CHAPTER 11
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Mechanical Jar Opener

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INTRODUCTION

Persons with limited arm, hand, and finger dexterity often encounter difficulty in trying to open many common household containers. Although there are a variety of commercial jar openers currently on the market, these devices still require the user to grasp the jar and apply the force necessary to open the container. While such devices may be helpful to some people, this project team decided to fully design, manufacture and test a mechanical jar opener that would require minimal user input and be helpful to a wide range of persons. The mechanical jar opener is an electric powered device that can sit on a kitchen counter top. The jar opener consists of three components: the drive system, the base plate system, and the cone and braking system. The drive system includes a small gear motor and two timing pulleys connected by a timing belt. The drive system is rigidly mounted to the base plate system. The base plate system consists of an aluminum plate fitted with circular cams and a rotating platen. The rotating platen is driven by a timing pulley and is fitted with spring loaded cam followers and a rubber pad. The jar is placed on the platen by the user. The lid of the jar is restrained by the cone and braking system. The cone and braking system includes a rubber-lined cone that physically restrains the lid, and a braking mechanism patterned after a commercial pony clamp. The cone braking system can be raised and lowered to accommodate different jar heights on a guide rod that is attached to the base plate. A friction force, which provides the grasping force needed to open the jar, is generated by the rubber linings on the platen and in the cone.

SUMMARY OF IMPACT

Arthritis sufferers have discomfort and often considerable pain when bending fingers, such as when opening a jar. Some are unable to perform this simple, but vital task. The mechanical jar opener opens common jars by pushing a button, which most can do without discomfort since the task does not involve finger bending or wrist rotation. As a result, this device allows the physically disabled to open jars with less pain than by hand or any other device and allows those previously unable to open jars an opportunity to be less dependent on others.

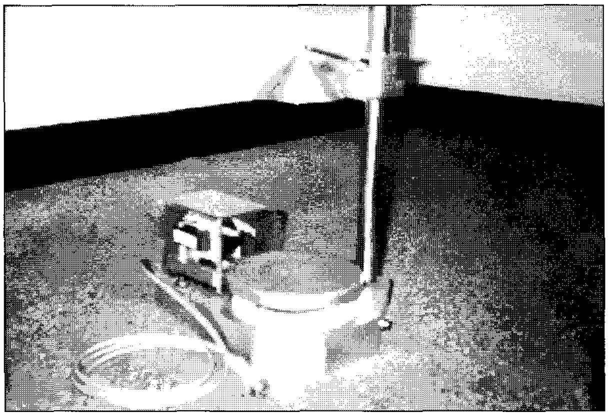

Figure 11.1. Mechanical Jar Opener.

TECHNICAL DESCRIPTION

The mechanical jar opener is designed for persons suffering with arthritis. The design team felt that by targeting arthritis suffers as the most likely users of the device, the eventual design solution would encompass a target audience of any person suffering from limited arm, hand or finger dexterity. The main design constraints are: 1) the device should require minimal user input; 2) the total device height should be under 16 inches so that the device could be stored on a kitchen counter top underneath overhead cabinets; 3) the device should be capable of handling containers of various shapes and materials with lids up to $3\frac{1}{2}$" in diameter, body diameters up to 6" and container heights up to 12"; 4) the device should operate with a counterclockwise twisting motion without damaging the integrity of the container; 5) the device should be portable, safe, easy to clean and require minimal maintenance.

The jar opener consists of three components; the drive system, the base plate system, and the cone and braking system. The drive system consists of a drive motor with its associated wiring and a timing pulley arrangement. The drive motor is a 110V, 60 Hz AC gear motor that has a running torque of 75 in-lbs at 7.5 rpm. Activation of the motor is initiated through a push button located on the base plate. The output shaft of the motor is keyed to a drive pulley. The power transmission link is completed through a timing belt connecting the drive and output pulleys. The components of the drive system are sized to provide a 1.67:1 drive ratio generating an output torque of 125 in-lbs. A mechanical limit switch indiscreetly located under the base plate deactivates the motor after the output pulley has completed 360” of rotation.

The base plate system consists of the base plate itself, a grooved shaft, platen, cams, and the guide rod. The aluminum base plate provides stability to the overall device and serves to link most of the other major components together. An area underneath the base plate has been machined out to house the drive system and the electronics. A stainless steel grooved shaft serves to connect the output pulley to the rotating platen. This shaft has been machined with a $\frac{1}{8}$" wide groove. A drive pin through the platen collar will slide up and down in this groove as the platen rises on the cams. The platen is an aluminum disk that is covered with a $\frac{1}{4}$" thick removable LINATEX rubber pad. This LINATEX pad has an experimentally determined coefficient of static friction of 0.6. It is on the center of this pad that the container will be placed when the opener is in use. When the grooved shaft rotates, the drive pin rotates the platen. Two stubby spring plungers, 180” opposed, that are fitted to the platen serve as cam followers. As the platen rotates, it tries to rise on the cams but is restrained by the positioning of the cone over the jar lid. The spring-loaded followers then compress and generate a downward force due to the cam profile. The two circular nylon cams are rigidly attached to the base plate with one cam fitting inside of the other. They have identical profiles but are arranged such that they are 180” opposed. The total lift on the cams is 0.135”. The preload and spring constant on each of the followers generates a vertical compressive force of 68 lbs. A stainless steel guide rod serves to link the base plate system to the cone and braking system. A keyway is machined along its length to provide lateral stability to the cone and braking system. The rod is fitted with a removable stop at the top end to prevent unintended removal of the braking assembly during operation.

The cone and braking system contains three elements: the braking mechanism, the connecting arm, and the cone. The braking mechanism is modeled after a standard $\frac{3}{4}$" pony clamp. An aluminum brake housing fits around the guide rod and houses three locking rings and a compression spring. Extensions are welded on two of the locking rings to facilitate raising and lowering of the system. One of the locking rings is fitted with a tab that corresponds to the keyway in the guide rod. This allows for vertical motion but prevents the assembly from rotating in the horizontal plane. The locking rings and spring combine to form an effective brake. The housing easily slides down the guide rod with the application of a small force. However, the housing is prevented from moving up the guide rod until a force is applied to the locking ring extension that compresses the spring and releases the brake. A $\frac{3}{4}$" square aluminum arm connects the brake housing to the cone. The aluminum cone is lined with $\frac{1}{16}$" thick LINATEX and serves to restrain the lid. The geometry of the cone provides the required flexibility to meet the established lid size constraints. The LINATEX generates the friction force required to break the manufacturer’s seal.

Tests of the jar opener were conducted by team members and by some prospective users at a meeting of the Arthritis Foundation. The device operated successfully at both test sessions and no real modifications needed to be made. The final cost of the jar opener is approximately $325. A production cost has been estimated at $50-$60.

Basic Wheelchair Design Modifications

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Client Coordinator: Dr. Steven Chavin, Veteran's Administration Hospital, Philadelphia, Pennsylvania
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INTRODUCTION

Institutionalized patients suffer from a variety of physical detriments that are associated with immobility and/or the aging process. Direct measurements of skeletal muscle size and weight indicate that as the body ages, it looses muscle mass. This finding is also true for patients that suffer from chronic ailments requiring hospitalization. Elderly patients, especially women, suffer from weakened bones and osteoporosis. Therefore, the elderly and patients who suffer from disabling ailments loose strength and postural stability, resulting in lost mobility and, for many, daily confinement to a wheelchair.

Standard wheelchairs are deficient in their design regarding the elderly, institutionalized patients or disabled persons. The sling type seat and backrests are made of a material which tend to give as the chair's use increases, leading to comfort and postural problems. Furthermore, the standard wheelchair does not have a reclining backrest, adjustable armrests, a seat with adjustable inclination angle, or adequate padding. These features are necessary for a comfortable sitting posture and even pressure distribution (over the seating and reclining surfaces), and are implemented in the design solution. These features are desirable for comfortable and proper sitting posture, according to the relevant literature.

The design deficiencies cause discomfort resulting from inappropriate sitting posture. Therefore, the designed chair has a rigid seat and backrest with layers of energy absorbing foam to insure even pressure distribution. In addition, the seat can incline up to 20" from the horizontal by actuating a hand-held, manual pneumatic pump that fills a baffled air bag. The backrest can recline up to 30" from the vertical, while keeping the armrests parallel to the horizontal, because the backrest and armrests are coupled. The armrest height is also adjustable in a manner that is totally independent of the reclining ability of the backrest. The coupling of the armrest and backrest is superior in design to currently available reclining backrests because a gap between the backrest and armrests is prevented. Finally, the chair easily disassembles into five component parts.

SUMMARY OF IMPACT

Most elderly, institutionalized or disabled persons spend countless hours seated in wheelchairs whose main design purpose is a means of transportation. The design features of this chair enable each individual to find his or her most comfortable position while seated for extended periods of time. Furthermore, the energy absorbing foam conforms to each individual's anatomy and insures the most comfortable pressure distribution, thereby, decreasing the likeliness of a patient suffering from recurring pressure sores. Additionally, the wheelchair can disassemble to facilitate its storage or transportation. Thus, a patient who finds himself confined to a wheelchair will be comfortable and content, while not falling subject to any postural-related ailments.

TECHNICAL DESCRIPTION

A linkage system for reclining seatback and adjustable armrests is designed so that the seatback and armrest are coupled. The seatback and front armrest support compose the vertical legs of a parallelogram and the armrest and the lower wheelchair frames compose the horizontal legs of a parallelogram. As the seatback reclines, the armrest moves with it (that is, the parallelogram flattens). The mechanism prevents a gap between the armrest and seatback found in custom wheelchairs. Once the desired position is reached, the mechanism is held in place by clamping a sliding link that occupies the diagonal of the parallelogram.

A bicycle style, cam-action quick release, locks the sliding link in place (i.e., prevents relative motion of the inner and outer tube in the sliding link). The armrest attaches to the seatback tube and front armrest tubes by a sliding pivot. This sliding pivot (outer tube) engages the inner tube using a locking L-handle spring plunger that will mesh with detents in the inner tube. A kinematic analysis performed on the four degree of freedom system, ensures that the coupled seatback and armrest mechanism move through the desired positions.

To minimize the total weight of the finished wheelchair, aluminum tube is selected for the majority of the frame system. Dynamic force analysis showed that 1” O.D. X 0.125” thick aluminum 6061 T6 tube provided adequate strength. The internal sliding tubes are of 0.750” O.D. solid round stock and are selected because of the need to machine pivot ends and detent holes. The pivot ends for the 1" tube are machined from 1” solid round stock. The lower wheelchair frame (that is, from the horizontal seat tube down) is modeled after an existing wheelchair, and is Heliarc welded. The upper wheelchair frame is attached with fasteners at the pivot points.

The wheelchair easily disassembles into five component parts. The seatback tubes and seatback compose an integral component that attaches to the pivot points with quick release pins. The armrest, front armrest support, and diagonal slider tubes connect to the lower frame with quick release pins. This assembly represents two more components, one per side. The horizontal plywood seating surface attaches to the seat tube by drop hooks, which are inverted U-shaped hooks that slide over and fit snugly around the seat tube frame. The two sides of the lower frame are linked with two diagonal tubes attached at the upper and lower pivot points on each side of the lower frame. The two diagonal tubes are fastened together at their respective midpoints. The lower pivot point of this X-brace structure attaches with a quick release pin to allow the two sides of the lower frame to collapse flatly when the pin is removed.

There is a baffled air bag system for seat inclination. The air bag has three cells connected by baffles that allow each cell to pressurize evenly. The baffled inclination wedge is sandwiched between two pieces of plywood attached with a continuous hinge. The air bag is inflated by actuating a handheld pump, similar to a blood pressure pump, with a bleeder valve to control the height and inclination. The pump is connected to the air bag by Tygon tubing and an oral tube flange. The air bag is protected from bursting by a pressure relief valve set to relieve at five pounds per square inch. The air bag is manufactured from polyurethane-coated nylon and is radio-frequency (RF) welded. The oral tube flange and relief valve must be compatible for RF welding.

To achieve an even pressure distribution over the human seating area (the bottom of the legs and buttocks), as well as for the sacral region of the lower back, Confor foam, a product of E.A.R. Specialty Composites, is used according to an existing scheme. Adequate padding for the seating surface is accomplished by utilizing the already proven design of former University of Delaware Senior Design students who determined the appropriate selection and arrangement for the different stiffness foams.

The final cost of the wheelchair is approximately $876.

Leg Brace Accommodating Seat

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Customer: Marnie King, OTR-L, Director of Occupational Therapy
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Advisor: Dr. Robert Allen
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INTRODUCTION

Our customer feels that a perching device should be developed for children with leg braces for use in a classroom environment. The seat is composed of three elements, the height adjustable seat, the spring-loaded wheels, and the base. The base is a T-shaped tripod (see Figure 11.2), with the seat affixed to the central bar and a footrest attached between the two front legs, connected by the lateral bar at the top of the T. The seat is a quick release system as found on bicycles. A lever releases the collar, allowing the seatpost to slide up or down as needed. The castors are designed so when weight is applied, the casters retract. When the user steps on the footrest, the casters retract allowing the base to rest on the floor. The chair was designed for ease of use; except for height adjustment, the device is operable by the children unassisted.

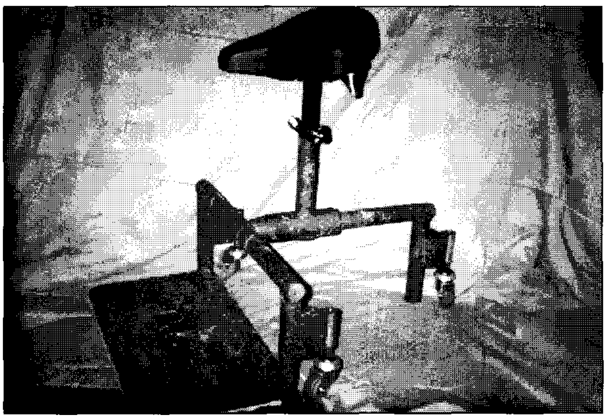

Figure 11.2. The Leg Brace Accommodating Seat.

SUMMARY OF IMPACT

The device enhances independent ambulation and choices in a classroom setting for children age three and older. The students targeted for this design are afflicted with muscular diseases, such as arthrogryposis multiplex congenita and cerebral palsy, that force them to wear locking leg braces. Having a chair that perches these students allows them to move about the classroom without unlocking the brace. This should provide a feeling of independence and comfort, and decrease the workload on the instructors.

TECHNICAL DESCRIPTION

The requirements placed by our customer are that the seat have a height range from eighteen to twenty-seven inches, and be easily adjustable without tools. The choice for the seat adjustment is based upon the considerations of simplicity, feasibility and ease of construction. The height of the seat is adjusted using a quick release collar, similar to those used on bicycles. The main benefits of the design are: ease of adjustment-flip up, unlock and flip down, and lock; cost, the entire mechanism including seat, post, and collar cost less then $80; very accurate adjustment to desired height; no tools; no set increments; and no complicated parts to break.

The next design problem involved the method of portability. The two stages considered are the stationary position with the wheels retracted, and the mobile position where the wheels are able to roll. The solution is adapted from the rolling stools in the library. These stools roll easily, but when weight is applied to the top of the stool, the spring-loaded wheels retract into the base. We decided upon a set of ladder casters selected from the McMaster-Carr catalog. The ladder casters have a wheel size of $2'' \times \frac{3}{4}''$, a $5\frac{15}{16}''$ overall height, and a 2” turning radius. A specification for the design is that the wheel needed to be able to turn 360”. If the caster is attached directly to a leg, either the leg would not be the height desired from the ground or the wheel would hit the leg. For this reason, spacer blocks are designed so that the caster clears the leg when turning, and the brackets on the caster are anchored into the blocks with bolts.

One difficult problem solved during the design process is that initially the force of the person leaning against the stool was horizontal. This causes the stool to slide away from the person, who at that point is lying on the floor. The weight of the person is to be applied to the stool before sitting. The base structure is a T- shaped tripod, with the crossbar in the front, with the single wheel in the rear. A platform, $\frac{1}{4}$" thick, 20" wide and 10" deep, is placed in front of the crossbar. This allows the person using the seat a wide variety of foot placements. The first designs with the platform included a bar to be placed on each side of the platform to prevent deflection, but after later calculations, even without the bar, the deflection is only 0.0687". With a $\frac{1}{4}$" plate that is greater than 25% of the thickness, as soon as the weight is applied to the platform, the wheels retract and place the platform on the ground.

The structure is constructed of $1\frac{1}{4}$" O.D. aluminum tubing, with a $\frac{1}{8}$" wall thickness. Lead was added for weight in the back leg and the rear central bar so that the center of gravity is behind the seatpost. The wheel base, from front to back, is fourteen inches. The distance between the front wheels is 20". All force analyses are derived from the points of contact of the wheels with the floor. The centroid of the structure is located 0.168" behind and 0.621" above the joint of the seatpost and the central bar.

Tests conducted using a volunteer and then one of the children affected by AMC proved successful. The final material cost of the device is about $200. The chair is painted with a splatter paint effect using bright colors which are attractive to children.

Moveable Forceplates: Modifications for Cerebral Palsy Patients

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Supervising Professors: Drs. R. Allen, R. Cope
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INTRODUCTION

A mounting and repositioning system for two biomechanics forceplates has been designed for Dr. Jim Richards at the University of Delaware Sports Science Laboratory. The design modifies a system currently in use. The existing system is inflexible in the numbers of available positions of the forceplates. The new system is specifically designed to accommodate the special needs of the cerebral palsy patients who are tested at the laboratory.

The basic design consists of a T-shaped channel recessed into a concrete floor. The T-shape allows the positions of the forceplates to be controlled in two directions so the forceplates can be arranged in three critical positions: front to back, side to side, and corner to corner. These three positions enable users of various strides to be tested. Cadmium-plated steel strips (ground to a tolerance ± 0.0005”) are bonded to the bottom of the channel to form a rigid base on which the forceplates rest, as specified by the manufacturer of the forceplates. Each forceplate is attached to an intermediate plate, also made of cadmium-plated steel. The intermediate plate is designed to offer greater access to the bolting location of the forceplates and to allow attachment of additional devices for moving the forceplates. Four DELRIN® ball plungers are screwed into each intermediate plate for repositioning. The plungers lift the plates off the steel rails so they can slide easily into the next position on their low friction DELRINB tips. The plates are bolted into the steel rails during testing to prevent them from sliding or rocking.

The overall system meets the goals set by the design team and customer: increase the mobility to three critical positions, improve the repositioning system, provide rigid connection between the forceplates and base during testing. Figure 11.3 shows one forceplate positioned in the T-channel.

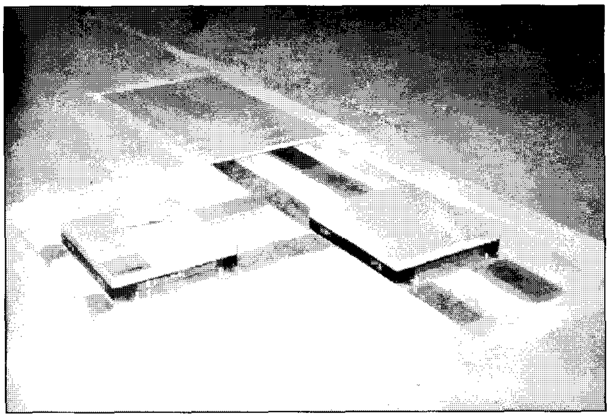

Figure 1 1.3. Moveable Forceplates: Modifications for Cerebal Palsy Patients.

SUMMARY OF IMPACT

Determination of joint forces and moments requires knowledge of the forces exerted on the foot when it is in contact with the floor surface. The calculation of these joint forces and moments plays a large role in the pre-surgical and post-surgical assessment of the lower extremity function, and only partial assessments are performed without this information. The previous forceplate setup restricted data collection to patients with a minimum 18” step length. This configuration accommodated approximately 50% of the ambulatory CP patients. As a consequence, lower extremity kinetics is indeterminate on at least half of the patient population. The moveable forceplates will allow laboratory personnel to collect ground reaction forces on virtually all cerebral palsy patients with bipedal gait capability. The unrestricted availability of ground reaction forces will create a dramatic change in the quality of functional gait assessments for a larger number of patients than before.

TECHNICAL DESCRIPTION

The design team identified three system components necessary to meet the goals of the project and satisfy our customer's needs: the plates must be able to be repositioned to accommodate for variations in the strides of the people being tested, the four load cells in each forceplate must be fully supported, and the plate must be rigidly attached to the underlying support to prevent motion during testing. The mounting system must also be safe for the users. The tops of the plates must be flush with the surrounding floor to prevent the Cl' patients from tripping over uneven surfaces.

The forceplate manufacturer, Advanced Mechanical Technology Inc. (AMTI), recommends at least a 5" solid foundation to isolate the mounting system from external vibrations. In order to keep the top surface of the force plates flush with the surrounding floor, the mounting system must be recessed into the existing concrete floor. This was done by contracting a construction company to cut and remove the desired section of concrete from the existing floor. Three additional inches of soil were then extracted from the pit and the necessary concrete base poured. A T-shaped channel was chosen because it enables the forceplates to reach the three critical positions while minimizing material requirements, as compared to a rectangular design. The long dimension of the channel (Channel A) is 8 ft. by 2 ft., while the adjoining perpendicular section (Channel B) is 3 ft. by 2 ft.

Six ground, cold-rolled $\frac{3}{4}$" steel strips were bonded to the bottom of this channel using PL400 Structural and Subfloor Adhesive. Each rail is 5" wide; the rails in Channel A are divided into two 4 feet sections, and those in Channel B are 3 feet in length. The steel rails provide a flat and rigid base to support the four corners of the forceplates, as specified by AMTI. The plates were finished to a flatness of ±0.005" (per AMTI). Holes ($\frac{1}{4}$–20) were drilled and tapped into the steel rails at 3" increments, allowing the forceplates to be fastened to the rails during testing.

Currently, the forceplates are held in place during testing by bolting them into the steel. However, the access to these bolt holes is limited. In order to improve accessibility for bolting the forceplates, an intermediate plate is deemed necessary. An intermediate plate of ground steel is attached to the forceplates using the side bolt hole locations on the forceplates, and counter-bored holes in the intermediate plate. The thickness of the plate is determined by the minimum thickness necessary to countersink the bolts into the bottom of the intermediate plate. The intermediate plate extends beyond the front and back edges of the forceplate, giving it final dimensions of $\frac{3}{8}$ "x18-a "x22". Additional devices can be attached to this excess material and improve access to the bolts that hold the plates in position during testing. $\frac{1}{4}$ -20x3 " bolts (along with $\frac{1}{4}$ xl $\frac{1}{2}$" washers) are used to rigidly fasten the plates to the steel rails. The holes in the intermediate plate are $\frac{1}{2}$" clearance holes; this extra clearance takes up any alignment error between the plates and rails.

Repositioning the plates is accomplished by sliding on low friction DELRINB ball-detents attached to the intermediate plate. After researching various sliding materials, DuPont's DELRINB was chosen because of its low coefficient of friction with steel (0.08-static, 0.14 dynamic), ability to be machined, wear, and strength. The calculated force necessary to move a forceplate and intermediate plate combination was determined to be 15.78 pounds. The change from lifting to sliding the forceplates between positions represents a 70% decrease in required force from the original 70 pounds needed to lift the forceplate.

A replacement floor is also required to cover the open pit areas, and to conceal the forceplates during testing. The design team decided to use $\frac{3}{4}$" BC plywood to provide a continuous surface with the surrounding floor. Ledges on each side of the channel provide support for the wood panels.

Total project cost for the prototype was $4,150.

A Language Training Aid for Mentally and Physically Disabled Children

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INTRODUCTION

A language training aid housing has been designed for use as a tool in the language skills training of a mentally and physically disabled child. The training aid consists of four modular components: the adjustable force paddle switch, a picture retention system, the case, an existing electronic circuit. The case houses the circuit, paddle, and the adjustable force mechanism. The paddle has been designed to accommodate a "picture retention system," which supplies a means to easily secure pictures to the paddle. The adjustable force mechanism allows the user to adjust the force needed to activate the unit through a large range of forces.

SUMMARY OF IMPACT

Children with severe physical or mental disabilities suffer from their inability to communicate. Learning is severely impaired because the teacher/pupil interaction is unidirectional. Methods for breaking the communications barrier have been developed that employ electronic circuits that "speak" when actuated by a switch adapted for the child's disability. Education begins with using a photograph mounted on the adapted switch, so the child learns to associate a recorded message with the photograph each time the switch is touched. The present project has advanced this technology by introducing an important new approach to mounting pictures to switches. Another innovation of this project has been the development of an adjustable-force switch. No other switch devices are currently available that combine a picture mount and force adjustment. Thus, this design heralds the next generation device for picture training. It is portable, very easy to operate, simplifies picture mounting, and has the flexibility to expand picture selection with four pictures. Each of these features is important for the educational and communications needs of these young children. The smile on Brian's face-one of the test subjects–during testing, best explains the impact that this project will have on children as they discover they can "speak." Life for them becomes far easier and more fulfilled.

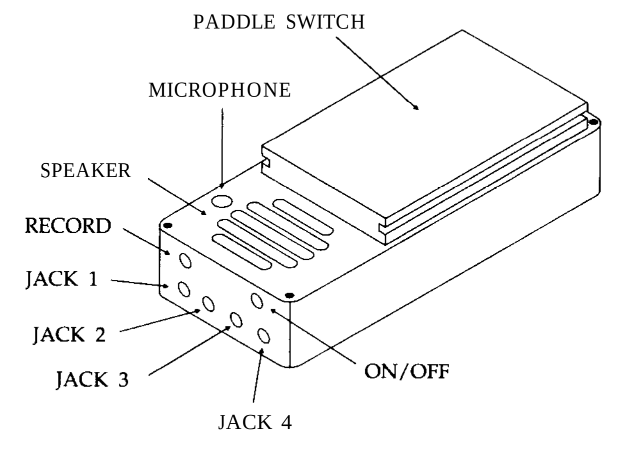

Figure 11.4. A Language Training Aid.

TECHNICAL DESCRIPTION

The case and an integrated paddle switch are designed for a unit that can playback an electronically recorded human voice when the paddle is depressed. The unit's size 1.5"H×7.75"L×3.69"W, lends to its portability. The width of the unit is smaller than the width of a standard VCR cassette; this is a size that we believe can be accommodated in one average-sized hand.

The design solution can be separated into three main subsystems: the case, the adjustable force paddle switch, and the picture retention system. The adjustable force paddle switch is an integral part of the case. The paddle has "legs," which are guided by the interior sides of the case. The paddle is suspended in the "up" position by the spring. In this position, the center of the paddle lays $\frac{1}{8}$" above the snap-action switch. To activate the switch, the paddle center must be moved through a $\frac{1}{8}$" distance. If a force is applied on an edge, the edge must be moved down a $\frac{1}{4}$" to activate the switch. The force needed to activate the switch can be adjusted by turning the knob in the recess of the bottom of the case. This knob is attached to a steel threaded rod; turning the knob causes the rod to rotate within the unit. This action drives the steel carriage upward consequently forcing the spring to be compressed between the carriage and the paddle. The spring force acting against the paddle causes a greater force to be needed to activate the snap-action switch, thus giving us our desired adjustable force mechanism.

Our selected picture retention system is a "slide-on" cover made of clear acrylic. The cover slides on by following grooves in the paddle's sides. This cover provides protection for the picture, and can be easily removed. This system accommodates pictures of sizes 3"×5" or less.

The case houses the electrical and mechanical components of the unit (Figure 11.5). It is made of polypropylene. The case is designed to help achieve the desired adjustable force mechanism. Integral parts of the case are two designed "walls" that constrained the spring carriage from rotating, giving a spring compression result as described previously.

Polypropylene is a suitable material for the mass production of the unit. Its use allows one to easily form the intricate shapes of the unit through injection molding with a relatively inexpensive plastic. Propylene lends itself to the reduction of total production costs, through excellent moldability and inexpensive cost.

The final cost of the language aid is approximately $169.

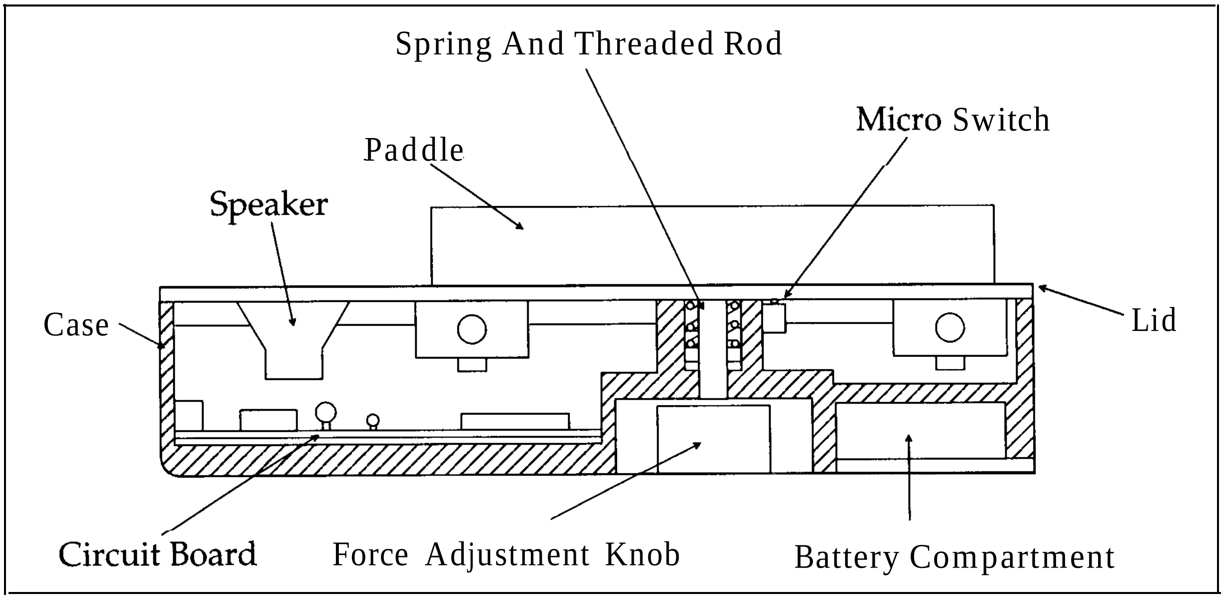

Figure 11.5. Cross-Section of a Language Training Aid.