VEX U - Reverse Engineering Online Challenge: Philips Sonicare Essence 5000

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Summary

Our submission for the VEX U - Reverse Engineering Online Challenge involves the disassembly process of the Philips Sonicare Essence 5000 Series electric toothbrush. We chose to dissect this product to explore the level of electronic complexity that can be involved in the making of a compact, common household item such as this.

During this process the proper safety precautions were taken. All power sources were disconnected, the batteries discharged, and safety glasses were worn during the disassembly process.

Dissection Procedure

First, we divided the toothbrush into two components by unscrewing the Head Brush from the Brushing Mechanism. After doing so, old credit/debit cards and a flat head screwdriver was needed to separate the lid from the frame. Care was taken when doing so, as the push button may fall once you separate both parts. Then, by applying pressure by pulling, the printed circuit board came off. Using the same method of applying pressure, the drive coils, spacers, iron core, batteries, charger coil and charger coil mount all separated. The rest of the components were separated through gentle handling.

A) Separation of the two main components: head brush and brushing mechanism.

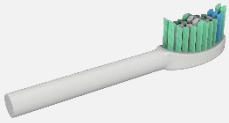
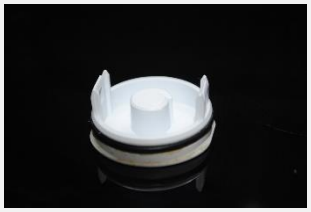
B) Circuit Board Removal

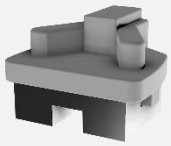
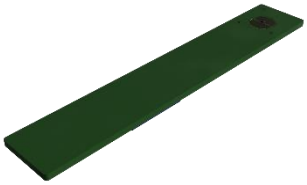
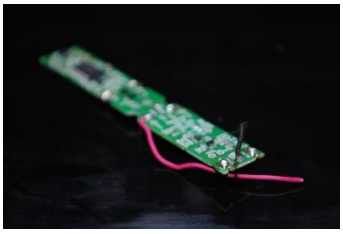
C) Complete component dissection

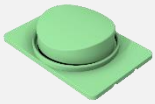
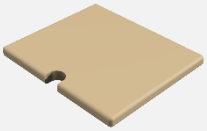
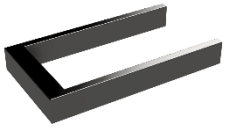
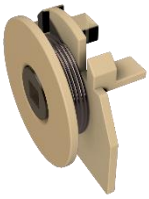
Figure-1A-C: Dissection Procedure

Component Analysis

Table 1. – Summary of each component and its function within the electric toothbrush.

Part Name	CAD Depiction	Real Life Component	Function
Head Shaft			Hold the brush hairs
Screw Cap			Maintain brush head in place
Rubber Ring			Reduces friction
Torsion Bars			Absorbs torsion directed to the head brush
Joint			Holds the torsion bars in place

Rubber Joint			Covers the joint
Lock			Constrains the head brush joint
Magnet			Makes the head brush vibrate
Magnet Mount			Holds the brush magnet
Lid			Encloses the batteries and inner system
Frame			Protects the toothbrush
Printed Circuit Board			Manages the electric current for the toothbrush

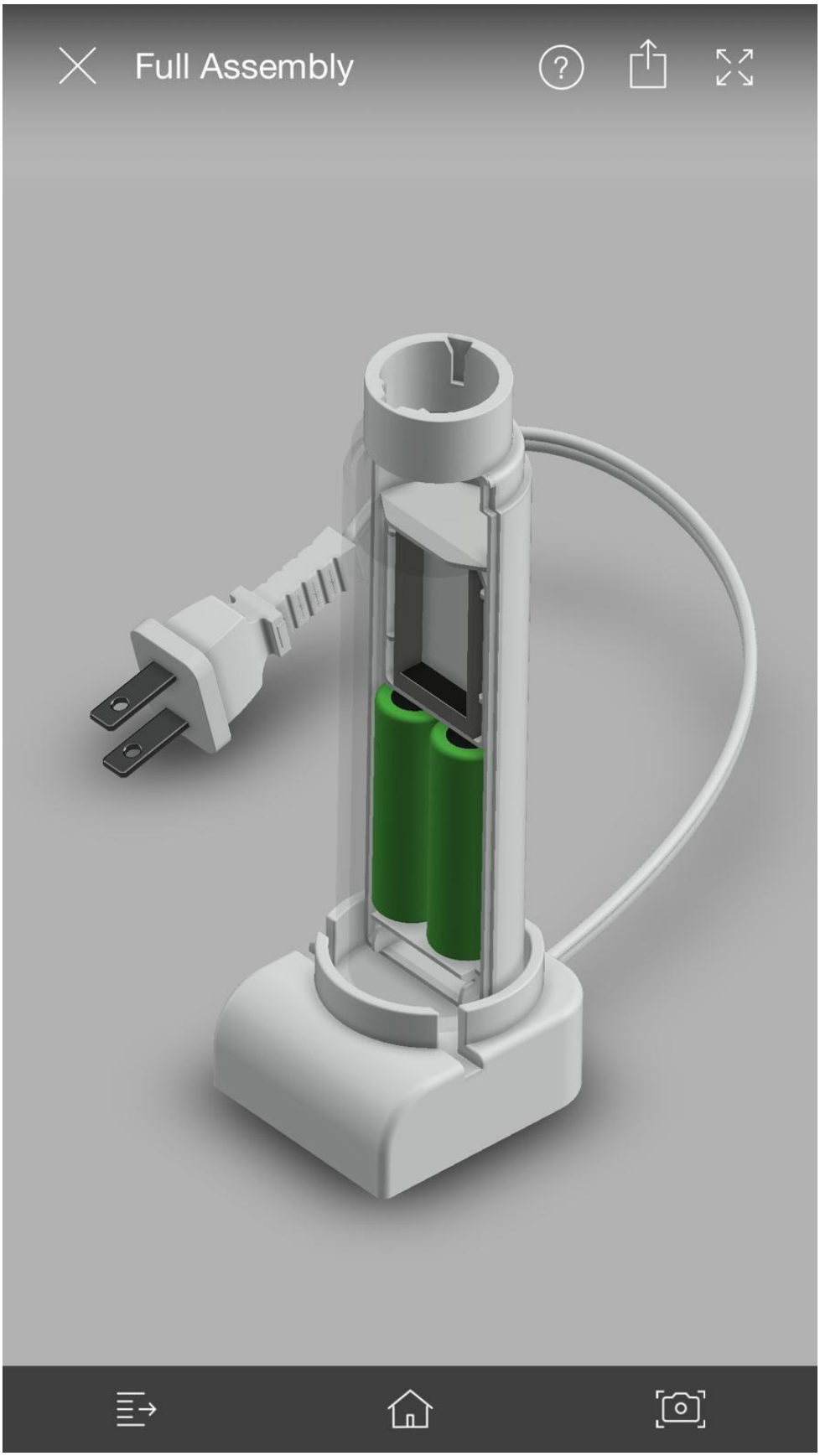
Push Button			Gives a signal to the PCB for vibration
Drive Coils			
Spacers			Separates the coils
Iron core			Amplifies the magnetic field through the coils
1.2V Ni-MH Battery			Supplies power to the system, allowing wireless use of the toothbrush
Charger Coil			Receives current from an inductive charger charge the batteries
Charger Coil Mount			Holds the charger coil in place

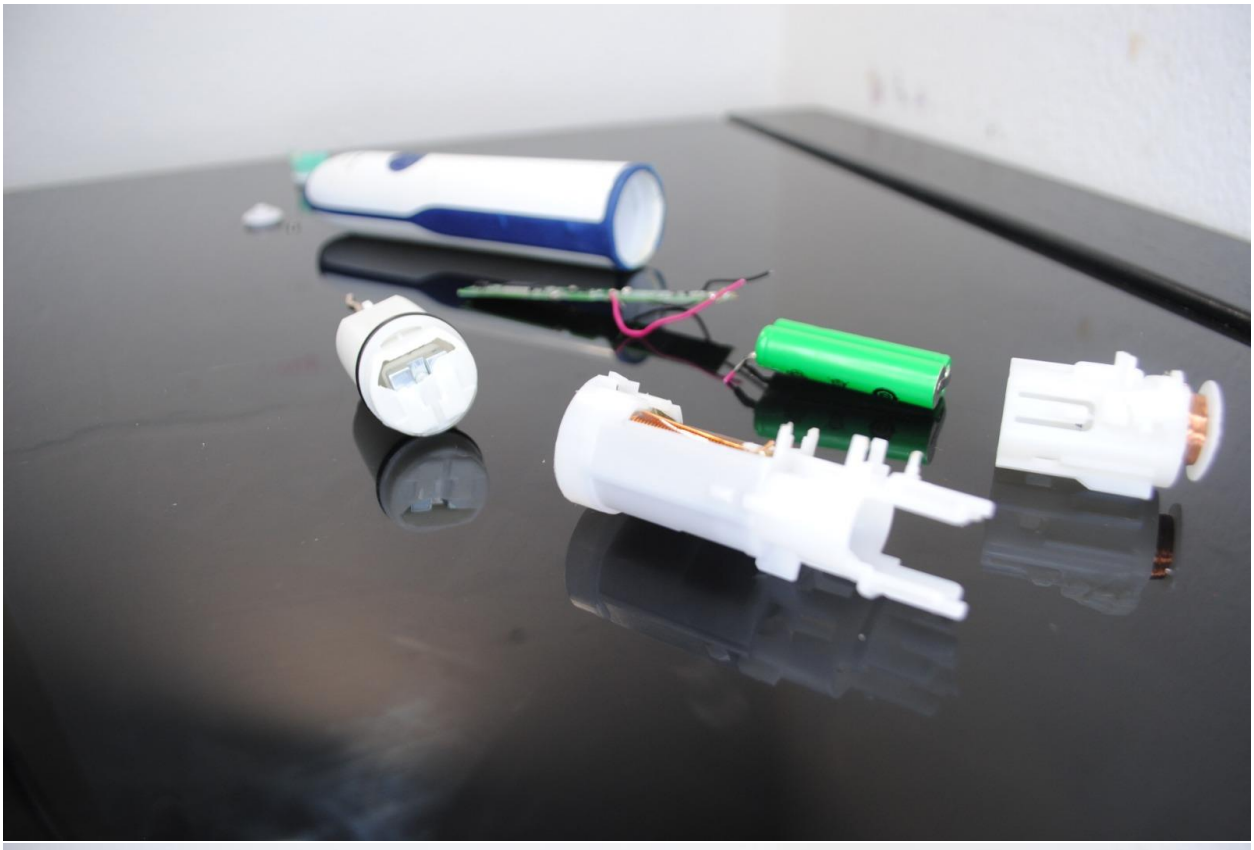
Electromechanical Design Analysis

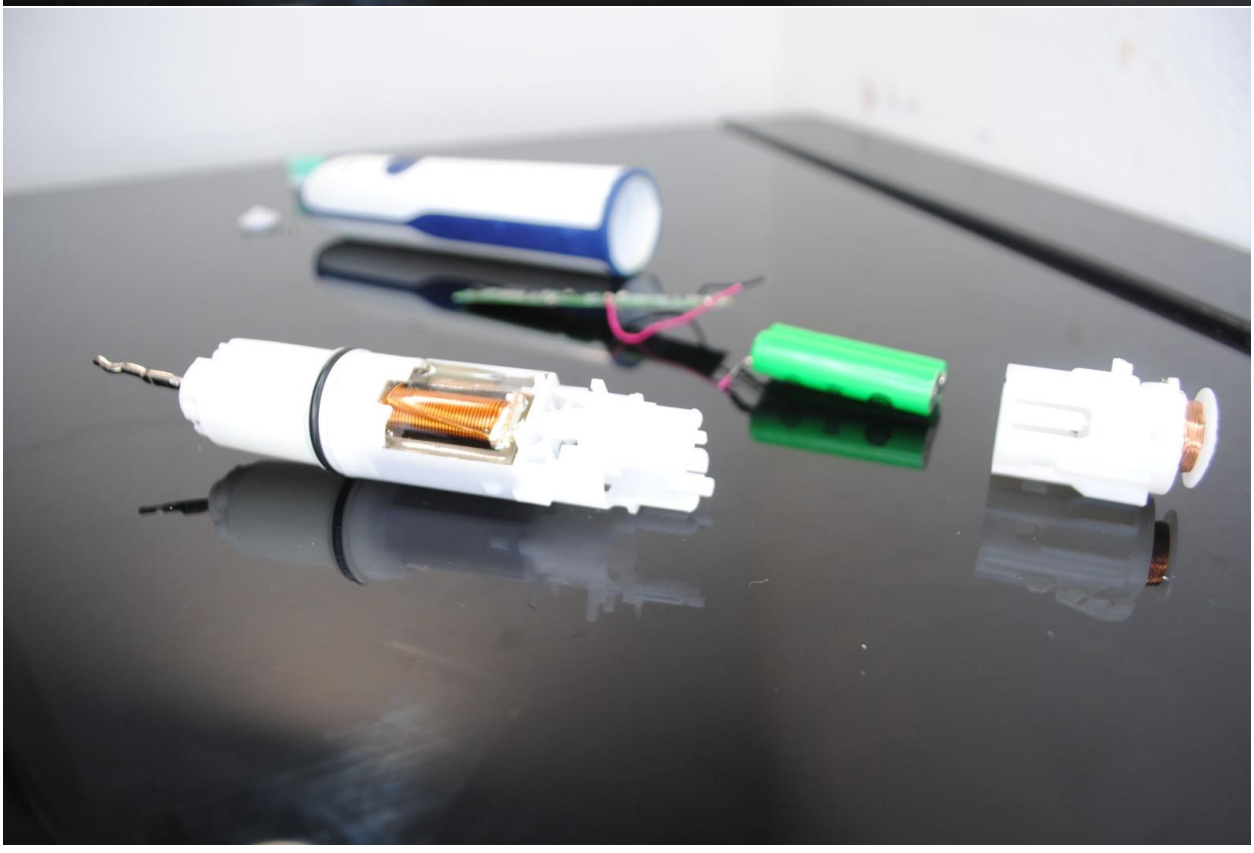
As the current travels along the drive coil, it creates a magnetic field normal to the area of the coil and it goes around to the other end of the coil. This moves the magnet, with its direction changing when the direction of the current across the coil changes. This change in direction occurs thanks to an H bridge inverter in the PCB. The PCB also includes amplifiers in the circuit to set the frequency of direction change signal to 516Hz. This vibration is carried to the brush itself by the torsion bars placed over the magnets, which prevent dangerous twisting and torsion to the head brush while transmitting the vibrations giving the user a more delicate movement. On the bottom of the toothbrush is a coil used for inductive charging, which supplies power to the two 1.2V Ni-MH batteries for energy storage.

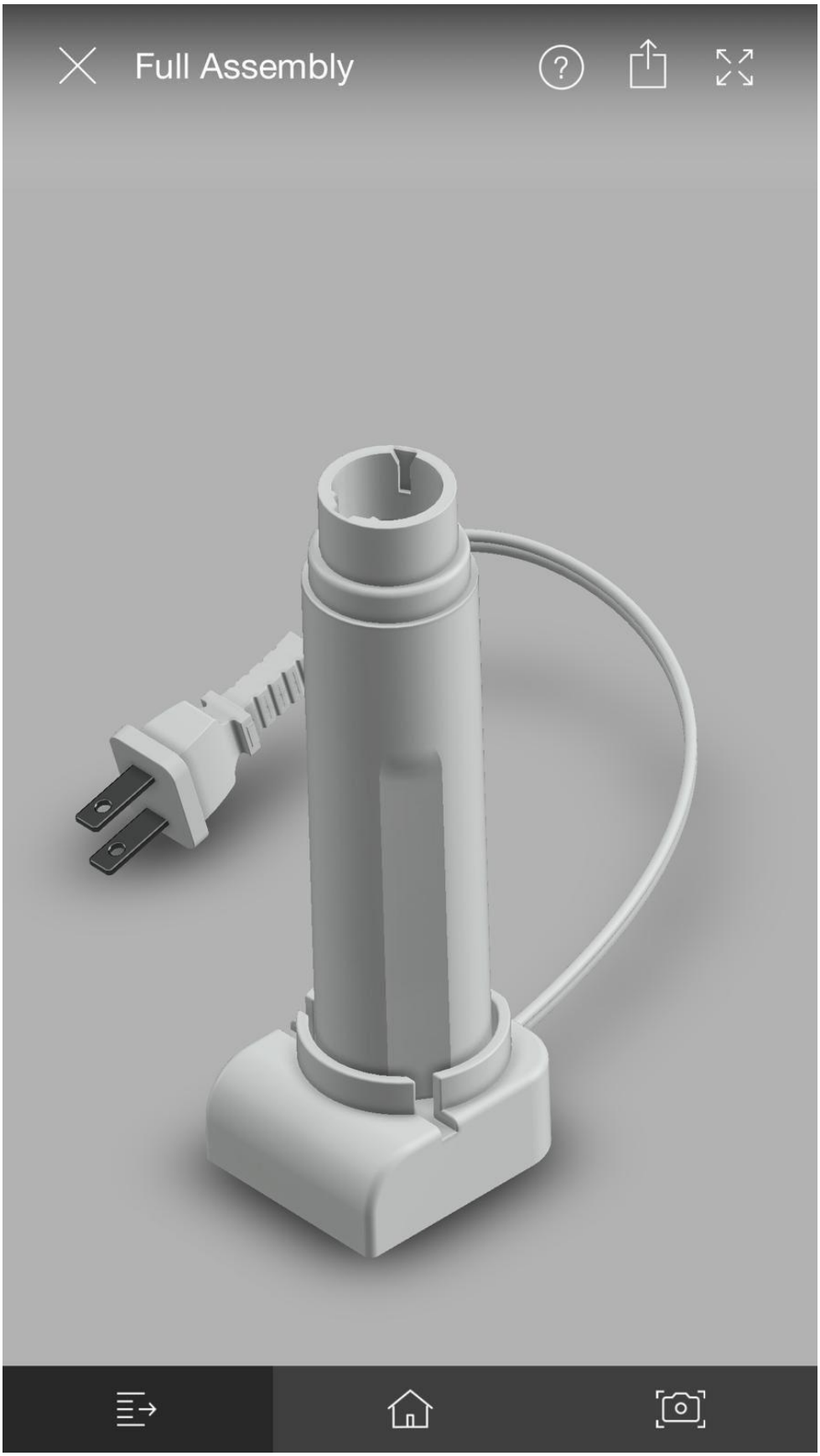
Conclusion

This challenge has taught us how a small tool such as the electronic toothbrush integrates a large amount of electric and magnetic field manipulations to achieve the simple task of vibrating a toothbrush. It showed us the possibilities that open thanks to the tools that electrical engineering provides. Not only that, but we were able to learn more about how engineers integrate these complex electrical designs into the physical and mechanical composition of the product, accounting for things such as PCB placement, and shielding electronics from water and humidity.


Full Assembly






Full Assembly