CHAPTER 18
UNIVERSITY OF TENNESSEE AT CHATTANOOGA

School of Engineering
Chattanooga, Tennessee 37403

Principal Investigator:

Edward H. McMahon (615) 755-4771

Mobile and Prone Workstation

Designers: Lorie Conley, Russel Crisp, Steve Gregg
Client Coordinator: Rhoda Ruffner, Siskin Hospital
Supervising Professor: Dr. Edward H. McMahon
School of Engineering
University of Tennessee at Chattanooga
Chattanooga, TN 37403

INTRODUCTION

The design project chosen by our group was a combination of a mobile prone device and a prone workstation to be used by the client, a four year old student at the Siskin Preschool. The client is in need of a device that will provide mobility while standing, allowing him development of socialization and language skills, and support his weight in a manner that will give proper skeletal alignment and prevent organ dysfunction. The problem statement the group developed included (a) the device must allow mobility for the client from a standing position, (b) stimulate hand and shoulder muscles, (c) it must also include a cleanable work station, (d) it must be adjustable, (e) it must be easily disassembled for transportation. The client's physical condition does not allow him to sit at a desk or table without restraint. It was necessary for the mobile stander to have a sufficiently large work space built onto the prone board to allow the client to do most anything that is required without leaving the stander.

The final design of the prone stander frame consisted of a tubing frame and one castor on each of the four comers. This insured the stability of the device, and helped alleviate a slight frame war-page problem anticipated with a proposed three wheel arrangement. The work station was made collapsible by using a hinge that is fastened to the lower side of the station and to a metal plate that then slides into a pocket on the prone board. This design provided for collapsibility as well as easy removal.

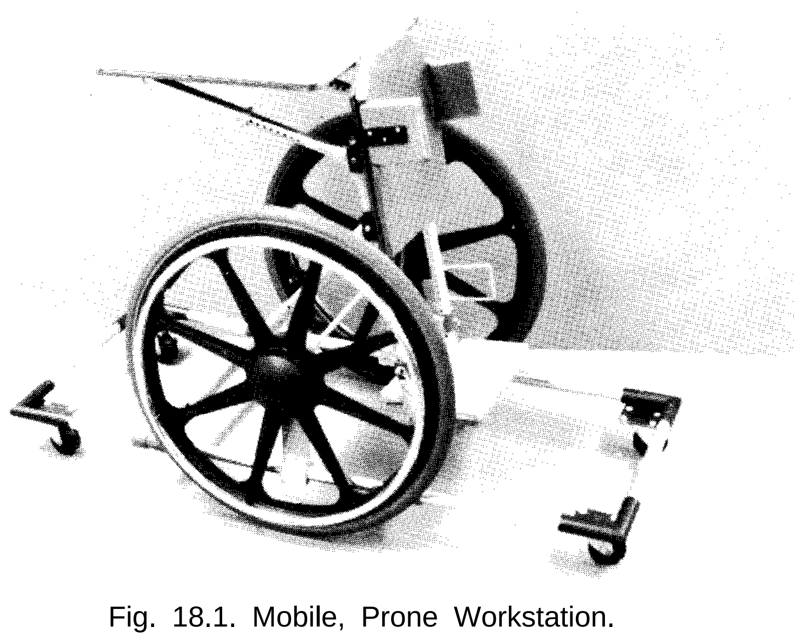

Fig. 18.1. Mobile, Prone Workstation.

SUMMARY OF IMPACT

The client is a four year old student who suffers from spinal bifida and hydrocephalus. His disability is characterized by a flaccid paralysis in his legs and a pronounced weakness in his back an abdominal muscles. He is in need of a device that will provide mobility while standing, allow him to develop social and language skills. The device met all of the initial criteria. During the development and construction of the device the client broke his leg and had foot surgery. At the request of the therapist, the device was modified to include the possibility of kneeling at the workstation. The client is able to work on the workstation while in an upright position.

TECHNICAL DESCRIPTION

The main technical problems were presented by assuring stability of the device while making the device very adjustable, collapsible, and light weight for portability. During the process of the design the needs were further complicated by changing conditions (a broken leg and foot operation) which suggested the device may be used from a kneeling position as well as later from a standing position.

The adjustments required included the height of the stander, the angle of the stander, the position of the workstation (parallel to the floor when the stander was adjusted to any angle and collapsible), the height of the foot (knee) rest, and the adjustability of the straps.

The need for adjustability caused numerous problems with the frame concerning straightness and alignment with the wheelchair wheels. Most adjustments were achieved using a tube within a tube. 1.25” OD and 1" OD aluminum tubing were used. PVC tubing fittings were used at the corners and for Tees to attach the uprights. This arrangement allowed for easy collapsibility. Hitch pins with clips were used to secure the tubing when adjusted.

Conventional 24” wheelchair wheels were purchased. To make sure the wheelchair wheels provided the friction necessary to drive the stander, a slot was milled in the aluminum block to allow the wheel axle to drop down closer to the floor. This also allowed for any irregularities in the floor. A piece of 7/16" all thread bar stock and two coupling nuts provided the support necessary. A locking caster wheel is attached to each comer for stability.

The workstation was made from 3/8" plywood and is both removable and collapsible. The workstation is attached using a hinge and adjustable tubing.

The cost for the device was $350.

Activity Center

Designers: Brian Eldridge, John Hoffman, and Stein Jacobsen
Client Coordinator: June Phillips, Orange Grove Center
Supervising Professor: Dr. Edward H. McMahon
School of Engineering
University of Tennessee at Chattanooga
Chattanooga, TN 37403

INTRODUCTION

The activity center is a custom designed center to improve the client's stimulation and motivation. The activity center was designed to provide six devices on an activity board that would vary in color, texture and sound. The board is white with brightly colored activities. The activities include:

Pull-Switch - This is a simple switch device to provide a visual stimulus in response to a pulling motion. The pull-switch consists of a ball on a piece of rope and a light. When the client pulls the ball a bright green light is activated

Joy Stick - The push-pull joy stick activity has up-down and left-right movements. The joy stick is wired to a toy organ that has been designed to work with the joy stick movements. Each of the four movements will have a different tone associated with them.

Slider Switch - A left to right slider switch was chosen as an activity to improve the client's forward trunk control. The slider switch moves 4 inches right to left. When the slider switch is pushed either right or left, the buzzer will sound.

Squeeze Bladder - The bladder activity consists of a rubber bladder that will produce a horn sound when squeezed.

Rotating Ball - The rotating ball was selected to provide the client with a new activity that would challenge him and improve his arm movements. Rotating the tennis ball produces a mechanical clicking sound.

Rotating Cylinder - The cylinder may be rotated for tactile sensations and squeezed for auditory stimulation. When the cylinder is squeezed, a tape recorder is activated. The tapes may be changed. The initial tape contains animal sounds.

SUMMARY OF IMPACT

The client is a five year old boy who is severely multi-handicapped and medically fragile. He is visually impaired and needs a lot of multi-sensory stimulation. He is in need of sensory input by sight, feeling (tactile), and sound. His sense of hearing is most acute. The device should incorporate all three senses and influence him to improve his undeveloped motor skills. The completed device appears to meet the needs outlined in the problem statement. The client's initial response was very positive. It will take some training for the client to access all of the stimuli.

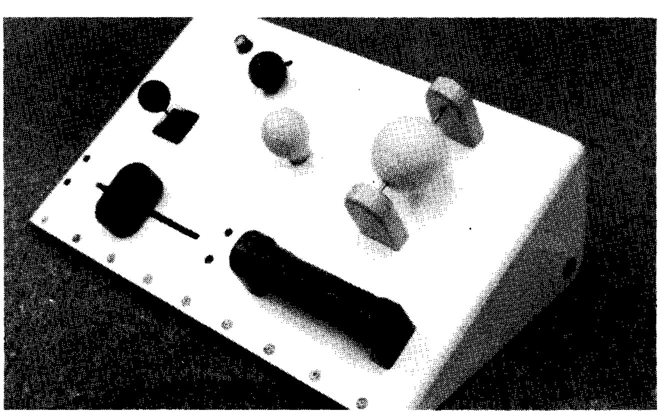

Fig. 18.2. Activity Center.

TECHNICAL DESCRIPTION

The body of the activity center is made from "Travicel." "Travicel" is a very rigid and tough lightweight plastic that can be easily cut, drilled and molded into our final design. This final design allows the angle of the top portion of the activity center to be adjusted from a 30 degree angle to a 45 degree angle by using slots cut out of the sides of the work-station. The activity is powered by six rechargeable "C" batteries.

Pull-Switch - A hole was drilled through the center of the ball so that the rope could be put through it. The ball was securely fastened to the rope by a series of knots. The end of the rope was then tied to a bent brass strip providing spring action. Another piece of copper stripping was positioned so that the bent strip would make electrical contact with it and turn on the light.

Joy Stick - The push-pull joy stick activity has up-down and left-right movements. The joy stick is wired to a toy organ that has been designed to work with the joy stick movements. Each of the four movements will close a different switch in the schematic shown below.

Slider Switch - The slider switch moves 4 inches right to left. When the slider switch is pushed either right or left, the brass electrical contacts are closed and a buzzer will sound.

Squeeze Bladder - The squeeze bladder activity consists of a rubber bladder, a pneumatic switch and an electronic horn circuit. When the rubber bladder is squeezed the air in the bladder will force the pneumatic switch to be activated and the electronic horn sound.

Rotating Ball - The activity consists of a tennis ball, a small diameter steel rod and a noise maker. The steel rod goes through the ball and the two supports mounted on the top surface of the activity center. When the ball is rotated a clicking noise is produced by a piece of spring steel and a gear.

Rotating Cylinder - The rotating cylinder will be constructed out of a 1 1/4 inch wooden dowel. The middle portion of the dowel was lathed out to allow for copper strips to be inlaid around the dowel. The cylinder was then covered with a textured material to form a squeeze grip. The inside of the cover has brass strips attached to it and the strips are connected electrically to each other by wire. When the cylinder is squeezed a **tape** player is activated. This allows for different types of sounds to be used so Will does not become tired of the same sounds. The cost for the device was $375.

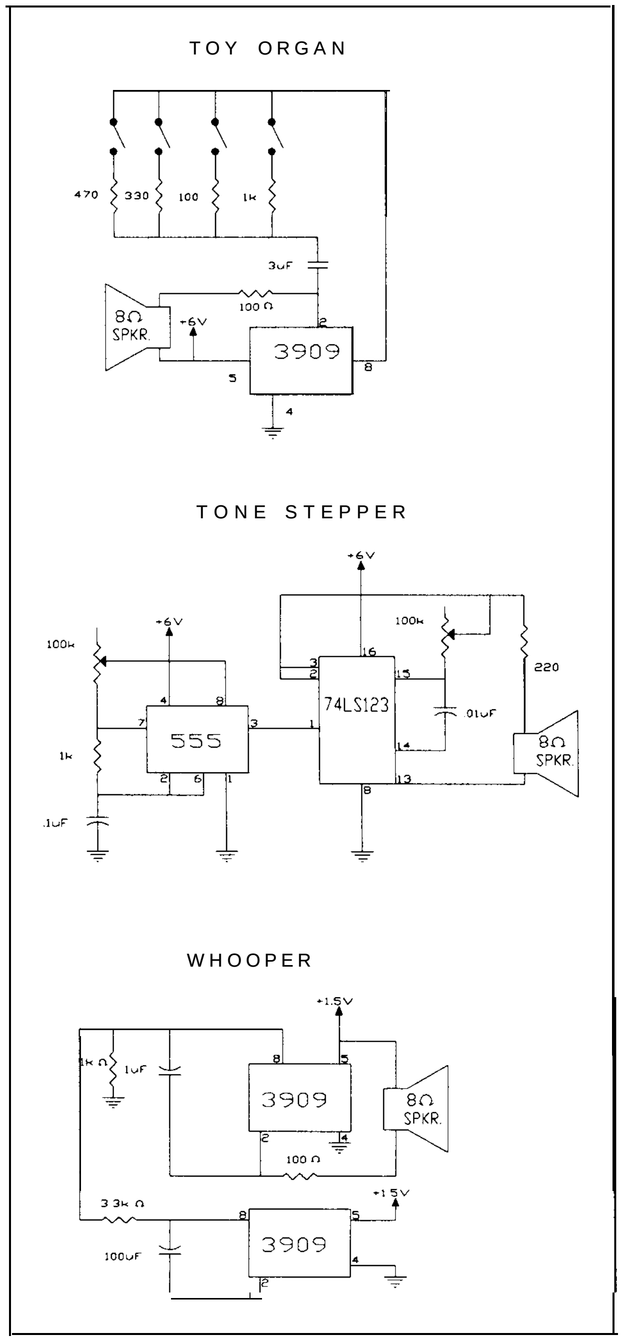

Fig. 18.3 Circuit Diagrams for the Activity Center.

Environmental Control Device

Designers: Julie Copeland, Trish Foster, Christy Warren
Client Coordinator: June Phillips, Orange Grove Center
Supervising Professor: Dr. Edward H. McMahon
School of Engineering
University of Tennessee at Chattanooga
Chattanooga, TN 37403

INTRODUCTION

The design is an environmental control system activated by two chin switches mounted on an adjustable support. The unit will allow the client to select an appliance with one chin switch and to turn it on or off with another chin switch. This device will allow the client to control the on/off state of four different appliances in her environment. A control panel is attached to the client's wheelchair so that she is able to see which appliances she is turning on/off and the state of all the appliances. The chin switches are placed near the client's head since it is the area of her body that she has control over. They are out of range of the saliva that the client produces to insure her safety. The switches are not easily activated if the client falls asleep and drops her head. The control circuit is attached to the wheel chair using a vinyl carrying case and is able to move along with the client's wheelchair for use at her home.

SUMMARY OF IMPACT

The client is a mentally retarded teenage female with Cerebral palsy. She has a type of retardation that is referred to as educable mental retardation (EMR), therefore, she has the ability to learn quickly. The Cerebral palsy causes a loss of control over her motor functions rendering her non-ambulatory. She does, however, have motor control over her head and neck region. The client is able to select each of the four devices and turn them on and off at will. The primary benefit of the system to the client is the degree of independence it affords.

TECHNICAL DESCRIPTION

The physical design consists of two basic parts. The first is a vertical support that will be attached to the client's wheelchair through the use of two brackets for the bottom support, and a "u" bolt for the top support. The bottom support will be secured to a horizontal bar between the two back wheels of the wheelchair. The two brackets will be formed at a 75 degree angle to offset the angle of the horizontal bar.

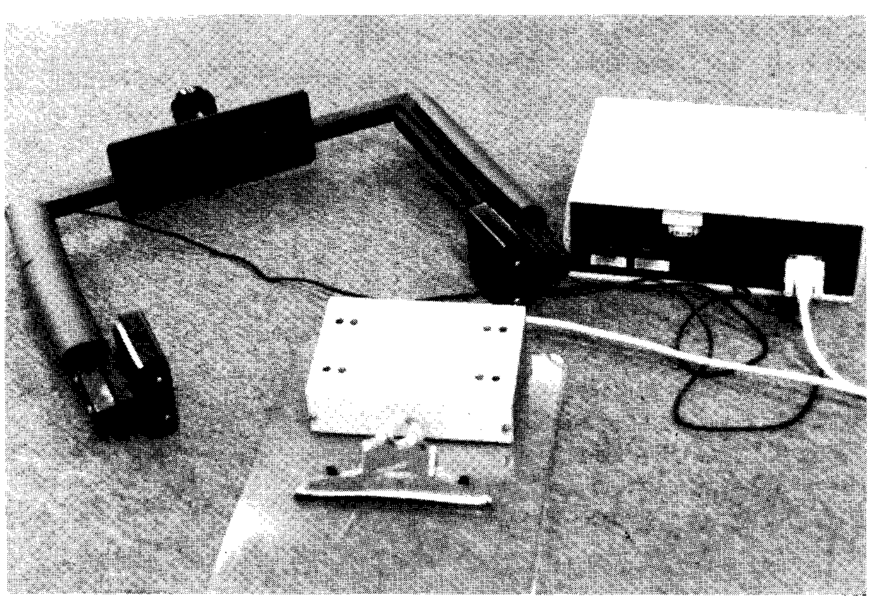

Fig. 18.4. Environmental Control Device.

TECHNICAL DESCRIPTION

The physical design consists of two basic parts. The first is a vertical support that will be attached to the client's wheelchair through the use of two brackets for the bottom support, and a "u" bolt for the top support. The bottom support will be secured to a horizontal bar between the two back wheels of the wheelchair. The two brackets will be formed at a 75 degree angle to offset the angle of the horizontal bar.

The height of the vertical support is 36 inches and is made of 1 inch square steel tubing (14 gauge). There are nine 3/8 inch holes drilled in the vertical support, 2 inches apart, to allow the "U" bar to be adjusted vertically to benefit the positioning of our client. The second part consists of a "U" shaped bar. The base of the bar is 14 inches in length. The arms of the bar are 13 inches in length. The "U" bar is made of 3/4 inch square steel tubing (14) gauge. The steel was cut into the three lengths mentioned above and welded together. The two 13 inch sections were welded at right angles to the ends of the 14 inch length. An 8" x 3 1/4" x 1/4" plate was centered and secured to the base of the "U" shaped bar for additional strength.

Electrical Design Description - Two 555 timers are used to translate the select and on/off switches to timing pulses. These pulses go through a Hex Schmitt Trigger (CD40106). This chip removes the spikes from the pulse clearing up most of the noise introduced by the switches. The select pulses enter 2 dual D flip flops (CD4013B). A reset switch sets the flip flops so that IC5:A D input is the only high input and **hence** is the only high output. The high output selects which appliance will be toggled by the on/off pulse; also, it lights up the LED next to that appliance on the indicator box. When the select button is pressed the pulse then sets the D input and output of IC5:B to a high and resets IC5:A, IC6:A, and IC6:B to low outputs. Each depression of the select switch will step through the flip flops in sequential order.

The on/off pulses enter 2 J/K flip flops (SK4027 B). These chips allow the high pulse to toggle the selected IC on and off. The chip uses the same pulse to change the chosen IC to the state from its previous state. This eliminates the need for a high pulse to turn the appliance on and a low pulse to turn it off; therefore, no inverter is required to make a low pulse.

From here the on/off pulses and select pulses are sent to two Hex buffers (CD4050B). These buffers clean up the pulses and send them to four quad bilateral switches (CD4016). Two of the switches, IC 9 and IC 10, send the on/off pulse to the transmitter. The other two switches, IC 7 and IC 8, send pulses to the respective LED's

The indicator LED's are housed in a separate chassis box. This box includes two sets of LED's; red LED's to indicate power, and a green LED's to indicate different selections. The chassis box is mounted to the Plexiglas tray on the client's wheelchair. A 6-volt, 10 amp rechargeable, gel-cell battery pack is used to power the device. The battery and circuitry is housed in the control box. The power switch, reset button, switch jacks, and recharger plug are located on this box. The control box will remain in a vinyl carrying bag that will be fastened to the back of the client's chair. Along with the control box, the carrying bag will contain a battery charger. The materials cost for this device was $370.

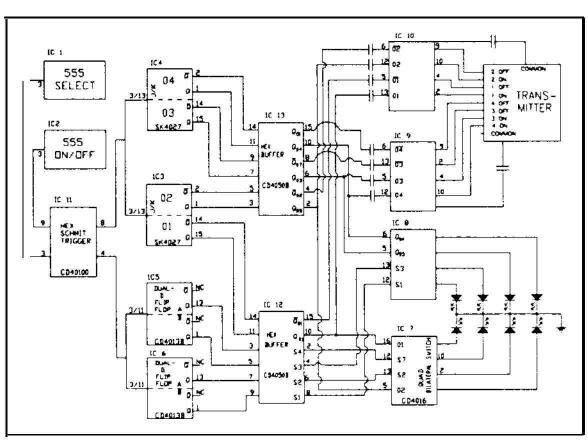

Fig. 18.5. Circuit Diagram for the Environmental Control Device.

Hydrotherapy Platform

Designers: Steve Logh y, Jeff Nance, Jeff Walker
Client Coordinator: Rhoda Ruffner, Siskin Hospital
Supervising Professor: Dr. Edward H. McMahon
School of Engineering
University of Tennessee at Chattanooga
Chattanooga, TN 37403

INTRODUCTION

To enhance the hydrotherapy treatments for the client, a patient at Siskin Hospital, a platform has been designed and built for use in the pool at Siskin. The hydrotherapy platform consists of three major components: the frame, the deck, and the legs. The assembly of the platform will be simple, first the legs will be inserted into the frame, and then the decks will be snapped on. The final design is a result of repeated analysis and iterative idea processing.

The device is relatively easily handled by two persons, simple to assembly, can be stored in a small space (1'-4" x 7'-4" x 4'-2"), and provides a stable, fully adjustable, safe, therapy surface. Construction was entirely of various PVC fittings and pipe except for the platform which was constructed of 1/16" thick aluminum.

SUMMARY OF IMPACT

The client has Cerebral palsy with spastic diplegia, which is characterized by low postural tone in her neck and trunk, while having increased tone in all her extremities. An adjustable, stable platform is needed to support the client and her therapist while in the water. Hydrotherapy is essential for the client because the buoyancy of the water gives her postural support, allowing for more normal posture and movement. Currently, she has been using the steps in one comer of the pool, which do not permit a great deal of exercises. With an adjustable platform, the client, assisted by her therapist, can work on her hydrotherapy in a more efficient and conducive environment.

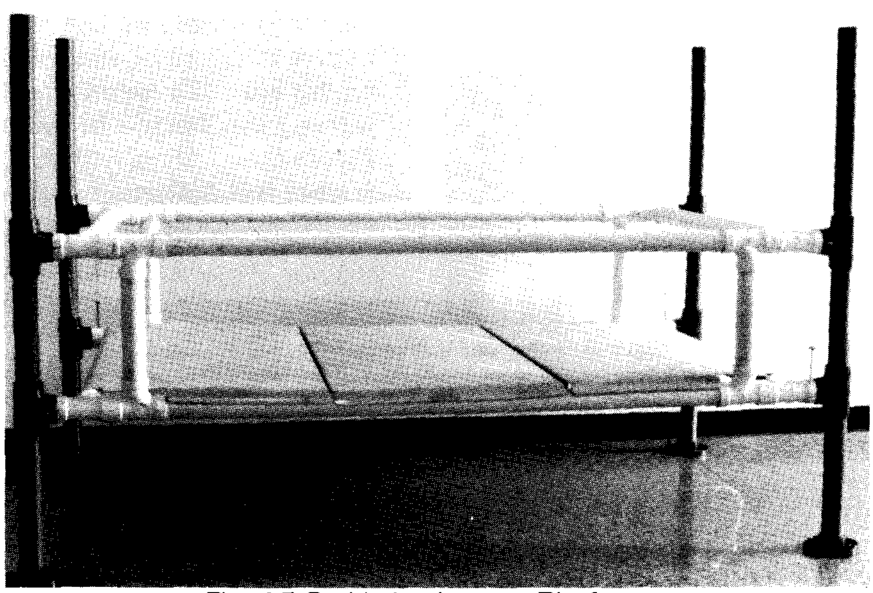

Fig. 18.6. Hydrotherapy Platform.

TECHNICAL DESCRIPTION

Frame - The initial design consisted of several pieces that required construction before the platform was operational. In order to reduce the number of pieces that must be assembled each time the platform is used, an integrated one piece design was developed. This frame will be 4 feet wide by 5 feet long by 1 foot high and made of 2.0" diameter schedule 40 PVC. The frame will ease assembly, facilitate easier height adjustment, decrease the possibility of lost parts, provide desired height railing, and create a rigid more stable structure. The unit will be stored *in* a small space beside the pool and this one piece design will allow for neat and simple storage. The frame was permanently glued together, requiring only the legs and deck to be added.

Deck - The platform material decided upon was aluminum. Aluminum was the least expensive material considered but required some professional quality fabricating techniques that would involve labor costs. The platform consist of three sections of 1/8 inch sheet aluminum. Each section is approximately 19.5"W x 48"L with a 1" edge turned down for structural support and rigidity. In order to provide a safe device for use in water, a nonaggressive, skid proof surface is needed to eliminate the chance of a patient accidentally slipping off the platform. To meet this objective the surface of the aluminum was sand blasted.

Legs - The legs will consist of 2.0 inch schedule 80 PVC pipe with a schedule 80 PVC pipe flange attached to the end. Each leg will slide into a schedule 80 PVC tee that has been altered by boring the inside diameter to match the outside diameter of the leg pipe. The tee is permanently attached to the frame and the flange is permanently attached to the leg. The pipe, tees, and flanges were drilled to accept a pin. Walter A Wood supplied a high strength tee that met the desired needs. The high strength was needed to resist the forces applied by the pins that connect the pieces to the leg pipe. Quick burst tests reveal that the fittings are at least 10% stronger than conventionally designed fittings. The flanges will have a rubber pad glued to the bottom of them to provide grip.

Pins - The pins are stainless steel for corrosion resistance and have a spring loaded ball to lock them securely into place after insertion. The pins were attached to the frame with stainless steel, nylon coated lanyards, to prevent loss and therefore ease assembly.

The cost for the device was $328, including the stainless steel panels that were fabricated.

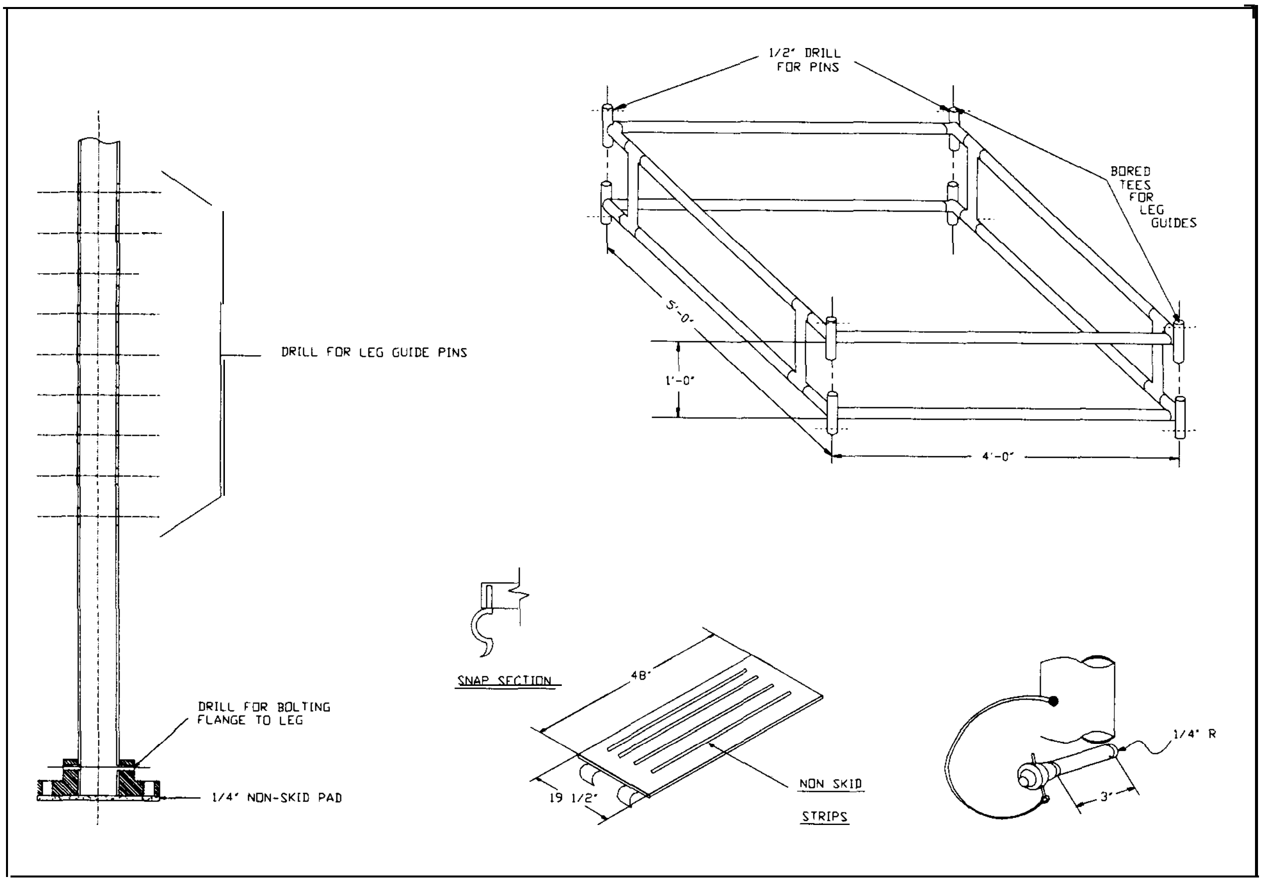

Fig. 18.7. Structure Diagram for the Hydrotherapy Platform.