CHAPTER 12
RENSSELAER POLYTECHNIC INSTITUTE

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A MOTORIZED ROCKING PLATFORM FOR A TUMBLE FORM CHAIR

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INTRODUCTION

This project consists of an electric motor driven rocking platform for a Tumble Form® chair. The Tumble Form® chair provides a comfortable seat with straps to secure a child with poor trunk control. The rocking motion of the platform serves as an incentive for the child's accomplishment or good behavior. The top of the apparatus is a platform to securely hold the chair. This platform rocks by rolling back and forth on a set of wheels, along an arched bottom base. The rocking platform is driven by a motor and pulley system. An ability switch allows the user to activate or deactivate the rocking motion of the platform.

Figure 12.1 Base showing driver which fits in the groove at the bottom of the platform.

SUMMARY OF IMPACT

Children who are physically challenged, especially those with spastic or hypertensive disorders, enjoy the soothing motion of a rocking chair. This chair/platform combination holds the child securely while permitting the child to initiate or terminate the rocking motion. Independent control by the child seems especially important for non-vocal clients. The rocking motion provides a sensory experience that soothes taut, aching muscles, improves awareness of body position and may contribute to developing a better sense of balance.

TECHNICAL DESCRIPTION

The base of the rocking platform is constructed from a sheet of medium density fiberboard (MDF), 4' X 8' X ¾". This material is strong, easy to machine and inexpensive. Two arcs are cut, each having a radius of 36". The concave side panel is shortened to a length of 8¼" from the center of the arc. The convex panel is shortened to a length of 4¼" from the center of the arc to the straight edge.

The top platform is constructed by attaching two sheets, 3" X 20" X 3/4", of pinewood between the convex panels, so the panels are 18½" apart. A flat base, 2' X 18½" X 3", is attached to the four sides, forming a rectangular box. This box is flipped over to form the top surface for the Tumble Form® chair to rest. The flat base is attached to the side panels ¾" below the edges to produce a retaining lip which could securely hold the edge of the platform. Four large coaster wheels are attached to the bottom surface of the flat base at the corners. The top platform fits securely over the bottom platform. The wheels under the top base glide along the respective concave arc of the bottom platform and produce the rocking motion. Two strips of wood are inserted onto the underside of the base, within the box. These strips are centered on the base at a 1.5" offset from each other. L-shaped brackets are placed along the inside edges for added strength.

The bottom platform is a rectangular box that houses the electrical and mechanical components, which drive the platform. This structure has concave side panels previously described. The front and back panels, 9½" X 17" X ¾", are attached to the arced side panels. The base of the platform, 17" X 36" X ¾", is added to the four sides to form the box.

Power for the oscillating platform is derived from an AC motor turning two circular pulleys with a drive belt. One pulley, with a large wheel, is placed in the center of the bottom platform. A rod, fastened with a flange, protrudes from the large wheel 6" from the center. When the top-oscillating platform is placed over the bottom stationary base, the rod will be positioned between the two strips of wood on the underside of the top base. As the wheel turns, the pin rotates to supply a linear force to the strips of wood. The path of the top is restricted to a linear back and forth motion, which follows the path of the arc; thus, the circular motion of the motor is transformed to the rocking motion of the platform. The circular wheel pulley is made from MDF with a diameter of 13 5/8". The wheel is routed along the side to form a groove for the ½" x 58" FHP belt that delivers power to the device. This wheel is placed in the center of the bottom base.

To allow the wheel to smoothly and freely rotate, a 12" diameter Lazy Susan ball bearing is attached underneath. The belt is attached around the wheel and held slightly taut by another pulley near the back corner of the base. This smaller pulley is attached to the motor.

A 154 RPM AC motor, Dayton, Model Number 4Z613, drives the pulley and belt. The motor has an input motor horsepower of 1/25 at 60 Hz. A 5 MFD, 370 V GE motor run capacitor is used in parallel with the motor. The motor is bolted to the inside back panel of the bottom platform. A 2" OD sheave is attached to the motor. Using a 58" long Browning FHP belt, previously mentioned, the platform cycles at roughly 20 RPM. The platform is designed to support a weight of 65 pounds. The motor is wired to a standard two-prong power cord. This cord is plugged into an AbleNet Power Link. This adapter is connected to an ability switch allowing the child to control the on and off power switch of the platform.

COST: One unit costs approximately $300.

Figure 12.2 Top View of Platform Showing Slot and Curved Bottom.

Figure 12.3. Completed and Assembled Unit.

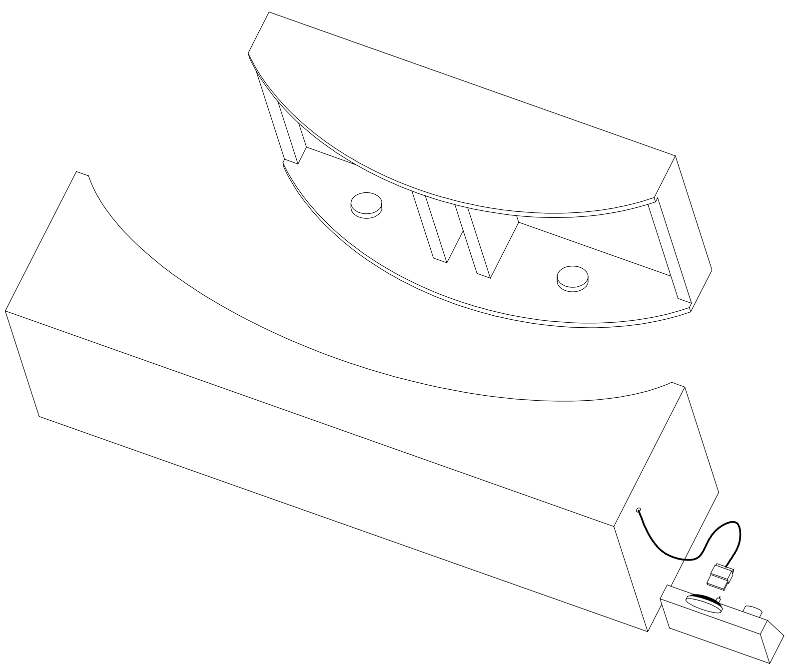

Figure 12.4. Schematic Side View.

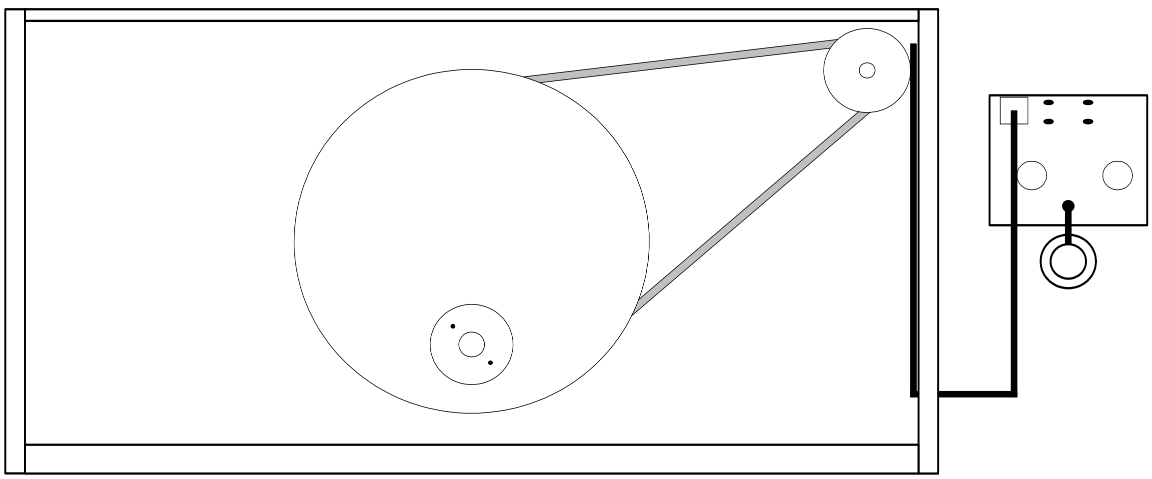

Figure 12.5. Schematic Top View of Base.

AN ASSISTIVE DEVICE FOR PUSHING ELEVATOR BUTTONS

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INTRODUCTION

The purpose of this project is to design and construct a device that to enable a person with quadriplegia to operate an elevator without assistance. The client is limited to the first floor of a two-story building due to his inability to activate the elevator buttons from the wheelchair. Outside the elevator, at each floor, there is one "call" button; one can only go up from Floor 1 or down from Floor 2. Inside the elevator there are two "floor" buttons, aligned horizontally. The device has been designed with two simulated fingers. A LED light in each finger shines a red dot to the wall where the fingers are pointing. The client aligns his electric wheelchair with the elevator buttons by using the red light of the LED guide alignment. The client then pushes the cheek button to thrust the fingers toward the elevator buttons. The elevator opens and the client enters the elevator. Then, the client guides his electric wheelchair to the inner set of buttons and repeats the process to go up or down.

SUMMARY OF IMPACT

The client likes being able to achieve a greater degree of freedom. His job is to deliver the mail throughout the two floors of the building. After practice, the client is now able to access the elevator. However, the large-diameter tires of the wheelchair often catch the carpet of the hallway and elevator, preventing alignment. This assistive device should allow him to go from one floor to the other without an assistant. Unfortunately, since the client is non-verbal, the possibility of the client being unable to open the elevator door forced abandonment of this project until a more reliable, robotic hand could be designed. The goal remains to provide the means for the client to operate the elevator unattended.

TECHNICAL DESCRIPTION

The device presses the elevator buttons with mechanical fingers via motion generated by a linear actuator. LEDs placed in the tips of the fingers allow the client to align the device with the elevator buttons using the joystick of his electric wheelchair. This device is mounted directly on the front of his wheelchair tray.

The client is protected from all electrical components. The circuitry consists of a timer delay circuit for the LEDs and a set of relays to extend and retract the actuator; this circuitry is contained in an ABS plastic housing. The device uses a 12-Volt rechargeable lead-acid battery which is also enclosed in a separate plastic housing and then mounted on the back of the wheelchair so that it is outside the client's reach. The electrical systems operating the electric wheelchair and the assistive device are isolated from one another.

The sliding arm and the linear actuator are the only moving parts of the system. The sliding arm is composed of 5/8" PVC pipe, PVC connection joints, and compression springs. The linear actuator had a 2" stroke, 7.5:1 gear ratio, and a 2" per second extension rate. The actuator can provide up to 100 pounds of force, but only one pound is necessary to activate the elevator buttons. This became an issue if the client came too close to the wall, since overextension would damage the wall or create a large enough moment arm to snap the base. Therefore, a compression spring is placed between the sliding arm and actuator where they connect. In this case, the actuator will continue to extend, but the sliding arm will slip and compress this spring instead.

The control buttons used to activate the targeting LEDs and to start the motion of the fingers are large in diameter so that they could be easily triggered.

These switches are fashioned with 1/8" phono plugs. A simple connection jack is installed to permit the client's assistant to choose an appropriate activation button and its location.

The device is designed so that it would not extend beyond the width of the wheelchair when it is not in use. The device is durable to prevent damage should the patient bump into a wall. The housing is reinforced with 1/4" Lexan©. The base, mounted to the wheelchair tray, is constructed of 1/2" and 3/8" Lexan©. The base of the device is a U-shaped clamp, which slides onto the tray to secure the system. To prevent it from becoming loose, blind holes filled with silicone caulk are placed on the sides in contact with the tray.

The entire apparatus is supported at the appropriate height via a 5/8" diameter steel threaded bar that fastens into the base and the housing. Threaded rod is employed since the device needed to be adjustable in height; the client may change wheelchairs from time to time.

The approximate cost of this project is $320.

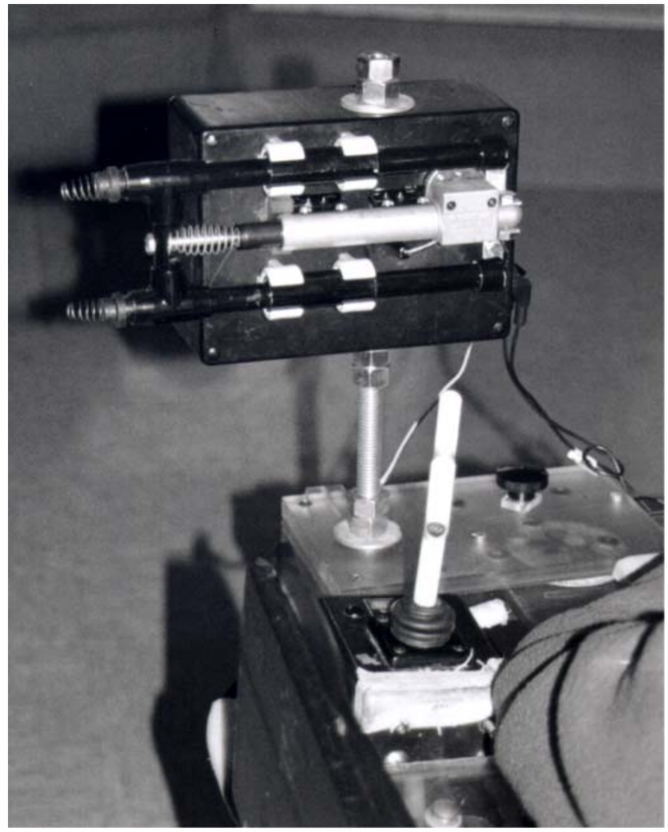

Figure 12.7. Fingers are Aligned via the Joystick.

Figure 12.6. Assistive Device Attached to Tray of an Electric Wheelchair.

CORDLESS SWITCHES FOR INCREASED SAFETY AND SIMPLE OPERATION OF ELECTRICAL ASSISTIVE DEVICES

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INTRODUCTION

Individuals with quadriplegia generally must use wires to connect the switches on the wheelchair to the toys and assistive devices they wish to operate. These wires present both a danger while walking near the client and a possible electrical hazard to clients and attendants. The cordless switch allows elimination of the wires by using Electromagnetic Waves (EMW) to communicate between the switches operated by the client and the toy or assistive device. EMW can be as safe as radio waves.

The cordless switch has two miniature elements, the transmitter and receiver. The transmitter may be inserted into the base of any switch that is activated by a push or a pull. When the switch button is pressed, the transmitter emits an EMW signal to the receiver that is placed within the toy or assistive device. The receiver is miniaturized and is inserted into the toy or assistive device. The maximum distance between transmitter and receiver can be changed by increasing or decreasing the power of the transmitter; this permits a simple means of preventing inter-room interference. By employing pairs of transmitters and receivers with non-interfering EMW signals (at different frequencies), several toys and assistive devices can be operated simultaneously by different clients in the same room. The miniaturized electronics of the cordless switch are adaptable to a variety of wired switches used to operate toys and assistive devices.

SUMMARY OF IMPACT

In the classroom setting, children with quadriplegia use a variety of cheek button switches to operate electronically activated equipment without assistance. Both clients and attendants appreciate the cordless switch because it permits removal of the connecting wires between switch and toy or assistive device; this simplifies setup. Also, by eliminating connecting wires, the cordless switch increases safety for walking in the classroom, eliminates wire breakage between devices, and the easily broken dangling wires on the wheelchair. Several cordless switches may be in use simultaneously because the cordless switches can be constructed with non-interfering frequencies.

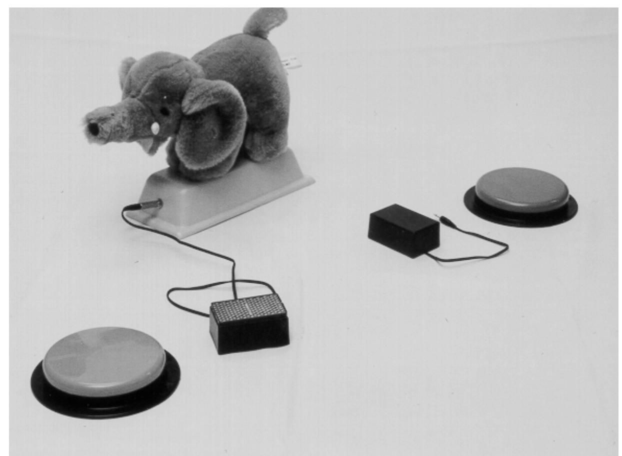

Figure 12.8. Water Shooting Toy with Two Cordless switches. Receiver Attached to Toy has a Solar Panel; the Other Uses Batteries.

TECHNICAL DESCRIPTION

An AM RF transmitter is used to transmit a signal to the receiver, which decodes it. The transmitter of the first prototype operates at 418 MHz; the supply voltage is 2 to 14 volts; and the working frequency is 303.8 to 433.92 MHz. The transmitter is purchased from Convergent Technology. A nine-volt battery is connected to pins 1 (Vcc) and 2 (GND). The antenna, a single loop of wire, is connected to pin 4 (DATA OUT). One of the signal wires of the ability switch is connected to pin 3 and one is connected to Vcc. The entire assembly is mounted on a resin soldering board and secured by lead-free solder. The transmitter is then placed within a 4-inch diameter, Jellybean, Ability Switch supplied by AbleNet.

The AM receiver captures the coded data from the 418 MHz AM transmitter. These modules show very high frequency stability over a wide operating temperature even when subject to mechanical vibration or manual handling. The RF supply voltage (RF + Vcc) is 4.5 to 5.5 volts; the AF supply voltage (AF + Vcc) is 4.5 to 5.5 volts; and the working frequency is 250 to 450 MHz. The receiver is purchased from Convergent Technology. Pins 1, 10, 12, and 15 are all connected to the positive terminal of 3 AA batteries, which are connected in series. Pins 2, 7, and 11 are connected to the negative terminal of the same 3 AA batteries. An antenna of the same type as the transmitter is connected to pin 3 (DATA IN). The center lead of a 2N3904 transistor is connected to pin 14. The left lead of the transistor is connected to GND. The right lead of the transistor is connected to one terminal of the coil in the 5V 500-ohm reed relay. The other terminal of the reed relay coil is connected to V_{cc}. The original 1/8th inch plug cut from the ability switch is connected across the other two terminals of the reed relay. The entire assembly is mounted on a resin soldering board and secured by lead-free solder. It is placed within a standard component box made by Radio Shack.

Each cordless switch cost approximately $77.40

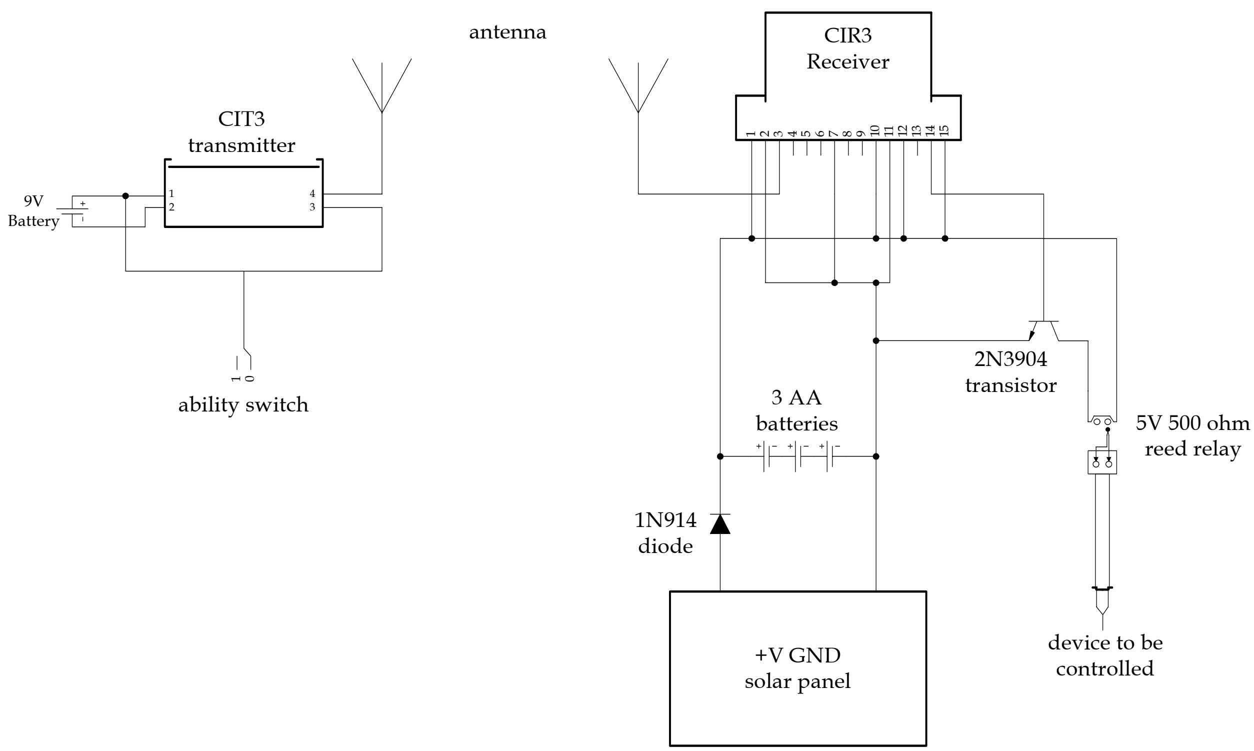

Figure 12.9. Circuit Diagrams of the Transmitter and Receiver.

A HEATING SYSTEM FOR AN ELECTRIC WHEELCHAIR USED IN VERY COLD WEATHER

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INTRODUCTION

This system is designed for a client with muscular dystrophy. Because of decreased strength and a limited range of motion in her upper body and arms, she has great difficulty dressing in heavy winter clothing. Her job, on a college campus, requires driving her electric wheelchair between campus buildings in all types of extreme weather conditions. This project is directed toward alleviating her problems in a climate that tends to mix extreme cold, wet snow, rain, and wind.

This heating system consists of three separate components that can be used individually or in combination as dictated by the severity of the weather. The primary component is a custom made lightweight poncho, tailored to fit the client as she sits in the wheelchair. The poncho is constructed to ease manipulation of this winter attire. A stiffened semicircle around the neck enables her to lift the poncho over her head.

The second component is a leg warming apparatus mounted on the underside of the wheelchair that blows warm air towards the back of the legs. The third component is the front half of a ThermalWear™ Warm Vest, which has a modular, cloth-covered plastic unit containing a salt solution that acts as a hot water bottle but is much lighter and can be easily electronically reheated. There is a harness that secures the half vest to the client's torso. Once heated, the salt solution in the half vest radiates heat for up to eight hours and is to be used during severely cold weather and/or prolonged exposure to the cold, i.e., while attending an outdoor sports event or waiting for a bus.

SUMMARY OF IMPACT

The primary benefits from the heating system are increased safety during sidewalk transportation in inclement weather, and potentially increased use of the wheelchair at outside college sports events. The heating system produces the client an increase in independence by making public transportation available with less risk to her health and comfort. The client would still like an outer fabric with a feminine design.

TECHNICAL DESCRIPTION

PONCHO

A designer fabricated the prototype poncho using her sewing machine. The poncho is a rounded, T-shaped, three-layer garment with a stiffened semicircle around the T-shaped neck opening. Velcro closures are sewn at the wrists, along the curve of the sleeve, and at the neck to minimize the opening and, thus, heat loss through these openings. Dimensions of the poncho are determined by directly measuring the client. The outer layer of the prototype poncho is lightweight, water resistant Nylon©. All edges are heat sealed prior to sewing. The middle layer is Mylar©, a silvery material, which acts as a radiant heat barrier. The layer next to the client is lightweight fleece for insulation and comfortable on skin. The poncho snaps open to allow the Mylar© to be removed for washing. The semicircle around the neck opening is stiffened using a 3/8" OD polyethylene tube placed into a tube of Nylon© that is sewn onto the poncho; the tube is removable for washing. A leg strap is used to restrain the poncho in windy weather. Using anodized aluminum angle, two catch plates are machined to fit the aluminum tubing supporting the wheelchair's footrests. Rectangular aluminum bar stock is machined to form clamp plates to hold the catch plates in place. One -inch Nylon© webbing with an appropriate snap is measured to fit across the client's calves to the catch plates.

LEG WARMING APPARATUS

The heating unit of the leg warming apparatus consists of a DC 12-volt hair dryer (Prime Products #12-0310) mounted under the seat of the wheelchair and adapted to have a remote on-off switch mounted for easy access by the client. The power source for the dryer is a 33-Ah 12-volt sealed lead acid battery (Panasonic LC-LA1233P with a pressure type contact terminal). The heating unit has an electrical supply independent of the batteries that drive the wheelchair, to prevent the wheelchair batteries from becoming drained and thus stalling the client somewhere in cold weather. A mishap from stalling the wheelchair in severe weather could be very dangerous to the client.

A simple toggle switch is wired into the power cord of the hair dryer and mounted to the arm of the wheelchair; a mounting bracket is manufactured. To mount the hair dryer under the wheel chair, a mounting block is made from Lexan© and a mounting bracket from aluminum plate. The mounting block consists of two U- shaped pieces that clamp over the head of the dryer and hold it in place. The aluminum plate is bent to hold the dryer and mounting block in the proper orientation to blow on the back of the client's legs. This assembly is bolted together, and bolted to the underside of the seat using pre-existing attachment holes.

The client asked that the battery be removable for the warmer months. A battery mount is machined from Lexan© and is held in place with two 1" webbing straps and 1" Fastex© fasteners. The battery mount is bolted to the back of the wheelchair, using pre-existing attachment holes. The battery is a sealed, deep-cycle, lead-acid type. To finish encapsulating the battery, a terminal bar is machined from Lexan©. This bar slides down over the terminals and is held in place with Nylon© screws that go through the pre-existing holes in each battery terminal and then screw into the tapped hole in the back of the Lexan© bar. This cage also secures the wiring against the terminals. On one end of the terminal bar is the pigtail with the connection for charging the battery. On the other is the connection for the hair dryer. A battery charger is modified with a compatible connector for charging the battery.

Vest

The ThermalWear™ half vest is not modified. However, due to the client's diminished arm strength, an adaptation is needed to enable the client to plug the vest in for warming both at home and at the office. A pigtail is wired with a connector compatible with the home and office battery chargers. Cost: The approximate cost is $500.00.

Figure 12.10 Clockwise From Top Left: Wheelchair Battery, Home and Office Battery Chargers, Thermalwear™Half Vest, Leg Strap, and Poncho.

Figure 12.11. Student Designer Demonstrating Fully Extended Poncho.

Figure 12.12. Heater Attached to Wheelchair.

Figure 12.13. Client Demonstrating Chest Vest.

Figure 12.14. Client demonstrating complete system in place.

JOYSTICK INTERFACE FOR A REMOTE CONTROL CAR

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INTRODUCTION

A common toy for children is a remote control car. However, the standard controller for a remote control car requires fine motor skills since triggers or switches are used for acceleration and steering. The required precision prohibits some children with physical challenges from playing with such devices. This project entails designing and building a joystick interface that is connected to either of two remote controlled electric toy cars. Thus, children capable of controlling the joystick of an electric wheelchair can play with these commercially available remote controlled toy cars.

SUMMARY OF IMPACT

The joystick controller is designed to interface with a standard remote control. Use of the joystick has simplified the control mechanism, making it easier for physically challenged individuals to play with these toys. The squeals of delight indicate that mentally and physically challenged children seem to enjoy having this new technology available to them.

TECHNICAL DESCRIPTION

Two different remote control cars are used: an indoor model and an outdoor model. The outdoor model is a Team Associated RC10 (Costa Mesa, CA) car with an XL2P (Airtronics, Anaheim, CA) pistol grip controller. The Airtronics controller consists of two three-terminal potentiometers: one to control the steering and one to control the acceleration. The center terminal is ground. For the steering potentiometer, a wire connection between one terminal and ground causes the car to turn in one direction. A connection between ground and the opposite terminal causes the car to turn in the opposite direction. A similar response occurs when such connections are made for the potentiometer that controls acceleration. For example, when a connection is made between a specific terminal and ground, the car accelerates to a fixed speed. The schematic demonstrates how the controller potentiometer interfaces with the joystick.

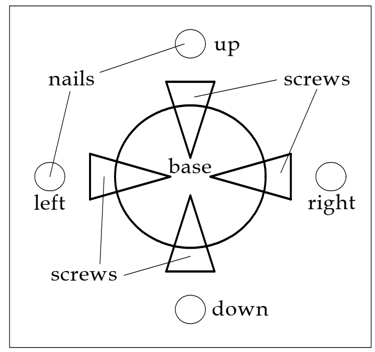

Figure 12.15. Schematic of Interface between controller potentiometer and the joystick.

For the Airtronics controller, 6-inch hookup wires are soldered to each of the two terminals and one ground for each of the two potentiometers, resulting in a total of six solder connections in the controller. These soldered wires are led to the plastic edge of the controller. Then a standard connector that connects to a computer joystick is fitted into the housing of the controller, and the six wires (three from each potentiometer) are inserted into the pinholes of the connector. After these wires are inserted, the case of the controller is closed, exposing only the connector that would allow a joystick interface.

The joystick is modified by inserting four metal screws horizontally into the base of the joystick at right angles to each other. Four pins are inserted vertically into the housing of the joystick so that moving the joystick in one direction makes contact between the pin in the housing and the screw in the base of the joystick's shaft. Releasing the joystick so that it is in the neutral position allows no contact between the pins and screws.

The two ground wires from the controller are soldered to the screws on the joystick base. One wire is soldered to the up and down screws; the other wire is soldered to the left and right screws. Each of the four wires representing the potentiometer terminals (two for left and right, two for forward and backward) is soldered to pins corresponding to the direction. The user must find which pins correspond to a particular direction by manipulating the joystick. The potentiometer terminal that causes right movement, for example, is connected via wire to the right pin in the base of the joystick. When the system is complete, moving the joystick forward will make a connection between the screw, which connects to ground, and the top pin, which connects to the potentiometer terminal that causes forward acceleration. The gearing of the car is enlarged and the motor is downgraded (fewer RPMs) to reduce the speed of the car; this allows safe use indoors as well as outdoors.

For the indoor model, a New Bright red (Wixom, MI) remote control car is used. This model uses simple contact switches, not potentiometers, making the setup easier. As before, wires are connected to the switch terminals in the controller that represent direction (left, right, forward, backward). Wires are

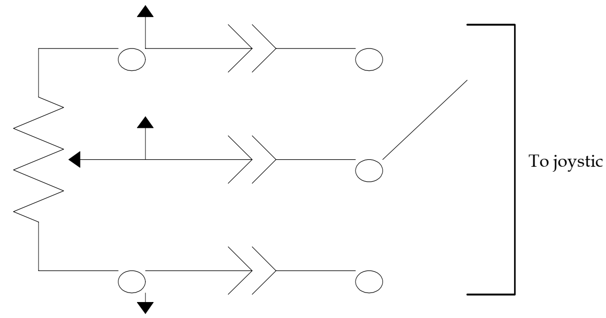

Figure 12.16. Airtronics Controller with Two Three-Terminal Potentiometers.

also soldered to the two ground terminals and then routed to a connector that is mounted to the plastic housing of the controller. The setup for the joystick is the same.

The modifications do not interfere with the normal operation of the car. Thus, unplugging the joystick from the controller allows for normal operation of the car with either controller.

Cost: The approximate cost for the cars, pistol grip and wiring is $480.00.

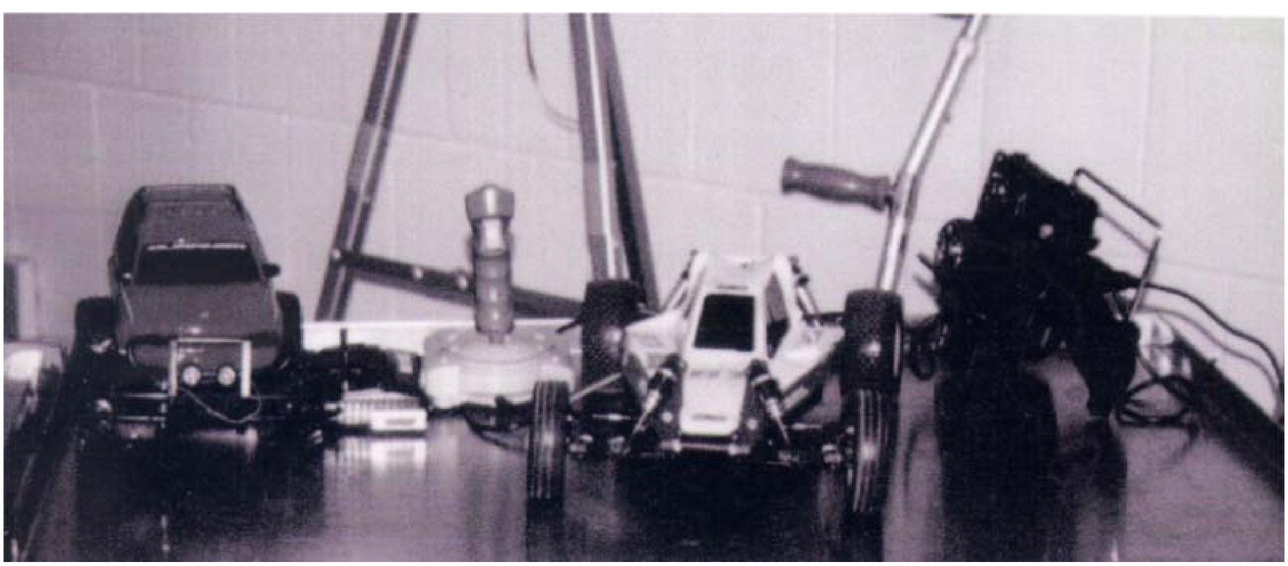

Figure 12.17. Cars and Controller.

NERF BALL CANNON TOY FOR IMPROVING HAND/EYE COORDINATION

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INTRODUCTION

Nerf Balls are toy balls, about 2" in diameter, having very little weight. Thus, even when traveling with considerable speed, they will inflict no injury when striking a child or adult. The Nerf Ball Cannon consists of an electronically controlled air gun, which fires Nerf balls at colorful targets, which when hit, will sway back and forth then set themselves in their original firing position. The Nerf Ball Cannon is aimed and fired by the client. Simple manipulation of large button switches directs the aiming and firing of the cannon. This simplicity of control prevents client frustration and ensures an entertaining period for learning important psychomotor skills such as depth perception, reaction time, and hand/eye coordination. This toy has been designed with the special needs in mind for mentally and/or physically challenged children.

The toy Nerf cannon consisted of several components that contribute to its single goal, that of allowing a child with special needs to fire this cannon at a target. To the greatest degree possible, electronics and servomotors have replaced muscular dysfunction. The cannon has a single barrel, which contains a spring to keep the Nerf balls, stacked in a row inside and toward the front of the barrel. Up to six Nerf balls can be loaded simultaneously. The rear of the cannon barrel is connected to a compressed air tank, which provides the necessary pressure to propel the balls toward the targets.

The cannon barrel is aimed in the horizontal and vertical directions using two separate mechanical mechanisms. By pressing large, round, colorful, button switches the electronic aiming controls are activated and the barrel is raised, lowered or traverses from right to left and back. The platform onto which the gun is attached is mounted on a shaft, which rotates in the horizontal plane via a gear motor. A linear actuator controls the vertical positioning of the gun. The designers created two brightly colored targets. The targets are delicately balanced on a platform such that anything that touches them causes them to swing. The targets are positioned at a distance from the cannon deemed suitable by the teacher. When a Nerf ball strikes the target, the target rocks back and forth, and assumes its original upright, stationary position after two or three oscillations. The balls are so light, and have so little mass, that they are safe to shoot in a classroom. After being fired, the Nerf balls are picked up from the floor by an attendant and inserted back into the cannon barrel for further target practice.

SUMMARY OF IMPACT

The main goal of this project is to produce a toy than can provide an enjoyable, learning experience for its users. Pressing buttons to aim and fire the cannon will promote hand-eye coordination. The vibrant colors and the pleasant movement of the targets will reward the user for success and help to maintain the attention. During the first learning session five children simply squealed with delight, but a sixth child seemed to be fearful. The cannon does make noise as it is fired.

TECHNICAL DESCRIPTION

The gun is a two-inch diameter PVC tube that holds up to six Nerf balls. The balls are held flush against the opening of the barrel by a spring, creating a semi-airtight seal. The end of the barrel is slightly constricted so that air pressure has to force the Nerf ball out the barrel. A tube connects a 2-½ gal, compressed air tank to the rear of the barrel. The air tank is filled prior to use with an electric air pump to 90 psi. The maximum safe tank pressure permitted is 125 psi. Because of its size, several hours of continuous play are required to lower the tank pressure such that the cannon would no longer "fire" the Nerf balls. An electrically controlled on/off valve is used to regulate airflow through the tube. A short burst of pressurized airflows from the tank into the barrel when it is triggered. Air pressure builds up in the barrel until a ball shoots out, then the air pressure inside the barrel drops and the spring in the barrel forces another ball toward the front of the barrel, where it is stopped by the constriction at the front of the barrel; the cannon is then ready to fire again.

The horizontal plane aiming mechanism consists of a 12VDC gear head motor, a set of 32 pitch gears, a torque transfer shaft, and a thrust bearing connecting the platform to the shaft. An H-bridge relay configuration circuit controls these mechanical components. The vertical aiming of the gun is obtained by an integration of a linear actuator controlled by double and single-switch relays. These aiming mechanisms are encased and mounted onto a table. The table is mounted on a cart, which allows for easy transport from room to room. The targets are designed with curved bottom side supports that are connected in the middle. Rubber bands are used to keep the targets in place while still allowing rocking motion when they are hit; they also dampen the rocking motion.

One unit costs approximately $800.

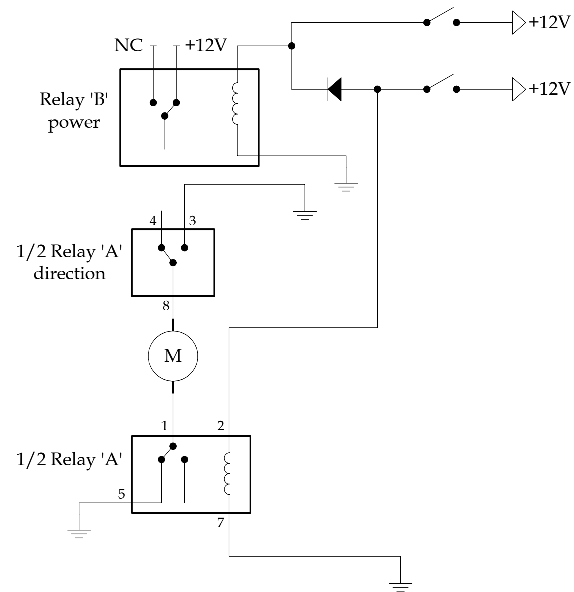

Figure 12.18. Circuit for Moving Gun in Horizontal Plane.

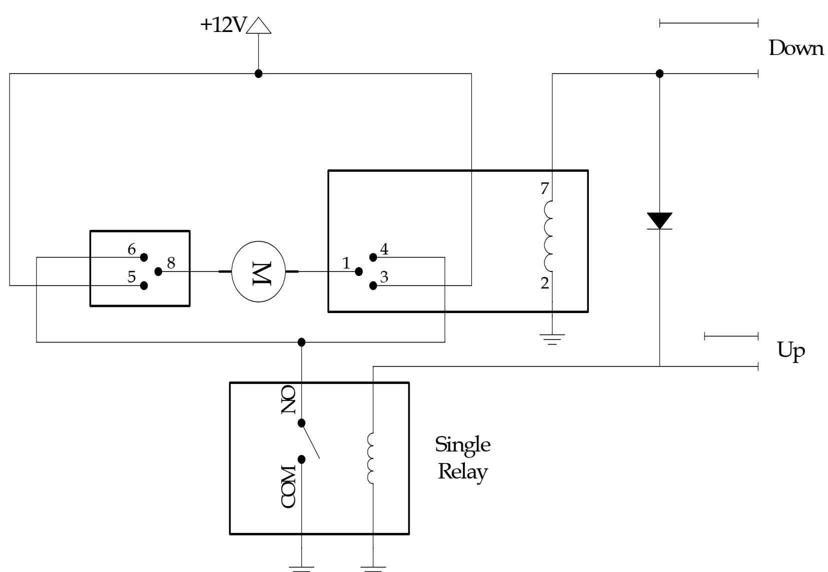

Figure 12.19. Circuit for Moving Gun in the Vertical Direction.

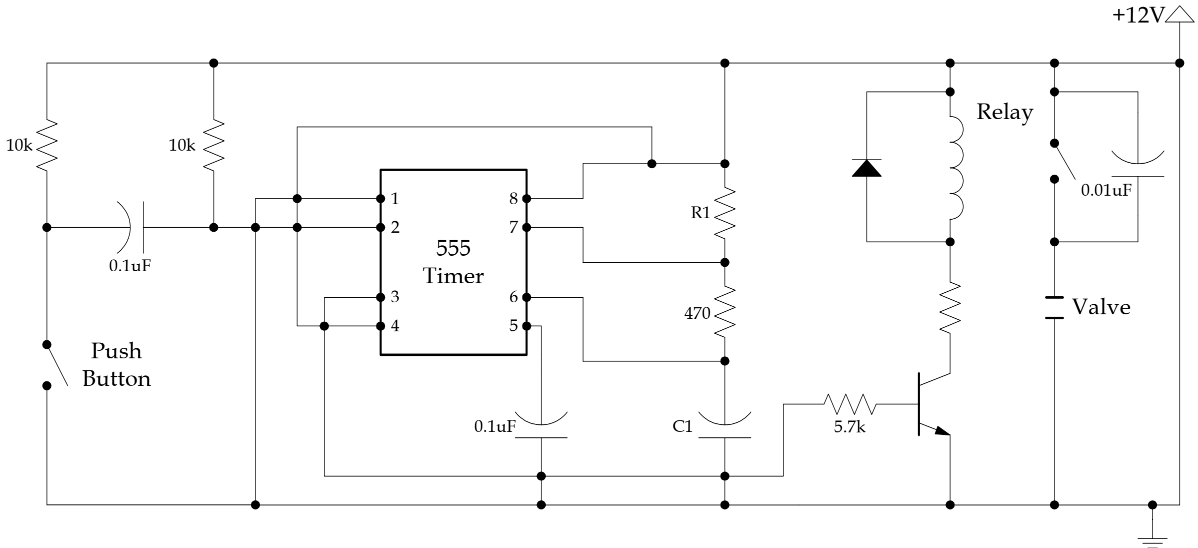

Figure 12.20. Timing Circuit for Gun Valve.

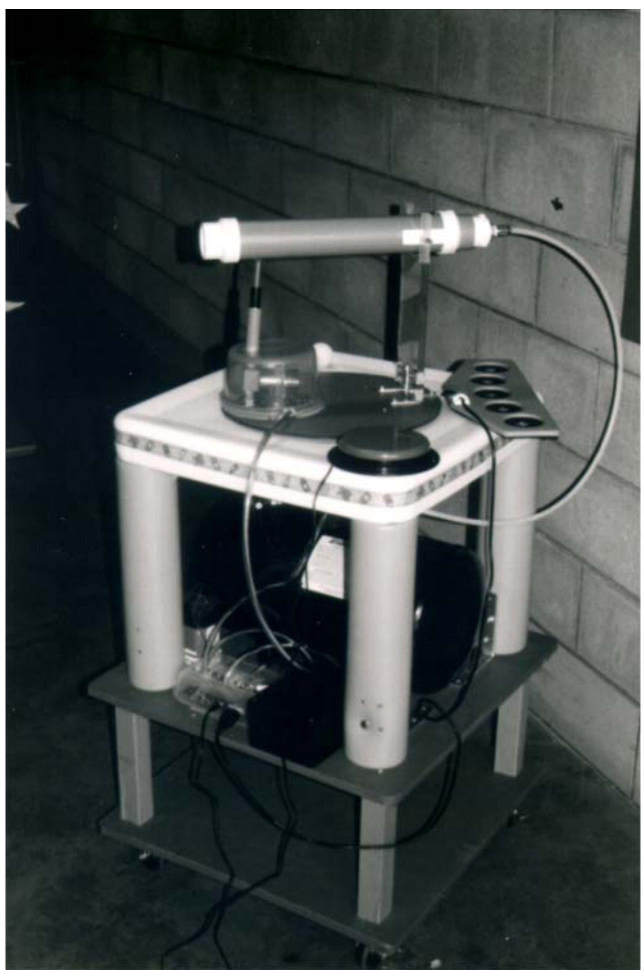

Figure 12.21. Nerf Ball Cannon System.

Figure 12.22. Close-Up of Top Platform.

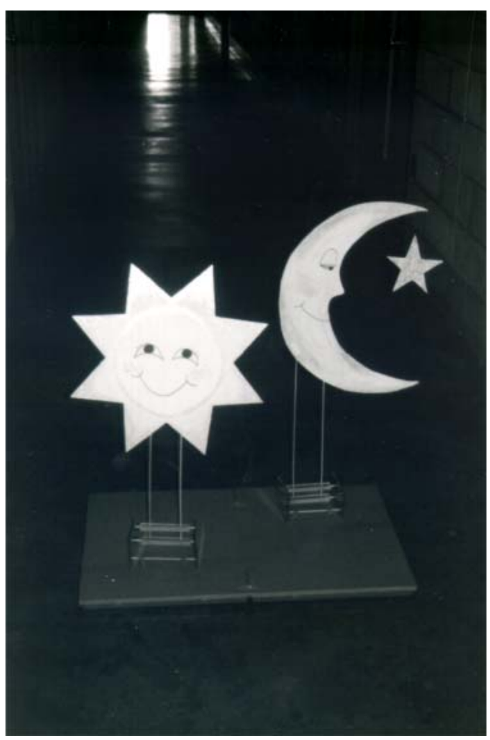

Figure 12.23. Nerf Cannon Targets.