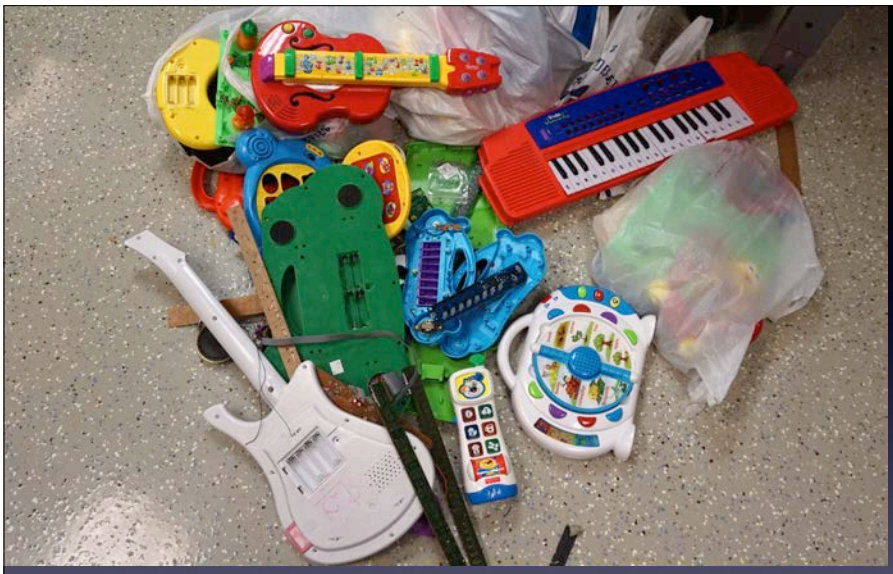
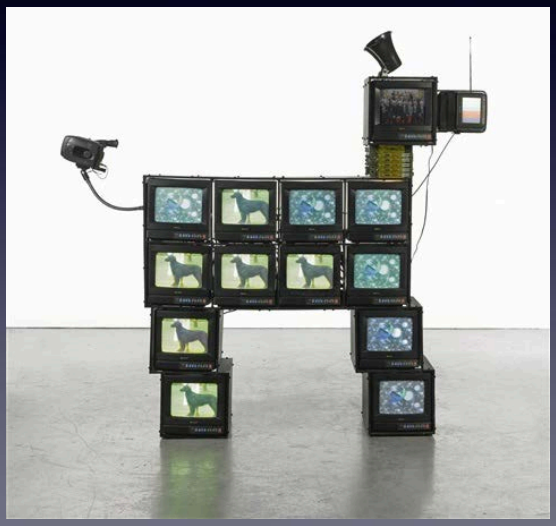


Hardware Hacking & Circuit Bending

CS5789 / ART4455 / SCLPT4455

THE UNIVERSITY OF UTAH

Nam June Paik

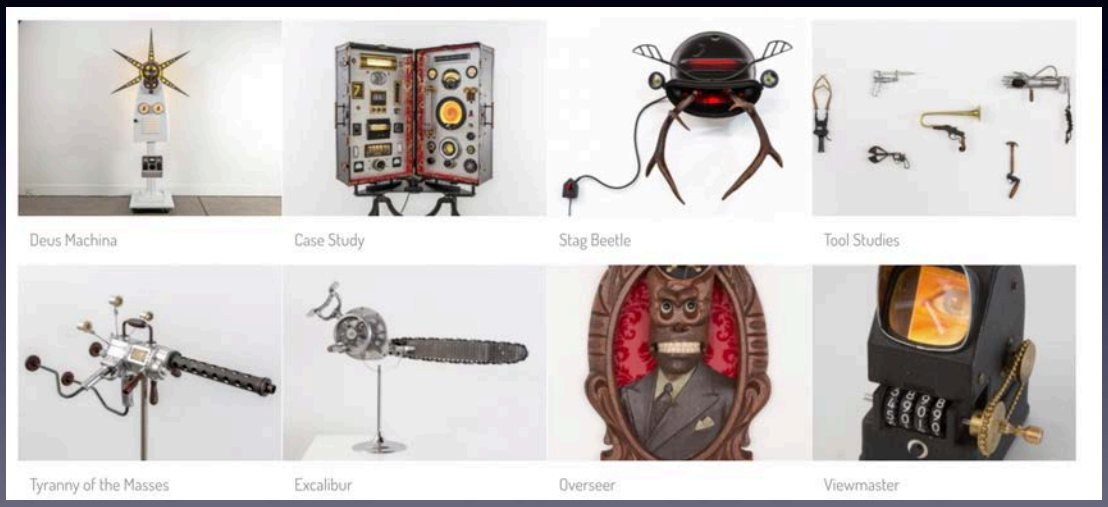


Nam June Paik

Nam June Paik

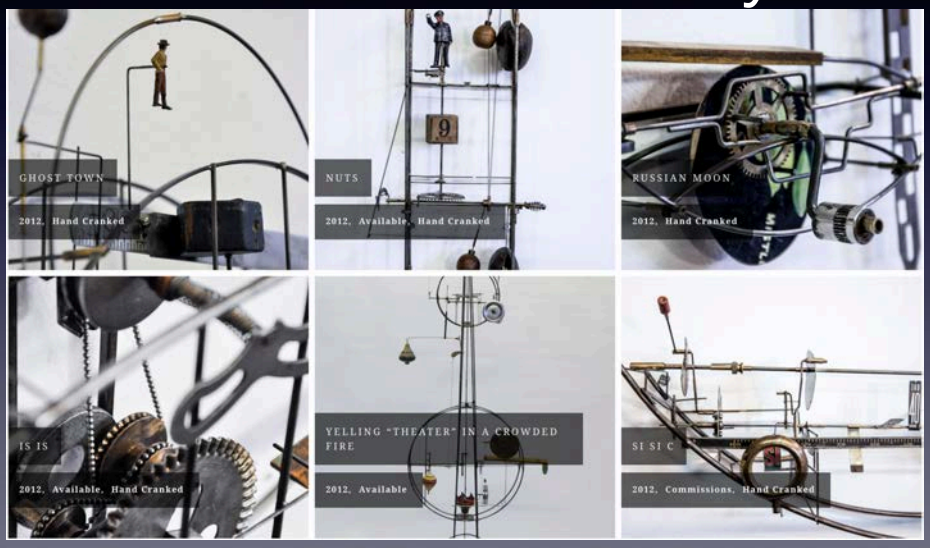
Nam June Paik

Nemo Gould



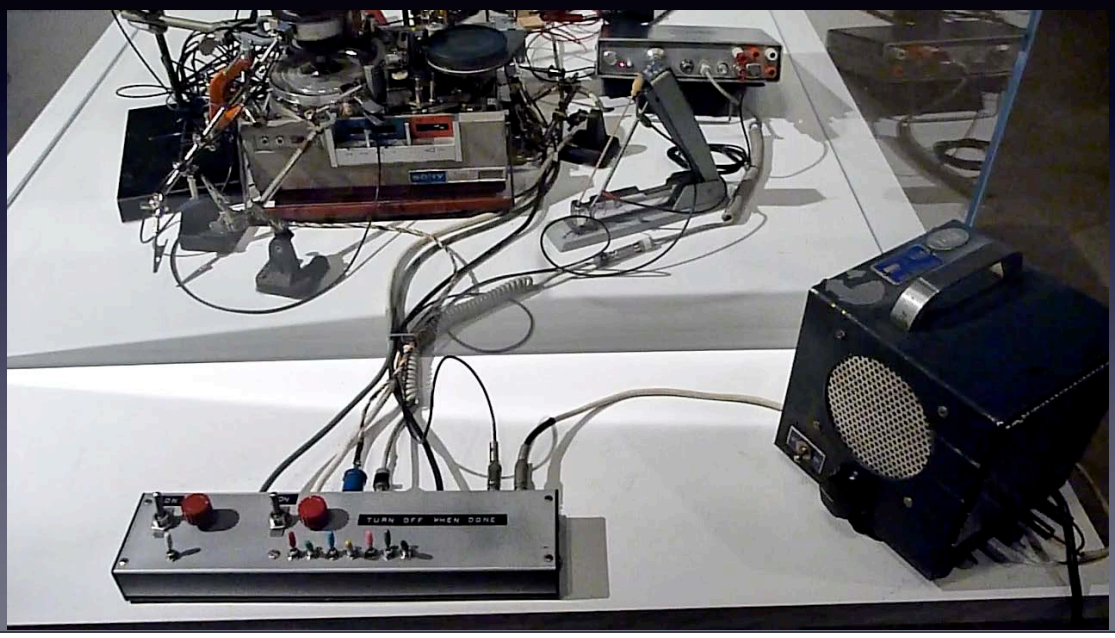
http://www.nemogould.com/portfolio-item/case-study/

Gina Kamentsky

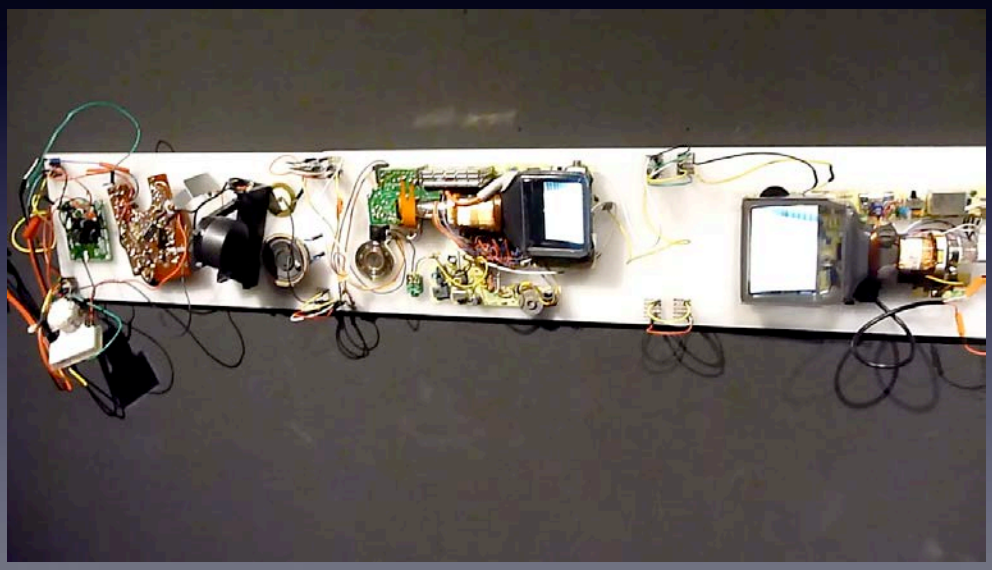


https://ginakamentsky.com/portfolio/

At CMU in 2016…



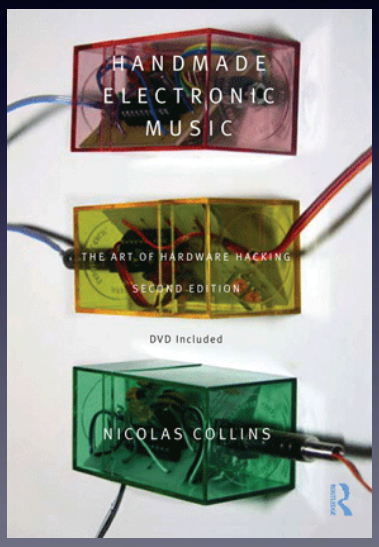
At UMOCA in 2015?

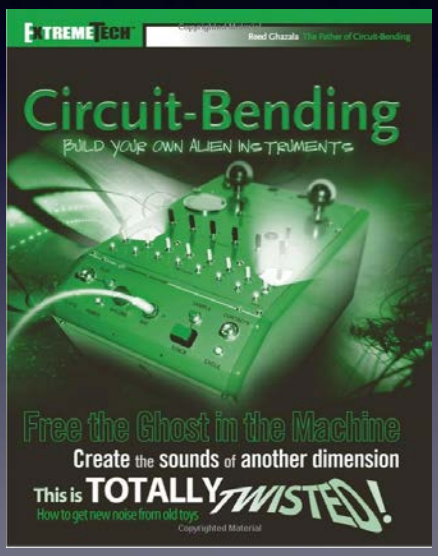


Circuit Bending

- Changing, modifying, or **“bending”** an existing circuit to do something different than what it was intended to do
- Typically noise-making circuits are bent to make different sounds than they were designed to make
- The easiest bend is to speed up and slow down the noise by changing the **clock** of the circuit…

Circuit Bending Books





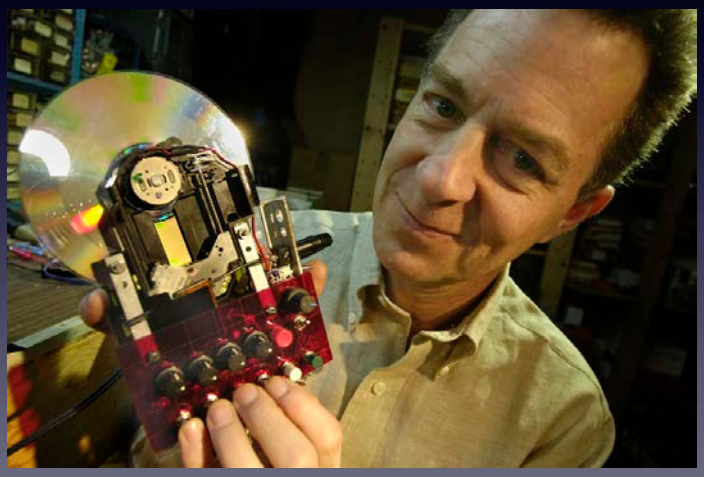
Reed Ghazala

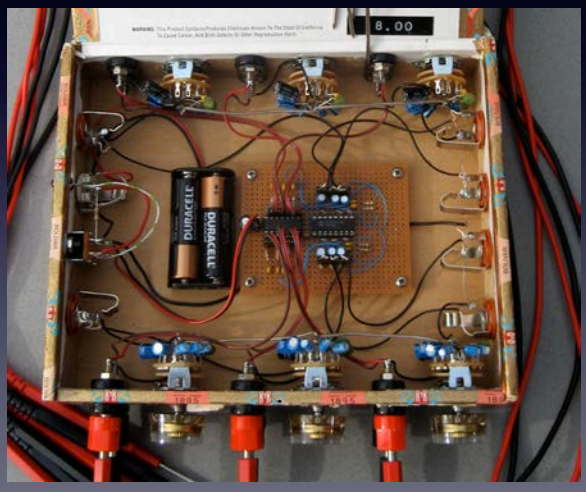
Reed Ghazala

Reed Ghazala

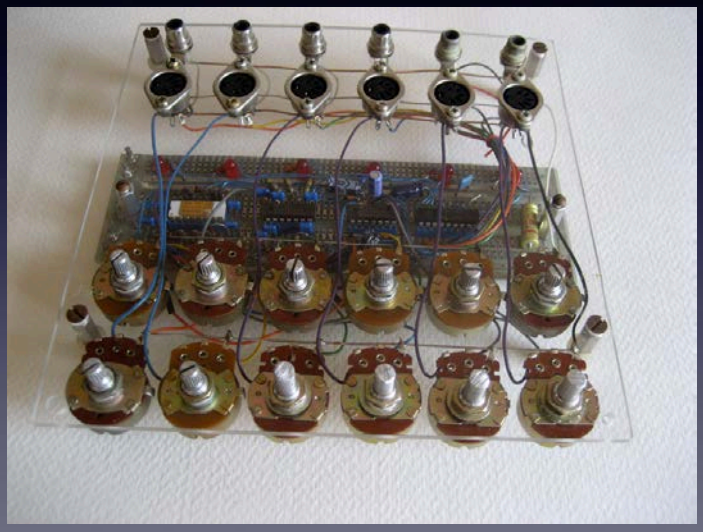
Reed Ghazala

Nic Collins

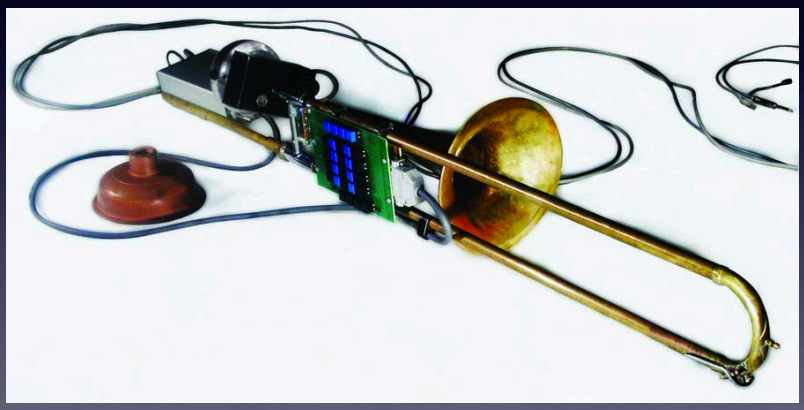




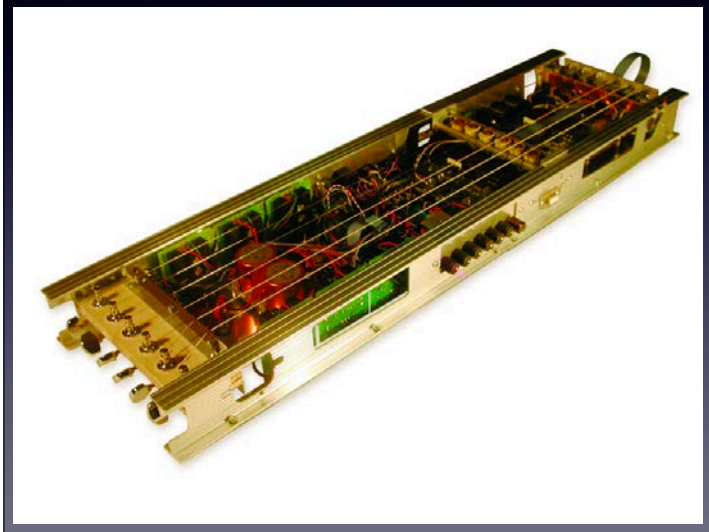
Nic Collins



Nic Collins

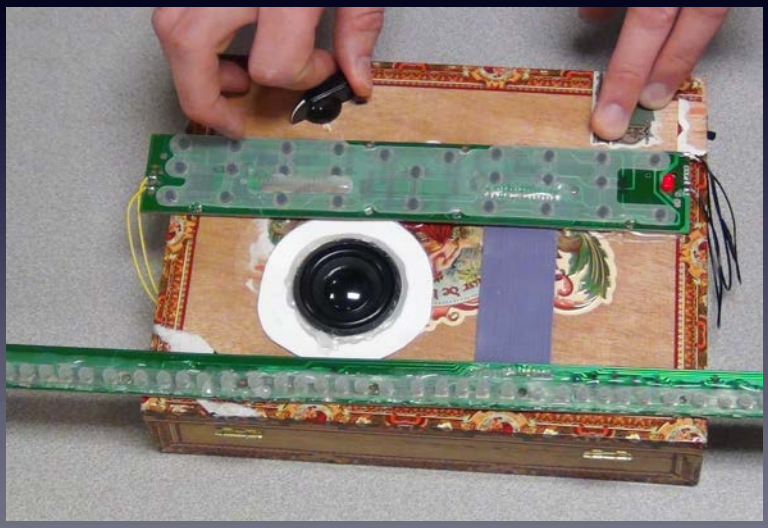


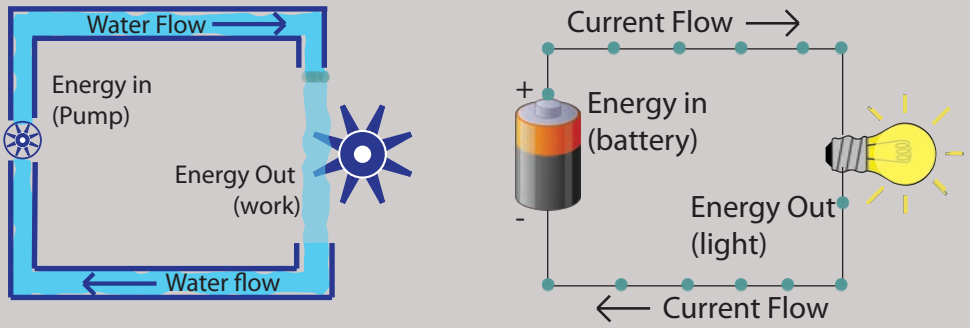
Nic Collins

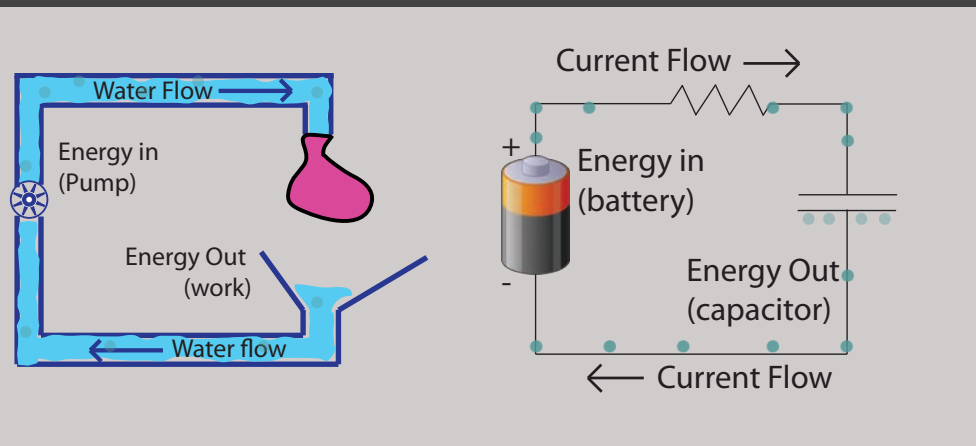


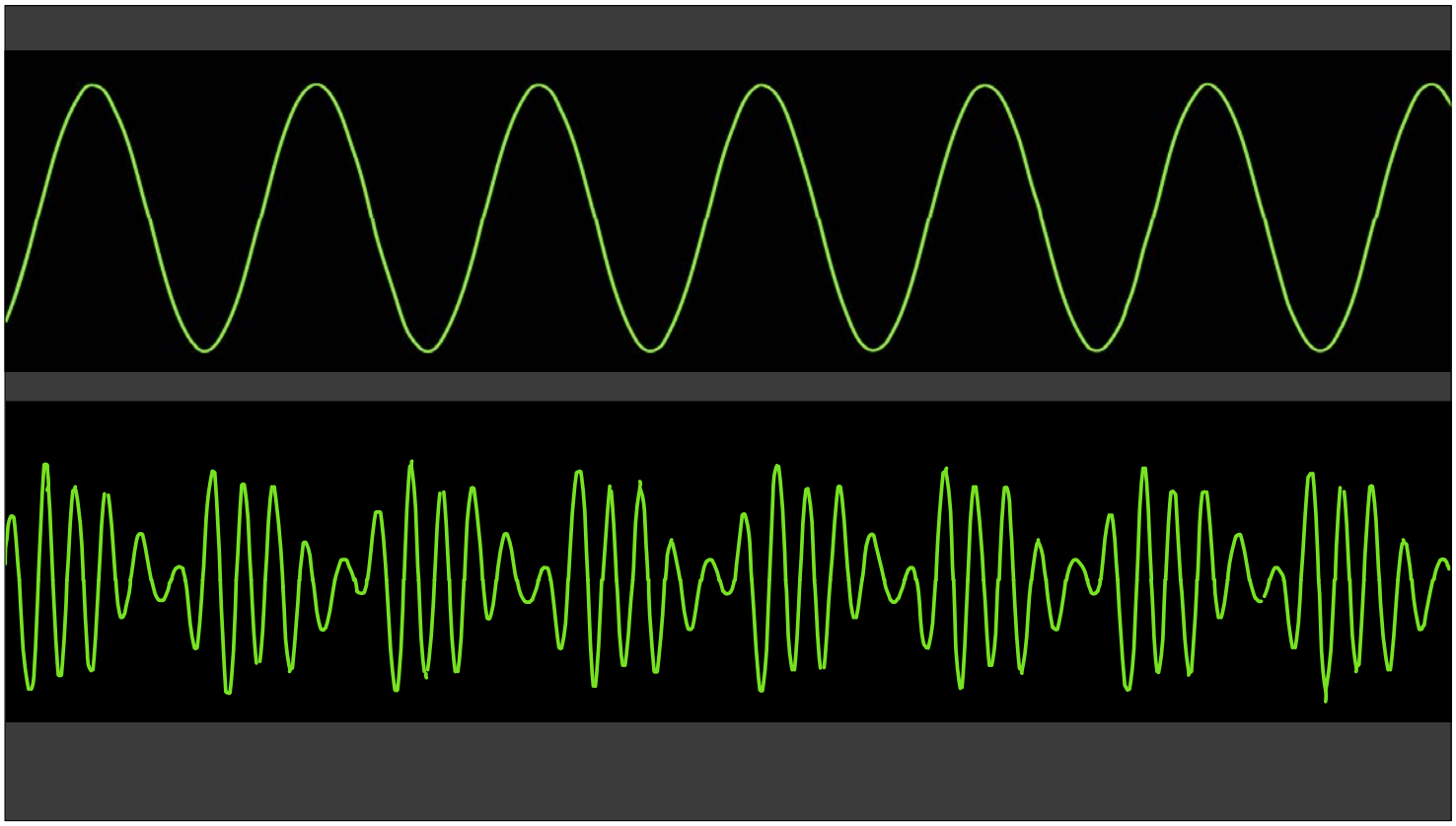
Simple Bending

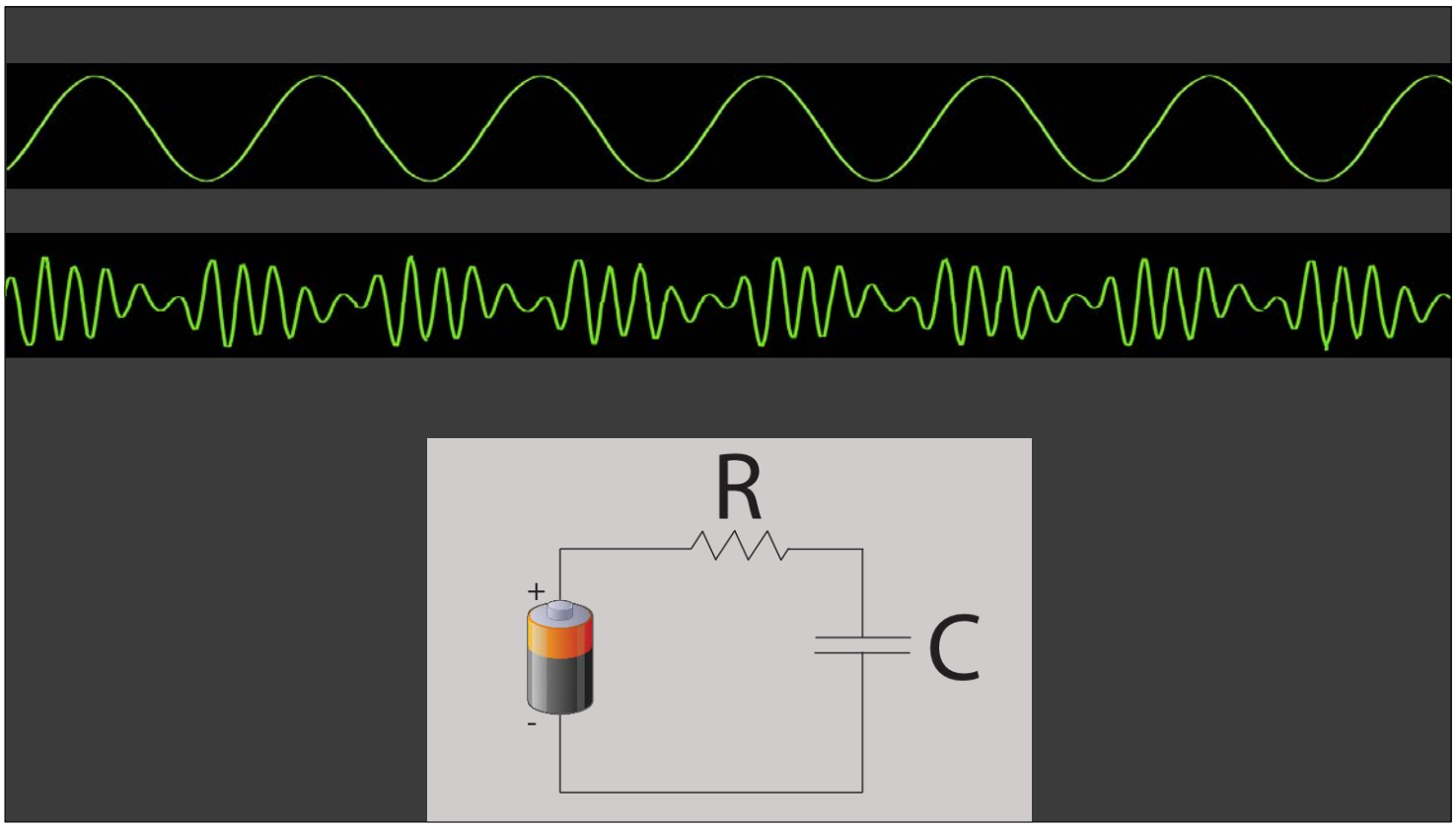
- Find and modify the clock in a circuit
- Make the clock variable with a knob or a light sensor (variable resistor)
- (optional) add a “body contact”



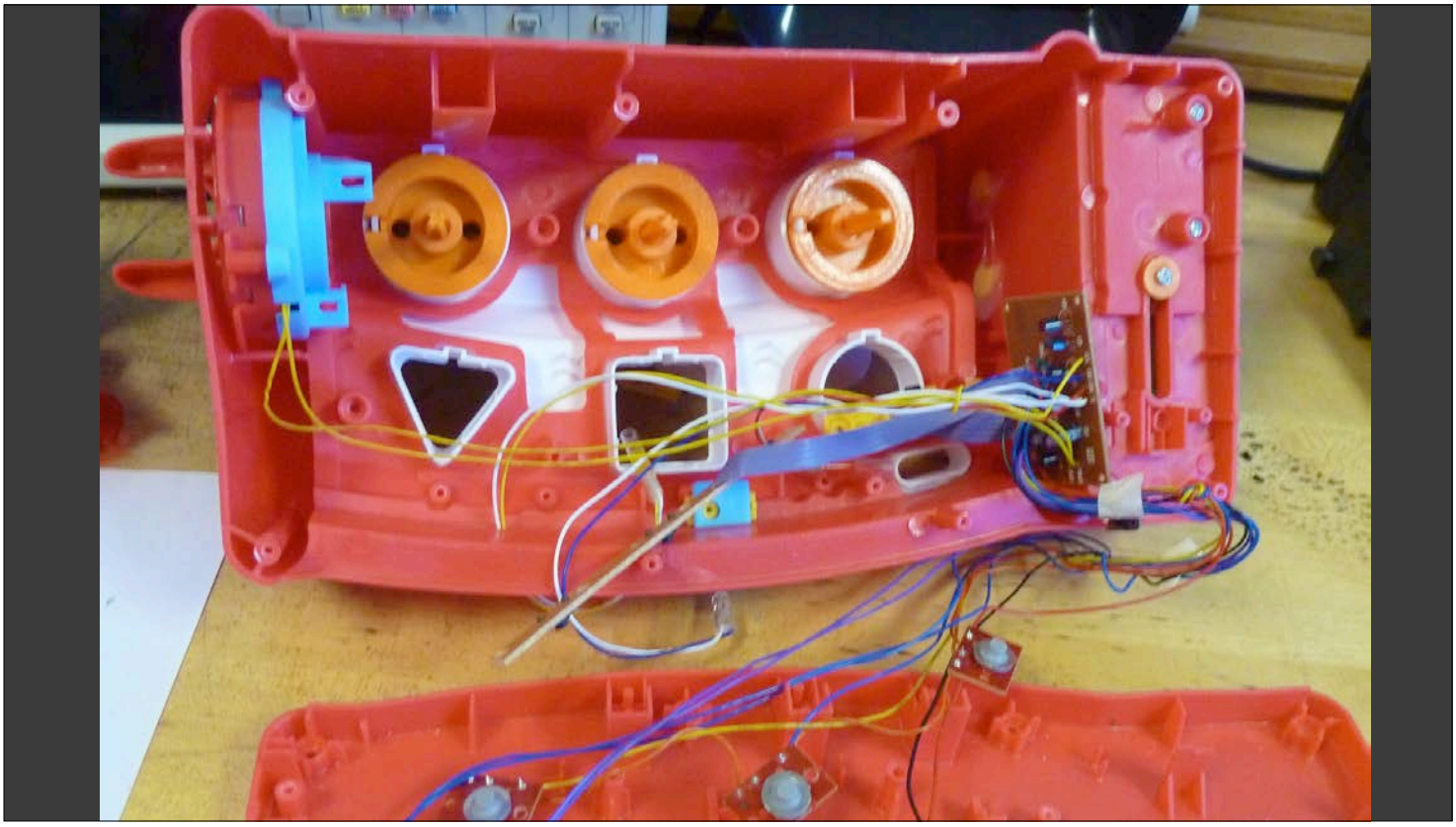

Water Flow
Energy in
(Pump)
Energy Out
(work)
Water flow
Current Flow
+
Energy in
(battery)
-
Energy Out
(light)
Current Flow

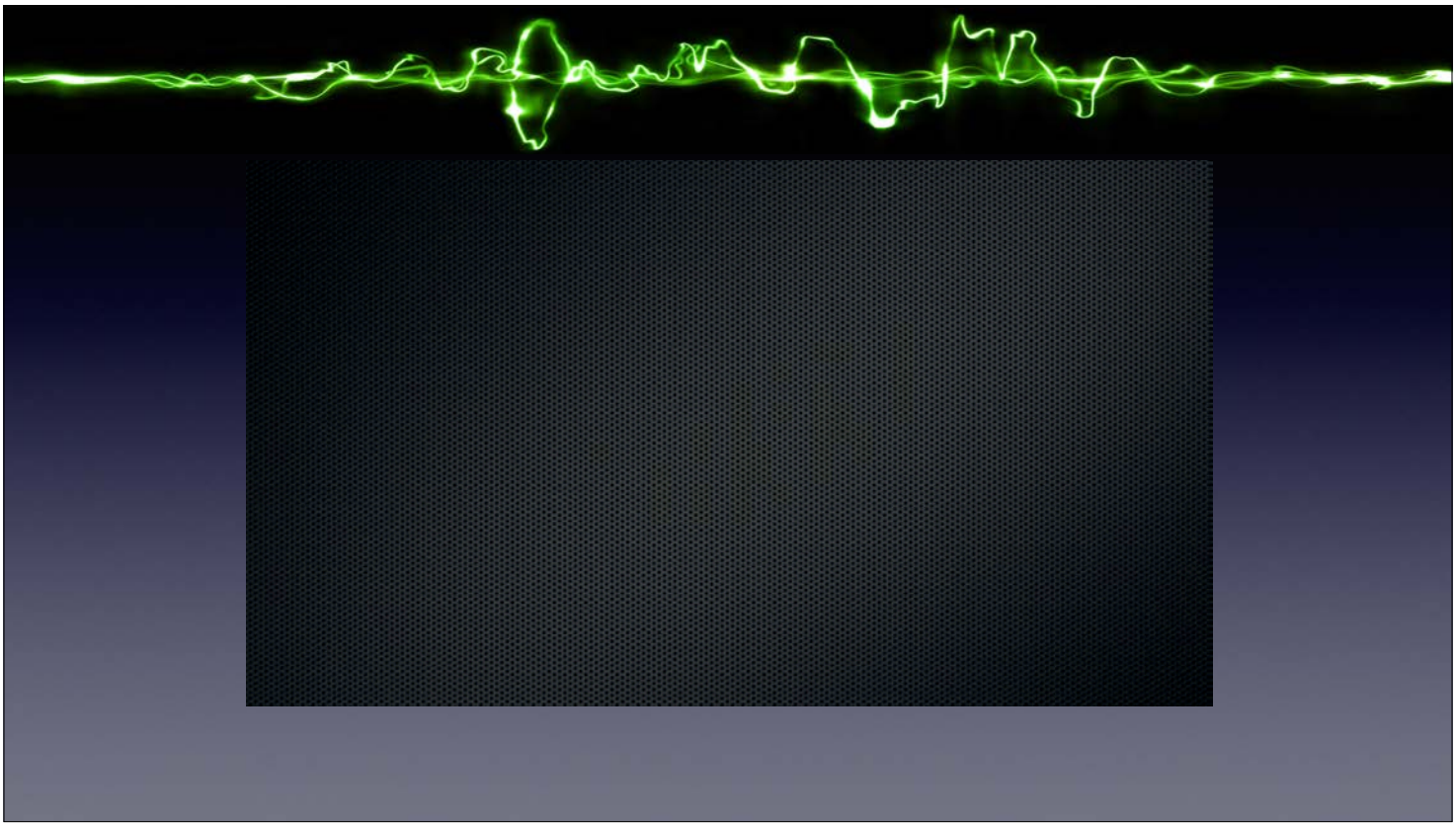

Water Flow
Energy in
(Pump)
Energy Out
(work)
Water flow
Current Flow
+
Energy in
(battery)
-
Energy Out
(capacitor)
Current Flow




R
+
-
C

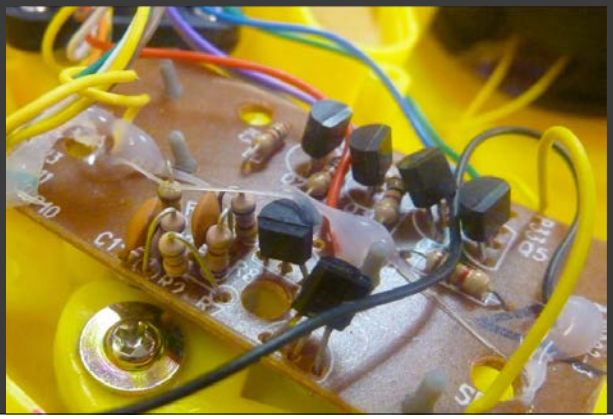

Fisher-Price
A B C
1 2 3 4 5 6 7 8 9 10

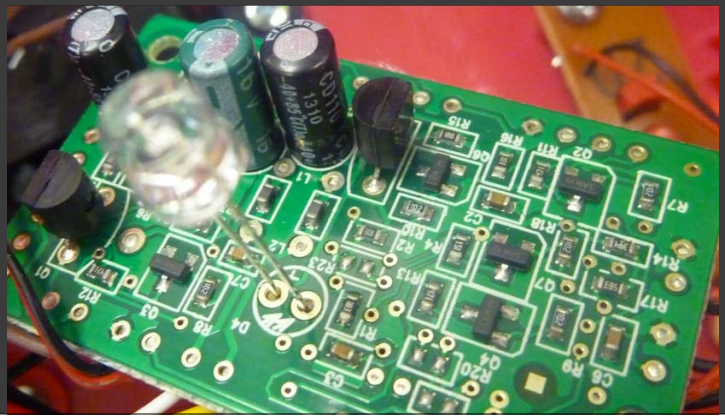


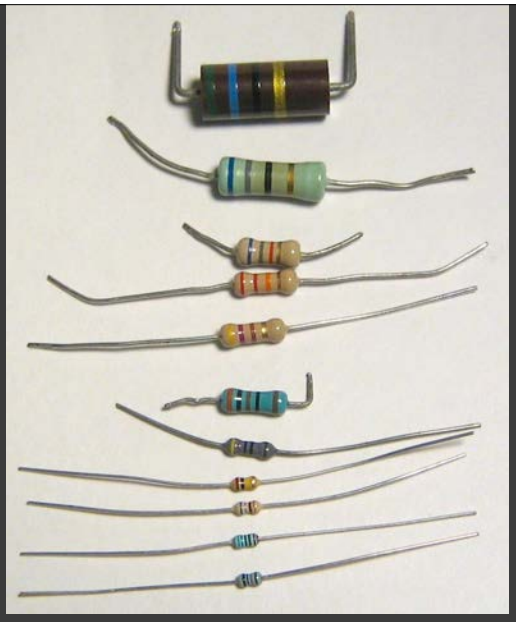



REVELATION

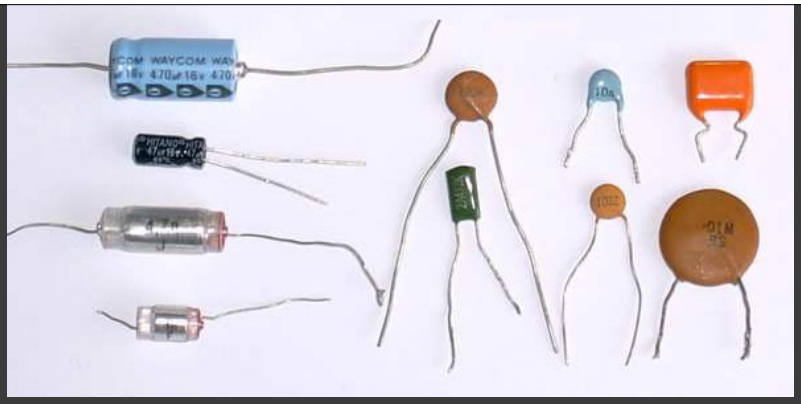

SAN CRISTOBAL
REVELATION



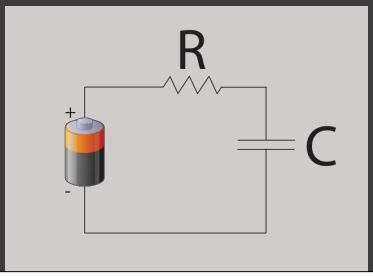




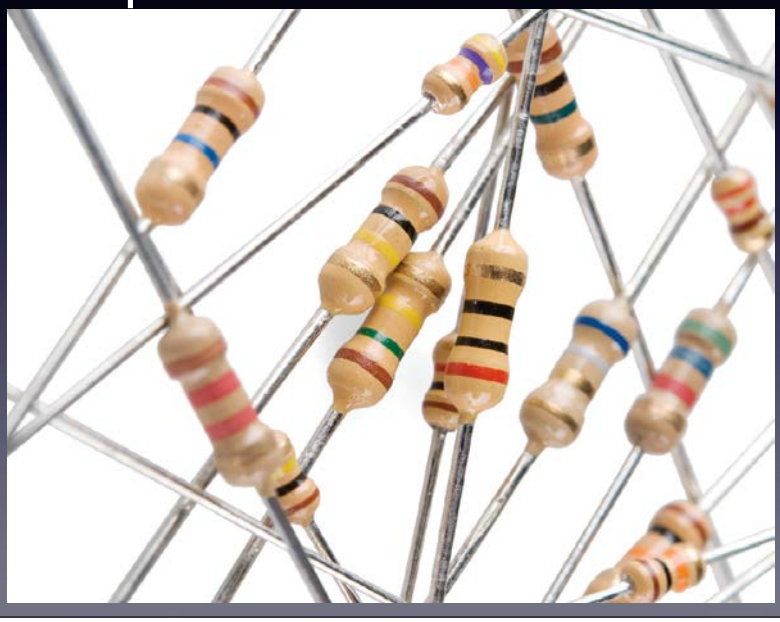
Resistors



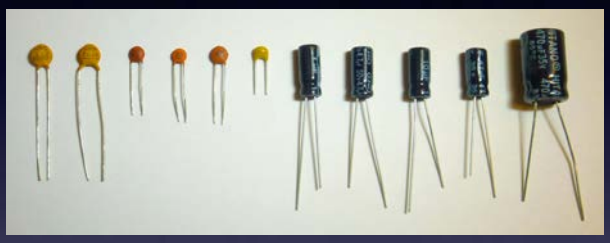
Capacitors

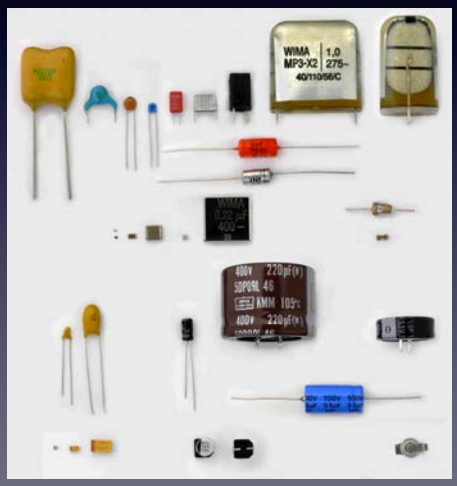


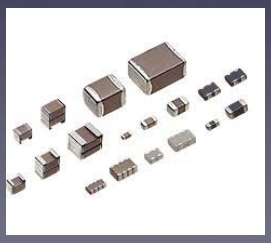
components - resistors



components - capacitors

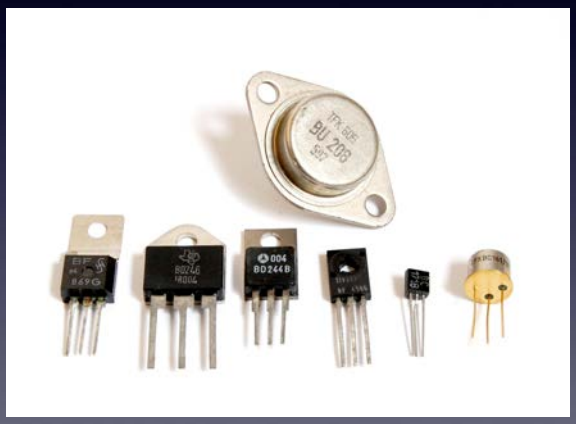




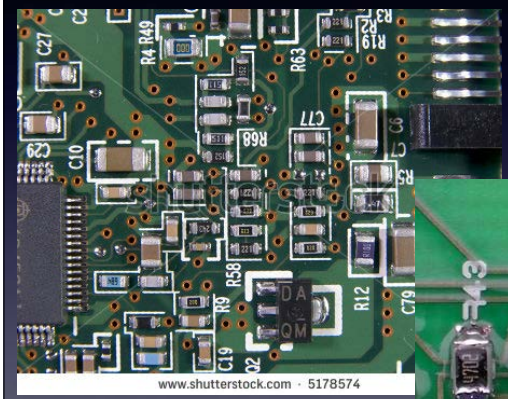


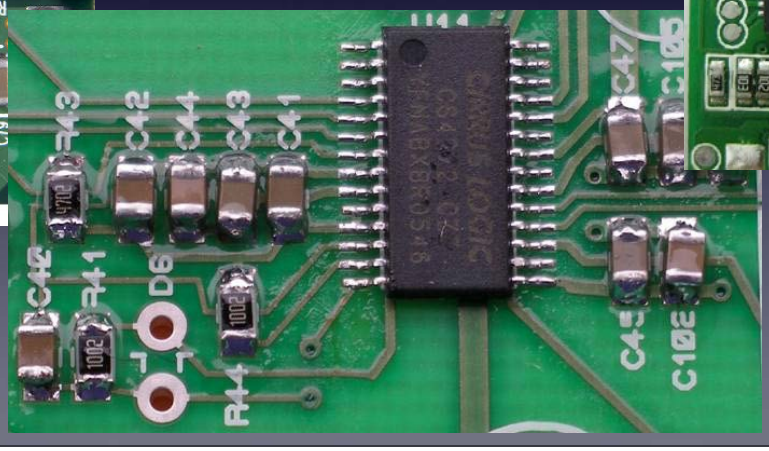
components - diodes

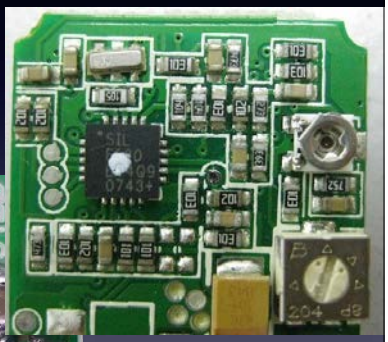
components - transistors



surface mount components







clock resistor

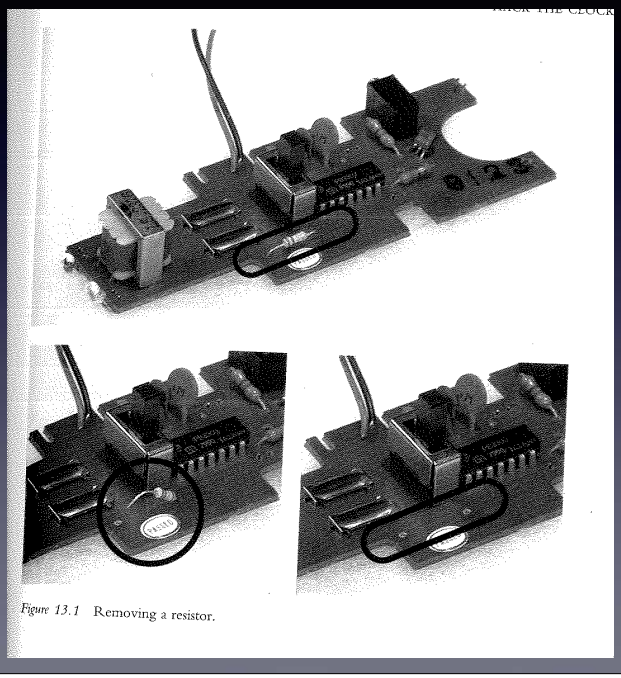


Figure 13.1 Removing a resistor.

resistor whiskers

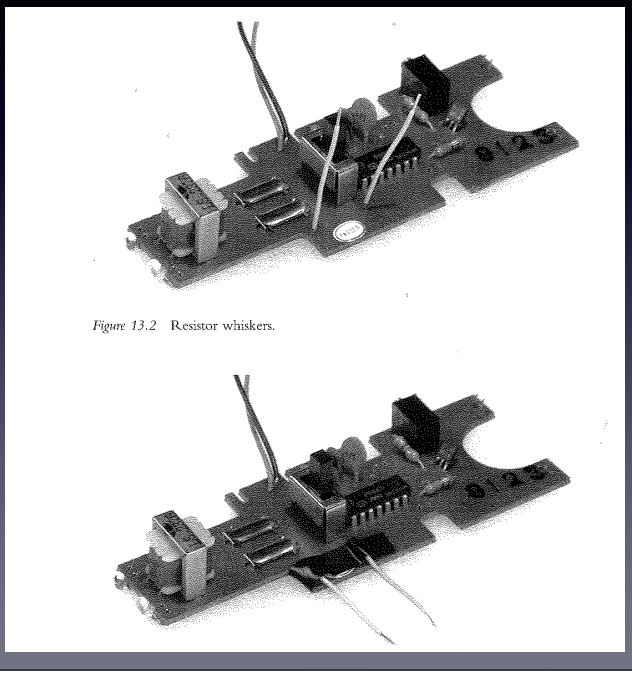


Figure 13.2 Resistor whiskers.

Alligator clips

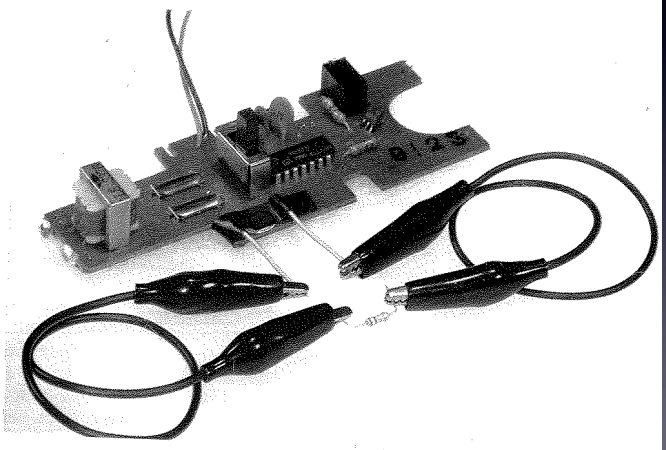


Figure 13.4 A remote resistor.

pot connection

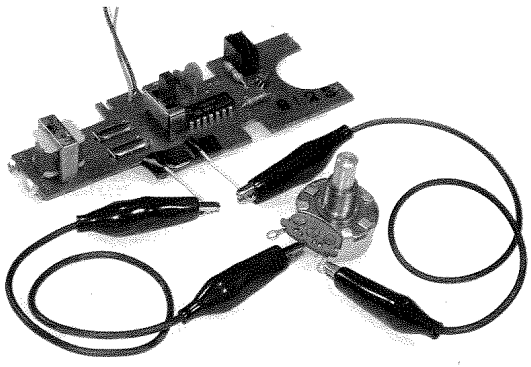
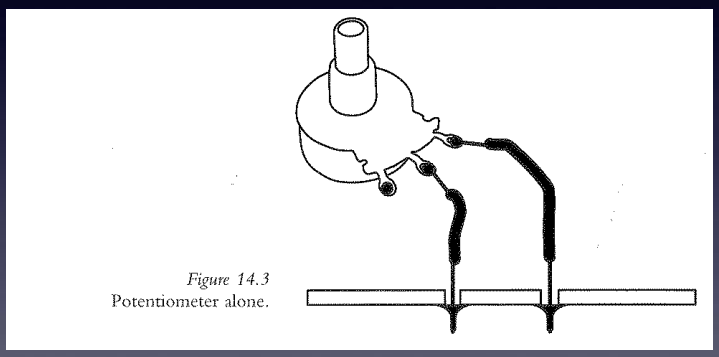
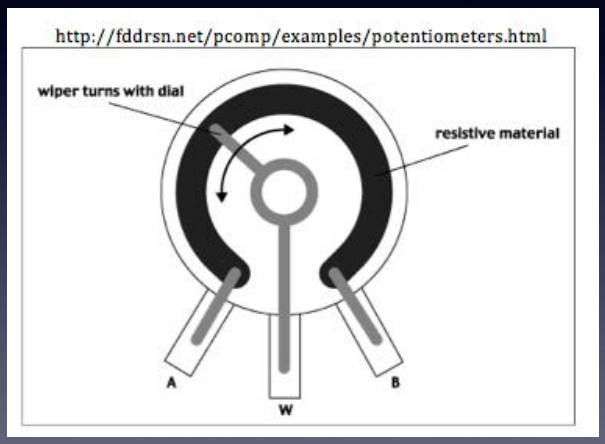


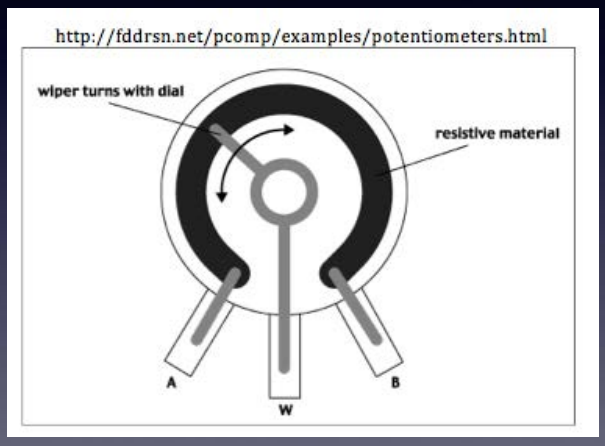
Figure 13.6
Pot substitute for a clock resistor.

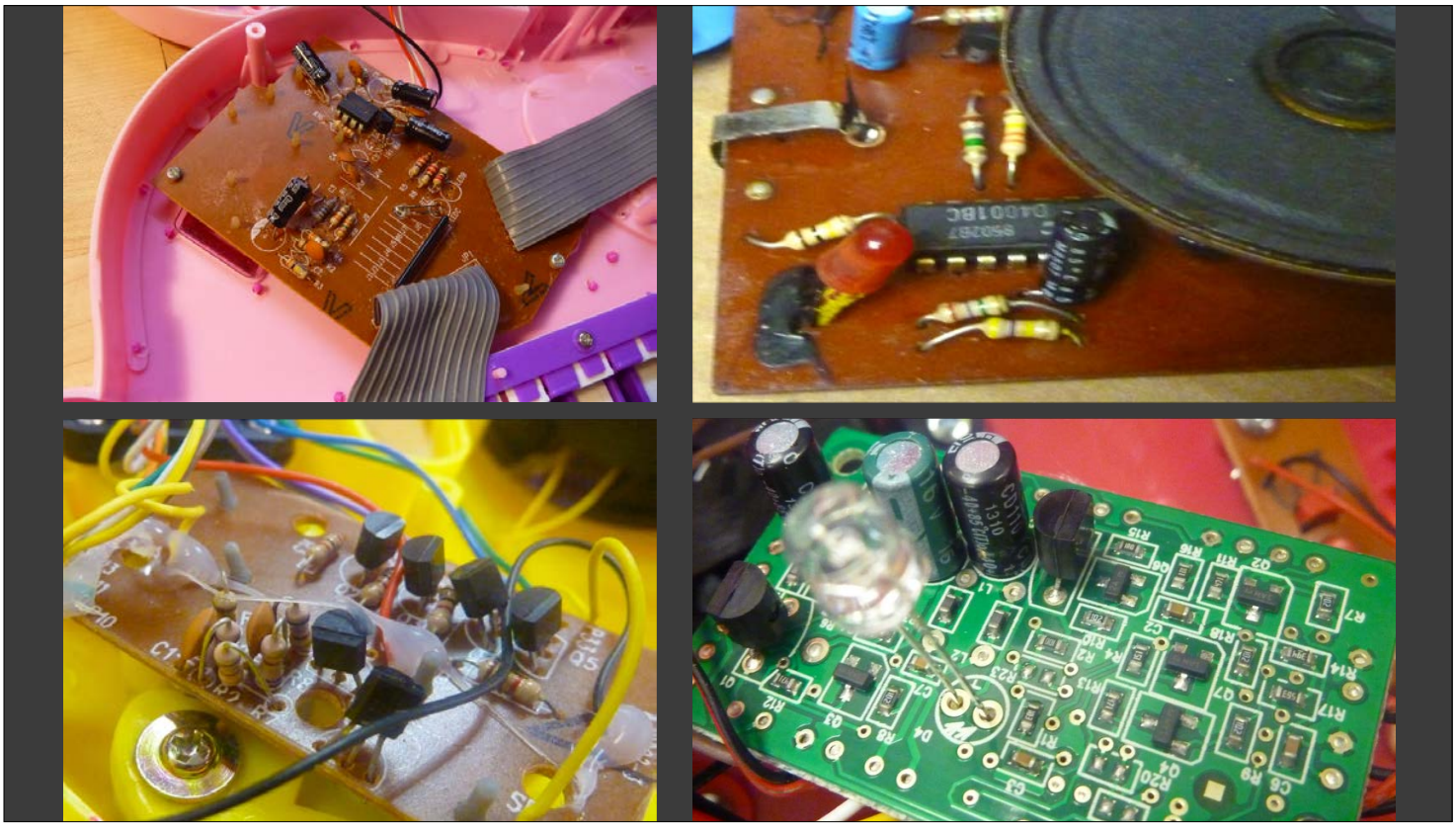
pot connection



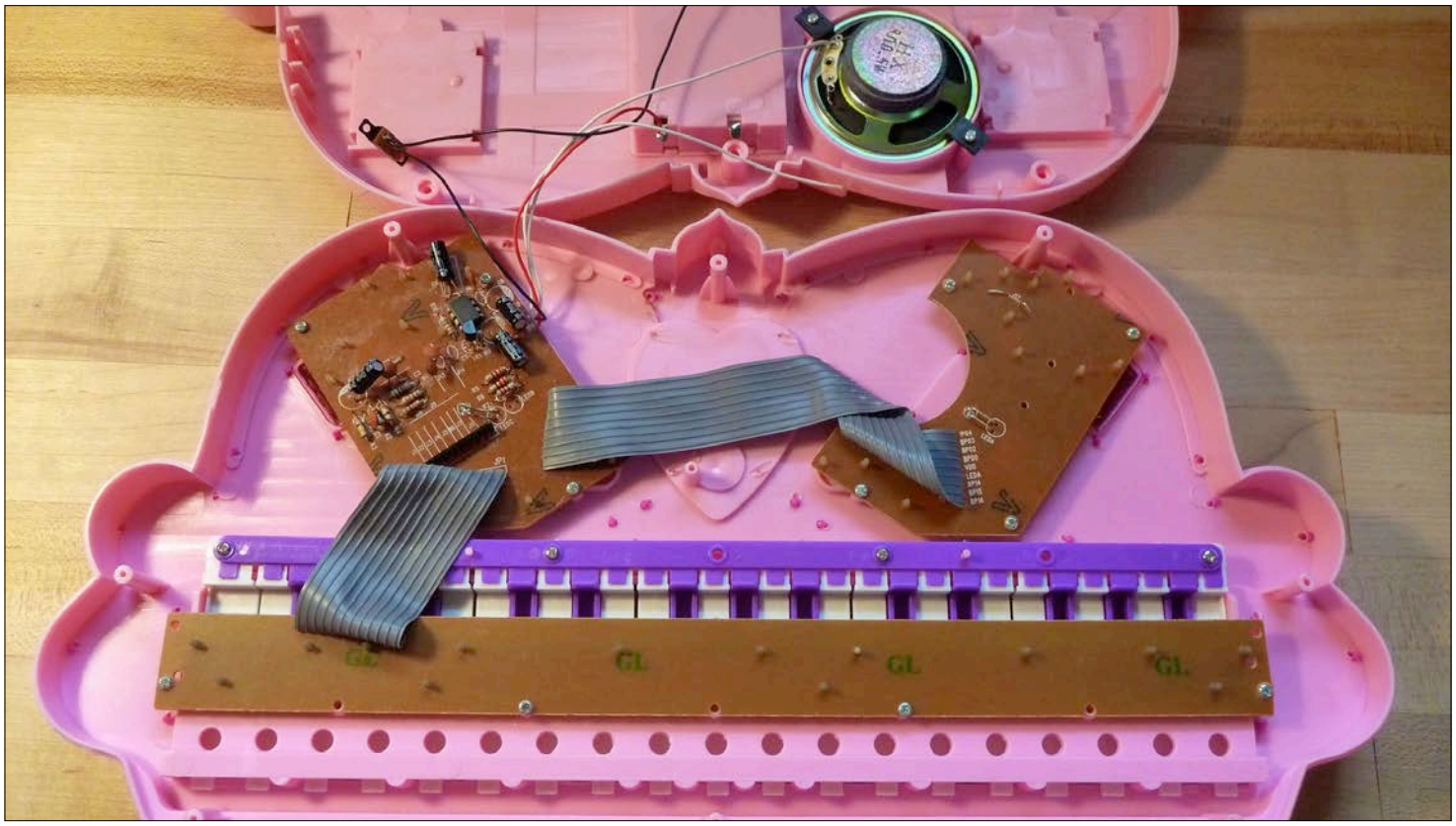


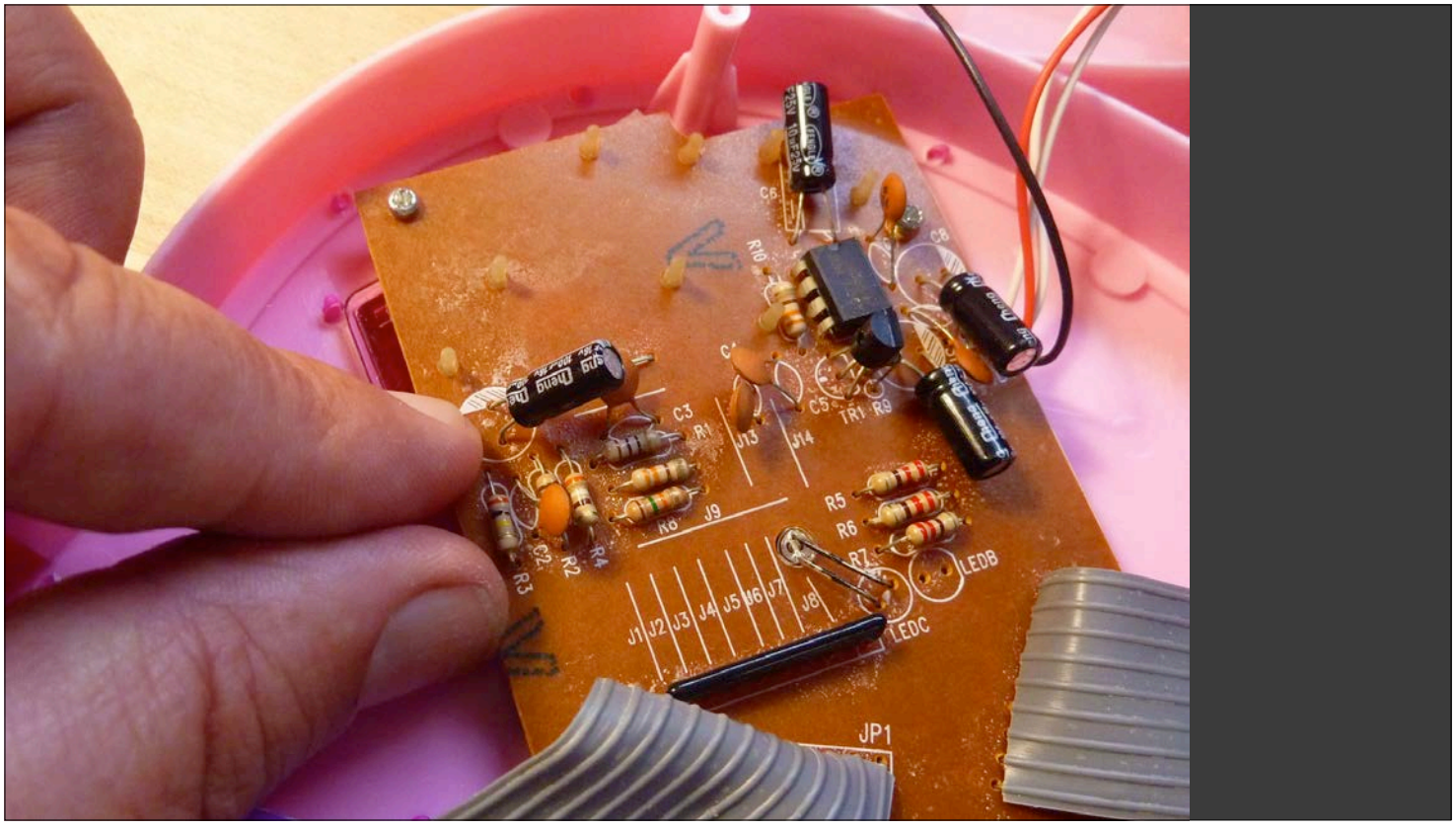
pot connection

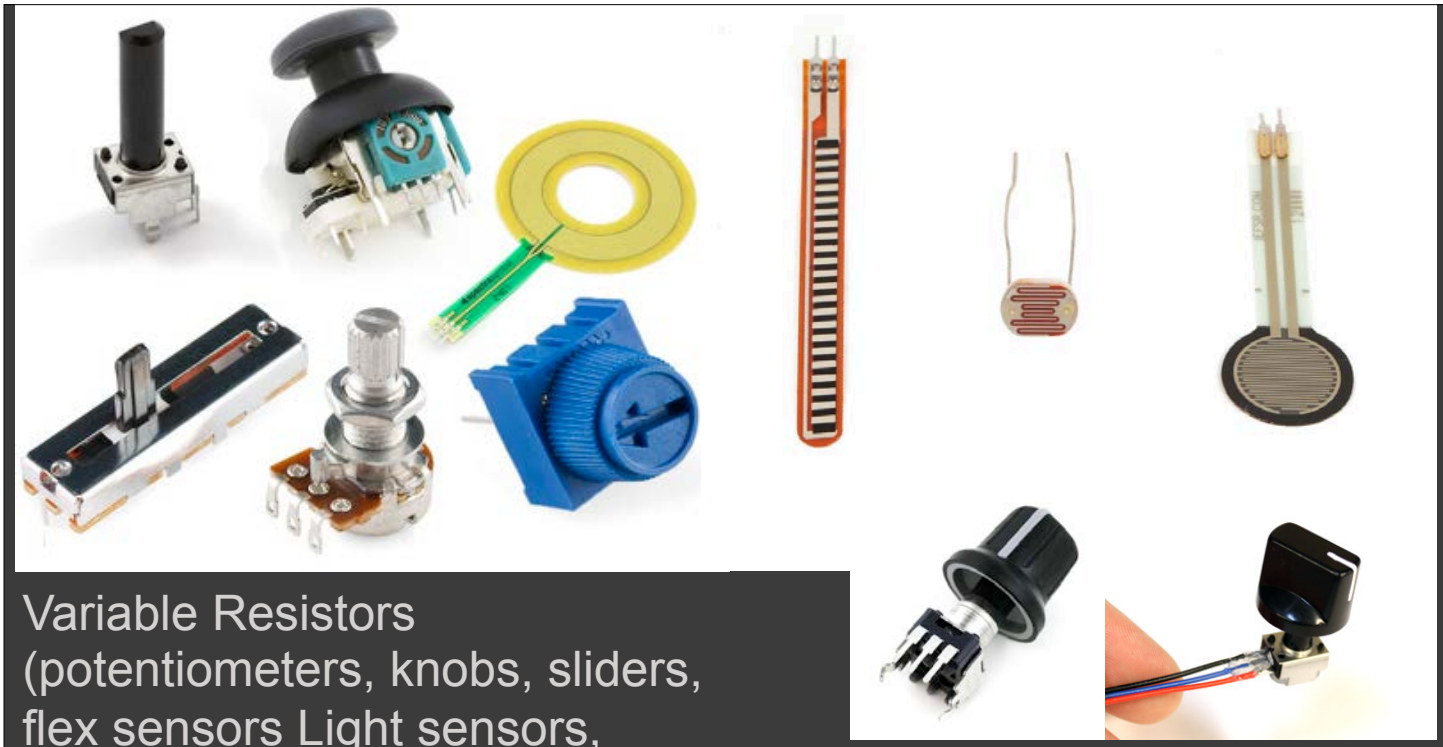





Disney



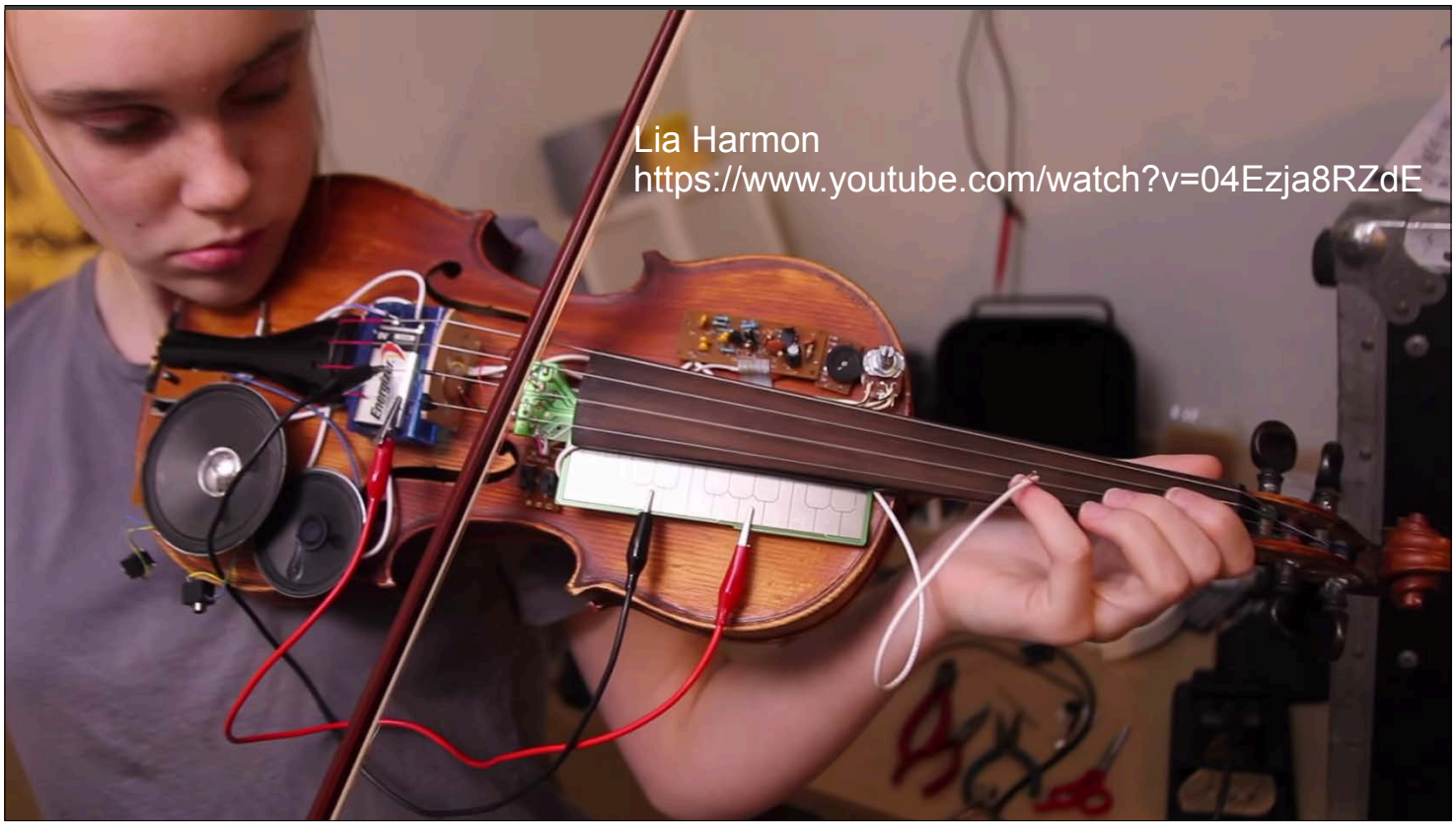

C6
R10
C4
C3
R1
C5
TR1
R9
J13
J14
R5
R6
R7
LEDB
LEDC
R8
J9
C2
R2
R4
R3
J1
J2
J3
J4
J5
J6
J7
J8
JP1

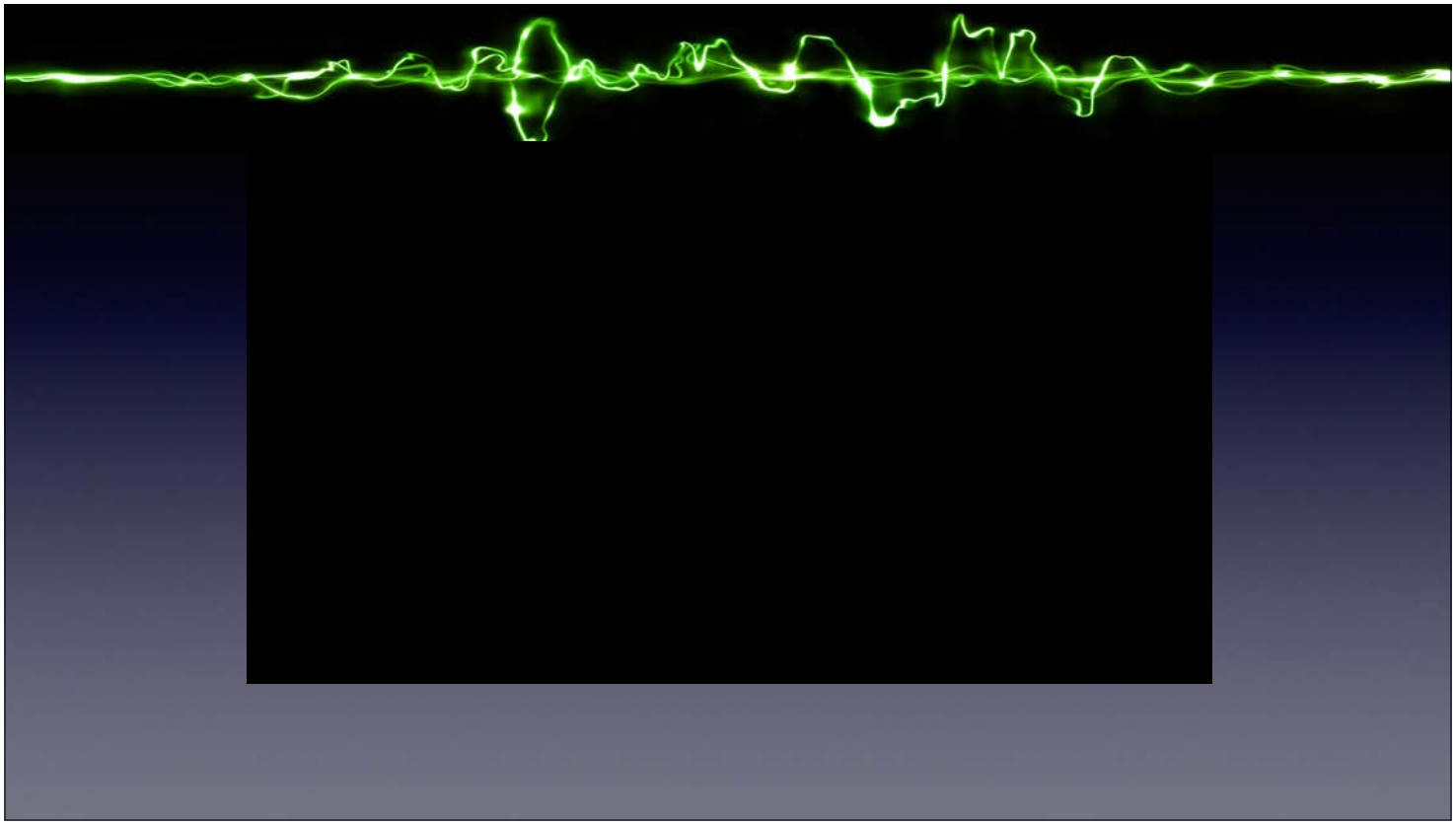


Variable Resistors (potentiometers, knobs, sliders, flex sensors Light sensors, touch sensors…)

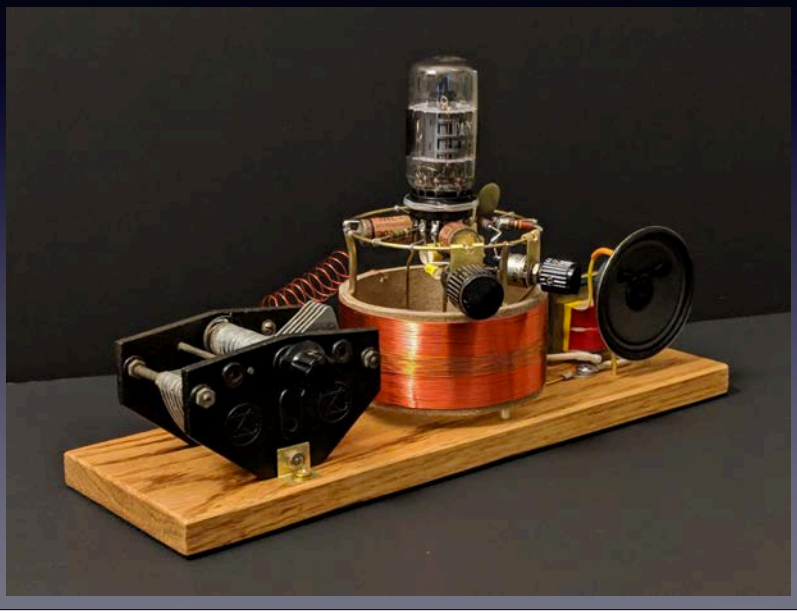
Madison Donnelly

Mike Ford

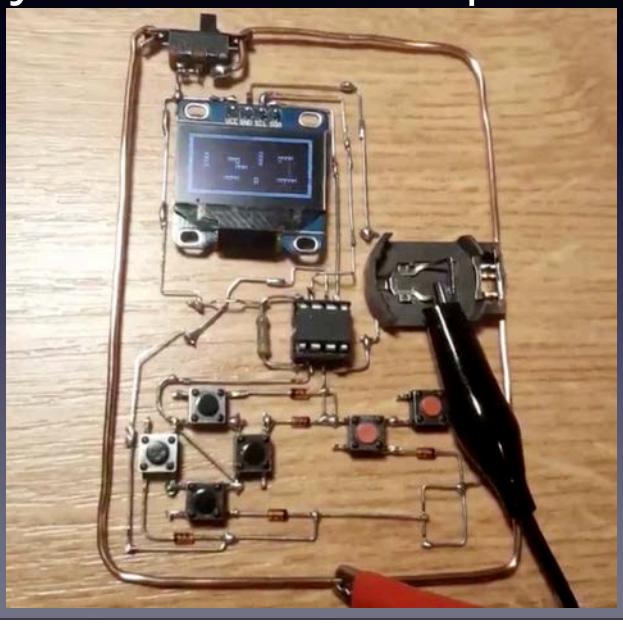

Lia Harmon
https://www.youtube.com/watch?v=04Ezja8RZdE



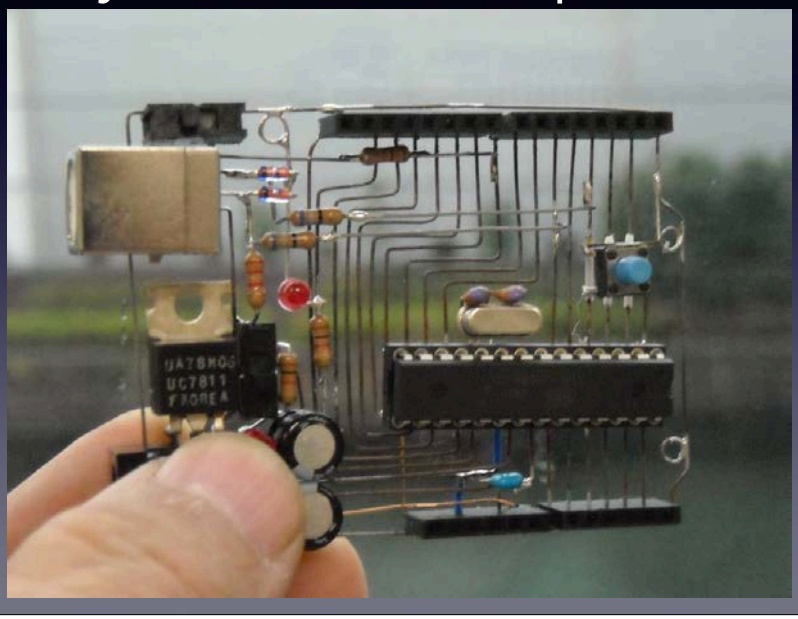
Hackaday Circuit Sculpture Contest



Hackaday Circuit Sculpture Contest



Hackaday Circuit Sculpture Contest

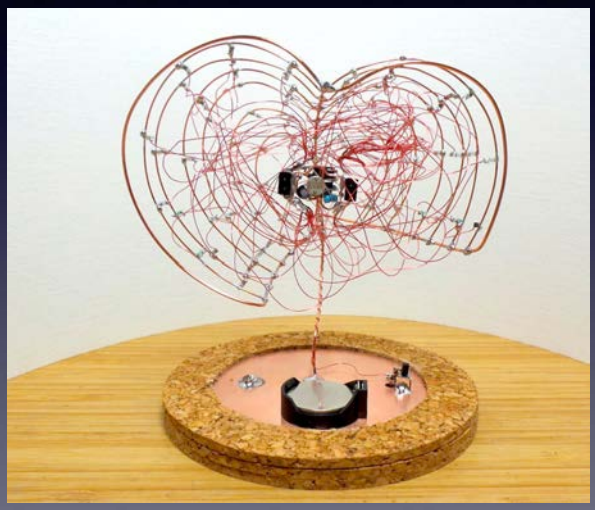


Hackaday Circuit Sculpture Contest

Hackaday Circuit Sculpture Contest

Hackaday Circuit Sculpture Contest

Hackaday Circuit Sculpture Contest



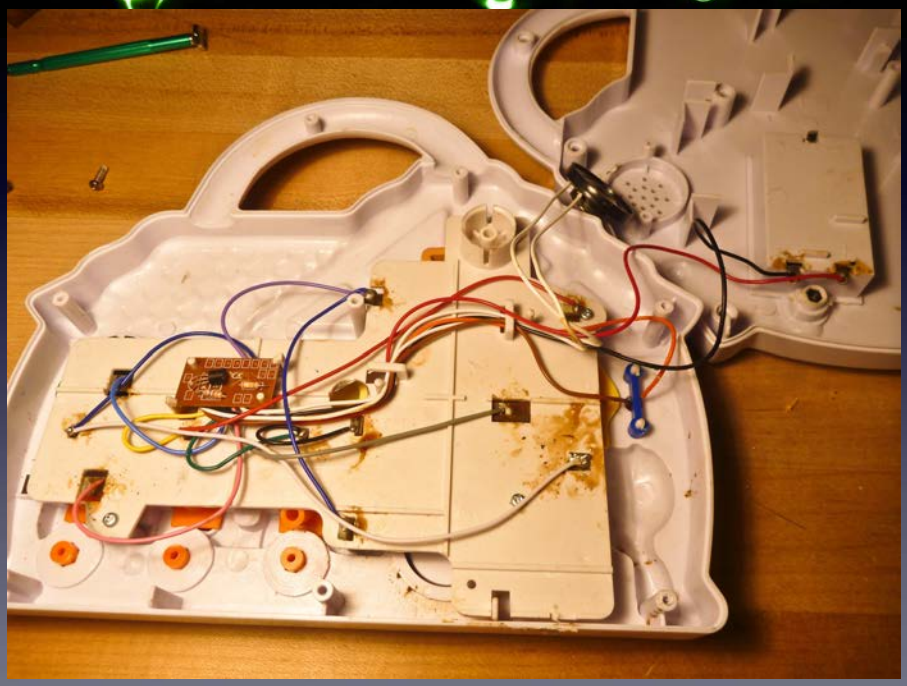
Hackaday Circuit Sculpture Contest

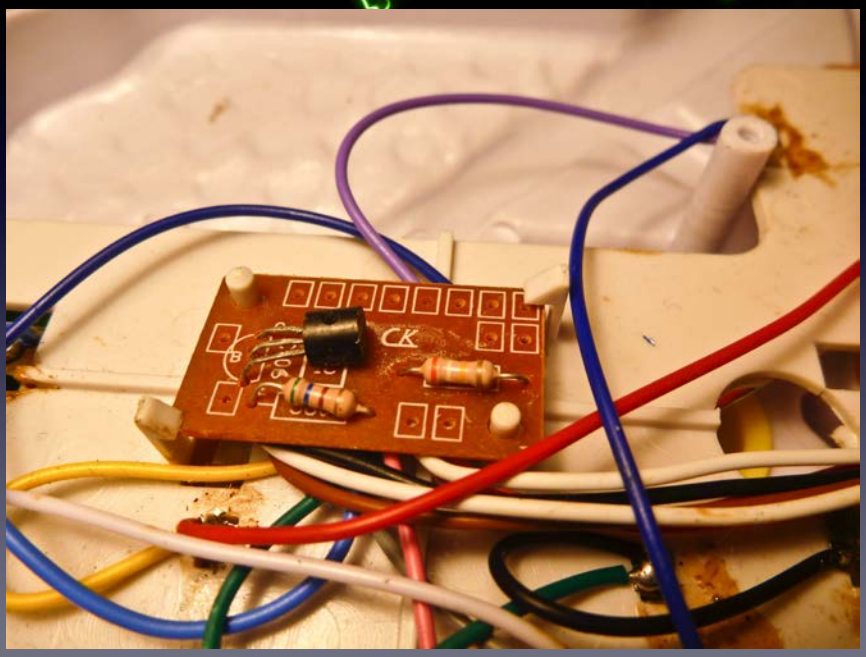
Another Example

Good looking Toy!

Take all the screws out…

Open it up…



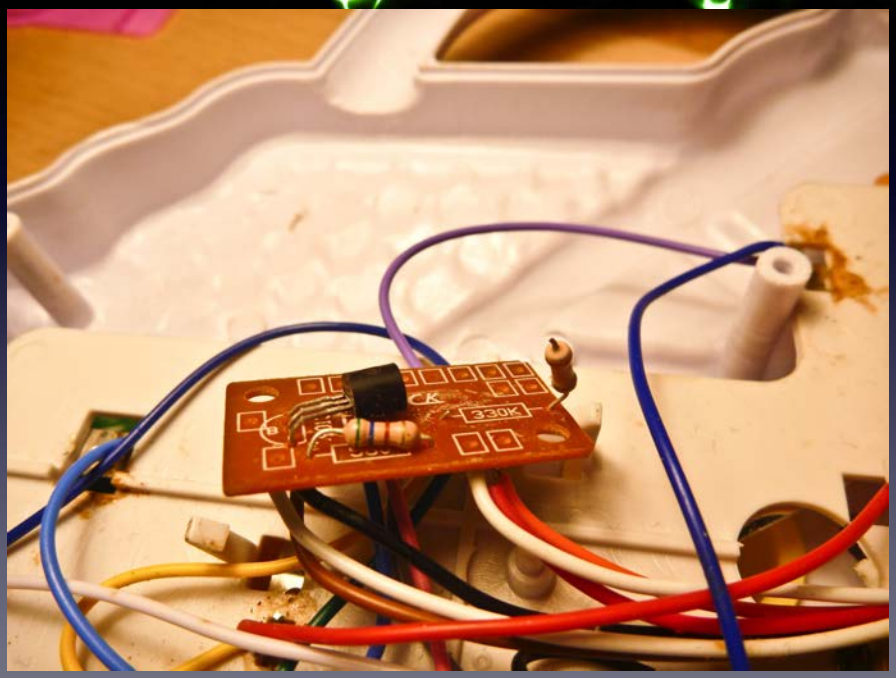


Good news - only two resistors.

One of them is even marked CK for Clock

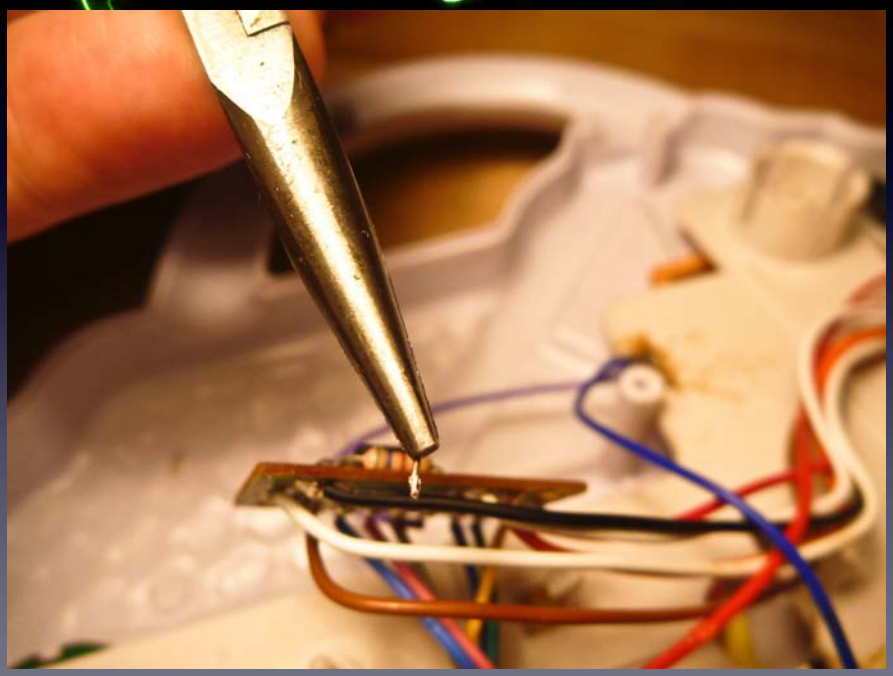
And, it tests positively for sound change.

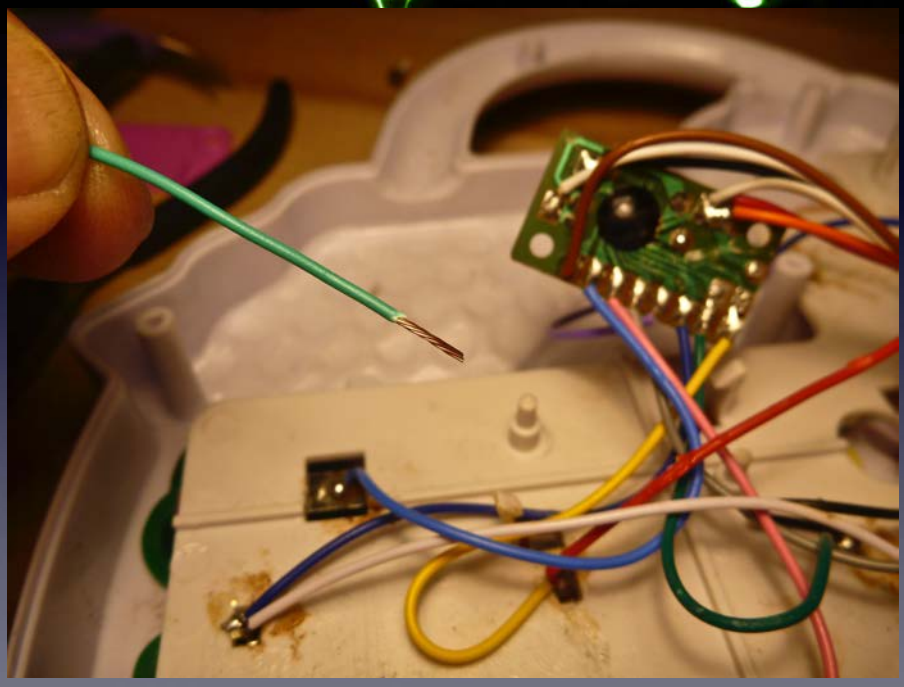
We don't need it so we can clip it out…



Hanging by one leg…

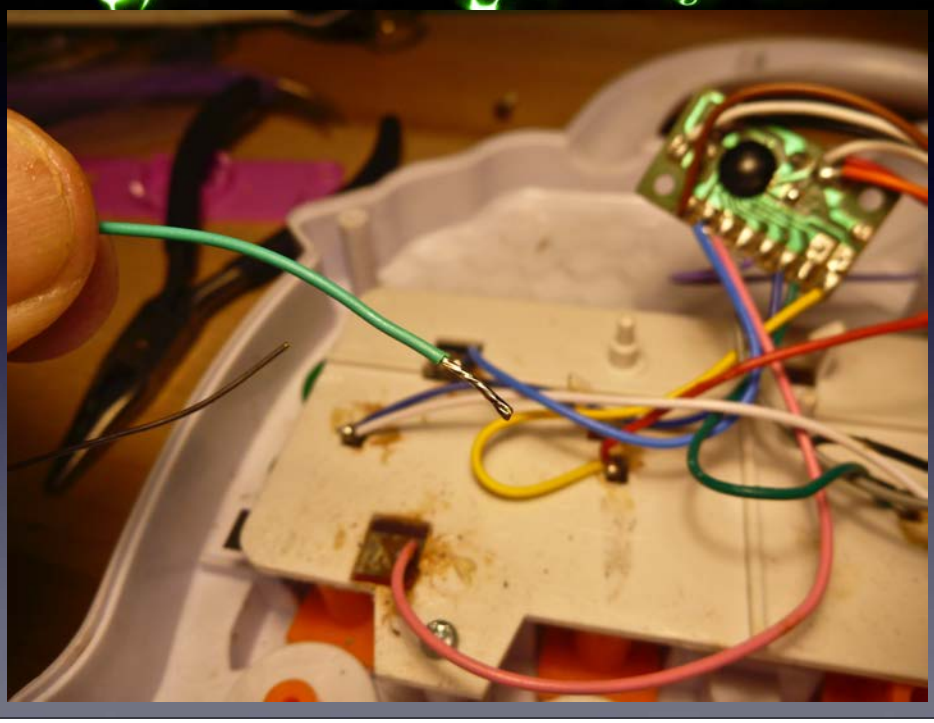
Now you can use a soldering iron and needlenose pliers and pull the leads out of the circuit board

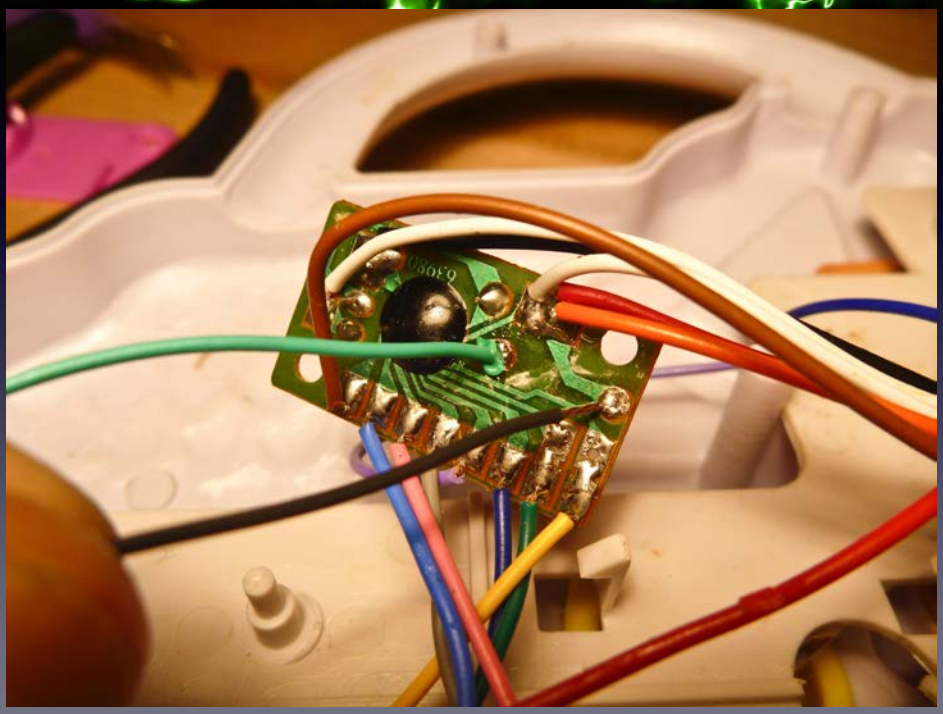




Here I'm using stranded wire…

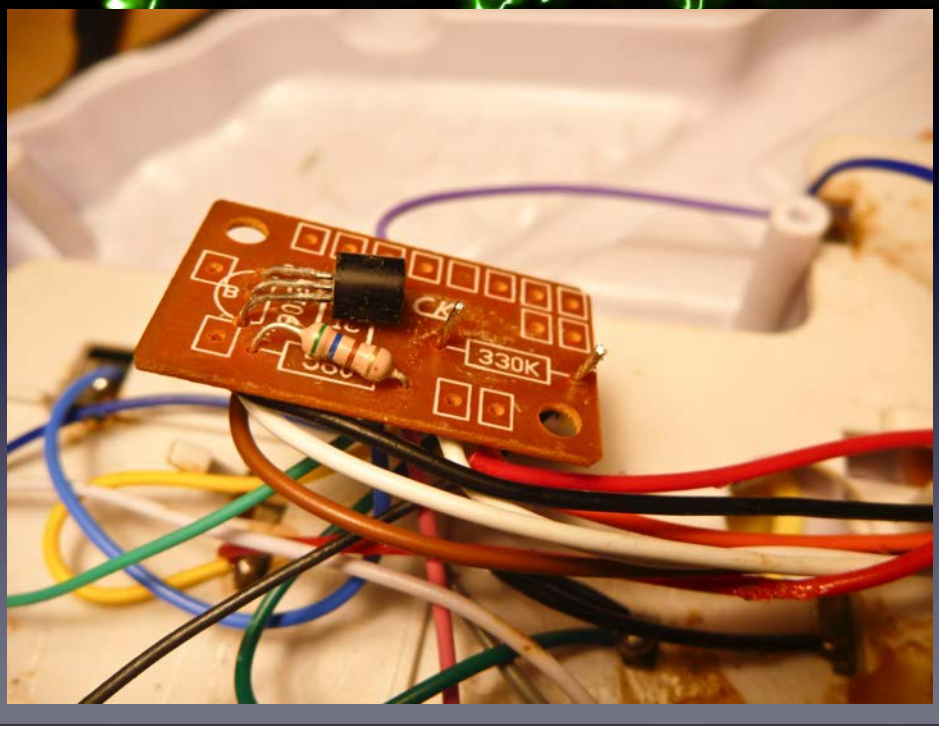
So, it helps to tin the wire first…





Then you can solder it into the hole that the resistor came out of…

Both holes have new wires soldered in place from the back



Those wires go to a pot

Notice that I've bent the wires through the solder lugs

pot connection

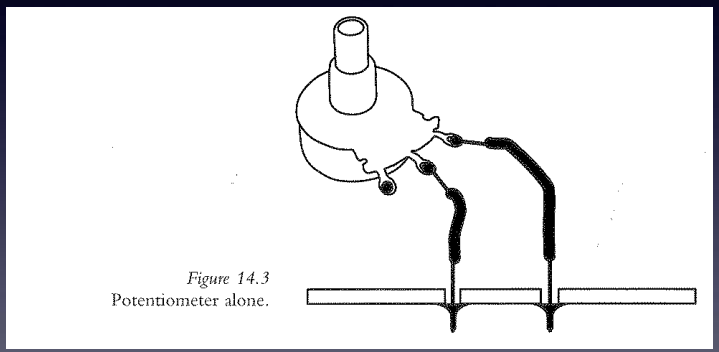
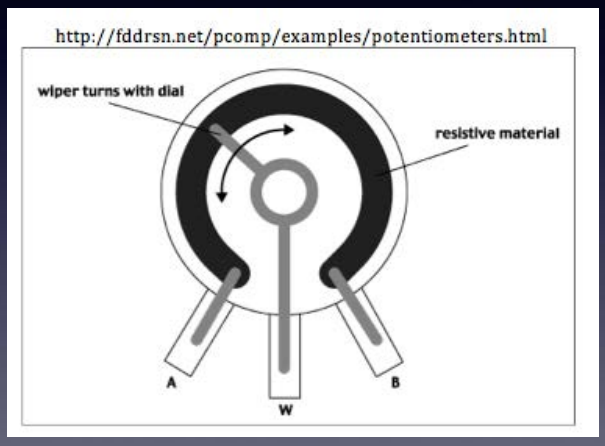
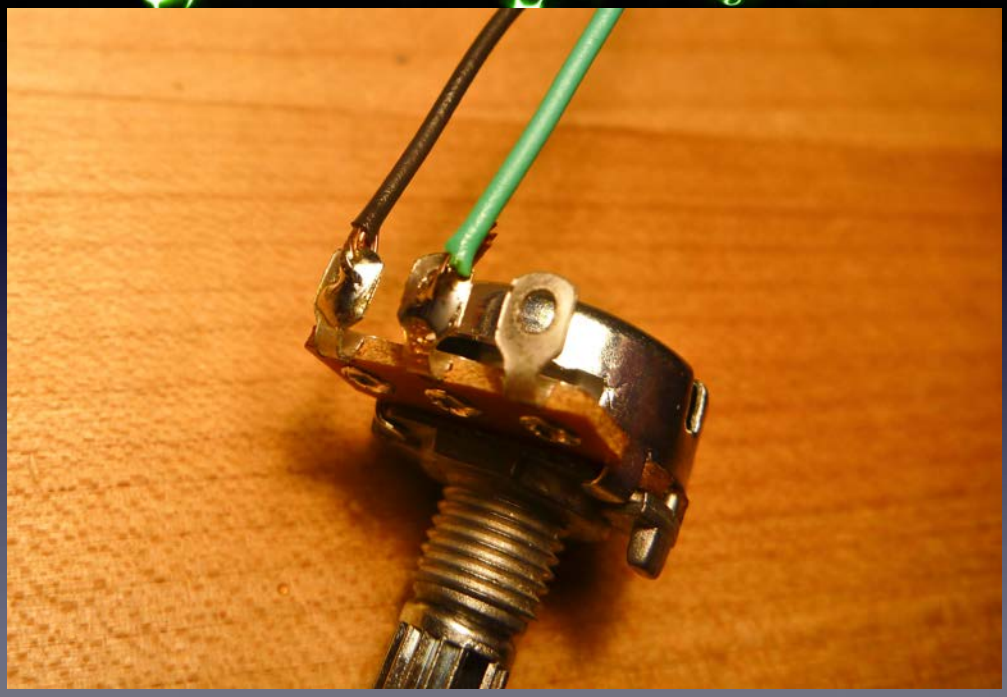


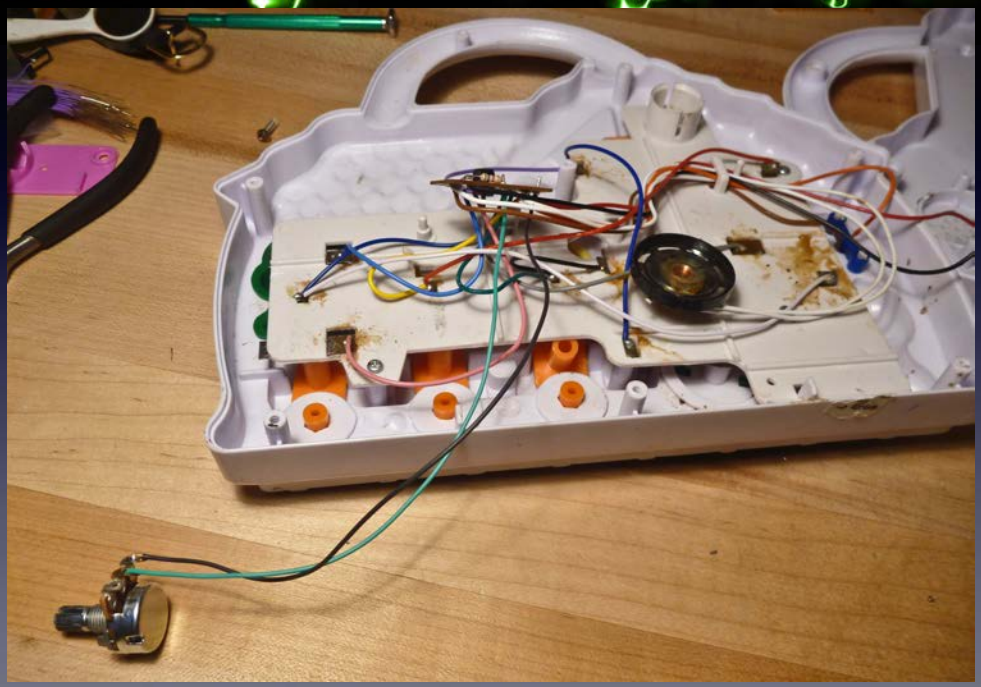
Figure 14.3
Potentiometer alone.



Wires soldered into place



The timing resistor has been replaced with a potentiometer (variable resistor knob)



And we're done with the pitch-bending phase of the hardware hacking…

Slightly trickier example

Surface-Mount resistors can
be really really tiny!

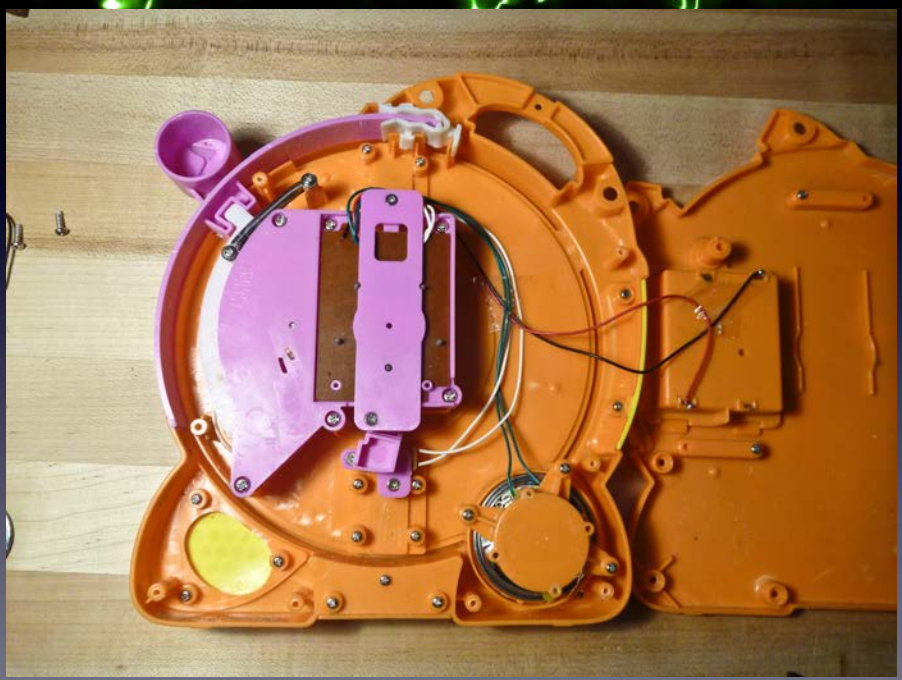
It can take good eyes
and a steady hand…

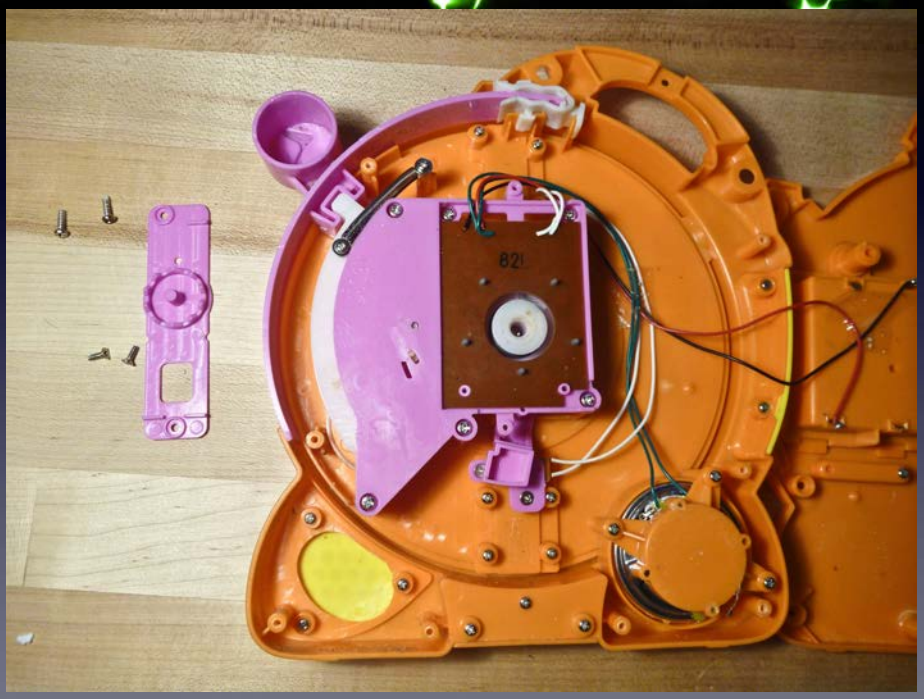
See ’n Say
in Espanol!

Find all
the screws…

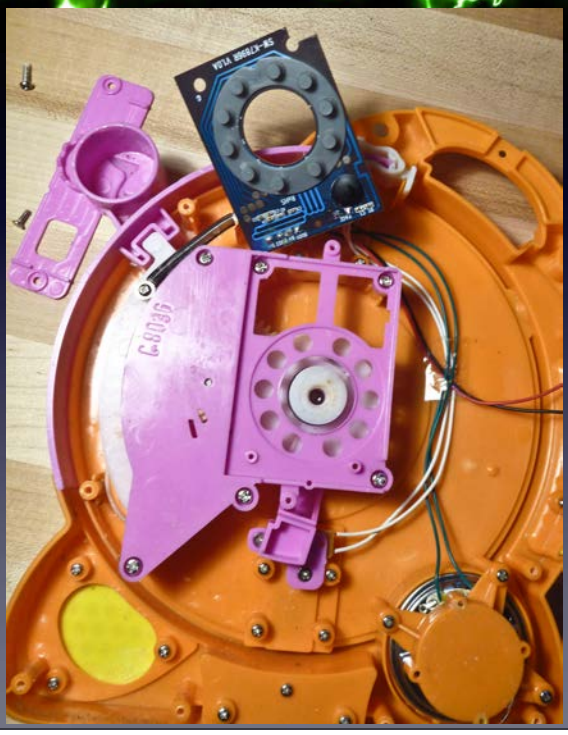
Look inside. It's
very common
for the battery
to be connected
on the back
side of the toy.

You can cut out
the battery pack
or you can clip
the wires and use
a new battery
holder…





Start taking off the support structures…



Exposing the circuit board. Note the nifty little switches in the rubber dimples.

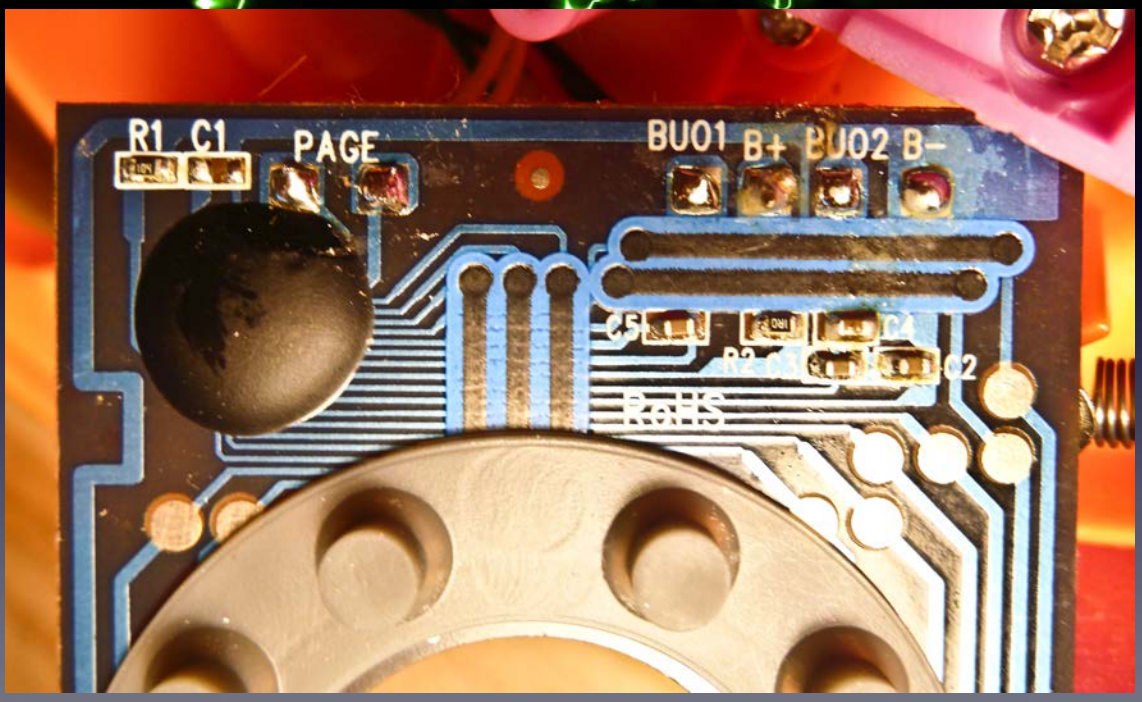
If you're lucky, one of the resistors will be relate to the timing circuit.

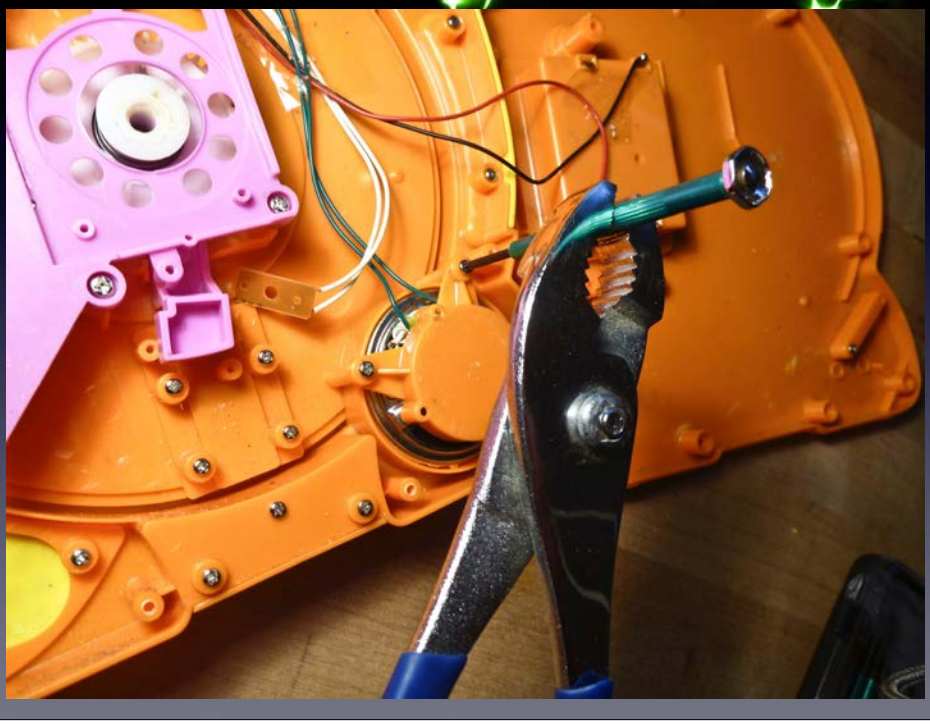
The resistors on this board are marked with R (R1, R2, etc.)

In general, the resistors are the little black specks with numbers printed on them.

The capacitors are generally the little tan specks without numbers.

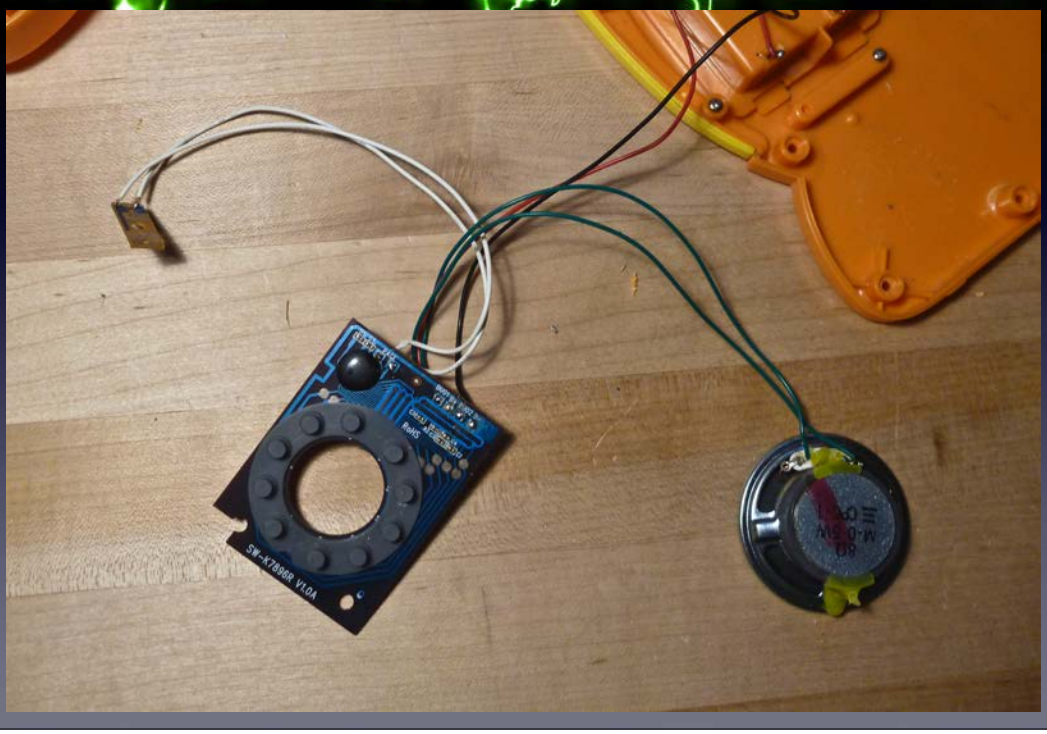
In this case, R1 is where the action is…

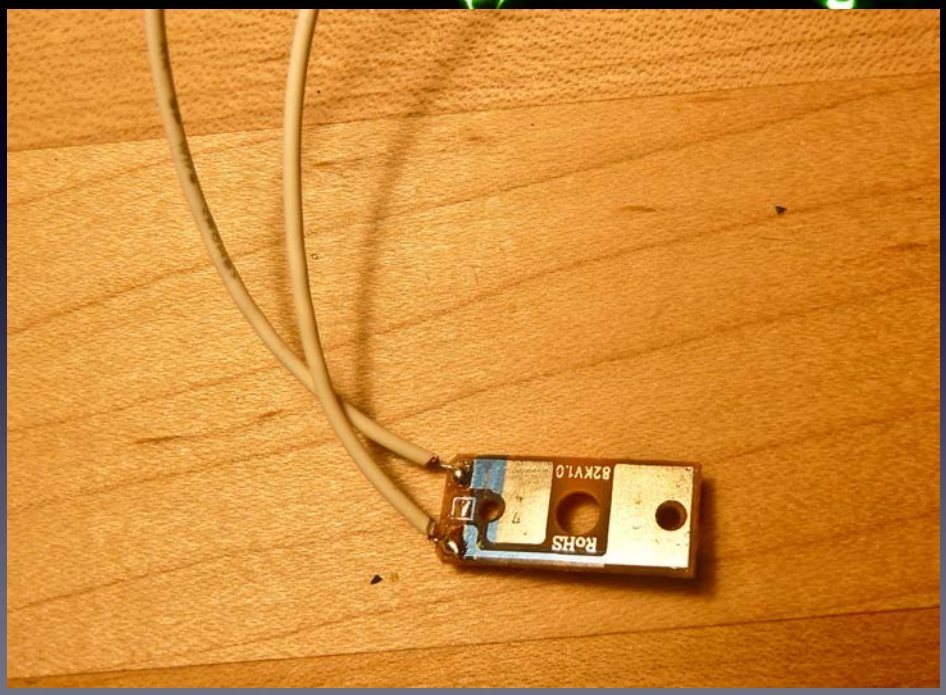




Meanwhile, sometimes the screws are really tight. It can help to use pliers to get more grip and more torque on the screwdriver…

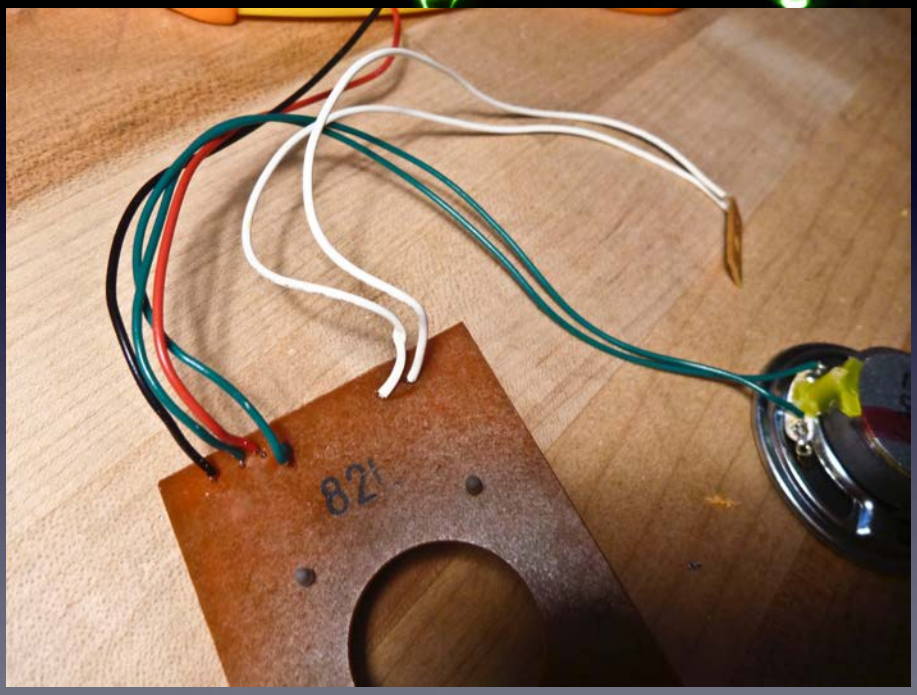
Here are the main guts of the toy - one main circuit board, one speaker, and one mini-board with two metal pads on it…





Here's that little circuit board with two metal pads on it…

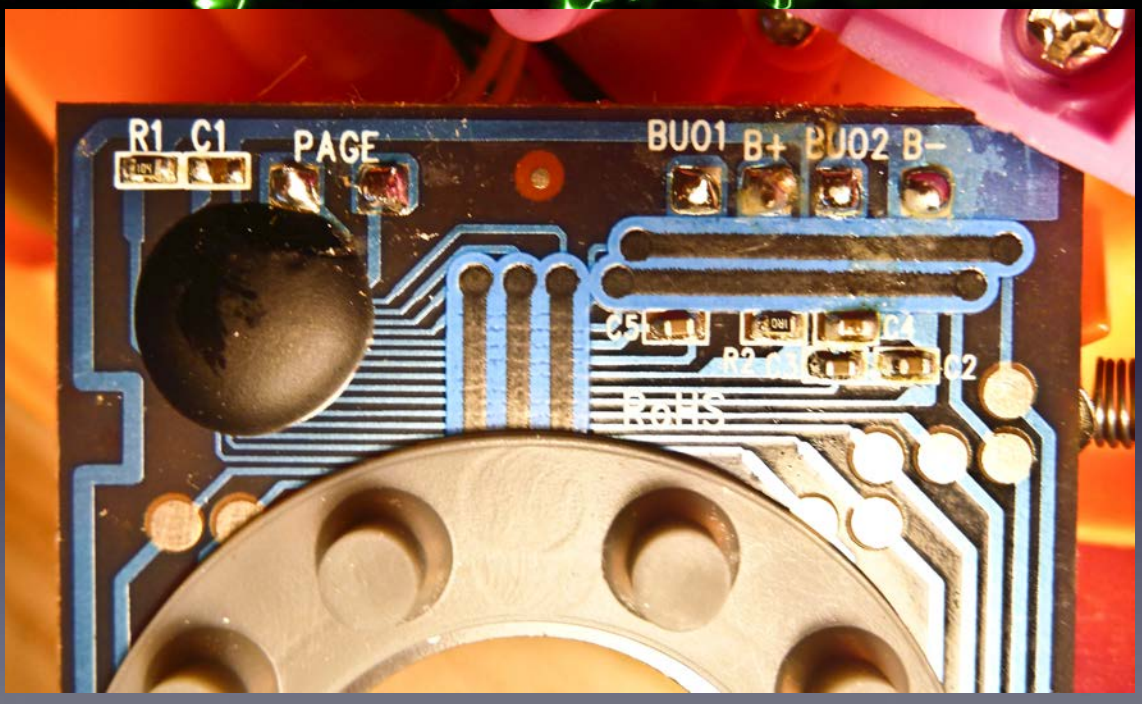
Turns out that in this toy, there's a little push-button when you turn the page that pushes this widget up, and makes contact with the two pads.

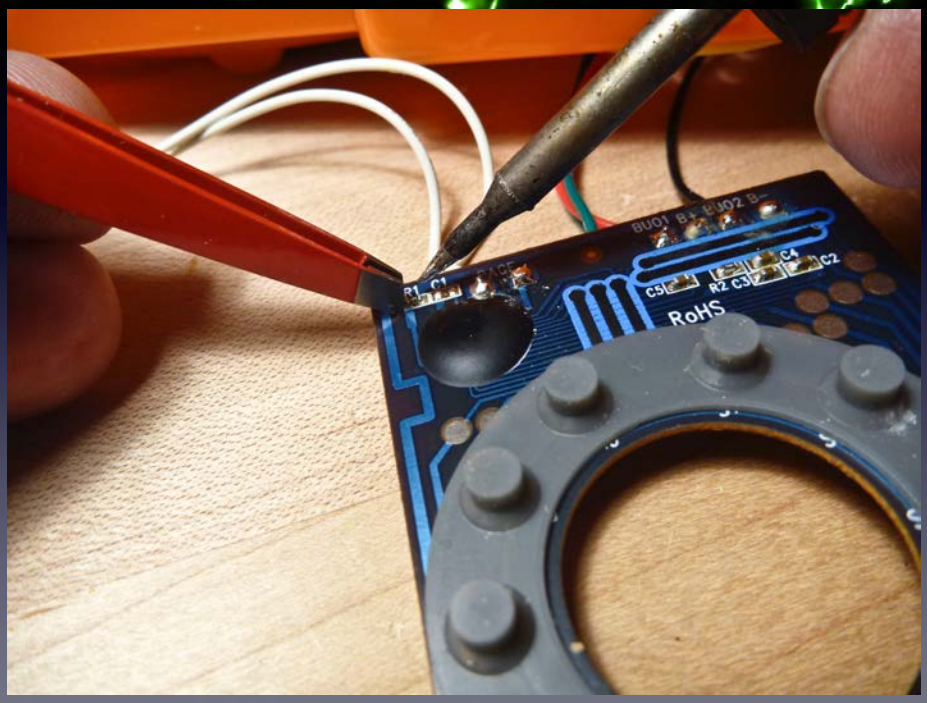


If you're taking things completely apart to repackage them, it's a good idea to take a picture of the board so that if any of the wires come off in the process, you can solder them back into the right place…

OK - back to the timing resistor.

It's really really really small!!!





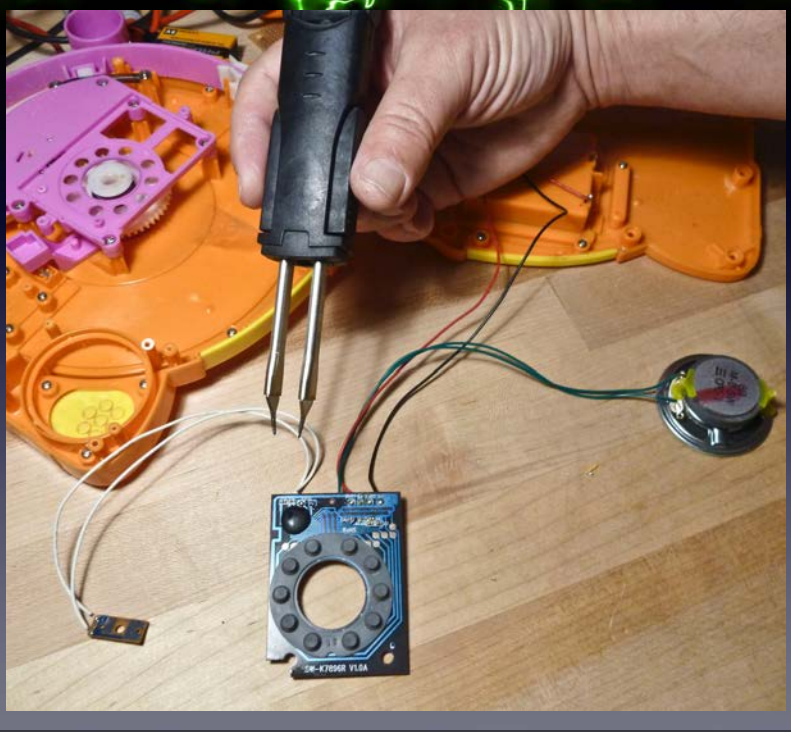
One way to get it off is to use tweezers while heating each side of the component.

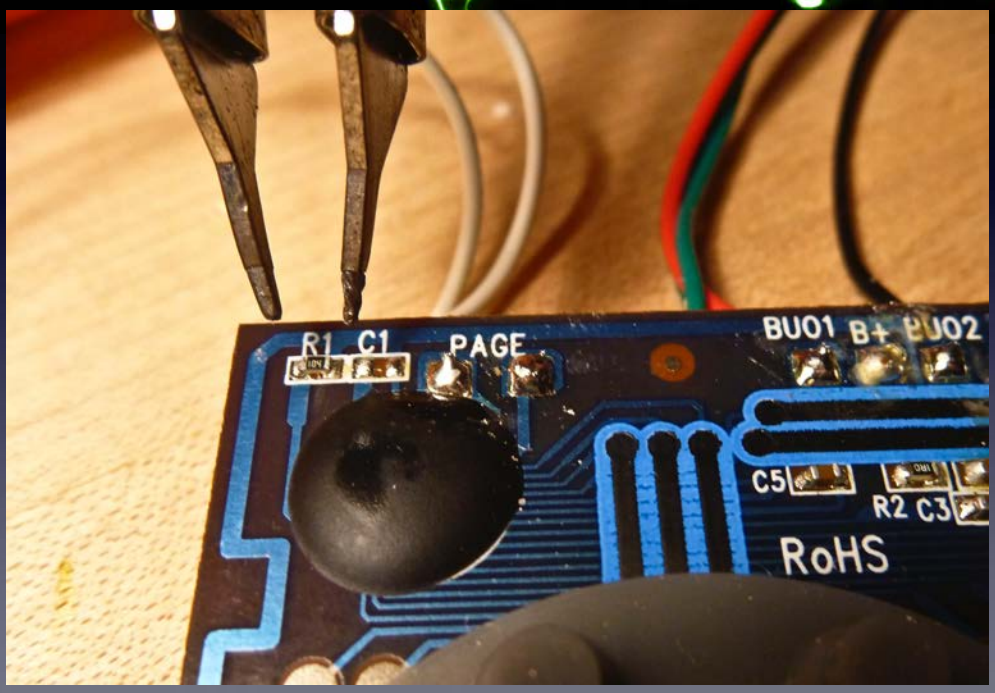
You can also use solder braid to remove much of the solder first…

Another method is using soldering tweezers.

These are basically tweezers where each side is a soldering iron tip.

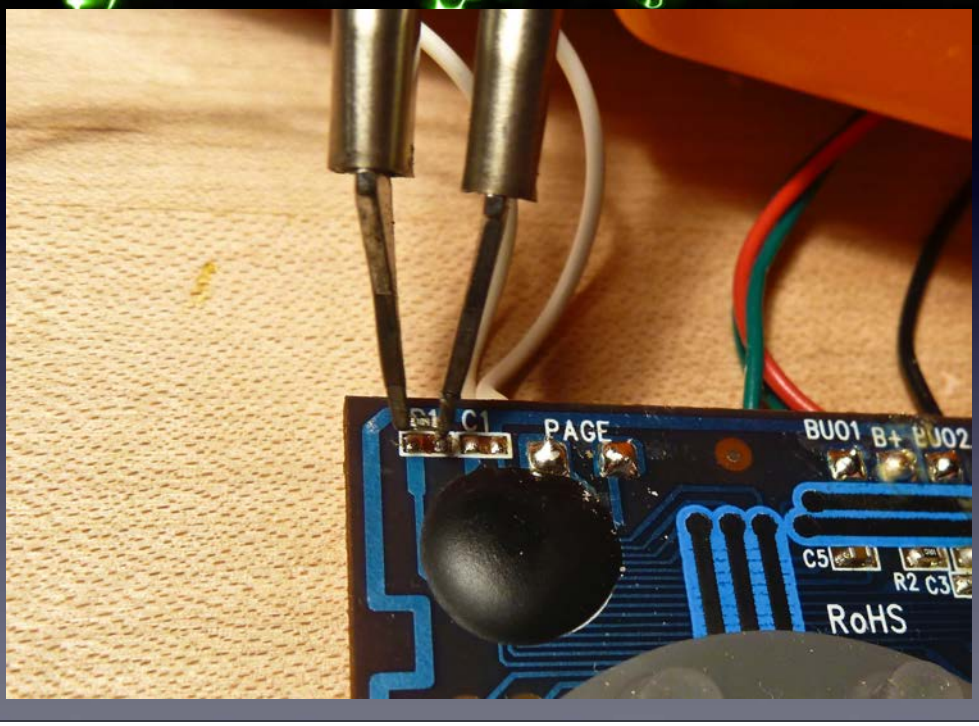
It lets you heat both sides of a tiny resistor at the same time…

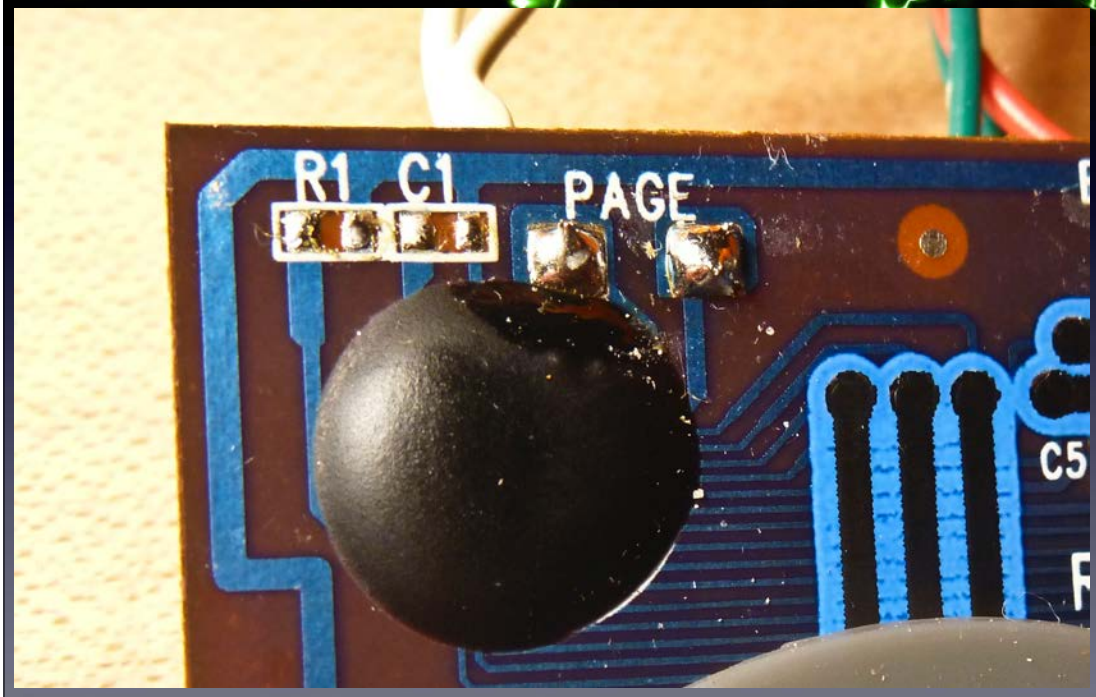




If you grab each side with the hot tweezers…

You should be able to lift off the tiny component…



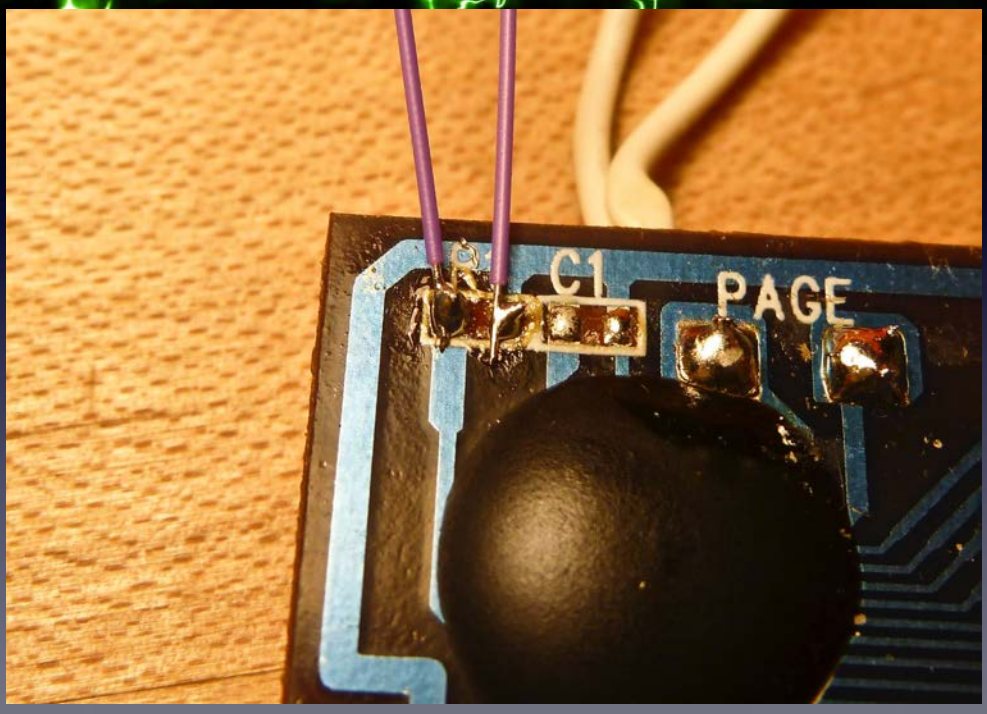


You're left with two tiny tiny solder bumps into which you can solder tiny tiny wires…

Here are some tiny tiny wires carefully soldered in.

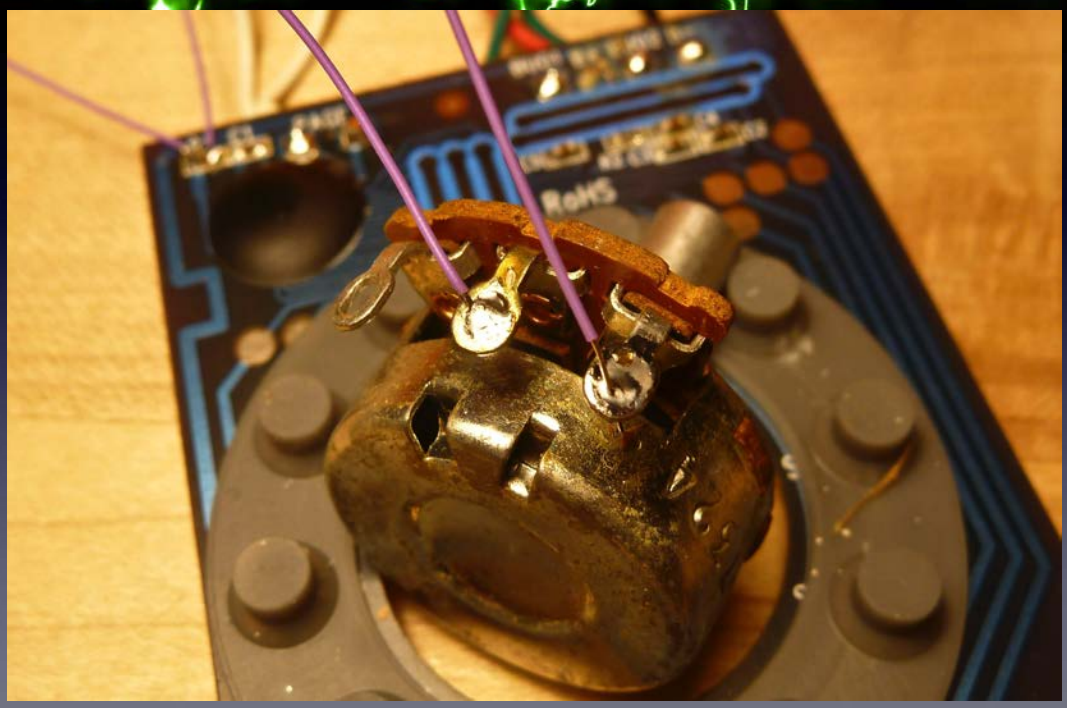
It helps to tin the wires first.

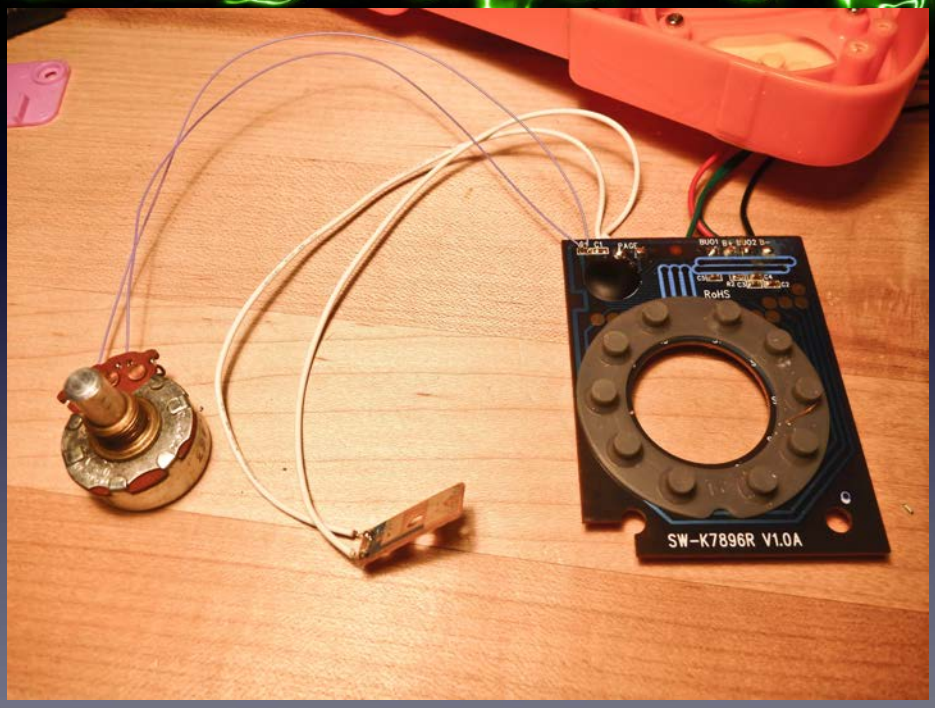
It also helps to use a magnifier…



Now prep a potentiometer

And solder in the wires





Finished with the pitch-bending portion of a hardware hack…

Whew!

- That's it - let's go bend some circuits!