CHAPTER 9

TEXAS TECH UNIVERSITY
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"Developing an Eye Tracking Device (ETD) for
Individuals with Handicaps"
An ETD Linked to a Computer Generated Communication System for
Students with Multiple Handicaps

Designers: Bobby Hudgens, Greg Hatfield, Reese Wright; First Team
Ka Lam William Chio and Chow Ming Wong; Second Team
Coordinator for the Disabled Students: Don Foreman
Supervising Professors: Dr. Michael Parten and Mr. Eddie Arrant
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INTRODUCTION

The purpose of designing an Eye-Tracking Device (ETD) was to develop a communication device for Terry, a 19-year-old teenager who has profound scoliosis and severe spasticity. Terry has never been able to communicate with those around him. Don Foreman, Terry's teacher, was convinced that although Terry had an uncontrollable body, he had a bright mind and a wonderful sense of humor. The difficulty was that the messages from the brain became garbled and uncontrolled before they could be uttered. Don was the only one who believed he was in touch with Terry's mind. He could communicate very crudely by a simple system of Terry's winking and Don's saying options until they hit on what Terry thought. The problem for the Senior Design Team was to find a way of getting Terry's imprisoned thoughts out to others--something that had not been accomplished in 19 years of internment in a state school. After two years of concentrated interdisciplinary research, the Senior Projects Team did free Terry's thoughts.

SUMMARY OF IMPACT

The ETD was a critical technological component in the Synthetic Speech Communications System built for Terry. The technology created by the Senior Projects Team opens up a whole new area of basic research related to communicating with the severely and profoundly disabled child.

This article will mention only a few of many ancillary benefits resulting from the Senior Projects Team's investigation. First, there is the improvement in Terry from the Hawthorne effect. People outside the school paid attention to him, asked his opinion. That improved his mental outlook.

A small amount of seed money from the NSF Senior Projects started this long-term project and convinced the Texas Rehabilitation Commission, the Ballenger School, and Texas Tech University to pool their financial and human resources to develop a system to be used specifically by Terry to benefit his life. This communication device allowed Terry to communicate with the outside world--to express his needs, to show his feelings, and to learn.

TECHNICAL DESCRIPTION

The corneal reflection method of eye-tracking uses the subject's cornea to reflect light from a stationary light source. The light source will cause a bright spot to appear on the cornea, and the bright spot will stay at the same position when the subject moves his eyes; thus, relatively speaking, the bright spot moves whereas the eyes do not. This is an important characteristic in determining the eye focus. One advantage of the corneal reflection method is that the bright spot shown on the pupil will remain in the same position on the cornea even though the head moves (Young & Sheena, p. 414). This is the main reason for Research Group #1 deciding to use the corneal reflection method to track the eye movement.

Bobby Hudgens determined that VOCAID with certain modifications was the voice synthesizer suitable for Terry. It can pronounce phrases such as "I WOULD LIKE TO USE THE BATHROOM" or "I AM IN PAIN". It can also pronounce the alphabet and the numbers. Although the vocabulary for VOCAID is limited, it is extremely useful for severely handicapped people.

Figure 1--Block Diagram of the Project represents the major components in the project. The video camera and its powerful zoom lens are responsible for obtaining the analog video signal from the eye. Then the PC-EYE digitizes the picture so that the computer can store PC-EYE digital data in its memory buffer. After data storage, the computer presents a menu which allows Terry to select by eye gaze the Vocaid graphics desired, and the computer will analyze the PC-EYE picture to find the gaze-point. After the gaze point is determined, the computer sends out proper data to the interface circuit which serves as a bridge between the computer and the Vocaid, so that the desired button of the Vocaid voice synthesizer can be activated, thus allowing Terry to talk.

The Synthetic Speech Communications System cost in excess of $2,000 for materials and supplies. The equipment costs were shared among the NSF, Texas Tech University, and Texas Rehabilitation Commission.

More than 400 student hours were spent in designing, fabricating and testing the system. Now that we understand the parameters of the System, it can be modified for other severely and profoundly handicapped children.

Preliminary data from Terry's case study indicate that these children are more intelligent than professional assessments indicate. Texas Tech University intends to investigate the learning abilities of similar children.

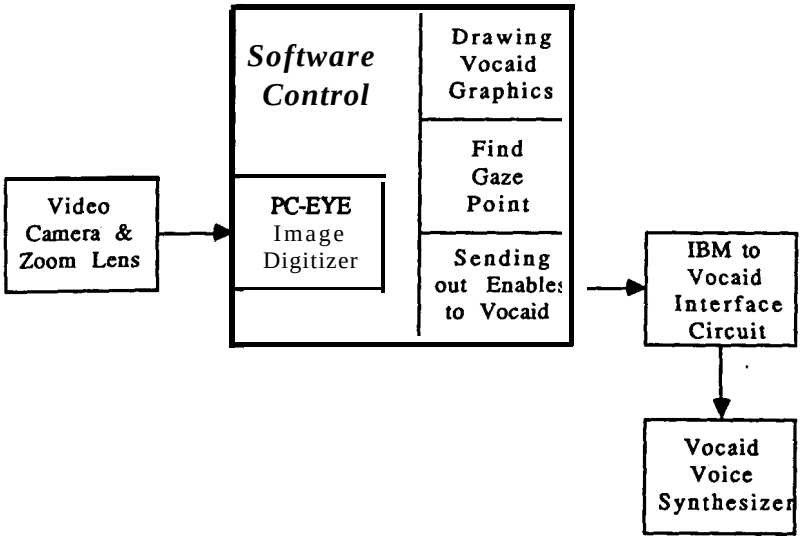

Fig. 1 Block Diagram of the Project

"Developing a Prototype of a Multiposition-Low-Base Wheelchair for the Classroom"
An Innovative Wheelchair for Children with Severe Cerebral Palsy

Designer: Ross McDonald
Teacher of the Disabled: Ms. Lynn Vitatoe
Supervising Professors: Mr. Jesse Jones
Department of Mechanical Engineering
Dr. Oliver D. Hensley and Dr. Donna Reavis
College of Education
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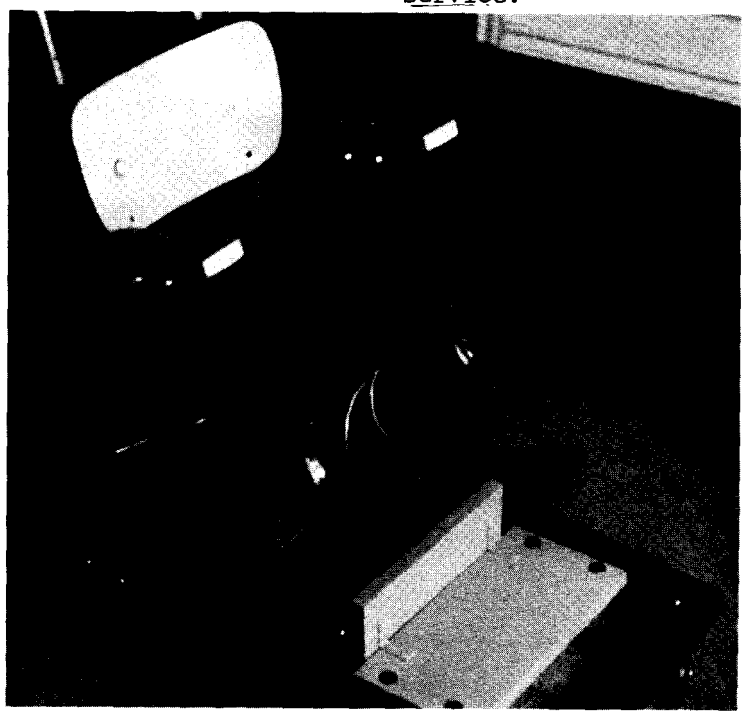
INTRODUCTION

A Multiposition-Low-Base Wheelchair for the classroom was designed and constructed for a child in the first grade of a regular public school. Jay, the recipient of this customized wheelchair, is a very intelligent and socially well-adjusted six-year-old with severe cerebral palsy with spastic quadriplegia. The disease and confinement to a conventional wheelchair have greatly retarded the movement and endurance of a youngster who is capable of competing and excelling scholastically with his classmates. Unfortunately, his spastic movements leave him without control of the lower hip area. His teacher and parents asked for a wheelchair that would allow Jay to sit at first grade tables, change his position as the furniture demanded and allow Jay to control the chair movement. Jay's teacher thought that the multipositioned chair would alleviate the physical fatigue experienced by Jay after two hours in a conventional wheelchair.

SUMMARY OF IMPACT

Jay thrived on being part of an experimental project. He discussed the design and enjoyed working with Ross and Ms. Vitatoe on the testing of the Multiposition-Low-Base Wheelchair.

Unfortunately, all project devices do not work forever. The Multiposition-Low-Base Wheelchair is a case in point. The adjustable height screw failed after a short service, leaving the chair functions below expectations. This is a problem for the University because Senior Projects students graduate and leave Lubbock and our departments do not make follow-up repair calls. The parents and Jay are gracious and will wait for another phase of Senior Projects students who might want to improve on the design. The PI's have proposed that public school maintenance workers repair and maintain assistive devices or that the parents do the repairs. Unfortunately, when we design and fabricate it and give it away, we still seem to own it when it needs service.



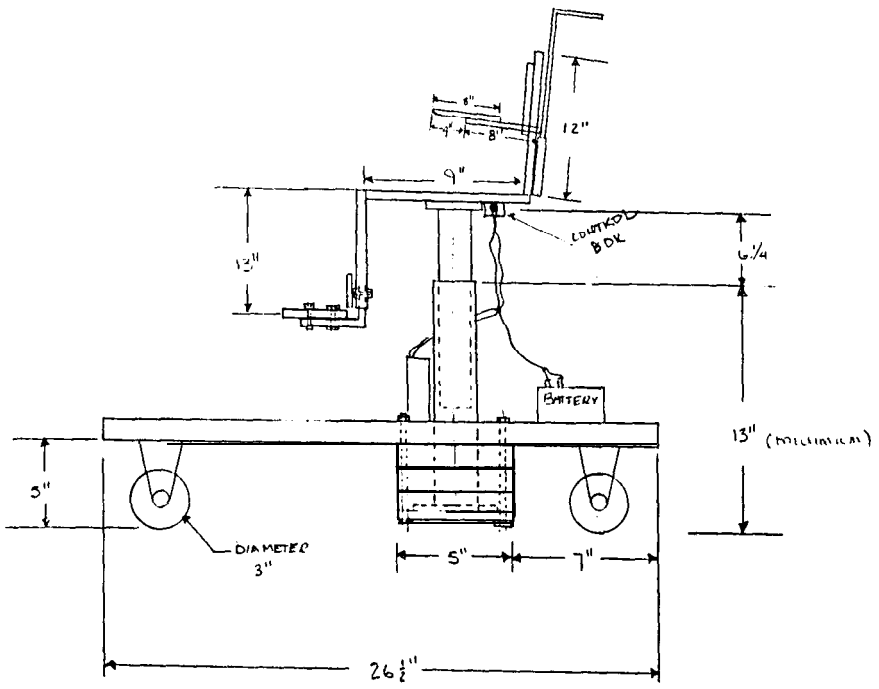
TECHNICAL DESCRIPTION

Mr. McDonald tried two design concepts which proved to be inappropriate. The third and final design concept which was adopted was a lift mechanism that is available on the market. Because the device was already constructed, time was saved by purchasing the lift mechanism rather than constructing one. The lift mechanism consists of a lead screw attached to a reversible DC motor which is geared down to enable the wheelchair seat to be raised up and down at a velocity of approximately 0.75 inches per second. The device is compact and can be operated by the wheelchair user. The lift mechanism allows a height differential of 6.25 inches for the chair. Additionally, because the lead screw is enclosed in a sleeve, the device is deemed to be quite safe.

After selection of the lift mechanism, the next step was the design of a complete apparatus compatible with the lift mechanism. The final design is shown in Figures 3 and 4 for side and front views, respectively. A design criterion for the construction of the wheelchair was that the device be able to grow with the child. To satisfy this requirement, the foot rests as well as initial height of the seat are adjustable to compensate for the child's growing body. An additional design constraint was that the wheelchair arms be removable to enable the wheelchair to be placed under a narrow or otherwise constricting desk. This goal was achieved.

The wheelchair is compact and designed to be pushed from the rear. The lift mechanism is controlled by the child so as to give him some autonomy. Thus, the child can adjust the seat height of the chair to his own satisfaction. The lift mechanism is powered by a compact rechargeable DC battery that fits under the seat of the apparatus. A bottom-heavy design was constructed to lessen the chance that the device could inadvertently tip over. This bottom-heavy design was constructed by using angle iron (1-inch flange) for the base frame.

The Multiposition-Low-Base Wheelchair development costs were $375 and 87 hours of student time.



DESIGN CONCEPT CONSTRUCTED (SIDE VIEW)

"Automated Packaging Process"
The Development of an Automated Egg Sorting Machine
for Mentally and Physically Disabled Students

Designers: Donna DiMarco, Boris Dmitrijev, Melvyn Fernandez
and David West
Coordinator for the Disabled Students: Mr. Jack Kirkpatrick
Supervising Professors: Mr. J. C. Jones and Dr. Oliver Hensley
Department of Mechanical Engineering and College of Education
Texas Tech University
Lubbock, Texas 79409

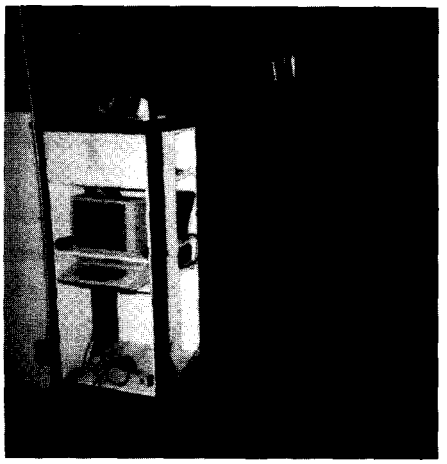
INTRODUCTION

This Senior Project addresses the difficult problem of designing, fabricating, and testing an automated egg sorting machine that could be operated by physically and mentally handicapped students. Commercially available equipment was not suitable as conventional machines are too hazardous to have in a sheltered workshop and they do not have the adaptive technology needed by handicapped persons. Consequently, the Senior Projects Team designed a system that incorporated every conceivable safety device and included innovative devices for performing the work while assuring maximum safety and access by handicapped students.

The Lubbock State School is a school for the mentally and physically handicapped. Some of these students earn a small income by stuffing miniature toys in plastic eggs. There are nine different toys which are stuffed into the eggs after which the eggs are stockpiled and subsequently packaged for delivery. These students can stuff approximately 200,000 eggs per week. The Lubbock State School had a production problem with the packaging of the toy eggs. The eggs are hand sorted and packed into boxes containing 250 eggs. Each of these boxes required a different mixture of toys according to individual contracts. This required individual sorting of the eggs for packaging. Only 80,000 eggs could be packaged per week. A huge backlog of stuffed but unpackaged eggs existed. This bottleneck prevented the school from placing more students in the workshop.

SUMMARY OF IMPACT

This project helped the Lubbock State School automate the packaging process. Bins to hold the eggs were designed and fabricated. An Apple II computer was used to control the output of eggs from each bin with the use of a computer interface system. By automating the packaging process with a computer interface system, the students at the State School became involved with the process. The Automated Egg Processing System eliminated the very large backlog of unpackaged eggs and permitted the School Coordinator to use more students. The Automated Egg Processing System worked beyond the expectations of the Coordinator of the workshop.



TECHNICAL DESCRIPTION

The Automated Egg Sorting System consists of storage bins, rotary disks, funnels and gravity chutes. The storage bins are capable of holding approximately 1500 eggs each. The 8-slot rotary disks turning at 6 RPM are able to deliver approximately 48 eggs per minute per bin. The funnel design ensures the delivery of only one egg at a time. The gravity chutes deliver the eggs from the bins to a central location without clogging.

The electrical system consists of a computer, related software, associated circuitry, photocells and electric motors. The computer used is a previously owned, inexpensive Apple II. The software is a program written in BASIC language. The associated circuitry includes transistors, 2 multiplexers and 2 demultiplexers connected to a 5- and 12-volt power supply. The photocells used are prefabricated 12-volt optical eyes. The motors are 110-volt, 6-RPM Dayton Electric Motors.

After fabrication and assembly of the above components, the system was evaluated for use in a sheltered workshop environment. Custom-designed adaptive devices for specific handicapped persons were designed, installed, and tested for use by particular persons. Test runs indicated that the packaging capability of the system was approximately 30 boxes of eggs per hour. When calculated on a weekly basis, 300,000 eggs per week can be packaged. The automated packaging process thus represents a 250 percent increase in productivity over the previous manual process.

At present, the Lubbock State School is packaging nine different toys, thus nine storage bins were required. Each 2x2x3 foot bin was constructed of #28 gage sheet metal (see Figure 1). The 12 cubic foot volume allows each bin to hold approximately 1500 eggs. The eggs are delivered to a rotary disk feeder by an off-centered funnel (see Figure 2). The funnel is off-centered to allow only one egg to drop from the bin at a time. The feeder consists of an 18-inch diameter disk driven by an electric motor. Each disk has eight 2.5-inch diameter slots machined in its face. These slots are centered on a 15.5-inch diameter circle. An egg drops into the slot and is rotated around until it becomes aligned with a delivery chute. The delivery chute system consists of folded #28 gage sheet metal. The chute system is an open trough. It is welded to the support structure of the bins. The chute converges to a convenient central location where the boxes are filled with eggs. The support structure of the bins is made of angle iron.

The final cost of the operational system was approximately $2,500 and over 384 hours of Senior Projects students' time and an additional 300 man hours from technicians and machinists employed by the Lubbock State School and the Biocybernetics Laboratory of Texas Tech University.

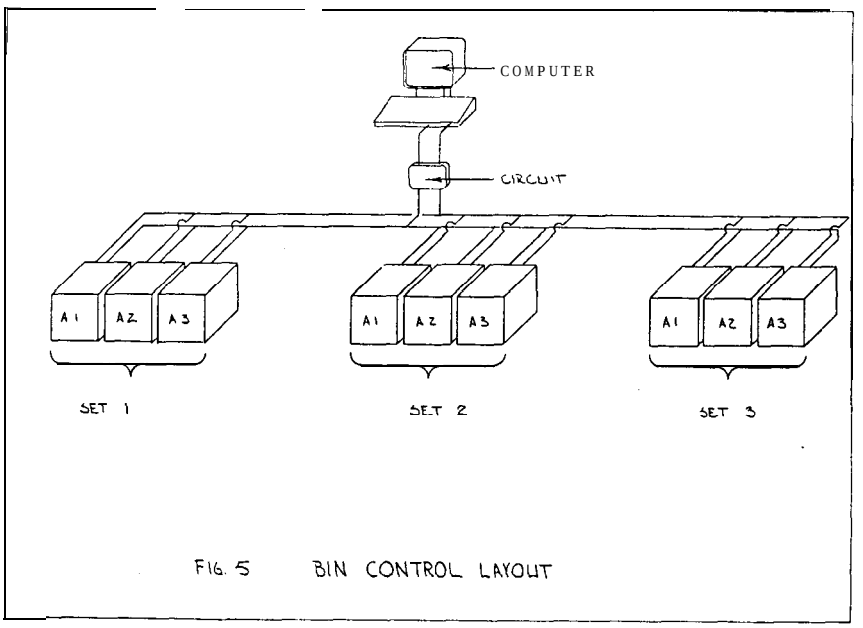


FIG. 5 BIN CONTROL LAYOUT

"Automated Gravel Bagging System"
Creating a Sheltered Workshop Laboratory that Provides Experience and Adaptive Equipment Needed by Handicapped Students

Designers: John Julian, Victor Deutsch, John Diederich
Coordinator for the Disabled Students: Mr. Jack Kirkpatrick
Supervising Professors: Mr. Jesse Jones and Dr. Atila Ertas
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Lubbock, Texas 79409-1021

INTRODUCTION

The purpose of the Automated Gravel Bagging System (AGBS) was to design and construct a sheltered-workshop laboratory that could be controlled by handicapped clients at the Lubbock State School.

Several of the bagging system's components were commercially available such as the vertical elevator, the sewing mechanism, the sump pump, and the linear actuator. Other components such as the weigher and gate mechanism were designed and fabricated by the project team. All components were either modified or designed to accommodate the particular client's disabilities.

Primary control of the system is achieved through the use of a computer terminal operated by a physically handicapped client. Mentally handicapped clients operate the system's on-line functions. Several customized adaptive devices were designed that enabled persons with particular disabilities to work in the system.

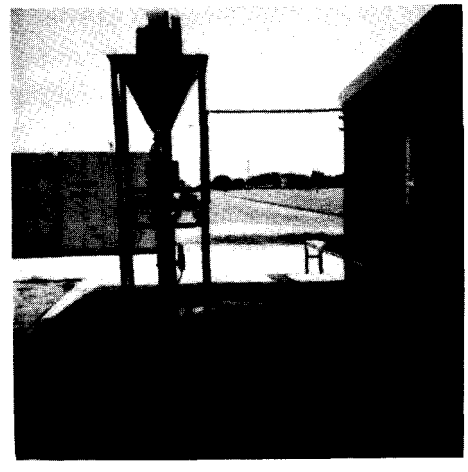
SUMMARY OF IMPACT

The Automated Gravel Bagging System presents many benefits to the clients. The handicapped students run the system from start to finish. Two primary benefits occur. The disabled student gains satisfaction, pride, and money every time he is successful in bagging a load of gravel. Success breeds success; therefore, the handicapped students are learning that they can perform most jobs if they will work with designers in modifying equipment that will interface with standard systems. The effects of this work success reach into the students' home life as well. The sheltered-workshop laboratory provides the first step toward work in the real world.

The students have learned valuable skills and they demonstrate they can make a valuable contribution to the production industry which is external to the Lubbock State School. Students can go out into the world, take a job at an assembly plant, and make $3.50 to $5.00 an hour. This is the goal of many of the clients at the State School.

Without the cooperation of the Senior Projects staff, the Texas Rehabilitation Commission, Lubbock State School staff, and the dedicated work of the Project Team, this laboratory and AGBS would not have been designed, built and tested.

The laboratory and system are in use every workday with students eagerly awaiting their turn to run the system.



TECHNICAL DESCRIPTION

The Automated Gravel Bagging System starts by using a vertical elevator to lift the gravel from a gravel bin located below ground to the hopper. The system then employs a gravel weigher mechanism to ensure that a uniform volume of gravel is delivered to the bags. Once the bags are filled, they are closed with a sewing mechanism and transported to a loading area by a non-driven conveyor. Computer control was incorporated into the system to supply the severely physically handicapped with a means of controlling various aspects of the operation. These control operations are simple but challenging, and they present no danger to the students from the moving machinery. The client's safety was of the utmost importance in the design of this system.

Gravel Pit

Gravel that is transported to the school will be dumped directly into a gravel pit. The pit's walls are designed to withstand the forces exerted by seven yards of gravel. Sloping the bottom of the pit at a 45-degree angle keeps the gravel flowing steadily toward the pit's lower door. This angle exceeds the concrete surfaces angle of repose, 37.5, which was found through experimentation.

Gate Mechanism

The main purpose of the gate mechanism is to regulate the flow of gravel to the vertical elevator. The gate consists of a vertical door and vertical running tracks. The running track is constructed of 1018 Hot Rolled steel. The bearings used in the running tracks are 0.75-inch O.D. with a 0.25-inch I.D. The bearings provide a smooth and easy vertical movement for the sliding door. The sliding door is constructed of 0.3125-inch-thick, 1010 Hot Rolled steel. The door is powered by a linear actuator that can raise the door up to 12 inches.

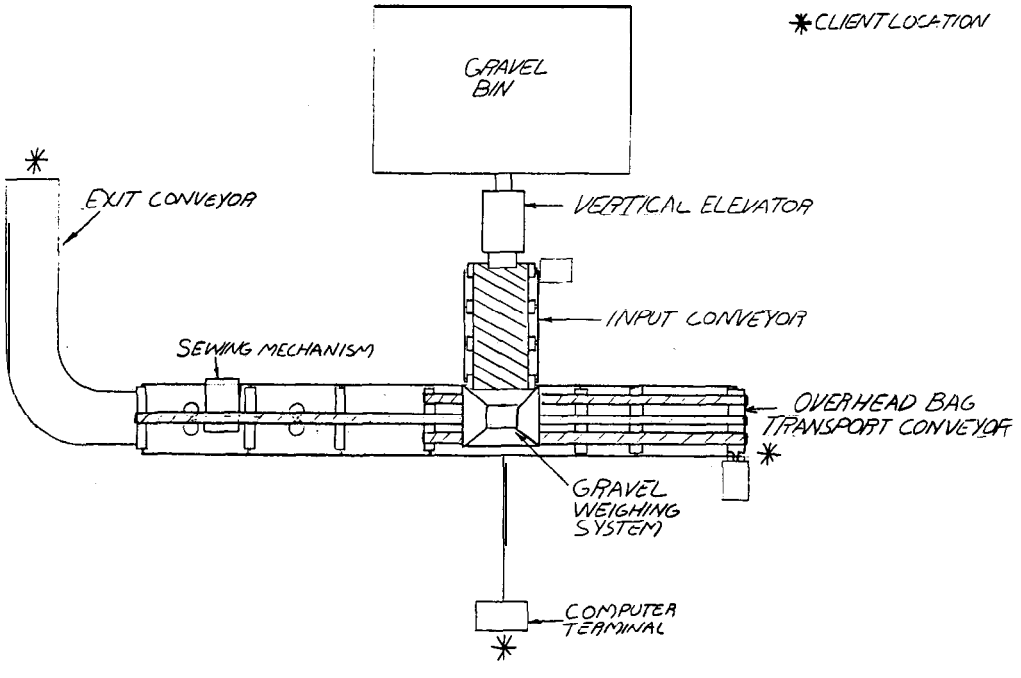
Linear Actuator

The force required to open and close the door is supplied by a Dayton linear actuator. The maximum extended distance and applied load is 12 inches and 300 pounds. This AC model comes with fully adjustable limit switches, which can be set to stop the motion of the lifting screw at any desired point of travel in either direction. This characteristic gives the system the required variable gravel flow and fast gravel flow shut-off.

Vertical Bucket Elevator

Transferring the gravel from the gravel pit to the surge bin is accomplished by using a vertical bucket elevator. The elevator's 220 CFM capacity more than meets the production requirement of 300 bags a day.

A symbol of success for most projects is completion on time and under budget. With a great deal of pride, the members of the gravel bagging project proclaim that their project accomplished both. The expenses incurred through completion of this project were less than the $5,000 estimated for the project which were mostly paid for by the Lubbock State School. Less than $500 was from the Senior Projects Fund.



GRAVEL BAGGING SYSTEM (TOP VIEW)

CHEST CONTROLLED SEWING MACHINES

Designer - Zane D. Curry[1]
Supervisor - Tom B. Leamon[2], Ph.D.
Merchandising, Environmental Design and Consumer Economics[1]
Industrial Engineering*
Texas Tech University
Lubbock, TX 79409

Introduction

Commercially available machines used in the stitching trade such as sewing machines, serging machines, etc. are normally controlled by a treadle operation, which changes sewing speed by acting through a series of mechanical linkages to the clutch on the sewing machine motor. In addition, the presser-foot (the device which locates the fabric in relationship to the needle or cutters) is normally foot operated. In practical terms, such machinery is not accessible to the wheelchair disabled and cannot be controlled by those who do not have use of their lower limbs. A student enrolled in the College of Home Economics, who intends majoring in fashion design is confined to a wheel chair due to a spinal cord injury. Functionally, she has no control of her lower limbs. The program in which she is enrolled has upwards of 18 hours of course work which require the use of sewing and allied machines which are operated with a treadle and with foot operation of the machine presser-foot. Without a design solution it would have been impossible for her to graduate from her chosen program.

Impact Summary

The occupations associated with sewing machines appear, on the one hand, to be highly compatible with the lack of mobility of paraplegics, in that they normally involve a fixed work station and can be operated from a sitting position. Such opportunities for wheelchair paraplegics are entirely vitiated by their need to gain manual access to the stitching area and by the need to use foot controls. It appears that both in the individual case under investigation and in a much wider sample of the disabled population, a solution to this problem would provide wide employment opportunities. Thus, a requirement for extendibility or generalizability of possible solutions was added to this design project. Namely, a solution was sought which could be reproduced on a variety of machines associated with stitching operations.

Technical Description

A detailed task analysis was performed, based on direct observation and analysis of video tapes of non-handicapped and the handicapped subject attempting to perform the operations.

The clear need to relocate the control location suggested electromechanical devices. However, the need for rapidly changing and highly consistent forces for use over extended periods, indicated that such solutions were likely to be expensive and had the potential for being unreliable. Consequently, the mechanical linkages that link treadle and the clutch on the drive motor were carefully examined and a solution based upon additional mechanical linkages was designed and a prototype built.

The stitching operation largely precludes the use of any hand controller, for precise positioning of the work piece in relationship to the needle or serging blade is an absolute requirement of the task. Consequently, alternative effector mechanisms were examined. Elbow and shoulder positions will produce adverse interactions with the precise control requirements of the hands, and an experimental configuration was developed, using a chest plate operating approximately in the region of the sternum. The potential for causing musculoskeletal stresses by the use of postural muscles to control this mechanism was considered, together with potentially low level of precision available from the operation of the control by these muscles.

In preliminary trials, however, the subject did not experience undo postural stress and very rapidly appeared to be able to obtain the fine positional control required. Several trials supported the suitability of this design solution.

A further question was raised; what is the comparison of the performance of the disabled with that of non-disabled operators. That is, would the design constrain the disabled subject into an inherently inferior performance pattern or could she be expected to reach full performance standards. An experiment was developed, and is currently being carried out, which compares the performance of able bodied subjects, both on traditional treadle control and on the chest control. Preliminary results showed that the chest control produces results at least equal to the treadle and there is evidence to suggest that the former is a preferred control, even for the able bodied subjects. The performance measures utilized, involved both the accuracy of line following and the time to complete the operations.

Subject to further experimentation and confirmation of these pilot studies, it appears that the device enables the disabled to operate any one of a series of machines by providing both access to and control of the machine. It appears to provide the potential for achieving equal performance with the able bodied using conventional controls.

"The Development of Assistive Devices for Deformed Hands"
Designing Devices that Allow Handicapped Children to Independently Operate Classroom Equipment

Designers: Ames Hwang, Valerie Matthews, and David Crowe
Coordinator for the Disabled: Mr. Jack Kirkpatrick
Supervising Professor: Dr. W. B. Jones
Department of Mechanical Engineering
Texas Tech University
Lubbock, Texas 79409

INTRODUCTION

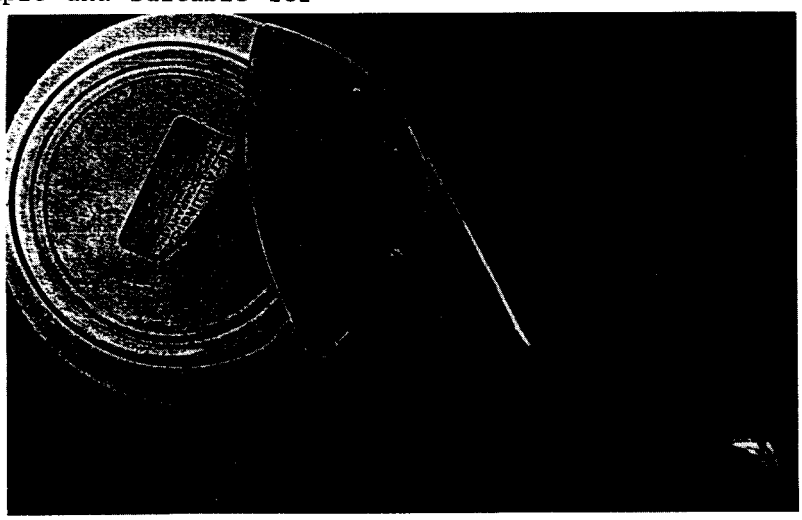
The manipulation of common machine tools and classroom furniture is very important in the Senior Projects' strategy for assisting handicapped students to integrate themselves into the mainstream of school and life. Some children have such severe deformities of the hands that they cannot function in an ordinary classroom. However, if they are given adaptive devices molded to their hand configurations, they can perform most operations in an ordinary class or in our Sheltered-Workshop Laboratories.

This Senior Project produced two prototype devices for use as assistive devices for deformed hands. The first device, a pair of modified pliers, increases a handicapped student's strength by about four times. The new head design is used to grip different shaped objects. It can turn knobs, pick up small objects, and open push-button seat belts. The handles are custom designed to fit the shape of the hand, easing the stress on the fingers of the handicapped student. The second device is a strap wrench primarily designed to open jars or door knobs. A continuous belt is attached to the one-piece handle. The belt is adjustable to various sizes of jars. The handle is also formed to fit the user's hand. Small forces are needed to operate the tools and the stresses incurred are relatively low. Both designs are simple and suitable for injection molding.

SUMMARY OF IMPACT

For a Senior Projects program to function efficiently requires a great deal of coordination among the handicapped students, the coordinators of the disabled, university professors and students who do most of the design, fabrication, and testing of various orthotic and assistive devices. All of our Senior Projects devices have grown out of needs of handicapped individuals. Many of the devices can be constructed only on a research university campus, such as Texas Tech University, where there is elegant education, sophisticated science and advanced technology.

The modification of Channellock Pliers and the development of a strap wrench ostensibly may seem a trivial and low-priority engineering and education problem. Not much basic research here. But, there is a great deal of production research that has significance for production of custom-designed tools for the handicapped. Most importantly, for our handicapped students to function in the Sheltered-Workshop Laboratories and in cooperative employment, they must have adaptive devices that they can use. These devices are used by handicapped students in school and later in cooperative employment.



TECHNICAL DESCRIPTION

The objective of this Senior Project was to modify two basic hand tools that can be used easily and effectively by handicapped school children to perform a variety of tasks. The two tools that have been selected are slip-joint pliers and a strap wrench. These tools will aid in the motions of pinching or grasping and twisting. The design of the tools will increase the strength of the child.

Torque and Leverage

A handicapped child can also increase his or her strength through leverage. The force required to hold an object (F1) can be achieved by applying a smaller force (F2) at a distance and creating opposing torques. The necessary force is decreased by a factor of x1/x2.

Results: Tool 1 - Pliers

The first tool is a modified pair of nine and one-half inch Channellock pliers. The purpose of this tool is to aid a handicapped child in grasping and/or turning small objects such as television or radio knobs. Another main function of the pliers is to help in unfastening the push-button type of seat belts.

This problem was approached first by studying a pair of commercially available Channellock pliers. A silicon rubber mold was made of the steel pliers, then an epoxy model was cast from the mold. Results of photoelastic analysis revealed that the greatest stress occurred at the narrow section of the upper handle when no torque was applied. This stress was nearly twice as great as the stress in the narrow section of the lower handle. Stress concentrations also occurred at the corners of the head of the pliers. However, the stress lines were uniform along the handles indicating no stress concentrations. A downward torque applied to the pliers showed increasing stresses in the upper handle. Conversely, an upward torque increased the stresses in the lower handle.

Tool 2 - Strap Wrench

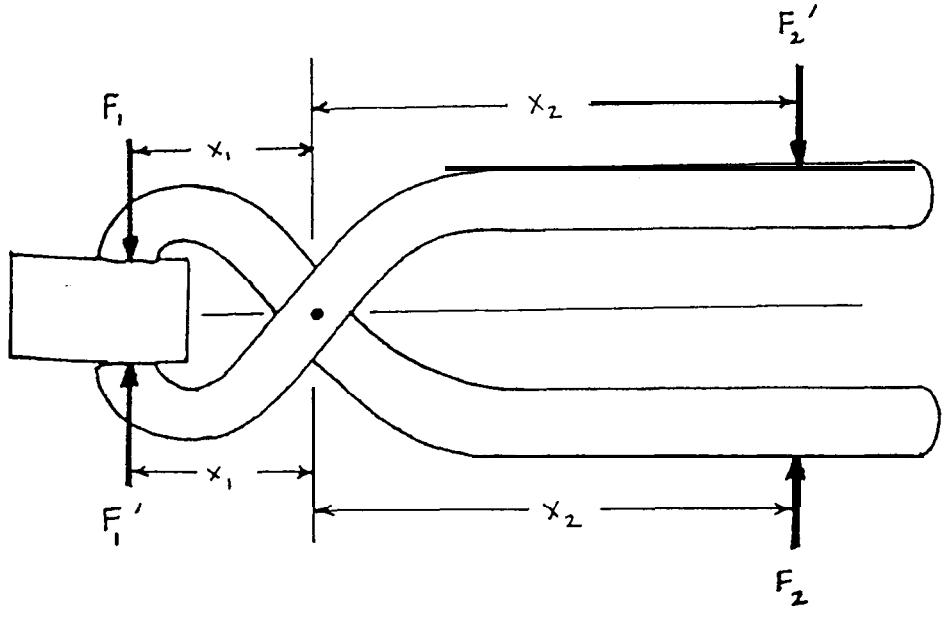
The second assistive tool is a strap wrench. The purpose of this tool is to help a child open jars, knobs, or anything that requires twisting. Unlike the modified pliers, the strap wrench is built entirely from scratch using new designs.

The frame was machined out of five-eighths-inch sheet aluminum. Two curves were cut into the head to accommodate both small and large diameters. An 18-inch, toothed polyurethane sewing machine belt was attached to the other end of the head. A notch was cut out of the aluminum near the end of the handle for the belt to go through for adjustment. A top plate was attached to the head of the tool to aid in placement and use of the tool. The handle of the strap wrench was dipped into the melted thermoplastic and shaped to the hand. The tool was designed to be pushed away from the body. The near side of the handle was cup-shaped to fit the eccentricities of the palm of the hand.

Texas Tech University's costs for tooling and production equipment were considerable. But, the actual allowable costs to this project were less than $200 and 56 hours of Senior Projects students' time.

$$F_1 x_1 = F_2 x_2 \qquad F_1' x_1 = F_2' x_2$$

$$F_2 = x_1/x_2 F_1 \qquad F_2' = x_1/x_2 F_1'$$



"Development of a Therapeutic Crawler"
The Design and Fabrication of a Therapeutic Crawler for Students with Multiple Handicaps

Designers: Jim Bielstein, Mike Etheridge, Lance Free,
Nat Phillips, Anita Green and Alan Tribble
Supervising Professors: Mr. Jesse C. Jones
Department of Mechanical Engineering
Dr. Oliver D. Hensley and Dr. Donna Reavis
College of Education
Texas Tech University
Lubbock, Texas 79409

INTRODUCTION

Pam is a physically and mentally handicapped twelve-year-old child. She is blind and non-ambulatory which restricts her to a wheelchair or bed. Pam's physical limitations are due to her slightly curved spine, one leg being shorter than the other, and below average motor skills. She exhibits poor posture and balance. She is unable to bear much weight on her arms or legs. Pam has little active movement and cannot independently attain positions; however, she does respond to physical therapy. She has normal muscular tone and adequate head and trunk control when sitting in a wheelchair. As a result of her present therapy, she can now stay in a four-point position (on hands and knees) for a short period of time.

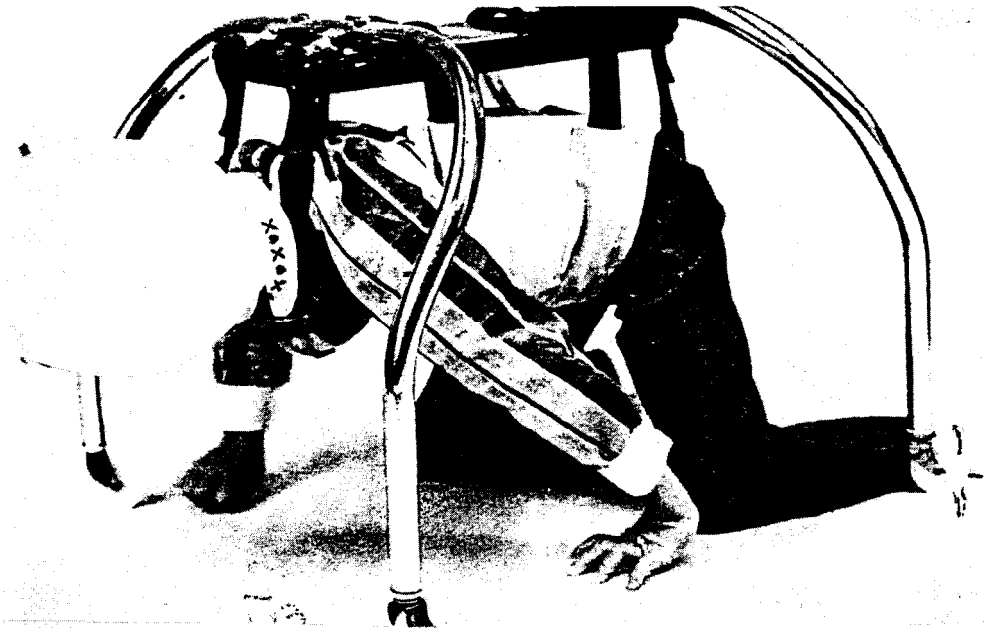
The physical goals for Pam are maintenance of a four-point position for an extended period of time and an increase in overall strength and balance. Her long-range physical goal is to increase her mobility. Also incorporated into her short- and long-range goals is the development of independence in self-help skills.

A crawler that was previously used in therapy was not adjustable, and in some ways movement was rough and slow. The new crawler is adjustable and can be adapted to improve the exercise of specific limbs.

SUMMARY OF IMPACT

The crawler was designed and fabricated to specifications as required by the therapist for Pam, the handicapped client for this project. This therapeutic aid device will give Pam a sense of independence and mobility, providing another way to explore her environment. Pam and other children with similar handicaps will use the crawler for improving their self confidence and exploring their environment.

By combining the support structure and leg assembly, harness assembly, and wheel assembly, a more adaptable and maneuverable crawler has been designed. This design significantly expands the client's rate of progress by adding to the tools of the therapist. The crawler, in the early stages of the client's therapy, aids in supporting her body in a four-point position while, afterwards, helping to develop balance and muscle control needed to begin independent crawling.



TECHNICAL DESCRIPTION

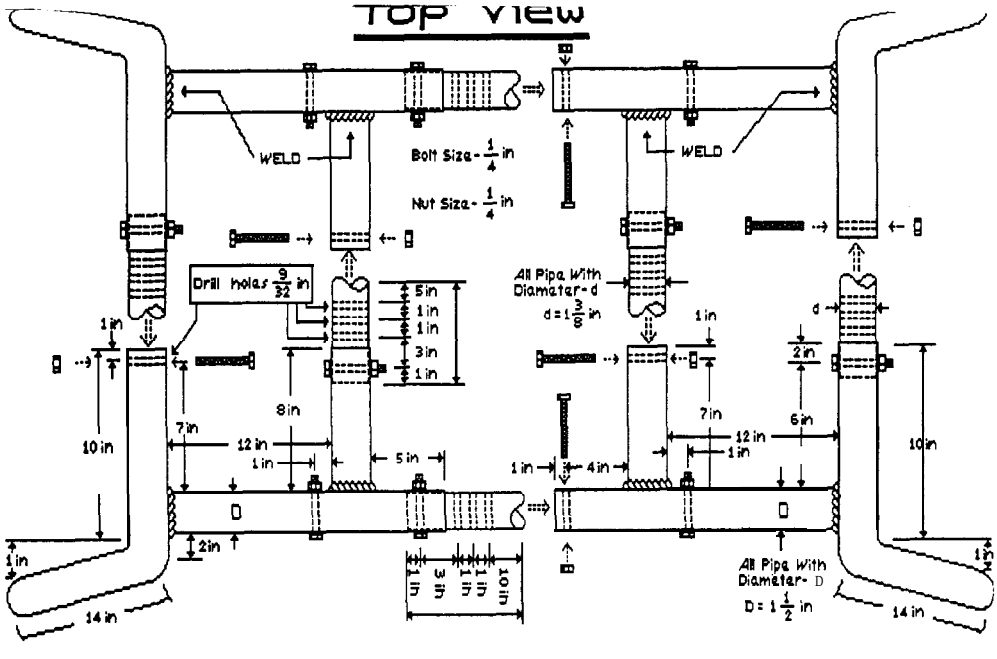
Taking into account the client's physical limitations and planned therapy, it was decided that she needed a device to aid in her therapy by improving balance and muscle control. The device chosen, based on the client's limitations, was a four-point position crawler. The crawler is composed of four multi-adjustable legs and supporting structure, a harness assembly, and a wheel assembly.

The crawler's legs span above the client and then arc down to create a supporting structure for the harness assembly and client. The legs and supporting structure are made of 1 5/16- and 1-inch steel tubing. The different pipe sizes are to allow enough of a clearance to produce a sliding fit, thus allowing for adjustability in length, width, and height. This adjustability accommodates the growth of the client and also the possibility of the crawler being used by another handicapped person. The crawler was designed with safety features such as a safety belt to hold the client in place, and legs that are designed wide enough to keep the wheels out of reach of the child. The crawler is adjustable in height from 10 to 13 inches. The wheels are 31 inches apart from side to side and 23 inches apart from front to back. The maximum yield strength in the legs is 54 ksi allowing a maximum load of 90 pounds.

The harness assembly maximizes comfort and support, thus potentially increasing the time spent in the crawler by the client. The harness consists of a 3/8-inch steel plate fitted with a cushion and supported by straps attached to the supporting structure. These straps are adjustable using buckles and clasps.

The wheel assembly includes roller-ball caster wheels as opposed to thin, flat caster wheels. Roller-ball caster wheels facilitate maneuverability on flat surfaces, indoors as well as outdoors. The wheels also have covers around them to prevent the client from rolling the crawler over her hands while crawling.

The Senior Projects' student time spent on design, fabrication and testing was 102 hours. Less than $200 was spent on materials and supplies.



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