CHAPTER 17
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Design of a Wheelchair Lift

Designers: Jeff Cox, Betsy O'Connor, Tim Sellers
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INTRODUCTION

The client requires a means of safe and easy access to her bedroom. The bedroom floor is fourteen inches below the rest of the house. The use of her bedroom would provide both privacy and access to a bathroom. Because of the mandatory twelve-inch run to one-inch rise code for ramps, a basic wheelchair ramp was not suitable for this installation. A vertical lift seemed to be the best approach for the design. A power screw, having been donated, was chosen as the actuator for the lift. After basic calculations were made to determine the load bearing abilities of the bedroom walls, ceiling, and floor, the side lift platform arrangement, presented here, was selected for the design. This lift would provide a means to attain the privacy that her present living conditions do not allow. Previously, her living room and dining room compromised her living quarters. This posed a number of problems to both herself and her family; she has a young son and an older daughter.

Ms. Jones may now be changed, bathed, and cared for in the privacy of her bedroom. In addition, her children will no longer be forced to wait in her bedroom while her aides attend to her. The problem of overcooling her house has also been eliminated. By closing her bedroom door, the room may be cooled by a single wall unit. This saves her money on her present electric bill, and also keeps the rest of the family comfortable.

SUMMARY OF IMPACT

The individual receiving the lift, a quadruple amputee, will be able to enter her own bedroom independently thus greatly enhancing her quality of life.

The lift will give her the privacy of sleeping in her bedroom instead of in the living room and, possibly allow her to cool only her bedroom using a window air conditioner instead of having to cool the entire home.

TECHNICAL DESCRIPTION

A power screw lifts the platform from one side. Each end of the side lifted has a trunnion that prevents rotation and lateral movement of the platform when in use. Each of the two trunnions has four bearings that prevent rotation of the platform from side to side and also two bearings that prevent lateral movement when the user enters or exits the lift. These bearings ride on vertical rails. These vertical rails have a single bar across the top that can be used as a handrail. In addition, there is an aluminum bar across the top of the two trunnions that also provides a low-position handrail at a height midway between the platform and the bar at the top of the bearing tracks.

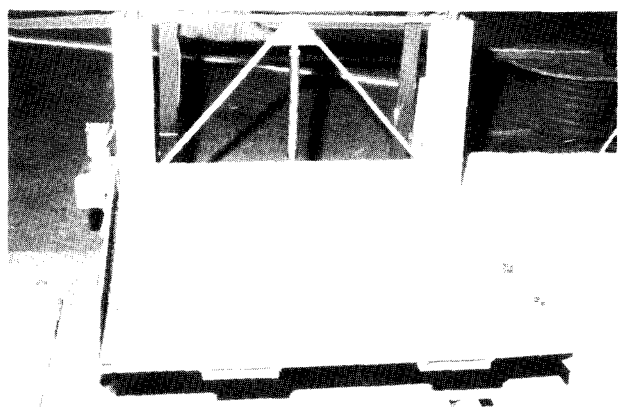

Figure 17.1. Wheelchair Lift.

The safety devices on the lift consist mainly of electrical interlocks that prevent use of the lift when the lift and the guards are not in the correct position. When the user desires to leave the room, she drives onto the platform and presses the "UP" button. This causes a short gate on the opposite end of the platform from the door to flip up. When this gate reaches the up position, the lift moves upward. When the platform reaches the upper floor, a limit switch shuts the power off to the power screw. When the user wants to enter the bedroom, she drives onto the platform and presses the "down" button. The user is prevented from driving off the platform by the short gate. Pressing the "down" button causes the platform to descend into the room. When the platform reaches the floor of the bedroom, a switch on the underside of the platform breaks the circuit to the power screw. The platform then stops and the short gate lowers, allowing the user to safely leave the lift. A short ramp attached to the platform at the same end of the platform as the gate allows the user to safely enter and exit the lift. This ramp is necessary since the platform is prevented from going all the way to the floor by its structure. The ramp is hinged on one end and has small wheels on the other to allow smooth operation. As the platform moves from the down to the up position, the ramp moves from mostly horizontal to mostly vertical. When the platform moves down into the room, the ramp moves toward horizontal. This ramp also prevents access under the platform from this direction.

The power screw is powered by twelve–Volt direct current provided by a deep-cycle battery. The battery is constantly charged by a charger run off household current. In the event of an interruption of the household power, the lift will still operate from the reserve capacity of the battery. When household current is restored, the charger will return the battery to its fully-charged condition.

The total cost of the project, not including personnel costs but including the value of donated parts, was approximately $900.

Floor to Wheelchair Lift

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Client Coordinator: Robert Perry
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INTRODUCTION

A transfer aid (lift) was designed and constructed for a child with multiple disabilities. His disabilities prevent him from standing and have caused obesity. Frankie uses a powered wheelchair and is quite independent in or out of his chair, however, he must be lifted from the floor and placed into the wheelchair by someone. Due to his size and weight, this task is difficult for the person lifting him. For these reasons, a lift is needed to move Frankie from the floor to the height of his wheelchair.

Therefore, the goal for this project was to design, select, and construct a vertical lift for a large child having multiple disabilities; the primary disability being the limited use of his legs. Design specifications were as follows:

1. vertical movement (lift) of 22” (floor to wheelchair)
2. Maximum lifting force of 300 lbs
3. Hands free operation for operator
4. Maximum project cost constrained to *$500*

The first major step in the design process involved the identification of the needs, objectives, and criteria. Using these guidelines, alternatives relating the lifting mechanism and basic design of the structure were developed.

SUMMARY OF IMPACT

The individual receiving this lifting device is a seven-year-old child with multiple disabilities. He uses a power wheelchair for mobility while at school and scoots around on the floor while at home. He is obese, causing his parents substantial problems transferring him into or out of his wheelchair.

The lift device works great and allows the parent to help the boy into his chair while having both hands free to assist him in case of any emergency. It will greatly reduce the number of hard lifts for the parents who are both experiencing back problems.

TECHNICAL DESCRIPTION

A design group brainstorming session was held to develop alternative ideas relating to the lifting mechanism and the frame/chassis design.

Several ideas were proposed for the lifting mechanism including pneumatic and hydraulic cylinders, electric winches, scissor jacks, and lever arrangements. A linear actuator was chosen since it provided the strength, safety, and availability required by the design.

Fewer alternative ideas were proposed for the frame/chassis. The three primary ideas proposed involved a modified version of a Hoyer Lift, a track/rail arrangement, and a channel and guide arrangement. The persons for which the lift is designed, previously expressed their dissatisfaction with a Hoyer Lift, so that alternative was eliminated. The channel/guide was selected over the track/rail since it was believed that it would be easier and less expensive to construct.

The design and selection of each major component were based primarily on structural integrity, appearance, and availability. The appearance and operation of the device are of utmost importance considering the location (inside of the home) and the individual using the device. Therefore, the final design consists of a square tubing rectangular frame, a trunnion assembly on wheels that ride on the frame, a folding seat, and a 115–Volt linear actuator that provides the motive force. The actuator is engaged by a foot controlled pedal, and travel is limited by resetable internal microswitches, and two additional microswitches provide emergency stopping capability in case of an overload or jamming of the trunnion assembly. The lift was designed for a maximum load of 300 lbs with a safety factor sufficient to allow for misuse and overloading without damage to the device.

The approximate cost of materials was $965.00 that includes the linear actuator donated by the Duff-Norton Co.

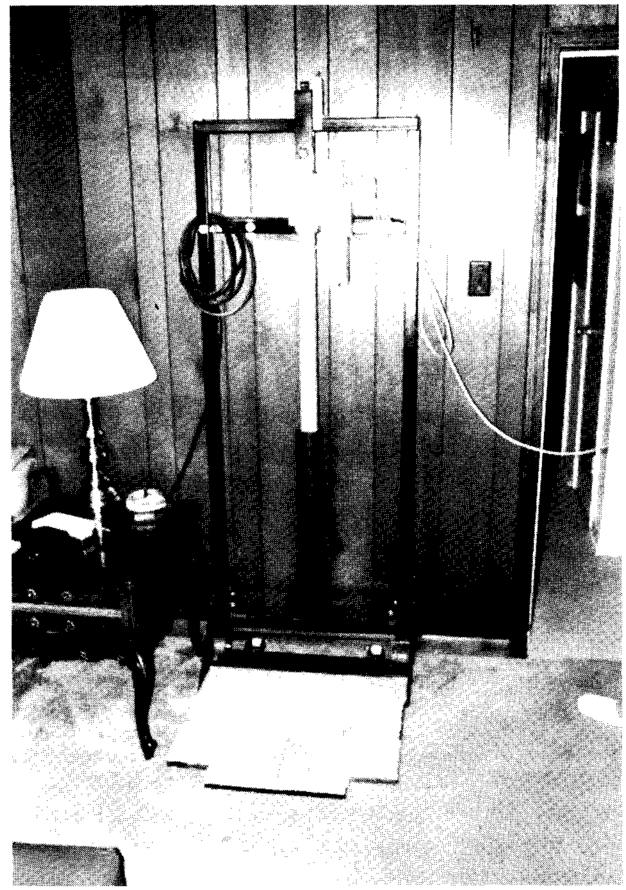

Figure 17.2. Floor to Wheelchair Lift.

Design of a Wheelchair Joystick Relocation Device

Designers: Hai Kim Le and Peterve Tran
Client Coordinator: Robert *Perry*
Advising Professor: Dr. Cecil H. Ramage
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INTRODUCTION

Daryl is a 9-year-old boy with Cerebral Palsy. He has little or no control of his arms and legs. He maneuvers his power wheelchair by moving a joystick mounted under his chin.

Previously, the joystick was mounted on a multi-jointed camera arm. When the joystick is not in use, relocation is required so that Daryl is free to move his head and has room to do other things. When Daryl is away from home the relocation of the joystick is sometimes performed by an adult other than his parents. This is a problem because other adults usually do not know where the joystick should be situated when in use and often do not know how to operate the mounting arm properly.

The approach taken to solve this problem was to automate the relocation of the joystick so that it could be operated by an adult. The design selected has the joystick mounted in a similar fashion to the old mount. Other solutions included an overhead-swinging arm and various head-mounted devices. The overhead swinging arm stores the joystick behind the chair when it is not in use. The head-mounted devices employ the motion of the head to operate the chair. All head-mounted devices were eliminated due to the difficult requirement that the head must be held still when the chair is not moving.

SUMMARY OF IMPACT

The recipient of this device, a nine-year-old gifted student with athetoid cerebral palsy, now has another barrier to his independence removed. He operates a power chair controlled by a chin-operated joystick. The joystick had been mounted on a universal “camera” multi-jointed arm. Caregivers experienced problems trying to locate the joystick in the correct position and the boy wasn't able to do it himself. The mount would often pop loose when bumped and always needed repairs.

The joystick relocation device returns the joystick to the correct position each time it is used. The switch controlling the activation of the relocater is currently out of the boy's reach, at the request of his mother. As soon as the control proves itself reliable to his mother, a suitable switch will be added to enable total self operation.

TECHNICAL DESCRIPTION

The relocation device consists of a primary arm driven by a 12–VDC motor through a variable friction slip clutch and worm and gear set. The gear ratio is 5. The motor provides 80 in-oz torque at 30 RPM. A secondary arm is attached to the other end of the primary arm and is driven by a $\frac{1}{4}$" pitch chain of 90-pitch length. A lo-tooth sprocket is fixed at the rotation axis of the primary arm. A 28-tooth sprocket is attached to the secondary arm. The joystick is mounted at the free end of the secondary arm. A double-pole double-throw ON-OFF-ON toggle switch is used to control the direction of the arm's motion. Two–limit switches are used to stop the arm at the active and stowed positions.

The total cost of this project was $488, including donated materials and labor.

Figure 17.3. Relocatable Joystick Support.

Swing Design for Physically Challenged Child

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Client Coordinator: Robert Perry
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INTRODUCTION

A swing, shown in Fig. 17.4, was designed and built for Rachel, a five-year-old client with spina-bifida. The only help she needs to use the swing is the assistance of an adult to lift her in and out of the seat. Weights are attached to a rod connected to the seat at a pivot centered at the front of the seat. Handles extend from the rod to Rachel's hand position. As she pushes the handles forward the weights swing back. When she pulls the handles towards her, the weights swing forward. This series of movements create the motion necessary for Rachel to swing.

SUMMARY OF IMPACT

The recipient of this device, a child with spina-bifida, will now be able to swing herself outside, independently, after being helped into the swing. This active and determined little girl will probably eventually be able to get in and out of the swing totally independent of help.

Previously this child was not able to keep the swing going and relied on her brothers or parents to push her.

Because this device really works, looks good, and is simple, it will provide several years of vigorous outside play activity for this child.

DESIGN ALTERNATIVES

Several alternative solutions were considered. A torsion spring and ratchet design evolved from the baby swing design presently on the market. The design utilizes a spring wound with a handle. This idea was not implemented for several reasons. The greatest drawback was that the swing could not be independently operated. It would require someone to wind the spring and provide the initial push to set the swing in motion. The mechanism would also require general maintenance to the moving parts and corrosion protection. Also, the mother wanted the child to have some physical input to the operation of the system.

Another alternative was an electric motor, employed to supply power to a shaft. This shaft would turn a cam that would be connected to the swing. As the cam turned, the swing would be driven upward. As the swing reached the maximum height, the cam would roll over, releasing the swing to be driven by gravity back to the opposite end of the arc. This idea was not selected primarily because of the electric motor used in its operation. Being outside, the motor would require water proofing, and continuing maintenance. The motor would require a power supply that must be portable, such as an extension cord used in an exterior receptacle. Again, this system would no require any physical input by the operator.

A third alternative was a self-propelled design that was somewhat similar to the design that was chosen. It would consist of a seat attached to an A-frame with a chain of three rigid members. This system would be powered by the operator and would act similar to a four bar linkage. As the operator applies a forward force to a handle, the swing would be set into backward motion. As the swing reaches its maximum altitude, a backward pull on the handle would cause a forward motion. This idea was mechanically as good as the one chosen, but was eliminated because safety considerations.

TECHNICAL DESCRIPTION

The swing seat is suspended by $\frac{3}{4}$ inch round sections of aluminum tubing pivoted from a wood A-frame. Tubing was chosen, instead of chains, to prevent Rachel from being able to flip herself out of the swing. The tubing is connected to the seat at two locations, in order to keep the angle of the swing in line with the angle of the tubing when the swing is in motion. This is done to prevent the swing from rotating (rocking motion) due to the moment created by the weights. If the rocking became excessive, it could possibly flip Rachel out of the swing.

The seat frame is constructed of $\frac{3}{4}$ inch round aluminum tubing in order to minimize weight. The seat has an adequate back support constructed of plywood, padded and upholstered for comfort. The seat also has proper restraints, a lap belt and a chest harness.

The rod supporting the weights is constructed of 1 inch square aluminum tubing and is pivoted at a point centered at the front of the seat. The rod extends in front of the user. Handles are attached to the end of the rod at a height suitable for Rachel.

The weights will be suspended approximately 18 inches from the base of the seat, and will be removable. There will be adequate space provided to add weights as necessary. As Rachel grows and her strength increases, her parents will be able to easily adjust the amount of weight needed.

Arma-flex, a very dense foam rubber was used to cover the entire seat frame. This material is designed to absorb any impact shock, and to "pad the blow." The result of impact may be a knot on the head, rather than a gash that would require stitches. The padded seat was designed to give her adequate back support (similar to the seat in her wheelchair).

This NSF project cost approximately $270.

Figure 17.4. Swing for Physically Challenged Child.

A Merry-Go-Round for a Physically Challenged Child

Designers: Ulix Goeffsch, Chris Foley, Tom Glaze, Alan Wright
Client Coordinator: Robert Perry
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INTRODUCTION

Physically challenged children mainstreamed in the Mobile County School System have very little opportunity to experience the joys of using playground equipment. A merry-go-round was designed and built using the needs of a six-year-old girl with spastic quadriplegic cerebral palsy. This equipment was designed to provide the child with a device that was both recreational and therapeutic so that the quality of life of the children using the equipment would be improved.

SUMMARY OF IMPACT

The recipient of this device, a six-year-old child with spastic quadriplegic cerebral palsy is a student at a local elementary school. She will be able to participate more fully and experience more interaction with both physically challenged and able-bodied classmates when the device is installed in the school's mainstream adaptive playground. Since specialized seating has been provided for four children and is hand powered, the child will participate as a team member to make the merry-go-round rotate.

TECHNICAL DESCRIPTION

The merry-go-round is powered by up to four children. The power mechanism is a system of levers, ratchets, bicycle sprockets, and bicycle chain. The children push on levers to rotate the platform. The axle of the merry-go-round is a "pipe-within-a-pipe." The inner pipe is cemented in the ground to support the ride. An angular contact tapered roller bearing supports an outer pipe that serves as the central hub of the device. The rotating platform is welded to the outer pipe, and is stabilized by adjustable wheels mounted between the platform and the inner pipe.

The frame is constructed using angle-iron and the platform is $\frac{3}{4}$ inch exterior plywood. The seats are modified deck chairs. To improve the support structure, lengths of angle iron are welded to the base of the stationary (inner) pipe, extending outward. The stationary pipe will be cemented into the ground in a location away from hard ground covering.

Safety was incorporated into the design in several areas. The seats will be supplied with adjustable head-restraints that will limit side-to-side head motion. They will also be equipped with seat restraints. The drive system is geared to limit the maximum rotational speed to 7 rpm. A safety guard made of vinyl mobile home skirting is located around the base of the platform and around the drive system. An additional stainless steel guard covers the drive mechanism to prevent the riders from pinching their hands in the chain and sprockets. In addition, stops are placed to limit the travel of the power levers.

The cost of the merry-go-round was approximately $930. This value does not include the costs of machining and welding the components for the design.

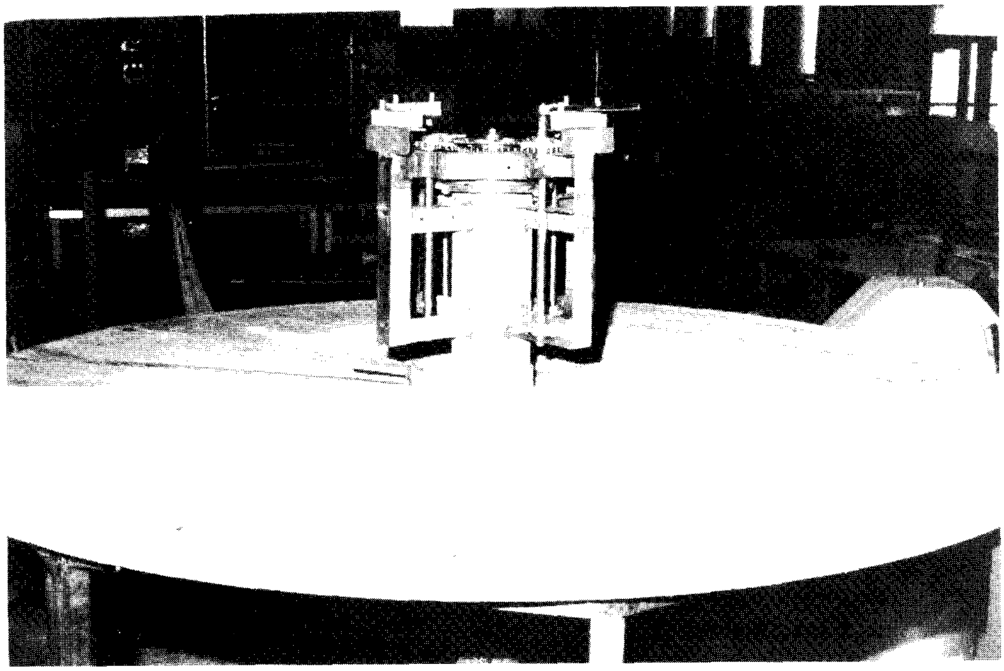

Figure 17.5. Merry-Go-Round Under Construction.

Specialized Weaving Device Concept and Thread Alternating Transmission

Designers: Raymond Lamb, Charles Tossy
Client Coordinators: Marty O'Malley
Supervising professor: Dr. George Douglas
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INTRODUCTION

A specialized weaving device was designed to allow the mentally and physically handicapped residents of L'ARCHE Mobile to weave with less outside assistance. For a senior design project, a thread alternating transmission was designed and built to fit the device. The transmission allows the user to pull a lever handle down 27" and then release it to alternate the threads. The transmission requires that the full 27" be reached to alternate the threads. If the full motion is not met, releasing the handle will return the threads to their initial positions. L'ARCHE Mobile is a Christian community where people with mental and physical handicaps live together as a family with non-handicapped people, called assistants. The residents of L'ARCHE attend a Day/Work Program on weekdays that focuses on their needs and abilities. Typical projects at the work shop include arts and crafts such as Christmas card etching and cloth weaving.

Weaving is one of the residents favorite crafts. Currently they have only simple frame looms to weave on that require most of the work to be done by the staff and can only make pot holder size weavings. The staff have a desire for the residents to be able to produce larger weavings up to the size of dining place mats and for the residents to perform more of the process independently. A commercially made loom is not suited to the residents due to its thread alternating mechanism that requires a sequence of operations that would be difficult for them to perform and remember.

SUMMARY OF IMPACT

The overall device concept and transmission will allow the residents of L'ARCHE Mobile to produce larger weavings and to perform more of the operations independently with less staff assistance. The current method of alternating the threads must be performed by the staff. When the staff are not available to alternate the threads the residents cannot weave. The transmission will allow the residents to continue weaving without the staff's direct participation. The staff will be free to work with other residents that may not be weaving. Weaving is important to the staff and residents because it is an enjoyable and satisfying activity for them. The weavings can also be distributed to the local community to promote awareness of the organization.

TECHNICAL DESCRIPTION

The overall device concept consists of a base and frame. The frame supports the weaving and is removable from the base. This feature allows multiple weaving projects to be accomplished on/at different times. The threads are attached to the frame by hooks or pins. The threads are supported and lifted on the frame by two slotted heddle bars. One half of the threads are supported by each bar. The bars are alternately raised to produce an opening between the threads (a shed) into which weave is inserted. The base supports the frame and contains a beater bar and thread alternating transmission. The beater bar has a removable handle to facilitate thread insertion and moves parallel to the threads to tighten each weave. A round cam was chosen to produce the lift required to alternate the threads. Cam follower bearings ride on the cams and are attached to the heddle bars. Parallel links attach the bars to the frame allowing only vertical motion. The transmission's main components are supported by a drive and cam shaft. The drive shaft has a 100-tooth gear and is keyed to the lever handle. The cam shaft is attached to an 18 tooth gear and two sets of free rotating cams. This 5.6:1 gear ratio allows the cams to be rotated 150" for a 27" motion of the lever handle. The cams are alternately rotated upward in pairs to lift the threads. When cams are not being rotated by the linkage, they are locked in place by a spring loaded switching system. The positive thread alternation is accomplished by locks in the switching system. When one cam pair is rotated to a set point they are locked into place and the opposite cam pair is released and lowered. If the set point is not reached the rotated cams are not locked and the locked cams are not released. The threads will return to their un-alternated positions.

The approximate cost of this project was $270.

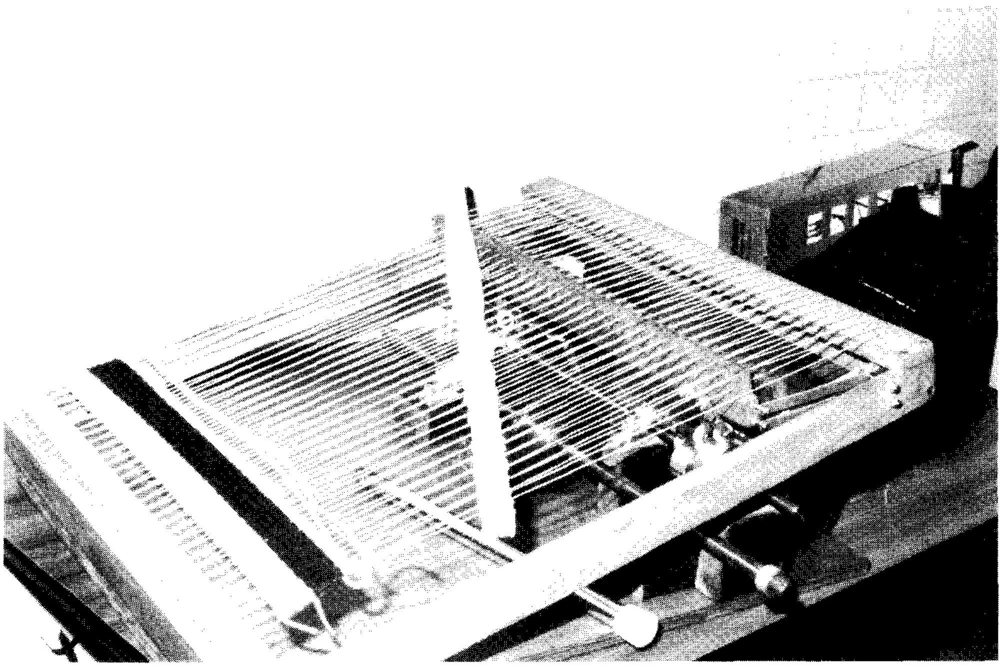

Figure 17.5. Loom for a Challenged Individual.

Modifications for a Standard Sewing Machine to Accommodate Handicapped Users

Designers: Neal Ankersen and Son Le
Client Coordinator: Marty O'Malley
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INTRODUCTION

A sewing machine adaptation was designed for L'Arche, a community of mentally and/or physically handicapped individuals. One of the activities available for the residents of L'Arche involves using a sewing machine to make various items. While performing the stitching operation, the users encountered much difficulty in producing either straight seams or seams starting at a specified location. This led to the initiation of a project to develop an aid that would assist the user in sewing a straight seam starting at a given location. If this can be accomplished, the number of possible users can be increased, and at the same time, the amount of damaged material can be minimized.

Several design possibilities were considered.

a) Design a cloth feeder that will operate along the principle of a computer printer.

b) Install a speed sensor that will control the sewing machine's motor speed relative to how fast a piece of material is being fed into the machine.

c) Design a clamp that will bind one edge of the material to be sewn. The clamp will be attached to the sewing machine's table top and will allow back and forth movement.

d) Attach the clamping device in the design above to rack and pinion assembly that will also allow side-to-side movement of the material.

e) Install a conveyor belt with a sticky surface parallel to the presser foot. As the material touches the conveyor's surface, it will be drawn under the presser foot.

SUMMARY OF IMPACT

The modified sewing machine was used at L'Arche until the springs for the material clamp failed. It has been requested that a group from the next project class examine the problem and recommend a solution.

TECHNICAL DESCRIPTION

The modification to the sewing machine will contain three main components:

a) Linear tracks to guide the material to the presser foot

b) Rack and pinion assembly to set the seam

c) Clamps to secure the material to the tracks.

A new table was constructed to provide mounting surfaces for the guide.

Fig. 17.7 illustrates a schematic of the sewing machine adaptation. Slots were milled in the table in front of and in back of the sewing machine cutout to provide for left-right motion of the linear track and clamp. A rack was mounted beneath each slot in brackets that allowed free sliding motion. Mating pinion gears were mounted on a pinion shaft that is rotated to move the racks. The shaft is supported by bearings near each end and extends through the front of the table where a control knob is provided to rotate the shaft. A linear track is attached to the two racks to provide motion parallel to the seam. A clamp, mounted to the track, holds the material as it is sewn.

To use the adaptation, the material to be sewn is placed in the clamp. The knob is rotated to adjust the distance from the seam to the edge of the material. The machine is started and the clamp and material is pushed forward to sew the seam.

The total cost of this project was $350.

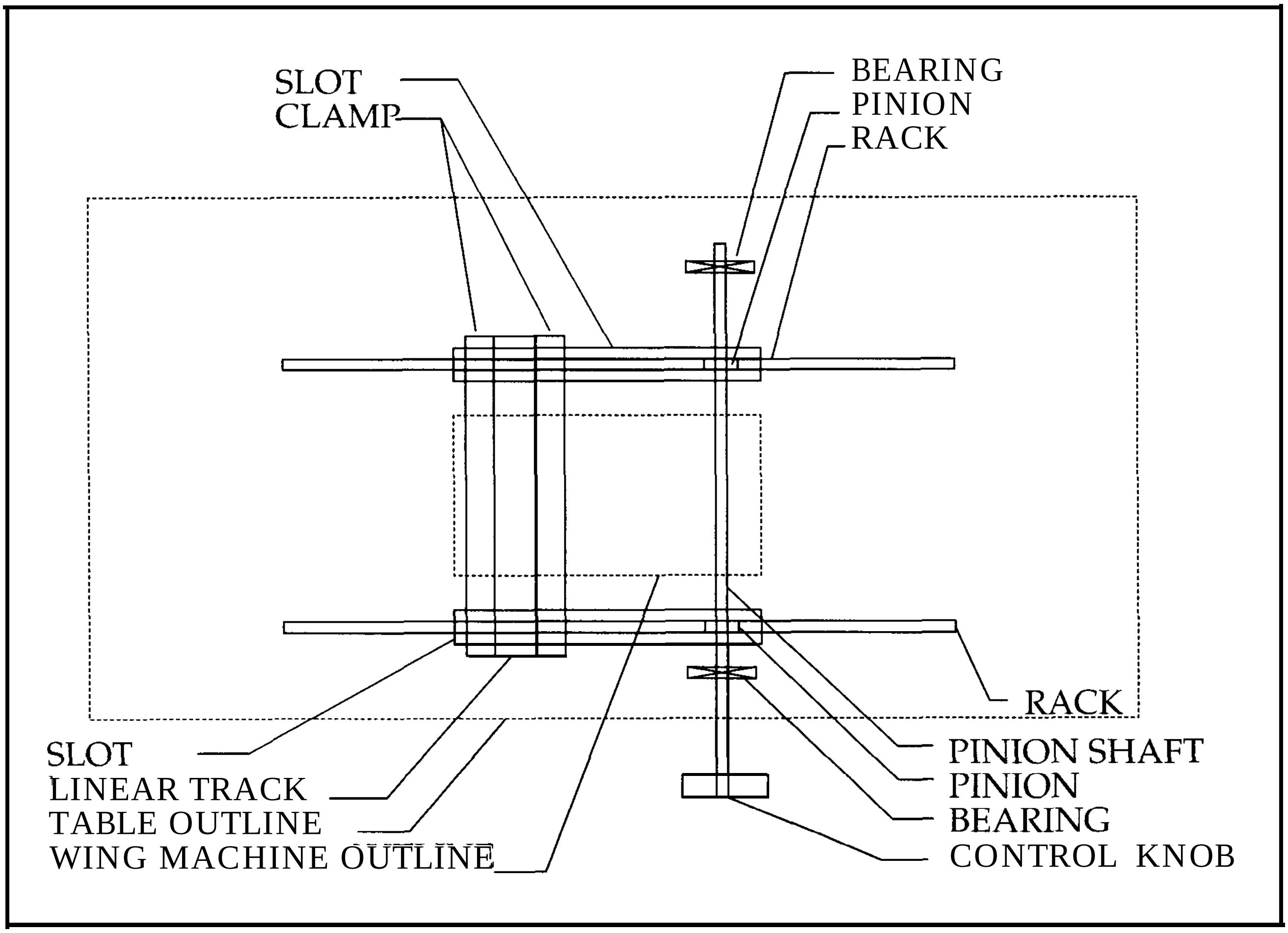

Figure 17.7. Sewing Machine Adaptation