CHAPTER 3
MONTANA STATE UNIVERSITY

College of Engineering
Department of Mechanical Engineering
Bozeman, Montana 59717

Principal Investigator:

R. Jay** Conant **(406) 994-2203

Arts and Crafts Work Station
A Work Station for Persons with Limited Arm Movement

Designers: Mark Wysocki and Julia Jennings
Supervising Professor: Dr. R. J. Conanf
Department of Mechanical Engineering
Montana State University
Bozeman, MT 59717

INTRODUCTION

This project arose from the need of a quadriplegic requiring a table on which to do crafts. The woman this work station was designed for has very limited strength and range of motion in either arm and no control of the muscles in her hands. A conventional desk does not allow independent writing, painting, or craft activities. A work station has been designed and built to meet these needs after evaluating products currently on the market, constructing models of possible design alternatives, and discussing the probable value of each alternative with occupational therapists and possible end users. The surface of the work station can be moved right and left and tilted up and down by the user through a joystick.

SUMMARY OF IMPACT

The work station allows the user to write a letter, tilt the surface to paint a picture, and move the surface to the right and left to reach the extremities of the work piece. The major benefit of this design is that it allows the user to do these things independently. The work station provides a great deal of physical as well as emotional therapy for the individual who has reduced the handicap associated with her disability.

TECHNICAL DESCRIPTION

The design process began by trying to accurately define the limits placed on our client by her recent disability. The client's physical therapist was contacted, medical muscle strength test results were reviewed with rehabilitation specialists, and the range of motion of each arm was measured to come to a greater understanding of the specific disability. The difficulties associated with using an ordinary desk were discussed with the client in hopes of gaining ideas for possible solutions. It was learned that the client had difficulty moving her hands in an area approximately twelve inches wide and eight inches deep directly in front of her. This range of motion did not allow her to access much of the table surface. A solution that allowed the client to access more of the table surface was determined to be ideal.

After determining the physical abilities of our client, a considerable effort was made to discover products currently available that could help our client. Rehabilitation professionals provided information on products that were currently being used by clients as well as literature they had received from adaptive equipment manufacturers. The ABLE DATA database was used to facilitate the search for existing designs that addressed similar needs. Several school desks, work desks, and drafting tables were found that would provide a partial solution. However, no one table or desk included all the necessary features (right and left motion of the table surface, tilting of the table surface, rotation of the table surface, and most importantly, independent use of the device). This market search supplied several good ideas which were included in design alternatives.

After defining functional abilities, and looking for a commercially available device the process of coming up with a unique design officially began. A desirability matrix was formed to sort out the features that were wanted in the design as shown in Figure 3.1. The matrix was comprised of the following general areas: tasks that the client wished to independently accomplish, features that would allow these tasks to be accomplished, and overall qualities of the design. The components of each general area were ranked according to importance after compiling the input from the client, rehabilitation professionals, and the designers. A great deal of time was spent involving the client in the design of the work station. This made the hopes of developing a product that would be used on a regular basis easier to achieve. The user was directly involved with the evolution of the design and felt some degree of control over the final shape and operation of the work station.

Fig. 3.1. Arts and Crafts Work Station.

The design specifications were next decided upon. Specifications on weight and overall table dimensions were set to allow portability and easy access by the user. Specifications of range of motion of the work station surface were set to give the user as much increase of access to the surface as was practical. Speed specifications were set to assure that the motions of the table were fast enough that the user did not get impatient waiting for the desired positioning, and not so fast that the work piece would topple over. Specifications for operating forces of the work station were set so that the client could easily operate controls.

After determining what features the design must have and setting the design specifications, a great deal of time was spent generating ideas for possible solutions. Brainstorming proved to be an excellent source of creative design solutions. Brainstorming groups targeted the overall table design as well as the design of individual components. This method of creative idea generation produced several unique concepts such as suspending the table surface from above to clear the under side of the table, or designing a device that clamped to the edge of a kitchen table. The three most promising combinations of individual components were coupled with the three most promising overall design concepts and were then developed into three design alternatives.

The next step in the design process was to build models of the design alternatives. The model building process allowed some of the major functional problems of building a work station to be eliminated before reaching the manufacturing stage of the project. Building and evaluating the models again gave the client a chance to see what the designs we were considering looked like before we built the actual work station. The client, as well as professionals in rehabilitation fields, was able to offer even more suggestions for improvements after examining the models. The final design was selected from one of the design alternatives and detailed design of each attribute was completed. The manufacturing of the work station then began.

The work station consists of a steel leg frame assembly which adjusts for height (34” to 46”) with telescoping legs to allow a variety of working heights and the possibility to use the table while in a standing wheelchair. The feet of the leg frame have locking casters to provide easy mobility for the 80 lb. work station and stability when in place. All frame and leg members are made of square steel tubing. The moving surface of the work station is made of plywood covered by Formica on the top and pine half round on the four edges. The surface mounts with two ball bearing drawer glides to an aluminum structural u channel U frame. This U frame tilts with the table surface and supports the drawer glides and a 1/15 HP induction gear motor which powers the right and left motion of the surface. The U frame is tilted by a power screw which attaches to the leg frame and is powered by a 35 in-lb. induction gear motor. All motors are controlled by a joystick and limit switches through relays. The electronic components (relays, circuit breaker, capacitor, transformer, and voltage rectifier) are housed in an aluminum box mounted to the leg frame at the rear of the table.

The mechanism that tilts the table surface consists of a six link jack system powered by a 1/2" ACME power screw. The stress in each link was determined by a computer program, and members were sized to prevent possibility of buckling. The motor was sized after determining the required energy of the system provided by a power screw with known efficiency. The tilting mechanism tilts the table from 0 degrees to 60 degrees at a rate of 30 degrees per minute.

The mechanism that moves the table surface right and left is a chain and motor driven sprocket arrangement which works like a rack and pinion. The chain size and sprocket diameter were determined by anticipating the desired surface speed. The motor was sized after determining the required energy of the system and using known efficiency of the drive mechanism. This mechanism moves the table surface right and left at a rate of about 2 inches per second.

All major structural components of the work station were analyzed to determine maximum stress in members, maximum stress at joints, and maximum stress in welds. Generally the components were designed with a factor of safety of three. The dangerous moving parts are shielded from the user. The electrical control system (joystick and limit switches) is a low current six volt circuit which controls a 120 volt circuit for the two motors through a system of relays. The low voltage control system adds to the safety of the design.

After completion, the work station was tested against the design specifications. Speeds, ranges of table motion, forces to operate the joystick that controlled the motors, and weight were measured, along with having the user fill out a usability survey. The testing uncovered a few problem areas that were corrected so that the user could make better use of the work station. Through testing it was determined that the minimum height of the work station was too high. This problem was solved by cutting approximately two inches off each leg.

The design process was concluded by documenting the development of the work station. The documentation outlines the factors involved in the design, manufacturing, and testing of the project. Suggestions for making the work station available to a wider range of users as well as suggestions for areas of possible improvement of the work station design were included.

The total cost of the materials for the project came to $425. All labor was donated.

Bicycle for a Visually Impaired Rider Modifications to a Mountain Bike

Designers: *Douglas* W. Carr, *Eric J. Shadle, Daniel M.* Evans
Supervising Professor: Dr. R. J. Conant
Department of Mechanical Engineering
Montana State University
Bozeman, MT 59717

INTRODUCTION

The attachments to a bicycle to be used by a visually impaired rider are designed to allow him/her to participate in the activity of independently riding a bicycle. The design includes a pair of stabilizers that when attached to the bicycle provide the rider with the security of knowing that he/she will be safe. The safety feature is that the bike will not tip over when the rider becomes disoriented or loses his/her balance. Another feature that is included in the design is a mechanism that aids the rider in the gauging of their turns by the use of springs. This is very helpful to the visually impaired rider due to the fact that they have a difficult time maintaining their sense of direction. The rider is able to independently operate the bicycle with the assistance of a sighted rider by use of a set of voice-activated headsets. The sighted rider imparts instructions to the visually impaired rider by means of constant verbal description of the terrain.

SUMMARY OF IMPACT

During our initial conversation with our client, we asked him what purpose this design would fill in his life. He told us that he did not get much physical activity but that if he did it was mostly in the form of walking with his dog or riding a tandem bicycle with his brother. He expressed to us the desire to operate a bicycle without his brother doing all of the steering and making all of the decisions. Our client thought that by using this bicycle he could get some exercise in a fun and challenging way.

After riding the bike for the first time, our client exclaimed to us, "and this is more than I ever expected."

TECHNICAL DESCRIPTION

Our bicycle is best described as a mountain bike. It is a bike with upright handlebars, clicker gears, and wide, knobby tires. An overall view of the bike is shown in Figure 3.2. The attachment that we designed for the bike includes an assembly to help the rider determine when the bike is in a straight and forward position, referred to as the neutral position. This assembly, which uses two springs as shown in Fig. 3.3, provides the rider with a feeling of resistance when he/she is attempting to turn the bike. One of the springs will be in tension while the other spring will do nothing. This enables the rider to maneuver back to the neutral position by reacting to the resistance of the springs. When there is no resistance, the springs are in equal tension, and the bike is in the neutral position.

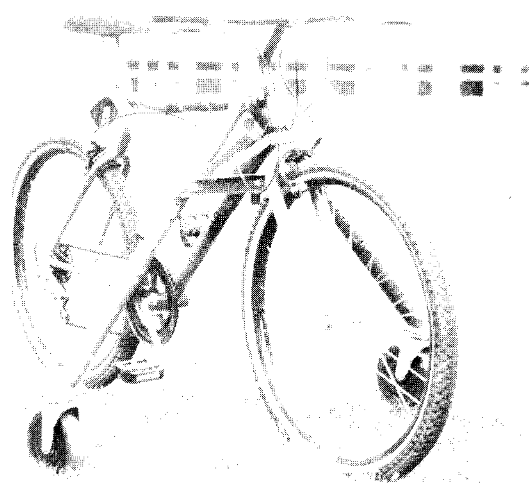

Fig. 3.2. Modified Mountain Bike for the Visually Impaired.

The next attachment to the bike is the stabilizer assembly. This entails two steel stabilizer tubes that are connected to the horizontal part of the bike frame. Each tube is welded to a half section of a 11/16" inside diameter steel tube. These half sections are then connected to the bike frame by use of two hose clamps. They are attached such that the angle between the two stabilizer tubes is 80 degrees. These stabilizer tubes are then attached to a set of caster type wheels by larger diameter tubes. These larger tubes are attached to the smaller stabilizer tubes by the use of two bolts which allow the stabilizer assembly to be adjustable in length. The stabilizer tubes and the larger diameter tubes have been drilled with holes that are spaced approximately 1" from each other. This allows for the beginning rider to have the assurance that the caster wheels are fairly close to the ground in case of panic. This also allows for the more experienced rider to have the freedom to negotiate tighter turns at greater speeds. The entire stabilizer assembly is secured to the bike with the use of two supports. Both of the supports are bolted to each of the stabilizers and to brackets that are welded to the bike.

The final part of the design involves the rider and not the bike. It entails a pair of voice-activated headsets. These headsets are used to give directions to the visually impaired rider from a companion rider.

The total cost for our project was $314.60. This includes the price for a relatively inexpensive mountain bike. The cost for attachments only was approximately $180.

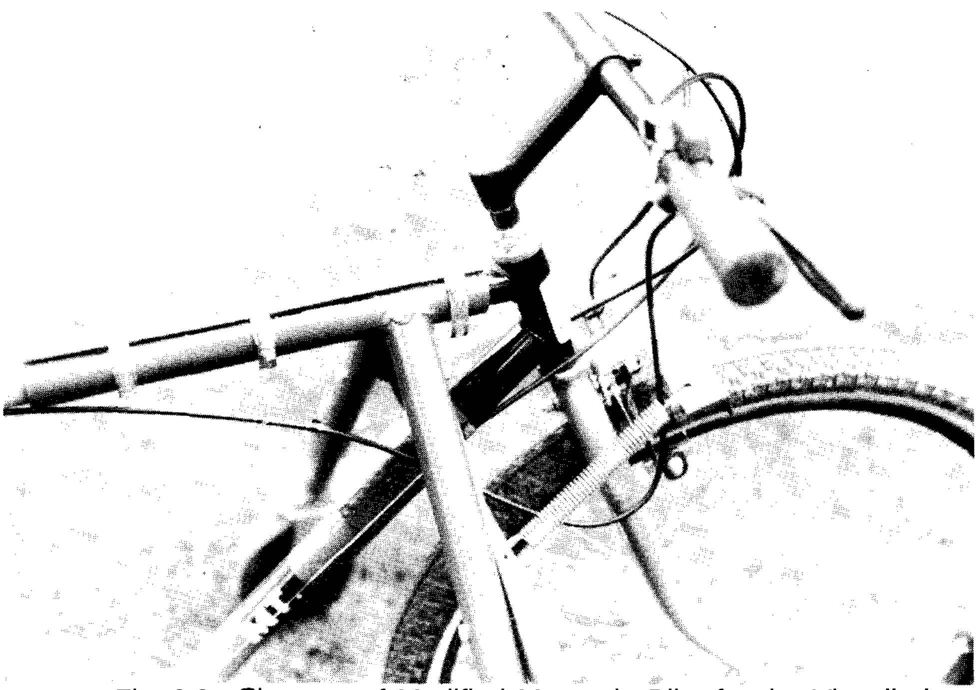

Fig. 3.3. Close-up of Modified Mountain Bike for the Visually Impaired.

Hydraulic Switch Mount
A Device for Positioning Electronic Switches

Designers: Alan L. Parshall and John C. Gray
Client Coordinator: Annalee Allen, Montana Center for Handicapped Children, Billings, MT
Supervising Professor: Dr. *R. J. Conant*
Department of Mechanical Engineering
Montana State University
Bozeman, MT 59717

INTRODUCTION

The Hydraulic Switch Mount (HSM) is designed to assist a speech and hearing therapist with positioning an electronic switch in any desired location during a therapy session. The patients communicate with the therapist through the control of a small electronic switch connected to a computer or similar device. A device is currently in use by the therapist, but has problems associated with its intended use. The greatest problem is that the control lever which locks all the joints, requires too much force by the therapist. This is a concern since the device is usually repositioned many times in an hour long therapy session. The clamp was also a concern since it doesn't attach to all the tables that are used at the center. The design of the HSM has taken these factors into account. A small force is required by the therapist to lock the HSM. This force is much less than the force required to operate the existing device. A modified clamp allows it to be used on all surfaces at the center.

SUMMARY OF IMPACT

Annalee Allen offered the following comments: "As a speech/language pathologist who works with speech output communication devices and adapted computer access, I repeatedly encounter situations where providing the physically handicapped individual with an optimum switch set-up to access the communication device or computer is the most difficult part of the process. I encounter difficulty with positioning equipment or switches for physically handicapped individuals on practically a weekly basis, and very little adaptive equipment for this purpose is available commercially. The hydraulic switch mount constructed by your students has been very useful in enabling me to place a switch where it is most easily and reliably accessed."

TECHNICAL DESCRIPTION

The HSM is a relatively simple device which firmly clamps to wheelchairs or tables and positions a small electronic switch within an approximate reach of 25 inches. The device consists of two thin-walled aluminum tubes 1.375 O.D. x 0.125 in. thick x 11 in. long, connected at the center by a swivel joint as shown in Figure 3.4. Located at opposite ends of

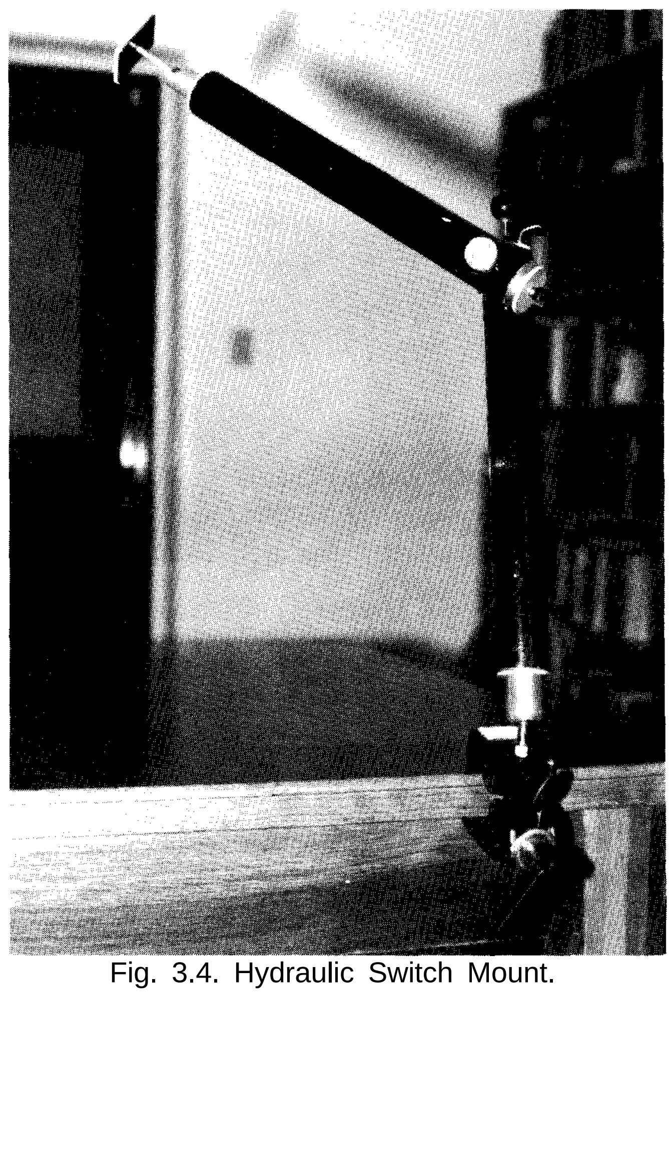

Fig. 3.4. Hydraulic Switch Mount.

each tube are ball and socket assemblies. These two assemblies have been designed with the same function which allows each to rotate in hemispherical patterns, but both differ in size. The lower joint uses a steel ball with a diameter of 1 inch. This gives the crucial holding force needed to withstand rotational forces up to 82 in-lbf. The upper assembly uses a steel ball of 3/4 inch diameter. This assembly was designed to fasten a small electronic Velcro-backed switch. Studs are inserted into each ball which then are attached to both the clamp and Velcro platform. At the mid-section of the HSM is a swivel joint which allows the two lengths of tubing to rotate 340 degrees. Therefore, a switch can be positioned within a spherical space with a 25 inch radius, relative to the table clamp.

When the HSM is in its desired position, it can be locked so that the entire device is stationary. To lock the device using one hand required that the designers use very small hydraulic cylinders at a low cost. This feature is accomplished through the use of a small hydraulic hand pump and two actuator cylinders inside the tubing. The hand pump mounts inside one of the tubes with the pump handle extending out at the end. The actuator cylinders are used to lock all the joints simultaneously. The pressure from the hand pump will be received by each of the two cylinders which will force steel plungers into each ball joint. This will enable the device to become rigid. When the HSM is no longer required to remain stationary, a needle valve can be opened, thus releasing the force on all the joints.

The swivel joint uses a novel method to keep the two members from rotating. When pressure is applied, a wedge forces the tubes together, compressing a rubber washer between the swivel surface and locks rigidly.

A table clamp was purchased and modified to accommodate the bevel edged tables at the center. The modification consisted of welding an aluminum extension to the upper jaw of the clamp so that the clamp would extend outward an additional 5/8 inch. This clamp has a female hexagonal insert which matches the male hexagonal end of the HSM. This enables the therapist to quickly attach and detach the clamp regardless of whether a table or tubing is used.

Two mediums could be used to transfer the force to the cylinders. One is mineral oil and the other is atmospheric air. In the original design air was to be the medium used, since air is readily available, the use of reservoir was unnecessary, and slow leaks could go by unnoticed for several minutes. Unfortunately, it was discovered in the late manufacturing stage of the design that air required excessive pumps (i.e. 80 strokes) to actuate the pressure cylinders. Airs compressibility was the cause of this problem. For this and other reasons oil was selected to be the pressure fluid medium. Oil is incompressible, allowing for a minimal amount of pump strokes. Oil also provides better feedback to the user while the device is being pressurized. This suggests that the operator can easily control the magnitude of the pressure going to the actuator cylinders. Air would allow very little control of the working pressure because of the number of pumps required to completely lock the device. If a leak happens to occur in the system while using air, the leak will take time to affect the holding pressure due to airs compressibility. If a leak developed when using oil, the HSM's holding force will react instantaneous to the loss of pressure and would present a hazard to the user since the device would fall quickly. To fix this problem, 22 gauge steel wire is used to clamp the hoses firmly to the barbed connections. Another problem with leaks consisted of the brass fittings leaking around the threads. This problem is alleviated by fabricating and installing 0.0625 inch thick lead gaskets between the fittings. The lead gaskets allow the fittings to be positioned in the desired direction and prevent any pressure loss. All other connections were sealed by using LOCTITE on the threads.

The total cost for the HSM, excluding labor and machining costs, is $120.

Cross Country Skiing for a Wheelchair Athlete
Adaptive Cross Country Ski Sled for a Paraplegic

Designers: Wade Stoelting, Theresa Lehman, Dale Ostlund
Client Coordinator: Lee Barkmann, Eagle Mount, Bozeman, MT
Supervising Professor: R. J. Conant
Montana State University
Bozeman, MT 59717

INTRODUCTION

The adaptive cross country ski sled is a design which allows a paraplegic to enjoy the winter sport of cross country skiing and to keep in shape for wheelchair racing. Current devices already exist which give a paraplegic the chance to experience cross country skiing, however, these are 'homemade' in that they were not engineered to attain the most of the skier and skis. This new sled is designed to make use of production racing skis, and to allow them to work to their potential. This sled is also designed to enhance the skier's input in the areas of strength and control.

SUMMARY OF IMPACT

This sled has opened the door to another recreational activity for our client. Nordic skiing technique requires more physical stamina than wheelchair racing and therefore has challenged our client's cardiovascular system as well as her balance and upper body strength. The sled has enabled our client to continue the physical conditioning necessary to maintain her strength and endurance during the winter months. It has also enabled her to enjoy the quiet beauty that characterizes Montana's mountains during the winter months.

TECHNICAL DESCRIPTION

The designed sled is similar to present designs in that it is a seat and framework assembly attached to cross country skis. One unique feature to this new design is its formed seat. The seat was formed out of aluminum sheet to match the shape of the skier. This formed seat provides not only front-to-back support, but also side-to-side support for the skier. This support gives the skier greater stability and therefore control of the sled. The seat is lined with a foam padding.

The framework which holds the seat is made out of round chrome moly tubing, the equivalent material used in some aircraft frames. This tubing provides excellent strength and weight characteristics as well as being aesthetically pleasing. All frame joints are TIG welded.

In this design the skier's legs are placed in front of them at a bent angle which prevents hyperextension, as shown in Figure 3.5. The tilted angle also keeps the skier from falling onto their legs leaning too far forward when pole planting.

An important feature of this design which allows the skis to function as they were designed is center-of-mass placement of the skier. By placing the skier's center-of-mass directly over the ski's point of maximum-pressure-distribution, the skier's weight is then distributed evenly over the length of the ski. This then provides the best possible glide for the skier. Closely related to this mounting position is the mounting system itself. The sled's frame is mounted to the skis in a 'ball and heel' style as shown in Figure 3.5. The 'ball' mount is effectively a pivot pin which allows for rotation, similar to that of a human foot pivoting forward on its ball. The 'heel' mount's purpose is to provide resting position on the ski for the frame, and for keeping the skis parallel. The idea for this type of mounting system came from the desire to model the human foot, the parameter for which the ski itself is designed. This type of mounting system also provides for natural ski flexure. By allowing the ski to flex and therefore conform to the snow, the sled is more stable, controllable and thus safe. This mounting system also allows for easy mounting and removal of the skis.

Incorporated into the design is a system which allows adjustment of the ski track width. This adjustability is possible through the use of square, telescoping chrome moly tubing.

The complete device weighs approximately 13 lbs. With the skis removed it is easy for the skier to transport the sled in the back seat of a car.

The cost of this project was approximately $388.00 for materials alone. The skis and foam for the seat were donated.

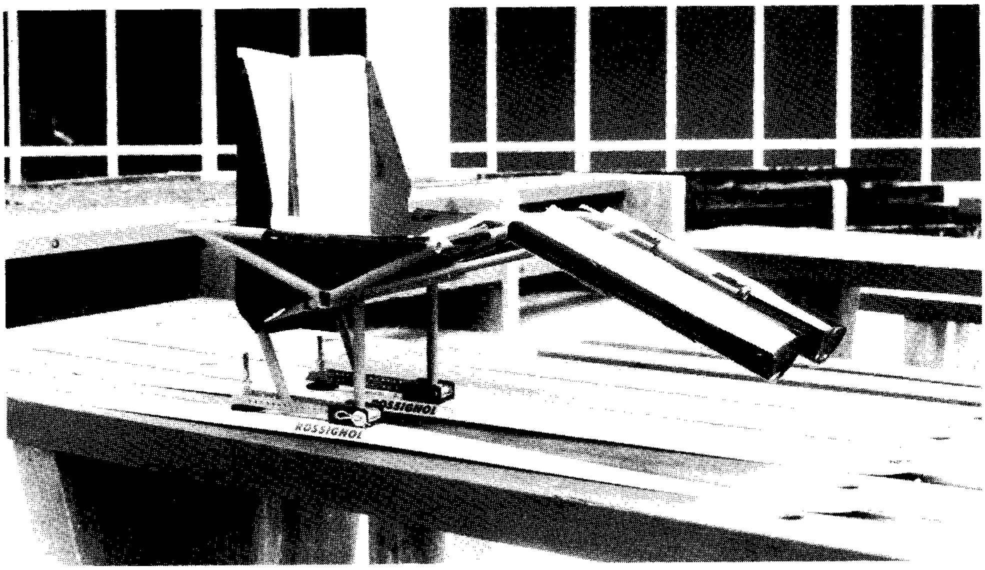

Fig. 3.5. Cross Country Ski Sled for a Paraplegic.

Lifting Ramp for a Quadriplegic An Assistive Device for Entering and Exiting a Pickup Truck

Designers: Alan Frantzich and Jon McQuillian
Supervising Professor: Dr. R. J. Conant
Department of Mechanical Engineering
Montana State University
Bozeman, MT 59717

INTRODUCTION

A person with quadriplegia requires assistance to get behind the steering wheel of a four-wheel-drive pickup. This assistance is usually provided by other people. When at least two other people are not available it causes a hardship on the person who helps the quadriplegic to and from the vehicle. The lifting ramp is designed to assist one person in transferring a quadriplegic person between the vehicle and wheelchair.

The lifting ramp attaches to the pickup inside the door below the outside edge of the driver's seat. When the seat of the lift is in the lowered position it is at wheelchair height, and raises to forty inches, the height of the driver's seat. The seat swivels to allow the wheelchair to be placed in a convenient spot next to the lift and still allow the client to be placed next to the driver's seat.

SUMMARY OF IMPACT

This device allows this person to be more independent of the availability of human assistance to operate his pickup. This device also reduces the effort required by and the possibility for injury to the assistant.

The device works very well within the design parameters and there have been no major problems discovered with the operation of the device.

TECHNICAL DESCRIPTION

The design of the lift had to consider the needs of the client and his assistant and also the constraints imposed by the vehicle. The client wanted a maximum lifting time of thirty seconds and flat seat and back to allow easy transfer. The assistant wanted any single piece not to exceed forty pounds in weight and the required lifting force to be provided by electrical or mechanical means. The design of the lift could not compromise the structural safety of the vehicle.

Before this project was undertaken the clients had done considerable product research, but were unable to find a satisfactory device to fill their need. At the beginning of the project a follow up search confirmed that there were no devices easily adaptable to a pickup truck. This meant that there were few guidelines to provide parameters for product design. However, one point that was emphasized was that the design should not affect the structural integrity of the pickup truck. Therefore, the approach of the design was to make a device that was not permanently attached to the pickup.

Research of the available types of power systems led to three promising options, which were: a hydraulic system, linear actuator, and an electric winch. A way of providing hydraulic power to the device was to tap into the vehicle's power steering pump. This option was not chosen because a potential failure may result in a loss of steering. The linear actuator was not chosen because it was expensive, had a slow cycle time and was susceptible to negative environmental conditions. The electric winch was chosen because it was comparatively inexpensive, it provided a desirable working time and operated with low maintenance.

Three design alternatives were considered before the final selection was made. The first alternative was a folding plate that mounted between the driver's door and the seat. When operated it would unfold using a four-bar linkage and provide a seat surface to lift a person from wheelchair height to the driver's seat. This method would have been powered by an electric winch. This method was not chosen because of space limitations which would have interfered with a workable linkage. A second alternative was to use a removable post, which attached below the driver's door. It would have used a sliding collar and jointed arm to position a seat next to a wheelchair in the lowered position and next to the driver's seat in the raised position. This device could have been powered by any of the three power sources mentioned above. This design was not chosen because a large bending moment would have been applied to the post. The resulting stress may have caused the post to exceed the design specification weight. The third alternative uses two parallel rails made from channel bar steel to provide a track that a cart can roll in.

The chosen alternative as shown in Figure 3.6 provides a design that met all the design specifications. The lift attaches to the pickup floor between the driver's seat and door. In this position the parallel channel bar rails contact the ground at an angle of seventy-five degrees. A removable seat is placed on a cart, which is pulled up and down the rails by an electric winch powered by the vehicle's twelve volt battery. The seat rotates upon the cart to allow the best access by the wheelchair. In the raised position it can be rotated to face the front of the vehicle and slid next to the driver's seat to accommodate the transfer (see Figure 3.7). The operation of the lift is controlled by a hand held remote switch, shown resting on the seat in Figure 3.6, and two limit switches at the minimum and maximum positions.

The total cost for this project, not including labor, is $500.

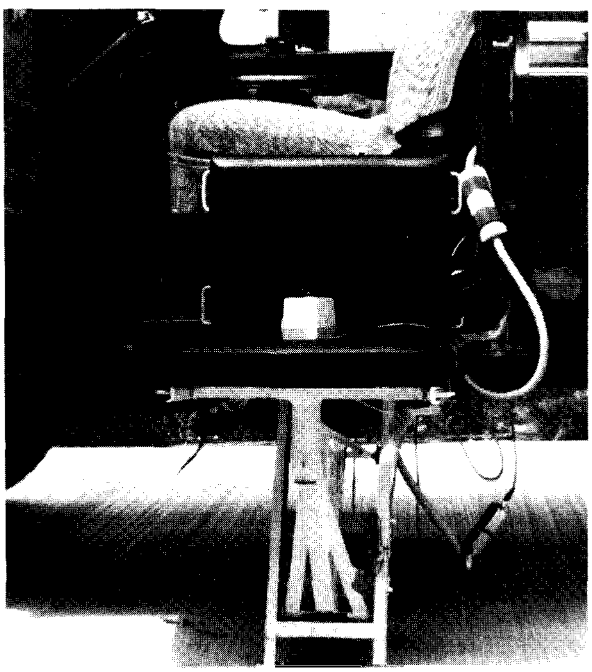

Fig. 3.6. Lifting Ramp for Quadriplegic.

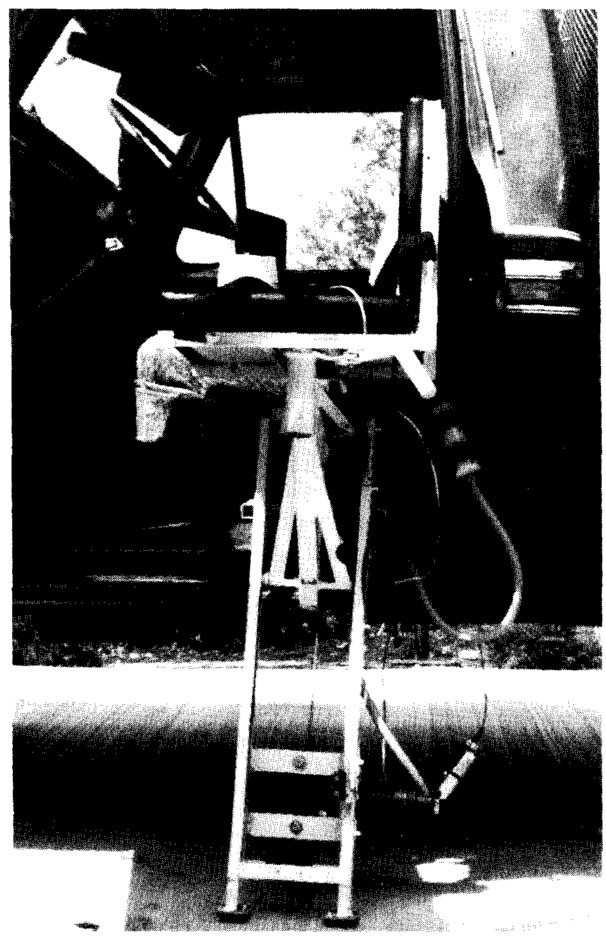

Fig. 3.7. Another view of Lifting Ramp for Quadriplegic.

Horseback Riding For Quadriplegics
An Adaptive Saddle for Quadriplegic Riders

Designers: Rob Kinzle, Greg Paulson, and Jeff Plant
Client Coordinator: Cyndi Dabney, Eagle Mount, Bozeman, MT
Supervising Professor: Dr. R. J. Conant
Department of Mechanical Engineering
Montana State University
Bozeman, MT 59717

INTRODUCTION

In Montana, riding horses is a way of life for some, and a form of recreation for others. Many people enjoy riding on a beautiful Montana day, but for others, this seems utterly impossible. People with physical disabilities only dream of the sheer pleasure that comes from riding a horse. This is especially true for people with quadriplegia. While people with paraplegia are able to ride, people with quadriplegia have fewer abilities and often do not have the opportunity to ride. Currently, the field of adaptive riding devices is very limited. In 1989, a design that enabled a child with Cerebral palsy to ride was developed by MSU students. The design utilized underarm supports to hold the child in an upright position. The symptoms of Cerebral palsy were similar enough to quadriplegia that Eagle Mount, the organization that requested the design, attempted to use the device for quadriplegic riders. In an attempt to continue the quadriplegic riding program, Eagle Mount, in coordination with Butterfield arena, constructed a design similar to MSU's. This design was functional but rather awkward to use. These designs provided a good foundation on which to develop concepts for the new design.

SUMMARY OF IMPACT

Cyndi Dabney, director of Eagle Mount's therapeutic riding program, offers the following comments: "The saddle was designed for individuals in our therapeutic riding program who have quadriplegia. Horseback riding is a sport that was unattainable by those individuals with quadriplegia until this saddle was completed. It is truly a gift of freedom for those individuals who had lost the ability to ride a horse due to their disability. There is no other saddle of its kind in use, and under correct supervision this saddle will enable many severely disabled individuals to again enjoy the physical and emotional benefits of horseback riding."

TECHNICAL DESCRIPTION

Discussion of the disability and a statement of need lead to a detailed evaluation of the problem and the formulation of a problem statement. The primary evaluation of the problem was based on the riders disability because this was the most limiting of the factors involved. Research revealed that upper body support was the primary focus of the design. This was made more difficult due to a standard set by North American Riding for the Handicapped Association (NARHA) which requires that the rider cannot be directly attached to the saddle. Further attention was given to the possibility of secondary injury and the development of pressure sores in the absence of weight shifts. A final concern stated by Eagle Mount was to provide ease of mounting and adjustability.

A search for existing designs used in other riding programs in the United States provided a starting point. No designs were found outside the state that conformed to NARHA standards. However, previous MSU students had designed an adaptive saddle for a child with Cerebral palsy. Eagle Mount attempted to use this saddle for quadriplegics in their riding program but it failed to work effectively. A modified version of this saddle was built by a local arena. This device provided the necessary upper body support, however, it lacked adjustability and lateral stability. Both of these devices utilized underarm support. After consultation with a physician, it was revealed that the underarm support was not desirable due to the possibility of damage to the Axillary nerve which is located under the arm. Also, he recommended the use of an inclined seat to rotate the pelvis forward, forcing the spine into a supportive, curved position.

The next step in the design process was to arrive at a set of design specifications. Safety was the primary focus of the specifications. The secondary focus was to allow the rider as much freedom as possible while still conforming to all safety standards. The final design specifications were arrived at based on evaluation of both the need statement and problem definition as well as input from the clients. It was their desire that the device look as much like a saddle as possible.

Group brainstorming activities, in conjunction with an evaluation of the related designs, resulted in three design alternatives. The final design resulted in an adaptation to a standard western-style saddle tree. The basic components include a polyethylene saddle tree, a support system including a chest pad and lateral support wings, and an inclined seating system. The primary intent of the design was to make it quickly and easily adjustable. This was accomplished by making the adjustable components out of telescoping tubing. In order to secure the components in their proper position without the use of tools, bicycle quick-releases were incorporated.

A prototype was constructed with the help of the MSU machinists and welders, which kept construction costs to a minimum. As the prototype was developed, alterations were made to the initial design concept. The most prominent alteration to the prototype was the addition of a small, adjustable back support, as shown in the figures.

The design has been tested with disabled riders. So far, results are very encouraging. One problem that has arisen is that the quick-releases tend to wear out because of excessive force applied to them. This has been remedied by purchasing higher quality quick-releases for the critical joints. Also, knowledge of proper use of the quick-releases is critical. The lateral stability of the rider in previous designs was a definite problem. This has been drastically reduced in this design. A problem related to the comfort of the horse was discovered during testing. The saddle tree was improperly selected for its intended use and irritated the horse. A saddle maker was consulted and a more versatile tree was incorporated into the prototype.

The saddlemaker, because of his inherent knowledge of the horse-saddle interface, was able to create a saddle that is more comfortable for the horse. He also designed a rigging system which is used to attach the saddle to the horse.

The cost of the adaptive saddle is $520, excluding labor costs.

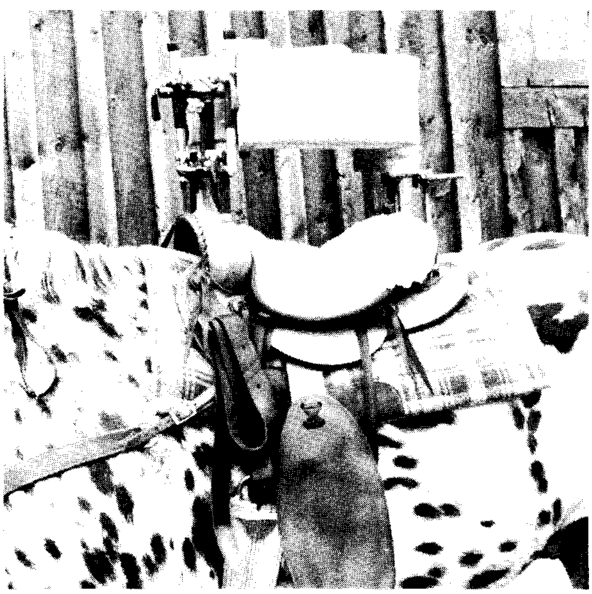

Fig. 3.8. Adaptive Saddle for Quadriplegic Riders.

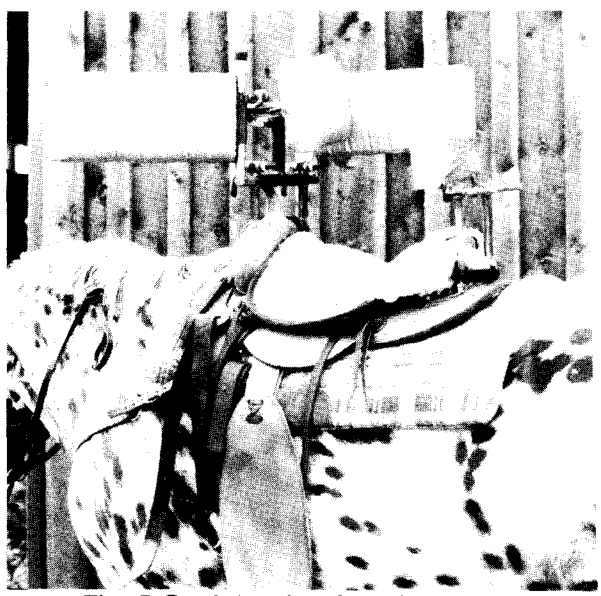

Fig. 3.9. Adaptive Saddle for Quadriplegic Riders in Open Mode.


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