

CHAPTER 2
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A Recreational Rafting Chair for Active Paraplegics

Designer: Dannette Donald

Client Coordinators: Special Populations Learning Outdoor Recreation and Education (SPLORE)

Supervising Professor: Gary T. Yamaguchi, Ph.D.

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INTRODUCTION

The recreational use of inflatable rafts by disabled individuals has become more common, particularly among active paraplegics. Currently, however, there is not a commercially available seating device for use by these individuals for white water river rafts. Therefore, a recreational chair that enables a disabled user to take part in white water river rafting has been designed. The final design consists of a one-inch PVC pipe structure covered with waterproof acrylic material and cushioned with high-density foam. The chair also has a swivel device that allows the user to face different directions during the course of a rafting trip.

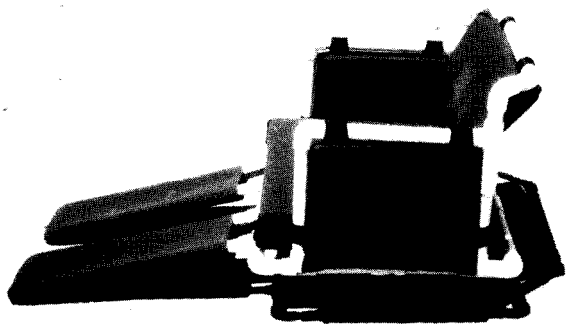


Figure 2.1. Side view of Rafting Chair.

SUMMARY OF IMPACT

White water river rafting is an exciting sport that any person may take part in, including those who are disabled. One particular organization, Special Populations Learning Outdoor Recreation and Education (SPLORE), is devoted to this cause. SPLORE commonly sponsors various outdoor activities for persons with any type of disability, including white water river rafting. For short, one-day excursions, persons with any and all disabilities are encouraged to participate. However, some in-

dividuals desire to do more. These individuals are invited to participate in rafting trips that may extend for two weeks, running along the Colorado River. To date, the only individuals who have participated in the extended trip have been very active paraplegics with full upper body function.

Currently, there are no commercially available seating devices for use on a white water river raft. The potential users of this device are, for the most part, very active individuals who have a zest for an active life. Their physical well-being is inextricably linked to their mental well-being, and recreation is an important factor to maintaining a healthy outlook on life. The psychosocial implications of enabling disabled individuals to participate fully in sporting activities are great, and are often underestimated by healthcare providers.

TECHNICAL DESCRIPTION

Disabled individuals usually sit on a square flotation device placed on top of a wooden bench mounted in the raft. However, while in the rapids the cushion has a tendency to move on the wood bench. This results in excessive movement and instability of the individual. Also, there is also very little within reach with which the individual can stabilize himself. Another problem arises because the legs of a paraplegic are uncontrolled and subject to potentially violent shifting during rapids, which can cause the individual to become even more unstable. If the river rafts were to overturn, which is not an uncommon event, the individuals in the raft must not be trapped underneath. Thus no straps or other securing devices may be utilized in the design of the rafting chair.

Thus, the main design requirement of the rafting chair is that it has to be safe, not cause pressure sores, as well as to be durable, reliable, dependable, and easily maintainable to the average person. Design objectives include a swivel mechanism so the

user can turn easily as the raft turns through currents, footrests to control awkwardly swinging legs, and lightweight to provide portability in rugged areas and to enable the user to utilize the device fairly independently. Perhaps the most important design objective, however is for the device to be esthetically pleasing and fun to use. If the device is not enjoyable to use, then it defeats its own purpose.

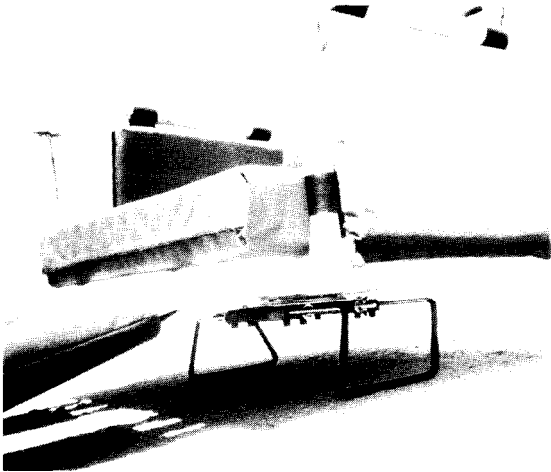


Figure 2.2. Front view of Rafting Chair.

The device presented here consists of three major components. First there is the skeleton of the chair that is composed of PVC pipe. The second component is composed of waterproof cloth and cushions that fill in the skeleton of the chair. Finally, a swivel mechanism mounts the chair assembly to a rigid base.

The first task was to construct the skeleton. PVC pipe was chosen as a primary material because it is lightweight, durable, inexpensive and easy to work with. One-inch diameter, schedule 40 pipe was chosen because it is the smallest diameter pipe that would be able to withstand the stresses applied during a rafting trip. The dimensions for the chair were taken from a normal sitting chair. It was designed to be wide enough to accommodate several

body types and allow for the placement of the cushions. A 22" X 22" square base was chosen to provide stability in all orientations. The back of the chair was designed according to wheelchair standards. The lower bar is at a height of 9", which provides support in the lower lumbar area. The upper bar is at a height of 15", which is designed to be just below the scapula of an average person, thus allowing full movement of the upper body. The upper bar is set back slightly in order to provide a more comfortable, slightly reclined seating position, as a 90° angle sitting position would not be comfortable for extended periods of time. The armrests are at a height of 8", which is just below the lower back bar. This height also enables the user to shift his own body weight. The footrests were designed to be individually adjustable, and to cradle each foot, and consist of two U-shapes that are attached to the base of the chair structure.

The cushions consist of 4" of high-density foam due to its durability and comfort. A high quality cushion is required to prevent pressure sores, especially in the presence of water. The arms and back of the chair are sufficiently cushioned with 2" foam. A high grade of waterproof acrylic material was chosen due to its durability and ability to withstand the elements. The maintainability and adjustability of the cushions are easily achieved through Velcro enclosures of the material. The swivel mechanism used was a commercially available boat chair mount. It consists of an adjustable securing device that will attach and secure the device to benches with varying widths.

The cost for the skeleton material was \$85. The foam cushions were \$18.50, and the material was \$155. The swivel device was \$25, thus bringing the total to \$283.50 for the raft chair. Seamstress work for the material is estimated at \$100. The proposed final design meets all of the objectives that were defined. The design enables the user to fully experience the sport of white water river rafting.

A Bathchair for a Young Adult With Cerebral Palsy

Designer: Scott E. Flechsig

Client Coordinator: Rita Alarie

Supervising Professor: Gary T. Yamagucki, Ph.D.

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INTRODUCTION

An improved bathchair has been designed for Christofer Alarie, a 22-year-old cerebral palsied (CP) child. The chair consists of two primary components, a frame and a seating system (Fig. 1). The frame is made of 1" aluminum tubing. The seating system, the chair's seat, back and leg support, is made of an awning material fixed to the frame with screws and finishing washers (Fig. 2). The chair sits on the floor of the tub, which is protected by split rubber tubing. The chair is very lightweight and portable.

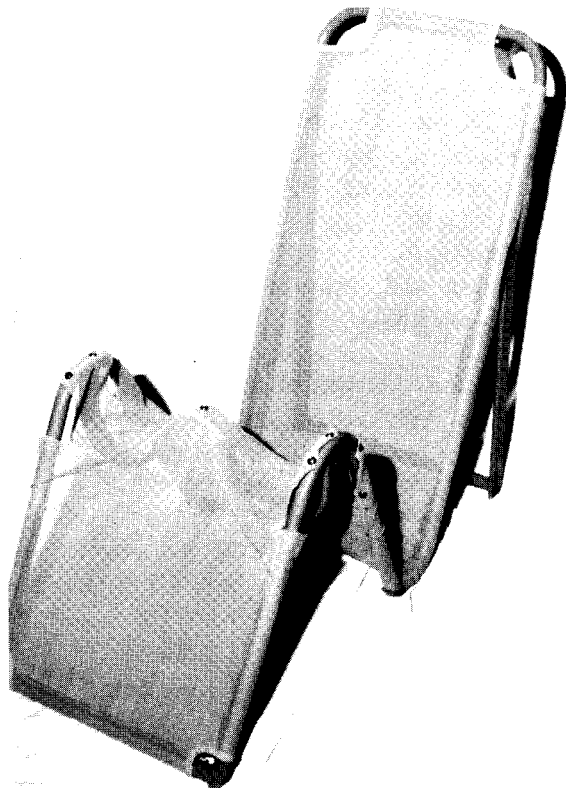


Figure 2.3. The improved bathchair.

SUMMARY OF THE IMPACT

As a result of his CI, Chris' motor control skills are underdeveloped and his body is severely atrophied and spastic. If his hips are not either fully extended or flexed beyond 90-degrees, his body becomes completely rigid.

One of Chris' greatest pleasures is to take baths or, as he puts it, to "jump in the shower." However, the design of his previous bath chair limited his enjoyment. The frame did not flex his hips enough for him to be comfortable. His legs and body often became rigid and required frequent flexing and repositioning. Also, the seating material (a nylon webbing material weaved similar to an outdoor lawn chair) scraped and pinched Chris' skin.

The new chair addresses these problems. The frame flexes Chris' body sufficiently to allow him to relax and provides adequate hip abduction. Also, the seating material does not pinch or chafe Chris' body and its rubberized surface helps to keep him upright in the chair.

TECHNICAL DESCRIPTION

The designer's work with Chris as his personal care attendant showed that improvements in his bathchair were necessary. The original major design requirements of the redesigned bathchair were: 1) the frame had to provide enough hip flexion to reduce Chris' rigidity; 2) the seating system had to be changed to prevent pinching of his skin; 3) it had to be lightweight and portable; 4) it had to have a lift mechanism to ease tub entry and exit; and finally (5) it had to be safe. Requirement (4) was later dropped when the family decided instead to elevate the entire tub, but a single-tube pneumatic scissors lift device was developed and may be used in subsequent adaptations of this design for other individuals.

The bathchair has two main components, the frame and the seating system. The frame consists of 1" aluminum tubing bent to shape, using a tube bender with a 3" radius, and welded end to end. To provide lateral stability to the frame, a 2"x1/2" double-hollow bar, bent into a "W" shape, was welded across the bend at the knees. The "W" bend was done to provide hip abduction. During the development of this design, Chris received a new wheelchair with a seat that provided extra hip abduction. This allowed him to sit more comfortably, so extra hip abduction was included as a feature in the bathchair design. Chris' legs are placed on either side of the ridge to provide the required abduction. Two "V" shaped 1" tubes were then welded to the back rest to prevent the chair from tipping over backwards.

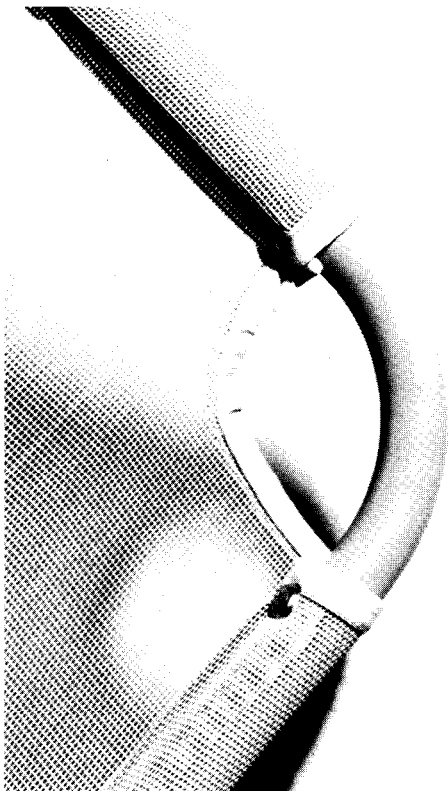


Figure 2.4. Detail of Seating/Frame Fixation.

The seating system is made from approximately 1-1/2 yards of a vinyl-coated, nylon mesh awning material. The material was designed for use in outdoor, windy conditions. It is strong enough to resist tearing and stretching and has been adapted as a seating material for lawn chairs. The vinyl coating also makes this material ideal for the design requirements. It makes the material waterproof and also helps to prevent Chris, who has limited upper torso control, from sliding side to side in the chair. Another useful feature is that the mesh was designed to allow 40 percent light to pass through it, so it is porous enough to allow water to flow freely through it but is still very strong. The material was cut to shape, reinforced at stress points, sewn and formed to fit the frame. The sling was then attached to the frame with 3/4" stainless steel #8 oval-head phillips screws and finishing washers (Fig. 2). The final step was to place split 1" neoprene rubber tubing over the frame on all points that would contact the tub surface to protect the tub's finish.

Tests were then conducted on the chair to determine its safety characteristics. The designer placed the chair in a bathtub full of water and tried to tip the chair by moving about in it. The chair seemed to be quite safe and was actually very comfortable.

This chair was designed specifically for Chris and his specific needs and body measurements. Possible future modifications include making the frame adjustable to the needs of more than one user and attachment of the lift mechanism.

The total cost of the bathchair was approximately \$100.

A Tray to Hold a Speak and Spell Device

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Client Coordinator: Pauline Boisselle, O.T.

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Supervising Professor: Gary T. Yamaguchi, Ph.D.

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INTRODUCTION

An adjustable, detachable tray to hold a speak and spell device was designed for a cerebral-palsied adolescent that wished to walk and talk at the same time, that is, utilize her speaking aid at the same time that she was using her electric wheelchair.

TECHNICAL DESCRIPTION

The tray, consisting of 1/4" plywood, mounts with specially constructed attachments to the individual's Mobie II handlebars. Velcro tape attached to the top surface of the tray holds the speak and spell device firmly to the tray during forward movement (Velcro tape is also attached to the underside of the speak and spell device). A wooden rim surrounds the top surface to further contain the device during bumpy rides over the rough terrain encountered on the Navajo reservation.

Two 1/4" steel rods welded into a U are screwed into the underside of the tray, and serve to attach

the tray itself to the handlebar mounts. The apex of the "U" is near the forward end of the tray (away from the user). Together with the mounting hardware, this construction allows the tray to be positioned very close to the user, if desired, by simply loosening the adjustment nuts and sliding the tray toward the user. A wrench mounted to the underside of the tray with a strong magnet allows periodic adjustments to be made in a matter of minutes.

Mounts attach to the handlebars with either machine screws (necessary to drill holes in the handlebars) or with hose clamps (not necessary to drill holes). The mounts are cylindrical steel tubes welded at right angles to a cylindrical half-section that fits over the handlebars. The tubes themselves accept the 1/4" steel rods attached to the base of the tray. Holes in the cylindrical tubes are tapped to accept the tray positioning adjustment bolts.

Total cost for the tray and mounting hardware is estimated to be under \$50.

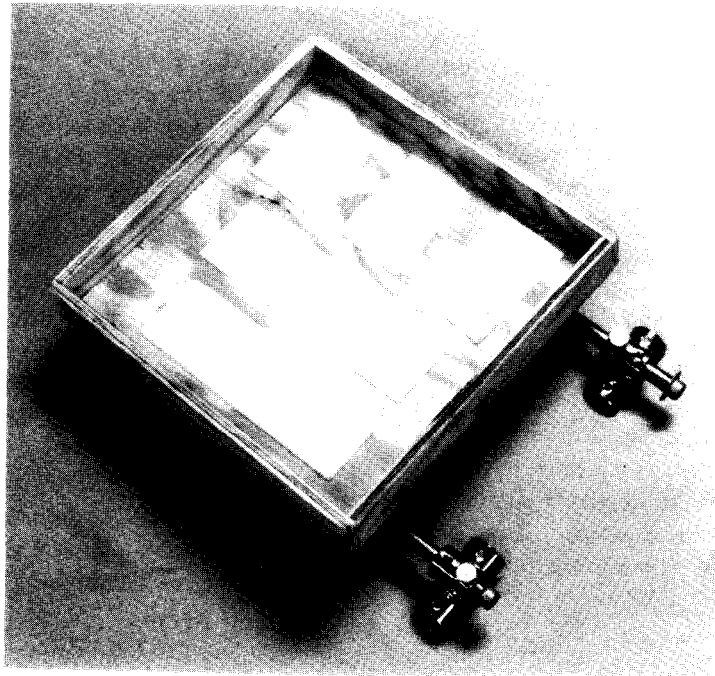


Figure 2.5. Top view of tray to hold a Speak and Spell Device.

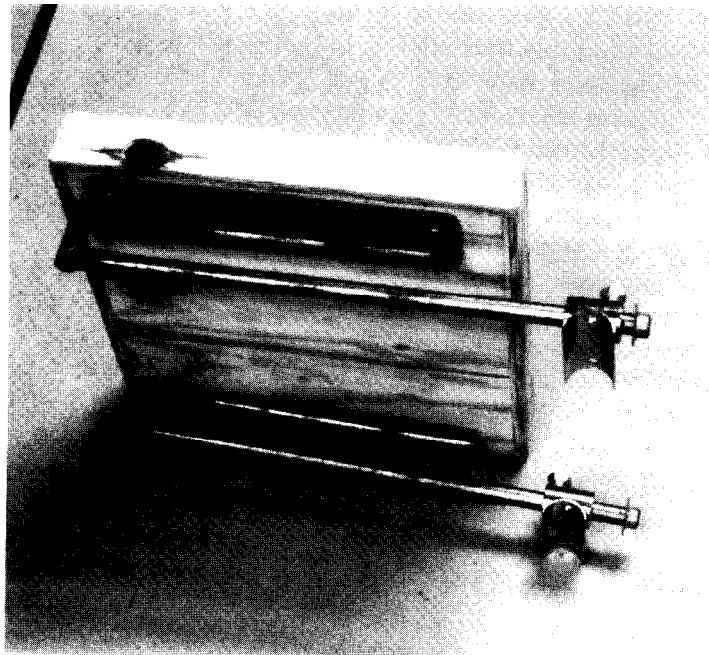


Figure 2.6. Bottom view of tray to hold a Speak and Spell Device.

Electromechanical “Busy Box”

Designers: Martha Jones, Ken Gustafson
Disabled Coordinator: Pauline Boiselle, O.T.
St. Michael's Association for Special Education, Window Rock, Arizona
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INTRODUCTION

Responding to a suggestion from an occupational therapist and other teachers at the St. Michael's Association for Special Education at Window Rock, Arizona, we have designed a device to develop and refine the motor skills of cerebral palsied children who require sensory stimulation. The “busy box” design is a four participant interactive work station that provides age- and ability-appropriate activities. These activities were designed to be fun and to deliver a positive stimulus in order to encourage the children to develop hand use that will improve the children's manual dexterity that can be directly applied to activities of daily living.

SUMMARY OF IMPACT

The St. Michael's School is home Monday through Friday to over 150 children, and about half of these students are cerebral palsied. One of the main challenges of the instructors at this institution is to provide functional training, and they have found that their success in doing this is increased with the use of sensory stimulation. These teachers have expressed a need for devices that will be exciting and stimulating to use while maintaining an instructional purpose. By offering a strong sensory stimulation, the device will entertain and captivate the children, while the repetition of physical tasks will improve motor control and increase the students' ability to perform activities of daily living. The ability to change the patterns of stimulation as well as the degree of difficulty will allow the box to be adaptable to the changing needs of the various students.

TECHNICAL DESCRIPTION

Due to the large variety of students at the St. Michael's School, and the variations in the abilities of each student, several main design objectives were set. The device was designed to be adaptable in order to serve as many students as possible. The de-

sign consists of a large trapezoidal cube with activities on each side (Fig. 1). The activities were designed to apply to the different ability and age levels that are represented at the school. This involved including activities for each of five groups: Younger (<10 year old) Sensory Stimulation Class, Older (>10 year old) Sensory Stimulation Class, Intermediate Trainable Class, Life Skills Class, and Multi-handicapped Class. Representative children from each class were used in developing goals for each planned activity.

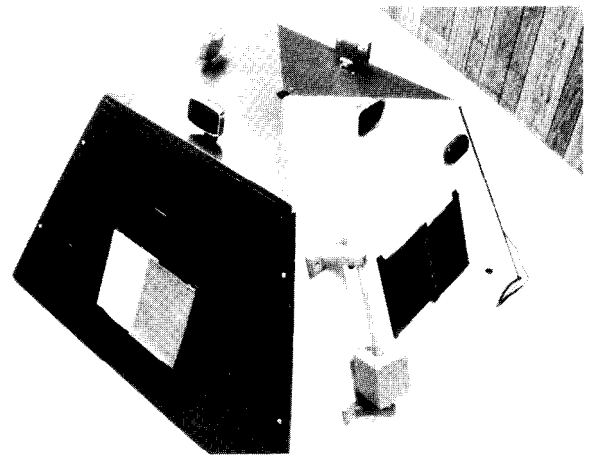


Figure 2.7. Electromechanical “Busy Box”.

In order to maintain this adaptability, the box can be placed on the floor for the children to sit around, or it may be placed on a sturdy table to be surrounded by children sitting in chairs or wheelchairs. Another aspect that adds diversity is the internal switch-board that is accessible by the teachers (Fig 2). This allows the instructor to vary the intensity of the stimulus (light and/or sound) rewarding the successful completion of each activity. The activities were also designed to be changeable with larger or smaller parts in order to alter the degree of difficulty associated with each. The box is designed to be

sturdy, portable, instructional, fun, shock resistant, and above all, safe. It will be able to withstand the normal wear and tear of usage by a large number of children.

The physical design of the “busy box” involves a trapezoidal box with a bottom square dimension of 3.5 feet, a top square dimension is 2 feet, and a height of 2.5 feet. The four sides are therefore slanting in towards the top of the box allowing a more accessible surface. The box is constructed of wood that has been sanded to a smooth and safe surface without sharp edges. The sides of the box are each painted a bright color: red, blue, yellow, and green.

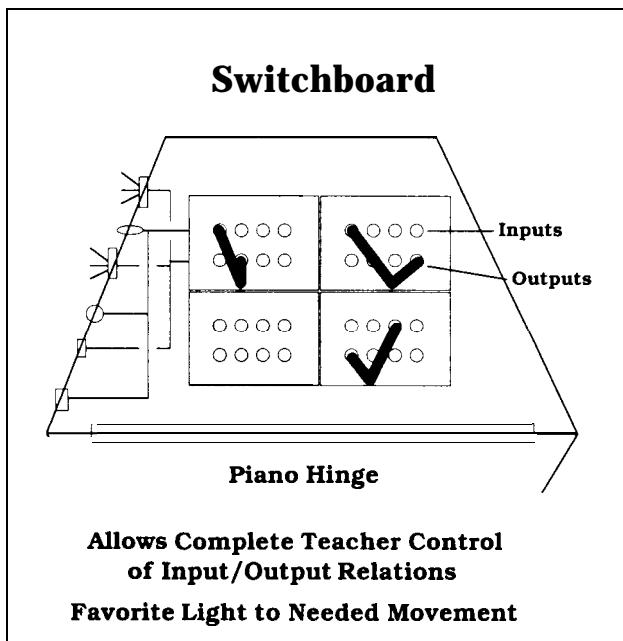


Figure 2.8. Details of
Electromechanical “Busy Box”.

The four sides of the box have been divided into four independent stations with one main power switch located on the top to activate the entire electric-driven device. The activities of the work stations have themes: gross motor control, fine motor control, and activities of daily living (young and old). One such activity is a horizontal track that supports a large bar that will activate a hidden

switch when fully pushed to the left or to the right. There is a similar device that runs horizontally. There are also cloth swatches that are connected by methods that clothes are fastened: zippers and buttons. Another activity involves shape recognition and steady control to insert the shapes into their appropriate holder. These shapes and holders can be replaced by different shapes and holders to allow different degrees of difficulty and variety. The knobs for these shapes can also be changed in size, shape, and character to foster the development of fine grasping.

Located inside the box, are the modular switchboard and the electrical equipment needed to provide the sensory stimuli. This is accessible only to the instructor by opening the locked-hinged side of the box. The switchboard is constructed of a pegboard that is divided into color-coded panels that correspond to the four sides of the box (Fig. 2.8). The “reward” switches to individual physical tasks are connected directly to the input jacks, while the electrical devices to provide “reward” stimuli are connected to the output jacks. Wires to the actual hardware are hidden behind the switchboard, while only connecting leads are accessible to the teachers. This allows the instructor to individually configure the tasks and rewards to specific individuals, e.g., so that auditory rewards are not given to those with hearing difficulties. Behind the switchboard lies the power source that plugs directly into a wall outlet and provides 12 Volts and 1 Ampere. The heavy electrical wire that connects the devices and the outputs is also color-coded to allow easy repair by the school’s employees. All electrical parts are rigidly mounted to either the bottom or sides of the box in order to make for a rugged device.

The device was shown to a local group that included bioengineers, occupational therapists, and disabled citizens before finalization of the design in order to make improvements based upon their feedback. The final cost of the device was approximately \$400, due mainly to the cost of the wood, the relatively high cost of some of the electrical parts, and the summation of many small parts.

Project Alpha

Designers: Jeff Kohls, Scott Fleischig, Tricia Croake

Client Coordinators: Darlene Johnson, Kelly King

Broadmor Elementary School

Supervising Professor: Gary T. Yamaguchi, Ph.D.

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INTRODUCTION

The physically challenged classroom at the Broadmor Elementary School recently purchased a Nintendo video game. The game controllers, standard for the game, are designed for normal levels of motor skill. However, some disabled students have difficulty using the game controllers because they lack the necessary motor skills. Consequently, a game controller was designed and built for cerebral palsied individuals that enables them to play computer games. Besides the recreational value of the device, it was found to be of value in encouraging these individuals to develop their motor skills.

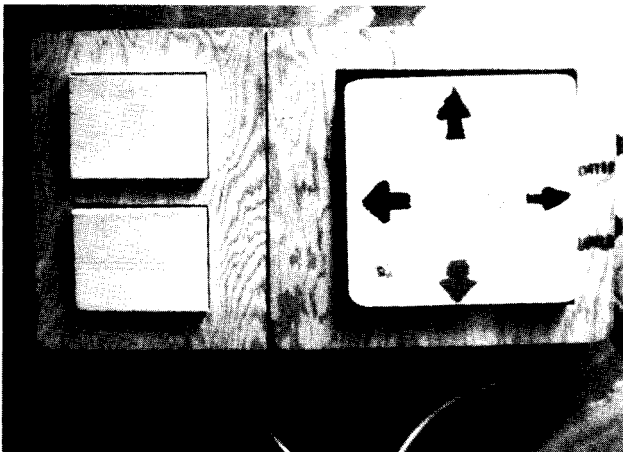


Figure 2.9. Photograph of Project Alpha—a link to Nintendo.

SUMMARY OF IMPACT

There are many devices that aid physically challenged children in daily functional tasks. However, devices that allow physically handicapped children access to the same recreational tasks as their normal peers are scarce. It is essential to a child's personal growth and development to have resources that supply amusement and indirectly contribute to a child's psychosocial development. Project Alpha links the physically challenged with Nintendo,

enabling them to play alone or together with other children.

TECHNICAL DESCRIPTION

The design requirements were: 1) its dimensions had to be less than 10" x 19" in length; 2) the buttons had to incorporate gross motor control ability; 3) it had to be simple in design in order for it to be used in a variety of situations. The game controller as constructed is a combination of two separately functional boxes. A variety of materials can be used but PVC plastic was found to be cost effective and structurally rigid. Box #1 (Fig. 2.10) functions as the input device for the Nintendo. It is 8" x 8-1/4" in size. A single pivot rotational button 6-1/2" square replaces the normal joystick and allows the child to input direction to a game in four basic directions: up, down, left and right. Box #2 replaces the normal "trigger", which functions to input "action". It is 8" x 9-1/2" in size. Two spring-loaded buttons, A and B, serve to input the trigger action by the Nintendo game. Buttons A and B are 3" x 6-1/2" in size and sit side by side with a 1-1/2" separation to allow for easy selectivity in the absence of fine motor skills. Boxes #1 and #2 (Fig. 2.10) are joined by a dovetail joint that allows for easy separation. The joint is made of aluminum and joined to the plastic boxes with screws. This enables a therapist to participate with a child in the operation of the game. A therapist may wish to have a child operate only the directional box while the therapist, or another child, operates the action box (or vice versa). By allowing the boxes to separate the functional properties of the controller, the usefulness of the device increases.

A modified Nintendo circuit board (Fig. 2.11) was used to transform voltage levels from the potentiometers and switches into digital control signals compatible with the game. The modifications included direct connections from input switches to the circuit board micro switches. This was done with

standard connector wire. Because of the large button sizes, the switches could be placed directly underneath the buttons of boxes #1 and #2.

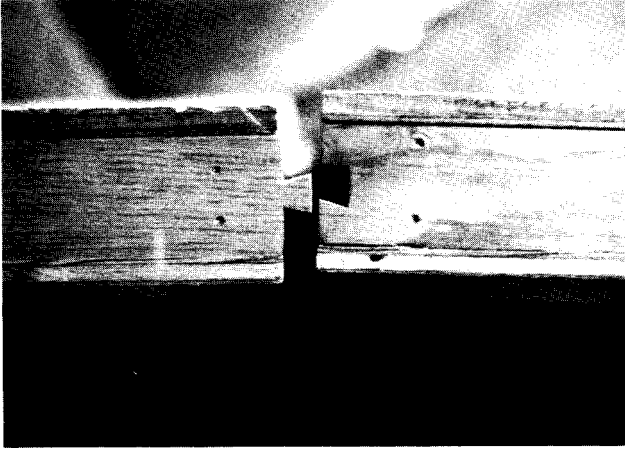


Figure 2.10. Detail of dovetail joint.

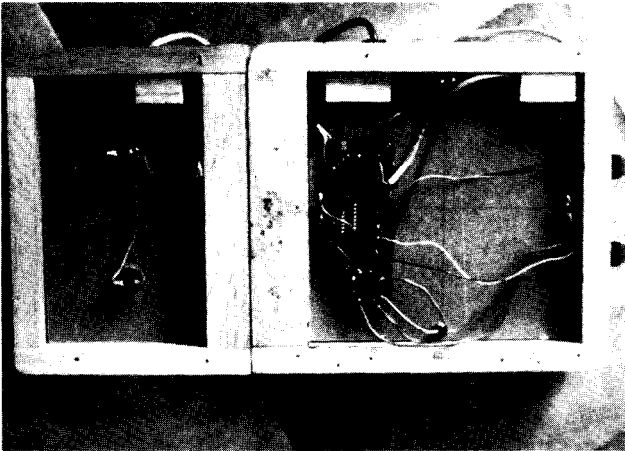


Figure 2.1 1. Modified Nintendo circuit board.

Tests were performed by volunteer bioengineering students with the Nintendo using various games. It was tested for response, ease of operation and stability. The controller was found to have response capabilities equal to a standard Nintendo controller. In addition, it was found to be easy to operate and very stable in construction. An evaluation of the controller's performance with the Broadmor physically challenged students was successfully performed. Modifications were suggested and implemented but these were found to actually reduce the simplicity of the controller, and hence its functionality. Project Alpha total cost of production was \$62.50.

Kayak System for Active Paraplegics

Designers: Thomas Lenzmeier, William Norling

Client Coordinators: Darlene Johnson, Kelly King

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INTRODUCTION

A system has been designed to allow active paraplegics to kayak. The system consists of a deflatable air bag and a torso support brace (Figs. 1, 2). The air bag insures that the lower body remains snugly and safely secure throughout all kayaking maneuvers. The air bag quickly deflates once the spray skirt is released to allow safe and easy exit from an inverted kayak. The torso support brace consists of a wide belt, connected to a rigid plastic plate. The brace allows the paraplegic to transfer body weight and forces due to mid torso contact to the kayak hull. Therefore, many of the important motions used in kayaking can be controlled by the torso instead of the legs. The system may be installed into many standard kayaks without modifications, although an additional air bag and minor changes to the shape of the torso support brace may be necessary in some instances.

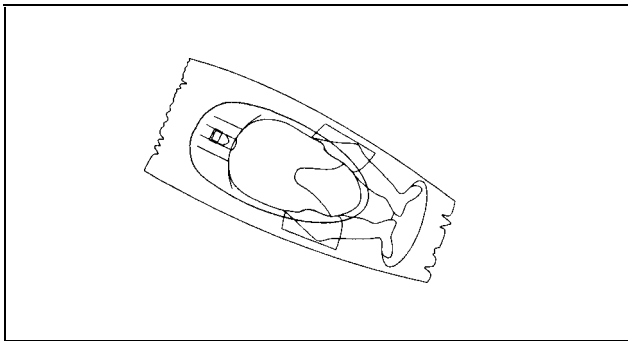


Figure 2.12. Diagram of the internal arrangement of the kayak system.

SUMMARY OF IMPACT

Paraplegics are often limited in the activities and sports in which they can participate. The lack of participation is usually not caused by a lack of desire to become involved but by the physical limitations of their bodies. Since kayaking is a sport that primarily requires upper body strength for propulsion, it is a logical activity for which a

paraplegic is quite well suited. Kayaking allows the paraplegic to be rid of his wheelchair and to be equally as mobile as non-handicapped peers. Therefore, kayaking can be not only physically, but also psychologically rewarding to the paraplegic.

TECHNICAL DESCRIPTION

In designing the paraplegic kayaking system, we were interested in creating a device that can be used by any active paraplegic that wishes to learn or to continue the sport of lake or river kayaking. In order to create such a system, we needed to find a way to secure the rider into the kayak without limiting his ability to quickly exit the cockpit in an emergency. Further, we needed to design a device to replace the forces created by a normal kayaker's leg, which are used surprisingly often in this sport, to control the rotation of the boat during many of the maneuvers. With these two requirements satisfied, the paraplegic will be able to perform nearly all the rudiments of kayaking.

To safely secure the rider's legs inside the kayak, we designed a deflatable air bag to be placed beneath the bow of the kayak (Fig. 2.12). The air bag is a modified standard kayak floatation bag that has been reduced in length. An inflation valve comes with the floatation bag and it is used for this purpose in our design. A larger outlet valve for the quick expulsion of the air has been added to ensure safe exit once a quick release plug is activated. The bag is attached with Velcro to the roof of the leg compartment. Securing the bag in this manner prevents loss after a wet exit and allows for easy installation and removal without much modification to the kayak. The valves are positioned for easy access to the cockpit. The inlet air valve, which is the standard valve for the floatation bag, consists of a short tube and can easily be blown into by the rider to fill the bag to the desired pressure. The outlet valve consists of a 3/4" PVC plastic elbow

that is fitted with a snap-type boat plug. The plug is sewn to the spray skirt by way of a 1" nylon webbing strap and plastic clip. The plug/skirt assembly allows one touch automatic deflation of the air bag by simply pulling the spray skirt release handle. In its riding position, the plug is expanded and in place, but after the skirt is released, the plug diameter is decreased and the plug is removed from the valve.

To replace the leg control needed for kayaking, the torso support brace was designed (Fig. 2.13). The brace consists of a belt and a rigid plastic support plate. The belt is a standard 4" nylon weight belt. Using aluminum rivets, a 14" X 12" X 1/4" plastic plate is attached to the belt. The exposed plastic is covered by 3/8" closed cell foam. By covering the brace with foam, we achieved buoyancy for the brace. The belt is worn around the mid torso of the paraplegic with the plastic plate located directly behind the person. While in the sitting position, the plate should just touch the floor of the boat. The nylon back straps present in nearly all kayaks are used to provide mating between the brace and the boat. The plate sits firmly on the bottom of the kayak just behind the seat. The paraplegic is then able to transfer forces from his torso movements to the bottom of the boat. Moments created by the movements are used to control the boat's response and stability while performing maneuvers in the water.

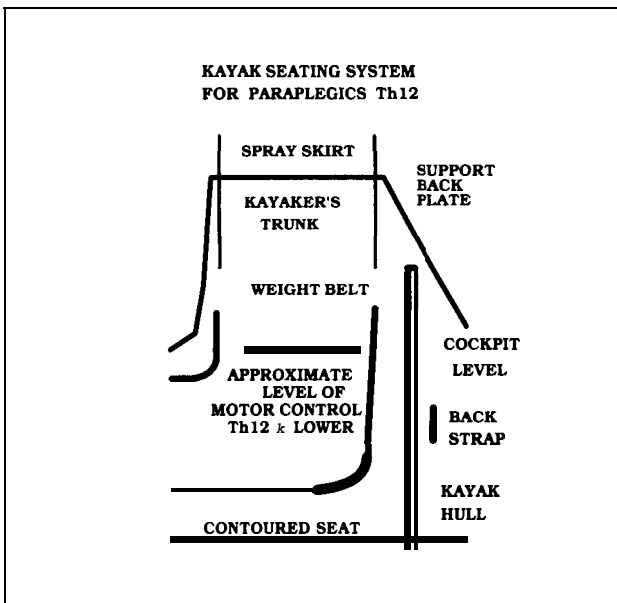


Figure 2.13. Back rest supporting assembly and positional information in kayak cockpit.

Pool tests of the kayak system were conducted. A volunteer tested the torso support brace and the air bag. The torso support brace seemed to offer the rider considerable maneuverability without the use of legs. The air bag kept the legs securely fastened throughout all motions. While the kayak was inverted, an emergency exit was performed. The bag was easily deflated in less than three seconds after the spray skirt was released. Also, the torso support brace slid easily out of the back harness during the escape. The support assembly was shown to float independently of the rider.

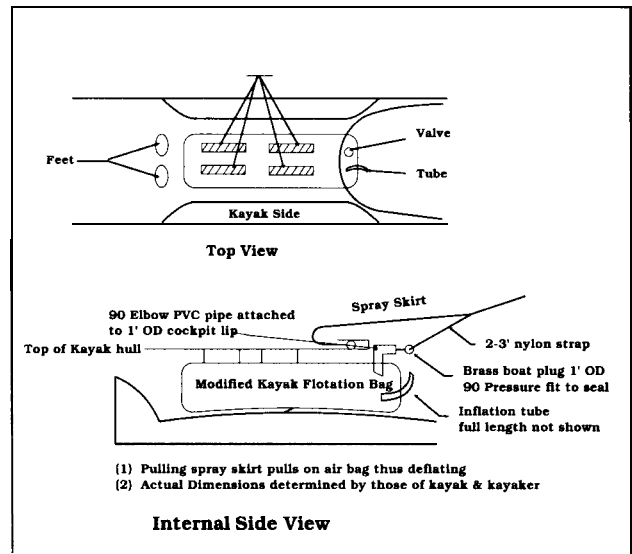


Figure 2.14. Modified flotation bag designed with quick release air valve for restriction of leg movements.

The total cost for one kayak system is approximately \$125. This figure only includes those devices shown in the pictures. The kayak and other gear that is required to participate in the sport is approximately an additional \$750.

A Mobilizer for a Child with Cerebral Palsy

Designer: Timothy M. Maurer

Supervising Professor: Gary T. Yamaguchi, Ph.D.

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INTRODUCTION

A mobilizing device has been designed for a Phoenix child with cerebral palsy. The client was unable to use standard wheelchairs by himself, i.e., he had to be placed into a wheelchair, and wanted a small scooter that would allow him to independently transfer into and out of, as well as provide for some mobility.

The Mobilizer consists of a tubular aluminum frame (round stock) arranged in a grossly rectangular fashion. Two corners of the frame are beveled (Figs. 2.15, 2.16). Two wheels are mounted on either side of the frame and one caster wheel is located on back of the frame. The frame is positioned approximately three inches off the ground for easy access by the child. An adjustable seat is fastened in the center of the frame towards the rear. The device is portable

through the use of quick release axles, which allows the wheels to be easily removed for transport.

SUMMARY OF IMPACT

It has been found that independent mobility influences the social, emotional and cognitive/intellectual development of physically disabled children (2.5 - 5 years old; Paulsson and Christoffersen, 1984). The Mobilizer increases the independence of Kristopher as it allows him to move about without the aid of an adult and without crawling on the floor. When other children run to another part of the yard or house, he can travel with them much more easily and quickly. This greatly increases Kristopher's ability to interact with his environment and believe it will ultimately improve his social skills.

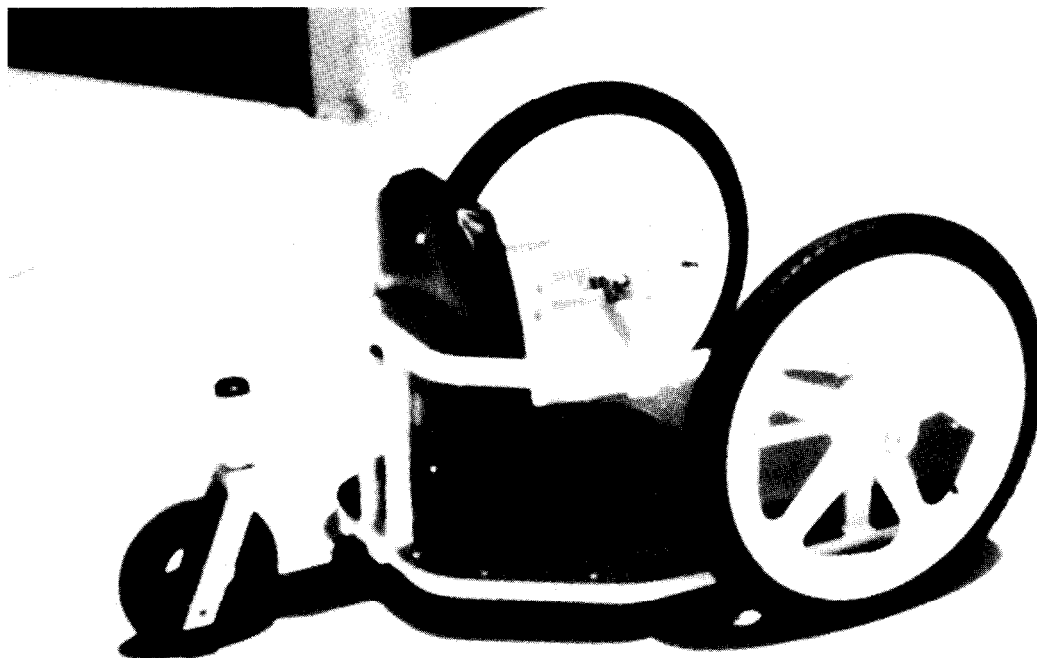


Figure 2.15. A mobilizer for a child with cerebral palsy.

TECHNICAL DESCRIPTION

The mobilizer was custom designed for Kristopher, but could be beneficial to other children who have limited use of their legs. The main design requirements of the mobilizer were: 1) it had to be small and maneuverable as it is often used within the house, 2) it had to be easy to get into and out of as Kristopher can only crawl, and 3) it had to be light in weight so that it could be easily hand powered by Kristopher. Therefore any device made for Kirstopher had to be very low to the ground, and made so that it wouldn't roll away from him as he attempted to clamber on.

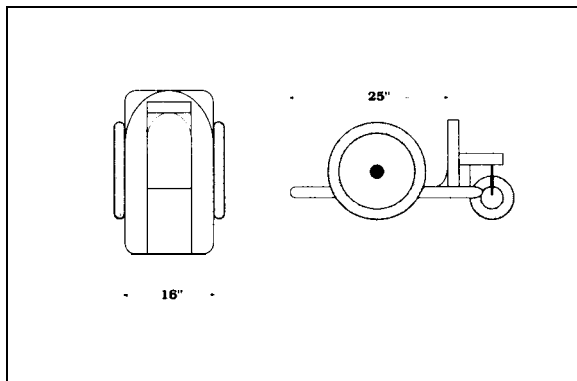


Figure 2.16. Diagram of mobilizer for a child with cerebral palsy.

The mobilizer device has three wheels, two of which are 16-inch diameter drive wheels that Kristopher turns with his hands via direct drive (in the same way that a wheel chair is propelled). The third wheel is a trailing, pivoting, caster type wheel obtained from a wheelchair parts manufacturer. This wheel arrangement allows the device to be turned around 360 degrees in a small area and makes it very maneuverable. The seat is mounted upon a central stabilizing member of the frame and can be

adjusted forward or backward. It is slightly inclined to aid Kristopher in maintaining balance. The entrance pathway to the seat (from the front) is covered with Kydex plastic and allows Kristopher unobstructed access to the seat of the device. The device is just three inches off the ground that allows Kristopher to drag himself onto and off of the Mobilizer easily. A lap belt can be used to hold Kristopher more securely in the seat, which attaches with Velcro.

The frame of the mobilizer is made of 7/8" diameter aluminum tubing, heliarc welded for rigid construction. The central member to which the seat is mounted is 1" square aluminum tubing. The seat frame was constructed of plywood, steel angle brackets, foam, and black vinyl. Custom molded foam was oriented within the seat to give a concave, body-holding form to the seat and back. The wheels are made of polymeric materials and were purchased together with their axle assemblies. Axle mounting plates and the rear wheel fork assembly are custom designed aluminum alloy components. The platform over the frame is dark blue Kydex plastic. The frame was coated with white enamel paint for an aesthetic appearance.

The final cost of the Mobilizer, including the cost of a steel prototype used in development was approximately \$1,250.

REFERENCE

Paulsson, K., and Christoffersen, M., "Psychosocial aspects on technical aids -- How does independent motility affect the psychosocial and intellectual development of children with physical disabilities?" *Proc. 2nd International Conference on Rehabilitation Engineering*, Ottawa, Canada, 1984.

Development Of A Therapeutic Busy-Box For Use By Children With Limited Fine-Motor Control

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INTRODUCTION

Many cerebral palsied children have a low level of motor control. This lack of control has a severe impact on the development of these children, both physically and mentally. Some believe that the lack of interaction with the surrounding environment leaves the children in mentally slow states. Some form of therapy is required to allow cerebral palsied children to develop more normally. According to Lily Davis of Saint Michael's Association for Special Education, in Northern Arizona there is a need for "therapeutic busy boxes," devices that hold a child's attention while keeping their hands busy. The CI literature lacks any reference to such devices. With over 17,000 children in Arizona alone there is a consumer demand for inexpensive busy boxes (1).

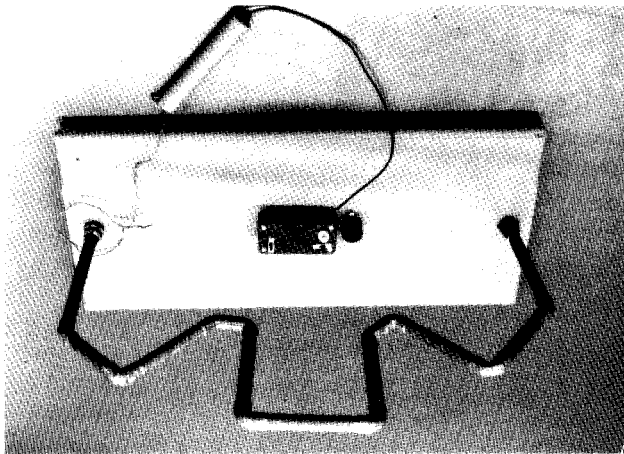


Figure 2.17. Picture of a device to encourage cerebral palsied individuals to develop motor skills.

CP is not a defect of muscle, but rather a lack of coordinating influences that result in movement and postural difficulties (2). One characteristic that all CP cases have in common is the non-progressive

neural state. That is, the damage to the motor center does not worsen, nor does it improve. Abnormal motor behavior typically associated with CP is seen as the outcome of a long process of compensation for underlying defects. Motor skills building on these "abnormal" patterns can become more and more abnormal. The development of devices to assist children (and adults) to learn "normal" function and unlearn "abnormal" function is a worthwhile endeavor that can provide for development of Activities of Daily Living Skills (ADLS) and an improved self-image.

In the development of this device six major goals were kept in mind: (1) Safe. (2) Develop three basic hand motions (gripping, supination, and pronation). (3) Make device enjoyable and easy to use. (4) Portable yet sturdy. (5) Easy repair and upkeep. (6) Robust. How these design goals were satisfied will be discussed in a later section.

SUMMARY OF IMPACT

The underlying hypothesis yet to be evaluated is if a busy box device can assist in the development of hand function of CP children. An additional consideration is the psychological effect of the device on the children.

The current device is proposed to allow children of all motor control levels to develop to any control level they can achieve. Additionally, the device can be used by "normal" children and even elderly stroke victims to regain lost function. Although the device was designed for children, it doesn't look like a child's toy, and therefore should not discourage older children or the elderly from using it.

TECHNICAL DESCRIPTION

The device to encourage cerebral palsied individuals to develop motor skills consists of copper pipe attached to a wooden base. Copper piping is inexpensive and readily available making it ideal for this application. The pipe is assembled into a geometric configuration that will allow for normal hand motion, with emphasis placed upon gripping, pronation, and supination. A ring-assembly consisting of a diameter-adjustable ring (heavy copper wire) attached to a wooden handle (broom handle) is passed over the copper piping. It is intended that users grip the handle and maneuver the ring so as to traverse the entire length of the pipe without touching it.

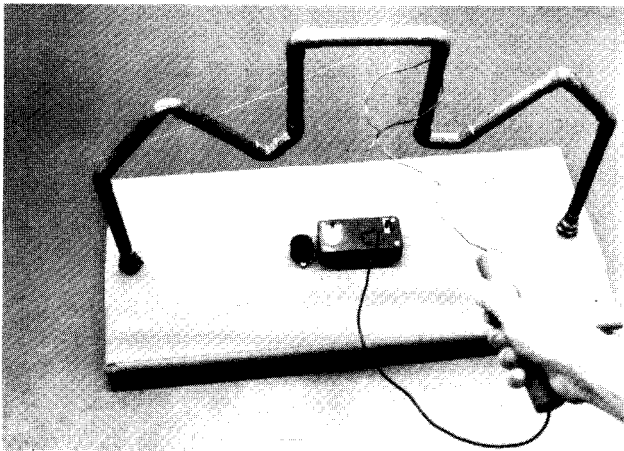


Figure 2.18. Picture of device to encourage cerebral palsied individuals to develop motor skills with operator.

The design consists of copper piping in a geometric configuration, determined by examining the normal range of motions of the hand and arm. A general heuristic that was used is to limit the angles of rotation to 180 degrees -- i.e., palm up to palm down. Also, the pipe was symmetric about a central axis so that the development of the left and right hands could be compared. The geometry is "M" shaped and requires complex hand movements. In moving the ring-assembly through the device many angles at different height are encountered. By no means do we claim that the "M" shape is the best; since the device is very inexpensive and production less than 2 hours, many similar devices could be made with different geometries rather easily.

The purpose of the alarm is to make the device more like a game. With the alarms in the off position the device can be used to simply develop the skills required to move the ring assembly through the piping. With the alarm on, children will attempt to move a ring over the copper pipe without touching the ring to the pipe. The alarm system consists of a piezoelectric siren and a flashlight bulb that will be powered by a nine-volt battery, which provides a sound loud enough and/or bright enough for the visual and hearing impaired. Other more elaborate circuit ideas and alarms were discarded due to the extra power requirements, costs, and safety issues.

A primary goal in the development was to maintain the therapeutic element of the device, i.e., make it robust and adaptable. This is accomplished in two manners: First the use of an adjustable ring will allow for lesser or greater difficulty (i.e., a smaller ring diameter would be harder to maneuver than a larger ring diameter). Secondly, the manner of ring movement can be altered, that is, to increase the difficulty the user can attempt to move the ring through the obstacle more quickly.

Consideration was given to the "ideal" geometry for such a device, since too sharp a turn may place the arm and hand into a very uncomfortable position. Future work on this design concept can be performed in developing newer geometries. Also, due to the ease of production, many devices of original geometries could be made by the older children at St. Michael's who possess adequate motor skills. When designing new geometries, the overall dimensions must be kept in mind. A device that is too tall or too long will be difficult for a child to play with, especially a child who has limited motor control. The dimensions of the current design were chosen based on reaching the ability of a child. The production cost of the device is approximately 40 dollars. All materials used can be obtained in local hardware stores.

REFERENCES

1. Walker, Andrea Sue. *Electromechanical "Busyboxes" for the St. Michael's Association for Special Education, Window Rock, Arizona.* Unpublished report.
2. Finnie, Nancie R. *Handling the Young Cerebral Palsied Child at Home.* E.P. Dutton & Co., Inc., 1968.

Variable-Mode Home Exercise System for a Partial Quadriplegic

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INTRODUCTION

A weight lifting unit was designed for a 21-year-old male, C5-C6 quadriplegic. A pulley system on an existing weight lifting machine was modified and attached to the frame (Fig. 2.19). Two types of resistance are provided, spring-loaded and isotonic. Varying thicknesses of surgical tubing created the different spring loads. Iron weights attached to a pulley system created the isotonic resistance. Glove leather lined wrist cuffs were used in place of the standard hand grips. Included with the system is a five-step set-up instruction booklet along with a series of exercises to be performed.

SUMMARY OF IMPACT

Public awareness of the handicapped community has increased in recent years. The specialized needs of the handicapped and the growing realization of their potential capabilities has produced an increased need for adaptive equipment. Despite this, a lack of well-designed recreational equipment (and funding) still remains.

This exercise system was designed for a young man who was very active athletically prior to injury. He needed a weight lifting system to increase his strength and endurance following discharge from the hospital. The system needed to be transportable, easily adjustable, and easy to disassemble and reassemble because of uncertainties in his living arrangements. The system was intended to be used not only as a strengthening device, but also as a motivational tool. It is in the latter use that we feel the greatest impacts will be made.

TECHNICAL DESCRIPTION

A wall mounted Life Line Pulley System from GNR Health Systems was modified to fit onto an aluminum frame with the dimensions calculated for safety and the patient's range of motion. The moment about the frame of the system was calculated to de-

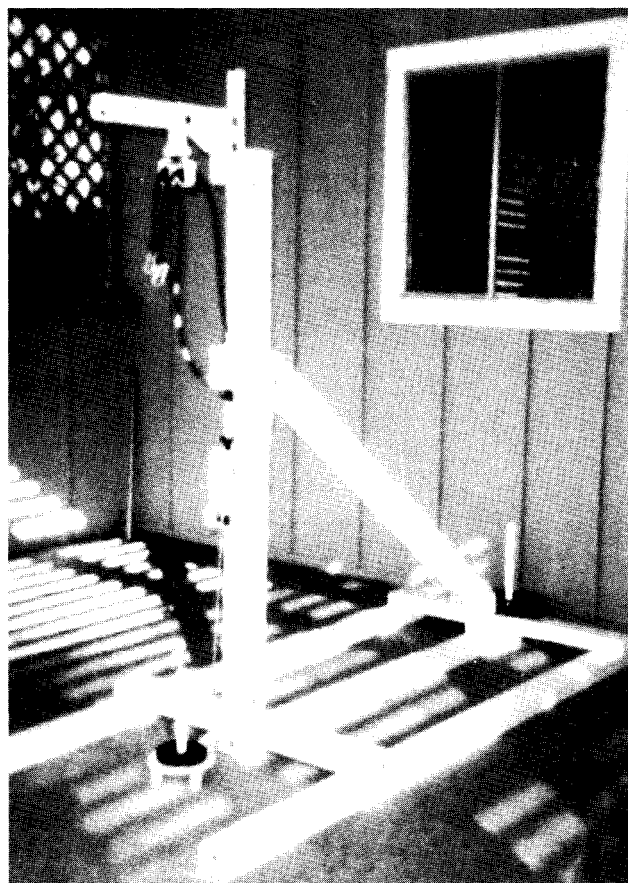


Figure 2.19. Picture of a home exercise system for a partial quadriplegic.

termine the amount of weight required to counterbalance the unit. The subject was lifting 40-pound weights on a pulley system in the hospital. Assuming the subject's strength improved sufficiently to lift 100 pounds on the pulley system (with a safety factor of two), a 200-pound force was used to calculate the dimensions of the unit. Six 22-pound weights were required to counterbalance the force applied to the pulleys.

A hollow, lightweight, rectangular frame made of aluminum was used because of its ability to withstand bending moments. It also has the added feature of matching the structural and dimensional characteristics of the existing system. The rectangular frame was reinforced at the joints with solid aluminum plugs to increase the surface area in contact with the screws and to keep it from bowing inward with repeated tightening of the wing nuts. A cable was placed through the inside of the diagonal tubing to the counterbalance weights to provide an additional measure of safety. Wing nuts and washers were used for easy assembly. Additional screws were added to strategic points to provide some structural redundancy.

In the final device, two types of resistance were provided, spring-loaded and isotonic. Varying thicknesses of surgical tubing were used to create a variable springlike load. Isotonic resistance was created by attaching iron weights to the existing pulley system. The wrist cuffs were attached to a steel cable that ran through the pulleys. The cable is able to withstand 370 pounds of axial load that is

170 pounds more than the safety factor of two requires. Extra cable also was provided for easy adjustment to allow for changes in the user's range of motion.

The leather wrist cuffs used in place of hand grips were lined with lamb's skin to provide a durable, but smooth interface. Detachable clips were used to allow for easy removal and attachment for the various exercises. Velcro closures made the cuffs easy to don independently. An additional wire was used to connect the cuff to the tubing for increased safety.

The subject stabilized himself in the wheelchair by using a strap that goes around the back of the chair and across his torso. Wheel locks on the subject's own wheelchair allow the chair to remain stable.

A booklet of written instructions and pictures was created to explain the five-step set-up, along with the exercises to be performed.

The final cost of the exercise system was approximately \$900 for materials and construction.

Ring Binder Opener/Closer for persons with Little or No Finger Manipulation

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INTRODUCTION

Designs for a ring-binder opening and closing device have been made for a physically challenged computer programmer who has limited finger range of motion and strength in both hands. The designs are relatively simple with one of the designs consisting of a single metal rod bent to shape, another of welded construction, and a third of "scissored" design. Thus, one device comes in a pair that fits around each of the patient's hands (see Fig. 2.20).

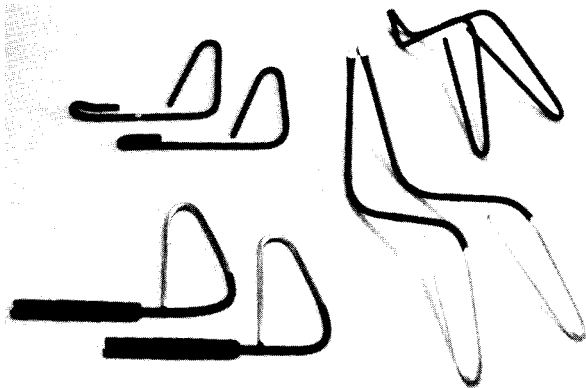


Figure 2.20. Ring Binder Opener/Closer.

The mode of wearing and use differs where one uses primarily the strength of the wrists and the other, the arm. Both designs/models are "one size fits all" type of devices and are easily used. These devices are powered by human energy sources and use of such devices are not limited to any one individual.

The modes of operation vary for the devices. Device 1 uses wrist movements. Thus, the device is worn in a cuff manner around the hand with the rod tip pointing outward, away from the back of the hand. The ring of the rod fits about the ring of the binder

and with both rods in place, the binder is opened by circular rotation of the hands. Closing the binder requires the opposite action of hand movements. A similar, more robust device that works with the same principle is shown in Fig. 2.21. These devices are enhanced by plastic shrink tubing, which increases the "grip" of the device against the slick metal ring.

Device 3 uses the arm movements instead. The device is designed like a pair of scissors, and to open the binder, place the two ends of the rods between the rings in manner depicted in Fig. 2.22. Open up the device (as if closing the thongs) between the rods to open the rings. To close, fit the thongs around the outside of the rings and push them together.

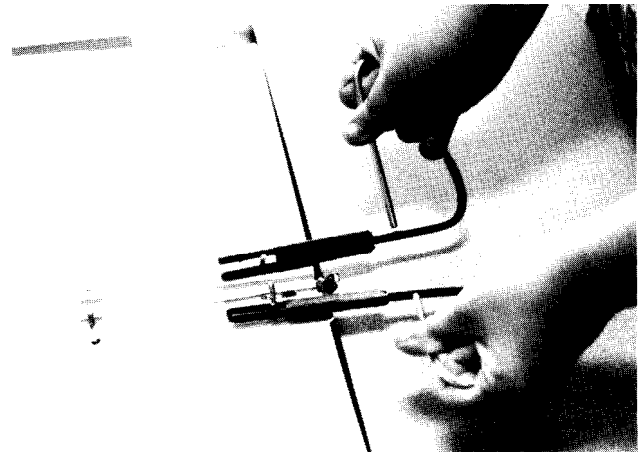


Figure 2.21. A more robust Ring Binder Opener/Closer.

SUMMARY OF IMPACT

Since the device is patient specific (those with no finger manipulative control), the summary of impact will be in direct reference to June, the patient. Because of contractures, June does not have much finger strength in both hands but still retains some

function in the palm region of both hands. She has requested for a device to allow her to open and close a 3-ring binder (or any multi-ring binder). The device will assist her in the required tasks and activity by making use of her wrist or arm motions. Both devices will be applicable to ring binders of various sized ring sizes.

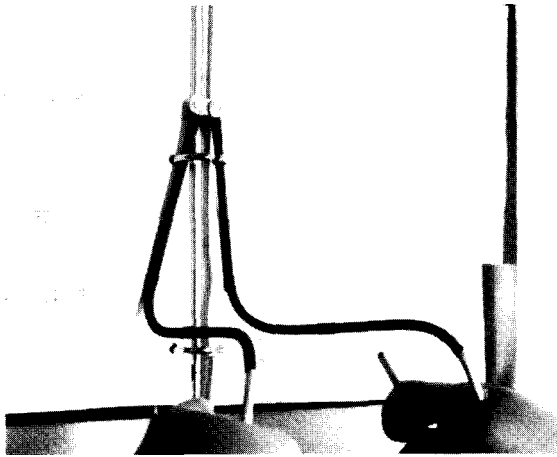


Figure 2.22. Ring Binder Opener/Closer using arm movements.

TECHNICAL DESCRIPTION

The devices were designed specifically for June, although other patients with similar disabilities would be able use such a device too. The design requirements were primarily (1) simplicity in use, (2) re-

quiring no finger activity, (3) durability and portability, (4) economically feasible, and (5) safe to use.

For design 1, the device is worn around the first set of phalanges like a "cuff." A steel rod with its end bent over backwards, extends from the upper portion of the device for about 10 centimeters. The entire cuff is sand-papered and cleaned, and a layer of paint is applied. The cost for building such a device was estimated at \$1.00.

Design 2 consists of three pieces of 3/16" steel rod. Two short pieces are welded onto the bent handle piece to form a fork. Shrink tubing narrows the gap between the fork tines, making for a more secure, tight grip on the binder rings. This design was the easiest to use, both in opening and closing the 3-ring binder.

For design 3, the device is worn in a similar method as in device 1. Again, a steel rod is used. The ends of the rod are beaten flat with a hammer (ensure that only one side is hammered on) until a flat surface of about 1 millimeter is achieved. A hole is drilled into each of the flat surfaces such that a brass stud can be inserted. The outer sides (sides that are not going to face each other when the rods are put together) are slightly reamed with a wedge bit. The rods are then bent to the desired shape and the flat surfaces are joint together with the brass stud beaten in place. The device is then smoothed and painted. Estimated cost is \$1.50.

Headache: An Electromechanical “Busy Box” for Cerebral Palsied Children

Designers: Lawrence Smith, May Movafagh

Disabled Coordinators: Pauline Boisselle, O.T.; Lily Davis, O.T.; Margaret Kelly, P.T. Assistant

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Supervising Professor: Gary T. Yamaguchi, Ph. D.

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INTRODUCTION

Headache is an electromechanical “busy box” designed for use by younger handicapped children (< 10 years old). This device represents a modification of an existing video arcade game called “Sweet Licks” that is manufactured by Namco. Our device is a large wooden box that contains four brightly colored characters. On two opposing sides of the box, there are panels containing four switches. Each switch controls one of the characters, but only one

panel is active at a time. When a switch is activated, the corresponding character pops up from the box and held for a predetermined period of time. If the character is struck on the head by a padded mallet before the time period expires, a hit is registered before the character returns to the box. Headache is intended to be used by two children at a time. One child operates the switches to elevate the characters, and the other attempts to hit them before time expires.

SUMMARY OF IMPACT

In general, cerebral palsy children are capable of gross hand movement, and have the ability to develop finer hand movements. Additionally, they require encouragement for the development of eye/hand coordination, and constructive physical activity. The need has been established for devices that provide immediate response in the form of loud noises, highly visual displays, multiple sensory stimulation, and challenge. Headache is a game that meets these needs while providing encouragement for the development of finer hand movement and eye/hand coordination. The device uses small commonly encountered switches to encourage the development of finger movements. Standard phone jacks are also provided to allow custom designed switches to be used. Gross arm movements are encouraged as the child attempts to hit the character to return it to the box. Challenge is provided by creating a competitive environment between the two players. Also, possibilities exist for adding loud buzzers, bright lights, and electronic scoring systems to increase the sensory stimulation and challenge.

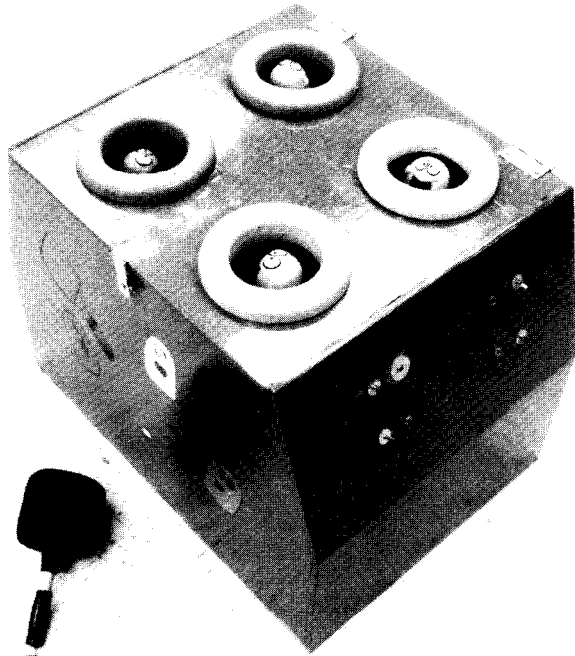


Figure 2.23. Headache.

TECHNICAL DESCRIPTION

This device is a game designed for two players. Each player is positioned near a panel of switches and given a hammer. One panel is activated at a time by setting a toggle switch located on the side of the device. The player with the activated panel operates switches to elevate brightly colored characters from the box. It is the objective of the opposing player to strike the character before a time limit is exceeded.

This design consists of two main parts. One part is the drive circuit that elevates the characters from the box. The other is the control circuit that determines which character is elevated, if a character is hit, and if a time limit expires. The drive circuit consists of a power supply constructed from two 25.6 volt transformers connected in series. The output is then rectified to a DC supply of approximately 90 volts (see Fig 2.24).

Solenoids are used to elevate the characters from the box. The characters are mounted on iron rods that travel through the center of two solenoids connected in series, obtained from the Sweet Licks game. The character-iron rod-solenoid arrangement is housed in a character assembly. For this device, only the bottom solenoid is connected. This is done to lower the current drawn by the solenoid and prevent damage to the relay that is used to switch the solenoid on and off.

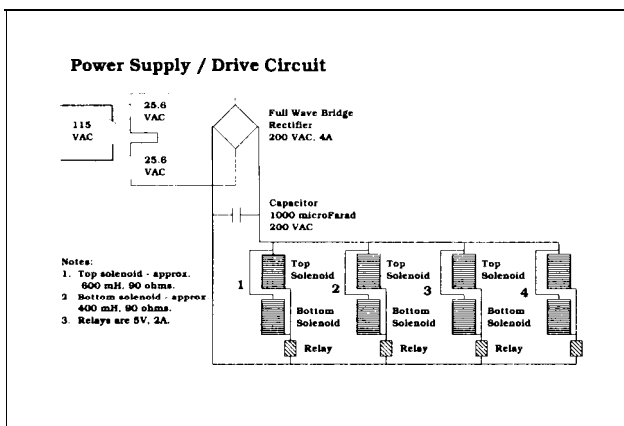


Figure 2.24. Drive Circuit.

The second part of the design is the control circuit. The control circuit consists of a power supply con-

structed from a 12.6V transformer. The output of this power supply is rectified to approximately 8VDC (see Fig. 2.25). This output is then reduced to 5V using a voltage regulator. The 5V is then used to power the TTL logic circuit. The relays that switch the solenoids are controlled by RS flip-flops. The RS flip-flops are constructed from TTL 7402 NOR gates. The output of the flip-flop is passed through a buffer (TTL 7404) and transistor (PNP type) to raise the voltage and current to a level n

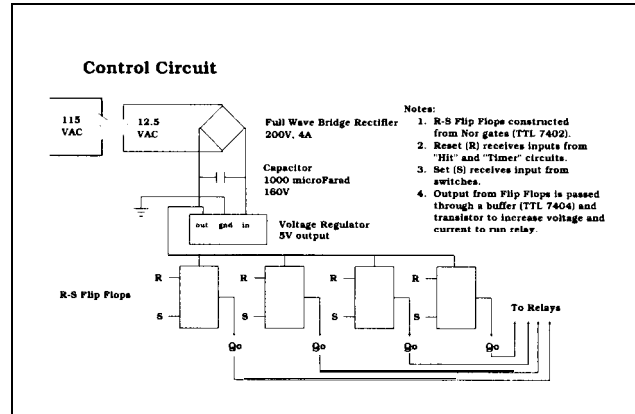


Figure 2.25. Control Circuit.

The S portion of each flip flop is connected to an OR gate (TTL 7432). Inputs for the OR gates are from the player panels. The location of the switches on the player panel indicate which character is activated. The R portion of each flip flop is also connected to an OR gate (TTL 7432). Inputs for these OR gates are from a microswitch mounted on the character assembly and a timer circuit constructed using TTL 555 timer chips. The final cost of Headache is approximately \$645.

A Car/Bus Seat for Children and Youths with No Torso Control

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INTRODUCTION

A car\bus seat has been designed for children at St. Michael's Association for Special Education in Window Rock, Arizona. The car seat consists of three parts, a backboard, two hooks, and a Type 3 shoulder and lap harness (Figs. 2.26, 2.27). The backboard is made of Lexan and is cut to support the torso and head. The hooks are made of stainless steel and attached to the backboard. This helps to keep the student in an upright position in case of an

accident or sudden stops. The harness consists of a lap belt, with two shoulder straps, and is attached to the backboard by four bolts. The harness is adjustable to fit a variety of sized students, and to snug them securely to the backboard. The backboard is padded to provide comfort to the back and head is equipped with detachable pillows to provide additional torso support. The car seat is portable and designed to fit most cars and buses.

SUMMARY OF IMPACT

Disabled Indian children in Northeastern Arizona attend St. Michael's School for Special Education in Window Rock. Many of these children spend up to 4 hours traveling over rough desolate areas. The roads range from asphalt to those only passable by four wheel drive vehicles. The vehicles used for transportation have only standard seat belt systems and are not equipped with wheelchair capabilities. Currently children without torso control are strapped inadequately during their journey to and from school. The car seat designed will meet the needs of these clients. It will allow the students to travel to school in a safer manner by providing physical support, comfort, and protection in case of an accident. It will also allow the drivers of the vehicles to concentrate on the terrain knowing the students are securely fastened in their seats.



Figure 2.26. A Car/Bus Seat for Children

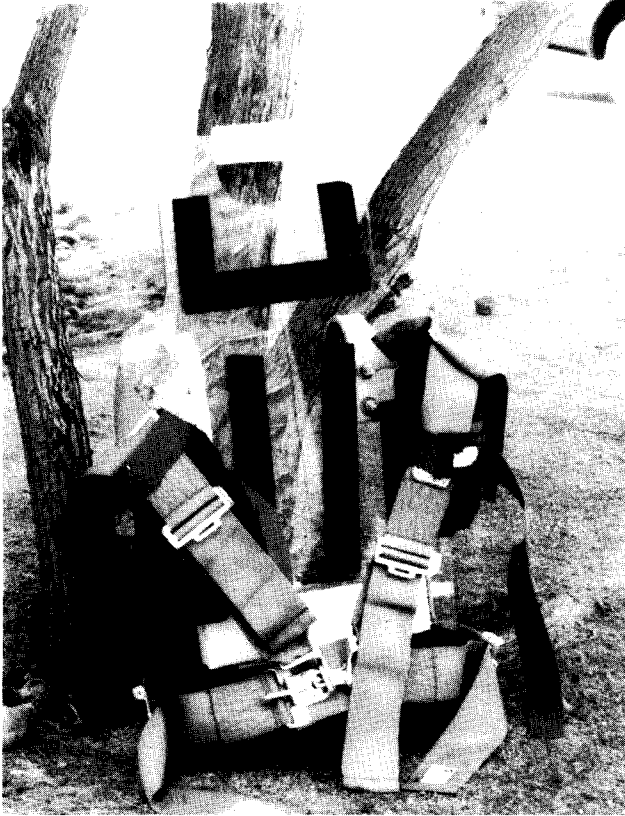


Figure 2.27. Another view of the Car/Bus Seat for Children.

TECHNICAL DESCRIPTION

The car seat was designed to meet the needs of students at St. Michaels school, but it may prove to be beneficial for students and families across the country. The main design requirements of the car seat were: (1) it had to be portable (the school has many vehicles); (2) inexpensive (so all students could be provided with a restraint system at a reasonable cost); (3) comfortable (so sores or other irritations

would not occur during transport); and (4) structurally sound and safe in a collision.

The car seat has three main components, the backboard, U-hook, and safety harness (Figs. 2.26, 2.27). The backboard is cut to fit the back and head and is made of 1/2" Lexan. It has slots cut into the bottom to allow for attachment to an existing vehicle seat belt. It is covered by a 4" foam pad to add comfort to the student during travel. The pads are removable and washable. Two other pads also attach to the backboard along the sides of the foam pad. These pads act as additional torso support. There is also an angled head pad attached so the seat can fit all sizes of students, while at the same time provide comfort and support.

The U-hook is an 11" x 5" x 1/4" piece of stainless steel bent to form a "U". It is attached to the backboard by two high strength stainless steel bolts. The hook fits over the back of most car seats and securely attaches the backboard to the car seat back.

The safety harness is a Type 3 lap and shoulder harness. It is attached to the backboard by four high strength stainless steel bolts. The lap belt keeps the student in place and from sliding off the seat, while the shoulder straps help to keep the student in an upright position.

Preliminary tests were conducted in a student's car as delivery of the device to St. Michael's special school was planned for the summer of 1992. An individual was strapped into the harness and driven around town. He felt very comfortable in the seat and remained upright during various quick stops. The final cost of the car seat for students with no torso control was approximately \$350.

