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## **Reverse Engineering Report: Mini Speaker**

### **Purpose**

As a group, we want to learn about the different parts of a portable speaker. We want to discover how they function separately and together. The areas of research we will focus on are how speakers produce sound and electrical engineering. This will give us information on the physics behind sound and how a circuit works.

### **Hypothesis**

We predict that the mini speaker is made up of two parts, a circuit board and a speaker, and that we will be able to successfully put them back together.

### **Analyze the Elements**

#### Functional Analysis:

An electrical signal is sent to the printed circuit board (PCB) when an audio cord is plugged into the speakers. This sends a signal that is carried throughout the PCB and deciphered by the circuits. It is then carried through electric cables to the top half of the speaker. Here, the voice coil carries the signal, creating a temporary electromagnet that

attracts or repels the field magnet as electricity flows back and forth. As the voice coil moves back and forth, it pushes against the cone, causing it to vibrate. This emits sound waves at various frequencies, producing music.

There is a mini light bulb in the speaker that is turned on by a switch. When the switch is turned off, the circuit is incomplete. Turning the switch on, creates a closed circuit that allows for an electric current to flow from the battery through the wires. The battery, the energy source, provides the voltage and the wires act as the conductor. The electricity then flows through the wires of the light bulb, heating the filament, causing it to produce light.

When the charger cord is plugged in, a constant source of voltage is pumped through the battery. The battery then stores this electricity and uses it when the speaker is turned on and the audio cord is plugged in.

#### Material Analysis:

The materials in the top of the portable speaker are a frame, permanent magnet, soft iron, voice coil, and a cone. The frame of the speaker is made of plastic because it is a durable and cheap material. It supports the cone and permanent magnet. The field magnet is a ceramic ferrite material that is made up of iron oxide, strontium, and a ceramic binder. The cone is made up of a treated paper coated in an adhesive glue. The material used for the voice coil is a plastic cone with fine gauge insulated copper wire wound around it.

The circuit board is made up of a thin layer of conductive material printed on the substrate, an insulating board. The substrate is made up of a paper reinforced phenolic

resin with a bonded copper foil on both sides. These materials are commonly used in household electrical items such as a mini speaker because they are less expensive. The printed circuits of the board are etched into the substrate, made of copper, and coated in tin-lead to prevent oxidation. Copper is used because of its conductivity.

There are also other materials such as resistors, capacitors, diodes, and integrated circuit chips. The resistors are made up of metal with a thin film of conductive, yet resistant, material inside. The purpose of the resistor is to limit the flow of electrons through a circuit and divide voltages. Capacitors harbour electrical charge and are made from two metal plates and an insulating material called a dielectric. The dielectric is made of any insulating material such as paper, glass, plastic, or rubber. Diodes allow current to flow in one direction by blocking the other. The integrated circuit is the brain of the PCB, and is the complex layering of semiconductor wafers and copper. These materials interconnect to form transistors, resistors or other components in a circuit. The combination of the wafers is called a die, which is packaged into a small chip.

#### Structural Analysis:

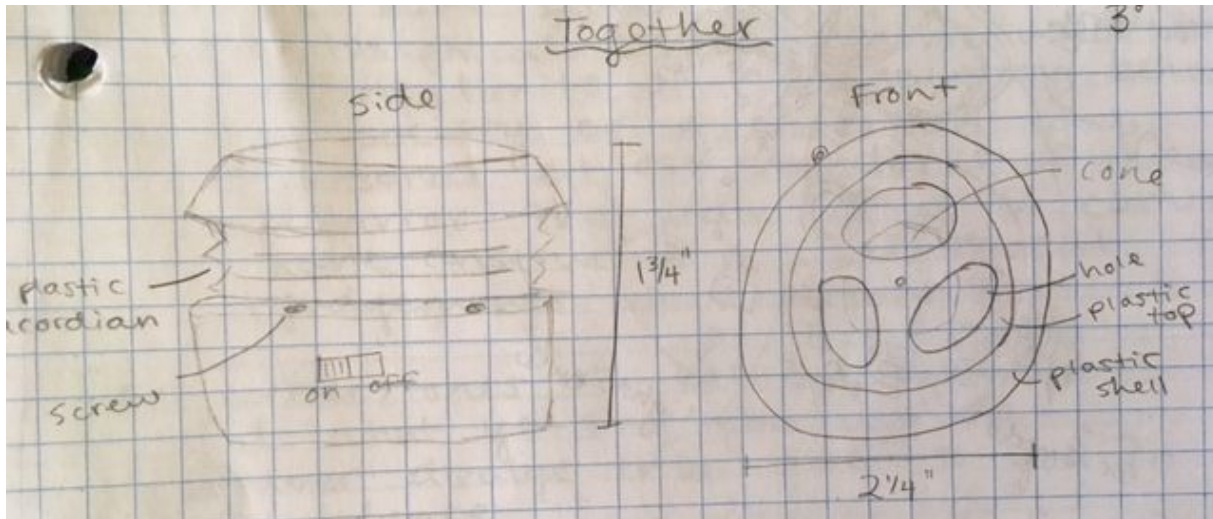
The top of the speaker unit is the speaker itself. The speaker is made up of the cone, voice coil, field magnet, wires, and electromagnet. The outer part of the cone is fastened to the outer part of the speaker's plastic rim. The inner part of the cone is attached to the voice coil, which is located in front of the field magnet. Wires run from the PCB to the voice coil.

The bottom of the speaker holds the printed circuit board and battery. The PCB has four cables running from it. Two are attached to the battery and the other two run to

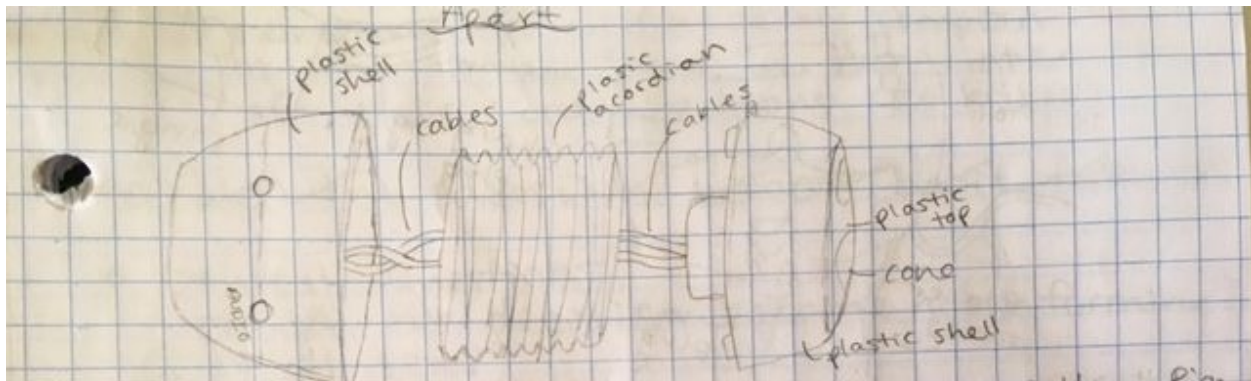
the top half of the speaker. The battery is placed first into the frame, and then the PCB sits on top of it. A plastic accordion connects the bottom half of the speaker to the top half.

Conceptual Sketches

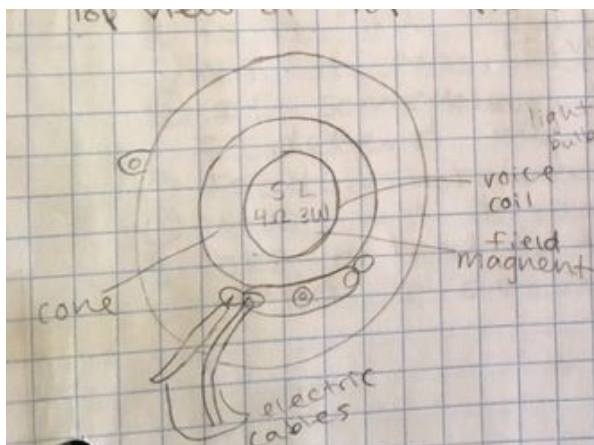
Object Before Disassembly:



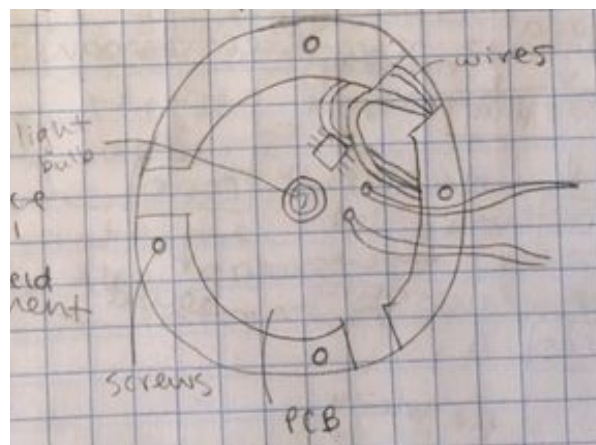
Taking Object Apart and How the Parts Connect:



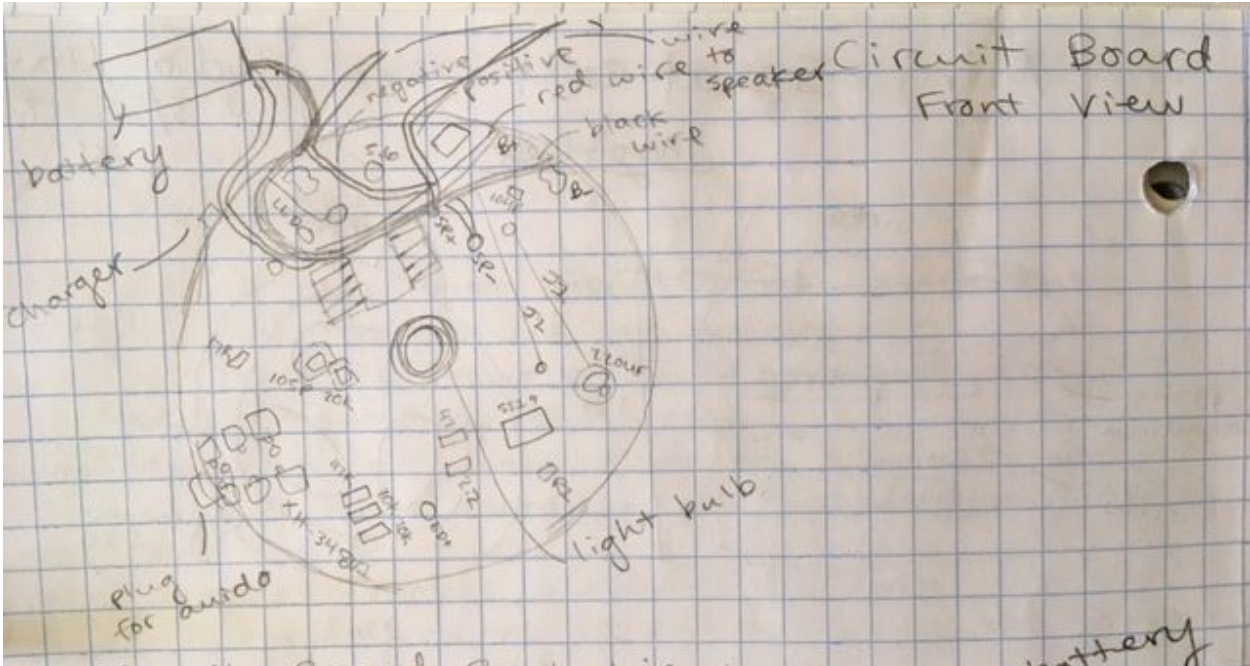
Bottom of Speaker:



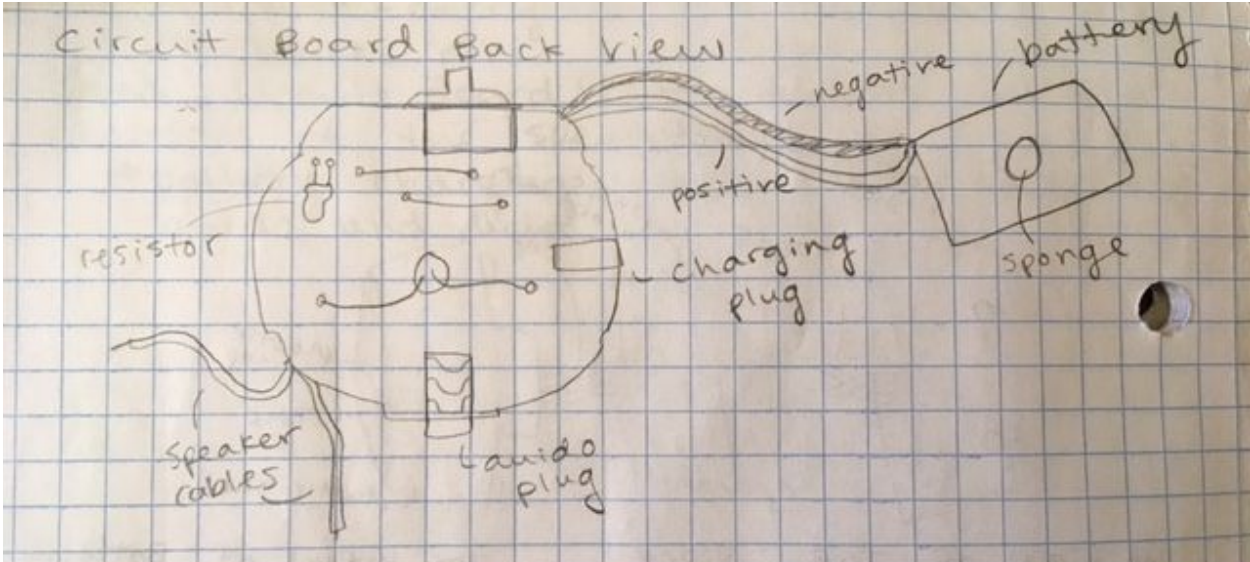
Circuit Board Inside Speaker:



Circuit Board Front View:



Circuit Board Bottom View:



Manufacturing Analysis:

The first half of the object consists of the speaker. The permanent magnet is made by combining iron oxide and strontium and then grinding the substance into a fine powder. The powder is mixed with a ceramic binder and closed in a metal die, which is put in a furnace so the mixture is bonded together. The frame is built from a plastic

sheet that is transported into a machine that cuts holes in the top and sides with a hydraulic press. It is then formed into its desired shape by the the hydraulic press. The cone is made out of composite paper that is glued together. The voice coil is constructed from multiple wires insulated with copper. They are wound together on a plastic bobbin, and then glued to the cone. The permanent magnet and frame are bolted together. Then the cone is attached to the top of the frame with glue.

The printed circuit board and light make up the second half of the object. The PCB is placed in the bottom part of the frame and then secured with screws. A plastic accordion is placed in between the two halves to protect the wires running from the PCB to the voice coil.

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