CHAPTER 24

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Biofeedback Posture Correcting Assistance Device

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Handicapped Coordinator: Peter Lanasa, Gorman Public School
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INTRODUCTION

The Biofeedback Posture Correcting Assistance (BPCA) Device was designed to assist a student from Gorman Public School in maintaining midline position of head when sitting in her wheelchair. This eight year old female student from Gorman School is afflicted with cerebral palsy, which is a condition of motor disorder characterized by paresis and lack of muscular control.

A more specific clinical picture of the child's functional status was obtained after meeting with the child, and with the various professionals who work with her. This indicated that the main problem that is hindering her overall performance in the school setting is her lack of proprioception.

This lack of proprioception or position sense of a body part in space does not provide her with the information needed to self correct abnormal postures. Furthermore, because her sensory feedback mechanism is not functioning properly she continuously tilts toward her affected side, which is the right side.

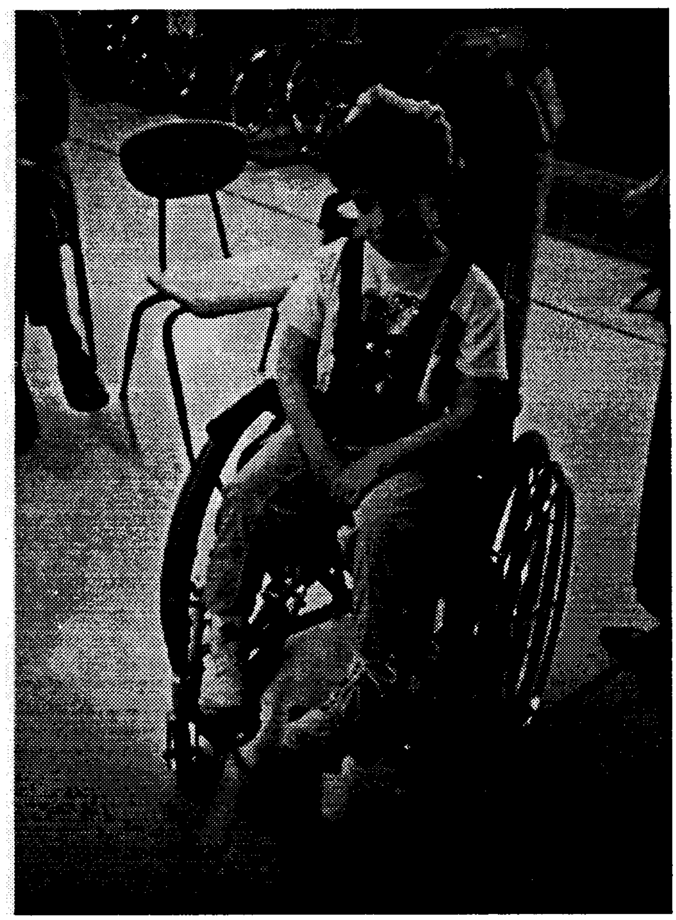
The purpose of this project was to design a device that would provide her with the information needed to self correct her posture. The BPCA device serves as a substitute for that information on appropriate position sense not provided by her own neurological system.

The unit consists of a logic circuit involving two mercury switches. It will be used with a tape recorder as a training tool in a therapeutic setting. If the child does not have her head positioned in midline, the tape recorder will be deactivated giving her the clue to return to midline.

SUMMARY OF IMPACT

After testing the final device on the child, it was found that the BPCA Device constitutes a very useful, safe, and relatively inexpensive training tool for children with posture problems. Also, the non-medical appearance of the BPCA Device makes it more aesthetically pleasing than other devices.

In general the BPCA Device provides the following advantages: allows the child to actively participate in controlling her body; facilitates learning; improves interaction with the environment; and enhances the development of positive motor skills.



TECHNICAL DESCRIPTION

The BPCA Device uses a simple logic circuit, two movement sensitive mercury switches, and a tape player that will be deactivated when the student is not in correct position.

The block diagram of the device gives a general picture of how it operates. When the student's head is in midline position, the two mercury switches activate the logic circuit that simultaneously generates action of the tape player and lighting of the LED. These switches were mounte.' on a headband, which is the position sensor. The driver consists of a transistor that closes a switch in the relay when the student is in correct position.

The original circuit design had to be modified because of availability of components and problems encountered when testing the circuit. First, it was found when testing the circuit that the mercury switches had a high contact resistance of approximately 200 K ohms. This was due to the fact that mercury switches are designed to normally be used at much higher voltages than what was used in the circuit. To correct this problem it was necessary to amplify the mercury switch operation by connecting them to the base of a transistor. The collector resistance values were chosen by measuring the collector voltage with a voltmeter and varying Rc until Vc=O. After doing this, both inputs to the NOR gate were 0 and the output was 1. (Truth table)

Two other transistors were added to the output of the NOR gate. This was done because the LED and the relay each require different currents. Both transistors are also saturated causing current to flow through the collector. One transistor closes the normally open relay switch that activates the tape player and the other transistor lightens the LED.

The transistors and the electromechanical relay switch from the original circuit are different from those in the current design. It was found when testing the circuit for hysteresis that the output of the NOR gate would oscillate at certain angles. Even though the analysis showed that the transistors were saturated, they were still in the linear range. Since this is unacceptable when used with digital circuits, a better quality transistor was purchased from Pioneer. After replacing these components, the device worked as desired. The analysis of the working design is:

Analysis of Switching Amplifier Circuit

Measured resistance of Hg switch = 200 K ohms
Equivalent switching amplifier circuit for each Hg switch is given by:
To check for saturation:

$i_\beta > i_C/\beta$

$i_C = 9\ V/100\ K = 0.09\ mA$

$i_C/\beta = 0.45\ \mu A$

$V_{\beta\beta} = 9\ V\ [100K/(204.7 + 100)K] = 2.954V$

$R_{\beta\beta} = 204.7\ K\ 11\ 100\ K = 67.18\ K\ ohms$

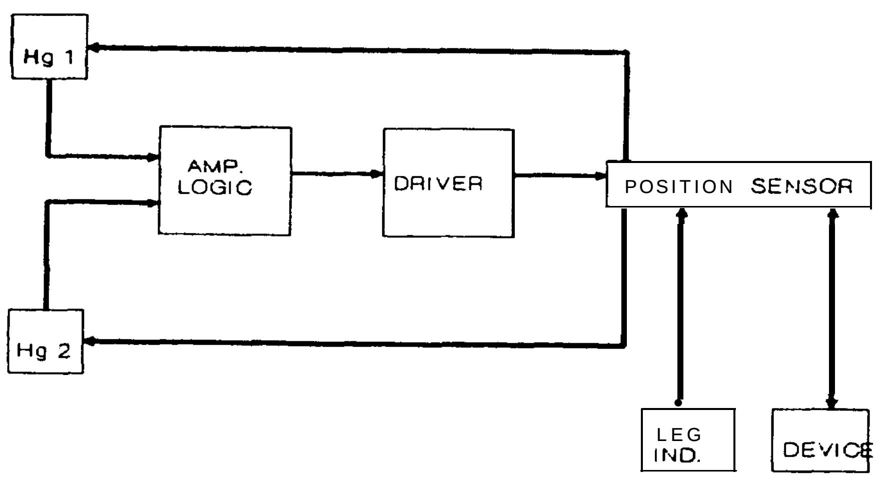
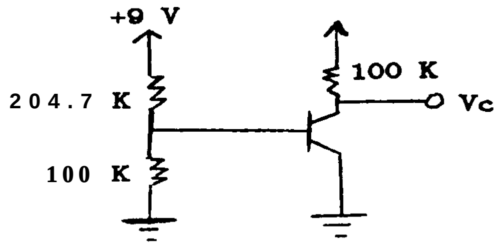


Fig. 7. Block diagram of BPCA Device



$i_\beta = [(2.954 - 0.7)V]/67.18K = 33.24$ mA
$33.24\ \mu A > 0.45\ \mu A$

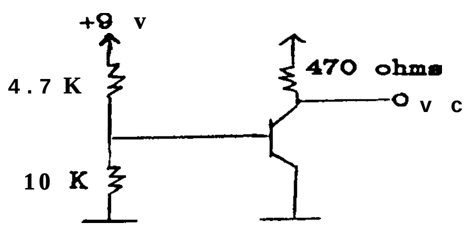
Analysis of Driver Circuit

$i_\beta > i_c/200$ *(For saturation)*

When Points 1 and 2 on gate are 0 *(Truth table):*

$V_{\beta\beta} = 9V(10K/14.7K) = 6.122$ V

$R_{\beta\beta} = 4.7K \| 10K = 3.197$ K



i, = 9V/470 ohms = 19.15 mA
$i_c/\beta = 0.0957$ mA
$i_\beta = [(6.122-0.7)V]/3.197$ K = 1.696 mA
1.696 mA > 0.0957 mA

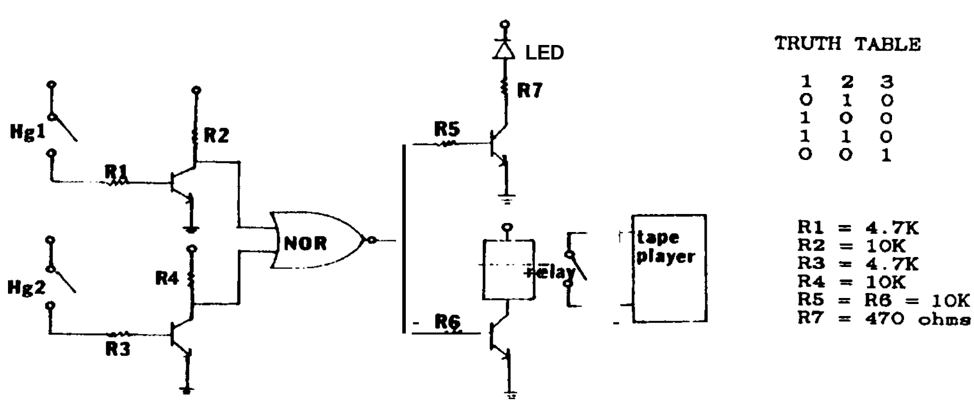
Therefore: NPN is saturated and transistor works as switch.

The electromechanical relay was also replaced. It was determined that a solid state relay would minimize hysteresis, eliminate inductive loads and increase operating life. The only significant hysteresis left was in the mercury switches themselves.

The circuit also required packaging. A circuit board was purchased with an encasement. All resistors and transistors were soldered onto the circuit board and the IC chip was plugged into a socket, therefore making it easier to replace if necessary. The LED and the Hg switches were placed on the outside of the box.

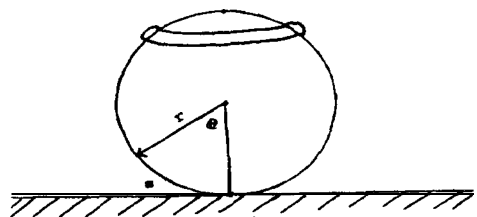
Safety is a critical factor in this design project since the device will be utilized by a child. Because mercury is highly toxic it was necessary to enclose the mercury switches in a protective encasement to prevent breakage. Adapting a tape player was accomplished by simply purchasing one that had a remote switch. Therefore, the device can be plugged into the tape player by way of a connector. This greatly simplified matters and leaves room for expansion if another adapted device is desired.

The positioning of the switches constitutes an important design criteria for the device. This was determined analytically by using a ball to simulate the child's head. The radius of the ball was calculated by measuring the circumference of the ball and using the formula $C = 2\pi r$. After attaching the switches to the ball and labelling it with appropriate reference points we proceeded to test for hysteresis.



FINAL CIRCUIT DESIGN

Hysteresis represents the directional behavior of the system. More specifically, it compares the directional behavior of the system when driven in the forward direction to that when being driven in the reverse direction. To test for hysteresis the ball was first rolled from 0° to 90” and then it was returned to the reference point. This was done for both right and left side. In each case the angle of activation and the angle of deactivation were determined as illustrated below:



Angle Simulation
r = radius; s = arch length.

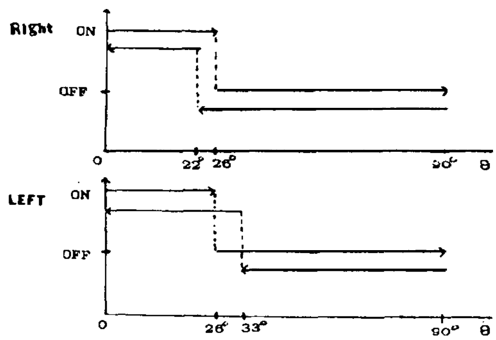
C = measured circumference = 26.5 in

$C = 2\pi r; r = C/2\pi = 4.22$ in

$ds = rd\theta$

$dr = ds/r\,(180°/\pi$ rad)

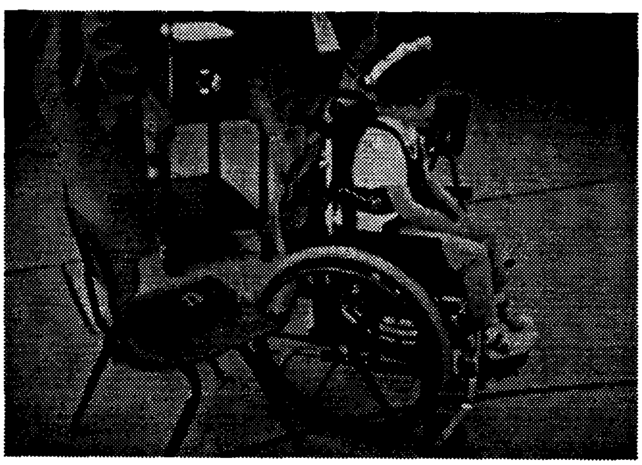
Where **r** (radius of ball) has already been calculated and ds is the change in arc length measured with a measuring tape after rolling the ball a certain distance. The final values were obtained after averaging the values for several trials.



Graph for Determining Hysteresis

Because the system is binary it has two functions (ON or OFF) and the deadband or difference between angle of activation and angle of deactivation constitutes a good representation of the hysteresis of the system.

A headband was used to further explore placement of the switches on the head. This enabled us to obtain a more precise placement of the switches, thereby minimizing hysteresis. The upper lateral medial portion of the head was found to be the most suitable position for the switches. The cost for the design and development of the BPCA Device was approximately $232.00.



Height Adjustable Orthotic Seating System

Designers: James M. Leaming and Vicky Matanguihan
Handicapped Coordinator: Peter Lanasa, Gorman Public School
Supervising Professor: Dr. Chandler Phillips
Department of Biomedical and Human Factors Engineering
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INTRODUCTION

This project was conceived with the idea to design a seating system that can be used by a student at Gorman Elementary School in Dayton, Ohio, with spastic Cerebral Palsy. The project involves the design and creation of a portable, lightweight, supportive seating system with adjustable base to allow for differing levels of height from the floor. Collection of human factors data, considering height, weight and materials requirements, formed the first phase of the project. Static force-analysis to determine the appropriate base geometry for maximal support and safety, followed by the engineering design of the seating system, formed the second phase of the project. The final phase, implementation and testing, consisted of a complete model and on-site testing with the student.

SUMMARY OF IMPACT

As a result of the complications associated with Cerebral Palsy, the student benefited from this project has great difficulty in maintaining a sitting position without support of his torso. Limited in muscle coordination and strength, the student struggles to maintain an upright posture. In addition, the spasticity of the student's hamstring muscles prevents him from sitting comfortably on the floor without his legs being contracted in an awkward position.

This seating system provides lateral supports and upper body restraints to align the student in an upright posture, thus enabling for correct anatomical positioning. Without such support, the child tends to lean forward possibly causing curvature of the spine and increasing future complications. This lack of support also forces the student to support his upper body weight with his arms, thereby not allowing him to use his hands freely in daily activities. Another function of the seating system will be to elevate the child off the ground, enabling him the freedom to be seated and comfortable despite a high degree of spasticity in his hamstring muscles. Through the utilization of these modifications to presently available seating systems, the child will be more secure knowing that he will not lose balance, and as a result, gain self-confidence and a more positive self-image.

TECHNICAL DESCRIPTION

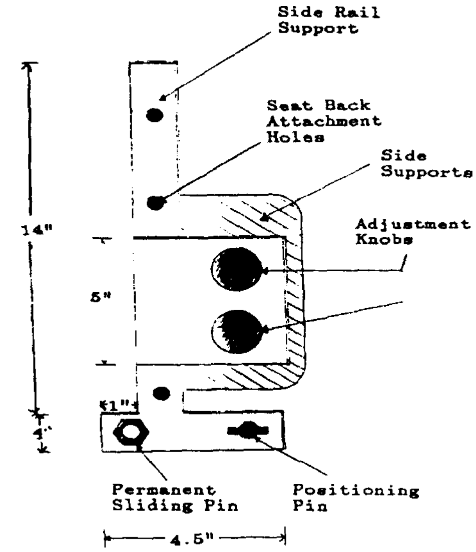
This project consisted of three phases that divided the task and enabled the progress of the project to be monitored. Through the completion of phase one of the project, the anthropometric measurement and setup of the data base of information pertaining to physical characteristics and limitations, the basis

for the seating system was developed. The measurements of the student were taken to provide the required information pertaining to the dimensions of the chair.

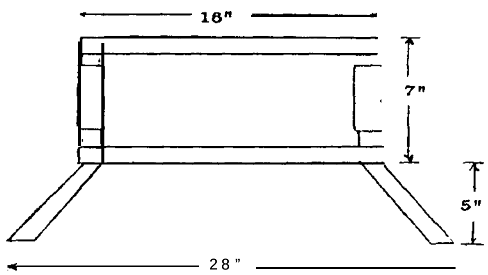
As part of the completion of this project, the seat must be adjustable in height, width and depth of seating. The range of this adjustability was determined with the approval of the staff at Gorman Elementary School. Also, during phase one, many base configurations were considered until a trapezoidal base was decided upon. This base seemed the most feasible due to the inherently high stability with respect to minimal weight requirements. This is essential in designing a chair that is portable and lightweight, as well as practical in implementation for use by the student.

During the second phase of the project, base system and materials were tested for static stability and force distribution. In this analysis, the force due to the weight of the chair, the force due to the weight of the child, and a horizontal force, representative of instability caused by an impulse pulling action, were considered. Also, a safety factor was considered. By estimating the maximum values for the student's weight, the sideways force, and the worst case for height of the chair from the floor, the minimum weight of the chair was determined. Many different materials met the requirements for the strength limitation, but the one that was decided upon was polyvinylchloride tubing because of its lightweight nature. Design and construction of the seating system concluded the second phase of the project. Phase three consisted of implementation of the completed model and on-site testing with the student to determine effectiveness.

During the developmental stage of the project, personal facilities have been utilized. Contracts were issued to various machine shops to establish competitive bids on the building of the prototype. Requirements of the machine shop were limited to basic metal working and model building for construction of the seat depth and side support adjustments. The Brehm Laboratory at Wright State University was finally decided upon and the plans for the required side support and movement system were sent to them for development. Testing of the completed project was done at Gorman Elementary School in Dayton, Ohio. The Height Adjustable Orthotic Seating System cost $660.00 to construct.



Metal Work for Seat Depth and Side Support Adjustments



Seat Base Configuration

Closet Adapter

Designers: Kheir Elhourani and Ghassan Souri
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INTRODUCTION

The subject for this project is a child who suffers from Myelomeningocele, which is an open defect in the spinal canal due to abnormal fetal development. More specifically, it is an outpouching of the bony vertebral column that has failed to form. This deformity is associated with neural tube disorders such as: bony deformities; loss of sensation; and paralysis of the trunk and the Iower extremities. Due to all the above mentioned physical problems, the ability of the child to reach for the closet is limited. Therefore, a new design for a closet adapter was needed.

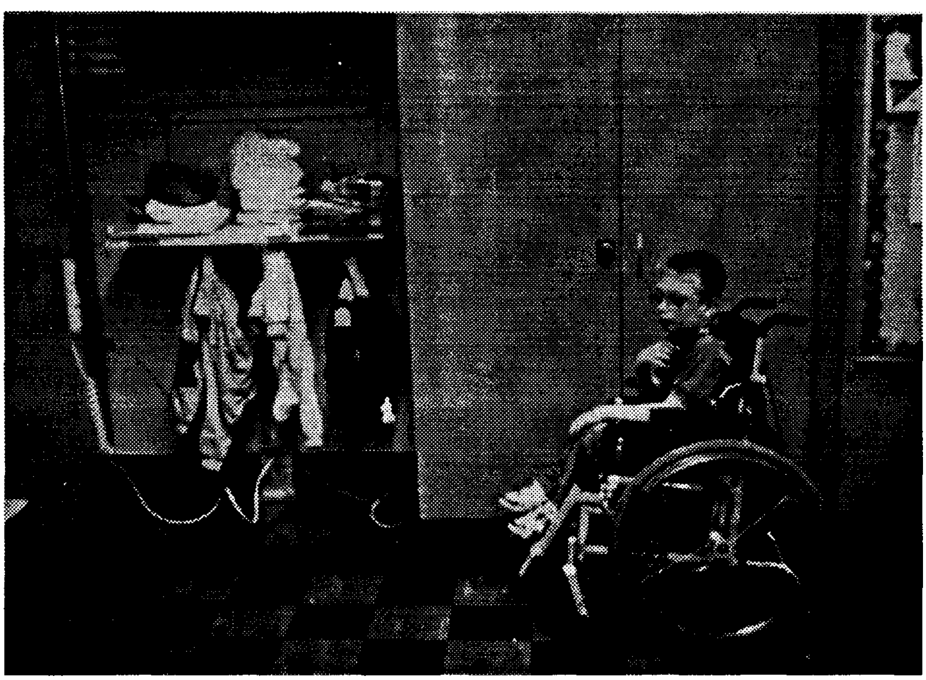
The new closet adapter slides up and down to the determined level that has been chosen by the child, using a simple switch. This allows the child to get his own clothes without any outside assistance.

SUMMARY OF IMPACT

The child and the staff at Gorman School were satisfied with the new design. After the new closet adapter was tested by the disabled child, it proved to be very useful in allowing the child to lead a more independent life. It also decreases the amount of the staff time needed during the day.

TECHNICAL DESCRIPTION

The Telemag Telescopic Pillar used in this design is an electrically driven telescoping actuator. The pillar is extended and retracted by driving the tube linearly in and out of the outer tube with great force and high precision. Extension and retraction are accomplished with an integral high-powered electric actuator. Requiring no maintenance whatsoever; it operates noiselessly to deliver thrust ranging from 220 to 882 lbs. Measurements of the

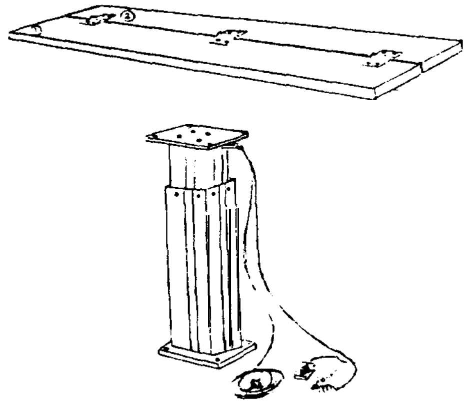


closet and the shelf were taken. Also an accurate measurement of the child's height in the wheelchair was taken to choose the minimum height needed for the telemag. It was found that the maximum height the child can reach using his hands is 40 in. This indicated that we had to choose a telemag with a minimum height less than or equal to 40 in. Based on this, a telemag with body height of 645 mm (28.8 in) and a stroke height of 500 mm (20 in) was chosen.

To minimize the danger of a sudden contact of the shelf with the subject, the following was done: A longitudinal cut was made along the shelf, then three hinges were placed along that cut. This way if the shelf slides down while the subject is beneath it, at that instant part (1) of the shelf will slide up as soon as it is in contact with the subject.

A wood base of 7 in was added to the height of the telemag to give a body height of 27 in. This allows the child to get his coat without having to bend.

After gathering all parts to form the final design, the new closet adapter was tested by the disabled child. It was found that the child could manipulate the switch to activate the telemag and choose the appropriate height to reach the standard coat hooks without any effort. This closet adapter cost $890.00 to build.



Telemag and Shelf