Reverse Engineering- Calculator

Purpose: To learn how the TI-30 calculators systems work together to display an output when an input is typed in.

Hypothesis: We think that when a button is pressed on the calculator, it sends a specific electronic signal through the circuit board to calculate and display an output on the screen.
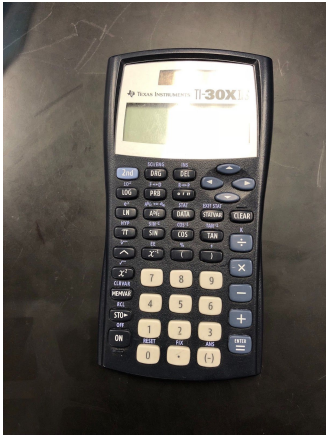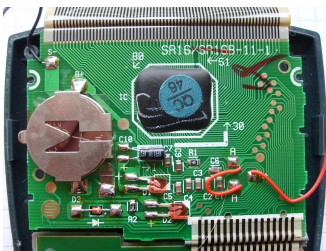
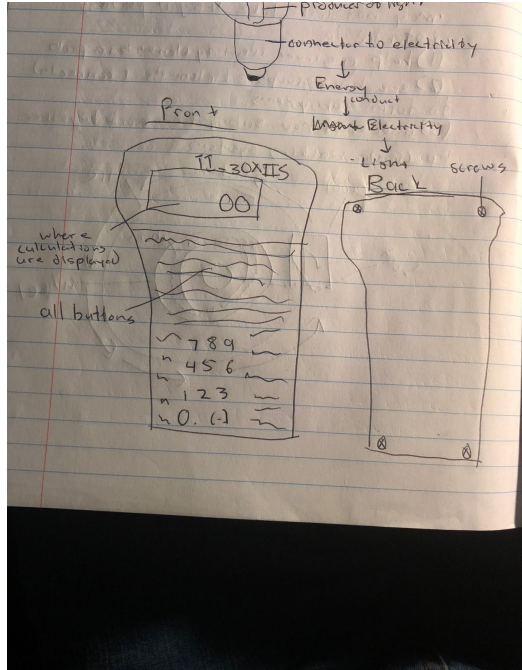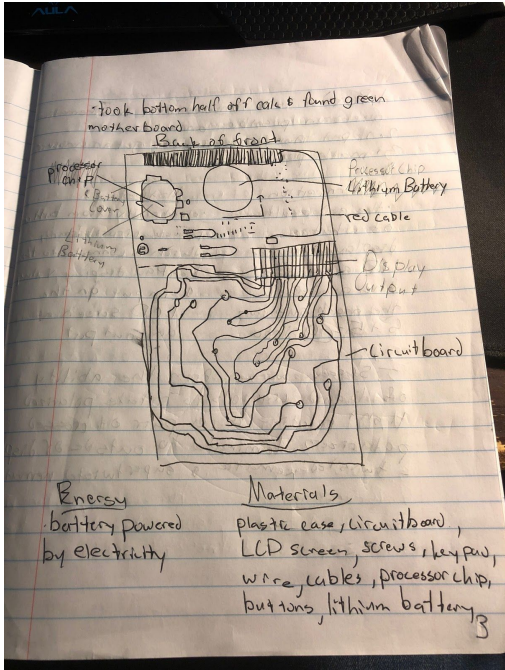**Sketches and Disassembly:**

Photo of the casing, buttons, and LCD screen of a TI-30 calculator
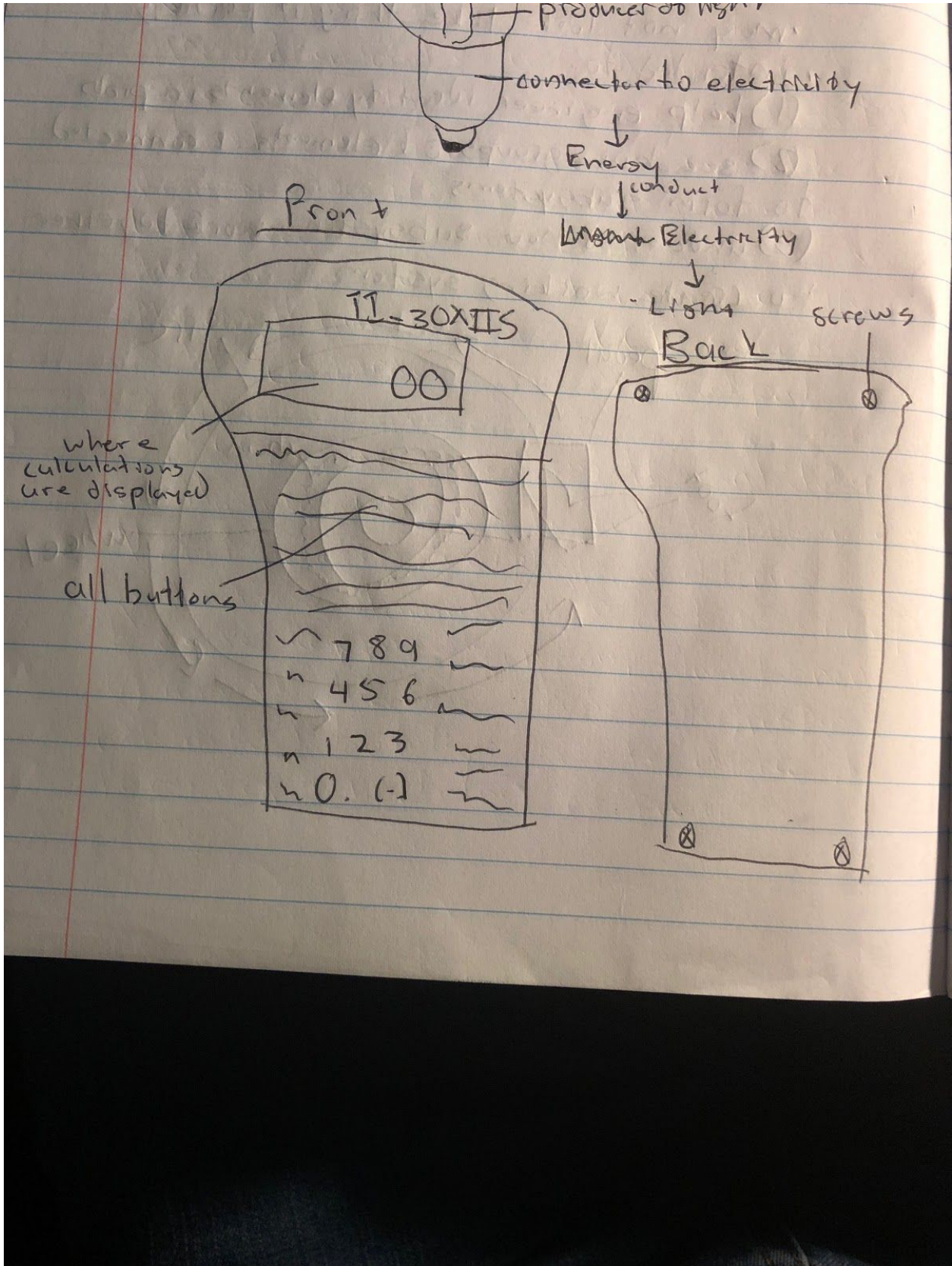

Photo of the circuit board inside a TI-30 calculator

Zoomed in photo of the top part of the calculator's circuit board, focusing on the microprocessor (black square in the middle)

took bottom half off case & found green
motherboard

Back of front

processor
chip &
Button
cell

Lithium
Battery

Processor chip
Lithium Battery

red cable

Display
Output

Circuitboard

Energy
battery powered
by electricity

Materials
plastic case, circuitboard,
LCD screen, screws, keypad,
wire, cables, processor chip,
buttons, lithium battery

produces no light

connector to electricity
↓
Energy
conduct
↓
Break Electricity
↓
Light   screws

Front

TI-30XIIS

00

where
calculations
are displayed

all buttons

7 8 9
4 5 6
1 2 3
0 . (-)

Back

producer 00 light

connector to electricity

↓

Energy
conduct
↓

Absorb Electricity

↓

front   · Light   screws

Back

TI-30XIIS

00

where
calculations
are displayed

all buttons

7 8 9
4 5 6
1 2 3
0 . (-)

These are the sketches we made when we disassembled the calculator

We attempted to contact the manufacturer for schematics, but received no response.

Analysis of Elements:

Functional Analysis: Electricity from the battery powers the circuit board. The circuit board sends information, and this information is displayed on the LCD screen in the form of numbers. If a different button is pressed, it sends a different signal through the circuit board and to the LCD screen. The circuit board contains a microprocessor, which is a small chip that computes the equations that are plugged into the calculator. By pressing a button, you complete a circuit inside the calculator, which sends electricity through the circuit board and routes information through the microprocessor. The microprocessor then interprets the information and sends it to the display screen, where it is shown as a numerical output. (Sources 1,3,4)

Structural Analysis: Calculators have plastic housing, which makes it easy to transport and keeps all of its internal parts together and safe from damage. A panel of the plastic cover can slide onto the front of the calculator and cover the screen and buttons when it's not being used for extra protection. There are four screws in the plastic casing, and they keep the outside hardware together. There is a liquid crystal display (LCD) screen, which displays numbers that people type in and the outputs calculated by the microprocessor. The LCD is connected to the circuit board and receives and converts signals from it. There are also rubber buttons with numbers and commands on them. They are attached to back of circuit board, and when pressed, each button sends a specific signal to the microprocessor. The last connection is the battery, which attaches to part of circuit board to provide power to whole device. (Sources 1,3)

Material Analysis: A TI-30 calculator has two main components: the hardshell cover and the circuit board. The hardardshell cover is made of plastic. It provides protection for the internal circuit and is lightweight, making it reasonably easy to carry around. However, it is still strong enough to prevent damage, and it is only slightly bendable. This plastic has no electrical, thermal, or chemical uses. It is merely used for protection and transportation. The second component is the circuit board. It is made of fiberglass epoxy resin with copper foil bonded to each side. The fiberglass epoxy resin provides a sturdy base for the circuit board, while the copper foil conducts electricity through the board. The copper has some very important electrical properties. Its electrical resistivity is 16.78 nΩ•m at 20 °C, and it has the highest electrical conductivity out of all metals (excluding precious metals). The conductivity of annealed copper (copper that has been altered to be more workable) is 00% IACS = 58.0 MS/m at 20 °C, decreasing by 0.393%/°C. These electrical properties are what makes copper the best metal to use in a circuit board. (Sources 2, 5)

Manufacturing Analysis: The calculator's printed circuit board is manufactured in a

series of steps. It is made through an additive process, where different parts are soldered to the board. To make the substrate (base of the board), woven glass fiber is dipped or sprayed with epoxy resin. It is then rolled out to the right thickness and semi-cured in an oven. These panels are stacked, alternating with copper foil, and pressed at 340 degrees F for about an hour to fully bond the board together. Then, holes are drilled in the board in a specific pattern. Some of the holes are used to conduct electricity, and those holes are lined with copper. Copper is plated onto the surface of the board to create the correct pattern of circuits. Each panel is sealed, then markings are stenciled onto the boards to show where each part goes. The boards go through machines that add the parts onto them. One machine puts solder paste on the correct area, and the next uses a "chip shooter" that places the parts on the board. Some components are too big or strangely shaped, and they are either added by a robot or manually. Then, everything is soldered to the board's circuits, and the manufacturing is completed. This manufacturing process uses both forming and joining methods. (Source 2)

Conclusion: Our hypothesis was correct, but we learned more about how exactly the calculator transfers signals and data through our reverse engineering process. We learned that pressing a button completes a circuit, and that completed circuit is what allows a specific signal to be sent which corresponds to the output shown on the LCD screen. We also learned what materials the different systems of the calculator are made of and how different material fulfill different requirements. Lastly, we learned about microprocessors, which is the main component in a calculator's computing process. Overall, we confirmed our hypothesis, but we learned much more about how the process actually works.

Sources:

1) https://www.explainthatstuff.com/calculators.html
2) http://www.madehow.com/Volume-2/Printed-Circuit-Board.html
3) https://electronics.howstuffworks.com/gadgets/other-gadgets/calculator2.htm
4) https://computer.howstuffworks.com/microprocessor.htm
5) https://www.nde-ed.org/GeneralResources/IACS/IACS.htm
6) https://de.m.wikipedia.org/wiki/Datei:TI-30X_IIS_board.jpg