CHAPTER 15
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UPDATED ASSISTED MUSICAL LEARNING DEVICE

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INTRODUCTION

The Assisted Musical Learning Device (AMLD) is an electronic device that combines both musical and educational applications, and is specifically developed for a child with cerebral palsy. However, the AMLD can be used by any child with a learning or physical disability. The inspiration for designing the AMLD arises from the desire to provide individuals with disabilities an opportunity to improve their academic skills and musical creativity.

The AMLD provides three things. The first is to give the client the enjoyment and satisfaction of playing a musical instrument. Second, it acts as a learning tool with which the client has the opportunity to recognize and learn some of the most basic educational fundamentals. Third, the AMLD acts as a form of exercise by developing good hand-eye coordination skills and strengthening the muscles in the arms by performing small movements required to operate the device.

The AMLD can be operated as either a musical instrument or an educational device. When in its musical mode, the AMLD produces five different piano sounds and drumbeats. When operated in its educational mode, it gives an audible output response of the alphabet, the number system, and of five different shapes.

SUMMARY OF IMPACT

The updated Assisted Musical Learning Device is an electronic device that combines musical creativity and educational applications into one. The AMLD allows a person to play a musical instrument, and makes learning basic hand and eye coordination skills through a unique control panel an enjoyable experience.

Figure 15.1. External Features of the AMLD.

TECHNICAL DESCRIPTION

The AMLD utilizes 52 large descriptive console control buttons measuring approximately 3.5 inches by 3.5 inches. The large size of the buttons act as larger targets offering the client greater ease of use compared to like devices currently on the market. The buttons can be removed and replaced by the other buttons corresponding to the alphabet, numbers, shapes, and/or musical buttons. Fig.15.1 displays the external features of the AMLD.

The original design of the AMLD suffered malfunctions due to certain electrical and mechanical problems. A peg system attached to each of the 52 buttons was used along with five ISD chips in order to output the corresponding audible sound when each button was depressed. The AMLD now incorporates wireless technology, optical bar code readers, and a microcontroller. A single, more advanced ISD chip that holds and stores more memory has replaced the five ISD chips. The main component or 'brain' of the AMLD is a micro-controller that coordinates the sensors, compares inputs with reference data, and sends a final output to the ISD for the audible sound.

The AMLD was originally designed for a child with cerebral palsy. The child's parents and/or therapist aids the client using the device by pressing one of five buttons on a wireless remote control (consisting of a Transmitter, TXM) corresponding to one of the five buttons on the device's console (as indicated by the lighting up of the red circles on Fig.15.1). When the operator presses the button on the remote, the appropriate control button lights up (a letter, number, shape, or musical sound), requesting the child to press the specific button. When the button is pressed, an assigned bar code is detected, and the corresponding functions occur to display the final audible output. The educational mode is implemented by using control buttons that display the alphabet, the number system, or five different shapes. The musical mode can use the same buttons, but the audible output is five different piano or drum sounds rather than a number, letter, or name of a shape. Whichever mode the client wishes to use, however, the AMLD operates in the same way.

The interchangeable control buttons in the AMLD combine to perform a digital logic meaning of each of the 26 letters, 11 numbers, 5 shapes, and 10 musical sounds. When depressed, optical reflective sensors determine logical input unique to each of the above mentioned designed buttons. Binary logic is programmed in a PIC16F877 micro-controller and the output goes into an Audio Voice Detector or ISD chip. In order for the signal to be heard clearly, LM386 amplifiers, along with two speakers, are used in the device.

Because of the large number of control buttons, each button is given an eight-bit binary code for identification. The eight-bit binary code is given by using a special black and white sequenced tape that can be detected by the sensors, OPB606A. When a single control button is pressed, the binary sequence makes contact with eight sensors, each detecting a single bit of the corresponding eight-bit sequence. The output of each sensor is then connected to the input of an amplifier, LM386 to amplify the signal.

Once a button has been pressed and the eight-bit signal has been detected, an eight-bit sequence is sent from the operational amplifiers to the PIC16F877 micro-controller. The PIC16F877 has 8192x14 words of FLASH program memory, 256 data memory bytes, 368 bytes of user RAM, and an integrated eight-channel 10-bit Analog-to-Digital converter. This component of the AMLD is in charge of acknowledging that a button has been pressed and identifying the eight-bit binary sequence corresponding to the pressed control button and whether it is the correct choice. Once the micro-controller has detected the signal and arranged the sequence, it then sends the eight-bit sequence out to an Integrated Signal Detector, ISD 1110. The ISD's record and playback features convert the digital output micro-controller to an analog signal that lasts for 10-second duration. The ISD 1110 chip then recognizes the sequence and stores it in an eight-bit address. The output from this chip is then amplified and played as an audible sound, allowing the client to enjoy its educational as well as its musical characteristics. A schematic of this action is shown in Fig 15.2 below. The total cost is approximately $500.
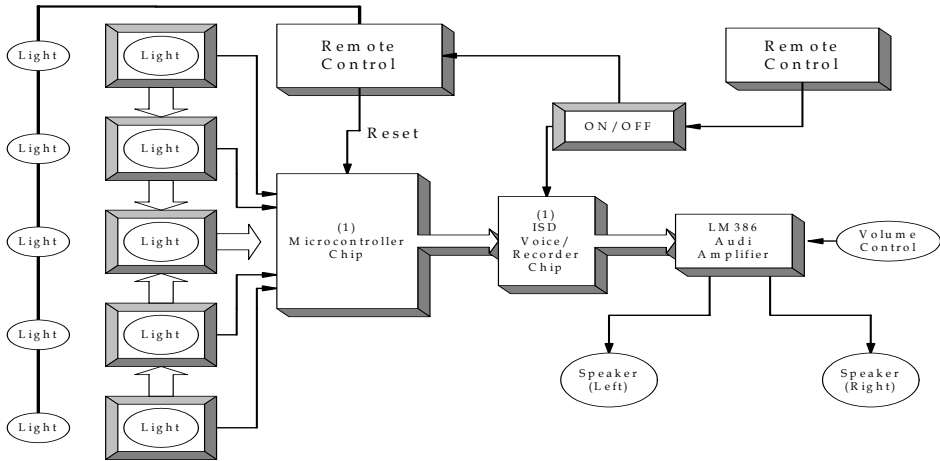

Figure15.2 – Block Diagram of AMLD.

VOICE REGOGNITION MODULE FOR VOICE ACITIVATED ELECTRONIC GRIPPING DEVICE

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INTRODUCTION

The E-Grip grasping device enables its user, who has limited manual strength and dexterity, to grip implements with handles. The gripping element provides the additional strength needed to perform these actions. The glove is voice activated and user specific. It works on four basic commands, which open and close the glove and make it very easy to operate.

SUMMARY OF IMPACT

This device is designed for a client who has weakness on the left hand side of his body due to a stroke. The client desires to partake in activities that he can no longer perform including golf and yard work. This device allows the user to selectively activate the glove by voice command in order to produce a variety of grip strengths. This device makes it possible for the client to become more independent.

TECHNICAL DESCRIPTION

The E-grip is a five-digit exoskeleton glove that facilitates a full range of motion from the fingers to the wrist. Two externally mounted stepper motors controlled by a microcontroller provide power for this motion. The motors facilitate motion by either extending or retracting a thread that is woven into the fingers of the glove. The glove used for the E-grip is a leather sport glove, similar to a golf or batting glove. The E-grip has four different levels of grip, which allow the user to manipulate the strength of grip needed. All of the actions are controlled by a voice control module, which can store up to 15 words or phrases. The module is speaker dependent, which allows only the user the ability to activate and deactivate it.

The voice recognition system used for the E-Grip is a VOICE DIRECT 364 IC speech recognition kit. This
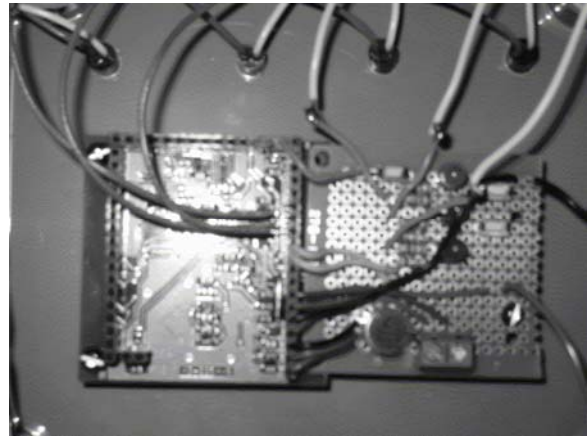

Figure 15.3. Voice Control Module.

kit contains a speaker dependent module, an omnidirectional electret microphone element, and an external speaker. The functional capability of the IC is determined by the configuration of specific I/O pins. The pin inputs (-TRAIN, -CL TRAIN, and –RECOG) generate the specific pin outputs and actions. Each word that is to be recognized must first be trained. During this training, the VOICE DIRECT system builds a template representing the individual's unique sound pattern for each word. The templates are then stored in the serial EEPROM. During recognition, the new pattern produced is compared to the stored templates to determine which command was spoken.

After the voice control module has been trained, speech recognition is accomplished through several steps. First, the signal from the external microphone is amplified and filtered to the analog inputs, which converts the analog waveforms to digital samples. The VOICE DIRECT 364 then generates a pattern of information, representative of the significant speech elements. Using a neural network, the pattern is then compared to existing patterns in the serial EEPROM. After a small number of candidate

templates are chosen, they are further processed to determine which one is the best match. If this match gives a score over a predefined threshold then the recognition system chooses the word associated with that template. The associated output is then produced and gives the signal for the microcontroller to perform a specialized action.
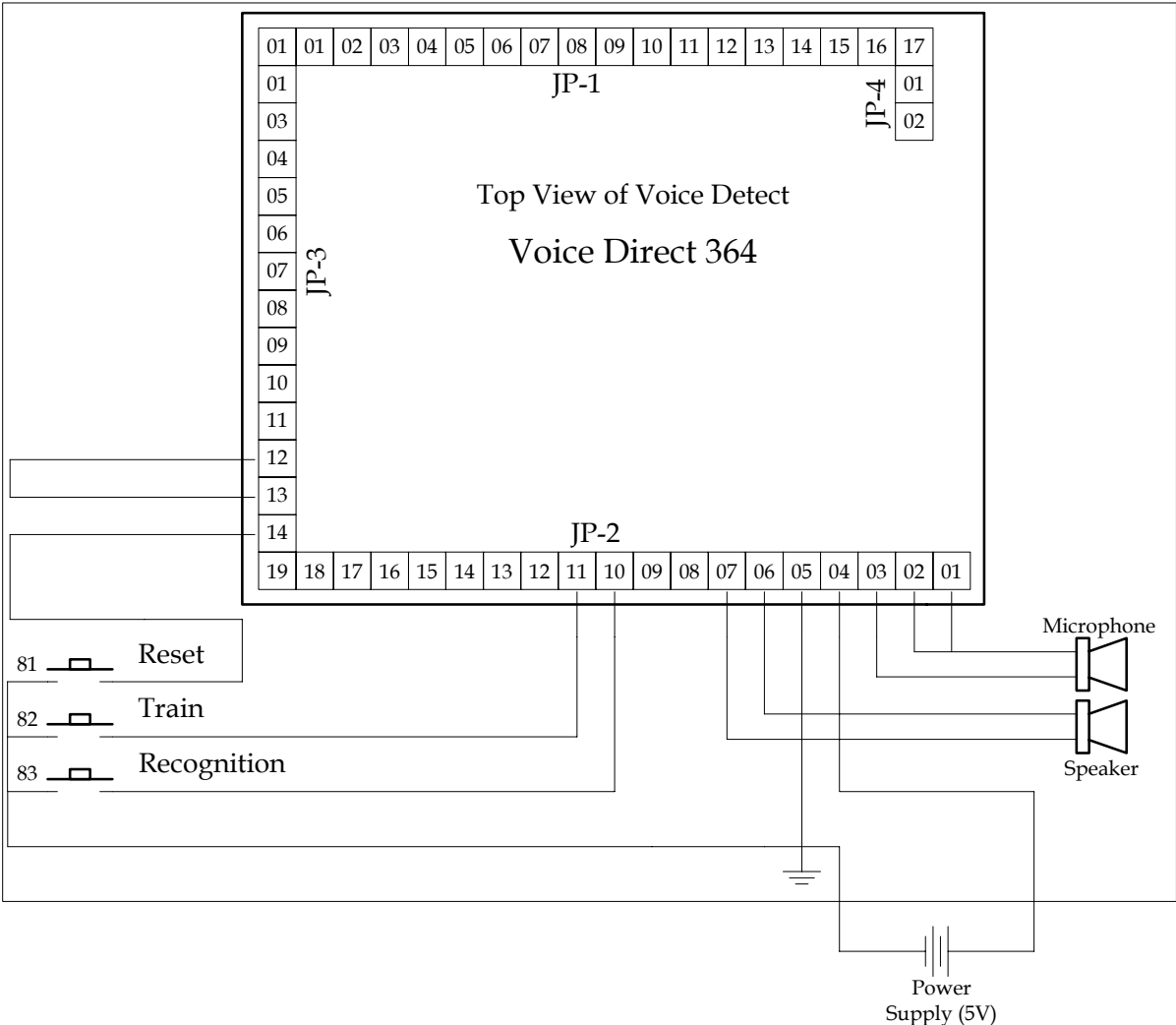
The cost of this part of the project is about $50.

Figure 15.4. Module Stand Alone Schematic.

VOICE ACTIVATED ELECTRONIC GRIPPING DEVICE

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INTRODUCTION

The E-Grip is designed for persons who are not able to fully grasp and release objects. It is intended for someone who has had a stroke and wishes to participate in activities such as golf, yard work, or simple household chores. The glove performs four functions, designated by the client's voice. The commands are loose grip, tight grip, open, and off. These choices allow the wearer to designate the force of the grip depending on what he or she wishes to grasp. The E-Grip facilitates a full range of motion of the fingers and wrist in a natural manner.

SUMMARY OF IMPACT

This glove is designed to replace an existing device devised for a client who had a stroke. The client has limited movement and strength in his left hand and has trouble gripping devices with handles. The E-Grip allows natural movement of the hand and will make it easier to grip objects without manual strength. This glove grants the client independence in performing everyday tasks.

TECHNICAL DESCRIPTION

The glove itself is a leather sport glove such as a golfing glove or a batting glove used in baseball. It is lightweight and has tiny ventilation holes to prevent the hand from sweating. The original design included Shape Memory Alloy actuators but, due to limited resources, clear fishing line was used instead. Two strands of the line are threaded through the holes in the glove- one strand for the top motor and one for the bottom motor. The separate strands are gathered at the end and tied to a washer on the individual stepper-motors. The motors are securely placed in a stretchy band attached to the glove. Relative to the arm, they are just above the wrist area on the top and bottom of the forearm.
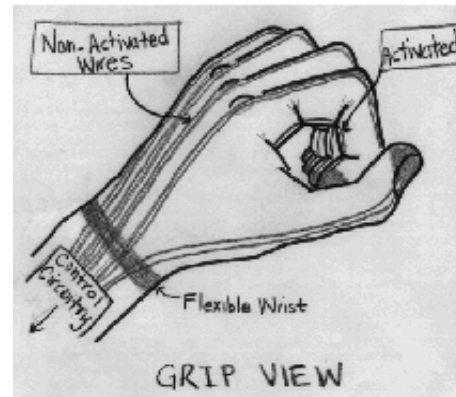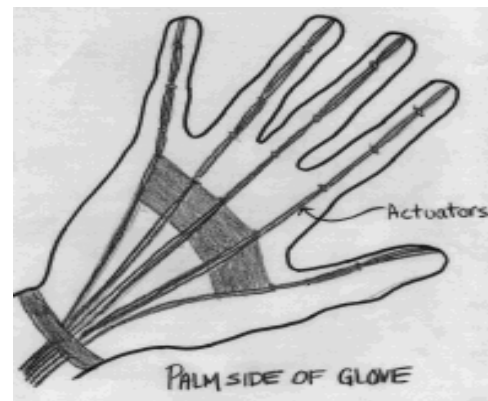

Figure 15.5. Top view of closed glove assembly.

Figure15.6. Bottom view of open glove assembly.

All components of the E-Grip are controlled by the microcontroller. The microcontroller receives its command from the voice control module. The output from the microchip is sent to one of the motor control chips, depending on the necessary action. These stepper-motor drivers consist of 16 pins, and the inputs are compatible with CMOS and TTL circuits. The drivers are capable of disabling outputs in case the temperature exceeds that of the chip limit.

The three inputs are the square wave that controls the frequency, the input that turns the motors on or off, and the direction input that controls which way the motor turns. The output current would ordinarily go from here to the motors. The drivers do not, however, supply the current needed for operation of the grip, so an amplifier must be added. Once the current is increased, it can then power the motors. A schematic of the stepper motor driver chip is shown in Fig. 15.7 below with its interaction with a stepper motor drive shown in Fig. 15.8.
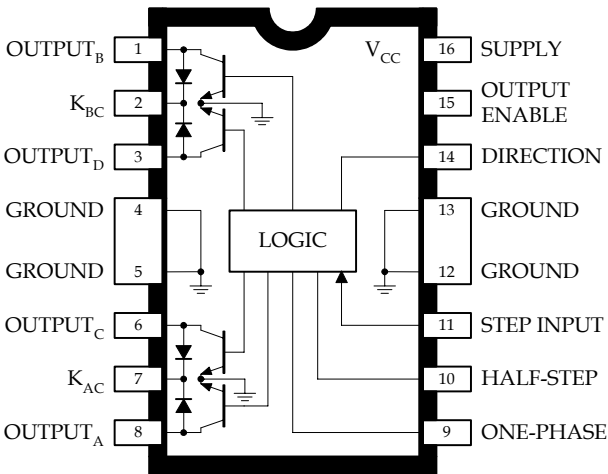
The cost of this portion of the project is about $250.
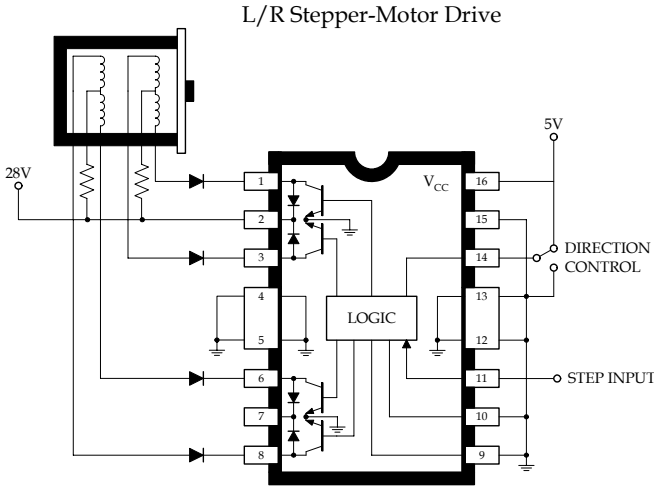

Figure 15.7. Schematic of Stepper Motor Driver Chip.

Figure 15.8. Stepper Motor Driver Chip Layout.

HEAD CONTROLLED WHEELCHAIR

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INTRODUCTION

The LED Head Directed Motorized Chair is designed to assist a client with cerebral palsy. The wheelchair uses an LED display panel in coordination with a head switch as a control apparatus to drive the wheelchair under the control of the client. This design uses a microcontroller to coordinate sensor information and to enable the motor driver circuits. The client depresses the head switch when the appropriate direction on the LED display appears, thus engaging the motor driver circuit. The motor circuits consist of two, pulse width modulators that control forward or reverse direction, and speed of the motors. These are the central drive circuits that control the motor direction.

SUMMARY OF IMPACT

This design differs from other motorized wheelchairs in that, unlike other control systems that use joysticks for control, this uses a head switch/LED display for movement. This design is suitable for all persons, including those with cerebral palsy, who have little to no control of their arms and hands.

TECHNICAL DESCRIPTION

The Microcontroller circuit consists of a Microcontroller, five LEDs, five pre-LED resistors, a head switch port, and two operational amplifiers. The microcontroller is the backbone of the design. The PIC used in this application is a 16C74a microcontroller, and its timer is set to produce 30 direction options per minute. The controller is used to integrate the head switch/LED display circuit to the motor circuits.

Two motor control circuits control the motors of the wheelchair. The basis of these controllers consists of a pulse width modulator. This circuit directs the motors by using forward and reverse biases. The device implements two motors, and each motor controls an individual wheel. The motors are
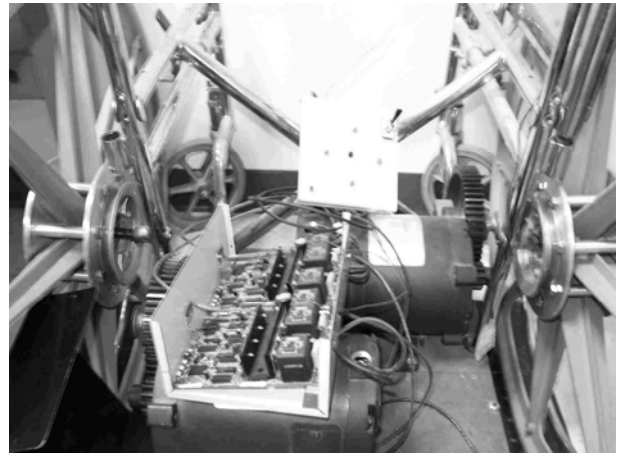

Figure 15.9. Motor Drive Circuit and LED Display.

connected to the wheels by a gear/V-belt motor drive system. Two power supplies power the entire electrical system. The entire system is placed under the wheelchair.

A pulse width modulation circuit drives the motors. The main function of this circuit is to drive the motors in a forward or reverse bias direction utilizing an H-bridge circuit. Typical H-bridge circuits use MOSFET's for biasing. However, since this device requires such a high current draw, relay switching is used. Two operational amplifiers are used at the output of the PIC microcontroller to increase the magnitude of the PWM waves. The peak-to-peak PWM outputs that come directly from the PIC are too small to be used for the motor control circuits.

The head switch port is used as a means to input connect the head switch to the PIC microcontroller. It is a common jack used with most headphones.

The LED display has five directional options [forward (F), backward (B), left (L), right (R), and stop]. The five LEDs are used as a visual aid to assist in movement control. Four green LEDs are designated for the FORWARD, REVERSE, RIGHT,

and LEFT directions and a red LED is used for stop. The circuit uses five pre-LED resistors of 630 ohms for voltage and current regulations. The display is controlled by the PIC microcontroller. When the direction that the client desires to travel is illuminated, the client compresses the head switch and the chair performs the desired action. During the action, the LED display remains on stop until the head switch is compressed showing that the action that is being performed wants to be ended. Every other option in the sequence is stop for precautionary reasons.

For this specific design, it is necessary to use a program that integrates two independent programs. The first consists of the directional LED cycling and the second implements the motor control outputs. These two programs are linked by the compression of the head switch.

The first part of the program is needed to control the directional LEs. It is in charge of the LED cycling through output pins D0-D4 of the PIC microcontroller. The order in which the lights cycle are FORWARD, RIGHT, LEFT, and BACKWARD. This process continues until the head switch is pressed. The head switch is the only input to the system and uses pin D5 of the microcontroller. The primary purpose of this is to notify the controller when to switch programs (either to toggle through the LEDs or to control the motor drive circuits).

The second part of the program is implemented when the head switch is compressed in LED cycling mode. The STOP LED is illuminated and remains so until the head switch is compressed again. Then, depending on which LED was illuminated when the head switch was pressed, outputs are sent to the two motor control circuits, which in turn control the movement of the motors (FORWARD, REVERSE, or no movement). This control is done via duty cycles. There are two PWM outputs on the PIC 16C74a controller. Due to independent wheel movement

(specifically for left and right turns), two outputs are needed. The microcontroller outputs duty cycles of 25 percent for forward motor movement, 50 percent for no movement, and 75 percent for reverse motor movement. The motors are mounted in opposite

Figure 15.10. Head Switch.

directions, so for FORWARD movement, one motor will need to go forward while the other goes in reverse. Opposite motor movement is necessary to go REVERSE.

The LED display lights the directions the chair travels. When the desired direction the client wishes to travel illuminates, the user compresses the head switch. The control circuit reads input and then outputs information to the motor circuits. The motor control circuits then forward or reverse biases the motors. The motor drive system connects the motors to the wheels of the chair, which turn according to the direction the motors are programmed to run.

The cost of this project is about $1150.

MULTI REMOTE COFFEE MAKER

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INTRODUCTION

The Multi Remote project is a device that automates the process of making coffee. Although there is a wide market of coffee makers that can be bought in most stores, there are few total automated coffee makers that are available for private use. Commercial use on automated coffee machines can be seen in the form of a vending machine; however, a compact version of such is not commercially available. The Multi Remote coffee maker serves as a means for the average person to have the advantage of the conventional automated coffee vending machine from the comfort of home. The Multi Remote Coffee Maker is illustrated in Fig. 15.11.

SUMMARY OF IMPACT

The Multi Remote Coffee Maker can be a valuable tool to the lives of many people. The coffee maker helps persons with motor control problems who may not be able to coordinate the process of adding the ingredients needed to make coffee. The machine can help physically people who might have a difficult time gathering all the elements needed to produce a cup of coffee.

TECHNICAL DESCRIPTION

The coffee maker can be broken down into two macro systems: one to distribute the proper amount of dry ingredients and one to heat and add the correct amount of water.

The ingredients the coffee maker distributes are instant coffee, powdered cream, and sugar. The dry ingredients are respectively stored in three cylinder bins at the top of the coffee maker labeled accordingly. Under the three cylinders is a platform that contains discs that rotate and drop a specific amount of that ingredient to a funnel, which then drops it into the cup. Three stepper motors power the discs. The motors are controlled by a series of integrated motor control driver chips.

Figure 15.11. Multi Remote Coffee Maker.

For brewing of water, the user must connect a water supply at a valve via a ¼ inch diameter hole. The water supply can either be standing water that is placed above the coffee maker or a pressurized source. From the input valve the proper amount of water flows in the heating container. The heating container is an insulted cup with a heating coil and a thermistor placed in it. The coil heats the water; the thermistor and a coordinating temperature controller monitor the temperature. At the desired temperature, the coil is turned off, and a second valve is opened to let the water flow from the heating container to the cup.

The two sections are controlled by a PIC. The initial inputs to the PIC come from a remote that is hard wired to it. The input to the PIC is the desired amount of dry ingredients that the user wishes, varying from no sugar and cream to very sweet and light and all combinations in between.

Total cost for the project is $319.11.

MULTI REMOTE AUTOMATED BLINDS

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INTRODUCTION

The automated blind portion of the Multi Remote project electronically controls a set of blinds through the use of a motor.

SUMMARY OF IMPACT

Along with the other parts of the Multi Remote project, the Automated Blinds is a tool that eases the tasks of the everyday user.   This product is especially useful for those who have a problem gripping pull cords that operate blinds and/or curtains.   This condition might result from arthritis, carpal tunnel syndrome or a number of other disorders.

TECHNICAL DESCRIPTION

The motor is activated by simply turning the toggle switch (shown on the right in Fig. 15.12) to the on position. If the switch on the motor is already in the on position, the user must turn it off and then back on to reactivate it. The blinds will move up or down depending on the position on the actuator and continue in that direction until it reaches its fully open or closed state. If the user desires the blind to go in the opposite direction that it is set to go, he or she must push the actuator switch to the opposite side.   To turn stop the blind in any position in between, the user simply turns the switch off at the desired location.

Referring to Fig. 15.13, the stop switch 2c is similar to a light switch, however it only stops the motor. This switch cannot start the motor. The stop switch
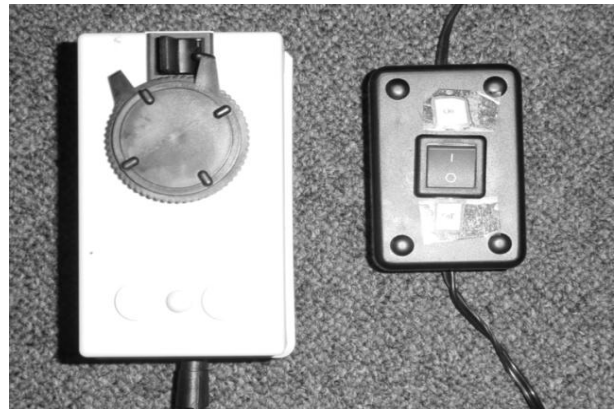

Figure 15.12: The Multi Remote Automated Blinds Controls.

is operated automatically by actuators 2a and 2b. It can also be operated by hand. When the motor runs, one actuator moves towards the stop switch while the other moves away. When the actuator pushes the stop switch from one side to the other, the motor stops. After the motor stops, the motor will not run again until power is turned off for at least two seconds, and then back on.   When the power is turned back on, the motor runs in the opposite direction until the other actuator moves the stop switch. The user adjusts the actuators closer to or farther away from the switch to set desired open and closed positions.   The user starts by setting both actuators close to switch 2c as shown.
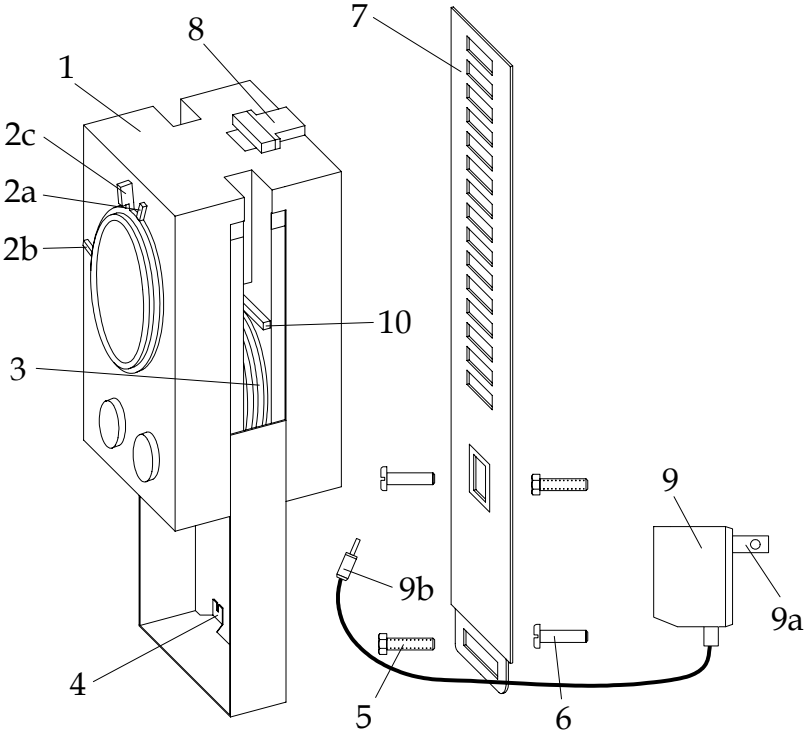
Components

1.	Housing
2a.	Actuator (Tipped)
2b.	Actuator (Flat)
2c.	Stop Switch
3.	Drive Wheel and Grove
4.	Safety Shield and Interlock Peg
5.	Wall Screws (2)
6.	Wall Anchors (2)
7.	Wall Bracket
8.	Lock
9.	AC-DC Adapter
9a.	AC plug
9b.	DC plug
10.	Bar

Figure 15.13: Mechanical Schematic of Control Device.

ELECTRIC GROCERY TRANSPORTER

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INTRODUCTION

The couple who use this device are elderly and, although generally healthy, requested an elevator of some sort to help them bring groceries into their house. This elevator would prevent them from having to carry their groceries (or other items) up a short flight of stairs. The proposed location for this device is in the garage of their house with the elevator lifting groceries up to a higher level, about eight feet above the garage floor.

This project entails the design and implementation of an electrical grocery lift for loads up to 150 pounds. The completed Electric Grocery Transporter is shown in Fig. 15.14. The device is essentially a reinforced metal plate attached to a set of wheels, which glide along two vertical rails. The lift is controlled by one up and down switch and two limit switches, which engage when the lift has reached the end of the rails.

SUMMARY OF IMPACT

The Grocery Transporter enables the clients to raise heavy objects into their house.

TECHNICAL DESCRIPTION

The Grocery Transporter is installed in the clients' garage. The Transporter requires ascending and stopping at an exact level of the top ledge of a three-foot wall in a raised foyer at the entrance to the main portion of the house. The lower limit places a loading box at a height of three feet off the garage floor; this configuration leaves a total travel distance of about six feet. Also, since the house is modular in its construction, the main sill the modular unit rests upon is midway of the travel of the device and inaccessible, requiring that all electrical conduits, etc. be mounted on the outside of the wall.

The mechanical design centers on a winch-pulley system wherein a winch raises a dolly up or down a vertical track. The track is mounted in a vertical

Figure 15.14: The Grocery Transporter.

position on a wall using one-inch thick veneered plywood acting as a medium to ensure solid attachment of the tracks. The track is fabricated from standard channel normally found in overhead sliding doors. These two channels are set at a certain gage sufficient to allow free motion of the completed dolly, in this case, about two feet. Through these channels, the dolly traverses on four sets of double wheels. Consideration is given to ensure these wheels do not bind since they are originally manufactured for overhead use in the above-mentioned tracks. Attached to each pair of wheel sets is a one-inch by three-inch aluminum bar. These two assemblies are attached to each other using equal angle aluminum channel. The length and setting of these two members determine the gage of the track.

A plate, manufactured with ¼ inch thick aluminum, is attached to these two cross members via two triangular shaped members. On top of the plate, a wooden box is attached. This wooden box has a front and rear door allowing easier access. Ribs are installed inside this box to prevent young children from using the Grocery Lift as a ride.

Power to raise and lower the dolly is provided by a Dayton Winch capable of providing a one-ton force. The particular winch used operates on 120V house current. This configuration is used to avoid the cost of a transformer and ancillary circuitry required to step down to 12 VDC, a more typical configuration

for hoisting winches. The winch utilized winds its cable on a spool using a gear motor with gearing aligned so the winch can rest within the gage of the track. The wire rope from the winch passes under the dolly and thru a pulley mounted on the wall at the top of the track. The pulley also has a planetary pulley mounted above it to prevent the wire rope from falling off during operation. The wire rope is then attached to the dolly using a hook and eyebolt. The wire rope configuration is a simple pulley system; there are no compound pulleys attached.
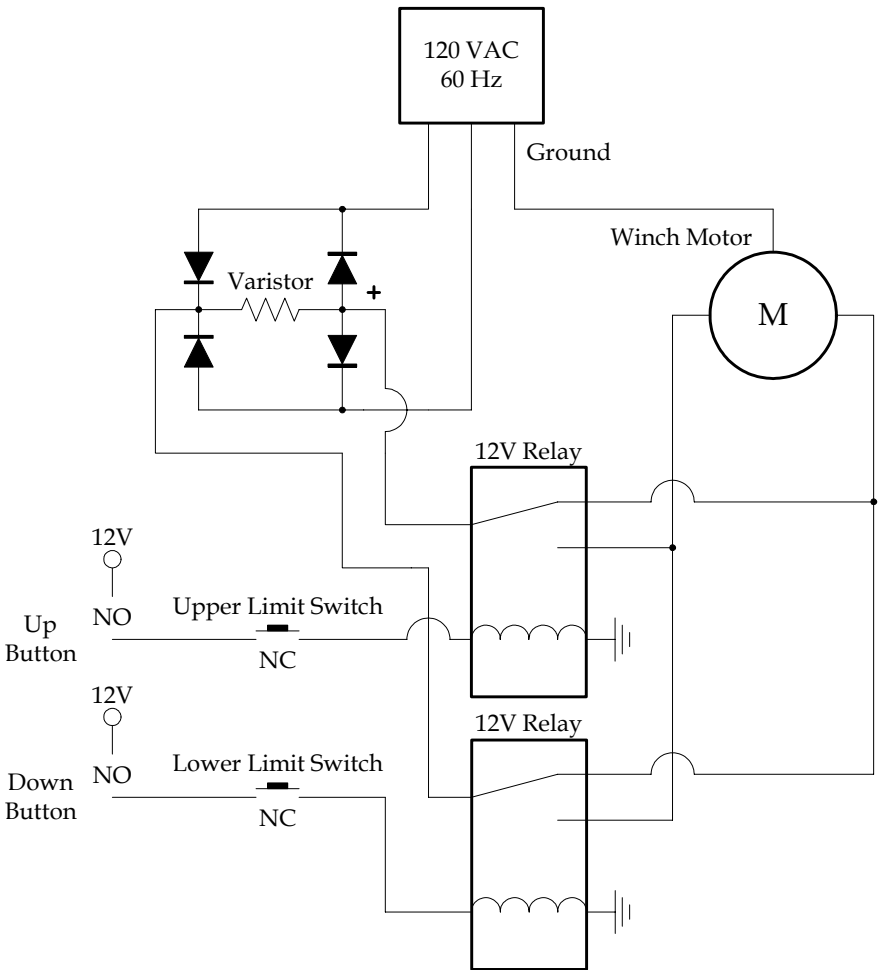

Figure 15.15: Schematic of Grocery Transporter Electrical Circuit.

The circuitry that controls the Transporter consists primarily of two relays and two limit switches. Power is supplied by 120V AC house current. One relay circuit of the bidirectional winch controls ascent movement with the second relay circuit controlling descent. The internal circuitry of the winch is not altered; however, the dynamic brake of the winch is set, via an internal switch in the winch, in the ascending direction, providing a precise stop location at the top of the track that is in line with the unloading platform. The device circuitry is mounted in a separate housing at the bottom of the track. All system wiring conforms to local codes and is protected by conduit when traversing outside the wall.

A detailed review of the circuit (Fig. 15.15) shows that 120 VAC power is supplied to both relays. A 12 Volt switch controls the travel of the dolly alternately by opening or closing the two relays. For example, if the dolly is descending, the relay that activates the winch to unwind is closed. When a lower limit switch is activated, the power from the 12V switch to the relay is cut thereby opening the descent relay that in turn stops the winch. Since the internal brake of the winch is set for the ascent direction, there is some settling of the wire rope and dolly, but further descent is arrested by stops placed in the track. In the meantime, the second relay that would activate the winch to wind the rope is open. When the dolly is in its lowest position, both relays are open preventing the winch from either winding or unwinding; this also holds true when the dolly is in its fullest ascent position. Raising the dolly is accomplished electrically in the same manner, considering of course that the dynamic brake immediately stops the winch when the upper limit switch is touched. Control of the 12V switch is through a mounted wall switch that the operator utilizes to raise or lower the dolly.

The limit switches are standard Cherry sub-miniature limit switches. These switches are mounted on brackets protruding from the walls. Small brackets that protrude from the dolly touch the activator arms of the limit switches to activate them. The upper limit switch is spring-loaded to facilitate setting since the Transporter is required to stop at an exact location.

To raise or lower the transporter, the user is first required to activate system power using an installed wall switch. The user then loads whatever is required to be lifted into the transporter and utilizing a second switch, the user signals the transporter to rise. Rise time to full height is approximately 15 seconds. The transporter is lowered in the same manner. The power switch also acts as an emergency power cut-off. If this switch is activated during transport, the unit stops immediately and holds position.

The cost of this project is approximately $700.