CHAPTER 5
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Motorized Easel for a Quadriplegic Artist

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INTRODUCTION

Our client is a quadriplegic artist who was injured 25 years ago in a logging accident that severed nerves in his upper spinal cord. As a result of this injury, he has severely limited arm movement, but is able to move his head. Despite this injury, he has become a landscape painter. He currently paints using an easel that allows him to paint from his wheelchair. By grasping a paintbrush between his teeth, he can work on small areas of the painting at a time. The easel is motorized to allow him to reach all parts of the canvas. Our client is now facing a new problem: because of chronic problems with pressure sores, he can only be in his wheelchair one hour a day. The rest of the day is spent in therapy or in bed. The new easel is designed to allow him to paint while he is in bed.

The new easel slides into position around the bed. It has controls, which our client can operate with his elbows, that allow him to move the canvas left and right, up and down, and to tilt it to the same angle as the bed. A paint palette is included, and located in an optimum position for him to access paint and paintbrushes. The easel can also be removed from the bed and lowered to a position that allows use from his wheelchair.

SUMMARY OF IMPACT

Our client's therapist made the following comments regarding this project: "Allowing (our client) to continue artwork, even while bedridden, gives his life more direction and purpose-it becomes more meaningful." She also stated that the easel is "probably . . . the most significant gift he will ever receive. Without such an easel, (our client) would definitely lose the positive feelings he now has about himself and would probably withdraw, losing the warmth and gregariousness he now possesses."

TECHNICAL DESCRIPTION

The design of the easel had to meet the needs of the client as well as the constraints imposed by the bed and wheelchair. The client wanted an easel that is easy to use from the bed as well as from his wheelchair.

Before undertaking this project, the design team did extensive product research. At the conclusion of the search, the design team could not find a satisfactory device that met the specifications and be under $500. While there are several products that work from a wheelchair, only one worked while in bed. This latter device is not motorized, and too expensive.

Research of the available systems for moving the painting around led to three promising options: a belt drive system, a power screw, and a rack and pinion. The belt system is not acceptable because it would develop slack, making it hard to position the painting precisely. The rack and pinion device is not suitable due to the expense of the custom gears needed in its construction. The power screw assembly is acceptable because it is inexpensive, compact, and easy to build.

Devices investigated to attach the easel into position at the bed and wheelchair include a clamp-on device, a crane support, and an A-frame support. The clamp-on device attaches onto the rails of the bed. This design is unacceptable because it requires an extra frame to mount it on the wheelchair, as well as being difficult for an attendant to move safely. The crane support slides into position from the side of the bed. To use it from the wheelchair, a joint is provided that swivels the painting into position. The crane support is not acceptable because the swiveling joint appeared too complex and the base support allows too much deflection. The A-frame support, the design implemented, fits around both the wheelchair and bed. The height is adjustable for either position. The A-frame consists of two vertical columns that are connected in the middle by a channel containing a power screw, and at the top by a square tube. These vertical columns are set in a base that allow them to slide up and down. The A-frame also provides attachment points for mounting controls and accessories.

The chosen design, shown in Figure 5.1, meets all of the design specifications. The assembly is pushed into position by an attendant. After this assistance, the client is able to operate controls that allow him to move the canvas to any needed position. The paint palette is also motorized and controlled by the client. The artist can move the palette into a position that allows him to grasp the paintbrushes in his mouth. With the paintbrush in his mouth, he can also get paint from the palette. The entire assembly can be pulled away from the bed and lowered to allow him to use it from his wheelchair.

The total cost for this project, not including labor, is $580.

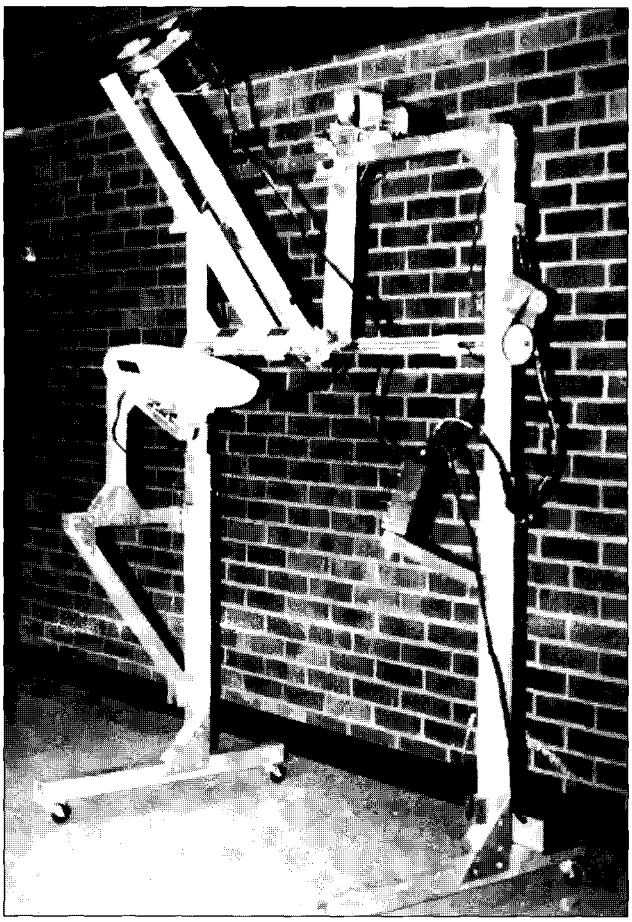

Figure 5.1. Motorized Easel for Quadriplegic Artist.

Horse-drawn Vehicle For Wheelchair Users

Designers: Zoe Burson, Doug Durflinger, Paul Thompson
Client Coordinator: Cyndi Dabney, Eagle Mount, Bozeman, MT
Supervising Professor: Dr. R.J. Conant
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INTRODUCTION

Driving a horse-drawn vehicle is a unique experience that has become a popular equestrian activity for people with disabilities. Vehicles of this type offer an open-aired feeling of freedom and fulfillment for ambulatory drivers. A wheelchair user enjoys a feeling of independence when driving a horse-drawn vehicle because it is versatile and drivable on a wide variety of terrains, including roads, arenas, and grass fields. Horse-drawn vehicles for wheelchair users provide a safe and comfortable ride, while access to diverse terrains challenges the disabled driver. Few activities reward wheelchair users in as many diverse ways as driving horse-drawn vehicles.

SUMMARY OF IMPACT

Eagle Mount, in coordination with Cottonwood Arena, currently utilizes a two-wheeled horse-drawn cart for recreational therapy for disabled persons. The functional limitations of the existing cart fail to provide for safe and proper usage by persons in wheelchairs. The cart's loading and unloading ramp has a 30” angle that prevents the wheelchair user from using the ramp independently, and makes it difficult for an able-bodied helper to assist. Another disadvantage of the existing cart is the rigid shafts that attach the cart to the horse. The shafts transfer the rocking motion from the horse's natural gait directly to the cart that makes it difficult for some wheelchair users to hold their torso upright. Furthermore, wooden wheels are used with no form of suspension, which has proven to be an added discomfort for the passengers. Finally, the lack of an adequate securing device for wheelchairs contributes to an unsafe ride. Eagle Mount requested that our design group consider these problems and design an improved version of the vehicle that would more adequately meet the needs of the users.

TECHNICAL DESCRIPTION

The design of the horse-drawn vehicle involved minimizing the assistance required in loading and unloading, developing a securing system for the wheelchair, and enhancing the overall comfort and safety of the vehicle.

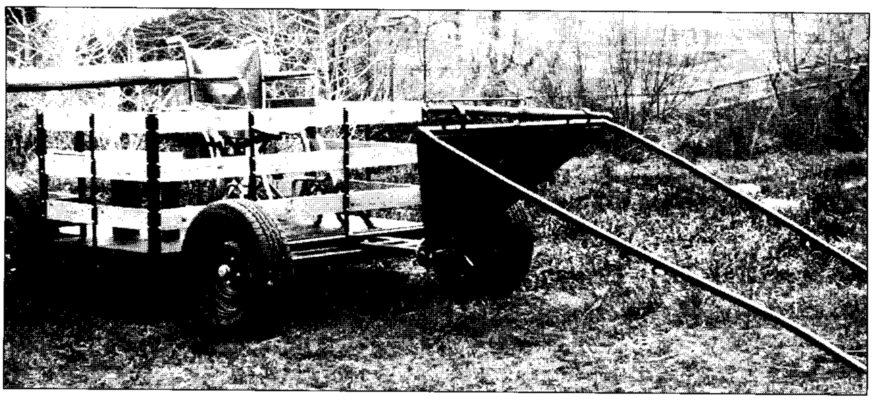

Figure 5.2. Horse-Drawn Vehicle for Wheelchair Users.

Extensive research was carried out in order to find existing technology applicable to wheelchair accessible horse-drawn vehicles. Riding centers, both for the disabled and for the able-bodied public, provided current information and technology. The number of manufacturers of horse-drawn vehicles for wheelchair users is limited in the United States due to liability insurance. However, programs in England are much more active. Due to inexplicit information on the subject, research of mechanics and suspension extended to a more prevalent industry–automotive design. Finally, a thorough patent search was carried out in order to locate possible ideas for securing devices and loading/unloading ramps.

The significant design considerations involve three separate categories: the suspension system, the securing device, and the loading/unloading ramp. These categories are then sub-divided again into three alternative classes. Possible forms of suspension include pneumatic tires, leaf springs, and coil spring shock absorber combinations. The pneumatic tires are selected for the project because of the ease of repair, maintenance, and adequate shock absorption. A four-wheeled vehicle is also selected for the project to eliminate the need for rigid shafts, thus eliminating the influence of the horse's gait on the vehicle. To secure the wheelchair to the vehicle, involved considering a pair of nylon hoops, an axle hold down device, and nylon tie-down straps. The nylon hoops or wheel “bras” are selected for the project because of the adaptability to different sizes of wheelchairs and ease of operation by the wheelchair user. The ramp ideas for loading and unloading included a ramp that slides out from under the vehicle, a ramp that lifts up into a gate, and a two-section ramp that incorporates both the sliding and folding functions. The ramp that slides out from underneath the vehicle is selected for the project due to its ease of use and because the length of the ramp could be longer than the other alternatives, thus minimizing the steepness of the ramp. Pneumatic tires, wheelchair wheel hoops, and a sliding ramp are selected as the optimum devices for their intended applications.

The horse-drawn vehicle is fabricated using steel as the primary material. Steel is chosen because of its durability, ease of machining, and its long life. Wood flooring and siding are used for aesthetics and practicality. The number of parts machined is limited to make replacement easier. Nylatron bushings are used in the steering system to reduce the need for upkeep and maintenance.

The completed horse-drawn vehicle, shown in Figure 5.2, provides a design that met all of the specifications. The ramp on the vehicle is lowered to allow easy loading of a wheelchair. Figure 5.3 shows the ramp in its extended position and the securing device holding the wheelchair firmly in the vehicle.

The total cost for this project, not including labor, is $802.63.

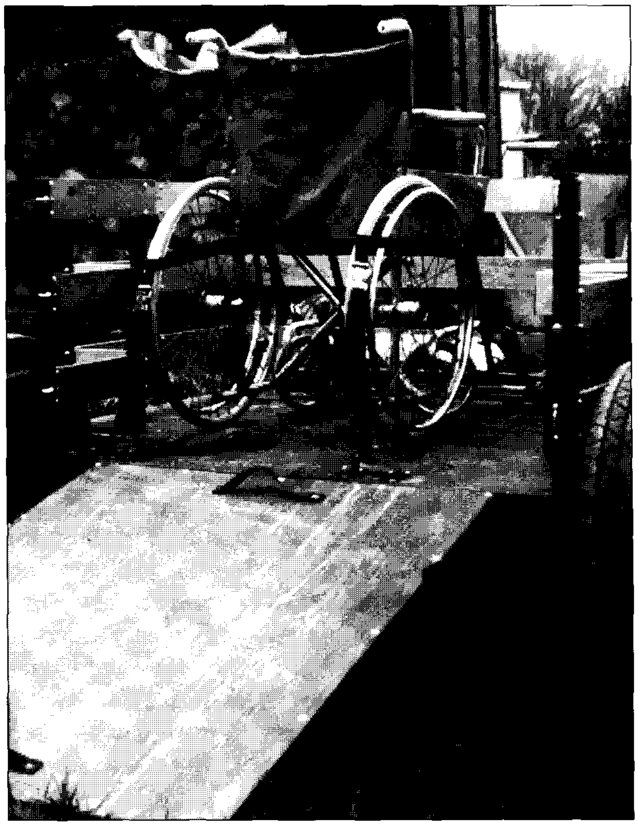

Figure 5.3. Horse-Drawn Vehicle For Wheelchair Users shown with the ramp in its extended position.

Adjustable Head Switch Mount

Designers: Thomas Bonner, Edward Evanson, and Brian Fuehrer
Client Coordinator: Annalee Allen, Montana Centerfor Handicapped Children, Billings, MT
Supervising Professor: Dr. R.J. Conant
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INTRODUCTION

Speech pathologists often use voice synthesizers along with computers to give a client the means to communicate. Clients with little physical control of their arms, hands, or legs are forced to use switches near their head to operate computers and speech synthesizers. In order for a speech pathologist to assess the best head switch location, an adjustable switch mounting system is used. Placement of these switches is difficult considering the small area around the client's head. This problem is amplified when clients are children. After the best location is determined, a switch is permanently mounted.

SUMMARY OF IMPACT

Our client coordinator stated that, "The adjustable head switch mount has already seen extensive use. It has been most successful in meeting the challenges of fine-tuned adjustability within a small area, as well as switch stability."

TECHNICAL DESCRIPTION

Part of the design process involved specifying design parameters based on the user's abilities and the diversity of pathologists' clients. Minimizing the force to secure the system was required because the pathologist makes approximately 30 adjustments during a half-hour office visit. A compact and fully adjustable switch mounting system was needed to locate a switch anywhere in the head area of clients as young as three or four years old. The switch mounting system had to attach to the client's wheelchair rather than a permanent location in order to most accurately simulate a future permanent switch installation. The safety of the client and the pathologist factored into the design of the switch mounting system.

The pathologist previously used a Bogen Magic Arm, as well as the Hydraulic Switch Mount (HSM), a 1990-91 NSF design project. Both of these devices look similar to the human arm; two straight "arm" segments with a ball joint at either end, and an "elbow" pin joint between the two "arms." The Bogen Magic Arm utilized a mechanical system to lock all three joints while the HSM employed a hydraulic system. Both devices are too large for assessments near the head area. The Hydraulic Switch Mount is also not desirable because it leaks hydraulic fluid.

Three design areas of the project were specified at the beginning of the project: the interface from switch to device, the device itself, and the interface from device to wheelchair. Research of existing solutions for the interface from switch to device revealed that conventional methods such as Velcro are unacceptable. A review of state-of-the-art technology indicated the excellent potential of using an optical-table magnet in this project. This type of magnet has the capability of turning "on" and "off" its magnet force. Research into possible alternatives for the device itself proved that shortening a Bogen Magic Arm is the best solution. The overall length of the Magic Arm is determined from correlating anthropometric data and average wheelchair dimensions. Three-dimensional vector mathematics and the concept of efficiencies are utilized in this analysis. Researching market products revealed the absence of any devices that could adequately attach to the wide variety of existing wheelchairs. Therefore, a clamp was designed and built. Structural analysis was performed to ensure that the design was sufficient for the user's needs.

The chosen alternative shown in Figure 5.4 is a modified Magic Arm with a variable friction locking knob. The size is reduced to an overall length of twelve inches instead of the previous seventeen inches because the larger size had proven too cumbersome. The optical table magnet mounts directly to the arm and attaches to small metal plates that are fastened to the switches. The clamp attaches to $\frac{1}{2}$" to

$1\frac{3}{4}$" diameter tubing, thereby accommodating a diverse population of wheelchairs. The arm mounting assembly can be rotated to maintain all the degrees of freedom in the Magic Arm.

Cost of the adjustable switch mount is approximately $237, excluding labor costs. Of this, the Bogen Magic Arm cost $116, the optical-table magnet cost $52, the clamp tightening knob from Bogen cost $8. The remaining $61 was for miscellaneous materials (that is, bolts, springs and other miscellaneous parts) and putting a chrome finish on the clamp.

Figure 5.4. Adjustable Head Switch Mount.

Independent Mobility Cart for Disabled Children

Designers: Chris Flack, Laine McNeil, and Todd Meling
Client Coordinator: Tamara Aldred, Occupational Therapist
Supervising Professor: Dr. R.J. Conant
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INTRODUCTION

As part of the maturing process, all young children need the opportunity to experience independent mobility at an early age. Without the benefits of a mobility device, children with a physical disability are prevented from gaining independence. Without mobility, a child requires assistance for the simplest of tasks. The addition of a mobility device greatly helps the child and eases the burden on the parents. Very few motorized carts are available to fill this need, and those that are tend to be very expensive.

The designed device allows our client, a young girl, to move around the home and daycare environments in a safe and independent manner. It allows for forward and reverse motion, and turning in any direction by means of a simple joystick. The cart is designed to keep the client at eye level with her peers, thus helping her integrate more readily. It is also supplied with a bumper pad to reduce injury to people and damage to household items.

SUMMARY OF IMPACT

The client's mother, a pediatric occupational therapist, offers the following comments: "This device allows independent mobility and fun for Eleanore, or other young children with severe motor impairments. It is less costly and more compact than a power wheelchair, and allows the child to learn to drive a powered device. It is also close to floor level which is developmentally appropriate for children of preschool through early elementary age who spend considerable amounts of time playing on the floor."

TECHNICAL DESCRIPTION

With a good understanding of the disability and having formulated a statement of need, the next step is to produce a problem definition. The major aspects of this definition came from the client's disability. The client has no use of her lower body or right arm. She can move her left arm only slightly and has very little grip.

A search of existing technology designed for similar cases revealed a variety of motorized carts, but few are manufactured for disabled children. Most are outdoor toy vehicles built solely as toys. The few devices found that fit the client's needs are either one-of-a-kind prototypes or too expensive to be a viable option.

A set of design specifications, of which safety is a key element, is established based on the client's needs, manufacturing feasibility, and group financial concerns. Safety is a key factor affecting each of the other specifications. Primary areas of concern are: weight, speed, turning radius, storage, transportation, and durability.

The next step in the design process is to formulate design alternatives that met these specifications, and choose the one that met the specification best. Due to the numerous restrictions placed on the design by the client's disability, all of the designs are similar. The only differences are in the means of propulsion. The first consisted of a drive shaft similar to that of a car. This is not a viable option because the turning radius is not acceptable for the client's small home. The second consisted of a dual planetary gear arrangement. Although this, of the designs considered, is the most maneuverable, it is ruled out due to the complex nature of planetary gears and the subsequent high cost. The best design, shown in Figure 5.5, (without the seat, which is being provided by our client) consists of two motors turning two drive wheels as in Figure 5.6. A fiberglass shell covers all moving parts while supplying a smooth, hard surface for the removable chair to sit on. The joystick is capable of transmitting a number of input signals to the motors that propel the cart. These signals are processed and passed to the motors by means of a system of relays and diodes that protect the motors from a possible short circuit. One interesting feature of the cart is its ability to turn while in place with no forward or reverse motion. The power is supplied by a 12 volt gel-cell rechargeable battery located behind the seat.

A prototype was constructed by the design group. A variety of subtle changes were made to the design as production progressed, in order to increase the design's effectiveness.

The total cost of the device, excluding labor, is $500.

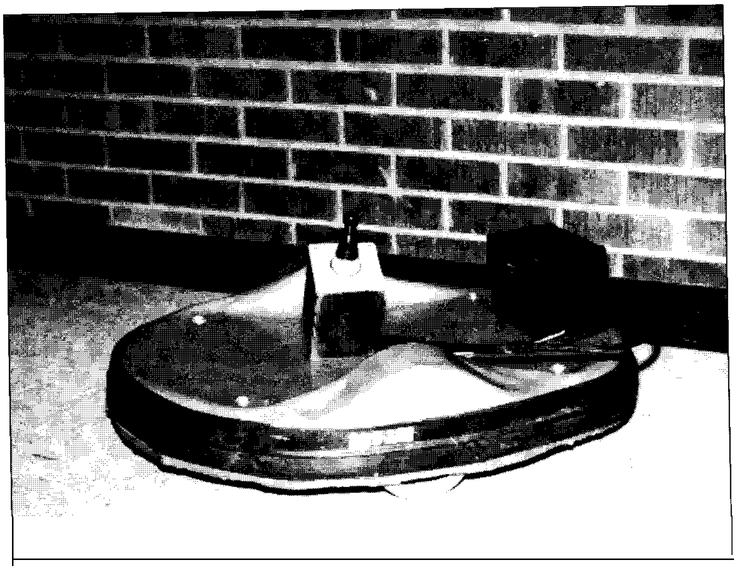

Figure 5.5. Independent Mobility Cart.

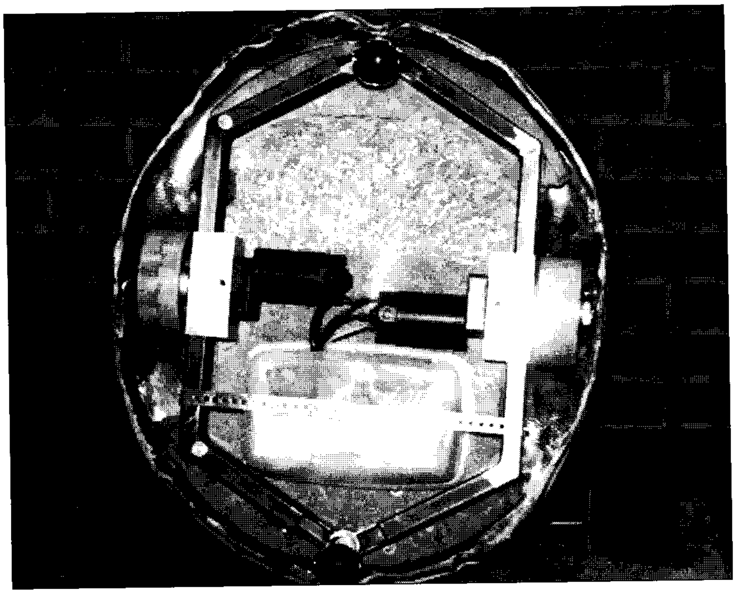

Figure 5.6. Bottom View of the Independent Mobility Cart.

Recreational Piano Playing for a Paraplegic

Designers: Jordan Peccia, Mark Warp, Danelle Wheeler
Supervising Professor: Dr. R.J. Conant
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INTRODUCTION

Playing the piano is a form of recreation enjoyed by many people. The general purpose of piano playing is to create music that is enjoyable to both the player and the listener. Enjoyable music flows together by coordinating the keyboard with the foot pedals. People with paraplegia are able to use the keyboard. However, their physical limitation does not allow them to coordinate the pedals with the keys being played. The result is an inability to play the music as desired.

Currently, the field of adaptive piano playing devices is extremely limited. While there have been a few attempts to design and build such a device, there are currently no devices on the market that meet the needs of a paraplegic who plays a traditional piano, either a vertical or grand piano. Further, none of these attempted devices offered a means of controlling the device with our client's specific needs in mind, or are adaptable to different types of pianos. For these reasons, a device that depresses the two most commonly used pedals during recreational play, the sustaining and damper pedals, is designed and constructed for our client.

SUMMARY OF IMPACT

The use of this pedal depressing device has enabled our client to play the piano in a more satisfying manner because of the additional flexibility allowed through use of the pedals. A drawback of this device is the impact noise generated when the solenoids move.

TECHNICAL DESCRIPTION

The design of the device is divided into two components. The first is the pedal actuating system. The second is the controlling device, or switch, for the pedal actuators. Several factors governed the design of these components, including the disability level of our client and his individual wishes. In addition, proper methods for the use of the piano pedals had to be facilitated by the design. Three design alternatives are formulated for each component of the design.

Design alternatives for the pedal actuator were generated by group brainstorming. Design specification and analysis are the factors that narrowed the ideas to the three viable alternatives. The brainstorming alternatives for the pedal actuating system included proportional and non-proportional actuation of the pedals. Thorough research revealed that several devices could accomplish both the proportional and non-proportional actuation. These devices are solenoids, step motors and linear actuators. After consultation with our client, the need for the middle pedal to be actuated is eliminated for he was not familiar with the use of it. This is one of the proportional pedals. Further, his playing abilities are not advanced enough to use the damping pedal in a proportional manner. Because of this knowledge, plus the magnitude of the expense and the construction complexities associated with proportional actuating devices, both pedals are actuated in a non-proportional manner.

Several factors contributed to the decision to use solenoids in the final design. Manufacturing feasibility and compliance with our established design specifications are two key factors. In addition, knowledge gained through research and the modeling of each of the alternatives played a key role. Engineering analysis is used in determining the necessary design parameters, including forces, displacements and required sizes. The final design is altered numerous times during the manufacturing stage due to observations resulting from the testing of working models and of the actual device. Nearly all problems are identified through these testing procedures.

In designing the second component of this device, the controller of the actuator, research into different switch types replaced the brainstorming facet. Consultations with our client and our design specifications narrowed these switch types to a momentary on/off switch, which is operated by depression on the switches with small displacements by our client's shoulder blades. The optimum location of these switches is determined through trial and error with our client. The material chosen to position this switch correctly and to hold it in the desired location is determined through static analysis.

Results from the preliminary testing proved to be encouraging. The major problem is the impact noise created by the two solenoids which close quickly when the pedals are actuated. While the preliminary design specifications and models demonstrated the design overcoming this problem, the actual device creates noise that is in excess of our client's wishes and our design specifications. This problem is currently being addressed with the aid of experts in the electronics field and observations made during testing.

While final construction of this device was planned and scheduled in detail, designing and redesigning continued during the construction phase as new situations arose.

Excluding labor, the cost of the piano pedal pusher for two pedals, which is shown in Figure 5.7, is $379.

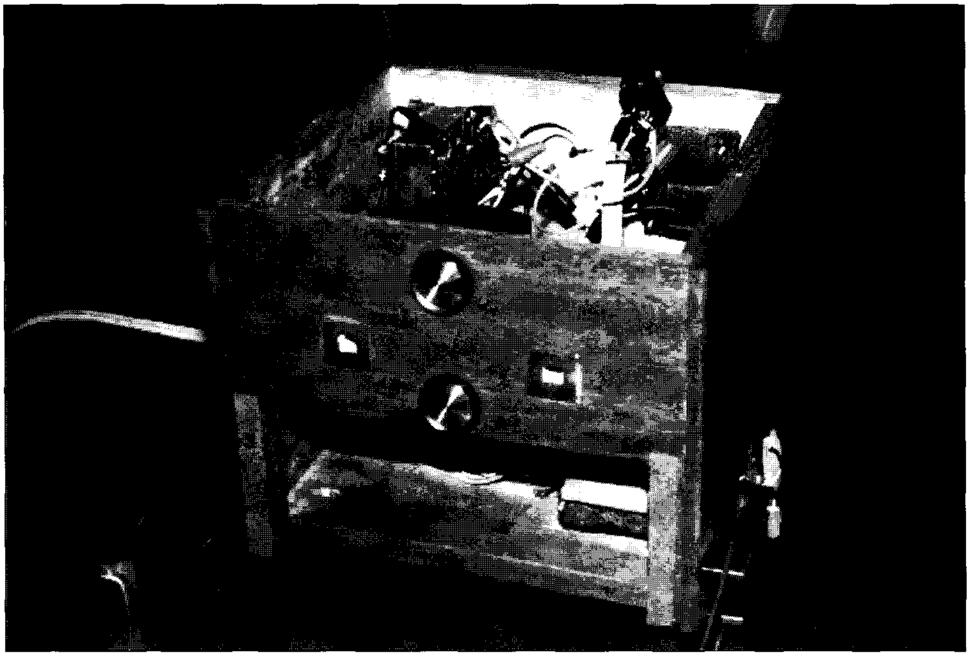

Figure 5.7. Recreational Piano Playing for a Paraplegic.

Modifications to a Rowing Ergometer for Use by Persons with Spinal Cord Injuries

Designers: Joe C. Bradley, Joseph D. Earsley, and Judd L. Mathiason
Supervising Professor: Dr. R. J. Conant
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INTRODUCTION

Wheelchair users experience a muscle imbalance due to the overuse of certain muscles in their daily living activities. This leads to increased stress and a greater risk of injury to bone joints. They also have difficulty obtaining an effective cardiovascular workout because the greatest demand for blood and oxygen comes from the largest muscles in the body, typically in the legs. This report describes the design of adaptations to a Concept II rowing ergometer to allow a strength and cardiovascular workout to be accomplished from a wheelchair (Figure 5.8) or an adapted seating system (Figure 5.9). The components can be configured to accommodate the abilities and desires of the user.

SUMMARY OF IMPACT

The device demonstrates the practicality of adapting existing equipment to the needs of people with disabilities. Disabled students described the difficulty they have in using the University's standard exercise equipment and the reluctance of officials to purchase specialized machines for a limited number of users.

Users with a broad range of spinal cord injury levels found exercises that met their individual needs from cardiovascular to therapeutic strengthening. They liked the convenience of performing a variety of exercises from a single position.

TECHNICAL DESCRIPTION

Research in biomechanics identified the muscle groups that need strengthening in the intended user group. A wheelchair user was videotaped in normal transit and on a treadmill to better study the mechanics of wheelchair operation by a person with specific physical limitations. From this information, exercises were identified which isolate the under used muscles in the upper body and allow an effective cardiovascular workout.

The movement vectors required of the system are identified from the list of exercises. Users are observed mimicking these motions on the unmodified Concept II seat and from a wheelchair placed behind the machine. Ideas are then generated regarding how to effectively connect these motions to the resistance of the Concept II inertial wheel. Mockups of 2 specific designs are built and tested by wheelchair users and their feedback is used to build the final prototypes. Feedback included ease of transfer to and from the seat, stability in the seat, and subjective comments regarding comfort, aesthetics, and level of effort required.

The system consists of three components that can be used in any combination to suit the particular needs of the user.

Pulley System A pulley system, shown just ahead of the wheelchair in Figure 5.8, replaces the handle on the Concept II. The ergometer chain is connected to the pulley system by a cable. Individual handle cables are spooled on each side of the center pulley, 24 inches apart. All pulleys are 4 inches in diameter. A parallel clamp system holds the assembly to the Concept II. The mounting device allows the system to be located anywhere along the Concept II main bar. The pulley system may be used from either the adaptive seat or a user's wheelchair.

"T" bar handle assembly The "T" bar handle, shown in Figure 5.9, consists of a 12-inch long bar that separates the grip cables. A cable thimble on one end of the "T" bar attaches via a carabiner to the ergometer chain. The assembly separates into two cables that continue to the grips. The "T" bar handle can be used with any of the seating options and provides the long range of motion required for the aerobic exercises.

Adaptive Seat A custom fiberglass seat, shown in Figure 5.9, is mounted on a pivoting base at a height of 15 inches for ease of transfer. This height also keeps the user at a distance above the pulleys that allows the proper force vector for the exercises. Structural aluminum tubing extends forward from the seat to support an adjustable foot rest. A channel on the leading edge of the seat base holds firmly to the rear leg of the Concept II. Casters extend from the rear of the base so that when the front is lifted the seat assembly may be pushed into position.

The prototype was built and tested for less than $300, not including labor and donated parts such as the fiberglass seat shell and Jay Active seat cushion.

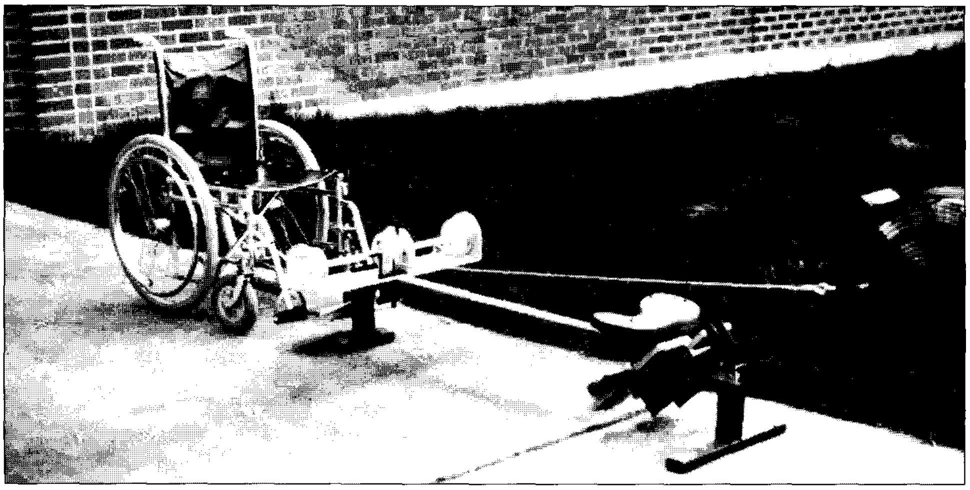

Figure 5.8. Photograph of the Pully System Rowing Ergometer.

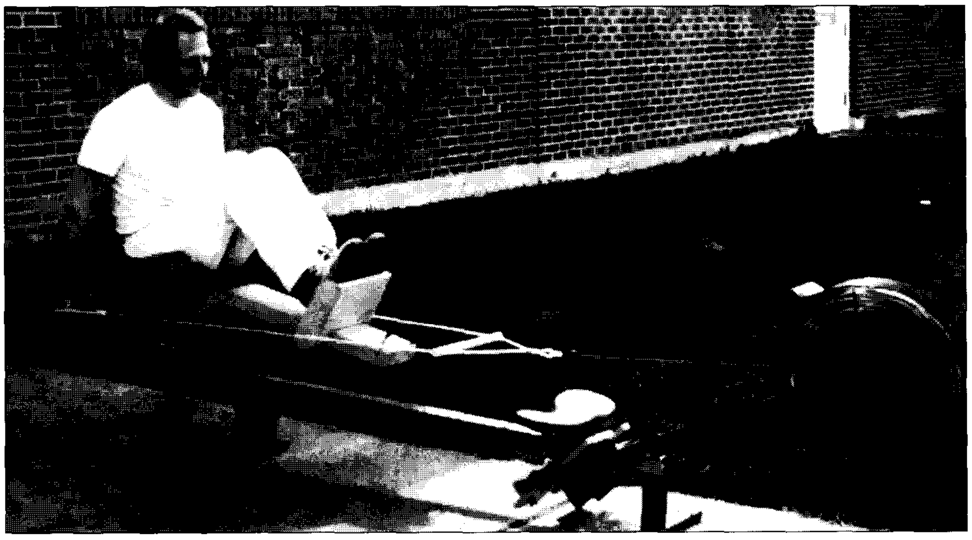

Figure 5.9. Photograph of the "T" Bar System with Fiberglass Seat Rowing Ergometer.

An Improved Ski Walker Design

Designers: Ernesf Belanger, Jeff Craig, and John Underdahl
Client Coordinafor: Sandy Colvard, Eagle Mount, Bozeman, MT
Supervising Professor: Dr. R.J. Conanf
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INTRODUCTION

Alpine skiing is a challenging form of outdoor exercise that enhances balance, builds leg strength, and gives the skier a feeling of accomplishment. These attributes make skiing a good therapeutic exercise for people with disabilities that affect balance and leg strength. Disabled skiers use equipment that is essentially the same as that used by able-bodied skiers, with one exception: disabled skiers require a device that is more sophisticated than ski poles to aid in balance and weight distribution. A ski walker is such a device. It is simply an ordinary walker mounted on skis. However, ski walkers currently used in disabled skier programs tend to be unstable, limited in adjustment range, and often suffer structural damage from the stresses placed on them by the skiers.

The new ski walker design incorporates a geometrically stable "A-frame" structure. This structural arrangement produces a device that is nonconfining, has a favorable strength to weight ratio, and enhances stability and control on a variety of terrain. Adjustment features are included in the structure and its accessories that allow the walker to fit a variety of users.

SUMMARY OF IMPACT

This device gives the skiers the support and stability they need, but also allows some independent control. Giving the skiers freedom to maneuver the ski walker adds to the therapeutic benefits that skiing provides. This design permits the skiers to use the three main principles in skiing; rotation, edging, and pressure.

This device is a big improvement over other ski walker designs and should be very beneficial to the Eagle Mount ski program.

TECHNICAL DESCRIPTION

A ski walker is a device that allows persons with balance and strength limitations associated with a disability to alpine ski. The disabled skier uses alpine boots and skis, but in place of ski poles the walker is used to give added support. The skier is assisted by another person who skis behind the walker controlling movement of the walker through tether lines and another assistant who skis beside the walker to prevent tipping.

This design resulted from research in the following areas: disabled users' needs and abilities, the advice of user assistants, and an examination of the strengths and weaknesses of current ski walkers. Analysis of this information uncovered the need for a strong, lightweight walker, with adjustments in height and ski length, that provides a stable and supportive environment for the skier. These features needed to be incorporated into the design while maximizing the ability of the users and their assistants to effectively control the device. From this research, design specifications are developed to quantify the structural dimensions, performance parameters, and cost limitations.

In assessing the needs and abilities of potential users of this device, their functional limitations are identified. A general lack of balance and leg strength are found to be the dominant common factors. This suggested that a good support system is needed to aid in maintaining balance and to distribute body weight, thereby relieving stress on the legs.

Research was conducted on the two types of ski walker devices used by the Eagle Mount program, a therapeutic recreation organization used as a consultant for this project. The first of these is a device that incorporates a turning system activated by having the user lean from side to side. This design is generally ineffective because the turning mechanism reduces the support given by the walker, and cannot be operated by users with low trunk strength. The second type of walker is an ordinary aluminum therapeutic walker mounted on a pair of skis. This device is also ineffective since it has a narrow width between the skis and has a tendency to tip easily when directed across the hill rather than down it. Several common problems also exist with both types of walkers. First, they limit the amount of room the skiers have to maneuver because of the short width between their skis. Second, they are both constructed of aluminum for weight reduction purposes, but this causes frequent problems with structural integrity. Third, both types of walkers have inadequate adjustment ranges to fit a large variety of users.

Group brainstorming sessions were used to develop a series of design alternatives that met the design specifications. These alternatives included several methods to keep the walker stable when it traversed a sidehill. This is to be accomplished by incorporating shock absorbers or linkage mechanisms to keep the arm supports of the walker level to the user at all times. These alternatives were evaluated with respect to their functionality, ease of manufacturing, and cost.

Our final design, as shown in Figure 5.10, incorporates a rigid frame with a wide base to provide stability and allow the skiers freedom to move their own skis. The base width of this walker is approximately one and one-half feet wider than an ordinary ski walker. The user's skis are attached to the skis of the walker by a pair of devices called adjustable ski-bras. These devices allow the user to stand in a comfortable position by adjusting the ski-bras to the appropriate width for that individual. Typical ski-bras are non-adjustable and are only available in a few different sizes. This design also incorporates adjustable arm rest supports and binding plates that allow for the accommodation of various length skis. The arm rest assemblies have a height adjustment range of ten inches compared to a four to six inch range adjustment incorporated into other ski walkers. The forearm rest sections are padded and cupped to provide comfortable support downward and laterally. The binding plates on the walker are sized to fit average adult ski bindings. This feature makes it easy to change skis on this walker, whereas on other walkers the skis are secured with bolts.

A prototype device was constructed and tested. The design proved to be an effective solution to the problem, yet one particular design modification was required: side handles were added to aid the assistant in tipping control. These handles allow the assistant skiing beside the walker to hold on in a much more comfortable manner.

The cost of this device was $350, excluding testing costs. Several parts of this design-were adapted from materials readily available from local hardware stores and bicycle shops.

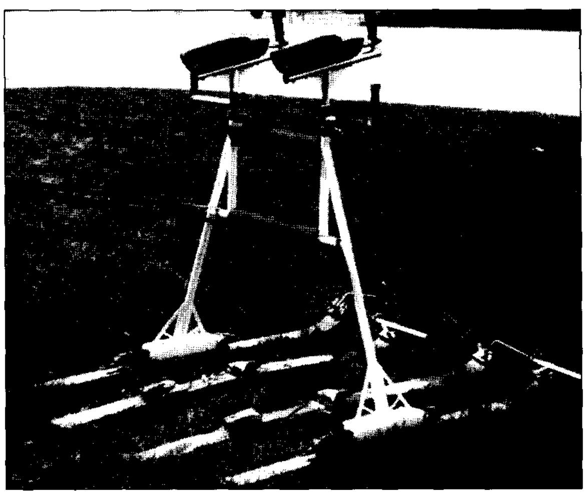

Figure 5.10. An Improved Ski Walker Design.