ESD-TR-66-104

MTR-175

USER'S DESCRIPTION OF THE DD-13 DISPLAY CONSOLE CONNECTED TO PHOENIX

JULY 1966

J. Mitchell

Prepared for

DEPUTY FOR ENGINEERING AND TECHNOLOGY
DIRECTORATE OF COMPUTERS
ELECTRONIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
L. G. Hanscom Field, Bedford, Massachusetts

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Project 508G

Prepared by

THE MITRE CORPORATION
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FOREWORD

The display console described herein permits the use of a typewriter, associated with the display memory for both input and output from the PHOENIX computer. Use of the typewriter is described in this document. It will probably be normal procedure for typewriter input and output to be routed not through the display memory, but rather through the PHOENIX Low-Speed Buffer. In this event, operation of the typewriter is described in the PHOENIX Reference Manual.

REVIEW AND APPROVAL

This technical report has been reviewed and is approved.

CHARLES A. LAUSTRUP, Col, USAF
Director of Computers
Deputy for Engineering and Technology

ABSTRACT

This report describes the dd-13 display console, as it will be connected to the PHOENIX computer for the benefit of prospective users.

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SECTION I

INTRODUCTION

This document, which supersedes TM-3930* in respect to the dd-13 display console only, describes this console for use with the PHOENIX computer.

1.1 GENERAL DESCRIPTION

The dd-13 Display consists of a display console cabinet and a logic cabinet. The display console contains a 16-inch diameter CRT, the operating controls, and the deflection and unblanking circuits for the CRT. The logic cabinet houses a 2048-word (24 bits per word) core memory, having a 6.4-microsecond cycle-time, an interface with the computer for transferring data to and from the memory, logic for interpreting memory data into CRT electron beam deflection and intensification commands, and controls for repetitively cycling through the memory, regenerating the display.

The Display interfaces with the PHOENIX computer through the High Speed Channel of the Tape Control Unit. The data transfer rate is 62,000 words per second. Data may be transferred in either direction under PHOENIX control. The Display can generate interrupts to PHOENIX.

The normal use for the bulk of the core memory is storing display program data. This data may be coded to command the display of points, straight lines (vectors), or alphanumeric characters. Data is normally taken from memory a word at a time, starting from an address specified by PHOENIX and progressing sequentially through successively higher numbered addresses. But memory data may be coded so as to require branching to any arbitrary address, so that the next word of display

*J. Mitchell, Description of the System Design Laboratory Display Consoles, the MITRE Corporation, Bedford, Massachusetts, TM-03930, 21 February 1964 (U) data is taken from that address, either unconditionally or at the option of the console operator.

A part of the memory, viz, the first 128 addresses, is normally reserved for the storage of data generated by the console operator. The operator has available three means for generating data; a set of 22 push-buttons, a light pencil, and a typewriter similar to the other PHOENIX typewriters. The light pencil is a photoelectric detector which may be used to detect a displayed symbol at which it is aimed; it then generates data identifying either the symbol address in display memory, or its position on the CRT. An interrupt is sent to the PHOENIX when this data is generated by the console operator.

Still another part of the memory is normally used for storing the description of microcharacters, whose characteristics are described in Section VI.

Any part of the memory may be used for temporarily storing data to be printed by the typewriter.

SECTION II

PHOENIX INTERFACE

Interface with the PHOENIX computer is made through the High Speed Channel (HSC) of the Tape Control Unit (TCU). The display will be HSC Device 1. Data is transferred through this interface at a rate of 250,000 six-bit characters (plus an odd parity bit) per second. The only operations possible through this channel are Read and Write (for a description of these operations, see the PHOENIX Reference Manual).

2.1 INTERRUPTS

2.1.1 Attention

Upon generation of inquiry messages (described in Section IV), the dd-13 generates an interrupt to PHOENIX. The effect of this interrupt is to set bit 12 of the NR register (TCU/HSC Special device attention) and bit 16 of the TS register.

2.1.2 Data Transfer Error

If a data transfer error occurs, bit 3 of the NR register will be set.

2.2 DATA FORMATS FOR WRITE OPERATIONS

A Write operation performed on the dd-13 will perform one of a number of actions at the display. The action performed is defined by the first non-zero character transmitted from the TCU. The permitted actions, and the coding required to perform them, are given in the following sections.

2.2.1 Load (21)

Where the first non-zero character is 21_8, the display stores data in its core memory. The two characters that immediately follow the command code define the 11-bit address in the display core into which the first data word will be stored. (The most significant bit of the first of these characters is discarded.) Subsequent words are stored in successively higher numbered addresses. The two characters immediately following the address characters define an eleven-bit word-count, which is the number of 24-bit words that are to be stored. (The most significant bit of the first of these characters is also discarded.) Subsequent characters are assembled into 24-bit words and stored as indicated above. If the bits in memory are identified from left to right as 0 through 23, the first data character will appear in bits 0 through 5, inclusive, and so on from left to right.

2.2.1.1 Exceptional Conditions

a) If the number of words of data actually transmitted is less than the number specified in the word count, all words received are stored as required and the residual word count is discarded.

b) If the number of words transmitted is greater than the number specified in the word count, those words in excess of the word count are discarded.

c) Given an initial address, a, and word count, w, where (a + w) is greater than 3777_8 , then word, n, where $(a + n) = 4000_8$, is stored in address 0000_8 and successive words are stored in addresses 0001, 0002, etc., until transmission stops or the word count is exhausted.

d) If the word count is zero, no data will be stored.

e) If a parity error is detected during transmission, loading is unaffected but an error signal is returned to the TCU. This error signal sets bit 3 of the PHOENIX NR Register.

f) If transmission stops before all word count and address characters are received, all received data is lost, including the command itself (as though there had been no transmission).

2.2.2 Load a Typewriter Message (22)

An initial non-zero character of code 22_8 is a command to type subsequent data on the display typewriter. As for the Load command, address and word count characters are required before actual data storage commences.

The address characters also identify the memory location from which the first three typewriter characters are taken; subsequently, 8-bit character codes are taken from successively higher numbered addresses until an EOM or PM code is encountered.

2.2.2.1 Exceptional Conditions

a. If the number of words transmitted is less than the word count, all words received are stored but no typing takes place, because the typing action is initiated only when the display's word count register is equal to one, and the word necessary to complete the word count has been received.

b. The other abnormal conditions listed in 2.2.1.1, b), c), d), and e) also apply to this command.

c. A typewriter Load command overrides a previous typewriter Load command; the display starts taking data from the new address, and successively higher numbered words, as soon as the word count data is received (this is true even when the word count is zero). It is indeterminate which is used first of the thru possible character codes.

Formats for data to be typed are given in Section V.

2.2.3 Transfer (25)

If the command character is 25_8 , the display prepares to transfer data from core to the computer. As for the Load commands, the Transfer command must be followed by two address characters and two word count characters. These characters complete the transmission; the data, starting from the address specified and continuing through successively higher numbered addresses for the total number of data words as required by the word count, is transmitted from the display in response to a Read operation following the Write operation used to send the Transfer command.

2.2.3.1 Exceptional Conditions

a) If a Write operation intervenes between the Transfer command and the Read operation, it is either a Load command (21 or 22), in which case it is ignored, or it is not a Load command, in which case it will be effective. In either case, it does not affect the successful completion of the Transfer on the next Read operation.

b) It is impossible to transfer the entire contents of display core in one operation because the maximum capacity of the word count register is 3777_8.

c. Given starting address, a, and word count, w, such that (a + w) is greater than 3777_8, the excess words are transferred out of addresses 0000 *et seq*.

d. If a parity error occurs during the actual transfer of data and it is desired to repeat the operation in order to get the correct data, a new Transfer command must be sent to the display.

2.2.4 Start Display (12)

If the command character is 12_8, the display logic commences reading data out of memory and interpreting it as display data for the console. The two characters immediately following the command character define the 11-bit display address from which the first word is to be taken. The most significant bit of the first of these characters is discarded.

2.2.4.1 Exceptional Conditions

Characters following the address characters will be discarded.

If the transmission is terminated before both address characters are received, the display will not start; however, the fact that a Start Display command was received is remembered, and display starts when a later Write operation, containing at least two characters following the command characters, is received. The display then starts at the address defined by the second and third characters of this later transmission.

2.2.5 Stop Display (16)

If the command character is 16_8 , the display logic stops taking words from memory for interpretation as display commands, and all characters after the command character are discarded.

2.2.6 Ring Bell Once (31)

Command character 31_8 rings the console bell once. All subsequent characters are discarded.

2.2.7 Ring Bell (32)

Command character 32_8 rings the console bell continuously, until turned off manually or by a Ring Once command. All characters after the command character are discarded.

2.2.8 Unlock Keyboard (36)

Command character 36_8 unlocks the typewriter keyboard. Initially it is locked by a Reset. Subsequent characters are discarded.

2.2.9 Lock Keyboard (26)

Command 26_8 locks the typewriter keyboard. All subsequent characters are discarded.

2.2.10 Message Mode (46)

Command character 46_8 causes the typewriter logic to provide an interrupt to the PHOENIX only upon operation of the EOM key. All subsequent characters of the transmission are discarded.

2.2.11 Character Mode (43)

Command character 43_8 causes the typewriter logic to send an interrupt to the computer each time a typewriter key is struck, unless a previous interrupt has not yet been asknowledged by a Read operation. All characters following the command character are discarded.

2.2.12 Reset (77)

Command character 77_8 resets the display logic idle condition (all registers cleared and no display operation). The contents of memory are not affected. The typewriter keyboard locks, any stacked inquiries are lost, and the typewriter is in Message Mode. This command has not yet been implemented.

2.2.13 Other Commands

Command codes other than those listed above, are ignored, and any characters that follow are discarded.

2.2.14 PHOENIX Formats for Write Operations

It is recommended that the command character (first non-zero character of a Write operation) be made the last character of the first PHOENIX word transmitted (bits 18 through 23, inclusive), so that PHOENIX and Display word boundaries will be the same. This restriction is important only for Load commands.

2.3 READ OPERATION FORMATS

Transmission of data from display memory to the computer results from a Read operation performed on the display. The transmission is initiated with two word-count characters specifying the number of display memory words to be sent (this count includes neither the word-count character themselves, nor the two subsequent characters). Initially, the next two characters will be null characters, but subsequently, they will be coded to tell the computer program the settings of the Branch switches (see Paragraph 3.8).

The words obtained from memory follow these four characters. The address, from which the first word is obtained, was either specified in a preceding Transfer command, or, if there has been no Transfer command since the last Read operation, it is address 0000. All subsequent words are obtained from successively higher numbered addresses in memory.

The number of words transmitted from memory was either defined in an immediately preceding Transfer command, or is equal to the number of inquiry words generated by the console operator since the last Read operation not preceded by a Transfer command. This defines the Inquiry Read. If no inquiries are generated, the transmission consists only of the word count (= ØØ) and 2 null characters.

SECTION III

DISPLAY PROGRAMMING

This section describes the data formats used for CRT display generation. The display data words contain a subset of eight control words (Mode words) that control the interpretation of subsequent words in memory. The previous history of the display program determines whether or not a data word is interpreted as a Mode word. If, through program error, an attempt is made to interpret a non-Mode word as a Mode word, a meaningless display may result. The particular mode defined by a Mode word is specified in bits 1 through 3, inclusive.

The origin of the coordinate system of the display is the lower left-hand corner of the screen (x = 0, y = 0). Ten bits each are used to define position on the screen; full-scale ($x = 1777_8$, $y = 1777_8$) is the upper right-hand corner. In addition, it is possible to offset the origin of the coordinate system by 1/4 full-scale to the right, left or upward by the means described below.

3.1 RASTER

0	1		3	4
u	0	0	0	u $\longrightarrow$ u

u = unused

The Raster word calls for the display of an array of points filling the entire coordinate system. This array is 128 x 128. The display of the array also depends upon the operation of the light pencil switch. If the light pencil switch is not operated, the time required for the Raster word is 6.4 microseconds. If the array is displayed, the display time is determined by the position of the light pencil, and it is a maximum of 55 milliseconds when the light pencil is not aimed within the coordinate area, and a minimum of about 10 microseconds when the pencil is aimed at the lower left-hand corner. The average display time is about 27 milliseconds. The Raster mode is only useful for the generation of inquiries as described in Section IV. The word following the Raster word is interpreted as a Mode word.

3.2 POINT MODE

0	1 3	4	14 23
u	0 0 1	X coordinate	Y coordinate

The Point mode is used to require the display of a point at the coordinates specified. Point mode display requires 9.6 microseconds. The data word, following a Point word, is interpreted as a Mode word.

3.3 CHARACTER MODE

0	1 3	4	14 23
s	0 1 0	X coordinate	Y coordinate

s = size

0 = small (about 1/8-inch high)

1 = large (twice the small size)

The Character Mode word prepares the logic for the subsequent display of a series of alphanumeric and special characters. The position of the center of the first character is given by the coordinates, unless all 20-bits are ONE; then the position will be defined by previous display data. Each character appears 1/64 (small) or 1/32 (large) of full scale, to the right of the previous one, until the X-coordinate system overflows. When overflow occurs, the next character appears at the left margin of the coordinate system, 1/64 (or 1/32) of full-scale, below the previous row. When, by successive decrements of this kind, the Y-coordinate system overflows, the next character appears at the extreme upper left of the coordinate system.

The Character Mode word requires 6.4 microseconds. Data words following the Character word are interpreted as characters to be displayed until the END character (77_8) is encountered.

0	6	12	18
1st char.	2nd char.	3rd char.	4th char.

Codes for the various characters are given in Appendix I. The use of michrocharacters, shown as M_n in Appendix I, is explained in Section VI and Appendix III.

The fixed characters require 9.6 microseconds, on the average, and the michrocharacters require 36 microseconds, on the average, to be displayed. Use of the light pencil increases each of these times by 0.8 microseconds. The word containing the END character requires 6.4 + tn microseconds, where t is 8.0 μsec for fixed characters and 33 μsec for microcharacters, and "n" is the number of character codes preceding the END character. The data word following the END character code is interpreted as a Mode word.

3.4 VECTOR MODE

0	1		3	4	5 – 13	14	15 – 23
d	0	1	1	x_s	dX increment	y_s	dY increment

d establishes the vector quality as solid (d = 0), or dashed (d = 1); x_s, y_s are the sign bits for the x and y increments; 0 = positive (to the right, or upward), 1 = negative (to the left, or downward), respectively.

The dX and dY increments are in ONEs complement form. Since there are only nine bits given for the increment, the tenth bit (the least significant one), is assumed equal to the sign bit.

The vector mode word displays a vector from the point defined by previous display data, and having specified x and y increments. This vector may be of any length from zero to the full diagonal of the coordinate system. Zero length vectors do not appear on the display as they have no unblank signal. The minimum displayable length is about 0.02 inch.

The vectors are displayed as specified, even though the specified increments may leave the end points beyond the coordinate system. Since the end points of the vectors become the new positions for the next mode words, if the increments carry these points beyond the coordinate system, there is an overflow in the x or y ten-bit positioning register, and effectively a wrap-around (the left and right edges, and top and bottom edges of the coordinate system may be considered contiguous). Overflow bits are simply discarded.

The time required for a vector display depends upon the length of the vector, as follows:

a. If either increment is equal to or greater than 1/4 of full-scale, the time is about 50 microseconds.

b. If either increment is greater than 1/16 of full-scale, but both are less than 1/4 full-scale, the display time is about 29 microseconds.

c. Otherwise the display time is about 12 microseconds.

The data word following a Vector word is interpreted as a Mode word.

3.5 SHORT VECTOR

0	1		3	14	23
d	1	0	0	X coordinate	Y coordinate

Where d has the same function here as it has for the Vector word.

The Short Vector word makes the display logic interpret following data words as though each specified three vectors of limited length. The position coordinates given are the starting point of the first vector, unless all 20 bits are ONE, in which case the starting point is that defined by previous display data.

The Short Vector word requires 6.4 microseconds. Subsequent words are interpreted as vectors. The data words following are decoded as:

0	1	4		8		12		16		20	
x_{s1}	dx_1	y_{s1}	dy_1	x_{s2}	dx_2	y_{s2}	dy_2	x_{s3}	dx_3	y_{s3}	dy_3

Where the x_s and y_s are the sign bits of the increment, as for the Vector word, and the subscripts identify the three vectors.

Only the three most significant bits of the increments that have maximum magnitudes 28 times the least coordinate difference, are shown; the two less significant bits are assumed equal to the sign bit in each case. Thus, vectors ranging in increment length from about 0.04 inch to 0.28 inch can be coded in each 8-bit group.

The display of a short vector requires, on the average, about 12 microseconds. A null vector is one where all 8 bits are ZERO, and the next following data word is interpreted as a Mode word. A Short Vector word containing a null vector requires about 6.4 + 10n microseconds, where n is the number of not-null vectors preceding the null vector in that word.

3.6 NEAR POINT

0	1		3	4	14 23
u	1	0	1	X coordinate	Y coordinate

The Near Point word makes the display interpret following data words as a succession of increments between points. The coordinates given in the Mode word are those of the first point displayed, unless all 20 bits are ONE, in which case the position of the first point is that defined by previous display data. A Near Point word requires 9.6 microseconds. The average time for the display of each point is 9 microseconds.

Subsequent words are interpreted as a series of 8-bit x- and y-increment groups (the coding of these increments is identical to that used for the Short Vector increments).

A null increment is defined as is a null vector in Short Vector data words. The next data word following a null increment is interpreted as a Mode word. A word containing a null increment takes 6.4, 12.8, or 20.8 microseconds, depending upon whether the first null vector is first, second, or third.

3.7 NEAR CHARACTER

0	1		3	4	14 23
s	1	1	0	X coordinate	Y coordinate

The Near Character word makes the display logic interpret following data words as characters to be displayed and increments between successive characters. The s bit has the same meaning as for a Character word. The X and Y coordinates define the center of the first character displayed unless all 20 bits are ONE, in which case the center of the first character is the position defined by previous display data. The Near Character word requires 6.4 microseconds.

Data words following the Near Character words are interpreted as follows:

0 5	6		9		12 17	18		21	23
1st char.	x_{s1}	dx_1	y_{s1}	dy_1	2nd char.	x_{s2}	dx_2	y_{s2}	dy_2

Character codes are identical to those used in Character mode (see Appendix I).

Increment codes are similar to those used in Short Vector and Near Point modes expect that the least possible, nonzero, increment is 1/64 full-scale. A null increment means that the character following this increment is displayed superimposed on the previous character; there is no automatic advance as in the Character mode.

The display of each character and the subsequent increment requires 12 microseconds (about 36 microseconds for microcharacters). The data word following the END character $\left(77_8\right)$ is interpreted as a Mode word. A word containing an END character takes 6.4 microseconds if the END character is first, and 12 or 36 microseconds if it is second.

3.8 BRANCH

0	1 3	4	9	10	11	12	13 23
u/d	1 1 1	s_1 s_2 s_3 s_4	s_5 s_6	b/d	b/s	h/v	address

When the display logic obtains a Branch word from memory, it decides whether to take the next Mode word from the next higher address or from the address given in the Branch word. The decision is made by a comparison between the status of the word's 0, and 4-9 bits, and the status of the Branch switches on the console's front panel. Bit 0 determines whether the up or the down position of these switches shall be tested. When switch n is set at the position determined by this bit, and when bit s_n is ONE, the next display word is taken from the next address in memory; otherwise, it is taken from the address given in bits 13-23.

There are two exceptions to this rule:

a) When the address given in bits 13-23 is 3777_8 , the next word is taken from the next address without reference to the Branch switch settings.

b) When the address is 0000, 0001, or 0002, the next word is taken from the next address.

The Branch word also controls certain display modifications using bits 10-12, inclusive, as follows:

1) When bit 10 is a 1, all subsequent displayed symbols, until the next Branch word, are displayed in the brighter of two available levels of brightness; if it is a 0, they are displayed at the lesser brightness.

2) When bit 11 is a 1, all subsequent displayed symbols, until the next Branch word, are displayed blinking at a rate of about 2 cycles per second; if it is a 0, they are displayed without blinking.

3) When bit 12 is a 1, all characters are rotated through a 90-degree angle counterclockwise and, in Character mode, the automatic increments between successive characters are upward on the screen. The effect is shown below. When bit 12 is a 0, characters are written horizontally as described in Paragraph 3.3

HORIZONTAL

a. Horizontal Writing

VERTICAL

b. Vertical Writing

Horizontal and Vertical Character Displays

The Branch word controls the offset of the origin as follows:

a) When the address portion of the Branch word is 0000, the origin is offset by 1/4 full-scale to the right.

b) When the address portion of 0001, the origin is offset 1/4 full-scale to the left.

c) When the address portion is 0002, the origin is offset 1/4 full-scale upward. A Branch word requires 8.0 microseconds.

SECTION IV

INQUIRY GENERATION

The console operator has three devices for generating data words for transmission to PHOENIX; these words are called Inquiries. Since one of these devices, the light pencil, can generate two kinds of inquiry, a total of four types of inquiry can be generated. The first two bits (bits 0 and 1) of the first word of the inquiry, identify the kind of inquiry. The formats of each inquiry, and the means of generating them, are given in the following paragraphs.

As each inquiry word is generated, it is stored in the display memory, starting at address 0000. Addresses 0000 through 0177_8 are set aside for inquiry storage, but these addresses may be used for display programs if it is remembered that the program will be destroyed by storage of inquiries.

When an Inquiry Read operation is preformed on the display (Paragraph 2.3), the word count transmitted to PHOENIX is equal to the number of inquiries generated since the last Inquiry Read, or Reset, and the data transmitted consists of those inquiries only. At the same time, the inquiry counter is set to 0 and the next inquiry generated is stored in address 0000.

4.1 LIGHT PENCIL - POSITION MODE

0	1	2	3	4	14 23
0	0	u	u	X coordinate	Y coordinate

The position mode inquiry word is generated by the light pencil only if it detects one of the points in the 128- x 128-array generated by the Raster display (Paragraph 3.1). Since the array is limited to 128 x 128, only the most significant 7 bits of the light pencil position are generated (bits 11-13 and 21-23 are all 0).

When the operator aims the light pencil at a displayed symbol (a Point, Vector, or Character), and when a Raster word is included in the display program, he has no control over the kind of inquiry generated. After the operator enables the light pencil switch, the first display detected by the light pencil (whether Raster point or symbol), is the one which determines the kind of inquiry generated and, after detection takes place, no further inquiry can be generated by the light pencil until its switch is released and again operated.

This is clearly undesirable, and a proposed modification will permit the generation of both kinds of light pencil outputs on each light pencil action. However, it will be some time before this modification is made.

Generation of the position mode inquiry word immediately sends an interrupt to PHOENIX.

4.2 LIGHT PENCIL - SYMBOL MODE

0	1	2 — 9	10 11	12	13 — 23
1	0	unused	n	u	address

The symbol mode of light pencil inquiry is generated when the light pencil detects a displayed symbol. Bits 13-23 contain the display memory address in which the code defining the displayed symbol is contained. Since data words may contain more than one symbol code, bits 10 and 11 identify which of the two, three, or four codes was responsible, and are coded 00, 01, 10, 11 to identify the first, second, third,and fourth, respectively.

As soon as this word is stored in the memory, an interrupt is sent to PHOENIX.

4.3 SWITCH INQUIRY

0	1	2 — 23
0	1	s_1 s_2---------------s_{22}

Depressing the Activate switch (below and to the right of the set of 22 inquiry switches on the console front panel) generates a switch inquiry. Bits s_1---s_{22} of the word are set to 1 only when the corresponding pushbutton is depressed while the Activate switch is depressed; otherwise, they are 0.

Operator of the Activate Key clears all switches. An interrupt is sent to PHOENIX, as soon as the inquiry word is stored in the memory.

4.4 TYPEWRITER

0	1	2 7	8	16
1	1	special	char. 1	char. 2

0	8	16
char. 3	char. 4	char. 5

etc.

The typewriter, associated with the display, generates inquiries that may consist of an arbitrarily large number of inquiry words, up to the limit of the inquiry memory.

A block of typewriter inquiry data words is, in general, terminated by either a Partial Message code $\left(x36_8\right)$, or an End of Message $\left(x17_8\right)$. The remainder of the inquiry word following one of these codes, is all ZEROs. The inquiry word following a word containing either of these codes (if any) must be identified as to its kind (light pencil, switch, typewriter) by its first two bits.

A number of different typewriter inquiries is possible, and they are identified by the coding of the first word.

4.4.1 Unlock Request

When the typewriter keyboard is locked, by either a Reset or a Lock command (Paragraph 2.2.9), the typist can generate only the following typewriter inquiry:

0 1	2 23
1 1	all zeros

This inquiry can be generated only with the SOM key (at upper right of keyboard).

4.4.2 Typewriter Unready

When the typewriter is not able to print data transmitted by a Load Typewriter command (Paragraph 2.2.2.) a typewriter inquiry is generated whose first eight bits are coded:

0							7
1	1	0	1	1	1	1	0

The remaining bits are irrelevant.

4.4.3 Typeout Complete

When the display logic has completed printing a message transmitted to it, an inquiry is generated whose first three bits are all ONE's; the remaining bits are irrelevant.

4.4.4 Typewriter Data

If the keyboard is unlocked, the typist may proceed to generate inquiry words by operating any key except the SOM key. The first 8-bits of the resultant inquiry are coded as follows:

0							7
1	1	0	0	0	0	0	0

The coding of each successive 8-bit group identifies the key struck. Where the bits of each character are identified 0, 1,...,7 the coding is as follows:

bit 0 identifies the ribbon color used (red = 1, black = 0)

bit 1 identifies the case shift (upshift = 1, downshift = 0)

bit 2-7 identify the key for appropriate codes, see Appendix II)

A block of typewriter inquiry words is terminated by a Partial Message or End of Message code. The End of Message code is entered only by operation of the EOM key on the keyboard. The Partial Message code is entered automatically by the display logic wherever the typing process is interrupted with some other action. Actions that can interrupt a typewriter input are as follows:

a) Inquiry Read.
b) Light pencil switch operation (whether or not a light pencil action is actually taken).
c) Switch inquiry.
d) A Lock command from the computer.
e) A key is struck after 176_8 inquiry words have been stored in memory.

Immediately following the completion of an a,b, or c, the typewriter keyboard is again unlocked (having been locked during the operation), and a new block of typewriter inquiry words (again identified by the code 11000000) may be started by striking any key except the SOM. If the Lock command interrupts an inquiry, the typewriter locks, and only the SOM key is effective. Similarly, if the inquiry memory is full (action e above), the keyboard remains locked until an Inquiry Read operation is performed, or the display is Reset and an Unlock command is received.

4.4.5 Interrupts in Typewriter Inquiry Generation

Typewriter inquiries generate interrupts to PHEONIX under various conditions, as follows:

a) Operation of the SOM key while the typewriter keyboard is locked generates an interrupt.

b) Generation of a Typewriter Unready message generates an interrupt.

c) A Typeout Complete message generates an interrupt.

d) Operation of the EOM key generates an interrupt, if the keyboard is unlocked.

e) Storage of 144_8 inquiry words generates an interrupt.

f) When the receipt of the Character Mode command (Paragraph 2.2.11) follows the last Reset or Message command, an interrupt will be generated for each operation of a typewriter key that generates the code 11000000 (at the start of a block of typewriter data). This provision permits the computer to handle each typed character individually, if so desired by the programmer.

4.5 ILLEGAL INQUIRY

Attempting to load an inquiry into a full inquiry memory area causes the inquiry to be discarded and the illegal inquiry light, on the console front panel, to light. To clear this light requires manual operation of the pushbutton that houses it.

SECTION V

TYPEOUT

The typewriter prints data received from the computer (see Paragraph 2.2.2) by using the codes given in Appendix II (use of codes, other than those specifically identified, results in various characters being printed: they are NOT no-ops).

A block of data to be typed must be terminated with a Partial Message (x36), or EOM (x17) character, otherwise the typewriter will simply continue through memory until by chance such a character is found.

Typeout takes place at a nominal 15 characters-per-second, except that the function codes take extra time. When the logic decodes a PM or EOM code it generates the Typeout Complete inquiry (see Paragraph 4.4.3).

SECTION VI

MICROCHARACTERS

The contents of certain display memory addresses, identified in Appendix I, control the appearance on the display of the microcharacters designated M_1 through M_{18} (see Appendix I). Rules for programming the contents of those addresses are given in Appendix III.

APPENDIX I

CHARACTER CODES FOR DISPLAY

Listed by Code (Octal)

Code	Symbol	Code	Symbol	Code	Symbol	Code	Symbol
00	blank	20	M_6	40	-	60	+
01	1	21	*	41	J	61	A
02	2	22	S	42	K	62	B
03	3	23	T	43	L	63	C
04	4	24	U	44	M	64	D
05	5	25	V	45	N	65	E
06	6	26	W	46	O	66	F
07	7	27	X	47	P	67	G
10	8	30	Y	50	Q	70	H
11	9	31	Ƶ	51	R	71	I
12	Ø	32	M_7	52	M_1	72	)
13	=	33	,	53	(	73	.
14	M_{12}	34	M_8	54	M_2	74	M_{16}
15	M_{13}	35	M_9	55	M_3	75	M_{17}
16	M_{14}	36	M_{10}	56	M_4	76	M_{18}
17	M_{15}	37	M_{11}	57	M_5	77	END

Listed by Groups

Alphabet

Symbol	Code	Symbol	Code	Symbol	Code
A	61	J	41	S	22
B	62	K	42	T	23
C	63	L	43	U	24
D	64	M	44	V	25
E	65	N	45	W	26
F	66	O	46	X	27
G	67	P	47	Y	30
H	70	Q	50	Z	31
I	71	R	51		

Numerals

Symbol	Code	Symbol	Code
Ø	12	5	05
1	01	6	06
2	02	7	07
3	03	8	10
4	04	9	11

Punctuation

Symbol	Code
(	53
)	72
,	33
.	73

Special

Symbol	Code
+	60
-	40
*	21
=	13
blank	ØØ

Control

END 77

Microcharacters

Microcharacter	Code	Address*	Microcharacter	Code	Address*
M_1	52	200-203	M_{10}	36	244-247
M_2	54	204-207	M_{11}	37	250-253
M_3	55	210-213	M_{12}	14	254-257
M_4	56	214-217	M_{13}	15	260-263
M_5	57	220-223	M_{14}	16	264-267
M_6	20	224-227	M_{15}	17	270-273
M_7	32	230-233	M_{16}	74	274-277
M_8	34	234-237	M_{17}	75	300-303
M_9	35	240-243	M_{18}	76	304-307

* Address is the octal address in the display memory from which the description of the microcharacter is obtained. Coding used for this description is given in Appendix III.

APPENDIX II

TYPEWRITER CODING

Type Element I

bits 0,1,2,3 / bits 4,5,6,7	0000	0001	0010	0011	0100	0101	0110	0111
0000	space		-	+	space		_	→
0001	1	*	J	A	$\vert$	←	j	α
0010	2	S	K	B	$	Σ	k	β
0011	3	T	L	C	`	t	λ	γ
0100	4	U	M	D	'	~	Ω	δ
0101	5	V	N	E	<	Λ	ψ	ϵ
0110	6	W	O	F	>	ω	{	f
0111	7	X	P	G	↑	∇	}	τ
1000	8	Y	Q	H	↓	≡	#	θ
1001	9	Z	R	I	/	Δ	"	i
1010	0			)	\			]
1011	=	,	(	.	?	;	[	:
1100								
1101		LF	CR	TAB		LF	CR	TAB
1110		PM	BK			PM	BK	
1111	EOM			DEL	EOM			DEL

LEGEND

EOM = End of Message or End of Transmission. LF = Line Feed.
CR = Carriage Return and Line Feed. PM = Partial Message.
DEL = Delete or Erase. BK = Backspace.
Codes for which no symbol is shown are unassigned. The typewriter cannot transmit these codes. Transmission of these codes to the typewriter will, however, cause characters to be printed, and must be avoided.
Bit Ø = 1(prints the same characters in red).

Type Element 2

bits 0,1,2,3 / bits 4,5,6,7	0000	0001	0010	0011	0100	0101	0110	0111
0000	space		-	+	space		_	→
0001	1	*	j	a	|	←	J	A
0010	2	s	k	b	$	S	K	B
0011	3	t	l	c	'	T	L	C
0100	4	u	m	d	'	U	M	D
0101	5	v	n	e	<	V	N	E
0110	6	w	o	f	>	W	O	F
0111	7	x	p	g	↑	X	P	G
1000	8	y	q	h	↓	Y	Q	H
1001	9	z	r	i	/	Z	R	I
1010	0			)	\			]
1011	=	,	(	.	?	;	[	:
1100								
1101		LF	CR	TAB		LF	CR	TAB
1110		PM	BK			PM	BK	
1111	EOM			DEL	EOM			DEL

APPENDIX III

RULES FOR CODING THE DESCRIPTIONS OF MICROCHARACTERS

The description of each character is stored in four 24-bit memory words. These bits (96) are treated as nineteen, five-bit groups, and one extra bit. Each five-bit group codes one 0.2 microsecond interval during which the electron beam may be on or off, and may move 0, 1, or 2 units vertically and/or horizontally. The detailed coding rules are as follows:

Backspace

The first bit of the 96 is set to a logical ZERO for most characters. When set to a logical ONE, the character position advance is inhibited and the character prints in the same space as the last character.

Upshift and Downshift

The first five-bit coding group may be coded differently (but not necessarily) from the other groups. When it is coded 01100, the character is shifted 1/4 character height upwards; when coded 00011, the character is shifted 1/4 character height downwards.

Line Segments

With the exception noted immediately above, all five-bit groups are coded as follows:

a) Blank/Unblank

The first bit controls the electron beam (on or off). A logical ZERO turns the beam is off, and a logical ONE turns the beam on. Beam turn-on should be programmed to occur as soon as the beam has stabilized at the start of the line to be displayed. Stabilization takes one time interval, without motion. With no beam motion programmed, the beam must not be turned off until two time intervals have elapsed after reaching the end of the line displayed. This restriction permits the deflection circuitry, whose delay is a longer than the intensification circuitry, to catch up.

b) Horizontal Beam Movements

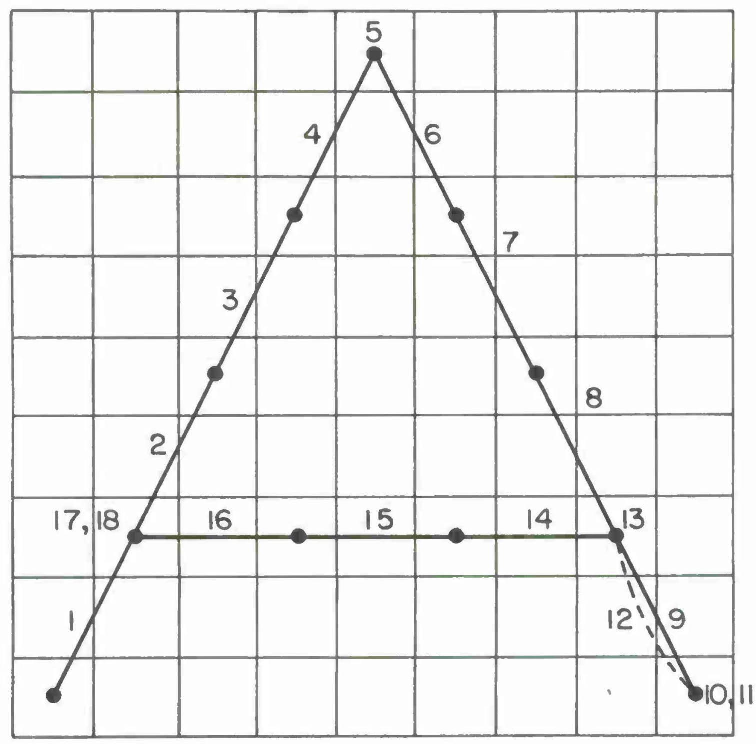
The second and third bits, of each five-bit group, control the horizontal motion of the electron beam in tracing the characters desired. A character is written by straight lines that join points in a nine by nine array. The beam initially starts in the lower left-hand corner of the array. In a time interval the beam may move 0, 1, or 2 units. When the second and third bits are both ZERO, there is no horizontal motion; when the bits are coded 01, the beam moves one unit horizontally, and when the bits are 10, the beam moves two units horizontally. These motions are all towards the right, initially. When motion towards the left is required, these two bits are coded 11; during that time interval the beam does not move horizontally but subsequent motion codes move it left. Whenever the code 11 is used, the direction of beam travel reverses. It is impossible to move outside the nine by nine array of points except, of course, that the upshift and downshift commands have the effect of moving the whole array up or down. Note that it is necessary to wait one time interval at every square corner in order for it to appear square.

c) Vertical Beam Movements

Bits four and five encode vertical motion of the beam, in exactly the same manner as bits two and three code the horizontal motion. However, the vertical distance between points in the nine by nine array is normally set to 4/3 of the horizontal distance thus giving a 4/3 height to width ratio for the characters.

Example of Microcharacter Programming

The diagram below shows how the letter "A" might be drawn using microcharacter coding, and illustrates the use of most of the rules given above.



	1	2	3	4	5
0	1 0 1 1 0	1 0 1 1 0	1 0 1 1 0	1 0 1 1 0	1 0 0
	6	7	8	9	
1 1	1 0 1 1 0	1 0 1 1 0	1 0 1 1 0	1 0 1 1 0	1 0
10	11	12	13	14	
0 1 1	1 1 1 0 0	0 0 1 1 0	0 0 0 0 0	1 1 0 0 0	1
15	16	17	18	19	
1 0 0 0	1 1 0 0 0	1 0 0 0 0	1 0 0 0 0	0 0 0 0 0	

NOTES

1. Beam initially at rest long enough to permit immediate turn-on
5. Pauses for 0.2 μsec. to obtain sharp corner, also vertical reverse.
10,11. Pauses for 0.4 μsec. to complete stroke before beam turn-off. Meanwhile, both horizontal and vertical motions are reversed.
12. Beam moving while turned off.
13. Pauses 0.2 μsec. to let beam settle.
17,18. Pauses to complete horizontal stroke before beam turn-off.

FIGURE 3. MICROCHARACTER CODING FOR THE LETTER A

Security Classification

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) The MITRE Corporation Bedford, Massachusetts	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

USER'S DESCRIPTION OF THE DD-13 DISPLAY CONSOLE CONNECTED TO PHOENIX

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

N/A

5. AUTHOR(S) (Last name, first name, initial)

Mitchell, Jonathan

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
July 1966	39	1

8a. CONTRACT OR GRANT NO. AF19(628)-5165 b. PROJECT NO. 508G c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) ESD-TR-66-104 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) MTR-175

10. AVAILABILITY/LIMITATION NOTICES

Distribution of this document is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Deputy for Engineering and Technology, Directorate of Computers, Electronic Systems Division, L.G. Hanscom Field, Bedford, Mass.

13. ABSTRACT

This report describes the dd-13 display console, as it will be connected to the PHOENIX computer for the benefit of prospective users.

DD FORM 1 JAN 64 1473

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Display Console Computer Interface Coding Inquiries PHOENIX Computer						

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