CHAPTER 14
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OPTIMIZATION OF ENVIRONMENTAL CONTROL TO FIT A SMALL LIVING SPACE

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INTRODUCTION

An Infrared Point and Click subsystem was designed as a low cost environmental control system (ECS) intended for people with disabilities in a dormitory room. ECSs enable improved access to appliances and other environmental assets in their homes. The systems must be able to accept many forms of input from devices, such as sip/puff switches or push buttons, and translate this input into many different forms of output.

Most ECSs are not optimized for the dormitory room environment; they have inappropriate functions that can be wasted. This waste reduces their cost effectiveness. Currently, the price of fully functional ECSs ranges from $1000 - $6000. Reduction of cost and optimization of environmental control in small living spaces (like a dormitory) would make ECSs more available to and practical for college students.

SUMMARY OF IMPACT

The adaptation of home automation for people with disabilities has greatly improved the accessibility in the home environment. The modern ECS has become sophisticated and is able to provide a large range of environmental controls and flexibility for users.

The current ECS appears to have the capability to adapt to any situation and almost any user. Almost complete control over appliances can be achieved. It would be possible to use all available functions in a house, but full functionality would not realistically be achieved in a small one-room environment.

The components of the Infrared Point and Click system were built and laboratory tested. The client did not return to school. Thus, the subsystem remains untested in the field.

TECHNICAL DESCRIPTION

OUTPUT METHOD: THE IR RECEIVERS

A standard remote control, the Joystick TV Remote Control (detailed later), or a simple IR transmitter may be used to activate the receiver. A simple IR transmitter, designed with the client's abilities in mind, was built for use with the receivers. It features a 15-pin connector similar to those found on many joysticks. A schematic is shown in Figure 14.1.

This circuit uses 555 TTL IC's (timer chips). In combination with the correct resistor and capacitor values, the three 555 timers create square wave oscillator circuits at the desired frequencies. R_1 is connected to pins 7 and 8 on the 555 timer IC. R_2 is connected to pins 7 and 2. C is connected to pin 2 and ground. Increasing R_2 in comparison to R_1 makes the duty cycle even. R_1 should not be less than 1kΩ.

One 555 timer drives the infrared emitting diode. Its fundamental frequency must be 38 kHz for the optimal response in the IR receivers. The timer can be activated directly with pin 14, resulting in a positive output from an IR detector module in a receiver. Activation of pin 14 issues one command.

The other two 555 timers oscillate at approximately 2 kHz and 5 kHz. These timers drive the main 38 kHz timer, creating 2 and 5 kHz bursts of the 38 kHz signal. In an IR detector module, this produces square waves at 2 and 5 kHz, corresponding to two additional commands.

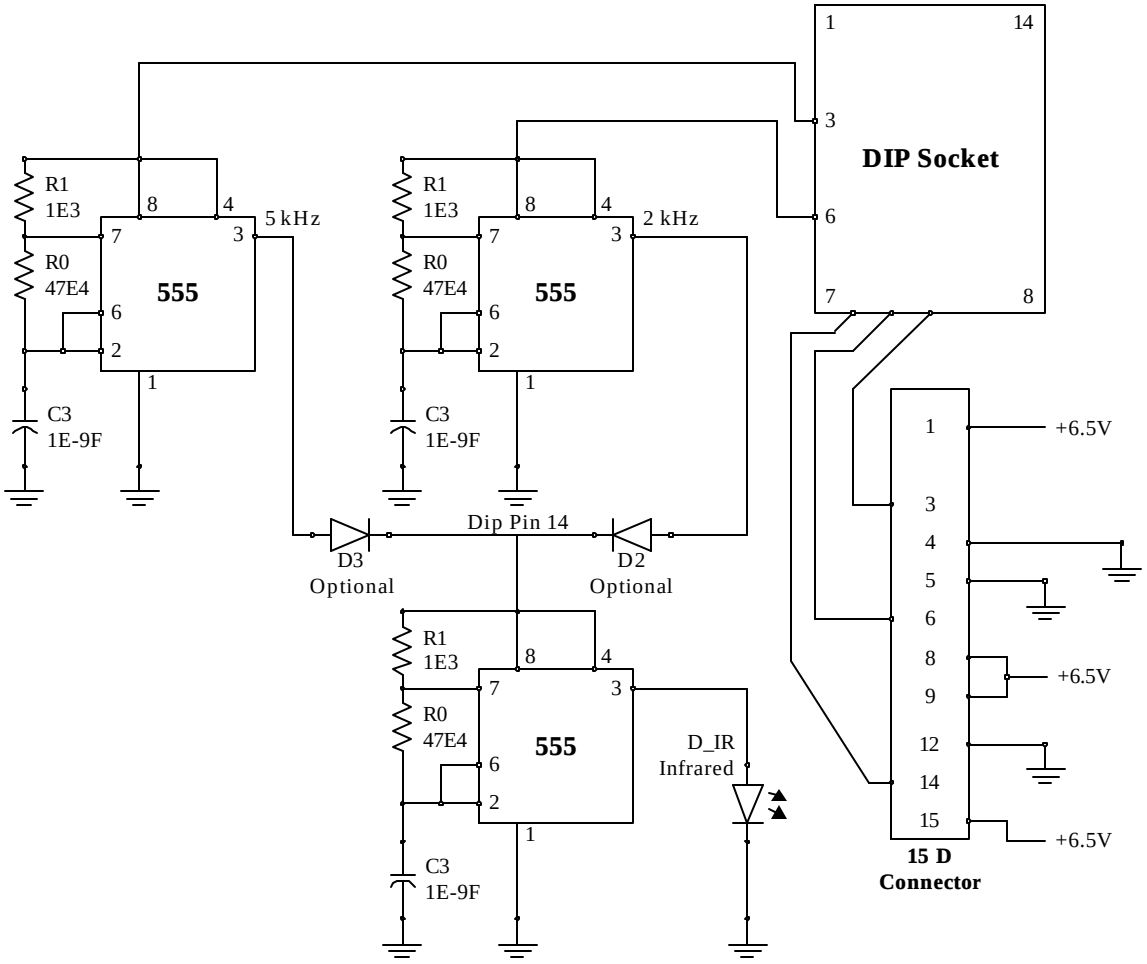

Figure 14.1. Schematic of a Simple, Thee-Command IR transmitter.

A lever style switch was built for the transmitter. Pulling on the lever results in an emission of a 38 kHz square wave IR signal. The control switches plug into the 15 D connector. Power is bridged by the switches through the transmitter's 6.5-volt battery pack (4 AA batteries), to pins 3, 6, and 14. Simple push buttons may be used as the switches, but there are many options that could potentially be used. The switch must use a 15 D connector and have the appropriate pin connections as given in this design to activate the transmitter.

The system uses a network of simple IR activated power relays. This provides control over lamps, on/off type appliances and the thermostat setback module.

Circuitry in the receiver stores the current state of the device. When a strong IR signal at the proper frequency is detected, the state is toggled. Toggling of the state also toggles a 5-volt relay, the contacts for which are rated for an amount of power sufficient for the appliance. The relay bridges a connection between the wall outlet and the appliance that is plugged into the receiver.

Figure 14.2 shows an electrical schematic for the IR receiver. The entire system is designed to run between 5 and 6.5 volts, optimally. This voltage is provided by a DC power source that plugs into a jack on the receiver. Note that the output from the IR detector module must be run through an inverter (74LS04), since it is originally active low. A 555 timer IC is used to create an oscillating square wave, serving as the clock. In this case, a NE556N (dual) timer IC was used because it was readily available. The IR detector module is a standard component, part #276-137, available from Radioshack®. It measures approxi-

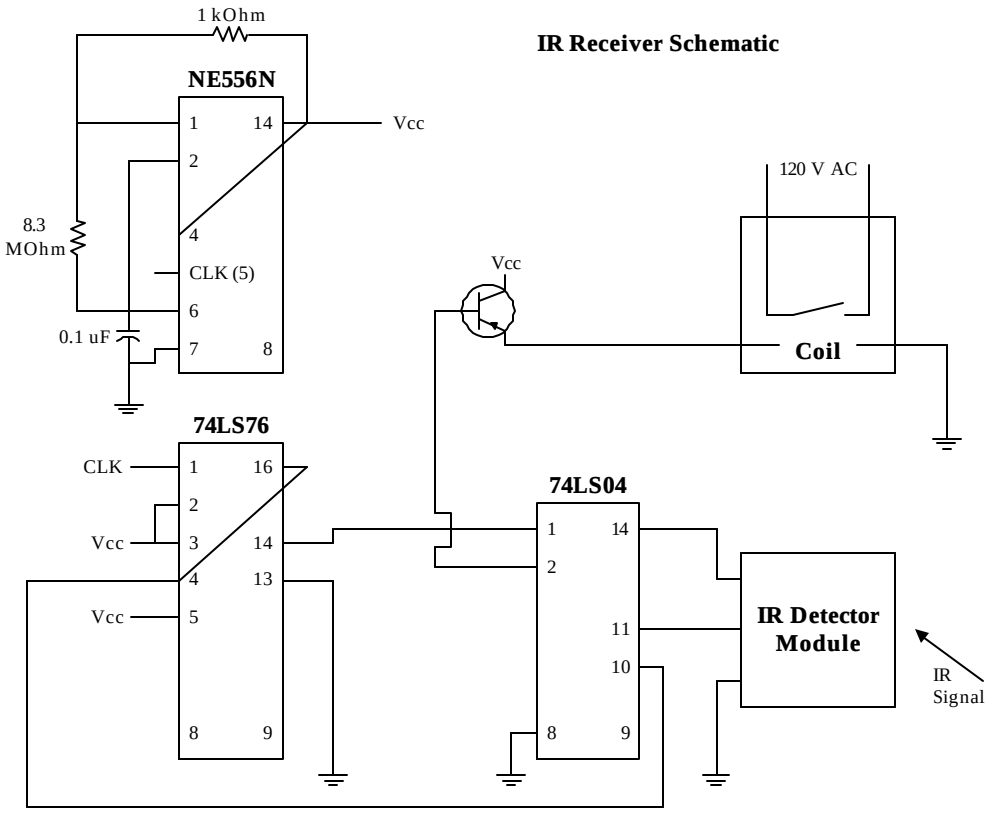

Figure 14.2. Electric Wiring Diagram of a Toggling Relay Circuit that Responds to IR Input.

mately 1.5 x 1.5 x 1 cm. Circuitry in the detector has a band-pass response of 38 kHz. The IR detector can recognize signals from the Switch Activated IR transmitter, or any standard remote control. The output of the detector is connected to pin 11 of the inverter (74LS04), since it is active low and a high output is required to toggle the J-K latch.

The detector module is so sensitive that the operation of a TV remote control can trigger a receiver as far away as 15 feet. Therefore, optical obstruction of the receiver with a 0.5 mm thick piece of opaque material (such as aluminum or plastic) is employed to reduce sensitivity. When a remote control is within 3 feet of the receiver, toggling of the relay is effective. Direction has an effect on selection as well, as the optical signal strength attenuates with increasing angle. Thus, both proximity and direction are employed to perform selection and activation simultaneously.

A J-K latch (74LS76) stores the state of the receiver. The latch receives a clock from the NE556N timer. If there is a DC signal at pin 4 of the latch during an upward clock transition, the state of the latch output (pin 14) will change. The state output of the latch, pin 14, is used to activate / deactivate the magnetic switch in the relay. The signal is first passed through the hex inverter to buffer the signal. Current loading on the 74LS76 output may result in instability in the state.

A typical NPN transistor is used as a simple current driver; the TTL components are not able to provide enough current for some of the larger relays. The relay interrupts the power to one prong in a 3-prong adapter. The controlled appliance plugs into the adapter, which is then plugged into the wall. The receiver is connected to this adapter by a cable.

JOYSTICK TV REMOTE CONTROL

The Joystick TV Remote Control is a device modification of an existing programmable remote control. The main function buttons (power, volume, channel) on a One For ALL™ remote control are connected via ribbon cable to a digital joystick. Some users with physical disabilities can use this improved joystick interface instead of the smaller buttons on the regular remote control, which are often difficult to manipu-

late. Design specifics for this modification are available from Dr. William Hyman, Biomedical Engineering Program Chair at Texas A&M University. Materials used in the construction of this device cost approximately $50.

INTEGRATION WITH OTHER SUBSYSTEMS

Integration of the Infared Point and Click subsystem with other subsystems can provide most functions requested by the client. This system currently provides no definite solution for light switches. The basic receiver could be used to interrupt the light switch circuit. Otherwise, lighting can be controlled through the on/off toggling of lamps plugged into the receivers. Temperature control is also available. Use of the Joystick TV Remote Control, existing garage door openers, and an RC100 or RC200 telephone provide the other functions requested by the client. Figure 14.3 shows the block diagram of this integrated system.

One function that cannot yet be implemented is control over the blinds. A modified receiver must be designed for this control option. The state output of the latch can be tied to reversed relays that alternately supply power in one direction or another to a motor in the presence of an incoming signal. Latch output and IR detector output would be ANDed together with an AND IC at the connection to each separate relay magnet. The motor, with appropriate interface and gearing, could then be used to open or close the blinds.

DISADVANTAGES

If a switch-controlled telephone is used, assistance is required to obtain the switch. Also, while depression of almost any button on a standard TV remote control can activate a receiver, use of the remote control on the receiver could inadvertently affect the television. Blind control, the least important function on the client's list, is not currently available.

The receivers' designs do not include an onboard power supply that can harness the needed current

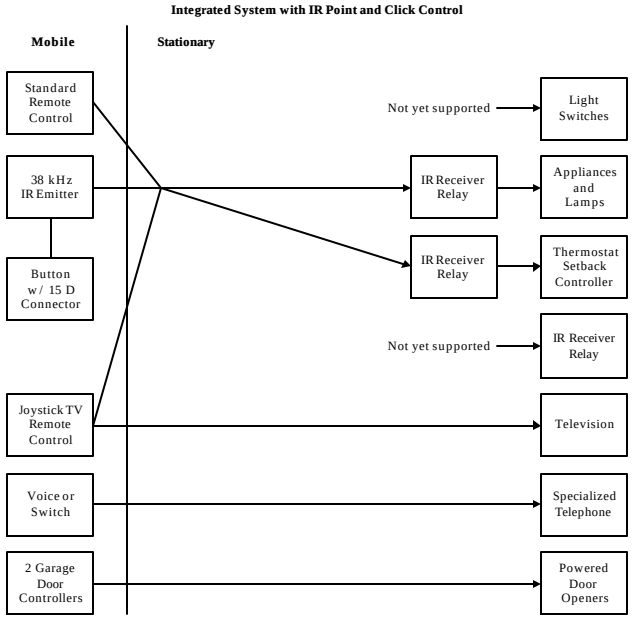

Figure 14.3. Environmental Control System.

from the incoming AC power. While a simple power supply could be implemented, the current design uses a 6V DC power supply that must occupy its own outlet. If there were a shortage of outlets, power strips would need to be purchased.

ADVANTAGES

The system has eliminated complex centralized control at a tremendous savings in cost. Each receiver's materials cost is approximately $25. This cost could be reduced by the integration of an onboard power supply.

The material cost of this system is $650. This includes 8 receivers, 8 power supplies, 2 power strips, the Joystick TV Remote Control, and the RC200 phone. The telephone comprises the majority of the cost ($400).

AN ARM BRACE FOR USE BY PATIENTS WITH LOWER BACK TROUBLE

Designers: Price Bradshaw III and Robert Meltzer
Client: Nicholas Cram, Director of Bioengineering
St. Joseph's Medical Center
Supervising Professor: W.A. Hyman
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INTRODUCTION

An arm brace was designed for a patient who had recently undergone lower back surgery and required support of the right arm. The brace is composed of three components: a lower back support, a lower arm support band, and an extendable rod attached to a pair of universal joints (Figure 14.4). The device is light, reasonably comfortable, and easily secured.

SUMMARY OF IMPACT

The client was a dentist who had recently undergone lower back surgery. The nature of his work requires long periods of time spent with his arms extended, causing lower back strain. The device reduces this strain by transferring the weight of the arm directly to the hips and legs. The design of the brace includes a set of steel rods that extend from the right arm to a back support belt worn around the waist. This design successfully reduces strain in the lower back.

TECHNICAL DESCRIPTION

The brace was designed for a specific patient but could be used for a number of individuals. The design requirements for the arm brace were that it: 1) relieve the strain on the lower back caused by the extension of the arm; 2) allow unrestricted range of motion of the arm; and 3) be lightweight and comfortable.

The arm brace is made of a standard lower back support belt, a lower arm brace similar to those used for tennis elbow, a hollow steel rod, a threaded steel rod, a nut, two cotter pins, and two universal joints. One universal joint is riveted to the outside of the back support belt on the right side. A cotter pin attaches a 12” hollow outer rod with a 0.5” inner diameter to this joint. A 0.5" nut is attached to a 0.5" threaded rod, 14” in length, to act as a stopcock. The nut can be used to change the length of the supporting brace by rotating it clockwise or counterclockwise. The threaded rod and attached nut are inserted into the hollow rod. The free end of the threaded rod is riveted to the lower arm support to complete the assembly (Figure 14.5).

Figure 14.4. Completed Arm Brace

The pair of universal joints at either end of the rods allows an almost unrestricted range of motion. The maximum extension distance of the rods is 26" and the minimum is 14". The device design is effective but the lower arm brace can reduce circulation if it is applied improperly or worn for extended periods of time.

The approximate cost of the arm brace is $45.00.

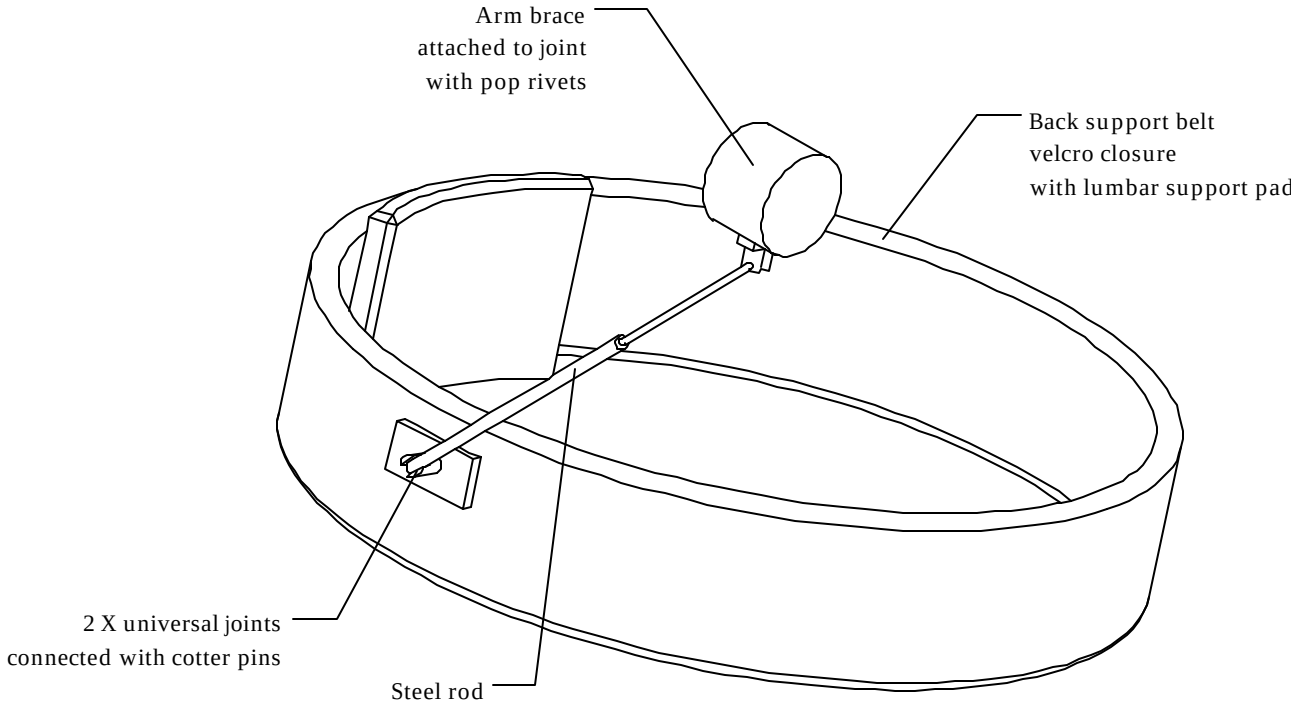

Figure 14.5. Arm Brace Assembly.

AUGMENTATIVE COMMUNICATION DEVICE

Designers: Gretchen Meyer and Emily Stephenson
Client Coordinator: Mrs. Peddicord
Music Therapist, Bryan Independent School District
Supervising Professor: W.A. Hyman
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INTRODUCTION

Augmentative communication devices are used in many school and therapy settings with students who have few or no speech capabilities. These devices provide a means for students to express themselves and to receive audio feedback corresponding to specific commands they have selected. An augmentative communication device can be defined according to the number of cells, or individual selections, the device provides. These cells are associated with a specific symbol or command. Each individual cell can be attached to an access mechanism that facilitates the audio feedback. The number and size of cells required is dependent on an individual's cognitive and motor abilities.

There are many different ways a user can access the system. These include touch, a remote switch, a scanning system, auditory scanning, and optical pointing. Finally, a digitized or synthesized speech recording and playback device must be integrated.

This project incorporated multiple remote switching devices (Figure 14.6). Four digital voice recorders, manufactured by Marlin P. Jones and Associates, were adapted for AC power. Each recorder used in this device can hold 10 seconds of speech.

SUMMARY OF IMPACT

Two augmentative communication devices were designed for specific students, but can each be adapted for various users. The first device was intended for a seven-year-old boy with autism. He had minimal speech capabilities and could not communicate with his teacher. He had been using a device, designed by his teacher, that consisted of a large piece of paper with pushpins. Various objects were suspended on the pushpins to communicate when he wanted to swing, color, eat, use the restroom, etc. The device did not provide auditory feedback.

Figure 14.6. Augmentative Communication Device

Digital voice recorders were used to design an augmentative communication device with four cells. Each cell, consisting of a remote switch, has a picture that represents something the child might want to express. When the switch is activated, the speaker plays a verbal message that corresponds to the student's choice. The device gives the student a way to communicate and provides auditory feedback to facilitate his speech development.

The second device was designed for a four-year-old boy with De George's Syndrome, a disease that affects the immune system. Due to his weak immune system, this child had no interaction with anyone but his parents and doctors for the first three years of his life. This lack of interaction with others has severely affected his communication skills. A device similar to the first was used with primary design alterations in the cell specifications and the recorded speech.

TECHNICAL DESCRIPTION

Each voice recorder was originally designed for battery (DC) power. Since the voice recorder continually uses power to maintain memory, the batteries die within two weeks. To resolve this problem, the four recorders have been converted to AC power by connecting each in parallel to an AC/DC adapter (Fig14.7). The device can now use AC power from a wall socket and retain memory as long as it is plugged in.

Each voice recorder was purchased with a standard play switch built into the mechanism. Record switches are added using momentary push button switches. After the recorders were adapted they were enclosed in a 15.5" x 8" x 1.75" wooden box.

The total cost of each device is approximately $60.

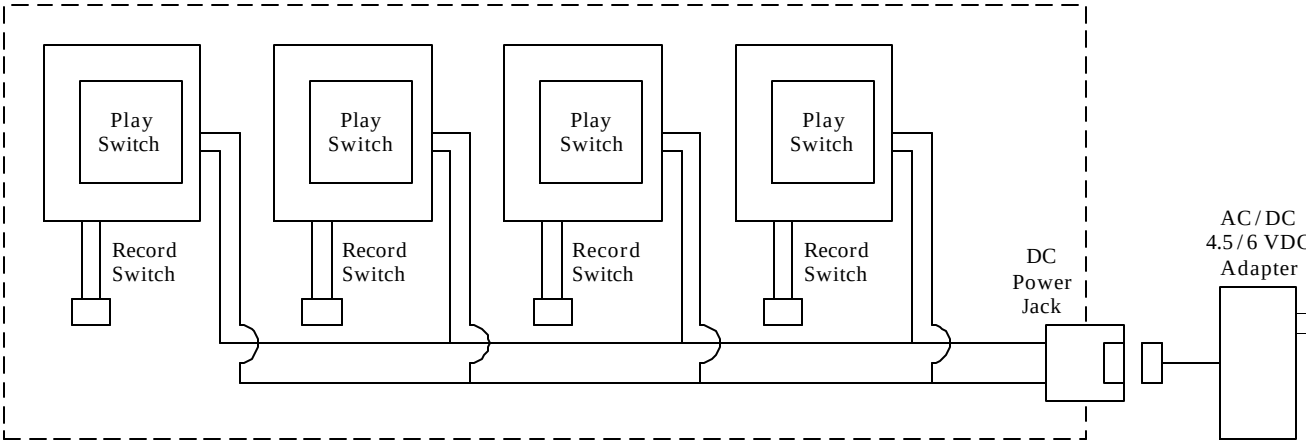

Figure 14.7. Device Configuration.

CLOTHES DRYER WITH FRONT MOUNTED CONTROLS FOR HANDICAPPED ACCESS

Designers: Jon Berkovich and Chris Stamper
Supervising Professor: W.A. Hyman
Biomedical Engineering Program
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INTRODUCTION

A clothes dryer was adapted to make the task of doing laundry simpler for people who use wheelchairs (Fig. 14.8). The design of the device is simple. The external control panel for the dryer was moved from the back to the front of the dryer and mounted with metal clamps. The internal wires were lengthened and a rectangular section of the dryer cover was removed to allow the wires to reach the controls. The dryer model was equipped with a front lint catcher, allowing the device to be used without external assistance.

SUMMARY OF IMPACT

Moving the dryer controls from the back to the front of the appliance enables wheelchair users to more easily dry their laundry.

TECHNICAL DESCRIPTION

The design requirements for the dryer were that it: 1) have a front lint catcher; and 2) have controls that are accessible from a seated position.

A GE model DDE 7500VALWH, serial number VA2 1 7 4 1 6 G, was used in this design. A 20" x 2" rectangular portion was removed from the front of the top cover of the dryer to provide space for the wires to reach the control panel. Each wire was lengthened by 6" using 150ºC, 12-guage electrical wire. Fourteen 16-guage male/female adapters were used to connect the existing wires with the new additions. Standard electrical tape insulated all wires exposed to the thermal environment of the dryer. Finally, two 2" oval stainless steel clamps were attached to each side of the dryer lid to ensure that the cover remained securely fastened.

The cost of the modified dryer was $160.

Figure 14.8. Front Mounted Dryer Controls.

ADAPTED SEE'N'SAY FOR CHILDREN WITH LIMITED DEXTERITY

Designers: Price Bradshaw and Rosalyn Metcalfe
Supervising Professor: W.A. Hyman
Biomedical Engineering Program
Texas A&M University
College Station, Texas 77843

INTRODUCTION

Children with limited dexterity often have difficulty operating toys such as the See'n'Say, which require physical manipulation. Because the See'n'Say is operated by pulling a lever, it requires both strength and dexterity. This toy was adapted by connecting a push button to a circuit to activate the lever (Figure 14.9).

SUMMARY OF IMPACT

The design was successful in allowing a child with poor dexterity to operate a See'n'Say with ease. Due to design limitations, the recordings were not played in full. Using a longer connecting chain may rectify this problem. In addition, the modified toy is not easily portable because the wood base is too heavy and bulky for a small child. This design is the first step towards a workable solution.

TECHNICAL DESCRIPTION

A ratchet and an industrial-strength circular fan motor were wired into a timing device activated by a push button. The See'n'Say lever was connected to the motor and ratchet with 1/8" brass safety chain. A sprocket type ratchet system was used to allow only unidirectional rotation. The timing device, referred to as a "one shot," is commercially available from IDEC Industries. The device was used to engage the motor for approximately two seconds.

During the two seconds, the motor rotates, pulling the lever of the toy downward, providing energy for the operation of the toy. After two seconds the motor stops rotating and the lever returns to its initial position, allowing the See'n'Say recording to be played.

The See'n'Say is elevated on a 4" x 4" wood block to allow the lever to clear the ratchet. The entire system is mounted on ¾" plywood with L brackets.

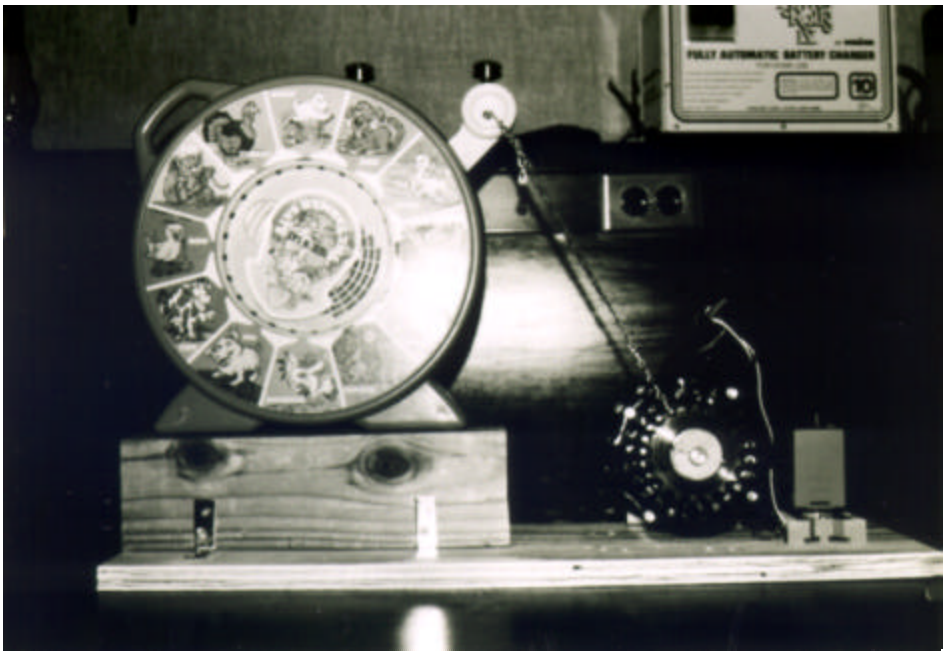

Figure14.9. Adapted See'n'Say.