CHAPTER 21
WRIGHT STATE UNIVERSITY

College of Engineering and Computer Science
Department of Biomedical and Human Factors Engineering
Dayton, Ohio 45435-0001

Principal Investigators:

Chandler A. Phillips (937) 775-5044
chandler.phillips@wright.edu

David B. Reynolds (937) 775-5044

LIGHTED CLOUD CEILING

Designers: Sudeepa Gupta, and Elizabeth Sowers
Client Coordinator: Brenda Anderson, Beavercreek Ankeney Middle School
Supervising Professor: Dr. Julie Skipper
Biomedical, Industrial and Human Factors Engineering Department
Wright State University
Dayton, OH 45435-0001

INTRODUCTION

Teachers in a middle school disability classroom desired a lighted ceiling for their current "visual room". The room consists of several visual therapy aids with rotating/flashing lights, including fiber optics. This room is designed to calm children during tantrums or episodes and to provide sensory stimulations.

The room was generally inviting except for its bare ceiling, which looked old and unattractive. The client wanted to give the ceiling a soft "cloudy" look with lights that run in different patterns for students to follow with their eyes. The client also wanted to have lights that are accessible for easy bulb replacement.

The final design is a set of ceiling panels with embedded rows of lights. The lights may run in different patterns. Fabric panels overlay the ceiling tiles, achieving the desired cloudy appearance.

Figure 21.1. Lighted Cloud Ceiling

SUMMARY OF IMPACT

The lights will improve the therapy room's design, contributing to both the calming and stimulating purposes of the room.

TECHNICAL DESCRIPTION

The device consists of 18 strands of LEDup brand LED Christmas lights embedded into the ceiling panels. Nine pairs of strands are connected to one another and one from each pair is plugged into one of nine sockets in the project box.

The project box contains two breadboards, one with the LM555, the 4017B and 2- 7416 inverters, and the other board containing 9 TRIACS and TRIAC drivers. These chips are soldered with several other components (resistors, capacitors, etc.). The project box and circuit are clamped to the ceiling, where the AC power supply is available and is controlled by a switch in the room. The procedure for using this device simply involves flipping a switch. There are no operation range limitations involved.

The arrangement of the lights allows a six-inch clearance around the sprinkler, and the pipes in the back of the room do not interfere with the design. Holes were drilled in the ceiling pads such that the lights are 3 inches apart and cover maximum area of the ceiling as desired. There are 18 rows of lights varying between 62 and 17 lights per row. However, because of the limitations of the circuitry, two rows were clumped together to illuminate at the same time. There are nine possible separate illuminations. To get the exact number of lights for each of the rows, these light strands were cut into smaller strands. Since these LED lights drew little current, a 2W, 560 Ohm resistor was used in the beginning and the end of each strand to drop the current. Given that these strands were smaller, the designers attached resistors, male and female plugs at the beginning and the end of each strand.

Figure 21.2. Ceiling with Fabric

Store-bought sheer fabric was sprayed with a fire-resistant spray. Three long panels of approximately seven yards each were cut and randomly pinned on the ceiling to give a cloudy billow effect.

A timing circuit was needed for controlling the lighting sequences. A versatile 555 timing chip (LM555) was used for this purpose. A 4017 Decade Counter was implemented to provide sequential logic output for pulse control of the timer.

An AC solid state relay was used to provide logic control of the 115V AC power for the lights. An AC solid-state relay was constructed using a 400V-4A TO-220 type TRIAC and an opto-coupled MOC 3031 Optoisolator TRIAC driver. The MOC 3031 contains an infrared-emitting diode optically coupled with a detector. The driver and TRIAC created a zero-voltage crossing circuit controlled by the logic output from the decade counter. A zero-voltage crossing circuit is a circuit that switches the load on or off only when the power-line sine wave passes through zero. When AC voltage is zero, no current flows, thus making it easier and safer for the relay to turn off or on. Given that the MOC3031 required a low level logic input, an inverter was used to invert the logic output obtained from the decade counter. A snubber arrangement to protect the TRIAC from reverse voltages was also used.

All parts of the circuit were individually soldered and tested, and then put together into a project box. Holes were drilled in the box and circuit board clips were inserted through them to hold the circuit boards. Several holes were drilled in the box to insert female plugs that were then connected to the male ends of the LED lights. Two more holes were drilled for an AC input to the circuit and a DC input from the transformer that drops 115V AC to 9V DC.

The total cost was approximately $860.

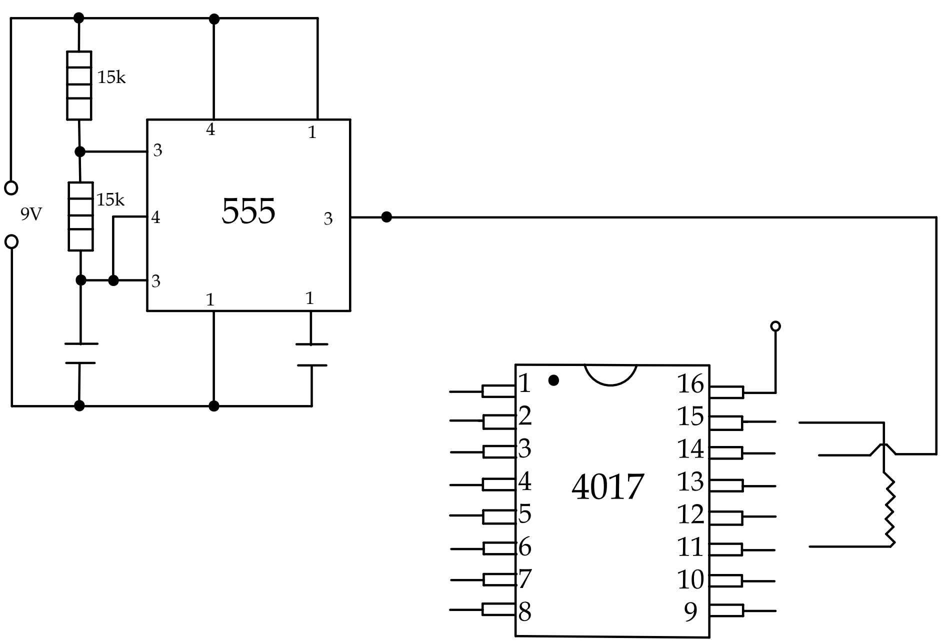

Figure 21.3. Timer and Decade Counter Circuit

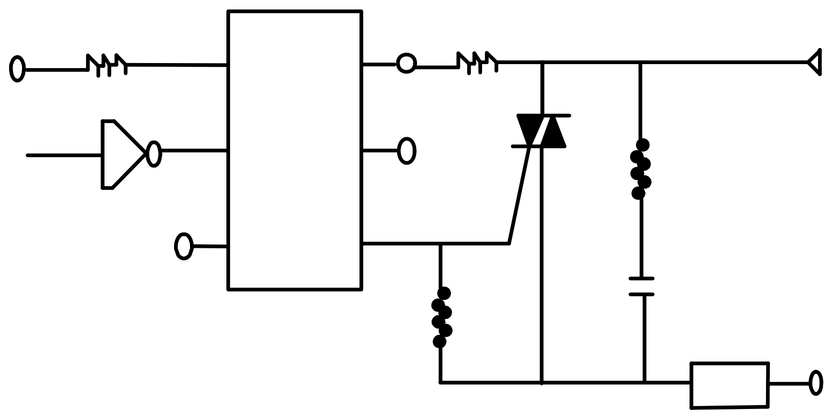

Figure 21.4. AC Solid State Relay Circuit

NURSING ALERT SYSTEM

Designers: Austin Balogh, and Jack Conyers III
Client Coordinator: Guy Parworth, United Rehabilitation Services
Supervising Professor: Dr. Thomas N. Hangartner
Biomedical, Industrial and Human Factors Engineering Department
Wright State University
Dayton, OH 45435-0001

INTRODUCTION

The staff of a rehabilitation center requested an efficient and standardized method of contacting the nurses in case of an accident or emergency. The nurses' station is located in a centralized location between several problem areas in the building. Although the nursing staff conducts rounds at various times throughout the day, nurses remain in the station for the majority of the day. If an emergency occurs, staff members must leave the scene to alert a nurse, or send another patient for help. The system is composed of five pieces: a nursing station unit and four units for locations where emergencies are most likely.

SUMMARY OF IMPACT

The problem area units allow a signal to be sent to the nursing station unit, which triggers an alarm and allows the nurses to send an acknowledgement that the alarm was received.

TECHNICAL DESCRIPTION

The system uses DC Voltage transformed from a wall outlet using a plug-in transformer. The chosen voltage was 9V since the BASIC Stamps microprocessors used to run the system are required to use a variable voltage from 6VDc to 24VDC. A current of 500 mA is sufficient to power all components. The nursing station unit issues power and commands to the four problem area units. It constantly queries the problem units. The problem units signal information in binary form if a button is pressed locally.

The nursing unit has one button for acknowledging if an alert comes in. It also contains eight LEDs, two per problem area. They show when an alert is present, and acknowledge that it has been pressed for a specific area. Another nursing unit feature is a buzzer alarm, which sounds when an alert comes in.

Figure 21.5. Nursing Station Unit Installed.

Each problem area unit consists of two buttons: an alert and reset. There are also two LEDs present on each problem unit: one informs the user that the button was pressed and the information has been sent to the nursing station, and the other shows that help is on the way once the "acknowledge" button has been pressed at the nursing station. The system is connected on a network.

When an "alert" button is pressed in any problem area unit, the nurses hear the alarm and press the "acknowledge" button in the nursing station unit. As soon as the "acknowledge" is pressed, the alarm sound ceases. The "acknowledge" light illuminates on the problem area unit panel showing that help is on the way. In addition, the "acknowledge" light illuminates in the nursing station, showing the nurses that the information was sent. After the problem is resolved, the nurse or staff member presses the "reset" button on the problem area unit panel. This turns off all unit area lights and resets the unit. In the case of an "acknowledge" being pressed before an alert is pressed, nothing happens and the system continues to run normally. In the unlikely case of all four or any combination of rooms having simultaneous problems, all lights remain on, and the alarm sounds each time a new "alert" is received.

The total cost of parts and labor was approximately $740.

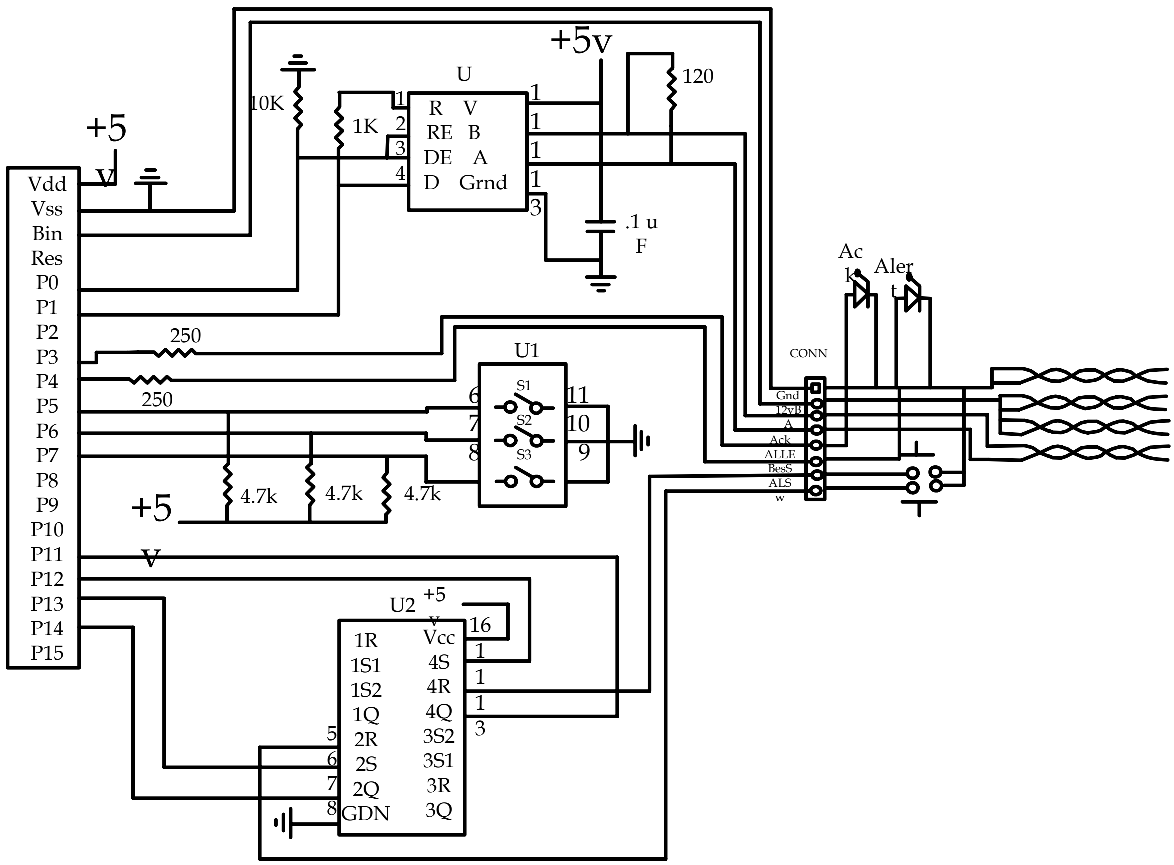

Figure 21.6. Problem Area Circuit Diagram

HAND WASHER

Designers: Johanna Bell, and Grant Roush
Client Coordinator: Guy Parworth, United Rehabilitation Services
Supervising Professor: Dr. David Reynolds
Biomedical, Industrial and Human Factors Engineering Department
Wright State University
Dayton, OH 45435-0001

INTRODUCTION

An automatic hand-washing device was designed to assist individuals with hand washing. The machine was required to have an independent power source to run electrical components, and to have water run into and out from it. The device has inner and outer housings. The inner housing is a water chamber, which contains the washing sponges; the user places a single hand inside this chamber. The outer housing contains a battery-powered motor used to spin sponges to scrub the hand. Plumbing provides water, and soap is available.

SUMMARY OF IMPACT

The mechanism utilizes soap and water, runs off of DC current, is stationary in a restroom setting, and fits easily into the space allotted.

TECHNICAL DESCRIPTION

The design incorporates electrical parts and moving parts with water. There are two housings: an outer housing that encases the motor, solenoid and electrical components, and an inner housing that encloses the sponges and flowing water (showerhead). The housings are made of acrylic. The acrylic is 1/4″ thick on all sides, except the base, which is 3/8″ thick. This allows for a sufficient surface area for bonding the pieces together. Minimal water exits the housing during washing with the aid of clear silicon sealant and Teflon tape.

For water input, a 12V, 14-watt solenoid valve is used to turn on and shut off water flow. The solenoid valve is rated for 80PSI, which is the standard water pressure in the building where it is to be used. The bottom of the inner housing has a hole cut into it to support a drain where water will be directed into one pipe that removes the waste water. Under ideal conditions, the device will be hooked directly into the building plumbing.

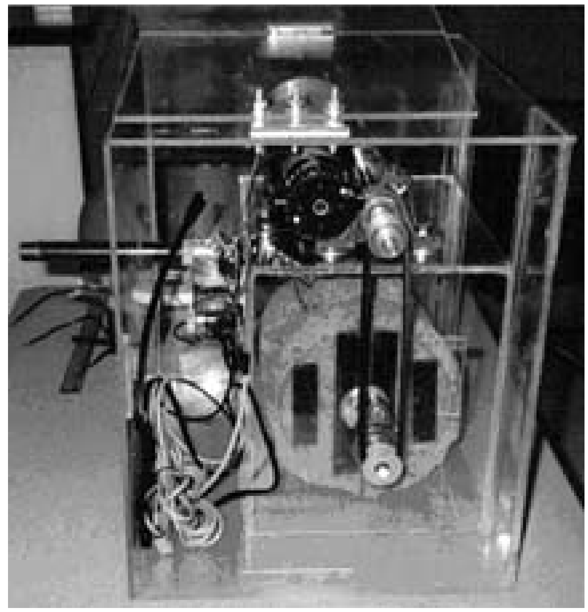

Figure 21.7. Hand Washer

A small, low-powered motor is used to spin the driveshafts of the sponges. The system uses two gears, one on the motor and the other on the driveshaft that is attached to the top of the inner housing. The gears use a 2:1 ratio; the larger gear is on the motor to increase the speed. The drive shaft on top of the inner housing is secured by two pillow blocks mounted to the top of the housing. This driveshaft drives two belts used to spin driveshafts on which two sponges are mounted on discs. The belts are connected to the driveshafts using 4 V-belt pulleys, and the sponge driveshafts are attached to the inner housing using two bolt flanges. A 12V DC, 136RPM motor is used to power the sponges. The low-voltage allows for the safest possible environment for the user.

Two batteries are used: one 12V, 7.5 Ah for the solenoid, and one 12V, 18 Ah for the motor. These batteries are rechargeable, and use connections that allow minimal contact with the terminals. The batteries are hooked up to the components using relay switches and infrared LED optical sensors. The relays function to minimize the current flow through the switches, since they can handle only 100 mA. The optical sensors are used to trigger the "on" and "off" setting of the device, and are mounted around the inner housing. When a hand is inserted, the device turns on; when a hand is removed, the device turns off.

The total cost was approximately $1155.

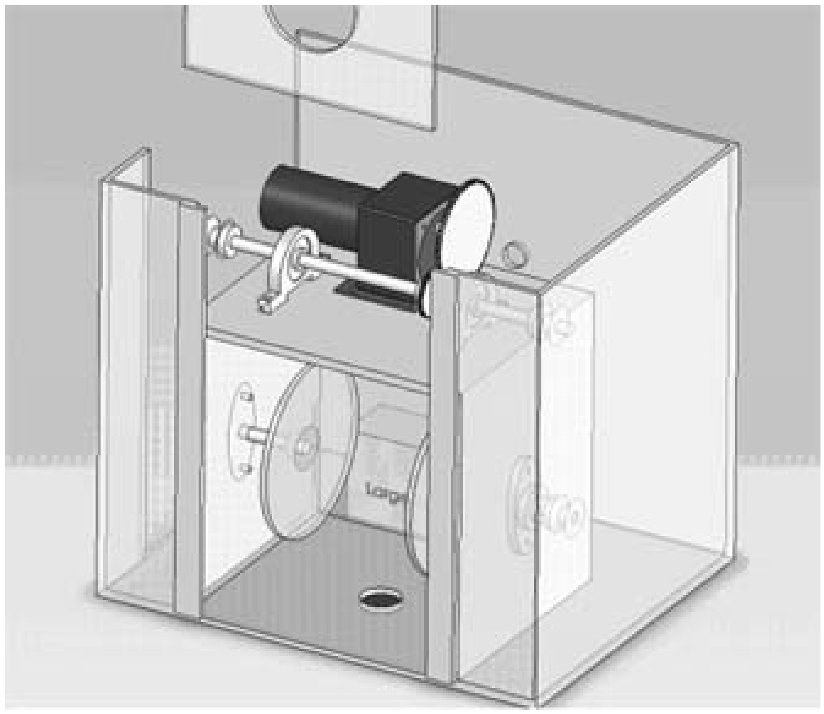

Figure 21.8 Solidworks CAD Drawing of Final Design

AUDIO-VISUAL ALERT SYSTEM

Designers: Andrea Bolds, and Victoria March
Client Coordinator: Guy Parworth, United Rehabilitation Services
Supervising Professor: Dr. Ping He
Biomedical, Industrial and Human Factors Engineering Department
Wright State University
Dayton, OH 45435-0001

INTRODUCTION

Staff members at a rehabilitation agency requested an audio-visual alert system in their adult activity center (AAC) room to notify the staff when a "help" button is pushed in the women's or men's restroom. The activity center is adjacent to both the women's and men's restrooms. At any given time, there are a total of five employees in the AAC room, all of whom are trained to respond to the call button from the restroom. The noise level in the AAC room often prevents these employees from hearing the alert siren from the restroom. The new design was to work in conjunction with an existing alert system.

SUMMARY OF IMPACT

The new system works in conjunction with the existing system, and expands the alert area by placing a second light tower in the AAC room. The women's and men's restrooms each have six stalls. A red pushbutton is located in each stall. When the button is pushed, it triggers a siren, and a blue light begins to flash outside the corresponding restroom. At the same time, a light tower turns on and the system flashes blue for men and green for women. The siren and the flashing lights do not stop until one of the reset buttons is pushed. This system requires little to no maintenance.

TECHNICAL DESCRIPTION

The system is composed of five major components: two transmitters, two receivers and a light tower that informs the staff in which restroom (men's or ladies') an alert button has been pressed.

Transmitter I is the reset button, and the only part of the system with which users will have contact on a daily basis. This wireless mobile pushbutton is located on the wall, under the light tower. The device runs off a 9-volt battery. Because the comparable receiver has a one-meter-long wire, the range of the transmitter is 500 meters. Receiver 1 is used for the reset. The receiver is powered by a 15V DC transformer. It is located in a project box in the AAC room next to the reset button.

Figure 21.9. Light Tower Installed in the Adult Activity Center

Transmitter 2 is a two-channel transmitter that is normally controlled manually, modified so that it now functions as a voltage-controlled switch. A 12-volt DPDT relay was used to short-circuit the pushbutton switch. To reduce maintenance requirements, the transmitter was changed from a 9-volt battery to a 9-volt DC transformer. This transmitter is located in the ceiling of the men's restroom; the location of the central hub. The range on this transmitter is 500 meters, the same as the one-channel transmitter. A voltage of 13.75 volts goes through the relay to activate the pushbutton. This voltage comes from the red pushbutton in the restroom. Receiver II is located in the AAC room and is connected to the light tower. This is where the signal is received to turn the light on. The power supply is a 24-volt transformer.

The light tower (Patlite Corporation) is located in the AAC room. It has two different alarm sounds. The blue light is paired with alarm 1 and the green light is paired with alarm 2. The sound is adjusted via a knob at the bottom of the tower. The range is from 0 to 90 dB. The client requested a minimum sound level of 70 db. The maximum volume of 90 dB was used. A project box, close to where the transformer plugs in, holds the 1A fuse for the tower.

The total cost was approximately $950.

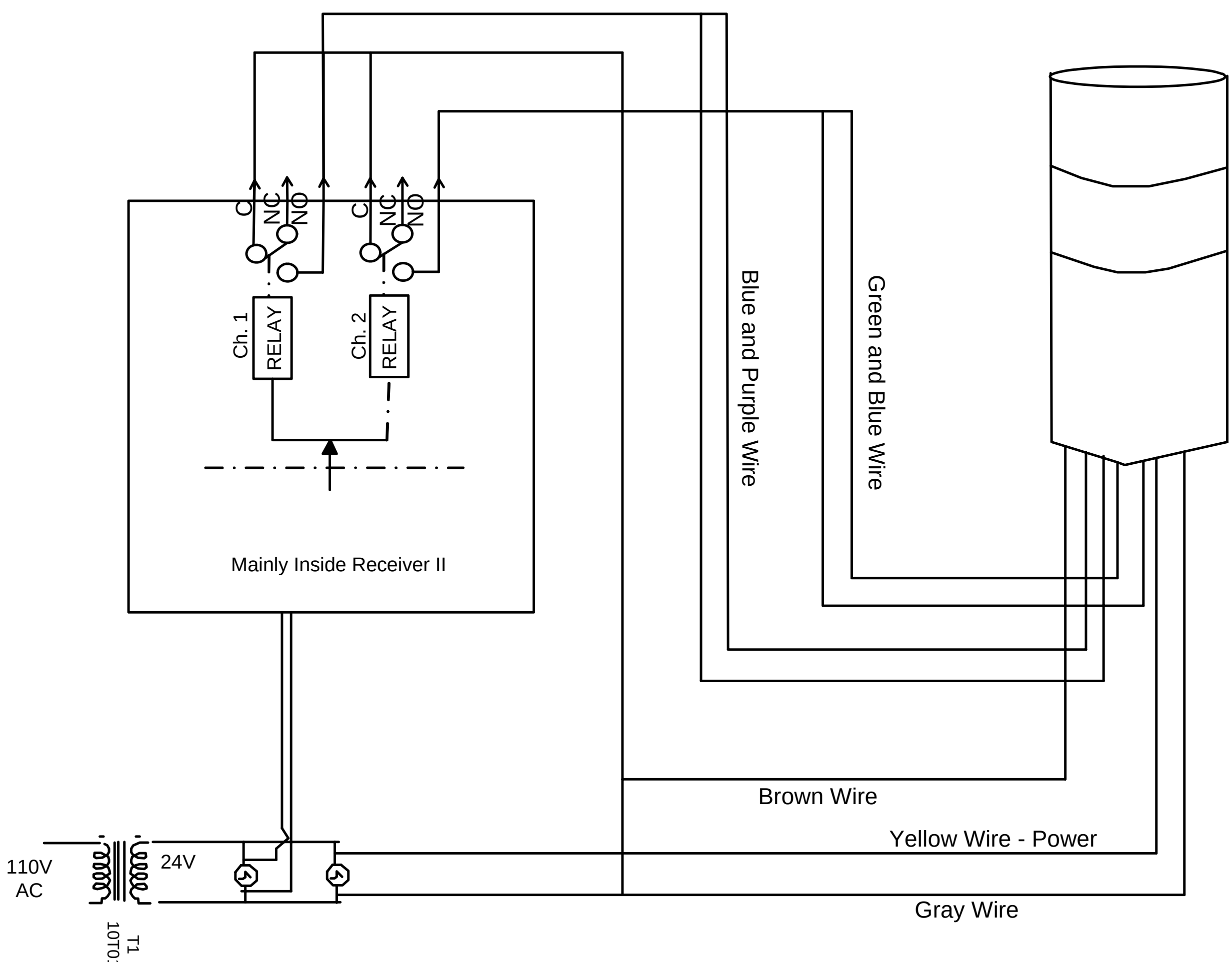

Figure 21.10. Connections between Receiver II and Light Tower

PAPER COLLATING MACHINE

Designers: Chet Closson, and Emily Ervin
Client Coordinator: Guy Parworth, United Rehabilitation Services
Supervising Professor: Dr. David Reynolds
Biomedical, Industrial and Human Factors Engineering Department
Wright State University
Dayton, OH 45435-0001

INTRODUCTION

A device was designed to aid a client in sorting a stack of papers into different piles, one sheet at a time. The client has the cognitive capability to decide where each paper is to be placed, but has physical limitations that make it difficult to sort the papers independently. The device specifications included being lightweight and portable. Additionally, the device was to be durable and to function as quietly as possible so as not to disturb others.

SUMMARY OF IMPACT

The user must have good arm control because the arm needs to stay in place for several seconds in order for the suction to begin lifting the paper. The user also may need to practice in order to lift the sheet of paper successfully and move it to the desired location.

TECHNICAL DESCRIPTION

The device consists of four major parts: the vacuum housing box, the vacuum, tubing and wires, and the arm piece. The purpose of the vacuum housing is to contain the vacuum and decrease the amount of noise. The box was created of scrap plywood. The length, width and height of the housing are 12, 9, and 6 inches, respectively.

The top of the box sits on hinges to allow easy access to the inside. On top of the box is a gold handle used to carry the device. The front has a latch for keeping the lid closed when transporting the device. There are three slots in the back of the housing for ventilation. On the left side of the box, a one-inch square has been cut out for the vacuum cord. When the device is not being used, the cord can slide through the hole and back into the box for storage. The right side of the box has a circle cut out with a diameter of ¾″. This is where the tubing and wires fit through the box. When the device is not being used, the tubing can be wrapped around the two

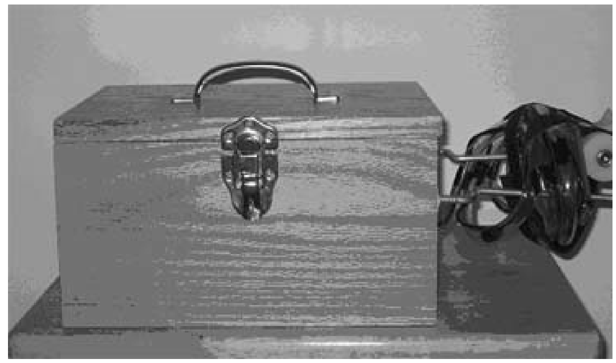

Figure 21.11. Front View of Paper Collating Machine

metal hooks attached to the right side. The hooks are screwed into the box, and are used only for storing the tube.

The vacuum is a computer keyboard vacuum. It is a standard vacuum that plugs into the wall and runs off 120 volts. A small vacuum was used in order to reduce the amount of suction and also to keep the device lightweight. The vacuum is secured to the bottom of the box with a bracket to prevent it from moving during transport.

Polyethylene tubing, with an inner diameter of 3/8″ and an approximate length of five feet, connects directly to the end of the keyboard vacuum. It attaches to a brass fitting at the other end. The fitting has a tight seal with the arm piece. Two five-foot 18-gage wires are taped to the tubing. These wires connect the vacuum switch to the switch in the arm piece. They are taped to the tube to prevent tangling.

The arm piece was machined from a nylon cylinder approximately 1 ½″ in diameter. It is six inches in length and has a 3/8″ threaded hole on each end. One end allows the fitting for the tube to twist into place. The other end was created only to simplify the drilling process. This end was closed off with a flat fitting that was threaded into place. The bottom of the arm piece has two grooves, two threaded holes, and one rectangular hole. The two grooves were cut to keep the Velcro straps in place when the client is using the device. The threaded holes were created to screw suction cups into place. The rectangular hole was created for the switch. Two smaller grooves were cut from this hole, allowing the wires attached to the switch to sit slightly inside the piece and not dangle in the way. The metal block fits over the switch to protect it, and is simply screwed into the nylon cylinder. On the top of the cylinder, a flat piece of acrylic is screwed into place so that the cylinder will not rotate on the user's arm when moving the arm piece.

The total cost of parts and labor was approximately $570.

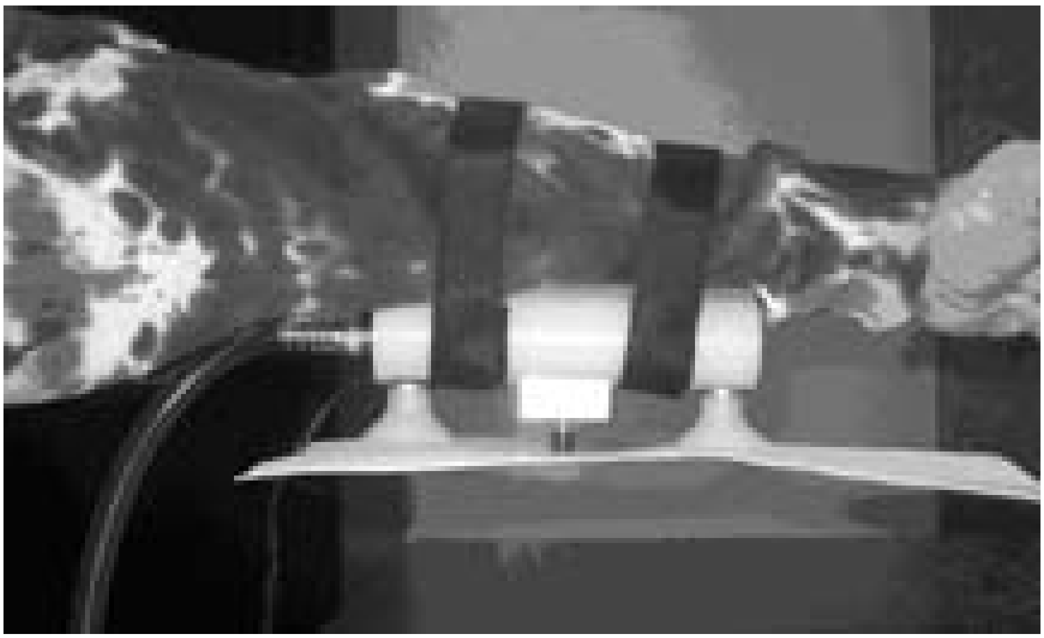

Figure 21.12. User Successfully Lifting a Single Sheet of Paper

ADAPTED RADIO

Designers: Veena Ganeshan, and Andrew Maley
Client Coordinator: Guy Parworth, United Rehabilitation Services
Supervising Professor: Dr. Blair Rowley
Biomedical, Industrial and Human Factors Engineering Department
Wright State University
Dayton, OH 45435-0001

INTRODUCTION

A standard radio was adapted for clients with limited fine-motor abilities so that they could independently control on/off, volume up, volume down, station up, station down, and AM/FM toggle switches. The radio was to be durable.

A conventional radio was rewired to accommodate adapted switches and a unique control interface upon which to mount the switches was built. A moderately priced model radio was rewired and fitted with headphone jacks so that adapted switches could be plugged into it. A wooden control interface was built and lined with Velcro so that switches could be attached to it and be easily rearranged.

SUMMARY OF IMPACT

This radio is now operable by both the factory set buttons and any adapted switch that uses a 1/8″ headphone plug. All factory-set buttons still operate as standard button switches and all functions may also be operated by pressing the appropriate adapted switch. Operating the radio requires only the push of a factory button or adapted switch that corresponds to the function desired.

The clients who were previously unable to operate standard switches can now operate the radio using the adapted switches. Users are able to reach the switches because of the specially designed interface. The device does not use more power than a standard radio, takes up only slightly more space than a standard radio, and does not require much training to use. It allows the users independence with a task that they could not previously perform.

TECHNICAL DESCRIPTION

The dimensions of the radio are 8.5″ X 3.5″ X 10.8″. Each speaker is 4.7″ X 5.9″. The weight of the radio is approximately seven pounds. The radio is rewired and designed to operate using adaptive switches with 1/8″ plugs. These switches are placed on a wood interface that consists of two parts. The wooden base has Velcro on top, used to attach the wood blocks to the base. The wood blocks have Velcro on the bottom to stick to the base. The blocks are designed with a vertical and an inclined portion for support and ease of use.

The mechanical design consists of two parts: the wooden base and six wooden blocks. The wooden base is a 3′ x 2′ oak-plywood board with Velcro on top and two handles for easy carrying. The second part consists of six wooden blocks. Each block is made out of 4″ X 4″ X 6″ wood chemically treated to withstand all weather conditions. There is Velcro on the slope and the bottom of the block. There is a hole on the top of the block, allowing the wired portion of the switch to pass through the back of the block. This prevents interference with the front portion of the interface. The sharp edges on the wood board were smoothed using sandpaper and lining to reduce the risk of injury.

The total cost was approximately $770.

Figure 21.13. User Operating the Adapted Radio

HEAT- AND OCCUPANCY-DETECTING SYSTEM

Designers: Jenna Garber and Mark King
Client Coordinator: Alena Hagendorn, Ohio Transportation Center
Supervising Professor: Dr. Ping He
Biomedical, Industrial and Human Factors Engineering Department
Wright State University
Dayton, OH 45435-0001

INTRODUCTION

A device was built to detect when there is an occupant in a vehicle and to track the temperature in a closed car. The device also automatically cools the car down when an occupant is inside at dangerous temperatures. An alarm system coincides with the car's cooling system to seek outside help in case the victim has no means of exiting the car without outside intervention. Door and engine sensors were added to make the device user-friendly and reliable.

SUMMARY OF IMPACT

Situations in which false alarms could be signaled include getting into the car while it is hot or driving in bumper-to-bumper traffic on a hot day. Both the engine and door sensors provide safeguards and a way to reset the circuit. These ensure that the system only activates in hazardous conditions.

TECHNICAL DESCRIPTION

A passive infrared motion sensor was selected for its ability to specifically detect heat radiation that living beings produce. This allowed a natural filtration via the glass windows of the car to prevent pedestrians from setting off a false motion signal, as infrared does not pass through glass easily. It also ensured that a change in heat radiation in the system is a living being, rather than someone bumping the car, or an object falling in the car, both of which would activate a motion sensor.

A basic thermistor (143-502LAG-RC1, Newark Company) was selected as the temperature-sensing device based on cost and reliability. The thermistor changes its electrical resistance in response to temperature changes. Resistance can be calculated by extrapolating the change in voltage within the circuit. Application of this principle to a basic comparator circuit proved to be the most optimal and accurate way to read temperature.

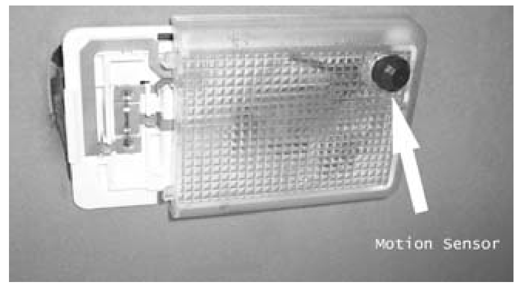

Figure 21.14. Motion Sensor Installed

The product sits in a 1.5″ x 9″ x 5″. plastic box. Once the device is installed in the user's vehicle, use is simple. If the system triggers by mistake, one need only open any of the doors or start the engine, as either of these actions immediately deactivates the horn and ventilation system. If, for some reason, this does not shut off the system, the user can simply separate the plastic connector that connects the product box to the car wires.

The transistor must support the current needed to trigger the relays connected to both the horn and the ventilation system. The relays required 160 mA. The NPN 2N2904 Transistor used can handle up to 200 mA of current. The Napion AMN12111 motion sensor was selected because of its size and its ability to detect slight motion. The slight motion detector allows very little movement before a signal is sent. The detector covers the entirety of the interior of the 1994 Saturn SL2 car in which the system is installed. The motion sensor provides an additional advantage of being able to be wired in parallel, offering bigger cars the advantage of having several motion sensors to ensure full coverage in the vehicle.

The thermistor permits the temperature/resistance relationship to stay within a 5% stability range. Once the final product was installed in the test car, it met all of the specifications.

The total cost was approximately $530.

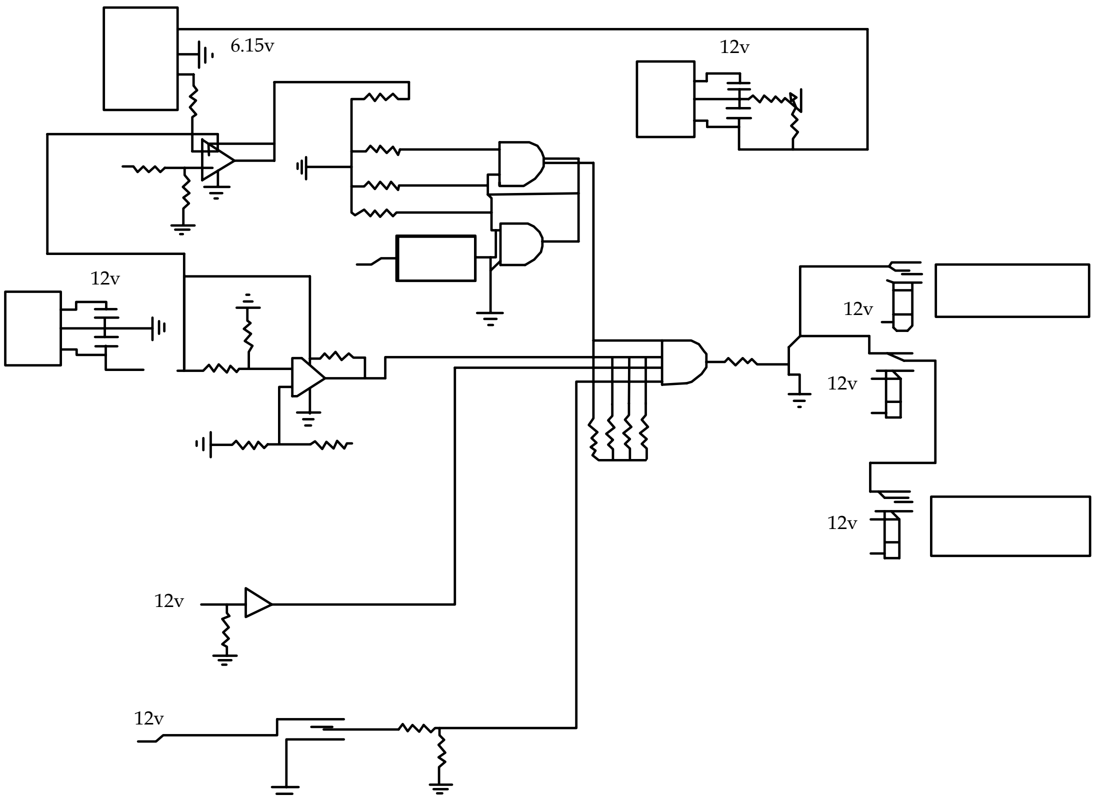

Figure 21.15. Circuit Diagram

ACOUSTIC VIBRATING PILLOW

Designers: Christina D. Schrider, and Jennifer Wappler
Client Coordinator: Diane Fredericks, Fairborn Primary School
Supervising Professor: Dr. Julie Skipper
Biomedical, Industrial and Human Factors Engineering Department
Wright State University
Dayton, OH 45435-0001

INTRODUCTION

A vibrating acoustic pillow was designed for children with autism in a special needs classroom. The product was requested to fulfill a need for an additional therapeutic device for the four- and five-year-old students who are receiving sensory integration therapy. The goal was to develop a design similar to the Somatron line of sensory pillows, mats, and chairs, yet include a stronger source of vibration and an integrated music source.

SUMMARY OF IMPACT

The new soft textured pillow that plays music and provides strong vibration is now in use in a classroom sensory integration therapy program.

TECHNICAL DESCRIPTION

The final design consists of a removable, stretch fabric cover with a pocket for the children to nestle under. The stretch fabric was also used to contain expanded polystyrene pellets in a three-section, two-layer bean-bag style pillow with two compartments used to house water mattresses, which assist in vibration wave propagation. The pillow was designed with hook and loop fasteners on the compartments housing the water mattresses, which allow access for repair or replacement in the event of a leak. All of the pellet compartments were sewn closed to prevent accidental ingestion of the pellets.

Hitachi massagers were used to provide vibration through contact with the water mattresses from beneath. They are embedded in the crib mattress foam and memory foam wedge. A Pillowsonic speaker system, located in the memory foam wedge under the child's head area, provides sound for the user but is not obtrusive to others in the classroom. The power, music components, and vibration control switches are in a foam wedge and base housed inside a steel project box under the pillow.

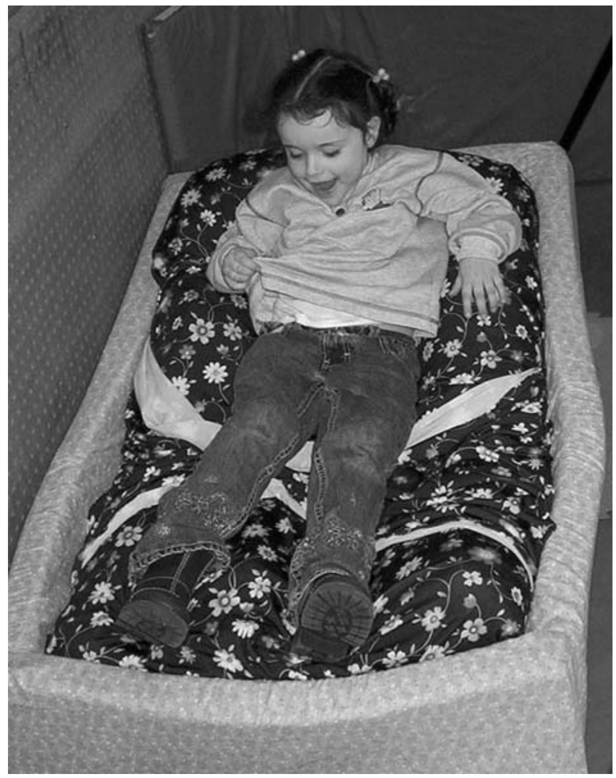

Figure 21.16. Child Using Acoustic Vibrating Pillow

The music and vibration are initiated simultaneously via dual-switch operation consisting of one on/off rocker switch and one timer switch. The power switch and timer switch work together to supply power to the pillow, but the power switch allows the user to interrupt a session before the timer has returned to the zero (off) position.

To meet classroom space constraints, the acoustic vibrating pillow was designed to be small. Additionally, the size, weight, and nylon belting handles ensure portability. The final dimensions of the product are 42″ long, 28″ wide, 14″ high at the head, and 9″ high at the foot of the pillow.

The total cost was approximately $725.

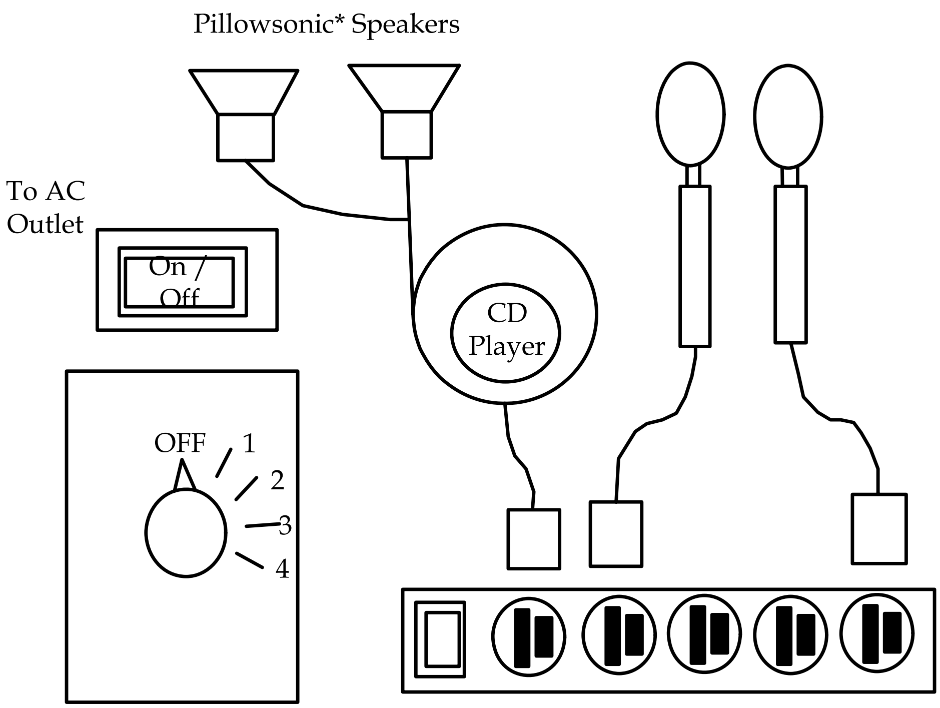

Figure 21.17. Circuit Diagram for the Acoustic Vibrating Pillow