Roger Arrick

PERCOM

THE

ELECTRIC CRAYON™

USERS MANUAL

PERCOM DATA COMPANY
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GARLAND, TEXAS 75042

the ELECTRIC CRAYON(tm)
Color Video Display Generator/Controller

USERS MANUAL

New	Dec 1979
Rev A	May 1980
Rev B	Nov 1980

PERCOM ELECTRIC CRAYON(tm)
USERS MANUAL
050-1010-001-A

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I INTRODUCTION

The Electric Crayon(tm) is a versatile color display generator/ controller. It may be connected to a computer or keyboard and a color tv set or video monitor to create a low cost, easy to use color display system.

Although intended primarily for color, the Electric Crayon(tm) may also be used to generate high resolution black and white displays.

The Electric Crayon(tm) is also a self-contained control computer with its own microprocessor and provision for an auxiliary dual-channel I/O interface -- over and above the computer/keyboard I/O -- for peripheral devices.

The Electric Crayon(tm) is capable of generating 10 display modes: an alphanumeric-semigraphics mode, a pure semigraphics mode and eight graphic modes. Depending on the mode, up to eight colors - plus black - may be used in generating a display. An internal character generator generates the standard 64-character ASCII subset consisting of capital letters, numerals, punctuation marks and selected symbols.

Included on-board is 1K of display memory (character-store memory), with provision for adding up to 5K bytes of additional refresh RAM -- 6K bytes are required for the highest density graphics modes.

Besides the refresh memory, 1K byte of program RAM may be installed.

The video output driver is designed for direct video input to a video monitor. However, the video output circuitry includes provision for user-installation of components to form a low cost modulator that will up-modulate the video for input to a tv antenna connection.

The Electric Crayon(tm) graphics operating system, called EGOS(tm), is included in an on-board ROM IC. EGOS(tm) accepts single-character commands and also communicates directly with BASIC language programs. Commands and their arguments may be supplied from a parallel output ASCII keyboard or they may be program generated and supplied via a computer output port.

The PC board includes provision to add an optional ROM for extending EGOS(tm) or adding customized utilities.

BASIC language source listings of several color graphics programs are included in the appendixes. An assembly listing of EGOS(tm) is also included in the appendix section. The BASIC programs are available on an optional Electric Crayon(tm) minidiskette.

System Requirements

1. For TRS-80* computer operation:

   a. Model I computer with Level II BASIC, 16-Kbyte memory and an Expansion Interface or Printer Adapter Cable (Radio Shack PN 26-1411).
   b. Interconnecting Cable, Percom PN 330-1010-002, or equivalent. See Appendix A7.

2. For operation with a computer other than the TRS-80* Model I, system requirements are essentially the same as set forth above. The Appendixes and Service Sheets of this manual include the information required to configure a system that does not use the TRS-80* Model I computer.

3. Display system: An NTSC color tv set or color monitor may be used as a color display system. The video output from the Electric Crayon(tm) must be converted to rf for tv sets which do not have direct video inputs -- as is the case for most tv sets. See Section II.

   An NTSC BW tv or BW monitor may also be used as a display system. As for the color tv, the Electric Crayon(tm) output video must be converted to rf for sets without direct video inputs.

4. Display Memory: The 1-Kbyte display memory (refresh memory) provide with the standard version of the Electric Crayon(tm) is adequate for operation in the alphanumeric, semi-graphics and low-density graphics modes. For higher density displays, additional display RAM must be installed. See Section II.

II HOOK-UP PROCEDURE

2.1 Introduction

The hook-up procedure consists of connecting a computer or keyboard, using the flat ribbon cable supplied, to an input of the Electric Crayon(tm), and connecting the Electric Crayon(tm) video output to a monitor or tv.

All of the Electric Crayon(tm) connectors as well as the on-off switch are located on the rear panel. The primary power cord also exits the rear panel. The connectors for a computer or keyboard and peripherals are visible through the elongated opening. The leftmost connector (viewed from the rear), referred to as the peripherals interface, is not active until an optional Peripheral Interface Adapter (PIA) IC is installed. See paragraph 2.6.4. The connector to the right, referred to as the computer interface, is used to interface to a computer or keyboard. The coaxial socket is the video output connector.

*** CAUTION ***

Be sure power is off on all equipment before beginning the hook-up procedure.

2.2 Connecting a Computer to the Electric Crayon(tm)

The following procedure is written for the TRS-80* computer but it is generally appropriate for all computers. Refer to Appendix A1 for information that may be needed to modify the interface if a different computer is used.

2.2.1 Equipment Requirements

Either an Expansion Interface or the Radio Shack Printer Interface Cable, PN 26-1411, is needed to connect a TRS-80* computer to the Electric Crayon(tm). Appendix A7 includes information for fabricating an interconnecting cable for computers other than a TRS-80* computer or for an ASCII keyboard.

2.2.1.1 Interconnecting Cable for TRS-80* Expansion Interface

An optional cable, Percom PN 330-1010-002, may be used for connecting the Electric Crayon(tm) to a TRS-80* computer with an Expansion Interface. Refer to the next-to-last page for procedures for ordering parts and optional items.

The information of Appendix A7 is also applicable for fabricating a cable for use with Expansion-Interface-equipped TRS-80* computers.

2.2.1.2 Interconnecting Cable for Printer Interface

An optional cable, Percom PN 330-1010-002, may be used for connecting the Electric Crayon(tm) to a TRS-80* computer via the Radio Shack Printer Interface Cable (PN 26-1411). Parts and options ordering information is included on the next-to-last page of this manual.

2.2.2 Procedure

The most convenient equipment arrangement is to locate the Electric Crayon(tm) to the left of the TRS-80* computer.

Plug one end of the interconnecting ribbon cable into the computer I/O PWB connector and the other end into the printer port of the Expansion Interface or the Printer Interface Cable.

NOTE: The cable exits down from each connector when properly installed.

2.3 Connecting a Keyboard to the Electric Crayon(tm)

Any parallel output ASCII-encoding keyboard may be used to operate the Electric Crayon(tm). Unless the optional PIA is installed, the keyboard must be interfaced via the computer I/O port. Refer to Appendix A1 for handshake control logic requirements, and data pinouts required to establish the hardware interface.

2.4 Connecting the Electric Crayon(tm) to a Display System

2.4.1 General Information

Video may be input to a display system either directly through a video input connector or indirectly, after up-modulation to rf, through antenna contacts. Usually the direct video input method produces a sharper display.

2.4.1.1 Coaxial Cable

Video (or rf if the optional internal modulator is used) is conducted out of the Electric Crayon(tm) via a 75-ohm coaxial cable. The information required to fabricate an appropriate cable is set forth in Appendix A2.

2.4.2 Procedure for Direct Video Input

Fabricate a 75-ohm coaxial cable using the information of Appendix A2, and connect it from the video connector of the Electric Crayon(tm) to the video input of the monitor or modified tv set.

2.4.3 Procedure for RF Input

The video output of the Electric Crayon(tm) must be up-modulated for rf input to a display system. Most tv sets will not accommodate direct video input. Refer to Don Lancaster's ''TV Typewriter Cookbook'' for a discussion of how to modify a tv for direct video input.

The video may be modulated either with an external modulator or with a modulator formed by installing components in the modulator circuit on the Electric Crayon(tm) printed wiring board.

Modulators that may be used external to the Electric

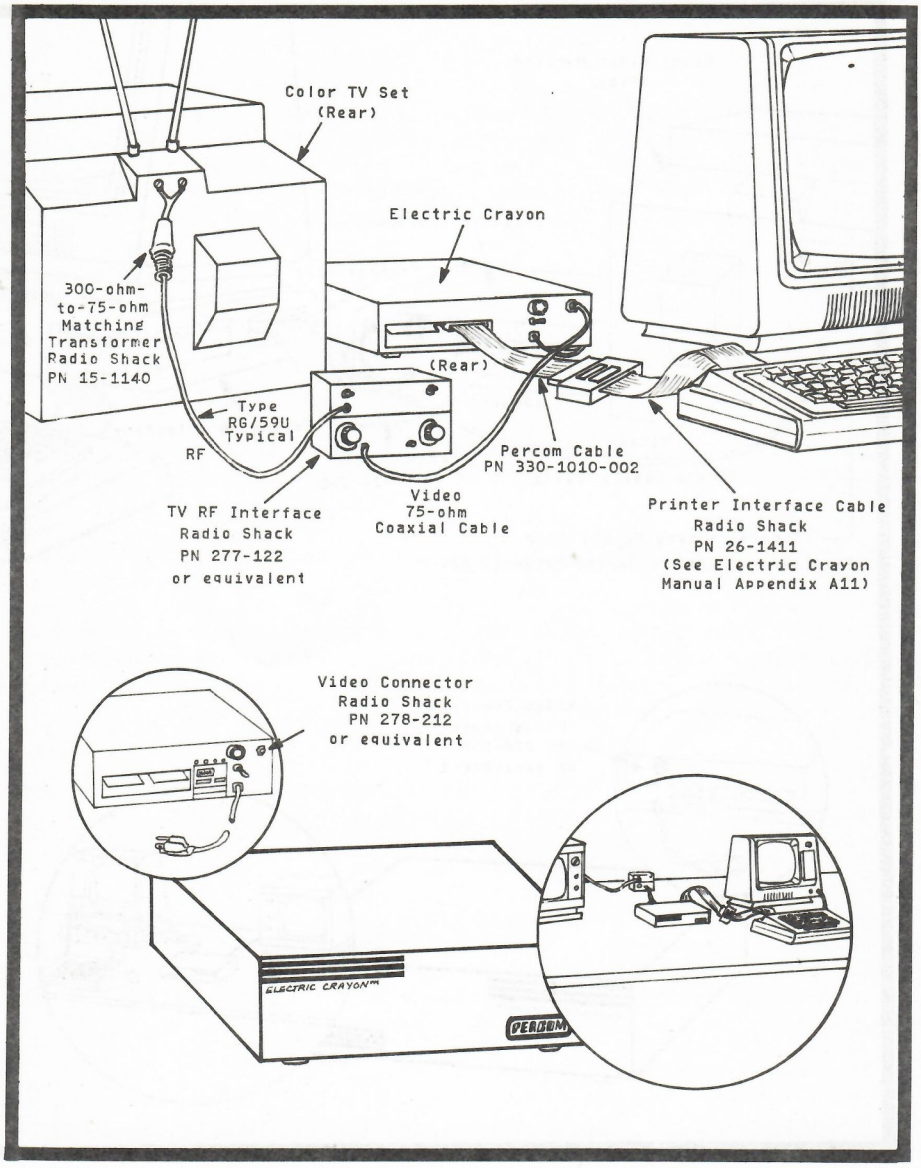

Figure 2.1 CONNECTING THE ELECTRIC CRAYON(tm) TO A COLOR TV SET AND TO THE TRS-80* COMPUTER VIA A PRINTER INTERFACE CABLE

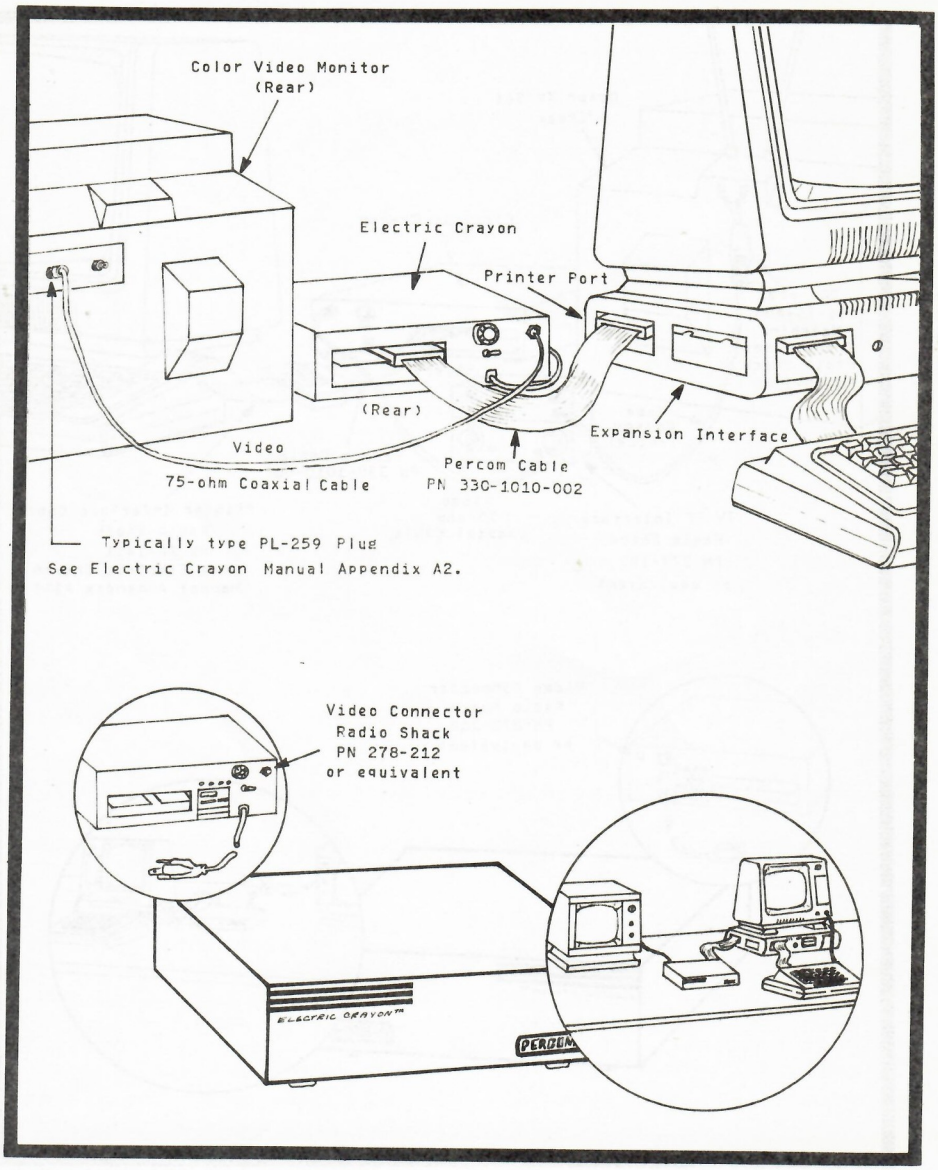

Figure 2.2 CONNECTING THE ELECTRIC CRAYON(tm) TO A COLOR VIDEO MONITOR AND TO THE TRS-80* COMPUTER VIA AN EXPANSION INTERFACE

Crayon(tm) are available from several sources including Radio Shack (PN 277-122). Appendix A12 includes information for using the Radio Shack modulator.

The procedures and parts required to convert the on-board video driver circuit to an up-modulator are covered in Appendix A3.

*** WARNING ***

The user assumes all responsibility for complying with Federal Communications Commission (FCC) regulations concerning the legal maximum levels of rf radiation if the internal modulator is installed.

An impedance matching transformer such as Radio Shack's 300- to 75-ohm Matching Transformer, part number 15-1140, may be used to connect the coaxial cable from the Electric Crayon(tm) to the tv antenna.

2.5 Connecting Peripherals to the Electric Crayon(tm)

The leftmost I/O port provides two parallel I/O channels for peripheral devices. The Electric Crayon(tm) is a complete, stand-alone control computer, and the range of peripheral devices that may be used is virtually limitless.

As previously mentioned, an optional Peripheral Interface Adapter (PIA) chip must be installed in the socket provided to enable the auxiliary peripheral I/O port. Appendix A1 includes information for making the hardware interface.

2.6 Installing Optional Circuits

NOTE: A memory map for the Electric Crayon(tm) is included in Appendix A5.

2.6.1 Additional Display Memory

The Electric Crayon(tm) includes provision for up to 6K bytes of refresh memory (character-store memory), the amount required for the highest density graphics modes. One K-byte, which is adequate for alphanumeric, semigraphics and the lower density graphics displays, is included as the initial complement of refresh RAM. Optional refresh memory may be added in 1K increments. Referring to the circuit schematic in Section V, the initial 1K of RAM is comprised of the two type 2114 memory chips, U17 and U29.

The appropriate sockets for adding RAM chip pairs (1K increments) are as follows:

U18, U30 : U19, U31 : U20, U32 : U21, U33 : U22, U34

* NOTE *

Before adding optional display memory chips, read Appendix A10, which concerns the selection of chips to ensure optimum

performance.

*** CAUTION ***

Type 2114 memory chips and all other MOS-type integrated circuits are extremely sensitive to destructive static charge build-up on the leads. When handling MOS ICs, the following precautions should be observed:

1. Wear clothes that do not create static charge.
2. Choose a place that is NOT carpeted (such as the kitchen).
3. Gather all materials and tools so that a trip to another part of the house is unnecessary.
4. Keep parts in conductive foam until they are installed.

2.6.2 Optional Program RAM

The Electric Crayon(tm) will accommodate an optional 1K byte of program memory. To install this option, add two type 2114 IC chips, identified as U25 and U26, in the circuit schematic of Section V. Observe the precaution of paragraph 2.6.1 concerning the handling of MOS circuits.

2.6.3 Optional Program ROM

An optional EPROM for special utilities or for expanding the capabilities of EGOS(tm) may be added, as U23, in the socket provided. Observe the precaution about handling MOS devices set forth in paragraph 2.6.1.

2.6.4 Optional Peripheral Interface Adapter

The peripheral I/O port may be activated by installing a type MC6821 Peripheral Interface Adapter IC, identified as U1 in the circuit schematic of Section V.. Observe the precaution set forth in paragraph 2.6.1 about handling MOS devices.

2.6.5 Internal RF Modulator

The Electric Crayon(tm) includes provision for an on-board rf modulator for up-modulating the ouput video as required for antenna input to a color tv set. Conversion of the video driver circuit to an up-modulator is covered in Appendix A3.

*** WARNING ***

The user assumes all responsibility for complying with Federal Communications Commission (FCC) regulations concerning the legal maximum levels of rf radiation if the internal modulator is installed.

III OPERATING INSTRUCTIONS

3.1 Display Modes

The Electric Crayon(tm) generates 10 different color display modes including an alphanumerics-semigraphics mode, a pure high-density semigraphics mode and eight graphics modes. Modes are selected with the M command, as discussed in paragraph 3.3. The displayed colors may be inverted (complemented) in all modes with a one-character command. The system initially ''comes up'' in mode zero.

MODE 0 -- Combination Alphanumerics-Semigraphics Mode

Alphanumeric display is 32 characters wide, 16 rows deep. Semigraphics display is 32 blocks wide, 16 blocks deep. Blocks are divided into four equal parts which may be independently lit. Blocks have the geometry shown below in the examples, and the individual parts may be illuminated as indicated. Refer to Appendix A4 for a detailed discussion.

```
|XXXXX|00000|          |XXXXX|00000|
|XXXXX|00000|          |XXXXX|00000|
|XXXXX|00000|          |XXXXX|00000|
|XXXXX|00000|          |XXXXX|00000|
|00000|XXXXX|          |00000|00000|
|00000|XXXXX|          |00000|00000|
|00000|XXXXX|          |00000|00000|
|00000|XXXXX|          |00000|00000|
```

X = illuminant 0 = extinguished

MODE 1 -- Semigraphics Mode

Similar to four-part semigraphics of Mode 0 except blocks are divided into six equal parts. Blocks have the form shown below. Refer to Appendix A4 for a detailed discussion.

```
|XXXXX|00000|          |00000|XXXXX|
|XXXXX|00000|          |00000|XXXXX|
|XXXXX|00000|          |00000|XXXXX|
|00000|XXXXX|          |XXXXX|00000|
|00000|XXXXX|          |XXXXX|00000|
|00000|XXXXX|          |XXXXX|00000|
|XXXXX|00000|          |00000|00000|
|XXXXX|00000|          |00000|00000|
|XXXXX|00000|          |00000|00000|
```

x = illuminant 0 = extinguished

MODE 2 -- 64 x 64 Graphics Mode

Display is 64 elements wide, 64 elements deep. Elements may

be either of four colors.

MODE 3 -- 128 x 64 Graphics Mode
Display is 128 elements wide, 64 elements deep. Elements may be either of four colors.

Display modes four through nine require that 1K byte to 5K bytes of additional display memory (character-store memory) be installed in the on-board sockets provided. These modes, as well as modes zero through three outlined above, are described in detail in Section IV. The procedure for installing optional refresh memory chips is included in Section II.

3.2 Display Colors
The Electric Crayon(tm) is capable of generating up to eight colors. Not all colors are available for all display modes.
Colors are selected by executing command Cn, where n is a numeral corresponding to one of the colors. All colors are available for Mode 0 semigraphics displays:

n = 0	is	green	n = 1	is	yellow
n = 2	is	blue	n = 3	is	red
n = 4	is	buff	n = 5	is	cyan
n = 6	is	magenta	n = 7	is	orange

The border for the alphanumerics-semigraphics and semigraphics modes is black. The border or background for the eight graphic modes is either green or buff, depending on whether the display is inverted or uninverted.

3.3 Commands
The graphics operating system, EGOS(tm), provides 11 commands:

A -- ALPHA COMMAND
Used to enter character strings. Type A X Y [string], where A is the command code, X is the horizontal ordinate, Y is the vertical ordinate and [string] is an alphanumeric character or line of alphanumeric characters.

Example: A 2 4 ADAM HAD 'EM. -- Displays the string ADAM HAD 'EM. beginning at two character positions to the right of the origin (upper LH corner) and four positions down.

NOTE: This command is enabled only in display MODE ZERO.

Cn -- COLOR SELECT COMMAND
Used to select colors. The numeral N determines the color. In Mode 0 semigraphics, colors are assigned as set forth in paragraph 3.2. In Mode 1 semigraphics, colors are assigned as follows: 0 = green or buff, 1 = yellow or cyan, 2 = blue or magenta, 3 = red or orange -- depending on whether the display is

inverted or uninverted. In display modes 2, 4, 6 and 8, four colors may be selected, as for Mode 1 semigraphics. The displayed colors may be inverted. In display modes 3, 5, 7 and 9, colors may be either black and green or black and buff.

NOTE: In display modes ONE through NINE, the selected (or previously selected color) may be the same as the border or background color and may not be visible unless contrasted against another color.

NOTE: Colors should be selected prior to generating display elements.

ERS -- ERASE COMMAND

This command erases the display. Caution: A display should be erased in the same mode in which it is generated. Generating a display in one mode and attempting to erase it in another mode will usually leave a noisy screen. It may also be necessary to erase AFTER changing to Mode 0.

H -- HORIZONTAL LINE COMMAND

This command generates a horizontal line in the semigraphics and graphics modes. Type H X Y L, where H is the command code, X and Y are beginning position coordinates and L represents the value of the line length.

Example: H 2 4 30 generates a 30-element line beginning at two elements to the left of the origin (upper LH corner) and 4 elements down.

NOTE: Colors and block patterns (semigraphics modes) should be selected before generating a line.

I -- INVERT COMMAND

This command inverts (complements) the set of displayed colors, including the background or border in the graphics modes.

LD* -- LOAD COMMAND

This command is used by advanced programmers to load assembly language programs into the Electric Crayon(tm) program RAM. Refer to Appendix A6.

Mn -- MODE SELECT COMMAND

Used to select the display mode. n = 0, 1, 2, ..., 9.

Pn -- PATTERN COMMAND

This command is used to determine which parts of semigraphics blocks are illuminant. For the Mode-0 4-part blocks, the value of n ranges from 0 (all parts extinguished) to 15 (all parts illuminant). In Mode 1, the value of n ranges from 0 to 63 for the 64 different patterns of the 6-part blocks. Both Mode 0 and

Mode 1 semigraphics patterns are discussed in detail in Appendix A4. The generation of all possible patterns for each mode is straightforward and is left as a checkout and familiarization procedure.

R -- REVERSE ALPHA COMMAND

Same as A (Alpha) command except characters and symbols are reversed, i.e., are displayed as dark characters on a bright background.

S -- SET

Similar to H (Horizontal line) command. S is used to 'set' a picture element at coordinates X and Y.

V -- VERTICAL LINE COMMAND

Same as the H (Horizontal Line) command except a line is generated vertically from top to bottom of the display.

3.4 Power-up

With the Electric Crayon(tm) hooked up as described in Section II, flip the on-off switch on the rear panel to On. The television set or monitor will display the following text in reverse format:

THE ELECTRIC CRAYON
BY PERCOM DATA COMPANY

The system powers up in Mode 0.

3.5 Checkout and Familiarization Procedure

NOTE

The importance of checkout and familiarization cannot be overemphasized. As with all complex electronic equipment, most problems are the result of a lack of understanding of operating procedures.

The following procedure is for operating the Electric Crayon(tm) with a TRS-80* computer, but the technique is essentially the same for other computers or for keyboard input.

3.5.1 Operation Using the LPRINT Command

(1) Erase the power up display by typing LPRINT "ERS" [E]

NOTE: In these procedures, [E] represents the TRS-80* ENTER command.

(2) Type: LPRINT "A 0 0 CHECKOUT AND FAMILIARIZATION" [E]
The words CHECKOUT AND FAMILIARIZATION will display beginning in the upper LH corner.

(3) Type: LPRINT "R 0 2 CHECKOUT AND FAMILIARIZATION" [E]
The words CHECKOUT AND FAMILIARIZATION will display in reversed format under the first string. Erase the screen.

(4) Type LPRINT "P15" [E]
P15 causes all four parts of the Mode 0 semigraphics block to be illuminant.

(5) Type: LPRINT "C0" [E]
C0 selects the color green.

(6) Type: LPRINT "S 0 0" [E]
A green semigraphics block will display at the origin.

(7) Repeat steps (5) and (6) except type C1, C2, ..., C7 in lieu of C0, and type 1 1, 2 2,.., 7 7 in lieu of 0 0. The result will be a diagonal "line" of eight different colored blocks. The color sequence will be green, yellow, blue, red, buff, cyan, magenta and orange.

3.5.2 Operation Using a BASIC Input Program

In order to simplify the manual entry and execution of commands, and to illustrate the ease with which the Electric Crayon(tm) may be operated with a computer and BASIC program, manually enter the following program in the TRS-80*.

```
10 INPUT A$
20 LPRINT A$
30 GOTO 10
```

Upon typing RUN, the TRS-80* computer will issue a question mark (?) prompt. Continue the checkout and familiarization procedure by typing and entering commands directly, i.e., without typing LPRINT.

(8) Type ERS [E] to erase the screen.

(9) Type C2 [E]

(10) Type S 0 0 [E]
A blue 4-part semigraphics block will display at the origin.

(11) Type P14 [E]

(12) Type S 1 1 [E]
The semigraphics block will display to the right and down one position from the block at the origin. The number 2 quadrant of the block will be extinguished.

(13) Repeat steps (11) and (12) except type P13, P12,..., P0

in lieu of P14 and type S 2 2, S 3 3,..., S 15 15 in lieu of S 1 1. Record each of the 16 patterns for future reference. NOTE. All four parts of the semigraphics block will be extinguished for pattern P0. Erase the screen.

(14) Type M1 [E]

(15) Type P63 [E]
P63 causes all six parts of the Mode 1 semigraphics block to be illuminant.

(16) Type C0 [E]

(17) Type H 0 0 32 [E]
A single-color, full-width ''bar'' will display across the top of the screen. The color will be either green or buff depending on whether the display mode is inverted or uninverted.

(18) Type C1 [E]

(19) Type H 0 1 32 [E]
A second bar (different color) will display across the screen.

(20) Repeat steps (18) and (19) for colors 2 and 3 and for Y ordinates 2 and 3. Four different color full length bars will be displayed.

(21) Type I [E]
The colors will invert. Enter I again to restore the original color set.

(22) Erase the screen and generate four different color vertical columns using the V (Vertical Line) command. The length argument, L, is 16 for both the M0 and M1 modes. Erase the screen.

(23) Repeat the procedure of steps (9) through (13) to generate all 64 illumination patterns of a Mode 1 6-part semigraphics block. P0 extinguishes all parts of a block and P63 causes all parts to be illuminant. Record the patterns for future reference.

At this point, all commands except LD* (Load Assembly Language Program) have been exercised. The LD* command is discussed in appendix A6. Also, the essential features of Mode 0 and Mode 1 have been explored.

3.5.3 Operation in Graphics Modes (Mode 2 -- Mode 9)
The familiarization procedures of paragraphs 3.5.1 and 3.5.2

apply as well to the full graphics modes except:

(a) neither command A (Alpha) nor command R (Reverse Alpha) are functional, and

(b) the P (Pattern) command is disabled because the display elements are not partitionable as for the semigraphics display blocks.

Modes are selected with the M command; displays should be erased after changing modes.

All modes are described in detail in Section IV. Recall that display modes four through nine require optional refresh memory.

3.5.3.1 Electric Crayon(tm) Scratchpad

Since it is usually necessary to sketch a graphics display before generating the actual CRT display, Percom has designed and printed a sketching pad for this purpose. Called the Electric Crayon(tm) Scratchpad, it consists of a grid of proportioned picture elements (pixels or pictels) on a tv 3:4-aspect-ratio layout. It may be used for the 128 x 192 or the 256 x 192 graphic modes. Scratchpads are supplied as 25-sheet tablets on 11-inch by 17-inch paper. Refer to the last page of this manual for ordering information.

3.6 Programmed Operation

Included in the Appendix section are several BASIC programs. These programs serve to demonstrate the versatile compositional capability of the Electric Crayon(tm) and to provide self-teaching programming examples. They may be entered and run in the same manner as for the three-line program of paragraph 3.5.2.

3.6.1 Disk-Stored Programs -- Electric Crayon(tm) Minidiskette

The BASIC programs mentioned above and an assembly language listing of the Electric Crayon(tm) operating system, EGOS(tm), are also available on an optional TRS-80* compatible Electric Crayon(tm) minidiskette. (Refer to the last page of this manual for ordering information.)

To load and run disk-stored programs, insert the program disk in the drive -- with the system interconnected and powered-up as described previously -- and press the computer Reset switch. For the Electric Crayon(tm) demo minidiskette, depressing the keyboard spacebar will cause selection and execution of the next program on the disk.

The Electric Crayon(tm) does not provide for cassette program or file storage.

IV DESCRIPTION

The Electric Crayon(tm) is a self-contained control computer with an integral color display generator/controller. An on-board graphics operating system, called EGOS(tm), accepts single-character commands which are used to position and generate text and multi-color graphics units such as dots, blocks and lines. Command characters and arguments may be input from a parallel ASCII keyboard or program generated and supplied via a computer output port. Either a color monitor or tv set may be used as the display unit. If a tv set is used, the video output of the controller/generator circuit must be up-modulated for antenna rf input. The Electric Crayon(tm) includes 1K byte of refresh memory and provides for adding up to 5K bytes of additional refresh RAM as required for higher density display modes. There is also provision for 1K byte of program RAM and a ROM IC for adding custom utilities.

4.1 Physical Description

The Electric Crayon(tm) PC board is mounted on stand-offs inside an enamel-finished metal chassis box which is 2-1/2 inches high by 12 inches wide by 9 inches deep. The on-off switch and all connectors are in the rear. The ac power cord also exits the rear panel. The chassis cover is held in place by two machine screws along the bottom edge of each side.

4.1.1 Rear Panel

The rear panel connectors are shown in the sketch of Figure 4.1. The Peripherals I/O interface, a 40-pin PWB plug visible through the elongated chassis opening, is on the left. The PWB plug to the right is for computer/keyboard interfacing. The video output jack is at the top.

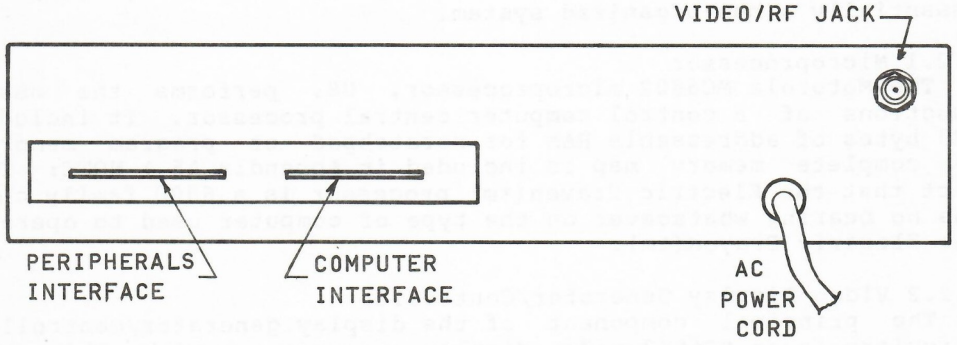

Figure 4.1 REAR PANEL CONNECTORS

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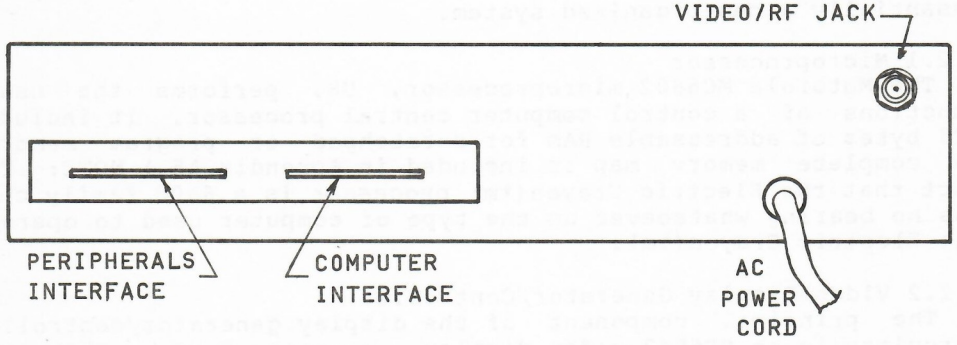


Figure 4.1 REAR PANEL CONNECTORS

4.1.2 Printed Circuit Board

A diagram of the printed circuit board (PCB) is included in Section V. Not shown is the power supply transformer, which is mounted on the bottom of the chassis, and wiring from board contacts to rear-panel-mounted components.

4.2 Functional Block Diagram Description

The following discussion is keyed to the block diagram of Figure 4.2. Refer to the circuit schematic and PC board assembly diagram of Section V when circuit component referents are mentioned.

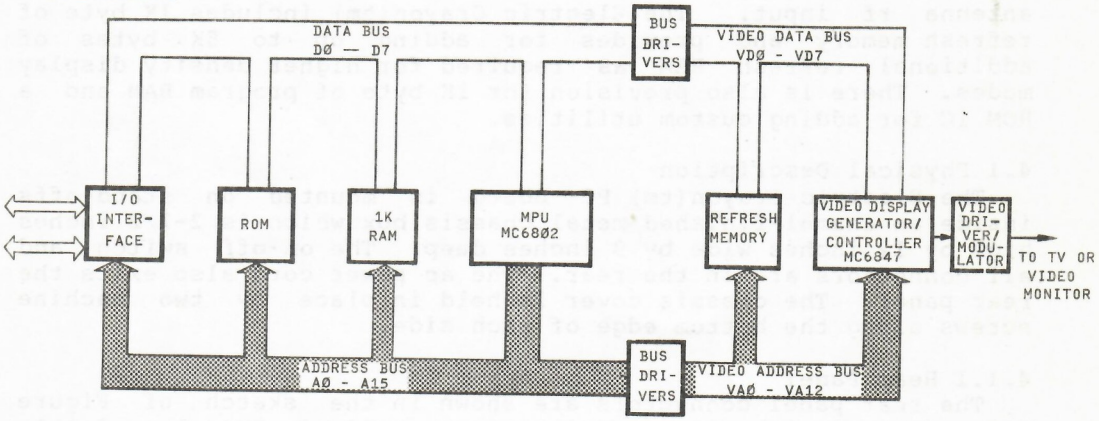


Figure 4.2 ELECTRIC CRAYON(tm) FUNCTIONAL BLOCK DIAGRAM

As suggested in Figure 4.2, the Electric Crayon(tm) is essentially a bus-organized system.

4.2.1 Microprocessor

The Motorola MC6802 microprocessor, U8, performs the usual functions of a control computer central processor. It includes 128 bytes of addressable RAM for scratchpad or program memory. (A complete memory map is included in Appendix A5.) NOTE: The fact that the Electric Crayon(tm) processor is a 6800 family chip has no bearing whatsoever on the type of computer used to operate the Electric Crayon(tm).

4.2.2 Video Display Generator/Controller

The principal component of the display generator/controller circuitry is an MC6847 video display generator, U5. This VDG chip reads data from memory to produce a composite video signal for the generation of alphanumeric, semigraphics and graphics displays. The output is suitable for either color or black and white displays. An internal character generator generates a

64-character ASCII subset. (Refer to the Mode-0 description below.) The video display generator/controller may be used to generate and compose two-, four- and eight-color graphics displays and two-color alphanumeric displays. The display modes are discussed in detail below.

4.2.3 Video Driver/Modulator

The video driver/modulator is comprised of the components associated with the printed wiring ground plane at the front LH corner of the PC board. As shipped, the Electric Crayon(tm) is capable of outputting video for direct video monitor input or for external up-modulation and antenna rf input. This is discussed in Section II. A complete internal up-modulator may be fabricated by adding a few inexpensive components to the existing driver/modulator circuit. Refer to appendix A3.

*** WARNING ***

The user assumes all responsibility for complying with Federal Communications Commission (FCC) regulations concerning the legal maximum levels of rf radiation if the internal modulator is installed.

The video driver/modulator circuit includes provision for rf audio input, but this feature had not been fully implemented at the time this manual was prepared. Implementation procedures will subseqently be made available.

4.2.4 Refresh Memory

The Electric Crayon(tm) is supplied with 1K-byte of refresh memory (character-store memory). This 1K byte consists of ICs U17 and U29, type 2114 static memory chips. The PC board includes sockets for adding up to five more K-bytes of refresh RAM as required for higher density graphics modes. Refresh memory is added as chip pairs in 1K increments as explained in Section II.

4.2.5 Read Only Memory (ROM)

Read-only memory is comprised of the EGOS(tm) operating system ROM chip, U35, and an optional ROM, U2, which -- if installed -- may be used to extend and enhance the 11-command repertoire of EGOS(tm).

4.2.6 1K RAM

One K-byte of RAM, U25 & U26 may be optionally added in sockets provided. This would typically be used in control system applications. These memory chips are also type 2114.

4.2.7 I/O Ports

The Electric Crayon includes circuitry for two, dual bidirectional parallel I/O ports. One I/O interface is referred to as the computer port and the other is referred to as the

peripherals port. The computer I/O interface is wired for direct connection to the printer output port of a TRS-80* computer. The interface may be rewired, if necessary, for other types of computers or keyboard input. Information concerning data pin assignments and handshake logic signal requirements is included in Appendix A1.

The peripherals interfacing port is not active until an optional MC6821 Peripheral Interface Adapter (PIA) -- U1 in the circuit schematic of Section V -- is installed. Appendix A1 also includes information for implementing this I/O port.

4.3 Display Modes

The Electric Crayon(tm) is capable of generating 10 display modes. These are described in detail below.

4.3.1 Display Mode 0 -- Alphanumerics-Semigraphics

This combination display mode generates either alphanumeric characters and symbols or semigraphic blocks.

The alphanumeric display is 32 characters wide by 16 rows deep. The character set includes upper case letters, numerals 0 - 10, punctuation marks, math operators + and = and the following symbols: \ / * & # $ % @ ( ) - ^ _ , . ← [ ] < >. The character matrix is 8-dots by 12 dots. Characters and symbols may be either green on black or orange on black, and may be displayed in reverse format.

The semigraphics display is 32 blocks wide by 16 blocks deep. Each block is subdivided into four equal rectangular parts, and each part is either bright or extinguished, depending on the current P (Pattern) command. All parts are extinguished for P0 and all parts are illuminant for P15. Each block may be any one of the eight available colors. Refesh memory = 1K byte.

4.3.2 Display Mode 1 -- 6-Part Semigraphics Mode

This display mode generates a display similar to the 4-part semigraphics blocks of Mode 0 except each block is divided into six equal rectangular parts. Command P0 extinguishes all parts and command P63 causes all parts to be illuminant. Four colors may be selected for each block, and the display may be inverted. Refresh memory = 1K byte.

4.3.3 Display Mode 2 -- 64 x 64 Graphics

The display matrix for Mode 2 is 64 elements by 64 elements. Each element or pixel equals four dot-clocks by three scan lines of a tv frame. Each element is either entirely "on" or entirely "off." Four colors are available including the background color, and the colors may be inverted. Refresh memory = 1K byte.

4.3.4 Display Mode 3 -- 128 x 64 Graphics

The display matrix is 128 elements wide by 64 elements deep. An element equals two dot-clocks by three scan lines. Two colors

are available, and the colors may be inverted. Refresh memory = 1K byte.

4.3.5 Display Mode 4 -- 128 x 64 Graphics
Same as Display Mode 3 except four colors are available, and the colors may be inverted. Requires 2K-byte refresh memory.

4.3.6 Display Mode 5 -- 128 x 96 Graphics
The display matrix is 128 elements wide by 96 elements deep. An element equals two dot-clocks by two scan lines. Two colors are available, and the colors may be inverted. Refresh memory = 2K bytes.

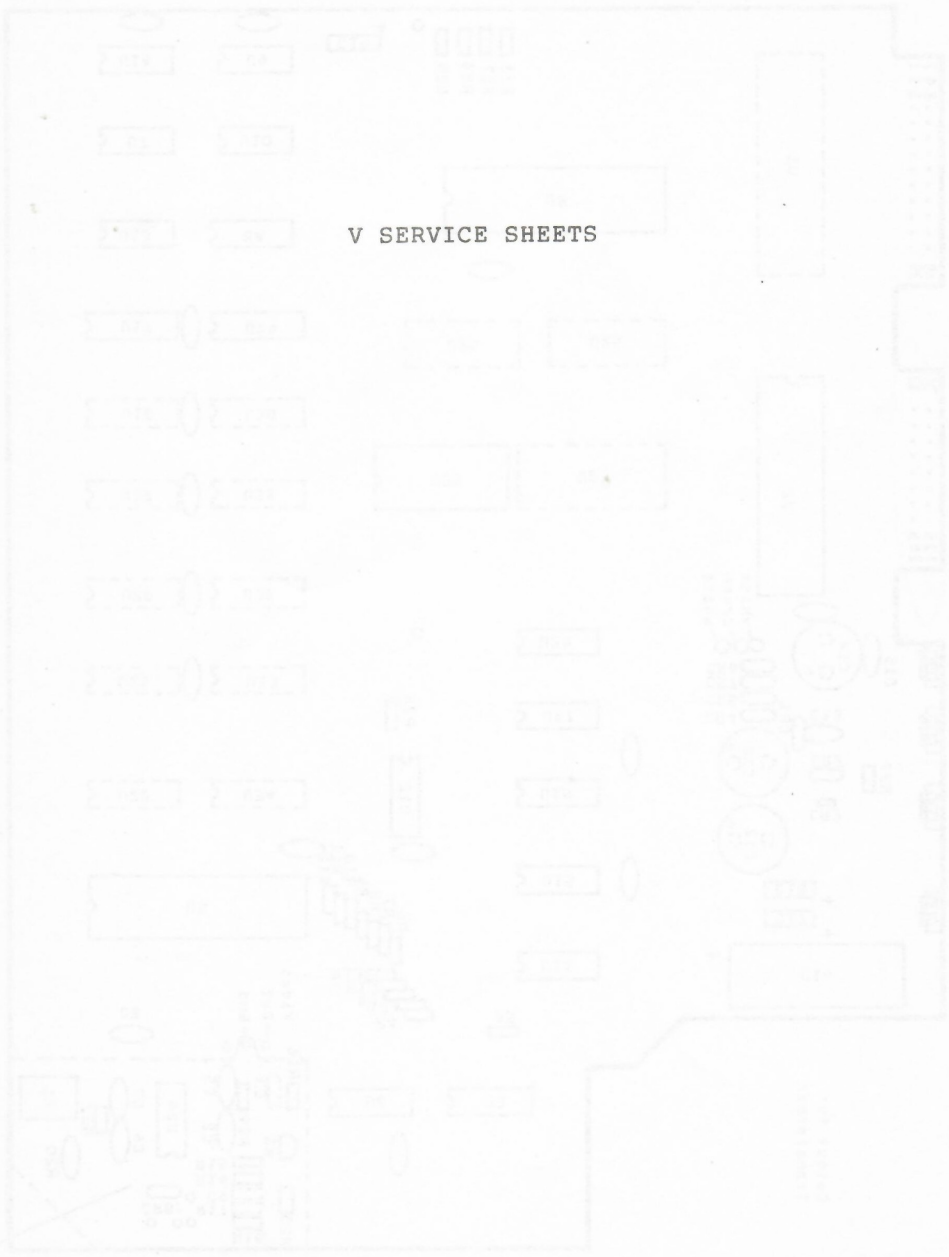
4.3.7 Display Mode 6 -- 128 x 96 Graphics
Same as display Mode 5 except four colors are available, and the colors may be inverted. Requires 3K byte of refresh memory.

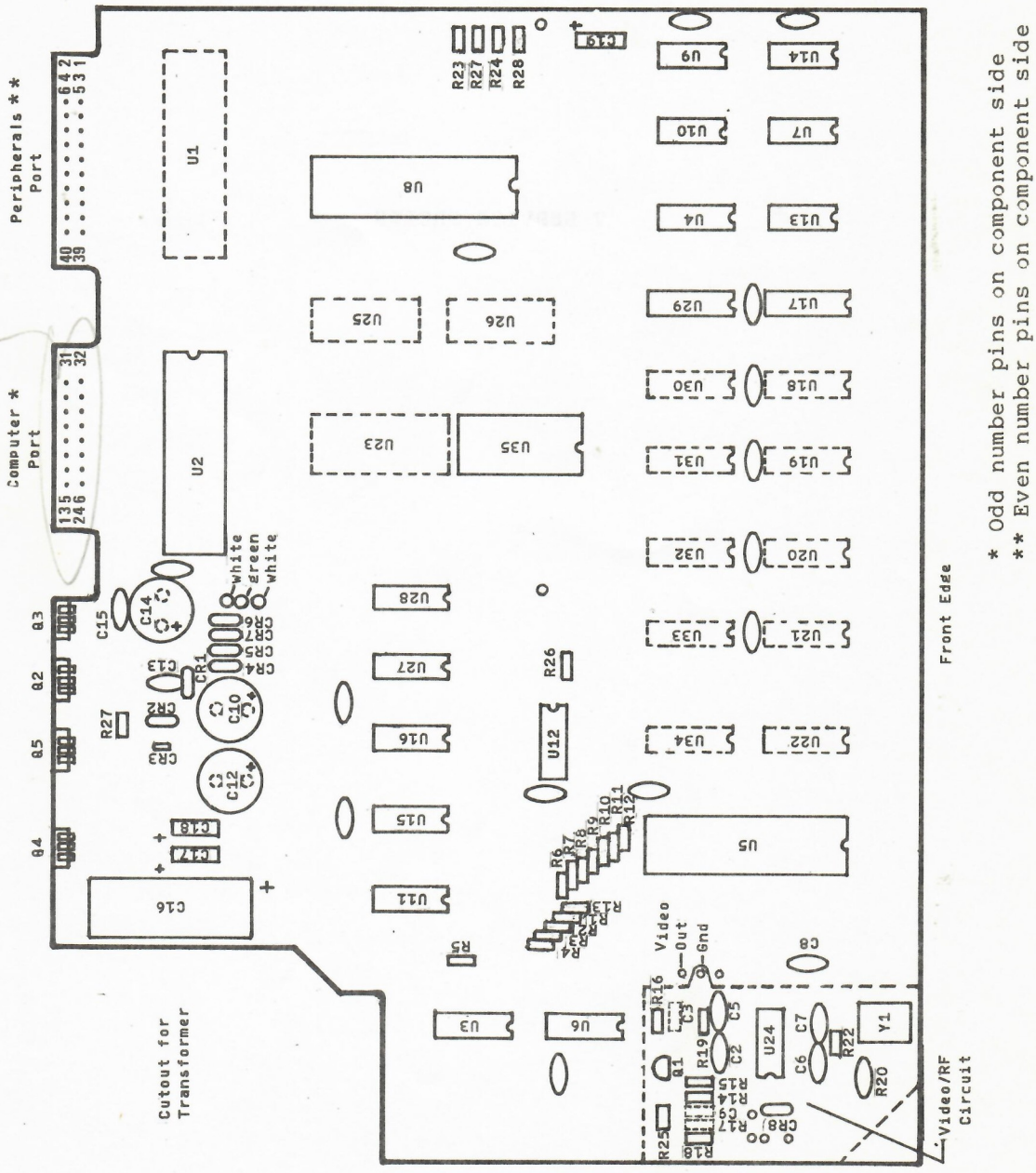
4.3.8 Display Mode 7 -- 128 x 192 Graphics
The display matrix is 128 elements wide by 192 elements deep. An element equals two dot-clocks by one scan line. Two colors are available, and the colors may be inverted. Refresh memory = 3K bytes.

4.3.9 Display Mode 8 -- 128 x 192 Graphics
Same as display Mode 7 except four colors are available, and the colors may be inverted. Refresh memory = 6K bytes.

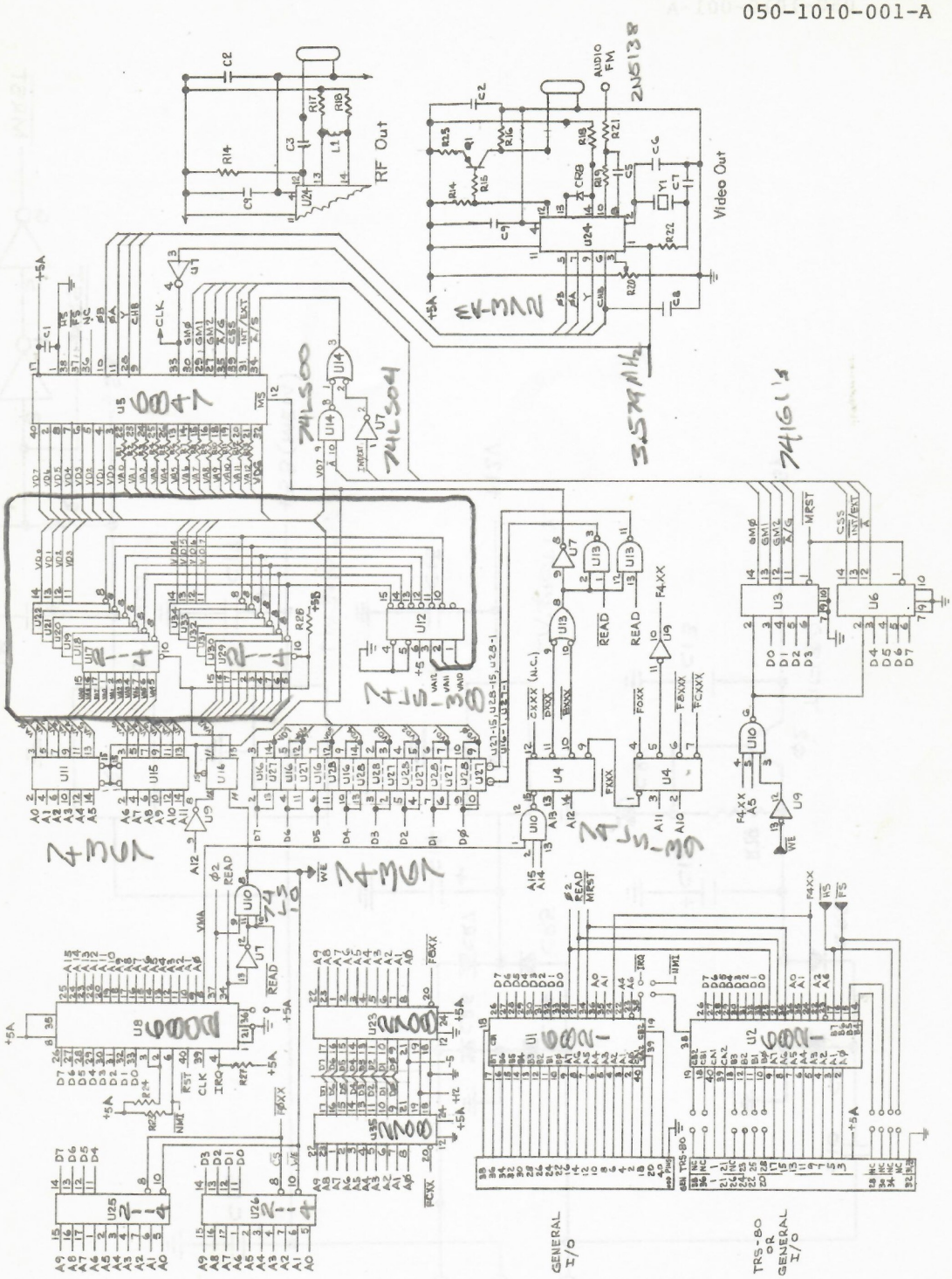
4.3.10 Display Mode 9 -- 256 x 192 Graphics
Display is 256 elements wide by 192 elements deep. Each element is one dot-clock by one scan line. Two colors are available, and the colors may be inverted. Refresh memory = 6K bytes.

V SERVICE SHEETS

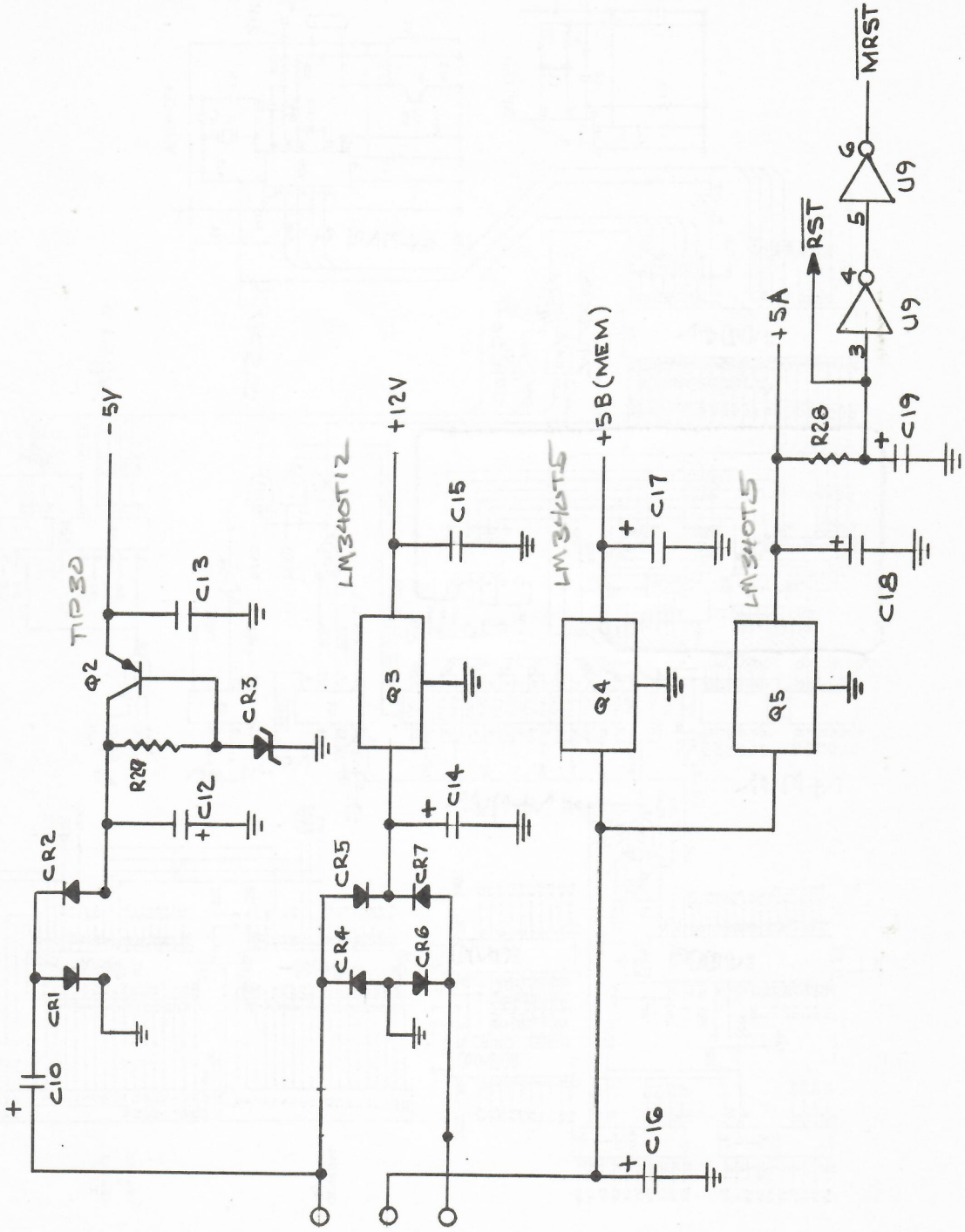




PRINTED CIRCUIT BOARD ASSEMBLY DIAGRAM



CIRCUIT SCHEMATIC (Sheet 1 of 2)



CIRCUIT SCHEMATIC (Sheet 2 of2)

PARTS LIST

INTEGRATED CIRCUITS

U1, U2 - 6821
U3, U6 - 74161
U4 - 74LS139
U5 - 6847
U7, U9 - 74LS04
U8 - 6802
U10 - 74LS10
U11, U15, U16, U27, U28 - 74367
U12 - 74LS138
U13, U14 - 74LS00
U17-U23, U29-U34, U25, U26 - 2114
U23, U35 - 2708
U24 - 1372

RESISTORS

R1-R13, R22 - 5.6 kohm
R14 - 2.2 kohm video driver; 75-ohm RF modulator
R15 - 330 ohm
R16 - 150 ohm
R17 - 240 ohm
R18 - 330 ohm, video driver; 240 ohm, RF modulator
R19, R29 - 680 ohm
R20 - 20 kohm trim potentiometer
R21 - value pending final design evaluation
R23, R24, R26, R27 - 4.7 kohm
R25 - 10 ohm
R28 - 10 kohm

CAPACITORS

C1, C4, C11, C20-C27 - 0.01 (bypass)
C2, C5, C8, C9 - 0.1 uF
C3, C13, C15 - 0.01 uF
C6, - 22 pF
C7 - 47 pF
C10, C12, C14 - 1000 uF, 25 V
C16 - 4700 uF, 16 V
C17-C19 - 33 uF, 16 V

DIODES

CR1, CR2, CR4-CR7 - 1N4001 (power rectifier)
CR3 - 1N752A (voltage regulator diode, 5 V)
CR8 - 1N914 (signal rectifier)

CRYSTAL

Y1 - 3.579545 MHz crystal

TRANSISTORS

Q1 - 2N5138
Q2 - TIP 30
Q3 - LM340T12
Q4, Q5 - LM340T5

APPENDIX SECTION

APPENDIX A1
I/O INTERFACE PIN-SIGNAL ASSIGNMENTS

COMPUTER PORT

Channel A:

PIN	SIGNAL	COMMENT
1	$\overline{\text{STROBE}}$	Input to Electric Crayon(tm)
21	BUSY	Output from Electric Crayon(tm)
3	DATA 0	
5	DATA 1	Parallel data in. DATA 0 is
7	DATA 2	least significant bit.
9	DATA 3	
11	DATA 4	Pins 31, 32 and 33 are
13	DATA 5	ground.
15	DATA 6	
17	DATA 7	

Channel B:

Refer to the circuit schematic in Section V for channel B wiring and pin-signal assignments.

PERIPHERALS INTERFACE

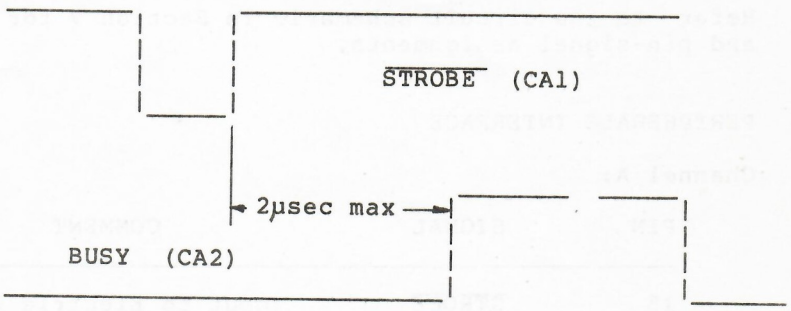
Channel A:

PIN	SIGNAL	COMMENT
18	$\overline{\text{STROBE}}$	Input to Electric Crayon(tm)
20	BUSY	Output from Electric Crayon(tm)
2	DATA 0	
4	DATA 1	
6	DATA 2	Parallel data in. DATA 0 is
8	DATA 3	least significant bit.
10	DATA 4	
12	DATA 5	Odd numbered pins are ground
14	DATA 6	potential.
16	DATA 7	

Channel B:

PIN	SIGNAL	COMMENT
18	$\overline{\text{STROBE}}$	Input to Electric Crayon(tm)
40	BUSY	Output from Electric Crayon(tm)
22	DATA 0	
24	DATA 1	
26	DATA 2	Parallel data in. DATA 0 is
28	DATA 3	least significant bit.
30	DATA 4	
32	DATA 5	
34	DATA 6	Odd numbered pins are at
36	DATA 7	ground potential.

$\overline{\text{STROBE}}$ and BUSY SIGNAL WAVEFORMS



$\overline{\text{STROBE}}$ is generated by the computer and BUSY is generated by the Electric Crayon(tm).

APPENDIX A2
COAXIAL CABLE

The video coaxial cable is constructed from standard RG59/U 75-ohm cable. Attach a type F-59 TV/FM connector (e.g., RS PN 278-211) to one end. This end will connect to the Electric Crayon(tm). The connector for the other end depends on the application:

For direct video input, a type PL-259 plug is appropriate for most video monitors.

For rf input to an impedance matching transformer (e.g., RS PN 15-1140) use a type F-59 connector.

The video input connector to an external modulator such as Radio Shack's TV RF Interface, PN 277-122, depends on the modulator used.

Appendix A3
VIDEO TO RF CONVERSION

Converting the Electric Crayon(tm) Video Driver/Modulator circuit for rf output should only be accomplished by an experienced technician. This procedure modifies the Electric Crayon(tm) without removing the PC card from the chassis.

*** WARNING ***

The user assumes all responsibility for complying with Federal Communications Commission (FCC) regulations concerning the legal maximum levels of rf radiation if the internal modulator is installed.

Parts Required: two 240-ohm resistors one 75-ohm resistor, one 0.1 uH inductor (Refer to step 12 below.) and two 0.1 uF disk capacitors.

Procedure:

1) Remove the cover of the Electric Crayon(tm). The modulator section is in the front right hand corner.

2) Remove Q1. Clip the leads close to the PC card. Watch for shorts to the ground plane.

3) Remove R14, R18 and CR8 by clipping the leads close to the body of the components, leaving as much lead as possible attached to the PC board.

4) Remove R15, R25 and R16 by clipping the leads close to the PC card. Watch for shorts to the ground plane.

5) Straighten the wire leads left on R14, R18 and CR8.

6) Lay one 240-ohm resistor across the leads remaining on R18 and solder attach. Trim off the excess leads.

7) Lay the 75-ohm resistor across the wires left on the PC board from R14 and solder attach. Trim off the excess leads.

8) Clip the leads of the remaining 240-ohm resistor, leaving about 1/4 inch on each end. Form the leads and insert the resistor in the PC card. Refer to the PC board assembly diagram in Section V for position. Solder the resistor from the top. Do not short leads to the ground plane.

9) Trim the leads of one disk capacitor so that a minimum lead length will extend below the PC board. Insert the capacitor in the board and solder in position as C3.

10) Clip the other disk capacitor leads so that a minimum lead length will extend below the PC board. Insert and solder in position as C9.

11) Unsolder the CR8 leads from the PC board.

12) Read the following notes and discussion and then solder inductor L1 to the CR8 pads.

* NOTE *

The lead length of L1 is critical. For proper operation, leads should not exceed 1/4 inch in length.

The value of L1 determines the frequency of operation and the channel you are on. This coil may be purchased as a 0.1 uH tuneable coil, or fabricated on almost any type of coil form which uses a ferrite slug for tuning. Prototypes were made on forms 1/8 inch in diameter with 3-1/2 turns of #22 enamel-insulated copper wire.

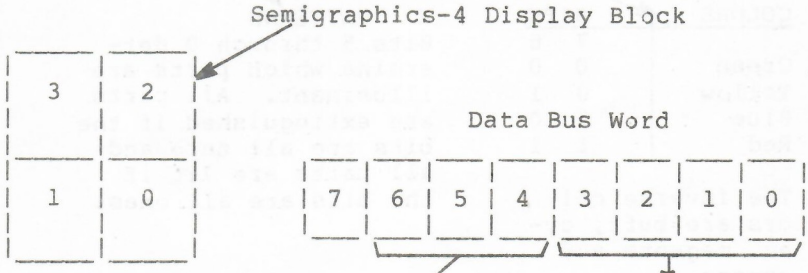
After the coil has been made and placed in the circuit, turn the television on to the desired channel (UHF 33-40), then turn the slug until a picture is on the screen. If all that is seen is ''confetti'', the coil may be resonating at the wrong frequency. Change channels until a picture is seen. Turning the slug down -- into the coil -- lowers the frequency (and channel), and unscrewing it produces the opposite effect. If the picture is seen at a wrong channel, adding more turns (one or two) will lower the frequency.

The duty cycle adjustment potentiometer, R20, varies the actual duty cycle of the 3.58 MHz clock. This is an optional part, as the MC1372 is internally set for a 50% duty cycle. Adjustment should be made while observing a picture and tuning the pot.

APPENDIX A4
DETAILED DESCRIPTION OF SEMIGRAPHICS MODES

The semigraphics display modes generate 8-dot by 12-dot rectangular display blocks. In display mode 0, the block is divided into four equal parts, and displays are referred to as semigraphics-4 displays. In display mode 1, the block is divided into six equal parts, and displays are referred to as semigraphics-6 displays. The color of the block and the illumination pattern are determined by individual data word bits. The data word bit assignments are set forth below.

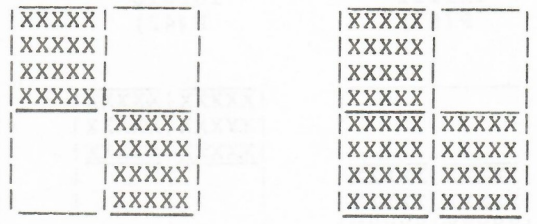
Mode 0 -- Semigraphics-4



COLORS	BITS 6	5	4
Green	0	0	0
Yellow	0	0	1
Blue	0	1	0
Red	0	1	1
Buff	1	0	0
Cyan	1	0	1
Magenta	1	1	0
Orange	1	1	1

PATTERNS

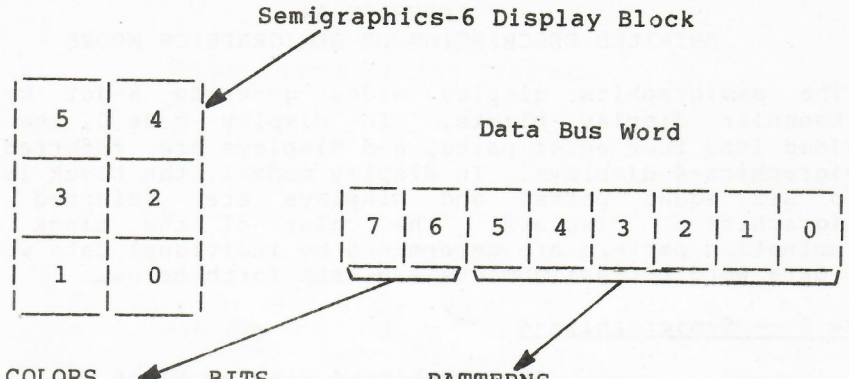
Bits 3 through 0 determine which parts are illuminant. All parts are extinguished if the bits are all zero and all parts are lit if the bits are all ones. Examples are shown below.



1 0 0 1 (P9) 1 0 1 1 (P11)

Mode 1 -- Semigraphics-6

The selection of patterns and colors for semigraphics-6 displays is the same, in principal, as for semigraphics-4 displays. Data word bit assignments for pattern and color selection are set forth below.



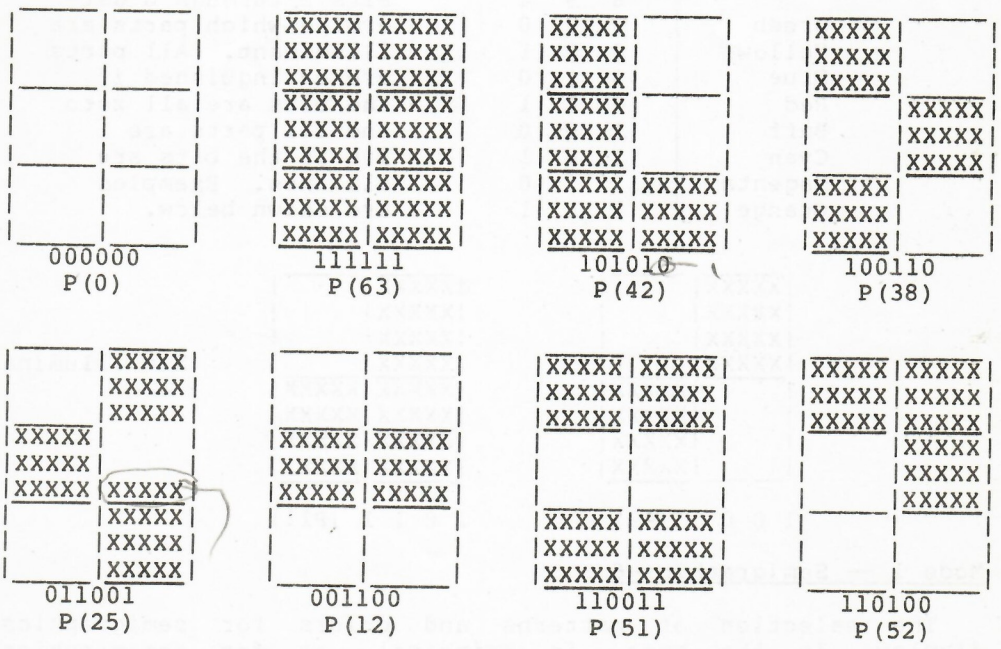
COLORS	BITS 7	6
Green	0	0
Yellow	0	1
Blue	1	0
Red	1	1

The inverse colors are buff, cyan, magenta and orange.

PATTERNS

Bits 5 through 0 determine which parts are illuminant. All parts are extinguished if the bits are all zero and all parts are lit if the bits are all ones.

Examples



X = illuminant

APPENDIX A5
ELECTRIC CRAYON MEMORY MAP

ADDRESS (hexadecimal)	FUNCTION
0000 - 007F	Scratchpad -- on 6802 chip
D000 - E7FF 6K	Display Memory (refresh memory)
F000 - F3FF	Optional 1K-byte program RAM
F400 - F7FF	Range within which PIA I/O may be addressed.***
F800 - FBFF	Optional program ROM
FC00 - FFFF	EGOS(tm) graphics operating system

***

Computer Port PIA:		Peripheral Port PIA:	
'A' Data	F404	'A' Data	F410
'A' Control	F405	'A' Control	F411
'B' Data	F406	'B' Data	F412
'B' Control	F407	'B' Control	F413

Mode Register -- F420

APPENDIX A6
MEMORY LOADER UTILITY -- LD* COMMAND

This utility may be used by advanced programmers for special effects and control environments.

DESCRIPTION:

The LD* command may be used to load data into the Electric Crayon(tm) memory. The data is entered as Motorola S1 and S9 ASCII hexadecimal records. S1 is a data record format and S9 is an end-of-file record format. The details of these formats are included in several Motorola documents, including the MC6800 Programmers Manual.

Data may be loaded into any address in the Electric Crayon(tm). The user must ensure that only valid RAM addresses are present in each S1 record. An Electric Crayon memory map is included in Appendix A5.

Each record is checked for a valid checksum as it is received. If an error is detected during loading, the Electric Crayon(tm) goes to Mode 0, and LOAD ERROR is displayed in the center of the screen.

When the S9 record is encountered, loading stops. If a non-zero address was included in the S9 record, control of the Electric Crayon(tm) resumes normal processing, i.e., waits for the next command.

PROCEDURE:

(1) Type and enter the LD* command.

(2) Type and enter each record, ending the file with an S9 record. If a keyboarding error is made, type and enter the LD* command to recover the memory load utility.

Appendix A7
INTERCONNECTING CABLE

I. TRS-80* COMPUTER

A cable for interconnecting the Electric Crayon(tm) to the Expansion Interface of a TRS-80* computer may be fabricated from the following parts:

Connectors:	34-pin Ribbon Connector, Winchester PN 53-34-0, or equivalent
Cable:	34-conductor flat ribbon cable, Winchester PN 55-3428-10, or equivalent. About 2 feet required.

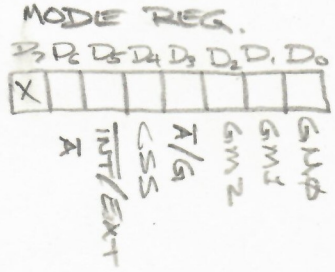
Attach one connector so that conductor no. 1 of the cable is connected to pin 1 of the connector. This end mates with the Electric Crayon(tm). Attach the second connector so that conductor no. 1 of the cable is connected to pin 1 of the connector. The connector caps must be on the same side of the ribbon. This end mates with the Expansion Interface printer port.

II. OTHER COMPUTERS OR KEYBOARD

For other computers or a keyboard, the cable and Electric Crayon(tm) connector are the same as described above. Refer to Appendix 1 and the circuit schematic of Section V for pin-signal assignments for determining the conductor assignments of the computer/keyboard connector.

APPENDIX A8
EGOS LISTING

```
                        NAM   CRAYON

                * ROM RESIDENT DRIVER FOR THE PERCOM ELECTRIC CRAYON (TM)
                * COPYRIGHT (c) 1979 PERCOM DATA COMPANY INC.
                * ALL RIGHTS RESERVED

                * VERSION 1.00 - DECEMBER 18, 1979

                * ELECTRIC CRAYON REGISTER ADDRESSES
   (D000)       VRAM   EQU   $D000      VIDEO RAM (1 TO 6K)
   (0000)       BASPAG EQU   $00        BASE PAGE RAM IN 6802 CHIP
   (FC00)       PROM1  EQU   $FC00      ADDRESS OF FIRST 1K PROM
   (F800)       PROM2  EQU   $F800      ADDRESS OF SECOND 1K PROM
   (F420)       MODREG EQU   $F420      MODE REGISTER
   (F404)       INPDAT EQU   $F404      INPUT PIA DATA REG
   (F405)       INPCTL EQU   $F405      INPUT PIA CONTROL REG
   (F406)       VDGDAT EQU   $F406      VIDEO DISPLAY GENERATOR PIA DATA
   (F407)       VDGCTL EQU   $F407      VIDEO DISPLAY GENERATOR PIA CONTROL

                * CONSTANTS
   (000D)       CR     EQU   $0D        CARRIAGE RETURN
   (000A)       LF     EQU   $0A        LINE FEED
   (0020)       SP     EQU   $20        SPACE

                * BASE PAGE STORAGE
   (0000)              ORG   BASPAG
0000            BYTLOC RMB   2         ADDRESS OF DISPLAY BYTE
0002            PIXLOC RMB   1         PIXEL LOCATION
0003            XLOC   RMB   1         X LOCATION OF POINT
0004            YLOC   RMB   1         Y LOCATION OF POINT
0005            COLOR  RMB   1         CURRENT COLOR VALUE
0006            PATERN RMB   1         CURRENT GRAPHIC BLOCK VALUE
0007            MASKO  RMB   1         MASK OFF BITS
0008            MASKI  RMB   1         MASK IN BITS
0009            CURMOD RMB   2         CURRENT MODE POINTER
000B            INVMSK RMB   1         ASCII INVERSION MASK
000C            MODVAL RMB   1         CURRENT MODE REGISTER VALUE
000D            CKSUM  RMB   1         CHECKSUM WORK AREA
000E            RECTYP RMB   1         RECORD TYPE FOR LOAD
000F            XHI    RMB   1         X REGISTER BUILD AREA
0010            XLO    RMB   1
0011            BYTCNT RMB   1         BYTE COUNT FOR LOAD
   (007F)       STACK  EQU   BASPAG+128-1 DEFINE STACK SPACE

   (FC00)              ORG   PROM1      START OF 1K PROM

                * ENTRY POINT VECTOR
FC00 7E FCAB    ENTRY  JMP   START

                * COMMAND TABLE
FC03 4D         CMDTBL FCB   'M
FC04 FD 13             FDB   SETMOD
FC06 43                FCB   'C
FC07 FD 32             FDB   SETCLR
FC09 48                FCB   'H
FC0A FD 3E             FDB   HORZLN
FC0C 56                FCB   'V
```



```
FC0D FD 56          FDB   VERTLN
FC0F 53             FCB   'S
FC10 FD 6E          FDB   SET
FC12 45             FCB   'E
FC13 FE C6          FDB   ERASE
FC15 50             FCB   'P
FC16 FD 82          FDB   SETPAT
FC18 41             FCB   'A
FC19 FD 8D          FDB   ASTRNG
FC1B 52             FCB   'R
FC1C FD 92          FDB   RSTRNG
FC1E 49             FCB   'I
FC1F FE ED          FDB   INVERT
FC21 4C             FCB   'L
FC22 FE FA          FDB   LOAD
FC24 00             FCB   0             END OF TABLE

                  * MODE TABLE
FC25 1F       MODTBL FCB   031,015,7,0,32,$40     MODE 0
FC26 0F 07
FC28 00 20
FC2A 40
FC2B 1F             FCB   031,015,3,0,32,$20     MODE 1
FC2C 0F 03
FC2E 00 20
FC30 20
FC31 3F             FCB   063,063,3,2,16,$08     MODE 2
FC32 3F 03
FC34 02 10
FC36 08
FC37 7F             FCB   127,063,1,3,16,$09     MODE 3
FC38 3F 01
FC3A 03 10
FC3C 09
FC3D 7F             FCB   127,063,3,2,32,$0A     MODE 4
FC3E 3F 03
FC40 02 20
FC42 0A
FC43 7F             FCB   127,095,1,3,16,$0B     MODE 5
FC44 5F 01
FC46 03 10
FC48 0B
FC49 7F             FCB   127,095,3,2,32,$0C     MODE 6
FC4A 5F 03
FC4C 02 20
FC4E 0C
FC4F 7F             FCB   127,191,1,3,16,$0D     MODE 7
FC50 BF 01
FC52 03 10
FC54 0D
FC55 7F             FCB   127,191,3,2,32,$0E     MODE 8
FC56 BF 03
FC58 02 20
FC5A 0E
FC5B FF             FCB   255,191,1,3,32,$0F     MODE 9
FC5C BF 01
FC5E 03 20
FC60 0F
```

```
                        * MODE TABLE ITEM DESCRIPTION
    (0000)              XMAX    EQU   0          MAXIMUM LEGAL X VALUE
    (0001)              YMAX    EQU   1          MAXIMUM LEGAL Y VALUE
    (0002)              CMAX    EQU   2          MAXIMUM LEGAL COLOR VALUE
    (0003)              SHFTCT  EQU   3          SHIFT COUNT
    (0004)              YSIZE   EQU   4          Y SIZE IN BYTES
    (0005)              MODBYT  EQU   5          MODE REGISTER BYTE

                        * INITIALIZATION GREETING MESSAGE
FC61 20                 GREETG  FCC   '      THE ELECTRIC CRAYON      '
FC62 20 20
FC64 20 20
FC66 20 54
FC68 48 45
FC6A 20 45
FC6C 4C 45
FC6E 43 54
FC70 52 49
FC72 43 20
FC74 43 52
FC76 41 59
FC78 4F 4E
FC7A 20 20
FC7C 20 20
FC7E 20 20
FC80 20
FC81 20                         FCC   '      BY PERCOM DATA COMPANY     '
FC82 20 20
FC84 20 20
FC86 42 59
FC88 20 50
FC8A 45 52
FC8C 43 4F
FC8E 4D 20
FC90 44 41
FC92 54 41
FC94 20 43
FC96 4F 4D
FC98 50 41
FC9A 4E 59
FC9C 20 20
FC9E 20 20
FCA0 20
FCA1 4C                 ERRMSG  FCC   'LOAD ERROR'
FCA2 4F 41
FCA4 44 20
FCA6 45 52
FCA8 52 4F
FCAA 52

                        * INITIALIZATION - ENTERED AT POWER-UP
FCAB 8E 007F            START   LDS   #STACK     SET UP STACK
FCAE 7F F405                    CLR   INPCTL     POINT TO DDR
FCB1 7F F407                    CLR   VDGCTL
FCB4 7F F404                    CLR   INPDAT     BOTH PORTS TO INPUT
FCB7 7F F406                    CLR   VDGDAT
FCBA 86 04                      LDA A #$04       CONFIGURE VDG PIA
```

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FCBC B7 F407          STA A VDGCTL
FCBF 86 24            LDA A #$24       CONFIGURE INPUT PIA
FCC1 B7 F405          STA A INPCTL
FCC4 B6 F404          LDA A INPDAT     SET READY FOR INPUT
FCC7 4F               CLR A            INITIALIZE RAM AREAS
FCC8 97 05            STA A COLOR
FCCA 43               COM A
FCCB 97 06            STA A PATERN
FCCD CE FC25          LDX   #MODTBL    SET TO MODE 0
FCD0 DF 09            STX   CURMOD
FCD2 A6 05            LDA A MODBYT,X   PLUG MODE REGISTER
FCD4 B7 F420          STA A MODREG
FCD7 97 0C            STA A MODVAL     SAVE REGISTER VALUE
FCD9 BD FED3          JSR   CLS        CLEAR SCREEN
FCDC 8E FC60          LDS   #GREETG-1  SET UP FOR GREETING DISPLAY
FCDF CE D000          LDX   #VRAM
FCE2 C6 40            LDA B #64        SET MESSAGE SIZE
FCE4 32       COPYLP  PUL A            COPY CHARACTERS TO SCREEN
FCE5 8A 40            ORA A #$40       DISPLAY AS REVERSE VIDEO
FCE7 A7 00            STA A 0,X
FCE9 08               INX
FCEA 5A               DEC B            LOOP UNTIL ZERO
FCEB 26 F7            BNE   COPYLP
FCED 8E 007F          LDS   #STACK     RESET STACK
FCF0 B6 F800          LDA A PROM2      CHECK FOR SECOND ROM
FCF3 81 7E            CMP A #$7E       MUST START WITH JUMP
FCF5 26 03            BNE   GETCMD     GO IF NO OTHER ROM
FCF7 BD F800          JSR   PROM2      CALL SECOND PROM

                  * GET NEXT COMMAND BYTE
FCFA BD FE30  GETCMD  JSR   INCHR      GET A CHARACTER
FCFD CE FC03          LDX   #CMDTBL    SET UP FOR SEARCH
FD00 A1 00    GTCMD1  CMP A 0,X        CHECK FOR MATCH
FD02 27 09            BEQ   PROCMD     GO IF FOUND
FD04 08               INX              BUMP TO NEXT ENTRY
FD05 08               INX
FD06 08               INX
FD07 6D 00            TST   0,X        END OF TABLE?
FD09 26 F5            BNE   GTCMD1     LOOP IF NOT
FD0B 20 ED            BRA   GETCMD     RETRY

                  * PROCESS COMMAND JUST ENTERED
FD0D EE 01    PROCMD  LDX   1,X        GET ROUTINE ADDRESS
FD0F AD 00            JSR   0,X        CALL COMMAND PROCESSOR
FD11 20 E7            BRA   GETCMD     CONTINUE LOOP

                  * SET NEW MODE
FD13 BD FDED  SETMOD  JSR   GETNUM     GET MODE NUMBER
FD16 C1 09    NEWMOD  CMP B #9         BIGGER THAN 9?
FD18 22 17            BHI   STMOD1     GO IF YES
FD1A 58               ASL B            MULTIPLY BY 6 (B*6=B*2+B*2+B*2)
FD1B 17               TBA
FD1C 1B               ABA
FD1D 1B               ABA
FD1E 8B 25            ADD A #-MODTBL/256*256+MODTBL CALC ENTRY ADDRESS
FD20 97 0A            STA A CURMOD+1
FD22 86 FC            LDA A #MODTBL/256
FD24 89 00            ADC A #0
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FD26 97 09           STA A CURMOD
FD28 DE 09           LDX   CURMOD     PLUG MODE REGISTER
FD2A A6 05           LDA A MODBYT,X
FD2C B7 F420         STA A MODREG
FD2F 97 0C           STA A MODVAL     SAVE MODE REGISTER VALUE
FD31 39       STMOD1 RTS              EXIT

              * SET NEW COLOR VALUE
FD32 BD FDED  SETCLR JSR   GETNUM     GET COLOR VALUE
FD35 DE 09           LDX   CURMOD     POINT TO MODE ENTRY
FD37 E1 02           CMP B CMAX,X     IS COLOR VALID?
FD39 22 02           BHI   STCLRX     GO IF NOT
FD3B D7 05           STA B COLOR      STORE CURRENT COLOR VALUE
FD3D 39       STCLRX RTS

              * DRAW HORIZONTAL LINE
FD3E BD FDEB  HORZLN JSR   GETXYN     GET X, Y, AND N PARAMS
FD41 27 12           BEQ   HRZLNX     GO IF LINE LENGTH = 0
FD43 37       HRZLN1 PSH B            SAVE LINE LENGTH
FD44 8D 2B           BSR   SETPNT     SET CURRENT X-Y POINT
FD46 33              PUL B            RESTORE LINE LENGTH
FD47 DE 09           LDX   CURMOD     POINT TO MODE TABLE
FD49 96 03           LDA A XLOC       INCREMENT X LOCATION
FD4B 4C              INC A
FD4C A1 00           CMP A XMAX,X     AT END OF LINE?
FD4E 22 05           BHI   HRZLNX     GO IF YES
FD50 97 03           STA A XLOC       SAVE NEW X
FD52 5A              DEC B            DECREMENT LOOP COUNT
FD53 26 EE           BNE   HRZLN1     LOOP UNTIL ZERO
FD55 39       HRZLNX RTS

              * DRAW A VERTICAL LINE
FD56 BD FDEB  VERTLN JSR   GETXYN     GET X, Y, AND N PARAMS
FD59 27 12           BEQ   VRTLNX     GO IF LENGTH = 0
FD5B 37       VRTLN1 PSH B            SAVE LINE LENGTH
FD5C 8D 13           BSR   SETPNT     SET CURRENT X-Y POINT
FD5E 33              PUL B            RESTORE LINE LENGTH
FD5F DE 09           LDX   CURMOD     POINT TO MODE TABLE
FD61 96 04           LDA A YLOC       INCREMENT Y LOCATION
FD63 4C              INC A
FD64 A1 01           CMP A YMAX,X     AT END OF COLUMN?
FD66 22 05           BHI   VRTLNX     GO IF YES
FD68 97 04           STA A YLOC       SAVE NEW Y
FD6A 5A              DEC B            DECREMENT LOOP COUNT
FD6B 26 EE           BNE   VRTLN1     LOOP UNTIL ZERO
FD6D 39       VRTLNX RTS

              * SET A POINT
FD6E BD FDD4  SET    JSR   GETXY      GET X AND Y PARAMETERS

              * SET POINT X-Y TO CURRENT COLOR
FD71 BD FE39  SETPNT JSR   LOCATE     GET LOCATION FOR X-Y POINT
FD74 BD FE77         JSR   SETMSK     SET UP MASKS

              * STORE PIXEL AT X-Y POINT
FD77 BD FE1A  STRPIX JSR   VLOAD      LOAD BYTE AT THAT LOCATION
FD7A 94 07           AND A MASKO      REMOVE OLD CONTENTS
FD7C 9A 08           ORA A MASKI      INSERT NEW CONTENTS
```

```
FD7E BD FE25          JSR   VSTORE    STORE BYTE BACK
FD81 39               RTS

                  * SET NEW PATTERN FOR MODES 1 & 2
FD82 DE 09        SETPAT LDX  CURMOD   POINT TO CURRENT MODE
FD84 6D 03             TST    SHFTCT,X IN SEMIGRAPHICS MODE?
FD86 26 04             BNE    STPATX   GO IF NOT
FD88 8D 63             BSR    GETNUM   GET THE PATTERN VALUE
FD8A D7 06             STA B  PATERN   SAVE NEW PATTERN VALUE
FD8C 39           STPATX RTS

                  * DISPLAY ASCII STRING
FD8D 7F 000B      ASTRNG CLR    INVMSK   CLEAR BIT MASK
FD90 20 04             BRA    PSTRNG

                  * DISPLAY ASCII STRING (REVERSE VIDEO)
FD92 86 40        RSTRNG LDA A #$40      SET BIT MASK
FD94 97 0B             STA A  INVMSK

                  * DISPLAY ASCII STRING
FD96 DE 09        PSTRNG LDX   CURMOD    POINT TO MODE TABLE
FD98 8C FC25           CPX    #MODTBL   IN MODE 1?
FD9B 26 30             BNE    FLUSH     ABORT IF NOT
FD9D 8D 35             BSR    GETXY     GET STARTING LOCATION
FD9F 7F 0007           CLR    MASKO     SET FOR TOTAL MASK-OUT
FDA2 BD FE30      PSTRG1 JSR    INCHR     GET A CHARACTER
FDA5 81 0D             CMP A  #$0D      END OF LINE?
FDA7 27 23             BEQ    PSTRG3    GO IF YES
FDA9 84 3F             AND A  #$3F      MASK TO 6 BITS
FDAB 9A 0B             ORA A  INVMSK    SET INVERSION BIT
FDAD 97 08             STA A  MASKI     SET UP FOR DISPLAY
FDAF BD FE39           JSR    LOCATE    SET UP COORDINATES
FDB2 8D C3             BSR    STRPIX    DISPLAY IT
FDB4 DE 09             LDX    CURMOD    POINT TO MODE TABLE
FDB6 96 03             LDA A  XLOC      GET X-Y LOCATIONS
FDB8 D6 04             LDA B  YLOC
FDBA 4C                INC A            ADVANCE X
FDBB A1 00             CMP A  XMAX,X    PAST END?
FDBD 23 07             BLS    PSTRG2    GO IF NOT
FDBF 4F                CLR A            RESET TO START OF LINE
FDC0 5C                INC B            ADVANCE Y
FDC1 E1 01             CMP B  YMAX,X    PAST END?
FDC3 23 01             BLS    PSTRG2    GO IF NOT
FDC5 5F                CLR B
FDC6 97 03        PSTRG2 STA A  XLOC      STORE NEW X-Y LOC
FDC8 D7 04             STA B  YLOC
FDCA 20 D6             BRA    PSTRG1
FDCC 39           PSTRG3 RTS

                  * FLUSH INPUT TO CARRIAGE RETURN
FDCD 8D 61        FLUSH  BSR    INCHR     GET A CHARACTER
FDCF 81 0D             CMP A  #$0D      IS IT RETURN?
FDD1 26 FA             BNE    FLUSH     LOOP IF NOT
FDD3 39                RTS

                  * GET X-Y COORDINATES
FDD4 DE 09        GETXY  LDX    CURMOD    POINT TO MODE TABLE
FDD6 8D 15             BSR    GETNUM    GET X VALUE
```

```
FDD8 E1 00          CMP B XMAX,X    IS IT VALID?
FDDA 23 02          BLS   GETXY1    GO IF YES
FDDC E6 00          LDA B XMAX,X    SET TO MAX
FDDE D7 03    GETXY1 STA B XLOC     STORE X LOCATION
FDE0 8D 0B          BSR   GETNUM    GET Y VALUE
FDE2 E1 01          CMP B YMAX,X    IS IT VALID?
FDE4 23 02          BLS   GETXY2    GO IF YES
FDE6 E6 01          LDA B YMAX,X    SET TO MAX
FDE8 D7 04    GETXY2 STA B YLOC     STORE Y LOCATION
FDEA 39             RTS

                    * GET X-Y LOCATIONS AND NUMERIC PARAMETER
FDEB 8D E7    GETXYN BSR   GETXY    GET X-Y COORDINATES

                    * GET NUMERIC PARAMETER
FDED 5F       GETNUM CLR B          INITIALIZE RESULT
FDEE 8D 40    GTNUM1 BSR   INCHR    GET A CHARACTER
FDF0 81 0D          CMP A #$0D      IS IT RETURN?
FDF2 27 14          BEQ   ABORT     ABORT COMMAND IF YES
FDF4 8D 18          BSR   NUMCK     IS IT NUMERIC?
FDF6 25 F6          BCS   GTNUM1    LOOP IF NOT
FDF8 84 0F    GTNUM2 AND A #$0F     MASK OFF DIGIT
FDFA 58             ASL B           B=B*2
FDFB 1B             ABA             ADD IN NEW DIGIT
FDFC 58             ASL B           B=B*8
FDFD 58             ASL B
FDFE 1B             ABA             NOW A=A+B*10
FDFF 16             TAB             SAVE NEW RESULT
FE00 8D 2E          BSR   INCHR     GET A CHARACTER
FE02 8D 0A          BSR   NUMCK     IS IT NUMERIC?
FE04 24 F2          BCC   GTNUM2    LOOP IF YES
FE06 5D             TST B           SET Z FLAG FOR NUMBER
FE07 39             RTS

                    * ABORT CURRENT COMMAND
FE08 8E 007F  ABORT LDS   #STACK    RESET STACK
FE0B 7E FCFA        JMP   GETCMD    TRY AGAIN

                    * CHECK CHARACTER FOR NUMERIC
FE0E 81 30    NUMCK CMP A #$30      IS IT < 0?
FE10 25 06          BCS   NUMCK1    EXIT IF YES
FE12 81 39          CMP A #$39      IS IT > 9?
FE14 22 02          BHI   NUMCK1    EXIT IF YES
FE16 0C             CLC             FLAG AS NUMERIC
FE17 39             RTS
FE18 0D       NUMCK1 SEC            FLAG AS NON-NUMERIC
FE19 39             RTS

                    * LOAD BYTE FROM VIDEO RAM
FE1A DE 00    VLOAD LDX   BYTLOC    GET ADDRESS OF BYTE
FE1C F6 F406  VLOAD1 LDA B VDGDAT   WAIT FOR FIELD SYNC PULSE
FE1F 58             ASL B
FE20 2B FA          BMI   VLOAD1
FE22 A6 00          LDA A 0,X       GET THE BYTE
FE24 39             RTS

                    * STORE BYTE TO VIDEO RAM
FE25 DE 00    VSTORE LDX  BYTLOC    GET ADDRESS OF BYTE
```

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FE27 F6 F406  VSTOR1 LDA B VDGDAT    WAIT FOR FIELD SYNC PULSE
FE2A 58              ASL B
FE2B 2B FA           BMI   VSTOR1
FE2D A7 00           STA A 0,X       STORE THE BYTE
FE2F 39              RTS

                * INPUT A CHARACTER FROM PIA
FE30 B6 F405  INCHR  LDA A INPCTL    CHECK STATUS
FE33 2A FB           BPL   INCHR     LOOP IF NOTHING THERE
FE35 B6 F404         LDA A INPDAT    GET CHARACTER
FE38 39              RTS

                * LOCATE ADDRESS OF X-Y COORDINATE
FE39 DE 09    LOCATE LDX   CURMOD    POINT TO MODE TABLE
FE3B 4F              CLR A           CLEAR RESULT FIELDS
FE3C 97 00           STA A BYTLOC
FE3E 97 01           STA A BYTLOC+1
FE40 97 02           STA A PIXLOC
FE42 D6 04           LDA B YLOC      MULTIPLY Y BY SIZE OF Y ROW
FE44 27 0F           BEQ   LOCAT2    GO IF Y=0
FE46 A6 04    LOCAT1 LDA A YSIZE,X   ADD IN ANOTHER ROW
FE48 9B 01           ADD A BYTLOC+1
FE4A 97 01           STA A BYTLOC+1
FE4C 96 00           LDA A BYTLOC
FE4E 89 00           ADC A #0
FE50 97 00           STA A BYTLOC
FE52 5A              DEC B           LOOP UNTIL 0
FE53 26 F1           BNE   LOCAT1
FE55 96 03    LOCAT2 LDA A XLOC      GET X COORDINATE
FE57 E6 03           LDA B SHFTCT,X  GET SHIFT COUNT
FE59 27 11           BEQ   LOCAT5    GO IF NONE
FE5B 44       LOCAT3 LSR A           DIVIDE X LOC BY 2
FE5C 76 0002         ROR   PIXLOC    ACCUMULATE REMAINDER
FE5F 5A              DEC B           LOOP UNTIL 0
FE60 26 F9           BNE   LOCAT3
FE62 C6 08           LDA B #8        CALC ADJ SHIFT COUNT
FE64 E0 03           SUB B SHFTCT,X
FE66 74 0002  LOCAT4 LSR   PIXLOC    RIGHT JUSTIFY
FE69 5A              DEC B           LOOP UNTIL ZERO
FE6A 26 FA           BNE   LOCAT4
FE6C 9B 01    LOCAT5 ADD A BYTLOC+1  ADD IN X OFFSET
FE6E 97 01           STA A BYTLOC+1
FE70 96 00           LDA A BYTLOC
FE72 89 D0           ADC A #VRAM/256 ADD BASE OF VRAM
FE74 97 00           STA A BYTLOC
FE76 39              RTS

                * SET UP MASKS FOR PIXEL MANIPULATION
FE77 DE 09    SETMSK LDX   CURMOD    POINT TO MODE
FE79 E6 03           LDA B SHFTCT,X  GET SHIFT COUNT
FE7B 27 29           BEQ   SEMGRM    GO IF SEMIGRAPHICS
FE7D 86 FC           LDA A #$FC      SET MASK FOR 4 COLORS
FE7F C0 02           SUB B #2        ADJUST SHIFT COUNT
FE81 1B              ABA             FIX UP MASK
FE82 1B              ABA
FE83 97 07           STA A MASKO     SAVE MASK OUT
FE85 43              COM A           INVERT FOR COLOR SELECT
FE86 94 05           AND A COLOR     GET COLOR BITS
```

```
FE88 97 08          STA A MASKI     SAVE MASK IN
FE8A 96 02          LDA A PIXLOC    GET PIXEL LOCATION
FE8C 40             NEG A           CALCULATE SHIFTS REQUIRED
FE8D 58             ASL B
FE8E 58             ASL B
FE8F 1B             ABA
FE90 8B 03          ADD A #3        VALUE NOW 0-3 OR 0-7
FE92 27 11          BEQ   STMSK2    EXIT IF NO SHIFT
FE94 5D             TST B           4 COLORS OR 2 COLORS
FE95 26 04          BNE   STMSK1    GO IF 2
FE97 36             PSH A           SAVE SHIFT COUNT
FE98 8D 01          BSR   STMSK1    SHIFT MASK 1 BIT*A
FE9A 32             PUL A           SET UP FOR SECOND SHIFT
FE9B 0D       STMSK1 SEC            FORCE 1 BITS INTO LOW END
FE9C 79 0007        ROL   MASKO
FE9F 78 0008        ASL   MASKI     FORCE 0 BITS IN LOW END
FEA2 4A             DEC A           LOOP THROUGH BIT COUNT
FEA3 26 F6          BNE   STMSK1
FEA5 39       STMSK2 RTS

                    * SET PATTERN FOR SEMIGRAPHIC MODES
FEA6 A6 05    SEMGRM LDA A MODBYT,X GET MODE BYTE
FEA8 80 30          SUB A #$30      CONVERT TO 16 OR 64
FEAA 2A 02          BPL   SEMGR1
FEAC 8B 50          ADD A #$50
FEAE 4A       SEMGR1 DEC A          PATTERN MASK=$0F OR $3F
FEAF D6 05          LDA B COLOR     GET COLOR
FEB1 58             ASL B           SHIFT LEFT 4
FEB2 58             ASL B
FEB3 58             ASL B
FEB4 58             ASL B
FEB5 CA 80          ORA B #$80      TURN ON BIT 7
FEB7 85 10          BIT A #$10      MODE 6?
FEB9 27 02          BEQ   SEMGR2    GO IF NOT
FEBB 58             ASL B           CONVERT TO 4 COLOR
FEBC 58             ASL B
FEBD 94 06    SEMGR2 AND A PATERN   COMBINE PATTERN WITH COLOR
FEBF 1B             ABA
FEC0 97 08          STA A MASKI     SET IN MASK
FEC2 7F 0007        CLR   MASKO     PRESERVE NO BITS
FEC5 39             RTS

                    * ERASE THE SCREEN
FEC6 8D 2F    ERASE  BSR   GETCHR   GET NEXT CHARACTER
FEC8 81 52          CMP A #'R       VERIFY REST OF 'ERS'
FECA 26 06          BNE   ERASE1
FECC 8D 29          BSR   GETCHR
FECE 81 53          CMP A #'S
FED0 27 01          BEQ   CLS
FED2 39       ERASE1 RTS

                    * CLEAR CRT SCREEN
FED3 DE 09    CLS    LDX   CURMOD    GET CURRENT MODE
FED5 A6 05          LDA A MODBYT,X  GET MODE BYTE
FED7 48             ASL A           SHIFT LEFT 1 BIT
FED8 2B 01          BMI   CLS1      GO IF MODE 1
FEDA 4F             CLR A           STORE 0 FOR ALL OTHERS
FEDB CE D000  CLS1  LDX   #VRAM     POINT TO VIDEO RAM
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```
FEDE E6 00    CLS2   LDA B 0,X       GET CURRENT RAM CONTENTS
FEE0 53              COM B           INVERT IT
FEE1 E7 00           STA B 0,X       STORE IT
FEE3 E1 00           CMP B 0,X       DID IT CHANGE?
FEE5 26 05           BNE   CLS3      GO IF NOT
FEE7 A7 00           STA A 0,X       STORE CLEAR CODE
FEE9 08              INX             ADVANCE POINTER
FEEA 20 F2           BRA   CLS2
FEEC 39       CLS3   RTS

              * INVERT THE BACKGROUND COLOR
FEED 96 0C    INVERT LDA A MODVAL    GET MODE REG VALUE
FEEF 88 10           EOR A #$10      INVERT CSS BIT
FEF1 97 0C           STA A MODVAL    STORE IT
FEF3 B7 F420         STA A MODREG
FEF6 39              RTS

              * GET CHARACTER FROM INPUT PORT
FEF7 7E FE30  GETCHR JMP   INCHR     (RELATIVE BRANCH BOOSTER)

              * LOAD A DATA USING MOTOROLA S1-S9 FORMAT
FEFA 8D FB    LOAD   BSR   GETCHR    GET NEXT CHARACTER
FEFC 81 44           CMP A #'D       VERIFY REST OF 'LD*' COMMAND
FEFE 26 49           BNE   LOAD5
FF00 8D F5           BSR   GETCHR    GET ANOTHER CHARACTER
FF02 81 2A           CMP A #'*
FF04 26 43           BNE   LOAD5
FF06 8D EF    LOAD1  BSR   GETCHR    GET A CHARACTER
FF08 81 53           CMP A #'S       IS IT 'S'?
FF0A 26 FA           BNE   LOAD1     LOOP IF NOT
FF0C 8D E9           BSR   GETCHR    GET ANOTHER CHARACTER
FF0E 81 31           CMP A #'1       IS THIS 'S1' HEADER?
FF10 27 04           BEQ   LOAD2     GO IF YES
FF12 81 39           CMP A #'9       IS THIS 'S9' RECORD?
FF14 26 F0           BNE   LOAD1     LOOP IF NOT
FF16 80 31    LOAD2  SUB A #'1       CONVERT TO 0 OR 8
FF18 97 0E           STA A RECTYP    SAVE RECORD TYPE
FF1A 7F 000D         CLR   CKSUM     RESET CHECKSUM
FF1D 8D 4F           BSR   LDBYTE    GET BYTE COUNT
FF1F 80 03           SUB A #3        ADJUST FOR COUNT, ADDRESS
FF21 97 11           STA A BYTCNT
FF23 8D 3E           BSR   LDADDR    GET ADDRESS
FF25 96 0E           LDA A RECTYP    'S9' RECORD?
FF27 26 0E           BNE   LOAD4     GO IF YES
FF29 96 11           LDA A BYTCNT    ANY DATA TO LOAD?
FF2B 27 0A           BEQ   LOAD4     GO IF NOT
FF2D 8D 3F    LOAD3  BSR   LDBYTE    GET A DATA BYTE
FF2F A7 00           STA A 0,X       STORE IT
FF31 08              INX             ADVANCE POINTER
FF32 7A 0011         DEC   BYTCNT    DECREMENT BYTE COUNT
FF35 26 F6           BNE   LOAD3     LOOP UNTIL 0
FF37 8D 35    LOAD4  BSR   LDBYTE    GET CHECKSUM
FF39 7C 000D         INC   CKSUM     CHECK IT
FF3C 26 0C           BNE   LOADX     GO IF BAD
FF3E 7D 000E         TST   RECTYP    CHECK RECORD TYPE
FF41 27 C3           BEQ   LOAD1     LOOP IF 'S1'
FF43 DE 0F           LDX   XHI       GET START ADDRESS
FF45 27 02           BEQ   LOAD5     GO IF NONE
```

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FF47 6E 00          JMP   0,X        GO TO START
FF49 39       LOAD5 RTS              COMMAND EXIT
FF4A 5F       LOADX CLR B            SET MODE TO 0
FF4B BD FD16        JSR   NEWMOD
FF4E BD FED3        JSR   CLS        CLEAR SCREEN
FF51 CE D0EB        LDX   #VRAM+235
FF54 8E FCA0        LDS   #ERRMSG-1
FF57 C6 0A          LDA B #10        SET COUNT
FF59 32       LOADX1 PUL A           SET UP MESSAGE
FF5A A7 00          STA A 0,X
FF5C 08             INX
FF5D 5A             DEC B
FF5E 26 F9          BNE   LOADX1     LOOP UNTIL ZERO
FF60 7E FE08        JMP   ABORT

                  * LOAD AN ADDRESS
FF63 8D 09    LDADDR BSR  LDBYTE     GET A BYTE
FF65 97 0F          STA A XHI        SAVE IT
FF67 8D 05          BSR   LDBYTE     GET ANOTHER BYTE
FF69 97 10          STA A XLO        SAVE IT
FF6B DE 0F          LDX   XHI        PICK UP ADDRESS
FF6D 39             RTS

                  * LOAD A BYTE (2 ASCII CHARACTERS)
FF6E 8D 0E    LDBYTE BSR  LDHEX      GET HEX DIGIT
FF70 48             ASL A            LEFT JUSTIFY IT
FF71 48             ASL A
FF72 48             ASL A
FF73 48             ASL A
FF74 16             TAB              SAVE IN B
FF75 8D 07          BSR   LDHEX      GET ANOTHER DIGIT
FF77 1B             ABA              COMBINE HALVES
FF78 16             TAB              COPY TO B
FF79 DB 0D          ADD B CKSUM      ADD TO CHECKSUM
FF7B D7 0D          STA B CKSUM
FF7D 39             RTS

                  * LOAD A HEX DIGIT (1 ASCII CHARACTER)
FF7E BD FE30  LDHEX JSR   INCHR      GET A CHARACTER
FF81 81 30          CMP A #'0        IS IT < 0?
FF83 25 C5          BLO   LOADX      ABORT IF YES
FF85 81 39          CMP A #'9        IS IT <= 9?
FF87 23 0A          BLS   LDHEX1     GO IF YES
FF89 81 41          CMP A #'A        IS IT < A?
FF8B 25 BD          BLO   LOADX      ABORT IF YES
FF8D 81 46          CMP A #'F        IS IT > F?
FF8F 22 B9          BHI   LOADX      ABORT IF YES
FF91 80 07          SUB A #7         REMOVE ALPHA BIAS
FF93 84 0F    LDHEX1 AND A #$0F      MASK OFF UNUSED BITS
FF95 39             RTS

                  * HARDWARE VECTORS
   (FFF8)           ORG   $FFF8
FFF8 FC 00          FDB   ENTRY IRQ VECTOR
FFFA FC 00          FDB   ENTRY SWI VECTOR
FFFC FC 00          FDB   ENTRY NMI VECTOR
FFFE FC 00          FDB   ENTRY REENTRY VECTOR
```

```
                    END
      00  ERROR(S) DETECTED


   SYMBOL TABLE:
ABORT   FE08    ASTRNG  FD8D    BASPAG  0000    BYTCNT  0011
BYTLOC  0000    CKSUM   000D    CLS     FED3    CLS1    FEDB
CLS2    FEDE    CLS3    FEEC    CMAX    0002    CMDTBL  FC03
COLOR   0005    COPYLP  FCE4    CR      000D    CURMOD  0009
ENTRY   FC00    ERASE   FEC6    ERASE1  FED2    ERRMSG  FCA1
FLUSH   FDCD    GETCHR  FEF7    GETCMD  FCFA    GETNUM  FDED
GETXY   FDD4    GETXY1  FDDE    GETXY2  FDE8    GETXYN  FDEB
GREETG  FC61    GTCMD1  FD00    GTNUM1  FDEE    GTNUM2  FDF8
HORZLN  FD3E    HRZLN1  FD43    HRZLNX  FD55    INCHR   FE30
INPCTL  F405    INPDAT  F404    INVERT  FEED    INVMSK  000B
LDADDR  FF63    LDBYTE  FF6E    LDHEX   FF7E    LDHEX1  FF93
LF      000A    LOAD    FEFA    LOAD1   FF06    LOAD2   FF16
LOAD3   FF2D    LOAD4   FF37    LOAD5   FF49    LOADX   FF4A
LOADX1  FF59    LOCAT1  FE46    LOCAT2  FE55    LOCAT3  FE5B
LOCAT4  FE66    LOCAT5  FE6C    LOCATE  FE39    MASKI   0008
MASKO   0007    MODBYT  0005    MODREG  F420    MODTBL  FC25
MODVAL  000C    NEWMOD  FD16    NUMCK   FE0E    NUMCK1  FE18
PATERN  0006    PIXLOC  0002    PROCMD  FD0D    PROM1   FC00
PROM2   F800    PSTRG1  FDA2    PSTRG2  FDC6    PSTRG3  FDCC
PSTRNG  FD96    RECTYP  000E    RSTRNG  FD92    SEMGR1  FEAE
SEMGR2  FEBD    SEMGRM  FEA6    SET     FD6E    SETCLR  FD32
SETMOD  FD13    SETMSK  FE77    SETPAT  FD82    SETPNT  FD71
SHFTCT  0003    SP      0020    STACK   007F    START   FCAB
STCLRX  FD3D    STMOD1  FD31    STMSK1  FE9B    STMSK2  FEA5
STPATX  FD8C    STRPIX  FD77    VDGCTL  F407    VDGDAT  F406
VERTLN  FD56    VLOAD   FE1A    VLOAD1  FE1C    VRAM    D000
VRTLN1  FD5B    VRTLNX  FD6D    VSTOR1  FE27    VSTORE  FE25
XHI     000F    XLO     0010    XLOC    0003    XMAX    0000
YLOC    0004    YMAX    0001    YSIZE   0004
```

Appendix A9
BASIC PROGRAM SOURCE LISTINGS

A CITY IN MOTION

```
10 POKE 16553,255
100 CLEAR 100 : CLS
110 DEFINT A-Z
3000 PRINT @512,"CITY - A STUDY OF A CITY IN MOTION"
3010 PRINT
3020 PRINT "THIS DISPLAY USES A GRAPHICS MODE OFFERING 4 COLORS IN 64"
3030 PRINT "ROWS OF 128 COLUMNS EACH."
3040 PRINT
3050 LPRINT "S9" : LPRINT : LPRINT "M4 ERS I"
3060 XM=127 : YM=63 : CM=3
3070 X=60 : Y=30 : DX=0 : C=1
3090 D=RND(4)
3100 IF D<>DX THEN DX=D : C=RND(CM)
3110 ON D GOSUB 3140,3180,3220,3260
3111 IF INKEY$=" " THEN GOTO 3300
3120 GOTO 3090
3140 Y=Y-2 : IF Y<0 THEN Y=Y+YM+1 : LPRINT "I"
3150 LPRINT "C";C;"S";X;Y;"S";X+1;Y;"S";X+2;Y;"S";X+3;Y
3160 LPRINT "C 0 S";X;Y+1;"S";X+1;Y+1;"S";X+2;Y+1;"S";X+3;Y+1
3170 RETURN
3180 X=X+4 : IF X>XM THEN X=X-XM-1 : LPRINT "I"
3190 LPRINT "C 0 S";X;Y;"S";X+1;Y;"C";C;"S";X+2;Y;"S";X+3;Y
3200 LPRINT "C 0 S";X;Y+1;"S";X+1;Y+1;"C";C;"S";X+2;Y+1;"S";X+3;Y+1
3210 RETURN
3220 Y=Y+2 : IF Y>YM THEN Y=Y-YM-1 : LPRINT "I"
3230 LPRINT "C 0 S";X;Y;"S";X+1;Y;"S";X+2;Y;"S";X+3;Y
3240 LPRINT "C";C;"S";X;Y+1;"S";X+1;Y+1;"S";X+2;Y+1;"S";X+3;Y+1
3250 RETURN
3260 X=X-4 : IF X<0 THEN X=X+XM+1 : LPRINT "I"
3270 LPRINT "C";C;"S";X;Y;"S";X+1;Y;"C 0 S";X+2;Y;"S";X+3;Y
3280 LPRINT "C";C;"S";X;Y+1;"S";X+1;Y+1;"C 0 S";X+2;Y+1;"S";X+3;Y+1
3290 RETURN
3300 LOAD 30,R
```

THE LIGHTS OF VEGAS

```
10 POKE 16553,255
100 CLEAR 100 : CLS
110 DEFINT A-Z
2000 PRINT @512,"NEON - A RANDOM GRAPHIC DISPLAY REMINISCENT OF LAS VEGAS"
2010 PRINT
2020 PRINT "THIS DISPLAY USES THE SEMIGRAPHICS MODE."
2030 PRINT "UP TO 15 DIFFERENT PATTERNS MAY BE DISPLAYED IN 8 COLORS IN 16"
2040 PRINT "ROWS OF 32 COLUMNS EACH."
```

```
2060 LPRINT "M 0 ERS"
2070 X=RND(32)-1 : Y=RND(16)-1
2080 P=RND(16)-1
2090 C=RND(8)-1
2100 IF (RND(2)-1) THEN C$="H" : L=32 : GOTO 2120
2110 C$="V" : L=16
2120 L=RND(L)
2130 LPRINT "P";P;" C";C;" ";C$;X;Y;L
2140 IF INKEY$=" " THEN GOTO 2160
2150 GOTO 2070
2160 LOAD 30,R
```

RECTANGLES IN EIGHT COLORS

```
10 POKE 16553,255
100 CLEAR 100 : CLS
110 DEFINT A-Z
1000 PRINT @512,"ALPHANUMERIC AND GRAPHIC CAPABILITY".
1010 PRINT
1020 PRINT "DISPLAY 32 DIFFERENT ASCII CHARACTERS IN 16 32-COLUMN LINES."
1030 PRINT "DISPLAY 15 DIFFERENT GRAPHIC BLOCKS IN 16 LINES OF 32 COLUMNS."
1040 PRINT
1050 PRINT "CHARACTERS MAY BE DISPLAYED IN NORMAL OR REVERSE VIDEO."
1070 LPRINT "M0 ERS I"
1090 X=0 : Y=0 : H=32 : V=16
1100 FOR C=0 TO 7
1110 LPRINT "P 15 C";C
1120 LPRINT "H";X;Y;H
1130 LPRINT "H";X;Y+V-1;H
1140 LPRINT "V";X;Y;V
1150 LPRINT "V";X+H-1;Y;V
1160 X=X+1 : Y=Y+1 : H=H-2 : V=V-2
1170 NEXT C
1180 LPRINT "A 12 7 ELECTRIC"
1190 LPRINT "A 13 8 CRAYON"
1200 FOR J=1 TO 10
1210 FOR W=1 TO 100 : IF INKEY$=" " THEN GOTO 1350 ELSE NEXT W
1220 LPRINT "I"
1230 NEXT J
1240 LPRINT "P 0"
1250 FOR C=0 TO 7
1260 X=X-1 : Y=Y-1 : H=H+2 : V=V+2
1270 LPRINT "V";X+H-1;Y;V
1280 LPRINT "V";X;Y;V
1290 LPRINT "H";X;Y+V-1;H
1300 LPRINT "H";X;Y;H
1310 NEXT C
1320 FOR W=1 TO 400 : IF INKEY$=" " THEN GOTO 1350 ELSE NEXT W
1340 GOTO 1090
1350 LOAD 30,R
```

Appendix A10
ADDING TYPE 2114 DISPLAY MEMORY ICs

Not all 2114 RAM ICs are suitable for display memory application principally because of inadequate temperature-speed characteristics. The 2114 ICs supplied with an Electric Crayon(tm) shipped from the factory are carefully selected to ensure optimum operation.

Percom cannot guarantee satisfactory operation of the Electric Crayon(tm) with non-factory installed display memory ICs.

If you should choose, however, to purchase and install your own expanded display memory, the following symptoms of defective chips are set forth as a troubleshooting aid.

*** CAUTION ***

Observe the precaution of paragraph 2.6.1 concerning the handling of MOS devices.

1) Sections of the screen cannot be erased with the 'ERS' command.
2) Display picture elements always remain either ''on'' or ''off''.
3) Symptoms of (1) or (2) occur only after continuous operation. (Temperature sensitive chip(s).)

Switching the position of individual 2114 chips will usually determine which chip (or chips) is defective.

Refer to the next to the last page of this manual for instructions on returning units for modification or repair.

Appendix A11
INTERFACING THE ELECTRIC CRAYON(tm) WITH THE RADIO SHACK PRINTER INTERFACE

This appendix describes the procedures and requirements for interfacing the Electric Crayon(tm) to a TRS-80* computer via the Radio Shack Printer Interface, PN 26-1411.

I. Modifications

Make the following modifications.

A. Printer Interface - Solder an insulated jumper wire, as close to the plastic case as possible, between conductor 35 and conductor 19. Refer to figure A11.1.
B. Electric Crayon(tm) - Early models of the Electric Crayon(tm) must be modified by soldering an insulated jumper wire between conductor 19 and the +5-volt trace. Refer to Figure A11.2.

II. Cable

The optional Percom Electric Crayon(tm)/Printer Interface Cable, PN 330-1010-002, will be required for connecting the Electric Crayon(tm) to the Radio Shack Printer Interface. Refer to the next-to-last page of this manual for ordering information.

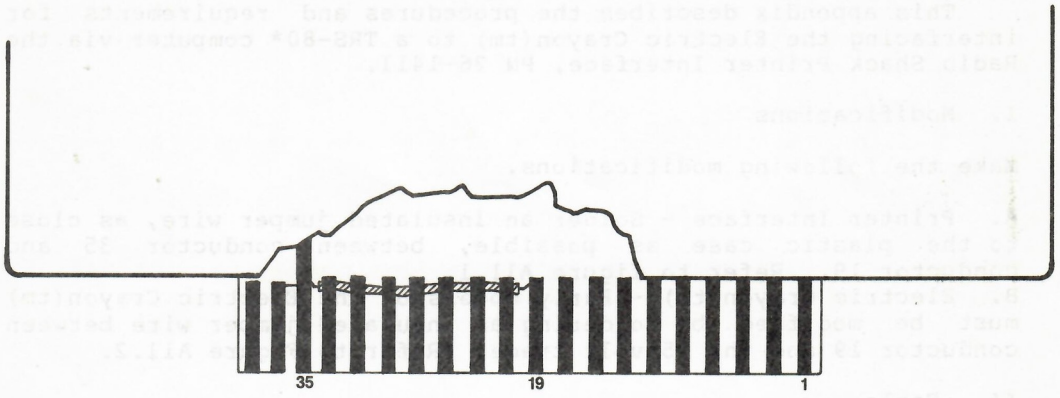

Figure A11.1 PRINTER INTERFACE MODIFICATION

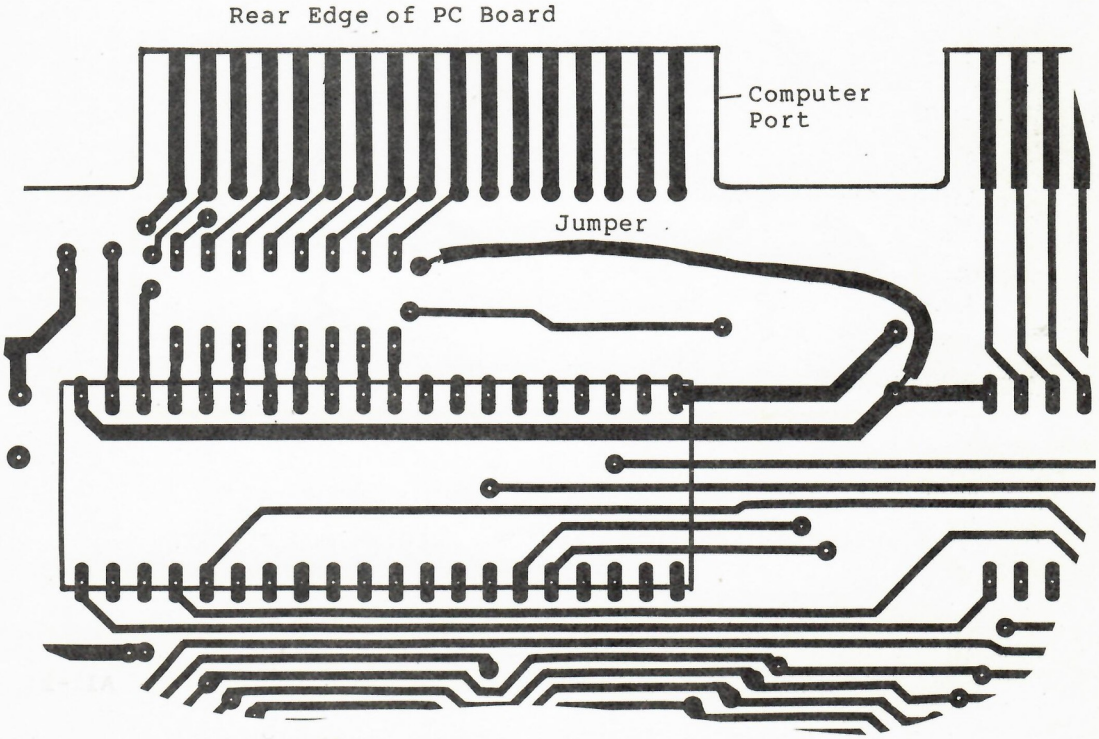

Figure A11.2 ELECTRIC CRAYON(tm) MODIFICATION

Appendix A12
USING RADIO SHACK RF ADAPTER PN 277-122

The following changes in the Radio Shack 277-122 RF Adapter are recommended before using it with the Electric Crayon(tm). Refer to your 277-122 manual for locations.

1) Remove R5, R6, R2 and CR1.
2) Solder an insulated jumper wire between points A and B. Figure A12.1.

WARNING!

The owner assumes all responsibility for complying with Federal Communications Commission (FCC) regulations concerning legal maximum levels of RF radiation if the Electric Crayon(tm) is used with an rf modulator.

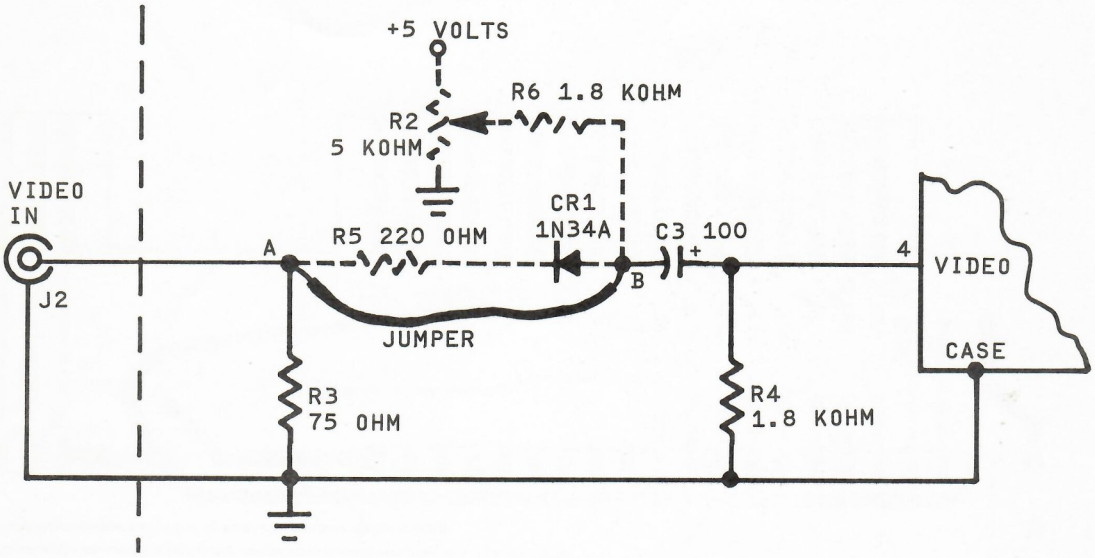

Figure A12.1 RADIO SHACK RF ADAPTER MODIFICATION

HOW TO RETURN A UNIT FOR REPAIR

You have done everything you know how to do. You have read and reread the instruction manual and technical memos but you still can't get the ^$*&@ thing to work!

Then it is time to let us help. We have yet to find a sick unit that cannot be restored to full health and vigor.

There are a few things you can do to help us when you return a unit for repair.

1. Write or call for return authorization before returning any merchandise. Returns without authorization will be refused.

2. When you return a unit for repair, enclose a complete description of the problem.

   *** NOTE ***

   Questions that do not relate to the reason the unit is being returned for repair must be sent in under separate cover.

3. Out-of-Warranty repairs are performed for a labor charge of $25.00 plus parts and shipping. If we find that a unit is functioning properly as received and does not require any service, the Checkout Charge is $15.00 plus shipping and insurance. Do not enclose any payment. The unit will be returned COD for authorized repairs and shipping.

4. When returning a unit for repair, pack it in a large carton with at least 3" of padding on all sides. We will not attempt to service any unit if there is shipping damage until the claim is settled (a real hassle). Ship prepaid by UPS or INSURED PARCEL POST to

   Percom Data Company, Inc.
   Service Department
   211 N. Kirby Street
   Garland, Texas 75042

We try to turn repairs around within one week.

HOW TO ORDER PARTS AND OPTIONAL ITEMS

HOW TO ORDER: Order by mail...we're as near as your mailbox... or order by phone.

TOLL-FREE PHONE ORDERS: To save you money and insure prompt service, we've installed a toll-free number: 1-800-527-1592 FOR PLACING ORDERS ONLY. In Texas, and for Customer Service, dial (214) 272-3421. We cannot transfer calls received on our toll-free number to other departments -- please help us serve you better by dialing the correct number.

PROMPT SERVICE: We ship the cheapest, fastest way. We use UPS up to 50 lbs. per item, 100 lbs. per shipment. We use truck-freight for large or heavy shipments. Transportation charges collected on delivery.

COD ORDERS: COD orders are accepted where possible.

OPEN ACCOUNT TERMS: Net 10 days to rated firms.

TEXAS SALES TAX: Texas law requires that we collect 5% sales tax on all shipments to Texas.

MINIMUM ORDERS: To all orders totaling less than $15.00, we will add a charge of $2.00 for handling.

RETURNS: Write or call for return authorization before returning any merchandise. RETURNS WITHOUT AUTHORIZATION WILL BE REFUSED.

DAMAGED SHIPMENTS: Have carrier note if received in damaged condition, then file claim. About concealed damage: contact carrier for inspection, then file claim. ve carrier note if received in damaged condition, then file claim. About concealed damage: contact carrier for inspection, then file claim.

PERCOM DATA CO. INC.
211 N. Kirby
Garland, Tx 75042
(214) 272-3421

STATEMENT OF LIMITED WARRANTY

For a period of 90 days from the date of delivery, Percom Data Co. Inc. warrants to the original purchaser that the computing equipment described herein shall be free from defects in material and workmanship under normal use and service. During this period, if a defect should occur, the equipment must be returned to the Percom Data Co. Service Facility at the above address for repair. The purchaser must prepay all shipping and insurance charges and must supply proof of purchase from Percom Data Co. or an authorized Percom dealer or distributor. Purchaser's sole and exclusive remedy in the event of defect is expressly limited to the correction of the defect by adjustment, repair or replacement at Percom's election and sole expense, except there shall be no obligation to replace or repair items which by their nature are expendable. No representation or other affirmation of fact, including, but not limited to, statements regarding capacity, suitability for use, or performance of the equipment, shall be or be deemed to be a warranty or representation by Percom Data Co. Inc., for any purpose, nor give rise to any liability or obligation of Percom Data Co. Inc. whatsoever.

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