	SL14004
- LED: Light Emitting Diode	SL06001

PLMVBF/2-15

Mr. Circuit Solderless Electronic Kit

(C) Step-By-Step Assembly Instructions

BLINKING LIGHT / LAB KIT A11

GET THE SOLDERLESS CIRCUIT BOARD AND BUILD THE PROJECT ALWAYS COMPARING YOUR WORK TO THE ASSEMBLY DIAGRAM.

( ) **STEP 1.**
Find the Battery Snap. Insert the red wire into hole 1f and the black wire into hole 1e.

( ) **STEP 2.**
Find the 6.8K ohm resistor (Blue, Gray, Red, Gold). Insert one lead into hole 17i and the other into hole 18i.

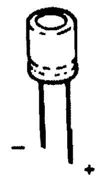
( ) **STEP 3.**
Find the 220 ohm resistor (Red, Red, Brown, Gold). Insert one lead into hole 11a and the other into hole 19a.

( ) **STEP 4.**
Find the 16K ohm resistor (Brown, Blue, Orange, Gold). Insert one lead into hole 18h and the other into hole 19h.

( ) **STEP 5.**
Find the red LED (light emitting diode). Insert its long lead into hole 11f and the short lead into hole 11e.

( ) **STEP 6.**
Find the Integrated Circuit 555. Install it in the board with the notch, dot or band at one end in the right direction, as shown in the assembly diagram (holes:17e, 18e, 19e, 20e, 17f, 18f, 19f and 20f).

( ) **STEP 7.**
Find the 10µF capacitor. Insert its positive lead (long lead) into hole18b and its negative lead into hole 17b.



( ) **STEP 8.**
Get five wires. Install them as follows: from 1i to 17h, from 1g to 11g, from 1d to 17a, from 17g to 20c and from 19g to 18d.

( ) **STEP 9**

STOP! Before you test your project verify it against the Assembly Diagram to be sure that all the components are installed in the right place. Also be sure there are no short circuits on the board (wires or leads touching each other). To operate the project follow the directions in the section called " Operating Instructions."

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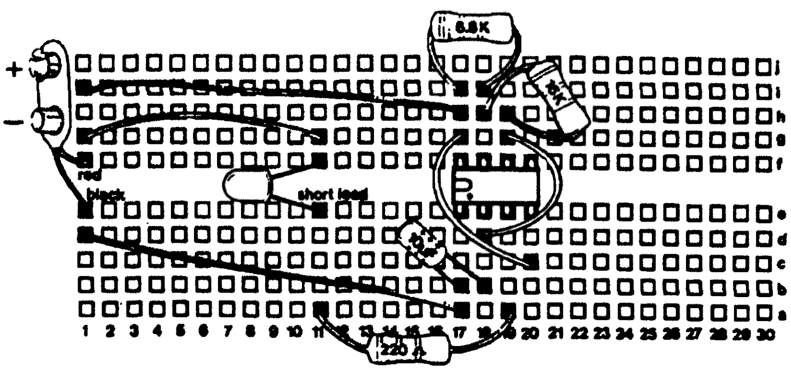
BLINKING LIGHT

ASSEMBLY DIAGRAM



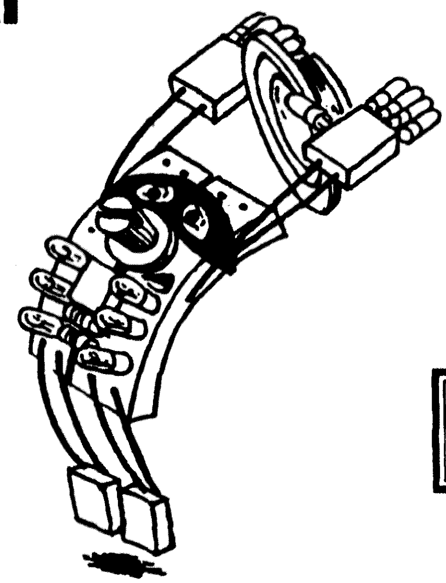
(D) OPERATING INSTRUCTIONS

1- Now that you have your Blinking Light assembled, connect a fresh 9 volt battery to the battery snap. As you do this the LED will start to blink.

(E) RESULTS & OBSERVATIONS

By performing this experiment you have found that by using the 555 Timer as a clock, you can build a device that is able to turn on and off an LED.

PLMVBS/1-15



Mr. CIRCUIT®

Solderless Electronic Kit

BURGLAR ALARM

LAB KIT A12

* * * START HERE * * *

(A) PURPOSE OF THIS PROJECT.

The purpose of this project is to build a useful Burglar Alarm.

(B) CIRCUIT DESCRIPTION

This burglar alarm is designed to be used with normally open (S1) or normally closed (S2) switches. If after the alarm is armed (battery connected) the normally closed switch (S2) is opened, or the normally open switch (S1) is closed, a positive voltage will be applied to the gate of the SCR causing it to conduct.

To learn more about the operation of an SCR refer to Mr. Circuit Lab Kit A7.

When the SCR conducts, the LED turns on, indicating that the alarm was activated.

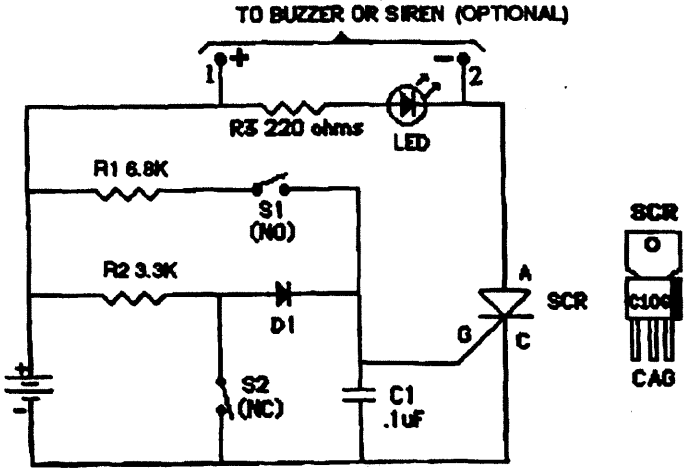
In order to have an audible signal, an optional 9-volt buzzer can be connected in points 1 and 2 of the circuit (see schematic diagram).

Once the alarm is triggered (LED on) the only way to stop it is by disconnecting the battery from the circuit.

Before connecting the battery, be sure that the two wires labeled S2 are connected together, and the two labeled S1 are not touching one another.

Now you are ready to assemble this project.

SCHEMATIC DIAGRAM & PARTS LIST



	Part #
- Battery Snap	SL35001
- R1:6.8K ohm	SL01085
- R2: 3.3K ohm	SL01077
- R3: 220 ohm	SL01049
- LED: Light Emitting Diode	SL06001
- SCR	SL13001
- C1: .1 µF Cap.	SL02016
- D1: Diode 1N4003	SL30001

PLMVBF/2-15

Mr. Circuit Solderless Electronic Kit

(C) Step-By-Step Assembly Instructions

BURGLAR ALARM / LAB KIT A12

GET THE SOLDERLESS CIRCUIT BOARD AND BUILD THE PROJECT ALWAYS COMPARING YOUR WORK TO THE ASSEMBLY DIAGRAM.

( ) **STEP 1.**
Find the Battery Snap. Insert the red wire into hole 1f and the black wire into hole 1e.

( ) **STEP 2.**
Find the 3.3K ohm resistor (Orange, Orange, Red, Gold). Insert one lead into hole 1h and the other into hole 5h.

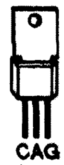
( ) **STEP 3.**
Find the other 6.8K ohm resistor (Blue, Gray, Red, Gold). Insert one lead into hole 1i and the other into hole 10i.

( ) **STEP 4.**
Find the 220 ohm resistor (Red, Red, Brown, Gold). Insert one lead into hole 17h and the other into hole 19h.

( ) **STEP 5.**
Find the red LED (light emitting diode). Insert its long lead into hole 19i and the short lead into hole 21i.

( ) **STEP 6.**
Find the diode. Notice that it has a band on one side of its body. Insert the lead on the side of the band into hole 12g and the other lead into hole 5g

( ) **STEP 7.**
Find the SCR (silicon controlled rectifier). Insert its three leads into holes 20g, 21g and 22g, with the lead on the side of the beveled edge into hole 22g.



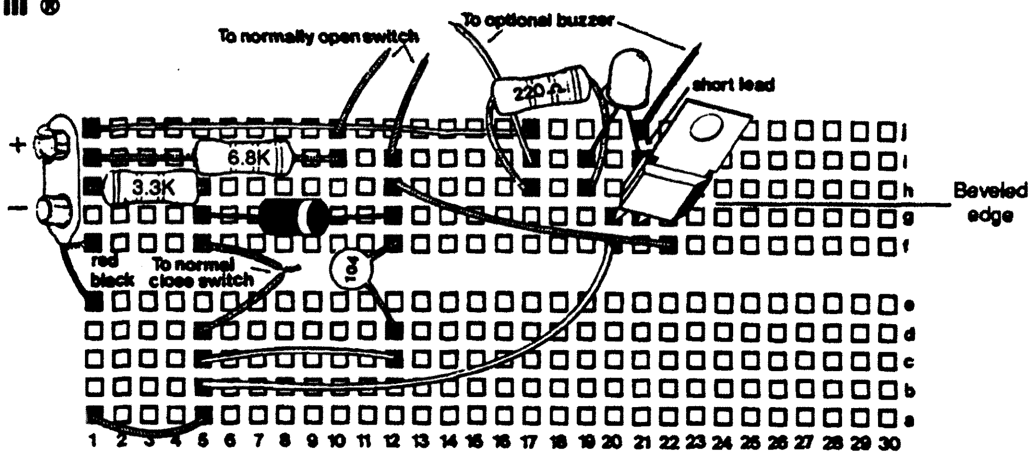
( ) **STEP 8.**
Find the .1µF capacitor (104). Insert one lead into hole 12d and the other into hole 12f.

( ) **STEP 9.**
Get nine wires. Install five as follows: from 1j to 17j, from 1a to 5a, from 5c to 12c, from 5b to 20f and from 12h to 22f.
Tight two wires together and connect one end to 5f and the other end to 5d.
Connect one wire to hole 10j and another wire to hole 12i. Leave the other end of these two wires unconnected.

( ) **STEP 10.**
STOP! Before you test your project verify it against the Assembly Diagram to be sure that all the components are installed in the right place. Also be sure there are no short circuits on the board (wires or leads touching each other). To operate this project connect a fresh 9-volt battery to the battery snap and open the normally closed switch or close to normally open and observe how the LED lights up.

BURGLAR ALARM

ASSEMBLY DIAGRAM



 PLMVBS/1-15

Mr. CIRCUIT®

Solderless Electronic Kit

AUTOMATIC NIGHT LIGHT

LAB KIT A13

*** * * START HERE * * ***

(A) PURPOSE OF THIS PROJECT.

The purpose of this project is to build an LED Night Light that turns on at night and goes off during the day.

(B) CIRCUIT DESCRIPTION

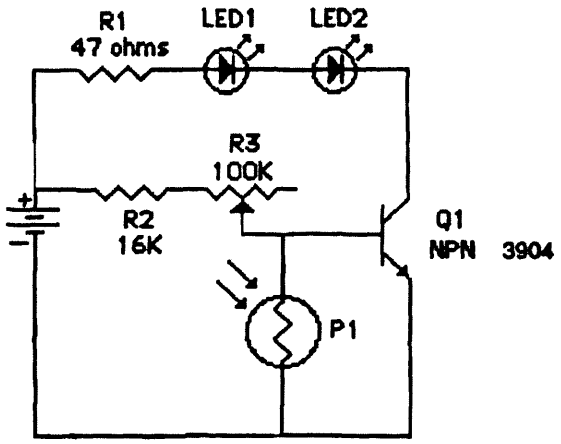
In the Automatic Night Light circuit, the two LEDs turn on at night and go off during the day. The brightness of the two LEDs is inversely proportional to the intensity of light received in the photocell.
The more light received by the photocell, the less the brightness of the LEDs, and viceversa.

With the potentiometer R3 you can adjust the sensitivity of the device, in order to keep the LEDs off under any level of light and then automatically turn them on when the light disappears.

In order to test this device, first connect the battery and then adjust R3 until the LEDs go off. Then shadow, with your hand, the face of the photocell and the LED should illuminate.

To learn more about the operation of the photocell or the transistor refer to Mr. Circuit Lab Kit A3 and A8 respectively.

SCHEMATIC DIAGRAM & PARTS LIST



	Part #
- Battery Snap	SL35001
- R1: 47 ohm	SL01033
- R2: 16K ohm	SL01094
- R3: 100K ohm Potentiometer	SL33008
- LED1 & LED2: LEDs	SL06001
- Q1: 2N3904 Transistor (NPN)	SL18001
- P1: Photocell	SL45028

PLMVBF/2-15

Mr. Circuit Solderless Electronic Kit

(C) Step-By-Step Assembly Instructions

AUTOMATIC NIGHT LIGHT / LAB KIT A13

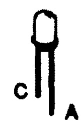
GET THE SOLDERLESS CIRCUIT BOARD AND BUILD THE PROJECT ALWAYS COMPARING YOUR WORK TO THE ASSEMBLY DIAGRAM.

( ) **STEP 1.**
Find the Battery Snap. Insert the red wire into hole 1f and the black wire into hole 1e.

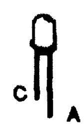
( ) **STEP 2.**
Find the 47 ohm resistor (Yellow, Violet, Black, Gold). Insert one lead into hole 1j and the other into hole 5j.

( ) **STEP 3.**
Find the other 16K ohm resistor (Brown, Blue, Orange, Gold). Insert one lead into hole 1g and the other into hole 6g.

( ) **STEP 4.**
Find one red LED (light emitting diode). Insert its long lead into hole 5i and the short lead into hole 7i.

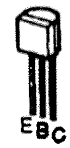


( ) **STEP 5.**
Find another red LED (light emitting diode). Insert its long lead into hole 7j and the short lead into hole 9j.

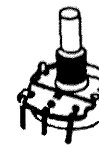


( ) **STEP 6.**
Find the photocell. Insert one lead into hole 10b and the other into hole 12b.

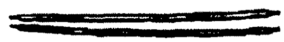
( ) **STEP 7.**
Find the 3904 transistor. Insert its leads into holes 11d, 12d and 13d. Be sure its flat side is pointing in the direction shown in the assembly diagram.



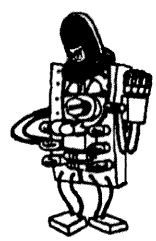
( ) **STEP 8.**
Find the potentiometer. Insert the wire connected to the center lead into hole 6f and the wire connected to the right lead into hole 12c.



( ) **STEP 9.**
Get three wires. Install the first wire from hole 1a to 10c, the second wire from hole 10a to 13a and the third wire from hole 9g to hole 11e.



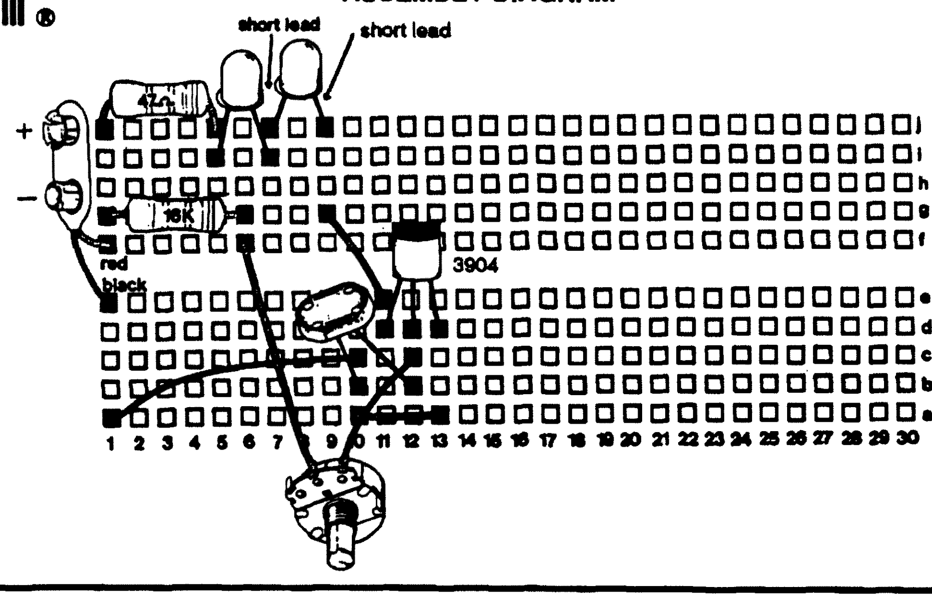
( ) **STEP 10.**
STOP! Before you test your project verify it against the Assembly Diagram to be sure that all the components are installed in the right place. Also be sure there are no short circuits on the board (wires or leads touching each other). To operate this project connect a fresh 9-volt battery to the battery snap and adjust R3 until the LEDs go off. Then shadow, with your hand, the face of the photocell and the LEDs should illuminate.



EKI®

AUTOMATIC NIGHT LIGHT

ASSEMBLY DIAGRAM



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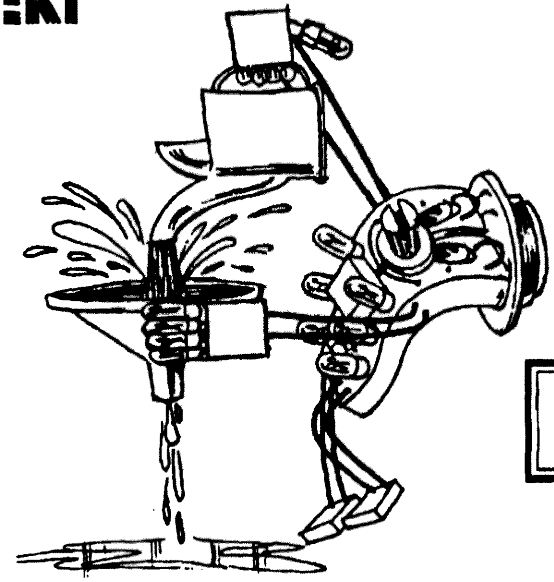


Mr. CIRCUIT®

Solderless Electronic Kit

DC TO DC POWER SUPPLY

LAB KIT A14

*** * * START HERE * * ***

(A) PURPOSE OF THIS PROJECT.

In this project you will construct a useful DC to DC adjustable power supply, which, when connected to a 9-volt battery, provides an adjustable output voltage between 0 and 9 volts.

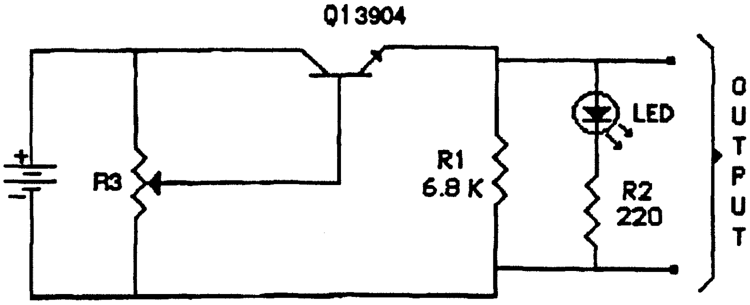
(B) CIRCUIT DESCRIPTION

The DC To DC Power Supply is able to supply an output voltage between 0 to 9 volts and an output current of up to 50 mA, therefore, it is ideal to supply DC to a host of electronic projects from portable radios to burglar alarms.

In order to use this power supply, connect a fresh 9-volt battery to the battery snap, then, using a voltmeter (multimeter) adjust potentiometer P1 until you get the desired output voltage.

In the circuit of the DC To DC Power Supply, transistor Q1 works as an adjustable resistor which changes its internal resistance, between collector and emitter, according to the voltage applied to its base, by potentiometer R3.
When the internal resistance of Q1 is close to 0 ohms, the output voltage of the power supply will be 9 volts. On the other hand, when the internal resistance of Q1 is very high (Q1 not conducting) the output voltage of the power supply will be 0 volts.
An LED in series with a 220 ohm resistor (R2) was connected to the output of the power supply. The brightness of this LED is proportional to the output voltage. The maximum brightness corresponds to 9 volts.
To learn more about the operation of the transistor or the potentiometer, refer to Mr. Circuit Lab Kit A2 or A8 respectively.
Now you are ready to assemble this project.

SCHEMATIC DIAGRAM & PARTS LIST



	Part #
- Battery Snap	SL35001
- R1: 6.8K ohm	SL01085
- R2: 220 ohm	SL01049
- R3: 100K ohm Potentiometer	SL33008
- Q1: 2N3904 Transistor (NPN)	SL18001
- LED	SL06001

Mr. Circuit Solderless Electronic Kit

(C) Step-By-Step Assembly Instructions

DC TO DC POWER SUPPLY / LAB KIT A14

GET THE SOLDERLESS CIRCUIT BOARD AND BUILD THE PROJECT ALWAYS COMPARING YOUR WORK TO THE ASSEMBLY DIAGRAM.

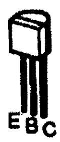
( ) STEP 1.
Find the Battery Snap. Insert the red wire into hole 1f and the black wire into hole 1a.

( ) STEP 2.
Find the 6.8K ohm resistor (Blue, Gray, Red, Gold). Insert one lead into hole 13f and the other into hole 13d.

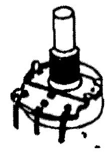
( ) STEP 3.
Find the other 220 ohm resistor (Red, Red, Brown, Gold). Insert one lead into hole 13g and the other into hole 25g.

( ) STEP 4 .
Find one red LED (light emitting diode). Insert its long lead into hole 25f and the short lead into hole 25e.

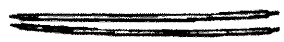
( ) STEP 5.
Find the 3904 transistor. Insert its leads into holes 11h, 12h and 13h. Be sure its flat side is pointing in the direction shown in the assembly diagram.



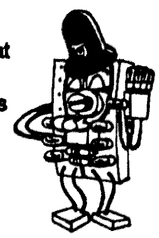
( ) STEP 6.
Find the potentiometer. Insert the wire connected to the center lead into hole 12g, the wire connected to the right lead into hole 1c, and the wire connected to the left lead into hole 1j.



( ) STEP 7.
Get five wires.
Install three wires as follows: one from 1i to 11i, one from 1b to 13b, one from 13a to 25d.
Connect one wire to hole 13c (Negative output) and another to 13j (Positive Output) . Leave the other end of these two wires not connected



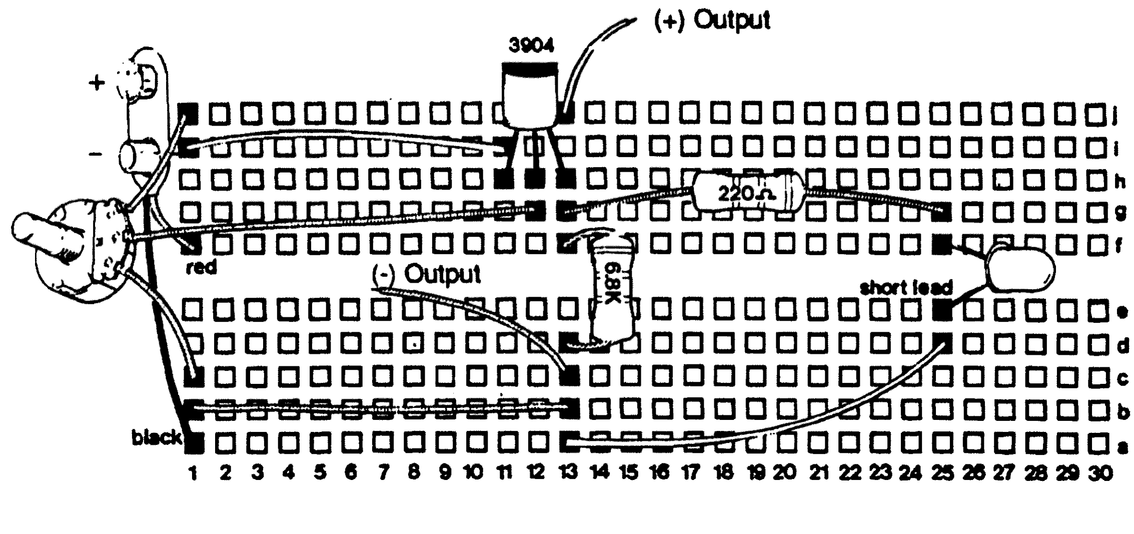
( ) STEP 8.
STOP! Before you test your project verify it against the Assembly Diagram to be sure that all the components are installed in the right place. Also be sure there are no short circuits on the board (wires or leads touching each other).

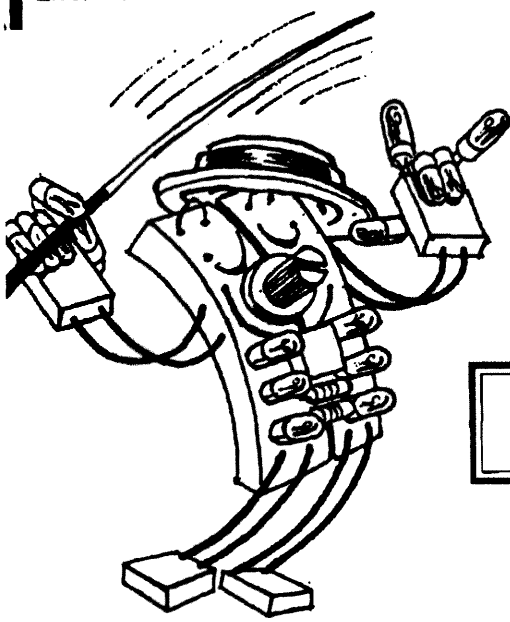


EKI®

DC TO DC POWER SUPPLY

ASSEMBLY DIAGRAM





Mr. CIRCUIT ®

Solderless Electronic Kit

ELECTRONIC METRONOME

LAB KIT A15

*** * START HERE * * ***

\) PURPOSE OF THIS PROJECT.

this project you will construct a useful Electronic Metronome.

3) CIRCUIT DESCRIPTION

metronome is a device used to aid in setting ıd keeping the tempo of music.

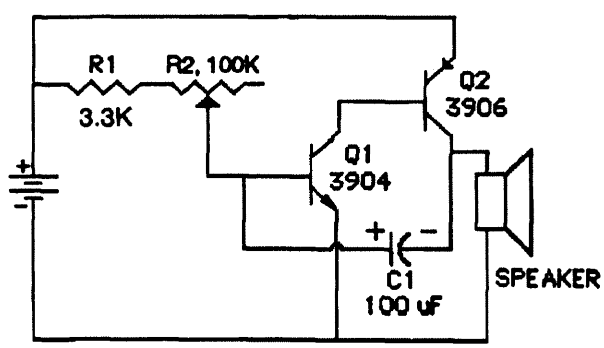
'aditional metronomes are mechanical and nploy a swinging arm that causes a clicking)und at the end of each swing. On those met- ınomes you adjust the tempo by adjusting the)eed of the oscillating arm.

In this project you build an electronic metronome which allows you to adjust the tempo by rotating to shaft on the potentiometer.

The circuit of the metronome is made of a low frequency two-transistor oscillator, similar to the one explained in Mr. Circuit Lab A10. The frequency of this oscillator is controlled by potentiometer R2 and by adjusting it, you speed up or slow down the tempo.

Now you are ready to assemble this project.

SCHEMATIC DIAGRAM & PARTS LIST



	Part #
- Battery Snap	SL35001
- R1: 3.3K ohm	SL01077
- R2: 100K ohm Potentiometer	SL33008
- Q1: Transistor 2N3904 (NPN)	SL18001
- Q2: Transistor 2N3906 (PNP)	SL18002
- C1: 100µF Cap.	SL05005
- Speaker	SL27001

PLMVBF/2-15

Mr. Circuit Solderless Electronic Kit

(C) Step-By-Step Assembly Instructions

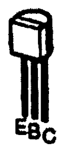
ELECTRONIC METRONOME / LAB KIT A15

GET THE SOLDERLESS CIRCUIT BOARD AND BUILD THE PROJECT ALWAYS COMPARING YOUR WORK TO THE ASSEMBLY DIAGRAM.

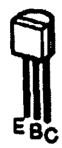
( ) **STEP 1.**
Find the Battery Snap. Insert the red wire into hole 1f and the black wire into hole 1e.

( ) **STEP 2.**
Find the 3.3K ohm resistor (Orange, Orange, Red, Gold). Insert one lead into hole 1h and the other into hole 5h.

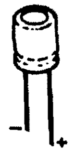
( ) **STEP 3.**
Find the 3904 transistor. Insert its leads into holes 11h, 12h and 13h. Be sure its flat side is pointing in the direction shown in the assembly diagram.



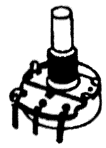
( ) **STEP 4.**
Find the 3906 transistor. Insert its leads into holes 15h, 16h and 17h. Be sure its flat side is pointing in the direction shown in the assembly diagram.



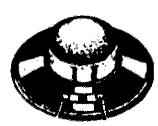
( ) **STEP 5.**
Find the 100µF capacitor. Insert its positive lead (long lead) into hole 12f, and its negative lead (short lead) into hole 17f.



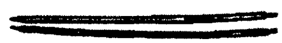
( ) **STEP 6.**
Find the potentiometer. Insert the wire connected to the center lead into hole 5i, and the wire connected to the left lead into hole 12j.



( ) **STEP 7.**
Find the speaker. Insert one of its leads into hole 17g, and the other into hole 19c.



( ) **STEP 8.**
Get four wires. Install them as follows: one from 1j to 15j, one from 11f to 16f, one from 1b to 13f and one from 1a to 19a.



( ) **STEP 9.**
STOP! Before you test your project verify it against the Assembly Diagram to be sure that all the components are installed in the right place. Also be sure there are no short circuits on the board (wires or leads touching each other). To operate this project just connect a fresh 9-volt battery to the battery snap.

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ELECTRONIC METRONOME
ASSEMBLY DIAGRAM