CHAPTER 15
TEXAS A&M UNIVERSITY

College of Engineering
Bioengineering Program
College Station, TX 77843

Principal Investigator:

William A. Hyman (409) 845-5593
w-hyman@tamu.edu

ORTHOTIC CONTACT FORCE MONITOR

Designer: Jon Olson
Client: Kevin Felton
Texas Scottish Rite for Hospital for Children
Supervising Professor: W.A. Hyman
Biomedical Engineering Program
Texas A&M University
College Station, TX 77843-3120

INTRODUCTION

The proper fitting of orthotic devices requires locating areas of excessive pressure and reducing those pressures, especially since many patients involved have compromised skin integrity or insensate skin, or may be unable to communicate discomfort. This device will be used as a fitting aid in the orthotics department of a hospital for children. It is a two-channel device with a force sensitive resistor (FSR), trimming circuit and visual LED display for each channel. The unit is self contained and battery powered.

SUMMARY OF IMPACT

This device will be tested for its usefulness in fitting orthotic devices to children in such a way that skin and discomfort problems can be avoided or minimized. The presence or development of skin wounds compromises both health (through infection) and rehabilitation (through ineffective or delayed use). Therefore improved, technically based fitting is an essential element in children's orthotics. If the device proves to be useful, it can be readily reproduced and/or modified, and its cost is such that it could become a readily and widely used tool.

TECHNICAL DESCRIPTION

The device utilizes a FSR as a means of sensing pressure. The FSR is a flat pad, the resistance of which is proportional to the pressure applied over the pad surface. The variation in pad pressure is used here as input to a display driver, a common integrated circuit (IC) chip used for signal strength indications in home and car stereos. The IC drives a 10 LED array on a logarithmic scale for visual interpretation of signal strength. The unit runs off a common 9-volt battery with snap-on connectors. The reference voltages, which are set by resistors and capacitors, were chosen for safe low voltage operation as well as extended battery life. The sensor scale is adjustable for different pressure ranges.

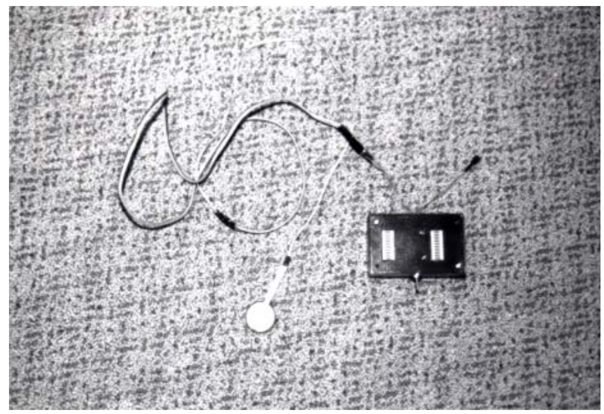

Figure 15.1. Orthotic Contact Force Monitor.

The use of the IC greatly simplified the circuit design, and added reliability with respect to breakage. From the battery source a diode assures the correct polarity and protects the circuit from damage that might result from even a momentary attempt to connect the battery backwards. A capacitor is used to assure a strong transient response of the power source as well as dampen any ripples or stray spikes. The power source leads interface directly with the sensitivity potentiometers and the FSR. As the pressure on the FSR increases, its resistance decreases and thus more voltage is allowed to pass into the IC.

The FSR is connected to pin 5, which is also connected to pin 4 through a capacitor and resistor in parallel as part of the circuit reference voltage. The IC compares the voltage on pins 4 and 5 to other voltages within the chip to determine the enabling of certain of the LEDs. Pin 4 receives some direct power from the voltage source via a 330-ohm resistor and isolated from ground by a zener diode and a capacitor. Pins 3 and 9 receive nine volts directly from the power supply. Pin 2 is connected directly to ground. As can be seen in the schematic, pins 6, 7 and 8 are connected to ground via resistive networks. These networks allow the discharge of the energized circuit and are responsible for the decay rate of the display. Pin 1 is the first or lowest LED representing low pressure on the FSR followed by pins 18 through 10 in the order shown. The IC enables the LED by switching the ground on and off, through a 1000-ohm resistor.

The components for this device cost about $70.

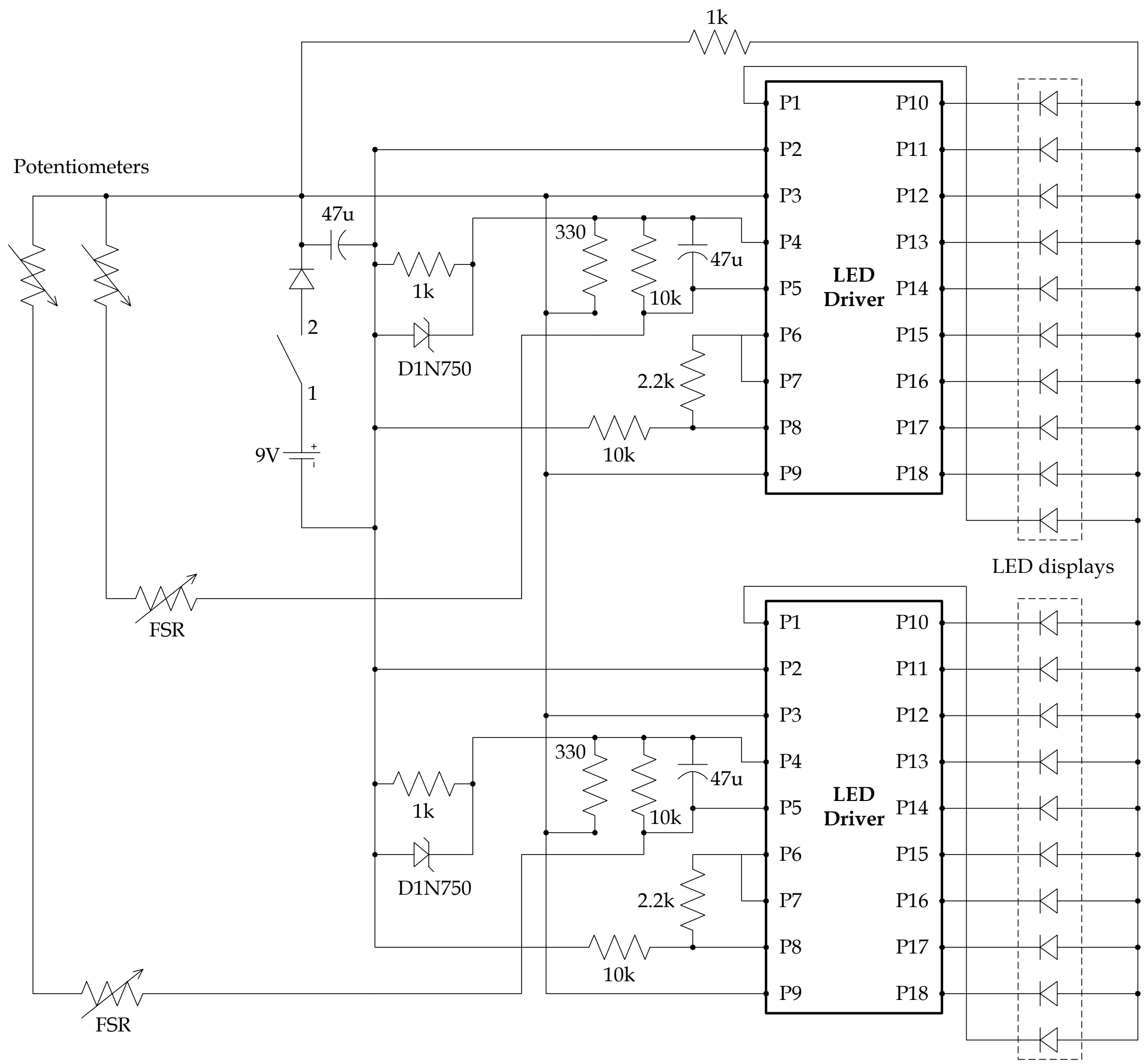

Figure 15.2. Circuit schematic.

PEDIATRIC TREADMILL

Designers: Kevin Belteau, Matthew Easton, Sean Booher
Client: Kathy Moody
United Cerebral Palsy of Greater Houston
Supervising Professor: W.A. Hyman
Biomedical Engineering Program
Texas A&M University
College Station, TX 77843-3120

INTRODUCTION

A powered treadmill was custom designed for use by young patients with cerebral palsy. The primary variables that differentiate this device from an adult treadmill are the size of the supports, the length, and the minimum operating speed. After examining a number of adult treadmills it was found that their minimum speed was too high, and the handrails were too big. However it was determined that building an adequate treadmill from scratch would be prohibitively complicated, and furthermore, an adult treadmill could be modified to meet the operating specifications for use by children. Therefore an adult treadmill was obtained and substantially modified to meet the needs of the young user.

SUMMARY OF IMPACT

This design allows young users to obtain the benefits of powered treadmill exercise in a physical configuration that is suitable for their size and walking ability. It is reasonably portable and can therefore also be used for home and satellite therapy. It is currently in use by therapists and initial feedback is that it is serving the intended purpose.

TECHNICAL DESCRIPTION

The product modified for this project was a Pro Form model 315 adult treadmill. Nearly all dimensions of the treadmill were reduced by one half, with the exception of the width. The major modifications involved reducing the belt speed and adding appropriately sized railings. The size reduction resulted in a substantial weight reduction and allows the unit to fit into the trunk of a car. When not in use the treadmill can be partially disassembled (see Figure 15.4) and the main part moved into a vertical position to reduce the space it occupies and aid in portability. An added hasp secures the platform in the vertical position.

Figure 15.3. Pediatric Treadmill Assembled.

A PVC handrail unit was fabricated for the front and sides of the treadmill, and a belt was added to help stabilize the user. The height of the handrails is approximately 19 inches. They fit by hand pressure into PVC end capes mounted to the treadmill platform. This provides sufficient security during use since the intended users cannot apply enough force to dislodge them. Still, they easily detach for transport. An anti leg crossover bar is also provided as part of the handrails. This bar runs parallel to the belt direction. It is 2 inches from the belt and 1.5 inches wide.

The treadmill is driven by the original electric motor with a new, custom-made 7-inch-diameter flywheel. This new flywheel changes the relationship between motor and belt speed to achieve the desired lower speed. This change also required a new drive belt. An appropriately sized automobile belt was used. Custom flywheel coverings were also added.

The controls were separated from the unit with plug-in connections to remove them from the reach of the user, and to enhance portability. A plastic key is required to be inserted to operate the device. During operation this key is attached to the user's clothing such that if the user falls or rides the belt too far backwards the key will readily disengage and the treadmill will stop immediately. An attendant hand held “kill switch” was also provided so that the device can be quickly stopped. Use of the device should always be supervised.

Figure 15.4. Pediatric Treadmill Disassembled For Transport.

YES/NO COMMUNICATOR

Designer: James Jerrnigan
Client: Kathy Moody
United Cerebral Palsy of Greater Houston
Supervising Professor: W.A. Hyman
Biomedical Engineering Program
Texas A&M University
College Station, TX 77843-3120

INTRODUCTION

This device is a prototype of a simple switch-operated yes/no communication doll that will drive the doll's head in the familiar (western) gestures of up and down head movement for yes, and side to side head movement for no, while also driving a prerecorded yes/no voice playback. The current system utilizes model airplane telemetry and servos to develop the required head movements from two single axis joysticks.

SUMMARY OF IMPACT

This design is the first part of a system that will provide timed yes or no head movements, as well as spoken words, for single action switch inputs. The current design allows therapist-operated head movements with vocalized or independent recorded aural output. It will ideally enhance teaching of cause-effect relationships, object-word associations, yes/no responses, and switch activation to children with developmental disabilities. The current design allows independent use in that the therapist can operate it in response to voice communications with the client or with respect to simulated switch input. The use of a doll adds a measure of interest to the therapeutic activity beyond that which the therapists can provide themselves. Devices such as this help facilitate visual, vocal and mechanical interactions in children with developmental disabilities.

TECHNICAL DESCRIPTION

The doll's head is driven by two servos connected to provide the two axes of rotation associated with yes and no head movements. The motion left/right, or up/down is proportional to the rotational movement of the respective joystick. Although beyond the design specifications for this project, the two joysticks can be operated simultaneously if desired for more complex head motion. The associated hardware and batteries are installed inside the doll's head and body. The input to the servos is via a remote control unit with two single axis joysticks, one for each direction of motion. As off-the-shelf model airplane equipment was used, no new electron design was required.

Figure 15.5. Doll and Controller.

A second version of this design will include the provision for single-action, pushbutton input triggering a pre-timed amount of back and forth head motion for yes and no. Digitally recorded yes and no messages will also be added to the next version. Two approaches are being pursued to achieve the more automated function. One is to reproduce the radio signals coming from the remote control in terms of signal content and duration. A design for such a circuit is shown in Figure 15.6. The second approach is to drive the input joysticks of the remote control with another device. The latter would leave the telemetry portion as is. In either case the provision of digital voice playback triggered by the same yes and no push buttons will be straightforward.

The cost of the equipment was approximately $100.

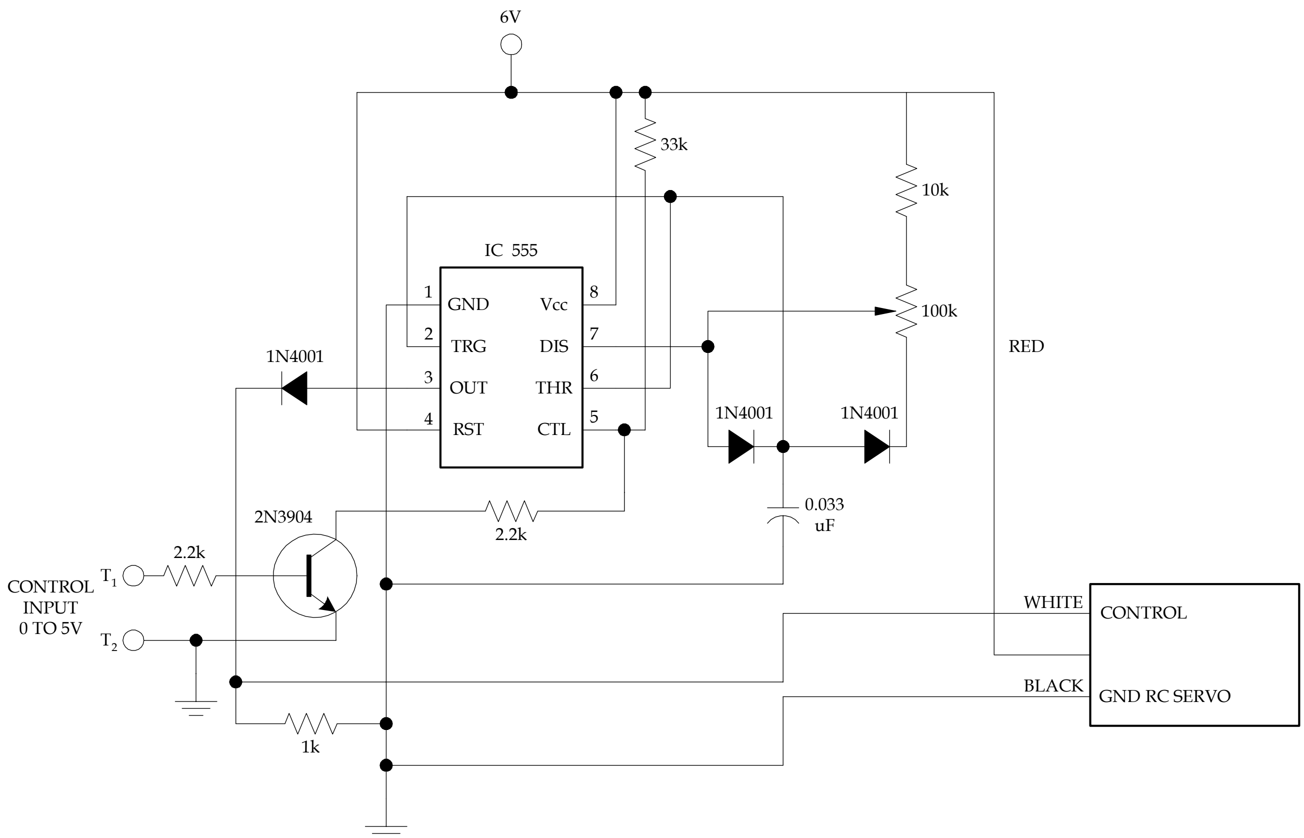

Figure 15.6. Schematic Of Telemetry Driver Circuit.

PORTABLE PARALLEL BARS REVISITED

Designer: Karen Petty
Client: Greta Cherry
United Cerebral Palsy of Greater Houston
Supervising Professor: W.A. Hyman
Biomedical Engineering Program
Texas A&M University
College Station, TX 77843-3120

INTRODUCTION

An expanding in-home pre-school therapy program requires a variety of easily portable therapy devices. The need for portable pediatric parallel bars was revisited in this project with the revised specifications of the need for multiple units of a lightweight device that can be easily carried. The solution consists of a plastic shelf from a widely available commercial three-shelf unit, PVC pipe and accessories, and baseball gym bags for transport. Three identical units were constructed for use by three therapists.

SUMMARY OF IMPACT

This design meets therapists' needs for an easily portable parallel unit that can be stowed in a vehicle. The oversize bags also accommodate other therapy gear being carried into the clients' homes. The design is reproducible by a reasonably handy parent such that it may be made available to children on a continuous basis, and not just when a therapist is in the home.

TECHNICAL DESCRIPTION

The base of the unit is one of the shelves from a commercial, consumer three-shelf system that is widely sold in discount stores. The vertical bars are PVC pipe selected to meet the pre-existing corner holes originally intended to hold the spacers between the shelves. The vertical pipes fit snuggly in the corner holes of the shelf and did not require fasteners. At one end of each of the four vertical posts a horizontal hole was cut to accommodate PVC pipe horizontal bars. The verticals were also cross-drilled, with matching holes in the horizontal bars, to accommodate plastic bolts to hold the vertical and horizontal pieces together. The horizontal bars extend well over the ends of the shelf unit to facilitate stepping onto, and off of, the base. However, these bars could be shortened to make them easier to transport without compromising the function of the overall design. End caps for the horizontal bars were also provided. The surface of the shelf was covered with carpet.

Baseball gym bags were provided to accommodate the vertical bar. The horizontal bars extend from a separate compartment at the bottom of the bag. A luggage type handle was added to the edge of the shelf/base to make it easy to carry. Bolts and end caps were in an accessory bag.

The assembly sequence is to insert the corner posts and then thread the horizontal bars through the holes at the top ends of the corners. End caps can then be used if desired, but are not essential. The vertical and horizontal bars can then be attached with the bolts if desired. After the horizontal bar is threaded through the hole in the top of the vertical bar, a slight twist of the vertical bar in the corner hole of the shelf effectively "locks" the vertical and horizontal bars together, eliminating the need for the bolts. Disassembly entails the reverse process. If necessary, the shelf/base can be secured with pressure applied with a foot while extracting the vertical bars.

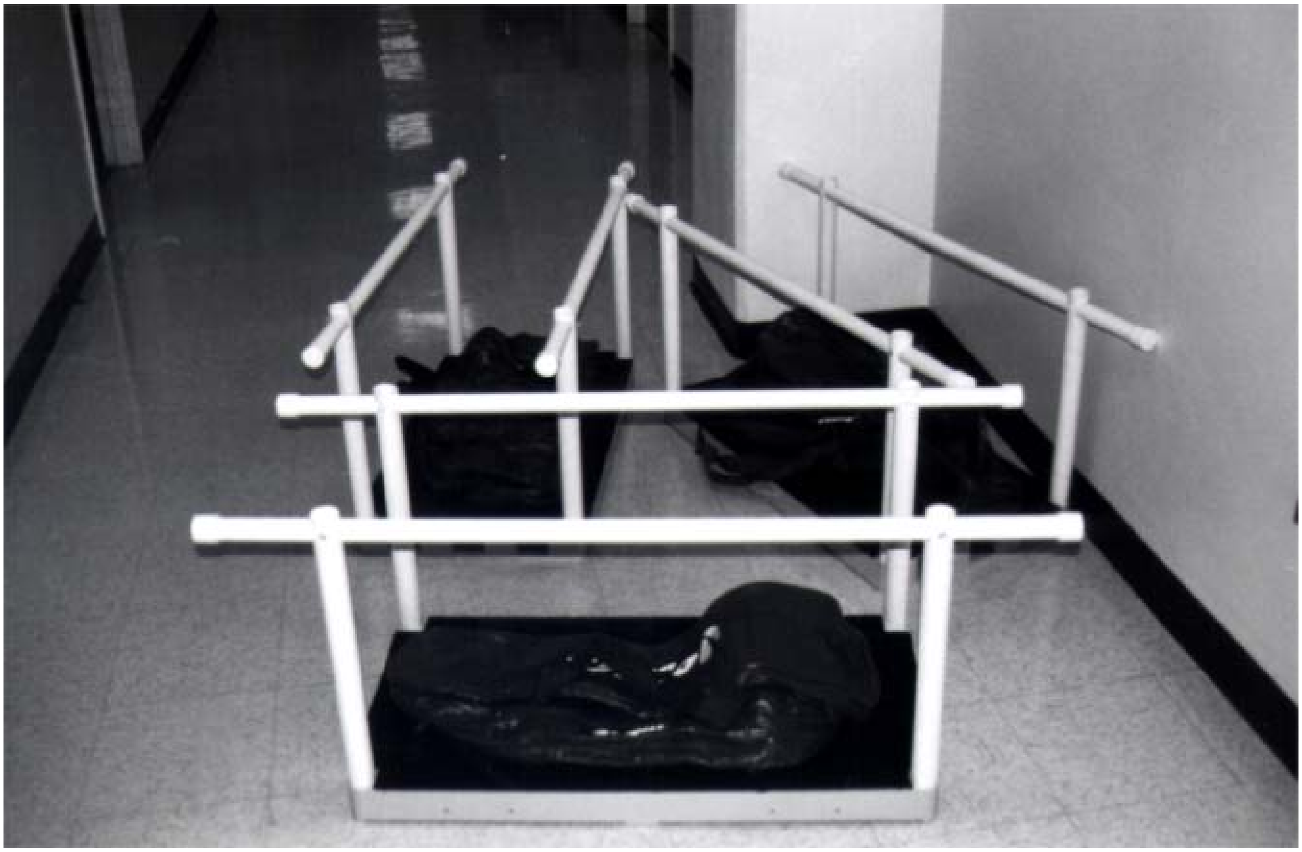

Figure 15.7. Portable Parallel Bars Set-Up with Gym Bags.

VESTIBULAR BALANCE CHAIR

Designers: Jason Begnaud and Robyn Rudloff
Client: Esther Lin
United Cerebral Palsy of Greater Houston
Supervising Professor: W.A. Hyman
Biomedical Engineering Program
Texas A&M University
College Station, TX 77843-3120

INTRODUCTION

A physical therapist was using a ball as a seating surface for vestibular and head and neck muscle therapy for children with muscular dystrophy. The child would sit on the ball and be tilted in various directions, requiring volitional effort to maintain positional stability. This method was very difficult for the therapist in that it required simultaneous support of the child during positioning, and it usually took two people to effectively use the method. In addition the child often felt very insecure, distracting him or her from the desired outcome.

The design requested was for a chair that could be easily tilted and controlled by the therapist while also being comfortable and secure for the child. Moreover, the angle of tilt needed to be self-limiting so that the child and chair could not fall over if the therapist lost control. The chair had to also be easily portable for home-based therapy. The solution is based on a purchased chair with added cushions and seat belt, added PVC anti-tip legs, and a ball to provided multi-axis tip angles.

SUMMARY OF IMPACT

This device is now in use and is reported to facilitate balance therapy with improved safety and an added measure of self-confidence for the child and therapist. The design is easily replicable so that parents can recreate it for continued home use between therapy sessions.

TECHNICAL DESCRIPTION

The design began with a purchased child's plastic chair. Waterproof padded cushions were fabricated to tie to the chair for easy cleaning and replacement. A seat belt was also added.

Figure 15.8. Vestibular Balance Chair.

PVC pipe was used for four wide angle legs with cross pieces added for stiffness. Holes were cut in the outer portion of each leg to accommodate the pipe, with 120-degree connectors used for at the chair base and 90-degree connectors used to attached the cross pieces.

Bolts were placed through drilled holes at the top of each leg as they penetrated the chair. The bolts prevent further penetration of the legs into the chair. All PVC connections and the PVC to chair interface, were secured with PVC cement. These legs do not reach the ground as the chair sits normally as their purpose is to limit the tilt angle rather than provide basic support.

The chair is placed on a large rubber ball while in use, with the ball providing the desired omni-directional tilt platform. The ball is selected to fit tightly between the legs so that the unit stays together during use. However the ball is easily removed form the legs for transport, so the ball can be used for other activities. If the chair is used for the same client as the portable parallel bars (see previous report) then the ball can be carried in the gym bag accompanying the parallel bars.

The diameter and compressibility of the ball must be selected to accommodate the weight of the child and the allowable degree of tilt. Various balls were tested with simulated weights and two selected for delivery with the units.

Leg length and angle for given weight and ground clearances were originally predicted by calculation and then confirmed experimentally with simulated child weights to assure that the required tilt angles could be achieved but that the chair could not tip over if those angles were exceeded.

The total cost of the project was approximately $50.

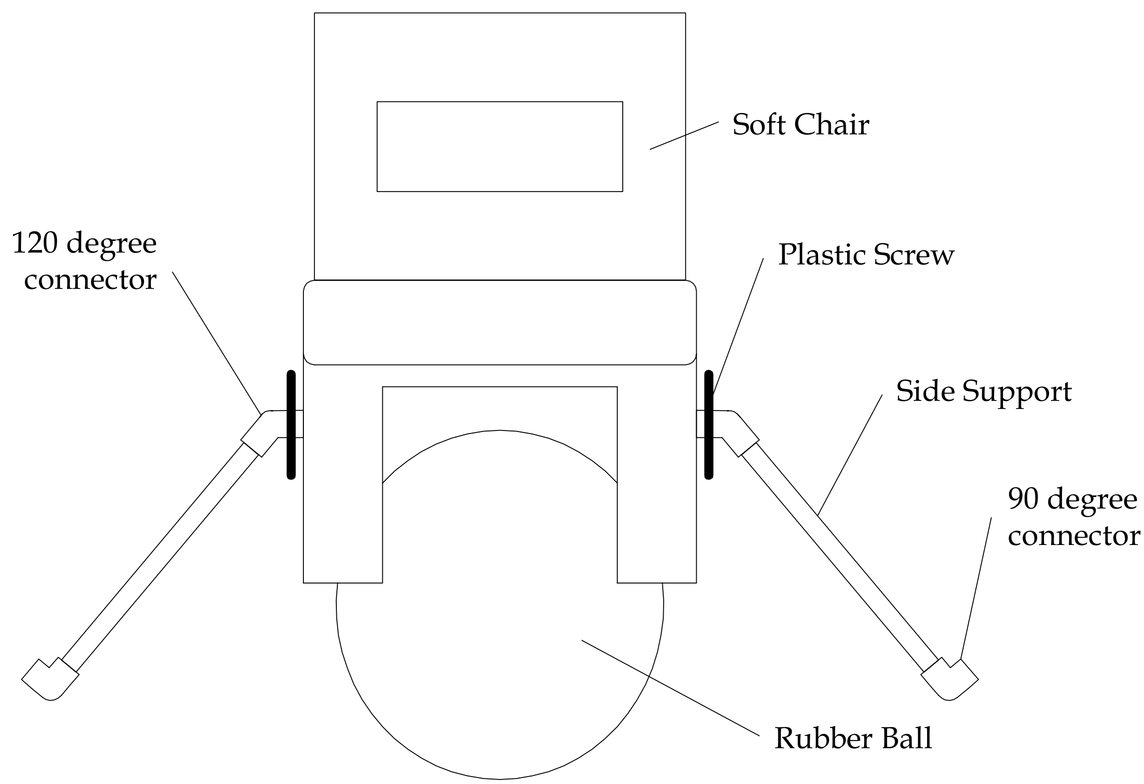

Figure 15.9. Schematic of Design.

FINE MOTOR TESTING KIT FOR HOME-BASED THERAPY WITH CHILDREN

Designer: Candice Danielle Pinson
Client: Simone Braquet
United Cerebral Palsy of Greater Houston
Supervising Professor: W.A. Hyman
Biomedical Engineering Program
Texas A&M University
College Station, TX 77843-3120

INTRODUCTION

The fine motor kit was designed for an occupational therapist for use during home-based visits to pre-school clients with fine motor disabilities. Lightweight, small and easily transportable, the kit is used for skill assessment and therapy. The design incorporates a number of different objects for specific motor skill tasks. These objects were previously used in a loose assortment without any specific means to organize, retain and carry them.

The main component of the kit is a tackle box that conveniently stores the contents in an organized way such that the required objects can be selected and used without unpacking the entire unit.

SUMMARY OF IMPACT

The target client group for this design is children from birth to three years with a variety of motor skill deficiencies involving grabbing, pinching, bi-lateral hand use, and midline orientation.

The components of the kit were selected to require each of these specific motor skills. The kit is used for both assessment and therapy. The client can also use the kit for general exploration. It is small, compact, self-contained and lightweight, so it meets the requirements for easy portability.

TECHNICAL DESCRIPTION

The kit consists of the main tackle box and a variety of toys and objects. The internal sections, compartments, and removable portions of the tackle box were all utilized, along with additional containers, to systematically isolate the object groups. The components include:

- Assorted beads and string/rope for stringing,
- A sorter/stacker set including a small cylinder drop for very fine finger dexterity,
- Foam blocks,
- A soft foam alphabet puzzle,
- Soft squeaking blocks,
- Lego stack n' learn blocks,
- Snap-on rings,
- Plastic toy nuts and bolts,
- Clothespins, and
- Crayons.

Since almost all of the objects used are commercial toys they are, for the most part, brightly colored, smooth, and non-toxic. Some objects are necessarily small and would present a choking hazard for the youngest users. These are appropriately labeled, although the entire collection is intended for use with direct therapist supervision and is considered to be a rehabilitation tool and not a toy. Fastening and storing mechanisms include:

- Velcro,
- Paper fasteners,
- Vinyl folders, and
- Clear cosmetic bags.

Several user tests were conducted to make sure that the contents of the box could be easily replaced in the specified packing pattern.

The cost of the box and components was about $95.

Figure 15.10. Kit Packed For Transport.

Figure 15.11. Contents Of Kit.

MECHANICAL REFRIGERATOR OPENER

Designer: Elisabeth Neely and Bincy Paulose
Client: Kathy Moody
United Cerebral Palsy of Greater Houston
Supervising Professor: W.A. Hyman
Biomedical Engineering Program
Texas A&M University
College Station, TX 77843-3120

INTRODUCTION

A device was needed to initiate refrigerator door opening for individuals with reduced upper body strength. Specifications were that it involve minimal encumbrance to the refrigerator, create no interference for other users, and be easy to maintain. Two similar solutions were investigated, both based on hinges or hinge components mounted to the refrigerator at the opening side, with a blade inserted into the magnetic seal. An integral lever extends out to the side away from the refrigerator and allows a pushing force to replace the normal pulling force, eliminating the need for grip, and providing a mechanical advantage. A wheelchair attachment was also investigated that could operate the lever via forward propulsion of the chair.

SUMMARY OF IMPACT

The task of opening a refrigerator is facilitated for individuals who have the mobility and strength to approach the refrigerator and retrieve/replace items in it, but who do not have the strength to achieve the initial pull required to break the magnetic seal of home refrigerators. The design was intended to be easily reproducible by others.

TECHNICAL DESCRIPTION

The key to each of the designs tested was to use a permanently mounted lever system to open the refrigerator door, replacing the standard pull force requirement with a push, and eliminating the need for grip strength. In the device illustrated a 6-inch strap hinge blade was used for the lever, with a modified, mating box hinge used to both secure the device to the inside lip of the refrigerator, and to provide the opening mechanism. The box hinge blade was cut (see Figure 15.13) so that it is partly mounted and partly moveable, with the moveable portion fixed to the strap hinge. The strap hinge portion was covered with non-slip tape to improve contact with the actuator that might be a hand, arm or another device, such as a swing-away pusher mounted on a wheelchair. A small L bracket with a light spring was mounted to the side of the refrigerator. This limits the stroke of the lever to just popping the door open. The closing door resets the device automatically.

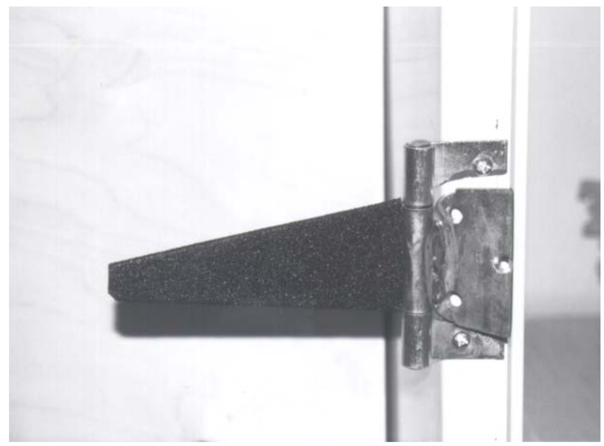

Figure 15.12. Mechanical Refrigerator Opener, Seen With Door Open and out of View.

Figure 15.13. Side View Showing Stop Bracket.

The second device also used a hinge, in this case with one blade as the lever and the second blade mounted to the side of the refrigerator. An extension to the free blade was then added to insert in the door seal. This version had less material in the door seal itself. However integrity of the door seal with either device in place was confirmed by using the standard paper strip (dollar bill) pull out test on the closed door at a position directly above and below the insertion point of the metal strip.

In each design, pressing on the free end of the hinge applies an opening force to the refrigerator that is increased by the relatively large lever arm. Moreover, the system allows pushing rather than pulling, a more powerful direction of force for many individuals, requiring less manual dexterity. When the door is allowed to close in the normal manner, the position of the hinge is automatically reset as the door closes on it.

A potential addition to these designs is a switch-operated solenoid to affect the required force on the lever. This modification would accommodate users who could not provide the force necessary in the current design, or could not reach the push lever. The activating switch could be mounted at any convenient location near the refrigerator. Appropriate users would still have to be able to manipulate what they wanted from the refrigerator, and re-close it.

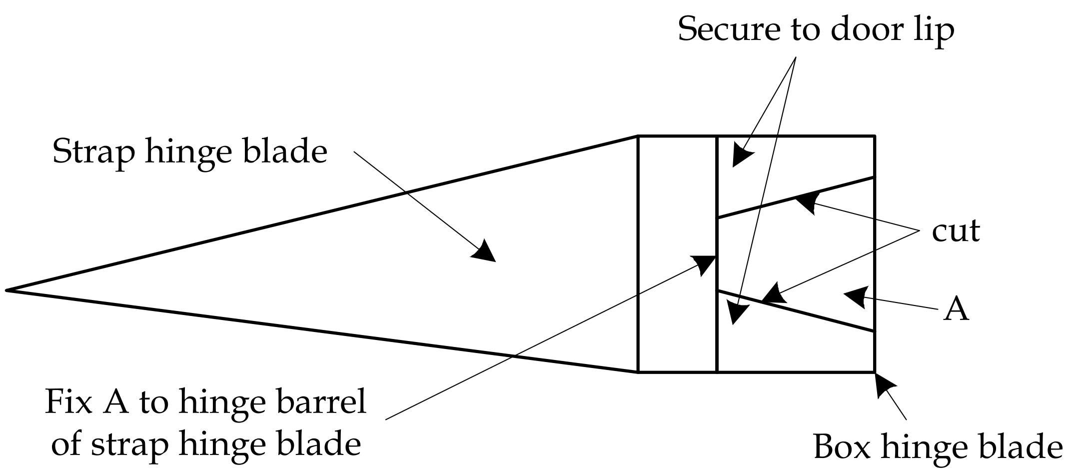

Figure 15.14. Schematic Of The Design.

CLASSROOM DESK FOR A CHILD IN A WHEELCHAIR

Designer: Tallana Hamilton
Client: Elizabeth Carpenter
College Station Independent School District
College Hills Elementary
Supervising Professor: W.A. Hyman
Biomedical Engineering Program
Texas A&M University
College Station, TX 77843-3120

INTRODUCTION

An essential element in the elementary school classroom setting for all children is a suitable desk or similar workspace. For children in wheelchairs the standard desk is often inadequate with respect to clearance under the desk in height, width and depth. In addition, limited mobility may require a larger work surface so that more things may be in reach, a suitable and accessible storage space, an easel like work surface for some tasks, and a finished result that does not stand out in the classroom environment. The client for this design had outgrown his previously modified desk, and was also getting a substantially larger wheelchair that was going to require greater under-desk area. The resulting desk design shown was manufactured from:

- A purchased desktop,
- Side legs obtained from an existing classroom desk and modified,
- A previously designed pullout storage unit, and
- A removable easel section.

SUMMARY OF IMPACT

This device is in current use by the child for whom it was designed. It meets his needs for under-desk access, adequate workspace, access to storage, and compatibility with the classroom environment. It is anticipated that further desk modifications will be required as he continues to grow.

TECHNICAL DESCRIPTION

The design is based on purchased or adapted components. The new desktop was purchased, as this was more cost/time effective than achieving an adequate finish from raw materials. The basic leg components were taken from an unused school desk. These were split to increase the width of the desk, and leg extensions were added to increase the range of the height adjustment. The right leg unit was further modified to accommodate an existing pullout storage unit that had been previously designed for this user. An adjustable easel section was constructed and added to the desktop. This unit is easily removed when a single, large, flat work surface is desired.

Figure 15.15. Modified Desk.

The original desk appeared to be satisfactory until the user obtained a new wheelchair; the desk did not allow him to move sufficiently far forward because the wheelchair contacted the back crossbar. A further modification was therefore undertaken to remove the crossbar and replace it with a modified A-frame as shown. This solved the access problem without requiring an even larger top surface, which would otherwise have become obstructive in the classroom.

The cost of components and fabrication was about $200.

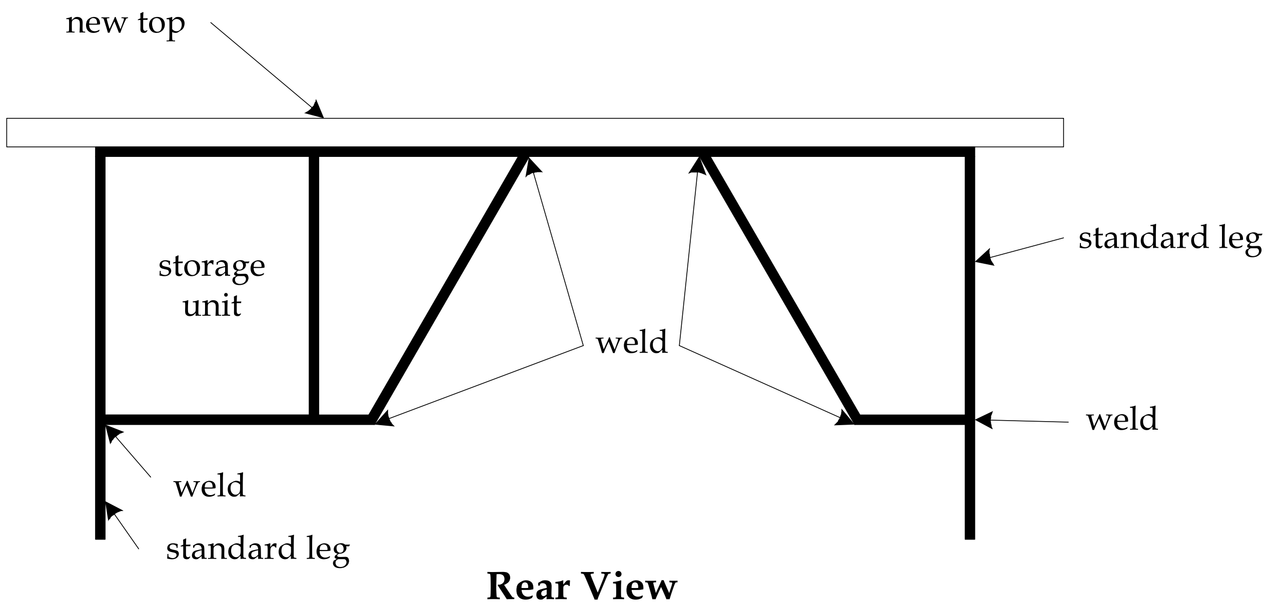

Figure 15.16. Sketch Of Rear View With Assembly Details.