CHAPTER 5
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Infrared Beacon For The Blind

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INTRODUCTION

The infrared beacon was designed specifically to aid blind persons in getting around the room and/or house. It consists of two small units, a transmitter and a receiver as shown in Fig. 5.1. The basic idea is that a transmitter is placed either above or alongside a doorway. The transmitter emits a beam of infrared (IR) light which is sensed by the receiver. Once this beam of energy is detected, the blind person will know the direction of the doorway and the approximate distance he is located from it. As he approaches the doorway, the frequency of the tone emitted from the speaker within the receiver increases. At approximately two feet from the doorway, the frequency reaches its maximum and the person knows that he is roughly an arm's length from his destination and can feel his way for the remainder of the distance. The transmitter is a simple inexpensive design which operates from a conventional 110 power outlet. The detector is a light, hand held unit which receives its power from a rechargeable nine volt battery.

SUMMARY OF IMPACT

Currently, the most widely used means for blind persons to move around their environment are either the long cane, a seeing eye dog, or via a personal aide. If neither an aide or a dog are available, the visually impaired person often has to either keep his cane nearby or feel his way around his environment using the walls. In the process of searching for his cane or a wall, he may trip and fall over obstacles causing unnecessary injuries and damage. With the use of the IR beacon, his life can be made safer and easier. Since the IR beacon consists of a transmitter placed permanently above a stationary point and the receiver can be secured to the person by means of a belt clip, the person will not need to search for a cane or wall, thereby reducing the risk of mishap. While the IR beacon does not detect the presence of objects which obstruct the persons path, it does alert him to the direction of certain reference points. Also, the audible tone enables the user to infer his distance from a reference point in his environment. Once the person adjusts to using this device and learns to judge relative distance conveyed by the tone, his general knowledge of the room layout in conjunction with the device will facilitate his movements. If multiple transmitters are placed throughout the area, the receiver will allow him to find his way easily and safely from one room to another. This concept will provide additional benefits if transmitters are placed in public environments with which the user is not familiar.

TECHNICAL DESCRIPTION

The IR beacon system consists of two modules shown in figure two. The transmitter unit mounts above or near a doorway and the receiver module is hand held.

The Transmitter - The transmitter module is powered by a 9 volt, 200 ma power supply and consists of three 1N6266GE 25mw IR emitting diodes. These were connected in parallel to the supply through six resistors. The resistors were calculated in order to produce a total current of 200 mA thereby sourcing approximately 70 mA per diode. This was the stated optimum operating current for the diodes. The emitters output a DC IR field at a wavelength of 920 nm which can be detected by the matched phototransistor detectors. The three diodes where arranged in a triangle in order to provide a greater effective beacon source size so that the receiver could sense it easily.

The Receiver - The receiver module is powered by a 9v battery. The detection stage consists of three Radio Shack TIL414 IR phototransistor detectors wired in parallel. This connection allows for a wider effective detection area. The range and sensitivity are controlled by means of a two MΩ pot within a voltage divider between the supply voltage and the collectors of the phototransistors. The voltage at this point is scaled via an operational amplifier in order to match the required input voltage of the voltage controlled oscillator (VCO). The VCO, a Harris ICL8038, converts the input voltage range of 5v to 9v into a frequency range of 600 Hz to 2500 Hz. By trial and error, the frequency range was adjusted by replacing the capacitor on pin 10 of the VCO. The DC offset of the sinusoidal output is then filtered using a coupling capacitor. The remaining ac component is then amplified by means of an op amp and input to a two inch, eight ohm speaker. This unit is housed in a black box measuring 3.5"w x 2"h x 6"d and weighing 10 ounces with battery. The total cost of both units is $73.50.

Preliminary testing of the units in one individual's home gave good performance. Florescent lighting was not a direct problem unless the user directly aimed the transmitter at the florescent fixture located in the ceiling. Bright sunlight also may confound the detection circuitry, however, this does not appear to present a problem in the usual home environment but will limit use of the current implementation to enclosed areas. Further work on the device is being done that will improve its performance. An IR lens will be added to enhance

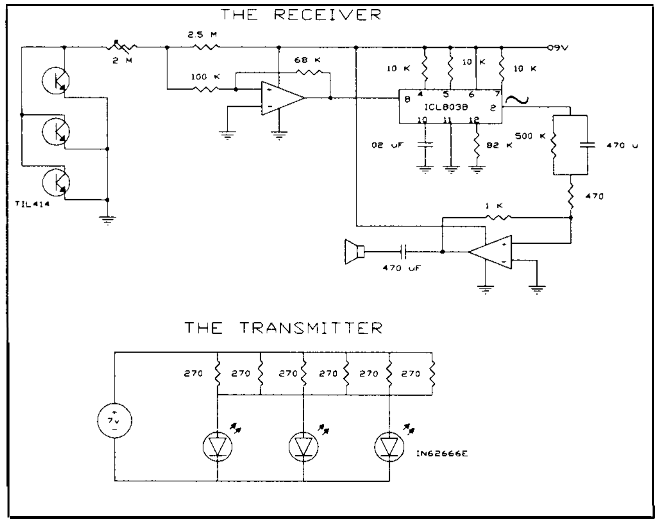

Fig. 5.2. Transmitter and Receiver Units.

phototransistor detection. Additionally, AM systems of different wavelengths are being designed which use both IR and radio frequency (RF) energy. The different frequencies will correspond to different parts of the home or environment, for instance 1000 Hz may represent the bedroom and 1500 Hz the bathroom. The receiver will phase lock to each frequency and increase its amplitude with distance. The short range IR system should find more use inside the house whereas the RF system will be better suited for outside environments.

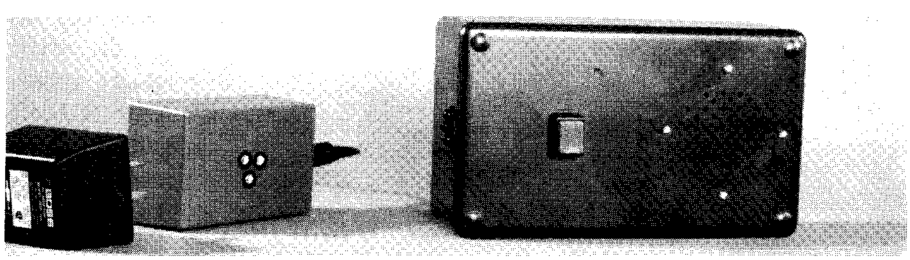

Fig. 5.1. Infrared Beacon for the Blind.

Automatic Bed Cover Controller

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INTRODUCTION

The automatic bed cover control was designed to allow a disabled person to be able to cover or uncover themselves in the absence of an attendant. This device is implemented with simple off the shelf parts obtained from either hardware or surgical supply stores. This implementation is made to work with a sip-n-puff switch control. Sipping on the relay changes the direction of the rolling of the bedcover, i.e. either cover or uncover. Puffing will turn the device on and off. The speed of the motor that controls the rolling of the bedcover is slow enough so that the user has plenty of time to react. Magnetic proximity switches are used to control the motor at the end of the travel at both ends in the event the user cannot stop the blanket in time. The overall design yields a smooth running inexpensive device that can be easily utilized by a wide range of individuals.

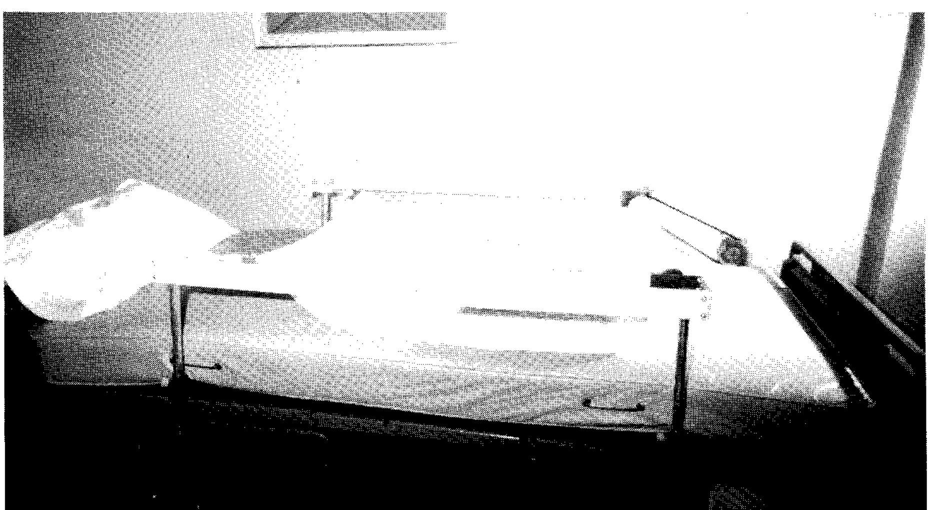

Fig 5.3. Automatic Bed Cover Controller.

SUMMARY OF IMPACT

The end result of such a device is that it provides independence and comfort to the end user. There are many times where one may wake in the middle of the night and be either very hot or chilly depending on changes in ambient temperature. It may be difficult to wake an attendant during the middle of the night and instances like this can sometimes put a strain on all people involved. The automatic bed cover controller will enhance the daily lifestyle of disabled individuals by providing them with the capability to perform a simple fundamental task.

TECHNICAL DESCRIPTION

Figure 5.3 shows a picture of the device on a typical hospital bed. The base of support for the structure is two stainless steel rods and attached sleeves used for supporting the sliding gates found on the side of a hospital bed. The rods have lips that can either bracket into a standard hospital bed or can attach to a boxspring. Each rod supports a sliding curtain support. The rear curtain supports have a bearing assembly attached which takes in the shaft of a heavy duty shade roller. The roller comes with a built-in pulley on each side. An additional heavy-duty pulley was attached on one side to provide the coupling of the motor to roller. The roller has curtain cords on each pulley which hold the attached blanket. This cord goes to the other side of the curtain support and through a spring loaded cord pulley which maintains the cord tight over the entire travel of the blanket and roller. If the person covers himself the motor turns the shade roller and unrolls the blanket, the curtain cord moves the end of the blanket out towards the head of the bed. When the person uncovers himself the blanket is pulled down by pulley systems on each side of the bed and wraps neatly around the roller. Attached on each end of the shade support brackets near the cord pulleys are magnetic proximity switches (GRI, PV-40C) which disable the motor upon closure. Hence it is impossible for the user to drive the clips that hold the blanket onto the turning pulleys. Movement of the blanket is controlled by a sip-n-puff switch which is interfaced to a digital control circuit. Sipping changes the direction in which the motor turns, puffing turns the motor on and off.

Figure 5.4 shows the basic control circuit for the system. The system consists of a 12 volt D.C. power supply (Power One, Cupertino CA) connected to a 12 volt D.C. motor (Dayton Motor, 42837). The movement and direction of the blanket is controlled by whether the motor is switched on and the polarity of the power supply on the motor. These two functions have been encoded with digital control logic.

Integrated circuits U1 and U2 (74HC109) are configured as a basic divide by two counters. U1 controls the direction and U2 controls the power to the motor. If a sip is made on the sip-n-puff, U1 is toggled which will either activate or deactivate relay R2 depending on the previous state of U1. As can be seen, this is a single pole-double throw relay with the motor connected to the poles and the power supply connected at opposite polarity at each throw. The state of the Q output connected to R2 will determine the polarity of the power supply. U2 is connected in the same way except R1 is a single pole-single throw relay. A puff on the sip-n-puff will toggle U2 and turn the power to the motor on or off. Integrated circuits U3 and U4 are J-K flip flops (74HC109) used for end stop contact switch debounce. For these IC's, J, K and CIK input are tied to ground and the set and clear inputs are pulled high and attached to separate ends of the single pole-double throw endstop switch. The center pole on each switch is grounded. The flip flop is therefore configured as a latch which removes any contact bounce when each connection to ground is made. The normal state (no endstop contact) is for the SET input (pin 5) to be grounded and the Q output to be high. If any of the end stops are activated, CLR is grounded and the Q output is set low on the appropriate flip flop. This causes two events to occur. The low transition on either output is ANDed in gate G1. This causes a low transition on the G1 output which toggles the monostable multivibrator (74HC4538) and sends a one millisecond pulse to gate G2. Hence if either endstop is contacted, the pulse will act as a puff input and toggle the motor off. One additional function is operational when an endstop is encountered. The Q outputs of U3 and U4 are routed to the CLR and SET inputs of U1 respectively. Hence contact of an endstop forces the blanket to be positioned to move in the direction away from the endstop as well as disengaging power to the motor.

This entire electronic system has been tested and is currently installed in a persons home for trial. The only problem that occurred was that there was some problem in opening the device in order to let the person in and out of bed. This required a modification of the brackets that hold the curtain supports to the rod assembly. Operation of the entire controller has been practically flawless and the individual is pleased with the systems performance.

The approximate cost of the device including the electronics and pulley system (not including the sip-n-puff) was $200.

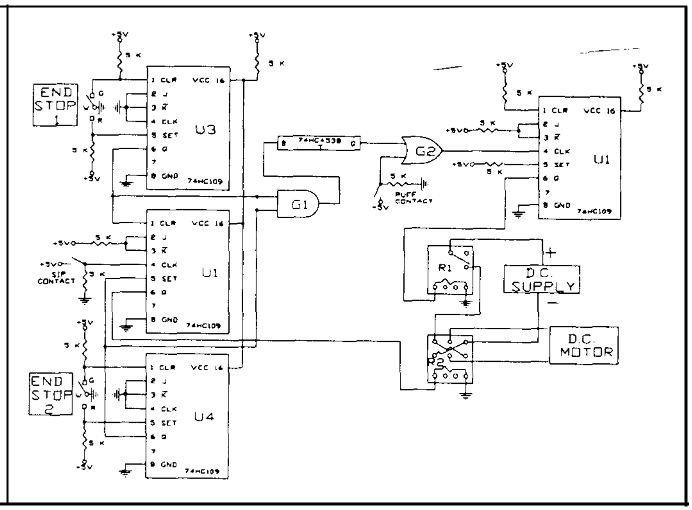

Fig. 5.4. Circuit for Automatic Bed Cover Controller.

Inexpensive Piezoelectric Contact Microphone For Voice Recognition

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INTRODUCTION

The purpose of this project is to design a microphone that is suitable for use in noisy environments. As speech recognition technology improves, eventually many devices will be routinely controlled through voice activation. In the future, it will be possible for automobiles, wheelchairs, and other motorized devices to be controlled with voice input. In order for these devices to operate safely in noisy environments, microphones which can reject ambient noise must be developed. These microphones should respond only to the voice of the user and not extraneous sounds such as horns, bells or other noise. A contact microphone was made using piezoelectric film directly attached to the throat in the Adam's apple area with two sided tape. The appropriate circuitry was constructed to interface the film microphone to a Intravoice VI speech recognition unit. Sound levels were adjusted using

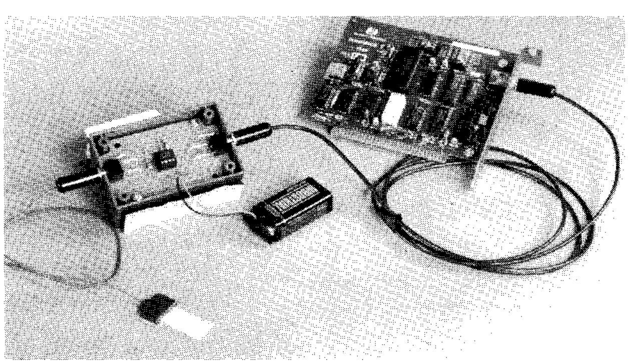

Fig. 5.5. Piezoelectric Contact Microphone for Voice Recognition.

adjustable gain and vocabularies were trained and tested. In general, results appear promising for using this approach as an inexpensive contact microphone which gives excellent audio fidelity in the presence of ambient noise.

SUMMARY OF IMPACT

This project will allow disabled individuals to make use of speech recognition under a wide variety of ambient conditions. The original application of this project was in the development of a controller for a voice activated wheelchair. The fabrication of inexpensive contact microphones will enhance the lifestyle of individuals who are able only to use their voice to interact with a computer system since they will be able to use voice recognition in a large number of diverse ambient environments.

TECHNICAL DESCRIPTION

Figure 5.5 shows the piezoelectric microphone connected via coaxial cable to a battery powered interface circuit. The output of this circuit is then fed to an Intravoice VI speech Recognition unit which is available with a large library of support software which can enable the user to use any standard commercial program as well as perform environmental tasks such as telephone control. The Piezo film is manufactured by Atochem Inc. (Valley Forge, PA). It is a thin flexible film encased in a flexible polymer coating which protects the film and enables one to easily contact it to a wide variety of surfaces. Figure 5.6 diagrams the equivalent circuit for a piezoelectric device. This simple model models the film as an internal voltage source in series with a capacitance. The amplitude of the voltage is proportional to the force placed on the film from an external source. If a load impedance terminates the film, the frequency response of output will be determined by the load. The 3 dB pole is simply $1/(2\pi RC)$. Hence proper interfacing must be performed in order to obtain proper amplitude and frequency response on the output.

Figure 5.7 depicts the piezo sensor and shows its' internal circuitry provided by the manufacturer.

The sensor can be purchased with or without an internal FET transistor which is used to boost the signal output. We chose the manufacturer provided FET interface which allows the user to alter gain but not frequency response. Inside the plastic holder that connects the coaxial wire to the film is the FET circuit which provides a load impedance of 10 MΩ to the film. This sets the lower 3 dB cutoff to approximately 6.6 Hertz as shown in the Figure 5.7. This provides adequate AC coupling of the film and also passes the majority of energy to the amplifier. We chose a value of R equal to a variable 50 KΩ potentiometer. This allowed us to control the amplitude of the output voltage. We then followed this with a non inverting op-amp buffer (LF353) to provide an interface into the Intravoice VI as shown in Figure 5.8. The circuitry was mounted in a box with battery and Velcro band for attachment to a persons belt as shown in Figure 5.5.

The film was attached to the Adam's apple with double sided tape and several vocabularies were trained for a variety of applications using the Intravoice VI speech recognition unit. This unit has software that enables the user to adjust a software audio gain associated with the board in order to obtain the optimal signal level for recognition. After appropriate adjustment of R shown in Figure 5.8, we were able to obtain speech recognition of 98 percent or greater. Extraneous noises were produced by clapping, ringing a bell loudly, and using a boat horn. These did not affect the microphone since it is sensitive to mechanical vibrations obtained primarily from the throat. Strong coughing, however, did sometimes confuse the Intravoice VI. It was found that if you put the unit into a "sleep" mode, coughing did not affect it until the unit was reactivated.

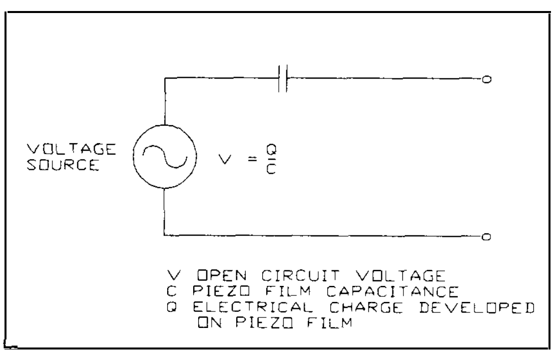

Fig. 5.6. Equivalent Circuit of Piezo Film.

We also discovered that moving the microphone in areas close to the Adam's apple does not affect the voice recognition to a large extent, however, the most accurate recognition was obtained when the microphone was fastened in exactly the same place where voice training took place.

Future plans include the design of an enclosure for the microphone that will look more attractive and also facilitate attachment to the throat. The cost of the entire project was $85.

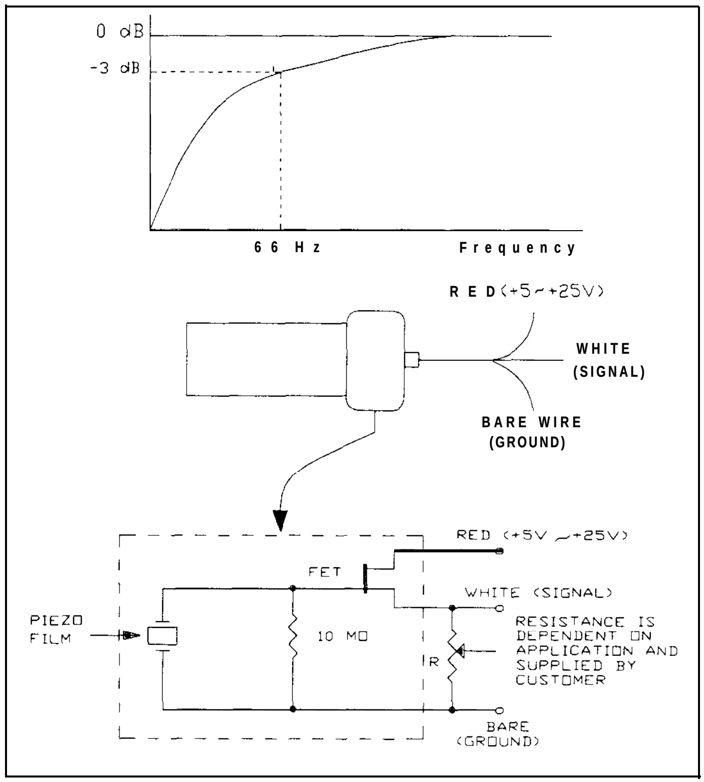

Fig. 5.7. Frequency Response of VS/FET.

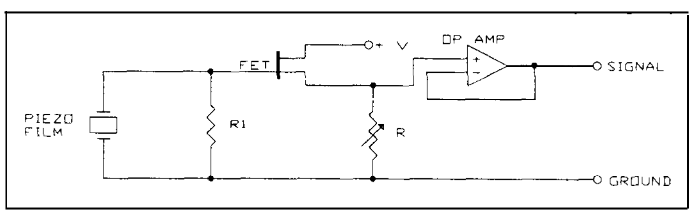

Fig. 5.8. Interface for the Intravoice VI .

Turning Desk with Computerized Control

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INTRODUCTION

The purpose of this project was to provide a means for disabled individuals to be able to refer to a large number of written documents at one time. The principal investigator has had involvement with several quadriplegic individuals who are either law students or practicing attorneys. This project was suggested by one of these individuals as a means to aid disabled individuals who have a business or have the requirement to view and analyze a large amount of written information without the intervention of an attendant. The turning table is a basic desk with drawers that has a circular section cut out in the center work area. This section can be raised or lowered and also rotated with the aid of two stepping motors under computer control. The principal investigator has previously described a voice activated environmental control system for the disabled in the 1990 NSF "Devices to aid the Disabled". This system has been extended to control the turning table described here. Via voice commands, the user may control the table to rotate a specified angular displacement, or he may either raise or lower the circular section to a desired height. This allows the user to view a number of books or documents that have been placed in different sectors of the table in a rapid sequential fashion so that the use of an attendant is not a constant necessity during intense study sessions. Although this project was targeted at attorneys, any disabled individual involved with studying a large number of documents will find use for this desk.

SUMMARY OF IMPACT

This device will provide an important aid for disabled individuals who must access a number of written volumes in a rapid sequential manner. This situation is similar to that of a student studying for an examination who has many books spread around a table. This type of desk will facilitate the work of highly motivated disabled individuals and provide them a level of independence from their attendants.

TECHNICAL DESCRIPTION

Figure 5.9 shows the overall design of the desk. The physical measurements of the desk are 72" x 43" x 34" high. The thickness of the desktop is 1" and the rotating circular inset must be able to turn up to 65 pounds. The circular section is 36" in diameter. The entire motion of the table is automated via a personal computer system with specialized software for environmental control.

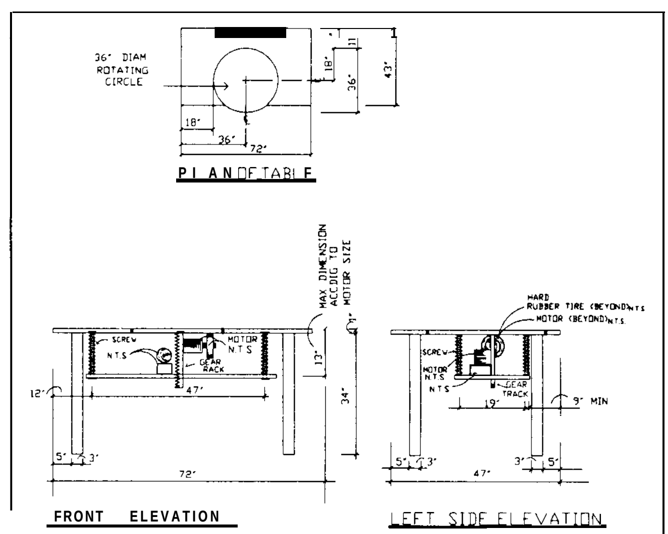

Fig. 5.9. Desk Design.

The bottom left portion of figure one shows the front elevation view of the desk and illustrates the mechanism by which the center of the table rotates. Two DC stepper motors (Deltran SV 100-P) which operate on 12 volts power and produce 12 in-lb of torque are used to implement the up/down and rotation mechanism. The first stepper motor is mounted to a rectangular wooden support base which is 47" x 19" and 1" thick. This base is recessed

9" from the front of the desk and a hole is drilled through the center of this base so that a gear rack may traverse vertically in order to adjust the vertical position of the rotating section. The first motor is mounted to the base and the gear rack is attached to this motor via a gear and support bracket. The top of the gear rack is bolted to a rotating bearing assembly which is bolted into the center of the circular inset. Hence the circular inset can freely rotate and can move up and down according to the gear rack position. A second stepper motor is bolted to the gear rack to provide the circular rotating motion. The front elevation view shows the second motor mounted and coupled to the table via a rubber tire. This tire is shown more clearly by the left side elevation. The motor is moved down to an appropriate position on the gear rack so that the tire firmly contacts the wooden inset. The rotation of the shaft of the second motor causes the tire to rotate which then turns the circular inset. This assembly is completely supported by the gear rack which can move vertically by rotation of the shaft of the first motor. The net result is a complete vertical and rotational control of the circular inset of the desk.

The hardware that drives the stepper motors is shown in Figure 5.10. This hardware is duplicated for each motor. A 555 timer circuit (MC1455) is configured as an astable multivibrator using the standard connections in the Motorola linear data manual. The frequency is given as $1.44/(R_3 + R_4 + R_6)C_3$. Capacitor C3 and potentiometer R_6 determine the frequency of the pulses used to drive the stepping motors and therefore determine the rate of vertical and rotational motion. C3 is chosen as 22 mf and the total resistance in the loop can be varied from 1.3 K to 10.3 K which gives a frequency variation from approximately 2 to 100 Hertz which is sufficient to adequately tune the speed of the motors.

Each of the stepping motors is driven by a Signetics SAA1042 stepping motor controller integrated circuit which contains high noise immunity input stages coupled to a two bit (4-state) bidirectional synchronous counter. The counter yields four discrete states used to drive standard four phase dual stator stepper motors. The counter outputs are coupled to a code converter which yields the proper stator drive outputs. The output of each code converter bit is then fed to four buffers which are used to drive transistors which will supply the necessary current to the stators of the stepper. Hence the SAA1024 contains all the functional modules for a complete digital interface to the stepper motors.

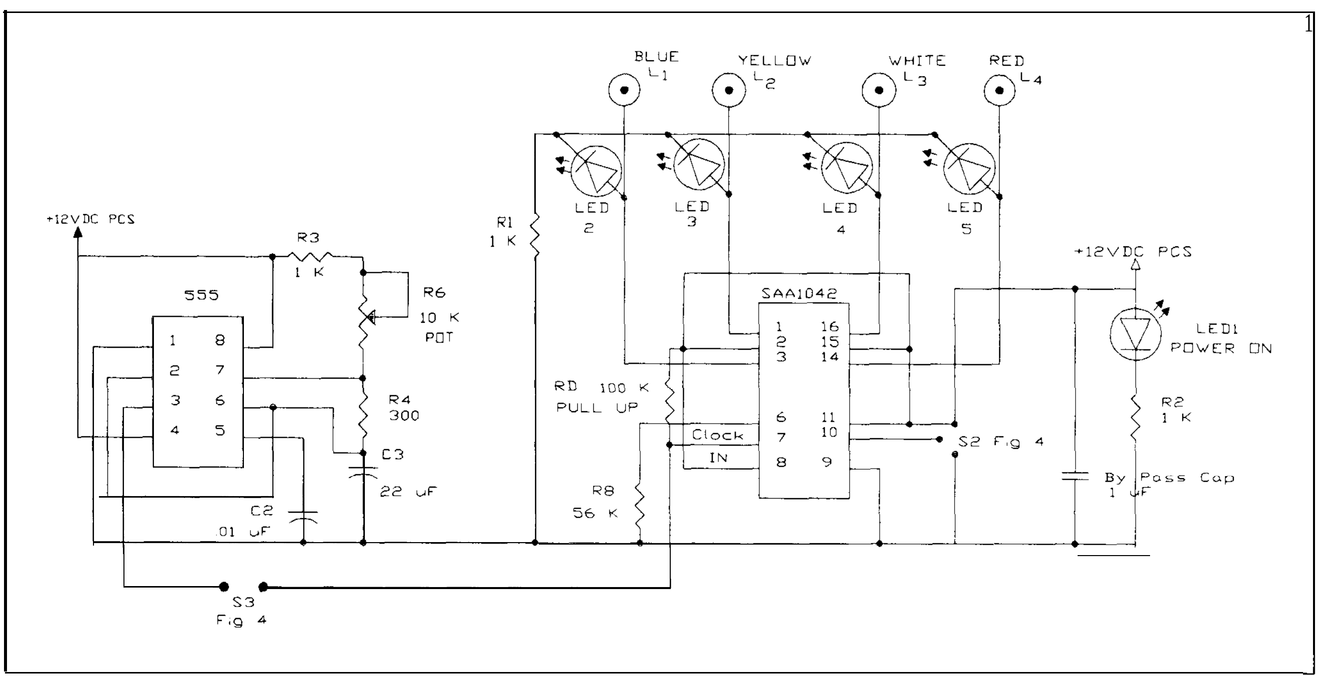

Fig. 5.10. Stepper Motor Circuit Diagram.

Figure 5.11 shows the computer interface to the SAA1024. For each motor, relay S3 is used to connect the 555 oscillator into the clock input for the four bit counter. This causes the counter to either count up or down depending on the state of the S2 single pole-double throw relay. Turning on S2 connects pin 10 of the SAA1024 to ground. This causes the counter to count up which will cause the rotation motor to move forward and the vertical motor to move up. Turning off S2 shorts pin 10 to pin 11 which causes the counter to count down. This will make the rotational stepper move in reverse and the vertical stepper move down. All relays are driven by 2N2222 transistors with diodes placed across the input coil to provide protection from current surges due to inductive discharge of the coil energy. All transistors are driven by MC1489 quad line receivers which translate the RS232 levels into digital levels and provide the necessary current drive to switch the transistors. The DSR, DTR, and CTS signals are used to toggle the transistors in the appropriate manner and the truth table for the RS232 control is given in the lower right hand comer of the figure. DSR selects the forward/reverse mode for both motors since this signal drives the relays for both steppers. DTR turns on the horizontal motor by connecting the 555 output to its SAA1024 input. CTS performs the identical function for the vertical motor.

The software that controls the RS232 port is a modification of the environmental control software program that we have previously described in the 1990 edition of this NSF publication. We have now added an additional module that controls a selectable RS232 port, COM1 through COM5 may be chosen. If the user selects table control, and utters commands, one of the operations described in the table will be performed. For example, if the user says “forward” then CTS will be set low to disable vertical movement. Simultaneously, DTR will be set high to enable the horizontal motor and DSR will be set high to configure the counter to count up. The other commands, “reverse’, “up’, and “down” perform the other functions outlined. If the user utters “stop”, all outputs are set to zero and both motors stop quickly. The Intravoice speech recognition unit is used for speech recognition.

All hardware and software for motor drive has been constructed and thoroughly tested. The table is currently being constructed at the machine shop at the New Jersey Institute of Technology and should be completed by the end of August. No problems with the final design are anticipated and the first table should hopefully be installed in a users home by mid September. The estimated cost of the project is $850.

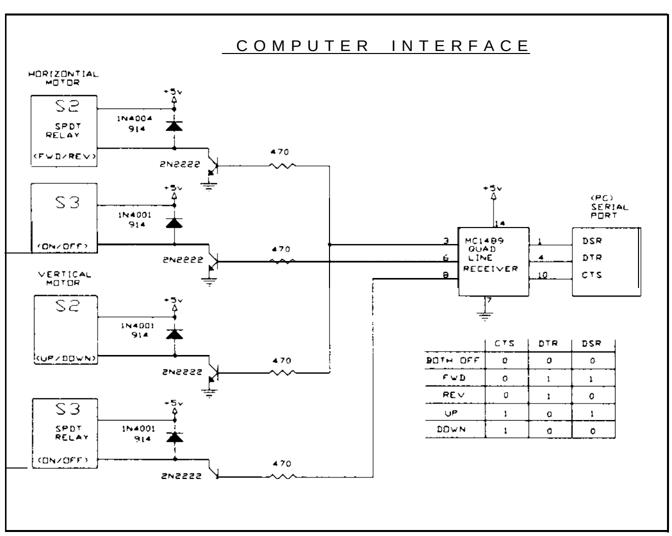

Fig. 5.1 1. Computer Interface for Turning Desk.