THE PRESSURE SENSITIVE TOUCH-PAD

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E.E.T. 454

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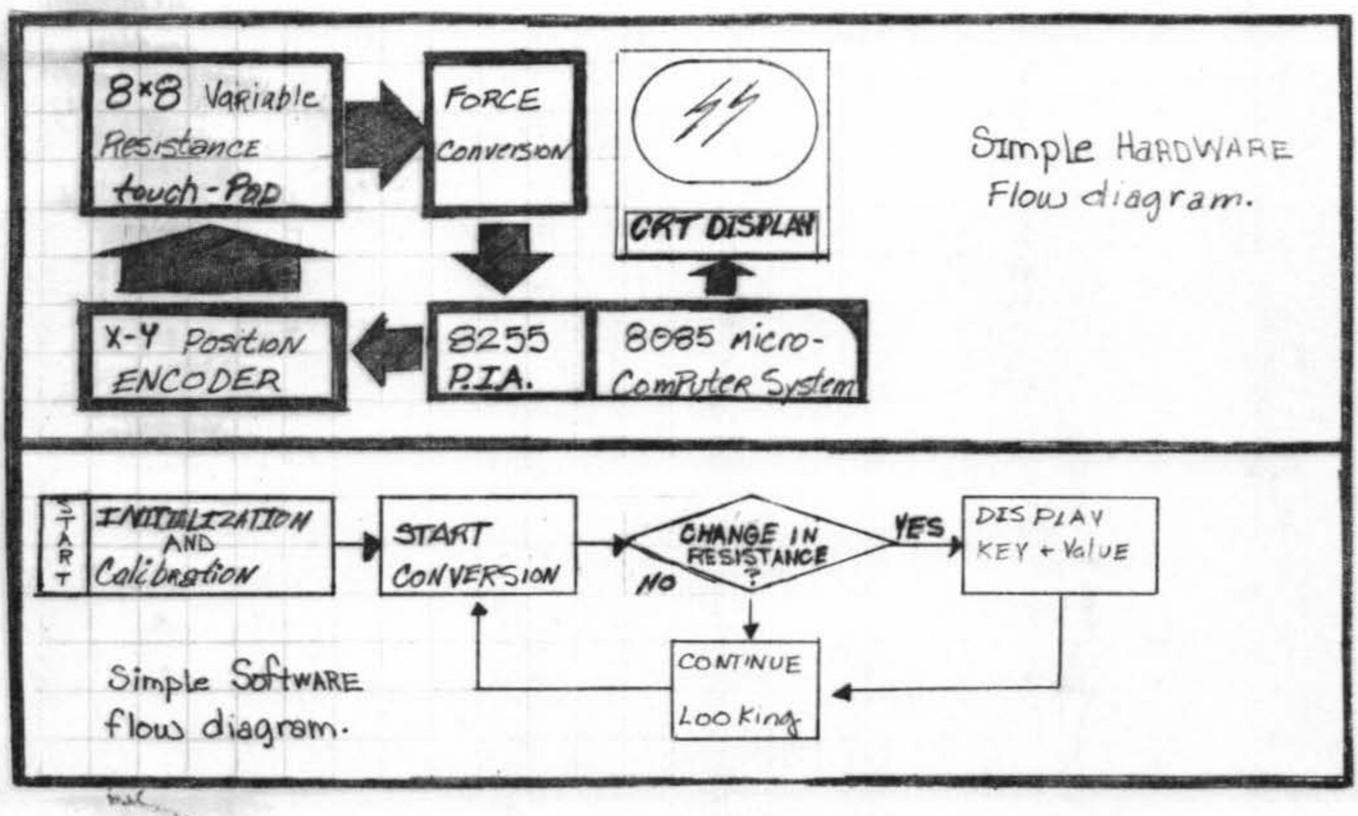
System Plan:

This project, which was designed by James P. Williams and Gregory F. Welch, will use an original design for a pressure sensitive touch-pad used to allow input to a microprocessor system.

The touch-pad will use a matrix of conductive foam squares which behave as variable resistors. Using some special scan circuitry, the software will continue to scan the touch-pad for a large change in resistance from one scan to another.

The problem faced is that of designing the hardware and the software required to scan the pressure sensitive touch-pad, and to determine (by software) whether or not a specific area of the touch-pad was being pressed.

The touch-pad should be such that a small child could use it to control a small vehicle such as a wheelchair. The positional data could represent the direction in which to move, and eventually, the amount of pressure could determine the speed at which the wheelchair moves.



Introduction:

The pressure sensitive touch-pad system was designed to eliminate the need for a positive (definite) depression of a specific key to perform a task. However, the touch-pad is still set-up in a matrix fashion, so that the area of the most pressure could be determined. The purpose of this is to facilitate control of a small vehicle by children with underdeveloped fine motor skills. Such children might have problems with pressing one specific key among many, and they might not be able to apply direct force on a key.

With this current system, the user would apply pressure to a certain area of the touch-pad, and the system would recognize the key (or area), and display a number on the video display terminal which corresponds to that area.

Software:

There are several special features in the touch-pad software which require further explaination.

The first area of interest is a typed subroutine called Value. The purpose of this subroutine is to allow the software to determine the amount of resistance (relatively) that is characteristic of a certain key or area. It begins by placing the count of the key OR'd with data to initialize the hardware on an output port. This selects the key to be read, and places a high on both the address latch enable (ALE) and the start conversion (SC). The values are OR'd together because the control is all processed through the same port.

Next, the routine places the count value on the output port twice again. Both times, the count is OR'd with the data required to control the hardware. The first time, a low is placed on the ALE line, and then a low on the SC line. This begins the process of conversion.

Finally, the routine loops, checking for an end of conversion (EOC) signal. When the data is ready, it is returned through the typed subroutine.

The next area of software interest is the main section of code. The main section of code is comprised of two loops, one inside the other. The outer loop repeats until either a break is encountered, or some other means such as a reset is used to halt the microprocessor. It begins by zeroing out (so to speak) several variables to be used. It then scans the keyboard and looks for the largest difference in resistance between the present and the last scan. Then, if this difference is greater than a threshold value, the number corresponding to the area pressed is displayed on the vdt.

The inner loop repeats sixty-four times, every time it is encountered. It begins by calling the Value subroutine which returns a value between zero and 128, representing the current value of resistance for that key. It then determines if the current scan value is less than the permanent value, then the permanent value is updated to the current value. Next, it determines the difference between the permanent value and the current value. Throughout the looping, it checks to see if that difference is the greatest found yet. If so, it stores the key number and the value, otherwise, it continues on to the next key.

Hardware:

The hardware consists mainly of two parts; the touch-pad, and the scan circuitry.

The touch-pad consists of 64 conductive foam squares which are sandwiched between eight conductive strips positioned in one direction below, and eight others in a perpendicular direction above. This forms an eight by eight matrix which allows which allows the scan circuitry to determine the current resistance of any square of foam.

The scan circuitry uses an eight channel digital demultiplexer, and an eight channel analog multiplexer. The software delivers a six bit word to this circuitry, three of which are used to place a high on one of eight lines using the demultiplexer, the other three which are used to select one of the eight channels of the analog multiplexer A/D converter. This chip then converts the analog signal on the selected line to an eight bit digital word which is then made available to the microprocessor. This, although it is an actual voltage reading, is used to represent the current resistance of the selected square. The larger the number, the greater the force applied to the square, the less the resistance.

Analysis:

There were two problems encountered during the development of the touch-pad which were considered to be major.

The first problem was that of selectivity. Originally, the touch-pad consisted of one large sheet of conductive foam with a matrix of wires above and below it. The problem was that pressure in one spot might appear as pressure in several spots. This problem was solved almost completely by seperating the sheet into 64 seperate squares of foam which did not come in contact with eachother. Then to further eliminate the problem, used flexible copper strips instead of the stiff wire originally used.

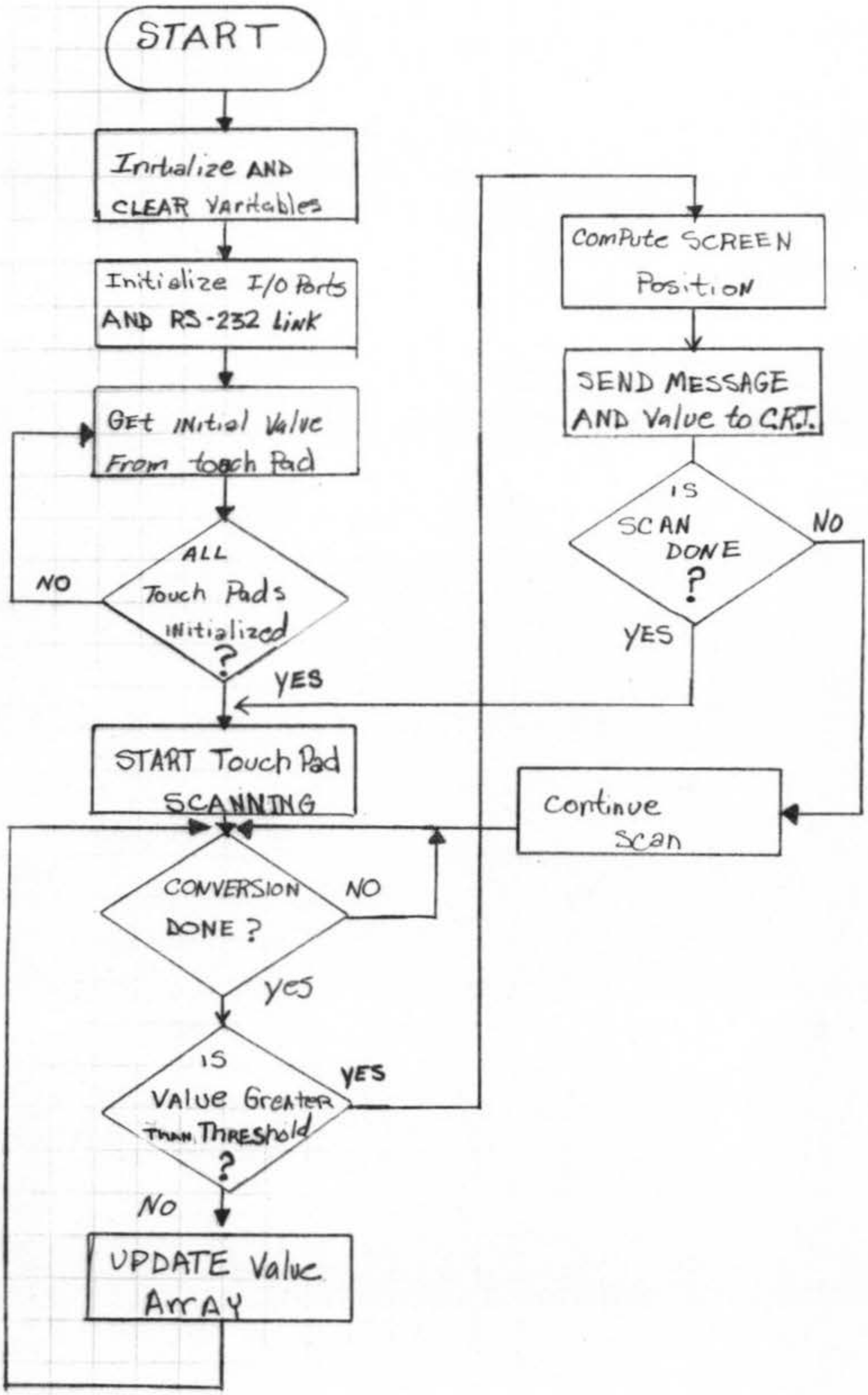
The second problem was that of determining with software, what actually represented a key being pressed. The first attempt kept the values read during each scan in an array which was updated with each scan. The problem was that because the array was being updated so frequently, there was never really time to determine if the change was due to an actual depression of the pad, or some other outside event. This problem was solved by updating the array only once at the begining of the program. Later scans are compared to this scan only, and the array is only updated if the movement (resistance change) seems to be opposite to that of a depression, in other words, settling of the foam.

In the future, one might seperate the conductive foam further with strips of insulating foam. This would tend to physically support the keys surrounding the one being pressed, but still still allow the flexibility of the original design.

Also, another nice improvement to be made in the future would be to allow the amount of pressure applied to control a device such as a motor. This would not be a very tough project enhancement as far as the current software is concerned. The byte value returned from the Value subroutine could be used directly to regulate the pulse width of a signal sent to a motor, thus varying the speed.

James P. Williams
Gregory F. Welch

Software flow of Program KYBD.P80



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IS-I1 PL/M-80 V3.1 COMPILATION OF MODULE KYBD
JECT MODULE PLACED IN :F9:KYBD.OBJ
OMPILER INVOKED BY:   :F1:PLM80 :F9:KYBD.P80 WORKFILES(:F0:,:F0:) DEBUG PAGEWIDT
                    -H(80) TITLE('/:F9:KYBD COMPILATION') DATE(04/30/85)


              /* THIS PROGRAM WILL PROCESS THE I/O FROM A
                 KEYBOARD WHICH USES CONDUCTIVE FOAM TO
                 VARY THE RESISTANCE BETWEEN +V AND THE
                 LINE GOING TO THE KEY.  THE KEYBOARD
                 CONSISTS OF 64 KEYS (8X8 MATRIX) WHICH
                 ARE MULTIPLEXED AND CONTROLLED BY THE
                 PROGRAM.  THE PROGRAM WILL OUTPUT AN
                 ADDRESS TO THE KEYBOARD WHICH WILL SELECT
                 A CERTAIN KEY.  THEN IT WILL (USING AN
                 A/D CONVERTER) INPUT THE VOLTAGE LEVEL
                 OF THAT KEY AND COMPARE IT TO THE LAST
                 VALUE FOR THAT KEY (OBTAINED EARLIER). */

  1           KYBD:DO;   /* BEGIN KYBD PROGRAM */

  2   1       DECLARE  /* VARIABLE DECLARATION SECTION */
                (COUNT,MAX$VALUE,DIFFERENCE,KEY$PUSHED,
                 THRESHOLD,VOLTAGE) BYTE,
                LAST$VALUE (64) BYTE,
                EOM LITERALLY '03H',
                COMMAND LITERALLY 'OUTPUT(83H)',
                KEY$SELECT LITERALLY 'OUTPUT(81H)',
                KEY$VALUE LITERALLY 'INPUT(80H)',
                DATA$READY LITERALLY '(INPUT(80H) AND 10000000B)=0',
                CLEARSCREEN(*) BYTE DATA(1BH,1CH,EOM),
                BLANKS(*) BYTE DATA('  ',EOM),
                FOREVER LITERALLY 'WHILE 1';

  3   1       VALUE:PROCEDURE BYTE;

                /* THIS ROUTINE ROUTINE RETURNS THE RELATIVE
                   VOLTAGE VALUE READ FROM THE VOLTAGE DIVIDER
                   FORMED BY A PERMANENT RESISTOR AND THE
                   VARIABLE RESISTOR (CONDUCTIVE FOAM) */

  4   2         KEY$SELECT=(COUNT OR 11000000B);
                  /* LOAD ADDRESS AND SETS ALE AND SC HIGH */
  5   2         KEY$SELECT=(COUNT OR 01000000B);
                  /* ALE STROBED LOW: LATCH ADDRESS */
  6   2         KEY$SELECT=COUNT;
                  /* SC STROBED: START CONVERSION */
  7   2         DO WHILE NOT(DATA$READY);
  8   3           END;
  9   2         RETURN (KEY$VALUE AND 01111111B);
                   /* MASK RESULT AND RETURN TO CALL LOCATION */
 10   2       END VALUE;
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 11   1        CHOUT:PROCEDURE (CH$SEND); /*SENDS ONE CHARACTER TO CRT SCREEN*/
 12   2          DECLARE CH$SEND BYTE; /*ADDRESS AND MASKING SPECIFIC TO S100*/
 13   2          DO WHILE(INPUT(0) AND 00000001B)=0;  /*AWAIT TXRDY*/
 14   3          END;
 15   2          OUTPUT(1)=CH$SEND;
 16   2        END CHOUT;

 17   1        DISPLAY:PROCEDURE(NUM); /* DISPLAYS A BYTE VALUE ON THE CRT */
 18   2          DECLARE (NUM,J) BYTE; J=100;
 20   2          DO WHILE J>0;
 21   3            CALL CHOUT(NUM/J+'0'); /* DISPLAY AN ASCII CHARACTER */
 22   3            NUM=NUM MOD J;
 23   3            J=J/10;
 24   3          END;
 25   2        END DISPLAY;


 26   1        MESSAGE:PROCEDURE(STARTADDR);  /*SENDS STRING TO CRT-UP TO EOM*/
 27   2          DECLARE STARTADDR ADDRESS,(CH$MESS BASED STARTADDR)BYTE;
 28   2          DO WHILE CH$MESS<>EOM;
 29   3            CALL CHOUT(CH$MESS);
 30   3            STARTADDR=STARTADDR+1;
 31   3          END;
 32   2        END MESSAGE;

 33   1        LOCATE:PROCEDURE(Y,X);  /* LOCATES CURSOR TO POSITION ON CRT */
 34   2          DECLARE (Y,X,I) BYTE,
                  HOME(*)BYTE DATA(1BH,12H,EOM),
                  RIGHT(*)BYTE DATA(10H,EOM),
                  DOWN(*)BYTE DATA(0AH,EOM);
 35   2            CALL MESSAGE(.HOME);  /* HOME CURSOR */
 36   2              DO I=1 TO Y;
 37   3                CALL MESSAGE(.DOWN);  /* MOVE CURSOR DOWN */
 38   3              END;
 39   2              DO I=1 TO X;
 40   3                CALL MESSAGE(.RIGHT); /* MOVE CURSOR RIGHT */
 41   3              END;
 42   2          END LOCATE;


 43   1        THRESHOLD=40;  /* SET THE THRESHOLD TO DECIDE
                                 IF A KEY WAS PRESSED */
 44   1        COMMAND=10011000B; /* INITIALIZE PORTS */
            /* A-INPUT, B-OUTPUT, C-CONTROL */
 45   1        CALL MESSAGE(.CLEARSCREEN); /* CLEAR THE SCREEN */


 46   1        DO COUNT=0 TO 63; /* GETS INITIAL VALUES FOR ARRAY */
 47   2          LAST$VALUE(COUNT)=VALUE;
 48   2        END;


 49   1        DO FOREVER;
 50   2          MAX$VALUE=0; /* ZERO OUT INITIAL VALUES */
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```
 51   2          KEY$PUSHED=0;
 52   2          DO COUNT=0 TO 63;
 53   3            VOLTAGE=VALUE; /* GET INITIAL VOLTAGE READING */
                   /* IF VOLTAGE VALUE IS LESS THAN LAST VALUE, THEN
                      UPDATE THE ARRAY VALUE */
 54   3            IF LAST$VALUE(COUNT)>VOLTAGE THEN          \
 55   3               LAST$VALUE(COUNT)=VOLTAGE;
 56   3            DIFFERENCE=VOLTAGE-LAST$VALUE(COUNT); /* DETERMINE THE
                                                          DIFFERENCE */
 57   3            IF DIFFERENCE>MAX$VALUE THEN DO;
 59   4               MAX$VALUE=DIFFERENCE; /* EXCHANGE VALUES IF LARGEST YET */
 60   4               KEY$PUSHED=COUNT;
 61   4               END;
 62   3          END;  /* END 0-63 LOOP */
 63   2        IF MAX$VALUE>THRESHOLD THEN DO; /* IF A VALID PUSH */
 65   3          CALL LOCATE(1,1); /* POSITION THE CURSOR */
 66   3          CALL DISPLAY(KEY$PUSHED); /* DISPLAY THE VALUE */
 67   3          END;
 68   2        END;  /* END DO FOREVER LOOP */
 69   1        END KYBD;  /* END KYBD PROGRAM */


DULE INFORMATION:

     CODE AREA SIZE      = 01CBH     459D
     VARIABLE AREA SIZE = 004EH      78D
     MAXIMUM STACK SIZE = 0006H       6D
     127 LINES READ
     0 PROGRAM ERROR(S)

ND OF PL/M-80 COMPILATION
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SIS-II OBJECT LOCATER V3.0 INVOKED BY:
-LOCATE :F9:KYBD.LNK TO :F9:KYBD.LOC COLUMNS(2) RESTARTO CODE(100H)&
*       SYMBOLS LINES PURGE PRINT(:F9:KYBD.MAP)

YMBOL TABLE OF MODULE KYBD
EAD FROM FILE :F9:KYBD.LNK
RITTEN TO FILE :F9:KYBD.LOC

ALUE TYPE SYMBOL                                      VALUE TYPE SYMBOL

      MOD  KYBD
2BH  SYM  MEMORY                                      02DDH SYM  COUNT
0EH  SYM  MAXVALUE                                    02DFH SYM  DIFFERENCE
E0H  SYM  KEYPUSHED                                   02E1H SYM  THRESHOLD
F2H  SYM  VOLTAGE                                     02E3H SYM  LASTVALUE
00H  SYM  CLEARSCREEN                                 0103H SYM  BLANKS
1C1H SYM  VALUE                                       01E5H SYM  CHOUT
23H  SYM  CHSEND                                      01FBH SYM  DISPLAY
324H SYM  NUM                                         0325H SYM  J
46H  SYM  MESSAGE                                     0326H SYM  STARTADDR
267H SYM  LOCATE                                      0328H SYM  Y
329H SYM  X                                           032AH SYM  I
06H  SYM  HOME                                        0109H SYM  RIGHT
10BH SYM  DOWN
1C1H LIN      3                                       01C1H LIN      4
1C8H LIN      5                                       01CFH LIN      6
1D4H LIN      7                                       01DDH LIN      8
1E0H LIN      9                                       01E5H LIN     10
1E5H LIN     11                                       01E9H LIN     13
F2H  LIN     14                                       01F5H LIN     15
1FAH LIN     16                                       01FBH LIN     17
1FFH LIN     19                                       0204H LIN     20
0DH  LIN     21                                       0223H LIN     22
36H  LIN     23                                       0242H LIN     24
245H LIN     25                                       0246H LIN     26
24CH LIN     28                                       0255H LIN     29
25CH LIN     30                                       0263H LIN     31
266H LIN     32                                       0267H LIN     33
26DH LIN     35                                       0273H LIN     36
282H LIN     37                                       0288H LIN     38
8FH  LIN     39                                       029EH LIN     40
A4H  LIN     41                                       02ABH LIN     42
10DH LIN     43                                       0115H LIN     44
19H  LIN     45                                       011FH LIN     46
2DH  LIN     47                                       013AH LIN     48
141H LIN     49                                       0141H LIN     50
146H LIN     51                                       014BH LIN     52
159H LIN     53                                       015FH LIN     54
16EH LIN     55                                       017AH LIN     56
189H LIN     57                                       0191H LIN     59
197H LIN     60                                       019DH LIN     61
19DH LIN     62                                       01A4H LIN     63
1AEH LIN     65                                       01B5H LIN     66
1BCH LIN     67                                       01BCH LIN     68
1BFH LIN     69
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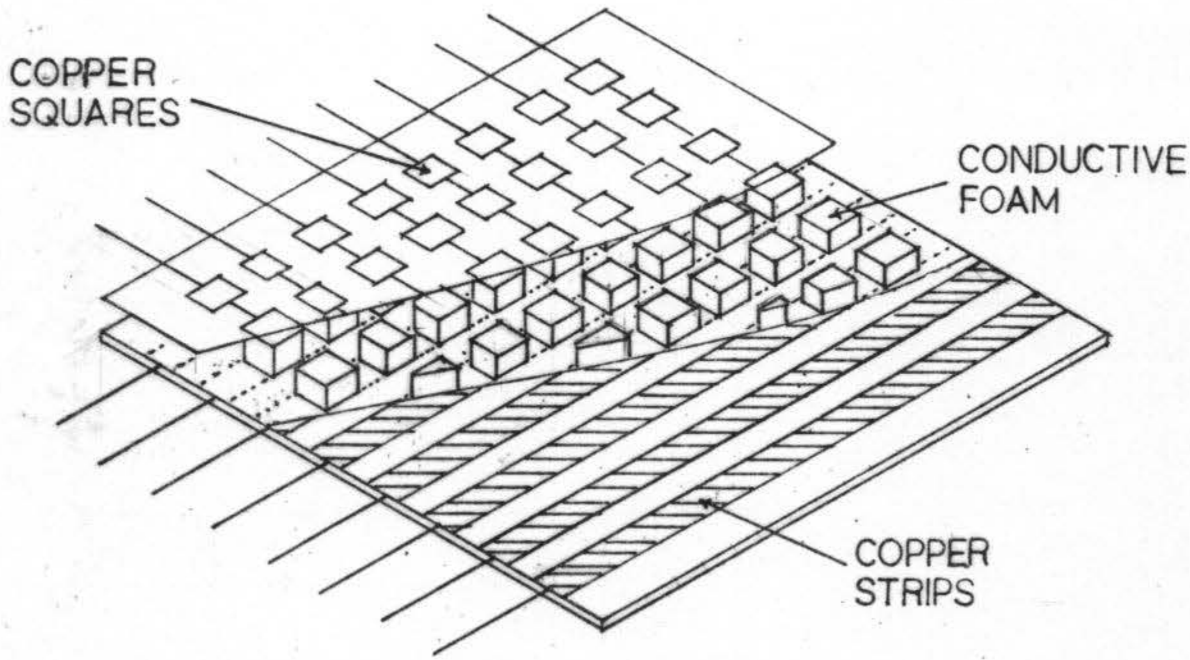
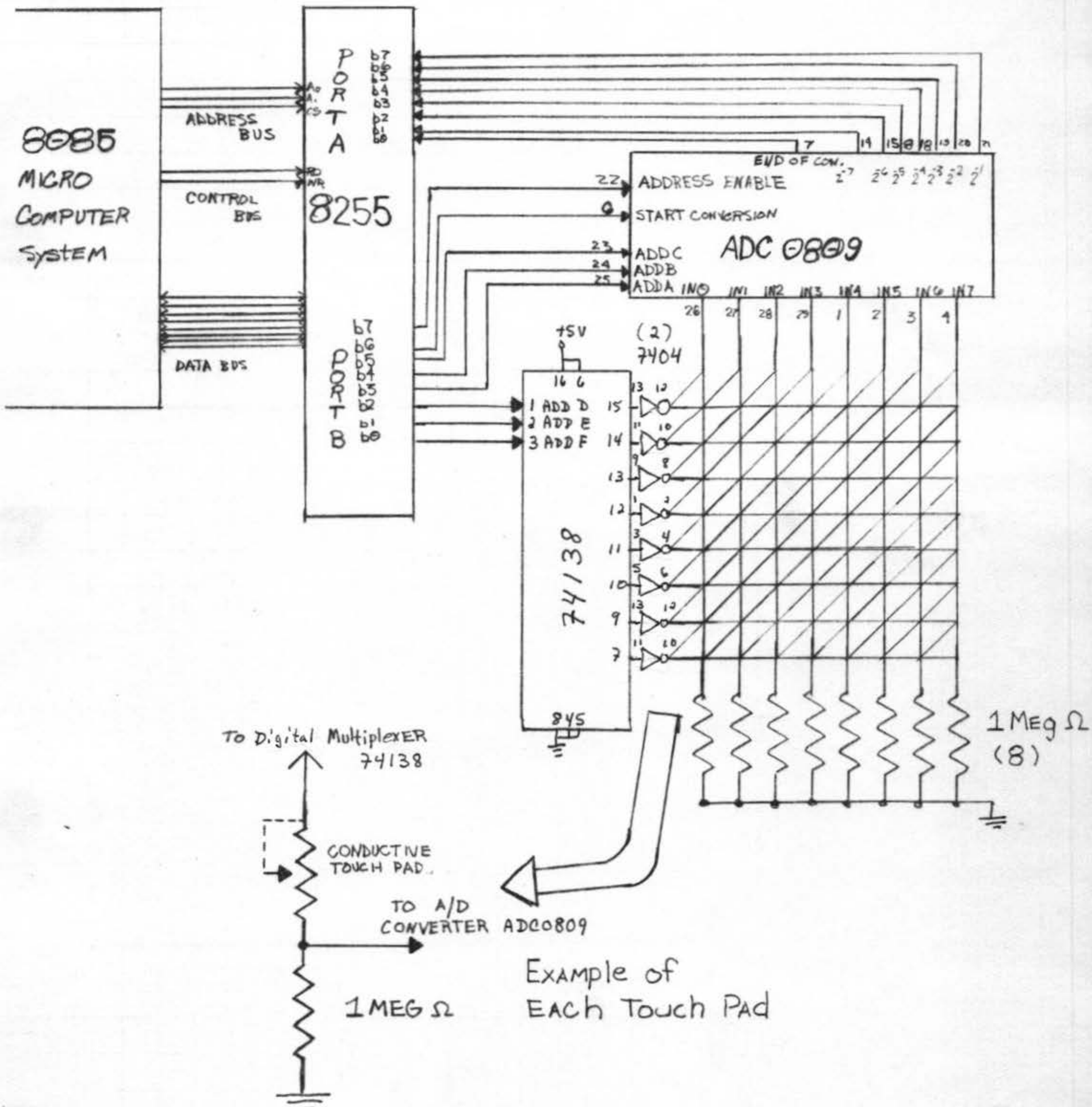

COPPER SQUARES
CONDUCTIVE FOAM
COPPER STRIPS


8085 MICRO COMPUTER System
ADDRESS BUS
CONTROL BUS
DATA BUS
PORT A
8255
PORT B
END OF CON.
ADDRESS ENABLE
START CONVERSION
ADDC
ADDB
ADDA
ADC 0809
IN0 IN1 IN2 IN3 IN4 IN5 IN6 IN7
+5V
(2) 7404
1 ADD D
2 ADD E
3 ADD F
74138
1 Meg Ω (8)
To Digital MultiplexER 74138
CONDUCTIVE TOUCH PAD
TO A/D CONVERTER ADC0809
1 MEG Ω
Example of Each Touch Pad