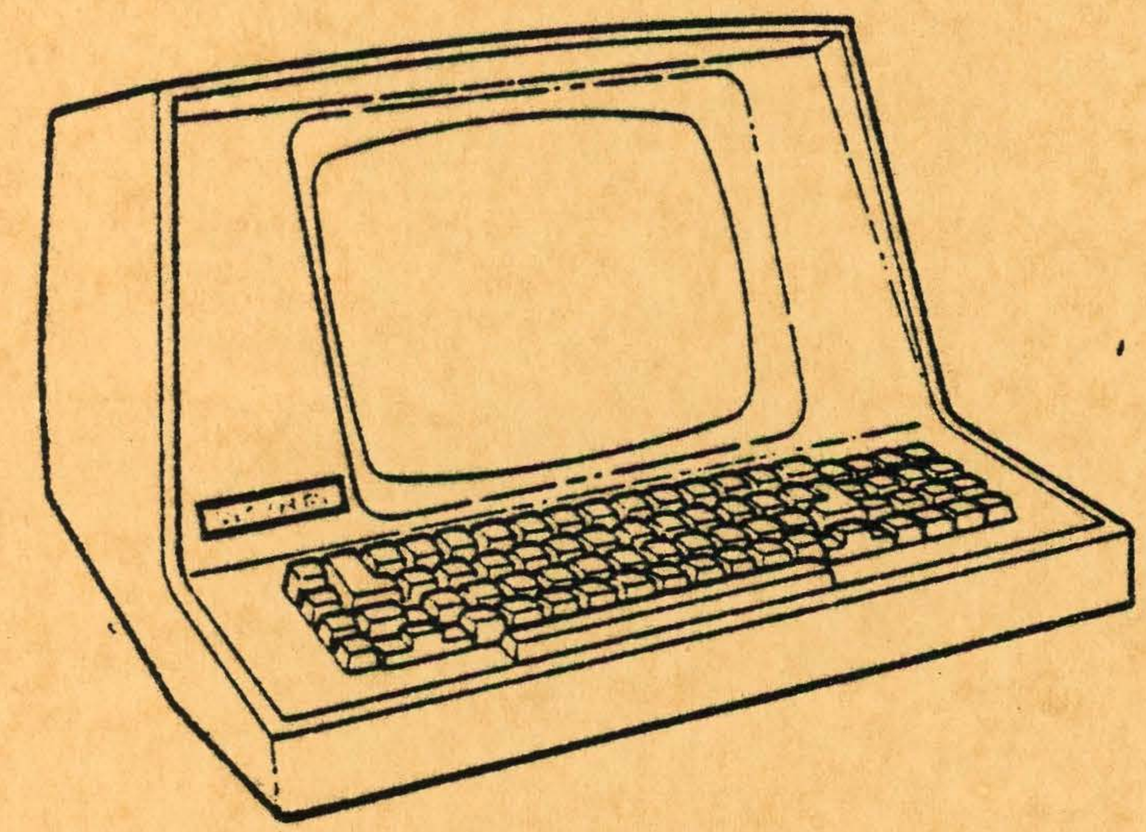
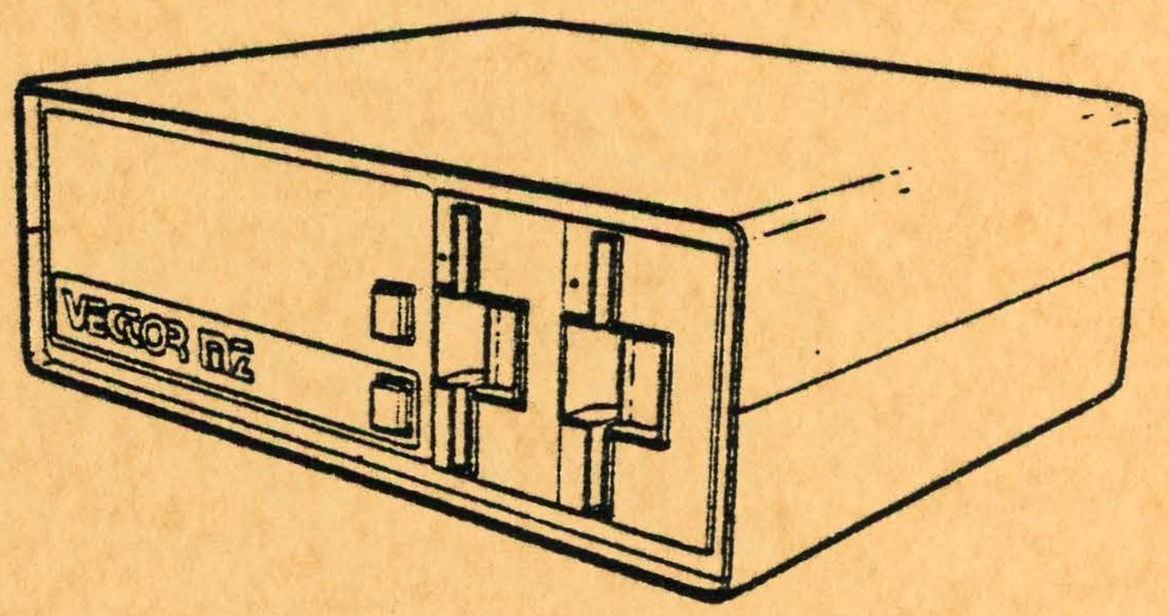
HIGH RESOLUTION GRAPHICS

USERS MANUAL





VECTOR

VECTOR GRAPHIC, INC.

TABLE OF CONTENTS

I. INTRODUCTION

1.1 SPECIFICATIONS

Bus Compatibility	S-100
Other Boards Required	Vector Graphic 8K Static RAM board Uses all 8K for screen memory
Monitor Required	Standard raster scan, taking composite video (cannot use Vector Graphic Mindless Terminal)
Resolution	Digital: 256 Horizontal 240 Vertical Gray Scale: 128 Horizontal 120 Vertical
Output	Composite video, conforming to RS-170
Switch Selectable Options	Digital or 16-level gray scale mode CPU wait state during screen refresh
Other Controls	Horizontal position
Other Features	Card extractors Cables for connection to 8K board
Power	8V @ 0.6A 8K Memory: 8V @ 1.5A additional

1.2 DESCRIPTION OF THE BOARD

The Vector Graphic High Resolution Graphics Display board provides the small computer user with the ability to generate graphic displays with 256 by 240 resolution elements in the digital mode or 128 by 120 pixels with 16 intensity levels in the gray scale mode. The 1:1 aspect ratio is compatible with the format for slow scan TV. The board is equally useful to display the output of a fast scan TV digitizer. Possible applications include image processing, feature extraction, storage scope replacement for inherently slow scans such as spectrum analyzers, transmission of images over voice

lines for remote surveillance, automated design, and a multitude of applications that the low cost of microcomputers and advanced peripherals will make practical for the first time.

This board must be used in conjunction with a Vector Graphic 8K Static RAM board, ordered separately. The TV monitor used with the board must be a standard TV monitor, which accepts COMBINED video and sync. The Vector Graphic Mindless Terminal cannot be used, although it may be included in the same system using a separate video board.

A variety of software is available for graphic displays, some of which is available from your dealer. Other software is available in the personal computing literature which has been written for older, lower resolution displays but which can be adapted with minor changes. At the back of this manual you will find a program which includes an x-y driver which plots or erases points on the screen which may be addressed as locations on a 256 by 256 grid. Such a driver is the basis for adapting most software.

If you develop programs for the display that would be of interest to others, please send us a source listing with an explanation on either tarbell tape, Micropolis disk, North star disk, or CP/M disk and we will try to include a limited amount under your authorship in future manuals.

1.3 DESCRIPTION OF THE MANUAL

This manual provides a discussion of the theory of operation of the High Resolution Graphics Display board, and a User's Guide explaining how to install and use the board.

II. THEORY OF OPERATION

The High Resolution Graphics Display board consists of the circuitry necessary to display high quality images and patterns on a standard raster scan TV monitor.

The Graphics board is used in conjunction with a Vector Graphic 8K Static Ram board (used for screen memory) and the two boards are interconnected by means of 5 jumper cables which are included with the Graphics board.

The High Resolution Graphics Display can be divided into five functional groups:

Horizontal sync

Vertical sync

Memory

Memory control

Video

2.1 HORIZONTAL SYNC

The horizontal sync circuitry consists of the necessary logic to produce a suitable horizontal synchronization signal for use by a TV monitor. A quartz crystal controlled oscillator produces a frequency of 14.318 MHz which must be counted down to produce the required horizontal sync pulse at the 15.75 KHz rate. The 14.318 MHz clock is first divided by two by A5 and the resulting 7.875 MHz is applied to the horizontal counters formed by A3 and A4. Using 74LS161 synchronous 4 bit binary counters which are preset to 56 results in a count of 456, thus the resultant output is 15.75 KHz. Preloading of the horizontal counters occurs when A4 generates a carry signal and A5-10 is set at the next clock occurrence. The resulting output is logically ANDed by B5 with the carry signal and applied to counters A3-9 and A4-9. As the 74LS161 requires that presetting be synchronous with the clock, this circuitry fulfills this requirement.

The same signal that is used to preset the counters is applied to A2, a 74221 dual one-shot, to produce a variable horizontal delay signal adjustable by the 10K potentiometer located at the top edge of the board. The 74221 timing components are adjustable to produce a delay of 2-20 micro-seconds. The trailing edge of the horizontal delay signal is used to fire the other half of the 74221 one-shot which is set up to produce a 5 micro-second horizontal sync pulse. This signal, with the horizontal delay signal, is then applied to gating logic formed by A1 to create a combined horizontal and vertical sync signal.

The horizontal blanking signal is formed by B3, a 74LS109 flip flop. The output from A5-10, count C7, is applied to the J and K inputs of B3. B3 is set by the leading edge of C1 and remains set for the duration of C7 which is 35.75 micro-seconds, at which time it is reset and blanking occurs for approximately 27 micro-seconds.

2.2 VERTICAL SYNC

The vertical sync circuitry on the High Resolution Graphics Display board consists of counting and timing logic to generate proper sync and blanking signals for use by a TV monitor.

Using the 15.75 KHz horizontal sync signal as a clock for the vertical counters formed by two 74LS161 synchronous 4 bit binary counters and flip flop B3, a total count of 262 is obtained. A proper vertical sync signal is created from counts 240 to 244 and vertical blanking occurs from counts 240 to 262. Counts 240-244 are created by the logical AND of C10, C11 and count 240. Count 240 is the carry output of counter B1. The leading edge of vertical sync causes the latch created by B4 to be set and generates vertical blank. This latch remains set until 261 occurs which clears the latch and also presets the vertical counters. 261 is created by the logical AND of C8, C10 and the carry outputs of counters B1 and B2.

The vertical sync signal is applied to the gating logic formed by A1 and the vertical blanking is applied to nand gate B5 and logically OR'ed with the horizontal blanking signal.

2.3 MEMORY CONTROL

The High Resolution Graphics Display board has the circuitry required to multiplex the address and data signals to the 8K memory board used as screen refresh memory. The board logic must be able to allow memory to be addressed by both the CPU and the video counters formed by the horizontal and vertical counters and allow transfer of data to and from the CPU as well as data to the TV monitor in the form of video information.

By replacing the control logic IC's on the 8K memory board with the Graphic board jumper cables the task of address and data control is transferred to the Graphics board.

The address lines to the memory are now multiplexed with the outputs of the video counters thus allowing access to the memory array by the CPU or the video counters. Board addressing is still determined by the address select switch on the 8K board as previous. If the user required access to the screen memory by the CPU, control would be gained when BOARD ENABLE was true, thus setting the tri state enables on the video counter buffers off and enabling the CPU bus address buffers.

The R/W control signal to the memory array is now formed by the logical AND of BOARD ENABLE and MWRITE. When data is to be read into the CPU, the data bus drivers are enabled by the AND of BOARD ENABLE, SMEMR and PDBIN.

2.4 VIDEO

The high resolution graphics board is capable of generating displays in two general formats:

Digital (on/off) mode

Gray scale mode

In the digital mode the display screen is defined as 256 horizontal x 256 vertical screen positions. Each element is equal to one bit of memory.

256 (horizontal) x 256 (vertical) = 65,536 bits
= 8192 bytes.

Since it is impractical to display the entire vertical field, only 240 vertical positions are actually displayed.

The memory data to be converted to a video compatible format is read byte by byte in a sequential manner as accessed by the addresses established by the video counters.

This data is received on the graphics board by an eight bit parallel shift register formed by D4 and D5. Data is clocked into this register by the trailing edge of count CO which occurs about 558 nsec after the address is true. This permits enough time for memory access requirements to be fulfilled. The latched data is then applied to a multiplexer, D6, which creates two 4 bit nibbles and outputs the most significant nibble first, least significant nibble last, to a 4 line to 1 line multiplexer which selects and outputs a serial stream of data at a 3.58 MHz rate.

In the gray scale mode of operation the 4 bit nibbles of data drive a 4 bit digital-to-analog convertor formed by a 7406 and appropriate scaling resistors to generate 16 levels of gray scale including black and white. The current from these resistors is applied to a current mirror consisting of Q1 and Q2 which produces a current in the collector of Q2 identical to the current in the collector/base of Q1. Since the input impedance is very low, the input currents are linearly independent of one another. The output current produces a video output and with the other sections of the 7406, a composite video signal including sync and blanking is formed.

III. USERS GUIDE

3.1 INSTALLATION

The High Resolution Graphics Display board is used in conjunction with a Vector Graphic 8K static RAM board. The 8K board must be ordered as a separate item, so that user's already possessing one can use the one they have.

To connect the two boards together first remove the IC's installed in locations J3, J4, J5, J6, and J7 on the 8K memory board.

On a flat surface place the 8K memory component-side up. Gently place the Graphics board on top of the memory board so that the dip connectors line up with the empty sockets on the memory board. Carefully insert the dip connector from J7 on the Graphics board into the socket marked J7 on the memory. In a similar manner repeat for J3 to J6. The results should look exactly as shown in Figure 1.

The two boards may now be inserted in your motherboard.

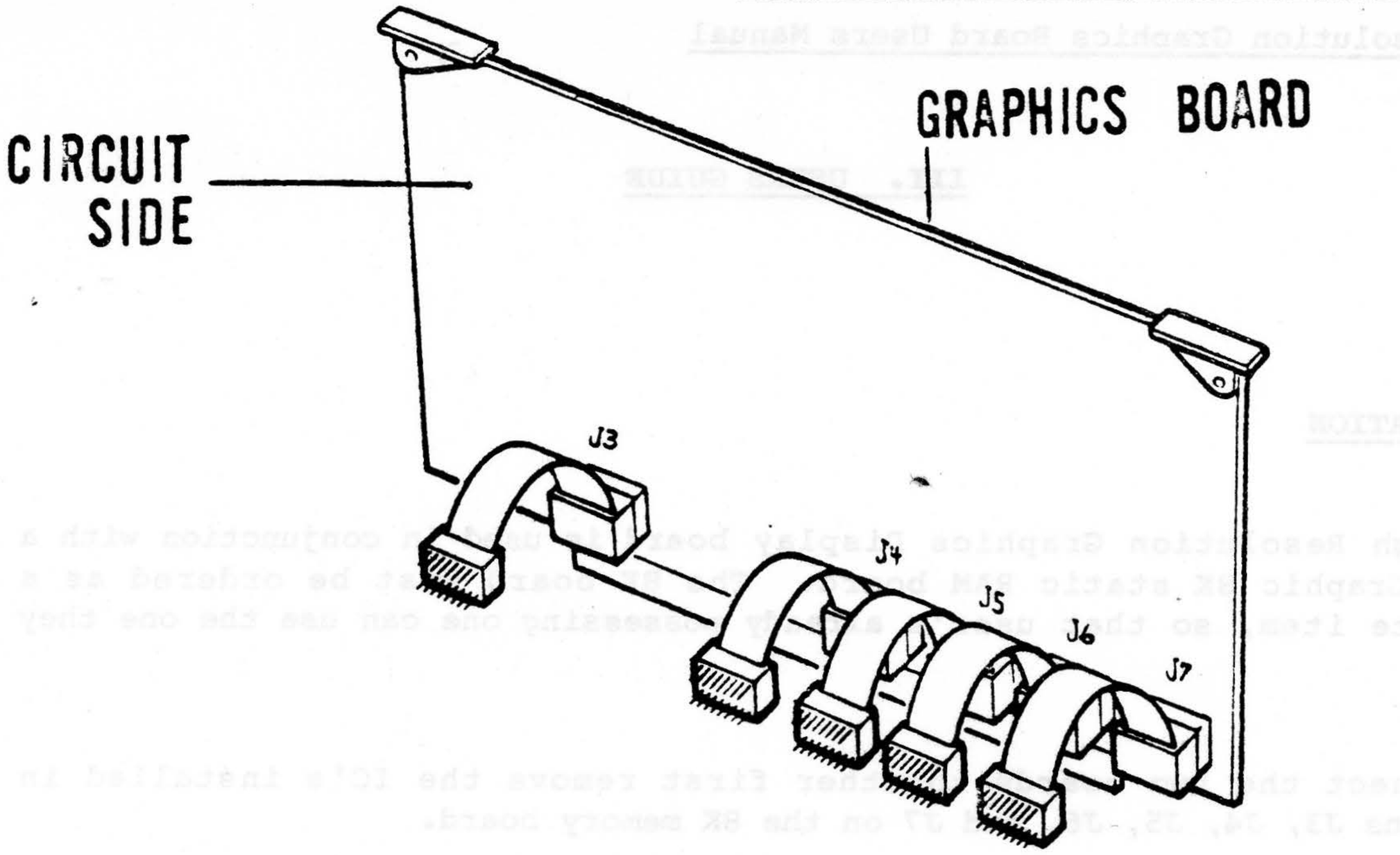


FIGURE 1

CONNECTING GRAPHICS BOARD

3.2 MEMORY ADDRESS

On the upper right-hand corner of the 8K board, you will find a dipswitch that controls the memory address space occupied by the 8K board. You may use any 8K segment up to FFFFH available in your system. In 32K systems, A000 to BFFF is usually used, while in the more recent 48K systems, E000 to FFFF must be used. The dipswitch is set as shown in the following table. Press a lever up for 1, down for 0. The most significant digit (A15) is on the left edge of the switch, and the digits continue to the right in the same order as in the table. The right-hand lever is not used for addressing -- it MUST be pressed up. (The down position write-protects the board, obviously not desired for this application.) Refer to the manual for the 8K board for information about other features of that board.

ADDRESS RANGE	SWITCH SETTING (1=ON)
0000 - 1FFF	0001
2000 - 3FFF	0011
4000 - 5FFF	0101
6000 - 7FFF	0111
8000 - 9FFF	1001
A000 - BFFF	1011
C000 - DFFF	1101
E000 - FFFF	1111

MEMORY ADDRESS SELECT ON 8K BOARD

3.3 DIGITAL OR GRAY SCALE

The dip switch on the High Resolution Graphics Display board permits the user to choose between digital video output (256 horizontal x 240 vertical) or gray scale video (128 horizontal x 120 vertical). Refer to Figure 2, below. Of the two levers identified as Digital Video and Gray Scale, one must be in the up (ON) position, and the other must be in the down (OFF) position. (If they are both in the ON position, the board will not work properly, but nothing will be harmed.)

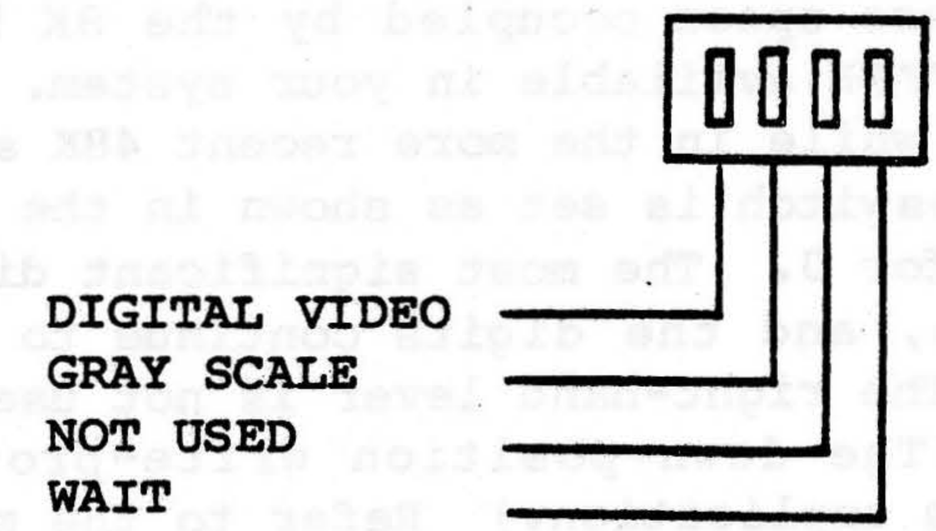


FIGURE 2 DIPSWITCH ON GRAPHICS BOARD

3.4 WAIT STATE

As shown in Figure 2, the dipswitch on the Graphics board also allows the user to choose between normal operation with no wait states or select a wait signal output. If the wait state is selected, it permits glitch free updating of the display by only allowing memory to be accessed during horizontal blanking. If the memory is accessed during the unblanked portion of the horizontal sweep, the CPU enters a wait state. When blanking occurs, the CPU is permitted to access memory. Note that if the wait signal is generated, consideration must be given to devices such as disk drives which may not be able to operate with wait states. Thus if graphics data is to be stored or retrieved from disk, it should be first loaded into normal RAM and then moved into the graphics memory. Of course if the wait is not selected, memory operates at full speed.

3.5 VIDEO OUTPUT

The output video is available on the two pin connector J1 located at the top of the Graphics board. Ground is the right hand pin when you are facing the component side of the board.

3.6 PROGRAMMING DISPLAY MEMORY

The correspondence between the contents of the 8K memory segment and the image on the screen is as follows. (A "pixel" is an area on the screen consisting of a 2 X 2 square of digital points or an equally sized area of gray coloration.)

In the gray scale mode, the second 4 bits in memory produce a gray scale pixel in the upper left-hand corner of the screen. The first 4 bits produce the pixel immediately to the right of this, as shown in Figure 3 below. Moving to the right, this pattern is repeated for the next higher byte in memory. The first line of 128 pixels on the screen are thus produced by the first 64 bytes of memory; the second 64 bytes then produce the second line on the screen, and so on. This continues for 120 lines of pixels, which use up most of the 8K. The remaining part of the 8K is NOT displayed. (I.e. the last 200 Hex bytes of the memory space are not used.)

In the digital mode, the second 4 bits in memory are mapped into the first pixel in the upper left-hand corner of the screen as shown below in Figure 3. The first 4 bits are mapped into the second pixel, also as shown in Figure 3. This continues from left to right and down the screen, just as in gray scale mode. The important point to remember is that the points are stored in memory pixel by pixel. As with the gray scale mode, the last 200 Hex bytes of the 8K memory space are not displayed. At the end of this manual, you will find a demonstration program. Near the end of this program you will find an XY plotter which can be used to set or erase any point (in digital mode) using X-Y coordinates.

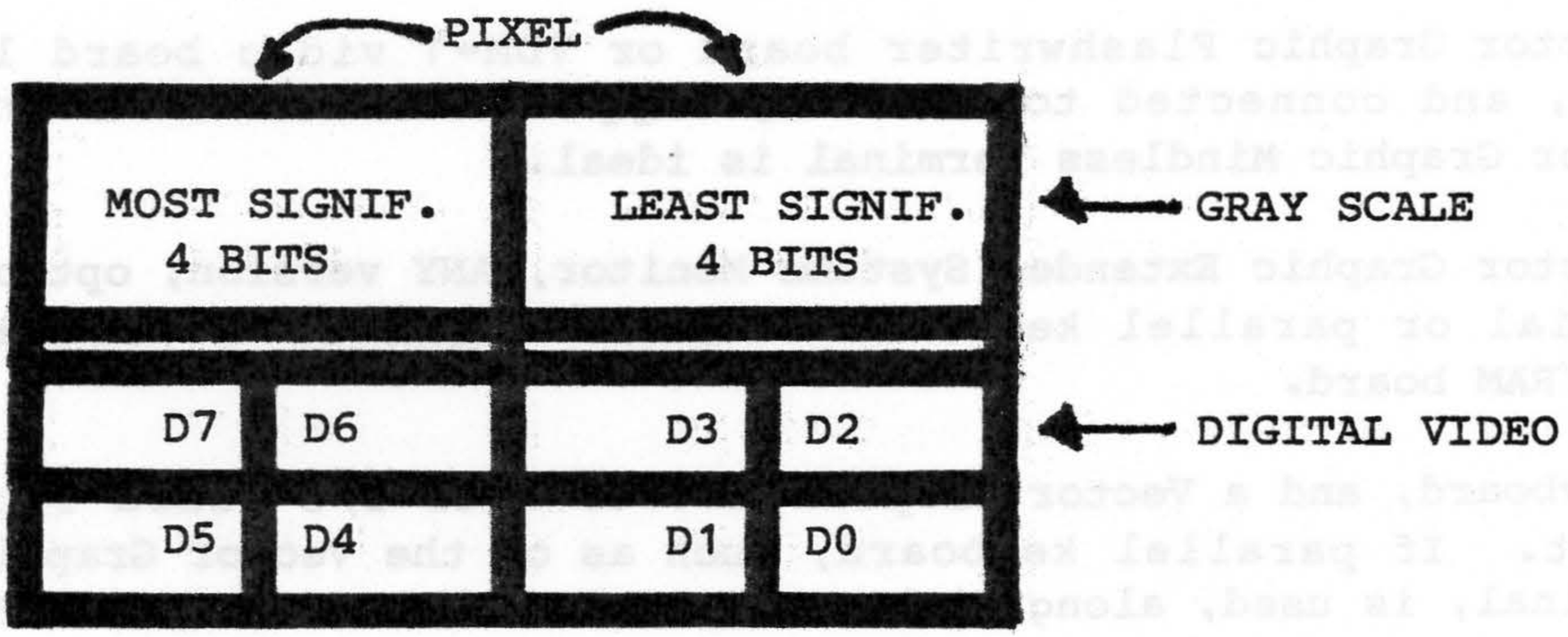


FIGURE 3 MAPPING OF MEMORY BY GRAPHICS BOARD

3.7 GRAPHICS DEMO DISK

As a separate item, a Graphics Demo Disk can be purchased that shows off the versatility of the High Resolution Graphics Display board. It includes a number of high resolution images, in both digital and gray scale modes, produced by TV digitizers, an alphanumeric output driver enabling use of the board as a terminal, and several demonstration programs. Among these programs is a simple language called "ROBOT" which can be used to create remarkable patterns on the screen.

3.8 ROBOT

The program entitled ROBOT is presented in the following pages as an Assembler listing. The code is also available on the Graphics Demo Disk, purchased separately. The use of this program is explained fully in the September, 1977 issue of Dr. Dobbs Journal. However, once the code is loaded and running, simply depress E on the keyboard in order to view a demonstration of its capabilities. If you then wish to go further, the program allows you to create infinite varieties of patterns such as the ones E will cause displayed.

The minimum equipment required is:

S-100 computer such as Vector MZ, or Vector 1, 1+, or 1++.

At least 8K of memory beginning at 0000.

A Vector Graphic Flashwriter board or VDM-1 video board located at D000, and connected to a memory mapped monitor. Flashwriter plus Vector Graphic Mindless Terminal is ideal.

A Vector Graphic Extended Systems Monitor, ANY version, option CV or EV (serial or parallel keyboard respectively), on a Vector Graphic PROM/RAM board.

A keyboard, and a Vector Graphic Bitstreamer I/O board for keyboard input. If parallel keyboard, such as on the Vector Graphic Mindless Terminal, is used, along with a Flashwriter board, then the Flashwriter keyboard port can be used instead of a Bitstreamer board.

High Resolution Graphics Display board with 8K of memory addressed at A000 or E000.

A second video monitor, one accepting combined video and sync, connected to the Graphics board.

Load the code at 0000 by any means possible. (Using the Demo Disk, just type "ROBOT" while under MDOS.) If the Graphics board is addressed at E000, then the program must be patched at two places before it can be used. Change 0296H and 0362H from A0 to E0.

Once the program is running, you can create your own displays by creating "macros". If you type control-X, then the program will save these macros within itself so that they become permanent. Remember to save the new program on disk or tape so that they are not lost.

3.9 A CHARACTER GENERATOR AND DISPLAY PROGRAM

Following ROBOT in this manual, you will find the listing for a character generator and display program. This program is used to display ASCII characters on the screen via the High Resolution Graphics Display board. As with ROBOT, it must be patched to run at E000 if the Graphics board is addressed at E000. The appropriate steps have the constants "BLOCK" and "BLOC" in them, which must be changed from A000 and A0 to E000 and E0 respectively. To make it easy, reassemble the program, changing only the EQUATES at the beginning. To use the program, call it with the desired ASCII code in the A register.

This program DOES NOT emulate standard memory mapped video boards. The High Resolution Graphics Display Board cannot display more than 32 5 X 7 characters on one line of the screen.

```
0000                    0010 * INTERACTIVE ROBOT CONTROL LANGUAGE *
0000                    0020 * WITH VECTOR GRAPHIC HI RES PLOT ROUTINE *
0000                    0030 * DR. DOBBS, SEPT. 1977.
0000                    0040 * R.S.HARP 1/29/78
0000                    0050 *
0000                    0060 * DEFINITIONS AND CONSTANTS
0000                    0070 *
0000                    0090 FLASH  EQU   0D000H        FLASHWRITER
0000                    0100 FLSH   EQU   0D0H
0000                    0110 HIRES  EQU   0A000H
0000                    0120 HRES   EQU   0A0H
0000                    0140 STACK  EQU   1FF0H         STACK LOCATION
0000                    0150 SEED   EQU   STACK
0000                    0155 BORW   EQU   SEED+2
0000                    0158 X      EQU   SEED+3
0000                    0160 Y      EQU   SEED+4
0000                    0162 DX     EQU   SEED+5
0000                    0164 DY     EQU   SEED+6
0000                    0165 SFLAG  EQU   SEED+7
0000                    0166 PTCN   EQU   0C098H        MONITOR OUTPUT
0000                    0170 CNTLC  EQU   0C0DCH        MONITOR CNTL C
0000                    0180 *
0000                    0190 * COMMANDS AND OPERATORS *
0000                    0200 *
0000                    0210 * A  ACCUMULATOR
0000                    0220 * B  BLACK TRACE
0000                    0230 * C  CLEAR SCREEN
0000                    0240 * D  DEFINE MACRO
0000                    0250 * F  FORWARD ONE STEP
0000                    0260 * H  HOME TO CENTER
0000                    0270 * N  FACE NORTH
0000                    0280 * R  ROTATE 45 DEG RIGHT
0000                    0285 * S  SENSE TRACE
0000                    0290 * T  TEST ACC FOR ZERO
0000                    0300 * W  WHITE TRACE
0000                    0310 * ' '  NO OPERATION
0000                    0320 * (,)  AS IN ALGEBRA
0000                    0330 * DEL  BACKSPACE
0000                    0340 * ?  RANDOM CHOICE
0000                    0350 * +,-  ACC OPERATIONS
0000                    0360 * (X)  SAVE PROG & RETURN TO MON
0000                    0370 *
0000                    0380 *
0000 31 F2 1F           0390 START  LXI   SP,SEED+2
0003 CD B0 02           0400        CALL  WHITE+1
0006 CD C0 02           0410        CALL  NORTH+1
0009 AF                 0415        XRA   A
000A D3 C8              0420        OUT   0C8H
000C CD 92 02           0422        CALL  CLEAR+1
000F CD B7 02           0424        CALL  HOME+1
0012 11 00 04           0430        LXI   D,MENU
0015 21 00 D0           0440        LXI   H,FLASH
0018 1A                 0450 I1     LDAX  D
0019 77                 0460        MOV   M,A
001A 13                 0470        INX   D
001B 23                 0480        INX   H
001C 7C                 0490        MOV   A,H
001D FE D4              0500        CPI   FLSH+4
001F C2 18 00           0510        JNZ   I1
0022 21 41 3D           0520        LXI   H,'=A'
0025 22 3A D0           0530        SHLD  FLASH+3AH
0028 21 30 30           0540        LXI   H,'00'
002B 22 3C D0           0550        SHLD  FLASH+3CH
002E 22 3E D0           0560        SHLD  FLASH+3EH
0031 31 F0 1F           0570 DIRCT  LXI   SP,STACK
0034 21 00 D0           0580 D1     LXI   H,FLASH
0037 06 20              0590 D2     MVI   B,32
0039 36 20              0600 D3     MVI   M,' '
003B 23                 0610        INX   H
003C 05                 0620        DCR   B
003D C2 39 00           0630        JNZ   D3
0040 0E 7F              0640        MVI   C,7FH
0042 CD B9 00           0650        CALL  FIND
0045 CA 37 00           0660        JZ    D2
0048 60                 0670        MOV   H,B
0049 68                 0680        MOV   L,B
004A 11 00 D0           0690        LXI   D,FLASH
004D CD 5D 00           0700        CALL  RCMD
0050 21 00 D0           0710        LXI   H,FLASH
0053 50                 0720        MOV   D,B
0054 58                 0730        MOV   E,B
0055 06 FF              0740        MVI   B,-1
0057 CD 5D 00           0750        CALL  RCMD
005A C3 34 00           0760        JMP   D1
005D                    0770 *
005D CD 8D 00           0780 RCMD   CALL  GETCH
0060 CD DC C0           0790 CMD    CALL  CNTLC
0063 C2 31 00           0800        JNZ   DIRCT
0066 E5                 0810        PUSH  H
0067 CD D1 00           0820        CALL  RESRV
006A 78                 0830        MOV   A,B
006B C2 71 00           0840        JNZ   C1
006E B7                 0850        ORA   A
006F E3                 0860        XTHL
0070 C9                 0870        RET
0071                    0880 *
0071 B7                 0890 C1     ORA   A
0072 E1                 0900        POP   H
0073 C8                 0910        RZ
0074 E5                 0920        PUSH  H
0075 CD B9 00           0930        CALL  FIND
0078 C2 8B 00           0940        JNZ   C2
007B E5                 0950        PUSH  H
007C 21 C0 F7           0960        LXI   H,-DANGR
007F 39                 0970        DAD   SP
0080 7C                 0980        MOV   A,H
0081 B7                 0990        ORA   A
0082 FA 31 00           1000        JM    DIRCT
0085 E1                 1010        POP   H
0086 23                 1020        INX   H
```

```
0087 23          1030         INX   H
0088 CD 5D 00    1040         CALL  RCMD
008B E1          1050 C2      POP   H
008C C9          1060         RET
008D             1070 *
008D 7B          1080 GETCH   MOV   A,E
008E E6 1F       1090         ANI   31
0090 FE 1F       1100         CPI   31
0092 D2 31 00    1110         JNC   DIRCT
0095 B2          1120         ORA   D
0096 CA 9C 00    1130         JZ    G1
0099 3E 7F       1140         MVI   A,7FH
009B 12          1150         STAX  D
009C 7C          1160 G1      MOV   A,H
009D B5          1170         ORA   L
009E C2 B0 00    1180         JNZ   G3
00A1 CD 51 01    1190 G2      CALL  RNDB
00A4 CD DC C0    1200         CALL  CNTLC
00A7 CA A1 00    1210         JZ    G2
00AA E6 7F       1220         ANI   7FH
00AC 4F          1230         MOV   C,A
00AD C3 B2 00    1240         JMP   G4
00B0             1250 *
00B0 4E          1260 G3      MOV   C,M
00B1 23          1270         INX   H
00B2 7A          1280 G4      MOV   A,D
00B3 B3          1290         ORA   E
00B4 C8          1300         RZ
00B5 79          1310         MOV   A,C
00B6 12          1320         STAX  D
00B7 13          1330         INX   D
00B8 C9          1340         RET
00B9             1350 *
00B9 D5          1360 FIND    PUSH  D
00BA C5          1370         PUSH  B
00BB 21 40 D0    1380         LXI   H,FLASH+40H
00BE 11 20 00    1390         LXI   D,32
00C1 06 1E       1400         MVI   B,30
00C3 79          1410         MOV   A,C
00C4 BE          1420 F1      CMP   M
00C5 CA CE 00    1430         JZ    F2
00C8 19          1440         DAD   D
00C9 05          1450         DCR   B
00CA C2 C4 00    1460         JNZ   F1
00CD 04          1470         INR   B
00CE C1          1480 F2      POP   B
00CF D1          1490         POP   D
00D0 C9          1500         RET
00D1             1510 *
00D1 C5          1520 RESRV   PUSH  B
00D2 06 13       1530         MVI   B,19          NO. OF COMMANDS
00D4 21 49 02    1540         LXI   H,TABL
00D7 79          1550         MOV   A,C
00D8 BE          1560 V1      CMP   M
00D9 23          1570         INX   H
00DA CA F1 00    1580         JZ    V2
00DD 23          1590         INX   H
00DE 23          1600         INX   H
00DF 05          1610         DCR   B
00E0 C2 D8 00    1620         JNZ   V1
00E3 C1          1630         POP   B
00E4 21 22 02    1640         LXI   H,CMD09
00E7 3E 39       1650 DIGIT   MVI   A,'9'
00E9 B9          1660         CMP   C
00EA D8          1670         RC
00EB 79          1680         MOV   A,C
00EC D6 30       1690         SUI   '0'
00EE D8          1700         RC
00EF BF          1710         CMP   A
00F0 C9          1720         RET
00F1             1730 *
00F1 7E          1740 V2      MOV   A,M
00F2 23          1750         INX   H
00F3 66          1760         MOV   H,M
00F4 6F          1770         MOV   L,A
00F5 C1          1780         POP   B
00F6 C9          1790         RET
00F7             1800 *
00F7 C9          1810 CMDBL   RET
00F8             1820 *
00F8 CD 8D 00    1830 CMDD    CALL  GETCH
00FB E5          1840         PUSH  H
00FC CD D1 00    1850         CALL  RESRV
00FF CA 31 00    1860         JZ    DIRCT
0102 78          1870         MOV   A,B
0103 B7          1880         ORA   A
0104 C2 0B 01    1890         JNZ   CD1
0107 E1          1900         POP   H
0108 C3 5D 00    1910         JMP   RCMD
010B             1920 *
010B CD B9 00    1930 CD1     CALL  FIND
010E C2 13 01    1940         JNZ   CD2
0111 36 7F       1950         MVI   M,7FH
0113 C5          1960 CD2     PUSH  B
0114 0E 20       1970         MVI   C,' '
0116 CD B9 00    1980         CALL  FIND
0119 C2 31 00    1990         JNZ   DIRCT
011C C1          2000         POP   B
011D 71          2010         MOV   M,C
011E 23          2020         INX   H
011F 36 3D       2030         MVI   M,'='
0121 23          2040         INX   H
0122 EB          2050         XCHG
0123 E3          2060         XTHL
0124 06 00       2070         MVI   B,0
0126 CD 8D 00    2080         CALL  GETCH
0129 3E 20       2090         MVI   A,' '
012B B9          2100         CMP   C
012C C2 34 01    2110         JNZ   CD3
012F 1B          2120         DCX   D
0130 1B          2130         DCX   D
0131 12          2140         STAX  D
```

```
0132 1B          2150          DCX   D
0133 12          2160          STAX  D
0134 CD 60 00    2170 CD3      CALL  CMD
0137 D1          2180          POP   D
0138 06 FF       2190          MVI   B,-1
013A C9          2200          RET
013B             2210 *
013B CD 8D 00    2220 CMDLP    CALL  GETCH
013E 79          2230          MOV   A,C
013F FE 29       2240          CPI   ')'
0141 C8          2250          RZ
0142 CD 60 00    2260          CALL  CMD
0145 C3 3B 01    2270          JMP   CMDLP
0148             2280 *
0148 CA 67 01    2290 CMDQM    JZ    SKIP
014B CD 51 01    2300          CALL  RNDB
014E C3 7B 01    2310          JMP   TEST
0151             2320 *
0151 E5          2330 RNDB     PUSH  H
0152 2A F0 1F    2340          LHLD  SEED
0155 29          2350          DAD   H
0156 7D          2360          MOV   A,L
0157 D2 5D 01    2370          JNC   CQ1
015A EE 2D       2380          XRI   2DH
015C 6F          2390          MOV   L,A
015D 22 F0 1F    2400 CQ1      SHLD  SEED
0160 E1          2410          POP   H
0161 E6 01       2420          ANI   1
0163 C9          2430          RET
0164             2440 *
0164 C2 6D 01    2450 CMDT     JNZ   CT1
0167 CD 5D 00    2460 SKIP     CALL  RCMD
016A C3 5D 00    2470          JMP   RCMD
016D             2480 *
016D E5          2490 CT1      PUSH  H
016E 2A 3C D0    2500          LHLD  FLASH+3CH
0171 7C          2510          MOV   A,H
0172 B5          2520          ORA   L
0173 2A 3E D0    2530          LHLD  FLASH+3EH
0176 B4          2540          ORA   H
0177 B5          2550          ORA   L
0178 E1          2560          POP   H
0179 FE 30       2570          CPI   '0'
017B CA 89 01    2580 TEST     JZ    T1
017E CD 5D 00    2590          CALL  RCMD
0181 06 00       2600          MVI   B,0
0183 CD 5D 00    2610          CALL  RCMD
0186 06 FF       2620          MVI   B,-1
0188 C9          2630          RET
0189             2640 *
0189 06 00       2650 T1       MVI   B,0
018B CD 5D 00    2660          CALL  RCMD
018E 06 FF       2670          MVI   B,-1
0190 C3 5D 00    2680          JMP   RCMD
0193             2690 *
0193 C8          2700 CMDPS    RZ
```

```
0194 E5          2710          PUSH  H
0195 CD F0 01    2720          CALL  GETA
0198 E1          2730          POP   H
0199 3E 27       2740          MVI   A,27H
019B BC          2750          CMP   H
019C C2 A7 01    2760          JNZ   CPS1
019F 3E 0F       2770          MVI   A,15
01A1 BD          2780          CMP   L
01A2 C2 A7 01    2790          JNZ   CPS1
01A5 E1          2800          POP   H
01A6 C9          2810          RET
01A7             2820 *
01A7 23          2830 CPS1     INX   H
01A8 0E 08       2840 PUTA     MVI   C,8
01AA 29          2850 P1       DAD   H
01AB 7C          2860          MOV   A,H
01AC D6 64       2870          SUI   100
01AE DA B3 01    2880          JC    P2
01B1 67          2890          MOV   H,A
01B2 23          2900          INX   H
01B3 0D          2910 P2       DCR   C
01B4 C2 AA 01    2920          JNZ   P1
01B7 4C          2930          MOV   C,H
01B8 7D          2940          MOV   A,L
01B9 21 3C D0    2950          LXI   H,FLASH+3CH
01BC CD C6 01    2960          CALL  TWOD
01BF 23          2970          INX   H
01C0 79          2980          MOV   A,C
01C1 CD C6 01    2990          CALL  TWOD
01C4 E1          3000          POP   H
01C5 C9          3010          RET
01C6             3020 *
01C6 36 2F       3030 TWOD     MVI   M,'0'-1
01C8 34          3040 P3       INR   M
01C9 D6 0A       3050          SUI   10
01CB D2 C8 01    3060          JNC   P3
01CE C6 3A       3070          ADI   '0'+10
01D0 23          3080          INX   H
01D1 77          3090          MOV   M,A
01D2 C9          3100          RET
01D3             3110 *
01D3 C8          3120 CMDMS    RZ
01D4 E5          3130          PUSH  H
01D5 CD F0 01    3140          CALL  GETA
01D8 E1          3150          POP   H
01D9 7C          3160          MOV   A,H
01DA B5          3170          ORA   L
01DB 2B          3180          DCX   H
01DC C2 A8 01    3190          JNZ   PUTA
01DF E1          3200          POP   H
01E0 C9          3210          RET
01E1             3220 *
01E1 CA 5D 00    3230 CMDA     JZ    RCMD
01E4 E5          3240          PUSH  H
01E5 CD F0 01    3250          CALL  GETA
01E8 E1          3260          POP   H
```

```
01E9 E3
01EA CD 8D 00
01ED C3 2E 02
01F0
01F0 21 3C D0
01F3 CD 8D 00
01F6 E5
01F7 21 00 00
01FA D5
01FB 3E 18
01FD BC
01FE D2 02 02
0201 67
0202 54
0203 5D
0204 29
0205 29
0206 19
0207 29
0208 16 00
020A 79
020B D6 30
020D 5F
020E 19
020F D1
0210 E3
0211 CD 8D 00
0214 CD E7 00
0217 E3
0218 CA FA 01
021B 33
021C 33
021D E3
021E 3B
021F 3B
0220 E3
0221 C9
0222
0222 CD F6 01
0225 78
0226 B7
0227 C2 2E 02
022A F1
022B C3 60 00
022E
022E E3
022F 7C
0230 B5
0231 2B
0232 C2 3E 02
0235 E1
0236 06 00
0238 CD 60 00
023B 06 FF
023D C9
023E

3270            XTHL
3280            CALL    GETCH
3290            JMP     ITER
3300 *
3310 GETA       LXI     H,FLASH+3CH
3320            CALL    GETCH
3330 NUMB       PUSH    H
3340            LXI     H,0
3350 N1         PUSH    D
3360            MVI     A,24
3370            CMP     H
3380            JNC     N2
3390            MOV     H,A
3400 N2         MOV     D,H
3410            MOV     E,L
3420            DAD     H
3430            DAD     H
3440            DAD     D
3450            DAD     H
3460            MVI     D,0
3470            MOV     A,C
3480            SUI     '0'
3490            MOV     E,A
3500            DAD     D
3510            POP     D
3520            XTHL
3530            CALL    GETCH
3540            CALL    DIGIT
3550            XTHL
3560            JZ      N1
3570            INX     SP
3580            INX     SP
3590            XTHL
3600            DCX     SP
3610            DCX     SP
3620            XTHL
3630            RET
3640 *
3650 CMD09      CALL    NUMB
3660            MOV     A,B
3670            ORA     A
3680            JNZ     ITER
3690            POP     PSW
3700            JMP     CMD
3710 *
3720 ITER       XTHL
3730            MOV     A,H
3740            ORA     L
3750            DCX     H
3760            JNZ     IT1
3770            POP     H
3780            MVI     B,0
3790            CALL    CMD
3800            MVI     B,-1
3810            RET
3820 *

023E E3
023F E5
0240 C5
0241 CD 60 00
0244 C1
0245 E1
0246 C3 2E 02
0249
0249 20
024A F7 00
024C 44
024D F8 00
024F 28
0250 3B 01
0252 29
0253 31 00
0255 7F
0256 31 00
0258 3F
0259 48 01
025B 54
025C 64 01
025E 2B
025F 93 01
0261 2D
0262 D3 01
0264 41
0265 E1 01
0267 43
0268 91 02
026A 42
026B A9 02
026D 57
026E AF 02
0270 48
0271 B6 02
0273 4E
0274 BF 02
0276 52
0277 C9 02
0279 46
027A EB 02
027C 18
027D 66 03
027F 53
0280 82 02
0282
0282 CA 67 01
0285 3A F7 1F
0288 A7
0289 3E 00
028B 32 F7 1F
028E C3 7B 01
0291
0291 C8
0292 E5

3830 IT1        XTHL
3840            PUSH    H
3850            PUSH    B
3860            CALL    CMD
3870            POP     B
3880            POP     H
3890            JMP     ITER
3900 *
3910 TABL       DB      ' '
3920            DW      CMDBL
3930            DB      'D'
3940            DW      CMDD
3950            DB      '('
3960            DW      CMDLP
3970            DB      ')'
3980            DW      DIRCT
3990            DB      7FH
4000            DW      DIRCT
4010            DB      '?'
4020            DW      CMDQM
4030            DB      'T'
4040            DW      CMDT
4050            DB      '+'
4060            DW      CMDPS
4070            DB      '-'
4080            DW      CMDMS
4090            DB      'A'
4100            DW      CMDA
4110            DB      'C'
4120            DW      CLEAR
4130            DB      'B'
4140            DW      BLACK
4150            DB      'W'
4160            DW      WHITE
4170            DB      'H'
4180            DW      HOME
4190            DB      'N'
4200            DW      NORTH
4210            DB      'R'
4220            DW      RIGHT
4230            DB      'F'
4240            DW      FORWD
4250            DB      18H
4260            DW      SAVE
4262            DB      'S'
4264            DW      CMDS
4265 *
4266 CMDS       JZ      SKIP
4268            LDA     SFLAG
4269            ANA     A               SET FLAGS
4270            MVI     A,0             RESET SFLAG
4272            STA     SFLAG
4274            JMP     TEST
4275 *
4280 CLEAR      RZ
4290            PUSH    H
```

```
0293 C5                 4300          PUSH  B
0294 21 00 A0           4310          LXI   H,HIRES
0297 01 00 20           4320          LXI   B,2000H
029A 3A F2 1F           4330 CL1      LDA   BORW
029D 2F                 4340          CMA
029E 77                 4350          MOV   M,A
029F 23                 4360          INX   H
02A0 0B                 4370          DCX   B
02A1 78                 4380          MOV   A,B
02A2 B1                 4390          ORA   C
02A3 C2 9A 02           4400          JNZ   CL1
02A6 C1                 4410          POP   B
02A7 E1                 4420          POP   H
02A8 C9                 4430          RET
02A9                    4440 *
02A9 C8                 4450 BLACK    RZ
02AA AF                 4460          XRA   A
02AB 32 F2 1F           4470          STA   BORW
02AE C9                 4480          RET
02AF                    4490 *
02AF C8                 4500 WHITE    RZ
02B0 3E FF              4510          MVI   A,-1
02B2 32 F2 1F           4520          STA   BORW
02B5 C9                 4530          RET
02B6                    4540 *
02B6 C8                 4550 HOME     RZ
02B7 E5                 4560          PUSH  H
02B8 D5                 4570          PUSH  D
02B9 21 80 80           4580          LXI   H,8080H
02BC C3 FB 02           4590          JMP   DISP
02BF                    4600 *
02BF C8                 4610 NORTH    RZ
02C0 AF                 4620          XRA   A
02C1 32 F5 1F           4630          STA   DX
02C4 3C                 4640          INR   A
02C5 32 F6 1F           4650          STA   DY
02C8 C9                 4660          RET
02C9                    4670 *
02C9 C8                 4680 RIGHT    RZ
02CA E5                 4690          PUSH  H
02CB 2A F5 1F           4700          LHLD  DX
02CE 7C                 4710          MOV   A,H
02CF 85                 4720          ADD   L
02D0 CD E0 02           4730          CALL  R1
02D3 4F                 4740          MOV   C,A
02D4 7C                 4750          MOV   A,H
02D5 95                 4760          SUB   L
02D6 CD E0 02           4770          CALL  R1
02D9 67                 4780          MOV   H,A
02DA 69                 4790          MOV   L,C
02DB 22 F5 1F           4800          SHLD  DX
02DE E1                 4810          POP   H
02DF C9                 4820          RET
02E0                    4830 *
02E0 FE 02              4840 R1       CPI   2
02E2 C2 E6 02           4850          JNZ   R2
02E5 3D                 4860          DCR   A
02E6 FE FE              4870 R2       CPI   -2
02E8 C0                 4880          RNZ
02E9 3C                 4890          INR   A
02EA C9                 4900          RET
02EB                    4910 *
02EB C8                 4920 FORWD    RZ
02EC E5                 4930          PUSH  H
02ED D5                 4940          PUSH  D
02EE 2A F3 1F           4950          LHLD  X
02F1 EB                 4960          XCHG
02F2 2A F5 1F           4970          LHLD  DX
02F5 7C                 4980          MOV   A,H
02F6 82                 4990          ADD   D
02F7 67                 5000          MOV   H,A
02F8 7D                 5010          MOV   A,L
02F9 83                 5020          ADD   E
02FA 6F                 5030          MOV   L,A
02FB 22 F3 1F           5040 DISP     SHLD  X
02FE 55                 5050          MOV   D,L
02FF 5C                 5060          MOV   E,H
0300 3A F2 1F           5070          LDA   BORW
0303 B7                 5080          ORA   A
0304 CA 0D 03           5090          JZ    DIS2
0307 CD 13 03           5100          CALL  PLOT
030A D1                 5110          POP   D
030B E1                 5120          POP   H
030C C9                 5130          RET
030D                    5140 ;
030D CD 21 03           5150 DIS2     CALL  ERASE
0310 D1                 5160          POP   D
0311 E1                 5170          POP   H
0312 C9                 5180          RET
0313                    5190 *
0313                    5290 * XY PLOTTER FOR HIGH RESOLUTION VIDEO BOARD
0313                    5300 * 256 X 256 VERSION.  TWO SUBROUTINES, PLOT
0313                    5310 * AND ERASE.  CALL EITHER WITH XY ADDRESS IN
0313                    5320 * DE REGISTERS.    ROUTINE WILL SET OR RESET
0313                    5330 * THE PROPER  BIT AT THE  PROPER  ADDRESS IN
0313                    5340 * SCREEN MEMORY. ALL REGISTERS ARE PRESERVED
0313                    5350 * EXCEPT A.  CALL CLEAR TO CLEAR SCREEN.
0313                    5360 *
0313                    5370 *
0313 E5                 5430 PLOT     PUSH  H                 PLOTTING ROUTINE
0314 CD 31 03           5440          CALL  ADR
0317 F5                 5442          PUSH  PSW
0318 A6                 5444          ANA   M
0319 32 F7 1F           5446          STA   SFLAG
031C F1                 5448          POP   PSW
031D B6                 5450          ORA   M
031E 77                 5460          MOV   M,A
031F E1                 5470          POP   H
0320 C9                 5480          RET
0321                    5490 *
0321 E5                 5500 ERASE    PUSH  H                 ERASE ROUTINE
0322 CD 31 03           5510          CALL  ADR
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Rev. 1-D 3/29/79

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0325 2F                5520          CMA
0326 F5                5522          PUSH  PSW
0327 B6                5524          ORA   M
0328 2F                5526          CMA
0329 32 F7 1F          5528          STA   SFLAG
032C F1                5529          POP   PSW
032D A6                5530          ANA   M
032E 77                5540          MOV   M,A
032F E1                5550          POP   H
0330 C9                5560          RET
0331                   5570 *
0331 AF                5580 ADR      XRA   A       COMPUTE XY ADDRESS
0332 D5                5590          PUSH  D       AND PROPER MASK BIT
0333 E1                5600          POP   H       SCREEN ADDRESS IN HL
0334 B4                5610          ORA   H       MASK IN A
0335 E6 01             5620          ANI   1
0337 29                5630          DAD   H
0338 B5                5640          ORA   L
0339 E6 03             5650          ANI   3
033B 6F                5660          MOV   L,A
033C AF                5670          XRA   A
033D B4                5680          ORA   H
033E E6 04             5690          ANI   4
0340 B5                5700          ORA   L
0341 EE 05             5710          XRI   5
0343 6F                5720          MOV   L,A
0344 AF                5730          XRA   A
0345 37                5740          STC
0346 17                5750          RAL
0347 2D                5760          DCR   L
0348 F2 46 03          5770          JP    $-5
034B F5                5780          PUSH  PSW
034C 7A                5790          MOV   A,D
034D 1F                5800          RAR
034E 1F                5810          RAR
034F E6 3F             5820          ANI   63
0351 6F                5830          MOV   L,A
0352 7B                5840          MOV   A,E
0353 2F                5850          CMA
0354 D6 10             5860          SUI   16
0356 0F                5870          RRC
0357 0F                5880          RRC
0358 0F                5890          RRC
0359 F5                5900          PUSH  PSW
035A E6 C0             5910          ANI   0C0H
035C B5                5920          ORA   L
035D 6F                5930          MOV   L,A
035E F1                5940          POP   PSW
035F E6 1F             5950          ANI   31
0361 C6 A0             5960          ADI   HRES
0363 67                5970          MOV   H,A
0364 F1                5980          POP   PSW
0365 C9                5990          RET
0366                   5995 * SAVE MACROS FROM SCREEN
0366 21 00 04          6030 SAVE     LXI   H,MENU
0369 11 00 D0          6040          LXI   D,FLASH
036C 1A                6050 SLOOP    LDAX  D
036D 77                6060          MOV   M,A
036E 23                6070          INX   H
036F 13                6080          INX   D
0370 7A                6090          MOV   A,D
0371 FE D4             6100          CPI   FLSH+4
0373 C2 6C 03          6110          JNZ   SLOOP
0376 3E 04             6120          MVI   A,4
0378 CD 98 C0          6130          CALL  PTCN          CLEAR SCREEN
037B C3 00 C0          6140          JMP   0C000H        MONITOR
037E                   6142 *RESERVE BLOCK FOR SCREEN SAVE
037E                   6144          ORG   START+1024
0400                   6148 MENU     DS    1024
0800                   6150 DANGR    EQU   $+64
```

SYMBOL TABLE

ADR	0331	BLACK	02A9	BORW	1FF2	C1	0071	C2	008B
CD1	010B	CD2	0113	CD3	0134	CL1	029A	CLEAR	0291
CMD	0060	CMD09	0222	CMDA	01E1	CMDBL	00F7	CMDD	00F8
CMDLP	013B	CMDMS	01D3	CMDPS	0193	CMDQM	0148	CMDS	0282
CMDT	0164	CNTLC	C0DC	CPS1	01A7	CQ1	015D	CT1	016D
D1	0034	D2	0037	D3	0039	DANGR	0840	DIGIT	00E7
DIRCT	0031	DIS2	030D	DISP	02FB	DX	1FF5	DY	1FF6
ERASE	0321	F1	00C4	F2	00CE	FIND	00B9	FLASH	D000
FLSH	00D0	FORWD	02EB	G1	009C	G2	00A1	G3	00B0
G4	00B2	GETA	01F0	GETCH	008D	HIRES	A000	HOME	02B6
HRES	00A0	I1	0018	IT1	023E	ITER	022E	MENU	0400
N1	01FA	N2	0202	NORTH	02BF	NUMB	01F6	P1	01AA
P2	01B3	P3	01C8	PLOT	0313	PTCN	C098	PUTA	01A8
R1	02E0	R2	02E6	RCMD	005D	RESRV	00D1	RIGHT	02C9
RNDB	0151	SAVE	0366	SEED	1FF0	SFLAG	1FF7	SKIP	0167
SLOOP	036C	STACK	1FF0	START	0000	T1	0189	TABL	0249
TEST	017B	TWOD	01C6	V1	00D8	V2	00F1	WHITE	02AF
X	1FF3	Y	1FF4						

```
CC00                    0010 ; CHARACTER GENERATOR AND
CC00                    0020 ; DISPLAY PROGRAM FOR THE
CC00                    0030 ; VECTOR GRAPHICS DISPLAY
CC00                    0040 ;
CC00                    0050 ; THIS LISTING CONTAINS A
CC00                    0060 ; TEST & KEYBOARD ECHO
CC00                    0070 ; ROUTINE STARTING AT
CC00                    0080 ; LINE # 3980
CC00                    0090 ;
CC00                    0100 ; CTRL D, CLEAR SCREEN
CC00                    0110 ; CTRL H, (08) BACKSPACE
CC00                    0120 ; CTRL M, (0D) RETURN
CC00                    0130 ;
CC00                    0140 ; NOV 6,1977 * G.THURMOND
CC00                    0150 ;
CC00                    0160 ; DEFINITIONS & CONSTANTS
CC00                    0170 ;
CC00                    0180 BLOCK  EQU   0A000H        HI RES BOARD
CC00                    0190 BLOC   EQU   0AOH
CC00                    0200 KEYS   EQU   0
CC00                    0210 KEYD   EQU   1
CC00                    0220 KEYM   EQU   40H
CC00                    0230 MONIT  EQU   0C000H
CC00                    0240 ;
CC00                    0250 ;
CC00                    0260 ;
CC00 C3 95 CE           0270        JMP   TEST
CC03                    0280 CURS   DS    2
CC05                    0290 ;
CC05                    0300 ; CHARACTER DISPLAY ROUTINE
CC05                    0310 ;
CC05                    0320 ; ENTER WITH ASCII CODE IN
CC05                    0330 ; THE ACCUMULATOR.
CC05                    0340 ; THIS ROUTINE DISPLAYS THE
CC05                    0350 ; 64 CHARACTER ASCII UPPER
CC05                    0360 ; CASE SET.  IT WILL ACCEPT
CC05                    0370 ; ALL ASCII CODES, BUT WILL
CC05                    0380 ; WRITE THE LOWER CASE SET
CC05                    0390 ; IN UPPER CASE.
CC05                    0400 ;
CC05                    0410 ;
CC05 E5                 0420 DISPL  PUSH  H
CC06 D5                 0430        PUSH  D
CC07 C5                 0440        PUSH  B
CC08 F5                 0450        PUSH  PSW
CC09 21 FF 9F           0460        LXI   H,BLOCK-1
CC0C FE 04              0470        CPI   4
CC0E CA 45 CC           0480        JZ    CLEAR
CC11 2A 03 CC           0490        LHLD  CURS
CC14 F5                 0500        PUSH  PSW
CC15 3E 20              0510        MVI   A,' '
CC17 CD 63 CC           0520        CALL  WRITE
CC1A F1                 0530        POP   PSW
CC1B FE 08              0540        CPI   8
CC1D CA 54 CC           0550        JZ    BS
CC20 FE 0D              0560        CPI   0DH
CC22 CA 35 CC           0570        JZ    SCROL
CC25 FE 20              0580        CPI   20H
CC27 DA 59 CC           0590        JC    EXIT+3
CC2A CD 63 CC           0600        CALL  WRITE
CC2D 23                 0610        INX   H
CC2E 23                 0620        INX   H
CC2F 7C                 0630        MOV   A,H
CC30 FE BE              0640        CPI   BLOC+1EH
CC32 DA 56 CC           0650        JC    EXIT
CC35 21 00 A0           0660 SCROL  LXI   H,BLOCK
CC38 01 80 A1           0670        LXI   B,BLOCK+180H
CC3B 0A                 0680 SCRL1  LDAX  B
CC3C 77                 0690        MOV   M,A
CC3D 03                 0700        INX   B
CC3E 23                 0710        INX   H
CC3F 78                 0720        MOV   A,B
CC40 FE BE              0730        CPI   BLOC+1EH
CC42 C2 3B CC           0740        JNZ   SCRL1
CC45 23                 0750 CLEAR  INX   H
CC46 7C                 0760        MOV   A,H
CC47 FE BE              0770        CPI   BLOC+1EH
CC49 CA 51 CC           0780        JZ    FINI
CC4C 36 00              0790        MVI   M,0
CC4E C3 45 CC           0800        JMP   CLEAR
CC51 21 C3 BD           0810 FINI   LXI   H,BLOCK+1DC3H
CC54 2B                 0820 BS     DCX   H
CC55 2B                 0830        DCX   H
CC56 22 03 CC           0840 EXIT   SHLD  CURS
CC59 3E 5F              0850        MVI   A,5FH
CC5B CD 63 CC           0860        CALL  WRITE
CC5E F1                 0870        POP   PSW
CC5F C1                 0880        POP   B
CC60 D1                 0890        POP   D
CC61 E1                 0900        POP   H
CC62 C9                 0910        RET
CC63                    0920 ;
CC63                    0930 ;    WRITE CHARACTER
CC63                    0940 ;
CC63                    0950 ; ENTER THIS ROUTINE WITH
CC63                    0960 ; LOWER LEFT CELL LOCATION
CC63                    0970 ; IN H & L, AND THE ASCII
CC63                    0980 ; CODE IN THE ACCUMULATOR.
CC63                    0990 ;
CC63 F5                 1000 WRITE  PUSH  PSW
CC64 C5                 1010        PUSH  B
CC65 D5                 1020        PUSH  D
CC66 E5                 1030        PUSH  H
CC67 FE 60              1040        CPI   60H
CC69 DA 6E CC           1050        JC    $+2
CC6C E6 5F              1060        ANI   5FH
CC6E 26 00              1070        MVI   H,0
CC70 6F                 1080        MOV   L,A
CC71 29                 1090        DAD   H
CC72 29                 1100        DAD   H
```

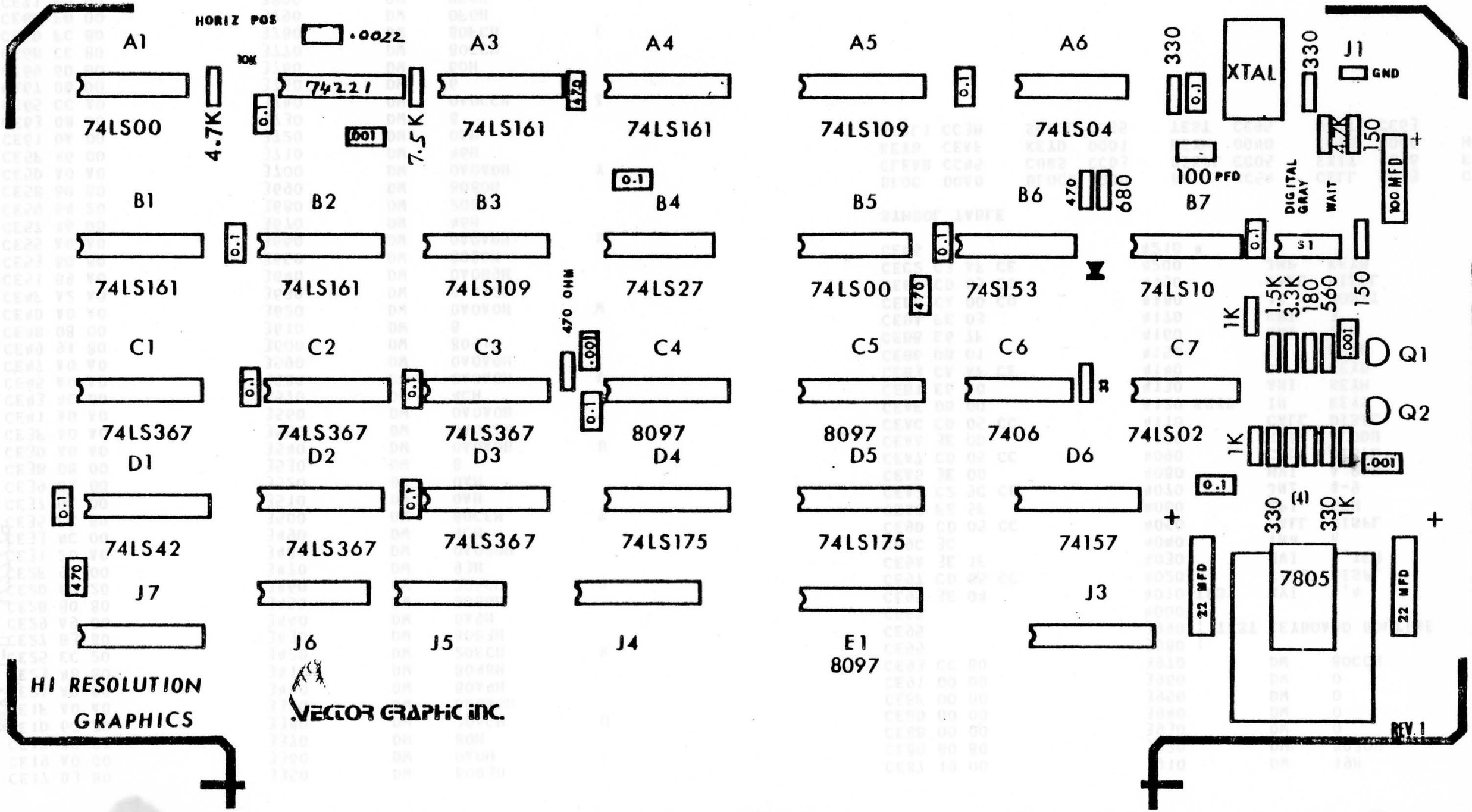
```
CC73 29                 1110          DAD   H
CC74 11 94 CB           1120          LXI   D,CHTAB-101H
CC77 19                 1130          DAD   D
CC78 E3                 1140          XTHL
CC79 11 00 FF           1150          LXI   D,-100H
CC7C 19                 1160          DAD   D
CC7D D1                 1170          POP   D
CC7E 01 3F 00           1180          LXI   B,3FH
CC81 3E 04              1190          MVI   A,4
CC83 F5                 1200 CELL     PUSH  PSW
CC84 09                 1210          DAD   B
CC85 13                 1220          INX   D
CC86 1A                 1230          LDAX  D
CC87 77                 1240          MOV   M,A
CC88 23                 1250          INX   H
CC89 13                 1260          INX   D
CC8A 1A                 1270          LDAX  D
CC8B 77                 1280          MOV   M,A
CC8C F1                 1290          POP   PSW
CC8D 3D                 1300          DCR   A
CC8E C2 83 CC           1310          JNZ   CELL
CC91 D1                 1320          POP   D
CC92 C1                 1330          POP   B
CC93 F1                 1340          POP   PSW
CC94 C9                 1350          RET
CC95                    1360 ;
CC95                    1370 ; 64 CHARACTER VERSION
CC95                    1380 ; ASCII TO 5X7 CHARACTER
CC95                    1390 ; DATA TABLE.
CC95                    1400 ;
CC95                    1410 ;
CC95 00 00              1420 CHTAB    DW    0               SP
CC97 00 00              1430          DW    0
CC99 00 00              1440          DW    0
CC9B 00 00              1450          DW    0
CC9D 0A 00              1460          DW    0AH             !
CC9F 0A 00              1470          DW    0AH
CCA1 08 00              1480          DW    8
CCA3 08 00              1490          DW    8
CCA5 55 00              1500          DW    55H             "
CCA7 44 00              1510          DW    44H
CCA9 00 00              1520          DW    0
CCAB 00 00              1530          DW    0
CCAD 55 00              1540          DW    55H             #
CCAF DD 80              1550          DW    80DDH
CCB1 DD 80              1560          DW    80DDH
CCB3 44 00              1570          DW    44H
CCB5 1B 20              1580          DW    201BH           $
CCB7 9B 00              1590          DW    9BH
CCB9 3B 80              1600          DW    803BH
CCBB 08 00              1610          DW    8
CCBD F0 20              1620          DW    20F0H           %
CCBF 06 00              1630          DW    6
CCC1 61 20              1640          DW    2061H
CCC3 04 80              1650          DW    8004H
CCC5 62 00              1660          DW    62H             &
CCC7 98 00              1670          DW    98H
CCC9 A9 80              1680          DW    80A9H
CCCB 48 80              1690          DW    8048H
CCCD 0A 00              1700          DW    0AH
CCCF 08 00              1710          DW    8
CCD1 00 00              1720          DW    0
CCD3 00 00              1730          DW    0
CCD5 18 00              1740          DW    18H
CCD7 A0 00              1750          DW    0A0H
CCD9 90 00              1760          DW    90H
CCDB 08 00              1770          DW    8
CCDD 09 00              1780          DW    9
CCDF 00 A0              1790          DW    0A000H
CCE1 01 80              1800          DW    8001H
CCE3 08 00              1810          DW    8
CCE5 2A 20              1820          DW    202AH
CCE7 4E 00              1830          DW    4EH
CCE9 6E 20              1840          DW    206EH
CCEB 08 00              1850          DW    8
CCED 02 00              1860          DW    2
CCEF 3B 20              1870          DW    203BH
CCF1 0A 00              1880          DW    0AH
CCF3 00 00              1890          DW    0
CCF5 00 00              1900          DW    0
CCF7 00 00              1910          DW    0
CCF9 0A 00              1920          DW    0AH
CCFB 40 00              1930          DW    40H
CCFD 00 00              1940          DW    0
CCFF 33 20              1950          DW    2033H
CD01 00 00              1960          DW    0
CD03 00 00              1970          DW    0
CD05 00 00              1980          DW    0
CD07 00 00              1990          DW    0
CD09 00 00              2000          DW    0
CD0B 08 00              2010          DW    8
CD0D 00 20              2020          DW    2000H           /
CD0F 06 00              2030          DW    6
CD11 60 00              2040          DW    60H
CD13 00 00              2050          DW    0
CD15 6C 20              2060          DW    206CH           0
CD17 A6 A0              2070          DW    0A0A6H
CD19 E0 A0              2080          DW    0A0E0H
CD1B 4C 00              2090          DW    4CH
CD1D 1A 00              2100          DW    1AH             1
CD1F 0A 00              2110          DW    0AH
CD21 0A 00              2120          DW    0AH
CD23 4C 00              2130          DW    4CH
CD25 6C 20              2140          DW    206CH           2
CD27 03 80              2150          DW    8003H
CD29 60 00              2160          DW    60H
CD2B CC 80              2170          DW    80CCH
CD2D CC A0              2180          DW    0A0CCH          3
CD2F 07 00              2190          DW    7
CD31 20 A0              2200          DW    0A020H
CD33 4C 00              2210          DW    4CH
CD35 07 00              2220          DW    7               4
```

```
CD37 65 00      2230        DW    65H
CD39 CD 80      2240        DW    80CDH
CD3B 04 00      2250        DW    4
CD3D EC 80      2260        DW    80ECH       5
CD3F CC 20      2270        DW    20CCH
CD41 20 A0      2280        DW    0A020H
CD43 4C 00      2290        DW    4CH
CD45 1C 80      2300        DW    801CH       6
CD47 B3 00      2310        DW    0B3H
CD49 A0 A0      2320        DW    0A0A0H
CD4B 4C 00      2330        DW    4CH
CD4D CC A0      2340        DW    0A0CCH      7
CD4F 06 00      2350        DW    6
CD51 50 00      2360        DW    50H
CD53 40 00      2370        DW    40H
CD55 6C 20      2380        DW    206CH       8
CD57 93 80      2390        DW    8093H
CD59 A0 A0      2400        DW    0A0A0H
CD5B 4C 00      2410        DW    4CH
CD5D 6C 20      2420        DW    206CH       9
CD5F 93 A0      2430        DW    0A093H
CD61 01 80      2440        DW    8001H
CD63 C8 00      2450        DW    0C8H
CD65 00 00      2460        DW    0           :
CD67 08 00      2470        DW    8
CD69 08 00      2480        DW    8
CD6B 00 00      2490        DW    0
CD6D 00 00      2500        DW    0           ;
CD6F 08 00      2510        DW    8
CD71 0A 00      2520        DW    0AH
CD73 40 00      2530        DW    40H
CD75 06 00      2540        DW    6           <
CD77 60 00      2550        DW    60H
CD79 42 00      2560        DW    42H
CD7B 04 00      2570        DW    4
CD7D 00 00      2580        DW    0           =
CD7F CC 80      2590        DW    80CCH
CD81 CC 80      2600        DW    80CCH
CD83 00 00      2610        DW    0
CD85 42 00      2620        DW    42H         >
CD87 04 20      2630        DW    2004H
CD89 06 00      2640        DW    6
CD8B 40 00      2650        DW    40H
CD8D 6C 20      2660        DW    206CH       ?
CD8F 06 00      2670        DW    6
CD91 08 00      2680        DW    8
CD93 08 00      2690        DW    8
CD95 6C 20      2700        DW    206CH       @
CD97 AB A0      2710        DW    0A0ABH
CD99 AC 00      2720        DW    0ACH
CD9B 4C 80      2730        DW    804CH
CD9D 19 00      2740        DW    19H         A
CD9F A0 A0      2750        DW    0A0A0H
CDA1 EC A0      2760        DW    0A0ECH
CDA3 80 80      2770        DW    8080H
CDA5 EC 20      2780        DW    20ECH       B
CDA7 B3 80      2790        DW    80B3H
CDA9 A0 A0      2800        DW    0A0A0H
CDAB CC 00      2810        DW    0CCH
CDAD 6C 20      2820        DW    206CH       C
CDAF A0 00      2830        DW    0A0H
CDB1 A0 20      2840        DW    20A0H
CDB3 4C 00      2850        DW    4CH
CDB5 EC 20      2860        DW    20ECH       D
CDB7 A0 A0      2870        DW    0A0A0H
CDB9 A0 A0      2880        DW    0A0A0H
CDBB CC 00      2890        DW    0CCH
CDBD EC 80      2900        DW    80ECH       E
CDBF B3 00      2910        DW    0B3H
CDC1 A0 00      2920        DW    0A0H
CDC3 CC 80      2930        DW    80CCH
CDC5 EC 80      2940        DW    80ECH       F
CDC7 B3 00      2950        DW    0B3H
CDC9 A0 00      2960        DW    0A0H
CDCB 80 00      2970        DW    80H
CDCD 6C 80      2980        DW    806CH       G
CDCF A0 00      2990        DW    0A0H
CDD1 A4 A0      3000        DW    0A0A4H
CDD3 4C 80      3010        DW    804CH
CDD5 A0 A0      3020        DW    0A0A0H      H
CDD7 B3 A0      3030        DW    0A0B3H
CDD9 A0 A0      3040        DW    0A0A0H
CDDB 80 80      3050        DW    8080H
CDDD 4E 00      3060        DW    4EH         I
CDDF 0A 00      3070        DW    0AH
CDE1 0A 00      3080        DW    0AH
CDE3 4C 00      3090        DW    4CH
CDE5 00 A0      3100        DW    0A000H      J
CDE7 00 A0      3110        DW    0A000H
CDE9 20 A0      3120        DW    0A020H
CDEB 4C 00      3130        DW    4CH
CDED A1 80      3140        DW    80A1H       K
CDEF B8 00      3150        DW    0B8H
CDF1 A9 00      3160        DW    0A9H
CDF3 80 80      3170        DW    8080H
CDF5 A0 00      3180        DW    0A0H        L
CDF7 A0 00      3190        DW    0A0H
CDF9 A0 00      3200        DW    0A0H
CDFB CC 80      3210        DW    80CCH
CDFD B1 A0      3220        DW    0A0B1H      M
CDFF AA A0      3230        DW    0A0AAH
CE01 A0 A0      3240        DW    0A0A0H
CE03 80 80      3250        DW    8080H
CE05 A0 A0      3260        DW    0A0A0H      N
CE07 E2 A0      3270        DW    0A0E2H
CE09 A4 A0      3280        DW    0A0A4H
CE0B 80 80      3290        DW    8080H
CE0D 6C 20      3300        DW    206CH       O
CE0F A0 A0      3310        DW    0A0A0H
CE11 A0 A0      3320        DW    0A0A0H
CE13 4C 00      3330        DW    4CH
CE15 EC 20      3340        DW    20ECH       P
```

```
CE17 B3 80          3350        DW    80B3H
CE19 A0 00          3360        DW    0A0H
CE1B 80 00          3370        DW    80H
CE1D 6C 20          3380        DW    206CH       Q
CE1F A0 A0          3390        DW    0A0A0H
CE21 A9 80          3400        DW    80A9H
CE23 48 80          3410        DW    8048H
CE25 EC 20          3420        DW    20ECH       R
CE27 B3 80          3430        DW    80B3H
CE29 A9 00          3440        DW    0A9H
CE2B 80 80          3450        DW    8080H
CE2D 6C 20          3460        DW    206CH       S
CE2F 93 00          3470        DW    93H
CE31 20 A0          3480        DW    0A020H
CE33 4C 00          3490        DW    4CH
CE35 CE 80          3500        DW    80CEH       T
CE37 0A 00          3510        DW    0AH
CE39 0A 00          3520        DW    0AH
CE3B 08 00          3530        DW    8
CE3D A0 A0          3540        DW    0A0A0H      U
CE3F A0 A0          3550        DW    0A0A0H
CE41 A0 A0          3560        DW    0A0A0H
CE43 4C 00          3570        DW    4CH
CE45 A0 A0          3580        DW    0A0A0H      V
CE47 A0 A0          3590        DW    0A0A0H
CE49 91 80          3600        DW    8091H
CE4B 08 00          3610        DW    8
CE4D A0 A0          3620        DW    0A0A0H      W
CE4F A2 A0          3630        DW    0A0A2H
CE51 B9 A0          3640        DW    0A0B9H
CE53 80 80          3650        DW    8080H
CE55 A0 A0          3660        DW    0A0A0H      X
CE57 46 00          3670        DW    46H
CE59 64 20          3680        DW    2064H
CE5B 80 80          3690        DW    8080H
CE5D A0 A0          3700        DW    0A0A0H      Y
CE5F 46 00          3710        DW    46H
CE61 0A 00          3720        DW    0AH
CE63 08 00          3730        DW    8
CE65 CC A0          3740        DW    0A0CCH      Z
CE67 06 00          3750        DW    6
CE69 60 00          3760        DW    60H
CE6B CC 80          3770        DW    80CCH
CE6D FC 80          3780        DW    80FCH       [
CE6F F0 00          3790        DW    0F0H
CE71 F0 00          3800        DW    0F0H
CE73 CC 80          3810        DW    80CCH
CE75 20 00          3820        DW    20H         \
CE77 42 00          3830        DW    42H
CE79 04 20          3840        DW    2004H
CE7B 00 00          3850        DW    0
CE7D CD A0          3860        DW    0A0CDH      ]
CE7F 05 A0          3870        DW    0A005H
CE81 05 A0          3880        DW    0A005H
CE83 CC 80          3890        DW    80CCH
CE85 00 00          3900        DW    0           ^
CE87 19 00          3910        DW    19H
CE89 80 80          3920        DW    8080H
CE8B 00 00          3930        DW    0
CE8D 00 00          3940        DW    0
CE8F 00 00          3950        DW    0
CE91 00 00          3960        DW    0
CE93 CC 80          3970        DW    80CCH
CE95                3980 ;
CE95                3990 ; TEST KEYBOARD ROUTINE
CE95                4000 ;
CE95 3E 04          4010 TEST   MVI   A,4
CE97 CD 05 CC       4020        CALL  DISPL
CE9A 3E 1F          4030        MVI   A,1FH
CE9C 3C             4040        INR   A
CE9D CD 05 CC       4050        CALL  DISPL
CEA0 FE 5F          4060        CPI   5FH
CEA2 C2 9C CE       4070        JNZ   $-9
CEA5 3E 0D          4080        MVI   A,0DH
CEA7 CD 05 CC       4090        CALL  DISPL
CEAA 3E 0D          4100        MVI   A,0DH
CEAC CD 05 CC       4110        CALL  DISPL
CEAF DB 00          4120 KEYB   IN    KEYS
CEB1 E6 40          4130        ANI   KEYM
CEB3 CA AF CE       4140        JZ    KEYB
CEB6 DB 01          4150        IN    KEYD
CEB8 E6 7F          4160        ANI   7FH
CEBA FE 03          4170        CPI   3
CEBC CA 00 C0       4180        JZ    MONIT
CEBF CD 05 CC       4190        CALL  DISPL
CEC2 C3 AF CE       4200        JMP   KEYB
CEC5                4210 *
```

SYMBOL TABLE

BLOC	00A0	BLOCK	A000	BS	CC54	CELL	CC83	CHTAB
CLEAR	CC45	CURS	CC03	DISPL	CC05	EXIT	CC56	FINI
KEYB	CEAF	KEYD	0001	KEYM	0040	KEYS	0000	MONIT
SCRL1	CC3B	SCROL	CC35	TEST	CE95	WRITE	CC63	


HORIZ POS
A1
A3
A4
A5
A6
74LS00
74LS161
74LS161
74LS109
74LS04
4.7K
10K
.0022
74221
.001
7.5K
.1
470
330
XTAL
J1
GND
4.7K
150
100 MFD
100 PFD
B1
B2
B3
B4
B5
B6
B7
74LS161
74LS161
74LS109
74LS27
74LS00
74S153
74LS10
470 OHM
470
680
DIGITAL
GRAY
WAIT
1K
1.5K
3.3K
180
560
150
Q1
Q2
C1
C2
C3
C4
C5
C6
C7
74LS367
74LS367
74LS367
8097
8097
7406
74LS02
D1
D2
D3
D4
D5
D6
74LS42
74LS367
74LS367
74LS175
74LS175
74157
330 (4)
330
1K
470
J7
J6
J5
J4
J3
E1
8097
7805
22 MFD
22 MFD
HI RESOLUTION
GRAPHICS
VECTOR GRAPHIC INC.
REV 1

SCHEMATIC ERRATA

1. The 8097 bus driver shown on the lower right side of the schematic is NOT an inverter.

2. A2, shown on the upper right hand corner of the schematic, should be a 74221.

3. The capacitor connected to pin 14 of A2 is .0022 Mf.

4. The resistor connected to pin 16 of A2 is 4.7K.

5. The resistor connected to pin 7 of A2 is 7.5K.

ZONE	LTR

74LS04 14.318 mHz

74LS109

HORIZONTAL COUNTER
COUNT=456 PRESET=56

HORIZ POSITION

H SYNC

7 MHZ CLOCK

VERTICAL COUNTER
COUNT=262
PRESET=0

V SYNC 240-244

H DELAY

H BLANK 2
VERT BLANK 1

C SYNC

C BLANK

DIGITAL VIDEO

MODE SELECT

GRAY SCALE

ALL JK FLIP FLOPS 74LS109
ALL PRESET AND CLEAR INPUTS HIGH

M WRITE

NOTE J3,J4,J5,J7 CORRESPOND TO
SOCKETS OF MEMORY BOARD

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: DECIMALS .XX ± .02 .XXX ± .010 ANGLES ± ½°	CONTRACT NO.
MATERIAL	APPROVALS / DRAWN G.M. STROUD 1-25 / CHECKED
FINISH	
NEXT ASSY / USED ON	

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED

HORIZONTAL COUNTER
COUNT=456 PRESET=56

HORIZ POSITION

7 MHZ CLOCK

V SYNC 240-244

H SYNC

H DELAY

H BLANK

VERT BLANK

C SYNC

C BLANK

COMPOSITE VIDEO OUTPUT

J1

DIGITAL VIDEO

MODE SELECT

GRAY SCALE

PIXEL

MSB LSB GRAY SCALE

D7 D6 D3 D2 / D5 D4 D1 D0 DIGITAL VIDEO

MSB LSB

ALL JK FLIP FLOPS 74LS109
ALL PRESET AND CLEAR INPUTS HIGH

NOTE J3,J4,J5,J7 CORRESPOND TO SOCKETS OF MEMORY BOARD

+5V LM340T-5 7805 +8V

GND

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: DECIMALS .XX ± .02 .XXX ± .010 ANGLES ±½°	CONTRACT NO.	VECTOR GRAPHIC, INC. WESTLAKE VILLAGE CALIF.	
MATERIAL	APPROVALS	DATE	HIGH RESOLUTION GRAPHIC DISPLAY
FINISH	DRAWN G.M. STROUD	1-25-77	SIZE / CODE IDENT NO. / DRAWING NO.
	CHECKED		