30 in ONE Electronic Projects Lab Operating Instructions

(Order Code EPL030)

OPERATION

CIRCUIT #2: The Electronic Storage Tank

In the preceding section of the manual we told you that a capacitor stored and released electricity in a circuit. Now you can see for yourself. After you complete the wiring, touch the free end of the LONG WIRE to 21 and then to 26. 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 touching the wire to 21 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 touch the wire to 26 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 in this case).

As you go through all the circuits, you'll learn lots of information just like this and 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.

Wiring Sequence 23-11-41, 10-27, 40-LONG WIRE (blue)

CIRCUIT #3: The One-Way Street

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

Complete the wiring, and then touch the two free ends of the LONG WIRES together. The LED lights up.....right? Now reverse the connections to the Batteries (21 and 23), and touch the LONG WIRES again. Nothing happens, because the flow of electricity is going in the opposite direction and the Diode won't let it through.

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

The 680 ohm Resistor in this circuit reduces the amount of electricity going to the LED (It can't take very much, or it will burn out).

A practical use for this circuit is as a continuity tester. It will allow you to see whether electricity is flowing through a particular circuit or component. This kind of testing can help you find where the problems are

if a circuit isn't working correctly.

Wiring Sequence 21-10, 11-27, 26-LONG WIRE, 23-LONG WIRE

CIRCUIT #4: The "Invisible Power" Radio

In the wiring sequence for this circuit you will see a term we haven't talked about yet...GROUND. The schematic symbols is..."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 (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 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 (also the metal ground rod) you will need for this at your local electronics 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 weak 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 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 6 instead of 7. 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 (Tandy sells one 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 DON'T
GET NEAR POWER LINES.

Wiring Sequence 5-6, 4-8, 1-ANTENNA (green), 7-3-2-32-35-Earphone,
9-33-34-EARPHONE, 7-GROUND

CIRCUIT #5: The Transistor, An Electronic "Trigger"

The small motion of pulling the trigger of a gun can release a large amount of power. The Transistor can work in much the same way, but before we explain how that's done let's look at the three connections on the Transistor (we mentioned that earlier, remember?).

COLLECTOR

BASE

EMITTER

The three connections are the BASE, EMITTER and COLLECTOR.

Complete the wiring sequence, press the KEY, and the LED will light up. This may not seem very impressive to you, but you will see how important it is in the next 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 (one Battery), "triggers" the larger amount of electricity in the output circuit (both Batteries), and the LED lights up.

This is a simple circuit, but it is important that you understand it well, 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.

Wiring Sequence 10-26, 11-16, 15-43, 17-23, 21-27, 22-29, 28-42

CIRCUIT #6: The Transistor and "Amplification"

Complicated electronic circuits are almost always made up of two or more simple circuits connected together. This project combines a radio like the one in CIRCUIT #4 with a one transistor amplifier. Connect the GROUND and ANTENNA just as you did before and tune in a station. You should get more sound from the EARPHONE this time. While you're listening, let's look at the Schematic, and see why the sound is louder.

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

Wiring Sequence 2-3-7-35-28-17-23, 4-8, 5-6, 9-29-36-34, 15-37-33,
16-20-EARPHONE, 32-21-18-EARPHONE, 1-ANTENNA, 2-GROUND

CIRCUIT #7: The Sunrise-Sunset Light

After the circuit is complete, hold the WIRE to 31 and watch the LED. It will slowly light up....like a sunrise. When the LED reaches its brightest point, remove the WIRE from 31 and the LED will dim and go off...like a sunset. If you touch the WIRE to 41 the LED will go off very quickly. In this circuit the Transistor is used as a switch. It switches on slowly because electricity can flow through the input of the Transistor to turn on the output and the LED. The 100K ohm Resistor reduces the amount of

electricity flowing in the input circuit and this makes the Capacitor charge more slowly. Touching 41 makes the Capacitor discharge very quickly, because it makes a "short circuit" (a path with little or no resistance) for the Capacitor to empty through.

What do you think will happen if you change the values of the Resistor or Capacitor? Write down your guess, and then try changing the resistor to 10K or 470K ohms. Next try the 10 microF capacitor in place of the 100 microF.

NOTE: The 10microF and 100microF capacitors are a special type of capacitor called ELECTROLYTIC, and they have a + and a - connection. Be sure to keep the wiring the same when you switch them or they could be damaged.

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

Wiring Sequence 21-10-30, 23-17-41, 11-26, 16-27, 15-40-WIRE

CIRCUIT #8: The 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 33. In about twenty to thirty seconds the LED will begin to light up. Remove the LONG WIRE and the LED will slowly go off. (It may take five minutes or so). As in the previous circuit, the LED will go off quickly if you touch the LONG WIRE to 41.

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.

Wiring Sequence 21-10-28-32, 23-17-41, 11-26, 27-16, 29-13, 12-40-WIRE, 14-15

CIRCUIT #9: The "Secret Code" Key

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

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

Wiring Sequence 22-19, 23-43, 32-34-20-EARPHONE, 33-35-15,
16-18-EARPHONE, 17-42

CIRCUIT #10: The 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, touch the LONG WIRE from 19 to either 30 or 32, and at the same time touch the LONG WIRE from 20 to either 34 or 36. Now you should be hearing a sound in the EARPHONE. Try as many combinations of touching the LONG WIRES as you can find and see how many different sounds you can get from the oscillator.

From looking at the Schematic you can see that touching 30 connects the 100K ohm resistor, and 32 connects the 470K ohm resistor. 34 connects the 0.0022 microF capacitor and 36 the 0.022 microF 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.

Wiring Sequence 22-19-LONG WIRE, 23-17, 33-31-37-35-15, 16-18-EARPHONE,
LONG WIRE-20-EARPHONE

CIRCUIT #11: The Beacon Light

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

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

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

NOTE: Don't forget about the + and - connections on the electrolytic capacitors.

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

Wiring Sequence 21-32-19, 23-17, 10-18, 11-16, 15-33-41, 40-20

CIRCUIT #12: 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 two or three centimetres wide. Fill in the entire rectangle with heavy pencil marks (a very soft pencil will be best). 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 your favourite 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.

Wiring Sequence 22-19-EARPHONE, 22-LONG WIRE, 23-17, 30-LONG WIRE, 16-18-EARPHONE, 15-31-37, 36-20

CIRCUIT #13: The Leaky Faucet

By now you should have no problem recognizing this circuit as an oscillator, and this one works just like the others you have built. But in this circuit (in fact in the next three) we are going to have fun with "sound effects."

When you finish the wiring you will begin to hear a slow clicking sound, something like a dripping faucet. Now let's see if you can put to work those notes you've been taking.

1. Can you think of a way to make the "dripping" get faster?

2. How about a way to make the "dripping" slower?

See what you come up with and then check with the answers below.

Wiring Sequence 22-32-19, 23-17, 16-18-EARPHONE, 15-39-33, 38-20-EARPHONE

CIRCUIT #14: The 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" on the late 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 10microF capacitor with the 100 microF 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 100 microF capacitor is much larger, it takes much longer for it to discharge, and the "bee" sound fades away more slowly.

Now change the 0.0022 microF. 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!

Wiring Sequence 22-32-19, 23-42-39, 33-37-15, 16-18-EARPHONE,
36-20-EARPHONE, 38-17-43

CIRCUIT #15: The Electronic Canary

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

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

Wiring Sequence 22-31-19, 23-42, 43-17-39, 26-30-15-37, 27-38,
16-18-EARPHONE, 36-20-EARPHONE

CIRCUIT #16: The Burglar Alarm

This circuit is turned on by disconnecting a wire, instead of by connecting one. Any time the LONG WIRE between 15 and 17 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 Tandy store. This same type of alarm circuit is used in professional burglar alarms, except that it is connected to very loud bells of buzzers, or a silent alarm that alerts the police, instead of an EARPHONE.

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 see if you can catch who's been getting into your "private stuff."

Wiring Sequence 22-19, 23-17-LONG WIRE (green)-15-35-32,
33-34-20-EARPHONE, 16-18-EARPHONE

CIRCUIT #17: The Touching 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 TOUCHING 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 24 and 26 with fingers of the same hand. Surprise! The LED lights up, and YOU are the conductor for the electricity. 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 24 and 26 with fingers from different hands. Does the LED still light? Wetting your fingers will help make better contact with the terminals.

Wiring Sequence 21-26-28, 23-31-14, 10-27, 11-13, 25-15, 29-16, 30-12-17

CIRCUIT #18: The 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 complete, 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 EARPHONE. 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 designed to use water as a conductor to complete the circuit.

Wiring Sequence 21-26, 23-17, 27-28-19, 29-LONG WIRE, 16-18-EARPHONE, 15-37-LONG WIRE, 36-20-EARPHONE

CIRCUIT #19: The Radio Station

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

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

A radio station like the one you have built is a combination amplifier-oscillator. The oscillator produces a high frequency radio wave that is

sent out into the air by the ANTENNA COIL. The frequency of the oscillation is set to match the setting on the radio dial by the TUNING KNOB (Remember, the TUNING KNOB is a variable capacitor.)

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

Wiring Sequence 22-4-30, 23-17-EARPHONE, 5-6-26, 27-16,
33-EARPHONE, 15-32-31-34, 3-7-35

CIRCUIT #20: The "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. Don't forget, you 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 ways as the other one, except you will have the convenience of hearing the alarm over the radio instead of through the EARPHONE.

Wiring Sequence 22-26, 23-14-17, 5-6-36, 4-31-29-27-19,
3-7-16, 28-15-37, 30-LONG WIRE,
12-35-LONG WIRE, 13-18, 34-20

CIRCUIT #21: The Metal Detector

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

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

Take a piece of metal (try a coin and touch it to the end of the ANTENNA COIL core. The squeal tone will go away to indicate the presence of

metal.

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

Wiring Sequence 22-26, 23-17, 5-6-36, 3-7-16, 4-27-30, 31-37-15

CIRCUIT #22: 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, again. 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 it is quieter).

This circuit is a two-transistor amplifier that uses the electricity created by the 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!

Wiring Sequence 21-10-28-32, 23-30-17, 11-26, 27-16,29-13,
33-31-12-EARPHONE, 14-15-EARPHONE

CIRCUIT #23: The Blinker

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

Just like the none transistor oscillator, the frequency of the multi-vibrator is controlled by the combination of resistors and capacitors. Since there is such a big difference in size between the capacitors used here and the other two capacitors in the kit, it would not be practical to use them here. But you can replace the 100K ohm resistor with the 470K ohm resistor and see what happens. You probably already know, but try it anyhow.

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

Wiring Sequence 21-26-24-28-30, 23-14--17-11, 27-38-13-10,
25-40-16, 29-41-12, 31-39-15

CIRCUIT #24: The Two-Transistor Oscillator

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

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

As in the BLINKER you can change the frequency by replacing the 100K ohm resistor.

Wiring Sequence 21-26-24-28-30,23-14-17-EARPHONE, 27-34-13-EARPHONE, 25-36-16, 29-37-12, 31-35-15

CIRCUIT #25: The Timer

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

Wiring Sequence 21-10-24-30, 23-14-17-42, 11-26, 28-12, 29-25-16, 31-41-15, 13-27-40-43

CIRCUIT #26: The Memory

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

Touch the LONG WIRE to 15 and the LED will light up. Now remove the wire from 15 and the LED stays on. It remembers the "order" you gave it to be "on." Next touch the LONG WIRE to 12 and the LED goes off. It will remember to stay off until you tell it to be on again by touching 15. In a computer this kind of circuit could be set to remember the number 3 or the letter A, or just about anything.

Another name for this circuit is the bistable switch or "flip-flop." It works the way it does because of the way the two transistors are connected. The explanation may seem a little confusing at first, but follow it carefully and you'll see that all the components are working just like we've shown you in other circuits.

Before you touch the LONG WIRE to 15 or 12, the left transistor is on, but when you touch 15 you make a short circuit around the input of that transistor and turn it off. When that happens, the electricity that was going through the left output begins to flow through the 10K ohm resistor and to the input of the right transistor. This turns on the right transistor's output and, of course, the LED. The LED stays on when the LONG WIRE is removed from 15, because the electricity that was flowing to the base of the left transistor through the 100K ohm resistor will continue to go through the output of the right transistor; it is following the path with least resistance. Electricity always does that. When the LONG WIRE is touched to 12, the input to the right transistor is short-circuited and the output on the right is turned off. This allows the flow of electricity

to return as it was before you did anything with the circuit.

Wiring Sequence 21-10-24, 23-14-17-LONG Wire, 11-26,
28-12, 30-15, 29-25-16, 31-27-13

CIRCUIT #27: The "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 wiring, touch the LONG WIRE from 25 to 31. Nothing happens. Now remove that wire and touch the LONG WIRE from 29 to 33. Again nothing happens, but if you touch both wires at the same time the LED will light. 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 airlock 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."

Wiring Sequence 21-10-24-28, 23-17-30-32, 11-26, 27-13-,
25-LONG WIRE, 12-33, 14-16, 15-31

CIRCUIT #28: The "OR" Gate

The 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 touch the LONG WIRE from 25 to 31. The LED should light. Now remove that connection and touch the LONG WIRE from 29 to 33. Again, the LED should light. Instead of needing both transistors to be on before the LED lights, like the AND gate. This circuit works if either one transistor OR the other is on. This is like having two wall switches in your room and either one of them will turn on the light.

This circuit works as it does because touching either one of the LONG WIRES turns on a transistor, and there is a complete path for the electricity to flow through the LED if either transistor is on. Again, trace the path of the electricity on the Schematic and you will see a path through either transistor output. When transistors are connected this way the outputs are said to be in "parallel."

Wiring Sequence 21-10-24-28, 23-14-17-30-32, 11-26, 27-16-13,
25-LONG WIRE, 29-LONG WIRE, 12-31,15-33

CIRCUIT #29: The "NAND" Gate

As you might suspect the NAND gate is the opposite of the AND gate (not AND). In this circuit you must connect both LONG WIRES (25 to 31 and 29 to 33) to turn the LED (the output) off. 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 (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.

Wiring Sequence 21-26-24-28, 23-11-17-30-32, 10-27-13,
25-LONG WIRE 29-LONG WIRE, 12-33, 14-16, 15-31

CIRCUIT #30: The "NOR" Gate

The NOR gate is another "logic" circuit and is the opposite of the OR gate (Not OR). Here, connecting either one input OR the other (25 to 30 or 29 to 32) will turn off the LED (output).

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

Wiring Sequence 21-26-24-28, 23-11-14-17-31-33, 10-13-16-27,
25-LONG WIRE, 29-LONG WIRE, 12-32,15-30

WHAT NEXT?

Now that you have built all the circuits in this kit, there are several different things you can do next. You may want to build them all again, or maybe just the ones you thought were really "special." If there were some circuits you would like to make permanent models of, you can buy the extra parts (resistors, capacitors, LED's, etc.) that you need at your local Tandy store.

If you want to learn more about electronics in kit form before you strike out on your own, Quasar Electronics has an extensive range of project kits for all interests and abilities. Also, there are many good books about electronics at your school or public library. Whether you plan to continue electronics as a hobby or make it a career, we hope you HAVE FUN!

By the way, here is the Schematic for the first circuit you built (the Siren). When you built it we bet it seemed pretty complicated, but now, with a little experimenting you can probably figure it out in no time.

Wiring Sequence 23-17-39, 24-14, 25-28, 29-37-15, 32-22-13-19
33-43, 12-42-38, 16-18-EARPHONE, 36-20-EARPHONE

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