CHAPTER 15
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SHOWER CHAIRS FOR INDIVIDUALS WITH CEREBRAL PALSY

Designers: 1998 Mechanical Engineering and Materials Science Senior Design Students
Client Coordinators: Dr. Gary Edwards, United Cerebral Palsy of Birmingham
*Supervising Professors: Drs. Alan Eberhardt, B.J. Stephens, Laura Vogtle**
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INTRODUCTION

Shower chairs currently on the market have failed to meet the needs of clients with cerebral palsy and their caregivers. Shortcomings include:

- Frames too weak for heavier clients, failing with repeated use;
- Mesh backing uncomfortable and abrasive to skin;
- Castors prone to rust, restricting mobility;
- Users' arms and legs protrude and catch in open sides;
- Clients may slide off seat; and
- Cleaning difficult due to low seat height.

Three different shower chairs were developed for three clients with varying conditions of cerebral palsy:

- an elderly man weighing approximately 300 pounds;
- a thin man with severe kyphosis of the upper spine, fused spinal segments in his lower spine, and knee flexion contractures; and
- a young woman, weighing less than 100 pounds, having severe curvature of the spine and spasticity of the arms and legs.

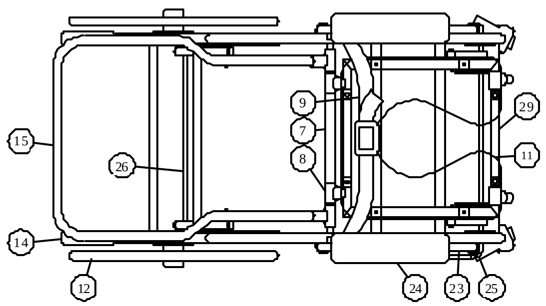
Many issues are considered in the design of the chairs, including durability, comfort and safety.

TECHNICAL DESCRIPTION

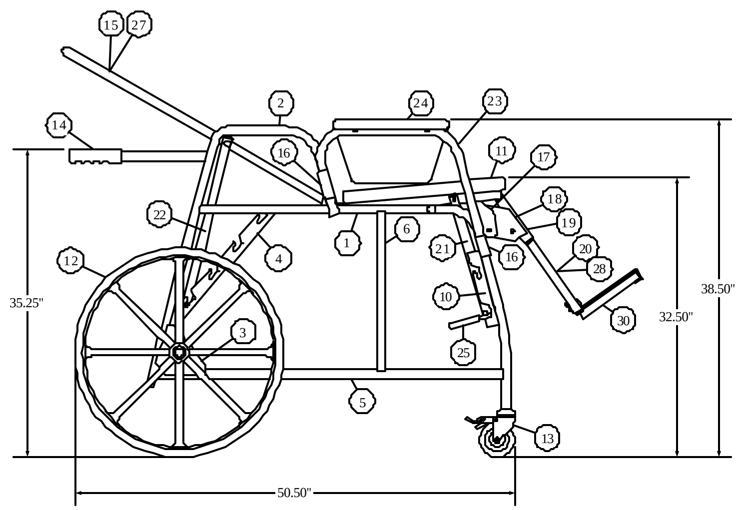
PRELIMINARY DESIGN

The preliminary design establishes the foundation for the specific designs by focusing on the following five major areas: the structural frame, adjustability, mobility, seating, and safety. The material for the frame was AISI-Type 304, satin-finish stainless steel thin walled tubing that meets the requirements for high strength, low weight, corrosion resistance, and aesthetics. The frame components are joined by gas argon arc welding, according to specification AWS WP1-01. Certified contractors performed all tube bending and welding. The preliminary chair design is shown schematically in Figure 15.1. This structural configuration was analyzed using Caesar II finite element software (Algor Inc., Pittsburgh, PA) for a distributed load representing a reclined 300-pound person. All frame members and joints yield safety factors greater than two. The 32.5-inch seat height makes cleaning easier for the caregiver.

There are two large solid rubber wheels in the rear and two smaller swivel type casters in the front to make the chair mobile. The brake-type casters are 4 inches in diameter and 1.5 inches in width, designed for a maximum 250-pound load. The metal components of the rear wheels and the front casters are stainless steel, ensuring durability and corrosion resistance.



ITEM NO.	REF. DWG NO.	DESCRIPTION	MAT'L	QTY.
1	B-01	1" DIA -12 GAUGE TUBE	304 SS	2
2	B-02	1" DIA -12 GAUGE TUBE	304 SS	2
3	M-01	1/4" THICK PLATE	304 SS	2
4	M-02	1/4" x 1 1/2" BAR	304 SS	2
5	-----	1" DIA -12 GAUGE TUBE (39" LENGTH)	304 SS	2
6	-----	1" DIA -12 GAUGE TUBE (18 3/4" LENGTH)	304 SS	2
7	-----	1" DIA -12 GAUGE TUBE (22" LENGTH)	304 SS	6
8	M-03	1 1/4" DIA - 12 GAUGE TEE	304 SS	4
9	-----	PADDED SEAT BELT	NYLON	1
10	M-04	1/4" x 1 1/2" BAR	304 SS	2
11	-----	PADDED SEAT	FOAM	1
12	-----	24" DIA WHEEL	RUBBER	2
13	-----	4" SWIVEL LOCKING CASTER	304 SS	2
14	-----	HANDGRIP	GEL FOAM	2
15	B-03	BACK FRAME ASSEMBLY	304 SS	1
16	-----	1 1/4" DIA TUBE (2.5" LENGTH)	304 SS	4
17	M-06	LEG REST ADJUSTMENT PLATE	304 SS	2
18	M-07	LEG REST ADJ. PLATE (SEAT ATTACHEMNT)	304 SS	2
19	M-08	LEG REST HINGE ASSEMBLY	304 SS	2
20	M-09	LEG REST ASSEMBLY	304 SS	1
21	M-10	SEAT ADJUSTMENT ROD ASSEMBLY	304 SS	1
22	M-11	BACK ADJUSTMENT ROD ASSEMBLY	304 SS	1
23	B-04	ARM REST FRAME	304 SS	2
24	-----	ARM REST PAD	FOAM	2
25	M-10	3/8" DIA SOLID ROD, BENT AND COVERED	304 SS	1
26	-----	3/8" DIA SOLID ROD, (24" LENGTH)	304 SS	1
27	C-01	COVERING MATERIAL FOR BACK FRAME	CLOTH	1
28	C-02	COVERING MATERIAL FOR LEGREST	CLOTH	1
29	M-05	SEAT FRAME ASSEMBLY	304 SS	1
30	M-12	FOOTREST ASSEMBLY	304 SS	1



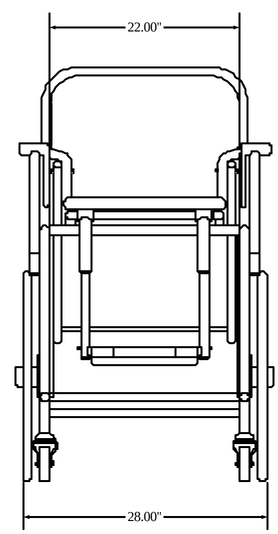


Figure 15.1. Schematic of the Preliminary Chair Design.

A support arm attached to the backrest establishes the angled position of the backrest, which fits into two slotted sidebars (Figure 15.1). For the seat adjustment there is a prop-hinge installed under the seat on each side. To adjust the seat upwardly, a second horizontal support bar fits into two slotted sidebars attached to the front frame. There is a handle beneath the seat, enabling the caregiver to easily adjust the seat rest. The leg rest rotates outward and locks with a positioning pin placed through pre-drilled holes.

Swing-away armrests provide easy transfer of the clients into and out of the shower chair. A 1.5" diameter piece of tubing is welded to each side in the middle near the base to act as a pivot. Another tube is welded to the front side of the chair to act as a harness for the swing-away armrest. The armrest is rotated by lifting it from the harness and swinging it toward the rear of the chair.

Fringe is welded to the bottom of the pivoting section to prevent the armrest from coming completely out of the rear tube. The armrests are fitted with padded side panels to keep the clients' arms from tangling during transport into and out of the chair. The footrest is designed to pivot from the leg rest as a solid piece, allowing the footrest to remain with the leg rest in any position. The one-piece construction prevents the clients' feet from becoming entangled.

Since the clients' skin comes in direct contact with the chair back and seat, comfort is extremely important. The backrest is made of awning material, which is soft to the touch, waterproof and durable. A clip-on padded toilet seat is use. It is durable yet comfortable, and allows easy access to the groin area for the caregiver. The clip-on feature allows it to be rotated 90 or 180 degrees for custom fitting.

A seatbelt is attached. Its locking device is located on the side of the chair frame to minimize discomfort. A pad attached to the belt prevents abrasion. A basket is attached to the backrest for storage of bathing items.

Figure 15.2. Shower Chair.

SHOWER CHAIR #1

Design Students: Robert Cooner, Leah Hardy, Dierdre Jackson, Lee Motes, Rafael Nunez, Otha Richardson, Sharron Williamson, Eddie Saunier

SUMMARY OF IMPACT

This shower chair was designed for a thin, frail man with cerebral palsy. He weighs approximately 65 pounds. He has restricted hip flexion due to fusion of sacral and lumbar vertebrae, severe kyphosis of the cervical spine, and knee flexion contractures (45-60 degrees flexion). This chair enables him to shower without the fear of falling out of the chair and without pain. Unlike before, he is able to remain in the shower long enough to allow for appropriate hygiene.

TECHNICAL DESCRIPTION

The primary design concerns were adjustability and comfort in both inclined and reclined positions. The client is extremely susceptible to pressure sores, so special attention was paid to seat and backing materials. Adjustability of the seat backing was achieved via tie-strings that secure the backing to the frame and allow the backing to be loosened or tightened as desired to contour with the client's back. The footrest is constructed of a stainless steel plate, attached to the leg rest. The foot and leg rest are attached directly to the seat so that they move with it, maintaining the desired angle. The toilet seat substrate is an open back, vinyl injection molded material clamped onto the seat frame. The square seat was sized to be 18.375 square inches because of complaints that the previous 21-inch seat was oversized. This was overlaid with an inflatable seat cushion (RoHO Inc., Belleview, IL) to provide increased comfort. The center hole has an 8-inch circumference for access.

The total cost of this shower chair is $1205.27. This includes $805 for parts and $360 for fabrication.

SHOWER CHAIR #2

Design Students: Michael Ball, Tina Childress, Michael Gordon, Jana Jenkins, Kristi McLain, Mitch Mansfield, Darin Odom, Tom Young

SUMMARY OF IMPACT

This shower chair was designed for a 300 lb. man with cerebral palsy, mental retardation and partial blindness. Previously purchased commercial shower chairs were unable to support his weight and had failed in service. As a result, he was usually bathed in his wheelchair. This shower chair will extend the life of his wheelchair by providing an appropriate shower medium.

TECHNICAL DESCRIPTION

In this design, specific areas of focus included the structural framework, ease of patient transfer from wheelchair to shower chair, comfort and safety. The client is above average in size, so the chair dimensions are larger and the frame is made to support more weight than the average shower chair. To increase ease of transfer, the seat height of the chair is near the height of his wheelchair seat (approximately 26 inches). This structural configuration was analyzed using Caesar II finite element software (Algor Inc., Pittsburgh, PA) for a distributed load of 1000 pounds, representing a worst case dynamic loading. All frame members and joints yield safety factors greater than two.

The total cost of this shower chair was $1,436.27. This includes $1028.11 for parts and $436.16 for fabrication.

SHOWER CHAIR #3

Design Students: Shane Wolfe, Jeremy Wolfe, Jim Gaydon, Jana Jenkins, Lee Motes, Jeff Gordon, Mitch Mansfield

SUMMARY OF IMPACT

This chair was designed for a young woman with severe cerebral palsy. Specific design issues in this case included comfort for her severely curved spine and prevention of her arm and legs extending beyond the chair, which has been problematic due to spasticity in her arms and legs. The completed chair relieves pain previously experienced by the due to ill-fitting equipment.

TECHNICAL DESCRIPTION

The preliminary design met the basic requirements, with minor modifications. The height of the seat back was extended to allow for head support in reclined positions. An 18 3/8" square-shaped, open front, padded seat was used. The seat is equipped with clips so that it can be easily removed, rotated, and repositioned, allowing the caregiver to optimally orient the opening to accommodate the client’s spinal curvature.

The total cost of this shower chair was $1,500.57. This includes $798.57 for parts and $702 for fabrication.

FOREARM MOTION/TORQUE ANALYZER

Student: Michael Wheatley
Project Coordinators: Drs. Stephanie Delucas[1], Edward Taub[2]
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INTRODUCTION

A forearm motion/torque analyzer was designed for patients recovering from strokes. It consists of a padded arm support and a grip that is moved through pronation and supination of the forearm. Torque and rotational motion are visually displayed on needle gauges, permitting the evaluator a convenient measure of relative improvement in wrist and forearm strength and range of motion. The guages also provide visual feedback to the patient during rehabilitation therapy.

SUMMARY OF IMPACT

Strokes may affect a person's control of the musculoskeletal system and abilities to perform skilled behaviors. There is a need for a therapeutic wrist motion/torque analyzer to allow stroke victims and evaluators to observe supination and pronation motor skills during rehabilitation. It also provides for limb isolation, variable resistance, comfort and versatility.

TECHNICAL DESCRIPTION

The motion/torque analyzer consists of a padded arm support, a mobile grip, a box housing spring and damper resistance, and needle gauges for measurement of torque and rotation (Figure 15.3). The padded armrest is attached to the device by a latch on each side, facilitating storage and contributing to the mobility of the device.

The device restrains the patient's arm with adjustable nylon D-ring straps to prevent the use of the shoulder in rotation of the affected limb. A special set of gloves allows the patients' hands to be secured in a "gripped" position. The hand grip is configured to allow ambidextrous finger positioning. Since the device is to be used in a medical environment, all exterior surfaces are non-absorbent and capable of withstanding repeated cleanings.

The grip is attached directly to a rack and pinion system that converts the rotational motion induced by the patient into linear motion. Two extension dampers are attached to the rack gear, one on each end (Figure 15.4). The stroke length of the cylinders was chosen so that a 170-degree rotation of the pinion gear does not exceed the stroke length of the cylinders. The hydraulic dampers increase or decrease the amount of resistance to motion in response to the rate at which they are deformed. The amount of resistance is a direct function of the rate at which the patient rotates his or her forearm. Additionally, the dampers do not increase resistance at range of motion extremes. Instead, as the patient reaches the extreme, by reducing the rate of rotation, the resistance offered by the damper decreases. As the patient's motor skills improve, the resistance may be increased proportionally to the rate of rotation. The length of the rack gear is sufficient to accommodate 85 degrees of rotation in either direction. As a safety measure, the tooth spaces on the rack gear corresponding to range of motion extremes are filled with epoxy.

Range of motion is measured directly from the shaft of the pinion gear, which is also the shaft to which the grip is attached. On the exterior of the device, a needle attached to the shaft indicates the degrees through which the shaft is rotated (Figure 15.4). Two additional needles attached to, but independent of, the shaft are used to indicate the maximum degree of rotation in both directions. The torque is measured according to the resistance offered by the damper. Since the diameter of the pinion gear is known, the torque will be the product of the damper force and the pitch radius of the gear. The damper force is measured by an extension spring attached in series to each of the two dampers. The dampers are threaded into the rack gear on one end. The other end of the damper is threaded into an adjustable turnbuckle that attaches to the spring through an eyebolt. Pins passing through each of the adjustable turnbuckles indicate the displacement of the spring to torque gauges mounted on the exterior of the device. An indicator needle on the exterior of the device attached to the pin moves linearly as force is applied to the spring. It indicates the torque the patient is applying according to a calibrated scale on the exterior of the device. A second freely moving needle, not attached to the spring, indicates the maximum torque applied. The same apparatus is used on both springs so that the torque may be measured in both directions. The adjustable turnbuckles allow the use of different springs and dampers to accommodate patients who are exceptionally stronger (or weaker) than the average patient.

The total cost of the wrist motion/torque analyzer was $420.61. This includes $176.61 for parts and $244 for fabrication.

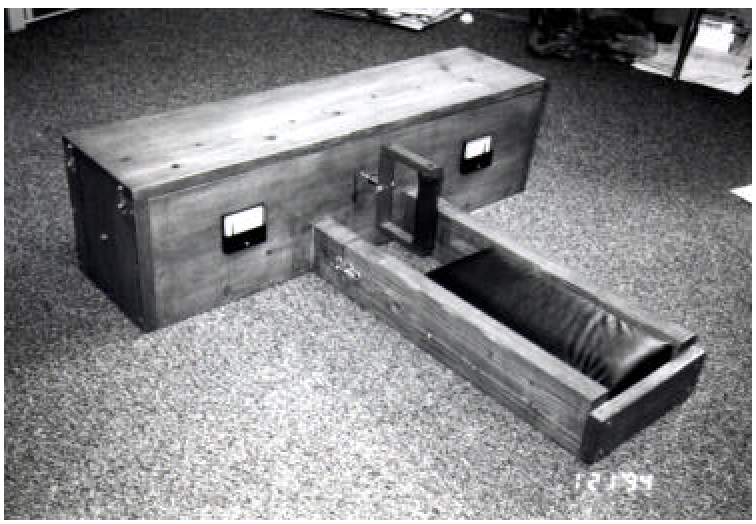

Figure 15.3. Wrist Motion/Torque Measuring Device.

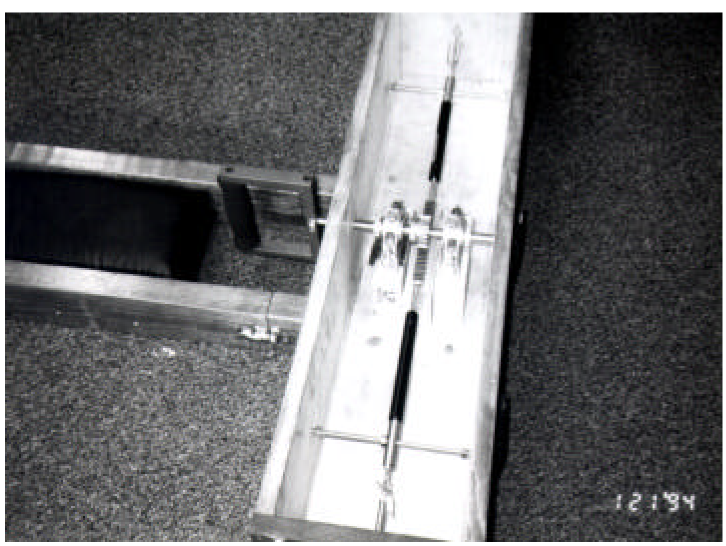

Figure 15.4. Rack and Pinion, Hydraulic Cylinders, and Needle Gage Attachments.

WHEELCHAIR HEADREST DESIGN

Designer: Aaron T. Joy
Client Coordinators: Dr. Gary Edwards, United Cerebral Palsy of Birmingham
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INTRODUCTION:

A headrest was designed for a woman with cerebral palsy. It restricts movement of her head to the left, prohibits her chin from dropping, and offers support to her head and neck. The device is constructed using commercially available hardware and is custom fitted to the client's head, providing comfort and cosmetic integrity. A detachable forehead strap is fitted to the device to provide additional support and prevent forward movement.

SUMMARY OF IMPACT

The head rest/support system is for a woman with cerebral palsy. The device allows her prolonged, accurate use of her augmentative communication device and facilitates eating and swallowing. The design provides comfortable support for extended periods of time throughout the day, with a detachable forehead strap that may be used when she is tired.

TECHNICAL DESCRIPTION

Previous designs were not durable and had insufficient infrastructure. They did not support the client's chin and jaw, which tend to drop as she tired. Her previous headrest also interfered with her eyeglasses and the infrared sensor used for her voice activation board.

Initially, a negative mold was made of the client's head and neck using plaster casting for subsequent fitting of components. From the negative mold, a positive mold was constructed for use in subsequent development. For the purpose of structural frame and attachment design, lateral and dorsal head forces were measured using a bathroom scale.

Rather than developing new components, commercial components were customized to minimize costs. The Whitmyer SOFT-1D (Whitmyer Biomechanix, Inc.,

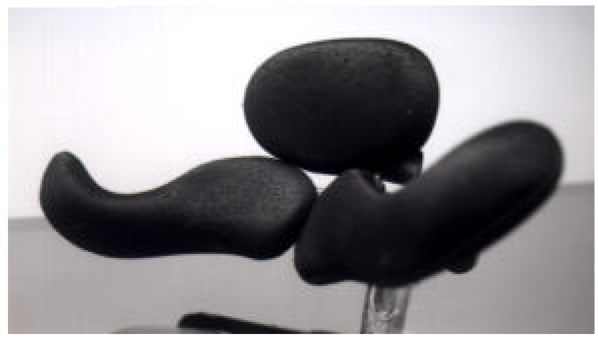

Figure 15.5. Headrest for Woman with Cerebral Palsy.

Figure 15.6. Rear View of Headrest Showing Mounts

Tallahassee, FL) was purchased because it met the criterion for chin support. It consists of left and right sub-occipital pads contoured to cradle the client's chin from ear to ear. One-half to one-inch clearance was allowed for lateral and vertical movement, while inhibiting movement to the left and cradling her chin.

The device was constructed of 14 gauge carbon steel plate, covered by closed-cell polyethylene foam and by water resistant Lycra that is soft to the touch. The occipital pad was reduced in size relative to the client's previous headrest to decrease interference with her eyeglasses during movement. The pad is prefabricated with a continuous plate of 14-gauge carbon steel and is covered with the same materials as the sub-occipital pads. The device is shown in Figure 15.5.

The headrest is attached to the mounting system via a 12-inch WBI to BOCK vertical adjusting bar, an occipital mounting bar, and a sub-occipital mounting fork (Figure 15.6). Each was constructed from seamless carbon steel tubing. The vertical adjusting bar enables the Whitmyer system to be attached to an existing BOCK square mount on the back of the patient's chair. The sub-occipital mounting fork connects both the left and right sub-occipital pads to the vertical adjusting bar. At the end of each rod is a 7/8-inch ball-rod, which attaches to the sub-occipital pad by means of switch mount clamps, internally located in each pad. The occipital mount connects the occipital pad to the sub-occipital fork with another 7/8-inch ball-rod.

A detachable forehead strap was attached to a pulley system and mounted to the headrest for prevention of vertical movement (Figure 15.7). The forehead strap is attached when the client is tired. The strap attaches to the occipital mount via a switch-mounting clamp.

The total cost of the headrest was $650. This includes $540 for parts and $110 for fabrication of the plaster molds.

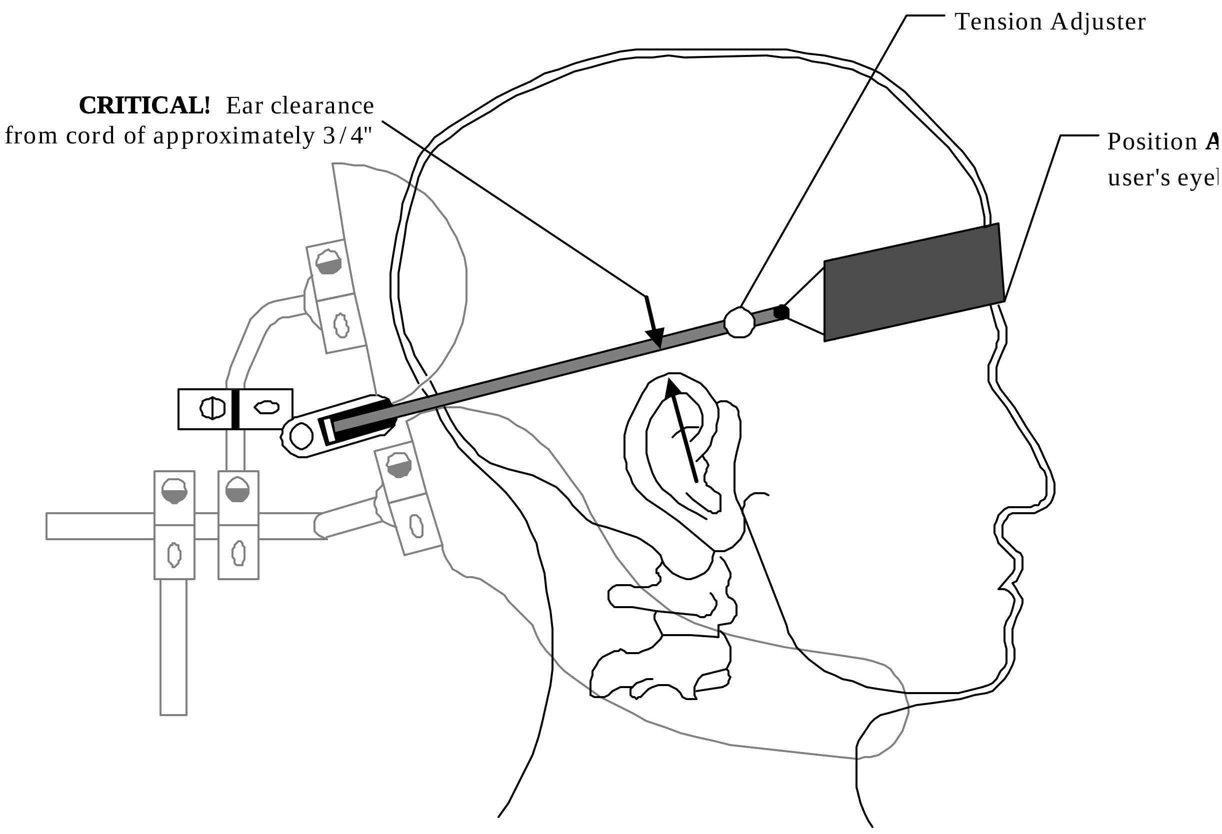

Figure 15.7. Forehead Strap for Headrest.