Science Fair®

60 IN ONE Electronic Project Lab

Requires one 9V, 2 "AA" batteries

Cat. No. 28-256

LIST OF EXPERIMENTS

1. AN ELECTRIC CIRCUIT
2. CIRCUIT RESISTANCE
3. CIRCUIT VOLTAGE
4. SERIES CIRCUITS
5. PARALLEL CIRCUITS

6. FLASH LIGHT
7. SIGNAL LAMP
8. FADER CONTROL
9. VISUAL RESPONDING CONTINUITY CHECKER
10. TRAFFIC LIGHTS

11. COMPASS
12. MAGNETIC AND NON-MAGNETIC MATERIALS
13. PERMANENT MAGNETISM
14. MAGNETIC POLARITY
15. MAGNETIC ATTRACTION AND REPULSION

16. MAGNETIC LINES OF FORCE
17. ATTRACTING AND REPELLING LINES OF FORCE
18. REED SWITCH
19. REED SWITCH CODE KEY
20. CRAZY PENDULUM

21. ELECTRO-MAGNETISM
22. ELECTRO MAGNET
23. MAGNETIC PULSE DETECTOR
24. AMPLIFIED MAGNETIC PULSE DETECTOR
25. MAGNETIC NOISE DETECTOR

26. MAGNETIC EFFECTS ON INDUCTANCE
27. MAGNETIC PULSE GENERATOR
28. ELECTRONIC SIREN
29. ELECTRONIC STORAGE TANK
30. ONE-WAY STREET

31. "INVISIBLE POWER" RADIO
32. TRANSISTOR AND "AMPLIFICATION"
33. TRANSISTOR, AN ELECTRONIC "TRIGGER"
34. SUNRISE-SUNSET LIGHT
35. SLOW MOTION SUNRISE-SUNSET LIGHT

36. "SECRET CODE" KEY
37. HIGHS AND LOWS OF OSCILLATION
38. BEACON LIGHT
39. MUSIC FROM A PENCIL
40. LEAKY FAUCET

41. BEE
42. ELECTRONIC CANARY
43. BURGLAR ALARM
44. TOUCH LIGHT
45. RAIN DETECTOR

46. RADIO STATION
47. "WIRELESS" RAIN DETECTOR
48. METAL DETECTOR
49. BLOWING "ON" A CANDLE
50. BLINKER

51. TWO-TRANSISTOR OSCILLATOR
52. TIMER
53. MEMORY
54. "AND" GATE
55. "OR" GATE

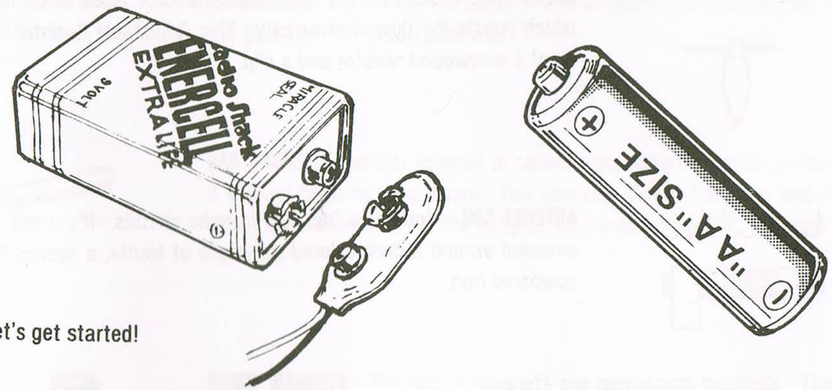
56. "NAND" GATE
57. "NOR" GATE
58. MOTOR DIRECTION
59. MOTOR APPLIED VOLTAGE AND MOTOR SPEED
60. CHANGE IN CURRENTLY BY MOTOR ROTATION

Your Science Fair 60 in One Electronic Project Lab will provide you with many hours of fascinating fun. It may also be your introduction to Magnetism, Electricity and Physics. If so, you are in for a lot of excitement.

This manual describes 60 different experiments and projects you can perform with this kit. Many of the parts are permanently attached to the colorful panel together with the durable plastic frame supports. Other parts are kept in the storage compartment on the right.

Before we begin, make sure you have one 9 volt battery and two AA batteries. We recommend Radio Shack's catalog number 23-464 or 23-583 for 9 volf, 23-468 or 23-582 for AA cells. Place the 9 volt battery in the battery holder (inside the panel) and check to see that the plus (+) and minus (-) markings on the battery match those on the holder as shown. Install the AA batteries into the battery holder inside the panel. Watch the + and - markings on the holder to correctly install batteries.

Don't ever leave the battery in the holder when you are not using your kit.

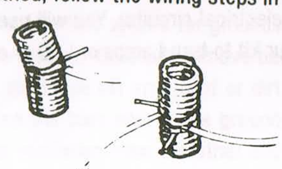


Now, let's get started!

MAKING CONNECTIONS

For example, the first connection, for your first project: "An Electric Circuit" will be from 1 to 63. Locate these two springs and choose a wire long enough to reach between them. To attach the wire, just bend the spring to one side with your finger and stick the wire into one of the gaps that you see. Now let the spring go and it will clamp the wire firmly in place.

After you have connected 1 and 63, make sure that the spring is touching the metal part of the wire and not the plastic insulation. The projects won't work if the metal part of the wire isn't touching the spring. Using this method, follow the wiring steps in this manual.



WIRING SEQUENCE

We'll give you the wiring for all of the sixty projects, but in a slightly different way ... the instructions will look like this, for Project No. 1 for example. (You will get to build the circuit in the project later.)

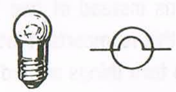
1-63, 2-3, 4-44, 46-64

This is called the WIRING SEQUENCE. It is important to make the connections in the order they are given to prevent damage to any of the electronic parts. If you follow the wiring sequence above, you will see that it is the circuit you just built.

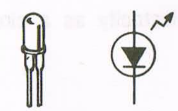
You can build, play with, and enjoy every circuit in this kit by just following the wiring sequences.

MEET THE PARTS OF YOUR KIT

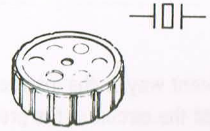
You've probably noticed many different kinds of parts on the CIRCUIT BOARD. We'll explain the purpose of each one of these components in this next section. This will help you understand what each components does and why it is used in the various circuits.



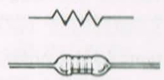
LAMPS: These are simple 3 volt bulbs, very much like standard flashlight bulbs. Be sure you connect only 3 volts to them; if you connect the 9 volt battery to one of them, you'll burn out the bulb.



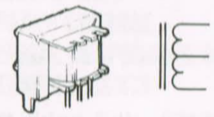
LED: That stands for Light Emitting Diode. It is a diode which emits light when current passes through it in one direciton – just like "regular" diodes.



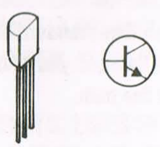
PIEZO BUZZER: The Piezo Buzzer in your kit will sound whenever electricity flows through it.



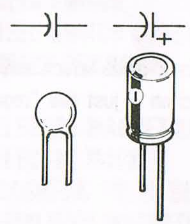
RESISTORS: These are brown tubular objects with color bands around them. Resistors oppose the flow of electricity.



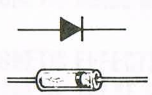
TRANSFORMER: Made from a plastic form, wound with hundreds of turns of very fine copper wire. Thin metal plates called laminations are inserted inside the center of the hollow plastic form.



TRANSISTOR: Transistors have three connections instead of two like the other parts you have seen. You'll see why this is important later. In your kit, transistors act either as switches to turn things on and off or as amplifiers to make signals louder or to increase the rate of signal change, or frequency.

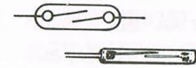


CAPACITORS: Capacitors store and release electricity as a circuit needs it.

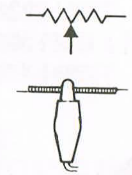


DIODE: The Diode does one simple thing. It allows electricity to flow through itself in only one direction.

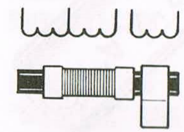
ELECTROMAGNET: The Electromagnet is a very fascinating but sim part. It illustrates the principle that electricity flowing through a of wire can produce a magnet and therefore it is called an Elect magnet. It is different from the Bar Magnet or Donut Magnets incl ed in your kit: those two types of magnets are called perman magnets. The Electromagnet functions as a magnet only when el tricity is connected to its terminals (49 and 50).



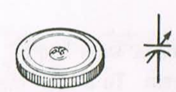
REED SWITCH: The Reed Switch is housed in a glass capsule. It opened or closed from the outside by means of a magnet. Encaps lated switches have many advantages; their contacts cannot dirty and they can even be used in an environment where there is danger of an explosion.



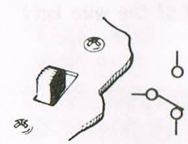
ADJUSTABLE RESISTOR: The Adjustable Resistor is an electronic p which resists the flow of electricity. This Adjustable Resistor is ma up of a wirewound resistor and a clip.



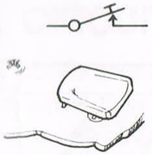
ANTENNA COIL: You'll use this part in radio circuits. It's a coil of w wrapped around a dark colored rod made of ferrite, a special form powdered iron.



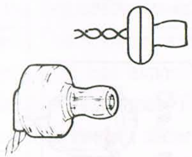
TUNING CAPACITOR: The Tuning Control in your kit with the white c lored plastic knob is actually a capacitor whose value can be chang by turning the attached knob. This type of capacitor is known as variable capacitor. It's used mainly in radio circuits.



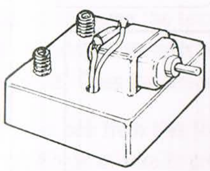
SWITCH: You know what a switch is – you use it to connect or disco nect electrical circuits. You will use the simple switch we've includ in your kit to turn Lamps or LED or other circuits on and off.



KEY: The Key is actually another switch. It's the same thing as an ordinary momentary contact push-button switch.



EARPHONE: You're already familiar with this part. You can listen to sounds through this instead of the Speaker. Also the Earphone uses less electricity than the Speaker.



MOTOR: The Motor Assembly is one of the most interesting items included in your kit. It can be used either as an electric motor, or as a generator of electricity. In some of the projects you put the Fan on the Shaft of this motor/generator.

BAR MAGNET: The Bar Magnet is called a permanent magnet because it always holds its magnetism. You also use it as a Compass and for other experiments. The Bar Magnet has polarity: a "N" end and a "S" end.

DONUT MAGNETS: The Donut Magnets are permanent magnets. They can be used for many simple and fascinating experiments.

RADIO CIRCUITS

When experimenting with a Radio circuit use the long piece of wire in your kit for making antenna and ground connections. Cut off a few feet of wire for grounding the Radio. A cold water pipe or a radiator pipe can be used for the ground. Carefully remove about 6 inches of insulation from one end of the ground wire. Be sure to scrape off any paint or dirt from the ground pipe so that you can see the bare metal, then wrap the bare end of the ground wire around the pipe and twist it tightly. Remove about 1/2 inch of insulation from the other end of the ground wire and connect it to the Ground terminal of the Radio circuit noted on the wiring diagram and schematic.

Remove about 1/2 inch of insulation from one end of the remaining piece of wire and connect it to the Antenna terminal of the Radio circuit noted on the wiring diagram.

Spread out the antenna wire. Or, you can connect the other end of this wire to a better antenna as we tell you later in the experiment.

NOTE

1. AN ELECTRIC CIRCUIT

Everybody talks about electric circuits and short circuits and open circuits, but few people can really define what an electric circuit is. Try asking some people what an electric circuit is. But before you do, you should know what it is.

Briefly, an electric circuit is a complete path for electrons to move from the negative source of voltage to the positive voltage terminal. A 1.5 V cell is a primary source of electricity. Therefore when we hook wires from the (–) terminal, and back to the (+) terminal, an electric current composed of moving electrons can flow through the circuit we have made.

The current which flows through a circuit can be used to perform work for us. The types of work we commonly obtain includes light, heat, movement, etc. The circuit for this particular experiment is used to produce light.

Hook up the circuit and check operation with the switch in both OFF ("DOWN") and then ON ("UP") position. The switch is used to complete the circuit when we want the lights on.

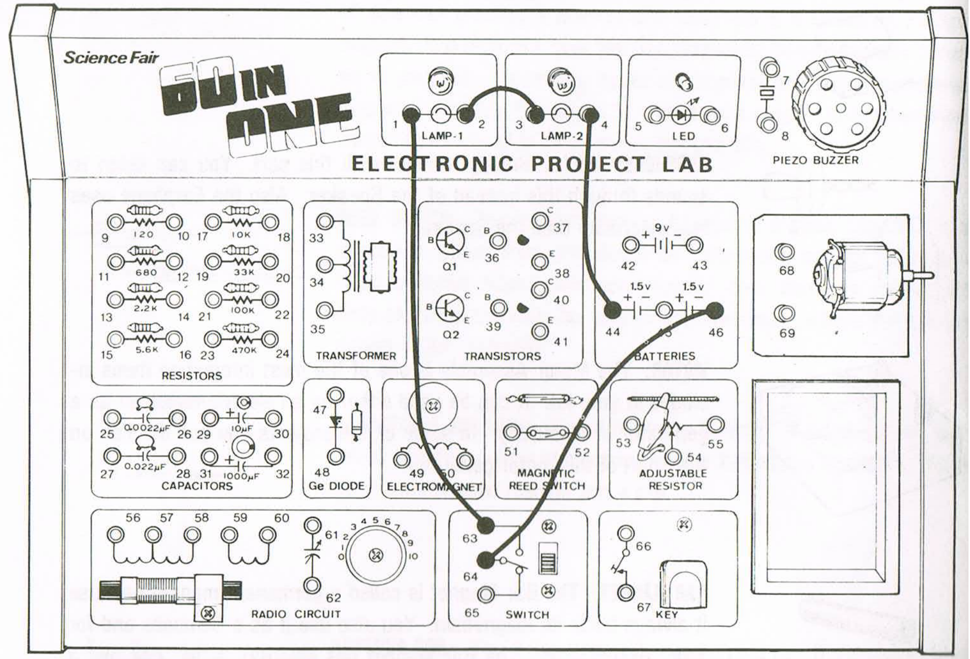
Set the Switch to ON and then disconnect one of the wires in the circuit. This is called an "open circuit". Notice that no current can flow in an open circuit and thus the lamps go out. Replace the disconnected wire.

Now we want to demonstrate what a "short circuit" is and what it does. Use an extra length of wire and connect it to terminals 63 and 64. Notice that now the switch has no control over the circuit, and the current continues to flow. The switch is said to be "shorted out" or "short circuited". Remove the extra wire.

Connect the extra wire across the Yellow Lamp. The circuit current is now higher than it was with the Yellow Lamp not shorted out, as evidenced by the Green Lamp glowing brighter. This reminds us that a short circuit generally causes a great increase in current in a circuit. Fuses and circuit breakers are used to protect the circuit as well as the source of voltage in case of a short circuit.

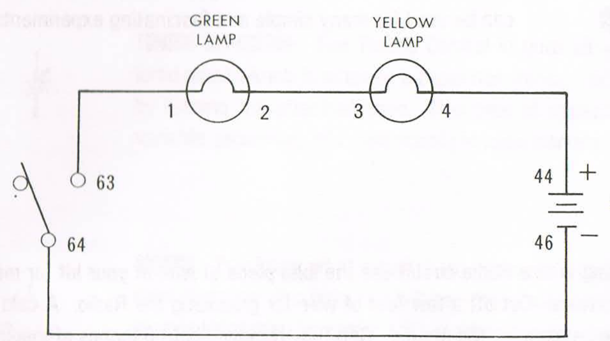
In this experiment we learned that an electrical circuit is a complete path for electrons to flow from the (–) source back to the (+) source, that an open circuit stops the flow of the current, but that a short circuit either causes the switch to have no effect or for the circuit current to be greatly increased. The short circuit passes the current which should flow through the short-circuited lamp.

NOTE



WIRING SEQUENCE:

1-63, 2-3, 4-44, 46-64.



2. CIRCUIT RESISTANCE

low that you know what a circuit is and how it conducts a current, let's see if we can control how much current flows in a circuit. Hook up the circuit and slide the Adjustable Resistor clip lead along the windings of the Adjustable Resistor. The lamp glows dim for low current levels and bright for high current levels.

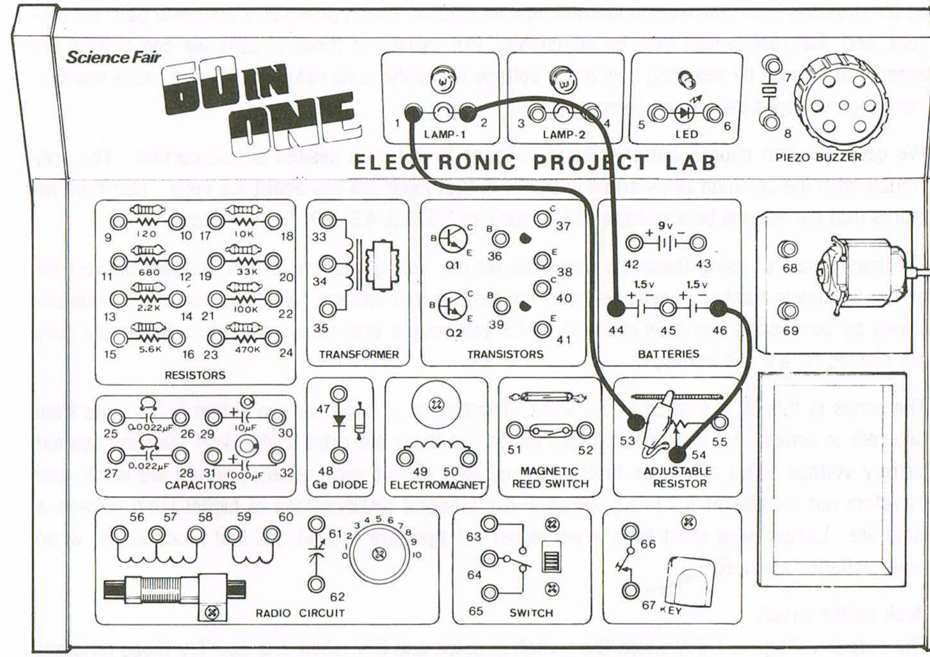
As the Adjustable Resistor is inserted into the circuit we can tell from the lamp that less current flows. The resistor resists the flow of current. A copper wire has very low resistance, but an open circuit has almost infinite resistance. For proper circuit operation we must have a correct amount of resistance. Resistance which is too low allows excessive current flow; whereas, high resistance doesn't allow enough current to flow.

Let's change the circuit to put the Electromagnet Winding in place of the Adjustable Resistor. Do this by changing the terminal 54 wire to terminal 49, and the 53 wire to 50. Does the Electromagnet Winding have resistance? Temporarily connect a spare wire across the Green Lamp to short-circuit it. Does the Green Lamp have resistance? Disconnect the circuit to save battery power.

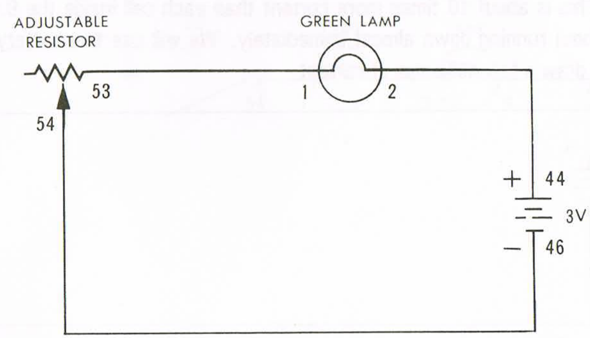
We can see from this that even wire has resistance which will limit current if there is a long enough length of wire to present sufficient resistance. All lamps have resistance. In fact everything has some resistance to the flow of current. The difference between a conductor and an insulator is resistance. Conductors have low resistance compared with the circuit load. Insulators have such high resistance that current flow is too low to be of any consequence.

The other resistors on the board have too high values for the current required to light the lamp with the battery voltages that the wire uses, but they have proper values of resistance for the transistor circuits you will be experimenting with later on.

NOTE



WIRING SEQUENCE:
1-53, 2-44, 46-54.



CIRCUIT VOLTAGE

e previous experiments you learned how an electric circuit provides a complete path for cur- , and that resistances may be adjustable. But usually in these circuits we can control the unt of current by selecting how much voltage we apply. Low values of voltage cause low cur- ; high voltages cause high current to flow.

generally can choose battery circuit voltages to obtain a desired circuit current. The only ble with the common zinc-carbon batteries is that each cell has about 1.5 volts. This then re- es that our voltage be a multiple of 1.5, such as 1.5, 3.0, 4.5, 6.0, 7.5, 9.0, etc.

handy part of using these 1.5 volt cells for our voltage source is that we can connect to- er whatever number of cells we need for the required voltage. A 3.0 volt source can be ob- ed by connecting two cells in series, a 4.5 volt source with three cells, etc. How many cells needed for a 9 volt battery?

lamps in this kit are rated at 2.5 volts. The closest voltage we can obtain is 3.0 volts from cells in series. Actually, all flashlight lamps like these are rated a little less than the nearest ery voltage. This allows us to obtain good light output with batteries which are weak, and efore not capable of full rated voltage. The greatest disadvantage of higher lamp voltage is life. Lamps have short lives when higher voltages are applied, but last much longer when r voltages are used.

k up the circuit.

output voltage is 1.5 V when the switch is down and 3 V when it is up. Try these different ages and observe the lamp. Which voltage causes the greater lamp current? ch voltage would allow the Lamp to burn longer before it goes out?

not try to apply the 9 volt battery voltage to the Lamp. This voltage is too great compared the 2.5 volt lamp voltage rating. Circuit current would be excessive and burn out the Lamp ess the 9 volt battery were very, very weak). Also the lamps require about 300 milliamperes) of current. This is about 10 times more current than each cell inside the 9 volt battery is to deliver without running down almost immediately. We will use this battery for transistor uits which only draw a few milliamps of current.

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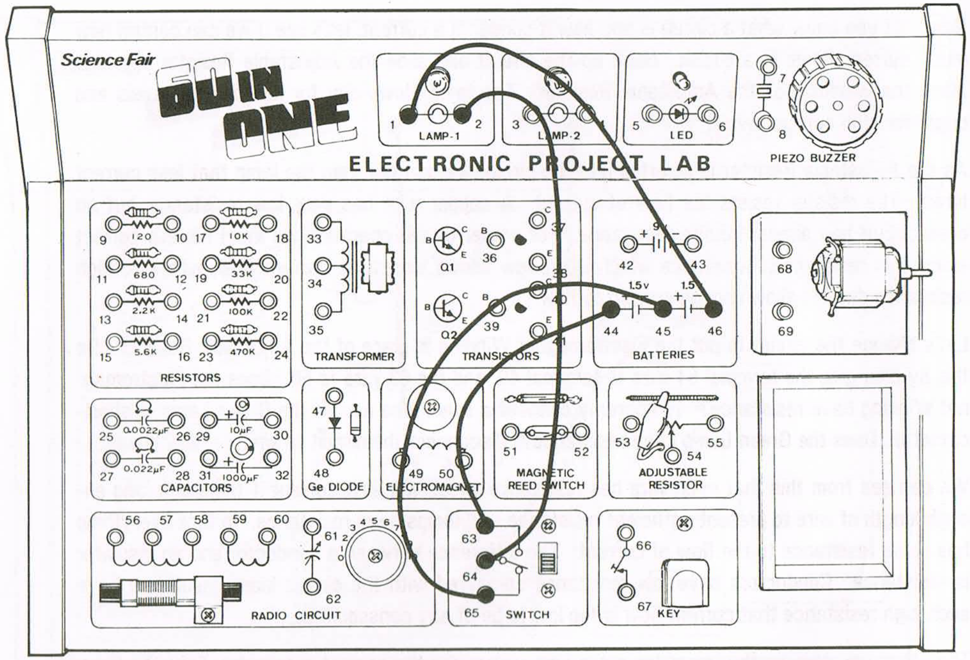
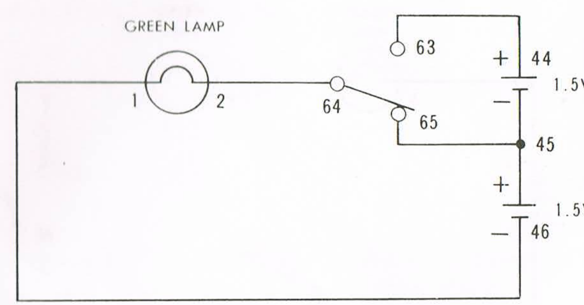


WIRING SEQUENCE:

1-46, 2-64, 44-63, 45-65.



SERIES CIRCUITS

e are two basic types of circuit connections that we can use for any two or more things h are wired into a circuit. These two different connection methods may be easily rememl if we can name them. The first method to consider is the one where the same circuit electurrent is made to flow through the two or more things one after the other. This type of cirs called the SERIES circuit. Each thing in a series circuit must conduct the same current. e things, we will call them circuit devices, are said to be "in series with each other".

up the series-circuit for this project. Notice that SWITCH and KEY must be ON for a Lamp ht, and that both Lamps light whenever one lamp is lighted. Both Lamps glow a little but not ll brilliance. Each Lamp drops one half of the total battery voltage of 3 volts because each has the same resistance. This means that each Lamp then has 1.5 volts across it. A olt lamp only glows dimly with 1.5 volts across it.

series circuit has three kinds of devices in series; cells, switch, key, and lamps. Each type of ce also has a series forming a Battery, Switch and Key in series, and two lamps in series.

will find series circuit in about every circuit you will use. Some examples of series circuits in- your door bell, lights, appliances, etc. Look around and you will see many series circuits. you describe in your own words what a series circuit is? Can you draw a schematic am of a series circuit?

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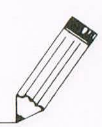
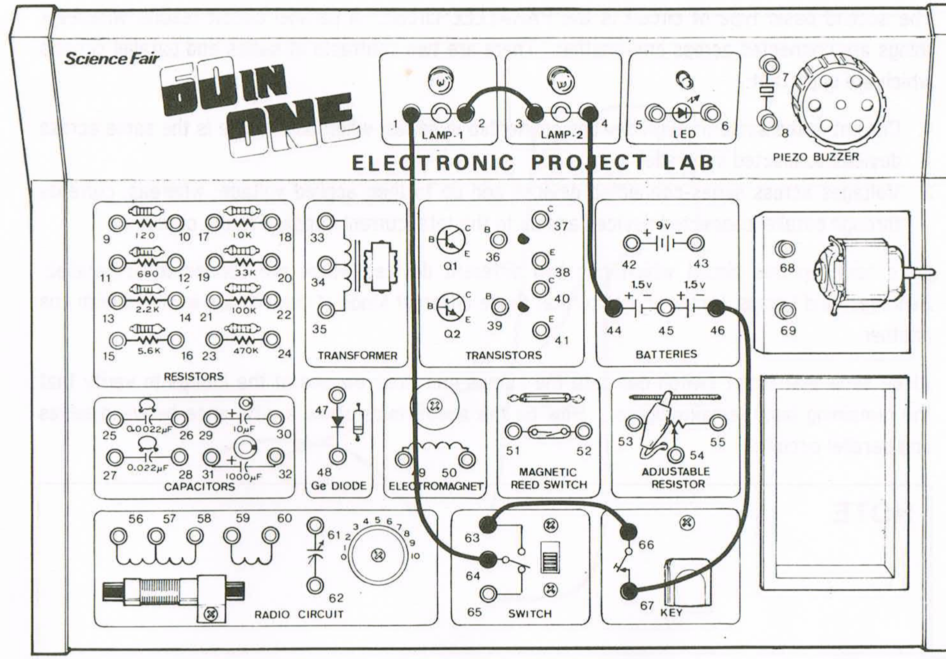
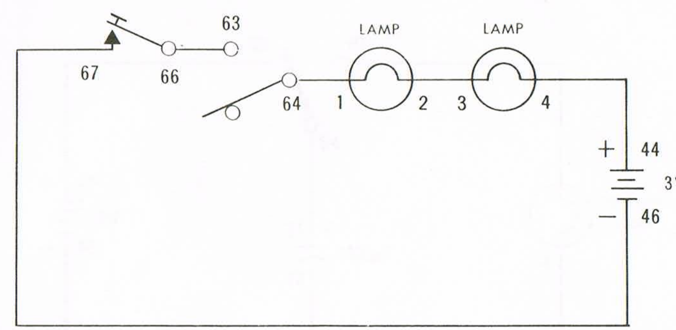




WIRING SEQUENCE:

1-64, 2-3, 4-44, 46-67, 63-66.



5. PARALLEL CIRCUITS

he second basic type of circuit is the PARALLEL circuit. A parallel circuit results whenever ings are connected across one-another. There are two contrasts of series and parallel circuits hich are important:

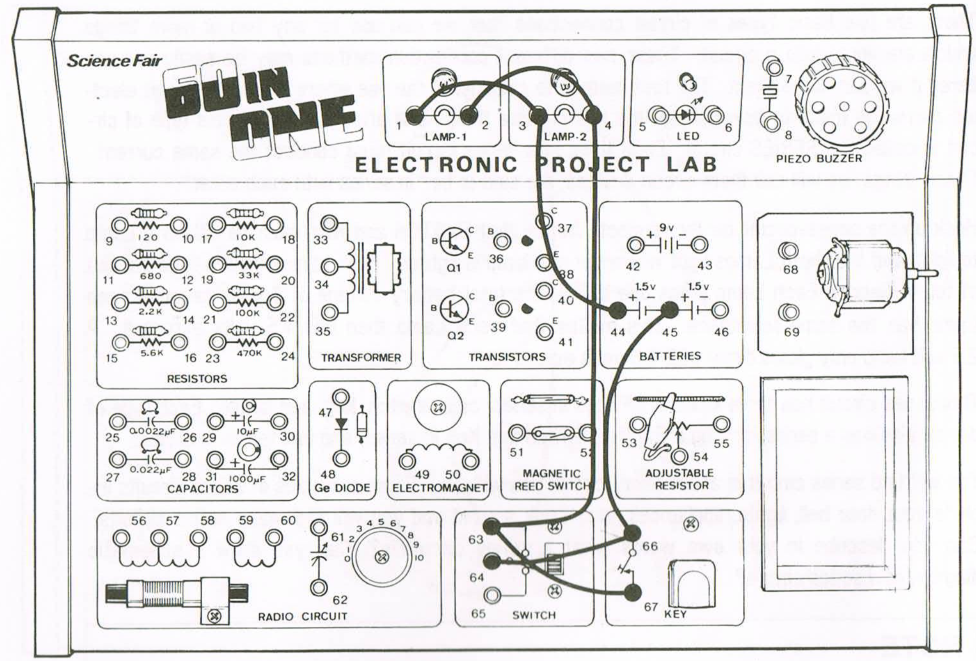
Current is the same through devices connected in series; whereas, voltage is the same across devices connected in parallel.

Voltages across series-connected devices add up to their applied voltage; whereas, currents through parallel connected devices add up to the total current supplied to the circuit.

et's hook up this circuit which has two different devices which are connected in parallel: witches, and Lamps. However, notice that these different kinds of devices are in series with one nother.

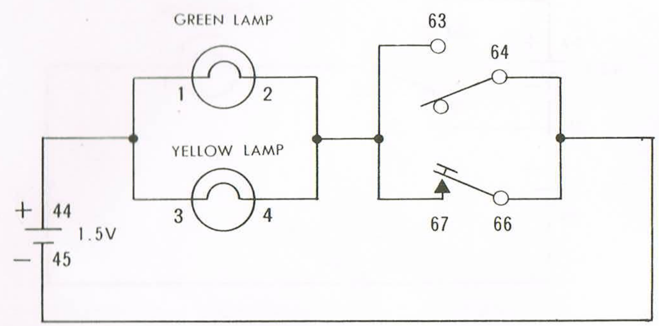
lso notice that either switch can turn the Lamps on. Unscrew one of the Lamps to verify that he remaining lamp remains lighted. How do the above tests show a difference between series nd parallel circuits?

NOTE



WIRING SEQUENCE:

1-3-44, 2-4-63-67, 45-66-64.



FLASH LIGHT

ind of flash light is not what you normally call a flashlight. This light produces a bright flash t so it can be correctly called a "flash light". This light is similar to a strobe flash used for graphy. Of course we are using an incandescent lamp; a strobe flash uses a rare gas) in a special arc lamp.

up the circuit, throw the switch down and charge the 1000 μF capacitor with the 9 V bat- Then, throw the switch up. The Lamp should flash one time as the energy stored in the Ca- r is dumped into the Lamp.

nly reason that the 2.5 volt lamp is not burned out by the 9 volt charge on the Capacitor is the low amount of energy stored within the Capacitor. Before the temperature of Lamp fi- t can increase to the burn-out point, the energy in the Capacitor is all used up.

ion: How can you apply 9 volts to a 2.5 volt lamp without burning out the lamp?
er: By applying it for only a fraction of a second as we are doing here.

olytic capacitors like the 1,000 μF unit used in this kit must be connected with their (+) and ads to the same polarity of the voltage connected. The (–) terminal 32 always to the (–) bat- erminal, and the (+) terminal 31 to the most positive voltage part of the circuit. The other capacitors are ceramic types which can be connected with either lead to either battery ter- without any trouble.

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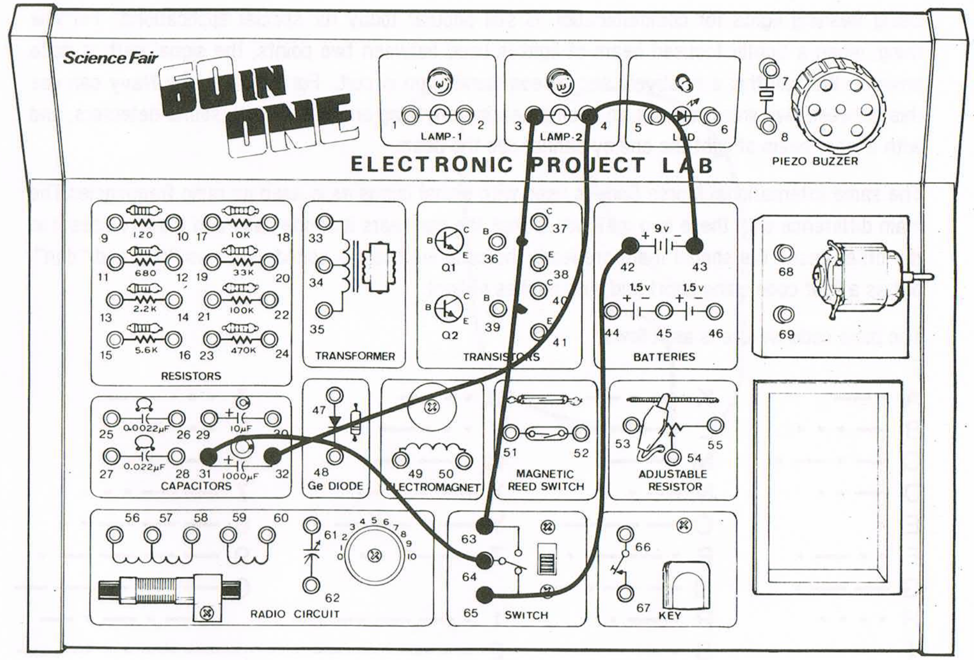
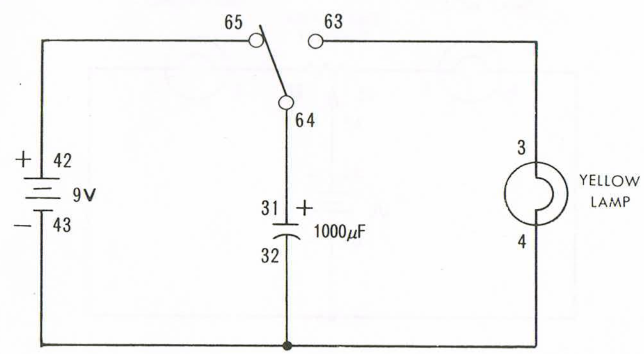


WIRING SEQUENCE:
3-63, 31-64, 32-4-43, 42-65



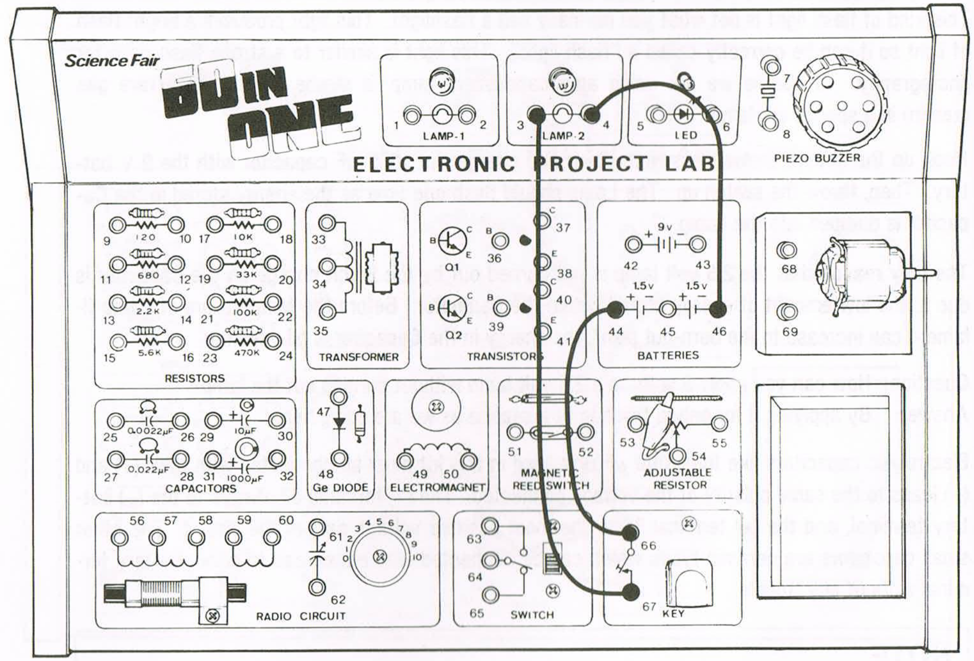
7. SIGNAL LAMP

Using flashing lights for communication is still popular today for special applications. For one thing, when a tightly focused beam of light is used between two points, the signal path is quite private. We call this a relatively secure communication circuit. For example, the Navy can use this between two ships without an enemy hearing anything on radio or with sound detectors, and with a laser beam of light the enemy cannot see the beam.

The same International Morse Code is used with signal lamps as is used on radio frequencies.The main difference with these two methods is that the ear hears it in one case and the eye sees it in the other case. We should therefore learn the code we hear as sounds such as "dit" and "dah", but as a light code using short and long flashes of light.

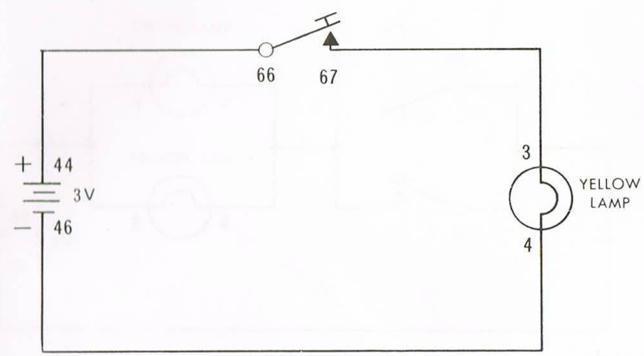
The lamp code we use is as follows:

A • —	K — • —	U • • —	4 • • • • —
B — • • •	L • — • •	V • • • —	5 • • • • •
C — • — •	M — —	W • — —	6 — • • • •
D — • •	N — •	X — • • —	7 — — • • •
E •	O — — —	Y — • — —	8 — — — • •
F • • — •	P • — — •	Z — — • •	9 — — — — •
G — — •	Q — — • —		0 — — — — —
H • • • •	R • — •	1 • — — — —	. • — • — • —
I • •	S • • •	2 • • — — —	, — — • • — —
J • — — —	T —	3 • • • — —	? • • — — • •



WIRING SEQUENCE:

3-67, 4-46, 44-66.



NOTE

FADER CONTROL

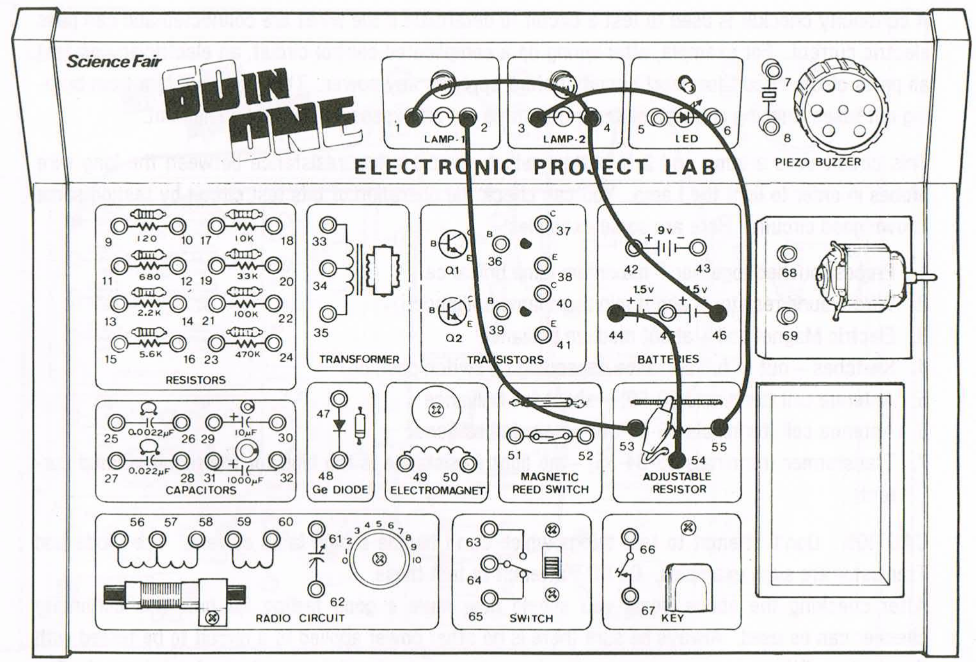
/ou ever been in a large auditorium or theater when the lights have been adjusted so that nt parts of the stage or auditorium become bright while other parts become dim? Well here cuit which is able to perform this kind of smooth control. It allows one light to go dim while ner light goes bright as only one control is adjusted.

djustable Resistor is used to control the current flow to the Lamps. When the Clip Lead is near the 53 terminal end, the current to the Green Lamp is high, but the current to the Lamp is low. When the Clip Lead is slid along the wire resistance element, the Green Lamp t gets smaller as the Yellow Lamp current gets larger. In the center of the element the ts are equal, resulting in equal lamp brilliance.

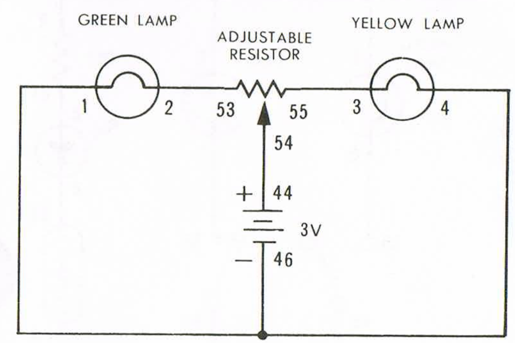
me kind of control is used on automobile speakers which are mounted in the front and rear car. This allows us to adjust the output so that the sound seems to be coming from the of the car. Also if someone in front or back wants to hear the radio when other passengers vant to be bothered by the radio while they talk, we can adjust for whichever speaker we

u think of some other applications of this fader circuit?

TE



WIRING SEQUENCE:
1-4-46, 2-53, 3-55, 44-54.



). VISUAL RESPONDING CONTINUITY CHECKER

continuity checker is used to test a circuit to determine if the wires are connected and can pass ectric current. For example, after wiring up a complicated control circuit, an electrician can test l parts of the circuit for short circuits before applying any power. This can save him from burn- g out fuses, tripping circuit breakers, or burning out an expensive piece of equipment.

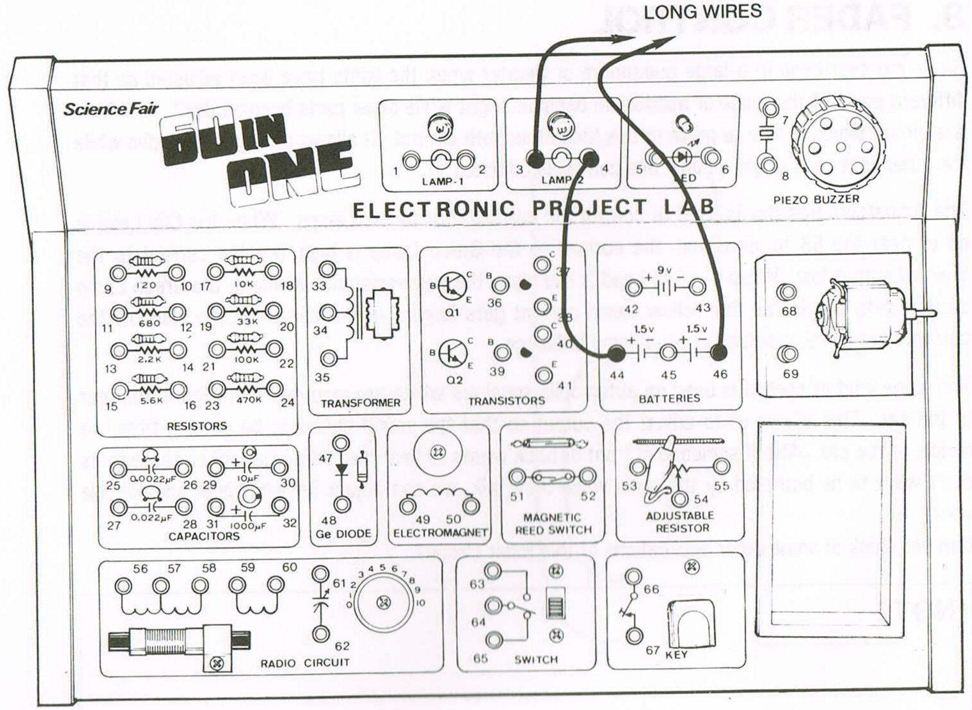
his circuit uses a lamp and 3 V battery which require a low resistance between the long wire robes in order to light the Lamp. You can check the operation of this test circuit by testing some nown good circuits. Here are some examples:

. Probes touched together – maximum lamp brilliance
. Wire-wound resistor – about minimum lamp brilliance
. Electric Magnet coil – about medium brilliance
. Switches – out or full brilliance depending on switch position
. Antenna coil (terminals 59-60) – about full brilliance
. Antenna coil (terminals 56-57-58) – near full brilliance
. Transformer (terminals 33-34-35) – no light (resistance is too high for the required lamp current).

CAUTION: Don't attempt to test things which can't handle a high lamp current. The Diode and Transistor are such examples. Do NOT attempt to test these.

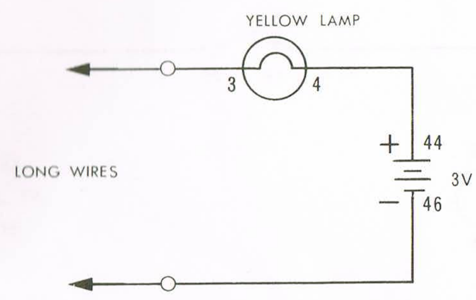
After checking the above items you should now have a good feeling for how this continuity checker can be used. Always be sure there is no other power applied to a circuit to be tested with this tester. Other power may cause the Lamp burn-out, circuit burn-out, or shock hazard. The ow 3 V of this circuit, of course, is safe by itself.

NOTE



WIRING SEQUENCE:

3-LONG WIRE, 4-44, 46-LONG WIRE.



TRAFFIC LIGHTS

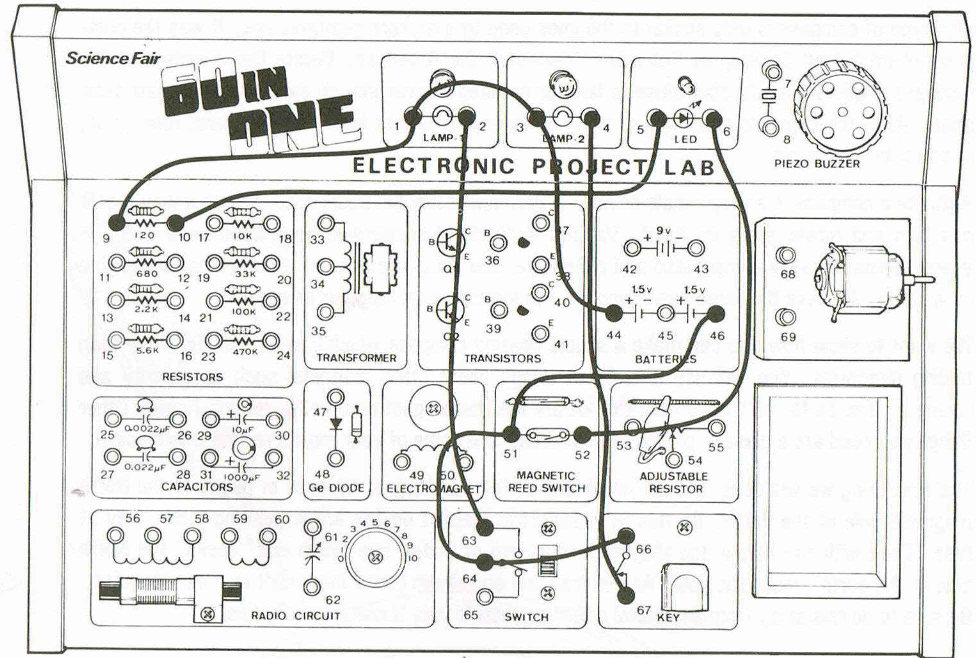
ellow, and green traffic lights have become universally used around the world. While there ecord of who first invented the traffic light, they seem to have first appeared in Detroit, an in the early 1920's. Traffic signs date back to the early Roman roads. With the inven- the automobile it became necessary for something such as lights to provide signals which e seen easily from a long distance.

traffic lights tend to be standardized in many ways. For vertically arranged lights the red op, yellow in the middle, and green on the bottom. The sequence is now arranged so that low light gives warning that a green is about to give way to a red, but usually a change d to green occurs without the use of the yellow light. This tends to keep people from start- on the yellow before any cross traffic has come to a stop.

raffic lights are now automatically controlled by the presence of a car above a sensing ele- the road. Also many lights are timed to aid the flow of traffic in the direction of the ma- f the cars on the road at the time.

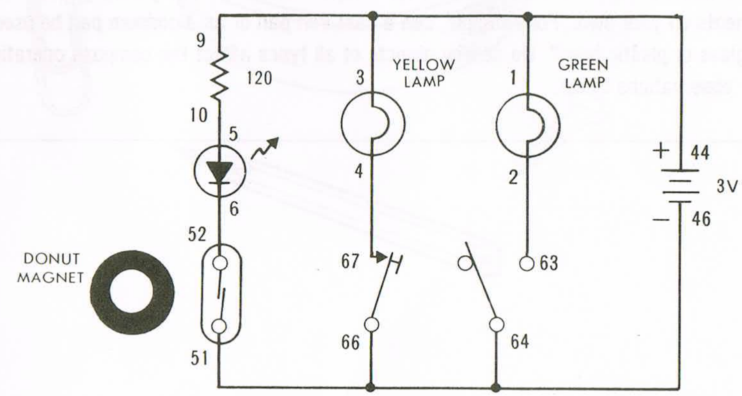
n use these traffic lights when playing with model cars or to teach your younger family r how traffic lights work and how to obey them. This can help them to keep from walking an intersection when they are facing a red light. You will want to practice with the circuit you can go from color to color smoothly. Have fun.
on the reed switch, bring the ring magnet near the reed switch.

TE



WIRING SEQUENCE:

2-63, 4-67, 5-10, 6-52, 9-1-3-44, 46-51-64-66.



11. COMPASS

This type of compass is very similar to the ones used by explorers centuries ago. It was the compass which helped Christopher Columbus "discover" the Americas. Before the invention of the compass, explorers would stay close to land or required a clear sky so they could navigate their ships. After the compass came along, men no longer had to fear losing sight of land, moon, sun, or stars for navigation.

Actually a compass is a very simple device - a permanent magnet suspended in such a way that it can turn and rotate easily by itself. Various methods of suspension have been used over the years. Some are very complicated and expensive, and some are no more than a magnet hanging by a string. All have the same basic function - to indicate directions for navigation.

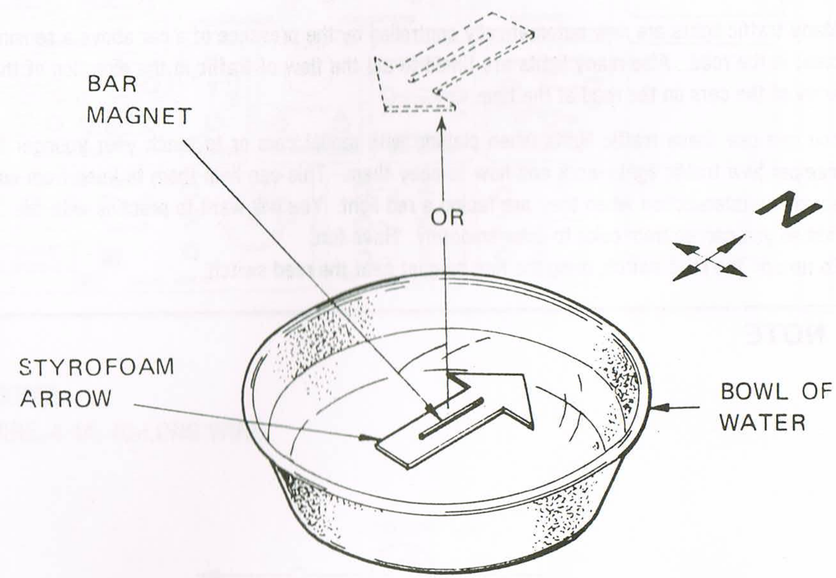
We want to show how you can make a simple floating compass which can be used for more than finding directions. You will use it to learn things about other magnets, such as polarity and strength. The parts you'll need from this kit are the Bar Magnet and the Styrofoam Arrow. Other things you need are a glass or plastic bowl of water and some of your mom's red fingernail polish.

The first thing we will do is find out which end of the Bar Magnet "seeks" or points to the North magnetic pole of the Earth. Do this by placing the Magnet on the arrow pointing either way at first. Then with the Arrow and Magnet in the bowl of water, see which end "seeks" the North pole of the earth's magnetic pole. At this time the styrofoam arrow may point in either direction. Be sure to do this away from any metal objects. Outside your home is usually best.

After you have determined which end of the bar magnet seeks North, remove it from the styrofoam arrow and paint this "N" end red with the nail polish. Nail polish is fast drying and quite permanent, and so it is suitable for this purpose.

When the nail polish is dry, insert the Bar Magnet back into the styrofoam Arrow with the painted end toward the arrow head. You will use this in later experiments, but now you may want to try some experiments on your own. For example, can a cast iron pan or an aluminum pan be used in place of the glass or plastic bowl? Do nearby objects of all types affect the compass operation? Describe your observations below.

NOTE



COMPASS

. MAGNETIC AND NON-MAGNETIC MATERIALS

n you were playing with the floating compass you no doubt noticed that some objects affect-e action of the compass, causing it to point away from North. Other objects had no effect on ompass. Let's consider why this is so.

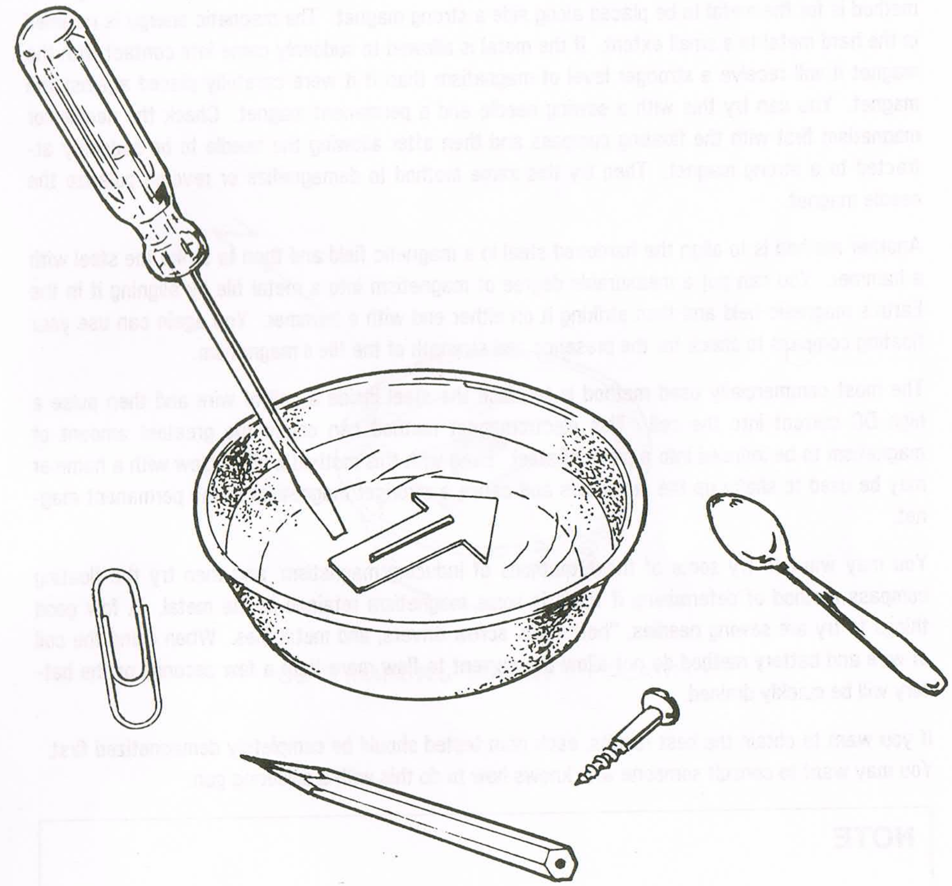
er some of the following household items to determine the way each one affects the floating net: tooth pick, paper clip, pencil, pen, small screw driver, all-metal bottle opener, steel screw, s screw, metal file, copper wire, aluminum measuring spoon, needle, etc.

with the floating compass in the center of the bowl of water, bring each of the items near the pass and verify the following:

Non-magnetic materials cause no movement of the compass.
Magnetic materials which are not magnetized themselves cause either end of the compass to be attracted to it.
Magnetic materials which are magnetized themselves cause one end of the compass to be attracted and one end to be repelled. When this magnetized material is turned around end-for-end, then the repelled end is attracted and vice versa.

efully try each item along with any others you want to experiment with. List the items below ording to how they affect the floating compass as described above. We'll consider the magne-d materials further in another experiment. The non-magnetized materials cause the magnetic e to be concentrated in the metal. This concentration of magnetism causes the metal to act a magnet itself. This induced magnetism is always attracted to the magnetic force which is sing it. This is why these metals are attracted to either end of the compass bar magnet.

NON-MAGNETIC MATERIALS	NON-MAGNETIZED MAGNETIC MATERIALS	MAGNETIZED MAGNETIC MATERIALS



13. PERMANENT MAGNETISM

In the previous experiment on magnetic and non-magnetic materials, you noticed how magnetized items can attract and repell the bar magnet. If you check each of these magnetized items you will notice that there is something common about each of these. Most or all of these are made of hardened steel. The metal file is a good example and a sewing needle is another. These items retain magnetism like the compass bar magnet.

Many permanent magnets are magnetized naturally by methods so simple that it is amazing. One method is for the metal to be placed along side a strong magnet. The magnetic energy is retained in the hard metal to a small extent. If the metal is allowed to suddenly come into contact with the magnet it will receive a stronger level of magnetism than if it were carefully placed against the magnet. You can try this with a sewing needle and a permanent magnet. Check the needle for magnetism first with the floating compass and then after allowing the needle to be suddenly attracted to a strong magnet. Then try this same method to demagnetize or reverse polarize the needle magnet.

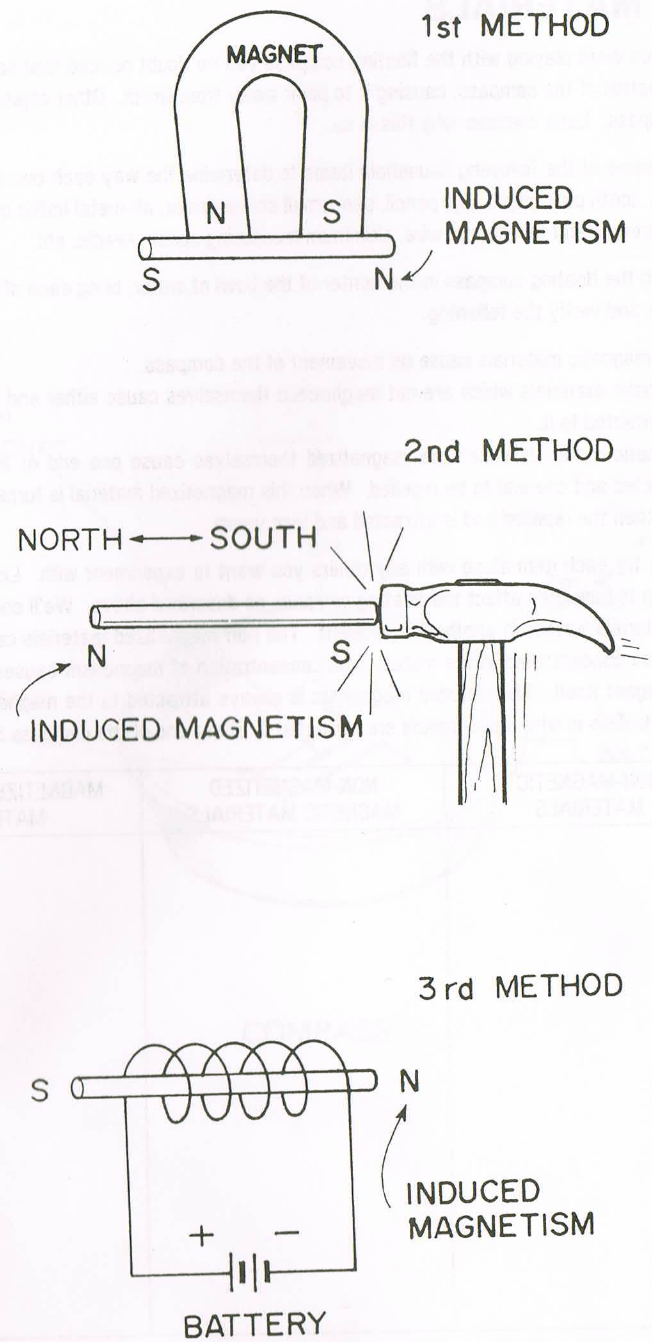
Another method is to align the hardened steel in a magnetic field and then to strike the steel with a hammer. You can put a measurable degree of magnetism into a metal file by aligning it in the Earth's magnetic field and then striking it on either end with a hammer. You again can use your floating compass to check for the presence and strength of the file's magnetism.

The most commercially used method is to place the steel inside a coil of wire and then pulse a high DC current into the coil. This electromagnet method can cause the greatest amount of magnetism to be induced into a piece of steel. Even with this method a short blow with a hammer may be used to shake up the molecules and cause a stronger magnetism in the permanent magnet.

You may want to try some of these methods of inducing magnetism, and then try the floating compass method of determining if there is some magnetism retained in the metal. A few good things to try are sewing needles, "hot" nails, screw drivers, and metal files. When using the coil of wire and battery method do not allow the current to flow more than a few seconds or the battery will be quickly drained.

If you want to obtain the best results, each item tested should be completely demagnetized first. You may want to consult someone who knows how to do this with a soldering gun.

NOTE



. MAGNETIC POLARITY

etism, like direct current (DC) voltage from a battery, has polarity. That is, one end of a per-nt magnet will always seek the north magnetic pole of the Earth. This end is then called the l of the magnet as it seeks the North, while the other end is labeled S.

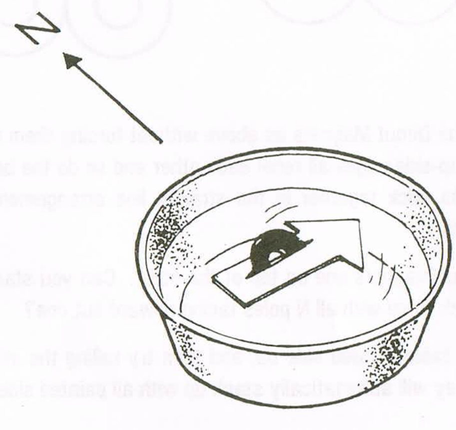
previous experiment, you have painted the N end of the Bar Magnet with red finger nail po-Now we want to mark the N side of each of the three donut magnets. Do this by placing one into the slot of the Styrofoam Arrow like you did with the Bar Magnet, and determine n side of the donut magnet seeks North. Be sure to do this in an area free of magnetic ma-s. Paint the N side of each donut magnet with the red finger nail polish.

part of the magnet that most strongly seeks North is called the magnetic pole. Long narrow tend to magnetize with N on one end and S on the other end of the longest dimension. The Magnet is an example of this. The donut magnets in this experiments are magnetized with N e flat side and S on the other flat side. You can prove this for yourself by placing one of the magnets flat side down on the Styrofoam arrow as a floating compass. Notice that it n't seek North. Now place it in the slot in the Arrow, and you will see it align itself strongly the painted side toward North.

e note that the poles of the magnets you have been using are not actually North and South . Let's see why not. Not too far from the geographic North pole is a point on the earth's sur-called 'the magnetic North pole'. It is through this point that lines of magnetic force flow gh and around the earth. Your compass magnet aligns itself along the lines of the earth's etic field. Therefore, the pole that points North is a North seeking pole. And, by convention, efer to the other pole as the South seeking pole although there is no actual South magnetic

you describe now what we mean by 'magnetic polarity' and how you would determine what it with a new magnet?

OTE

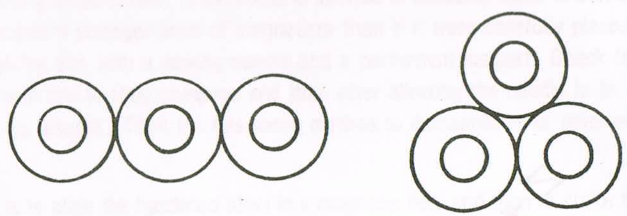


DETERMINING MAGNET POLARITY

15. MAGNETIC ATTRACTION AND REPULSION

One of the most important properties of a magnet is: LIKE-REPEL, UNLIKE ATTRACT. This means that S poles repel other S poles but attract N poles, and likewise N poles repel each other but attract S poles.

Now that you have painted the N poles of the Donut Magnets in a previous experiment we can use them to have fun with this law of magnetism. Try to arrange the Donut Magnets on a smooth table top with all N poles (painted sides) facing upwards in the following arrangements. Try to have each magnet touch its neighbor magnet.

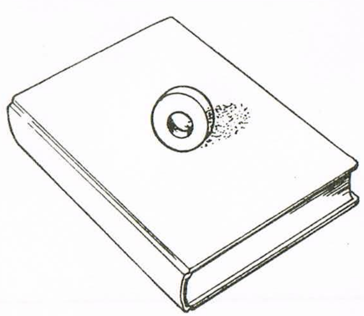


Obviously you can't arrange the Donut Magnets as above without forcing them to come together. The reason for this that the top-side edges all repel each other and so do the bottom-side edges. Can you arrange them now to stick together in the straight line arrangement? This one is a fooler. Try this on your friends.

Now let's try sticking the donut magnets one on top of the other. Can you stack them with all N poles facing up? Can you stack them with all N poles facing upward but one?

If you lay one magnet on the table painted side up, and then try rolling the other two up to this one, what are the odds that they will automatically stack up with all painted sides up? Try this on your friends.

Here is a typical carnival trick! Hide a donut magnet inside the front cover of a hard-bound book. Now try to balance another donut magnet on its edge on the cover of the book. It can't be done directly over the inside magnet. The trick of course is for you to balance the Magnet on the cover of the book first before slipping the Magnet inside the front cover. Now after someone bets you he can do it too, you slip the magnet inside. This can lose friends so don't force him to pay up.



Each one of these tricks demonstrate the properties of all magnets: like poles repel, unlike poles attract. When you have learned this law of magnetism you can begin to put magnetism to work for you. It is this property of magnetism which is used in electric motors to cause the shaft to rotate and do work for us. Can you find other places around your home where magnetic attraction or repulsion is used?

Now that you have an idea of the basic properties of all magnets, let's see how we can put those properties to work for us.

Place all three donut magnets on a wooden pencil or plastic bodied ball point pen. Make sure that like poles face each other so each magnet repels its neighbor.

Now as you tip the pencil to get the magnets to fall to the lower end of the pencil you will see the action of a magnetic spring. Even when the pencil is held vertically, and the bottom donut is kept from coming off, they are prevented from touching each other. This experiment works best if the pencil is somewhat large in diameter so it almost fills the donut magnet holes.

This magnet spring action could be used where something must be supported without having a conduction path between the supported object and the support. The main problem with this of course is that it takes very strong magnets to support much weight. This magnetic action is still waiting for an inventor to make good use of it. Would you like to be that inventor?

Try doing this same thing using a piece of string in place of the pencil. Can you explain why it won't work? You might use this method when asking someone to try to get these magnets to pass from one hand to the other on some device (such as a string) without the magnets touching one another. After you have allowed the friend to try it with a string, you take out your pencil and do it like magic.

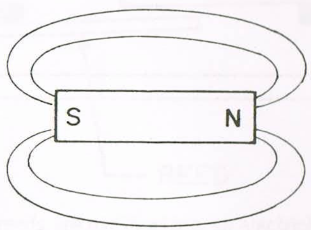
After showing your friend how easy it is done, you might want to quickly remove the magnets from the pencil and ask him if he can stack them on the pencil the first time so that all magnets repel their neighbors. If he can do it the first time, your friend understands the basic law of LIKE POLES REPEL.

Here's a thought to give to your friend. When holding the pencil vertically so that only the bottom donut magnet is resting on your fingers, are you also having to support the weight of the other magnets even though they are floating above the bottom magnet?

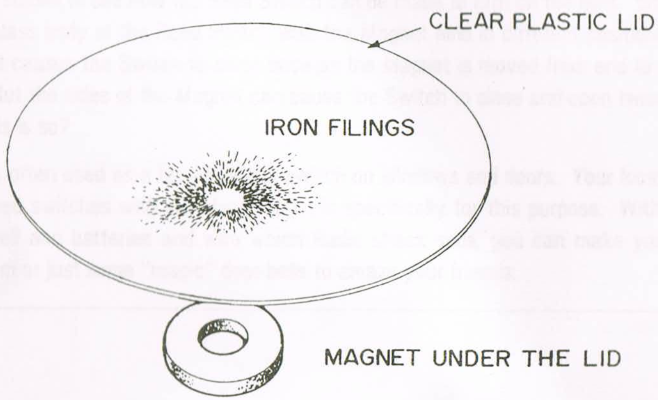
16. MAGNETIC LINES OF FORCE

lagnetism is a strange force to most people. The reason for this may be because it can't be een. On the other hand, springs don't surprise people because they can see the coiled up steel hich is causing either a pulling or pushing force. What we need then is some way to visualize is invisible magnetic force.

omeone long ago found that if small particles of soft iron, or iron filings, are brought near a trong magnetic field, they form patterns of shapes which help us to visualize the invisible magne- c lines of force. The iron dust tries to form a complete bridge between the N and S poles of a agnet. This shows us that the force is BETWEEN THE MAGNETIC POLES.



orrow a clear plastic lid from your mother. It can be a refrigerator dish cover, a coffee can lid, c. Spinkle some fine iron filings on the smooth side of the lid and then place this down over a uple of donut magnets lying on the table. The iron filings will arrange themselves along the es of magnetic force. Tap on the lid with your finger in order to vibrate it. This hastens the for- ation and helps overcome friction on the surface of the lid.



u'll want to try different magnets and different positions for the magnets to verify that the agnetized strings of iron particles always try to connect themselves between the N and S poles. y not to get the iron dust particles near the magnet without the plastic lid between them or they ll stick to the magnet and be difficult to remove. If you do get some stuck to a magnet, you can e a sewing needle which is magnetized like a magnetic broom to brush the particles to a weak ot on the magnet, where they will then stick to the needle instead of the magnet. The needle n then be easily wiped clean of particles.

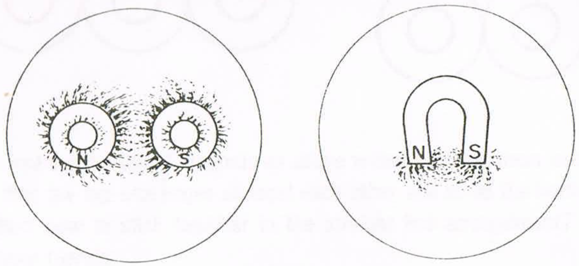
NOTE

17. ATTRACTING AND REPELLING LINES OF FORCE

Use the iron filings and plastic lid from the previous experiment for this experiment. What we want to see here is how the action of the iron filings follows definite laws of magnetism. These laws may be stated as:

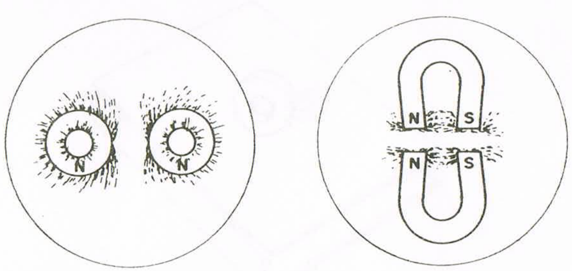
1. Lines from S poles are attracted to N poles (and N poles to S poles).
2. Lines from S poles are repelled from S poles (and N poles from N poles).

The first of these laws we can see with a single horse-shoe magnet or with two of the donut magnets. Lay the donut magnets next to each other on the table with one N side up and one S side up. Place them just far enough apart to keep them from sticking together. Tap the lid as you did in the previous experiment to get the best alignment of particles. Your results should be something like this.



The second law deals with the repelling action. This requires two of either donut or horse-shoe magnets in order to see the results of the repelling action. Place the Magnets as close together as the repelling force will allow. Now when the iron filings are placed over the Magnets the results should be something like shown below. Notice the area between the poles is free of filings because no lines of magnetic force cross from pole to pole but are repelled from each other.

Now after trying both of these magnetic laws you can see why the Donut Magnet always causes the iron filings to vacate the area over the donut hole. The magnetic polarity all around the hole is the same (either N or S) so there is a strong repelling force on the face of the Magnet around the hole. This action is the same as that between the two magnets which are placed near each other with the same type poles facing each other.

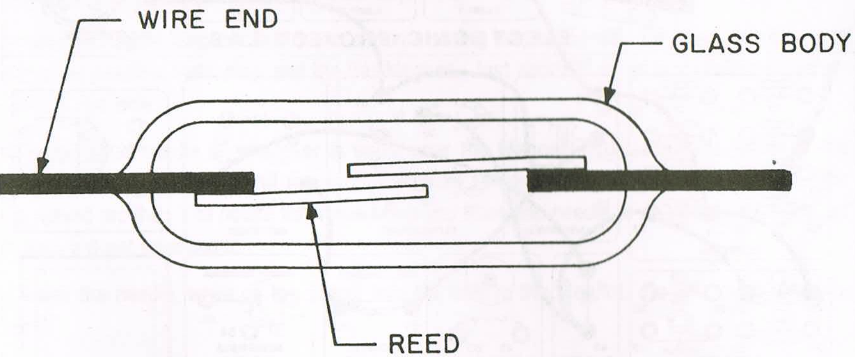


Armed with these two laws you can now tell from the arrangement of iron filings how the fields of magnetism are arranged. After experimenting with these filings a while you will be able to visualize the magnetic forces without having to use the filings. When you can do this, magnetism is no longer a strange unknown force. Have fun!

NOTE

3. REED SWITCH

netic lines of force can make two soft iron objects (like pins, needles, or nails) stick together. Reed Switch is made of two very soft iron reeds which are positioned in their glass body so they are very close together but not quite touching.

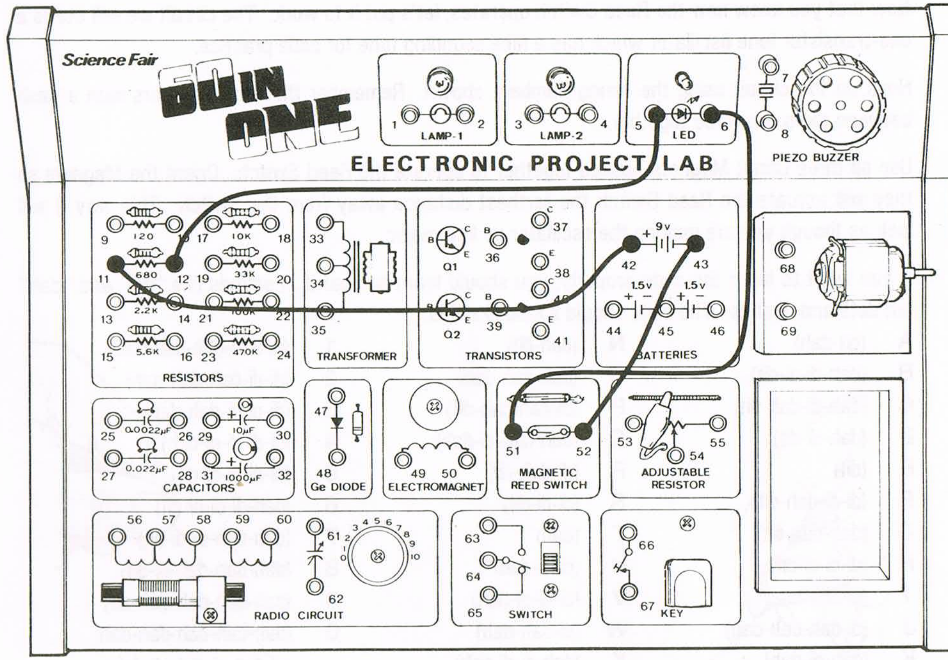


n no magnets nearby the reeds are not touching, so electricity cannot pass through. This is si- r to an open switch. When a strong magnet is brought near the Switch, the reeds pass the netic lines of force and become attracted to each other like little magnets. This is then a ed switch. When the magnet is removed the reeds come apart because they are very soft which does not retain much permanent magnetism.

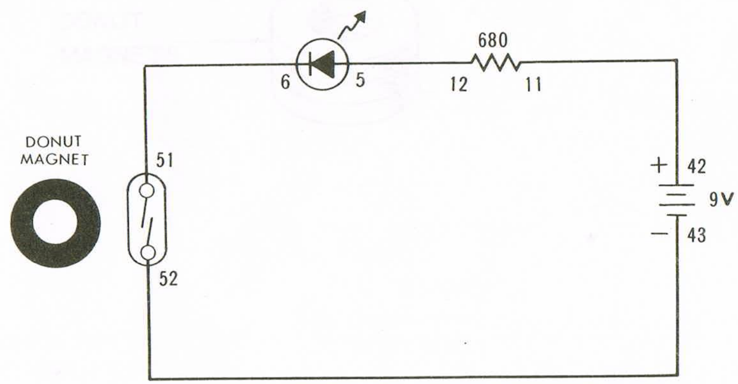
k up the circuit shown to see how the Reed Switch can be made to turn on the light. Move the net along the glass body of the Reed Switch with the Magnet held in different positions. The e of the Magnet causes the Switch to close once as the Magnet is moved from end to end on Reed Switch. But the sides of the Magnet can cause the Switch to close and open twice. Can explain why this is so?

Reed Switch is often used as a burglar alarm switch on windows and doors. Your local Radio ck store has reed switches with matching magnets specifically for this purpose. With these the buzzers, bell and batteries and wire which Radio shack sells, you can make your own glar alarm system or just some "magic" door bells to amaze your friends.

OTE



WIRING SEQUENCE:
5-12, 6-51, 11-42, 43-52.



19. REED SWITCH CODE KEY

Now that you know how the Reed Switch operates, let's put it to work. The circuit we will use is a one-transistor tone oscillator which has a nice sounding tone for code practice.

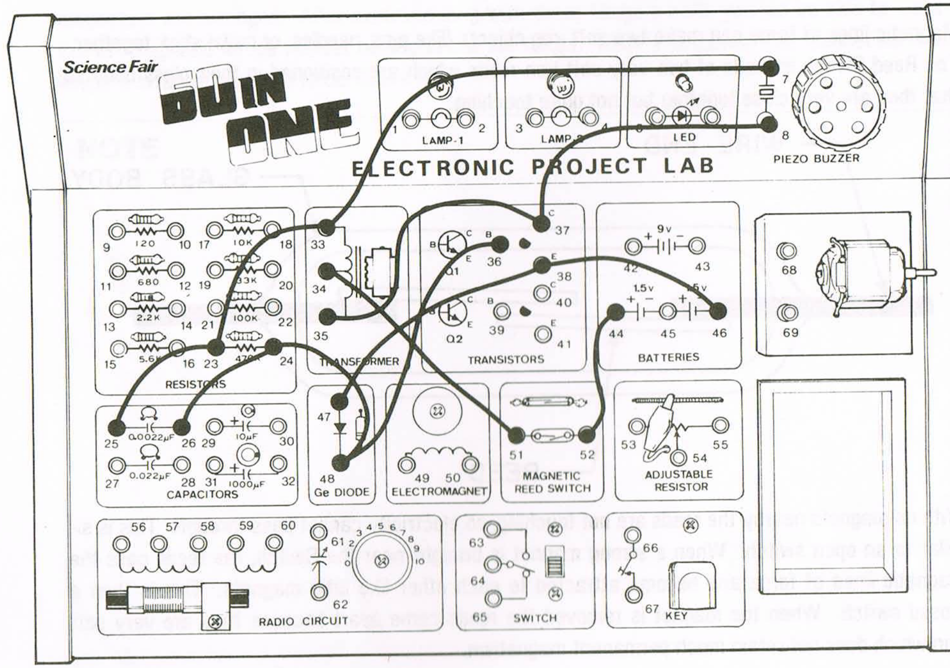
Hook up the circuit using the wiring numbers shown. Remember that only numbers with a dash between them are wired together.

Use all three Donut Magnets hooked together to operate the Reed Switch. Orient the Magnets so they will actuate the Reed Switch the farthest distance away from the Switch. This way it will look as though you are making the oscillator go like magic.

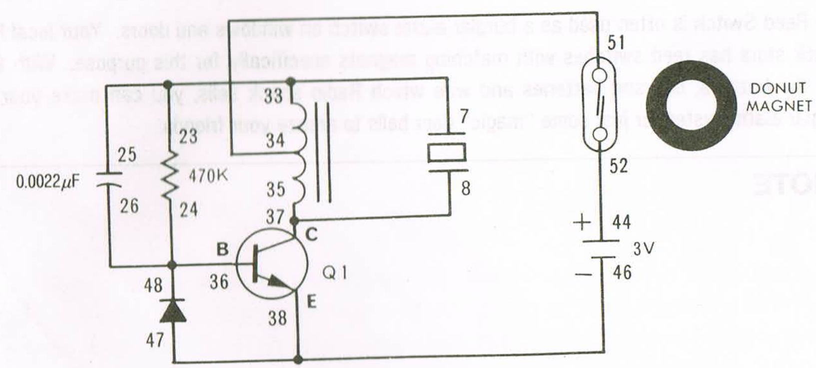
If you want to learn the code properly, you should learn to hear it in sounds like "dit" and "dah" not dots and dashes. The code should sound like this:

A	(dit-dah)	N	(dah-dit)	1	(di-dah-dah-dah-dah)
B	(dah-di-di-dit)	O	(dah-dah-dah)	2	(di-di-dah-dah-dah)
C	(dah-di-dah-dit)	P	(di-dah-dah-dit)	3	(di-di-di-dah-dah)
D	(dah-di-dit)	Q	(dah-dah-di-dah)	4	(di-di-di-di-dah)
E	(dit)	R	(di-dah-dit)	5	(di-di-di-di-dit)
F	(di-di-dah-dit)	S	(di-di-dit)	6	(dah-di-di-di-dit)
G	(dah-dah-dit)	T	(dah)	7	(dah-dah-di-di-dit)
H	(di-di-di-dit)	U	(di-di-dah)	8	(dah-dah-dah-di-dit)
I	(di-dit)	V	(di-di-di-dah)	9	(dah-dah-dah-dah-dit)
J	(di-dah-dah-dah)	W	(di-dah-dah)	0	(dah-dah-dah-dah-dah)
K	(dah-di-dah)	X	(dah-di-di-dah)	.	(di-dah-di-dah-di-dah)
L	(di-dah-di-dit)	Y	(dah-di-dah-dah)	,	(dah-dah-di-di-dah-dah)
M	(dah-dah)	Z	(dah-dah-di-dit)	?	(di-di-dah-dah-di-dit)

NOTE



WIRING SEQUENCE:
7-33-23-25, 8-37-35, 26-24-48-36, 34-51, 44-52, 46-38-47.



. CRAZY PENDULUM

nvisiable magnetic forces can be used to play all kinds of tricks. We are conditioned to ex- the results of the forces of gravity which are also unseen, but it is strange for us to see some e reactions caused by the magnet forces available to us. Let's experiment with some of magnetic powers on common household items.

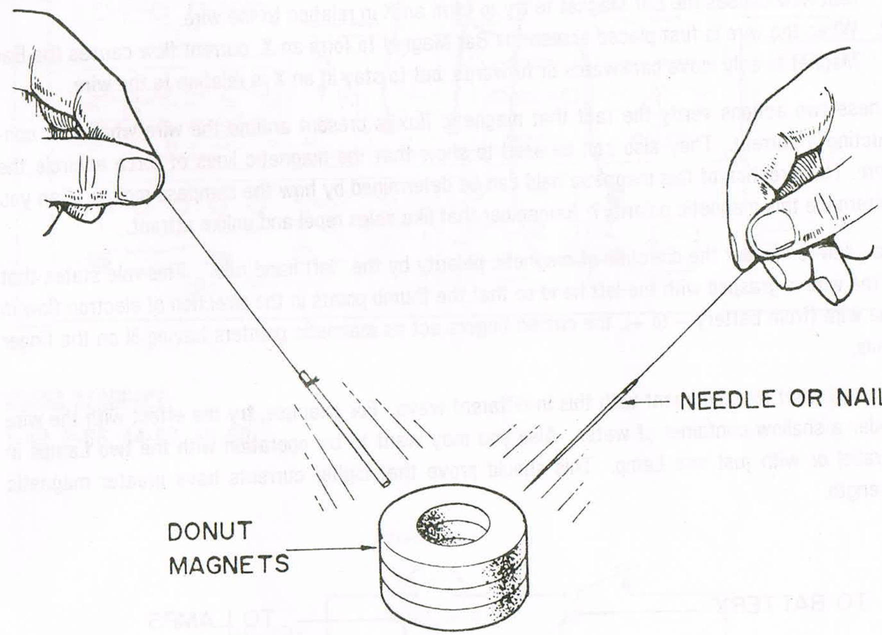
the stacked Donut Magnets in order to obtain a strong magnetic field. Tie some thin thread to things as needles, nails, pins, and the Bar Magnet. Just about 6" or so is sufficient to exper- t with it this time.

e swinging the needle or whatever is used, near the Magnet, notice how the power of the net can capture it and cause it to continue to point to some spot on the Magnet even as the g is moved around. You notice this most when you allow the needle to be within about 1/8" of Magnet, but not touching it.

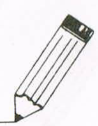
to lower the needle, while on the string, into the hole in the Magnet. Do you know why you 't do it?

e the Donut Magnets up on the table, side by side, with two N sides up and one S side up. ce the one with the S side up in the middle. Now try to slowly swing a magnetized needle or Magnet over the Donut Magnets along the line formed by the magnets. Why can't this gnetized pendulum swing in a straight line?

p a string through one of the Donut Magnets and try to swing it like a pendulum over the re- ining two magnets. When the two magnets are placed with opposite poles facing upward, and swinging donut kept about 1/4" above them, where does the swinging magnet always get cap- ed? Can you explain its action in terms of magnetic force laws, like repel, and opposite at- ct? Draw an illustration of how these magnets arrange themseleves.



NOTE



21. ELECTRO-MAGNETISM

Now that you have experimented with permanent magnets you will want to advance into magnets created by an electric current. It is a basic fact of electricity that anytime an electric current (electrons) moves in a circuit there is always a magnetic field present. This is true for a single wire just as well as for a coil of wire. First we want to see the effects of magnetism from a single wire which is conducting a current.

Put the Bar Magnet and Styrofoam Arrow in a small dish of water like you did for the COMPASS experiment. Now wire up the circuit according to the wiring instructions. Use the long wire supplied in this kit to form a single wire electromagnet over tne compass.

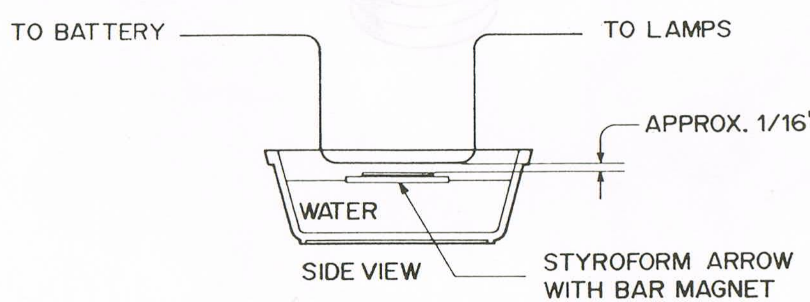
There are two actions you will want to observe as you press the key:

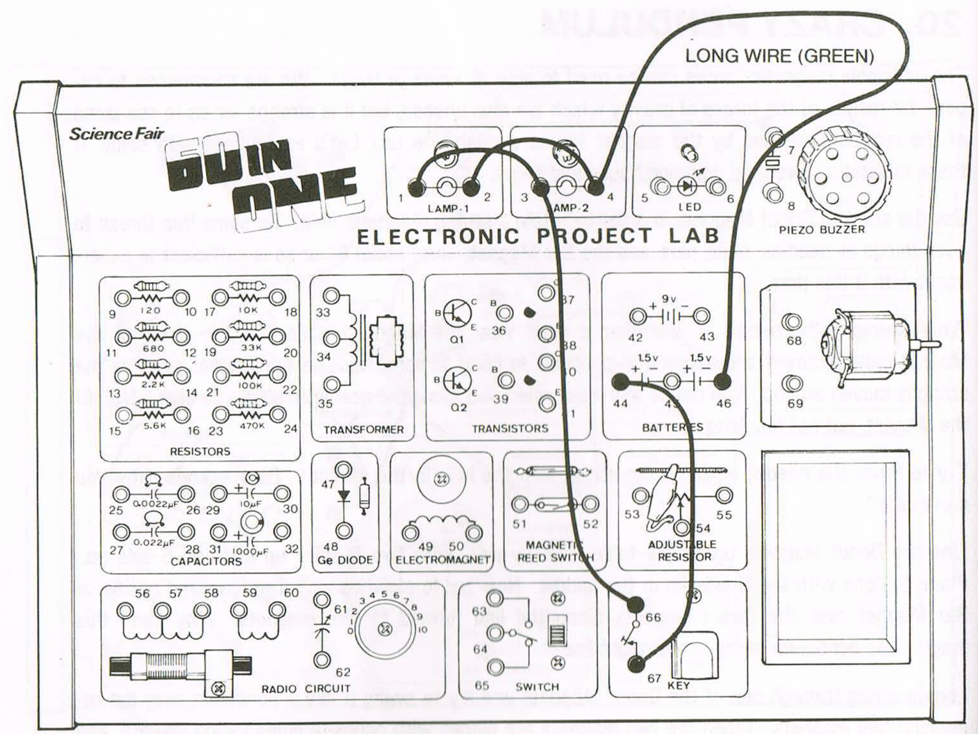
1. When the wire is first placed along the length of the Bar Magnet as shown in the drawing, current flow causes the Bar Magnet to try to form an X in relation to the wire.
2. When the wire is first placed across the Bar Magnet to form an X, current flow causes the Bar Magnet to only move backwards or forwards, but to stay in an X in relation to the wire.

These two actions verify the fact that magnetic flux is present around the wire when it is conducting a current. They also can be used to show that the magnetic lines of force encircle the wire. The direction of this magnetic field can be determined by how the compass moves. Can you determine this magnetic polarity? Remember that like poles repel and unlike attract.

You can remember the direction of magnetic polarity by the "left hand rule". This rule states that if the wire is grasped with the left hand so that the thumb points in the direction of electron flow in the wire (from battery – to +), the circled fingers act as magnetic pointers having N on the finger nails.

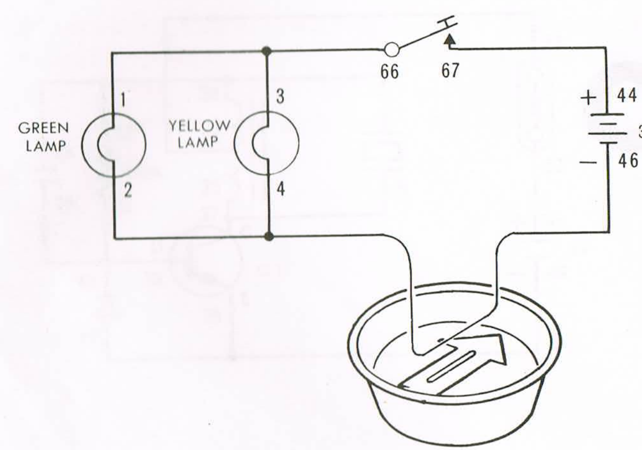
You will want to experiment with this in different ways. For example, try the effect with the wire under a shallow container of water. Also you may want to try operation with the two Lamps in parallel or with just one Lamp. This should prove that higher currents have greater magnetic strength.





WIRING SEQUENCE:

1-3-66, 2-4-LONG WIRE (GREEN)-46, 44-67.



ELECTRO MAGNET

gh a single wire can show magnetic field strength, a coil of wire can concentrate this field can obtain a much stronger electric magnet. It is this electric magnet which is used to per-vork for us. Maybe you have seen the big electric magnets which are used to move steel These are this same basic type of electromagnet.

up the circuit according to the wiring instructions. We are using a Lamp to limit the current nd save some battery life. The Key switch is also used in order to save power and allow us ily turn the current on and off.

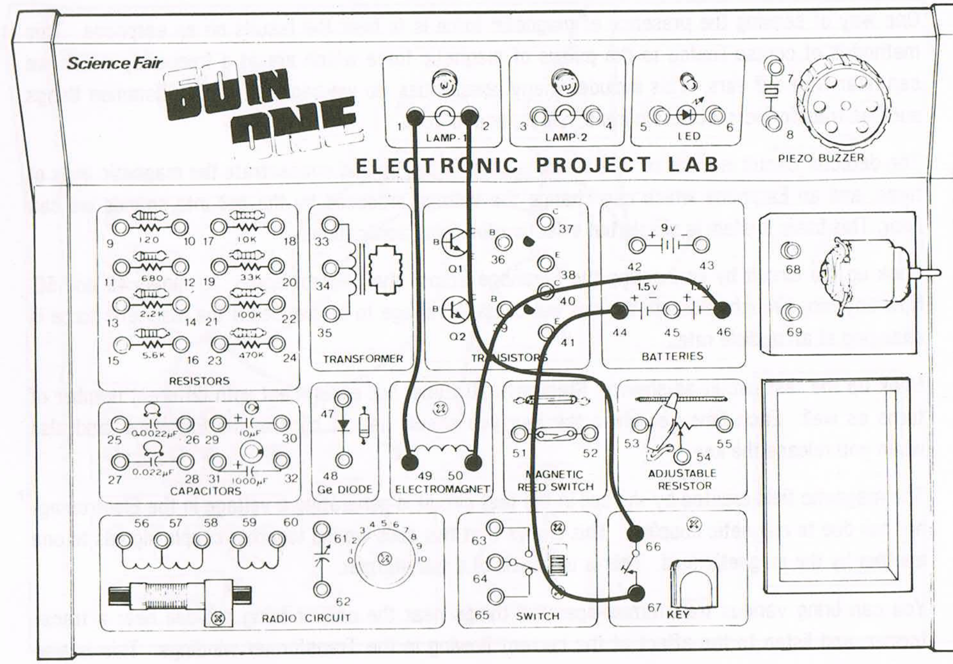
e string and needle, nail, pin, and magnets you used for the CRAZY PENDULUM experiment ermine the electric magnet effects. Notice how you can cause pendulum action to be in-ed by properly pulsing the Key switch. Some older electric clocks have used this method to a pendulum swinging.

vitching the leads to terminals 49 and 50 on the electromagnet. Does this change the poles magnet (N to S and S to N)? How can you tell? Use a magnetized needle for best results checking this.

that a different symbol is used in this schematic than the one used on the panel. This is to you another symbol which is used for this device. You will find other symbols used besides but you might as well start by learning these two kinds first.

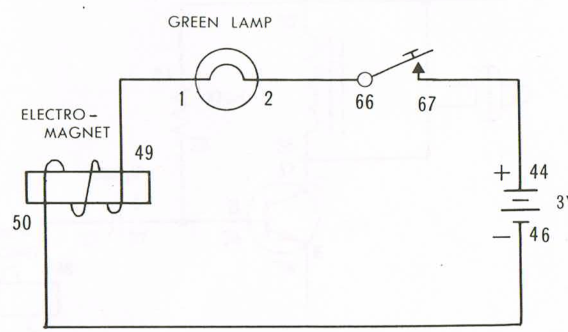
omagnets are in common use around the home as well as in every factory, school, hospital, Some devices which use electromagnets are bells, buzzers, motors, vibrators, and relays. ou list some of the things around your house which use electromagnets?

TE



WIRING SEQUENCE:

1-49, 2-66, 44-67, 46-50.



23. MAGNETIC PULSE DETECTOR

One way of sensing the presence of magnetic force is to hear the results on an earphone. This method is of course limited to the pulses of magnetic force which are at a frequency which we can hear with our ears. This includes many possibilities, so we can check some common things such as transformers, soldering irons, relays, and motors.

The detector circuit is a coil of wire which is used to pickup and concentrate the magnetic lines of force, and an Earphone which can change the voltage produced by the coil into sounds we can hear. This basic system is simple but effective for some applications.

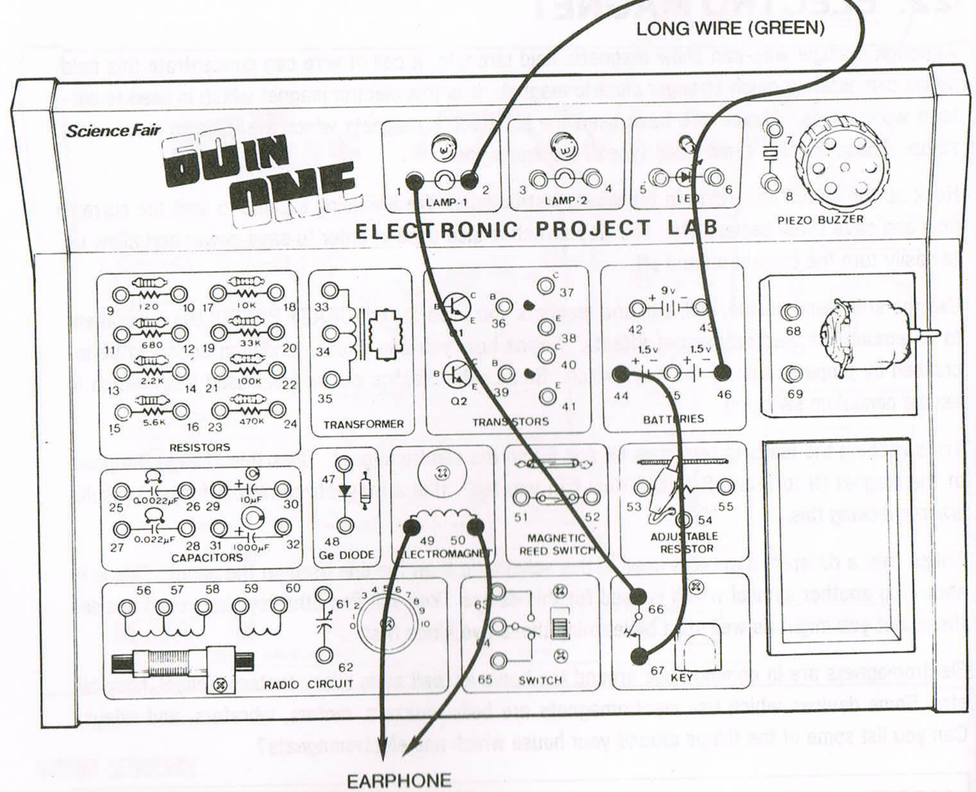
Hook up the circuit by connecting the Earphone across the Electromagnet, terminals 49 and 50. Now anything brought close to the coil will cause a voltage to be induced if the magnetic force is changing at an audible rate.

Hook up the test circuit as shown. Start with 10 turns, but experiment with different number of turns as well. Each time you close the Key you should hear a click in the Earphone, and also when you release the key.

The magnetic field created by the coil in the test circuit is generating a voltage in the Electromagnet coil due to magnetic coupling. This shows that two coils wound together couple signals to one another by the magnetic field. This is the basis of a transformer.

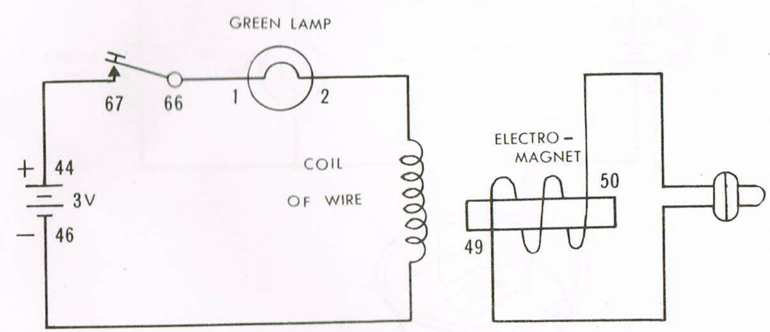
You can bring various transformer-operated things near the coil, or bring the coil near a transformer, and listen to the effect of the current flowing in the Transformer windings. This is also true for electric motors and other current operated devices. A soldering gun brought close to the coil will generate an especially strong 60 Hertz signal. Experiment with some things around the house but don't get near any voltage or rotating tools, etc., which may be dangerous.

NOTE



WIRING SEQUENCE:

1-66, 2-LONG WIRE (GREEN)-46, 44-67, 49-EARPHONE, EARPHONE-50.



24. AMPLIFIED MAGNETIC PULSE DETECTOR

ou probably noticed that the magnetic pulse detector which used only a coil and earphone was ot very sensitive. That is, it took quite a large magnetic change coupled to the coil in order to ear anything in the Earphone. The logical answer for this situation is to add an amplifier so that ne sensitivity can be greatly increased. This circuit does this for you.

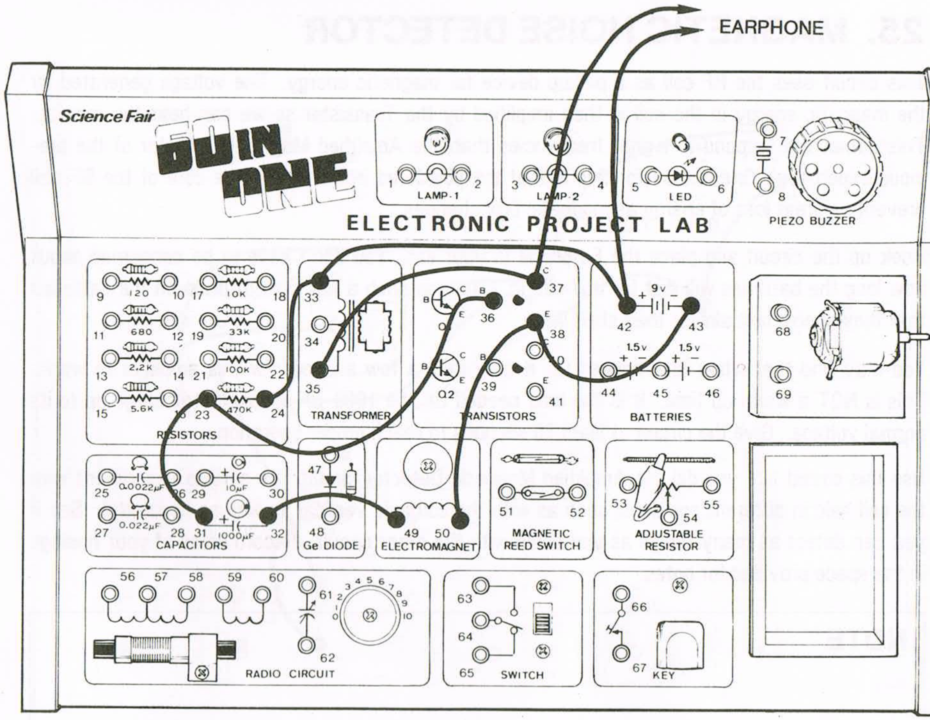
he circuit takes the very low voltages generated in the Electromagnet coil and increases them ıany times, typically 200 times or so. This makes the coil sensitive enough to even be able to ear a telephone receiver's magnetic field. It can also be used to find electrical wiring which is arrying the current from a light dimmer control to the light. The vertical synchronization on a elevision set is so strong that this circuit can detect when the set is turned on by hearing the 60 ertz buzz. Just bring the coil near the set and experiment with what position gives a strong pick p. The television yoke transformer is radiating this strong signal.

ou will find it fun just to walk around your home with this circuit and find how many places in our house have strong magnetic fields. You will soon realize that all light dimmers, fluorescent mp ballasts, and transformers radiate a strong magnetic field. Aren't you glad that such fields re not harmful? Imagine the problems that might be caused if they were.

ı summary, you should now know that a coil of wire which has a current flowing in it will gener- te a magnetic field. Furthermore, the very same coil can be used as a detector of magnetic elds by noting a current being generated within the windings of the coil.

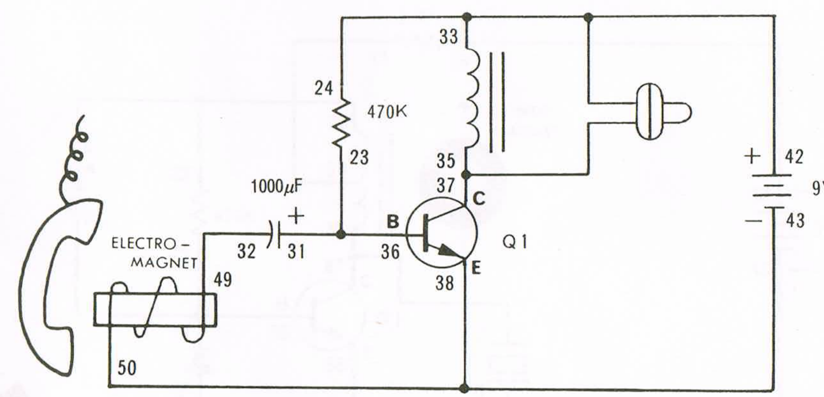
he laws which we take advantage of when we use coils as Electromagnets were first put forth / a French scientist Andre Maria Ampere in 1826. The unit of current, the ampere, is named fter him. The law dealing with the generation of current in a coil due to magnetic flux is attribut- d to Michael Faraday, an English physicist, in 1831. These applications have been with us for a ng time.

NOTE



WIRING SEQUENCE:

24-33-42-EARPHONE, EARPHONE-37-35, 31-23-36, 32-49, 43-38-50.



25. MAGNETIC NOISE DETECTOR

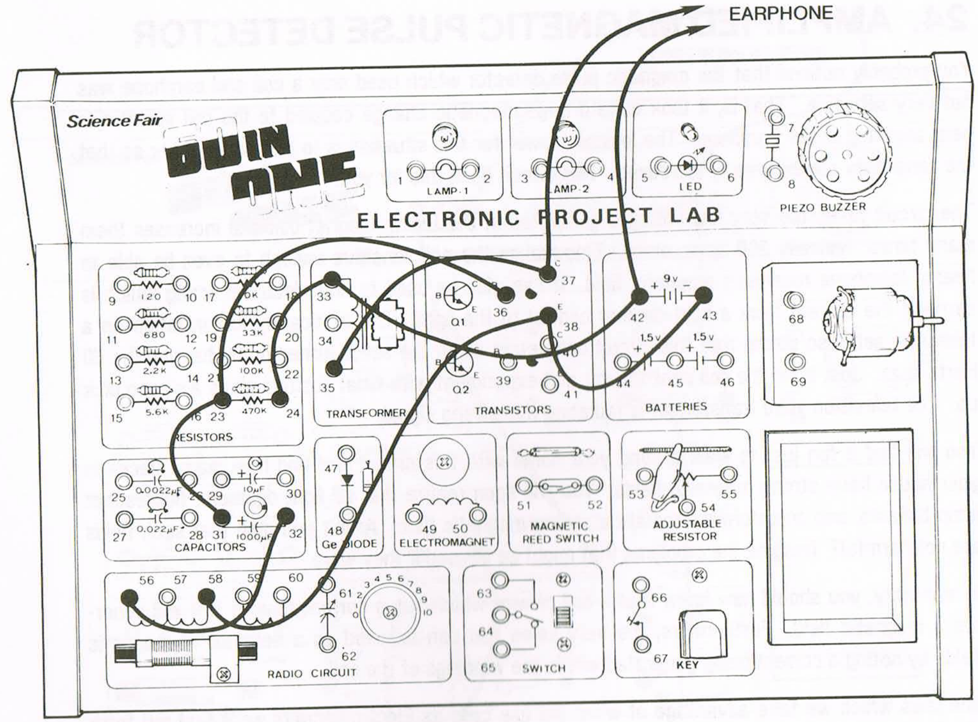
This circuit uses the RF coil as a pickup device for magnetic energy. The voltage generated by the magnetic energy in the coil is then amplified by the Transistor so we can hear the results. This circuit will respond to higher frequencies than the Amplified Magnetic Detector of the previous experiment. One reason for this is that the powdered iron used for the core of the RF coil prevents a great loss of energy as magnetic flux changes.

Hook up the circuit and place the Earphone in your ear. You don't have to be concerned about how long the batteries will last for this circuit. There is such a low current drain on the batteries that they should last almost their shelf life.

You may find that when first hooked up, it may take a few seconds for this amplifier to work. This is NOT a warm up time. It is the time needed for the 1000 μF capacitor to charge up to its normal voltage. Give the circuit at least 30 seconds to reach proper operation.

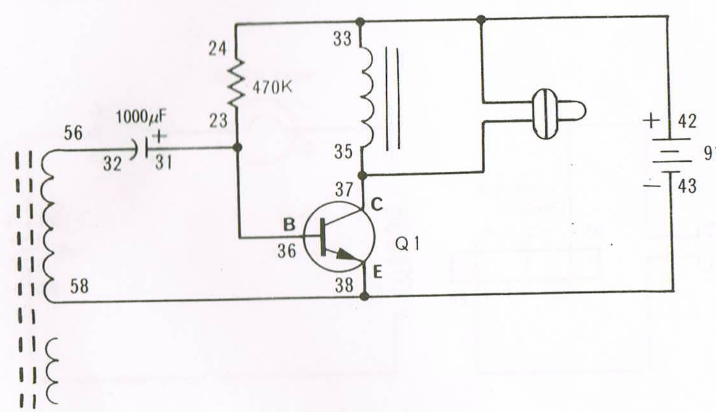
Use this circuit like you did the Amplified Magnetic Detector circuit. Be sure to experiment with the coil held in different positions, such as with the coil axis vertical as well as horizontal. See if you can detect as many things as you could with the other circuit. Record some of your findings in the space provided for notes.

NOTE



WIRING SEQUENCE:

24-33-42-EARPHONE, EARPHONE-37-35, 31-23-36, 32-56, 43-38-58.



6. MAGNETIC EFFECTS ON INDUCTANCE

experiment uses a low-level, square wave oscillator to demonstrate how magnetic lines of e can disturb the magnetic force in a transformer. The transformer is made up of many turns ire on a soft iron core resulting in high inductance. Inductance is a rating of the relationship veen the voltage generated across the coil and the current change causing it. A high induc- e causes a high voltage to be generated as current is changed.

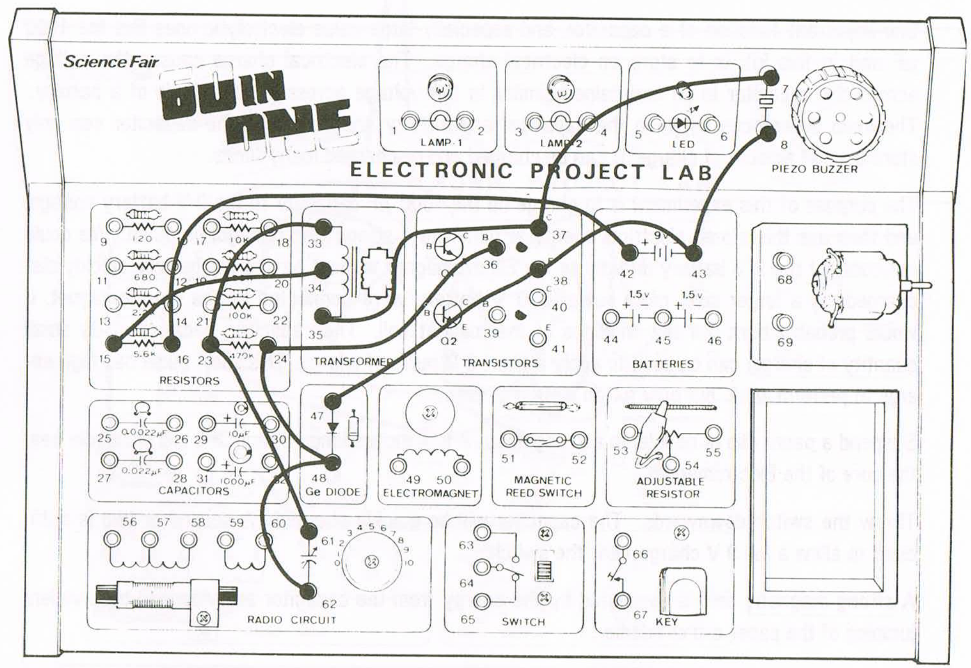
up the circuit and adjust the Tuning capacitor for a pure sounding tone. Depending on how h gain your Transistor has, you may be able to disconnect the Tuning capacitor from the cir- to obtain a pure tone, or you may have to set the capacitor fully counter-clockwise and warm ne Transistor with your fingers to get oscillations to start. Oscillations are weak but very pure ne.

g a Donut Magnet near the Transformer. Notice that the oscillations change whenever the nanent Magnet is being moved near the Transformer. This is because the magnetic flux from Magnet disturbs the magnetic path in the Transformer which is used for feedback to keep the lations going.

nets stuck together and moved around the Transformer should make you able to stop oscilla- .

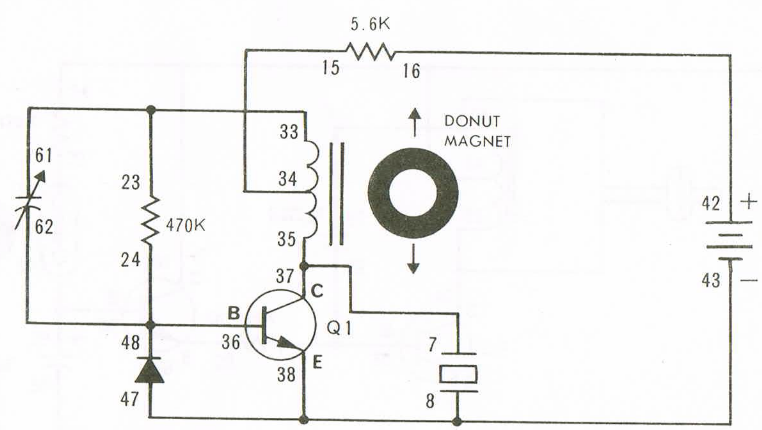
effect of two magnetic fields in an inductor or transformer is put to use in some industrial rol devices. The constant voltage transformer and the saturable reactor are two examples.

OTE



WIRING SEQUENCE:

7-37-35, 8-43-38-47, 15-34, 16-42, 33-23-61, 62-48-24-36.



27. MAGNETIC PULSE GENERATOR

One important function of a capacitor, and especially large value electrolytic ones like the 1000 μF unit in this kit, is to store an electrical charge. The electrical charge causes the voltage across the capacitor to be maintained similar to the voltage across the terminals of a battery. The main differences between the capacitor and battery are that while the capacitor can only store a small amount of charge, it can be charged and discharged many times.

The purpose of this experiment is to charge up the 1000 μF capacitor to the 9 V battery voltage, and then use this stored electrical energy to generate a strong electromagnetic pulse. We could not connect the 9 V battery directly to the Electromagnet without having the battery quickly discharged. If a larger size, more powerful 9 V battery were connected to the Electromagnet, it would probably burn out the windings of the magnet coil. The capacitor, because of its small quantity of charge, can be used to apply a short 9 V pulse of energy. This short pulse has high energy to perform work, but only for an instant of time.

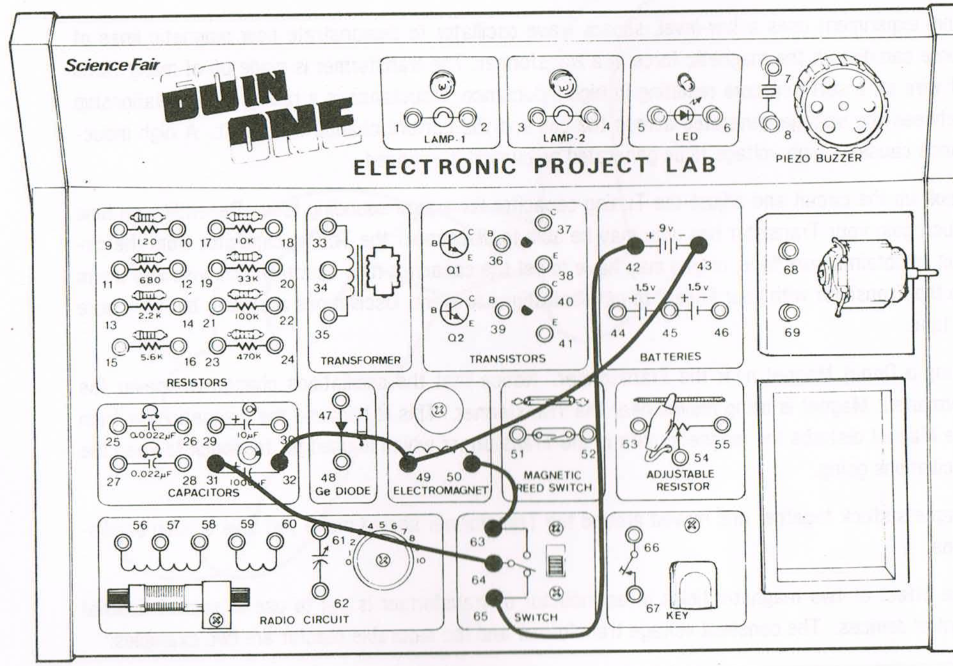
Suspend a paper clip or needle on a string about 2 to 4 inches long. Dangle the clip or needle near the core of the Electromagnet.

Throw the switch downwards. The capacitor will be quickly charged. A second or two is sufficient to allow a full 9 V charge. Lift the switch.

A strong magnetic field is generated by the energy from the capacitor as evidenced by a violent jumping of the paper clip or needle.

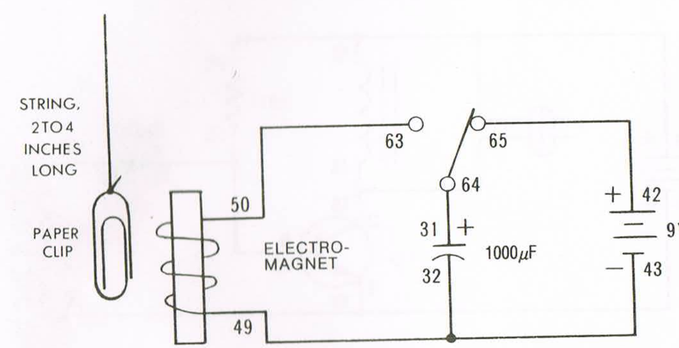
You may want to experiment with how long the capacitor charge can be stored. A very good capacitor can hold a charge for hours.

NOTE



WIRING SEQUENCE:

31-64, 32-49-43, 42-65, 50-63.

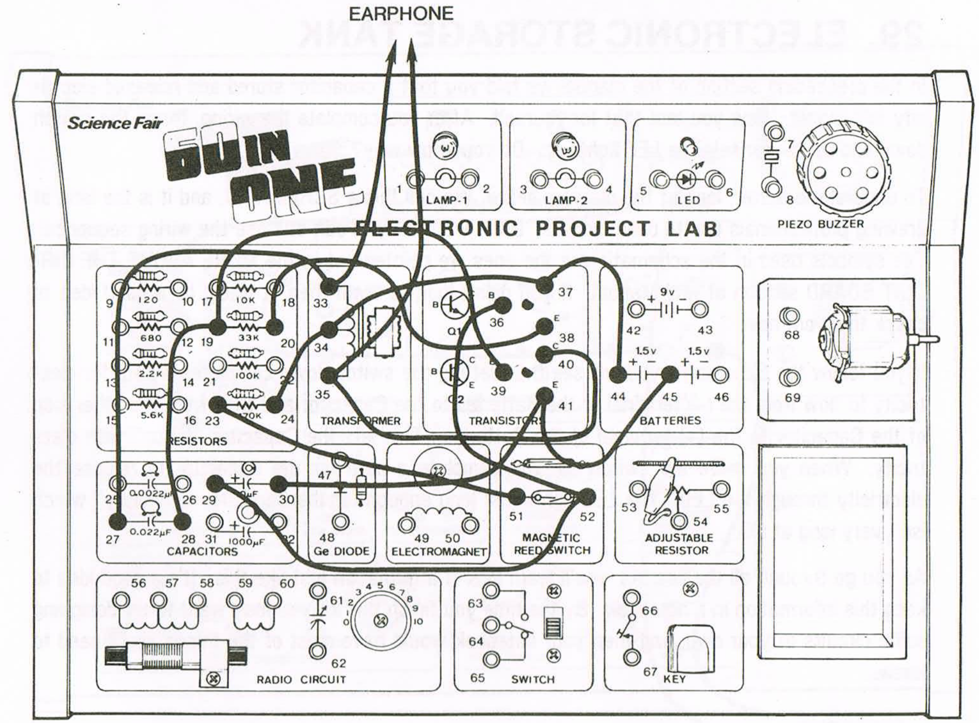


28. ELECTRONIC SIREN

this circuit, one transistor forms the blocking oscillator and another transistor controls the os- ation frequency. This transistor limits the current to be supplied to the base resistor of the nsistor forming the blocking oscillator, and changes the sound tone level to provide a sound like iren.

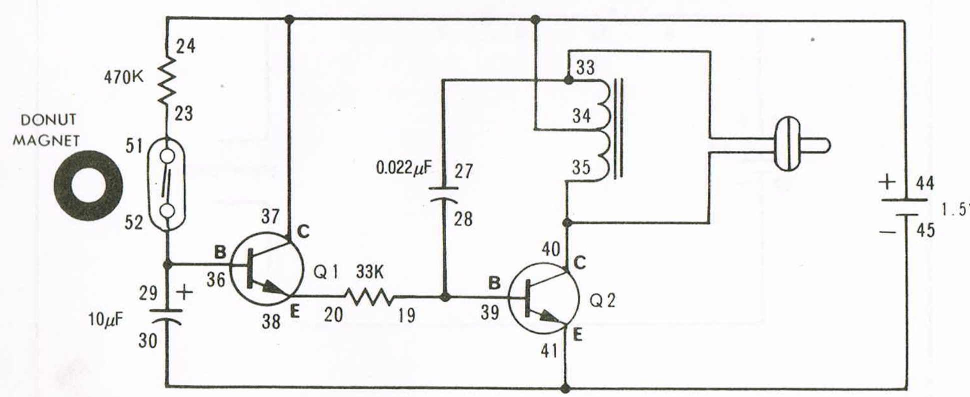
ter you finish the wiring, bring the ring magnet near the reed switch to turn it on. Then, the und tone will be sequentially raised to the siren level. Next, separate the magnet from the itch to turn it off. Then, the sound tone will be sequentially lowered. Play by moving the ring agnet to and fro. Replace the 470 k ohm resistor by a 100 k ohm resistor. The time required to ange the sound tone will be changed.

NOTE



WIRING SEQUENCE:

20-38, 23-51, 24-34-37-44, 27-33-EARPHONE, EARPHONE-35-40, 29-52-36, 30-41-45, 28-19-39.



29. ELECTRONIC STORAGE TANK

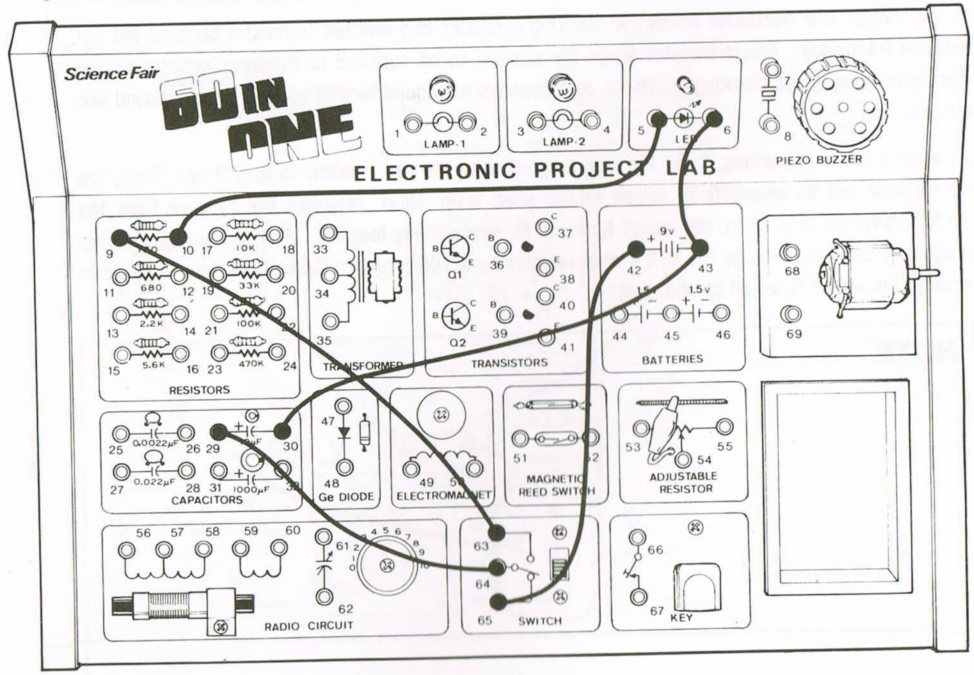
In the preceeding section of the manual we told you that a capacitor stored and released electricity in a circuit. Now you test that for yourself. After you complete the wiring, throw the switch down and up. Surprise! The LED lights up. Do you know why?

To understand better, look at the diagram below. We call this a SCHEMATIC, and it is the kind of drawing professionals use to build circuits. Don't worry... you can still use the wiring sequence. The symbols used in the schematic are the ones we pointed out in the MORE ABOUT THE CIRCUIT BOARD section of this Manual. If you didn't look at them then, it would be a good idea to check them out now.

If you follow the Schematic, you will see that setting the switch down completes a path for electricity to flow from the (–) terminal of the Batteries to the Capacitor and then from the other side of the Capacitor to the (+) terminal of the Batteries. This lets the Capacitor "fill up" with electricity. When you move the switch up, you complete a path for the Capacitor to release the electricity through the LED. The LED lights just long enough for the Capacitor to "empty" which isn't very long at all.

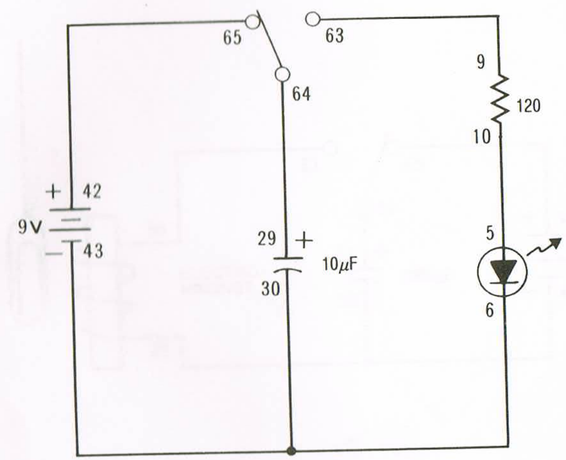
As you go through all the circuits, you'll learn lots of information just like this. It's a good idea to keep this information in a notebook. By the time you finish this kit you may want to try designing some circuits of your own, and then your notebook would have most of the things you'd need to know.

NOTE



WIRING SEQUENCE:

5-10, 6-43-30, 9-63, 29-64, 42-65.



ONE-WAY STREET

remember what LED stands for? ... Light Emitting Diode. And you may recall that we
that a diode only lets electricity flow in one direction. Here's proof.

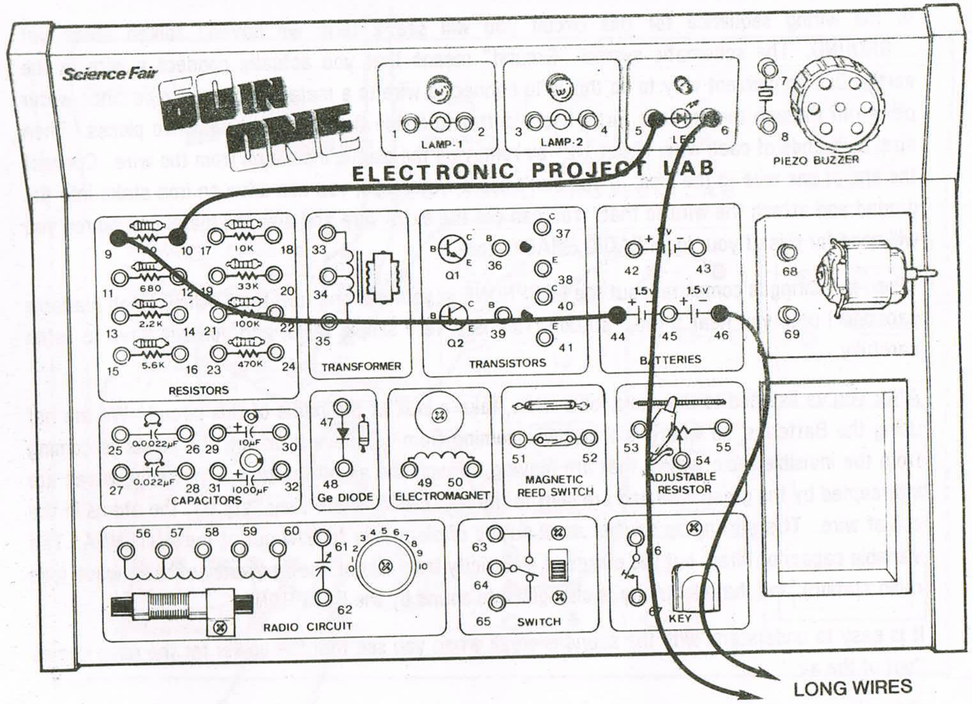
te the wiring, and then touch the two free ends of the LONG WIRES together. The LED
p... right? Now reverse the connections to the Batteries (44 and 46), and touch the LONG
again. Nothing happens, because the flow of electricity is going in the opposite direction
Diode won't let it through.

Schematic you can see how the Diode must be connected for it to light. The (+) positive
the Batteries go to the arrow-head and the (–) negative side of the Batteries go to the line.
ould be good information for your notebook. You are keeping one, aren't you?

0 ohm Resistor in this circuit limits the amount of electricity going to the LED for it can't
ery much, else it will burn out.

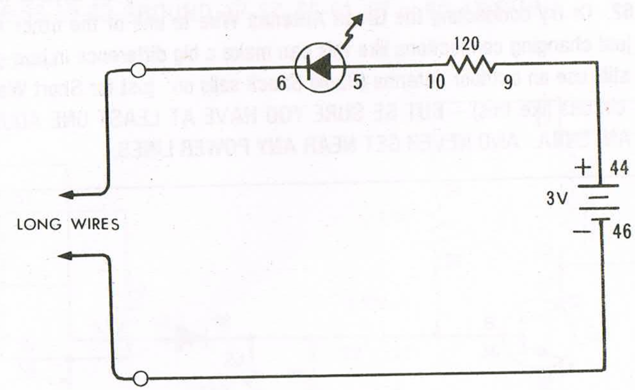
tical use for this circuit is as a continuity tester, which it will allow you to see whether elec-
is flowing through a particular circuit or component. This kind of testing can help you find
the problems are if a circuit isn't working correctly.

TE



WIRING SEQUENCE:

5-10, 6-LONG WIRE, 9-44, 46-LONG WIRE.



31. "INVISIBLE POWER" RADIO

In the wiring sequence for this circuit you will see a term we haven't talked about yet ... GROUND. The schematic symbol "Ground" means that you actually connect a wire to the earth. One convenient way to do this is to connect a wire to a metal, cold water pipe since water pipes run through the ground. First, use a cutter to divide the green wire into two pieces. Then strip both ends of each wire, about 1/2" by removing the plastic insulation from the wire. Connect the end of one wire to the pipe. If you can't use a water pipe, you can drive an iron stake into the ground and attach the wire to that. You can get the extra wire and also the metal ground rod you will need for this at your local RADIO SHACK store.

When the wiring is completed, put the EARPHONE in your ear and turn the TUNING Knob (variable capacitor) until you hear a radio station. This is a very simple radio, and you will have to listen carefully.

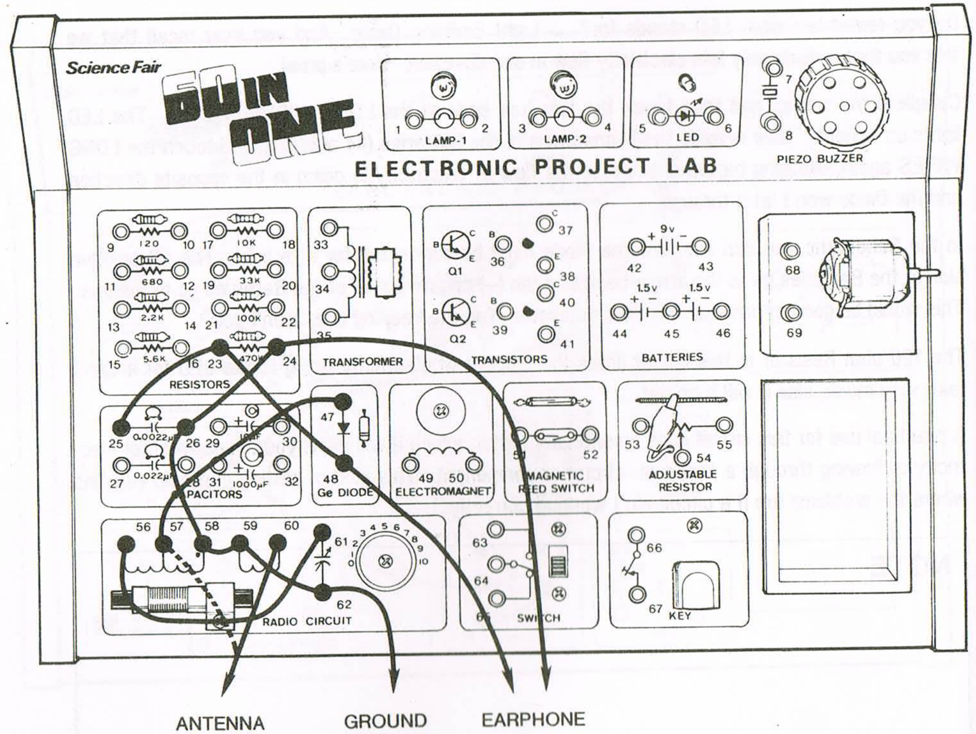
After you've listened to the radio for a while, take a look at the name of this circuit. We are not using the Batteries, so where is the power coming from? Believe it or not, the power is coming from the invisible radio waves that are moving through the air all the time. The radio waves are intercepted by the green wire and are sent to the ANTENNA where they "stir up" the atoms in the coil of wire. This stirring up causes small pulses of electricity to flow out of the ANTENNA. The variable capacitor filters out the pulses of electricity from all but one frequency of radio wave (one radio station), and that electricity is changed into sound by the EARPHONE.

It is easy to understand why the sound is weak when you see that the power for the radio comes "out of the air."

NOTE: In a schematic if two wires cross like this + they are not connected, and if they cross like this ✦ they are connected.

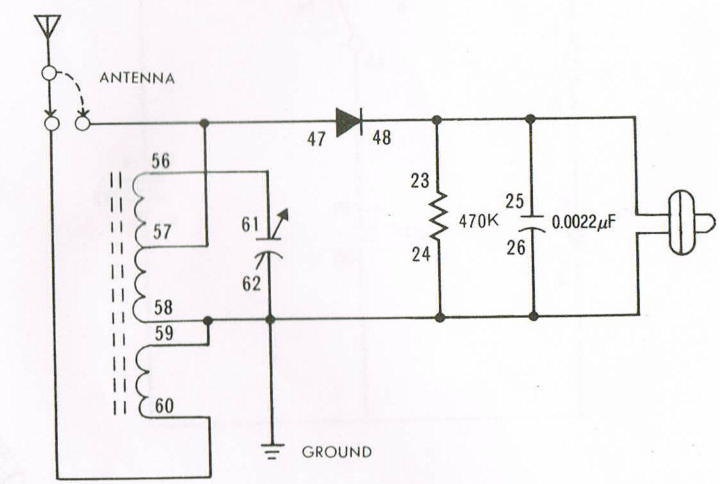
Reception not very good? OK, try some experiments. Try connecting the Ground wire to terminal 61 instead of 62. Or try connecting the Green Antenna Wire to one of the other ANTENNA terminals. Often just changing connections like this can make a big difference in how good the Radio works. Better still, use an outdoor antenna (Radio Shack sells on just for Short Wave Radios – it works well for circuits like this) – BUT BE SURE YOU HAVE AT LEAST ONE ADULT HELP YOU INSTALL THE ANTENNA. AND NEVER GET NEAR ANY POWER LINES.

NOTE



WIRING SEQUENCE:

25-23-48-EARPHONE, EARPHONE-24-26-58-59-62, 47-57, 56-61, 57 or 60-ANTENNA, 62-GROUND.

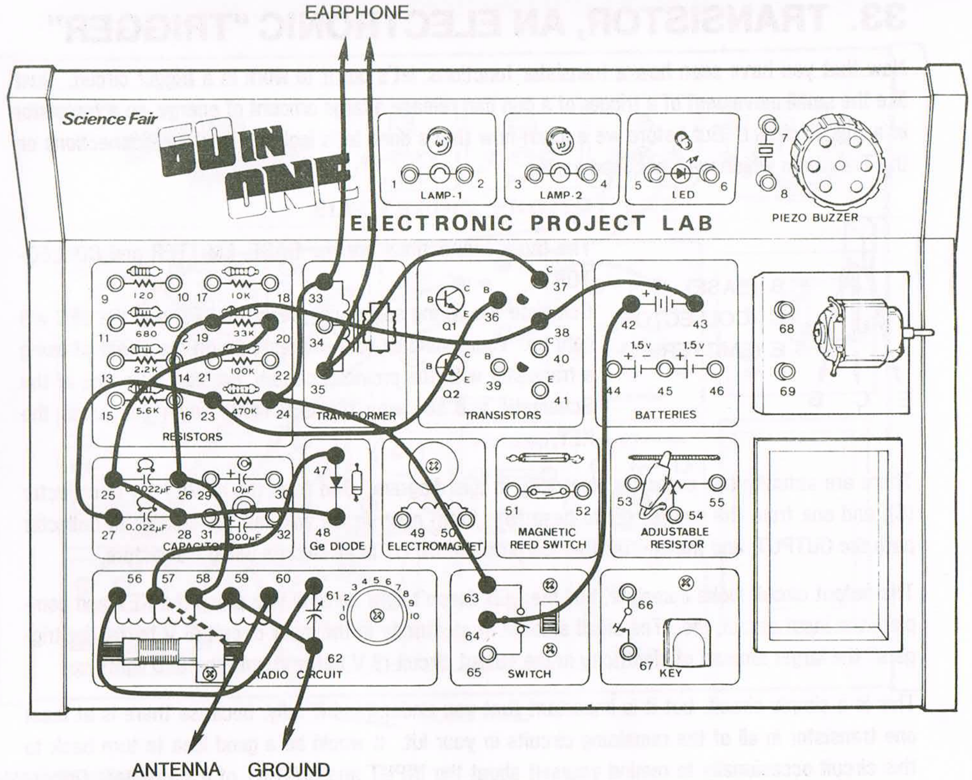


. TRANSISTOR AND "AMPLIFICATION"

plicated electronic circuits are almost always made up of two or more simple circuits connect-
gether. This project combines the invisible power radio with one transistor amplifier. Con-
the GROUND and ANTENNA just as you did before and tune in a station. You should get
sound from the EARPHONE this time. While you're listening, let's look at the Schematic, and
why the sound is louder.

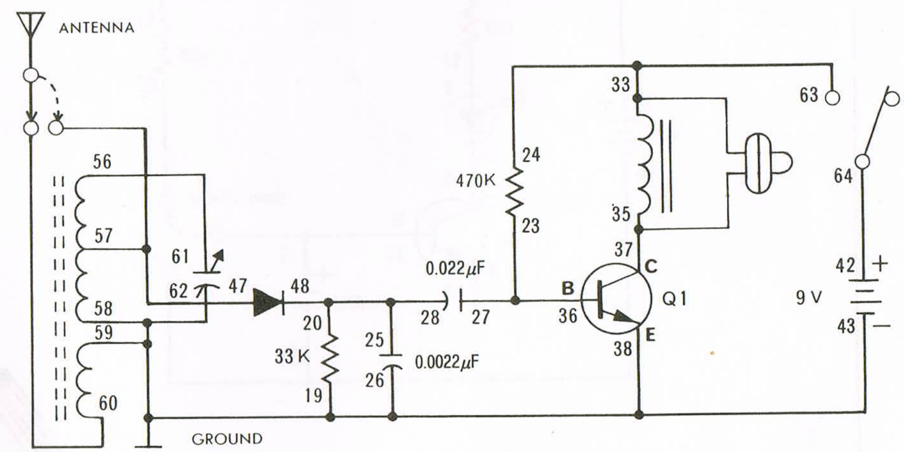
e "INVISIBLE POWER" RADIO the pulses of electricity stirred up by the radio waves were
ed into sound by the EARPHONE. In this circuit those same pulses of electricity are connect-
the INPUT of the Transistor in the circuit. As the pulses turn the INPUT on and off they
e a "mirror image" of the pulses in the OUTPUT. Remember that the OUTPUT is controlled
he INPUT. The pulses from the OUTPUT are connected to the EARPHONE and are much
ger than the INPUT signal, because the Batteries are connected to the OUTPUT of the tran-
r. Getting a high power signal from a low power signal in this way is called AMPLIFICATION.

OTE



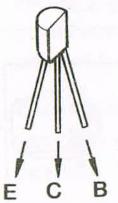
WIRING SEQUENCE:

20-25-28-48, 27-23-36, 37-35-EARPHONE, EARPHONE-33-24-63, 42-64, 43-38-19-26-58-59-62-GROUND, 47-57, 56-61, 57 or 60-ANTENNA.



33. TRANSISTOR, AN ELECTRONIC "TRIGGER"

Now that you have seen how a transistor functions, let's put it to work in a trigger circuit. Just like the small movement of a trigger of a gun can release a large amount of energy, a transistor in a trigger circuit. But before we explain how that's done let's look at the three connections on the Transistor which we mentioned earlier.



B (BASE)
C (COLLECTOR)
E (EMITTER)

The three connections are the BASE, EMITTER and COLLECTOR.

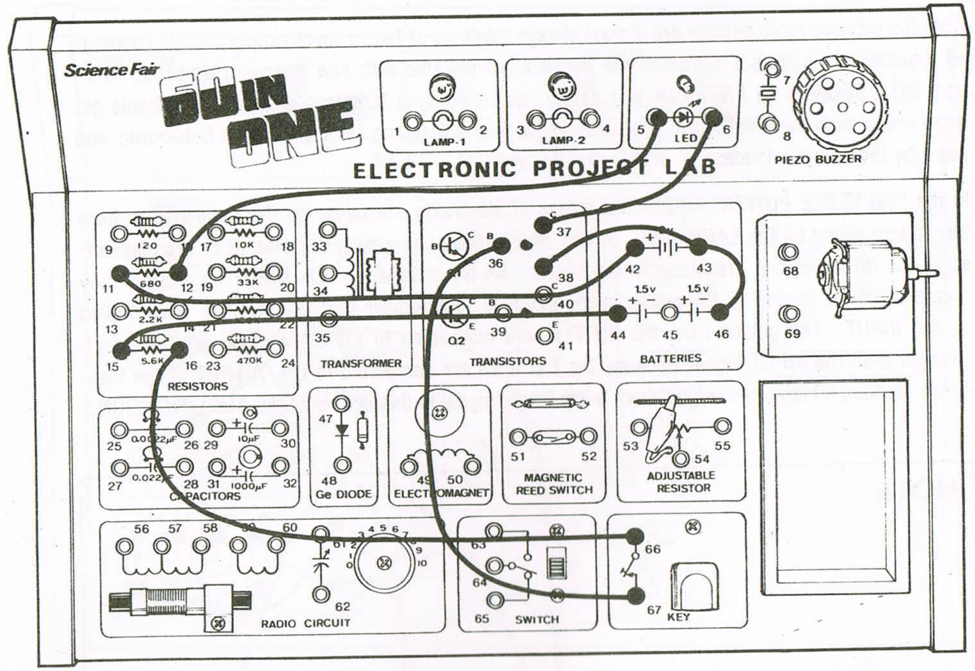
Complete the wiring sequence, press the KEY, and the LED will light up. You should be very impressed with the effect of using a transistor with the previous circuit. For now let's look at the Schematic and see why the LED lights when you press the KEY.

There are actually two paths for electricity in this diagram. One from the emitter (E) to collector (C), and one from the emitter (E) to base (B). From now on we will call the emitter to collector path the OUTPUT, and the emitter-to-base path the INPUT in all circuits using transistors.

The output circuit looks complete, but the LED doesn't light up until you press the KEY and complete the input circuit, too. The small amount of electricity in the input circuit (3 V battery), "triggers" the larger amount of electricity in the output circuit (9 V battery), and the LED lights up.

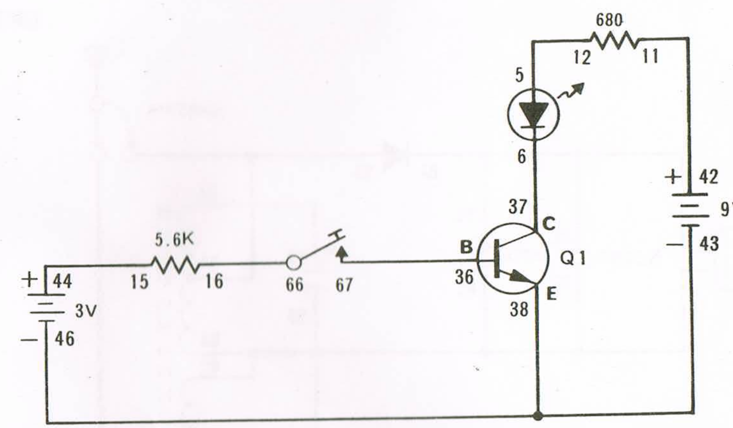
This is a simple circuit, but it is important that you understand it fully, because there is at least one transistor in all of the remaining circuits in your kit. It would be a good idea to turn back to this circuit occasionally to remind yourself about the INPUT and OUTPUT of a transistor. Or better still, just put the information in that notebook you are keeping.

NOTE



WIRING SEQUENCE:

5-12, 6-37, 11-42, 15-44, 16-66, 36-67, 38-43-46.



SUNRISE - SUNSET LIGHT

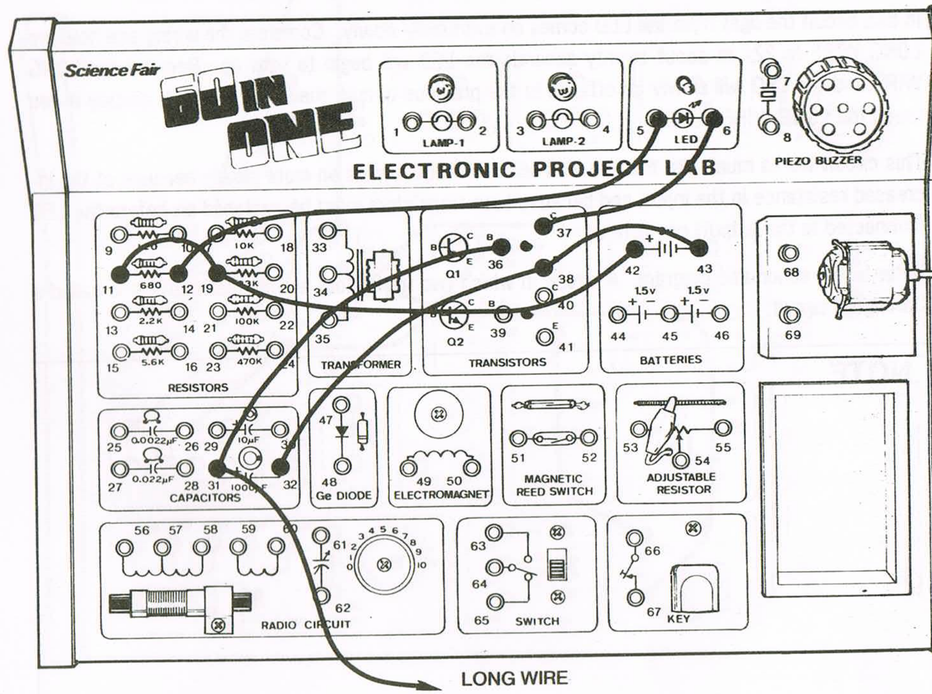
circuit is complete, hold the WIRE to terminal 20 and watch the LED. It will slowly light a sunrise. When the LED reaches its brightest point, remove the WIRE from 20 and the dim and go off ... like a sunset. If you touch the WIRE to 32 the LED will go off very In this circuit the Transistor is used as a switch. It switches on slowly because the 1000 citor must be "filled up" or charged before the electricity can flow through the input of sistor to turn on the output and the LED. The 100 k ohm Resistor reduces the amount of y flowing in the input circuit and this makes the Capacitor charge more slowly. Touching s the Capacitor discharge very quickly, because it makes a "short circuit" (a path with o resistance) for the Capacitor to empty through.

you think will happen if you change the values of the Resistor or Capacitor? Write down ess, and then try changing the resistor to 10 k ohm, 100 k ohm or 470 k ohm. Next try the apacitor in place of the 1000 μF.

TE: The 10 μF and 1000 μF capacitors are a special type of capacitor called ELEC-TIC, and they have a (+) and a (–) connection. Be sure to keep the wiring the same you switch them or they could be damaged.

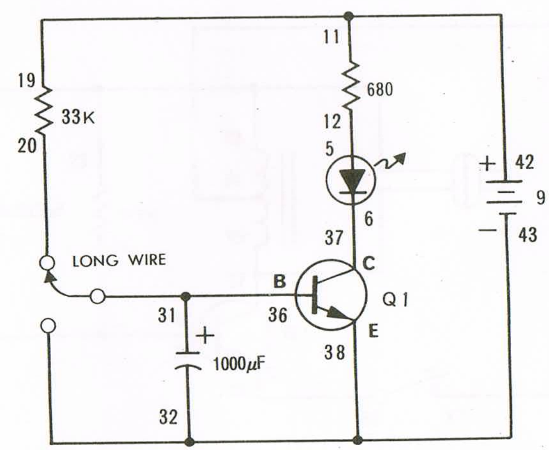
get the results you expected when you made the changes? Don't forget to make notes!

TE



WIRING SEQUENCE:

5-12, 6-37, 11-19-42, 32-38-43, 36-31-LONG WIRE.



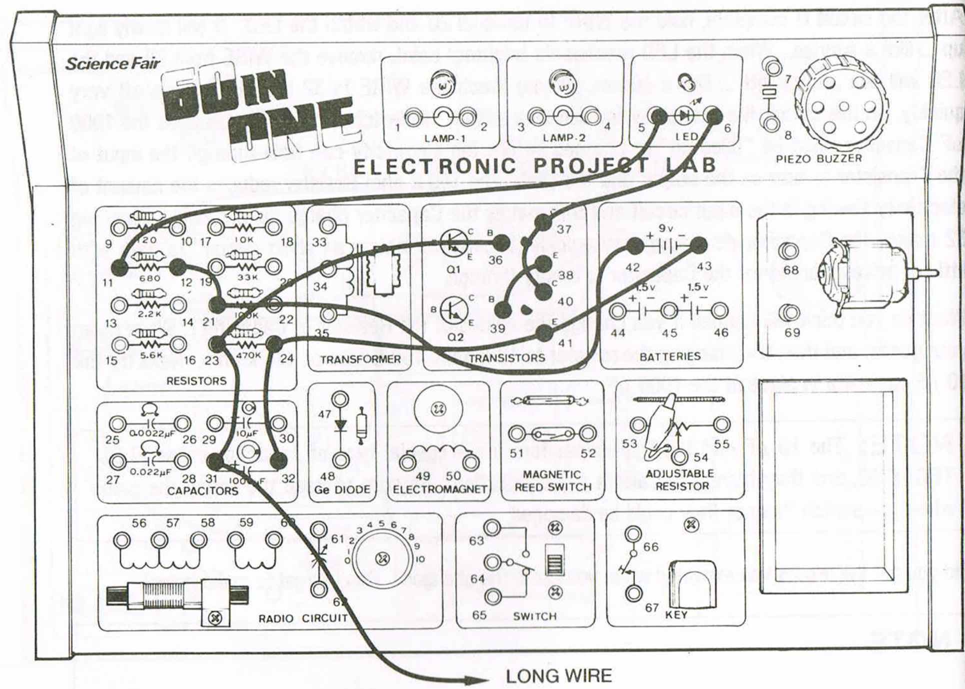
35. SLOW MOTION SUNRISE – SUNSET LIGHT

In this circuit the light from the LED comes on extremely slowly. Complete the wiring and hold the LONG WIRE to 22. In about twenty seconds the LED will begin to light up. Remove the LONG WIRE and the LED will slowly go off. As in the previous circuit, the LED will go off quickly if you touch the LONG WIRE to 32.

This circuit works much like the previous one. The LED comes on more slowly because of the increased resistance in the input, and because both transistors must be switched on before the LED (connected to the output) can light up.

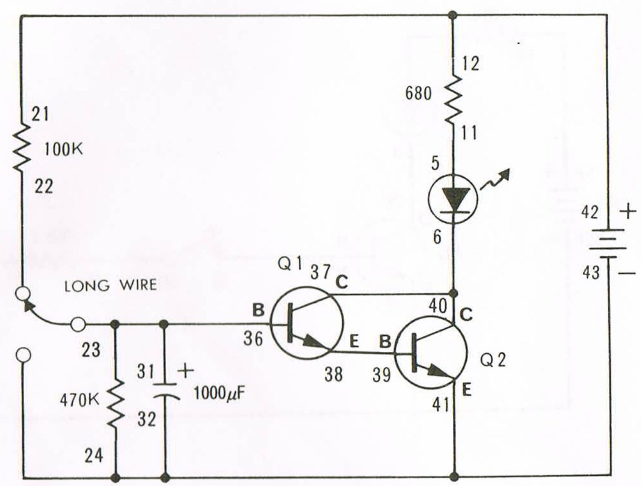
Refer to the schematic diagram. A circuit in which two transistors are coupled like this is called a Darlington circuit.

NOTE



WIRING SEQUENCE:

5-11, 6-37-40, 12-21-42, 32-24-41-43, 36-23-31-LONG WIRE, 38-39.



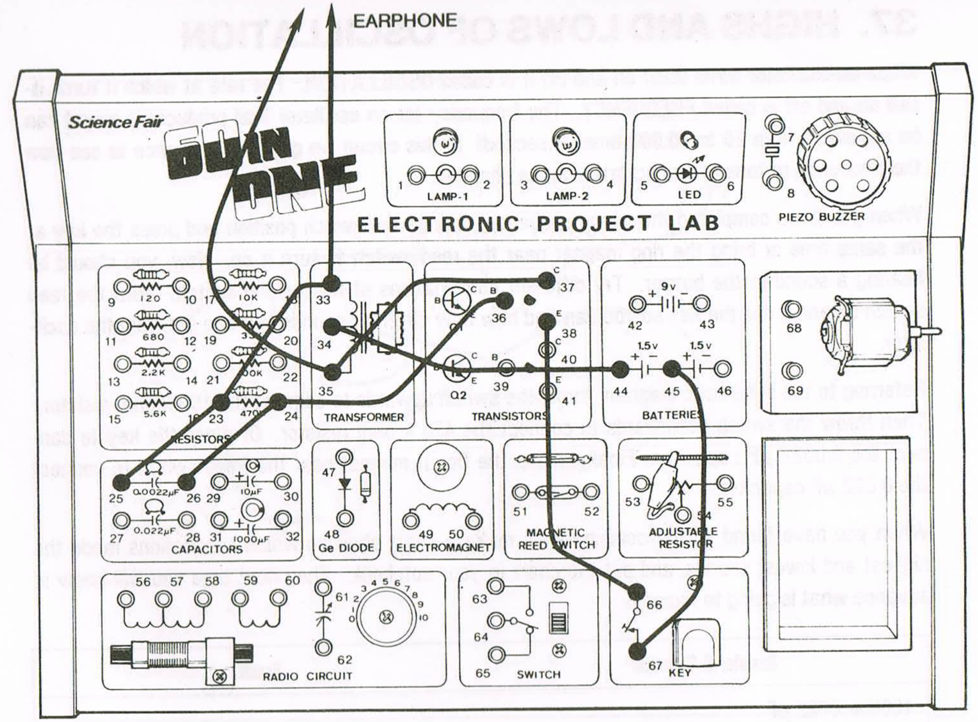
'SECRET CODE" KEY

the connections have been made, press the KEY and you will hear a sound in the EAR- By following the MORSE CODE chart below you will be able to send messages with a ser- ts (short sounds) and dashes (longer sounds). Of course Morse Code isn't really a se- . It was the first means of electronic communication ... by telegraph and then radio. It is by radio operators all over the world. You will learn the code faster, and have more fun, actice sending messages back and forth with a friend.

of circuit used here is called an OSCILLATOR. The sound in the EARPHONE is caused s of electricity, just like it was in the radios that you built. The difference is that the ome from the circuit turning itself on and off instead of from the radio waves. The oscilla- on and off because of something called feedback. You have heard another example of at concerts, when the loudspeakers start to "squeal". This happens when the speaker ophone get too close together and the sound from the speaker "feeds back" into the mi- . The same thing happens in the oscillator except the microphone is replaced by the in- e transistor, and the speaker is replaced by the output. At a concert, feedback is annoy- n an oscillator it is necessary for the circuit to work at all.

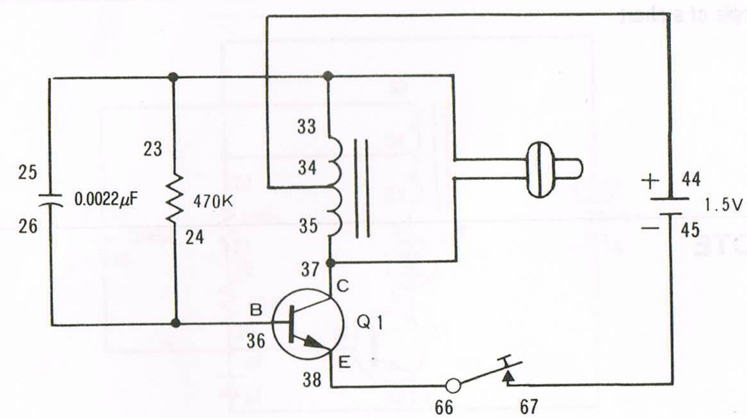
—	K	— • —	U	• • —	4	• • • • —
• • •	L	• — • •	V	• • • —	5	• • • • •
— •	M	— —	W	• — —	6	— • • • •
• •	N	— •	X	— • • —	7	— — • • •
	O	— — —	Y	— • — —	8	— — — • •
— •	P	• — — •	Z	— — • •	9	— — — — •
— •	Q	— — • —			0	— — — — —
• •	R	• — •	1	• — — — —		• — • — • —
	S	• • •	2	• • — — —	,	— — • • — —
— — —	T	—	3	• • • — —	?	• • — — • •

E



WIRING SEQUENCE:

25-23-33-EARPHONE, EARPHONE-35-37, 26-24-36, 34-44, 38-66, 45-67.



37. HIGHS AND LOWS OF OSCILLATION

When an oscillator turns itself on and off it is called OSCILLATION. The rate at which it turns itself on and off is called FREQUENCY. The frequency for an oscillator that produces a sound can be anywhere from 20 to 20,000 times a second! In this circuit we give you a chance to see how the frequency or tone of an oscillator can be changed.

When you have completed the wiring sequence, change the switch position and press the key at the same time or bring the ring magnet near the reed switch to turn it on. Now, you should be hearing a sound in the buzzer. Try different combinations of turning the switch. Turn the reed switch on and press the key so you can find how may different sounds you can get from the oscillator.

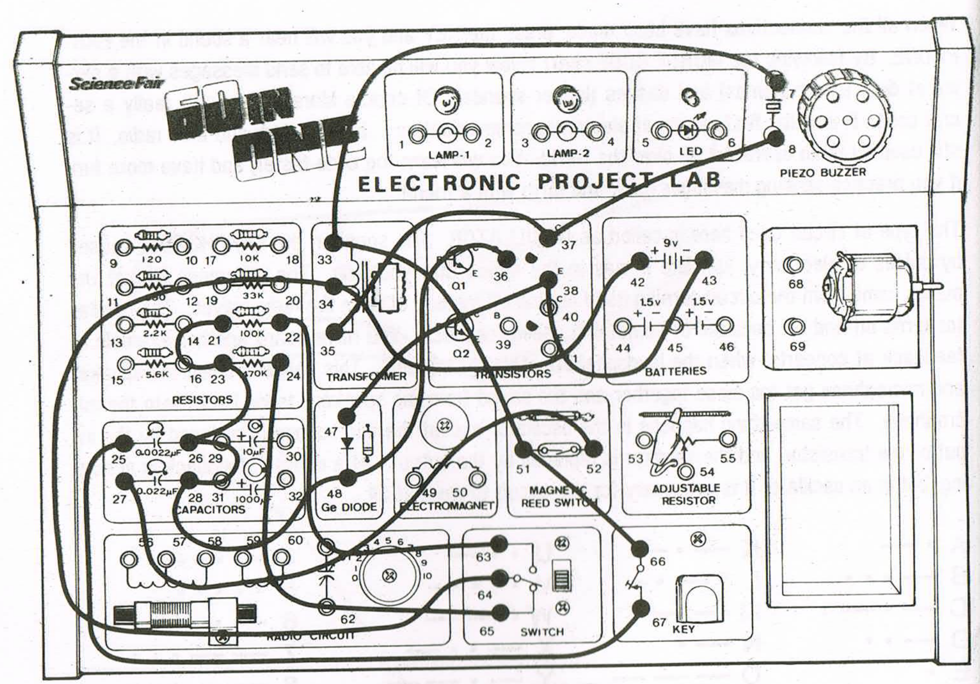
Referring to the schematic diagram, throw the switch upwards to connect the 100 k ohm resistor. Then throw the switch downwards to connect the 470 k ohm resistor. Or press the key to connect the 0.0022 μF capacitor. Finally, move the Donut magnet near the Reed switch to connect the 0.022 μF capacitor.

When you have found all the combinations, make a chart showing which connections made the highest and lowest sounds, and put the chart in your notebook. Then next time you will know in advance what is going to happen.

Resistor & Capacitor	Results
100K + .0022 μF	
100K + .022 μF	
470K + .0022 μF	
470K + .022 μF	

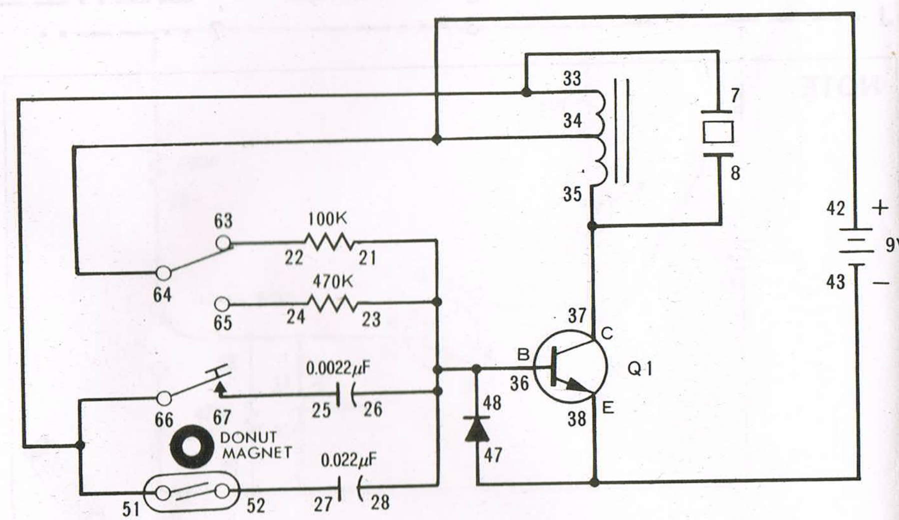
Example of a chart

NOTE



WIRING SEQUENCE:

7-33-51-66, 21-23-26-28-48-36, 22-63, 24-65, 25-67, 27-52, 35-37-8, 42-34-64, 43-38-47.



BEACON LIGHT

ou ever noticed the flashing lights on the tops of tall buildings or towers? They flash on so low-flying planes won't hit them. The type of circuit you will build here is similar to the ntrolling those very important lights.

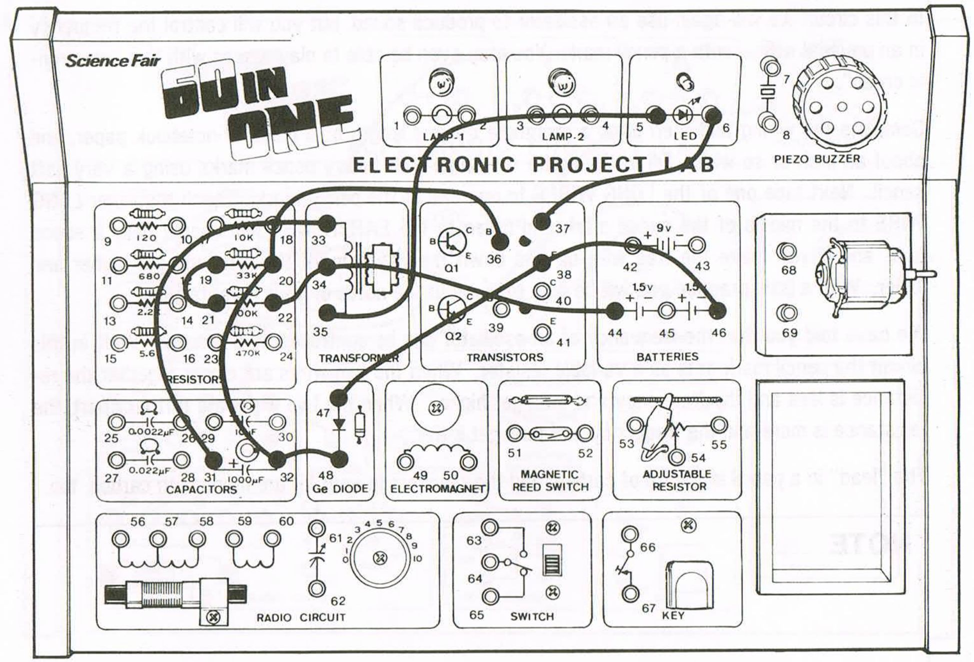
ou have finished the wiring, the LED will begin to flash on and off slowly, like a beacon ow look at the Schematic. Does it look familiar? It should, because it is an oscillator very ke the last two circuits you have built. The difference is that it has a much lower fre- than the others. With what you learned in the last circuit, you won't be surprised to see s slow oscillator uses the largest capacitor and the "strongest" resistor.

might suspect, changing the resistor or capacitor will alter the frequency of this oscillator go ahead and try it.

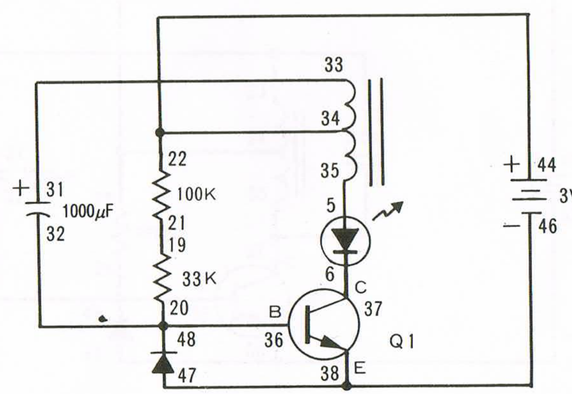
TE: Don't forget about the (+) and (–) connections on the electrolytic capacitors.

ESTION: Could the frequency become so fast that you wouldn't be able to see the oing on and off?

TE



WIRING SEQUENCE:
5-35, 6-37, 19-21, 22-34-44, 31-33, 36-20-32-48, 46-38-47.



39. MUSIC FROM A PENCIL

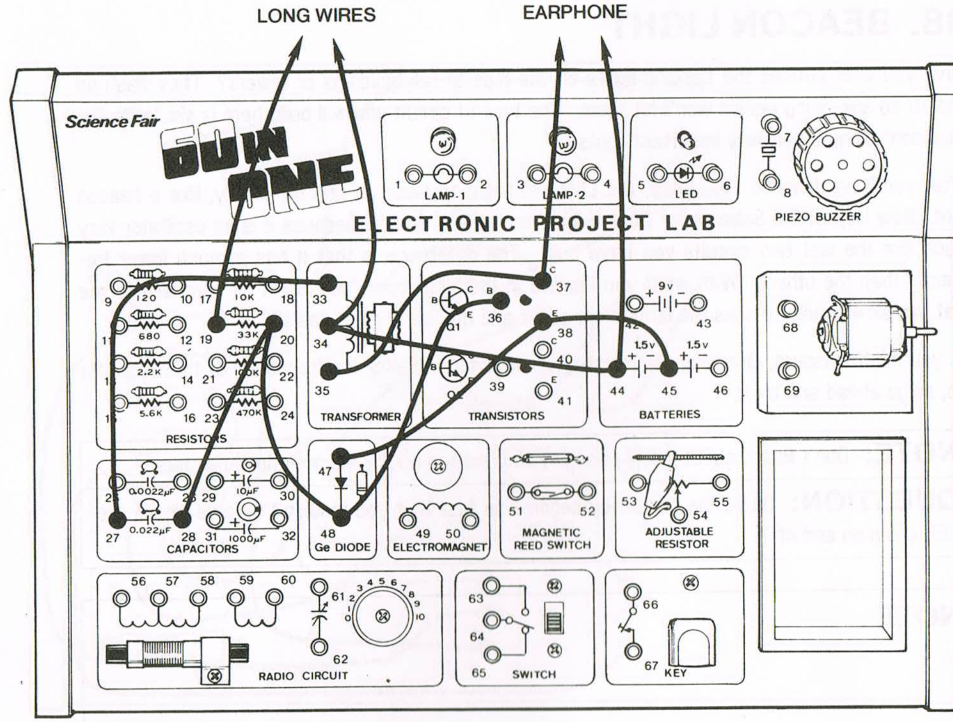
In this circuit we will again use an oscillator to produce sound, but you will control the frequency in an unusual way ... with a pencil mark. You may even be able to play a song with this "electronic organ".

Complete the wiring and then draw a rectangle the full length of a piece of notebook paper, and about an inch or so wide. Fill in the entire rectangle with heavy pencil marks using a very soft pencil. Next tape one of the LONG WIRES to one end of the pencil mark. Touch the other LONG WIRE to the middle of the pencil mark and listen to the EARPHONE. You should hear a sound now, and if you move the free wire up and down the pencil mark the tone will get higher and lower. With a little practice you will be able to pick out the notes of your favorite song.

We have told you that the frequency of an oscillator can be controlled by a resistor. Well, in this circuit the pencil mark acts as a variable resistor. When the two wires are closer together the resistance is less and the frequency and tone get higher. When the two wires are farther apart, the resistance is more and the frequency and tone get lower.

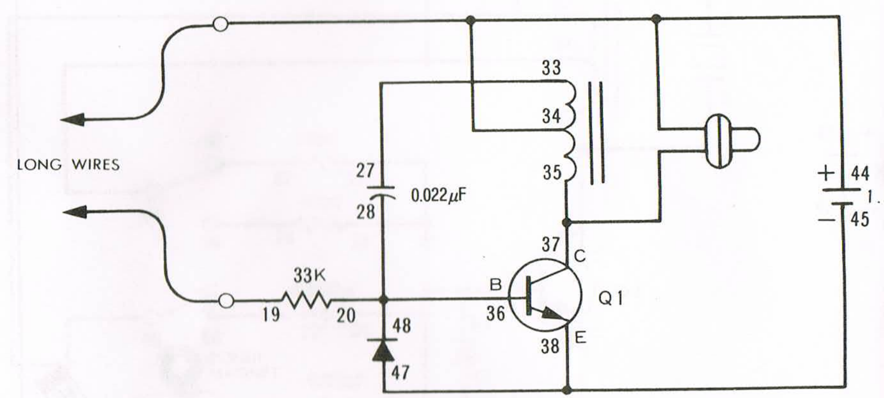
The "lead" in a pencil is a form of carbon, and the resistors in your kit are made with carbon, too.

NOTE



WIRING SEQUENCE:

19-LONG WIRE, 27-33, 28-20-48-36, 35-37-EARPHONE, EARPHONE-44-34-LONG WIRE, 45-38-47.



LEAKY FAUCET

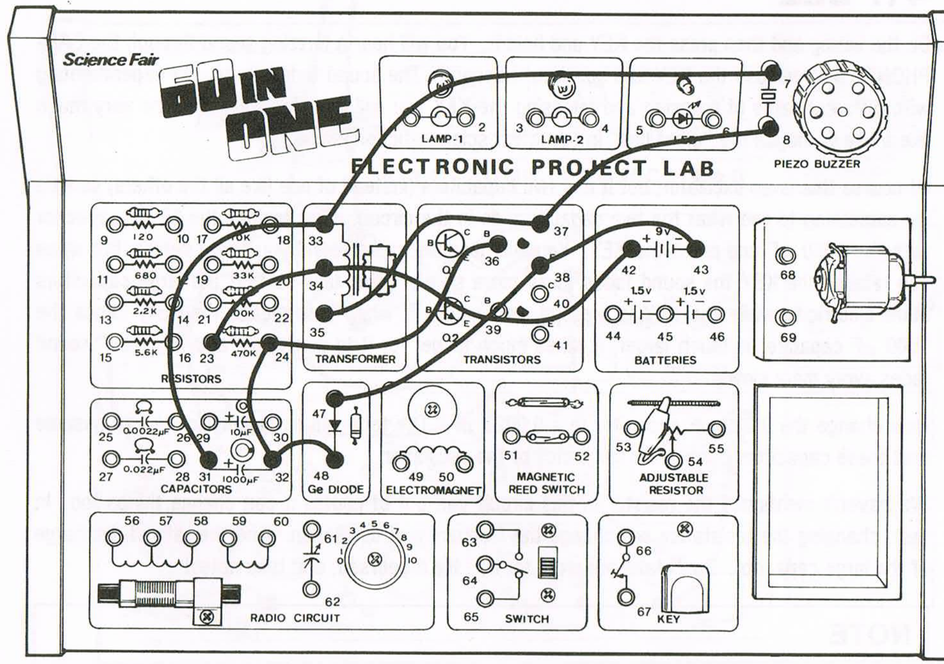
v you should have no problem recognizing this circuit as an oscillator, and this one works e the others you have built. But in this circuit we are going to have fun with "sound ef-

you finish the wiring you will begin to hear a slow clicking sound, something like a dripping Now let's see if you can put to work those notes you've been taking. Can you think of a to make the "dripping" get faster?

hat you come up with and then check with the answers below.

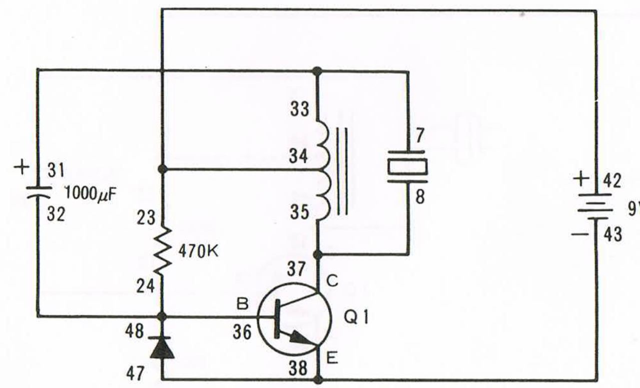
e the 470 k ohm resistor to 10 k ohm. Changing to one of the smaller resistors will the oscillation so fast that it won't sound anything like a dripping faucet anymore.

TE



WIRING SEQUENCE:

7-33-31, 8-37-35, 23-34-42, 36-24-32-48, 43-38-47.



41. BEE

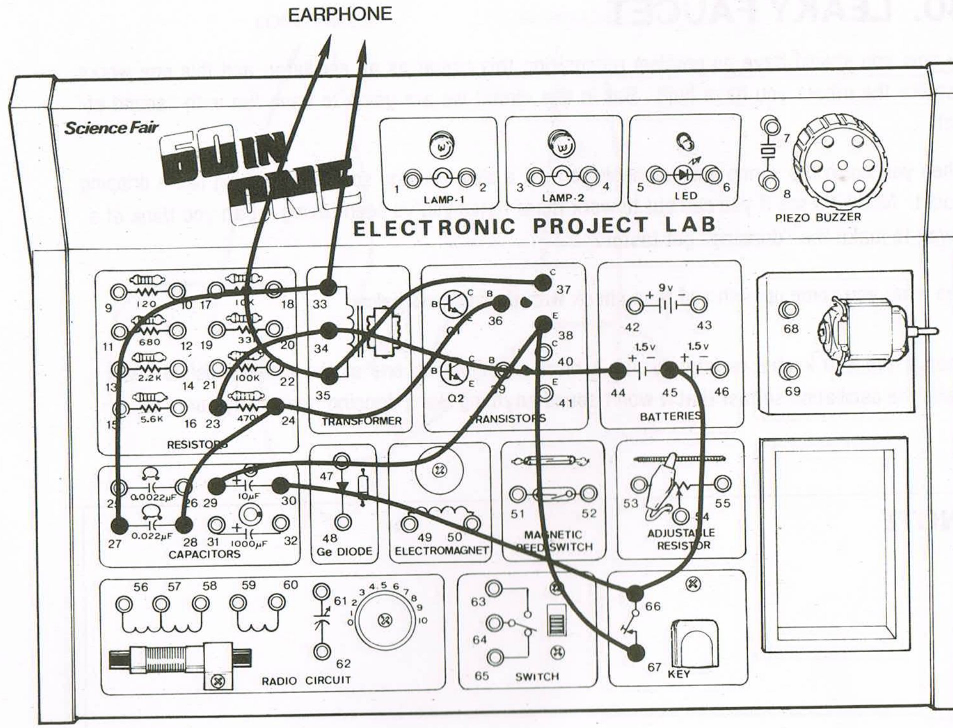
Do the wiring and then press the KEY and hold it. You will hear a buzzing sound through the EARPHONE. Now release the KEY and see what happens. The sound fades away. By experimenting with different rates of pressing and releasing the KEY you will be able to get a sound very much like a bee or maybe the "giant bee" in the latest science-fiction movie.

Of course this is an oscillator, but it has two capacitors (instead of one like all the others) so let's try something to see what the two capacitors do in the circuit. First replace the 10 μF capacitor with the 1000 μF and press the KEY. You will hear the same sound you heard before, but when you release the KEY the sound fades away more slowly. This tells us that the large capacitors store electricity while the KEY is pressed and release it when you release the KEY. Since the 1000 μF capacitor is much larger, it takes much longer for it to discharge, and the "bee" sound fades away more slowly.

Now change the 0.022 μF capacitor to a 0.0022 μF. The tone will be higher, so we can assume that these capacitors control the frequency of the oscillation.

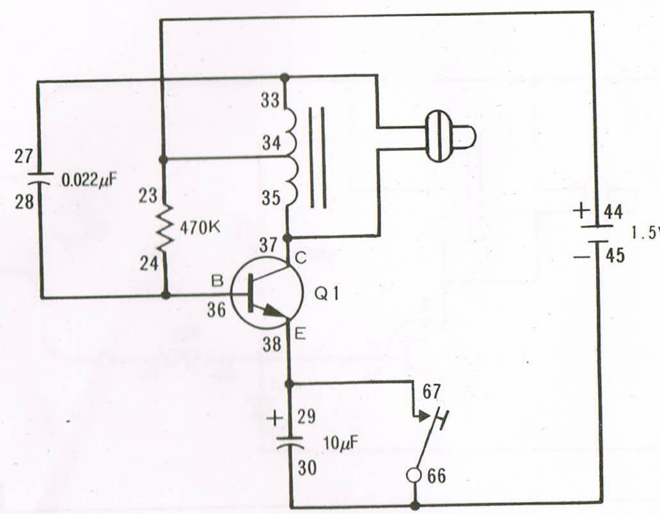
We haven't mentioned the resistor in this circuit yet, but of course it can change things too. In fact, changing the resistance will change the frequency of oscillation. And the rate of discharge of the large capacitor. Don't take our word for it ... try it yourself, and take notes!

NOTE



WIRING SEQUENCE:

23-34-44, 27-33-EARPHONE, EARPHONE-35-37, 28-24-36, 29-38-67, 30-66-45.

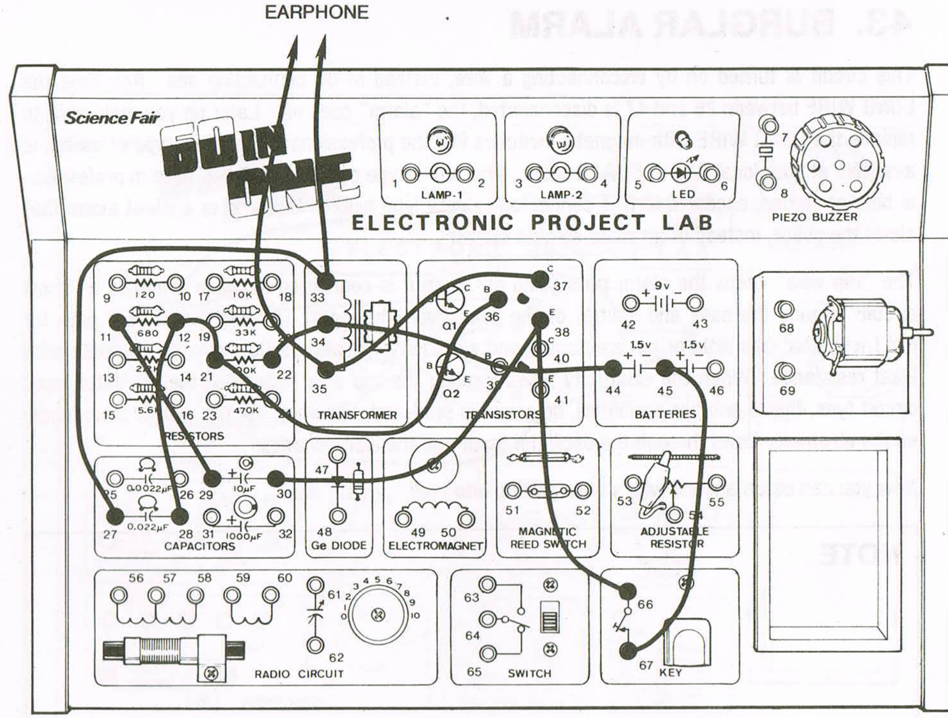


ELECTRONIC CANARY

ay be beginning to think that an oscillator is the only electronic circuit! Well it isn't, but it so many different things, and make so many different sounds, we just had to show them to The name of this circuit gives things away, but go ahead and get the wiring done and see you think of our "canary".

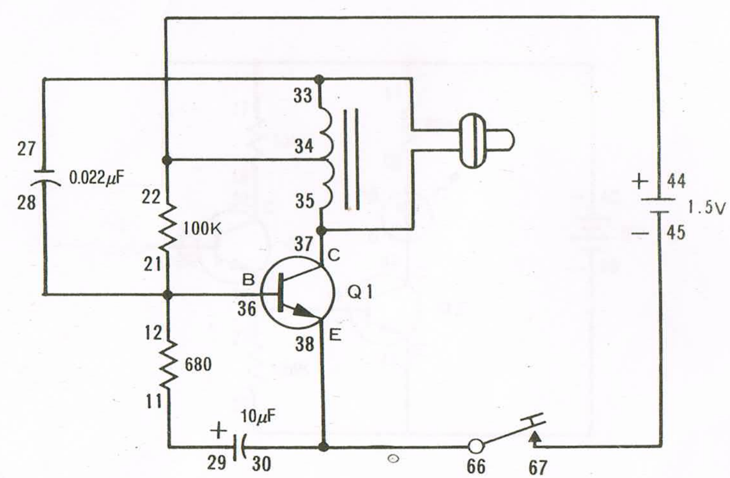
you play with this for a while, we hope you will put your notes to work and see how you can this "bird call". You may create a sound more like a prehistoric flying reptile, or a "space HAVE FUN!!

TE



WIRING SEQUENCE:

11-29, 22-34-44, 27-33-EARPHONE, EARPHONE-35-37, 28-12-21-36, 30-38-66, 45-67.



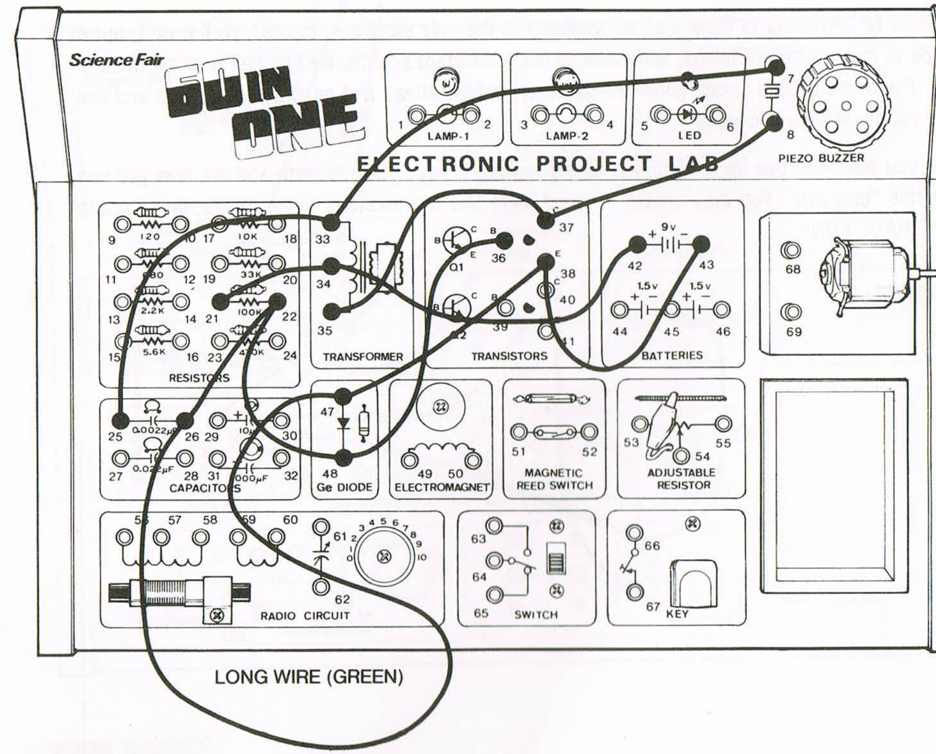
43. BURGLAR ALARM

This circuit is turned on by disconnecting a wire, instead of by connecting one. Any time the LONG WIRE between 26 and 47 is disconnected, the "alarm" goes off. Later on you may want to replace the LONG WIRE with magnetic switches like the professionals use. This type of switch is available at your local RADIO SHACK store. This same type of alarm circuit is used in professional burglar alarms, except that it is connected to very loud bells or buzzers, or a silent alarm that alerts the police, instead of an piezo-electric buzzer.

The "trip wire" keeps the alarm from going off when it is connected because it makes a "short circuit" around the base and emitter of the Transistor (the input). A short circuit is a path for electricity that has little or no resistance, and electricity will always flow through the path with least resistance. When the electricity flows through the trip wire instead of the oscillator input circuit (yes, this is another oscillator), no sound is produced, but when the trip wire is disconnected the electricity flows through the oscillator input and the alarm sounds.

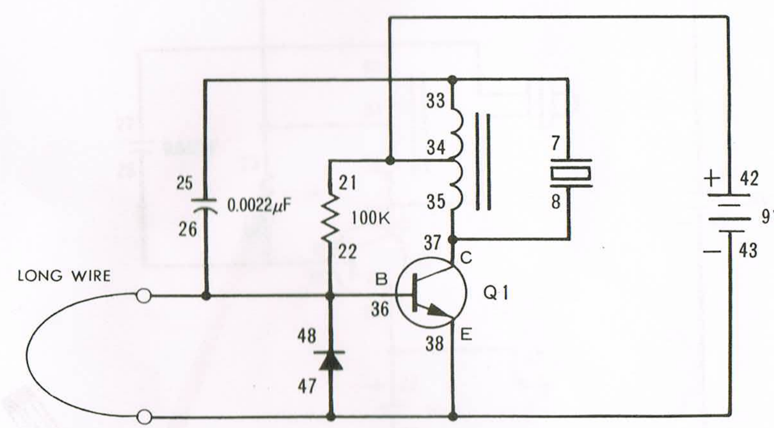
Now you can catch anyone who's been getting into your "private stuff".

NOTE



WIRING SEQUENCE:

7-33-25, 8-37-35, 21-34-42, 36-48-22-26-LONG WIRE (GREEN)-47-38-43.



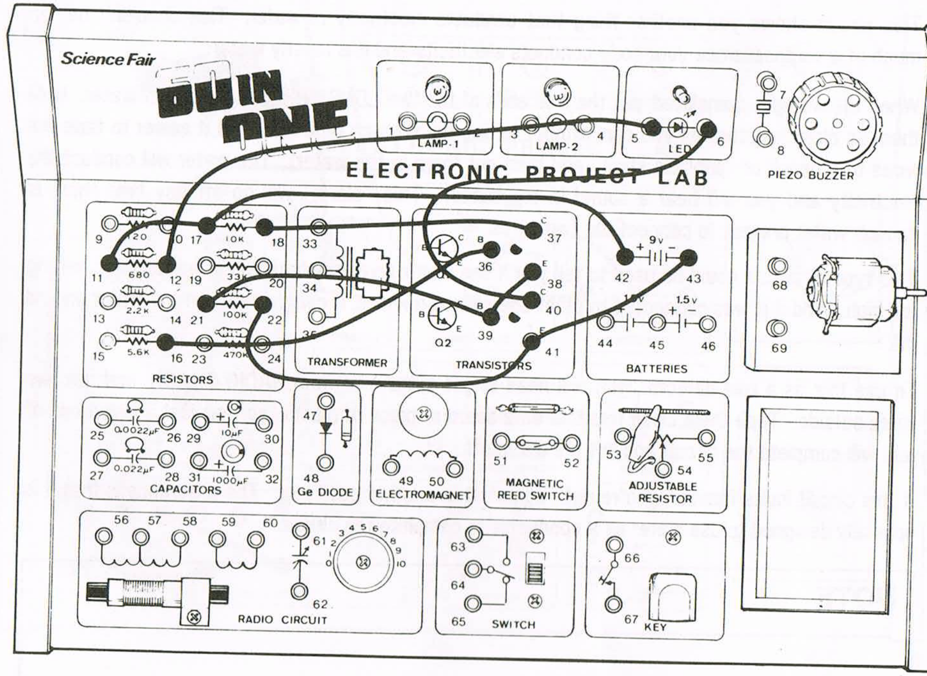
44. TOUCH LIGHT

Up until now, all of the circuits have used wire to carry or "conduct" electricity and make them work. However, there are other things that conduct electricity, and you will discover one you probably haven't thought of – in the TOUCH LIGHT.

When you complete the wiring sequence you will notice nothing is happening. That's OK because the circuit isn't finished yet. The final step is to touch 11 and 15 with fingers of the same hand. Surprise! The LED lights up, and YOU are the conductor for the electricity. But there is no reason for you to worry about getting a shock from this or any of the circuits in this kit, because the amount of electricity being used is very low.

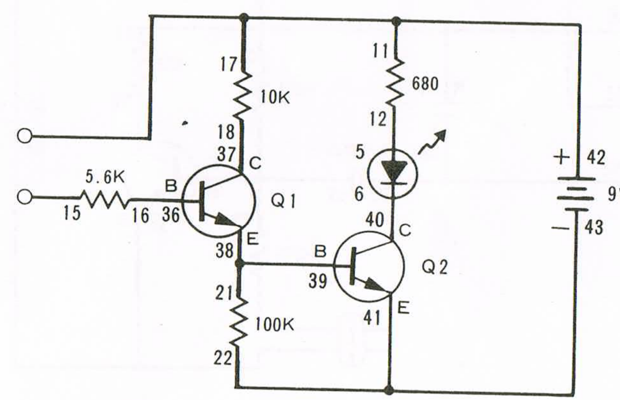
This circuit is a two-transistor amplifier. The small amount of electricity that flows through you completes the input and lets the power from the batteries flow in the output circuit and through the LED. Before you go on to the next circuit, try touching 11 and 15 with fingers from different hands. Does the LED still light? Wetting your fingers will help make better contact with the terminals.

NOTE



WIRING SEQUENCE:

5-12, 6-40, 11-17-42, 16-36, 18-37, 21-39-38, 22-41-43.



45. RAIN DETECTOR

This circuit shows you another thing that conducts electricity ... water. This shouldn't be too much of a surprise, since your body conducts electricity and it is mostly water:

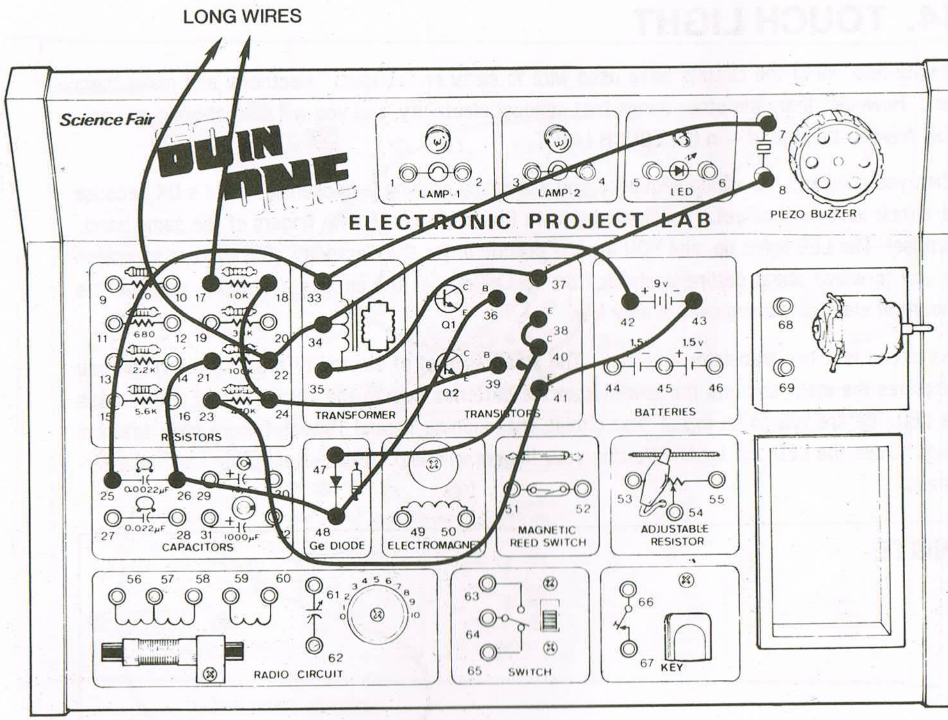
When the wiring is completed, put the free ends of the two LONG WIRES in a glass of water. Hold them as close together as you can without letting them touch (you may find it easier to tape the wires to a pencil or "popsicle stick" and then put them in the water). The water will conduct the electricity and you will hear a sound in the buzzer. This "alarm" will go off any time there is enough water present to connect the two wires.

This type of circuit could be used to tell you if the water level in a bath tub or aquarium is getting too high. And if it was connected to other specialized devices, it could even turn the water on and off.

To use this as a rain detector, you will need to get extra wire from RADIO SHACK, and run two wires outside. Tape them close together on a board or piece of plastic, so that just a few drops of rain will complete the circuit and set the alarm off.

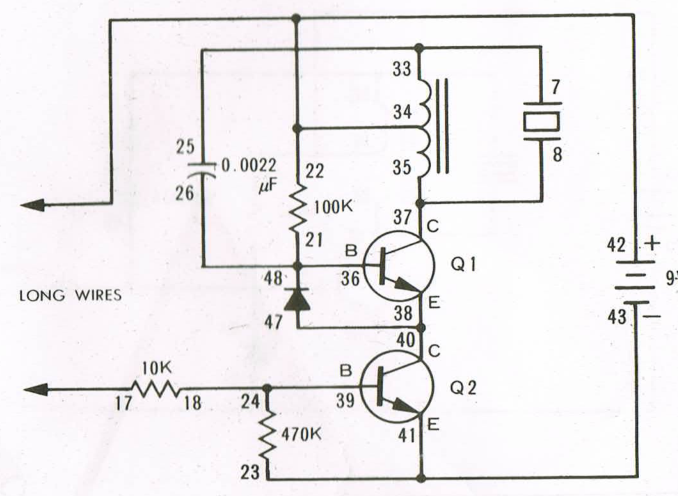
If this circuit looks familiar, you're right again! It is another oscillator. The difference is that it is specially designed to use water as a conductor to complete the circuit.

NOTE



WIRING SEQUENCE:

7-33-25, 8-37-35, 17-LONG WIRE, 18-24-39, 21-26-48-36, 23-41-43, 38-40-47, 42-34-22-LONG WIRE.



6. RADIO STATION

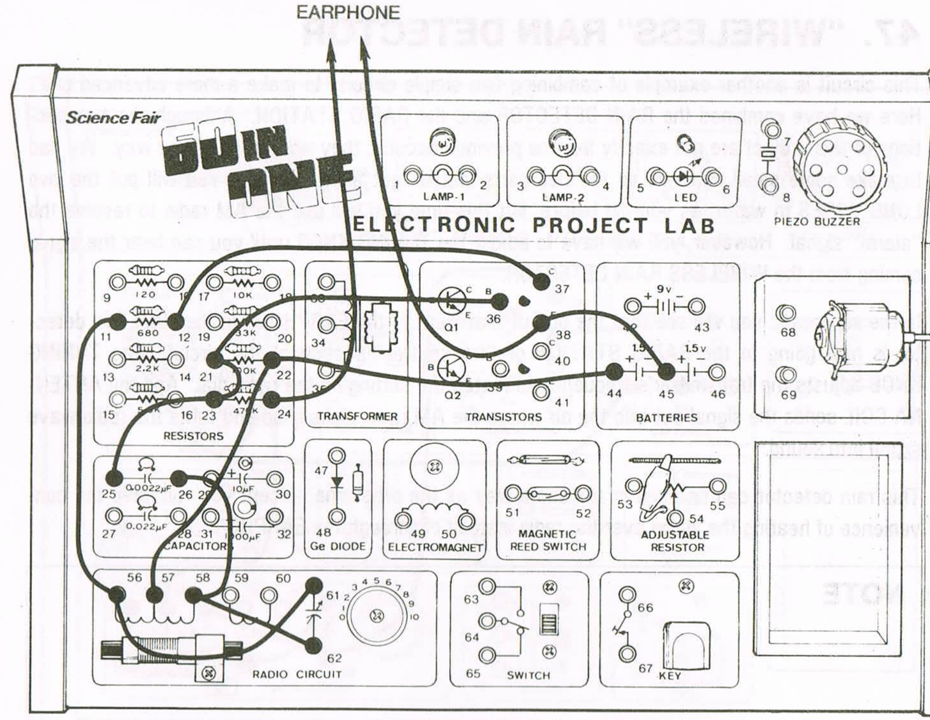
you ever wanted to be a radio announcer or "DJ", here's your chance. After you finish the wir-, you will need an AM radio to receive your "broadcast". The radio should be about one foot ay from the RADIO STATION, to begin with, and should be tuned to a place on the dial where ere is no other station.

w adjust the TUNING KNOB on the RADIO STATION, while speaking into the EARPHONE, until u hear your voice on the radio. Once you have your broadcast tuned in, you can experiment to e how far away your signal can be received. The Federal Communication Commission (FCC) esn't allow the operation of strong radio stations without a license, so don't be disappointed if e signal carries only a few feet.

radio station like the one you have built is a combination amplifier-oscillator. The oscillator pro-ces a high frequency radio wave that is sent out into the air by the ANTENNA COIL. The fre-ency of the oscillation is set to match the setting on the radio dial by the TUNING KNOB (Re-mber, the TUNING KNOB is a variable capacitor.)

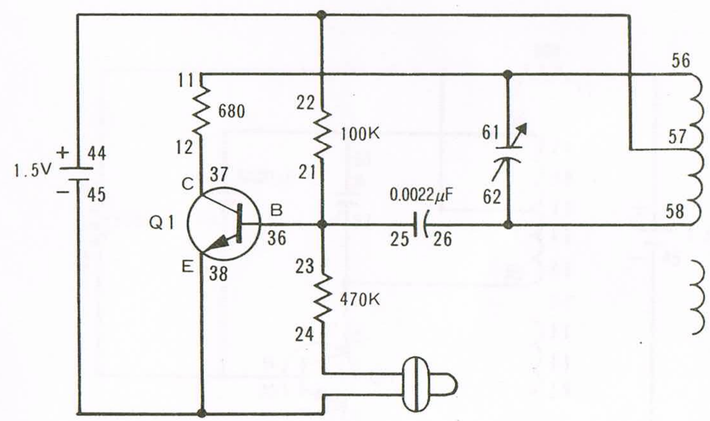
e strength or "amplitude" of the radio waves is controlled by the amplifier, and the amplifier is ntrolled by the small amount of electricity produced by the EARPHONE when you talk into it. In s way, the input from the EARPHONE (your voice) controls the amplitude of the radio waves. e AM radio is able to turn these changes in the strength or "amplitude" into the sound that mes out the radio's speaker. Amazing, isn't it! While we're talking about it, have you ever ndered what "AM" stands for? It stands for amplitude modulation. Modulation is another word change.

NOTE



WIRING SEQUENCE:

11-56-61, 12-37, 24-EARPHONE, EARPHONE-38-45, 25-23-21-36, 26-58-62, 44-22-57.



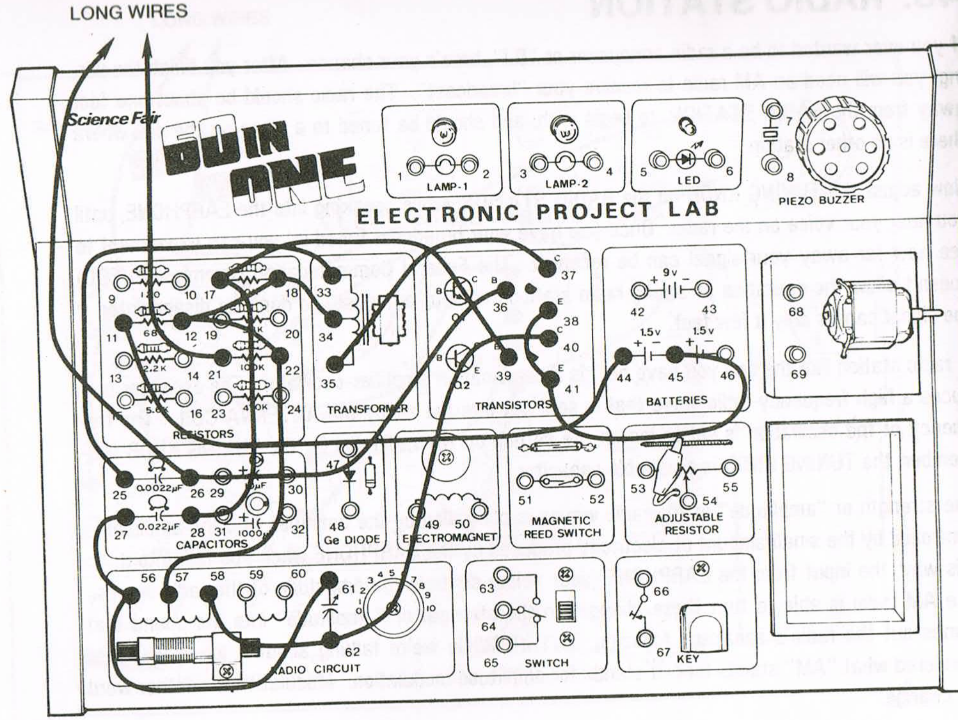
47. "WIRELESS" RAIN DETECTOR

This circuit is another example of combining two simple circuits to make a more advanced one. Here we have combined the RAIN DETECTOR and the RADIO STATION. Although the two sections of this project are not exactly like the previous circuits, they work in the same way. We had to make some small changes so the two parts would "get along" better. You will put the two LONG WIRES in water, as you did before, but this time you will use the AM radio to receive the "alarm" signal. However, you will have to adjust the TUNING KNOB until you can hear the signal coming from the WIRELESS RAIN DETECTOR.

In the schematic you will see that the output that went to the EARPHONE in the other rain detector is now going to the RADIO STATION or "transmitter" section of the circuit. The TUNING KNOB adjusts the transmitter's frequency to match the setting on the radio dial. And the ANTENNA COIL sends the signal out into the air where the AM radio picks it up and turns the radio wave signal into sound.

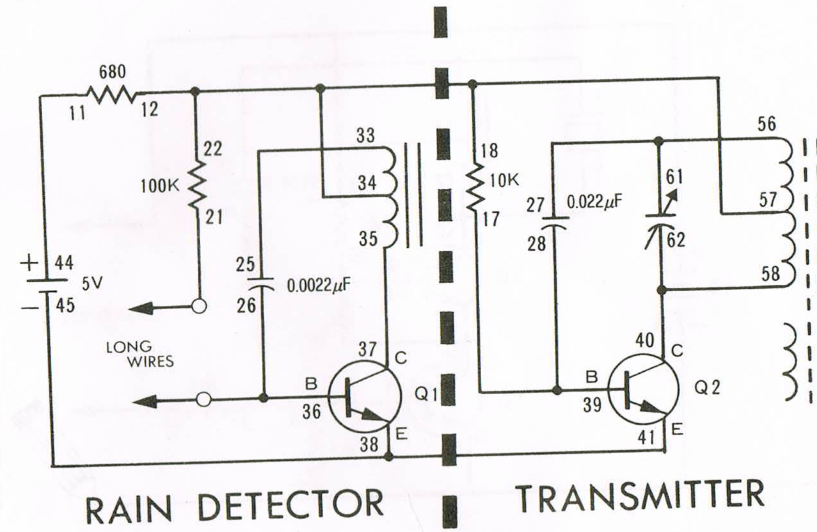
This rain detector can be used in the same way as the other one, except you will have the convenience of hearing the alarm over the radio instead of through the EARPHONE.

NOTE



WIRING SEQUENCE:

11-44, 21-LONG WIRE, 25-33, 27-56-61, 28-17-39, 34-18-12-22-57, 35-37, 36-26-LONG WIRE, 38-41-45, 40-62-58



48. METAL DETECTOR

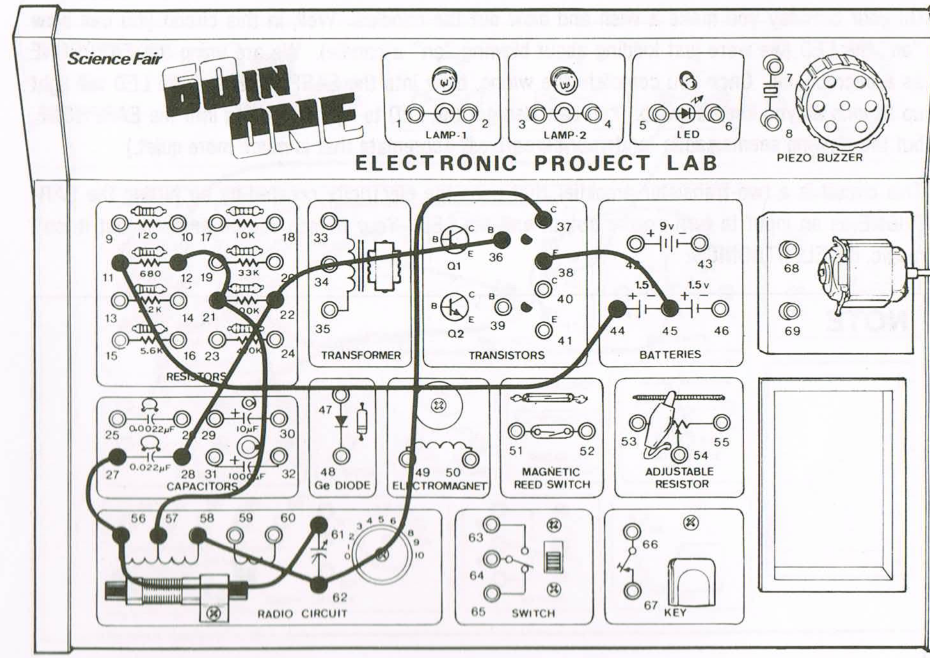
erhaps you have seen people at a beach or park searching for "buried treasure" with their metal etectors, and you've wondered how an electronic device can "see" the metal. ell, here's one way.

hen the circuit is completed, you will again need an AM radio to act as the "voice" of the circuit, ut this time the radio will be tuned in a different way. Set the dial to a station that is weak and oes not come in very clearly. Then adjust the TUNING KNOB until the radio station is blocked ut by a "squeal". Next, fine-tune the TUNING KNOB until you get the lowest tone "squeal" you an. Now you're ready to test the METAL DETECTOR.

ake a piece of metal, such as a coin, and touch it to the end of the ANTENNA COIL core. The queal tone will go away to indicate the presence of metal.

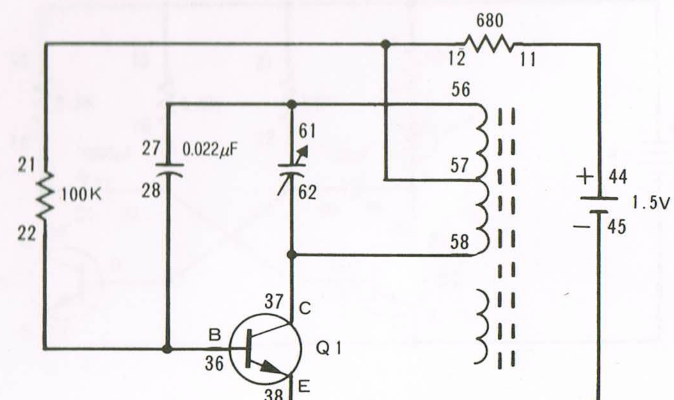
his circuit is a radio wave transmitter similar to the others you built, but in this circuit the signal om the transmitter is used to interfere with or block out another weak radio signal. When metal touched to the core of the ANTENNA COIL the frequency of the blocking signal is changed nough to stop its interference with the weak radio station, and that is your signal that metal is esent.

NOTE



WIRING SEQUENCE:

11-44, 12-21-57, 27-56-61, 28-22-36, 37-62-58, 38-45.

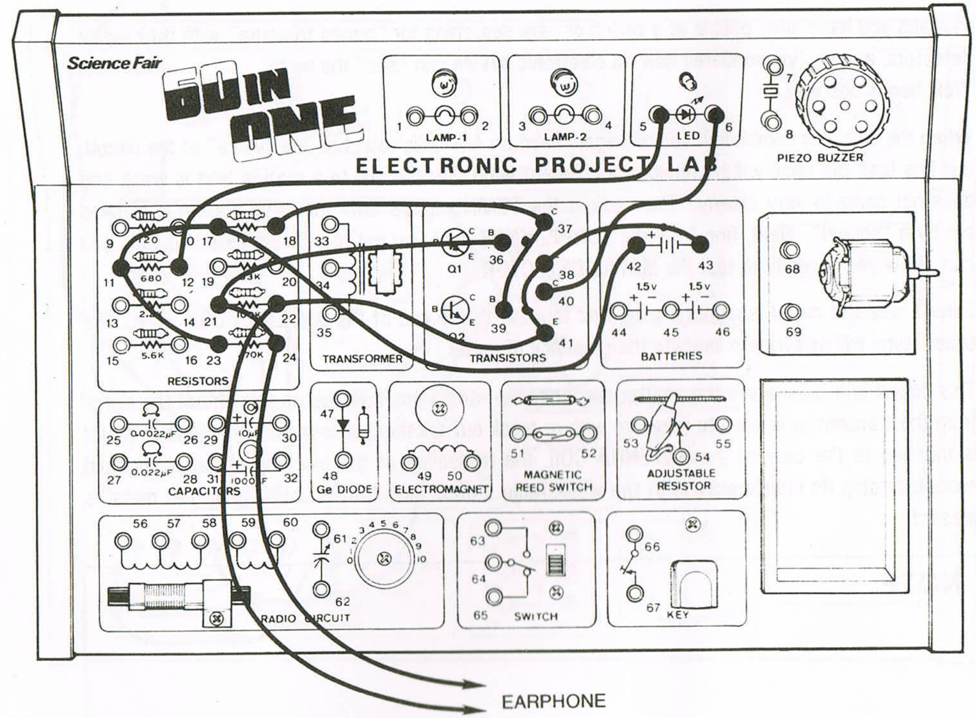


49. BLOWING "ON" A CANDLE

On your birthday you make a wish and blow out the candles. Well, in this circuit you can blow "on" the LED (we were just kidding about blowing "on" a candle). We are using the EARPHONE as a microphone. Once you complete the wiring, blow into the EARPHONE and the LED will light up as long as you keep blowing. You can also get the LED to light by yelling into the EARPHONE, but the blowing seems easier (and your parents will appreciate that is much more quiet.)

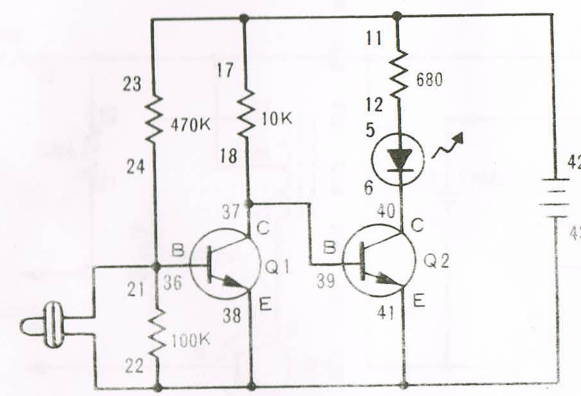
This circuit is a two-transistor amplifier that uses the electricity created by air hitting the EARPHONE as an input to turn on the output and the LED. Your friends will be amazed, but it isn't magic, it's ELECTRONICS!

NOTE



WIRING SEQUENCE:

5-12, 6-40, 18-37-39, 23-11-17-42, 36-21-24-EARPHONE, EARPHONE-22-41-38-43.



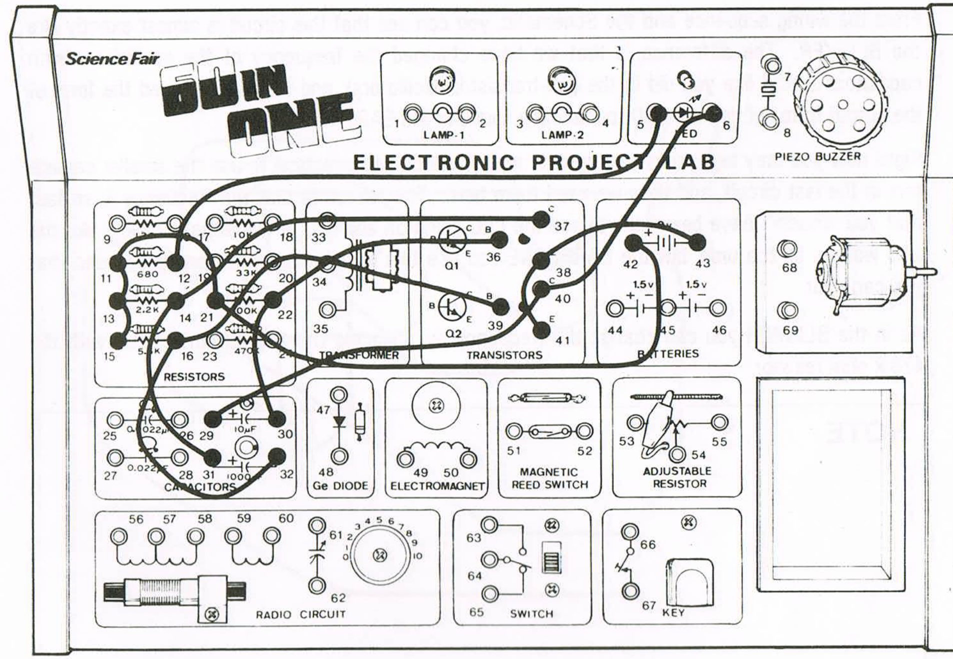
50. BLINKER

circuit like this one might be controlling the blinker in your parents' car. Since it turns on and f you might guess that it is an oscillator ... and you'd be right. It's a type of oscillator called an table multivibrator. It is designed so that, when one transistor is on the other is off; and they ntinually switch back and forth, or vibrate, from "on" to "off".

st like the one transistor oscillator, the frequency of the multivibrator is controlled by the com- nation of resistors and capacitors. Since there is such a big difference in size between the ca- citors used here and the other two capacitors in the kit, it would not be practical to use them re. But you can replace the 100 k ohm resistor with the 470 k ohm resistor or 33 k ohm resistor d see what happens. You've probably guessed already, but try it anyhow.

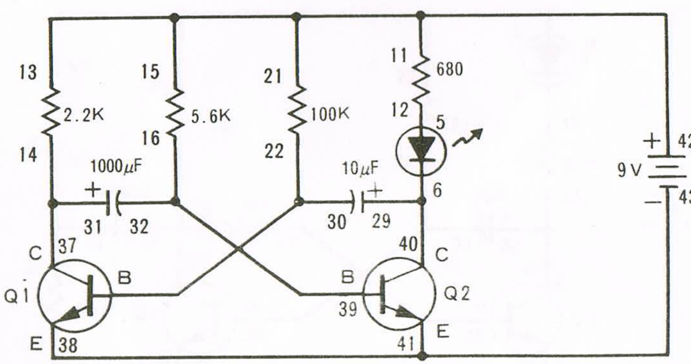
nally, do you know which transistor is on when the LED is on? You should be able to tell from e schematic. It's the right one ... of course!

NOTE



WIRING SEQUENCE:

5-12, 6-40-29, 15-13-11-21-42, 30-22-36, 31-14-37, 32-16-39, 41-38-43.



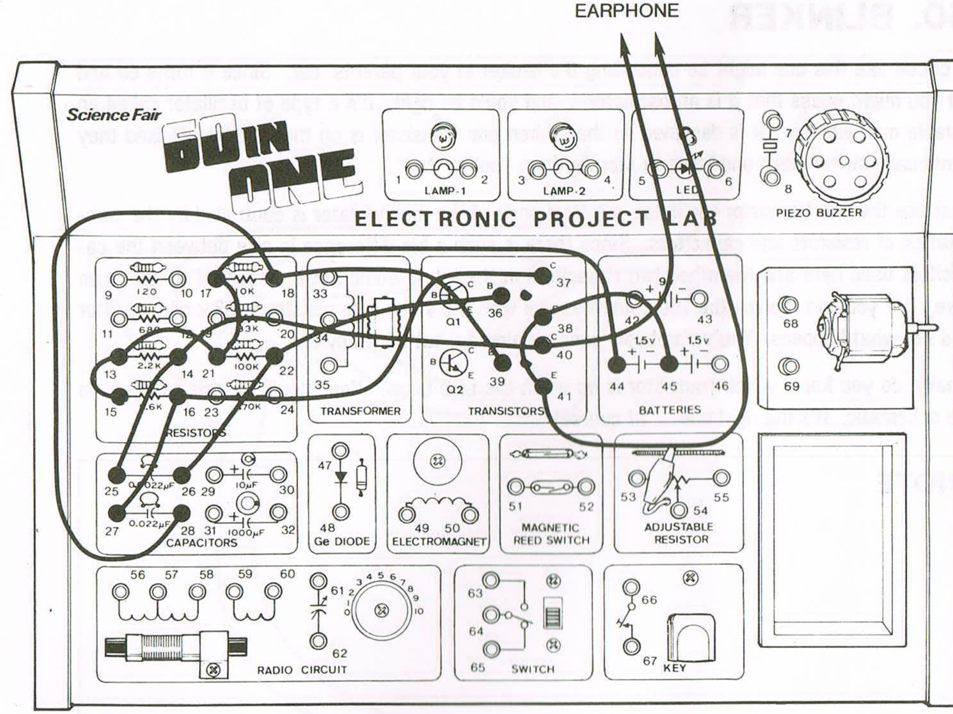
51. TWO-TRANSISTOR OSCILLATOR

rom the wiring sequence and the Schematic, you can see that this circuit is almost exactly like e BLINKER. The difference is that we have changed the frequency of the oscillation (with apacitors ... just like you did in the one-transistor oscillators), and we also changed the form of e output from lighting the LED to making a sound in the EARPHONE.

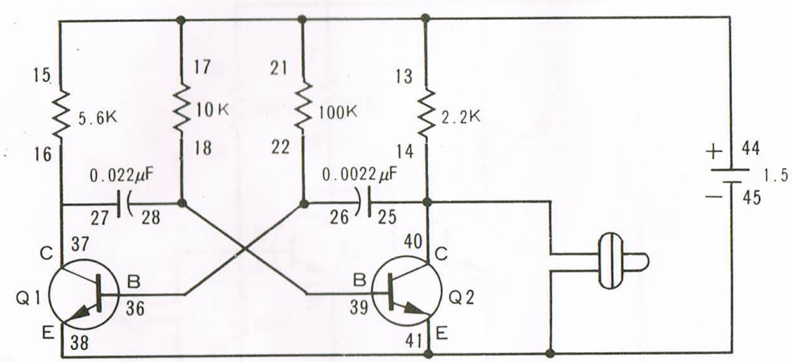
ight now you may be asking why we told you it wouldn't be practical to use the smaller capaci-rs in the last circuit, and then we used them here. The reason is that the frequency is so fast at you wouldn't have been able to see the LED going on and off. It would have looked like the ED was on all the time, but the EARPHONE can use this high frequency to produce sound that ou can hear.

s in the BLINKER you can change the frequency by replacing the 100 k ohm resistor with the 70 k ohm resistor.

NOTE



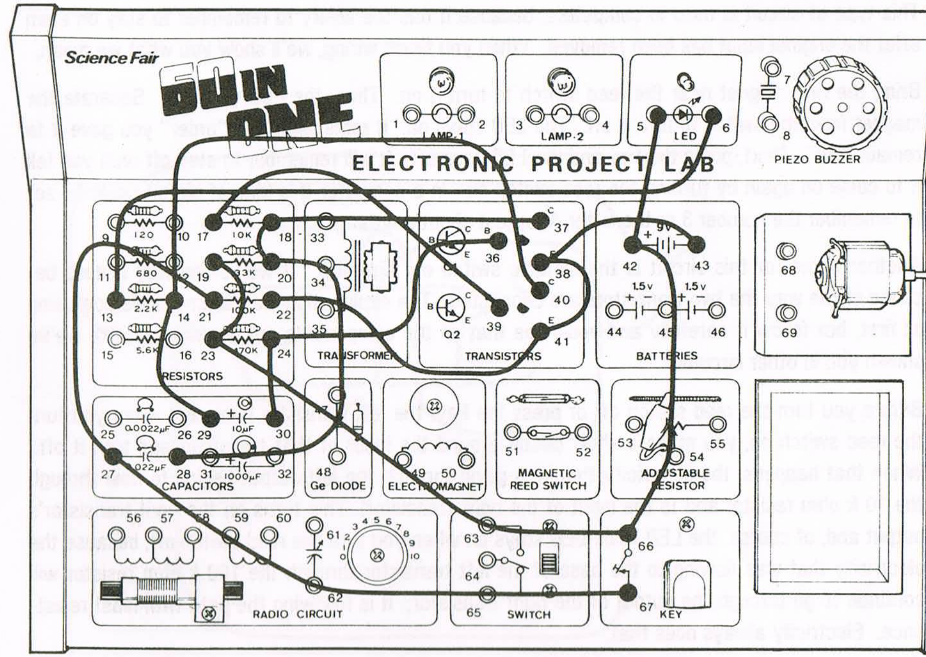
WIRING SEQUENCE:
15-13-21-17-44, 25-14-40-EARPHONE, EARPHONE-41-38-45, 26-22-36, 27-16-37, 28-18-39.



52. TIMER

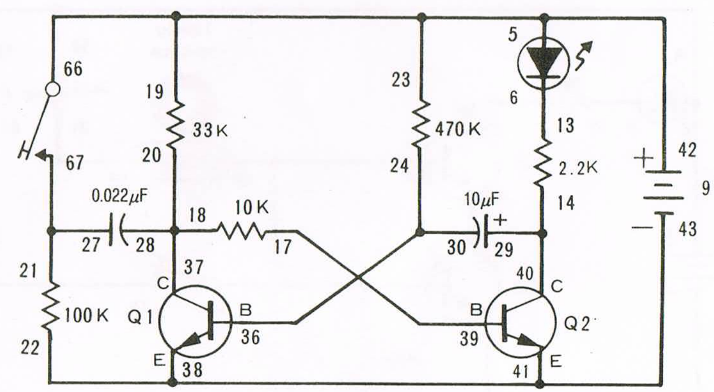
his circuit is also a multivibrator, but it is a special kind called a one-shot multivibrator. When ou finish wiring you'll see why it is called that. Press the KEY and release it immediately. The ED will light and stay on for a few seconds and then go off. It will stay on for the same amount f time every time you press the KEY, even if you hold the KEY down longer sometimes. The time he LED stays on is controlled by the 10 μF capacitor, so you could change the time by changing he capacitor – or the resistor that controls its discharge (the 100 k ohm). The name "one-shot" omes from the fact that the LED only comes on once for each time the input is connected by ressing the KEY.

NOTE



WIRING SEQUENCE:

5-42-66-23-19, 6-13, 17-39, 21-27-67, 22-41-38-43, 28-20-18-37, 29-14-40, 30-24-36.



53. MEMORY

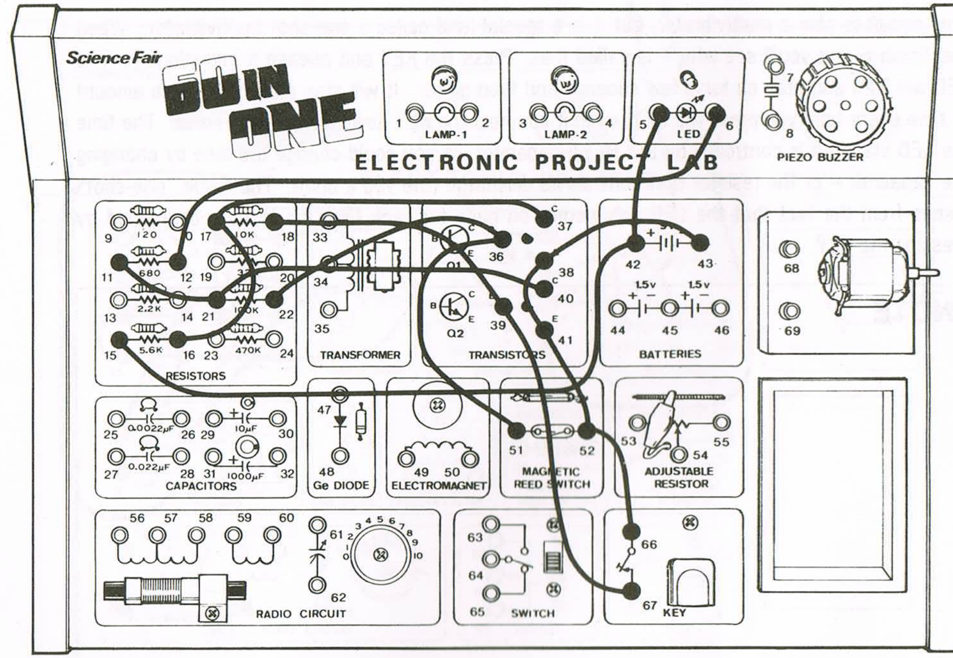
his type of circuit is used in computers, because it has the ability to remember to stay on even fter the original input has been removed. When you finish wiring, we'll show you what we mean.

ring the ring magnet near the reed switch to turn it on. Then, the LED will light. Separate the nagnet from the switch to turn it off. The LED stays on. It remembers the "order" you gave it to emain "ON". Next, press the key and the LED goes off. It will remember to stay off until you tell t to come on again by turning the reed switch on. In a computer this kind of circuit could be set o remember the number 3 or the letter A, or just about anything.

nother name for this circuit is the bistable switch or "flip-flop". It works the way it does be-ause of the way the two transistors are connected. The explanation may seem a little confusing t first, but follow it carefully and you'll see that all the components are working just like we've hown you in other circuits.

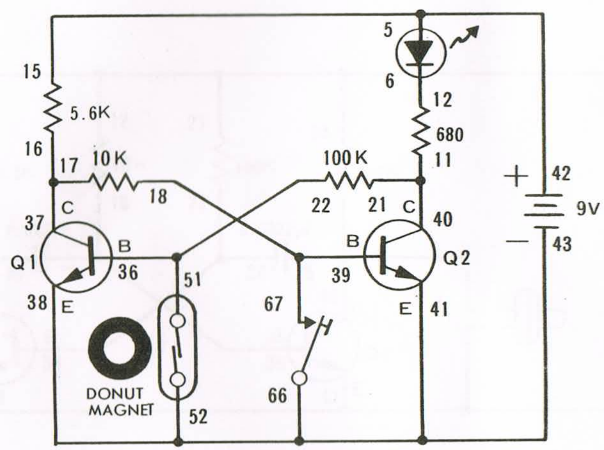
efore you turn the reed switch off or press the key, the left transistor is on, but when you turn he reed switch on, you make a short circuit around the input of that transistor and turn it off. Vhen that happens, the electricity that was going through the left output begins to flow through he 10 k ohm resistor and to the input of the right transistor. This turns on the right transistor's utput and, of course, the LED. The LED stays on when you turn the reed switch off, because the lectricity that was flowing to the base of the left transistor through the 100 k ohm resistor will ontinue to go through the output of the right transistor; it is following the path with least resist-nce. Electricity always does that.

Vhen you press the KEY, the input to the right transistor is short-circuited and the output on the ight is turned off. This allows the flow of electricity to return as it was before you did anything vith the circuit.



WIRING SEQUENCE:

5-42-15, 6-12, 11-21-40, 16-17-37, 18-39-67, 22-36-51, 43-38-41-52-66.



NOTE

54. "AND" GATE

The AND gate is another type of circuit that is used in computers (and in your calculator, too). In fact all the remaining circuits are used in computers – but there are other uses too.

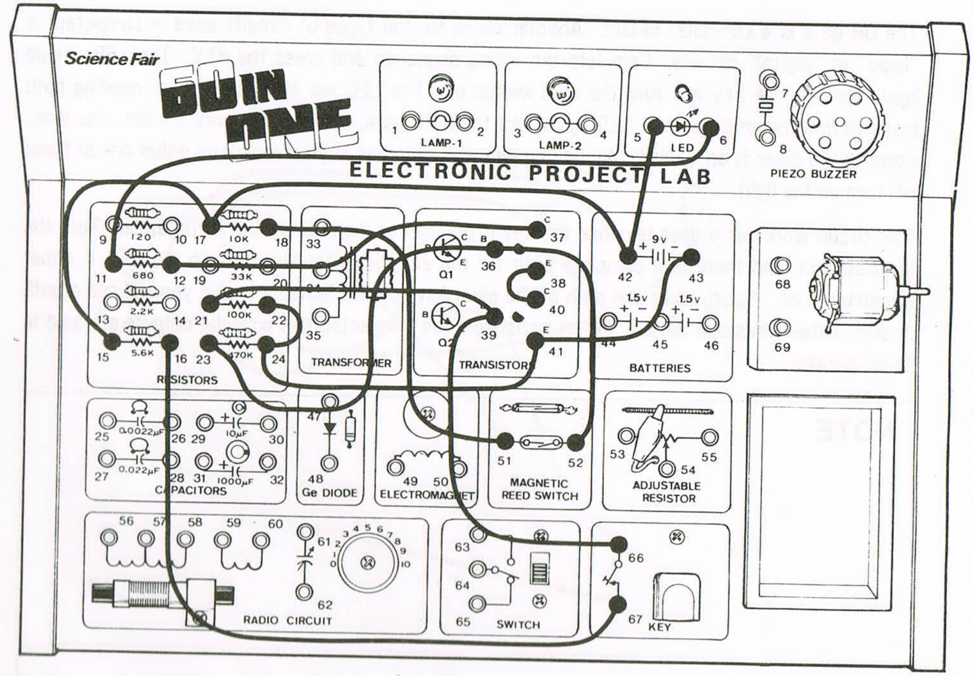
When you finish the wiring, press the key. Nothing happens. Now release the key and turn the reed switch off. Nothing happens, but if you press the key and turn the reed switch on, the LED will light on. It's like having two wall switches in your room and having to turn them both on before the light comes on. Computers use these circuits to add things together. By using many of these circuits, the computer can add many things together.

Besides in a computer, can you think of a use for this circuit? How about ... for telling an astronaut whether both hatches of the spaceship's air lock are closed? There are many more uses and we're sure you'll think of some of them.

The AND gate works as it does because both transistors have to be on before there is a complete path for the electricity to flow through the LED. Look at the Schematic and trace the output circuit's path.

When transistors are connected in this way the outputs are said to be in "series".

NOTE



WIRING SEQUENCE:

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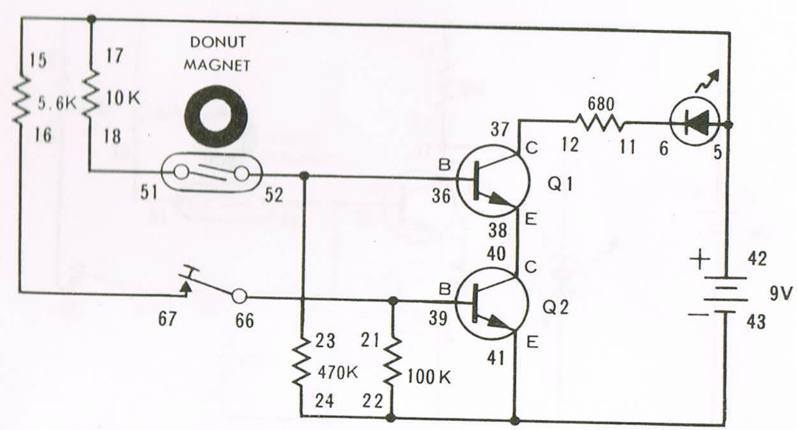
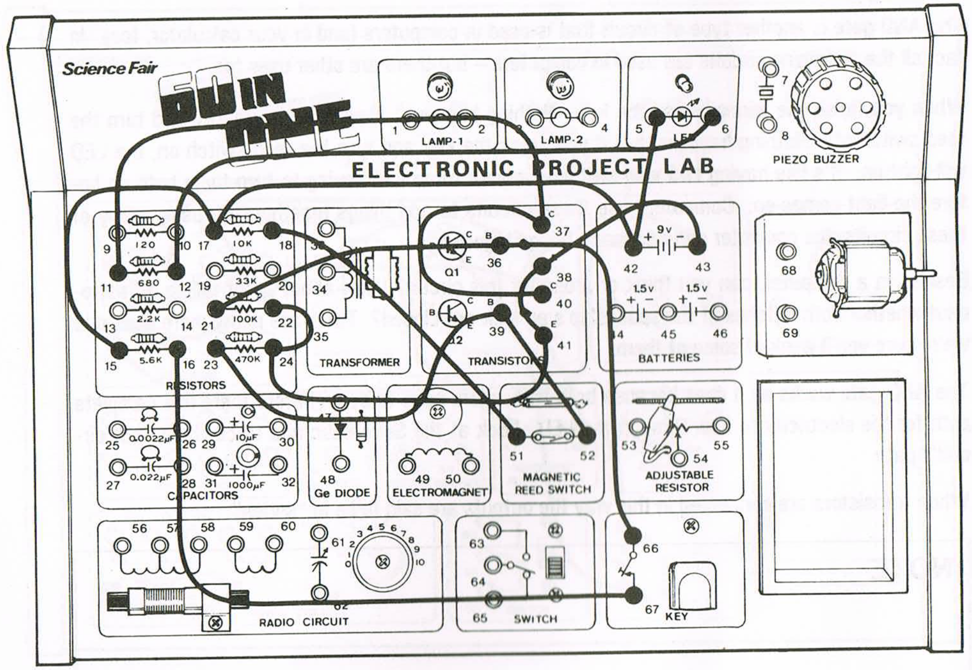


55. "OR" GATE

'he OR gate is a computer circuit. Another name for the types of circuits used in computers is logic" or "digital" circuits. Complete the wiring sequence and press the KEY. The LED should ght. Release the key and turn the reed switch on. The LED will light. Instead of needing both ransistors to be on before the LED lights, like the AND gate, this circuit works if either one tranistor or the other is on. This is like having two wall switches in your room and either one of them vill turn on the light.

'his circuit works as it does because the key is pressed or the reed switch is turned on. Turn the ransistor on, and there is a complete path for the electricity to flow through the LED if either ransistor is on. Again, trace the path of the electricity on the Schematic and you will see a path hrough either transistor output. When transistors are connected this way the outputs are said to e in "parallel".

NOTE



WIRING SEQUENCE:

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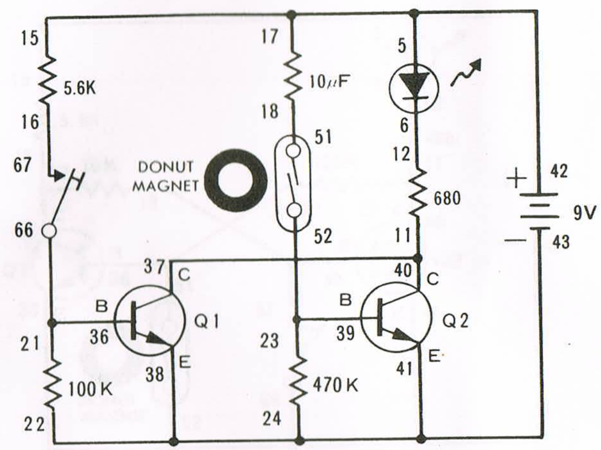


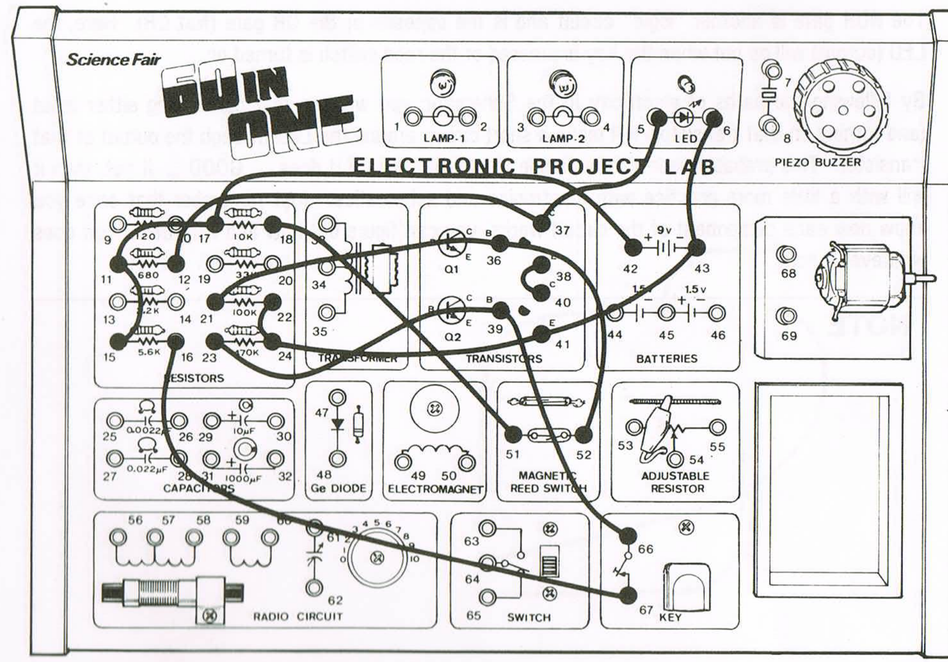
56. "NAND" GATE

As you might suspect the NAND gate is the opposite of the AND gate (Not AND). The LED (the output) will go out when the reed switch is turned on with the key pressed.

One use for a NAND gate, besides in a computer, might be for the door buzzer in your parent's car. They have to close both doors (the two inputs) to turn off the buzzer (the output).

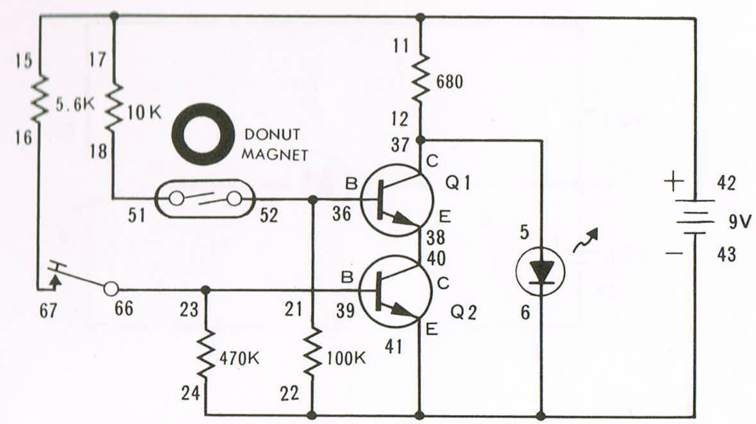
In the Schematic you will see that when both connections are made, both transistors are on, and that makes a short circuit around the LED, through the output circuits of the transistors. The LED then has to go off.

NOTE



WIRING SEQUENCE:

5-37-12, 6-43-41-24-22, 15-11-17-42, 16-67, 18-51, 21-36-52, 23-39-66, 38-40.

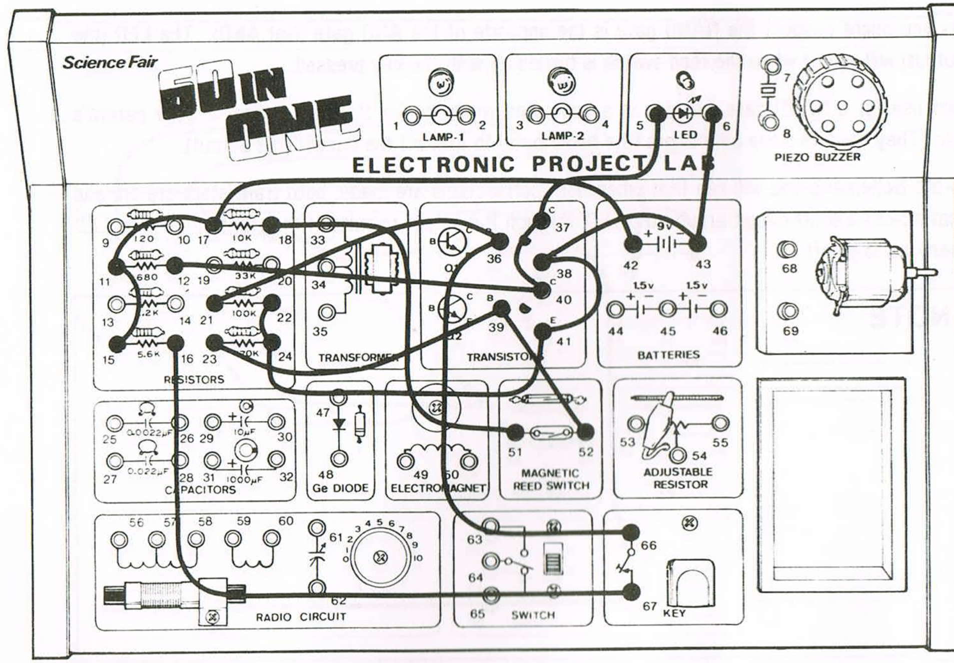


7. "NOR" GATE

NOR gate is another "logic" circuit and is the opposite of the OR gate (Not OR). Here, the) (output) will go out when the key is pressed or the reed switch is turned on.

following the paths of electricity in the Schematic you will see that connecting either input d turning on that transistor) will make a short circuit around the LED through the output of that nsistor. This probably seems very simple to you by now. If it does ... GOOD ... if not, then it with a little more practice with electronics and schematics. Just remember that once you w now each component of the circuit works, you can figure out how and why the circuit does atever it does.

IOTE



WIRING SEQUENCE:

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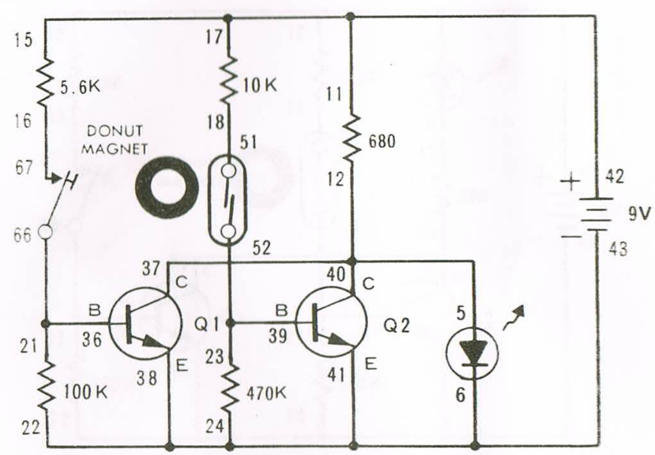

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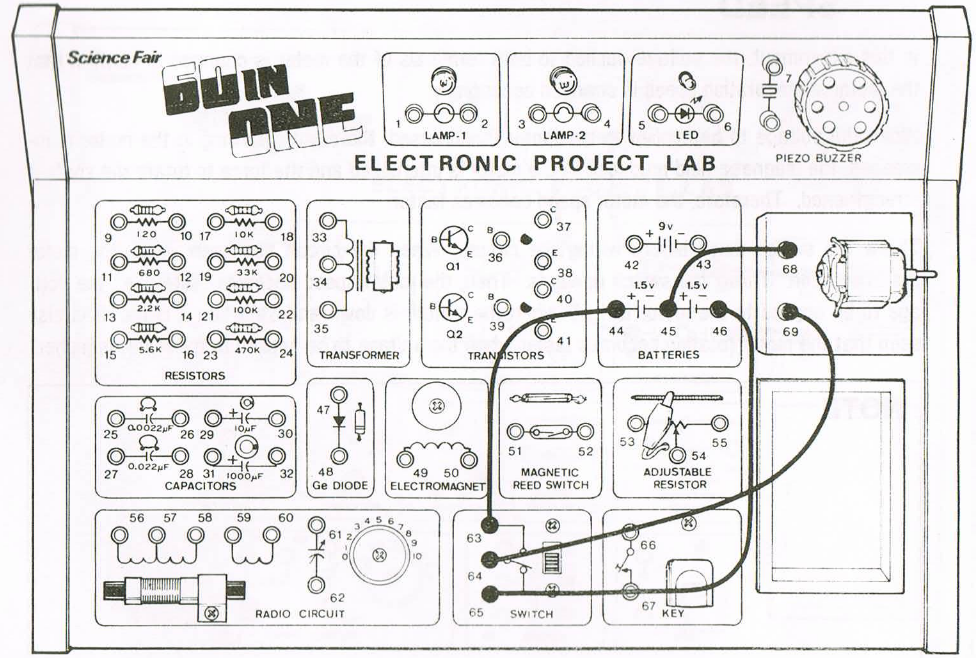
8. MOTOR DIRECTION

this experiment, the motor shaft is rotated forward and backward. When a voltage is applied tween both terminals of the motor and a current is allowed to flow in the motor, the motor shaft ates in a certain direction. When the polarity of the voltage applied between the terminals is anged, the current direction is changed and the motor shaft rotates in the opposite direction.

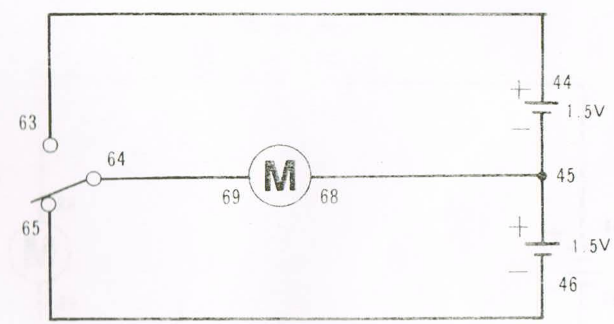
ose the switch before wiring the circuit. When the wiring is finished, the motor shaft starts ro-ion. When the switch is lifted upwards, the polarity of the voltage applied to the motor termi-ls will be changed and the current direction will be inverted. The motor shaft will then rotate in e reverse direction.

NOTE



WIRING SEQUENCE:

44-63, 45-68, 46-65, 64-69.



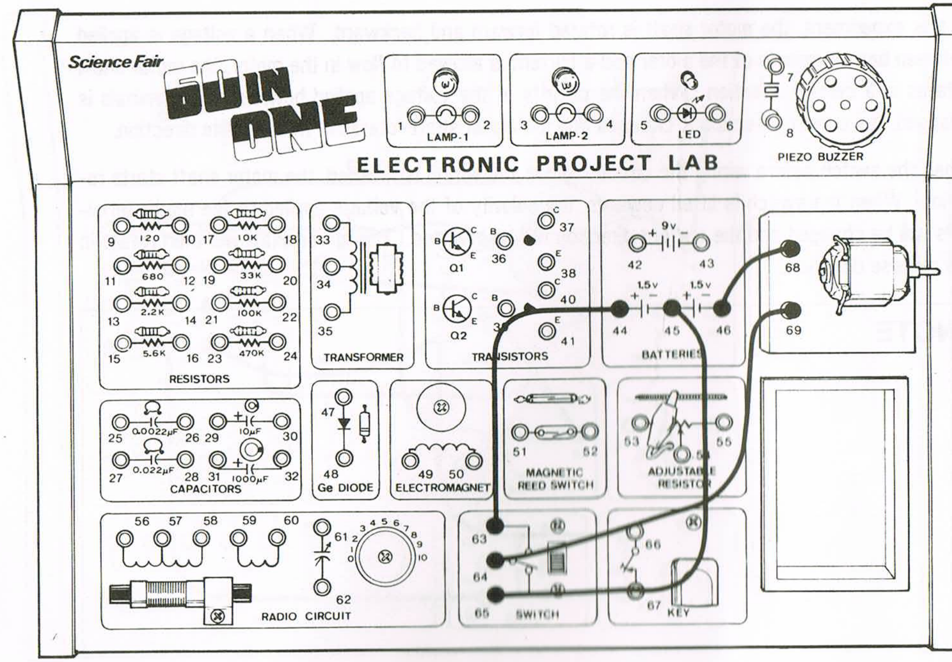
59. MOTOR APPLIED VOLTAGE AND MOTOR SPEED

In this experiment, the voltage applied to both terminals of the motor is changed to confirm that the motor shaft rotation speed is changed accordingly.

When the voltage to be applied to the motor is increased, the current flowing in the motor is increased, the magnetic field produced in the motor is intensified and the force to rotate the shaft is strengthened. Therefore, the motor speed becomes faster.

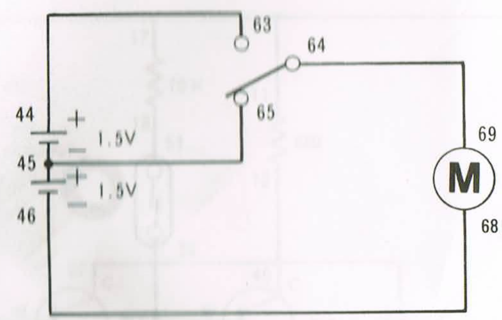
Throw the switch down before wiring the circuit. When the circuit has been wired, the motor starts rotation. Throw the switch upwards. Then, the motor speed becomes faster, i.e., the voltage to be applied to the motor is 1.5V when the switch is down and 3V when it is up. It is also seen that the motor rotation becomes faster when the voltage to be applied to the motor is higher.

NOTE



WIRING SEQUENCE:

44-63, 45-65, 46-68, 64-69.



60. CHANGE IN CURRENT BY MOTOR ROTATION

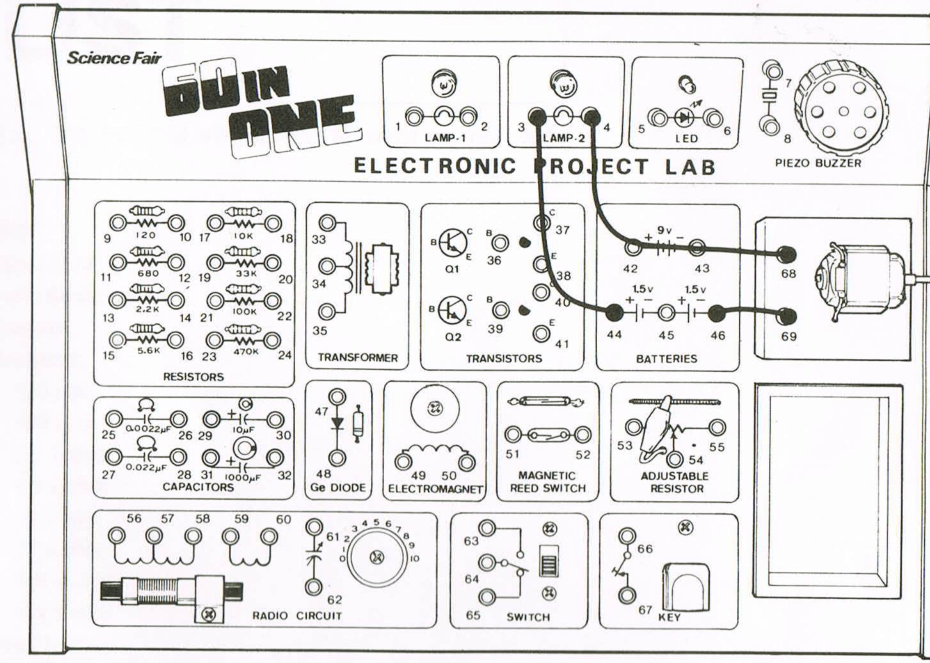
This experiment is carried out to study how the DC resistance value is changed by the motor speed.

Before you start this experiment, remove the propeller which is connected to the motor.

The DC resistance is minimum when the motor is in pause and it increases as the motor speed rises. Namely, when a certain voltage is applied to the motor, first a large current flows in the motor and as the motor rotates, the current becomes smaller, becomes constant at a certain level and the motor speed becomes constant, too. It is assumed that the load applied to the motor is constant. When the circuit has been wired, the motor rotates slowly and the lamp glows dimly. Stop the motor rotation with your finger. Then, the lamp lights bright. Release your finger. If the motor does not start rotation then, rotate it lightly with your finger. As the motor starts rotation, the lamp light becomes dim as the motor speed is increased.

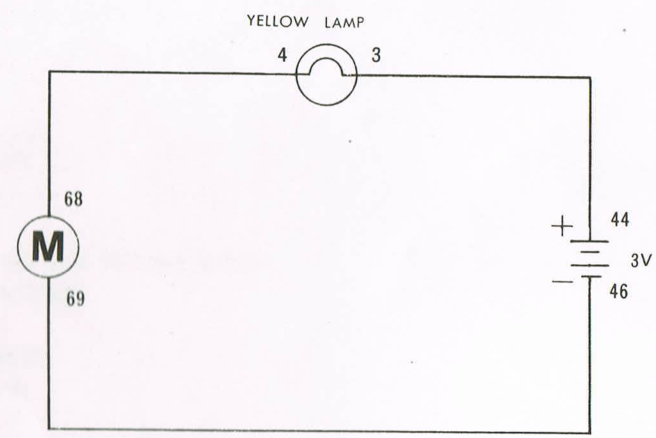
The DC resistance of the motor changes as the motor rotates, and it appears as a change in current at a certain voltage level.

NOTE



WIRING SEQUENCE:

3-44, 4-68, 46-69.



NOTES, IDEAS AND APPLICATIONS

PARTS LIST

NOTE: Most of these parts are already mounted on the Platform inside the Box. This Parts List will just serve to remind you what parts make up your Lab Kit.

Adjustable Resistor
Antenna, Green 3M
Arrow, styrofoam
Bar Antenna with 5 leads
Bar Magnet
Battery Snap
Battery Holder for 9V Battery, plastic
Battery Contact, single, metal (2)
Battery Contact, double, metal
Battery Case for UM 3 × 2, plastic
Buzzer
Capacitors:
  0.0022 μF, ceramic
  0.022 μF, ceramic
  10 μF, electrolytic
  1000 μF, electrolytic
Clip for Adjustable Resistor
Diode, germanium 1N60
Donut Magnet (3)
Electro Magnet
Earphone
Frame, right, plastic
Frame, left, plastic
Holder for Bar Antenna, plastic
Holder for Buzzer
Iron Filings
Knob for VC, plastic
Knob for Key Lever
Key Lever
Lamp, 2.5V 0.3A Yellow
Lamp, 2.5V 0.3A Green
Lamp Socket (2)
LED
Motor Base
Motor Support
Motor
Paper Panel
Parts Container
Propeller
Resistors:
  120 ohm
  680 ohm
  2.2 k ohm
  5.6 k ohm
  10 k ohm
  33 k ohm
  100 k ohm
  470 k ohm
Reed Switch
Ring for Buzzer Support
Slide Switch
Spring Terminal (69)
Screws:
  2.6 × 4 mm (3)
  3 × 6 mm (5)
  4 × 12 mm
  Nut, 3 mm (3)
  Nut, 4 mm
  Tapping, 3 × 5 mm
  Tapping, 3 × 6 mm
  Lug 3 mm (2)
Transformer
Transistor 2SC1684 (Q,R), 2SC828A (Q,R) (2)
Variable Capacitor 265pF
Wires:
  Yellow 350 mm (2)
  Blue 250 mm (4)
  Red 150 mm (9)
  White 75 mm (4)

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