CHAPTER 9
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Children's Hospital Schoolroom Design Project

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INTRODUCTION

The Children's Hospital of New Orleans, in conjunction with Orleans Parish Public Schools, operates a classroom in the hospital for children to continue their studies while receiving prolonged medical treatment. Currently the Schoolroom is extremely cluttered and unorganized due to poor planning and inadequate furnishings. This environment has proven to be distracting to many students, especially those who have suffered severe head trauma. The room has little allowance for staff and patient traffic, and the floor plan is not suitable for wheelchair access. The goal of this project is to write a detailed proposal to redesign the Schoolroom to create an optimal environment for learning while considering human factors, psychological effects, and architectural points of view. The proposal was developed in two phases. The first consisted of the most important and most easily accomplished redesign, while the second embodied state-of-the-art advances. This organization was adopted as a customer requirement with funding agencies in mind.

SUMMARY OF IMPACT

Execution of the proposed redesign of the Schoolroom will result in improved access to the facility and an environment more conducive to study for a large population of disabled children. Federal accessibility standards, consulted when designing the room, resulted in a proposed room that would be entirely accessible to patients confined to wheelchairs. Human factors and ergonomic calculations are considered in the design so that a student population from ages 5 - 18 years would have appropriately sized chairs and tables. A room color scheme is chosen to be minimally distracting to head trauma patients. Sound distraction would be controlled with carpeting, an automatically opening door, and computer headphones. Schoolroom personnel are very satisfied with this proposal, and various aspects of this proposal are currently under discussion at the administrative level as part of the development of a new facility.

TECHNICAL DESCRIPTION

Two separate room proposals are created to accommodate different levels of funding and future expansion. Plan one, illustrated in Figure 9.1, is a baseline proposal that meets all the essential customer requirements at the lowest possible price. Plan two, illustrated in Figure 9.2, is a more expensive proposal with more options for the students and teachers. In both plans, the proposed changes to the Schoolroom are organized into five categories: environmental, furniture, storage, electrical, and miscellaneous. All changes are detailed as to physical plant involvement, specific vendors, equipment model numbers, and cost.

Plan one environmental category items aim to create an atmosphere to promote concentration and relaxed learning. A light blue color scheme is selected since it is a cool color that will not encourage physical activity. This color is matched with color carpet, blinds, and paint with the help of an interior decorator. The furniture category items are selected using ergonomic calculations based on anthropometric tables for 5th percentile 5 year olds and 95th percentile 18 year olds. Space for the furniture is maximized by placing the computer workstations in existing book recesses to create better traffic flow. The storage category items help to organize the room and make it less cluttered. The volume of books currently in the room is used to determine the amount of shelving and storage space needed. The electrical items provide for adequate lighting at the workstations and include the installation of two new electrical outlets for computers and hospital equipment.

Plan two proposes a new computer system that is expandable to include CD ROM capacity for the latest in educational software. A television/VCR is also included to provide modem visual instruction with videos. The miscellaneous items are primarily equipment to make the room and workstations more comfortable for persons with disabilities. A variety of computer accessories such as monitor stands and anti-glare filters make the computer stations adaptable. In addition a bean bag chair and storage seat provide for a separate reading area in the classroom.

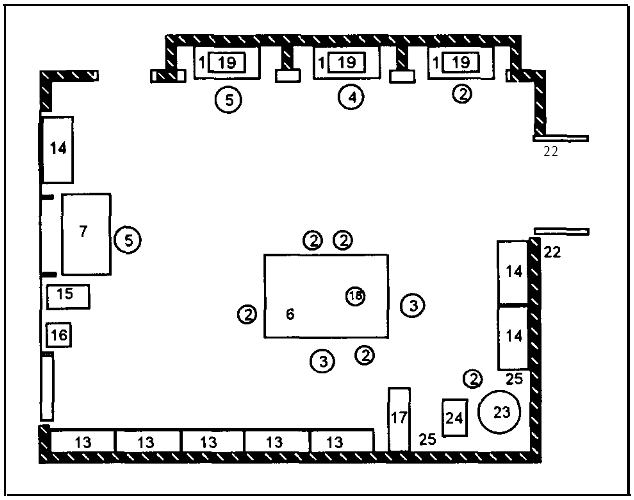

Figure 9.1. The Plan One Proposal for the Classroom Redesign.

In the plan one AutoCAD drawing shown in Figure 9.1, the furniture layer consists of: 1) computer tables, 2) static chairs for young children, 3) static chairs for adolescents, 4) a padded chair with armrests, 5) adjustable workstation chairs, 6) an existing worktable, and 7) an existing teacher's desk. The storage layer consists of: 13) book shelves, 14) supply cabinets, 15) filing cabinets, 16) an existing filing cabinet, 17) a reading rack. The electrical layer consists of: 18) a new floor electrical outlet and 19) existing computers. Finally, the miscellaneous layer consists of: 22) automatic door openers, 23) a bean bag chair, and 24) a story seat. Other minor proposed items are not indicated on the above AutoCAD drawing due to size constraints. The cost of plan one including shipping, tax and installation is $6,899.

The plan two proposal additions shown in Figure 9.2 include in the furniture layer: 8) an audiovisual cart, 9) study carrel, 10) large adjustable height worktable, 11) an adjustable computer workstation, 12) teacher's desk. The electrical layer additions include: 20) Macintosh Centris 610 and 21) Television/VCR. Finally, the miscellaneous additions include: 26) new automatic door openers, and 27) a projection screen. The cost of plan two is $22,173.

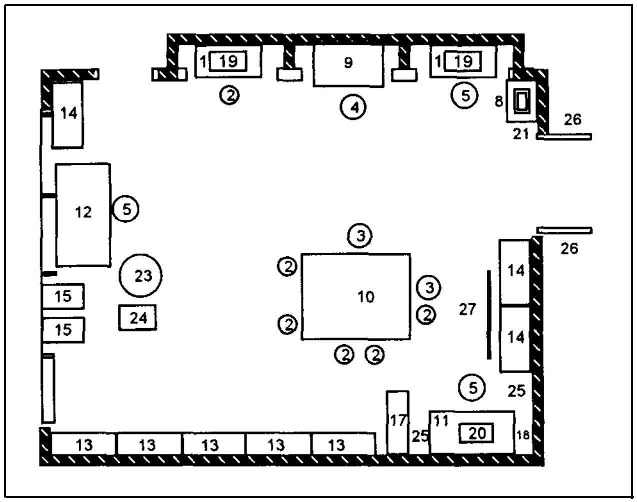

Figure 9.2. The plan two proposal for the classroom redesign.

An Automatic Door Opener for the Schoolroom

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INTRODUCTION

An automatic door opener has been designed for the entrance to the Children's Hospital Schoolroom. The opener consists of a door-mounted drive assembly, two external control boxes, and one limit switch. The opener is powered by a 90VDC gear motor and operates by engaging a semi-pneumatic wheel with the floor (see Figure 9.3). A pre-existing standard mechanical door return is used to close the door. The opening speed, opening range, and delay before closing are all adjustable through the use of two timing relays and a motor speed control. Fail-safe circuits are also included to provide emergency power-off capability as well as limit detection. In the event of a power failure, the drive mechanism is disengaged, thereby allowing normal manual door operation.

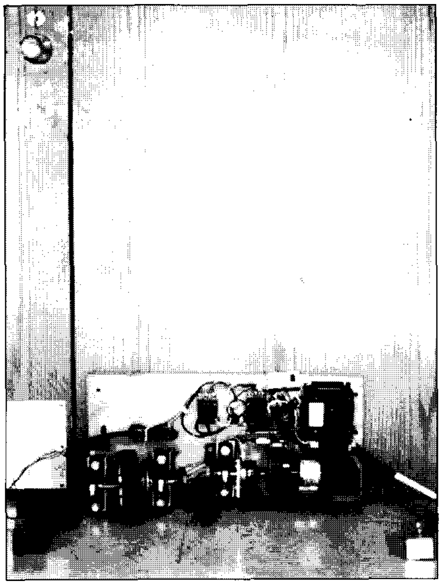

Figure 9.3. Creation Industries Automatic Door Opener with Housing Removed.

SUMMARY OF IMPACT

The Schoolroom of Children's Hospital is a branch of the Orleans Parish Public Schools that provides instruction to children who suffer disabling illness or trauma requiring prolonged hospitalization. The accessibility of the current facility housing the Schoolroom is poor due to cumbrous double doors that are difficult for individuals requiring assistance to open. As a result, the Schoolroom personnel often find their instructional efforts to be inefficient simply due to the physical limitations of the building. The main functions provided by the door opener are: 1) ease of operation by seated individuals, 2) normal door usage when unpowered, 3) a low noise level to avoid student distraction, 4) compliance with hospital safety codes, 5) simple installation, and 6) an emergency power shut off. Also, the final design is to be easily adjustable with regard to opening speed, opening range, closing delay, and placement of control circuitry. Importantly, the basic design of this device could be easily adapted to fit a wide variety of home and office doors, as demonstrated by prototype testing on off-site laboratory doors. Thus, the device meets the needs of the Schoolroom and offers a potential benefit to a broad clientele.

TECHNICAL DESCRIPTION

The drive components (Figure 9.4) consist of a 90VDC gear motor (Maxitorq model 6Z914, 1/20 hp, gear ratio 49:1), a magnetic clutch (Inertia Dynamics model F022, 50 in-LB max torque), a flexible coupling (Flexthane model CC5-37-A), $\frac{1}{2}$ in. steel drive shaft (3 in.) and axle (8 in.), and a 6 in. diameter semi-pneumatic drive wheel. The mounting components consist of a 0.75×12×24 in. oak door mounting plate, a motor mount, and three shimmed or offset $\frac{1}{2}$ in. I.D. pillow blocks. The mounting plate attaches to the bottom of the door using two 0.375 in. bolts, one acting as a pivot pin, the other as a slot-guide. This configuration allows the wheel to follow fluctuations in the floor. The motor is mounted in line with the clutch. The wheel axle is coupled to the drive shaft through the flexible coupling. The location of the drive wheel and the angle of the axle with respect to the door can be adjusted by changing the placement of the pillow blocks. The wheel develops an adequate friction drive force from the floor contact created by the weight of the device as it pivots about the mounting pin. The magnetic clutch has a limiting torque of 50 in-lbs. that determines the upper limit of opening force the motor can develop (also the minimum force required to stop door opening, approximately 2 lbs.). The closing mechanism is provided by a pre-existing standard mechanical hinged door return.

The control components (Figure 9.5) consist of two wall-mounted normally open, momentary contact switches that activate the drive circuitry, a motor speed control (Dayton, model 4Z827C, 115 VAC input, 90VDC output), the motor and clutch timing relays (IDEC model RTE-P21-AC120), a SPST snap-action limit switch, and a power shut-off SPST switch and indicator light. The unit is activated by pushing either of the momentary contact switches to simultaneously engage the motor and clutch timing relays. The speed of the door is adjusted by changing the dial setting of the motor speed control. The distance the door opens and the time the door remains open can be adjusted by changing the setting of the timing relays. The limit switch (or series of limit switches) serves to safeguard timer relay failure. The emergency power shut-off switch is located on the top of the unit to allow quick easy access. The entire device is enclosed in a grounded sheet metal housing. The final cost of the automatic door opener was approximately $400.

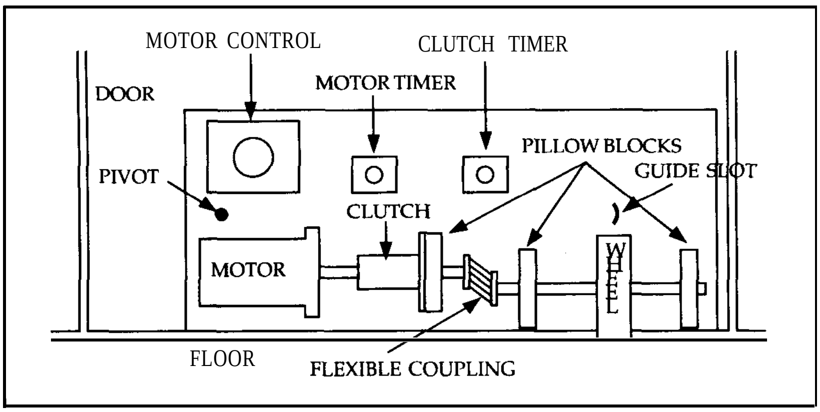

Figure 9.4. General Schematic of Functional Design.

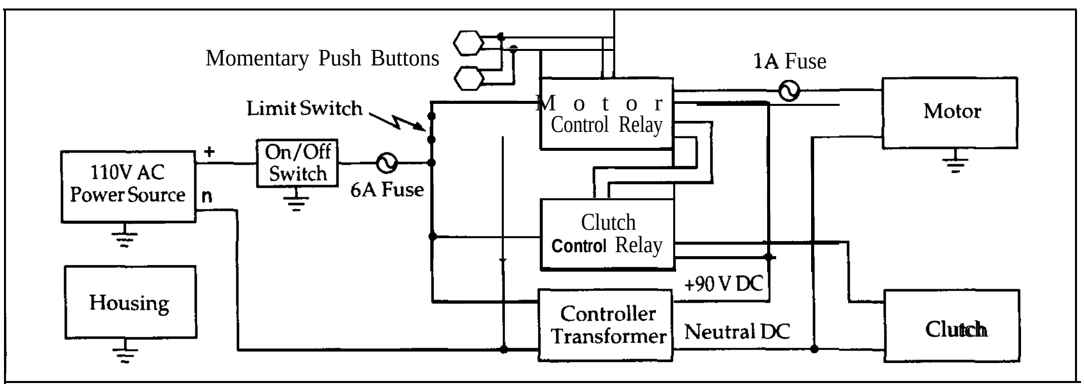

Figure 9.5. General Control Circuit Wiring Schematic.

The Bioassist Portable Wheelchair Assist Drive

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Client Coordinator: Mona Herbert
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Supervising Professors: Dr. D. A. Rice and Dr. R. C. Anderson
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INTRODUCTION

A portable power assist drive was designed for a collapsible wheelchair used by an eight-year-old boy with Ehler's Danlos Syndrome. The conceptual design of this device is based on the client's desire to have a simple, inexpensive source of power to help push the wheelchair up inclines and over long, straight distances. The drive consists of five modular components and two twelve-volt batteries easily assembled onto the wheelchair without the use of tools. The main drive unit, batteries, and control circuitry are located directly under the seat (see Figure 9.6). An on-off switch and variable speed controls are within reach of the patient's hand, and an emergency power-off override switch is located on the footrest of the wheelchair. The drive unit may be disengaged by either using the clutch on the wheel or by raising the unit along slots on the chair. Chair modification consisted of only three small welds to create stable attach points for the drive. The unit adds approximately sixty pounds to the chair, and is easily stored in a the trunk of a car. The power assist drive attains walking speeds.

SUMMARY OF IMPACT

Ehler's Danlos Syndrome is a congenital genetic disorder that hinders the body's collagen production. One effect of this disease is the development of hypermobile joints. These patients are often subject to muscle cramps and excessive fatigue because the muscles surrounding the joints must compensate for loosed ligamentous stability. Travel by wheelchair provides relief for fatigued lower limbs, but requires upper limb use. On long trips the chair must be pushed by an attendant. The Bioassist power assist drive is developed for our client to relieve such fatigue as well as to give him a larger measure of independence. Our present design accomplishes these goals, while providing sufficient power to ascend inclines, adequate speed to keep up with walking adults, and portability. A one-week field test was conducted with the client at his suburban New Orleans home. The chair has been delivered to the client and his satisfaction with chair operation is very high. Typical installation and tear down times run approximately five minutes.

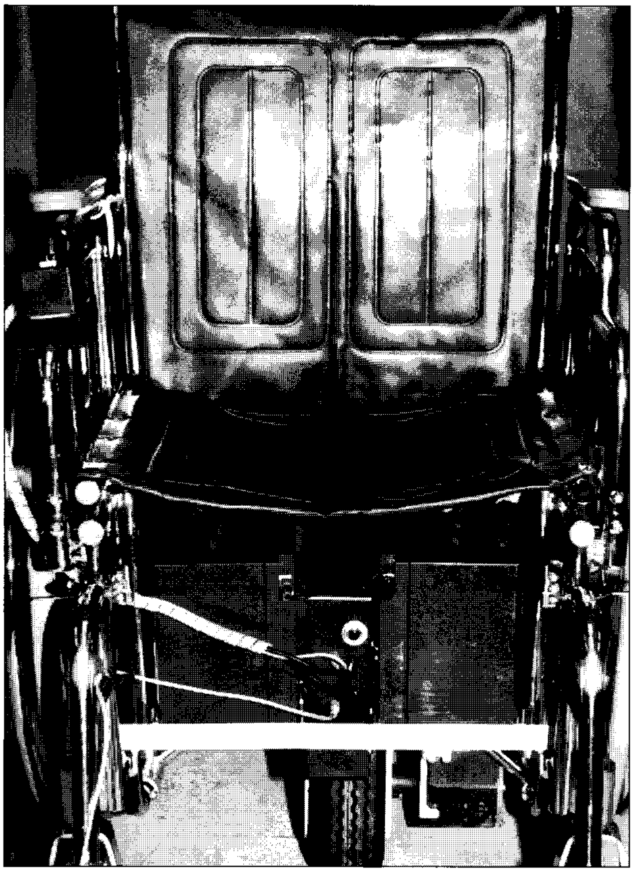

Figure 9.6. The Bioassist Portable Wheelchair Power Assist Drive.

TECHNICAL DESCRIPTION

The portable wheelchair power assist was designed with a particular client, passenger load, and environment in mind, but the design could be easily attached to most wheelchairs. The major design criteria of the assist drive are as follows: 1) the unit must be simple and portable, 2) it must attach to a standard collapsible wheelchair, 3) it must be designed to work in conjunction with a human power source, and 4) it must be easy and safe to attach and use.

The assist drive consists of five main components and two sealed 12-V batteries (see Figure 9.7). The components are as follows: 1) the motor and wheel unit consisting of a non-reversible, fhp, 12VDC motor, a right-angle gear reducer, and a small pneumatic tire, 2) a welded aluminum battery and circuitry box holder that rests on the metal members of the chair, 3) the circuitry box which contains all of the necessary speed control circuitry and wiring, 4) the speed control and power switch unit, and 5) the foot switch which must remain pressed to maintain power to the motor.

The motor and wheel unit have an aluminum bar welded to them to facilitate attachment to the wheelchair. It can only be attached in one position to assure correct assembly. The aluminum bar is attached to the two rear vertical posts of the chair with two wing-nuts and to a front member with a single wing nut. The drive unit may be disengaged by lifting the clutch plate on the center of the wheel to rotate it free of the gear head, or the entire unit may be raised off of the ground and reattached. The two sealed 12V batteries weigh a total of 36 pounds. The batteries are rechargeable by any standard car battery recharger. The batteries are placed in the holder with the terminals facing inward, the only orientation for which the connections can be made to assure correct, safe assembly. Wiring connections are color coded and the cables are cut to lengths that fit on the batteries only one way. The circuitry box is also designed to be assembled only one way. The motor power is fused with a 20 amp circuit breaker to shut off the chair in the event of a stall. The control circuitry consists of a pulse width modulation circuit to control the speed of the motor, a snubbing diode to prevent back flow of armature current into the circuitry, and wiring to connect to the batteries, switches, and motor. The front face of the box contains a jack for the foot switch, the on/off switch, and the speed control. The two motor connections located on the back of the box are coded so that the positive lead is a banana type connector, while the negative lead is an RCA type connector. It is physically impossible to reverse these two connectors, so the motor will always turn in the proper direction. The final cost of the portable wheelchair power assist is approximately $500.

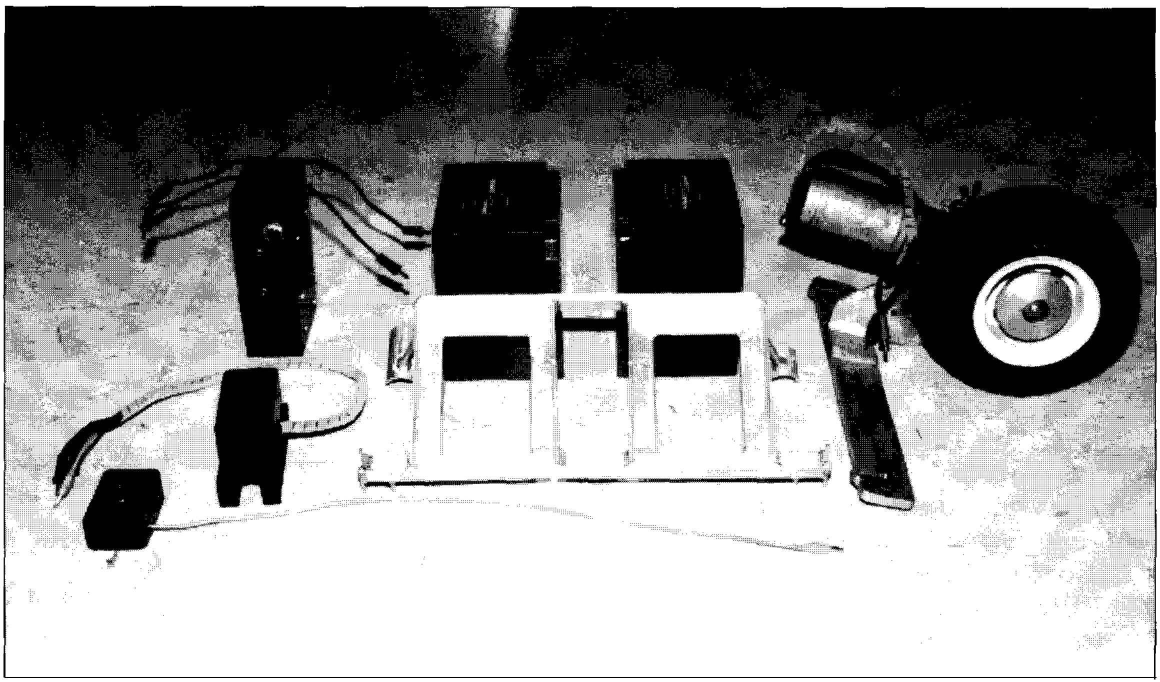

Figure 9.7. Main components of the assist drive.

The PAT-XL Myoelectric Training Device

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INTRODUCTION

A myoelectric training device is a project designed for upper limb deficient children. The device, called the PAT-XL ((Play And Train - Deluxe, see Figure 9.8), capitalizes on the enthusiasm these children have for video games in order to encourage them to generate EMG signals appropriate for the control of myoelectric prostheses. This device uses EMG signals from selected sites to control the operation of the "A" and "B" buttons of a Nintendo Gameboy. These buttons have a variety of functions for different games, but are typically reserved for firing and jumping the video character. The unaffected hand is free to control the position and movements of the video character. This configuration is intended to provide the necessary incentive for bimanual coordination. Further, the therapist can adjust the switched settings of the PAT-XL to change a comparative threshold voltage and thereby affect the development of muscle control by regulating the degree of muscle contraction required to operate the Gameboy.

SUMMARY OF IMPACT

Limb deficient children who are to be fitted with myoelectric controllers or prostheses must first undergo therapy with myoelectric training devices. It is important to fit myoelectric prostheses at a young age since late fitting generally decreases the likelihood a child will accept the device. However, gaining voluntary control of the muscles of the affected limb is difficult, and very young children often do not appreciate the future benefit from developing such control. Consequently, muscle training therapy sessions frequently become daunting, tedious, and ineffectual. Therefore, it becomes vital to the success of the therapy that training devices be interesting enough to maintain a young child's concentrated attention. The PAT-XL is such a device. Evaluation of the PAT-XL on a number of clients at Children's Hospital showed that it is, in fact, capable of consistently provoking an interested, even prolonged response. Preliminary assessment suggests that this new device provides a more beneficial, efficient, and cost effective therapy than normally expected. Children's Hospital therapists have requested that an additional PAT-XL be built for their use.

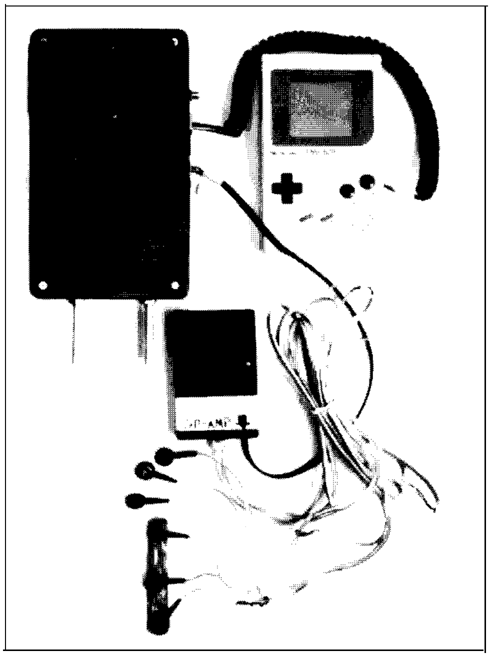

Figure 9.8. The PAT-XL Myoelectric Training Device System.

TECHNICAL DESCRIPTION

The Biomedical Engineering Class of 1991 developed a number of myoelectric training devices for the Occupational Therapy Department of Children's Hospital in conjunction with the current NSF program. Each of these devices employed a differential pre-amplifier with variable gain settings (0.2x, lx, and 5x) as the front-end interface for EMG signal acquisition. The PAT-XL utilizes this same interface. The pre-amplifier has two channels of 4-lead input capable of acquiring the signals from two muscles simultaneously. The pre-amplifier is powered by an internal 9-V battery. The conditioned signal is output over a 4-wire telephone cable and modular jack into the PAT-XL where the signal is amplified and compared to an adjustable threshold voltage (see Figure 9.9). In this way, the therapist is able to regulate the degree of muscle contraction required to activate the Gameboy. When the desired threshold is reached on a given channel, an LED is turned on to provide feedback to the therapist and client. The output from the PAT-XL is an on/off voltage that enters the Gameboy and overrides the existing "A" and "B" button switches through reed relays. When not being used in therapy, removal of the PAT-XL from the Gameboy returns the "A" and "B" buttons to their normal operation. The PAT-XL is also powered by an internal 9-V battery.

The final cost of the PAT-XL, including the Nintendo Gameboy, is approximately $130.

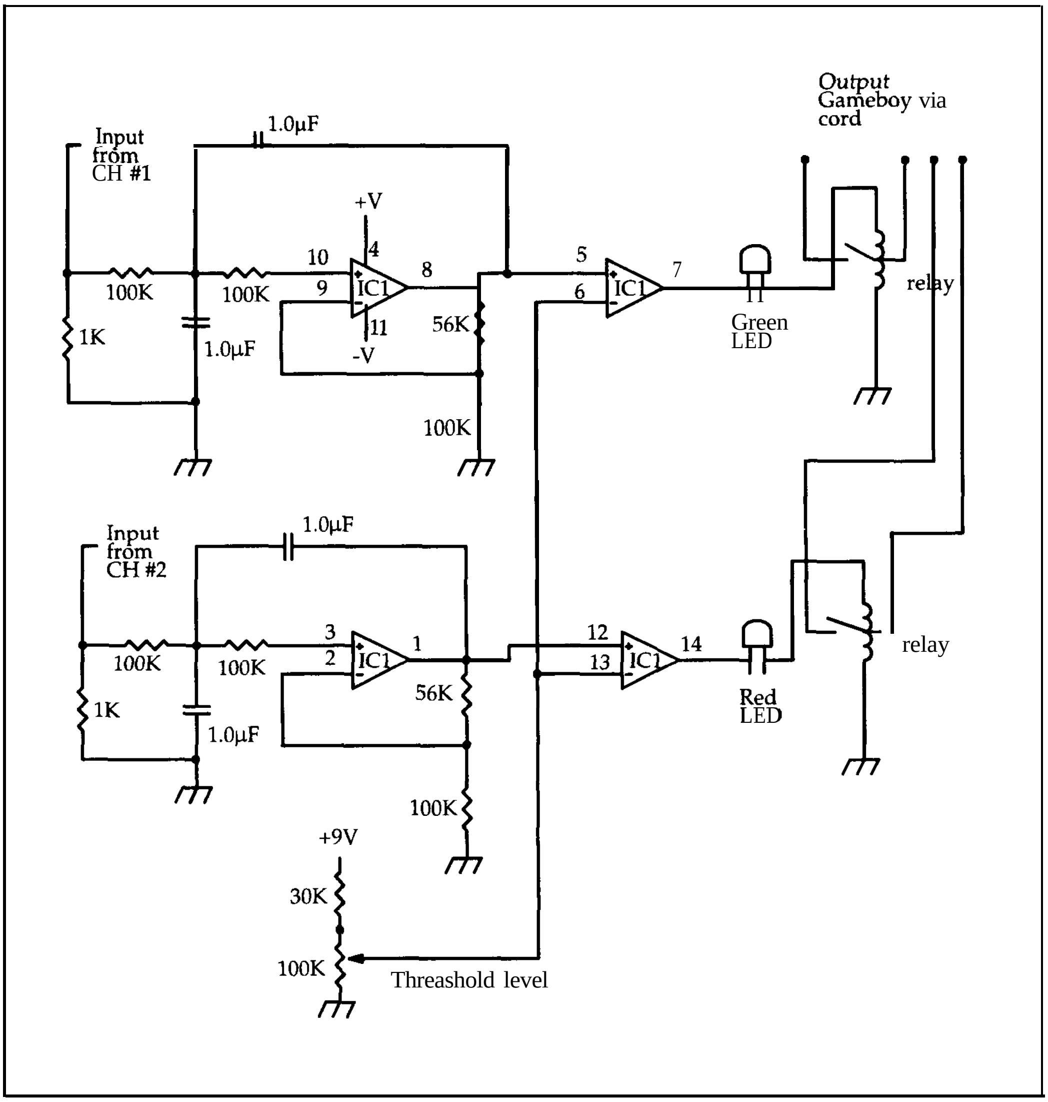

Figure 9.9. Circuit Schematic of the PAT-XL.

The INTECH Self-Feeder

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Client Coordinator: Eileen Bohan, 0. T.
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INTRODUCTION

The INTECH self-feeder was designed for a 20-year-old college student with ankylosed elbows. Our client can independently manage all aspects of the feeding process except he cannot bend his elbows; therefore, he wanted a feeder that would bring a utensil from plate level to mouth level. The design requirements placed a strong emphasis on the need to make the self-feeder as simple as possible because our client feels that existing commercial designs are too complex to operate, and too "high-tech" in appearance. Consequently, the INTECH self-feeder was designed to minimize control operations while functioning to simply raise and lower a variety of utensils. The self-feeder was also designed to be portable, requiring that the device be light weight and powered by a 12VDC rechargeable battery. Our client also has limited hip flexion, and is most comfortable in the standing position while he eats, so the self-feeder was designed to accommodate his standing height.

SUMMARY OF IMPACT

The INTECH self-feeder is portable and simple to operate (see Figure 9.10). The self-feeder is placed to the left of the food plate and turned on with a low-force rocker switch. The desired utensil is manually placed in the utensil holder and lowered through a momentary contact toggle switch. The lowered utensil is loaded manually, then raised on the powered drive as activated through the toggle switch. The entire device is then rotated manually to a comfortable eating position. The utensil holder can accommodate almost any standard fork or spoon, and the slow motion of the utensil holder enables our client to eat a wide variety of foods. With this feeding device, our client will be able to manage all aspects of the feeding process.

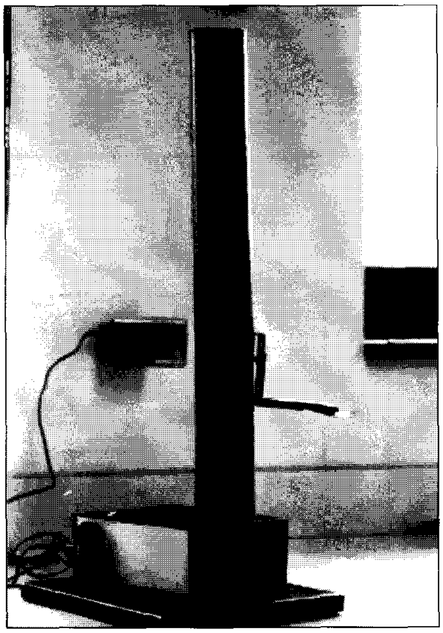

Figure 9.10. The Intech Self-Feeder.

TECHNICAL SUMMARY

The INTECH self-feeder consists of three main components: 1) a PVC tower housing a follower sprocket, toothed drive belt, and utensil holder, 2) a metal box containing the gearmotor, drive sprocket, battery, and control circuitry, and 3) a wooden turntable covering a rotating bearing.

Figure 9.11 shows the schematic of the basic components. The metal (steel) box is mounted to the wooden turntable that allows 90 degrees of rotation of the utensil. Two magnetic stops are located on the turntable to allow correct manual positioning and to stabilize the feeder during use. The motor is mounted to the top of the box to facilitate disassembly during service. Control switches are mounted on the front bottom panel and a recharge jack is mounted on the rear bottom panel.

The tower housing the drive tram is constructed from PVC pipe. The PVC pipe is slotted to provide a straight track for vertical motion of the utensil holder. The utensil holder is connected to a toothed nylon belt driven by a small 12VDC reversible gearmotor attached to a drive sprocket. A follower sprocket is mounted at the top of the tower. Limit switches are positioned at both ends of the track to stop the utensil holder at the limits of the feeder's excursion. A nylon skirt is placed along the track slot to keep food and dirt out of the tower. The utensil holder is comprised of a rigid steel mounting arm to which is fastened a vinyl sleeve. The sleeve is of a size to firmly hold many ordinary utensils.

The control circuitry consists of a master on/off rocker switch in series with the battery, a momentary contact, normally-open, DPDT toggle switch in series with the power input, and two normally closed, snap-action limit switches in series with the motor. The master on/off switch activates power and isolates the recharge circuit while the feeder is off. The battery is recharged with a 12VDC, 500mA outlet transformer that can also act to provide transformed residential power to operate the feeder. The momentary contact, DPDT switch allows the user to reverse gearmotor polarity and to precisely adjust the utensil to the desired level while eating.

The total cost of this device was approximately $150.

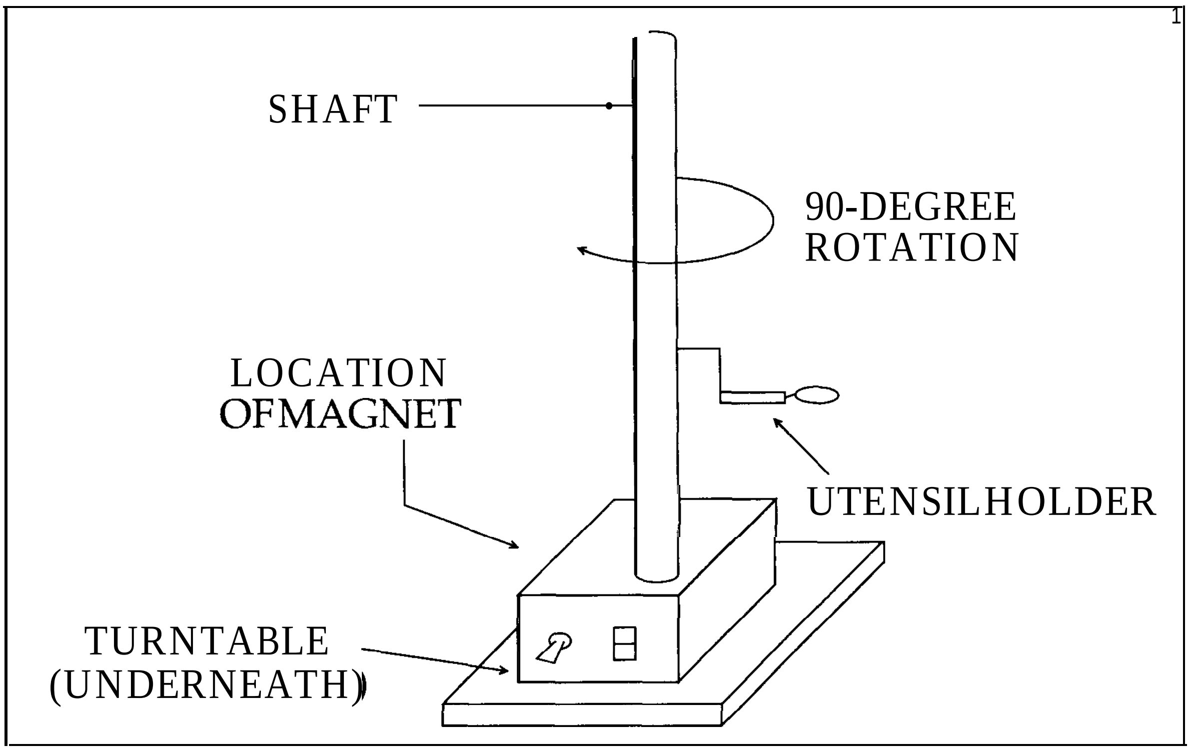

Figure 9.11. Schematic Representation of the Intech Self-Feeder.

Portable Powered Wheelchair Drive System

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INTRODUCTION

The objective of this project is to design a portable wheelchair drive system to power a standard collapsible wheelchair, without making chair modifications (see Figure 9.12). The resulting power drive is portable and breaks down to four main components: 1) a standard 12VDC sealed lawn and garden battery, 2) the solenoid pack, 3) the motor and friction drive system, and 4) the hand-operated control switches. All parts are detachable to allow the chair and drive to be stored in a car trunk. The drive is mounted directly behind the seat, with the battery placed beneath. Power is transferred to each wheel of the chair through friction drive wheels, and each rear wheel of the chair is driven and controlled independently. Through the control of two single-pole double-throw toggle switches mounted on the arm of the wheelchair, the drive can produce eight distinct movements, straight forward, straight backward, right and left hard turns, right and left wide forward turns, and right and left wide backward turns. The resulting wheelchair drive system is capable of producing adult walking speeds, is highly maneuverable, and simple to operate.

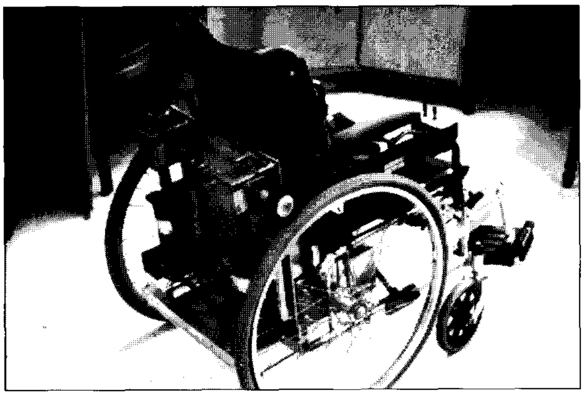

Figure 9.12. Portable Wheelchair Drive System (With Housing Removed] Mounted to a Common Model Wheelchair.

SUMMARY OF IMPACT

Powered wheelchairs are an obvious advantage to confined patients, not only from the standpoint of reducing the level of exertion in normal daily activity, but also by decreasing their level of dependence on an attendant. However, commercial designs of powered wheelchairs are most often prohibitively expensive and too large to transport by family automobile, thus making access to these devices limited. Subsequently, the goal of this project is to develop an inexpensive portable wheelchair drive that could be attached to the most common models of collapsible wheelchairs in an effort to provide assistive technology to the broadest clientele. This design has accomplished the project objective by providing a relatively inexpensive, easily installed and operated, and highly functional power drive system that can be mounted on common chair models without chair modifications or specialized assembly techniques. Client trails demonstrated that all chair functions can be quickly learned by an eight-year-old child.

TECHNICAL DESCRIPTION

The wheelchair operates on a friction drive where a 3” rubber wheel engages each of the pneumatic tires of the wheelchair. Adequate contact between the friction drive wheels and the tires is provided by the free weight of the drive assembly as it rests on the tires. The mounting to the wheelchair frame is accomplished using the rear structural members of the chair. Tubular support members are inserted into the bottom horizontal members of the chair to act as frame extensions. The frame of the drive is also attached to the wheel axles with aluminum mounting plates.

The drive develops power from two 1/6 hp, instantly reversible permanent magnet 12VDC motors (Dayton) connected to two right-angle gear reducers (Dayton, model 6z436, 5:1). Motor current is supplied by a sealed, 12 volt lawn and garden battery. The battery is rechargeable using a standard automotive battery recharger.

The switching mechanism that controls chair movement consists of eight single pole, normally-open solenoids, four for each motor circuit (see Figure 9.13). Two double pole, double throw toggle switches are mounted to the arm of the chair and act to simply control motion by activating or reversing the motors in various combinations. For example, to make the chair go forward, both switches are pushed forward. To make a hard left, the left wheel is reversed, while the right wheel is switched forward.

With the power drive installed, the wheelchair can be set to function manually, or with the friction drive. This is achieved by engaging or disengaging the friction drive. This feature makes it possible to put the wheelchair components together and wheel it to the appropriate area to be used instead of carrying it piece by piece to the desired area and then assembling it.

The total cost of the power drive system was approximately $650.

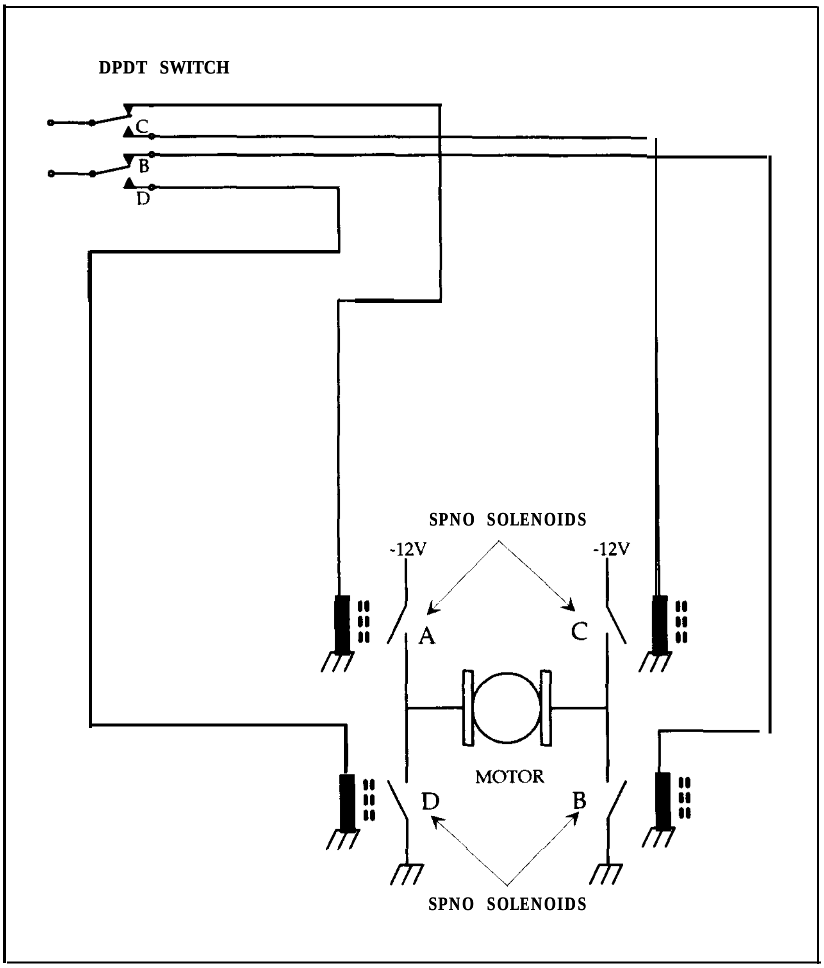

Figure 9.13. Direction Control Circuit of the Left Motor.

Automatic Door Opener

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INTRODUCTION

An automatic door opener has been designed for unspecified wheelchair users in the New Orleans area as part of a program at Children's Hospital to help instruct parents of disabled children how to modify various assistive devices for use in the home. The purpose of this project is to design a very simple, easily installed door opener that could be used to open typical light weight office or bedroom doors. The door opener consists of three main components: a rotating motor drive, a detachable pulley system, and a housing for the motor (see Figure 9.14 and Figure 9.15). The motor is powered with standard 110VAC residential current. It can be operated by a hand-held remote control or a wall mounted switch. The motor is supported by a housing that may be bolted to either a wall that is at a 90" angle to the door or to the ceiling at the level of the top of the door. This keeps the motor and its moving parts out of reach. A pulley system links the rotating motor to the door. The pulley system is easily detachable to provide quick transformation back to a normal door.

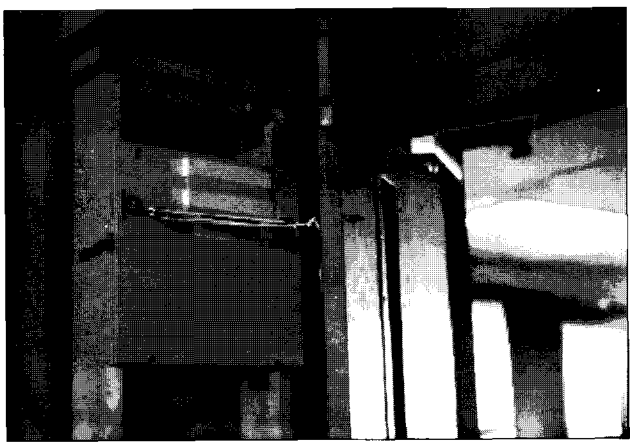

Figure 9.14. The Wall Mounted Door Opener in Relation to the Open Door Position.

SUMMARY OF IMPACT

People confined to wheelchairs are often frustrated by home, work, or public facilities not designed to accommodate their disabilities. In some instances, even the simple task of opening a door can cause ill-feelings of unnecessary dependence. While many public facilities have ramps and automatic entrances for disabled individuals, few private offices or homes are so equipped. The lack of automatic doors in the private sector is mainly due to high cost and the difficulty of installation and maintenance. The automatic door opener design of this project represents an option to commercially available doors that is both inexpensive and easily implemented. This design is simple enough that the typical home odd jobber can install and operate it without difficulty, and is capable of providing a valuable service for a wide variety of potential clients.

TECHNICAL DESCRIPTION

The automatic door opener is suitable for virtually any home or office door. Five main design requirements for the opener are: 1) it had to be unobstructive in the doorway to allow for the passage of an adult sized wheelchair, 2) it had to open and close the door in a typical fashion, 3) it had to be easily installed, 4) it had to be safe to use, and 5) it had to allow the simultaneous normal operation of the door.

The 110VAC drive motor was taken from a Genie G2500 $\frac{1}{4}$ HP Screw Drive Garage Door Opening System (The Genie Company, Alliance, Ohio) and modified. The output shaft was cut to approximately 5 inches. An adjustable steel ring was fixed to the shaft to provide an attach point for the nylon pulley cord. Two wheel stops were placed on the shaft to limit the winding of the cord (see Figure 9.15). For purposes of safety, the original housing of the motor and control electronics is not modified. Similarly, the limit switches and control logic provided with the Genie G2500 for the opening and closing of the door are retained, including the sensor to detect door obstruction. Installation required correct positioning of the limit switches above the door. Also, the ability to open and close the door via hand-held remote control or wall mounted button switches is unmodified from the Genie G2500. A standard damped, spring loaded door closer must operate in conjunction with this opener design.

The motor mount was made of two 2"×6"×18" wooden beams forming the top and bottom sides of the case, two 2"×6"×14" wooden beams forming the left and right sides of the case, and two $\frac{3}{8}$"×17"×18" pieces of plywood forming the front and back of the case. The motor and shaft were secured inside the wooden casing by a 1" metal strip bolted to the left and right sides of the wood casing and to the front of the original motor case.

A tackle made of two double pulleys, one attached to the door and the other to the housing of the motor, is used to increase the opening force and reduce the opening speed developed by the motor. The pulleys are attached with metal buckles to facilitate their disassembly if desired. One-quarter inch U-bolts are used to secure the buckles to the door and motor mount. The nylon cord is first anchored to the motor, threaded twice through the pulleys, then anchored to the door. The double pulley system acted to reduce force generation requirements and eliminated the need for a motor speed control.

The safety features incorporated into this design include automatic power-off if the movement of the door is obstructed for more than two seconds, automatic re-opening of the door if it is obstructed for more than 24 seconds during closing, and an automatic stop if an infrared safety beam across the entrance is obstructed during closing.

The final cost of the automatic door opener was approximately $195.

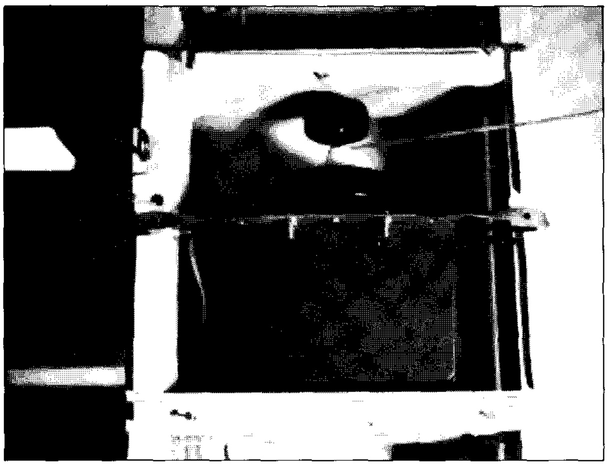

Figure 9.15. The Modified Genie G2500 1/4 Hp Motor and Cord Winding Mechanism.