CHAPTER 17

UNIVERSITY OF DELAWARE

College of Engineering
Department of Mechanical Engineering
Newark, Delaware 19716

Principal Investigator:

Robert H. Allen (302) 451-2421

Development of an Automated Mechanism for the Wagner Limb Lengthener

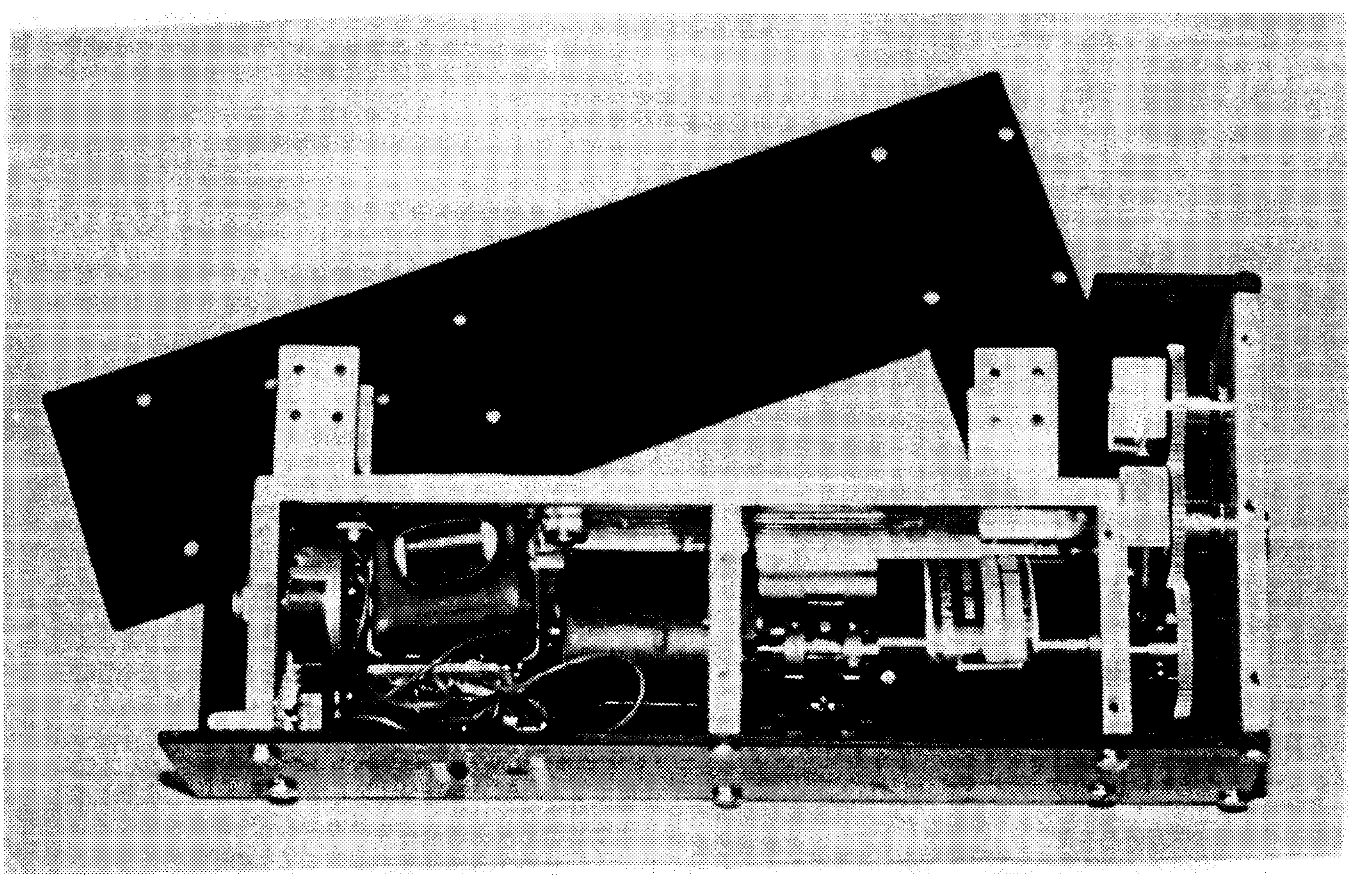
Designers: Regina Knotts, Amy Lerner, Laura Mullen, Sean Stroud
Disabled Coordinator: Freeman Miller, MD
Alfred I. Du Pont Institute
Supervising Professor: Dr. Robert Allen
Mechanical Engineering Department
University of Delaware
Newark, DE 19716

INTRODUCTION

The goal of this project was to design, build and test a modification of an existing leg lengthening device that will safely provide a continuous, adjustable rate of lengthening. The Wagner External Fixator was chosen for modification. The modification designed includes an assembly that replaces the handle normally used for length adjustments. The assembly is mounted on the external housing of the fixator and the top of the threaded rod that caused the lengthening. A DC motor with geared speed reduction is used to provide continuous lengthening over a period of twelve hours each day. An additional system was designed to monitor the patterns of motion near the bone distraction site. This system is designed to indicate the effects of different weight bearing exercises on the motion in the bone regeneration area. Testing was performed to certify that the design performs acceptably under a variety of loading conditions.

SUMMARY OF IMPACT

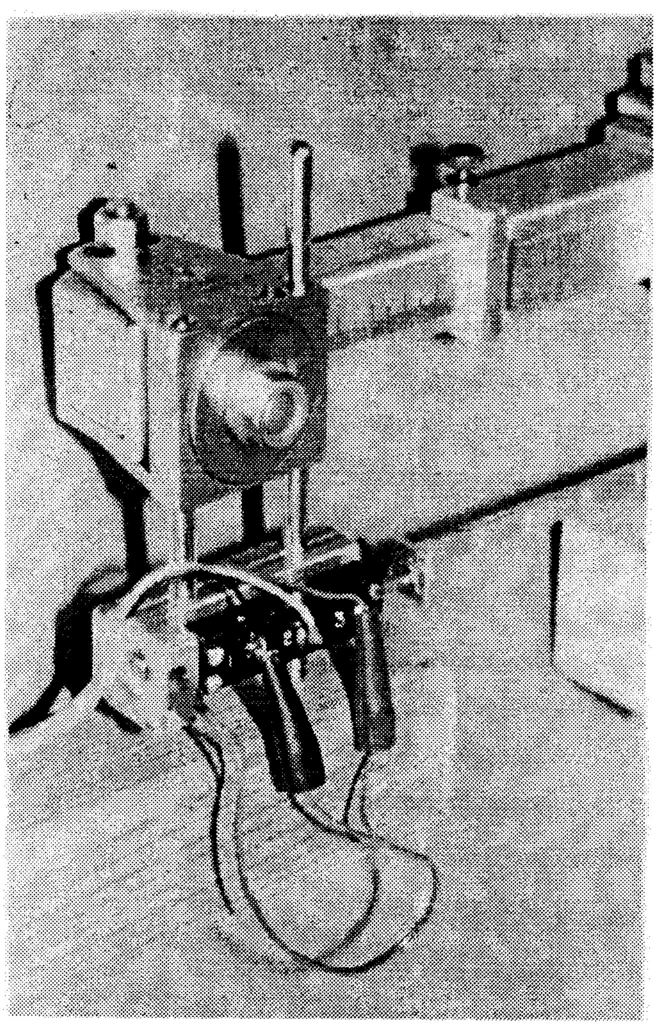
Leg lengthening is a medical procedure that has become increasingly common in recent years. Its most common use is for correction of leg length discrepancies in children. The Wagner device is one of several currently used for the procedure. Lengthening is achieved by manually turning a knob on a threaded rod four times a day, causing a total of 1 mm of lengthening each day.

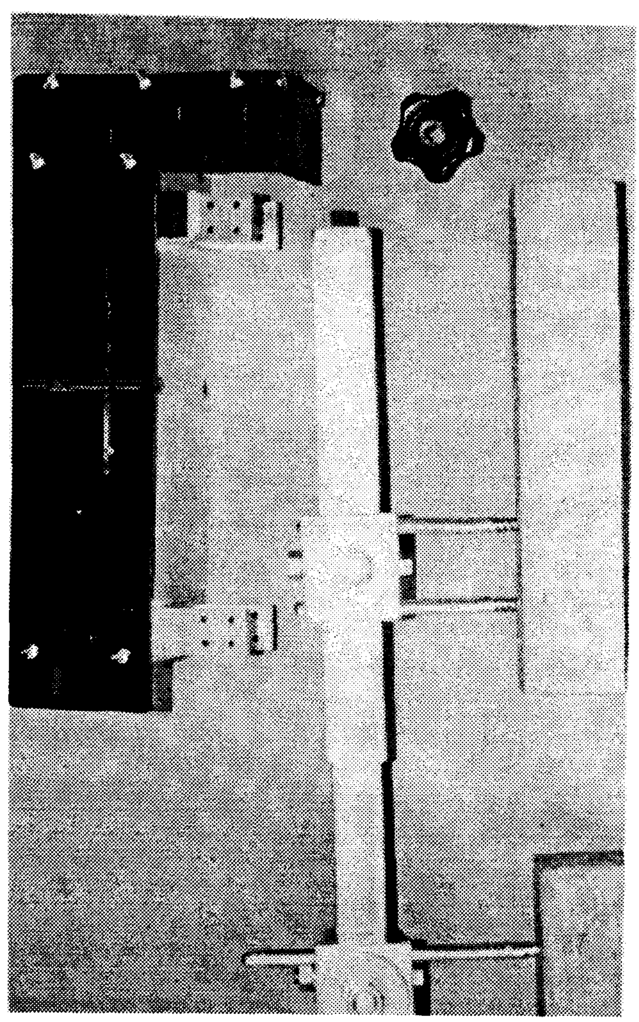


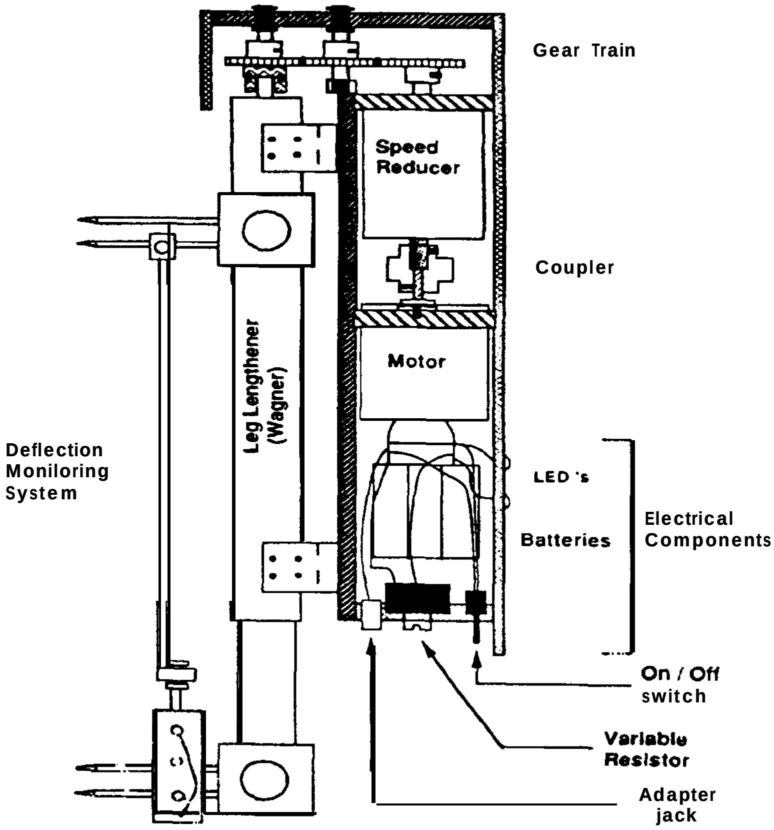
These abrupt adjustments cause both pain and anxiety for the patient and make accurate control of the process difficult. By providing a slower, more continuous rate of lengthening, it is hoped that the device designed will significantly reduce the pain associated with the leg lengthening procedure, and improve the healing process. Because small motions in the bone regeneration site are believed to encourage healing, the monitoring system will aid in analysis of the process and device.

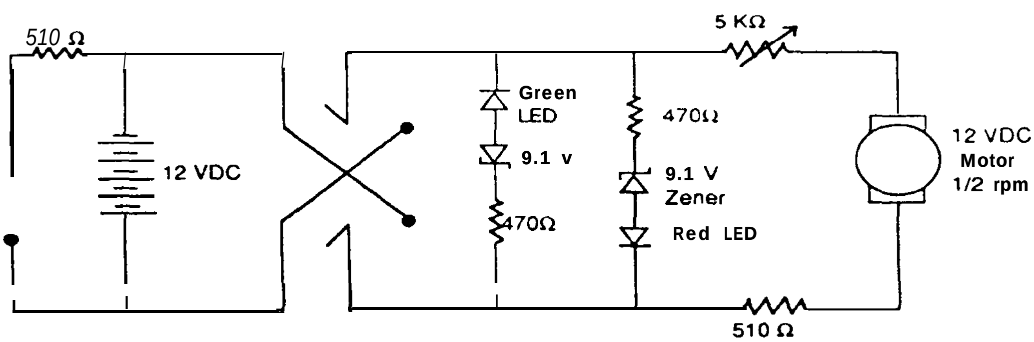
TECHNICAL DESCRIPTION

The designed component provides an automatic means of lengthening for those patients whose lengthening mechanism is the Wagner device. The automated mechanism replaces the knob currently used for lengthening and directly turns the threaded rod. The driving mechanism includes a 1/2 RPM DC motor, a 248:1 speed reducer and a small gear train. The speed of lengthening may be adjusted between 0.5 mm and 2 mm in 12 hrs., and the direction may be reversed to provide compression after the lengthening process. The motor is powered with a set of five 2.4 V rechargeable Ni-Cd batteries, which may be simultaneously recharged with an AC adapter. The driving mechanism is contained in a plastic and aluminum housing that is mounted on the external housing of the Wagner device. Two LED's are included to show the direction of motion and to indicate that enough power is being supplied by the battery pack. A Zener diode prevents the lights from lighting if the battery voltage drops below 10.5 V. The entire assembly adds approximately 2.5 Ibs. to the existing device, and may be removed when not in use.









Electrical Circuit Diagram

The monitoring system consists of an electrical potentiometer mounted on the pins and pin displacement data collection with an IBM PC data acquisition system. A precision wound linear potentiometer is used to measure the deflection of the pins due to weight bearing loads. Voltage is supplied across the potentiometer with a small 3 V lithium battery. The change in voltage is monitored and recorded by an Analog/Digital data acquisition system in an IBM PC computer. A cable is used to connect the potentiometer to the data acquisition system. The computer converts the voltage change to displacement and displays the results as a function of time. An accuracy of approximately 0.1 mm was obtained by the system.

RECOMMENDATIONS FOR IMPROVEMENTS

Loading Conditions

Many assumptions were made in the structural analysis of the Wagner device due to lack of sufficient testing. More careful analysis and perhaps testing of the actual loading conditions would be useful and may impact motor and speed reducer selection.

Improved Packaging

For actual production of this type of device, it would be desirable to provide a one piece plastic covering for the four pieces currently used. This covering could be manufactured of injection molded or heat formed plastic to allow smoother corners, easier installation, and possibly lighter weight.

Reduced Size

It would have been desirable to reduce the size and weight of the device for enhanced patient comfort. The size is currently limited by the speed of the reducer and motor, which may be limited by loading conditions. It may be possible to design a custom geared motor to reduce size.

Data Logger for Portable Monitoring

We strongly recommend that a portable data logger and software package be used for the monitoring system. This would significantly reduce interference with normal activities and allow greater versatility in data collection and manipulation

Smoke Clearing Cauterizer
An Electra-surgical Knife That Permits the Surgeon to Operate in a Smoke Free Environment

Designer: Flip Britton
Consultant: Dr. Nadiv Shapira
Supervising Professor: Dr. Robert H. Allen
Department of Mechanical Engineering
University of Delaware
Newark, DE 19716

INTRODUCTION

Hand held cautery devices are commonly used in surgery to incise tissue and/or to coagulate blood vessels. The cauterizing process generates a significant amount of smoke. This smoke is potentially hazardous to the operating room staff. It also interferes with the surgeon's visual field. There are some smoke removal devices currently available, but they have not proven adequate. The development of an effective smoke removal device that can be an integral part of the cautery knife is desired.

This research was to asses smoke removal by laminar suction and suction enhanced by vorticose air flow, and to incorporate effective smoke removal into a cautery knife prototype. Although the testing failed to conclude that a vortex significantly enhances smoke removal, a prototype was designed and manufactured. The design is such that removable blades can be easily adapted to create a variety of air flows. This should allow further study and a refinement of the design.

VORTEX RESEARCH

The preliminary literature search revealed that developing a mathematical model of vortex suction was beyond the scope of this project. But simple flow theory predicts that any specified flow induced inside a suction tip should only affect the flow outside the tip very near the tip opening

It was decided that the effectiveness of vortex smoke removal would be determined by empirical data obtained through a series of controlled studies. Two types of studies were considered. The first was to address the effect of a vortex on the volume of air that could pass through a suction tip. The second was the effect on the geometry of the flow field near the suction tip.

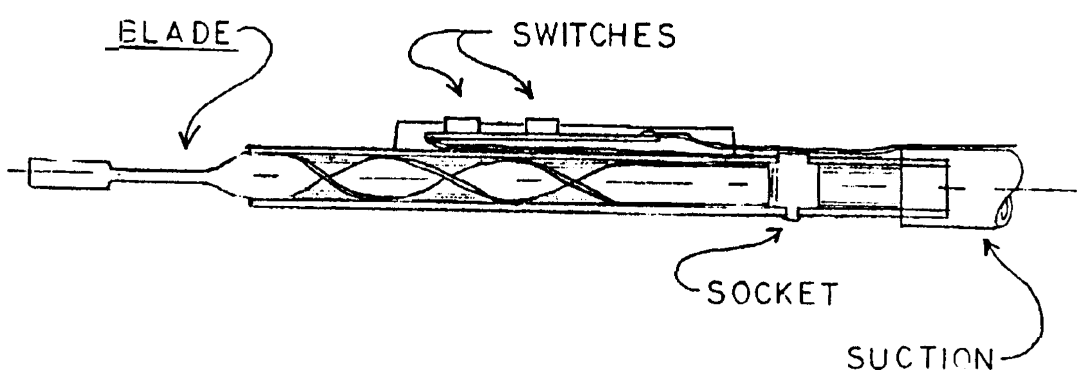


Fig. 1. Cauterizing Knife

Due to practical limitations, control volume experirnents were abandoned and full attention was given to the flow field study.

The flow field tests were based on the original testing performed by Dr. Shapira. A parameter was identified as the critical distance. That is the maximum distance at which a suction device can be placed from smoke source and still remove smoke effectively.

Several tests were conducted to look at this parameter. In no single test was there conclusive evidence to substantiate the effectiveness of the vortex either way. The tests were all somewhat subjective, as quantifying smoke amounts was beyond the scope of lab equipment available. I observed the flow field around the suction a great number of times and it is my opinion that there is no significant value in the effect of the vortex on smoke removal.

TECHNICAL DESCRIPTION

It was determined that vortex testing was inconclusive, and that the prototype should be designed such that it could be used for further testing. The design was then to be determined by other constraints and to leave the option for vortex or laminar flow to be determined.

The vortex insert, developed during the vortex testing, was a thin sheet of aluminum sheared to the inside diameter of the suction tip and twisted to create the vortex flow. This design was simple to construct and left the effective cross section of the suction tip nearly unaffected. It was decided that this vortex insert could become part of the actual blade, reducing the number of parts. It was determined that the socket for the blade/flow insert should be located toward the back of the knife allowing more options as to vortex length.

To ensure compatibility with existing Bovie machines, it was decided that, for the prototype, the switches, cord, and plug would be salvaged from a commercially manufactured Bovie knife.

Several Bovie knives were examined and 3/4 inch was set as the limit of the outside diameter of the prototype.

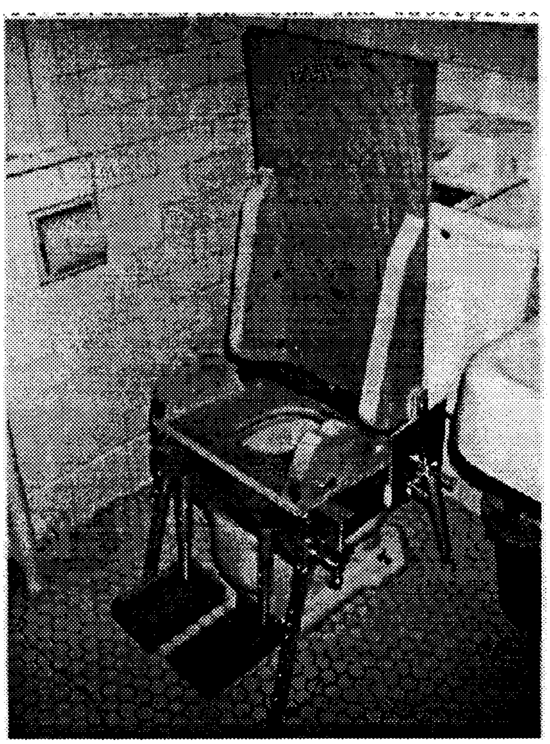
The prototype was manufactured with nine interchangeable stainless steel blades. The device and three blades (two vortex and one laminar) were taken into the operating room and some field tests were performed. Initial results were positive in, that, with all blades, a majority of the generated smoke was removed. Further testing should determine whether the vortex suction is more effective.

A Toilet Support for the Severely Disabled

Designers: Lisa Castagna, Muzaffer Egeli, Tina Susi
Disabled Coordinator: James W. Fee Jr.
A. 1. DuPont Institute
Supervising Professor: Robert Allen
Department of Mechanical Engineering
University of Delaware
Newark, DE 19716

INTRODUCTION

A toilet support for severely disabled children has been designed and constructed. Some severely disabled children are developmentally and psychologically ready for toilet training, but are usually physically unable to do so because their households lack the appropriate facilities. The intention of this device is to assist children who are at the age where toilet training is necessary, but who lack the security, coordination, and inclination to do so. Emily Selvaggio, a 7 year old girl who has Cerebral Palsy, has just this problem. This design is intended for specific use by Emily and is constructed keeping Cerebral Palsy children in mind. The seat, however, is made adjustable to accommodate for as many ages of children and as many disabilities as possible. The base of the design is made of aluminum piping and angel bar, attached to which are various adjustments. If the backrest and bottom seat were to go into mass production, the specific design would call for a fiberglass core with a waterproof coating. However, because of the lack of time, money and materials, the prototype is constructed out of wood covered with foam and waterproof coating.



SUMMARY OF IMPACT

A toilet support for the severely disabled has been designed and built to enable the handicapped child to be toilet trained. Using this device will give Emily the confidence it takes to enable her to be successfully toilet trained. The primary contribution of the design is that, once properly positioned onto the seat, the user can be completely independent. This design provides adequate support so that she and other children can be left unattended for short periods of time, while still allowing for a great deal of adjustability. This adjustability is necessary because children within the desired age group, 3-8 years of age, grow rapidly. Considering the environment where the design is being used, the prototype is easily cleaned and maintained. The system is versatile enough to be easily attached and removed from any conventional toilet seat. For portability, the product is lightweight, weighing only 25 lbs. The angle of the backrest and bottom seat is adjusted independently to provide greater control of hip flexion, avoiding hyperextension. The toilet support is sturdy enough to uphold a young person weighing up to 100 lbs., and withstands forces resulting from possible thrust reflexes due to involuntary spasms of the child.

TECHNICAL DESCRIPTION

The square frame of the toilet support design is make of four pieces of 15x15x2 aluminum angle bar, 1/8 inch thick. These dimensions are used according to average household toilet dimensions with a 14 inch width. So that the frame can be rested properly onto the toilet, removable telescoping legs were produced for the additional stability, and for the use of the toilet support with a commercially available portable potty. Each leg is make of two aluminum circular tubes: the larger one with an outer diameter of 1 inch, and an inner diameter of 3/4 inches; and the smaller one with an outer diameter of 3/4 inches and an inner diameter of 1/2 inch. The toilet support was made secure by inclining the telescoping legs at a 15 degree angle with respect to the frame. Since the average height of most toilet seats are 16 inches, the maximum leg length is 22 inches, and the minimum leg length is 14 inches. The outer skeleton dimensions of the backrest are 25x14x5/8 inches, while the dimensions of the seat are 14x11x5 inches. The oval aperture is 7½x5 inches. If this design 'were to be mass produced, three differently dimensioned seats would be produced.

Various seat dimensions

Age (yrs.)	**3-4**	**5-6**	**7-8**
Width (in.)	14	14	14
Depth (in.)	**7.5**	**9.5**	**11.5**
Aperture (in.)	**4x5**	5x6.5	6x8

So that the child can sit comfortably on the seats, a soft cushiony foam was obtained that was 1 inch thick, and had a compression ratio of 1/2 and recovery of 100%. Finally, to ensure user comfort and easy cleaning, the seats were coated with yellow plastic coating. Attached to the backrest is a head rest, chest harness, and hip strap to provide additional support. Two angled slits were cut out of the bottom corners of the backrest for insertion of the hip straps. To adjust the height and width of the chest harness, six slits were cut on each side of the backrest. Additional slits were cut out of the bottom seat through which a second hip strap is threaded and attached with Velcro beneath the seat. These straps will provide additional hip support at various angles. The footrests are made of aluminum, removable, telescoping legs. Each footrest is fabricated separately using the same pipe dimensions as previously mentioned for the legs attached to the frame. Since Emily's dimensions from her kneecaps to her feet are 11 inches, the maximum length of the footrest is 11 inches and the minimum is 8 inches. The pedals for the footrest are made of wood with overall dimensions of 7x1/2x1/2 inches. In order for the footrest to be attached onto the frame, slots were cut 1 1/2 inches downward on the legs. The frame is then fit into the slot of the footrest onto the frame. It is necessary that the angle of the backrest be adjusted independently from the angle of the bottom seat. To ensure this independency, a gear mechanism, which employs a gear used in the seat of a car, is positioned on the side of the frame, away from the toilet. The gear mechanism is strong enough to withstand impact forces up to 400 lbs. on the seat. The gear mechanism is used to change the angle between the backrest and frame from 105 to 60 degrees. The lever is lifted, the seat appropriately positioned, and the lever replaced. The device will consist of a gear, two springs, a lever, and meta extensions from the mechanism. A steel slab 14x1x1/8 inches was welded onto the gear in order for the backrest to rotate at the center of rotation of the gear while being attached to the backrest at positions farther from the center for added stability. To ensure safety for the Cerebral Palsy child, the lever of the gear mechanism is behind the seat out of the reach of the child. The bottom seat angle ranges from zero to thirty degrees, This mechanism consists of two adjustments, positioned on both sides of the toilet support. A plastic, grip-size knob is easily turned to adjust the seat angle. The simplest way to account for a wide range of geometries of toilets is to have an adjustable device clamped onto the bowl of the toilet. This clamped method is composed of two 4 1/2x4 1/2x1/8 inch aluminum sheets with two 3 1/2 inch brass hinges attached at the tops of the sheets. A 3/8 inch diameter bolt with a stopper at one end and plastic nut at the other is threaded into the aluminum sheet until the stopper reaches the bowl. Complete trunk, head, leg, hip, and feet support is necessary for the proper positioning, comfort, and security of the child. The trunk of the user is supported by using a 5 inch belt made of 1 inch thick soft cushiony foam with a 2 inch thick strap. By using the various slots that were cut through the backrest, the chest harness can be adjusted vertically and horizontally. The cores of the headrest and leg separator were made out of foam. Each core was covered with pink foam and then plastic coated, The headrest is secured to the seat using Velcro so that it can be removed is not needed. Straps are connected to the leg separator. These straps go across the users legs, through guides on the tops of the wings. The ends of the straps wrap around a metal bar and are velcroed into position. For foot support, slits were cut into the pedals and straps inserted through these slits and around the foot.

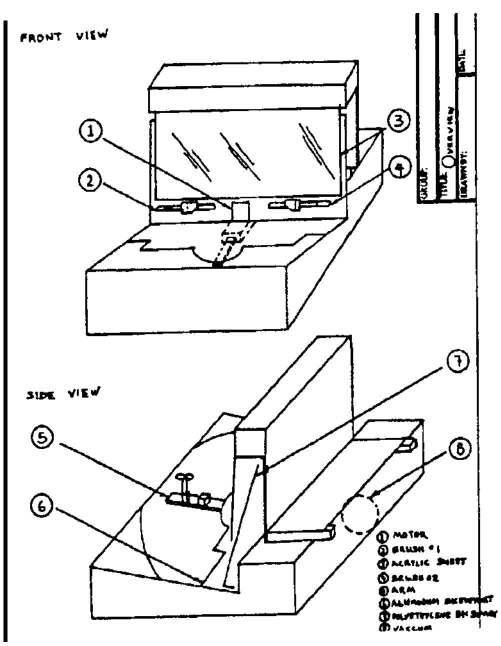
Page Turner
An Automated Page Turning Device for the Physically Impaired

Designers: Thomas Bockius, Marie Chan, T. R. Masino
Customer: Dr. Thomas Sicoli
A. I. DuPont Institute
Supervising Professor: Dr. Robert Allen
Department of Mechanical Engineering
University of Delaware
Newark, DE 19716

INTRODUCTION

The page turner is an automated device used to turn the pages of a book by those who are physically impaired. Our page turner is designed to turn the pages of a book in either direction, one page at a time. Because our page turner is to be used in a rehabilitation school, the book sizes it can handle are those of normal textbooks. Specifically, the smallest book (in the flat open position) measures 10 inches wide and 8 inches high. The largest book measures 20 inches wide and 12 inches high.

By merely activating a left or right switch (such as a sip and puff switch or a microswitch), the user can turn the page of a book in either direction. The user stops the page turning process using another switch.



The page turner will be used by physically impaired children and adolescents continuing their education while undergoing rehabilitation. Page turners currently available on the market are not satisfactory, as they are unreliable and often damage pages.

SUMMARY OF IMPACT

Our page turner was designed to turn the pages of different sized books in either direction for people with physical disabilities that restrict them from holding and turning the pages of a book. By making the page turner adaptable for any type of switch (e.g., sip and puff or regular microswitches), the user can feel more independent. The page turner was designed to require very little assistance once it is set up, allowing our customer, Dr. Sicoli, to more effectively assist all his students.

1. Motor
2. Brush 1
3. Acrylic Sheet
4. Brush 2
5. Arm
6. Aluminum Book Support
7. Polyethylene Book Support
8. Vacuum

TECHNICAL DESCRIPTION

Our design has 3 main parts. These parts are: a mechanism to lift and turn a page, a mechanism to ensure that only one page is turned at a time, and a mechanism to hold the pages in a clearly readable position.

Vacuum is used to lift the page. The advantages of vacuum over the currently used friction and adhesive methods are that it is more reliable, won't damage the pages, and is more easily controlled.

A radial arm with its center based beneath the center of the book is used to transport the page across the book. The main advantage of this is that there is only one mechanism lifting and transporting the pages. To be adjustable for different lengths, we designed a sliding piece to be attached onto the arm. The sliding piece on the arm has attached to it suction cups through which the vacuum is applied.

To ensure that one page is turned at a time, we used brushes. These brushes are actual paint brushes that were machined down to function properly in our prototype. The brushes press lightly on the page ends on both sides of the book to provide resistance that is strong enough to hod back and sticking pages. We also decided to use Velcro on the book support to provide further resistance to the sticking pages. None of the automated page turners that we looked into currently on the market utilize and such devices to solve the problem of too many pages getting turned at a time.

To hold the pages in a readable position we developed the design of the transparent shield and its movement mechanisms. The shield is pressed against the pages while the book is read. When the page is turned, the shield is moved up and out of the way. To hold the book itself in a readable position, we used long office clips to secure it to the polyethylene book support.

We developed a vacuum system that connects our vacuum pump to our suction cups and gives us the correct flow corresponding to user commands. The vacuum system, starting with the suction cup on the left side, has an aluminum pipe bent into the required position on the slider part of the arm. Attached to the aluminum pipe is flexible bubble tubing, which is then attached to a three-way electric solenoid valve. This is a universal valve with the flow control operated by electrical input. This first solenoid valve also will have an identical line attached to it coming from the right suction cup. a second identical solenoid valve, attached to the first solenoid valve, will release the suction on the page after the vacuum shuts down by opening one line to the atmosphere.

By using vacuum we avoid the problem of pages not getting turned, the vacuum's reliability has been proven in the printing industry. Our page turner is the only one that we know of that uses vacuum to lift the page.
The body to contain our mechanisms and systems has a 24x24 inch aluminum base and the rest of the casing is built out of plywood. We built an aluminum book support plate to be situated at a 15 degree decline to hold the book in a clearly readable position. Onto the aluminum support we attached strips of Velcro that provides resistance to ensure only one page is turned at a time. At a right angle to the aluminum plate, we attached an adjustable polyethylene support upon which the back of the book rests. The polyethylene support measures 14x24 inches, and has slots that hold the brush mechanisms and allow them to be adjusted as well.

The page turner cost four hundred and twenty dollars ($420) to build. It is equipped with female jacks for 1/8 inch male plugs. This allows users with varying disabilities to use the page turner.

Unfortunately, we were unable to complete our prototype due to time constraints. However, future students will be working on it until it is completed.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