CHAPTER 7
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CUSTOM WALKER WITH ROTATIONAL HIP SUPPORT

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INTRODUCTION

The client was a young child with athetoid cerebral palsy who used a walker for ambulation. She had outgrown her walker, and no commercial walkers fit her specialized needs. The goal of our project was to provide a custom walker that the client could use for both gait training and quotidian ambulation. We developed a custom walker with a rotational hip support, sling seat, and armrests that could accommodate her narrow shoulders. The walker facilitated increased mobility and independence.

SUMMARY OF IMPACT

The custom walker has been well accepted by the client. The large tires allow her to traverse terrains that she was unable to navigate before, thus enabling her to attend activities such as a sibling's soccer game. The rotational hip support, suggested by her therapist, appears to improve her gait while walking. The client's mother commented, "[She] has never had a walker that suits her like this one… Do you know what it means to go where you want to instead of where your mother chooses to push you in your chair?"

TECHNICAL DESCRIPTION

Fig. 7.1 shows the custom walker. The walker is based on an adapted commercial frame, Busy Bee (Ottobock), which has been tested for safety and reliability. Custom armrests, a sling seat, and rotational hip support are added to a steel top bar that attaches to the commercial frame. The armrests are adjusted to a relatively narrow lateral position to accommodate the client's torso. The hip support is mounted on the rear of the top bar. For structural testing, the total dead load was assumed to be 60 pounds which is the estimated maximum weight of the client. Modeling indicated that at this load the steel would not yield, and the deformations would be infinitesimally small.

Figure 7.1. Custom Walker with Rotational Hip Support.

The hip support, which is constructed from the hip belt of a backpacking frame pack, opens in the front and is closed with a plastic clip. A heat-molded polyethylene panel inside the belt provides rigidity and flexibility. The belt attaches to a slotted back plate (see Fig. 7.2) to allow vertical adjustment. The rear end of the back plate has a threaded coupling that attaches to a boat rail antenna mount, which provides simple rotational adjustment using a single knob. The antenna mount can be adjusted horizontally on the top bar to re-center the client after the hip rotation angle is changed. The walker also has an easily removable sling seat, which is shown in Fig. 7.3.

Custom armrests are constructed from bicycle handgrips, metal, foam, molded polyethylene and neoprene because the armrests on the original frame were too large. The couplings that attach the arm support to the frame clamp to the top bar, so they can be adjusted in angular and fore-aft position.

The cost of parts for the custom walker was $335, not including the Busy Bee frame.

Figure 7.3 Custom Walker in Use.

Figure 7.2. Slotted Back Plate and Rotational Hip Support.

COUNTER FOR INDIVIDUALS WITH VISUAL AND MOBILITY IMPAIRMENTS

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INTRODUCTION

A local non-profit corporation employs adults with cognitive and physical disabilities to perform tasks such as counting objects for shipping and assembly. The current counting aid is too small to be operated easily or independently by many employees. The goal of this project was to provide five digital counting aids that would be easy to increment, read, and reset. Specific objectives were to build discrete, durable, portable, safe, and rechargeable counting devices. A counting unit was designed that included a large LED display for the count, a large ergonomic button to increment the count, an input jack for external switches, and a small enclosure. The design also supported a rechargeable battery source. Five units were assembled and delivered to the client.

Figure 7.4 The Counter in Use.

SUMMARY OF IMPACT

The counters have increased the number of employees able to perform tasks and increased the productivity of some employees. Employees with poor vision and limited manual strength and dexterity can use the counting aids because they are easy to read and increment. Because the devices can be reset independently, employees do not need to wait for a work coach to reset their counting aids before starting the next task. This enables employees to perform more counting tasks per work day. A client coordinator remarked, “The students seemed determined to make the products as user-friendly as possible. I was very impressed with the durability and weight of the [counters] because it was something I asked for specifically”.

TECHNICAL DESCRIPTION

A photograph of a counter is shown in Fig. 7.4. Commercially available enclosures were utilized for the counters to save machine and assembly time. The enclosure is made of aluminum with an angled display face. Five enclosures were machined and each can accommodate buttons, switches, jacks and the LED display. The edges of the enclosures are filed to remove sharp edges, the exteriors are coated with protective Plasti-Dip, and rubber feet have been added to increase traction and durability.

The LED display, which consists of three 1.5 inch digits, rests on the 60-degree sloped panel of the counter housing. The red increment button is mounted in the middle of the top of the device, and the two black reset buttons protrude from the middle of each side. The increment button can be actuated with very little force applied at many angles, and has a long mechanical life (five million cycles). The reset buttons also require little force to actuate, but must be held on for about three seconds to prevent accidental resetting.

The back of the device contains an on-off switch, an external input jack and a battery recharger jack. The on-off switch is a two inch tall rocker switch, and the external input jack is a small metal jack that accepts one-eighth inch male plugs. This jack allows any desired switch to be used to increment the counter. The LED display is protected from the exterior by Lucite and backed by a nylon panel. This panel is secured by bolts connecting to the enclosure on both sides of the LED display, and supports the circuit board via standoffs. The battery pack is also well secured, immobilized by nylon ties bolted to the enclosure's base.

The electronic circuitry (see Fig. 7.5) is based on a counter chip (MM74C925) that receives input from the increment and reset buttons and displays the current count by driving an LED display that is quickly lit digit-by-digit to save power consumption. A seven-segment display with one and one-half inch digits, which uses low-power LEDs to backlight each segment, provides a large display while saving battery life. The common anode LED display interfaces to the counter chip, a common cathode display, by inverting the driver output with NPN transistors. The input increment signal is debounced using an RC circuit and Schmitt trigger. A high-capacity NiMH battery pack and charger from Radio Shack powers the counter. In empirical tests, the counter ran for an average of 54 hours per charge, indicating that it will need recharging only once each work week.

The cost of parts for each of the five counters was approximately $105.

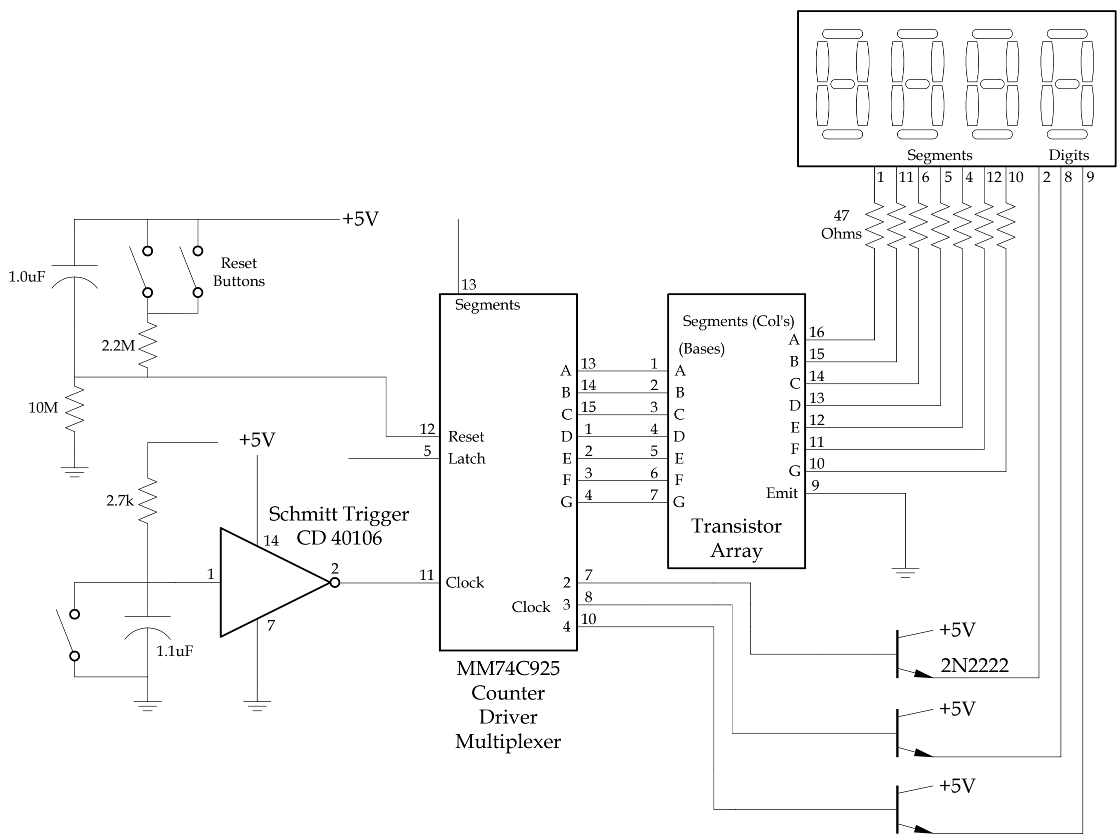

Figure 7.5. Counter Schematic.

DRESSING SUPPORT SYSTEM

Designers: Sarah Park, Ronald Lee
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INTRODUCTION

The client, a 9-year-old girl with spastic diplegic cerebral palsy, had difficulty putting on pants, shoes, and socks without outside help. We designed a device to increase her independence while dressing.

SUMMARY OF IMPACT

The device enables the client to dress faster and with less effort. This increases her self-esteem and independence. After five months of use, the client's father said: "The dressing chair… has worked out very well. It's well designed, it looks nice, and she uses it every morning. It helps her to be independent, and that makes our lives easier, too".

TECHNICAL DESCRIPTION

Fig. 7.6 shows the client using the device, which consists of a chair, parallel bars, a shoe/clothes rack, and a platform. Additional features include a shoehorn, no-slip foam covers on the bars, a cushioned backrest, and height-adjustability for both the chair and parallel bars.

A kneeling chair is used as the main structure because it is height-adjustable and has a natural forward and downward incline. The downward incline of the seat helps the client maintain her balance by shifting her center of gravity forward.

The steel parallel bar structure is designed for simplicity, safety, and height adjustability. A plywood platform with dimensions 42 inches by 39 inches by ¾ inch is used as the base for the design to prevent tipping. The edges of the platform are beveled at 45 degrees to prevent tripping. A one and one-half inch trapezoidal wooden step is included below the chair to also prevent tripping. The height of the parallel bars adjusts using ball detents on the inner tubes and a series of holes in the outer tubes.

Figure 7.6. Client Using the Dressing Device.

The parallel bars are connected to the chair at its front leg with 90-degree elbow joints, forming a single stable unit. In addition, a crossbar is connected between the rear vertical members of the parallel bar structure to minimize shearing motion and increase stability. The bottom, horizontal members of the parallel bar structure are bolted to the plywood base.

A shoe/clothes rack attaches to the side of the bar structure. A shoehorn attaches to the structure with a Velcro, as shown on the left vertical bar in Fig. 7.7. The structure includes a padded back support, which was an important safety feature included through discussions with the coordinator. Black, non-slip foam attached to both side bars provides additional comfort and grip.

The cost of parts for the project was approximately $300.

Figure 7.7. Dressing Support System.

RETRACTABLE HEAD POINTER

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INTRODUCTION

This client has cerebral palsy, no use of his right arm, and only limited use of his left arm. His job involves moving, sorting, and otherwise manipulating small, light objects such as sheets of paper, plastic tags, and pens. Currently, this is accomplished with his left arm and considerable difficulty. Because he has good head control, a cap-mounted pointer was designed to assist him in performing his job. In contrast to most commercial products, this device uses a small and relatively unobtrusive mounting system. An electric motor, mounted to the client's wheelchair, extends and retracts the pointer. The user controls the telescoping pointer using a single lever switch.

SUMMARY OF IMPACT

After two months of use one of the client's supervisors remarks, "The head pointer allows an individual who is really interested in working do more jobs. The head pointer allows this person to work with paper, something he was not able to do before without destroying the paper." His other supervisor comments, "The head pointer has enabled a gentleman to perform his work independently and the smile on his face says it all."

TECHNICAL DESCRIPTION

The Retractable Head Pointer, shown in Fig. 7.8, uses a commercial automotive power antenna for both the motor and the pointer. The motor uses 12V power from the client's wheelchair battery. To allow for a full range of relative motion, a length of vinyl tubing is inserted between the motor and the antenna, housing the motor-to-antenna controlling cable. The tubing is attached with compression fittings to the motor on one end and to the antenna on the other end. This allows the tubing to be removed and replaced easily.

The original motor control circuitry is removed, leaving only a DC motor whose direction of rotation

Figure 7.8. Retractable Head Pointer, Motor and Control Box with Switch.

is easily controlled. This control is accomplished by varying the polarity of the voltages of the power leads using a SPDT switch with a long lever. The circuit uses two DPST relays to isolate the switch itself from the motor current, which can reach 1.5A. A 2A fuse between the control circuit and the battery provides short circuit protection.

Fig. 7.9 shows the pointer mounted to a user and the wheelchair. Two modified binder clips attach the pointer to the client's hat. The clip attached to the bill of the cap uses a piece of heat-shrink tubing, while the clip at the back of the hat holds an eye bolt that extends slightly outward. The positioning of the attachment points provides optimal position of the pointer relative to the head. Padding at the rear attachment point maximizes comfort. A spring mechanism connects the motor to the wheelchair to improve range of motion (see Fig. 7.8).

Electrical connectors attach at three points: the battery, the control box, and the motor. To ensure that no chance for confusion exists, each point uses a different type of plug and jack; interlocks within the connectors prevent misconnection. The battery cable connects to the main cable via an axial two-lead jack. The main cable plugs into the control box with a sixlead plug. Finally, the control cable connects to the motor with a four-lead plug. All connectors are easy-off, protecting the components from accidental jerks.

The pointer tip consists of a piece of soft rubber cut in a cross shape and wrapped around the end of the antenna. The rubber is held in place with a cable tie. This design provides excellent friction for moving sheets of paper and for other manipulation, and is very inexpensive and easy to replace.

The cost of parts for the project was $120.

Figure 7.9. Retractable Head Pointer in Use.

TASK CUEING TIMER

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INTRODUCTION

A man with autism relied on supervisors to enforce task durations and schedule. A device was designed to limit this supervision. The Task Cueing Timer (TCT) uses visual, auditory, and tactile stimuli to cue him to start and stop a task. A progression of colored, blinking lights helps him to anticipate the end of his activities. Start, Finish, and Reward windows provide additional visual cueing. An audible buzzer and vibrating wristband also help to signal the end of a task. It is hoped that the TCT will help the client better understand his task beginnings, their completions, and his next activity, and thereby give him more independence in his daily routine.

SUMMARY OF IMPACT

In addition to his autism, the client also is affected by deafness and visual impairments, seeing primarily with his left eye. This combination of disabilities makes the goal of improving his independence a challenge. The TCT was designed with careful input from the client's three therapists, as well as his mother, to provide signals and stimuli that would most attract and interest him. After five months of use, the client's supervisor commented: "It has been going well. I would consider us very much still in the teaching phase of its use. (The client) loves the lights and will attend to it for a certain period of time, but not always the time set. He sometimes puts his head down while it is on, and misses some of the lights moving along towards 'finished'… The vibration device has come in handy. He will look up when the device starts to vibrate, whereupon we show him the 'break is finished' or whatever the next card happens to be and he then begins to process the transition. So as of yet he does not understand that when the timer goes off, he should transition, but with the continued pairing, I think the association could be made. The teaching process is a long one, but advantages have been noticed.

Figure 7.10. Task Cueing Timer.

TECHNICAL DESCRIPTION

The TCT consists of two main parts. The first part is the user interface, mounted on the top of the enclosure, which allows the supervisor to set the time duration and cueing mechanisms of the TCT. The second part includes the visual stimuli of the front display and the additional audible and tactile cues.

The user interface comprises an LCD display, three cue toggle switches, four momentary pushbuttons for setting the time duration, and a power switch. The four-digit LCD display can be set in increments of one or five minutes using two of the pushbuttons. The other two buttons are for "start/stop" and "reset". The cue switches toggle to select any combination of visual, audible, or tactile stimuli. Timer accuracy was tested and confirmed to be accurate to within one second for periods up to 60 minutes.

The front of the TCT is shown in Fig. 7.10. The visual stimuli include a string of large LEDs that slowly approach the "reward window", changing from green to red as time progresses. At the start, the first green LED on the left blinks for a period of time, then stays on. Then the next green LED blinks and stays on, and so on. At task completion, an illuminated slide in the reward window (upper right) cues the client to his next activity. The client is familiar with these slides, and thus the design allows easy incorporation into his routines. Illuminated start and finish windows reinforce the beginning and ending of the time durations. If the audible cue is selected, a buzzer sounds to signal the completion of a task. If the tactile cue is selected, a vibrating wristband activates upon task completion.

Fig. 7.11 shows the electrical schematic for the hardware involved in cueing. The PIC 16F84 processor controls all cues through its output ports. The signals are either fed through 555 timer circuitry, or through an inverter to drive blinking or continuous activation, respectively. Complete connections are shown for the first 555 timer, enclosed with a dashed box. All pins found on the left side of PIC16F84 are shared by a second PIC processor, which controls a Maxim LCD driver, and a Varitronix four-digit LCD display, as shown in Fig. 7.12. An adjustable stand allows the TCT to be positioned at an appropriate viewing angle, either on a table top or over the back of a chair, and a carrying strap provides portability. Rechargeable NiMH batteries provide long battery life and low maintenance. Battery life testing confirmed at least eight hours of use before recharging. The batteries are charged via an external charger, which plugs into the TCT when it is not being used.

The cost of parts for the project was approximately $220.

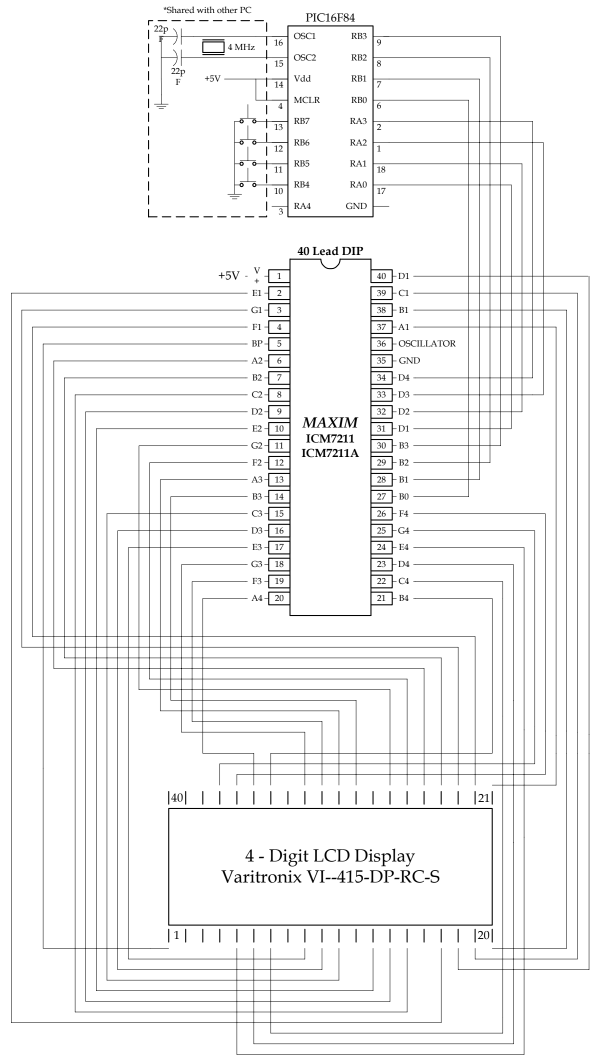

Figure 7.11. Schematic of the Cueing Hardware.

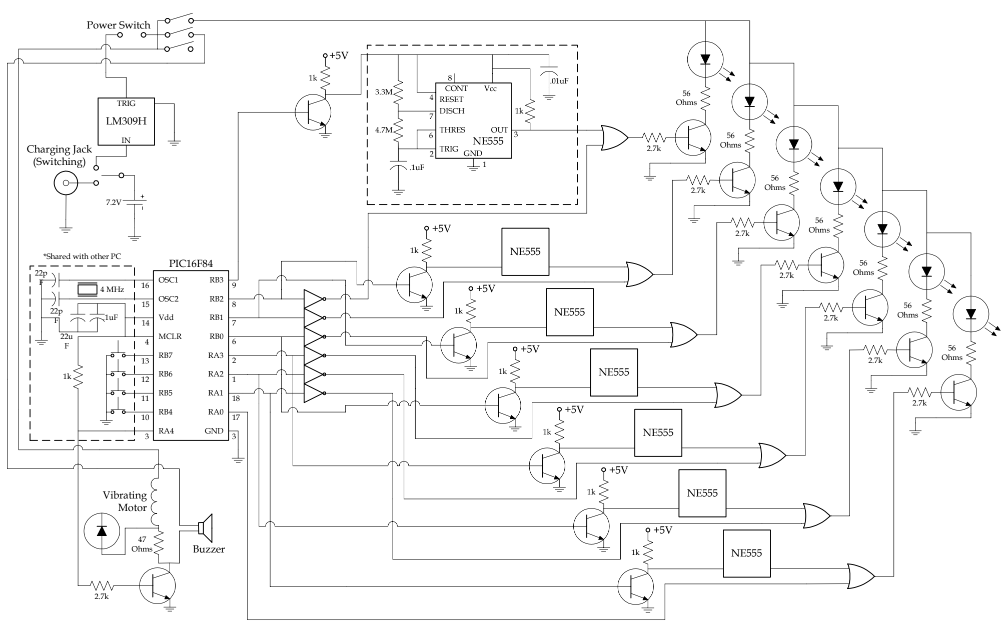

Figure 7.12. Schematic of the LCD Display Hardware.

AUDIBLE COUNTER

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INTRODUCTION

An agency provides employment to people with a variety of disabilities, including cerebral palsy, mental retardation, and visual and mobility impairments. The employees are paid to complete basic tasks that often involve counting an assigned number of objects for placement in supply kits or papers for work packets. The counters used currently are small and difficult to increment and reset; therefore, they are not suitable for many employees. The goal of this project was to design a counter that could receive input from a variety of external switching devices and output the count with both a large visual display and spoken numbers. Specific objectives included: usable by employees with a variety of disabilities, adaptable to needs of new employees, easy to use, portable, unobtrusive, rechargeable, and able to accept a wide range of input devices. A base unit was designed with multiple input ports to which either a commercial switch or two custom-designed motion-sensing switches could be connected. Audio and visual outputs of the count are available, and the design allowed for simple addition of other input devices

SUMMARY OF IMPACT

Workers at the agency are paid by the amount of work they accomplish, rather than the amount of time they are on the job. Employees often say that they do not earn as much money as they would like. The audible counter allows some employees to perform jobs not previously possible, and helps others improve their efficiency, allowing them to earn more money. After two months of use, the assistant director, commented, "The audible counter was brilliant and the students exceeded my expectations for that counter. The consumers enjoy the continuous feedback it provides and it therefore works as an incentive to stay on task for longer periods of time". A supervisor added "The audible counter has allowed several of our employees to become independent in work in which they previously depended on their supervisor. "

TECHNICAL DESCRIPTION

The audible counter, shown in Fig. 7.13, consists of the counter unit, three interchangeable inputs (a foot pedal, an ultrasonic motion sensor, and a passive infrared sensor), and a Plexiglas storage container that doubles as a stand for the counter unit.

The device is powered by six internal AA NiMH batteries, which require a specialized charging circuit that monitors both the voltage and temperature of the batteries during each charge cycle. These batteries will power the device for approximately one work week under moderate use and can be recharged in two to three hours. A high-efficiency switching regulator delivers power to the audio amplifier and also the PIC microcontroller, which controls the overall system.

The foot-pedal, visible at the bottom of Fig. 7.13, is made of a metallic case with a textured, rubber top. This commercial pedal is normally used with an electronic keyboard, and it connects to the counter unit with a ¼ inch plug. The custom-built ultrasound motion sensor (stored in the container at the top left of Fig. 7.13) is a black rectangular box with two metallic cylinders coming out of the front. One is the transmitter and the other is the receiver. Passing a hand or other object in front of these transducers triggers an increment signal. This device terminates in a four-pin plug. The passive infrared device (stored in the upper right of Fig. 7.13) is a small black box with a plastic dome centered on the top face. Passing a hand in front of this device also increments the count; it uses the same connector as the ultrasound sensor.

A double-sided printed circuit board, fabricated using iron-on methods, contains the electronic circuit. This board minimizes total size, provides good product durability, and accommodates the two surface mount IC's used in the device.

The front of the device (Fig. 7.13) contains two LCD displays. The smaller display, showing "07", indicates the goal count for a worker to reach before starting a new batch. This display, 1.5 inches tall, helps those employees who do not understand the concept of numbers to detect their completion of a task by matching the current count display to the static goal display. The larger display ("03") is the current count, displayed in large four inch LCD's. Beneath the smaller display is the speaker, which voices the current count upon each increment.

The audio output uses an ISD voice record/playback chip with on-board memory, in which computer-generated sampled numbers are stored. A differential audio amplifier, chosen due to its efficiency and high output power for low supply voltages, drives the speaker. The audible counter also has a volume control and an automatically switching headphone output.

The cost of parts for the audible counter was $193.

Figure 7.13. The Audible Counter.

STRETCH AND EXERCISE STATION

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INTRODUCTION

A client, a nine-year old girl, has a form of cerebral palsy that affects only her legs and causes spasms and stiffness. The goal of this project was to provide her with a stretching and exercise machine that would improve her strength and flexibility and aid in her self-sufficiency. This was accomplished by modifying an existing weight bench to meet our client's specific needs. The completed station provides four exercises and can be used daily with only minimal assistance from an adult caregiver. Two passive stretches are supported, a hamstring stretch and an abductor stretch, as well as two active exercises, a quadriceps extension and a hip raise.

SUMMARY OF IMPACT

The client's cerebral palsy causes both of her legs to spasm and stiffen. Physical therapy focusing on leg stretches and exercises is the current intervention employed. Our client's physical therapist makes weekly visits to assist with stretches and exercises; however, these activities now can now be performed daily. The client's physical therapist says that, "The stretching and exercise station has allowed [the client] to be an active participant in her therapy. She is able to invent her own exercises and enjoys being somewhat in charge of her stretching activities." She also states that the device helps "improve the client's level of independence and cooperation in that part of treatment which is not always fun."

TECHNICAL DESCRIPTION

Fig. 7.14 shows the completed design, which involves modifying a commercial weight bench. The factory lat tower is modified to provide a hamstring stretch by changing the angle of the tower and adding a ratcheted leg lifting mechanism. A pulley system provides a 2:1 mechanical advantage and allows the client to easily raise her leg to a secure position. Safety bars on both sides of the bench seat, coated with rubber, allow the client to traverse the length of the bench without involving her legs. The bars also act as handholds during exercise and help with mounting and dismounting from the bench seat.

An abductor wedge was designed for placement between our client's legs during the abductor stretch. This wedge positions her legs at an appropriate angle for maximizing the benefits of the stretch. A bracket was placed on the bottom of the wedge so that it can be mounted on the vertical lat tower bar and act as a cushion to prevent the client from accidentally bumping her head on the bar during other exercises (see Fig. 7.14).

The original arm curl support was modified to serve as an incentive tray. The incentive tray holds any item with the use of industrial Velcro and guide pins. Fig. 7.15 shows the client doing an abductor stretch with a keyboard attached.

The leg exercise L-bar, which is used for the quadriceps extension and hip raise, was modified with additional position holes. These holes allow the foam support pad bars to be placed in multiple configurations allowing the device to grow as our client grows. A quick release pin was also added so the L-bar can easily be removed when not in use. Finally, a wheel is added at the base of the lat tower so the bench can be moved easily, and industrial felt pads are placed on the bench feet to protect floor surfaces.

The cost of parts for the project was approximately $400.

Figure 7.14. Exercise and Stretching Device Station.

Figure 7.15. A Client Preparing for an Abductor Stretch.

ASSISTIVE WORK CHAIR

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INTRODUCTION

A client with autism is employed in an office setting where she sits in a standard office chair. The seat is too high for her because she is less than three feet tall. She currently clambers into the seat, but this is inconvenient and potentially dangerous. A device was built that consists of a set of steps that extend and retract from a base under the chair. This allows the client to step safely and comfortably into her seat. Retraction of the steps is necessary for aesthetics, unobtrusiveness, and safety in a crowded environment. The device couples the extension and retraction of the steps to the rotational swivel of the chair and does not require electrical power.

SUMMARY OF IMPACT

The assistive work chair has provided a safe and simple method for the client to sit in her chair. One of the client's supervisor's says, "The work chair has made [the client] much more comfortable in her work environment and her production has increased." Another supervisor added, "The chair is a dream come true, it is the chair we have been wishing for since the consumer started working (here)... The consumer can now rest her feet and work more comfortably."

TECHNICAL DESCRIPTION

The assistive work chair is a standard office chair with a mechanically retractable step. Fig. 7.16 shows the work chair with the steps extended. The rotation of the seat is coupled with the retraction or extension of the steps. In its default position, the steps are retracted into the base under the chair.

Figure 7.16. Assistive Work Chair.

When the seat is rotated 90 degrees (as in Fig. 7.16), the seat locks into position and the steps extend outward, allowing the user to mount or dismount.

The steps are made of ¾ inch solid red oak, which provides a good combination of strength and weight efficiency. The steps weigh approximately 11 pounds. The base is made of plywood because it does not need to withstand any direct stress. The steps are connected to the base via 24 inch drawer slides rated for loads of 100 pounds. The drawer slides have friction-reducing ball bearings that enable the steps to slide in and out under their own weight when tilted. The slides' sole connection to the base is by a pivot rod, allowing them to tilt freely up and down about the pivot. The default position of the slides is back-end tilted down as shown in Fig. 7.17a. This tilt is maintained by a spring of sufficient strength to pull down the back ends of the slides. When the drawer slides are tilted at this angle, gravity retracts the steps down into the base.

When the user wants to extend the steps, the seat is swiveled until it is aligned with the steps as in Fig. 7.16. A torque arm rotates with the seat, which pulls up on the back end of the drawer slides via a rope and pulley. This rope overcomes the counteracting spring force and reverses the tilt of the slides as shown in Fig. 7.17b. Gravity then extends the steps out of the base, allowing the user to step onto or off the chair. The seat is lightly locked into this position by a cabinet door latch (not pictured) whose spring-loaded jaws clamp onto the torque rod. This lock prevents the chair from swiveling while the user is mounting or dismounting.

When the steps are no longer needed, the seat is jogged out of its lock and rotated to its original position. This slacks the rope holding up the drawer slides. The spring is strong enough to force the drawer slides to tilt down again, enabling gravity to retract the steps back into the base.

The cost of parts for the device was $108.

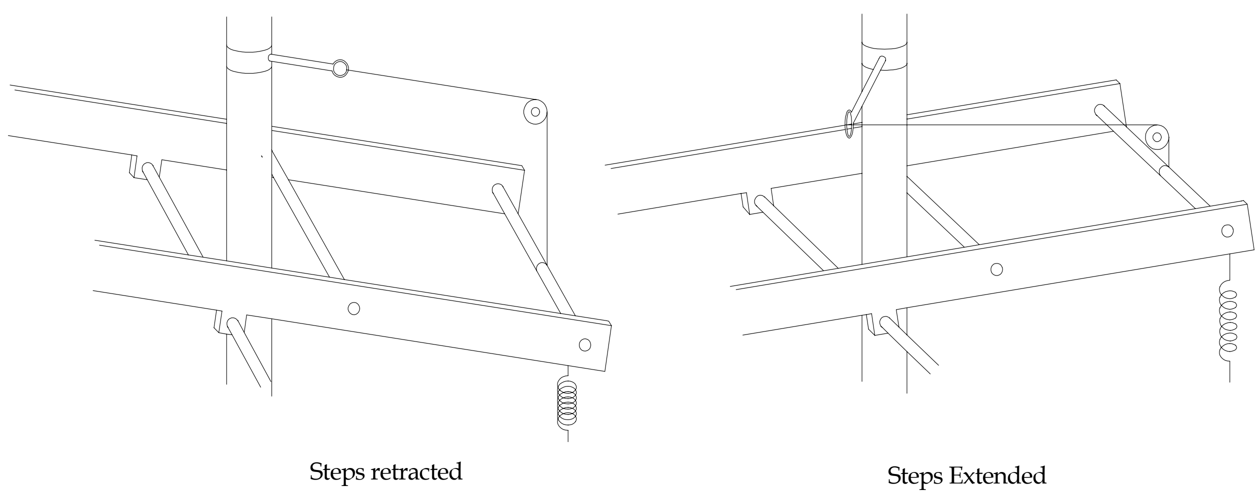

Figure 7.17. Step Control Mechanism.