CHAPTER 13
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Wheelchair Conversion Kit

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INTRODUCTION

A wheelchair conversion kit has been designed for transforming a standard or conventional wheelchair into one that is a one-armed drive. The kit consists of a linkage system attached to one side of the wheelchair at two locations: the rear axle and at the bottom of the frame near the front caster (Figure 13.1). By operating the handle on top of the linkage system, the wheelchair can be propelled, maneuvered and stopped. By pushing on the handle, a drive mechanism grabs the top of the rear wheel and propels the chair forward; when the mechanism is in "reverse gear," pulling on the linkage drives the wheel backward. Steering is accomplished by rotating the handle, which is connected to one of the front casters through another linkage. A brake lever, also located on the handle, is used to activate a pair of ordinary bicycle caliper brakes. The kit assembles and disassembles with ordinary tools in less than one hour and can be applied to either side of the chair. The wheelchair with the kit installed can still be folded for transport or storage. Testing the kit in propulsion, maneuvering and braking indicated satisfactory results.

SUMMARY OF IMPACT

People suffering from such tragedies as strokes and car accidents sometimes lose the use of functions on one side of their body either temporarily or permanently. People who have the use of only one arm cannot satisfactorily operate a standard wheelchair. Some help has arrived in one-arm driven wheelchairs on the market today; however all these systems are permanent designs. Because of this, institutions such as hospitals that have the need for predominantly standard wheelchairs but also a need for some one-arm drive models, do not stock one-arm drive wheelchairs. Our kit addresses this problem in that it has a multipurpose nature; once the kit is attached to the chair it is a one-arm model, and once disassembled, the chair can be used once again as a standard wheelchair. Our low-priced kit ($300) could give hospitals or other institutions the opportunity to stock these kits and install them as the need arises.

Fig. 13.1. Wheelchair.

TECHNICAL DESCRIPTION

The wheelchair conversion kit was designed for a one-armed person of two hundred and fifty pounds or less with a normal range of motion of the arm but with minimum strength and coordination. The main design requirements of the wheelchair conversion kit were:

- It was a kit design that could be easily assembled and disassembled using standard tools and no special knowledge.
- It had to be able to be completely operated by the use of one arm.
- It had to be easy to operate and its performance had to be comparable to that of a standard wheelchair.

- It had to be portable, i.e., it must be lightweight and foldable for ease of transport or storage.
- It had to be an interchangeable left or right design.
- It had to be virtually maintenance free and reliable;
- It had to be cost competitive with current permanent designs; and
- It had to be aesthetically pleasing.

Of course safety was also of utmost importance.

The wheelchair conversion kit consists of four major systems: the drive, steering, braking and follower assemblies. The chair is constructed mainly of 1/4" flat aluminum stock (Al 6061-T6) except for the steering shafts which are 1/4" round steel stock. The four bar linkage system was designed for a coupler path that was as comfortable as possible for the user at the handle with the two fixed ground points at the rear axle and at the bottom frame near the front caster. A force of 12 pounds tangential to the rear wheel was determined to propel the wheelchair at a reasonable speed and the four bar linkage has a mechanical advantage of between two and three, depending on its position. Therefore the user needs to input between four and six pounds of force on the handle to comfortably drive the chair.

The drive mechanism on the wheelchair takes advantage of the large rear wheel radius to reduce the input force required. The drive mechanism works by imitating how an actual hand propels a normal wheelchair. Two "feet", which are rectangular pieces of aluminum stock with grooves on the bottom, hang on 3 1/2" "legs" above the wheel (Figure 13.2). One is driven into contact with the wheel and (through a toggle point) moves the wheel forward as the linkage is pushed forward. When the linkage is pulled back on the recoil stroke, the "foot" moves along the wheel. For reverse "gear", the other "foot" is used in the opposite motion by pulling on the handle. Direction is obtained by a switch mechanism located on the coupler link for changing from forward to reverse and vice versa. Steering is accomplished by rotating the handle that turns a linkage system consisting of two steel rods connected by universal joints (Figure 13.3). This in turn rotates the front caster that has a straight fork for ease of turning and a much smaller turning radius. This system was necessary since the steering is attached to the coupler link and must be able to follow the four bar through its range of motion and still be able to rotate.

Braking is accomplished by ordinary bike caliper brakes attached near the front bottom of the rear wheels. The brakes are activated by squeezing the lever on the handle. The follower system consists of two sets of 1/8" aluminum and plastic flat stock which wrap around the front link. The follower system was necessary to keep the four bar from moving side to side thus keeping the motion in one plane.

Tests performed indicated assembly times in less than an hour, good maneuverability capabilities (acceleration, doorways, tight corners) and little required maintenance. Lastly final cost of building our prototype was approximately $300. For actual production of our kit, we believe it could be marketed at approximately $500.

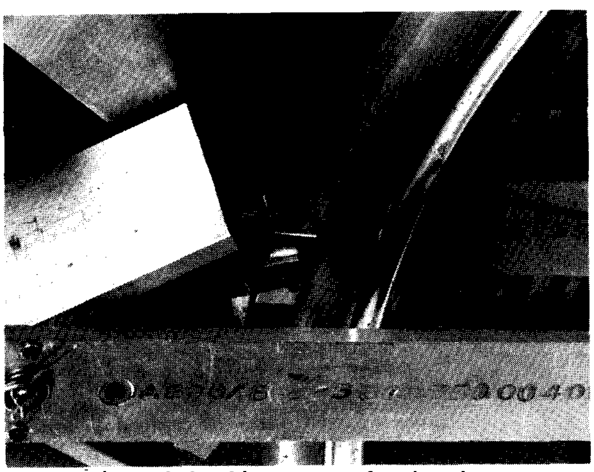

Fig. 13.2. Close-up of Wheel.

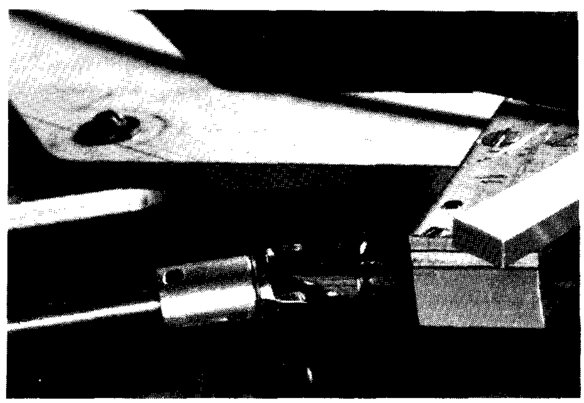

Fig. 13.3. Steering Mechanism for Wheelchair.

A Lifting Stool for Brain-Injury Victims

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INTRODUCTION

A lifting device was designed to lift patients from a Bryn Mawr Rehabilitation Hospital bed to the height of a wheelchair. Since the beds consist of a mattress that lies directly on the floor, the device must vertically lift the patient from a height of approximately 5 inches to a height of 30 inches. The lifting stool will significantly reduce the burden, and number of back injuries the hospital's nurses and staff are experiencing. The device consists of an aluminum frame on which folding tracks are attached (Figure 13.4). The tracks can be folded out of the bed, and the patient can then be raised or lowered into or out of the bed while sitting on the padded adjustable seat that rides in these tracks. The seat is raised and lowered through the use of a hand winch, which is mounted in the rear of the lifting stool. The entire stool is mounted on casters, and the tracks were designed to fold as to make the lifting stool as portable as possible. In addition, an effort was made to keep the design as simple as possible so that the device would be easy to operate and have a minimum number of parts.

SUMMARY OF IMPACT

Many of the patients that utilize the Bryn Mawr Rehabilitation beds are brain-injury victims. They are confined to these special beds that consist of a 5 inch high mattress lying directly on the floor that is surrounded by a 2 foot high collapsible padded frame, with only a 1 foot high wall at the opening. The hospital staff must lift these patients out of these beds numerous times daily, which has proven to be a very strenuous and burdensome process. The lifting task inflicted many back injuries upon the staff at Bryn Mawr, thus reducing the number of available staff members at any given time. It is perceived this lifting device will provide a more efficient and safe means for transporting patients from these beds, while also accommodating the patients with more comfort during the process.

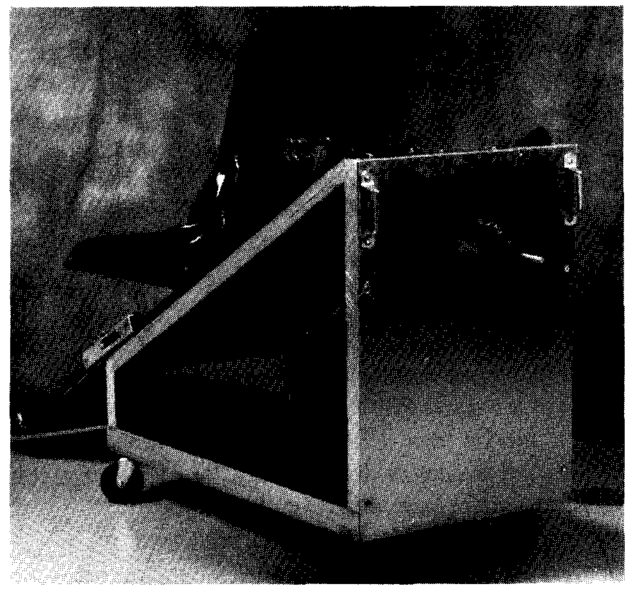

Fig. 13.4. Lifting Stool.

TECHNICAL DESCRIPTION

The lifting stool was designed for a specific purpose, but could be implemented into other rehabilitative capacities. The primary design goals of the lifting stool are to have:

- A maximum 300 pound lifting capability.
- A vertical lift from a height of 5 to 30 inches.
- An adjustable seat with back and head support having a reclining range of 45-90 degrees, in order to provide adequate comfort and stability for the brain-injured patients.
- A minimum number of parts, to reduce the possibility for misplacement of parts and provide easy operation.
- Enough portability for easy transporting throughout the hospital and clearance of a 39 inch wide doorway.

Finally, the stool had to be safe and as financially feasible as possible. The lifting stool has four main components: the housing, the lifting mechanism, the seat, and the tracking system.

The housing of the device consists of 3” x 3” x 1/4" and 2” x 2” x 1/4" aluminum L-beams heliarc welded at all the joints. The vertical L-beams were cut in order to create a 30 degree incline of the top face. The back, incline, and front of the frame is covered by 1/16" aluminum sheet metal, while the bottom is covered with 1/8" aluminum sheet metal. The housing is mounted on four 5” diameter casters (two swivel with brakes and two rigid), each with a load capacity of 290 pounds. The housing is the foundation that the rest of the device relies upon.

A hand-cranking winch is the lifting mechanism utilized in the device. It has a gear ratio of 41:1. The back, incline, and front of the frame are covered by 1/16" aluminum sheet metal, while the bottom is covered with 1/8" aluminum sheet metal. The housing is mounted on four 5” diameter casters (two swivel with brakes and two rigid), each with a load capacity of 290 pounds. The housing is the foundation that the rest of the device relies upon.

A hand-cranking winch is the lifting mechanism utilized in the device. It has a gear ratio of 41:1. The winch is mounted to a 1/4" aluminum plate located on the inside back of the housing frame. The cable implemented with the winch is a heavy duty, high tensile strength 3/16" galvanized steel aircraft craft cable with a 4200 pound weight capacity. The cable is attached through the middle steel bar of the chair frame.

The entire seat consists of two main parts: the chair frame and the adjustable seat. The adjustable seat is mounted on a chair frame having an I-beam construction. This I-beam design consists of 3 steel bars (1” x 1/2" x 30”) welded at a 30 degree, to match the incline of the housing. These steel bars are sandwiched between two aluminum sheets. The top sheet consists of two 1/8" sheets welded at a 30 degree angle while the bottom is a 1/16" sheet bent at the same angle. The sheets are attached to the steel bars by means of flathead 8-32 screws. Standard garage rollers were threaded and attached through the two outer steel bars of the frame. A seat adjustment track is rigidly attached to the chair frame. This track is an aluminum slotted hollow rectangular bar with four strategically spaced holes in the sides. These holes allow the seat to be adjusted at different angles (45-90 degrees). Attached to the back of the adjustable seat is an aluminum adjustment arm and bracket, which is locked at the chosen angle in the adjustment track by a 3/8" diameter zinc-plated steel quick release pin. The adjustable seat is comprised of a dense two inch thick foam cushion covered with vinyl and supported by two 1/2" thick rectangular pieces of plywood (21” x 29” each) hinged at the joint by a continuous 21” long steel hinge. The vinyl is secured to the plywood by staples on the underside of the plywood. Also, two 2” wide padded vinyl safety straps are attached on the back of the adjustable seat. These straps use Velcro to secure the patients to the stool during operation.

The tracks used on the lifting stool are standard galvanized steel garage door tracks. There are two tracks located on either side of the housing frame. Each track consists of two sections: a top section that is actually attached to the housing frame and a bottom section that extends past the frame and into the bed, when fully extended. The two sections of the track are connected by heavy duty strap hinges. These hinges are attached to the top of two sections of rectangular aluminum bar stock, which were then attached to the sides of the two track sections. To prevent misalignment of the track extensions when fully extended: a steel plate was connected to the top inside of each of the aluminum bar sections, and a 1/8" thick aluminum sheet was attached between the two extensions. A locking table hinge was attached to the sides of the two rectangular bar sections so that the tracks are locked into place when fully extended into the bed and also when hinged upwards.

The final cost of the materials needed to create the lifting stool was approximately $715.

Computer Table Amenable for Handicapped Individuals

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INTRODUCTION

A computer table (Figure 13.5) has been designed for handicapped individuals associated with residing at the A. I. DuPont Institute in Wilmington, Delaware. The table has features that make it more suitable for individuals in wheelchairs, beds, or gournies than conventional tables. One of these features is adjustable legs. Located on the tabletop, a crank can be turned by hand to adjust the height of the table. A keyboard and printer can be placed on small tops that slide out to the user improving accessibility. Two upper shelves are on the table. They can be placed at two different heights and can easily be removed. The user has the option of two shelves, one shelf, or no shelves. The table is also mobile through the use of caster wheels.

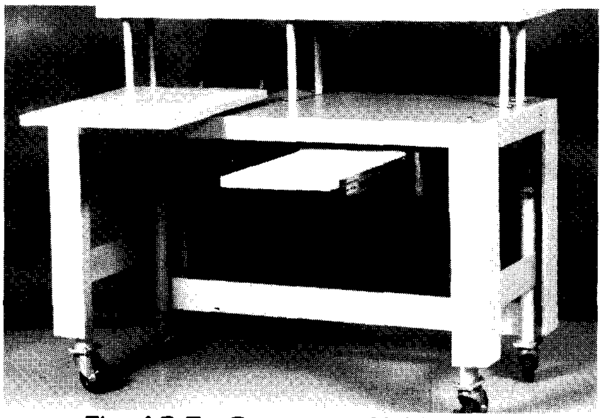

Fig. 13.5. Computer Table.

SUMMARY OF IMPACT

Most of the computer tables available are not completely adequate for those confined to a wheelchair. One reason for this is flexibility; a table should be adaptable to be used by students who are in a variety of wheelchair sizes. Students can also work more independently if they could reach all the computer components without assistance. The computer table currently designed meets these needs. The mobility of the table was an important criteria because there are instances where it is more convenient to bring the table to the user than bring the user to the table. It is expected that the table will make computer usage easier in some cases and possible in others.

TECHNICAL DESCRIPTION

Of the several design requirements, the two main requirements are as follows.

- The table can accommodate various size wheelchairs.
- The user be able to operate the keyboard, disk drives and printer without assistance.
- The table had to accommodate patients in beds and reclining wheelchairs.
- The table had to be portable.
- The cost was to be kept to a minimum.

The table can be studied as three subsystems. The first system, and the most complicated, is the adjustable legs. A screw and nut design has been implemented here. Basically, a lower leg keeps a nut fixed while a power screw spins in and out the top of it. The table top moves up and down with the screw.

The next subsystem is the tabletop itself. It has two slide-out tops for equipment to rest on. One top is located on top of the table and is designed for the computer and keyboard. The other top is located beneath the table and, when it is extended from the table, it is located directly beside the user. The final subsystem is the upper shelves. There are two shelves that when placed together go all the way across the table. Four legs hold the left shelf up, while only two hold the right shelf. The right shelf is supported on the right by its legs and on the left by the other shelf.

The lower legs are adjustable using 1” power screws and supernuts. Steel pipes, 1 1/2" in diameter, are used on the bottom of the legs. Fastened at the bottom of the pipes are casters, and fastened at the top are the supernuts. The screws travel through the nuts into the pipes. Sprockets rest on shoulders machined on the screws near the top of the screws for a chain drive. Directly above the sprockets are radial/thrust bearings, which also rest on machined shoulders. Two aluminum pieces are fastened to the bottom of the table, and rest on the bearings. The screws go through the pieces; the three pieces are just tall enough such that the screws do not come in contact with the bottom of the tabletop. The other screw comes all the way through the tabletop, and the very top of this screw has been machined for a crank. One of the aluminum pieces in each pair has a small portion machined away to place an e-clip. The two pieces essentially sandwich the clip and prevent the tabletop from being lifted off the screws. The assembly is designed such that the weight of the table is transmitted to the aluminum pieces, to the bearings, and finally to the screws.

The tabletop is 3/4" plywood which has Formica on both top and bottom, and its dimensions are 24” x 52”. Attached to the tabletop are two small tops that can slide out. These are made of sheet metal; however, the top for the keyboard is reinforced with particle board. Both tops are capable of withstanding loads over 100 lbs. The keyboard top is 18” x 24" and the other top (designed for the printer to rest on) is 12” x 24”.

The tops for the upper shelves are both 12’x 26” and made of 1/2" plywood that also has Formica on both sides. The legs for the shelves are 1" aluminum pipes. The legs are connected to the tops with wooden flanges. There are three holes drilled in the pipes near the bottoms of them. One can adjust the top shelves’ height by placing pins in one of the top two holes. The legs go through the tabletop and rest on the pins. The lowest hole will be beneath the tabletop and one places a bolt through it to keep the shelves from being pulled out of the table.

The approximate material cost for the prototype is $300.