# CHAPTER 10
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# CAUSE AND EFFECT DEVICE

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## INTRODUCTION

A Memory-Cause and Effect device was built because of the flexibility and enjoyment for someone using such a device. Regular cause and effect devices only light up or make a sound when you complete one task. This device will light up when the user has completed one task, but it will also provide a greater reward if the task can be completed four times in a row. To complete this task four times there has to be an understanding of the concept of cause and effect and also simple memory skills. With this memory game, there are also levels of difficulty so it can be used with a variety of clients. With both the cause and effect and memory components the device should be fun and interesting for the user.

## SUMMARY OF IMPACT

The device is designed to help teach cause and effect to the user. The operator should be able to use this device on a desk or tabletop. The device will flash a random display of lights that the user will have to repeat correctly to obtain a lightshow. If the light sequence is repeated incorrectly a light will turn on to indicate a wrong answer. The difficulty of the light sequence will be able to be controlled from a switch that can be set to three different level settings.

## TECHNICAL DESCRIPTION

The Cause and Effect Device consists of three main components: input buttons, output lights, and a controller. The input buttons were selected to be large lit momentary action push buttons, so the operator can easily hit these buttons. In addition, the sequence the operator is to repeat can be presented to the operator by lighting up these buttons in the order they are to be pressed. By lighting up the buttons themselves, problems with associating a light with a different button are avoided.


Figure 10.1. Cause and Effect Device.

The output lights consist of the lighted buttons themselves as well as three indicator lights. A red light indicates that the operator has not successfully repeated the pattern. A green light indicates that the pattern has been repeated correctly so far. A large white flashing beacon serves as the 'big reward' if the operator successfully repeats the pattern four times in a row.

The controller for the Cause and Effect Device was selected to be a programmable logic controller (PLC). Several other projects have been designed using a microcontroller. Using a slightly different controller allowed comparing a PLC to these microcontrollers. A PLC is an off-the-shelf device, which will allow the operator to replace it in case of failure.

The PLC that was chosen is the Allen Bradley Micrologix 1000. This PLC requires 24 volts DC to power the relays and to operate on. This PLC contains six relay outputs and ten 24 volts inputs that are available for use. It has a memory limit of 1024 instruction words with an error of plus/minus 12%. The cost of the PLC was about $225 from Border States Electric.

By using a PLC, the circuitry for the Cause and Effect Device is trivial: the relay outputs are placed in series with power and the lights. By closing a relay, the corresponding light turns on. The button inputs are also easy to connect: the +24V is connected to the PLC's inputs in series with the buttons. A challenge was the programming of the PLC itself using ladder logic.

The programming of the controller using ladder logic was challenging. Four ladders (similar to four programs) are written to control the functions:

Ladder 1 (Level Select and Randomizer): This ladder activates the subroutines, randomizes the sequence of lights, and selects the levels. The level select switch activates the level select. When the level is selected, it activates a series of move instructions. These move instructions send different times and counts to the timers and counters. The randomizer consists of one timer that counts up to 17 counts in 17 sec and then resets and counts up to 17 again. When an operator presses the go button it grabs one of those 17 counts randomly, depending on the count the timer is on.

Ladder 2 (Flashing Light Sequence): The Light Sequence consists of 17 different sequences. This light sequence uses one timer and five bits in every flash and one delay timer. The timer in the sequence, times how long the light is on depending on the level selected. The five bits control a pulse to the counter, which counts the number of flashes and then shuts off the sequence.

Ladder 3 (Responses): The response consists of latches and unlatches, the latches latch when a correct answer is given and then trigger the next response depending on the order that the lights flashed in

Ladder 4 (Rewards): There are three types of rewards: correct light, wrong light and super light. The wrong light comes on after a wrong response. This light will come on for five seconds and then turn off, indicating a wrong response. The correct light comes on after a correct response that is triggered from the correct response counter discussed in ladder four. This light will also come on for five seconds and turn off, indicating the response was given for the sequence of lights correct. The super light also lights up both the wrong light and the correct light. This happens when the user gets four correct responses, and the lights will stay on for 10 seconds.

All together, these ladders contain 129 rungs and 1012 instructions words. This program maxed out our processor's memory.

***Results***

While using a PLC did work for this project a microcontroller would have been better. The initial design would have required 200 timers:, more simply achievable with a microcontroller using 200 bytes of RAM. The PLC, however, only had 40 timers, forcing us to simplify some of the light sequences. Second, the PLC had problems with latching and unlatching the button inputs. This problem was addressed at the cost of time and program space. A microcontroller could make this a trivial problem by connecting the buttons to interrupt lines. Finally, the memory available on a $225 PLC was taxed with a fairly simple task. A $5 PIC processor would have been able to do the same, although it could not be programmed in ladder logic. Considering the complexity of the program, a structured C program on a PIC processor would probably have been as easy to develop and maintain.

The total cost for this project was $508.00.

# VOICE CONTROLLED TV REMOTE

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## INTRODUCTION

A Voice Controlled TV Remote was designed, built, tested, and delivered. This remote control uses voice recognition technology to allow the operator to turn a TV on and off, select channels, and adjust the volume of a TV using voice commands.

## SUMMARY OF IMPACT

Through the use of this device, a person who has voice control but lacks motor control of his hands will be able to enjoy watching television better. This in turn will help him keep up-to-date on world events (through news programs), follow favorite sports teams, etc. Moreover, it will give this person greater autonomy, no longer depended on help from another person to operate the buttons on a remote.

## TECHNICAL DESCRIPTION

The Voice Controlled TV Remote was designed in two stages. The first stage developed a normal keypad controlled TV remote, and the second stage added an alternate voice input.

The TV remote was developed by using a PIC16F876 microcontroller to read several push buttons, and then drive an IR transmitter through a 555 timer. The infrared remote controls operate by transmitting a signal using pulses of infrared light. To keep various remotes from interfering with each other, a special set of codes have been designed that identify the make and model of television that is being controlled. For this project, signals were generated to operate a GE Model 13GP300 television. These codes were determined using reverse engineering: the signals from a working remote were recorded using an IR detector and an oscilloscope. The PIC was then programmed to generate like signals – verified by using the PIC to control the TV's operation remotely.

Once a working TV remote was developed, a voice input was added. This included a microphone, a wireless transmitter and receiver pair between the microphone and TV remote, and a voice recognition chip.

The voice recognition chipset used in the design, Voice Direct 364, proved to be an appropriate selection in voice recognition technology. The module came complete with all switches and components necessary and was easy to assemble. The manual included in the kit described the steps to train and use the system. Once constructed, the device was found to be easy to use and quite accurate. It was also found that interfacing the Voice Direct 364 with other circuitry was rather effortless. The following paragraphs explain how the Voice Direct 364 operates.

Voice Direct 364 performs speaker-dependent discrete word recognition by comparing a pattern generated in real time with previously trained word templates. The pattern generated by Voice Direct 364 is based on a digital reconstruction of the voice command. Each word to be recognized must first be

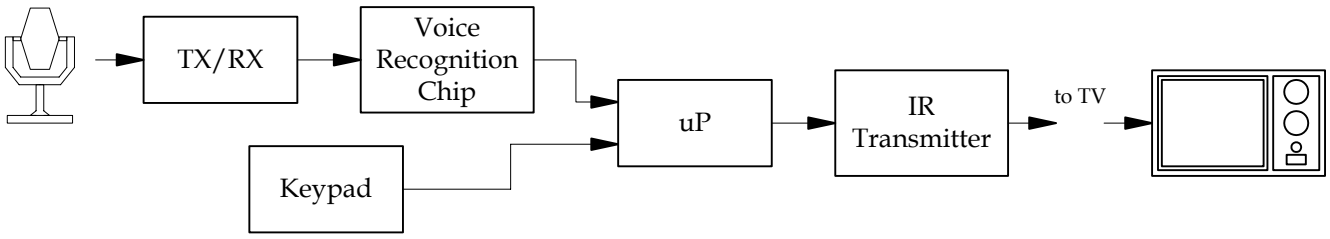


Figure 10.2. Voice Controlled TV Remote Components.

trained. During training, Voice Direct 364 constructs a template representing the individual speaker's unique sound pattern for each specific word or phrase to be recognized. Templates are stored in serial EEPROM memory. During recognition, a new pattern is produced and compared to the stored templates to determine which word was spoken.

The total cost of this device was $430.

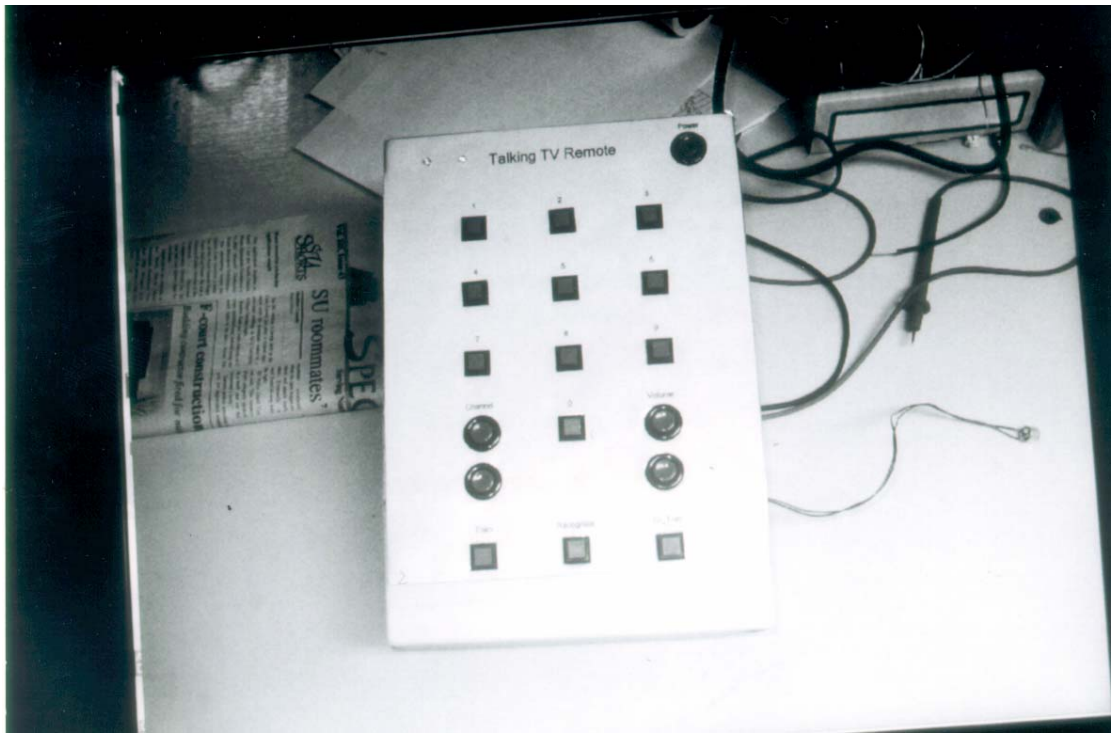


Figure 10.3. Voice Controlled TV Remote.

# SPEAKER VOLUME DISPLAY

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## INTRODUCTION

Without the ability to hear well, hearing impaired speakers are unaware of noise levels. Hearing background noise allows people to adjust their conversation level so they are not shouting in the library or whispering at a loud concert.

For a person who has normal hearing, the intensity of his or her own voice can be self-monitored in the context of background noise. Typically, when a person talks, he or she gets feedback from the listener as to whether speech is too soft or too loud.

The goal of this project is to create a device that will assist individuals with hearing impairment in adjusting their voices to the level of room noise. This device must be discrete so as not to draw attention to the user.

## SUMMARY OF IMPACT

This device will give a speech–language pathologist a tool to help patients learn how loud they should talk in different environments. By simply looking at a display, they can judge how loud the background noise is as well as how loud they are talking.

## TECHNICAL DESCRIPTION

Two units were developed for this device: a base unit that monitors the background noise and displays both the speaker's voice intensity and the background noise, as well as a handheld unit that monitors the speaker's voice. The base unit contains the background noise microphone, a Panasonic

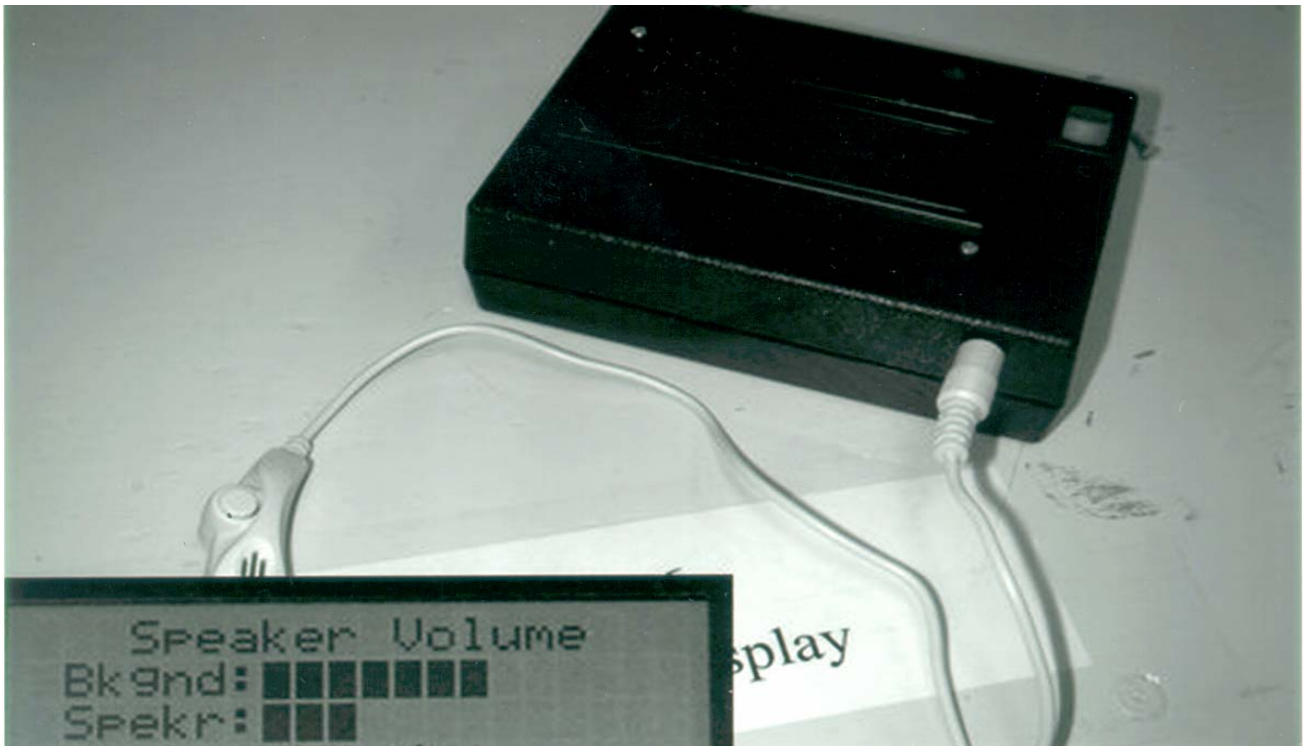


Figure 10.4. Speaker Volume Display.

WM-60AY. The speaker's unit contains a lavaliere omni-directional microphone. Signals from both microphones are passed through a 200Hz - 12kHz band-pass filter. These signals are then rectified and low-pass filtered with a one Hz cutoff frequency. The magnitude of this rectified signal is then proportional to the sound level detected by each microphone. This level is monitored with a 10-bit A/D using a PIC16F876 microcontroller. This microcontroller subsequently drives an LCD display, with a bar chart indicating the volume of the corresponding signal.

The goal for the speaker is then to make the voice bar match the length of the background bar.

A nine-volt battery, which powers the unit, is specified to provide 595 mA.hrs. The Speaker Volume Display draws 25 mA of current. Therefore a simple calculation shows that the system's battery life is approximately 24 hours.

The Speaker Volume Display was tested from 30 dB to 90 dB in the controlled environment of a concert. Thirty decibels is the noise level found in a very quiet room, although most quiet rooms contain noise levels of 40 decibels due to fans and other noises. Ninety decibels is a very load environment comparable to what may be found at a loud concert or bar. One potential concern was that the device may be overloaded in the upper decibel ranges and the device would be rendered useless. However, testing revealed that the device will not overload in tests up to 90 dB.

Real world tests were also carried out. One was at a local establishment meant for recreation and revelry. This was a good test of the loud background range, in this case at or above 80dB. This real world test results were similar to those in the controlled testing. The device gave excellent feedback to the user if there was a need to talk louder.

Another real world test was done late at night at a bar with loud background noise as indicated on the LCD display. Overall, the display worked well in quiet and noisy environments.

The total cost of the speaker volume display was approximately $210.

# ARCHERY AIMING SYSTEM

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## INTRODUCTION

A device allows an individual with quadriplegia to perform the acts of aiming and firing a crossbow using simple controls. The device will allow the user to aim a crossbow in the x- and y-axis directions; when the crossbow is pointed at the desired location, the user will then be able to fire the arrow. The device has a targeting system so that the user will be able to see where the crossbow is pointed without being directly in the line of sight.

An aiming and firing device was created to be compatible with a normal crossbow. A micro-controller was used to read a program that will allow the user to aim and fire the bow. The PIC controls the motors in the stand, operating them at a slow speed. A LCD or LED visual display of arrows (left, right, up, and down) shows which way the bow is moving. A Jelly Bean pressure switch or joystick will allow the user to choose which direction they would like to move the bow. Once the bow is aimed properly, the user will be able to fire using the same controller.

## SUMMARY OF IMPACT

The recipient has had quadriplegia since a car accident six years ago. Since then, she has defied doctors' predictions by learning how to talk, how to eat with the help of others, and even how to use a computer on her own. In order to become a more independent, the client would like to be able to again participate in some of the hobbies she enjoyed before her accident; one of these activities is archery. Currently there are many archery systems to aid people with paraplegia or quadriplegia. Unfortunately there are currently no devices to help people with C-2,3 quadriplegia. The goal of this project, using ideas from systems already available, is to design a system that will allow the client and other individuals with quadriplegia to aim and fire a crossbow utilizing a minimum number of inputs.

Figure 10.5. Archery Aiming System.

## TECHNICAL DESCRIPTION

To operate a crossbow as shown below, the operator must be able to aim the crossbow, turn off the safety, and fire the crossbow. In addition, the crossbow must be mounted to a stand with the servo motors controlled by the operator.

### *User Controls*

An off-the-shelf operator interface called Jelly Bean was selected as the best option for the user's input. This is mounted onto the wheelchair utilizing a home-made telescoping arm.

### *Visual Display*

The visual display consists of an array of color-coded LEDs. As seen in the panel display diagram, Figure 10.6, the colors of the LEDs correspond to the different functions of the device. The PIC logic controller is mounted on the same circuit board as the panel display. The PIC was chosen due to its ease of use and familiar programming.

### *Stand*

The panel display is connected to motors located on a tripod stand. A motorized pan head (Bescor

Model MP-101) is attached to a tripod and used to move the crossbow in the horizontal and vertical directions. The pan-head can be removed from the tripod for easier portability. Also, the pan-head has its own separate power source consisting of four AA batteries. A tripod was chosen as the stand because of its ease in setup and portability. The tripod chosen was the Bescor Medium Duty Fluid Head Model TX-25. This model is rugged and durable enough to withstand normal environmental pressures. The tripod includes rubber feet and leg spikes for a sure grip on most surfaces. The mount on the top of the tripod will need to be modified in a way so it can hold a crossbow.

### *Visual Aiming*

A laser was chosen for the visual aiming aspect of the system. Since the crossbow is to be mounted to the side of the user, and since the user has limited head movement, an aiming device is required. The laser will allow the user to see where the arrow is being aimed at on the target by watching the projected laser beam. The type of laser chosen is a BSA weaver-mount laser Model LS650 and has its own battery power supply.

### *Solenoid Trigger*

A pneumatic solenoid switch controls the firing of the crossbow. It is attached either to the stock of the bow or to the mount of the tripod depending on the model of crossbow given to work with. Once the pneumatic solenoid is energized, it will allow air pressure to depress the trigger, therefore operating the release and firing the arrow. The 6V DC linear solenoid was not used since it could not generate the six pounds of pressure required to depress the trigger of the crossbow.

### *Power Supply*

Most of the major components used in the aiming and firing device (i.e. the pan-head and laser) come with their own power supply. The only other components that require a dedicated power supply are the circuit board and the PIC controller. The PIC microcontroller requires a power input of five VDC, which is provided using AA batteries. This power supply is located in the user panel with a removable section on the casing where the batteries can be interchanged. The solenoid needed to depress the trigger on the crossbow requires a source of 24 VDC. The source used to provide this power is the two 12 VDC batteries used to motorize the user's wheelchair.

### *Operations*

The assembly of the crossbow begins with the stand. The stand must be extended to the height the user wishes to use it at and then be locked into place. Once the stand is set up, the pan-head is attached to the top of the stand by flipping the black lever outwards and then releasing the lever so the pan-head is securely in place. After this, the air cylinder unit is placed on top of the pan-head and screwed securely in place by turning the round disk-like lever. The crossbow is now ready to be put on top of the air cylinder unit. The crossbow slides into place using the two pegs on the surface air cylinder unit. The user interface (LED screen) is attached to a telescoping arm that is then attached to the user's wheelchair. The Jelly Bean is then attached to a telescoping arm, which is adjusted to the user's cheek. The Jelly Bean and air cylinder unit are attached to the user interface through their proper cords. The motor's cord is attached to the pan-head and then to the user interface. The air cylinder is powered by the 24 VDC source on the user's wheelchair through another cord. The stand and crossbow should be set off to the left of the user. The system is now ready to be used.

To begin the program, the on/off switch is turned on, which allows power to flow to the circuit. The LED lights are initially off. The mechanical safety on the crossbow may be set to fire position once the user is ready to use the system. Once the user has pressed the Jelly Bean, the initial LED sequence begins; the AIM light turns on and then off, followed by the SAFETY light turning on and then off. This sequence is continued until the user either chooses AIM or SAFETY. Once the user has chosen AIM, the directional arrows, UP, RIGHT, DOWN, LEFT, and EXIT toggle on and off in the previously mentioned sequence. The user may then choose a direction to aim the crossbow by depressing the Jelly Bean when the correct LED is lit. The crossbow will then move in that direction until the Jelly Bean has been pushed again. After the aiming in that direction is complete, the directional LED sequence will automatically start with the EXIT LED again. If the user wishes to leave the directional sequence, the Jelly Bean is to be pushed when the EXIT LED is lit. This will take the user back to the AIM/SAEFTY sequence. The user may then go to AIM again or may choose the SAFETY LED which will take the user to the FIRE /EXIT mode that allows for extra safety when preparing to fire. This way, the user must push the Jelly Bean to either FIRE or EXIT, in this sequence.

The EXIT will take the user back to the AIM /SAFETY sequence while pressing the Jelly Bean when the 'FIRE' LED is lit will fire the crossbow. Once the crossbow has been fired, the sequence is stopped and the Jelly Bean must be pushed in order to start the AIM/SAFETY sequence again.

The total cost of this device was $429.


Figure 10.6. Panel Display.