STAR TRACER

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INTRODUCTION
A mirror board was designed for enhancing hands-on learning about the nature of visual processing disorders experienced by individuals with dyslexia. A previous version of a mirror board was made out of a wood board base, a 12x12 inch square piece of mirror, Styrofoam, and two bent pieces of coat hangers. The device worked by placing the mirror in a notched out section of the wood board so that it would stand up with a slight tilt. Then the coat hanger pieces were bent and placed into two holes drilled into the base, and then the Styrofoam was rested on the hangers as a raised divider in the middle of the mirror. Finally, a piece of paper with the image of a star outlined by a bigger star was placed onto the wood board.

Once set up, students attempted to trace the two stars by looking into the mirror. Anyone who tries this finds out that it is difficult to complete the task. When attempting to trace the star, the mind is confused by looking into the mirror and cannot relay to the hands which direction to move the pencil in order to turn the edges of the star. Unfortunately, a client’s mirror boards were not made from durable material and the client was in need of new mirror boards.

SUMMARY OF IMPACT
The newly designed mirror boards are durable, lightweight, contained in one piece, and can be quickly and easily transported and assembled. Thirty new mirror boards were made. The new versions were renamed “Star Tracers.” Since receiving the new star tracers, the client has used them in elementary schools, and with church groups and civic groups. In addition, university classes have used the Star Tracers to educate future teachers.
Figure 20.1. Completed Star Tracer
TECHNICAL DESCRIPTION

Initial designing plans involved the goals of making the Mirror Boards lighter, safer, more durable, and easier to transport. Each Mirror Board was designed to incorporate its own carrying case. This was accomplished by making the base of the Mirror Board the actual case; the divider that would replace the piece of Styrofoam would be the lid to the case. Sides were added onto the base and then notched. A section was cut into these sides so that the divider could be slid into the grooves and therefore act as a lid to the casing.

Prices on available hinges were researched. If a hinge was to be used, the price to build the Mirror Boards was going to increase dramatically. Instead of using an expensive, fancier hinge it was decided that aluminum rods could be used instead. Four pieces of aluminum rod would be used and four holes would be drilled into the base in order to hold the pieces of aluminum. The aluminum rod would be bent at the top and Velcro would be wrapped around the top bent portion in order to hold the divider onto the aluminum rods. The other side of the Velcro would therefore be placed on the divider board. The divider board was to be durable yet lightweight and inexpensive. It was decided that particleboard be used as the divider and lid of the casing.

Finally, the mirror had to be chosen. The problems associated with the mirror were that the mirror was heavy, breakable, and contained sharp and jagged edges that could possibly cut someone. As an alternative, mirrored Plexiglas was used.

After all of the products were decided upon, and a prototype was built, the construction of 30 mirror boards began. After they were assembled, the wood was varnished and polished to seal the wood. It was decided that small luggage carts would be purchased from a local store to transport the Star Tracers. The pieces of each Star Tracer were placed into the base casing and the divider lids were slid into place. Ten of the Star Tracers were placed onto each cart and they were easily transported to the client.
Figure 20.2. Disassembled Compacted Star Tracer.
POWER-ASSISTED TRICYCLE

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INTRODUCTION

The tricycle has been designed for a seven-year-old client who has been diagnosed with osteogenesis imperfecta (OI), a genetic disorder characterized by bones that are essentially too brittle. This condition leads to bone fractures occurring often with little or no apparent cause. The client has Type III OI and exhibits symptoms of a short stature (he is the size of a three-year-old), bones that fracture easily, loose joints, poor muscle development, and bone deformity. The client can sit in an upright position, but his legs must be supported underneath and positioned in front of him. The development of this tricycle for the client has been an engineering design challenge due to the customization for his small size, restricted range of motion, and physical limitations.

There are commercially available handicap tricycles on the market. However, they are mainly designed for people with simple balance problems to more involved cases of cerebral palsy, spina bifida, Downs syndrome, muscular dystrophy, and autism. There are no known commercially available customized tricycles available for persons with OI. Even if a commercial design were available, it is likely that it would be too large for the client and not provide adequate support.

SUMMARY OF IMPACT

The opportunity to overcome physical limitations provides an increased sense of confidence in the client’s abilities. The developmental therapists that work with the client anticipate that use of the tricycle will promote his bone growth, muscle mass, strength, coordination, and range of motion. It is hoped that the opportunity for continual physical growth through use of the tricycle will ultimately result in the necessary strength development that will allow him to stand upright and perhaps take his first steps.

TECHNICAL DESCRIPTION

The frame of the tricycle is made from one-inch AISI 1020 steel tubing. Steel tubing provides the necessary strength properties for the tricycle. The frame alone is nearly 38 inches long, 13 inches tall, and 24 inches wide. These dimensions allow the seat to be at least 18 inches off the ground, as well as enabling the tricycle to fit through standard handicapped doors. With these dimensions, the tricycle is also stable, with an overall center of mass just below the client’s posterior. This is vital in preventing tipping.

The steering motion is the same as conventional bikes; however, the fork of the front wheel is not directly under the handlebars as in conventional bikes. The fork is located approximately 20 inches in front of the client’s reach. Due to the client’s limited range of motion, the handlebars are replaced with a ten inch steering wheel. The steering wheel is connected to a steering column that attaches to the fork via two U-joints. The U-joints are required to be at a combined angle of 57 degrees so the client will be able to steer the tricycle. This angle was found by using the client’s measurements, the location of the fork, the size of the u-joints, and simple trigonometry. The turning radius of the tricycle is designed to be approximately four feet. A limit in the steering capability is incorporated for safety reasons.

A commercially available Tumble Forms® is used. The seat has a built in three-point restraining device. A seat frame is designed to attach the seat to the tricycle frame through standard clamps. The seat frame is designed so that the restraining belts help stabilize the seat. The seat frame is made from .09 inch aluminum sheet.

Linear-type pedal motion is accomplished through use of a right angle bevel gear system. Two pedal crankshafts are designed from half-inch steel rod to attach the pedals to the gears. The height of the
crank arm is seven inches. A small shock absorber is mounted to one of the crank arms to add resistance to the pedal stroke. The shock absorber mounting is adjustable along the crank arm to allow for increasing resistance as needed. The pedaling system has variable stroke that is independent of the pedaling speed and will never force the client’s legs. Foot restraints are positioned on the pedals to prevent the client from rotating his legs laterally during load cycles.

The pedal stroke has been coupled to a linear velocity transducer (LVT). When the client pedals the tricycle, the LVT triggers the power supply to the motor. The signal from the LVT requires conditioning before entering the microprocessor. This is accomplished through a precision full-wave rectifier with gain. Then the signal is sent through a low-pass filter, which will provide the microprocessor with a smooth signal ranging between 0 and 5 volts. This signal transmits the rate at which the client is pedaling to the HC12 microprocessor.

The output of the microprocessor is sent through additional signal conditioning. An H-Bridge circuit controls the current necessary to drive the motor. In the past, senior design groups have spent the whole semester working on an H-bridge and rarely getting it to work. Due to the complexity of the design an H-Bridge rated at 12 volts, and 35 continuous Amps was purchased.

Electrical feedback of the tricycle speed ensures that the motor is running at a speed proportional to the work being done by the client. A Hall Effect sensor located on the fork of the tricycle provides this feedback. Hall Effect sensors vary in their ratings as well as the type of feedback signal they produce. A Hall Effect sensor that is capable of producing a signal directly to the microprocessor with no conditioning is being used.

The drive train component took a very long time to design and evaluate. The main system of the drive train rests on the differential in the rear axle. Since the tricycle is rear-driven, the differential allows for rotation of the rear tires at different angular velocities when cornering. The differential is driven by a 152 in-lb, 0.25 horsepower gear motor through a 1.13:1 ratio chain drive. The motor is powered by a 12 VDC lead acid battery. A standard wall outlet battery charger is also incorporated into the electrical design.

To translate the angular velocity of the axle to the wheels, friction slip clutches were employed. Friction washers were placed on either side of the hub, along with a spring washer and 2 notched washers to make the wheel rotate when the axle rotates. Since the diameter of the axle is 1", the wheel hubs had to be modified. An Acetal sleeve bearing was incorporated so that the wheels could spin freely on the axle when the friction drive was not engaged. To engage the friction drive a quick-release cam nut, similar to that on a standard bicycle tire, was used. Disengaging the wheels was important so that the tricycle could be moved when not in use.

When the client discontinues his effort to pedal the tricycle, the motor ramps down for a smooth stop. From the stop position, the tricycle can be put into reverse gear. In the unlikely event that the motor should suddenly stop during operation, the slip clutch on each rear axle will prevent rear wheel lockup.
NON-INVASIVE INFANT RESPIRATION AND TEMPERATURE MONITOR

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INTRODUCTION
The non-invasive infant respiration and temperature monitor detects the respiration rate and temperature of a sleeping infant and outputs the respiration rate, temperature and an alarm for lack of respiration or high temperature. This monitor reduces the risk of crib death, or Sudden Infant Death Syndrome (SIDS) caused by a cessation of breathing known as apnea.

The non-invasive infant respiration and temperature monitor uses a pressure pad placed along side the infant’s rib cage to detect pressure changes caused by respiratory movement. It also includes a temperature sensor placed beneath the infant in order to detect fever. An infant positioning pad is used to prevent the infant from moving away from the pressure pad or off of the temperature sensor. A liquid crystal display (LCD) outputs the respiration rate and temperature. A warning message is displayed on the LCD for a 10-second pause in breathing or temperatures over 99° Fahrenheit. A

Figure 20.4. Infant Respiration and Temperature Monitor.
buzzer also sounds for lack of breathing or fever.

**SUMMARY OF IMPACT**
The non-invasive infant respiration and temperature monitor reduces the risk of crib death for all infants including those at risk for SIDS. Risk factors include infants born to mothers who smoked during pregnancy, infants born to teenage mothers and infants with siblings lost to SIDS. By continually monitoring the breathing rate of these infants, the likelihood of crib death occurring diminishes greatly. The monitors currently available for infants at risk for SIDS are available by prescription and involve wires attached to the infant. These include the transthoracic electrical impedance monitor, which uses electrodes attached to the infant’s chest, and the pulse-oximetry monitor attached to an extremity such as the foot or finger of the infant.

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In order to detect the respiration rate, a highly sensitive pressure sensor is attached to the air-filled pouch. The output from the pressure sensor is amplified and filtered for high-frequency noise before being input to the A/D Converter of the microprocessor.

A solid-state temperature sensor is embedded in the infant-positioning pad beneath the infant in order to sense the infant’s body temperature. The output from the temperature sensor is amplified and biased before being input to the A/D Converter of the microprocessor.

An LCD is connected to the microprocessor and displays respiration and temperature information as well as alarm messages. A piezo-electric buzzer is also attached to the microprocessor and sounds for lack of respiration lasting 10 seconds or longer as well as fever.

The microprocessor is programmed to analyze the pressure signal and calculate the respiration rate. The respiration rate in breaths-per-minute is output to the LCD. If no respiration is detected for 10 seconds, a buzzer sounds and a warning message is displayed on the LCD. The microprocessor has also been programmed to calculate the temperature and display it in degrees Fahrenheit on the LCD. A buzzer sounds for temperatures above 99°F.

The monitor continues to monitor respiration and temperature when an alarm sounds. If the alarming condition returns to an acceptable range, the monitor resumes normal operation. Otherwise, the alarm must be acknowledged by cycling microprocessor power.

The total cost for the project was approximately $80.

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**TECHNICAL DESCRIPTION**
The non-invasive infant respiration and temperature monitor consists of hardware and software as well as non-electrical physical components. The hardware consists of sensors, circuitry and a microprocessor. Programming was done on a Motorola HC11 microprocessor using the C Language. Other components include an air-filled pouch used to detect respiration and an infant positioning pad that ensures proper contact between the monitor and the infant.

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The monitor continues to monitor respiration and temperature when an alarm sounds. If the alarming condition returns to an acceptable range, the monitor resumes normal operation. Otherwise, the alarm must be acknowledged by cycling microprocessor power.

The total cost for the project was approximately $80.
PERSONAL COMMUNICATION DEVICE

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INTRODUCTION
The Personal Communications Device for Individuals with Speech Impairments (PCDISI) was designed to aid a person in communicating with another individual. The device is designed based on a current production model of the LightWRITER™ (LW) manufactured by Toby Churchill Ltd. A LW is a device that allows a user to type sentences or phrases via an attached keyboard. The sentences or phrases are displayed on a pair of LCD screens. One screen faces the user and the other faces the person the user is “talking” to. In addition to the display our design includes a speech output that speaks what the user types.

SUMMARY OF IMPACT
Currently, the clients have one LW and were interested in purchasing more; however additional LWs are beyond their budget. Furthermore, they were seeking a device with similar functionality that could be built and tailored to the specific needs of a given individual.

TECHNICAL DESCRIPTION
The personal communications device consists of a standard PS/2 keyboard, a Motorola HC11E9 microprocessor, twin four line by 40 character LCD displays, and a RC Systems text-to-speech (TTS) processor. The design utilizes off-the-shelf components in an effort to reduce component cost and to simplify the design. An HC11E9 running in single chip mode controlled the keyboard, LCD screens, and the TTS processor. The various devices use TTL compatible voltage levels, therefore enabling a direct interface to the HC11, simplifying the design.

Several different ports are being used on the HC11 to control the various components. The text-to-speech processor uses the serial communication interface port. The LCD screens and the keyboard use generic input/output (I/O) ports. The design utilizes most of the available I/O resources of the HC11. The rationale for this was to maximize resource efficiency and to minimize programming, packaging, and power consumption.

The HC11 receives input from the keyboard, converts it into an ASCII value, and outputs that ASCII value to the LCD displays and the TTS processor. The HC11 is just under the white plastic connector in Figure 20.7. The board on the left in Figure 20.7 is the TTS. Also shown is the speaker for the TTS, the internal battery pack, and the volume control.

The keyboard outputs characters by means of a scan code; different from the standard ASCII character set. The LCD screens and the text-to-speech processor take only ASCII input. This presents a problem, as somehow the keyboard input must be converted to ASCII so that it can output to the LCD screens and the text-to-speech processor. The keyboard’s PS/2 interface contains two wires of interest, the data and clock lines. Both lines are connected to generic I/O pins of the HC11. The clock line is monitored for a transition from the idle state (high) to the start state (low). Transition data is
“read” by the HC11. Data is shifted one bit at a time into an internal register as it is received by the I/O port. This must be done for the data is sent serially by the keyboard as the character’s scan code. The HC11 checks this scan code against known values. When it finds a match, it outputs the associated ASCII value to the LCD displays and the TTS processor. The program includes checks for CAPS LOCK key, Shift key, etc.

The LCD displays and the TTS processor receive the ASCII value separately. The LCD displays require parallel data. The TTS could operate with parallel data, however, due to the limited number of I/O pins on the HC11 and to maintain upgrade capability of the TTS, the data is sent serially through the SCI port of the HC11. Configuration of those ports on the HC11 was matched to the needs of the device. Default configurations were used on the LCD displays and the TTS.

An infinite loop dominates the programming. The keyboard input is read, displayed on the LCDs and “spoke” by the TTS. Those three steps are then repeated. The unit does contain a battery voltage level indicator. The battery voltage is checked while waiting for input from the keyboard. When the battery voltage drops below approximately eight volts, the LED color will turn from green to red, alerting the user that the battery needs to be charged via an external connector visible in the upper right of Figure 20.7.

The cost of parts/material was about $400.
INTRODUCTION
There is a demand for specialized sporting equipment to meet the needs of individuals with disabilities. The problem faced is to develop a partially automated casting device suitable for use by an individual with a disability. The casting device with the associated motorized reel will be the first step in enabling a wide range of people with disabilities to fish. This device may then be used in conjunction with various control systems to meet the needs of a specific individual, for example, sip and puff, head switch, or joystick control. The project focused on the design and construction of the casting device.

SUMMARY OF IMPACT
The intention of the project was to design a casting and retrieval system that can be used by an...
individual with limited manual dexterity. It is important to note that a hands free casting system is not being proposed. The casting as well as the retrieval will require push-button inputs. The individual is able to press buttons, but does not have enough coordination/strength to cast without assistance.

**TECHNICAL DESCRIPTION**

With the intent of enabling an individual with a handicap to fish independently, the design executes the following sequence of operations. First, the user turns on the device and adjusts the desired cast distance using two pushbutton inputs. From this point, the cock input is selected to ready the casting arm for the cast. Next, the individual presses the cast pushbutton to wind the torsion spring, activates the line release solenoid, activates the trigger solenoid, and then de-activates all components at the appropriate time during the cast. The final step in the operation is to depress the retrieval pushbutton to latch the reel and set the system for fishing. Once a fish is hooked the retrieval button can be used to bring the line in close enough for another cast.

Some of the details of the mechanical portion of the design include a sorbothane bumper and steel main shaft. The main plate, reel holder, bearing blocks and trigger mechanism are 6061-T6 aluminum. The stepper motor is mounted below the main plate, with the drive belt coming through the bottom of the plate. The line release solenoid is mounted on one side of the reel holder with the John’s Reel on the other side. A cable connects the two over the top of the reel holder pulley. The trigger mechanism is operated by a solenoid mounted underneath the main plate. The fishing pole holder is mounted on bearings. It is made of aluminum and is allowed to rotate between the bumper and the self-locking trigger mechanism.

The control system will use four user inputs, one limit switch input, and will control four pieces of hardware: stepper motor, push type solenoid, pull type solenoid, and a double digit seven-segment display. The functional block diagram is provided below.

The control system consists of the MC68HC912B32 evaluation board (EVB). The controller accepts five inputs, performs calculations, and then controls the hardware accordingly.

![Figure 20.9. Casting Device Component Diagram](image-url)
INTRODUCTION
By simply using different types of switches, the lives of children with disabilities can be changed. For example, activating a battery-operated toy with an assistive switch allows even children with severe disabilities the opportunity to control external events. This control over external events helps a child to understand cause and effect, predictability, and normality. When a child with developmental disabilities understands the connection between the activation of a switch and the resulting action it triggers, the knowledge of cause and effect is gained. Therefore, the basis for future learning is established.

SUMMARY OF IMPACT
One of the current problems facing assistive technology users, including switch users, is the cost of the available items. One way to provide more affordable solutions is to educate and teach the families of switch users how to make their own switches and adaptors. For example, some assistive technology vendors sell large button switches from $25.00 to $45.00, tread switches for $40.00, and pillow switches for $35.00. Amazingly, all of the parts used to make these assistive switches can be bought and custom made into assistive devices for an average cost of around $10.00. The “Life’s a Switch” manual details for readers of any background how to adapt and make switches to create their own assistive switches.

TECHNICAL DESCRIPTION
In order to accomplish these objectives and successfully create more cost effective and reliable devices, the “Life’s a Switch” manual covers the following topics: safety, basic circuits, equipment operation, switch technology, switch adaptation, switch design and implementation, and troubleshooting. The manual is written for a generally non-technical audience with the purpose of enabling readers with the knowledge to construct their own assistive switches.

The safety section of the manual assumes that the reader has limited knowledge of electrical safety and battery care. The purpose of this section is to teach the basics of electrical safety and battery care so the reader is safe and comfortable when working with either power supply.

The basic circuits section provides an overview of voltage, current and resistance, Ohm’s law, the basic elements in a circuit, the role of switches, and the difference between parallel and series circuits. The understanding of these subjects is necessary for one to successfully construct an assistive switch.

The tools needed for constructing assistive switches include a multimeter, soldering iron and wire stripper. The equipment operation guide instructs the reader in the use and basic safety of these tools.

The switch technology section introduces the reader to the specific terminology used with switches. With this information, the section also helps the reader choose what type of switch is best suited for a required application and an overview of commercially available switches.

Adapting normal switches to make assistive switches requires the construction of battery
interrupters, extension cords, and jacks and plugs. The switch adaptation section includes instructions for these needs and an overview of how all the components fit together with the switch and a device connected to the switch, such as a toy.

The final switch design and implementation section compiles the knowledge from all previous sections as instructions detailing different applications of assistive switches. This section allows for the most creativity of the reader. A troubleshooting guide following this section helps the reader correct likely mistakes made during the construction of assistive switches.

An accompanying workshop to this manual provides hands-on experience for the public in making assistive switches. The workshop focuses on teaching the basic switch construction skills and the specific application of assistive switches to adapting toys for the use of children with disabilities.

Figure 20.11. Switch Workshop.
INTRODUCTION
The audio messaging system was designed to assist people who cannot talk. This device is a handheld box that plays prerecorded messages. These messages can be stored on the device at a time. Any message can be played by pressing the button corresponding to the prerecorded message. This device aids persons who are in situations where other communication options are not available. This device differs from the products currently available in the number of messages available in a portable unit. This project was designed using a commercially available voice chip controlled by a Complex Programmable Logic Device (CPLD).

SUMMARY OF IMPACT
This device was designed to be lightweight enough for a small child to operate and easily carry. It also needed to be inconspicuous and easy to operate. This allows the person using the device to have it with them. This device is designed to help the user communicate easier and more efficiently. This allows increased self-sufficiency.

TECHNICAL DESCRIPTION
This design was implemented using an ISD 2560 voice chip. This voice chip was chosen because it had a storage capacity of 120 seconds, and it was designed specifically to record and play voice messages. This chip had a sample rate of 4.0 kHz and a filter pass band of 1.7 kHz. It had the potential for high quality voice playback. The ISD 2560 was also fully addressable and can be controllable by a CPLD.

The 120-second message storage capacity was divided up into sixteen segments. Each message on the chip corresponded to a button on the external casing of the design. The duration of each message was approximately 7.5 seconds. A membrane keypad was selected because of its lightweight and low profile.

The membrane keypad used in the design also had a removable legend. The legend beneath the keypad can be changed to reflect changes in the contents of the messages. The microphone used in the design was the WM-62PC electret microphone manufactured by Panasonic. This microphone was omni-directional and had a passband that extended from 20-16,000Hz.

The amplifier used in this design was the LM 386-N. This amplifier can be used at various voltage levels including 5VDC. This voltage requirement allowed it to be connected to the same voltage source as the voice chip and the XILINX chip. The amplifier was connected differentially to help reduce popping when the messages start and stop. The amplifier was connected to the volume control for the system. A 100kΩ logarithmic-taper stereo volume controlled the playback volume. The circuit diagram for the design is shown in figure two.

The cost of parts was approximately $80.00
Figure 20.13. Circuit Diagram.
ADAPTIVE HEARING ASSISTIVE DEVICE

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INTRODUCTION
The problem addressed by this project is that hearing aids can be expensive and many people with hearing disabilities cannot afford them. The main reason for these high costs is that each individual’s hearing problems are unique and hearing aids have to be custom made to address a particular hearing problem.

There are four main hearing problems that are addressed by this design. First, there is difficulty hearing at certain frequencies. In this case, a hearing aid that amplifies everything may do more harm than good. Second, many people have problems hearing in noisy environments because of the background noise. Third, hearing loss in only one ear is common. Fourth, there are the cases of severe hearing loss that can dramatically hinder a person’s ability to perform daily activities.

This design’s solution to these four problems is to use analog electronics in a network of filters that can adjust the gain for a wide range of different frequencies. An additional feature will be the ability to adjust the amount of gain in each ear that the user hears. The goals of this project are to make the design flexible enough to help a majority of the people with hearing loss, make the design inexpensive, and make the design small enough so as not to interfere with every day life.

The first requirement of this design is that it must be able to handle the entire frequency range of sound. The second requirement of this design deals with the gains for each of the signals. The volume of the output signal falls into two categories: the volume of each frequency band, and the volume to each ear. This design requires that the minimum gain for this device be low enough so that hearing is not damaged any further and also that the maximum gain is loud enough to help extreme cases of hearing loss.

According to the Occupational Safety and Health Administration, any noise louder than 85 decibels (dB) can cause hearing loss over an extended period of time.

SUMMARY OF IMPACT
The system of filters allows the user to amplify only the frequencies that they need, while the directional microphone that is used removes a majority of the background noise present in a noisy environment taking care of the second type of hearing loss mentioned.

One application for this device would be to have individuals who would like a hearing aid take a hearing test. Then based on the results of that test, the designer could set the value of the gain for each frequency stage as well as the gain to each ear, and provide the user with a product where he or she only needs only to control the master volume of the device.

TECHNICAL DESCRIPTION
The design uses a system of five analog filters: one low-pass, three band-pass, and one high-pass filter. Each filter covers a different range of frequencies and the gain for that filter can be adjusted by the user. The design also includes a circuit to adjust the volume from one ear to the other if the user has hearing loss in only one ear. The result is a system much like a graphic equalizer, allowing the user to adjust the hearing aid to best fit his or her personal hearing problems. Finally, a circuit is added that allows the user to also send the signal to either the left or right ear, or send an equal signal to both ears.

Currently the device does a number of things well. First, all five frequency ranges can be easily adjusted and there is a noticeable difference in the signal coming in when they are. During testing, adjustments allow for the subject wearing it to tune into the television or to a certain style of music. When adjusted properly, it also reduces a large
amount of background noise and allows the user to hear the person in the foreground more clearly. Volume to the left and right ear are easily adjusted.

However, there are some drawbacks that occurred during testing. The high-pass filter was designed differently than the other four filter stages. This resulted in much lower input impedance than the other four filters. The low input impedance of the high-pass filter meant that it drew more current than the other filters, which produced a soft high-pitch tone no matter how the filters were adjusted. At times the tone became very loud if the gain on the high-pass filter was turned all the way up because then it drew almost all of the current and none of the signal went to the other filters. To solve this problem, a wide band pass filter should be used instead of the high-pass filter. This would provide similar input impedance to the rest of the filters, and would hopefully remove this design flaw.

The packaging for this design is also a cause for concern. The prototype clips onto a belt and headphones are plugged into a stereo jack. This seems bulky, but if it went into production, then the size could be reduced by half, if not more.

The power consumption of this device is equal to about 4.1 W, which is slightly higher than hoped for when doing the original design. This implies that the device would need to be powered by a rechargeable battery in order to be practical. The design works for about 10 hours before the signal begins to get clipped, at which point the device becomes useless.

The overall cost of this project was approximately $30.