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Bone Conduction: A New Perspective, With a New Device

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INTRODUCTION

The science of bone conduction for communication relies on vibrations traveling through the bones that lead to the inner ear canal to create the allusion of sound. This technology has lead to several recent improvements in communication. Currently bone conduction technology is being used in the medical device field to aid those with hearing disabilities, and it is also being studied as a viable alternative to other hearing technology such as cochlear implants. Bone conduction is finally being looked at as a tool for recreational use. There are many emerging devices that utilize the concept of bone conduction for communication. Most of these devices are exterior ones that may be subjected to external conditions such as rain, and wind.

The design I have been working on relies on bone conduction that originates from inside the mouth. By designing the bone conduction apparatus for use inside the mouth, you eliminate environmental impact to the quality of sound, and allow the device to be more discrete which may be more appropriate in different conditions.

BACKGROUND

The idea for an intra-oral bone conduction mouth guard for sports and recreational use comes from the lack of availability of such technology. So far intra-oral bone conduction apparatuses do not exist outside of the medical device field. Current technology for sports communication between a coach and a player relies upon a headset worn externally by a player. With a mouth guard design, coaches in contact sports can broadcast plays to their players wirelessly to speed up the efficiency of the team. The players themselves will not have to worry about external conditions disabling their communication with the coaches because the communication device will be located in their mouth. Additionally the mouth guard design has the added benefit of protecting the players' teeth. For recreational use, the apparatus can be shrunk down and placed towards the back of the mouth, so that it remains out of sight, and so that it doesn't prevent the user from performing daily oral activities such as eating. The other benefit to a mouth guard design is that it can be easily removed, and no surgery is required.

DESIGN OBJECTIVES

- Design an intra-oral mouth guard to be constructed using FDA approved materials.
- The device will be designed to be manufactured in a multi-phase 3D printing process.
- Choose components for maximum user safety and device efficiency.
- Design the mouth guard to optimize vibrational output.

METHODS AND DESIGN

The device works by applying a varying current generated from a wireless receiver to solenoid actuator chambers within the device. This varying current creates a magnetic flux within a coil of magnetic copper wire, which can be calculated, and optimized using the modified version of Ampere's Law below:

$$B = \mu_0 \frac{N}{L} I_0 = \mu_0 n I_0$$

This magnetic flux acts on a neodymium magnet that is placed within the coil. This assembly is the driving force of my design.

In addition to the actuators, the device will be able to be charged wirelessly via an induction charged battery and an induction docking case or pad. Users will be able to carry the device around in its case that will simultaneously charge the device's battery. The design of the device requires the user's teeth to maintain static occlusion with the mouth guard. This allows maximum vibration to travel through the jaw and into the inner ear to create the allusion of sound.

Figure 1

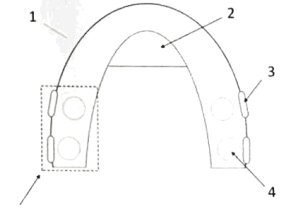
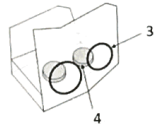


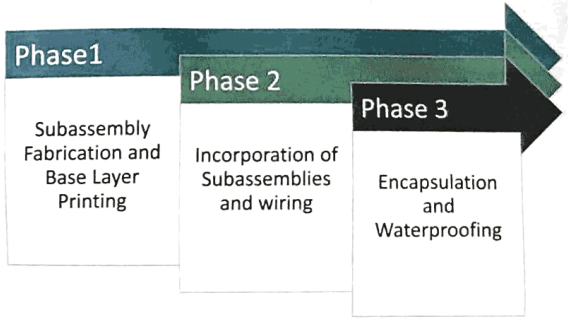
Figure 2



1. **Mouth Guard Body:** Designed to be made of Ethel Vinyl Acetate(EVA) plastic via a 3D- printing process. EVA Plastic is currently used in the manufacture of many sports equipment products, and in the Biomedical Engineering field.
2. **Central Control Assembly**: Contains the battery, the induction coil for charging, the wireless receiver for connecting to wireless devices, as well as all the necessary circuits, chips, etc. for controlling the device.
3. **Solenoid Actuator Coil**: A coil of magnet wire that is wound into several loops to create a magnetic flux that will act on the Neodymium Magnet.
4. **Neodymium Magnet**: A simple rare earth magnet that will create the communicational vibrations.
5. **Solenoid Actuator Assembly**: The assembly that comprises of the Solenoid Actuator Coil, and the Neodymium Magnet. This assembly is designed to create the vibrations needed for bone conduction to occur.

3-PHASE 3D PRINTING PROCESS

The device is also designed to be manufactured by a multi-process 3D printing process, to insure that it remains watertight. This will process will ensure maximum safety to the user as well as increased durability and lifespan of the device itself.



The 3-phase process above utilizes the advantages of additive 3D printing technology to ensure uniform consistency and quality. This method ensures a watertight seal around the entire device to prevent any malfunctions or user harm. It does this because each additive layer is fused to each other, creating a solid, uniform texture and consistency.

RESULTS AND CONCLUSION

This simple design provides a base model for future development. Using Ampere's law, the force of the solenoid actuator assemblies can be maximized for the best performance for use inside the mouth. In addition, further development can be made to maximize effectiveness of vibrational communication between the device and the jaw. Such improvements could include the variation of sizing and placement of the subcomponents, or by changing the materials to increase vibrational conductivity.

Intra-oral bone conduction has many great possibilities and applications both within sports, and in everyday life applications. One possible future stage of development for recreational intra-oral bone conduction involves creating an implantable device in the form of a false tooth. Intra-oral bone conduction has a great potential to shape the future of everyday life, both on the field and off.

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