CHAPTER 8
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ACCESSIBILITY SYSTEM FOR A SCHOOL STAGE

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INTRODUCTION

A student with cerebral palsy who uses a wheelchair is unable to access the stage in her high school. This limits her ability to participate in band, graduation and other stage activities. It is estimated that the student will use the stage no more than ten times per year. The stage does not meet the regulations of the American with Disabilities Act (ADA) which requires that public buildings have handicapped access to all areas of the building. The stairways to the stage are also less than the ADA minimum width of 36 inches.

The school needs a means to allow the student, and those with similar disabilities, to gain access to the stage. One possibility is to use an existing door to the rear of the stage, which opens to the school's parking lot. This was as unacceptable option, as it would require the student to go outside during inclement or cold weather. Existing products that could meet this need include: 1) a ramp; 2) a portable lift that can be stored when not in use; or 3) a permanent lift that would attach to the stairway railing. A ramp is not practical, as it would require a run in excess of 30 feet, and require at least one landing, to meet ADA requirements. Portable lifts cost $8,000 to $20,000, exceeding the school's budget. Purchasing a permanent lift would require substantial building modifications for ADA compliant installation. Building alterations could be done by volunteers, but the cost of purchasing the lift is prohibitive.

The problem was solved using a van lift which was donated for this project, shown in Fig. 8.1. The lift will be installed in a stairwell that separates the stage from a storage room. This will require significant, but not extensive, modifications to the storage room and stairwell. These modifications will preserve existing stairways and exit doors and ensure the school will be in compliance with local fire codes. This solution was chosen because of its low cost and its minimal impact on the appearance and continued use of the stage.

Figure 8.1. Modified Van Lift with Box Containing Hydraulic Motor and Battery

SUMMARY OF IMPACT

The lift will provide accessibility to the raised stage for all individuals and will make the school compliant with current ADA regulations. The student will now be able to access the stage and participate in the band with her fellow classmates. Traditionally, the band has always played on the stage for athletic events, but the band relocated to the bleachers to allow this student to participate. The graduation ceremony has also always been held on the stage. By having access to the stage, this student will be able to participate equally in school traditions and will no longer be the reason for changes to these traditions.

TECHNICAL DESCRIPTION

A van lift was modified and designed to be in a stairwell between the gym and the stage. The lift folds downward into the stairwell and lowers a platform to the ground level. The student drives her wheelchair onto the platform, which lifts her to the stage. As the lift platform is too small to allow a wheelchair to turn, it was necessary to locate the lift such that she exits the platform on the side opposite the entrance. To install the lift, the stage area will need to be remodeled. A doorway will be cut into the wall that separates the storage room from the stairwell. This route will allow easy access to the lift, hide the lift to maintain the gym and stage appearance, and provide an emergency exit route for the student via the exit doors outside of the storage room. All modifications to the stage and building for this design will be performed by volunteers to minimize the budget impact on the school. The cost for these building renovations was estimated to be $12,000 to $15,000.

Modifications were also required for the lift. A hydraulic pump and motor were donated by Blizzard Corporation (Calumet, MI) to power the lift. A 12V car battery is used to power the motor. The use of a DC power system eliminates the need to provide an AC power connection for the lift, which minimizes building modification costs. The original lift had a hydraulic cylinder capable of lifting the platform 33 inches, but this application required a vertical rise of 36 inches. To obtain the maximum vertical travel possible for the lift, a hydraulic cylinder was purchased with a 36 inches stroke length. To install the longer cylinder, the crossbar of the lift was raised to allow for full extension and head clearance for the student when the lift is in the raised position. The lift is capable of 36 inches of vertical travel, but the stage is 38 inches from the ground level. To solve this problem, the lift will sit two inches deep into the stage and a two-foot long ADA compliant ramp will be built, as shown in Fig. 8.2.

A pulley system connects the hydraulic piston and lift platform. A new roller chain and connection system for the pulleys was also installed. To make maintenance easier, a removable side panel was added and a storage box was created to hold the battery, pump and motor. The lift was made more aesthetically-pleasing by using black paint and Michigan Tech graphics.

The approximate cost for this project is $985 ($560 for materials and $425 for labor). The van lift (value undetermined) and the hydraulic motor and pump (approximately $1000) were donated by Blizzard Corporation.

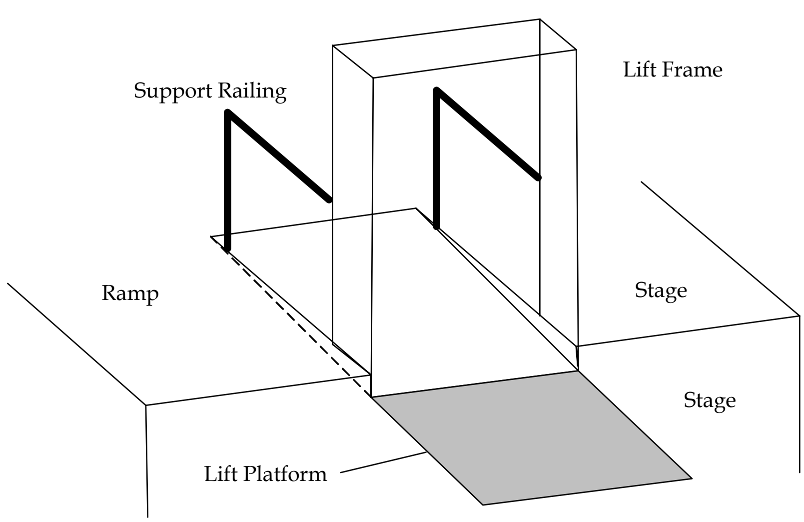

Figure 8.2. Schematic Showing Lift Frame in Extended Position, Installed into Stage.

LIFT AND TRANSPORT SYSTEM

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INTRODUCTION

People who rely on assistive devices such as canes, walkers, and wheelchairs often experience difficulty moving objects around their home. Physical therapists and home visitors have noted that elderly clients, in particular, are unable to move and empty a bedside commode bucket unassisted. This results in an unhygienic home environment and a loss of independence. The client requested a device capable of allowing people with ambulatory impairments to move objects, weighing up to 20 pounds, around the home unassisted. The team was unable to find any device on the market that directly met all of the client's needs.

After meeting with the client and conducting preliminary research, the team decided that the most versatile device would be one that is free standing and self powered. The team decided to include a remote control mechanism to allow for the widest range of users, including people in wheelchairs. The device that was developed, shown in Figure 8.3, has a lifting mechanism that moves from the ground to countertop height, and a remote-controlled base that allows the user to drive the device around the house.

SUMMARY OF IMPACT

The inability of a person to move everyday objects around the home represents a significant loss of independence. The client was required to ask for assistance for tasks such as carrying groceries into the house, doing laundry, or emptying the bedside commode buckets. When that assistance was not available, these tasks were either left undone or were performed inadequately. Home health professionals visiting the client would often find delivered groceries spoiling in the doorway, laundry piling out of its hamper, and trails of waste between the bedside commode and the bathroom from when the patients attempted to empty the buckets themselves. Using this device will allow people with mobility impairments to function independently in their homes.

Figure 8.3. Final Lift and Transport System

TECHNICAL DESCRIPTION

From discussions with the client, it was determined that the device must: 1) adequately perform its function; 2) be statically stable when fully loaded; 3) be maneuverable in small spaces; 4) be easy to operate; and 5) be non-threatening in appearance.

For stability, the device was designed with a steel two-foot by two-foot base and a lighter aluminum lifting frame that reaches 42 inches in height. This height was chosen based on the dimensions of standard kitchen countertops. The electronic components for the base were purchased from suppliers that traditionally sell parts for remote control vehicles. The majority of these were purchased from Tower Hobbies. The base had four rubber tires, each 3.5 inches in diameter. An electric motor (Monster Maxx PRO 19 turn Motor) was attached to a drive train that spun the rear wheels while an electric servo (Hitec HS-5945MG Coreless High Torque 2BB MG Servo) was used to control the front two wheels. Both the motor and servo were controlled by a standard remote-control vehicle transmitter and receiver set (Futaba 2DR 2-Channel AM transmitter and receiver). The remote control has one stick to control the forward velocity of the device, and one to control the steering of the front wheels. The motor and servo are powered by a 7.2 volt, 3000mAh nickel metal hydride battery.

The lift mechanism consists of a ball screw assembly that angles backward so that the load is situated over the wheel base when fully lifted. Attached to the ball screw assembly is an aluminum scoop with a beveled edge that rode via linear bearings on two precision ground steel rods running parallel to the screw. The ball screw is turned by an electric motor of the same make as the drive motor. The lift motor is controlled by a large toggle switch that is attached to the back of the device and powered by the same type of battery as mentioned above. The batteries and control circuit are wired through a switch and battery charger so that the device can be plugged into any 110-volt power source to recharge. A schematic of this circuit can be seen in Figure 8.4. A painted polycarbonate shell was placed around the device to hide the electronics inside, and provide an appealing appearance.

To evaluate the effectiveness of the device in meeting the design objectives, the team developed a series of tests. First, the device was loaded to the maximum amount, dictated by the parameters of the project, and the force needed to cause the rear wheels to leave the ground was measured. A small obstacle course was built to simulate a "worst case scenario" in which the device would be used. This course included a right-angle corner, a half-inch threshold, a wheel-chair ramp following ADA specifications, and a transition from linoleum floor to carpet. Lastly, senior citizen volunteers operated the device and were asked to complete a questionnaire concerning its ease of control and its appearance.

The device passed every test. The input from the senior citizen volunteers was positive. Two areas of suggested improvement were noted: the first was that the lift mechanism was noisy, and the second was that the device appeared too large. The complaint of noise from the users arises from excessive vibrations in the lifting assembly during use. A larger ball screw or a dampening box around the metal gears may lessen the noise. To make the device appear smaller, the lifting frame could be modified to taper at the top.

The total cost of materials placed directly in the device was approximately $1790.

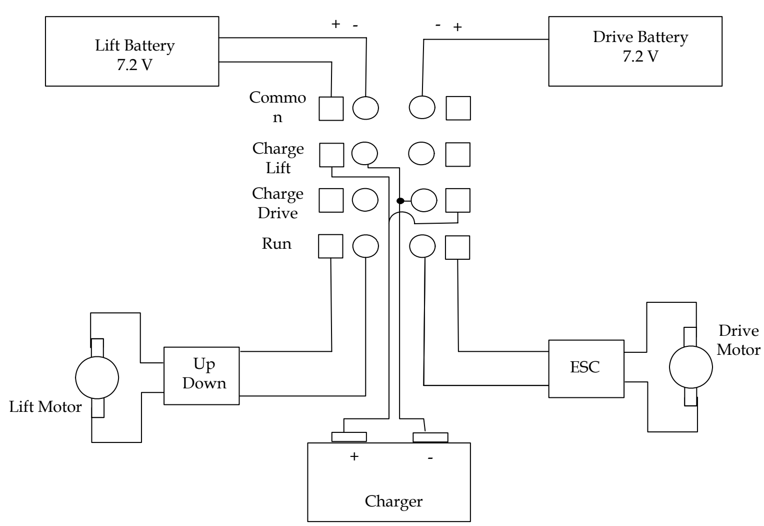

Figure 8.4. A Circuit Schematic of the Device's Charging and Power Wiring

MILK CARTON OPENER

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INTRODUCTION

Elderly people and people with disabilities often have meals delivered to their homes. During home visits, it became apparent that some people do not consume the milk that is delivered with the meals because they are unable to open the cardboard milk container. The milk carton opener was designed to assist in opening single- portion cardboard cartons. The client for whom this device was designed specified several design constraints for the device. These included that the final product could be easily manufactured at a low cost, and be easily cleaned. The top view of the milk carton opener is illustrated in Fig. 8.5. This view shows the two projections that puncture the milk carton as well as the opening where the milk drains.

SUMMARY OF IMPACT

The milk carton opener will allow people with limited mobility and dexterity to maintain their independence. This device will stop unnecessary waste of milk and allow an important part of a healthy diet to be reinstated.

TECHNICAL DESCRIPTION

A three-dimensional model of the device was created using solid modeling software (Ideas Version 10). The three-dimensional model was then used to create a plaster prototype of the device. The prototype lacked the durability of a production unit, but was useful for testing. The prototype maker first lays down very thin sheets of plaster. Then, a printer head goes over the plaster and lays glue over the solid areas of the device on that plane. This process of laying down layers of plaster and then gluing is repeated until the prototype is complete. When the prototype is complete, the plaster milk carton opener is sifted out of the loose plaster. The plaster device was coated with an epoxy to strengthen the walls and increase the durability for testing. The device is a single piece that could be molded easily out of plastic. This will reduce the

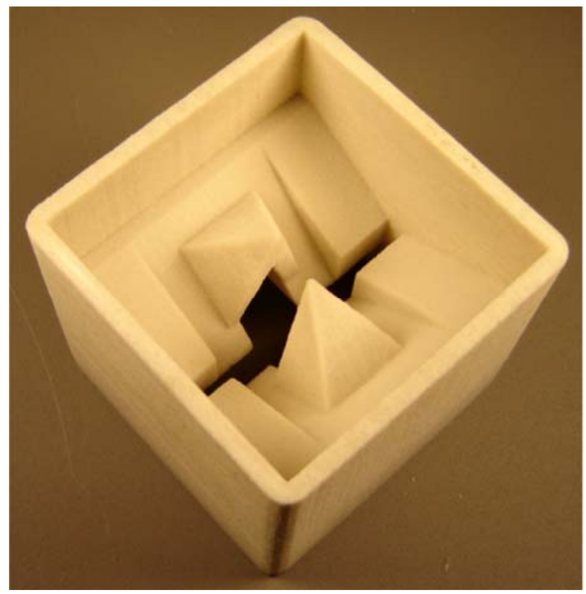

Figure 8.5. Top View of Finished Milk Carton Opener

manufacturing costs of the device and, additionally, will make it easier to clean and maintain.

To use the device, the milk carton is inserted upside-down into the top of the device. The milk carton will be punctured by the two pyramid-shaped projections at the base of the rib found on cardboard cartons. As pressure is applied to the top of the milk carton the projections will open up the milk carton allowing the milk to flow out into a cup below the device as the milk carton is pulled back. The final wall thickness was .125 inches. A cut-away view of the three dimensional model can be seen in Figure 8.6. This figure highlights the internal design and the lip designed to connect to the adjoining cup.

A cup was designed to snap onto the bottom of the opener to provide a sturdy base and allow a seal to be created so that no milk will spill. The device could also be used with the milk carton placed upright and the opener pushed down on top of it.

The milk could then be poured into any ordinary container. As the milk carton is pushed into the opener, the walls of the carton expand slightly. The dimensions of the device were chosen to allow for expansion of the milk carton while it is being compressed.

During meetings with healthcare professionals, it was determined that the people who would be using this device can generate at least ten pounds of force with their hands. To determine the force necessary to puncture a milk carton using the device, the device was placed on a load cell. A milk carton was filled with sand to simulate the milk, and the carton was inserted into the device. A computer data acquisition system collected the force placed on the device as a function of time. The average maximum force was 13 pounds, which is higher than the design objective. The roughness of the plaster may contribute to this force, and it could be lowered by using a smoother material.

The cost of this device is approximately $50.

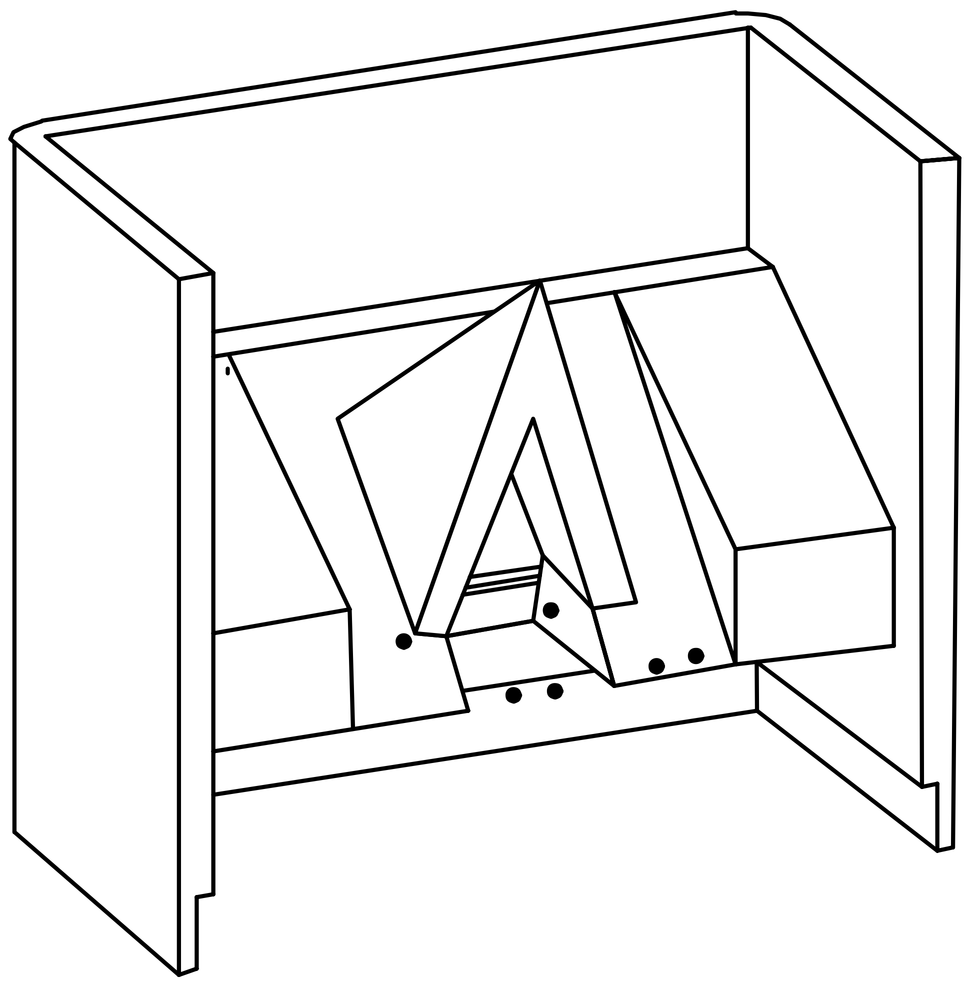

Figure 8.6. Cut-Away Line Drawing of Interior of the Milk Carton Opener

TOOTHBRUSH ASSIST DEVICE

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INTRODUCTION

People with limited or no mobility in their wrists or hands have difficulty maintaining proper oral hygiene. Current assist devices allow an individual to hold the toothbrush, but still require rotation of the toothbrush to clean all surfaces of the teeth. Since these individuals are not able to rotate their hands or wrists, this requires an assistant to turn the toothbrush. The prototype has bristles on all sides of the brush, as shown in Figure 8.7.

SUMMARY OF IMPACT

This device will allow individuals with limited mobility the ability to brush their teeth without assistance. This will improve their oral hygiene, level of independence, and quality of life. In addition to impacting the user, the device will also affect the individual's assistant by allowing him to perform other tasks during this time.

TECHNICAL DESCRIPTION

During initial conversations with the client, two design constraints were identified. First, the device must be able to clean all tooth surfaces. Secondly, the device must interface with existing assistive technology to grip a toothbrush. Due to these constraints, it was decided early in the design phase to maintain the toothbrush handle and only modify the head. Two designs were considered. The first would resemble an oversized pipe cleaner, with bristles oriented 360° around a central shaft. The second design would utilize four toothbrush heads each at a 90° angle to each other. For each of these designs, it is vital that the characteristics of commercial toothbrush bristles be maintained. Bristles are produced so that they optimally clean tooth surfaces and do not damage the enamel. Both of these designs were approved by the clients, as they met their design constraints.

A supplier for toothbrush bristles could not be found, therefore the second design was chosen. The heads of three toothbrushes were removed from their handles, and they were glued to the head of a fourth toothbrush with an adhesive suitable for plastics. Since this created a wide toothbrush, a prototype was also created with child sized toothbrush heads. A concern with this design is damage to the soft tissue on the inside of the cheek. To ensure that this damage is not detrimental to oral hygiene, future work will examine the effects of brushing on oral soft tissues.

The cost of this device is approximately $15.

Figure 8.7. Photograph of Two Modified Toothbrush Prototypes (Adult-Sized Toothbrush Heads on Left, Child-Sized Heads on Right)