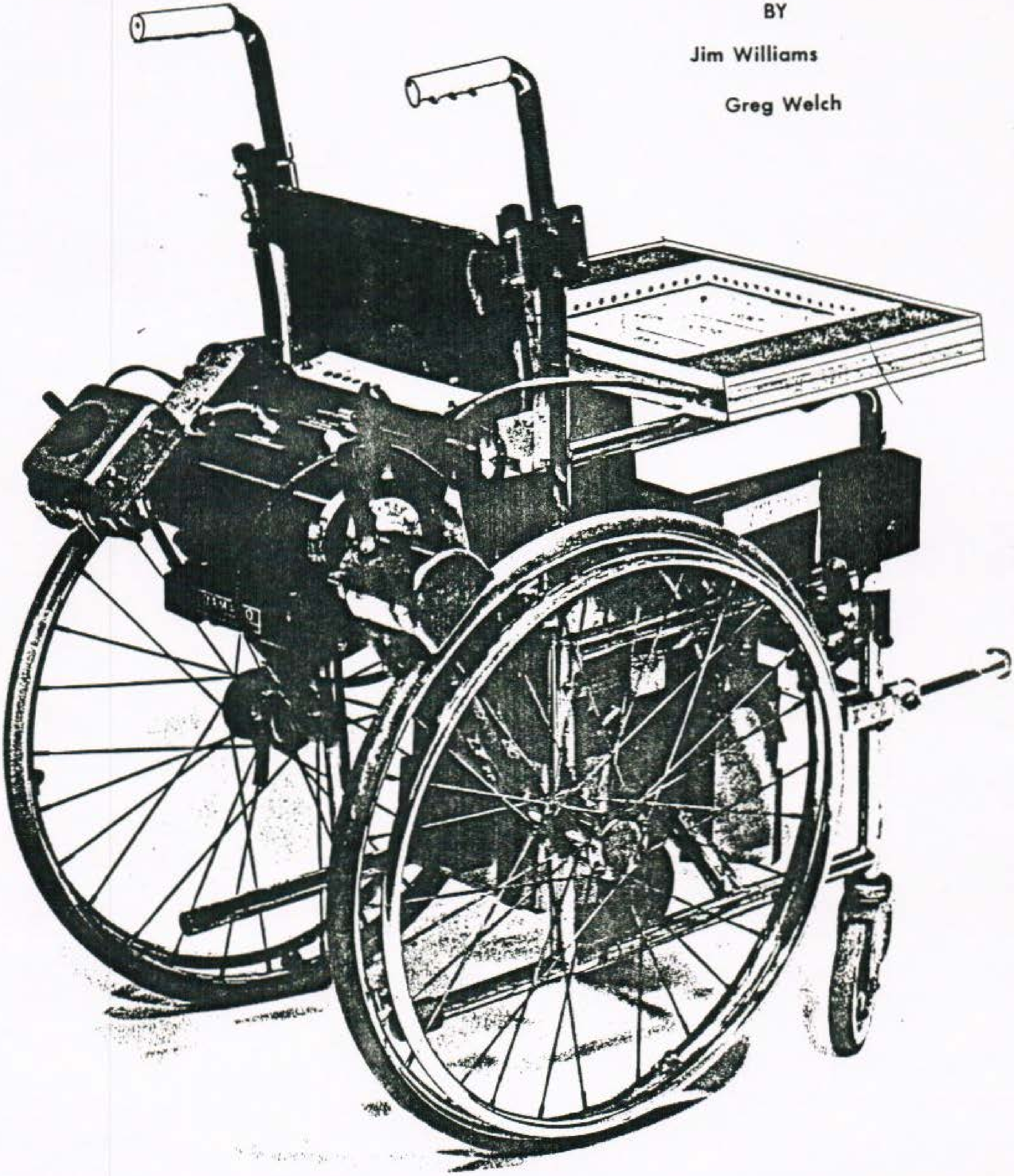
THE EASY CHAIR

BY

Jim Williams

Greg Welch



THE EASY CHAIR

James P. Williams - Gregory F. Welch

May 5, 1986

WHAT IS IT?

J
- Microprocessor controlled wheelchair
- Aid to handicapped (cerebral palsy victims)
- Learning tool for children with inexperience in mobility
- Effective means of introduction to powered mobility
- Funded by The Wabash Center (for handicapped children) in West Lafayette, Indiana

SPECIFICATIONS

G
- Must add safegaurds to powered mobility
- Must introduce a "force-free" method of input
- Should be removable without defacing the wheelchair
- Should be adaptable as child develops motor skills

DESCRIPTIONS

- Overall block diagram
  - G > Touch pad - Drool proof, etc.
  - J > Ultrasonics
  - G > Computer - New (re-written) monitor
  - J > Tone generator
  - G > Motor control - D/A (4 Bit) Zero & span
  - J > Power supply

TEST RESULTS

G
- Touch Pad & Ultrasonics
  - > Verified hardware operation (general)
  - > Used software test routines

G
- Motor control
  - > Monitored with oscilloscope
    - = Initial design produced incorrect references
    - = Modified to better meet specifications, and allow for offset & range adjustments

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- Power supply
  - > Monitored battery voltage with storage 'scope
    - = Developed plots and determined that current design was sufficient
    - = Regulator moved outside of enclosure for reduced temperature

TIME ACTION PLAN

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- Major portion completed on time (or ahead of schedule)

COST

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- Development cost slightly exceeded projected cost (due to miscellaneous development expenses)

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ABSTRACT

The Easy Chair is a microprocessor controlled electric wheelchair for small children with muscular disorders.

Because of the unique methods of control, this special wheelchair can be used by children with both limited muscular dexterity and strength.

Also, because of several safegaurds incorporated into the design, even children with limited experience in mobility can operate the powerful wheelchair safely.

The following report details the design and theory of The Easy Chair. It is assumed that the reader has some degree of knowledge in the field of electrical engineering.

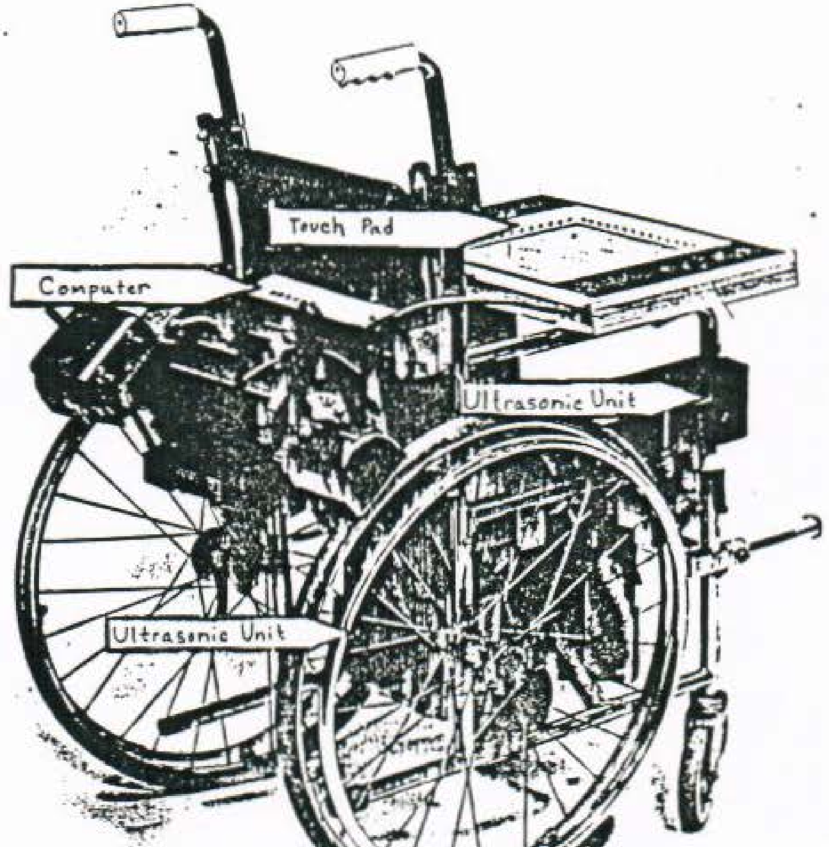


Figure 1.0 The Easy Chair

INTRODUCTION

The development of The Easy Chair is a very significant advancement for three main reasons. First of all, for many years small children with muscular disorders have had severly limited opportunities to acquire any experience in mobility. Secondly, this lack of mobility limited the opportunities to initiate communication with others. Thirdly, this lack of communication limited further their learning capabilities.

The original idea for such a wheelchair belongs to Professor George Karlin of the Special Education department at Purdue University. Professor Karlin first conceived such a device while working with cerebral palsy victims at The Wabash Center, Lafayette, Indiana. George Karlin also acted as an intermediator between the designers and the physical therapists at the center.

The idea behind a microprocessor controlled wheelchair (The Easy Chair) is to provide a safe mode of transportation for young children with muscular disorders such as cerebral palsy. Because the users will be so young, typically two to six years old, the chair was envisioned as being equipped with a variety of special devices. These devices would not only allow them to control wheelchair movement with only limited muscular force, but will also protect them from any undesireable circumstances.

The original electric wheelchair comes equipped with a Damaco D88 Add-On power unit. This unit includes batteries, the drive units (motors and controllers), and a proportional joystick controller.

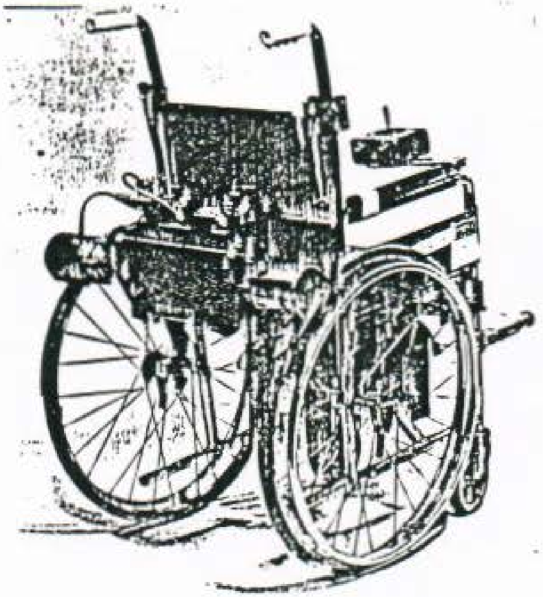


Figure 1.1 The Original Electric Wheelchair

The Easy Chair consists of this original wheelchair, with the addition of three extra devices:

(1) An infrared touch pad
(2) An ultrasonic ranging system
(3) A computer control system

These three additional devices not only make operation by handicapped children more feasable, but they also give the wheelchair an added measure of control and safety.

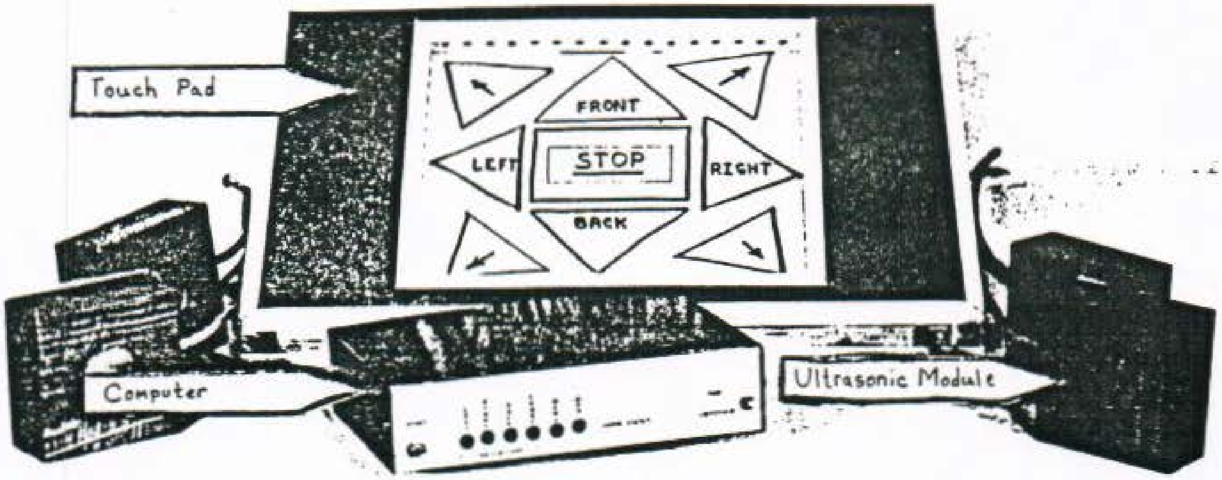


Figure 1.2 Added Devices

Shown below is a general block diagram for The Easy Chair which should give the reader am overall idea of how the different devices interract.

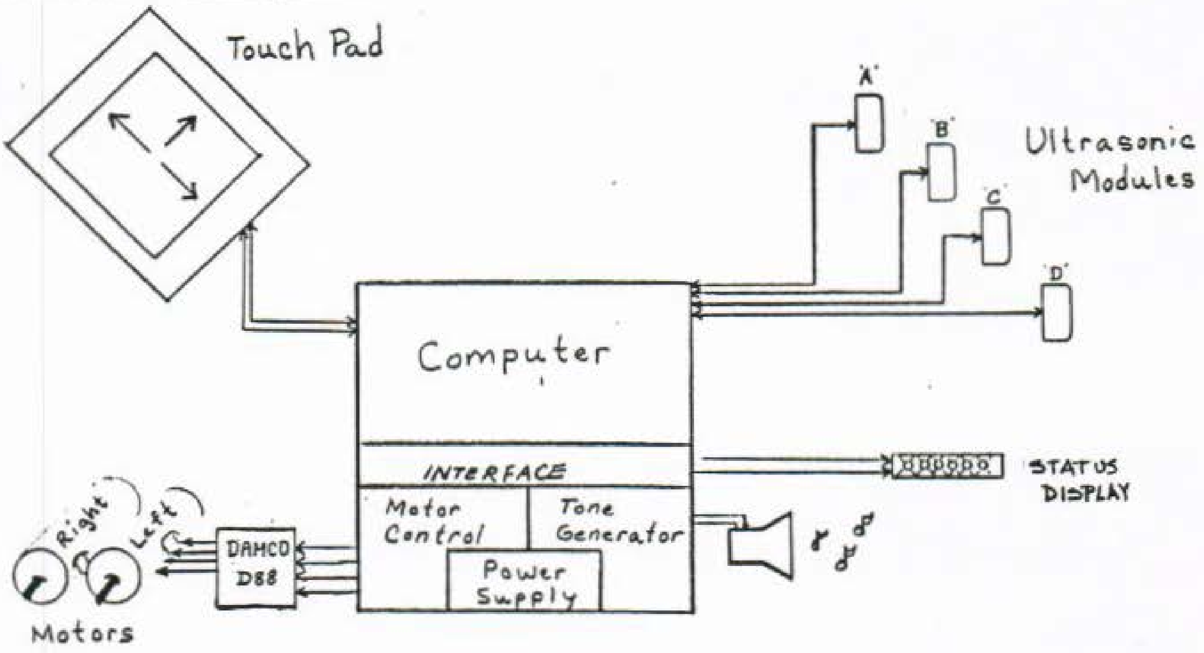


Figure 1.3 The Easy Chair Block Diagram

This report begins with the discussion of the infrared touch pad, including thoughts about why such a device was chosen. Then it explores the design and theory of the ultrasonic ranging system. Finally, it addresses the computer control system, along with the circuitry required to control the original wheelchair.

THE INFRARED TOUCH PAD

SPECIFICATIONS

The infrared touch pad is to be known as the input system for the control of the chair. It is thought of as the only real-time method of input to the computer control system. Therefore, it must meet several requirements which will allow it to be used to alter the current system configurations, or just to control the chair.

Specifications for the Easy Chair were outlined by an Occupational Therapist, Physical Therapist, and a classroom teacher from The Wabash Center in Lafayette, Indiana. This outlining was assisted by George Karlin, Special Education project coordinator at Purdue University, Lafayette, Indiana.

1) It was determined that a touch sensitive input surface requiring minimal pressure would best suit the needs of the small children. The system needed to be adaptable to different children, some of whom are incapable of generating high response force.

2) The touch-pad should use a common medium for set-up, to increase the independance of the system and its users. This is to say that it should be possible to simply plug in or unplug the touch-pad, and to switch between the pad and the current joystick with little or no effort.

3) It should be totally self-contained as a unit, electronics and all. Again, this would increase the independance of the system.

4) The touch-pad should be constructed in such a way that it could be attached to the current center off-set mounting arm of the wheelchair (which swings out of the way of the user), with the option of resting on the lap tray of the chair. These two methods will result in the touch-pad being as ambidextrous as possible.

5) The unit should be large enough to be easily viewed and touched, but small enough so as not to be obtrusive to the user and the wheelchair. A general touch-pad area of ten inches by ten inches was set for initial dimensions.

6) The size and locations of the symbols on the touch-pad (used to control the wheelchair) must be programmable. This will accomodate different ranges of motion.

7) The touch pad must be moisture proof. Children with such handicaps as cerebral palsy frequently have oral motor problems which result in excessive drooling. Any reasonable amount of moisture should not cause the wheelchair to malfunction.

In the early design stages, it had been thought that a total hardware solution was the most reliable and consistant solution to the problems presented for a touch pad. However after carefully studying that route, and testing the results, it was determined that a combination of approximately equal amounts of hardware and software would allow the most flexible design. The following sections describe the present solution, and how it is implemented.

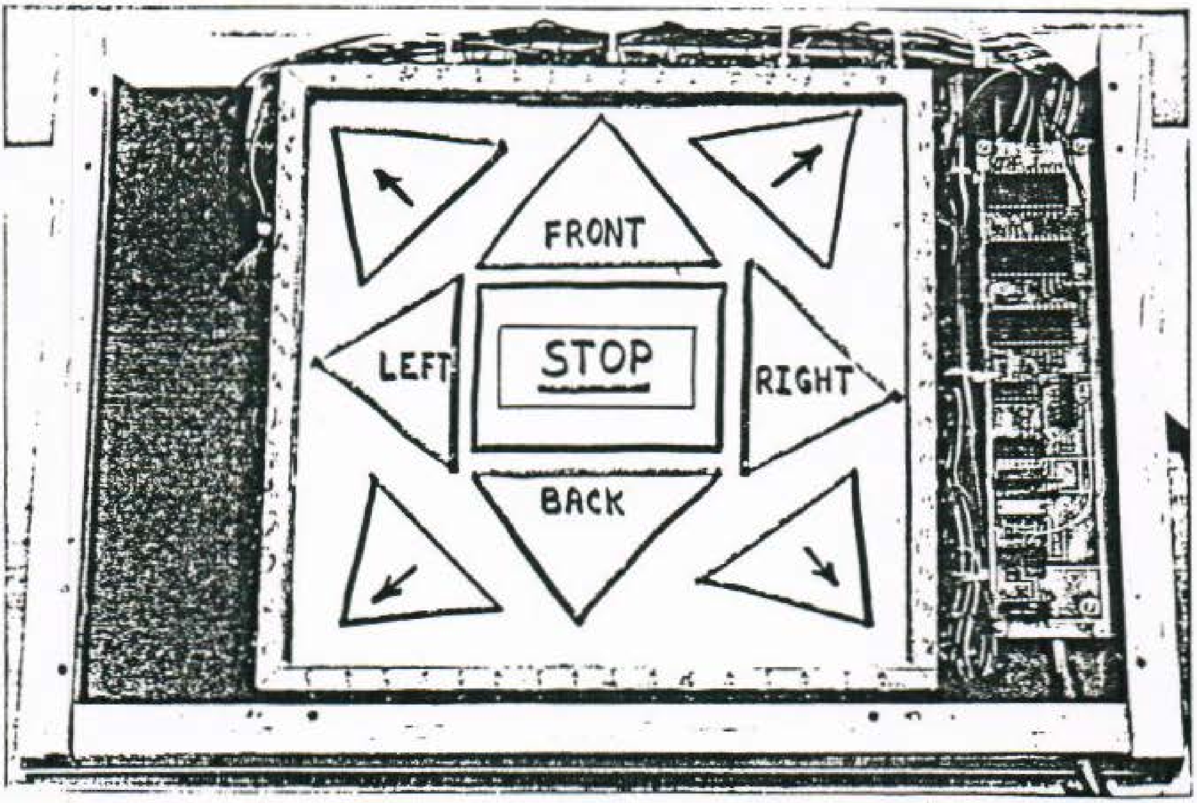


Figure 2.0 The Infrared Touch Pad

BLOCK DIAGRAM

The block diagram for the touch pad is shown below. It consists of six main blocks which include the row decoding (selecting) block, the column decoding block, the extra decoding block (which includes the menu-select decoding), the touch-pad block, the row/column detect block, and the menu-select detect block. Each of these blocks will be discussed in greater detail in the following sections. (See also Figure 2.4 Schematics)

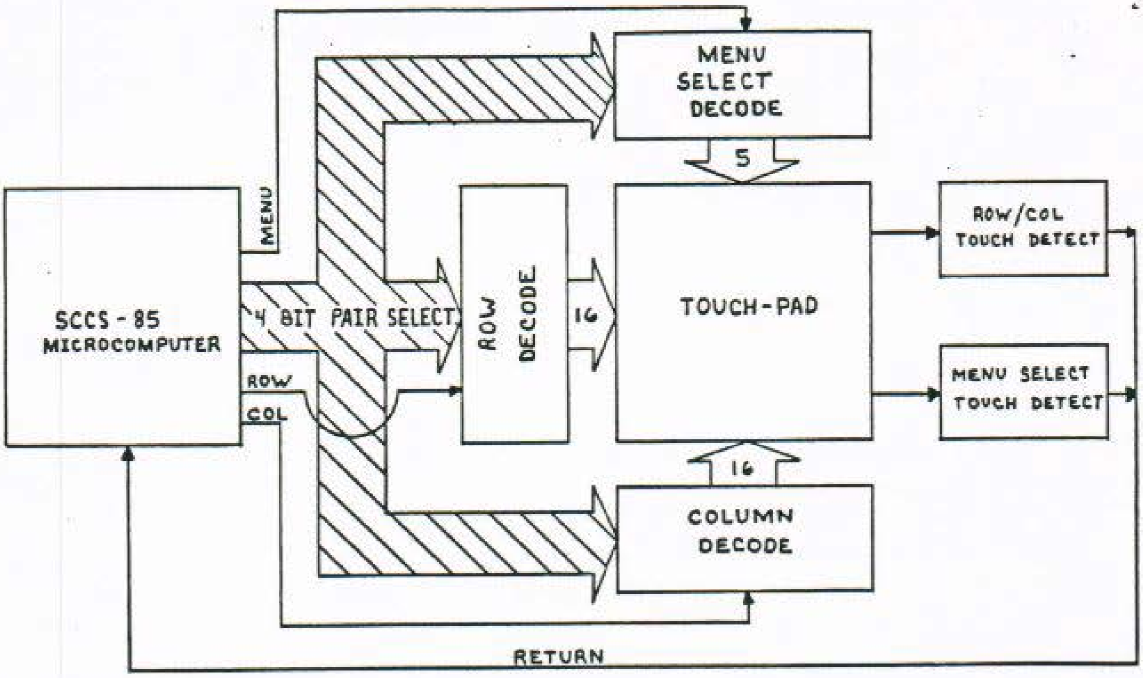


Figure 2.1 Touch Pad Block Diagram

I. THE ROW DECODING BLOCK

The row decoding block is one such block where the seven bit control word which is sent to the touch-pad circuitry is interpreted to select a certain LED/phototransistor pair.

The decoding is accomplished by sending the lower four bits of the seven bit touch-pad word to the pad. This nibble gives a zero through fifteen (F Hex) count which is used to select one of the sixteen ***row, column*** or ***extra*** LEDs. Then by using the upper three bits, one of three chip select lines is brought high.

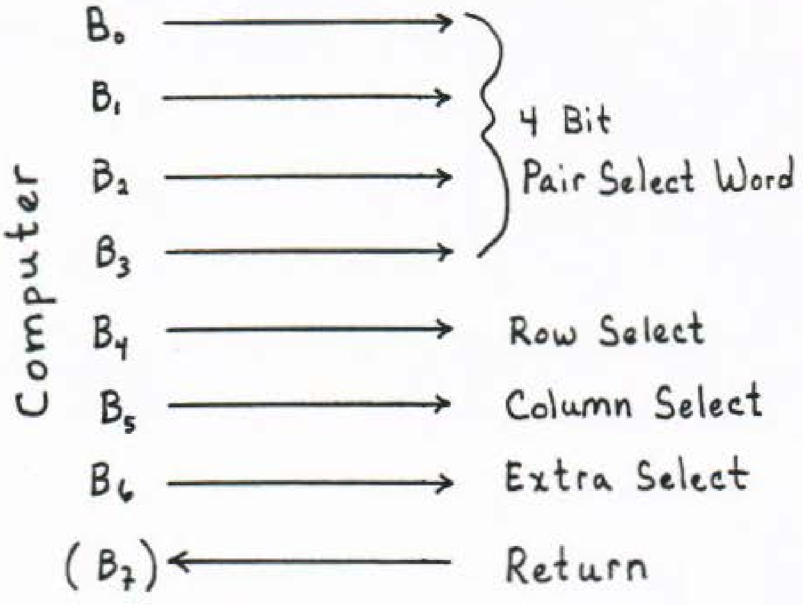


Figure 2.2 Touch Pad Control Word Diagram

To accomplish this, a 74154 4 to 16 line decoder is used. The outputs of this 74154 are low when they are selected, so they are used to provide a ground path for the infrared LEDs and phototransistors, thus allowing them to be turned on only when they are selected.

It is appropriate at this time to accent the fact that the select lines are used to select both an LED and a phototransistor. With this scheme, if there is nothing blocking the beam path from the LED to the phototransistor, then the phototransistor should be turned on.

II. THE COLUMN DECODING BLOCK

The column decoding block functions in almost the same fashion as the row decoding block. The only difference is that of the select line which is used to select the column decoding chip. Of the three selct lines (which correspond to the upper three bits of the touch-pad word), one is used to select the row decoding chip, one the column decoding chip, and one the extra decoding chip. The select lines use a `positive logic', so for instance to select the column pairs, the column select bit must be high (+5 volts).

Again, in the same fashion as the row decoding, this block selects certain LED/phototransistor pairs which are then monitored by the touch detection circuitry.

III. THE EXTRA DECODING BLOCK

Again, the basic function of the extra decoding block is the same as that of the row and column decoding blocks. However, this block serves no one single function such as row or column decoding.

The term extra is meant to reflect the odd or 'extra' decoding that is done by this block. At the present time, it serves to select one of the five menu-select LED/phototransistor pairs for observation.

In refering to figure 2.4, it should be noted that the three 'menu select' lines are passed through tri-state buffers before they are connected to the LED/phototransistor pairs. This is because smaller LEDs and phototransistors had to be used for the five menu select pairs (to fit between the column pairs in the pad).

These smaller phototransistors had lower off-state resistance, which caused problems when they were not selected. Normally when a pair is not selected, +5 volts is connected to the cathode of the LED and to the emitter of the phototransistor. This would not allow either to be turned on. With these five menu select pairs however, the +5 volts (seen when not selected) caused the menu-select detect circuitry to send a touch message to the computer. Therefore, the tri-state buffers were used, which present an open circuit in their non-selected state.

IV. THE TOUCH PAD BLOCK

This block contains the actual touch-pad with the LEDs and phototransistors mounted in it, and the slot for the selected menus to be inserted into (see figure 4). Along the vertical and horizontal sides of the sunken touch area, are alternately mounted 32 infrared LEDs and 32 phototransistors, one across from each LED. These pairs were alternated to reduce the amount of light being received in error.

The LEDs and phototransistors were carefully aligned so as to achieve the maximum signal recieved when a signal is sent. Each of the cathodes of the LEDs along with the emitters of the phototransistors across from them, are tied to the select lines of the 74154s (see also The Row Decoder Block and The Column Decoder Block).

The touch-pad also contains five seperate pairs which are mounted perpendicular to the row and column pairs, along the edge of the pad. These serve the purpose of allowing the computer to detect which menu is in the pad. The paper menus have five corresponding holes which can be cut open or left intact (closed), representing zeros and ones.

The anodes of all of the infrared LEDs (both row/column LEDs and menu-select LEDs) are tied high through a single series limiting resistor. Also, the cathode of each LED is connected to the emitter of its corresponding phototransistor. Therefore, when the pair is selected, and the cathode and the emitter are both taken to ground, turning on the LED and allowing the phototransistor to be turned on.

V. THE ROW/COLUMN DETECT BLOCK

This block is where the status of each phototransistor is transformed into a level that can be interpreted by the computer. With this signal, the computer can determine whether the beam is obstructed or not (corresponding to a touch or no touch).

As mentioned previously, the collectors of all of the phototransistors are tied together and pulled high through a single pull-up resistor (100k ohms). When any one of the LED/phototransistor pairs is selected, an infrared light beam from the selected LED should turn the phototransistor on, bringing the collector voltage somewhere near ground. If while one pair is selected, the beam is blocked, the phototransistor will remain turned off. In this case, the collector voltage approaches +5 volts because of the pull-up resistor.

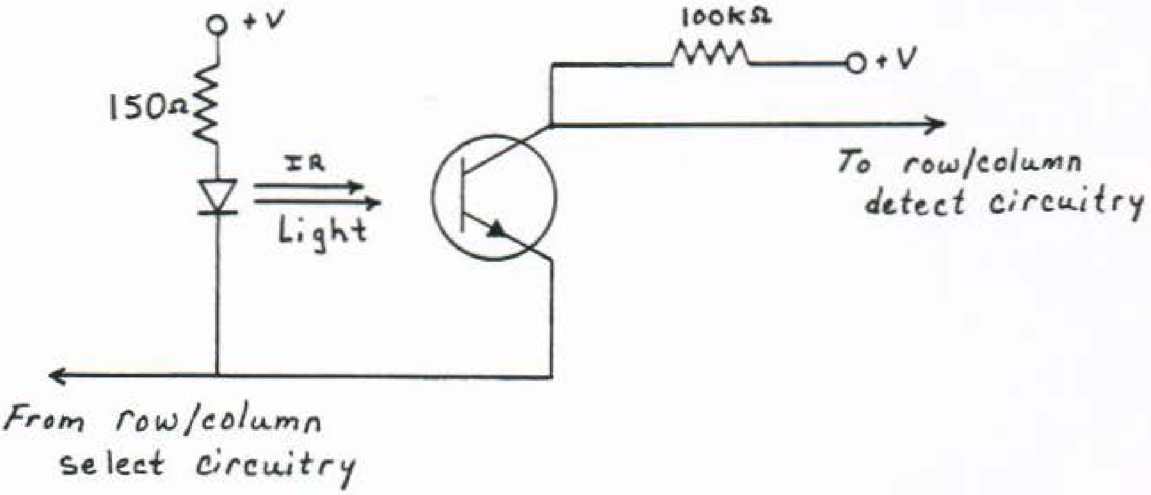

+V
150Ω
IR
Light
100kΩ
+V
To row/column detect circuitry
From row/column select circuitry

Figure 2.3 Sample LED/Transistor Circuitry

Because of the change in collector voltage from when a beam is blocked to when one is not blocked, the collectors are used as the the input to the row/column detect circuitry. This circuitry begins with two comparators which have adjustable references.

The first comparator is set up in an inverting fashion, so that when any collector voltage is below the reference (no beam blocked), the output of the comparator is at positive saturation. However, if any collector voltage swings above the reference, the output goes to negative saturation (close to ground). This output is then used as the input to the second comparator.

This second comparator uses the same reference voltage as the first one, however, it is set up in a non-inverting fashion. The main purpose of the second comparator is to clean-up the signal.

When the selected beam is *not* broken, the output of the first comparator (which is the input to the second) is high. This also sends the second conparator into positive saturation. The output of the second comparator, is then sent through an OR gate which has one input tied low, to further clean it up.

This signal is then further conditioned by the status of the row or column selects, to become the RCRET (row/column return) signal. This RCRET signal is then combined with the MSRET signal (menu-select return) to provide one single RET (return) signal for the computer. This signal is polled by the software as a single bit input to a port. By polling in this fashion, the computer can continuously look for a touch, and process one accordingly if it is encountered.

VI. THE MENU-SELECT DETECT BLOCK

The circuitry in the menu-select detect block is almost the same as the row/column detect block. The only real differences are first of all the size of the pull-up resistor for the phototransistor, and secondly the extra select signal is used instead of the row/column selects (for conditioning).

It is appropriate at this time to note the reason for combining the three different chip selects (row select, column select, extra select) with the RCRET and the MSRET signals (see also the Touch-Pad Schematic). Normally if neither the row or column chip is selected, then the RCRET signal is high, falsely signaling a beam being broken. The same problem is encountered when the menu-select chip is not selected, the MSRET signal is high, falsely signaling a beam being broken.

To eleviate this problem, the row and column chip selects are AND'ed with the RCRET signal, and the extra chip select is AND'ed with the MSRET signal. With this conditioning, RCRET can *only* go high when either the 'row' or 'column' chips are selected. Also, MSRET can *only* go high when the 'extra' chip is selected.

The resulting signals are OR'd together to form a single RET line which is high whenever any selected beam is broken. This leaves the computer free to select either a row, column or menu-select (extra) beam, and then determine by polling one line (RET) whether or not that beam is being broken.

Shown below is a photograph of the printed circuit board used inside the touch pad. Several of the main integrated circuits are labeled to help the user locate any components on the board.

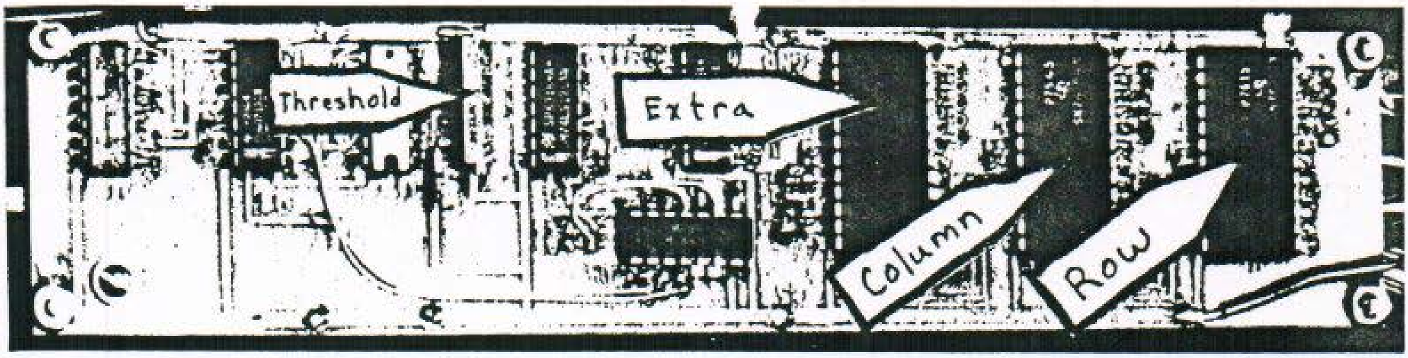


Figure 2.5 Printed Circuit Board and Components

GENERAL DISCUSSION

As was mentioned earlier in the scope of the project, the original thought had been that a total hardware system would be best. With such a system, the computer would only have to respond to some sort of interrupt from the touch-pad. During its service request, the computer could then simply read which location had been touched. This would tend to leave the computer more free to do other tasks.

Very briefly, all of this could have been provided by using a hardware clock to run several counters. These counters could in turn select each row pair, then each column pair, and finally each menu-select pair (a process now handled by the computer).

The major disadvantage to this method was that the scan process would be set in one certain fashion, unable to change if a better process was discovered. With the present method, the computer supplies the count to the pad. With this system, the count can be supplied in any order, able to change with only minor software changes.

The current method of using infrared light beams (instead of some other form of detection) was decided upon for various reasons.

1) Other touch-pad schemes such as capicitive touch sensing, and pressure sensitive membrane type keypads, are all affected by water, or saliva in this case.

2) Most important, breaking a light beam requires the least amount of pressure of any method studied.

The decision to use identical circuits for the RCRET and the MSRET may at first seem redundant. However, because of the limited amount of physical space between the column LEDs and phototransistors, smaller optical components had to be used. These smaller components required the same type of detection circuitry, with only the change of the pull-up resistor.

So, because the two blocks need to be electrically isolated, and because the needed gates and comparators (for duplicate circuitry) were in fact available, it was decided to duplicate the row/column detection for the menu-select detection.

THE ULTRASONIC RANGING SYSTEM

SPECIFICATIONS

The ultrasonic ranging system is considered a protective device. Its major function is to prevent damage to the chair or injury to its operator. It is also necesary to protect other young children who might be in the general area of the chair (innocent bystanders).

When designing the ultrasonic ranging system, the following specifications were used as guidelines.

1) The system should be able to sense any object within approximately four feet of the chair, from any of four different directions.

2) It should audibly warn the user of these obstructions, so as to allow time to take corrective actions.

3) It should also be possible to turn this audible feedback off.

4) If corrective actions are not taken in time to avoid a collision, the chair should stop automatically.

5) It should be possible to place the ultrasonic units in any desired location on the wheelchair, and should should not deface it in any manner.

6) If a major failure should occur, it should be possible to remove and retire the complete sytem without effecting normal operation of the wheelchair.

7) Without a major failure, it should be possible to turn the ranging system off.

8) Other than stopping the chair in an emergency, the system is not to take offensive control at anytime as this would deter the user from learning to be in complete control of the wheelchair. (It is anticipated that after some practice, the user will be able to control the wheelchair without the use of the ranging system.)

With these specifications in mind, the ultrasonic system generally performs two main functions: It provides feedback to the user as to the approach of obstacles, and it provides a failsafe method of stopping the chair should the child fail to respond to the system's warning.

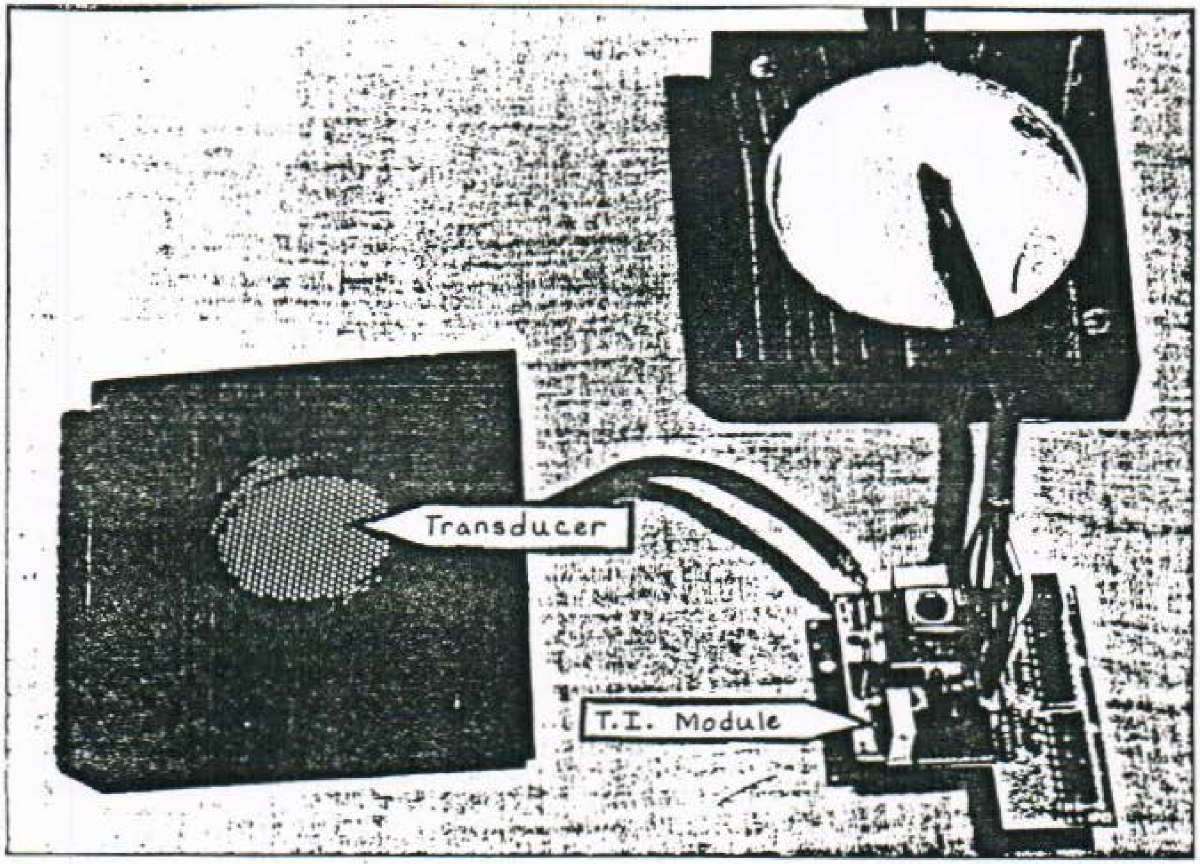


Figure 3.0 Ranging Module

BLOCK DIAGRAM

The block diagram for the ultrasonic system (shown below) consists of four principal parts. These include four directional transducers, the tone generator, a timer to aid in distance calculations, and the additional I/O board which is the system's interface to the computer. Each of these blocks will be discussed in greater detail in the following sections.

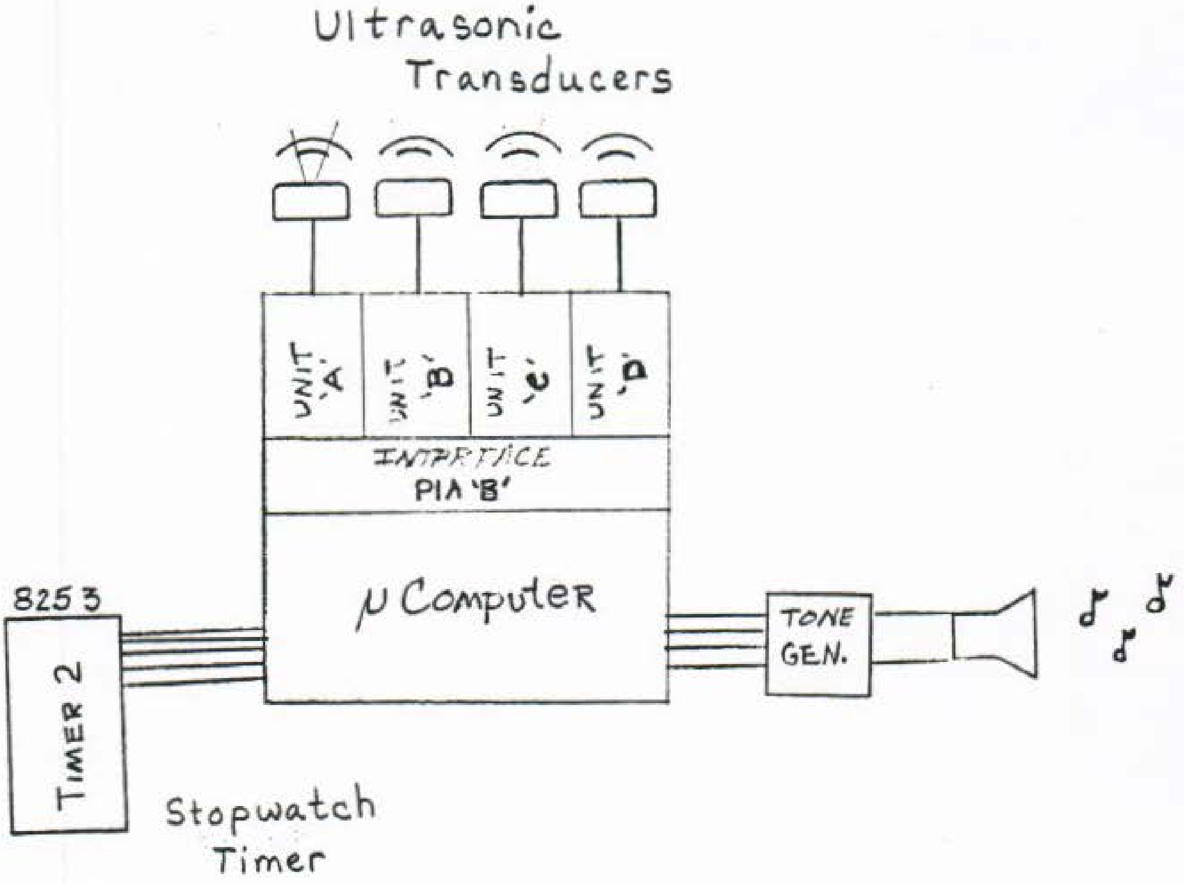


Figure 3.1 Ultrasonic System Block Diagram

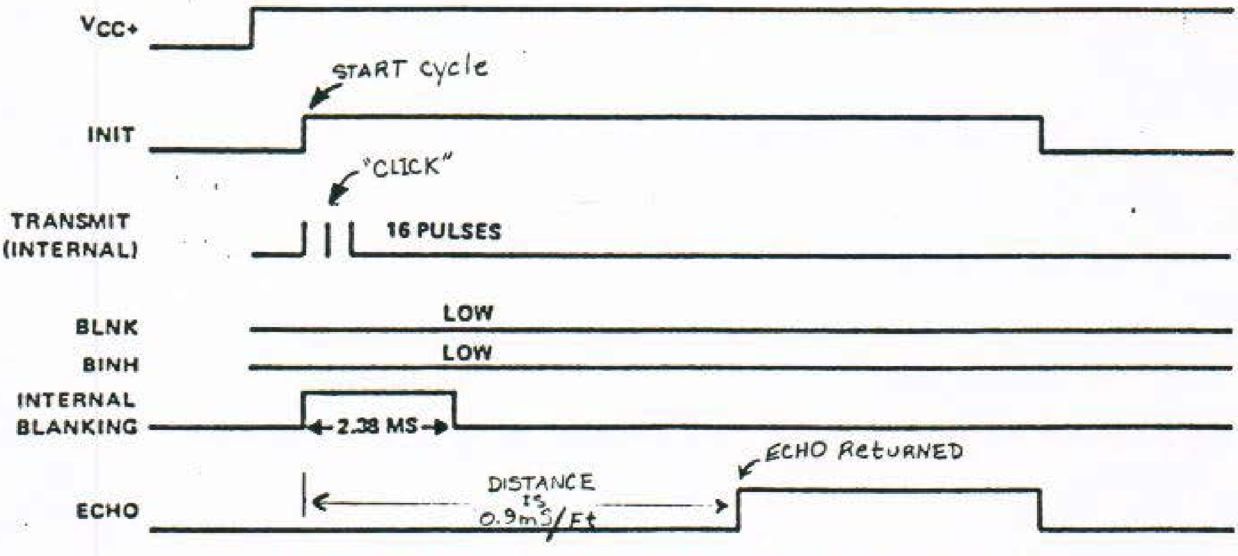
I. THE DIRECTIONAL TRANSDUCER BLOCK

The directional transducer block is the heart of the ranging system. It consits of four complete and seperate ranging modules. Each module contains a 50 kHz, 300 volt electrostatic transducer, and a small amount of drive circuity. Each module is capable of ranging from four inches to approximately 35 feet with less than two percent maximum error. (See also Figure 3.2 Ranging Module Schematic)

Each ranging module contains a Texas Instruments SN28827 sonar ranging module. This T.I. module provides the 150 volt bias for the transducer and pulses the transducer with 16 cycles of a 50 kHz, 300 volt waveform. This pulse can actually be heard with the naked ear, as it sounds like a short click. This ultrasonic waveform travels at the speed of sound (0.9 ms/foot) until it strikes an obstacle and its echo returns to the transducer at the same speed.

The module provides a controlable blanking period to allow transducer vibration to disapate before it is enabled to wait for a returning echo. All control signals are TTL compatible, but the echo output is of open collector type and needs a pull-up resistor in order to get a reliable TTL signal.

There are three main control signals. The INIT* input starts the ranging process by sending out the click. The BLNK* input defeates the internal echo blanking. And the ECHO* output signals when the click is returned. All three signals are active low, and their relationships to eachother are demonstrated below in Figure 3.3 Timing Diagram.



EXAMPLE OF A SINGLE-ECHO-MODE CYCLE WITHOUT BLANKING INPUT

Figure 3.3 Timing Diagram

The only devation from Texas Instruments design was that a large capacitor was added in parallel with the power connections as they enter each transducer's driver. This was done in order to supply the rated 2000 mA each transducer needs during the 326 uS transmit period. This is such a rapid drain that the power supply could not source it through six feet of cabling.

II. THE TONE GENERATOR BLOCK

The tone generator block consists mainly of the XR2206 function generator chip (capabale of switching between two selected tones) and an LM2002, eight watt audio power amplifier chip. (See also Figure 3.4 Tone Generator Schematic)

The XR2206 has the ablitiy to output two selectable tones. These tones are selected by switching the TTL level at the FSK input. This allows several types of warnings to be generated. The two tones are seperatly adjustable and independent. These adjustments are made to R4 and R6. See Figure 3.4 Tone Generator Schematic. The potentiometer R7 is a volume adjustment.

Turning the tone off is done with the Amplitude Modulation input. If the AM input is held at half the supply voltage, the output will be turned off. Control was accomplished by switching a voltage divider in and out. This voltage divider has two equal resistances (in series) to ground, creating a reference of one half that of the supply. The junction between the two resistors is connected to the AM input to the chip. An NPN transistor is used to shunt the bottom resistor of the divider when it is turned on, thus turning the output on (or off). This transistor is controlled by a TTL level sent from the computer, allowing the sound to be turned on and off.

III. THE ADDITONAL PIA AND TIMER BLOCKS

To supply the needed output for the tone circuit and the ultrasonic units, a second 8255 programable port had to be added. It is configured to have 20 bits of output and 4 bits of input. Ports A, B, and the lower four bits of C are defined as output. The higher four bits of port C defined as input.

Port A controls the ultrasonics INIT* and BLNK* of each transducer. Port B outputs a digital word to be used by the motor control circiuts for direction and speed control. Port C controls the tone generator with its upper half and receives the ECHO* from the transducers on the lower half. (See also Figure 3.5 Additional Parallel Group)

The timer block consists of three programmable timers within an 8253 timer chip. The 8253 is part of the SCCS-85 computer. (See also Figure 4.4 Timer Group, I/O Addressing Group).

The fist timer is configured to count down from 65,535 (OFFF Hex) and is used as a stop watch during the ranging cycle. The second is used for the generation of the 16 times baud clock needed by the 8251 for RS-232C communication. The last of the three timers on the chip is used for what is termed a `heartbeat' timer. With the help of a relay, if the timer counts out it will return the chair to the joystick configuration. So if the computer should fail, within 80 milliseconds the timer will count out, and control will return to the joystitk.

GENERAL DISCUSSION

The ranging system seems to perform very well. The transducer modules are fairly simple to use, and they are both accurate and reliable. The only noticable drawback to the ultrasonic units would be the audible click when the transducer fires. This sound could become annoying after time, but one should remember that they can be shut off after they are no longer needed.

From a designers standpoint, using a prebuilt module for the units was definitely better than trying to design the modules themselves. Because they were not familiar, this made troubleshooting harder in the few instances they failed to work. After time, however, that was no longer a problem because of more familiarity.

For reasons of flexibility and pleasing tones, the decision was made to design our own tone circuit. This was chosen instead of buying small tone transducers such as piezo buzzers.

The main problem encountered here was in attempting to drive the eight ohm load of the speaker. After trying to use several voltage amps, current amps, transformers and push-pull amps, it was decided to use an LM2002. This is a self contained amplifier chip which is specifically made for such a purpose.

The additional I/O board was constructed using a point-to-point soldering technique. This method was chosen because it took less time than to create a printed circuit board, and it is a more reliable method that wire wrapping.

The I/O board contains the circuits for the tone generator, the motor control, the power supply (conditioning), the additional parallel port, and the status LED circuitry.

COMPUTER AND MOTOR CONTROL

SPECIFICATIONS

The computer and motor control systems are possibly the most improtant parts of the Easy Chair system. A failure in either of these two systems could render the entire system inoperative.

The following guidelines were used when choosing the computer for The Easy Chair:

1) As is the case with all of the components, the computer must be extremely rugged.

2) Also, it must be usable in the sense that it is user friendly, allowing anyone to alter several different characteristics of the chair.

3) It should have an RS-232C serial interface to allow it to communicate with other devices.

4) It should be designed so that should the computer fail, the chair would revert back to control by joystick.

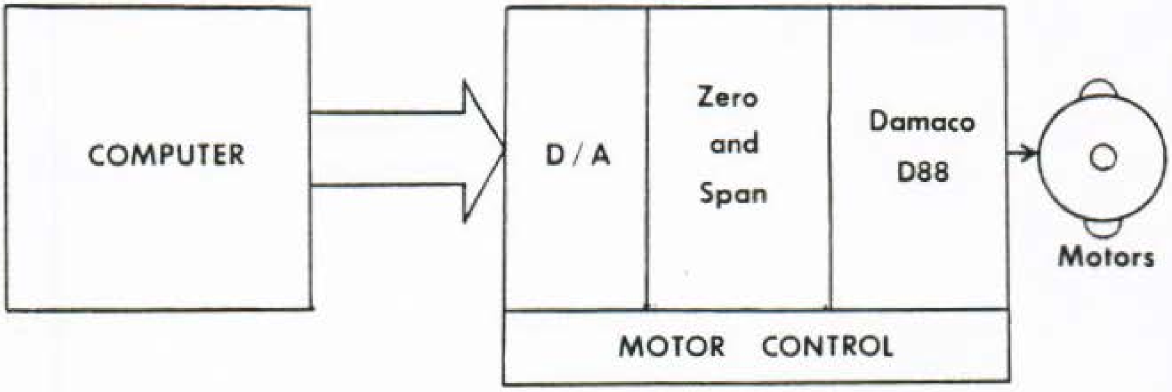
5) It should have the capability to "remember" several settings, even after the power has been removed.

6) It should have the capability to perform some limited self-diagnostics, to identify possible problems.

The computer decided upon was the SCCS-85 single board computer, available at Purdue University. This is an 8085 based computer with many options for memory and I/O.

It was chosen because of its flexibility, the ease of use, and the fact that several faculty members in the Electrical Engineering Technology department at Purdue University are very familiar with it.

BLOCK DIAGRAM



DETAILED BLOCK DESCRIPTIONS

I. THE COMPUTER BLOCK

The computer was initially built according to the manual provided. After opperation was verified, the following changes were made.

The clock speed was increased to speed execution time. Memory configurations were altered to accomodate eight kilobytes of EPROM (for startup sequence and monitor), and eight kilobytes of NOVRAM (non-volatile battery backup RAM) for variable storage, program development, and touch pad menu information. The NOVRAM will allow the system to be reconfigured by anyone, at any time. (See also Figures 4.2-4.7)

With the computer in normal operation, a major consideration is the software. This software includes routines which process input from the touch pad, monitor perimeters with the ranging system, control the motors through digital-to-analog circuitry.

Aside from those "real-time" responsibilites of the computer, it will also allow the user to alter such settings as the ranging distances, the audible feedback, the speed settings, durations, and menus which contain the settings mentioned.

Under normal operation, the user would first select a menu to be used for the operation. Once that menu was inserted into the touch pad, the computer would recognize it and alter settings to match those of the menu. With a menu in place, the user can select any defined area on the menu, and the computer will move the chair in the direction defined for that area. While the chair is moving, the computer will use the ultrasonic ranging system to alert the user of any obstructions.

All of this is accomplished through very complex assembly language software. Outlines for this software can be found in Appendix B: Software Outlines. These outlines will offer an overall view of how the chair is controlled. For further detail, one can consult the actual source code found in Appendix C: Software Listing. This code is effectively commented to offer the most possible insight into the different routines.

II. THE MOTOR CONTROL BLOCK

The motor control block contains all the necessary circuitry to switch control between joystick and the computer, and then to allow the computer to replace the joystick electronically.

The motor control circuit uses a single hexadecimal byte to control both motors. With four bits per motor this gives 16 different speeds; eight speeds forward and eight speeds in reverse. Although eight speeds may not at first seem like much, when compared to the resolution of the joystick it allows for many different speed options.

Operation of the controller is fairly straight forward. Two AD558 digital to analog converters are used to create a digitally controlled voltage which is variable from 0-2 volts. This output is then used as the input to a zero and span circuit, which allows the computer generated voltage to be adjusted so that it can effectively replace the joystick.

Using test equipment, the voltage potentials of the joystick pots were measured. The zero and span circuitry is adjusted to match not only this precise reference, but also the range available with the joysticks. (See also Figure 4.8 Motor Control Schematic)

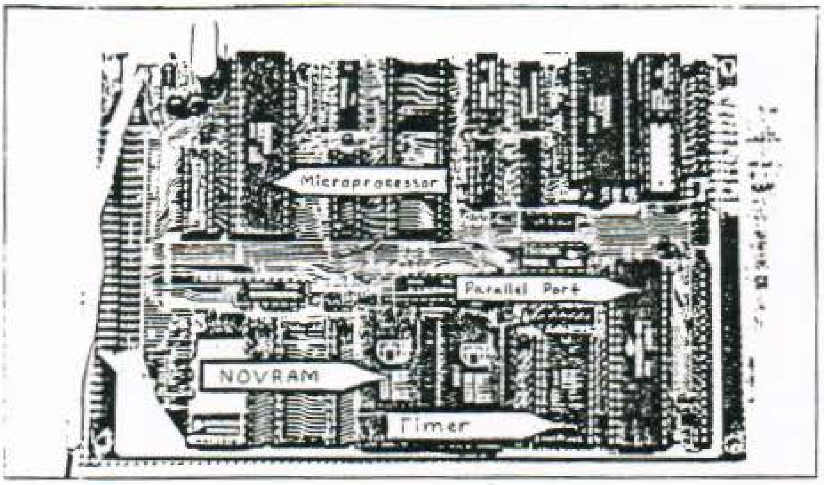


Figure 4.0 SCCS-85 Single Board Computer

GENERAL DISCUSSION

When experimenting with different types of memory, EEPROM's were used for a short time. However, because of timing problems, the RAM was changed to NOVRAM's. This is not to say that the NOVRAM's are without fault, but operation is faster and more reliable than that of the EEPROM's.

As is mentioned in the software outlines, the software can detect several different types of errors with the system. These errors can include something as complex as a bad chip, to something as simple as a menu not fully in place.

This error checking software also uses some special voltage loops in the different connectors. These loops are used to determine whether or not the connections are intact. If they are not (for whatever reason) the software will signal an error by lighting the correct LED, and ignore the corresponding device. (See below, Figure 4.10 Status LED's and Control Switches)

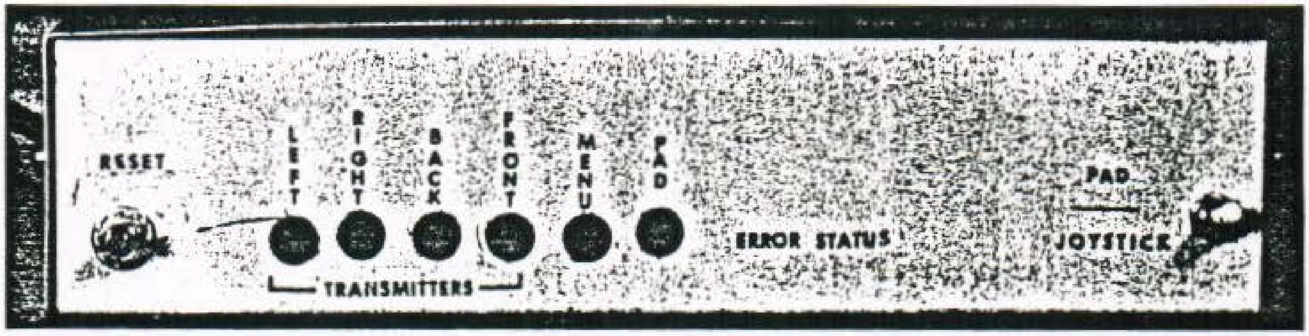


Figure 4.10 Status LED's and Control Switches

The motor control circuitry was modified from previous designs, to give added control to the signals. As mentioned previously, there are now adjustments for both the zero and span of the outputs from the D/A converters. This is in contrast to the original design which afforded only zero (offset) adjustment, but no adjustments for the span or range of the signals.

CONCLUSION

The project as a whole ran very smoothly. All of the design criteria was met, and in some cases surpassed. The work was completed at least on time, with much of it completed ahead of schedule.

As far as software is concerned, the original monitor program used in the SCCS-85 computer has been modified to reduce uneeded code. Then all of the routines to control the overall system were added, and also several small test routines. These test routines exercise each of the seperate components of the system to assure that they are working correctly.

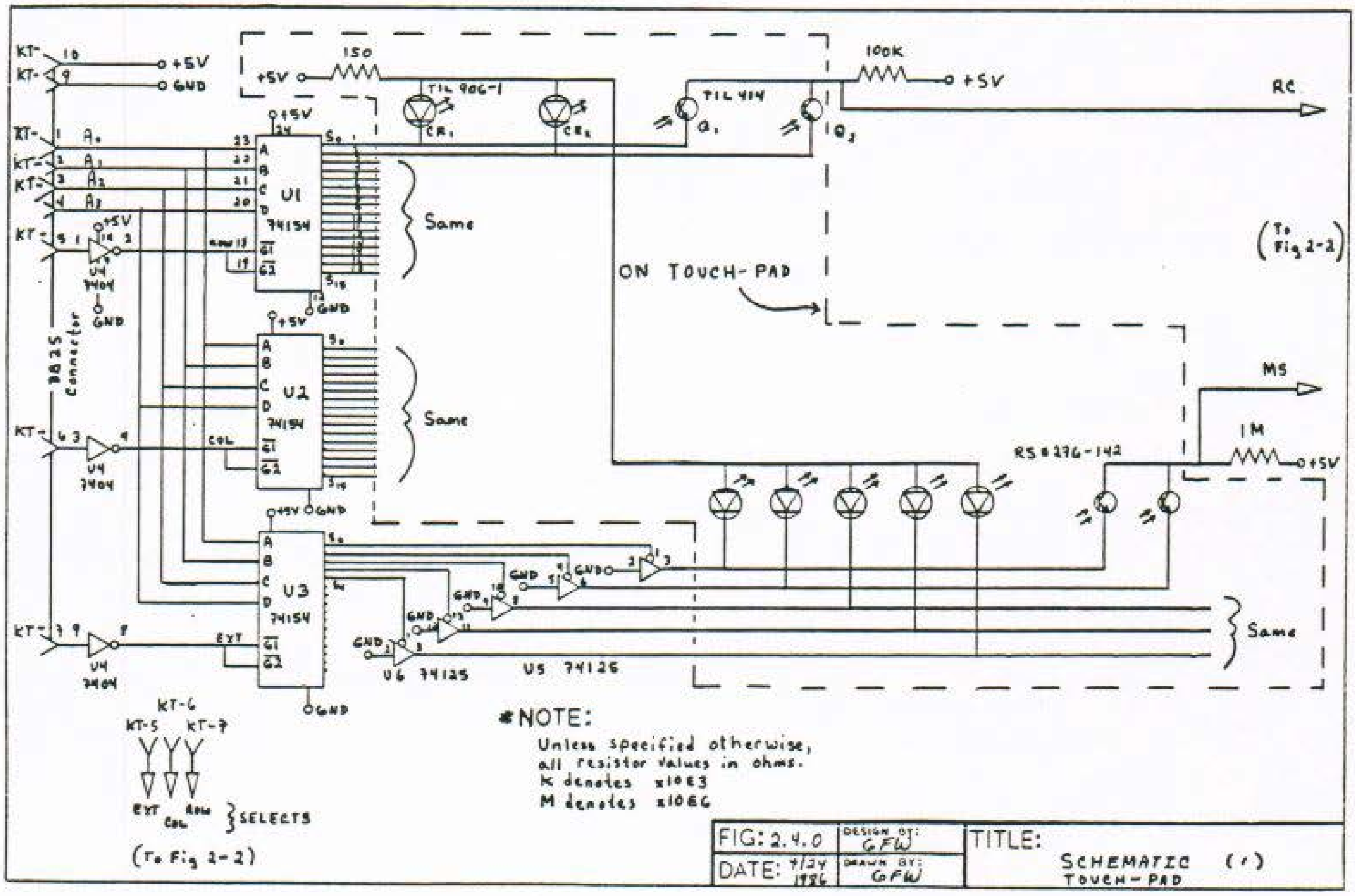
As mentioned earlier, discussion of the software in a text form, would be very difficult for the reader to understand. For this reason, the software is explained in the software outlines found in Appendix B Software Outlines. These software outlines use a general 'English language' format, rather than flow charts or diagrams. Actual subroutine and variable names are used in the outlines so that the reader can refer to the code with less difficulty.

In the future, a major recomendation would be to check thoroughly for 'second source' vendors. For instance, after checking with Polaroid for the ultrasonic transducers and ranging modules, they were later found for almost one third the original cost at a second vendor. Also, the cost of LEDs and phototransistors could be lowered by purchasing from a large wholesale distributor, (due to the quantity).

Another thought would be that if the touch-pad were constructed just slightly larger, the same LEDs and transistors could be used for all of the detection. This would eliminate the need for special menu-select detect circuitry, and the special smaller LEDs and transistors.

Overall for the project, having two people working together seemed to greatly enhance not only productivity and problem solving, but also enthusiasm. It always helps to have 'fresh' ideas to solve a problem. With two people working together, it seemed that one problem could usually be solved with the help of another person's 'fresh' outlook.

Because of the durability, ease of use, safety and flexibilty, The Easy Chair does provide an effective mode of transportation for handicapped children. With the assistance of the Easy Chair User's Manual, the system can be used by virtually anyone.



*NOTE:
Unless specified otherwise,
all resistor values in ohms.
K denotes x10E3
M denotes x10E6

FIG: 2.4.0
DATE: 4/24 1986
DESIGN BY: GFW
DRAWN BY: GFW
TITLE: SCHEMATIC (1) TOUCH-PAD

Figure 2.4.0 Touch Pad Schematics

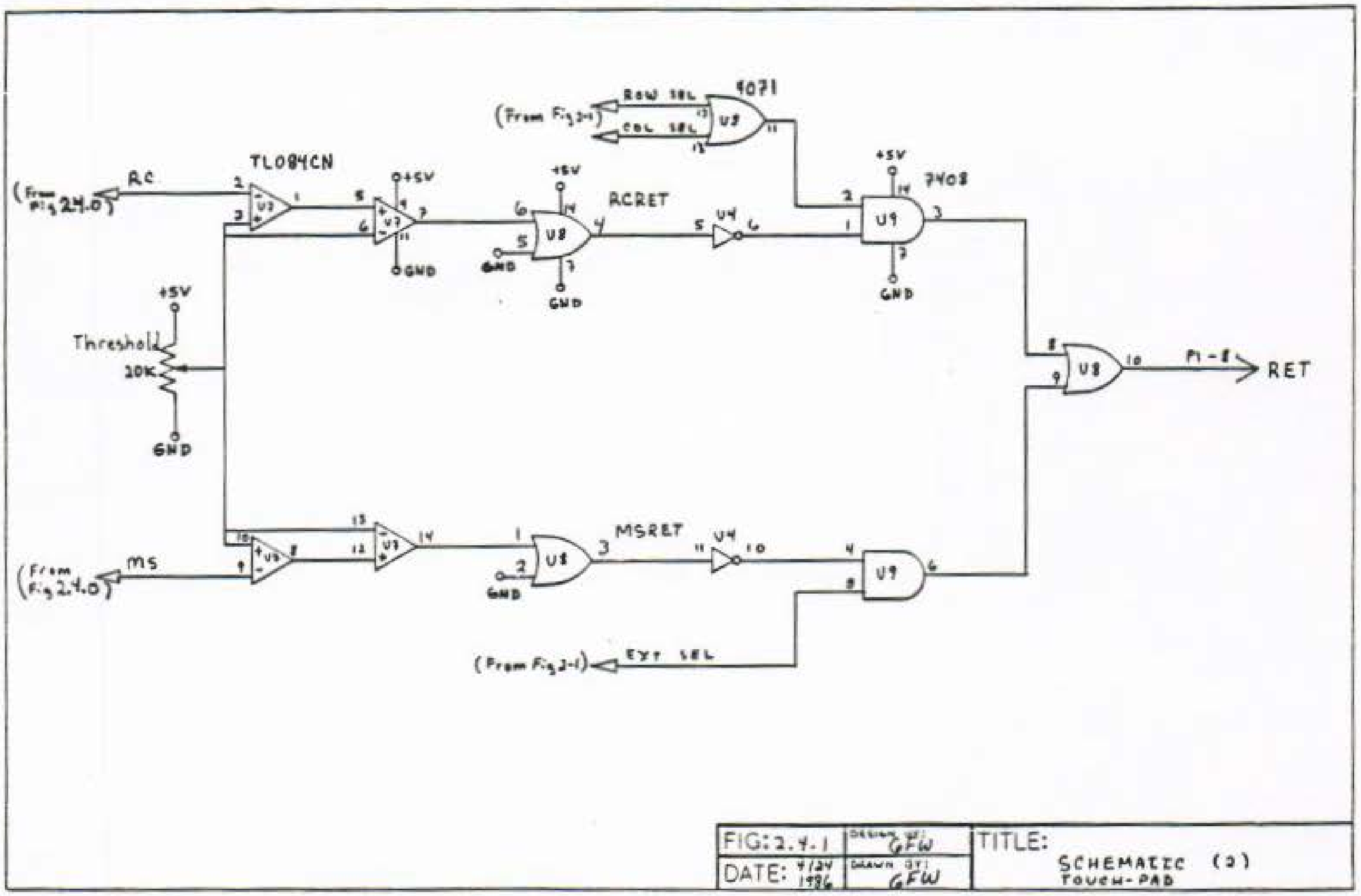


Figure 2.4.1 Touch Pad Schematics

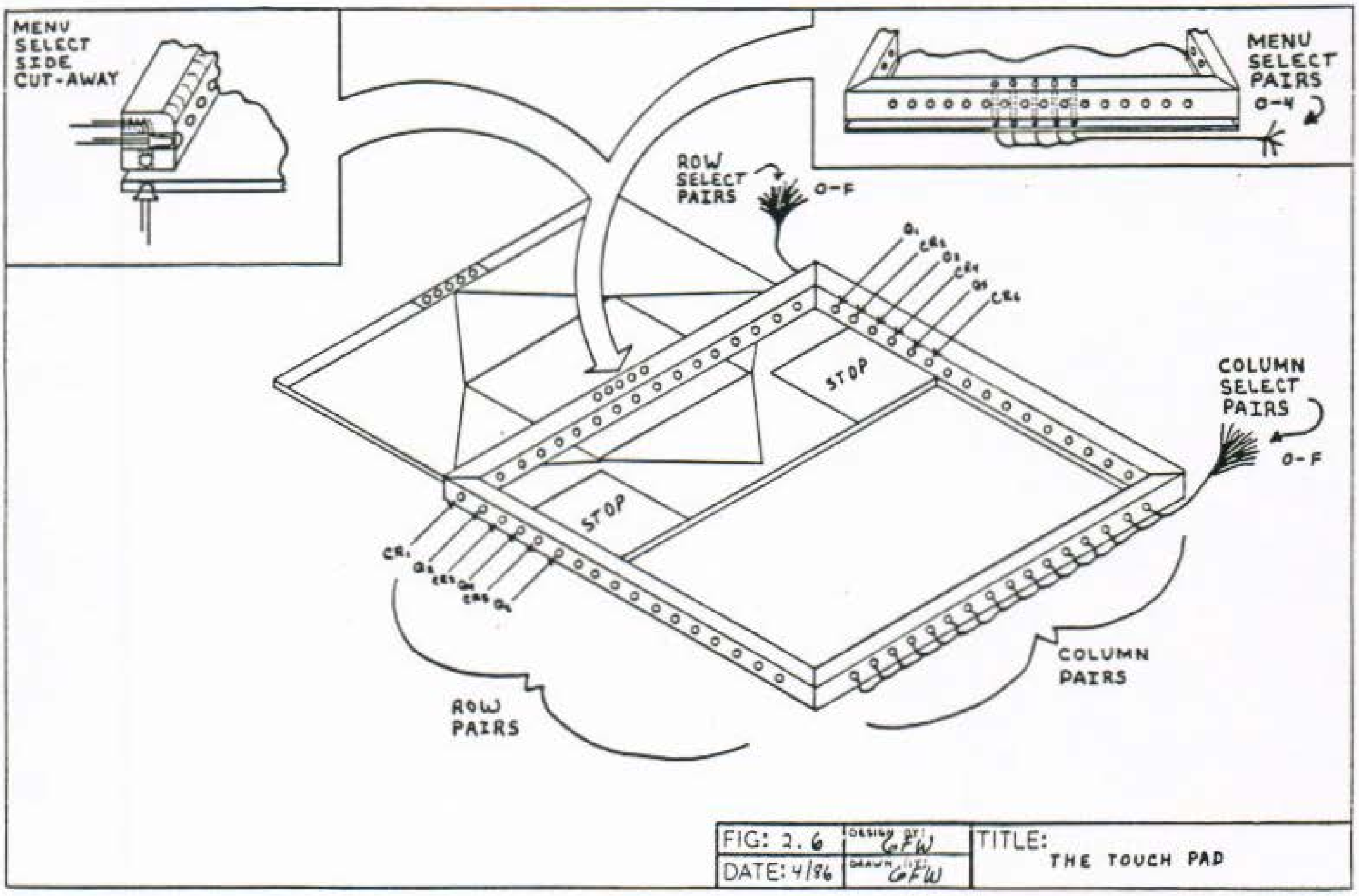
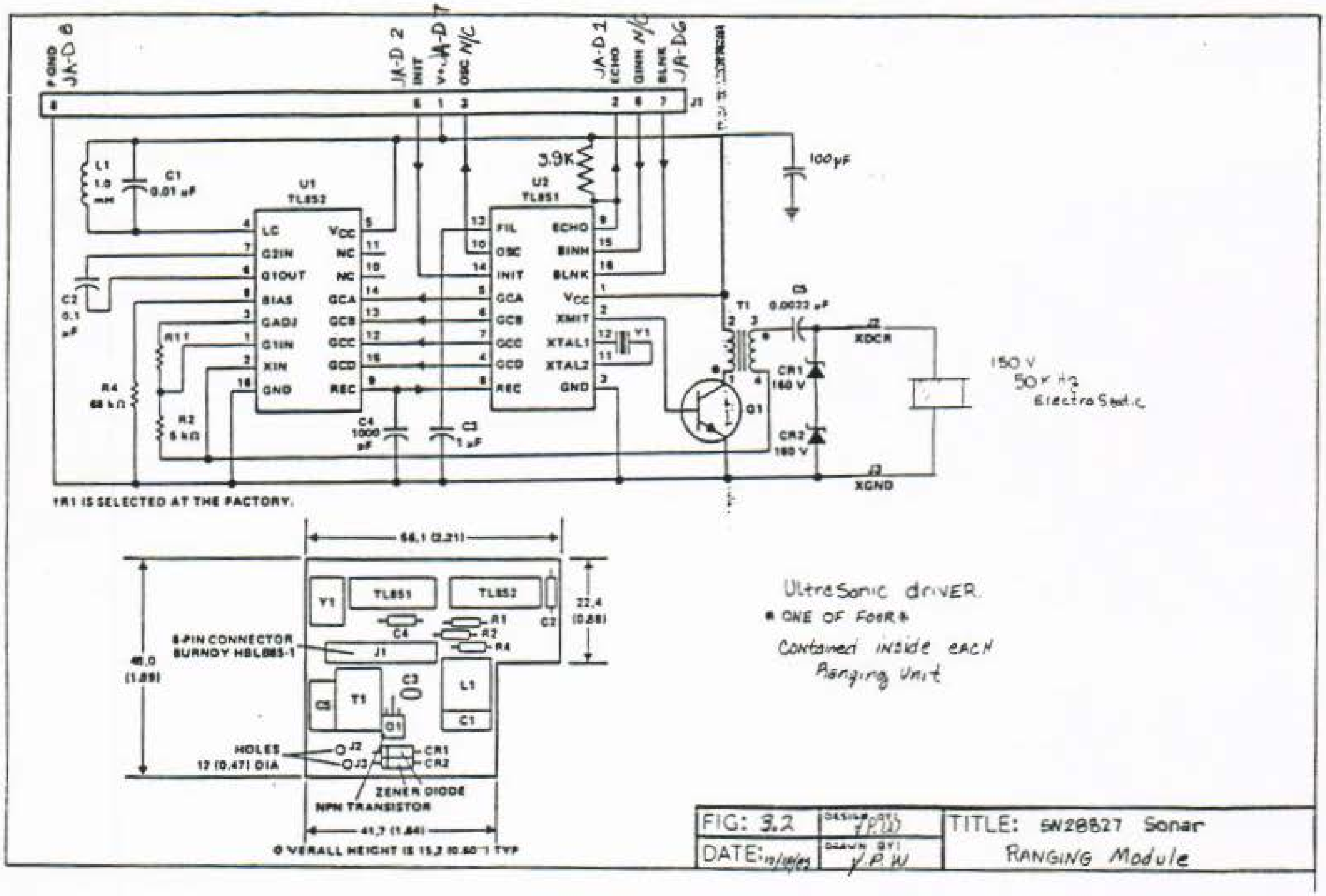


Figure 2.6 Pictorial with Cut-away



Ultrasonic driver
• ONE OF FOUR •
Contained inside each
Ranging Unit

FIG: 3.2
DESIGN BY: [illegible]
DATE: 11/09/89
DRAWN BY: Y.P.W
TITLE: SN28827 Sonar
RANGING Module

Figure 3.2 Ranging Module Schematic

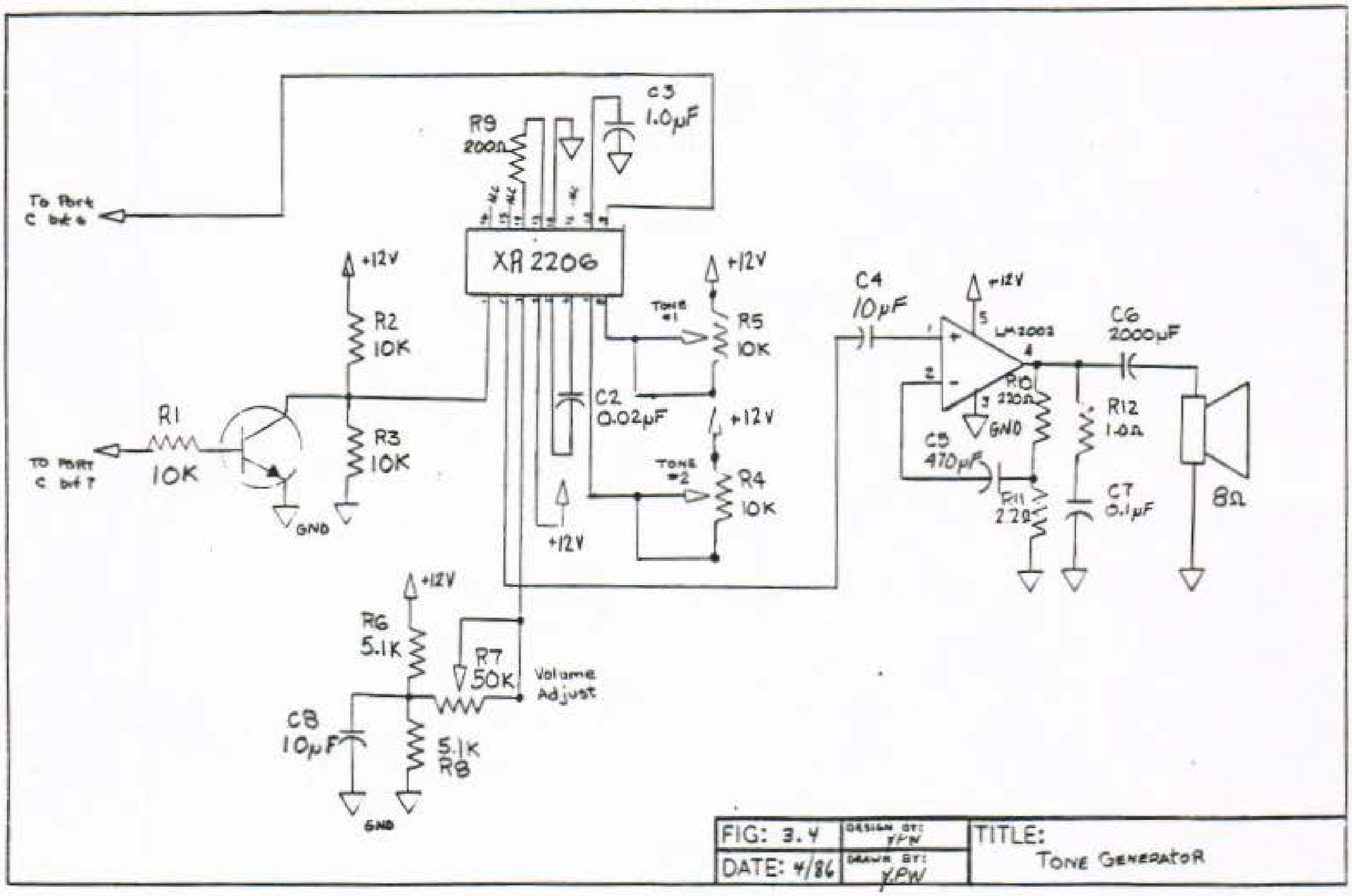


Figure 3.4 Tone Generator Schematic

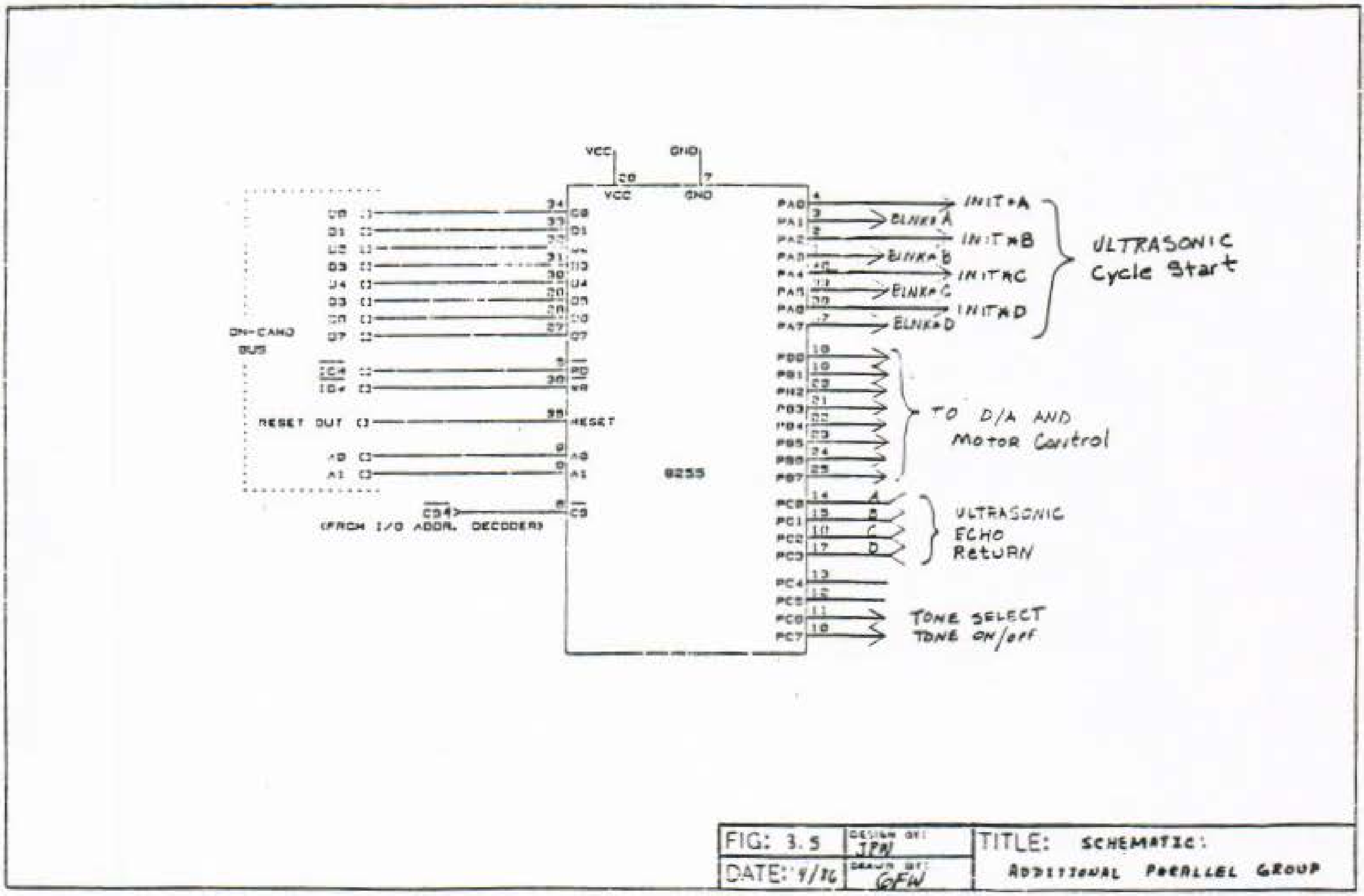


Figure 3.5 Additional Parallel Group Schematic

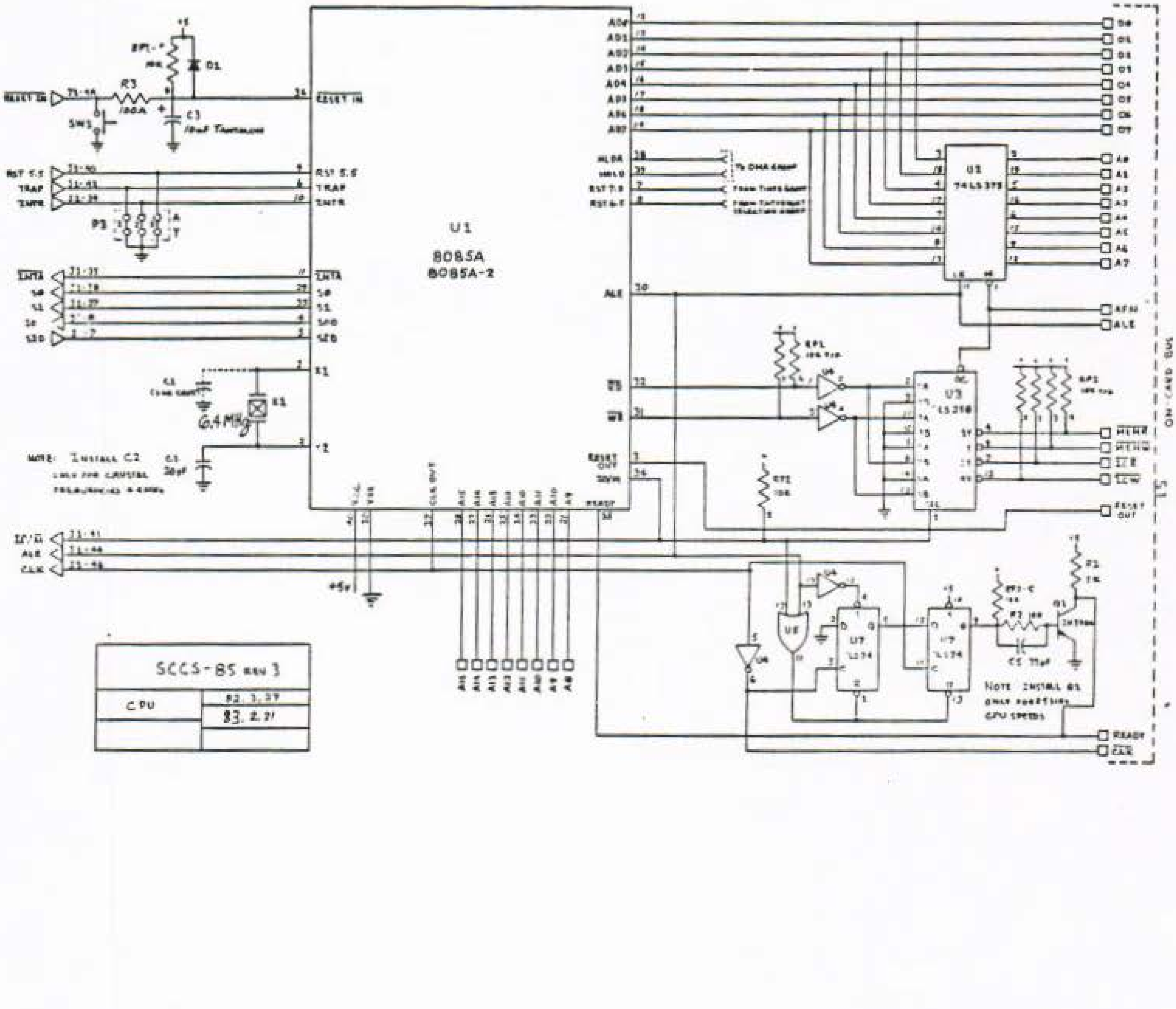


Figure 4.2 CPU Schematic

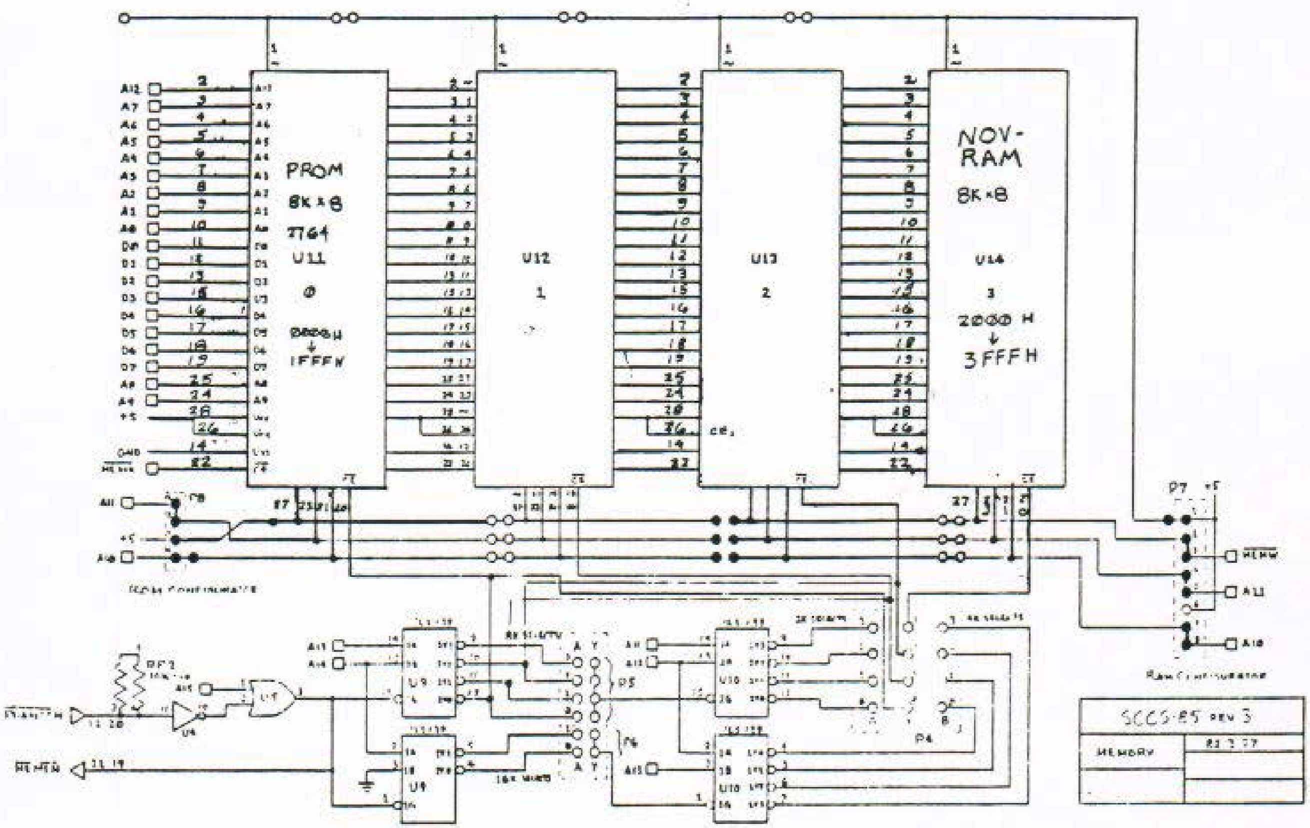


Figure 4.3 Memory Schematic

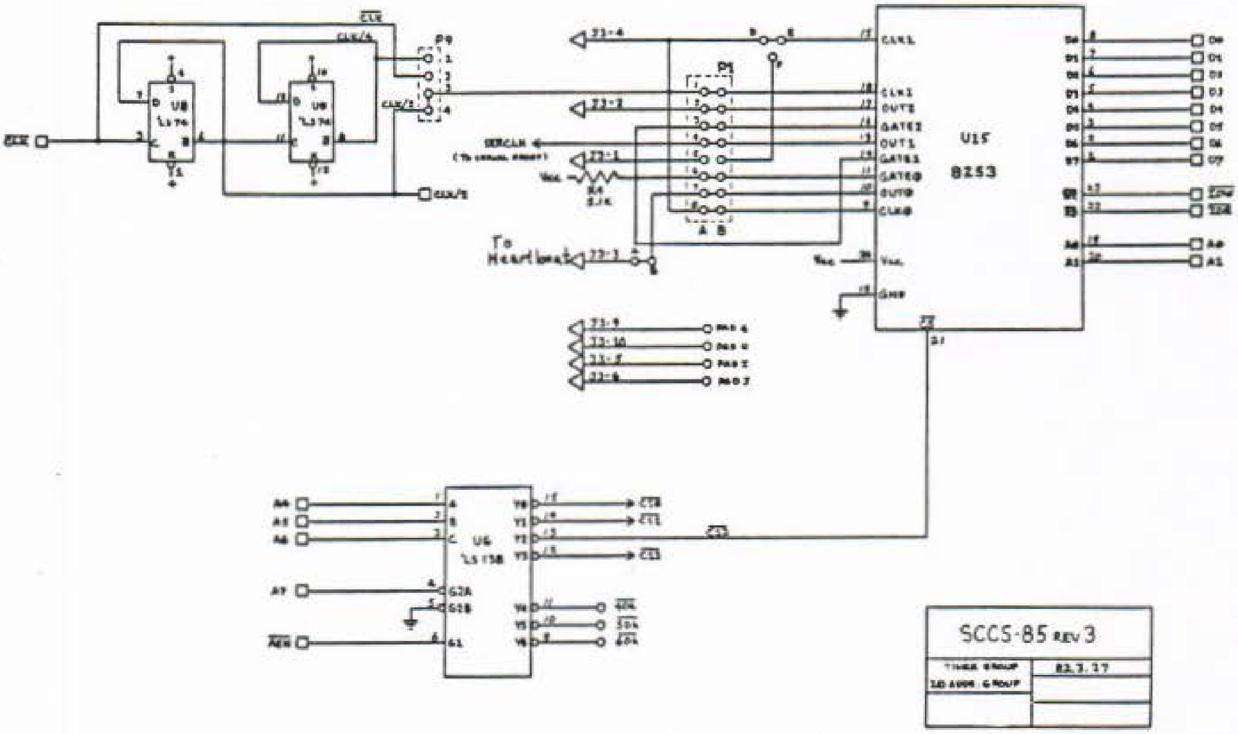


Figure 4.4 Timer Group, I/O Addressing Group Schematic

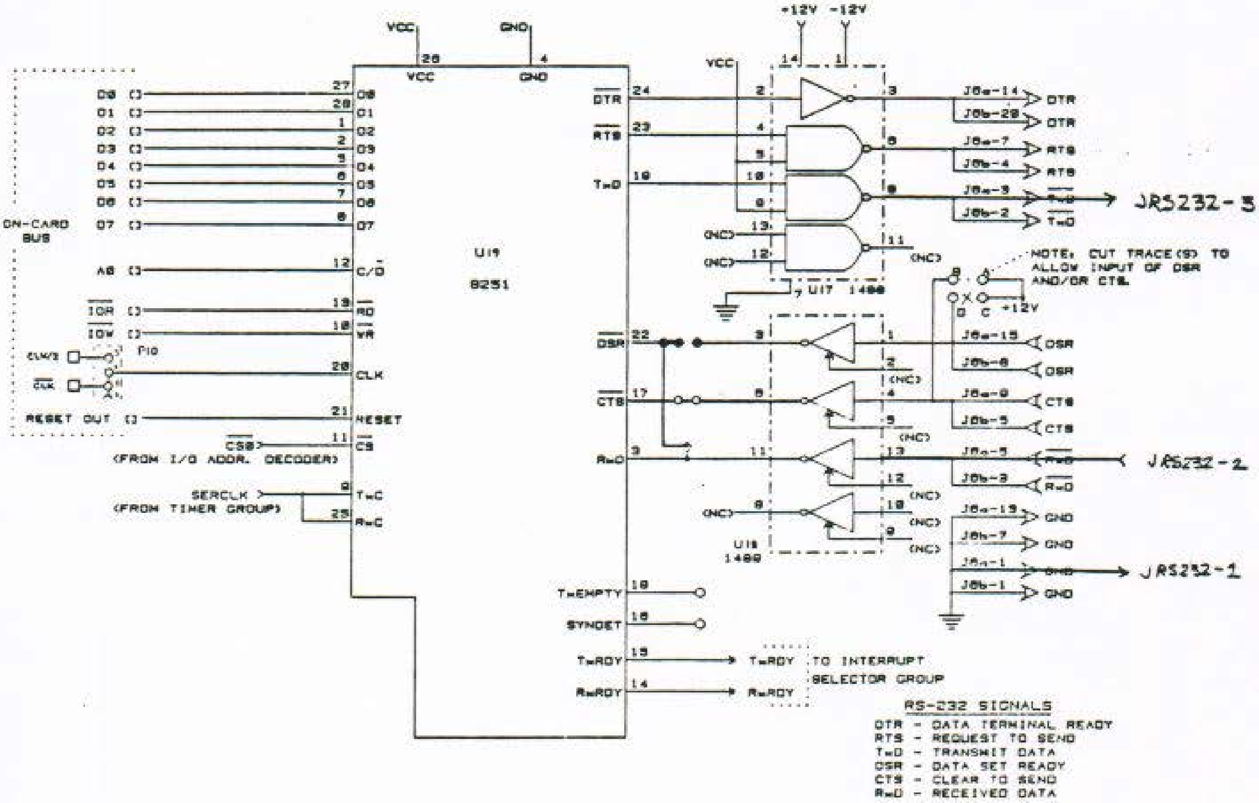


Figure 4.5 Serial Group Schematic

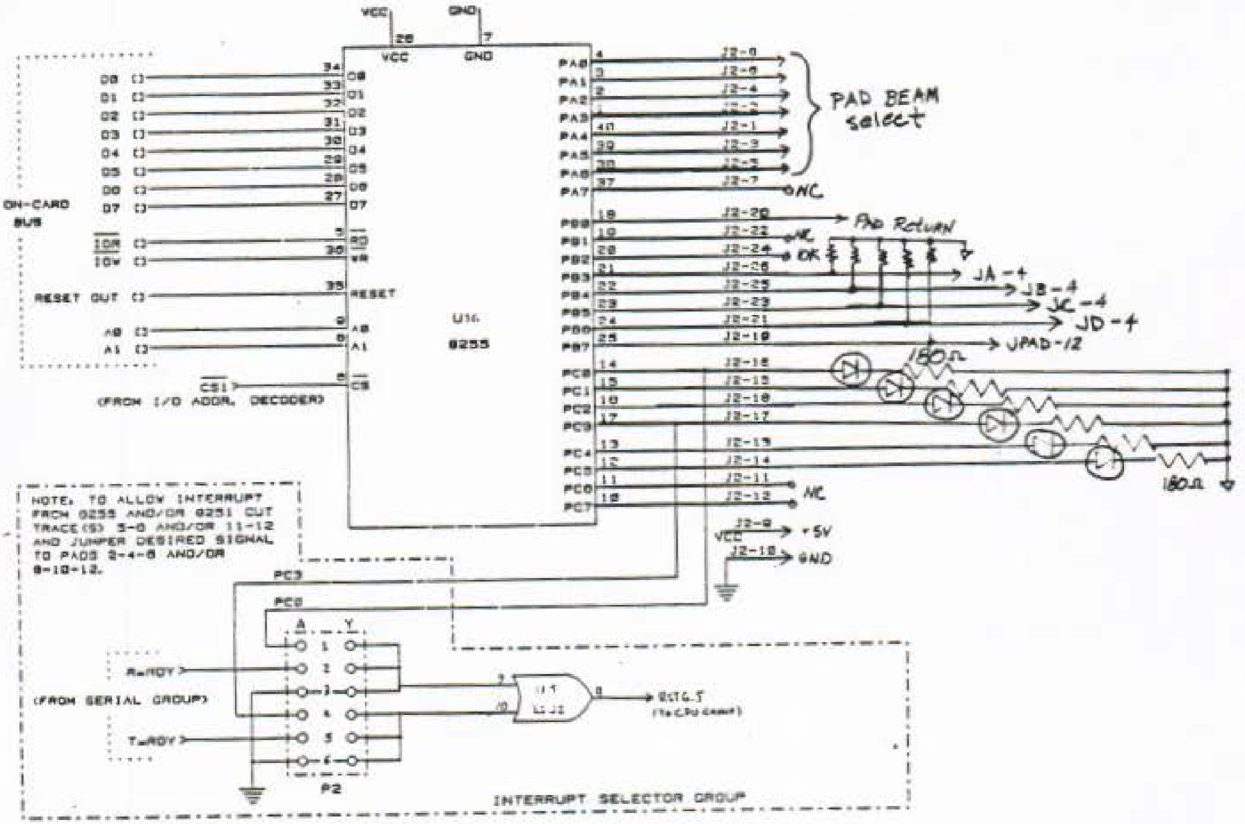


Figure 4.6 Parallel Group, Interrupt Group Schematic

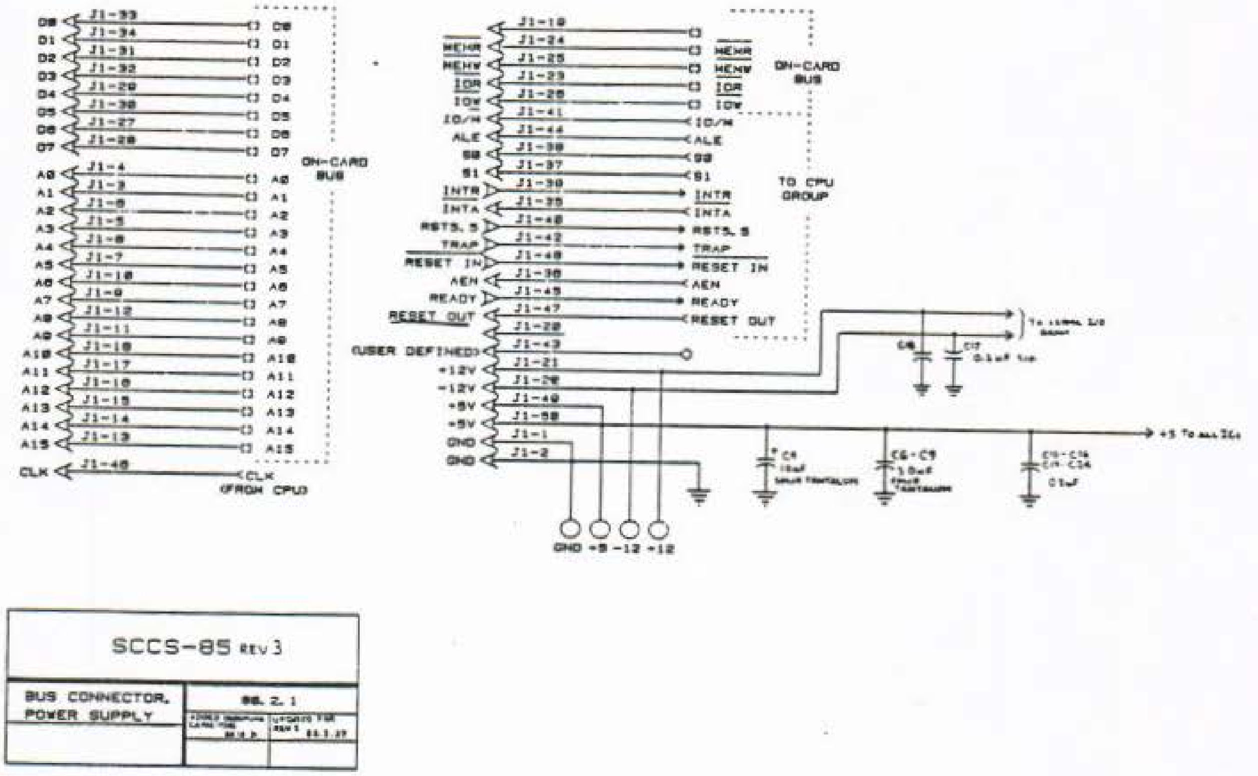


Figure 4.7 Bus Connector Schematic

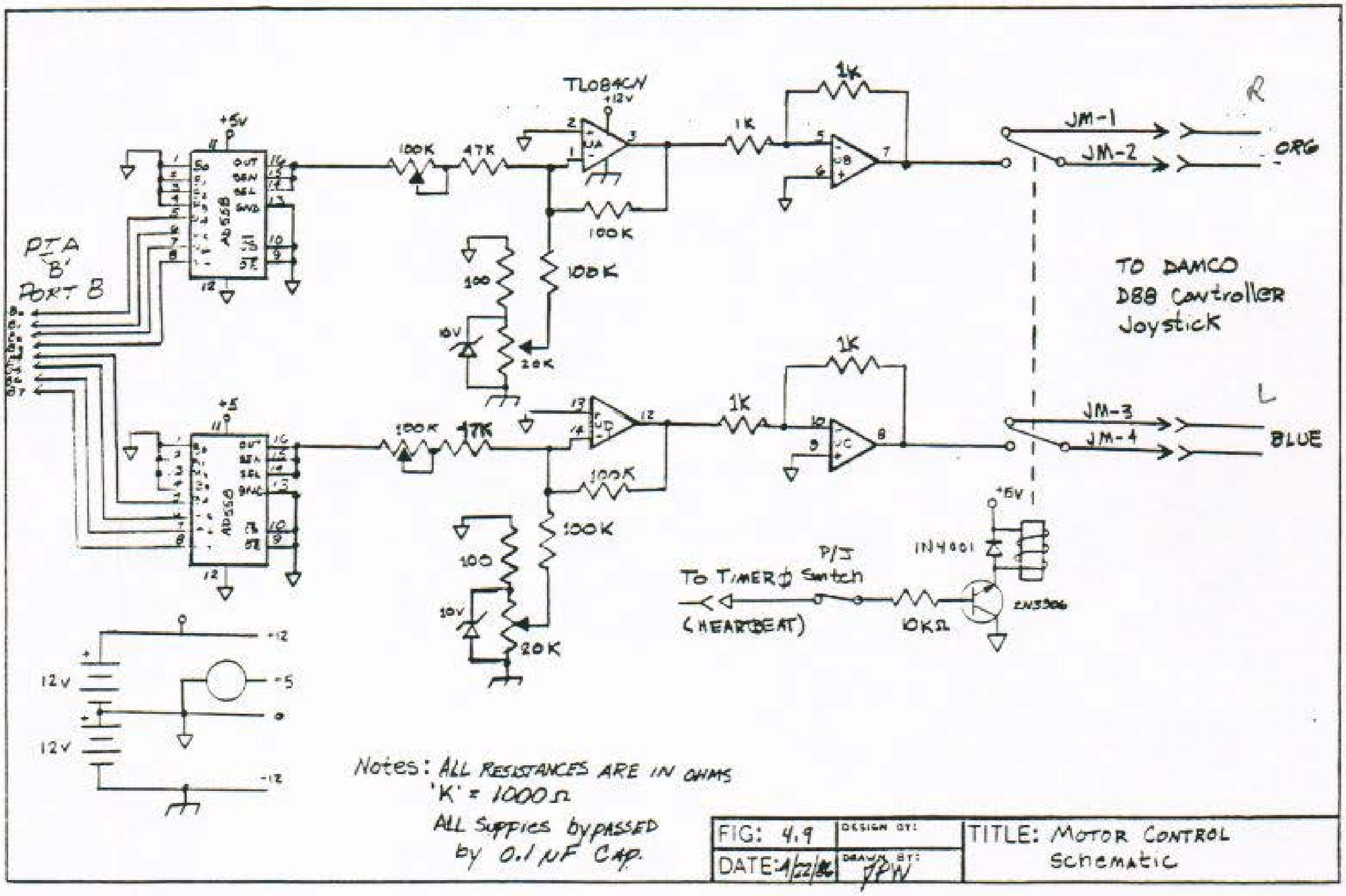


Figure 4.9 Motor Control Schematic

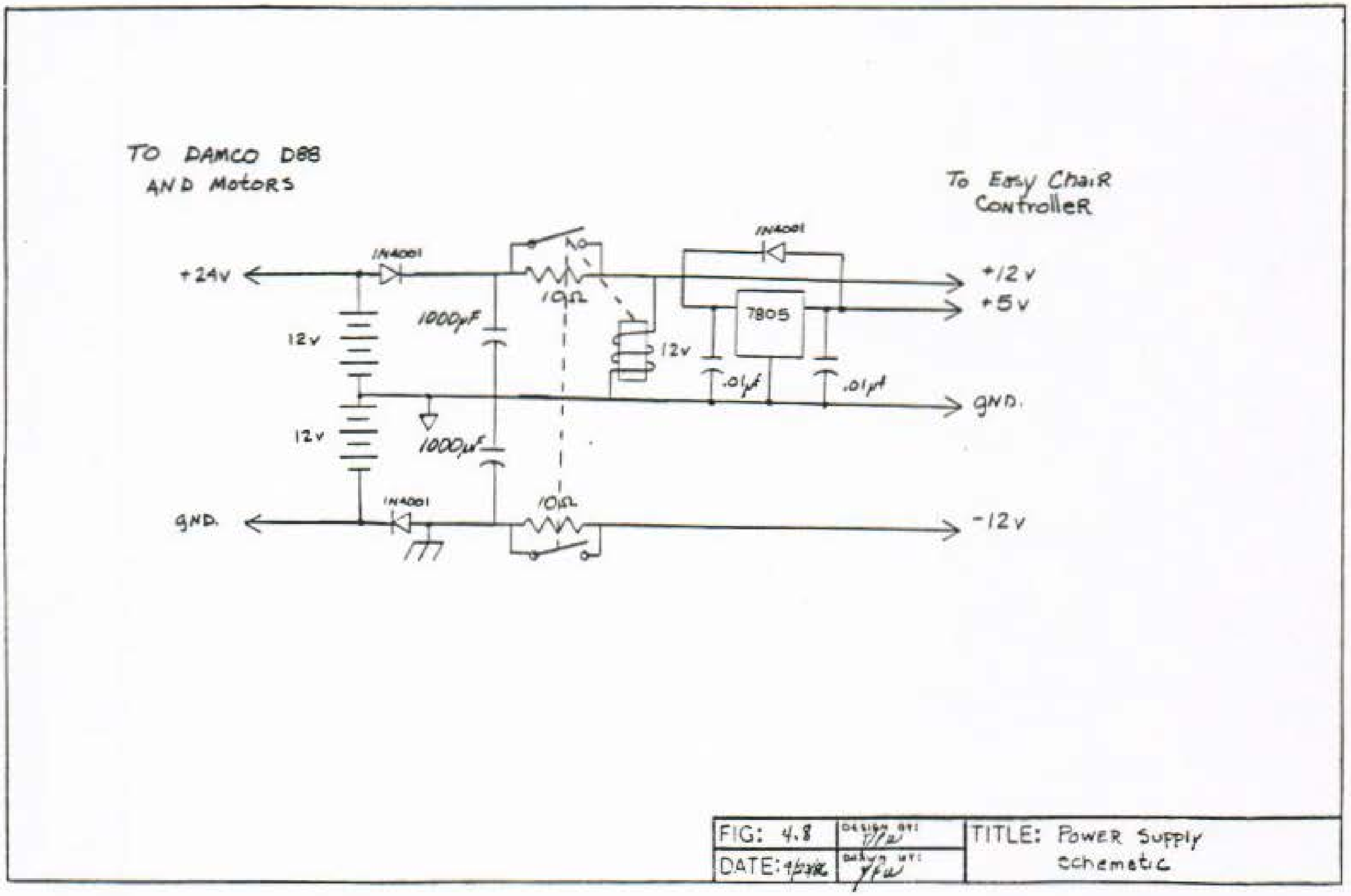


Figure 4.8 Power Supply Schematic

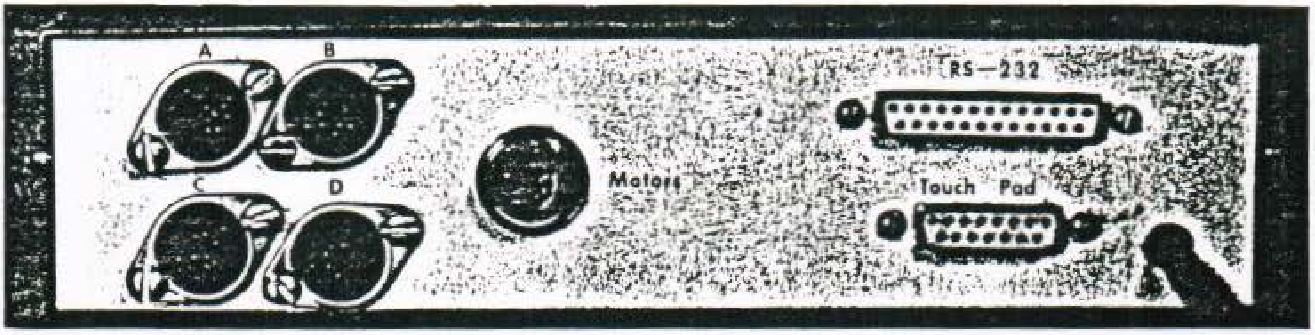


Figure 4.11 Connectors and Jacks

MAIN PROGRAM LOOP

```
INITIAL:    Set stack pointer
            Initialize ports
            Initialize counters
            Send stop values to motors (no ramp)
RUNCHR:     Set flag for heartbeat on
            Call HRTBEAT to refresh the heartbeat timer
            Call MENCHK routine to act on current menu
            Call ULTRA to check ultrasonic units
            Call PADCHK to act on current pad touch
            Call EXTCHK to see if user has chosen to exit
            IF menu not valid (if empty)
               THEN call STOP
                    Go to RUNCHR:
AOK1:       IF DURATION zero
               THEN call STOP
                    Go to RUNCHR:
AOK1:       Call UPDATMTR
            Go to RUNCHR:
```

HRTBEAT

```
HRTBEAT:    Refresh heartbeat counter to maximum value
            Return
```

MENCHK

```
MENCHK:    Check to see that the pad is connected
           IF the pad is not connected
              THEN light pad error LED
                   Call STOP
                   Return
              ELSE clear pad error LED
                   Call PADRD (determine menu number)
                   IF menu error
                      THEN light menu error LED
                      ELSE clear menu error LED
                           IF menu number 1
                              THEN call PROMEN
                              ELSE read menu variables
           Return
```

ULTRA

```
ULTRA:    Check to see if the front unit is connected
                  IF unit not connected
                     THEN light correct U.S. error L.E.D.
                          Return
                     ELSE read the object distance
                          IF object within critical range
                             THEN call STOP
                             ELSE IF object within warning range
                                  THEN sound warning
                             ELSE return
```

PADCHK

```
PADCHK:   Check to see that the pad is connected
          IF the pad is not connected
             THEN light the pad error LED
                  Call STOP
                  Return
             ELSE clear the pad error LED
                  Call PADRD routine to scan the pad
                  IF pad touched
                     THEN call the CHKTBL routine
                          IF valid location and DURATION not 0
                             THEN IF a new motion
                                  THEN call INITMTR
          Return
```

UPDATMTR

```
UPDATMTR:
RAMP1:      IF CNTRAMP not zero
               THEN go to LBL4:
RSPD1CHK:   Store RMCS in RMOTOR (in case RMTS=RMCS)
            IF RMTS=RMCS THEN go to LSPD2CHK:
            IF RMTS>RMCS THEN call RGTFWD (determine RMOTOR)
            IF RMTS<RMCS THEN call RGTREV (determine RMOTOR)
LSPD1CHK:   Store LMCS in LMOTOR (in case LMTS=LMCS)
            IF LMTS=LMCS THEN go to LBL3:
            IF LMTS>LMCS THEN call LFTFWD (determine LMOTOR)
            IF LMTS<LMCS THEN call LFTREV (determine LMOTOR)
LBL3:       Decrement DURATION
            Set RMCS to RMOTOR
            Set LMCS to LMOTOR
            Combine LMCS & RMCS into one byte
            Output motor speed byte
            Return
LBL4:       Decrement CNTRAMP
            Return
```

STOP

```
STOP:       Set RMTS to MTRSTOP
            Set RMTS to MTRSTOP
            IF both motors already stoppec
               THEN return
STOP2:      Set CNTRAMP to STOPRAMP
            Set RAMPCNT to STOPRAMP
STOP1:      Short delay
            Call UPDATMTR
            IF both motors not stopped
               THEN go to STOP1:
            Store zero in DURATION
            Store zero in LAST1
            Return
```

PADRD

```
PADRD:
MENU:       Initialize loop counters
            Set menu select counter to 0
LOOP3:      Decrement menu select counter
            Mask counter to select menu select LEDs
            Output count to light IR LED
            Short Delay
            Input from touch pad return to see if beam broken
            Combine into menu number byte
            Rotate menu number byte left one bit
            IF counter at 0
               THEN rotate menu number byte right one bit
               ELSE go to LOOP3:
ERR1:       IF menu number byte is 0 (none of the 5 beams broken)
               THEN signal menu error in status word (H)
                    Go to PNTDAT:
ERR2:       IF menu number byte is 1FH (all 5 beams broken)
               THEN signal menu error in status word (H)
                    Go to PNTDAT:
SCAN:       Clear row/column data register
ROW:        Set row counter to 17 (row 16 plus 1)
LOOP4:      Decrement row counter
            Mask counter to select row LEDs
            Output count to light IR LED
            Short delay
            Input from touch pad return to see if beam broken
            IF beam being broken
               THEN rotate row count 4 bits
                    Store row number in row/column data register
                    Go to COL:
               ELSE IF row counter at 0 (all 16 rows scanned)
                    THEN return
                    ELSE go to LOOP4:
COL:        Set column counter to 0FFH (column 0 minus 1)
LOOP2:      Increment row counter
            Mask counter to select row LEDs
            Output count to light IR LED
            Short delay
            Input from touch pad return to see if beam broken
            IF beam being broken
               THEN combine row number with row/column register
                    Mask status word (H) to show a touch
               ELSE IF column counter at 0FH
                    THEN return
                    ELSE go to LOOP2:
PNTDAT:     Put row/column data in (L)
            Return
```

PROMEN

```
PROERR:    Sound error horn if executed here
PROMEN:    Clear flag to verify there is a current entry
PRO2MEN:   Wait for pad being touched
           IF invalid touch
              THEN go to PROERR:
           IF sample menu in pad
              THEN go to PROERR:
           Get location of correct table
SNDCHK:    IF sound ON/Off selected
              THEN toggle sound setting
                   Go to PRO2MEN:
RANCHK:    IF ranging ON/OFF selected
              THEN toggle ranging setting
                   Go to PRO2MEN:
RRCHK:     IF ramp rate selected
              THEN get input from ramp bar on pad
                   Store value in correct table
                   Go to PRO2MEN:
LRD:       IF left (A) ranging distance selected
              THEN get input from range bar on pad
                   Store value in correct table
                   Go to PRO2MEN:
RRD:       IF right (B) ranging distance selected
              THEN get input from range bar on pad
                   Store value in correct table
                   Go to PRO2MEN:
FRD:       IF front (C) ranging distance selected
              THEN get input from range bar on pad
                   Store value in correct table
                   Go to PRO2MEN:
BRD:       IF back (D) ranging distance selected
              THEN get input from range bar on pad
                   Store value in correct table
                   Go to PRO2MEN:
DEFAREA:   IF define area selected
              THEN get input from range bar on pad
DEFOK1:            Store value as current entry number
                   Get upper left corner of area
                   Get lower right corner of area
DEFOK2:            Locate area address in memory
DEFOK3:            Store row/col min/max values in entry
                   Mark menu control word as NOT empty
                   Go to PRO2MEN:
SELAREA:   IF select area was chosen
              THEN get input from range bar on pad
SELOK1:            Store value as current entry number
SELOK2:            Locate area address in memory
SELOK3:            Store pointer to area address
                   Go to PRO2MEN:
```

(Continued on next page)

PROMEN

```
PROERR:     Sound error horn if executed here
PROMEN:     Clear flag to verify there is a current entry
PRO2MEN:    Wait for pad being touched
            IF invalid touch
               THEN go to PROERR:
            IF sample menu in pad
               THEN go to PROERR:
            Get location of correct table
SNDCHK:     IF sound ON/Off selected
               THEN toggle sound setting
                    Go to PRO2MEN:
RANCHK:     IF ranging ON/OFF selected
               THEN toggle ranging setting
                    Go to PRO2MEN:
RRCHK:      IF ramp rate selected
               THEN get input from ramp bar on pad
                    Add 1 and store value in correct table
                    Go to PRO2MEN:
LRD:        IF left (A) ranging distance selected
               THEN get input from range bar on pad
                    Double, add USSTOP and store in correct table
                    Go to PRO2MEN:
RRD:        IF right (B) ranging distance selected
               THEN get input from range bar on pad
                    Double, add USSTOP and store in correct table
                    Go to PRO2MEN:
FRD:        IF front (C) ranging distance selected
               THEN get input from range bar on pad
                    Double, add USSTOP and store in correct table
                    Go to PRO2MEN:
BRD:        IF back (D) ranging distance selected
               THEN get input from range bar on pad
                    Double, add USSTOP and store in correct table
                    Go to PRO2MEN:
DEFAREA:    IF define area selected
               THEN get input from range bar on pad
DEFOK1:             Store value as current entry number
                    Get upper left corner of area
                    Get lower right corner of area
DEFOK2:             Locate area address in memory
DEFOK3:             Store row/col min/max values in entry
                    Mark menu control word as NOT empty
                    Go to PRO2MEN:
SELAREA:    IF select area was chosen
               THEN get input from range bar on pad
SELOK1:             Store value as current entry number
SELOK2:             Locate area address in memory
SELOK3:             Store pointer to area address
                    Go to PRO2MEN:
```

(Continued on next page)

(Continuation of PROMEN:)

```
LMTR:       IF left motor speed selected
               THEN set flag for left motor data
                    Go to MOK1:
RMTR:       IF right motor speed selected
               THEN clear flag for left motor data
                    Go to MOK1:
               ELSE go to DUR:
MOK1:       IF flag set for left motor data
               THEN set left motor speed
               ELSE go to RSET:
RSET:       Set right motor speed
            Go to PRO2MEN:
DUR:        IF duration selected
               THEN IF no entry selected
                       THEN go to PROERR:
DOK1:               Get input from duration bar on pad
                    Store duration with current entry
                    Go to PRO2MEN:
RESMEN:     IF reset menu selected
               THEN wait for another input for verification
                    IF reset selected again
                       THEN Set global parameters to defaults
                            Set all ten areas to defaults
                            Mark control word for empty menu
                            Go to PRO2MEN:
```

CHKTBL

```
CHKTBL:     Set ENTRY to 0
            Set memory pointer at the first entry of the table
ROWMIN:     IF touched row < minimum row
               THEN go to NXTENT1:
COLMIN:     IF touched column < minimum column
               THEN go to NXTENT1:
            Increment memory pointer
ROWMAX:     IF touched row > maximum row
               THEN go to NXTENT2:
COLMAX:     IF touched column > maximum column
               THEN go to NXTENT2:
VALID:      Increment memory pointer
            Store pointer value in MTRADDR
            Increment ENTRY
            Return
NXTENT1:    Increment memory pointer
NXTENT2:    Increment memory pointer to next motion data
            Increment ENTRY
            IF ENTRY is 10 (all 10 entries checked)
               THEN return
               ELSE go to ROWMIN:
```

INITMTR

```
INITMTR:    Set memory pointer to MTRADDR
            Read left/right motor target speed from table
            Mask for right target speed only (low nibble)
            Store in RMTS
            Mask for left target speed only (high nibble)
            Rotate left data to low nibble
            Store in LMTS
            Increment memory pointer
            Read DURATION from table
            Get RAMPCNT value
            Store in CNTRAMP
            Return
```

(Continuation of PROMEN:)

```
LMTR:        IF left motor speed selected
                THEN set flag for left motor data
                     Go to MOK1:
RMTR:        IF right motor speed selected
                THEN clear flag for left motor data
                     Go to MOK1:
                ELSE go to DUR:
MOK1:        IF flag set for left motor data
                THEN set left motor speed
                ELSE go to RSET:
RSET:        Set right motor speed
             Go to PRO2MEN:
DUR:         IF duration selected
                THEN IF no entry selected
                        THEN go to PROERR:
DOK1:                Get input from duration bar on pad
                     Store duration with current entry
                     Go to PRO2MEN:
RESMEN:      IF reset menu selected
                THEN wait for another input for verification
                     IF reset selected again
                        THEN Set global parameters to defaults
                             Set all ten areas to defaults
                             Mark control word for empty menu
                             Go to PRO2MEN:
```

CHKTBL

```
CHKTBL:     Set ENTRY to 0
            Set memory pointer at the first entry of the table
ROWMIN:     IF touched row < minimum row
                THEN go to NXTENT1:
COLMIN:     IF touched column < minimum column
                THEN go to NXTENT1:
            Increment memory pointer
ROWMAX:     IF touched row > maximum row
                THEN go to NXTENT2:
COLMAX:     IF touched column > maximum column
                THEN go to NXTENT2:
VALID:      Increment memory pointer
            Store pointer value in MTRADDR
            Increment ENTRY
            Return
NXTENT1:    Increment memory pointer
NXTENT2:    Increment memory pointer to next motion data
            Increment ENTRY
            IF ENTRY is 10 (all 10 entries checked)
                THEN return
                ELSE go to ROWMIN:
```

INITMTR

```
INITMTR:    Set memory pointer to MTRADDR
            Read left/right motor target speed from table
            Mask for right target speed only (low nibble)
            Store in RMTS
            Mask for left target speed only (high nibble)
            Rotate left data to low nibble
            Store in LMTS
            Increment memory pointer
            Read DURATION from table
            Get RAMPCNT value
            Store in CNTRAMP
            Return
```

RGTFWD, RGTREV, LFTFWD, LFTREV

```
RGTFWD:   IF CNTRAMP is 0
             THEN increment RMCS
                  Store in RMOTOR
          Return

RGTREV:   IF CNTRAMP is 0
             THEN decrement RMCS
                  Store in RMOTOR
          Return

LFTFWD:   IF CNTRAMP is 0
             THEN increment LMCS
                  Store in LMOTOR
          Return

LFTREV:   IF CNTRAMP is 0
             THEN decrement LMCS
                  Store in LMOTOR
          Return
```

```
                ;*********************************************************
                ;*             EASY CHAIR THE BEST IN CHAIRS             *
                ;*********************************************************
                ;
4000 =          BASE     EQU     4000H    ;BASE ADDRESS OF MONITOR
5A00 =          MONRAM   EQU     5A00H    ;BASE ADDRESS OF RAM FOR MONITOR
5FFF =          ENDRAM   EQU     5FFFH    ;END OF RAM MEMORY
0100 =          MRSIZ    EQU     0100H    ;MONITOR RAM SIZE
5B00 =          USRRAM   EQU     MONRAM+100H   ;FIRST BYTE OF USER RAM
00FF =          EOL      EQU     0FFH     ;END OF STRING (LINE) CHARACTER
0007 =          BEL      EQU     07H      ;BEEEEEEEEEEEEEEP
000D =          CR       EQU     0DH      ;CARRIAGE RETURN
000A =          LF       EQU     0AH      ;LINE FEED
001C =          HOME     EQU     01CH     ;CURSOR UP AND LEFT
001B =          ESC      EQU     01BH     ;ESCAPE
007F =          RUB      EQU     07FH     ;RUBOUT
0013 =          XOFF     EQU     013H     ;DC3 (X-OFF)
0011 =          XON      EQU     011H     ;DC1 (X-ON)
000F =          MWIDTH   EQU     0FH      ;CONTROLS THE WIDTH OF "DUMP" "PUNCH"
                ;                         ;COMMANDS:
                ;                         ;            0FH = 16 BYTES, 52 COLUMNS
                ;                         ;            07H = 8 BYTES, 28 COLUMNS
0020 =          TIME0    EQU     20H      ;8253 TIMER ZERO
0021 =          TIME1    EQU     21H      ; TIMER ONE
0022 =          TIME2    EQU     22H      ;  TIMER TWO
0023 =          TIMCTL   EQU     23H      ;8253 CONTROL REGISTER
0010 =          PIAA     EQU     010H     ;PIA A DATA REGISTER
0011 =          PIAB     EQU     011H     ;PIA B DATA REGISTER
0012 =          PIAC     EQU     012H     ;PIA C DATA REGISTER
0040 =          PIAD     EQU     040H     ;PIA D DATA REGISTER
0041 =          PIAE     EQU     041H     ;PIA E DATA REGISTER
0042 =          PIAF     EQU     042H     ;PIA F DATA REGISTER
0043 =          PIBCNTL  EQU     043H     ;#2 PIA CONTROL REGISTER
0013 =          PIACNTL  EQU     013H     ;#1 PIA CONTROL REGISTER
0001 =          SERCON   EQU     01H      ;ACIA CONTROL REGISTER
0000 =          SERDAT   EQU     00H      ;ACIA DATA REGISTER
0001 =          PROMSK   EQU     00000001B        ;PROGRAM MENU DETECT
00FF =          TRUE     EQU     0FFH
0000 =          FALSE    EQU     00H
0001 =          BEAMSK   EQU     00000001B        ;MASK FOR DETECT (PIAB B0)
0010 =          ROWMSK   EQU     00010000B        ;MASK FOR ROW SELECT (PIAA)
0020 =          COLMSK   EQU     00100000B        ;    COLUMN SELECT (PIAA)
0040 =          EXTMSK   EQU     01000000B        ;    EXTRA SELECT (PIAA)
                                                  ;EXTRA SELECT INCLUDES:
                                                  ;MENU SELECT LEDS/TRANS.
                                                  ;ULTRASOUND DIRECTION LEDS
0080 =          TOUCH    EQU     10000000B        ;MASK FOR A TOUCH [HL]
001E =          VALMEN   EQU     00011110B        ;VALID MENU NUMBER MASK
                                                  ;NOTE THAT BIT 0 IS USED TO SIGNAL
                                                  ;THE PROGRAM MENU.
0040 =          MENERR   EQU     01000000B        ;MASK MENU ERROR
0020 =          PADERR   EQU     00100000B        ;MASK LED/TRANS. ERROR
0001 =          PADLED   EQU     00000001B        ;MASK FOR PAD ERROR LED (OUTPUT)
0002 =          MENLED   EQU     00000010B        ;  "   "  MENU  "   "    "
0004 =          LUSLED   EQU     00000100B        ;(SAME) LEFT U.S.
0008 =          RUSLED   EQU     00001000B        ;(SAME) RIGHT U.S.
```

```
0010 =          BUSLED  EQU     00010000B       ;(SAME) BACK U.S.
0020 =          FUSLED  EQU     00100000B       ;(SAME) FRONT U.S.
0080 =          PADLOOP EQU     10000000B       ;PAD +5V LOOP (CONNECTED?)
0040 =          LUSLOOP EQU     01000000B       ;LEFT U.S. .......
0020 =          RUSLOOP EQU     00100000B       ;RIGHT U.S. .......
0010 =          BUSLOOP EQU     00010000B       ;BACK U.S. .......
0008 =          FUSLOOP EQU     00001000B       ;FRONT U.S. .......
0004 =          PJMASK  EQU     00000100B       ;MASK FOR INPUT FROM PAD/JOYSTICK
0008 =          MTRSTOP EQU     08H             ;1/2 OF 16D VALUE (USED TO STOP)
0004 =          RONOFF  EQU     00000100B       ;FLAG TO SIGNAL RANGING ON
0002 =          SONOFF  EQU     00000010B       ;FLAG TO SIGNAL SOUND ON
0001 =          EMPTMEN EQU     00000001B       ;FLAG TO SIGNAL EMPTY MENU
                                                ;(NOT PROGRAMMED)
000C =          USSTOP  EQU     0CH             ;ULTRASONIC STOPPING DIST
                                                ;( 8 INCHES)
0004 =          STOPRMP EQU     04H             ;STOPPING RAMP RATE

                ;BEGIN EQUATES FOR PROGRAMMING MENU (SEE PROMEN)
                ;NUMBERS REPRESENT LOCATIONS OF MENU CHOICES ON THE
                ;PROGRAMMING MENU.  MS NIBBLE: ROW, LS NIBBLE: COLUMN
0021 =          SOUND   EQU     21H     ;SOUND ON/OFF
0031 =          RANGE   EQU     31H     ;RANGING ON/OFF
0041 =          RAMP    EQU     41H     ;ENTER RAMP RATE
0051 =          BACKR   EQU     51H     ;BACK...
0061 =          FRONTR  EQU     61H     ;FRONT...
0071 =          LEFTR   EQU     71H     ;LEFT RANGING DISTANCE
0081 =          RIGHTR  EQU     81H     ;RIGHT...
00A1 =          DEFINE  EQU     0A1H    ;DEFINE AREA
00B1 =          SELECT  EQU     0B1H    ;SELECT AREA FOR EDITING
00C1 =          LEFTM   EQU     0C1H    ;LEFT MOTOR SPEED
00D1 =          RIGHTM  EQU     0D1H    ;RIGHT...
00E1 =          TIME    EQU     0E1H    ;DURATION TIME
0009 =          RESET   EQU     09H     ;RESET MENU SELECTION
00EB =          BAR1BEG EQU     0EBH
00EE =          BAR2BEG EQU     0EEH
                ;
                ;=============================================================
                ; VECTORS FOR HARDWARE INTERRUPTS

5B00 =          RST0    EQU     USRRAM+    000H    ; NOT USED - MONITOR RESET
5B08 =          RST1    EQU     USRRAM+    008H    ;
5B10 =          RST2    EQU     USRRAM+    010H    ;
5B18 =          RST3    EQU     USRRAM+    018H    ;
5B20 =          RST4    EQU     USRRAM+    020H    ;
5B24 =          TRAP    EQU     USRRAM+    024H    ;
5B28 =          RST5    EQU     USRRAM+    028H    ;
5B2C =          RST55   EQU     USRRAM+    02CH    ;
5B30 =          RST6    EQU     USRRAM+    030H    ;
5B34 =          RST65   EQU     USRRAM+    034H    ;
5B38 =          RST7    EQU     USRRAM+    038H    ;
5B3C =          RST75   EQU     USRRAM+    03CH    ;
                ;=============================================================
                ; RST 0 ENTRY POINT - POWER UP RESET    ;RST 0
4000                    ORG     BASE+0
4000 310060             LXI     SP,ENDRAM+1
4003 C38746             JMP     INITIAL
```

```
4006 00                 NOP
4007 00                 NOP
                  ;==================================================================
                  ; RST 1 ENTRY POINT
4008                    ORG     BASE+08H                  ; RST 1
4008 C3085B             JMP     RST1
400B 0000000000         DB      0,0,0,0,0
                  ;==================================================================
                  ; RST 2 ENTRY   POINT
4010                    ORG     BASE+10H                  ; RST 2
4010 C3105B             JMP     RST2
4013 0000000000         DB      0,0,0,0,0
                  ;=================================================================
                  ; RST 3 ENTRY POINT
4018                    ORG     BASE+18H                  ; RST 3
4018 C3185B             JMP     RST3
401B 0000000000         DB      0,0,0,0,0
                  ;=================================================================
                  ; RST 4 ENTRY POINT
4020                    ORG     BASE+20H                  ; RST 4
4020 C3205B             JMP     RST4
4023 00                 NOP
                  ;=================================================================
                  ; TRAP ENTRY POINT
4024                    ORG     BASE+24H                  ; TRAP
4024 C3245B             JMP     TRAP
4027 00                 NOP
                  ;=================================================================
                  ; RST 5 ENTRY POINT
4028                    ORG     BASE+28H                  ; RST 5
4028 C3285B             JMP     RST5
402B 00                 NOP
                  ;=================================================================
                  ; RST 5.5 ENTRY POINT
402C                    ORG     BASE+2CH                  ; RST 5.5
402C C32C5B             JMP     RST55
402F 00                 NOP
                  ;=================================================================
                  ; RST 6 ENTRY POINT
4030                    ORG     BASE+30H                  ; RST 6
4030 C3305B             JMP     RST6
4033 00                 NOP
                  ;================================================================
                  ; RST 6.5 ENTRY POINT
4034                    ORG     BASE+34H                  ; RST 6.5
4034 C3345B             JMP     RST65
4037 00                 NOP
                  ;=================================================================
                  ; RST 7 ENTRY POINT
4038                    ORG     BASE+38H                  ; RST 7
4038 C3385B             JMP     RST7
403B 00                 NOP
                  ;=================================================================
                  ; RST 7.5 ENTRY POINT                     ;RST 5.5
403C                    ORG     BASE+3CH
403C C33C5B             JMP     RST75
```

```
403F 00                 NOP
              ;==================================================================
4040                    ORG     BASE+40H


              ;
              ; POWER-UP AND RESET INITIALIZATION
              ; NOW INITIALIZE USART CHIP
              ;
4040 310060   START:    LXI     SP,ENDRAM+1     ;INIT. SP FOR MONITOR
4043 3E82               MVI     A,82H   ;FORCE USART TO EXPECT CMND WORD
4045 D301               OUT     SERCON
4047 3E40               MVI     A,040H  ;NOW MAKE USART TO EXFECT MODE WORD
4049 D301               OUT     SERCON
404B 3ECE               MVI     A,0CEH  ;MODE BYTE -
404D D301               OUT     SERCON  ;  11 00 11 10
404F 3E37               MVI     A,037H  ;COMMAND BYTE -
4051 D301               OUT     SERCON  ;  0 0 1 1 0 1 1 1
              ;
              ; INITIALIZE TIMER CHIP TO GENERATE 16X BAUDRATE FOR
              ;
4053 210E00             LXI     H,000EH             ; 7200 BAUD
                                                    ;[1/(16*7200)]/[1/3.2 MHZ]
4056 3E76               MVI     A,76H               ;INIT TIMER 1 TO DIVIDE BY N
4058 D323               OUT     TIMCTL              ;
405A 7D                 MOV     A,L                 ;
405B D321               OUT     TIME1               ;
405D 7C                 MOV     A,H                 ;
405E D321               OUT     TIME1               ;
              ;
              ; INITIALIZE MONITOR RAM PERTAINING TO CONSOLE I/O
              ;
4060 AF                 XRA     A                   ;MAKE A ZERO
4061 32005A             STA     ECHOFL              ; 0=ECHO 1=NO ECHO
4064 3E0F               MVI     A,MWIDTH            ; INITIALIZE WIDTH
4066 32015A             STA     WIDTH               ;    .
              ;
              ; PRINT STARTUP MESSAGE - ALSO EFFECTIVE WAY TO WAIT A FEW
              ;                         CHAR PERIODS WHILE DOUBLE BUFFERED
              ;                         INPUT SETTLES.
4069 111A55             LXI     D,CLS               ;CLEAR SCREEN
406C CD3F49             CALL    MSG
406F 11A652             LXI     D,STMSG             ;PRINT STARTUP MESSAGE
4072 CD3F49             CALL    MSG                 ;
4075 DB00               IN      SERDAT              ;EAT POSSIBLE GARBAGE CHARACTER
              ;
              ; INITIALIZE REMAINDER OF MONITOR RAM
              ;
4077 3EFF               MVI     A,EOL               ; ON POWER UP NO ANSWER
4079 32365A             STA     MISCBF              ;
407C 210032             LXI     H,3200H             ; INITIALIZE
407F 220C5A             SHLD    CLKBCD              ;CLOCK FREQ IN BCD
4082 CDA247             CALL    BCDTBIN             ;
4085 220E5A             SHLD    CLKBIN              ;        AND   BINARY
4088 CD1F49             CALL    M50128              ; MULT BY 50/128 (0.4)
408B 220A5A             SHLD    D50DIV              ;   CASE SOMETHING GOES WRONG
              ;         LXI     H,ENDRAM            ;UNCOMMENT FOR MEM TEST
```

```
                ;       LXI     D,USRRAM        ; ON RESET/POWER UP
                ;       CALL    MTO
                ;
                ; COMMAND LEVEL - GET CHARACTER; JUMP TO APPROPRIATE ROUTINE


408E CDDF49     COMND:  CALL    SETJMP          ;RUBOUT ABORTED COMNDS COME HERE

4091 119A52             LXI     D,PRMPT         ;PRINT COMMAND PROMPT
4094 CD3F49             CALL    MSG
4097 CDD247             CALL    CI      ;
                ;       ANI     7FH     ;PUT IN IF UCASE TAKEN OUT
409A CD024A             CALL    UCASE   ;CONVERT LOW TO UP CASE & STRIPS PARITY
                ;
                ; SEQUENCE BELOW IS KLUDGE TO ALLOW CR AND ? AS ONE CHAR COMNDS
                ;
409D FE0D               CPI     CR      ;SPECIAL CASE, (CR) IS NOP THAT DOES NOT
409F CA8E40             JZ      COMND   ;  CLEAR THE ANSWER
40A2 118E40             LXI     D,COMND ;ADDR FOR PSEUDO CALL COMPLETED BY PCHL
40A5 D5                 PUSH    D       ;
40A6 FE3F               CPI     '?'     ;SPECIAL CASE '?', MUST NOT CLEAR
40A8 CADD40             JZ      ASK     ; ANSWER FIRST.
                ;
                ; NOW FOR THE REAL COMMANDS...
                ;
40AB 67                 MOV     H,A     ;PUT FIRST CHAR INTO H
40AC CDD247             CALL    CI      ;GET SECOND CHAR
                ;       ANI     07FH    ;UNCOMMENT IF CALL UCASE REMOVED
40AF CD024A             CALL    UCASE   ;
40B2 6F                 MOV     L,A     ;PUT SECOND CHAR INTO L
40B3 CDEE49             CALL    SPACE   ;GOD KNOWS WHAT FOR...
40B6 011550             LXI     B,CMDS  ;SCAN COMMAND TABLE...COMND IN H&L
40B9 0A         CMDNXT: LDAX    B       ;GET COMMAND FROM TABLE
40BA 57                 MOV     D,A     ;  GET FIRST LETTER
40BB 03                 INX     B       ;  POINT TO SECOND LETTER
40BC 0A                 LDAX    B       ;  GET SECOND LETTER
40BD 5F                 MOV     E,A     ;  .
40BE 03                 INX     B       ;  POINT TO LOWER BYTE OF ADDRESS
40BF CDFF47             CALL    CMP16   ;COMPARE TO COMND TYPED
40C2 CAD040             JZ      CMDFND  ;FOUND IT
40C5 03                 INX     B       ;SKIP OVER ADDR OF COMMAND JUST CHECKED
40C6 03                 INX     B       ;POINT TO UPPER BYTE OF ADDR THEN NXT CMD
40C7 7A                 MOV     A,D     ;CHECK FOR END OF TABLE
40C8 B3                 ORA     E       ;
40C9 C2B940             JNZ     CMDNXT  ;NOT END...TRY NEXT ENTRY
40CC CDA849     ERRER:  CALL    PRBAD   ;PRINT ERRER MESSAGE AND RETURN.  "COMND"
40CF C9                 RET             ;  IS ON STACK AS RETURN ADDR FOR COMMAND
                ;                       ;  NOTE ALL THE COMMANDS USE ERRER LABEL.
                ;
40D0 3EFF       CMDFND: MVI     A,EOL   ;CLEAR ANSWER
40D2 32365A             STA     MISCBF  ;
40D5 0A                 LDAX    B       ;GET LOWER BYTE OF ADDRESS
40D6 5F                 MOV     E,A     ;  .
40D7 03                 INX     B       ;POINT TO LOWER BYTE
40D8 0A                 LDAX    B       ;GET UPPER BYTE
40D9 57                 MOV     D,A     ;  .
```

```
40DA 7C                 MOV     A,H     ;COMMAND EXPECTS FIRST LETTER IN A REG
40DB EB                 XCHG            ;
40DC E9                 PCHL            ;
                ;
                ;***************** END OF COMMAND LEVEL ***********************

                ;**********************BEGINNING OF ASK*************************
                ;
                ;       PRINT   ONE BYTE NOTE LEFT BY LAST COMMAND
                ;
40DD CDEE49     ASK:    CALL    SPACE
40E0 11365A             LXI     D,MISCBF
40E3 CD3F49             CALL    MSG
40E6 C9                 RET
                ;***********************END OF ASK*******************************

                ;**********************BEGINNING OF HELP************************
                ;
                ; HELP
40E7 118051     HELP:   LXI     D,PHELP
40EA CD3F49             CALL    MSG
40ED C9                 RET
                ;***********************END OF HELP******************************

                ;**********************BEGINNINS OF GOTO************************
                ;
                ; GOTO ROUTINE - STARTS EXECUTION IN MEMORY LOCATION

40EE CDD948     GOTO:   CALL    GHW     ;GET HEX WORD
40F1 DACC40             JC      ERRER   ;
40F4 CD5849             CALL    OKCK    ;
40F7 D8                 RC              ;
40F8 E5                 PUSH    H
40F9 CD0C48             CALL    CRLF
40FC AF                 XRA     A
40FD CDF247             CALL    CO
4100 CDF247             CALL    CO
4103 E1                 POP     H
4104 E9                 PCHL            ;               AND GO

                ;***********************END OF GOTO******************************
                ;
                ;**********************BEGINNING OF MEMTST**********************
                ;
4105 CD7B48     MEMTST: CALL    FROMTO          ;GET FROM AND TO ADDRESSES
4108 DACC40             JC      ERRER           ;
410B EB                 XCHG                    ;
410C CD5849             CALL    OKCK            ;CHECK WITH USER BEFORE STARTING
410F DA7741             JC      MTEND           ;
4112 4C         MT0:    MOV     C,H             ;STOP AT XX?? WHERE XX-1 IS THE
4113 0C                 INR     C               ;UPPER BYTE OF THE USERS TO ADDR
4114 0600               MVI     B,00H           ; ALSO USE OF COUNTER
4116 C5                 PUSH    B
4117 0600               MVI     B,0             ;CLEAR B PATTERN MODIFIER
4119 62         MT1:    MOV     H,D             ;
411A 6B                 MOV     L,E             ;
```

```
411B 7D        MTFILL: MOV    A,L           ;LOW BYTE TO ACCUM.
411C AC                XRA    H             ;XOR WITH HIGH BYTE
411D A8                XRA    B             ;XOR WITH PATTERN
411E 77                MOV    M,A           ;STORE IN ADDR
411F 23                INX    H             ;INCREMENT ADDR
4120 7C                MOV    A,H           ;LOAD HIGH BYTE OF ADDR
4121 B9                CMP    C             ;COMPARE WITH STOP ADDR
4122 C21B41            JNZ    MTFILL        ;LOOP IF NOT DONE
               ;
               ; READ AND CHECK TEST DATA
               ;
4125 62                MOV    H,D
4126 6B                MOV    L,E           ;GET STARTING ADDR
4127 7D        MTTST:  MOV    A,L           ;GET LOW BYTE
4128 AC                XRA    H             ;XOR WITH HIGH BYTE
4129 A8                XRA    B             ;XOR WITH MODIFIER
412A C5                PUSH   B             ;
412B 47                MOV    B,A
412C 7E                MOV    A,M
412D B8                CMP    B             ;COMPARE WITH MEMORY LOCATION
412E C25941            JNZ    MTFXIT        ;ERRER EXIT
4131 C1                POP    B
4132 23                INX    H             ;UPDATE MEMORY ADDRESS
4133 7C                MOV    A,H           ;GET HIGH BYTE
4134 B9                CMP    C             ;COMPARE WITH STOP ADDR
4135 C22741            JNZ    MTTST         ;LOOP BACK
4138 3A015A            LDA    WIDTH         ;GENERATE ((WIDTH+1)*4)-1
413B 37                STC                  ;  .
413C 17                RAL                  ;  .
413D 37                STC                  ;  .
413E 17                RAL                  ;  .
413F A0                ANA    B             ;CHECK FOR TIME FOR CRLF
4140 CC0C48            CZ     CRLF          ;CRLF IF RUNNING OUT OF LINE
4143 04                INR    B             ;UPDATE MODIFIER
4144 EB                XCHG
4145 3E21              MVI    A,'!'         ;PRINT PASS DONE MESSAGE
4147 CDF247            CALL   CO            ;
414A EB                XCHG
414B C1                POP    B
414C 05                DCR    B
414D C5                PUSH   B
414E C21941            JNZ    MT1           ;RESTART WITH NEW MODIFIER
4151 C1                POP    B
4152 112351            LXI    D,MTGOOD
4155 CD3F49            CALL   MSG
4158 C9                RET                  ; FOR 255 TIMES THEN TO CMDS
4159 113A51    MTFXIT: LXI    D,MTERR       ;PRINT ERRER ADDRESS
415C CD3F49            CALL   MSG
415F CD7849            CALL   PHW
4162 115C51            LXI    D,MTREAD
4165 CD3F49            CALL   MSG
4168 CD8349            CALL   PHB
416B 115351            LXI    D,MTWROT
416E CD3F49            CALL   MSG
4171 78                MOV    A,B
4172 CD8349            CALL   PHB
```

```
4175 C1                 POP     B
4176 C1                 POP     B

                ;
4177 C9         MTEND:  RET                           ;RETURN TO COMMAND LOOP
                ;
                ;
                ;*****************END OF MEMTST****************************

                ;*****************BEGINNING OF TEST BOARD*****************

4178 CD0C48     TSTBRD: CALL    CRLF                  ;THIS ROUTINE ALLOWS THE
417B 115750             LXI     D,MTSBRD              ;USER TO DO A HARDWARE
417E CD3F49             CALL    MSG                   ;CHECK OF THE PIAS AND
                                                      ;TIMER CHIPS
4181 3E77               MVI     A,77H
4183 D323               OUT     TIMCTL                ;TIMER 1
4185 3EB7               MVI     A,0B7H
4187 D323               OUT     TIMCTL                ;TIMER 2
4189 97                 SUB     A                     ;TO DIVIDE BY
418A D321               OUT     TIME1
418C D322               OUT     TIME2
418E 3E20               MVI     A,20H
4190 D321               OUT     TIME1
4192 D322               OUT     TIME2

4194 3E80               MVI     A,80H
4196 D313               OUT     PIACNTL               ;SET PIAA
4198 D343               OUT     PIBCNTL               ;AND PIAB TO
419A 3E30               MVI     A,30H
419C D323               OUT     TIMCTL
419E D310       LOOPA:  OUT     PIAA                  ;LOOP THROUGH
41A0 D312               OUT     PIAC                  ; SHOULD APPEAR
                                                      ;AS STAIRSTEP ON
41A2 D341               OUT     PIAE                  ;LOGIC ANALIZER
41A4 3C                 INR     A
41A5 CD0E4A             CALL    HRTBEAT
41A8 C39E41             JMP     LOOPA                 ;LOOP FOREVER

                ;*****************END OF TEST BOARD ********************

                ;*****************BEGINNING OF MEMED***********************
                ;
                ; MEMED - HEXADECIMAL MEMORY EDITOR
                ;
41AB 115350     MEMED:  LXI     D,EDM2  ;PRINT "CR, LF, ("
41AE CD3F49             CALL    MSG

41B1 CDD948             CALL    GHW
41B4 D2C041             JNC     OK      ;GET HEX WORD INTO HL, JUMP IF VALID

41B7 FE2F               CPI     '/'     ;BAD CHAR RECEIVED - WAS IT "/"
41B9 C8                 RZ              ;GO BACK TO COMMAND LEVEL IF SO

41BA CDAB49             CALL    PRBAD   ;PRINT "WHAT ?"
41BD C3AB41             JMP     MEMED   ;THEN TRY AGAIN
```

```
41C0 CD3642     OK:      CALL    DISCON  ;DISPLAY CONTENTS OF LOCATION
41C3 CDC941              CALL    EDIT    ;THEN BEGIN EDITING
41C6 C3AB41              JMP     MEMED   ;LOOP IF EDIT RETURNS
                ;
                ;        END     MEMED
                ;
                ;
                ; GET EITHER A NEW HEX BYTE TO BE WRITTEN WHERE HL POINTS,
                ; FOLLOWED BY ANOTHER COMMAND, OR JUST ANOTHER COMMAND.
                ;
41C9 CDF048     EDIT:    CALL    GHB     ;GET THE NEW HEX BYTE IF TYPED
41CC D2F441              JNC     EDBYTE  ;GOOD BYTE TYPED - PUT IN MEMORY
41CF FE27                CPI     027H    ;DOES USER WANT LITERAL CHARACTER ?
41D1 CAEF41              JZ      EDLIT   ;  YEP...
41D4 FE5E                CPI     '^'     ;DOES USER WANT CONTROL CHARACTER ?
41D6 C2FD41              JNZ     NEXT    ;NOPE...MUST BE COMMAND OR ERRER...
41D9 CDD247              CALL    CI      ;GET CHAR
41DC E67F                ANI     07FH    ;STRIP PARITY
41DE FE40                CPI     040H    ;SEE IF MAKES SENSE...
41E0 DA2042              JC      EDBAD   ;DUMMY
41E3 FE60                CPI     060H    ;FIGURE OUT WHAT TO SUBTRACT...
41E5 DAEA41              JC      EDUC    ;IS UPPER CASE...OK AS IS
41E8 D620                SUI     020H    ;LOWER CASE...MUST BE MOVED DOWN
41EA D640       EDUC:    SUI     040H    ;CONVERT TO CONTROL CHAR
41EC C3F441              JMP     EDBYTE  ;
41EF CDD247     EDLIT:   CALL    CI      ;GET CHAR
41F2 E67F                ANI     07FH    ;BETTER STRIP PARITY
41F4 77         EDBYTE:  MOV     M,A     ;ELSE STORE IT IN MEMORY
41F5 CDEE49              CALL    SPACE   ;SPACE TO REINFORCE THAT ONCE TWO DIGITS
                ;                        ;  ARE ENTERED, LOCATION IS CHANGED.
41F8 CDD247              CALL    CI      ;AND GET ANOTHER CHAR & ECHO IT
41FB E67F                ANI     7FH     ;KILL TOP BIT
41FD FE0D       NEXT:    CPI     CR      ;CARRIAGE RETURN?
41FF C20642              JNZ     E1
4202 23                  INX     H
4203 C32342              JMP     PR      ;YES- PRINT NEXT LOCATION
4206 FE20       E1:      CPI     ' '     ;OR BLANK
4208 C20F42              JNZ     E2
420B 23                  INX     H
420C C32342              JMP     PR      ;YES- DO THE SAME
420F FE2E       E2:      CPI     '.'     ; PERIOD?
4211 CA2342              JZ      PR      ;PRINT CURRENT LOCATION
4214 FE2D       E3:      CPI     '-'     ; DASH?
4216 C21D42              JNZ     E4
4219 2B                  DCX     H
421A C32342              JMP     PR      ;YES - PRINT PREVIOUS LOCATION
421D FE2F       E4:      CPI     '/'     ;SLASH?
421F C8                  RZ              ;EDIT ALL DONE IF SO
4220 CDAB49     EDBAD:   CALL    PRBAD   ;IF NONE OF THE ABOVE, PRINT "WHAT ?"
4223 CD2942     PR:      CALL    DISMEM  ;DISPLAY THE NEW CURRENT MEMORY LOCATION
4226 C3C941              JMP     EDIT    ;AND LOOP

                ; PRINT CR, LF THEN AN ( FOLLOWED BY THE CONTENTS OF HL IN HEX.

4229 115350     DISMEM:  LXI     D,EDM2  ;DO CR,LF, "("
422C CD3F49               CALL    MSG
422F CD7849               CALL    PHW
4232 CD3642               CALL    DISCON
4235 C9                   RET
                ; **** DISCON ****
                ;
                ; PRINT ') = ' FOLLOWED BY THE CONTENTS OF THE MEMORY LOC.
                ; POINTED TO BY HL
                ;
4236 114E50     DISCON: LXI     D,EDM1  ;
4239 CD3F49               CALL    MSG     ;
423C 7E                   MOV     A,M     ;GET CONTENTS OF MEM LOC.
423D CD8349               CALL    PHB     ;PRINT IT
4240 114F50               LXI     D,EDM3  ;
4243 CD3F49               CALL    MSG     ;
4246 E5                   PUSH    H       ;SAVE ADDRESS
4247 CD4548               CALL    DISASC  ;CONVERT TO PRINTABLE
424A 7C                   MOV     A,H     ;PRINT ' ' OR '^'
424B CDF247               CALL    CO      ;
424E 7D                   MOV     A,L     ;PRINT CHARACTER
424F CDF247               CALL    CO      ;
4252 E1                   POP     H
4253 CDEE49               CALL    SPACE   ;
4256 C9                   RET
                ;
                ;*********************END OF MEMED*****************************

                ;*********************BEGINNING OF LOADER*********************
                ;
                ; HEX-FORMAT LOADER
                ;         NOTE:   RECORD LENGTH = 00 TAKEN AS EOF
4257 CDA048     LOADER: CALL    GBIAS   ;GET BIAS
425A DACC40               JC      ERRER   ;BAD CHAR - QUIT
425D 22025A               SHLD    BIAS    ;STORE BIAS
4260 CD5849               CALL    OKCK    ;CHECK WITH USER BEFORE JUMPING
4263 D8                   RC              ;
4264 3A005A               LDA     ECHOFL  ;SAVE ECHO FLAG
4267 32385A               STA     MISCBF+2;MISCBF & MISCBF+1 USED BY ANSWER
426A 3E11                 MVI     A,XON   ;START DATA COMING
426C 32005A               STA     ECHOFL  ;NON-ZERO VALUE (XON) TURNS OFF ECHO
426F CDF247               CALL    CO      ;
4272 CD9642     LOAD1:  CALL    GETREC  ;READ IN ONE REC, (A) = RECORD LENGTH
4275 B7                   ORA     A       ;SET Z-FLAG ON RECORD LENGTH
4276 3E47                 MVI     A,'G'   ;ANSWER TO QUESTION = GOOD
4278 CA8242               JZ      DONE    ;IF LENGTH = 0 THEN DONE
427B 7A                   MOV     A,D     ;(D) = ERRER FLAG ON GETREC RETURN
427C B7                   ORA     A       ;SEE IF THE "ERRER" FLAG IS NON-ZERO.
427D CA7242               JZ      LOAD1   ;IF NOT, GO DO NEXT RECORD
4280 3E42                 MVI     A,'B'   ;STORE "BAD" FLAG IN ANSWER TO QUESTION
4282 32365A     DONE:   STA     MISCBF  ;STORE GOOD/BAD STRING
4285 3EFF                 MVI     A,EOL   ;    .
4287 32375A               STA     MISCBF+1;    .
428A 3A385A               LDA     MISCBF+2;RESTORE ECHO FLAG
428D 32005A               STA     ECHOFL  ;    .
4290 3E13                 MVI     A,XOFF  ;STOP FURTHER OUTPUT
4292 CDF247               CALL    CO      ;
```

```
4295 C9                  RET              ;RETURN TO COMMAND LEVEL
                 ;
                 ;       END     LOADER
                 ;
                 ;
                 ; *** GETREC *** READ IN ONE RECORD
                 ;
4296 CDB742      GETREC: CALL    FNDMRK  ;SKIP TO RECORD MARK
                 ;
4299 CDD142              CALL    LGHB    ;GET THE RECORD LENGTH
429C 4F                  MOV     C,A     ;  INTO THE C REG.
429D CDD142              CALL    LGHB    ;GET LOAD ADDRESS FIELD INTO H & L
42A0 67                  MOV     H,A     ;
42A1 CDD142              CALL    LGHB    ;
42A4 6F                  MOV     L,A     ;
42A5 D5                  PUSH    D       ;SAVE D&E
42A6 EB                  XCHG            ;
42A7 2A025A              LHLD    BIAS    ;ADD BIAS
42AA 19                  DAD     D       ;
42AB D1                  POP     D       ;RESTORE D&E
42AC CDD142              CALL    LGHB    ;GET THE RECORD-TYPE BYTE AND IGNORE
42AF CDC442              CALL    DATA    ;PUT THE NEXT (C) BYTES INTO MEMORY
                                         ;STARTING WHERE HL POINTS
42B2 CDD142              CALL    LGHB    ;READ THE CHECKSUM BYTE
42B5 79                  MOV     A,C     ;PUT THE RECORD LENGTH BACK INTO A REG.
42B6 C9                  RET             ;RETURN FROM GETREC. (D) CONTAINS THE
                                         ;  SUM OFF ALL HEX BYTES READ, AND SO
                                         ;  IS EFFECTIVELY AN ERRER FLAG
                 ;       END     GETREC
                 ;
                 ;
                 ; *** FNDMRK *** - FIND RECORD MARK
                 ;                    IGNORES ALL TEXT UNTIL ":" FOUND, THEN RET
                 ;
42B7 CDD247      FNDMRK: CALL    CI      ;GET CHARACTER
42BA E67F                ANI     07FH    ;STRIP OFF 8TH BIT
42BC FE3A                CPI     ':'     ;
42BE C2B742              JNZ     FNDMRK  ;NOT RECORD MARK - GET NEXT CHAR
42C1 1600                MVI     D,0     ;CLEAR D REGISTER (ERRER ACCUMULATOR)
42C3 C9                  RET             ;
                 ;
                 ;       END     FNDMRK
                 ;
                 ; *** DATA *** - INPUT ALL DATA BYTES
                 ;                 (C) = NUMBER OF BYTES TO READ IN
                 ;                 (D) = ERRER FLAG ACCUMULATOR MAINTAINED BY LGHB
                 ;
42C4 41          DATA:   MOV     B,C     ;COPY C REG. TO B
42C5 78          LOOP:   MOV     A,B     ;GET REMAINING BYTE COUNT
42C6 B7                  ORA     A       ;GET FLAGS
42C7 C8                  RZ              ;RETURN FROM SUBR. IF NONE LEFT
42C8 05                  DCR     B       ;ELSE DECREMENT B REG.
42C9 CDD142              CALL    LGHB    ;GET BYTE FROM DATA FIELD
42CC 77                  MOV     M,A     ;STORE IN MEMORY
42CD 23          DATA1:  INX     H       ;BUMP POINTER
42CE C3C542              JMP     LOOP    ;GO BACK FOR NEXT CHAR.
```

```
                ;
                ;       END     DATA
                ;
                ;
                ; *** LGHB *** - LOADER GET HEX BYTE
                ;                SAME AS GHB EXCEPT ADDS BYTE GOTTEN TO ERRER
                ;                ACCUMULATOR IN D REGISTER
                ;
42D1 CDF048     LGHB:   CALL    GHB     ;GET BYTE
42D4 F5                 PUSH    PSW     ;SAVE BYTE
42D5 82                 ADD     D       ;ADD TO (D)
42D6 57                 MOV     D,A     ;PUT SUM IN D-REG
42D7 F1                 POP     PSW     ;RESTORE BYTE
42D8 C9                 RET             ;
                ;
                ;       END     LGHB
                ;
                ;***********************END OF LOADER****************************
                ;
                ;**********************BEGINNING OF DUMP************************
                ;
                ; DUMP1 IS AN ENTRY POINT FOR EXTERNAL USE OF ROUTINE
                ;
42D9 CD7B48     DUMP:   CALL    FROMTO  ;GET BEGINNING ADDRESS AND BYTE COUNT
42DC DACC40             JC      ERRER   ;NON HEX CHAR TYPED - WHAT ?? ? ?? ?
42DF CD5849             CALL    OKCK    ;CHECK WITH USER BEFORE CONTINUING
42E2 D8                 RC              ;
42E3 3A015A     DUMP1:  LDA     WIDTH   ;GET WIDTH
42E6 47                 MOV     B,A     ;
42E7 2F                 CMA             ;ROUND DOWN STARTING ADDRESS
42E8 A5                 ANA     L       ;
42E9 6F                 MOV     L,A     ;
42EA 7B                 MOV     A,E     ;ROUND UP ENDING ADDRESS
42EB B0                 ORA     B       ;
42EC 5F                 MOV     E,A     ;
42ED E5                 PUSH    H       ;D&E=START-ENDING-1
42EE CDF649             CALL    SUB16   ;
42F1 2B                 DCX     H       ;
42F2 D1                 POP     D       ;
42F3 EB                 XCHG            ;
42F4 CD0C48             CALL    CRLF    ;GO TO NEW LINE
42F7 CD7849             CALL    PHW     ;PRINT MEMORY ADDRESS
42FA E5                 PUSH    H       ;PUT RAM ADDRESS ON STACK
42FB 21365A             LXI     H,MISCBF;GET BUFFER ADDRESS
42FE E3                 XTHL            ;PUT BUFFER ADDRESS ON STACK
                ;                       ;GET RAM ADDRESS OFF
                ;
                ; AT THIS POINT TOP OF STACK HAS BUFFER ADDRESS
                ;               H&L HAS RAM ADDRESS
                ;
42FF 7E         DI1:    MOV     A,M     ;GET BYTE
4300 23                 INX     H       ;POINT TO NEXT BYTE IN RAM
4301 CDEE49             CALL    SPACE   ;
4304 CD8349             CALL    PHB     ;PRINT BYTE IN HEX
4307 E67F               ANI     07FH    ;STRIP PARITY
4309 FE20               CPI     020H    ;CHECK FOR PRINTABLE
```

```
430B DA1343            JC      DI3      ;NOT PRINTABLE - PRINT '.'
430E FE7F     DI2:     CPI     07FH     ;MAY BE PRINTABLE - CHECK FOR RUBOUT
4310 C21543            JNZ     DI4      ;NOPE..OK
4313 3E2E     DI3:     MVI     A,'.'    ;NOT PRINTABLE - REPLACE WITH SPACE
4315 E3       DI4:     XTHL             ;GET BUFFER ADDRESS
4316 77                MOV     M,A      ;PUT CHAR OR SPACE IN BUFFER
4317 23                INX     H        ;
4318 E3                XTHL             ;PUT BUFFER ADDRESS BACK
4319 13                INX     D        ;DECREMENT COUNT OF NUMBER OF BYTES LEFT
431A 7D                MOV     A,L      ;
431B A0                ANA     B        ;END OF LINE - PRINT ASCII AND CRLF
431C C2FF42            JNZ     DI1      ;KEEP GOING IF NOT AT END OF LINE
431F E3       DMPLIN:  XTHL             ;GET BUFFER ADDRESS
4320 36FF              MVI     M,EOL    ;TERMINATE STRING
4322 21365A            LXI     H,MISCBF;POINT BACK TO START OF BUFFER
4325 E3                XTHL             ;PUT BUFFER ADDRESS BACK ON STACK
4326 CDEE49            CALL    SPACE    ;SPACE OVER A COUPLE
4329 CDEE49            CALL    SPACE    ;
432C D5                PUSH    D        ;
432D 11365A            LXI     D,MISCBF;POINT TO BEGINNING OF ASCII BUFFER
4330 CD3F49            CALL    MSG      ;PRINT ASCII BUFFER
4333 D1                POP     D        ;
4334 7B                MOV     A,E      ;
4335 B2                ORA     D        ;
4336 CA4243            JZ      DMPEND   ;DONE
4339 CD0C4B            CALL    CRLF     ;
433C CD7849            CALL    PHW      ;PRINT MEMORY ADDRESS
433F C3FF42            JMP     DI1      ;
4342 E1       DMPEND:  POP     H        ;CLEAN OFF STACK
4343 3EFF              MVI     A,EOL    ;CLEAR ANSWER...
4345 32365A            STA     MISCBF   ;
4348 C9                RET              ;
              ;
              ;***********************END OF DUMP*******************************
              ;
              ;**********************BEGINNING OF IOPORT**********************
              ;
              ; IO - I/O PORT MANIPULATION
              ;
4349 CDF04B   IOPORT:  CALL    GHB                ;GET PORT NUMBER
434C DACC40            JC      ERRER              ;
434F 32385A            STA     MISCBF+2           ;DON'T TROMP ON EOL
4352 3EC9              MVI     A,0C9H             ;STORE RETURN
4354 32395A            STA     MISCBF+3           ;
4357 CDEE49            CALL    SPACE              ;
435A CDD247            CALL    CI                 ;GET IOPORT COMMAND
435D CD024A            CALL    UCASE              ;STRIP PARITY
4360 CDEE49            CALL    SPACE              ;
4363 FE52              CPI     'R'                ;IF NOT R, CHECK OTHERS
4365 C26C43            JNZ     IOP1               ;
4368 CD7E43            CALL    IOPR               ;IOPORT READ ROUTINE
436B C9                RET                        ;
436C FE57     IOP1:    CPI     'W'                ;IF NOT W, CHECK M
436E C27543            JNZ     IOP2               ;
4371 CD9E43            CALL    IOPW               ;IOPORT WRITE ROUTINE
4374 C9                RET                        ;
```

```
4375 FE4D        IOP2:   CPI     'M'             ;IF NOT M, THEN WHAT DO
4377 C2CC40              JNZ     ERRER           ;  YOU WANT ?
437A CDB943              CALL    IOPM            ;IOPORT MONITOR ROUTINE
437D C9                  RET                     ;
                 ;       END     IOPORT          ;MAIN PROGRAM
                 ;
                 ; IOPR - IOPORT READ SUBCOMMAND
                 ;
437E 3EDB        IOPR:   MVI     A,0DBH          ;STORE "IN" INST
4380 32375A              STA     MISCBF+1        ;
4383 CD375A              CALL    MISCBF+1        ;GET BYTE FROM PORT
4386 11E850              LXI     D,IOPDA         ;PRINT 'DATA= '
4389 CD3F49              CALL    MSG             ;
438C CD8349              CALL    PHB             ;PRINT BYTE IN HEX
438F CDEE49              CALL    SPACE           ;
4392 CD4548              CALL    DISASC          ;PRINT BYTE IN ASCII
4395 7C                  MOV     A,H             ;
4396 CDF247              CALL    CO              ;
4399 7D                  MOV     A,L             ;
439A CDF247              CALL    CO              ;
439D C9                  RET                     ;
                 ;
                 ; IOPW - IOPORT WRITE COMMAND
                 ;
439E 11E850      IOPW:   LXI     D,IOPDA         ;PRINT 'DATA= '
43A1 CD3F49              CALL    MSG             ;
43A4 CDF048              CALL    GHB             ;
43A7 DACC40              JC      ERRER           ;BAD CHAR TYPED...
43AA CD5849              CALL    OKCK            ;CHECK TO BE SURE
43AD D8                  RC                      ;MUST HAVE GOOFED...
43AE F5                  PUSH    PSW             ;SAVE DATA
43AF 3ED3                MVI     A,0D3H          ;STORE "OUT" INST
43B1 32375A              STA     MISCBF+1        ;
43B4 F1                  POP     PSW             ;GET DATA BACK
43B5 CD375A              CALL    MISCBF+1        ;WRITE DATA
43B8 C9                  RET                     ;
                 ;
                 ; IOPM - IOPORT MONITOR COMMAND
                 ;
43B9 11EF50      IOPM:   LXI     D,IOPMM         ;PRINT '@ 50MS * '
43BC CD3F49              CALL    MSG             ;
43BF CDF048              CALL    GHB             ;
43C2 DACC40              JC      ERRER           ;BAD CHAR...
43C5 CD5849              CALL    OKCK            ;GIVE ESCAPE A CHANCE...
43C8 D8                  RC                      ;
43C9 4F                  MOV     C,A             ;WOULD YOU BELEIVE C FOR COUNTER?
43CA CD0C48              CALL    CRLF            ;
43CD 3EDB                MVI     A,0DBH          ;STORE "IN" INST
43CF 32375A              STA     MISCBF+1        ;
43D2 1600                MVI     D,0             ;
43D4 CD375A      IOPM1:  CALL    MISCBF+1        ;GET BYTE FROM PORT
43D7 CD8349              CALL    PHB             ;PRINT BYTE IN HEX
43DA CDEE49              CALL    SPACE           ;
43DD CD4548              CALL    DISASC          ;PRINT BYTE IN ASCII
43E0 7C                  MOV     A,H             ;
43E1 CDF247              CALL    CO              ;
```

```
43E4 7D                MOV     A,L           ;
43E5 CDF247            CALL    CO            ;
43E8 11F950            LXI     D,IOPSM       ;PRINT ',  '
43EB CD3F49            CALL    MSG           ;
43EE 41                MOV     B,C           ;WAIT (C)*50MS
43EF 04                INR     B             ;CHECK FOR ZERO
43F0 05       IOPM2:   DCR     B             ;
43F1 CAFA43            JZ      IOPM3         ;
43F4 CD1548            CALL    D50MS         ;
43F7 C3F043            JMP     IOPM2         ;
43FA 14       IOPM3:   INR     D             ;CHECK TO SEE IF IT IS TIME
43FB 3A015A            LDA     WIDTH         ;  FOR A ROUSING ROUND OF CRLF
43FE B7                ORA     A             ;CLEAR CARRY
43FF 1F                RAR                   ;CUT DOWN ONE
4400 A2                ANA     D             ;
4401 CC0C48            CZ      CRLF          ;
4404 C3D443            JMP     IOPM1         ;
              ;
              ;***********************END OF IO PORT COMMAND************
              ;
              ;********************************************************
              ;*            BEGINNING OF ULTRASONIC ROUTINE            *
              ;********************************************************

4407 CD0E4A   USFNT:   CALL    HRTBEAT           ;RELOAD HEARTBEAT
440A 3E00              MVI     A,00H
440C D340              OUT     PIAD              ;RESET INIT LINE ON SONICS
440E D322              OUT     TIME2             ;ZERO MSB OF COUNT
4410 D322              OUT     TIME2             ;     LSB OF COUNT
4412 3E01              MVI     A,01H
4414 D340              OUT     PIAD              ;SEND OUT SONIC BOOM
4416 115000            LXI     D,0050H           ;DELAY FOR < 1 MILLISEC.
4419 CD8747            CALL    DELAYD            ; OFF TO DELAY
441C 3E03              MVI     A,03H             ;SEND OUT BLANK INHIBIT
441E D340              OUT     PIAD              ; BUT KEEP BOOM HIGH
4420 3A125A   LOOPD:   LDA     MAXFNT            ;GET MAX FRONT DIST.
4423 47                MOV     B,A
4424 CD4445            CALL    CNTCK             ;FIND OUT HOW LONG
4427 7C                MOV     A,H
4428 B8                CMP     B                 ; BOOM HAS BEEN GONE
4429 DA3744            JC      NEXTA             ; IF SO FORGET IT
442C 3E00              MVI     A,00H
442E D340              OUT     PIAD              ;RESET EVERYTHING
4430 210000            LXI     H,0000H           ; CLEAR DIST.
4433 22105A            SHLD    FNTDST
4436 C9                RET

4437 DB42     NEXTA:   IN      PIAF              ;TEST FOR BOOM
4439 E601              ANI     01H               ;MASK OFF DIRECTION
443B FE01              CPI     01H               ;TEST FOR DIRECTION
443D C22044            JNZ     LOOPD             ;IF NOT BOOM THEN WAIT
4440 3E00              MVI     A,00H
4442 D340              OUT     PIAD              ;RESET INIT LINE
4444 CD4445            CALL    CNTCK             ;GET COUNTER IN HL
4447 CD5345            CALL    BEEP
444A CD5345            CALL    BEEP
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444D CD7245            CALL    FNDDT          ;FIND DISTANCE
4450 22105A            SHLD    FNTDST         ; STORE AS FRONT
4453 C9                RET

4454 CD0E4A   USBACK:  CALL    HRTBEAT        ;RELOAD HEARTBEAT
4457 3EB0              MVI     A,0B0H         ;INITIALIZE 8253 COUNTER
4459 D323              OUT     TIMCTL         ;TIMER2 BINARY COUNT MODE 0
445B 3E00              MVI     A,00H
445D D340              OUT     PIAD           ;RESET INIT LINE ON SONICS
445F D322              OUT     TIME2          ;ZERO MSB OF COUNT
4461 D322              OUT     TIME2          ;     LSB OF COUNT
4463 3E04              MVI     A,04H
4465 D340              OUT     PIAD           ;SEND OUT SONIC BOOM
4467 115000            LXI     D,0050H        ;DELAY FOR < 1 MILLISEC.
446A CD8747            CALL    DELAYD         ; OFF TO DELAY
446D 3E0C              MVI     A,0CH          ;SEND OUT BLANK INHIBIT
446F D340              OUT     PIAD           ; BUT KEEP BOOM HIGH
4471 3A155A   LOOPF:   LDA     MAXBAK         ;GET MAX BACK DIST.
4474 47                MOV     B,A
4475 CD4445            CALL    CNTCK          ;FIND OUT HOW LONG
4478 7C                MOV     A,H
4479 B8                CMP     B              ; BOOM HAS BEEN GONE
447A DA8844            JC      NEXTB          ; IF SO FORGET IT
447D 3E00              MVI     A,00H
447F D340              OUT     PIAD           ;RESET EVERYTHING
4481 210000            LXI     H,0000H
4484 22135A            SHLD    BAKDST
4487 C9                RET

4488 DB42     NEXTB:   IN      PIAF           ;TEST FOR BOOM
448A E602              ANI     02H            ;MASK OFF DIRECTION
448C FE02              CPI     02H            ;TEST FOR DIRECTION
448E C27144            JNZ     LOOPF          ;IF NOT BOOM THEN WAIT
4491 3E00              MVI     A,00H
4493 D340              OUT     PIAD           ;RESET INIT LINE
4495 CD4445            CALL    CNTCK          ;GET COUNTER IN HL
4498 CD5345            CALL    BEEP
449B CD5345            CALL    BEEP
449E CD7245            CALL    FNDDT          ;FIND DISTANCE
44A1 22135A            SHLD    BAKDST         ;AND STORE AS
44A4 C9                RET                    ;BACK DIST.

44A5 CD0E4A   USRT:    CALL    HRTBEAT        ;RELOAD HEARTBEAT
44A8 3EB0              MVI     A,0B0H         ;INITIALIZE 8253 COUNTER
44AA D323              OUT     TIMCTL         ;TIMER2 BINARY COUNT MODE 0
44AC 3E00              MVI     A,00H
44AE D340              OUT     PIAD           ;RESET INIT LINE ON SONICS
44B0 D322              OUT     TIME2          ;ZERO MSB OF COUNT
44B2 D322              OUT     TIME2          ;     LSB OF COUNT
44B4 3E10              MVI     A,10H
44B6 D340              OUT     PIAD           ;SEND OUT SONIC BOOM
44B8 115000            LXI     D,0050H        ;DELAY FOR < 1 MILLISEC.
44BB CD8747            CALL    DELAYD         ; OFF TO DELAY
44BE 3E30              MVI     A,30H          ;SEND OUT BLANK INHIBIT
44C0 D340              OUT     PIAD           ; BUT KEEP BOOM HIGH
44C2 3A185A   LOOPH:   LDA     MAXRT          ;GET MAX RIGHT DIST.
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44C5 47                 MOV     B,A
44C6 CD4445             CALL    CNTCK           ;FIND OUT HOW LONG
44C9 7C                 MOV     A,H
44CA B8                 CMP     B               ; BOOM HAS BEEN GONE
44CB DAD944             JC      NEXTC           ; IF SO FORGET IT
44CE 3E00               MVI     A,00H
44D0 D340               OUT     PIAD            ;RESET EVERYTHING
44D2 210000             LXI     H,0000H
44D5 22165A             SHLD    RTDST
44D8 C9                 RET

44D9 DB42       NEXTC:  IN      PIAF            ;TEST FOR BOOM
44DB E604               ANI     04H             ;MASK OFF DIRECTION
44DD FE04               CPI     04H             ;TEST FOR DIRECTION
44DF C2C244             JNZ     LOOPH           ;IF NOT BOOM THEN WAIT
44E2 3E00               MVI     A,00H
44E4 D340               OUT     PIAD            ;RESET INIT LINE
44E6 CD4445             CALL    CNTCK           ;GET COUNTER IN HL
44E9 CD5345             CALL    BEEP
44EC CD7245             CALL    FNDDT           ;GET DISTANCE
44EF 22165A             SHLD    RTDST           ;STORE AS RIGHT
44F2 C9                 RET

44F3 CD0E4A     USLFT:  CALL    HRTBEAT         ;RELOAD HEARTBEAT
44F6 3EB0               MVI     A,0B0H          ;INITIALIZE 8253 COUNTER
44F8 D323               OUT     TIMCTL          ;TIMER2 BINARY COUNT MODE 0
44FA 3E00               MVI     A,00H
44FC D340               OUT     PIAD            ;RESET INIT LINE ON SONICS
44FE D322               OUT     TIME2           ;ZERO MSB OF COUNT
4500 D322               OUT     TIME2           ;     LSB OF COUNT
4502 3E40               MVI     A,40H
4504 D340               OUT     PIAD            ;SEND OUT SONIC BOOM
4506 115000             LXI     D,0050H         ;DELAY FOR < 1 MILLISEC.
4509 CD8747             CALL    DELAYD          ; OFF TO DELAY
450C 3EC0               MVI     A,0C0H          ;SEND OUT BLANK INHIBIT
450E D340               OUT     PIAD            ; BUT KEEP BOOM HIGH
4510 3A1B5A     LOOPJ:  LDA     MAXLFT          ;GET MAX LEFT DIST.
4513 47                 MOV     B,A
4514 CD4445             CALL    CNTCK           ;FIND OUT HOW LONG
4517 7C                 MOV     A,H
4518 B8                 CMP     B               ; IF GEATER
4519 DA2745             JC      NEXTD           ; IF SO FORGET IT
451C 3E00               MVI     A,00H
451E D340               OUT     PIAD            ;RESET EVERYTHING
4520 210000             LXI     H,0000H
4523 22195A             SHLD    LFTDST
4526 C9                 RET

4527 DB42       NEXTD:  IN      PIAF            ;TEST FOR BOOM
4529 E608               ANI     08H             ;MASK OFF DIRECTION
452B FE08               CPI     08H             ;TEST FOR DIRECTION
452D C21045             JNZ     LOOPJ           ;IF NOT BOOM THEN WAIT
4530 3E00               MVI     A,00H
4532 D340               OUT     PIAD            ;RESET INIT LINE
4534 CD4445             CALL    CNTCK           ;GET COUNTER IN HL
4537 CD5345             CALL    BEEP
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453A CD5345            CALL   BEEP
453D CD7245            CALL   FNDDT          ;GET DISTANCE
4540 22195A            SHLD   LFTDST         ;STORE AS LEFT
4543 C9                RET

4544 F5        CNTCK:  PUSH   PSW
4545 3E80              MVI    A,80H
4547 D323              OUT    TIMCTL         ;LATCH CURRENT COUNT
4549 DB22              IN     TIME2          ;GET LSB
454B 2F                CMA                   ; FLIP IT TO REAL TIME
454C 6F                MOV    L,A
454D DB22              IN     TIME2          ;GET MSB
454F 2F                CMA                   ; FLIP TO REAL TIME
4550 67                MOV    H,A
4551 F1                POP    PSW
4552 C9                RET

4553 3A205A    BEEP:   LDA    MENCTRL        ;GET SOUND FLAG
4556 E602              ANI    SONOFF         ;MASK TO SEE IF SOUND ON
4558 FE02              CPI    SONOFF         ; IS IT ON ?
455A C0                RNZ                   ; IF NOT FOGET IT
455B 3E40              MVI    A,40H
455D D342              OUT    PIAF           ;TURN ON TONE
455F 54                MOV    D,H            ;DELAY FOR
4560 5D                MOV    E,L            ; DIST.COUNT
4561 CD8747            CALL   DELAYD         ;WAIT FOR IT
4564 3EC0              MVI    A,0C0H         ;CHANGE TONE
4566 D342              OUT    PIAF
4568 54                MOV    D,H            ;DELAY FOR
4569 5D                MOV    E,L            ;DIST COUNT
456A CD8747            CALL   DELAYD
456D 3E00              MVI    A,00H          ;NOW TURN EVERYTHING OFF
456F D342              OUT    PIAF
4571 C9                RET

4572 11F000    FNDDT:  LXI    D,00F0H        ;COUNT TO DIST. RATIO
4575 01FFFF            LXI    B,0FFFFH       ; ZERO BC
4578 03        LOOPM:  INX    B
4579 CDF649            CALL   SUB16          ;HL=HL-DE
457C D27845            JNC    LOOPM          ;DONE YET?
457F 69                MOV    L,C            ;MOVE BC TO HL
4580 60                MOV    H,B
4581 C9                RET

4582 3A205A    ULTRA:  LDA    MENCTRL        ;GET MENU CONTROL WORD
4585 E604              ANI    RONOFF         ;MASK TO SEE IF RANGING ON
4587 FE04              CPI    RONOFF         ;
4589 C0                RNZ                   ;RETURN IF RANGING OFF
458A DB11              IN     PIAB           ;GET +5 VOLT DATA (LOOP) FROM CONN.
458C E608              ANI    FUSLOOP        ;MASK TO GET FRONT CONNECTOR STATUS
458E FE08              CPI    FUSLOOP        ;AFTER COMPARE, Z SET = CONNECTED
4590 CA9B45            JZ     FUSOK          ;CONTINUE IF CONNECTED
4593 3E20              MVI    A,FUSLED       ;GET DATA TO LIGHT FRONT US ERROR LED
4595 CDF04A            CALL   SETERR         ;LIGHT THE FRONT US ERROR LED
4598 C3C945            JMP    ULTRA1
459B 3E20      FUSOK:  MVI    A,FUSLED       ;CLEAR LED ERROR
```

```
459D CDFC4A             CALL    CLRERR      ;
45A0 CD0744             CALL    USFNT       ;ULTRASONIC RANGING FRONT
45A3 2A1C5A             LHLD    TIMDLY      ; DELAY FOR SCAN
45A6 EB                 XCHG
45A7 CD8747             CALL    DELAYD
45AA 2A105A             LHLD    FNTDST      ;MAX FRONT DIST.
45AD 7C                 MOV     A,H
45AE B5                 ORA     L
45AF FE00               CPI     00H         ;IF GREATER THAN MAX
45B1 CAC945             JZ      ULTRA1      ; THEN FORGET IT
45B4 113555             LXI     D,FNTMSG    ; PRINT RANGE DIST.
45B7 CD3F49             CALL    MSG         ; MESSAGE
45BA CD7849             CALL    PHW         ; AND FRONT DIST. VALUE
45BD CD0C48             CALL    CRLF
45C0 7D                 MOV     A,L         ;CHECK FOR UNSAFE DIST
45C1 FE0C               CPI     USSTOP      ;IF GREATER THEN ULTRA STOP
45C3 D2C945             JNC     ULTRA1      ; THEN CONT.
45C6 CDEB4B             CALL    STOP        ; IF LESS STOP
45C9 DB11       ULTRA1: IN      PIAB        ;GET +5 VOLT DATA (LOOP) FROM CONN.
45CB E610               ANI     BUSLOOP     ;MASK TO GET BACK CONNECTOR STATUS
45CD FE10               CPI     BUSLOOP     ;AFTER COMPARE, Z SET = CONNECTED
45CF CADA45             JZ      BUSOK       ;CONTINUE IF CONNECTED
45D2 3E10               MVI     A,BUSLED    ;GET DATA TO LIGHT BACK US ERROR LED
45D4 CDF04A             CALL    SETERR      ;LIGHT THE BACK US ERROR LED
45D7 C30846             JMP     ULTRA2
45DA 3E10       BUSOK:  MVI     A,BUSLED    ;GET DATA TO CLEAR BACK US ERROR LED
45DC CDFC4A             CALL    CLRERR
45DF CD5444             CALL    USBACK      ;ULTRASONIC RANGE BACK
45E2 2A1C5A             LHLD    TIMDLY      ; DELAY FOR SCAN
45E5 EB                 XCHG
45E6 CD8747             CALL    DELAYD
45E9 2A135A             LHLD    BAKDST      ;MAX BACK DIST.
45EC 7C                 MOV     A,H
45ED B5                 ORA     L
45EE FE00               CPI     00H         ;IF GREATER THAN MAX
45F0 CA0846             JZ      ULTRA2      ;THEN FORGET IT
45F3 113E55             LXI     D,BAKMSG    ; PRINT RANGE DIST.
45F6 CD3F49             CALL    MSG         ; MESSAGE
45F9 CD7849             CALL    PHW         ; AND FRONT DIST. VALUE
45FC CD0C48             CALL    CRLF
45FF 7D                 MOV     A,L         ;CHECK FOR UNSAFE DIST
4600 FE0C               CPI     USSTOP      ;IF GREATER THEN ULTRA STOP
4602 D20846             JNC     ULTRA2      ; THEN CONT.
4605 CDEB4B             CALL    STOP        ; IF LESS STOP
4608 DB11       ULTRA2: IN      PIAB        ;GET +5 VOLT DATA (LOOP) FROM CONN.
460A E620               ANI     RUSLOOP     ;MASK TO GET RIGHT CONNECTOR STATUS
460C FE20               CPI     RUSLOOP     ;AFTER COMPARE, Z SET = CONNECTED
460E CA1946             JZ      RUSOK       ;CONTINUE IF CONNECTED
4611 3E08               MVI     A,RUSLED    ;GET DATA TO LIGHT RIGHT US ERROR LED
4613 CDF04A             CALL    SETERR      ;LIGHT THE RIGHT US ERROR LED
4616 C34746             JMP     ULTRA3
4619 3E08       RUSOK:  MVI     A,RUSLED    ;GET DATA TO CLEAR RIGHT US ERROR LED
461B CDFC4A             CALL    CLRERR
461E CDA544             CALL    USRT
4621 2A1C5A             LHLD    TIMDLY      ; DELAY FOR SCAN
4624 EB                 XCHG
```

```
4625 CD8747             CALL    DELAYD
4628 2A165A             LHLD    RTDST           ;MAX RIGHT DIST.
462B 7C                 MOV     A,H
462C B5                 ORA     L
462D FE00               CPI     00H             ;IF GREATER THAN MAX
462F CA4746             JZ      ULTRA3          ; THEN FORGET IT
4632 114655             LXI     D,RTMSG         ; PRINT RANGE DIST.
4635 CD3F49             CALL    MSG             ; MESSAGE
4638 CD7B49             CALL    PHW             ; AND FRONT DIST. VALUE
463B CD0C48             CALL    CRLF
463E 7D                 MOV     A,L             ;CHECK FOR UNSAFE DIST
463F FE0C               CPI     USSTOP          ;IF GREATER THEN ULTRA STOP
4641 D24746             JNC     ULTRA3          ; THEN CONT.
4644 CDEB4B             CALL    STOP            ; IF LESS STOP
4647 DB11      ULTRA3:  IN      PIAB            ;GET +5 VOLT DATA (LOOP) FROM CONN.
4649 E640               ANI     LUSLOOP         ;MASK TO GET LEFT CONNECTOR STATUS
464B FE40               CPI     LUSLOOP         ;AFTER COMPARE, Z SET = CONNECTED
464D CA5846             JZ      LUSOK           ;CONTINUE IF CONNECTED
4650 3E04               MVI     A,LUSLED        ;GET DATA TO LIGHT LEFT US ERROR LED
4652 CDF04A             CALL    SETERR          ;LIGHT THE LEFT US ERROR LED
4655 C38646             JMP     ULTRA4
4658 3E04      LUSOK:   MVI     A,LUSLED        ;GET DATA TO CLEAR RIGHT US ERROR LED
465A CDFC4A             CALL    CLRERR
465D CDF344             CALL    USLFT           ;ULTRASONIC RANGE LEFT
4660 2A1C5A             LHLD    TIMDLY          ; DELAY FOR SCAN DELAY
4663 EB                 XCHG
4664 CD8747             CALL    DELAYD
4667 2A195A             LHLD    LFTDST          ;MAX LEFT DIST.
466A 7C                 MOV     A,H
466B B5                 ORA     L
466C FE00               CPI     00H             ;IF GREATER THAN MAX
466E CA8646             JZ      ULTRA4          ; THEN FORGET IT
4671 114F55             LXI     D,LFTMSG        ; PRINT RANGE DIST.
4674 CD3F49             CALL    MSG             ; MESSAGE
4677 CD7B49             CALL    PHW             ; AND FRONT DIST. VALUE
467A CD0C48             CALL    CRLF
467D 7D                 MOV     A,L             ;CHECK FOR UNSAFE DIST
467E FE0C               CPI     USSTOP          ;IF GREATER THEN ULTRA STOP
4680 D28646             JNC     ULTRA4          ; THEN CONT.
4683 CDEB4B             CALL    STOP            ; IF LESS STOP
4686 C9        ULTRA4:  RET                     ;GO BACK TO CALLING
                                                ;     ROUTINE


               ;****************** END OF SONICS ROUTINE ****************
               ;
               ;*****************  BEGINNING OF CHAIR PROGRAMS ***********
               ;
               ; INITIAL - ROUTINE TO INITIALIZE THE CHAIR UPON STARTUP
               ;
4687 310060    INITIAL:LXI      SP,ENDRAM+1     ;RESET STACK POINTER
468A 3E82               MVI     A,10000010B     ;PORT A: OUTPUT
468C D313               OUT     PIACNTL         ;PORT B: INPUT
                                                ;PORT C (UPPER): OUTPUT
                                                ;PORT C (LOWER): OUTPUT
468E 3EB0               MVI     A,0B0H          ;INITIALIZE 8253 COUNTER
```

```
4690 D323              OUT     TIMCTL            ;TIMER2 BINARY COUNT MODE 0
4692 3E81              MVI     A,81H             ;8255 PIA D=IN E=IN
4694 D343              OUT     PIBCNTL           ;F=OUT

4696 3E08              MVI     A,MTRSTOP         ;GET VALUE TO STOP MOTORS
4698 322E5A            STA     RMCS              ; SET MOTOR OUTPUT
469B 322D5A            STA     LMCS              ; TO STOP AT FIRST
469E 322C5A            STA     RMTS
46A1 322B5A            STA     LMTS
46A4 07                RLC                       ;ROTATE TO MS NIBBLE
46A5 07                RLC
46A6 07                RLC
46A7 07                RLC
46A8 F608              ORI     MTRSTOP           ;COMBINE FOR BOTH L & R MOTORS
46AA D341              OUT     PIAE              ;SEND STOPS TO MOTORS
46AC 3E30              MVI     A,30H             ;SET UP TIMER 0 FOR
46AE D323              OUT     TIMCTL            ; HEARTBEAT PROTECTION
46B0 210008            LXI     H,0800H           ; SET SCAN DELAY
46B3 221C5A            SHLD    TIMDLY            ; FOR DELAYING ULTRA SAMPLE
46B6 111A55            LXI     D,CLS             ; CLEAR SCREEN
46B9 CD3F49            CALL    MSG
46BC 11F254            LXI     D,MSG1            ; PRINT A MESSAGE SO
46BF CD3F49            CALL    MSG               ; WE KNOW WE MADE IT

                ;****************************
                ;
                ; RUNCHR - MAIN SOFTWARE LOOP.  REPEAT LOOP CONSTANTLY, REGARDLESS
                ;       OF THE PAD/JOYSTICK SETTING, BUT DO NOT UPDATE HEARTBEAT
                ;       IF SWITCHED TO JOYSTICK
                ;
                ;****************************

46C2 00         RUNCHR: NOP
46C3 00                 NOP
46C4 00                 NOP
46C5 3EFF               MVI     A,TRUE
46C7 32355A             STA     HEARTON
46CA CD0E4A             CALL    HRTBEAT ;CHECK PAD/JOYSTICK SWITCH, UPDATE
                                        ;HEARTBEAT IF SWITCHED TO PAD
46CD CD154A             CALL    MENCHK  ;DETERMINE MENU NUBER, READ GLOBAL
                                        ;MENU PARAMETERS
46D0 CD8245             CALL    ULTRA   ;CALL U.S. RANGING ROUTINE
46D3 CDA44A             CALL    PADCHK  ;CHECK PAD FOR TOUCH, READ DATA NEEDED
                                        ;IF A VALID TOUCH.  PROGRAM MENU IF
                                        ;APPROPRIATE.
46D6 CD5D48             CALL    EXTCHK  ; SEE IF USER HAS RS-232 CONNECTED
                                        ; AND IF THEY WANT THE MONITOR PRG.
46D9 3A205A             LDA     MENCTRL ;GET MENU CONTROL WORD
46DC E601               ANI     EMPTMEN ;MASK TO SEE IF EMPTY MENU
46DE FE01               CPI     EMPTMEN ;
46E0 C2E946             JNZ     AOK1    ;UPDATE IF MENU NOT EMPTY
46E3 CDEB4B             CALL    STOP    ;OTHERWISE, STOP MOTORS
46E6 C3C246             JMP     RUNCHR
46E9 3A315A     AOK1:   LDA     DURATION
46EC FE00               CPI     00H
46EE C2F746             JNZ     AOK2
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 46F1 CDEB4B              CALL    STOP
 46F4 C3C246              JMP     RUNCHR
 46F7 CD854B    AOK2:     CALL    UPDATMTR ;UPDAT MOTORS IF APPROPRIATE (AT CORRECT
                                          ;TIME SO AS TO RAMP).
 46FA C3C246              JMP     RUNCHR

                ;****************************
                ; END OF MAIN LOOP
                ;****************************
                ;
                ; PADRD - ROUTINE TO CHECK THE PAD, DETERMINE ERROR STATUS, RETURN
                ;         TOUCH LOCATION OF THERE IS ONE.
                ;
                PADRD:                                  ;
 46FD 210000    MENU:     LXI     H,00H                 ;RESET HL FOR NEW DATA/STATUS INFO
 4700 0E00                MVI     C,00H                 ;RESET (C) FOR NEW TOUCH LOCATION
 4702 0605                MVI     B,05H                 ;LOAD MENU SELECT COUNTER+1
 4704 05        LOOP3:    DCR     B                     ;DECREMENT COUNTER OF MENU SELECT BITS
 4705 78                  MOV     A,B                   ;TRANSFER (B) TO (A) FOR OUTPUT
 4706 F640                ORI     EXTMSK                ;MASK FOR EXTRA DEMUX SELECT
 4708 D310                OUT     PIAA                  ;OUTPUT COUNT TO SELECT MENU SELECT BIT
 470A 11A000              LXI     D,0A0H                ;SET UP DELAY COUNT
 470D CD8747              CALL    DELAYD                ;SHORT DELAY
 4710 DB11                IN      PIAB                  ;INPUT TRANSISTOR STATUS
 4712 E601                ANI     BEAMSK                ;PREPARE INPUT DATA (MASK)
 4714 B4                  ORA     H                     ;OR CURRENT (H) DATA WITH LED STATUSL
 4715 17                  RAL                           ;ROTATE THE (A) LEFT TO MOVE BITS ONE
 4716 67                  MOV     H,A                   ;TRANSFER RESULT TO (H) AGAIN
 4717 78                  MOV     A,B                   ;CHECK COUNT TO SEE IF = 0
 4718 FE00                CPI     00H                   ;
 471A C20447              JNZ     LOOP3                 ;REPEAT PROCESS IF 5 PAIRS NOT YET SCANNED
 471D 7C                  MOV     A,H                   ;VALIDATE MENU DATA
 471E 1F                  RAR                           ;REPOSITION THE MENU DATA (ROTATED)
 471F 67                  MOV     H,A                   ;
 4720 FE00      ERR1:     CPI     00H                   ;CHECK FOR NO BEAMS BLOCKED (NO'MENU)
 4722 C22A47              JNZ     ERR2                  ;CHECK FOR NEXT ERROR IF NOT ERROR 1
 4725 2640                MVI     H,MENERR              ;SIGNAL MENU ERROR
 4727 C38547              JMP     PNTDAT                ;FINISH AND PRINT MSGS
 472A FE1F      ERR2:     CPI     1FH                   ;CHECK FOR ALL BEAMS BROKEN (FALSE MENU)
 472C C23447              JNZ     SCAN                  ;CONTINUE SCAN IF NO MENU ERRORS
 472F 2640                MVI     H,MENERR              ;SIGNAL MENU ERROR
 4731 C38547              JMP     PNTDAT                ;FINISH AND PRINT MSGS

 4734 0E00      SCAN:     MVI     C,00H                 ;CLEAR ROW/COL REGISTER
 4736 0610      ROW:      MVI     B,10H                 ;INITIAL COUNTER VALUE OF 16 LEDS + 1
 4738 05        LOOP4:    DCR     B                     ;DECREMENT COUNTER
 4739 78                  MOV     A,B                   ;TRANSFER COUNT TO ACCUM
 473A F610                ORI     ROWMSK                ;PREPARE FOR ROW SELECT (MASK)
 473C D310                OUT     PIAA                  ;OUTPUT ROW LED/TRANSISTOR SELECT
 473E 11A000              LXI     D,0A0H                ;LOAD DELAY COUNTER
 4741 CD8747              CALL    DELAYD                ;SHORT DELAY
 4744 DB11                IN      PIAB                  ;GET TRANSISTOR STATUS
 4746 E601                ANI     BEAMSK                ;PREPARE INPUT FROM TRANSISTOR (MASK)
 4748 FE00                CPI     00H                   ;SET ZERO FLAG
 474A CA5647              JZ      COUNT3                ;CONTINUE LOOP IF NO TOUCH ('1'=TOUCH)
 474D 78                  MOV     A,B                   ;TRANSFER COUNT TO ACCUM
```

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474E 17                 RAL                        ;ROTATE COUNT VALUE TO MS NIBBLE
474F 17                 RAL
4750 17                 RAL
4751 17                 RAL
4752 4F                 MOV     C,A                ;SAVE ROW IN ROW/COL REGISTER
4753 C35D47             JMP     COL                ;JUMP TO COL SCAN BECAUSE ROW TOUCHED

4756 78       COUNT3:   MOV     A,B                ;MOVE COUNT TO 'A' TO DO ZERO CHECK
4757 FE00               CPI     00H                ;REPEAT UNLESS CURRENTLY ZERO
4759 C23847             JNZ     LOOP4              ;CONTINUE LOOP IF NOT COUNTED OUT
475C C9                 RET                        ;RETURN IF LOOP COMPLETED W/NO TOUCH

475D 06FF     COL:      MVI     B,0FFH             ;LOAD COLUMN COUNTER - 1
475F 04       LOOP2:    INR     B                  ;INCREMENT COLUMN COUNTER
4760 78                 MOV     A,B                ;TRANSFER COL COUNT TO ACCUM
4761 F620               ORI     COLMSK             ;PREPARE CN LED/TRANSISTOR SELECT (MASK)
4763 D310               OUT     PIAA               ;SELECT LED/TRANSISTOR
4765 11A000             LXI     D,0A0H             ;LOAD DELAY COUNTER
4768 CD8747             CALL    DELAYD             ;CALL SHORT DELAY
476B DB11               IN      PIAB               ;INPUT TRANSISTOR STATUS
476D E601               ANI     BEAMSK             ;PREPARE INPUT FOR USE (MASK)
476F FE00               CPI     00H                ;SET ZERO FLAG
4771 CA7E47             JZ      COUNT4             ;REPEAT LOOP IF NO TOUCH ('1'=TOUCH)
4774 78                 MOV     A,B                ;TRANSFER COUNT TO ACCUM
4775 B1                 ORA     C                  ;COMPLETE ROW/COL DATA IN ACCUM
4776 4F                 MOV     C,A                ;SAVE ROW/COL DATA IN 'C'
                                                   ;HIGH NIBBLE: ROW
                                                   ;LOW NIBBLE: COLUMN
4777 7C                 MOV     A,H                ;MASK (H) TO SHOW A VALID TOUCH
4778 F680               ORI     TOUCH              ;
477A 67                 MOV     H,A                ;
477B C38547             JMP     PNTDAT             ;PRINT MESSAGE

477E 78       COUNT4:   MOV     A,B                ;CHECK TO SEE IF COUNT=16 DECIMAL
477F FE0F               CPI     0FH                ;SCANNED ALL 16 LEDS?
4781 C8                 RZ
4782 C25F47             JNZ     LOOP2              ;CONTINUE LOOP 2 TO CHECK FOR COL TOUCH
4785 69       PNTDAT:   MOV     L,C
4786 C9                 RET
              ;
              ;****************** END OF PAD READ ROUTINE **************
              ;

4787 3A355A   DELAYD:   LDA     HEARTON
478A FE00               CPI     FALSE
478C CA9247             JZ      DELAYE
478F CD0E4A             CALL    HRTBEAT            ;DON'T LET HEARTBEAT DIE !!
4792 1B       DELAYE:   DCX     D                  ;DECREMENT DELAY COUNT
4793 7A                 MOV     A,D                ;COMPARE D AND E
4794 B3                 ORA     E                  ;CHECK TO SEE IF DE=0
4795 C29247             JNZ     DELAYE             ;REPEAT IF <>0
4798 3A355A             LDA     HEARTON
479B FE00               CPI     FALSE
479D C8                 RZ
479E CD0E4A             CALL    HRTBEAT
47A1 C9                 RET
```

```
                  ;*****************************************************
                  ;* UTILITY ROUTINES -                                  *
                  ;*****************************************************
                  ; BCDTBIN - CONVERT BCD IN H&L TO BINARY IN H&L
                  ;              ONLY H&L CHANGED
47A2 C5           BCDTBIN:PUSH    B         ;
47A3 D5                   PUSH    D         ;
47A4 54                   MOV     D,H       ;COPY ORIGINAL
47A5 5D                   MOV     E,L       ;
47A6 2600                 MVI     H,0       ;INITIALIZE UPPER PART OF RESULT
47A8 0600                 MVI     B,0       ;INITIAL UPPER PART OF B&C
47AA 7A                   MOV     A,D       ;GET UPPER DIGIT
47AB 0F                   RRC               ;
47AC 0F                   RRC               ;
47AD 0F                   RRC               ;
47AE 0F                   RRC               ;
47AF E60F                 ANI     0FH       ;
47B1 6F                   MOV     L,A       ;START RESULT
47B2 CD4F49               CALL    MULT10    ;SHIFT UP ONE DIGIT IN BASE 10
47B5 7A                   MOV     A,D       ;GET NEXT TO TOP DIGIT
47B6 E60F                 ANI     0FH       ;
47B8 4F                   MOV     C,A       ;
47B9 09                   DAD     B         ;COMBINE WITH TOP DIGIT
47BA CD4F49               CALL    MULT10    ;SHIFT UP ONE DIGIT IN BASE 10
47BD 7B                   MOV     A,E       ;GET NEXT TO BOTTOM DIGIT
47BE 0F                   RRC               ;
47BF 0F                   RRC               ;
47C0 0F                   RRC               ;
47C1 0F                   RRC               ;
47C2 E60F                 ANI     0FH       ;
47C4 4F                   MOV     C,A       ;
47C5 09                   DAD     B         ;COMBINE WITH TOP TWO DIGITS
47C6 CD4F49               CALL    MULT10    ;SHIFT UP ONE DIGIT IN BASE 10
47C9 7B                   MOV     A,E       ;GET BOTTOM DIGIT
47CA E60F                 ANI     0FH       ;
47CC 4F                   MOV     C,A       ;
47CD 09                   DAD     B         ;COMBINE WITH TOP THREE DIGITS
47CE D1                   POP     D         ;
47CF C1                   POP     B         ;
47D0 C9                   RET               ;
                  ;       END     BCDTBIN ;
                  ;
                  ;
                  ; CALLIN - INDIRECT CALL TO (H&L)
                  ;
47D1 E9           CALLIN: PCHL              ;
                  ;                         ;
                  ;       END     CALLIN  ;
                  ;
                  ; I/O ROUTINES
                  ;
47D2 DB01         CI:     IN      SERCON           ;WAIT FOR DATA READY
47D4 E602                 ANI     2                ;
47D6 CAD247               JZ      CI               ;
47D9 DB00                 IN      SERDAT           ;GET BYTE
```

```
47DB F5                 PUSH    PSW                 ;SAVE PSW
47DC 3A005A             LDA     ECHOFL              ;CHECK ECHO FLAG
47DF B7                 ORA     A                   ;
47E0 C2FD47             JNZ     COEND               ;IF NOT ZERO ECHO-RET ON CO
47E3 F1                 POP     PSW                 ;ECHO CHARACTER
47E4 F5                 PUSH    PSW                 ;
47E5 C3F347             JMP     C1                  ;GO ECHO CHARACTER
                ;
                ;
                ; CISTAT - RETURNS NON-ZERO IN A IF RECIEVER BUFFER HAS A CHAR
                ;
47E8 C5         CISTAT: PUSH    B                   ;
47E9 F5                 PUSH    PSW                 ;
47EA DB01               IN      SERCON              ;
47EC E602               ANI     2                   ;
47EE C1                 POP     B                   ;
47EF 78                 MOV     A,B                 ;
47F0 C1                 POP     B                   ;
47F1 C9                 RET                         ;
                ;
                ;**** CO CONSOLE OUTPUT - DESTROYS ONLY FLAGS...
                ;
47F2 F5         CO:     PUSH    PSW                 ;
47F3 DB01       C1:     IN      SERCON              ;
47F5 0F                 RRC                         ;
47F6 D2F347             JNC     C1                  ;
47F9 F1                 POP     PSW                 ;
47FA F5                 PUSH    PSW                 ;
47FB D300               OUT     SERDAT              ;
47FD F1         COEND:  POP     PSW                 ;
47FE C9                 RET                         ;
                ;****** CMP16 ** 16 BIT COMPARE H&L AND D&E *******************
                ;
                ;       IF( H&L = D&E ) Z=1, CY=0
                ;       IF( H&L > D&E ) Z=0, CY=0
                ;       IF( H&L < D&E ) Z=0, CY=1
                ;
47FF E5         CMP16:  PUSH    H                   ;SAVE PSW & H&L
4800 F5                 PUSH    PSW                 ;
4801 7C                 MOV     A,H                 ;IF H  = D ENOUGH INFO FOUND
4802 92                 SUB     D                   ;
4803 C20848             JNZ     CMP16E              ;
4806 7D                 MOV     A,L                 ;IF H=D THEN COMPARE LOWER BYTES
4807 93                 SUB     E                   ;
4808 E1         CMP16E: POP     H                   ;
4809 7C                 MOV     A,H                 ;
480A E1                 POP     H                   ;
480B C9                 RET                         ;
                ;       END     CMD16               ;
480C D5         CRLF:   PUSH    D
480D 11EF54             LXI     D,MCRLF
4810 CD3F49             CALL    MSG
4813 D1                 POP     D
4814 C9                 RET
                ;
                ; D50MS - DELAY FOR 50 MILLI-SECONDS
```

```
                 ;
4815 F5          D50MS:   PUSH    PSW                  ;SAVE PSW
4816 E5                   PUSH    H                    ;SAVE H&L
4817 2A0A5A               LHLD    D50DIV               ;
481A E3          D50MSL:  XTHL                         ;18
481B E3                   XTHL                         ;18
481C E3                   XTHL                         ;18
481D E3                   XTHL                         ;18
481E E5                   PUSH    H                    ;11
481F E1                   POP     H                    ;10
4820 2B                   DCX     H                    ; 5
4821 23                   INX     H                    ; 5
4822 2B                   DCX     H                    ; 5
4823 7C                   MOV     A,H                  ; 5
4824 B5                   ORA     L                    ; 4
4825 C21A48               JNZ     D50MSL               ;11
4828 E1                   POP     H                    ;
4829 F1                   POP     PSW                  ;
482A C9                   RET
                 ;
                 ; D10MS - DELAY 10 MS
                 ;
482B E5          D10MS:   PUSH    H        ;
482C F5                   PUSH    PSW      ;
482D 210103               LXI     H,769    ;
4830 7D          DTWIDL:  MOV     A,L      ;    ;~0.01 SECONDS ON A 2 MHZ 8085     5
4831 B4                   ORA     H        ;    ;  (CPU CLOCK FREQ)                  4
4832 2B                   DCX     H        ;    ;                                   10
4833 C23048               JNZ     DTWIDL   ;    ;                 8085/8080       7/10
4836 F1                   POP     PSW      ;    ;                 TOTAL          26/29
4837 E1                   POP     H        ;
4838 C9                   RET              ;
                 ;        END     D10MS    ;
                 ;
                 ; D5SEC - DELAY 5 SECONDS
                 ;
4839 C5          D5SEC:   PUSH    B                    ;
483A 0664                 MVI     B,064H               ;WAIT 5 SECOND FOR +25 SWITCHING
483C CD1548      ON16W1:  CALL    D50MS                ;REGULATOR TO TURN ON OR OFF.
483F 05                   DCR     B                    ;
4840 C23C48               JNZ     ON16W1               ;
4843 C1                   POP     B                    ;
4844 C9                   RET                          ;
                 ;        END     D5SEC                ;
                 ;
                 ; DISASC - DISPLAY ASCII A-REG INTO H&L
                 ;
4845 F5          DISASC:  PUSH    PSW     ;SAVE PSW
4846 E67F                 ANI     07FH    ;STRIP PARITY
4848 2620                 MVI     H,020H  ;PUT SPACE IN H-REG
484A FE20                 CPI     020H    ;CHAR < 020H ?
484C D25348               JNC     DA1     ;NO-IS PRINTABLE
484F 265E                 MVI     H,05EH  ;NOT PRINTABLE - C = '^'
4851 C640                 ADI     040H    ;MAKE PRINTABLE
4853 FE7F        DA1:     CPI     07FH    ;IS RUBOUT ?
4855 C25A48               JNZ     DA2     ;NOPE...AOK
```

```
4858 3E20                  MVI     A,020H  ;YEP-MAKE SPACE
485A 6F          DA2:      MOV     L,A     ;
485B F1                    POP     PSW     ;RESTORE PSW
485C C9                    RET             ;

                 ;*******************************************************
                 ;*                  EXIT TO MONITOR ROUTINE            *
                 ;*******************************************************

485D DB01        EXTCHK:   IN      SERCON  ;SEE IF THERE IS A CHAR
485F E602                  ANI     02H
                                           ; IF ZERO THEN NONE
4861 C8                    RZ              ; IF NO CHAR. THEN FORGET IT
4862 DB00                  IN      SERDAT  ;GET CHAR. FROM  CONSOL
4864 FE45                  CPI     45H     ; IS IT 'E' FOR EXIT
4866 CA4040                JZ      START   ;OFF TO MONITOR THEN
4869 C9                    RET

                 ;*******************************************************
                 ;         FRMCNT - ASKS " FROM "XXXX" TO "YYYY         *
                 ;*******************************************************

486A D5          FRMCNT:   PUSH    D       ;
486B E5                    PUSH    H       ;
486C CD7B48                CALL    FROMTO  ;
486F DA9D48                JC      FRTOE   ;
4872 E5                    PUSH    H       ;
4873 CDF649                CALL    SUB16   ;CALC NUMBER OF BYTES TO BE PROCESSED
4876 D1                    POP     D       ;
4877 2B                    DCX     H       ;H&L = NEGATIVE OF NUMBER OF BYTES
4878 C39648                JMP     FRCLN   ;THIS DOES XCHG & CLEANS OFF STACK...
                 ;         END     FROMTO
                 ;
                 ; FROMTO - " FROM "XXXX" TO "YYYY
                 ;
487B D5          FROMTO:   PUSH    D       ;
487C E5                    PUSH    H       ;
487D 116951                LXI     D,PLO   ;PROMPT FOR LO LIMIT
4880 CD3F49                CALL    MSG     ;
4883 CDD948                CALL    GHW     ;
4886 DA9D48                JC      FRTOE   ;RETURN IF ERRER
4889 116451                LXI     D,PHI   ;PROMPT FOR HI LIMIT
488C CD3F49                CALL    MSG     ;
488F EB                    XCHG            ;
4890 CDD948                CALL    GHW     ;
4893 DA9D48                JC      FRTOE   ;
4896 EB          FRCLN:    XCHG            ;
4897 E3                    XTHL            ;GET CRAP OFF OF STACK
4898 E1                    POP     H       ;
4899 E3                    XTHL            ;
489A E1                    POP     H       ;
489B B7                    ORA     A       ;BETTER BE SURE CARRY IS CLEAR
489C C9                    RET             ;RETURN...
489D E1          FRTOE:    POP     H       ;
489E D1                    POP     D       ;
489F C9                    RET             ;
```

```
                ; GBIAS - GET 16 BIT BIAS
                ;
48A0 F5         GBIAS:  PUSH    PSW             ;SAVE PSW
48A1 E5                 PUSH    H               ;  AND H&L
48A2 D5                 PUSH    D               ;  AND D&E
48A3 117051             LXI     D,PBIAS         ;PRINT BIAS MESSAGE
48A6 CD3F49             CALL    MSG             ;
48A9 CDD948             CALL    GHW             ;GET BIAS
48AC D2CC48             JNC     GBIAS2          ;IF NO CARRY GOOD BIAS ENTERED
48AF FE2D               CPI     '-'             ;CHECK FOR NEGATIVE BIAS
48B1 CABF48             JZ      GBIAS1          ;OHHH- WANT NEGATIVE NUMBER ...
48B4 FE0D               CPI     CR              ;CARRIAGE RETURN ?
48B6 C2D448             JNZ     GBIASE          ;NOPE ERRER
48B9 210000             LXI     H,0             ;AHHHH - NO BIAS
48BC C3CC48             JMP     GBIAS2          ;
48BF CDD948     GBIAS1: CALL    GHW             ;GET NEGATIVE BIAS
48C2 DAD448             JC      GBIASE          ;BAD CHAR...BYE
48C5 110000             LXI     D,0             ;
48C8 EB                 XCHG                    ;SET UP SUBTRACTION FROM ZERO
48C9 CDF649             CALL    SUB16           ;NEGATE BIAS
48CC CD0C48     GBIAS2: CALL    CRLF            ;PREVENT A MESS
48CF D1                 POP     D               ;RESTORE D
48D0 F1                 POP     PSW             ;LOOSE ORIGINAL H&L
48D1 F1                 POP     PSW             ;RESTORE PSW
48D2 B7                 ORA     A               ;CLEAR CARRY
48D3 C9                 RET
48D4 D1         GBIASE: POP     D               ;RESTORE D&E
48D5 E1                 POP     H               ;RESTORE ORIGINAL H&L
48D6 F1                 POP     PSW             ;RESTORE PSW
48D7 37                 STC                     ;SET CARRY
48D8 C9                 RET


                ;
                ; GHW - GET HEX WORD
                ;
48D9 C5         GHW:    PUSH    B
48DA F5                 PUSH    PSW
48DB CDF048             CALL    GHB             ; GET FIRST BYTE IN A-REGISTER
48DE DAED48             JC      GHWEND          ; RETURN IF BAD CHAR
48E1 67                 MOV     H,A             ; MOVE BYTE TO FINAL DESTINATION
48E2 CDF048             CALL    GHB             ; GET SECOND BYTE
48E5 DAED48             JC      GHWEND          ;
48E8 6F                 MOV     L,A             ;
48E9 C1                 POP     B               ;
48EA 78                 MOV     A,B             ;
48EB C1                 POP     B               ;
48EC C9                 RET                     ;
48ED C1         GHWEND: POP     B               ;
48EE C1                 POP     B               ; DO NOT RESTORE A
48EF C9                 RET                     ;
                ;       END     GHW             ;
                ;
                ; GHB - GET HEX BYTE
                ;
48F0 C5         GHB:    PUSH    B               ; SAVE B&C
48F1 CD0549             CALL    GHD             ; GET FIRST HEX DIGIT IN A-REG
```

```
48F4 DA0349             JC      GHBEND            ; IF BAD CHAR QUIT AND PASS BACK
48F7 07                 RLC                       ; SHIFT TO UPPER HALF OF BYTE
48F8 07                 RLC                       ;   .
48F9 07                 RLC                       ;   .
48FA 07                 RLC                       ;   .
48FB 47                 MOV     B,A               ; SAVE FIRST DIGIT
48FC CD0549             CALL    GHD               ; GET SECOND DIGIT
48FF DA0349             JC      GHBEND            ; BAD CHAR READ, RET IT TO CALLER
4902 B0                 ORA     B                 ; COMBINE FIRST AND SECOND DIGITS
4903 C1         GHBEND: POP     B                 ; RESTORE ORIGINAL B&C
4904 C9                 RET                       ;
                ;       END     GHB               ;
                ;
                ; GHD - GET HEX DIGIT
                ;
4905 CDD247     GHD:    CALL    CI                ; GET CHARACTER & ECHO
                ;       ANI     07FH              ; PUT IN IF UCASE TAKEN OUT
4908 CD024A     ATH:    CALL    UCASE             ; MAP LOWER TO UPPER CASE AND
                ;                                 ;   STRIP PARITY.
490B FE30               CPI     '0'
490D D8                 RC                        ;       NON-HEX CHARACTER
490E FE3A               CPI     ':'               ; IF  (A) =< '9'+1
4910 DA1C49             JC      GHD2              ;       '0'-'9' TYPED - CONVERT
4913 FE41               CPI     'A'               ; IF  (A) < 'A'
4915 D8                 RC                        ;       NON-HEX CHARACTER
4916 FE47               CPI     'G'               ; IF  (A) >= 'G'
4918 3F                 CMC                       ;       .
4919 D8                 RC                        ;       NON-HEX CHARACTER
491A D607               SUI     07H               ; SHIFT 'A'-'F' DOWN
491C D630       GHD2:   SUI     '0'               ; CONVERT
491E C9                 RET                       ;
                ;       END     GHD               ;
                ;
                ; M50128 - MULTIPLY BY 50/128
                ;
491F 0601       M50128: MVI     B,1     ;DIVIDE BY TWO SO * 12.5
4921 CDCA49             CALL    SHRHL   ;  WILL FIT IN 16 BITS.
4924 CDBF49             CALL    RNDHL   ;  AND ROUND
4927 54                 MOV     D,H     ;SAVE *1
4928 5D                 MOV     E,L     ; .
4929 29                 DAD     H       ;*2
492A 29                 DAD     H       ;*4
492B 44                 MOV     B,H     ;SAVE *4 IN D&E
492C 4D                 MOV     C,L     ;
492D 29                 DAD     H       ;*8
492E 09                 DAD     B       ;*12
492F EB                 XCHG            ;GENERATE * 0.5
4930 0601               MVI     B,1     ;  .
4932 CDCA49             CALL    SHRHL   ;  .
4935 19                 DAD     D       ;*12 + *0.5
4936 0604               MVI     B,4     ;DIVIDE H&L BY 16
4938 CDCA49             CALL    SHRHL   ;
493B CDBF49             CALL    RNDHL   ;ROUND
493E C9                 RET
                ;       END     M50128
                ; MSG -
493F F5         MSG:    PUSH    PSW
4940 1A         LOUPE:  LDAX    D       ;GET CHAR
4941 FEFF               CPI     EOL     ;END OF STRING?
4943 13                 INX     D       ;BUMP POINTER
4944 CA4D49             JZ      MDN     ;JUMP IF SO
4947 CDF247             CALL    CO      ;ELSE PRINT IT
494A C34049             JMP     LOUPE   ;DO IT AGAIN
494D F1         MDN:    POP     PSW
494E C9                 RET
                ;
                ; MULT10 - MULTIPLY H&L BY 10
494F D5         MULT10: PUSH    D       ;
4950 29                 DAD     H       ;*2
4951 54                 MOV     D,H     ;SAVE *2
4952 5D                 MOV     E,L     ;
4953 29                 DAD     H       ;*4
4954 29                 DAD     H       ;*8
4955 19                 DAD     D       ;*10
4956 D1                 POP     D       ;
4957 C9                 RET             ;
                ;
4958 D5         OKCK:   PUSH    D
4959 F5                 PUSH    PSW
495A 111D51             LXI     D,MOK
495D CD3F49             CALL    MSG
4960 CDD247             CALL    CI
4963 E67F               ANI     07FH
4965 FE0D               CPI     CR
4967 CA7149             JZ      OKCKEND
496A 113B50             LXI     D,ABORT
496D CD3F49             CALL    MSG
4970 37                 STC
4971 CD0C48     OKCKEND:CALL    CRLF
4974 D1                 POP     D
4975 7A                 MOV     A,D
4976 D1                 POP     D
4977 C9                 RET
                ;       END     OKCK
                ;
                ; PHW - PRINT HEX WORD
4978 F5         PHW:    PUSH    PSW             ; SAVE A-REGISTER AND FLAGS
4979 7C                 MOV     A,H             ;
497A CD8349             CALL    PHB             ; PRINT HIGH-ORDER BYTE
497D 7D                 MOV     A,L             ;
497E CD8349             CALL    PHB             ; PRINT LOW-ORDER BYTE
4981 F1                 POP     PSW             ; RESTORE A-REGISTER AND FLAGS
4982 C9                 RET                     ;
                ;       END     PHW             ;
                ;
                ; PHB - PRINT HEX BYTE
4983 F5         PHB:    PUSH    PSW             ; SAVE PSW
4984 C5                 PUSH    B               ; SAVE B&C
4985 47                 MOV     B,A             ; SAVE LOWER NIBBLE
4986 0F                 RRC                     ; SHIFT TO LOWER HALF OF BYTE
4987 0F                 RRC                     ;
```

```
4988 0F                 RRC                           ;   .
4989 0F                 RRC                           ;   .
498A CD9549             CALL    PHD                   ; PRINT UPPER HEX DIGIT
498D 78                 MOV     A,B                   ; GET LOWER NIBBLE
498E CD9549             CALL    PHD                   ; ...AND PRINT
4991 78                 MOV     A,B                   ; RESTORE ORIGINAL BYTE TO A
4992 C1                 POP     B                     ; RESTORE B&C
4993 F1                 POP     PSW                   ; RESTORE PSW
4994 C9                 RET                           ;
               ;        END     PHB                   ;
               ;
               ; PHD - PRINT HEX DIGIT
4995 F5        PHD:     PUSH    PSW                   ;SAVE PSW
4996 E60F               ANI     0FH                   ; MASK OFF LOWER NIBBLE
4998 C630               ADI     '0'                   ; CONVERT '0'-'9' TO ASCII
499A FE3A               CPI     '9'+1                 ; IF '0'-'9'
499C DAA149             JC      PHD1                  ;       THEN DONE
499F C607               ADI     'A'-':'               ; CONVERT 'A'-'F'
49A1 CDF247    PHD1:    CALL    CO                    ; PRINT DIGIT
49A4 F1                 POP     PSW                   ;
49A5 C9                 RET                           ;
               ;        END     PHD                   ;
               ;
               ; POPPC - POP THE PC INTO H&L
               ;        - ON RETURN (H&L) = ADDRESS RETURNED TO
49A6 E1        POPPC:   POP     H                     ;
49A7 E9                 PCHL                          ;

               ; ***** PRBAD - PRINT ' WHAT ?' **** DESTROYS D&E ****
49A8 114650    PRBAD:   LXI     D,BAD    ;
49AB CD3F49             CALL    MSG      ;
49AE C9                 RET              ;
               ;        END     PRBAD
               ;
               ; RETJMP - RETURN JUMP
               ;        SETS STACK POINTER TO (RJSP) AND PC TO (RJVECT)
               ;        DOES NOT DESTROY ANY REGISTERS
49AF 22045A    RETJMP:  SHLD    RJSAV    ;
49B2 2A065A             LHLD    RJSP     ;
49B5 F9                 SPHL             ;
49B6 2A045A             LHLD    RJSAV    ;
49B9 E5                 PUSH    H        ;
49BA 2A085A             LHLD    RJVECT   ;
49BD E3                 XTHL             ;
49BE C9                 RET
               ;
               ; RNDHL - ADD CARRY FLAG TO H&L TO ROUND AFTER USING
               ;          SHRHL TO DIVIDE BY A POWER OF 2
49BF F5        RNDHL:   PUSH    PSW                   ;
49C0 7D                 MOV     A,L                   ;
49C1 CE00               ACI     0                     ;ROUND
49C3 6F                 MOV     L,A                   ;
49C4 7C                 MOV     A,H                   ;PROPAGATE POSSIBLE ROUND-UP
49C5 CE00               ACI     0                     ;  CARRY INTO H.
49C7 67                 MOV     H,A                   ;
49C8 F1                 POP     PSW                   ;
```

```
49C9 C9                 RET                            ;
                ;
                ; SHRHL - SHIFT RIGHT H&L - ZERO FILL ON LEFT
                ;         SHIFTS (B) BITS
49CA C5         SHRHL:  PUSH    B        ;SAVE B
49CB F5                 PUSH    PSW      ;SAVE A
49CC 04                 INR     B        ;CHECK FOR NO MORE BITS TO SHIFT
49CD 05         SHRHLL: DCR     B        ;
49CE CADB49             JZ      SHRHLE   ;
49D1 B7                 ORA     A        ;CLEAR CARRY FLAG
49D2 7C                 MOV     A,H      ;GET H
49D3 1F                 RAR              ;SHIFT RIGHT
49D4 67                 MOV     H,A      ;PUT H BACK
49D5 7D                 MOV     A,L      ;GET L
49D6 1F                 RAR              ;SHIFT RIGHT
49D7 6F                 MOV     L,A      ;PUT L BACK
49D8 C3CD49             JMP     SHRHLL   ;BACK...
49DB C1         SHRHLE: POP     B        ;RESTORE A
49DC 78                 MOV     A,B      ;  .
49DD C1                 POP     B        ;RESTORE B
49DE C9                 RET              ;BYE...
                ;       END     SHRHL    ;
                ;
                ; SETJMP - SET SP AND PC FOR RETJMP
                ;           DOES NOT DESTROY ANY REGISTERS
49DF E5         SETJMP: PUSH    H        ;
49E0 210400             LXI     H,04     ;GET SP BEFORE PUSH H AND RET ADDR
49E3 39                 DAD     SP       ;
49E4 22065A             SHLD    RJSP     ;
49E7 E1                 POP     H        ;GET H&L BACK
49E8 E3                 XTHL             ;GET RET ADDR
49E9 22085A             SHLD    RJVECT   ;SQUIREL AWAY
49EC E3                 XTHL             ;PUT RET ADDR BACK
49ED C9                 RET              ;

                ; ***** SPACE ***** PRINT SPACE
49EE F5         SPACE:  PUSH    PSW
49EF 3E20               MVI     A,' '
49F1 CDF247             CALL    CO
49F4 F1                 POP     PSW
49F5 C9                 RET

                ; ***** SUB16 ***** 16 BIT SUBTRACT (H&L) <- (H&L) - (D&E)
                ;       IF     (D&E)  <  (H&L)     CY = 1
                ;       IF     (D&E)  >= (H&L)     CY = 0
49F6 D5         SUB16:  PUSH    D        ;
49F7 F5                 PUSH    PSW      ;
49F8 7D                 MOV     A,L      ;
49F9 93                 SUB     E        ;
49FA 6F                 MOV     L,A      ;
49FB 7C                 MOV     A,H      ;
49FC 9A                 SBB     D        ;
49FD 67                 MOV     H,A      ;
49FE D1                 POP     D        ;
49FF 7A                 MOV     A,D      ;
4A00 D1                 POP     D        ;
```

```
4A01 C9                RET              ;
               ;
               ; UCASE - SUBROUTINE WHICH CHECKS THE A REG FOR A LOWER CASE
               ; ASCII LETTER. IF ONE PRESENT, IT IS CONVERTED TO UPPER CASE.
               ; IF NOT PRESENT, NOTHING DONE.  STRIPS PARITY FIRST.
4A02 E67F      UCASE:   ANI     07FH    ;STRIP PARITY
4A04 FE61               CPI     61H
4A06 3F                 CMC
4A07 D0                 RNC             ;DON'T CONVERT IF BEFORE 'A'
4A08 FE7B               CPI     7BH
4A0A D0                 RNC             ;DON'T CONVERT IF AFTER 'Z'
4A0B D620               SUI     20H     ;CONVERT LOWER TO UPPER
4A0D C9                 RET
               ;
               ; HRTBEAT - SUBROUTINE WHICH REFRESHES THE HEARTBEAT COUNTER (TIME0).
               ;
4A0E 3E00      HRTBEAT: MVI     A,00H   ;LONGEST AVAILABLE COUNTER VALUE
4A10 D320               OUT     TIME0   ;LEAST SIG BYTE OF TIMER
4A12 D320               OUT     TIME0   ;MOST SIG BYTE OF TIMER
4A14 C9                 RET
               ;
               ; MENCHK - SUBROUTINE TO CHECK THE MENU NUMBER, AND DO ONE OF THE
               ;          FOLLOWING: SIGNAL AN ERROR AND STOP THE CHAIR IF IT IS
               ;          AN INCORRECT MENU (0 OR 32), CALL THE PROGRAM MENU IF
               ;          APPLICABLE, OR READ THE GLOBAL MENU VARIABLES FOR THE
               ;          SELECTED MENU, AND RETURN THE MENU NUMBER.
               ;
4A15 DB11      MENCHK:  IN      PIAB    ;READ THE +5 LOOP FROM THE PAD CONNECTOR
4A17 E680               ANI     PADLOOP ;MASK TO DETERMINE THE CONNECTOR STATUS
4A19 FE80               CPI     PADLOOP ;VALUE READ, 1=CONNECTED, 0=DISCONNECTED
4A1B CA2C4A             JZ      PADOK1  ;CONTINUE IF PAD CONNECTED
4A1E 3E01               MVI     A,PADLED ;GET DATA TO LIGHT PAD ERROR LED
4A20 CDF04A             CALL    SETERR  ;LIGHT THE PAD ERROR LED
4A23 3E40               MVI     A,MENERR; PAD ERROR WILL GIVE MENU ERROR
4A25 CDFC4A             CALL    CLRERR  ; SO CLEAR MENU LED
4A28 CDEB4B             CALL    STOP    ;STOP THE CHAIR (RAMP DOWN) IF DISCONN.
4A2B C9                 RET
4A2C 3E01      PADOK1:  MVI     A,PADLED ;GET DATA TO CLEAR PAD LED
4A2E CDFC4A             CALL    CLRERR  ;CLEAR THE PAD LED (ALL IS OK)
4A31 CDFD46             CALL    PADRD   ;DETERMINE MENU NUMBER OR STATUS (IF ERROR)
4A34 7C                 MOV     A,H     ;PUT MENU NUMBER (STATUS) IN (A)
4A35 E640               ANI     MENERR  ;MASK FOR MENU ERROR
4A37 FE40               CPI     MENERR  ;MASK FOR MENU ERROR
4A39 C2454A             JNZ     PADOK2  ;IF VALID MENU, THEN PROCEED, OTHERWISE...
4A3C 3E02               MVI     A,MENLED ;GET DATA TO LIGHT THE MENU ERROR LED
4A3E CDF04A             CALL    SETERR  ;LIGHT THE MENU ERROR LED
4A41 CDEB4B             CALL    STOP    ;STOP THE CHAIR (RAMP DOWN) IF MENU ERROR
4A44 C9                 RET
4A45 3E02      PADOK2:  MVI     A,MENLED ;GET DATA TO CLEAR THE MENU LED
4A47 CDFC4A             CALL    CLRERR  ;CLEAR MENU ERROR LED
4A4A 7C                 MOV     A,H     ;PUT MENU NUMBER (STATUS) IN (A)
4A4B E601               ANI     PROMSK  ;MASK PROGRAM MENU NUMBER
4A4D FE01               CPI     PROMSK  ;MASK TO SEE IF PROGRAMMING MENU IN PAD
4A4F C2564A             JNZ     IFTBL1  ;SEE IF MENU 1 IF NOT PROGRAMMING MENU
4A52 CD504C             CALL    PROMEN  ;CALL ROUTINE TO ALLOW TABLE UPDATES
4A55 C9                 RET
```

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4A56 7C         IFTBL1: MOV     A,H      ;PUT MENU NUMBER IN (A)
4A57 E61E               ANI     VALMEN   ;MASK FOR VALID MENU NUMBERS (0-16)
4A59 1F                 RAR              ;ROTATE TO USE ONLY 4 OF THE 5 MENU BITS
4A5A FE01               CPI     01H      ;CHECK TO SEE IF MENU NUMBER 1 (SAMPLE MENU)
4A5C C2664A             JNZ     OTHERS   ;CHECK FOR NUMBER 3 (TABLE 2) IF NOT 2
4A5F 210956             LXI     H,SAMPLE ;PUT STARTING ADDRESS OF SAMPLE TBL IN (HL)
4A62 CD7F4A             CALL    GETVARS  ;GET GLOBAL VARIABLES FROM TABLE
4A65 C9                 RET
                OTHERS:         ;
                                ;BEGIN BY DETERMINING THE STARTING ADDRESS OF TABLE
                                ;FORMULA TO CALCULATE OFFSET IS AS FOLLOWS...
                                ;         (MENU NUMBER - 2)(50) = OFFSET
                                ;NOTE THAT THE MENU TABLES ARE 50 BYTES LONG,
                                ;MENU 0 IS INVALID, AND MENU NUMBER 1 IS THE
                                ;SAMPLE MENU (HARD CODED).
                                ;
4A66 D602               SUI     02H      ;SUBTRACT 2 FROM MENU NUMBER (SEE ABOVE)
4A68 CD754A             CALL    MULT50   ;MULTIPLY A BY 50 (SEE ABOVE)
4A6B 54                 MOV     D,H      ;TEMPORARY STORE OF HL IN DE
4A6C 5D                 MOV     E,L      ;(SAME)
4A6D 21005B             LXI     H,USRRAM ;GET STARTING ADDRESS OF FIRST TABLE
4A70 19                 DAD     D        ;ADD OFFSET TO TABLE START ADDRESS
4A71 CD7F4A             CALL    GETVARS  ;GET GLOBAL VARIABLES FROM TABLE
4A74 C9                 RET

                ;
                ; MULT50 - ROUTINE TO MULTIPLY A BY 50D (32H).  RESULT WILL
                ;         BE PLACED IN HL, AND HL ARE THE ONLY REGISTERS DESTROYED.
                ;
4A75 210000     MULT50: LXI     H,0000H ;CLEAR HL FOR THE RESULT
4A78 6F                 MOV     L,A      ;PUT NUMBER IN L FOR INITIAL ADD
4A79 29                 DAD     H        ;DAD 5 TIMES TO MULTIPLY BY 32H (50D)
4A7A 29                 DAD     H        ;
4A7B 29                 DAD     H        ;
4A7C 29                 DAD     H        ;
4A7D 29                 DAD     H        ;
4A7E C9                 RET
                ;
4A7F 22225A     GETVARS: SHLD   GBLTBL   ;PUT STARTING ADDRESS IN GLOBAL POINTER
4A82 7E                 MOV     A,M      ;PUT MENU CONTROL WORD IN A
4A83 32205A             STA     MENCTRL  ;STORE CONTROL WORD IN VARIABLE
4A86 23                 INX     H        ;STEP POINTER UP ONE
4A87 7E                 MOV     A,M      ;PUT RAMP RATE IN A
4A88 321F5A             STA     RAMPCNT  ;STORE RAMP RATE IN VARIABLE
4A8B 23                 INX     H        ;(CONTINUE W/SAME.....)
4A8C 7E                 MOV     A,M      ;
4A8D 32155A             STA     MAXBAK   ;BACK U.S. DISTANCE
4A90 23                 INX     H        ;
4A91 7E                 MOV     A,M      ;
4A92 32125A             STA     MAXFNT   ;FRONT U.S. DISTANCE
4A95 23                 INX     H        ;
4A96 7E                 MOV     A,M      ;
4A97 321B5A             STA     MAXLFT   ;LEFT U.S. DISTANCE
4A9A 23                 INX     H        ;
4A9B 7E                 MOV     A,M      ;
4A9C 32185A             STA     MAXRT    ;RIGHT U.S. DISTANCE
4A9F 23                 INX     H        ;
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4AA0 22245A              SHLD    BEGTBL  ;STORE ADDRESS OF ENTRY IN BEGIN POINTER
4AA3 C9                  RET
                ;
                ; PADCHK - SUBROUTINE TO DETERMINE THE STATUS OF THE PAD.  IF THE
                ;        PAD IS NOT BEING TOUCHED, THEN IT WILL SIMPLY RETURN WITH
                ;        NO ACTION.  IF THE PAD WAS TOUCHED, IT WILL CALL A ROUTINE
                ;        TO DETERMINE IF THE LOCATION WAS AMONG VALID LOCATIONS FOR
                ;        THE CURRENT MENU.  IF SO, IT WILL CALL ANOTHER ROUTINE TO
                ;        INITIALIZE THE MOTOR PARAMETERS.
                ;
4AA4 DB11       PADCHK:  IN      PIAB    ;READ THE +5 LOOP FROM THE PAD CONNECTOR
4AA6 E680                ANI     PADLOOP ;MASK TO DETERMINE THE CONNECTOR STATUS
4AA8 FE80                CPI     PADLOOP ;VALUE READ, 1=CONNECTED, 0=DISCONNECTED
4AAA CABB4A              JZ      PADOK3  ;CONTINUE IF PAD CONNECTED
4AAD 3E01                MVI     A,PADLED ;GET DATA TO LIGHT PAD ERROR LED
4AAF CDF04A              CALL    SETERR  ;LIGHT THE PAD ERROR LED
4AB2 3E40                MVI     A,MENERR; PAD ERROR WILL GIVE MENU ERROR
4AB4 CDFC4A              CALL    CLRERR  ; SO CLEAR MENU LED
4AB7 CDEB4B              CALL    STOP    ;STOP THE CHAIR (RAMP DOWN) IF DISCONN.
4ABA C9                  RET
4ABB 3E01       PADOK3:  MVI     A,PADLED ;GET DATA TO CLEAR PAD ERROR LED
4ABD CDFC4A              CALL    CLRERR
4AC0 CDFD46              CALL    PADRD   ;SCAN THE PAD FOR A TOUCH
4AC3 7C                  MOV     A,H     ;PUT PAD STATUS WORD IN A
4AC4 E680                ANI     TOUCH   ;
4AC6 FE80                CPI     TOUCH   ;
4AC8 C0                  RNZ             ;RETURN IF NO TOUCH
4AC9 CD094B              CALL    CHKTBL  ;DETERMINE IF TOUCH WAS A VALID LOCATION
                                         ;FOR THIS CURRENT MENU (CHECK TABLE)
4ACC 3A265A              LDA     ENTRY   ;GET THE TABLE ENTRY NUMBER
                                         ;0 SIGNALS NO TABLE ENTRY VALID W/TOUCH
                                         ;ENTRY OF 1-10 MEANS A MATCH FOUND
4ACF FE00                CPI     00H     ;SEE IF THE ENTRY IS 0
4AD1 C8                  RZ              ;RETURN IF NO TABLE ENTRY MATCH FOUND
4AD2 3A325A              LDA     LAST1   ;SEE IF SAME AS LAST ENTRY
4AD5 47                  MOV     B,A
4AD6 3A265A              LDA     ENTRY
4AD9 B8                  CMP     B
4ADA C2E64A              JNZ     PADOK4  ;IF NOT SAME AS LAST, GET NEW VARS
4ADD 2A275A              LHLD    MTRADDR ;IF SAME AS LAST, REINIT DURATION
4AE0 23                  INX     H
4AE1 7E                  MOV     A,M
4AE2 32315A              STA     DURATION
4AE5 C9                  RET
4AE6 3A265A     PADOK4:  LDA     ENTRY
4AE9 32325A              STA     LAST1
4AEC CD664B              CALL    INITMTR ;IF VALID ENTRY MATCH, INIT. MOTOR VARS.
4AEF C9                  RET

                ;
                ; SETERR - ROUTINE TO TAKE THE ERROR BIT PASSED IN THE ACC. AND
                ;        UPDATE THE ERROR LEDS TO REFLECT THE NEW ERROR.  THIS WILL
                ;        USE THE VARIABLE ERRWRD (ERROR WORD) TO STORE THE CURRENT
                ;        SYSTEM ERRORS.  WITH THIS, SEVERAL ERRORS CAN BE DISPLAYED
                ;        DISPLAYED AT THE SAME TIME.
                ;
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```
4AF0 47         SETERR: MOV     B,A      ;PUT THE NEW ERROR WORD IN B
4AF1 3A215A             LDA     ERRWRD   ;GET THE CURRENT ERROR WORD
4AF4 B0                 ORA     B        ;COMBINE THE CURRENT ERRORS WITH THE NEW
4AF5 32215A             STA     ERRWRD   ;UPDATE ERROR WORD
4AF8 2F                 CMA              ;COMPLEMENT FOR NEGATIVE LOGIC
4AF9 D312               OUT     PIAC     ;LIGHT THE CORRECT ERROR LEDS
4AFB C9                 RET
                ;
                ; CLRERR - ROUTINE TO COMPLEMENT SETERR.  THIS ROUTINE WILL TAKE
                ;         THE ERROR BIT (LED) TO BE CLEARED (PASSED IN A) AND CLEAR
                ;         THAT LED WHILE LEAVING THE REST ON (SET).
                ;
4AFC 2F         CLRERR: CMA              ;COMPLEMENT THE BIT TO BE CLEARED
4AFD 47                 MOV     B,A      ;PUT THE ERROR CLEAR WORD IN B
4AFE 3A215A             LDA     ERRWRD   ;GET THE CURRENT ERROR WORD
4B01 A0                 ANA     B        ;COMBINE THE CLEAR WORD WITH THE CURRENT
4B02 32215A             STA     ERRWRD   ;UPDATE ERROR WORD
4B05 2F                 CMA              ;COMPLEMTN FOR NEGATIVE LOGIC
4B06 D312               OUT     PIAC     ;LIGHT (OR TURN OFF) THE CORRECT LEDS
4B08 C9                 RET
                ;
                ; CHKTBL - ROUTINE TO DETERMINE WHETHER OR NOT THE LOCATION
                ;         TOUCHED IS AMONG THE VALID LOCATIONS FOR THE CURRENT MENU.
                ;         THE TABLE ENTRY NUMBER (OUT OF 10) WILL BE RETURNED IN
                ;         THE VARIABLE ENTRY.  IF NOT VALID, ENTRY WILL BE 0, ELSE
                ;         ENTRY WILL BE 1-10.
                ;
4B09 0600       CHKTBL: MVI     B,00H    ;CLEAR B TO STORE ENTRY NUMBER
4B0B 3E00               MVI     A,00H    ;CLEAR A
4B0D 32265A             STA     ENTRY    ;CLEAR ENTRY TO BEGIN
4B10 54                 MOV     D,H      ;MOVE HL TO DE SO HL CAN BE USED TO POINT
4B11 5D                 MOV     E,L      ;
4B12 2A245A             LHLD    BEGTBL   ;GET STARTING ADDRESS OF MENU DATA TABLE

4B15 7E         ROWMIN: MOV     A,M      ;GET ROW/COL FROM TABLE
4B16 E6F0               ANI     0F0H     ;MASK OFF ROW
4B18 4F                 MOV     C,A      ;SAVE THIS IN C
4B19 7B                 MOV     A,E      ;GET ROW/COL FROM PAD
4B1A E6F0               ANI     0F0H     ;MASK OFF ROW
4B1C B9                 CMP     C        ;IS PAD ROW < TABLE ROW ?
4B1D DA5A4B             JC      NXTENT1  ;IF SO FORGET IT

4B20 7E         COLMIN: MOV     A,M      ;GET ROW/COL FROM TABLE
4B21 E60F               ANI     0FH      ;MASK OFF COL
4B23 4F                 MOV     C,A      ;SAVE THIS IN C
4B24 7B                 MOV     A,E      ;GET ROW/COL FROM PAD
4B25 E60F               ANI     0FH      ;MASK OFF COL
4B27 B9                 CMP     C        ;IS PAD COL < TABLE COL ?
4B28 DA5A4B             JC      NXTENT1  ;IF SO FORGET IT

4B2B 23         ROWMAX: INX     H        ;NEXT TABLE LOCATION
4B2C 7E                 MOV     A,M      ;GET ROW/COL FROM TABLE
4B2D E6F0               ANI     0F0H     ;MASK OFF ROW
4B2F 4F                 MOV     C,A      ;SAVE THIS IN C
4B30 7B                 MOV     A,E      ;GET ROW/COL FROM PAD
4B31 E6F0               ANI     0F0H     ;MASK OFF ROW
```

```
4B33 B9                 CMP     C        ;IS PAD ROW > TABLE ROW ?
4B34 DA3D4B             JC      COLMAX   ;IF SO ONWARD
4B37 CA3D4B             JZ      COLMAX   ;IF EQUAL ONWARD
4B3A C35B4B             JMP     NXTENT2  ;IF NEITHER THEN FORGET IT

4B3D 7E        COLMAX:  MOV     A,M      ;GET ROW/COL FROM TABLE
4B3E E60F               ANI     0FH      ;MASK OFF COL
4B40 4F                 MOV     C,A      ;SAVE THIS IN C
4B41 7B                 MOV     A,E      ;GET ROW/COL FROM PAD
4B42 E60F               ANI     0FH      ;MASK OFF COL
4B44 B9                 CMP     C        ;IS PAD COL > TABLE COL ?
4B45 DA4E4B             JC      VALID    ;IF SO ONWARD
4B48 CA4E4B             JZ      VALID    ;IF EQUAL ONWARD
4B4B C35B4B             JMP     NXTENT2  ;IF NEITHER THEN FORGET IT

4B4E 23        VALID:   INX     H
4B4F 22275A             SHLD    MTRADDR
4B52 04                 INR     B
4B53 78                 MOV     A,B
4B54 32265A             STA     ENTRY    ;STORE ENTRY NUMBER
4B57 62                 MOV     H,D      ;RESTORE HL FROM DE
4B58 6B                 MOV     L,E      ;
4B59 C9                 RET

4B5A 23        NXTENT1: INX     H        ;INCREMENT POINTER TO TABLE DATA FOR NEXT
4B5B 23        NXTENT2: INX     H        ;ENTRY ROW/COL MINIMUM.
4B5C 23                 INX     H        ;
4B5D 23                 INX     H        ;
4B5E 04                 INR     B        ;INCREMENT ENTRY COUNTER
4B5F 78                 MOV     A,B      ;CHECK TO SEE IF COMPLETELY THROUGH 10 ENTRIES
4B60 FE0A               CPI     0AH      ;
4B62 C2154B             JNZ     ROWMIN   ;TRY NEXT ENTRY
4B65 C9                 RET              ;NO VALID TOUCH, RETURN
               ;
               ; INITMTR - ROUTINE TO INITIALIZE THE MOTOR VARIABLES (GET THE DATA
               ;         FROM MEMORY).
               ;
4B66 2A275A    INITMTR: LHLD    MTRADDR  ;GET STARTING ADDRESS OF MOTOR DATA
4B69 7E                 MOV     A,M      ;PUT LEFT/RIGHT MOTOR DATA IN A
4B6A E60F               ANI     0FH      ;MASK FOR RIGHT MOTOR DATA ONLY
4B6C 322C5A             STA     RMTS     ;STORE SPEED IN RIGHT MOTOR TARGET SPEED
4B6F 7E                 MOV     A,M      ;GET LEFT/RIGHT MOTOR DATA AGAIN
4B70 E6F0               ANI     0F0H     ;MASK FOR LEFT MOTOR DATA ONLY
4B72 0F                 RRC              ;ROTATE LEFT MOTOR DATA TO LS NIBBLE
4B73 0F                 RRC              ;
4B74 0F                 RRC              ;
4B75 0F                 RRC              ;
4B76 322B5A             STA     LMTS     ;STORE SPEED IN LEFT MOTOR TARGET SPEED
4B79 23                 INX     H        ;MOVE POINTER TO DURATION DATA
4B7A 7E                 MOV     A,M      ;PUT DURATION IN A
4B7B 32315A             STA     DURATION ;STORE MOTION DURATION
4B7E 3A1F5A             LDA     RAMPCNT
4B81 32335A             STA     CNTRAMP
4B84 C9                 RET
               ;
               ; UPDATMTR - ROUTINE TO DETERMINE THE NEXT VALUE TO BE SENT TO THE
               ;       MOTOR SO THAT IT CAN EFFECTIVELY RAMP UP TO THE TARGET SPEED.
               ;       THIS WILL THEN SEND THE PROPER CODE TO THE MOTOR D/A CIRCUIT,
               ;       OR STOP THE MOTORS IF THE DURATION HAS BEN FULFILLED.
               ;
               UPDATMTR:
4B85 3A335A    RAMP1:  LDA     CNTRAMP ;GET THE CURRENT RAMP COUNTER (FOR RATE)
4B88 FE00              CPI     00H     ;CHECK TO SEE IF IT IS COUNTED OUT
4B8A C2E64B            JNZ     LBL4    ;IF NOT, THEN CONTINUE (DCR RAMP COUNT)

4B8D 3A2C5A    RS1CHK: LDA     RMTS    ;GET THE RIGHT MOTOR TARGET SPEED
4B90 32305A            STA     RMOTOR  ;SET DEFAULT RIGHT MOTOR VALUE
4B93 47                MOV     B,A     ;TRANSFER TO B
4B94 3A2E5A            LDA     RMCS    ;GET RIGHT MOTOR CURRENT SPEED
4B97 B8                CMP     B       ;COMPARE RMTS TO RMCS
4B98 CAA74B            JZ      LS1CHK  ;IF RMTS = RMCS THEN CHECK LEFT DATA
4B9B D2A44B            JNC     LBL1    ;IF RMCS > RMTS THEN TO LBL1
4B9E CD2D4C            CALL    RGTFWD  ;RMCS < RMTS SO INCREMENT FWD
4BA1 C3A74B            JMP     LS1CHK  ;
4BA4 CD354C    LBL1:   CALL    RGTREV  ;RMCS > RMTS SO INCREMENT REV
4BA7 3A2B5A    LS1CHK: LDA     LMTS    ;GET THE LEFT MOTOR TARGET SPEED
4BAA 322F5A            STA     LMOTOR  ;SET DEFAULT LEFT MOTOR VALUE
4BAD 47                MOV     B,A     ;TRANSFER TO B
4BAE 3A2D5A            LDA     LMCS    ;GET LEFT MOTOR CURRENT SPEED
4BB1 B8                CMP     B       ;COMPARE LMTS TO LMCS
4BB2 CAC14B            JZ      LBL3    ;IF LMTS = LMCS THEN CHECK DURATION
4BB5 D2BE4B            JNC     LBL2    ;IF LMCS > LMTS THEN TO LBL2
4BB8 CD3D4C            CALL    LFTFWD  ;LMCS < LMTS SO INCREMENT FWD
4BBB C3C14B            JMP     LBL3    ;
4BBE CD454C    LBL2:   CALL    LFTREV  ;LMCS > LMTS SO INCREMENT REV
4BC1 3A315A    LBL3:   LDA     DURATION ;GET THE CURRENT DURATION COUNTER
4BC4 3D                DCR     A       ;DECREMENT THE DURATION COUNTER
4BC5 32315A            STA     DURATION ;STORE THE CHANGE IN VARIABLE
4BC8 3A305A            LDA     RMOTOR  ;GET NEW MOTOR VALUE
4BCB 322E5A            STA     RMCS    ;UPDATE THE CURRENT SPEED
4BCE 3A2F5A            LDA     LMOTOR  ;
4BD1 322D5A            STA     LMCS    ;
4BD4 07                RLC             ;ROTATE LEFT MOTOR DATA TO MS NIBBLE
4BD5 07                RLC
4BD6 07                RLC
4BD7 07                RLC
4BD8 47                MOV     B,A     ;TEMPORARY TRANSFER TO B
4BD9 3A2E5A            LDA     RMCS    ;GET NEW RIGHT MOTOR DATA
4BDC B0                ORA     B       ;COMBINE LEFT AND RIGHT MOTOR DATA
4BDD D341              OUT     PIAE    ;OUTPUT NEW MOTOR DATA TO D/A CKT
4BDF 3A1F5A            LDA     RAMPCNT
4BE2 32335A            STA     CNTRAMP
4BE5 C9                RET
4BE6 3D        LBL4:   DCR     A       ;DECREMENT THE RAMP COUNT
4BE7 32335A            STA     CNTRAMP ;UPDATE THE RAMP COUNTER
4BEA C9                RET
               ;
               ; STOP - ROUTINE TO STOP THE MOTORS, USING A RAMP TO THE STOP.
               ;
4BEB 3E08      STOP:   MVI     A,MTRSTOP
4BED 322C5A            STA     RMTS
4BF0 322B5A            STA     LMTS
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4BF3 3A2E5A              LDA     RMCS
4BF6 47                  MOV     B,A
4BF7 3A2D5A              LDA     LMCS
4BFA B8                  CMP     B
4BFB C2024C              JNZ     STOP2
4BFE 3E08                MVI     A,MTRSTOP
4C00 B8                  CMP     B
4C01 C8                  RZ
4C02 3E04       STOP2:   MVI     A,STOPRMP
4C04 32335A              STA     CNTRAMP
4C07 321F5A              STA     RAMPCNT
4C0A 11000A     STOP1:   LXI     D,0A00H
4C0D CD8747              CALL    DELAYD
4C10 CD854B              CALL    UPDATMTR
4C13 3A2E5A              LDA     RMCS
4C16 47                  MOV     B,A
4C17 3A2D5A              LDA     LMCS
4C1A B8                  CMP     B
4C1B C20A4C              JNZ     STOP1
4C1E 3E08                MVI     A,MTRSTOP
4C20 B8                  CMP     B
4C21 C20A4C              JNZ     STOP1
4C24 3E00                MVI     A,00H    ;ALLOW THE NEXT PAD INPUT TO BE USED
4C26 32315A              STA     DURATION
4C29 32325A              STA     LAST1
4C2C C9                  RET

                ;
                ; RGTFWD - ROUTINE TO DETERMINE RMOTOR WHICH WILL ALTER RMCS
                ;          TO MOVE FORWARD.
                ;
4C2D 3A2E5A     RGTFWD: LDA     RMCS     ;OTHERWISE IF 0, GET NEW SPEED
4C30 3C                  INR     A        ;STEP SPEED UP BY 1
4C31 32305A              STA     RMOTOR   ;STORE IN RMOTOR TO BE SENT TO MOTOR
4C34 C9                  RET
                ;
                ; RGTREV - SAME, BUT TO REVERSE.
                ;
4C35 3A2E5A     RGTREV: LDA     RMCS     ;OTHERWISE IF 0, GET NEW SPEED
4C38 3D                  DCR     A        ;STEP SPEED DOWN BY 1
4C39 32305A              STA     RMOTOR   ;STORE IN RMOTOR TO BE SENT TO MOTOR
4C3C C9                  RET
                ;
                ; LFTFWD - SAME, BUT FORWARD MOTION FOR LEFT MOTOR.
                ;
4C3D 3A2D5A     LFTFWD: LDA     LMCS     ;OTHERWISE IF 0, GET NEW SPEED
4C40 3C                  INR     A        ;STEP SPEED UP BY 1
4C41 322F5A              STA     LMOTOR   ;STORE IN LMOTOR TO BE SENT TO MOTOR
4C44 C9                  RET
                ;
                ; LFTREV - SAME, BUT FOR REVERSE.
                ;
4C45 3A2D5A     LFTREV: LDA     LMCS     ;OTHERWISE IF 0, GET NEW SPEED
4C48 3D                  DCR     A        ;STEP SPEED DOWN BY 1
4C49 322F5A              STA     LMOTOR   ;STORE IN LMOTOR TO BE SENT TO MOTOR
4C4C C9                  RET
```

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               ;
               ; PROMEN - ROUTINE TO ALLOW THE USER TO CREATE, RESET OR EDIT ANY
               ;       ONE OF THE 14 POSSIBLE MENUS.  IT WILL ALLOW THEM TO UPDATE
               ;       ANY OF THE GLOBAL PARAMETERS, OR THE INDIVIDUAL AREA DATA.
               ;
4C4D CDEB4F    PROERR: CALL    RASBER  ;SOUND ERROR TONE IF NEEDED
4C50 3E00      PROMEN: MVI     A,FALSE
4C52 32355A            STA     HEARTON
4C55 3E00              MVI     A,00H   ;0 OUT ENTRY VAR
4C57 32265A            STA     ENTRY
4C5A 3E00      PRO2MEN: MVI    A,00H
4C5C 322F5A            STA     LMOTOR
4C5F 32305A            STA     RMOTOR
4C62 CD734F            CALL    POLL    ;WAIT FOR PAD TOUCH
4C65 3A345A            LDA     PADFLG  ;GET PAD/MENU STATUS FLAG
4C68 FE00              CPI     FALSE   ;SEE IF PAD OK
4C6A C8                RZ
4C6B E5                PUSH    H       ;SAVE TOUCH LOCATION INFO FOR LATER
4C6C 7C                MOV     A,H     ;PUT VALID MENU NUMBER IN A
4C6D E61E              ANI     00011110B ;MASK TO GET THE MENU NUMBER
4C6F FE02              CPI     00000010B ;TRYING TO CHANGE THE SAMPLE MENU?
4C71 CA4D4C            JZ      PROERR  ;IF SO, SOUND ERROR AND RETURN, OTHERWISE...
4C74 1F                RAR             ;ROTATE TO GET MENU NUMBER
4C75 CD664A            CALL    OTHERS  ;GET LOCATIONS OF GLOBAL VARIABLES,
                                       ;    AND START OF MENU TABLE
4C78 E1                POP     H       ;RESTORE TOUCH LOCATION DATA
4C79 7D                MOV     A,L     ;PUT TOUCH LOC. IN A FOR COMPARISONS
4C7A FE21      SNDCHK: CPI     SOUND   ;SOUND ON/OFF SELECTED?
4C7C C2874C            JNZ     RANCHK  ;CHECK RANGING IF NOT
4C7F 3E02              MVI     A,SONOFF ;GET SOUND ON/OFF MASK
4C81 CD574F            CALL    ONOFF   ;TOGGLE FROM ON TO OFF, VISA VERSA
4C84 C35A4C            JMP     PRO2MEN
4C87 FE31      RANCHK: CPI     RANGE   ;RANGING ON/OFF SELECTED?
4C89 C2944C            JNZ     RRCHK   ;CHECK RAMP-RATE IF NOT
4C8C 3E04              MVI     A,RONOFF ;GET RANGING ON/OFF MASK
4C8E CD574F            CALL    ONOFF   ;TOGGLE FROM ON TO OFF, VISA VERSA
4C91 C35A4C            JMP     PRO2MEN
4C94 FE41      RRCHK:  CPI     RAMP    ;RAMP RATE SELECTED?
4C96 C2B54C            JNZ     LRD     ;CHECK LEFT RANGING DISTANCE IF NOT
4C99 CDFC4F            CALL    HORN1   ;HIGH BEEP
4C9C 3EEE              MVI     A,BAR2BEG ;GET BEGINNING ROW/COLUMN OF BAR 2
4C9E CDD04E            CALL    BARREAD ;WAIT FOR PAD TOUCH, RETURN VALUE OF 0-10 IN A
4CA1 47                MOV     B,A     ;TEMPORARY XFER TO B
4CA2 E6F0              ANI     0F0H    ;MASK TO SEE IF ANY VALUE IN MS NIBBLE
4CA4 FE00              CPI     00H     ;
4CA6 C24D4C            JNZ     PROERR  ;IF ANYTHING IN MS NIBBLE, THEN THERE WAS
                                       ;AN INVALID TOUCH, SO SOUND ERROR AND RETURN
4CA9 78                MOV     A,B     ;RESTORE A TO B
4CAA C601              ADI     01H     ;ADD ONE TO THE RATE, 'CAUSE 0 RATE NO GOOD
4CAC CD4E4F            CALL    RRATE   ;UPDATE TABLE VALUE OF RAMP RATE
4CAF CD0250            CALL    HORN2   ;LOW BEEP
4CB2 C35A4C            JMP     PRO2MEN
4CB5 FE71      LRD:    CPI     LEFTR   ;LEFT RANGING SELECTED
4CB7 C2DA4C            JNZ     RRD     ;CHECK MOTOR DURATION IF NOT
4CBA CDFC4F            CALL    HORN1   ;HIGH BEEP
4CBD 3EEE              MVI     A,BAR2BEG ;GET BEGINNING ROW/COLUMN OF BAR 2
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4CBF CDD04E            CALL   BARREAD ;WAIT FOR PAD TOUCH, RETURN VALUE OF 0-10 IN A
4CC2 47                MOV    B,A     ;TEMPORARY XFER TO B
4CC3 E6F0              ANI    0F0H    ;MASK TO SEE IF ANY VALUE IN MS NIBBLE
4CC5 FE00              CPI    00H     ;
4CC7 C24D4C            JNZ    PROERR  ;IF ANYTHING IN MS NIBBLE, THEN THERE WAS
                                      ;AN INVALID TOUCH, SO SOUND ERROR AND RETURN
4CCA 78                MOV    A,B     ;RESTORE A TO B
4CCB 87                ADD    A       ;DOUBLE VALUE FOR RANGING DISTANCE
4CCC C60C              ADI    USSTOP  ;ADD 0 'CAUSE 0 NO GOOD
4CCE 2A225A            LHLD   GBLTBL  ;PUT START OF TABLE ADDRESS IN POINTER
4CD1 CDCA4E            CALL   LRUDATE ;UPDATE LEFT RANGING VALUE IN TABLE
4CD4 CD0250            CALL   HORN2   ;LOW BEEP
4CD7 C35A4C            JMP    PRO2MEN
4CDA FE81       RRD:   CPI    RIGHTR  ;LEFT RANGING SELECTED
4CDC C2FF4C            JNZ    FRD     ;CHECK MOTOR DURATION IF NOT
4CDF CDFC4F            CALL   HORN1   ;HIGH BEEP
4CE2 3EEE              MVI    A,BAR2BEG ;GET BEGINNING ROW/COLUMN OF BAR 2
4CE4 CDD04E            CALL   BARREAD ;WAIT FOR PAD TOUCH, RETURN VALUE OF 0-10 IN A
4CE7 47                MOV    B,A     ;TEMPORARY XFER TO B
4CE8 E6F0              ANI    0F0H    ;MASK TO SEE IF ANY VALUE IN MS NIBBLE
4CEA FE00              CPI    00H     ;
4CEC C24D4C            JNZ    PROERR  ;IF ANYTHING IN MS NIBBLE, THEN THERE WAS
                                      ;AN INVALID TOUCH, SO SOUND ERROR AND RETURN
4CEF 78                MOV    A,B     ;RESTORE A TO B
4CF0 87                ADD    A       ;DOUBLE VALUE FOR RANGING DISTANCE
4CF1 C60C              ADI    USSTOP  ;ADD 0 'CAUSE 0 NO GOOD
4CF3 2A225A            LHLD   GBLTBL  ;PUT START OF TABLE ADDRESS IN POINTER
4CF6 CDC94E            CALL   RRUDATE ;UPDATE LEFT RANGING VALUE IN TABLE
4CF9 CD0250            CALL   HORN2   ;LOW BEEP
4CFC C35A4C            JMP    PRO2MEN
4CFF FE61       FRD:   CPI    FRONTR  ;LEFT RANGING SELECTED
4D01 C2244D            JNZ    BRD     ;CHECK MOTOR DURATION IF NOT
4D04 CDFC4F            CALL   HORN1   ;HIGH BEEP
4D07 3EEE              MVI    A,BAR2BEG ;GET BEGINNING ROW/COLUMN OF BAR 2
4D09 CDD04E            CALL   BARREAD ;WAIT FOR PAD TOUCH, RETURN VALUE OF 0-10 IN A
4D0C 47                MOV    B,A     ;TEMPORARY XFER TO B
4D0D E6F0              ANI    0F0H    ;MASK TO SEE IF ANY VALUE IN MS NIBBLE
4D0F FE00              CPI    00H     ;
4D11 C24D4C            JNZ    PROERR  ;IF ANYTHING IN MS NIBBLE, THEN THERE WAS
                                      ;AN INVALID TOUCH, SO SOUND ERROR AND RETURN
4D14 78                MOV    A,B     ;RESTORE A TO B
4D15 87                ADD    A       ;DOUBLE VALUE FOR RANGING DISTANCE
4D16 C60C              ADI    USSTOP  ;ADD 0 'CAUSE 0 NO GOOD
4D18 2A225A            LHLD   GBLTBL  ;PUT START OF TABLE ADDRESS IN POINTER
4D1B CDCB4E            CALL   FRUDATE ;UPDATE LEFT RANGING VALUE IN TABLE
4D1E CD0250            CALL   HORN2   ;LOW BEEP
4D21 C35A4C            JMP    PRO2MEN
4D24 FE51       BRD:   CPI    BACKR   ;LEFT RANGING SELECTED
4D26 C2494D            JNZ    DEFAREA ;CHECK MOTOR DURATION IF NOT
4D29 CDFC4F            CALL   HORN1   ;HIGH BEEP
4D2C 3EEE              MVI    A,BAR2BEG ;GET BEGINNING ROW/COLUMN OF BAR 2
4D2E CDD04E            CALL   BARREAD ;WAIT FOR PAD TOUCH, RETURN VALUE OF 0-10 IN A
4D31 47                MOV    B,A     ;TEMPORARY XFER TO B
4D32 E6F0              ANI    0F0H    ;MASK TO SEE IF ANY VALUE IN MS NIBBLE
4D34 FE00              CPI    00H     ;
4D36 C24D4C            JNZ    PROERR  ;IF ANYTHING IN MS NIBBLE, THEN THERE WAS
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                                          ;AN INVALID TOUCH, SO SOUND ERROR AND RETURN
4D39 78                  MOV     A,B      ;RESTORE A TO B
4D3A 87                  ADD     A        ;DOUBLE VALUE FOR RANGING DISTANCE
4D3B C60C                ADI     USSTOP   ;ADD 0 'CAUSE 0 NO GOOD
4D3D 2A225A              LHLD    GBLTBL   ;PUT START OF TABLE ADDRESS IN POINTER
4D40 CDCC4E              CALL    BRUDATE  ;UPDATE LEFT RANGING VALUE IN TABLE
4D43 CD0250              CALL    HORN2    ;LOW BEEP
4D46 C35A4C              JMP     PRO2MEN
4D49 FEA1      DEFAREA:  CPI     DEFINE   ;DEFINE MENU SELECTED?
4D4B C2A24D              JNZ     SELAREA  ;CHECK SELECT AREA IF NOT
4D4E CDFC4F              CALL    HORN1
4D51 3EEE                MVI     A,BAR2BEG ;GET BEGINNING ROW/COLUMN OF BAR 2
4D53 CDD04E              CALL    BARREAD  ;WAIT FOR PAD TOUCH, RETURN VALUE OF 0-10 IN A
4D56 47                  MOV     B,A      ;TEMPORARY XFER TO B
4D57 E6F0                ANI     0F0H     ;MASK TO SEE IF ANY VALUE IN MS NIBBLE
4D59 FE00                CPI     00H      ;
4D5B C24D4C              JNZ     PROERR   ;IF ANYTHING IN MS NIBBLE, THEN THERE WAS
                                          ;AN INVALID TOUCH, SO SOUND ERROR AND RETURN
4D5E 78                  MOV     A,B      ;RESTORE A TO B
4D5F FE00                CPI     00H      ;SEE IF 0 SELECTED AS ENTRY NUMBER (1-10 OK)
4D61 C2674D              JNZ     DEFOK1   ;IF 0 NOT SELECTED, THEN CONTINUE
4D64 C34D4C              JMP     PROERR   ;OTHERWISE CALL RASBERRIES, RETURN TO PROMEN
4D67 CDFC4F    DEFOK1:   CALL    HORN1
4D6A 32265A              STA     ENTRY    ;STORE 1-10 NUMBER TEMPORARILY IN ENTRY VAR
4D6D CD734F              CALL    POLL     ;GET UPPER LEFT CORNER OF BOX (MIN VALUES)
4D70 CDFC4F              CALL    HORN1
4D73 55                  MOV     D,L      ;PUT MIN VALUES IN D
4D74 D5                  PUSH    D        ;SAVE FIRST TOUCH LOCATION
4D75 CD734F              CALL    POLL     ;GET LOWER RIGHT CORNER OF BOX (MAX VALUES)
4D78 D1                  POP     D        ;GET FIRST TOUCH LOCATION (MIN VALS)
4D79 5D                  MOV     E,L      ;PUT MAX DATA IN E
4D7A 3A265A              LDA     ENTRY    ;GET THE CURRENT ENTRY NUMBER FROM MEM
4D7D 2A245A              LHLD    BEGTBL   ;SET MEM POINTER AT START OF ENTRIES
4D80 D601                SUI     01H      ;REDUCE ENTRY NUMBER BY 1, TO GET LOOP CNTR
4D82 FE00      DEFOK2:   CPI     00H      ;IS A DOWN TO 0 YET?
4D84 CA8F4D              JZ      DEFOK3   ;IF SO, THEN POINTER IS AT CURRENT ENTRY
4D87 23                  INX     H        ;OTHERWISE INCREMENT POINTER 4 TIMES TO
4D88 23                  INX     H        ;GET TO NEXT ENTRY IN TABLE
4D89 23                  INX     H
4D8A 23                  INX     H
4D8B 3D                  DCR     A        ;DECREMENT ENTRY COUNTER (NOW AT NEXT ENTRY)
4D8C C3824D              JMP     DEFOK2   ;REPEAT CHECK
4D8F 22295A    DEFOK3:   SHLD    POINTER  ;SAVE STARTING ADDRESS OF POINTER
4D92 72                  MOV     M,D      ;PUT MIN VALS IN TABLE
4D93 23                  INX     H        ;INCREMENT POINTER TO MAX VAL LOCATION
4D94 73                  MOV     M,E      ;PUT MAX VALS IN TABLE
4D95 CD0250              CALL    HORN2    ;SOUND LOW (FINISH) HORN
4D98 2A225A              LHLD    GBLTBL   ;GET START ADDRESS OF TABLE
4D9B 7E                  MOV     A,M      ;GET TABLE CONTROL WORD
4D9C E6FE                ANI     11111110B ;CLEAR BIT 0 TO SIGNAL MENU NOT EMPTY
4D9E 77                  MOV     M,A      ;RESTORE THE CONTROL WORD
4D9F C35A4C              JMP     PRO2MEN  ;RETURN W/OUT ZEROING OUT ENTRY
4DA2 FEB1      SELAREA:  CPI     SELECT   ;SELECT AREA SELECTED?
4DA4 C2E14D              JNZ     LMTR     ;CHECK LEFT MOTOR SPEED IF NOT
4DA7 CDFC4F              CALL    HORN1
4DAA 3EEE                MVI     A,BAR2BEG ;GET BEGINNING ROW/COLUMN OF BAR 2
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4DAC CDD04E             CALL    BARREAD ;WAIT FOR PAD TOUCH, RETURN VALUE OF 0-10 IN A
4DAF 47                 MOV     B,A     ;TEMPORARY XFER TO B
4DB0 E6F0               ANI     0F0H    ;MASK TO SEE IF ANY VALUE IN MS NIBBLE
4DB2 FE00               CPI     00H     ;
4DB4 C24D4C             JNZ     PROERR  ;IF ANYTHING IN MS NIBBLE, THEN THERE WAS
                                        ;AN INVALID TOUCH, SO SOUND ERROR AND RETURN
4DB7 78                 MOV     A,B     ;RESTORE A TO B
4DB8 FE00               CPI     00H     ;SEE IF 0 SELECTED AS ENTRY NUMBER (1-10 OK)
4DBA C2C04D             JNZ     SELOK1  ;IF 0 NOT SELECTED, THEN CONTINUE
4DBD C34D4C             JMP     PROERR  ;OTHERWISE CALL RASBERRIES, RETURN TO PROMEN
4DC0 CDFC4F    SELOK1:  CALL    HORN1
4DC3 32265A             STA     ENTRY   ;STORE IN ENTRY VAR FOR TIME BEING
4DC6 2A245A             LHLD    BEGTBL  ;SET MEM POINTER AT START OF ENTRIES
4DC9 D601               SUI     01H     ;REDUCE ENTRY NUMBER BY 1, TO GET LOOP CNTR
4DCB FE00      SELOK2:  CPI     00H     ;IS A DOWN TO 0 YET?
4DCD CAD84D             JZ      SELOK3  ;IF SO, THEN POINTER IS AT CURRENT ENTRY
4DD0 23                 INX     H       ;OTHERWISE INCREMENT POINTER 4 TIMES TO
4DD1 23                 INX     H       ;GET TO NEXT ENTRY IN TABLE
4DD2 23                 INX     H
4DD3 23                 INX     H
4DD4 3D                 DCR     A       ;DECREMENT ENTRY COUNTER (NOW AT NEXT ENTRY)
4DD5 C3CB4D             JMP     SELOK2  ;REPEAT CHECK
4DD8 22295A    SELOK3:  SHLD    POINTER ;SAVE STARTING ADDRESS OF POINTER
4DDB CD0250             CALL    HORN2   ;LOW BEEP (FINISH)
4DDE C35A4C             JMP     PRO2MEN ;RETURN W/OUT ZEROING OUT ENTRY
4DE1 FEC1      LMTR:    CPI     LEFTM   ;WAS LEFT MOTOR SETTING SELECTED?
4DE3 C2F64D             JNZ     RMTR    ;IF NOT, CHECK THE RIGHT MOTOR LOCATION
4DE6 3EFF               MVI     A,TRUE  ;SET FLAG FOR LEFT MOTOR DATA
4DE8 322F5A             STA     LMOTOR
4DEB 3A265A             LDA     ENTRY   ;GET THE TABLE ENTRY VALUE
4DEE FE00               CPI     00H     ;SEE IF CURRENT ENTRY IS 0 (SHOULD NOT BE)
4DF0 C20B4E             JNZ     MOK1    ;IF NOT 0, THEN CONTINUE
4DF3 C34D4C             JMP     PROERR  ;OTHERWISE SOUND ALARM AND RETURN
4DF6 FED1      RMTR:    CPI     RIGHTM  ;WAS LEFT MOTOR SETTING SELECTED?
4DF8 C24A4E             JNZ     DUR     ;IF NOT, CHECK THE RIGHT MOTOR LOCATION
4DFB 3E00               MVI     A,FALSE ;CLEAR FLAG FOR LEFT MOTOR DATA
4DFD 322F5A             STA     LMOTOR
4E00 3A265A             LDA     ENTRY   ;GET THE TABLE ENTRY VALUE
4E03 FE00               CPI     00H     ;SEE IF CURRENT ENTRY IS 0 (SHOULD NOT BE)
4E05 C20B4E             JNZ     MOK1    ;IF NOT 0, THEN CONTINUE
4E08 C34D4C             JMP     PROERR  ;OTHERWISE SOUND ALARM AND RETURN
4E0B CDFC4F    MOK1:    CALL    HORN1
4E0E 3EEB               MVI     A,BAR1BEG ;GET BEGINNING ROW/COLUMN OF BAR 1
4E10 CDD04E             CALL    BARREAD ;WAIT FOR PAD TOUCH, RETURN VALUE OF 0-10 IN A
4E13 47                 MOV     B,A     ;TEMPORARY XFER TO B
4E14 E6F0               ANI     0F0H    ;MASK TO SEE IF ANY VALUE IN MS NIBBLE
4E16 FE00               CPI     00H     ;
4E18 C24D4C             JNZ     PROERR  ;IF ANYTHING IN MS NIBBLE, THEN THERE WAS
                                        ;AN INVALID TOUCH, SO SOUND ERROR AND RETURN
4E1B 2A295A             LHLD    POINTER ;SET MEM POINTER TO CORRECT ENTRY
4E1E 23                 INX     H       ;GET TO LEFT MOTOR DATA
4E1F 23                 INX     H
4E20 3A2F5A             LDA     LMOTOR  ;GET LEFT MOTOR SETTING FLAG
4E23 FE00               CPI     FALSE   ;IF FALSE, THEN ENTERING RIGHT MOTOR DATA
4E25 CA3B4E             JZ      RSET    ;GO TO SET RIGHT MOTOR SPEED
4E28 78                 MOV     A,B     ;GET BAR INPUT BACK
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4E29 C603                ADI    03H      ;ADD 3 TO GET CORRECT MOTOR DATA
4E2B 07                  RLC             ;SWITCH NIBBLES
4E2C 07                  RLC
4E2D 07                  RLC
4E2E 07                  RLC
4E2F 47                  MOV    B,A      ;PUT IN B AGAIN
4E30 7E                  MOV    A,M      ;GET CURRENT MOTOR SETTING
4E31 E60F                ANI    0FH      ;CLEAR OUT OLD LEFT MOTOR DATA
4E33 B0                  ORA    B        ;COMBINE NEW LEFT DATA W/OLD RIGHT DATA
4E34 77                  MOV    M,A      ;RESTORE IN TABLE
4E35 CD0250              CALL   HORN2    ;LOW BEEP (FINISH)
4E38 C35A4C              JMP    PRO2MEN
4E3B 78         RSET:    MOV    A,B      ;GET BAR INPUT BACK
4E3C C603                ADI    03H      ;ADD 3 TO GET CORRECT MOTOR DATA
4E3E 47                  MOV    B,A      ;PUT BACK IN B AGAIN
4E3F 7E                  MOV    A,M      ;GET OLD MOTOR DATA (CURRENT SETTINGS)
4E40 E6F0                ANI    0F0H     ;CLEAR OUT OLD RIGHT MOTOR DATA
4E42 B0                  ORA    B        ;COMBINE OLD LEFT DATA W/NEW RIGHT
4E43 77                  MOV    M,A      ;RESTORE IN TABLE
4E44 CD0250              CALL   HORN2    ;LOW BEEP (FINISH)
4E47 C35A4C              JMP    PRO2MEN
4E4A FEE1       DUR:     CPI    TIME     ;DURATION AREA SELECTED?
4E4C C27F4E              JNZ    RESMEN   ;CHECK RESET MENU SELECTION
4E4F 3A265A              LDA    ENTRY    ;GET THE TABLE ENTRY VALUE
4E52 FE00                CPI    00H      ;SEE IF CURRENT ENTRY IS 0 (SHOULD NOT BE)
4E54 C25A4E              JNZ    DOK1     ;IF NOT 0, THEN CONTINUE
4E57 C34D4C              JMP    PROERR   ;OTHERWISE SOUND ALARM AND RETURN
4E5A CDFC4F     DOK1:    CALL   HORN1
4E5D 3EEE                MVI    A,BAR2BEG ;GET BEGINNING ROW/COLUMN OF BAR 2
4E5F CDD04E              CALL   BARREAD ;WAIT FOR PAD TOUCH, RETURN VALUE OF 0-10 IN A
4E62 47                  MOV    B,A      ;TEMPORARY XFER TO B
4E63 E6F0                ANI    0F0H     ;MASK TO SEE IF ANY VALUE IN MS NIBBLE
4E65 FE00                CPI    00H      ;
4E67 C24D4C              JNZ    PROERR   ;IF ANYTHING IN MS NIBBLE, THEN THERE WAS
                                         ;AN INVALID TOUCH, SO SOUND ERROR AND RETURN
4E6A 78                  MOV    A,B      ;RESTORE TOUCH BAR VALUE
4E6B 2600                MVI    H,00H    ;0 OUT H FOR MULT
4E6D 6F                  MOV    L,A      ;PUT VALUE IN L FOR MULT
4E6E CD4F49              CALL   MULT10   ;MULTIPLY TOUCHED BAR VALUE BY 10
4E71 7D                  MOV    A,L      ;GET VALUE*10 FROM L (NEVER > FFH)
4E72 2A295A              LHLD   POINTER ;SET MEM POINTER AT CORRECT ENTRY IN TABLE
4E75 23                  INX    H        ;MOVE POINTER TO DURATION LOCATION IN TABLE
4E76 23                  INX    H
4E77 23                  INX    H
4E78 77                  MOV    M,A      ;PUT NEW DURATION IN TABLE
4E79 CD0250              CALL   HORN2    ;LOW BEEP (FINISH)
4E7C C35A4C              JMP    PRO2MEN
4E7F FE09       RESMEN:  CPI    RESET    ;WAS THE RESET MENU FUNCTION SELECTED?
4E81 C24D4C              JNZ    PROERR   ;RETURN AND SOUND ERROR IF NO MENU CHOICE
                                         ; WAS SELECTED (BAD TOUCH)
4E84 CDFC4F              CALL   HORN1    ;BEEP TO ACKNOWLEDGE THE FIRST TOUCH
4E87 CD734F              CALL   POLL     ;WAIT FOR SECOND RESET TO VERIFY
4E8A 7D                  MOV    A,L
4E8B FE09                CPI    RESET    ;WAS THE RESET VERIFIED?
4E8D C24D4C              JNZ    PROERR   ;RETURN WITH ERROR SOUND IF NOT.
4E90 CDFC4F              CALL   HORN1
```

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4E93 2A225A               LHLD    GBLTBL  ;OTHERWISE, RESET MENU
4E96 3E07                 MVI     A,00000111B ;SET CONTROL WORD FOR RESET MENU,
                                          ;     SOUND ON, RANGING ON.
4E98 77                   MOV     M,A     ;STORE MENU CONTROL WORD IN TABLE
4E99 23                   INX     H
4E9A 3E04                 MVI     A,04H   ;DEFAULT RAMP RATE
4E9C 77                   MOV     M,A
4E9D 23                   INX     H
4E9E 3E0A                 MVI     A,0AH   ;DEFAULT A, B, C AND D RANGING DISTANCES
4EA0 77                   MOV     M,A
4EA1 23                   INX     H
4EA2 77                   MOV     M,A
4EA3 23                   INX     H
4EA4 77                   MOV     M,A
4EA5 23                   INX     H
4EA6 77                   MOV     M,A
4EA7 23                   INX     H
                                          ;DONE WITH GLOBAL VARS (ALL DEFAULT NOW)
4EA8 060A                 MVI     B,0AH   ;LOAD COUNTER FOR TEN MENU AREAA TO DEFAULT
4EAA 3E00         DEFLT:  MVI     A,00H   ;STORE 0'S IN ROW/COL MIN/MAX FOR DEFAULTS
4EAC 77                   MOV     M,A
4EAD 23                   INX     H
4EAE 77                   MOV     M,A
4EAF 23                   INX     H
4EB0 3E08                 MVI     A,MTRSTOP ;SET SPEED DEFAULTS (LEFT/RIGHT) AT STOP
4EB2 07                   RLC
4EB3 07                   RLC
4EB4 07                   RLC
4EB5 07                   RLC
4EB6 F608                 ORI     MTRSTOP
4EB8 77                   MOV     M,A
4EB9 23                   INX     H
4EBA 3E00                 MVI     A,00H   ;DEFAULT DURATION TO 0
4EBC 77                   MOV     M,A
4EBD 23                   INX     H
4EBE 05                   DCR     B       ;DECREMENT TABLE ENTRY COUNTER
4EBF B8                   CMP     B       ;IS COUNT DOWN TO ZERO?
4EC0 C2AA4E               JNZ     DEFLT   ;REPEAT FOR NEXT ENTRY IF NOT
4EC3 CD0250               CALL    HORN2   ;CALL LOW TONE TO SIGNAL DONE
4EC6 C35A4C               JMP     PRO2MEN



                  ;
                  ; RRUDATE, LRUDATE, FRUDATE, BRUDATE - ROUTINES TO MODIFY THE EXISTING
                  ;       VALUES FOR RANGING DISTANCE (RRUDATE=RIGHT RANGE UPDATE)
                  ;
4EC9 23           RRUDATE: INX    H       ;POINTER AT DESIRED RANGE IN TABLE
4ECA 23           LRUDATE: INX    H
4ECB 23           FRUDATE: INX    H
4ECC 23           BRUDATE: INX    H
4ECD 23                   INX     H
4ECE 77                   MOV     M,A     ;PUT NEW RANGING DISTANCE IN TABLE
4ECF C9                   RET
```

```
                ;



                ;
                ; BARREAD - ROUTINE TO TAKE THE ROW/COLUMN START OF THE BAR,
                ;          AND RETURN A NUMBER 1-11 CORRESPONDING TO BAR LOCATIONS
                ;          0-10.  THIS VLUE CAN THEN BE MANIPULATED TO DO WHATEVER.
                ;
4ED0 F5         BARREAD: PUSH   PSW
4ED1 CD734F              CALL   POLL    ;WAIT FOR PAD TOUCH
4ED4 F1                  POP    PSW
4ED5 BD         RR0:     CMP    L       ;TOUCHED WHERE ON THE BAR?
4ED6 C2DC4E              JNZ    RR1     ;IF NOT, CHECK THE NEXT
4ED9 3E00                MVI    A,00H   ;RETURN VALUE TOUCHED ON THE BAR
4EDB C9                  RET
4EDC CD444F     RR1:     CALL   MSNDCR  ;DECREMENT MS NIBBLE
4EDF BD                  CMP    L       ;TOUCHED WHERE ON THE BAR?
4EE0 C2E64E              JNZ    RR2     ;IF NOT, CHECK THE NEXT
4EE3 3E01                MVI    A,01H   ;RETURN VALUE TOUCHED ON THE BAR
4EE5 C9                  RET
4EE6 CD444F     RR2:     CALL   MSNDCR  ;DECREMENT MS NIBBLE
4EE9 BD                  CMP    L       ;TOUCHED WHERE ON THE BAR?
4EEA C2F04E              JNZ    RR3     ;IF NOT, CHECK THE NEXT
4EED 3E02                MVI    A,02H   ;RETURN VALUE TOUCHED ON THE BAR
4EEF C9                  RET
4EF0 CD444F     RR3:     CALL   MSNDCR  ;DECREMENT MS NIBBLE
4EF3 BD                  CMP    L       ;TOUCHED WHERE ON THE BAR?
4EF4 C2FA4E              JNZ    RR4     ;IF NOT, CHECK THE NEXT
4EF7 3E03                MVI    A,03H   ;RETURN VALUE TOUCHED ON THE BAR
4EF9 C9                  RET
4EFA CD444F     RR4:     CALL   MSNDCR  ;DECREMENT MS NIBBLE
4EFD BD                  CMP    L       ;TOUCHED WHERE ON THE BAR?
4EFE C2044F              JNZ    RR5     ;IF NOT, CHECK THE NEXT
4F01 3E04                MVI    A,04H   ;RETURN VALUE TOUCHED ON THE BAR
4F03 C9                  RET
4F04 CD444F     RR5:     CALL   MSNDCR  ;DECREMENT MS NIBBLE
4F07 BD                  CMP    L       ;TOUCHED WHERE ON THE BAR?
4F08 C20E4F              JNZ    RR6     ;IF NOT, CHECK THE NEXT
4F0B 3E05                MVI    A,05H   ;RETURN VALUE TOUCHED ON THE BAR
4F0D C9                  RET
4F0E CD444F     RR6:     CALL   MSNDCR  ;DECREMENT MS NIBBLE
4F11 BD                  CMP    L       ;TOUCHED WHERE ON THE BAR?
4F12 C2184F              JNZ    RR7     ;IF NOT, CHECK THE NEXT
4F15 3E06                MVI    A,06H   ;RETURN VALUE TOUCHED ON THE BAR
4F17 C9                  RET
4F18 CD444F     RR7:     CALL   MSNDCR  ;DECREMENT MS NIBBLE
4F1B BD                  CMP    L       ;TOUCHED WHERE ON THE BAR?
4F1C C2224F              JNZ    RR8     ;IF NOT, CHECK THE NEXT
4F1F 3E07                MVI    A,07H   ;RETURN VALUE TOUCHED ON THE BAR
4F21 C9                  RET
4F22 CD444F     RR8:     CALL   MSNDCR  ;DECREMENT MS NIBBLE
4F25 BD                  CMP    L       ;TOUCHED WHERE ON THE BAR?
4F26 C22C4F              JNZ    RR9     ;IF NOT, CHECK THE NEXT
4F29 3E08                MVI    A,08H   ;RETURN VALUE TOUCHED ON THE BAR
4F2B C9                  RET
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4F2C CD444F    RR9:     CALL    MSNDCR  ;DECREMENT MS NIBBLE
4F2F BD                 CMP     L       ;TOUCHED WHERE ON THE BAR?
4F30 C2364F             JNZ     RR10    ;IF NOT, CHECK THE NEXT
4F33 3E09               MVI     A,09H   ;RETURN VALUE TOUCHED ON THE BAR
4F35 C9                 RET
4F36 CD444F    RR10:    CALL    MSNDCR  ;DECREMENT MS NIBBLE
4F39 BD                 CMP     L       ;TOUCHED WHERE ON THE BAR?
4F3A C2404F             JNZ     BADENT1 ;IF NOT, SOUND ALARM AND RETURN
4F3D 3E0A               MVI     A,0AH   ;RETURN VALUE TOUCHED ON THE BAR
4F3F C9                 RET
4F40 CDEB4F    BADENT1: CALL RASBER     ;SOUND RASBERRIES (BAD ENTRY NOISE)
4F43 C9                 RET
               ;

               ;
               ; MSNDCR - ROUTINE TO DECREMENT THE MS NIBBLE OF A BYTE
               ;
4F44 0F        MSNDCR: RRC              ;PUT HIGH NIBBLE IN LOW
4F45 0F                 RRC
4F46 0F                 RRC
4F47 0F                 RRC
4F48 3D                 DCR     A       ;DECREMENT HIGH NIBBLE
4F49 07                 RLC             ;RETURN HIGH NIBBLE TO HIGH SPOT
4F4A 07                 RLC
4F4B 07                 RLC
4F4C 07                 RLC
4F4D C9                 RET
               ; /

               ;
               ; RRATE - ROUTINE TO MODIFY THE RAMP RATE VALUE IN THE CURRENT.
               ;
4F4E 2A225A    RRATE:   LHLD    GBLTBL  ;GET STARTING LOCATION OF THE TABLE
4F51 23                 INX     H       ;MOVE POINTER TO RAMP RATE
4F52 77                 MOV     M,A     ;PUT NEW RAMP RATE IN TABLE
4F53 CD0250             CALL    HORN2   ;LOW BEEP TO SIGNAL DONE
4F56 C9                 RET
               ;
               ;
               ; ONOFF - ROUTINE TO TOGGLE THE STATUS OF THE BIT PASSED IN A
               ;         IN THE MENU CONTROL WORD, TURNING SOUND/RANGING, ON/OFF.
               ;
4F57 47        ONOFF:   MOV     B,A     ;XFER MASK TO B
4F58 2A225A             LHLD    GBLTBL  ;POINT TO FIRST LOCATION OF CURRENT TABLE
4F5B 4E                 MOV     C,M     ;PUT CURRENT MENU CONTROL WORD IN C
4F5C 79                 MOV     A,C     ;PUT     "      "       "        "   " A
4F5D A0                 ANA     B       ;AND SELECTED BIT WITH CONTROL WORD
4F5E B8                 CMP     B       ;COMPARE WITH SELECTED BIT
4F5F CA694F             JZ      TURNOFF ;IF SELECTED BIT IS A 1, THEN MAKE A 0
4F62 79        TURNON:  MOV     A,C     ;PUT CURRENT MENU CONTROL WORD BACK IN A
4F63 B0                 ORA     B       ;SET SELECTED BIT HIGH.
4F64 77                 MOV     M,A     ;RESTORE CONTROL WORD TO TABLE
4F65 CDFC4F             CALL    HORN1   ;HIGH BEEP TO SIGNAL ON
4F68 C9                 RET
4F69 78        TURNOFF: MOV     A,B     ;GET SELECTED BIT MASK
4F6A 2F                 CMA             ;COMPLEMENT SELECTED BIT MASK
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4F6B 47                 MOV     B,A      ;PUT BACK IN B
4F6C 79                 MOV     A,C      ;PUT CURRENT MENU CONTROL WORD IN A
4F6D A0                 ANA     B        ;AND COMPLEMENT OF SELECTED BIT MASK WITH A
4F6E 77                 MOV     M,A      ;RESTORE CONTROL WORD TO TABLE
4F6F CD0250             CALL    HORN2    ;LOW BEEP TO SIGNAL OFF
4F72 C9                 RET
                ;
                ;
                ; POLL - POLL THE TOUCH-PAD TO WAIT FOR A TOUCH, AND THEN WAIT FOR
                ;        A NO TOUCH (THE OBJECT REMOVED FROM THE PAD).
                ;
4F73 CD5D48     POLL:   CALL    EXTCHK   ;CHECK FOR 'E' FROM CONSOL
4F76 CD9C4F             CALL    PDMNCHK  ;CHECK FOR PAD, MENU ERROR AND SEE IF
                                         ;STILL THE PROGRAM MENU.
4F79 3A345A             LDA     PADFLG   ;GET PAD/MENU STATUS FLAG
4F7C FE00               CPI     FALSE    ;SEE IF PAD OK
4F7E C8                 RZ
4F7F 7C                 MOV     A,H      ;GET TOUCH STATUS WORD
4F80 E680               ANI     TOUCH    ;CHECK FOR A TOUCH
4F82 FE80               CPI     TOUCH
4F84 C2734F             JNZ     POLL
4F87 D5         NTCH:   PUSH    D
4F88 110002             LXI     D,0200H
4F8B 1B         DELAYG: DCX     D                  ;DECREMENT DELAY COUNT
4F8C 7A                 MOV     A,D                ;COMPARE D AND E
4F8D B3                 ORA     E                  ;CHECK TO SEE IF DE=0
4F8E C28B4F             JNZ     DELAYG             ;REPEAT IF <>0
4F91 D1                 POP     D
4F92 DB11               IN      PIAB     ;WAIT FOR NO TOUCH
4F94 E601               ANI     BEAMSK
4F96 FE01               CPI     BEAMSK
4F98 CA874F             JZ      NTCH     ;IF TOUCH, CONTINUE TO LOOP
4F9B C9                 RET
                ;
                ;
                ; PDMNCHK - ROUTINE TO CHEK THE PAD AND MENU, SIGNAL ERRORS AND LOOP
                ;        IF THERE ARE ANY, OR CONTINUE IF NOT.  ALSO, THIS WILL
                ;        CHECK TO SEE THAT THE PROMEN MENU IS STILL IN PLACE, AND
                ;        RETURN IF NOT.
                ;

4F9C 3EFF       PDMNCHK: MVI    A,TRUE   ;SET PAD/MENU OK FLAG TO TRUE (BEGINNING)
4F9E 32345A             STA     PADFLG   ;
4FA1 DB11               IN      PIAB     ;READ THE +5 LOOP FROM THE PAD CONNECTOR
4FA3 E680               ANI     PADLOOP  ;MASK TO DETERMINE THE CONNECTOR STATUS
4FA5 FE80               CPI     PADLOOP  ;VALUE READ, 1=CONNECTED, 0=DISCONNECTED
4FA7 CABA4F             JZ      PADOK5   ;CONTINUE IF PAD CONNECTED
4FAA 3E01               MVI     A,PADLED ;GET DATA TO LIGHT PAD ERROR LED
4FAC CDF04A             CALL    SETERR   ;LIGHT THE PAD ERROR LED
4FAF 3E40               MVI     A,MENERR; PAD ERROR WILL GIVE MENU ERROR
4FB1 CDFC4A             CALL    CLRERR   ; SO CLEAR MENU LED
4FB4 3E00               MVI     A,FALSE  ;SIGNAL PAD/MENU OK FLAG AS NOT OK
4FB6 32345A             STA     PADFLG   ;
4FB9 C9                 RET
4FBA 3E01       PADOK5: MVI     A,PADLED ;GET DATA TO CLEAR PAD LED
4FBC CDFC4A             CALL    CLRERR   ;CLEAR THE PAD LED (ALL IS OK)
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4FBF CDFD46              CALL    PADRD   ;DETERMINE MENU NUMBER OR STATUS (IF ERROR)
4FC2 7C                  MOV     A,H     ;PUT MENU NUMBER (STATUS) IN (A)
4FC3 E640                ANI     MENERR  ;MASK FOR MENU ERROR
4FC5 FE40                CPI     MENERR  ;MASK FOR MENU ERROR
4FC7 C2D54F              JNZ     PADOK6  ;IF VALID MENU, THEN PROCEED, OTHERWISE...
4FCA 3E02                MVI     A,MENLED ;GET DATA TO LIGHT THE MENU ERROR LED
4FCC CDF04A              CALL    SETERR  ;LIGHT THE MENU ERROR LED
4FCF 3E00                MVI     A,FALSE ;SIGNAL PAD/MENU OK FLAG AS NOT OK
4FD1 32345A              STA     PADFLG  ;
4FD4 C9                  RET
4FD5 3E02       PADOK6:  MVI     A,MENLED ;GET DATA TO CLEAR THE MENU LED
4FD7 CDFC4A              CALL    CLRERR  ;CLEAR MENU ERROR LED
4FDA 7C                  MOV     A,H     ;PUT MENU NUMBER (STATUS) IN (A)
4FDB E601                ANI     PROMSK  ;MASK PROGRAM MENU NUMBER
4FDD FE01                CPI     PROMSK  ;MASK TO SEE IF PROGRAMMING MENU IN PAD
4FDF C8                  RZ              ;RETURN IF ALL OK, AND STILL PROMEN MENU
4FE0 3E00                MVI     A,FALSE ;SIGNAL PAD/MENU OK FLAG AS NOT OK
4FE2 32345A              STA     PADFLG  ;
4FE5 3E02                MVI     A,MENLED
4FE7 CDF04A              CALL    SETERR
4FEA C9                  RET
                ;
                ;
                ; RASBER - SUBROUTINE TO SOUND A 'RASBERIES' TONE TO ALERT THE USER
                ;          OF AN ERROR IN MENU ENTRY (FROM PROMEN)
                ;
4FEB F5         RASBER:  PUSH    PSW
4FEC 3E04                MVI     A,04H   ;SOUND RASBERRY COUNTER
4FEE CDFC4F     RAS1:    CALL    HORN1   ;SOUND LOW BEEP ONCE
4FF1 CD0250              CALL    HORN2   ;SOUND HIGH BEEP ONCE
4FF4 3D                  DCR     A
4FF5 FE00                CPI     00H     ;IS RASBERRY COUNTER ZERO?
4FF7 C2EE4F              JNZ     RAS1    ;REPEAT IF NOT COUNTED OUT
4FFA F1                  POP     PSW     ;OTHERWISE RETURN
4FFB C9                  RET             ;
                ;
                ;
                ; HORN1 - ROUTINE TO SOUND THE FIRST OF TWO TONES
                ;
4FFC F5         HORN1:   PUSH    PSW
4FFD 3E40                MVI     A,40H   ;LOAD THE VALUE FOR FIRST TONE
4FFF C30550              JMP     HORNA
5002 F5         HORN2:   PUSH    PSW
5003 3EC0                MVI     A,0C0H  ;LOAD VALUE FOR SECOND TONE
5005 D342       HORNA:   OUT     PIAF    ;SEND VALUE TO SOUND CIRCUIT
5007 D5                  PUSH    D
5008 110030              LXI     D,3000H ;SHORT DELAY
500B CDB747              CALL    DELAYD
500E 3E00                MVI     A,00H
5010 D342                OUT     PIAF
5012 D1                  POP     D
5013 F1                  POP     PSW
5014 C9                  RET
                ;
                ;
                ;
                ; ROM CONSTANT ALLOCATION - ALPHABETICAL ORDER (SORTOF)
                ;                           - FUNCTIONAL ORDER TOO
                ; COMMAND TABLE
5015 444D       CMDS:   DB      'DM'            ;DUMP MEMORY
5017 D942               DW      DUMP            ;
5019 444C               DB      'DL'            ;DOWN LOAD
501B 5742               DW      LOADER          ;
501D 454D               DB      'EM'            ;EDIT MEMORY
501F AB41               DW      MEMED           ;
5021 474F               DB      'GO'            ;GO
5023 EE40               DW      GOTO            ;
5025 4845               DB      'HE'            ;HELP COMMAND
5027 E740               DW      HELP            ;
5029 494F               DB      'IO'            ;IO PORT R/W/M
502B 4943               DW      IOPORT          ;
502D 5442               DB      'TB'            ;TEST TIMERS AND PORTS ON BOARD
502F 7841               DW      TSTBRD          ;
5031 544D               DB      'TM'            ;TEST MEMORY
5033 0541               DW      MEMTST          ;
5035 5243               DB      'RC'            ;RUN WHEELCHAIR
5037 8746               DW      INITIAL         ;
5039 0000               DB      0,0             ;END OF TABLE MARK
                ;
                ; MESSAGES...
503B 2041424F52ABORT:   DB      ' ABORTED  '
5045 FF                 DB      EOL
5046 2057484154BAD:     DB      ' WHAT ?'
504D FF                 DB      EOL
504E 29         EDM1:   DB      ')'
504F 203D20     EDM3:   DB      ' = '
5052 FF                 DB      EOL
5053 0D0A       EDM2:   DB      CR,LF
5055 28                 DB      '('
5056 FF                 DB      EOL
5057 0D0A       MTSBRD  DB      CR,LF
5059 5445535449         DB      'TESTING TIMERS AND PIA PORTS',CR,LF
5077 4C4F4F4B20         DB      'LOOK FOR 1000 HZ SQUAREWAVE ON TIMER OUTPUTS',CR,LF
50A5 4441544120         DB      'DATA ANALIZER SHOULD SHOW PORTS COUNTING',CR,LF
50CF 494E204120         DB      'IN A STAIRSTEP FASTION',CR,LF
50E7 FF                 DB      EOL
50E8 444154413DIOPDA:   DB      'DATA= '
50EE FF                 DB      EOL
50EF 402035306DIOPMM:   DB      '@ 50mS * '
50F8 FF                 DB      EOL
50F9 2C2020     IOPSM:  DB      ',  '
50FC FF                 DB      EOL
50FD 0D0A       GCLKM:  DB      CR,LF
50FF 454E544552         DB      'ENTER CPU CLK FREQ XXXX KHZ: '
511C FF                 DB      EOL
511D 204F4B203FMOK:     DB      ' OK ?'
5122 FF                 DB      EOL
5123 0D0A       MTGOOD: DB      CR,LF
5125 4D454D4F52         DB      'MEMORY TEST PASSED'
5137 0D0AFF             DB      CR,LF,EOL
513A 0D0A       MTERR:  DB      CR,LF
513C 4D454D4F52         DB      'MEMORY TEST FAILED AT '
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5152 FF                 DB      EOL
5153 3A2057524FMTWROT:  DB      ': WROTE '
515B FF                 DB      EOL
515C 2C20524541MTREAD:  DB      ', READ '
5163 FF                 DB      EOL
5164 20544F20  PHI:     DB      ' TO '
5168 FF                 DB      EOL
5169 2046524F4DPLO:     DB      ' FROM '
516F FF                 DB      EOL
5170 4F46465345PBIAS:   DB      'OFFSET VALUE ? '
517F FF                 DB      EOL
5180 0D0A0A0A0APHELP:   DB      CR,LF,LF,LF,LF,LF,LF,LF
5188 2020202057         DB      '     WELCOME TO THE EASYCHAIR MONITOR'
51AC 0D0A               DB      CR,LF
51AE 2020544845         DB      '  THE FOLLOWING TWO CHARACTER COMMANDS'
51D4 0D0A               DB      CR,LF
51D6 2020202020         DB      '           ARE AVAILIBLE : '
51F0 0D0A0D0A           DB      CR,LF,CR,LF
51F4 444D202044         DB      'DM  Dump Memory'
5203 0D0A               DB      CR,LF
5205 444C202044         DB      'DL  Down Load from dev. system'
5223 0D0A               DB      CR,LF
5225 454D202045         DB      'EM  Edit Memory'
5234 0D0A               DB      CR,LF
5236 474F202047         DB      'GO  GOto'
523E 0D0A               DB      CR,LF
5240 494F202049         DB      'IO  I/O port r/w/m'
5252 0D0A               DB      CR,LF
5254 5442202054         DB      'TB  Test Board utitily'
526A 0D0A               DB      CR,LF
526C 544D202054         DB      'TM  Test Memory'
527B 0D0A               DB      CR,LF
527D 5243202052         DB      'RC  Run Chair program'
5292 0D0A               DB      CR,LF
5294 0D0A0A0A0A         DB      CR,LF,LF,LF,LF
5299 FF                 DB      EOL
529A 0D0A      PRMPT:   DB      CR,LF
529C 4541535936         DB      'EASY6'
52A1 0D0A               DB      CR,LF
52A3 203E               DB      ' >'
52A5 FF                 DB      EOL
52A6 2A2A2A2A2ASTMSG:   DB      '****************************************'
52CF 0D0A               DB      CR,LF
52D1 2A2A2A2020         DB      '***     EASYCHAIR CONTROLER V 6.0       ***'
52FA 0D0A               DB      CR,LF
52FC 2A2A2A2A2A         DB      '****************************************'
5325 0D0A               DB      CR,LF
5327 0D0A               DB      CR,LF
5329 2020544849         DB      '  THIS SYSTEM WAS CREATED BY :'
5347 0D0A0A             DB      CR,LF,LF
534A 2020202020         DB      '         JAMES WILLIAMS '
5361 0D0A               DB      CR,LF
5363 2020202020         DB      '             AND'
5372 0D0A               DB      CR,LF
5374 2020202020         DB      '          GREGORY WELCH'
538A 0D0A0A             DB      CR,LF,LF
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538D 2020495420        DB      '  IT IS THE CONTROLER PROGRAM THAT'
53AF 0D0A              DB      CR,LF
53B1 204F504552        DB      ' OPERATES THE ULTRASONICS, LIGHT BOARD,'
53D8 0D0A              DB      CR,LF
53DA 414E44204D        DB      'AND MOTORS OF THE EASYCHAIR WHEELCHAIR.'
5401 0D0A              DB      CR,LF
5403 2054484953        DB      ' THIS PROGRAM ALSO ALLOWS MENUS FOR'
5426 0D0A              DB      CR,LF
5428 2054484520        DB      ' THE LIGHT BOARD TO BE CREATED FOR '
544B 0D0A              DB      CR,LF
544D 2045414348        DB      ' EACH CHILD AND ADDED TO AND CHANGED '
5472 0D0A              DB      CR,LF
5474 204153204E        DB      ' AS NEEDED.'
547F 0D0A              DB      CR,LF
5481 20414C4C20        DB      ' ALL ATTEMPTS WERE MADE TO FORESEE ALL'
54A7 0D0A              DB      CR,LF
54A9 2054484520        DB      ' THE POSSIBLE PROBLEMS THAT MAY ARISE.'
54CF 0D0A              DB      CR,LF
54D1 2020202020        DB      '        HOWEVER, -NO- PROMISES.'
54EF 0D0AFF     MCRLF: DB      CR,LF,EOL
54F2 574845454CMSG1:   DB      'WHEELCHAIR NOW UNDER COMPUTER CONTROL'
5517 0D0AFF            DB      CR,LF,EOL
551A 0A0A0A0A0ACLS:    DB      LF,LF,LF,LF,LF,LF,LF,LF,LF,LF,LF,LF,LF,LF
5528 0A0A0A0A0A        DB      LF,LF,LF,LF,LF,LF,LF,LF,LF,LF,LF,HOME,EOL
5535 46524F4E54FNTMSG: DB      'FRONT = ',EOL
553E 4241434B20BAKMSG: DB      'BACK = ',EOL
5546 5249474854RTMSG:  DB      'RIGHT = ',EOL
554F 4C45465420LFTMSG: DB      'LEFT = ',EOL
5557 4C45442F54ROWERR: DB      'LED/TRANSISTOR ERROR IN ROW (0-F): ',EOL
557B 4C45442F54COLERR: DB      'LED/TRANSISTOR ERROR IN COLUMN (0-F): ',EOL
55A2 5041442054TCHMSG: DB      'PAD TOUCHED AT LOCATION: ',EOL
55BC 424547494EINTMSG: DB      'BEGIN INFRA-RED TOUCH PAD DIAGNOSTICS',EOL
55E2 454E44204FENDMSG: DB      'END OF INFRA-RED TOUCH PAD DIAGNOSTICS',EOL
5609 06        SAMPLE: DB      00000110B ;MENU CONTROL WORD
560A 02                DB      02H     ;RAMP RATE
560B 10                DB      10H     ;BAK,FNT,LFT,RGT RANFGING DIST
560C 10                DB      10H
560D 10                DB      10H
560E 10                DB      10H
                                       ;BEGIN ENTRY 1
560F 00                DB      00H     ;ROW/COL MIN
5610 44                DB      44H     ;ROW/COL MAX
5611 AC                DB      0ACH    ;MOTOR SPEEDS (L/R)
5612 10                DB      10H     ;DURATION
                                       ;NEXT ENTRIES
5613 05                DB      05H
5614 4A                DB      4AH
5615 CC                DB      0CCH
5616 10                DB      10H
                                       ;
5617 0B                DB      0BH
5618 4F                DB      4FH
5619 CA                DB      0CAH
561A 10                DB      10H
                                       ;
561B 50                DB      50H
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561C A4                 DB      0A4H
561D 8C                 DB      8CH
561E 10                 DB      10H
                                        ;
561F 55                 DB      55H
5620 AA                 DB      0AAH
5621 88                 DB      88H
5622 10                 DB      10H
                                        ;
5623 5B                 DB      5BH
5624 AF                 DB      0AFH
5625 C8                 DB      0C8H
5626 10                 DB      10H
                                        ;
5627 B0                 DB      0B0H
5628 F4                 DB      0F4H
5629 46                 DB      46H
562A 10                 DB      10H
                                        ;
562B B5                 DB      0B5H
562C FA                 DB      0FAH
562D 44                 DB      44H
562E 10                 DB      10H
                                        ;
562F BB                 DB      0BBH
5630 FF                 DB      0FFH
5631 64                 DB      64H
5632 10                 DB      10H
                                        ;
5633 00                 DB      00H
5634 00                 DB      00H
5635 88                 DB      88H
5636 01                 DB      01H
                                        ;
                                        ;END OF SAMPLE TABLE DEFINITIONS
               ;
               ; RAM ALLOCATION IN ALPHABETICAL AND FUNCTIONAL ORDER
               ;
5A00                    ORG     MONRAM         ;BEGINNING OF MONITOR RAM
               ;
5A00           ECHOFL: DS       1              ;ECHO FLAG: 0=ECHO 1=NO ECHO
5A01           WIDTH:  DS       1              ;WIDTH+1 = NUMBER OF BYTES PER LINE
5A02           BIAS:   DS       2              ;BIAS FOR LOAD
5A04           RJSAV:  DS       2              ;TEMP SAVE AREA FOR RETJMP
5A06           RJSP:   DS       2              ;RETURN JUMP STACK POINTER
5A08           RJVECT: DS       2              ;RETURN JUMP VECTOR (PC)
5A0A           D50DIV: DS       2              ;COUNTER FOR TIMING OF 50MS PULSE
5A0C           CLKBCD: DS       2              ;CLOCK FREQUENCY IN BCD
5A0E           CLKBIN: DS       2              ;CLOCK FREQUENCY IN BINARY
5A10           FNTDST: DS       2              ;ULTRASONIC FNT DIST.
5A12           MAXFNT: DS       1              ; MAX FRONT DIST.
5A13           BAKDST: DS       2              ;          BACK DIST.
5A15           MAXBAK: DS       1              ; MAX BACK DIST.
5A16           RTDST:  DS       2              ;         RIGHT DIST.
5A18           MAXRT:  DS       1              ; MAX RIGHT DIST.
5A19           LFTDST: DS       2              ;          LEFT DIST.
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5A1B          MAXLFT: DS      1               ; MAX LEFT DIST.
5A1C          TIMDLY: DS      2               ;DELAY TIME
5A1E          HONOFF: DS      1               ;HIGH SPEED FLAG
5A1F          RAMPCNT: DS     1               ;RAMP RATE
5A20          MENCTRL: DS     1               ;MENU CONTROL WORD (FLAGS...)
5A21          ERRWRD: DS      1               ;CURRENT ERROR WORD (SETERR,CLRERR)
5A22          GBLTBL: DS      2               ;STARTING ADDRESS OF GLOBAL MEN VARS
5A24          BEGTBL: DS      2               ;STARTING ADDRESS OF TABLE ENTRIES
5A26          ENTRY:  DS      1               ;CURRENT ENTRY NUMBER (IN DATA TABLES)
5A27          MTRADDR: DS     2               ;ADDRESS OF CURRENT ENTRY DATA
5A29          POINTER: DS     2               ;POINTER USED IN PROMEN TO UPDATE TABLE
5A2B          LMTS:   DS      1               ;LEFT MOTOR TARGET SPEED
5A2C          RMTS:   DS      1               ;RIGHT MOTOR TARGET SPEED
5A2D          LMCS:   DS      1               ;LEFT MOTOR CURRENT SPEED
5A2E          RMCS:   DS      1               ;RIGHT MOTOR CURRENT SPEED
5A2F          LMOTOR: DS      1               ;VALUES TO BE SENT TO L & R MOTORS
5A30          RMOTOR: DS      1               ;
5A31          DURATION: DS    1               ;DURATION OF MOTOR ACTION
5A32          LAST1:  DS      1               ;LAST ENTRY NUMBER
5A33          CNTRAMP: DS     1               ;IMEDIATE RAMP COUNT
5A34          PADFLG: DS      1               ;PAD/MENU OK FLAG
5A35          HEARTON: DS     1               ;HEARTBEAT ON/OFF FLAG
5A36          MISCBF: DS      17              ;BUFFER FOR USE BY COMMANDS
              ;                               ;PUT LAST SO AN OVERRUN WON'T BOMB
              ;                               ;SYSTEM
                              ;END OF EASYCHAIR MONITOR

              ;+++++++++++++++++++++++++++++++++++++++++++++++++++++++++
5A47                  END
```

THE INFRARED TOUCH PAD

40 - Infrared LEDS	$ 26.00
40 - Infrared phototransistors	22.00
1 - Miscellaneous wood/plastic	60.00
1 - Electronic components	85.00
1 - Electronic cable	27.00
1 - Miscellaneous hardware	75.00

	295.00

ULTRASONIC RANGING

4 - Ultrasonic transducers	375.00
1 - Electronic components	50.00
1 - Electronic cable	32.00

	457.00

COMPUTER AND MOTOR CONTROL

1 - Working 8085 based computer	400.00
1 - Additional 8255 PIA	17.00
1 - 2816A EEPROM	16.00
2 - DS1225 8K NOVRAM	32.00
2 - AD558 D/A Converters	15.00
1 - Electronic components	15.00
1 - Power supply components	27.00

	522.00

MISCELLANEOUS COSTS

1 - Miscellaneous	55.61

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GRAND TOTAL $ 1329.61

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