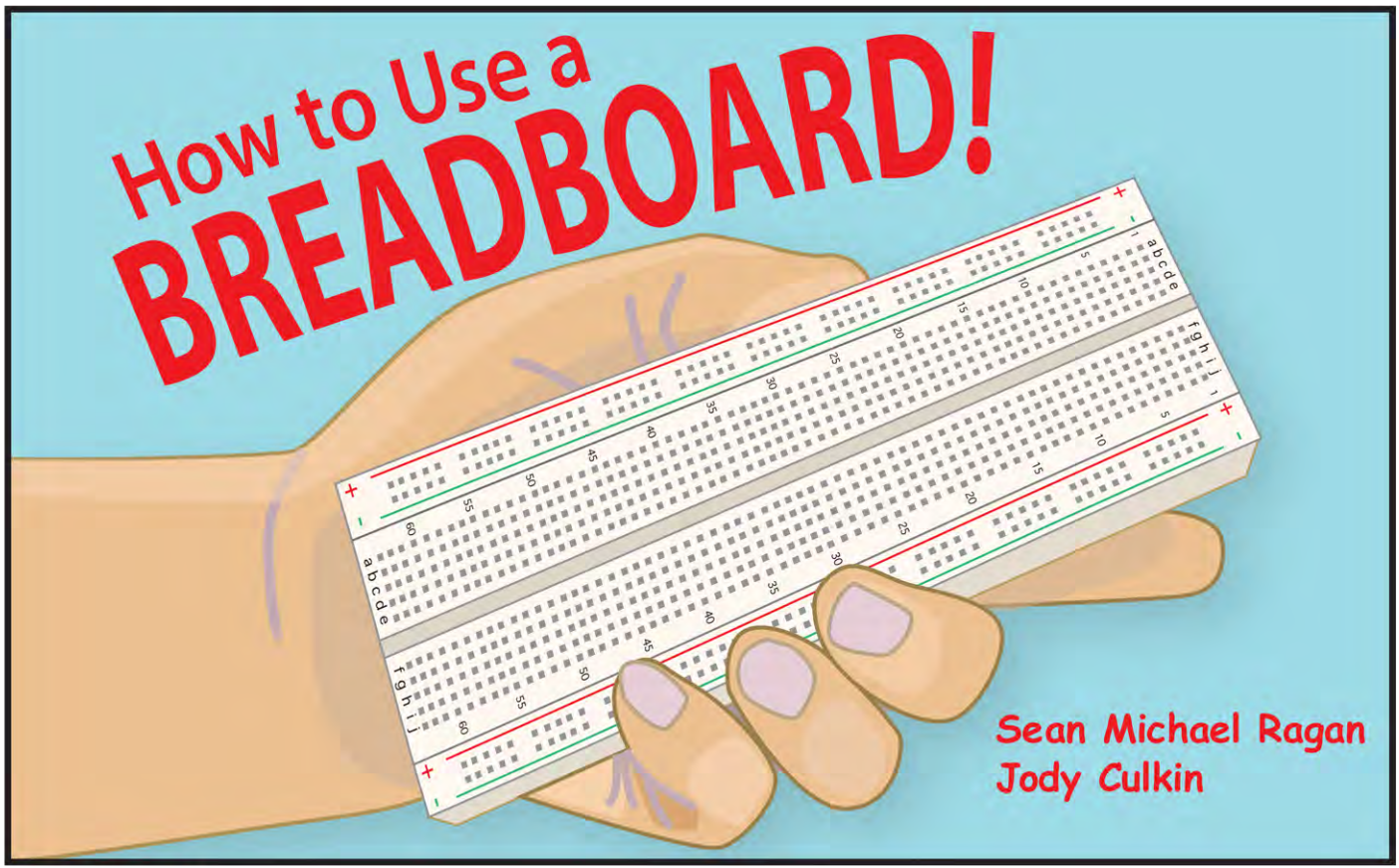
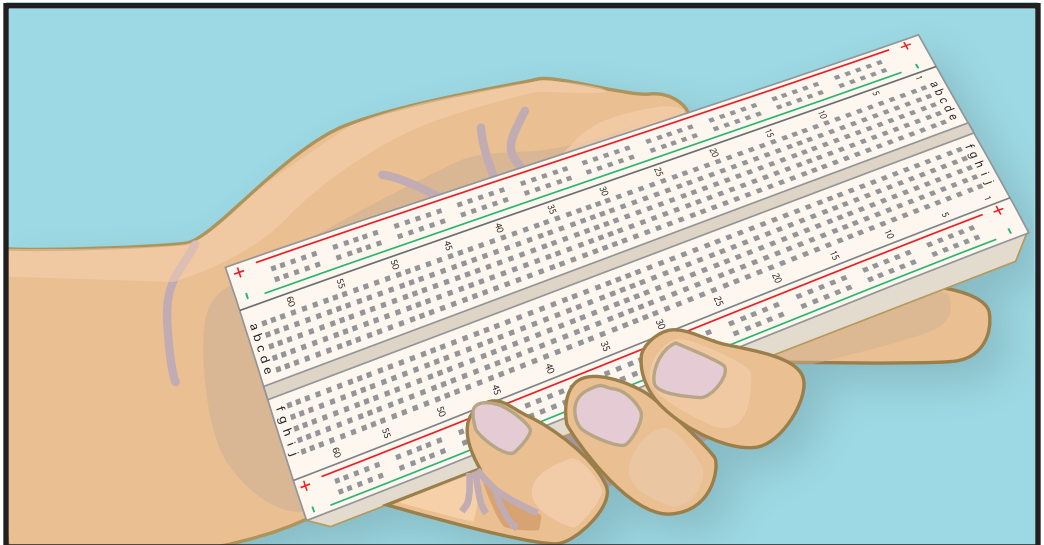
Make:

How to Use a BREADBOARD!



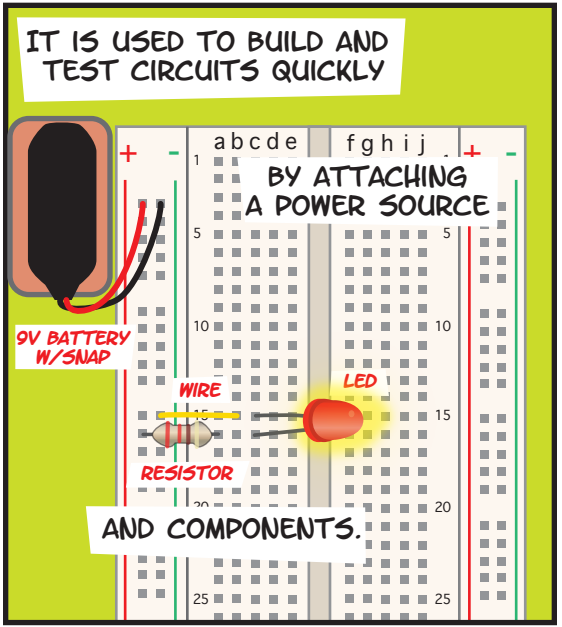
Sean Michael Ragan
Jody Culkin

Handbook

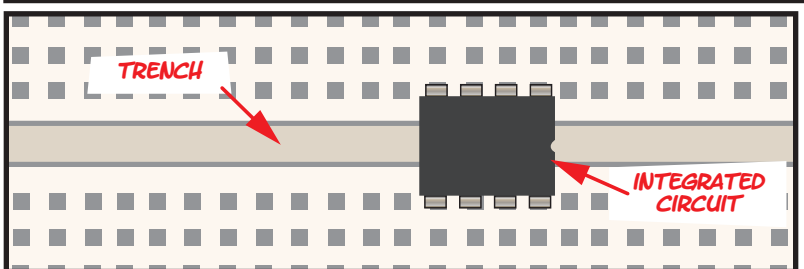


A **SOLDERLESS BREADBOARD** IS A PLASTIC BOX FULL OF METAL STRIPS, WITH A GRID OF HOLES ON TOP.

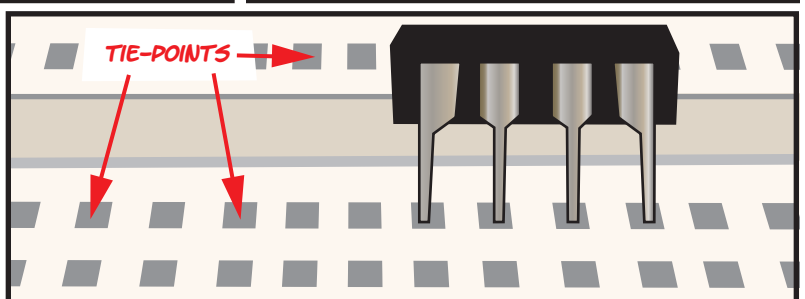
IT IS USED TO BUILD AND TEST CIRCUITS QUICKLY



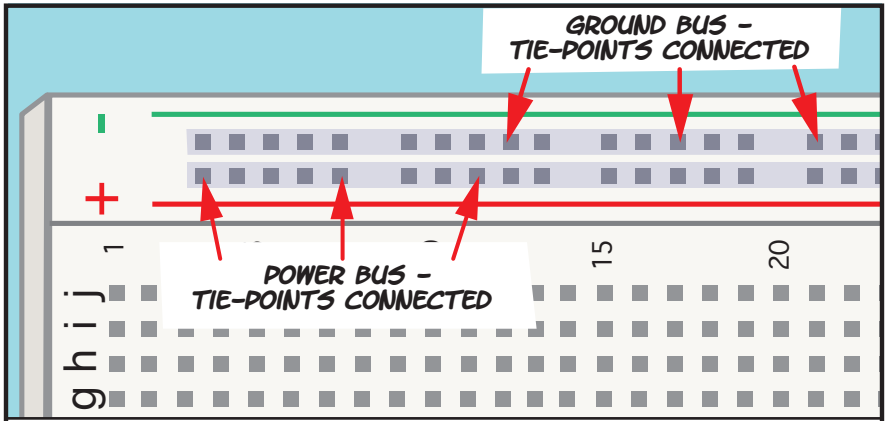
BY ATTACHING A POWER SOURCE AND COMPONENTS.



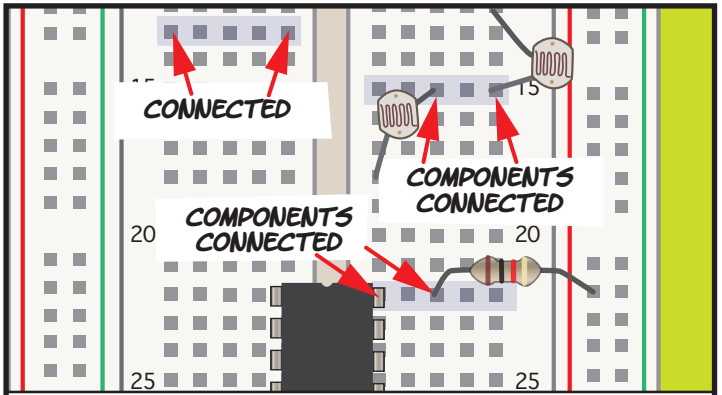
USUALLY A BREADBOARD HAS A SLOT DOWN THE MIDDLE CALLED A **TRENCH**. THE WIDTH IS DESIGNED SO MANY **INTEGRATED CIRCUITS** (**ICS**) FIT RIGHT ACROSS IT.



THE HOLES, CALLED **TIE-POINTS**, ARE THE SAME DISTANCE APART AS THE PINS ON MANY **ICS** AND OTHER COMPONENTS.

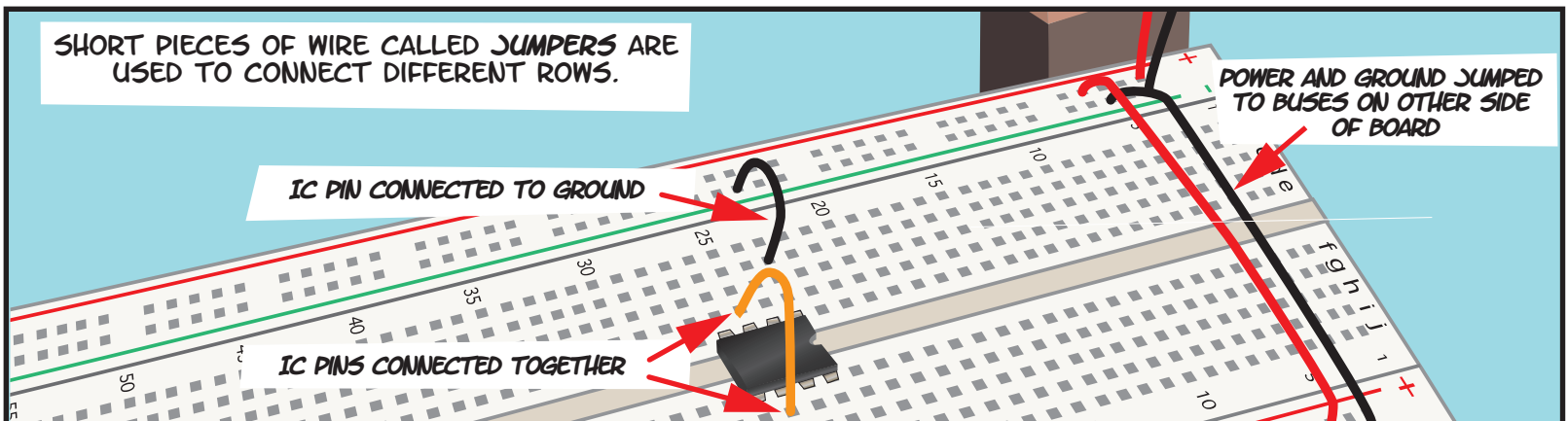


A BREADBOARD'S LONG EDGE USUALLY HAS TWO **DISTRIBUTION BUSES** FOR CONNECTING **POWER** AND **GROUND**.



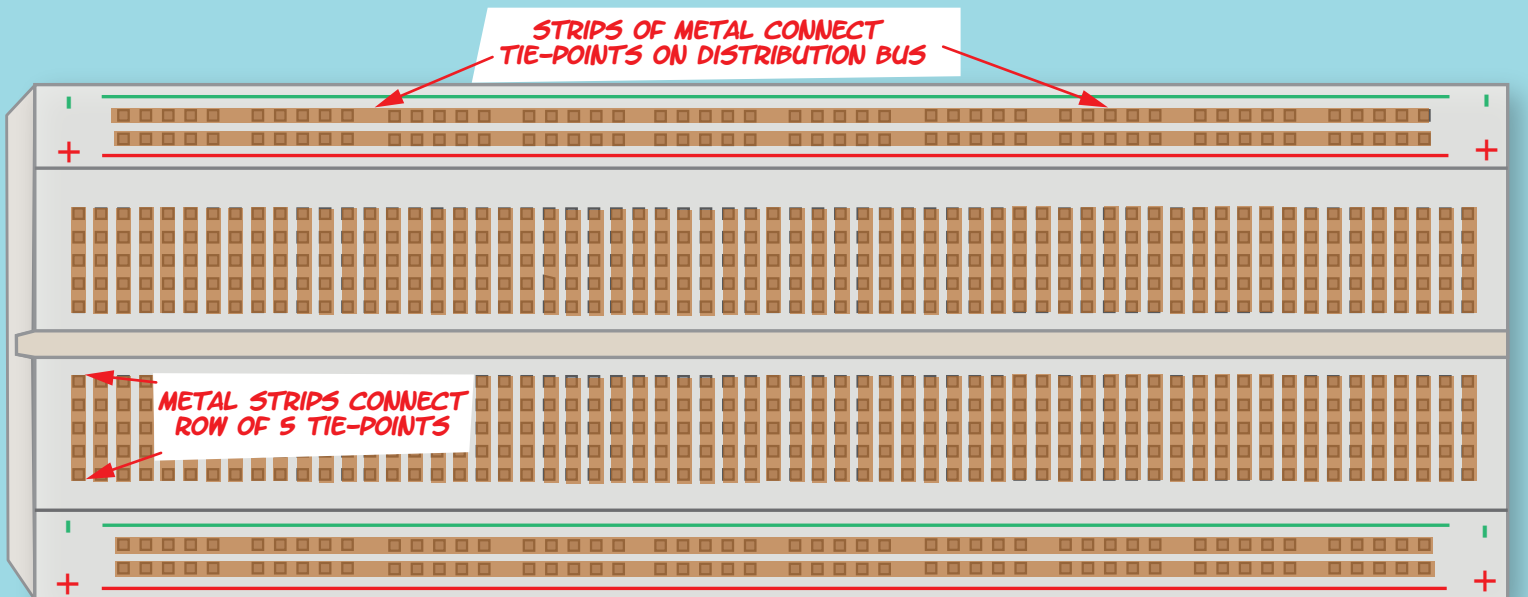
ROWS OF CONNECTED TIE-POINTS RUN PERPENDICULAR TO THE BUSES. TO CONNECT COMPONENT LEADS, PUT THEM IN THE SAME ROW.

SHORT PIECES OF WIRE CALLED **JUMPERS** ARE USED TO CONNECT DIFFERENT ROWS.



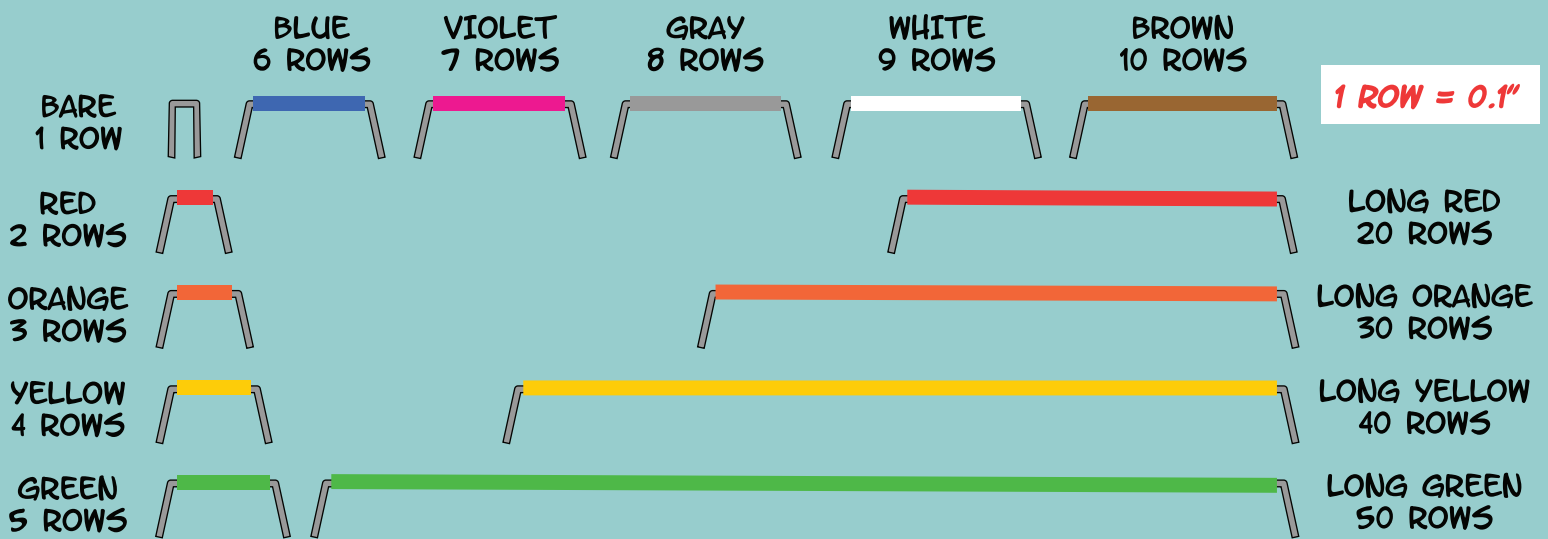
USING A SOLDERLESS BREADBOARD ALLOWS YOU TO GET YOUR CIRCUIT UP AND RUNNING QUICKLY SO YOU CAN TEST IT. ONCE YOU HAVE IT JUST RIGHT, YOU CAN BUILD A MORE PERMANENT VERSION ON PERFBOARD OR A PCB!

WHAT WOULD AN "X-RAY VIEW" OF A BREADBOARD LOOK LIKE?



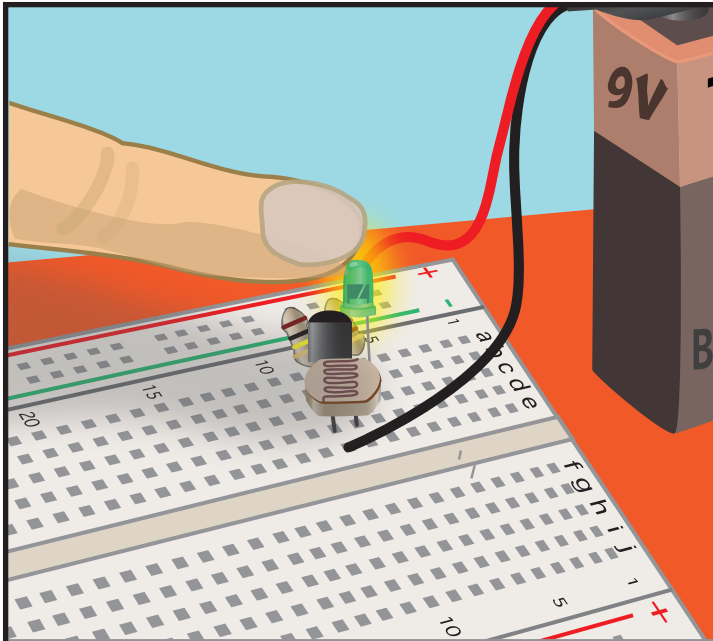
WE CAN SEE THE STRIPS OF METAL BENEATH THE TIE-POINTS. THERE ARE LONG STRIPS BENEATH THE DISTRIBUTION BUSES AND SHORT STRIPS CONNECTING ROWS OF 5 TIE-POINTS.

YOU CAN MAKE YOUR OWN JUMPERS FROM **22-GAUGE INSULATED SOLID COPPER WIRE.** CUT THEM AT LEAST 1/2" LONGER THAN THE DISTANCE YOU WANT TO BRIDGE, STRIP 1/4" OFF EACH END, AND BEND THE STRIPPED BITS DOWN.



KIT CONTAINS 10 JUMPERS OF EACH LENGTH

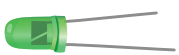
OR YOU CAN SAVE TIME BY USING A ***JUMPER WIRE KIT*** THAT COMES WITH AN ASSORTMENT OF WIRES PRE-CUT TO BRIDGE ANY NUMBER OF BREADBOARD ROWS BETWEEN 1 AND 10, PLUS SPECIAL "LONG" JUMPERS THAT BRIDGE 20, 30, 40, AND 50 ROWS. THESE WIRES HAVE THEIR ENDS ALREADY STRIPPED AND BENT, AND FOLLOW A STANDARD COLOR CODE SO YOU CAN PICK OUT THE RIGHT LENGTH AT A GLANCE. THE DRAWINGS IN THIS BOOK FOLLOW THE SAME COLOR CODE.



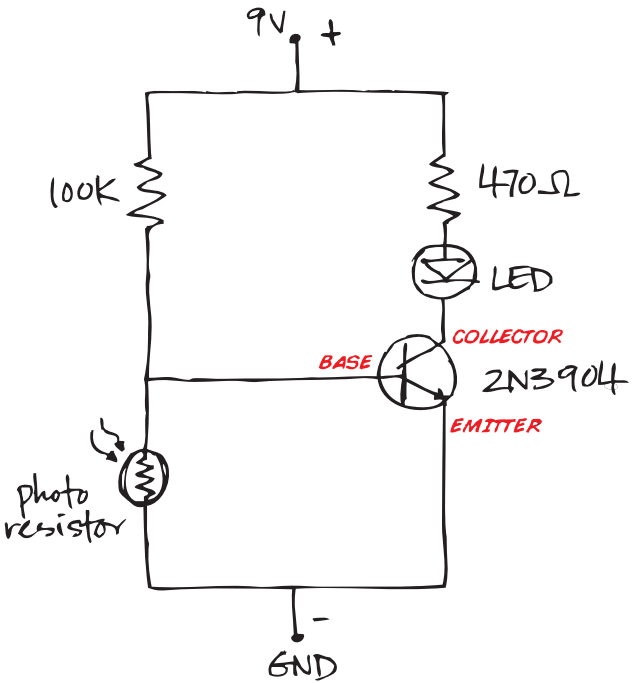
CIRCUIT #1

Build a Dark Detector!

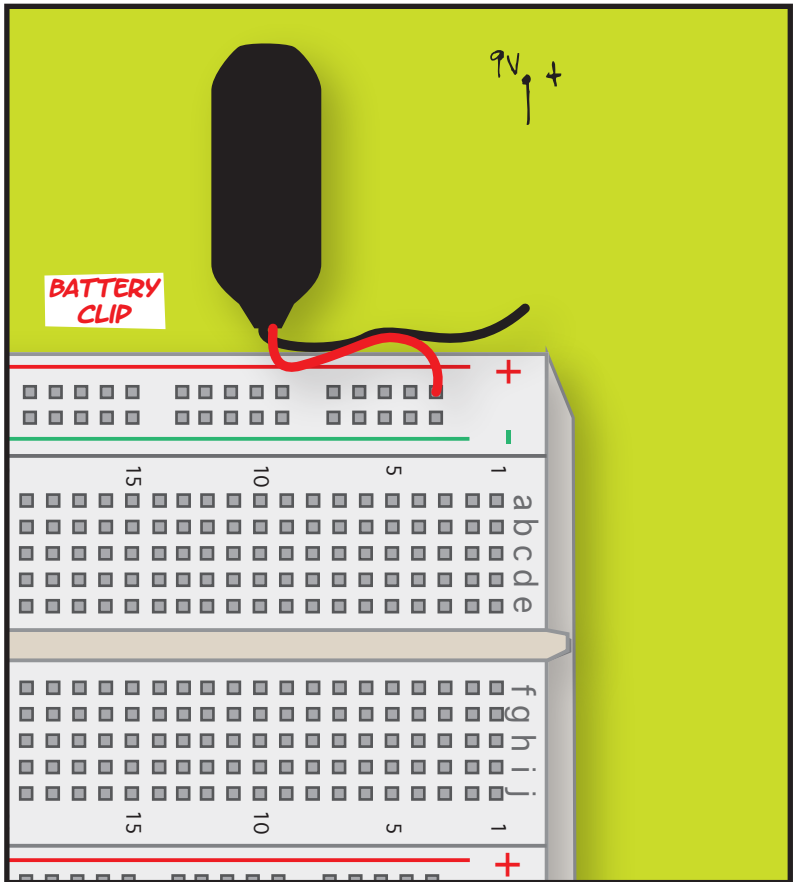
PARTS YOU WILL NEED:

- 1 9V BATTERY W/SNAP 
- 1 470Ω RESISTOR 
- 1 100KΩ RESISTOR 
- 1 GREEN LED 
- 1 2N3904 NPN TRANSISTOR 
- 1 PHOTORESISTOR 

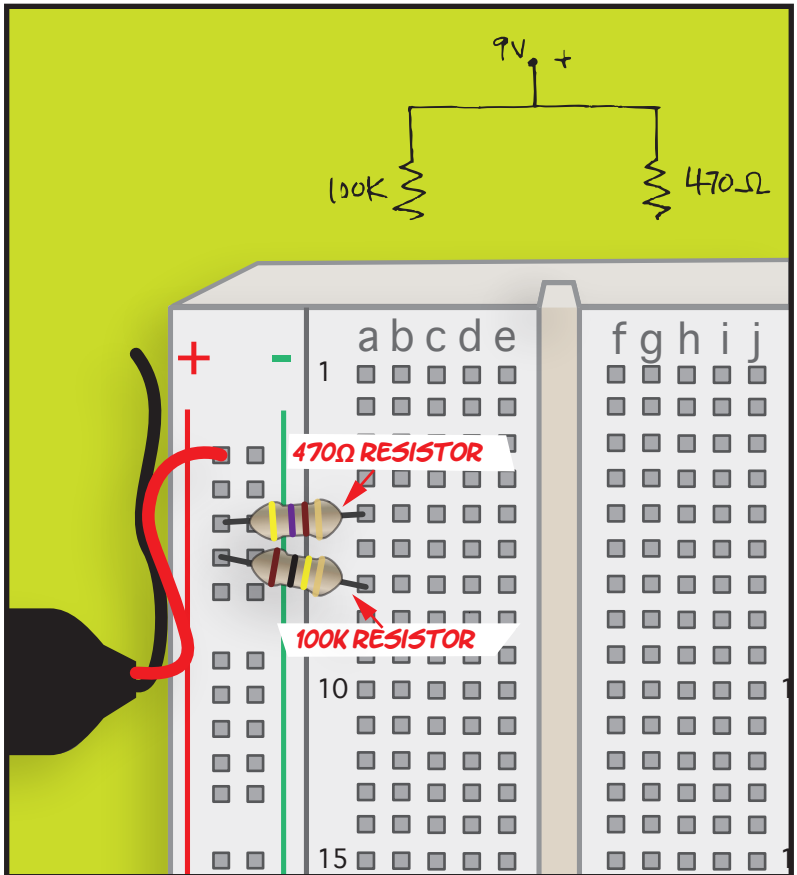
THE TRANSISTOR WILL TURN ON THE LED WHEN THE VOLTAGE TO ITS BASE LEAD GOES HIGH. IN THE LIGHT, THE PHOTORESISTOR HAS A LOW RESISTANCE, AND THE TRANSISTOR BASE VOLTAGE STAYS LOW.



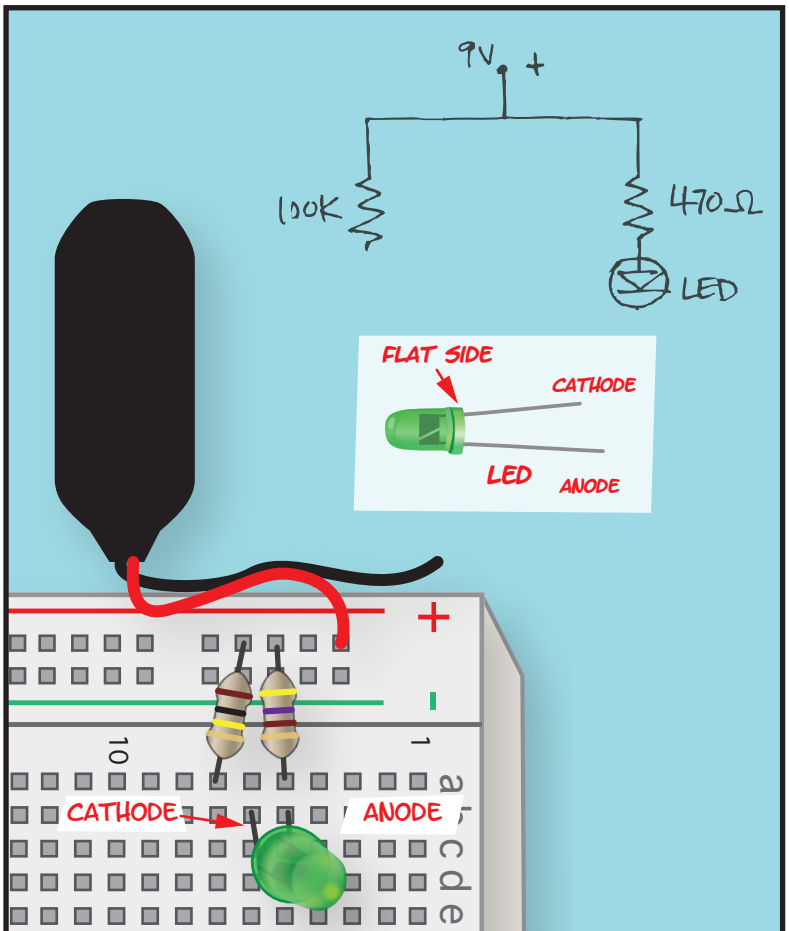
IN THE DARK, THE PHOTORESISTOR HAS A HIGH RESISTANCE, CAUSING THE TRANSISTOR BASE VOLTAGE TO GO HIGH, ALLOWING CURRENT TO FLOW THROUGH THE LED.



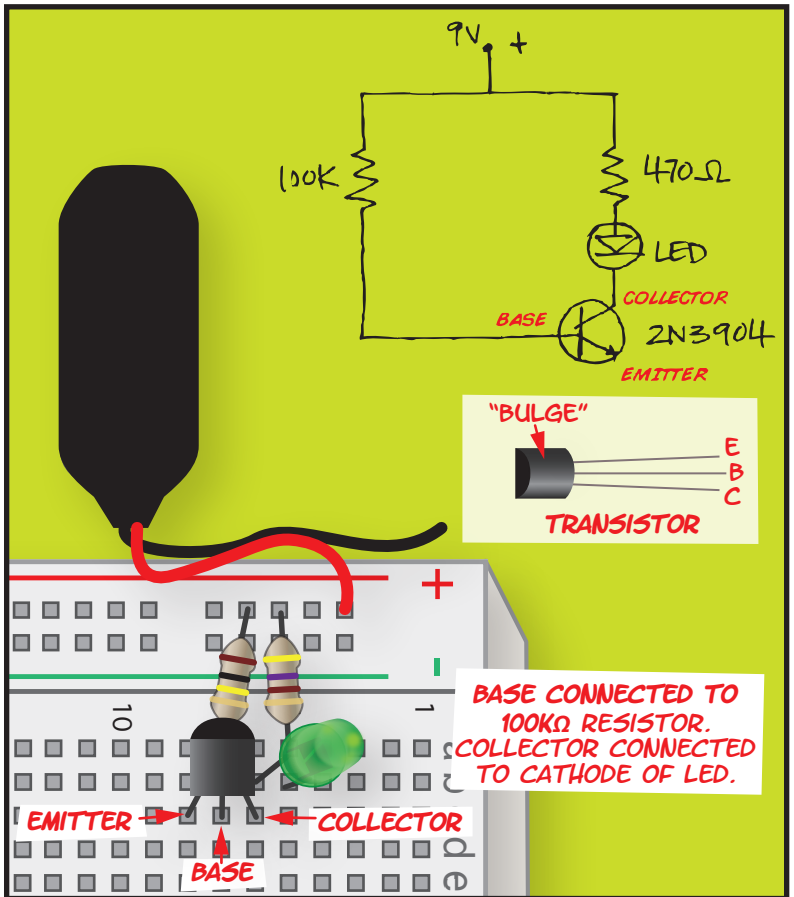
FIRST, CONNECT THE CURRENT SOURCE (IN THIS CASE, THE RED LEAD OF A 9V BATTERY CLIP) AT THE "TOP" OF THE CIRCUIT.



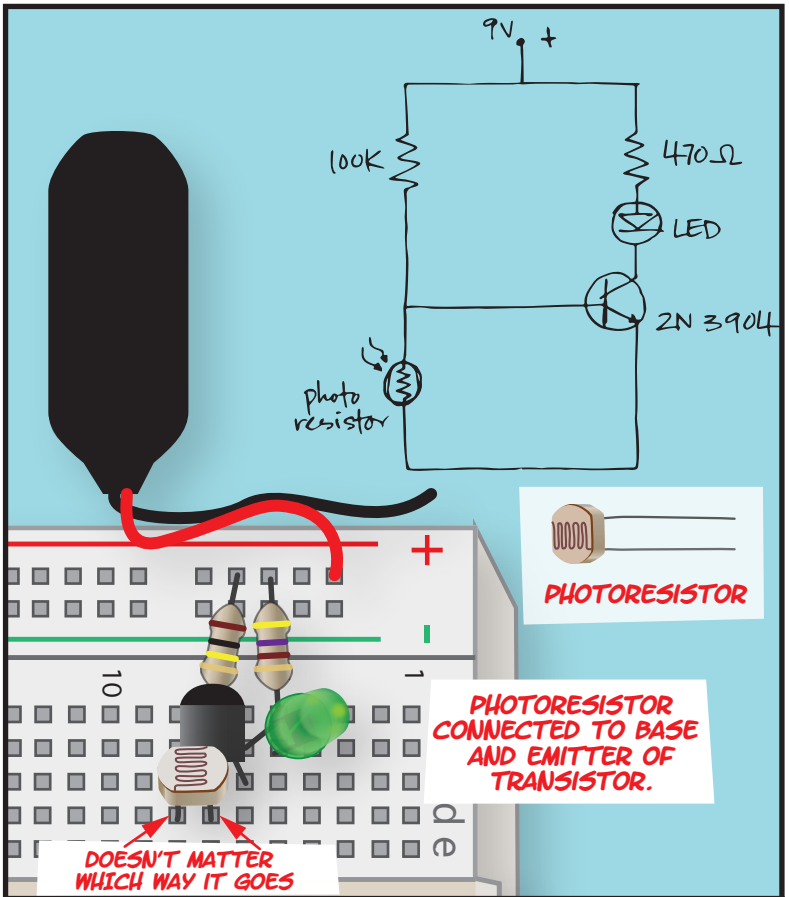
HOOK UP 2 CURRENT-LIMITING RESISTORS TO PROTECT THE COMPONENTS FROM DAMAGE: A STRONG ONE (100KΩ) FOR THE TRANSISTOR BASE AND A WEAK ONE (470Ω) FOR THE LED.



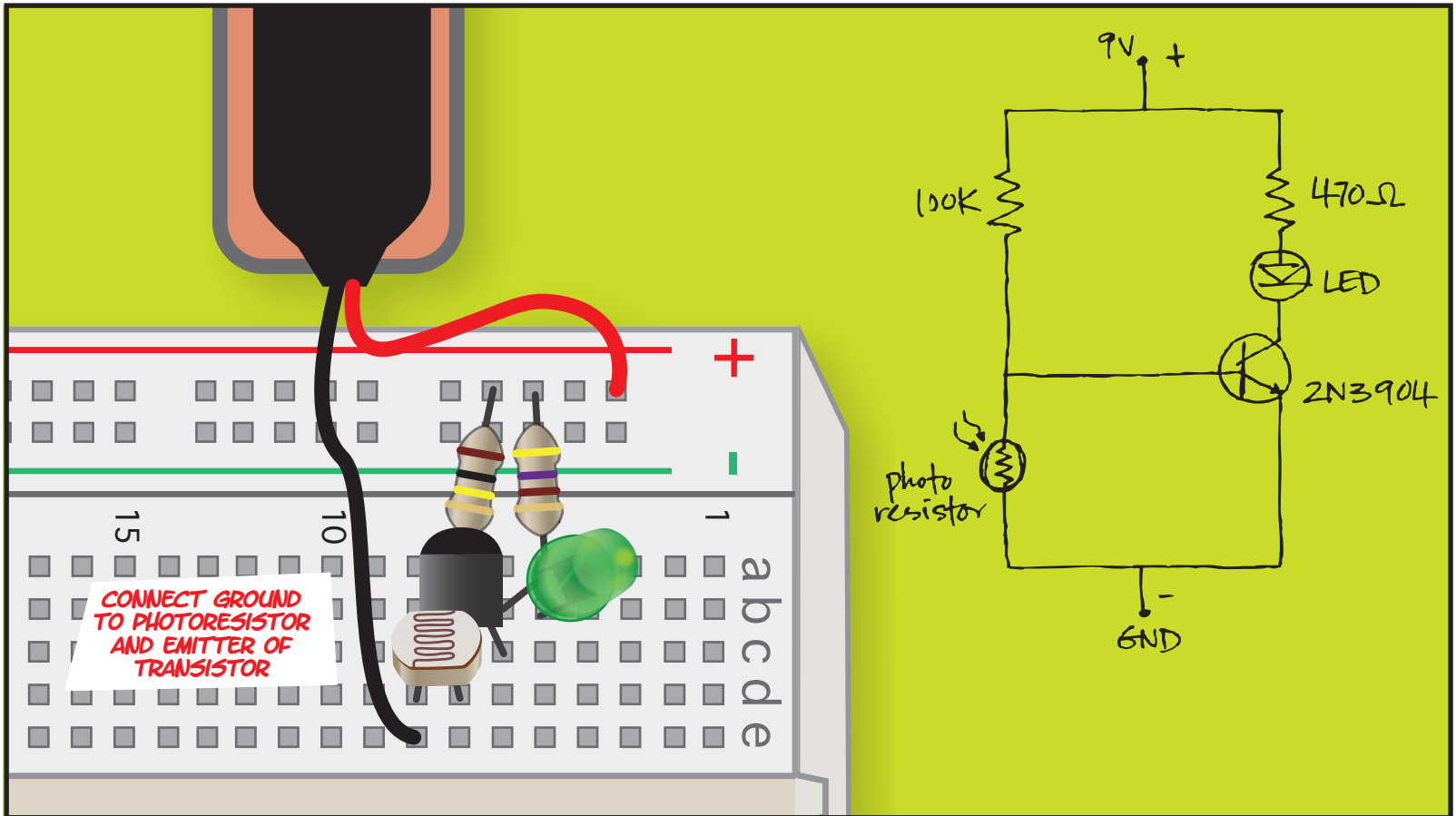
ADD THE LED. CONNECT THE **ANODE** (LONG LEAD) TO THE 470Ω RESISTOR.



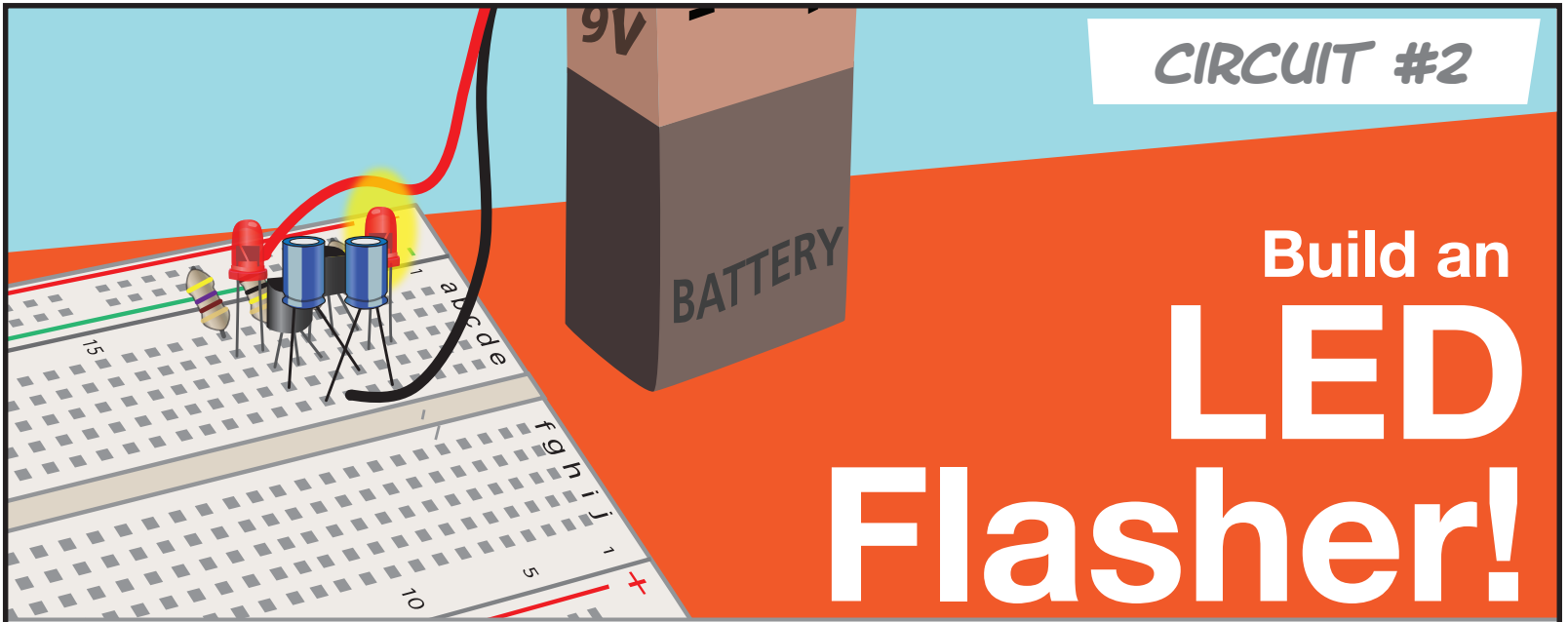
TO TURN THE LED ON AND OFF, THIS CIRCUIT USES AN NPN TRANSISTOR. MAKE SURE THE "BULGE" IS FACING THE RIGHT WAY.



THIS PHOTORESISTOR SENSES WHETHER IT'S LIGHT OR DARK. CONNECT IT BETWEEN THE TRANSISTOR'S BASE AND EMITTER.



FINALLY, CONNECT THE BLACK LEAD OF THE BATTERY CLIP (GROUND). ATTACH A BATTERY TO THE CLIP. WHAT HAPPENS WHEN YOU COVER THE PHOTORESISTOR WITH YOUR THUMB? WHAT HAPPENS WHEN YOU SHINE A LIGHT ON IT? HOW COULD YOU REARRANGE THESE COMPONENTS TO MAKE A "LIGHT DETECTOR"?

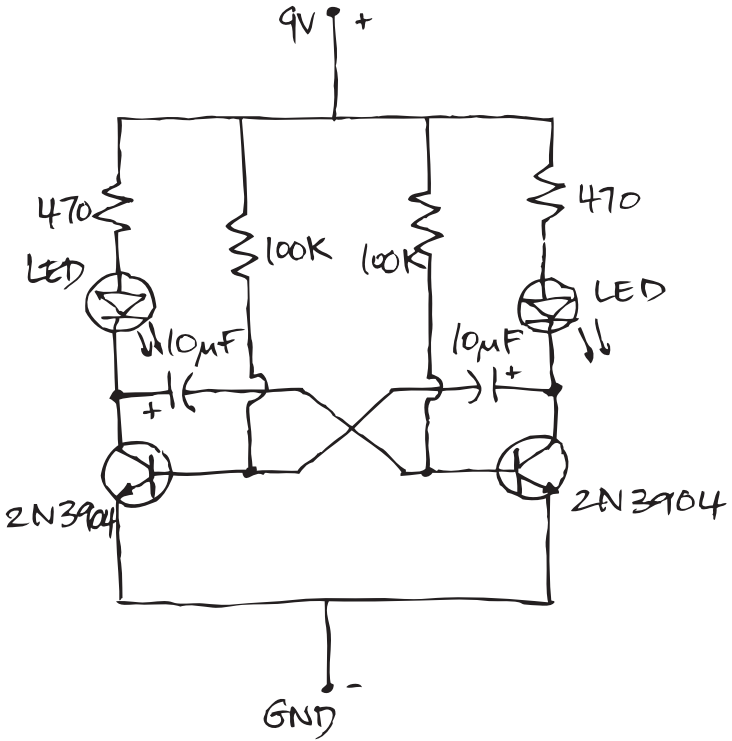


CIRCUIT #2

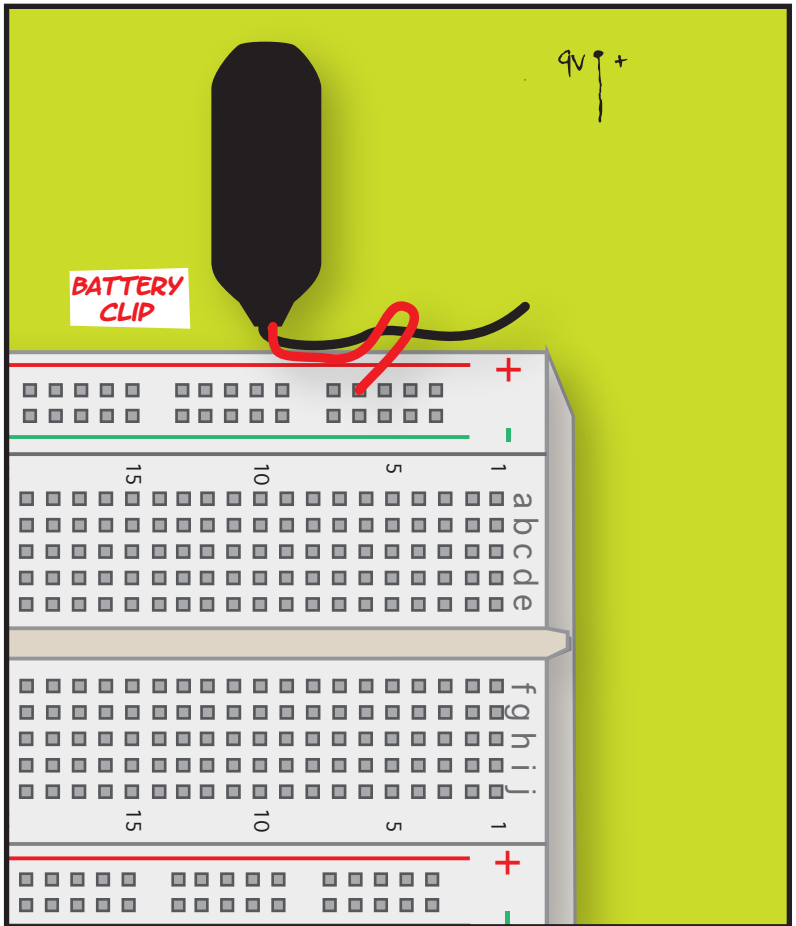
Build an LED Flasher!

PARTS YOU WILL NEED:

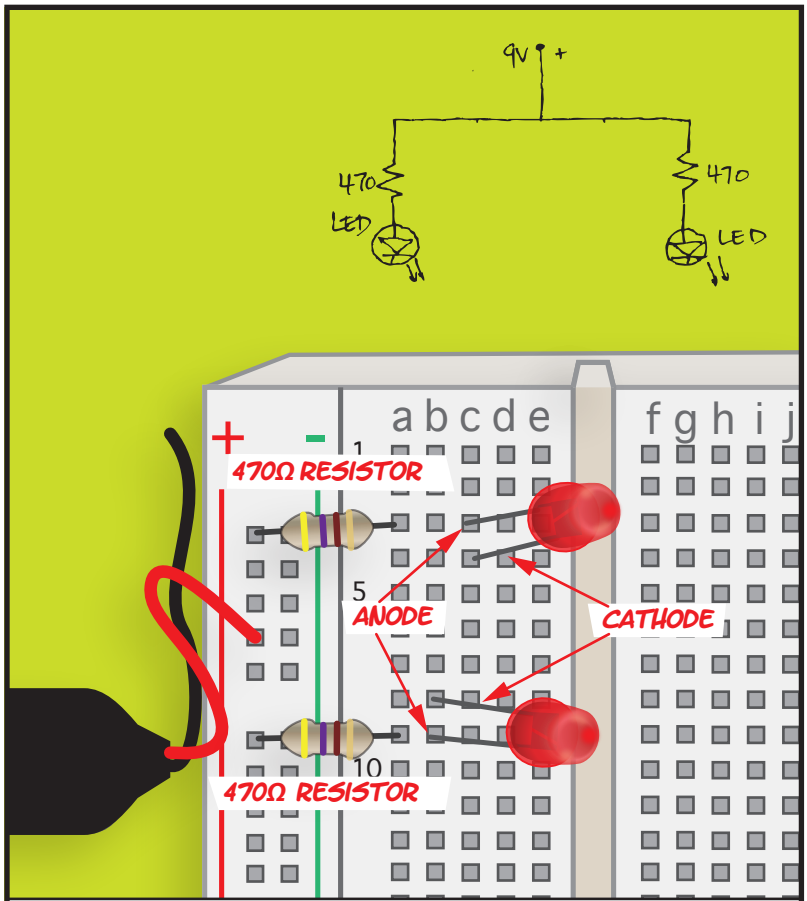
- 1 9V BATTERY W/SNAP
- 2 470Ω RESISTORS
- 2 100KΩ RESISTORS
- 2 RED LEDS
- 2 2N3904 NPN TRANSISTORS
- 2 10µF ELECTROLYTIC CAPACITORS



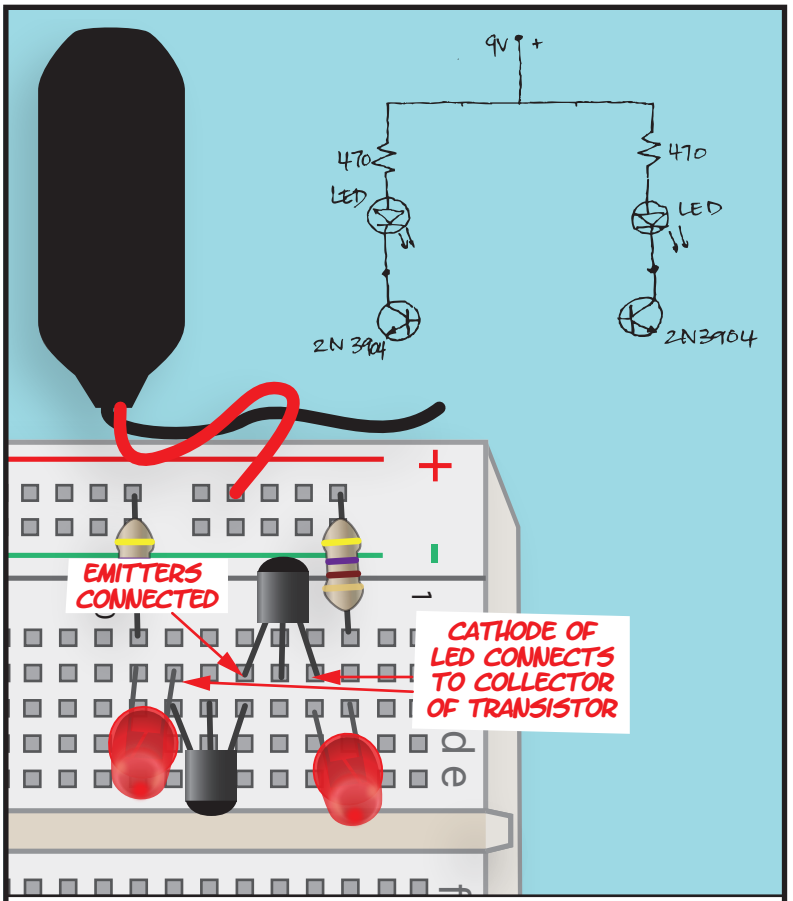
THIS PERFECTLY SYMMETRICAL CIRCUIT IS CALLED AN ***ASTABLE MULTIVIBRATOR***. EACH SIDE HAS A RESISTOR, A CAPACITOR, AND A TRANSISTOR THAT ALTERNATELY SWITCH EACH OTHER ON AND OFF, CAUSING THE LEDS TO FLASH.



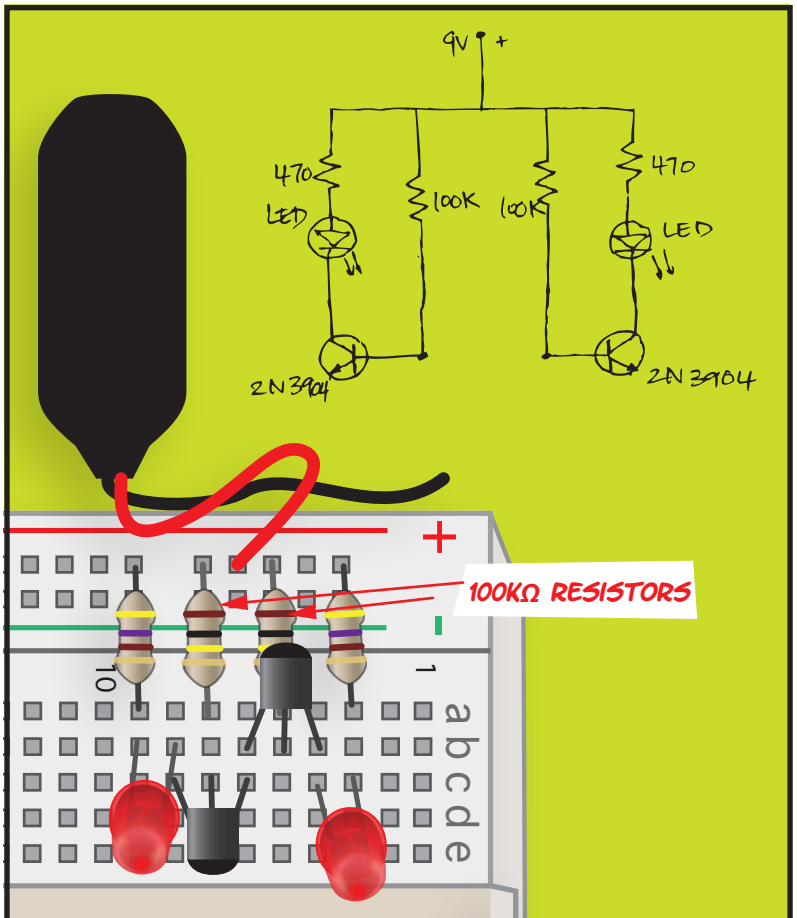
FIRST, CONNECT THE CURRENT SOURCE AT THE "TOP" OF THE CIRCUIT.



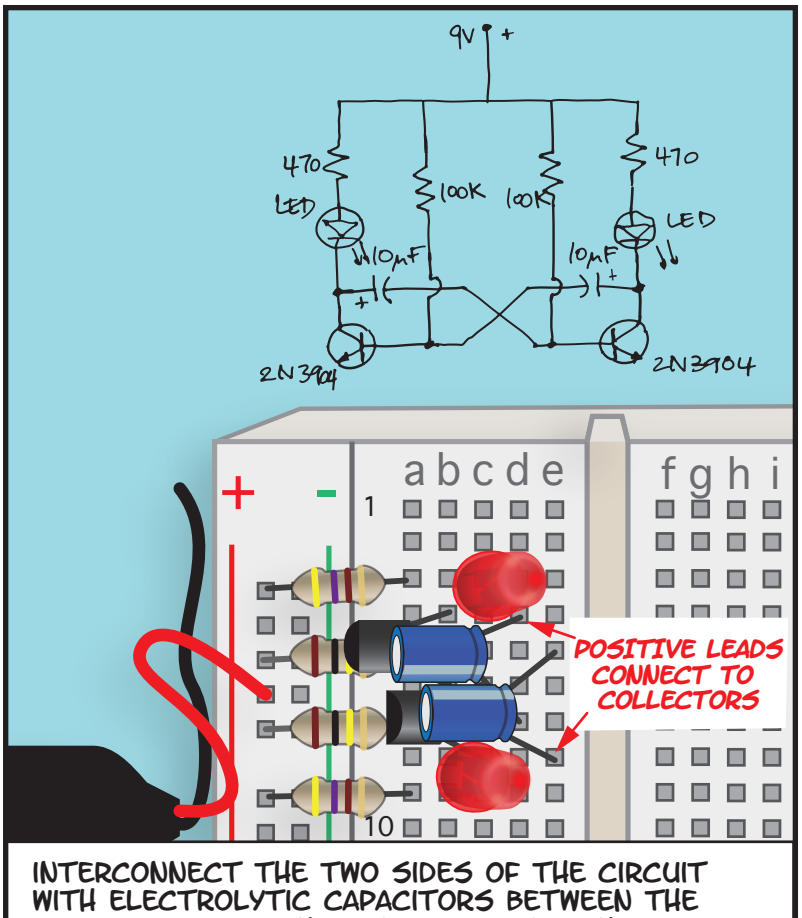
AS USUAL, WE PROTECT THE LEDS WITH CURRENT LIMITING RESISTORS. CONNECT THE ANODE (LONG LEAD) OF EACH LED TO A RESISTOR.



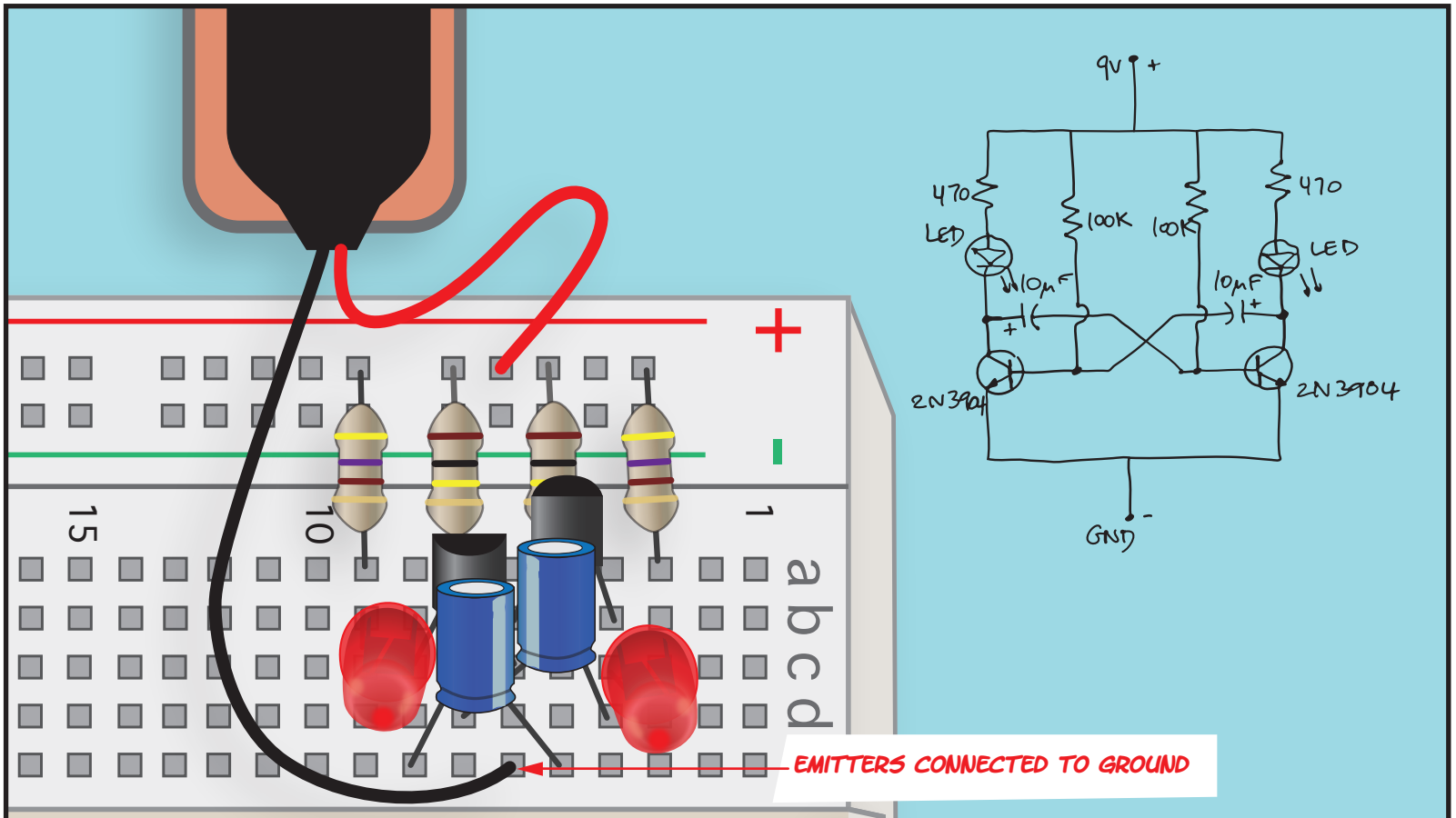
CONNECT THE 2 NPN TRANSISTORS. THEIR EMITTERS WILL BOTH BE GROUNDED AND GO IN THE SAME ROW.



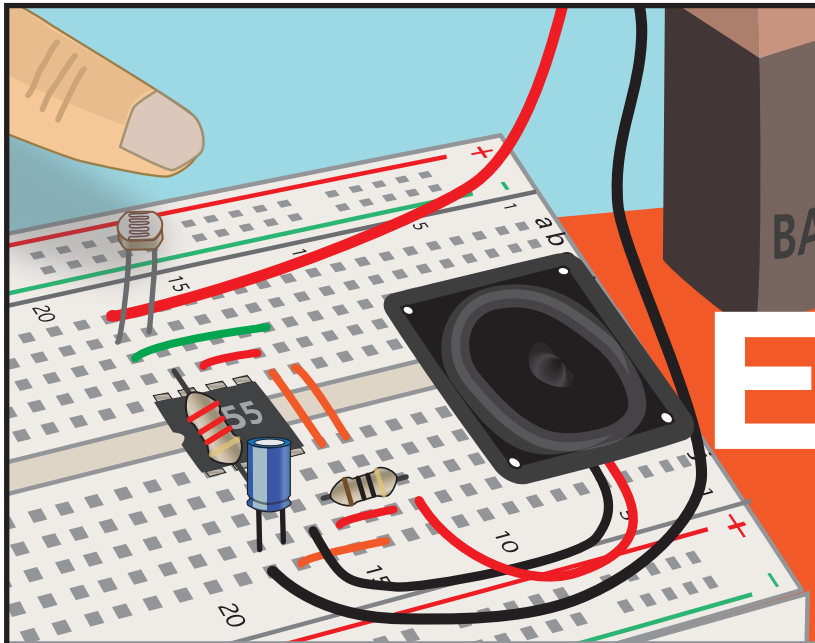
CONNECT EACH TRANSISTOR BASE TO POWER THROUGH A 100KΩ CURRENT-LIMITING RESISTOR.



INTERCONNECT THE TWO SIDES OF THE CIRCUIT WITH ELECTROLYTIC CAPACITORS BETWEEN THE COLLECTOR OF EACH TRANSISTOR AND THE BASE OF THE OTHER. THESE WILL CHARGE AND DISCHARGE ALTERNATELY AS THE LEDS FLASH.



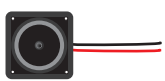
FINALLY, COMPLETE THE CIRCUIT BY CONNECTING THE "BOTTOM" TO GROUND. WHAT HAPPENS WHEN YOU CONNECT THE BATTERY? HOW COULD YOU CHANGE THE CIRCUIT TO SPEED THINGS UP? OR SLOW THEM DOWN?

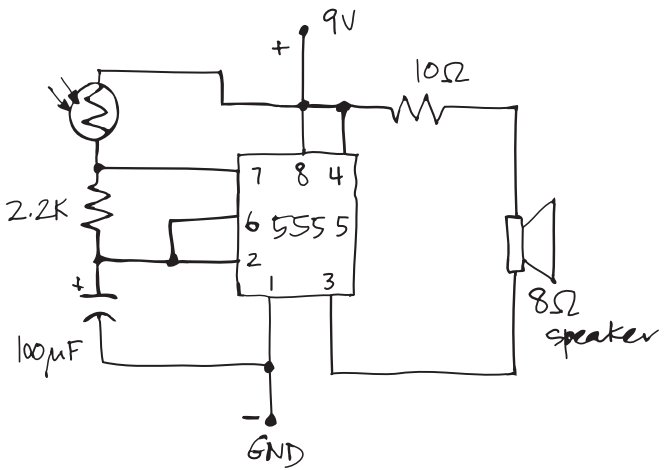


CIRCUIT #3

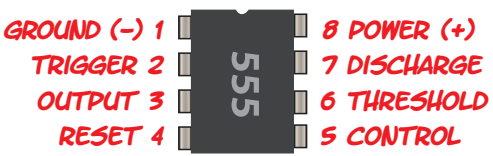
Build an Electronic Cricket!

PARTS YOU WILL NEED:

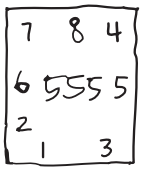
- 1 9V BATTERY W/SNAP 
- 1 555 TIMER IC 
- 1 2.2KΩ RESISTOR 
- 1 10Ω RESISTOR 
- 1 8Ω SPEAKER 
- 1 PHOTORESISTOR 
- 1 100µF ELECTROLYTIC CAPACITOR 
- JUMPER WIRES 



555 TIMER

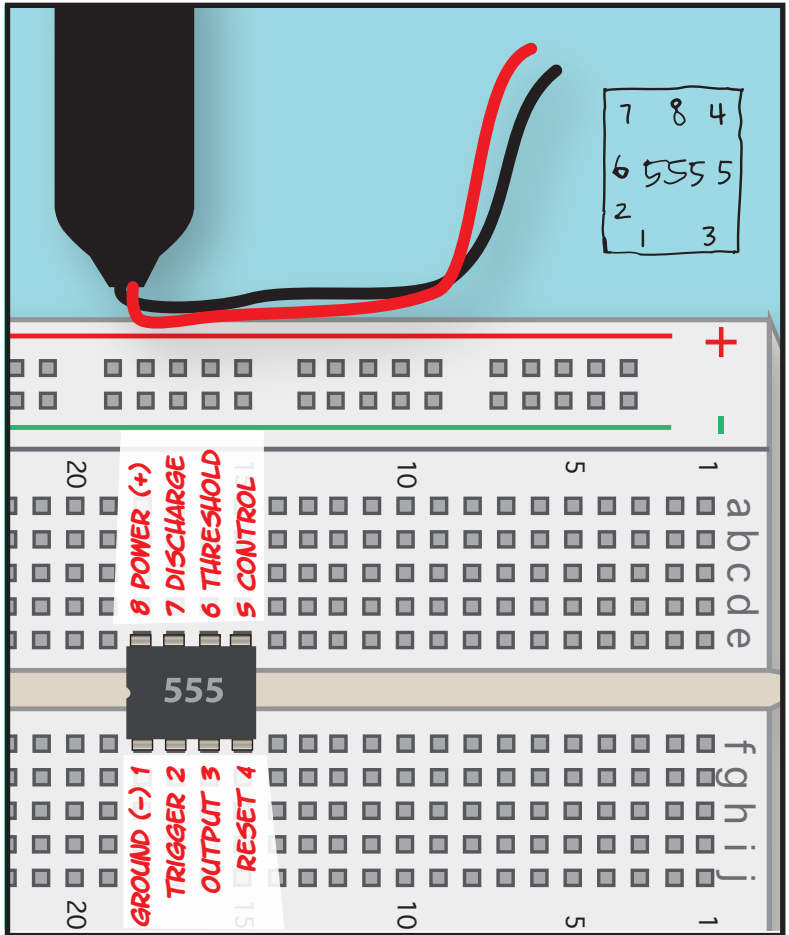


PIN-OUT



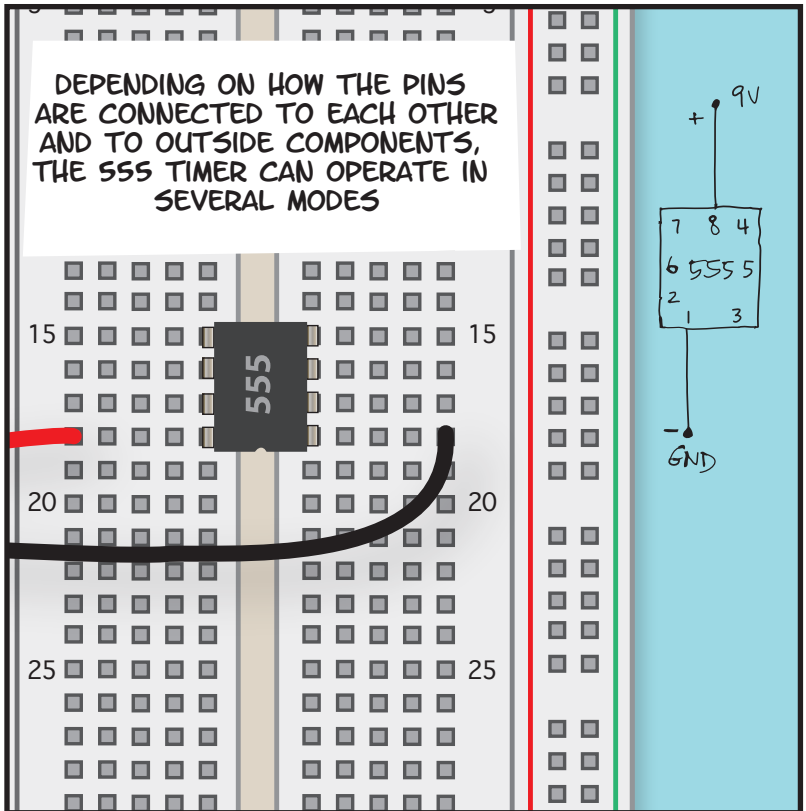
SCHEMATIC

THIS CIRCUIT USES AN ***INTEGRATED CIRCUIT (IC)***. THIS ONE'S THE FAMOUS ***555 TIMER*** IC. THERE ARE SO MANY USES FOR THE 555 IT WOULD BE IMPOSSIBLE TO LIST THEM ALL, BUT THE WORD "TIMER" IS KEY: IF YOUR CIRCUIT NEEDS TO DO SOMETHING FOR A SET PERIOD OF TIME, OR NEEDS TO REPEAT SOMETHING EVERY SO OFTEN, A 555 CAN PROBABLY MAKE IT HAPPEN.



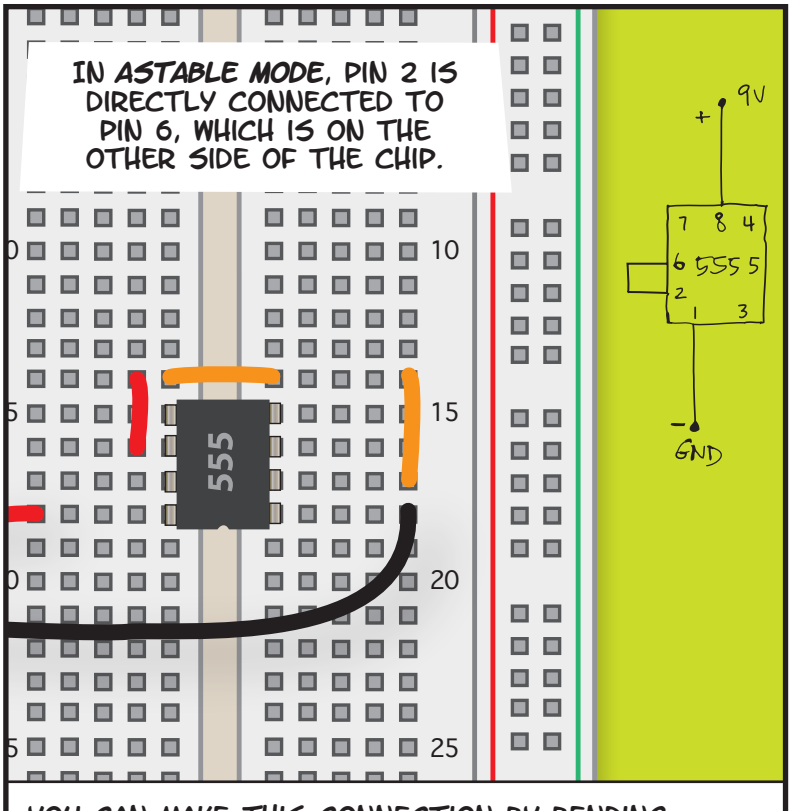
WHEN BREADBOARDING A CIRCUIT WITH AN IC, IT'S USUALLY A GOOD IDEA TO PLACE THE CHIP FIRST.

DEPENDING ON HOW THE PINS ARE CONNECTED TO EACH OTHER AND TO OUTSIDE COMPONENTS, THE 555 TIMER CAN OPERATE IN SEVERAL MODES

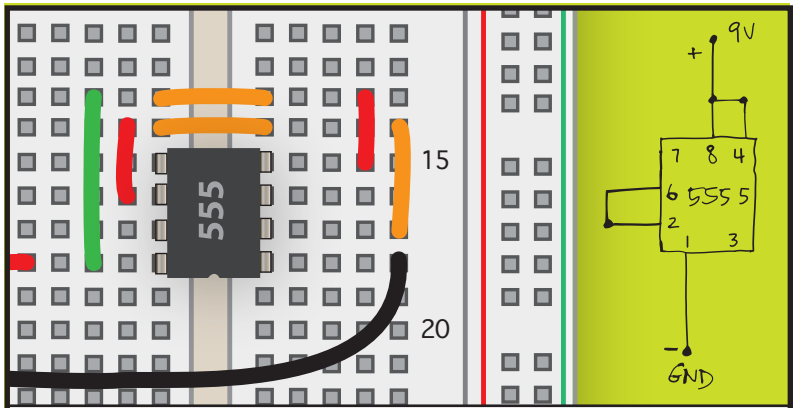


LIKE ANY CIRCUIT, AN IC NEEDS POWER AND GROUND CONNECTIONS TO WORK. THE 555 TAKES POWER THROUGH PIN 8, AND IS GROUNDED THROUGH PIN 1. SO FIRST CONNECT THE RED BATTERY CLIP LEAD TO PIN 8 AND THE BLACK LEAD TO PIN 1. DON'T CONNECT THE BATTERY TO THE CLIP JUST YET

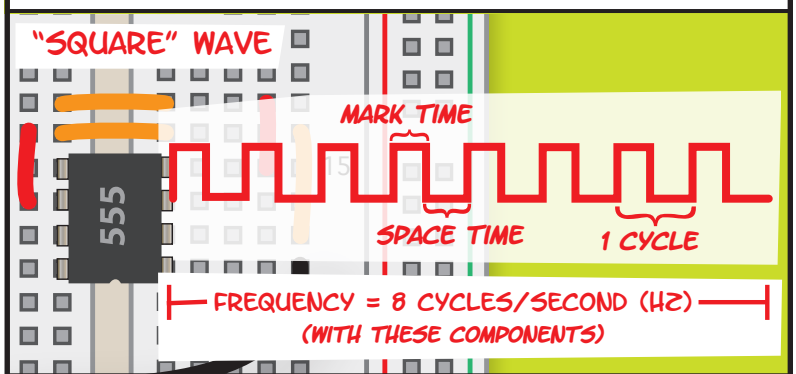
IN *ASTABLE MODE*, PIN 2 IS DIRECTLY CONNECTED TO PIN 6, WHICH IS ON THE OTHER SIDE OF THE CHIP.



YOU CAN MAKE THIS CONNECTION BY BENDING ONE JUMPER WIRE OVER THE BACK OF THE CHIP, OR BY USING THREE FLAT JUMPER WIRES TO GO "AROUND" IT, AS SHOWN HERE. THIS METHOD USES MORE PARTS, BUT GIVES A NEATER BREADBOARD. YOUR JUMPERS WILL LAST LONGER, TOO, IF YOU DON'T BEND THEM AROUND TOO MUCH.

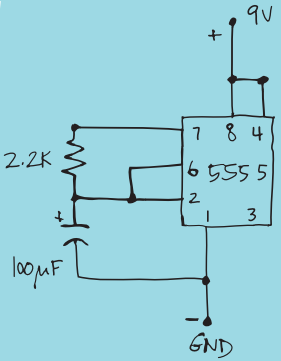


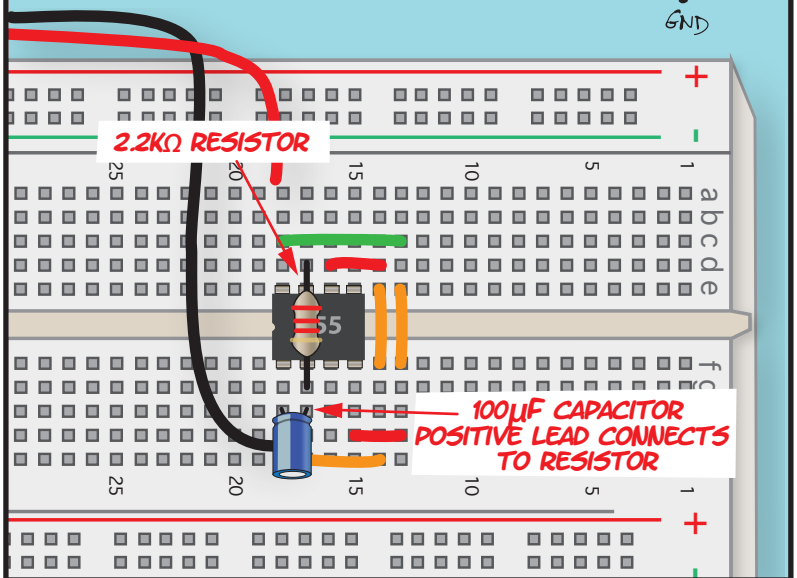
IN ASTABLE MODE, PIN 4 IS DIRECTLY CONNECTED TO POWER/PIN 8, WHICH IS ALSO ON THE OPPOSITE SIDE OF THE CHIP. BEND A JUMPER WIRE OVER THE BACK OF THE CHIP OR GO "AROUND" AS BEFORE.



IN ASTABLE MODE, THE 555 OUTPUTS AN ENDLESS SERIES OF "SQUARE" PULSES FROM PIN 3.

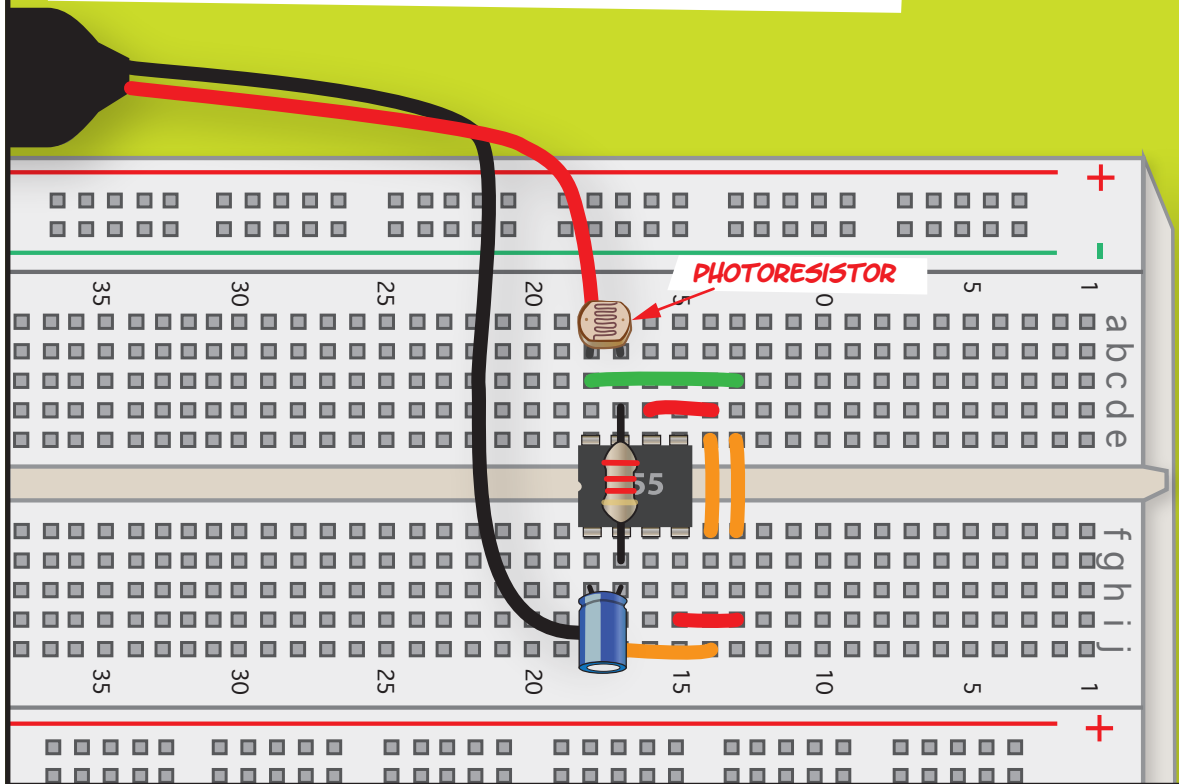
WE CAN CHOOSE THE VALUES OF CONNECTED RESISTORS AND CAPACITORS TO SET THE ***FREQUENCY***, ***MARK TIME*** AND ***SPACE TIME*** OF THESE PULSES.

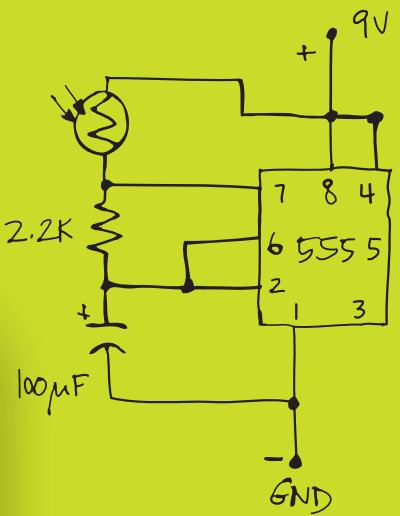




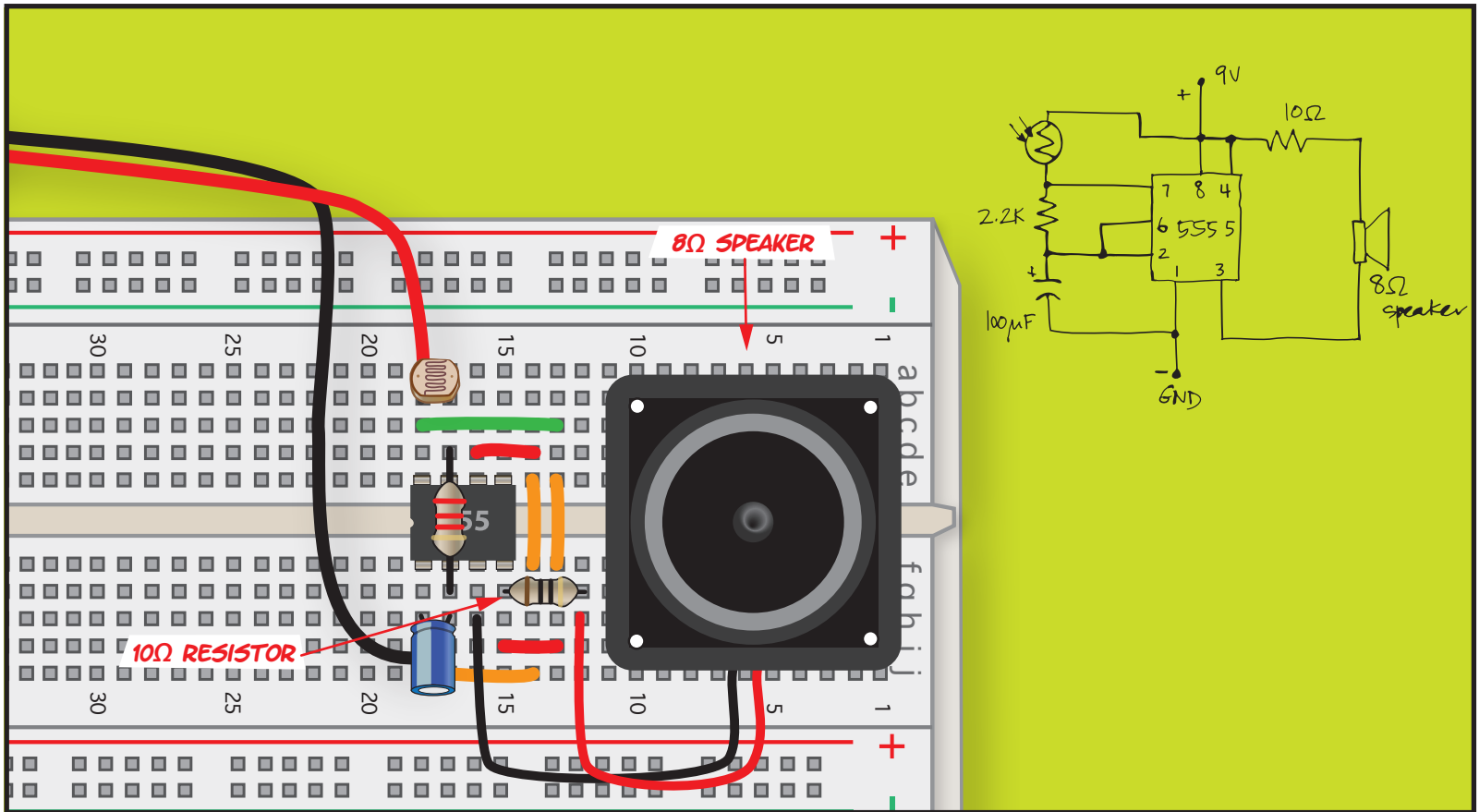
THE SPACE TIME DEPENDS ON THE VALUES OF THE RESISTOR BETWEEN PINS 2 AND 7 AND THE CAPACITOR.

THE MARK TIME, AND THE OVERALL FREQUENCY OF THE PULSES, DEPENDS ALSO ON THE VALUE OF THE RESISTOR CONNECTED BETWEEN PIN 7 AND POWER.

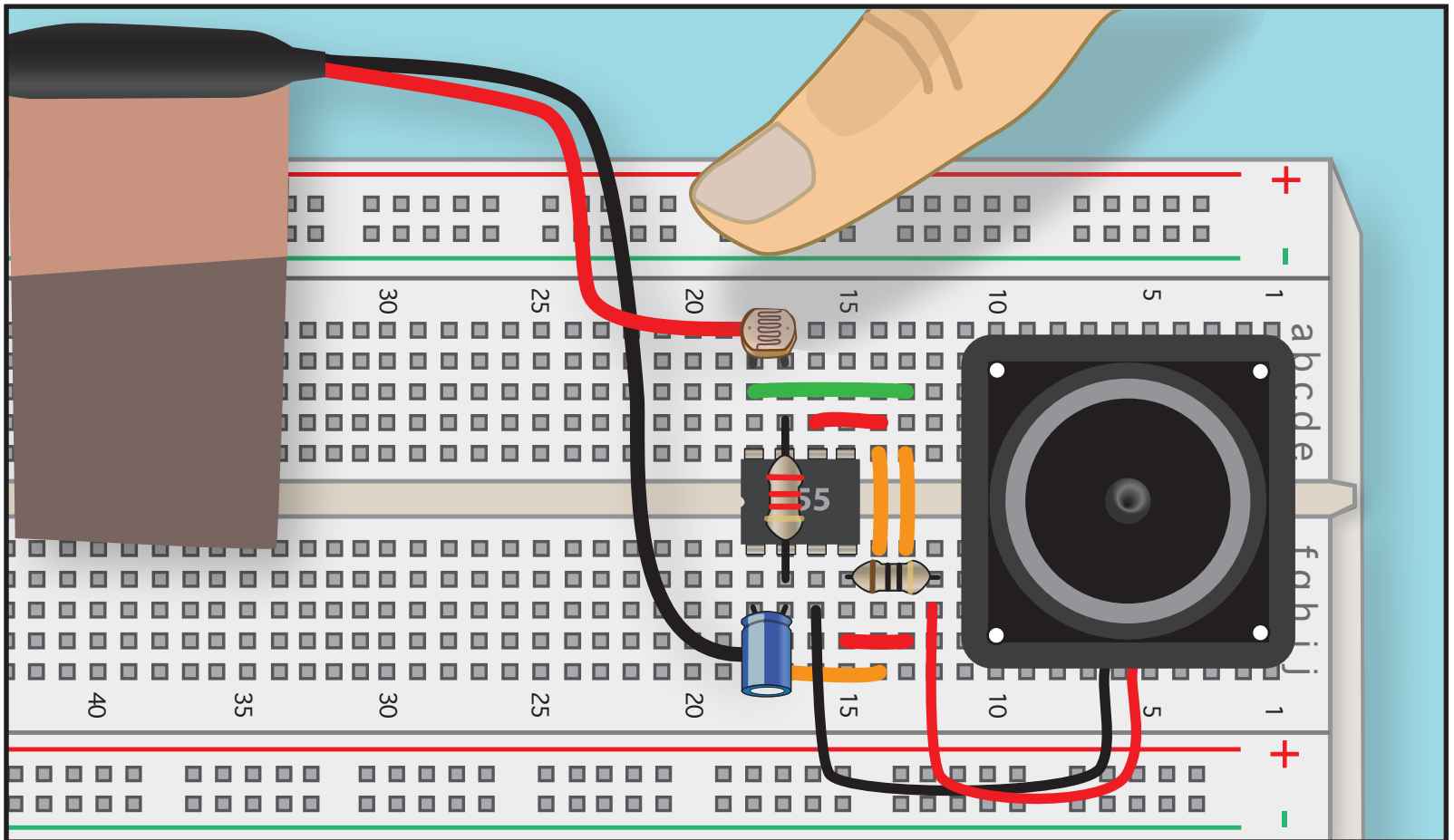




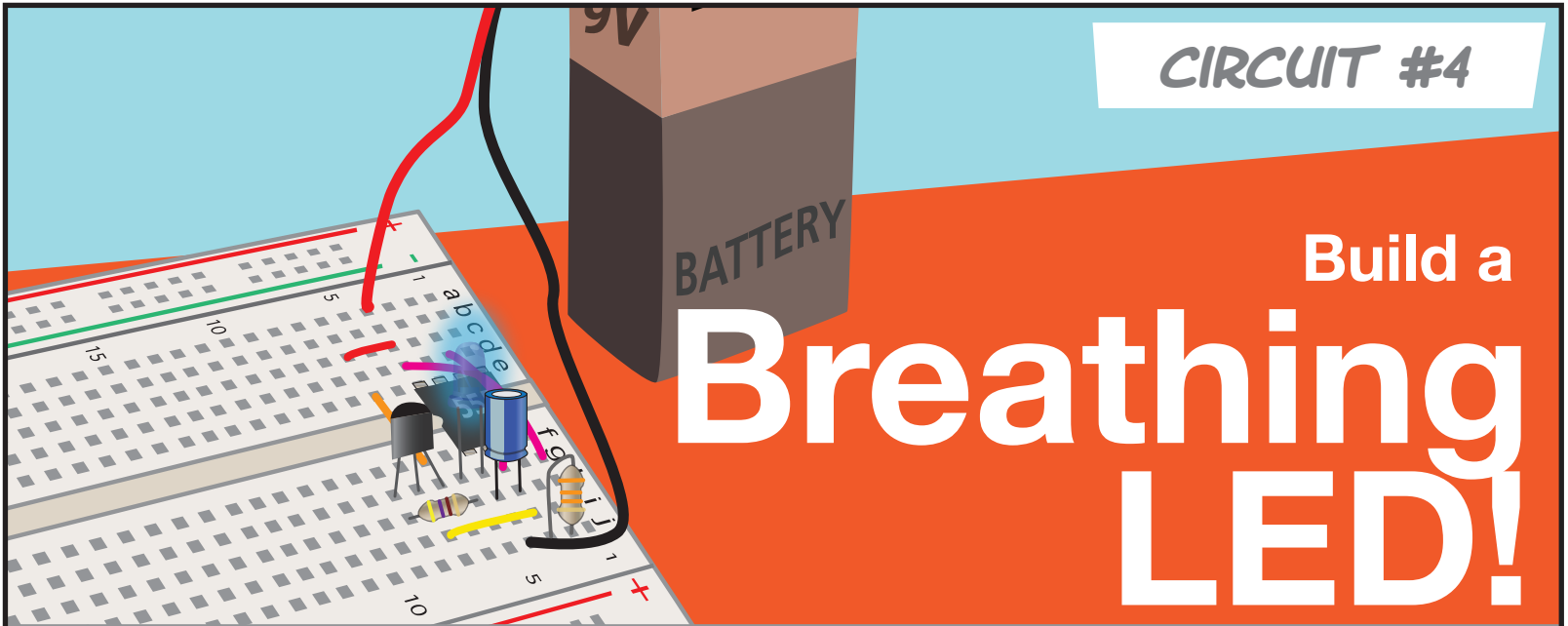
WE'LL CONNECT A PHOTORESISTOR HERE, WHICH PROVIDES A VARIABLE RESISTANCE DEPENDING ON HOW MUCH LIGHT IS SHINING ON IT. HENCE, THE FREQUENCY WILL ALSO VARY WITH LIGHT.



FINALLY, WE'LL CONNECT A SPEAKER BETWEEN PIN 3 AND POWER, ADDING A SMALL 10Ω RESISTOR IN SERIES. REMEMBER THAT PIN 4 IS ALREADY CONNECTED TO POWER, SO YOU CAN HOOK UP THE SPEAKER AS SHOWN, OR WITH THE 10Ω RESISTOR AT PIN 8. IT DOESN'T MATTER HOW THE BREADBOARD LOOKS, ONLY THAT THE CIRCUIT CONNECTIONS ARE RIGHT!



NOW ATTACH THE BATTERY AND LISTEN. YOU MAY NOT HEAR ANYTHING FOR A MOMENT. HOW DOES IT WORK?

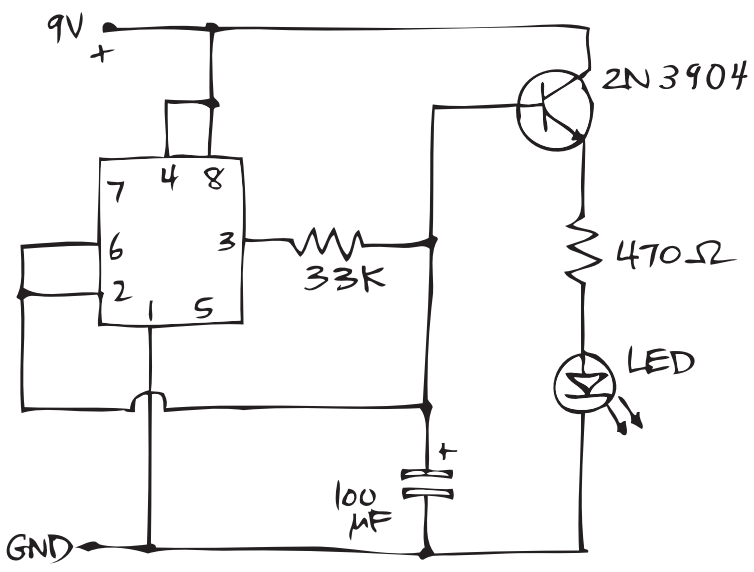


CIRCUIT #4

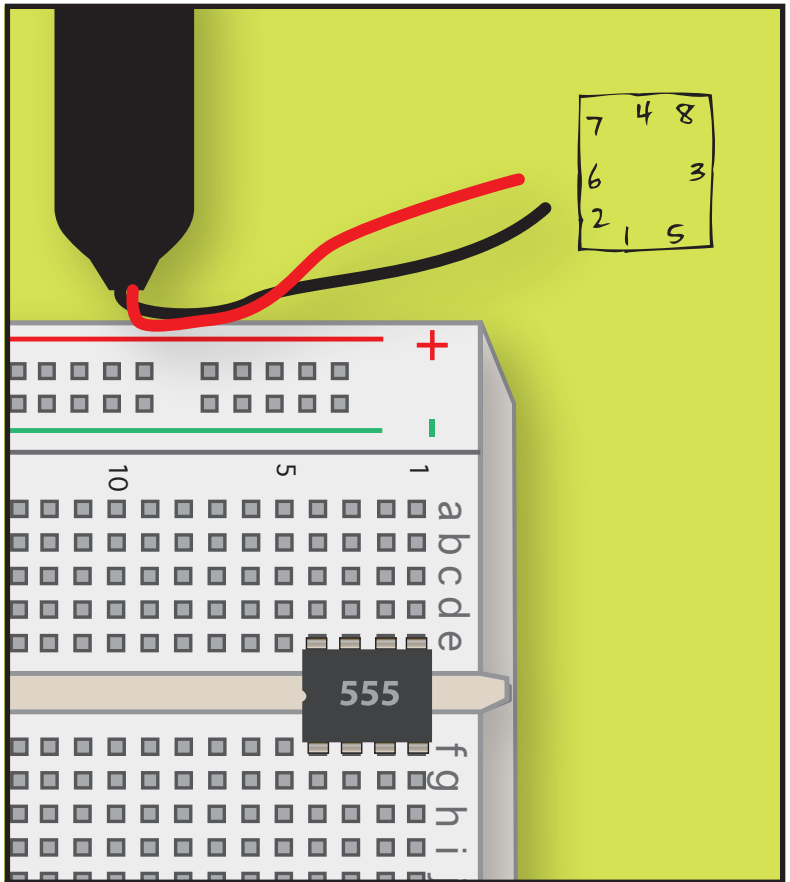
Build a Breathing LED!

PARTS YOU WILL NEED:

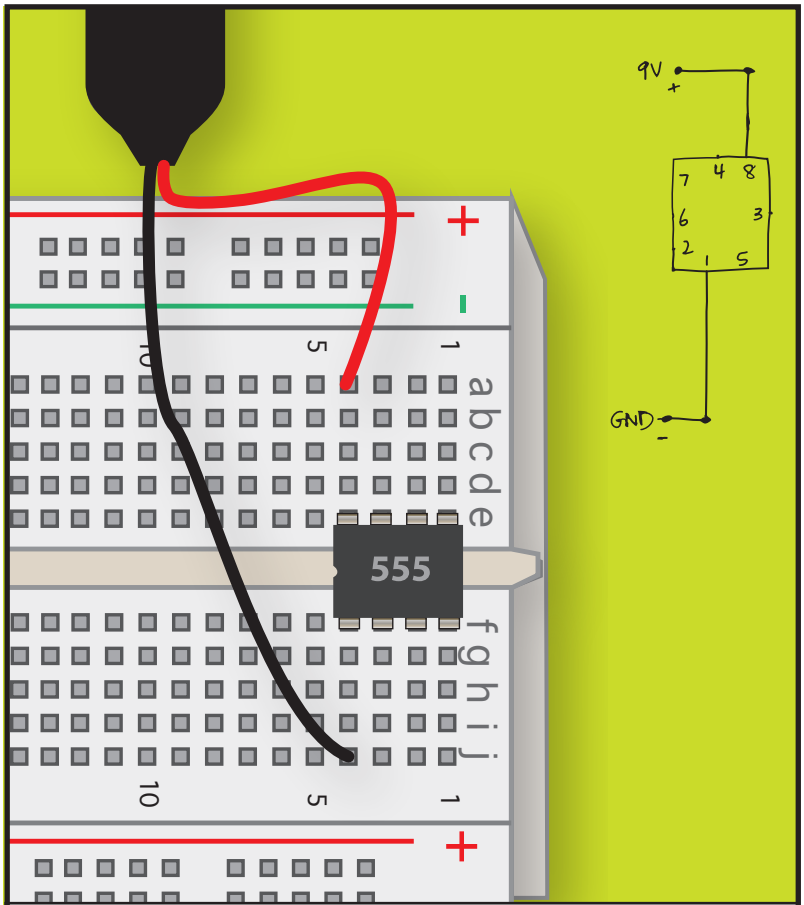
- 1 9V BATTERY W/SNAP
- 1 555 TIMER IC
- 1 470Ω RESISTOR
- 1 33KΩ RESISTOR
- 1 BLUE LED
- 1 2N3904 NPN TRANSISTOR
- 1 100µF ELECTROLYTIC CAPACITOR
- JUMPER WIRES



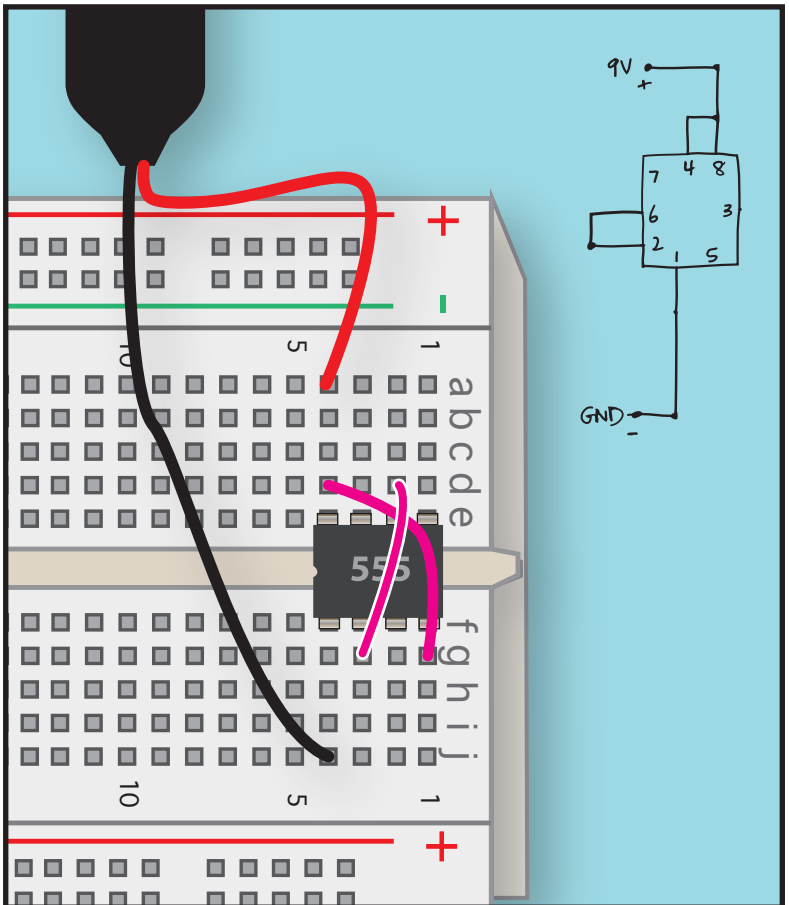
THIS CIRCUIT USES A 555 TIMER IN ASTABLE MODE TO CONTROL A LIGHT SOURCE (AN LED) INSTEAD OF A SPEAKER.



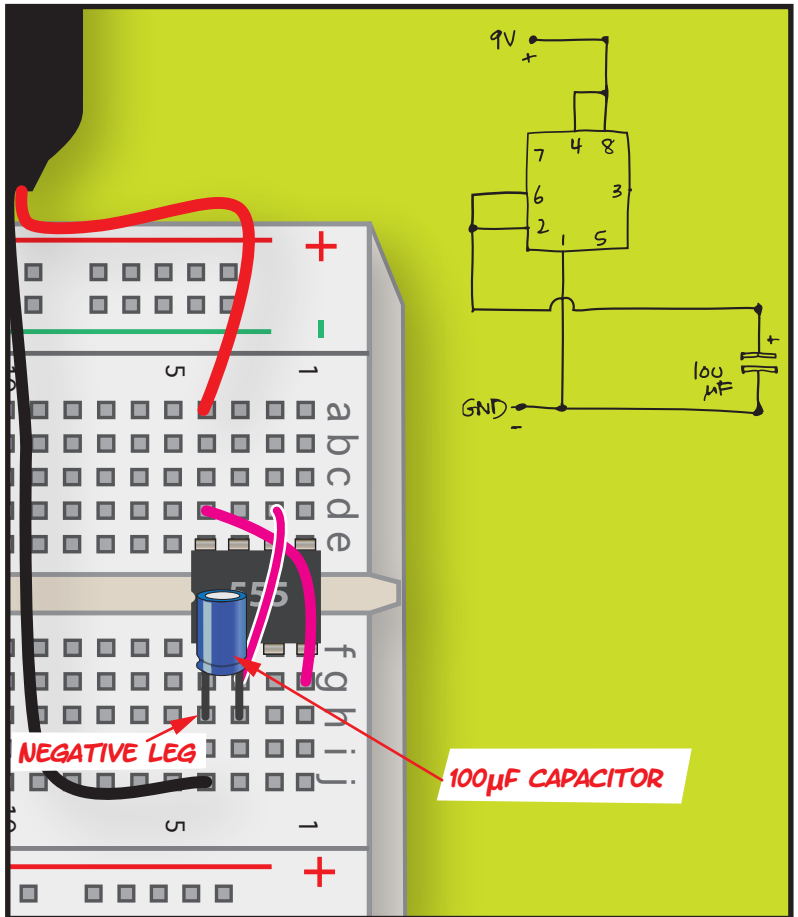
START BY PLACING THE 555. REMEMBER THAT THE PINS ARE NUMBERED DIFFERENTLY IN THE CIRCUIT DIAGRAM THAN ON THE PHYSICAL CHIP!



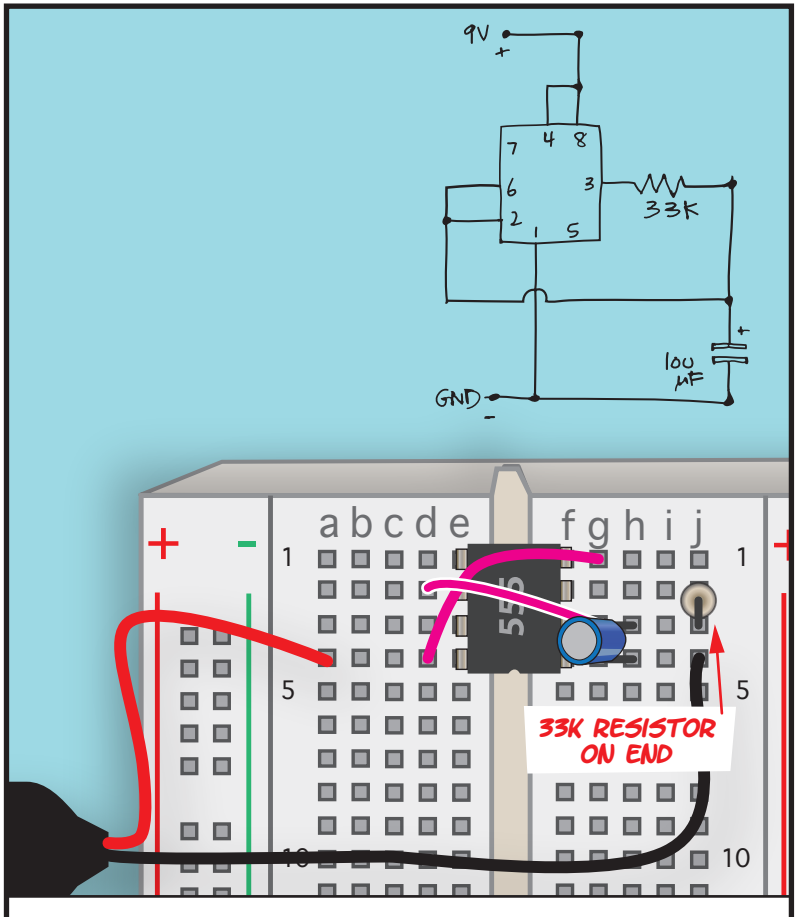
CONNECT THE BATTERY CLIP RED LEAD TO PIN 8 (POWER), AND THE BLACK LEAD TO PIN 1 (GROUND). DON'T ATTACH THE BATTERY JUST YET.



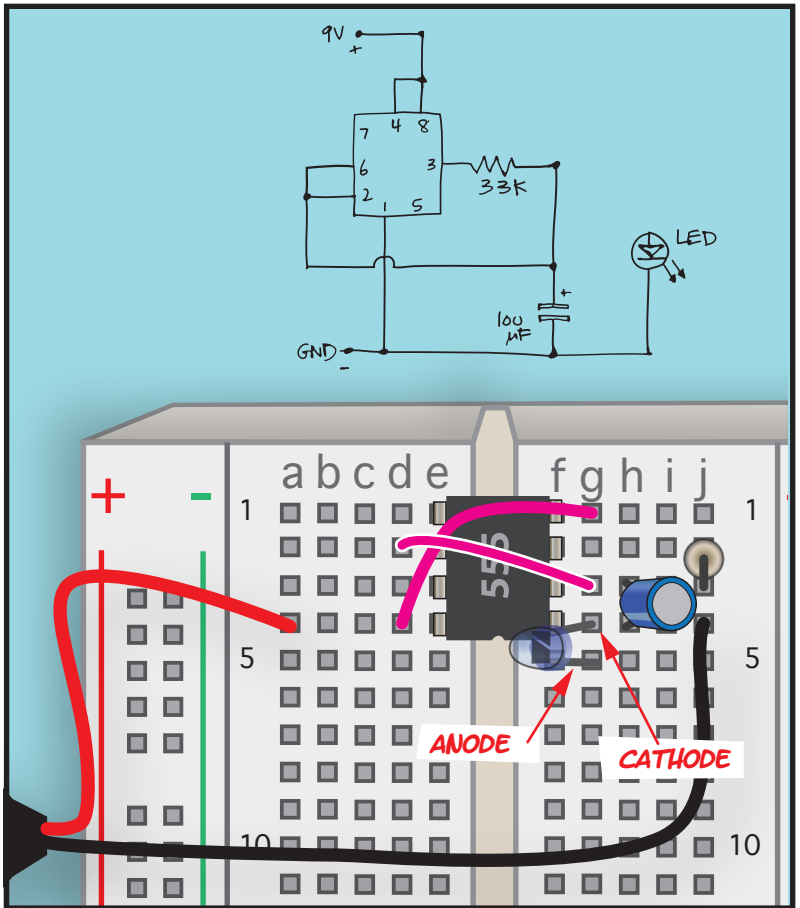
INSTEAD OF GOING "AROUND," THIS TIME, LET'S CONNECT PINS 4 AND 8 WITH A JUMPER BENT ACROSS THE BACK OF THE CHIP. SAME GOES FOR PINS 2 AND 6.



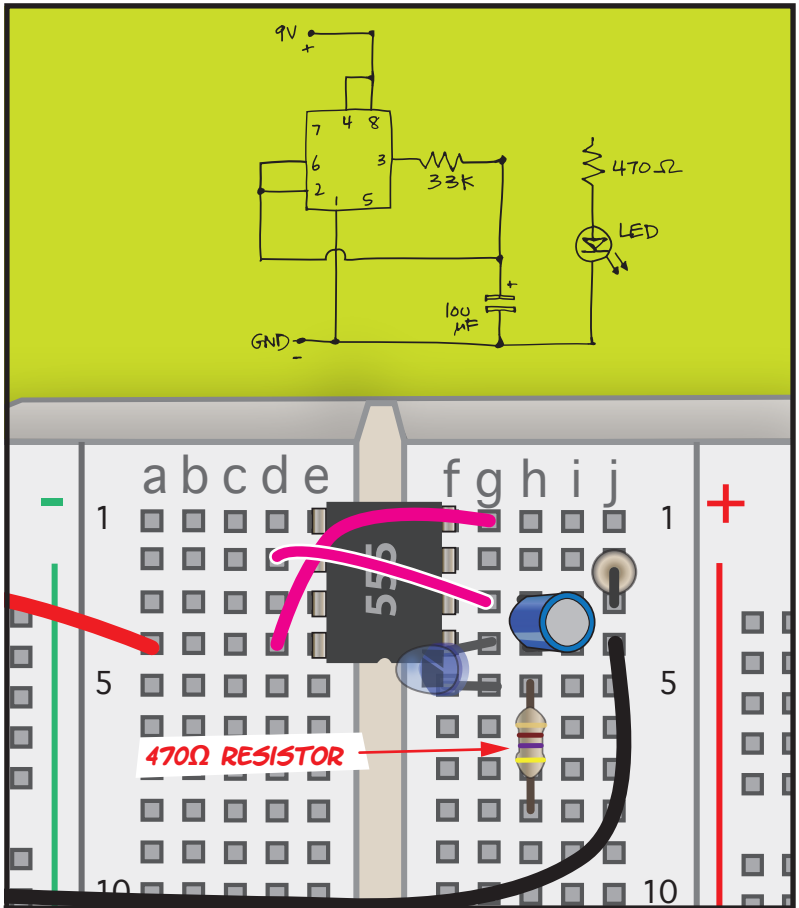
PLACE THE ***CAPACITOR*** BETWEEN ***PIN 2*** AND ***GROUND***. BE SURE THE ***NEGATIVE*** LEG GOES TO GROUND.



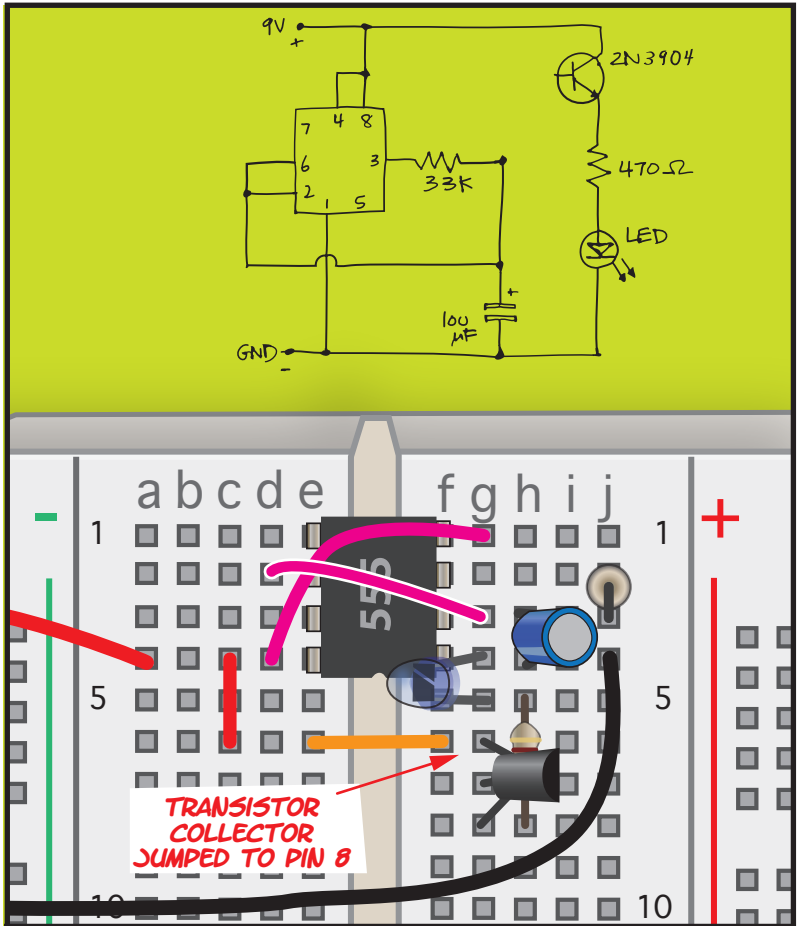
ADD THE STRONG ***RESISTOR*** BETWEEN ***PIN 3*** AND ***PIN 2***. THERE'S NOT ENOUGH ROOM FOR IT, LONGWAYS, SO WE'LL STAND IT VERTICALLY ON END.



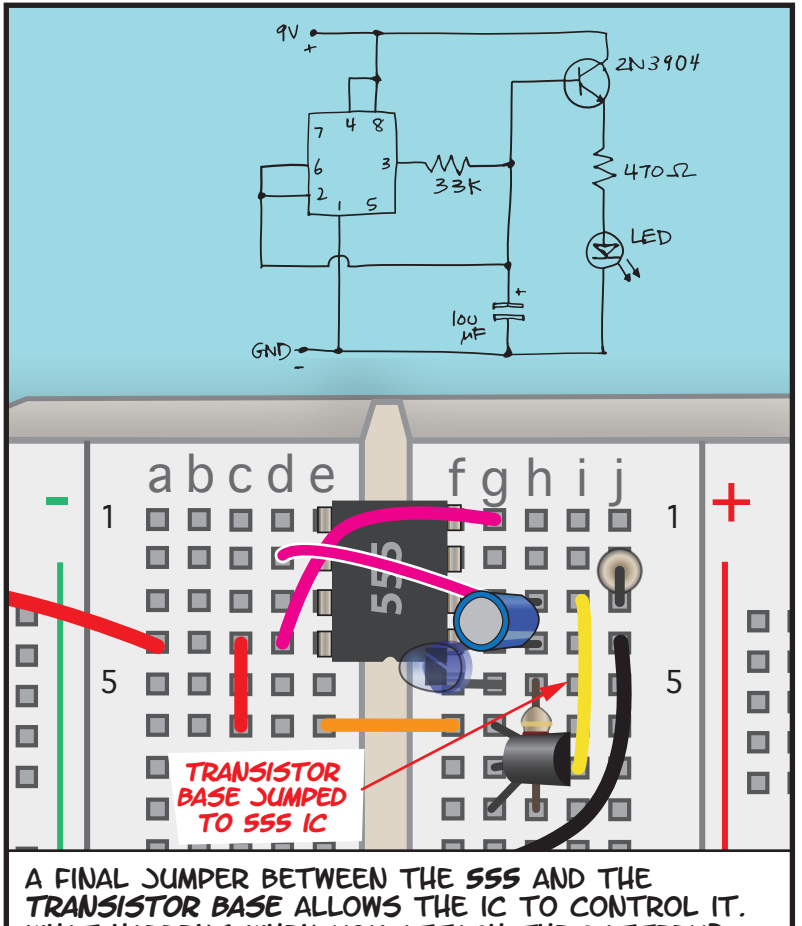
NOW THE LED SWITCHING CIRCUIT, STARTING WITH THE LED ITSELF. THE CATHODE (SHORT LEAD) CONNECTS TO GROUND.



AS ALWAYS, WE NEED A CURRENT-LIMITING RESISTOR IN SERIES TO PROTECT OUR LED FROM DAMAGE. ADD IT NEXT.

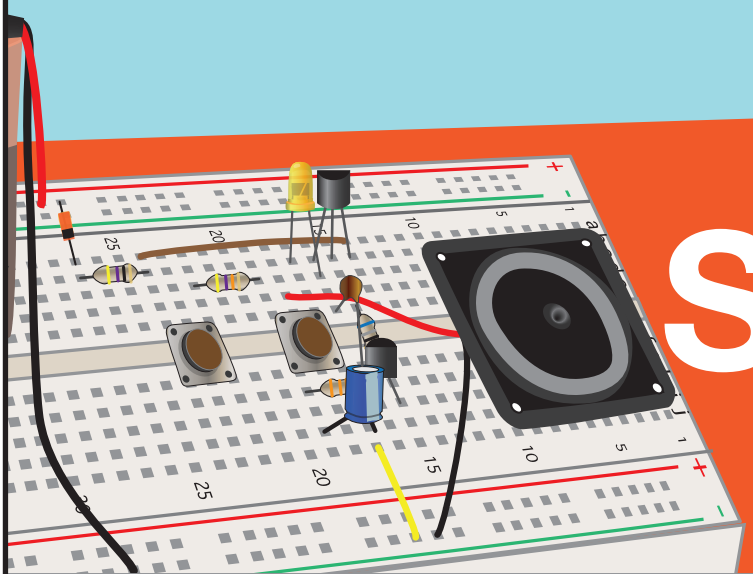


NOW ADD THE ***TRANSISTOR***. CONNECT ITS COLLECTOR TO POWER/PIN 8 WITH TWO JUMPER WIRES.



A FINAL JUMPER BETWEEN THE ***555*** AND THE ***TRANSISTOR BASE*** ALLOWS THE IC TO CONTROL IT. WHAT HAPPENS WHEN YOU ATTACH THE BATTERY? WHY? WHAT HAPPENS IF YOU CHANGE THE VALUE OF THE CAPACITOR?

CIRCUIT #5

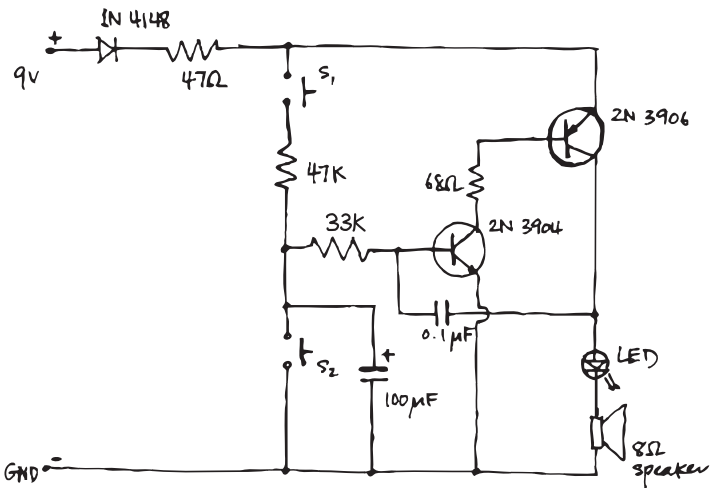


Build a Screaming Siren!

PARTS YOU WILL NEED:

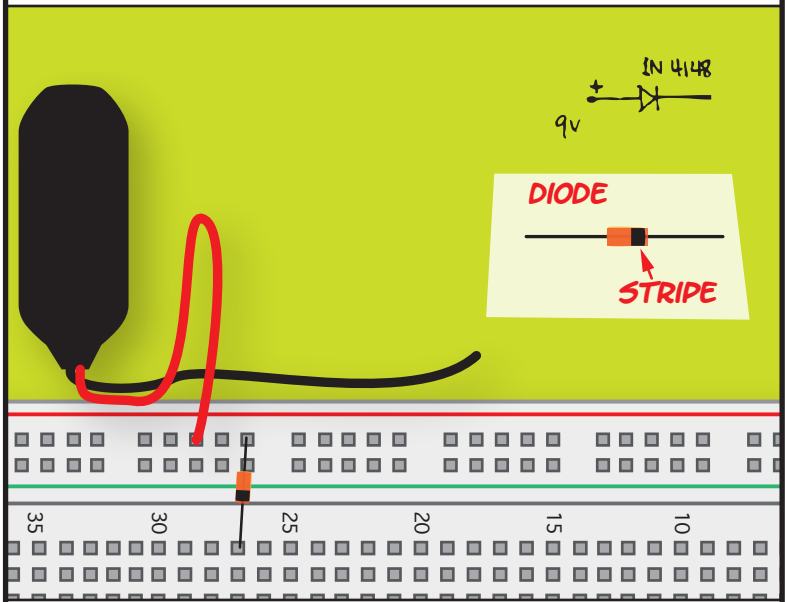
- 1 9V BATTERY W/SNAP
- 2 MOMENTARY SWITCHES
- 1 47Ω RESISTOR
- 1 68Ω RESISTOR
- 1 33KΩ RESISTOR
- 1 47KΩ RESISTOR
- 1 1N4148 DIODE
- 1 YELLOW LED
- 1 2N3904 NPN TRANSISTOR
- 1 2N3906 PNP TRANSISTOR
- 1 100µF ELECTROLYTIC CAPACITOR
- 1 0.1µF CERAMIC CAPACITOR
- 1 8Ω SPEAKER W/LEADS
- JUMPER WIRES

ALIEN INVASION! PRESSING SWITCH 1 SLOWLY CHARGES THE BIG ***CAPACITOR*** AND THE BASE OF THE NPN TRANSISTOR, CAUSING THE FREQUENCY OF PULSES THROUGH THE SPEAKER AND LED TO GRADUALLY INCREASE. RELEASE THE SWITCH, AND THE PITCH FALLS AWAY AS THE CAPACITOR SLOWLY DISCHARGES THROUGH THE 33K RESISTOR.



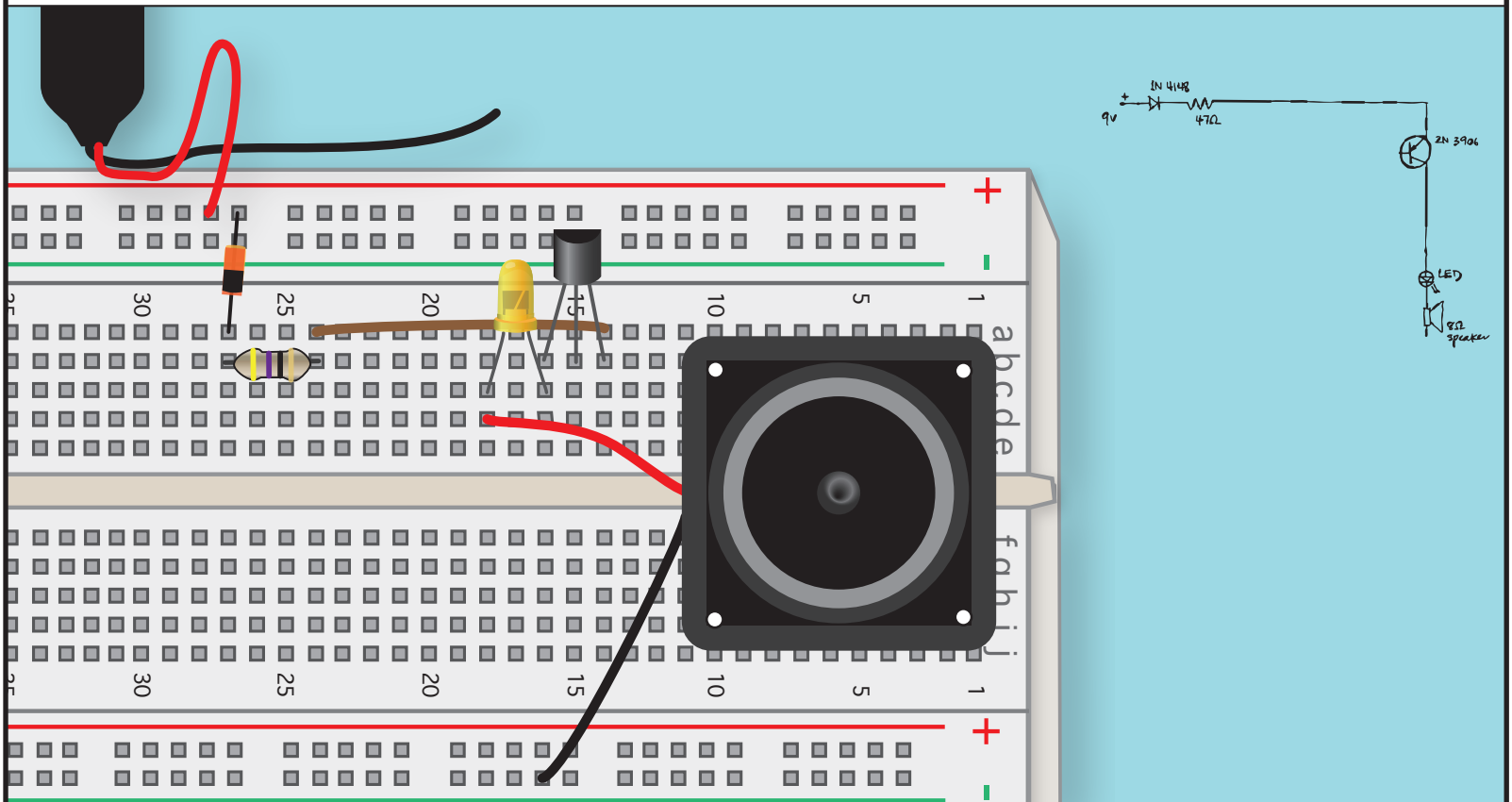
PRESSING SWITCH 2 DISCHARGES THE CAPACITOR DIRECTLY TO GROUND, INSTANTLY STOPPING BOTH SOUND AND LIGHT.

AFTER CONNECTING THE RED LEAD TO THE POWER BUS, ADD A ***DIODE*** TO CARRY POWER FROM THE BUS TO THE CIRCUIT. A DIODE IS LIKE A ONE-WAY VALVE FOR ELECTRICITY. THE STRIPE ON THE CASE SHOWS THE DIRECTION CURRENT IS ALLOWED TO FLOW, SO MAKE SURE YOU GET IT POINTED THE RIGHT WAY.



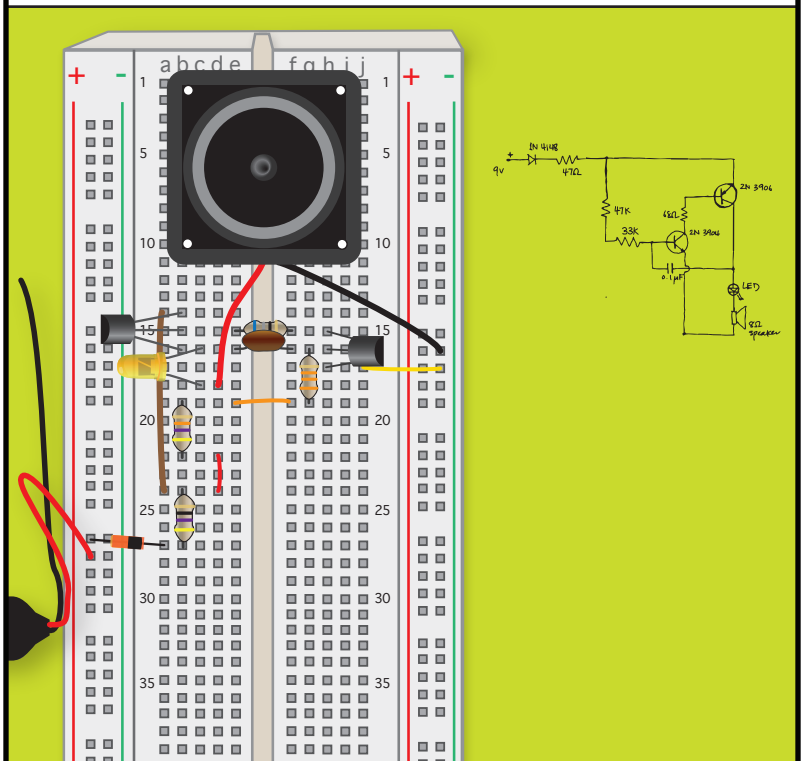
YOU ALREADY KNOW ABOUT DIODES THAT EMIT LIGHT (AKA ***LEDS***), BUT THEY CAN DO OTHER STUFF, TOO—LIKE PROTECT A CIRCUIT FROM DAMAGE IN CASE SOMEONE ACCIDENTALLY HOOKS UP THE BATTERY BACKWARDS.

FIRST INSTALL THE OUTPUT COMPONENTS (THE LED AND THE SPEAKER) AND THE PNP TRANSISTOR THAT SWITCHES THEM ON AND OFF. DON'T FORGET THE CURRENT-LIMITING RESISTOR TO PROTECT THE LED!

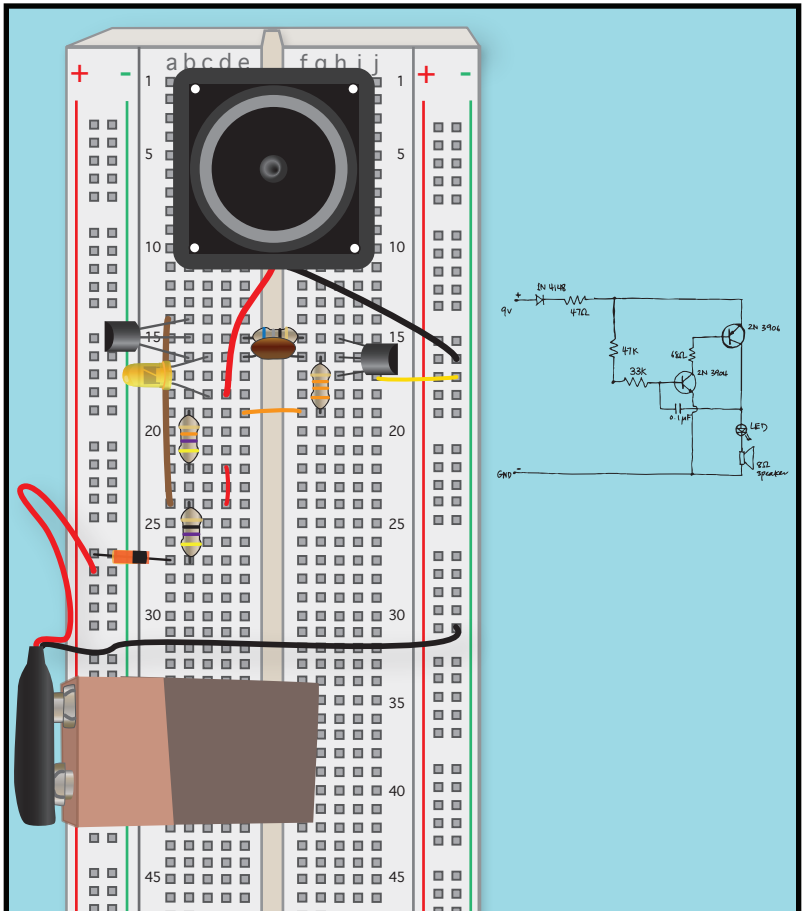


IF YOU WERE TO CONNECT THE BATTERY NOW, WOULD THE CIRCUIT DO ANYTHING? WHY OR WHY NOT?

NOW CONNECT THE NPN TRANSISTOR, THE REST OF THE RESISTORS, AND THE SMALL CAPACITOR. SEE HOW THE CAPACITOR CONNECTS THE OUTPUT OF ONE TRANSISTOR TO THE BASE OF THE OTHER?

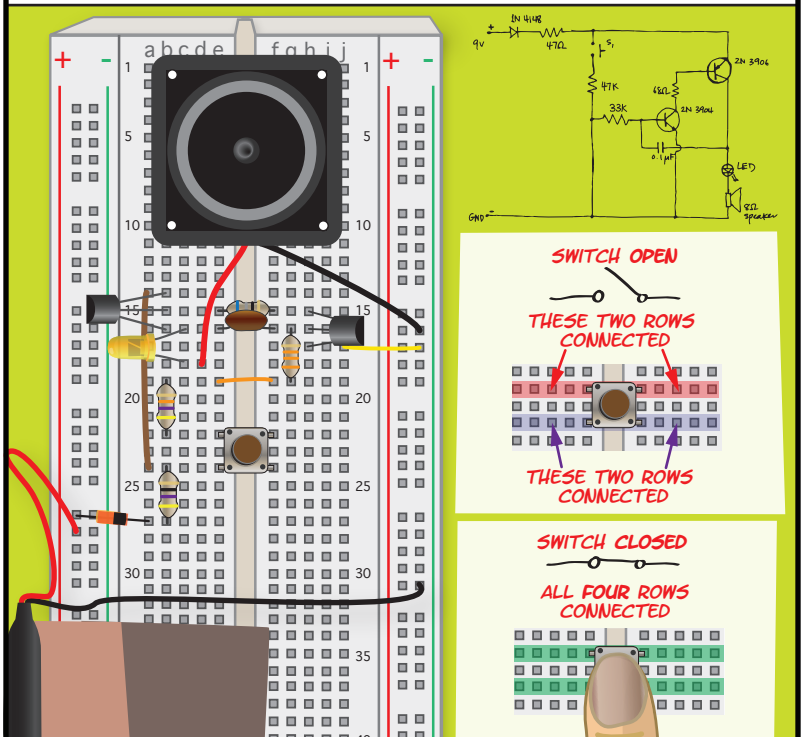


THOUGH IT LOOKS A BIT DIFFERENT, YOU'VE JUST BUILT ANOTHER ***ASTABLE MULTIVIBRATOR*** CIRCUIT. REMEMBER THE LED FLASHER CIRCUIT (#2)?



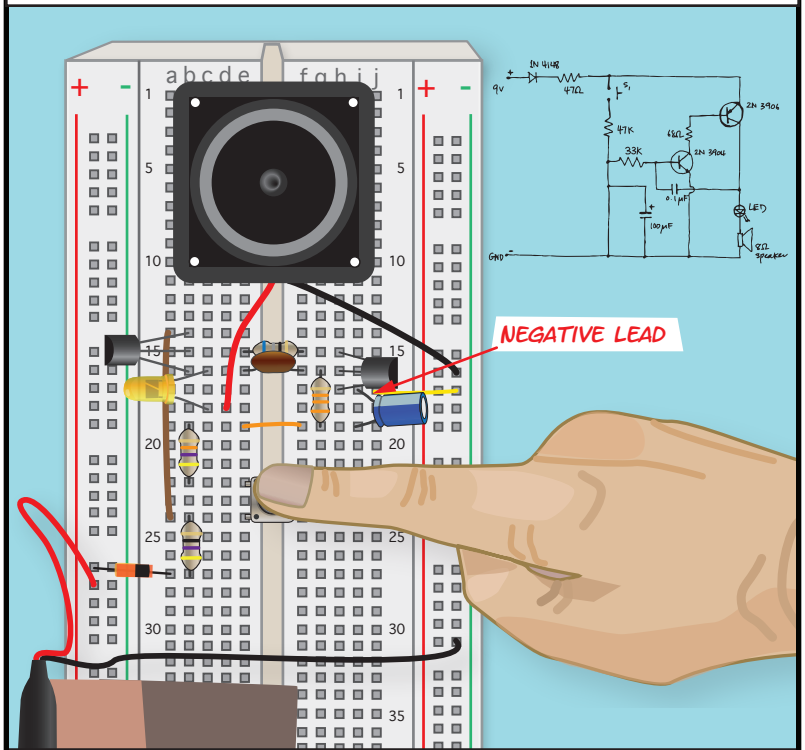
CONNECT THE BLACK BATTERY CLIP LEAD TO THE GROUND BUS, THEN TOUCH THE CONTACTS OF A 9V BATTERY TO THE CLIP TERMINALS. WHAT HAPPENS NOW?

LET'S ADD A ***BUTTON*** SO WE DON'T HAVE TO USE THE BATTERY TO TURN THE CIRCUIT ON AND OFF. A BUTTON IS JUST A TYPE OF ***SWITCH***. THIS ONE IS A ***MOMENTARY***, ***NORMALLY OPEN*** SWITCH – THE CIRCUIT IS CLOSED ONLY WHILE THE BUTTON IS PRESSED.



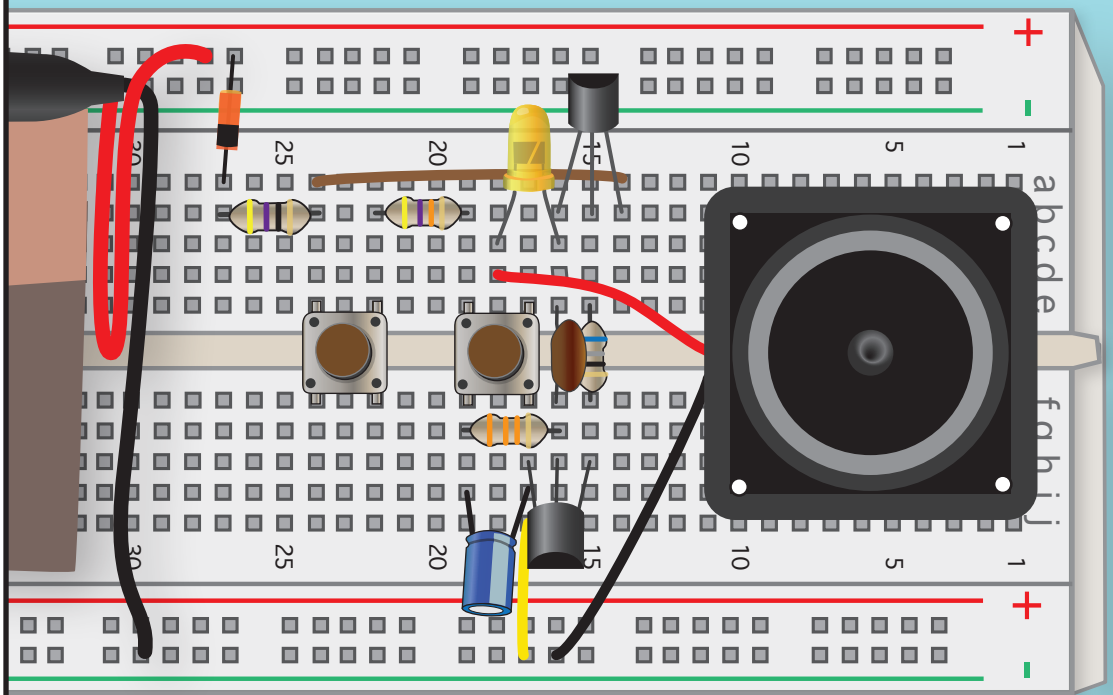
REMOVE THE SHORT RED JUMPER WIRE, INSTALL THE SWITCH, ATTACH THE BATTERY CLIP TO THE BATTERY, AND PUSH THE BUTTON. WHAT HAPPENS?

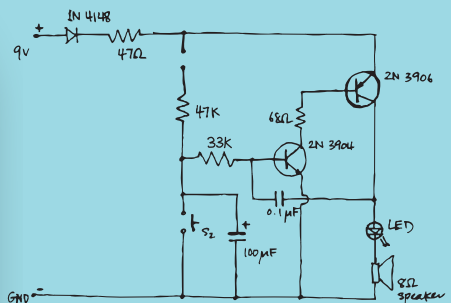
NOW WE'LL MAKE IT A BIT MORE INTERESTING. ADD A BIG 100µF ELECTROLYTIC CAPACITOR BETWEEN THE 33K RESISTOR AND GROUND. REMEMBER ELECTROLYTIC CAPACITORS ARE POLARIZED!



PUSH THE BUTTON AND HOLD IT DOWN FOR A FEW SECONDS. WHAT HAPPENS? WHAT HAPPENS WHEN YOU LET GO? WHY?

FINALLY, REPLACE THE SHORT ORANGE JUMPER WIRE WITH A SECOND SWITCH. THIS ONE GOES BETWEEN THE POSITIVE LEG OF THE CAPACITOR AND GROUND.

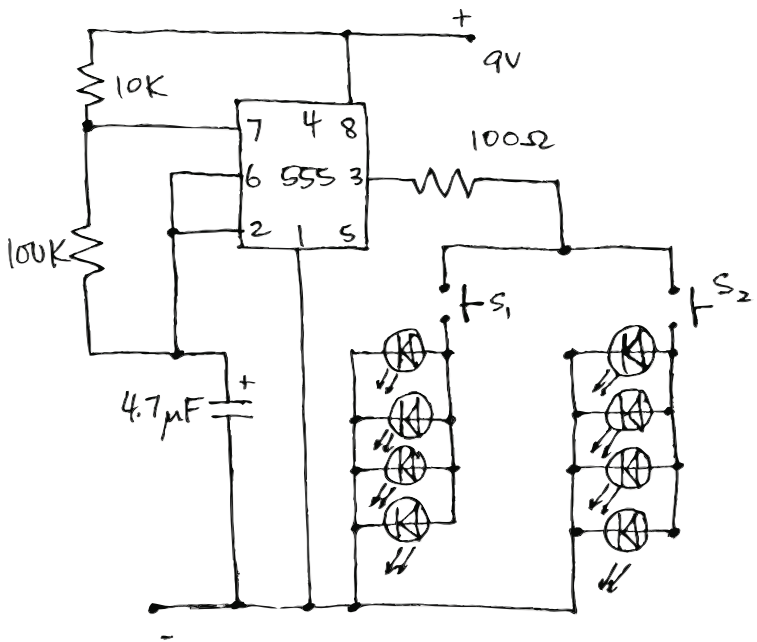




PUSH SWITCH 1 FOR SEVERAL SECONDS, THEN LET GO AND PUSH SWITCH 2. WHAT HAPPENS? WHY?

Build a BIKE SIGNAL LIGHT!

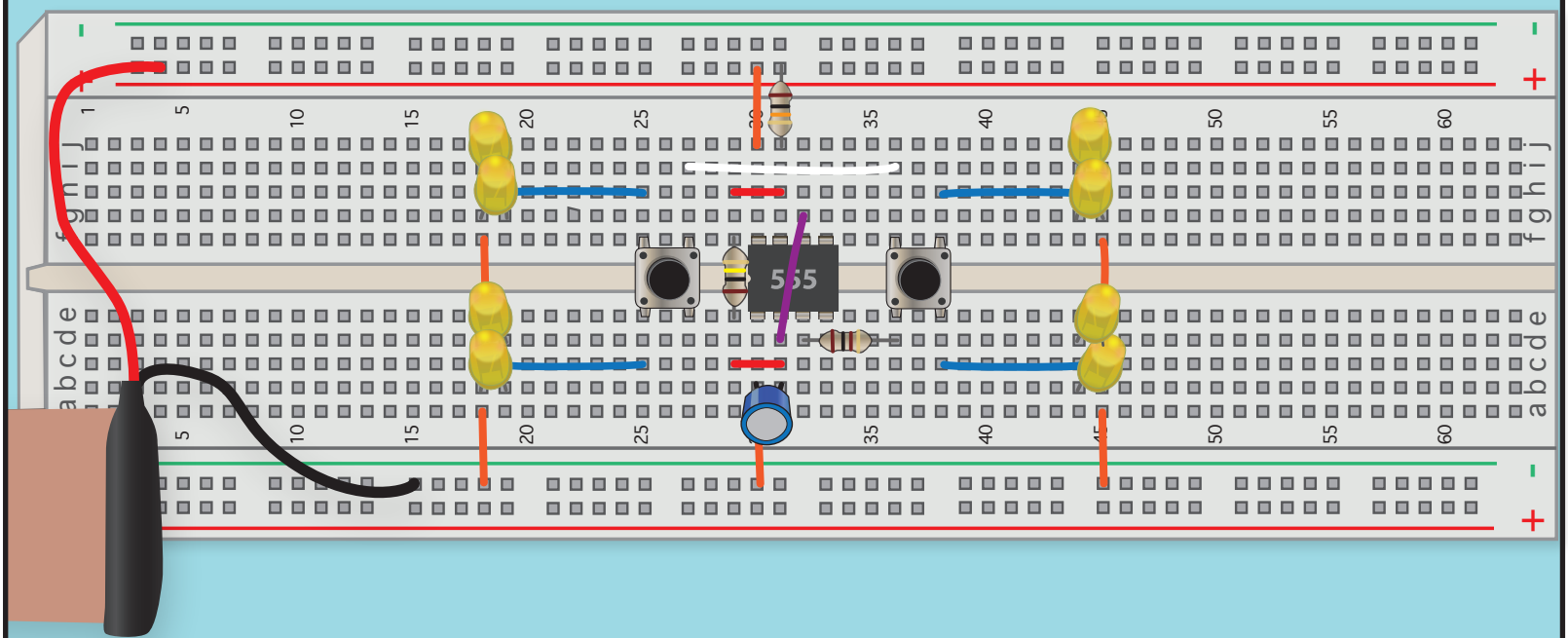
CIRCUIT #6



PARTS YOU WILL NEED:

- 2 MOMENTARY SWITCHES
- 1 555 TIMER IC
- 1 100Ω RESISTOR
- 1 10KΩ RESISTOR
- 1 100KΩ RESISTOR
- 1 4.7μF ELECTROLYTIC CAPACITOR
- 8 YELLOW LEDS
- 1 9V BATTERY W/SNAP
- JUMPER WIRES

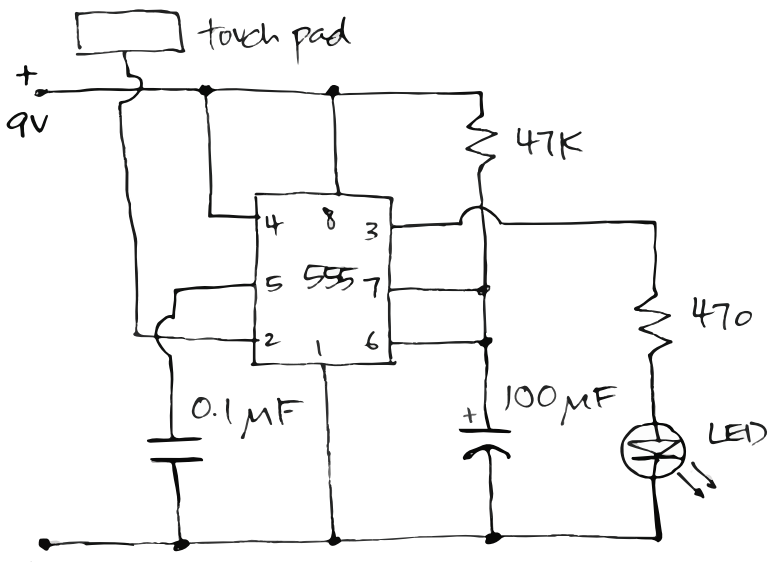
SAFETY FIRST! LET OTHERS KNOW WHICH WAY YOU'RE GOING WITH THIS EASY LED FLASHER CIRCUIT. PUT THE BUTTONS ON THE HANDLEBARS AND PUSH ONE OR THE OTHER TO SIGNAL "RIGHT TURN" OR "LEFT TURN," AND BOTH TOGETHER TO SIGNAL "STOP."



AN ASTABLE 555 TIMER SWITCHES THE CURRENT ON AND OFF TO FLASH THE LEDS, AND THE FLASHING RATE IS SET BY THE CAPACITOR AND THE RESISTORS CONNECTED TO PINS 2 AND 7. WHAT IS THE OTHER RESISTOR FOR? WHEN YOU PUSH BOTH BUTTONS AT ONCE, DO THE LEDS FLASH TOGETHER OR SEPARATELY? WHY?

Build a TOUCH SWITCH!

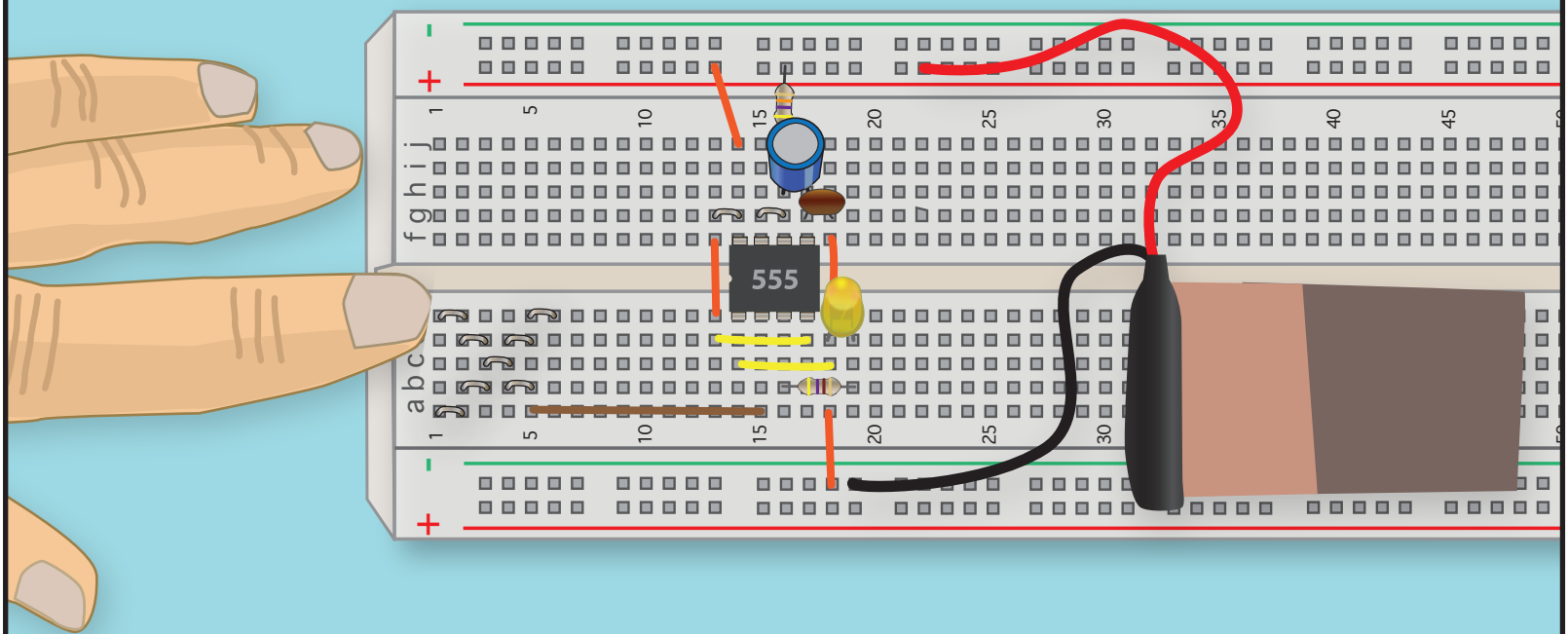
CIRCUIT #7



PARTS YOU WILL NEED:

- 1 555 TIMER IC
- 1 470Ω RESISTOR
- 1 47KΩ RESISTOR
- 1 0.1µF CERAMIC CAPACITOR
- 1 100µF ELECTROLYTIC CAPACITOR
- 1 YELLOW LED
- 1 9V BATTERY W/SNAP
- JUMPER WIRES

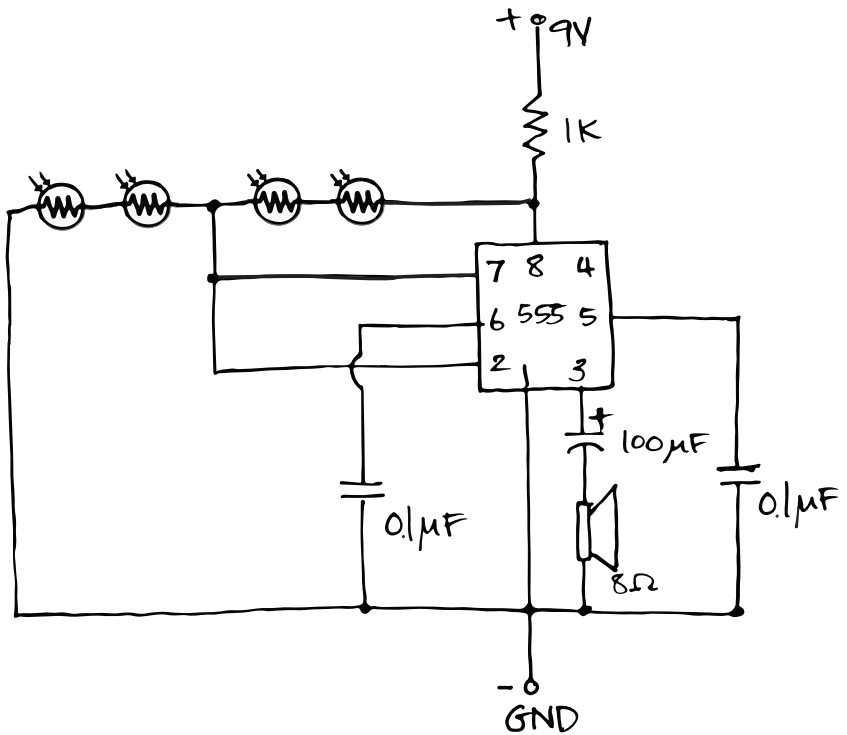
WHO NEEDS A MECHANICAL SWITCH WHEN A BIT OF BARE METAL WILL DO? THIS SIMPLE TOUCH SWITCH CAN BE USED TO TRIGGER LIGHTS AND SENSORS, OR AS AN ALARM!



HERE THE 555 TIMER IS WIRED IN ***MONOSTABLE*** (OR ***ONE SHOT***) MODE. INSTEAD OF AN ENDLESS SERIES OF PULSES, PIN 3 OUTPUTS A SINGLE PULSE WHEN YOU TOUCH THE METAL "X" CONNECTED TO PIN 2. THE LENGTH OF THE PULSE DEPENDS ON THE VALUE OF THE RESISTOR AND CAPACITOR CONNECTED TO PINS 6 AND 7.

Build a LIGHT THEREMIN!

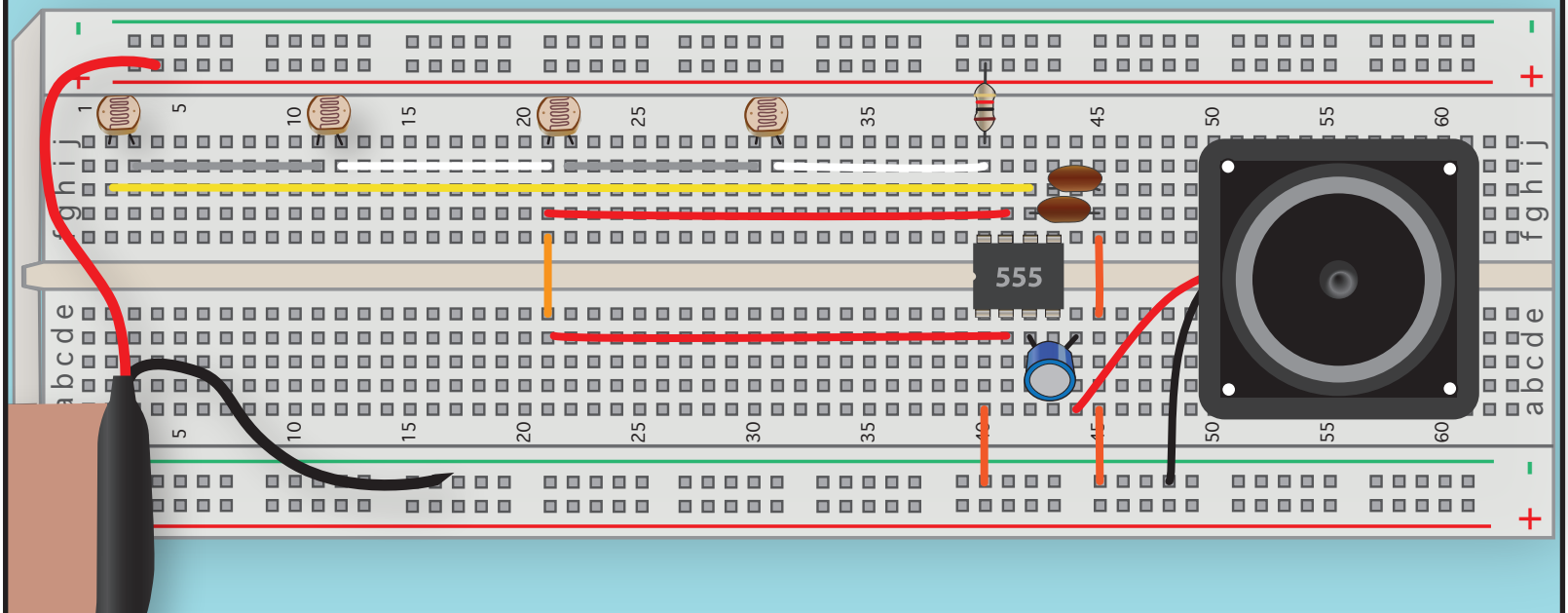
CIRCUIT #8



PARTS YOU WILL NEED:

- 4 PHOTORESISTORS
- 1 555 TIMER IC
- 1 1KΩ RESISTOR
- 2 0.1µF CERAMIC CAPACITORS
- 1 100µF ELECTROLYTIC CAPACITOR
- 1 8Ω SPEAKER W/LEADS
- 1 9V BATTERY W/SNAP
- JUMPER WIRES

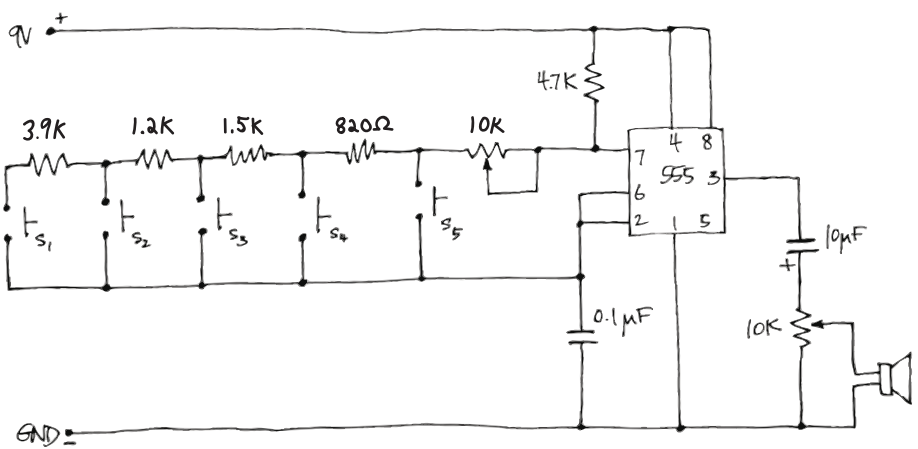
ARE YOU A FAN OF THE EERIE SOUNDTRACKS FROM CLASSIC HORROR OR SCI-FI MOVIES? A ***THEREMIN*** IS THE ELECTRONIC INSTRUMENT BEHIND A LOT OF THOSE SPOOKY SOUNDS. YOU CAN CREATE YOUR OWN, SIMPLE, LIGHT-BASED VERSION OF A THEREMIN USING A ***555 TIMER IC*** AND SOME ***PHOTORESISTORS***. JUST LIKE ITS BIG BROTHER, THE PITCH IS CONTROLLED BY A WAVE OF YOUR HAND!



THE 555 IS WIRED IN ASTABLE MODE AGAIN, HERE, BUT THIS TIME IT'S A STRING OF PHOTORESISTORS THAT CONTROLS THE FREQUENCY OF THE PULSES OUTPUT BY PIN 3. BLOCKING LIGHT FALLING ON THE PHOTORESISTORS CAUSES THE TOTAL RESISTANCE, AND THE FREQUENCY OF THE SOUND, TO CHANGE.

Build a BLUES ORGAN!

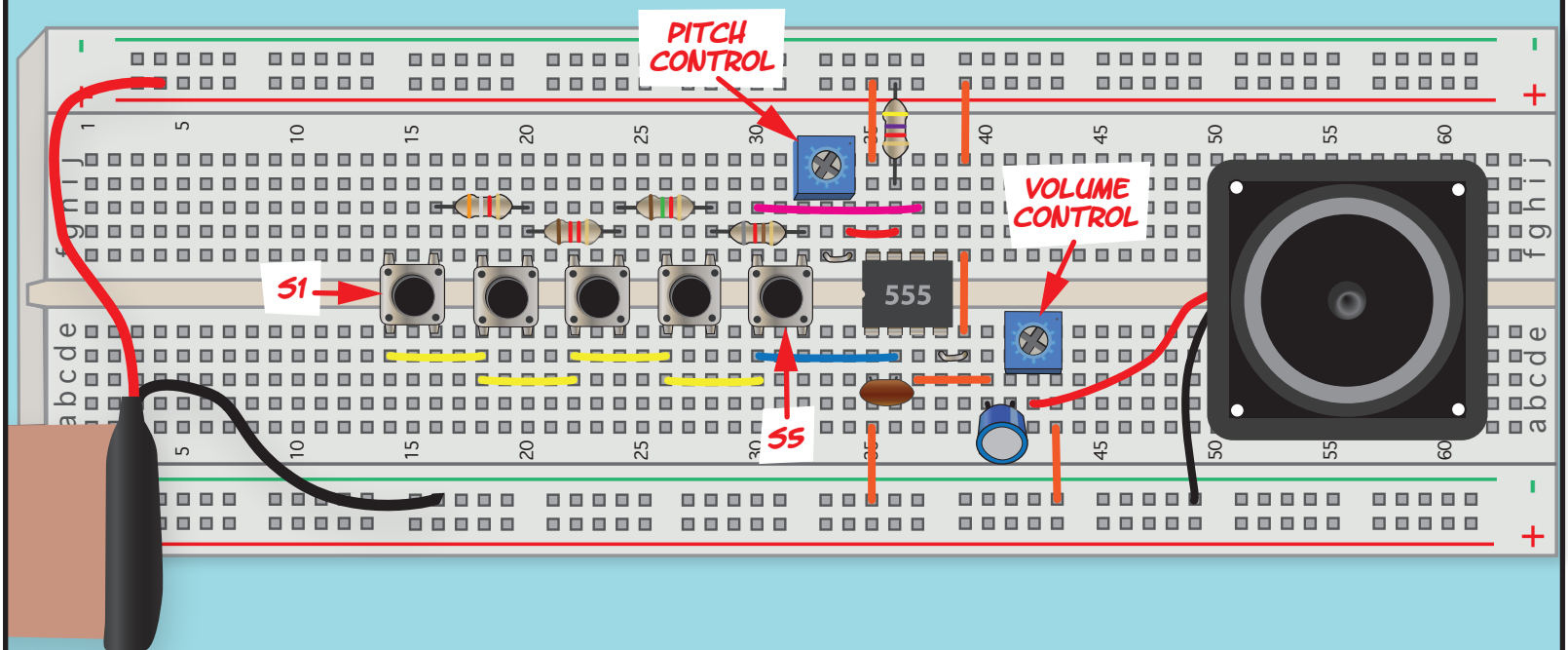
CIRCUIT #9



PARTS YOU WILL NEED:

- 5 MOMENTARY SWITCHES
- 1 555 TIMER IC
- 1 4.7KΩ RESISTOR
- 1 820Ω RESISTOR
- 1 1.2KΩ RESISTOR
- 1 1.5KΩ RESISTOR
- 1 3.9KΩ RESISTOR
- 2 10KΩ POTENTIOMETERS
- 1 0.1μF CERAMIC CAPACITOR
- 1 10μF ELECTROLYTIC CAPACITOR
- 1 8Ω SPEAKER W/LEADS
- 1 9V BATTERY W/SNAP
- JUMPER WIRES

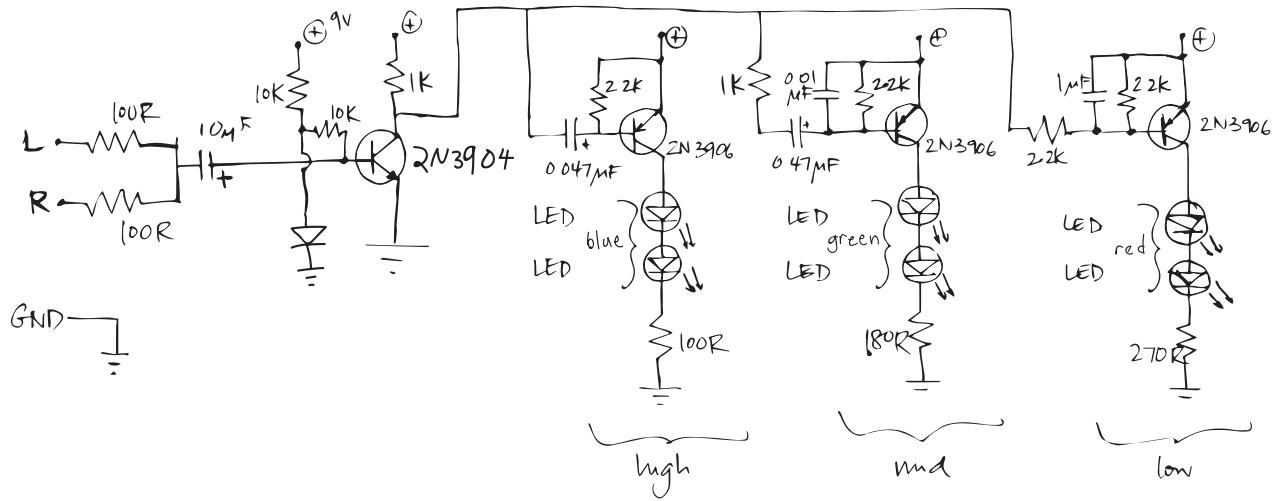
LET'S MAKE A LITTLE MUSIC! THIS FIVE-NOTE ORGAN USES OUR OLD FRIEND THE 555 TIMER IC AS A FREQUENCY GENERATOR, AND HAS ADJUSTABLE PITCH AND VOLUME CONTROLS.



THE 555 IS WIRED — YOU GUESSED IT — IN ASTABLE MODE AND HAS A RESISTOR "LADDER" CONNECTED ACROSS PINS 2 AND 7. WHEN S1 IS CLOSED, ALL 4 RESISTORS ARE IN THE LOOP, THE RESISTANCE IS HIGHER, AND THE PITCH IS LOWER. WHEN S5 IS CLOSED, ONLY 1 RESISTOR IS IN THE LOOP, THE RESISTANCE IS LOWER, AND THE PITCH IS HIGHER. WHAT HAPPENS IF YOU PRESS MORE THAN ONE BUTTON AT THE SAME TIME? WHY?

Build an LED COLOR ORGAN!

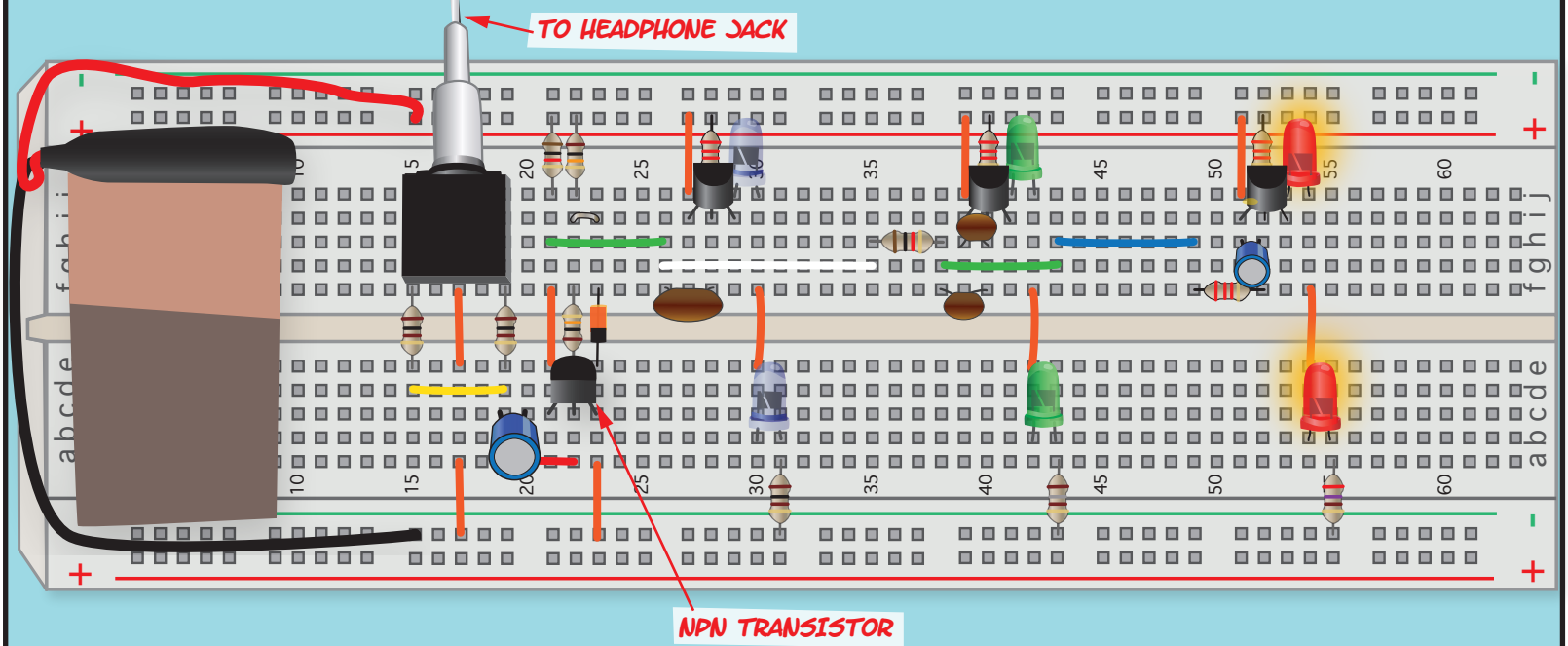
CIRCUIT #10



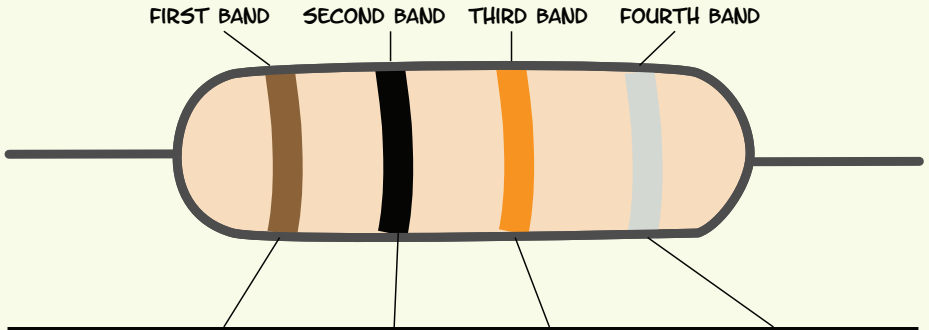
PARTS YOU WILL NEED:

- 1 MICROPHONE JACK
- 3 100Ω RESISTORS
- 2 10KΩ RESISTORS
- 4 2.2KΩ RESISTORS
- 2 1KΩ RESISTOR
- 1 180Ω RESISTOR
- 1 270Ω RESISTOR
- 1 1µF ELECTROLYTIC CAPACITOR
- 1 0.01µF CERAMIC CAPACITOR
- 1 10µF ELECTROLYTIC CAPACITOR
- 1 0.47µF CERAMIC CAPACITOR
- 1 0.047µF CERAMIC CAPACITOR
- 1 DIODE
- 3 2N3906 PNP TRANSISTORS
- 1 2N3904 NPN TRANSISTOR
- 2 RED LEDS
- 2 BLUE LEDS
- 2 GREEN LEDS
- 1 9V BATTERY W/SNAP CONNECTOR
- MISC JUMPER WIRES

VISUALIZE YOUR MUSIC AS A MULTICOLOR LIGHTSHOW! THIS CIRCUIT DISPLAYS THE FREQUENCY SPECTRUM OF ANY STEREO AUDIO SIGNAL YOU PLUG INTO THE MICROPHONE JACK. YOU'LL NEED A 1/8" HEADPHONE CABLE WITH PLUGS AT BOTH ENDS, PLUS A PHONE OR MP3 PLAYER.



LOW-FREQUENCY SIGNALS (LIKE BASSLINES) ARE DISPLAYED AS RED FLASHES, MID-FREQUENCY SIGNALS (LIKE VOCALS) AS GREEN FLASHES, AND HIGH-FREQUENCY SIGNALS (LIKE LEAD GUITAR) ARE DISPLAYED AS BLUE FLASHES. AS DRAWN, BOTH RIGHT AND LEFT AUDIO CHANNELS ARE COMBINED. HOW COULD YOU MODIFY THIS CIRCUIT TO DISPLAY THE TWO CHANNELS SEPARATELY?



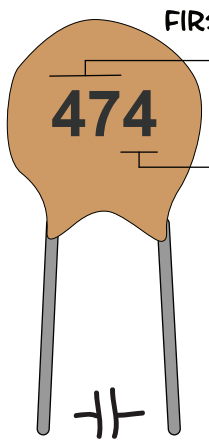
BLACK	0	0	MULTIPLY X 1	SILVER ± 10%
BROWN	1	1	MULTIPLY X 10	GOLD ± 5%
RED	2	2	MULTIPLY X 100	
ORANGE	3	3	MULTIPLY X 1,000	
YELLOW	4	4	MULTIPLY X 10,000	
GREEN	5	5	MULTIPLY X 100,000	
BLUE	6	6	MULTIPLY X 1,000,000	
PURPLE	7	7		
GRAY	8	8		
WHITE	9	9		

WONDERING HOW TO READ THE COLOR CODES ON YOUR RESISTORS? HERE'S A CHART THAT EXPLAINS WHAT THE COLORS MEAN ON A FOUR BAND RESISTOR. FIVE BAND RESISTORS USE THE SAME COLORS BUT ARE MORE PRECISE.

CAPACITORS HAVE A PROPERTY CALLED ***CAPACITANCE*** WHICH REPRESENTS HOW MUCH ELECTRICAL CHARGE THEY CAN STORE, AND IS MEASURED IN UNITS CALLED ***FARADS*** (F). IN PRACTICE, ONE FARAD IS AN ENORMOUS CAPACITANCE. THE ***MICROFARAD*** IS A MORE COMMON UNIT OF MEASURE.

1,000,000 PICOFARADS = 1 MICROFARAD

CERAMIC CAPACITORS



FIRST 2 DIGITS CARRY OVER

= 470,000 pF

4 ZEROES

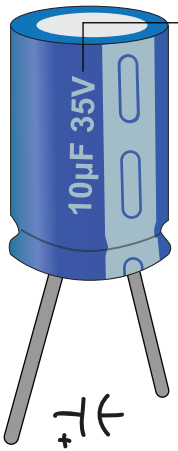
THIRD DIGIT = NUMBER OF ZEROS

NOT POLARIZED

MARKED IN PICOFARADS

1,000,000 MICROFARADS = 1 FARAD

ELECTROLYTIC CAPACITORS



MAXIMUM SAFE VOLTAGE

= 10 µF = 10 uF

MEAN THE SAME THING

STRIPE OR ARROW = NEGATIVE LEAD

POLARIZED

MARKED IN MICROFARADS

UNLIKE CERAMIC CAPACITORS, ELECTROLYTIC CAPS ARE ***POLARIZED***, MEANING ONE LEAD IS POSITIVE AND ONE IS NEGATIVE, AND YOU HAVE TO BE CAREFUL NOT TO MIX THEM UP. HOOKING UP THE LEADS BACKWARDS CAN DAMAGE AN ELECTROLYTIC CAPACITOR, AS CAN APPLYING A VOLTAGE ABOVE ITS MAXIMUM RATING. FOR THIS BOOK, DON'T USE ANY CAPACITOR RATED LESS THAN 9V.

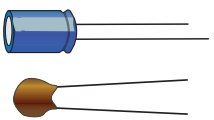
Full Components List

PART NAME	SUCH AS	CIRCUIT NUMBER 1	2	3	4	5	6	7	8	9	10	YOU'LL NEED
BREADBOARD, 830 TIE POINT, 4 BUS	JAMECO 2125026	1	1	1	1	1	1	1	1	1	1	1
JUMPER WIRE KIT, 22 AWG, 140 PIECE	JAMECO 2179711	1	1	1	1	1	1	1	1	1	1	1
9V BATTERY	JAMECO 2112461	1	1	1	1	1	1	1	1	1	1	1
9V BATTERY CLIP WITH WIRE LEADS	JAMECO 216452	1	1	1	1	1	1	1	1	1	1	1
1/8" STEREO AUDIO JACK (BREADBOARD-FRIENDLY)	JAMECO 2168131										1	1
8-OHM SPEAKER WITH WIRE LEADS	JAMECO 2234134			1		1			1	1		1
CAPACITOR, CERAMIC, 0.01µF ("103"), MINIMUM 9V RATING	JAMECO 15229										1	1
CAPACITOR, CERAMIC, 0.047µF ("473"), MINIMUM 9V RATING	JAMECO 1947351										1	1
CAPACITOR, CERAMIC, 0.1µF ("104"), MINIMUM 9V RATING	JAMECO 151116					1		1	2	1		2
CAPACITOR, CERAMIC, 0.47µF ("474"), MINIMUM 9V RATING	JAMECO 25558										1	1
CAPACITOR, ELECTROLYTIC, 1µF, MINIMUM 9V RATING	JAMECO 330772										1	1
CAPACITOR, ELECTROLYTIC, 4.7µF, MINIMUM 9V RATING	JAMECO 330781						1					1
CAPACITOR, ELECTROLYTIC, 10µF, MINIMUM 9V RATING	JAMECO 330692		2							1	1	2
CAPACITOR, ELECTROLYTIC, 100µF, MINIMUM 9V RATING	JAMECO 330740			1	1	1		1	1			1
CDS PHOTORESISTOR, 3K (LIGHT)	JAMECO 202403	1		1					4			4
SMALL SIGNAL DIODE, IN4148	JAMECO 36038					1					1	1
IC, 555 TIMER, 8 PIN DIP	JAMECO 27423			1	1		1	1	1	1		1
LED, BLUE, SMM	JAMECO 2179711				1						2	2
LED, GREEN, SMM	JAMECO 2210706	1									2	2
LED, RED, SMM	JAMECO 333526		2								2	2
LED, YELLOW, SMM	JAMECO 333614					1	8	1				8

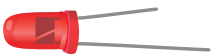
PART NAME	SUCH AS	CIRCUIT NUMBER 1	2	3	4	5	6	7	8	9	10	YOU'LL NEED
POTENTIOMETER, 1/2W, 10K	JAMECO 2118791									2		2
RESISTOR, 1/4W, 5%, 10Ω	JAMECO 690380			1								1
RESISTOR, 1/4W, 5%, 47Ω	JAMECO 690540					1						1
RESISTOR, 1/4W, 5%, 68Ω	JAMECO 690582					1						1
RESISTOR, 1/4W, 5%, 100Ω	JAMECO 690620						1				3	3
RESISTOR, 1/4W, 5%, 180Ω	JAMECO 690689										1	1
RESISTOR, 1/4W, 5%, 270Ω	JAMECO 690726										1	1
RESISTOR, 1/4W, 5%, 470Ω	JAMECO 690785	1	2		1			1				2
RESISTOR, 1/4W, 5%, 820Ω	JAMECO 690849									1		1
RESISTOR, 1/4W, 5%, 1K	JAMECO 690865								1		2	2
RESISTOR, 1/4W, 5%, 1.2K	JAMECO 690881									1		1
RESISTOR, 1/4W, 5%, 1.5K	JAMECO 690902									1		1
RESISTOR, 1/4W, 5%, 2.2K	JAMECO 690945			1								1
RESISTOR, 1/4W, 5%, 3.9K	JAMECO 691008									1		1
RESISTOR, 1/4W, 5%, 4.7K	JAMECO 691024									1		1
RESISTOR, 1/4W, 5%, 10K	JAMECO 691104						1				2	2
RESISTOR, 1/4W, 5%, 33K	JAMECO 691227				1	1						1
RESISTOR, 1/4W, 5%, 47K	JAMECO 691260					1		1				1
RESISTOR, 1/4W, 5%, 100K	JAMECO 691340	1	2				1					2
SWITCH, SPST MOMENTARY, PUSHBUTTON, NORMALLY OPEN	JAMECO 1586074					2	2			5		5
SMALL SIGNAL TRANSISTOR, NPN, 2N3904, TO-92	JAMECO 178597	1	2		1	1					1	2
SMALL SIGNAL TRANSISTOR, PNP, 2N3906, TO-92	JAMECO 38375					1					3	3

PARTS ARE AVAILABLE INDIVIDUALLY OR AS A PRE-PACKAGED KIT FROM MAKERSHED.COM.

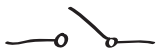
Glossary

TERM	DEFINITION	EXAMPLE	SYMBOL
BREADBOARD	A SOLDERLESS BREADBOARD IS A PLASTIC BOX FULL OF METAL STRIPS, WITH A GRID OF HOLES ON TOP, USED TO BUILD AND TEST CIRCUITS QUICKLY.		
CAPACITOR	A CAPACITOR IS A COMPONENT THAT IS USED TO STORE AN ELECTRIC CHARGE. IT CONSISTS OF ONE OR MORE PAIRS OF CONDUCTORS SEPARATED BY AN INSULATOR. CAPACITANCE IS MEASURED IN FARADS. ELECTROLYTIC CAPACITORS ARE POLARIZED, WITH A POSITIVE AND NEGATIVE LEAD. CERAMIC CAPACITORS AREN'T POLARIZED.		
CURRENT	CURRENT (I) IS THE FLOW OF ELECTRICAL CHARGE. IT IS MEASURED IN AMPERES.	$I = V/R$	A, mA, μA, etc.
DIODE	A DIODE IS A COMPONENT WITH TWO LEADS THAT ALLOWS CURRENT TO FLOW IN ONLY ONE DIRECTION, BLOCKING THE FLOW IN THE OTHER DIRECTION.		
FREQUENCY	FREQUENCY IS THE NUMBER OF CYCLES PER UNIT OF TIME, SUCH AS NUMBER OF CYCLES PER SECOND. IT IS MEASURED IN HERTZ.		Hz, MHz, kHz, etc.

Glossary (continued)

TERM	DEFINITION	EXAMPLE	SYMBOL
GROUND	GROUND IN ELECTRONICS REFERS TO A REFERENCE VOLTAGE OF ZERO POTENTIAL.	 USUALLY BLACK WIRE	
INTEGRATED CIRCUIT	AN INTEGRATED CIRCUIT COMBINES MULTIPLE ELECTRONIC CIRCUITS ON A LAYER OF SEMICONDUCTOR MATERIAL.		
LIGHT EMITTING DIODE (LED)	AN LED IS A DIODE THAT EMITS LIGHT WHEN A VOLTAGE IS APPLIED TO IT.		
PHOTO RESISTOR	A PHOTORESISTOR IS A RESISTOR THAT DECREASES ITS RESISTANCE WHEN EXPOSED TO LIGHT.		
POTENTIOMETER	A POTENTIOMETER IS A VARIABLE RESISTOR, THE RESISTANCE OF WHICH CAN BE CHANGED BY TURNING A KNOB OR SCREW.		
RESISTANCE	RESISTANCE (R) REFERS TO A MATERIAL'S OPPOSITION TO THE FLOW OF ELECTRONS. IT IS MEASURED IN OHMS	$R=V/I$	$\Omega, k\Omega, M\Omega$, etc.
RESISTOR	A RESISTOR IS A COMPONENT THAT LIMITS THE FLOW OF ELECTRICAL CURRENT IN AN ELECTRONIC CIRCUIT.		

Glossary (continued)

TERM	DEFINITION	EXAMPLE	SYMBOL
SCHEMATIC	A SCHEMATIC IS A DIAGRAM OF AN ELECTRICAL CIRCUIT. IT SHOWS THE PATH THAT CURRENT WILL FOLLOW. THE LAYOUT DOES NOT NECESSARILY MAP TO THE PHYSICAL LAYOUT OF THE CIRCUIT COMPONENTS.		
SWITCH	A SWITCH IS A DEVICE THAT MAKES OR BREAKS A CONNECTION IN AN ELECTRIC CIRCUIT.		
TRANSISTOR	A TRANSISTOR IS A COMPONENT USED TO AMPLIFY AND SWITCH ELECTRONIC SIGNALS AND ELECTRICAL POWER.		
VOLTAGE	VOLTAGE (V) IS A MEASURE OF ELECTRICAL POTENTIAL. IT IS MEASURED IN VOLTS.	$V=IR$	V, mV, kV, etc.
WAVELENGTH	WAVELENGTH IS THE DISTANCE BETWEEN CORRESPONDING POINTS IN CYCLES OF A WAVEFORM.	 SHORT WAVELENGTH  LONG WAVELENGTH	λ

CREDITS

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NOTES AND IDEAS