CHAPTER 9

RENSSELAER POLYTECHNIC INSTITUTE

School of Engineering
Department of Biomedical Engineering
Jonsson Engineering Center
Troy, New York 12180-3590

Principal Investigators:

John B. Brunski (518) 276-6548
David G. Gisser (518) 276-6083

An Artist's Workstation for the Functionally Impaired

Designers: John Kotes, Jim Scott, Karen Weigandt
Disabled Coordinators: Todd Lefkowicz, Deb Feldman Albany CP Centerfor the Disabled
Supervising Professors: Drs. M. A. McCarthy, J. B. Brunski, J. C. Newell
Department of Biomedical Engineering
Rensselaer Polytechnic Institute Troy, NY 12180-3590

INTRODUCTION

This project involved the design and construction of a custom-made artist's workstation for a client, JS, afflicted with cerebral palsy. JS's lower extremities are paralyzed and he is confined to a wheelchair, which he operates with a joystick mounted on his laptray. JS's speech is severely impaired and he is difficult to understand. Any mental retardation that may be present is minimal and not clearly evident. He has limited movement in his upper extremities that allows a small range of motion. JS favors his right side to a large degree and his movements are very slow. However, his movements are precise and deliberate.

JS wishes to pursue art as a possible career. Due to cerebral palsy, JS lacks the strength and gripping ability to remove caps from pens and markers, to open paint containers, and to manipulate basic devices that are used in art such as an easel, a pencil sharpener, a lamp, or objects he is painting.

These problems have always resulted in a loss of otherwise productive artistic time as well as creating great dependence on an assistant to manually remove a pen cap or open a paint container.

We decided that the design and implementation of a self-sufficient, custom-made artist's workstation for JS would allow him to eliminate his dependence on others and aid him in his pursuit of art as a possible vocation (Figs. 1,2).

SUMMARY OF IMPACT

Repeated testing and demonstrations at the Albany CP Center for the Disabled have shown the great enhancement this workstation has had on JS's ability to pursue art independently. The design has met and exceeded all criteria set forth by the physical therapist and JS's art teacher. Every aspect of the workstation can be operated by JS; this has

Fig. 1

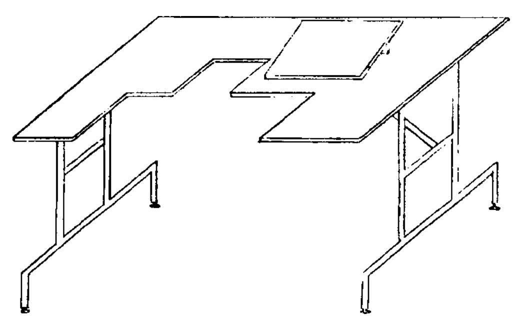


Fig. 2

eliminated his dependence on others for his art. JS constantly provided input during the workstation's design and construction. This interaction enabled us to produce a table with which JS is both satisfied and comfortable. Each feature could be tested and perfected before being attached to the table. The ability of the workstation to be easily transported eases the burden on JS's parents and allows greater flexibility. Furthermore, the use of simple construction and basic components allows easy maintenance and repair. This is especially important since the table will be used at home.

TECHNICAL DESCRIPTION

Design Criteria

The table and its features must meet several specifications for it to be used successfully. The table frame itself must be high enough to clear the client's wheelchair laptray, which is 31" high and permanently attached to the wheelchair. Also, a 4 1/2" high joystick on the laptray further constrains the geometry of the table. The frame of the table should be easily and quickly collapsible for easy transport.

The easel must rotate and lock into place at various orientations to allow JS to reach all points comfortably. The easel also must be able to be adjusted so that the angle of inclination of the easel may be varied. A set-up must be designed to allow JS to access paints available for mixing on a palette. The paints must be maintained in an air-tight environment and provide sufficient room for six to eight different colors.

A design solution must be devised to address JS's inability to remove/recap pens and markers. Any solution must consider JS's weak gripping ability and lack of strength. In addition, the pen seal must be complete to avoid drying of the pens and/or markers.

Other desired features include a carousel to hold pencils, erasers, and paint brushes, a water trough to hold water needed for mixing paints and rinsing brushes, a palette knife with storage sheath to mix paints, a mechanical hinged arm that will be fixed to the table to position models or photographs for different perspectives, a pencil sharpener that JS can operate independently, and an overhead light which JS can turn on and off himself.
As with all other features on the table, these systems must be strategically located so that they are within range of JS's limited ability to move and accented in such a way as to maximize his strength and flexibility.

Finally, the entire table surface should provide a smooth working surface and easy clean-up.

Design Details

The top of the table is made of 1/2" plywood with a 1/8" laminate attached by contact cement. The table top is 32" by 53" with a cutout (Figs. 1,2) that allows JS to get close enough to reach everything and allow room for the joystick control on the wheelchair. The plywood top sits on a frame of 1 1/4" square aluminum tubing, which was welded professionally by Ralph Carl of LaGrangeville, NY (Fig. 3). The table legs are also constructed of this tubing and fold like card table legs (Figs. 4,5). Added support is provided by struts located between the frame and each leg. There are furniture feet on the bottom of each leg to preserve balance and evenness on uneven floor surfaces.

The paint containers are three-ounce jelly jars. These are kept in a small pinewood box that is 9 1/2" long, 5 1/2" wide, and 2 3/4" high. There is a layer of rubber attached to the lid of the box that keeps the paint containers air-tight when the box lid is closed. The box is opened and closed by using two small draw catches that provide a pressure seal.

The pen cap system is mounted on top of the paint box. Three pieces of pine-wood 1 1/2" high, 1 1/2" thick and 9 1/2" long are placed on top of each other with five holes drilled in one side. Rubber "caps" consisting of properly sized rubber tubing are glued into each of these holes. This board is placed on a triangular piece of wood 9 1/2" long that puts the pens/markers at a 45 degree angle to the table.

The easel is also made of 1/2" plywood with a laminate covering and is 15" wide by 12" high with a 1/2" ledge to support the art work. Two clips are attached near the top of the easel to hold any art work. The easel sits on a "lazy susan" turntable bearing that is 12" in diameter. The easel is supported by a 1/4" solid steel rod that is bent into an U-shape frame. The frame is 12" wide at the bottom with 9" side arms. The top of the frame is to the back of the easel with brackets that allow the rod to rotate and permit the height of the easel to be adjusted. Also, grooves are cut into the lazy susan base so that the supporting rod may hold the easel at 45 and 60 degree angles. When the rod is not placed in either groove, the easel lies flat. The easel is equipped with Velcro so that it may be fastened during transport.

The carousel and water trough were purchased. The water trough is a Tupperware container that JS can open by himself. The container lid is attached with a chain that prevents it from falling out of JS's reach when it is removed. The carousel and water trough can change places on the table. All of these features are on the right side of the table. The lamp is also on the right and hangs over the easel to illuminate the art work. The lamp has a touch switch that allows JS to turn on the light by touching any metal portion of the lamp.

On the left side of the table is a battery-operated pencil sharpener and a palette knife with protective sheath. These are set on triangular blocks at 45 degrees from the table surface. The mechanical arm, which holds the objects and photographs which JS paints, is also located on the left-hand side of the table. This mechanical arm is the only feature that JS cannot operate totally independently.

Costs

The following is a breakdown of the expenditures for the different aspects of the artist's workstation. Table Features: lamp ($8), touch switch ($15), light bulb ($3), mechanical arm ($28), clip ($1), palette sheath ($1), palette knife ($6), Velcro ($12), carousel ($15), pencil sharpener ($11), batteries ($4). Frame: materials ($50). Easel: slide bolt ($6), lazy susan ($12), steel rods ($4), piano hinge ($7), clips ($1.25). Paint Box and Pen Cap System: draw catches ($6), hinges ($3), chain ($1.50), rubber ($15), wood ($18), brackets ($4), hardware ($5), grips ($2). Water Trough: chain ($1), Tupperware ($2.50). Art Supplies: palettes ($5), paint ($30), markers ($18), pencils ($5), erasers ($3), paint brushes ($8), sketch pads ($10). Miscellaneous: stain ($4), liquid nails ($6), contact cement ($10), spray paint ($7), plywood ($21), laminate ($20), drill and router bits ($17), bastard file ($4), glides ($4), safety caps ($2), laminate ($5), spray paint ($4), clips ($1.50), levers ($5), hardware ($5). Total cost: $436.75.

Comments on Design Alternatives

During the design process, many ideas arose for each part of the table. Although theoretically sound, some ideas were rejected because of time constraints, cost, availability of certain tools or incompatibility. For example, the table was originally to be supported by two 'Y-shaped wooden legs parallel to each other and positioned at the sides of the table. Since these legs would be fixed and not collapsible during transport of the table, we rejected this design.

Also, we considered a motor-powered paint dispenser that would squeeze paint onto his palette similar to a toothpaste tube on a series of roller racks. This option was rejected after analyzing its cost and construction difficulty.

The lid on the paint box was originally designed to open and close by motorized descending screws or levers. We decided to utilize the toolbox-type latches instead of the motorized lid, which is more likely to cause to problems. More importantly, JS was able to easily manipulate these types of latches.

Possible designs for the pen cap removal system included the idea of a clamp that would automatically remove the pen caps. This was rejected because the clamp would not provide a suitably easy way of putting the caps back on. Thus, the rubber-lined holes that act as permanent caps were adopted as the optimal solution.

Also, we had originally designed a spring-loaded shaft to lock the easel into position once JS rotated it to the desired position. This shaft needed a spring with a low spring constant in order for JS to use it. Consequently, this shaft did not provide enough stiffness to hold the easel steady while JS painted. Instead, we used a slide bolt that locks into the slots of the lazy susan base. The slide bolt provides enough support and is easy for JS to move.

Design Evaluation

Upon testing of the table at the Center for the Disabled, we found that the dimensions were ideal and met all specifications. JS was easily able to drive his wheelchair into and out of the table notch. At no time did JS have any difficulty maneuvering his wheelchair into the cutout. It was therefore decided that protective padding along the edge of the table was unnecessary.

JS was able to operate the toolbox latches on the paint container box with ease, as well as uncap and recap all pens and markers. JS was also able to manually operate the pencil sharpener independently. He also could easily rotate the lazy susan to any position he desired and lock it into position. All outlined features have been tested so that they will be in JS's optimal range of motion and comfort. JS is excited at the prospect of having a table that allows him such a degree of independence in the enhancement of his artistic endeavors.

One possible change of design would have been the purchase of a paint container box with the latches already adhered as suitable draw catches were difficult to find. Also, a linear actuator would have allowed for motorized inclination of the easel while still allowing the easel to rotate on the lazy susan. However this would significantly increase costs.

We feel that our project is unique for several reasons. The workstation is especially durable yet built with basic hardware and other components that are both easy and economical to replace. Because this workstation will be located in JS's home and not at the Center for the Disabled where rehabilitative engineers are present makes it imperative that JS's family has an easy time with repair and maintenance. We feel that we have attacked a difficult problem with many constraints

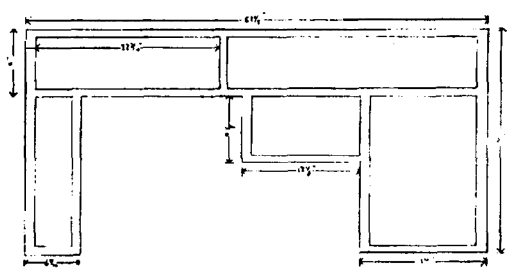


Fig. 3

and solved it in the simplest, most effective, and most efficient manner possible. After extensive testing at the Albany CP Center, our design group, JS's therapist, and JS are more than satisfied with the completed, final product. A user's manual with pertinent information concerning restocking, operating, and maintenance has also been developed.

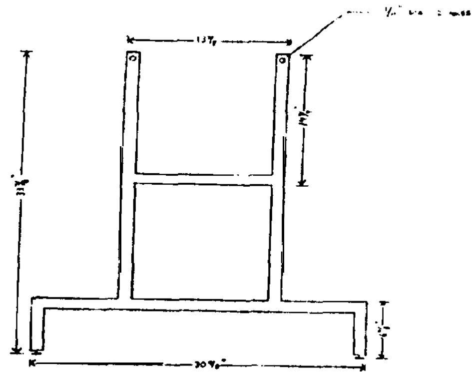


Fig. 4

Fig. 5

Wheelchair Swing
A Wheelchair Swing for Cerebral Palsy Children

Designers: Jeff Amundson, Patty Irish, Peter Namkoong
Disabled Coordinators: Todd Lejkowicz, Kimberly Stalicher Albany CP Centerfor the Disabled
Supervising Professors: Drs. M. A. McCarthy, J. B. Brunski, J. C. Newell
Department of Biomedical Engineering
Rensselaer Polytechnic Institute Troy, NY 12180-3590

INTRODUCTION

A wheelchair swing has been designed for handicapped children at the Albany CP Center for the Disabled in Albany, NY. The swing consists of two modular components, the frame and the swing. The frame is rectangular in shape and has triangular supports connected to each corner to add support and stability (Figs. 1,2). These triangular supports fold in when not in use for easy storage of the swing. The swinging unit consists of four hanger arms, the platform, and associated hinges. The platform remains parallel to the floor during swinging to accommodate those children who are unable to hold their heads up. The swing is powered by human force at present, but can be modified in the future to accommodate other power sources. The unit is portable through the use of retractable wheels, and also can be disassembled for transport.

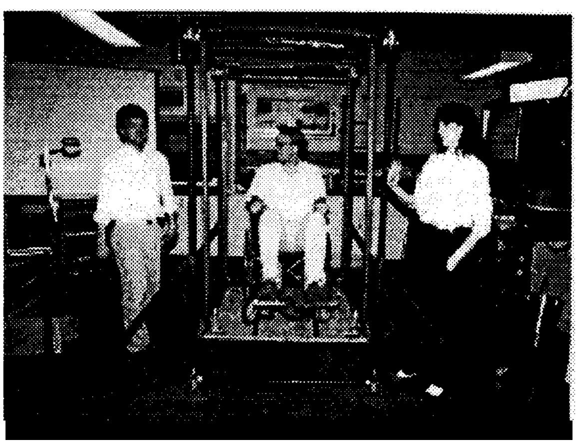


Fig. 1

SUMMARY OF IMPACT

Many cerebral palsy clients lack a sense of cause and effect within their environment. They are often confined to a manual wheelchair that inhibits their interaction with the environment and their development of independence. It has been found that such clients benefit from therapeutic external stimulations such as rocking and vibrations. It is important to develop communication with the client via these stimulations, whether it is an audible

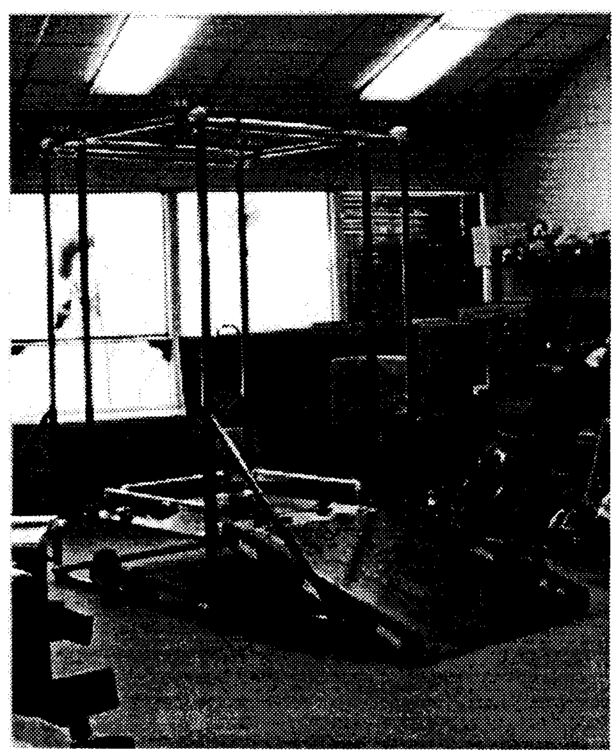


Fig. 2

response or a simple show of emotion. Once a low level of communication is established, variations in the stimulation can begin to teach the client to increase his or her level of communication. The wheelchair swing meets these needs of many clients. The swing provides a unique stimulation that is difficult to provide in any other manner. It gives the feeling of weightlessness, speed, and flight. The stimulation that the wheelchair swing provides is an invaluable therapeutic tool for clients to exhibit emotions and develop communication. Also, there is the possibility in the future of motorizing the passive swing so that the client can control the stimulation that he or she is receiving, thereby further increasing interaction with their environment.

TECHNICAL DESCRIPTION

The wheelchair swing was designed with a particular student-client in mind, but could be both beneficial and recreational to many student-clients at the CP Center. The main design requirements of the swing were: 1) it had to be as small as possible, due to the limited amount of space in the classrooms at the Center; 2) it had to be portable, so that it could be moved to the corner of the room when not in use; 3) it had to provide a sufficient level of stimulation, i.e., it had to have a significant range of motion; 4) it had to swing with the platform remaining parallel to the floor, making it safer for those students unable to hold their heads steady; and 5) the platform itself had to be adaptable to accommodate all sizes and types of wheelchairs, so as to allow all wheelchair-bound students to utilize the benefits of the swing. Finally, it had to be safe to use.

The wheelchair swing has two main components, the frame and the swinging platform (Figs. 1,2). The frame is a rectangular structure consisting of 1" steel pipe sections connected with structural pipe fittings. These structural pipe fittings secure the pipe via allen bolts. Connected to each upright pipe section of the rectangle is a triangular support. These supports stabilize the frame when the swing is in use. The supports fold in alongside the frame when not in use to conserve storage space. Each triangular support possesses an adjustable screw-down foot that provides added stability. A retractable wheel is located on each side of a lever that raises the frame and lowers the wheel, providing portability of the entire frame.

The swinging platform consists of four hanger arms, a platform and associated hinges. The entire swing component is attached to the frame via U-bolts. The four hanger arms are made from 1 1/4" square steel tubing. The platform is a 3 1/2' x 3 1/2' x 3/4" piece of plywood connected to the hanger arm cross beams. Connected to the platform are three 1/2" pipe railings located on both sides and the front of the platform. These railings prevent the wheelchair from being accidentally pushed off the platform when being loaded onto the platform. They also provide an added safety feature when the swing is in use. The wheelchair is secured to the platform via four nylon webbing straps. These straps are attached to the platform through slots in the platform. This manner of attachment allows various types of wheelchairs to be attached securely to the platform. A ramp for wheelchair access is provided (Fig. 2).

Each hinge consists of two 1/2" radial bearings, a 1/2" steel shaft and two bearing housings. The bearing housings are fabricated from 4” angle iron with holes cut in the proper places for the bearings. The shaft is press fitted into a 1/2" hole in the hanger arm. Two bearings are then press fitted onto the shaft, one on each side of the hanger arm. The bearing housings are attached to the bearings. Tests of the swing were conducted by having a volunteer BME design student swing in an E&J wheelchair fixed on the platform. Hand force was sufficient to initiate and maintain the swinging motion of the platform (Fig. 1). One design modification that came out of this test was the allowance of additional clearance between the hanger arms of the platform and the frame's vertical supports.

The final cost of the wheelchair swing, prior to painting, was approximately $565. An estimated cost to paint the swing (at a commercial auto paint shop) is $200.

A Motorized Feeding Device

Designers: Noelle Mann, Camilla Santos, Wendy Zenzen
Disabled Coordinators: Todd Lefkowicz, Laurie Murray Albany CP Centerfor the Disabled
Supervising Professors: Drs. M. A. McCarthy, J. B. Brunski, J. C. Newell
Department of Biomedical Engineering
Rensselaer Polytechnic Institute Troy, NY 12180-3590

INTRODUCTION

The client is a 28-year-old woman with spastic quadriplegia. She has limited control of her arms and legs, arthritis in her hips and spine, and is confined to a wheelchair that operates with a joystick. She is presently fed by hand but wants the independence of being able to feed herself. Currently, the feeders on the market are expensive, unreliable, and heavy. Many feeders use driving mechanisms involving controls with push buttons and knobs that our client is unable to operate. She needs a feeder that she can operate and control in an effective manner.

The feeder designed here (Fig. 1) is operated by a joystick that makes best use of the client's abilities. The arm of the feeder has two degrees of freedom, being able to slide up and down, and rotate toward and away from the client.

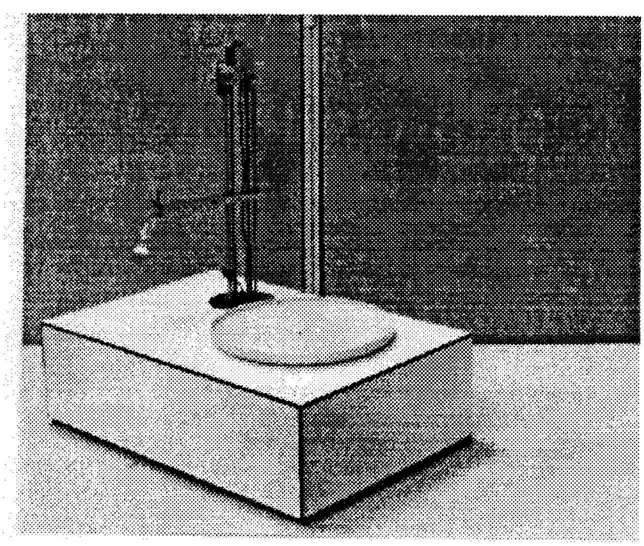


Fig. 1

Both these motions are controlled by the joystick. A lazy susan device allows the plate to rotate. The plate's rotation is controlled by pushing the fire button on the joystick. The power to the entire unit is supplied by the battery on her wheelchair.

SUMMARY OF IMPACT

This feeder should have a major impact on the client's independence. She will no longer have to depend on someone to feed her. Because the device is compact and drives by the wheelchair battery she can bring the feeder with her if she wants to go to a restaurant with her family. By tailoring the device controls to the client's abilities a very useful product has resulted.

TECHNICAL DESCRIPTION

The dimensions of the feeder base are 21.5 x 14.5 x 6.5 inches to accommodate the necessary parts.

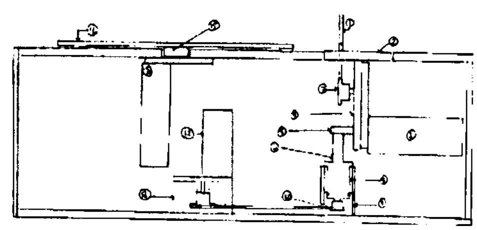


Fig. 2

Two pulley systems provide for vertical and horizontal motion of the arm. The arm is mounted on two vertical shafts by linear bearings. A belt is attached to the arm between the bearings and runs on pulleys at the top and bottom of the shafts. A 12V DC gear motor (Motor 1, Part #3, Fig. 2) rotating at 25 RPM, is connected to the bottom pulley and drives the arm.

The top brace on the shaft supports the mount for the upper pulley, and maintains separation of the shafts. The supports for the upper pulley allow for tension adjustment in the belt. The supports are two rectangular pieces with a hole drilled into each for a steel shaft that holds the pulley. Tension in the belt is adjusted by two screws held vertically under the top brace by aluminum plates secured to the shafts. These screws push the top brace up, extending the belt as necessary.

The arm is 7.8 inches long and sweeps through a distance of 6.3 inches. This length is sufficient to allow the spoon/ fork to sweep across the center of the plate and extend six inches over the edge of the feeder. The spoon/fork is mounted at a 20 degree angle with respect to the longitudinal axis of the arm so that when the arm is extended over the feeder, the end of the spoon/fork will be facing the client. The belt of the pulley is fixed to the arm by two set screws.

A hole slightly larger than 3 inches is cut into the top of the base to allow clearance for the aluminum disk supporting the shafts. This bottom brace is supported by the mount for Motor 1 (Part #3, Fig. 2). The lower pulley is encased in the base, thus preventing food and fingers from interfering with the motion of the pulley.

The horizontal or "sweeping" motion of the arm is accomplished through a second pulley system. Motor 1, which drives the arm up and down, is mounted on a rectangular piece of aluminum, which supports the aluminum disk that holds the shafts. This piece sits vertically and another aluminum piece, the motor shelf, attaches to it horizontally. A third cylindrical piece, made of steel, is attached to the underside of the horizontal piece. The cylindrical piece is placed in a bearing, and a pulley is attached to the bottom of the piece. The bearing is press fit into another mount, made of aluminum, so that it is held above the base of the feeder. The bearing mount has a piece cut out of its lower section to allow the belt of the second pulley system to pass through it. This pulley is driven by a second 12V DC gear motor, rotating at 4.5 RPM, designated as Motor 1 (Part #12, Fig. 2). Motor 2 is mounted vertically, with the shaft pointing downward. The motor is mounted on two wooden pieces secured to the base. Tension in the second pulley is provided by a third pulley mounted on a large screw in the base.

The movement of the plate is in the clockwise direction only. A 10.5 inch diameter lazy susan is the major moving part for the plate rotation. A third gear motor, Motor 3 (Part #14, Fig. 2), operating at 4.5 RPM, is mounted vertically underneath the plate, so that the motor shaft is in the center of the plate. The shaft of the motor attaches to the underside of the lazy susan device by a metal plate with a hole drilled for the motor shaft. The attachment is bolted to the lazy susan. Motor 3 is bolted directly to the underside of the top of the base. A hole is cut in the base to accommodate the motor shaft and plate attachment.

The spoon/fork mount consists of a clamping device to hold the spoon or fork in place by a screw. The spoon or fork is mounted under the arm at approximately a 20 degree angle. This mount allows any spoon or fork to be used since it clamps the utensil onto the arm and allows for easy removal of the spoon or fork. To prevent food from being pushed off the plate, a lip is placed along the edge of the plate.

A joystick controls movement of the arm. The joysticks "fire" button is used to rotate the plate. All three motors are 12V DC gear motors. Motor 1 drives the arm up and down. Motor 2 drives the arm back and forth. Motor 3 rotates the plate. The client's wheelchair battery is a 12V DC battery and serves as the power source. In order for the design to operate as planned, double pole, double throw relays are used to reverse the current and accordingly the rotation of the motors.

Limit switches are necessary to avoid vertical and rotational movement of the arm beyond the extremes and to prevent unnecessary wear on the motor. The limit switches are mounted physically at the base and on the top of the shaft system. They are mounted in the feeder base at the extreme points of motor rotation. The total cost of this project (including machining) was $522.

A Modified Toaster and a Stove Controller for Operation by the Manually Impaired

Designers: Alfred Concemi, Vrushali Gokhale, John Martinez
Disabled Coordinators: Todd Lefkowicz, Bob Bascombs Albany CP Centerfor the Disabled
Supervising Professors: Drs. M. A. McCarthy, J. B. Brunski, J. C. Newell
Department of Biomedical Engineering
Rensselaer Polytechnic Institute Troy, NY 12180-3590

INTRODUCTION

The original problem definition of the toaster project required us to modify a toaster so that it could be adapted to be used with a training aid that the clients currently use as a part of their therapy. The training aid is a switching device that allows the clients to turn on/off small electrical appliances. After beginning the design, we discovered a toaster already on the market that satisfied the project requirements; we were able to purchase a Sunbeam Model 20030 Fully Automatic toaster that automatically raises and lowers the bread into the toaster once the bread has been inserted into the toasting slot. This eliminated the need for the touchpad and the training aid that we were planning to use in our design. We designed a modification to the top of the toaster so that bread can be easily inserted and removed. The second project undertaken was the modification of the electric stove in the kitchen of the Cerebral Palsy Center. The current design of the stove requires the client to push and turn a dial to turn the stove burner on and off and to set the temperature level. This design is too difficult for the clients to use independently. In addition, the control panel of the stove is to the right of the stove instead of in front, as in most stoves. This location made it nearly impossible for wheelchair-bound clients to operate the controls, and posed a serious safety hazard due to the proximity of the control panel to the burners.

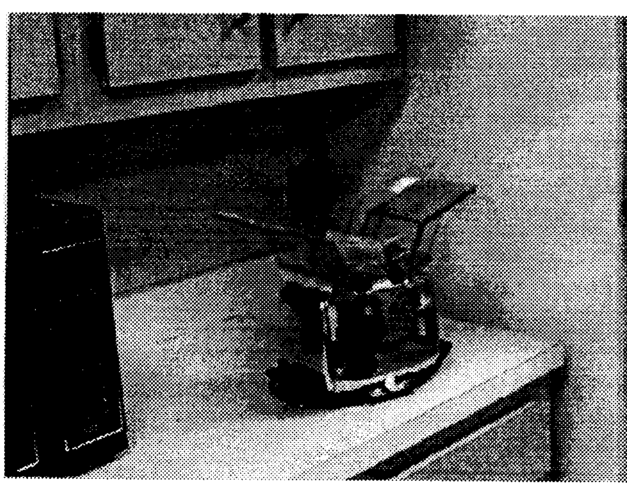


Fig. 1.

SUMMARY OF IMPACT

For many disabled adults, the focus of their therapy is on daily activities such as cooking and self-care. The kitchen environment is challenging for the physically and mentally disabled; the levers, buttons, dials and settings on household appliances are difficult to use. Many clients cannot use their upper extremities and can, at the most, use a head pointer or a gross hand motion. Often, the clients rely on assistance from the therapists to use appliances. To these clients cooking is a motivating activity as well as a functional task. The modified toaster allows the clients to slide the bread into the toasting slot after which the automatic cycle takes care of the rest. The stove controller allows the clients to choose the temperature setting of the burner by toggling the touch pad. This allows the clients to control the burner, thus providing them with a degree of freedom and control they previously lacked.

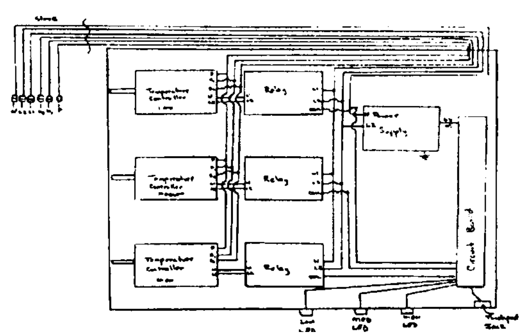


fig. 2

TECHNICAL DESCRIPTION

Toaster

The toaster is a Sunbeam Model 20030 Fully Automatic toaster. Upon activation by a toggle switch, it will automatically lower the bread, toast it, and raise it. Modifications consisted of ramps (Fig. 1) made of l/Cinch thick sheets of Lexan polycarbonate acrylic. These were attached to the toaster to assist the clients with inserting the toast. The sections of the ramps were glued together with ordinary super-glue (cyanoacrylate). Lexan was used because of its high strength, smooth surface, ease in cleaning, ease in manufacture, and heat resistance (225^{o}F glass transition temperature and 800^{o}F point of combustion). The top section of the ramp is 5” long and 6” wide that is large enough for a slice of bread to be placed. The back has a 1" high edge that prevents the bread from falling off as the client is sliding the bread into the toaster. The inclined section of the ramp is 3” long and 6” wide with a 1" edge along the back. This section was originally at a 45^{o} angle to both the top section and the base of the ramp. The angle has been changed to 60^{o} and is steep enough so that as the bread slides over the leading edge of the ramp, gravity will cause the bread to fall into the toasting slot easily. The base section is 2 inches long and extends to the side edge of the toaster. It is also mounted flush with the toasting slot. Finally there are two 1 3/4" wide sections, one in the front and one in the rear, which act to stabilize the ramp against any sudden impact, especially a downward force on the outermost edge of the top section. The ramp is bolted to the toaster chassis and cut down so that the bolt does not protrude through the hex nut. The head of the bolt is inside the toaster chassis to prevent the nut from coming loose and falling inside the toaster, especially when the ramps are being removed. The bolt will not fall through because of friction with the ramps. Between the two toasting slots is bolted a wedge-shaped section that acts to redirect the bread if it is about to overshoot the toasting slot. The cost of parts and construction was $92.

Stove Control

The design required a minimal amount of modification to the stove. Only six additional wires would have to be attached to one of the temperature control units in the stove (Fig. 2). The stove control unit controls the temperature setting of each burner. The stove temperature control unit consists of a temperature-sensitive, bimetallic mechanical switch to regulate the temperature of the burner. The design replaces the stove’s temperature control unit. There will be six wires coming out of the stove and going into the control box as shown in the mechanical schematic of the stove controller (Fig. 2). Our design will incorporate three separate temperature control units that have been pre-set to temperature settings of low, medium and high. Each control unit will be connected to a 240V AC, 10-amp, general-purpose relay. The three relays will be controlled by the temperature level selection circuit. Input for the selection circuit will be received from a touch pad. Power to the circuit will be supplied by a separate 6V DC power supply (Fig. 2). The relays act as high-voltage switching circuits. For this design it was necessary to find relays that were powerful enough to handle the large currents in the stove burner (determined to be about 8 amps), and that also would require a minimal amount of power to operate. The relays we decided to use in our design are manufactured by Potter & Bnunfield and have eight silver cadmium contacts, and are rated at 6V AC switching capability. The relays require a current of approximately 200 mA to operate. The temperature control units used in our design are identical with the units found in the stove. These units are the 5500 series infinite switch Uni-kits manufactured by the Robertshaw Controls Company. The units are electrically rated for 15 amps at 120/240V AC resistive load. While the stove is in use only one relay will be switched on, and as a result only one temperature unit will be active and controlling the temperature of the stove burner. This process will be controlled by a combination of digital circuitry, and the touch pad (details available). The design incorporates a mod-4 counter circuit to control the temperature selection. The client has four settings to choose from (off, low, medium and high), and can toggle among them by depressing the touch pad. The mod-4 counter circuit has a “wraparound” feature. Once the high setting has been reached, the next setting will be “off”. This feature allows the clients to continually cycle through the setting selections. Once a temperature setting other than “off” has been selected, the client has no further interaction. The selection of one of the temperature settings automatically turns on the relay that controls the selected temperature control unit, and the stove burner begins to heat up. The approximate cost of the stove project was $300.

Standing/Transfer Unit: A Device to Assist and Encourage Standing for a Functionally Impaired Girl

Designers: James Goldfarb, Gena Spinelle, Christine Derse
Disabled Coordinators: Todd Lejkowicz, Peter Hiemsfra Albany CP Centerfor the Disabled
Supervising Professors: Drs. M. A. McCarthy, J. B. Brunski, J. C. Newell
Department of Biomedical Engineering
Rensselaer Polytechnic Institute Troy, NY 12180-3590

INTRODUCTION

KC is a 12-year old girl born with cerebral palsy. Her therapist feels that she is capable of standing and transferring between chairs, but does not have the skills or the motivation. The goal of our project is to design and build a system that will help and motivate KC in learning the skills of standing and transferring between chairs.

The design consists of two main parts (Figs. 1,2): (1) a standing/transfer rail that KC can grasp when she tries to pull herself up out of her chair into a standing position; and (2) a motivation switch in the cushion of her chair, which activates a positive reinforcer when she stands up.

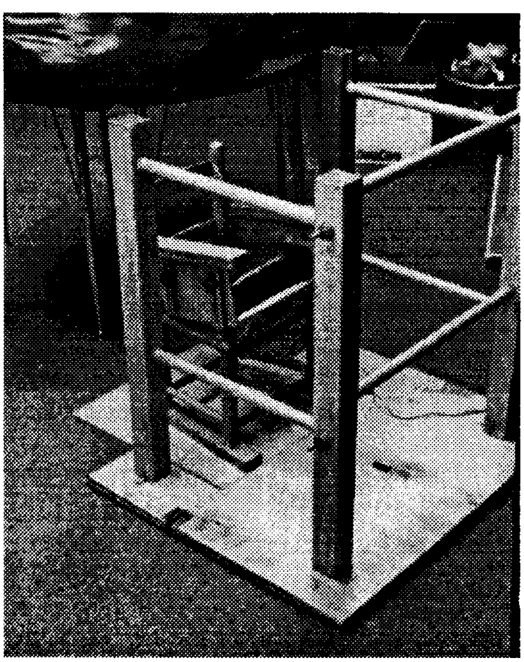


Fig. 1

SUMMARY OF IMPACT

KC rarely walks but instead spends most of her time sitting in a chair or on the floor. When she does walk, it is with assistance. KC has poor balance and a wide-based stance, which makes it difficult for her to walk on her own. She is willing to stand up and take a few steps if someone stands in front of her with hands extended and prompts her to do so. KC holds onto the hands in front of her to pull herself up out of the chair. Without this prompting, she has no motivation to get out of her chair. To get KC to stand and eventually walk on her own, a device is needed that will encourage her to stand without prompting from others. KC's teachers also would like to see her transfer herself from one chair to another, for instance, from her classroom chair to her wheelchair or vice-versa. The goal of the Standing/Transfer Unit is to teach KC to pull herself up from a chair and eventually transfer herself from her classroom chair to her wheelchair. The unit provides the support and stability needed to help our client learn to stand on her own. It also goes beyond the scope of her immediate needs. The unit will allow KC to transfer herself from her classroom chair to another chair on her own. She is not yet capable of performing this task, but KC can use the unit to develop these skills.

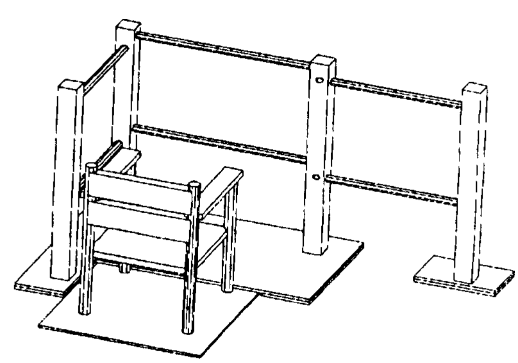


Fig. 2

TECHNICAL DESCRIPTION

The Standing/Transfer Unit is comprised of two sections. The first section is the part of the device which KC will use to pull herself up out of her chair, called the Standing/Transfer Rail. The second section is the switch used to activate the reinforcer, called the Motivation Switch.

Standing/Transfer Rail

The main goals of the Standing/ Transfer Rail are to aid KC in standing and transferring. The rail provides something for KC to grasp as she pulls herself out of her classroom chair into a standing position. This component provides support, stability, security, and allows her to maintain her balance. Once KC learns to stand with the aid of the unit, she can then learn to transfer between chairs. The unit is a three-sided post and rail structure (Figs. 1 and 2). It will be placed in front of KC's chair. The posts are made from 3x3 pieces of poplar choice wood and are cut to a length of 33 1/2". The edges of the posts were rounded using a router and sandpaper. The rails are 1 1/8" wooden dowels. The two front rails are 24" long, while the four side rails are 18" long. To attach the rails to the posts, 1 1/8" holes were drilled 1 1/2" into the 3x3's. The centers of the front dowels were placed 15 1/2" and 32" from the bottom of each post. The centers of the side rails were placed 13" and 30" from the bottom of each post. The permanent dowels were inserted with carpenter's cement. Once the dowels were inserted into the 3x3's, 1/4" holes were drilled 3/4" from the edge of the 3x3, 2" deep. Wooden pegs cut from a 1/4" dowel were then hammered into the side of the 3x3 through the dowel. The pegs were cut and sanded so that they were flush with the 3x3. In order for the unit to be used for transfers, one side swings open so that the unit becomes L-shaped (Fig. 2). The rails on the right side are not cemented and pegged, but are attached with 1/4" x 4 1/2" eye bolt-dowel plugs, so they will not weaken the rails. To use the unit for transfers, the right side will be detached and then reattached in the open position. The unit is mounted on a base. The base is a bi-level configuration made from two pieces of 3' x 2 1/2' x 1/2" poplar plywood. The edges of the assembled base are rounded using a router and sandpaper. The two levels of the base are glued and screwed together. The base fits over and around the base of KC's chair. The side cuts of the entire base will be 22 1/2" wide. This is 1/2" wider than the base of her chair. The front cut of the upper level is 11" deep and slides up against the chair legs. The front cut of the lower level is 14 1/4" deep and slides up against the front of the chair base. The posts are attached to the base with carpenter's cement and 1/4" x 4 1/2" lag bolts screwed up through the bottom of the base. The section of the base under the removable post is cut from the rest of the base.

Motivation Switch

To get KC to stand on her own, she needs some form of motivation. Thus, when KC stands, she will be rewarded by a positive reinforcer that should keep KC's attention for extended periods of time. A specific movement made by KC should determine when the switch was activated. This would teach KC that her actions were responsible for the activation of the motivator. Therefore, four pressure switches were placed at the comers of a 6 1/2" x 4 1/2" square. When KC tries to stand, her buttocks will rise out of the chair, taking all the pressure off the switches. This will close the circuit and turn on a motivator. The switches are momentary pushbutton switches of the normally closed type. The four switches are connected in series, ending in a 1/8" plug that will be connected to the desired motivator. Thus, all the switches have to be closed to complete the circuit. If only one switch is closed the whole circuit will remain open. The shell of the unit is made from pine and 1/8" hardboard. The bottom piece is a single piece of 11" x 9" x 1/8" hardboard. Both the middle and top pieces are made from two pieces of 9 1/2" x 7 1/2" x 1/8" hardboard glued together. One of the top pieces of hardboard has four holes drilled through it for the top of the switches to be placed. This piece is glued to another undrilled piece of 9 1/2" x 7 1/2" hardboard. The middle horizontal piece is made from two pieces of 1/8" hardboard glued together and then drilled for the switches and springs to pass through. All KC's weight will rest on the middle and top pieces of hardboard and not on the switches themselves. These four pieces of hardboard are more than sufficient to support her weight.

The seat switch is designed to be used at the Center with several toys. The current passing through the switch must be low in order for the switch to be safe. By using 1/8" plugs and sockets, the reinforcer that we have modified is compatible with the existing toys and switches at the Center. We purchased a Big Bird Dancin' Radio and modified it to be triggered by a switch via a 1/8" plug.

The cost of this project was $176.

Vibrating Platform: A Multipurpose Evacuation Vehicle and Teaching Aid for the Severely Disabled

Designers: Donald Chickering, Brian Garvey, Marie Luby
Disabled Coordinator: Todd Lefkowicz Albany CP Centerfor the Disabled
Supervising Professors: Drs. M. A. McCarthy, J. B. Brunski, J. C. Newell
Department of Biomedical Engineering
Rensselaer Polytechnic Institute Troy, NY 12180-3590

INTRODUCTION

The client for this project suffers from profound cerebral palsy and is blind and deaf. He is 6'2" and weighs 230 pounds. He has limited motion of his arms and almost no movement of his legs. He does have fine motor control of his hands allowing him to use small buttons and switches.

A vibrating platform has been designed and constructed to: (1) act as a means of transporting the client during an emergency evacuation at the CP Center in Albany; and (2) teach the client the concept of cause and effect through positive reinforcement.

The client is loaded on and off the platform by rolling him up and down the sides. When in the unlocked position (Fig. 1), the edges of the sides of the platform rest on the floor. The sides are secured in their upright position by a strap that goes across the middle of the platform. The platform is maneuvered by two straps, one on each end, and moves by the four swivel casters that can lock in place to mobilize the platform. Four vibrators are located in parallel at the upper end of the platform where the upper part of the client's body will be rested (Fig. 2).

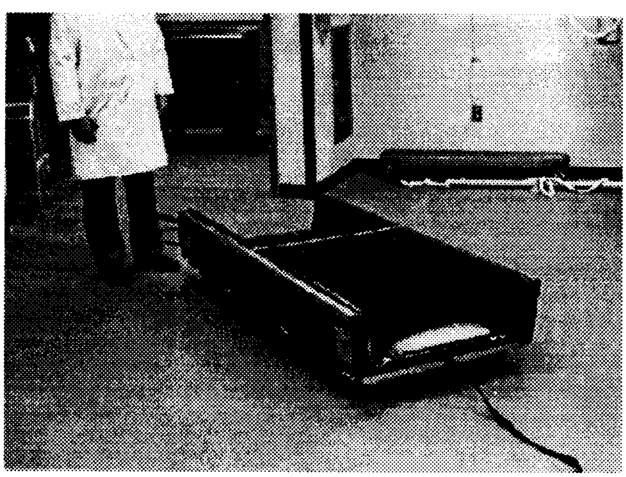
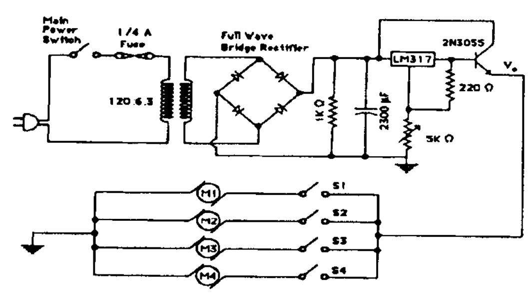


Fig. 1

SUMMARY OF IMPACT

In an emergency, it is not always easy to remove a disabled individual from a building. The platform allows evacuation of a severely disabled individual from a classroom in a quick and safe manner. The use of the platform will reduce the likelihood of injury to the patient during transport in an emergency. Also, the incorporation of the vibration units into the body of the vehicle results in a dual purpose for the platform. The vibration is used as positive reinforcement for the patient. By performing a specific task, the patient receives the physical stimulation through vibration. This is an attempt at motivating the patient to learn. It helps to teach the patient the relationship between cause and effect. By learning this simple task, the patient can advance in his learning abilities.



Electrical circuitry. M1, M2, M3, and M4 are the four vibrators.

Fig. 2

TECHNICAL DESCRIPTION

The vibrating platform provides a quick and easy mode of transportation and acts as a learning tool for the client. The former platform used to transport the client is not suitable since it is not big enough and allows the patient to be subject to injury during transport. The vibration system is a means of keeping the patient motivated by providing him with a new versatile form of stimulation.

The platform has four enclosed vibrators (Fig. 2). These are wired to an electrical converter mounted on the underside of the platform. The electrical converter is contained in a box on which the power switch and vibrator controls are located and where the power cord is attached.

The frame of the platform is 70' x 28' and is composed of L-shaped 1/8" thick steel with a support member welded and placed horizontally across the middle. The main bed consists of a 1/2" thick piece of plywood on which a series of layers is placed. First a 1/2" thick piece of hard insulation is placed on the wood. The four vibrators rest flush with the insulation inside holes cut in the insulation. Pieces of soft foam are placed underneath the vibrators to separate them from the wood. On top of the hard insulation, a piece of 2" thick soft foam is placed. Finally, the composite is covered with vinyl and secured to the underside of the wood by staples and velcro. The velcro allows for easy access and maintenance of the vibrators. The main bed is placed in the steel frame. The bolts are placed through the casters and the frame and finally, secured in the plywood. The sides of the bed are each made of a 70" x 10" x 1/2" piece of plywood. A piece of 2" soft foam is set on top of the wood and both wood and pad are encased in vinyl. The sides are attached to the main frame with four hinges each. Two straps for steering are looped around the frame at the two ends of the platform. To lock the sides in their upright position, a strap is placed across the middle of the platform. The strap is cemented to the frame and velcroed and sewn to the sides of the platform.

The four vibrators are placed in parallel at the top of the platform. Each of the vibrators is composed of a 3 volt motor offset by a small weight that is encased in plastic. The vibrators are battery-operated components used inside "massaging pillows" available from GNC stores (a health store chain). They are wired to an electrical converter that allows for the operation of the vibrators via the wall outlet.

The converter is a 120 V circuit (Fig. 2) consisting of 6.3 V transformer, full wave bridge rectifier, capacitor, resistors, potentiometer, voltage regulator, and a transistor. There is a main power switch connected to a fuse to prevent damage to the system. The circuitry converts 120 volt AC power supply to a 3 volt/2.5 amp power supply. This is necessary to run the vibration motors. The converter is enclosed in a box that is mounted on the underside at the end of the platform. The box has the main power switch (which is lighted), the four individual switches, and the power cord jack. The power cord is removable at the box, allowing for quick removal when the platform must be used for transportation. The four separate switches enable different combinations of vibration to be applied to the client.

The client is loaded and unloaded on and off the platform by rolling him up the side. The sides are then secured in their upright position by the middle strap. The client is ready to be taken to the desired location simply by using the two straps on the ends of the platform to steer the platform. The swivel casters allow comers to be taken without too much difficulty.

When not being used for transportation, the sides can rest on the floor. The vibration unit can be used as a learning tool by plugging it into a timing box. This timing box can be connected to the client's tasks that include a hand-operated pedaling machine. When the client performs a certain task correctly, the timing box will be activated that will then turn on the vibration system. The therapists now can choose any combination of the vibrators to be turned on and stimulate the client.

The platform was constructed at a total cost of $387.12.

A Modified Alarm Clock and Call Button System for the Functionally Impaired

Designers: John E. Barry, George J. Hafsios, Adam L. Jung
Disabled Coordinators: Todd Lefkowicz, Marisa Caprara Albany CP Centerfor the Disabled
Supervising Professors: Drs. M. A. McCarthy, J. B. Brunski, J. C. Newell
Department of Biomedical Engineering
Rensselaer Polytechnic Institute Troy, NY 12180-3590

INTRODUCTION

The purpose of this project was two-fold. First, to modify a conventional alarm clock to be used by an individual with cerebral palsy. Second, to incorporate a call button system into the final design to allow the individual to alert her support staff when needed. This individual lacks fine motor control in every part of her body except for her head and neck. She communicates using a head-pointer with a communications board. Because her exceptional abilities to operate her headpointer, we decided to incorporate this into our design. Essentially, this project serves to bypass the conventional alarm clock mechanical switches with large, highly sensitive membrane switches (Fig. 1) that can be operated with our client's head-pointer. Furthermore, the call button system involves the use of a large pressure switch that can be activated by gross hand motions.

SUMMARY OF IMPACT

The individual for whom this project was designed currently resides in an Intermediate Care facility. As such, she possesses a higher degree of independence than many individuals afflicted with cerebral palsy. While it will not completely free her from staff care, our project provides her with an additional level of independence. She no longer completely relies on others to wake her each morning. This project helps to strengthen this individual's self-image, which is very important in her therapeutic development process.

Several of her peers in this facility can set a traditional digital alarm clock. This project will allow this particular individual to share this ability with her friends and roommate.

In her current state, this individual must sometimes wait for long periods of time before staff members are available to assist her. If she needs any type of assistance during the night, she cannot normally get it immediately. The call button system will allow her to notify the staff immediately when assistance is required. This convenience will further increase her independence.

TECHNICAL DESCRIPTION

The operation of the alarm clock involves the activation of switches with a headpointer. This design uses an array of membrane switches offered by TASH, Inc., to set the clock and its alarm (Fig. 1). The switch array's output is channeled through a DB-9 connection, and hence is easily detachable. The clock is hung on the client's bed rail using metal hooks in a position where she can read it. Also

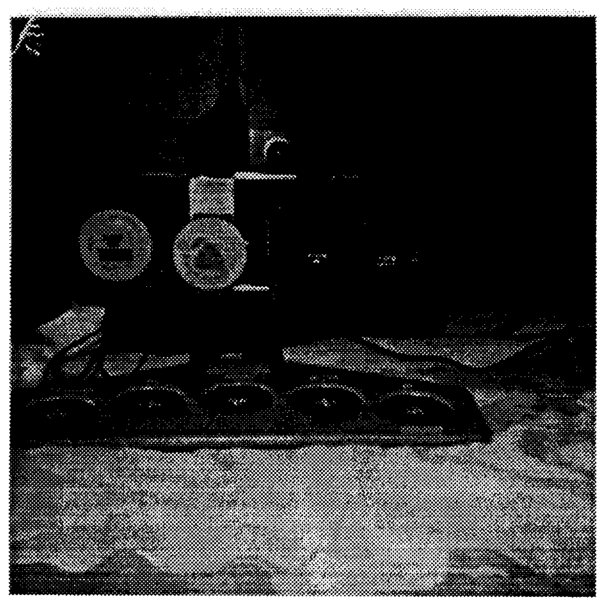


Fig. 1

mounted in this way are two switches (TASH, Inc.), one for turning the alarm off in the morning and one for calling the staff. We decided to follow a modular design for the clock because of the size and weight advantages relative to a single unit and the ease of adaptations to it. Although our design incorporates more wires than a single unit, the individual color-coded parts are easy to connect and lightweight.

Clock Operation

When the "minutes" button is pressed on the wafer board (Fig. 1), the 74279 S-R latch is set so its output, Q, is high. This enables the 74163 4-bit binary counter to begin counting. The actual signal sent to the clocks bypassed switch is the least significant bit of this counter, QA. This changes from high to low or vice-versa every time the counter is incremented, i.e., $1_{10} = \underline{1}_2$, $2_{10} = 1\underline{0}_2$, $3_{10} = 1\underline{1}_2$, $4_{10} = 10\underline{0}_2$. As shown by the underlined digit, the least significant bit changes with every count. The counter increments after every clock pulse it receives. These clock pulses are generated by a 555 timer in a stable multi-vibrator configuration, which generates a periodic square wave pattern. After the counter reaches 9 (1001_2), the least significant bit has been high five times (five pulses to the clock and thus, five minutes incremented). At this point, as determined by a 7400 Quad NAND gate, which outputs low only if the clock counts 1001_2, the S-R latch is reset so its output is low. This clears the counter to 00002 and disables its counting until the switch is pressed again. A five-minute increment was used in this project for its ease of operation. Another circuit captures and holds the signal from the "set" and "alarm/ time" buttons. On most clocks, for the clock time or the alarm time, the user must hold down the appropriate set button while pressing the minute and hours buttons. The client cannot do this with only one head pointer. Our client presses her "set" button that puts the circuit into set mode and holds a high on the line to the clocks set button until the membrane set button is pressed again. This is accomplished by toggling a 7474 D flip-flop's output by connecting the Q output to its input and clocking the input into the flip-flop (the output of which then becomes what the input was). An identical circuit is utilized to enable our client to toggle between alarm and time set modes via the "alarm/time" button. To set the alarm ON/OFF from either the bed or the wafer, we have included a large round pad button mounted at bedside. The separate "alarm off" pad is connected to the "alarm on" button on the switch array by a 7432 OR gate (active low signals), which in turn leads to a 7474 capture and hold circuit similar to those mentioned above for the set circuitry. Thus, the clock can be activated by either the bedside switch or the switch on the TASH wafer. For the "hour" button, the incoming signal from the DB-9 port is channeled directly through a 7400 NAND gate used as an invertor.

Electrical relays are connected to the leads of each clock switch to effect the actions of the circuits described. Rather than using relays in this design, transistor switching could have been employed. The use of transistors, however, involves clock-specific considerations calculations for their proper use, and is therefore specific to the alarm clock chosen. Relays, on the other hand, allow the alarm clock to be treated as a "black box," and henceforth any digital alarm clock may be substituted in the design. Three light-emitting diodes (LEDs) are used to indicate the present mode of operation of the alarm clock. D1, a yellow diode, indicates that the alarm clock is currently operating in the Set mode. D2, a green LED, indicates that the "alarm/time" switch is currently selecting alarm set. Finally, D3, a red LED, has been installed to indicate that the alarm is set to go off at a specified time as set in the alarm set mode. The heart of the call button design is a Woods RF transmitter/receiver pair. This system allows the operator to remotely toggle a 120V AC wall outlet on/off. An Archer electronic chime (Model #273-071) is connected in parallel to a variable AC-to-DC converter. By changing the voltage output of the converter, the volume level of the chime can be varied between 67 and 83 db. This chime is mounted outside a plastic case that houses all electrical connections for safety.

The "call button" large pad is permanently wired via a 6" long 1/8" coaxial cord to a separate debounding circuit similar to those described earlier. This circuitry was then attached to the Woods transmitter and sealed. The metal cover of the housing unit was replaced by a 5" long segment of acrylic plastic to eliminate possible RF interference from the metal.

The cost of this project was approximately $500.

Motorized Cart

Designers: Michelle Conerfy, Bill Kupiec, Tina Zibro
Disabled Coordinators: Todd Lejkowicz, Barbra Weiss
Albany CP Center for the Disabled
Supervising Professors: Drs. M. A. McCarthy, J. B. Brunski, J. C. Newell
Department of Biomedical Engineering
Rensselaer Polytechnic Institute Troy, NY 121803590

INTRODUCTION

The main problem that the therapists encountered with KC, a 23 month-old child afflicted with cerebral palsy, is that she is virtually unaware of her surroundings, her position in the environment, her own body, and her capabilities. Therefore, the main objective of her therapy now is to make KC aware of her environment and its limitations. The goal of the project was to design a motorized cart, the movement of which she could control by pressing on a switch.

SUMMARY OF IMPACT

The motorized cart that we have designed will enhance KC's environmental awareness and prepare her to crawl. We hope through the use of the cart that she will understand her mobility in her environment thus stimulating her to crawl. Secondly, her positioning on the wedge that is built on the cart will somewhat simulate the crawling position, thereby building the strength and coordination necessary in her arms to crawl.

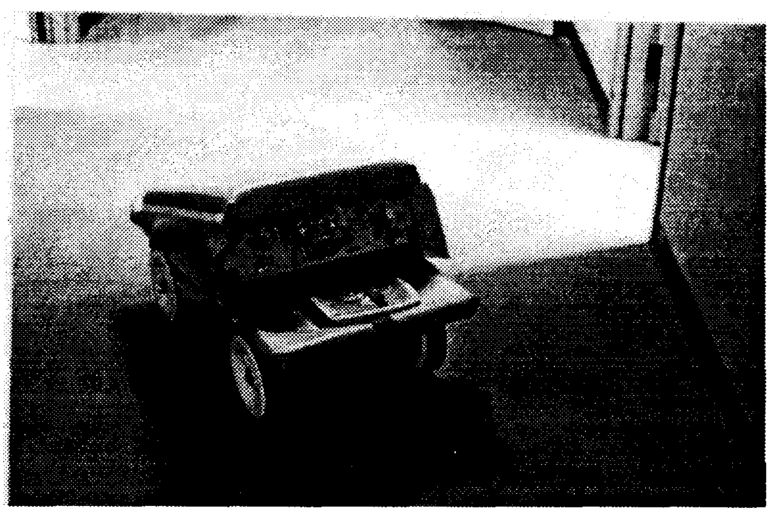


fig. 1

TECHNICAL DESCRIPTION

The design of the cart consists of a motor-driven platform activated by a pressure-sensitive panel. The platform is a 36” x 20” x 3/4" piece of plywood surrounded by a foam bumper and covered by pink vinyl. Snaps are sewn to an elastic strap making it possible for the strap to be easily attached to or removed from the platform.

Atop the platform sits the adjustable wedge (Fig. 1). The wedge is also made of plywood and is upholstered with 2” foam and pink vinyl. The adjustability of the wedge allows for the cart to be used as KC grows. The wedge is 24” x 20” x 3/4" in size and is secured to the platform by hinges. The adjustability feature was accomplished by attaching eight 1 1/2" L-brackets to the top of the platform and a 6” x 20” x 3/8" piece of plywood to the underside of the wedge. This hinged piece of plywood can be inserted into the L-brackets to allow for three different positions of adjustability; anything more would have caused the incline of the wedge to be too great.

The cart moves when pressure is exerted on the detachable 3” x 8” plastic handpanel that is on the platform in front of the wedge. The panel serves as the power switch for the 1/2 HP motor and the 75 dB electronic beeper. The beeper is incorporated to act as a stimulus for KC. It is connected so that when the handpanel is depressed and the motor is activated, the beeper will sound, otherwise no beep will be heard. The panel is wired to the motor and gearbox located on the right-hand side of the rear axle. Two switches on the right underside of the platform allow for the cart to move forward or backward at a high or low speed. The high speed of the cart is 2 1/2 mph. The low speed of 1 mph is accomplished using four 5 watt - 1 ohm resistors connected in parallel, yielding a total resistance in the circuit of 1/4 ohm. The circuit is powered by a 6 volt rechargeable DC battery, equipped with a 25 amp fuse. The normal operating current flowing through the circuit is 2 amps. Under conditions in which the motor is stressed to the point of stalling, the circuit output is 8 amps; replacement of the fuse due to high currents is unlikely.

Due to the cost factor, serviceability, ease of assemblage, and relatively short lead time for part arrival, parts from a “Power Wheels” miniature toddler car were used. The front and rear axles, 3/8" in diameter and 19’long, were secured using 6” L-brackets bolted to the platform. The four wheels, surrounded by rubber treads, are 8” in diameter and 2” wide. Should one of the wheels become loose, a cotter pin was placed in each axle at the L-bracket to prevent the axle from sliding. In order for the right-hand side rear axle to fit through the gearbox, the axle had to be machined down to 1/4" and then brought back up to size to fit properly through the wheel. This resizing was accomplished using a thin piece of metal stripping cut to fit into the hole where the axle would pass through the wheel. Because the axle does not move while the cart is in motion, there is no danger of heat generation from the metal axle against the metal stripping. An additional 6” L-bracket screwed into the platform secures the gearbox and motor and prevents them from spinning with the wheels. The battery is attached to the underside of the platform by a metal brace, 6” screws, and wing-nuts, which can easily be loosened to remove the battery if so desired.

The final product meets the immediate and future needs of our client, and was completed within the time frame given. This efficient use of time and money was accomplished by using already existing materials rather than spending needless time building parts that already existed.

Time permitting, the project could have included an alternate position for KC on the wedge. The use of the cart with KC in a sitting position was just recently discovered. If this possibility was brought up earlier, the wedge could have been adapted for such a position.

The cost of the project was $336.

Active Stimulation Box: A Learning Apparatus for the Mentally Handicapped

Designers: Scoff R. Beaupre, Lewis P. C. Leung, Dawn Klein&ester
Disable Coordinator: Todd Lejkowicz Albany CP Centerfor the Disabled
Supervising Professors: Drs. M. A. McCarthy, J. B. Brunski, J. C. Newell
Deparfmenf of Biomedical Engineering
Rensselaer Polytechnic Institute Troy, NY 12180-3590

INTRODUCTION

A teacher at the CP Center in Albany had developed a communication aid for the disabled, and in particular for a ten-year-old girl named JB. The aid consisted of a wooden structure that can hold various objects in eight compartments. The intent was to use the device to teach handicapped students the relationships between objects. The objective of this project has been to develop the electronics behind the already existing communication/education aid in order to produce an active stimulation box. As presented, the box consisted of upper and lower panels, each with four distinct Plexiglas windows, behind which objects or pictures may be placed (Figs. 1,2). The final design includes adjustable-angle panels beneath the objects in each compartment, partitions between the compartments, display lights in each compartment, and indicators over each window to indicate selections and the scanning process.

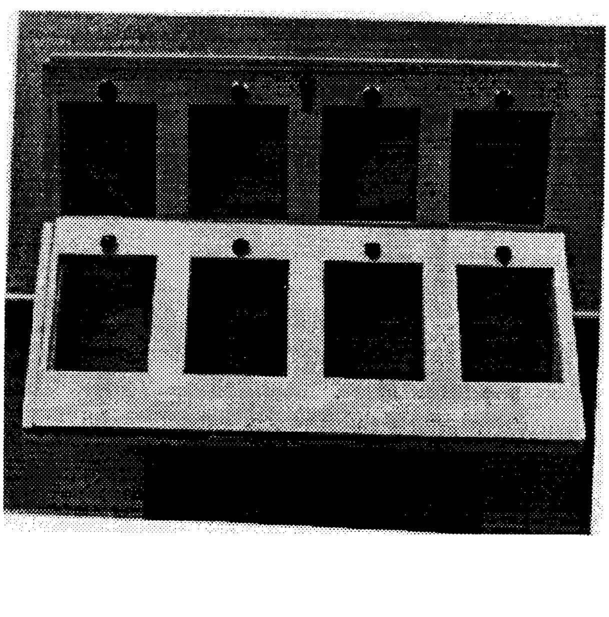


Fig. 1

SUMMARY OF IMPACT

The hypothesis is that through independent work with the aid, our client will sharpen her powers of association, learn correlations between the concrete and the abstract, and most importantly, learn to express her everyday needs more effectively. It is hoped that this will in turn lead to increased function and independence in her environment, which will be an exhilarating and rewarding experience for her and will relieve somewhat the attention required from her supervisors. The completed design enables our client to use the association aid with the assistance of a supervisor or on her own, thereby promoting her ability to associate similar concrete objects with varying degrees of object abstraction.

TECHNICAL DESCRIPTION

Our aims have been the design and construction of the association scheme for the windows, the input

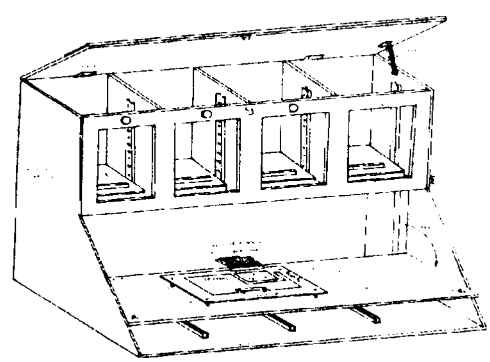


fig. 2

methods and reinforcement interfaces, and the development of circuitry to support the chosen scanning and selection methods. The design has accomplished each of these objectives, and realizes several added desirable features as well. The aid functions in three modes, one "normal" mode, where the client sits at the box and touches the panels, and two "remote" modes, where the client operates the box via remote switches. In mode 1, the client chooses an object in the upper or lower panel compartments by pressing on the Plexiglass window behind which the object sits. She then chooses a match from the other panel in a similar manner. Lights indicate her choices, and positive (toys) or negative (buzzer) reinforcements reflect her match. In mode 2, for clients with poor upper extremity control, the client can scan through the match choices herself by repetitively hitting a remote switch. She then chooses the appropriate response by hitting a second switch when the correct choice is lit. Standard jack interfaces allow use of the popular "cheek" and "cushion" switches, with which the clients are familiar. In mode 3, the digital circuitry scans automatically through the upper or lower windows by lighting the lamps over each box successively. The client then indicates her choice with a single switch. The selection indicator transition time interval is easily adjusted by the supervisor on the box's rear control panel and ranges between 0.5 and 6 seconds. Likewise, separate delay circuits for the positive and negative reinforcement durations give adjustable reinforcement times between 0.5 and 20 seconds. An association scheme of 16 on-off rocker switches, correlating each of the four upper windows with each of the four lower windows, is being used. This allows each of the upper windows to be associated with any of the lower windows in any combination or permutation. Four banks (groups) of four rocker switches are needed, and any "on" state indicates an electrical connection between the upper window corresponding to the group number and the lower window corresponding to the switch number within that group. Whenever a switch is turned on, the corresponding compartments are rendered active, and their background lamps automatically illuminate. Compartments that are not included in the association scheme are ignored in all modes. The switches are located in banks on the back surface of the box, each group behind its corresponding compartment. The controller has been designed using TTL digital logic. Two interface cables connect to the circuit board, a 50-pin ribbon cable for DC I/O and 25 conductor 20 gauge cable for AC power supply to the indicators and background lamps through the relay interfaces. In mode 1, the circuit accepts an initial choice from any active compartment, and an indicator lights over the compartment. This choice may be overridden by selecting another active compartment from the same panel, or it may be matched by selecting an active choice from the opposite panel. In the latter case, positive or negative reinforcement timers are activated reflecting the match. These timers close a relay that closes the contacts of the output jack. Once the delay is complete, if the match were correct, the flip-flop states are reset so that the indicators turn off, ready for another match. If the match were incorrect, then the original choice is retained and the second choice is reset, so that another attempt to match can be made. This can be overridden by selecting another compartment from the same panel. Modes 2 and 3 rely upon scanning of the choices. In the scanning sequence, the indicators light successively one at a time on a clock pulse, and the scan loops from indicator 4 to indicator 1. A T-type flip-flop design was chosen as the simplest to implement in realizing the state transitions. In mode 2, the clock pulse is provided by the client's external switch, whereas in mode 3, an astable multivibrator based on the 555 timer provides the clock pulse that is used to trigger the flip-flops. After the first choice is made by the supervisor, the circuit automatically detects the panel (upper or lower) that was hit, and activates the selection indicator on the opposite panel. If, during the scrolling process, the circuitry tries to go to a state that is an inactive compartment, an auxiliary 74121 monostable multivibrator is triggered, sending a pulse on the order of about 500 nanoseconds to the state-determining flip-flops. This causes an immediate transition to the next state. Thus, inactive compartments are skipped in the scrolling and selection process. Standard connections via 1/8" phono jacks are provided for general interface with the digital circuitry. This allows the use of the many already existing standard reinforcement toys and input switches, and makes the unit more versatile. We have also made modifications to the current box design to include lower partitions, a rear compartment for the electronics, adjustable floor panels, and lighting for the compartments to display the objects more effectively. The total cost of the design project was $475.

An Audio-Based Communication Device

Designers: Jackson Kwan, Wilma Lawrence, Peter Murano
Disabled Coordinator: *Todd Lejkowicz*
Albany CP Center for the Disabled
Supervising Professors: Drs. M. A. McCarthy, *J. B.* Brunski, *J.* C. *Newell*
Department of Biomedical Engineering
Rensselaer Polytechnic Institute, Troy, NY 12180-3590

INTRODUCTION

The objective of this project is to enable the client to communicate his immediate needs more effectively with caregivers in the client's home. "Doc" is a retired dentist in his seventies who is disabled due to the effects of diabetes and strokes, and now requires 24-hour care.

Caregivers must adapt to Doc's limitations to discover his needs. Strokes have left him with limited communication abilities. He can understand most speech and sometimes written text. His hearing is fine but his eyesight is deteriorating. He can sometimes repeat spoken words. He can consistently say the words "yes" and "no", but uttering a word to describe what he wants without prompting is beyond his abilities. He also has trouble initiating an interaction other than by groaning.

His current care is given by his son's family and a 24-hour home health aide. When they want information from him, they are careful to phrase questions in a way that allows Doc to simply answer "yes" or "no". They are familiar with his customary activities and requirements and can make good guesses as to what Doc may want. Temporary aides who are not familiar with Doc and his routine often require more training time than their duty time affords.

Doc has additional constraints on his communication process. Sometimes questions need to be repeated. Occasionally he says "yes" when he means "no". Sometimes his groans do not appear to have any significance. He can decide between two things, but may become confused if given a list of more than two things to choose from. This prevents him from using most of the communication boards that are readily available as augmentative communication devices.

Given these constraints and requirements, a system involving voice recognition and speech synthesis devices was devised. The system works by asking a series of questions to which the client replies either "yes" or "no" .

SUMMARY OF IMPACT

Recovery from a stroke with its multiple problems can be a long-term process. The complex problems in communication disorders often make recovery a slow and frustrating experience leaving the patient feeling powerless and frustrated. It often leads to depression, with the patient giving up hope and slipping into a vegetative state.

Doc has been very receptive to working with the speech synthesizer designed herein. Although he was initially frustrated by his inability to understand the electronic voice, he continued to work at understanding individual words, focusing on the words that were easier for him to understand. We also found that his understanding was better when used in context than in isolation.

Doc has just started using the voice recognition part of the system which we hope will give him a feeling of independence and control over some of his attempts to communicate. The first attempt, in a laboratory setting, proved that the system could recognize his responses. However, because of distractions in the laboratory, Doc found it difficult to focus on the one task. The constant background noise in the lab made it even more difficult to understand both Doc and the speech synthesizer. Our original goal for the project was to offer possible independence in some areas of communication. Since working with the communication system, we have realized that there is still a certain learning curve that has to be overcome before one can effectively use the system. However, the communication board will work with unfamiliar caregivers and with relatives who have been reluctant to try to speak to Doc. This is a major step in opening up pathways of communication to Doc.

TECHNICAL DESCRIPTION

Speech Recognition/Speech Synthesizer unit

We have designed a computer-based design with a speech recognition/ synthesizer hookup. It asks the client a series of questions based on a menu hierarchy that helps to determine the client's needs. Instead of visually displaying the menu choices, they are read to the client, one at a time. A vocal response is solicited from the client through the speech recognition system.

The control system consists of a control program written in BASIC and a text file detailing the menu structure. In the construction of the control program, the major question was: How much control should the program grant the menu designer? The first design had the menu structure built into the program. Allowing only four items per menu level, all a menu designer had to do was to input the items and their phonetics into a text file and the program would take care of the rest. This design made it easy for the menu designer but severely hampered the flexibility of the system.

With a suggestion from a programming consultant, we changed the menu structure. For each item in the menu file, there are now five pieces of information. There is a record code for the item, the name of the item, the phonetics of the item, the record to go to upon a "yes" response from the client and the record to go to upon a "no" response from the client. For example, a line in the menu file is:

Record #/English Phon./"yes" res./"no" res.

When the program starts, it reads the menu file into five arrays. At each line, the speech synthesizer reads the item by its phonetics. The computer then solicits a "yes" or a "no" response from the client. With his/her response, the program goes to the next menu line dictated by the record code listed under the "yes" or "no" array. If a code under the "yes" array at a particular menu line is zero, it means that it has come to an end of the menu hierarchy. Therefore the computer will signal for the attention of the caregiver and repeat the chosen item through the speech synthesizer. The chosen item also will be displayed on the screen and left there until the caregiver presses "C" to clear the screen. An operational flowchart shows the details of how the system works.

There is also a time-out feature built into the program where it has to wait for Doc to say "yes" or "no". If Doc does not respond to a question in more than a certain amount of time, the program will automatically reset back to the top of the menu hierarchy. This time delay is currently set at two minutes and can easily be changed from within the BASIC source code.

The new menu structure design shortens the program by two-thirds. It now allows any form of menu item associations with any number of menu items. It gives the menu designer more flexibility and control. However, it also places more responsibility on the menu designer and anticipates a moderate level of computer literacy. However, due to the flexibility and programming elegance gained through this menu structure design, we decided that it is a worthwhile tradeoff.

The cost of this project was approximately $300, which includes a voice recognition unit (Voice Master, $160), speech synthesizer hardware and software ($60) and wireless microphone ($70).