CHAPTER 8
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Motorized Training Cart

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INTRODUCTION

We have successfully designed, constructed, and tested a motorized training cart to aid disabled children in learning to maneuver an electric wheelchair (Figure 8.1).

The children we specifically worked with were Jeremy, Michael, Jason, and Patrick, all from the "Emerging Skills" class. These boys, like the other children in this class, are all becoming more aware of their environment. They are exploring and beginning to understand their surroundings through sensory and motor experiences. The boys, however, are unique in that they have a walking disability. Jeremy and Michael cannot walk at all and will soon have corrective surgery, while Jason can walk with only a walker. Jeremy currently has an electric wheelchair on order, and could benefit from a wheelchair training device as represented by our design project.

Because of their disabilities, Jeremy, Michael, Jason, and Patrick could find the use of an electric wheelchair to be a very frightening experience. These children are accustomed to remaining stationary or moving at very slow paces. If they are placed in a wheelchair, they would have to operate an unfamiliar device traveling at a speed of approximately three miles per hour. It is felt that these children need a training device similar to a wheelchair but offering more security and movement at a slower pace. Therefore, our primary objective was to design a system to serve as a transitional medium to the electric wheelchair.

SUMMARY OF IMPACT

The motorized training cart that we have designed will prepare a non-mobile child to use an electric wheelchair by developing his/her skills in manipulating a joystick to control the movement of the cart. We hope that, through the use of the cart, the child will become more comfortable and familiar with maneuvering an electrical device, thus aiding him/her to learn to use a motorized wheelchair. Secondly, we hope that the child will better understand his/her mobility in the environment, thereby developing greater spatial perception and coordination necessary to operate an electric wheelchair.

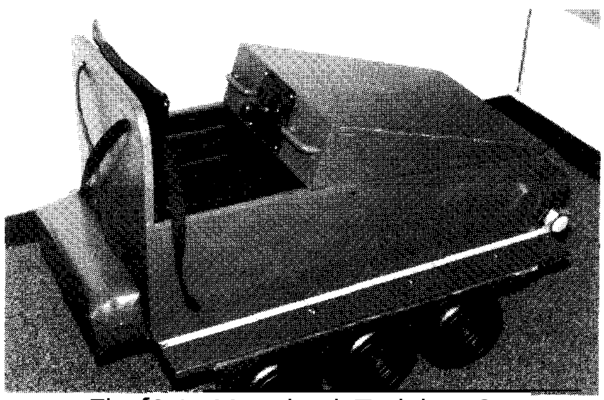


Fig. 8.1. Motorized Training Cart.

TECHNICAL DESCRIPTION

The design of the motorized cart addressed several mechanical and electrical considerations to provide for a safe and efficient wheelchair training device.

A. Mechanical

A commercially available cart design (Hedstrom's "B.O.S.S.") consisted of a molded plastic body attached to a welded frame. Since this commercial design required the child to sit in the vehicle with a bent knee position, its molded plastic body was unsuitable for our design. The physical therapists at Pinewoods Center emphasized the importance of having a flat bed so that the child occupant could extend his/her leg muscles. Wood was chosen for the material of the flat-bed body design because of availability, low cost, structural strength, fabricability, and wood's good strength-to-weight ratio. We selected plywood for all the parts of the cart body except for the two side panels. The advantages of plywood, especially for the cart's base, are its high strength and minimal defects produced from the cross-lamination of thin slices of wood. The two side panels were constructed from white pine wood for its softer qualities. Since it is not necessary for the side panels to support any large loads, and since they would encounter the most human contact, pine's smoother and softer qualities would be more appropriate. These qualities do not, however, significantly diminish its strength; the ultimate compression strength of pine is 7,300 psi.

We used 1" thick wood and 1.5" wood screws to attach the plywood and pine parts of the body. The hip measurement ("width") of an average four-year old child is 9". The width of our cart interior is 14", giving a total of 5" of additional space for a larger child. Since the original width of the frame of the B.O.S.S. cart was 27", there is 6.5" of extra width on each side of the cart. The length of the cart is 36", which is 6" longer than the original B.O.S.S. cart. The additional length was necessary to accommodate the straight leg position of the child inside the cart. Due to the stability of a six-wheel design, we were not concerned with the possibility of tipover. We therefore positioned the base so that 3" extended from both the front and the rear of the original length for uniformity. A battery compartment was constructed at the front end of the cart.

In order to encourage proper seating and stability of the occupant in the cart, we built a pommel into the base of the cart. The pommel was constructed from a 3.5" diameter wooden spool surrounded by foam and covered with vinyl. A 0.75" diameter wooden dowel was secured inside the spool, leaving a 1" extension which mated with a hole in the base of the cart.

In attaching the wooden body onto the original B.O.S.S. cart frame, it was not possible to attach the flat base of the wooden body directly onto the frame, since the motor partially extended above the frame. Our solution was to utilize the lower half of the original plastic body, since this had been molded to accommodate the mounted positions of the motors. To remove the upper half of the plastic body from the lower half, we cut around the perimeter of the mold using an Exacto knife. The wood body was then placed onto the lower portion of the plastic body and attached with 2.5" carriage bolts positioned on the ledges of the cart and fastened beneath the plastic mold between the wheels.

Several safety features were incorporated into our design. The hood of the cart was attached to the front panel with a continuous hinge, which effectively eliminated any gaps between moving parts of the cart. Velcro strips were attached with epoxy to the top edge of the side panels and the lower edge of the hood to insure hood closure while the cart moved. Slots were cut into the back panel of the cart and buckled utility straps were used for seat belts. Wooden handles were installed on either side of the joystick to keep the child's hands inside of the cart. Padding and cushions inside the cart and bumpers outside the cart provided comfort and additional safety. Vinyl-covered polyurethane foam (1" thick) was used for the seat cushion and the side panel padding. Two 20"x 2.5" x 6" foam blocks covered with vinyl were constructed for use inside the cart to accommodate different sized children. The pommel adjustment and various size side panel padding meet the adjustability requirements requested by Pinewoods Center. The cart's front and rear bumpers were constructed from similar foam blocks also covered in vinyl and attached to the body of the cart with epoxy. Assuming a low spring constant of 10 lb/in for the foam block, a maximum weight of the cart as 50 lbs, and a maximum speed of 1 mi/hr, we calculated a maximum bumper deflection of the foam to be about 2" (details on request). Since the foam is 2.5" thick and we intentionally underestimated the spring constant of the foam, the foam bumpers are more than sufficient to cushion impacts.

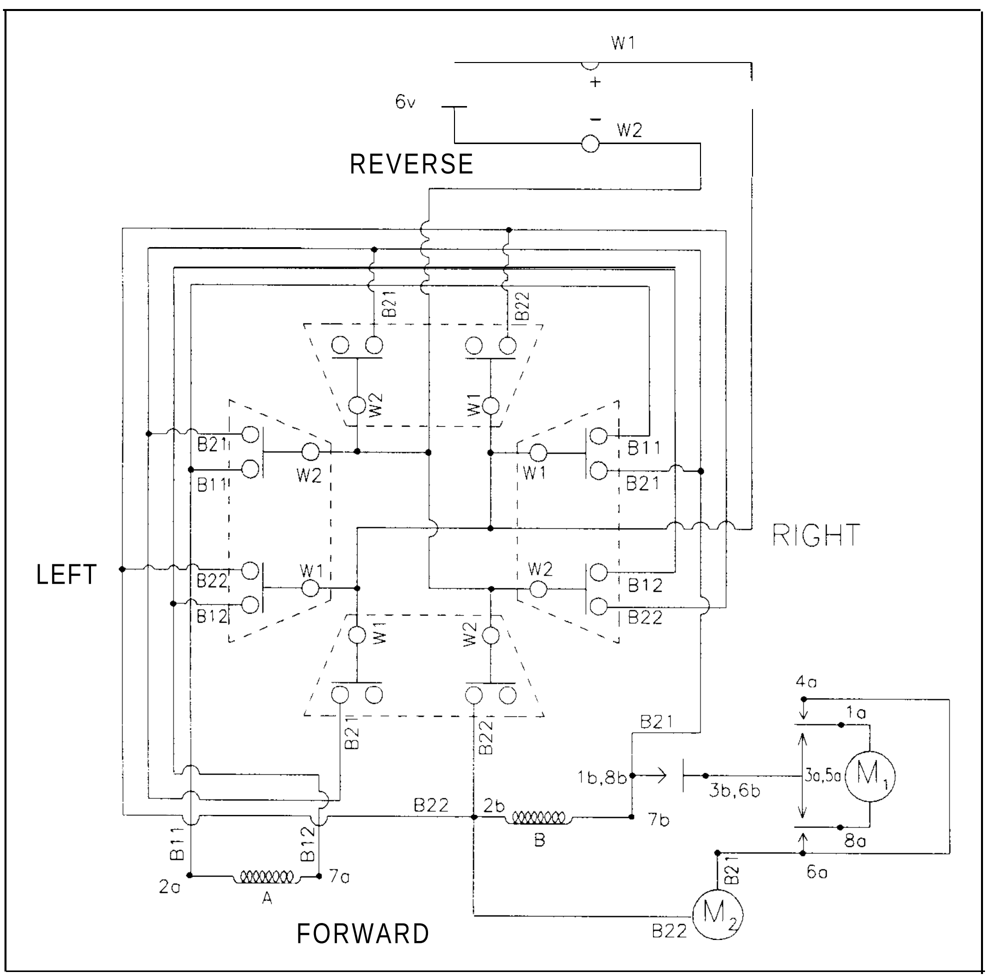
B. Electrical

During preliminary stages of cart design, the primary electrical design issue was the cart's speed. The speed had to be slow enough to allow the child to control the movement of the cart properly, but fast enough to provide for an experience similar to that in a motorized wheelchair.

The original B.O.S.S. toddler cart operated with two motors in parallel directed by a four-pin joystick circuit and powered by two 6-volt gel-type rechargeable batteries equipped with two 30-amp fuses. The normal operating current when the cart is unloaded is approximately 10 amps. The motors and circuit configurations were the same for both low and high speeds; however the batteries were arranged in parallel for low speed and arranged in series for high speed. The low and high speed arrangements supply each motor and the cart with six volts and 2.5 mi/hr and 12 volts and 5 mi/hr, respectively, while the approximate speed of a motorized wheelchair is 3 mi/hr.

Although the cart's low speed and the speed of a wheelchair are approximately the same, we need the cart to be slightly less than half the wheelchair speed, *e.g.*, 1.2 mi/hr, for training. Therefore, the velocities of both battery configurations were too fast and had to be modified. However, because both the low and high speeds were too fast, we felt that it was only necessary to alter one circuit, the low speed. To determine the best way to slow the cart down, we first researched the governing equations for the electrical characteristics and torque relationships of DC motors.

Since there is a direct relationship between the voltage e_m and speed v of a DC motor, we decided to try and reduce the speed by reducing the voltage supplied to the motors. To determine the appropriate voltage for our cart, we inserted a resistor in series with the motor. We built varying size resistors by winding different lengths of 22 gauge copper wire around an aluminum post. Implementing the various resistances, the voltage and distance/ time were measured until we reached a range of appropriate speeds. We needed the speed to fall in the range of 0.92 to 1.36 mi/hr, which corresponded to 2.3 and 3.3 volts, respectively. Based on a linear fit to the data, the DC motor constant was 2.5 volts/mi/hr. Using our speed v to be 1.2 mi/hr, we calculated the desired voltage to be 3 volts.



To obtain 3 volts at the motors, we elected to rewire the motors in series; this would allow the two motors to share six volts from one battery. To wire the motors in series, we chose to remove the left motor, M1 and wire it directly with the right motor, M2 (Figure 8.2).

Altering the wires for M1 caused the left motor to direct the left wheels in the same direction as the right side. However this caused a problem when turning, because the two sets of wheels are supposed to rotate in opposite directions. Implementing this design therefore also required us to rewire the joystick circuit to correct the direction of the motors caused by placing them in series.

Compensating for the joystick directional problem was slightly complicated and required the attachment of two electromechanical relays. The two relays were wired as shown in Figure 8.2. Relay A was wired to M1 in series to M2 at points 3 and 6 while points 2 and 7 were wired to the joystick. When the cart is turning, points 2 and 7 activate the coil of the relay which in turn reverses the direction of M1, allowing the cart to turn. However, reversing the direction of M1 entails a small time delay that could cause a slight jerking motion. Relay B wired in parallel with relay A compensates for the time delay by activating its coil just prior to the activation of relay A's coil. Wiring the two relays in parallel also reduces the resistance introduced to the circuit by the relays.

Implementing relays in our design was the best choice because when used properly, relays have the advantages of (1) long life, (2) operation over large temperature ranges, (3) satisfactory characteristics at high altitude, in dust and sand, (4) satisfactory operating speed, and (5) simple circuitry. Although the relays serve our purpose with many advantages, there are also two concerns: (1) contact bounce, and (2) failure of contacts. The first problem of contact bounce would occur when the child drives over any rough bumpy surface causing the contacts to move. The second problem of failure of contacts could be caused by excessive movement of the contact parts causing fatigue and failure. However, both these concerns are minor because: (1) the child will most probably be riding on a semi-smooth surface free of rocks and bumps, thereby allowing us to ignore bounce, and (2) a majority of the cart use will be in the forward and reverse directions and therefore the relays will not be activated very frequently.

Although we chose to implement a series motor design to meet our speed and voltage requirements, there were other alternatives considered. The other major alternative to the electrical design was to purchase new 3-volt rechargeable batteries. These batteries would replace the original 6-volt batteries thus supplying less voltage to the motors. This technique was not implemented because 3-volt gel-type batteries are not standard and are not manufactured by any battery company that we researched. However, if a battery technique is preferred, eight 1.2-volt D-type rechargeable batteries can be attached in series to achieve the necessary current and then three sets of the eight are attached in parallel to achieve the 3-volt requirement, totaling 48 batteries, 24 for each motor.

Our final cart moved at approximately 1 mi/hr unloaded and with a 30-pound load. These results were perfect for the needs of our client and served to meet our primary objective.

The approximate cost of this design was $391.

An Antishear Device for Use in Knee Rehabilitation

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INTRODUCTION

Strengthening programs are essential for stabilization of the knee after ligament damage, which causes joint laxity. Laxity can be minimized by strengthening the joint muscles. Therefore, as part of rehabilitation following injury of the anterior cruciate ligament (ACL), a patient will frequently perform exercises on an *isokinetic* exercise machine, such as the BIODEX. During exercises, a patient tries to extend the lower leg against a resistance force, usually applied at the ankle. A concern during such exercises, however, is how to control and ideally eliminate the shear forces that tend to pull the tibia anteriorly relative to the femur, thereby straining the ACL, when the quadriceps muscles contract. We have designed an attachment for a BIODEX machine that minimizes the shear force on the tibia during isokinetic exercise.

SUMMARY OF IMPACT

A patient, JM, was injured during a varsity soccer game. The injury was classified as a third degree tear of the ACL. He underwent surgery for ACL repair. Initially, during rehabilitation, JM's physician would not allow JM to extend his leg against resistance beyond 45 degrees due to stress on the ACL. However, once the BIODEX machine was retrofitted with our antishear device, JM could perform full-leg extensions earlier in his rehabilitation. It has been estimated that within a year, five more athletes and two to three other members of the campus community could benefit from rehabilitation involving the antishear device.

TECHNICAL DESCRIPTION

For the relevant isokinetic exercises, a two-dimensional statics analysis of the knee joint (details on request) reveals that the shear force at the tibiofemoral joint can be decreased by decreasing the moment arm from the center of the knee to the point of action of the force on the tibia. Consequently, in the anti-shear device, a design goal was to raise the pad from the ankle to approximately the middle of the tibia. Other design goals included ease of attachment of the antishear device to the BIODEX, fabrication at a cost less than available commercial units (*i.e.*, less than $595), and reproducible positioning of the device on the crank of the BIODEX.

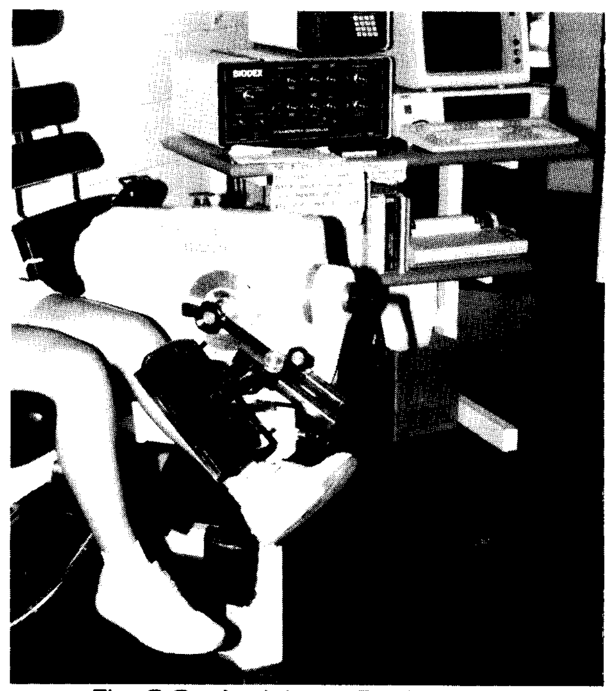

Fig. 8.3. Antishear Device for Use in Knee Rehabilitation

The resulting antishear device consists of four components: U-bar, clamp, pivot and pad. The antishear device is connected to the BIODEX by inserting the U-bar into the crank of the BIODEX. A tibial pad is attached to the pivot. The pivot is attached to the U-bar by a clamp, which also enables adjustment of the pad's height. The device is reversible; it may be used to allow extension of either leg.

The U-bar was made of steel tubing with a square cross-section. The "U" was made by welding three segments together. The clamp was also made from steel tubing, but with a slightly larger internal dimension so as to slip over the U-bar and be clamped in the desired position. The pivot consisted of two pieces of steel pipe, one with a 0.75" diameter and the other with a 1" diameter. The 1" pipe was reamed to allow for a smooth bearing surface with the 0.75" pipe. The smaller pipe was welded to the clamp. The other end of the smaller pipe was tapped to fit a screw-on cap that held the one pipe in place. The pad consisted of a 2" x 10" x 0.125" piece of steel, which was welded at its middle to the 1" diameter cylinder of the pivot. This piece was connected to an aluminum sheet (approximately 10" x 10" x 0.125") that was contoured to fit the shin. The Al plate had slots for Velcro straps that could strap the pad to the shin. A piece of foam, 2" thick and vinyl-covered, was glued to the aluminum sheet. The cost was approximately $200 for all parts.

The following analysis evaluated the device's mechanical sufficiency in static and dynamic loading. During leg extension, the maximum loads on the pad were assumed to be 200 LB (flexion) to 300 LB (extension), based on literature. The critical part is the U-bar, particularly where it attaches to the crank of the BIODEX. A fatigue and yield analysis using Von Mises stresses and Goodman-Langer criteria (details on request) indicated that under worst case conditions the critical part's life was greater than 10^7 cycles. Similarly, a fatigue analysis of the fillet and butt welds in the U-bar suggested a fatigue life of more than one million cycles.

A Mechanical Feeder and an Arm-Damping Device for a Disabled Individual

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INTRODUCTION

The first objective was to modify the design of a mechanical feeder (Figure 8.4) for a disabled individual with athetosic Cerebral palsy (BC, a 22-year old male) so that he could eat without the assistance of a therapist. The feeder has a spoon mechanism that picks up the food from a plate and delivers it to the user via a mechanical arm. A second objective was to consider the feasibility of a damping device for the client's arm, in order to steady the side-to-side motion and undesirable up-and-down motion of the patient's arm.

SUMMARY OF IMPACT

This project could lead to a system that enables BC to eat on his own without the assistance of a therapist. From the beginning, BC has expressed his desire to have his own apartment someday and to live independently. Therefore, this design is one step in that direction. At the present time, BC is one of the few people at the Albany CP Center who requires help when eating. With implementation based on our project, he might feel more comfortable when eating with others. The damping device for his arm will help BC in eating and also assist him in other important aspects of life, such as job performance and social interactions.

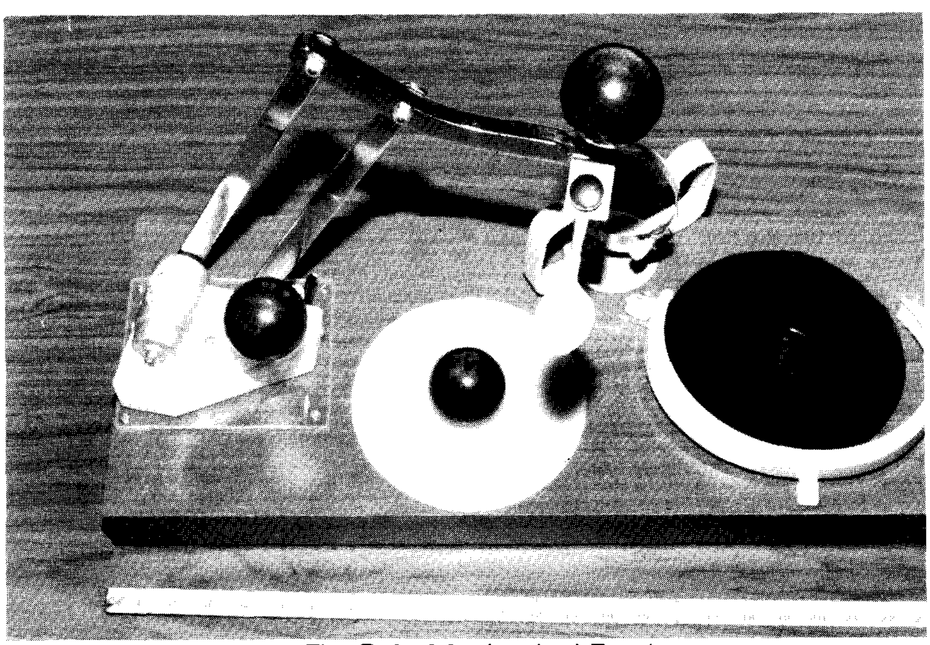

Fig. 8.4. Mechanical Feeder.

TECHNICAL DESCRIPTION

In the feeder (Figure 8.4), the damper brings the arm up slowly to the individual's mouth after the food has been scooped up onto the spoon. This prevents the food from flying off the spoon or the spoon from hitting the person in the mouth. The knob on the arm brings the arm down to the plate and moves the spoon across the plate. The knob next to the plate rotates the plate about 15 degrees each time it is pushed so that the food is eventually scooped up from all parts of the plate.

BC's original feeder did not suit his needs. To meet BC's specifications, the redesigned feeder has a new viscous damper and new spoon mechanism. The damper is a spring device that allows the arm of the feeder to slowly return to its resting position. The original spoon was very large and could have choked our client. To alleviate this problem, we used a smaller, teflon-coated spoon. Also, we placed a swivel mechanism under the base of the arm so that it can rotate about three axes rather than just two. The swivel is made of 1/4" Plexiglas and is connected to the arm through a pin and slide device. One major problem with most mechanical feeders is picking up food. In order to solve this problem, we placed a lip around the edge of the plate. This will force the food onto the spoon rather than having the spoon simply push the food off the plate.

The main purpose of this damping device for the arm is to enable a patient to eat on his own. The damping mechanism is an arm splint with two dashpots attached along the side of the device at the elbow (Figure 8.5). The splint was made with the collaboration of Ron Cahill, Cahill Orthopedic Laboratory in Troy, NY (details on request). An analysis of the arm as a dynamic system shows that an arm of mass M supported by a spring and dashpot in parallel is a second-order mechanical system. By solving the equation of motion for this system (details on request) it becomes clear that the dashpot properties can be selected to control the motion and filter out (low pass filter) unwanted oscillations, *i.e.,* tremors in BC's arm movements.

The total cost of the project was about $200.

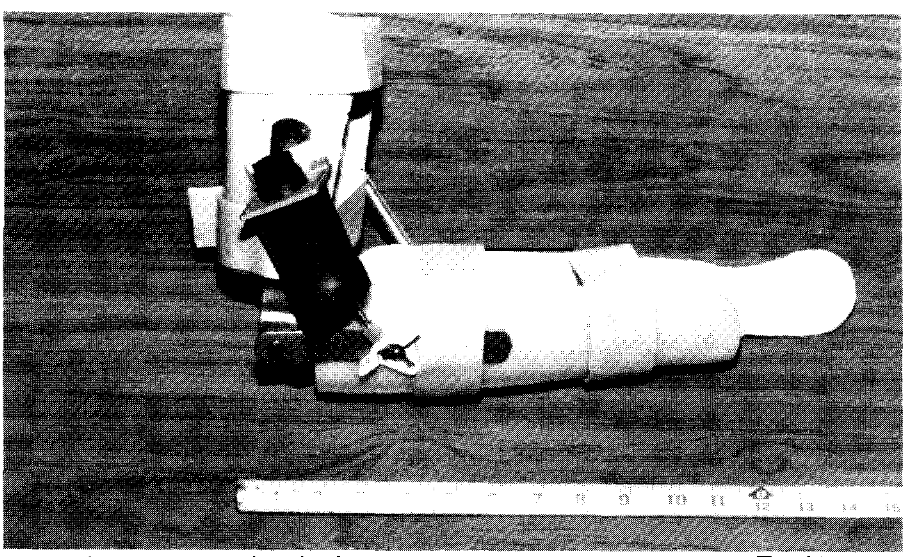

Fig. 8.5. Mechanical Feeder and an Arm-Damping Device for a Disabled Individual

A Portable Kitchen Table for the Disabled

Designers: Matthew Kyran Kelly, Michelle Lynn Leonard, Barbara Ann Schulz
Client Coordinator: Linda Lynch,
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INTRODUCTION

This project solves a problem encountered by a group of students at the Cerebral Palsy Center for the Disabled. Since many of the students are wheelchair-bound, their access to conventional tables and kitchen devices is limited. Many of the clients also have limited strength and cannot lift any appreciable weight above that of a small utensil. Therefore, the purpose of this project was to design a table that would allow handicapped or disabled individual's access to kitchen equipment necessary for baking. This table is meant for use in a controlled environment in order to teach independent living at the CP Center. This prototype may also serve as a model for a table design used in the home. Also, the table may be used by one person or the entire class of five or six persons.

This table design (Figure 8.6) relates to another project that involves the modification and fabrication of equipment that will dispense ingredients into a bowl on the railing side of the table (see Kitchen Appliances by Held, Olbrich and Valentino).

SUMMARY OF IMPACT

The table was designed as an aid to baking. It meets many of the class's needs and allows even the most disabled client with whom we worked to contribute significantly to the baking process. While the table may be used by an individual, the group interaction afforded by the accommodation of six students can be an invaluable teaching tool. The table also gives the clients a much needed sense of independence.

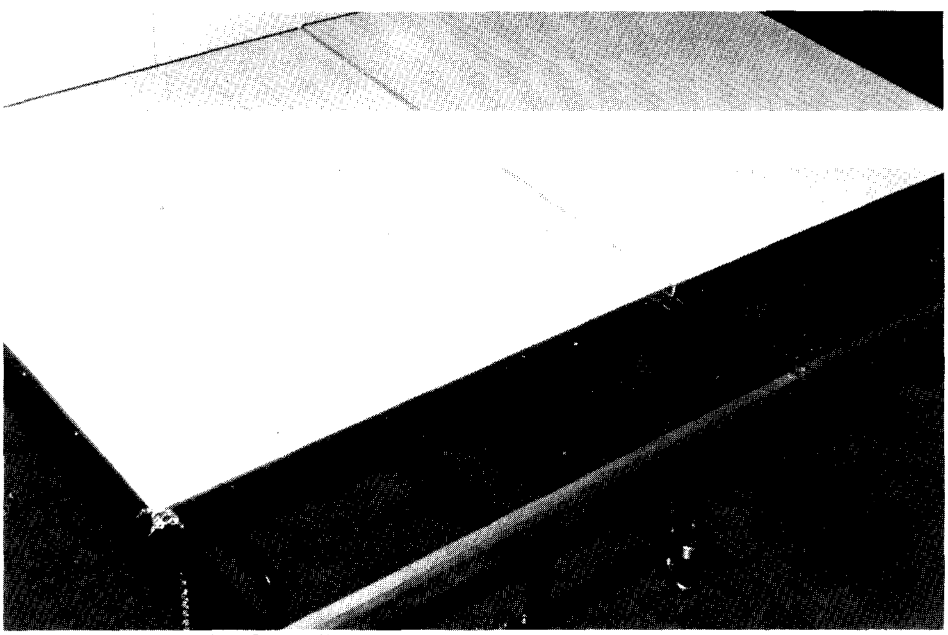

Fig. 8.6. Portable Kitchen Table for the Disabled.

TECHNICAL DESCRIPTION

The table was designed to be portable and collapsible. These criteria were met with a design that incorporates many of the support and portability features of a typical folding Ping-Pong table. In order to collapse the table, its two halves are brought to the center so that they rest almost vertically on the supportive base. A metal spring-locking mechanism holds the table in position when locked. The leg supports under each half of the table fold flush to the underside of the table's surface.

At present, the table weighs 134 lbs and is supported by four casters, each capable of supporting up to 300 lbs. In its upright position, the height of the table is 59 1/2" and its width measures 18" at the base and 22" at the top. This table will fit through most standard doors as well as the extra wide doors at the CP Center. In its fully open position, the table is 72" long by 52 3/4" wide (Figure 8.6). The height of the table is 31".

The support for the table consists of steel tubing, brackets and braces bolted to the table and welded wherever appropriate. The leg supports are prefabricated steel tube construction designed for table use. Brackets and hinges for the legs are made of 1/8"-thick steel. The steel tubing for the supportive base is 1" square and 1/8" thick. The base is also made from this steel tubing. It is a rectangular supportive structure at the center of the table 41" long and 18" wide. There are casters positioned under the corners of the base for mobility. They have foot-controlled brakes to prevent movement of the table when in use or in storage. The dimensions of the wood (3/4" plywood) and Formica alone measure 42" x 36" x 13/16" for each half.

An analysis was made of the mechanical stability of the table plus railing (details on request). It was determined that the maximum weight allowed on the table before tipping was about 245 lbs.

The table cost about $550, with major costs due to caster ($158), welding (labor $83), Formica table-top ($60), prefabricated legs and brackets ($60) and molding ($38).

Kitchen Appliances

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INTRODUCTION

The purpose of this project is to help a class at the Cerebral Palsy Center in Albany to bake more independently. The class consists of six students with varying capabilities. The main physical limitation is in strength and fine and gross motor control. This class supports itself through a number of activities, including baking and bake sales.

When we observed this class baking, they did little to help in the process. Their teacher, Linda Lynch, did most of the measuring of the ingredients, since most of the students lacked the motor control or strength necessary for this task. Once the ingredients were in the mixing bowl, the students were able to help mix. However, it was necessary for Linda to finish the mixing and insure that the batter was of the correct consistency. We determined that the clients participated the least in measuring the various ingredients used in their recipes. The ingredients used in their cookie recipes usually consisted of flour, sugar, baking powder or baking soda, vanilla extract, and brown sugar. Of these ingredients, the students were only able to easily measure the brown sugar due to its dense and cohesive nature.

Therefore, we designed several dispensers to measure the ingredients for the students, without the need for motorization or other electronic assistance. Electronic devices were eliminated from our design in order to provide the students with a sense of participation and some motor control training by proper use of the dispensers. The dispensers are built to be used on the CP portable kitchen table work station by Kelly, Leonard and Schultz of RPI.

SUMMARY OF IMPACT

We presented the final design to Linda Lynch and her class at the CP Center in Albany and discussed the benefits they will derive from it. The main impact of the appliances is to increase the student participation in their weekly cooking projects. The students have enjoyed working with the appliances.

TECHNICAL DESCRIPTION

The task of measuring and dispensing ingredients can be broken down into three major sub-groups: bulk ingredients (1/3 cup or more), small volumes of dry goods (teaspoons), and small volumes of liquids (fractions of a teaspoon). A dispensing unit was designed and built for each group.

The three main aspects of the project are the bulk dry goods dispenser, the liquid dispenser, and the dispenser for the baking soda and powder (Figure 8.7). The bulk dry goods dispenser for sugar and flour consists of a clear Plexiglas drawer within a case. A hopper containing the bulk ingredient is mounted on top of the case. When the drawer is pushed closed, compressing the sponge, the ingredient in the hopper fills the drawer. Then the sponge provides the force to push the drawer back out. The drawer contains an insert, which is basically a small box, with no top or bottom, that contains a specific volume when the drawer is closed. When the drawer is pushed in, the insert fills to capacity. The size of the insert therefore determines the volume dispensed.

The liquid dispensers are modified lotion pump bottles. The pump bottles dispense a constant volume (1/4 tsp.) per pump. A large plastic target is affixed to the top of the spout. This target serves the dual purpose of providing a larger surface on which to press in order to activate the pump, and insuring that the students do not place their fingers in front of the spout. These pump bottles are mounted in a plastic base that keeps the pump bottles stable and at a fixed angle when in use. The pump bottles need to be inclined slightly in order to insure that the liquid dispensed by the bottle will end up in the bowl regardless of the amount of force used to pump the bottle. The pump bottles are easily removed from the support base for storage or cleaning.

There is also a need to dispense small volumes of dry goods, specifically baking soda and baking powder. The commercially available "Tilt-A-Spoon" product seemed ideal for this task (details on request). The "Tilt-A-Spoon" resembles an ordinary sugar dispenser, but dispenses teaspoon amounts of dry goods (such as sugar or coffee creamer). It does this by having a tube that extends from the spout down to about an inch from the bottom of the container. When it is inverted only the material directly below the tube is dispensed, resulting in about one teaspoon of material being dispensed. However, some of the students lacked the range of motion needed to invert the bottle, and thus could not use the "Tilt-A-Spoon" device. In order to make the "Tilt-A-Spoon" usable by all the students, a device that would support the "Tilt-A-Spoon" and allow it to be rotated without great coordination was devised. This device holds the "Tilt-A-Spoon" and allows it to rotate from an upright position to an inverted position, thus dispensing its contents. The "Tilt-A-Spoon" dispenser can be easily removed for storage and cleaning. The device is mounted on a base that will be secure during use.

The total design cost was approximately $150.

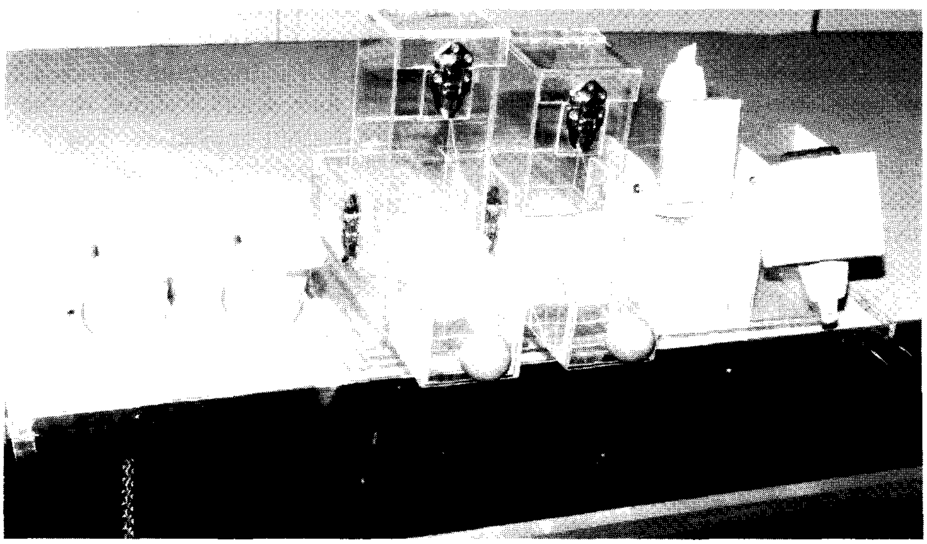

Fig. 8.7. Kitchen Dispensers.

Environmental Control Unit

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INTRODUCTION

Our group designed an Environmental Control Unit (ECU) for a quadriplegic patient at Albany Medical Center, named Michael. The client has limited movement of his head, shoulders, and arms and is therefore unable to operate the electrical devices in his room. The ECU is intended to give him the independence to control up to eight appliances in his room, such as his television, radio, or any other appliance that is plugged into a socket.

The design was based on a commercially available unit that allows the operation of home appliances with a radio frequency remote control device.

SUMMARY OF IMPACT

The ECU device provides Michael with an independent means to interact with his environment. This should not only build his confidence and give him more privacy, but also limit the amount of attention he needs from others. We hope that the unit will also help Michael to further develop his motor skills.

TECHNICAL DESCRIPTION

The Radio Shack unit (Figure 8.8) consists of a receiver module, a radio frequency transmitter and a module for each appliance to be controlled (up to eight). The transmitter sends a signal to the receiver that then sends a signal to the module controlling the desired appliance. The problem with this system as purchased is that there are 16 small buttons, eight for ON and eight for OFF, which would make it difficult for Michael to operate. Therefore, we reduced the operative buttons to three: one button to toggle through the eight choices and one button each for ON and OFF control of the device. Also, a power button was installed to reduce battery drain when the unit was not in use. All of the buttons are large and easily accessible to Michael.

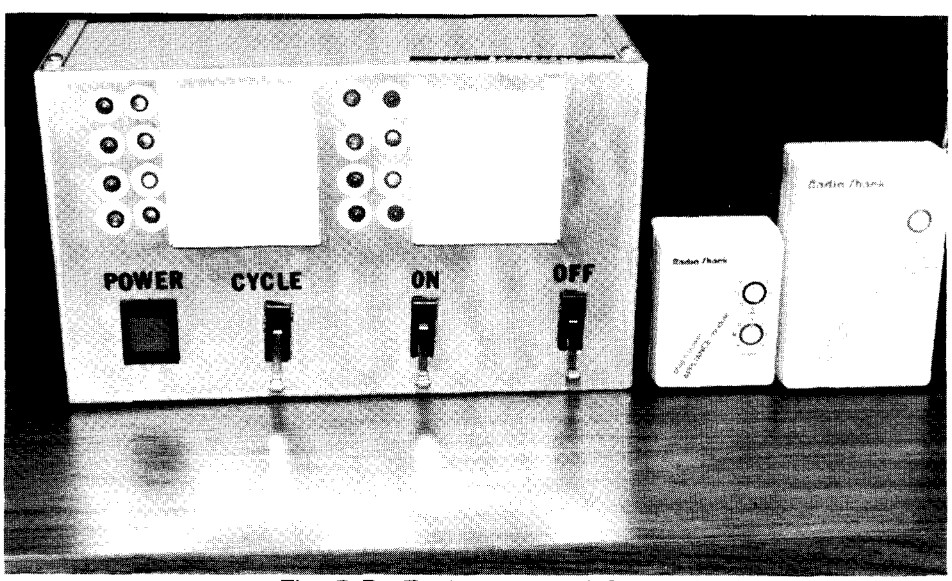

Fig. 8.8. Environmental Control Unit.

The circuit we fabricated to serve our needs consisted of three basic sections: a debounce circuit, a channel selector, and an ON/OFF operational logic. The debounce circuit insures that one clean pulse is delivered each time the select switch is toggled, as opposed to the multiple signals that could occur. The channel selector toggles from one channel to the next each time the selector switch is toggled. Finally, the ON/OFF logic performs the desired function on the chosen appliance.

The debounce circuit has a Quad Nand Gate 7400 (Figure 8.9; further details on request). The signal is normally Vcc (5 volts) but it goes low when the switch is depressed and then returns back to Vcc when the switch is released. The output signal is sent to the next position of the circuit - the channel selector.

The channel selector section (Figure 8.9) is composed of an 8-bit shift register having eight outputs. The data are shifted from one output to the next with each low-to-high voltage transition at the clock input. This low-to-high pulse comes from the debounce circuit.

The ON/OFF logic section (right-hand portion of Figure 8.9) contains two basic elements, NAND gates and Reed Relays. The NAND gates have two inputs and operate such that the output from the gate is high except when both inputs are high, in which case the output is low. We used 16 NAND gates (or 4 QUAD NAND gates), 8 to turn the appliances on, and 8 for off. The Reed Relays act as normally open switches that close when a high voltage exists across a coil in the Relay.

The total cost of our unit was $400. Since comparable ECU devices that are currently available sell for about $5,000, our unit is therefore very economical and relatively easy to construct.

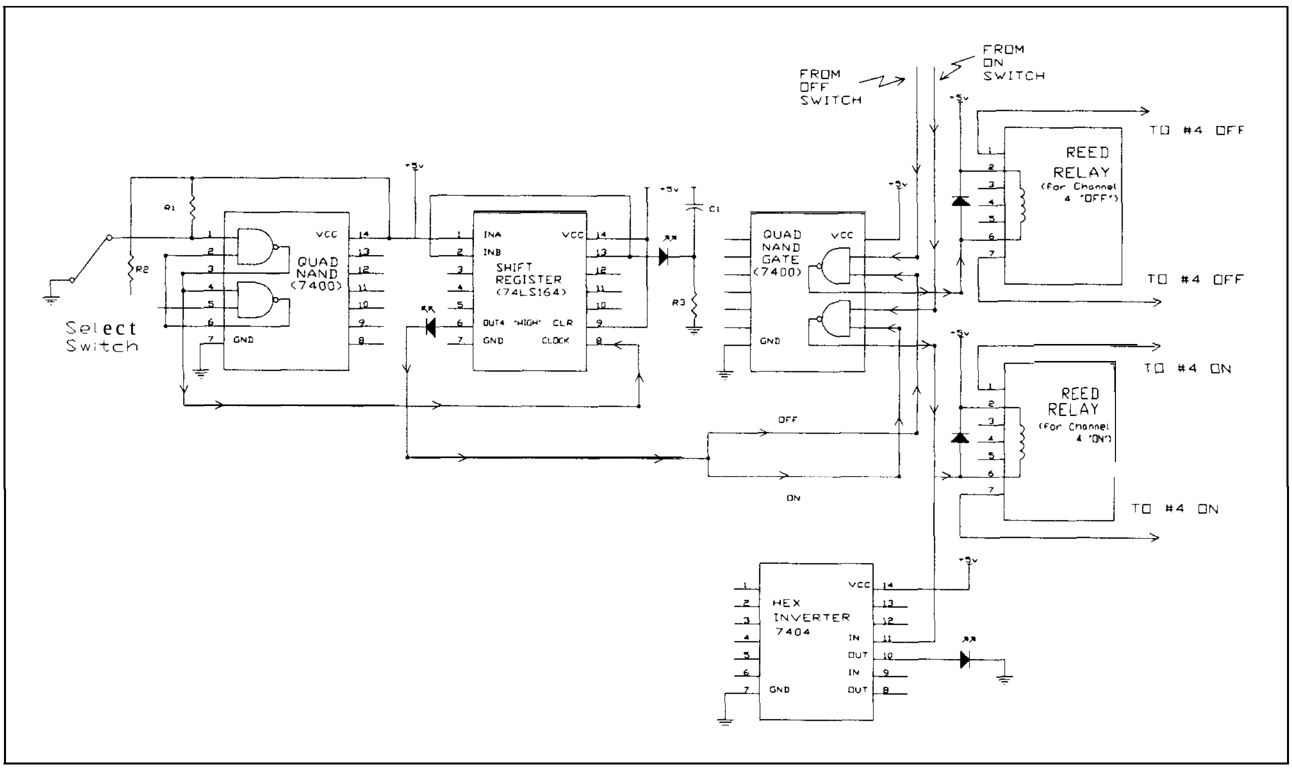

Fig. 8.9. Environmental Control Unit.

Toy Train System to Promote Social Interaction Among Disabled Preschool Children

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INTRODUCTION

In an effort to promote social interaction within a class of preschoolers with Cerebral palsy, we designed a toy that will encourage interaction. At present, most of the toys used by disabled preschoolers are designed for use by one child at a time. Many feel that this develops an individualized environment among the children. In order to promote interaction, a toy must be designed that will allow a number of children to all play at the same time and must also incorporate features where the actions of one child will affect the actions of others and also reward the children when they play as a group.

Taking into account the interests and abilities of the children, our group decided to design a toy train system to encourage one to four children to play at once (Figure 8.10).

SUMMARY OF IMPACT

It frequently happens that disabled children only have access to toys that are designed for use by one child at a time. However, class instructors feel that an interactive environment in the classroom would be beneficial to the children. Our toy train system helps accomplish this by being exciting for the children to use and by providing rewards for group play. The therapists at the CP Center were confident that children would learn the interactive procedure necessary to cause the motion of the train and would also enjoy playing with the toy. One reservation they had was that the tasks involved might be too complex for the youngest and least able children.

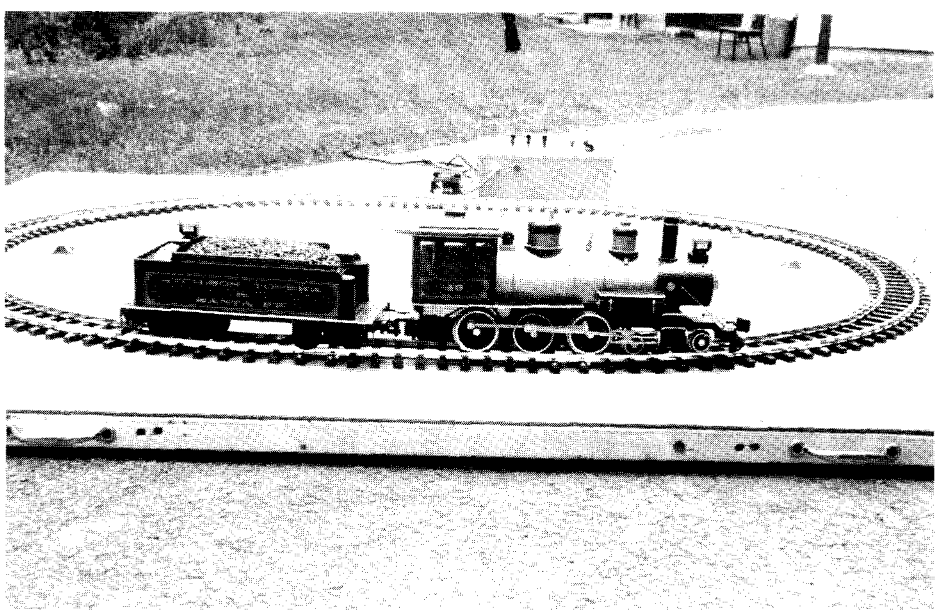

Fig. 8.10. Toy Train.

TECHNICAL DESCRIPTION

The basic concept of play is as follows. At the four corners of the train track's rectangular frame are workstations numbered from #1 to #4 containing a 1/4" standard jack for special switches and a light. Depending on the abilities of the children playing with the toy, different switches (*e.g.*, contact, pull, sweep, head tilt) can be used. To begin play, the operator uses toggle switches on the control box to select the number of players. Workstation #1 is always active, and by toggling any of the three switches on the control box to the ON position, the corresponding workstation (#2-#4) is/are activated. The operator then sets a variable timer and is signaled by a lighted LED, also on the control box, to hit the toy's reset button. Once this is done, the operator's LED is turned off and the timer begins. As the timer starts, the lights at each of the workstations are lighted. This stimulus attracts the children to hit the nearby switch. This action will be rewarded by the action of an accessory that is mounted in the center of the track. There is one accessory per workstation and they include two red lights, a buzzer, and a chime. With a number of different accessories, the operator can put children at workstations that provide the stimulus that they enjoy the most.

To encourage interaction among the children, the variable timer comes into play. Should all of the children's' switches be hit within the time limit, this "group play" will be rewarded by the motion of a large-scale toy train, complete with lights and sound. The train will continue moving until the teacher hits the "train stop" button on the control box. Incorporating a reward with a longer duration and a number of different stimuli should help instill and reinforce the concept of group play within the children.

The train is a commercially available Bachmann brand G-scale train. Each car is about a foot long (Figure 8.10), which is large enough to capture the attention of the children. The 14-section track is mounted on two interlocking frames, each measuring 75" x 35". The framework is made of a 1/8" plywood mounted over a framework of 2" x 3" lumber (details on request). Handles are attached for easy transportation and there are hasps that lock the sections together when assembled. The whole unit is covered with several coats of polyurethane for protection against spills, etc.

The electronic control box for the train (12" x 8" x 4.5") houses the power supply and control circuitry. The necessary external wiring for the workstations and accessories is routed through the plywood base and attached to the studs. To provide the necessary electrical connection between the two sections of the framework (for the two workstations' switches and lights), the second frame piece is equipped with four 1/4" plugs. When the frame is assembled these can be inserted into four 1/4" jacks that are installed on the first frame piece. The power supply was a GHOF 12VDC model that can produce up to 1.7 amps. The lights used at each of the workstations were 8 mm green LEDs. The buzzer was an Archermodel 273-054 and the chime was an Archer model 273-071. These can all be obtained at a Radio Shack outlet. Circuit details are available upon request.

The overall cost of producing this interactive toy train was roughly $500, including $135 for the model train and $120 for four special switches to be used at the workstations.

Motorized Seesaw to Promote Social Interaction

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INTRODUCTION

The objective of the design project was to encourage social interaction among a group of young children with Cerebral palsy. The therapists wanted to not only keep the children occupied and entertained, but to help them learn to socially interact with one another. This is attempted through design of a motorized toy seesaw that would require both children on the toy to operate a switch to activate the movement of the seesaw. We designed a battery-operated toy, with the motorized action taking the place of the children's weight and action (Figure 8.11).

SUMMARY OF IMPACT

The idea of a toy seesaw is to provide enjoyment and fun for the children. As handicapped as they are, they are still children and would benefit from play. Since the children must be closely supervised, they are restricted to play with only certain types of toys. This seesaw adds diversity to their rather limited selection of toys.

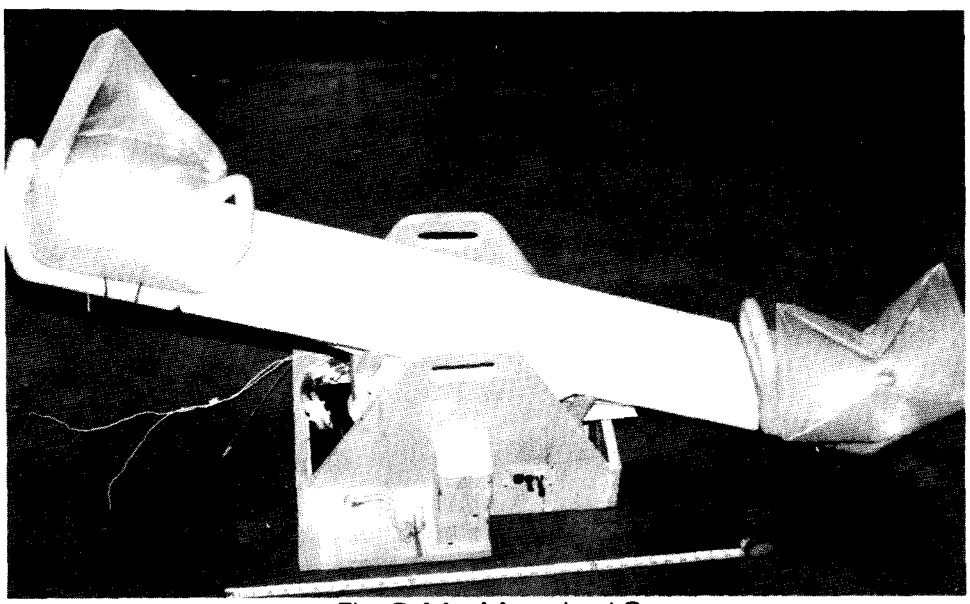

Fig. 8.11. Motorized Seesaw.

TECHNICAL DESCRIPTION

The seesaw is an extensive modification of a commercial product. All parts are newly designed and fabricated except for the bench of **the seesaw.**

The concept is to pump water to simulate the movement action of the children on a screen. Two water pumps, activated alternately, pump water from the low end of the seesaw to the high end to create the shift in balance. Friction is reduced by using a bearing surface between the base and bench. Any weight differential between the two children is compensated by using a mechanical leverage adjustment, thus reducing the amount of the water necessary to overcome friction and initiates the seesaw motion. The seesaw is powered by a 12 V motorcycle battery and is thus portable; the base detaches from the bench and can be easily moved via its carrying handles. The electronics control the switching of the pumps.

The commercially available toy seesaw (details on request) was capable of holding two children, each weighing 85 lbs., one on either end of the seesaw bench. A new base of the seesaw was fabricated from 1" pine with a polyurethane top coat for durability and prevention of injuries to the children from wood splintering. It measured 16" tall by 20" long with a width of 16". The sides of the base have handles to allow teachers and therapists to transport the unit. The width of the base was determined by the size of a conveyor roller that was used as a pivot for the bench to ride on. The conveyor roller is a galvanized steel cylinder mounted on a steel shaft using ball bearings. The bench rests on the roller in one of several adjustment locations. These adjustment locations are used to compensate for the weight difference between the children, each location producing a different leverage factor for the bench.

The drive train consists of two portable water pumps and a 12-volt motorcycle battery. Each pump provides water to a reservoir on one side of the seesaw bench. Once the switches are activated the appropriate pump turns on and begins to fill the reservoirs (collapsible water storage tanks) located within the seat housing. The cycle time to complete one shift in balance was decided upon by performing time trials: children might be frightened if the time were too short, and might be bored if the cycle were too long. Suitable cycle times ranged from 15 to 30 seconds.

Pumping rates depended on the cycle time and the amount of friction within the system. Assuming no friction and that leverage compensation would reduce the weight difference between the children to a maximum of 10 lbs, the flow rate to produce the desired movement is approximately 90 gal/hr.

Electronics

The electronic control for the two water pumps consists of three parts: (1) a circuit that accepts the input from the children's switches to enable the rest of the circuit to work appropriately when both switches are pressed; (2) the portion that determines which of the two pumps is to be activated; and (3) the circuit that turns the pumps on or off. An overview of the circuit follows (detailed circuits available upon request).

Briefly, the circuit determines the initial state the seesaw is in. Based on that, the circuit turns on the appropriate pump that will shift the seesaw once when both user switches (mercury switches) are pressed by the children. At anytime, only one pump should be on with the other off.

The cost of the design was approximately $300.

A Device for Loading Soda Cans Into a Vending Machine

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Client Coordinator: Jean-Marie,
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Supervising Professors: Drs. J.C. Newell, J. B. Brunski, L.E. Ostrander
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INTRODUCTION

At the CP Center for the Disabled, Cerebral palsy patients are assigned specific occupations as part of their treatment. One task for several students is loading new cans of soda into the two vending machines at the Center. The students' disabilities greatly affect their muscular coordination and therefore their ability to properly place the cans into the machine. Several of the students suffer from tremors, making it difficult to properly position cans inside the slots. In particular, placing cans into the bottom slots is the most difficult obstacle. The bottom slots are located down in a trough behind the front panel, which limits access. The restriction of being bound in wheelchairs hampers these students' ability to reach far enough into the machine to correctly position the can in the slot. In order to enable these students to reach the lower slots in the machine, our primary objective was to design a device that would extend their reach beyond their current capability and allow them to place cans down into the trough. Ideally, the device would also stabilize their jerky motions, permitting better placement of the cans as well.

SUMMARY OF IMPACT

The coordinator at the CP Center, Jean-Marie, was delighted with our loading device (Figure 8.12). It required minimal force to operate and provided firm arm support while minimizing weight and optimizing the reach. During field trials of the design, Jean-Marie felt that the device would greatly benefit the students who suffer from tremors. She felt that with practice, the other students would significantly benefit from the device. One student was particularly excited; he viewed the device as a toy and enjoyed performing his tasks.

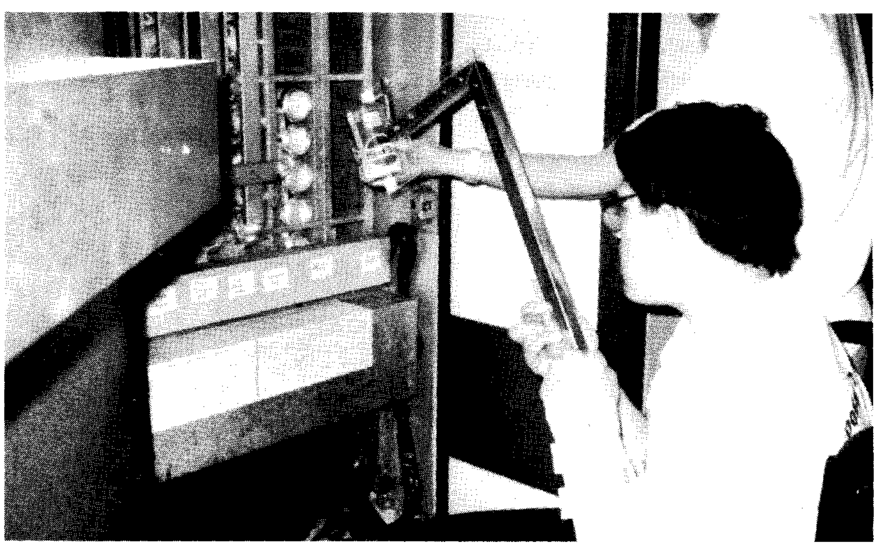

Fig. 8.12. A Device for Loading Soda Cans into a Vending Machine.

TECHNICAL DESCRIPTION

The device consisted of several parts (Figure 8.12). The bar itself is composed of polished aluminum tubing 1" square. The wall thickness of the bar is about 1/16". The bar has been cut into two pieces that are joined with steel side braces screwed into the inside surface of the bar.

The gripper arms are constructed from 1/4"-thick transparent Plexiglas The movable gripper arm is connected to the bar with an O-ring and spring assembly which hooks onto an eye-screw on the bar. This arm rotates via a binder pin which is affixed through the aluminum bar. Each of the gripper arms is coated on the end with a plastic dip material that hardens on contact. Ridges at the ends of the gripper arms are meant to grasp the edges of the soda cans. The string connected to the tracking assembly is 1/8"-diameter nylon which is doubled for added strength. The tracking mechanism is derived from folding door tracking which consists of a metal slider that slides along a piece of steel with a lip to contain the slider. The slider is connected to a screw that runs through a hole milled in the steel tracking and aluminum bar around which the string is affixed on the inside of the bar. A Plexiglas handle is fastened to the slider with glue to allow for control of the tracking. When the control knob is pulled toward the operator, the nylon cable becomes taut and applies a force to the top of the movable gripper arm, which creates a moment about the pivot point. As the force is increased, the moment exceeds the moment applied by the spring and the arm rotates outward. Once the bottom tip of the arm moves approximately 1/4", the can will fall. To reset the device to the rest position, the operator need only release the knob. The spring will then pull the arm back to its original position.

To use the device the client will approach a can that is lying on its side. Once he has positioned the gripper mechanism above the can, he will pull back on the control knob to open the gripper of the device. Then he will place the open gripper arm around the can and release the knob. The spring will close the gripper and secure the can. Next, the client can move the arm into the soda machine to the location where the can is to be dropped. Since the can will be held in place by the spring, the client can use both arms to guide the device without worrying about the can being released. Once the can is in place, the client will pull back on the knob with his free arm and the can will drop into the appropriate slot.

Theoretical analysis of the force required to operate the gripper (details on request) show that a force of about 0.3 LB is needed. The force depends on the spring constant in the gripper and the geometry of the mechanism. The design actually required a force of about 2 lbs due to friction in the metal tracking.

The approximate total cost of the device was $100.