CHAPTER 14
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POWER ASSISTED WALKING TRAINER

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INTRODUCTION

The Variable Assisted Walker (VAW) is a device to be used by a 14-year-old child. She had surgery to release tension in her Achilles tendons and allow for better leg movement when walking. She has difficulty walking without fatigue. Additionally, her tonic leg position with little knee movement creates a problem with moving in a straight line. The VAW (see Figure 14.1) is a device that will enable the child full motion of her legs in a predetermined manner, thereby teaching coordination, increasing muscle strength and allowing for mobility within her school. The VAW is a fixed walker frame, mounted on a mobile platform. The platform utilizes the features of a Nordic-Track© exercise system design. The foot pedals trigger the operation of a DC motor, and thereby facilitate walking while allowing mobility around the learning center.

SUMMARY OF IMPACT

. The device enables the student to gradually increase leg strength while allowing mobility around her school. VAW will help guide corrective walking motion. The design incorporates many safety features that are important for children with disabilities.

TECHNICAL DESCRIPTION

The overall structure of the VAW is aluminum. The skating mechanism, tensioner, variable pulse width circuit, steering mechanism, and main control panel have all been successfully tested and meet necessary requirements.

The device provides a method of power assistance for the student. The design incorporates a skating mechanism to produce a walking motion (see Figure 14.1). The skates are lightweight and have low friction resistance. They are attached to pulleys, which allows the student to step forward with one foot while the other foot is pulled back.

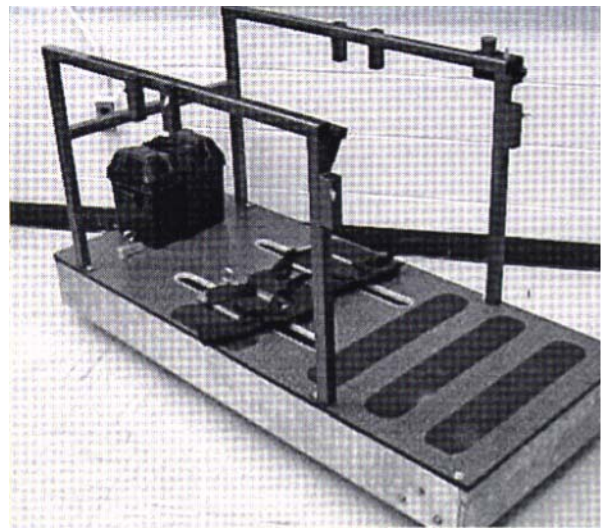

Figure 14.1. Variable Assisted Walker.

A 1/4 Hp 12-volt DC motor is used. The current is supplied to the motor by a 12-volt deep cycle marine battery with an 80amp/hr capacity. A variable pulse width generation circuit that latches to a digital logic relay controls the motor. The pulse width is initially triggered by two sets of Photo-Diodes, which change state by the operation of sliding pedals. The low to high change output signals created by a comparator are forwarded to an OR-gate. The pulse is then directed to a monostable multi-vibrator, which holds the signal for predetermined pulse duration. The circuit incorporates an internal reset function that allows for a constant high pulse. Implementing a variable resistor will provide variable pulse widths. In addition, the motor controller includes a continuous mode feature, which enables the motor to run continuously. The student simply changes the control switch to continuous mode.

The tensioning unit was obtained from a Nordic-Track© exercise unit. The tensioner consists of a flywheel, belt, spring, and adjustment control. The student can vary the degree of tension placed upon the flywheel and resistance on the foot pedals by using the adjustable control knob.

A steering mechanism was also implemented into the design of the walker. This mechanism allows the student to remain in a straight line or be turned left or right in a fixed turning radius.

The cost of this project was approximately $1500.

GAIT RACER FOR GAIT AND WHEELCHAIR TRAINING

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INTRODUCTION

This Gait Racer was designed to improve the quality of life of a 15-year-old boy who has used a wheelchair for most of his life. Choices of similar devices are limited to either an assistive walking device or a wheelchair. This product combines these two options, allowing the boy to alternate between practicing to walk safely and sitting to rest. He can also use the device to wheel himself manually as he desires and ultimately provide more independence in his mobility.

SUMMARY OF IMPACT

The Gait Racer was designed to help children with physical handicaps learn to walk. A gait training method was implemented to fulfill the design criteria. A harness is placed on the child that suspends his weight from the boom allowing smooth foot movement. As the child's abilities increase, a larger bearing load is applied to his feet. After training, the child may be able to walk unaided.

TECHNICAL DESCRIPTION

All major components of the Gait Racer are adjustable. This includes the heights of the boom, seat, footrest, harness, and handrails. In addition, the forward-to-rear location of the harness has four positions. This is to accommodate children of different heights and weights. The mainframe components are made of steel. Each component was sized by performing stress and deflection calculations. The base-frame subassembly is designed with the rear wheel support plates welded into place. An appropriate size spacer was placed in between to prevent distortion of the plates when welded. Two 1 x 3 cross bars are welded at the rear to strengthen the structure and provide a mounting platform for the 2 x 4 upright with base plate. Two 2 x 6 steel plates are welded to the underside of the cross bars where the base plate of the upright mounts on top. These plates add rigidity to resist torsional forces. Four handrail adjustment pins are welded onto the top of the base-frame as guides for the handrails. Mounting holes are provided on the base-frame bottom for the caster wheels.

Figure 14.2. Gait Racer.

The boom is made of 2-inch round pipe with a 1/8-inch thickness. The bend in the boom has a curvature of 4 inches. Four 3/8-inch clearance holes are drilled for the eyebolts. These eyebolts provide different locations for the harness strap, thus making the device usable for people of various weights. Two u-bolts are welded to the shorter end of the boom for mounting to the 2 x 4 upright with a backing plate. These u-bolts provide a precise level of adjustability.

Five ½-inch clearance holes are provided on the bottom half of the upright for adjustable mounting of the seat. The seat release mechanism is made up of ½- inch aluminum brackets and spring-loaded release pins with pull knobs. The seat bottom pivots down as the brackets rotate on a 2-inch round pipe section. A bracket is also provided for mounting the seat back.

1-inch diameter aluminum hand rails with 2 ½-inch radius bends are mounted on guide pins. These pins have six tapped holes each, 1 inch apart, for a total adjustability in height of 6 inches. The handrails are held tightly in place and can be quickly adjusted by ¼-20 bolts with knobs. In addition, the armrest pads are mounted on the handrails.

The caster wheels are attached on bottom of the 1 x 3 frame with one nut each. The wheels include safety brake hardware to provide stability when a child is secured to the device.

The harness assembly is comprised of a full body harness, carabiners, and adjustable straps. It is normally used for rescue operations; therefore it is durable and adjustable. The carabiner is specified for a maximum weight in excess of this design requirement. The adjustable straps can support the up to 1200 pounds. A caregiver or therapist can adjust the harness based on the child's height and weight. The extra length of the strap allows the child to be placed in the seat before disconnecting the straps.

The cost of this project was approximately $800.

COMPACT STANDING WHEELCHAIR

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INTRODUCTION

The Compact Standing Wheelchair (CSW) was designed for a student who needs to be transferred from a wheelchair to a standing supine board as part of his mobility program. The device is similar to a regular wheelchair (see Figure 14.3). It is unique because it utilizes three positions. The device can shift from a sitting position to a flat position, and then to a standing position. The CSW will take the place of two separate devices the student previously used. This device will help ease transitions and requires less storage space when not in use.

SUMMARY OF IMPACT

The design criteria for the CSW were defined mainly by the needs the particular student who has little muscle tone and poor control of most of his body. He cannot sit up straight independently. His wheelchair is usually tilted back to support his head. In addition, the student needs support to maintain a sitting position. He uses a tray to keep his arms in front of him. He cannot reach for anything close to his body or on either side of his body. Every day he is placed into a stander to give his legs circulation, strengthen leg muscles, and place him in a position best suited for class work. The paraprofessionals had been lifting him out of his wheelchair and placing him on the stander to move him into the standing position. The student's low muscle tone and the cumbersome nature of altering positions in a stander made this process time consuming and difficult. The CSW was designed to address these problems.

TECHNICAL DESCRIPTION

The overall structure of the CSW is composed of mild steel 1-inch in diameter and 0.083 inch thick. The measurements of the CSW as a whole were determined by the standards for average wheelchairs and doorframes.

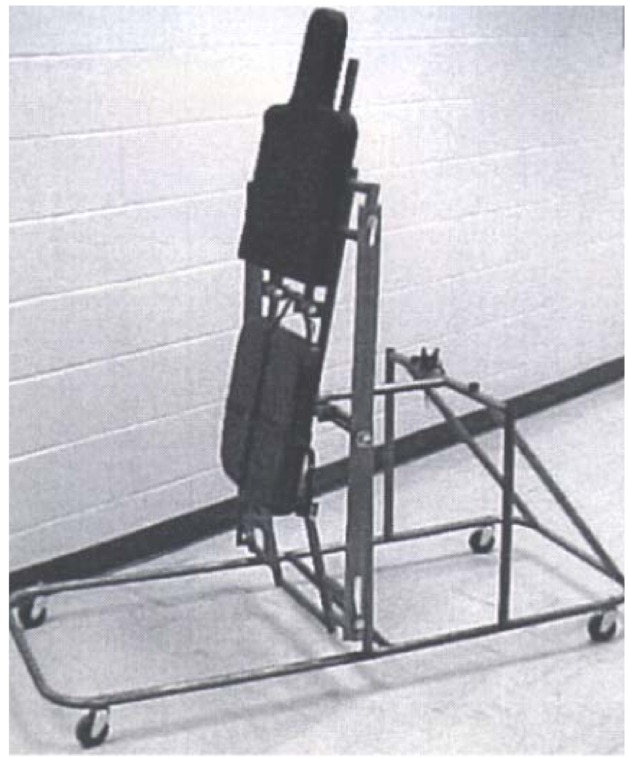

Figure 14.3. Compact Standing Wheelchair.

The base of the CSW is similar to the stander that was previously used by the student. Using an established device's measurements assures the safety of this device. As few welded joints as possible were used to decrease the amount of potential failure in the device. Four bends were used in the bottom of the base. The rest of the device was put together like the base of the stander the student previously used.

The design of the CSW was based on a slider joint mechanism. The chair would slide from a sitting to a laying position and then pivot about a fixed point into a standing position. The slider mechanism was composed of a pivot using a cam. The slot in which it slides was cut from a thin sheet of metal. The slot was determined at its maximum and minimum points (laying position and sitting position). The four-slider joints were placed two on each side, one on the leg rest and one on the backrest.

The pivot point is in the middle of the seat. There are locking mechanisms to keep the chair in both the sitting and standing positions. The device is moveable due to the use of caster wheels. The back wheels may be locked into position for safety.

The cost of materials was approximately $350.

AUTO BLINDS

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INTRODUCTION

Auto Blinds were created to benefit children with disabilities. The device consists of two motors that control the tilting and sliding of the slits (see Figure 14.4). This design was chosen because the children for whom it was designed do not have full motor functions. For this reason, it is difficult for them to turn a rod to adjust the tilt of the slits or pull a cord that will open or close blinds.

SUMMARY OF IMPACT

The automation of blinds gives a child in a wheelchair the ability to operate the blinds independently despite motor disabilities. The children feel that they are accomplishing something without any assistance while utilizing this device.

TECHNICAL DESCRIPTION

The material used for the rail is aluminum, and the slits are made of vinyl. This design has two 12-V DC motors. A coupler connects a 12-V DC motor to the shaft, which turns the blinds. The 12-V DC motor is connected to a switch that reverses the current of the motor. This motor controls the motion of the slits and has a range of motion from 00 to 1800.

The other 12-V DC motor is connected to another shaft. This shaft is connected to the worm gear, and the worm gear is also connected to the coupler. There is a chain and sprocket on the shaft. The motor drives the worm gear, which in effect turns the chain. This mechanism is the same as those seen in bicycles. To make the blinds move from one side to the other as the chain moves, a c-clamp is designed to connect the chain and the blinds. Everything is interconnected into one unit in order to make the mechanism slide the blinds back and forth. The chain carries the motion of the first slider from the left to the right, and this first slider controls all the others. The approximated linear velocity of the auto blinds is 2 inches per second.

A circuit that allows the current to flow in two directions across a 12-V DC motor was included. When the current flows in one direction through the motor, the blinds open. When the current flows in the opposing direction, the blinds close. To operate this circuit, a logic symbol is connected to a power supply. The power supply is connected to two MOSFETs, a p-channel and an n-channel MOSFET. The p-channel MOSFET is used to switch the positive supply to the motor for forward direction. It is turned on when the logic symbol is approximately 12 V. When this occurs, the n-channel MOSFET is automatically closed. The n-channel MOSFET is turned on when the voltage is approximately 0 V. When this happens, the p-channel closes, thus allowing no current to flow through. An n-channel MOSFET is used to switch the negative supply to the motor for reverse direction. Using the two MOSFETs allows the motor to be controlled in the stop, forward and reverse modes.

The cost of the materials was approximately $200.

Figure 14.4. Vertical Blinds.

ADJUSTABLE WHEELCHAIR FOR EASY REACHING

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INTRODUCTION

The adjustable wheelchair was designed to help a person in a wheelchair reach to high places. The device also provides easy transfer when the patient goes to bed (see Figure 14.5). This adjustable device is a simple electromechanical jack that is mounted and secured at the bottom center of a wheelchair. Once the motor is secure to the frame, it can be set into a vertical motion by remote control.

SUMMARY OF IMPACT

The device allows children with disabilities greater independence because the vertical motion of the wheelchair seat allows them to reach items they would not normally be able to grasp.

TECHNICAL DESCRIPTION

The overall structure of the wheelchair is constructed from standard stainless steel tubing, 7/8′′ in diameter. The high strength-to-weight ratio and durability of this material provided the necessary structural integrity needed to support a maximum weight of 300 pounds. The frame supports and seat are designed in such a way that all members come together at 90-degree angles with the existing frame for easy welding. The seat support and jack platform are fastened together by bolts and nuts. Any additional components are also attached in the same manner.

The vertical movement is completed by the jack mechanism that is divided into three telescoping sections inside the housing. Each section is raised or lowed by the torque that the DC electric motor provides. The driving gear is connected to the motor, which is then geared down by two other gears in order to have the desired speed needed to safely operate the motor. In addition, this motor assures a large lifting capability due to the high torque produced by the output. The DC motor is already incorporated with a jack mechanism that includes a circuit and a sensing remote receiver. The actual motion results from pressing the up/down button on the remote pad, therefore providing a signal that triggers the motor by applying voltage. Furthermore, the circuits contain an external 15-amp fuse and kill switch in case of an over load. In addition to the lifting device, an adjustable backrest support is also implemented.

The approximate cost of the Adjustable Wheelchair is $450.00.

Figure 14.5. Adjustable Wheelchair.

PORTABLE WHEELCHAIR LIFTER

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INTRODUCTION

The portable wheelchair lifter (PWL) was designed to provide extra mobility for people who use wheelchairs. A larger model was originally designed but was scaled down due to budget concerns (see Figure 14.6). Although it would not actually be possible to use this smaller model, it does demonstrate that the design principle of such a device can be achieved. The PWL is able to lift a desired object in an upward and downward motion. The design principles of the PWL include ergonomics and easy operation. The device was also designed to be safe for usage in a school setting.

SUMMARY OF IMPACT

The design process was focused on the comfort and safety of the user. The PWL was designed to be stable and easy to use to enhance the level of safety when the device is operated. To make the PWL a convenient device for users, it was designed to be portable, as opposed to a stationary like others that are available. Users operate the device themselves.

TECHNICAL DESCRIPTION

The model that was built is approximately ¼ the size of the original model. The overall structure of the PWL is composed of 6061 aluminum. A miniature 24- volt DC gear motor is used to operate the device. It has a maximum rotational speed of 215 rpm and a torque of 45 in-oz. Its gearbox has a 19.7 to 1 ratio. The motor is powered by a 24-volt DC power supply. The motor's maximum current output is 0.6 amps.

Two ½-inch, 10-treads-per-inch acme screws were used because of their self-locking capability. This is an important safety feature to prevent the elevated platform from moving downward. Each screw is 18 inches long and is machined at both ends to accommodate gears and bearings. Both screws are supported at the bottom by thrust bearings and at the top by flanged ball bearings. The total threaded length is 16 inches. These are matched with a bronze nut attached to a steel flange that is screwed to the platform support. Upon operation of the DC motor, the platform is able to lift in an upward and downward motion for a total of 16 inches. Four 3/8-inch aluminum rods with linear bearings guide the platform.

A ¼-inch steel shaft linked to both acme screws ensures both acme screws have the same rotational speed and torque output.

The cost of materials was approximately $1000.

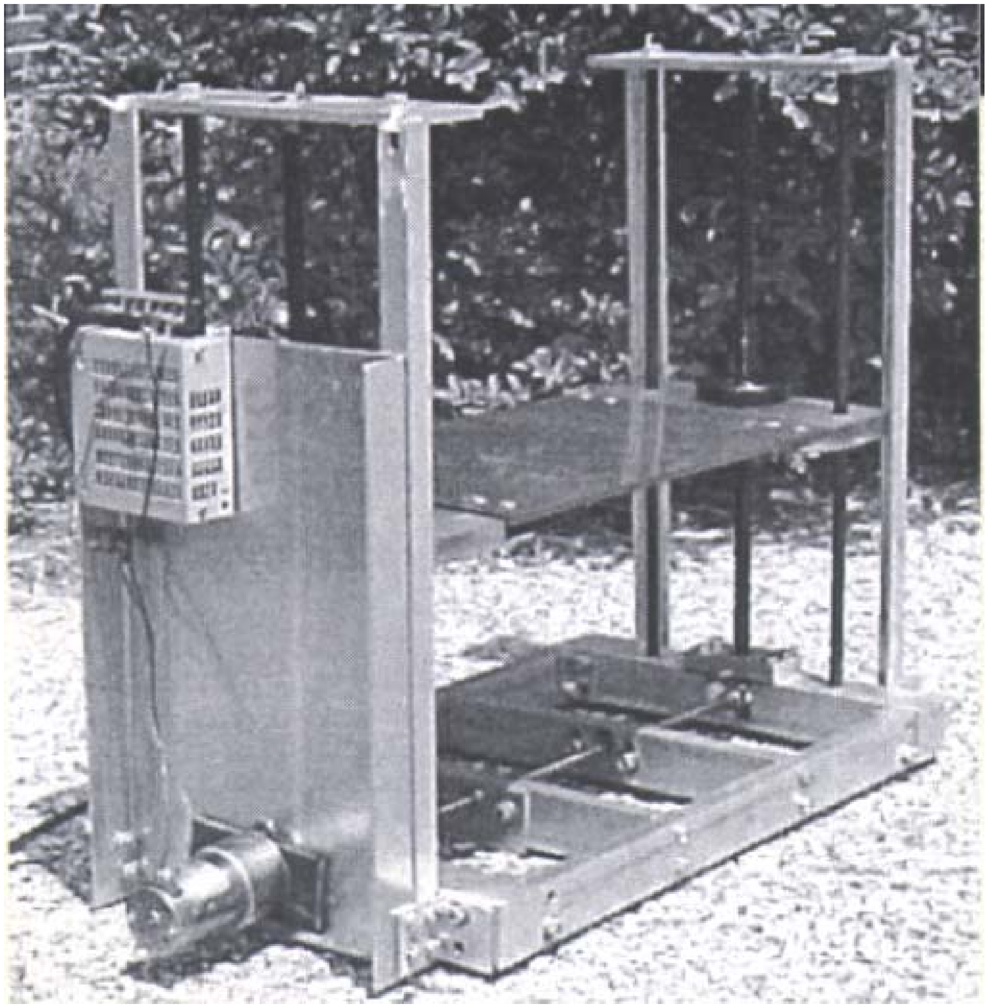

Figure 14.6. Portable Wheelchair Lifter.

DIRECTIONAL DIVERTER FOR A CHILD'S WALKER

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INTRODUCTION

The directional diverter (DD) was designed to provide enhanced mobility for children with multiple handicaps. The device is a motorized platform that is controlled by the assistant via a joystick (see Figure 14.7). The bottom frame of any standard walker device can be bolted to the platform, thus providing a security and safety. The individuals for whom this device is intended have reduced motor and cognitive skills. The main goal of the DD is to allow greater mobility for the children through an alteration of their existing walker. The walker was designed to be controlled by the child's assistant. This may enhance physical therapy sessions.

SUMMARY OF IMPACT

The design criteria for the DD were defined mostly by the needs of a 17-year-old student who has visual impairments. The designs of standard walker devices already available were also taken into consideration. In general, traditional walker devices are heavy and difficult to maneuver through narrow hallways and around obstacles. The walkers are also expensive. It was therefore decided that any major altering of the walker would be unnecessary. The implementation of a dolly to which the walker could be bolted was a simpler and more effective alternative. With the use of a Basic Stamp Microcontroller, the assistant can easily control the motors that drive the dolly and provide steering through the use of a joystick. The overall mobility of the user is greatly increased by implementing this feature.

TECHNICAL DESCRIPTION

The overall structure of the DD was constructed from angle slotted zinc members that were bolted together. All additional parts were fastened to the frame using nuts and bolts.

The electrical components responsible for providing motion to the DD are two 24V, 1/20 hp DC motors. Power is supplied by two 12V, 9.5 amp hour rechargeable lead acid batteries. A Basic Stamp Micro Controller converts the analog signals coming from the joystick to digital signals that are interpreted by the interface board. The interface board outputs analog signals to the motor controllers. Depending on the signal, a relay is activated and opens or closes a circuit. The activated circuit in turn determines the motor output (counter clockwise or clockwise), thus providing the appropriate motion. Steering is accomplished when the pivoting wheel turns more slowly than the opposite wheel. This difference causes the DD to turn in the direction of the pivoting wheel. The main advantage of this steering technique is that it allows the DD to turn while it is stationary.

In designing the DD certain safety issues had to be considered. Among the most important were stability of the entire unit (walker plus dolly), the possibility of electrical shock, and the power output of the motors. The device incorporates two driving motors that also serve as steering motors. This was done was to reduce the possibility of any tipping or jerking motion of the entire unit. The cost and complexity of the unit were reduced through the utilization of only one pair of motors rather multiple motors for steering and driving. In choosing the motors, the output had to be great enough to provide power adequate for steering and forward/reverse motion, while at the same time not overpowering the unit. It is for this reason that 1/20 hp motors were chosen. The maximum speed of the DD matches that of its user, which is about 1 ft/s. Using insulated wire and the installation of a protective covering over the main circuitry reduces the risk of electric shock and short circuits. The cost of materials was approximately $600.

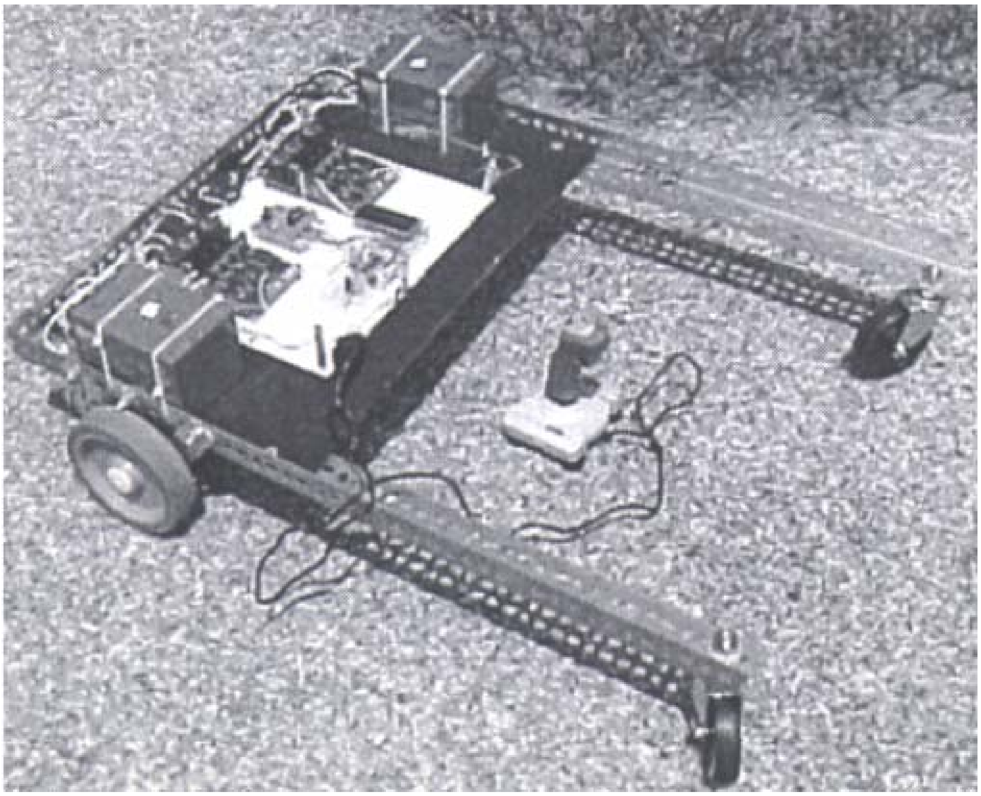

Figure 14.7. Directional Diverter.

E- STICK: ELECTRONIC WALKING STICK FOR PEOPLE WITH VISUAL IMPAIRMENTS

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INTRODUCTION

The E-Stick is an electronic walking aid for people with visual impairments (see Figure 14.8). The device's primary function is to provide the user with object notification and vertical plane drops. It produces vibrations in the handle of the stick to notify the user of any objects and drop-offs detected by the sensors. The secondary function of the E-Stick is to provide the user with his or her relative position and direction in reference to landmarks. This is determined by the use of GPS and a compass. This information is referenced against land-marked positions. The stick then informs the user of this information though a voice output

SUMMARY OF IMPACT

This project simplifies indoor and outdoor navigation.

TECHNICAL DESCRIPTION

The E-Stick is microcontroller-based. The primary function outlined in the section above consists of a battery-operated, small microcontroller programmed in Basic. This program reads the infrared sensors and outputs the processed information to small pager-motors to produce the vibrational output. The battery, microcontroller, sensors, and motors are embedded within the stick.

The secondary function of the E-Stick is also microcontroller-based. This separate microcontroller is also battery-powered and is more complex and programmed in C. This microcontroller interfaces with the GPS receiver, the compass, and the output voice module. The secondary functional components lie in a box attached to the stick and can be removed without interfering with the E-Stick's primary operation.

The cost of materials was approximately $1200.

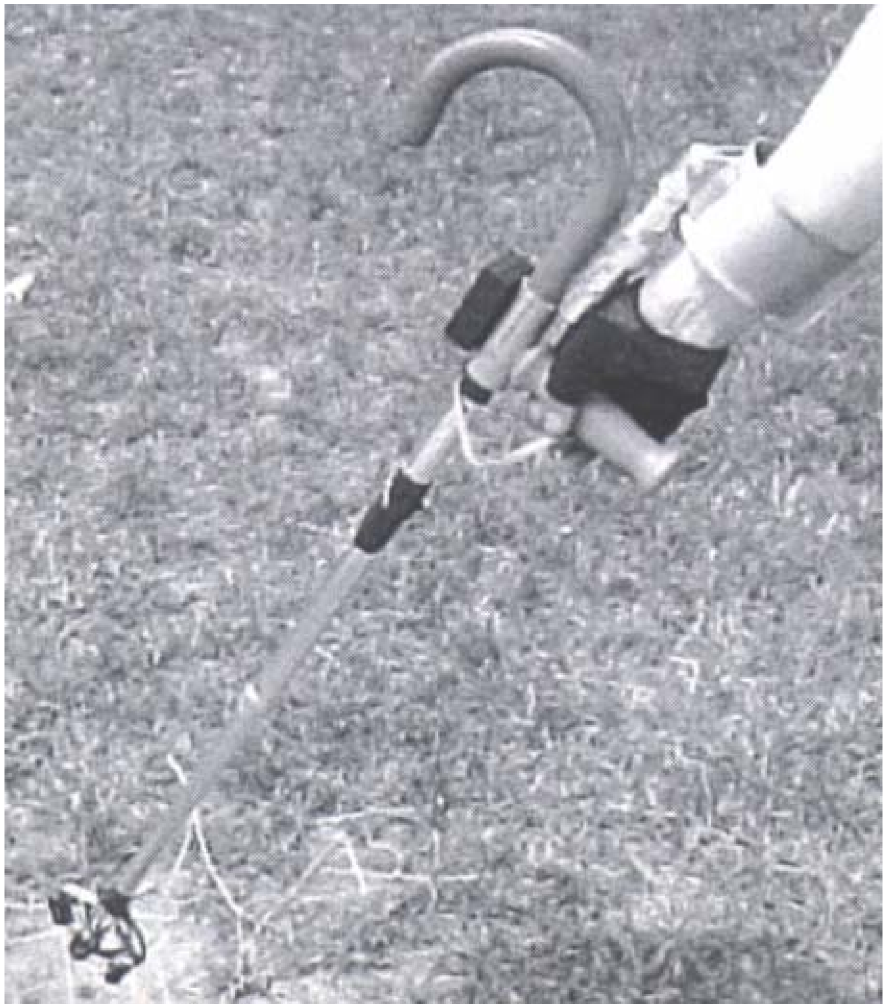

Figure 14.8. E- Stick.