

CHAPTER 7

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Electronic Compass for the Blind

*Designer: Brian J. Deneen
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INTRODUCTION

A blind student has expressed the desire to be able to more readily determine her orientation when outdoors. In short a desire for a compass that she could employ in order to determine the direction of streets and the like to enable her more freedom in her travel.

A compass that has the ability to detect the earth's magnetic field and its direction that can give this information to the seeing-impaired user has been designed and constructed. The electronic compass detects the earth's magnetic field through the employment of the Sprague UGS-3503 linear Hall-effect sensors. The output of the device is an audible signal giving the direction.

SUMMARY OF IMPACT

Knowing one's orientation is especially critical for the seeing impaired. This compass is a small simple device that will give an audible indication of north or south. It is easily carried in a purse or shirt pocket and should be useful for people placed in new and unfamiliar surroundings.

TECHNICAL DESCRIPTION:

The electronic compass may be divided into three sections. They are: detection, amplification of detected signal, and an output section.

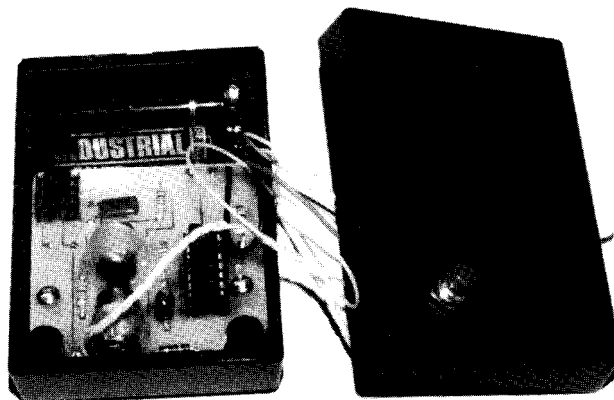


Fig. 7.1. Compass for the Blind.

The detection of the earth's magnetic field was accomplished through the employment of two UGS-3503 linear Hall-effect sensors and a magnetic circuit constructed around the sensors. The sensors are arrayed in an anti-parallel fashion such that the difference in their outputs correspond to a radial deviation from North. The magnetic circuit is employed in order to increase the strength of the magnetic field in the neighborhood about the sensors. The use of two Hall-effect sensors doubles the sensitivity and reduces the temperature dependence.

The Sprague UGS-3503 linear Hall-effect sensor was chosen due to its sensitivity. The device operates upon the Hall-effect principle. Specifically, a discrete charge moving through a magnetic field will be subject to a force that is proportional to the cross product of the charge's vector velocity and the magnetic field vector. A current of charged particles flowing through a non-parallel magnetic field will experience a force perpendicular to their normal path of travel. Therefore, it is possible to measure potential perpendicular to the flow of electric current in a conducting sheet.

As was stated previously, the difference in the outputs of the two sensors is to be amplified. The difference voltage between the outputs correspond to angular distance from a northerly orientation. A differential amplifier with a gain of approximately 4000 was used to amplify this difference voltage. A capacitor is placed in the feedback path of the amplifier. This yields a one pole low-pass filter that eliminates high frequency interference. Also, a low noise type of operational amplifier is also employed in the design.

The output of the amplifier section is connected to the input of a voltage controlled oscillator (VCO). Again for simplicity, the VCO from a 4046 was used. The frequency to input voltage response is controlled by a capacitor between pins 6 and 7 and resistors from pins 11 and 12 to ground on the 4046. A schematic is given in the following figure.

The cost of the project was \$44.00.

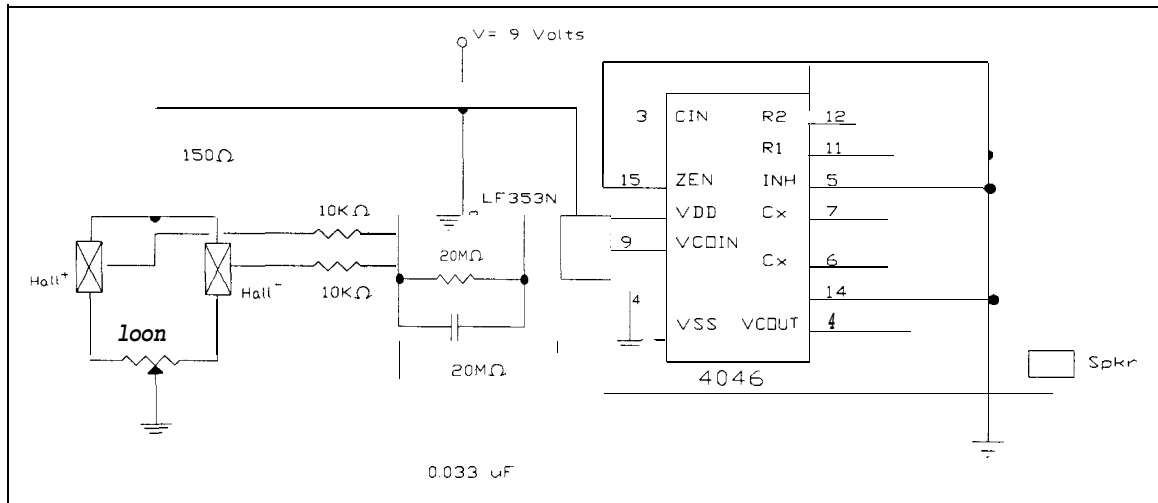


Fig. 7.2. Schematic for the Electronic Compass for the Blind.

Smoke Detector for the Deaf

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INTRODUCTION

The Smoke Detector for the Deaf is a device to allow hearing impaired people the comfort of being alerted in case of a fire. An ordinary General Electric smoke alarm is adapted to alert a deaf person in the event of a fire. By using a flashing strobe light to alert a person, this device overcomes the problem of auditory alarms that are of no use for a deaf person. The strobe is set at an optimal flashing rate that will have the capability to awaken a sleeping person. By using a Radio Shack universal interface, strobe lights can be placed throughout the home. Each strobe can be activated by a single alarm by coding the alarm signal and sending the signal through the house wiring where the strobe

lights are plugged into a receiver unit set at the same code.

SUMMARY OF IMPACT

Many hearing impaired people are capable of a life of independence and freedom. This freedom is not without its risks, however. Certain situations exist where their impairment is a liability or even life threatening. An unnoticed fire in the home is an example of a life threatening occurrence that a hearing impaired person cannot be alerted to through conventional ways. Smoke alarms depend on the sense of hearing to alert a person. This design will hopefully give the user a sense of well-being in her home knowing that if there is ever a fire, she now has the capability to be alerted.

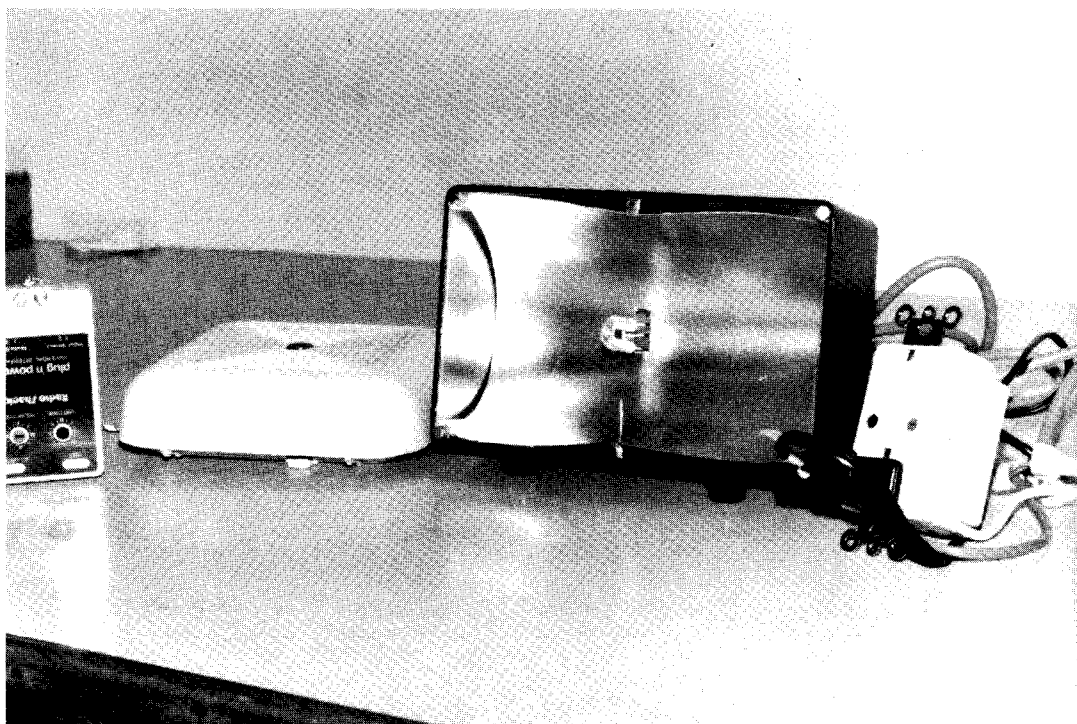


Fig. 7.3 Smoke Detector.

TECHNICAL DESCRIPTION

The smoke alarm consists of three components: a General Electric smoke alarm, a Radio Shack universal interface and receiver, and a strobe light, designed and built to work with the alarm.

The GE smoke alarm unit was chosen because the horn has a monostable output. When smoke is sensed the horn is activated and has approximately 6 volts at the output.

The strobe light circuit consists of three basic parts: the flashtube, a voltage doubler circuit, and a trigger circuit. The strobe is powered by standard 120 volts AC. The 120 VAC is converted to approximately 320 volts by the 160 peak voltage doubler circuit. This voltage is stepped up to 4 kV by a trigger transformer. The xenon flashtube receives the 4 kV across the trigger and cathode causing it to ionize. When this occurs, the bulb flashes.

The horn of the alarm is directly wired to a Radio Shack universal sending unit. The sending unit is triggered by a DC voltage (6-18 volts). This unit is plugged directly into an existing wall socket run-

ning off the power lines of the house. This unit codes the signal it sends out through the AC power lines.

The signal is received by remote modules in the house with the same code setting. The receiver unit takes the place of a wall socket. When the smoke alarm is triggered, the sending unit sends out a coded signal that the receiver picks up and, in turn, triggers the strobe light. As long as the alarm is activated, the strobe light will also flash.

The flashing rate should be optimally set at 1 to 3 hertz. Therefore the potentiometer should be set at its maximum.

The smoke alarm can be placed anywhere in a person's home, but the strobe light should be placed near a person's bed to insure he or she is awakened by the flash. Other strobes can be placed throughout the home using other receiver units set at the same code.

Total cost of the smoke detector, including all parts, was approximately \$75.

Reading Without Sight-Text to Voice Conversion

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INTRODUCTION

The text to voice converter is a device to help visually impaired and others with reading disabilities, by having documents read to them. This device overcomes the need of a middle person to read books, magazines, or letters to the disabled. This device consists of a hand scanner and a voice synthesizer. The hand scanner is used to scan in the document, and the synthesizer is used to produce near human speech quality voice. The physically disabled will be required to control the hand scanner and to do a small amount of user input to an IBM PC.

SUMMARY OF IMPACT

The ability to read ordinary text such as a magazine or a newspaper would be invaluable to the blind. This project demonstrates that it can be done inexpensively and effectively. However, the interaction with the computer required by the user is still too complicated and dependent on sight for the average person. Improvements to the system should be made to the software so responses to the operator would be in voice commands.



Fig. 7.4. Text to Voice Conversion System.

TECHNICAL DESCRIPTION

The Text to Voice Converter consists of four major components. A hand held scanner will be used to scan the selected text for reading and place the output in a file. The text is required to be of basic fonts found in most books and magazines. Speech is produced by a voice synthesizer that will be driven and powered by an IBM PC. The third part of the device is the software. The software is required to initialize the speech synthesizer, run an optical character recognition (OCR) software, run a specialized spell checker, and to download the final ASCII file to the synthesizer. Finally, an IBM PC or compatible will be called upon to run the software, control the scanner, and control the speech synthesizer.

Hand Scanner - The purpose of the hand scanner is to convert the text image, of the document, to a Tagged Image File Format (TIFF). This file can be processed by the computer. The scanner selected for this device is the Scan-Man from Logitech. This scanner has a selectivity of 100 to 400 dpi. A range of 200-400 dpi is recommended for the processing required.

Speech Synthesizer - The speech synthesizer is the output end of the system. Its purpose is to take in ASCII text and output a near human quality voice that will be intelligible with some training. The speech synthesizer selected was the V8601 by RC Systems. The V8601 synthesizer is a complete phoneme based text to speech synthesizer. It has a 32K buffer that allows for redefining system parameters, an exception dictionary, and also the text downloaded to it. The V8601 also has stand alone capabilities that means additional software or memory is not required. The V8601 runs off a 5 volt power supply, which is supplied by the PC. The synthesizer connects directly to the parallel port of the computer.

Software - The first part of the software is the initialization software of the synthesizer. This contains system adjustments to improve the synthesizer's speech by changing the tone, volume, pitch, etc. The initialization also contains an exception

dictionary that is approximately 8K in size. The exception dictionary will take words that the synthesizer pronounces incorrectly and makes it pronounce them correctly.

The second part of the software is the OCR software. This software is used to drive the scanner and takes the output of the scanner and places it in a file. The OCR software, after making the TIFF file, will be used to convert the file to an ASCII text file. The OCR software selected was Catchword from Logitech. The software is written for feature extraction character recognition. This is also the slowest part of the system. OCR software does not recognize all of the characters in the TIFF file, thus further processing is involved. This is where the third part of the software comes in.

The specialized spell checker checks the ASCII text file for @ signs. The @ sign is the character used to show where unrecognized characters are. When the spell checker comes to an @ sign it takes that word and compares it to words in a dictionary. The spell checker takes the most likely word and replaces the misspelled word.

The last part of the software is a simple DOS batch file that controls the loading and reloading of files. The batch job simply downloads the initialization software to the synthesizer, runs the OCR software, runs the spell checker, and downloads the resulting file to the synthesizer. The final step of the batch file is to loop back to the running of the OCR software. This is repeated until the document is finished being read.

Computer - The purpose of the computer is to control the speech synthesizer, the scanner, and the software. The requirements of the computer system are an IBM compatible PC with one floppy drive, 640K of memory, 20 MB hard drive, and standard keyboard. An AT class computer is desirable because of the reduced processing time.

Cost - The total cost for this project was about \$500. This price does not include the computer system.

Learning to Count

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INTRODUCTION

This design will assist a learning disabled person in learning to count to ten. The design is targeted at helping those in the three to five year old learning level. The person playing the game will already know the words and numerical value of the numbers one through ten. This design will help the student associate the numerical symbols used with counting to ten.

SUMMARY OF IMPACT

The concept of numbers is important to be able to function in society. This design addresses the problem of teaching counting to the learning disabled. Students will receive practice counting with little direct interaction from the teacher. The unit will not be fully tested until the coming academic year.

TECHNICAL DESCRIPTION

The user operation of the game is simple; he or she just turns on the game and pushes the buttons. The game has ten push buttons each with two numerical displays under them, eleven numerical displays at the top and an on/off switch on the top. The numerical displays discussed are .8 inch high 7-segment LED displays. The buttons are placed far enough apart to prevent a nearby button from being accidentally pressed. The volume control on the chime allows the game to become more compatible with various surroundings, such as a lower level for the home or a higher level for classroom use.

When the game is first turned on, all the numerical displays under the buttons are blanked and all the top numerical displays are illuminated. The game is then ready for user input when the top display is blanked and the buttons' numerical displays each contain an integer one through ten. Each button's numerical display has a unique integer randomly

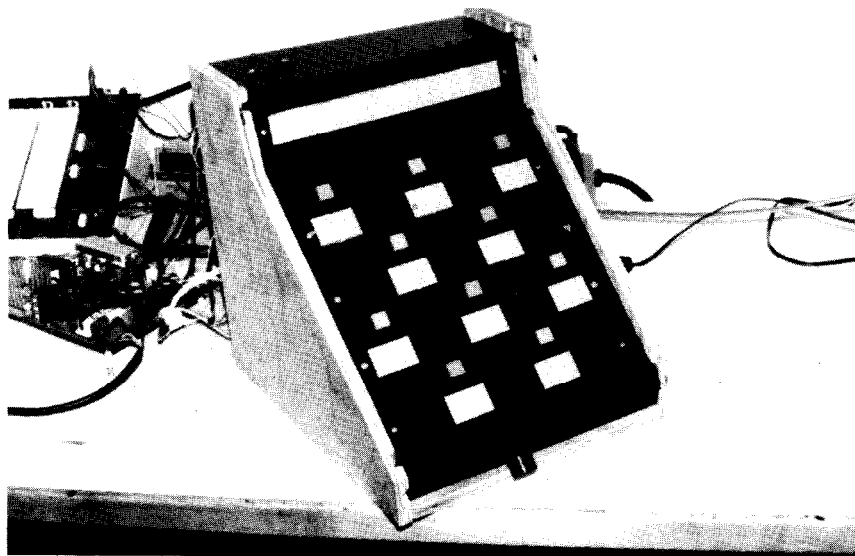


Fig. 7.5. Learning to Count Device.

generated at the start of every game. The random placement will allow the student to learn the numbers instead of learning the pattern. For example, one time the number two may be at button position one, and another time the number two may be at position five. If the number is one through nine, the display on the left will be blank, and the right display will show the single digit number.

Once the student has completed the count to ten, there is a pause for approximately five seconds before the game goes into its restart routine. Then, the chime sounds for three seconds while the top display flashes on and off. The game then clears all the displays, begins the random number placement under each button position, and readies for the student to play again. The game is ready for student input once each display under the buttons shows a number one through ten. If the student presses the correct button, the chime sounds for one second and the correct number lights up in the top display. The top display is intended to help the student keep track of where he is in the count. If the student presses an incorrect button, nothing will happen. Other learning games, which have different sounds or actions for right and wrong responses, have had problems with the student trying to get the wrong response.

The game operation is controlled using the Motorola MC68HC11A8 microprocessor (μP) and various CMOS and TTL logic integrated circuits (IC). The CMOS and TTL logic ICs transfer information between the μP and the numerical displays and buttons. The μP takes care of the initialization of the game, the placement of random numbers, the analysis of the input, and the response for a correct answer.

The device will be powered by plugging into a standard household AC outlet. The power supply has an in-line fuse from the AC outlet to the power transformer. The power transformer is capable of supplying the needed dc voltages of 5v at 5 amps and 12v at 2 amps required for proper running of the μP , ICs, chime, and transistors.

The software used to control the game operation is the Motorola 6800 assembly language. The software program has several subroutines corresponding to the phase of the game.

The first subroutine called Button position generates a random integer for each button display. Once all the numbers are assigned, the program goes to the subroutine to enable the timer interrupt. The numbers under the buttons are displayed from a time interrupt subroutine. When the numbers under the buttons are not being displayed, the program is in a looping subroutine called Wait for input loop. This subroutine is constantly checking for the "correct number" to be 11, that is the signal that the game is over and the restart procedures are to begin. During the playing of the game, the wait loop subroutine will be put on hold for either an interrupt from a button being pressed or the timer interrupt. The device is "off" even after it is plugged in. An on/off switch turns "on" the game by supplying power to the microprocessor. The μP is set up such that once power is supplied to the unit; it will go into its read only memory and begin running the permanently stored program.

The program's initialization subroutine places initial values in the variables used in controlling game operations. The subroutine also turns off all the numerical displays. The top display is turned off by sending out a hex 9 through the μP 's port C bits 4-7 to the BCD to decimal decoder (2U4). This sends out a low at the 9 position on the IC 2U4 causing all the interconnected AND gates to be low which then sent through the transistors turns off the displays. The button position displays are turned off by sending a hex F out through port C bits 0-3 to the BCD to decimal decoder causing a high at all the transistor switches that results in turning off all the button displays.

The μP program controls the random number placement by generating the number, changing the number to an integer, placing the integer in a memory address corresponding to a button position, and displaying the numbers through a timer interrupt routine. The numbers are displayed through a multiplexing routine.

The number is generated by reading the value of the 16 bit timer/counter that is built into the μP . The counter value is changed to an 8 bit number by dividing the number by 25710. The program then finds the range the number fits into and assigns an integer value that creates the random integer. The cost of the device was approximately \$175.

A Child's "Answer Box" Interface for the Apple IIe Computer

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INTRODUCTION

Not everyone has the ability to type accurately on a computer keyboard, and an elementary-school aged child is even less likely to have this ability. If a child lacks fine motor skills, then the chance that the child will be adept at typing skills is usually remote.

To compound the problem, if the child does not possess good verbal skills, the ability to communicate is further complicated. The child's ability to provide meaningful answers to a teacher's questions is severely limited. The answer box is a system that allows such a child to display answers on a computer screen without the need for keyboard skills. Using this system, the child can easily answer questions from worksheets, flashcards and other material the teacher provides.

As the teacher no longer has to spend time trying to understand the speech the child cannot produce properly, both the teacher and the child enjoy easier and more reliable communications. The child can then spend more time actually learning new material rather than struggling to demonstrate knowledge due to a speech limitation or inability to type an answer properly.

SUMMARY OF IMPACT

The student is provided with a tool to make communicating answers to given problems easier and possibly more enjoyable. With a simple push of one of four buttons, a clear and fast answer to the problem is selected. No complicated instructions in the system use are necessary.

The teacher is provided with a clear indication of which answer the student wishes to choose, allowing for immediate feedback. The teacher is also provided with the ability to change a set of possible answers to fit different assigned problems.

Teachers already have enough to learn to do as it is, so the answer box menu system is as simple as possible. This will allow the teacher to immediately use the system rather than spend valuable time having to learn a set of lengthy instructions.

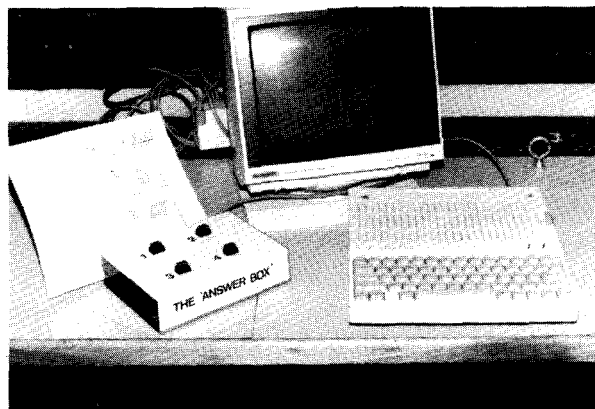


Fig. 7.6. Answer Box Device.

TECHNICAL DESCRIPTION

The Answer Box System can be described by breaking it into separate sections:

- An Apple IIe computer with disk drive, keyboard and monitor screen are used as part of the system primarily because of its ready availability in a school setting. The Apple IIe has, as a standard feature, a game port connection for joysticks, mouse connections and other applications.
- An answer box hardware interface is designed for the student's use and is attached to the game port of the Apple IIe computer.
- Answer box Software to run the system is written in the Applesoft BASIC language and is designed to respond to input from the keyboard as well as the answer box hardware.

APPLE IIe COMPUTER

In order to function properly, the answer box system expects the Apple IIe computer to have at least the following features present: One 5 1/4 inch floppy drive, a standard keyboard and a monochrome computer monitor screen. In addition, the game port of the Apple IIe is needed. The software that the answer box program is written in is standard on Apple IIe machines and is often called "Applesoft BASIC."

ANSWER BOX HARDWARE

The game port used by the answer box provides a +5 volt supply to an application and two separate input lines. The answer box hardware uses both lines. Each of four input switches or buttons connects the +5 volt supply to an input line through a known resistance value for the software to detect an input. To accomplish this, two switches are connected in parallel with different fixed resistor values. (This setup is used for the other two switches as well). Using the two fixed resistor values, if either switch is pressed, two different voltages appear at the input line. This voltage difference will allow the software to determine which of the two switches was pressed. If both switches were pressed, a third voltage different from either of those would be present, allowing the software to determine that both switches were pressed at one time.

Since the game ports are not interrupt driven, a momentary press of a switch may not present the desired analog voltage at the input for a sufficient length of time. Since the software has other tasks to perform in addition to polling the answer box for activity, it may not have a chance to see the activity if the switch depression lasts only a short time. To rectify that situation, a 555 timer configured for monostable output (one-shot activity) is included in each switch arrangement.

ANSWER BOX SOFTWARE

The software will be running under Apple DOS 3.3 and is written in Applesoft BASIC. The program resides on one 5 1/4 inch floppy disk that is self-loading; that is, the user need only insert the disk and turn on the computer and the program will take care of the rest.

At the start of the program, the first task to perform is a check of the game port to determine if the answer box hardware is connected. Since the hardware is designed so proper connection places a known voltage at the input of the game port, the software needs to check the game port. This is done by a BASIC statement "X = PDL(#)" where # indicates the desired input line. This statement returns a value in X in the range of 0 to 255 depending on the input voltage. Simply checking for the expected value range, given the answer box known resistor value, will tell the program if the answer box is connected. If it is not, an error message will be generated on the screen providing instructions as to what to do next, and the program will continually check until an answer box is connected.

Once an answer box is properly connected, the program presents the main screen with the menu of choices available and the default set of four answers for the switches. An area on the screen is made ready to print out the answer corresponding to a switch press, and the program continues. A **keypress** is the method the teacher will use to make menu choices such as change the given answer set to a new set of four answers, clear the screen, quit the program, etc. This check for a **keypress** results in one of these key choices, the program will execute a subroutine to perform the task and return to the main program loop. If no key is pressed, the program will continue on.

At some point in the program's use, answers will be displayed on the screen. Once an answer has been displayed on the screen, there is no reason for it to remain on the screen indefinitely. This section of the program is designed to check how long an answer has been on the screen and if it has been on for too long, it will be blanked out. In this way, the users will not be needlessly distracted when going on to another task.

The main looping of the program is from the section checking the keyboard through the answer box activity check. This loop is repeated until the teacher ends the program with the menu choices or until the machine is actually turned off.

The cost of the project, excluding the Apple IIe computer was \$45.

Positive Reinforcement Trainer

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INTRODUCTION

Rudimentary skills can be extremely difficult to teach a severely handicapped person. The simple practice of turning on a switch can be confusing to severely handicapped persons. The confusion could be due to the fact that most of the time the same switch is used to turn a device both on and off. Some method of separating the two functions of a switch could be used to relieve this confusion for the handicapped person.

This instrument separates **the** turning of a switch on from the turning of a switch off. The "Positive Reinforcement Trainer" (hereafter referred to as the PRT) is a switch that latches closed for a selected length of time and then automatically shuts off. The PRT then automatically resets itself and is then ready for another cycle. This switching action will be used to turn a tape player with a tape of the preferred music of the handicapped person in it. This will give the handicapped person positive reinforcement for turning on the tape player via the PRT. It is hoped that after repeated sessions with the device that the handicapped person will then establish the relationship of pressing the switch to turning **on the** tape player.

SUMMARY OF IMPACT

The positive reinforcement trainer solves a specific problem for one learning disabled student. The device will be put into use the next academic year. It does perform to specifications and hopefully will make a difference.

TECHNICAL DESCRIPTION

The design is separated into three parts. These are, **the** electrical design, mechanical design, and the testing of the PRT. The description **that** follows will first detail the electrical design of **the** PRT and then it will discuss the mechanical design of the PRT. Finally, testing for the completed unit will be discussed.

It can be seen from Figure 7.8 that the electrical design of the PRT is simple yet effective. The circuit consists of a timer circuit (IC1 and its timing circuitry) that will drive a reed relay that is packaged in a DIP type package. The timer is configured as a restartable one-shot oscillator. The output pulse is initiated by pressing and releasing the momentary switch S1. The duration of the output pulse is varied by switching in different resistances via S2. The resistance switched into the circuit by S21 and trimmed with R will set the rate at which Ct is charged and therefore the duration of the output pulse. The output pulse created by IC1 actuates the relay, latching it closed. When the relay is latched closed, the tape player (not shown) that the unit is attached to will then play. At the end of the pulse the relay opens, shutting off the tape player.

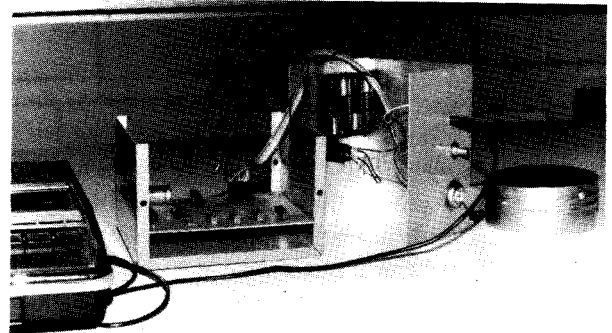


Fig. 7.7. Positive Reinforcement Trainer.

One of the trimpots R1, R2, R3, or R4 determine the time interval for the latch-up of the switch. Ct is chosen as 1000 F. The trimpots are used to allow the time interval to be manually timed more closely to those specified than would be possible using standard values of resistance alone. The trimpots also serve the dual purpose of compensating for the large variance in values for large electrolytic capacitors (such as Ct).

The time intervals specified were 15, 30, 45 and 60 seconds.

Since the current drain of the PRT is highly dependent on its state at a given time all calculations were done for the worst case. The battery was selected using these worst case values. In this manner the PRT is insured of meeting battery life specifications. The total current drain of the PRT is 20mA.

The design specifications for the PRT indicated that the unit should be battery powered with a minimum life of 60 hours of continuous use. Battery selection was accommodated by referring to *Eveready Battery Engineering Data*, Vol. 2, 1982. The battery selected was Eveready E91. This is an alkaline "AA" battery that is commonly available. Four of these batteries are used in series to produce the nominal operation voltage of 6 volts.

The mechanical design of the PRT consists of the housing selection and the component placement. The housing selected for the PRT is a 6" x 5" x 4" *minibox* manufactured by Bud. It is a type CU-2107B. This case is a thin (0.040") aluminum case that is very easy to work with for prototype projects such as the PRT.

The entire circuit (see Figure 7.8) except for S1, S2, S3, and the cable that connects the PRT to the tape player, is mounted on a PC board inside the hous-

ing. The PC board is mounted on the bottom of the housing using 1/2" stand-offs. S1 is connected with a phono connector mounted on the side of the housing. The on-off keylock switch, S2, is mounted on the side of the PRT as well for easy access. The cable that connects the PRT to the tape player is connected to the output of the reed relay on the PC board and fed out of the housing through 1.5mm mike jack and fed to the input of the tape player by a patch cord to the input mike jack (labeled "to tape player" in Figure 7.8).

The testing was done at room temperature in a setting representative of that for which it is designed. For testing purposes, the PRT was cycled through each of its timing pulses a total of 10 times. The mean values of the 10 time tests are given for the 4 settings. Percent error was calculated on these values. The cost of components was \$50.

RANGE	15	30	45	60
Mean	15.7	33	44.5	63.1
% Error	4.67%	10.00%	-1.11%	5.17%

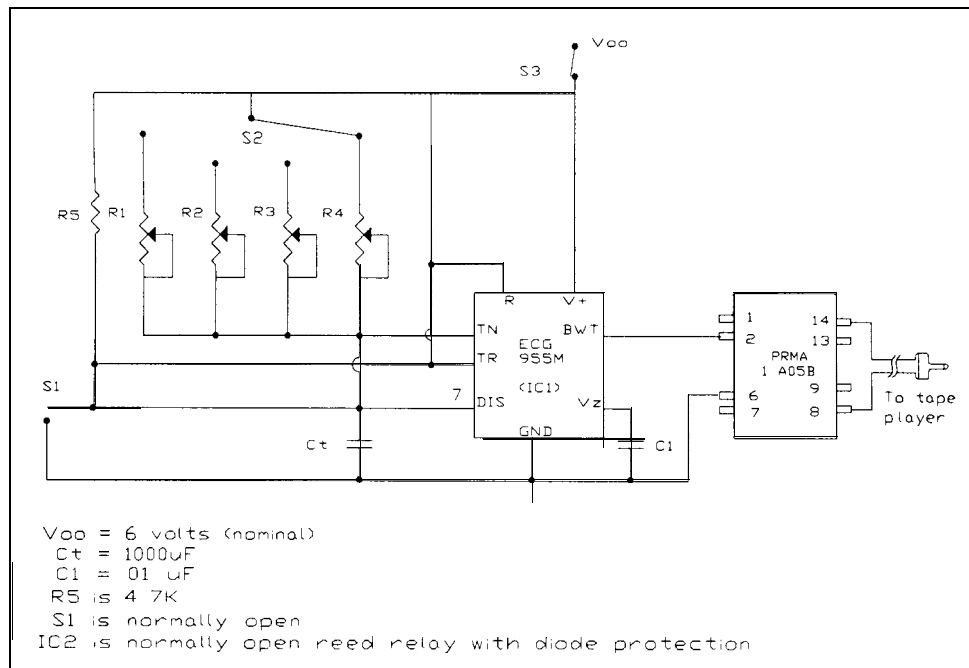


Fig. 7.8. Schematic for Trainer.

