# CHAPTER 10

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# THE CO. JONES FEEDER

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Therapist: Roberta Torman, LOTR, Children's Hospital
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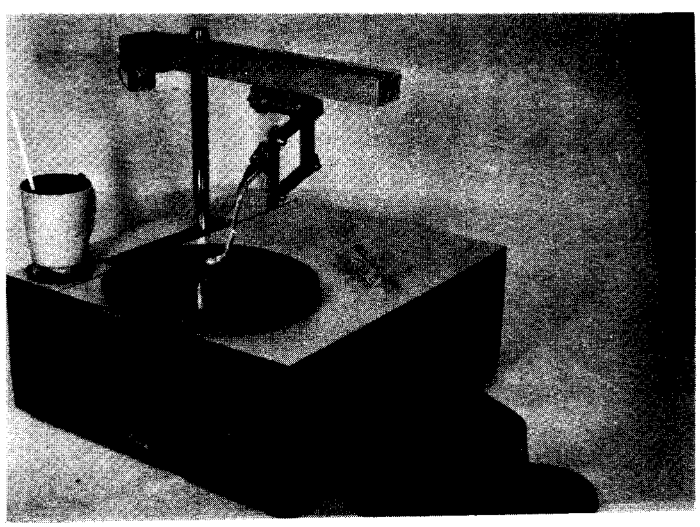
## INTRODUCTION

The Co. Jones feeding device is designed for use by a Cl-C2 quadriplegic with incomplete transection. The feeder moves a spoon with three orthogonal axes of motion that are controlled independently. The process is controlled by an arm lever and a headset with mercury switches. The arm lever is triggered with slight up or down movement. The patient has good head motion to the sides and front and back, facilitating operation of the headset switches. With this device the patient can pick up food from anywhere on a stationary plate. Alternatively, a pencil or other instrument can replace the spoon permitting the client to draw on paper or manipulate other items.

## SUMMARY OF IMPACT

This device was designed for use by specific client who has recently died. Independently, Children's Hospital selected it for testing and use in their occupational therapy department.

The design is adaptable to other patients' specific needs by using other switches in place of the original set. The feeder has been demonstrated with soft and particulate foods such as pudding, red beans and rice, jambalaya, peas, and cake.



Co. Jones Feeder. Note I-bar spoon and pencil holder. Cap contains mercury switches to control spoon translation.

TECHNICAL SUMMARY

This feeder was designed so that a spoon can be moved in all three directions in space. This is achieved through the use of three separate driving systems: one for forward or reverse, one for left or right, and one for up or down. Mercury switches in a headset and a momentary contact switch on the unit provide the control.

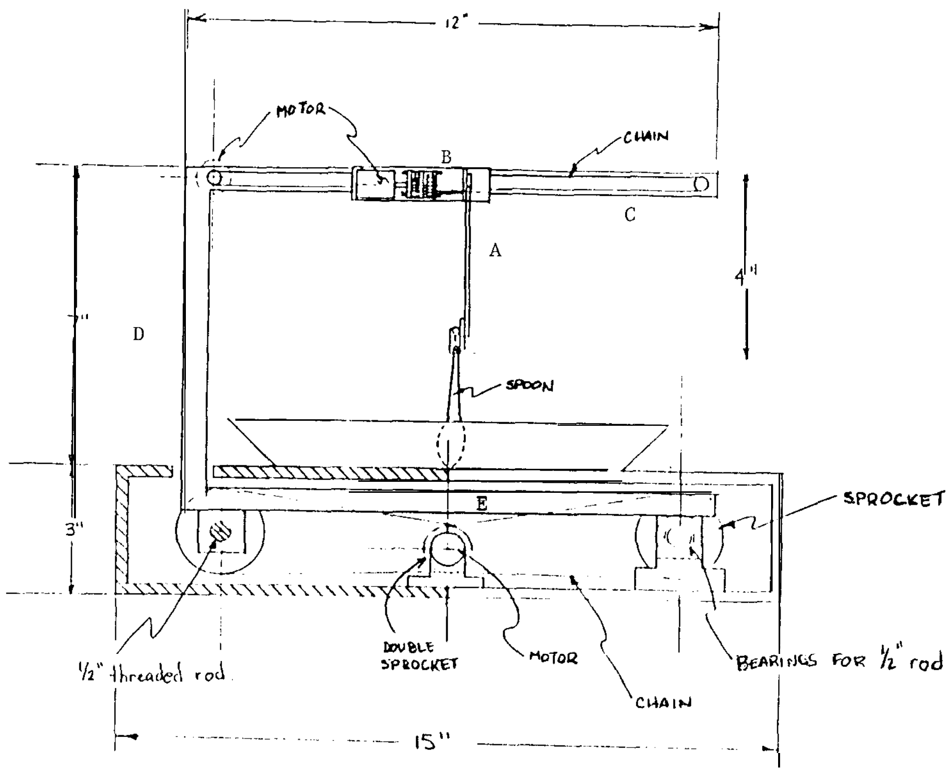
The figure shows the basic mechanism that includes a spoon, a four-bar mechanism (A), a trolley (B) on crossarm (C) that mounts on a vertical support (D). The vertical support fastens to the base trolley (E) that is hidden in the base of the unit.

The spoon connects to the elevating motor through a four-bar mechanism that keeps its bowl level. The elevating motor is carried on a trolley in the crossarm to provide right and left motion. A belt and pulley system moves the crossarm trolley.

The base trolley provides the forward and reverse motion by a chain and sprocket driven screw drive. The chain system is necessary in order to keep the two drive screws synchronized. Limit switches protect the feeder from jamming or damage.

Safety features include low voltage operation of 12 volts from a breaker protected line power supply and interlocks to prevent the mechanism from working if the base is opened.

Cost of the prototype is $310, but analysis of the design suggests that this could be reduced considerably by minor material and design modifications.




Frontal section of Co. Jones feeder.

# THE LNS FEEDER
## A CONTROLLABLE FEEDING MACHINE FOR USE BY PEOPLE WITH MOTOR OR ARTICULATORY DIFFICULTIES

DESIGNERS:John Ammon; Frances Balding; Rachelle Meaux; Theodore Paxton
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INTRODUCTION

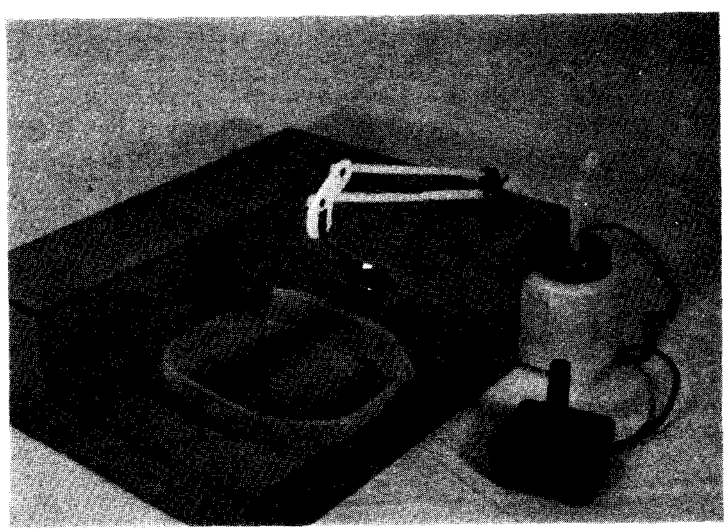
This feeding device is designed to assist the handicapped in their pursuits to lead a normal life. The feeder is joystick controlled, and can be run either on batteries or by line current. It is built of wood and is covered with formica for ease in cleaning. The plate of the feeder moves left to right, and the arm move forward to scoop up food and bring it to the mouth. The arm is hooked to a spring that helps to raise the food smoothly. A wide variety of foods may be eaten with this device, but items such as meat need to be cut first.

We designed the LNS feeder to enable a five-year-old girl afflicted with arthrogryposis to feed herself. The current controller is a joystick, but other controllers may be substituted to adapt to other types of disability.

SUMMARY OF IMPACT

Our client's therapist notes that "She has adapted very well to her feeding device, even though she displays decreased range of motion and muscle strength in both upper extremities. She uses her upper right extremity to operate the joystick". Our observations of our client have led us to believe that she enjoys operating the feeder, and is very enthusiastic about being able to feed herself now.

With this feeding device, our client will have more control over her environment and thus gain some of the independence necessary for proper psychosocial development, as well as relieving her family of some of the burden of caring for her.



The LNS Feeder

TECHNICAL DESCRIPTION

The LNS Feeder simplifies the process of moving food from a plate to the mouth. Normal eating with a spoon requires motion with at least four degrees of freedom (motion along or about four axes). The minimal set of motions is: 1. rotation of the spoon to pick up food, 2. right and left motion to select food, 3. back and forth motion to scoop food, and 4. up and down motion to transport the food from the plate to the mouth. We reduced these motions to two degrees of freedom in order to simplify the device and make it easier to control.

The plate with the food moves to the right and left under direct joystick control. A spoon on a moveable arm moves forth and back under direct joystick control.

The other two degrees of freedom are avoided as follows. When the spoon reaches the near edge of the plate, a mechanism raises it automatically to mouth height and presentation position for eating. Spoon shape and the shape of the near edge of the plate obviate the need of the scooping motion for food pickup.

The LNS Feeder consists of four main parts: A base unit that contains the motors and control circuitry, a moveable (and removable) plate for food, an arm that holds a spoon, and a joystick for control.

Base Unit

The base unit is sturdily constructed of wood and covered with plastic laminate. It maintains a low and unobtrusive profile to enhance social acceptability. It contains the circuitry, motors, and mechanical systems. Two gearmotors drive the device by pulling the plate and arm mounts along guiding tracks. Limit switches prevent the motors from grinding when motion extremes are reached. Power is provided by a 12 V line powered DC supply or an auxiliary battery pack.

Plate

The plate is formed by cutting and heat forming part of a standard plastic (Tupperware) container. Hook and loop (Velcro) fasteners attach the plate to the plate mount. Markings permit visual alignment when fastening. This makes the plate easily removable for washing or serving.

Arm and spoon

The arm mounts on a trolley that slides along a track hidden in the base. The arm itself is a four bar mechanism that keeps the spoon level at all times. The spoon is normally lowered to slide on the plate, but when it nears the front edge of the plate an internal linkage pulls the mechanism to its elevated position.

Joystick

The joystick is a familiar and standard device commonly used for playing computer games. It is connected to the circuitry in the base unit by a standard DB-9 connector. Since its operation is on or off, rather than proportional control, it could be replaced with another set of control switches that can be individualized for each user. Even with individual controls, the feeder could be shared among several users.

Cost

The total cost of this prototype, excluding labor, is $ 275. If it were put into production the cost would be reduced considerably.

FJJ Self Feeder
# A MECHANICAL FEEDING MACHINE FOR VICTIMS OF ARTHROGRYPOSIS

Designers: J. Baldwin, J. Pascarella, and F. Ali
Therapist: Dianne Patterson, LOTR, Children's Hospital
Supervising Professor: David A. Rice, Ph. D., P.E.
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## INTRODUCTION

Being able to eat in a social setting is crucial for the proper development and happiness of any person. Many handicapped children cannot feed themselves unaided, use, or afford commercially available machines.

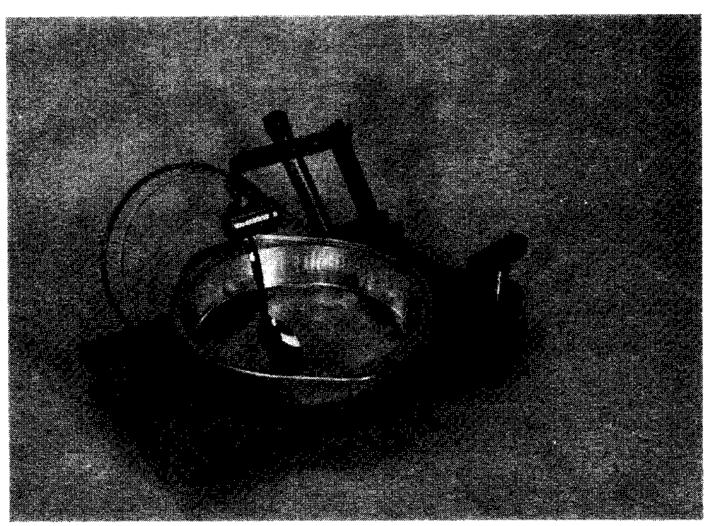
There are several feeding machines currently available from commercial manufacturers that are inappropriate for individuals with arthrogryposis. Some are motorized, requiring a source of power that may not always be available, and some are mechanical. The mechanical devices are cheaper, but still cost about $600. These are suitable for many, but are not always adaptable for a given individual's range of motion or for the intelligence, size, and strength of a child.

We designed the feeder for a specific client, Lindsay, a four year old who cannot bend her elbows or raise her arms. She has difficulty moving her arms medially, but does have good gripping ability with one hand and can push and pull with shoulder and body action.

The primary goal is to design a machine that is effective, portable, rugged enough for use in a kindergarten cafeteria, and as unobtrusive as possible. Secondary goals include low cost, obvious principles of operation, and maximum adaptability.

## SUMMARY OF IMPACT

Lindsay learned to use the machine with coaching on her first session. Colored dots placed on the base and handle worked well as a teaching tool to show proper positions for scooping and food presentation. She can eat pudding, grits, mashed potatoes, and spaghetti. Use with particulate food is made possible by increasing the slope of the plate edges. She has had the machine for several months and eats two or three meals a day with it.



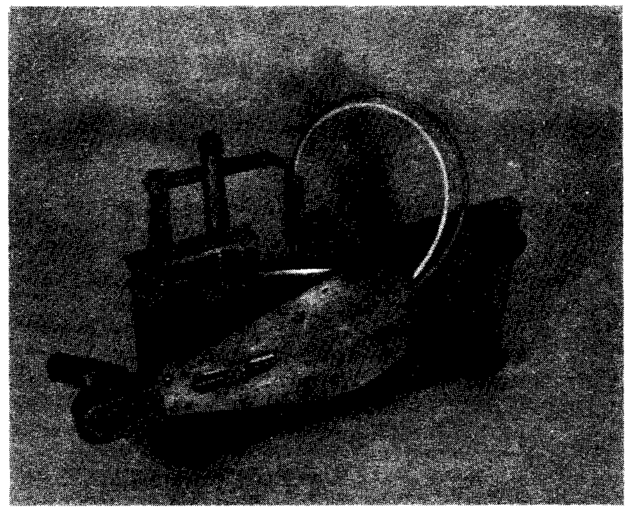
FJJ Self Feeder- front view

TECHNICAL DESCRIPTION

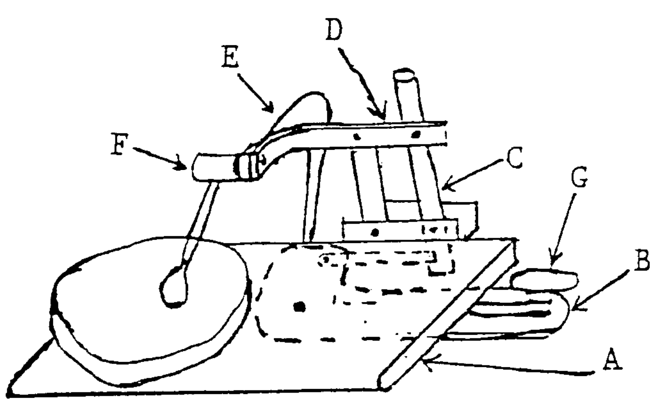
Our design starts with a 9" by 13" wood board (A) stabilized by suction cup feet. A pie plate is fastened with Velcro to a lazy-susan bearing that permits plate rotation. A lever (B), mounted on the underside of the board pivots an upright (C). The upright is paired with a second to support a beam (D) on pivots. This arrangement keeps the beam horizontal as the lever raises and lowers the assembly.

The spoon is rotated by turning a handle (G) at the end of the lever. A cable (E) transfers this motion to a spool (F) mounted at the end of the horizontal bar. When the spoon is pushed into the plate it sweeps along a radius from the center and is held level at the volition of the user. Spoon rotation is limited to protect the mechanism and to keep the spoon in its useful range.

The parts are designed to be assembled for either a right- or lefthanded person, and are made from aluminum to ensure easy machinability, corrosion resistance, and light weight. The lever and cable arrangement is not limited to the current configuration. They may even be made detachable for foot operation, but this is beyond the scope of this work. We estimate that the cost of fabricating the feeder. in small suantities, to be about $300.



FJJ Self Feeder- back view




FJJ Self Feeder- x-ray view

# AUTOFEAST
## A Self Feeding Device for C2-C3 Quadreplegics

Designers: Mark Cardinal; Jeff Hoffman; Peter Kim; Ray Shashaty
Therapist: Dianne Patterson, Children's Hospital
Supervising Professor: David A. Rice, Ph. D., P.E.
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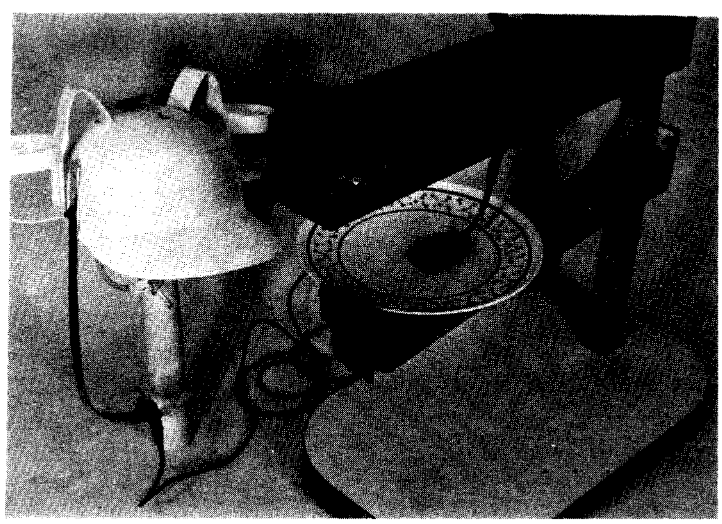
INTRODUCTION

The Autofeast self-feeding device will give handicapped individuals, particularly quadriplegic with little movement, the freedom to feed themselves. The design is simple and allows an individual to move food from a plate to his mouth with a single chin control. When the mouth is closed, the spoon moves back to a resting position, and the plate begins to rotate, giving the individual a choice of what to eat next. The user then opens his or her mouth causing the spoon to move forward. The spoon scoops food off the plate and continues moving toward the mouth. Once inside the mouth the spoon stops until the user closes his or her mouth and the spoon pulls out leaving the food behind and returns to the resting position.

SUMMARY OF IMPACT

The feeder was designed for a nine-year-old C2-C3 quadriplegic who lacks complete tongue control and has motion limited to facial expression and jaw position. The Autofeast device will improve the independence of the user during meals and will relieve some of the burden of caring for him from his family. As of this writing, the prototype shown has been successfully demonstrated with a variety of foods and will be released to the client as soon as the safety review is completed.



Autofeast Feeder. Note cap with chinswitch.

TECHNICAL SUMMARY

The Autofeast self feeder is designed for an individual with extremely limited motion. As such, it must carry out the normal functions of a spoon without direction, responding only to the user's commands from the chinswitch to proceed.

The feeder consists of four active parts: a motorized plate holder, a cantilevered feeding beam that supports a spoon trolley, a spoon guiding system, and a control system. These parts are supported by an adjustable vertical post with a base that rests on a table or across wheelchair arms.

The plate holder is cantilevered from the post. It contains a gearmotor that turns a lazy susan bearing with a friction drive at adjustable speeds of 10 to 30 rpm. A plate is fastened to this bearing with hook and loop fastener. Four removable guide pins assist in initial positioning of the plate since centering on the bearing is necessary.

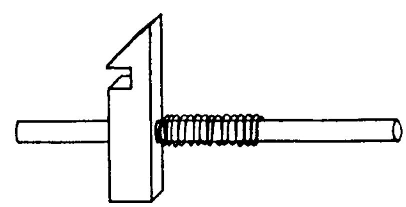
The feeding beam is formed from square aluminum tubing and contains the drive system. The spoon trolley slides in a slot milled in the underside of the beam and is pulled along by a chain and sprocket assembly driven by a gearmotor.

A spoon holder pivots on the spoon trolley and rises and falls as it follows a track suspended from the feeding beam. The track is carefully shaped to constrain the spoon to follow the contour of the plate. When the spoon reaches the front edge of the plate, the spoon rises and latches in its elevated position. It remains elevated during food presentation, and is released only when the trolley returns to its rest position. Thus the spoon has only one degree of freedom with two states and moves forward and backward between the resting position and the user's mouth.

The control system consists of a single 4PDT relay, two limit switches, and a command microswitch mounted under the chin on a headband. The control system and the motors are powered by a single 12 VDC breaker protected line powered supply. A power pilot light is provided for the user for help in diagnosis of malfunction. Sturdy construction and simple design should make mechanical malfunctions very rare, but electric problems are more likely. These will be due to incomplete connection of the user managed electrical connectors of the power and control systems.

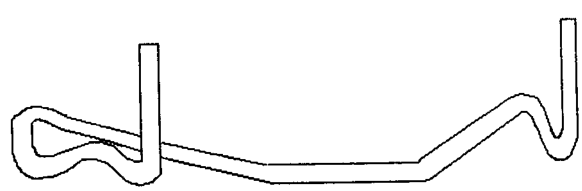
Safety is enhanced by using low voltages to power the feeder and enclosing all mechanical parts that could cause injury.

The Autofeast self-feeding device is simple and can be constructed with a limited number of parts of relatively generic nature. The approximate cost of this project, excluding the cost of the time invested, is $150.00.



Latch hook with return spring for holding spoon raised.

Pin for attaching spoon trolley to drive chain.



Track for guiding spoon holder. The reverse bend on the left (rear) engages the latch release on the spoon trolley.

# SPUD SPOONER FEEDING DEVICE
## A feeding device for quadriplegics with limited finger motion

Designers: Jeanette E. Dalton; Z. Maria Oden; Salena D. Zellers; Andrew Zerkle
Therapist: Peter Fayard, Children's Hospital
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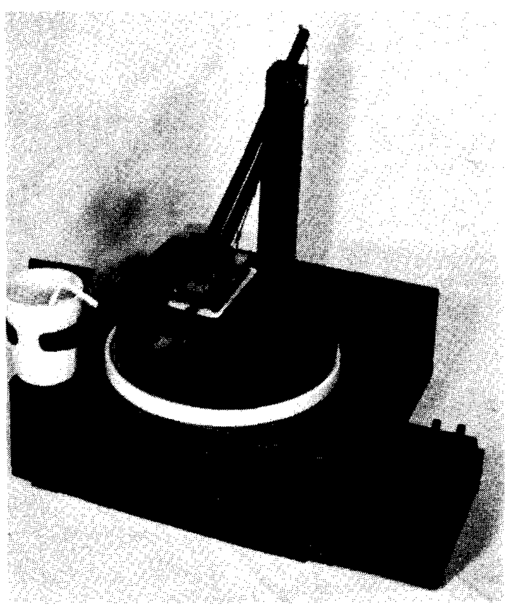
INTRODUCTION

The Spud Spooner enables a person to feed himself if he has control over the movement of the fingers on one hand. This would include disabilities such as a person in a body cast or a person with two broken arms, someone that has locked elbows or even a quadriplegic with slight movement in the fingers. The feeder allows the person to eat all types of food as long as it is either in bite-size pieces or is of a soft or semi-solid texture. Three color-coded switches operate this feeding device. These switches are easy to control and will operate the actions of the plate and spoon. All the movements of the Spud Spooner are designed for user compatibility and ease of adjustment such that control over eating can now be enjoyed by those people who otherwise are dependent upon others for every daily activity.

SUMMARY OF IMPACT

Children's Hospital has selected the Spud Spooner for use in the Occupational Therapy department for patient evaluation and for training in the ADL laboratory.



The Spud Spooner. Note the attractive wooden construction and the split spoon.

## TECHNICAL SUMMARY

The Spud Spooner consists of a special spoon, a lifting arm, and a translating and rotating plate that are set in an aesthetic base. The arm, spoon, and plate are moved by the coupled action of several motors that are currently controlled by three momentary contact switches.

The Spud Spooner uses a unique spoon that is split down the center and opens and closes like a crayfish claw. This approach handles many of the problems common to mechanical feeders by permitting the spoon to remain level at all times and by facilitating food pickup without requiring a pusher or backstop.

The lifting arm is a four-bar mechanism that keeps the spoon level. The plate is mounted on a platform that translates right and left and rotates.

The motors and control circuitry are hidden in the attractive wooden base for safety and aesthetic purposes.

### Operation

The control interface uses double throw momentary contact batwing switches. These are mounted on a box that fastens to the base but can be positioned anywhere. The circuitry can easily be modified to use single throw switches with toggling relays if the client cannot operate the original switches.

The first switch controls the spoon and the arm. Pulling the switch causes the spoon to close around or on the food. This action then initiates raising the arm and spoon to the presentation position. Pushing the switch opens the spoon and lowers it to the plate. This design keeps the arm mechanically simple and the control easy and straightforward.

The other two switches control the position and orientation of the plate. Since the spoon always returns to the same position relative to the base, moving the plate permits food selection from anywhere on it. This operation requires two degrees of freedom, but the plate could be moved continuously by an automatic mechanism. This allows the user random access by timing the spoon motion appropriately.

Safety is enhanced by enclosing all hazardous mechanisms and using low voltage (12 V) for power. The feeder may be operated using either batteries or a mains power supply.

The cost of this device, excluding R and D and labor, is $150.

SPINAL EXTENSION CHAIR FOR USE IN CASES OF MYELOMENIGOCELE

Designers: Ronald Mosrie, Marta L. Villarraga
Therapist: Geralyn Giffin, LOTR, Children's Hospital
Supervising Professors: David A. Rice, Ph.D.,P.E. and
Ronald C. Anderson, Ph.D.
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INTRODUCTION

Myelomenigocele is a spinal formation defect whereby the neural arches of the vertebra do not close properly. This can result in the protrusion or damage of the spinal cord, leading to severe neurologic degeneration. While this affliction can be catastrophic, in many instances it is possible to rehabilitate an affected child and return some degree of ambulatory freedom. Much of the therapy necessary to accomplish this is in the form of postural exercise, where the extensor muscles of the lower spine and upper leg are required to maintain position. These muscles are also critical to trunk support and knee extension during ambulation. One way in which postural exercise can be achieved is to have the child sit with an anteriorly rotated pelvis. This position forces the spine into extension, and can be achieved with a seat that that is tilted forward. The purpose of this project was to design, build, and implement such a chair so that the client could get the needed exercise during ordinary daily activities.

SUMMARY OF IMPACT

As of the date of this report, the chair (Figure 1.) has been in the possession of the physical therapy clinic at Children's Hospital for the initial trail and observation of the intended client. The physical therapists have reported a generally satisfactory result in that the client was able to comfortably maintain an anterior pelvic rotation and spinal extension. It was remarked that the client was "doing beautifully" and "really liked the chair". However, the child has grown since the original design was initiated and some of the dimensions of the chair require modification at this time. More importantly, it is now apparent that the original intention to have the child kneel on a padded rest in order to partially support her weight is not feasible from the standpoints of comfort and postural control. Apparently that the child's knees should be extended to encourage use of the quadriceps. Thus, the chair has now been returned to the Department of Biomedical Engineering for second generation design changes.

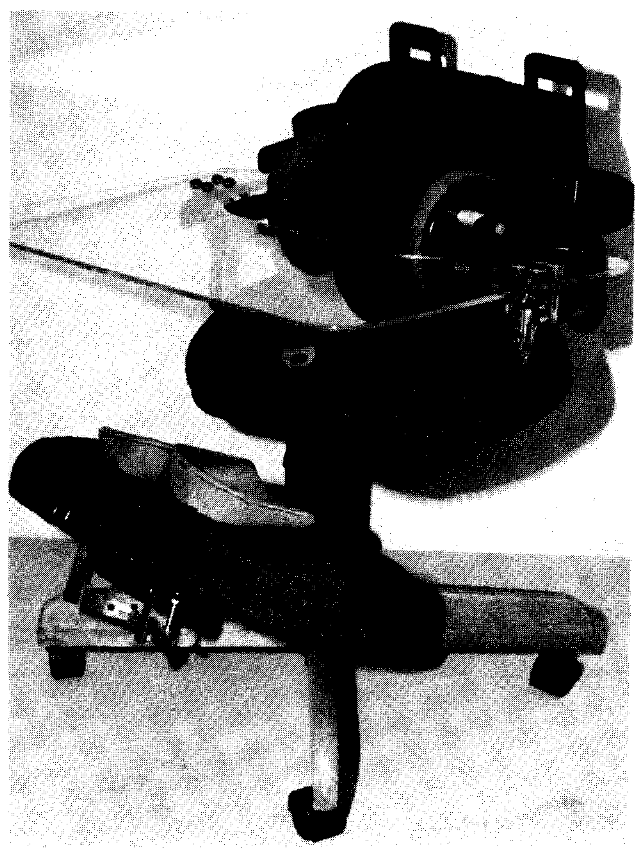

Figure 1. Spinal extension chair

## TECHNICAL DESCRIPTION

The chair is modified from a knee chair of the Balans design. The seat consists of a broad foam-filled cushion tilted forward approximately 10°. Knee cups were strapped to a similar foam-filled knee rest to provide stable, cushioned knee support. The chair back is intended to provide broad thoracolumbar support in an upright, lordotic position. Two encircling steel brackets, welded to the chassis, have foam-filled pads attached on either side to give adjunct lateral support. The chair back, seat, and knee rest are mounted on a welded chassis and attached to a base with casters so it can be easily moved from room to room. Steel brackets are welded to the chassis to which a clear acrylic tray can be clamped to provide a playing surface for the child during the time spent in the chair.

Since it is anticipated that the client will be only able to support a large portion of her weight on an intermittent basis, slotted steel uprights are welded to the chassis above the chair. This allows nylon straps to secure a plastic chest harness to prevent the client from falling forward as she tires. A modified automobile safety belt is included as well, in order to prevent the child from slipping out of the chair.

The approximate total cost of this project was $200.00. We feel that the this design is simple, easily manufactured, and above all, effective in providing postural therapy in a non-clinical environment.

# MOTORIZED TRICYCLE

Designers: Bob Newhard and William Gooding
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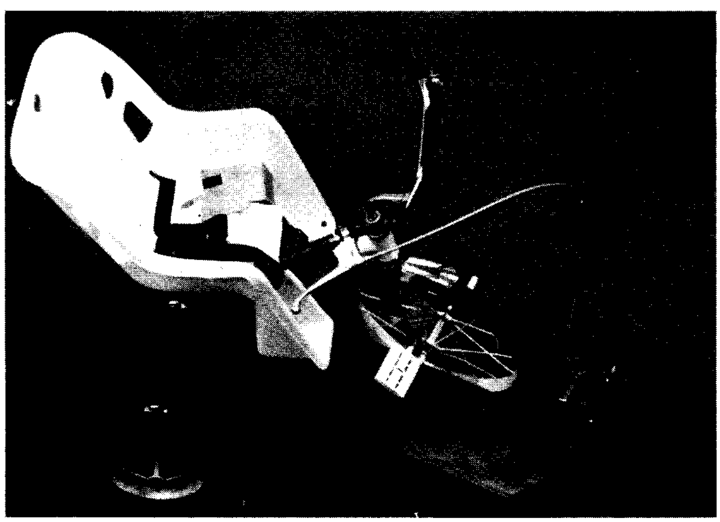
## INTRODUCTION

One of the major problems the young paraplegic faces is the difficulty in using some toys and in playing with his or her peers. This reduces the child's chances to learn valuable social skills and can impair physical, cognitive, and emotional development. The purpose of this project is to adapt a common tricycle so that it can be used by a child with lower extremity paralysis. The device consists of three modules: a seat, a propulsion unit, and a speed controller. The design emphasizes safety, utility, and portability.

## SUMMARY OF IMPACT

Children's Hospital has received this device for the Department of Occupational Therapy. They will use it in house to evaluate their clients and will release the tricycle to suitable clients for long or short term loans, as is deemed appropriate.



Assembled tricycle showing seat, controls, and controller and battery housing.

## TECHNICAL DESCRIPTION

We planned to augment a tricycle with as little modification as possible because acquiring standard equipment minimizes cost and maximizes reliability and repairability.

The system is divided into modules: the seat, the propulsion unit, and the controls. The modular design permits fast field assembly and enhances portability since each piece is compact and the tricycle itself does not need to be carried if one is available at the destination.

Attachments to the tricycle are made with screw operated hose clamps. Only a screwdriver is required for assembly, and no modifications to the tricycle are needed.

### Seat

The new seat is a standard add-on child seat made for use on a bicycle. The tricycle seat supports the weight, and a simple tubular A-frame fastens it to the rear axle. This provides both lateral and longitudinal stability. The harness that comes with the seat keeps the child from falling.

### Propulsion Unit

As shown by the figure, the propulsion unit looks much like a skateboard. A slot in the center receives the front tricycle wheel which is held in place by gravity and does not touch the ground. This prevents the wheel and pedals from rotating. The rear of the board is supported by two ball casters that permit the tricycle steering to work.

An electric gearmotor drives a standard skateboard wheel. This wheel is remounted so that it is fixed on its axle and its two bearings support the driven axle. Two specially machined pillow block mounts position this drive wheel in line with, and just in front of the front tricycle wheel thus supporting most of its weight and causing the steering to be self-centering. The motor is powered by a 12 volt rechargeable gel-cell through an external line powered charger.

### Controls

Control is provided through a switch and a lever. These are mounted on the handlebars with screw operated hose clamps.

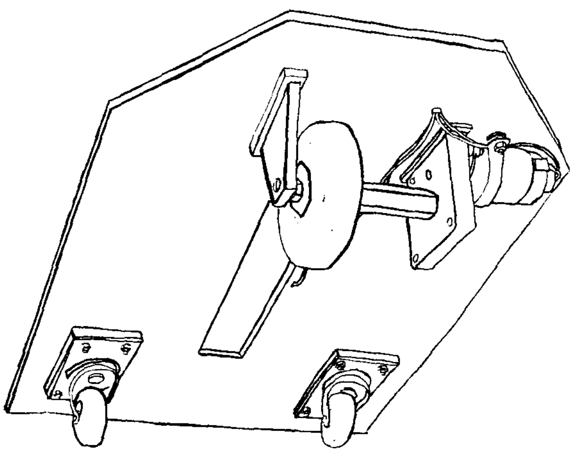
The double throw momentary contact switch determines the direction of motion, permitting the device to proceed both forward and backward. The switch is moved in the direction of the proposed motion to activate the motor. This makes the device usable with minimal training. When the switch is released, the motor stops.

Forward speed is controlled by a lever actuated Bowden cable, a standard bicycle brake lever and cable. This cable operates a series rheostat that is mounted on the propulsion unit. A spring returns the control to its lowest speed when the lever is released. Top speed is 1/2 mph and it may be reduced by the parent or therapist using a child-resistant screwdriver control mounted on the propulsion module.

Reverse allows the child operator to get out of tight spots, and is limited to a single low speed. To enhance safety, both forward and reverse speeds are limited so that the child is unlikely to damage him or herself or other objects by hitting them.

### cost

The straightforward design, simple construction, and use of standard mass produced components make this device relatively inexpensive to manufacture. Total construction costs are about $100 for small quantities which makes the device affordable to many families.



Tricycle propulsion unit showing motor, drive wheel, slot, and casters.

DIAGNOSTIC TRANSDUCER TO MONITOR DEFECT MATURATION
IN LIMB LENGTHENING PROCEDURES

Student Designer: Brad Rohr
Attending Physician: Michele M. Zembo, M.D.
Supervising Professor: Ronald C. Anderson, Ph.D.
Department of Biomedical Engineering
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INTRODUCTION

Limb length discrepancy in children can result from a number of pathologies including congenital deformity, severe osteomyelitis, achondroplasia, and trauma to the growth plate or afflicted bone. The extent of the discrepancy can be such that severe physical and emotional disabilities result . In some instances it is possible to use circular external fixation frames to correct severe limb shortening or angular deformation. This operation requires that an osteotomy be created at some point within the viable bone tissue. The external apparatus is fixed to the two fragments of bone via thin transfixing wires which pass through the bone and surrounding soft tissues to attach to the frame. It then becomes possible to slowly distract the two bone segments by lengthening the frame. The tissue that forms in the gap created begins as a soft tissue which must undergo maturation and calcification to become functional bone. The formation of the defect tissue is greatly dependent upon distraction rate, but it is difficult for the surgeon to assess the status of the maturing tissue non-invasively in order to provide optimal deformity correction. The purpose of this project was to create a transducer (shown in Figure 1) which can easily attach to an external frame and assess the maturation of the defect tissue, taking advantage of the the fact that the material stiffness gradually increases as the tissue matures.

SUMMARY OF IMPACT

At present, the prototype of the transducer is fully operational and is being used in the laboratory to correlate the level of transverse force at the defect (in response to a moment applied to an aluminum replica of a tibia) to the stiffness of the material "filling" the space between upper and lower pieces of the fixture. The results indicate that the transducer is capable of identifying the difference between material with a stiffness of fibrous tissue and material with a stiffness corresponding to 10% dense cancellous bone at low levels of applied moment . This suggests that the device will be able to identify the point where the precursor soft tissues begin to differentiate into calcified tissue, and thus allow the surgeon to assess the lengthening procedure. It has also been demonstrated that the transducer can identify differences in materials of stiffnesses corresponding to mature and immature bone. Thus, the device will be useful in determining when healing is adequate and when the device can be removed without fear of refracture. The current transducer will be modified with a skin pad and will be used to evaluate patients at Children's Hospital on a preliminary basis this fall.

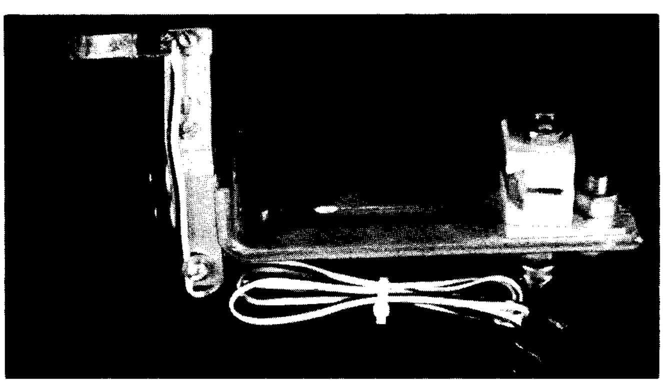

Figure 1. The diagnostic transducer. The strain-gaged cantilever component is located in the upper left corner.

## TECHNICAL DESCRIPTION

The sensing device consists of a small aluminum cantilever beam to which a 120Ω uniaxial strain gage is bonded. The gage was incorporated in a quarter-bridge circuit to a strain gage conditioner which can be nulled to eliminate signals associated with initial preload upon placement. The beam is rigidly fixed to an adjustable support bracket on one end, and currently has a cyanoacrylate bonded acrylic knife-edge on the other. This arrangement proved to be quite sensitive in bench tests. The second generation design will employ a pinned pad to interface with the patients skin, rather than the knife-edge.

The support bracket is mounted to slotted extension of an adjustable clamp. The adjustable bracket is designed to allow approximately one inch of radial excursion to account for eccentric variation in the surgical placement of the external frame. The slotted extension similarly provides three inches in height adjustment. And the clamp is so designed to allow its application to any point on the ring components of the external frame. The ability to provide precise placement of the transducer is critical to its effective application as a monitor of the condition of a specific location on the surface of the affected limb.

The total cost to produce this device was approximately $50.00. The transducer is a simple and effective way of non-invasively obtaining a quantitative measurement of tissue maturation, and provides the surgeon with information that has been previously unattainable.

# WEIGHING DEVICE FOR QUADRIPLEGICS

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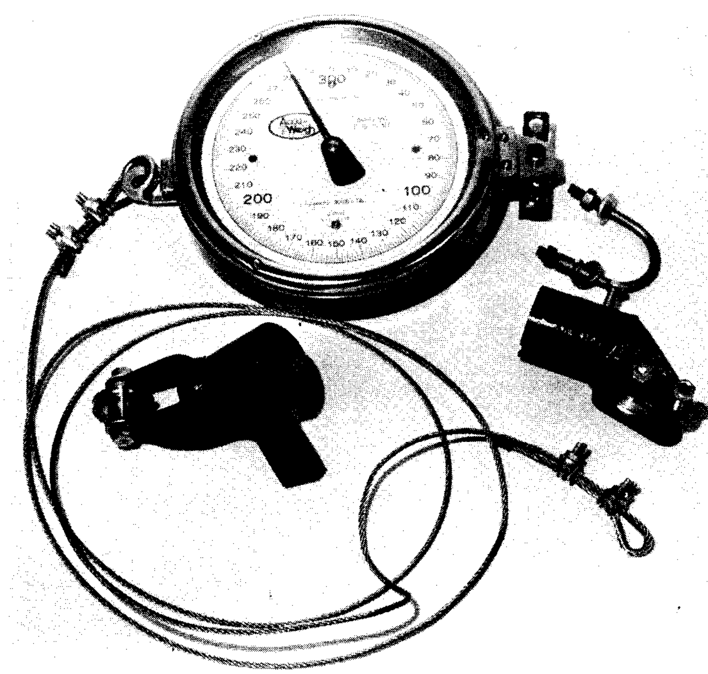
## INTRODUCTION

Careful monitoring of body weight is necessary for health maintenance of paralyzed people. Home weighing of children can be done by having a parent hold the child while standing on a scale, then subtracting the parent's weight. This is cumbersome ordinarily, but when the child gets too large to do this, the need for weighing may be the final reason for institutionalization of the child.

Most families with a paralyzed member will have a hoist to lift the patient from bed to bath or chair. By fitting the hoist with a scale, weighing can occur without difficulty. This device is designed as a kit that can be attached to commercial hoists (such as a Hoyer lift) with simple tools and no modification of the hoist itself.

## SUMMARY OF IMPACT

This weighing device was designed for a quadriplegic on a ventilator who lives some distance from Children's Hospital so that frequent travel for routine weighing is beyond the family's means. The device was used successfully in the client's home until her untimely death, and has now been delivered to another quadriplegic client. As of this writing there are no reports from the new recipient.



Prototype scale kit. Safety upgrades are described in the Technical Description.

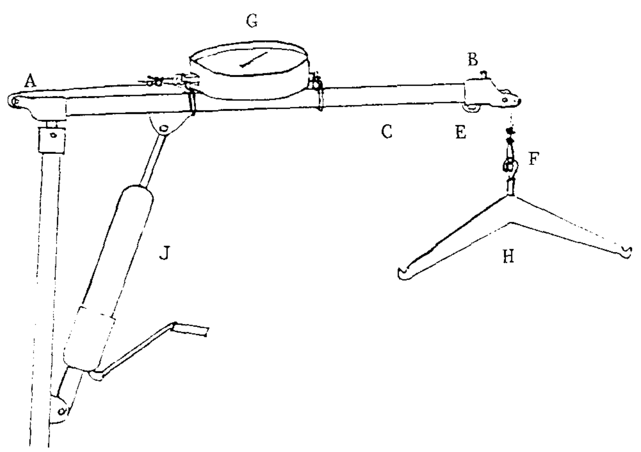
TECHNICAL DESCRIPTION

A spring scale attaches to the hoist boom with U-bolts in a place that is comfortable for viewing. Two ball-bearing pulleys guide a 1/8 in stainless steel aircraft cable from the scale through the boom to the cantilevered end. The pulleys are supported in brackets that fasten to the ends of the boom. A new cable eye is formed near the existing eye of the boom where the patient sling usually attaches. By hooking the sling to the cable eye, the patient's weight is transferred via the cable to the scale, and the reading can be taken. The device can be left attached to the hoist since it doesn't interfere with normal operation.

Several features enhance safety. All parts were designed with a safety factor of three or greater. The brackets that support the pulleys have set screws, but the load forces them onto the boom. The cable eyes are shown formed in the cable by the photograph, but the design has changed after the photograph. Now they are made with stainless steel rigging eyes that are swaged onto the cable. A safety chain runs from the new sling eye to the old sling eye, supporting the patient if any part of the cable, scale, or linkage should slip or fail. The open construction permits visual inspection of critical parts. A Safety and Operation manual given to the patient's family describes these features and advises periodic checks to maintain a high level of reliability.

The accuracy of the system is limited by accuracy of the scale, friction in the cable and pulley system, and calibration procedures. This system, as opposed to a strain gage approach, performs independently of boom angle or elevation. Tare weight, the weight of the sling and other patient accoutrements, can be adjusted at the scale so that true patient weight is shown. The calibration for this is described in the Safety and Operation manual. The system shows an error of less than 1 lb with use of a special dithering procedure (described in the manual) to reduce the effect of friction and less than 3 lb otherwise.

The cost of the weighing system is less than $200, much less than other systems that provide comparable results.




Weighing system as mounted on a hoist. The figure shows the pulleys and brackets (A, B), hoist boom (C), boom eye (E), cable eye (F), scale (G), sling (H), and boom jack (J). Not shown is the safety chain.


S. VALENTA