NATIONAL SCIENCE FOUNDATION
1997
ENGINEERING SENIOR DESIGN PROJECTS TO AID PERSONS WITH DISABILITIES

Edited By

John D. Enderle

Brooke Hallowell

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Creative Learning Press, Inc.
P.O. Box 320
Mansfield Center, Connecticut 06250

PUBLICATION POLICY

Enderle, John Denis
National Science Foundation 1997 Engineering Senior Design Projects To Aid Persons With Disabilities / John D. Enderle, Brooke Hallowell
Includes index
ISBN 0936386843

P.O. Box 320
Mansfield Center, Connecticut 06250

Printed in the United States of America

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FOREWORD

Welcome to the ninth annual issue of the National Science Foundation Engineering Senior Design Projects to Aid Persons with Disabilities. In 1988, the National Science Foundation (NSF) began a program to provide funds for student engineers at universities throughout the United States to construct custom designed devices and software for individuals with disabilities.[1] Through the Bioengineering and Research to Aid the Disabled (BRAD) program of the Emerging Engineering Technologies Division of NSF, funds were awarded competitively to sixteen universities to pay for supplies, equipment and fabrication costs for the design projects. A book entitled, *NSF 1989 Engineering Senior Design Projects to Aid the Disabled* was published in 1989, reporting on the projects that were funded during the first year of this effort.

In 1989, the BRAD program of the Emerging Engineering Technologies Division of NSF increased the number of universities funded to twenty-two in 1989. Following completion of the 1989-1990 design projects, a second book was published, describing these projects, entitled, *NSF 1990 Engineering Senior Design Projects to Aid the Disabled.*

In 1991, North Dakota State University (NDSU) Press published a third issue of the *NSF 1991 Engineering Senior Design Projects to Aid the Disabled.* This book described the almost 150 projects carried out by students at twenty universities across the United States during the academic year 1990-91.

NDSU Press published the fourth issue of the *NSF 1992 Engineering Senior Design Projects to Aid the Disabled* in 1993. This book described the almost 150 projects carried out by students at twenty-one universities across the United States during the 1991-92 academic year.

[1] In January of 1994, the Directorate for Engineering (ENG) was restructured. This program is now in the Division of Bioengineering and Environmental Systems, Biomedical Engineering & Research Aiding Persons with Disabilities Program.

NDSU Press published the fifth issue of the *NSF 1993 Engineering Senior Design Projects to Aid the Disabled* in 1994. This book described ninety-one projects carried out by students at twenty-one universities across the United States during the 1992-93 academic year.

Creative Learning Press Inc. published the sixth issue of the *NSF 1994 Engineering Senior Design Projects to Aid the Disabled* in 1997. This book described ninety-four projects carried out by students at nineteen universities across the United States during the academic 1993-94 year.

In 1998, Creative Learning Press Inc. published the seventh issue of the *NSF 1995 Engineering Senior Design Projects to Aid the Disabled* in 1998. This book described one hundred and twenty-four projects carried out by students at nineteen universities across the United States during the 1994-95 academic year.

The eighth edition, the *National Science Foundation 1996 Engineering Senior Design Projects to Aid Persons With Disabilities,* was published in 1999. This book described ninety-three projects carried out by students at twelve universities across the United States during the 1995-96 academic year.

This book, funded by the NSF, describes and documents the NSF supported senior design projects during the ninth year academic year of this effort, 1996-97. As before, the purpose of this manuscript is to report on the engineering senior design projects developed and implemented by participating schools. Each chapter describes the activity at a single university and, except for the first two chapters, was written by the principal investigator(s) at that university, and revised by the editors of this publication. Individuals wishing more information on a particular design should contact the designated supervising principal investigator. An index is provided so that projects may be easily identified by topic.

It is hoped that this manuscript will enhance the overall quality of future senior design projects directed toward persons with disabilities by providing examples of previous projects, and by motivating faculty at other universities to participate because of the potential benefits to the student, school, and community. Moreover, the new technologies used in these projects will provide examples in a broad range of applications for new engineers. The ultimate goal of both this publication and all the projects that were built under this initiative is to assist individuals with disabilities in reaching their maximum potential for enjoyable and productive lives.

This NSF program has brought together individuals with widely varied backgrounds. Through the richness of their interests, a wide variety of projects were completed, and are in use. A number of different technologies were incorporated in the design projects, to maximize the impact of each device on the individual for whom it was developed.

A two-page project description format is generally used in this text. Each project is introduced with a nontechnical description, followed by a summary of impact that illustrates the effect of the project on an individual's life. A detailed technical description then follows. Photographs of the devices and other important components are incorporated throughout the manuscript.

None of the faculty received financial remuneration for supervising the building of devices or writing software within in this program. Each participating university typically has made a five-year commitment to the program.

Sincere thanks are extended to Dr. Allen Zelman, a former Program Director of the NSF BRAD program, for being the prime enthusiast behind this initiative. Additionally, thanks are extended to Drs. Peter G. Katona, Karen M. Mudry, Fred Bowman and Gil Devey, former and current NSF Program Directors of the Biomedical Engineering and Research to Aid Persons with Disabilities Programs, who have continued to support and expand the program.

We wish to acknowledge and thank Ms. Shari Valenta for the cover illustration and the artwork throughout the book, drawn from her observations at the Children's Hospital Accessibility Resource Center in Denver, Colorado. We also wish to acknowledge and thank William Pruehsner for drawing the technical illustrations used throughout the book and Jessica DeSimone for editorial assistance.

Readers familiar with previous editions of this book will note that John Enderle moved from North Dakota State University to the University of Connecticut in 1995. With that move, annual publications also moved from NDSU Press to Creative Learning Press Inc. in 1997. During 1994, Enderle also served as NSF Program Director for the Biomedical Engineering & Research Aiding Persons with Disabilities Program while on a leave of absence from NDSU.

Brooke Hallowell is a faculty member in the School of Hearing and Speech Sciences at Ohio University. Hallowell's primary area of expertise is in neurogenic communication disorders. She has a long history of collaboration with biomedical engineering in curriculum development, teaching, assessment, and research.

The editors welcome any suggestions as to how this review may be made more useful for subsequent yearly issues. Previous editions of this book are available for viewing at the WEB Site for this project: http://nsf-pad.bme.uconn.edu/.

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August 2000

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1997
ENGINEERING SENIOR DESIGN PROJECTS TO AID PERSONS WITH DISABILITIES

Chapter 1
INTRODUCTION

John Enderle and Brooke Hallowell

Devices and software to aid persons with disabilities often need custom modification, are prohibitively expensive, or nonexistent. Many persons with disabilities do not have access to custom modification of available devices and other benefits of current technology. Moreover, when available, engineering and support salaries often make the cost of custom modifications beyond the reach of the persons who need them.

In 1988, the National Science Foundation (NSF), through its Emerging Engineering Technologies Division, initiated a program to support student engineers, at universities throughout the United States, designing and building devices for persons with disabilities. Since its inception, this NSF program (originally called Bioengineering and Research to Aid the Disabled) has enhanced educational opportunities for students and improved the quality of life for individuals with disabilities. Students and university faculty provide, through their normal Accreditation Board for Engineering and Technology (ABET) accredited senior design class, engineering time to design and build the device or software. The NSF provides funds, competitively awarded to universities for supplies, equipment and fabrication costs for the design projects.

Outside of the NSF program, students are typically involved in design projects that incorporate academic goals for solid curricular design experiences, but that do not necessarily enrich the quality of life for persons other than, perhaps, the students themselves. For instance, students might design and construct a stereo receiver, a robotic unit that performs a household chore, or a model racecar.

Under this NSF program, engineering design students are involved in projects that result in original devices, or custom modifications of devices, that improve the quality of life for persons with disabilities. The students have opportunities for practical and creative problem solving to address well-defined needs, and persons with disabilities receive the products of that process. There is no financial cost incurred by the persons served in this program. Upon completion, the finished project becomes the property of the individual for whom it was designed.

The emphases of the program are to:

?? Provide disabled children and adults student-engineered devices or software to improve their quality of life and provide greater for self-sufficiency;

?? Enhance the education of student engineers by designing and building a device or software that meets a real need; and

?? Allow the university an opportunity for unique service to the local community.

Local school districts and hospitals participate in the effort by referring interested individuals to the program. A single student or a team of students specifically designs each project for an individual or a group of individuals with a similar need. Examples of projects completed in years past include a laser-pointing device for people who cannot use their hands, a speech aid, a behavior modification device, a hands-free automatic answering and hang-up telephone system, and an infrared beacon to help a blind person move around a room. The students participating in this project have been singularly rewarded through their activity with the disabled, and justly have experienced a unique sense of purpose and pride in their accomplishment.

The Current Book

This book describes the NSF supported senior design projects during the ninth year of this effort during the academic year 1996-97. The purpose of this publication is twofold. First, it is to serve as a reference or handbook for future senior design projects. Students are exposed to this unique body of applied information on current technology in this and previous editions of this book. This provides an even broader education than typically experienced in an undergraduate curriculum, especially in the area of rehabilitation design. Many technological advances originate from work in the space, defense, entertainment and communications industry. Few of these advances have been applied to the rehabilitation field, making the contributions of this NSF program all the more important.

Secondly, it is hoped that this publication will serve to motivate students, graduate engineers and others to work more actively in rehabilitation. This will ideally lead to an increased technology and knowledge base to effectively address the needs of persons with disabilities.

This introduction provides background material on the book, elements of design, and highlights the engineering design experiences at three universities that have participated in this effort.

After the introduction, 18 chapters follow, with each chapter devoted to one participating school. At the start of each chapter, the school and the principal investigator(s) are identified. Each project description is written using the following format. On page one, the individuals involved with the project are identified, including the student(s), the professor(s) who supervised the project, and key professionals involved in the daily lives of the individual for whom the project has been developed. A brief nontechnical description of the project follows with a summary of how the project has improved a person's quality of life. A photograph of the device or the device modification is usually included. Next, a technical description of the device or device modification is given, with parts specified only if they are of such a special nature that the project could not otherwise be fabricated. An approximate cost of the project is provided, excluding personnel costs.

Most projects are described in two pages. However, the first or last project in each chapter is usually significantly longer and contains more analytic content. Individuals wishing more information on a particular design should contact the designated supervising principal investigator.

Some of the projects described are custom modifications of existing devices, modifications that would be prohibitively expensive to the disabled individual were it not for the student engineers and this NSF program. Other projects are unique one-of-a kind devices wholly designed and constructed by the student for the disabled individual.

Engineering Design

As part of the accreditation process for university engineering programs, students are required to complete a minimum number of design credits in their course of study, typically at the senior level.[1, 2] Many call this the *capstone course*. Engineering design is a course or series of courses that brings together concepts and principles that students learn in their field of study. It involves the integration and extension of material learned throughout an academic program to achieve a specific design goal. Most often, the student is exposed to system-wide analysis, critique and evaluation. Design is an iterative, decision making process in which the student optimally applies previously learned material to meet a stated objective.

There are two basic approaches to teaching engineering design, the traditional or discipline-dependent approach, and the holistic approach. The traditional approach involves reducing a system or problem into separate discipline-defined components. This approach minimizes the essential nature of the system as a holistic or complete unit, and often neglects the interactions that take place between the components. The traditional approach usually involves a sequential, iterative approach to the system or problem, and emphasizes simple cause-effect relationship.

A more holistic approach to engineering design is becoming increasingly feasible with the availability of powerful computers and engineering software packages, and the integration of systems theory, which

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[1] Accrediting Board for Engineering and Technology (1999). Accreditation Policy and Procedure Manual Effective for Evaluations for the 2000-2001 Accreditation Cycle. ABET: Baltimore, MD.
[2] Accrediting Board for Engineering and Technology (2000). Criteria for Accrediting Engineering Programs. ABET: Baltimore, MD.

addresses interrelationships among system components as well as human factors. Rather than partitioning a project based on discipline-defined components, designers partition the project according to the emergent properties of the problem.

A design course provides opportunities for problem solving relevant to large-scale, open- ended, complex, and sometimes ill-defined systems. The emphasis of design is not on learning new material. Typically, there are no required textbooks for the design course, and only a minimal number of lectures are presented to the student. Design is best described as an individual study course where the student:

Selects the device or system to design

- ?? Writes specifications
- ?? Creates a paper design
- ?? Analyzes the paper design
- ?? Constructs the device
- ?? Evaluates the device
- ?? Documents the design project

Project Selection

In a typical NSF design project, the student meets with the client (a person with a disability and/or a client coordinator) to assess needs and to help identify a useful project. Often, the student meets with many clients before finding a project for which his or her background is suitable.

After selecting a project, the student then writes a brief description of the project for approval by the faculty supervisor. Since feedback at this stage of the process is vitally important for a successful project, students usually meet with the client once again to review the project description.

Projects are often undertaken by teams of students. One or more members of a team meet with one or more clients before selecting a project. After project selection, the project is partitioned by the team into logical parts, and each student is assigned one of these parts. Usually, a team leader is elected by the team to ensure that project goals and schedules are satisfied. A team of students generally carries out multiple projects.

Project selection is highly variable depending on the university, and the local health care facilities. Some universities make use of existing technology to develop projects to aid the disabled by accessing databases such as ABLEDATA. ABLEDATA includes information on types of assistive technology, consumer guides, manufacturer directories, commercially available devices, and one-of-a-kind customized devices. In total, this database has over 23,000 products from 2,600 manufactures and is available from:

http://www.abledata.com
or
(800) 227-0216

More information about this NSF program is available at

http://nsf-pad.bme.uconn.edu

Specifications

One of the most important parts of the design process is determining the specifications, or requirements that the design project must fulfill. There are many different types of hardware and software specifications.

Prior to the design of a project, a statement as to how the device will function is required. Operational specifications are incorporated in determining the problem to be solved. Specifications are defined such that any competent engineer is able to design a device that will perform a given function. Specifications determine the device to be built, but do not provide any information about how the device is built. If several engineers design a device from the same specifications, all of the designs would perform within the given tolerances and satisfy the requirements; however, each design would be different. No manufacturer's name or components are stated in specifications. For example, specifications do not list electronic components or even a microprocessor since use of these components implies that a design choice has been made.

If the design project involves modifying an existing device, the modification should be fully described in as much detail as possible in the specifications. In this case, it is desired to describe the device by discussing specific components, such as the microprocessor, LEDs, and electronic components. This level of detail in describing the existing device is appropriate because it defines the environment to which the design project must interface. However, the specifications for the modification should not provide any information about how the device is to be built.

Specifications are usually written in a report that qualitatively describes the project as completely as possible, and how the project will improve the life of an individual. It is also important to provide motivation for carrying out the project in the specifications. The following issues are also addressed in the specifications:

?? What will the finished device do?

?? What is unusual about the device?

Specifications also include a technical description of the device, and contain, usually in tabular format, all of the facts and figures needed to complete the design project. The following are examples of important items included in technical specifications.

Electrical Parameters

interfaces

voltages

impedances

gains

power output

power input

ranges

current capabilities

harmonic distortion

stability

accuracy

precision

power consumption

Mechanical

size

weight

durability

accuracy

precision

vibration

Environmental

location

temperature range

moisture

dust

Paper Design and Analysis

The next phase of the design is the generation of possible solutions to the problem based on the specifications, and selection of the optimal solution. This involves creating a paper design for each of the solutions and evaluating performance based on the specifications. Since design projects are open-ended, many solutions exist, solutions that often require a multidisciplinary system or holistic approach for a successful and useful project. This stage of the design process is typically the most challenging because of the creative aspect to generating problem solutions.

The specifications previously described are the criteria for selecting the best design solution. In many projects, some specifications are more important than others and trade-offs between specifications may be necessary. In fact, it may be impossible to design a project that satisfies all of the design specifications. Specifications that involve some degree of flexibility are helpful in reducing the overall complexity, cost and effort in carrying out the project. Some specifications are absolute and cannot be relaxed whatsoever.

Most projects are designed in a top-down approach similar to the approach of writing computer software by first starting with a flow chart. After the flow chart or block diagram is complete, the next step involves providing additional details to each block in the flowchart. This continues until sufficient detail exists to determine whether the design meets the specifications after evaluation.

To select the optimal design, it is necessary to analyze and evaluate the possible solutions. For ease in analysis, it is usually easiest to use computer software. For example, PSpice, a circuit analysis program, easily analyzes circuit analysis problems. Other situations require that a potential design project solution be partially constructed or breadboarded for analysis and evaluation. After analysis of all possible solutions, the optimal design selected is the one that meets the specifications most closely.

Construction and Evaluation of the Device

After selecting the optimal design, the student then constructs the device. The best method of construction is to build the device module by module. By building the project in this fashion, the student is able to test each module for correct operation before adding it to the complete device. It is far easier to eliminate problems module by module than to build the entire project, and then attempt to eliminate problems.

Design projects should be analyzed and constructed with safety as one of the highest priorities. Clearly, the design project that fails should fail in a safe manner, a fail-safe mode, without any dramatic and harmful outcomes to the client or those nearby. An example of a fail-safe mode of operation for an electrical device involves grounding the chassis, and using appropriate fuses; thus if ever a 120-V line voltage short circuit to the chassis should develop, a fuse would blow and no harm to the client would occur. Devices should also be protected against runaway conditions during the operation of the device, and also during periods of rest. Failure of any critical components in a device should result in the complete shutdown of the device.

After the project has undergone laboratory testing, it is then tested in the field with the client. After the field test, modifications are made to the project, and then the project is given to the client. Ideally, the design project in use by the disabled person should be periodically evaluated for performance and usefulness after the project is complete. Evaluation typically occurs, however, when the device no longer performs adequately for the disabled person, and is returned to the university for repair or modification. If the repair or modification is simple, a university technician will handle the problem. If the repair or modification is more extensive, another design student is assigned to the project to handle the problem as part of their design course requirements.

Documentation

Throughout the design process, the student is required to document the optimal or best solution to the problem through a series of required written assignments. For the final report, documenting the design project involves integrating each of the required reports into a single final document. While this should be a simple exercise, it is usually a most vexing and difficult endeavor. Many times during the final stages of the project, some specifications are changed, or extensive modifications to the ideal paper design are necessary.

Most universities also require that the final report be professionally prepared using desktop publishing software. This requires that all circuit diagrams and mechanical drawings be professionally drawn. Illustrations are usually drawn with computer software, such as OrCAD or AutoCAD.

The two-page reports within this publication are not representative of the final reports submitted for design course credit, and in fact, are a summary of the final report. A typical final report for a design project is approximately 30 pages in length, and includes extensive analysis supporting the operation of the design project. Usually, photographs of the device are not included in the final report since mechanical and electrical diagrams are more useful to the engineer to document the device.

The next three sections illustrate different approaches to the design course experience. At Texas A&M University, the students work on many small design projects during the two-semester senior design course sequence. At North Dakota State University, students work on a single project during the two-semester senior design course sequence. At the University of Connecticut, students are involved in distance learning and a WWW based approach.

Texas A&M University Engineering Design Experiences

The objective of the NSF program at Texas A&M University is to provide senior bioengineering students an experience in the design and development of rehabilitation devices and equipment to meet explicit client needs identified at several off campus rehabilitation and education facilities. Texas A&M has participated in the NSF program for six years. The students meet with therapists and/or special education teachers for problem definition under faculty supervision. This program provides very significant “real world” design experiences, emphasizing completion of a finished product. Moreover, the program brings needed technical expertise that would otherwise not be available to not-for-profit rehabilitation service providers. Additional benefits to the participating students involve their development of an appreciation of the problems of disabled persons, motivation toward rehabilitation engineering as a career path, and recognition of the need for more long-term research to address the problems for which today's designs are only an incomplete solution.

Texas A&M University's program involves a two-course capstone design sequence, BIEN 441 and 442. BIEN 441 is offered during the Fall and Summer semesters, and BIEN 442 is offered during the Spring semester. The inclusion of the summer term allows a full year of ongoing design activities. Students are allowed to select a rehabilitation design project, or another general bioengineering design project.

The faculty at Texas A&M University involved with the rehabilitation design course have worked in collaboration with the local school districts, community rehabilitation centers, residential units of the Texas Department of Mental Health and Mental Retardation (MHMR), community outreach programs of Texas MHMR, and individual clients of the Texas Rehabilitation Commission and Texas Commission for the Blind.

Appropriate design projects are identified in group meetings between the staff of the collaborating agency, the faculty, and the participating undergraduate students enrolled in the design class. In addition, one student is employed in the design laboratory during the summer to provide logistical support, as well as pursue his or her own project. Each student is required to participate in the project definition session, which adds to the overall design experience. The meetings take place at the beginning of each semester, and periodically thereafter as projects are completed and new ones identified.

The needs expressed by the collaborating agencies often result in projects that vary in complexity and required duration. To meet the broad spectrum of needs, simpler projects are accommodated by requiring rapid completion, at which point the students move on to another project. More difficult projects involve one or more semesters, or even a year's effort; these projects are the ones that typically require more substantial quantitative and related engineering analysis. Projects are carried out by individual students or a team of two.

Following the project definition, the students proceed through the formal design process of brainstorming, clarification of specifications, preliminary design, review with the collaborating agency, design execution and safety analysis, documentation, prerelease design review, and delivery and implementation in the field. The execution phase of the design includes identifying and purchasing necessary components and materials, arranging for any fabrication services that may be necessary, and obtaining photography for their project reports. Throughout each phase of the project, the faculty supervises the work, as well as the teaching assistants assigned to the rehabilitation engineering laboratory. These teaching assistants are paid with university funds. The students also have continued access to the agency staffs for clarification or revision of project definitions, and review of preliminary designs. The latter is an important aspect of meeting real needs with useful devices. In addition to individual and team progress, the rehabilitation engineering group meets as a group to discuss design ideas and project progress, and to plan further visits to the agencies.

One challenging aspect of having students be responsible for projects that are eagerly anticipated by the intended recipient is the variable quality of student work, and the inappropriateness of sending inadequate projects into the field. This potential problem is resolved at Texas A&M University by continuous project review, and by requiring that the project be revised and reworked until it meets faculty approval.

At the end of each academic year, the faculty and the personnel from each collaborating agency assess which types of projects met with the greatest success in achieving useful delivered devices. This review has provided ongoing guidance in the selection of future projects. The faculty also maintains continuous contact with agency personnel with respect to ongoing and past projects, that require repair or modification. In some instances, repairs are assigned as short-term projects to currently participating students. This provides an excellent lesson in the importance of adequate documentation.

Feedback from participating students is gathered each semester using the Texas A&M University student "oppinionaire" form as well as personal discussion. The objective of the reviews is to obtain students' assessment of the educational value of the rehabilitation design program, the adequacy of the resources and supervision, and any suggestions for improving the process.

North Dakota State University Engineering Design Experience

North Dakota State University (NDSU) has participated in this program for six years. All senior electrical engineering students at NDSU are required to complete a two-semester senior design project as part of their study. These students are partitioned into faculty supervised teams of four to six students. Each team designs and builds a device for a particular disabled individual within eastern North Dakota or western Minnesota.

During the early stages of NDSU's participation in projects to aid the disabled, a major effort was undertaken to develop a complete and workable interface between the NDSU electrical engineering department and the community of persons with disabilities to identify potential projects. These organizations are the Fargo Public School System, NDSU Student Services and the Anne Carlson School. NDSU students visit potential clients or their supervisors to identify possible design projects at one of the cooperating organizations. All of the senior design students visit one of these organizations at least once. After the site visit, the students write a report on at least one potential design project, and each team selects a project to aid a particular individual.

The process of a design project is implemented in two parts. During the first semester of the senior year, each team writes a report describing the project to aid an individual. Each report consists of an introduction to the project establishing the need for the project. The body of the report describes the device; a complete and detailed engineering analysis is included to establish that the device has the potential to work. Almost all of the NDSU projects involve an electronic circuit. Typically, devices that involve an electrical circuit are analyzed using PSpice, or another software analysis program. Extensive testing is undertaken on subsystem components using breadboard circuit layouts to ensure a reasonable degree of success before writing the report. Circuits are drawn for the report using OrCAD, a CAD program. The OrCAD drawings are also used in the second phase of design, which allows the students to bring a circuit from the schematic to a printed circuit board with relative ease.

During the second semester of the senior year, each team builds the device to aid an individual. This first involves breadboarding the entire circuit to establish the viability of the design. After verification, the students build a printed circuit board(s) using OrCAD, and then finish the construction of the project using the fabrication facility in the electrical engineering department. The device is then fully tested, and after approval by the senior design faculty advisor, the device is given to the client. Each of the student design teams receives feedback throughout the year from the client or client coordinator to ensure that the design meets its intended goal.

Each design team provides an oral presentation during regularly held seminars in the department. In the past, local TV stations have filmed the demonstration of the senior design projects, and broadcast the tape on their news show. This media exposure usually results in viewers contacting the electrical engineering department with requests for projects to improve the life of another individual, further expanding the impact of the program.

Design facilities are provided in three separate laboratories for analysis, prototyping, testing, printed circuit board layout, fabrication, and redesign/development. The first laboratory is a room for team meetings during the initial stages of the design. Data books and other resources are available in this room.

There are also twelve workstations available for teams to test their design, and verify that the design parameters have been meet. These workstations consist of a power supply, waveform generator, oscilloscope, breadboard, and a collection of hand tools.

The second laboratory contains Intel computers for analysis, desktop publishing and microprocessor testing. The computers all have analysis, CAD and desktop publishing capabilities so that students may easily bring their design projects from the idea to implementation stage. Analysis software supported includes Microsoft EXCEL and Lotus 123 spreadsheets, PSpice, MATLAB, MATHCAD, and VisSim. Desktop publishing supported includes Microsoft Word for Windows, Aldus PageMaker, and technical illustration software via AutoCAD and OrCAD. A scanner with image enhancement software and a high-resolution printer are also available in the laboratory.

The third laboratory is used by the teams for fabrication. Six workstations exist for breadboard testing, soldering, and finish work involving printed circuit boards. Sufficient countertop space exists so that teams may leave their projects in a secure location for ease in work.

The electrical engineering department maintains a relatively complete inventory of electronic components necessary for design projects, and when not in stock, has the ability to order parts with minimal delay. The department also has a teaching assistant assigned to this course on a year round basis, and an electronics technician available for help in the analysis and construction of the design project.

There were many projects constructed at NDSU (and probably at many other universities) that proved to be unsafe or otherwise unusable for the intended individual, despite the best efforts of the student teams under the supervision of the faculty advisors. These projects are undocumented.

University of Connecticut Design Experiences

In August 1998 the Department of Electrical & Systems Engineering (ESE) at UConn, in collaboration with the School of Hearing and Speech Sciences at Ohio University, received a five-year NSF grant for senior design experiences to aid persons with disabilities. This NSF project was a pronounced change from previous design experiences at UConn that involved industry sponsored projects carried out by a team of student engineers. In order to provide effective communication between the sponsor and the student team, a WWW based approach was implemented.[3] Under the new scenario, students worked individually on a project and were divided into teams for weekly meetings. The purpose of the team was to provide student derived technical support at weekly meetings. Teams also formed throughout the semester based on need to solve technical problems. After the problem was solved the team dissolved and new teams were formed.

Each year, 25 projects are carried out by the students at UConn. Five of the twenty-five projects are completed through collaboration with personnel at Ohio University using varied means of communication currently seen in industry, including video conferencing, the WWW, telephone, e-mail, postal mailings, and videotapes.

ESE senior design consists of two required courses, Electrical Engineering (EE) Design I and II. EE Design I is a two-credit hour course in which students are introduced to a variety of subjects. These include: working on teams, design process, planning and scheduling (time-lines), technical report writing, proposal writing, oral presentations, ethics in design, safety, liability, impact of economic constraints, environmental considerations, manufacturing and marketing. Each student in EE Design I:

Selects a project to aid a disabled individual after interviewing a person with disabilities;

- ?? Drafts specifications;
- ?? Prepares a project proposal;
- ?? Selects an optimal solution and carries out a feasibility study;
- ?? Specifies components, conducts a cost analysis and creates a time-line; and
- ?? Creates a paper design with extensive modeling and computer analysis.

EE Design II is a three-credit hour course following Design I. This course requires students to implement a design by completing a working model of the final product. Prototype testing of the paper design typically requires modification to meet specifications. These modifications undergo proof of design using commercial software programs commonly used in industry. Each student in EE Design II:

- ?? Constructs and tests a prototype using modular components as appropriate;
- ?? Conducts system integration and testing;
- ?? Assembles final product and field-tests the device;
- ?? Writes final project report;
- ?? Presents an oral report using PowerPoint on Senior Design Day; and
- ?? Gives the device to the client after a waiver is signed.

Course descriptions, student project homepages and additional resources are located at http://design.ee.uconn.edu/.

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[3] Enderle, J.D., Browne, A.F., and Hallowell, B. (1998). A WEB Based Approach in Biomedical Engineering Design Education. Biomedical Sciences Instrumentation, 34, pp. 281-286.

The first phase of the on-campus projects involves creating a database of persons with disabilities and then linking the student with a person with a disability. The A.J. Pappanikou Center provided a database with almost 60 contacts and a short description of the disabilities in MS Access. The involvement of the Center was essential for the success of the program. The A.J. Pappanikou Center is Connecticut's University Affiliated Program (UAP) for disabilities studies. As such, relationships have been established with the Connecticut community of persons affected by disabilities, including families, caregivers, advocacy and support groups and, of course, persons with disabilities themselves. The Center serves as the link between the person in need of the device and the ESE Design course staff. The Center has established ongoing relationships with Connecticut's Regional Educational Service Centers, the Birth to Three Network, the Connecticut Tech Act Project, and the Department of Mental Retardation. Through these contacts, the Center facilitates the interaction between the ESE students, the client coordinators (professionals providing support services, such as the speech-language pathologists, physical and occupational therapists), the individuals with disabilities (clients), and clients' families.

The next phase of the course involves students' selection of projects. Using the on-campus database, each student selects two clients to interview. The student and a UConn staff member meet with the client and/or client coordinator to identify a project that would improve the quality of life for the client. After the interview, the student writes a brief description for each project. Almost all of the clients interviewed have multiple projects. Project descriptions include: contact information (client, client coordinator, and student name) and a short paragraph describing the problem. These reports are collected, sorted by topic area, and put into a Project Notebook. In the future, these projects will be stored in a database accessible from the course server for ease in communication.

Each student then selects a project from a client that he/she has visited, or from the Project Notebook. If the project selected was from the Project Notebook, the student visits the client to further refine the project. Because some projects do not involve a full academic year to complete, some students work on multiple projects.

Following project selection, students submit a project statement that describes the problem, including a statement of need, basic preliminary requirements, basic limitations, other data accumulated, and important unresolved questions.

Specific projects at Ohio University are established via distance communication with the co-principal investigator, who consults with a wide array of service providers and potential clients in the Athens, Ohio region.

The stages of specification, project proposal, paper design and analysis, construction and evaluation, and documentation are carried out as described earlier in the overview of engineering design.

To facilitate working with sponsors, a WWW based approach is used for reporting the progress on projects. Students are responsible for creating their own WWW sites that support both html and pdf formats with the following elements:

?? Introduction for layperson

?? Resume

?? Weekly reports

?? Project statement

?? Specifications

?? Proposal

?? Final Report

Weekly Schedule

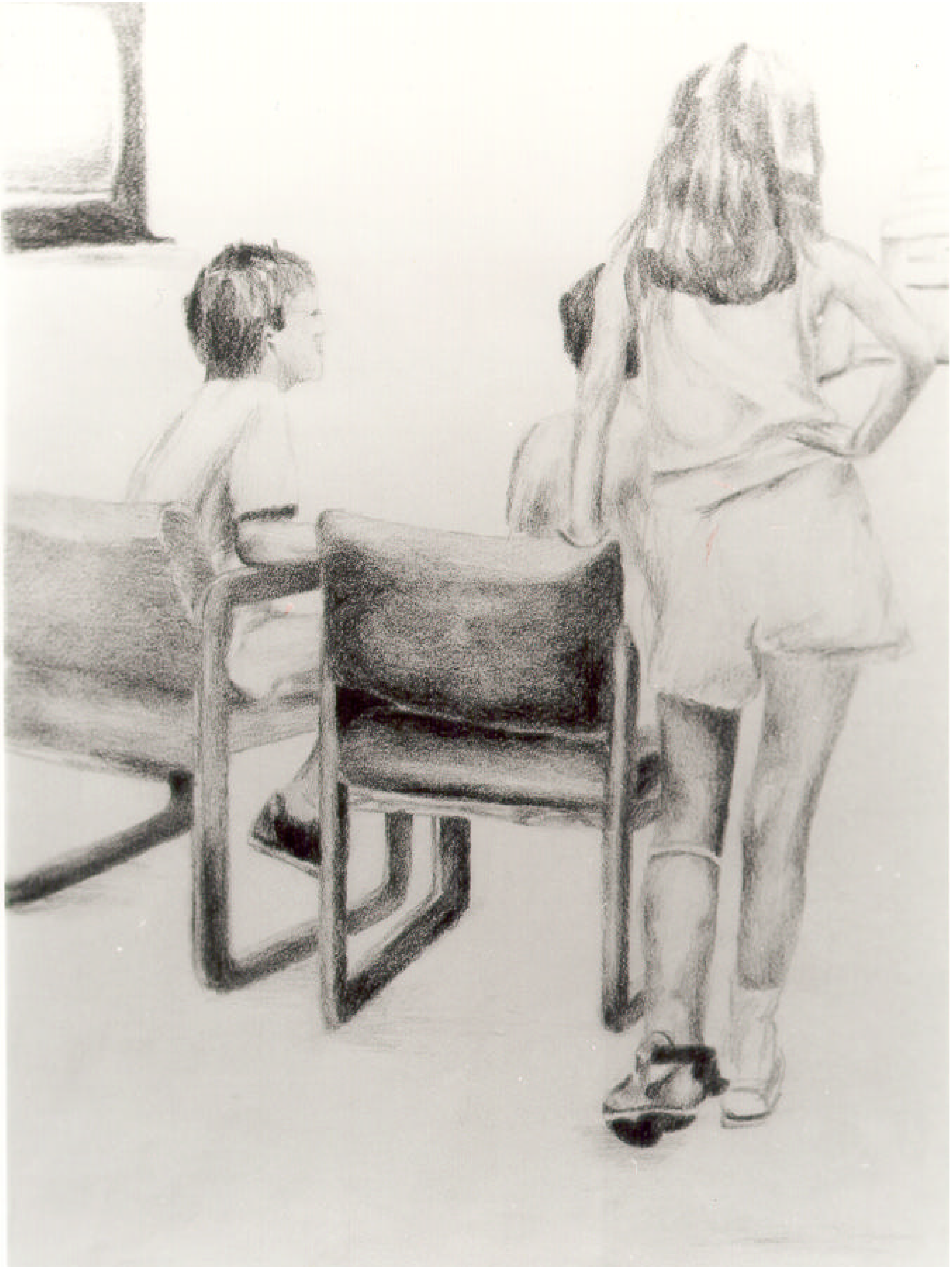
Weekly activities in EE Design I consist of lectures, student presentations and a team meeting with the instructor. Technical and non-technical issues that impact the design project are discussed during team meetings. Students also meet with clients/coordinators at scheduled times to report on progress.

Each student is expected to provide an oral progress report on his or her activity at the weekly team meeting with the instructor, and record weekly progress in a bound notebook and on the WWW site. Weekly report structure for the WWW includes: project identity, work completed during the past week, current work within the last day, future work, status review and at least one graphic inserted into the report. The client and/or client coordinator uses the WWW reports to keep up with project so that they can provide input on the progress. Weekly activities in EE Design II include team meetings with the course instructor, oral and written progress reports, and construction of the project. As before, the WEB is used to report project progress and communicate with the sponsors.

For the past two years, the student projects have been presented at the annual Northeast Biomedical Engineering Conference.

Other Engineering Design Experiences

Experiences at other universities participating in this NSF program combine many of the design program elements presented here. Still, each university's program is unique. In addition to the design process elements already described, the State University of New York at Buffalo, under the direction of Dr. Joseph Mollendorf, requires that each student go through the preliminary stages of a patent application. Naturally, projects worthy of a patent application are actually submitted. Thus far, a patent was issued for a "Four-Limb Exercising Attachment for Wheelchairs" and another patent has been allowed for a "Cervical Orthosis."



Chapter 2
IMPROVING DESIGN PROJECTS TO AID PERSONS WITH DISABILITIES: FOCUS ON EDUCATIONAL OUTCOMES

Brooke Hallowell

Of particular interest to persons interested in the engineering education are the increasingly outcomes focused standards of the Accrediting Board for Engineering and Technology (ABET).[2] This chapter is offered as an introduction to the ways in which improved foci on educational outcomes may lead to: (a) improvements in the learning of engineering students, especially those engaged in design projects to aid persons with disabilities, and consequently, (b) improved knowledge, design and technology to benefit individuals in need.

Brief History

As part of a movement for greater accountability in higher education, US colleges and universities are experiencing an intensified focus on the assessment of students' educational outcomes. The impetus for outcomes assessment has come most recently from accrediting agencies. All regional accrediting agencies receive their authority by approval from the Council for Higher Education Accreditation (CHEA), which assumed this function from the Council on Recognition of Postsecondary Accreditation (CORPA) in 1996. The inclusion of outcomes assessment standards as part of accreditation by any of these bodies, such as North Central, Middle States, or Southern Associations of Colleges and Schools, and professional accrediting bodies, including ABET, is mandated by CHEA, and thus is a requirement for all regional as well as professional accreditation. Consequently, candidates for accreditation are required to demonstrate plans for assessing educational outcomes, and evidence that assessment results have led to improved teaching and learning and, ultimately, better preparation for entering the professions. Accrediting bodies have thus revised criteria standards for accreditation with greater focus on the "output" that students can demonstrate and less on the "input" they are said to receive.[3]

"Meaningful" Assessment Practices

Because much of the demand for outcomes assessment effort is perceived, at the level of instructors, as a bureaucratic chore thrust upon them by administrators and requiring detailed and time-consuming documentation, there is a tendency for many faculty members to avoid exploration of effective assessment practices. Likewise, many directors of academic departments engage in outcomes assessment primarily

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[1] Accrediting Board for Engineering and Technology (2000). Criteria for Accrediting Engineering Programs. ABET: Baltimore, MD.

[2] Hallowell, B. & Lund, N. (1998). Fostering program improvements through a focus on educational outcomes. In Council of Graduate Programs in Communication Sciences and Disorders, Proceedings of the nineteenth annual conference on graduate education, 32-56.

[3] Hallowell, B. (1996). Innovative Models of Curriculum/Instruction: Measuring educational Outcomes. In Council of Graduate Programs in Communication Sciences and Disorders, Proceedings of the seventeenth annual conference on graduate education, 37-44.

so that they may submit assessment documentation to meet bureaucratic requirements. Thus, there is a tendency in many academic units to engage in assessment practices that are not truly "meaningful".[3]

Although what constitutes an "ideal" outcomes assessment program is largely dependent on the particular program and institution in which that program is to be implemented, there are at least some generalities we might make about what constitutes a "meaningful" program. For example:

> An outcomes assessment program perceived by faculty and administrators as an imposition of bureaucratic control over what they do, remote from any practical implications… would not be considered "meaningful." Meaningful programs, rather, are designed to enhance our educational missions in specific, practical, measurable ways, with the goals of improving the effectiveness of training and education in our disciplines. They also involve all of a program's faculty and students, not just administrators or designated report writers. Furthermore, the results of meaningful assessment programs are actually used to foster real modifications in a training program.[2]

Outcomes Associated with Engineering Design Projects

Despite the NSF's solid commitment to engineering design project experiences, and widespread enthusiasm about this experiential approach to learning and service, there is a lack of documented solid empirical support for the efficacy and validity of design project experiences and the specific aspects of implementing those experiences. Concerted efforts to improve learning, assessment methods and data collection concerning pedagogic efficacy of engineering design project experiences will enhance student learning while benefiting the community of persons with disabilities.

Agreeing on Terms

There is great variability in the terminology used to discuss educational outcomes. How we develop and use assessments matters much more than our agreement on the definitions of each of the terms we might use to talk about assessment issues. Still, for the sake of establishing common ground, a few key terms are highlighted here.

Formative and Summative Outcomes

Formative outcome indices are those that can be used to shape the experiences and learning opportunities of the very students who are being assessed. Examples are surveys of faculty regarding current students' design involvement, on-site supervisors' evaluations, computer programming proficiency evaluations, and classroom assessment techniques.[4] The results of such assessments may be used to characterize program or instructor strengths and weaknesses, as well as to foster changes in the experiences of those very students who have been assessed.

Summative outcome measures are those used to characterize programs (or college divisions, or even whole institutions) by using assessments intended to capture information about the final products of our programs. Examples are student exit surveys, surveys of graduates inquiring about salaries, employment, and job satisfaction, and surveys of employers of our graduates.

The reason the distinction between these two types of assessment is important is that, although formative assessments tend to be the ones that most interest our faculty and students and the ones that drive their daily academic experiences, the outcomes indices on which most administrators focus to monitor institutional quality are those involving summative outcomes. It is important that each of academic unit strive for an appropriate mix of both formative and summative assessments.

Cognitive/Affective/Performative Outcome Distinctions

To stimulate our clear articulation of the specific outcomes targeted within any program, it is helpful to have a way to characterize different types of outcomes. Although the exact terms vary from context to context, targeted educational outcomes are commonly characterized as belonging to one of three domains: cognitive, affective, and performative. Cognitive outcomes are those relating to intellectual mastery, or mastery of knowledge in specific topic areas. Most of our course-specific objectives relating to a specific knowledge base fall into this category. Performance outcomes are those relating to a student's or graduate's accomplishment of a behavioral task. Affective outcomes relate to personal qualities and values that students ideally gain from their experiences during a particular educational program. Examples are appreciation of various racial, ethnic, or linguistic backgrounds of individuals, awareness of biasing factors

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[4] Angelo, T. A., & Cross, K. P. (1993). Classroom assessment techniques: A handbook for college teachers. San Francisco: Josey-Bass.

in the design process, and sensitivity to ethical issues and potential conflicts of interest in professional engineering contexts.

The distinction among these three domains of targeted educational outcomes is helpful in highlighting areas of learning that we often proclaim to be important but that we do not assess very well. Generally, we are better at assessing our targeted outcomes in the cognitive area, for example, with in-class tests and papers, than we are with assessing the affective areas of multicultural sensitivity, appreciation for collaborative teamwork, and ethics. Often, our assessment of performative outcomes is focused primarily on students' design experiences, even though our academic programs often have articulated learning goals in the performative domain that might not apply only to design projects.

Faculty Motivation

A critical step in developing a meaningful educational outcomes program is to address directly pervasive issues of faculty motivation. Faculty resistance is probably due in large part to the perception that outcomes assessment involves the use of educational and psychometric jargon to describe program indices that are not relevant to the everyday activities of faculty members and students. By including faculty, and perhaps student representatives, in discussions of what characterizes a meaningful assessment scheme to match the missions and needs of individual programs, and by agreeing to develop outcomes assessment practices from the bottom up, rather than in response to top-down demands from administrators and accrediting agencies, current skeptics on our faculties are more likely to engage in assessment efforts.

Additional factors that might give faculty the incentive to get involved in enriching assessment practices include:

> [Consider] outcomes assessment work as part of annual merit reviews; [provide] materials, such as sample instruments, or resources, such as internet sites, to simplify the assessment instrument design process; demonstrate means by which certain assessments, such as student exit or employer surveys, may be used to [a] program's advantage in negotiations with… administration (for example, to help justify funds for new equipment, facilities, or salaries for faculty and supervisory positions); and notice and reward curricular modifications and explorations of innovative teaching methods initiated by the faculty in response to program assessments.[2]

A Call for Collaboration

With the recent enhanced focus of on educational outcomes in accreditation standards of ABET, and with all regional accrediting agencies in the Unites States now requiring extensive outcomes assessment plans for all academic units, it is increasingly important that we share assessment ideas and methods among academic programs. It is also important that we ensure that our assessment efforts are truly meaningful, relevant and useful to our students and faculty.

Future annual publications pertaining to assessment issues as they relate to NSF-sponsored engineering design projects to aid persons with disabilities will include requests for collaboration among students and faculty to enhance associated educational outcomes in specific ways. The editors of this book look forward to input from the engineering education community for dissemination of further information to that end.

Chapter 3
ARIZONA STATE UNIVERSITY

College of Engineering and Applied Sciences
Bioengineering Program
Department of Chemical, Bio & Materials Engineering
Tempe, Arizona 85287-6006

Principal Investigators:

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Jiping He, Ph.D. (602) 965-0092

ARCHERY ASSISTING PROSTHESIS FOR BELOW-ELBOW AMPUTEES

Designers: Tim Nieman
Client: Richard Dillenburg
Supervising Professor: Jiping He, Ph.D.
Department of Chemical, Bio & Materials Engineering
Arizona State University
Tempe, Arizona 85287-6006

INTRODUCTION

An archery device was designed to aid a person with a below-elbow amputation. It will help the person grasp the bow in a comfortable and safe manner. The design is very adaptable to different situations, such as archery competitions, archery hunting, and target practice. The prosthetic was made primarily of aluminum and fiberglass to minimize weight.

SUMMARY OF IMPACT

An essential aspect of a patient's rehabilitation after an injury is resuming recreational activities, as well as returning to work and family roles. When the injury involves amputation of a limb, a return to the patient's recreational activities can speed mental healing, improve self-image, and restore functionality in everyday events.

In the present case the patient was unable to continue practicing archery due pain caused by prosthetic devices. The patient's residual limb terminated approximately 8 cm below the elbow. This meant that the load bearing soft tissue area was reduced, and thus the forces caused the patient a great deal of pain. The new prosthesis was designed to eliminate this pain.

TECHNICAL DESCRIPTION

The design requirements of the archery prosthesis can be broken into two main categories: patient requirements, and usage requirements.

Patient Requirements:

1. Capable of being used on a below elbow amputee with a residual skeletal forearm between 4-15 cm in length.
2. Device weight less than 1.5 times that of estimated original limb weight.
3. Comfortable under all possible loading conditions that the user may experience.
4. Safe for use in all situations.
5. Non-allergenic, biocompatible, and ergonomic during use.
6. Size and form similar to that of the user's anatomical counterpart.

Usage Requirements:

1. Capable of handling draw weights between 50 and 90 pounds (corresponding to the compressive strength of prosthetic).
2. Able to withstand tensile forces of 8 pounds and a torque of 10 foot-pounds.
3. Adjustable prosthetic angles and lengths for optimal bow positioning.
4. Bow able to disconnect from the prosthesis in a reasonable amount of time (maximum time of 15 sec).
5. All components suitable for outdoor use (all weather conditions)

After considering several designs it was decided that the best way to attach the prosthesis to the residual arm was to have the patient flex his elbow during use. This allowed the forces previously placed on the soft tissues of the residual limb to be redistributed to the elbow and the posterior surface of the ulna. Pain occurring with other available prostheses was eliminated. Since the patient had a very short residual limb, it did not interfere with the operation of the bow.

The portion of the prosthetic encompassing the arm was manufactured by taking a cast of the user's arm while was flexed at 90?. The cast was made from 20 cm above the elbow to 12 cm below the elbow. It was then used to produce a mold in which the user placed his arm. The mold was made of graphite/fiberglass/Kevlar laminate, an industry standard for prosthetic and orthotic applications. This material works very well, in terms of providing a stable base for the prosthesis and being biocompatible under long-term usage. A small piece of strap, 5R1, was rigidly attached to the distal end of the molded prosthesis using fiberglass. It can be tightened to better secure the prosthetic to the arm.

One of the major components of the prosthetic is the mechanism that holds the bow. An IceRoss Lock Mechanism is used. It consists of a plastic body and a ridged pin. The pin was mounted and attached to the bow by a bracket. When the pin is inserted into the body, a one-way gear rotates with the ridges of the pin and holds it securely in place. The pin can be released by pressing a large push button on the side of the IceRoss Lock Mechanism. Pressing this button releases the pin by pushing the gear into the body and out of alignment with the pin. The button is spring loaded, and thus the gear slides back into place once the button is released. The pin itself is 1 cm in diameter and performed with a large safety factor under testing. It held the required 8-pound tensile force. The body of the lock mechanism supported all of the compressive forces, relieving the pin from this duty. The pin withstood the required 10 foot-pounds of torque. An additional pin of 3/8? diameter, called the counter pin, protrudes from the mounting bracket. The purpose of this pin is to prevent any rotation around the axis of the pins.

A 30 mm O.D. aluminum tube with a pyramid pivot joint on each end was used to attach the 5R1 to the IceRoss Lock Mechanism. The pyramid pivot joints allowed the user to adjust the angle of the bow from 0? to 10?, up to 5? more than the average angle used. The joints were attached to both the 5R1 and the locking mechanism by four 5-32 machine screws. The length of the archery prosthetic could be adjusted by changing the length of the aluminum tube.

Figure 3.1. Archery Device Being Tested by Designer.

The final archery prosthetic weighs 4.5 pounds. It was tested extensively by the designer, using many different drawing techniques and loading conditions (see Figure 3.1). It was deemed to be functional, safe, and comfortable. Testing also revealed that removal and attachment of the bow using the lock mechanism took approximately 4 sec., which was well under the 15 sec. requirement.

The final cost of the archery prosthesis was approximately $300.

MEDICATION MANAGEMENT SYSTEM: AN AUTOMATIC PILL DISPENSER FOR PERSONS WITH MENTAL ILLNESS

Designers: Julie Hochstrasser
Client Coordinator: Triple R Foundation Behavioral Health Services
Supervising Professors: Gary Yamaguchi, Ph.D. and James Sweeney, Ph.D.
Department of Chemical, Bio & Materials Engineering
Arizona State University
Tempe, Arizona 85287-6006

INTRODUCTION

The purpose of this project was to design a medication management system for an individual with mental illness who has difficulty keeping track of her medication regimen. The individual takes multiple medications, each of which need to be taken at fixed dosages and prescribed intervals. However, due to the symptomatology of the disability, judgment and motivation are diminished and thus the ability to comply with the medication regimen is adversely affected.

SUMMARY OF IMPACT

The client is an adult with schizophrenia, a disease of the brain that can be largely treated with medication. If untreated, it may interfere with activities of daily living. It is vitally important that individuals follow their medication regimen in order to control this disorder.

TECHNICAL DESCRIPTION

This device dispenses medication up to three times a day at predetermined times. When medicine is dispensed, there is a voice-recorded message that says, "Jane Doe, it is time to take your medication". After this voice message, a buzzer sounds for up to ten minutes. This buzzer is intended to command the patient's attention to the degree that she is compelled to go to the device, shut it off, and remove the medication.

The device operates on an electrical timer (120 volts AC). The timer includes a transformer that regulates the output to 24 V AC. The timer is programmable and operates three separate channels in sequential order.

The program is set to meet the individual's medication regimen and has three on/off times per day.

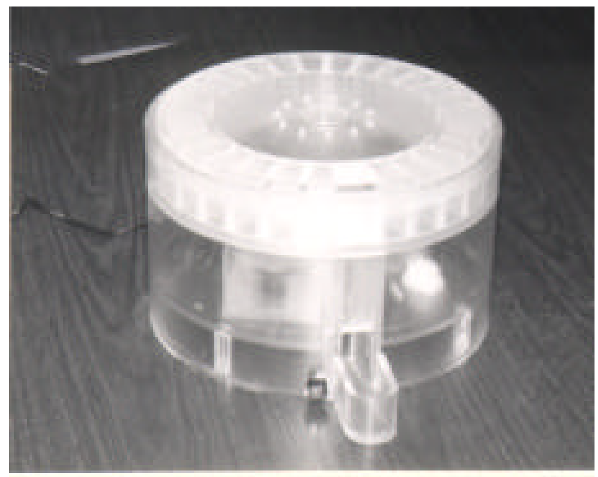

Figure 3-2. Medication Management System Prototype.

When the timer turns on, it starts powering channel 1. The output of this channel goes into a circuit that runs a motor for one minute. This motor is geared down to run at a speed of 0.034 RPM. The motor rotates a pill carousel, which revolves to an open slot that serves as a chute for the medicine to fall down into a pill-receiving tray.

After channel 1 turns off and channel 2 turns on. The output of this channel powers a circuit that contains the voice IC playback system. After one minute channel 2 turns off and channel 3 turns on. The output of channel 3 powers a circuit that contains the buzzer. This buzzer will sound for ten minutes or until it is manually turned off by a switch. Each circuit is described in more detail below:

Circuit One: This circuit controls the motor. The timer's 24V AC output is rectified and passed through a filter to obtain a DC current. Next, the voltage, regulated to output 12 V DC, powers the motor.

Circuit Two: This circuit controls the voice IC playback. The output of channel 2 is rectified and filtered in the same manner as channel 1. However, the voltage is regulated down to 6 V DC for the voice IC. When powered, the IC plays the message, "*Jane Doe, it's time to take your medication.*"

Circuit Three: This circuit controls the buzzer. The output of channel 3, like channel 2, is rectified, filtered and regulated down to 6 V DC. This powers the buzzer.

All of the circuit components, the motor, and the timer are housed within one unit. The system casing is cylindrical, with the pill-tray carousal on the top. The system is locked together by a hex screw, which requires a special screwdriver to remove. The patient's case manager will keep this screwdriver. The manager will refill the pill-tray once a week and make programming changes as needed.

The final cost of the system is approximately $570. Figure 3.3 shows the prototype.

Future Work

Several limitations that existed in the prototyping stage will not exist when product is taken to full stage production. For example, the prototype fabrication was limited to Plexiglas and PVC. In mass production, an acrylic (Acrylonitrile Butadiene Styrene (ABS)) will be used. ABS is lighter, more durable, and less expensive than Plexiglas. The manufacturing process will be thermoforming or vacuum forming. Molds will need to be made for this process but costs will be offset by reduced production time and use of less expensive materials.

Some components will be replaced with new components in mass production. For example, the electric timer will be replaced with a microprocessor chip. Additionally, the spur gear, custom made by Apache Gear, will be replaced by a stock gear made by Boston Gear, which will significantly reduce the cost.

All of the system's components will be 20 to 30 percent less expensive when purchased in bulk quantity. A preliminary analysis indicates that the product will cost approximately $260 per unit in mass production.

Figure 3.3. Disassembled View of Prototype.

DUAL PURPOSE BABY SEAT

Designer: Ahmed Al-Haj
Client: Katherine Turner
Supervising Professors: Gary Yamaguchi, Ph.D. and Jiping He, Ph.D.
Department of Chemical, Bio & Materials Engineering
Arizona State University
Tempe, Arizona 85287-6006

INTRODUCTION

The purpose of this project was to design a baby car seat that could also be used as a stroller. The seat has four wheels, attached to a supporting shaft, which can be folded away by simply pulling a spring-loaded pin and rotating the wheel mechanism into the folded position when it is being used as a car seat. The handle for the stroller is designed such that it does not interfere with the device when it is being used as a car seat. The design provides the child with the necessary safety when it is being used in both car seat and stroller modes.

SUMMARY OF IMPACT

Babies may become upset and/or uncomfortable when they are placed in and lifted out of car seats or strollers. The dual function design of this device eliminates the need to transport the baby between car seat and stroller. When used as a stroller, the wheels are simply extended from the folded position to the engaged position.

TECHNICAL DESCRIPTION

A car seat was bought and modified so that it could be used as both a stroller and a car seat. A 3/8? steel rod was passed through both the front and rear of the car seat. This rod acted both as a support and a pivot point for the wheels and their supporting shaft. (See Figure 3.4) The supporting shaft was made from 3/4? OD steel rod. Rollerblade wheels were used for all four wheels. The front wheels were attached to the supporting rod such that they were free to rotate in any direction, while the direction of the rear wheels was fixed. This allows the user to turn the stroller in any direction with ease.

The supporting shaft is locked in place by two rectangular pieces of steel (see Figure 3.5), one on each side of the shaft. These rectangular pieces, ½ by ½ inches and approximately 2 inches in length. They are welded to a steel plate that is bolted to the car seat.

Figure 3.4. Side View of Stroller with Wheels in the Folded Position.

All four wheels use the same locking system. Supporting shafts are released by simply pulling a spring-loaded pin. The supporting shafts must each be rotated approximately 130? to fold up the wheel structure. At this point the supporting shafts snap into a clip, which locks them in the folded position. The rods supporting the wheels were painted both for aesthetic purposes and to prevent rusting.

The handle is made of T6061 aluminum because it both lightweight and malleable. A 1? wide piece of aluminum was bent into a U shape and riveted to the rear of the baby seat. When the wheels are extended into place, the handle is slightly above the waist level of the caregiver, for ease of reach. The handle is positioned so that it will not interfere with the device in its car seat mode.

Modifications to the original car seat do not interfere with the integrity of the structure. The stroller was tested extensively to ensure that it was stable and structurally sound before it was presented to the client.

The total cost of the dual-purpose baby seat is $360. This includes $52 for the car seat, $50 for the roller-blade wheels and bearings, $180 for labor, and $80 for other miscellaneous parts.

Figure 3.5. Dual Function Design Being Used as a Stroller.

LAUNDRY CART TO AID A PERSON WITH A NEUROMOTOR DISORDER

Designer: Jessica Long
Client: Erica Gehres
Supervising Professor: Dr. Gary Yamaguchi
Department of Chemical, Bio & Materials Engineering
Arizona State University
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INTRODUCTION

A laundry cart has been designed for a person with a neurological disorder affecting the motor system. The laundry cart includes a handle, a base, a supporting bar, brakes, one brake lever, and a laundry basket (See Figure 3.6). The supporting bar is used to distribute the weight of the basket and its contents throughout the base. The bar is also used to hold the laundry basket in place. The braking system has been modified so that only one lever is needed to break both of the wheels. The laundry basket can be detached for easy storage.

SUMMARY OF IMPACT

A variety of neurological disorders can limit a person's agility, strength, and movement. At times persons with neurological disorders are able to carry on normal activities. In other instances, easy tasks, such as taking the laundry down the stairs, may be a hardship. Therefore, a modified laundry cart has been designed to allow a person to transport laundry up and down the stairs with ease. Brakes have been added to give the user increased control. The brake system enables the user to simply pull on one lever to stop both wheels, freeing one hand to hold on to a railing. An extended application of this design is to use the laundry cart to transport groceries and other bulky items to and from a multi-level building. The design is compact so that it can be stored in the trunk of a car.

TECHNICAL DESCRIPTION

The design requirements of the laundry cart were:

1. The design must be lightweight (not to exceed 7 pounds).

2. It must not be bulky or hard to handle.

3. It must be stable so the user is not thrown off balance.

Figure 3.6. Laundry Cart in Use by Client.

4. It should be easy to use.

5. The operator must have one hand free to balance herself going down the stairs.

6. The width of the bottom portion of the basket cannot exceed 11?. (This is to ensure the device can be placed on a step without toppling over).

7. The wheels must be large enough to go up a 90-degree grade.

8. The overall design must not look abnormal or out of place. It should match the existing decor and look like a normal laundry hamper.

The laundry cart has two main components, the frame, and the laundry basket. The frame and handle bar are made of aluminum rod which has been cut and modified. The base of the laundry cart is constructed of 1? ? 1/16? ? 1? aluminum angle. The metal was cut, bent, and welded to the desired shape. A supporting bar (15.25? ? .5? ? 1?) is used to distribute the weight of the basket and its contents between the bar and base. Four rectangular pieces of aluminum metal are used to attach the shaft and breaks. The two wheels, with a diameter of 8?, are attached to the rear of the base. Shim RSX brake sets have been modified so that only one lever is needed to brake both wheels.

Figure 3.7 shows the cart being used by the client. She found that the cart was easy to maneuver and very lightweight. She did not have a problem rolling the cart up and down the stairs.

The final cost of the laundry cart was approximately $192.

Figure 3.7. Disassembled View of Laundry Cart

POWERED TABLE FOR A WHEELCHAIR

Designer: Omar El-Tawil
Supervising Professors: Gary Yamaguchi, Ph.D. and James Sweeney, Ph.D.
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Tempe, Arizona 85287-6006

INTRODUCTION

The purpose of this project was to design a powered table for an electric wheelchair. This table is folded and unfolded by an electric motor so that it can be used by persons with quadriplegia. The table, which is attached to an aluminum frame, folds to the side of the wheelchair when it is not being used. A 12-Volt permanent DC magnet gearmotor drives a gearbelt that in turn rotates the table into position. The table can be operated manually by simply releasing a pin that uncouples the table from the motor.

SUMMARY OF IMPACT

Wheelchair accessories play a very important role in helping persons with physical disabilities. A very important accessory is the table. Unfortunately, most of the tables on the market today are manually operated and cannot be used by persons with quadriplegia. Thus there is a need for a table that is not operated manually. This powered table design may be used for many activities, such as eating and writing. The design makes the table easy to use and the user can operate it without aid from other persons. Depending on user preference, this table can be attached to either the right or the left side of the wheelchair with little modification. It is ideal for persons with quadriplegia, but any person in a wheelchair may use it.

TECHNICAL DESCRIPTION

The powered table consists of a PVC tabletop that is mounted on a frame made of T6061 aluminum. The table is driven by a 12 V permanent DC magnet gearmotor. This motor is mounted to the bottom of the aluminum frame. The entire frame is mounted to the right side of the wheelchair via 5 U-bolts.

A permanent DC magnet gearmotor is used because it has an internal locking mechanism that keeps the drive shaft locked in place when the motor is not powered. The motor is connected directly to the wheelchair's 12 V battery. The user engages the motor with a DPDT (Double Pole Double Throw) toggle switch. The toggle switch can be mounted at any position convenient to the user. The motor is bi-directional so that the table can be moved both to and from the usable position. The motor operates at 6 RPM and is capable of 50 in-lb of torque. The motor is coupled to the table by a 2L583 synchronizing gearbelt. The drive pulley and the driven pulley attached to the table both have the same diameter and thus the gear ratio is 1:1. When the motor is engaged the table rotates from the vertical position at the side of the chair to the horizontal position above the persons lap. In other words the table rotates 270?, taking 7.5 sec.

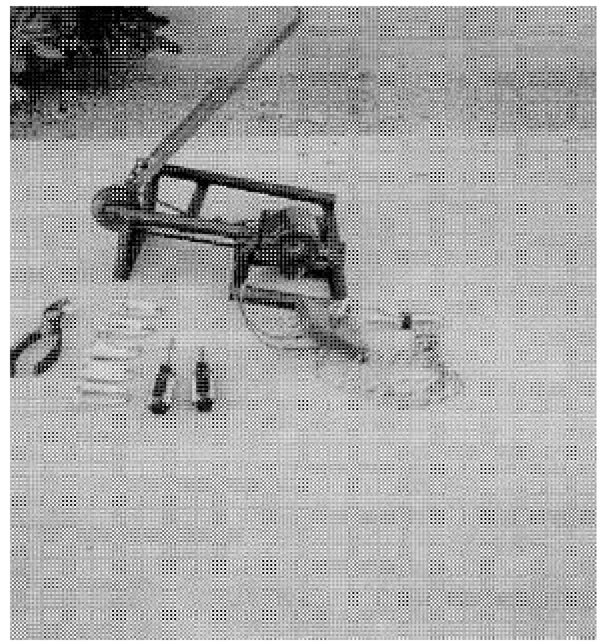


Figure 3-8. Powered Table for a Wheelchair.

The table is also designed so that it can be operated manually. Under normal circumstances the axle to which the table is attached is fixed to the pulley. By pushing in a pin, the axle can be released from the pulley, allowing the user to fold and unfold the table manually. The pin is spring-loaded. Once it is released the axle re-locks to the pulley. (See Figure 3-8)

The total cost of the project was $189. The major expense was the 12 V motor at $90. The pulleys were $14 each and the aluminum was $13. The cost of $189 does not include machining or labor.

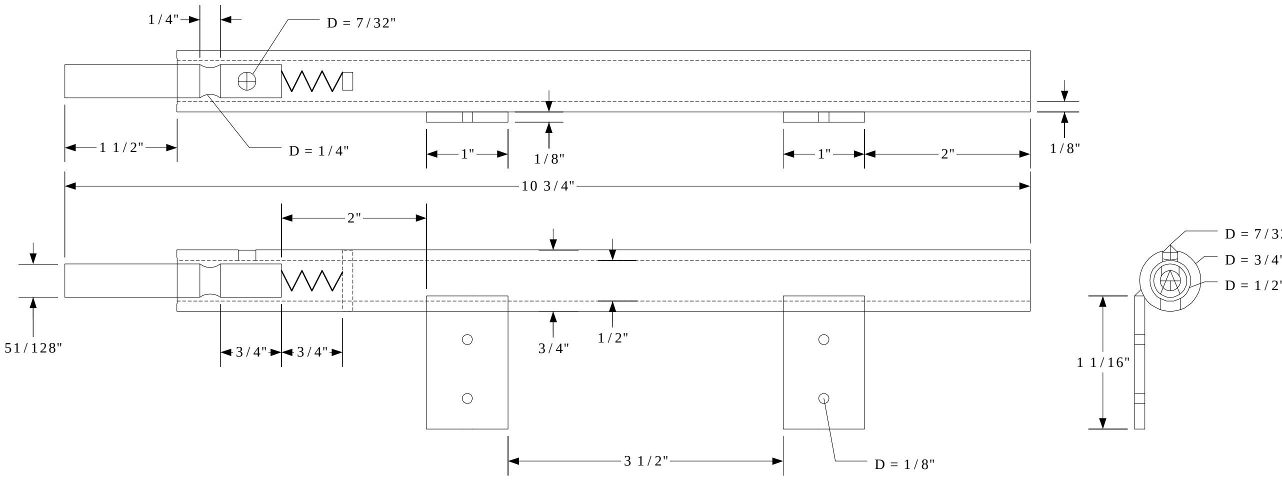


Figure 3.9. Rotating Axle and Locking Mechanism.

STAND-ASSIST COMMODE

Designer: Gregory L. Furman
Client Coordinators: Greenfields Retirement Community
Supervising Professor: Gary Yamaguchi, Ph.D.
Department of Chemical, Bio & Materials Engineering
Arizona State University
Tempe, Arizona 85287-6006

INTRODUCTION

The Stand-Assist Commode is a device to facilitate sitting and standing for elderly people. When raising a person, the device first lifts the toilet seat vertically; then, the seat rotates and assists the individual in standing. The process is reversed to help a person sit. The device has handrails, which are raised and lowered with the seat so that the individual can help steady him or herself.

The device operates through the use of hydraulic cylinders, connected to the water supply at the rear of the toilet. The user controls the system by simply adjusting a needle valve. The device includes a frame and a mount for the toilet seat. It is designed such that it can be used on any conventional toilet bowl without having to make large modifications.

SUMMARY OF IMPACT

A common problem that occurs as people get older is the onset of arthritis. This disease limits a person from doing everyday activities such as standing and sitting. Although this device was designed to help a specific individual with arthritis sit and stand independently, it could be used to help anyone with a weakened lower body.

TECHNICAL DESCRIPTION

The Stand-Assist Commode uses hydraulics to assist a person to the standing and/or sitting position. The front cylinders have a stroke length of 10 inches and the rear cylinders have a stroke length of 14 inches. Both cylinders have a bore diameter of 2 inches. The rear stroke length is longer because the seat must be rotated forward so that the individual is urged to stand.

The water supply for the cylinders is obtained by tapping into the preexisting water supply lines at the back of the toilet. Use of water pressure in the existing lines to actuate the cylinders obviated the need for a hydraulic pump. The water flows to the cylinders through 1/4 inch polyethylene tubing. The tubing is connected to the various components such as the cylinders, the valves, and the water supply with brass compression fittings. A disadvantage to this system is that the toilet cannot be flushed at the same time that the cylinders are working, since they both use the same water supply. After using the toilet, the user must first raise himself and then flush.

The user controls the system through the use of a manual 5-port, 3-position detented valve. The first position allows water to flow into the bottom of the cylinders and out of the top, thus raising the cylinders. The second position stops all water flow and thus locks the cylinders in position. The third position allows water to flow into the top of the cylinders and out of the bottom, thus lowering the cylinders. The valve is extremely easy to use and can be mounted to any position convenient for the user.

The Stand-Assist Commode consists of a U shaped base that sits on the floor. This base is placed around the bottom of the toilet. The front cylinders are mounted to this base at an angle of approximately 46?. The rear cylinders are attached to a structure that is mounted to the base. The tops of all four cylinders are attached to a seat plate, which is machined from stainless steel. The user's toilet seat attaches directly to the seat plate.

The total cost of this project is approximately $700. The hydraulic cylinders, which were purchased for $550, constitute the greatest portion of the expense.

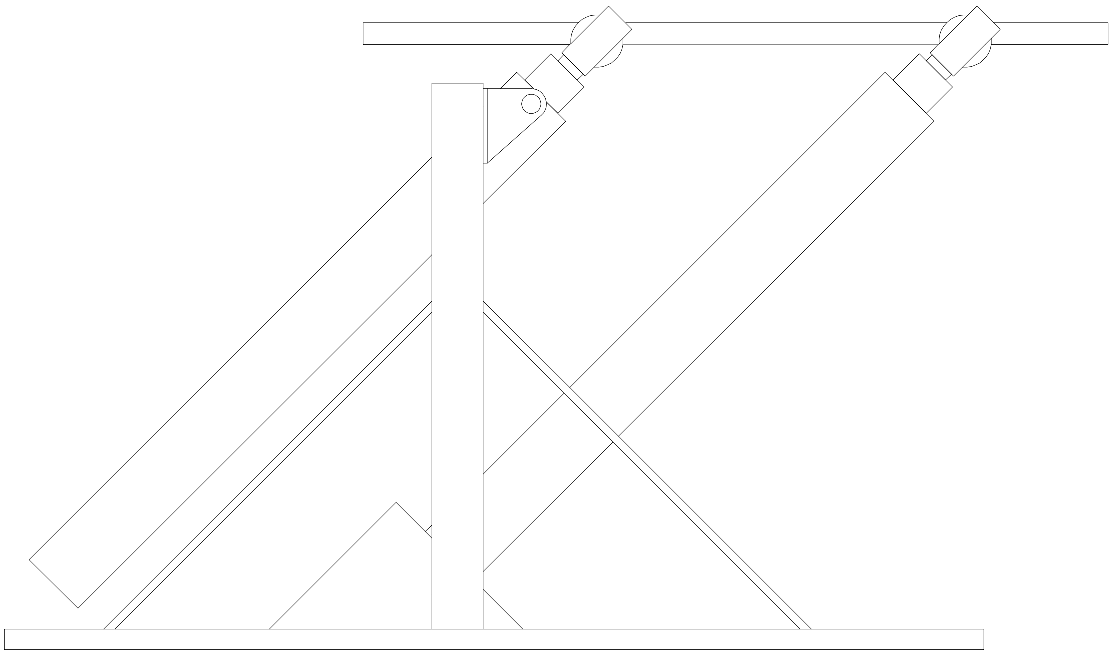


Figure 3.10. The Stand-Assist Commode (Sitting Position).

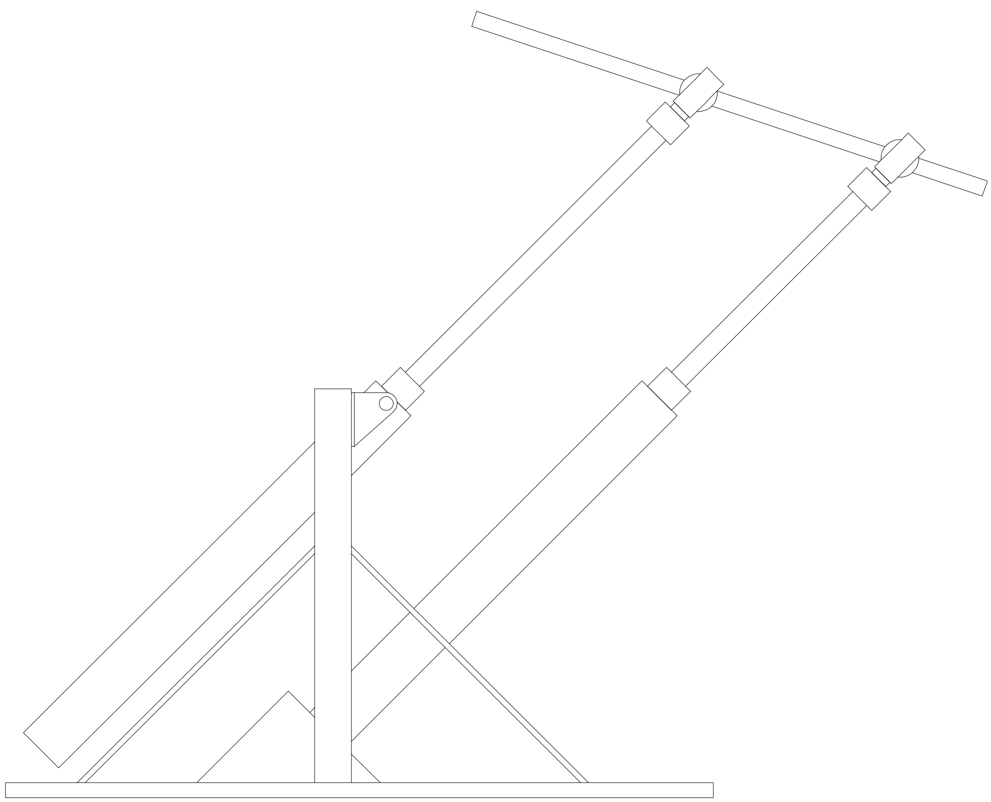


Figure 3.11. The Stand-Assist Commode (Standing Position).

THE SUN-SEEKER: A SOLAR PANEL SYSTEM FOR RECHARGING WHEELCHAIR BATTERY APPLIANCES

Designer: Wasiem Qutteneh
Client: Tedde Scharf
Supervising Professor: Dr. Gary Yamaguchi
Department of Chemical, Bio & Materials Engineering
Arizona State University
Tempe, Arizona 85287-6006

INTRODUCTION

The Sun-Seeker, a solar panel system, has been designed to recharge batteries for people who use electric wheelchairs. The system is universal in design for all wheelchairs. It is portable and can be disassembled for transport. The Sun-Seeker consists of two solar panels (12 volts each) and a manual tracking system. Each solar panel is square and is covered with a styrene top for protection. The solar panels are supported by a suspension system that consists of four aluminum bars. This overhead system (the solar panels and suspension system) pivots about its center of mass. It is affixed to an aluminum shaft attached to the wheelchair. The solar panels are rotated by using a manual actuator. The panels are free to rotate 360? clockwise and counterclockwise.

Human factors engineering was applied advantageously in the design of the actuator. When the actuator is pushed, spring plungers embedded in the actuator provide a stimulus (about 2.3 lbs), which is close to the force of pushing. This tangible feedback is reinforced by a clicking noise that signals movement of the overhead system.

SUMMARY OF IMPACT

The purpose of the Sun-Seeker is to recharge the batteries of electric wheelchairs. This gives the user greater freedom to partake in normal activities without recharging batteries. This device is lightweight and fits on most electric wheelchairs. The solar panels are relatively inexpensive and are affordable for most wheelchair users.

TECHNICAL DESCRIPTION

The Sun-Seeker is a universal design. It can be mounted on a wheelchair, clamped onto a table, or fixed on a roof to charge a 12 volt or 24 volt battery.

Figure 3.12. Picture of Sunseeker Being Used by Client.

The Sun-Seeker consists of two solar panels (12 volts each) and a manual tracking system. Each solar panel is rectangular in shape and has dimensions of 19.3 in. long by 17.3 in. wide, or a total area of 4.74 ft^2. Each solar panel is covered with styrene concealment to protect the solar cells from damage. The solar panels are connected in a series yielding an output of 24 volts and 1.67 Amps. The solar panels are 12% efficient in converting sun energy into electrical energy. They produce 40 watts. The total weight of the solar panels and the suspension system is approximately 12 lbs.

The solar panels are mounted by an aluminum suspension system that consists of four aluminum bars. Each bar has a diameter of 0.500 in. and is bolted to the solar panels. The suspension system is connected to a supporting aluminum shaft by a joint around which the whole system pivots. The supporting shaft is 34.00 in. long with a 0.750 in. outer diameter and a 0.500 in. inner diameter. The lower end of shaft is coupled to a manual aluminum actuator that is capable of rotating the overhead system 360? clockwise and counterclockwise.

The actuator is an S-shaped object with two tubes protruding from its ends. The upper tube is coupled to the support shaft and has dimensions of 1.150 ? 0.002 in. O.D., 0.750 ? 0.002 in. I.D., and a length of 1.250 in. The lower tube, about which the overhead system rotates, is coupled to a clamp and has dimensions of 1.500 ? 0.002 in. O.D., 0.700 ? 0.002 in. I.D., and a length of 1.500 in.

Embedded in the walls of the lower tube are four stainless steel spring plungers. They are attached in a criss-cross shape. Each spring plunger has body length of 5/8 in., nose length of 3/32 in., and nose diameter of 0.07 in. The intent of the plungers was to provide a stimulus that approximates the force of pushing. When the actuator is pushed, the spring plungers provide the change in pressure (about 2.3 lbs) required to move the shaft. The user is provided tangible feedback via a clicking noise that is made when the overhead system is moved.

A clamp was attached to the bottom of the supporting shaft so that the whole system could be mounted to a wheelchair. The clamp consists of three components: a coupler to the actuator, a U-shaped body, and a tightening screw. The coupler is an aluminum bar of 0.700 in. diameter and 1.500 in. long. The U-shaped body has a wall thickness of 0.375 in. and is 2.910 in. long. A 1/4?-20 screw was used.

A 4-amp voltage regulator was used to control the voltage of the solar panels. That is, charging of the batteries is controlled by shunting the photovoltaic array when the battery is fully charged. The controller has a built-in temperature compensation sensor that assures the batteries are properly charged regardless of the thermal environment. Both the solar panels and the voltage regulator were purchased from ETA Engineering Inc., located in Scottsdale, Arizona.

Figure 3.13. Rear View of Sunseeker, Showing Method of Attachment to Wheelchair.

Tests of the Sun-Seeker were conducted by having the designer push the actuator when the entire system was fixed on a desk. Hand force was sufficient to initiate movement of the system.

The total cost of the project was $760.

MOBILITY VEHICLE FOR A CHILD WITH CEREBRAL PALSY

Designer: Stacey A. McCollum
Client: Sidney
Supervising Professors: Jiping He, Ph.D. and Gary Yamaguchi, Ph.D.
Department of Chemical, Bio & Materials Engineering
Arizona State University
Tempe, Arizona 85287-6006

INTRODUCTION

A child's electric toy car was redesigned so that a young girl with cerebral palsy could use it. The car is powered by a 12 V electric motor. The child initiates acceleration by pushing a button once and stops it by pushing the button a second time. The car's mechanical steering was converted to electrical steering by directly connecting a 12 V reversible electrical motor to the steering column. The steering, like the acceleration, can be controlled by simply pushing buttons. A seat was custom made for the client and installed in the vehicle. A shoulder harness and a lap belt were installed both to safely secure the child and to help her sit up straight.

SUMMARY OF IMPACT

Children with cerebral palsy are often confined to wheelchairs that limit their interaction with the environment and their development of independence. A child's sit-in car was modified so that a child with cerebral palsy could use it without assistance from anyone. The car provides the child with a sense of independence that she would not have otherwise, and does not make the child feel self-conscious in front of other children. Additionally, it enables the child to be stimulated in novel ways, and will help develop the child's upper body strength and coordination skills. The restraining belts in the car were designed such that they would help the child sit upright, while requiring some therapeutic effort from the child. The design requires the child to control the car through a series of buttons.

TECHNICAL DESCRIPTION

Modification of the existing vehicle involved redesigning three main components: (1) the steering mechanism, (2) the seat and restraining mechanism, and (3) the accelerator and brake pedals.

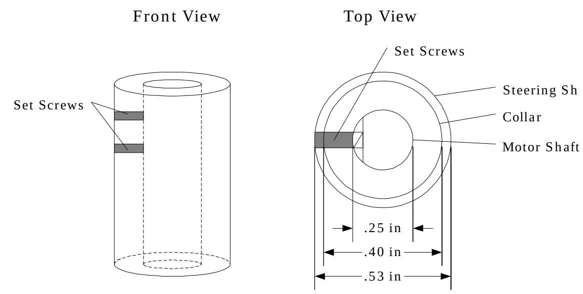


Figure 3.14. Collar for Attachment of Motor to Steering Shaft.

The mechanical steering wheel was replaced by a system that could be operated by simply engaging one button for a right turn and another button for a left turn. The steering wheel was removed and a 12 V DC reversible motor was coupled directly to the steering shaft using a 3-inch-long collar). Two setscrews were used to ensure that the collar would not move. (See Figure 3.14).

The motor was geared down to 5 RPM so that the child could properly control the steering. The motor is capable of producing 1440 in-oz of static torque, which is more than enough to rotate the steering shaft under normal operating conditions. A circuit was designed to allow forward and reverse rotation of the motor. When the child pushes a button on the left, a single pole double throw (SPDT) switch moves from its NC position to its NO position, causing the motor to rotate counterclockwise. When the right button is pushed the SPDT switch moves from its NC position to its NO position and a double pole double throw (DPDT) switch moves to the NO position causing the motor to rotate clockwise. (See Figure 3.15)

A seat was custom-made and installed in the car to help the child with proper support. The seat is held in place with Velcro straps and can be easily removed to use for other purposes. A shoulder harness and a lap belt were installed both to safely secure the child and to help her sit up straight. These straps were designed to aid the child while not allowing her to become totally dependent on the straps.

The vehicle is rear wheel driven. A 12 V motor, left unchanged, is attached to the axle of both wheels. The maximum speed of the car is 3 miles per hour. The foot pedal that had originally been used to engage the system was replaced with a push button. The button was designed so that when pushed once the car would accelerate, and when pushed a second time the car would stop. The button requires very little pressure to engage, which is important for a child with cerebral palsy. A tabletop was made and placed in the car. The accelerator button, as well as the right and left turn buttons, can be placed at any position on the tabletop convenient for the child. Velcro is used to secure the buttons to the tabletop.

The total cost to modify this vehicle was $396.19. The 12 V DC reversible motor was purchased for $127.29 and the push buttons for $146.00. Other miscellaneous parts comprised the rest of the $396.19. It should be noted that the original vehicle, which was supplied by the family, was worth about $500.00.

No pictures of the final project are included because the parents did not feel comfortable having pictures taken.

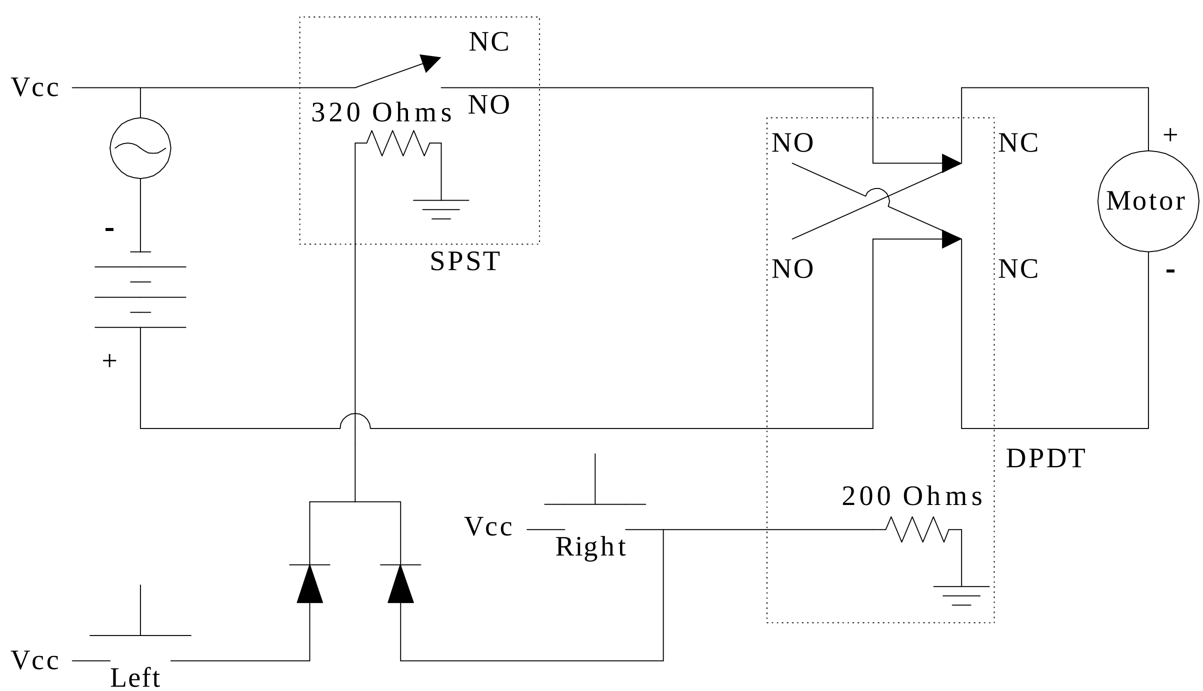


Figure 3.15. Steering Circuitry

OFF-ROAD WHEELCHAIR FOR MULTIPLE TERRAIN CONDITIONS

Designer: Andreas Ahha
Client: Mr.Dave Martin
Supervising Professors: Gary Yamaguchi, Ph.D. and James Sweeney, Ph.D.
Department of Chemical, Bio & Materials Engineering
Arizona State University
Tempe, Arizona 85287-6006

INTRODUCTION

An off-road wheelchair was designed for use on multiple types of terrain. The frame of the wheelchair consists of an oval shaped aluminum tube that is approximately 3 feet in length. This aluminum tube is used as a base for the seat, the front axle, and the suspension system. The wheelchair has three wheels, two in the front and one in the rear. Twenty-six inch mountain bike wheels are used in the front. These wheels are attached to the front axle at an angle, both to help improve the stability of the chair, and to help the user grasp the propulsion handles with ease. A sixteen-inch wheel is used in the rear. This wheel is attached to the frame by way of an elastomer suspension system that is free to rotate as the rear wheel turns. The suspension system was fabricated by inserting a stainless steel axle through the elastomers. When the rear wheel strikes an obstacle the elastomers are compressed between an aluminum plate and a bolt, thus alleviating some shock for the user. The fork of the rear wheel is attached to the bottom of the suspension system using conventional bicycle steering bearings. The bicycle is propelled by two handles, each of which is attached to the outside of a front wheel by means of a bicycle free wheel. Braking is accomplished by pressing a pair of pads on the handles against the front wheel rims. Quick release pins allow the bike to be easily dissembled. The seat, front wheels, and front axle are detachable.

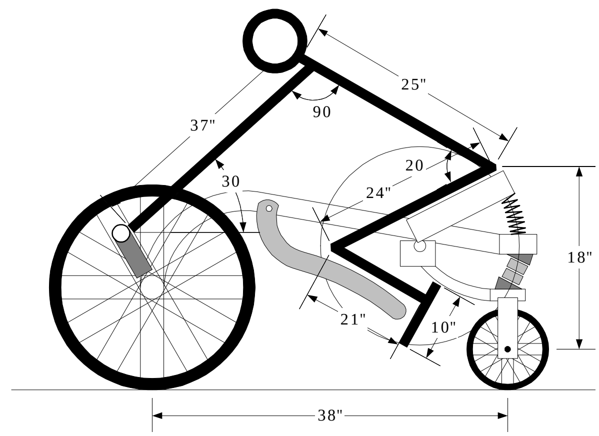


Figure 3.16. Schematic of Off-Road Wheelchair, with Dimensions

SUMMARY OF IMPACT

Many persons with paralysis of the legs are highly active. Some perform activities that would be difficult even for people with no disabilities. The design of an off-road recreational wheelchair allows persons with lower-body paralysis to push their recreational limits to much higher levels than current wheelchair designs permit. The overall design of this wheelchair allows the user to enjoy the excitement of off-road activities with fewer limitations. The lightweight design of the wheelchair in combination with the specialized arrangement of its parts allows the user to perform difficult maneuvers over rough terrain by using their hands and by moving their center of weight. The chair is designed such that is able to withstand a great deal of force during downhill-style riding over rough terrain.

More than just an aid for an individual with a disability, the wheelchair is also a recreational vehicle. Thus the aesthetics are based on the latest designs in recreational equipment. Although the wheelchair was made for a particular client, an effort was made to manufacture the chair from easy-to-find common parts so that the price would be affordable for any potential users.

TECHNICAL DESCRIPTION

The wheelchair was designed with a particular client in mind, but during the design process average human dimensions were considered to make the design more universal. The requirements for the design were:

1) Forces from curbs of height or depth of up to 15 cm at speeds of up to 20 mph should not damage the wheelchair;

2) While moving at low speeds the user should be able to maneuver through passages that have a width of only 3 ft; 3) The user should be able to easily climb over obstacles with sectional semicircular profile of radius up to 1 ft; 4) The wheelchair should be portable.

The single tube frame was designed to be compact and lightweight. Aluminum tubing was used throughout the design. Lower density advanced material, like graphite composites, could be used in future designs. All of the tubing used in the design are standard sizes (e.g. 0.5?, 1?, and 4?) and are easy to purchase. The design used an oval shaped main tube with a major axis of approximately 5? and a minor axis of approximately 3?. This was simply made by compressing a 4? circular tube into the proper shape. The suspension, seat, rear wheel and front wheels were all attached to this oval shaped tube (Figure 3.17). The additional insertion and welding on the mainframe tube were strategically located at points that increased the overall strength of the frame.

The braking system for the current design is brake pads attached on the propulsion handles. The hands of the user can also be used as maneuvering brakes. He/she would have to wear special gloves for high speed maneuvering. Future improvements could include disc brakes, or an in-the-hub braking system on the front and/or rear wheels. The current design didn't include this option because of an effort to minimize both weight and price.

The propulsion of the wheelchair is achieved by the use of two variable size handles, which are attached to the wheels through two single speed conventional free wheels. The free wheels are used to push the

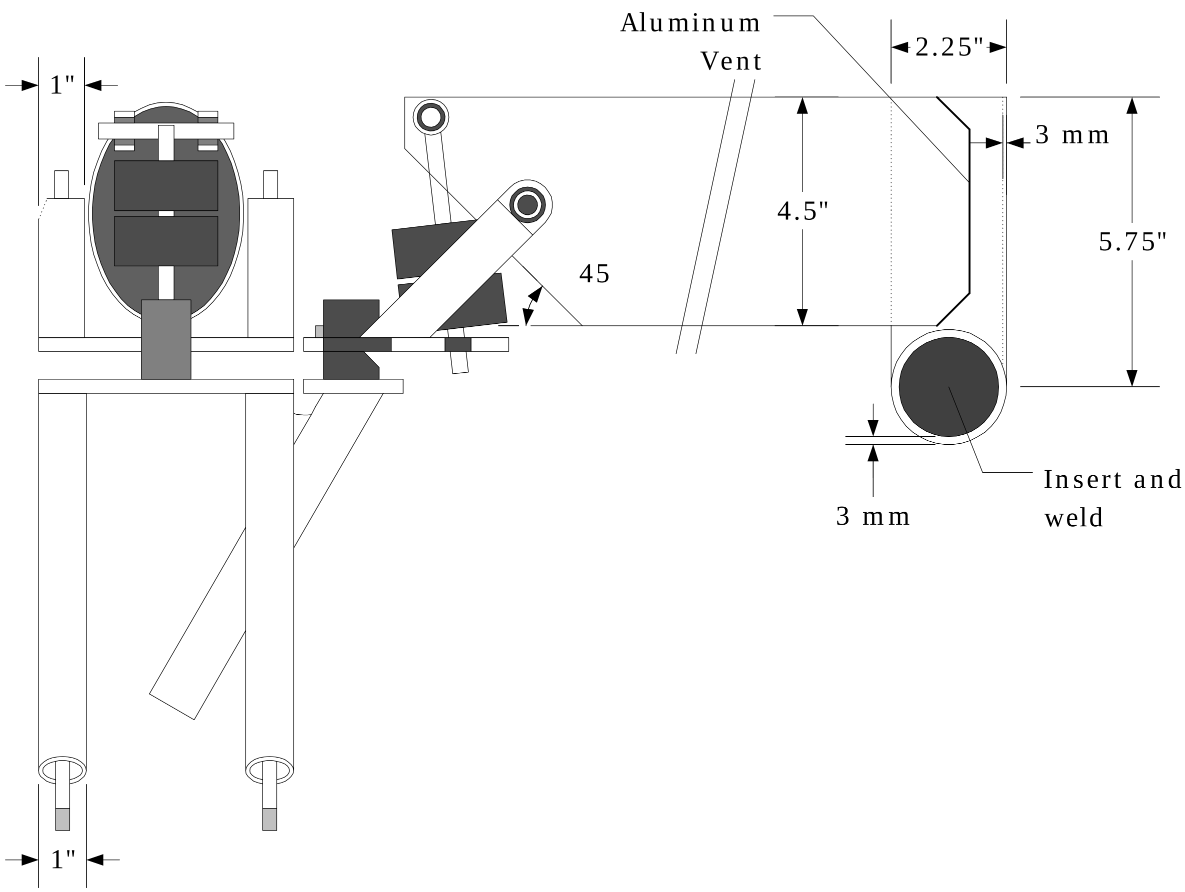


Figure 3.17. Rear View and Side View of the Main Frame and Attachments.

Figure 3.18. User Propelling Wheelchair.

wheels forward with repetitive rotations of the handles. (See Figure 3.18).

The steering of the wheelchair is achieved by applying varying braking forces on each wheel, as is done on a conventional wheelchair. Other methods for steering were considered:

1) Allow the front wheels to rotate by rotating their axle and including bearings;

2) Attach cables which will steer the rear wheel. The cables would run from the rear wheel's top fork plate to the handles in such a way that steering would be achieved from motion not used for propulsion.

The seat is constructed of two pieces: 1) the rear backrest cushion, and 2) the lower cushion. The cushions are connected to each other with a 90-degree bend polymer plate. The plate can be replaced in the future by a suspended joint for better support. The seat is attached on the mainframe tube with quick release pins. In the future suspension could also be added between the lower cushion and the frame.

Figure 3.19. The Transfer from Traditional Wheelchair to Off-Road Wheelchair.

The wheelchair was designed for an individual who was selected according to the following criteria: 1) weight of the user, 2) Familiarity with different multiple types of wheelchairs, 3) Upper body strength, and 4) Interest in recreational activities.

During the final testing by the client the following were listed as the major advantages of the Off-Road Wheelchair:

1) The sitting position allows more freedom of movement and reaching objects laying in the front of the wheelchair is easier;

2) The center of weight is low for a more stable ride;

3) The sitting arrangement of the user is such that he/she can achieve better stability by shifting his/her weight during fast motion and turning;

4) The user can employ the handles to propel himself over a curb with out any risk of falling due to the 26" high impact wheels in the front;

5) The frame design creates a high-strength low-weight (less than 25 lb) setup.

6) The frame design uses conventional aluminum 6061-T6 tubing, which is inexpensive and easy to find, in contrast to bend or variable thickness tubing;

7) The positioning of the front wheels allows the user clearance for transferring from another chair to this wheelchair. (See Figure 3.19);

8) Vibrations perpendicular to the spinal cord are reduced, minimizing the risk of spasms and pain for the user, due to the use of elastomer suspensions and placement of the user such that he/she is not sitting over the large wheel axles;

9) It is easy to change the overall width of the wheelchair for home use and for off-road use where the stability requirements are altered;

10) The user can perform high-strength curb climbing at a high speed;

11) The wheelchair folds into a small package once the various quick release parts have been removed (26"x33"x15");

12) The wheelchair is stable when used on a sloped pavement where standard wheelchair designs tend to move sideways.

The design's disadvantages reported by the user included:

1) The rear rotating wheel tends to obstruct motion over very steep obstacles like steps;

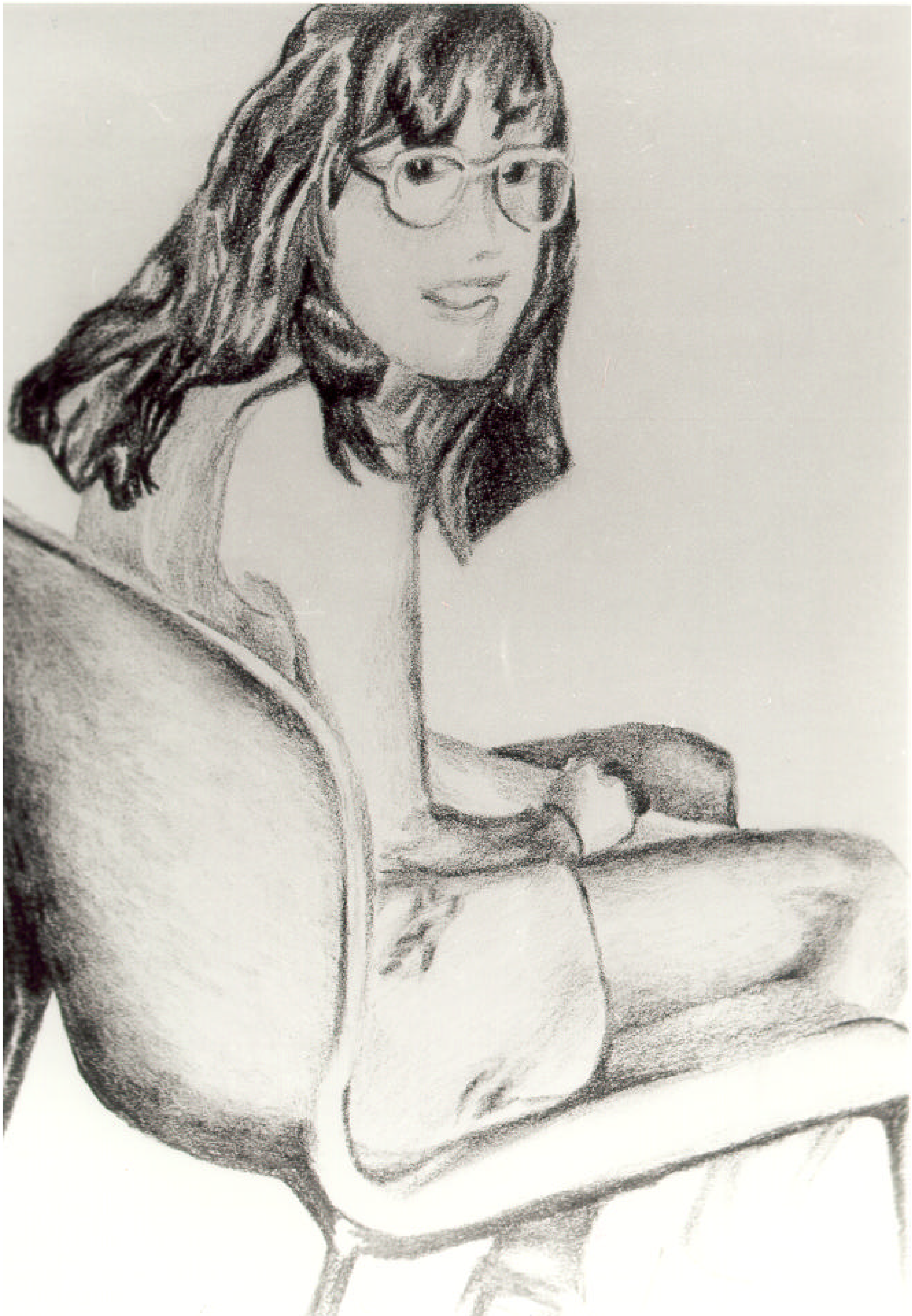
2) The slope of the seat should be adjustable to the needs of the user;

3) The brake's ergonomics should be improved so that they can be used simultaneously during maneuvering and propelling.

The client had described many problems that he had with his previous wheelchair. Most of the problems seemed to occur when he was traveling outdoors. Specifically, he mentioned the problems that he had with the small casters used on traditional wheelchairs. He concluded that the newly designed off-road wheelchair alleviated many of his problems. He emphasized the important psychological aspects of using a wheelchair that is designed as a recreational vehicle and not just an aid for a disabled person.

The final cost of the wheelchair was approximately $750.

Figure 3.20. Side View of User on Off-Road Wheelchair.



Chapter 4
BINGHAMTON UNIVERSITY

Thomas J. Watson School of Engineering and Applied Science
Department of Mechanical Engineering
Binghamton, NY 13902-6000

Principal Investigator:

Richard S. Culver (607) 777-2880
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PORTABLE VESTIBULAR SYSTEM

Designers: Matthew Hoenig, Angelo Motta, Thierry Servius
Client Coordinator: Renee Packer
Handicapped Children's Association
Supervising Professor: Richard Culver, Ph.D.
Department of Mechanical Engineering
Binghamton University
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INTRODUCTION

Physical therapists at the Handicapped Children's Association require a portable frame, similar to a swing that can be carried on house calls to clients. This portable vestibular system helps children develop sensory integration. It is light enough (only 22 pounds) to be carried by one person yet supports up to 100 pounds. It is easily folded into a portable size and is compact enough to fit into the back seat of a car. Its easy assembly requires only one person.

SUMMARY OF IMPACT

Children with sensory integration difficulties have trouble using and integrating two or more senses at the same time. Therapists use input devices and a variety of methods to accustom the child to different multisensory stimuli. This system provides an initial swinging motion that can be incorporated with other stimuli as part of a therapeutic program. Thus, a portable vestibular system makes it easier for therapists to make house calls to provide therapy for children.

TECHNICAL DESCRIPTION

The swing-like frame of the vestibular system consists of a 48" transverse beam and two sets of removable v-shaped legs. The frame is composed of aluminum tubes, 3/4" I.D. x 1" O.D. The angle separating the legs is 60 degrees. The angle between the transverse beam and legs is 100 degrees.

Three-prong brackets of 3/4" steel rod connect the legs and transverse beam. The brackets are welded in a configuration that holds the transverse beam and legs in the proper orientation. The brackets insert into the leg and beam pipes, and are glued with epoxy cement to the transverse beam. Plastic-coated steel cables, 1/8Ó diameter and fastened with horseshoe cable clamps, are permanently wrapped around each steel bracket to provide an anchor for the swing. Another cable, stretched snugly between the anchoring bracket cables, provides a centered attachment point with a hook to connect a swing seat. A cable connects the swing seat to the attachment point.

Figure 4.1. Photograph of the Portable Vestibular System

The v-shaped legs come in two telescoped sections: the section of each leg is 42" long, the lower 45" long. A collar of steel pipe, with an outside diameter of 5/4", covers the middle of each leg. The two steel collars, glued to the lower legs, strengthen the legs, and each leg can be taken apart at this point. Nylon bungee rope, measuring 84", was fastened by pins to the piping to hold the assembly together and simplify setup. The legs extend a maximum 46" when telescoped. When assembled, the legs are 46" apart at the base. A cable between the legs keeps the legs from spreading under load.

Initial testing demonstrates that the frame supports a load up to 160 lbs. However, the system would move left to right horizontally when subjected to a load moving in a circular pattern. This motion was reduced to an acceptable level by attaching straps 2" x 1/8" across the base of the legs.

Safety features include rubber-coated screws to prevent scratching and rubber caps on the feet of each leg to prevent the legs from sliding.

The final cost of the system is approximately $320.

DUAL-SEATED PHYSICAL STIMULATION SWING

Designers: Meredith Hasenbein, Jason Bahr, Fletcher Clarcq
Client Coordinator: Pat Voorhis
Appalachen BOCES
Supervising Professor: Richard Culver, Ph.D.
Department of Mechanical Engineering
Binghamton University
Binghamton, NY 13902-6000

INTRODUCTION

A dual-seat swing for physical stimulation was designed for two sisters, ages 21 and 16, who have severe kyphosis, scoliosis, cerebral palsy, and mental retardation. The swing provides the two sisters with enjoyable physical and sensory stimulation, and meets their special requirements: padding to prevent rashes and sores, headrests for head and neck to compensate for lack of muscle control, restraining straps for chest and feet, footrests to keep legs and feet in the proper seated position, and an overall 40- degree backward tilt to support their weight. After several possible solutions were explored, the simplest approach for this unusual dual-seat system was chosen: a lightweight plastic frame that holds two wooden seats. The frame is attached to chains hanging from the ceiling.

SUMMARY OF IMPACT

Two clients were both in need of a system that provides physical and sensory therapeutic benefits while enhancing their overall quality of life by enabling them to novel movement experience. The swing allows the two young women to rest in a proper seated position while experiencing a sense of suspension in the air and movement back and forth.

TECHNICAL DESCRIPTION

The swing consists of three major parts: two seats, the plastic seat frame, and the assembly used to suspend the frame from the ceiling. The seats, built from 2 x 8" pinewood and 3/8" plywood, are fully padded and covered with quilted material. Each seat is equipped with fully padded headrests and footrests along with chest and foot straps. PVC plastic tubes beneath the padding serve as leg separators. The frame is built from 1 1/4" furniture-grade plastic tubing. Chains are suspended from hooks driven into the ceiling of the clients' porch. The chains attach to the plastic seat frame by steel straps wrapped around the plastic tubing.

The device is safety tested. All edges are rounded and the pinewood is painted and padded. The safety straps meet testing standards. The seats can support over 100 lb. each, the seat frame 200 lb. The chains can sustain a 500 lb. load.

The approximate total cost for materials is $100.

Figure 4.2. Dual-Seated Physical Stimulation Swing.

AUTOMATIC SLIDING DOOR OPENER

Designers: Michael Meilunas, Mark Seus, Colum Gibbons
Client Coordinator: Dave Scudder
Intellidapt
Supervising Professor: Richard Culver, Ph.D.
Department of Mechanical Engineering
Binghamton University
Binghamton, NY 13902-6000

INTRODUCTION

Manual opening and closing of a sliding glass door is impossible for many wheelchair-bound individuals. An automated sliding door opener can compensate for clients' limited mobility. By pressing a button on a personal remote control, the client activates a motor that turns a screw-drive mechanism. The screw-drive then moves a trolley setup that is attached to the frame of the sliding door, pulling the door open or pushing it closed. This design is a modified version of a commercially available garage door opener.

SUMMARY OF IMPACT

The automatic sliding door opener was built for a wheelchair-bound individual who has only minimal use of his arms and hands. Sliding glass doors require a moderate amount of strength such that the client has required assistance to enter and exit his own home. Assistance is not always available, however, especially in emergency situations. With the push of a button on a remote control, he is now able to go indoors and outdoors as desired, increasing self-sufficiency and fostering a greater sense of freedom and independence.

TECHNICAL DESCRIPTION

The Automatic Sliding Door Opener is built from a standard garage door opener, and consists of two trolleys mounted on the sliding glass door, a screw-drive mechanism encased in an I-beam, and a compact 1/2 horsepower AC motor housed in an all-weather plastic case. The garage door opener comes with these components, except for the second trolley. Unlike a garage door, which opens vertically, the I-beam section is installed on its side to provide the horizontal sliding motion needed. Additional modifications include seven small mounts holding the screw-drive I-beam in place, and two large mounts holding the motor. Fourteen small "filler" pieces are also added to secure the I-beam and two trolleys, ensuring durability.

Figure 4. 3. Automatic Sliding Door Opener

A custom aluminum bracket is used to attach the trolleys to each other and to the door.

The system includes two safety sensors: an electric eye and a force sensor. The eye's infrared beam causes the door to be pulled open when anything breaks its path. The door will also return to the open position if the force sensor encounters sufficient resistance. These sensors come with the commercial garage door opener system.

This system was first tested on a simulated door and house frame. It was then successfully installed in the client's house. Overall performance is good, and the mounts and brackets are notably sturdy. Trolley length, bracket size and motor power can all be adjusted to various door sizes and forces required to open and close different doors. Manual operation is quick: flip two switches, one on each trolley, and the sliding glass door will operate normally.

The commercial garage door opener costs $180. With additional materials, including the second trolley ($42) and custom bracket ($75), total design cost is a reasonable $429.

Figure 4.4. Detail of Aluminum Bracket.

ADAPTABLE COMPUTER CHAIR

Designers: Ethan Boivie, Paul Clark, Danielle Dick
Client Coordinator: Inalou Davey
Rehabilitation Services Inc.
Supervising Professor: Richard Culver, Ph.D.
Department of Mechanical Engineering
Binghamton University
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INTRODUCTION

Commercial computer chairs do not provide the needed trunk, head and foot support that some children with disabilities require; nor do they provide an adjustable range of support for varying individual needs and levels of involvement. Similarly, commercially available computer chairs for persons with disabilities are often expensive, lack adjustability and portability, and are too large and cumbersome to be used in standard computer facilities, especially if a therapist or caretaker is also present beside the client. The adaptable chair can be used at desks that accommodate chairs only 24 inches high, 25 inches wide, and 25 inches deep. The chair includes the main adjustability, portability and safety mechanisms clients require: sitting height from 18 to 22 inches above the floor, backward tilt rotation from 0 to 30 degrees, lockable casters, bolsters to push the client forward in the chair, cinch straps for arms and legs, and supports and straps to secure the feet at the correct angle and prevent 'dangling feet.'

SUMMARY OF IMPACT

An adaptable computer chair was designed and built for a four-year-old client with cerebral palsy and good cognitive abilities. The client's rehabilitation agency required portable chairs that allow room for a therapist to be beside a client in a small room that has insufficient space for large commercially available adaptive chairs. A therapist must be able to set up and secure the chair outside the small room before wheeling the client in. A touch-screen computer is used in the client's speech therapy, so the chair must allow him to sit forward and be highly involved.

Although initially designed for one client, the chair now accommodates several children, ages 4 to 13, with a variety of needs.

Figure 4.5. Adaptable Computer Chair.

TECHNICAL DESCRIPTION

The chair consists of an inner seat and outer frame, both constructed from birch plywood and held together on either side by two hand screws that are held in place by friction between the two sections.

Two vertical slots in each side of the outer frame allow the inner seat to be moved vertically, and a horizontal slot in the front of the inner seat allows rotation. Casters are attached to the chair by two-by-fours that run along the bottom of the chair frame.

A Velcro cinching strap, threaded through the back of the chair, secures the client's trunk in place. The plywood arm rests, padded with foam liner and attached to the inner chair, move in tandem with seat adjustments. The plywood foot supports can be moved up and down a plywood leg rest to the desired position and then secured with a hand screw. Two Velcro cinching straps secure the feet in place. Aluminum sheeting inlaid around the slots, and foam-pad lining on the back and seat of the chair increase durability and comfort.

The plywood, casters, padding, hand screws, and other hardware and finishing products amount to $175 total. Similar commercial chairs cost $450 to $850.

MOTORIZED MOBILITY AID

Designers: Chris Broner, Ian Majid, Nilesh Patel
Client Coordinator: Reva Reid
Rehabilitation Services Inc.
Supervising Professor: Richard Culver, Ph.D.
Department of Mechanical Engineering
Binghamton University
Binghamton, NY 13902-6000

INTRODUCTION

The motorized mobility aid was designed and built for a two-year-old child with cerebral palsy. It consists of a plywood platform to stand on, a cushioned steel, plywood and PVC carriage, and a simple drive portable control system. The device, weighing 20 pounds, is designed for both indoor and outdoor use at moderate speeds over uneven terrain, and is configured to fit through standard 32-inch doorways. It has a number of features that encourage development and independence: straps to assist driver balance, dual controls to ensure even use and symmetrical development of hands and arms, and a carriage that feels open and free while maintaining safety standards.

SUMMARY OF IMPACT

The mobility aid was designed with the two-year-old, 25-pound, 32-inch-tall client's strengths and challenges in mind. Most importantly, her legs do not support her weight. She cannot walk but can support her body weight when appropriate measures are taken to maintain her balance. The mobility aid allows her to stand while moving about, encouraging interaction with her peers while strengthening her legs. She also has limited development of the right side of her body, with best use of her left hand. The dual-control system mandates that she use both hands, and the configuration of the device ensures that she uses both arms and does not rest them on the device's frame. Portability and ruggedness for the outdoors provide the client added flexibility and independence.

TECHNICAL DESCRIPTION

The motorized mobility aid consists of five main sections: a circular 30" diameter plywood platform, a motorized drive system, a steel and plywood back-support frame, a PVC safety frame on the sides and front, and driving controls mounted on the front.

Figure 4.6. Motorized Mobility Aid.

The device is driven by motors and drive wheels located in the middle of the platform on each side. A cut in the platform on either side of the front dolly wheel allows for flexibility in uneven terrain, and the top of each drive wheel is 3 inches above the surface of the platform. Wheel covers are provided for safety. The motors, attached to the wheels, are mounted through additional cuts in the platform.

The PVC frame extends from the top of the steel backing to the front of the platform, where it detaches at two points. A pin at each point secures the frame while the device is in use. Overall, the frame is bent and configured to keep the driver positioned at the platform's center, to ensure balance, and to keep the driver's arms inside the platform perimeter, at the same time creating a feeling of unconfined openness. When not in use, the PVC frame folds over the foldable steel backing.

The steel backing extends through the platform and is hinged above the platform so it can be folded down. Safety straps extend from a cushioned plywood back support attached to the steel frame.

The two control switches mounted on the PVC frame are activated by gently pushing hinged levers that attach to the switches. The switches are 20 amp, double pole, double throw, momentary switches that move the device only when both levers are pushed. The device stops automatically otherwise. The entire switch mount is angled toward the driver; the angle is adjustable. The switches have been tested for sustained use for 45 minutes.

The cost of this device is $330.

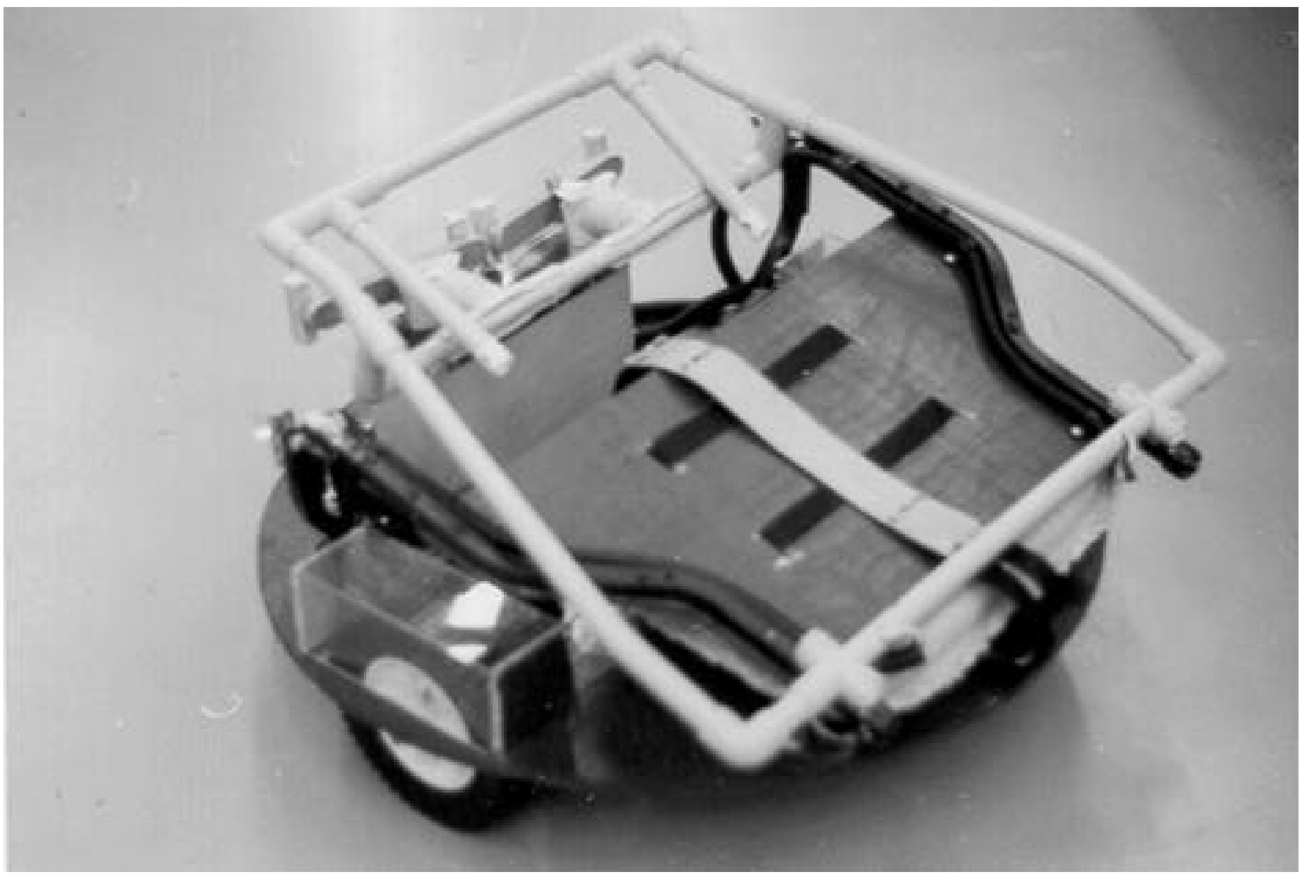

Figure 4.7. Another View of the Motorized Mobility Aid.

MOTORIZED ACTION / REACTION CART

Designers: Kevin Conklin, Alana Schaefer, Quang Su
Client Coordinator: Donna Boisvert, Mary Claire Marasco
Vestal School District
Supervising Professor: Richard Culver, Ph.D.
Department of Mechanical Engineering
Binghamton University
Binghamton, NY 13902-6000

INTRODUCTION

The action/reaction cart is a motorized wheelchair with a simple control system that allows clients to move forward by repeatedly pressing a large button. The control system consists of a switch that requires repeated use to move the cart forward. There are no gears; movement is smooth and unabrupt. The cart is also equipped with standard wheelchair components, including padding, footrests and a battery driven motor. It can be driven on playground blacktop, gym floors, and other areas young clients are likely to go. The cost is significantly less than that for similar commercial systems.

This action/reaction cart helps children with severely limited or slowed movement capabilities move and interact with their peers.

SUMMARY OF IMPACT

The cart was designed for a nine-year-old girl with Rett's Syndrome. The cart's features are vital to her physical therapy. She cannot walk or talk. Her therapists report the motorized cart allows her to interact with other children on the playground, participate in gym class, and gain a new sense of motivation. Like other children with Rett's syndrome, the client requires frequent encouragement. She has a will to move, and often wants to do something physical, but her slowed movement demands that she exert effort for up to 15 minutes to complete a simple action. To sustain her will and build confidence, the cart's switch functions for a few seconds when hit. The client must remove her hand and hit the switch again to continue movement.

TECHNICAL DESCRIPTION

The motorized action/reaction cart is built on the frame of a commercial wheelchair. A padded child-sized car seat, motor, battery, electrical circuitry, and a footrest are mounted on a piece of birch plywood, which is bolted to the wheelchair. All the electrical components are located behind the car seat. The car seat provides a soft comfortable ride, and comes with an adjustable harness strap that fits across the chest and holds the client in place.

Figure 4.8. Motorized Action / Reaction Cart

A button switch, four inches in diameter, is used to control the cart. It is attached to a foam-covered aluminum bracket fixed to the car seat. The switch bracket can be rotated out of the way when the client is placed in the seat. A circuit, powered by a motorcycle battery, connects the switch to the motor, and the wheelchair wheel is driven by a small rubber wheel attached to the motor. The circuit is designed to stop the cart if the client's hand is not removed from the circuit after a predetermined length of time. Hand pressure must be completely removed and re-applied to reactivate the circuit. An emergency cut-off switch can be activated any time the cart is in motion. A key lock prevents unauthorized use. As an extra safety precaution, a Tupperware dish catches any possible leakage from the battery. There is no steering control, since steering is beyond the client's abilities.

The birch plywood footrest is mounted on a tubular frame attached to the body of the cart. Adjustable straps on the footrest prevent the client from kicking her legs. An additional PVC tubular frame on either side of the wheelchair prevents the client from touching the wheels.

The final cost of the system is approximately $350. Similar commercial systems cost approximately $3000.

Figure 4.9. Another View of the Motorized Action / Reaction Cart

TODDLER HAND PROPELLED TRICYCLE

Designers: Jason Charkow, Barbara Charlap, Steven Proulx
Client Coordinator: Colleen Griffith, Reva Reid
Johnson City School District
Supervising Professor: Richard Culver, Ph.D.
Department of Mechanical Engineering
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INTRODUCTION

A hand-propelled tricycle was built for a two-year old child, whose lower legs have been amputated. Commercial hand-propelled tricycles are typically not designed for children as small as this client. The chain-driven systems used in commercial tricycles are not as safe or easy to use as the friction-drive design presented here. This hand-propelled tricycle is easy to maneuver, and is as stable, durable and comfortable as commercial tricycles.

SUMMARY OF IMPACT

The tricycle was designed for one child, but is easily adaptable for clients with similar needs. The client has highly developed upper body strength and excellent balance. At 28 pounds, he has age-appropriate weight, reach and proportions. The tricycle's novel design permits less work and greater safety. Use of the tricycle helps develop self-confidence and allows the client to interact more easily with other children.

TECHNICAL DESCRIPTION

This tricycle is constructed from three children's riding toys: a Tyke's Taxi, a twelve-inch tricycle, and a ten-inch tricycle.

The front assembly wheel mechanism includes a twelve-inch front tricycle wheel, a three-inch idler wheel, and a nine-inch front tricycle wheel. Commercial hand propelled tricycles are typically chain driven, but this tricycle uses a three-inch idler wheel to drive movement. The lower front wheel rotates forward as the idler wheel rotates forward. Without the idler wheel, the lower front wheel would rotate backwards when the upper front wheel is rotated by the user. The front rotation point occurs near the center of the idler wheel, which is positioned for maximum contact and minimum friction with the other two wheels. This makes it easy to crank the upper wheel and go. These three wheels are attached to 1/4 x 1-1/2 inch stock aluminum bar. The nine and twelve inch wheels run on plastic bearings to reduce friction.

The tricycle's rear assembly is the rear wheel assembly of the Tyke's Taxi. The front wheel assembly is connected to the rear wheel assembly using the Tyke Taxi's neck tube. The angle between the front wheel assembly and the back assembly is 90 degrees

The seat is constructed of wood board, foam rubber padding and vinyl material. Sheet metal is riveted to the lower level of the rear assembly to provide a place for the client to rest his feet while riding the tricycle.

The approximate cost is $100.

Figure 4.10. Toddler Hand Propelled Tricycle.

MOTORIZED JEEP FOR A TODDLER

Designers: Eric Lopez, Michael Rabin, Israel Ruez
Client Coordinator: Reva Reid
Southern Tier Independence Center
Supervising Professor: Richard Culver, Ph.D.
Department of Mechanical Engineering
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Binghamton, NY 13902-6000

INTRODUCTION

The motorized jeep is an electric vehicle suitable for a two-year-old toddler with strength and coordination only in the hands and arms. The jeep, based on a four-wheel toy car frame, travels at walking speed or below, is easy to control, and has exceptional maneuverability. It also allows the child to sit or stand with support. In a standing position, body pressures are redistributed and the client is brought to eye level with other children. The jeep is markedly less expensive than commercial options.

SUMMARY OF IMPACT

The two-year-old client has cerebral palsy with spastic quadriplegia. She is unable to walk, stands only with assistance, and is unable to hold herself upright in a sitting position. However, moderate hand grasp strength and moderate flexion and extension of the lower arms provides her with the control needed to operate a vehicle on her own. The jeep allows her to stand, relieving the pressure she experiences in the abdominal cavity due to slouching when she sits.

Figure 4.11. Toddler Motorized Jeep.

TECHNICAL DESCRIPTION

The toddler jeep is based on a Power Wheels toy car frame with two centrally located drive wheels and a single wheel in the front and back. The drive train, drive wheels and axle are bolted with brackets to the underside of the jeep frame. The seat is mounted with PVC flanges inside the upper side of frame, and includes seat padding, seat supports and other final touches. Two momentary reversible toggle switches control the jeep when two levers are depressed forward or backward, singularly or simultaneously. The control panel with the control levers is attached to the seating system.

Altogether, the motorized jeep comes to $350, well below the $6000 to $7000 for commercially available electric wheelchairs.

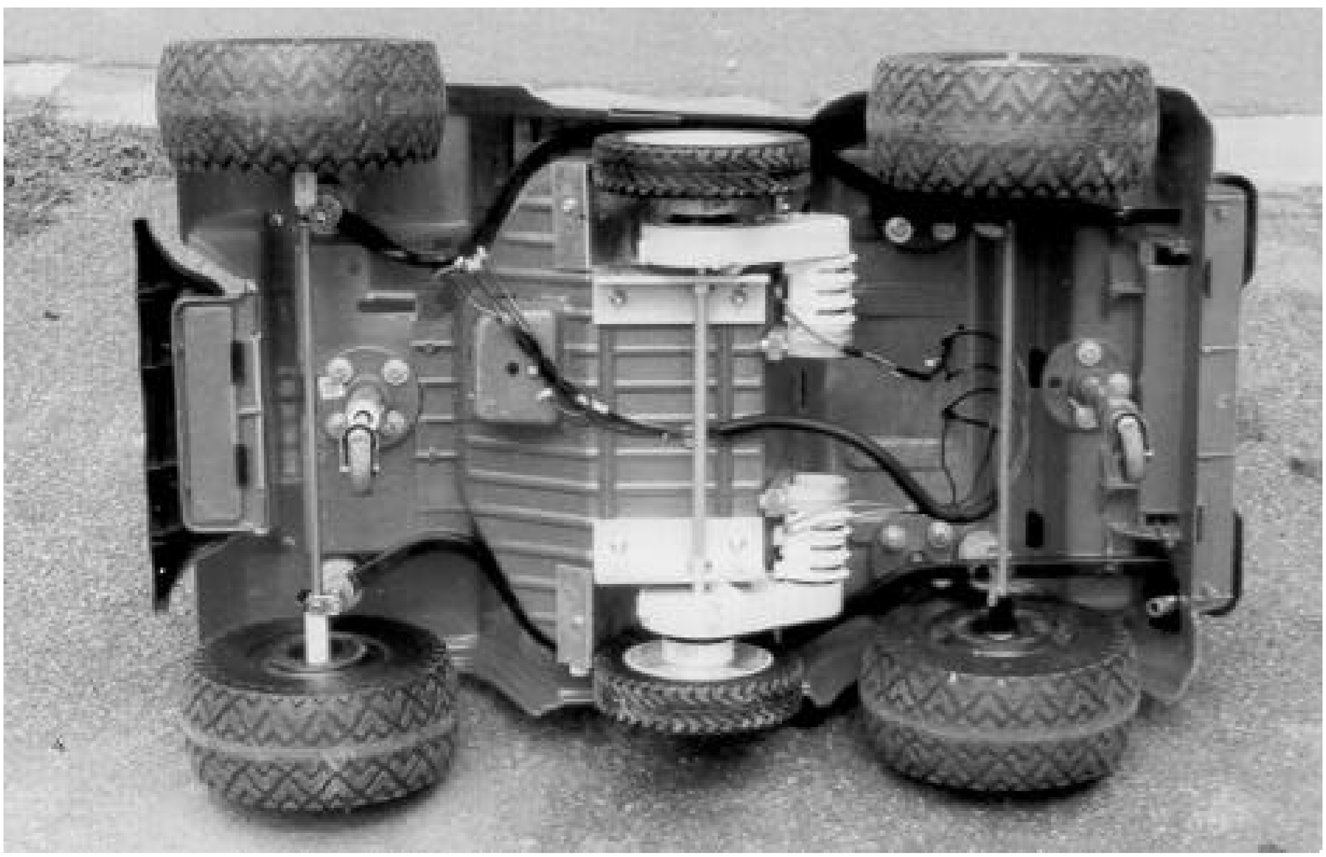

Figure 4.12. Bottom view of the Toddler Motorized Jeep.

MODIFIED ROWING MACHINE

Designers: Kristen Guilfoil, James Rodriguez, Mark Warren
Client Coordinator: Donna Boisvert
Vestal School District
Supervising Professor: Richard Culver, Ph.D.
Department of Mechanical Engineering
Binghamton University
Binghamton, NY 13902-6000

INTRODUCTION

The modified rowing machine is designed for those who want to exercise the entire range of motion in their legs without relying on the legs for strength, and for those who want upper body strengthening without strain to the back or spine. Users rely on their arms instead of their legs to push their seat back and forth. Based on a commercial lifting rower, the machine includes foot rests and foot straps to hold feet and legs in place, a seat belt to prevent falls while in motion, a tapered seat back for back support, and additional safety features to stabilize the machine while the client mounts it.

SUMMARY OF IMPACT

The modified rowing machine was custom designed and built as an exercise device for a thirteen-year-old client with spina bifida. He is paralyzed from the waist down but has full range of involuntary motion and flexibility in his lower body. His feet are angled at 45 and 50 degrees, and one leg is approximately one inch shorter than the other. He also has full upper body movement and strength, even with his limited spinal flexibility. The design is easily transferable for clients with similar needs.

TECHNICAL DESCRIPTION

A commercially available lifting rower with a minimal number of moving parts was modified to meet the client's requirements. The redesigned parts include the arm bars, the seat and the foot rests.

The arm bars are made immobile so the seat may slide back and forth when a force is applied to them. To accomplish this, the arm bars are moved from their standard position on a joint in the center of the machine, to a new location at the base of the machine. The bars were detached from the center joint by removing the bottom lip of the bar. They were then reinstalled at the base, in which two holes had been drilled.

The commercial rower comes without a seat back. A steel bar and a piece of wood were used to create a tapered back that does not interfere with the client's rowing motion. The sheet metal fits between the wheels in the track and the bottom of the seat. To prevent the seat from moving while the client is getting on, the sliding track and base are connected to each other using two brackets. A seat belt is added for safety.

To accommodate the client's angled feet, holes were drilled on the back of the existing footrests, and the footrests may be slid back onto the bar at the appropriate angle. This is a quick approach easily adaptable to other clients' needs. To account for difference in leg length, the center of the footrest was cut out and filled with wood of sufficient thickness.

The final cost was approximately $185.

Figure 4.13. Photograph of the Modified Rowing Machine.

VACUUM PAGE TURNER

Designers: Brian Hallgren, Natacia Palmer
Client Coordinator: Susan Ruff
Southern Tier Independent Center
Supervising Professor: Richard Culver Ph.D.
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INTRODUCTION

This vacuum assisted page turning device requires only slight movement over a sensor to automatically turn pages forward or backward. An infrared photocell detects the reader's movement, and a suction-cupped arm attached to a vacuum pump system pivots, grabs onto a page, and turns it. The page-turner accommodates a wide variety of reading materials of different sizes, including books, magazines, and binders with normal and laminated pages. The angle at which the reading material faces the user is also adjustable.

SUMMARY OF IMPACT

The vacuum page-turner was originally designed and built for a client with muscular dystrophy. It is appropriate for a wide range of individuals. Whether on the job or in the privacy of one's home, the page turner works with the simplest hand movement, making the world of printed material available to those who might otherwise be limited.

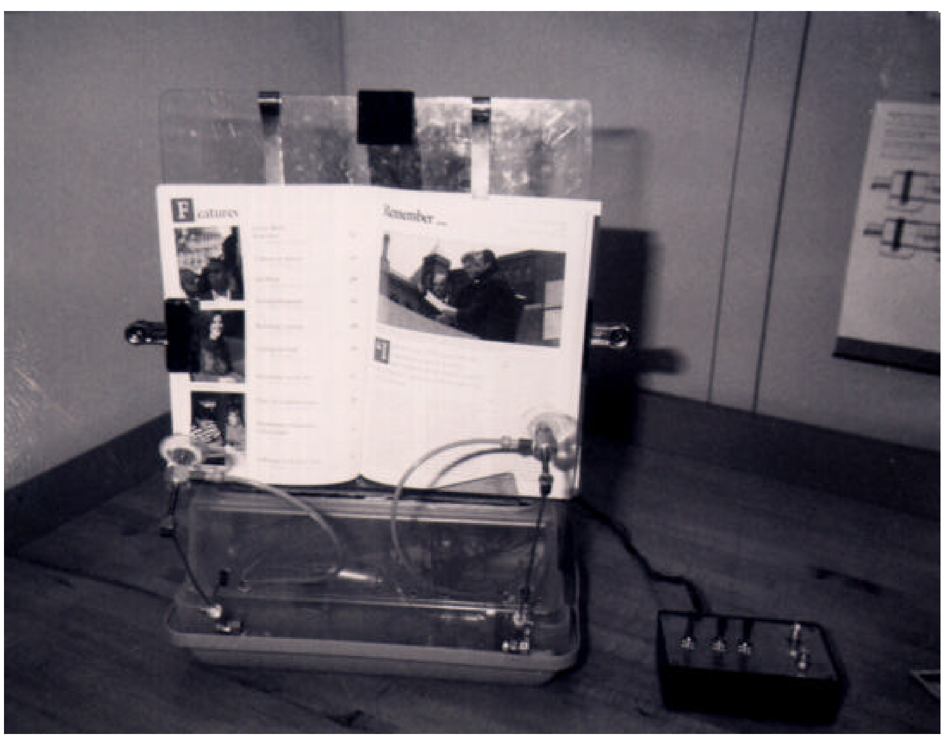

Figure 4-14. Vacuum Pager Turner.

TECHNICAL DESCRIPTION

The vacuum page turner consists of a sensor package, a sloped box-like housing to support a book, pivot arms to turn pages, a suction cup on the end of each arm to grab pages, a worm gear box to move the arms, a vacuum pump with solenoid valves, and a vacuum regulator switch to drive the suction cups.

The page-turner is controlled by two infrared photocell emitter-detector packages, one for each page-turning direction. When the reader's finger is placed over an emitter-detector package, the emitter beam is refracted, the detector senses the refracted light, and an electric pulse activates the mechanical system.

When the system is activated, the vacuum pump depressurizes the air tank to a pre-set vacuum level. Next, the worm gear box activates one of the arms and pivots it forward. The right arm is activated to page forward, while the left arm is activated to page backwards. Once the activated arm comes in contact with the page, a solenoid is switched to the open position, allowing atmospheric air to pressurize the air tank. This causes the page to be drawn to the suction cup. Then the arm pivots downward, drawing the suctioned page away from the others. A planetary motor rotates a large arm from underneath, swiping the page to the opposite side of the binding. When the swiping arm is counter-rotated, it pushes the page backwards.

The two pivot arms consist of long, slender steel hollow rods mounted opposite one another along the sides of the housing. One end of a pivot arm is screwed to a pivot point on either the right or the left side of the housing. The arms are attached well below the bottom edge of a book so as not to obstruct a reader's view regardless of the viewing angle chosen. The other end of each arm attaches to a treated aluminum cylindrical sleeve. A spring between the arm and sleeve permits the arm to travel as needed according to the reading material being turned.

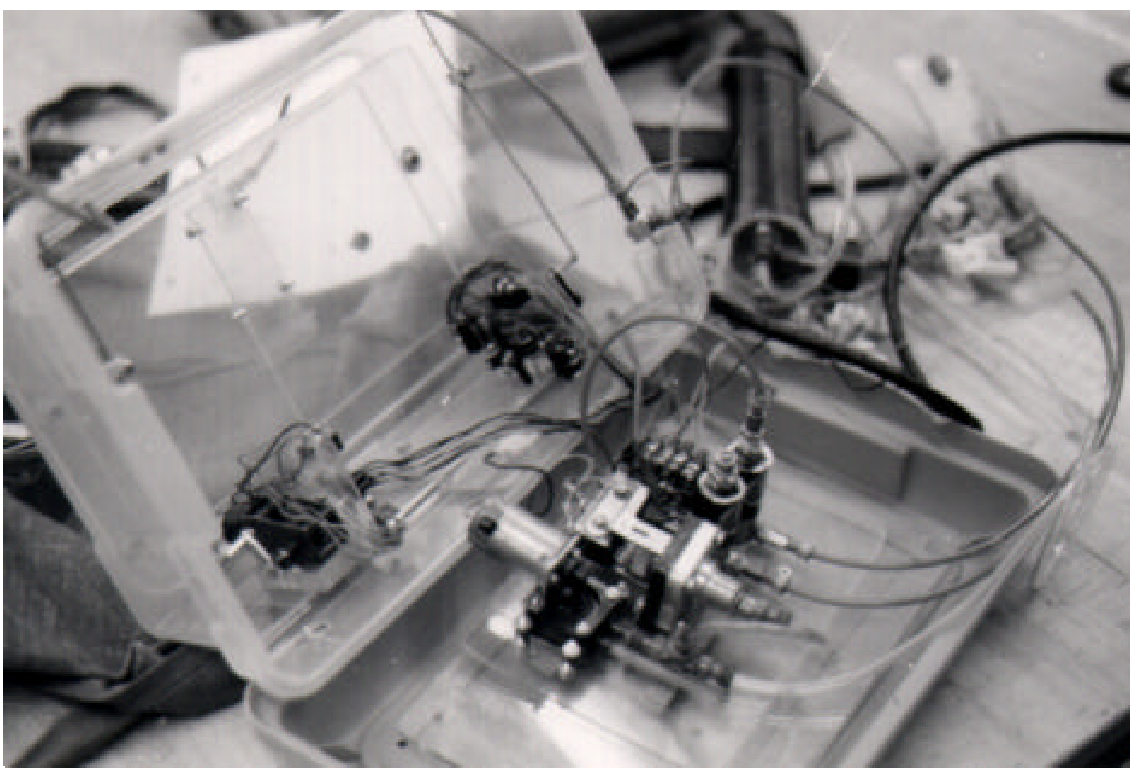

Figure 4-15. Internal View of the Vacuum Pager Turner.

PORTABLE POOL LIFT

Designer: Quan Su
Client coordinator: Christine Washburn
Handicapped Children's Association
Supervising Professor: Richard Culver, Ph.D.
Department of Mechanical Engineering
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INTRODUCTION

A school district requires a portable lift to raise and lower high school students into a swimming pool. Commercial pool lifts require permanent alteration of the pool facility in order to anchor a lifting frame to the pool deck. The Portable Pool Lift uses flotation as the lifting force, so that a rigid, load-bearing mounting system is not required. An inverted rectangular plastic tank, attached to pivoting PVC plastic arms, provides a flat lifting surface, which raises and lowers the student into the water. The rotating arms are attached to a plastic frame, which is anchored to the pool by a post. The post fits into an existing hole in the poolside. Clips are used to engage a lip on the pool surround.

Attached to the top of the flotation tank is a hardwood board, which extends toward the pool edge. In the raised position, this board rests on the side of the pool. This serves as a seat and slide board for moving the student from poolside onto the lift. In operation, the student moves onto the board and holds onto the plastic frame attached to the flotation tank, as shown in Figure 4.16. Air is pumped into the tank via the frame, which is attached to an air source, a converted shop vacuum cleaner. As water is displaced from the tank, it rises off the poolside until the rotating arms are vertical, at which time the air supply is removed and the flotation tank is allowed to settle slowly into the water, expelling air back through the vented frame. When the tank reaches its bottom position, the seat board butts up against the side of the pool, holding the tank away from the side and keeping the rotating arms at an angle so that a vertical lifting force will cause them to rotate, as shown in Figure 4.17. At this point the student is submerged and can move around in the water, supported by his buoyancy. Figure 4.18 shows the frame and air pump sitting on the pool deck.

Figure 4-16. Portable Pool Lift in Raised Position.

Figure 4.17. Portable Pool Lift in Lowered Position.

SUMMARY OF IMPACT

A school district is required by the Americans with Disability Act to provide access to its pool for two entering students. District authorities did not want to make permanent modifications to the pool. A commercial pool lift is very expensive. The Portable Pool Lift can be installed in about five minutes and allows assistive aides to move the students into and out of the water with minimum effort. The Portable Pool Lift weighs about 30 pounds, so it can easily be lifted out of the water and stored in an adjacent storeroom.

Figure 4-18. Portable Pool Lift and Air Pump on Poolside.

TECHNICAL DESCRIPTION.

The swinging arms and flotation tank are made of PVC plastic to avoid rust. It is lightweight and easy to fabricate. The furniture-grade PVC tubing is supplied with slip joints, which are used as hinges for the rotating arms. The rigid support frame, which supports the rotating arms and flotation tank, serves as a piping system for conveying air from the blower to the flotation tank. PVC ball valves are mounted in the arms of the support frame to control the airflow for inflation and evacuation. However, it is easier to control the flow by simply pushing the nozzle on the supply hose into its connecting hole in the frame with the air pump running. When sufficient air has been injected into the flotation tank, the supply hose is removed and the connecting hole serves as a vent.

Although reversible shop vacuums exist, an old vacuum was modified in this case to provide a positive pressure air source. The air source has to provide a static air pressure of at least 24 inches of water in order to operate the Portable Pool Lift.

As shown in Figure 4.18, a vertical post is used to anchor the top portion of the frame to the pool. This post uses a wedging action to hold it in the hole in the pool deck, although it is not necessary to hold it that tight. The lower anchor clips are made of modified slip joints with wing nut tightening screws. These are pulled tightly against the protruding lip to hold the Portable Pool Lift tightly in place. In addition to these anchoring points, a rubber-coated steel wedge is forced under the edge of the base to keep it from rotating out from the wall under the flotation tank's lifting force. The base support frame and side support frame are designed to fit the clients' pool. Additional anchoring systems could accommodate the particular geometry of a given swimming pool edge.

HINGED DOOR OPENER

Designers: Daryl Derkowski, Jonathan Yost, Mark Howe
Supervising Professor: Richard Culver, Ph.D.
Department of Mechanical Engineering
Binghamton University
Binghamton, NY 13902-6000

INTRODUCTION

A door opening device was designed for an adult man with paraplegia. The client desired a device that would allow him to open his front door without the aid of another person. The device was to allow for either manual or automatic opening while ensuring safety for anyone who would come in contact with it. Some existing solutions appeared useful but were expensive, ranging in price from $1200 to $1500.

Figure 4.19. Hinged Door Opener

SUMMARY OF IMPACT

As a result of the door opener the client has become more independent in his daily life. Now that he can open his door, he is able to go outside independently, or to open the door to allow someone into his home.

TECHNICAL DESCRIPTION

The hinged door opener was made by purchasing a garage door opener and modifying its internal machinery. A lever arm was devised and mounted on the gear drive sprocket on top of the opener. The arm, made mostly of aluminum, consists of a shaft that connected to the sprocket at the base, with two arms extending off the top of the shaft. A wheel was attached between the ends of the two arms so that no mark would be made on the client's wall where the arms would push the door open.

After the construction of the arm, a new motor was put into the opener to slow the speed at which the sprocket would rotate. The original speed was around 1500 RPM. The new speed was approximately 6 RPM, requiring around 5 seconds for the door to be opened. Installing this new motor required some modifications to the internal setup of the garage door opener. A new motor mount had to be constructed for the modified due to its different shape. A three-inch adapter was added to the end of the motor shaft

The front end of the casing was cut out slightly so that the motor could fit into the device properly. The original shield for the light was left installed to cover areas where wires might otherwise be exposed.

The total cost of the hinged door opener and accessories required for the project came to $308. The garage door opener cost $150 and the aluminum bar cost $25. The new motor and capacitor cost a total of $99. The remaining costs were made up from some minor modifications that were made to the door itself. Two spring hinges ($22) and two L braces ($9) were purchased to help support the door opener on the door. The total cost was from $900 to $1200 lower than the price of a commercial door opener.

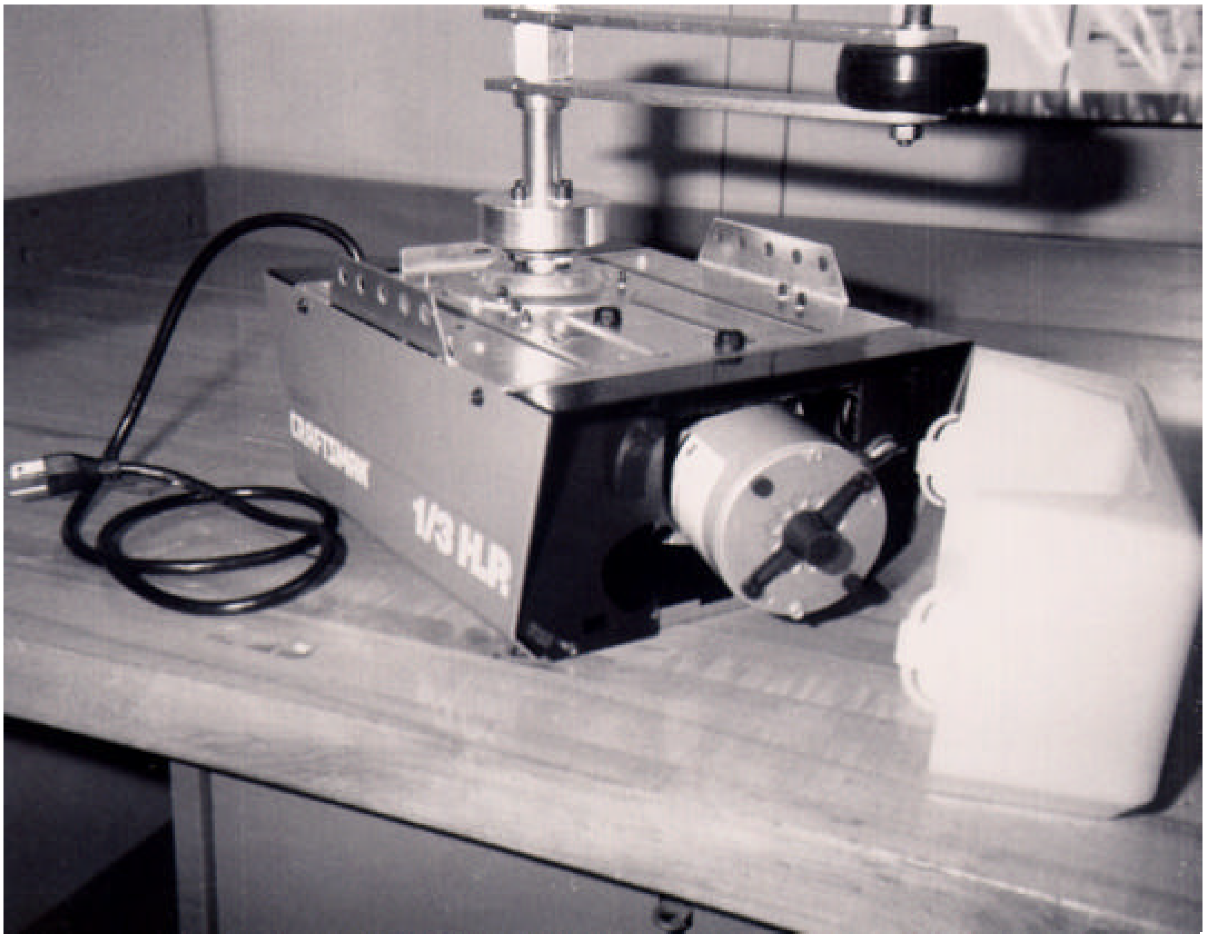

Figure 4.20. Low Speed Motor in Door Opener.

WHEELCHAIR LIFT

Designers: Scott Jantzen, Steve Albert, Quang Su
Client Coordinator: Valdo Rogers
Broome Developmental Center
Supervising Professor: Richard S. Culver, Ph.D.
Department of Mechanical Engineering
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Binghamton, NY 13902-6000

INTRODUCTION

A wheelchair lift was designed and built to facilitate wheelchair repair and servicing for a developmental center. The pivoting legs of the lift and table consist of two rotating rectangular frames placed at a slight angle to each other. When the table is lowered, the angle between the legs makes the table tilt so that one edge is lower than the other as it reaches the floor. The wheelchair can be rolled onto the tilted tabletop, where a spring-loaded rotating flange is used to secure it. When the lifting arm is lifted, it rotates the legs, raising the table and wheelchair to normal table height. In the vertical position, the legs can be locked against a wooden frame that supports them. When not in use, the handle is stored in the reversed position in the legs. The flange can be held flat against the tabletop by a clip when it is not needed. The wheelchair is held in place on the tabletop with Velcro straps while it is being serviced.

Figure 4.21. Wheelchair Lift in Raised Position

Figure 4.22. Wheelchair lift Lowered for Loading.

SUMMARY OF IMPACT

The client, a developmental center, has a large number of wheelchairs that require regular servicing and repair. Normally, technicians service them on the floor since, at 100 pounds or more, they are too heavy to lift to table height. The limited space in the workshop prevents using a ramp for raising the wheelchairs and precludes a space dedicated solely to lifting wheelchairs. The wheelchair lift described here requires minimal space, and can be used as a regular working surface when not needed for wheelchair repair.

TECHNICAL DESCRIPTION

The wheelchair lift is constructed of common building materials. The lower frame is made of 2x6, 2x4 and 1x6 lumber. The table top is 3/4 in plywood. The legs are Type-L, 3/4 in. copper tubing. The lifting handle is a special, 5/8 in. copper tubing with 1/2 in. steel rod glued inside to increase bending resistance.

The legs are set at a 5? angle, such that, when lowered to the floor, the high end is approximately 10 inches off the floor. The copper tube runs in bearings made by holes through the fir lumber. When raised to a vertical position, regular 4-inch bolt latches lock each of the four legs rigidly against the wooden frame. The two legs that hold the lifting handle are topped with T connections, providing the lifting handle access to the legs.

The pivoting flange is made from 20-gage sheet steel, which is bent over the edge of the plywood. It is attached to the tabletop with a piano hinge. Leaf springs, bent from piano wire, push the flange up from the tabletop to an angle. When a large wheelchair wheel rolls against it, it locks in place, keeping the wheelchair from rolling backward. When removing the wheelchair, rotating clips on each side of the table allow the flange to be held flat against the tabletop.

The approximate cost of materials for the wheelchair lift is $50. To our knowledge, there is no comparable device on the commercial market.

Figure 4.23. Detail of Flange.

GAIT EXERCISER

Designer: Alex Ross
Client Coordinator: Colleen Griffith
Johnson City School District
Supervising Professor: Richard S. Culver, Ph.D.
Department of Mechanical Engineering
Binghamton University
Binghamton, NY 13902-6000

INTRODUCTION

An instrumented frame has been built to stimulate gait dexterity in young children. The frame consists of three parts: an adjustable support frame, instrumented walking beams, and a control console that provides visual feedback when the walking beams are depressed (Figures 4.24 and 4.25). The load level at which a red light for each beam turns on can be adjusted to encourage the child to place full weight on each leg.

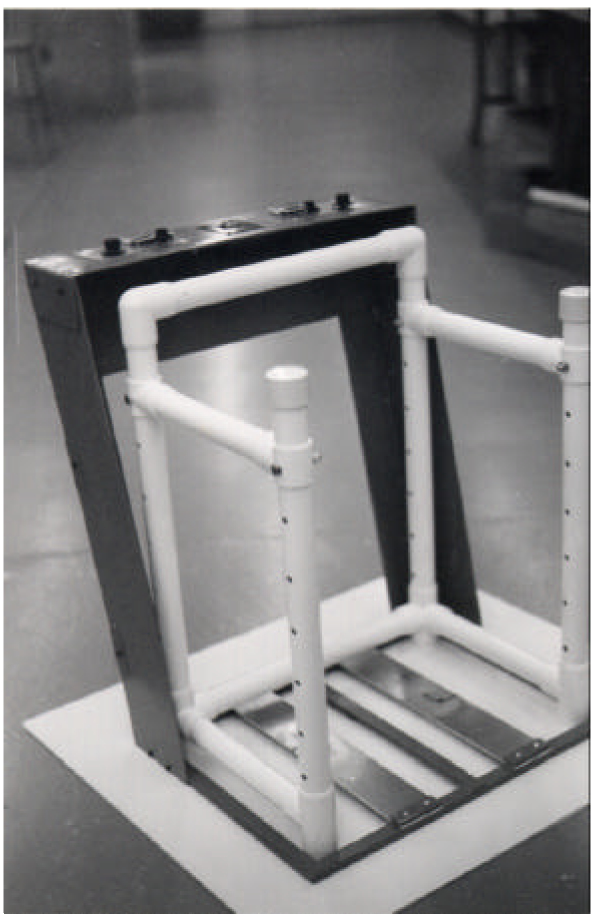

Figure 4.24. Gait Exerciser - Rear View

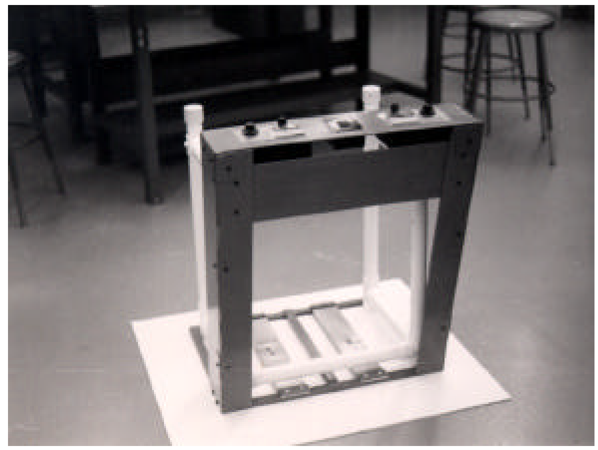

Figure 4.25 Gait Exerciser - Front View.

SUMMARY OF IMPACT

The Gait Exerciser was developed for children with limited walking ability in a school setting. A device that gives them feedback when they are walking properly was requested. Feedback is provided via red lights that turn on when the user applies sufficient load on the walking beam to reach a preset level. Audio signals can also be attached to the system to make a sound when the desired load is reached. The independent adjustment for the preset load on each walking beam allows the system to accommodate children with special disabilities. It will also accommodate children with weights ranging from 30 to 60 pounds. Comparable commercial systems are very expensive and do not provide the desired adjustability.

TECHNICAL DESCRIPTION

The Gait Exerciser walking beams are made of 3x1/4 inch aluminum plates, to which strain gages have been mounted on top and bottom. When a child steps on the beam, the beam deflects, activating the strain gages, which register pressure electrically. Wires from the gages travel through the frame to the console where the electronic controls are mounted.

The circuit functions by measuring the difference in voltage between the two strain gages on the walking beam. This voltage difference is acquired by passing the two voltage signals, one from each strain gage, through a differential amplifier. Next, the signal is next filtered to remove high frequency and 60 Hz noise. A non-inverting amplifier is used to amplify the signal so that it is of the same magnitude as the power supplies (? 9V). The resulting output signal is input to a voltage comparator in which the user has set a reference voltage. When the reference voltage is reached, a visual output is generated. A diagram of the circuit is given in Figure 4.26.

In operation, the sensitivity and the base weight of the user can be adjusted by the therapist through dial controls so that the walking load is indicated on a meter. This can be set to turn on a red light when the desired load above the base weight load has been applied. The child supports him/herself with the plastic beams on the support frame.

The support frame is made from 1 1/4 inch furniture grade PVC plastic. The horizontal arms can be adjusted vertically. The support frame for the walking beams is 1/2x1 inch steel bar. The control console is made from 1/8 inch 6061-T6 aluminum. When in use, the walking beams are covered with sheet rubber, with feet painted on the surface to indicate where the child should step. The cost of the gait exerciser materials is $120.

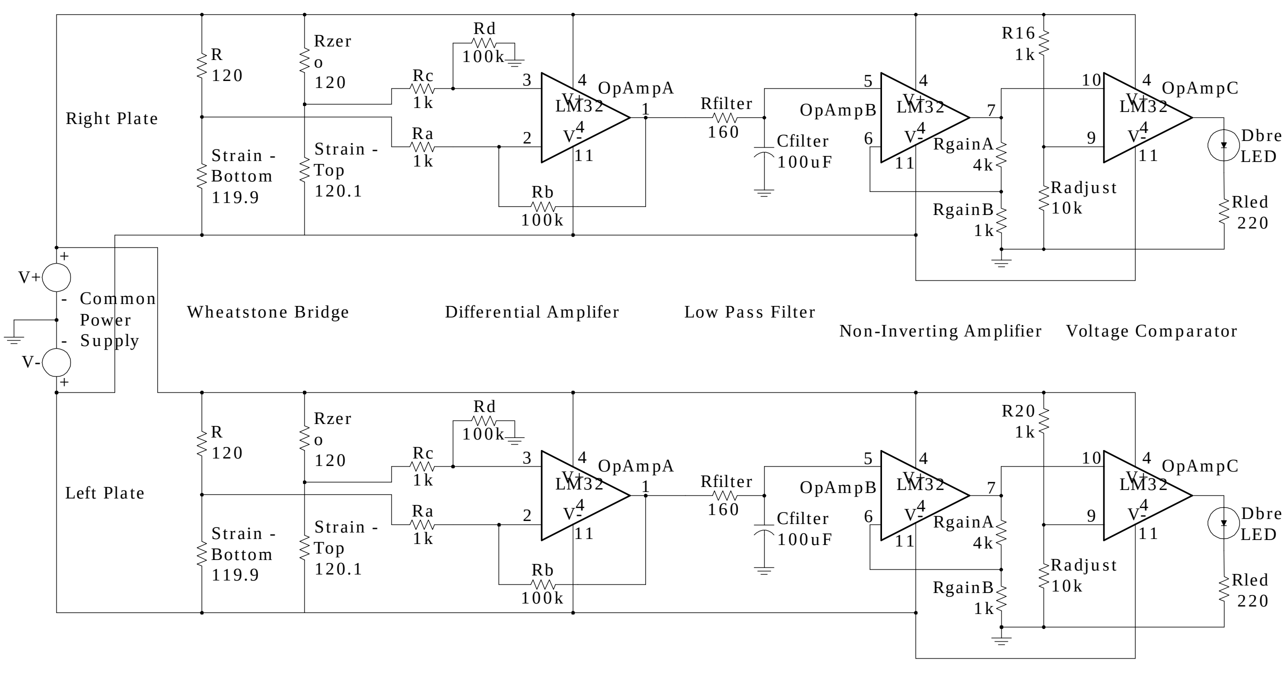

Figure 4.26. Circuit Diagram for Gait Exerciser.

Chapter 5
DUKE UNIVERSITY

School of Engineering
Department of Biomedical Engineering
Durham, North Carolina 27708-0281

Principal Investigator:

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WHEELCHAIR CONTROL SIMULATOR

Designer: Drew Narayan
Client Coordinator: Robbin A. Newton
Lenox Baker Children's Hospital
Supervising Professor: Dr. Laurence N. Bohs
Department of Biomedical Engineering
Duke University
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INTRODUCTION

A wheelchair control simulator was designed so that children could practice using controls typical of motorized wheelchairs while a therapist monitors their progress. The wheelchair control simulator includes a joystick, a processing and display unit, a video monitor, and a custom motorized car with a CCD camera mounted to the front. As a child drives the car through a maze, sensors on the car detect when the car hits a wall. The number of hits, the time moving, and the elapsed time are combined into a running score that motivates the child and provides feedback to the therapist. A four-section LED display indicates the time moving, total time, overall score, and number of hits to each of the four sensors. The monitor shows the camera's view to provide the child with the sense of sitting in the car. This device can be used by therapists to assess whether a child will be able to operate a motorized wheelchair safely. At the same time it is entertaining for the child.

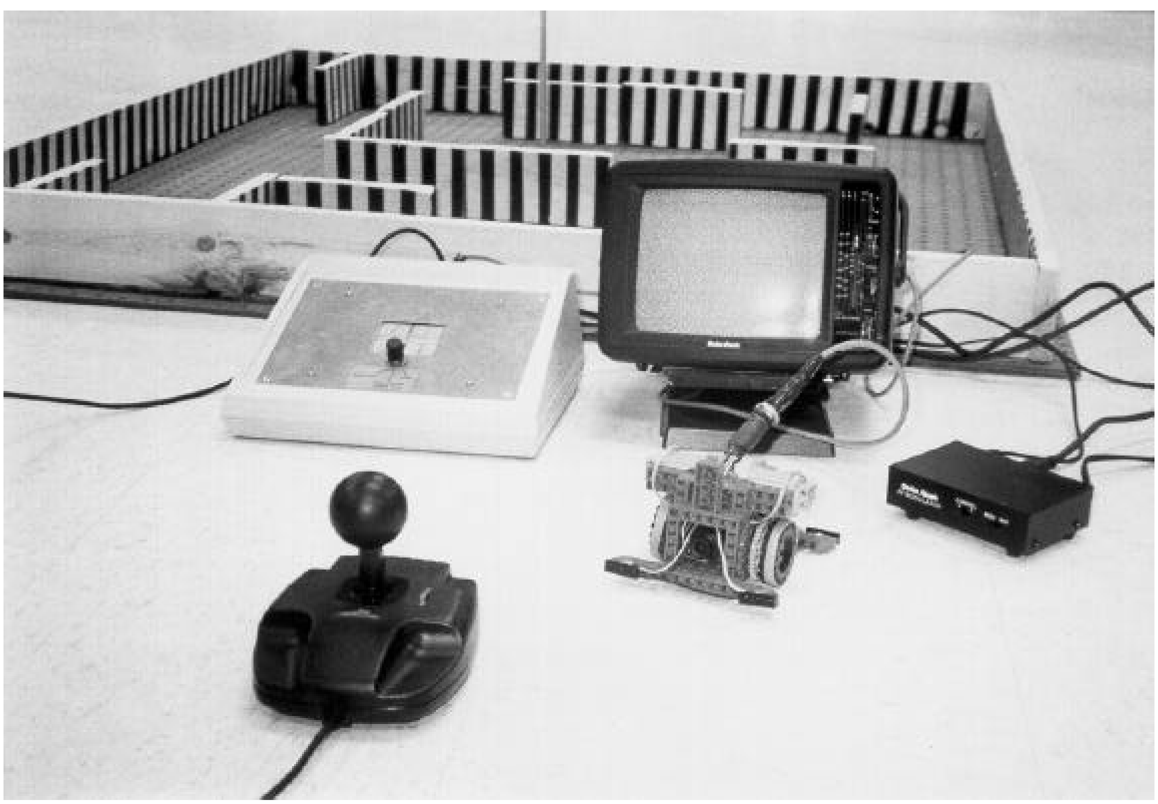

Figure 5.1. Components of Wheelchair Control Simulator.

SUMMARY OF IMPACT

Each year about 50 children at Lenox Baker Children's Hospital could benefit from motorized wheelchairs. Because such wheelchairs are expensive and potentially dangerous, therapists must assess whether a child could benefit from a motorized wheelchair, and if so, whether they are ready to try driving one. The wheelchair control simulator allows children to practice "driving" while the therapist monitors their skills with a running score.

Experience with the simulator to date indicates that two modifications could greatly improve its usefulness. First, using radio control rather than a wire tether would improve the car's maneuverability, since the car has a limited range and sometimes does not turn properly. Second, the switches that sense hits to walls could be more sensitive and reliable. These improvements may be addressed in a future design.

TECHNICAL DESCRIPTION

The wheelchair control simulator has five main components: a joystick, a processing and display unit, a motorized car, a monitor, and a maze, as shown in Figure 5.1. The joystick, a modified Radio Shack Avenger 700, controls the movement of the motorized car. The aviator style handle of the joystick is replaced with a 1.75-inch diameter ball to simulate a standard wheelchair joystick, which was not used because of cost. The joystick is attached to the processing and display unit using a 15-pin D-subminiature connector.

The core of the processing and display unit (Figure 5.2) is the Z180 microprocessor on the SmartCore Z1 Board (Zworld Engineering, Davis, CA). The microprocessor program was developed in Dynamic C using the SmartCore Development Board (Zworld). The microprocessor receives input from touch sensors and a display mode selector switch via a 74LS373 latch. Output from the processing and display unit appears on a four-section LED display, each section comprising two seven-segment digits. This unit serves several functions: to control the movement of the motorized car, to process information from the touch sensors, to control the display, and to provide a power supply. The unit converts the nonlinear output from the joystick into an amplified, linear input for the motors of the car. This is accomplished using a dual analog to digital converter (ADC0844), low pass digital filters, a dual digital to analog converter (DAC0890), and two push-pull current amplifiers. To process information from the touch sensors, a software loop on the SmartCore reads data continuously from the input register (74LS373). The microprocessor counts a hit only if it registers on five consecutive loops, preventing a hit from being counted more than once.

The microprocessor also continuously monitors the signals from a three-position rotary switch and displays either: 'Time Moving and Total Time', 'Hits' (the number of hits on each of the four touch sensors), or 'Overall Score and Total Time'. A real time clock on the Z1 board keeps track of the total elapsed time. The following equation is used to compute the score:

$$\text{Overall Score} = (1000 - 10 * (\text{total hits})) * (\text{time moving}) / (\text{total time}).$$

The motorized car is constructed from Legos with all pieces secured with epoxy to ensure durability. Separate motors drive each of the rear wheels of the car so that a tight turning radius is achieved. The speed and direction of each motor is controlled by altering the amount and polarity of the voltage and current applied to the motor, thereby allowing the car to move in any direction. Each motor is geared down three times to reduce speed and increase torque. Touch sensors are attached to each of the four corners of the car and a CCD camera is bolted in the interior of the car. The car is equipped with bumpers to protect the camera, and a wire tether connects the car to the processing and display unit. The tether contains a total of nine wires: one for each of the ground sensors, two for the CCD camera, one for each of the two motors, and a common ground.

A standard five-inch black and white television monitor displays the output of the CCD camera. The processor and display unit can be attached to any television, using the Channel 3 and 4 modulator included in the unit. The maze is made of a 4'x4' pegboard base with 1"x4" wooden blocks, each with two protruding dowels on the bottom to attach to the base. The wooden blocks may be placed in any desired orientation by the therapist depending on the child's skill level.

The total cost of the wheelchair control simulator was approximately $830.

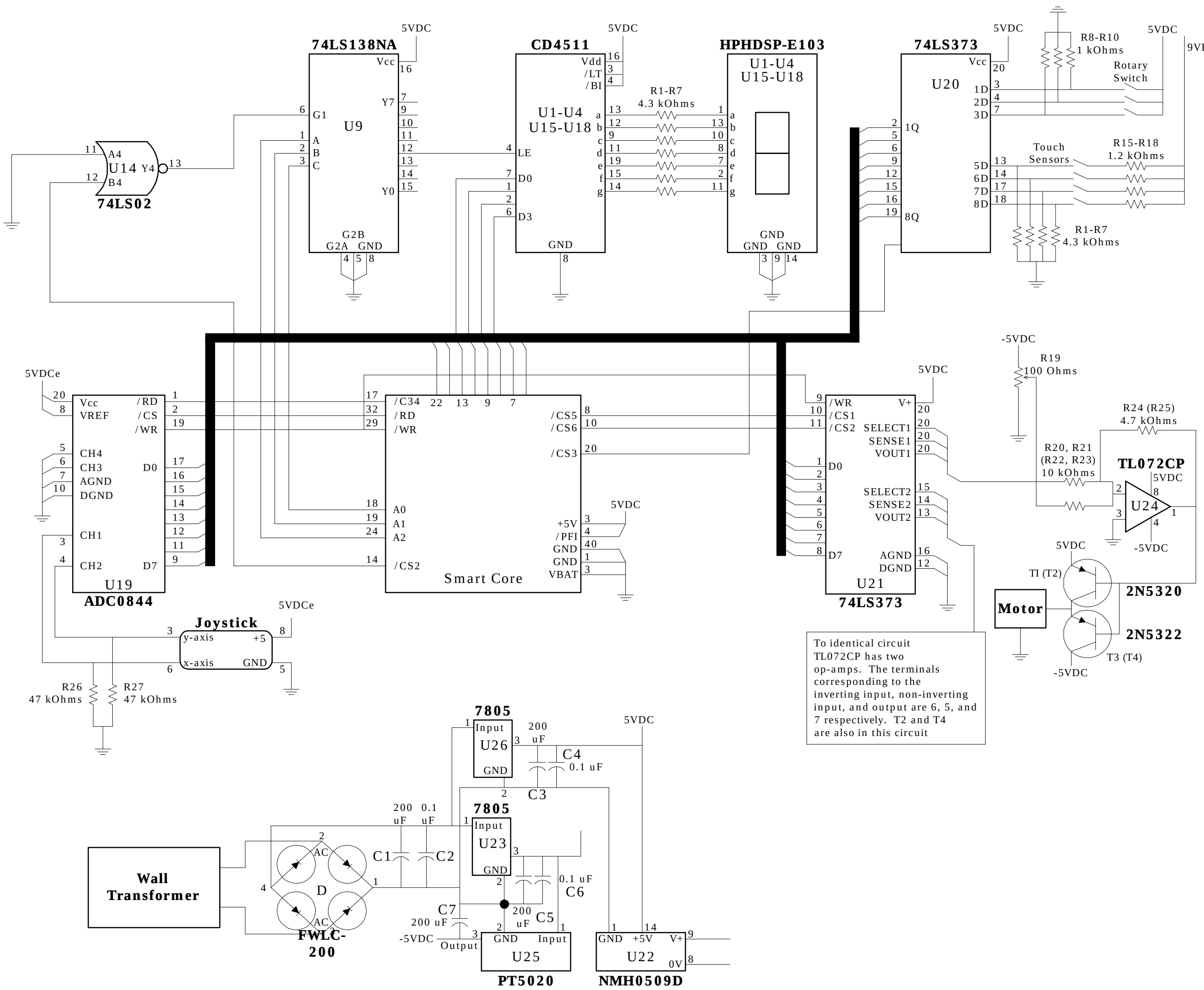

Figure 5.2. Schematic of the Processing and Display Unit.

HOCKEY GOALIE SLIDER

Designers: Brian Feldman, Donna Geddes, Larry Maciolek
Client Coordinator: Robbin A. Newton
Lenox Baker Children's Hospital
Supervising Professor: Dr. Laurence N. Bohs
Department of Biomedical Engineering
Duke University
Durham, NC 27708-0281

INTRODUCTION

A hockey goalie slider has been designed for an eleven-year-old boy with cerebral palsy, to enable him to better participate in neighborhood street hockey games. The basis of the slider is the monorail track of a Concept II™ (Morrisville, Vermont) Indoor Rower. The custom seat is situated so that it slides laterally on the track. Using this device, the client can use his legs as well as his arms to move from side to side. Leg extensions and feet prevent the device from tipping or sliding on the pavement. The seat can be adjusted for added comfort, and telescoping legs allow the seat height to be varied to accommodate the client's growth. A Velcro safety belt secures him safely to the slider. Wheels and handles are mounted on the slider for portability. Finally, a custom stick with a rounded handle allows the client added control in stopping the puck.

SUMMARY OF IMPACT

The client has a form of cerebral palsy known as pyramidal diplegia. This type of cerebral palsy renders one's legs weak, and results in a lack of lower body coordination. The hockey goalie slider allows the client to participate more actively in neighborhood street hockey games with other children, including his twin brother who does not have cerebral palsy. Previously, the client had played goalie by sitting in front of the goal with his legs to the side. The slider allows him to sit in an upright position, where he can cover the goal more easily and follow the game better.

The hockey goalie slider also enables therapeutic activity. By using his legs to slide across the goal mouth, the client builds lower body strength and improves coordination. The hockey goalie slider has proven to be safe, durable, portable, and fun. Because the height and seat positioning are adjustable, the client will be able to enjoy it for years to come.

TECHNICAL DESCRIPTION

The hockey goalie slider is comprised of five components: a rail, telescoping legs, feet, a seat, and side pads. The rail is the track monorail from a Concept II™ Indoor Rower, which was generously donated by the company. It is constructed of I-beam aluminum extrusion with a thin stainless steal overlay on the top surface. The sliding mechanism uses eight roller bearings, four contacting the underside of the beam and four contacting the topside of the beam. Rubber stops are attached to each end of the rail to prevent the seat from sliding off the end. The width of the slider is 48 inches to accommodate the size of the standard hockey goal.

Telescoping legs are used to adjust the height of the slider. These legs were obtained from a Parabody weightlifting-spotting stand and are bolted to the monorail. The legs allow the height of the seat to range from 15" to 20".

To insure that the device cannot be tipped either frontward or backward, extensions were added to the legs of the slider. Each consists of a 14" long, 2" wide, ¼" thick steel bar that slides into the legs of the Parabody stand. These extensions are secured by set-screws. Rubber feet are attached to the end of each extension to prevent the apparatus from sliding on the pavement as the client slides back and forth.

The seat cushion was donated by Health Care Equipment (Chapel Hill, NC), and the seat back is custom made to match. Both are upholstered with black vinyl and foam padding. The cushion is bolted onto an aluminum plate mounted on the sliding mechanism. The back support is vertically adjustable using a knob in the J-bar that attaches the back support to the aluminum plate. Horizontal seat adjustment is achieved via a slot in the J-bar where it attaches to the plate, allowing the seat to be adjusted forward or backward relative to the sliding rail. The seat is also angularly adjustable using the bolts that anchor the seat. The seat rests on springs that add cushion and shock absorption. A 3-inch wide Velcro safety belt holds the client securely in the seat and can be attached and removed by the client.

Vertical side pads, made from modified seat cushions, are mounted on fixture brackets and attached to the ends of the rail. These allow the client to move laterally by pushing with his arms and elbows. A knob allows the height of the side pads to be adjusted.

A custom stick was also made by attaching the aluminum handle from a fishing net to the blade of a street hockey stick. The round handle allows the client to maneuver the stick more easily than he could maneuver his previous stick.

Empirical testing shows that the slider is safe, durable, usable, and portable. Theoretical testing of the device suggests that it cannot be tipped over.

The total cost of the hockey goalie slider was approximately $550, including $125 in machining costs.

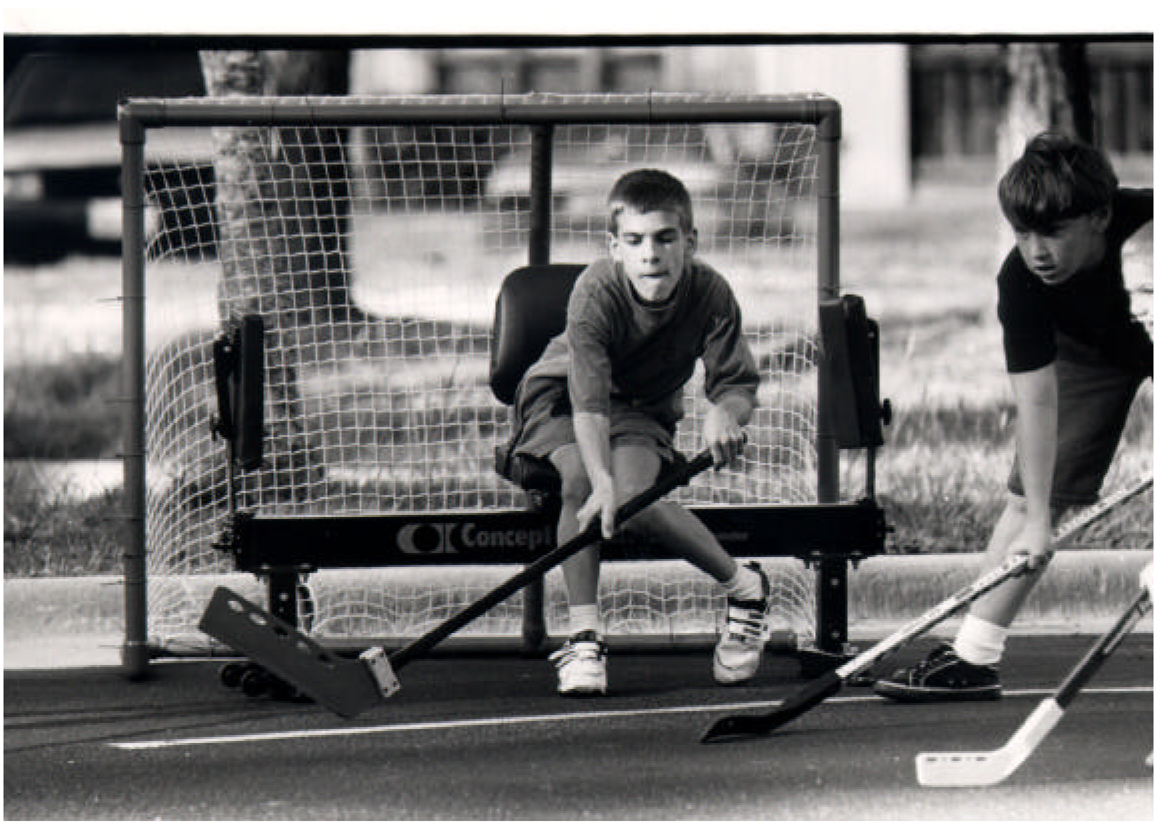

Figure 5.3. Hockey Goalie Slider.

SPELLING AND TACTILE IDENTIFICATION GAME

Designers: Frank Fernandez, Varish Goyal
Client Coordinator: Jean Hartford
Child and Adolescent Life Program
Duke University Medical Center
Supervising Professor: Dr. Laurence N. Bohs
Department of Biomedical Engineering
Duke University
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INTRODUCTION

A spelling and tactile identification game has been designed as an enjoyable learning tool for children with visual impairments. The device operates in two modes: spelling or tactile. In spelling mode, the device asks the child to spell a word by selecting the appropriate buttons on a custom keyboard. In tactile mode, a grid is placed over the keyboard, which allows the placement of 21 objects. The device asks the child to find a specific object and to push the corresponding button. In either mode, the parent or therapist may choose from six different Braille keyboard overlays so the child cannot memorize the positions of the objects and letters. In both modes, the child is told whether he or she is correct or if he or she should try again. A microprocessor controls digitally recorded voice chips, which ask the child to spell words or find objects, and tell him or her whether or not the correct answer is given.

SUMMARY OF IMPACT

The spelling and tactile identification game is designed to be both educational and entertaining. It is intended for use by children with visual impairments. The design is versatile, operating in either spelling or tactile mode using six different overlays. Unfortunately, the device must be connected to a PC computer, which is unavailable in the playroom of the client's agency. A standalone version of the project, which will not require connection to the PC, is under development.

TECHNICAL DESCRIPTION

The spelling and tactile identification game includes four main components: the input section, the processing unit, the voice chips, and a speaker. The input section consists of two switches and a custom keyboard. A three-position switch determines whether the machine is in spelling mode, in tactile mode, or off. A six-position rotary dial switch selects which overlay is being used. The keyboard consists of 28 push buttons arranged in four rows of seven buttons. In spelling mode, the keys correspond to the 26 letters of the alphabet, plus an "enter" key and a "next word" key. One of six different overlays may be chosen, each containing a Braille letter label for each switch; the labels are in a different order for each overlay. In tactile mode, each button of the top three rows corresponds to one of 21 shapes. The rows of the keyboard are connected to the outputs of a latch, which is driven by four microprocessor data bits. The columns of the keyboard are connected to seven of the inputs of a latch, which is read by the microprocessor.

The processing unit consists of a Z180 microprocessor on the Smartcore Z1 Board (Zworld Engineering, Davis, CA). The switch values are latched and read by the microprocessor to determine the mode and the overlay. After determining the mode, the microprocessor activates the voice chips, which play messages such as "Can you find the fuzzy ball?" (in tactile mode) or "Can you spell the word dog?" (in spelling mode). The microprocessor then latches one of the rows of the keyboard high while holding the others low and scans the keyboard to identify whether or not the correct button(s) is pushed. The processor then scans the columns to see if any of the buttons are pushed. If no button is pushed, the processor latches the next row high and scans the columns again. This process continues until a pushed button is located, and then a buzzer is sounded to indicate to the child that a push has been registered. Once the key location has been determined, the processor ensures that the key has been released before registering another key value. In addition, the processor checks to make sure two buttons are not pushed at once. If more than one button is being pushed, it waits until only one button is actuated.

Four ISD90 (Information Storage Devices, San Jose, CA) 90-second voice chips store messages, including 200 spelling words, 21 object names, and a few phrases. The microprocessor accesses the recordings using the address lines of the voice chips. To send a specific message, the processor transmits the address of the message to the voice chip using its data lines. Because the voice chip has 10 address lines, while the microprocessor has only eight data lines, two of the address lines on the processor are used along with the data lines to address the voice chips. Two other address lines are used to select which voice chip will be turned on. This minimizes power consumption since three of the four voice chips are in standby mode at all times. When a voice chip is selected, its output to the speaker is enabled using a relay.

The final cost of the spelling and tactile identification game is approximately $540.

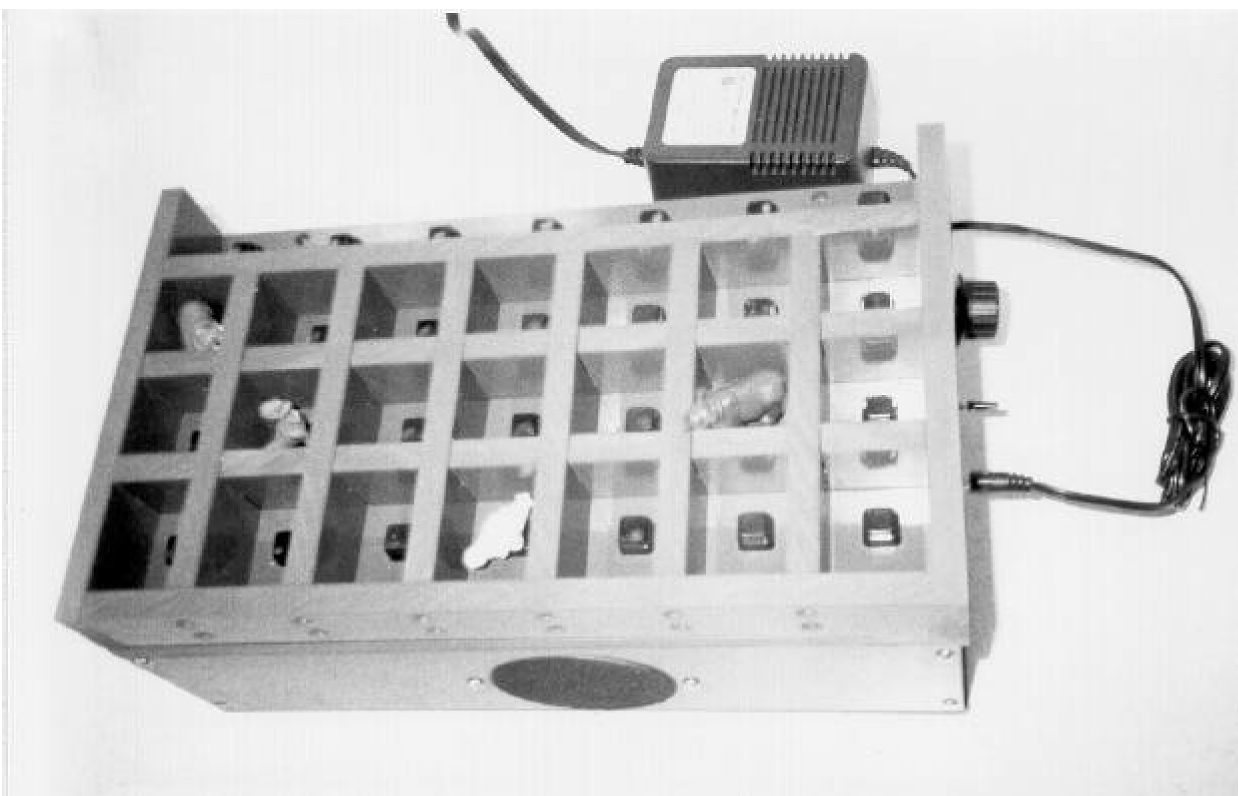

Figure 5.4. Spelling and Tactile Identification Game in Tactile Mode.

Chapter 6
MANHATTAN COLLEGE

School of Engineering
Mechanical Engineering Department
Riverdale, NY 10471

Principal Investigator:

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MOTORIZED ADJUSTABLE PARALLEL BARS

Designers: Steven Lembo, Ahmed Mahmud, James Masucci
Client Coordinators: Kathy Ruff, O.T., Dan Schipf, Brandywine Nursing Home, Briarcliff Manor, NY
Supervising Professor: Dr. Daniel W. Haines
Mechanical Engineering Department
Manhattan College
Riverdale, NY 10471

INTRODUCTION

The client, an occupational therapist, uses a set of parallel bars to retrain walking skills in individuals with limited motor ability. There is an optimum bar height setting for each individual. Adjusting the bars to a new height is time-consuming and tedious. She requested a motorized system to quickly adjust the height of the bars with less effort.

SUMMARY OF IMPACT

This system meets the requirement for bar adjustability. However, it involves power cords that must be strung along the floor to provide power to the motors (Figure 6.1). This proved unacceptable for the client, and the parallel bars have been restored to their original configuration.

TECHNICAL DESCRIPTION

Originally, each of the two horizontal bars rested on two vertical supports, set at approximately the quarter points of the bars. Standing twelve inches away from each vertical support are the lifting devices, which are based on the rack and pinion principle with an electric motor, turning the pinion.

Figure 6.1. Adjustable Parallel Bars.

Figure 6.3 shows an overall view of the motorized adjustable parallel bars. The four motors are controlled by panel mounted on a support, shown on the left in Figure 6.3.

The cost of the Adjustable Parallel Bars is $439.17

Figure 6.2. Designer Adjusting a Lifting Mechanism.

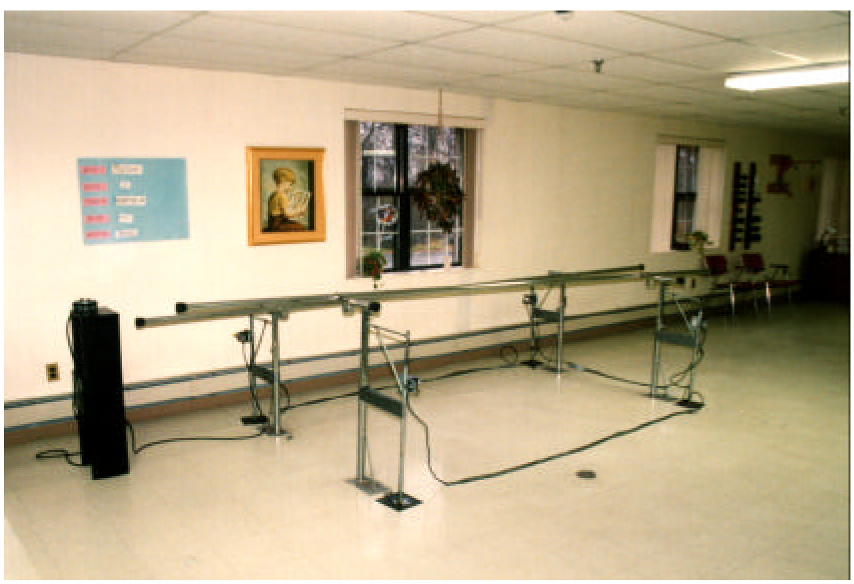

Figure 6.2. Overall View of the Adjustable Parallel Bars.

THE SCOOPER: A MOTORIZED SYSTEM TO FILL A FLOWER POT WITH SOIL

Designers: Eric Alemany, Charles Collado, Luis Miranda
Client Coordinators: Susan Holmes, Gloria Laemmel, Dan Schipf
Brandywine Nursing Home, Briarcliff Manor, NY
Supervising Professor: Dr. Daniel W. Haines
Mechanical Engineering Department
Manhattan College
Riverdale, NY 10471

INTRODUCTION

The client, a horticultural therapist at a nursing home, requested a device to aid residents who have difficulty filling a flowerpot with soil due to multiple sclerosis. It was important that the device be battery-powered because of a lack of electric supply in the nursing home greenhouse.

The Scooper allows the pot to be tipped so that the user may push soil into it. When the user activates a switch, the pot is lifted to the vertical position.

SUMMARY OF IMPACT

The Scooper met the expectations of the clients and is now in use in the nursing home greenhouse.

Figure 6.4 The Scooper

TECHNICAL DESCRIPTION

The Scooper, shown in Figure 6.4, consists of a DC motor in a transparent plastic housing. A chain is wound around a spool that is turned by the motor. The other end of the chain is attached to a ring encircling the green pot. When the pot is resting on its side, the activation of a switch turns on the motor, pulls the pot to its vertical position. Any of a wide variety of switches could be used. A close-up of the Scooper is shown in Figure 6.5

The cost of the Scooper is $63.03.

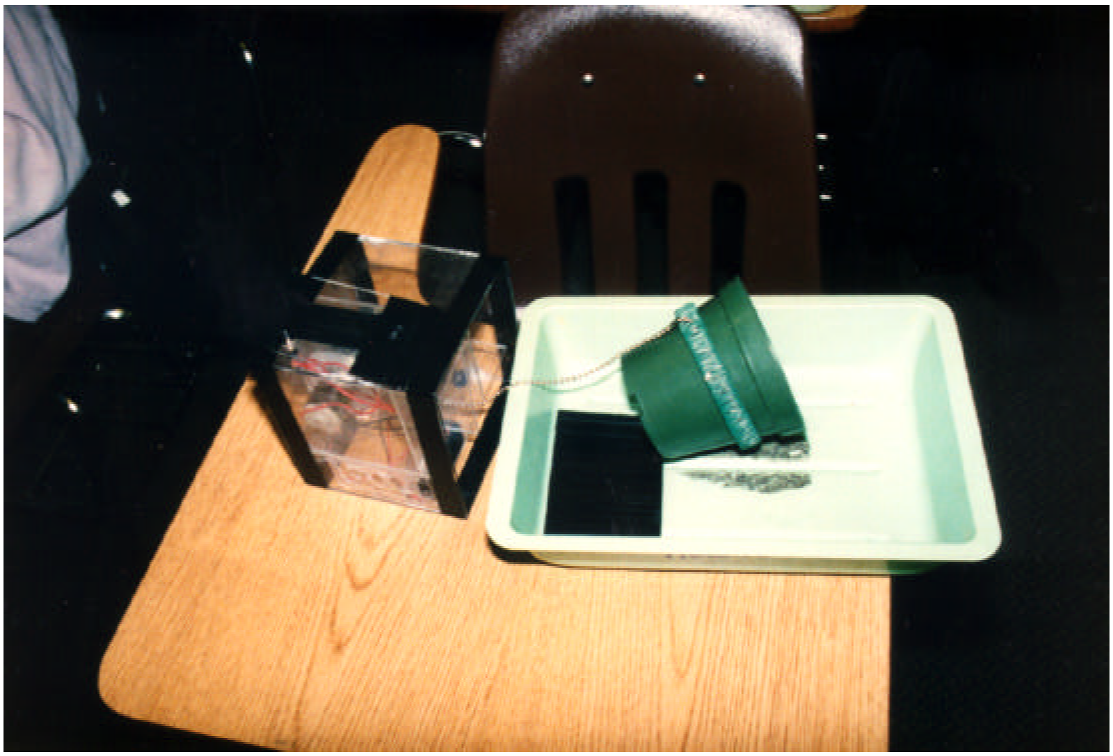

Figure 6.5. Close-up View of the Scooper.

MODIFICATIONS AND ENHANCEMENTS TO THE LAZY SUSAN AND WATERWORKS PRODUCTS

Designers: Lawrence C. Ciufo, Tai Tien Ly, John Thankachan, Robert S. Vitelli
Client Coordinators: Susan Holmes, Gloria Laemmel, Dan Schipf
Brandywine Nursing Home, Briarcliff Manor, NY
Supervising Professor: Dr. Daniel W. Haines
Mechanical Engineering Department
Manhattan College
Riverdale, NY 10471

INTRODUCTION

For more than five years, the designers of Manhattan College have built devices to serve the special needs of individuals who use a nursing home greenhouse. Some of these devices, such as plant watering devices and adjustable tables, have functioned well from the outset. Others have developed problems, and warrant modification based on observations after a period of use. The Lazy Susan and the Water Works, earlier projects, fell in the latter category. The Lazy Susan quickly became inoperable. The principal switch on the Water Works required improvement.

SUMMARY OF IMPACT

The goal of this project was to improve existing products. These goals were accomplished and the clients are pleased with the outcome.

TECHNICAL DESCRIPTION

Figure 6.6 shows the four designers with their products. The Lazy Susan is a turntable, rotated by an electric motor and powered by a battery. Its purpose is to water successively up to five plants resting on the turntable. A nursing home resident can water several plants in succession by rotating the Lazy Susan and operating the on-off switch of the battery operated Water Works. Figure 6.7 shows a close-up of the Water Works at the left and the Lazy Susan in the center.

The Lazy Susan had a rusted and misaligned motor shaft. It was put back into full service after realignment and greasing of the shaft.

The switch for the Water Works is based on the rocker arm principle. A mercury switch mounted on the rocker was used to operate the unit. The original designers intended for the rocker to return to its original position when the pressure was released. However, this feature malfunctioned. The conducting wire attached to the rocker became caught. A wire of sufficient length was attached and located in a better position. The rocker now returns freely.

The cost of the materials for this project was less than $30.00.

Figure 6.6. Photograph of Four Designers with the Improved Products.

Figure 6.7. Close-up of the Water Works (Left) and the Lazy Susan (Center).

A CUSTOM TRAVEL DESK FOR A WHEELCHAIR USER

Designers: Sean P. Foley, Thomas V. Naudus, Leon J. Zick
Client Coordinator: Dan Schipf
Brandywine Nursing Home, Briarcliff Manor, NY
Supervising Professor: Dr. Daniel W. Haines
Mechanical Engineering Department
Manhattan College
Riverdale, NY 10471

INTRODUCTION

A wheelchair user requested a custom lapboard that incorporated the items he needed most often.

SUMMARY OF IMPACT

The client reported satisfaction with the Travel Desk and indicated that he uses it frequently. Figure 6.8 shows him with his new Travel Desk, flanked by two members of the design team

Figure 6.8. The Travel Desk.

TECHNICAL DESCRIPTION

The Travel Desk is a Plexiglas board on which a set of items prescribed by the user is mounted. The items include a clipboard, writing pad, calculator, and desk lamp. The desk was fitted to the dimensions of the user and his wheelchair. Figure 6.9 shows a close-up of the Travel Desk.

The desk is padded and notched to accommodate the wheelchair's joystick control. It is securely affixed to the desk by straps.

The cost of the Travel Desk is $373.67.

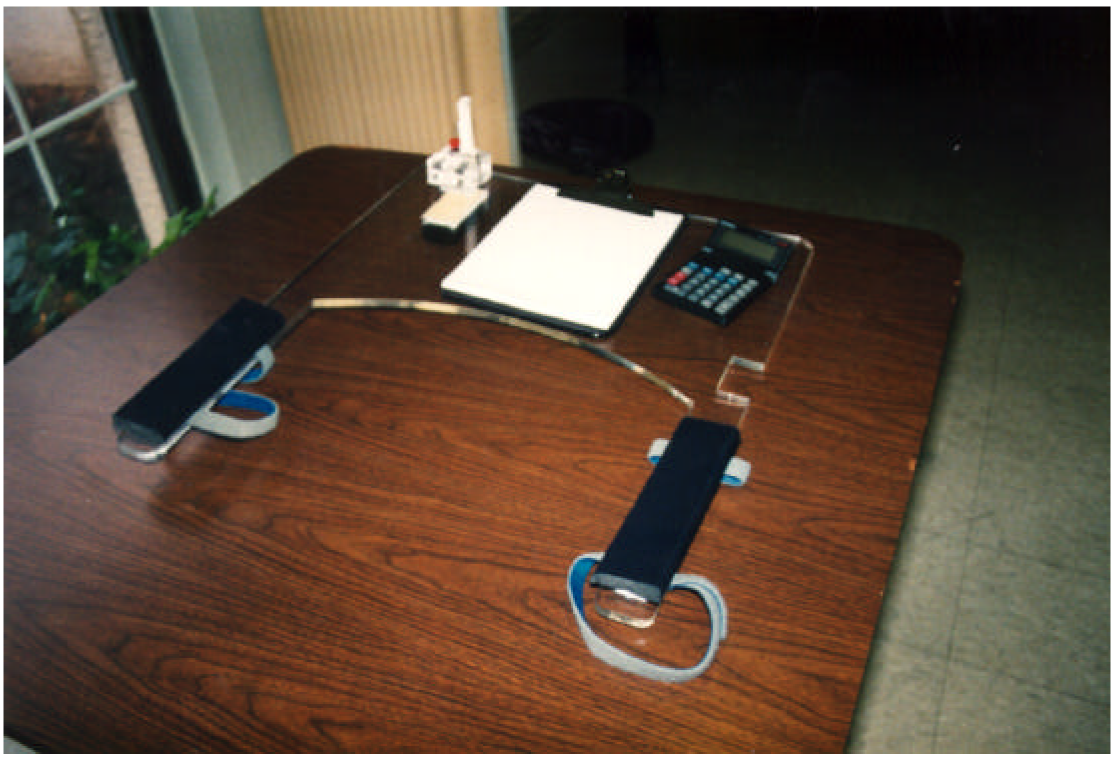

Figure 6.9. Close-Up of the Travel Desk.

CUSTOMIZED DESKS FOR NURSING HOME RESIDENTS

Designers: Steven Lembo, Ahmed Mahmud, James Masucci
Client Coordinators: Mrs. Murphy, Mrs. Sasser, Alex Avelino, Dan Schipf
Brandywine Nursing Home, Briarcliff Manor, NY
Supervising Professor: Dr. Daniel W. Haines
Mechanical Engineering Department
Manhattan College
Riverdale, NY 10471

INTRODUCTION

In recent years Manhattan College designers have provided a number of successful pieces of furniture to enhance the work and entertainment of nursing home residents. Considerations involve space constraints and residents' physical limitations. At times residents request modifications after using products.

Two individuals who share the same room requested tables to hold their personal items, including a television set. The tables were to have two shelves each for storage, and to be mounted on wheels for ease of cleaning. The clients also requested a power cord for easy connection of their electronic equipment. The administrators of the nursing home required that any electrical work comply with the New York State code.

One resident requested a lamp to be mounted on a computer desk previously built for him.

SUMMARY OF IMPACT

The three clients report that they are pleased with their products, which are currently in use.

TECHNICAL DESCRIPTION

Figures 6.10 and 6.11 show the residents' tables. Stock tables were simply assembled.

The desk with mounted lamp is shown in Figure 6.12. Also present is the power strip furnished by the designers.

The cost of the working desks and modifications was $275.55.

Figure 6.10. Customized Desk with Power Strip.

Figure 6.11. Customized Desk.

Figure 6.12. Customized Desk with Lamp.

LIFTING MECHANISM FOR WHEELCHAIR REPAIR

Designers: Eric Alemany, Charles Collado
Client Coordinators: Paul Notto, Freddie Rodriguez, Dan Schipf
Brandywine Nursing Home, Briarcliff Manor, NY
Supervising Professor: Dr. Daniel W. Haines
Mechanical Engineering Department
Manhattan College
Riverdale, NY 10471

INTRODUCTION

Nursing home technicians are frequently called upon to repair wheelchairs. It is necessary to raise the chair from floor to desk level for servicing. A hydraulic lift once used for lifting residents in and out of a bathtub had been adapted for this purpose. The technicians requested that its small and shaky platform be improved.

SUMMARY OF IMPACT

The designers developed a stable platform of adequate size. The clients were pleased with the outcome.

TECHNICAL DESCRIPTION

Figure 6.13 shows the large rectangular plywood platform provided. Not visible is the support system, which consists of a transverse steel support beam. This beam and its attachment were effective in stabilizing the platform such that cable stays were not required.

The cost of the lift accessories is $249.35.

Figure 6.13. A Lifting Mechanism for Wheelchair Repair.

A DECORATED WALL-MOUNTED WHEEL OF FORTUNE FOR NURSING HOME RESIDENTS

Designers: Lawrence C. Ciufo, Ty Tien Ly, John Thankachan
Client Coordinator: Laura Meza, O.T.
Brandywine Nursing Home, Briarcliff Manor, NY
Supervising Professor: Dr. Daniel W. Haines
Mechanical Engineering Department
Manhattan College
Riverdale, NY 10471

INTRODUCTION

One popular activity in the recreation room of a nursing home is a "wheel of fortune" game. Residents enjoy betting on the outcome and some are capable of spinning the wheel. The wheel they had been using was crudely constructed and consequently stopped at the same location (Bankrupt!) on each spin. Furthermore, the wheel often became detached and fell to the floor. This was decidedly an unsatisfactory situation. They client requested a replacement wheel.

SUMMARY OF IMPACT

Many residents expressed their pleasure and appreciation for the product, which is currently in use.

TECHNICAL DESCRIPTION

Figure 6.14 shows two of the designers with the Wheel of Fortune. A close-up of the wheel is shown in Figure 6.15. Made of decorated plywood, it is attached to a flanged mounted steel ball bearing pillow block with a ½-inch bore. The wall column on which it was to be mounted consisted of panels of sheetrock to conceal piping, and was not adequate to support the wheel. Consequently, the pillow block was mounted on a plywood panel that was attached directly to the wall through the column by means of toggle bolts

The cost of the Wheel of Fortune was $298.41.

Figure 6.14. Wall-Mounted Wheel of Fortune

Figure 6.15. A Decorated Wall-Mounted Wheel of Fortune.

THE SIDE-TABLE: AN ADJUSTABLE TABLE FOR USE IN A NURSING HOME GREENHOUSE

Designers: Luis Miranda, Thomas Naudus, Robert Vitelli
Client Coordinator: Susan Holmes
Brandywine Nursing Home, Briarcliff Manor, NY
Supervising Professor: Dr. Daniel W. Haines
Mechanical Engineering Department
Manhattan College
Riverdale, NY 10471

INTRODUCTION

During 1995-1996, Manhattan College designers had built the "Up N Down" table for nursing home residents who work in a greenhouse. This table had many desirable features, and has proven to be useful in the greenhouse. However, the Up N Down table was not well suited for some residents in wheelchairs. The supports that extended from the end of the table interfered with these residents' arms. A horizontal bar that supported the jack of the table interfered with their feet. The client requested another table, retaining the vertical adjustment feature, but with leg spacing to fit around the wheel of the wheelchair so that the table could be brought close to the sides of residents in wheelchairs. The outcome was a new table, the Side-Table.

Figure 6.16 The Side-Table.

SUMMARY OF IMPACT

The Side-Table met the design requirements and is currently in use.

TECHNICAL DESCRIPTION

One unique feature of the Side-Table is a top that can be slid over its support frame safely and easily. Figure 6.16 shows two of the designers with the Side-Table. The crank that operates the jack to provide vertical adjustment is shown on the right.

A close-up of the crank and jack mechanism is shown in Figure 6.17. The frame is mounted on wheels. The table surface can be shifted about six inches to the right or left. An underside view of the table, revealing the sliding feature, is shown in Figure 6.18. The cost of the Side-Table is $277.49.

Figure 6.17. Close-up of the Crank and Jack Mechanism.

Figure 6.18. The Underside View of the Side-Table.

Chapter 7
NEW JERSEY INSTITUTE OF TECHNOLOGY

Department of Electrical and Computer Engineering
Newark, New Jersey 07102

Principle Investigator:

Stanley S. Reisman (201) 596 3527
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A VIBRATORY ALARM FOR A VENTILATOR

Designer: Andrew Gil Ventura
Client Coordinator: Susan Drastal
Kessler Institute for Rehabilitation, West Orange, New Jersey
Supervising Professor: Dr. Stanley Reisman
Department of Electrical and Computer Engineering
New Jersey Institute of Technology
Newark, New Jersey 07102

INTRODUCTION

The purpose of this design project was to construct a non-auditory alternative to the audible alarm found on a commercial ventilator unit. The client, who has a hearing impairment, is the caretaker of a patient on a ventilator. The system consists of a vibratory-motion wireless transmitter and receiver, both battery powered, contained in two separate cases. The transmitter connects to the alarm output of the ventilator. The receiver is contained in a case that can be worn as a beeper. The unit is small, lightweight and inexpensive.

SUMMARY OF IMPACT

A patient recovering from a stroke was discharged to his home to be cared for by a close relative who has a hearing impairment. The patient was confined to a ventilator with an audible alarm that would sound if the ventilation exceeded preset limits. Because the caregiver could not hear the alarm, he was confined to the patient's room, afraid to leave in case the respirator were to malfunction. The alternative design allows the caregiver unlimited freedom of motion within the house, up to a distance of 50 feet from the ventilator. The vibratory alarm is similar to that of a beeper.

Other uses for such a device are envisioned. For example, a non-audible alarm is suitable in any noisy environment. One potential use of this device would be for nurses moving around hospital floors. Another would be for caregivers at home who may otherwise be worried about operating a vacuum cleaner or other noisy appliance, or about moving to a part of the house distant from the patient.

TECHNICAL DESCRIPTION

This project features an RF transmitter unit and RF receiver unit that can operate up to 50 feet apart without requiring line-of-sight transmission. This allows the two units to be in different rooms with walls or doors between. The transmitter unit is attached to the ventilator with a two-wire cable. When the ventilator alarm is activated, the transmitter is triggered and it, in turn, sends a signal to the receiver. The signal is continuously sent as long as the alarm is active. The receiver signals the caregiver through a motor, which creates a vibratory output.

Several difficult issues were overcome in order to develop this project. One issue concerned the interface between the ventilator and the transmitter unit. It was first hypothesized that the circuitry of the ventilator would have to be modified. However, the ventilator that was used had a BNC connector to allow the use of remote alarms. This remote alarm connector could be modified by jumper settings within the ventilator. The option chosen provided a normally open circuit (no alarm condition) that became short-circuited under alarm conditions. This option was used to turn the transmitter on and off.

The second issue was related to the mode of signaling the caregiver. Possible options included vibratory and visual indicators. The vibratory option was selected and the receiver was designed as a beeper with a vibratory output. A motor similar to a beeper motor was used with a head which, when contacting the case, provided a strong vibratory output.

The transmitter is housed in a case of 1.5 by .75 by 2.5 inches. It is powered by a 12-volt alkaline battery, type MN21 or A23. A small LED is illuminated when the transmitter is on and the brightness of the LED indicates the condition of the battery.

The receiver is lightweight and is housed in a case of 4.5 by 2.5 by 1.0 inches. It operates on two AAA alkaline batteries, for a total of 3 volts. It has a clip for attaching the unit to an article of clothing. The strength of the motor's vibration can be adjusted by a potentiometer inside the case.

The cost for the entire prototype unit (excluding the ventilator) is about $100.00. The electronics for the transmitter and receiver were purchased as a package so that no design or construction of these circuits was necessary.

Figure 7.1. A Vibratory Alarm for a Ventilator.

VOICE ACTIVATED COMPUTER REBOOT SYSTEM

Designers: Ji Gang Zhu, Eddie Ching
Client Coordinator: Susan Drastal
Kessler Institute for Rehabilitation, West Orange, New Jersey
Supervising Professor: Dr. Stanley Reisman
Department of Electrical and Computer Engineering
New Jersey Institute of Technology
Newark, New Jersey 07102

INTRODUCTION

The goal of this project was to design and develop a low cost voice activated computer reboot device for people who have difficulty using a computer keyboard or control buttons. Rebooting a computer becomes necessary in several different situations. First, if a computer becomes hung up, the only option may be a reboot. Second, a laptop with a power saving feature will shut down if it is not used for some period of time. If a person is using the computer in a voice operated mode and the computer shuts down, the voice operation also becomes inactive and there is no way to re-start the machine by voice. A voice activated system was designed to interface with and provide signaling to a computer to make it reboot or re-start. The project was designed to be an independent device, functioning independently of the host computer.

SUMMARY OF IMPACT

Computers are becoming almost indispensable to many, including people with disabilities. Therefore, it is important to design computers and peripherals so that all people can at least turn the computer on and off and perform simple word processing tasks. For many people with disabilities, the voice is the best or the only means of interfacing with a computer. There are several voice operated word processing systems available to address this problem. However, the computer itself must also be controlled by voice. Persons who require voice activation features need desktop computers to have voice activated booting and rebooting functions, as well as a means of turning the computer on from an off condition. Such persons have these same requirements for laptops, as well as a need to circumvent the additional problem of a power-saving feature that shuts down the computer after a period of non-use, such that voice operation becomes inactive. A stand-alone voice activated system, separate from the computer it is controlling, was designed. The system was to have an output that could be used to control the computer.

TECHNICAL DESCRIPTION

The voice activated reboot system consists of two main subsystems that are interfaced together. The control subsystem is implemented by a R-31J evaluation board and READS (Rigel's Embedded Applications Development System). It has an Intel 8031 microcontroller, 32K of SRAM, 32K of monitor EPROM, 4 I/O ports, 12 general purpose digital input/output bits and an RS232 serial port. The voice recognition subsystem is centered around the HM2007 voice recognition chip, which was selected because it provides the basic required functions and is available at low cost and in small quantities. The chip was purchased as part of a development system from Images Company. It features single chip speaker dependent isolated word voice recognition, recognizes a maximum of 40 words, supports two control modes (manual and CPU), has a response time of less than 300 ms, and operates from one 5-volt supply. It can be connected to a microphone at its analog front end and to 64K SRAM. The voice recognition subsystem acquires the input from the microphone and processes the voice pattern. The control subsystem monitors and controls the operation of the voice recognition unit.

The HM2007 voice recognition chip has six control functions of which four were used in this project: RECOG, TRAIN, RESULT and RESET. In addition, the HM2007, in the CPU mode, has a K bus and S bus available, which are connected to the I/O pins of the microcontroller through bus transceivers. When the microcontroller sends the TRAIN command to the HM2007, the HM2007 begins training for a selected word. The RECOG command causes the HM2007 to initiate the recognition process for the word spoken into the microphone. The RESULT command causes the HM2007 to send the recognition result to the microcontroller. The RESET command will clear the patterns in the SRAM of the HM2007.

Once the training mode is completed, the normal operating mode is as follows. When the user issues a voice command, the voice recognition system processes the voice input and sends the result of the recognition to the control unit. The control unit then examines the resulting word number and decides if the result is a reboot command, a clear command, or no match. If a reboot command is found, the control unit sends a pulse to the host computer reset pins and causes the computer to reboot. If the clear command is recognized, the control unit commands the voice recognition unit to clear all the voice patterns in its memory and change into the training mode. Figure 7.2 is a block diagram of the operation of the system.

The device was successfully completed and tested. Future work will address the problems encountered with the HM2007, including its poor performance in noisy environments. The costs for the project totaled approximately $200 due to the use of voice recognition and microcontroller development systems.

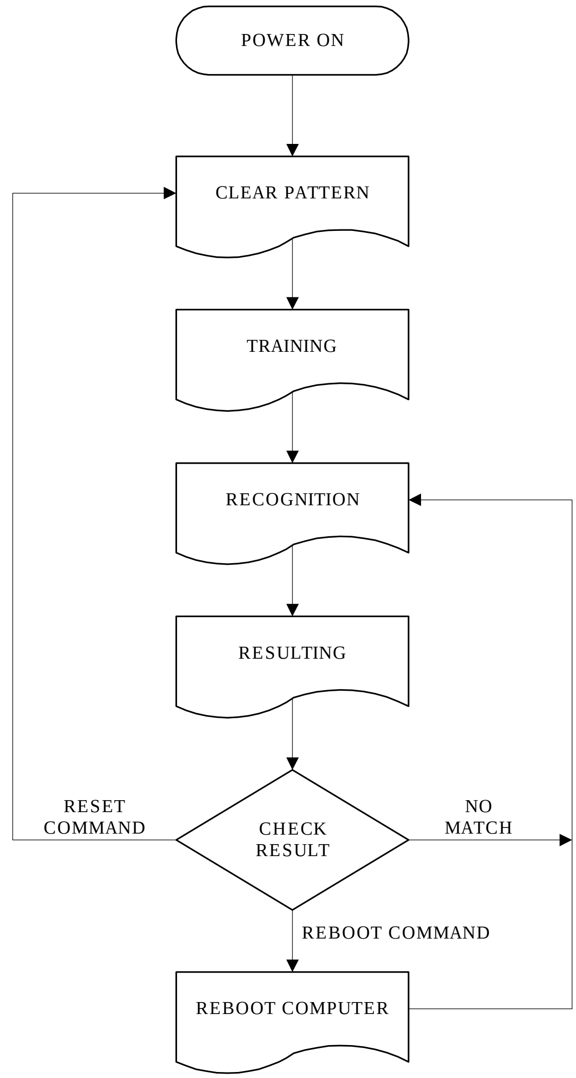

Figure 7.2. Block Diagram of the Operation of the System.

INTERFACE FOR TELEPHONE VOICE ACCESS

Designer: Gerald Aska
Client Coordinator: Susan Drastal
Kessler Institute for Rehabilitation, West Orange, New Jersey
Supervising Professors:
Dr. Stanley Reisman
Department of Electrical and Computer Engineering
Professor Philip Fabiano
Department of Engineering Technology
New Jersey Institute of Technology
Newark, New Jersey 07102

INTRODUCTION

The goal of this project was to design and develop an inexpensive voice control interface for telephone use by persons with disabilities. The device provides telephone features commonly used today, including dialing, flash for call waiting, redialing, phone on/off hook, and speed dialing. It also provides access to features provided by the telephone company. Additionally, the interface can answer incoming calls. The device is placed between the telephone set and the subscriber line connected to a central office. It contains a voice recognition module interfaced to a microcontroller. The user operates the interface through a microphone that provides both the voice control and voice input to the telephone line after a connection is made. The device contains a speaker that allows the user to receive feedback during the dialing (control) process and to hear the person at the other end of the connection.

SUMMARY OF IMPACT

A universal device such as a telephone should be accessible by all, including persons who are unable to use their hands because of deformity, amputation, paresis, or paralysis. Currently, many persons with disabilities are deprived of the means to telephone access. This device provides a hands-free means of accessing the control functions of the telephone to either initiate or receive a call, and to send and receive spoken information after the call is completed. The control is performed through voice recognition of simple one- or two-word commands, which include dialing information. The user receives feedback as to the progress of the dialing. In order to be as versatile as possible, the interface provides access to all commonly available features of the telephone system including speed dialing, call waiting, and redialing.

TECHNICAL DESCRIPTION

A block diagram of the system is shown in Figure 7.3. A description of the blocks follows:

The telephone is a simple line telephone of the type commonly used in homes. No modifications are made to the telephone. The transducers are a microphone and speaker. The microphone is used as the interface between the user and the voice recognition circuit. It provides control information to the unit and allows the user to speak to the person at the other end of the connection. The speaker allows the user to listen to the person at the other end, and provides feedback to the user regarding the progress of the control.

The switch is used to determine whether the telephone or the voice recognition circuit is connected to the telephone line. The voice recognition circuit determines the position of the switch.

The voice recognition circuit provides all the control signals for the interface unit. It sends control signals to operate the switch as well as signals to the touch-tone generator.

The touch-tone generator receives input from the voice recognition circuit. The tones sent out from this unit to the central office are used for dialing, and depend on the signal from the voice recognition unit as well as the number requested by the user.

The memory allows for such features as speed calling, redialing and call forwarding. The controller provides the overall control of the system. The voice recognition unit accepts the following commands:

?? Access - to switch the system from manual mode to voice command mode

?? Answer – to answer an incoming call

?? Dial - causes desired number to be sent over the telephone line

?? On hook - terminates existing call

?? Redial - redials last number dialed

?? Mute - activates mute service (distant end cannot hear local conversation)

?? Clear - deactivates mute

?? Flash - generates a switch hook flash for custom calling features (call waiting, conference, speed calling).

Voice recognition is performed by a HM2007 voice recognition chip and was purchased as a development system from Images Company. This system is interfaced to an 8751 microcontroller and uses integrated circuits for touch-tone dialing and telephone line interface. In addition, a voice switched speakerphone integrated circuit is used to provide the two-way conversation ability.

The interface unit has been built and tested. The cost for the unit is approximately $300. Further information on this project is available from the principal investigator.

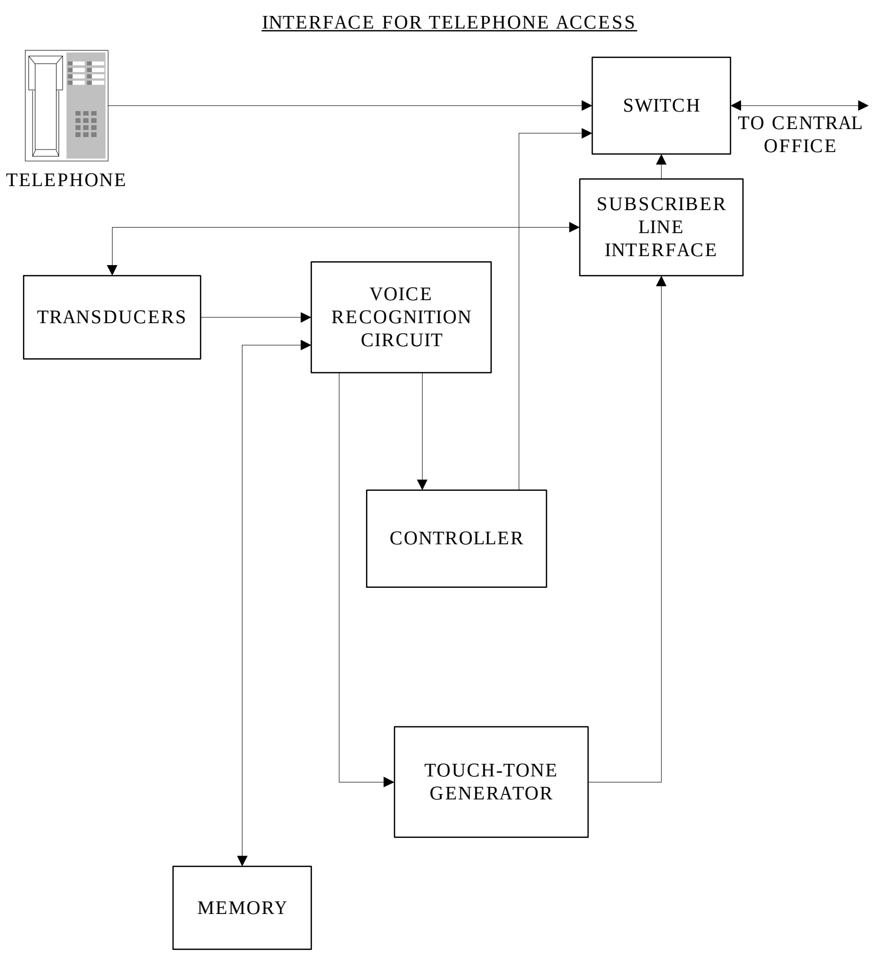

Figure 7.3. Block Diagram of the Interface for Telephone Voice Access.

Chapter 8
NORTH CAROLINA STATE UNIVERSITY

College of Engineering
College of Agriculture and Life Sciences
Biological and Agricultural Engineering Department
D. S. Weaver Laboratories
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Principal Investigators:

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OUTDOOR WHEELCHAIR SWING FOR TEENAGED CLIENTS

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Client Coordinator: Jan Baker
Tammy Lynn Center for Developmental Disabilities, Raleigh, North Carolina
Supervising Professors: Dr. Susan M. Blanchard, Dr. Roger P. Rohrbach
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INTRODUCTION

Many of the older clients in a center for persons up to 18 years of age with developmental disabilities use wheelchairs. The center's existing wheelchair swing can accommodate only extremely small wheelchairs and fails to meet appropriate standards for day care licensing. A wheelchair swing that could accommodate a wide range of wheelchair sizes and styles and would comply with all standards for day care licensing was designed (Figures 8.1, 8.2).

Figure 8.1. Outdoor Wheelchair Swing.

SUMMARY OF IMPACT

Swinging is considered an excellent source of recreational therapy for people of all ages with disabilities. A playground swing for the user of a wheelchair can provide a safe and relaxing activity and can be rewarding for those who are capable of swinging themselves. Most wheelchair swings are designed for small children, but teen-agers in wheelchairs, especially those with developmental disabilities, can receive a great deal of pleasure from swinging outdoors.

TECHNICAL DESCRIPTION

The design involved locating an adequate restraint system, designing a sturdy swinging platform and loading ramp, developing a fail-safe backup system, completing an acceptable and sturdy frame, and minimizing the tasks of an assistant during loading. Extensive research for existing wheelchair restraint systems and wheelchair swings was conducted. Patent records, product literature, discussion with staff, standards documentation, and past National Science Foundation projects for persons with disabilities provided much information and direction.

A manufactured wheelchair restraint system for vehicles was chosen to secure the wheelchair because it is simple and safe, can be operated quickly, and because staff members are familiar with using such systems in their vans. The system secures the wheelchair with four polyester straps, which run around the wheelchair frame and snap into a steel ring. The opposite ends of the straps are clipped into custom restraint tracks welded to the platform floor. All straps are hand tightened and remain securely tensioned by a cam buckle. The straps are stored indoors when the swing is not in use, and can be replaced from the manufacturer when they become worn.

According to standards, loading ramps are required to have a slope of 1:12 or less. Due to this requirement and the size of the wheelchair platform, a 4-foot loading ramp was required. Hinging this ramp in the middle and again at the platform provides easy maneuverability. A front barrier along the loading ramp provides a fail-safe means to contain the wheelchair on the platform in the event that the restraint system should loosen during swinging. The front barrier, loading ramp, and platform are made from tread plated 6061-T6 aluminum. This material was chosen for its durability, high yield strength, and high strength-to-weight ratio features, which enable a long yet lightweight loading ramp. Also, the tread plate design adds traction for safe loading and unloading on a possibly wet or soiled ramp. Use of aluminum restraint tracks and hinges allows for strong and permanently welded connections. Side flanges two inches high were also welded onto the sides of the ramp and platform to add safety and rigidity. Lengths of treated wood cover the flanges so that the sharp metal edges are covered.

An inverted "V" style frame was chosen because of its stability and use of the least amount of materials. It is constructed of treated lumber because this is aesthetically pleasing, easy to work with, inexpensive, and very durable. All wooden edges are rounded to remove sharp and splintering edges, and the members are connected with galvanized lag screws.

A wooden extension was bolted to the top frame beam to attach a pull rope. This allows capable wheelchair clients to swing themselves by pulling on the rope during their forward swing. The swing platform is suspended by a combination of galvanized chain and "S" hooks with manufactured steel swing hangers at the top and steel anchor shackles at bottom. Similarly, the ramp and front barrier chains are attached to the main swing chains by spring snap links at the top and quick links at the bottom. All chains are covered by vinyl tubing to eliminate pinch points as required by day care licensing standards.

Figure 8.2. Ramp in Extended Position.

The completed outdoor wheelchair swing meets all required standards and is currently being used by wheelchair clients. The ramp is lowered to allow easy loading of a wheelchair. The wheelchair is secured with the 4 restraint straps and the ramp and front barrier are raised to achieve a safe swinging position. An assistant may swing the wheelchair manually. If the occupant is capable, he or she may propel the swing by using the pull rope.

The total cost for this project, not including labor, was approximately $700.

PORTABLE PADDED CHAIR FOR CHILDREN

Designers: Michael Wade, Christopher Ehrhardt
Client Coordinator: Beth Buck
Tammy Lynn Center for Developmental Disabilities, Raleigh, North Carolina
Supervising Professors: Dr. Susan Blanchard, Dr. Roger P. Rohrbach
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North Carolina State University
Raleigh, North Carolina 27695-7625

INTRODUCTION

The staff at a center for children with developmental disabilities requested a chair to provide posture support needed by children, ages birth to three years. This chair was to be lightweight and portable, while having adjustable padding devices and a tray (Figures 8.3, 8.4).

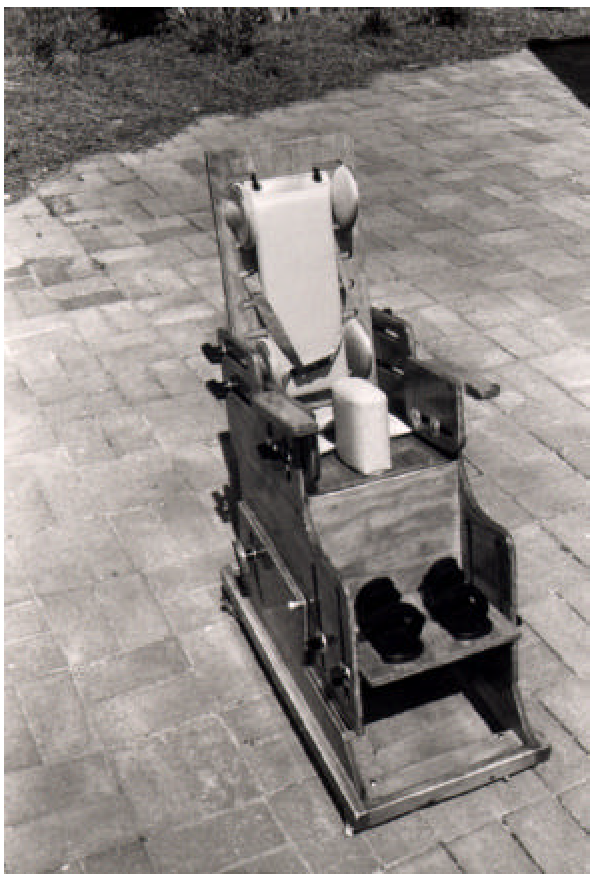

Figure 8.3. Portable Padded Chair.

SUMMARY OF IMPACT

The children for whom the chair was designed greatly needed a chair that would provide proper posture support and a feeling of comfort and safety. While the chairs currently available individually provided one of these aspects, there were none that met all the needs of the staff and children.

For a child with developmental disabilities, being comfortable while sitting in a chair can be a great challenge. Much of the child's energy and focus are consumed by just trying to get comfortable. The advantage of this chair is that it provides comfort, such that the child is more relaxed and able to focus on play or other activities.

TECHNICAL DESCRIPTION

The design involved developing a chair that would fit children, ranging in age from birth to three years. This meant that the chair needed an adjustable headrest, footrest, backrest, armrest, and padded supports. Patent documents, product literature, ergonomic data, and staff members were useful sources for this information.

The padding, supports, and foot restraint chosen for this chair were purchased through a commercial catalog, as they needed to meet specifications established by the center. These specifications included ease of cleaning, adequate support and comfort, and aesthetic appeal. Purchasing this padding from a commercial dealer allowed for the exact sizes necessary for the chair. The seat and back padding were simply tied to the frame of the chair. The head and support pads were attached using clamping knobs. This allowed for easy adjustment of the head and support pads.

Selecting material for the chair was a difficult task. It was necessary to choose a material that would not only be strong and durable, but also aesthetically pleasing. Plywood was used for the main construction of the chair. This material was easily available, durable, and, when sanded and stained, aesthetically pleasing. Another specification for the chair was that it could be moved or kept stationary. To fulfill this need, lockable casters were attached to the chair frame. The casters allowed the chair to roll freely and, when necessary, to be locked in place to secure the child.

The backrest was designed to move forward 3-1/2 inches. This created a seat depth range with a maximum of 11 inches and a minimum of 7-1/2 inches. The armrest was built to adjust upwards as well as forwards. The armrest can be raised 1-1/2 inches and moved forward 2 inches. A minimum distance of 4 inches from the seat can be achieved by adjusting the footrest from its maximum distance of 10 inches. The head rest and side supports were created to adjust to a maximum spacing of 7 inches and a minimum spacing of 4 inches between supports. By using slots in the side of the frame, the chair can be tilted backward to a 45-degree angle.

The total cost for this project, not including labor, was approximately $260.

Figure 8.4. Padded Portable Chair with Tray in Place.

DOUBLE STROLLER FOR AN ABLE-BODIED AND A DISABLED CHILD

Designers: Heidi Lane, Robert Schoderbek
Client Coordinator: Beth Buch,
Tammy Lynn Center for Developmental Disabilities, Raleigh, North Carolina
Supervising Professors: Dr. Susan Blanchard, Dr. Roger P. Rohrbach
Biological and Agricultural Engineering Department
North Carolina State University
Raleigh, NC 27695

INTRODUCTION

Staff members at a center for children with developmental disabilities requested a double stroller that could accommodate a child with a disability and an infant for use by families involved with the center. There are no existing strollers on the market that meet the needs of some families. Available adaptive strollers tend to be much larger than normal strollers and yet only hold one child with a disability. Existing normal strollers provide no head or hip support for children with disabilities. The double stroller provides support for the child with disabilities and more like a general-use stroller than an adaptive one.

SUMMARY OF IMPACT

Strollers facilitate the activities of a family with multiple children and are especially useful if one or both of the children cannot walk. A stroller that can hold an able-bodied infant or toddler and an older child with a disability provides the means for easier movement and allows both children to participate in outings.

TECHNICAL DESCRIPTION

The design of the double stroller involved researching information on existing strollers, and designing a sturdy frame, a seat that provides adequate support for the child with a disability, a foot rest for the adaptive seat, and a normal seat.

The first step was to gain as much knowledge as possible about existing products and the needs of disabled children. Patent documents, the center staff, and literature on safety hazards provided information needed for this design project. Because of its high strength and low deformation characteristics, steel was used in the construction of the frame. The wheels were ordered from Graco, Inc., and the pieces that the wheels slide into were donated.

Figure 8.5. Double Stroller.

The adaptive child's seat provides the client with three different positions for harnesses and head support. Both the head and hip supports have different sized padding that can be attached simply by pressing Velcro strips together. This allows for varying amounts of support, depending on the need and size of the child in the adaptive seat. There are also straps for the adaptive footrest. Both the head and hip support systems can be removed by the user if needed.

The completed double stroller tested positively for its ability to hold 50 pounds in each seat using the Standard Consumer Safety Performance Specification for Carriages and Strollers. The stroller was also tested for its rolling resistance, which was less than 0.1, indicating that little effort is required to push it.

The cost of construction is approximately $257. This includes all metal components, fabric, paint, and miscellaneous hardware. The cost is within the range of non-adaptive double strollers presently on the market, and far less than most adaptive strollers.

Figure 8.6. A Client Tries out the Double Stroller while the Designers Look Onward.

SWITCH ACTIVATED SWING FOR CHILDREN UP TO 50 POUNDS

Designers: Tiwanna N. Bazemore and Addie E. Dillon
Client Coordinator: Beth Buch
Tammy Lynn Center for Developmental Disabilities, Raleigh, North Carolina
Supervising Professors: Dr. Susan M. Blanchard, Dr. Roger P. Rohrbach, Dr. Gerald Baughman
Department of Biological and Agricultural Engineering
North Carolina State University,
Raleigh, North Carolina 27695-7625

INTRODUCTION

A modified infant swing was requested for use at a center for children with developmental disabilities. It was intended to hold, support and swing a child who weighing up to 50 pounds. Existing infant swings are not sturdy or powerful enough to safely swing a 50-pound child, and current swing seat models of do not offer enough head or torso support for a child who lacks sufficient muscle control. In addition, sterility of the seat is an important factor overlooked by many manufacturers. Through meetings with consultants at the center, the specifications required to meet safety needs were established. Further consultation with university engineers facilitated the generation of design ideas for altering the swinging mechanism and frame of a typical infant swing.

The chosen design consists of an offset crank and motor to drive the swing, and a wooden A-frame to support the swinging child (Figures 8.7, 8.8). The seat is a contoured, supportive feeder seat with a modified PVC pipe frame to secure the seat to the chains. It has proper chest and head restraints. The seat is easy to clean and maintain. It is also adaptable for use with an outdoor swing set.

SUMMARY OF IMPACT

Infants enjoy swinging from a very early age, and many types of wind-up swing are available for able-bodied infants up to 25 pounds in weight. Small children with developmental disabilities also enjoy swinging, but often are not capable of swinging themselves, nor small enough to use existing infant swings safely. External stimulation, such as swinging, is relaxing and recreational. A motorized swing set for a small child would provide entertainment for many children with disabilities.

Figure 8.7. Switch-Activated Swing.

TECHNICAL DESCRIPTION

The overall dimensions of the swing design were determined by the body size of 95% of 50-pound children. The height of the swing is 68 inches and the width 48 inches. The depth of the base is 56 inches to prevent tipping during swing motion. A 5 by 6 foot area is the minimum space desired for safe operation.

The frame of the swing is an A-frame made out of douglas fir wood. The top member is a 4-by-4, which supports the suspended driving mechanism. The legs are each 2-by-4s and are attached to the top member by sturdy sawhorse brackets. Each bracket contains a wedge and a 3/8-inch carriage bolt to hold the members together. The legs are braced with a swinging aluminum bar on each side, which is permanently attached to one leg and swings up to latch on the opposite leg, providing sufficient lateral support. This frame design allows for simple disassembly involving (unlatching the cross bars and removing the two carriage bolts in the sawhorse brackets).

The driving mechanism consists of a 30 RPM, 1/10 horsepower shaded-pole motor attached to a pulley system, which is attached to an offset crank. Figure 8.8 shows a close-up view of the driving mechanism, with the motor-pulley system connection, the offset crank, supporting bearings, and the housing unit for the pulley system.

The pulley system allows for fine-tuning of the motor speed to match the natural frequency of the swing. The pulley is covered by a plastic housing unit to prevent injury. The motor-pulley system provides the appropriate rotation speed for the offset crank, which is threaded through vertical slots of two oblong rings suspended from the top of the frame by swing hangers. The top points of the rings serve as the pivot points of the pendulum arm, and the bottom portions of the rings are free to move with the circular motion of the offset crank. The chains are attached to the bottom portions of the rings. The rings catch the horizontal components of the circular motion of the offset crank that translates into the appropriate swinging motion.

The most important factor in selecting a seat was the support it provided for a child. Existing swing seats were not satisfactory to the client, so alternative options were explored. A feeder seat was considered because it offers hip and torso support and also has a bolster to keep the child from slipping. An additional chest harness and lateral head support are used in conjunction with the feeder seat to offer optimal support. The plastic seat material and supports are washable and waterproof. The swing can be used outdoors if necessary.

A PVC piping cradle was designed to snugly hold the seat, and nylon strapping threaded through the harness slots of the seat provides secure attachment to the PVC cradle. The seat cradle is suspended by 2/0 Inco double loop chains, which are ideal for swings and playground equipment. The working load limit for these chains is 255 pounds, which is more than adequate for this swing. Two chains connect to the front sides of the seat cradle to the suspended rings. The backsides of the cradle have two short chains that hook into the full-length chains, forming triangles. The lower portions of the chains are covered with PVC piping to meet day care safety standards and to prevent tipping of the seat.

The total cost of the swing and seat was approximately $740. This included $385 for the feeder seat and supporting harness.

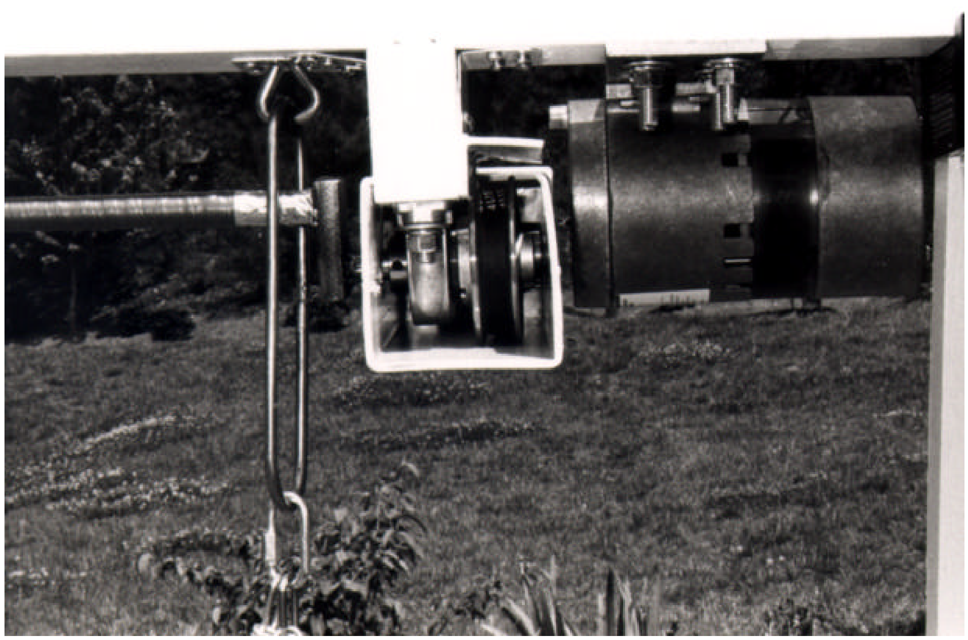

Figure 8.8. Driving Mechanism for the Swing.

SPEAKING SCHEDULE BOARD

Designers: David Chilton, Jason Geddes, Eric Kelly
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INTRODUCTION

The speaking Schedule Board is an interactive modular system for organizing daily schedules. It sequentially announces a series of tasks or activities to its user. The system consists of a control module and up to 10 response modules (Figure 8.9). The control module determines the overall sequencing of tasks. Each response module contains an independent voice record-store-playback unit. Audio announcements of tasks are programmed into the response modules and the schedule is arranged by the order in which the units are plugged together. The module containing each subsequent announcement lights an indicator. When the user presses the large task button, the announcement is played. Once an announcement has been played, the system progresses, after a delay, to the next module in the series. The system modules are light and compact, making the device usable at school and at home. This system represents a significant advancement over a rudimentary voice announcement system previously used by the client.

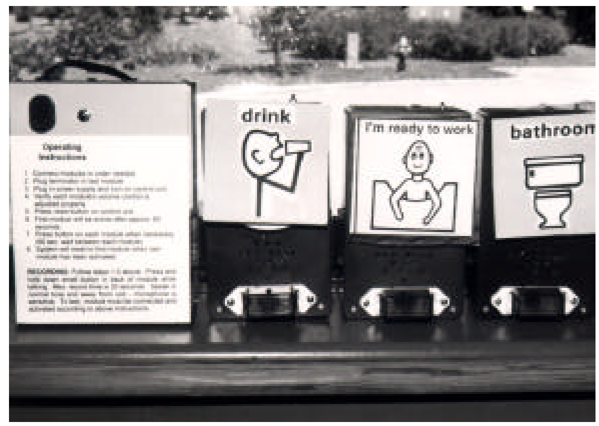

Figure 8.9. Speaking Schedule Board.

SUMMARY OF IMPACT

The Speaking Schedule Board was designed for a student with multiple disabilities. She is non-verbal and non-ambulatory. To facilitate her development, her instructors want her to have an interactive tool for implementing her daily schedule. Prior to using this system, she was using picture frames that included a feature for recording and playing short messages. However, their sound quality is poor, and the playback button is too small for the client to use. Additionally, the frames do not present a visual indication of which task the client is to accomplish next. The newly designed system is modular, allowing the instructors to configure as many tasks (up to 10) as they wish to schedule. The voice recording and playback circuits represent a significant improvement over previous devices. Physically, the modules incorporate large, sensitive, lighted push buttons that are easy for the client to use. Since the system automatically sequences the assigned tasks, she has become more interactive with her daily scheduling. The client's mother, and the residential and instructional staff of the center for developmental disabilities the client attends, report that they are very pleased with the system. Although this device was specifically designed for a specific student's needs, it would be useful for any individual requiring structured scheduling cues. Similar but less sophisticated devices have been developed to provide both scheduling cues and aural stimulation.

TECHNICAL DESCRIPTION

The main design requirements for this system were that it 1) be lightweight, 2) provide visual, tactile, and auditory stimuli, 3) allow easily programmed voice output, and 4) provide easy rearrangement and reuse of schedule elements. From these requirements, a modular system was developed, comprised of a master control unit and several response units that may be plugged together (Figure 8.10). The modularity of this system allows the number of tasks in the sequence to be varied (up to 10), and the order of tasks rearranged without re-recording task announcements. The master control unit serves three functions by providing:

1) DC power to the remaining modules, 2) a delay timer for sequencing tasks, and 3) task sequencing to the chain of attached response modules. The two 4-bit address buses from the control module, passed from module to module, are the key to enabling task sequencing to be determined simply by the order in which the modules are plugged together. One bus (ADDR) always exits the base unit with a value of zero. Each module in the chain adds one to the value before passing it on to the next module. Thus, each module sees a unique address value on the ADDR bus. The second bus (ADDRESS) is passed unchanged through the entire series of modules. When the control module initializes, it sets the value of the ADDRESS bus to zero. Whenever a response module is activated, the control module starts a 60 second timer. When the timer expires, the control module increments the value on the ADDRESS bus. This delay allows multiple activations of the task switch so the message may be repeated before the system advances to the next response module. At the end of the chain of response modules, a termination plug routes the ADDR bus back to the control module as the TERMINATOR bus. When a comparator in the control module finds the ADDRESS bus equal to the TERMINATOR bus, a reset signal is generated. This reinitializes the control module so it will begin sequencing through the series of response modules again. Each response unit contains its own voice record-store-playback circuit. Visible on the exterior of each response module are the task switch, next task light, record button, microphone, volume control, and speaker. Internal to the response module is the digital voice record circuit, audio amplifier, and supporting logic. Each response module compares the values on the ADDR and ADDRESS buses and, when it finds them to be equal, enables itself. The combination of the position dependent ADDR value and the generated ADDRESS value from the control module serve to sequence the activation of each response module. Whenever a response module is enabled, its indicating light will be illuminated. This directs the user as to which button to press next. If a task button is pressed on a response module that is not enabled, the button press is ignored by the system. The system is powered by commercial AC power. Thus, while the system is portable, it is not mobile. Power is converted in the control module to low voltage DC, which is transferred through the module connectors. Construction costs were approximately $1,855. While each module was not exceedingly expensive on its own, the large number of response modules (10) built, along with the single control module, increased the total system cost. A system using a common audio amplifier and speaker housed in the control module would be less expensive. Using a multimessage record-store-playback device may also be less expensive, but would result in less flexibility for rearranging the schedule.

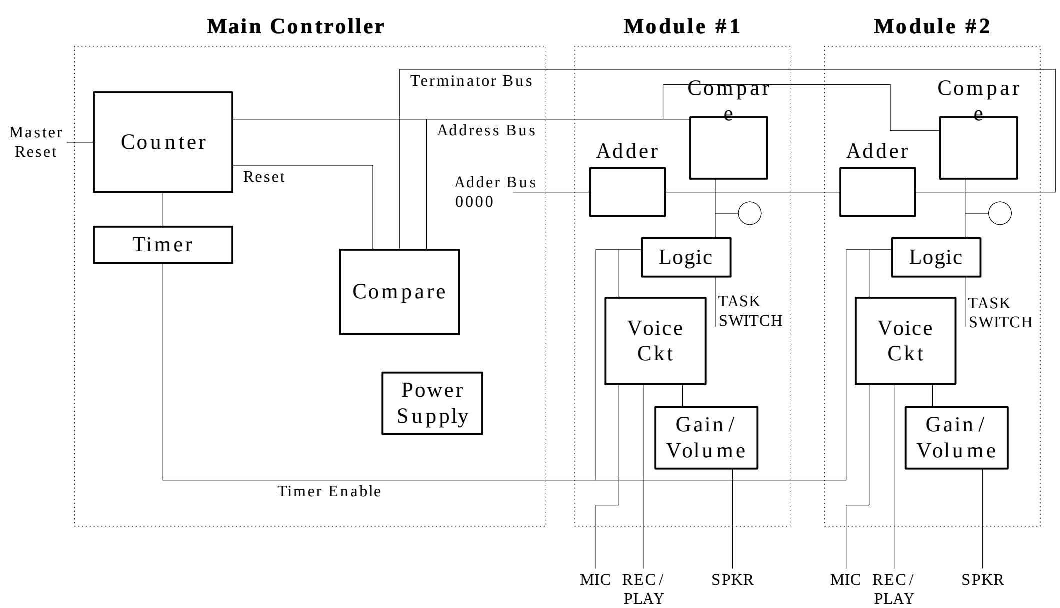

Figure 8.10. Speaking Schedule Board.

TALKING COMMUNICATIONS BOARD

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INTRODUCTION

The Talking Communications Board plays prerecorded voice messages associated with physical objects pulled off the board. It was designed to address the communication abilities of a specific student at a center for children with developmental disabilities. The board operates by allowing the caregiver to record up to ten different messages. For each message, there is a position where an object, attached by Velcro, can be pulled away from the board. This action triggers the playback of the recorded message. The concept was taken from a preexisting (non-speaking) board being used by the student. The new board is large enough to hold ten objects yet is still portable (Figure 8.11). The device is battery powered, so the unit is completely mobile. The recorded messages are readily changeable by the student's teachers and family members.

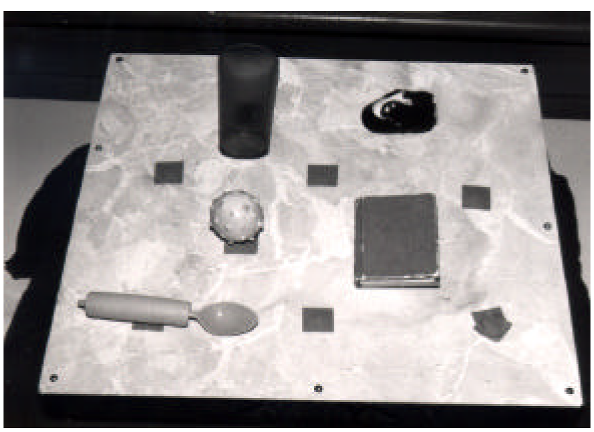

Figure 8.11. Talking Communications Board.

SUMMARY OF IMPACT

The Talking Communications Board was designed for a 12-year-old boy who is blind and severely retarded, with severely limited communication abilities. His only method of communication is through the use of a "vocabulary" of 30 physical objects attached to a board by Velcro tabs. When presented the board, he "speaks" by removing objects. For example, if he removes a cup, this means that he is thirsty. If he removes a baby shoe, this means he would like to go for a walk. Prior to receiving the current device, the student used a board with attached objects. However, that board had only two positions. The goals of this project were to increase the number of objects on the board and add a voice response to the removal an object. Addition of the voice messages allow him to communicate with people who do not know his vocabulary of objects, draw more attention to his needs, and facilitate learning of new vocabulary through increased verbal feedback. Although designed for a specific individual, this device would also be useful for anyone with speech, cognitive, and/or visual impairments. For example, some patients with Alzheimer's disease may communicate with objects in a similar fashion; adding the audible messages would yield similar benefits. This project may also be useful for normally developing children. It can be used to teach toddlers vocabulary in a more tactile way than a "See-and-Say". The configurability of objects and messages provide flexibility not afforded by more structured devices.

TECHNICAL DESCRIPTION

The main design requirements of the board were that it: 1) accommodate a reasonable number of objects, 2) provide voice response upon removal of an object, and 3) be portable. A block diagram of the system is shown in Figure 8.12.

An initial prototype board, without electronics, was developed to determine the physical dimensions and number of objects the student could tolerate. The prototype was 14 by 16 inches, large enough to hold up to 10 objects yet small enough to be portable. After a one-week trial, a clinician determined that the final device should be designed for 10 objects, and that its dimensions should be 17 inches wide by 15 inches deep with a thickness tapering from 4 inches at the rear to 1 inch at the front. Several types of sensors were considered for detecting the removal of an object. Magnetic switches were selected, as they were inexpensive, insensitive to ambient conditions (e.g., light), and not dependent on a significant degree of motor skill. The magnetic switches are embedded in the top of the unit and covered with a Velcro mating patch. The objects have a flat rare-earth magnet attached under the mating Velcro patch. The magnets are strong enough to actuate the switches through the Velcro, but not strong enough to affect adjacent switches. An ISD 2590-voice chip handles the recording, storage and playback of the voice messages. This integrated circuit device can store 90 seconds of audio data in fully addressable, non-volatile memory. It easily switches between play and record modes, has a built-in microphone preamplifier and speaker amplifier, and has an "end of message" signal that is used to place the system in a power-conserving standby mode. The microphone is embedded in the rear of the case along with all control switches. A speaker is installed in the left side of the case. The volume from the voice chip is adequate for areas with normal ambient noise levels. An audio output jack is also available so the board could be connected to an external amplified speaker if needed. Control and sequencing requirements of the system include: 1) detecting removal of an object, 2) determining when to record a message, 3) selecting modes (record, play, standby), and 4) addressing the voice chip for the selected message to play/record. The digital control logic was implemented using a Xilinx 3020L Field Programmable Gate Array (FPGA). This FPGA is reprogrammable so that minor functional changes in the operation of the system can be implemented without major rewiring. The only other logic elements needed were a 555-timer device to generate a system clock and a serial PROM to store the FPGA configuration data for power-up initialization. Four D-cell batteries supply power for the system. Smaller batteries would work as well but would not last as long as the D-cells selected The system power is regulated to 5 volts DC so either rechargeable or non-rechargeable batteries can be used. No provision was made for recharging the batteries in the system. The batteries are housed in a small drawer in the right side of the case. Construction of the Talking Communication Board is relatively inexpensive. The case was fabricated from wood and Plexiglas. The design uses relatively few components, none of which are expensive. The total cost of the parts needed to construct the system was approximately $177.

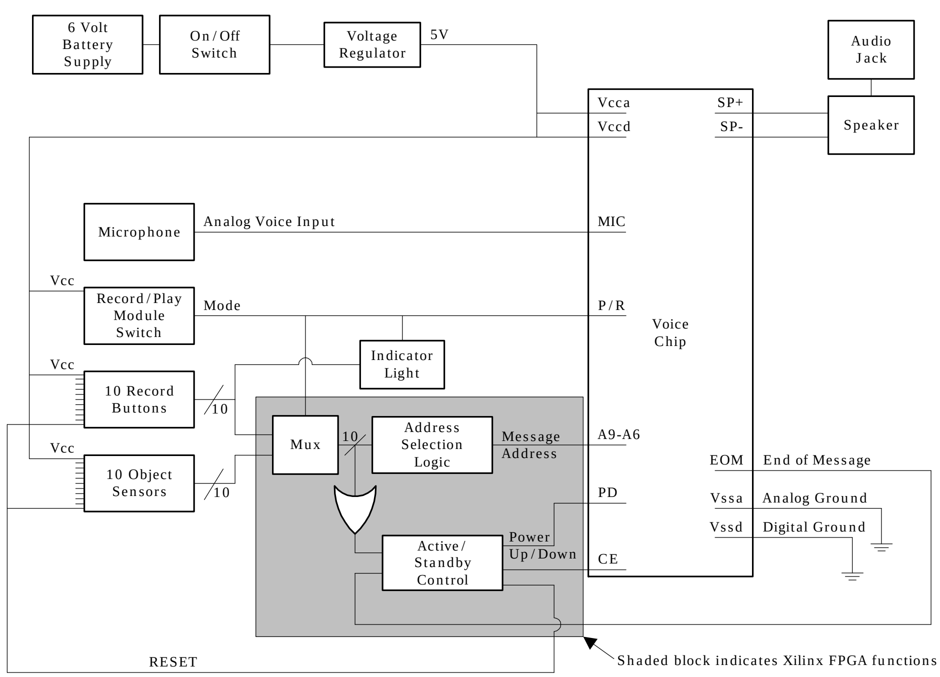

Figure 8.12. Talking Communications Board.

Chapter 9
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PROGRAMMABLE DIGITAL SPEECH SYNTHESIZER

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INTRODUCTION

A private practice of speech-language pathologists uses previously designed voice communication assistants (VCAs) to aid patients with limited verbal skills in expressing words and phrases. These devices allow the patient to press a button, which then causes a word, such as "yes" or "room", to be "spoken" by the device. While these devices are useful, they are limited in their capabilities due to 1) associating a single word with each button, and 2) not allowing customization through use of different words or phrases. The device described here was designed to overcome these two limitations.

The goal is to design an affordable, fully programmable (i.e., allowing changeable messages), battery operated, lightweight, hand held, and easy to use VCA. This VCA incorporates a matrix of buttons that act as the interface to the user. The button leads to a keyboard encoder chip that determines the address of the button pressed and relays it to the controller processor. The processor, in turn, prompts the digital record and playback chip to either record or play back a message for the corresponding button, depending on the mode of operation (playback or record). The VCA also incorporates a distress siren, operated by a separate button, for emergency use.

SUMMARY OF IMPACT

Over the past few years, the client has found VCAs to be valuable for allowing patients to communicate with staff members. Previous designs have been limited, however, by having few and fixed phrases. By allowing different phrases to be “spoken”, and by allowing each phrase to be reprogrammed, this device should enhance the usefulness of VCAs by allowing them to be customized for each patient.

TECHNICAL DESCRIPTION

The VCA uses an array of 16 buttons to act as the interface for the user. When a button is pressed, a message is played or a new message is recorded, depending upon the current mode of operation. (playback or record).

The VCA uses a keypad encoder to determine which button was pressed, and outputs the corresponding address to the controlling processor. The processor then determines what mode of operation the unit is in, and prompts the digital record / playback chip to perform the corresponding function.

If the VCA is in record mode, the digital record / playback chip records a message via the onboard microphone. If the unit is in playback mode, the digital record / playback chip outputs the recorded audio message to the amplifier and, in turn, to the speaker. If the distress siren button is pressed, a button / siren is activated until the button is pressed again.

Operational Processing:

A DS5000 microprocessor was selected to control the VCA. This processor has four 8-bit ports, a lithium battery backup, and 32k of RAM, making it a self-contained unit, simplifying the hardware design and reducing cost considerably. Upon power-up, the DS5000 initializes itself (by setting up interrupt vectors, output ports, etc.) and waits for a button to be pressed. Once pressed, an MM74C922 keypad encoder pulls the data available (DA) line to the microprocessor high. The processor then determines if the mode switch is set to record or playback. Depending upon its setting, it then proceeds in one of two ways: playback mode or record mode.

In playback mode, the microprocessor reads the keypad encoder chip's output as an address of the message to be played. The microprocessor powers up the

ISD2590 digital Record and Playback chip, places the chip in playback mode, and sends the address of the message to the ISD chip. The Chip Enable pin on the ISD chip is then pulled low, activating the current message. Once an End of Message (EOM) marker is encountered, the ISD chip is then powered down to save power.

In record mode, the microprocessor reads the keypad encoder chip's output as an address at which the audio message is to be recorded. The ISD chip is first powered up and the address of the message is sent to the ISD chip. Next, the chip enable pin is held low for the duration of the recording. Once the button is lifted or the record time limit is reached, the ISD chip is again powered down.

In addition to the record and playback mode, an alarm siren is also included. When the alarm button is pressed, a piezo electric element is driven directly from a 5V supply.

The final implementation of the VCA meets all of the requirements established by the client. The buttons are large and easily manipulated; the emergency siren is sufficiently loud; the corners are dull; each of the 16 messages are fully programmable with phrases of up to 5 seconds each; and the unit can be switched from record to playback mode.

In order to reduce power consumption over previous designs, the 11MHz clock was reduced to 1MHz. This reduces the overall power consumption to 11mA.

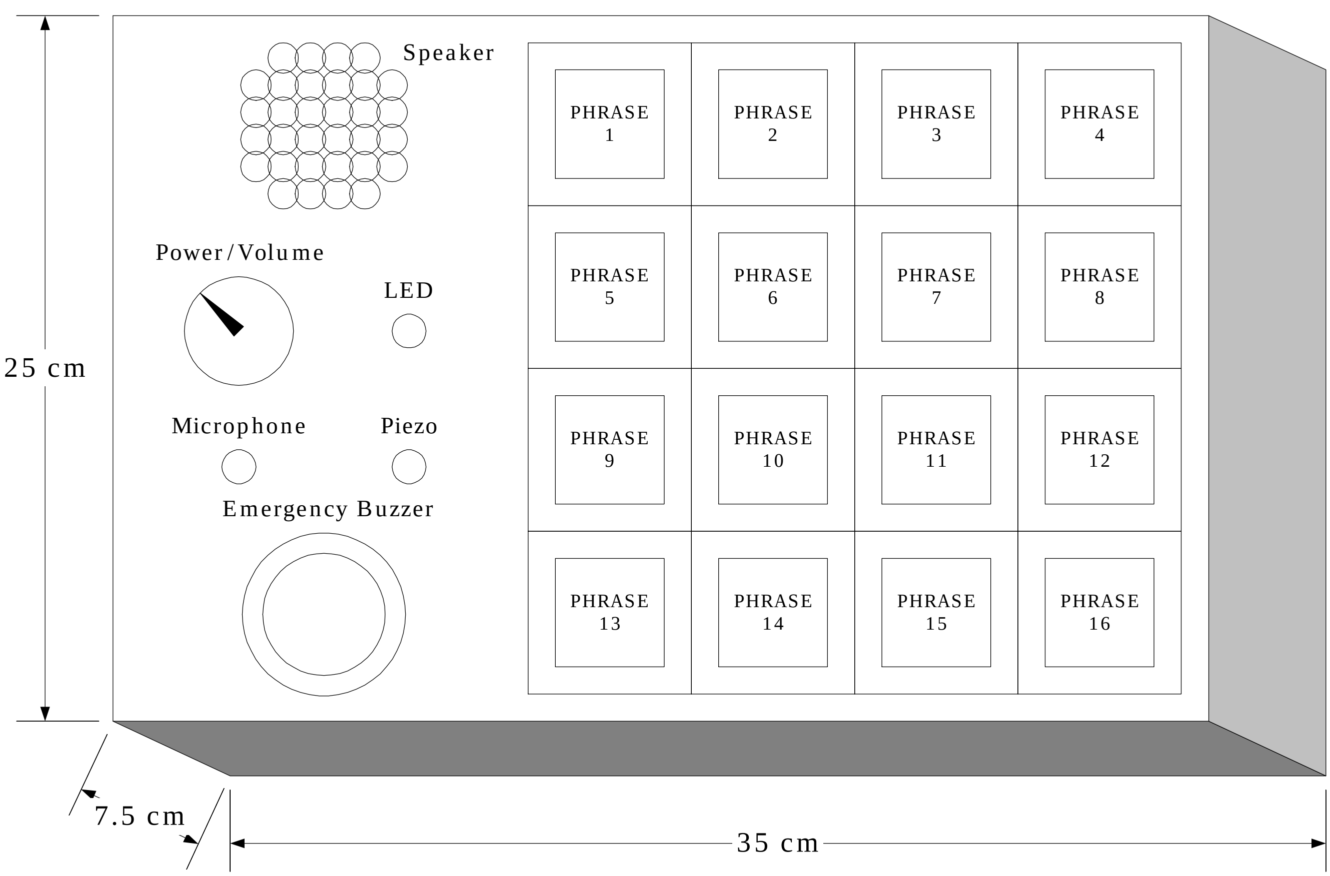

Figure 9.1. Configuration of the Verbal Communication Assistant. The record / playback switch is recessed and located on the back to prevent accidental switching to record mode.

AUDIO AMPLIFIER

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INTRODUCTION

An Audio Amplifier was built for patients who have difficulty vocalizing at a volume needed for effective communication. It entails a microphone headset that amplifies the voice of the operator and transmits it to a nearby FM receiver. The FM receiver is then able to amplify the patient's voice for improved communication.

SUMMARY OF IMPACT

The purpose of this project was to design a voice amplifier that will be portable and effective in allowing the user the freedom to participate in conversation without overexertion. The design consists of a small personal voice amplification aid for those who are unable to vocalize at the volume needed for everyday conversation. When used with any standard FM receiver, this device provides effective amplification of the user's voice. In addition, once the transmitter and/or radio receiver are tuned, the design is simple and easy to use, requiring no difficult manipulation. This device will enhance the ability of the operator to communicate with others by making his or her voice loud enough to be clearly understood. To date, the design has not been field tested.

TECHNICAL DESCRIPTION

The Audio Amplifier consists of three main parts: the microphone, amplifier, and FM transmitter. For ease of use and comfort to the operator, a Shure HW501 microphone headset was selected. This microphone can be worn comfortably throughout the day, and has in impedance of 200 Ohms, and a frequency response range of 50 to 15,000 Hz (well beyond the vocal range). In order to amplify the signal from the microphone, a Texas Instruments TLC251 low-power operational amplifier was used. This amplifier acts as a buffer between the microphone and the FM transmitter. A Sound Feeder SF120 (manufactured by Akron Research Inc.) takes the amplified audio signal and broadcasts an FM signal from 88MHz to 108MHz. This device was selected since it is readily available, has low power consumption, and is FCC certified.

Since the device operates on the FM band, any FM radio could be used as the receiver. An FM receiver based upon the Philips TDA7000 chip was included in the design. The TDA7000 is a chip that implements a mono FM radio from an antenna to the audio output signal that will be sent to the amplifier. This chip was chosen due to the requirement for only one tunable LC circuit of which one variable capacitor is required to perform all the tuning. This results in ease of tuning, and also keeps the size to a minimum because only a small number of external ceramic plate capacitors and resistors are required.

The internal workings of the TDA 7000 consists of a local oscillator, mixer, two-stage IF filter, IF limiter and amplifier, FM demodulator, and an audio muting circuit. Before the actual signal enters the chip from the antenna, it passes through an external RF selective LC circuit that suppresses unwanted signals, such as TC. The signal then enters the chip's mixer, where the signal is mixed with the VCO frequency. The signal then passes through a series of two IF filters and an IF limiter/amplifier. The IF signal then enters the FM demodulator and is converted to the audio frequency. This is then amplified and sent to a speaker, from which the operator's voice can then be heard.

The transmitter portion of this circuit requires a single 1.5V battery and draws a total of 10.19mA. This should provide continuous use for approximately 90 hours when supplied with a AA battery. The receiver portion of the circuit draws 11.6mA at 9V, resulting in a life of approximately 1 hour.

The cost of this project is approximately $124

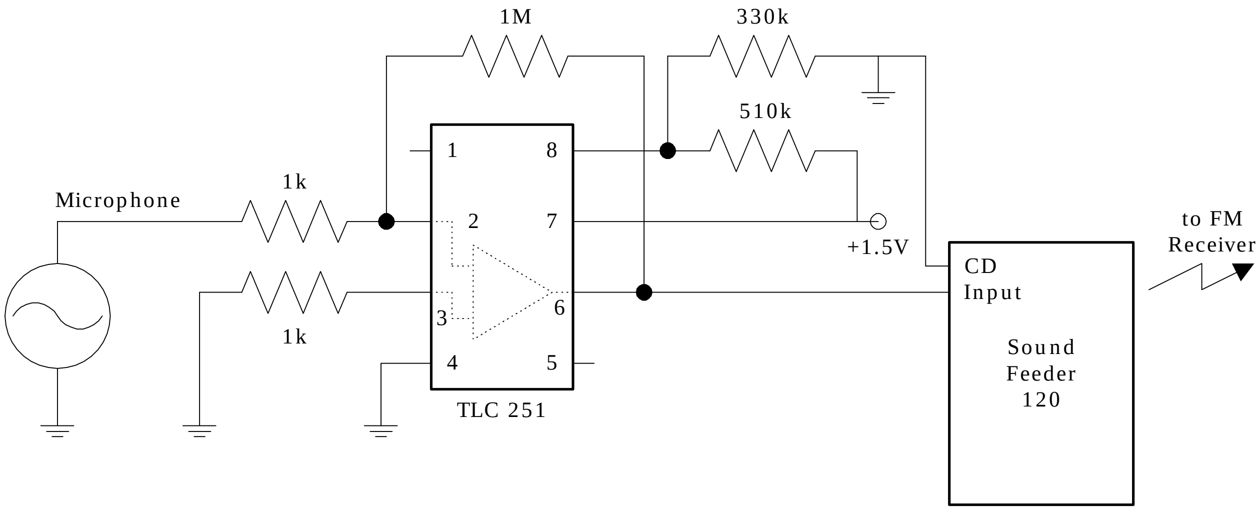

Figure 9.2. Transmitter Portion of the Audio Amplifier.

MOTORIZED CLAMP

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INTRODUCTION

Typically, woodworking requires two hands: one to hold the project and one to do the work, such as painting or varnishing. Unfortunately, this makes woodworking challenging for those with limited use of an arm or hand. This project was designed to help a client who enjoys woodworking. The Motorized Clamp is easily controlled by one hand. It holds an object in place, enabling the operator to use one fully functional arm and hand to work on the project. It entails a robotic arm with a clamp attached. Switches located on a nearby control box control the arm.

SUMMARY OF IMPACT

For those with limited use of an arm or hand, woodworking can be challenging. The Motorized Clamp is a device that can be easily controlled with one hand, effectively giving the operator a second hand for working.

TECHNICAL DESCRIPTION

The mechanical construction of the robotic arm consists of two rotational joints for the base and shoulder, and a prismatic joint for the clamp, as shown in figure 9.3. The device is made of lightweight aluminum to provide a sturdy base and to maximize the carrying capacity of the device.

12V DC servomotors are used to drive each joint. These motors are geared down using work gears to prevent slippage. The base joint is capable of rotating +/- 90 degrees and carries the rest of the root on a lazy-Susan bearing. The shoulder joints are actuated using a threaded rod. This arrangement allows greater loads to be lifted by gearing down the DC motor, provides some added stability to the shoulder joint, and prevents slippage by using a work-gear. The clamp is also actuated using a threaded rod, which moves the clamp from +14cm in the full-open position fully closed.

A control switch is used to move the arm from one position to another. This is accomplished by sending a signal from the user's input switch to the position circuitry, which, in turn, controls the motor for the desired motion. The clamp and arm are designed with sensory feedback to prevent hyper-positioning.

Two 6V lantern batteries provide power. The expected life of the batteries is approximately 6 hours of continuous use. Since the motors are not run at all times while the operator is woodworking, this should provide adequate power for one or two weeks of normal use.

The circuitry involved in this design deals with powering and controlling the motors. Power is provided to the motors via a +12V supply. A double-pole double-throw switch is used for each joint to allow the operator to select the direction of motion of the motor, causing the arm to move up or down or the clamp to open or close. Normally closed switches are located on the +12V line to prevent hyper-positioning the arm. When the clamp reaches a limit, a sensor opens the switch (normally closed), shutting off power to the clamp.

The total cost of the arm is $277.85

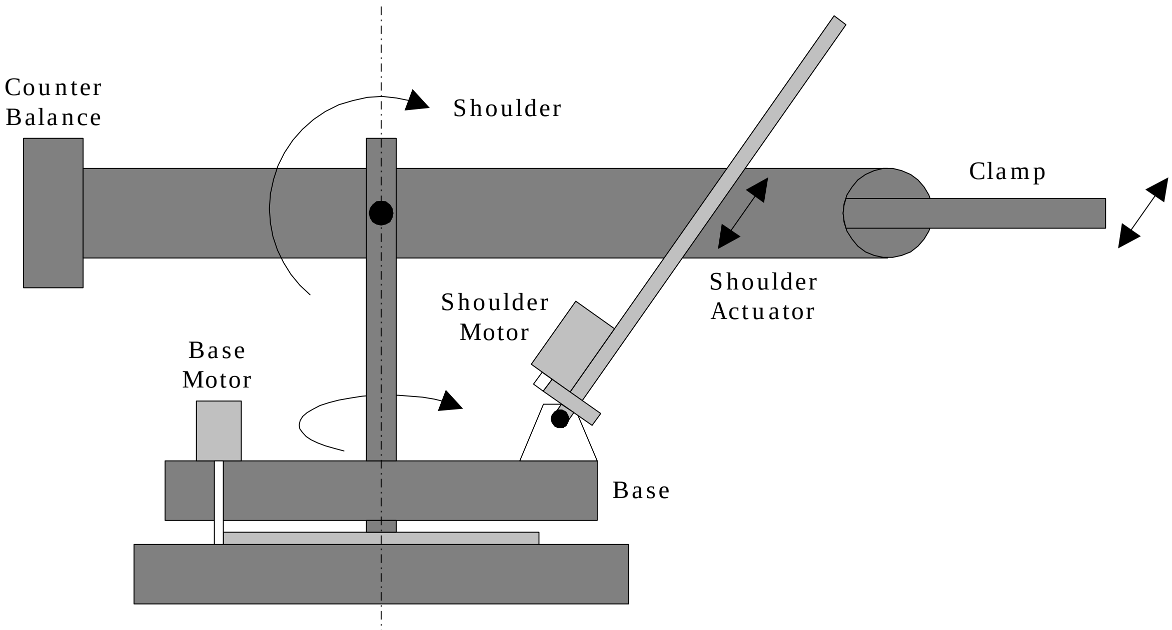


Figure 9.3. Mechanical Configuration of the Motorized Clamp.

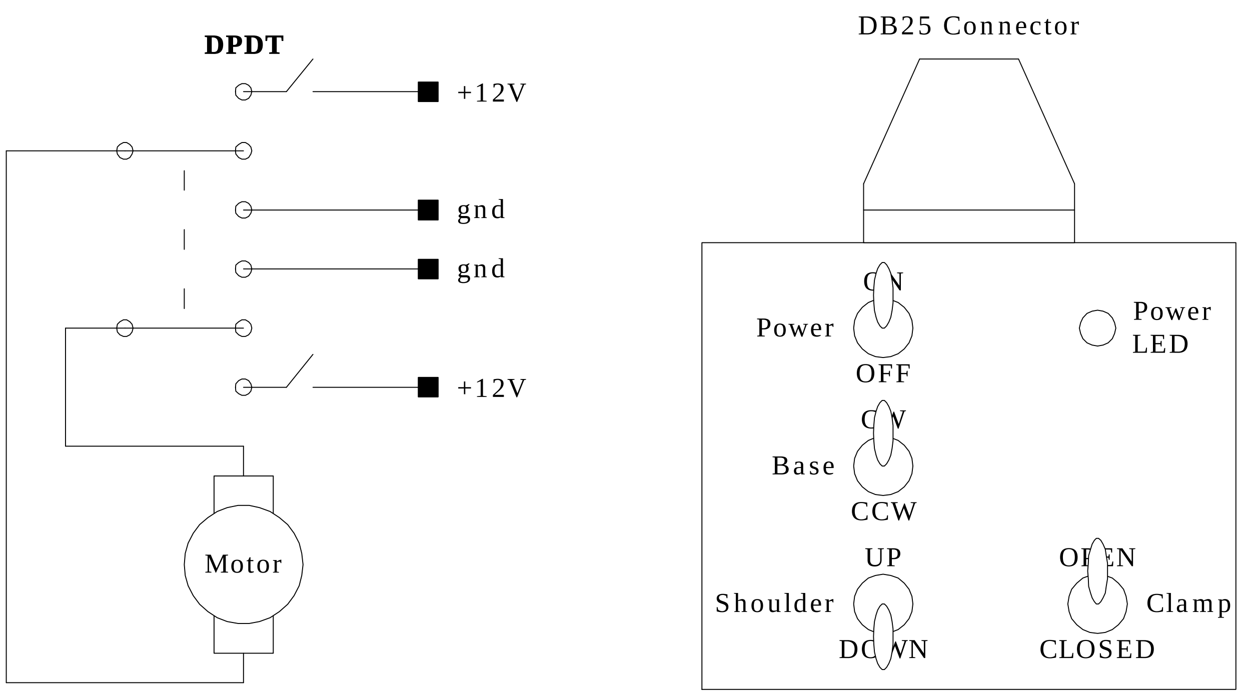
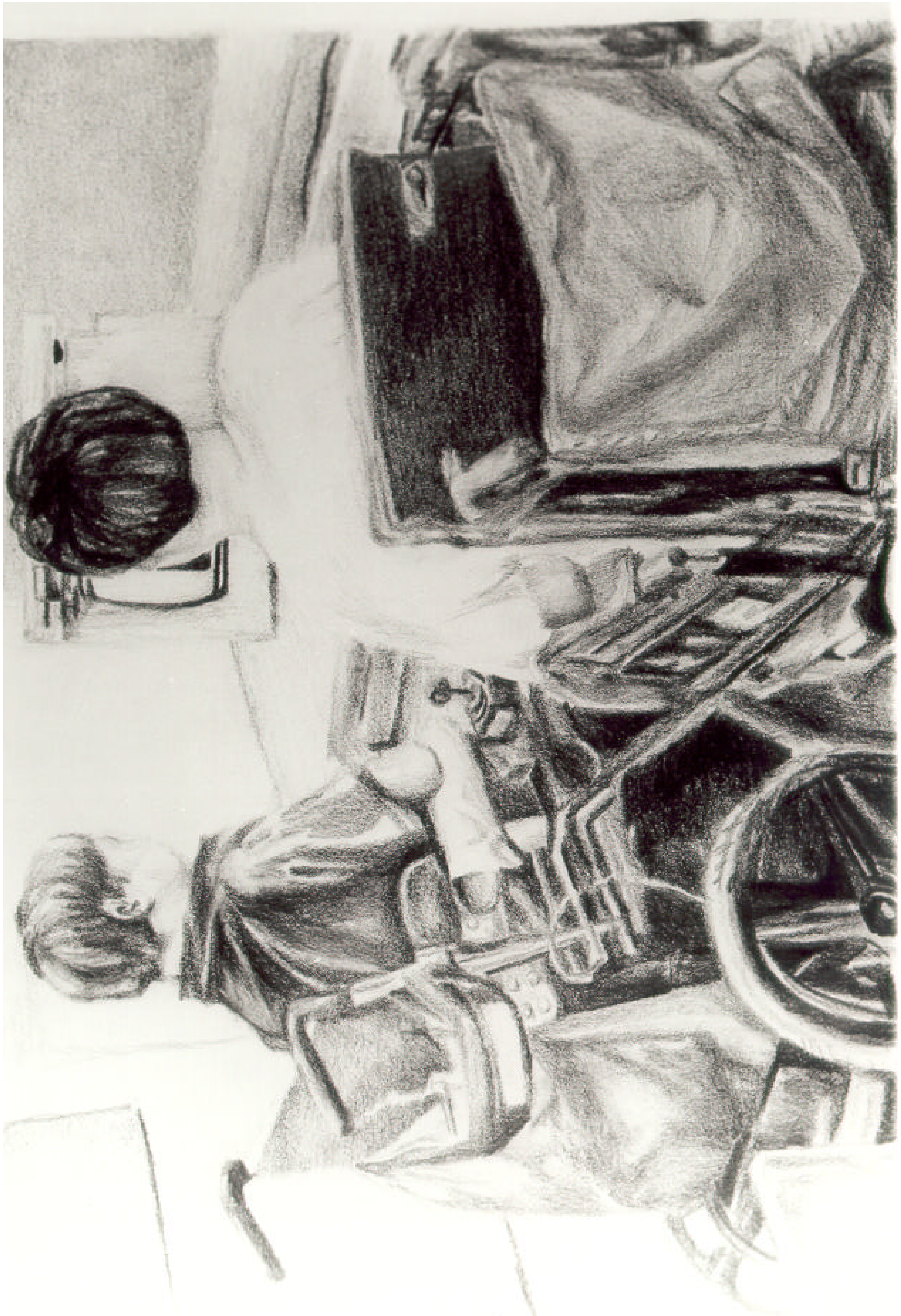


Figure 9.4. Electrical Configuration of the Motorized Clamp. Each of the three motors can be driven forward or backwards. To prevent hyperextending a joint, sensors are used to shut off power to the motor if driven too far.



Chapter 10
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A PORTABLE DEVICE FOR MONITORING VOCAL INTENSITY

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INTRODUCTION

A portable device for monitoring vocal intensity is designed for patients with speech impairment. It is a portable device to assist speech-language pathologists and their patients in acquiring information on episodes of overly high volume in everyday conversations. The device incorporates the TMS320C50 DSK board, a low-cost digital signal processor (DSP) board equipped with 14-bit input/output analog-to-digital (ADC) and digital-to-analog (DAC) converters. It is battery operated and wearable around the waist. Signals from either a throat or lapel microphone are sampled and amplified with an adjustable gain through the onboard A/D converter. Digital signal processing algorithms coded in TMS320C50 assembly language perform voice intensity level calculations on the sampled speech signal. The DSK board will generate a beep sound if the voice intensity exceeds a threshold preset by the clinician. The pattern of the audible sound is programmable based on the preference of the patient.

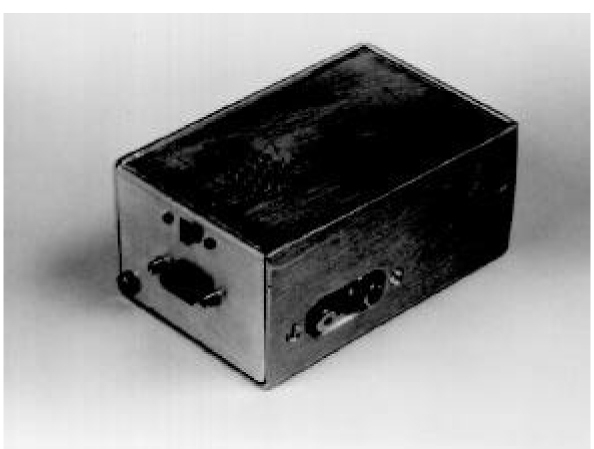

Figure 10.1. Portable Speech Analyzer

SUMMARY OF IMPACT

Speaking loudly may result in vocal cord pathologies such as vocal nodules. Chronic hoarseness, breathiness, or complete loss of voice are the most common symptoms of vocal nodules. Abnormal vocal quality and/or loss of voice not only can be devastating to one's job performance, but can also have profound psychological effects. The primary method of treating patients with voice disorders related to vocal abuse involves monitoring of vocal habits. Typically, patients are asked to self-monitor loudness throughout the day and make adjustments in their phonatory behaviors as indicated. It is not surprising that this treatment strategy is often unsuccessful. A continuous monitoring device would be much more effective in objectively determining an individual's natural voice pattern.

The monitoring device can also serve as a reminder (through beep sounds) when excessively high intensity of voice is detected. Whenever the normal intensity range is exceeded, the portable unit produces an audible tone alerting the patient. In addition, a total daily count is registered to further assist the clinician in monitoring a patient’s progress toward recovery.

The portable speech analyzer meets the needs of many clients. It gives them a sense of control to bring their voice level down when alerted, thus preventing irreversible damage to the vocal cords. The availability of the portable unit also leads to fewer office visits and, in turn, to a reduction in the healthcare cost for the patient.

TECHNICAL DESCRIPTION

The main design requirements for this project were that it be: 1) portable and as small as possible for the patient to wear around the waist without discomfort; and 2) microprocessor-based, allowing easy entering of patient-dependent parameters and maintenance of a log of episodes of interest.

The design incorporated the Texas Instruments TMS320C50 digital signal processor (DSP) DSK board. The fixed point TMS320C50 DSP provides 10 K of on chip RAM with an instruction cycle of 50 nsec. The DSK board comes with the Texas Instruments TLC32040C Analog Interface Circuit (AIC). The AIC is a highly integrated component that combines the function of a 14-bit A/D, a 14-bit D/A, input anti-aliasing filter, output reconstruction filter, and a serial CPU interface. The AIC can be programmed for various sampling rates, anti-aliasing frequencies, and input gains. For the portable speech analyzer, the input speech signal from the microphone pre-amplifier is sampled at 8 KHz by the AIC.

The algorithm for the portable speech analyzer utilizes two buffers each of 240 points (one frame). While one buffer is being filled, the other one would be processed. Four buffer status flags are used to control processing. The RBUFSEL flag is set to control one of the two input buffers are currently being filled. PBUFSEL controls which buffer is being processed. BUF1RDY and BUF2RDY indicate that the corresponding buffer is full and ready to be processed. The main processing loop continuously checks for a full buffer. Upon finding a full buffer, the subroutine for the power calculation is called. During the processing, the other buffer is filled by the interrupt service routine (ISR). In the power subroutine, the power associated with the 240 samples in the buffer is calculated. The calculated power value is then added to a running sum that calculates the averaged power of 10 consecutive frames. The averaged power is then compared with a set threshold. If the averaged power exceeds the threshold, then a warning tone is generated. The output warning could also be realized in the form of a mechanical vibration.

The size of the portable unit is 4 5/16 by 2 11/16 by 2 1/16 inches. The housing contains the DSK board, the microphone preamplifier, the beeper unit, and the batteries. The portable unit consumes three 9-volt alkaline batteries. The DSK board itself runs from two 9-volt batteries (+9 and –9 volts) and the microphone preamplifier also requires a separate 9-volt supply.

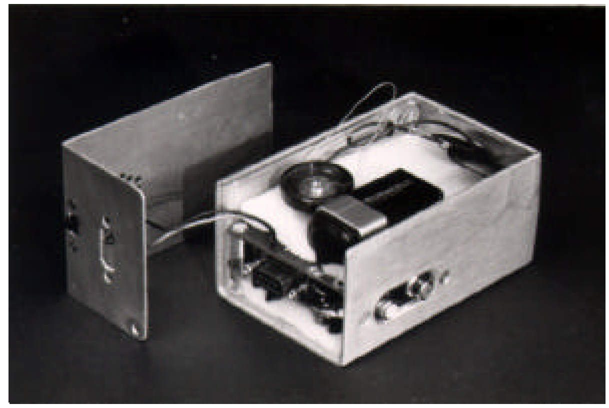

Figure 10.2. Internal View of Portable Speech Analyzer.

The current consumption during the loading of code from PC to the DSK is 240 mA with a minimum required voltage of 6 volts. During processing, the current consumption drops to 100 mA with a minimum required voltage of 4 volts. In order to save battery life, in the absence of any input voice signal, the processor is put into the idle mode (via software), where the current consumption is further dropped to 50 mA. The overall continuous running time for the portable unit is approximately 3 hours.

A three-digit display can also be incorporated to the design to display the number of times excessive volume occurred. A programmer BCD counter with asynchronous RESET (74HC160) is used. The BCD output is directly fed to the BCD-to-Seven Segment latch/decoder/display driver (74HC4511). A common cathode 7 segment LED display is directly connected to 74HC4511. This arrangement is identical for all three digits. However, the “ripple-carry out” output of the counter driving the least significant digit must be given as the clock input to the next counter. The RESET and LOAD pins of the counters are tied to the supply.

The device was tested for various levels of high volume voice signals, and in each case the device was successful.

The final cost of the project is approximately $200.

A DSP-BASED DEVICE FOR ISOLATED WORD RECOGNITION

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INTRODUCTION

An isolated word recognition system is developed for training children with phonetic disorders. The device serves as an effective tool in assisting the speech-language pathologist to help children overcome problems with the pronunciation of words. The device performs the task of isolated word recognition using real-time digital signal processing algorithms. The device utilizes the TMS320C31DSK board, a low-cost floating-point digital signal processor (DSP) board equipped with 14-bit input/output analog-to-digital (ADC) and digital-to-analog (DAC) converters. An uttered word received by the microphone is sampled and amplified with an adjustable gain through the onboard A/D converter. Upon acquiring the sampled speech signal, digital signal processing algorithms coded in TMS320C31 assembly language perform isolated word recognition algorithms. The DSK board generates a pre-recorded sound if the word is pronounced correctly.

SUMMARY OF IMPACT

Children with phonetic disorders often substitute one speech sound for another. Based on the substitution pattern, a specialist prescribes certain exercises to correct the problem. Close monitoring of the child's practice is crucial in determining the effectiveness of therapy. Parental involvement is desirable but may not always be possible. A computer-based monitoring system can be very effective in providing feedback to the child as to whether a desired word has been produced correctly or not. With more and more families having personal computers, children with articulation problems will benefit from customized software and a dedicated digital signal processing (DSP) board to correct phonetic disorders.

Typically, the child with an articulation problem will have a pattern of substitution (e.g., “wabbit” for “rabbit”). With this design, the clinician can also monitor the rate of substitution. The DSP-based device gives the child a sense of independence and control.

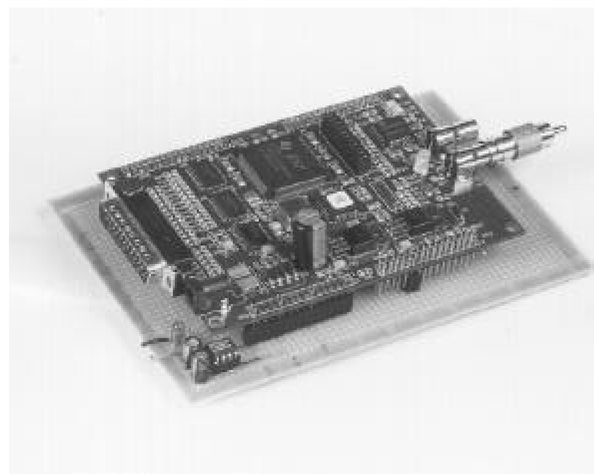

Figure 10.3. Word Recognition Device.

The availability of this system may also lead to fewer office visits, which ideally translates into a reduction of the healthcare cost for the child.

TECHNICAL DESCRIPTION

The word identification/verification system had the following requirements: limited vocabulary, isolated word, and high signal-to-noise ratio (SNR). A PC-based system with a dedicated DSP board is developed to accomplish this task. The design is carried out on the Texas Instruments TMS320C31 digital signal processor (DSP) DSK board. The floating point TMS320C31 DSP provides 2 K of on chip RAM with an instruction cycle of 40 nsec. The DSK board comes with the Texas Instruments TLC32040C Analog Interface Circuit (AIC). The AIC is a highly integrated component that combines the function of a 14-bit A/D, a 14-bit D/A, input anti-aliasing filter, output reconstruction filter, and a serial CPU interface. The AIC can be programmed for various sampling rates, anti-aliasing frequencies, and input gains. The input speech signal from the microphone pre-amplifier is sampled at 8K Hz by the AIC. Since, the on chip RAM of 2K is not sufficient for the application of this project, an additional 32 K bytes of external SRAM is designed and appended to TMS320C31 DSK board.

For the 32K external SRAM all necessary signals are tapped through dual row headers. The male end is soldered to the DSK board, while the female is soldered to the memory board. The address line A0-A14 are buffered using two 74HCT244 (octal unidirectional buffer). The buffered addressed lines are connected to the SRAM address lines. The data lines are not buffered. The chip select signals for the SRAMs are derived from the DSK board. This is the SRAM / signal decoded by the PAL 22v10 on the DSK. The memory is mapped beginning 80A000h. An on-board regulator is necessary since the DSK board is capable of supplying only 50 mA for expansion purposes.

Software design process was divided into component problems, the solutions for which result in the overall speech recognition system. The first problem is to determine if a word has begun. This is by calculating the signal energy, and how many zero crossings take place within a 40-sample (5 ms) buffer. Once the word has definitely begun, a 160- (20 ms) sample buffer of speech is taken in order to start processing. The 20 ms buffer is compatible with speech applications, because this is a period that speech spectra stay relatively stationary. Next, the input speech samples are windowed by a 30 ms Hamming window in order to obtain a more distinct main lobe as compared to the side lobes in frequency, and to reduce leakage. The 160-point buffers are filled by use of an interrupt service routine (ISR), which is enabled while processing of the previous buffer is initiated.

Processing of the present buffer is done first by calculating the auto-correlation of the 20 ms speech buffer. The buffer is modeled by a 10-coefficient all-pole filter when the system is in the training module. These auto-correlation coefficients are used to obtain the linear predictive coding (LPC) coefficients to describe an all-pole discrete time filter. The LPCs are obtained using Levinson-Durbin algorithm. The number of LPC coefficients determines the accuracy of the filter response as compared to the true signal spectrum. For this design, the number of coefficients is assumed to be 10, sufficient enough to describe the signal spectrum yet small enough for the amount of available memory, and meeting real-time processing requirements. Storage of the word reduces to the number of buffers filled in a given word, multiplied by 10 LPC coefficients. These templates are stored while the processor is still in the training mode.

In the recognition mode, the auto-correlation functions of the spoken word are passed through an inverse all-pole FIR filter described by the LPC coefficients stored in permanent memory. The output of the filter represents the error energy between the present input signal and the response of the template filter. If the word is a match, the output of the filter should yield very low error energy. If the word is not a match, the output of the filter should yield very high error energy. Time warping, to adjust for the speed of pronunciation, is also implemented in the recognition algorithm. This is done by running a segment of auto-correlation through three different templates, each of which describes the word in different consecutive time frames. The template that produces the lowest error energy is considered the correct time frame match between the auto-correlation and the corresponding template.

A second problem is to determine, while in training or in recognition mode, when the word has ended. This is done through the use of high and low thresholds. These thresholds are compared numerous times to the present energy of the signal. When the thresholds have been logically exceeded, a bit in the artificial flags register is set to indicate that the word is over.

Upon the recognition of an uttered word, a pre-recorded sound is played to provide feedback about the correct pronunciation to the child. If need be, other types of feedback can also be provided. Although at this point a PC is required to load the program, the device can be made standalone, portable, and less costly by employing flash memory. The design was tested for different words and recognized all the correctly pronounced words without error.

The final cost of the project without a PC is approximately $200.

Chapter 11
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SHOULDER BRACE REPLACE A SLING AND ALLEVIATE ELBOW AND NECK PROBLEMS

Student Designers: Mark Reinhardt, Paul Rignel and Thomas Zugelder
Consulting Physical Therapist: Meredith Reinhardt
Supervising Professor: Joseph C. Mollendorf, Ph.D.
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INTRODUCTION

When a person undergoes shoulder surgery or suffers shoulder dislocation, he/she is required to place the corresponding arm in a sling to allow the shoulder to heal. After the sling is used for six to eight weeks, complications can occur in the elbow, shoulders and neck.

Wearing a sling for an extended period of time causes two major complications in the elbow. The first major problem is adaptive shortening of the biceps brachii and brachioradialis. When a patient keeps a muscle in a shortened position for an extended period of time, the muscle actually shortens due to loss of tissue. This causes a reduced range of motion in the elbow. Another problem that also limits the range of motion in the elbow is capsular restriction in the humeral-unlar and humeral-radial joints.

In addition to problems in the elbow, complications may also occur in the shoulders and neck. Sustained pressure on the upper trapezius facilitates muscle contraction, causing a hypertonic upper trapezius. This contributes to cervical spine dysfunction and altered shoulder girdle mechanics.

With the occurrence of these problems, the patient may require extended physical therapy.

SUMMARY OF IMPACT

The present shoulder brace is to accomplish a wide range of goals. For medical purposes, it must meet minimum requirements to allow for proper healing: full support for the weight of the arm and maintenance of the shoulder in the proper healing position. To minimize other potential medical problems discussed previously, it should allow for free range of elbow motion. Using this brace to rehabilitate the shoulder will dramatically improve the comfort for the patient wearing it and allow for freedom of motion and greater use of the hand.

Figure 11.1. Finished Brace as Worn.

TECHNICAL DESCRIPTION

The shoulder brace consists of three major components: the support system, the arm brace and the rigid link between the two.

The support system is comprised primarily of three materials. First, a 4 x 19 inch piece of San-Splint® thermo-formable plastic is used for the major support and connection site of the rigid link and the straps. The size of the San-Splint® used is dependent on the rib cage size of the patient. The San-Splint® extends from the center of the spine to two inches short of the center of the sternum. This piece of material is positioned just below the pectoralis major and formed to the contour of the patient's body. The second material used is Kushionflex® self-adhesive, closed cell foam padding.

Finally, Velwrap? strapping material is used to help support the weight of the arm and keep the San-Splint® in place.

The second major component of the shoulder brace was purchased as a complete unit: the IROM? Elbow brace. This unit has Velcro closures around the arm and forearm. The brace has the capability to limit extension and flexion of the elbow with a simple pin adjustment.

The final component of the shoulder brace is the rigid link that connects the support system to the IROM? Elbow brace. This link is made of low carbon steel. The rigid link extends around the outside of the arm and is fastened to the elbow brace as shown in Figure 11.2. This link is made to carefully position the shoulder. Specifically, it is in 10? of abduction, 15? of internal rotation, and 10? of flexion. This prototype is not adjustable. It could be modified to accommodate as many people and diagnoses as possible.

The total cost of materials and supplies is about $143 dollars.

Figure 11.2. Top View of Brace.

INDIVIDUALIZED WHEELCHAIR WORKSTATION

Student Designers: Karl Kuriger and Michael Moses
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INTRODUCTION

The Wheelchair Workstation is a unit designed to help school children with disabilities complete their tasks. This population was selected as the target for design because of the amount of time children spend in school. Accessible working sites are not always available. The unit provides a portable working surface as well as convenient storage for working materials. It consists of a storable tabletop, a beverage holder, and two storage compartments. The larger compartment fits larger items, such as books, while the smaller compartment is designed for pens, pencils, eyeglasses, etc. Both compartments feature lids that double as padded armrests. The major attribute of the unit is that its location on the chair ranges from a non-obtrusive storage position behind the chair, to a convenient working location at the user's side.

Figure 11.3. Unit in Stored Position.

Since the workstation is interchangeable with an existing wheelchair armrest, no modifications to the chair are required. This feature is important because such modifications may void a wheelchair manufacturer's warranty. Additionally, the unit can be removed when not in use, and replaced with the chair's original armrest component.

SUMMARY OF IMPACT

The Wheelchair Workstation is designed to make it easier for children in wheelchairs to do their schoolwork. The accommodations of the unit are expected to increase the user's independence and self-confidence.

TECHNICAL DESCRIPTION

The Wheelchair Workstation travels between the in-use and stored positions via a four-bar linkage mechanism. Two anodized aluminum links connect the workstation to a 0.1-inch stainless steel mounting plate, completing the four bars of the linkage. Stainless steel was selected for the mounting plate because of the large moment generated by the weight of the unit on the links.

The aesthetics of the Wheelchair Workstation were an important consideration in its design. Both storage compartments and padded armrests are upholstered in a synthetic leather to maintain a soft appearance.

The total cost of materials and supplies is about $465.

Figure 11.4. Unit in Use Position.

PAGE TURNER FOR INDIVIDUALS WITH DISABILITIES

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INTRODUCTION

The objective of this project was to design and build a device that would turn the pages of a book or magazine for individuals with limited or no upper body motion. A person with this type of disability may find it difficult or impossible to read independently.

Although this device was not designed with a specific person in mind, it can easily be modified to meet the needs of many individuals.

SUMMARY OF IMPACT

A page turning device was designed and built. It works with a variety of reading materials. This device helps to increase the independence of individuals who may otherwise not be able to turn pages.

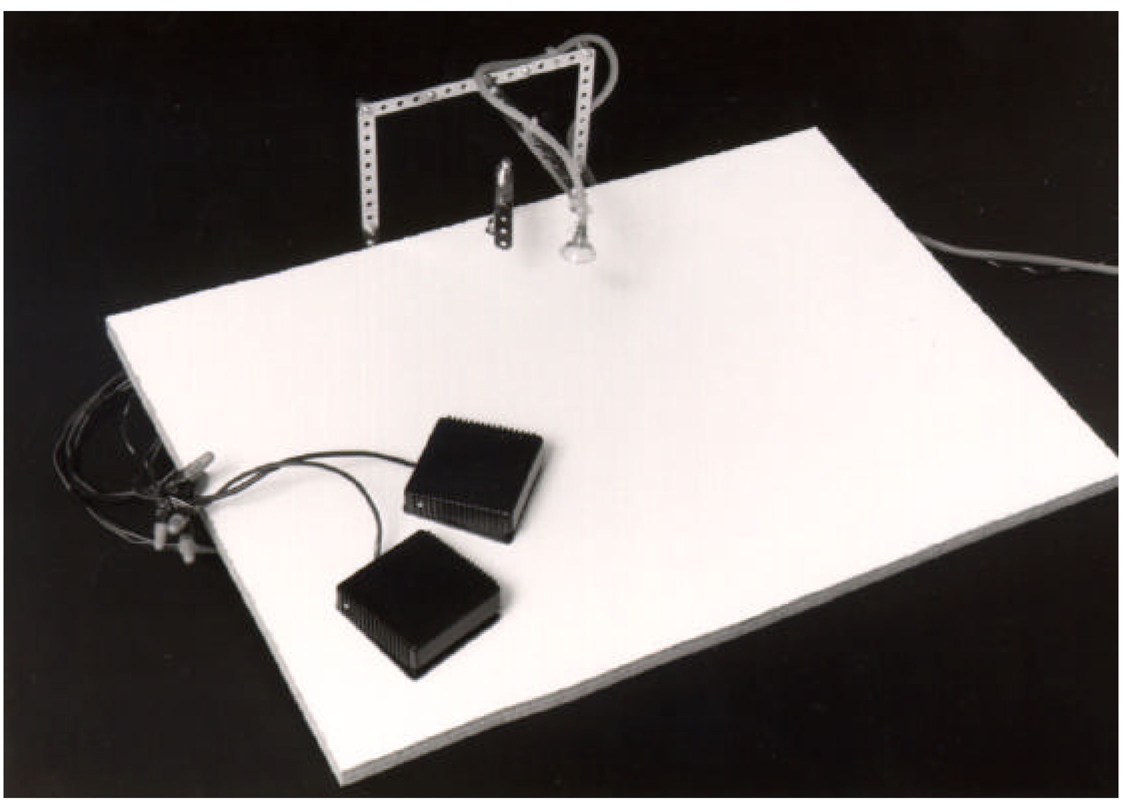

Figure 11.5. Finished Page Turner Unit.

TECHNICAL DESCRIPTION

The Page Turner consists of two main components: a vacuum component and a translational component.

The vacuum component consists of a submersible pump, an aspirator valve, and a water reservoir, although any suitable vacuum source would suffice.

The vacuum is used to lift the page. The amount of suction can be varied slightly by a valve on the vacuum line. This is done to compensate for different paper porosity.

The translational component consists of a 4-bar mechanism and a rotating arm.

The 4-bar mechanism moves the vacuum line from right to left as it holds the page.

After the 4-bar mechanism and vacuum line lift the page, the arm rotates 180?, turning the page during its motion.

Two 3-volt permanent magnet D.C. motors power the 4-bar mechanism and rotating arm. The motors are operated via foot pedal switches.

The total cost of materials and supplies is about $116.

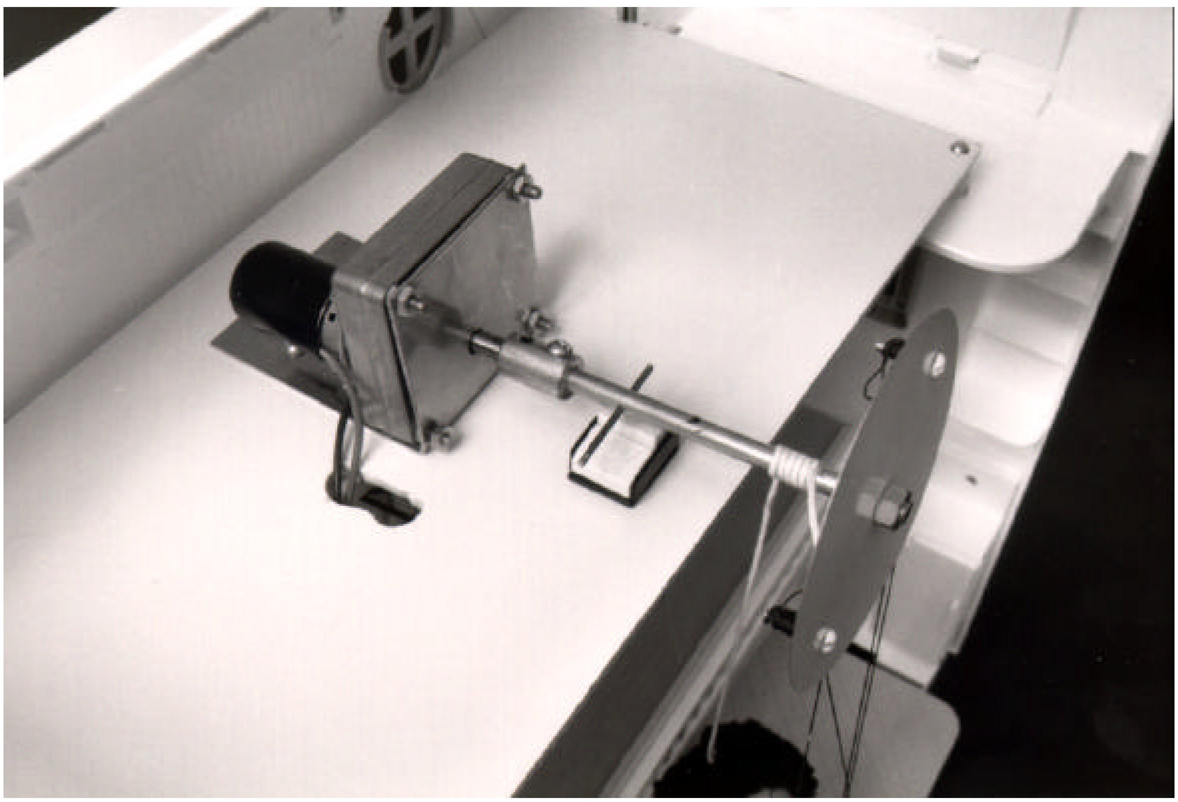

Figure 11.6. Close-up of the Translational Component of the Page Turner.

BED-WHEELCHAIR TRANSFER SYSTEM

Student Designers: Tiffany Bristow, Todd Esse, Nathaniel Getzel, Frank Robertson and Alex Roxin
Supervising Professor: Joseph C. Mollendorf, Ph.D.
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INTRODUCTION

A means of transfer from a bed to a wheelchair, and vice-versa, is essential for persons with quadriplegia. Currently, there are no transfer devices on the market that are easy to use, storable and affordable. Many involve discomfort or awkwardness for the user.

The Bed/Wheelchair Transfer System was designed to be less bulky, less expensive, and more comfortable for the user. In addition to alleviating constraints on storage and affordability, it also allows a family member or a friend to assist the patient without resorting to professional assistants.

SUMMARY OF IMPACT

This design is intended to provide individuals with physical challenges a more affordable transfer device that will improve their quality of life.

TECHNICAL DESCRIPTION

The design for the Bed/Wheelchair Transfer System consists of three main components: the platform/ramp, the pulley system, and the transfer device.

Platform/Ramp

In order for the wheelchair to be raised to the height of the bed, it must rest on a platform. The platform is large enough to accommodate the dimensions of the standard wheelchair and strong enough to withstand the combined load of the wheelchair and person. The platform also stabilizes the wheelchair, locking it in place and assuring that no tipping or rocking occurs. In addition, the platform height is adjustable to accommodate a range of bed heights and can be easily pushed underneath the bed for storage.

The ramp is used to transport the wheelchair from ground level to the top of the platform. The ramp also accommodates the size of the wheelchair and can support a 350 lbf load. The ramp is easily joined to the platform by a hinge that must withstand a 150 lbf load and possible torque. The hinge also allows the ramp to be folded onto the platform and stored with it.

Pulley system

The pulley system supplies the power to slide the support carrying the 170 lbf load. The system is composed of several pulleys attached to ropes that are connected to a hand crank. Once the hand crank is activated, the pulleys help guide the sheet across to the wheelchair. The pulley system can be reversed by merely placing the support bars on the opposite side and using the hand-crank in the opposite direction.

Transfer Device

The transfer device is composed of a denim sheet that supports the person. It is lightweight and easy to apply and remove. It can support loads up to 170 lbf during transfer and offers as little friction as possible during sliding. The denim sheet also has removable supports made of wood to help distribute the person's weight throughout the sheet.

Integration of Components

The procedure for wheelchair bed transfer begins with the person moving the wheelchair up the ramp onto the platform and applying the brake. The person reclines the seat to a horizontal position. With the denim sheet already underneath the person, the assistant attaches the support bars to the sheet through the brass grommets. Using the hand-crank, the assistant transports the person from the wheelchair to the bed. Once the transfer is complete, the assistant detaches the support bars from the sheet. The denim sheet can either remain underneath the person or can be removed with assistance. This process can be reversed, transporting the person from the bed to the wheelchair, by simply placing the support bars on the opposite side as before and using the hand-crank in the opposite direction.

Several improvements can be made to this device. It would be worthwhile to design a platform with hydraulic legs. This would make the design more universal. Similarly, a small, efficient motor might take the place of the hand-crank. Lastly, the denim sheet could also be lined with Teflon material on the bottom to ensure minimal friction during the sliding of the sheet.

The total cost of materials and supplies is about $150.

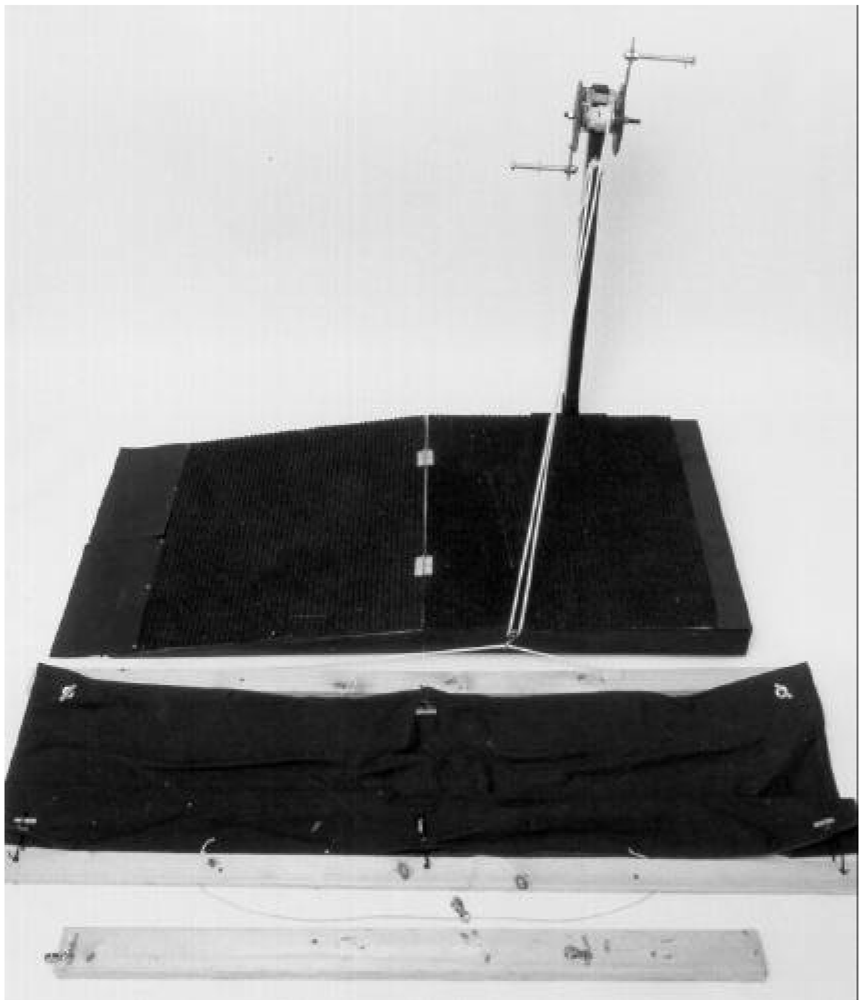

Figure 11.7. Components of the Wheelchair Transfer System.

PANTS AIDING DEVICE: AN ASSISTIVE CHAIR TO FACILITATE DRESSING AND UNDRESSING

Student Designers: Joshua L. Donay, Albert Ruiz, Eugene Detke and James Smith
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INTRODUCTION

The act of getting dressed independently seems to be trivial for most individuals. Yet for a person with paralysis of the legs, this task can be tedious. With the aid of a hoop-like ring, and a specially designed chair, the Pants Aiding Device (PAD) provides an easy, quick, and convenient solution.

SUMMARY OF IMPACT

The PAD consists of two main components: the chair and the PAD. Together, both are used in accomplishing the task of putting on pants.

The PAD is a hoop-like ring with two long handles and four clips for fastening on the pants (See Figure 11.9). Handle length is set to provide an easy way to slip the pants onto the feet of the individual. The PAD is adjustable, via hinges, to accommodate different waist sizes.

The chair itself has five main components: the leg apparatus, the harness, the pulley system, the hydraulic jack, and the rocker arm. Acting like a reclining chair, the leg apparatus serves to raise the legs of the individual. Once the heels are off the ground, the pants, through use of the PAD, can be pulled onto the legs. Upon lowering the legs back down, the PAD can be detached from the pants, and the individual can pull the pants up to his/her thighs. The act of pulling the pants under the buttocks area is especially challenging. The harness was designed for the upper body only, leaving the lower body free. One's arms extend through the harness that goes under the armpits. To the right of the person sitting in the chair are two handles, both of which are attached to the hydraulic jack. The closer of the two handles can be pumped up and down to activate the jack. As the jack goes up, the rocker arm creates a pivoting seesaw motion. The far end of the rocker arm is attached to a cord, which in turn travels up and over the pulley system to the harness. This motion pulls the individual up and off the seat. Once at a desirable height, the pants can be pulled the rest of the way onto the individual. The second of the two handles on the jack is the release valve. A quarter-turn counterclockwise allows the jack to retreat, and the individual to descend back onto the chair. The task of putting one's pants on is accomplished quickly, easily and efficiently.

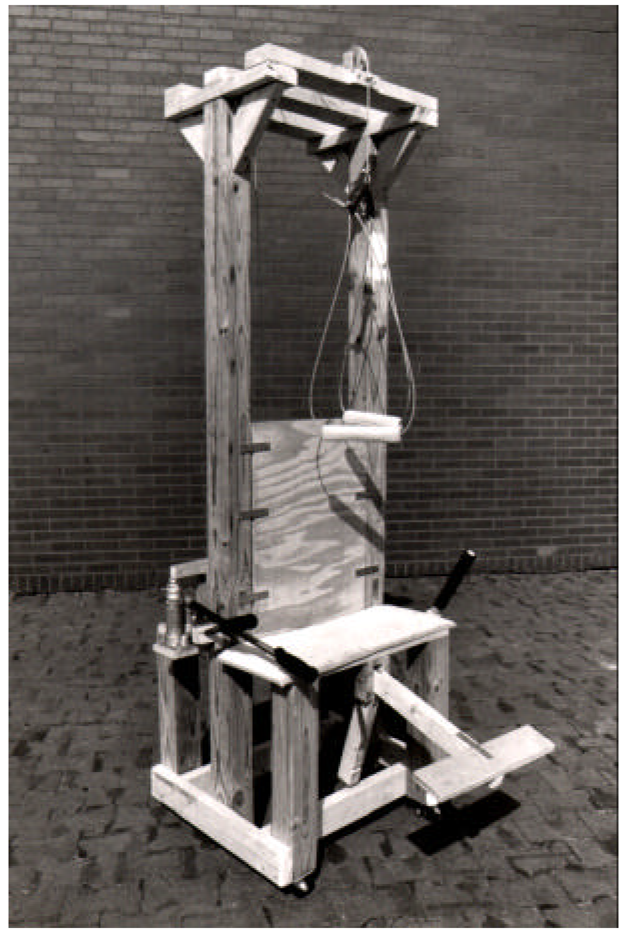

Figure 11.8. Basic Chair Arrangement.

TECHNICAL DESCRIPTION

Technically, the PAD is a simple device. The length of the rocker arm is designed to magnify the travel of the jack by a factor of about two; the length after the pin is about double the length before the pin. This allows less pumps of the jack to acquire a reasonable height for the individual. A vertical distance of three inches is accomplished with a mere 15 strokes of the jack and sufficient force on the harness, which a person can easily provide. The release valve only need be turned a quarter of a turn to allow the jack to descend.

For refinement, the leg apparatus could be constructed with adjustability to allow for different size legs. It is designed to rest on the calves of the individual, leaving the heels of the feet free for the purpose of putting on the pants. Also for refinement, the harness could be modified to apply pressure to the body, not just up on the shoulders. This would provide greater comfort and allow for maximum arm motion.

The total cost of materials and supplies is about $150.

Figure 11.9. Hoop-like Ring with Pants Attached.

A TELEPHONE CONTROL UNIT TO FACILITATE DIALING AND ANSWERING

Student Designers: Scott Woeppel, Tim Gelnett, Tomas Czerwinski, Tom Seitz and Arvind Bhonghir
Supervising Professor: Joseph C. Mollendorf, Ph.D.
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INTRODUCTION

It is virtually impossible for persons with quadriplegia to dial or answer a conventional telephone. Hence, a device was designed to enable persons with quadriplegia to use a telephone.

The Telephone Control Unit integrates a breath actuator, Cermatek dialing board, Motorola computer board, speaker and microphone interface and an LCD display. To use the telephone the user must be placed in front of the unit. He or she must respond to commands displayed on the LCD by use of the breath actuator. The LCD displays both commands and numbers according to a program contained on the Motorola computer board. The device then utilizes the Cermatek dialing board to simulate tones, and finally, to dial the input phone number. The user then interfaces with his/her caller via a speaker and microphone.

SUMMARY OF IMPACT

The Telephone Control Unit allows persons with quadriplegia to regain independence in using the telephone. It also affords the user privacy when using the device.

Figure 11.10. Finished Unit.

TECHNICAL DESCRIPTION

The Telephone Control Unit (Figure 11.11) contains five major components: a Motorola control board, a Cermatek dialing board, an LCD Display, a breath actuator and a speaker/microphone interface.

The Motorola control board is the most significant component of the device. It contains a computer chip that is programmed through interface with a PC. The program is structured in such a way that it allows the user to perform the same functions of a standard phone. These include manual dialing, memory dialing and flash. The Motorola control board receives its input from a breath actuator and then displays the output of the response on a LCD display.

The breath actuator is simply a pressure sensor box connected by a ¼-inch piece of flexible vinyl hose for input, and a wire lead connected to the Motorola control board as output. When the user blows into the hose, it simply closes a circuit that initiates a response to the Motorola control board. The pressure sensor is adjustable to as little as 1/4 PSI and up to 4 PSI. The responses made by the individual are prompted by the statements displayed on the LCD.

The LCD is a 40 by 2 character display that allows a large viewing area for easy readability. Statements pertaining to telephone functions, for example, "manual dialing" or "memory dialing" are shown on the display. Brackets are placed around one statement at a time. The brackets move to each subsequent statement about every 1.5 seconds and scroll back to the original statement, with a complete cycle of up to 60 seconds. When the user blows into the breath actuator, the function corresponding to the statement will be initiated. After 60 seconds, the whole sequence resets itself. When the user attains the telephone number he or she wishes to dial on the LCD, the number is transferred to an analog signal, which is then sent to the Cermatek board.

The Cermatek board is the interface between the Motorola control board and a standard phone line. The Cermatek board converts the analog signal of each number into a dialing tone. The sequence of numbers is then dialed on a standard phone line, making the desired contact.

The user may communicate through a mounted speaker and microphone. These components can be adjusted for comfort. When in place, the speaker and microphone unit can be screwed tightly into position.

If the Telephone Control Unit were to be mass-produced, the programming costs could be eliminated and the device could be made for about $275.

The total cost of materials and supplies is about $396.

Figure 11.11. Components.

CELLO SUPPORT: A WHEELCHAIR ATTACHMENT FOR CELLO PLAYING

Student Designers: Matthew Gounis and Andrew Tyo
Client Coordinator: Professor John A. Neal, Ph.D.
Supervising Professor: Joseph C. Mollendorf, Ph.D.
Technical Advisors: Daniel Cook, Kenneth Peebles and Roger Teagarden
Mechanical and Aerospace Engineering Department
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INTRODUCTION

The goal of this project was to design and build a wheelchair attachment that would allow a person in a wheelchair to play the cello. It was originally developed for a client with spina bifida, a congenital condition in which the spinal column does not fully close during fetal development. The client's legs are paralyzed, but upper body control is good. This wheelchair modification may be of use for individuals with other disabilities that impair use of the legs, such as cerebral palsy.

The wheelchair attachment is designed to support the instrument by its endpin. Thus, the cello is held in place while the musician bows and fingers the instrument.

SUMMARY OF IMPACT

The ability to play an instrument has the potential to positively impact a child's mental and physical development. Learning to play the cello helps children exercise and improve their fine and gross motor skills. The wheelchair modifications described here are designed to assist persons with limited or no use of their legs in supporting the cello for the proper playing position.

TECHNICAL DESCRIPTION

The brace is conveniently designed to quickly slide into the existing footrest mounts of the wheelchair. The cello support is easily attached to the chair, requiring minimal assistance.

The brace may be used by musicians of various heights and playing styles. Its arms telescope to varying lengths. The telescoping arms are locked in place by a pair of stainless steel quick release pins. The clearance between the sliding structural components was carefully chosen to prevent galling, as well as to

Figure 11.12. Wheelchair with Cello Support.

eliminate excessive play. The endpin can be positioned as close as 14 inches from the front wheels of the chair to a maximum distance of 26 inches.

The endpin of the cello is held in place by a lightweight, aluminum tube that is attached to the brace by a locking clamp. The clamp is fully adjustable in its position along the front strut of the brace and can be freely rotated and locked in all planes. The emphasis placed on cello positioning was a critical aspect of the final design.

The cello brace is primarily constructed of aluminum. Aluminum tubing provides for adequate strength to support the cello and is lightweight so as not to be cumbersome to the cellist. Anodization should be considered for increased durability and part life.

The total cost of materials and supplies was about $435.

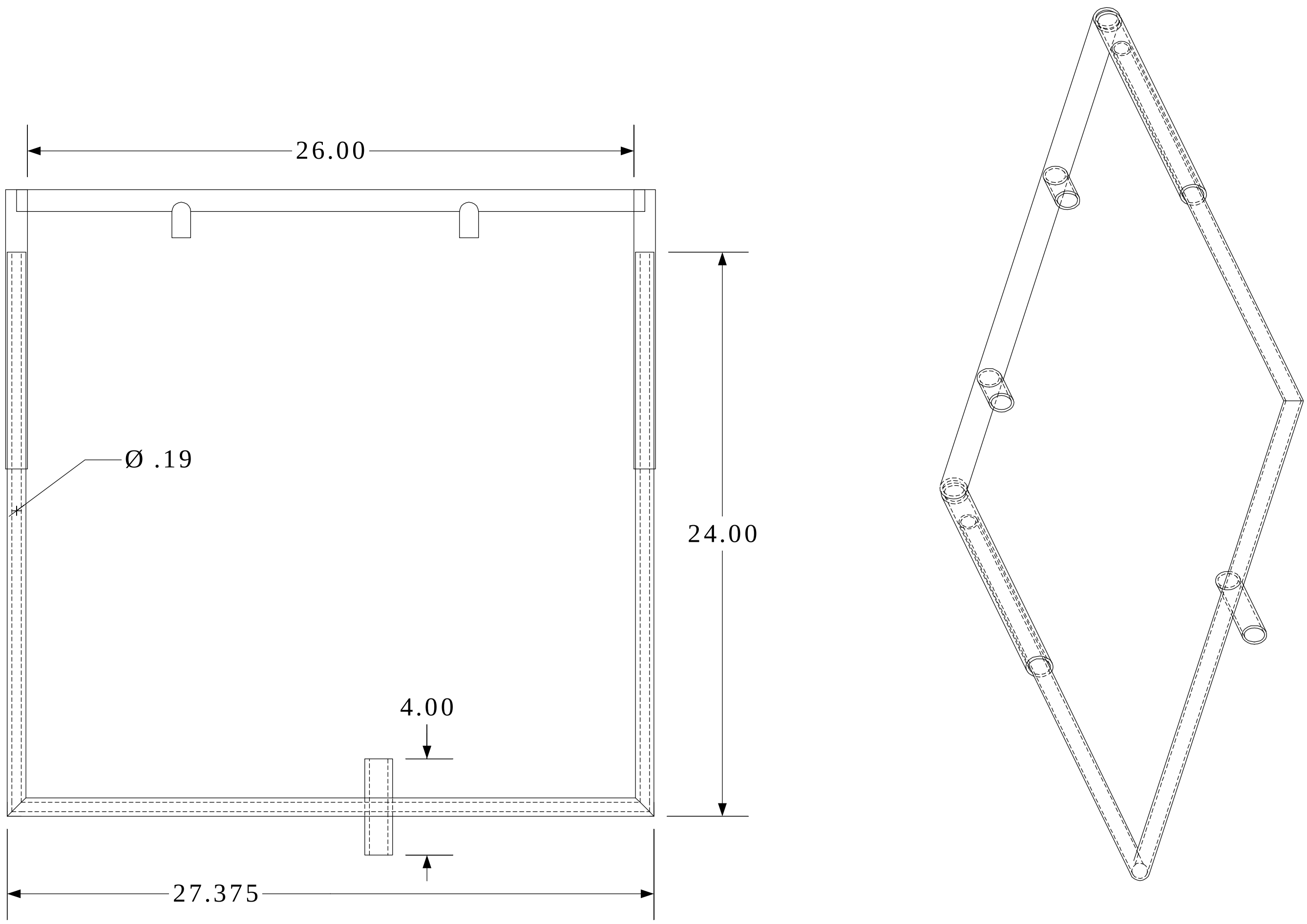

Figure 11.13. CAD Drawing of Cello Brace.

HEATED GLOVES

Student Designer: Wayne A. Willis
Client Coordinator: Chad Welles, Manzella Glove Company
Supervising Professor: Joseph C. Mollendorf, Ph.D.
Mechanical and Aerospace Engineering Department
State University of New York at Buffalo, Buffalo, NY 14260-4400

INTRODUCTION

During the colder months, the outdoor activities of people with arthritis can be hindered due to inadequate heat retention in winter gloves. Joint pain and hand cramping may occur while shoveling snow or waiting for a bus. Gloves are often not warm enough to facilitate such activities. To solve this problem, a battery-operated glove was designed to provide heat by means of electrical resistance.

SUMMARY OF IMPACT

The heated glove is warmer than conventional gloves because of the battery source and insulation used. OUTLAST? SIERRA TRF2 is a thin (1.72 mm), insulative fiber that works interactively with the wearer to maintain a comfortable temperature barrier against cold weather. It absorbs and retains excess body heat, distributing it uniformly throughout the fabric to minimize cold spots. With such a superb insulator, there is less heat lost to the environment and less power draw on the battery, resulting in longer battery life. The outer layer is made from a thin, breathable material called Thermal Stretch? . The thinness of the glove allows for better dexterity as well. Overall, it results in a warmer, yet less bulky glove that provides maximum comfort.

TECHNICAL DESCRIPTION

First, the pattern for the glove was traced onto a composite layer of material consisting of OUTLAST? insulation and Thermal Stretch? . The pattern was then cut out to form the top and bottom layers of the actual glove. Placing the outer shell material (Thermal Stretch?) back to back, the glove was then sewn. The heating element in the glove is made from Nichrome wire with a resistance of 6.750 ? /ft. Approximately three feet of wire was wrapped around small rubber tubing, which was subsequently sewn onto the back-hand layer of the insulative fiber. This portion was then covered with a thin layer of cloth to prevent contact between the heated wire and the wearer's skin.

Figure 11.13. Interior of Glove.

Once the thumb was sewn in and the and the glove turned right side out, construction was complete.

When connected to the power source, adequate heat was provided at 12-volts and 0.25 amps. Thus, a 12-volt Nicad battery pack with a 1200 mAh rating can last for about 4.8 hours of constant use. Replacing the batteries, however, could be quite costly, so it is suggested that the user purchase a battery re-charger.

The materials were provided at no cost.

Figure 11.14. Glove with Battery.

ADAPTIVE TV REMOTE CONTROLLER

Designers: Alison Callaghan and Rajah Gray
Supervising Professor: Joseph C. Mollendorf, Ph.D.
Mechanical and Aerospace Engineering Department
State University of New York at Buffalo, Buffalo, NY 14260-4400

INTRODUCTION

Ordinary off-the-shelf universal remote control devices are not designed with the needs of people who have limited use of their arms or hands in mind. An adaptive TV remote controller was designed to facilitate TV viewing for such individuals.

SUMMARY OF IMPACT

The design is intended to lessen the amount of movement needed to scroll through channels. The need to hit the switch each time a new channel is desired is eliminated by the presence of the control unit. The user can now hold down the switch while watching as the channels scroll up, and release the switch when the desired channel is reached. While the switch is held, the control unit simulates a user input of "channel-up."

TECHNICAL DESCRIPTION

Essentially, the control unit is a junction box between the user switch and the remote. Power for the control unit (4 AA batteries) is independent of the remote controller's power source (2 AAA batteries) and is located within the control unit itself. An extra power source was required because the device's own power source did not provide the necessary six volts required to power the control unit.

The Adaptive TV Remote Controller addresses a problem important to persons with limited arm or hand use.

The total cost of materials and supplies was about $120.

Roger Krupski and William Willerth provided much-valued assistance in the circuit design for the control unit.

Figure 11.15. Control Unit and TV Remote.

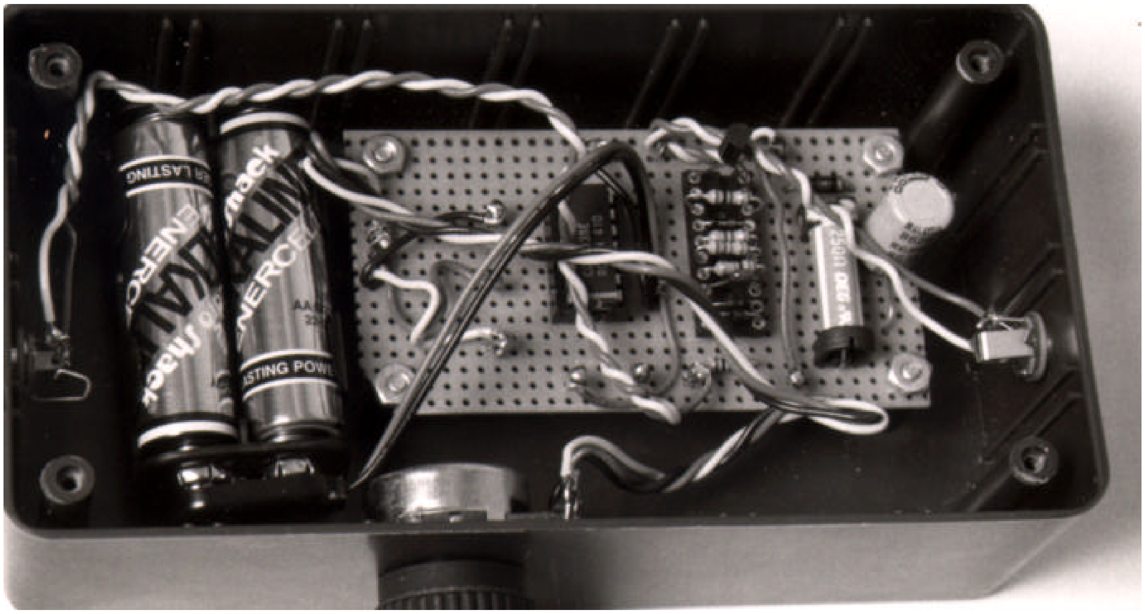

Figure 11.16. Inside View of Control Unit.

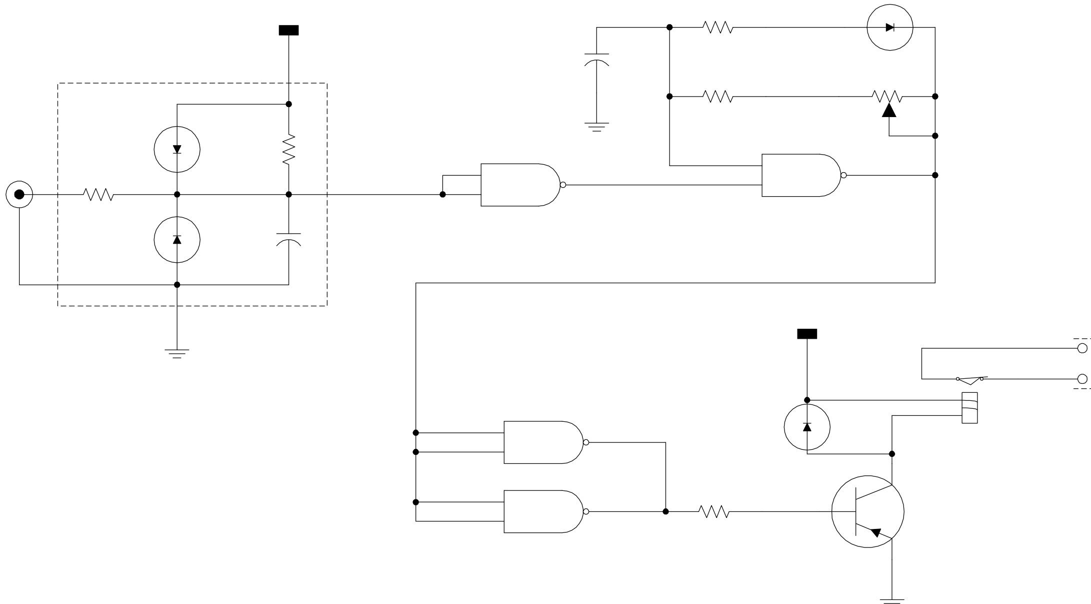

Figure 11.17. Schematic of Control Box Circuit

HYDRAULIC WHEELCHAIR SEAT TO FACILITATE TRANSFERS

Student Designers: Christopher Granelli and Keith Donaldson
Supervising Professor: Joseph C. Mollendorf, Ph.D.
Mechanical and Aerospace Engineering Department
State University of New York at Buffalo, Buffalo, NY 14260-4400

INTRODUCTION

People in wheelchairs who lack upper body strength often have difficulty transferring to and from the wheelchair. Often, they need assistance with transfers. Commercially available wheelchairs that provide aid for transfers are expensive. This design is a hydraulically operated wheelchair seat to assist a person in getting into and out of the wheelchair. Upon exiting the chair, the individual presses a switch that engages the hydraulic unit. A piston/cylinder pushes a hinged seat from underneath, which causes the seat to pivot about its front edge. The modification was kept as simple as possible for safety, ease of use, durability, and cost savings.

Figure 11.18. Seat in Normal Position.

Figure 11.19. Seat in Raised Position.

SUMMARY OF IMPACT

This modification provides an affordable alternative to personal assistance for wheelchair transfers. It can be made to mount on any ordinary wheelchair without interfering with regular activities. It is hoped that it will increase users' independence.

TECHNICAL DESCRIPTION

As in any typical wheelchair, cross-braces support the frame. These braces had to be moved forward to make space for this modification. At the rear of the frame additional support was added to help keep it rigid. At the base of our modification is a 17 by 24 by 3/8-inch aluminum plate that serves as a mounting surface for a hydraulic power unit, hydraulic cylinder, and battery.

The single-acting hydraulic power unit consists of a motor, pump, solenoid, and reservoir. See the schematic in Figure 11.20 for details. The motor is powered by a 12-volt, 720-amps continuous-use marine battery. The pump is rated at 1.6 gal / min at 2500 psi and is supplied by the internal reservoir. Oil from the reservoir travels through the pump and into the 1 ½-inch bore, 6-inch stroke piston that raises the seat. The setup can lift a maximum of 3750 lbs. Because the power unit is single acting, the weight of the user is used to cause the piston to down stroke. The solenoid acts as a release valve on the down stroke, which allows the oil to bleed back into the reservoir.

The seat was mounted with four hinges and pivots around the front edge. When the piston is at full stroke, the seat is inclined at a 35? angle from the normal seating position. This angle provides sufficient leverage to assist the user in exiting the chair.

The total cost of materials and supplies is about $510.

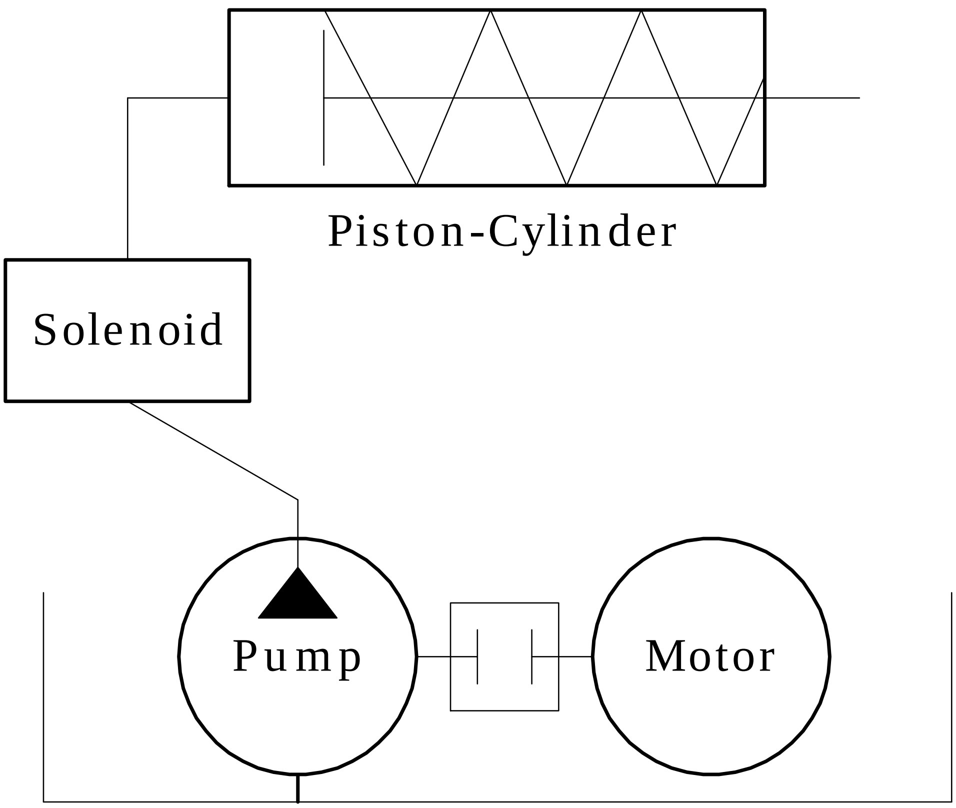

Figure 11.20. Schematic of Power Unit.

ENTRY & EXIT AID FOR AN ADULT CAR SEAT

Designers: Kristin Hatch and Joseph Segreto
Supervising Professor: Joseph C. Mollendorf, Ph.D.
Mechanical and Aerospace Engineering Department
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INTRODUCTION

Getting into and out of a car is a challenge for many individuals with limited mobility. Existing car seats tend to be small and low to the ground. Car doors tend to further limit accessibility. An assistive device designed to alleviate this issue was previously built. However, this device had significant disadvantages: it was specified for only one car; installation was difficult; and major car alterations were needed. The current design project was focused on achieving easy access to and from a car while eliminating prior disadvantages.

SUMMARY OF IMPACT

An assistive device was designed to provide easy and safe access to and from an automobile. Installation is quick and easy, and no alterations to the car are needed. The design is universal for most cars with bucket seats. It will allow more freedom, greater ease, and less frustration for persons with limited mobility.

TECHNICAL DESCRIPTION

The main components of the car seat attachment are: a base plate with U-shaped frame, two sliding rails, a mounting board, a rotating turntable, a seat, and four lockable straps. The two rails attach to the inside of the base plate, 10 inches apart from on another.

The rails are 18 inches when collapsed and 35 inches when fully extended. The mounting board attaches between the two rails. The turntable is sandwiched between the mounting board and the seat and secured to both. Two straps wrap around the attachment, perpendicular to the rails. The two remaining straps attach at the end of the U frame.

The device is designed to rest on the front passenger seat of a car, with the device's seat facing forward. The straps wrap around the car seat, fastening it to the car seat's rails. A cushion is placed under the rear of the base. This allows the device to be level on any seat to which it is fastened.

Figure 11.21. Car Seat Attachment Placed on Passenger Seat of Car.

Operation of the device is simple. To exit the car, the mounting plate and seat slides the passenger out of the car along the two rails. The seat is then turned clockwise, facing the user away from the car. Entering the car is accomplished by reversing this procedure.

This design is easy and safe to use, quick to install, and requires no car alterations. It affords increased independence for the user and reduces caregiver burden.

The total cost of materials and supplies is about $95.

Figure 11.22. Car Seat Attachment Extended Out of the Car.

THE GRAPPLING WALKING CANE: A DEVICE TO FACILITATE WALKING AND OBJECT ACQUISITION

Student Designers: Eugene Darlak and David Palen
Supervising Professor: Joseph C. Mollendorf, Ph.D.
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INTRODUCTION

Most human movements involve some stress on the back. For persons with back injuries, even simple spontaneous movements, such as those involved in leaning over to pick up an object, can lead to a pinched nerve, torn ligament, or strained muscle.

A device was designed to help people with limited mobility grasp objects at a distance without bending over. Essential crieria were that it be easy to use, aesthetically pleasing, lightweight, and easy to maintain

The grappling walking cane was an ideal base for the design because of its common use and existing market. The cane is made of aluminum and plastic, so it is lightweight. With its extension, the cane is over three feet long, eliminating the need to bend over.

Figure 11.23. Grappling Cane.

SUMMARY OF IMPACT

It is hoped that the Grappling Walking Cane will aid a substantial number of people who have limited mobility by allowing them to obtain objects that would normally be out of their reach, and that it will reduce the possibility of aggravating back injuries. The mechanical system allows for grasping and holding a large variety of objects.

Figure 11.24. Mechanical Extension Grasping an Object.

TECHNICAL DESCRIPTION

A motor turns a threaded rod, causing a claw to move down a guiding channel. The grip is based on the force of the motor jamming the outer surface of the claws into the bottom of the cane.

The electrical system (see Figure 11.24) is based upon a simple 3-volt motor that can change direction through alterations in electrical polarity.

The cane can be used for grasping a wide range of objects, particularly anything with a handle or ring around which the extension can fit.

The total cost of materials and supplies is about $86.

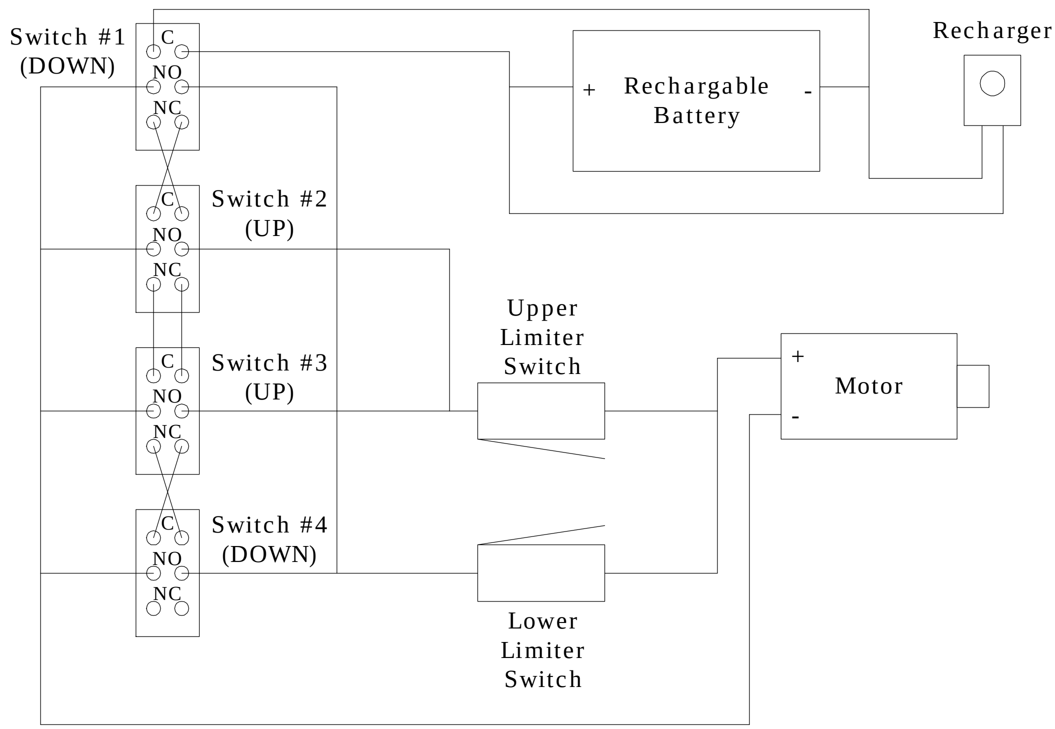

Figure 11.24. Circuit Diagram.

RELEASABLE KNEE IMMOBILIZER FOR PATIENTS WITH KNEE INJURY

Student Designer: Timothy M. McAvinney
Supervising Professor: Joseph C. Mollendorf, Ph.D.
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INTRODUCTION

An inexpensive alternative to flexible knee braces was designed to increase comfort and compliance for patients who wear immobilzers following knee injury or surgery. Immobilizers are worn for support and protection during healing of the knee joint. Often, when patients sit for long periods of time or engage in activities in which the brace is cumbersome or uncomfortable (e.g., driving a car or using a rest rooms), they remove the knee immobilizer. It may also be removed for exercise. Because of the inconvenience of repeated application and removal, patients may choose to leave the immobilizer off, contrary to physician recommendation.

Flexible braces permit locking or flexing of the knee joint. They are designed to support the knee of a walking patient. They range in price from $250 to for a non-custom brace to $1000 or more for a custom-fit carbon fiber composite unit.

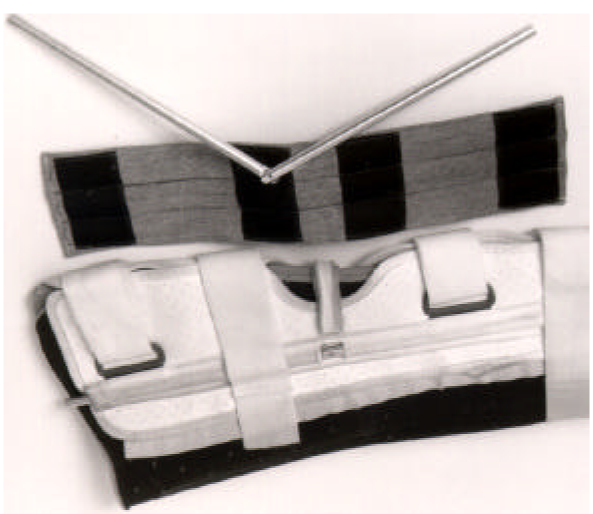

Figure 11.26. Immobilizer Components.

Figure 11.27. Immobilizer “Locked”.

SUMMARY OF IMPACT

The design of the Releasable Knee Immobilizer allows patients to “unlock” the brace for the purposes of sitting, driving, and other activities that provide sufficient support for the knee and leg, even though it is in the flexed position. Benefits include support of the joint and surrounding structures to promote healing, increased comfort, improved compliance with doctors’ instructions, ease of operation, and a cost that is approximately 10% of flexible knee braces on the market.

TECHNICAL DESCRIPTION

The Releasable Knee Immobilizer consists of four main components (Figure 11.26). The body of the immobilizer consists of a 3/8-inch thick piece of open cell foam that has a backing of a felt material with Velcro adhered to it.

Secured to this foam are 1) a nylon sleeve containing the metal bars that provide lateral support to the knee joint, and 2) two pieces of white vinyl attached to Velcro straps and buckles, which are used to wrap the immobilizer around the injured leg. One of the bars is shown outside its sleeve in Figure 11.26.

A cloth pouch contains the three metal bars that are placed behind the knee to prohibit bending of the joint. This pouch is attached to the foam with Velcro.

The immobilizer is applied by placing the sculpted area of the immobilizer even with the knee joint, wrapping the foam around the leg, and tightly securing the four Velcro straps. To unlock the brace without removing it, the cloth pouch containing the metal stays is removed from behind the knee, allowing the knee to bend.

The solid metal rods that normally provide lateral support to the knee have been replaced by rods that contain an overlapping, split-type joint. Half of a cylinder (down the long axis of the rod) has been machined off of each rod, and then the two pieces were joined with a pin. The overlapping portions prevent flexing of the rod along the axis of the pin (see Figure 11.26, bottom item). The rod can bend in the same direction as the knee, providing lateral support when the immobilizer is locked.

To return the immobilizer to its rigid form, the leg is straightened and the cloth pouch is reapplied to the foam via the Velcro strips. Some care is required in aligning the pouch with the rest of the brace to maintain proper support. This is not particularly difficult and becomes easier with practice.

Figure 11.27 shows the immobilizer in the locked position on a seated individual. Figure 11.28 shows the immobilizer in its unlocked position. The cloth pouch containing the metal stays that go behind the knee are shown in the foreground.

Figure 11.28. Immobilizer “Unlocked”.

The Releasable Knee Immobilizer successfully meets the design goals. It provides needed support for the knee, increases comfort and compliance, and offers a release system that is quicker and easier than removing the immobilizer. Additionally, is cost is attractively low.

Total cost of materials and supplies is approximately $30.

The authors thank Karen Burg for assistance in sewing, and the machine shop staff at SUNY-Buffalo for machine work.

MEAL TRANSPORTER HOT PLATE FOR MEALS ON WHEELS

Student Designers: David Messing, Sean Miller and Paul Shapiro
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INTRODUCTION

Meals on Wheels is a non-profit organization that delivers hot meals to seniors and persons with disabilities. A volunteer transports twelve hot meals in an insulated container over the course of one hour. Health codes specify that the food temperatures must be maintained at 140 degrees Fahrenheit.

The meal transporter hot plate is designed for a particular delivery container. The hot plate does not require a power source while in use and is lightweight. The energy released from the plate will compensate for the loss of heat when the container door is opened. This allows the volunteer to complete a one-hour delivery period while maintaining the required temperature at which food must be served.

SUMMARY OF IMPACT

The meal transporter hot plate will facilitate daily delivery and kitchen operations. The design promotes an increase of heat transfer capabilities. This will allow food to stay warm for longer delivery periods, allowing Meals on Wheels volunteers to reach more clients and increase the overall efficiency of their daily routines.

The original design was an electric hot plate that required frequent repairs. Now, after the initial investment, there will be a decrease in overall expenditures because the hot plate presently described does not require additional maintenance. Also, because it is lightweight, it will reduce delivery person fatigue.

TECHNICAL DESCRIPTION

One design constraint was to make the hot plate fit perfectly in the base of its transporter. The final dimensions are 13 by 17 by 1 inches. The design involves a base, a cover, and an O-ring gasket. The base consists of a thick plate with a pocketed center. An O-ring groove is cut from the perimeter of the base where gasket material is placed.

The heat storage material, PCM, ISO-T90, has a heat of fusion of 70 BTU per pound. During the phase change, 280 BTU are released. Fifty-five percent of the heat release occurs during the phase change.

The heat plate requires two hours of heat addition at 250 degrees F to reach its full potential.

The total cost of materials and supplies was about $270.

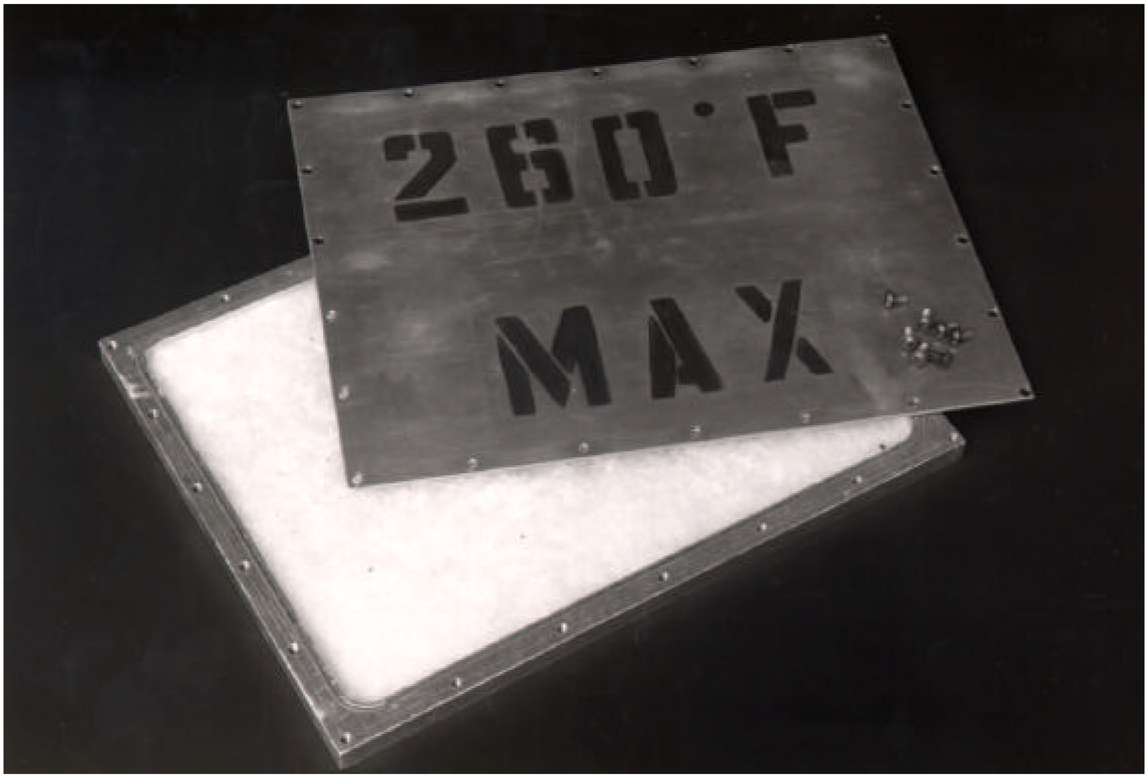

Figure 11.29. The Interior Components of the Meal Transporter Hot Plate.

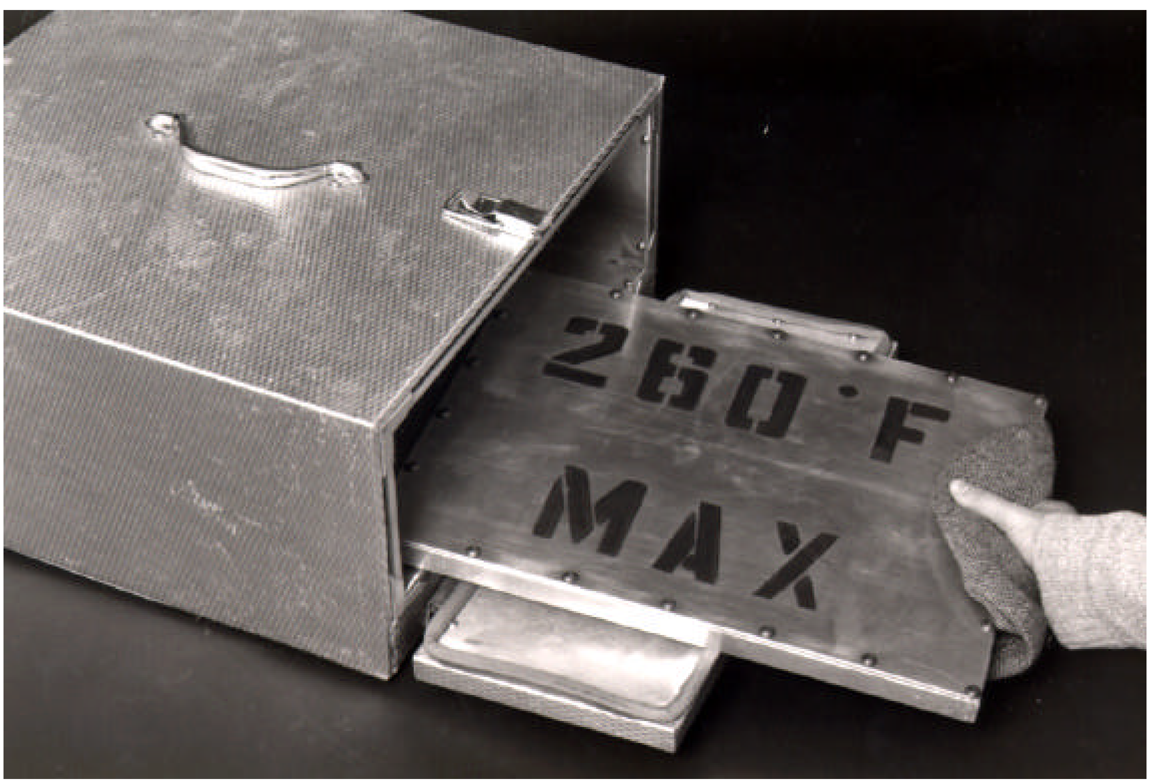

Figure 11.30. Meal Transporter Hot Plate.

AUTOMATED PAGE TURNER

Student Designers: Mark Forest, Matt Kelly, Jeff Olenjniczak and Brian Rasbach
Supervising Professor: Joseph C. Mollendorf, Ph.D.
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INTRODUCTION

A device was designed to turn the pages of a book or magazine with the simple push of a button. This device enables a person with limited use of his or her hands or arms to read without the assistance of others.

SUMMARY OF IMPACT

The main goal of this project was to create a page-turner that reliably turns a single page at a time, forward or backward. Reliability problems constitute the greatest flaw in existing page turning devices. Operation of the present device is initiated via a two-button panel, one button for turning one page forward, and the other for turning one page backward.

The entire device is contained on an inclined easel. The reading material rests on an adjustable sliding stopper attached to the easel. This accommodates different sizes of reading material and enables viewing of the book or magazine at a comfortable angle.

The page-turner is powered by a DC battery pack, making the device portable.

TECHNICAL DESCRIPTION

The automated page turner grabs and lifts a single page of reading material. A metal "finger", with adhesive at its tip, is attached to an armature that stands over the center of the book in the "ready" position. The armature consists of a series of three interacting four-bar linkages. Each linkage has a distinctive function in providing the armature with the necessary degrees of freedom to reach and / or lift each page.

The armature is driven from side to side by a high torque gear-motor, mounted at the top left of an inclined easel. When one of the operating buttons is pressed, the motor moves the main linkage to the appropriate side of the book (whether forward or backward) until the finger touches the page. The linkage then changes directions and returns to the "ready position."

The metal finger employs a second linkage to attach it to the floating link in the main linkage. This suspension linkage serves three purposes. First, it accommodates the varying thickness of different books, and of sections within the same book. Second, it suspends the finger in a vertical fashion out over the book in a plane parallel to that contained by the main linkage. Third, the armature has a built-in ratcheting linkage that automatically advances the reel of adhesive during the return stroke of every forward page advancement. This ensures that a fresh portion of adhesive is available following every forward cycle.

Another principle component is a timing belt with two pulleys, mounted within the plane of the easel. This mechanism is driven by the right pulley, which is powered by another high torque gear-motor. The pulley on the right side a simple idler pulley.

Extending several inches out from the loop created by the timing belt and two pulleys are two lightweight aluminum members. These members are located at exactly opposite positions on the belt, and constitute the final component the page encounters before coming to rest in its new position. After the armature lifts the page, the belt mechanism advances the page by sweeping the aluminum members in the appropriate direction. For forward movement, the members sweep left to right and for backward movement, the members sweep right to left. These members then come to rest after the belt completes exactly one half revolution. This forces the members to exchange their original resting positions. The belt mechanism is then ready for another cycle in either direction.

This device is equipped with a mounting system to accommodate various sizes of reading material. The book or magazine to be read is placed on a vertically adjustable sliding rail. The book and the rail together slide vertically until the book meets a positive stop at the top of the easel. The rail is then tightened down using two knobs, which hold the reading material in position for the adhesive armature to operate correctly.

The prototype shown in these photographs is a electro-mechanically driven proof-of-concept design. Everything that needs to occur mechanically is complete and occurs without human intervention. However, the electrically coordinated timing of this device is incomplete. At this point, the device cannot operate without human intervention to manage the timing of the two main devices it employs. Ideally, a microprocessor will coordinate the correct interaction of the working mechanisms.

The total cost of materials and supplies is approximately $280.

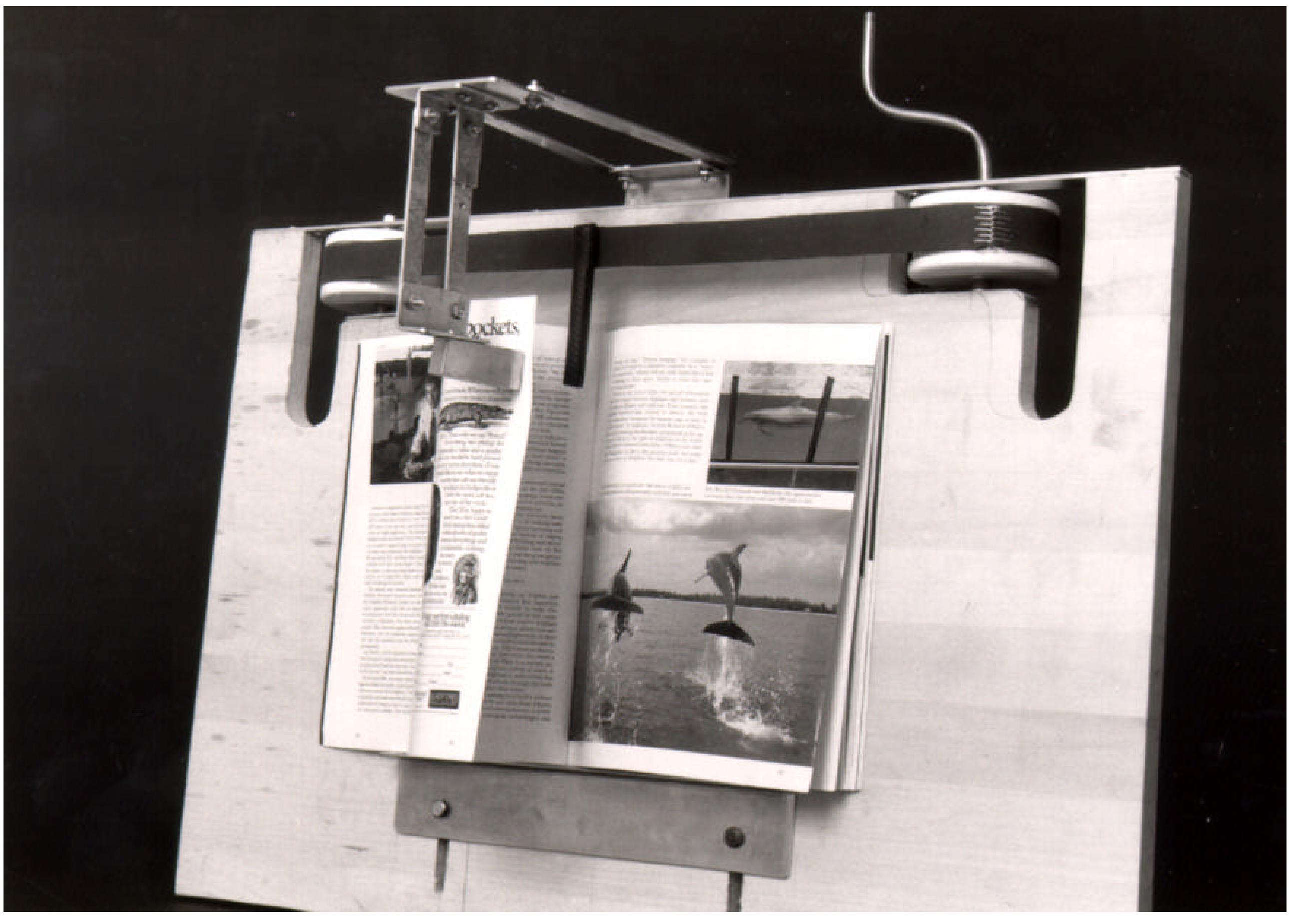

Figure 11.31. Page Turner Prototype.

AUTOMATED DOLL HOUSE

Student Designer: David Johnston and Mark W. O'Connor
Supervising Professor: Joseph C. Mollendorf, Ph.D.
Mechanical and Aerospace Engineering Department
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INTRODUCTION

An automated dollhouse was designed and built for a five-year-old child born with arms that end at the elbow. She is unable to play with most available toys. The device was designed with a spring-loaded rocker switch. When the switch is pushed, music is played and the doll begins to march in place inside the dollhouse. Manipulation of the doll is achieved through a system of strings connected to a motor. This allows the child to play with a doll.

SUMMARY OF IMPACT

The automated dollhouse was intended to help improve the client's motor skills, to keep her amused, and to facilitate her learning of cause-and-effect relationships. In order to accomplish these goals, it was important that the toy be entertaining. Music accompanies the motion of the doll to maintain her attention.

TECHNICAL DESCRIPTION

The control unit is a simple spring-loaded switch that controls a motor. The motor is powered by a 12-volt battery and is geared down to 32 rpm. As the motor rotates clockwise, a bar on the motor shaft flips a switch that changes the polarity and causes the motor to reverse direction. After about 60 degrees of rotation, the bar on the shaft flips the switch back, returning the shaft rotation to a clockwise direction. This causes an oscillatory effect on the shaft.

A circular plate is attached to the end of the shaft. Strings are attached to each end of the circle. The strings, in turn, are attached to the arms and legs of the doll. The strings are aligned such that when the left arm and right leg rise, the opposite arm and leg fall.

The doll is secured in a harness made of an L bracket and two screws. The L bracket is fastened to the dollhouse floor with two plates and four wing nuts. The batteries, motor assembly with doll, and control panel can be removed from the dollhouse. This allows the dollhouse to fold up for easy storage.

Music from a *Fisher Price* toy was added. The control button was tied into the *Fisher Price* toy so when the button is pushed one of three melodies is played. There are three additional buttons on the toy that light up and play a preprogrammed tune when pushed.

The total cost of materials and supplies was about $92.

Figure 11.32. Doll Inside Doll House.

A SELF-SHIFTING SEAT CUSHION TO PREVENT BED SORES

Student Designers: David J. Halady, Richard A. Walpole and Daniel P. Wiegand
Supervising Professor: Joseph C. Mollendorf, Ph.D.
Mechanical and Aerospace Engineering Department
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INTRODUCTION

The medical industry spends approximately 7 billion dollars a year on the treatment and prevention of decubitus ulcers (bed sores). A bedsore may form when a critical pressure is incident on the skin for an extended period of time. Such is the case of immobile persons who are wheelchair and bed bound. One solution is to develop a seat cushion that shifts the immobile person in a pattern similar to that of a mobile person. The seat cushion detects areas where bedsores are likely to form and shifts these high-pressure zones around. It is important to note that the wheelchair cushion is only one application of such a product. Now that proof-of-concept is complete, a cushion the size of a bed mattress could easily be made using the same technique.

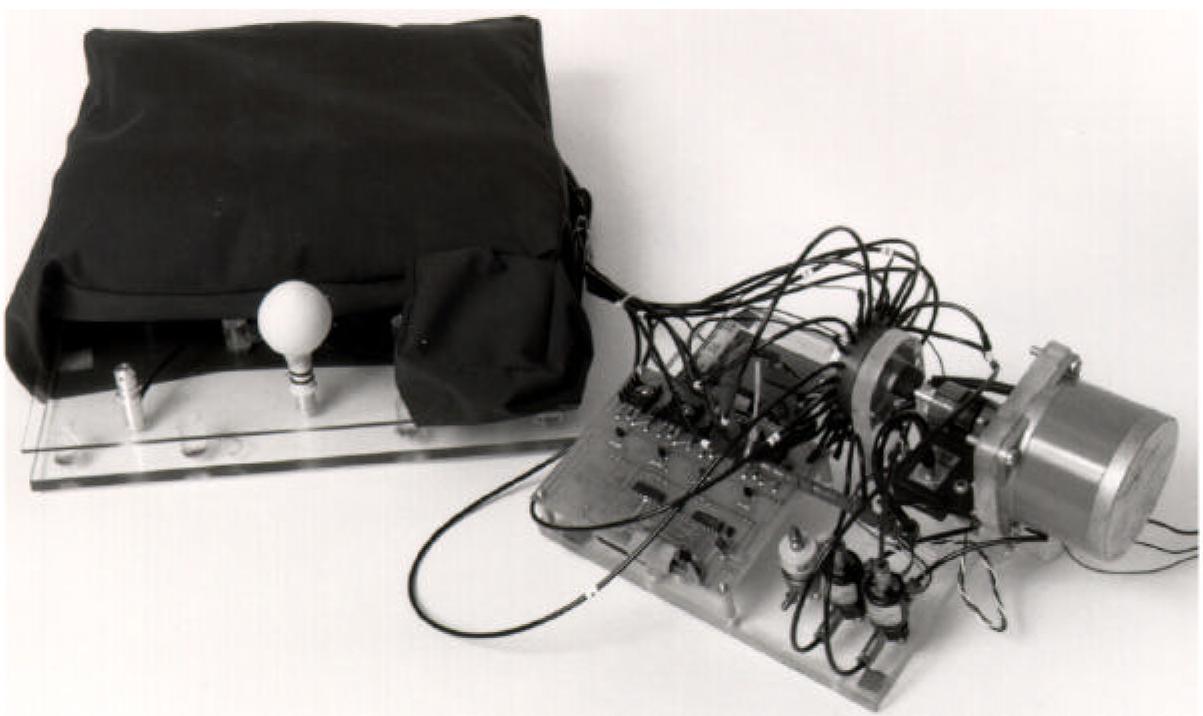

Figure 11.33. Self-Shifting Seat Cushion Prototype.

SUMMARY OF IMPACT

The Self-Shifting Seat Cushion has potential to be implemented in many hospitals and other health care institutions, alleviating physical pain and reducing medical costs.

TECHNICAL DESCRIPTION

This cushion seeks out high-pressure areas and distributes the pressure to other areas. This process is done repeatedly to stop tissue breakdown.

The seat cushion is in the shape of a square consisting of nine (three by three) airtight cells, each of which is connected to a pneumatic wafer valve with small diameter tubing.

Upon powering up the system, the seat cushion begins to fill with air. Once all the cells are filled, the patient sits on the cushion. The next step is to sample and vary the pressures. If the pressure in a cell is too high, as determined by set points within an EVBU, air is exhausted. With the pressure reduced, the surrounding cells will have to make up the difference in the loss of support in that region. Hence, the high-pressure areas will be shifted to a new area for a short time. In this manner, no single area will have too high a pressure for an extended period of time.

The total cost of materials and supplies is about $550.

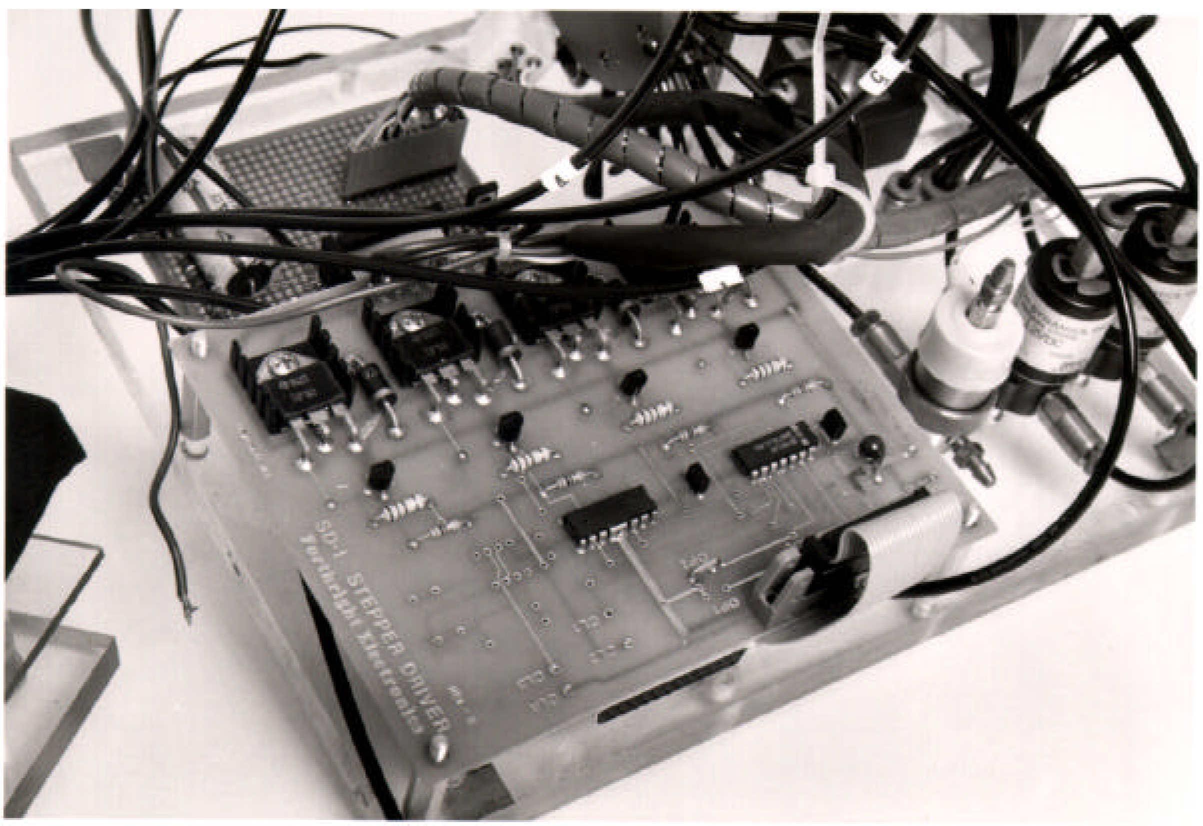

Figure 11.34. Control Board for Self-Shifting Seat Cushion.

HEIGHT ADJUSTABLE WHEELCHAIR TO FACILITATE HORIZONTAL TRANSFERS

Student Designers: Clifford J. Solowiej, Jeremy Francis and Jon Bechtel
Supervising Professor: Joseph C. Mollendorf, Ph.D.
Mechanical and Aerospace Engineering Department
State University of New York at Buffalo, Buffalo, NY 14260-4400

INTRODUCTION

This project addresses a serious problem faced by caregivers who assist in the horizontal transfer of the patients in wheelchairs: back injuries due to incorrect lifting methods. This device may also alleviate patients' mobility problems associated with height constraints.

Figure 11.35. Full View of Wheelchair.

SUMMARY OF IMPACT

There are no known devices that perform the same functions as the Height Adjustable Wheelchair. The mechanism is designed to help reduce physical strains on caregivers. Since the operation of the device involves simply pushing a button, individuals with adequate use of their hands can use this device to transport themselves and increase independence in such environments as the bathroom and / or kitchen.

TECHNICAL DESCRIPTION

The mechanism is composed of two main assemblies: a stationary platform and a chair. The platform is constructed of a rectangular sheet of aluminum, providing a stable housing for the hydraulic system and the wheels. The chair is made of aluminum tubing with four, single-acting, hydraulic cylinders (9" stroke) fitted to each corner. The ends of the piston rods are fastened to the mounts that are bolted to the platform.

The hydraulic circuit is rather simple. For the chair to move in the upward direction, output from the HPU is channeled into a flow divider. From this, four output lines receive equal volumetric flow rates of fluid that are sent directly to each cylinder. This provides a stable and level movement of the chair as the cylinders are actuated. Chair movement in the downward direction is achieved by energizing a solenoid relief valve on the HPU. This allows the internal springs in the cylinders to push the fluid back through the lines and flow divider to the hydraulic reservoir.

The wheelchair is fitted with three brakes, one on each front wheel and the third on the left rear wheel. When the chair is in its full vertical position, sufficient torque can develop on the wheels causing a tendency for the chair to move. The brakes ensure that the chair will stay in place during the operation of transporting an individual from the chair to a bed.

The total cost of materials and supplies was about $1,400.

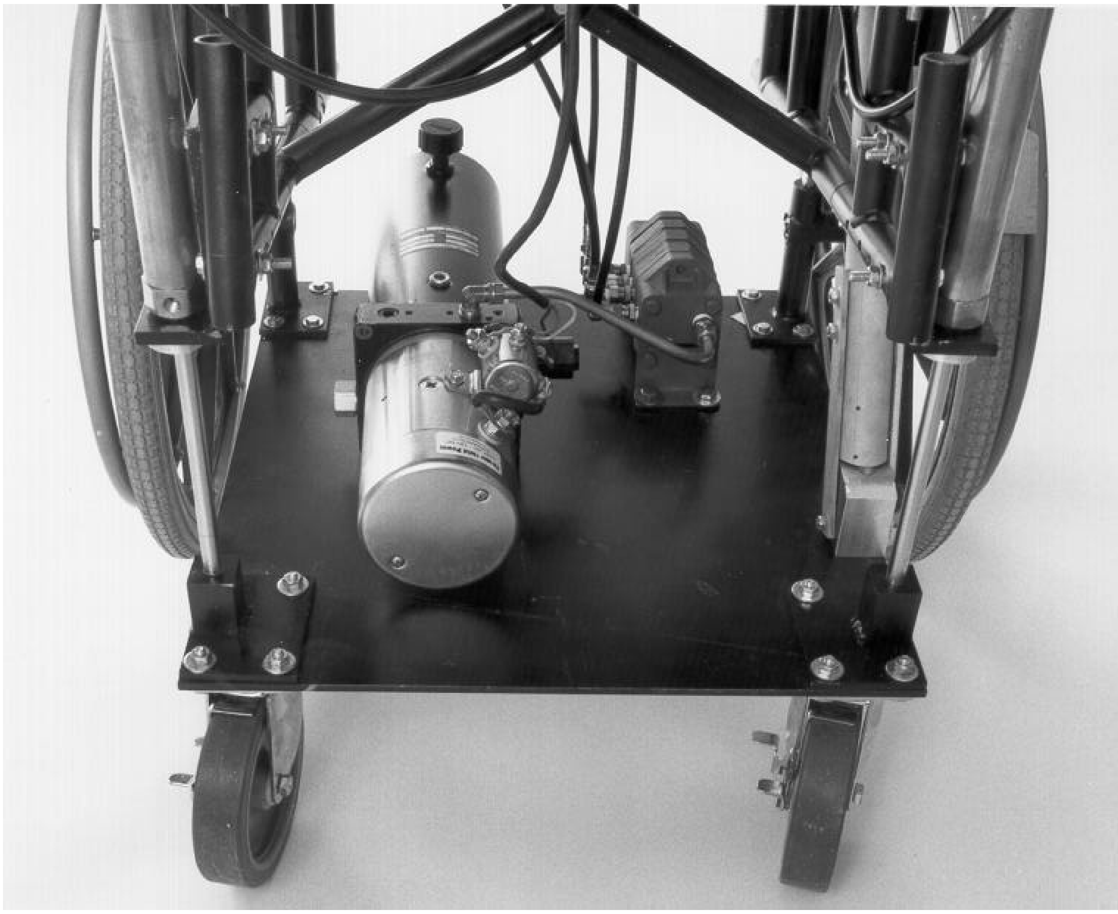

Figure 11.36. Close-up of Hydraulic System for the Adjustable Height Wheelchair.

ELECTRIC FINGER TO TURN ON THE STENTIEN SYSTEM

Student Designer: Chung Park
Supervising Professor: Joseph C. Mollendorf, Ph.D.
Mechanical and Aerospace Engineering Department
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INTRODUCTION

A device was designed to press the power switch on a Macintosh computer's keyboard once the user turns on the main power of the Stentien System, a system that enables a person with a disability to use the programs in the computer. It connects and disconnects the AC power to the power strip via an infrared signal controller. The computer and other equipment, such as printer and monitor, are plugged into the power strip. However, the system is neither programmed nor equipped to turn on the power switch. Therefore, someone else has to press the power switch for the user. Hence, there was a need for a device that presses the Macintosh power switch when the user turns on the Stentien System.

SUMMARY OF IMPACT

This Electric Finger has three components: an AC-DC converter, the clamping device and the switch-pressing device. The AC-DC converter is plugged into the power strip of the Stentien System. The clamping device with the switch-pressing device is attached on the far right side of the keyboard. The switch-pressing device is placed such that the rod from the motor shaft lines up with the power switch. The power line from the AC-DC converter is plugged into the socket on the back of the Electric Finger.

When the user turns the Stentien System on, the AC power is sent to all the computer components, including the electric finger. After a small time delay, the motor turns for one second

In case of failure on the first trial, which does not happen under normal conditions, the device can be tried again after five to 10 minutes, allowing the capacitors to discharge. If an able-bodied person is available, the discharging can be done in an instant by pressing the two switches on the back of the box.

Figure 11.37. Electric Finger Mounted on Keyboard.

TECHNICAL DESCRIPTION

This Electric Finger has two major components: the mechanical parts (switch-pressing arm and clamping device) and the electric circuit that controls the electric operating device. The required force to press the power switch on the Macintosh keyboard is about 0.6 Newtons. The difference in height when the key is pressed and released is 4 mm. A clamping device holds the entire assembly on the keyboard and must keep the package stable while it is in motion. Since it pushes the power switch key against its own holding force, the motion creates a reacting force on the clamp.

The circuit in the Electric Finger consists of two input sources and two power lines for the circuit and the motor. The basic concept for the circuit is derived from the Schmitt trigger design. Since the trigger executes a certain amount of exponential voltage increase into a step response, the triggering tie can be set by adjusting the time of the exponential increase of the voltage.

The cost of materials and supplies is about $150.

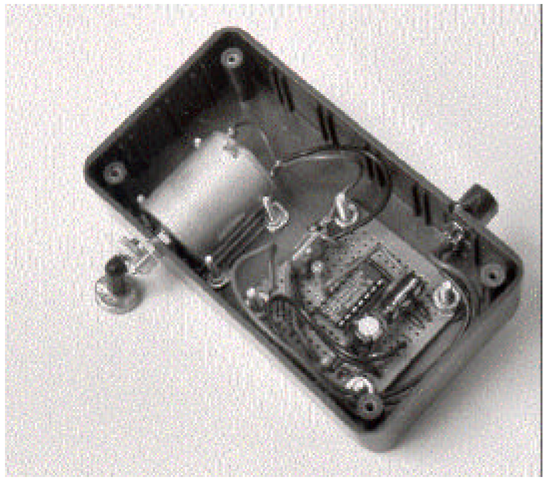

Figure 11.38. Electric Finger Motor and Circuit Board.

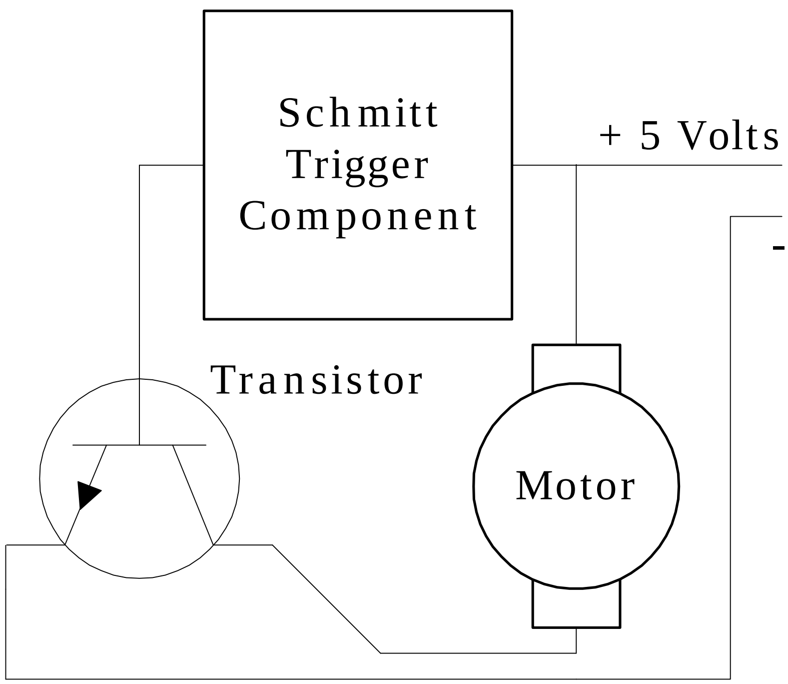

Figure 11.39. Simplified Circuit for the Electric Finger.

HAND SPORT SUPPORT

Designer: Mark Hepworth
Supervising Professor: Joseph C. Mollendorf, Ph.D.
Mechanical and Aerospace Engineering Department
State University of New York at Buffalo, Buffalo, NY 14260-4400

INTRODUCTION

People with hand problems, such as arthritis, sensitive joints or muscles, or poor hand function, may find it painful or difficult to play sports that require hand strength and movement. The Hand Sport Support is an exoskeletal device that augments strength during sports activity. The device is attached to the forearm and palm area of the user. Hand-held sporting equipment, such as a tennis racquet, baseball bat, golf club, can be attached to the device, shown in Figure 11.40. When the user strikes a ball, the force from the equipment is directed away from the hand and translated to the forearm.

SUMMARY OF IMPACT

The Hand Sport Support was developed to assist individuals who have problems participating in sports due to a hand disability. The device is designed to direct impact forces from the equipment away from the hand to the forearm. Other devices in the marketplace merely support or act as a “Band-Aid” to the hand. The Hand Sport Support moves with the hand and simulates the wrist movement of the user. Other supports and devices in the marketplace restrict movement and become a hindrance. This device is adjustable so that users can change the strap length to the desired fit, as shown in Figure 11.41.

TECHNICAL DESCRIPTION

The part of the device that supports sporting equipment with varying handle widths is made from aluminum tubing four inches long with a 1.5-inch diameter. A finger screw is used to fix the equipment handle in place inside the tube. The tube is attached to a Teflon disk that is two inches in diameter and geared so that a pin can be placed in the teeth to stop rotation. A Teflon disk rotates on a Plexiglas forearm attachment that was constructed to the shape of a plaster mold of the forearm. The forearm attachment contains a fixed aluminum pin that pivots into and away from the gear. The forearm attachment has a Teflon support that runs the length of the Plexiglas, limiting part flexing. Closed cell foam is placed on the underside of the device, between the palm side of the forearm and the forearm attachment for dampening.

The total cost of materials and supplies is about $25.

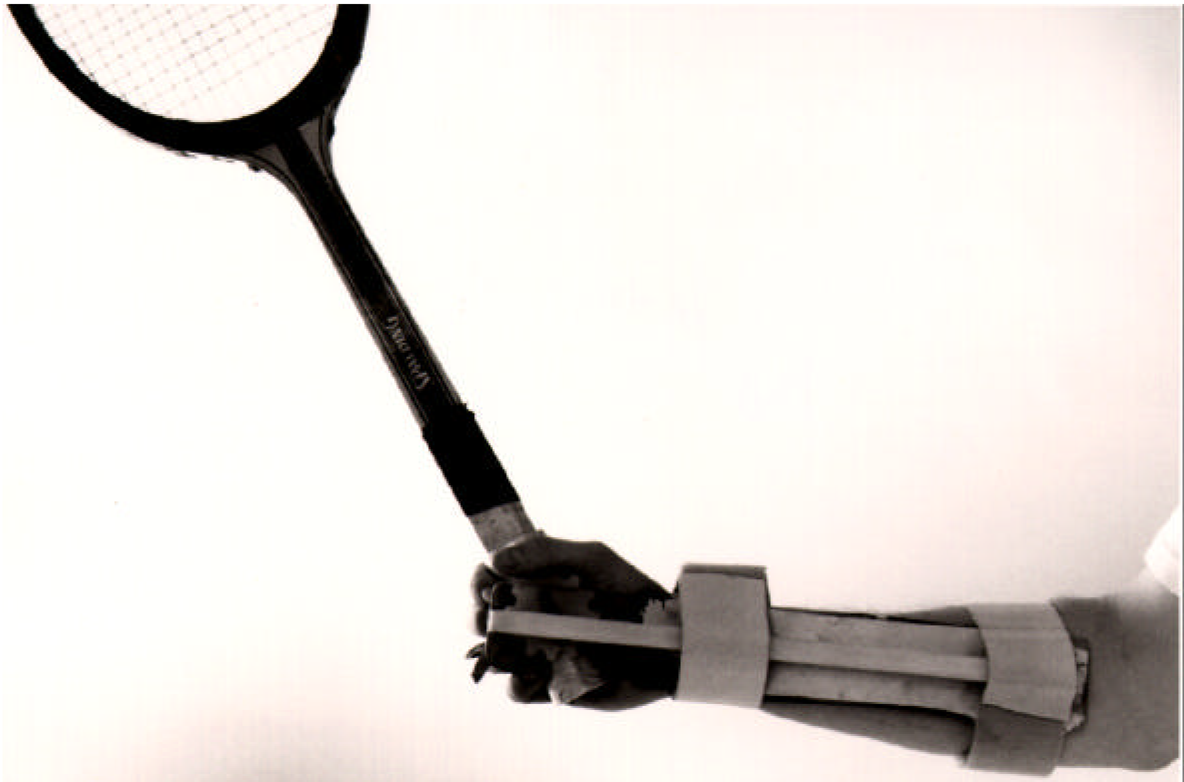

Figure 11.40. Hand Support with Tennis Racquet.

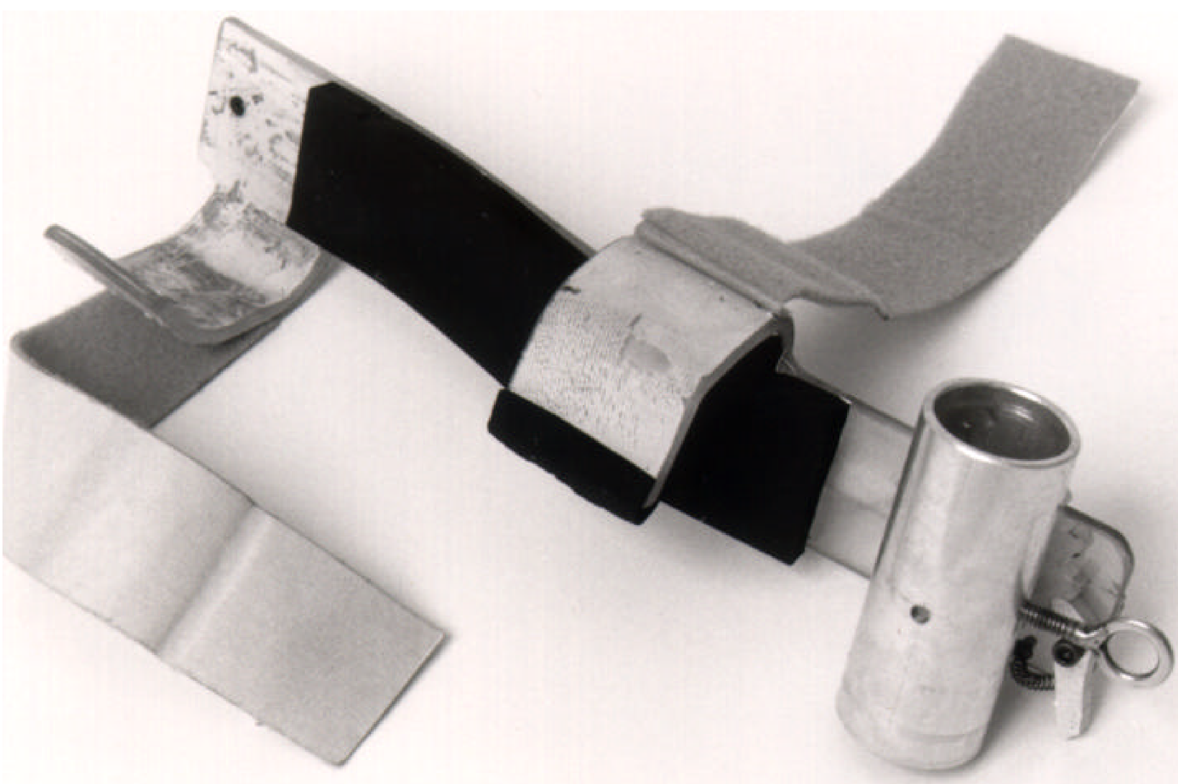

Figure 11.41. Hand Support Unit.

Chapter 12
TEXAS A&M UNIVERSITY

College of Engineering
Bioengineering Program
College Station, TX 77843

Principal Investigator:

William A. Hyman (409) 845-5532
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AN AUTOMATED SIDE-BY-SIDE REFRIGERATOR DOOR OPENER

Designers: Katie Allen and Christopher Howard
Client Coordinator: Cheryl Linn
United Cerebral Palsy of Greater Houston
Supervising Professor: W.A. Hyman
Biomedical Engineering Program
Texas A&M University
College Station, Texas 77843

INTRODUCTION

An automated side-by-side refrigerator door opener was made for the adult program at the United Cerebral Palsy Center of Greater Houston. A single linear actuator simultaneously opens both doors (Figure 12.1). A flat arm, attached to the linear actuator, holds two swivel arms that are each fixed to a single door. The entire system is operated by a switch that opens the doors when pushed up and closes the doors when pushed down. The switch was designed to accommodate most adult patients.

SUMMARY OF IMPACT

It is difficult for individuals in wheelchairs to open refrigerators. In the current project, a switch is positioned so that the wheelchair is not in the path of the opening door. The doors swing open wide enough to allow a wheelchair to pass. In the future, the switch may be changed to a mat or portable pushbutton.

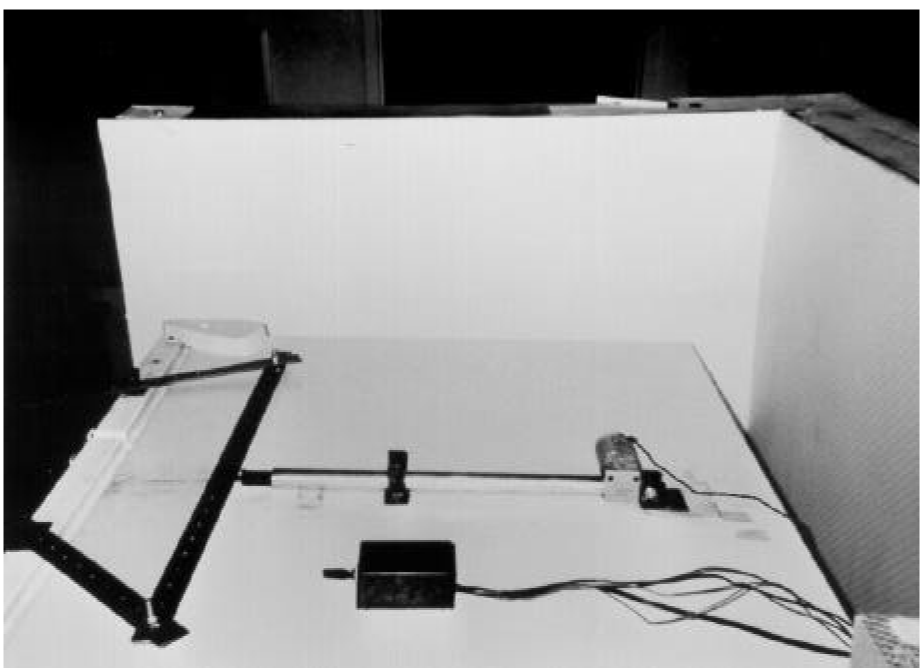


Figure 12.1. Automated Refrigerator Door Opener.

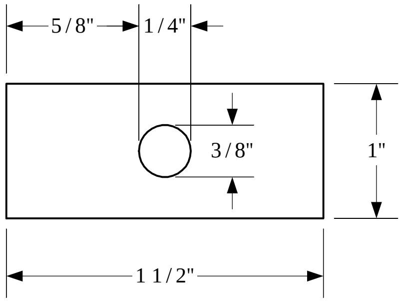


Figure 12.2. Peg and Plate Mounting.

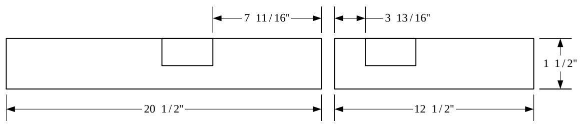


Figure 12.3. Plate Positioning on Refrigerator Door.

TECHNICAL DESCRIPTION

The door opener consists of four parts: 1) the arms, 2) the bar, 3) the linear actuator, and 4) the switch. Glued to each refrigerator door is a 2” x 1” steel plate mounted with a ¼” threaded steel peg (Figure 12.2). The doors are 12.5” and 20.5”. Peg 2 is positioned 3 13/16” from the inside edge of the door and peg 1 is positioned 7 11/16” from the inside edge of the door (Figure 12.3). Both are flush with the front of the door. Steel epoxy glue is used throughout.

Two 1” wide steel arms with pre-drilled 1/4“ diameter holes connect the linear actuator to the doors and force the doors open when the actuator moves outward. The arms vary in length due to the different door widths. Arm 1 is 9” and is attached to the longer door with peg 1. Arm 2 is 7” and is attached to the shorter door with peg 2. The pegs and arms are placed to allow for maximal door opening.

The bar is cut from the same 1” steel as the two arm pieces. It is 15” in length and attaches to the actuator with a ¼” screw that is 7/8” long located in the middle of the bar. Arm 1 is positioned 1” from the outside edge of the bar and arm 2 is positioned 2” from the opposite edge. Both arms are held in place by a loosely tightened ¼” nut and bolt. This allows the arms to have unrestricted movement during the opening and closing of the doors.

The linear actuator is a model Motion 85615/85616 Ball Drive Actuator, manufactured by Motion Systems Corporation (Figure 12.4). It has a dynamic operating load of 100 pounds and a static operating load of 600 pounds. The stroke length of the actuator is 12“ and a 12 VIC Permanent Magnet Brush DC Motor powers it. An AC adapter from Radio Shack provides conventional power to the actuator.

The actuator is positioned by a ¼” screw into a 2” x 3.75” steel plate mounted with screw holders. The screw holders are two 1” square steel plates, ¼” thick, welded upright onto the bottom plate (Figure 12.5). Each screw holder has a ¼” hole drilled through the middle of the 1” plate. The plate with screw holders is positioned on the refrigerator 4” from the back and 17” from the right side.

To prevent the actuator rod and casing from moving back and forth, a steel guide is placed 11.5” from the front of the refrigerator (not including the doors) and 17” from the right side. The guide is composed of a bottom plate made of ¼” steel measuring 2” x 1” and two upright restraining guides made of 1/8” steel measuring 0.5” x 2”. The restraining guides are welded to the bottom plate 1 3/16” apart. The guide is glued onto the top of the refrigerator, approximately in the middle of the rod casing.

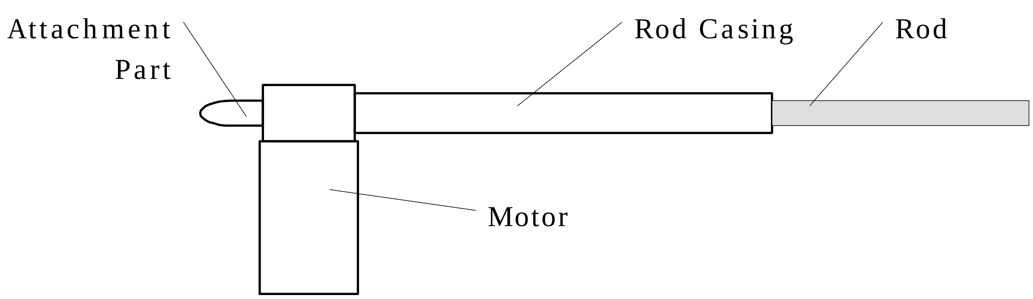


Figure 12.4. Linear Actuator.

The switch has three basic positions: up, down, and middle. The up position moves the actuator outwards, the down position moves the actuator to its original position, and the middle position turns the actuator off. To increase the size of the switch, a Styrofoam box was placed over the original device. This allows the switch to be moved by either a hand or fist, lessening the amount of coordination and dexterity required. The box is 4.25” long, 8” wide, and 2” high, a sufficient size for the user population. The switch is attached to the side of the refrigerator by a magnet, allowing it to be moved when not in use. The doors can be operated conventionally at all times.

A sketch of the unit is shown in Figure 12.6.

Expenses were as follows:

Linear actuator	Donated by Motion Systems
AC adapter	$22
Steel	$80
Misc. supplies	$50
Fabrication	$50

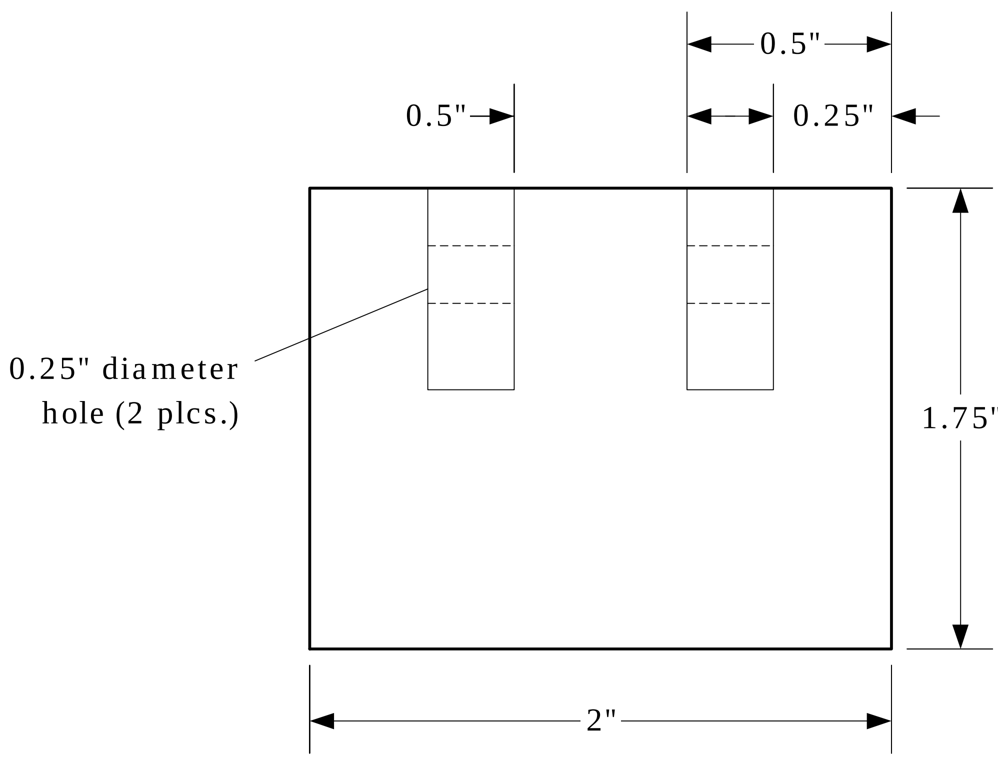


Figure 12.5. Attachment Plate.

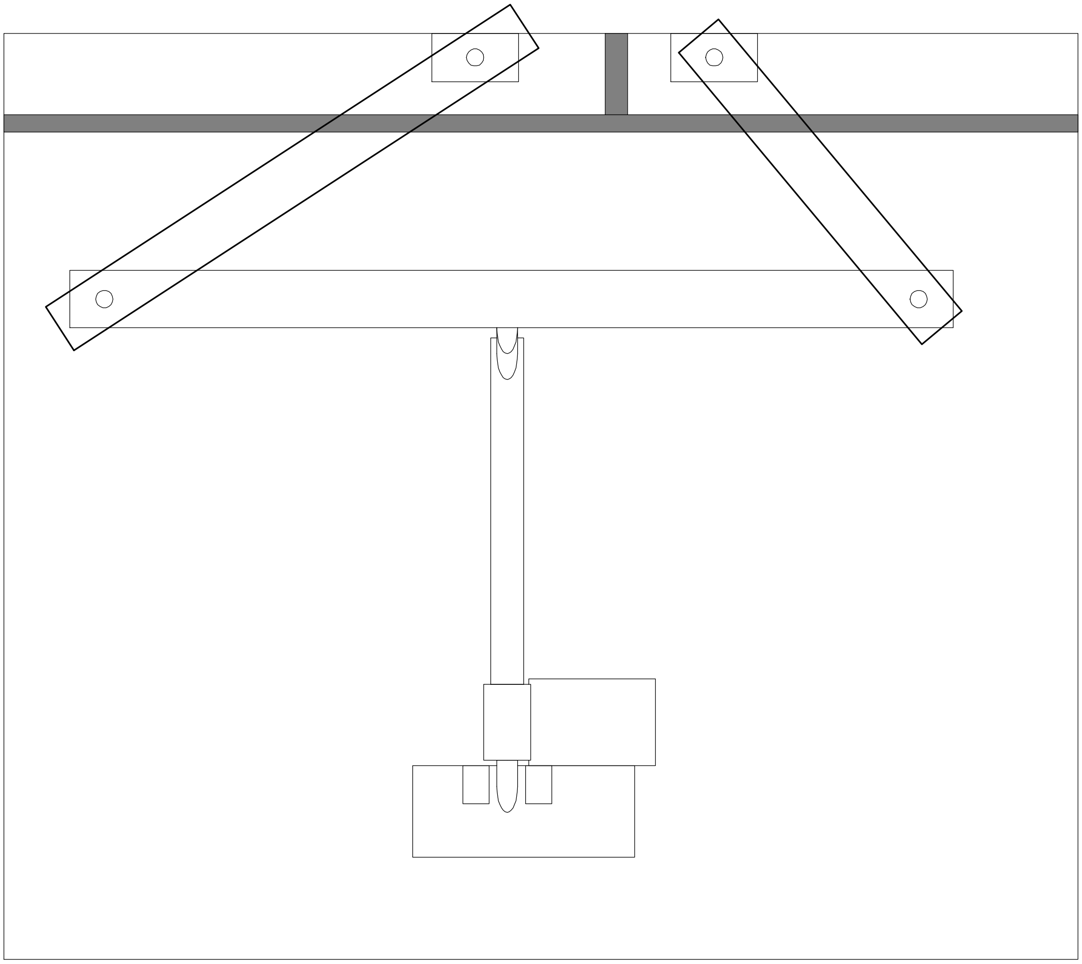


Figure 12.6. Schematic Drawing of the Refrigerator Door Adaptation.

PORTABLE PARALLEL BARS FOR CHILDREN WITH WALKING DIFFICULTIES

Designers: Gretchen Meyer and Emily Stephenson
Client Coordinator: United Cerebral Palsy Institute of Greater Houston
Supervising Professor: WAY. Hyman
Biomedical Engineering Program
Texas A&M University
College Station, Texas 77844

INTRODUCTION

Portable parallel bars for children with walking difficulties (Figure 12.7) were designed to be easily transported by a therapist for in-home patient care. They may also be installed permanently. The bars consist of two PVC pipe railings seated in galvanized steel pipe flanges. All parts are available in any large home center and the system can be easily and inexpensively constructed.

SUMMARY OF IMPACT

Due to the restructuring of the Cerebral Palsy Institute into smaller home health care satellites, existing parallel walking bars do not meet the needs of many clinicians because they are not easily transported and because they are expensive, heavy, and consist of many parts. This design is lightweight and compact. The bars are small enough to be stored the trunk of a car, and require a minimal amount of space when assembled.

Figure 12.7. Portable Parallel Bars.

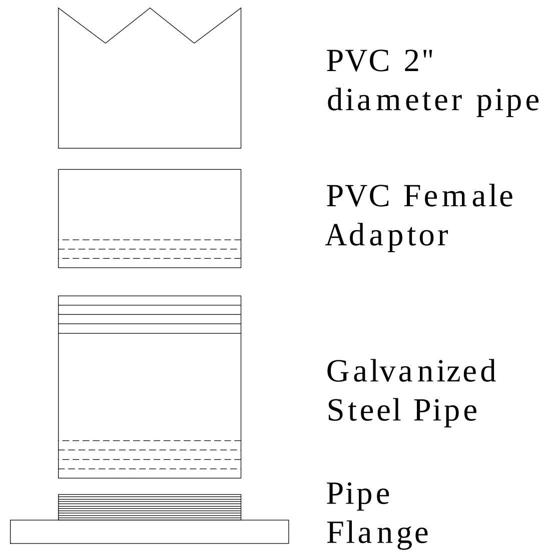


Figure 12.8. Base Construction.

TECHNICAL DESCRIPTION

The main design requirements of the portable parallel bars were that they be: 1) suitable for small children, 2) easily transportable (lightweight, involving few parts, quickly assembled), 3) sturdy, 4) and safe.

The railing supports are built with four 2" diameter galvanized steel pipe flanges attached to two 8" x 32" pieces of fabric covered plywood. The plywood bases are both covered with a 14" x 38" piece of fabric and padded with a 10" x 34" piece of cotton matting. The fabric and matting are attached with a staple gun. Two pipe flanges are placed on a plywood base 20" apart and attached by four 1/4" x 1" lag screws.

Connected to each pipe flange is a 4" piece of 2" diameter threaded galvanized steel pipe. The steel pipe is then attached to a 2" diameter PVC pipe female adapter (Figure 12.8). The adapter enables the PVC pipe legs to be firmly seated in the base.

Each vertical support is constructed from 2" diameter PVC pipe, 19" in length. A U-shaped cut, approximately 1.5" deep, is removed from each support using a jigsaw and a 1/4" diameter hole is drilled 0.75" from the top of the leg (Figure 12.9). The supports are permanently attached to the female adapter using PVC pipe adhesive or epoxy. The total base/leg component is two feet tall, a height appropriate for pediatric patients.

The two horizontal railings each consist of a 5' piece of 1 1/2" diameter PVC pipe with a 1 1/2" diameter PVC rounded cap. The caps protect the user from the unfinished ends of the railings. After assembly, a 1/4" diameter hole is drilled 6" from the end of each rail. The PVC pipe is painted after sanding and applying one coat of primer.

The parallel bars are assembled by placing the two bases 4' apart, measuring from the legs. The rails are placed in the legs and secured with a hex cap screw and wing nut, with the wing nut facing the outside.

The approximate cost of the parallel bars is $75.00.

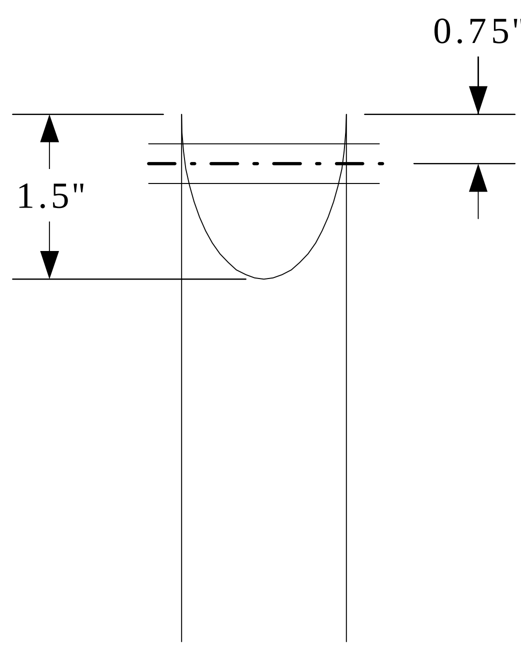


Figure 12.9. Pipe Cut-Out Detail.

PORTABLE PARALLEL BARS WITH A TEXTURED WALKWAY

Designers: Lisa Foster and Lisa Magliolo
Client Coordinator: Gretta Cherry
United Cerebral Palsy of Greater Houston
Supervising Professor: W. A. Hyman
Biomedical Engineering Program
Texas A&M University
College Station, Texas 77844

INTRODUCTION

A set of parallel bars with a textured walkway was built for children with cerebral palsy. The design consists of a platform with three different textures, a ramp, a step, and parallel bars (Figure 12.10). The base is rectangular and has two supports to provide stability. The platform is accessible by a ramp on one end and a step on the other. The ramp and step fold for easy storage. The parallel bars are removable and the unit transportable.

SUMMARY OF IMPACT

The textured walkway is designed to create different sensations as children walk, so that they may learn to alter their steps accordingly, while fostering improvements in balance and coordination.

TECHNICAL DESCRIPTION

The main design requirements of the textured walkway were that it: 1) have at least three different textures; 2) be portable; 3) have a ramp and a stair; and 4) have parallel bars for safety and balance.

The textured walkway has three main components: the platform, the ramp, and the step. The platform is created with 1/2" plywood measuring 45" x 22" supported by two 2" x 4" boards, which span the length of the plywood. The 2" x 4" supports are attached 2 3/4" from each edge by four 2" zinc corner braces (two on each side). Eight screws are countersunk along each support for torsional support. The supports raise the finished platform to a height of 4 ½". All edges are covered with white vinyl.

Layers of cardboard inserts beneath the different walking textures are added to level the surface of the textured walkway. 1/8" hobby plywood covers the cardboard to assure that the foundation is hard and flat. The three textures include a 16" x 22" piece of gray carpet attached to the base with 5/8" brads, a 14 ½" x 22" piece of blue foam attached with glue, and a 14 ½" x 22" piece of black and white tile attached with self-adhesive backing.

The ramp is ½" painted plywood measuring 20" x 13 ½". The step consists of four pieces of wood, two 3" x 0.5" x 1.5" legs, one 13" x 0.5" x 2.5" step platform, and one 13"x 0.5" x 2.5" attachment board. The ramp and step are attached to opposite ends of the platform with four 3" x 3" hinges. Anti-slip traction tape is applied to both the ramp and step.

Four 1 1/4" holes are drilled 2" from each corner of the platform. Four 1" diameter PVC pipe connectors are inserted into the drilled holes. The four vertical supports are made from 1" diameter PVC pipe, 24" in length, and are inserted into the pipe connectors. The two handrails are 1" PVC pipe, 40" in length, and are connected to the vertical supports by two 1" PVC elbows, secured with PVC cement.

The estimated cost is $75.00.

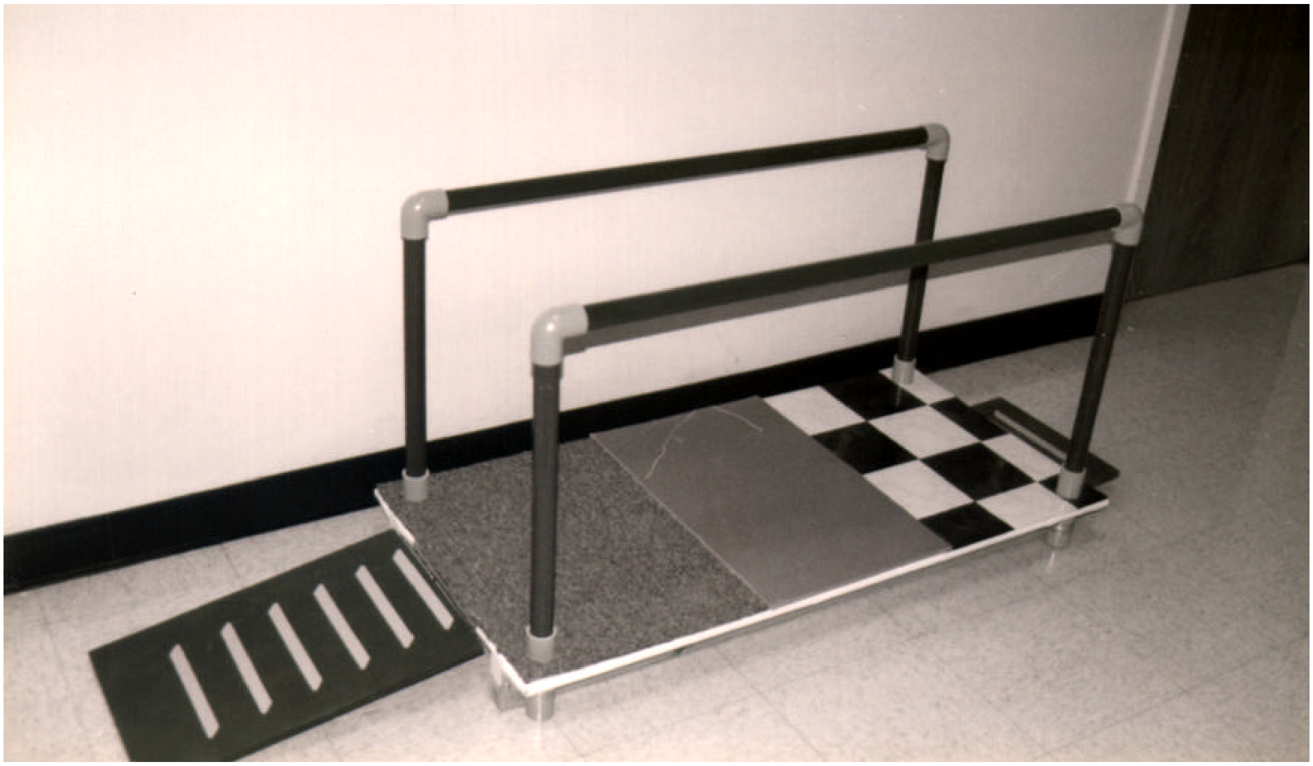


Figure 12.10. Parallel Bars with a Textured Walkway.

AN ADJUSTABLE TABLE FOR CHANGING OLDER CHILDREN

Designers: Elisabeth Neely and Bincy Paulose
Client Coordinator: Liz Crawford
Therapist, College Station Independent School District
Supervising Professor: W.A. Hyman
Biomedical Engineering Program
Texas A&M University
College Station, Texas 77843

INTRODUCTION

A variable height changing table has been designed for teachers at an elementary school (Figure 12.11). The device consists of two main parts: (1) a table and (2) a foot-operated hydraulic lift. The hydraulic mechanism was purchased from a catalogue. Its pedal and release knob/shaft are easily removed and stored inside the unit to clear the floor area when desired. The changing table measures 25.5" x 19.5" and can lift 440 pounds. The front rail is attached with two strap hinges so that the rail may be lowered to allow children to climb onto the table. There is a storage space between the hydraulic lift and table for diapers and related items.

SUMMARY OF IMPACT

The changing table was designed teachers who work with children who are four years of age and older. They requested a table that could be lowered to the ground to allow the children to climb onto the table with little assistance, thus preventing back problems experienced by the staff. Prior to having this device, the teachers were changing the children on the floor of the bathroom to avoid lifting them three feet to the conventional table.

TECHNICAL DESCRIPTION

The main design requirements of the table were that it: 1) fit into an allotted space (approximately 51" x 20" and 32" in height) 2) be lowered and raised with a foot pump; 3) have a table top covered in a material that was easy to clean; 4) have railings on two or more sides to ensure safety; 5) be able to accommodate children's varying size and weight, and 6) be safe to use.

Figure 12.11. Variable Height Changing Table.

The hydraulic lift is constructed of heavy gauge steel and massive welds for superior strength. The lift measures 25.5" x 19.5" and is elevated 0.5" per stroke of the foot pedal. It has a minimum height of 5" and a maximum height of 21". To raise the height of the changing table, a storage space with a height of 10" was added between the lift and table.

The base of the changing table is 1.25" plywood measuring 34"x 20.5". It is attached to the hydraulic lift with four carriage bolts (5/16" x 1.5"). The dimensions of the 1.25" plywood tabletop are 50" x 20.5". The base and the top of the table are connected to four 8"x 2"x 4" pieces of wood located 1/25" from each corner of the base at the back and flush with the corners in the front (Figure 12.12). Three sides of the storage space were enclosed with 1.25" plywood. The dimensions of the two sidepieces are 20.5" x 8". The back piece measures 33" x 7.75".

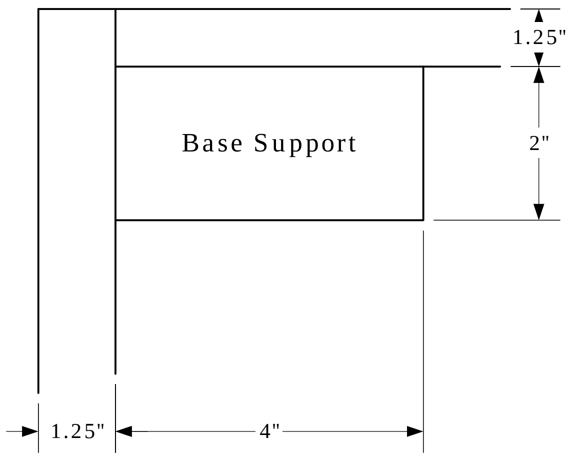


Figure 12.12. Back Base Support Dimensions.

The tabletop has 5” side railings on all sides, and is supported by 1.5” x 1.5” x 5” sections of wood located 0.5” from each corner (Figure 12.13). All railings are made from 0.5” plywood, the two side railings measuring 20.5” x 6.25” and the front and rear railings measuring 50” x 5”. The front railing is attached with two 4” strap hinges. Two hook and eye catches hold the railing in the upright position. The hinges are attached with four 0.75” screws and four hex nuts. The wood table components are attached with screws and nails.

The table is stained with golden oak wood stain and varnished with clear gloss. A pad for the tabletop is made from a piece of 0.5” foam, hot glued to a cardboard backing and wrapped in cloth and clear vinyl.

The estimated final cost for this project is $825.00, with the hydraulic lift priced at $720.00

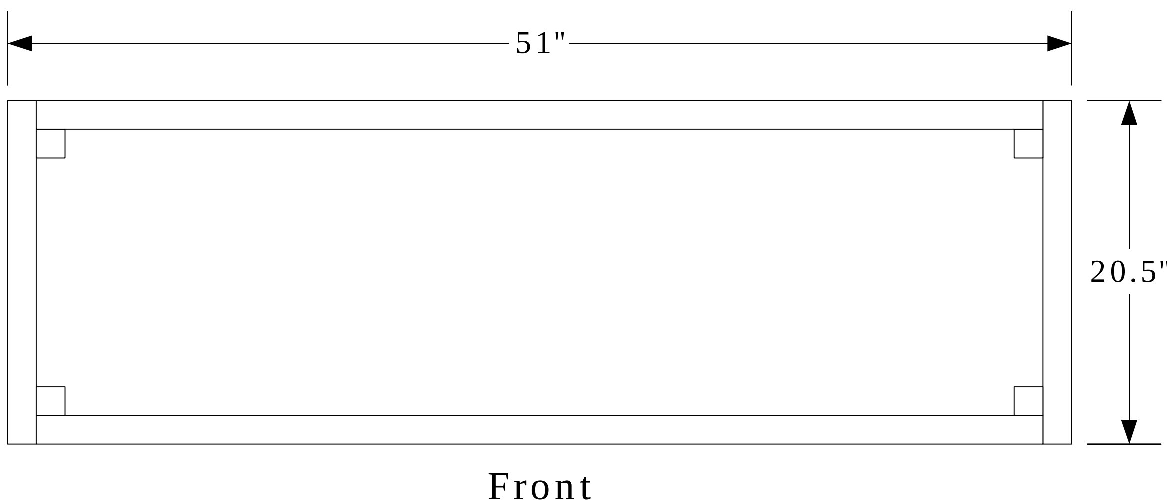


Figure 12.13. Tabletop Dimensions.

AN ELECTRONIC BLOCK TOY

Designer: John Holcomb
Client Coordinator: Teressa Edmonds
United Cerebral Palsy of Greater Houston
Supervising Professor: W.A. Hyman
Department of Biomedical Engineering
Texas A&M University
College Station, Texas 77843

INTRODUCTION

An electronic toy requiring the sequential placement of blocks was designed for children with cerebral palsy. The toy consists of an enclosed rectangular box and six wooden blocks of different shapes (Figure 12.14). The blocks fit into six corresponding holes on the top of the box, each block fitting only one hole. An electronic switch located at the bottom of each hole is triggered upon insertion of the correct block. An electronic circuit monitors the sequential placement of the blocks, which are labeled with large numbers that correspond to their correct placement order. When a block is placed into its corresponding hole in the correct order a large segmented LED display indicates the block number. A chime sounds when all six blocks are placed into the holes in the correct order. If any block is placed incorrectly a buzzer sounds and the toy is reset. The blocks are shaped and weighted to be easily handled by children. The toy is battery-operated, small, and portable.

SUMMARY OF IMPACT

Many children with cerebral palsy have difficulty with eye and hand coordination. The toys that are designed to improve these skills often lack a sufficient level of stimulation and cognitive challenge.

The development of eye and hand coordination greatly increases the interaction between the child and his or her surroundings. The sequential block game is unique in terms of the level and type of stimulation it provides. The child must consider not only placing each block in the appropriate hole but also the order of block placement. In addition, the successful completion of block placement is reinforced by both visual and audible stimuli.

TECHNICAL DESCRIPTION

The primary design considerations of the sequential block toy were that it: 1) include a minimum of four blocks; 2) have blocks approximately two inches wide; 3) be portable; and 4) provide a sufficient level of auditory and visual stimulation.

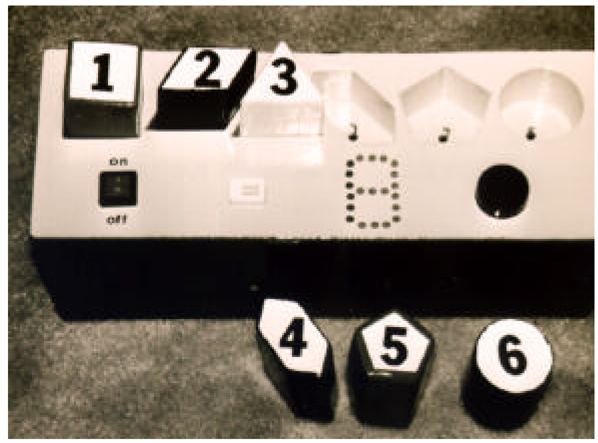


Figure 12.14. Electronic Block Toy.

The box is 6" in height with top dimensions of 14" x 6" (Figure 12.14). It is constructed of 1/4" plywood with an insert of dimensional 2" x 4" lumber into which the six holes are cut. The insert is attached to the inside top of the box to provide the walls for the six holes. The bottom of the holes is made of 1/4" plywood, approximately 13.5" x 3". The bottom of the box is made of two pieces of 1/4" plywood, 6" x 6" and 6" x 7.5". The smaller bottom piece is hinged to allow battery access. Each of the six blocks is made of a solid piece of dimensional lumber with an approximate width of 2" and height of 4.5".

The block shapes were symmetrically formed using a table and band saw. After the blocks were formed, the holes were cut in both the box top and insert with a jig saw to ensure a proper fit between the blocks and holes. The box was assembled with glue and 3/4" screws. Finally, the box and blocks were painted with acrylic paint in various bright colors.

The electrical component of the design required the use of several specialized components (Figure 12.15). Although sequential switches can be monitored using digital AND/OR gate chips, the most straightforward approach is to use a programmable logic chip such as the PAL22V10 used in this design. The PAL chip can be programmed with PALASM software and a digital chip programmer. Both can be found in a typical digital electrical engineering laboratory. The exact details of the programming are more extensive than can be provided here.

The PAL chip was programmed to recognize a sequence of six inputs from the switches at the bottom of each hole. The lever-type switches have an L-shaped extension. The extension fits through a small hole in the plywood of the block hole bottom. When triggered, each switch provides a 5-volt input to the PAL, which is recognized as a positive or correct input. Grounding the input pins of the PAL chip via a 1M? resistor provides the negative input. The PAL chip requires a clock signal to indicate when to monitor the inputs. This signal is provided by a 555-timer chip that is designed to provide a clock signal at approximately 1.5-second intervals. This interval allows the block to settle without causing multiple input triggers. The PAL sequence includes resting states for each block and an error state that is entered when a block is placed in the incorrect order. The chime indicating the correct placement of all the blocks is triggered by the output of the state for the sixth block. The incorrect buzzer is triggered by the error state. The correct block number is displayed by sending the output from each state to a second PAL chip that determines the proper LED segments to be lit. The outputs to the LED lights, the buzzer, and the chime cause a transistor to switch on, which provides the necessary voltage. The entire circuit requires four D batteries.

The components were obtained from Radio Shack and from the Rehabilitation Engineering Laboratory at Texas A&M University. The cost of the block toy was approximately $40.

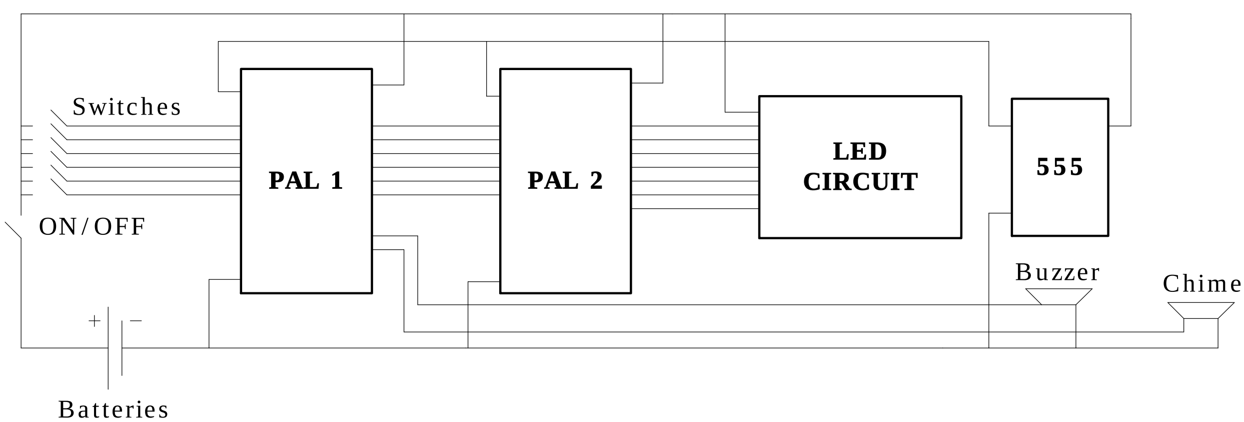


Figure 12.15. Generalized Circuit Diagram.

A REFRIGERATOR DOOR ADAPTATION FOR ADULTS IN WHEELCHAIRS

Designers: Elisabeth Neely and Bincy Paulose
Supervising Professor: W.A. Hyman
Department of Biomedical Engineering
Texas A&M University
College Station, Texas 77840

INTRODUCTION

An adaptation for a standard refrigerator door was designed for adults in wheelchairs (Figure 12.16). The device is designed for a standard refrigerator with a side opening. It cannot be adapted to a side-by-side refrigerator unit. It consists of two basic parts: the arm and the hinge. The hinge is a triangular strap hinge, with one arm attached to the side of the refrigerator and the other to a metal arm that extends beyond the end of the hinge and is inserted into the door between the insulation and the refrigerator frame (Figure 12.17). Pressing the metal arm causes the refrigerator door to open. As the door closes, the arm is trapped, and the device is again ready for use. If the door opener is not needed, it can be removed and folded back on the outside of the refrigerator. The unit is easily installed and inexpensive to build.

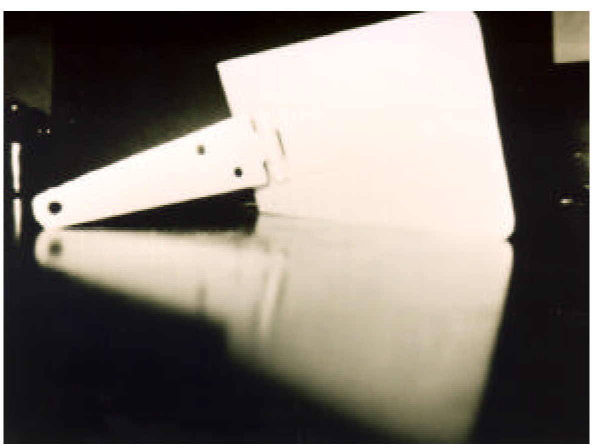


Figure 12.16. Refrigerator Door Adaptation.

SUMMARY OF IMPACT

Many people have difficulty opening a refrigerator door from a wheelchair because it is hard to produce enough force from a seated position. The design of this unit is based on the assumption that pushing is easier that pulling. A modification that could be easily attached to a standard refrigerator was needed.

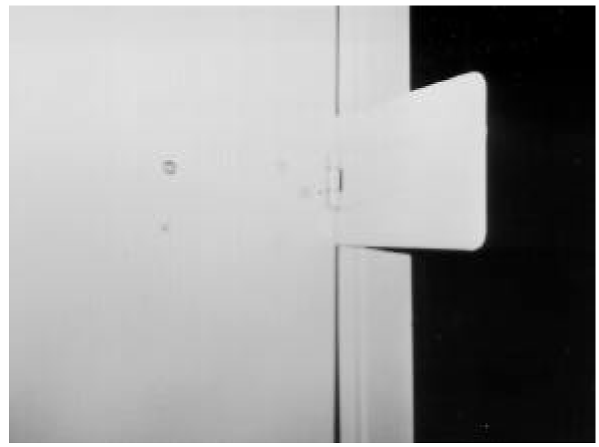
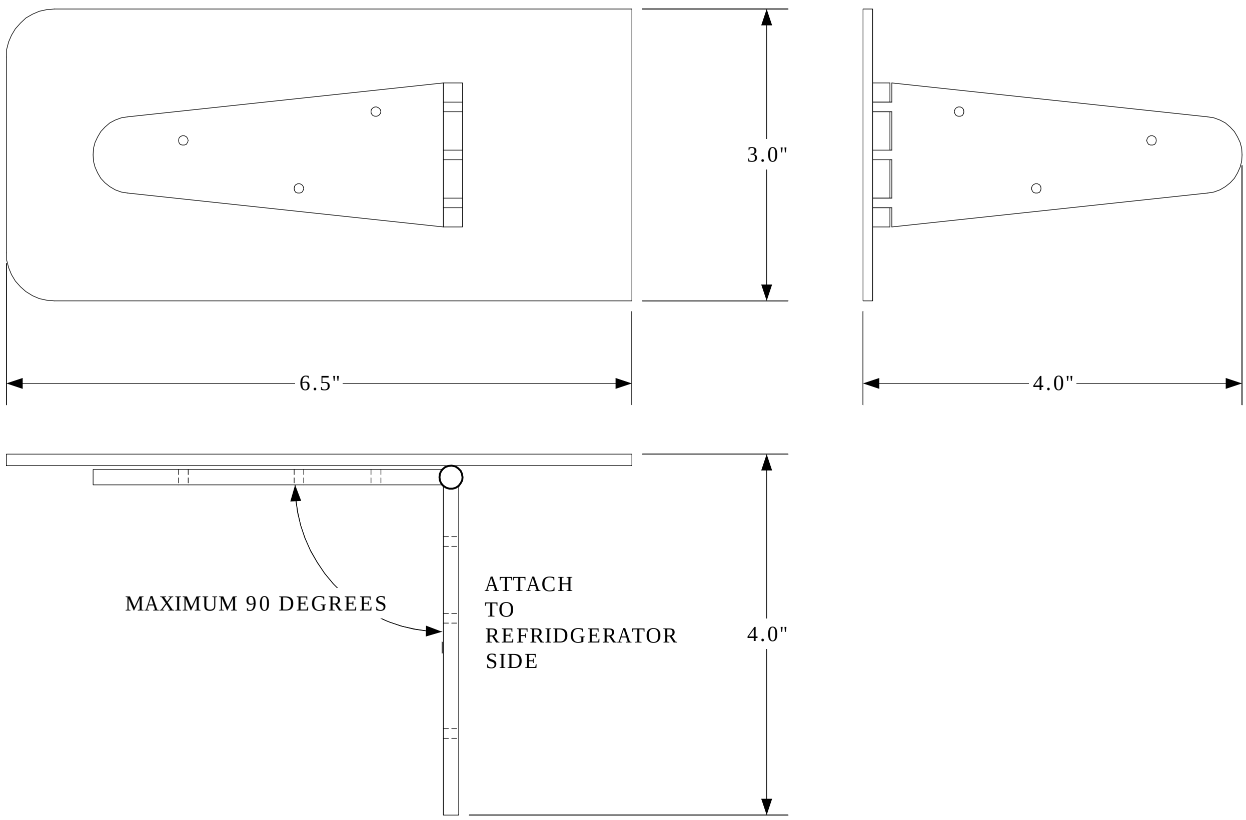


Figure 12.17. Installed Refrigerator Door Adaptation.

TECHNICAL DESCRIPTION

The main design requirements of this refrigerator adaptation were that it be inexpensive, simple, and easy for a person in a wheelchair to use. It is composed of a hinge and an arm. The hinge used is a 4" zinc strap hinge. One arm of the hinge is affixed with plastic steel epoxy to a 3" x 6.5" piece of 22 gauge weld steel (Figure 12.17). The edges of the steel are filed and rounded to prevent injury to the user. The device is attached to the side of the refrigerator with three 1.5" stainless steel screws.

The final cost of the device is approximately $10.



Figures 12.18. Mechanical Drawing of the Refrigerator Door Adaptation.

MODIFIED TRICYCLE AND WAGON FOR CHILDREN IN WHEELCHAIRS

Designers: Melissa Melton and Anna Whitehead
Client Coordinator: Lynn Anfinson
Special Education Coordinator, College Station Independent School District
Supervising Professor: W.A. Hyman
Department of Biomedical Engineering
Texas A&M University
College Station, Texas 77843

INTRODUCTION

Two existing pieces of playground equipment at a local elementary school, a rickshaw cart attached to a tricycle (Figure 12.19) and a wagon (Figure 12.20), were modified for use by students in wheelchairs. were improved. The rickshaw and wagon were fitted with a bicycle seat and highchair seat, respectively, so children with limited motor skills could safely use both toys. These additions provide extra support and security to passengers, with increased lumbar support and a safety belt restraint.

Figure 12.19. Modified Tricycle.

SUMMARY OF IMPACT

Three pre-school aged children at a local elementary were unable to participate in playground activities because they were confined to wheelchairs. The modified tricycle rickshaw and wagon were designed for safe play during use with the assistance of a classmate. A child rides in the attached seat of the tricycle or wagon as a classmate pedals or pulls.

Figure 12.20. Modified Wagon.

TECHNICAL DESCRIPTION

Tricycle Assembly

A child's bicycle seat was centered and balanced on a rickshaw cart attached to a tricycle. A 5/16" drill bit was used to drill two holes through the rickshaw cart, corresponding to the existing holes in the bicycle seat. Two 5/16" bolts with nuts and washers were used to attach the seat to the cart.

Wagon Assembly

The four screws holding the seat cushion to the frame were removed. Detaching the seat allows the frame to be easily accessible. Two ¼" holes were drilled through the chair frame, one in approximately the middle of each side bar.

Two 2" x 4" planks (pieces 1 and 2) with a length of 12" were placed perpendicularly onto a 1" x 2" plank (piece 3) with a length of 12.5". This construction allowed the chair to be placed in a slightly reclined fashion. Four 1/4" holes were drilled through the wooden frame, two on each side, approximately 2" from the each end (Figure 12.21). Corresponding holes were drilled into the wagon near the back. One

¼" hole was drilled through pieces 1 and 2, corresponding to the holes in the chair frame.

To attach the high chair seat to the wooden frame two bolts (1/4" x 2.5") are positioned downward in the chair frame and hammered, so the bolt heads are flush with the frame. Four bolts (1/4" x 3") are positioned downward in the wooden frame. The four original screws in the chair frame are tightened to re-attach the cushion. The two bolts in the chair frame are placed in the corresponding holes in the wooden frame and secured with a ¼" nut. The four bolts in the wooden frame are placed in the corresponding holes in the wagon and secured with a ¼" nut, which allows all components to be maximally tightened.

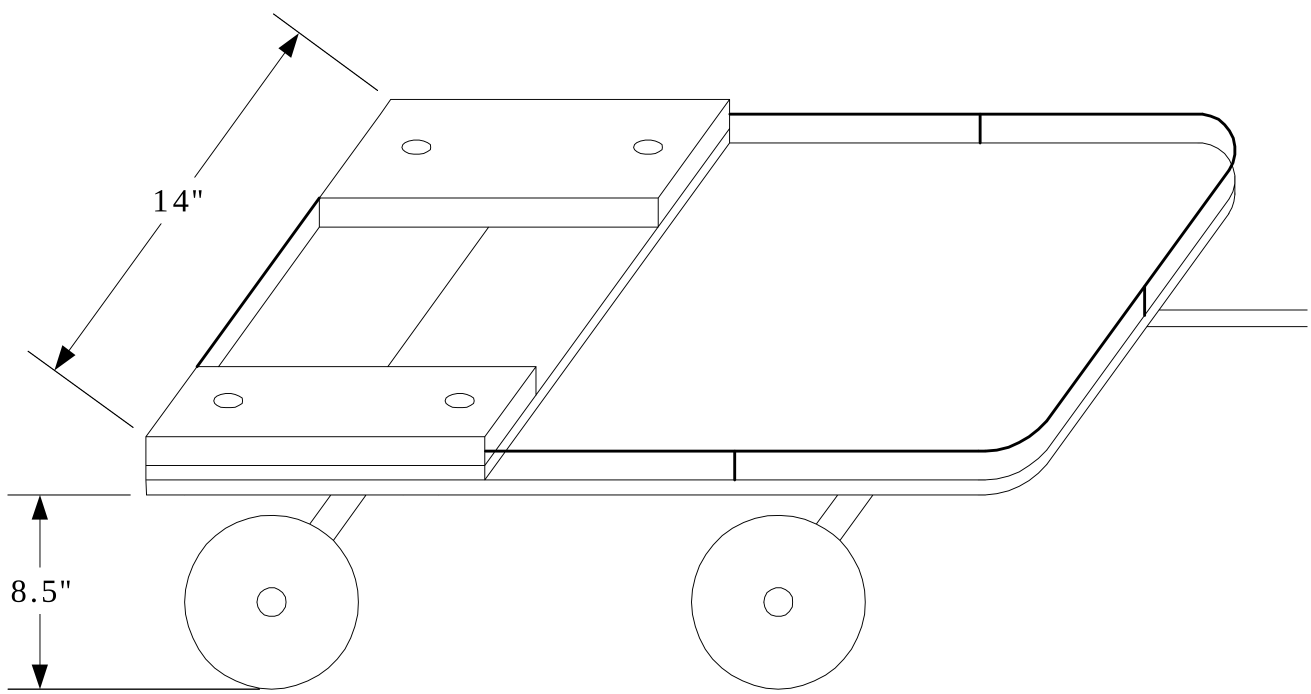


Figure 12.21. Wagon with Attachment Sites for Carrier Seat.

COLLAPSIBLE REHABILITATION STEPS

Designers: Price Bradshaw III and Robert Meltzer
Client Coordinator: United Cerebral Palsy of Houston
Supervising Professor: W.A. Hyman
Department of Biomedical Engineering
Texas A&M University
College Station, Texas 77843

INTRODUCTION

A set of collapsible steps was designed for children with cerebral palsy. It consists of a large box containing two sets of smaller nested boxes (Figures. 12.22). The outside box is mounted on casters for storage and transport. These five boxes create a set of five steps - three up and two down (Figure 12.23).

SUMMARY OF IMPACT

These steps are designed to assist children with motor problems learn to accommodate stairs. The steps can simulate regular stairs when the boxes are placed so that they begin at an elevation of 6" and increase 6" with each step. They can be used as an obstacle course when placed at varied distances apart, allowing the child to negotiate different riser heights and stride lengths.

TECHNICAL DESCRIPTION

The design requirements of the device were that it: 1) be lightweight, so that it could be easily transported; 2) be small enough to fit into the trunk of an average car; 3) have casters for easy transport; 4) be sturdy enough to hold adults; and 5) be safe.

The steps have three main components: a large box and two sets of smaller nested boxes. The boxes were constructed out of 3/4" plywood, each with four faces. The largest measures 24" x 16" x 18", the middle boxes 21.5" x 8" x 12", and the smallest 20" x 8" x 6". The largest box has four casters and a brass handle attached to opposing 16" x 18" rectangles. Strips of anti-slip traction tape were applied on the walking surface of all five boxes. All boxes were assembled with wood screws and can be combined into a single nested unit with four bolts and wing nuts. The boxes were coated with tung oil to preserve the wood and increase durability. Four casters were added to help improve transportability.

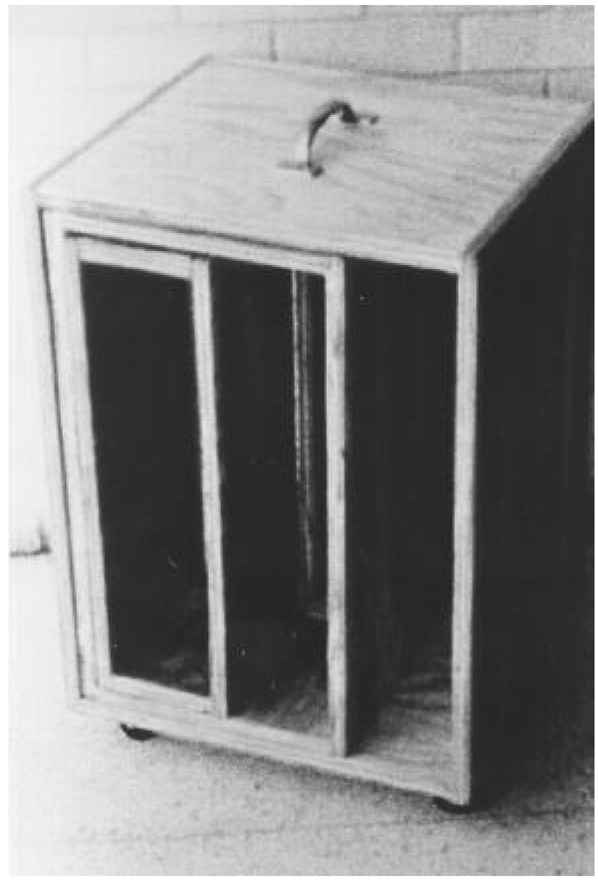


Figure 12.22. Nested Steps.

Although the collapsible unit is small enough to fit into the trunk of a car, it is too heavy to be easily carried because of the ¾" plywood used for rigidity and durability.

The total project cost was approximately $75.00.

Figure 12.23. Steps Expanded for Use.

Chapter 13
UNIVERSITY OF DELAWARE

College of Engineering
Department of Mechanical Engineering
Newark, Delaware 19716

Principal Investigator:

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A BEACH WHEELCHAIR TRANSPORTER FOR HANDICAPPED CHILDREN

Designers: Robert Banks, Chris Lawler, Cleveland Dargan, and Kevin Stolfo
Client Coordinator: Carol Barlow
Harbor Health Care and Rehabilitation Center
Supervising Professors: Drs. M. Keefe, D. Wilkins, A. Parvizi-Majidi
Department of Mechanical Engineering
University of Delaware
Newark, DE 19716

INTRODUCTION

A wheelchair transporter (Figure 13.1) was designed to carry a child in a wheelchair across the beach. It is an aluminum wheel-driven, platform device accessible via a collapsible ramp. It accommodates varied loads and different wheelchairs. Aluminum surfaces were treated to inhibit corrosion. Smooth edges ensure safety.

SUMMARY OF IMPACT

A beach wheelchair transporter was designed to accommodate any wheelchair; eliminate the need to transfer children from a custom chair to a beach chair; provide space for supplemental equipment, such as a respirator; be resistant to corrosion; be durable; and be aesthetically appealing. In the future, a permanent ramp may be added, and the upper frame may be welded to eliminate the need for pipe fittings.

TECHNICAL DESCRIPTION

The wheelchair transporter was designed to facilitate taking children in wheelchairs to the beach. The design was based on that of landscaping trailer decks, wood decks with simple metal framing underneath for support. The principle design requirements were that it be: lightweight; able to be pushed across the sand; able to hold a minimum load of 173 pounds (to accommodate the client's heaviest combination of chair and child); easy and quick to set up; corrosion-resistant; and safe to use.

The pinewood deck will support any wheelchair wheelbase. The upper frame, a railing assembly, is constructed of lightweight seamless aluminum tubing, painted for corrosion resistance. The varied tube lengths are joined by aluminum structural pipe fittings. The back of the railing has a quick-release assembly to enable loading from the rear. The lower frame, or truss, is made of lightweight, stiff, hollow, aluminum square tubing, also painted for corrosion resistance. The square beams were butt-welded for high strength.

Wheels were selected over a sled, treads, or a hover concept for ease of movement across sand. A disc was welded to a machined collar to create the aluminum wheel hubs. A steel axle was slip-fitted and pinned into the hubs. The pillow blocks are sealed and shielded. Lithium grease in the bearings was purged and replaced with boat trailer grease, which is better suited to salty, wet environments. Splined studs were press-fitted into the hubs to accommodate the bolt pattern on the wheels.

For added corrosion resistance, all aluminum surfaces were abraded with a steel brush, then primed and painted using coatings designed for aluminum. The wood deck was coated several times with polyurethane for weather resistance.

The wheelchair is held on the transporter via ratcheting tie-down straps, which are inexpensive and quick and easy to use.

The client provided a portable access ramp, which could easily be attached permanently via a hole pattern that could mate with three studs on the rear of the transporter.

Tests of the transporter were conducted by loading it with an adult in a wheelchair and pushing him around the beach. The metrics set forth in our design criteria were met and no major adjustments were needed.

The final cost of the wheelchair transporter is approximately $800.

Figure 13.1. Beach Wheelchair Transporter.

EASY ACCESS

Designers: Tim Clark, Keith Metzger, Eric Ramos, Steven Rosenberg
Client Coordinators: Vince Evans, Pat Moore
Supervising Professors: Drs. Dick Wilkins, Michael Keefe, Suresh Advani
Department of Mechanical Engineering
University of Delaware
Newark, DE

INTRODUCTION:

A personal storage system to be attached to a powered wheelchair was designed for a student with a progressive muscular disease. Because of his limited upper body motion and strength, the student needed a device that would carry the storage bag from its original resting position to a position where the student could access his personal belongings.

The system is mounted on top of the student's lap tray (Figure 13.2). A four-bar linkage with a DC motor drives a rigid storage bag. It is controlled via a push-button toggle switch. Top and bottom brackets are designed to allow easy mounting and disassembly from either side or from the front of the lap tray.

SUMMARY OF IMPACT

A student with a progressive muscular disease, involving limited upper body motion and strength, requested a means of accessing his belongings from a bag that is usually stored on the back of his wheelchair. The Easy Access device was designed to meet this need, and to promote the student's self-reliance and independence.

TECHNICAL DESCRIPTION

Listed in order of importance, the design criteria were that the Easy Access device: 1) provide storage for personal items and school supplies, 2) accommodate a particular range of upper body motion, 3) be accessible to a student with low grip strength and limited ability to move objects, 4) be aesthetically pleasing, 5) allow for the student's entry to and exit from the wheelchair, 6) cost less than $1,000, 7) be lightweight, 7) not interfere with the operation and functionality of the wheelchair or its accessories (including the motor, battery, electrical controls, lap tray, joystick, neck support assembly, etc.), and 8) meet the dimensions for a wheelchair and its accessories specified by the universal guidelines for wheelchair accessibility in the Americans with Disabilities Act (ADA). Compliance with the ADA ensures that the chair will fit through standard doorways and onto public transportation.

The design has five main components: a personal storage unit, a four-bar linkage system, power and transmission, electrical control, and a protective cover. The storage unit combines a rigid frame using fabric stiffeners and nylon liners. The rigid frame and large opening of the bag allow for easy accessibility of stored materials. An outside shell of canvas material is used to emulate commercial backpacks.

The linkages are designed as a rocker-rocker four-bar system. Two identical sets of standard four-bars are situated at either end of the storage unit for stability. A common rotating shaft powers the two drivers. The initial and final positions of the bag are set to obey ADA laws, and accommodate the customer's range of motion. The initial position is such that the additional width to the wheelchair is minimized, while the final height of the bag is placed 3" above the lap tray.

Weight restriction is necessary for portability. For this reason, the battery and DC motor were separated from the portable system. For simplicity, the DC motor is permanently attached to the bottom of the wheelchair seat, near the 24V battery. A flexible power drive shaft is used to connect the power from the DC motor to the gearbox that generates the proper torque. The gearbox is then connected onto the drive shaft by a spring coupler.

For easy accessibility, a large pushbutton is used to control the raising and the lowering of the linkage system. When the large pushbutton switch is activated, the motor is powered and the linkage system moves. When the linkages reach a given upper point, they trigger a limit switch that simultaneously activates the brake and cuts the power to the motor. When the switch is activated again, the brake is released and the motor is powered in the reverse direction. Again, the linkage system travels until it reaches the lower limit switches, activating the brake and cutting the power to the motor. A jog switch has also been included so the circuitry can be bypassed in case the linkages are stopped mid-path.

Finally, the portable linkage system is housed in a protective cover. This cover protects most of the moving parts and electronics from dirt and wear. In addition, the cover provides the rigid structure needed to mount the system to the lap tray. The cover also offers aesthetic value to the design.

Modifications for the device include the use of a geared DC motor mounted on the housing to drive the shaft. This will eliminate the need for a flexible shaft.

An estimate of the final cost for the storage system is approximately $700.

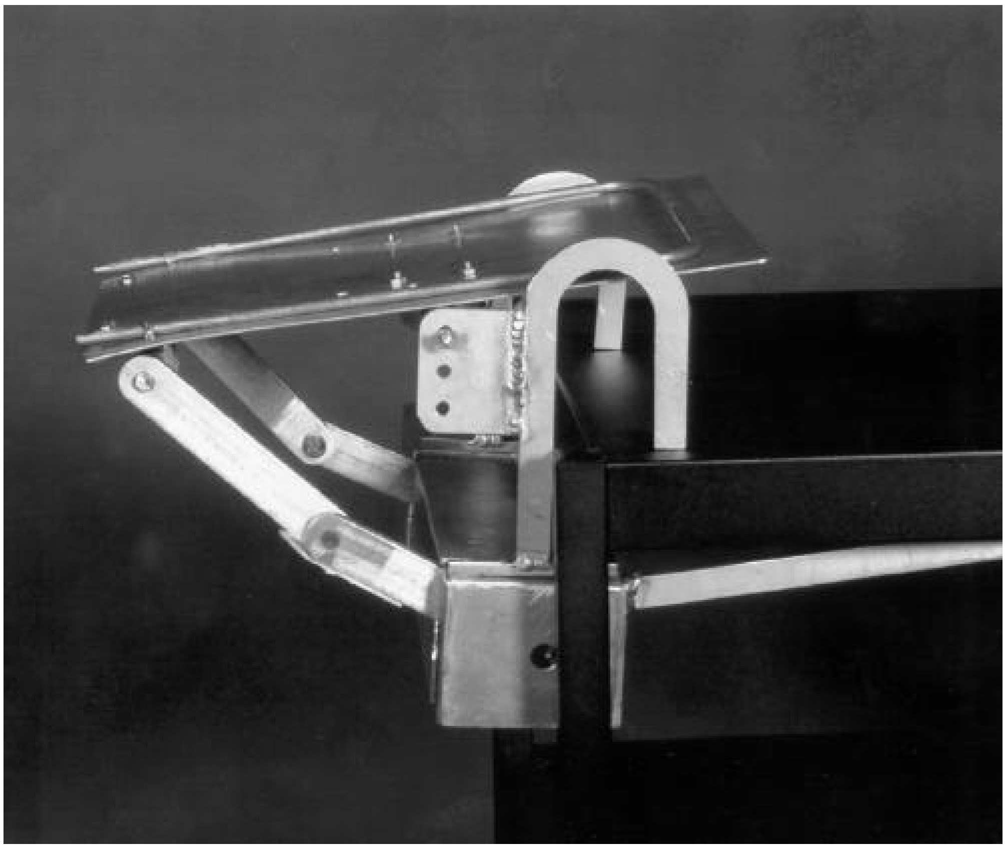

Figure 13.2. Easy Access.

Chapter 14
UNIVERSITY OF MASSACHUSETTS LOWELL

James B. Francis College of Engineering
Assistive Technology Program
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MORSE CODE TO TELEPHONE CONVERTER

Designer: Marc Todd
Supervising Professor: Donn A. Clark
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INTRODUCTION

In today's world of advanced communications, the telephone provides the ability to connect with unlimited sources of information. For many persons with physical disabilities, the restrictive design of the telephone prohibits access for emergency assistance, business opportunities, and contact with family and friends. New telephone designs are needed to offer custom interfacing for control of basic phone functions.

A prototype telephone was designed for a student at a local educational institution for the blind. The unit is dialed via a customized hand operated Morse code device. Other external features include customized headset, pick-up, hang-up and error handling.

SUMMARY OF IMPACT

A high school student who is blind and has severe motor control disabilities desired to use the telephone without assistance. He has excellent verbal skills and is highly intelligent, so is an excellent candidate for employment. He wanted to take an available position as a receptionist but his motor skills were not sufficient for him to dial a standard telephone or pick up the handset without assistance.

Morse code was chosen as the input language because of its simplicity and because the student is already familiar with it. Morse coding devices are flexible and easily adaptable to accept various inputs, including motion from a hand, knee, toe, head, or finger.

Using a series of five dots and/or dashes, all digits and keypad symbols are available to the user. The prototype unit accepts a series of Morse code sequences as input while all other interactive telephone functions, such as the receiver component and hang-up/answer capabilities, are external and customized to individual needs.

TECHNICAL DESCRIPTION

The telephone unit is comprised of two individual subsystems communicating between one another. The first is a micro-controller circuit that accepts Morse code as input. The second is a telephone circuit that communicates with the micro-controller and performs all standard phone functions.

A program drives the micro-controller to regulate the timing and feel of the customized hand operated actions. The algorithm polls the input device and waits for an event to occur. When one of the Morse code controls is pressed, the program delays processing the dot or the dash until the user releases. This allows for fast or slow user input.

The series of dots and dashes are stored until five events are recorded, at which time the algorithm converts the Morse code number to its respective dialing code. The special dialing code is sent to the telephone circuit.

The telephone circuit generates a tone corresponding to the dialing code received. This tone is sent via the telephone lines to the local phone company, from which that number is dialed. The telephone circuit also handles incoming calls and handset functions and allows keypad dialing.

Many people with disabilities already have the skills, if not the mechanisms, to operate the switches needed to use Morse code but lack the tools to convert their talents. The custom interface telephone with Morse code dialing is constructed for use with several input devices. The client operates a two-stick customized hand-operated Morse code unit appropriate for his limitations. Any device using standard male phone jack connectors and toggling between short and open would be operational.

The pick-up/hang-up feature involves a nine-pin connection. The client uses a double-throw double-pole switch embedded in a harness made especially for him. However, any device connecting the appropriate wires of the ninepin port is suitable.

The receiver outlet is a standard handset connection, allowing devices such as an everyday headset or a speakerphone extension to be used.

Not including accessories such as speakerphone extensions and the custom Morse code input device, the cost of this system is under $50.00.

KEYPAD PROGRAMMABLE ELECTRONIC DOOR STRIKE

Designer: Scott Brownstein
Client Coordinator: Prof. Donn Clark, Assistive Technology Program
Supervising Professor: Mr. Alan Rux
Department of Electrical and Computer Engineering
University of Massachusetts Lowell
Lowell, MA 01854

INTRODUCTION

A device was designed to enable a woman with multiple sclerosis to control the front door of her house from her bed. She wanted to allow a visiting nurse or friend into her home, but also desired the security of a locked front door. A coded keypad, similar to those found on touch-tone telephones, allows specific individuals to have access to her home without disturbing her.

SUMMARY OF IMPACT

The client is able to positively identify visitors over an intercom and let them enter her home. When she is sleeping, care providers can let themselves in using the keypad.

The system entails a wireless intercom and house wiring for communication with a battery back up in case of power failure. The keypad, with a changeable code, is a critical component, obviating the need to distribute keys to potential visitors.

TECHNICAL DESCRIPTION

The Keypad Programmable Electronic Door Strike device consists of four main components: a wireless intercom, a keypad and decoder, an electric door strike, and a battery back up

The wireless intercom unit is a Nutone Comtek Chime Talk Door Answering Intercom with Outdoor Speaker and Push Button. The inside unit "master speaker " was modified to add a switch to control a X 10 switch-closure sending unit and a piezo buzzer horn as an entry alert. This unit has a “press to talk” lever, which was changed to a pull cord switch such as those found in hospitals and nursing homes. The front door unit was not altered, but was connected to the keypad switch assembly. The wiring cable of both was combined to pass through the doorframe.

The Keypad is a Storm series 2000, 12-key pad from Keymat Technology. It is a weatherproof unit connected to a digital lock circuit that uses only nine of the keys (three are not connected), and adds to the security of the entry code. The digital lock uses an LSIKSI LS7222 IC for the decoder, memory and control circuitry. This IC has stand-alone lock logic, momentary lock contro1 outputs, internal keyboard debounce circuit, and high noise immunity. A 555 timer was used to provide a 9-millisecond delay on the door strike power-on command signal to make the door open after the correct code was selected. Upon entry of an incorrect code, the latch is energized.

The Electric Door Strike unit is a Home Automation HAS-5 190 12 - 16 V-DC, 800 mA unit. Either the front door keypad or the modified Xl0 lamp module can activate this door strike. The X10 modification ensures that the module will not latch but pulse on only when its command code is detected from the household wiring.

The piezo buzzer is activated when the door strike is energized to let the client know when the door strike is active for door opening. The battery back-up circuitry is in the front door electronic box. The circuitry includes a 12-volt NiCad battery and charging circuitry. This back-up is activated when power is lost to the household. It powers only the front door keypad and door strike coil. There is no control from the bedroom when power is lost, but care providers can still get into the house through the use of the keypad code. The battery can supply back-up power for over 24 hours. This time could be extended with a battery of larger amp-hour capacity.

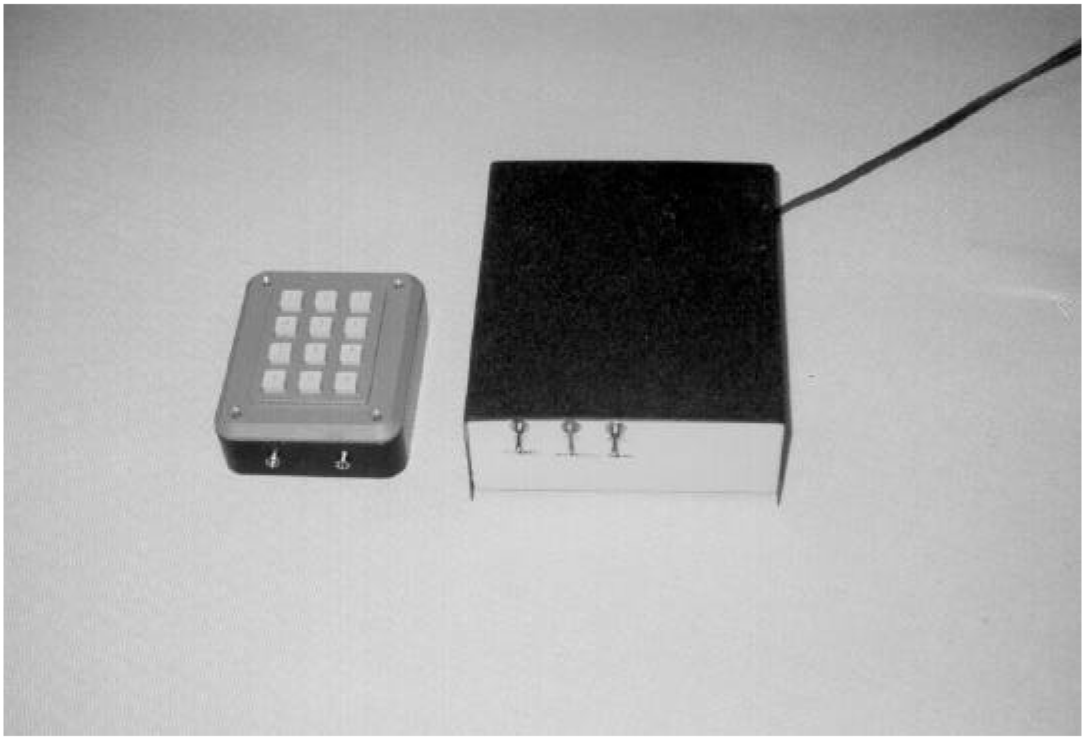

Figure 14.1. Keypad Programmable Electronic Door Strike.

ADAPTATION OF A RADIO REMOTE CONTROLLER

Designer: Laura Zimmer
Client Coordinator: Prof. Donn Clark, Assistive Technology Program
Supervising Instructor: David Wade
Department of Electrical and Computer Engineering
University of Massachusetts - Lowell
Lowell, MA 01854

INTRODUCTION

A remote control device was adapted, with larger buttons and color-coding, for an 18-year-old boy who enjoys listening to a radio but was not able to independently control a standard one. The client has cognitive and motoric limitations as well as poor vision.

SUMMARY OF IMPACT

A commercial portable radio that came with a remote control was selected. Among the many features of the remote control, the most important were keys for power, volume up and down, and tuning. The modification entailed adding buttons for these functions in custom keypads. Four large (approximately 4" by 2"), brightly colored buttons were mounted onto a metal case containing the remote. The new buttons are large enough to operate with a fist. The colors (red, green, blue and yellow) provide cues to help compensate for the client's limited vision.

The client now has enhanced environmental. Additionally, he enjoys entertaining others, playing the role of disc jockey at informal events (The volume up button being his favorite.).

TECHNICAL DESCRIPTION

A production remote packaged with the radio was disassembled. The printed circuit card was installed in a metal box, increasing the controller's size and durability. Two momentary switches were wired in parallel to each selected command and mounted on the new case. To create one large button, the two momentary switches were covered with one piece of colored plastic. Current limiting resistors were mounted in series with the new switches. A lens cap was placed over the LED. The batteries to power the remote are accessible through one end of the case.

The costs were primarily associated with the mechanical aspects of the project. The case to hold the remote circuit card was roughly $12.00. The momentary switches are available for less than a dollar. The plastic for the button covers was obtained for $10.00. Miscellaneous supplies, such as batteries, clips, the lens cap, and hardware, cost less than $8.00.

Figure 14.2. Client with Adapted Remote Control Device.

VOICE CONTROLLED PHONE DIALER

Designer: John Otto Schenk
Client Coordinator: John Otto Schenk
Supervising Professor: Donn A Clark
Department of Electrical Engineering
University of Massachusetts at Lowell
Lowell, MA 01854

INTRODUCTION

A voice controlled phone dialer was designed for a client with reduced vision and diminishing sensory acuity in the fingers.

SUMMARY OF IMPACT

The device relieved the client's difficulty in using the telephone.

TECHNICAL DESCRIPTION

A voice controlled phone dialer incorporates voice recognition DSP chips, flash memory devices, and existing phone dialers. The design was based on digital control logic, digital signal processing (DSP) and analog. Existing dialer chips, application notes, and basic electrical engineering concepts were applied. Use of existing integrated circuits simplified the design process.

A voice recognition unit controls a switch matrix, which, in turn, controls the phone dialer. Three functions are available: direct number dialing, storage numbers of associated with a name, and recall of stored names. These functions are controlled through familiar words defined and spoken by the user.

Solid-state relays and logic gates were used to replace the matrix of switches that controlled the tone generator or dialer circuit in a regular telephone. Digital logic was implemented to control these switches. An algorithmic state flow chart was first drawn to describe the intended operation of these switches. Two types of memory, programmable and read only, were implemented. With the addition of minor supporting circuitry, including a buffer amplifier and a reference oscillator, a binary controlled switch matrix was developed.

DSP provided a compact solution for a seemingly complex problem. The task of producing a reliable electrical response to specific spoken words is challenging. There are few chips under $100 that operate flawlessly. A hm2007 DSP chip was used in a prototype circuit. A voice recognition unit was built and then connected to a static memory unit (for storage of voice recognition output), and to the switch matrix. The unit allows control through single words. Storage of several binary word patterns can be recalled sequentially. Timing logic, implemented with a simple astable oscillator and a counter, ensures that more than one function can be initiated when a single word is spoken.

A buffer amplifier inserted between the output of the voice recognition unit and the switch matrix allows for a binary decimal display of the word spoken. This provides feedback to the user regarding which word was coded.

The dialer is 7" long, 5 inches wide wide, and four inches deep. It weighs less than one pound. It may be easily replicated. The dialer has other applications, such as security locks and general voice controlled switching systems.

The total cost was below $130.00.

COMPUTER CONTROLLED SPEAKER TELEPHONE

Designer: Rick Bouley
Client Coordinator: Prof. Donn Clark, Assistive Technology Program
Supervising Instructor: Alan Rux
Department of Electrical and Computer Engineering
University of Massachusetts Lowell
Lowell, MA 01854

INTRODUCTION

Computerized speech recognition was used to help a person with spinal cord injury control his telephone.

SUMMARY OF IMPACT

The client is now able to answer and receive calls, as well as to dial out to make calls.

TECHNICAL DESCRIPTION

This project used a commercially available Panasonic speakerphone with a computer digital interface. Twenty switches make up the keyboard in a 4 x 5 matrix on the speakerphone, allowing for control of answering and dialing of selected numbers in memory storage. This matrix of rows and columns was paralleled with nine small Switchcraft IC-type DIP relays, and buffered using two hex driver digital ICs. The computer has an I/O Digital Interface Card. Nine digital lines were used. Power for the relays and ICs was taken from the I/O Card. Power for the speakerphone came via its own wall plug power supply. The relays provided the electrical isolation between the two systems. The software for control is written in Visual Basic from Microsoft.

The cost of this project was $ 263.50

Figure 14.3. Computer Controlled Speaker Telephone.

VOICE ACTIVATED ENVIRONMENTAL CONTROL UNIT

Designer: Gregg Browinski
Supervising Professor: Donn Clark
Assistive Technology Program
Electrical Engineering Department
University of Massachusetts at Lowell
Lowell, MA 01854

INTRODUCTION

A voice activated environmental control unit was developed for a man who is paralyzed from the neck down due to an automobile accident. Though he does have enough mobility in his arms to operate a motorized wheelchair, his quadriplegia has reduced his fine motor skills.

SUMMARY OF IMPACT

This voice-enabled system can be used by anyone capable of coherent speech. Blind individuals, those with motoric limitations, and able-bodied persons may employ a similar system.

TECHNICAL DESCRIPTION

The system has three components: the voice recognition (VR) engine, a controlling platform, and hardware. The system receives its voice input from a head-worn wireless microphone. This allows the client freedom to move about in his apartment while maintaining control of the system. A RF link connects the microphone to the base unit, which is then channeled into a standard PC sound card.

The VR engine, IBM's Voice Type Application Factory, interprets the speech and returns the associated text to the Visual Basic (VB) program through a third party Custom Control or OCX. The VB program, essentially a state machine, then either changes state or writes a sequence of bits out to a digital l/O card. Each external device has a pattern of bits, or ID, associated with it. For the remote, each bit pattern specifies a single button. The client's ventilation system is controlled by a series of logic gates and relays, while his lights and television are controlled through the interfaced universal remote control. Using "Plug 'n Power" or X-10 technology, lights and outlets can be toggled while the remote communicates directly with the TV once the correct manufacturer's code has been entered.

In keeping with the modularity of the overall design, the VR portion uses content files, listings of acceptable words, for each program state. Restricting the number of possible matches resulted in simultaneously improving its accuracy and speed.

The VB program is modular in its series of drop-down menus. To promote usability, the menus reflect the layout of the client's apartment. Each room has a corresponding drop-down menu containing a list of the devices in that room. Personalizing the menus and program flow facilitates the user's learning.

The universal remote was attached to the digital I/O card via an RS-232 cable. After determining the pinout from the remote's controlling IC for each button, the sequences were hard-coded into the VB program.

Switching relays were used to simulate pressing of the buttons. The "Plug 'n Power" button accessed the X-10 control center, which toggled the individual X-10s directly.

Highlights of the design include power, versatility, user-friendliness, and cost-effectiveness. The power of the system lies in the use of voice recognition. Any individual without a severe speech impairment can use it. It gives the user's voice the ability to accomplish what his body cannot.

The versatility of the system is due primarily to the modularity built into the VB program and VR engine, which ensures that any modifications can be made quickly and without affecting current system operation.

User-friendliness was an important criterion in this design project from its initiation. The wireless microphone gives the user freedom of movement within his home. Visual and audible prompts are relayed back during operation to enhance user awareness. The VR engine has up to a 95% successful recognition rate. If the engine makes mistakes, they can be undone by a spoken RESET command available in all contexts.

Although the system requires a PC for operation, the 486 based machine used in the initial system had recognition times of nearly one second and an overall response time of just over two seconds.

Commercially available systems with comparable functions may cost $5000 and up, whereas the total component cost for this design was slightly under $1200.

Figure 14.4. Voice Activated Environmental Control Unit.

COMPUTER INTERFACE FOR HOSPITAL BED CONTROL

Designer: Bob Hughes
Client Coordinator: Prof. Donn Clark, Assistive Technology Program
Supervising Professor: Alan Rux
Department of Electrical and Computer Engineering
University of Massachusetts Lowell
Lowell, MA 01854

INTRODUCTION

The purpose of this project was to design a simple interface between a voice activated computer and a hospital style bed for a 49-year-old man with a spinal cord injury. The bed has a hand-held control to raise and lower the feet, torso or head, depending on the buttons pushed. It also has an elevator function that raises and lowers the entire bed.

The interface must be parallel to the hand-held control to allow functionality in case of computer breakdown and to allow control by healthcare providers and family members. A Dallas Watchdog timer chip was added for safety. If control and hand shaking with the computer are lost, the output control is put into high-impedance mode, and the device is electronically removed from the bed controller.

SUMMARY OF IMPACT

A client with a spinal cord injury uses this voice control system to control his hospital bed. Previously, he had to rely on healthcare workers or his son to make adjustments. Now, if the client wants to sit up and watch television, or simply reposition the bed for comfort, he speaks a command and the computer system, through the bed controller interface, obeys. This device helps make the client more independent.

TECHNICAL DESCRIPTION

The system uses the IBM Voice-type Factory speech recognition software and interface drivers written in Visual Basic 4.0. The digital interface from the computer to the bed controller unit is a Computer Boards, Inc. interface card, CIO-111024. This card provides 24 I0 lines through a 37-pin connector mounted on a PC Card, which plugs into the computer bus slot. The heart of the card is a single 82C55 chip operating in mode 0; the signals are TTL with capability of 15 mA Sourcing, and 64mA Sinking. An extension cable connects the interface card and computer and can be unplugged at both ends. The interface uses Port A on the Multiport Board. A0 to A.5 are used to control the bed and A6 is used to strobe the Dallas chip. As long as the Dallas chip is getting strobed the data will pass through the 74LS244 buffer and to the relays that are in parallel with the hand control switches. The Dallas DS1233 chip requires a transistor buffer to drive the 74LS7244 chip G1 and G2 pins.

The Dallas chip operation serves as a safety feature as well as a check in the operational mode. If the computer gets hung up, it would have to put data on the address lines and toggle A6 in order for the bed to operate. For added safety, the relays also have a double normally-open contacts configuration. All control lines have pull-up or pull-down resistors to keep the circuit stable in power-up and power-down conditions. The I/0 card supplies five-volt DC power and ground. All components are socket mounted to facilitate field repair.

To install this control unit, the original hand control unit is removed by unplugging it from the bed controller and replacing it with the cable from the new unit, which has an identical hand unit. The control box and the new hand control switch units have Velcro strips for securing both to the bed.

The cost of the project was $634. The most expensive item is the replacement hand-held switch unit.

Figure 14.5. Computer Interface for Hospital Bed Control.

VOICE OPERATED WHEELCHAIR USING DIGITAL SIGNAL PROCESSING TECHNOLOGY

Designer: Walter R. McGuire Jr.
Supervising Professor: Professor Donn A. Clark
Assistive Technology Program
Department of Electrical Engineering
The University of Massachusetts at Lowell
Lowell, MA 01851

INTRODUCTION

A Voice Operated Wheelchair was developed using commercially available digital signal processing (DSP). The device does not require a personal computer or any other costly component. It provides a safe, economical, and compact solution for persons with quadriplegia. The device is small enough to hide under the seat of the wheelchair, consumes low battery power, and can be converted to fit most existing motorized wheelchairs at minimal cost.

SUMMARY OF IMPACT

The development of the Voice Operated Wheelchair using DSP provides a person with even minimal speech capabilities freedom while traveling in a wheelchair.

TECHNICAL DESCRIPTION

The heart of the voice-operated system is the digital signal processing circuit. Supporting the DSP is the programmable logic circuit, the converter circuit and the mechanical safety switch circuit. The signal processing circuitry consists of a commercially available DSP chip, which receives verbal commands from the user with the aid of a simple microphone (Figure 14.6).

The first phase of redundancy helps avoid undesirable responses from the system and the surrounding environment. The verbal commands are outputted from the DSP chip in the form of an eight-bit word, which are then taken by the logic circuit and analyzed. Part of the logic circuitry is a commercially available PIC chip that processes the eight-bit input and makes a decision based on that information. Once again, redundancy is featured. The decision is then further processed in the next circuit, which takes the digital input and converts it into the necessary analog output that is needed to produce the desired response from the motor controller (for example, moving the wheelchair in the forward direction). The final section of circuitry is the mechanical switch that overrides all of the aforementioned circuitry. This circuit acts as a failsafe against erroneously entered commands.

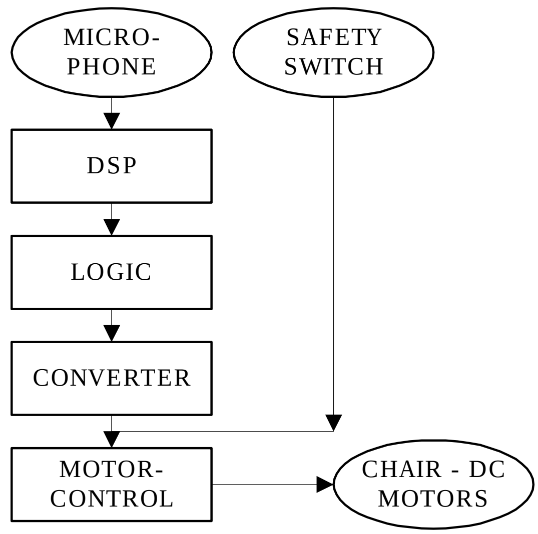

Figure 14.6. DSP Driven Voice Operated System.

Figure 14.7. Voice Operated Wheelchair.

VOICE ACTIVATED WHEELCHAIR LIFT SWITCH

Designer: Walter R. McGuire Jr.
Supervising Professor: Professor Donn A. Clark
Assistive Technology Program
Department of Electrical Engineering
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INTRODUCTION

The Voice Activated Wheelchair Lift Switch was designed to assist a man with quadriplegia. The design incorporates technology already in use in the client's home, namely, his environmental control system (ECS).

SUMMARY OF IMPACT

The device is used by the client, who, until now, has been dependent on his family to exit his home. This device gives him the ability to raise and lower his wheelchair lift, and to open his garage door, allowing him access to the outdoors.

TECHNICAL DESCRIPTION

This design consists of three main circuits making up the switch: the X-10 circuit, the timer circuit and the relay circuit (Figure 14.8). The switch component is the interface between the voice system and the wheelchair lift.

The home that the switch was designed for has an existing voice operated ECS that operates with X-10 technology. The X-10 appliance modules were modified to pass a 5-volt DC pulse when accessed through the addressing of the X-10 via the ECS. The 5-volt pulse triggers the timer, which is a 555-device, set up to act in the monostable mode. The 555 timer has an RC time constant set to the length of the lift's travel duration, approximately 23 seconds. As the one-shot is charging, the 555's output of 5 volts activates a solid state relay, which, in turn, activates the lift and / or garage door. The device was susceptible to external noise that would trip the timer when the client's wife would use the garage door opener or the wheelchair lift manually. Inserting filter capacitors from all of the V_{cc} to Ground terminals rectified this problem.

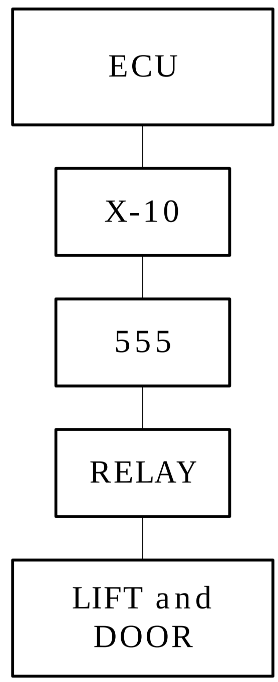

Figure 14.8. Custom Switch Block Diagram.

This device can be expanded for many applications simply by customizing the RC timing circuitry. It can also be made to stand alone, omitting the need for the environmental control system and X-10 technology by replacing it with an inexpensive DSP voice recognition system. The reduced cost would make the device more accessible to those in need of this technology.

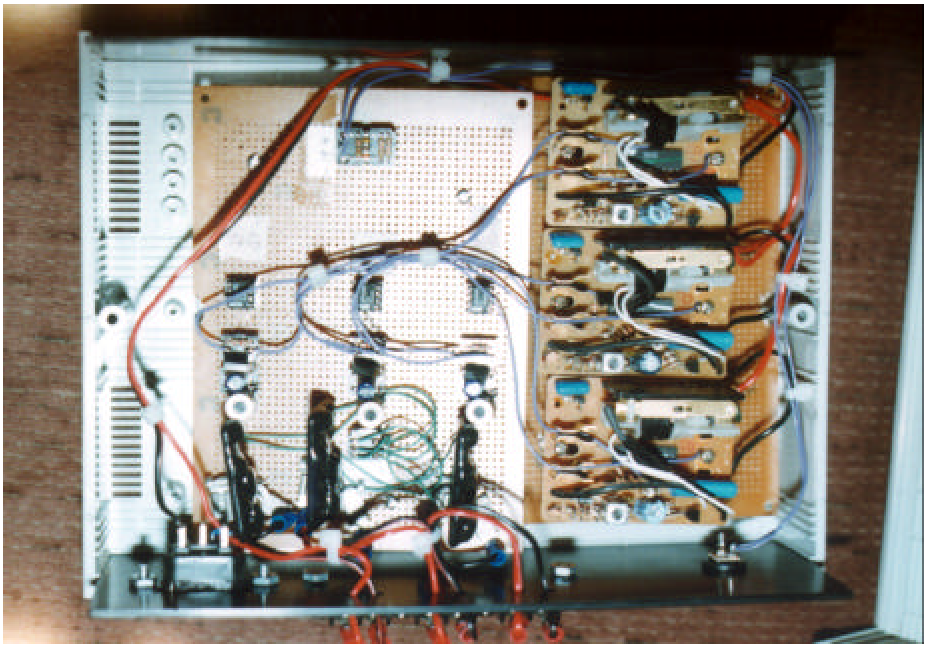

Figure 14.9. Circuit Boards in the Voice Activated Wheelchair Lift Switch.

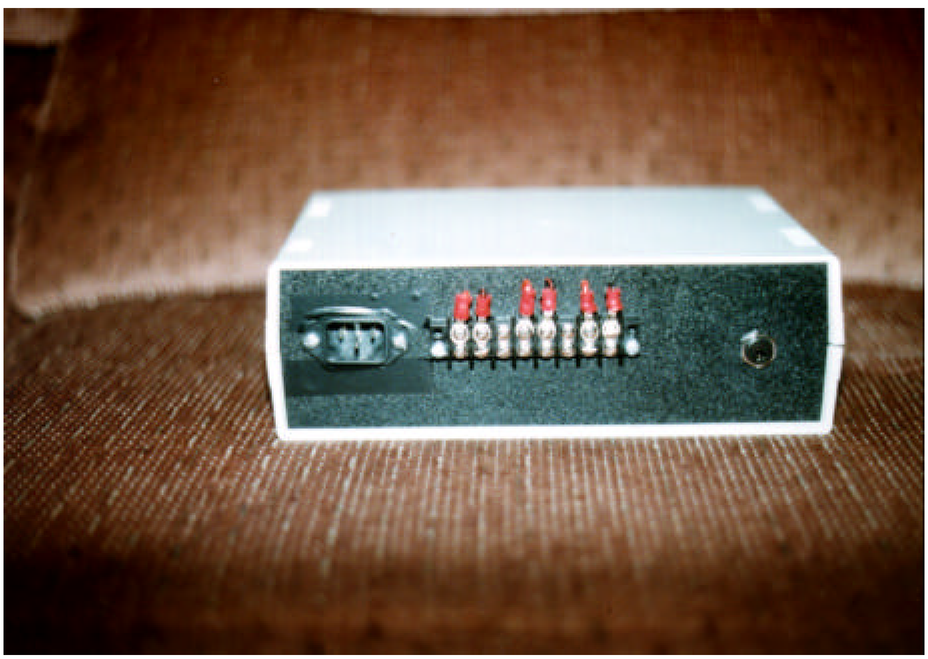

Figure 14.10. Voice Activated Wheelchair Lift Switch.

MOTORIZED EXERCISE BICYCLE

Client Coordinator: Prof. Donn Clark, Assistive Technology Program
Supervising Professor: Alan Rux
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INTRODUCTION

An exercise bicycle was modified by adding an electric motor, for a woman who has limited use of her legs due to a progressive neuromuscular disease. In the past, the client used an exercise bike, but her disease took away her ability to move the pedals. Using this device, she has an opportunity to get the exercise she needs.

SIIMMARY OF IMPACT

An electric motor and modified motor controller were added to an exercise bicycle. The client comments that she uses the bicycle daily, and that it provides needed range-of-motion exercise to her arms and legs, slows muscle atrophy, helps with weight control, and increases her sense of well being. Such an adaptive device could assist others with neuromuscular deficits and perhaps stroke and cardiac patients as well.

TECHNICAL DESCRIPTION

The rider sits on the seat of the DP Air Gometer Exercise Bicycle, placing her feet on the pedals and her hands on the handlebars. When used in its original state, the crank turns as the handlebars move toward and away from the rider. A large plastic fan wheel turns and provides more resistance the faster it turns. The fan was removed. A steel mounting plate was welded on the frame of the bike. To measure the torque required to push the pedals, an able-bodied rider rested his foot on one pedal while a spring scale was hung from the opposite pedal. As he pulled downward on the spring scale, the required force was 19.5 in-lbs. The minimum rate of rotation for the pedals was determined to be 2.5 RPM, while the maximum was found to be 45 RPM.

The DC brush motor selected was a Bison Gear and Engineering series 746 DC Gearmotor #507-02-128 with right angle drive. A matching controller, Minarik Corp. model XPO5-115AC, was purchased. It is equipped with the following features: current limit, voltage (IR) compensation, acceleration adjuster, deceleration adjuster, and maximum speed setting. The motor and controller were an excellent match for this design, as well as the cheapest and simplest solution.

Figure 14.11. Motorized Exercise Bicycle.

The motor, the motor controller, fuse holder, and ground fault interrupter were all mounted to the underside of the frame. A main power switch and power indicator were mounted to the topside of the frame, where the rider can easily reach them. In addition, a start / stop switch and speed control were mounted inside the control box that sits between the two handlebars, in front of the rider. Wiring to the start / stop switch and speed control is fed from the motor controller, up through the frame, and through a hole in the bottom of the control box. Finally, the power cord is strung from the back of the bike, where it can be conveniently plugged into a typical wall outlet. A plastic shroud along with a plastic fan cage was remounted on the front of the bike. The shroud and cage enclose the motor, sprockets, chain, controller, GFI, fuse, and all associated wiring. The only modifications accessible to the rider are the main power switch power indicator, start / stop switch, speed control, and power cord.

The motor controller was set for a maximum speed of 45RPM, the acceleration / deceleration setting was adjusted for a usable ramp rate, and the current limit was set so that if a person's feet fall off the pedals the resistance caused by the pedal against a leg easily stops the motor from rotating.

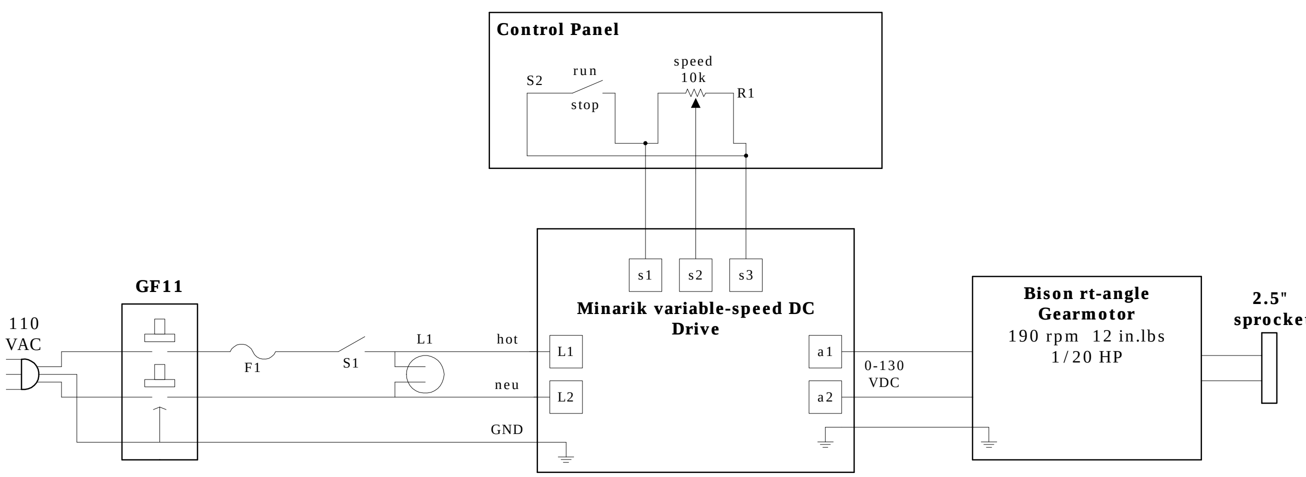

Figure 14.12. Circuit Diagram Used for the Motorized Exercise Bicycle.

WIRELESS REMOTE CONTROLLER

Designer: Nancy Donahue
Client Coordinator: Margaret Mahoney, Anne Sullivan Center, Early Intervention Program, Tewksbury, MA
And Donn Clark, Assistive Technology Program
Supervising Professor: David Wade
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INTRODUCTION

A four-year-old girl can push buttons, but has little strength in her fingers, hands and arms. She can point her forefinger and move her hand slowly but she has neither the accuracy to touch a specific button nor the strength to depress one. A switch box was developed to allow her to control devices such as lights and a television.

SUMMARY OF IMPACT

A Radio Shack Remote Control X10 unit was modified and remounted in a large project box with three large diameter jellybean switches, one pink, one purple, and one yellow (the client's favorite colors). Each appliance module was painted the same color as the switch that controls it. The device allows the client to have some control of her environment.

TECHNICAL DESCRIPTION

There arc three parts to the Plug 'N Power ™ system. The first part, the wireless controller, sends RF signals to the wireless control center, which is plugged into the wall power outlet. The control center then sends signals on a high frequency carrier through the house wiring. These signals are received by appliance modules. They turn the appliances connected to them on and off. The wireless controller makes the Radio Shack's Plug 'N Power ™ system easier to operate for users with physical challenges.

The wireless controller was removed from the plastic box it was purchased in and remounted on a vector prototype board to allow for additional circuitry. The board was, in turn, mounted in a large box, with the three jellybean switches mounted on its top (Figure 14.13).

The house code select switch contacts were removed. Code A to H was then hardwired to switch position A with a jumper wire. The switch contacts for the individual appliance units were also removed and their contact closures were replaced with a CD4066 analog switch IC.

The transmitter required two switches for each device, one to turn the device on and one to turn the device off. The system was modified so that one switch turns the device on and off. A J-K flip/flop, 74HC76 wired in the toggle mode was used to control the analog switches (See switch schematic in Figure 14.15). The switch, when depressed, toggles to the alternate position and also limits the closure and transmit time of the control command signal. A 555 timer IC provides the ground to the analog switch. When the timer releases the ground after 100 milliseconds, the controller sends the proper control codes to the receiver for the appliance modules and then waits for the next jelly-

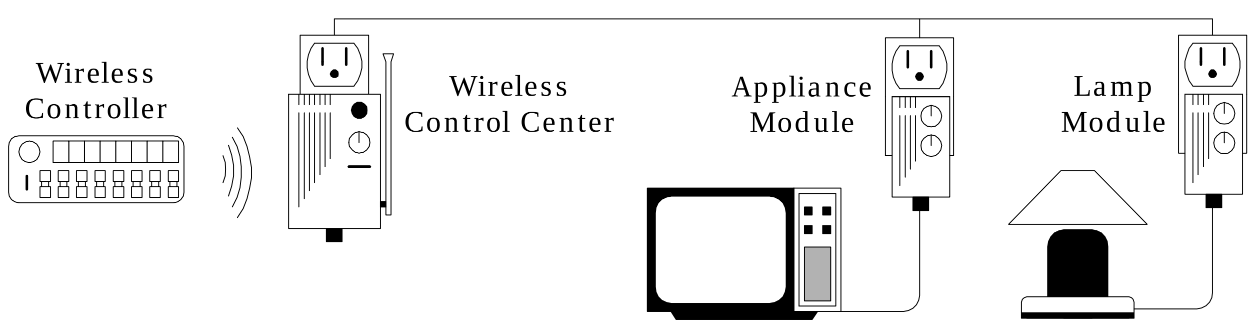


Figure 14.13. Drawing of the Wireless Remote Controller.

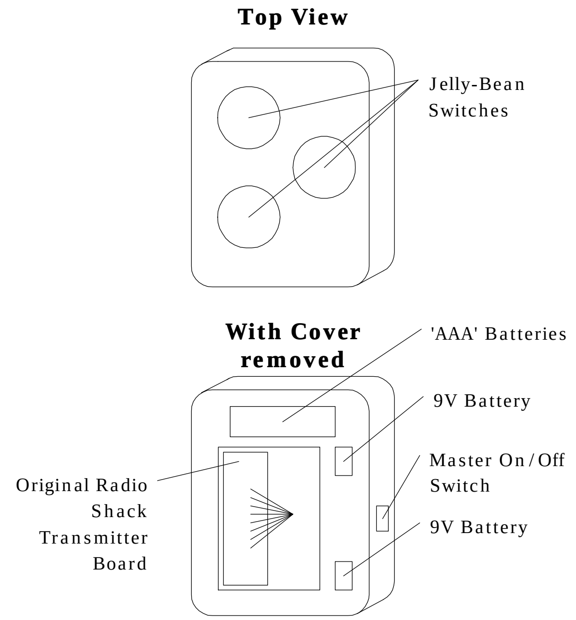


Figure 14.14. Diagram of Switches for the Wireless Remote Controller.

jellybean switch closure. Four AAA batteries provide power to the timer's digital circuit (JK flip/flops and analog switches) via a Master Power Switch. The Radio Shack controller is powered by a nine-volt battery and has its own power-down circuits to limit power drain.

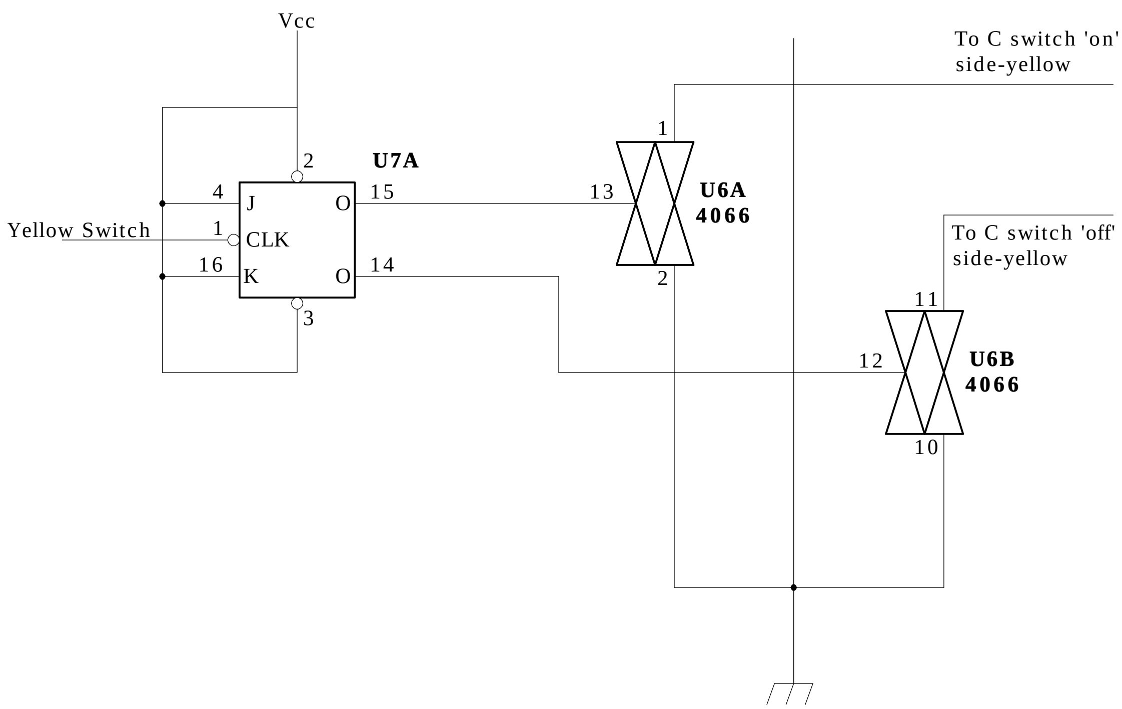
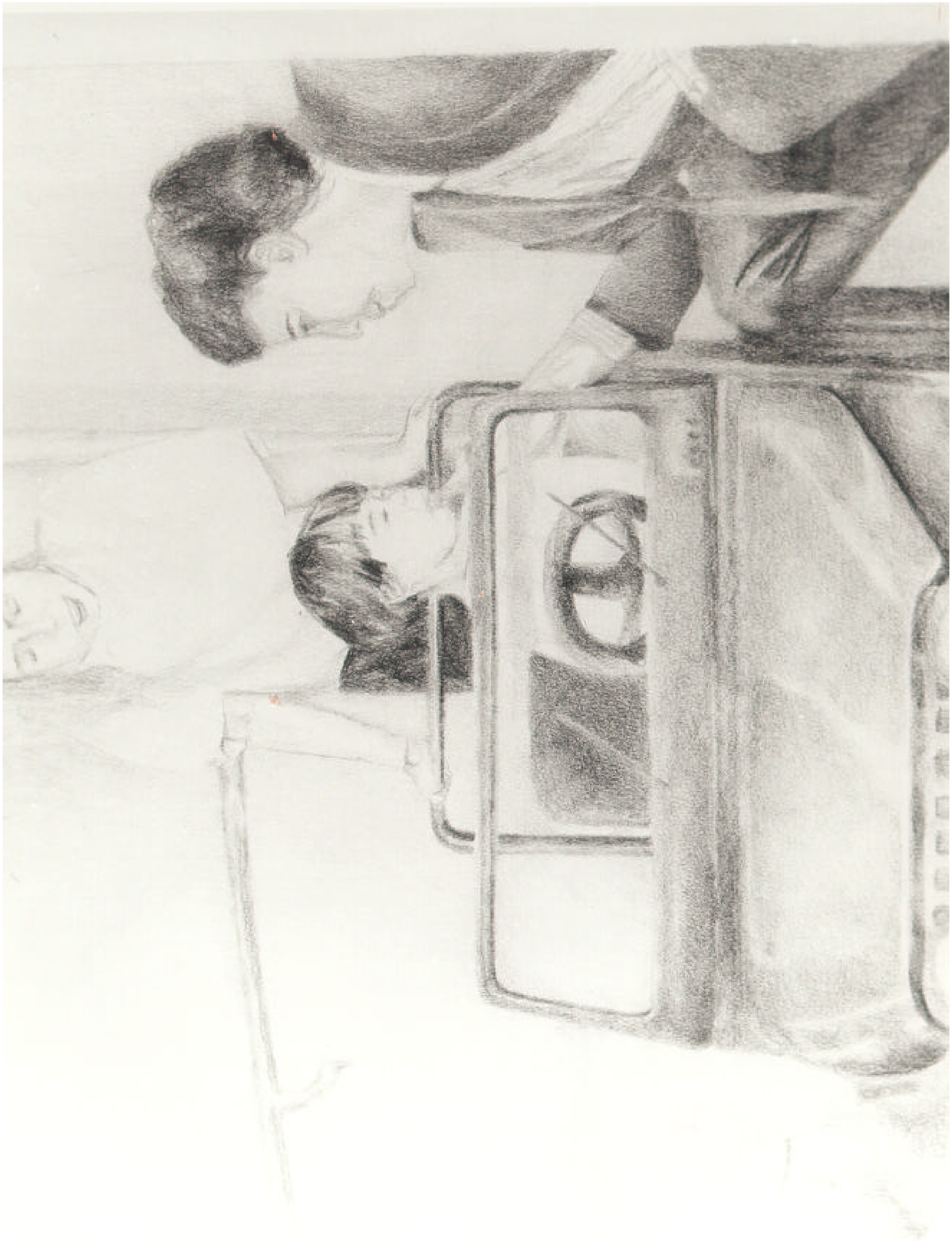


Figure 14.15. Circuit Diagram for Wireless Remote Controller.



Chapter 15
UNIVERSITY OF TENNESSEE AT CHATTANOOGA

College of Engineering and Computer Science
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Principal Investigator:

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WHEELCHAIR LIFT

Designers: M. Bishop, B. Gipson, J. Heywood, J. Lewis, H. Sinson
Client Coordinator: Molly Littleton
Supervising Professor: Dr. Edward H. McMahon
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INTRODUCTION

A mobile device was designed to lift and support a 28-year-old client with hemiparalysis due to hydrocephaly. He is four feet tall and weighs approximately 130 pounds. The client's family members were having great difficulty lifting him. They requested a removable mobile seat that includes an armrest and a lifting mechanism. The device was to be easy to operate, stable and secure.

SUMMARY OF IMPACT

The device met all the client's requirements. A motorized lift was originally included in the design, but the client's family requested a manual lift for weight reduction. Family members are now able to successfully lift and transport the client without difficulty. A suggestion for improvement was a higher back on the chair portion, so a headrest was added.

Figure 15.1 Wheelchair Lift.

TECHNICAL DESCRIPTION

The removable seat and seat back are constructed of 3/8-inch square steel tubing along with 0.5-inch thick plywood, padded with foam and covered in vinyl. The armrests were removed from a standard wheelchair. New armrests were made of plywood and covered with foam and vinyl.

The bottom side of the chair is fitted with hollow channel to accommodate the lift mechanism. A pair of handles on the back of the chair assists in moving and guiding the chair. It is set on four swivel casters to allow for mobility when on the floor. The leg rest was made out of 0.5-inch plywood and has two more casters at one end. The opposite end was connected to the seat frame using nuts and bolts.

The lifting mechanism is shown in Figure 15.2. The side frames and wheel are parts from a standard manual wheelchair. The frame of the lifting mechanism is attached to the side frames using U-bolts. The lifting frame is made from steel tubing. The fixed portion of the frame consists of 1) two horizontal 4” x 4” pieces of tubing attached to the side frames, and 2) two ground and hardened 1” shafts attached vertically between the tubing. The device was built from two pieces of 2” x 4” tubing (attached to the vertical shafts using 4 linear bearings), the forks and the lifting mechanism. The forks are made from 1” x 4” tubing and are attached to the 2”x 4” tubing with wing nuts and bolts. Also attached to the fork mechanism is the lifting device, similar to those commonly used on boat trailers. The handle is side mounted. The 5” wheel was removed from the bottom and replaced by a 2” wheel to prevent tipping. To operate the device, the fork mechanism is engaged with the hollow channel on the seat. The hand crank is used to raise the seat. When raised to the full position, the combined unit operates like a manual wheelchair.

The total cost was $ 820.

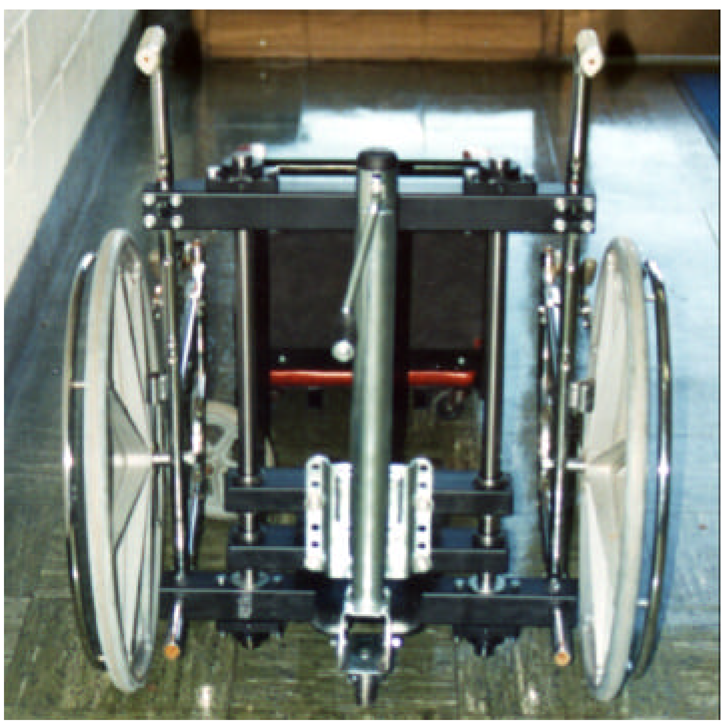

Figure 15.2. Close up of Wheelchair Lift.

TUMBLE FORM LIFT

Designers Brian Collins, Richard Collins, Yong Su Kim, Robert Meeks
Client Coordinator: Judy Kurtz, Dr. Rick Rader
Supervising Professor: Dr. Edward H. McMahon
College of Engineering and Computer Science
University of Tennessee at Chattanooga
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INTRODUCTION

A device was designed to assist a caregiver in lifting a client from a Tumbleform chair into his or her arms. Caregivers who regularly lift clients are susceptible to repetitive strain injury to the lower back. The greatest risk of injury is when the caregiver lifts a person from the ground to a height of 18 inches. Beyond 18 inches there is less strain because the shoulder and back work together to avoid injury. The requirements for the device were that it: lift the patient and Tumbleform chair 18 inches off the ground, be safe for the caregiver and patient, lift the patient in a reasonable amount of time (approximately 15 seconds), be mobile, be compatible with and not damage the Tumbleform chair, lift between 250 and 300 pounds, and be powered internally.

SUMMARY OF IMPACT

The Tumbleform Lift meets the design criteria. The limited switches work well, and the caregivers find the main control switch to be useful.

TECHNICAL DESCRIPTION

The main components of the Tumbleform lift are the frame, the linear actuator and battery, the lifting spoon, and the spoon support. These components and their production are described in detail below.

Frame:

The frame is made primarily of two-inch square steel tubing, welded together. Two solid steel shafts and two one-inch square steel tubes support the top piece of the frame. The solid steel shafts, one inch in diameter, also serve as the guide rods for the lifting spoon. The shafts are attached to the frame at the top and bottom by steel shaft supports. The shafts are secured in the shaft supports by a setscrew or pin. The one-inch square tubes are bolted to the rest of the frame and function as supporting members and as a conduit for the electrical wiring from the battery.

The frame rides on four rotating, locking rubber castors, mounted at each corner. The wheel size of the castors is 2 ½ x 15/16 inches and the mount height is 3 3/16 inches. The plate size is a perfect fit for the two-inch-wide frame at 1 3/16 by 2 inches. Each wheel is rated at a capacity of 90 pounds, which gives a sufficient total capacity of 360 pounds. The caregiver pushes the device with the two bike handlebars, which are welded to the frame.

Linear Actuator:

The linear actuator is simply a screw gear that converts rotary to linear motion. A 12-volt DC motor controls the actuator. The actuator is a standard model with an 18-inch stroke. It lifts up to 500 pounds. The speed of the lift is dependent on the load applied. For typical loads, the speed is 60 inches per minute, which translates to 18 seconds per stroke, close to the target speed of 15 seconds per stroke.

The actuator is safe. It is equipped with an over travel protector, secondary brake, telescoping tubes for shielding, and thermal overload protection. Additionally, the motor is encased in sheet metal to prevent patients or caregivers from coming into contact with it.

The linear actuator is connected by pins to the frame and lifting spoon. The power source for the motor is a 12-volt DC, deep-cycle marine battery. The battery is stored in the steel battery rack bolted to the back of the frame.

Lifting Spoon:

The lifting spoon is the component on which the tumbleform chair rests. It is made of three pieces of sheet steel and three pieces of angle iron, welded together. The angle irons are 2 x 1 x 3/16 inches. The back and side sheets are 1/8 inch thick, and the bottom sheet is 3/16 inch thick. The lifting spoon is designed so that it will extend 4 inches down from where it is welded to the spoon support so that base of the Tumbleform chair can roll over it.

Spoon Support:

The spoon support is the component to which the lifting spoon is welded. It glides up and down the solid steel shafts. The spoon support is made up of welded 2-inch square tubing. Four flanged linear ball bearings are bolted to the support to provide a smooth glide on the shafts. When the bearings are lined up correctly, the nuts can be securely tightened to hold the bearings in place.

The total cost for this device was $ 950.

Figure 15.3. Tumbleform Lift.

ROTATING TASK TABLE FOR FOUR

Designers: B. Dakin, K. Green, D. Leinart, B. Stone
Client Coordinator: Jennifer Chase and Rick Rader
Supervising Professor: Dr. Edward H. McMahon
College of Engineering and Computer Science
University of Tennessee at Chattanooga
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INTRODUCTION

A table with a rotating surface was built for use by two to four clients engaged in tasks to develop motor skills and hand-eye coordination. Clients sit at the table and engage in a sequence of therapeutic tasks, for example, taking plastic square blocks from a small basket and placing them in a container with a square opening. When a client completes a task, he/she presses a large mushroom button. When all of the clients at the table have pressed their buttons, the rotating surface turns, delivering a new task to each client.

SUMMARY OF IMPACT

In the past, each client sat at separate half-moon tables and worked separately. The teacher hand delivered each task and secured it to the table with Velcro. When the client was finished with a task, the teacher removed the task and again hand-delivered a new one. The design of this table allows the clients to work together and have more control of their workspace.

Figure 15.4. Rotating Task Table.

TECHNICAL DESCRIPTION

The table has a square tabletop with a rotating round center that is flush with the top of the table. The equipment for the tasks is attached to the round section with Velcro strips. A motor is mounted beneath the center of the table with cross-type bracing to support it. A cam switch controls the rotating motion. The power source is AC.

The motor is 1/14 hp with a gear reduction of 1:256. The final speed is 5.6 rpm. The four switches on the table and a limit switch mounted to a cam on the shaft control the motor. When all four buttons are pushed, the tabletop rotates 1/4 turn. If less than four clients are at the table, the switches are disconnected, automatically closing the relay. The circuit is shown in Figure 15.5.

The tabletop is 75" x 75", constructed of multiple sheets of 3/4" plywood. The moving portion is made of sheet metal. Both the moving and fixed parts of the table were covered with 1/4" Plexiglas. Cutouts were made in the table to permit wheelchairs to be moved close to the table. The legs are removable so that the device is portable.

The total cost for the table for four was $875.

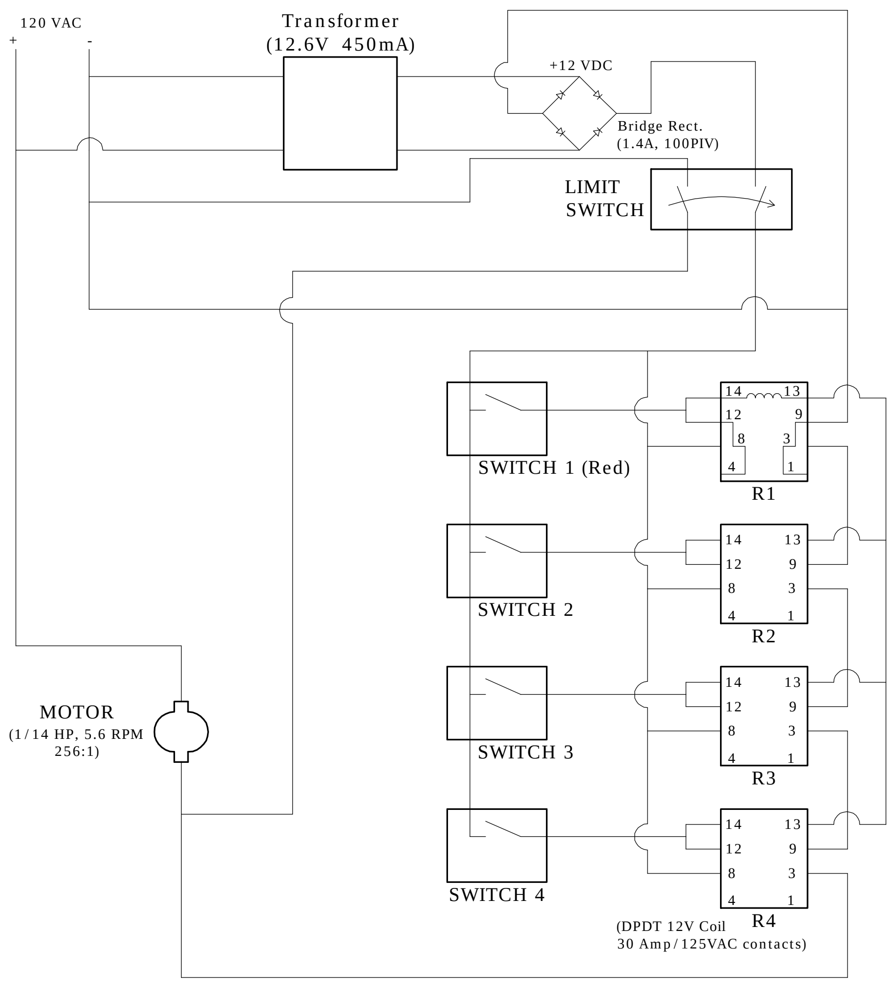

Figure 15.5. Circuit Diagram for Rotating Task Table.

SUNSHINE ON DEMAND

Designers: Mike Lawson, Don Holmes, Greg Iles, Ken Cox
Client Coordinator: Karen Lasseter, Dr. Rick Rader
Supervising Professor: Dr. Edward H. McMahon
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University of Tennessee at Chattanooga
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INTRODUCTION

The Sunshine On Demand project was created to assist a client with seasonal affective disorder. One treatment for seasonal affective disorder is increased real or simulated exposure to sunlight. A light box was built, using high intensity fluorescent bulbs to simulate sunlight. The client sits in front of the light box for 30 to 60 minutes per day, providing her the benefit of sunlight on days when it is not possible to go outside.

SUMMARY OF IMPACT

Sunshine On Demand provides an artificial sunlight source in a safe and practical manner. The light box uses minimal space and is portable, having wheels and weighing only 13 pounds. The design is also safe. A Plexiglas diffuser protects all of the bulbs in the light box. Power to the foot switch has been reduced to 12 volts DC. The timer helps prevent overexposure.

TECHNICAL DESCRIPTION

The light box was purchased from SunBox Company of Gaithersburg, Maryland, and has a 7-year warranty. The light box measures 23 by 15.5 by 3.25 inches and weighs only 13 pounds. It produces 10,000 LUX of light, sufficient to treat the client.

A timing circuit was added to control the client's daily exposure. This circuit uses a motorized timer to keep track of the total time the light box is on each day. For example, if the timer is set for 30 minutes and the client activates the light box for 5 minutes, the timer counts off 5 minutes and allows the remaining 25 minutes to be used at a later time, until the timer is reset. The timer is controlled by a foot switch for easy use. As a safety precaution, power to the foot switch has been reduced to 12 volts DC. The circuit is shown in Figure 15.7.

The light box and timer are mounted to a tubular steel stand. The frame was be made of 1-inch tubing for the main supports and 1-inch tubing for the cross braces. All tubing was welded together for strength and appearance. Wheels were

Figure 15.6. Sunshine On Demand.

added to the back of the stand to allow for easy moving, but they do not touch the floor unless tilted, to prevent unwanted rolling. The stand was painted yellow with DuPont® paint. The light box was mounted onto the stand and an adjustable bracket was used to allow the light box to swivel. The timer circuit was placed in a plastic electrical box and mounted onto the stand.

The total cost for this device is $700, including the light box.

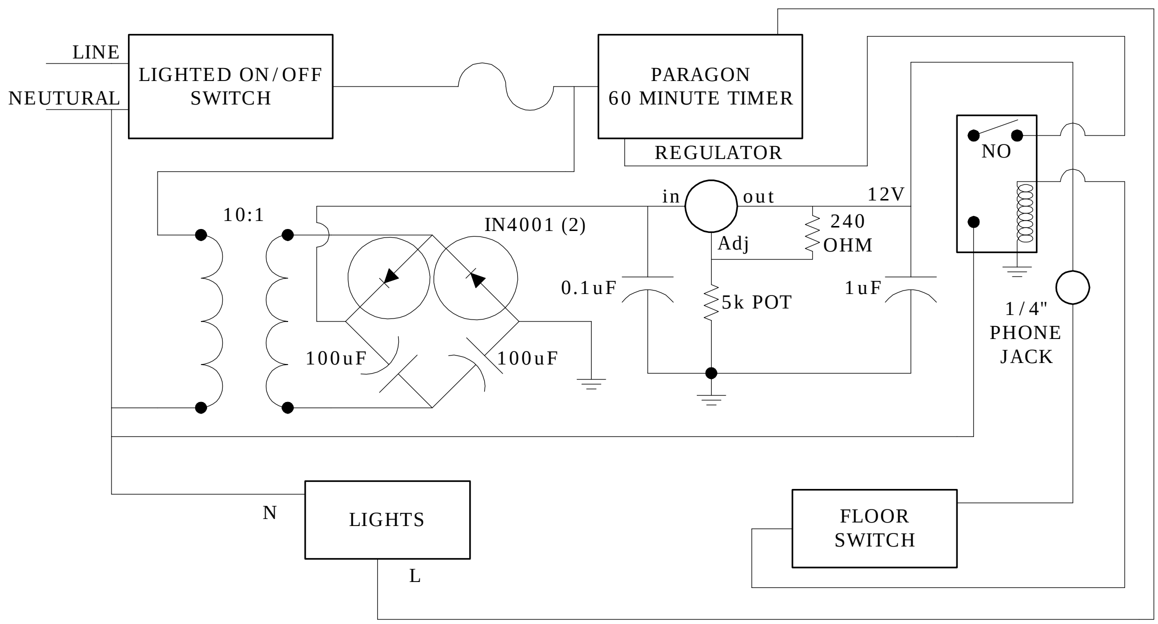

Figure 15.7. Circuit Diagram for Sunshine On Demand.

PAIN-O-METER

Designers: Tim Cunnyngham, Deanna Dailey, Mahssa Eftekhar, Doug McAlister
Client Coordinator: Dr. Rick Rader
Supervising Professor: Dr. Edward H. McMahon
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INTRODUCTION

The Pain-O-Meter was designed to allow a nonverbal client and/or a person with a cognitive disability to communicate the extent of pain to a caretaker and/or doctor. Keys display a series of facial expressions depicting varied levels of pleasure and pain. The number of keys was reduced to four to facilitate decision making for the patient.

SUMMARY OF IMPACT

The project assists caregivers in determining the extent and type of pain so that they may respond quickly and appropriately.

Figure 15.8. Pain-O-Meter

TECHNICAL DESCRIPTION

Circuit: The circuit (Figure 15.9) consists of a variety of electronic elements. Five digital voice chips were used to produce the five different pain level indicators. Five uA741 op amps were placed between the voice chips and the speaker to act as a buffer. A microphone, 5 mini momentary SPST push buttons, and 5 SPST toggle switches were used for recording sounds on the voice chips. The toggle switches were used as a safety device to prevent accidental erasure of the set recordings. The push buttons allow the recorded message to be changed after the toggle switch has been turned on. The power source is an AC/DC 9-volt converter that can be plugged into a wall outlet to run off a typical 110-voltage source (household electricity). A 2K-ohm resistor and a 2.5K resistor were used to step the 9-volt power source down to a 5-volt power source that can be used by the voice chips. A DPST toggle switch was used to turn the power on and off for the Pain-O-Meter. Five momentary SPST pushbutton switches were attached to the voice chips so that, when they are pushed, a voice is heard describing the level of pain that the patient has. There are indicators for five different levels of pain, varying from no pain to excruciating pain.

Cabinet Dimensions: The cabinet for the Pain-O-Meter is made of ABS plastic. The keyboard top and the back panel are made of aluminum so that the parts to the design can be mounted easily. The entire size of the cabinet is 10" in length, 8.0" in width, and 4" in height. The aluminum keyboard panel was 8" in length and 8.31" in width. The push buttons that indicate each level of pain have a 0.25" diameter. The labels that represent each level of pain are located above each push button. The microphone is located on the upper right corner of the rear panel, along with AC/DC plug and the five toggle switches.

The total cost is $ 300.

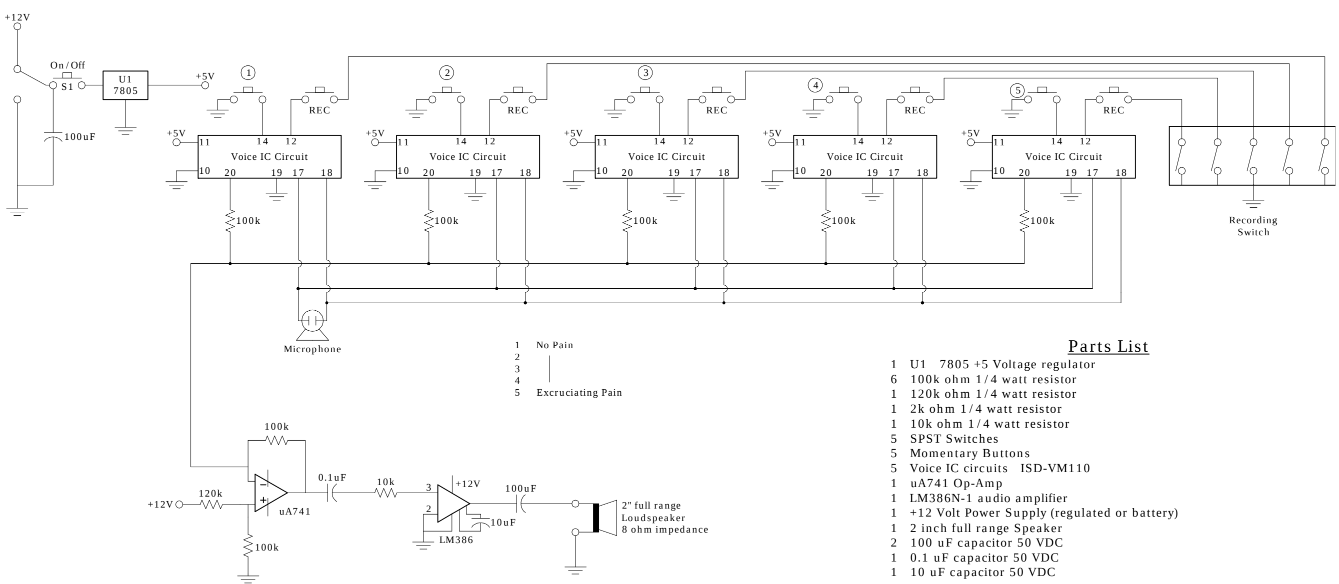

Figure 15.9. Circuit Diagram for the Pain-O-Meter.

MOTORIZED SWING

Designers: Scott Daniels, Jason McGlohon, Jason Hooper, Verle B. Thompson III
Client Coordinator: Laura Meyers, Dr. Rick Rader
Supervising Professor: Dr. Edward H. McMahon
College of Engineering and Computer Science
University of Tennessee at Chattanooga
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INTRODUCTION

The motorized swing allows children to teach themselves cause and effect relationships while enjoying stimulating motion. The swing can be controlled by a child, using a remote switch, or by a caregiver. A timer on the device allows the client to operate the device for a set period of time. For the swing to continue to move, the client must restart the swing. The most important design considerations were safe operation, mobility, ease of accessibility, and a maximum weigh limit of 100 pounds.

SUMMARY OF IMPACT

The swing is in use and the client appears to enjoy it greatly.

TECHNICAL DESCRIPTION

The final design for the motorized swing is composed of an A-frame, constructed from 3/4" pipe, and a drive mechanism, incorporating a DC variable drive motor connected to a drive plate to move the swing arm.

The entire swing rests on four "feet", which level the swing on uneven floors. The swing becomes mobile when tilted back onto two casters on the back of the frame base. The frame can be easily moved from room to room. The bars that support the Tumbleform chair are covered in foam pipe insulation for added safety. A sheet metal box encloses the motor with two exhaust fans to reduce heat build-up. The swing is manually operated by either: 1) the child, via a pressure plate switch located on a tray in front of him/her, or 2) the caregiver, via a manual on/off switch. A "panic" button, on the front of the motor cover box, automatically shuts off the swing. A fuse box on the inside of the motor cover box protects the motor and circuitry in case of a power surge.

The frame was bent using a conduit bender, then welded at the top center. The crossbars were cut with a pipe cutter and welded into place. All of the plate metal pieces were cut from a single sheet of 1/4" steel using a torch. The rough edges were ground off using a disc grinder. The holes for the drive plate bearings and the hole in the drive wheel were drilled. The slots in the drive plate were machined. The bolt holes in the motor support plate were drilled.

Figure 15.10. Photograph of the Motorized Swing.

The total cost for this device is $900.

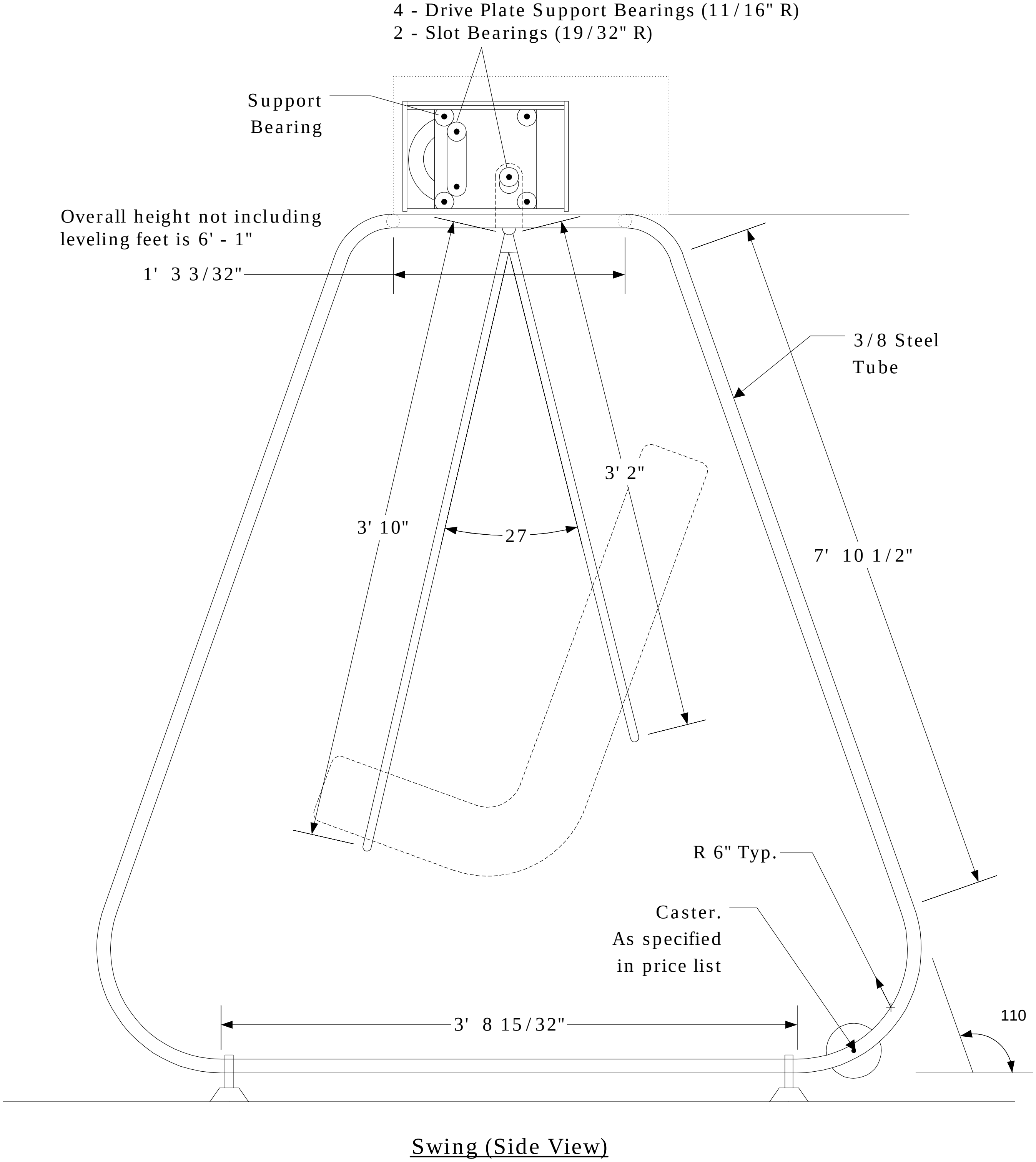
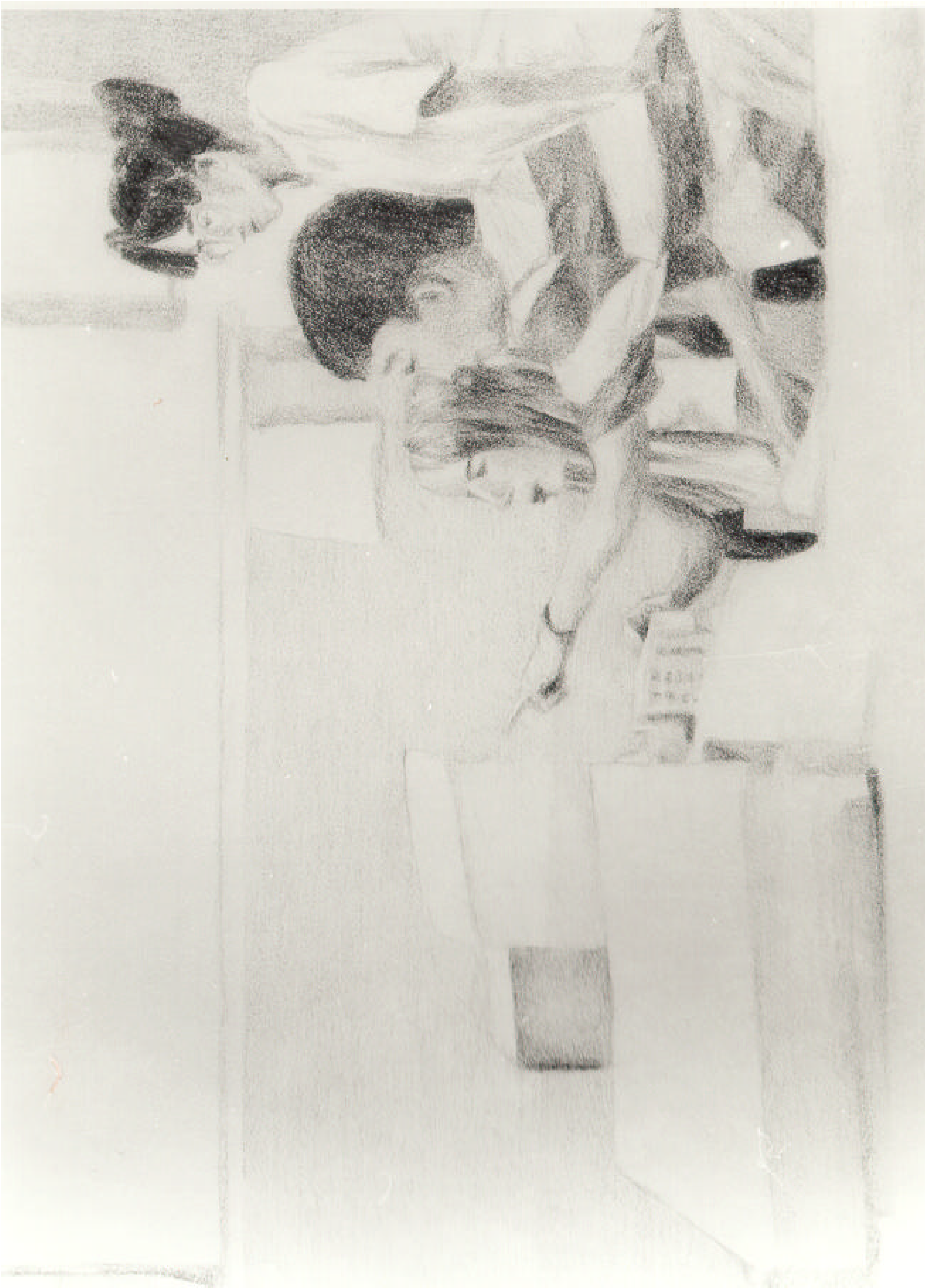


Figure 15.11. Mechanical Drawing of the Swing.



Chapter 16
UNIVERSITY OF TOLEDO

College of Engineering
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WHEELCHAIR STAIR LIFT SYSTEM

Designers: Steven Zetts, Hamad Nasser Al-Ajmi, Takeshi Maeda, Shawn Weaver, Mechanical Engineering Students
and Heng Aik-Hoong, Electrical Engineering and Computer Sciences Student
Client Coordinator: Dr. Gregory Nemunaitis, Department of Rehabilitative Medicine, Medical College of Ohio
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INTRODUCTION

A wheelchair lift system was designed to transfer a client in a wheelchair from the main floor of his residence to his basement. A stairway must be available to other occupants of the house. The client remains in his wheelchair during the transport. Modification of the wheelchair has been minimized. The system required replacement of the existing steps. It includes a cantilevered platform, a chain driven lift, and two structural channels for support.

SUMMARY OF IMPACT

The wheelchair lift system allows the client access to his basement. It conforms to ASME codes and standards.

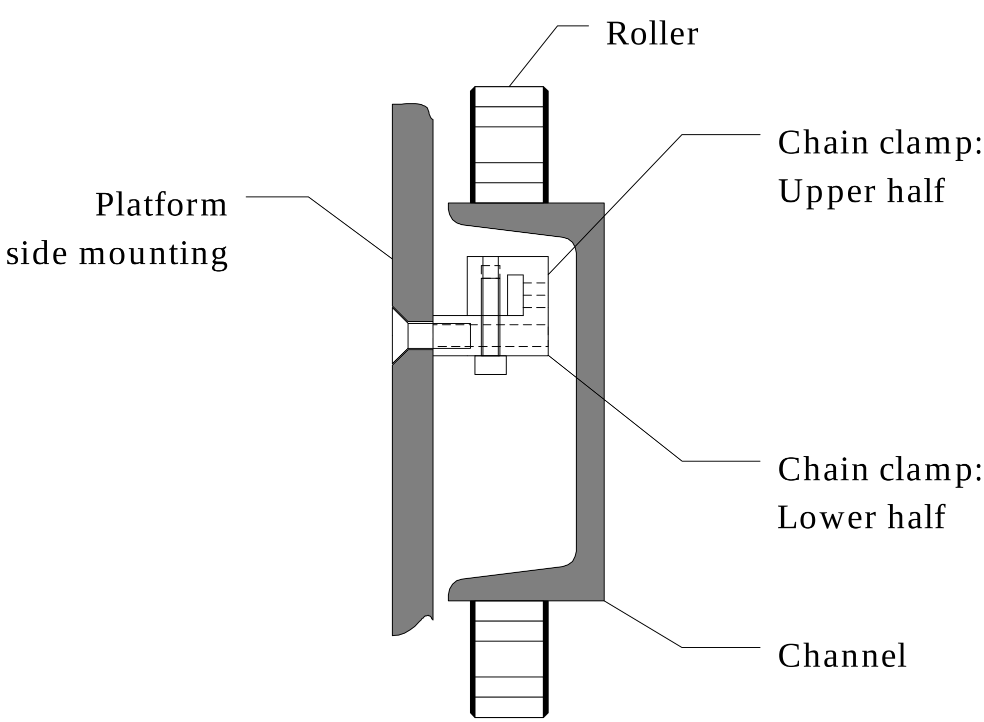

Figure 16.1. Schematic Illustration of the Wheelchair Lift System.

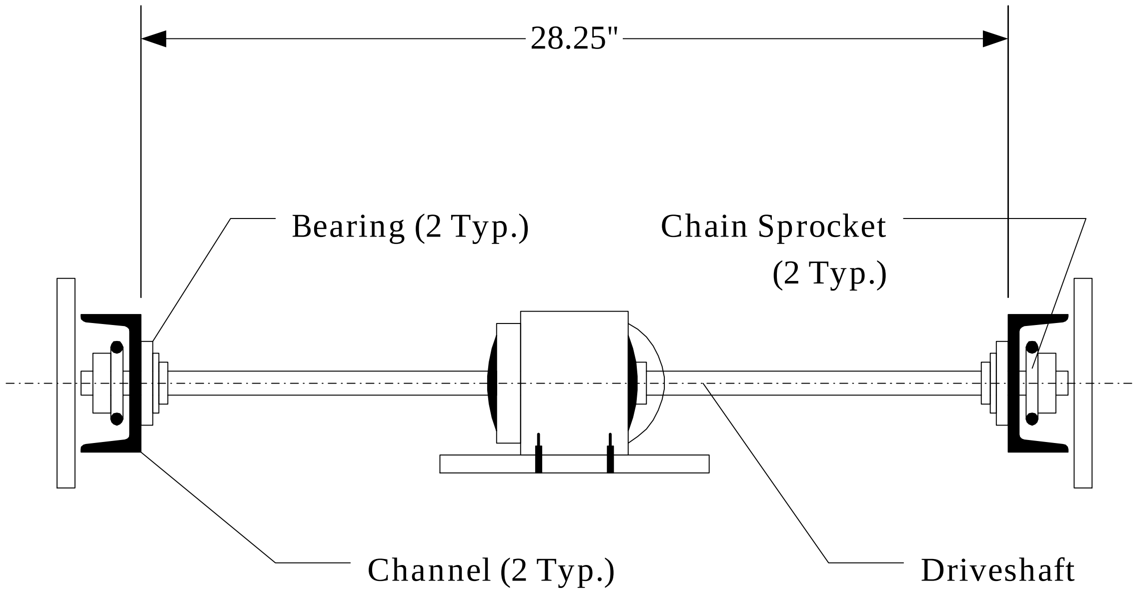

Figure 16.2. Components of the Drive System.

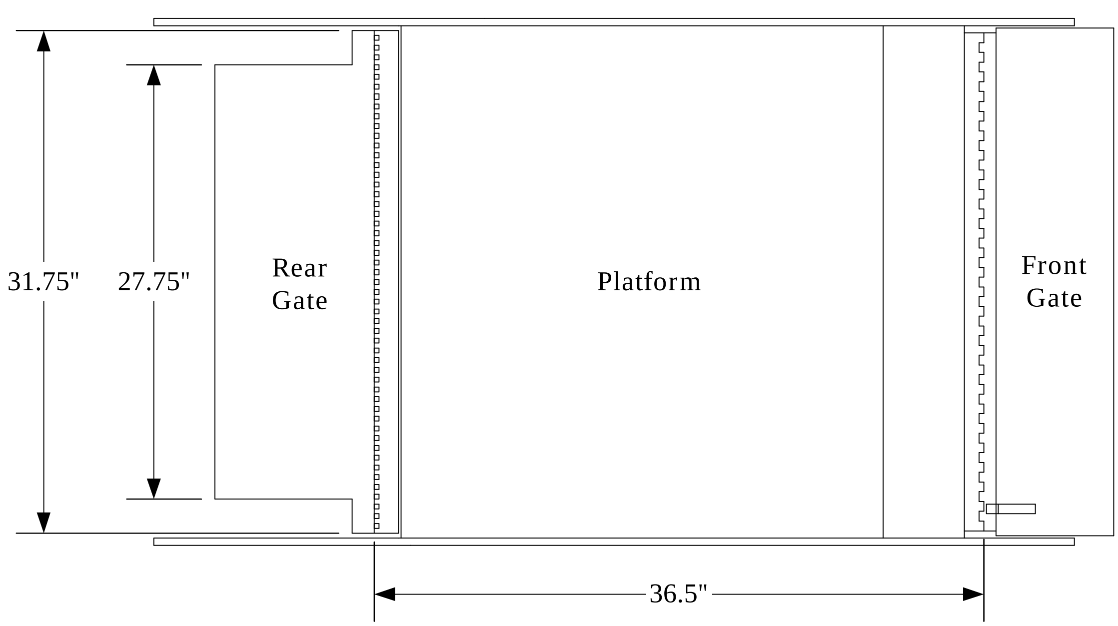

Figure 16.3. Platform with Front and Rear Gates.

TECHNICAL DESCRIPTION

The design and development of the system consisted of four main parts: 1) replacement of existing steps, 2) design of a cantilevered platform to carry the wheelchair up and down, 3) design of a chain-driven lift to move the platform and the wheelchair up and down, and 4) design of a structural support system. Figure 16.1 shows a schematic illustration of the main components of the system and depicts the platform side mounting, the chain clamps, and the channel supporting system.

A steeper stairway was required, to provide clearance between the lift passenger and the existing header. This was a simple matter since the basement is unfinished. A stairway angle of 45^{o} provides sufficient clearance. The width of the stairway was reduced to 27.5 inches to accommodate the platform support channels. The new steps did not meet current building codes. A "Non-conforming Permit" was obtained, given that the proposed configuration represented a structural improvement. The door at the top of the stairway was replaced because it opened toward the stairs, obstructing the placement of support channels between the doorjambs. A wider (36") door, aligned with the stairway opening in the floor, makes it possible for the 27" wheelchair to pass.

Two structural channels, below the platform, running parallel to the stairs, provide a support system. They are bound by the 35" opening in the main floor, allowing sufficient space for the wheelchair to pass. The platform that carries the wheelchair was cantilevered using rollers on either side. Each channel is lag bolted to the floor joists at the top of the stairs and to the concrete floor at the bottom of the stairs. The width of the platform was maximized so that it just fits through the opening in the main floor.

A chain-driven system provides a cost-effective means of moving a platform on rollers. The drive system is a brake motor flange mounted to a helical-worm gear drive with a hollow shaft output. Figure 16.2 illustrates the different components of this system, including a motor and a drive shaft. The motor, obtained from Boston Gear, is splash-proof, with an output of 39 RPM (yielding a chain speed of 28 ft/min w/17 tooth drive). The shaft has #40 chain drive sprockets at both ends. The chain has a load rating of 4300 lbs, 20 times the actual load.

The platform shown in Figure 16.3 has attached rollers that follow the support channels. It descends at the same angle of the steps, 45 degrees. Safety gates at either end of the platform secure the wheelchair. Polyurethane rollers, used as followers, offer a smooth and quiet ride, are lightweight, low cost, and require no lubrication.

The platform is normally at the bottom of the steps, allowing the stairs to be used in the usual fashion. An open, spring loaded, pushbutton switch serves a call switch at the top of the stairs. The passenger controls the platform while in transit, using with a normally-open, three-position, spring-loaded toggle switch. The platform automatically stops when it arrives at the full up and down positions. Microswitches at both ends are used to open the proper electrical circuits. A spring retractable electrical cable reel provides power to the platform. A sensor plate that covers the underside of the platform, required by code, has several lever-actuated switches attached. If any switch is activated, power to the motor is cut, and the lift stops. The electrical circuit schematic for this control system is shown in Figure 16.4.

The 120 V AC reversible break-motor, operating at 0.5 hp and 1725 rpm, is geared at a reduction ratio of 45:1. This AC motor network includes 4 sets of safety sensor switches or microswitches located on the safety plate, at the rear gate, at the front gate, at the bottom of the stairway, and on the safety belt. The safety switches at the front gate and at the bottom of the stairway are in parallel and linked together with the rest of the safety switches in a cascade form. An override button feature is connected across and in parallel to all the safety switches. This allows the user flexibility and authority in making a decision against any warning signal triggered by the safety switches. On the other hand, the control system network runs on a separate independent DC power supply because the logic control unit and relays are incompatible with AC power supply characteristics.

Two parallel toggle switches are incorporated in the logic control unit. The one labeled "call box" is stationary and mounted at the top of the flight of stairs, while the other, labeled "control box" is on the platform. The signal from the DC power source is split in two when fed into the logic control unit. One goes through a buffer, while the other is channeled through an inverter. These two opposite signals then flow through two separate relays, located exactly between the motor and the AC source. Both of these relays are SPDT (Single-Pole-Double-Throw) contacts. The two relays act as the polarity flipping mechanism. The motor stage (which depends on the correct direction of rotation to run) operates as desired when the joystick toggle switch is pushed or pulled.

This project was budgeted at $2,000. Total spending did not exceed $300, as local businesses and friends of the client donated about $1700. Contributions included: a motor and gear box, donated by Boston Gear; materials donated by E & C Manufacturing and Art Iron Inc., both from Toledo, Ohio; machining of several parts, by Custom Machine & Tool from Palmyra, WI; and construction the new stairway, by the woodworking shop of Sylvania Southview High School.

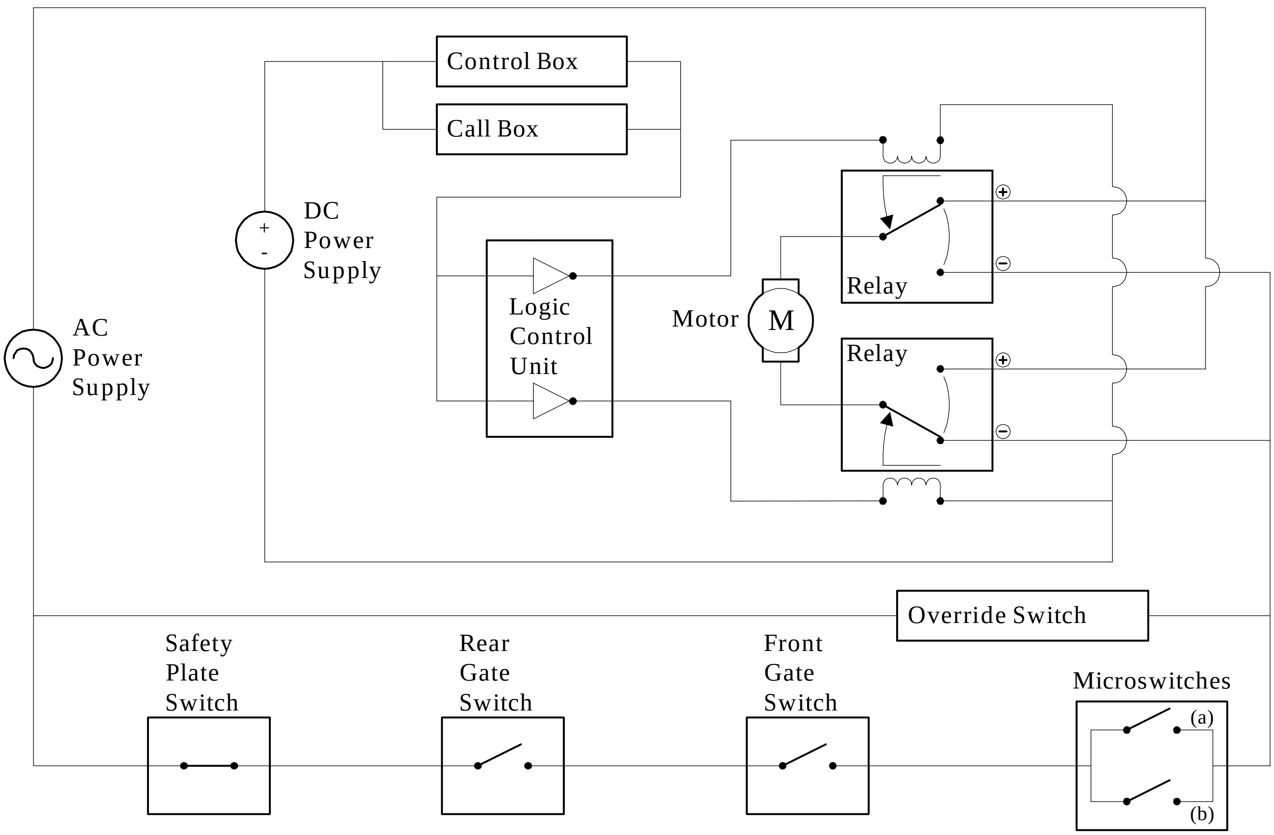

Figure 16.4. Schematic of the Electric Circuit for the Control System.

FOLDING SHOWER/COMMODE CHAIR

Designers: Theodore Mosler, Matthew Beier, Nathan Newlove, Ahmad Al-Jasem, Ali Al-Luqman, Ahmad Awad, Bachmai Cao, Mathew Steiner, Tynesha Wells, Ling Mei Wong
Client Coordinator: Dr. Gregory Nemunaitis, Department of Rehabilitative Medicine, Medical College of Ohio
Supervising Professors: Dr. Donald Leo and Dr. Nagi Naganathan
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INTRODUCTION

A folding shower/commode chair facilitates travel for a person with tetraplegia. The prototype is lightweight and includes folding armrests, a transfer seat, and interchangeable cushions. It can be folded to be compact for travel and storage. The front legs rotate towards the back. The armrests disengage from the seat frame and rotate upward 90 degrees for chair access and downward 270 degrees for travel and storage. The seat frame folds upward against the back frame. The chair frame, seat frame, transfer seat, and armrest are aluminum. The seats, armrests, and back support cushions are made of Wolmanized plywood and covered with a layer of foam and vinyl for comfort.

Figures 16.5 and 16.6 illustrate the shower/commode chair, in both folded and unfolded positions.

Figure 16.5. Unfolded Shower / Commode Chair .

Figure 16.6. Folded Shower / Commode Chair.

SUMMARY OF IMPACT

The shower/commode chairs being used at the Medical College of Ohio serve dual purposes. They can be put into a bathtub for an individual to sit down and take a shower, or they can be wheeled directly over a standard toilet or a space large enough for a receptacle to be placed underneath. Wheels with brakes allow the chair to move freely or lock in place. However, these chairs are too bulky for travel. For automobile travel, they must fold to a compact size.

TECHNICAL DESCRIPTION

The criteria specified by the client were that the chair be compact and lightweight, have a strong back piece to support the user, have rigid armrests to provide support, something to prevent water from escaping onto the floor, and armrests for easy transfer from the wheelchair to the shower/commode chair and vice versa. To prevent pressure sores, the client requested that the seats be padded and interchangeable - one for the commode and one for the shower chair. Wheels were not necessary.

The chair is 36 inches high and 18.5 inches wide, which allows it to fit inside a standard bathtub, and still fit over the largest commercial or residential toilet. When completely folded, its height and width do not change, but its depth decreases from 18 to 4 inches.

The chair frame was constructed from 7/8 inch 6061-T6 anodized black aluminum tubing, which offers good mechanical strength and is ideal for welding. It folds so that the back of the frame, made from bent aluminum tubing, remains rigid. The seat folds up toward the back. One of the front legs folds toward the front, the other toward the back. The armrests fold down.

The seat is connected to the back of the chair frame by a continuous aluminum hinge, which evenly distributes the load applied to the seat across the seat's back support. The front legs are connected to the back frame by horizontal tubes and sleeves which rotate about the back legs, locking in the open or closed position via pull ring spring plungers. With the spring plunger pin protruding through the rotating sleeve, it can be easily guided into two holes drilled in the back leg for the open and closed positions. By pulling on the ring handle and rotating the front leg, the ring may be released and the leg turned until it snaps into position.

The frame was connected using mechanical fasteners and welding. A back brace was used to provide the seat back support. A continuous hinge on the back brace allows the seat frame to be folded up. Aluminum angles, with leg dimensions 1 x 1 x 3/16 inches, were used for the back brace and the seat frame. The inside dimension of the seat frame is 18.5 by 16 inches.

Holes were drilled in the side angles of the seat frame, to allow the transfer board and armrests to lock in place. The armrest consists of two main parts, the pivoting arm and the leg. The arm is made of 1 x 1 inch channel, 1/8 inch thick. Mounted on the arm is a 1/2 inch vinyl-covered cushion placed over a piece of wolmanized plywood. The leg, made of aluminum tubing (OD of 5/8 inches, wall thickness of 0.065 inches), rotates about a pivot on the arm. A plastic stopper and a handle are also mounted on the leg.

The armrest can be folded up along the back frame, allowing the user to transfer from a wheelchair to the shower/commode chair, and vice versa. The armrest can be folded by rotating it 270 degrees in the downward position so that the height of the folded chair will not exceed the height of the back frame. A transfer seat can be attached to the right or to the left side of the shower/commode chair. Its legs are adjustable to account for any height difference that may occur between the bathroom floor and the base of the bathtub.

Four water resistant cushions were designed: a shower seat cushion, a commode seat cushion, a transfer seat cushion, and a backrest cushion. Also, two armrest cushions were added to provide padding for the armrests. All of the cushions were constructed by wrapping marine vinyl around a piece of open cell foam and Wolmanized plywood. The open cell foam provides soft padding on top of the plywood, which provides support. An elliptical hole was centered on the commode seat cushion. In order to prevent water from spilling from the bathtub, the transfer seat cushion tilts to an angled position, channeling any water that runs onto the transfer seat back into the bathtub.

All design calculations conform to the structural strength specifications of the American with Disabilities Act (ADA). The total weight of the main chair is 20.7 lbs., the weight of its frame being 7.2 lbs. and the weight of its cushions 13.5 lbs. The total weight of the transfer seat is 6.9 lbs., the weight of its frame being 3.2 lbs. and the weight of its cushion 3.7 lbs. The total combined weight of the chair, the transfer seat and cushions is 27.6 lbs. The cost for parts was $600. Construction of the chair was done at Bionix Development Corporation in Toledo, Ohio, and at the University of Toledo Mechanical, Industrial and Manufacturing Engineering machine shop.

GRASS FUNCTIONING WHEELCHAIR TIRE ASSEMBLY

Designers: James Johnson, Anthony Kehres, Mohamad Badreddine, Faisal Omar Mahroogi,
Client Coordinator: Dr. Gregory Nemunaitis
Rehabilitative Medicine, Medical College of Ohio and St. Vincent Mercy Medical Center
Supervising Professor: Dr. Nagi Naganathan
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INTRODUCTION

A universal castor enables patients in wheelchairs to traverse various types of terrain while retaining maneuverability. The design incorporates a wide tire to increase maneuverability on soft surfaces and a raised center to retain chair performance on hard surfaces. Computer controlled machining was used to machine the tires since they incorporated a series of large radii in their profiles. Large radii create a smooth transition between the various surfaces on the tires, improving function by reducing the perpendicular forces that oppose turning, and by introducing a vertical force component that promotes a sliding effect to improve turning.

SUMMARY OF IMPACT

The client is an active person with paraplegia who uses a wheelchair that has the tendency to sink into the soil and tip over. A new tire / wheel assembly was designed and manufactured to maintain the current wheelchair maneuverability on hard surfaces while improving it on softer terrain. The new tire showed an improvement in supporting the load by exhibiting a decrease in the sinking depth from 2" to 0.5". Improvements in the turning and transition movements on dry lawn surfaces were also achieved.

TECHNICAL DESCRIPTION

With the original wheelchair tire assembly, the front tires were sinking into the soil as client traversed his lawn. Forward movement was difficult and turning nearly impossible. The main problem was to prevent the front wheels from sinking into the soil. This could be achieved either by shifting the center of mass so that less weight would be put on the front tires, or by increasing the surface area of the tire to provide better weight distribution. Because increasing the contact area of the tire would cause a decrease in maneuverability on hard surfaces, the goal was to increase surface contact on soft surface, while minimizing surface contact on hard surfaces. Wide tires that distribute the weight over a larger area are available in the market, but result in reduced maneuverability on hard surfaces. Figure 16.7 shows a schematic of the total assembly. It includes a tire assembly, a fork, and an axial shaft. The tire assembly shown in Figure 16.8 in-

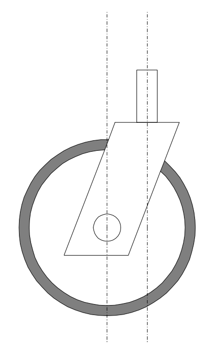

Figure 16.7. Total Castor Assembly.

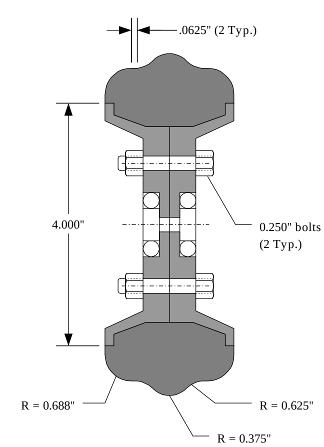

Figure 16.8. Tire Assembly.

cludes a three-piece tire/rim assembly in which the two-rim section is made of polypropylene and the tire is made of polyethylene. Polypropylene was selected for its hardness, rigidity, and low reactivity. Polyethylene was selected for low reactivity, good wear resistance, and sufficient stiffness. The tire assembly turns inside a fork made of 1 in. thick stainless steel plates. The tire assembly is also mounted on a 5/8 in. diameter stainless steel shaft using 2 radial bearings (shown in Figure 16.8), each having 2 seals. Each bearing is rated at 500 lbs. The width of the new tire was chosen as 3 inches as opposed to the 1.25 in. width of the original manufacturer tire. The commonly used Bearing Capacity Equation was used to calculate the required area to support the weight of the client and his wheelchair. The trial and error method was then used to determine the sinking depth that produced the calculated support area; this depth was estimated as 2.0" for the manufacturer tire and 0.5" for the new wide tire. Reduced sinking caused a reduction in the side forces that oppose turning.

The tire profile, shown in Figure 16.9, incorporates a bell-raised center to maintain the present maneuverability on hard surfaces. The raised center has smooth sloping radii with no sharp edges. The purpose of the radii is to minimize the perpendicular contact of opposing forces while turning in soft surfaces when the raised center is embedded in the soil. By avoiding normal contact there is a vertical force component that reduces resistance and induces sliding over the soil instead of soil displacement. This sliding effect further enhances turning ability on soft surfaces. Treads were omitted to reduce friction.

Computer numerically controlled (CNC) machining was employed to manufacture the tires. All components were manufactured at the Mechanical Engineering machine shop, including the CNC machining.

To analyze the characteristics and the effectiveness of the design, subjective and objective data were collected through a series of test runs using the prototype. During each run, the forces required to initiate the movement are directly measured using a series of linear spring scales attached to the drive wheels. After the run is complete, the operator fills out a questionnaire, using a 1 to 10 scale, 10 being excellent and 1 being poor. Tests were conducted on concrete and on dry lawn. Five types of maneuver were evaluated: 360 degrees right and left turns, forward and reverse motions of 10 feet, and forward to reverse motion.

During the right (left) turn test, the wheelchair was positioned on the test surface with the right (left) wheel brake in the on position. With the chair stationary, a force is applied to the left (right) rear tire to create the 360 degrees turning motion. During the forward (reverse) motion test, the wheelchair is positioned on the test surface and moved forward (reverse) 2 to 3 feet to align the front wheels with the rear wheels. With the chair stationary, equal forces are applied to both rear tires simultaneously to create a 10 ft forward (reverse) motion. During the forward to reverse motion test, the wheelchair is positioned on the test surface and moved forward 2 to 3 feet to align the front wheels with the rear wheels. With the chair stationary, equal forces are applied to both rear tires simultaneously to create a reverse motion that continues until the front tires are realigned with the rear tires.

Test results indicate improvements on dry lawn surfaces over the standard tire in turning and transition movements. The rigidity of the tire material causes damage to the interior flooring, so a material change is recommended.

The cost of all material is $225.

HAND POWERED BIKE

Designers: Justin Daugherty, Omar Alzaffin, Steven Emerick, Easa Obaid Al-Suwaidi
Client Coordinator: Dr. Gregory Nemunaitis, Department of Rehabilitative Medicine, Medical College of Ohio
Supervising Professors: Dr. Nagi Naganathan and Dr. Donald Leo
Department of Mechanical, Industrial & Manufacturing Engineering
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INTRODUCTION

The purpose of this project was to build a hand-powered bike for a client with quadriplegia. A Joy-rider, an adult tricycle, was adapted to allow the client to transfer power to the rear wheel via hand pedaling. A constant velocity (CV) joint was employed and added to the bike to accomplish this task. The adaptation of the tricycle also included developing a driving system, consisting of a driving shaft attached to the CV joint, a transmission shaft, a sprocket, and a chain. Reconfiguring the pedaling system required the use of custom-made U-shaped handgrips, a footrest, and a specially designed fork. The original fork was replaced because it was not suitable for driving the bike with the pedals on top of it. The adapted bike, including its seat and footrest, functions much like a wheelchair.

SUMMARY OF IMPACT

A patient with a spinal cord injury has no control over most of his muscles, from the chest down. He has good arm movement, but limited gripping power in his hands and fingers. Before his injury, the client had been an avid road biker and wanted to get back into the sport. Most of the bikes on the market for people with physical challenges have front wheel drive, which did not work for the client. The front tire would slip, making it difficult to operate while going uphill or riding on loose stones. Another problem in available designs is that they require the rider to lean during turns. Without control over his trunk muscles, the client cannot drive them.

The client tested the adapted tricycle, which met most of the design objectives.

TECHNICAL DESCRIPTION

There are few rear-steering tricycles. One disadvantage associated with them is that, in turning aside to avoid an obstacle, the rear wheels often foul and hit the obstacle, even when the front wheel has cleared and passed it. An adult tricycle, the Joyrider tricycle, manufactured by the Trailmate Corporation, was purchased and adapted (Figure 16.10.). Its low center of gravity reduces the risk of tipping, while its frame allows for easy modifications. The bike is rated at 250 lbs.; the client weighs 230 lbs. The seat was ideal: it has a high back support, and allows for easy transfer from a standard wheelchair.

Figure 16.10. Bike Before Adaptation.

The adaptation process required a CV joint to power and steer the purchased tricycle. The center of the CV joint houses the driving shaft that transmits power from the rider to the tricycle. This joint, donated by Dana Corporation, has a maximum turning angle of 80 degrees. Its inner race turns while transmitting power to the outer race, with a gear and a chain attached. A mounting mechanism was attached and fixed to the frame of the tricycle to hold the outer race.

The Joyrider comes equipped with a coaster brake that allows the rider to reverse the pedaling motion for braking. The bike also has a caliper brake attached to the front wheel, normally used as a stopping brake. Since the coaster brake is being applied for stopping in this adaptation, the caliper brake can be used for parking. The lever that actuates the caliper brake is a pull and release device. A self-indexing device was employed to lock the caliper in place.

A custom made u-shaped handgrip is used to transfer power from the patient's arms to the back wheel. This grip was designed to accommodate the client's limited gripping ability. It has front and back pads. The front pad is ergonomically designed so that the hand forms comfortably to it. The back pad helps to hold the rider's hand up against the front pad. The handgrip is oriented vertically instead of horizontally, as it would be in most bicycle pedaling systems, because the vertical orientation allows for more natural placement of the hands throughout the cycling motion.

Carbon steel with yield strength of 120,000 psi was used for the driving shaft, which has a length of 8 inches. A force of 100 lbs on each pedal was estimated. The pushing and pulling forces on the pedals, along with the weight of the rider's arms and other bike parts (the CV joint, the chain and the sprocket) will bend and twist the shaft. The maximum bending moments and maximum torques acting on the shaft were estimated. A 0.80-inch shaft was selected corresponding to a factor of safety of 3.

The fork of the bike as purchased could not be used because it was not suitable for driving the bike with the pedals on top. A new fork was designed and built. It was welded to the lower part of the original fork after the upper handlebars were removed, as shown in Figure 16.11. Three tubes with two different tubing sizes were used for the new fork: two tubes with an OD of 1.05 in., a thickness of 0.109 in, and a length of 11.5 in., and one tube with an OD of 1.66 in., a thickness of 0.134 in., and a length of 8.25 in. All tubes are made of ASTM structural steel tubing with a minimum tensile strength of 58,000 psi. The two longer tubes were welded to two upper steel plates that hold the flange bearings of the driving shaft. These two tubes were then welded together to a steep plate to form a U-shaped part. The third and shorter tube was welded from its top to the U shaped part, forming the new fork.

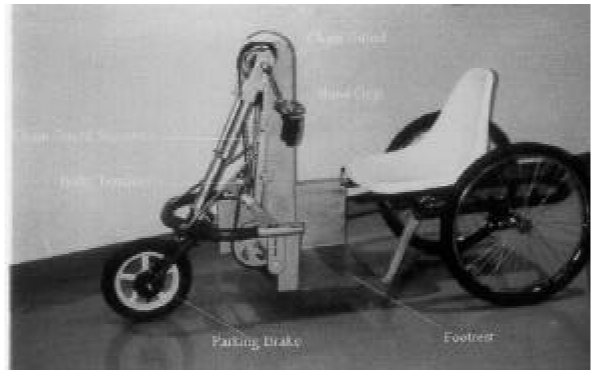

Figure 16.11. Bicycle After Adaptation.

The CV joint and the driving shaft were fabricated at Dana Corporation, Toledo, Ohio. The original upper part of the fork, handlebars, chain guard, and feet pedals were first removed from the original bike. The new fork was then welded to the lower part of the original fork. The CV joint and the driving shaft were mounted with flange bearings to the steering system at the top of the U shape part of the new fork. The custom-made handgrips were then attached to the crank arms that were fixed to the end of the driving shaft.

A transmission shaft was mounted where the original crank had been. The same diameter of 0.625 inches was used for this shaft, the length of which is 21 inches. The transmission shaft was made from stainless steel, with a yield strength of 40,000 psi. A custom made footrest, welded to the main frame, was attached in place of the foot pedals after the pedaling system was reconfigured. A chain guard was added to protect the rider, and a bully tensioner was used as a chain guide. All fabricated components are painted silver.

The costs of all parts, including the purchased Joyrider, totaled $550.

HAND ASSIST

Designers: Jill Phillips, Julia Lintern, Jill Scandridge, Mechanical Engineering Students
and Seth Carmody, Electrical Engineering and Computer Sciences Student
Client Coordinator: Dr. Gregory Nemunaitis, Department of Rehabilitative Medicine, Medical College of Ohio
Supervising Professors: Dr. Donald Leo
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The University of Toledo
Toledo, Ohio, 43606

INTRODUCTION

An electrically controlled handgrip and release orthotic was designed for a client with quadriplegia due to a fifth cervical spinal cord injury. The prototype employs a forward / reverse switch to control power. An electric lead routes this signal into an independent motor which then powers an orthotic affixed to the hand that lacks muscle control. A rack and pinion, attached to the brace, are used to produce hand motions. The motor rotates the pinion that pushes the rack unit, creating a moment about the patient's metacarpal joint. This moment rotates the fingers, which are splinted together such that they move as one unit, enabling the hand to grasp an object. An important feature is the maximization of the range of grasp, and the minimization of the fixture size for aesthetic purposes.

SUMMARY OF IMPACT

This prototype was developed for a patient with quadriplegia, who wanted to grip and release one of his hands to be able to drink from a glass, write and pick up objects. The device uses the patient's intact motor ability in the biceps and shoulder muscles, and is powered via a simple forward / reverse switch. The working prototype enables the patient to hold a variety of cup sizes and bring them to his mouth in proper orientation. The simple switch allowed him to control finger rotation.

TECHNICAL DESCRIPTION

Criteria for the prototype were that it have three integrated functions: finger manipulation, forearm rotation, and maintenance of a rigid wrist. First, it would have to manipulate the fingers in a grasping motion. Secondly, it would have to splint the wrist to orient it for the grasping position. Thirdly, it would have to reorient the forearm, rotating it about 90 degrees toward the body.

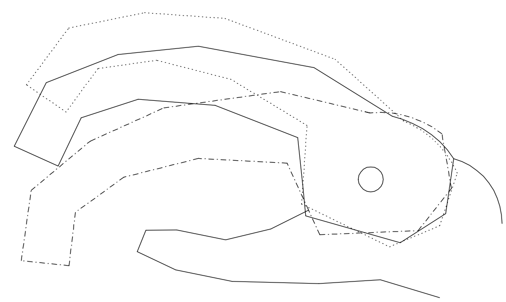


Figure 16.12. Claw Design Concept.

The design of the Hand Assist was based on a conventional amputee myoelectric arm. Almost every amputee arm utilizes a claw-type device that emulates fingers and pivots about a single point. Figure 16.12 shows this claw design, which maintains the natural curvature of the fingers, and induces a rotation about the metacarpal joint. This design allows for finger manipulation while maintaining a rigid wrist. The correct forearm orientation is accomplished through the use of a splint.

When the patient's hand was held in the desired grasping position, his thumb joint was immobile and was in a posture not conducive to grasping. Thus, it became necessary to build an artificial thumb, or a prop that would react against the force of the rotating digits, as shown as part E in Figure 16.13. It was important that the device not induce more than 0.68 psi of pressure on the patient's skin, to prevent skin irritation and inflammation. A prefabricated fully padded aluminum brace was incorporated.

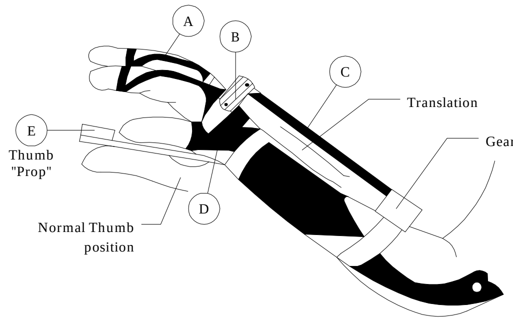


Figure 16.13. Final Design of the Handgrip.

The final design incorporated a switch, mounted on the patient's wheelchair and controlled with his shoulder motion. An attached 9.6 V battery allows current to flow to a single motor. This motor is able to turn either way, and thus induce the pushing and pulling of a rack that forces a moment arm at the metacarpal joint of the user.

The final prototype is shown in Figure 16.14. It includes four main parts: a finger fixture (part A), a moment linkage (part B), a grasp inducing rack (part C), and a brace fixture (part D). The electric assembly includes: 1) a two way toggle switch featuring spring return to neutral position, with reed contact due to small amperage of circuit, 2) a pushbutton enclosure for the toggle switch, 3) a micro motor with gear reduction assembly, 4) a stainless steel motor enclosure with hinge attached, and 5) a 9.6 volts DC rechargeable battery with recharger.

The finger fixture (part A) consists of flexible plastic finger rings that are connected to each other so that the fingers move as a unit. A lower digit stabilizer, made of aluminum, is connected to the moment arm, and a single aluminum extension across the middle finger ring holds the flexible finger rings to the lower digit stabilizer. The moment linkage (part B) is made of aluminum. It was machined to be made thin enough to float inside the slot of the rack, compensating for the angular rotation of the arm versus the desired translation of the rack. The grasp inducing rack (part C) is made of brass and purchased from Ohio Belting & Transmission Co. The mechanism allows the motor power to be transformed to a moment arm about the metacarpal joint.

The motor has a gear head reducer that lowers the rotational speed of the motor to approximately 14 RPM. The pinion is made of 5/8” steel wire that was machined to the spindle specifications. The rack is long enough so that the motor and pinion are near the elbow. The housing of the rack unit is mounted on a brace; this was required to stabilize, support, guide and protect the rack. The base brace (part D) is a padded single-spine prefabricated aluminum brace with nylon Velcro adjustment straps. No break was allowed in the brace fixture, to ensure wrist complete immobility. The brace fixture is used to mount the finger fixture and the wrist rack, and provides a mounting place for the motor, racks and gearbox. A Velcro upper arm harness, attached to the base brace, controls the client's forearm pronation/supination. This allows the client to grasp a wide range of object sizes. The thumb prop, made of aluminum, is affixed to the upper portion of the forearm fixture. A spongy rubber covering, glued onto the prop area, is used for raised friction and padding.

The cost of parts is about $600.

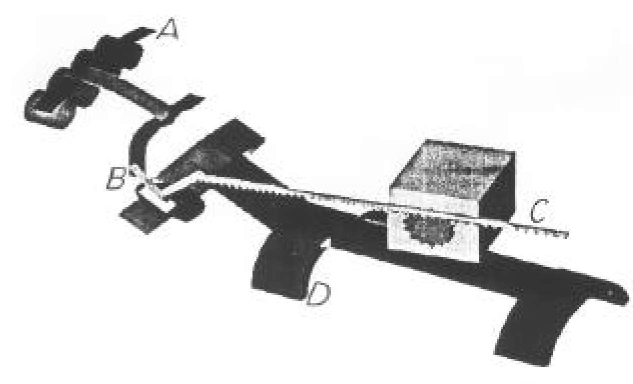
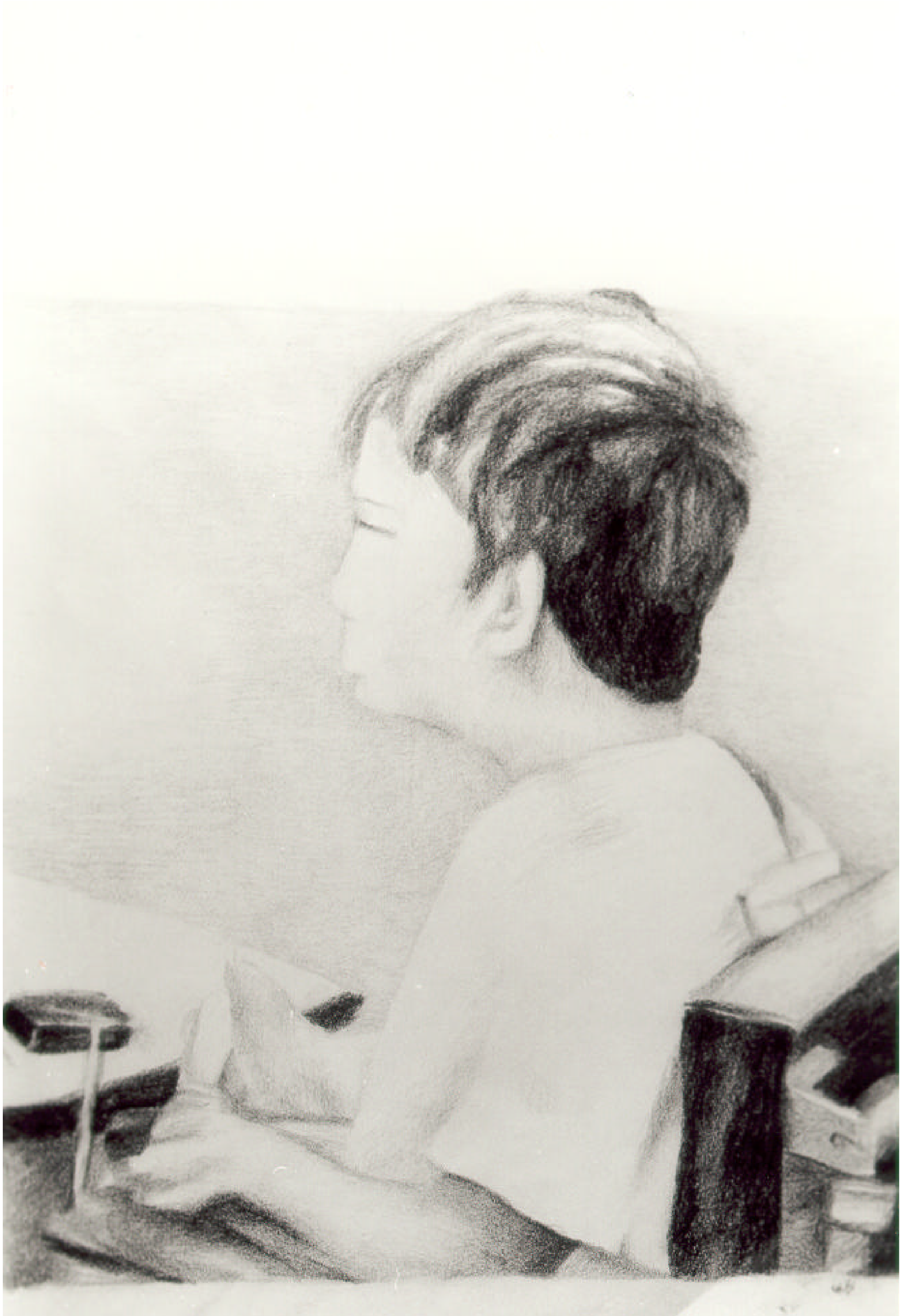


Figure 16.14. Final Hand Assist Prototype.



Chapter 17
UTAH STATE UNIVERSITY

College of Education
Center for Persons with Disabilities
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TRANSFER LIFT

Designers: Maury Flake, Rich Geddes, Blaine Thurgood
Client Coordinator: Richard Escobaq USU AT Development and Fabrication Laboratory, Center for Persons with Disabilities
Supervising Professor: DK Thomas H. Frank
Mechanical &Aerospace Engineering Department
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INTRODUCTION

A system was designed to lift a client off a wheelchair seat, thereby freeing caregivers from heavy lifting. After the client is lifted, a transfer board may be placed underneath him, providing a stable support, and bridging across to the desired location. In many settings such a lifting device would provide a quick and easy means of transferring people without back injury.

SUMMARY OF IMPACT

The objective of this project was to design and develop a cost-effective method of transporting a client from a wheelchair to another location with minimal human effort.

There were several design requirements, including that the product be: user friendly, aesthetically pleasing, stable while a person is being lifted, safe, simple to add to an existing wheelchair, designed with 250 pounds lifting capacity, cost-effective, and portable.

TECHNICAL DESCRIPTION

The project can be broken down into three components: the lifting mechanism, the seat assembly, and the wheelchair/lift interface.

The development of the lifting mechanism included several design iterations that affected size, shape, and appearance, yet yielded the same function.

Square tubing was chosen to surround the mechanical jack because interfacing to a square, flat surface is considerably easier than interfacing to a curved surface. Square tubing is strong and stable, and prevents the lift from rotating axially.

A mechanical screw jack was chosen over a hydraulic jack or electric actuator to reduce cost, control weight, and prevent leakage.

The seat assembly is located behind the client, out of the way. With a forklift design, the seat has a cradle effect, unlike overhead sling devices, which make some users feel as though they are hanging and out of control.

The telescopic side support bars act as armrests and make the client feel secure. Attached to the end of the support bar is a crossbar, which provides support for the client and enhances the integrity of the framework.

The entire lift system can be used with a standard manual wheelchair after removing the wheelchair handgrips and drilling two l/8" holes for upper pin placement. The only other attachment area is at the lower wheelchair frame where four l/4" u-bolts are used to hold the aluminum base plate that supports the mechanical screw jack and the seat.

Project costs are under $400.

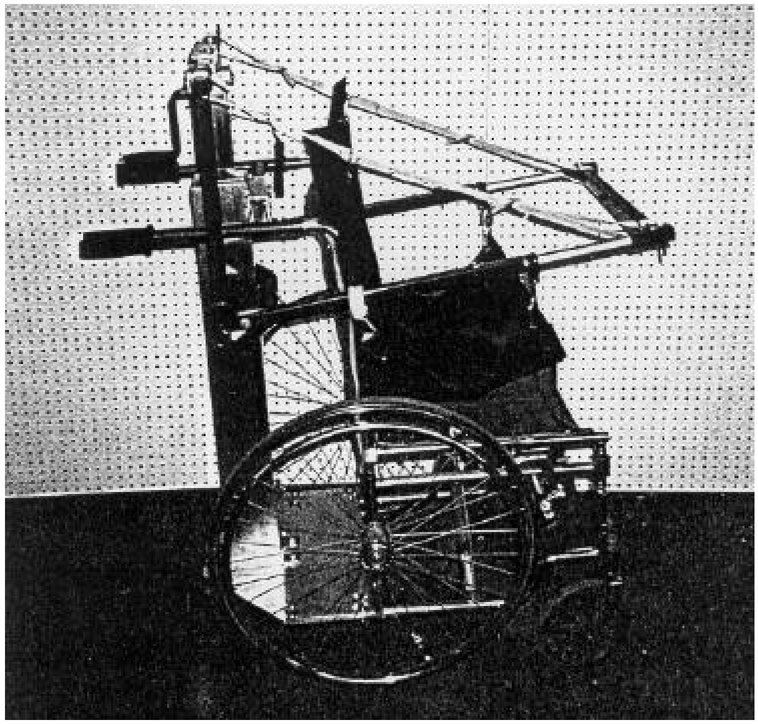

Figure 17.1. Transfer Lift.

ASSISTIVE SHOPPING DEVICE

Designers: Jerilyn Downs, Chris Potteq Devan Slade, Eric Staker
Client Coordinator: Richard Escobaq USU AT Development and Fabrication Laboratory, Center for Persons with Disabilities
Supervising Professor: Dr J. Clair Batty
Mechanical &Aerospace Engineering Department
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INTRODUCTION

A folding assistive shopping device was designed to help persons who use manual wheelchairs shop at any store. Many stores have powered scooters for shopping, but these are often difficult for users of wheelchairs to transfer into, and do not aid users in transporting purchased goods home.

SUMMARY OF IMPACT

The shopping device eliminates the difficulty of maneuvering both a wheelchair and a cart simultaneously, and enables the user to return home with the items purchased. The requirements and restraints included: user safety, stability, simplicity, fabrication cost under $200; weight of approximately 20 lbs; load capacity of 100 lbs, collapsibility, portability, maneuverability, adaptability to different wheelchairs, durability, style, and minimal social stigma.

TECHNICAL DESCRIPTION

The Assistive Shopping Mechanism was constructed out of chromed tubular steel so it would withstand corrosion and also be pleasing to others, so as not to draw unwanted attention. The mechanism folds on hinges. Support tubes add stability. The weight constraint, combined with the weight of probable users, required a lightweight durable fabric for a bag instead of using tubular steel for the basket. The material selected was Corduroy, a lightweight, durable fabric that can withstand substantial wear and force. The bag is attached by strong Velcro straps, positioned optimally for support.

The bag rests upon the lower frame on a l/4" sheet of ABS plastic, so that the top frame does not have to support the entire load.

Three caster wheels, like those normally found on manual wheelchairs, were used to enhance maneuverability and decrease attention to the cart.

Connecting arms that link the frame of the cart to the arm supports of a wheelchair are constructed with swivel collars, allowing for rotation such that the arms are adaptable to fit different widths of wheelchair frames.

Quick release grips are welded to hinges that rotate vertically to allow for different heights in wheelchair attachment sites. The arms can be attached to either the front or back of a wheelchair with no modifications. By attaching the shorter connecting arm, the cart can be easily side mounted to a wheelchair.

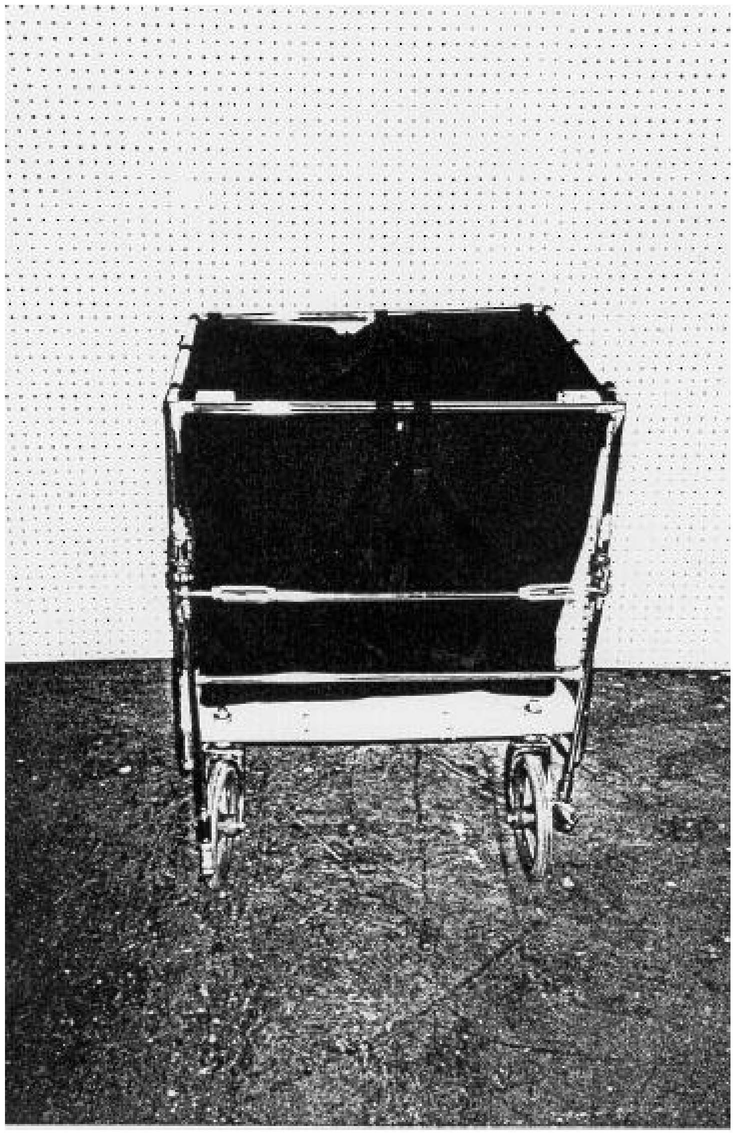

Figure 17.2. The Assistive Shopping Mechanism.

HAND-POWERED TRICYCLE

Designer: Jim Kinsley
Client Coordinator: Richard Escobaq USU AT Development and Fabrication Laboratory, Center for Persons with Disabilities
Supervising Professors: Dr. Beth Foley, Department of Communicative Disorders, Ms. Amy Henningsen, Occupational Therapist, Center for Persons with Disabilities
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INTRODUCTION

For a young child with limited or no use of his or her lower extremities, operating a commercially available tricycle is not an option. Several different types of hand-powered tricycles have been developed and marketed. Unfortunately, most are prohibitively expensive. Given the significant benefits of independent mobility for young children with physical disabilities, there is a need to develop a safe, inexpensive hand-powered tricycle that can be easily modified to accommodate specific consumer characteristics.

The purpose of this project was to develop a hand-powered tricycle for a six-year-old consumer with spina bifida, having no use of lower extremities.

The hand-powered tricycle was designed following an analysis of the specific needs and abilities of this consumer. Its primary purpose was to facilitate the development of upper body strength and endurance, while giving the consumer an opportunity to engage in age-appropriate outdoor recreational activities. Another important consideration was that the proposed design be cost-effective. For this reason, the tricycle was assembled using recycled bicycle and wheelchair parts at a cost of less than $200.

SUMMARY OF IMPACT

Although this project was initiated with a specific child in mind, the design is flexible, to meet the needs of a range of children and young adults with similar impairments. There are no welded parts, and the construction is such that it can be easily adjusted to fit varying size and weight requirements. Anyone wishing to replicate the design can easily obtain existing parts from used bicycles, making this an extremely cost effective recreational mobility option.

The primary benefit of this project is that it can enable an individual with limited lower extremity use to increase upper body strength and endurance. This can translate into increased independence in other activities of daily living.

The hand-powered tricycle also gives the consumer access to a popular out-door recreational activity. It can provide increased opportunities for social interaction with family members, peers and the larger community and, in doing so, heighten emotional and physical well being.

TECHNICAL DESCRTPTION

The purpose of this project was to make a hand powered tricycle that was inexpensive to make and could be duplicated without welding or machining. Using different size bicycle frames and wheels enables one to make a tricycle of the desired height and length. By using the wheelchair frame as a pivoting connection to the bicycle frame, the tricycle is made adjustable; the lower pivoting bar on the frame is easily relocated.

The wheelchair frame was disassembled, and the collapsible center cross frame was repositioned in the lower section of the framework. This made the chair wider for stability, as well as adjustable. The seat frame was created by reversing the hooks and placing a 1" angled piece of 3/l6" flat steel, using the existing hole and a longer screw to hold the seat in place.

Two bicycle frames were used. One frame is the main structure supporting the entire framework, while the other is only needed for an additional crank for the hand pedals. The main frame was cut, leaving the front fork, mainframe, and rear wheel support. The other frame was also cut, leaving the parts from the seat to the crank for the hand crank apparatus. The main frame is connected to the front lower cross arm of the wheelchair. The arm was cut in half and placed in a tube inside the lower crank arm, making a snug fit. 3/l6" machine screws with nylock nuts make the tricycle adjustable. Adjustable cables in the front and back of the seat frame attach the bicycle frame to the wheelchair frame, providing stability and adjustability.

A front wheel with a three-speed coaster hub was used for optional speeds and also for braking capabilities. A chain running between the upper crank arm and the front wheel hub required two idler sprockets to keep the chains clear of the framework. These sprockets were taken from the bicycle's derailer. It is important that these sprockets are made of steel, as many inexpensive bikes have plastic sprockets that do not hold up to the pressure exerted on them

Costs are less than $100.

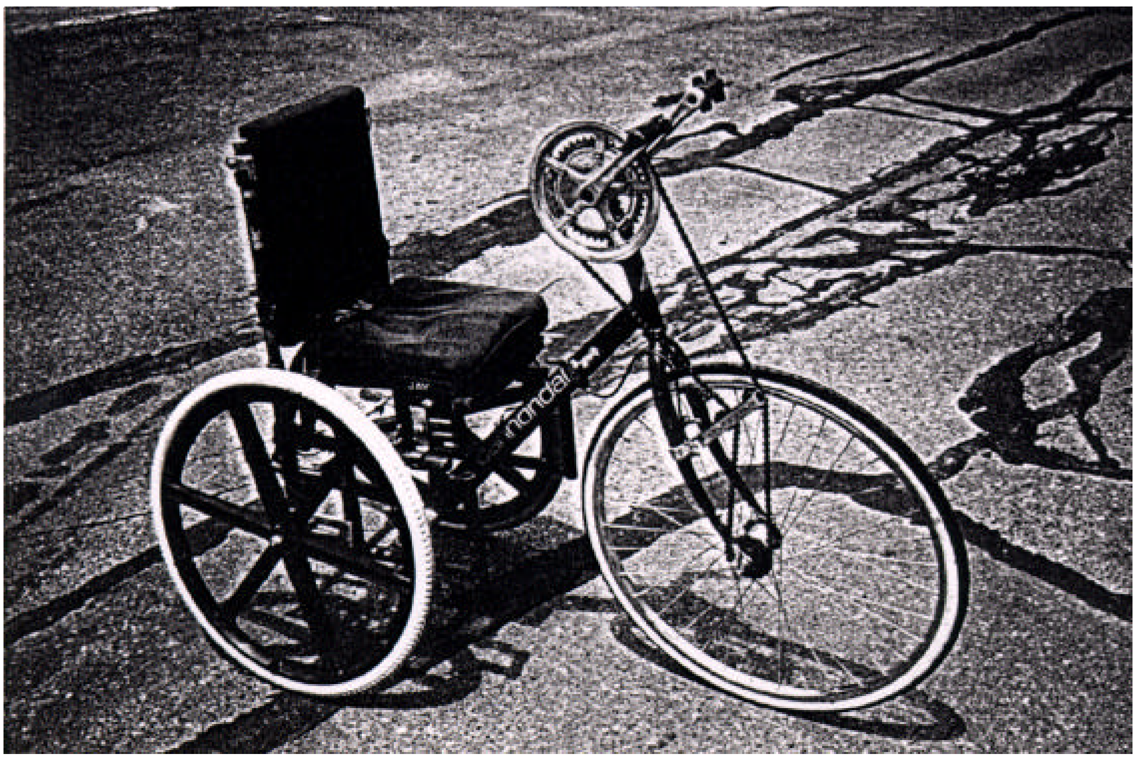

Figure 17.3. The Hand-Powered Tricycle.

TEEN JOYSTICK-CONTROLLED GO-CART

Designer: Rich Kauer
Client Coordinator: Richard Escobaq USU AT Development and Fabrication Laboratory, Center for Persons with Disabilities
Supervising Professors: Dr. Beth Foley, Department of Communicative Disorders, Ms. Amy Henningsen, Occupational Therapist, Center for Persons with Disabilities
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INTRODUCTION

Concern for the appropriateness of powered mobility for children has lessened as children as young as 24 months have demonstrated that they can safely operate powered vehicles such as toy jeeps and cars. Powered vehicles allow children with disabilities to experience movement, and control and can facilitate their social, cognitive, perceptual and functional development.

Although an increasing number of joystick-controlled products are now available for young children with disabilities, few are appropriate for young adults with disabilities who exceed the size and weight limitations of "kiddie-type" vehicles. In addition, available devices are expensive, and require special adaptations for individuals who do not have sufficient cognitive and/or motor ability to use them independently.

The purpose of this project was to design an inexpensive joystick-controlled go-cart for a 15-year-old boy with spastic cerebral palsy. Although this consumer had access to a powered wheelchair in school, his home was not wheelchair accessible and opportunities for using the chair were limited. For this reason, he had a continuing need for powered mobility training to ensure development of the skills he needs to control a powered wheelchair safely. In addition, he expressed an interest in having some form of independent mobility other than a wheelchair to use for recreational purposes. He eagerly participated in the development of his “hot rod,” which was assembled and customized using parts from old wheelchairs.

SUMMARY OF IMPACT

This go-cart design incorporates a number of important safety features, including a five-point harness and a roll bar. It utilizes a wheelchair base, batteries, and a seating system. This design can be replicated using recycled wheelchair parts for well under $200.

TECHNICAL DESCRIPTION

A powered wheelchair was widened by detaching the cross braces and using them to make the lower support frame. The font end of the wheelchair, where the front wheels are attached, was cut off. The frame was lengthened by 16 inches using 3/8" aluminum pipe inside of the chrome pieces, cut from the frame of a manual wheelchair. These inner pieces run the entire length of the frame making it more rigid. A front wheel frame was reattached by welding it to the frame. The frame is reinforced with additional cross members, welded to give added support. During testing, the cart withstood weights of over 240 pounds.

A fiberglass seat replaced the sling seat that is standard with most of these types of powered chairs. This seat was placed in front of the battery compartment between the rear wheels. A metal floor and foot rail were welded to the tubular frame. The battery compartment was covered with a plastic shell.

All components of the go-cart are from recycled materials, except for the two 12-volt batteries that power the two 24-volt motors that operate the cart. The turning radius is very small, as the rear wheels are run independently with separate motors.

Total cost was under $100, including the two 12-volt batteries.

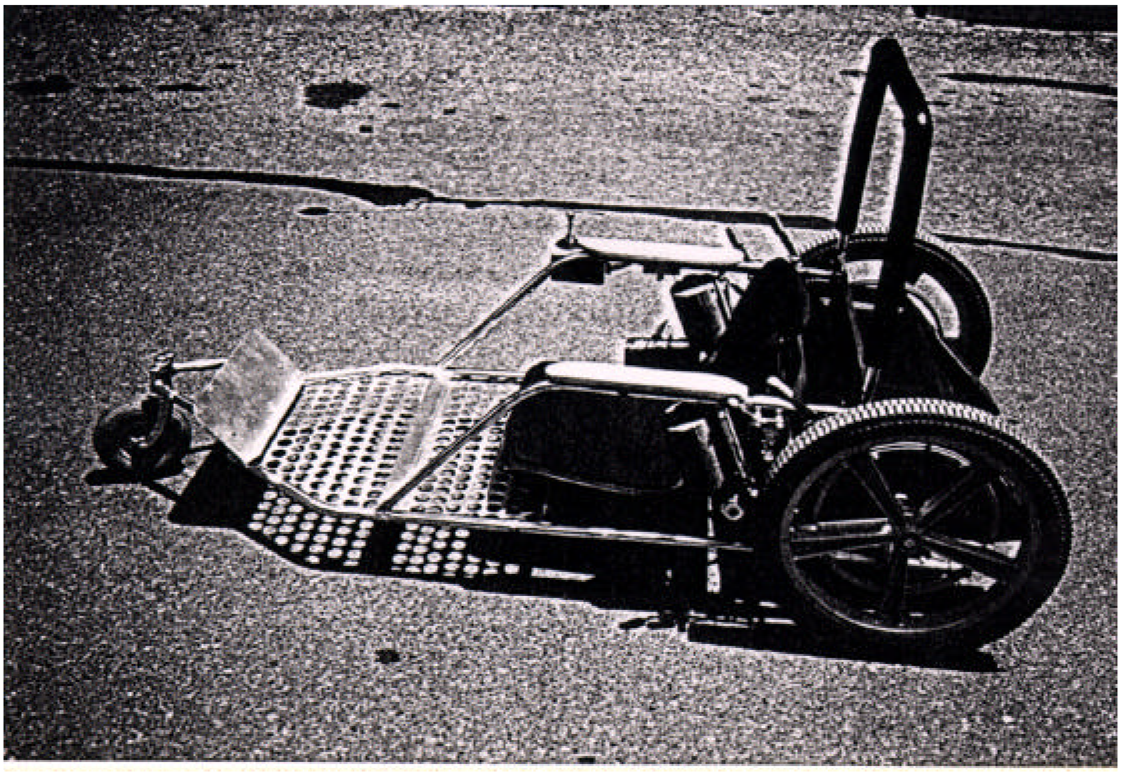

Figure 17.4. Teen Joystick-Controlled Go-Cart.

TOY JEEP ADAPTATION

Designers: Troy Kunzler, Cameron Evans, Shawn Hawk, Eric Worthen
Client Coordinator: Dr Richard Baer; Center for Persons with Disabilities
Supervising Professors: Dr. Beth Foley, Department of Communicative Disorders, Ms. Linda Chisholm, Center for Persons with Disabilities, Ms. Amy Henningsen, Occupational Therapist, Center for Persons with Disabilities
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INTRODUCTION

Some young children with mobility impairments have a need for an alternative mode of transportation that is affordable and fits their environment. Powered wheelchairs are not always affordable or feasible for a young child. Also, wheelchairs are conspicuous and may not always accommodate the social needs of the young child.

An affordable adaptation kit with joystick control was designed for the readily available Power Wheels Jeep, a small battery-powered toy car made for children between the ages of four and 10. The kit makes the Jeep accessible for children who do not have adequate muscle control in the legs or arms to operate the standard Jeep.

SUMMARY OF IMPACT

The adaptation kit makes it possible for the parent of a child with a mobility impairment to purchase the Power Wheels Jeep, and without unreasonable difficulty, adapt the Jeep to be controlled by a joystick. This enables young children to have a reasonably affordable, alternative mode of transportation that is both practical and fun.

TECHNICAL DESCRIPTION

The Jeep adaptation kit is composed of two parts. The first part is a joystick interface to the wiring of the Jeep. A small board of relays is connected to the motors that control the Jeep. The kit uses two independently powered motors for the two rear wheels. The joystick interface provides separate power and control to turn each wheel separately. This results in a one-wheel turning method (left or right rear), a two-wheel drive for straight forward, or one-wheel drive for reverse.

The second part of the adaptation kit involves modification of the front wheels to accommodate the turning method employed. This is accomplished by locking the front wheels, using a piece of wood placed in between the front tires and mounted to the frame. On this wood two smaller swivel wheels are attached. These swivel wheels are lower than the existing wheels, which results in the original wheels not being in contact with the ground. This allows the front portion of the Jeep to "free wheel" in order to accommodate the one-wheel drive turning technique.

Project costs are under $300, including the toy Jeep.

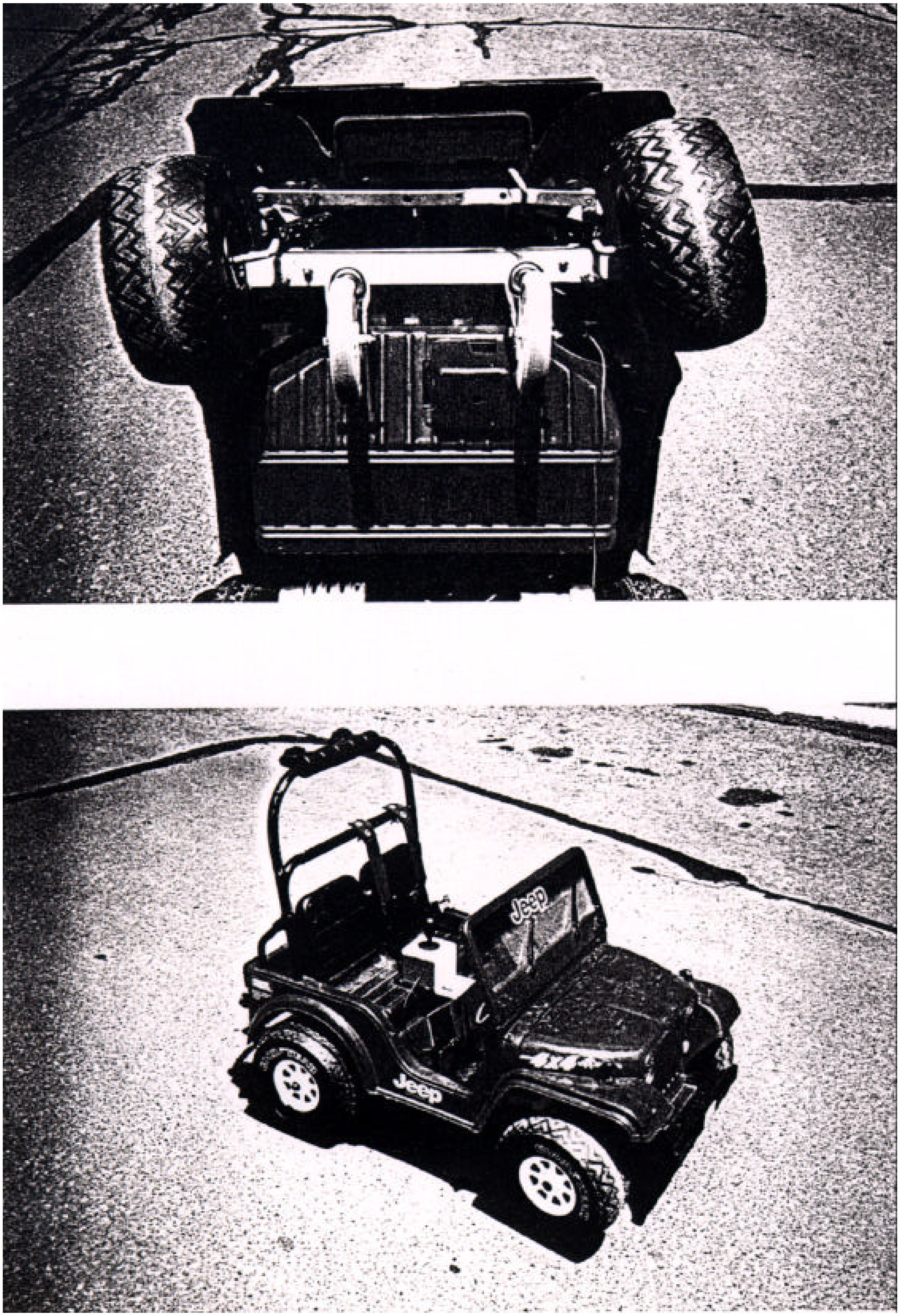

Figure 17.5. Toy Jeep Adaptation Design Project.

ASSESSMENT AND REMEDIATION TOOL FOR PHONOLOGICAL DISORDERS

Designer: Cameron Evans
Client Coordinator: Dr. Beth Foley, Department of Communicative Disorders
Supervising Professors: Dr: Ben Abbott, Electrical and Computer Engineering, Dr Boyd Israelson, Electrical and Computer Engineering DI: Nicholas Flann, Computer Science, Dr. Beth Foley, Department of Communicative Disorders
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INTRODUCTION

Over three million children and many adults in the United States have some difficulty with articulation, the production of speech sounds, and/or phonology, the knowledge and use of speech sounds. Problems with production of intelligible speech are referred to as articulatory or phonological disorders. A national shortage of speech-language pathologists (SLPs), the professionals who treat these disorders, has resulted in inappropriately large caseloads for most SLPs. Due to time constraints, many children who need intensive speech therapy receive only minimal treatment during the most important developmental years. Since a shortage of time is one of the main factors interfering with the quality of care for children with moderate to severe speech sound disorders, there is a need for a product that can significantly contribute to the productivity of practicing SLPs faced with time constraints.

The purpose of this project was to develop a prototype for an intelligent software tool for the assessment and remediation of phonological disorders. It utilizes two computer tools. The first is a high quality speech recognition system that was needed for transcription and analysis of children's speech samples. The second is a knowledge-based tool developed by a master's degree student in computer science, with assistance from faculty in computer science and communicative disorders. This tool was developed to take in a recorded speech sample, transcribe it phonetically, compare the transcription with the correct production of each word, then identity and describe any deviations present in the sample using the terminology preferred by SLPs.

By integrating these two components in a user-friendly interface, this project was designed to provide the SLP with a detailed summary of the assessment information, thus enabling her to move more quickly to the intervention phase of treatment. In addition, the results of the assessment can be used to select appropriate computer assisted instructional activities and stimuli for children with simpler disorders, so they can work on their speech independently, or with supervision, while receiving active response-contingent feedback on their progress.

SUMMARY OF IMPACT

This prototypical intelligent software tool integrates state-of-the-art speech recognition technology and a phonological disorder knowledge based tool into a program that can complete a phonological disorder assessment. It provides the SLP a description of a child's use of normal and/or deviant phonological processes, and based on that description, designs appropriate remediation exercises, using a highly interactive, and engaging multimedia format. Further development of the tool is needed to increase both the quality of the speech sample recording and the accuracy of the phonetic transcription of the recordings. Once the accuracy of the system reaches a level comparable to a trained listener and extensive field-testing has been completed, the product can be recorded on a CD and used with confidence by the SLPs.

TECHNICAL DESCRIPTION

The Phonological Disorder Assessment and Remediation Software Tool was developed using an IBM-compatible personal computer equipped with multimedia hardware (CD ROM, sound card, speakers, microphone, and modem).

The prototype consists of two parts, the user interfaces, and programming among the different components. A brief technical description of each follows.

USER INTERFACES

The project required the design and implementation of an interactive, multimedia, user-friendly Client

User Interface (WI). Each client using the system is prompted to produce 44 target words, which comprise the input for the assessment. Once the target words have been spoken and recorded, the CUI sends the speech recordings to the Speech Recognition Engine, using simple DOS commands and files.

A SLP User Interface (WI) was also needed so that data obtained from the GUI could be displayed appropriately and played back if desired. An important design consideration was that SLPs using the system must be able to make changes easily in both assessment reports and proposed intervention activities and stimuli, if necessary.

Project costs are under $460.

DYNAMIC SEAT CUSHION

Designers: Brian Anderson, Gary Malmgren, and Trent Gunnell
Client Coordinator: Dr. Richard Baer, Department of Communicative Disorders
Supervising Professors: Dr. Beth Foley, Department of Communicative Disorders, Ms. Linda Chisholm, Center for Persons with Disabilities, Ms. Amy Henningsen, Occupational Therapist, Center for Persons with Disabilities
Utah State University
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INTRODUCTION

A dynamic seat cushion was designed to prevent pressure sores. By alternating the air pressure, the seat assists the natural shift of an individual, thus reducing pressure on the individual's seating area, as well as facilitating blood flow through a wave or pulsing action of high versus low pressure. This theoretically could alleviate the problems of constant pressure with individuals in wheelchairs.

SUMMARY OF IMPACT

Humans have a physiological need to shift body weight to decrease pressure and stimulate circulation throughout the seating area. A dynamic cushion simulates, as closely as possible, the natural sitting behaviors of the body.

TECHNICAL DESCRIPTION

The design incorporates a modified Roho brand Hi-Profile seat cushion, chambered so that air can be moved by both rows and quadrants. By moving air row by row, a low-pressure trough, followed by a high-pressure crest, may be created (Figure 17.6). By isolating a low-pressure trough between two crests, the area of pressure is reduced, thus improving circulation. By moving this wave at the appropriate speed, pressure may be relieved and circulation improved in the seating area.

After a series of waves, the cushion returns to a predetermined baseline pressure throughout. From this position, one half (front and rear quadrants) of the cushion inflates to the high pressure point. After a set number of minutes, this side returns to baseline and the other half of the cushion inflates to the high pressure point. Again, after a set amount of time, this side returns to baseline, and the front half (left and right quadrants) inflates to the high pressure point, followed by the opposite side. The cushion then returns to baseline and remains there for a desired amount of time. At this point, the wave cycle begins again.

Various medical professionals are providing feedback to evaluate the theory of a weight shift and a wave of low pressure to relieve pressure and improve circulation. With this information, the appropriate modifications will be made and a working prototype will be developed.

Estimated costs are approximately $1000.

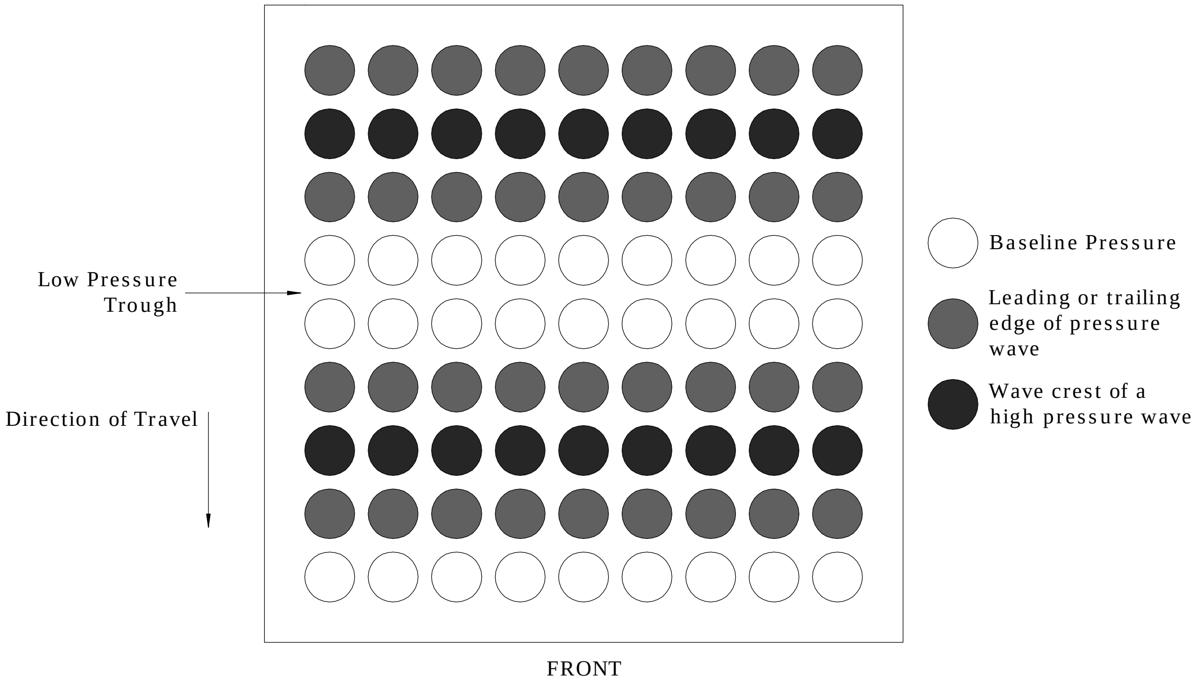

Figure 17.6. Dynamic Seat Cushion (View From Above the Cushion).

JOYSTICK-CONTROLLED MOTORIZED TOY VEHICLE

Designers: Cheryl Freeman, Jeremy Freeman, and Paul Rew
Client Coordinator: Mr. Richard Escobar; USU AT Development and Fabrication Laboratory
Supervising Professor: Dr Steve Folkman, Department of Mechanical and Aerospace Engineering Utah State University
Logan, Utah 84322

INTRODUCTION

Independent mobility for disabled children is crucial to their development as self-confident, self-reliant adults. Unfortunately, many insurance companies and related professionals are reluctant to recommend or fund motorized wheelchairs for small children (age four and older) who have not yet proven their ability to operate motorized vehicles or who will grow out of the expensive chairs very quickly. A series of modifications allow the conversion of a commercially available motorized toy car for joystick control. The modifications are simple, inexpensive, and able to be completed by most parents or other caregivers of disabled children.

SUMMARY OF IMPACT

Two major goals were to make the modifications to the vehicle inexpensive and simple to perform. The parts may be purchased at stores that are accessible to most Americans (Radio Shack, a hardware store, an auto parts store, and an electrical supply store). Only basic tools are required: a hacksaw, a Phillips screwdriver, a few wrenches, and a drill.

TECHNICAL DESCRIPTION

As purchased from the store, the toy motorized vehicle has a forward / reverse switch, a high speed / low speed switch, and a steering wheel by which the child controls the direction of the vehicle. The vehicle is powered by two six-volt batteries controlled by a "gas pedal" on the floor of the vehicle, supplying power to two motors that turn the vehicle's back wheels. The modifications transfer all of this capability into a joystick, mounted on the vehicle, within the child's reach. The joystick controls power, direction, and speed.

Automobile relays are wired to the joystick and the car's motors to control forward / reverse motion. A steering motor is attached to the front wheels so that the child's own arm strength is not required to turn the vehicle's wheels. The design uses an automobile windshield wiper motor as a steering motor. This motor is connected to the joystick through automobile relays. The relays are housed in a circuit box that is attached securely under the body of the vehicle, protected from damage by use or inadvertent contact.

It is estimated that the modifications would take about four hours to complete. The final cost of modifications is approximately $100, in addition to the cost of a toy motorized vehicle (about $200).

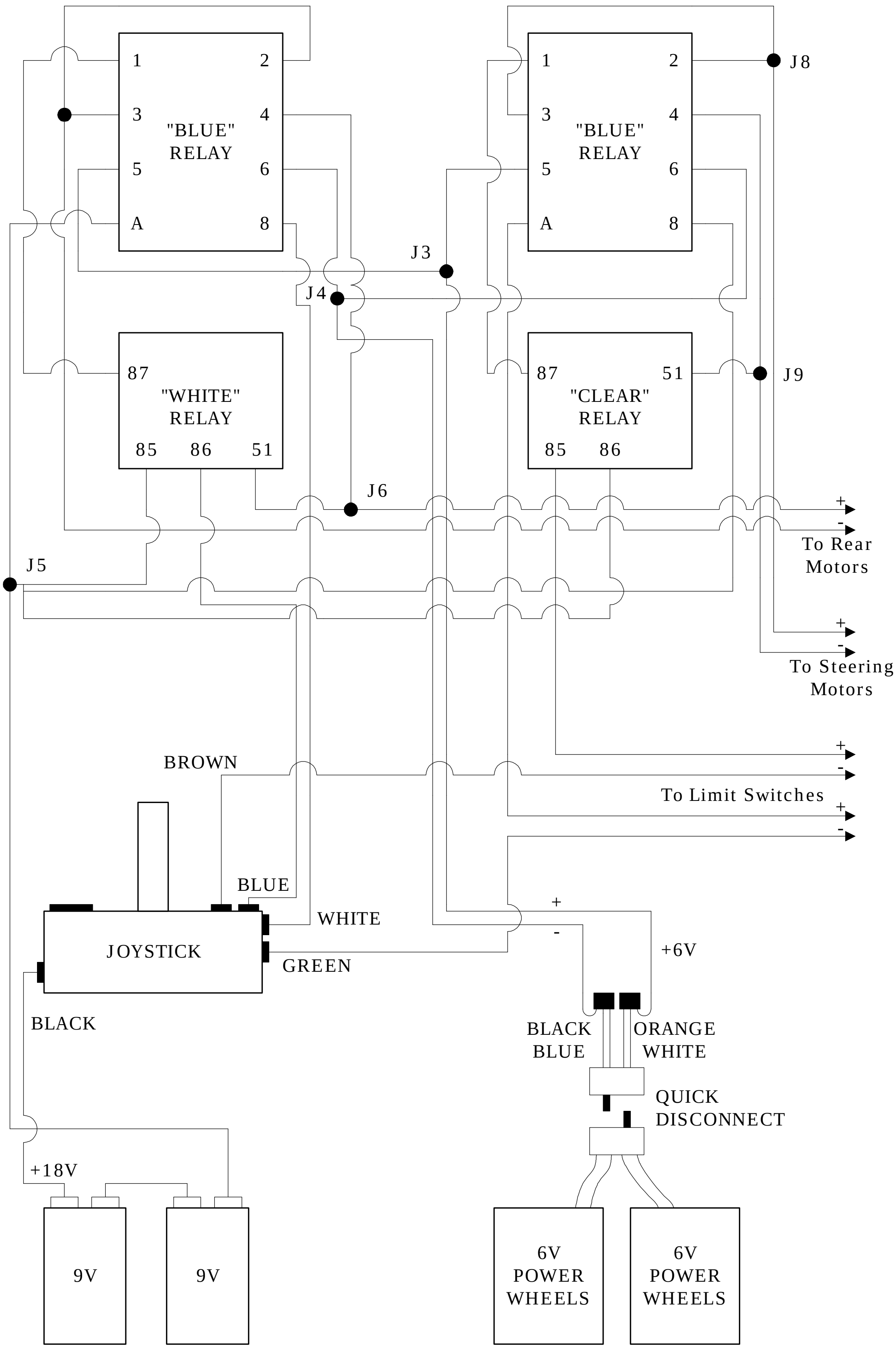

Figure 17.7. Circuit for the Joystick-Controlled Motorized Toy Vehicle.

Chapter 18
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MODIFICATION TO THE EVAC CHAIR

Designers: Carl Kaiser, Kevin Tomaszewski
Supervising Professor: Dr. Bertram N. Ezenwa
Departments of Physical Medicine and Rehabilitation, and Mechanical Engineering,
Wayne State University Detroit, MI 48201

INTRODUCTION

An EVAC Chair (Emergency Descent Model 300H) (Figure 18.1) is an emergency evacuation device designed to escort handicapped individuals down stairwells of multi-level buildings during crisis situations, such as fires. The main problem with that device is the amount of effort/strength needed by the caregiver to maneuver an individual in the chair on level ground (Figure 18.2). This could result in early caregiver fatigue during operation, or lower back injury.

Problems with previous modifications include: instability, lack of rigidity, and a non-ergonomic release mechanism. Although the design intent was valid, the adaptation did not work, and could not maintain the weight of an occupant.

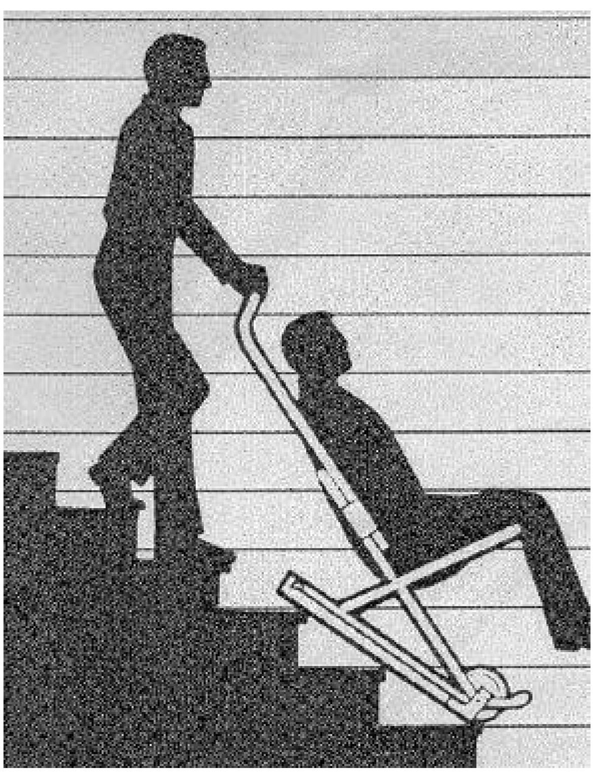


Figure 18.1. EVAC Chair used for down stairwell evacuation.

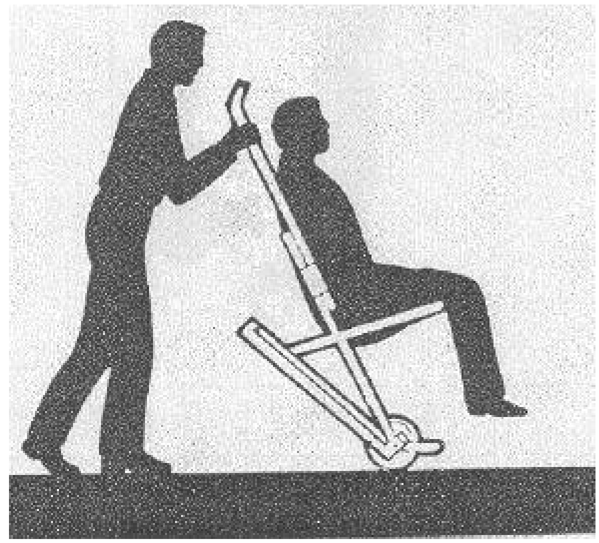


Figure 18. 2. EVAC Chair used to transport an individual on level ground.

SUMMARY OF IMPACT

The main objective of this project was to design and build an enhancement to the EVAC Model 300H evacuation chair in order to enable easy transportation of occupants on level ground. The redesign makes it possible to transport and maneuver an individual in the chair on level ground with minimum effort/strength. It off-loads the weight from the caregiver, and protects the lower back region.

TECHNICAL DESCRIPTION

The objective of the design was to increase functionality by considering ergonomics of level ground mobility, rigidity of any additions, simple means of use, low operator effort, and reduced muscle fatigue. Figure 18.3 shows the forces that were analyzed to begin the design, and the optimum height of additional structure, 'H'.

In order to determine the height, patient comfort (proper seating position) and operator maneuverability and comfort were considered, along with dimensional restrictions, and the handle configuration.

The value of 'H' (handle configuration) was determined to be 10", based on numerous laboratory tests. The lower the height, the more stable the chair. On the contrary, the higher the height, the better the position (knee to chest) of the passenger, and the better the maneuverability for the operator.

With the determined height of 10 inches, and the maximum allowable weight of 300 lbs., moment analysis determined that 182 lbs was the maximum weight to be sustained. Thus, at the given height, any modifications to the system must be able to withstand 182 lbs. of force, eliminating the need for operator 'lift.'

Two additional wheels add stability to the system and allow for better maneuverability, without the worry of tipping the chair.

Aluminum was the chosen because it is lightweight and has high strength in various grades. 6061 material was used because it has the highest strength for this design.

Any components to be added had to be small enough to retract beneath the seat while the system was being

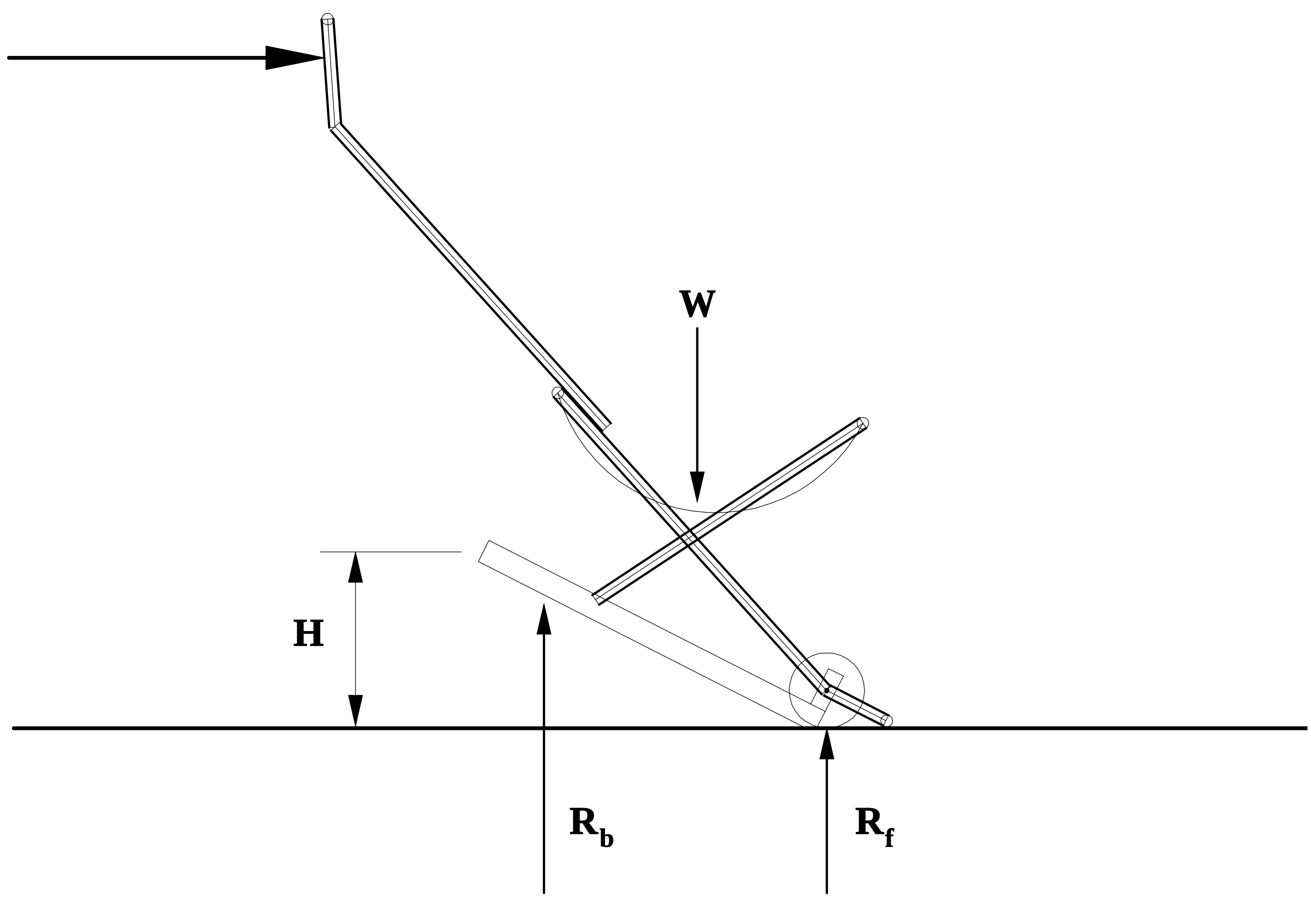


Figure 18. 3. Force Balance Schematic.

used in a stairwell (Figure 18.4)

The two castor wheels were chosen for their ability to withstand high forces, and to swivel for a reverse direction. The bar already in the chair was used as an axle. To allow for a swivel motion, this axle was fitted with brass bushings.

The KT Hinge Bracket was incorporated with the dual wheel support structure to provide a rigid design. The hinge is stable, rigid, self-locking, and easy to use, and allows operation in the reverse direction.

The KT Hinge Bracket is constructed out of rigid 1/8-inch steel. It is pieced together in such a way that the bracket angles slightly down at the main connection. This allows the hinge to lock down with the assistance of gravity, giving it rigidity in both tension and compression. The chair can be maneuvered in the forward and reverse direction without collapse. A foot pedal is also integrated in the design, allowing for easy retractability. Positioned with a three-inch lever

Figure 18. 4. Adaptation for Level Ground Transportation. Folded for Stairwell Use.

arm, when stepped on, the pedal unlocks the hinge, overcoming gravity by using the operator's weight. When unlocked, the wheel system can be easily rotated upward and secured away. A locking mechanism is used to hold the retractable wheel system while transporting an individual down a stairwell. This system utilizes a nylon extension block and a spring setscrew. This setscrew was drilled to allow a bike cable to be fed into it. The bike cable was attached to a shifter that allows the setscrew to travel in and out of the block for releasing or locking.

The overall design of the chair is shown below. It shows the chair in the retracted position. The enhancement to the chair, the KT Hinge Bracket, is not interfering with the original intent of the chair. The next desired position is the locked position of the KT Hinge Bracket. This allows for ease of travel on a level surface, as shown below. The adapted system is shown in Figure 18.5.

The total cost of this project was $189.03.

Figure 18. 5. Adaptation for Level Ground Transportation in Use.

WHEELCHAIR INGRESS/EGRESS BRUISE PREVENTION

Designer: Mark Piekny
Supervising Professor: Dr. Bertram N. Ezenwa
Departments of Physical Medicine and Rehabilitation, and Mechanical Engineering,
Wayne State University Detroit, MI 48201

INTRODUCTION

The design objective was to develop an add-on device to prevent a wheelchair occupant from bruising and cutting himself during ingress and egress. The add-on was to be adjustable to protect the occupant when the leg support is in an extended position.

The client does not have the use of his legs. When sitting he keep his knees bent and his legs folded close to his torso. He uses his upper body strength to hop in and out of his wheelchair. This process causes abrasions of exposed body surfaces when contact is made with the edges of the leg support (illustrated in Figure 18.6).

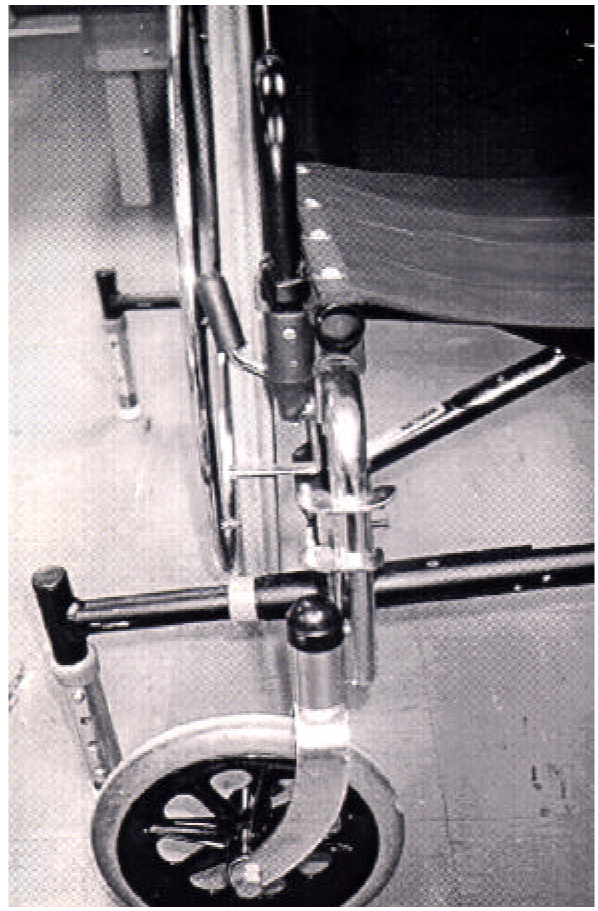


Figure 18.6. Sharp Edges with Potential for Injury During Ingress / Egress.

SUMMARY OF IMPACT

This device will prevent bruising and laceration when hard contact occurs between the wheelchair occupant and the part of the wheelchair illustrated above. The device is functional with the leg support extended, and easily mounted and removed without special tools.

TECHNICAL DESCRIPTION

Two layers of foam fulfill the pertinent requirements (namely, bruise prevention & durability through due care design measures). To displace higher loads, a Super Lux foam was selected for the core pad layer. To displace lower loads, Neoprene foam was chosen as the outer pad layer. Since the protruding wheelchair hardware is tubular, the foam was purchased in tube form. Because the protrusions are pronounced, a thick layer of foam was required to provide a cushion beyond the end point of the protrusions. Multiple layers and additional specially shaped pieces were used. The design geometry of the foam padding was determined by analyzing a model of the underlying wheelchair member, taking into account the compression ratios of each foam type and the requirements of universality. Geometry was finalized after confirming commercially available stock shapes and sizes. To provide for bending and angular adjustment relief, darts were cut into the padding at critical points. To provide for ease of angular adjustment, the two layers of padding were allowed to move freely relative to each other. To enhance fitting, the underlying wedge-shaped pieces of padding were attached with Velcro.

Figure 18.7. Geometry-Specific Design.

The two foam layers are enveloped in a vinyl boot, secured to the outer foam layer with Velcro strips and circumferentially with additional Velcro strips at each edge. Finally, straps on either end of the boot are tightened around connecting members to prevent axial rotation and shimmy of the pad assembly. An elastic Lycra panel allows the boot to conform to the adjusted angle of the wheelchair member.

The entire assembly can be mounted or removed in about 5 minutes.

Figure 18.7 shows the illustration of the geometry-specific design. The final assembled system is shown, covering the sharp edges, in Figure 18.8.

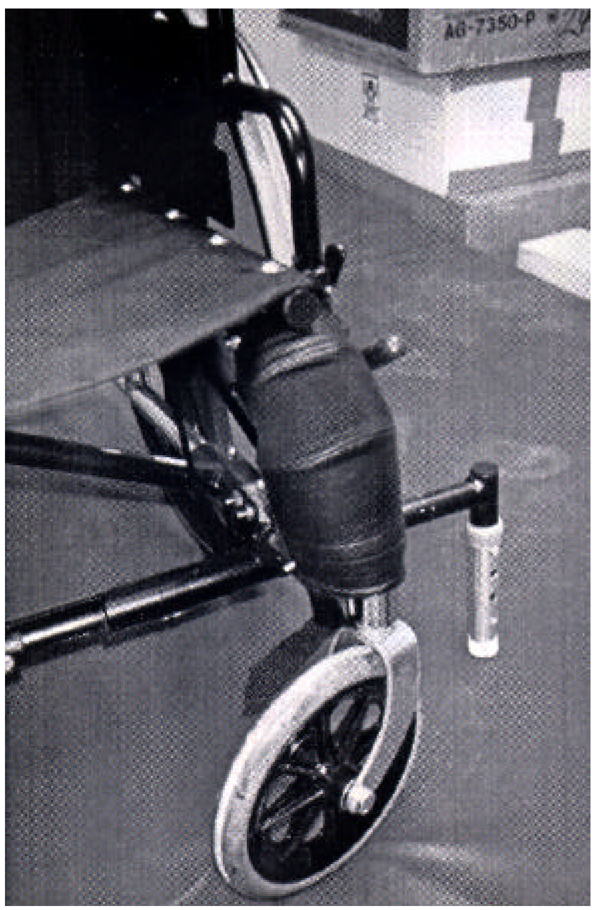


Figure 18.8. Adaptation to Eliminate Sharp Edges.

DESIGN OF FORCE FEEDBACK SYSTEM FOR STROKE PATIENTS

Designers: John Bowlby, Mark Fox, Tim Puente
Supervising Professor: Dr. Bertram N. Ezenwa
Departments of Physical Medicine and Rehabilitation, and Mechanical Engineering,
Wayne State University Detroit, MI 48201

INTRODUCTION

A stroke patient showed signs of motor return when presented persistently with mechanical stimulation and positive visual reinforcement. A caregiver wanted to expand the scope of stimulation to facilitate more return via a force feedback system with the following capabilities:

?? When pressed with hand, a visual force readout proportional to the effort in the direction of the applied force is obtained.

?? The system accommodates paralysis of either a right or left hand.

?? The device is ergonomically efficient for hand usage.

?? The system is able to sense all levels of force produced by the patient.

Based on the above requirements, the purpose of this project was to design a device that produces visual feedback to motivate and reinforce the recovery of a patient with paralysis due to stroke.

SUMMARY OF IMPACT

The force feedback system could play a major role in recovery from paralysis for stroke patients.

TECHNICAL DESCRIPTION

The mechanical section of this device consists of the bedside table, and the hand pad adaptation. Spiral springs were added to the interface of the mounting pad and the hand pad to off-load the sensors when not in use. Tracks and rollers were mounted to the bottom of the bedside table to allow the device to slide side to side, to accommodate for either right or left hand usage. The top of the bedside table was used for the placement of the visual display monitor and the corresponding electrical instrumentation.

Figure 18.9. Force Feedback with output to a personal computer

Attached to the table is the pad for hand-press, on which the patient applies his/her force. This force is detected by load cells, strategically placed on the mounting pad. There are five possible directions of force for which the patient may get visual feedback: fore, aft, left, right and downward.

Once a force is applied, an electrical signal is sent to the instrumentation, which converts the signal into a corresponding force readout, observed on the display monitor.

The system is shown in Figure 18.9.

The design specifications are as follows:

?? Load cells detect loads from 1 to 40 lbs.

?? A signal conditioner handles signals corresponding to 1 to 40 lb of force input.

?? The display monitor responds to a signal range of interest.

?? The overall weight of the hand pad and plate assembly is minimized.

?? There is an optional adaptation for a computer display.

?? The system must be able to accommodate either left or right hand paralysis.

Materials and Costs are as follows:

(2) ¼” x 10” x 9” 6061T6 Aluminum plate
$18.15 each

(1) ¼” x 19” x 8” 6061T6 Aluminum plate
$22.00

NLS Series 8000 Signal Conditioner; 8000-2-09*-60*
$334.00

Triplett Model TB-52; 450-103
$180.00

(5) RT Planar Beam Force Sensor Model 802
$48.00 each

(2) Stanley Box Tracks Model 3J403
$30.85 each

(4) Stanley Hangers Model 3J368
$24.78 each

Invacare Overbed Table Model 6417
$125.00

BK Elevating Support Unit
$85.00

Total $1183.12

Tests show that the system performed as designed.

The total cost of the system was $1183.12.

ACTIVITY ENABLING ENVIRONMENT

Designers: Jacqueline Henderson, Linda LaFleur
Supervising Professor: Dr. Bertram N. Ezenwa
Departments of Physical Medicine and Rehabilitation, and Mechanical Engineering,
Wayne State University Detroit, MI 48201

INTRODUCTION

A 6-year-old child has severe spastic quadriplegia. He is unable to walk and has limited use of his hands while lying on the floor. He cannot stand up nor can he hold himself up while lying down on a mat. He would like to be able to play with his favorite toy during class play periods.

The objective of this design was to develop an activity-enabling environment that will overcome the child's physical limitations to allow him to use his toys, an adapted remote control car and an activity box for matchbox cars.

SUMMARY OF IMPACT

The client is able to play along with other children in his class.

TECHNICAL DESCRIPTION

After numerous visits with the client and ergonomic considerations, a platform was designed to enable the client to play with his toys. The platform is a stable, low-lying device that allows a toy to be placed at a convenient angle and height without slipping. It has adjustable legs.

The main performance focus in the design was to develop a simple platform that allows for quick assembly. It also needed to be stored conveniently because the play area in the client's school is located in a small congested room with many tools and other toys. The platform folds out when being used, and back in so that it can be carried, like a briefcase, for easy transport.

The design was created using AutoCAD 13.

Although aluminum is light and durable, it was not used because it is not very durable in winter and not easy to weld. Also, metal platform edges may not be safe for the client. Metals such as steel and aluminum may be too cold. Wood was thus selected because it is strong enough, yet light, durable, and easy to work with.

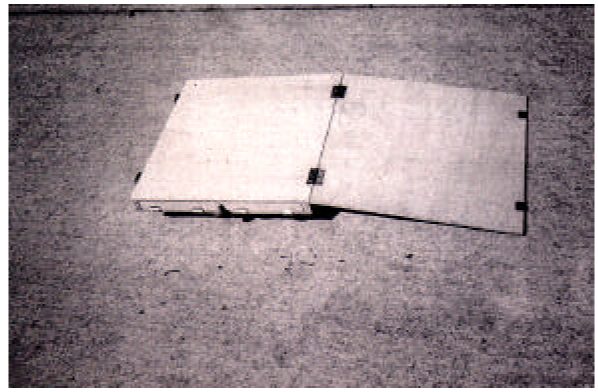


Figure 18.10. Activity Enabling Environment (unfolded).

Figure 18.11. Activity Enabling Environment in a folded position and adapted remote controlled car.

The developed activity environment consisted of an inclined platform with non-skid surface and storage compartment (Figure 18.10). Figure 18.11 shows the system in the folded state. The client can play with his toys using the inclined section. An adapted remote controlled toy car is included. To ensure that the car stays within sight of our client, the play area was secured with a nylon hose barb splicer, 2 inches in diameter and 4 feet long (Figure 18.12).

During tests, the activity enabling system performed as designed.

The total cost is $156.37.

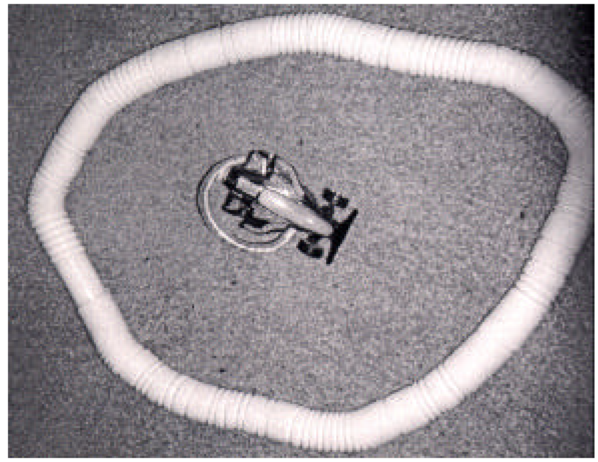
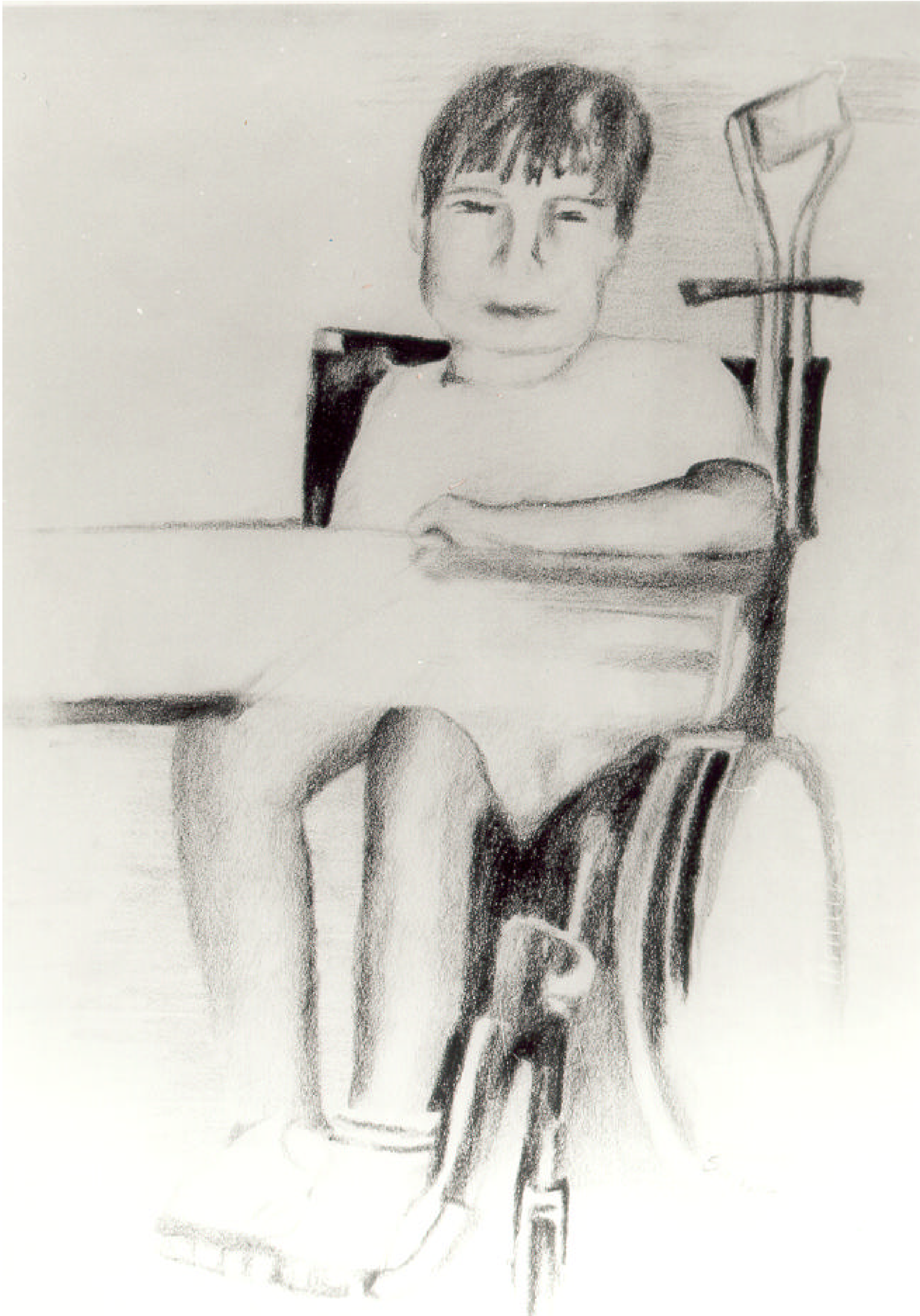


Figure 18.12. Nylon Hose Barb Splicer to Secure the Toy Car During Use.



Chapter 19
WRIGHT STATE UNIVERSITY

College of Engineering and Computer Science
Department of Biomedical and Human Factors Engineering
Dayton, Ohio 45435-0001

Principal Investigator:

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THE TOILEVATOR

Designers: Sherry Kunovic, Steve Poelzing, Tonya Skidmore
Supervising Professor: Dr. Thomas Hangartner
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INTRODUCTION

Due to physical limitations, many individuals have difficulty moving to and from a seated position. In many cases physical assistance is needed, via another person or a mechanical device. When another person is needed for assistance in using a toilet, embarrassing and uncomfortable situations may arise. Thus, a mechanical device to aid in lifting and lowering a person from a toilet is needed.

There are currently two devices available. The first is an elevated toilet, which adds three to four inches to the standard 14-inch height. The second is a seat attached to a frame with handles, which fits over the installed toilet. Neither of these devices provides a tilting position or additional lifting. Also, since they are both elevated but do not return to the standard toilet height once the individual is seated, they can be uncomfortable and awkward to use.

Also on the market is a reclining chair that lifts and tilts the individual to a near standing position and returns to a seated position at a comfortable height. The Toilevator incorporates this design concept in conjunction with a toilet.

The client has Inclusion Body Myocitis (IBM), a degenerative muscle disease. He has limited strength and range of motion. He currently uses an elevated seat and toilet but has difficulty getting up and down without the help of another person. In order for him to use the toilet independently and easily, he needs a mechanical device that lifts and lowers him to and from a height of at least 26” with a tilt motion.

SUMMARY OF IMPACT

The client can use the toilet comfortably and independently. In time, the design may be patented and marketed, providing an effective solution for other people who have difficulty using the toilet due to physical impairments.

Figure 19.1. The Toilevator.

Figure 19.2. Tilt and Lift Motion of the Toilevator.

TECHNICAL DESCRIPTION

A lift and tilt combination was designed in order to minimize the distance the user must move to and from the seat. It lifts the user to a near standing position and lowers to a comfortable height.

The design of the device had to fit most standard household toilets, especially the client’s. The range of motion had to make optimal use of both tilt and lift so that it is effective and comfortable to use, thus eliminating the need for the other devices or personal assistance. Since the design of electrical devices for use near water can be hazardous and difficult, the power lift mechanism had to utilize the household water supply and pressure instead of electricity. The frame must have rails to allow the user to align him in the proper position. It required a no-slip interface at the floor that would resist corrosion. Also, due to the client's weakened condition, the device required an easy user control.

Other specifications were that the Toilevator: allow for slow ascent and descent, incorporate parts suitable for use with water (to prevent rust), include hand rails for user comfort and stability, eliminate movement of the device except for the desired seat lift and tilt, and have no leakage.

Once the desired range of motion was determined, an appropriate power mechanism was needed. A hydraulic cylinder is the best way to power the device, since it is the most commonly used way of utilizing a fluid for power in a confined space. The current cylinder fulfills the related specifications. It is made of PVC, which will not rust when used with water. If properly assembled, it does not leak. It is also made to be used with pressure, and is capable of lifting 250 pounds. PVC pistons are not readily available, but they can be constructed out of standard-size, readily available parts.

Since the frame need only be four inches above the floor, mounting it on the floor, rather than attaching it to the wall behind the toilet, was easier and allowed for more stability. The back holes on the toilet rim were used for stability and anchoring of the frame. Slots in the frame allow for slight adjustment of the frame size to ensure a good fit to any standard household toilet. Reinforcement support beams prevent the frame from buckling under any applied lateral or front to back forces, such as a kick. Handles are attached to the frame to aid the user in proper alignment to the toilet seat.

The three components of the control mechanism are the user control, the valve controls, and the Bowden pull configuration. The user control is a single hand control placed next to the handles of the toilet seat on either the left or right side. It moves along with the toilet seat and controls the motion by opening and closing the control valves in the plumbing. With a single hand control, as opposed to multiple controls or foot actuators, the client can remain stable and easily

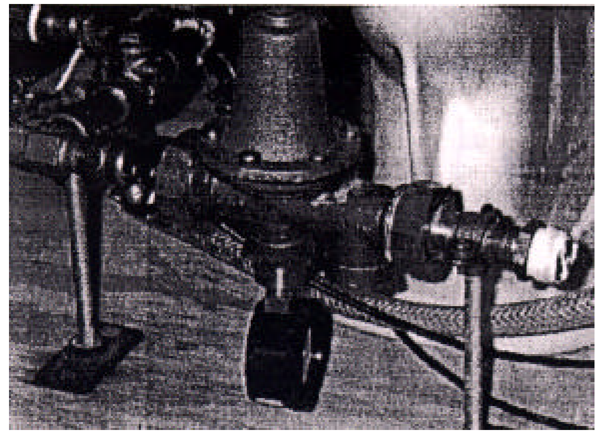

Figure 19.3. Plumbing Assembly

control movement during lifting and lowering. A wide range motion controller is used, since it is less physically challenging to operate than push buttons or switches.

The valves of the control mechanism regulate the flow of water in and out of the pistons, which raise and lower the seat. Ball cock valves manage reservoir levels. The valves are easy to operate, inexpensive, and seal properly. It is also easy to adjust the angle of the lever arm to facilitate opening and closing of the valve with the Bowden pull.

The user control is placed near the handles, which move with the frame during ascent and descent. The valves are secured near the floor under the toilet. The Bowden pull configuration is used to operate the motion. To maintain a neutral position when the control is not in operation, springs are attached to the valves. With this layout the user has control of his motion at all times. When the user lets go of the user control, it returns to the neutral position, closing both valves and stopping the motion. This allows the client to stop and reposition himself if he loses his balance or reverses his motion.

The standard toilet shut-off valve is replaced with a copper T-connection and two separate shut-off valves, one to the toilet and one to the Toilevator. This is the only plumbing modification. A hose attaches the plumbing of the Toilevator to the shut-off valve.

Inside the unit, from the hose connection in the direction of water flow, there is a pressure-reducing valve, which maintains the water pressure at 20 psi. From there, it enters the first ball cock valve, which, when open, allows the pistons to fill, raising the seat. The check valve placed before this valve keeps the valve from opening when the load on the pistons is greater than 20 psi. When the second ball cock valve is opened, water is pushed out of the pistons, lowering the seat. The water empties into the toilet tank through a vacuum breaker, preventing water from entering the drain line from the tank, as required by plumbing code.

The total cost of the Toilevator is $1200.

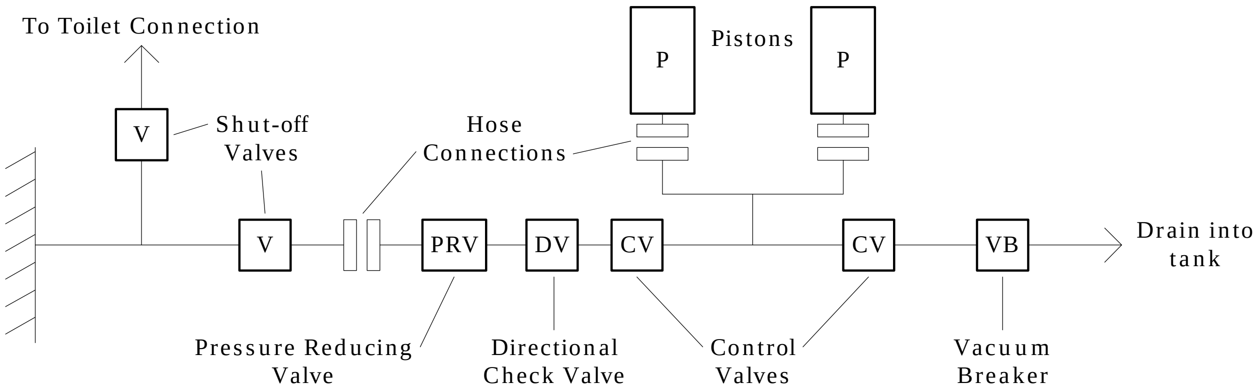

Figure 19.4. Plumbing Diagram.

MULTIPLE RAMP EYE TRACKING DEVICE

Designers: Josh Noble, Anupam Bedi
Client Coordinator: Kim Potter
Supervising Professor: Dr. Ping He
Department of Biomedical and Human Factors Engineering
Wright State University
Dayton, Ohio 45435-0001

INTRODUCTION

A ball drop toy in a classroom was modified for students with cognitive and motion tracking disabilities. The toy incorporates a series of five wooden ramps and a racquetball. The ramps have a hole cut into alternating ends to allow the passage of the ball. This configuration allows a student to drop a ball through the uppermost hole and watch the ball roll down the series of ramps until it drops through the hole in the last ramp. At this point, the ball is held in the base of the ball drop until the student starts the process over again.

Prior to the modification, students in wheelchairs were excluded from play with the toy because they could not reach the top hole, four to five feet off the ground. One student, with only a single digit on the distal end of each arm, was unable to grasp the ball, so was also excluded from play.

All of the students are capable of activating switches centered at their chests.

The manually operated device was made completely automatic by incorporating an elevator to carry the ball to the top of the ramp. Three switches control the elevator system, one starting the motor, a second automatically stopping the motor when the elevator reaches the top, and the third stopping the elevator at the bottom.

Design requirements included that it be easy to move and stable, and that it operate via a rechargeable battery due to possible safety hazards associated with power cords.

SUMMARY OF IMPACT

The students were able to adapt to the new modifications to the ball drop toy. All of the students now play with the toy, including those in wheelchairs and those unable to pick up a ball.

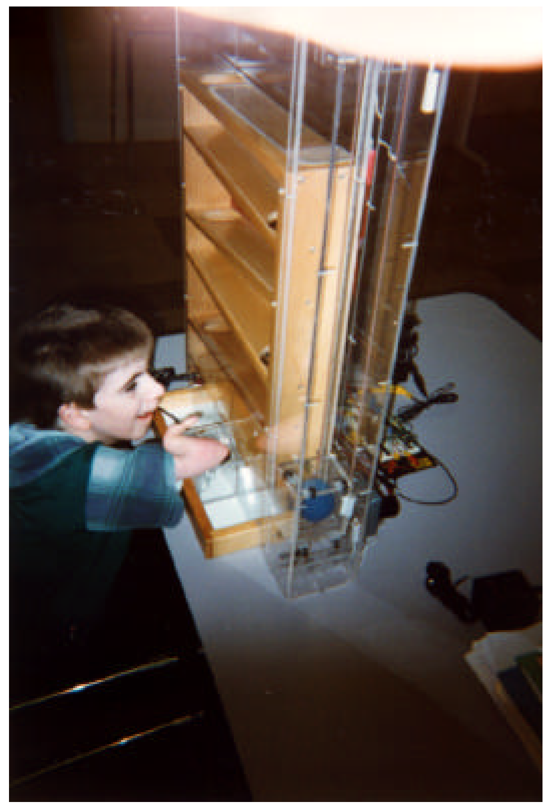

Figure 19.5. Multiple Ramp Eye Tracking Device.

TECHNICAL DESCRIPTION

The Multiple Eye Tracking Device involves a configuration that places the motor at the bottom of the toy and uses a 3D chain as a driveline. The system uses an elevator car that is attached to the drive chain on both the top and the bottom of the car. This makes the motor pull the elevator car up and down, and helps keep the car from jamming during downward motion.

The system is composed of three parts: the elevator car, a tilt floor inside the elevator car, and a groove cut into the side of the toy. The system functions by having a tab on the tilt floor run in the groove on the toy's side. When the elevator car nears the top of the toy, the groove ends and forms a stop. The motor continues to lift the elevator car as the tilt floor tab comes into contact with the stop. As the car rises, the tilt floor is forced to move in a rocker motion to expel the ball. A magnetic reed switch is mounted at the top of the elevator shaft to signal when the motor to stop. If it fails to stop, a mechanical limit switch stops the motor, preventing the elevator car from hitting the top of the elevator shaft.

The single-pole double-throw (SPDT) momentary rocker or panel switch initiates the motor drive circuit. When the student pushes it, an output pulse is sent to start the motor. The elevator begins its ascent to the top of the device. Four pulleys and a drive sprocket are used to allow the driveline to run along the shield walls and remain clear of the elevator car as it moves up and down. Once the elevator car reaches the top, it enters the vicinity of a magnetic reed switch, which stops the car and delays the motor, allowing the ball ample time to be released from the elevator car. The motor then begins turning in the opposite direction and the elevator descends to its starting position and stops when it encounters another magnetic reed switch. Both the top and bottom locations have SPDT mechanical limit switches to prevent the elevator from going too far up or down.

The ball travels through the ramps until it reenters the elevator car. A gate prevents the ball from entering the shaft when the elevator is not at its starting position. The gate consists of a small square sheet of acrylic hung by two springs, attached to the side of the device that partially covers the hole. When over the hole, the gate is held in place by two tracks attached at each side.

The total cost of the Multiple Ramp Eye Tracking Device is $750.

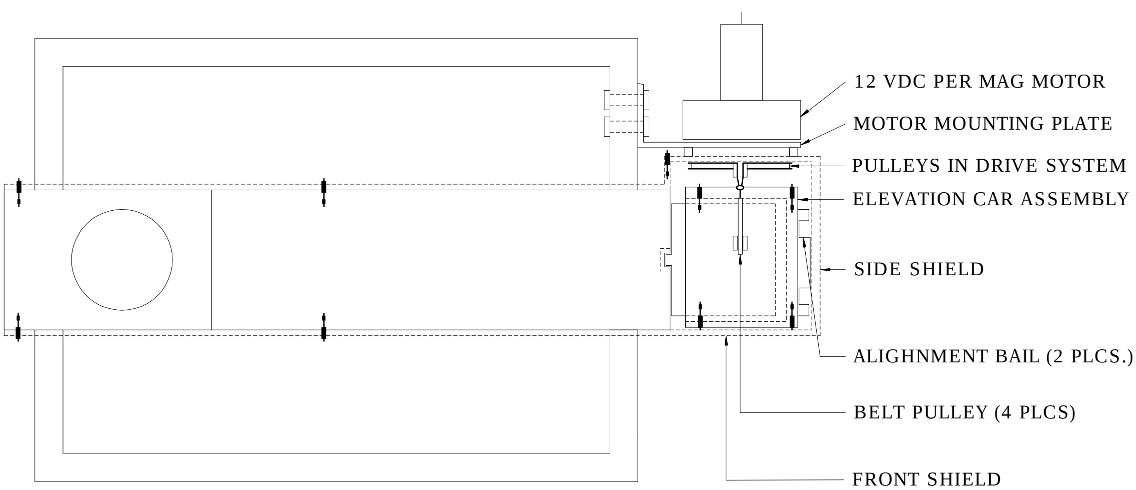

Figure 19.6. Schematic of Drive System: Top View.

PROSTHETIC ALIGNMENT DEVICE

Designers: James Marous, Brian Ruhe
Supervising Professor: Dr. D.B. Reynolds
Department of Biomedical and Human Factors Engineering
Wright State University
Dayton, Ohio 45345-0001

INTRODUCTION

A prosthetic alignment system was designed to maximize fit and functionality of a leg prosthesis for individual patients. Individual prosthetic components must be adjusted for three different axes in order to ensure compatibility and functionality with the user. First, each prosthetic component must be adjusted for rotation about the major axis of the residual limb. Rotating the axis of the prosthetic about the central axis ensures that both the residual limb and the prosthetic lie in precisely the same plane and function as a unit.

A prosthetic system must be able to slide in the medial/lateral (M/L) and anterior/posterior (A/P) directions. The prosthetic component must be aligned so that the prosthetic lies directly under the central axis of the residual limb and does not lie further from this central axis than would cause instability. Finally, a prosthetic alignment system must allow angulation of the prosthetic with respect to the patient's residual limb. A prosthetic alignment system must allow up to 15 ° of angulation with respect to an axis drawn along the center of the residual limb.

Current alignment systems are not designed to be left in the prosthesis permanently, but only to be used during initial alignment and then removed after adequate measurements relating to alignment have been taken. Such systems are heavy and expensive and are not adequate for permanent use. They also do not allow independent adjustment of each axis. Most current systems are comprised of a single bolt threaded through the entire alignment system that holds all three axes pre-set. Loosening the central bolt releases all three axis alignments and requires adjustment of all three axes when the bolt is again tightened.

SUMMARY OF IMPACT

This device allows for independent adjustment of each axis while the prosthetic alignment system is installed on a patient. The unit can be installed on a patient's prosthesis without a significant increase in prosthetic cost. The low weight and thickness ensure no significant added weight or height. The device is durable and allows for high reliability and low maintenance.

Figure 19.7. Prosthetic Alignment Device.

TECHNICAL DESCRIPTIONS

The prosthetic alignment device consists of two circular dishes that slide across each other on a smooth surface. The center square bolt is used to take up torque. Four setscrews are arranged to control slide in the A/P and M/L directions. Each screw is threaded into the center of its respective dish and meets the flat side of the center bolt. When the unit is adjusted to its full slide position, the screw lengths are adjustable. No screw ever protrudes beyond the radius of the dish.

A screw running into the center of the center bolt maintains compression between the dishes. When this screw is tightened, the heads of the bolt are drawn together and the dishes are compressed with respect to one another. The dishes are made of 70-75 aluminum, the center bolt and setscrews of steel, and the rotating pyramid assembly of 4-6 titanium. The aluminum dishes are hard coated with 0.001” anodization. The setscrews have a beveled point to engage the center bolt. To achieve slide of the center bolt, one loosens the setscrews in the direction of travel, and then tightens the opposite screw to lock the center dish in position.

The top dish was made to accept the standard European 4-bolt pattern. The bolts, manufactured separately, are inserted from the bottom of the dish and seated in cutouts in the dish body. These bolts mate to standard 4-hole patterns on the wearer’s socket, already an integral part of most prosthetic systems. Each dish is approximately 5/16” thick and 0.78” high.

The center bolt is a square shank and head, compressing the two plates, and controlling torque through the center of the device. The male portion of the bolt seats into the female portion. The bolt is locked into place by a screw threaded into the center through the bottom dish. When this screw is tightened, the male and female portions of the center bolt are drawn together and the bolt fixed. A circular plug is backed into the screw to prevent it from loosening due to vibration while walking. The amount of torque applied to the center screw determines the amount of compression generated between the plates.

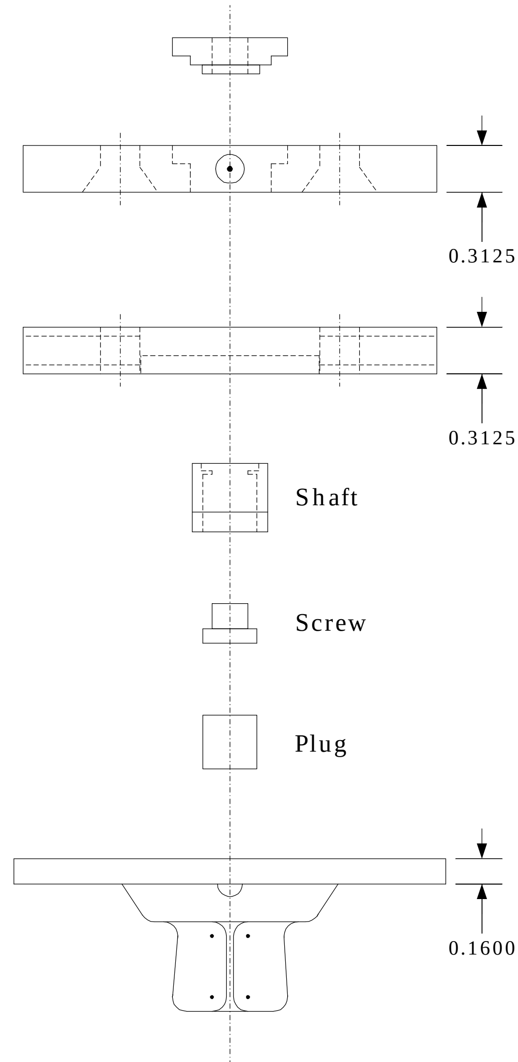

Figure 19.8. Assembly of Prosthetic Alignment Device.

The total cost of the Prosthetic Alignment Device is $400.

A SWITCH DRIVEN MOTOR CONTROLLED ARM FOR POSITIONING A COMMUNICATION DEVICE ON A WHEELCHAIR

Designers: Yogesh Patel, Angelo M. Ripepi, Nedim L. Tosyali
Supervising Professor: Dr. Blair Rowley
Department of Biomedical and Human Factors Engineering
Wright State University
Dayton, Ohio 45435-0001

INTRODUCTION

A motor-driven, switch-controlled arm for positioning a computerized communication device was designed for a 29-year-old woman with cerebral palsy. The client is non-verbal and uses a communication device from the Prentke Romich Company. She remains seated in her wheelchair throughout the day. Because of limited motor ability in her arms, she cannot move the communication device to the front of her lap tray or control a Prentke Romich mounting system without the assistance of another person.

The communication device is fixed on a mechanical arm that moves from the back of the wheelchair to the desired location in front. The arm enables the client to position independently her communication device. The device is operable with a switch that uses the 24-volt DC power from her wheelchair.

SUMMARY OF IMPACT

The new motor controlled arm for positioning a communication device enables the client to communicate more independently with her teachers and family.

TECHNICAL DESCRIPTION

The design involves a mechanical arm that moves from the back of the wheelchair to the desired location in front. Specifications included that the device: operate with the batteries provided with the wheelchair; have minimal control switches; be made of durable, weather-resistant material; have easily accessible circuitry, sealed for all weather conditions; have a soft switch, requiring minimal finger pressure; and be properly grounded.

The design incorporates a rotational motor for rotation over the head, a stainless steel rod that bends 90 ° and attaches to the motor, and a counterweight block of steel that attaches to the shaft. A support wheel, seen on the bottom of the communication device, provides support when the device is positioned on the lap tray. The storage position in the back includes a pedal switch that opens the circuit and, when depressed, prohibits backward motion of the communication device. The switch is mounted on the backrest in the rear of the wheelchair.

Figure 19.9. A Switch Driven Motor Controlled Arm for Positioning a Communication Device on a Wheelchair.

The rotational motor is a Barber-Colman DC motor, which can produce 300 in-lbs. of torque and rotate at 2.3 rpm. The mounting of the motor had to be stable and strong enough to handle the weight of the motor, the communication device, and the counterweight. Two aluminum plates are used for the mounting. The two plates are bolted together at a 90 ° angle. The larger plate is mounted on the rods of the backseat and the other allows for the attachment of the motor on the right side of the chair. The battery source is the 24-volt Invacare wheelchair power supply. The pedal switch is mounted on the backrest to stop the backward motion of the communication device. The momentary switch is the control mechanism used by the client to position the communication device.

The total cost is $950.

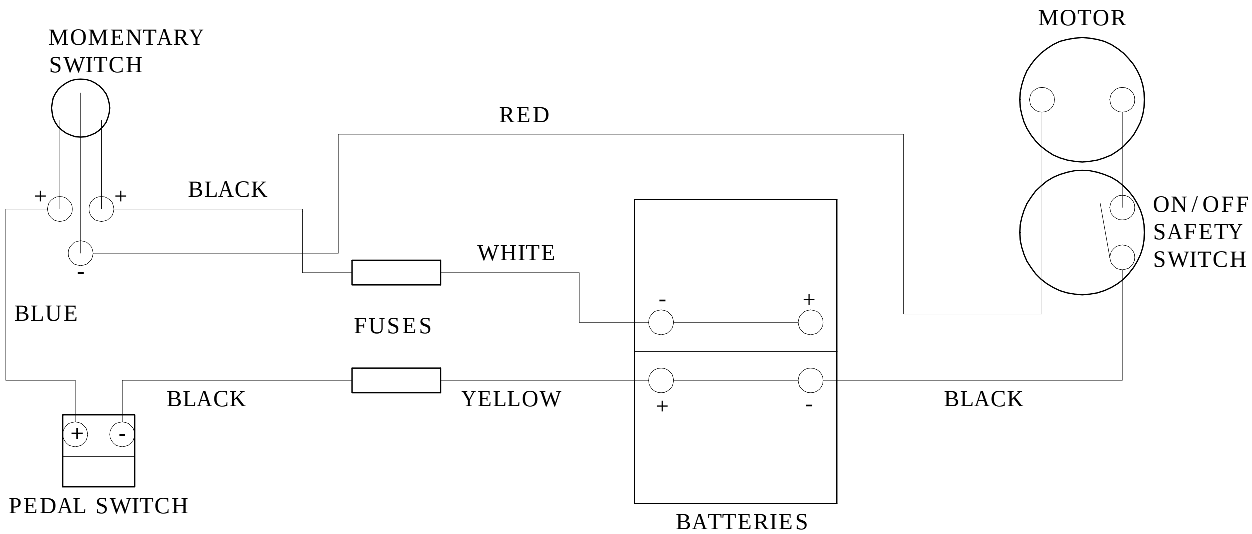

Figure 19.10. Circuitry for the Switch Driven Motor Controlled Arm

BENCH ALIGNMENT AND MEASUREMENT DEVICE

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INTRODUCTION

Precise means of measuring needed distances and angles for the production and alignment of prosthetic limbs are inefficient and inaccurate. Currently, practitioners use crude devices, loosely held tape measures, and plumb-bobs to estimate these values. Patients often spend countless hours with practitioners, making adjustments until a prosthesis fits properly.

There are several steps in fitting a patient for a prosthesis. The determination of a patient's activity level, casting of the residual limb, marking of all landmarks and bony prominences, and choice of the appropriate type of prosthetic to be made are all important steps. Human error can increase the time to make needed adjustments for a comfortable fit. Sometimes, sockets must be completely remade.

A laser system, the Bench Alignment and Measurement Device (BAMD), allows exact alignment and measurement. A wide-angle perspective is gained by increasing the distance from the patient, yielding a better assessment of socket alignment.

SUMMARY OF IMPACT

The BAMD may help reduce costs because of less time spent by prosthetists. The BAMD may prevent errors in alignment, saving additional labor and material costs. Original testing has involved above—the-knee amputees (AKA), but the BAMD could also be used for alignment of the socket for below-the-knee amputees (BKA) as well

TECHNICAL DESCRIPTION

Medical Alignment Systems, a company in Salt Lake City, Utah, produced a laser to allow for the generation of the needed reference lines. This company currently manufactures radiation alignment lasers used in hospitals and clinics. By combining the different lasers, developers constructed a system with constant vertical and rotational lines.

Figure 19.11. Bench Alignment and Measurement Device.

The BAMD consists of four components: the laser unit, tripod, macro slider, and measurement stand. The laser unit is comprised of two laser beams diffused through a small curved lens (actually, a glass rod). The first laser beam produces a fixed vertical reference line, used to determine the patient's load line, running through the knee center. The second laser beam intersects the vertical line at knee center and rotates about this center. This beam is used to connect the knee center and any desired anatomical landmark, most often the Ischial Tuberosity. These projected lines are then traced directly onto the test socket and enable the prosthetist to use these visual references in the final assembly and alignment of the prosthesis.

The laser unit has a three-meter focal length and uses 630 nm wavelength diodes. It is critical the unit be level, positioned at the focal length, and perpendicular to the frontal plane of the patient. There are two bubble levels mounted on the laser unit to verify that the laser line is true vertical or horizontal, depending on unit orientation.

A standard camera/camcorder tripod provides support for the unit, and allows for the range of position adjustment needed. The tripod head tilts to hold the laser unit in a vertical mode, for alignment and angle projection, or in a horizontal mode, for distance measurement. The tripod has a height range of 13” to 61”, which exceeds the expected 14” to 54” range, based on an average height range of 4’10” to 6’4”.

The Macro Slider provides a forward/back adjustment range of 3.125” and left/right adjustment range of 4.5”. This allows the laser unit to be positioned correctly without moving the tripod back and forth or side to side. The correct position is at the focal length and perpendicular to the frontal plane of the patient.

The measurement stand, in conjunction with the laser unit in the horizontal mode, provides the necessary length measurements. It is 61” tall. The vertical post and side supports are constructed of 1”x 6” pine mounted on a 1.25”x 15” sandwiched pine base. Mounted on the vertical post is a measurement tape with a range of 11.5” to 58.5” and a Plexiglas note board.

The approximate cost of this device is $750. The cost was kept reasonable thanks to the donation of the laser and the labor involved in its manufacture by Medical Alignment Systems.

Figure 19.12. Taking Measurements with the BAMD.

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