CHAPTER 15
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An Independently Operated Standing-Assist Chair

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INTRODUCTION

The Stander (Fig. 15.1) is a device that enables the user to shift from a seated position to a standing position. The difficulty of this seemingly simple action can only be fully understood and the benefits fully appreciated by individuals who are limited by a handicap that prevents independent standing. The Stander was designed for a quadriplegic with partial function of the upper extremities, and is intended to be operated independently, a significant benefit for use at home. Its operation is based upon a hydraulic ram and pump pair used for auto body work. The pump is mounted on and goes up with the seat while the ram generates the force to lift the seat from below.

Figure 15.1. Stander.

SUMMARY OF IMPACT

Mr. Gernot Aistrop is a 33 year old male occupational therapy student at the University of Florida Medical School. He also happens to be a C6 quadriplegic, 12 years post injury. Gernot's remarkable skill and determination in independence and work activities have enabled him to complete both the academic and clinical portions of the demanding occupational therapy curriculum. However, his concern regarding the debilitating effects that the body suffers as a result of being confined to a wheelchair for extended periods of time over many years was the impetus for this project. These problems include cardiopulmonary problems, skin breakdown, hypotension and gastrointestinal complications to name a few. The degenerative effects of these problems stem from and are attributed to the constant seated position that must be endured following injury or disease that causes paralysis and the inability to stand upright.

TECHNICAL DESCRIPTION

While designing the Stander, various constraints were implemented. Specifically, these constraints were to construct the Stander for a custom fit to Gernot, to employ maximum safety protection, to keep the device relatively light, to make it easy to enter and exit, to make it portable, and to make it sturdy for exercise. A custom fit was made possible by precise body measurements. Most importantly, Gernot's feet, calves, and thighs influenced the dimensions of the Stander in several ways. The height of the seat was set at the length of the calf. This was necessary in order to place the angle of the knee at 90 degrees while sitting. By doing so, Gernot would slide in the seat a minimal amount during the shift to an erect posture. The calf length also determined the placement of the knee brace that supports all the diagonal forces during the standing process. The length of Gernot's thighs and feet determined the seat length and the size of the foot plates. Standing height and arm length were then used to set the height of the frame. This allowed for the use of the frame as an exercising device by enabling Gernot to use the frame as a handhold while doing shoulder lifts while standing.

Safety was a major concern due to Gernot's disability. While using the Stander, Gernot needed to be secured to the seat to avoid the dangerous possibility of him falling out of the device or of it tipping over due to a center of gravity shift. For this reason seatbelts, kneebrace, footplates, and hand supports were included in the design. Seatbelts were attached to the back and seat frames of the chair. By using Velcro and thumbloops, the belts could easily be secured by Gernot in spite of his limited dexterity. The kneebrace was mounted by a simple hinge on the frame, within reach of the seated user. The brace is rotated into position below the knees and then locked by flipping a latch over a pin located on the seat post. Since Gernot still retained partial sensory function, the kneebrace was well padded for comfort. To aid in the stability of the Stander, footplates were welded to the frame. By doing so, the users own weight is transferred to the frame and helps keep the Stander in position. Finally, hand supports were placed on the seat (an aluminum par and the handle to the pump of the hydraulic cylinder) to allow Gernot to adjust his position during the shift from seated to standing positions.

Figure 15.2. Ram Under Seat.

To keep the weight of the Stander down, aluminum tubing was used to construct the frame. By welding straight segments to 90 degree elbows, a frame both lightweight and strong was constructed. For the seat, aluminum sideframes are tied together by plywood bases of the seat and back. Where solid bars were used for some of the angle frame, lightening holes were drilled at regularly spaced intervals to further lighten the Stander. This also enhanced the appearance making it acceptable to use in the living room of Gernot's home.

Due to the nature of Gernot's disability, the Stander was designed for ease of entry and exit. As he has the ability to transfer from one chair to another, the Stander needed to be designed such that an unobstructed path to the seat could be created. This is accomplished by placing a hinged gate on the frame that would also function as a handhold while standing. The gate was constructed of aluminum tubing like the rest of the frame, and could lock into place when closed by falling into slots on the hinges. To unlock, the gate only needed to be lifted one fourth of an inch before rotation to the open position. When closed, the gate aided in stabilizing the Stander, especially when Gernot was lifting his weight by pushing down on the frame.

To make the Stander portable, the frame and chair were constructed to be detachable from one another in order to reduce the bulk of any one piece. This was accomplished by placing a series of removable pins through both the frame and chair. When together, the assembly was quite rigid. Detaching the frame from the chair required more strength and coordination than Gernot could offer, thus an assistant is required for this operation.

To provide Gernot with an opportunity to stretch and exercise while standing, the frame was designed to a height at which he could use it for handholds. While standing he pushes off from the frame and lifts his body off the ground providing good and well controlled upper body exercise. He also gets a workout while pumping the chair to an erect position (see Fig. 15.3) with the hydraulic cylinder. Cost of parts for the Stander totaled about $600.

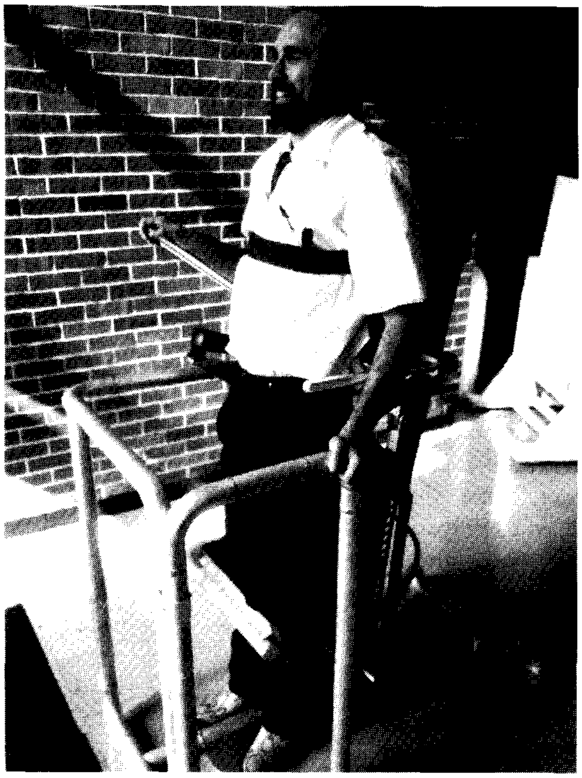

Figure 15.3. Gernot after first use of Stander.

Computer Cursor Control for Disabled Computer Users

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INTRODUCTION

Many quadriplegics and other similarly disabled people lead reasonably functional lives with the aid of computers. Computers permit them to communicate, control their environment, and work at productive jobs. Interfacing with the machines is the main obstacle to widespread use of computers by those without use of their hands. Programs requiring keyboard applications can be accessed using mouth-sticks and similar devices, however these devices are unwieldy to use and frequently tiring. They also do not permit the operator to easily access programs which depend upon cursor movement for proper operation, such as drafting programs and "Windows" type of operating systems. Therefore, there is clearly a need for computer cursor control by many people who are unable to use a regular computer mouse.

A device that permits cursor control using only the tongue and lips, functioning in a similar manner as a mouse, is described here. It has been appropriately called MouthMouse. The MouthMouse was designed for Ken, a senior Electrical Engineering Student at UF who is confined to a sip-and-puff controlled wheelchair.

SUMMARY OF IMPACT

Contact was made with Ken directly. He explained his need to access cursor driven software that he encountered in the engineering curriculum. After trying the prototype of our MouthMouse he gave this evaluation: "The MouthMouse gave me control of the cursor with ease. Currently I use a trackball that I move with a mouthstick. This is rather complicated since it is hard to look at the screen and move the cursor at the same time. The clicking worked extremely well. I believe that with practice I will get to use the MouthMouse rather well."

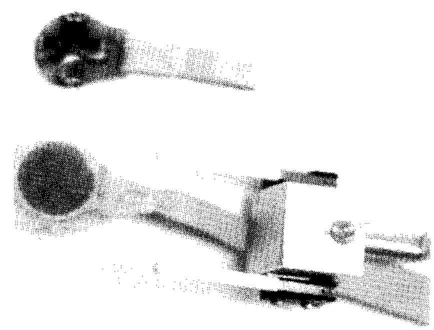

Figure 15.4. Sensor Pad [Top] and Complete Mouthmouse.

TECHNICAL DESCRIPTION

The MouthMouse is composed of a mouth pad, mouth buttons, and interface circuitry. A physical support system was also designed and constructed to facilitate use of the MouthMouse. The completed prototype is shown in Fig. 15.4, along with an uncompleted sensing pad. The mouth pad is made up of a "sandwich" of force sensors and elastomer between two circular PC boards. The heart of the MouthMouse is its force sensing resistors (FSRs), commercially available from Interlink electronics, Carpenteria, Cal. The FSR is a polymer thick film device that exhibits a decreasing resistance with increasing force applied normal to the device surface. Four 0.2" circular sensors are arranged to form the mouth pad (Fig. 15.4). An elastomer column was attached onto each FSR to facilitate force transmission through the top pad. A top pad pivots about a ball bearing on the sensor pad, allowing the user to transmit force to individual sensors. The top and sensor pads are sealed with silicone, Silastic Medical Adhesive Type A, manufactured by Dow Corning, Midland, Mich.; this isolates the user from the mouth pad. Silastic was also used to create a custom padding that would allow a comfortable fit in the user's mouth. A sketch of how the unit fits into the mouth is shown in Fig. 15.5. The standard mouse clicking function is accomplished by a mouth buttons mechanism that uses two micro-switches with extended levers. These levers rest on the bottom lip, where clicking is accomplished by moving the lower lip.

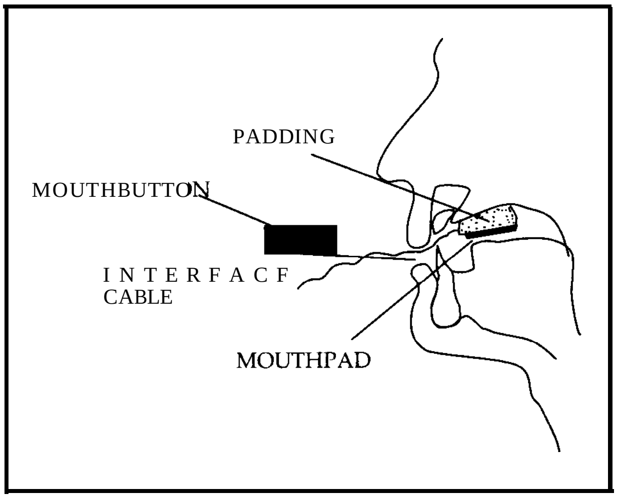

Figure 15.5. MouthMouse fit in mouth.

A mouse driver circuit was made using the FSRs as the feedback element around a Schmitt trigger. In this way, a simple force-to-frequency converter is made. When no force is applied, the sensor is an open circuit. When the FSR is pressed, oscillation begins, its frequency increasing with increasing force. To operate the mouse the user presses on the pad with his or her tongue, directing the force in the desired direction. It should be noted that the cursor is velocity rather than position controlled. The more force applied onto the mouth pad, the faster the cursor will move. The approximate cost of the MouthMouse is $15 for the mouth pad and $55 for the interfacing circuit (the cost of the interfacing circuit includes a !&IO-commercial computer mouse).

Preliminary evaluation has been performed with a MouthMouse prototype on a subject. Cursor control was accomplished by use of the mouth pad. The user gained better control as he adapted to the particular sensitivity of the pad; as a result, he was able to position the cursor at different locations on the screen with relative ease. Preliminary evaluation of the mouth buttons was also performed. The user was able to activate a mouth button with his lower lip while moving the cursor with his tongue, simulating the dragging function of the mouse.

Prototype evaluation indicates that the MouthMouse will be a convenient device for quadriplegic computer users. It has been shown that the MouthMouse permits cursor control with the tongue and lip, allowing the operator to access programs that require cursor movement for proper operation. Its design allows for almost universal fitting and quick adaptation. Several applications, not only cursor movement, are possible: a steering mechanism for a wheelchair, and a control for a robotic arm are a few of the possibilities.

Figure 15.6. Ken operating Mouthmouse.

Microprocessor-Driven, Puff-Controlled Mirror System for a Quadriplegic

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INTRODUCTION

This mirror system enables Ken, a quadriplegic student whose degree of paralysis precludes enough head rotation, to see to the rear of his wheelchair. This is important during reverse direction maneuvers. The system consists of a motor-driven arm and mirror that are moved by Ken via sip-and-puff action. Fig. 15.7 shows the controller box, motor drive unit, arm, and mirror. The heart of the system is a Motorola 68HCll microcontroller. This system not only offers the subject a rear-view field, but also ensures independent access to a mirror to check, for cosmetic purposes, the individual's hair, nose and teeth. When the mirror is not in use it can be rotated and stored behind the wheelchair.

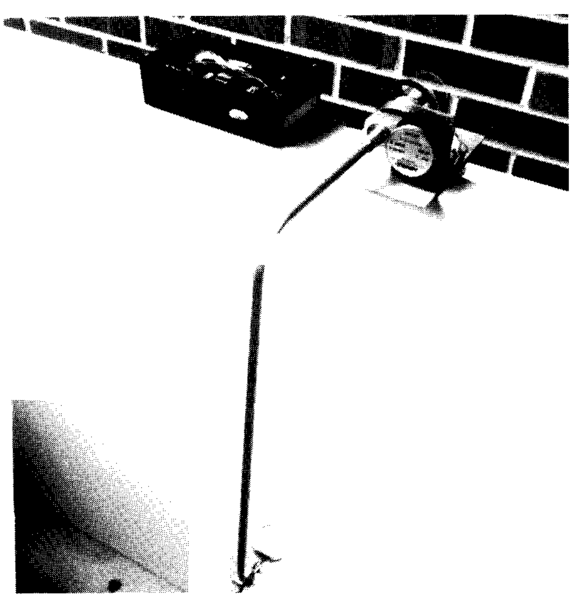

Figure 15.7. Rearview Mirror System.

SUMMARY OF IMPACT

The system has been designed for Ken, a ventilator-dependent quadriplegic. The mirror has enabled him to view objects behind him, which in general alleviates the problem of backing into obstacles. Ken is also able monitor his personal appearance without aide intervention, which consequently adds to his independence. The design was well thought out and developed, thus can be used by most other quadriplegics in its present form.

TECHNICAL DESCRIPTION

The system consists of 1) the microprocessor with its support electronics and 2) the motor and mirror assemblies.

Microprocessor and Support Electronics:

The electronics package is mounted in any convenient location on the chair. A Motorola 68HC11 microprocessor is used in the system. Software that guides the mirror resides in the on-chip EEPROM. The chip is run in special-bootstrap mode. In this mode, at reset or power-on, the MCU (microcontroller unit) jumps directly to the beginning of EEPROM where the program begins. Half of the board is a wire-wrap area. This is used primarily for the stepper motor drivers. Two Sprague UCN-5804B Translator/Drivers are used to drive the two stepper motors. The MCU only needs to provide the direction, the mode of step, and a high to low pulse to step. Voltage from the chair (12V) is used directly for the arm-actuating stepper motor. A 78L05C offers a regulated 5V at 100mA to the microprocessor. Another 7805, rated at 1A, is used to supply the mirror-panning stepper motor and also supply voltages to the two driver chips.

Finally, a housed gauge pressure sensor has been mounted on the board to detect the puff. The pressure sensor is sensitive to the ambient temperature, but this is corrected in software by establishing a "no-puff" value with relative actuating pressures. Four distinct types of breaths are used--Hard puff, soft puff, hard sip and soft sip. These actions correspond to the mirror's two degrees of freedom; a combination of actions has been reserved for simple storage (a piezo element sounds to confirm storage) and retrieval of the mirror. The output of the sensor did not need to be prescaled or impedance matched and was therefore connected directly to an A/D pin of the microprocessor.

Motor and Mirror Assemblies:
The motor assembly attaches behind Ken's headrest. To keep weight at a minimum, all parts except the brass gear, mirror, motors, bearings and cable assembly are aluminum. Because the linear stepper motor is fixed to the gear, it rotates with the arm, consequently, an acrylic spool is used to keep the "piggy-backing" motor's wires from interfering with the mechanism. A standard stepper motor is used in conjunction with a spur gear to rotate the arm, and a small linear-motion stepper motor is used to pan the mirror via a cable in a spring housing. The cable fits quite well in its housing, and therefore an insignificant delay occurs when changing from a push to a pull.

Because the individual can only control two degrees of freedom, blind spots may be evident. Therefore, a third degree a freedom has been built into the system. The mirror is attached by a ball and socket joint that offers the third axis and allows for temporary adjustments by someone other than the subject. Fig. 15.8 shows mirror mount details.

Finally, the system was designed to be easily assembled and disassembled for any later changes or adjustments. The total cost of the microprocessor mirror system was approximately $300. Further details regarding software and any other elements can be obtained from the principle investigator.

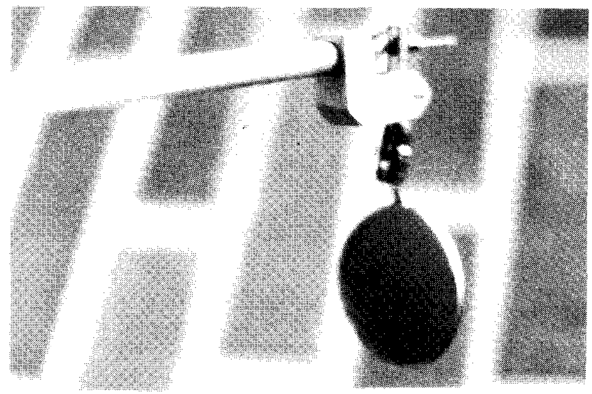

Figure 15.8. Mirror Mount.