CHAPTER 13
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

College of Applied Life Studies
Division of Rehabilitation Education
S. Oak Street
Champaign, Illinois 61821

Principal Investigator:

Mark G. Strauss, Ph.D. (217) 333-4613

Transfer Device and Swivel Mechanism

Designer: Rebecca Gaa
Client Coordinator: Laura Buss
Supervising Professor: Dr. Mark Strauss
Division of Rehabilitation Education and
Department of General Engineering
University of Illinois at Urbana-Champaign
Champaign, IL 61820

INTRODUCTION

A request was made by a person with Cerebral Palsy, who uses a wheelchair, for a device that would enable him to be able to get into a reclining chair independently so he could watch TV in comfort, and not have to remain in his wheelchair all day. The major considerations in this project are: (1) being able to have the area between the chair and the television clear so that the view is unobstructed, (2) not blocking the living room area where the chair is, (3) a device that is light enough to be moved for easy cleaning and usage, and (4) independent operation and transfer.

SUMMARY OF IMPACT

The devices delivered to the client met with his approval. Some problems that developed over the course of the project arose primarily from the swivel mechanism. The chair designed is a chair that reclines and inclines. When the chair is in its upright position, the center of mass is not at the center of the chair, but slightly forward. This fact, combined with the weight of the user and the chair itself, caused enough deflection in the Lazy Susan bearing to allow the two pieces of plywood to rub together. When this occurs, the user is unable to turn his chair. To counteract this affect, ten ball bearings are positioned in a circle around the large bearing to guard against deflection and allow the device to easily rotate. A piece of metal cut to the shape of the plywood is mounted onto the underside of the top piece of plywood. The ball bearings turn upon the metal, and allow for less friction than would occur with the plywood. Once these improvements had been made, the swivel device worked smoothly. Because of the extreme cost, a larger Lazy Susan bearing was not purchased.

Figure 13.1. Photograph of Transfer Device and Swivel Mechanism.

TECHNICAL DESCRIPTION

The most effective design in satisfying the needs of the client is a transfer device, consisting of a set of parallel bars mounted to plywood, and a swivel mechanism for the chair. The client is able to transfer from his wheelchair to another chair using a set of parallel bars. A 3” length is the minimum needed to make this transfer. The parallel bars also need to be able to support his full body weight (approximately 95 lb.). Because he has extremely limited use of his legs, while transferring from his wheelchair to the reclining chair, all of his weight is on one of the bars at one point. This causes both bending and shear loads to be applied both to the parallel bars and the screws that attach the bars to the plywood. 1" outer diameter steel metal pipes are used with “Key Klamp” flanges to construct the parallel bars. The flanges allow the pipes to fit inside of them, and be tightened with a hex wrench. This allows for easy installation and repair if needed. The steel pipes are also covered with pipe insulation to allow for some padding during transfer. The dimensions of the parallel bars, and the types of flanges needed, are described in Figure 13.2 and Figure 13.3.

The parallel bars are mounted to a $\frac{5}{8}$" thick piece of plywood for stability reasons. The piece of plywood is 29"×62", with Sections cut out on the sides so that the entire unit weighs less, and is more aesthetic. 2" is left around the entire base of the flanges to ensure that the shear and bending forces are accommodated.

The swivel mechanism is designed so that the client's reclining/inclining chair can be placed on top of it, and be rotated to face the TV. The chair weighs approximately 150 lbs. Thus, the design project need to support a total weight of approximately 250 lb., including the client. A 12" diameter "Lazy Susan Bearing," as well as 10 individual ball bearings are mounted with bolts (Lazy Susan Bearing) and wood screws (ball bearings) between two pieces of 5/8" thick plywood (36"×30$\frac{1}{4}$" for top piece and 36"×30" for the bottom piece) to accomplish this. The Lazy Susan Bearing is placed in the middle of the 29$\frac{1}{4}$" x 30$\frac{1}{4}$" portion of the swivel device. The 10 individual ball bearings are placed in a larger circle around the large bearing to protect against deflection and subsequent friction between the pieces of plywood when the chair is placed upon it. A piece of metal is also mounted under the top piece of plywood so that the 10 individual bearings have a harder rolling surface and less friction than the plywood itself. 2"×1" finishing boards were placed around the 29$\frac{1}{4}$"×30$\frac{1}{4}$" area on the top piece of plywood, such that the chair just fits inside this area and will not slide off of the swivel device.

A locking mechanism is built into the swivel device so that the chair does not rotate during transfer, resulting in possible injury. A flange with a 1.0" diameter hole is screwed to the top piece of plywood and 1$\frac{1}{4}$" hole is drilled in both the top piece of plywood, and a tab off of the bottom piece of plywood. A 6" steel nipple, threaded at both ends, is screwed into the flange and then machined with four slots in the top end. These slots are machined such that a 1" diameter wooden rod, with a pin punched through it, easily fits through the nipple, flange, and holes in the plywood, with the pin fitting easily into the slots in the nipple. The deeper slots are positioned such that when the pin is resting at the bottom of them, the wooden rod is in contact with the side of the hole in the bottom piece of plywood. In this position, the swivel device does not turn. The smaller slots on the nipple constitute an unlocked position where the swivel turns.

The only improvement that could be made to the parallel bar mechanism is in the mounting device. There is a slight amount of deflection in the $\frac{5}{8}$" plywood when the parallel bars are torqued outward. This deflection could easily be reduced by using thicker plywood or a stiffer material. The total cost of the project is $252.

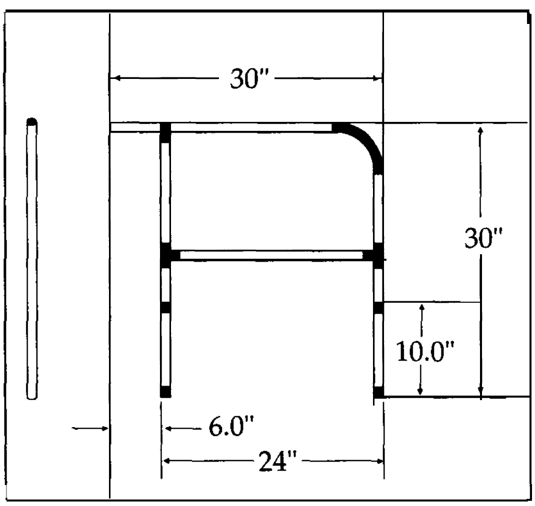

Figure 13.2. Side View of Handrails.

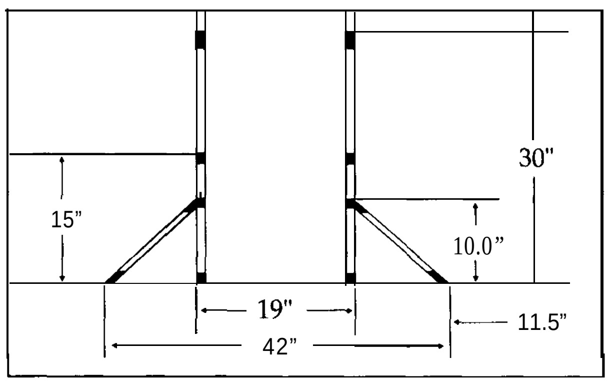

Figure 13.3. Front View of Handrails.

Design of a Transport Device for Two Three-Wheeled Electric Scooters

Designers: Richard *Fudacz and* **Chris** *Dyrby*
Supervising Professor: Dr. Mark Strauss
Division of Rehabilitation Education
University of Illinois at Urbana-Champaign
Champaign, IL 61820

INTRODUCTION

A married couple in Springfield, IL, own two Pride Shuttles, three-wheeled electric scooters, to assist with their mobility. The gentleman suffered a stroke earlier in his life, and has no use of his left arm and partial use of his left leg. One limitation that he has is the distance that can be traveled when walking. The woman had her lower lumbar spine fused and also has arthritis in her knees. Due to the fusion, she has difficulty lifting light objects. Also, the arthritis limits the amount of walking she can do. They requested an easy way to transport their electric scooters without the difficulty of disassembly to lift them into the trunk of their Chevrolet Cavalier.

SUMMARY OF IMPACT

Each scooter weighs approximately two-hundred pounds and can be disassembled into three sections; the maximum weight of any section is sixty pounds. A custom trailer was designed to transport the scooters. The trailer designed is similar to a tilting snowmobile trailer. It has bed dimensions of five-feet by five-feet, instead of the standard four by eight feet.

TECHNICAL DESCRIPTION.

To meet the needs of the clients, the device designed must:

- Work with a mid-sized automobile (i.e., a Chevrolet Cavalier). This type of car cannot use standard bumper lifts.
- Carry two, two-foot by four-foot electric scooters long distances.
- Keep the scooters as one unit (assembled) for transport.
- Have a means to keep the scooters out of harsh weather, i.e., an enclosed space.
- Allow full use with only one hand, and without requiring great strength or stability by the operator.

These general constraints led to the design of a modified snowmobile trailer.

Trailer Constraints

- The trailer should have a maximum one-hundred pound tongue weight and one-thousand pound overall weight, as dictated by the hauling capacity of the vehicle.
- Must be easy to maneuver when driving.
- Must be as low as possible to the ground for mounting and dismounting the bed of the trailer.
- Since the electric scooters may be driven onto the trailer, a ramp with a slope no greater than 1" of rise for every 8" of run must be used (ANSI standards).
- The space used must be large enough for people to be able to secure the carts to prevent bouncing during transport.

With the couple's limited mobility, concerns about their safety is also a prime factor in the design of the project.

Safety Considerations

- Should not require the couple to get onto the trailer for fear of them falling off or having to step down off the trailer and tripping.

- With their physical impairments, no lifting of the scooters was desired.

The trailer designed is similar to a tilting snow-mobile trailer. It has bed dimensions of five-feet by five-feet, instead of the standard four by eight feet. For attachment to a car, the designed trailer has a three foot tongue. Sloping side-walls, 48” high at the rear and 36” in front, and a roof to protect the scooters from the weather is used in the design. The roof itself is bent to resemble the roof of a house; this bend gives the trailer’s roof strength to resist bending when wind hits it while traveling. For access to the enclosure, doors are placed at the rear of the trailer. To control the tongue weight, the axle of the trailer can be placed 36” to 39", (60 to 65 percent of the bed length), back from the front of the trailer. This also places the center of gravity between the axle and hitch. The bed of the trailer sits thirteen inches off the ground, giving a maximum height of five feet, which includes the side-walls. The trailer bed when fully tilted about its axle creates an angle of approximately 25” with the ground.

Resting in channels on the outer edges of the trailer is a slide-out platform that is pulled out of the trailer bed in order to load the scooters. When the scooters are loaded and secured, the platform is then pulled back onto the trailer bed with the use of an electric winch. The platform is $57'' \times 53\frac{1}{2}''$, with rectangular carbon-steel tubing creating its frame, and a wooden floor covering the frame. The platform is able to slide on and off the trailer by use of six 4” diameter polyurethane wheels.

Loading Procedure

The trailer remains secured to the car while loading and unloading. The trailer is tilted by a screw jack placed near the front of the trailer bed. As the handle of the jack is rotated, the front of the trailer bed is lifted until the rear touches the ground. With the rear of the bed on the ground, the slide out platform rolls down the side channels onto the ground and out of the trailer bed. Fully extended, the platform makes an angle of 4” with the ground. The back of the platform rests three inches off the ground due to the rear wheels. Therefore, a fold out ramp is included at the end of the platform. The ramp, eighteen inches long, is split into two sections so as to have a separate ramp for each scooter. This is necessary to prevent the scooter’s wheels from having to climb three inches from the ground to the top of the platform. After the scooters are on the platform, they are easily secured for transport by use of nylon straps. An electric winch then draws the platform back onto the bed.

Shown in Figure 13.4 through Figure 13.7 are illustrations of the transport device for two three-wheeled electric scooters. Approximate cost of the device is $1700.

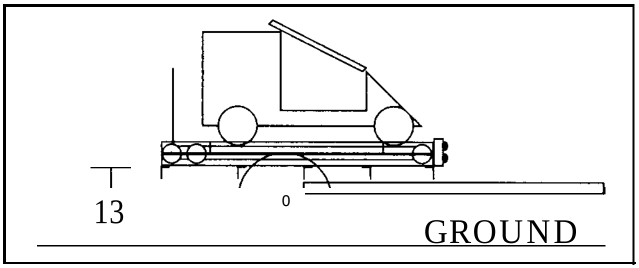

Figure 13.4. Platform and Trailer Parallel to the Ground.

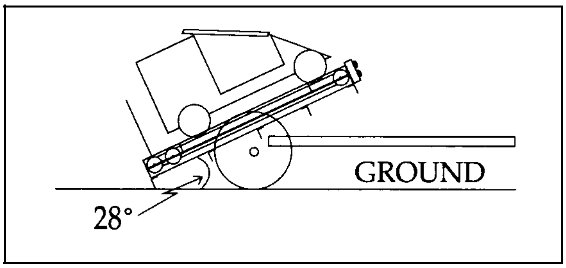

Figure 13.5. Trailer Fully Tilted.

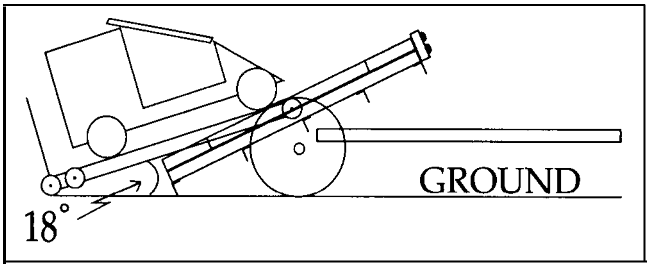

Figure 13.6. Platform 50% Extended.

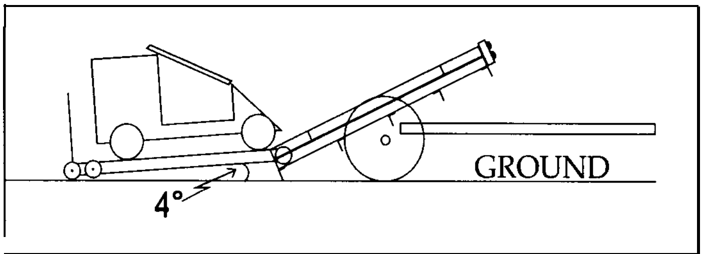

Figure 13.7. Platform Fully Extended.

Tactile Pacer

Designer: William P. McGrath
Client Coordinator: Client's mother
Supervising Professor: Dr. Mark Strauss
Division of Rehabilitation Education and
Department of General Engineering
University of Illinois at Urbana-Champaign
Champaign, IL 61820

INTRODUCTION

This project was initiated to aid a thirteen year old girl who has had a brain tumor surgically removed. Her disability makes it difficult for her to stay on task and perform tasks quickly. One solution to these problems, found by her therapist, is to use an auditory pacing device, such as a metronome, to restore her body's natural sense of time awareness. Based on this principle, a portable, tactile pacing device is developed in this project. Worn like a broach pin on the inside of the person's clothing, the coil vibrator resonates against the person's collar bone. This vibrator is controlled and powered by a battery pack which clips onto the person's waist by a belt clip. The pulse rate of the vibrator is adjustable between 0.5 Hz and 1.25 Hz. Both the on-off switch and the frequency control are easily accessible and are externally mounted on the battery pack unit.

Figure 13.8. Photograph of Tactile Pacer.

SUMMARY

The problem is to aid a girl who has lost her ability to concentrate as well as her natural awareness of time due recent brain tumor surgery. The desired solution is to improve her concentration ability so she could carry out tasks without being distracted using a portable tactile pacing device.

PROJECT CONSTRAINTS

- Small and portable: The device was intended to be worn on the person. Consequently, the size and weight of the device are minimized so it would be as non-intrusive as possible for its user.

- Attached to responsive location on body: When the tactile pacer was being developed, speech and hearing science researchers were consulted to determine where would be the most effective location for placement of the pacer. Research shows that the pacer stimulus would be most perceived on a bone area, such as the sternum, collar bone, hip bone, or wrist.

- The control device must be easy to operate and need no explanation. No inner casing adjustments are permissible.

- The product is used by a 13 year old girl through all activities. Therefore, the device must be durable enough to withstand being bumped and dropped.

- Sufficient power supply and power efficiency for more than six hours of use at a time without recharging.

- The device needs to look attractive to the girl.

TECHNICAL DESCRIPTION

The Audiological Engineering Corporation uses small battery operated vibrators to convert auditory sounds into tactile stimuli. Since this vibrator satisfies the specification, it is used to provide the tactile pacing stimulus to the client. The vibrator is optimally powered by an 8V, 250 Hz signal. The current draw varies between 40 to 100mA. A main goal of the circuit design is to allow for easy adjustment of the vibrator to provide $\frac{1}{2}$ to $1\frac{1}{4}$ Hz bursts of 250 Hz. The $\frac{1}{2}$ to $1\frac{1}{4}$ Hz pulse rate was requested by the client. The CMOS 556 timer chip is ideal for this problem. This chip contains two oscillators which can be independently set at different frequencies set in free run, astable mode.

The output of the second oscillator is controlled by a 500 kΩ single turn potentiometer. The full rotation of the potentiometer varies the output of the first oscillator between $\frac{1}{2}$ to $1\frac{1}{4}$ Hz. The output of the second oscillator is set at 250 Hz. The result of the two oscillators working together is that the first oscillator enables the output of the second oscillator, which resulted in bursts of 250 Hz square waves occurring at a frequency between 0.5 and 1.25 Hz.

PRODUCT SPECIFICS

A CMOS family microchip is chosen because energy efficiency is essential and quick switching speed is unnecessary. The Texas Instruments TLC556CN is chosen for its minimal quiescent current drain of 2.6 mA, and the chip's ability to work under varying voltages (2-18 V). It is necessary to choose a chip that can operate under varying voltages, since the circuitry is powered from batteries which fluctuate in their voltage output as the batteries deteriorated over time. The energy efficiency of the circuitry is optimized for 3 weeks of continuous operation without needing the 4 AA alkaline batteries replaced.

A 2N2222 invertor is used to improve the power efficiency of the circuit. For the given desired frequency, the CMOS 556 oscillators has a duty cycle ranging from 58 percent at $\frac{1}{2}$ Hz to 66 percent at $1\frac{1}{4}$ Hz. A duty cycle less than 50 percent is desired to minimize the voltage drawing time of the vibrator and, thus, improve the power efficiency of the circuit. Hence, an invertor is placed between the first and second oscillator, producing duty cycles of 42 percent at $\frac{1}{2}$ Hz and 37 percent at $1\frac{1}{4}$ Hz. The transistor reduces the duty cycle by making a formally high signal output low and a low output high. The 2N2222 transistor is chosen because it is an easily attainable, inexpensive invertor.

The ON voltage from the second CMOS 556 oscillator triggers the gate of the MOSFET N transistor, causing 6 V to be delivered to the vibrator. The gate is opened and closed at 250 Hz caused by the second oscillator. The MOSFET N is chosen because it inexpensively performs, without bias, this voltage reduction.

The durable, aesthetically designed circuitry enclosure is fabricated to have a self-contained battery compartment, so the enclosure will never have to be opened, exposing the circuitry and the 4 AA batteries housed in a $3\frac{1}{4}$ “x5.6” x $1\frac{1}{2}$" (UL rated high-impact ABS plastic) enclosure, which is worn on the waist by a belt clip. The cable connecting the vibrator to the circuitry unit has a quick disconnection 5/32" plug and jack so the cable or circuitry are not damaged in the event of the cable being accidentally pulled.

SAMPLE CALCULATIONS

Calculations were performed to determine the values for the two resisters and capacitor that would give the desired oscillation frequency to the TLC556CN. The formula is as follows:

$$\text{Frequency of oscillation} = \frac{\mathbf{1.38}}{(R_A + 2R_B)C}$$

$$\text{Duty Cycle} = \frac{R_A + R_B}{R_A + 2R_B}$$

For example, the low frequency oscillator has R_A = 222K ohms, R_B = 270K ohms, and C = 1.5 µF. Thus,

Predicted frequency =

$$\frac{\mathbf{1.38}}{(220K + 2 \times 270K) \times 1.5\ 10^{-6}} = 1.2Hz$$

Duty cycle = $\dfrac{220K + 270K}{220K + 2 \times 270K}$ = .644 = ***64.4*** percent

The total cost of the device is $89.

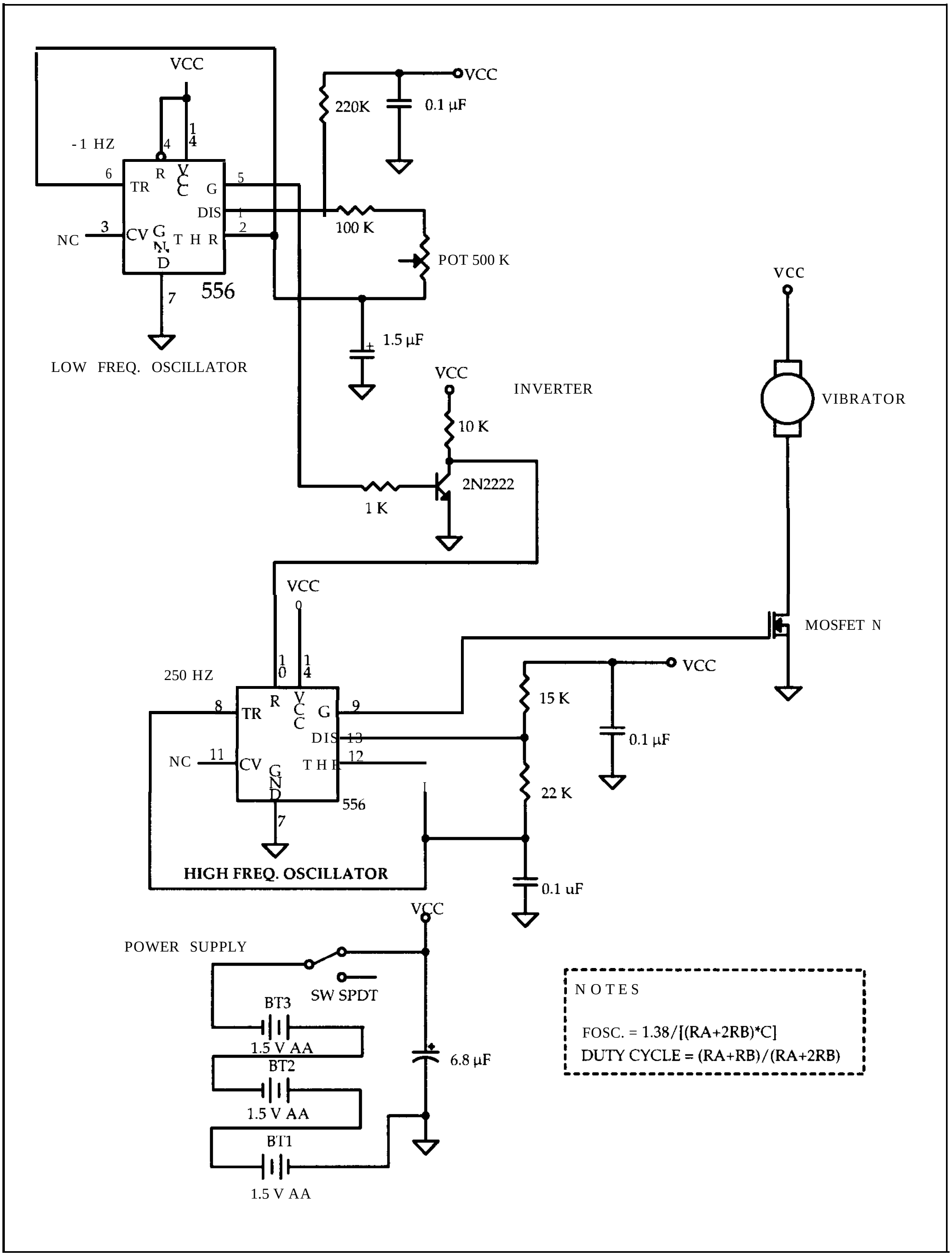

Figure 13.9. Schematic of Tactile Vibrator